PHILIPS

Data handbook

PHILIPS Electronic components and materials

Components and materials

Book C14 1986

Electrolytic and solid capacitors

PHILIPS Electrolytic and solid capacitors C14 1986

ELECTROLYTIC AND SOLID CAPACITORS

page

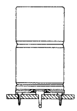
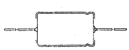
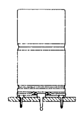
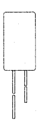
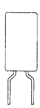
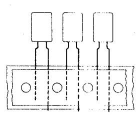
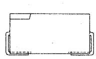
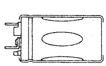
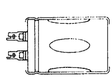
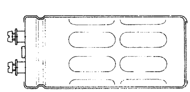
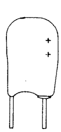
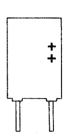
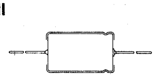
Type survey ii

Selection guide
- Aluminium electrolytic capacitors 2
- Solid aluminium capacitors 4

Introduction
- General 7
- Principles 7
- Description 8
- Electrical impedance 10
- Ripple current 12
- D.C. leakage current 12
- Life time 13
- Reliability 14
- Tests and requirements 14

Device specifications
- Aluminium electrolytic capacitors 23
- Solid aluminium capacitors 383
- Maintenance types 523

TYPE SURVEY

type	application	series number 2222...	characteristic	page
ALUMINIUM ELECTROLYTIC CAPACITORS				
Miniature/small		014	low impedance; LV	41
		021	small dimensions; LV	79
  	long-life, general, industrial	030 031 032 033	LV	109
		041 042 043	HV	203
		065	low leakage current	257
		117	LV; ultra miniature	339
Miniature/small  	extra long-life, industrial	108	acc. to CECC; LV	285
		118	125 °C; LV	353
		132	acc. to DIN 41257; LV	365
		133	acc. to DIN 41257; HV	365
Miniature/small    	long-life, general, industrial	035	LV	153
		037	LV	187
		036	LV	171
		013	low leakage current; LV	25
		116	long-life; LV	323
Miniature; surface mounted 	general	085	LV	271
Large  	long-life, industrial	050	acc. to CECC; LV	223
		051	small dimensions; LV	247
		052	acc. to CECC; HV	223
		053	small dimensions; HV	247
Large 	long-life, industrial, military	114 115	screw terminal	299
SOLID ALUMINIUM CAPACITORS				
Miniature  	very long-life, general, industrial	122	acc. to CECC; resin dipped	407
		124	epoxy potted	491
Miniature/small 	very long-life, military, industrial	121	acc. to CECC	385
		123		435
		125		511

DATA HANDBOOK SYSTEM

Our Data Handbook System comprises more than 60 books with specifications on electronic components, subassemblies and materials. It is made up of four series of handbooks:

ELECTRON TUBES	BLUE
SEMICONDUCTORS	RED
INTEGRATED CIRCUITS	PURPLE
COMPONENTS AND MATERIALS	GREEN

The contents of each series are listed on pages iv to viii.

The data handbooks contain all pertinent data available at the time of publication, and each is revised and reissued periodically.

When ratings or specifications differ from those published in the preceding edition they are indicated with arrows in the page margin. Where application information is given it is advisory and does not form part of the product specification.

Condensed data on the preferred products of Philips Electronic Components and Materials Division is given in our Preferred Type Range catalogue (issued annually).

Information on current Data Handbooks and on how to obtain a subscription for future issues is available from any of the Organizations listed on the back cover.
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T2a	**Transmitting tubes for communications, glass types**
T2b	**Transmitting tubes for communications, ceramic types**
T3	**Klystrons**
T4	**Magnetrons for microwave heating**
T5	**Cathode-ray tubes** Instrument tubes, monitor and display tubes, C.R. tubes for special applications
T6	**Geiger-Müller tubes**
T7	**Gas-filled tubes** (will not be reprinted)
T8	**Colour display systems** Colour TV picture tubes, colour data graphic display tube assemblies, deflection units
T9	**Photo and electron multipliers**
T10	**Plumbicon camera tubes and accessories**
T11	**Microwave semiconductors and components**
T12	**Vidicon and Newvicon camera tubes**
T13	**Image intensifiers**
T14	**Infrared detectors**
T15	**Dry reed switches**
T16	**Monochrome tubes and deflection units** Black and white TV picture tubes, monochrome data graphic display tubes, deflection units

(T13, T14, T15:) Data collations on these subjects are available now. Data Handbooks will be published in 1985.

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The red series of data handbooks comprises:

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S2a Power diodes

S2b Thyristors and triacs

S3 Small-signal transistors

S4a Low-frequency power transistors and hybrid modules

S4b High-voltage and switching power transistors

S5 Field-effect transistors

S6 R.F. power transistors and modules

S7 Surface mounted semiconductors

S8 Devices for optoelectronics
Photosensitive diodes and transistors, light-emitting diodes, displays, photocouplers, infrared sensitive devices, photoconductive devices.

S9 Power MOS transistors

S10 Wideband transistors and wideband hybrid IC modules

S11 Microwave transistors

S12 Surface acoustic wave devices

INTEGRATED CIRCUITS (PURPLE SERIES)

The purple series of data handbooks comprises:

EXISTING SERIES		Superseded by:
IC1	**Bipolar ICs for radio and audio equipment**	IC01N
IC2	**Bipolar ICs for video equipment**	IC02Na and IC02Nb
IC3	**ICs for digital systems in radio, audio and video equipment**	IC01N, IC02Na and IC02Nb
IC4	**Digital integrated circuits** CMOS HE4000B family	
IC5	**Digital integrated circuits – ECL** ECL10 000 (GX family), ECL100 000 (HX family), dedicated designs	IC08N
IC6	**Professional analogue integrated circuits**	
IC7	**Signetics bipolar memories**	
IC8	**Signetics analogue circuits**	IC11N
IC9	**Signetics TTL logic**	IC09N and IC15N
IC10	**Signetics Integrated Fuse Logic (IFL)**	IC13N
IC11	**Microprocessors, microcomputers and peripheral circuitry**	IC14N

NEW SERIES

IC01N	**Radio, audio and associated systems** Bipolar, MOS	(published 1985)
IC02Na	**Video and associated systems** Bipolar, MOS Types MAB8031AH to TDA1524A	(published 1985)
IC02Nb	**Video and associated systems** Bipolar, MOS Types TDA2501 to TEA1002	(published 1985)
IC03N	**Integrated circuits for telephony**	(published 1985)
IC04N	**HE4000B logic family** CMOS	
IC05N	**HE4000B logic family — uncased ICs** CMOS	(published 1984)
IC06N	**High-speed CMOS; PC54/74HC/HCT/HCU** Logic family	(published 1985)
Supplement to IC06N	**High-speed CMOS; PC74HC/HCT/HCU** Logic family	(published 1985)
IC07N	**High-speed CMOS; PC54/74HC/HCT/HCU — uncased ICs** Logic family	
IC08N	**ECL 10K and 100K logic families**	(published 1984)
IC09N	**TTL logic series**	(published 1984)
IC10N	**Memories** MOS, TTL, ECL	
IC11N	**Linear LSI**	(published 1985)
IC12N	**Semi-custom gate arrays & cell libraries** ISL, ECL, CMOS	
IC13N	**Semi-custom** Integrated Fuse Logic	(published 1985)
IC14N	**Microprocessors, microcontrollers & peripherals** Bipolar, MOS	(published 1985)
IC15N	**FAST TTL logic series**	(published 1984)

Note

Books available in the new series are shown with their date of publication.

COMPONENTS AND MATERIALS (GREEN SERIES)

The green series of data handbooks comprises:

C1 **Programmable controller modules**
PLC modules, PC20 modules

C2 **Television tuners, coaxial aerial input assemblies, surface acoustic wave filters**

C3 **Loudspeakers**

C4 **Ferroxcube potcores, square cores and cross cores**

C5 **Ferroxcube for power, audio/video and accelerators**

C6 **Synchronous motors and gearboxes**

C7 **Variable capacitors**

C8 **Variable mains transformers**

C9 **Piezoelectric quartz devices**

C10 **Connectors**

C11 **Non-linear resistors**
Voltage dependent resistors (VDR), light dependent resistors (LDR), negative temperature coefficient thermistors (NTC), positive temperature coefficient thermistors (PTC)

C12 **Potentiometers, encoders and switches**

C13 **Fixed resistors**

C14 **Electrolytic and solid capacitors**

C15 **Ceramic capacitors**

C16 **Permanent magnet materials**

C17 **Stepping motors and associated electronics**

C18 **Direct current motors**

C19 **Piezoelectric ceramics**

C20 **Wire-wound components for TVs and monitors**

C21* **Assemblies for industrial use**
HNIL FZ/30 series, NORbits 60-, 61-, 90-series, input devices

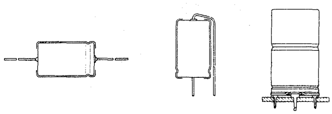
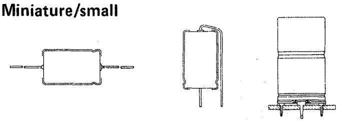
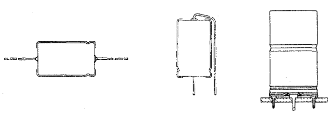
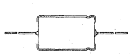
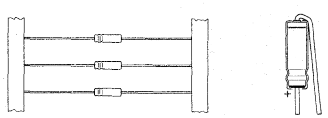
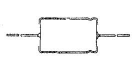
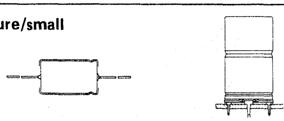
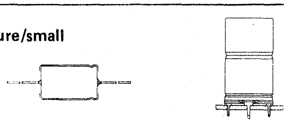
C22 **Film capacitors**

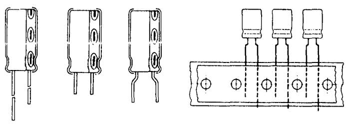
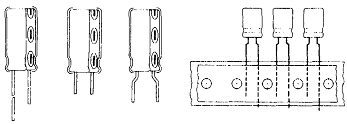
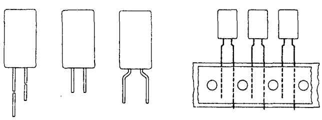
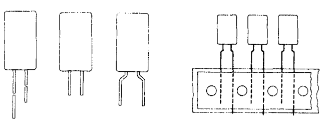
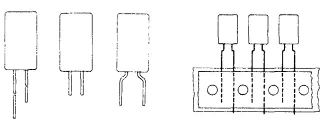
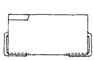
* Will be issued in 1985.

SELECTION GUIDE

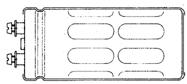
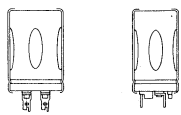
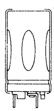
SELECTION GUIDE

ALUMINIUM ELECTROLYTIC CAPACITORS

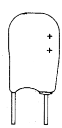
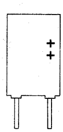
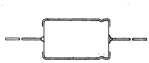
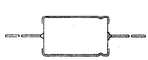
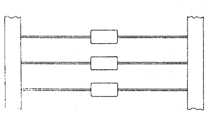
type	series number 2222 . . .	application	nominal capacitance μF	rated voltage (U_R) V	page
Miniature/small 	014	long-life, general, industrial; low impedance for s.m.p.s.	1 to 10 000	6,3 to 100	41
Miniature/small 	021	long-life, general, industrial; small dimensions	0,22 to 15 000	10 to 100	79
Miniature/small 	030 031 032 033	long-life, general, industrial	0,33 to 15 000	6,3 to 100	109
	041 042 043		1 to 220	160 to 385	203
Miniature 	065	long-life, general, industrial; low leakage current	0,33 to 68	6,3 to 25	257
Ultra miniature 	117	general	0,1 to 0,22	6,3 to 63	339
Small 	108	extra long-life, industrial	2,2 to 2 200	6,3 to 100	285
Miniature/small 	118	extra long-life industrial, military	1 to 15 000	6,3 to 200	353
Miniature/small 	132 133	extra long-life, industrial DIN 41257	1 to 4 700	10 to 350	365

type	series number 2222 . . .	application	nominal capacitance µF	rated voltage (U_R) V	page
Miniature/small 	035	general	0,1 to 4 700	6,3 to 100	153
Miniature/small 	037	general	0,1 to 10 000	6,3 to 100	187
Miniature 	036	long-life, general, industrial	0,15 to 470	6,3 to 63	171
Miniature 	013	long-life, general, industrial; low leakage current	0,15 to 220	10 to 25	25
Miniature 	116	extra long-life, industrial	0,47 to 470	6,3 to 50	323
Miniature; surface mounted 	085	general	0,1 to 22	6,3 to 63	271

ALUMINIUM ELECTROLYTIC CAPACITORS (continued)

type	series number 2222 . . .	application	nominal capacitance μF	rated voltage (U_R) V	page
Large 	114 115	long-life industrial	150 to 220 000	10 to 385	299
Large 	050 052	long-life, industrial	47 to 68 000	10 to 385	223
Large 	051 053	long-life, industrial; small dimensions	68 to 150 000	10 to 385	247

SOLID ALUMINIUM CAPACITORS

type	series number 2222 . . .	application	nominal capacitance μF	rated voltage (U_R) V	page
Miniature; resin dipped 	122	very long-life, general, industrial	0,1 to 68	6,3 to 40	407
Miniature; epoxy potted 	124	extra long-life, general, industrial	0,1 to 68	6,3 to 40	491
Small 	121	very long-life, military, industrial	2,2 to 330	6,3 to 50	385
Small 	123	very long-life, military, industrial	2,2 to 2 200	4 to 40	435
Miniature 	125	long-life military, industrial	0,22 to 68	4 to 35	511

INTRODUCTION

INTRODUCTION

1. GENERAL

Electrolytic and solid capacitors are most commonly used in such circuit functions as filtering, coupling, smoothing and by-passing, and for energy storage, or wherever there is a need for capacitive reactance.

These functions are often applied under specific circumstances and the requirements specified by users have grown steadily. The outcome has been a wide range of electrolytic and solid capacitor programmes to cover the different applications, for example:

General purpose	radio, television, and general/industrial applications.
Professional/industrial	long life and high reliability – telecommunications equipment, electronic data processing.
	high temperature – motor cars.
	small size – hybrid circuits, paging systems.
	low equivalent series resistance at high frequency – switched-mode power supplies.

2. PRINCIPLES

The essential property of a capacitor is to store electrical charge. The amount of electrical charge (Q) in the capacitor (C) is proportional to the applied voltage (U). The relationship of these parameters is:

$$Q = C \cdot U$$

where Q = charge in coulombs (C)
C = capacitance in farads (F)
U = voltage in volts (V)

The value of capacitance is directly proportional to the (anode) surface area and inversely proportional to the thickness of the dielectric layer, thus:

$$C = \epsilon_r \cdot \epsilon_0 \cdot \frac{A}{d},$$

where ϵ_0 = absolute permittivity ($8{,}85 \times 10^{-12}$ F/m)
ϵ_r = relative dielectric constant (dimensionless)
A = surface area (m^2)
d = thickness of dielectric (oxide) layer (m)

The dielectric layer consists of aluminium oxide (Al_2O_3) which is formed by an electrochemical oxidizing process of aluminium. This layer withstands extremely high electrical field strength. During the electrochemical forming process the dielectric layer is exposed to the physical limit of electrical field strength mentioned above. So the thickness of the layer is determined by a voltage U_F, the so-called forming voltage. To avoid changing the thickness of the layer during normal use the operating voltage should always be lower than the forming voltage. For general purpose electrolytic capacitors the value of U_R/U_F is about 0,8 (U_R being the rated voltage). Types for professional and industrial applications are sometimes rated to 0,6. Solid capacitors are rated to approx. 0,25 due to various reasons.

The relative dielectric constant of Al_2O_3 is approx. 8 (dimensionless), its electrical field strength amounts to 7.10^8 V/m.

3. DESCRIPTION

The above-mentioned dielectric layer is electrically contacted on one side by its base metal (aluminium) and on the other side by a conductor, being an electrolyte in the case of an electrolytic capacitor and a solid semiconductor in the case of a solid capacitor. The metal contact electrode is called the anode. To obtain high capacitance values per unit volume the surface of the anode is artificially enlarged by etching processes.

Aluminium electrolytic capacitors

The containing electrode opposite to the anode is an ionic conductor in the case of an electrolytic capacitor. Because of this ionic conduction the potential of the anode should never be lower than the potential of the electrolyte: if the potential of the anode is lower than that of the electrolyte, positive hydrogen ions will move through the dielectric layer to the anode metal where they are discharged.

The hydrogen gas so formed blows up the dielectric layer, causing a high leakage current or even a short circuit. In the case of the anode being at a positive potential with respect to the electrolyte (this is the case of normal use) the oxidizing ions are driven towards the dielectric layer.

These oxidizing ions are not able to pass through the dielectric layer at field strengths lower than the physical limit (7.10^8 V/m). In the case of a defect in the dielectric layer the limiting field strength might be reached even during normal use. In that case the oxidizing ions will pass through the defect to the anode metal where new oxide is formed, which repairs the defect.

It is necessary to make electrical contact to the electrolyte from outside. This is usually done by inserting an etched aluminium electrode into the electrolyte. This electrode, called the cathode, is always covered by a relatively thin oxide layer. To avoid direct mechanical contact between the oxide layers of cathode and anode (which would cause mechanical damage of the dielectric) a soft spacer of porous paper is used which also serves as a sponge for the electrolyte.

The total thickness of the system described is only a fraction of a millimetre. Therefore, during manufacture, long strips of the described system are wound into cylindrical bodies and encased. Figure 1 shows a cross-section of a typical design.

Solid aluminium capacitors

In a solid capacitor the contacting electrode opposite to the anode is formed by manganese dioxide (MnO_2), a semiconductor, and called the cathode. Therefore, in principle, the potential of the anode with respect to the cathode is allowed to be positive as well as negative. However, due to the absence of oxidizing ions, no self-repairing effect of the dielectric layer by the leakage current is obtained. In practice it is advisable to maintain the anode potential positive with respect to the cathode, because no solid capacitor is absolutely free of moisture, so ionic reactions could take place.

Via the system manganese dioxide — aluminium foil — case — tinned leads, the cathode is electrically connected with the outside in our 121 and 123 series of solid aluminium capacitors (Fig. 1). A glass fibre spacer is used to avoid direct mechanical contact between anode layer and the aluminium contact foil.

In the 122 series of solid aluminium capacitors the cathode is connected to the outside via the system manganese dioxide — graphite — silver — tin solder — tinned leads (Fig. 2).

NOTE:

Standard MIL-C-62 for **dry** electrolytics is based on a now obsolete construction and does not apply to **solid** aluminium capacitors.

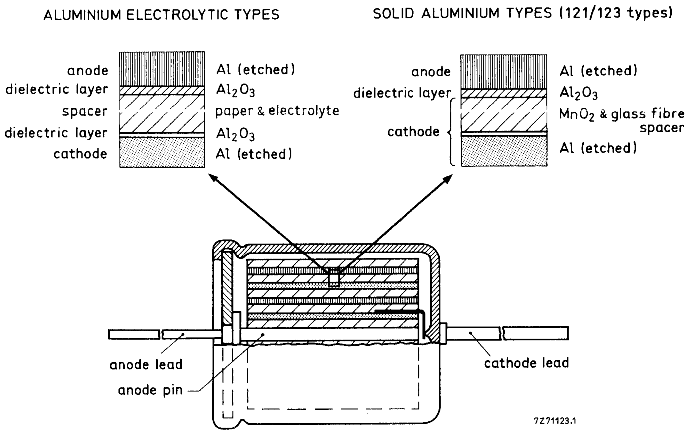


Fig. 1.

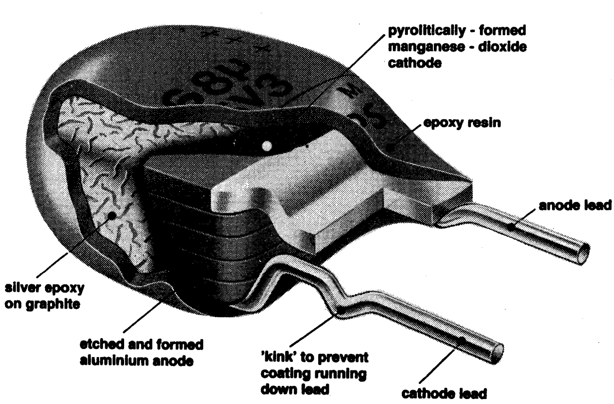


Fig. 2 Solid aluminium type 2222 122.

4. ELECTRICAL IMPEDANCE

The electrical impedance Z of a capacitor in its reference plane (being the connecting points on a printed-wiring board) consists of a real part R, and an imaginary part j. X, thus:

$$Z = R + j.X \quad \text{and} \quad \tan\delta = \frac{R}{X}$$

where R = the equivalent series resistance (ESR) (Ω)
j. X = the imaginary part of the series impedance (Ω)
Z = the complex series impedance (Ω)
tan δ = dissipation factor (dimensionless)

The actual values of R and X depend upon two parameters: the frequency f and the temperature T. It is usual to express X in terms of C_s (equivalent series capacitance) and ω:

$$X = -\frac{1}{\omega C_s} \qquad \omega = 2.\pi.f, \ f \text{ in (Hz)}$$

At high frequencies (> 100 kHz) an inductive part contributes to the impedance, changing X into $X = j\omega L$, where L = inductance in H.

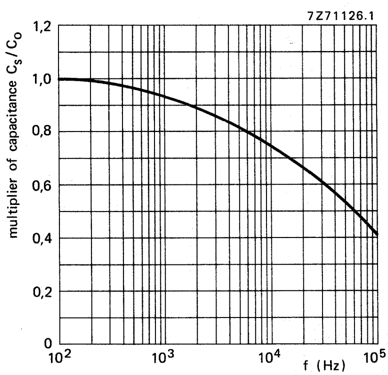


Fig. 3 Typical capacitance as a function of frequency. C_0 = capacitance at 25 °C, 100 Hz.

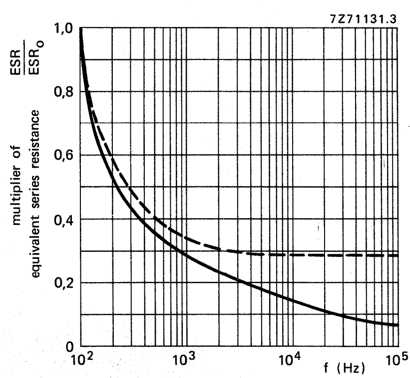


Fig. 4 Typical ESR as a function of frequency; ESR_0 = ESR at 25 °C, 100 Hz.
- - - - - Alumium electrolytic capacitors;
——— Solid aluminium capacitors.

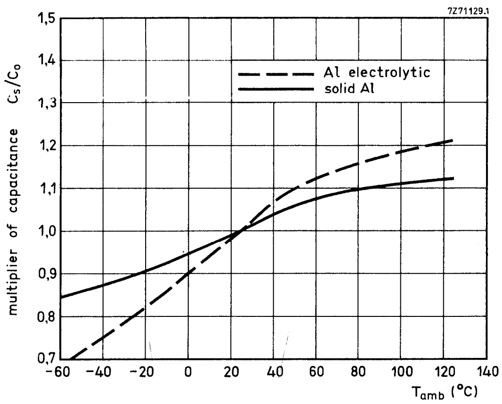


Fig. 5 Typical capacitance as a function of ambient temperature; C_0 = capacitance at 25 °C, 100 Hz.

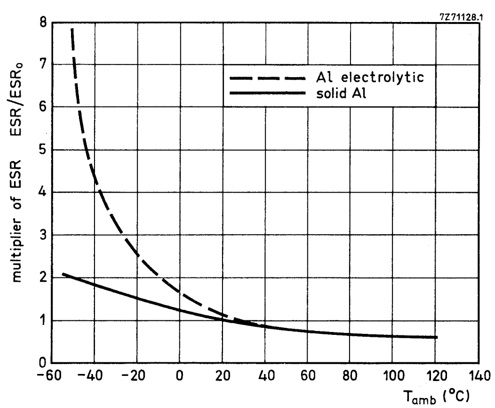


Fig. 6 Typical ESR as a function of ambient temperature. ESR_0 = ESR at 100 Hz, at 25 °C.

5. RIPPLE CURRENT

In various applications a considerable amount of ripple current (I_r) passes through the capacitor. Due to the equivalent series resistance (R) power (P) is dissipated in the device: P (watt) = $I_r^2 \cdot R$.

The power causes an increase in temperature of the capacitor core. In the data sheets the maximum permissible ripple current ($I_{r\,max}$) is generally specified in such a way that it causes an equilibrium temperature difference (ΔT) between core and upper category temperature of 10 °C. A ripple current I_a different from $I_{r\,max}$ causes a temperature difference $\Delta T = \left(\frac{I_a}{I_{r\,max}}\right)^2 \times 10\ ^oC$, so the actual core temperature $T_{core} = T_{amb} + \left(\frac{I_a}{I_{r\,max}}\right)^2 \times 10\ ^oC$. Temperature equilibrium is reached when the power (P) passes through the case surface into the ambient. From this it is clear, that the maximum permissible ripple current depends on the maximum permissible temperature of the capacitor, equivalent series resistance, case size and ambient temperature (T_{amb}).

In the data sheets the maximum permissible ripple current is specified under certain conditions,

$$I_r = \sqrt{\frac{P}{R}} = \sqrt{\frac{\alpha \,.\, S\,(T_c - T_{amb})}{R}}$$

where I_r = ripple current (A); R = equivalent series resistance (Ω); P = heat dissipation (W); α = heat transfer coefficient (W/m² °C); S = heat transfer surface area (m²); T_c = temperature of case surface (°C); T_{amb} = ambient temperature (°C).

6. D.C. LEAKAGE CURRENT

In normal use a small amount of direct current passes through the capacitor. This current is called the d.c. leakage current (I_l) and depends on the applied voltage and temperature. The dependency of I_l/I_0 (I_0 being the d.c. leakage current at voltage U_R and 25 °C) on temperature, is shown in Fig. 7 for an aluminium electrolytic capacitor and a solid aluminium capacitor.

The dependency of I_l/I_0 as a function of U/U_R is given in Fig. 8 for an aluminium electrolytic capacitor and a solid aluminium capacitor, U being the working voltage.

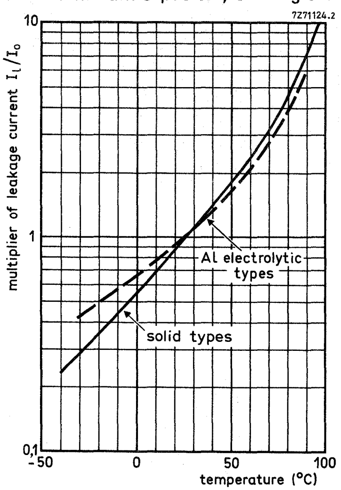


Fig. 7 Typical d.c. leakage current as a function of temperature. I_0 = d.c. leakage current during continuous operation at T_{amb} = 25 °C.

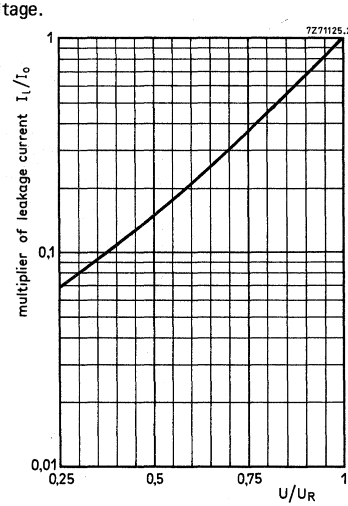


Fig. 8 Typical d.c. leakage current as a function of U/U_R. I_0 = d.c. leakage current at U_R at a discrete constant temperature within category temperature range, U is working voltage.

7. LIFE TIME

Aluminium electrolytic capacitors

The phenomena which determine the life time of an aluminium electrolytic capacitor are, among others, changes of the following parameters exceeding the specified limits:

- capacitance
- dissipation factor
- impedance
- d.c. leakage current

Most of them are directly or indirectly caused by a failure mechanism occuring in the electrolyte (drying out, chemical reactions).

Two types of electrolyte can be distinguished:

a. Glycol-electrolyte which is somewhat aggressive to the dielectric layer at higher temperatures. This liquid has a relatively high specific resistance and high temperature coefficient.

b. modern electrolytes (based upon DiMethyl Acetamide) require very good sealing (due to high diffusiveness of the volatile solvent). This liquid has a relatively low specific resistance and a low temperature coefficient, and can generally be used over a wider temperature range than the glycol type of electrolyte.

In general the life time of an aluminium electrolytic capacitor can be increased by a factor of 2 when the temperature is dropped by 10 °C.

By using the capacitor at a voltage lower than the rated voltage, the d.c. leakage current decreases, which means that the process of forming hydrogen gas at the cathode takes place at a lower rate. This also improves the life time of the capacitor.

The typical life time at U_R, as given in the data sheets, is the time during which the number of inoperatives is $\leqslant 1\%$.

Criteria for an inoperative are: $\Delta C/C \geqslant 50\%$;
impedance $\geqslant 3$ x stated limit;
tan δ (and ESR) $\geqslant 3$ x stated limit;
d.c. leakage current $\geqslant 3$ x stated limit.

Solid aluminium capacitors

The end of life is determined by gradual degradation of the dielectric oxide layer, resulting in increase of leakage current. The life time can be increased by derating the voltage and, to a less extent, the temperature.

Due to the fact that no electrolyte is used in solid aluminium capacitors the associated failure mechanisms do not occur.

NOTE

Some solvents for cleaning printed-circuit boards after soldering may adversely affect electrolytic capacitors. Please contact local sales office for suitable cleaning agents.

8. RELIABILITY

In life testing, reliability can be determined by means of a failure rate (F.R.), which is expressed as:

$$\text{Failure rate (F.R.)} = \frac{\text{number of failures during test}}{\text{number of components tested x test duration}}$$

Two types of failures can be found:

- catastrophic failures: short circuits, open circuits.
- degradation failures: parameter drifts outside the specification limits.

With aluminium electrolytic capacitors degradation failures mostly occur, due to factors like:

- agressiveness of the electrolyte.
- diffusion of the electrolyte.
- material impurities and other accidents of production.

The failure rate of solid aluminium and tantalum capacitors is determined by short circuits or open circuits, due to breakdown of the dielectric layer. The electron current does not constitute a repair action in this oxide layer.

The failure rate in solid tantalum capacitors is mostly influenced by a field-crystallization process. The F.R. can be improved by lowering the temperature and applied voltage or placing a series resistor in the circuitry.

The phenomenon of the formation of a low resistance aluminium oxide does not exist in solid aluminium capacitors, therefore they have greater reliability than solid tantalum types. Under the most severe conditions (maximum category temperature, rated voltage), the catastrophic failure rates (with a 60% confidence level) are:

- electrolytic capacitors 10^{-6}/h,
- solid aluminium capacitors 10^{-7}/h.

Analysis of failure in the field (under normal operating conditions) shows a far better F.R.: $\approx 10^{-9}$/h for solid aluminium capacitors.

9. TESTS AND REQUIREMENTS

The description of tests and requirements, given in the following tables, is valid for the complete range of aluminium electrolytic capacitors and solid aluminium capacitors. Specific tests for a certain type of capacitor are not included in these tables; those tests are given in the data sheet of the relevant type.

Aluminium electrolytic capacitors

In the description of the procedure and the requirements of the tests, in some case distinction has to be made for the different types of aluminium electrolytic capacitors with respect to their size or with respect to their application fields. In the table this distinction is indicated in the columns 'type' with the indication for size:

- m for miniature types,
- s for small types,
- l for large types,
- lt for large types with screw terminals,

or with the indication for application fields:

- 1 for long-life grade types,
- 2 for general-purpose grade types.

If no indication is given in these columns, reference is made to all types.

IEC 384–4 sub clause	IEC 68–2 test method	name of test	procedure (quick reference)		requirements	
			type	description	type	description
–	Ua	Tensile strength of terminations	m s	Loading force 10 N for 10 s.	m s l	No visible damage.
			l	Loading force 20 N for 10 s.		
–	Ub	Bending of terminations	m s	Loading force 5 N, two consecutive bends.	m s	No visible damage
–	Uc	Torsion of terminations	m s	Two successive rotations of 180° in opposite direction, 5 s per rotation.	m s	No visible damage.
–	Ud	Torque on nut (stud)	lt	Torque of 1,76 Nm gradually applied.	lt	No visible damage.
9.8.2	Tb (method 1A)	Resistance to soldering heat	m s l	Solder bath: 260 °C, 10 s, for capacitors with printed-wiring pins.	m s l	No visible damage, marking legible, $\Delta C/C \leqslant 5\%$.
	Tb (method 1B)			Solder bath 350 °C, 3,5 s for capacitors with solder leads or tags.		
9.8.1	Ta	Solderability	m s l	Solder bath: 235 °C, 2 s for capacitors with printed-wiring pins, 270 °C, 2 s for capacitors with solder leads or tags, immersed up to 2 mm from the body.	m s l	No visible damage, marking legible, good tinning.

IEC 384–4 sub clause	IEC 68–2 test method		name of test	procedure (quick reference) type	procedure (quick reference) description	requirements type	requirements description
9.9	Na		Rapid change of temperature		5 cycles of 3 h at upper and lower category temperature.		No visible damage, no leakage of electrolyte.
9.10	Fc		Vibration	1	10 to 500 Hz, 0,75 mm or 10g (whichever is less), 2 directions, 3 h per direction.		No visible damage, no leakage of electrolyte, marking legible;
				2	10 to 55 Hz, 0,75 mm or 10g (whichever is less), 2 directions, 3 h per direction.		$\Delta C/C \leqslant 5\%$ with respect to initial measurement.
9.11	Eb		Bump	1	40g, 2 directions, 4000 bumps total.		No visible damage, no leakage of electrolyte; $\Delta C/C \leqslant 5\%$ with respect to initial measurement.
				2	40g, 2 directions, 1000 bumps total.		
	Climatic sequence	Ba	Dry heat		16 h at upper category temperature, no voltage applied.		No visible damage, no leakage of electrolyte.
	Climatic sequence	D	Damp heat, cyclic		1 cycle of 24 h at 55 ± 2 °C, R.H. 95 to 100%, no voltage applied.		
	Climatic sequence	Aa	Cold		2 h at lower category temperature, no voltage applied.		No visible damage, no leakage of electrolyte.
9.12.1	Climatic sequence	M	Low air pressure		5 min. at 15 to 35 °C, at atmospheric pressure of 85 mbar, last minute U_R applied.		No visible damage, no evidence of breakdown or flashover.
	Climatic sequence	D	Damp heat, cyclic		5 cycles of 24 h at 55 ± 2 °C, R.H. 95 to 100%, no voltage applied.		
9.12.2	Climatic sequence	Qc	Sealing		1 min. in water at upper category temperature + 5 °C.		No continuous chain of bubbles.
	Climatic sequence				Final measurement		No visible damage, no leakage of electrolyte, marking legible; d.c. leakage current $\leqslant$ stated limit; $\tan\delta \leqslant 1{,}2\times$ stated limit; $\Delta C/C \leqslant 10\%$.

IEC 384–4 sub clause	IEC 68–2 test method	name of test	procedure (quick reference)		requirements	
			type	description	type	description
9.13	Ca	Damp heat, steady state		56 days at 40 °C, R.H. 90 to 95%; no voltage applied.		No visible damage, no leakage of electrolyte, marking legible; d.c. leakage current $\leqslant$ stated limit, tan $\delta \leqslant$ 1,2 x stated limit, insulation resistance $>$ 100 MΩ, no breakdown or flashover below 1000 V.
					1	$\Delta C/C \leqslant$ 10%.
					2	$\Delta C/C \leqslant$ 20%.
9.14	–	Endurance				No visible damage, no leakage of electrolyte, marking legible; d.c. leakage current $\leqslant$ stated limit, insulation resistance $>$ 100 MΩ, no breakdown or flashover below 1000 V.
			1	2000 h** at upper category temperature, U_R applied.	1	$\Delta C/C \leqslant$ 15% and $\leqslant$ –30% for $U_R \leqslant$ 6,3 V, $\Delta C/C \leqslant$ 15% for 6,3 V $< U_R \leqslant$ 160 V, $\Delta C/C \leqslant$ 10% for $U_R >$ 160 V; tan $\delta \leqslant$ 1,3 x stated limit, impedance at 1 kHz or 10 kHz $\leqslant$ 2 x stated limit.*
			2	1000 h at upper category temperature, U_R applied.	2	$\Delta C/C \leqslant$ 25% and $\leqslant$ –40% for $U_R \leqslant$ 6,3 V. $\Delta C/C \leqslant$ 30% for 6,3 V $< U_R \leqslant$ 160 V, $\Delta C/C \leqslant$ 15% for $U_R >$ 160 V; tan $\delta \leqslant$ 1,5 x stated limit or min. 0,40 (whichever is greater), impedance at 1 kHz or 10 kHz $\leqslant$ 3 x stated limit.*
9.15	–	Surge		From source of 1,15 x U_R for $U_R \leqslant$ 315 V or 1,1 x $U_R >$ 315 V, RC = 0,1 ± 0,05 s, 1000 cycles of 30 s on, 330 s off.		No visible damage, no leakage of electrolyte; d.c. leakage current $\leqslant$ stated limit, tan $\delta \leqslant$ stated limit, $\Delta C/C \leqslant$ 15%.
			1	At upper category temperature.		
			2	At 25 °C.		

* If stated in the detail specification.

** Capacitors 2222 032, 033, 039, 042, 043, 114, 115 are specified at 5000 h; requirements are as stated under type 1.

IEC 384–4 sub clause	IEC 68–2 test method	name of test	procedure (quick reference)		requirements	
			type	description	type	description
9.16	–	Reverse voltage		1 V in reverse polarity followed by U_R in forward polarity, both for 125 h at upper category temperature.		D.C. leakage current ⩽ stated limit, tan δ ⩽ stated limit, ΔC/C ⩽ 10%.
9.17	–	Pressure relief	I It	D.C. voltage applied in reverse direction producing a current of 1 to 10 A.	I It	Pressure relief opens prior to danger of explosion or fire.
9.18	Ha	Storage at upper category temperature		96 ± 4 h at upper category temperature.		No visible damage, no leakage of electrolyte; d.c. leakage current ⩽ 2 x stated limit, tan δ ⩽ 1,2 x stated limit; ΔC/C ⩽ 10%.
9.19	Hb	Storage at low temperature		72 h at a temperature of 15 °C below the lower category temperature.		No visible damage, no leakage of electrolyte; d.c. leakage current ⩽ stated limit, tan δ ⩽ stated limit; ΔC/C ⩽ 10%.
9.20		Characteristics at high and low temperature		**Step 1:** reference measurement at 20 °C of capacitance, impedance at 100 Hz and tan δ.		
				Step 2: measurement at lower category temperature.		Impedance at 100 Hz ⩽ 7 x value of step 1 for U_R ⩽ 6,3 V or U_R > 160 V, ⩽ 5 x value of step 1 for 6,3 < U_R ⩽ 16 V, ⩽ 4 x value of step 1 for 16 < U_R ⩽ 160 V.
				Step 3: Measurement at upper category temperature.		D.C. leakage current ⩽ 5 x stated limit at 85 °C, ⩽ 3 x stated limit at 70 °C.
9.21		Charge and discharge		For U_R ⩽ 160 V: 10^6 cycles of 0,5 s charge to U_R (RC = 0,1 s) and 0,5 s discharge (RC = 0,1 s). For U_R > 160 V: under consideration.		No visible damage, no leakage of electrolyte, ΔC/C ⩽ 10%.

Solid aluminium capacitors

In the description of the procedure and the requirements of the tests, in some cases distinction has to be made for the types 2222 121, 2222 122 and 2222 123. In the table this distinction is indicated by 121/123 or 122 in the columns 'type'. If no indication is given in these columns reference is made to all types.

IEC 384–4 sub clause	IEC 68–2 test method	name of test	procedure (quick reference)		requirements	
			type	description	type	description
–	Ua	Tensile strength of terminations		Loading force 10 N for 10 s.		No visible damage; no rupture of wires
–	Ub	Bending of terminations		Loading force 5 N, two consecutive bends.		No visible damage; no rupture of wires
–	Uc	Torsion of terminations	121/ 123	Two successive rotations of 180° in opposite direction, 5 s per rotation.	121/ 123	No visible damage.
9.8.2	Tb (method 1A)	Resistance to soldering heat	122	Solder bath: 260 °C, 10 s, for capacitors with printed-wiring pins.		No visible damage, marking legible, $\Delta C/C \leqslant 5\%$.
	Tb (method 1B)		121/ 123	Solder bath: 350 °C, 3,5 s, for capacitors with solder leads.		
9.8.1	Ta	Solderability	122	Solder bath: 235 °C, 2 s for capacitors with printed-wiring pins, immersed up to 2 mm from the body.		No visible damage, marking legible, good tinning.
			121/ 123	Solder bath: 270 °C, 2 s for capacitors with solder leads, immersed up to 2 mm from the body.		
9.9	Na	Rapid change of temperature		5 cycles of 30 min at upper and lower category temperature.		D.C. leakage current ⩽ stated limit,* $\tan \delta \leqslant$ stated limit, $\Delta C/C \leqslant 10\%$
9.10	Fc	Vibration		10 to 500 Hz, 0,75 mm or 10g (whichever is less), 2 directions, 3 h per direction.		No visible damage, marking legible; $\Delta C/C \leqslant 5\%$ with respect to initial measurement.

* For capacitors 2222 122, 15 s value of d.c. leakage current measured after 5 min.

IEC 384–4 sub clause	IEC 68–2 test method		name of test	procedure (quick reference) type	procedure (quick reference) description	requirements type	requirements description
9.11	Eb		Bump		40g, 2 directions, 4000 bumps total.		No visible damage; $\Delta C/C \leqslant 5\%$ with respect to initial measurement.
	Climatic sequence	Ba	Dry heat		16 h upper category temperature, no voltage applied.		No visible damage.
	Climatic sequence	D	Damp heat, cyclic		1 cycle of 24 h at 55 ± 2 °C, R.H. 95 to 100%, no voltage applied.		
	Climatic sequence	Aa	Cold		2 h at lower category temperature, no voltage applied.		No visible damage.
9.12.1	Climatic sequence	M	Low air pressure		5 min. at 15 to 35 °C, at atmospheric pressure of 85 mbar, last minute U_R applied.		No visible damage.
	Climatic sequence	D	Damp heat, cyclic		5 cycles of 24 h at 55 ± 2 °C, R.H. 95 to 100%, no voltage applied.		No visible damage.
	Climatic sequence				Final measurement.		No visible damage, marking legible; d.c. lekage current ⩽ stated limit,* tan $\delta \leqslant$ 1,2 x stated limit, insulation resistance > 100 MΩ, no breakdown or flashover below 1000 V.
						121/ 123	$\Delta C/C \leqslant 5\%$.
						122	$\Delta C/C \leqslant 10\%$.
9.13	Ca		Damp heat, steady state		56 days at 40 °C, R.H. 90 to 95%; no voltage applied.		No visible damage, marking legible; d.c. leakage current ⩽ stated limit;* tan $\delta \leqslant$ 1,2 x stated limit, insulation resistance > 100 MΩ, no breakdown or flashover below 1000 V.
						121/ 123	$\Delta C/C \leqslant 5\%$.
						122	$\Delta C/C \leqslant 15\%$.

* For capacitors 2222 122, 15 s value of d.c. leakage current measured after 5 min.

IEC 384–4 sub clause	IEC 68–2 test method	name of test	procedure (quick reference)		requirements	
			type	description	type	description
9.14	–	Endurance	122/ 123	2000 h at 125 °C, U_R^{**} applied.		No visible damage, marking legible; d.c. leakage current ⩽ stated limit, tan δ ⩽ 1,2 x stated limit, insulation resistance > 100 MΩ, no breakdown or flashover below 1000 V, ΔC/C ⩽ 10%.
			121	5000 h at 125 °C, $U_R^{\blacktriangle}$ applied.		
				5000 h at 85 °C, U_R applied.		
9.15	–	Surge		From source of 1,15 x U_R at 85 °C or 1,15 x derated voltage at 125 °C, 1000 cycles of 30 s on, 330 s off.		No visible damage; d.c. leakage current ⩽ stated limit, tan δ ⩽ stated limit.
					121/ 123	ΔC/C ⩽ 5%.
					122	ΔC/C ⩽ 10%.
9.16	–	Reverse voltage		0,30 x U_R in reverse polarity at 85 °C for 125 h, followed by U_R in forward polarity at 85 °C for 125 h.		D.C. leakage current ⩽ stated limit, tan δ ⩽ stated limit, ΔC/C ⩽ 10%.
			121/ 123	0,15 x $U_R^{\blacktriangle}$ in reverse polarity at 125 °C for 125 h, followed by $U_R^{\blacktriangle}$ in forward polarity at 125 °C for 125 h.		
			122	0,30 x U_R^{**} in reverse polarity at 125 °C for 125 h, followed by U_R^{**} in forward polarity at 125 °C for 125 h.		
9.18	Ha	Storage at upper category tempera- ture		96 ± 4 h at upper category temperature.		No visible damage; d.c. leakage current ⩽ stated limit,* tan δ ⩽ stated limit.
					121/ 123	ΔC/C ⩽ 5%.
					122	ΔC/C ⩽ 10%.

* For capacitors 2222 122, 15 s value of d.c. leakage current measured after 5 min.
** 25 V for 40 V versions (capacitors 2222 122).
▲ 40 V for 50 V versions.

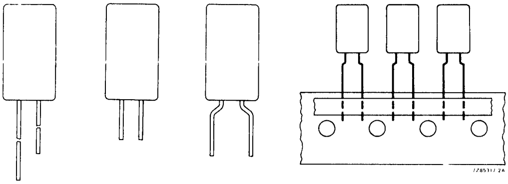
IEC 384–4 sub clause	IEC 68–2 test method	name of test	procedure (quick reference)		requirements	
			type	description	type	description
		Long storage (⩾ 1 year)		At ambient temperature.		D.C. leakage current ⩽ stated limit*
9.20		Characteristics at high and low temperature		**Step 1:** reference measurement at 20 °C of capacitance, impedance at 100 Hz and tan δ.		
				Step 2: measurement at lower category, 2h		Tan δ ⩽ 2 x stated limit, impedance ratio ⩽ 2, ΔC/C ⩽ 20%.
				Step 3: measurement at 85°C, 16 h		D.C. leakage current ⩽ 10 x stated limit,* tan δ ⩽ stated limit, ΔC/C ⩽ 20%.
9.21		Charge and discharge		10^6 cycles of 0,5 s charge to U_R and 0,5 s discharge.		No visible damage, ΔC/C ⩽ 5%.

* For capacitors 2222 122, 15 s value of d.c. leakage current measured after 1 min.

ALUMINIUM ELECTROLYTIC CAPACITORS

ALUMINIUM ELECTROLYTIC CAPACITORS

- **Low-leakage version of 2222 036 series**
- **Miniature type**
- **Single ended**
- **Long life**
- **General and industrial applications**
- **Alternative for tantalum capacitors**



QUICK REFERENCE DATA

Nominal capacitance range (E6 series)	0,15 to 220 μF
Tolerance on nominal capacitance	−20 to + 20%*
Rated voltage range, U_R (R5 series)	10 to 25 V
Leakage current after 2 min	0,002 CU or 0,7 μA
Category temperature range	−55 to + 85 °C
Endurance test	2000 h at 85 °C
Shelf life at 0 V	500 h at 85 °C
Basic specification	IEC 384-4, long-life grade DIN 41332/DIN 41259
Climatic category	
IEC 68	55/085/56
DIN 40040	FPF

Selection chart for C_{nom}-U_R and relevant case sizes.

C_{nom} μF	U_R (V) 10	16	25
0,15			11
0,22			11
0,33			11
0,47			11
0,68			11
1			11
1,5			11
2,2			11
3,3			11
4,7			11
6,8			11
10			11
15			11
22			11
33		11	13
47	11		13
68	11		13
100		13	
150	13		
220	13		

case size	nominal dimensions (mm)
11	Ø 5 x 11
13	Ø 8,2 x 11

* ± 10% to special order.

APPLICATION

These capacitors are suited for those applications where a low leakage current is required. In many cases they are a cost-effective substitute for tantalum capacitors.
The capacitors are mainly used for high impedance coupling and decoupling purposes in consumer applications, such as audio and television circuits, and in industrial applications, such as measuring and regulating circuits.
Other applications are in timing and delay circuits with large time constants. The taped versions are suitable for automatic insertion and for cutting and forming equipment.

DESCRIPTION

The capacitor has etched and oxidised aluminium foil electrodes rolled up with a paper strip impregnated with an electrolyte. The capacitor is in an all-insulated aluminium case.

MECHANICAL DATA

Dimensions in mm

The capacitor is available in 6 styles:
style 1: long leads; in boxes;
style 2: straight short leads; non preferred, in boxes;
style 3: bent short leads (only case size 11); non preferred, in boxes;
style 4: long leads; on tape on reel, positive leading;
style 5: long leads; on tape in ammunition pack;
style 6: long leads; on tape on reel, negative leading.

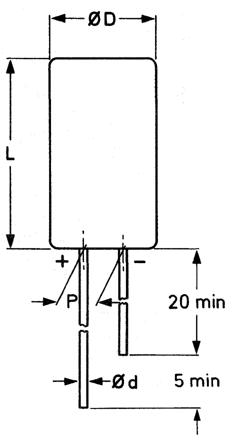


Fig. 1 Style 1; see Table 1 for dimensions d, D, L and P.

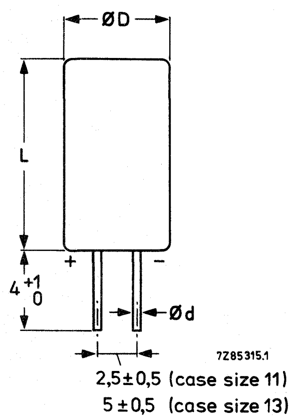


Fig. 2 Style 2; non preferred, see Table 1 for dimensions d, D and L.

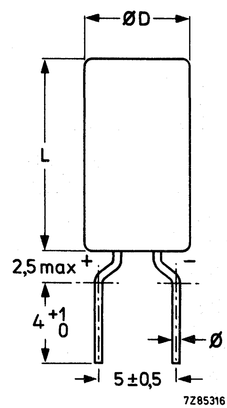
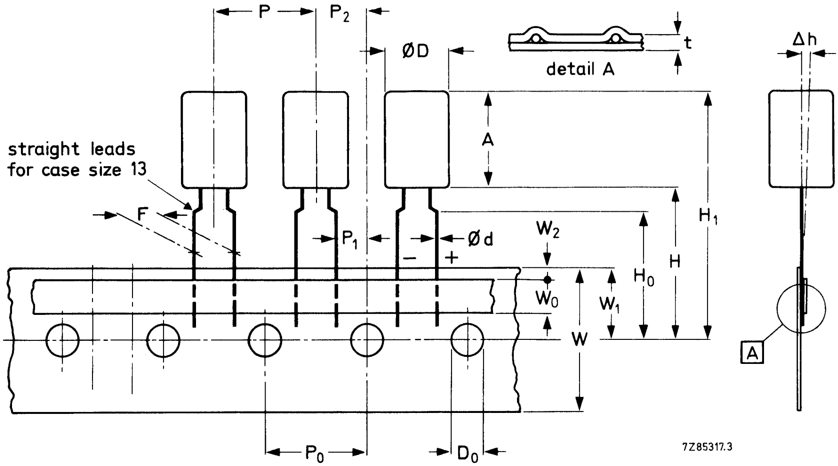


Fig. 3 Style 3; case size 11 only; non preferred, see Table 1 for dimensions d, D and L.

Table 1

case size	dimensions				mass approx. g
	d	D_{max}	L_{max}	P	
11	0,5*	5,5	12,0	2,5	0,4
13	0,6	8,7	12,0	5,0	1,1

* 0,6 mm under consideration.



→ direction of tape transport (positive leading)

Fig. 4 Styles 4, 5 and 6; see Table 2 for dimensions. For style 6 the tape transport is in opposite direction (negative leading).

Table 2

	symbol	case size		tol.
		11	13	
Body diameter	D	5,5	8,7	max.
Body height	A	12,0	12,0	max.
Lead-wire diameter	d	0,5*	0,6	± 0,05
Pitch of component	P	12,7	12,7	± 1,0
Feed-hole pitch	P_0	12,7	12,7	± 0,2**
Hole centre to lead	P_1	3,85	3,85	± 0,5
Feed hole centre to component centre	P_2	6,35	6,35	± 0,7
Lead-to-lead distance	F	5,0	5,0	+ 0,6/−0
Component alignment	Δh	0	0	± 1,0
Tape width	W	18,0	18,0	± 0,5
Hold-down tape width	W_0	6,0	6,0	min.
Hole position	W_1	9,0	9,0	± 0,5
Hold-down tape position	W_2	2,5	2,5	max.
Height of component from tape centre	H	18,0	18,0	+ 1,5/−0
Lead-wire clinch height	H_0	16,0	–	± 0,5
Component height	H_1	32,0	32,0	max.
Feed-hole diameter	D_0	4,0	4,0	± 0,2
Total tape thickness	t	0,9	0,9	max.

* 0,6 mm under consideration.
** Cumulative pitch error: ± 1 mm/20 pitches.

Marking

The capacitors are marked as follows:

on the top

- nominal capacitance;
- code letter for tolerance on nominal capacitance, according to IEC62;
- rated voltage;
- polarity identification.

on the circumference

- name of manufacturer;
- group number (**013**);
- code letter of manufacturer;
- date code (year and month) according to IEC 62.

Minimum atmospheric pressure 8,5 kPa

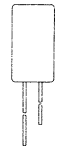
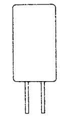
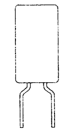
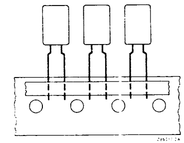
PRODUCT SAFETY

Non-solid electrolytic capacitors may contain chemicals which can be regarded as hazardous if incorrectly handled; caution is necessary should the outer case be fractured.

ELECTRICAL DATA

Unless otherwise specified all electrical values in Table 3 apply at an ambient temperature of 20 to 25 °C, a frequency of 100 Hz, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 45 to 75%.

Table 3

U_R V	nom. cap. μF	max. r.m.s. ripple current at T_{amb} = 85 °C mA	max. d.c. leakage current at U_R after 2 min μA	max. tan δ	case size*	catalogue number 2222 013 followed by					
						 style 1	 style 2	 style 3	 on reel** style 4	in ammopack style 5	on reel▲ style 6
10	47	55	1,0	0,16	11	54479	84479	64479	24479	34479	44479
	68	70	1,4	0,16	11	54689	84689	64689	24689	34689	44689
	150	130	3,0	0,16	13	54151	64151		24151	34151	44151
	220	160	4,4	0,16	13	54221	64221		24221	34221	44221
16	33	50	1,1	0,13	11	55339	85339	65339	25339	35339	45339
	100	120	3,2	0,13	13	55101	65101		25101	35101	45101
25	0,15	5,0	0,7	0,08	11	56157	86157	66157	26157	36157	46157
	0,22	6,5	0,7	0,06	11	56227	86227	66227	26227	36227	46227
	0,33	8,0	0,7	0,06	11	56337	86337	66337	26337	36337	46337
	0,47	9,5	0,7	0,06	11	56477	86477	66477	26477	36477	46477
	0,68	11	0,7	0,06	11	56687	86687	66687	26687	36687	46687
	1,0	13,5	0,7	0,06	11	56108	86108	66108	26108	36108	46108
	1,5	16,5	0,7	0,06	11	56158	86158	66158	26158	36158	46158
	2,2	20	0,7	0,06	11	56228	86228	66228	26228	36228	46228
	3,3	25	0,7	0,06	11	56338	86338	66338	26338	36338	46338
	4,7	29,5	0,7	0,06	11	56478	86478	66478	26478	36478	46478
	6,8	36	0,7	0,06	11	56688	86688	66688	26688	36688	46688
	10	43	0,7	0,06	11	56109	86109	66109	26109	36109	46109
	15	46	0,8	0,08	11	56159	86159	66159	26159	36159	46159
	22	56	1,1	0,08	11	56229	86229	66229	26229	36229	46229
	33	105	1,7	0,06	13	56339	66339		26339	36339	46339
	47	110	2,4	0,08	13	56479	66479		26479	36479	46479
	68	130	3,4	0,08	13	56689	66689		26689	36689	46689

* Case size 11: ϕ5 mm x 11 mm; case size 13: ϕ8,2 mm x 11 mm (nominal dimensions).
** Positive leading.
▲ Negative leading.

Capacitance

Nominal capacitance at 100 Hz and T_{amb} = 20 °C — see Table 3

Tolerance on nominal capacitance at 100 Hz — −20 to + 20%

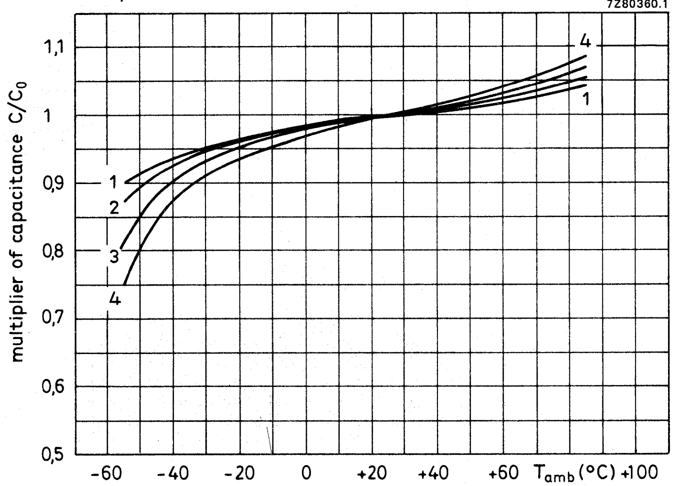


Fig. 5 Typical multiplier of capacitance as a function of ambient temperature; C_0 = capacitance at 20 °C, 100 Hz.
Curve 1 = 25 V; 0,15 to 2,2 μF; curve 2 = 25 V, 3,3 to 6,8 μF; curve 3 = 25 V, 10 to 68 μF; curve 4 = 10 V/16 V.

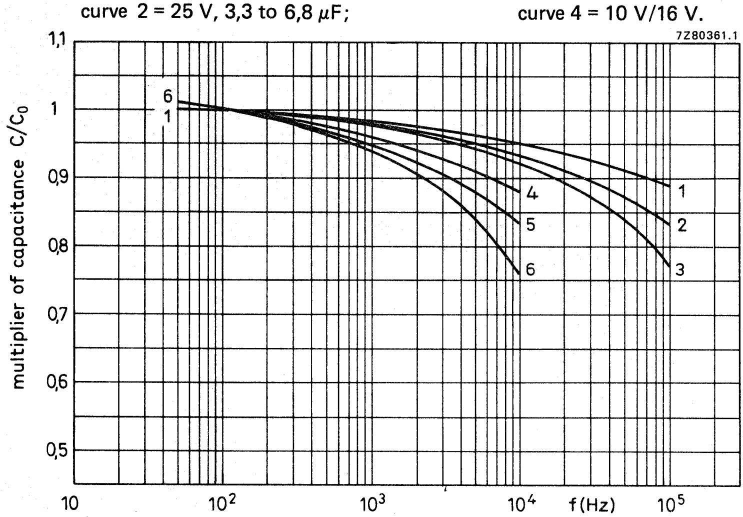


Fig. 6 Typical multiplier of capacitance as a function of frequency; C_0 = capacitance at 20 °C, 100 Hz.
Curve 1 = 25 V, 0,15 to 2,2 μF; curve 2 = 25 V, 3,3 to 6,8 μF; curve 3 = 25 V, 10/15 μF; curve 4 = 25 V, 22 to 68 μF; curve 5 = 16 V; curve 6 = 10 V.

Voltage

Max. permissible voltage at ≤ 95 °C (core temperature ▲)	1,6 x U_R
Ripple voltage* = max. permissible a.c. voltage providing the following three conditions are met:	
(a) max. (d.c. + peak a.c.) voltage	1,6 x U_R
(b) max. peak a.c. voltage without d.c. voltage applied	2 V
(c) momentary value of applied voltage	between 1,6 x U_R and −2 V
Surge voltage = max. permissible voltage for short periods	1,6 x U_R
Reverse voltage = max. d.c. voltage applied in the reverse polarity for short periods	2 V

Ripple current**

Maximum permissible r.m.s. ripple current at 100 Hz and T_{amb} = 85 °C	see Table 3

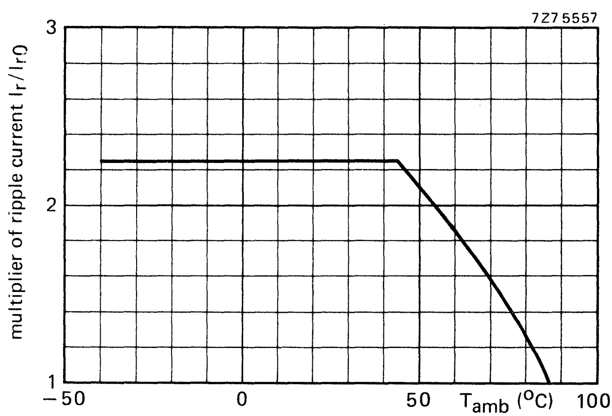


Fig. 7 Typical multiplier of ripple current as a function of ambient temperature; I_{r0} = ripple current at 85 °C, 100 Hz.

▲ See Introduction, section 5, "Ripple current".

* Specified ripple voltages are not applicable if the maximum permissible ripple current is exceeded. In that case the ripple current is decisive.

** Specified ripple currents are not applicable if the maximum permissible ripple voltage is exceeded. In that case the ripple voltage is decisive.

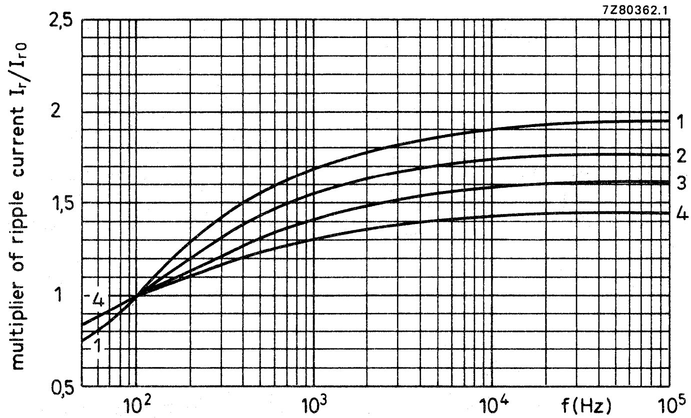


Fig. 8 Typical multiplier of ripple current as a function of frequency;
I_{r0} = ripple current at 85 °C, 100 Hz.
Curve 1 = 25 V, 0,15 to 2,2 μF; curve 3 = 25 V, 10 to 68 μF;
curve 2 = 25 V, 3,3 to 6,8 μF; curve 4 = 10 V, 16 V.

Non-sinusoidal ripple currents have to be analyzed into a number of sinusoidal currents. The following requirements must then be satisfied:

$$\sum_n \frac{I_n^2}{r_n} \leqslant I_{r\,max}^2$$

$I_{r\,max}$ = maximum ripple current at 100 Hz and applicable ambient temperature;
I_n = ripple current at a certain frequency;
$\sqrt{r_n} = I_r/I_{r0}$ = multiplying factor at a same frequency.

Charge and discharge current

There is no limit on the charge or discharge rate. If the capacitors are charged and discharged continuously several times per minute, the charge and discharge currents have to be considered as ripple currents flowing through the capacitor. The r.m.s. value of these currents should be determined and the value thus found must not exceed the applicable limit. (See also Tests and requirements.)

D.C. leakage current

Maximum d.c. leakage current 2 min after application of U_R at T_{amb} = 20 °C — see Table 3 (0,002 CU or 0,7 μA, whichever is greater)

If owing to prolonged storage and/or storage at an excessive temperature (> 40 °C) the d.c. leakage current is too high, application of the rated voltage for some hours will cause the d.c. leakage currrent to fall to a value lower than specified in Table 3.

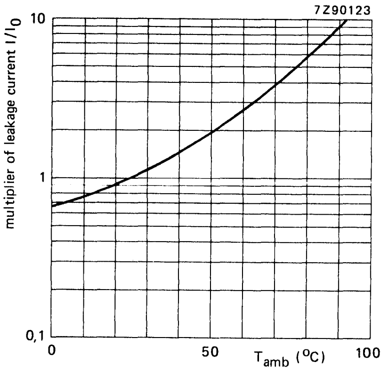


Fig. 9 Multiplier of d.c. leakage current as a function of ambient temperature; I_0 = d.c. leakage current during continuous operation at 25 °C and U_R.

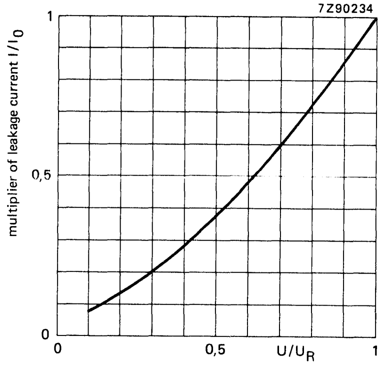


Fig. 10 Multiplier of d.c. leakage current as a function of U/U_R; I_0 = d.c. leakage current during continuous operation at 25 °C and U_R.

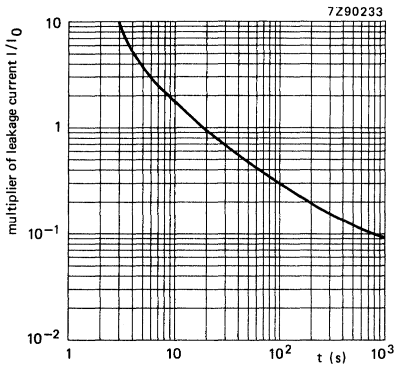


Fig. 11 Multiplier of typical d.c. leakage current as a function of time; I_0 is d.c. leakage current value as specified in Table 3.

Tan δ (dissipation factor)

Maximum tan δ at 100 Hz and T_{amb} = 25 °C, measured by a four-terminal circuit (Thomson circuit) — see Table 3

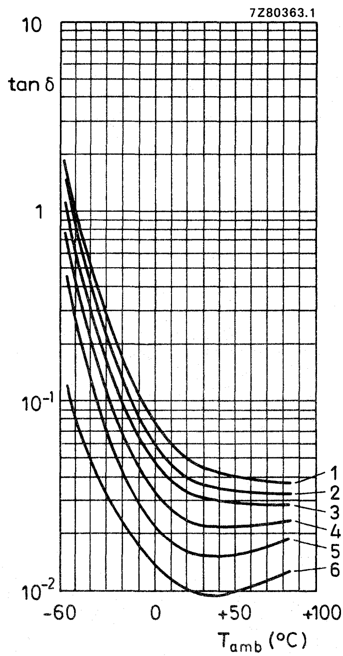


Fig. 12 Typical tan δ at 100 Hz as a function of ambient temperature.
Curve 1 = 10 V;
curve 2 = 16 V;
curve 3 = 25 V, 22 to 68 μF;
curve 4 = 25 V, 10/15 μF;
curve 5 = 25 V, 3,3 to 6,8 μF;
curve 6 = 25 V, 0,15 to 2,2 μF.

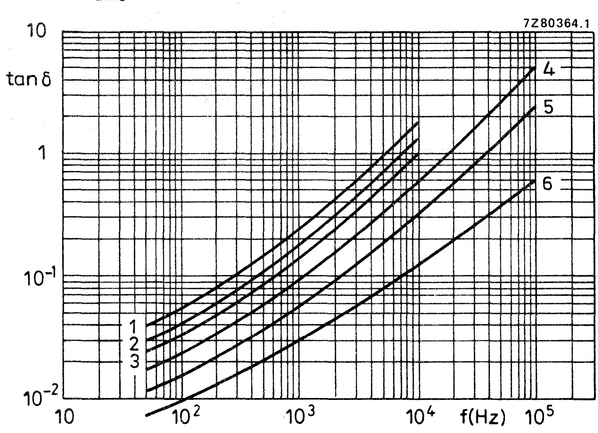


Fig. 13 Typical tan δ as a function of frequency at T_{amb} = 20 °C.
Curve 1 = 10 V;
curve 2 = 16 V;
curve 3 = 25 V, 22 to 68 μF;
curve 4 = 25 V, 10/15 μF;
curve 5 = 25 V, 3,3 to 6,8 μF;
curve 6 = 25 V, 0,15 to 2,2 μF.

Equivalent series resistance (ESR)

ESR = tan $\delta/\omega C$

Maximum tan δ and C at 100 Hz and T_{amb} = 25 °C — see Table 3

Equivalent series inductance (ESL)

Case size 11	typ. 13 nH
Case size 13	typ. 16 nH

Impedance (Z)

Maximum impedance at T_{amb} = 20 °C, −25 °C and −40 °C and 10 kHz, measured by a four-terminal circuit (Thomson circuit) — see Table 4

Maximum ratio between impedances at T_{amb} = −25 °C and + 20 °C at T_{amb} = −40 °C and + 20 °C, and at T_{amb} = −55 °C and + 20 °C, at 100 Hz measured by a four-terminal circuit (Thomson circuit) — see Table 4

Table 4

U_R V	nom. cap. μF	case size*	maximum impedance at 10 kHz T_{amb} = 20 °C Ω	T_{amb} = −25 °C Ω	T_{amb} = −40 °C Ω	maximum impedance ratio at U_R and 100 Hz $\frac{Z \text{ at } -25\ °C}{Z \text{ at } +20\ °C}$	$\frac{Z \text{ at } -40\ °C}{Z \text{ at } +20\ °C}$	$\frac{Z \text{ at } -55\ °C}{Z \text{ at } +20\ °C}$
10	47	11	2,8	11,9	31,9	2	3	5
	68	11	1,9	8,2	22,1	2	3	5
	150	13	0,9	3,7	10,0	2	3	5
	220	13	0,6	2,6	6,8	2	3	5
16	33	11	2,7	12,1	33,1	1,5	2	4
	100	13	0,9	4,0	11,0	1,5	2	4
25	0,15	11	300	1070	3870	1,5	2	3
	0,22	11	205	727	2636	1,5	2	3
	0,33	11	136	485	1758	1,5	2	3
	0,47	11	96	340	1234	1,5	2	3
	0,68	11	66	235	853	1,5	2	3
	1,0	11	45	160	580	1,5	2	3
	1,5	11	30	107	387	1,5	2	3
	2,2	11	20,5	72,7	264	1,5	2	3
	3,3	11	13,6	48,5	176	1,5	2	3
	4,7	11	9,6	34,0	123	1,5	2	3
	6,8	11	6,6	23,5	85,3	1,5	2	3
	10	11	6,0	25,0	75	1,5	2	3
	15	11	4,0	16,7	50	1,5	2	3
	22	11	3,2	13,6	40,9	1,5	2	3
	33	13	1,4	4,9	17,6	1,5	2	3
	47	13	1,3	5,3	15,6	1,5	2	3
	68	13	1,0	4,4	13,2	1,5	2	3

* Case size 11: ϕ 5 mm x 11 mm; case size 13: ϕ 8,2 mm x 11 mm (nominal dimensions).

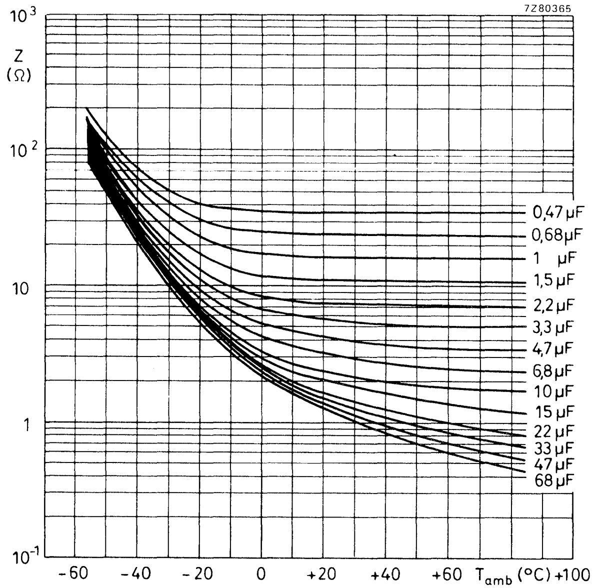


Fig. 14 Typical impedance at 10 kHz as a function of ambient temperature, case size 11.

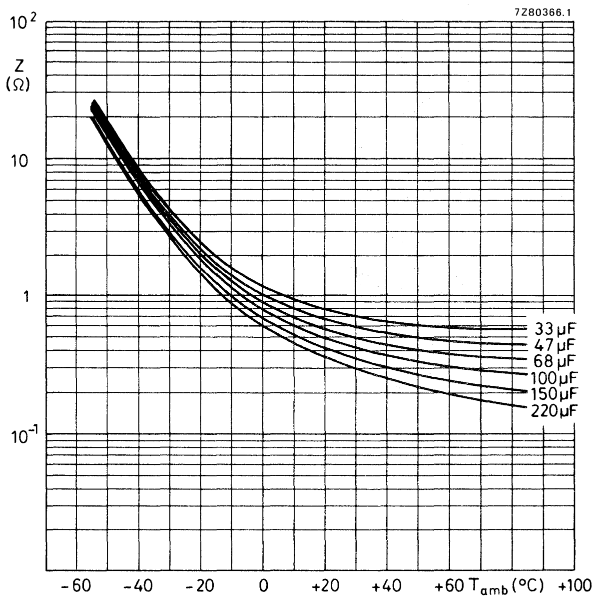


Fig. 15 Typical impedance at 10 kHz as a function of ambient temperature, case size 13.

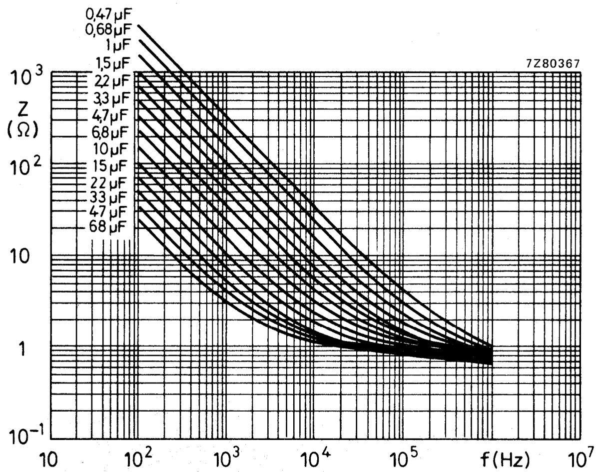


Fig. 16 Typical impedance as a function of frequency at T_{amb} = 20 °C, case size 11.

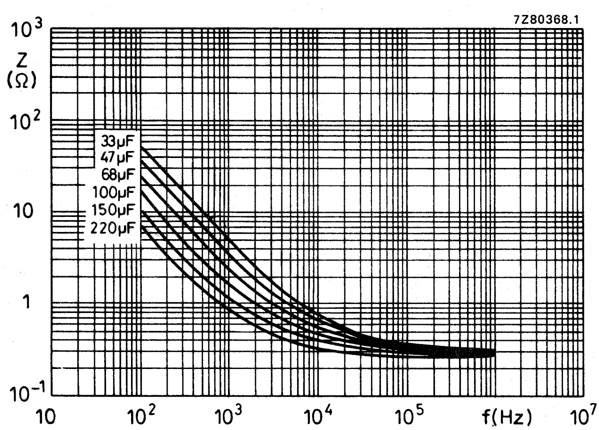


Fig. 17 Typical impedance as a function of frequency at T_{amb} = 20 °C, case size 13.

OPERATIONAL DATA

Category temperature range	−55 to +85 °C
Typical life time	
at T_{amb} = 40 °C	70 000 h
at T_{amb} = 85 °C	3 000 h
at T_{amb} = 95 °C	1 500 h
at T_{amb} = 105 °C	750 h
Shelf life at 0 V and T_{amb} = 85 °C	500 h

PACKING

Capacitors of styles 1, 2 and 3 are supplied in boxes, those of styles 4, 6 and 5 on tape on reel and in ammunition pack respectively. The numbers per box, per reel and per ammunition pack are given in Table 5.

Table 5

case size	number of capacitors				
	style 1 per box	style 2 per box	style 3 per box	styles 4 and 6 per reel (min.)	style 5 per ammunition pack
11	1000	1000	1000	1000	2000
13	1000	1000	1000	500	1000

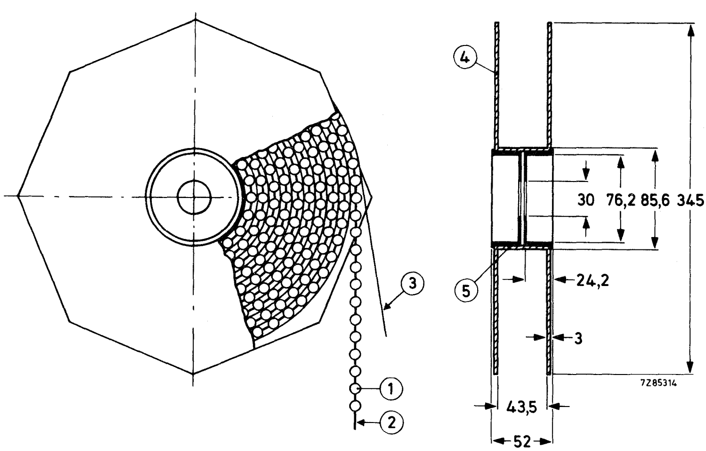


Fig. 18 Capacitors (style 4) on tape on reel.

1 = capacitor
2 = tape
3 = paper
4 = flange
5 = cylinder

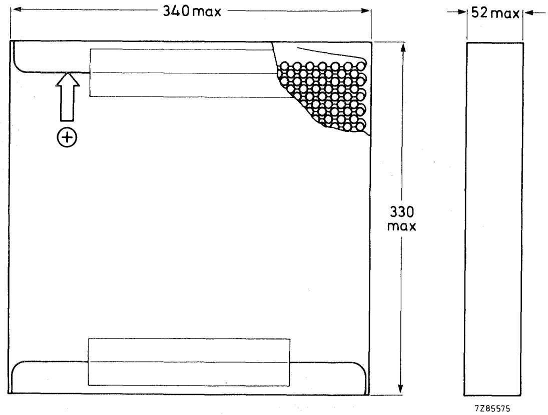


Fig. 19 Capacitors (style 5) on tape in ammunition pack.

TESTS AND REQUIREMENTS

See Introduction, section 9, under aluminium electrolytic capacitors, with the following addition.

After *endurance test, 2000 h, 85 °C,* the capacitors meet the following requirements:

$\Delta C/C \leqslant \pm 15\%$;

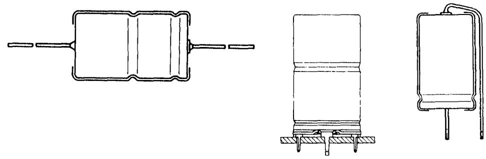
tan $\delta \leqslant$ 130% of specified value;

d.c. leakage current $\leqslant$ specified value.

After *shelf life test, 500 h, 85 °C,* the capacitors meet the same requirements as after endurance test, except for leakage current: $\leqslant$ 200% of specified value. The rated voltage shall be applied to the capacitors for minimum 30 min., at least 24 h and not more than 48 h before measurements.

Note: Capacitors 2222 013 are miniature, long-life grade.

ALUMINIUM ELECTROLYTIC CAPACITORS



- **Miniature and small types**
- **Axial leads and single ended**
- **Long life**
- **Low impedance, high ripple current**
- **For Switched Mode Power Supplies (SMPS)**

QUICK REFERENCE DATA

Nominal capacitance range (E6 series):	1 to 10 000 μF
Tolerance on nominal capacitance:	−10 to + 50%
Rated voltage range, U_R (R5 series):	6,3 to 100 V
Category temperature range:	−55 to + 85 °C
Endurance test at 85 °C:	2000 h
Shelf life at 0 V; 85 °C:	500 h
Basic specifications:	IEC 384-4, long-life grade DIN 41316 DIN 41240
Climatic category IEC 68: DIN 40040:	 55/085/56 FPF

case size	nominal dimensions (mm)	
3	Ø 6 x 10	miniature
5a	Ø 8 x 11	miniature
4	Ø 6,5 x 18	miniature
5	Ø 8 x 18	miniature
6	Ø 10 x 18	miniature
7	Ø 10 x 25	miniature
00	Ø 10 x 30	small
01	Ø 12,5 x 30	small
02	Ø 15 x 30	small
03	Ø 18 x 30	small
04	Ø 18 x 40	small
05	Ø 21 x 40	small

Selection chart for C_{nom}-U_R and relevant case sizes.

C_{nom} μF	U_R (V) 6,3	10	16	25	40	63	100
1						3	
1,5						3	
2,2						3	
3,3						3	
4,7						3	3
6,8						3	
10						3	4/5a
15					3	4/5a	5
22					3	4/5a	5
33				3	4/5a	5	6
47			3		4/5a	5	7
68		3	4/5a		5	6	
100	3		4/5a	5	6	7	01
150		4/5a	5	6	7	00	
220	4/5a		5	6	7/00	01	03
330	5		6	7	01	02	
470		6	7	00	01	02	05
680		7	00	01	02	03	
1 000		00	01	02	03	05	
1 500	00	01	02	03	04	05	
2 200	01	02	03	04	05		
3 300	02	03	04	05	05		
4 700	03	04	05	05			
6 800	04	05	05				
10 000	05	05	05				

* Case sizes 3 to 7 (miniature types) are still under development; information on these capacitors is derived from development samples, and does not necessarily imply that they will go into regular production.

APPLICATION

These capacitors with high CU-product per unit volume are designed for use in switched-mode power supplies (SMPS) or other applications where high ripple currents at high frequencies occur. Their low ESR, tan δ and impedance values, even at high frequencies and low temperatures render them suitable for bypass and coupling applications in high-frequency equipment.

DESCRIPTION

The capacitors have etched and oxidized aluminium foil electrodes rolled up with a paper strip impregnated with an electrolyte. The capacitors are in an aluminium case, which is insulated with a blue plastic sleeve.

The capacitors are available in 3 styles, all with soldered-copper leads.

Style 1: axial leads; all case sizes; case sizes 3 to 7 are supplied on bandoliers.
→ Style 2: single ended; with mounting ring with printed-wiring pins; especially for use in applications with severe shocks and vibrations; case sizes 02 to 05.
Style 3: single ended; case sizes 3 to 7 and 00 to 02.

MECHANICAL DATA

Dimensions in mm

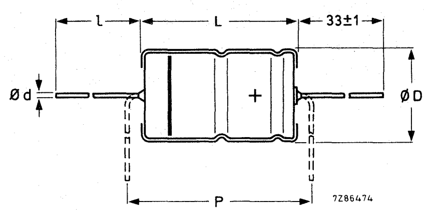


Fig. 1 Style 1; see Table 1a for dimensions d, D, L, l and P.

Table 1a

case size	d	l	style 1 D_{nom}	L_{nom}	D_{max}	L_{max}	P_{min}	mass approx. g
3	0,6	*	6,0	10,0	6,3	10,5	15	0,70
5a	0,6	*	8,0	11,0	8,5	11,5	15	1,1
4	0,8	*	6,5	18,0	6,9	18,5	25	1,3
5	0,8	*	8,0	18,0	8,5	18,5	25	1,7
6	0,8	*	10,0	18,0	10,5	18,5	25	2,5
7	0,8	*	10,0	25,0	10,5	25,0	30	3,3
00	0,8	55 ± 1	10,0	30,0	10,5	30,5	35,0	4
01	0,8	55 ± 1	12,5	30,0	13,0	30,5	35,0	6,3
02	0,8	55 ± 1	15,0	30,0	15,5	30,5	35,0	8,2
03	0,8	55 ± 1	18,0	30,0	18,5	30,5	35,0	10,9
04	0,8	34 ± 1	18,0	40,0	18,5	41,5	45,0	14
05	0,8	34 ± 1	21,0	40,0	21,5	41,5	45,0	19

* Case sizes 3 to 7 are supplied on bandoliers in boxes or on reels (see PACKING).

Table 1b

case size	style 2						mass approx. g
	d_1	d_2	D1	$D2_{max}$	D3	L	
02	0,8	1 + 0,1	15,0	17,5	16,5 ± 0,2	31 ± 1	8,6
03	0,8	1 + 0,1	18,0	19,5	18,5 ± 0,2	31 ± 1	11,5
04	1,0	1,3 + 0,1	18,0	19,5	18,5 ± 0,2	42 ± 1	14,5
05	1,0	1,3 + 0,1	21,0	22,5	21,5 ± 0,2	42 ± 1	19,7

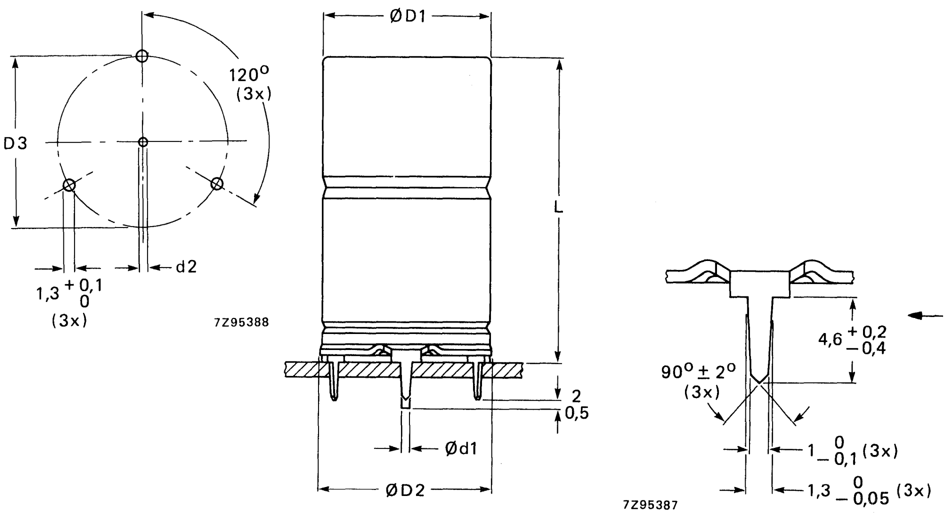


Fig. 2 Style 2; see Table 1b for dimensions d_1, d_2, D1, D2, D3 and L.

Table 1c

case size	d	style 3			mass approx. g
		D_{max}	L_{max}	P	
3	0,6	6,3	12,5	3,5– 7,5	0,55
5a	0,6	8,5	13,0	5 –10	1,0
4	0,8	6,9	21,5	5 –10	1,2
5	0,8	8,5	21,5	5 –10	1,6
6	0,8	10,5	21,5	7,5–12,5	2,3
7	0,8	10,5	28,0	7,5–12,5	3,1
00	0,8	10,5	34,0	7,5–12,5	3,8
01	0,8	13,0	34,0	7,5–12,5	6,1
02	0,8	15,5	34,0	10,0–15,0	8,0

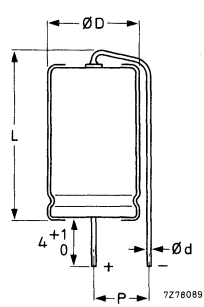


Fig. 3 Style 3 see Table 1c for dimensions d, D, L and P.

Marking

The capacitors are marked with:
- nominal capacitance;
- tolerance on nominal capacitance
- rated voltage;
- group number; code of origin;
- name of manufacturer;
- date code (year and month) according to IEC 62;
- band to identify the negative terminal;
- + signs to identify the positive terminal (not for case sizes 3 and 5a).

Mounting

The capacitors are suitable for mounting on printed-wiring boards; the required hole diameters are shown in Table 1d.

Table 1d

style	lead/pin diameter	required hole diameter
1 and 3	0,6 mm lead 0,8 mm lead	0,8 + 0,1 mm 1,0 + 0,1 mm
2	0,8 mm anode pin 1,0 mm anode pin cathode pins	1 + 0,1 mm 1,3 + 0,1 mm 1,3 + 0,1 mm

Minimum atmospheric pressure 8,5 kPa

PRODUCT SAFETY

Non-solid electrolytic capacitors may contain chemicals which can be regarded as hazardous if incorrectly handled. Caution is necessary should the outer case be fractured.

ELECTRICAL DATA

Table 2

Unless otherwise specified all electrical values in Table 2 apply at an ambient temperature of 20 to 25 ^{o}C, a frequency of 100 Hz, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 45 to 75%.

U_R V	nom. cap. μF	max. r.m.s. ripple current at T_{amb} = 85 ^{o}C (mA)	max. d.c. leakage current at U_R after 1 min μA	max. tan δ	max. ESR $m\Omega$	max. impedance $m\Omega$ at 10 kHz	max. impedance $m\Omega$ at 100 kHz	case size	catalogue number* 2222 014 followed by
6,3	100	75	7,8	0,20	3200	1700	1500	3	.3101
	220	135	12,5	0,20	1450	770	680	5a	**
	220	145	12,5	0,20	1450	770	680	4	.3221
	330	200	16,5	0,20	960	520	460	5	.3331
	1500	525	61	0,26	290	250	220	00	.3152
	2200	700	88	0,27	205	180	140	01	.3222
	3300	900	129	0,30	150	100	90	02	.3332
	4700	1170	182	0,32	114	70	80	03	.3472
	6800	1470	261	0,37	91	50	60	04	.3682
	10 000	1800	382	0,43	72	50	60	05	.3103
10	68	70	8,1	0,14	3300	2100	1750	3	.4689
	150	130	13	0,14	1500	930	800	4	.4151
	150	140	13	0,14	1500	930	800	5a	**
	470	325	32	0,14	470	300	260	6	.4471
	680	445	45	0,14	330	210	180	7	.4681
	1000	470	64	0,18	300	180	160	00	.4102
	1500	700	94	0,19	212	160	140	01	.4152
	2200	850	136	0,20	152	100	90	02	.4222
	3300	1000	202	0,22	111	80	70	03	.4332
	4700	1500	286	0,24	85	50	60	04	.4472
	6800	1800	412	0,28	69	50	60	05	.4682
	10 000	2260	604	0,30	50	50	60	05	.4103

* Replace dot in catalogue number by:
1 for style 1, case sizes 00 to 05, supplied in box;
2 for style 1 on bandoliers on reel (preferred for case sizes 3 and 4) } case sizes 3 to 7
3 for style 1 on bandoliers in box (preferred for case sizes 5a to 7) }
4 for style 2; case sizes 02 to 05;
8 for style 3; case sizes 3 to 02.

** See Table 3.

U_R (V)	nom. cap. (µF)	max. r.m.s. ripple current at T_{amb} = 85 °C (mA)	max. d.c. leakage current at U_R after 1 min (µA)	max. tan δ	max. ESR (mΩ)	max. impedance (mΩ) at 10 kHz	max. impedance (mΩ) at 100 kHz	case size	catalogue number* 2222 014 followed by
16	47	65	8,5	0,11	3700	2100	1700	3	.5479
	68	100	10,5	0,11	2600	1450	1200	5a	**
	68	105	10,5	0,11	2600	1450	1200	4	.5689
	100	125	13,5	0,11	1750	1000	800	5a	**
	100	130	13,5	0,11	1750	1000	800	4	.5101
	150	180	18,5	0,11	1150	670	530	5	.5151
	220	220	25	0,11	800	450	360	5	.5221
	330	305	36	0,11	530	300	240	6	.5331
	470	415	49	0,11	370	210	170	7	.5471
	680	500	70	0,13	320	180	160	00	.5681
	1000	715	100	0,13	218	110	100	01	.5102
	1500	900	148	0,14	156	100	100	02	.5152
	2200	1270	215	0,15	114	70	80	03	.5222
	3300	1560	321	0,17	86	50	60	04	.5332
	4700	1820	455	0,20	71	50	60	05	.5472
	6800	2000	654	0,24	59	50	60	05	.5682
	10 000	2400	984	0,26	44	50	60	05	.5103
25	33	65	9	0,09	4300	2100	1800	3	.6339
	100	165	19	0,09	1450	700	600	5	.6101
	150	230	27	0,09	950	470	400	6	.6151
	220	280	37	0,09	650	320	270	6	.6221
	330	390	54	0,09	430	210	180	7	.6331
	470	540	74	0,11	392	180	160	00	.6471
	680	600	106	0,12	295	130	110	01	.6681
	1000	920	154	0,12	200	100	100	02	.6102
	1500	1040	229	0,13	145	70	80	03	.6152
	2200	1480	334	0,13	99	50	60	04	.6222
	3300	1800	500	0,14	71	50	60	05	.6332
	4700	2140	709	0,15	54	50	60	05	.6472

* Replace dot in catalogue number by:
1 for style 1, case sizes 00 to 05, supplied in box;
2 for style 1 on bandoliers on reel (preferred for case sizes 3 and 4) } case sizes 3 to 7
3 for style 1 on bandoliers in box (preferred for case sizes 5a to 7) } case sizes 3 to 7
→ 4 for style 2; case sizes 02 to 05;
8 for style 3; case sizes 3 to 02.

** See Table 3.

U_R V	nom. cap. μF	max. r.m.s. ripple current at T_{amb} = 85 °C (mA)	max. d.c. leakage current at U_R after 1 min μA	max. tan δ	max. ESR mΩ	max. impedance mΩ at 10 kHz	max. impedance mΩ at 100 kHz	case size	catalogue number* 2222 014 followed by
40	15	45	7,6	0,08	8500	3300	3000	3	.7159
	22	55	9,3	0,08	5800	2300	2000	3	.7229
	33	85	12	0,08	3900	1500	1350	5a	**
	33	90	12	0,08	3900	1500	1350	4	.7339
	47	95	15,5	0,08	2700	1050	960	5a	**
	47	105	15,5	0,08	2700	1050	960	4	.7479
	68	145	20	0,08	1850	740	660	5	.7689
	100	200	28	0,08	1250	500	450	6	.7101
	150	280	40	0,08	850	330	300	7	.7151
	220	340	57	0,08	580	230	200	7	**
	220	365	57	0,08	600	220	170	00	.7221
	330	500	84	0,08	405	150	120	01	.7331
	470	575	117	0,08	285	110	110	01	.7471
	680	800	167	0,08	197	100	100	02	.7681
	1000	1100	244	0,08	134	70	80	03	.7102
	1500	1330	364	0,10	112	60	70	04	.7152
	2200	1660	532	0,11	84	50	70	05	.7222
	3300	1900	796	0,14	71	50	60	05	.7332
63	1	13	4,4	0,06	95 000	40 000	35 000	3	.8108
	1,5	16	4,6	0,06	64 000	27 000	23 000	3	.8158
	2,2	20	4,8	0,06	43 000	18 000	16 000	3	.8228
	3,3	24	5,2	0,06	29 000	12 000	10 500	3	.8338
	4,7	29	5,8	0,06	20 000	8500	7400	3	.8478
	6,8	35	6,6	0,06	14 000	5900	5100	3	.8688
	10	42	7,8	0,06	9500	4000	3500	3	.8109
	15	63	9,7	0,06	6400	2700	2300	5a	**
	15	68	9,7	0,06	6400	2700	2300	4	.8159
	22	78	12,5	0,06	4300	1800	1600	5a	**
	22	82	12,5	0,06	4300	1800	1600	4	.8229
	33	115	16,5	0,06	2900	1200	1050	5	.8339
	47	135	22	0,06	2000	850	740	5	.8479
	68	190	30	0,06	1400	590	510	6	.8689
	100	260	42	0,06	950	400	350	7	.8101
	150	345	61	0,06	670	370	220	00	.8151
	220	500	87	0,06	457	150	120	01	.8221
	330	650	129	0,06	305	150	120	02	.8331
	470	870	182	0,06	214	100	100	02	.8471
	680	1030	261	0,06	148	80	100	03	.8681
	1000	1600	382	0,06	100	50	70	05	.8102
	1500	1800	571	0,08	89	50	70	05	.8152

* Replace dot in catalogue number by:
1 for style 1, case sizes 00 to 05, supplied in box;
2 for style 1 on bandoliers on reel (preferred for case sizes 3 and 4) } case sizes 3 to 7
3 for style 1 on bandoliers in box (preferred for case sizes 5a to 7) } case sizes 3 to 7
4 for style 2; case sizes 02 to 05; ←
8 for style 3; case sizes 3 to 02.

** See Table 3.

U_R V	nom. cap. µF	max. r.m.s. ripple current at T_{amb} = 85 °C (mA)	max. d.c. leakage current at U_R after 1 min µA	max. tan δ	max. ESR mΩ	max. impedance mΩ at 10 kHz	max. impedance mΩ at 100 kHz	case size	catalogue number* 2222 014 followed by
100	4,7	16	6,8	0,05	17 000	7400	6400	3	.9478
	10	55	10	0,05	8000	3500	3000	5a	**
	10	60	10	0,05	8000	3500	3000	4	.9109
	15	85	13	0,05	5300	2300	2000	5	.9159
	22	105	17	0,05	3600	1600	1350	5	.9229
	33	140	24	0,05	2400	1050	910	6	.9339
	47	195	32	0,05	1700	740	640	7	.9479
	100	340	64	0,05	838	315	200	01	.9101
	220	650	139	0,05	381	150	120	03	.9221
	470	1090	286	0,05	178	100	100	05	.9471

Table 3

U_R V	nom. cap. µF	case size	catalogue number: style 1 on bandoliers on reel	catalogue number: style 1 on bandoliers in box	catalogue number: style 3
6,3	220	5a	2222 014 90534	2222 014 90535	2222 014 90536
10	150	5a	2222 014 90501	2222 014 90502	2222 014 90503
16	68	5a	2222 014 90504	2222 014 90505	2222 014 90506
	100	5a	2222 014 90507	2222 014 90508	2222 014 90509
40	33	5a	2222 014 90511	2222 014 90512	2222 014 90513
	47	5a	2222 014 90514	2222 014 90515	2222 014 90516
	220	7	2222 014 90517	2222 014 90518	2222 014 90519
63	15	5a	2222 014 90521	2222 014 90522	2222 014 90523
	22	5a	2222 014 90524	2222 014 90525	2222 014 90526
100	10	5a	2222 014 90527	2222 014 90528	2222 014 90529

* Replace dot in catalogue number by:
1 for style 1, case sizes 00 to 05, supplied in box;
2 for style 1 on bandoliers on reel (preferred for case sizes 3 and 4) } case sizes 3 to 7
3 for style 1 on bandoliers in box (preferred for case sizes 5a to 7) }
→ 4 for style 2; case sizes 02 to 05;
8 for style 3; case sizes 3 to 02.

** See Table 3.

Capacitance

Nominal capacitance at 100 Hz and T_{amb} = 20 °C — see Table 2

Tolerance on nominal capacitance at 100 Hz — −10 to + 50%

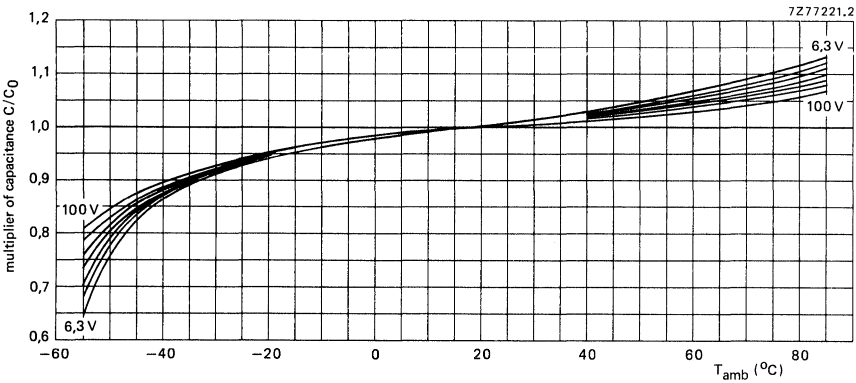


Fig. 4 Multiplier of capacitance as a function of ambient temperature; **case sizes 3 to 7**; C_0 = capacitance at 20 °C, 100 Hz.

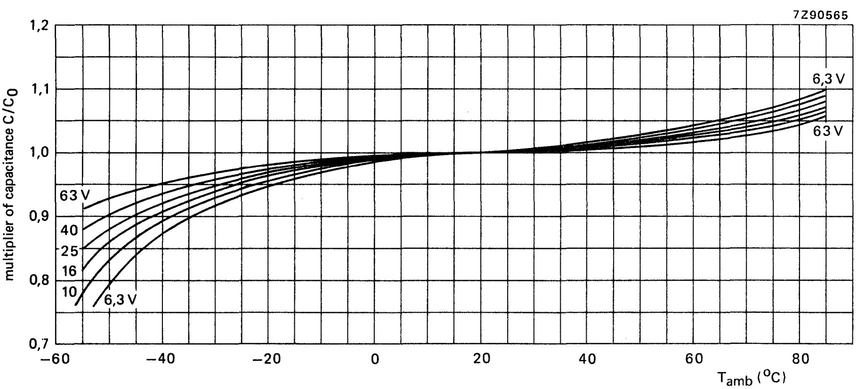


Fig. 5 Multiplier of capacitance as a function of ambient temperature; **case sizes 00 to 05**; C_0 = capacitance at 20 °C, 100 Hz.

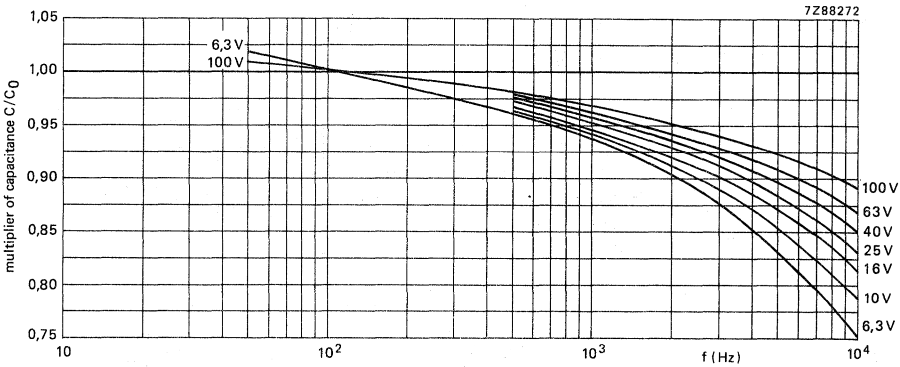


Fig. 6 Multiplier of capacitance as a function of frequency; **case sizes 3 to 7**; C_0 = capacitance at 20 °C, 100 Hz.

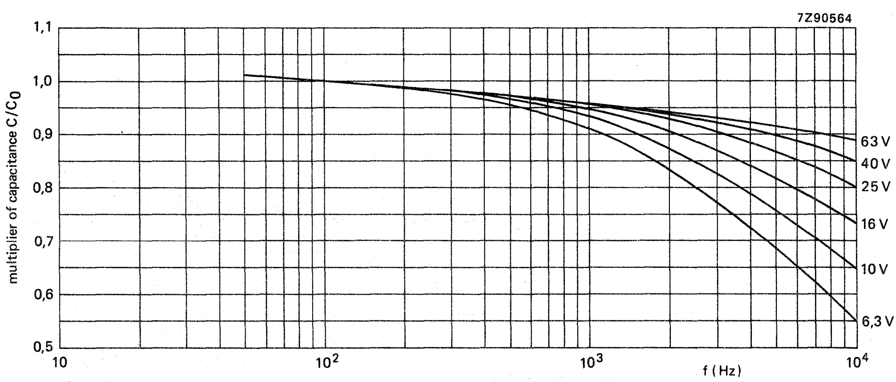


Fig. 7 Multiplier of capacitance as a function of frequency; **case sizes 00 to 05**; C_0 = capacitance at 20 °C, 100 Hz.

Voltage

	core temperature▲	
	<60 °C	60 to 95 °C
Rated voltage = max. permissible voltage	1,1 x U_R	U_R
Ripple voltage* = max. permissible a.c. voltage providing the following three conditions are met:		
a) max. (d.c. + peak a.c.) voltage	1,1 x U_R	U_R
b) max. peak a.c. voltage without d.c. voltage applied	1 V	
c) momentary value of applied voltage	between U_R and −2 V	
Surge voltage = max. permissible voltage for short periods	1,2 x U_R	1,15 x U_R
Reverse voltage = max. d.c. voltage applied in the reverse polarity for short periods	1 V	

Ripple current**

Maximum permissible r.m.s. ripple current at 100 Hz and T_{amb} = 85 °C — see Table 2

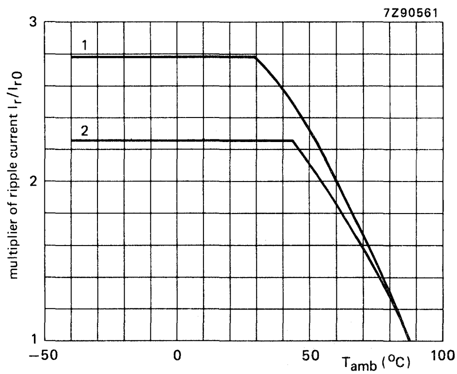


Fig. 8 Multiplier of ripple current as a function of ambient temperature; I_{r0} = ripple current at 85 °C, 100 Hz.

curve 1 = case sizes 3 to 7;
curve 2 = case sizes 00 to 05.

▲ See Introduction, section 5, "Ripple current".

* Ripple voltages are not applicable if the maximum permissible ripple current is exceeded. In that case the ripple current is decisive.

** Ripple currents are not applicable if the maximum permissible ripple voltage is exceeded. In that case the ripple voltage is decisive.

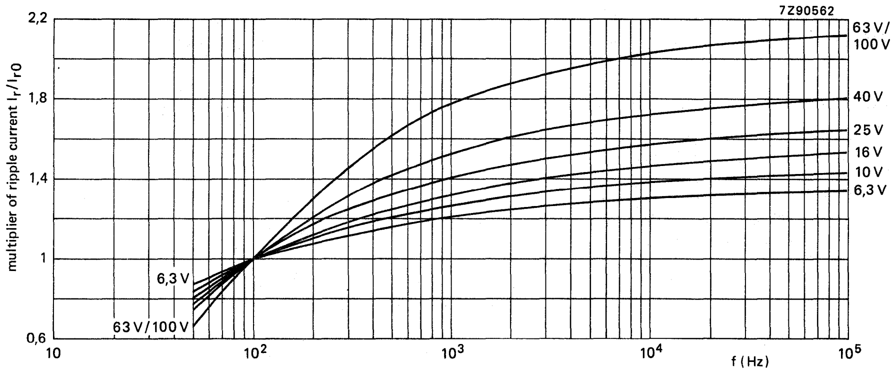


Fig. 9 Multiplier of ripple current as a function of frequency, **case sizes 3 to 7;** I_{r0} = ripple current at 85 °C, 100 Hz.

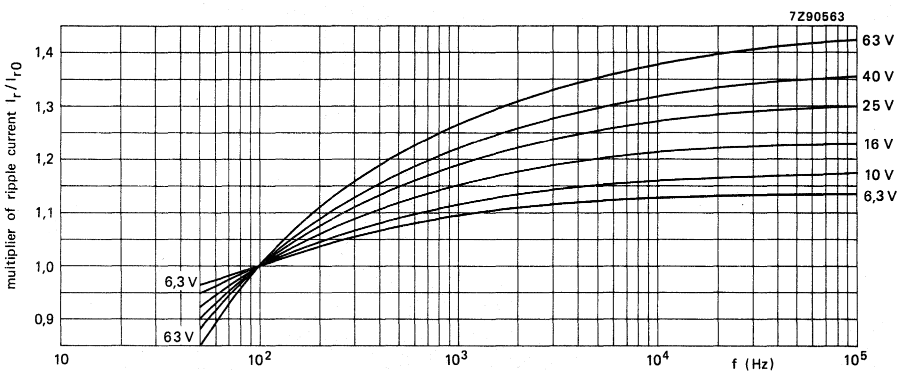


Fig. 10 Multiplier of ripple current as a function of frequency, **case sizes 00 to 05;** I_{r0} = ripple current at 85 °C, 100 Hz.

Non-sinusoidal ripple currents have to be analyzed into a number of sinusoidal currents and the following requirements shall then be satisfied:

$$\sum_{n} \frac{I_n^2}{r_n} \leqslant I_{r\,max}^2$$

$I_{r\,max}$ = maximum ripple current at 100 Hz and applicable ambient temperature;

I_n = ripple current at a certain frequency;

$\sqrt{r_n} = I_r/I_{r0}$ = multiplying factor at a same frequency.

Charge and discharge current

The capacitors may be charged from a source without internal resistance and they may be discharged by short-circuiting. If the capacitors are charged and discharged continuously at a rate of several times per minute, the charge and discharge currents have to be considered as ripple currents flowing through the capacitors. The r.m.s. value of these currents should be determined and the value thus found must not exceed the applicable limit.

D.C. leakage current

Maximum d.c. leakage current 1 min after application of U_R, at T_{amb} = 25 °C	see Table 2 (0,006 CU + 4 μA)
Maximum d.c. leakage current 5 min after application of U_R, at T_{amb} = 25 °C	0,002 CU + 2 μA
D.C. leakage current during continuous operation at U_R,	
at T_{amb} = 25 °C, case sizes 3 to 7	0,1 x values of Table 2
at T_{amb} = 25 °C, case sizes 00 to 05	0,01 x values of Table 2
at T_{amb} = 85 °C	⩽ values of Table 2

If owing to prolonged storage and/or storage at an excessive temperature (> 40 °C) the d.c. leakage current is too high, application of the rated voltage for some hours will cause the d.c. leakage current to fall to a value lower than specified in Table 2.

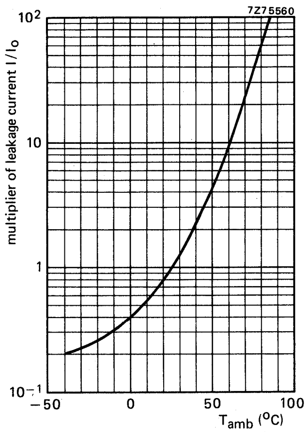


Fig. 11 Multiplier of d.c. leakage current as a function of ambient temperature, **case sizes 00 to 05;** I_0 = d.c. leakage current during continuous operation at 25 °C and U_R.

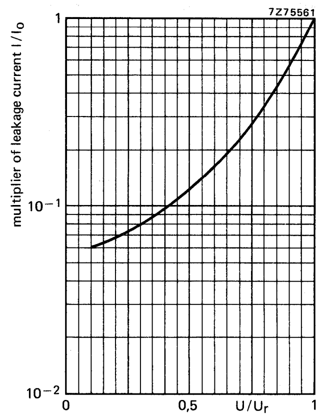


Fig. 12 Multiplier of d.c. leakage current as a function of U/U_R, **case sizes 00 to 05;** I_0 = d.c. leakage current during continuous operation at 25 °C and U_R.

Tan δ (dissipation factor)

Maximum tan δ at 100 Hz and T_{amb} = 25 °C measured by means of a four-terminal circuit (Thomson circuit)	see Table 2

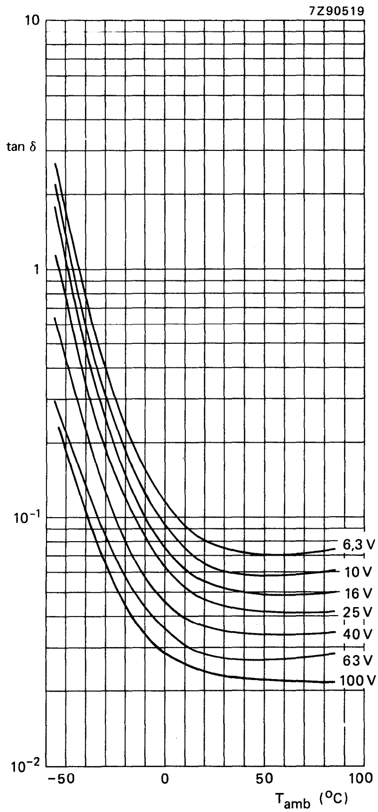


Fig. 13 Typical tan δ as a function of ambient temperature at 100 Hz; **case sizes 3 to 7.**

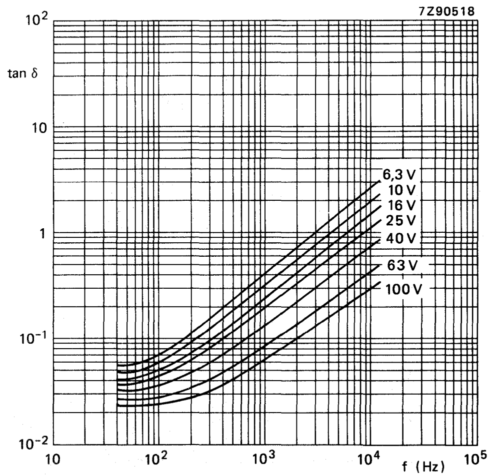


Fig. 14 Typical tan δ as a function of frequency at 25 °C, **case sizes 3 to 7.**

Equivalent series resistance (ESR)

Maximum ESR at 100 Hz and T_{amb} = 25 °C, measured by means of a four-terminal circuit (Thomson circuit)	see Table 2

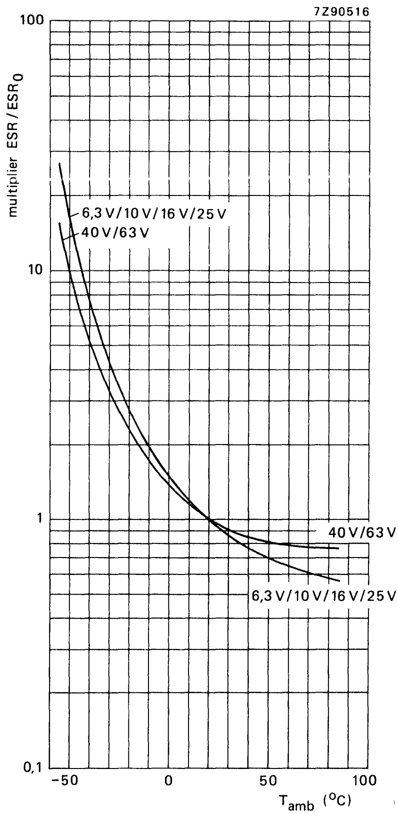


Fig. 15 Multiplier of ESR as a function of ambient temperature, **case sizes 00, 01 and 02**; ESR_0 = typ. ESR at 20 °C, 100 Hz.

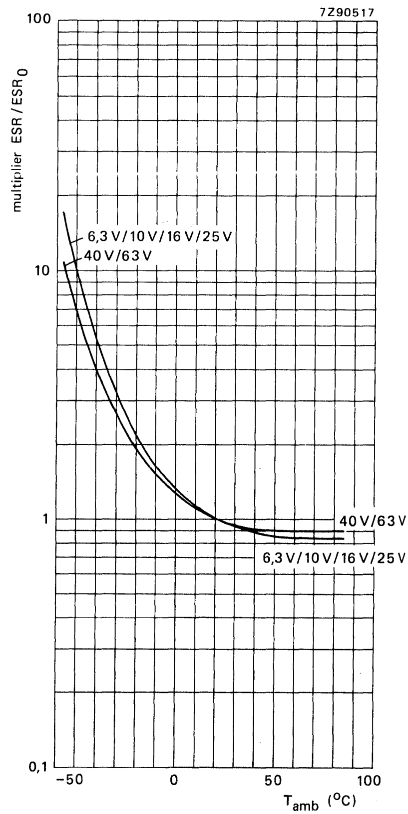


Fig. 16 Multiplier of ESR as a function of ambient temperature, **case sizes 03, 04 and 05**; ESR_0 = typ. ESR at 20 °C, 100 Hz.

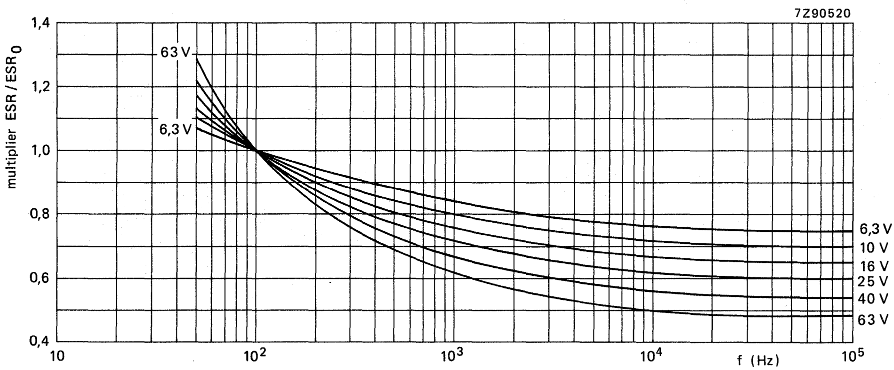


Fig. 17 Multiplier of ESR as a function of frequency, **case sizes 00 to 05;** ESR_0 = typical ESR at 20 °C, 100 Hz.

Impedance

Maximum impedance at T_{amb} = 25 °C and 10 kHz or 100 kHz, measured by means of a four-terminal circuit (Thomson circuit) — see Table 2

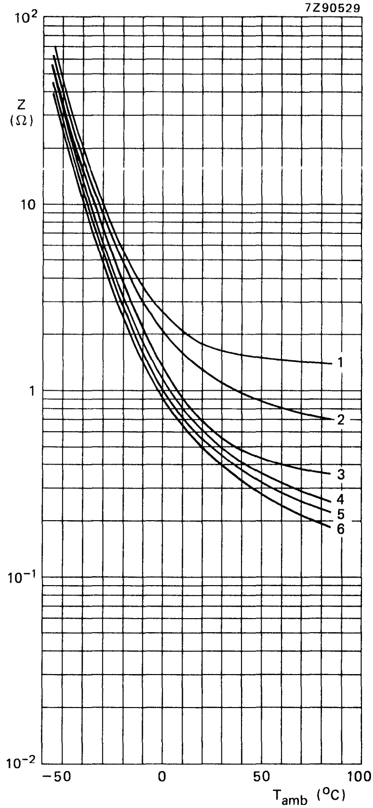


Fig. 18 Typical impedance as a function of ambient temperature at 10 kHz; **case size 3:**

curve 1 = 4,7 μF, 100 V;
curve 2 = 10 μF, 63 V;
curve 3 = 22 μF, 40 V;
curve 4 = 47 μF, 16 V;
curve 5 = 68 μF, 10 V;
curve 6 = 100 μF, 6,3 V.

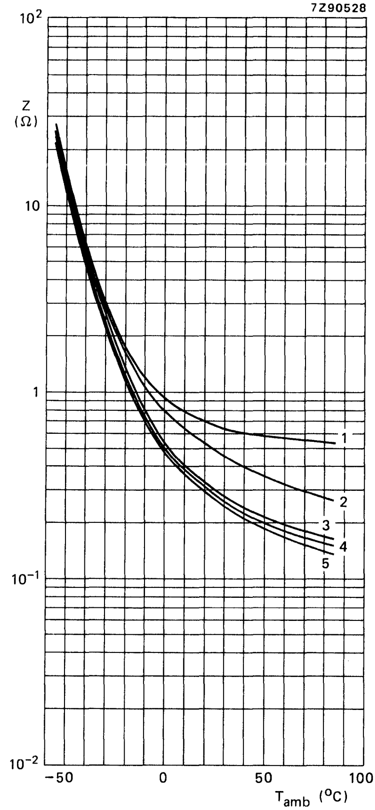


Fig. 19 Typical impedance as a function of ambient temperature at 10 kHz; **case size 5a:**

curve 1 = 22 μF, 63 V;
curve 2 = 47 μF, 40 V;
curve 3 = 100 μF, 16 V;
curve 4 = 150 μF, 10 V;
curve 5 = 220 μF, 6,3 V.

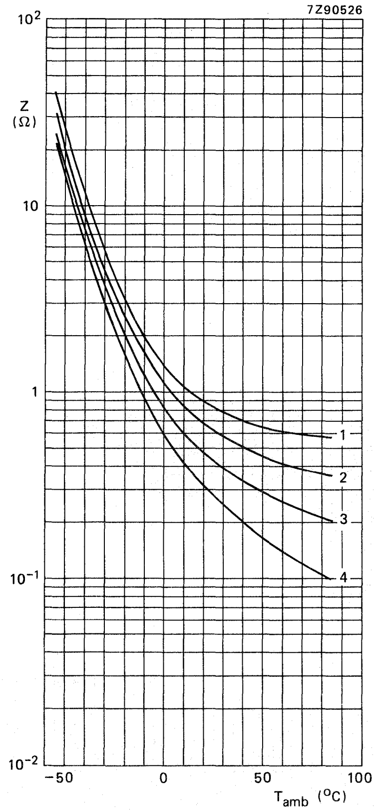


Fig. 20 Typical impedance as a function of ambient temperature at 10 kHz; **case size 4:**

curve 1 = 22 μF, 63 V;
curve 2 = 47 μF, 40 V;
curve 3 = 100 μF, 16 V;
curve 4 = 220 μF, 6,3 V.

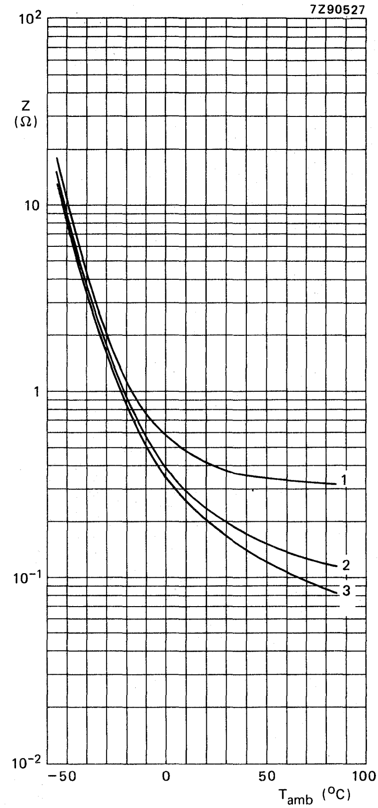


Fig. 21 Typical impedance as a function of ambient temperature at 10 kHz; **case size 5:**

curve 1 = 47 μF, 63 V;
curve 2 = 150 μF, 16 V;
curve 3 = 330 μF, 6,3 V.

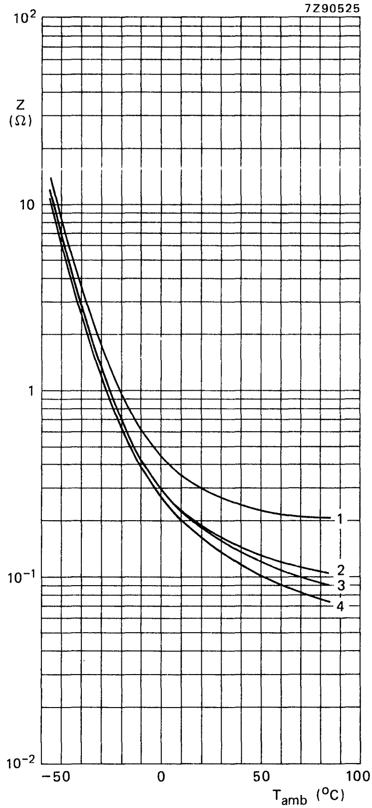


Fig. 22 Typical impedance as a function of ambient temperature at 10 kHz; **case size 6:**

curve 1 = 68 μF, 63 V;
curve 2 = 150 μF, 25 V;
curve 3 = 220 μF, 25 V;
curve 4 = 330 μF, 16 V.

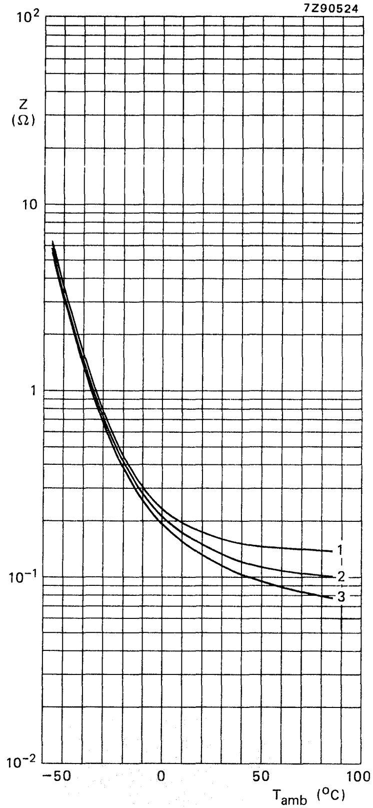


Fig. 23 Typical impedance as a function of ambient temperature at 10 kHz; **case size 7:**

curve 1 = 100 μF, 63 V;
curve 2 = 220 μF, 40 V;
curve 3 = 470 μF, 16 V.

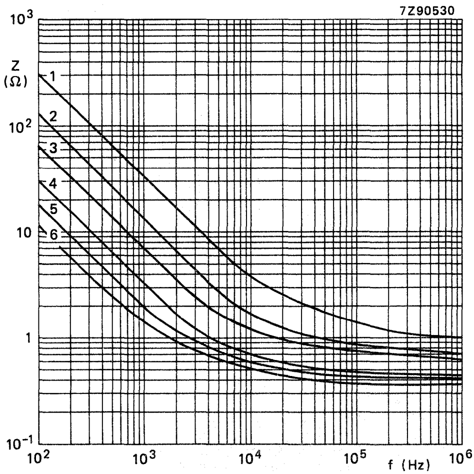


Fig. 24 Typical impedance as a function of frequency at T_{amb} = 20 °C;
case size 3:

curve 1 = 4,7 μF, 100 V;
curve 2 = 10 μF, 63 V;
curve 3 = 22 μF, 40 V;
curve 4 = 47 μF, 16 V;
curve 5 = 68 μF; 10 V;
curve 6 = 100 μF; 6,3 V.

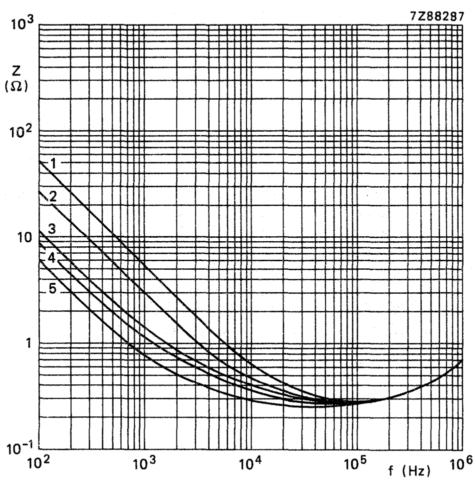


Fig. 25 Typical impedance as a function of frequency at T_{amb} = 20 °C;
case size 5a:

curve 1 = 22 μF, 63 V;
curve 2 = 47 μF, 40 V;
curve 3 = 100 μF, 16 V;
curve 4 = 150 μF, 10 V;
curve 5 = 220 μF, 6,3 V.

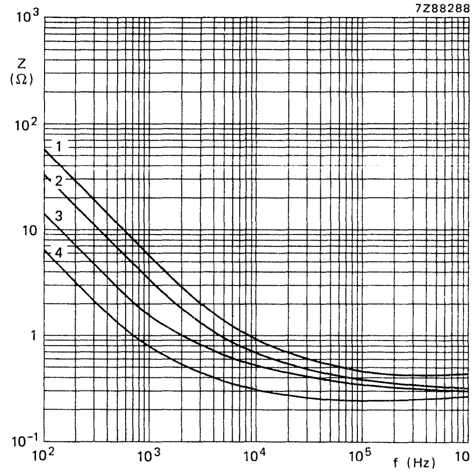


Fig. 26 Typical impedance as a function of frequency at T_{amb} = 20 °C;
case size 4:

curve 1 = 22 μF, 63 V;
curve 2 = 47 μF, 40 V;
curve 3 = 100 μF, 16 V;
curve 4 = 220 μF, 6,3 V.

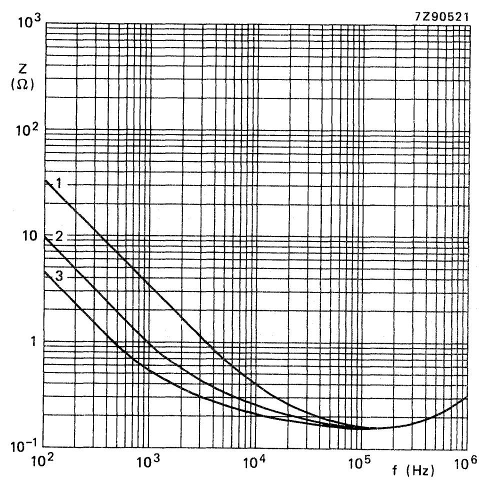


Fig. 27 Typical impedance as a function frequency at T_{amb} = 20 °C;
case size 5:

curve 1 = 47 μF, 63 V;
curve 2 = 150 μF, 16 V;
curve 3 = 330 μF, 6,3 V.

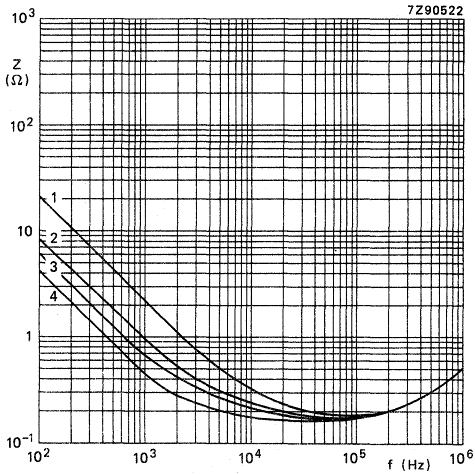


Fig. 28 Typical impedance as a function of frequency at T_{amb} = 20 °C;
case size 6:

curve 1 = 68 μF, 63 V;
curve 2 = 150 μF, 25 V;
curve 3 = 220 μF, 25 V;
curve 4 = 330 μF, 16 V.

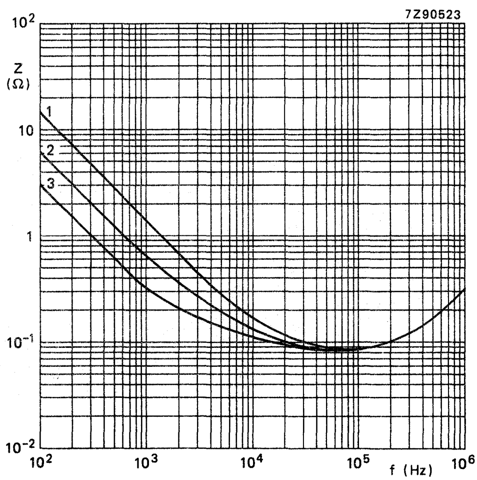


Fig. 29 Typical impedance as a function of frequency at T_{amb} = 20 °C;
case size 7:

curve 1 = 100 μF, 63 V;
curve 2 = 220 μF, 40 V;
curve 3 = 470 μF, 16 V.

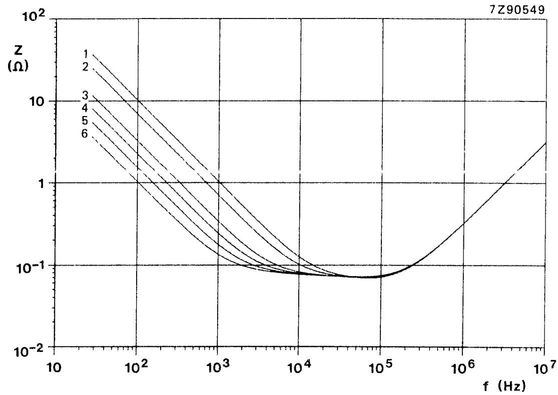


Fig. 30 Typical impedance as a function of frequency at T_{amb} = 20 °C, **case size 00.**
curve 1 = 150 μF, 63 V;
curve 2 = 220 μF, 40 V;
curve 3 = 470 μF, 25 V;
curve 4 = 680 μF, 16 V;
curve 5 = 1000 μF, 10 V;
curve 6 = 1500 μF, 6,3 V.

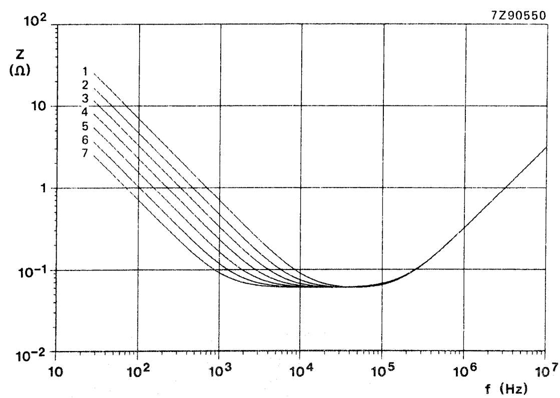


Fig. 31 Typical impedance as a function of frequency at T_{amb} = 20 °C, **case size 01.**
curve 1 = 220 μF, 63 V;
curve 2 = 330 μF, 40 V;
curve 3 = 470 μF, 40 V;
curve 4 = 680 μF, 25 V;
curve 5 = 1000 μF, 16 V;
curve 6 = 1500 μF, 10 V;
curve 7 = 2200 μF, 6,3 V.

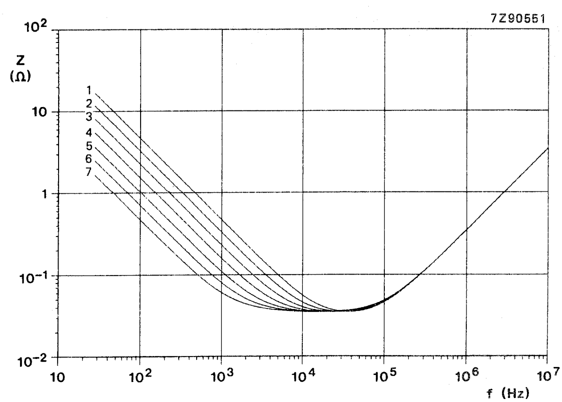


Fig. 32 Typical impedance as a function of frequency at T_{amb} = 20 °C, **case size 02.**
curve 1 = 330 μF, 63 V;
curve 2 = 470 μF, 63 V;
curve 3 = 680 μF, 40 V;
curve 4 = 1000 μF, 25 V;
curve 5 = 1500 μF, 16 V;
curve 6 = 2200 μF, 10 V;
curve 7 = 3300 μF, 6,3 V.

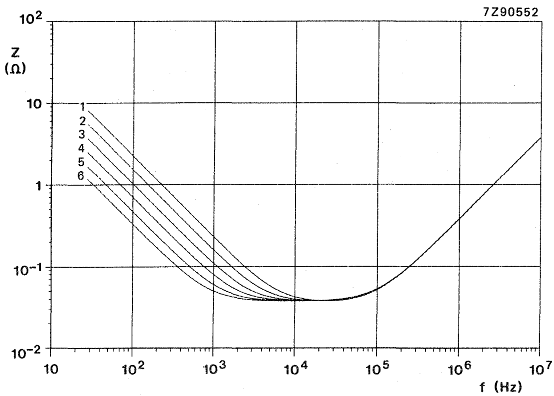


Fig. 33 Typical impedance as a function of frequency at T_{amb} = 20 °C, **case size 03.**

curve 1 = 680 μF, 63 V;
curve 2 = 1000 μF, 40 V;
curve 3 = 1500 μF, 25 V;
curve 4 = 2200 μF, 16 V;
curve 5 = 3300 μF, 10 V;
curve 6 = 4700 μF, 6,3 V.

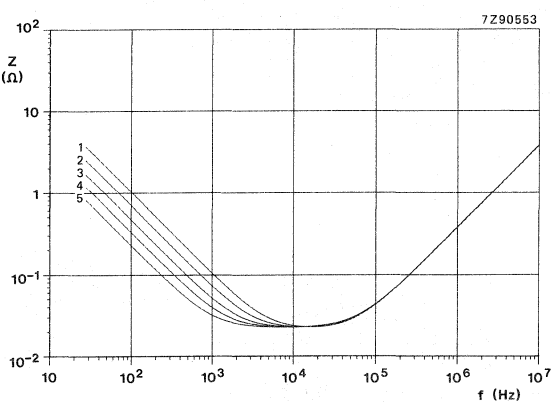


Fig. 34 Typical impedance as a function of frequency at T_{amb} = 20 °C, **case size 04.**

curve 1 = 1500 μF, 40 V;
curve 2 = 2200 μF, 25 V;
curve 3 = 3300 μF, 16 V;
curve 4 = 4700 μF, 10 V;
curve 5 = 6800 μF, 6,3 V.

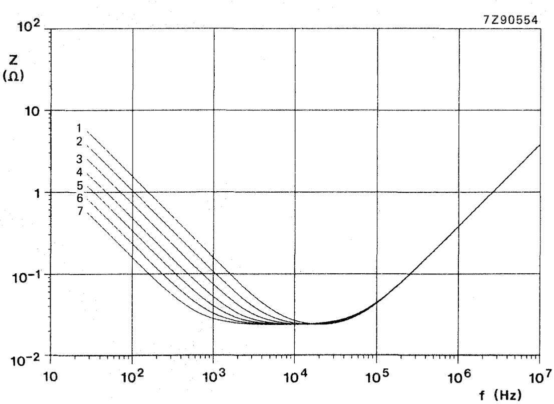


Fig. 35 Typical impedance as a function of frequency at T_{amb} = 20 °C, **case size 05.**

curve 1 = 1000 μF, 63 V;
curve 2 = 1500 μF, 63 V;
curve 3 = 2200 μF, 40 V;
curve 4 = 3300 μF, 25 and 40 V;
curve 5 = 4700 μF, 16 and 25 V;
curve 6 = 6800 μF, 10 and 16 V;
curve 7 = 10 000 μF, 6,3, 10 and 16 V.

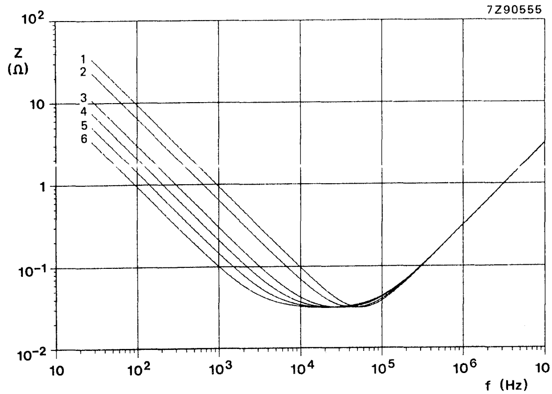


Fig. 36 Typical impedance as a function of frequency at T_{amb} = 85 °C, **case size 00.**

curve 1 = 150 μF, 63 V;
curve 2 = 220 μF, 40 V;
curve 3 = 470 μF, 25 V;
curve 4 = 680 μF, 16 V;
curve 5 = 1000 μF, 10 V;
curve 6 = 1500 μF, 6,3 V.

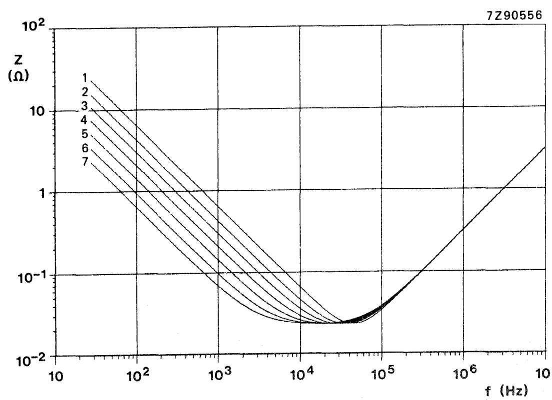


Fig. 37 Typical impedance as a function of frequency at T_{amb} = 85 °C, **case size 01.**

curve 1 = 220 μF, 63 V;
curve 2 = 330 μF, 40 V;
curve 3 = 470 μF, 40 V;
curve 4 = 680 μF, 25 V;
curve 5 = 1000 μF, 16 V;
curve 6 = 1500 μF, 10 V;
curve 7 = 2200 μF, 6,3 V.

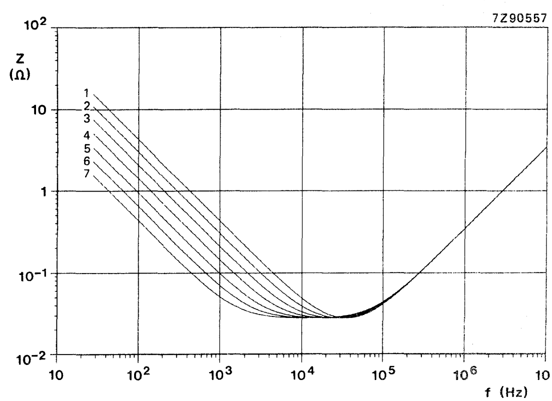


Fig. 38 Typical impedance as a function of frequency at T_{amb} = 85 °C, **case size 02.**

curve 1 = 330 μF, 63 V;
curve 2 = 470 μF, 63 V;
curve 3 = 680 μF, 40 V;
curve 4 = 1000 μF, 25 V;
curve 5 = 1500 μF, 16 V;
curve 6 = 2200 μF, 10 V;
curve 7 = 3300 μF, 6,3 V.

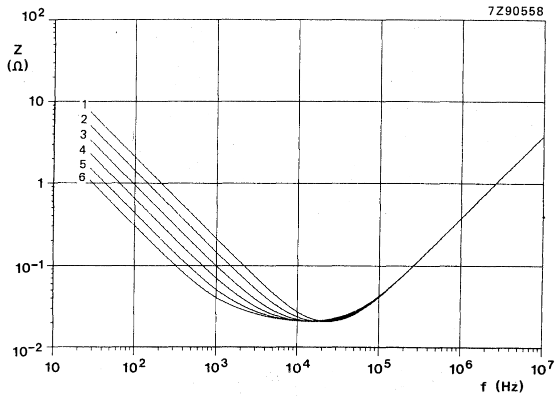


Fig. 39 Typical impedance as a function of frequency at T_{amb} = 85 °C, **case size 03.**

curve 1 = 680 μF, 63 V;
curve 2 = 1000 μF, 40 V;
curve 3 = 1500 μF, 25 V;
curve 4 = 2200 μF, 16 V;
curve 5 = 3300 μF, 10 V;
curve 6 = 4700 μF, 6,3 V.

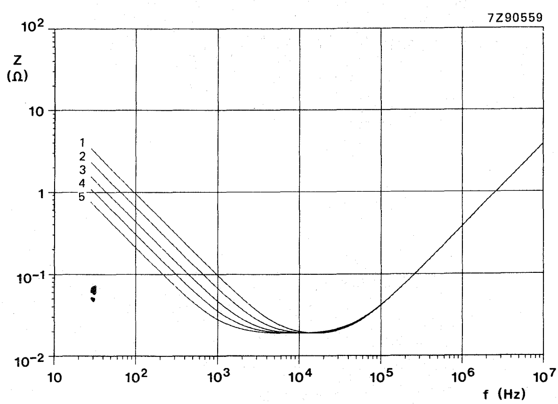


Fig. 40 Typical impedance as a function of frequency at T_{amb} = 85 °C, **case size 04.**

curve 1 = 1500 μF, 40 V;
curve 2 = 2200 μF, 25 V;
curve 3 = 3300 μF, 16 V;
curve 4 = 4700 μF, 10 V;
curve 5 = 6800 μF, 6,3 V.

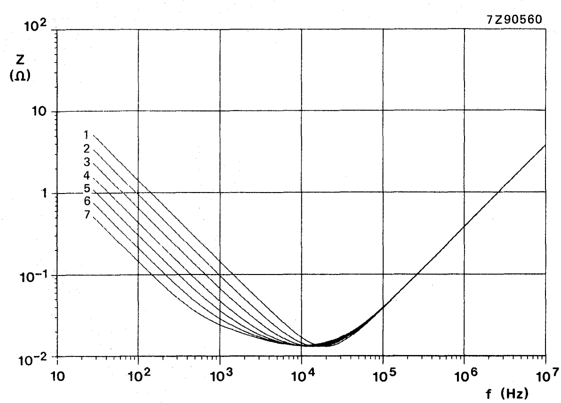


Fig. 41 Typical impedance as a function of frequency at T_{amb} = 85 °C, **case size 05.**

curve 1 = 1000 μF, 63 V;
curve 2 = 1500 μF, 63 V;
curve 3 = 2200 μF, 40 V;
curve 4 = 3300 μF, 25 and 40 V;
curve 5 = 4700 μF, 16 and 25 V;
curve 6 = 6800 μF, 10 and 16 V;
curve 7 = 10 000 μF, 6,3, 10 and 16 V.

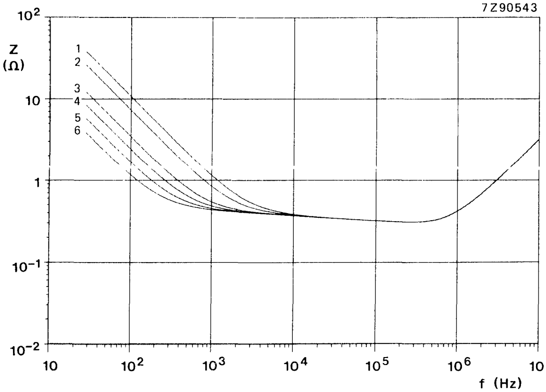


Fig. 42 Typical impedance as a function of frequency at T_{amb} = −25 °C, **case size 00.**

curve 1 = 150 μF, 63 V;
curve 2 = 220 μF, 40 V;
curve 3 = 470 μF, 25 V;
curve 4 = 680 μF, 16 V;
curve 5 = 1000 μF, 10 V;
curve 6 = 1500 μF, 6,3 V.

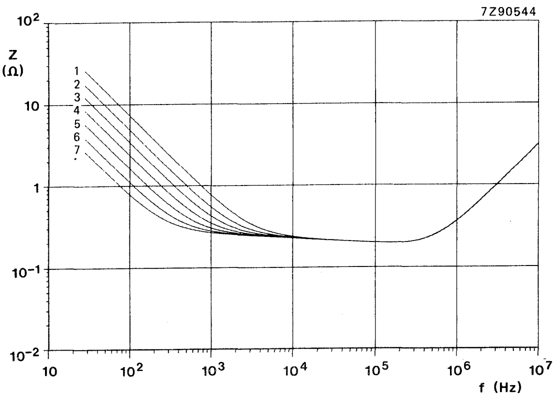


Fig. 43 Typical impedance as a function of frequency at T_{amb} = −25 °C, **case size 01.**

curve 1 = 220 μF, 63 V;
curve 2 = 330 μF, 40 V;
curve 3 = 470 μF, 40 V;
curve 4 = 680 μF, 25 V;
curve 5 = 1000 μF, 16 V;
curve 6 = 1500 μF, 10 V;
curve 7 = 2200 μF, 6,3 V.

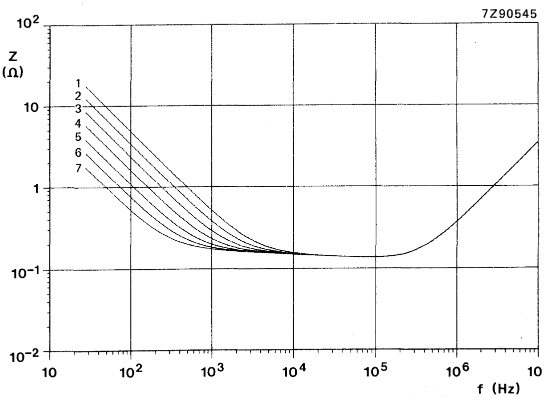


Fig. 44 Typical impedance as a function of frequency at T_{amb} = −25 °C, **case size 02.**

curve 1 = 330 μF, 63 V;
curve 2 = 470 μF, 63 V;
curve 3 = 680 μF, 40 V;
curve 4 = 1000 μF, 25 V;
curve 5 = 1500 μF, 16 V;
curve 6 = 2200 μF, 10 V;
curve 7 = 3300 μF, 6,3 V.

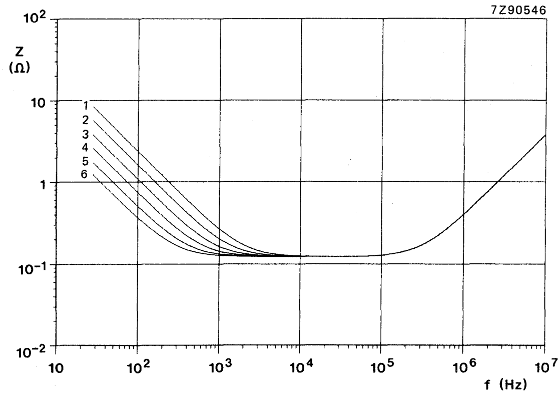


Fig. 45 Typical impedance as a function of frequency at T_{amb} = −25 °C, **case size 03.**

curve 1 = 680 μF, 63 V;
curve 2 = 1000 μF, 40 V;
curve 3 = 1500 μF, 25 V;
curve 4 = 2200 μF, 16 V;
curve 5 = 3300 μF, 10 V;
curve 6 = 4700 μF, 6,3 V.

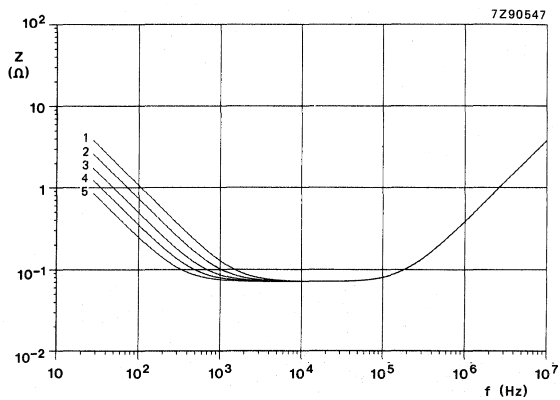


Fig. 46 Typical impedance as a function of frequency at T_{amb} = −25 °C, **case size 04.**

curve 1 = 1500 μF, 40 V;
curve 2 = 2200 μF, 25 V;
curve 3 = 3300 μF, 16 V;
curve 4 = 4700 μF, 10 V;
curve 5 = 6800 μF, 6,3 V.

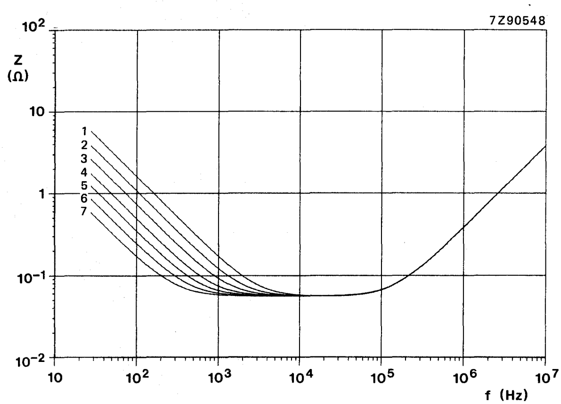


Fig. 47 Typical impedance as a function of frequency at T_{amb} = −25 °C, **case size 05.**

curve 1 = 1000 μF, 63 V;
curve 2 = 1500 μF, 63 V;
curve 3 = 2200 μF, 40 V;
curve 4 = 3300 μF, 25 and 40 V;
curve 5 = 4700 μF, 16 and 25 V;
curve 6 = 6800 μF, 10 and 16 V;
curve 7 = 10 000 μF, 6,3, 10 and 16 V.

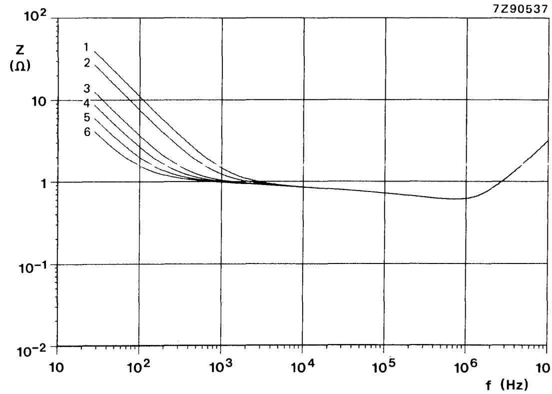


Fig. 48 Typical impedance as a function of frequency at T_{amb} = −40 °C, **case size 00.**

curve 1 = 150 μF, 63 V;
curve 2 = 220 μF, 40 V;
curve 3 = 470 μF, 25 V;
curve 4 = 680 μF, 16 V;
curve 5 = 1000 μF, 10 V;
curve 6 = 1500 μF, 6,3 V.

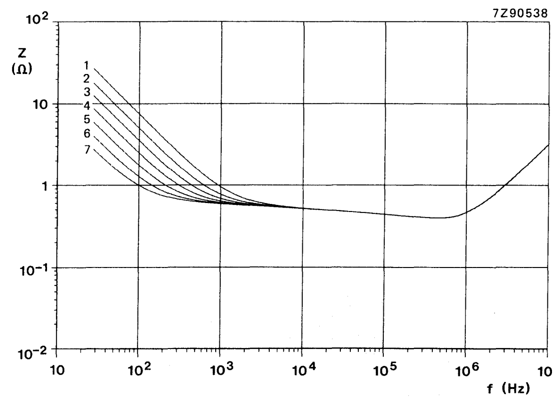


Fig. 49 Typical impedance as a function of frequency at T_{amb} = −40 °C, **case size 01.**

curve 1 = 220 μF, 63 V;
curve 2 = 330 μF, 40 V;
curve 3 = 470 μF, 40 V;
curve 4 = 680 μF, 25 V;
curve 5 = 1000 μF, 16 V;
curve 6 = 1500 μF, 10 V;
curve 7 = 2200 μF, 6,3 V.

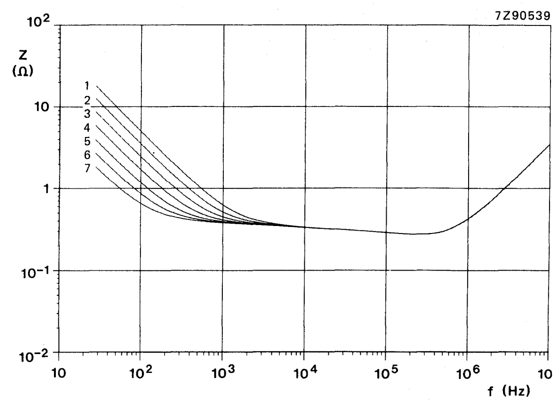


Fig. 50 Typical impedance as a function of frequency at T_{amb} = −40 °C, **case size 02.**

curve 1 = 330 μF, 63 V;
curve 2 = 470 μF, 63 V;
curve 3 = 680 μF, 40 V;
curve 4 = 1000 μF, 25 V;
curve 5 = 1500 μF, 16 V;
curve 6 = 2200 μF, 10 V;
curve 7 = 3300 μF, 6,3 V.

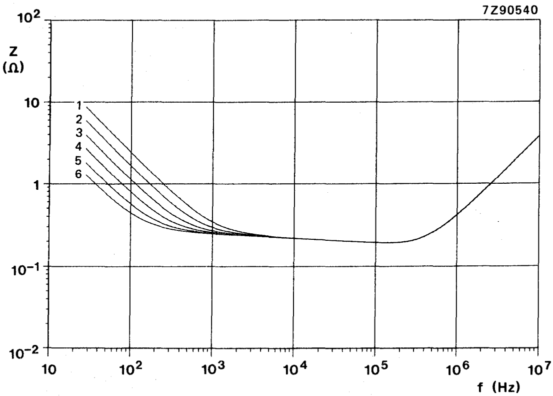


Fig. 51 Typical impedance as a function of frequency at T_{amb} = −40 °C, **case size 03.**

curve 1 = 680 μF, 63 V;
curve 2 = 1000 μF, 40 V;
curve 3 = 1500 μF, 25 V;
curve 4 = 2200 μF, 16 V;
curve 5 = 3300 μF, 10 V;
curve 6 = 4700 μF, 6,3 V.

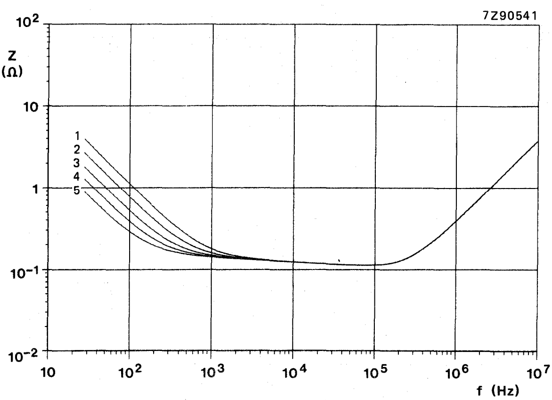


Fig. 52 Typical impedance as a function of frequency at T_{amb} = −40 °C, **case size 04.**

curve 1 = 1500 μF, 40 V;
curve 2 = 2200 μF, 25 V;
curve 3 = 3300 μF, 16 V;
curve 4 = 4700 μF, 10 V;
curve 5 = 6800 μF, 6,3 V.

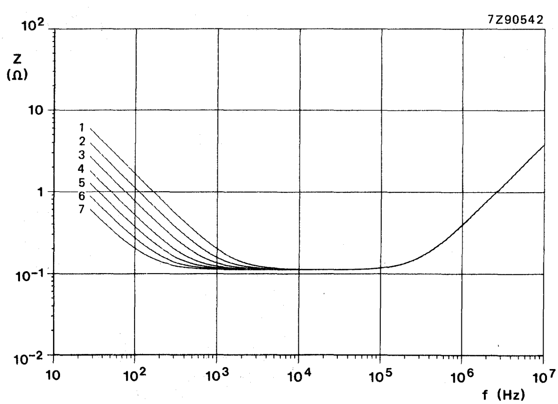


Fig. 53 Typical impedance as a function of frequency at T_{amb} = −40 °C, **case size 05.**

curve 1 = 1000 μF, 63 V;
curve 2 = 1500 μF, 63 V;
curve 3 = 2200 μF, 40 V;
curve 4 = 3300 μF, 25 and 40 V;
curve 5 = 4700 μF, 16 and 25 V;
curve 6 = 6800 μF, 10 and 16 V;
curve 7 = 10 000 μF, 6,3, 10 and 16 V.

Fig. 54 Typical impedance as a function of frequency at T_{amb} = −55 °C, **case size 00.**
curve 1 = 150 μF, 63 V;
curve 2 = 220 μF, 40 V;
curve 3 = 470 μF, 25 V;
curve 4 = 680 μF, 16 V;
curve 5 = 1000 μF, 10 V;
curve 6 = 1500 μF, 6,3 V.

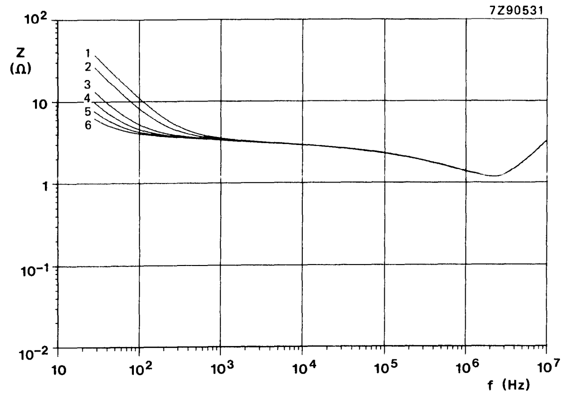


Fig. 55 Typical impedance as a function of frequency at T_{amb} = −55 °C, **case size 01.**
curve 1 = 220 μF, 63 V;
curve 2 = 330 μF, 40 V;
curve 3 = 470 μF, 40 V;
curve 4 = 680 μF, 25 V;
curve 5 = 1000 μF, 16 V;
curve 6 = 1500 μF, 10 V;
curve 7 = 2200 μF, 6,3 V.

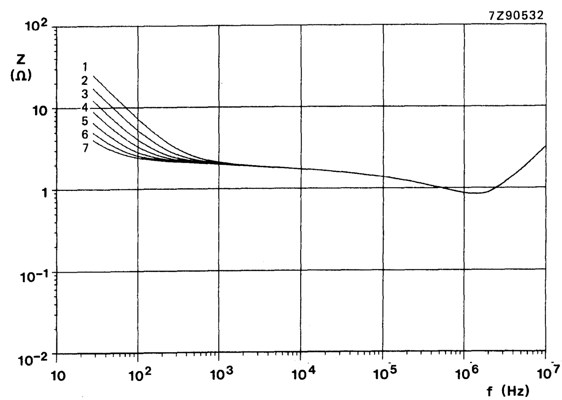
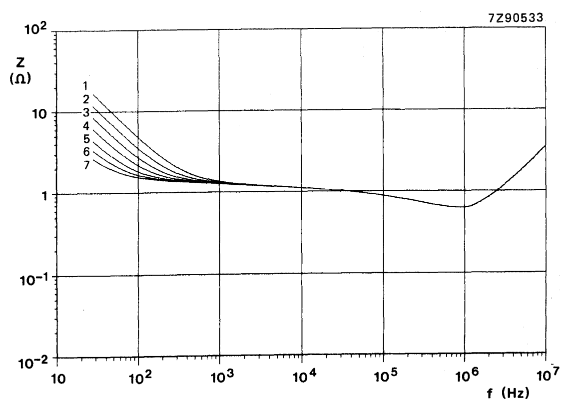


Fig. 56 Typical impedance as a function of frequency at T_{amb} = −55 °C, **case size 02.**
curve 1 = 330 μF, 63 V;
curve 2 = 470 μF, 63 V;
curve 3 = 680 μF, 40 V;
curve 4 = 1000 μF, 25 V;
curve 5 = 1500 μF, 16 V;
curve 6 = 2200 μF, 10 V;
curve 7 = 3300 μF, 6,3 V.



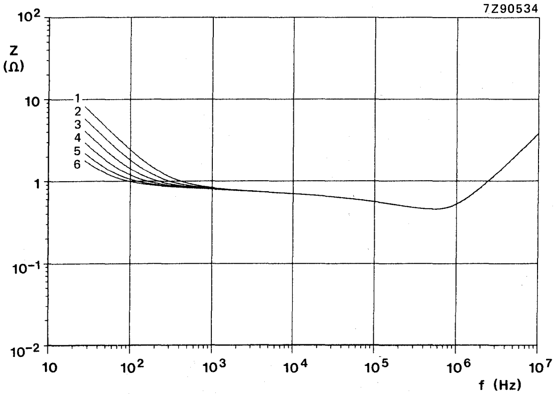


Fig. 57 Typical impedance as a function of frequency at T_{amb} = −55 °C, **case size 03.**

curve 1 = 680 μF, 63 V;
curve 2 = 1000 μF, 40 V;
curve 3 = 1500 μF, 25 V;
curve 4 = 2200 μF, 16 V;
curve 5 = 3300 μF, 10 V;
curve 6 = 4700 μF, 6,3 V.

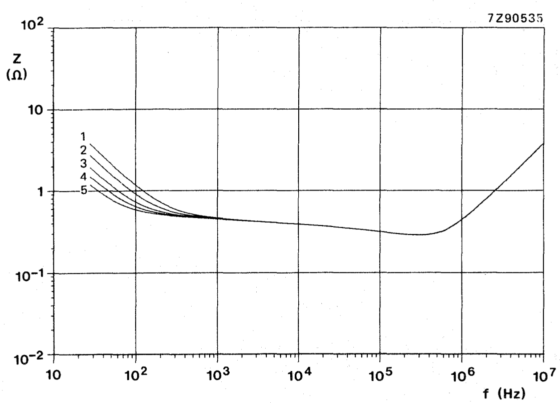


Fig. 58 Typical impedance as a function of frequency at T_{amb} = −55 °C, **case size 04.**

curve 1 = 1500 μF, 40 V;
curve 2 = 2200 μF, 25 V;
curve 3 = 3300 μF, 16 V;
curve 4 = 4700 μF, 10 V;
curve 5 = 6800 μF, 6,3 V.

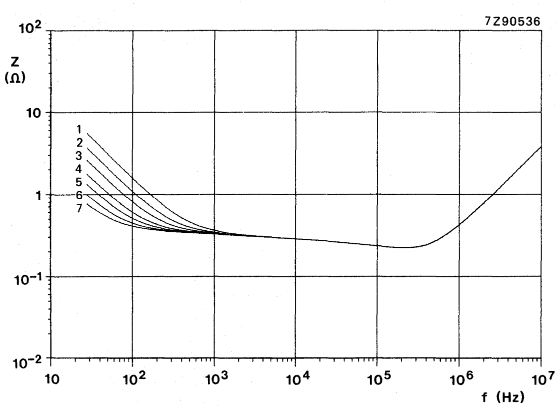


Fig. 59 Typical impedance as a function of frequency at T_{amb} = −55 °C, **case size 05.**

curve 1 = 1000 μF, 63 V;
curve 2 = 1500 μF, 63 V;
curve 3 = 2200 μF, 40 V;
curve 4 = 3300 μF, 25 and 40 V;
curve 5 = 4700 μF, 16 and 25 V;
curve 6 = 6800 μF, 10 and 16 V;
curve 7 = 10 000 μF, 6,3, 10 and 16 V.

Equivalent series inductance (ESL)

Case sizes 3 and 4	typ. 30 nH
Case size 5a	typ. 85 nH
Case size 5	typ. 50 nH
Case sizes 6 and 7	typ. 65 nH
Case sizes 00 and 01	typ. 50 nH
Case size 02	typ. 55 nH
Case sizes 03, 04 and 05	typ. 60 nH

OPERATIONAL DATA

Category temperature range: −55 to + 85 °C

Typical life time	T_{amb} = 85 °C	T_{amb} = 40 °C
case sizes 3 to 7	3000 h	70 000 h
case sizes 00 to 05	5000 h	100 000 h

Shelf life at 0 V and T_{amb} = 85 °C: 500 h

PACKING

All capacitors are supplied in boxes, except case sizes 3 to 7 of style 1, which are on bandoliers in boxes or on reels. The number of capacitors per box or per reel is shown in Table 4.

Table 4

case size	number of capacitors style 1 per reel	style 1 per box	styles 2 and 3 per box
3	1000	1000	1000
5a	500	500	1000
4	1000	1000	1000
5	500	500	1000
6	500	500	1000
7	500	500	500
00		200	200
01		200	200
02		200	200
03		200	200
04		100	100
05		100	100

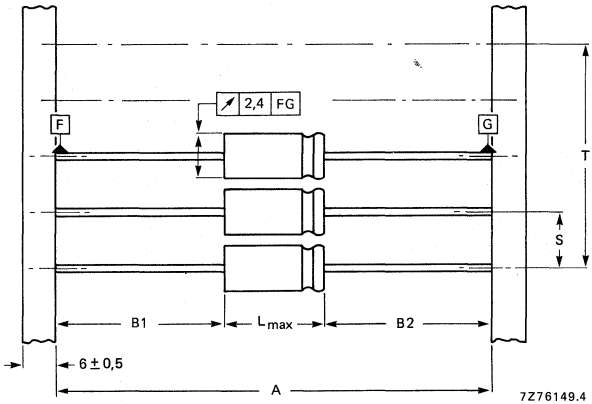


Fig. 60 Style 1 capacitors (case sizes 3 to 7) on bandoliers: the bandolier to which the negative capacitor terminals are connected is blue. See Table 5 for dimensions A, S, T and L_{max}.
$|B1 - B2|$ = max. 1,4 mm.

Table 5

Dimensions in mm

case size	A	S	T for number (n) of capacitors		L_{max}
			$n < 50$	$50 < n < 100$	
3	63,5 ± 1,5	10 ± 0,4	10 (n-1) ± 2	10 (n-1) ± 4	10,5
5a	63,5 ± 1,5	10 ± 0,4	10 (n-1) ± 2	10 (n-1) ± 4	11,5
4	73 ± 1,6	10 ± 0,4	10 (n-1) ± 2	10 (n-1) ± 4	18,5
5	73 ± 1,6	10 ± 0,4	10 (n-1) ± 2	10 (n-1) ± 4	18,5
6	73 ± 1,6	15 ± 0,75	15 (n-1) ± 2	15 (n-1) ± 4	18,5
7	73 ± 1,6	15 ± 0,75	15 (n-1) ± 2	15 (n-1) ± 4	25,0

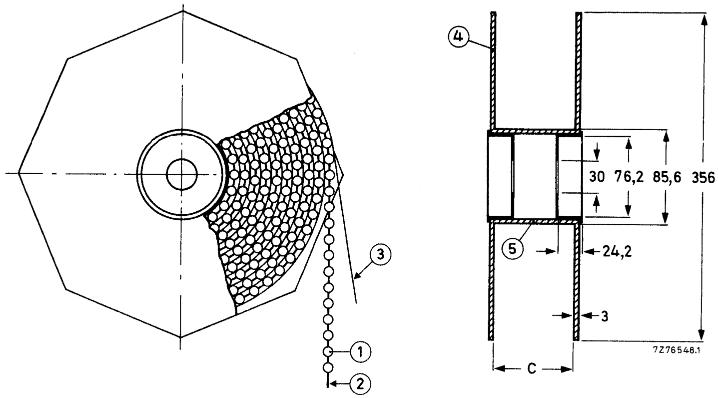


Fig. 61 Style 1 capacitors (case sizes 3 to 7) on bandoliers on reel; dimension C is 83,5 mm for case sizes 3 and 5a, and 88,5 mm for case sizes 4, 5, 6 and 7; the overall width of the reel is 94,5 mm and 99,5 mm respectively.

1 = capacitor
2 = bandolier
3 = paper
4 = flange
5 = cylinder

TESTS AND REQUIREMENTS

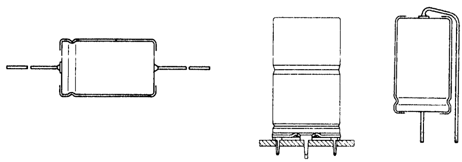
See Introduction, section 9, under aluminium electrolytic capacitors.

After *shelf life test, 500 h, 85 °C,* the capacitors meet the same requirements as after endurance test. The rated voltage shall be applied to the capacitors for minimum 30 min, at least 24 h and not more than 48 h before measurements.

Note: Capacitors 2222 014 are miniature and small types, long-life grade.

ALUMINIUM ELECTROLYTIC CAPACITORS

- Miniature and small types
- Axial leads and single ended
- Very high CU-product per unit volume
- Long life
- General and industrial applications



QUICK REFERENCE DATA

Nominal capacitance range (E6 series):	0,22 to 15 000 μF
Tolerance on nominal capacitance:	± 20%
Rated voltage range, U_R (R5 series):	10 to 100 V
Category temperature range:	−55 to + 85 °C
Endurance test at 85 °C	
case sizes 2 to 7:	1000 h*
case sizes 00 to 05:	2000 h
Shelf life at 0 V, 85 °C:	500 h
Basic specifications	
case sizes 2 to 7:	IEC 384-4, G.P. grade, DIN 41332, type II
case sizes 00 to 05:	IEC 384-4, L.L. grade, DIN 41316
Climatic category	
IEC 68:	55/085/56
DIN 40040:	FPF

case size	nominal dimensions (mm)	
2	Ø 4,5 x 10	miniature
3	Ø 6 x 10	
5a	Ø 8 x 11	
4	Ø 6,5 x 18	
5	Ø 8 x 18	
6	Ø 10 x 18	
7	Ø 10 x 25	
00	Ø 10 x 30	small
01	Ø 12,5 x 30	
02	Ø 15 x 30	
03	Ø 18 x 30	
04	Ø 18 x 40	
05	Ø 21 x 40	

Selection chart for $C_{nom}-U_R$ and relevant case sizes

C_{nom} μF	U_R (V) 10	16	25	40	63	100
0,22					2	
0,33					2	
0,47					2	
0,68					2	
1					2	2
1,5					2	
2,2					2	2
3,3					2	
4,7					2	2
6,8					2	2
10					2	3
15					2	4/5a
22				2	3	4/5a
33					3	4
47			2	3	4/5a	5
68		2			4/5a	6
100	2		3	4/5a	5	7/00
150		3	4/5a	5	6	01
220	3	5a	4	6	7/00	01
330	5a	4	5	7	01	02
470	4	5	6	00	01	03
680	5	6	7/00	01	02	04
1000	6	7/00	01	01	03	05
1500	7/00	01	01	02	04	
2200	01	01	02	03	05	
3300	01	02	03	04		
4700	02	03	04	05		
6800	03	04	05			
10 000	04	05				
15 000	05					

* 2000 h under consideration.

APPLICATION

These capacitors have extremely high CU-product per unit volume, which render them very suitable for applications, where high requirements are imposed on size and mass, e.g. portable and mobile equipment. They are mainly used for smoothing, coupling and decoupling purposes in consumer applications, such as audio and video circuits, and in other applications such as measuring, regulating, timing and delay circuits. The bandoliered version is extremely suitable for automatic insertion and for cutting and forming equipment.

DESCRIPTION

The capacitors have etched and oxidized aluminium foil electrodes rolled up with a paper strip impregnated with an electrolyte. The capacitors are in an aluminium case.
The capacitors are available in 3 styles, all with soldered-copper terminations.

Style 1: axial leads; case insulated with a blue plastic sleeve; all case sizes; case sizes 2 to 7 are supplied on bandoliers.
Style 2: single ended; with mounting ring with printed-wiring pins; especially for use in applications with severe shocks and vibrations; case sizes 02 to 05.
Style 3: single ended; case insulated with a blue plastic sleeve; case sizes 2 to 7 and 00 to 02.

MECHANICAL DATA

Dimensions in mm

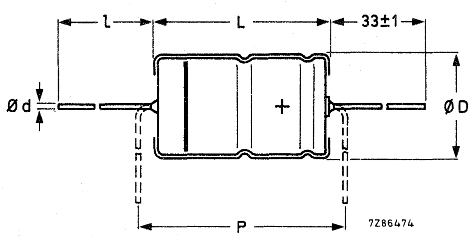


Fig. 1 Style 1; see Table 1a for dimensions d, D, L, l and P.

Table 1a

case size	d	l	style 1 D_{nom}	L_{nom}	D_{max}	L_{max}	P_{min}	mass approx. g
2	0,6	*	4,5	10,0	5,0	10,5	15	0,50
3	0,6	*	6,0	10,0	6,3	10,5	15	0,70
5a	0,6	*	8,0	11,0	8,5	11,5	15	1,1
4	0,8	*	6,5	18,0	6,9	18,5	25	1,3
5	0,8	*	8,0	18,0	8,5	18,5	25	1,7
6	0,8	*	10,0	18,0	10,5	18,5	25	2,5
7	0,8	*	10,0	25,0	10,5	25,0	30	3,3
00	0,8	55 ± 1	10,0	30,0	10,5	30,5	35	4
01	0,8	55 ± 1	12,5	30,0	13,0	30,5	35	6,3
02	0,8	55 ± 1	15,0	30,0	15,5	30,5	35	8,2
03	0,8	55 ± 1	18,0	30,0	18,5	30,5	35	10,9
04	0,8	34 ± 1	18,0	40,0	18,5	41,5	45	14
05	0,8	34 ± 1	21,0	40,0	21,5	41,5	45	19

* Case sizes 2 to 7 are supplied on bandoliers in boxes or on reels (see PACKING).

Table 1b

case size	style 2						mass approx.
	d_1	d_2	D1	$D2_{max}$	D3	L	g
02	0,8	1 + 0,1	15,0	17,5	16,5 ± 0,2	31 ± 1	8,6
03	0,8	1 + 0,1	18,0	19,5	18,5 ± 0,2	31 ± 1	11,5
04	1,0	1,3 + 0,1	18,0	19,5	18,5 ± 0,2	42 ± 1	14,5
05	1,0	1,3 + 0,1	21,0	22,5	21,5 ± 0,2	42 ± 1	19,7

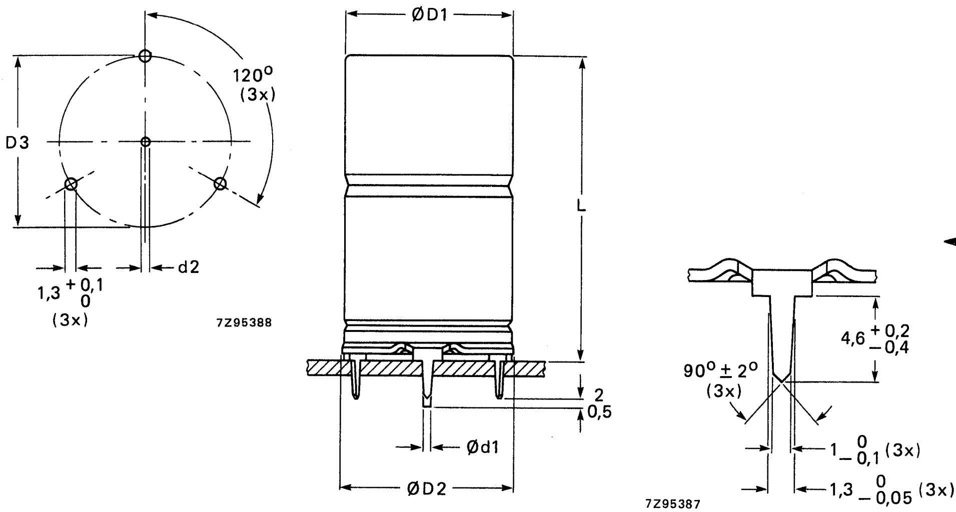


Fig. 2 Style 2; see Table 1b for dimensions d, D1, D2, D3 and L.

Table 1c

case size	style 3				mass approx.
	d	D_{max}	L_{max}	P	g
2	0,6	5,0	12,5	2,5– 5	0,40
3	0,6	6,3	12,5	3,5– 7,5	0,55
5a	0,6	8,5	13,0	5 –10	1,0
4	0,8	6,9	21,5	5 –10	1,2
5	0,8	8,5	21,5	5 –10	1,6
6	0,8	10,5	21,5	7,5–12,5	2,3
7	0,8	10,5	28,0	7,5–12,5	3,1
00	0,8	10,5	34,0	7,5–12,5	3,8
01	0,8	13,0	34,0	7,5–12,5	6,1
02	0,8	15,5	34,0	10,0–15,0	8,0

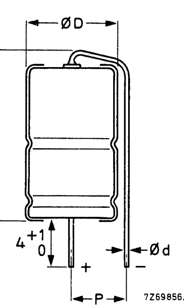


Fig. 3 Style 3; see Table 1c for dimensions d, D, L and P.

Marking

The capacitors are marked with:
- nominal capacitance;
- tolerance on nominal capacitance;
- rated voltage;
- group number; code of origin;
- name of manufacturer;
- date code (year and month) according to IEC 62;
- band to identify the negative terminal;
- + signs to identify the positive terminal (not for case sizes 2, 3 and 5a).

Mounting

The capacitors are suitable for mounting on printed-wiring boards; the required hole diameters are shown in Table 1c.

Table 1d

style	lead/pin diameter	required hole diameter
1 and 3	0,6 mm lead 0,8 mm lead	0,8 + 0,1 mm 1,0 + 0,1 mm
2	0,8 mm anode pin 1,0 mm anode pin cathode pins	1 + 0,1 mm 1,3 + 0,1 mm 1,3 + 0,1 mm

Minimum atmospheric pressure 8,5 kPa

PRODUCT SAFETY

Non-solid electrolytic capacitors may contain chemicals which can be regarded as hazardous if incorrectly handled. Caution is necessary should the outer case be fractured.

ELECTRICAL DATA

Table 2

Unless otherwise specified all electrical values in Table 2 apply at an ambient temperature of 20 to 25 °C, a frequency of 100 Hz, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 45 to 75%. (See also the relevant paragraphs).

U_R V	nom. cap. μF	max. r.m.s. ripple current at T_{amb} = 85 °C mA	max. d.c. leakage current at U_R after 1 min μA	max. tan δ	max. ESR Ω	max. impedance Ω at 10 kHz	max. impedance Ω at 1 kHz	case size	catalogue number* 2222 021 followed by
10	100	65	10	0,20	3,2	2,0		2	. 4101
	220	110	17	0,20	1,5	0,91		3	. 4221
	330	165	24	0,20	1,0	0,61		5a	. 4331
	470	210	32	0,20	0,68	0,43		4	. 4471
	680	285	45	0,20	0,47	0,29		5	. 4681
	1000	400	64	0,20	0,32	0,20		6	. 4102
	1500	530	94	0,23	0,25	0,18		7	**
	1500	570	94	0,23	0,245		0,30	00	. 4152
	2200	740	136	0,25	0,177		0,20	01	. 4222
	3300	920	202	0,27	0,128		0,14	01	. 4332
	4700	1150	288	0,29	0,100		0,096	02	. 4472
	6800	1480	412	0,34	0,079		0,066	03	. 4682
	10000	1840	604	0,40	0,064		0,045	04	. 4103
	15000	2200	904	0,50	0,054		0,040	05	. 4153
16	68	60	11	0,16	3,8	2,4		2	. 5689
	150	100	18	0,16	1,7	1,1		3	. 5151
	220	150	25	0,16	1,2	0,73		5a	. 5221
	330	200	36	0,16	0,77	0,48		4	. 5331
	470	265	49	0,16	0,55	0,34		5	. 5471
	680	365	69	0,16	0,38	0,24		6	. 5681
	1000	510	100	0,16	0,26	0,16		7	**
	1000	530	100	0,16	0,260	0,175		00	. 5102
	1500	680	148	0,19	0,205		0,267	01	. 5152
	2200	880	216	0,21	0,150		0,182	01	. 5222
	3300	1120	321	0,23	0,111		0,121	02	. 5332
	4700	1380	455	0,25	0,087		0,085	03	. 5472
	6800	1760	656	0,30	0,070		0,060	04	. 5682
	10000	2100	964	0,36	0,058		0,042	05	. 5103

* Replace dot in catalogue number by:
1 for style 1, case sizes 00 to 05, supplied in box;
2 for style 1 on bandoliers on reel (preferred for case sizes 2, 3 and 4) } case sizes 2 to 7
3 for style 1 on bandoliers in box (preferred for case sizes 5a, 5, 6 and 7) } case sizes 2 to 7
4 for style 2; case sizes 02 to 05;
8 for style 3; case sizes 2 to 02.

** See Table 3.

Table 2 (continued)

U_R V	nom. cap. µF	max. r.m.s. ripple current at T_{amb} = 85 °C mA	max. d.c. leakage current at U_R after 1 min µA	max. tan δ	max. ESR Ω	max. impedance Ω at 10 kHz	max. impedance Ω at 1 kHz	case size	catalogue number* 2222 021 followed by
25	47	50	11	0,14	4,8	2,6		2	. 6479
	100	90	19	0,14	2,3	1,2		3	. 6101
	150	135	27	0,14	1,5	0,80		5a	**
	150	145	27	0,14	1,5	0,80		4	. 6151
	220	170	37	0,14	1,0	0,55		4	. 6221
	330	240	54	0,14	0,68	0,36		5	. 6331
	470	325	75	0,14	0,48	0,26		6	. 6471
	680	450	106	0,14	0,33	0,18		7	**
	680	480	106	0,14	0,323	0,175		00	. 6681
	1000	630	154	0,14	0,220	0,095		01	. 6102
	1500	780	229	0,17	0,179		0,20	01	. 6152
	2200	1020	334	0,19	0,132		0,136	02	. 6222
	3300	1240	499	0,21	0,099		0,091	03	. 6332
	4700	1650	709	0,23	0,079		0,064	04	. 6472
	6800	2000	1024	0,28	0,064		0,044	05	. 6682
40	22	40	9	0,11	8,0	3,2		2	. 7229
	47	70	15	0,11	3,8	1,5		3	. 7479
	100	120	28	0,11	1,8	0,70		5a	**
	100	130	28	0,11	1,8	0,70		4	. 7101
	150	180	40	0,11	1,1	0,47		5	. 7151
	220	250	57	0,11	0,8	0,32		6	. 7221
	330	350	83	0,11	0,53	0,21		7	. 7331
	470	440	117	0,12	0,404	0,175		00	. 7471
	680	580	167	0,12	0,279	0,095		01	. 7681
	1000	730	244	0,12	0,190	0,095		01	. 7102
	1500	815	364	0,15	0,159		0,160	02	. 7152
	2200	1170	532	0,17	0,118		0,110	03	. 7222
	3300	1500	796	0,19	0,090		0,073	04	. 7332
	4700	1815	1132	0,21	0,072		0,051	05	. 7472

* Replace dot in catalogue number by:
1 for style 1, case sizes 00 to 05, supplied in box;
2 for style 1 on bandoliers on reel (preferred for case sizes 2, 3 and 4) } case sizes 2 to 7
3 for style 1 on bandoliers in box (preferred for case sizes 5a, 5, 6 and 7) } case sizes 2 to 7
4 for style 2; case sizes 02 to 05;
8 for style 3; case sizes 2 to 02.

** See Table 3.

Table 2 (continued)

U_R V	nom. cap. μF	max. r.m.s. ripple current at T_{amb} = 85 °C mA	max. d.c. leakage current at U_R after 1 min μA	max. tan δ	max. ESR Ω	max. impedance Ω at 10 kHz	max. impedance Ω at 1 kHz	case size	catalogue number* 2222 021 followed by
63	0,22	5	4,1	0,09	650	250		2	.8227
	0,33	5	4,1	0,09	440	170		2	.8337
	0,47	8	4,2	0,09	310	120		2	.8477
	0,68	10	4,3	0,09	210	81		2	.8687
	1	12	4,4	0,09	150	55		2	.8108
	1,5	12	4,6	0,09	100	37		2	.8158
	2,2	21	4,8	0,09	65	25		2	.8228
	3,3	25	5,2	0,09	44	17		2	.8338
	4,7	31	5,8	0,09	31	12		2	.8478
	6,8	31	6,6	0,09	21	8,1		2	.8688
	10	35	7,8	0,08	13	5,5		2	.8109
	15	40	9,5	0,08	8,5	3,7		2	.8159
	22	55	12	0,08	5,8	2,5		3	.8229
	33	65	16	0,08	3,9	1,7		3	.8339
	47	100	22	0,08	2,7	1,2		5a	**
	47	105	22	0,08	2,7	1,2		4	.8479
	68	120	30	0,08	1,9	0,81		5a	**
	68	125	30	0,08	1,9	0,81		4	.8689
	100	175	42	0,08	1,3	0,55		5	.8101
	150	245	61	0,08	0,85	0,37		6	.8151
	220	350	88	0,08	0,60	0,25		7	**
	220	350	88	0,08	0,614	0,20		00	.8221
	330	480	129	0,08	0,409	0,14		01	.8331
	470	570	182	0,08	0,287	0,10		01	.8471
	680	770	261	0,08	0,199	0,080		02	.8681
	1000	1035	382	0,08	0,135	0,065		03	.8102
	1500	1330	571	0,11	0,122		0,143	04	.8152
	2200	1740	836	0,13	0,099		0,098	05	.8222

* Replace dot in catalogue number by:
1 for style 1, case sizes 00 to 05, supplied in box;
2 for style 1 on bandoliers on reel (preferred for case sizes 2, 3 and 4) } case sizes 2 to 7
3 for style 1 on bandoliers in box (preferred for case sizes 5a, 5, 6 and 7) } case sizes 2 to 7
4 for style 2; case sizes 02 to 05;
8 for style 3; case sizes 2 to 02.

** See Table 3.

Table 2 (continued)

U_R V	nom. cap. μF	max. r.m.s. ripple current at T_{amb} = 85 °C mA	max. d.c. leakage current at U_R after 1 min μA	max. tan δ	max. ESR Ω	max. impedance Ω at 10 kHz	at 1 kHz	case size	catalogue number* 2222 021 followed by
100	1	14	4,6	0,08	130	90		2	.9108
	2,2	20	5,3	0,08	58	41		2	.9228
	4,7	21	7	0,08	27	19		2	.9478
	6,8	25	8	0,08	19	13		2	.9688
	10	45	10	0,08	13	9		3	.9109
	15	55	13	0,08	8,5	6		5a	**
	15	60	13	0,08	8,5	6		4	.9159
	22	67	17	0,08	5,8	4,1		5a	**
	22	72	17	0,08	5,8	4,1		4	.9229
	33	90	24	0,08	3,9	2,7		4	.9339
	47	120	32	0,08	2,7	1,9		5	.9479
	68	165	45	0,08	1,9	1,3		6	.9689
	100	230	64	0,08	1,3	0,9		7	**
	100	262	64	0,07	1,150	1,0		00	.9101
	150	415	94	0,07	0,645	0,61		01	.9151
	220	454	136	0,08	0,610	0,56		01	.9221
	330	544	202	0,09	0,420	0,40		02	.9331
	470	695	286	0,09	0,310	0,29		03	.9471
	680	971	412	0,09	0,195	0,18		04	.9681
	1000	1161	604	0,10	0,160	0,15		05	.9102

* Replace dot in catalogue number by:
1 for style 1, case sizes 00 to 05, supplied in box;
2 for style 1 on bandoliers on reel (preferred for case sizes 2, 3 and 4) } case sizes 2 to 7
3 for style 1 on bandoliers in box (preferred for case sizes 5a, 5, 6 and 7) } case sizes 2 to 7
4 for style 2; case sizes 02 to 05;
8 for style 3; case sizes 2 to 02.

** See Table 3.

Table 3

U_R V	nom. cap. μF	case size	catalogue number style 1 on reel	style 1 in box	style 3
10	1500	7	2222 021 90524	2222 021 90525	2222 021 90526
16	1000	7	90517	90518	90519
25	150	5a	90534	90535	90536
	680	7	90527	90528	90529
40	100	5a	90537	90538	90539
63	47	5a	90541	90542	90543
	68	5a	90544	90545	90546
	220	7	90511	90512	90513
100	15	5a	90547	90548	90549
	22	5a	90551	90552	90553
	100	7	90531	90532	90533

Capacitance

Nominal capacitance at 100 Hz and T_{amb} = 20 °C	see Table 2
Tolerance on nominal capacitance at 100 Hz	± 20%

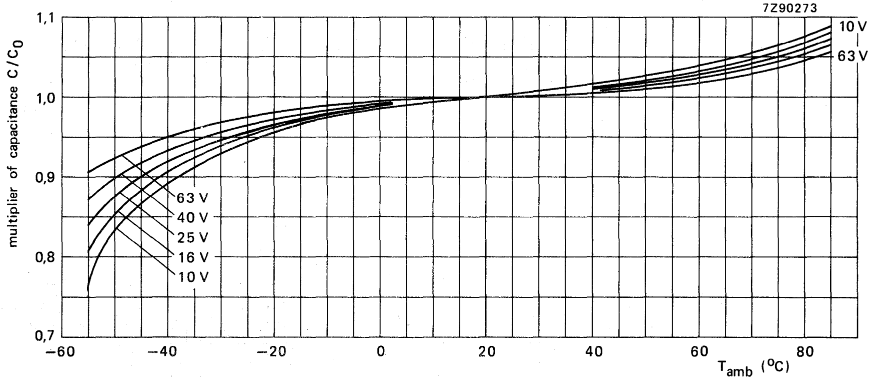


Fig. 4 Multiplier of capacitance as a function of ambient temperature; **case sizes 00 to 05;** C_0 = capacitance at 20 °C, 100 Hz.

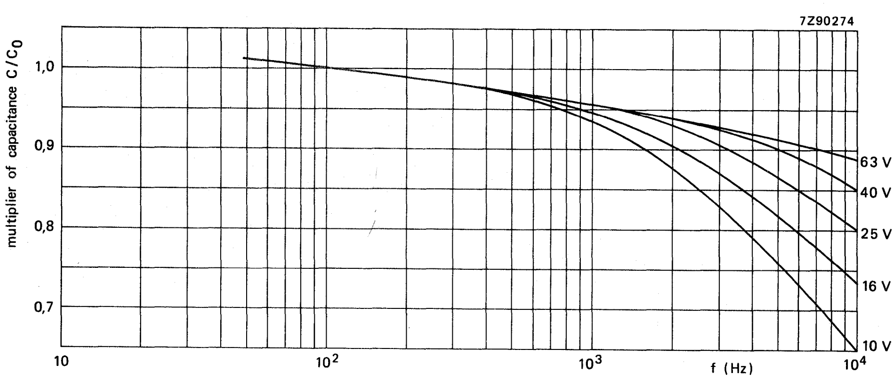


Fig. 5 Multiplier of capacitance as a function of frequency; **case sizes 00 to 05;** C_0 = capacitance at 20 °C; 100 Hz.

Voltage

	core temperature ▲	
	< 60 °C	60 to 90 °C
Rated voltage = max. permissible voltage	1,1 x U_R	U_R
Ripple voltage* = max. permissible a.c. voltage providing the following three conditions are met:		
a) max. (d.c. + peak a.c.) voltage	1,1 x U_R	U_R
b) max. peak a.c. voltage without d.c. voltage applied	2 V	
c) momentary value of applied voltage	between U_R and −2 V	
Surge voltage = max. permissible voltage for short periods	1,2 x U_R	1,15 x U_R
Reverse voltage = max. d.c. voltage applied in the reverse polarity for short periods	2 V	

Ripple current*

Maximum permissible r.m.s. ripple current at 100 Hz and T_{amb} = 85 °C — see Table 2

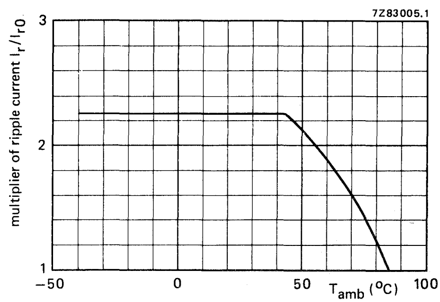


Fig. 6 Multiplier of ripple current as a function of ambient temperature; I_{r0} = ripple current at 85 °C, 100 Hz.

▲ See Introduction, section 5, "Ripple current".

* Ripple voltages are not applicable if the maximum permissible ripple current is exceeded. In that case the ripple current is decisive.

** Ripple currents are not applicable if the maximum permissible ripple voltage is exceeded. In that case the ripple voltage is decisive.

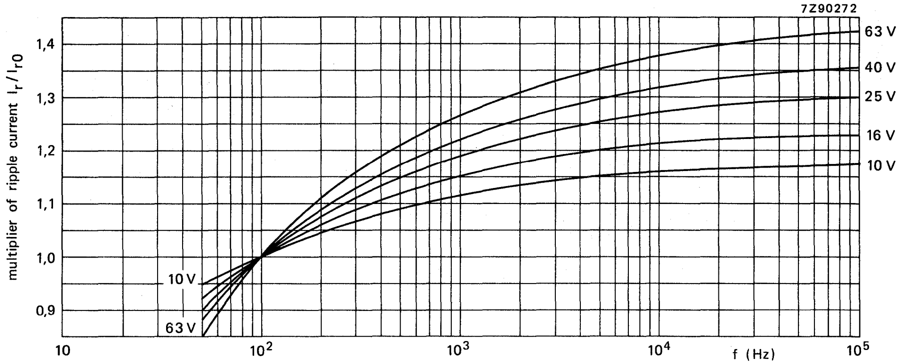


Fig. 7 Multiplier of ripple current as a function of frequency; **case sizes 00 to 05**; I_{r0} = ripple current at 85 °C, 100 Hz.

Non-sinusoidal ripple currents have to be analyzed into a number of sinusoidal currents and the following requirements shall then be satisfied:

$$\sum_n \frac{I_n^2}{r_n} \leqslant I_{r\,max}^2$$

$I_{r\,max}$ = maximum ripple current at 100 Hz and applicable ambient temperature;
I_n = ripple current at a certain frequency;
$\sqrt{r_n} = I_r/I_{r0}$ = multiplying factor at a same frequency.

Charge and discharge current

The capacitors may be charged from a source without internal resistance and they may be discharged by short-circuiting. If the capacitors are charged and discharged continuously at a rate of several times per minute, the charge and discharge currents have to be considered as ripple currents flowing through the capacitors. The r.m.s. value of these currents should be determined and the value thus found must not exceed the applicable limit.

D.C. leakage current

Maximum d.c. leakage current 1 min after application of the rated voltage at T_{amb} = 25 °C	see Table 2 (0,006 CU + 4 μA)
D.C. leakage current during continuous operation at U_R, **case sizes 00 to 05**, at T_{amb} = 25 °C	approx. 0,01 x values stated in Table 2
at T_{amb} = 85 °C	≤ values stated in Table 2

If the d.c. leakage current is too high, owing to prolonged storage and/or storage at an excessive temperature (> 40 °C), application of the rated voltage for some hours will cause the d.c. leakage current to fall to a value lower than specified in Table 2.

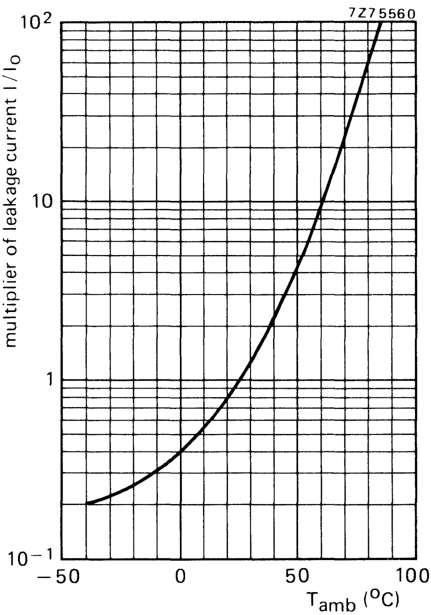


Fig. 8 Multiplier of d.c. leakage current as a function of ambient temperature; **case sizes 00 to 05**; I_0 = d.c. leakage current during continuous operation at 25 °C and U_R.

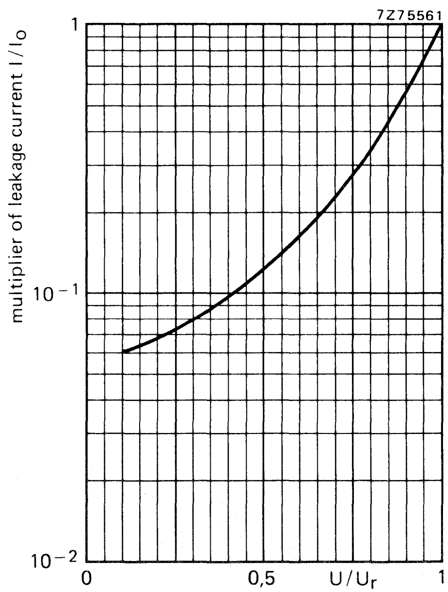


Fig. 9 Multiplier of d.c. leakage current as a function of U/U_R; **case sizes 00 to 05**; I_0 = d.c. leakage current during continuous operation at 25 °C and U_R.

Tan δ (dissipation factor)

Maximum tan δ at 100 Hz and T_{amb} = 25 °C, measured by means of a four-terminal circuit (Thomson circuit) — see Table 2

Equivalent series resistance (ESR)

Maximum ESR at 100 Hz and T_{amb} = 25 °C, measured by means of a four-terminal circuit (Thomson circuit) — see Table 2

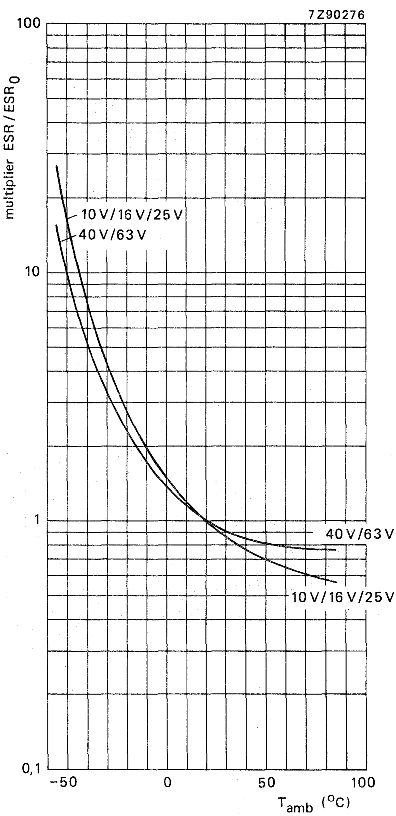


Fig. 10 Multiplier of ESR as a function of ambient temperature, **case sizes 00, 01 and 02;** ESR_0 = typical ESR at 20 °C, 100 Hz.

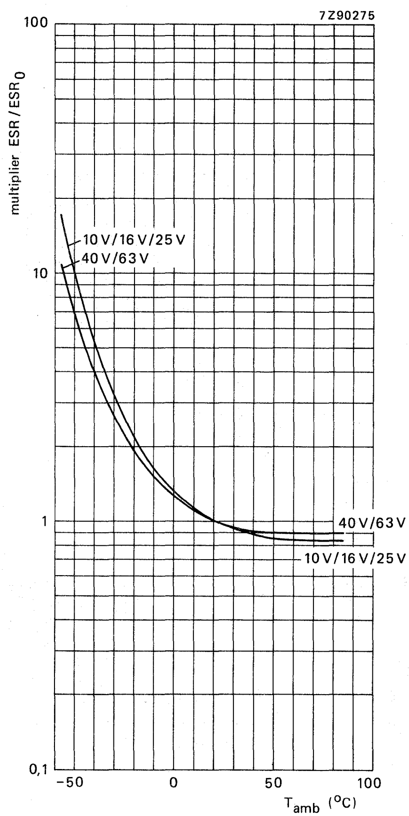


Fig. 11 Multiplier of ESR as a function of ambient temperature, **case sizes 03, 04 and 05;** ESR_0 = typical ESR at 20 °C, 100 Hz.

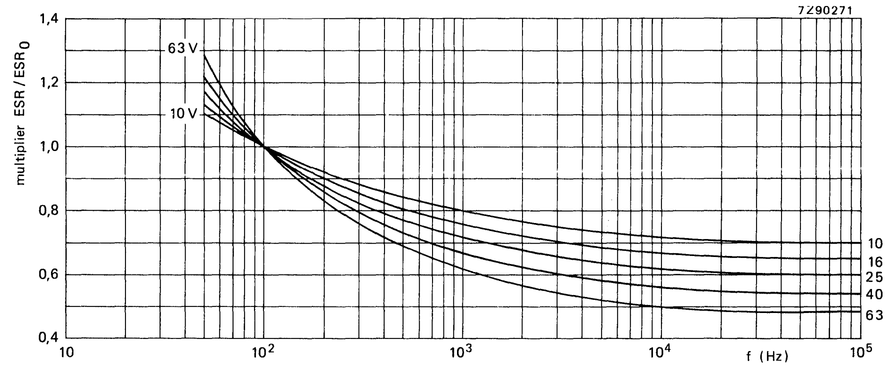


Fig. 12 Multiplier of ESR as a function of frequency; **case sizes 00 to 05**; ESR_0 = typical ESR at 20 °C, 100 Hz.

Impedance

Maximum impedance at T_{amb} = 25 °C and 1 kHz or 10 kHz, measured by means of a four-terminal circuit (Thomson circuit) — see Table 2

$z = Z \times C_{nom}$, at 10 kHz; **case sizes 2 to 7** — see Table 4

Table 4

T_{amb}	$z = Z \times C_{nom}$ (Ω μF) at U_R; at 10 kHz					
	10 V	16 V	25 V	40 V	63 V	100 V
+20 °C	⩽ 200	⩽ 160	⩽ 120	⩽ 70	⩽ 55	⩽ 90
−25 °C	⩽ 1200	⩽ 750	⩽ 560	⩽ 300	⩽ 180	⩽ 600
−40 °C	⩽ 3200	⩽ 2000	⩽ 1500	⩽ 900	⩽ 500	⩽ 1600
−55 °C	typ. 9000	typ. 6500	typ. 5000	typ. 3000	typ. 1500	typ. 5000

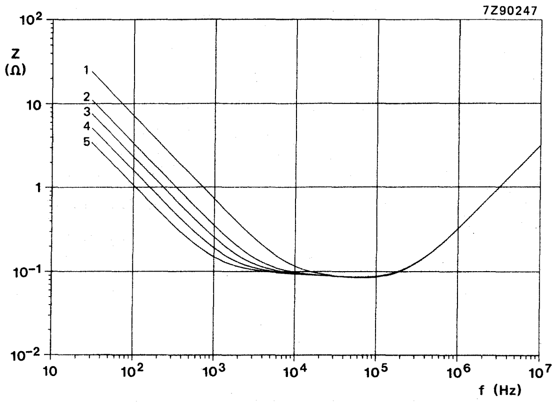


Fig. 13 Typical impedance as a function of frequency at T_{amb} = 20 °C, **case size 00.**

Curve 1 = 220 μF, 63 V;
curve 2 = 470 μF, 40 V;
curve 3 = 680 μF, 25 V;
curve 4 = 1000 μF, 16 V;
curve 5 = 1500 μF, 10 V.

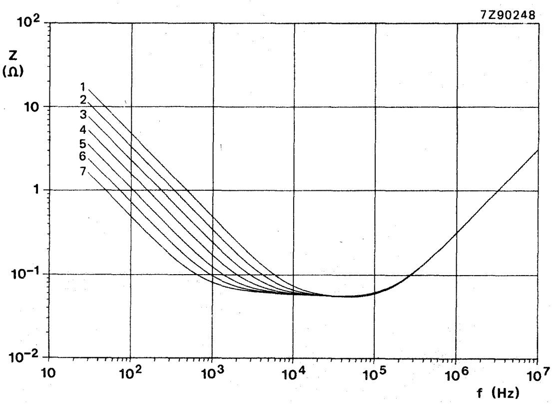


Fig. 14 Typical impedance as a function of frequency at T_{amb} = 20 °C, **case size 01.**

Curve 1 = 330 μF, 63 V;
curve 2 = 470 μF, 63 V;
curve 3 = 680 μF, 40 V;
curve 4 = 1000 μF, 25 V and 40 V;
curve 5 = 1500 μF, 16 V and 25 V;
curve 6 = 2200 μF, 10 V and 16 V;
curve 7 = 3300 μF, 10 V.

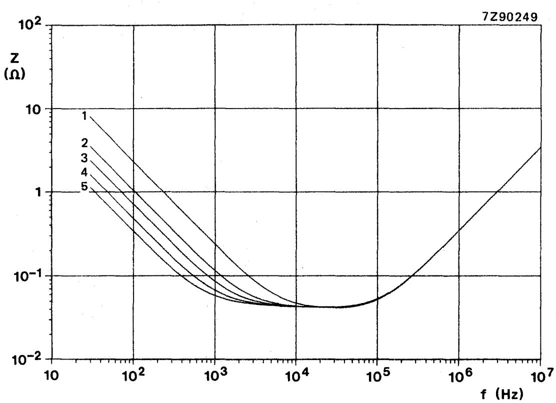


Fig. 15 Typical impedance as a function of frequency at T_{amb} = 20 °C, **case size 02.**

Curve 1 = 680 μF, 63 V;
curve 2 = 1500 μF, 40 V;
curve 3 = 2200 μF, 25 V;
curve 4 = 3300 μF, 16 V;
curve 5 = 4700 μF, 10 V.

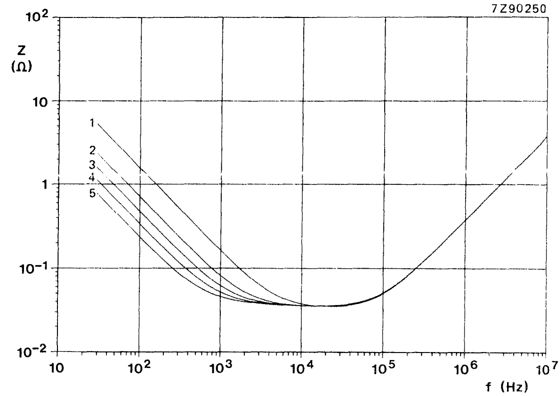


Fig. 16 Typical impedance as a function of frequency at T_{amb} = 20 °C, **case size 03.**

Curve 1 = 1000 μF, 63 V;
curve 2 = 2200 μF, 40 V;
curve 3 = 3300 μF, 25 V;
curve 4 = 4700 μF, 16 V;
curve 5 = 6800 μF, 10 V.

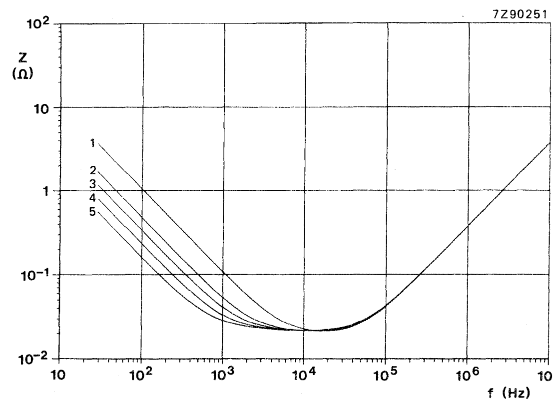


Fig. 17 Typical impedance as a function of frequency at T_{amb} = 20 °C, **case size 04.**

Curve 1 = 1500 μF, 63 V;
curve 2 = 3300 μF, 40 V;
curve 3 = 4700 μF, 25 V;
curve 4 = 6800 μF, 16 V;
curve 5 = 10 000 μF, 10 V.

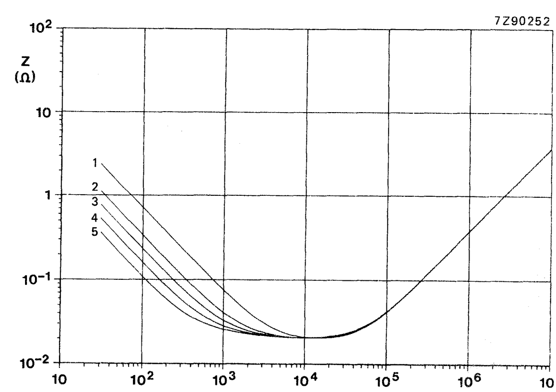


Fig. 18 Typical impedance as a function of frequency at T_{amb} = 20 °C, **case size 05.**

Curve 1 = 2200 μF, 63 V;
curve 2 = 4700 μF, 40 V;
curve 3 = 6800 μF, 25 V;
curve 4 = 10 000 μF, 16 V;
curve 5 = 15 000 μF, 10 V.

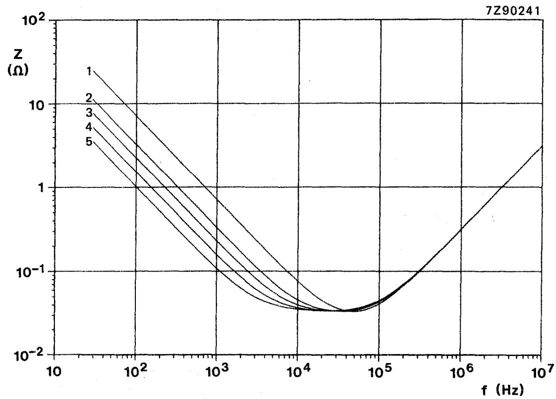


Fig. 19 Typical impedance as a function of frequency at T_{amb} = 85 °C, **case size 00.**
Curve 1 = 220 μF, 63 V;
curve 2 = 470 μF, 40 V;
curve 3 = 680 μF, 25 V;
curve 4 = 1000 μF, 16 V;
curve 5 = 1500 μF, 10 V.

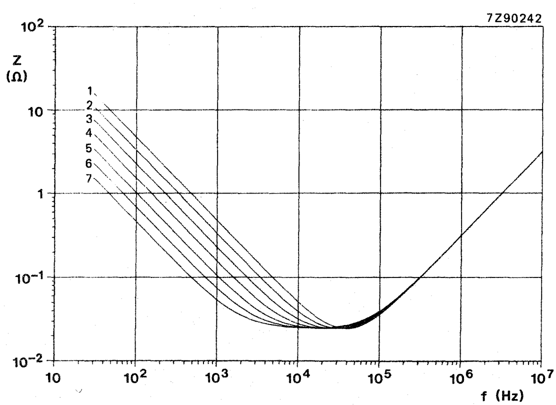


Fig. 20 Typical impedance as a function of frequency at T_{amb} = 85 °C, **case size 01.**
Curve 1 = 330 μF, 63 V;
curve 2 = 470 μF, 63 V;
curve 3 = 680 μF, 40 V;
curve 4 = 1000 μF, 25 V and 40 V;
curve 5 = 1500 μF, 16 V and 25 V;
curve 6 = 2200 μF, 10 V and 16 V;
curve 7 = 3300 μF, 10 V.

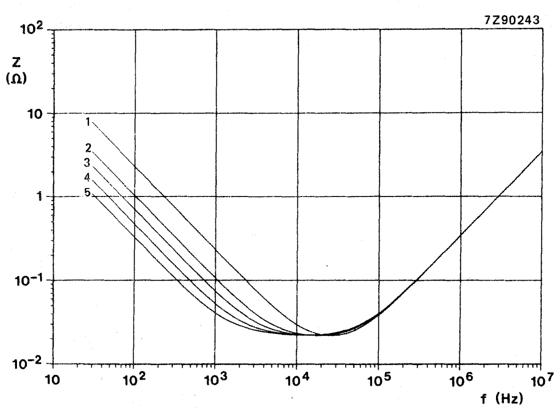


Fig. 21 Typical impedance as a function of frequency at T_{amb} = 85 °C, **case size 02.**
Curve 1 = 680 μF, 63 V;
curve 2 = 1500 μF, 40 V;
curve 3 = 2200 μF, 25 V;
curve 4 = 3300 μF, 16 V;
curve 5 = 4700 μF, 10 V.

Fig. 22 Typical impedance as a function of frequency at T_{amb} = 85 °C, **case size 03.**

Curve 1 = 1000 μF, 63 V;
curve 2 = 2200 μF, 40 V;
curve 3 = 3300 μF, 25 V;
curve 4 = 4700 μF, 16 V;
curve 5 = 6800 μF, 10 V.

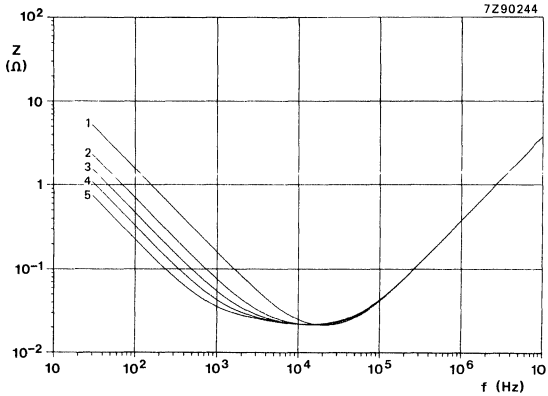


Fig. 23 Typical impedance as a function of frequency at T_{amb} = 85 °C, **case size 04.**

Curve 1 = 1500 μF, 63 V;
curve 2 = 3300 μF, 40 V;
curve 3 = 4700 μF, 25 V;
curve 4 = 6800 μF, 16 V;
curve 5 = 10 000 μF, 10 V.

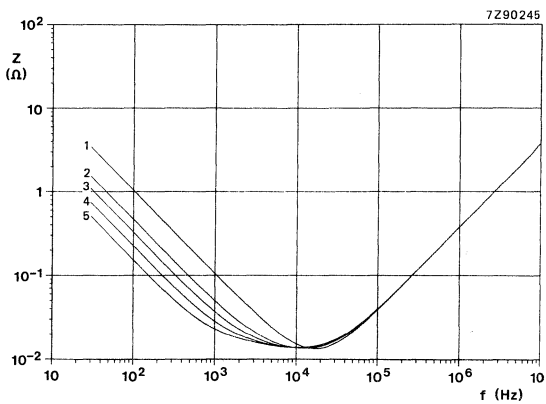
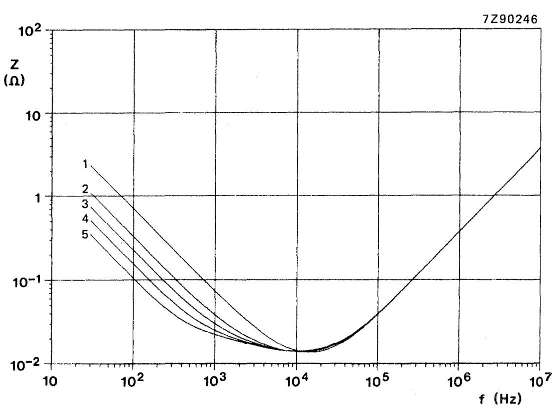


Fig. 24 Typical impedance as a function of frequency at T_{amb} = 85 °C, **case size 05.**

Curve 1 = 2200 μF, 63 V;
curve 2 = 4700 μF, 40 V;
curve 3 = 6800 μF, 25 V;
curve 4 = 10 000 μF, 16 V;
curve 5 = 15 000 μF, 10 V.



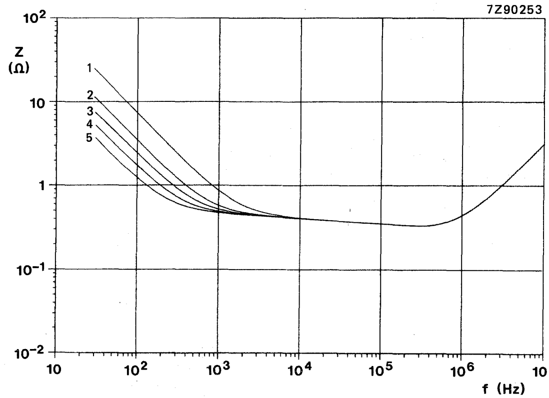


Fig. 25 Typical impedance as a function of frequency at T_{amb} = −25 °C, **case size 00.**
Curve 1 = 220 μF, 63 V;
curve 2 = 470 μF, 40 V;
curve 3 = 680 μF, 25 V;
curve 4 = 1000 μF, 16 V;
curve 5 = 1500 μF, 10 V.

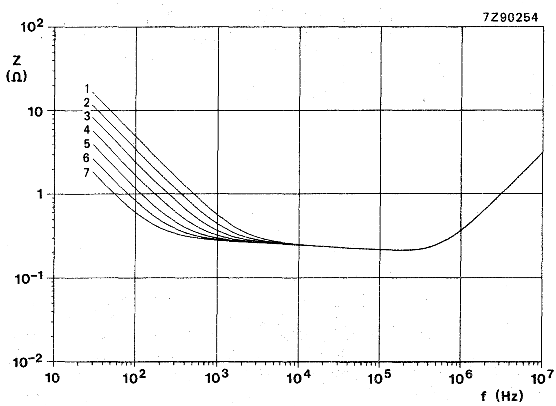


Fig. 26 Typical impedance as a function of frequency at T_{amb} = −25 °C, **case size 01.**
Curve 1 = 330 μF, 63 V;
curve 2 = 470 μF, 63 V;
curve 3 = 680 μF, 40 V;
curve 4 = 1000 μF, 25 V and 40 V;
curve 5 = 1500 μF, 16 V and 25 V;
curve 6 = 2200 μF, 10 V and 16 V;
curve 7 = 3300 μF, 10 V.

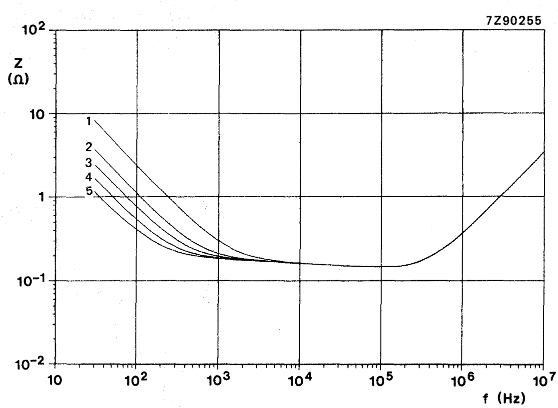


Fig. 27 Typical impedance as a function of frequency at T_{amb} = −25 °C, **case size 02.**
Curve 1 = 680 μF, 63 V;
curve 2 = 1500 μF, 40 V;
curve 3 = 2200 μF, 25 V;
curve 4 = 3300 μF, 16 V;
curve 5 = 4700 μF, 10 V.

Fig. 28 Typical impedance as a function of frequency at T_{amb} = −25 °C, **case size 03.**

Curve 1 = 1000 μF, 63 V;
curve 2 = 2200 μF, 40 V;
curve 3 = 3300 μF, 25 V;
curve 4 = 4700 μF, 16 V;
curve 5 = 6800 μF, 10 V.

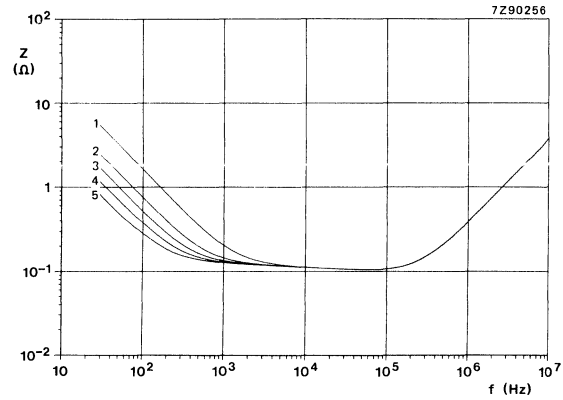


Fig. 29 Typical impedance as a function of frequency at T_{amb} = −25 °C, **case size 04.**

Curve 1 = 1500 μF, 63 V;
curve 2 = 3300 μF, 40 V;
curve 3 = 4700 μF, 25 V;
curve 4 = 6800 μF, 16 V;
curve 5 = 10 000 μF, 10 V.

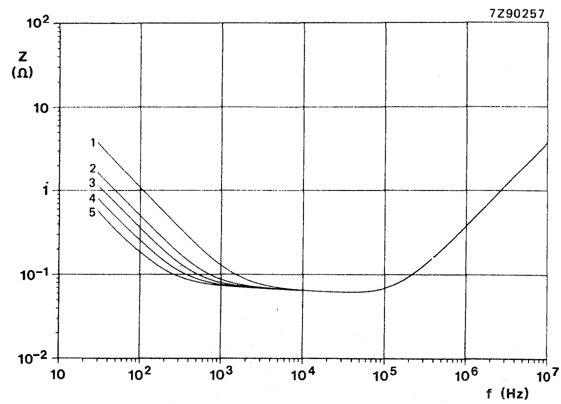
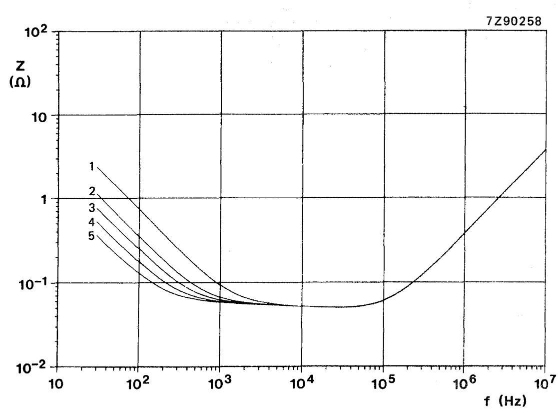


Fig. 30 Typical impedance as a function of frequency at T_{amb} = −25 °C, **case size 05.**

Curve 1 = 2200 μF, 63 V;
curve 2 = 4700 μF, 40 V;
curve 3 = 6800 μF, 25 V;
curve 4 = 10 000 μF, 16 V;
curve 5 = 15 000 μF, 10 V.



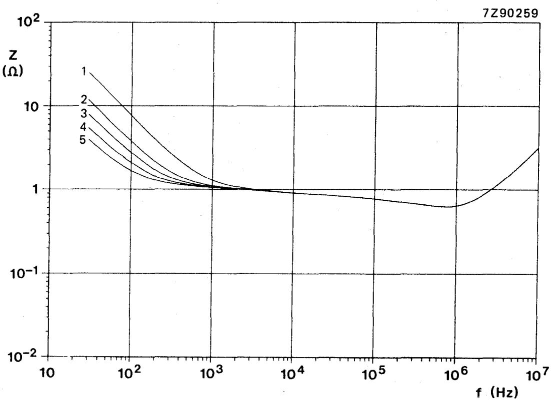


Fig. 31 Typical impedance as a function of frequency at T_{amb} = −40 °C, **case size 00.**

Curve 1 = 220 μF, 63 V;
curve 2 = 470 μF, 40 V;
curve 3 = 680 μF, 25 V;
curve 4 = 1000 μF, 16 V;
curve 5 = 1500 μF, 10 V.

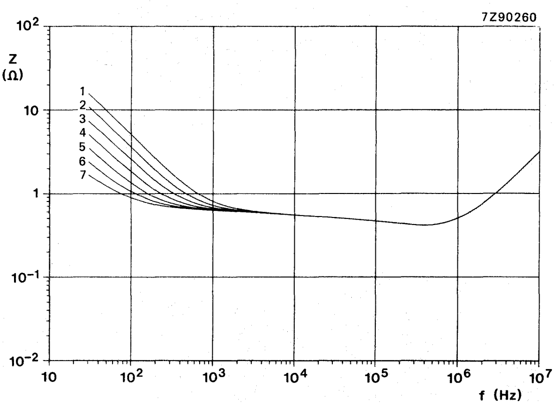


Fig. 32 Typical impedance as a function of frequency at T_{amb} = −40 °C, **case size 01.**

Curve 1 = 330 μF, 63 V;
curve 2 = 470 μF, 63 V;
curve 3 = 680 μF, 40 V;
curve 4 = 1000 μF, 25 V and 40 V;
curve 5 = 1500 μF, 16 V and 25 V;
curve 6 = 2200 μF, 10 V and 16 V;
curve 7 = 3300 μF, 10 V.

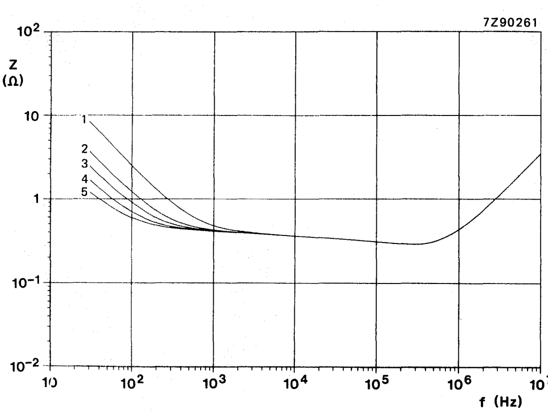


Fig. 33 Typical impedance as a function of frequency at T_{amb} = −40 °C, **case size 02.**

Curve 1 = 680 μF, 63 V;
curve 2 = 1500 μF, 40 V;
curve 3 = 2200 μF, 25 V;
curve 4 = 3300 μF, 16 V;
curve 5 = 4700 μF, 10 V.

Fig. 34 Typical impedance as a function of frequency at T_{amb} = –40 °C, **case size 03.**
Curve 1 = 1000 μF, 63 V;
curve 2 = 2200 μF, 40 V;
curve 3 = 3300 μF, 25 V;
curve 4 = 4700 μF, 16 V;
curve 5 = 6800 μF, 10 V.

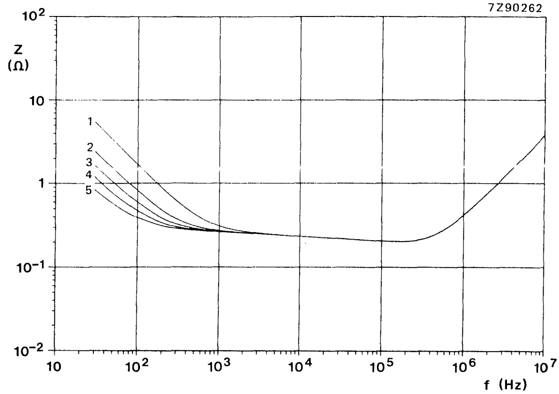


Fig. 35 Typical impedance as a function of frequency at T_{amb} = –40 °C, **case size 04.**
Curve 1 = 1500 μF, 63 V;
curve 2 = 3300 μF, 40 V;
curve 3 = 4700 μF, 25 V;
curve 4 = 6800 μF, 16 V;
curve 5 = 10 000 μF, 10 V.

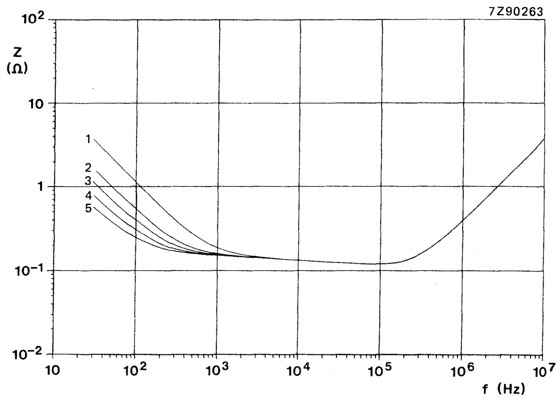
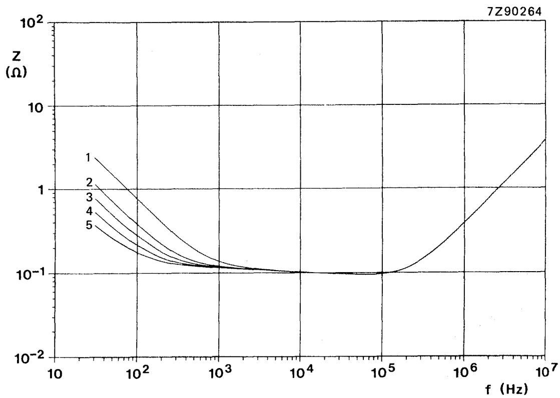


Fig. 36 Typical impedance as a function of frequency at T_{amb} = –40 °C, **case size 05.**
Curve 1 = 2200 μF, 63 V;
curve 2 = 4700 μF, 40 V;
curve 3 = 6800 μF, 25 V;
curve 4 = 10 000 μF, 16 V;
curve 5 = 15 000 μF, 10 V.



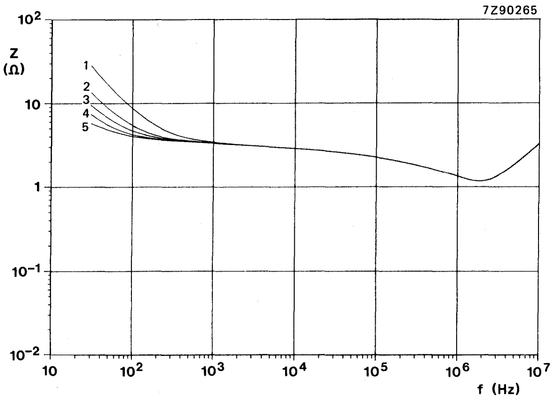


Fig. 37 Typical impedance as a function of frequency at T_{amb} = −55 °C, **case size 00.**

Curve 1 = 220 μF, 63 V;
curve 2 = 470 μF, 40 V;
curve 3 = 680 μF; 25 V;
curve 4 = 1000 μF; 16 V;
curve 5 = 1500 μF; 10 V.

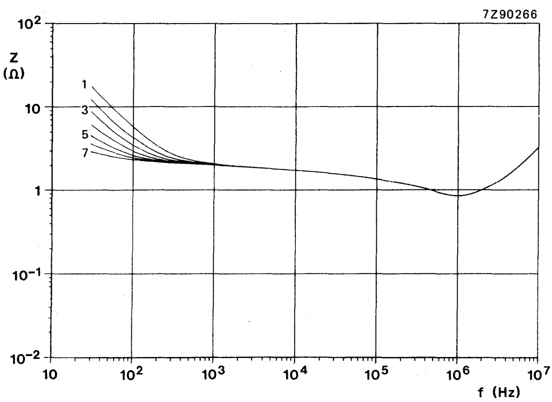


Fig. 38 Typical impedance as a function of frequency at T_{amb} = −55 °C, **case size 01.**

Curve 1 = 330 μF, 63 V;
curve 2 = 470 μF, 63 V;
curve 3 = 680 μF, 40 V;
curve 4 = 1000 μF, 25 V and 40 V;
curve 5 = 1500 μF, 16 V and 25 V;
curve 6 = 2200 μF, 10 V and 16 V;
curve 7 = 3300 μF, 10 V.

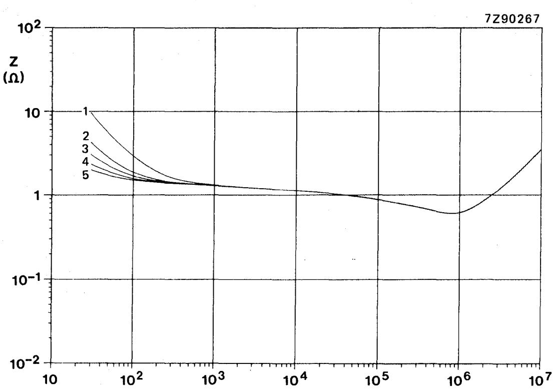


Fig. 39 Typical impedance as a a function of frequency at T_{amb} = −55 °C, **case size 02.**

Curve 1 = 680 μF, 63 V;
curve 2 = 1500 μF, 40 V;
curve 3 = 2200 μF, 25 V;
curve 4 = 3300 μF, 16 V;
curve 5 = 4700 μF, 10 V.

Fig. 40 Typical impedance as a function of frequency at T_{amb} = −55 °C, **case size 03.**
Curve 1 = 1000 μF, 63 V;
curve 2 = 2200 μF, 40 V;
curve 3 = 3300 μF, 25 V;
curve 4 = 4700 μF, 16 V;
curve 5 = 6800 μF, 10 V.

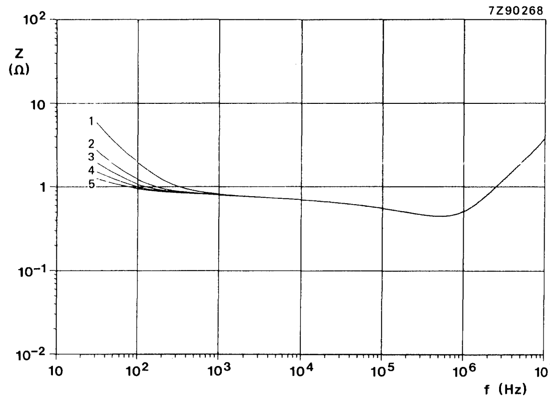


Fig. 41 Typical impedance as a function of frequency at T_{amb} = −55 °C, **case size 04.**
Curve 1 = 1500 μF, 63 V;
curve 2 = 3300 μF, 40 V;
curve 3 = 4700 μF; 25 V;
curve 4 = 6800 μF, 16 V;
curve 5 = 10 000 μF, 10 V.

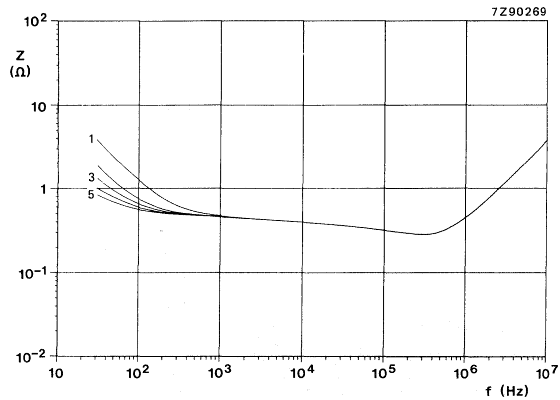
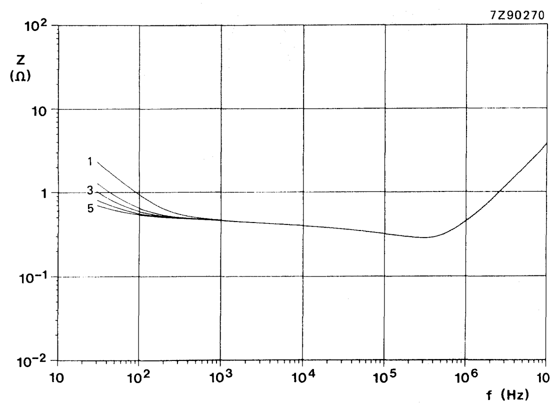


Fig. 42 Typical impedance as a function of frequency at T_{amb} = −55 °C, **case size 05.**
Curve 1 = 2200 μF, 63 V;
curve 2 = 4700 μF, 40 V;
curve 3 = 6800 μF, 25 V;
curve 4 = 10 000 μF, 16 V;
curve 5 = 15 000 μF, 10 V.



Equivalent series inductance (ESL)

Case size 2	typ. 17 nH
Case sizes 3 and 4	typ. 30 nH
Case size 5a	typ. 85 nH
Case size 5	typ. 50 nH
Case sizes 6 and 7	typ. 65 nH
Case sizes 00 and 01	typ. 50 nH
Case size 02	typ. 55 nH
Case sizes 03, 04 and 05	typ. 60 nH

OPERATIONAL DATA

Category temperature range: −55 to + 85 °C

Typical life time	T_{amb} = 85 °C	T_{amb} = 40 °C
case sizes 2 to 7	2000 h	50 000 h
case sizes 00 to 05	5000 h	< 100 000 h

Shelf life at 0 V and T_{amb} = 85 °C: 500 h

PACKING

All capacitors are supplied in boxes, except case sizes 2 to 7 of style 1, which are on bandoliers in boxes or on reels. The number of capacitors per box or per reel is shown in Table 5.

Table 5

case size	number of capacitors		
	style 1 per reel	style 1 per box	styles 2 and 3 per box
2	3000	1000	1000
3	1000	1000	1000
5a	500	500	1000
4	1000	1000	1000
5	500	500	1000
6	500	500	1000
7	500	500	500
00		200	200
01		200	200
02		200	200
03		200	200
04		100	100
05		100	100

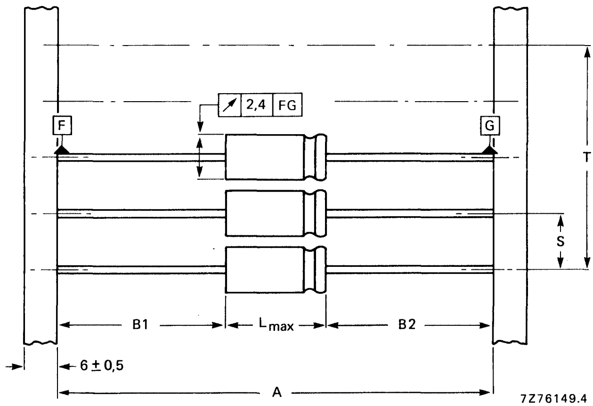


Fig. 43 Style 1 capacitors (case sizes 2 to 7) on bandoliers: the bandolier to which the negative capacitor terminals are connected is blue. See Table 6 for dimensions A, S, T and L_{max}.
$|B1-B2|$ = max. 1,4 mm.

Table 6

Dimensions in mm

case size	A	S	T for number (n) of capacitors		L_{max}
			$n < 50$	$50 < n < 100$	
2	63,5 ± 1,5	5 ± 0,4	5 (n-1) ± 2	5 (n-1) ± 4	10,5
3	63,5 ± 1,5	10 ± 0,4	10 (n-1) ± 2	10 (n-1) ± 4	10,5
5a	63,5 ± 1,5	10 ± 0,4	10 (n-1) ± 2	10 (n-1) ± 4	11,5
4	73 ± 1,6	10 ± 0,4	10 (n-1) ± 2	10 (n-1) ± 4	18,5
5	73 ± 1,6	10 ± 0,4	10 (n-1) ± 2	10 (n-1) ± 4	18,5
6	73 ± 1,6	15 ± 0,75	15 (n-1) ± 2	15 (n-1) ± 4	18,5
7	73 ± 1,6	15 ± 0,75	15 (n-1) ± 2	15 (n-1) ± 4	25,0

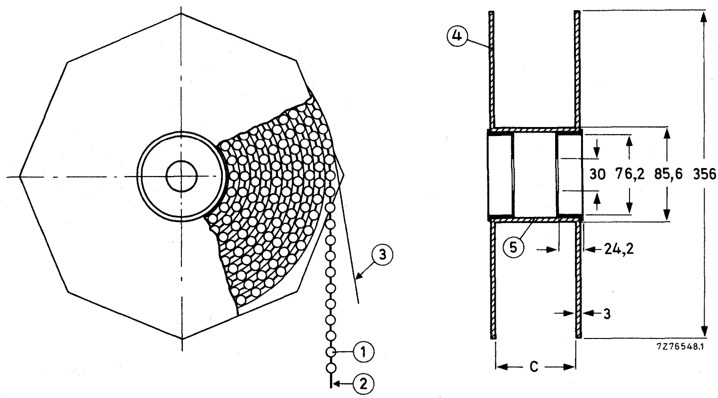


Fig. 44 Style 1 capacitors (case sizes 2 to 7) on bandoliers on reel; dimensions C is 83,5 mm for case sizes 2, 3 and 5a, and 88,5 mm for case sizes 4, 5, 6 and 7; the overall width of the reel is 94,5 mm and 99,5 mm respectively.

1 = capacitor
2 = bandolier
3 = paper
4 = flange
5 = cylinder

TESTS AND REQUIREMENTS

See Introduction, section 9, under aluminium electrolytic capacitors, with the following addition.

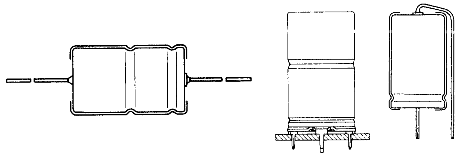
After *shelf life test, 500 h, 85 °C,* the capacitors meet the same requirements as after endurance test, except for d.c. leakage current (case size 2 to 7): ≤ 200% of specified value. The rated voltage shall be applied to the capacitors for minimum 30 min., at least 24 h and not more than 48 h before measurements.

Note:

Capacitors 2222 021 are miniature types, general-purpose grade, and small types, long-life grade.

ALUMINIUM ELECTROLYTIC CAPACITORS

- **Miniature and small types**
- **Axial leads or single ended**
- **Long life**
- **General and industrial applications**



Selection chart for C_{nom}-U_R and relevant case sizes

C_{nom} µF	U_R (V) 6,3	10	16	25	40	63	100	160	250	350	385
0,33						2					
0,47						2					
0,68						2					
1						2	2				4
1,5						2					
2,2					1	2	2		4		5
3,3				1		2	2				
4,7			1			2	3	4	5	6	7
6,8		1			2	2	3			00	00
10	1			2	2	3	4/5a	5	7/00	01	01
15			2		2	3			01	01	02
22		2		2	3	4/5a	5	7/00	01	02	03
33	2		2		3		6	01	02	03	04
47		2		3	4/5a	5	7	02	03	04	04
68	2		3			6	00	02	04	05	05
100		3		4/5a	5	7	01	03	05		
150	3		4/5a	5	6	00	02	04			
220		4/5a	5	6	7/00	01	03	05			
330		5	6	7	01	02	04				
470	5	6	7	00	01	02	05				
680	6	7	00	01	02	03	05				
1 000	7	00	01	02	03	05					
1 500	00	01	02	03	04	05					
2 200	01	02	03	04	05						
3 300	02	03	04	05	05						
4 700	03	04	05	05							
6 800	04	05	05								
10 000	05	05									
15 000	05										
2222 030; 031; 032; 033 see pages 109 to 151								2222 041; 042; 043 see pages 203 to 221			

Miniature types

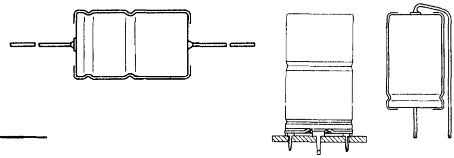
case size	nominal dimensions mm	series number
1	Ø 3,3 x 11	030
2	Ø 4,5 x 10	030
3	Ø 6 x 10	030
5a	Ø 8 x 11	030
4	Ø 6,5 x 18	031 041
5	Ø 8 x 18	031 041
6	Ø 10 x 18	031 041
7	Ø 10 x 25	031 041

Small types

case size	nominal dimensions mm	series number
00	Ø 10 x 30	032 042
01	Ø 12,5 x 30	032 042
02	Ø 15 x 30	032 042
03	Ø 18 x 30	032 042
04	Ø 18 x 40	033 043
05	Ø 21 x 40	033 043

ALUMINIUM ELECTROLYTIC CAPACITORS

- **Miniature and small types**
- **Axial leads and single ended**
- **Long life**
- **General and industrial applications**



QUICK REFERENCE DATA

Nominal capacitance range (E6 series):	0,33 to 15 000 μF
Tolerance on nominal capacitance:	−10 to +50%
Rated voltage range, U_R (R5 series):	6,3 to 100 V
Category temperature range:	
case sizes 1 to 7	−55 to +85 °C
case sizes 00 to 05	−40 to +85 °C
Endurance test at 85 °C	
case size 1:	1000 h
case sizes 2 to 7:	2000 h
case sizes 00 to 05:	5000 h
Shelf life at 0 V; 85 °C:	500 h
Basic specifications:	
IEC 384-4, long-life grade*	
DIN 41316 (6,3 to 63 V versions)	
DIN 41332 (100 V version)	
Climatic category	
IEC 68, case sizes 1 to 7:	55/085/56
case sizes 00 to 05:	40/085/56
DIN 40040, case sizes 1 to 7:	FPF
case sizes 00 to 05:	GPF

case size	nominal dimensions (mm)	series number	
1	Ø 3,3 x 11	030	miniature
2	Ø 4,5 x 10		
3	Ø 6 x 10		
5a	Ø 8 x 11		
4	Ø 6,5 x 18	031	
5	Ø 8 x 18		
6	Ø 10 x 18		
7	Ø 10 x 25		
00	Ø 10 x 30	032	small
01	Ø 12,5 x 30		
02	Ø 15 x 30		
03	Ø 18 x 30		
04	Ø 18 x 40	033	
05	Ø 21 x 40		

* Not applicable to case size 1, which is general-purpose grade.

Selection chart for C_{nom}-U_R and relevant case sizes.

C_{nom} μF	U_R (V) 6,3	10	16	25	40	63	100
0,33						2	
0,47						2	
0,68						2	
1						2	2
1,5						2	
2,2					1	2	2
3,3				1		2	2
4,7			1			2	3
6,8		1			2	2	3
10	1			2	2	3	4/5a
15			2		2	3	
22		2		2	3	4/5a	5
33	2		2		3		6
47		2		3	4/5a	5	7
68	2		3			6	00
100		3		4/5a	5	7	01
150	3		4/5a	5	6	00	02
220		4/5a	5	6	7/00	01	03
330		5	6	7	01	02	04
470	5	6	7	00	01	02	05
680	6	7	00	01	02	03	05
1 000	7	00	01	02	03	05	
1 500	00	01	02	03	04	05	
2 200	01	02	03	04	05		
3 300	02	03	04	05	05		
4 700	03	04	05	05			
6 800	04	05	05				
10 000	05	05					
15 000	05						

APPLICATION

These capacitors with high CU-product per unit volume are mainly used for smoothing, coupling and decoupling purposes in consumer applications, such as audio and television circuits, and in industrial applications, such as measuring and regulating circuits. Other applications are in timing and delay circuits. The taped versions are extremely suitable for automatic insertion and for cutting and forming equipment.

DESCRIPTION

The capacitors have etched and oxidized aluminium foil electrodes rolled up with a paper strip impregnated with an electrolyte. The capacitors are in an aluminium case, which is insulated with a blue plastic sleeve.

The capacitors are available in 3 styles, all with soldered-copper leads.

Style 1: axial leads; all case sizes; case sizes 1 to 7 are supplied on bandoliers.
Style 2: single ended; with mounting ring with printed-wiring pins; especially for use in applications with severe shocks and vibrations; case sizes 02 to 05.
Style 3: single ended; case sizes 1 to 7 and 00 to 02.

MECHANICAL DATA

Dimensions in mm

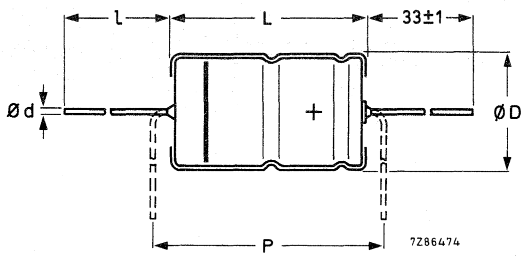


Fig. 1 Style 1; see Table 1a for dimensions d, D, L, l and P.

Table 1a

case size	d	l	style 1					mass approx. g
			D_{nom}	L_{nom}	D_{max}	L_{max}	P_{min}	
1	0,6	*	3,3	11,0	3,5	12,0	15	0,35
2	0,6	*	4,5	10,0	5,0	10,5	15	0,50
3	0,6	*	6,0	10,0	6,3	10,5	15	0,70
5a	0,6	*	8,0	11,0	8,5	11,5	15	1,1
4	0,8	*	6,5	18,0	6,9	18,5	25	1,3
5	0,8	*	8,0	18,0	8,5	18,5	25	1,7
6	0,8	*	10,0	18,0	10,5	18,5	25	2,5
7	0,8	*	10,0	25,0	10,5	25,0	30	3,3
00	0,8	55 ± 1	10,0	30,0	10,5	30,5	35,0	4
01	0,8	55 ± 1	12,5	30,0	13,0	30,5	35,0	6,3
02	0,8	55 ± 1	15,0	30,0	15,5	30,5	35,0	8,2
03	0,8	55 ± 1	18,0	30,0	18,5	30,5	35,0	10,9
04	0,8	34 ± 1	18,0	40,0	18,5	41,5	45,0	14
05	0,8	34 ± 1	21,0	40,0	21,5	41,5	45,0	19

* Case sizes 1 to 7 are supplied on bandoliers in boxes or on reels (see PACKING).

Table 1b

case size	style 2						mass approx.
	d_1	d_2	D1	$D2_{max}$	D3	L	g
02	0,8	1 + 0,1	15,0	17,5	16,5 ± 0,2	31 ± 1	8,6
03	0,8	1 + 0,1	18,0	19,5	18,5 ± 0,2	31 ± 1	11,5
04	1,0	1,3 + 0,1	18,0	19,5	18,5 ± 0,2	42 ± 1	14,5
05	1,0	1,3 + 0,1	21,0	22,5	21,5 ± 0,2	42 ± 1	19,7

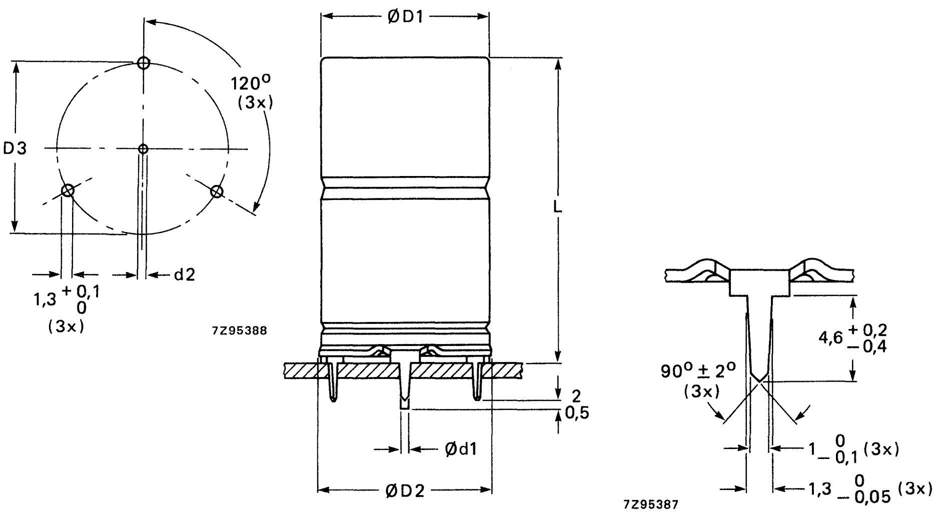


Fig. 2 Style 2; see Table 1b for dimensions d_1, d_2, D1, D2, D3 and L.

Table 1c

case size	d	style 3			mass approx.
		D_{max}	L_{max}	P	g
1	0,6	3,5	14,0	2,5– 5	0,25
2	0,6	5,0	12,5	2,5– 5	0,40
3	0,6	6,3	12,5	3,5– 7,5	0,55
5a	0,6	8,5	13,0	5 –10	1,0
4	0,8	6,9	21,5	5 –10	1,2
5	0,8	8,5	21,5	5 –10	1,6
6	0,8	10,5	21,5	7,5–12,5	2,3
7	0,8	10,5	28,0	7,5–12,5	3,1
00	0,8	10,5	34,0	7,5–12,5	3,8
01	0,8	13,0	34,0	7,5–12,5	6,1
02	0,8	15,5	34,0	10,0–15,0	8,0

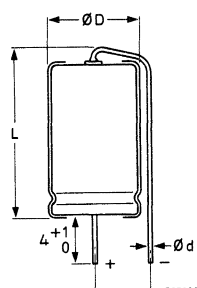


Fig. 3 Style 3 see Table 1c for dimensions d, D, L and P.

Marking

The capacitors are marked with:
- nominal capacitance;
- tolerance on nominal capacitance (not for case size 1);
- rated voltage;
- group number; code of origin;
- name of manufacturer;
- date code (year and month) according to IEC 62;
- band to identify the negative terminal;
- + signs to identify the positive terminal (not for case sizes 1 to 5a).

Mounting

The capacitors are suitable for mounting on printed-wiring boards; the required hole diameters are shown in Table 1d.

Table 1d

style	lead/pin diameter	required hole diameter
1 and 3	0,6 mm lead 0,8 mm lead	0,8 + 0,1 mm 1,0 + 0,1 mm
2	0,8 mm anode pin 1,0 mm anode pin cathode pins	1 + 0,1 mm 1,3 + 0,1 mm 1,3 + 0,1 mm

Minimum atmospheric pressure 8,5 kPa

PRODUCT SAFETY

Non-solid electrolytic capacitors may contain chemicals which can be regarded as hazardous if incorrectly handled. Caution is necessary should the outer case be fractured.

ELECTRICAL DATA

Table 2

Unless otherwise specified all electrical values in Table 2 apply at an ambient temperature of 20 to 25 °C, a frequency of 100 Hz, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 45 to 75%.

U_R	nom. cap.	max. r.m.s. ripple current at 85 °C	max. d.c. leakage current at U_R after 1 min.	max. tan δ	max. ESR	max. impedance Ω		case size	catalogue number * 2222 followed by
V	μF	mA	μA		Ω	at 10 kHz	at 1 kHz		
6,3	10	14	5	0,30	47,8	20		1	030 .3109
6,3	33	42	11	0,25	12,1	6,1		2	030 .3339
6,3	68	53	22	0,25	5,86	2,9		2	030 .3689
6,3	150	87	10	0,25	2,66	1,3		3	030 .3151
6,3	470	220	22	0,25	0,85	0,43		5	031 .3471
6,3	680	350	30	0,25	0,59	0,29		6	031 .3681
6,3	1000	480	42	0,25	0,40	0,20		7	031 .3102
6,3	1500	450	61	0,28	0,30		0,23	00	032 .3152
6,3	2200	610	88	0,29	0,21		0,16	01	032 .3222
6,3	3300	790	129	0,32	0,15		0,11	02	032 .3332
6,3	4700	1000	182	0,34	0,12		0,07	03	032 .3472
6,3	6800	1280	261	0,39	0,09		0,05	04	033 .3682
6,3	10000	1570	382	0,45	0,07		0,05	05	033 .3103
6,3	15000	1600	571	0,67	0,07		0,05	05	033 .3153
10	6,8	14	5	0,25	58,6	24		1	030 .4688
10	22	42	11	0,20	14,5	7,3		2	030 .4229
10	47	53	24	0,20	6,78	3,4		2	030 .4479
10	100	87	10	0,20	3,19	1,6		3	030 .4101
10	220	150	18	0,20	1,45	0,73		5a	030 .4221
10	220	150	18	0,20	1,45	0,73		4	031 .4221
10	330	220	24	0,20	0,97	0,48		5	031 .4331
10	470	350	33	0,20	0,68	0,34		6	031 .4471
10	680	480	45	0,20	0,47	0,24		7	031 .4681
10	1000	430	64	0,20	0,32	0,20		00	032 .4102
10	1500	570	94	0,23	0,25		0,20	01	032 .4152
10	2200	740	136	0,24	0,18		0,14	02	032 .4222
10	3300	950	202	0,27	0,13		0,09	03	032 .4332
10	4700	1220	286	0,29	0,10		0,06	04	033 .4472
10	6800	1500	412	0,34	0,08		0,04	05	033 .4682
10	10000	1520	604	0,49	0,08		0,05	05	033 .4103

* Replace dot in catalogue number by:
1 for style 1, case sizes 00 to 05, supplied in box;
2 for style 1 on bandoliers on reel (preferred for case sizes 1 to 4) } case sizes 1 to 7
3 for style 1 on bandoliers in box (preferred for case sizes 5a to 7) } case sizes 1 to 7
4 for style 2, case sizes 02 to 05;
8 for style 3, case sizes 1 to 02.

U_R V	nom. cap. µF	max. r.m.s. ripple current at 85 °C mA	max. d.c. leakage current at U_R after 1 min. µA	max. tan δ	max. ESR Ω	max. impedance Ω at 10 kHz	max. impedance Ω at 1 kHz	case size	catalogue number * 2222 followed by
16	4,7	14	5	0,20	67,8	26		1	030 .5478
16	15	42	12	0,16	17,0	8		2	030 .5159
16	33	53	27	0,16	7,72	3,6		2	030 .5339
16	68	87	11	0,16	3,75	1,8		3	030 .5689
16	150	150	19	0,16	1,70	0,80		5a	030 .5151
16	150	150	19	0,16	1,70	0,80		4	031 .5151
16	220	220	26	0,16	1,16	0,55		5	031 .5221
16	330	350	36	0,16	0,78	0,36		6	031 .5331
16	470	480	49	0,16	0,55	0,26		7	031 .5471
16	680	400	70	0,16	0,38	0,18		00	032 .5681
16	1000	550	100	0,16	0,26	0,12		01	032 .5102
16	1500	680	148	0,19	0,21		0,17	02	032 .5152
16	2200	880	216	0,20	0,15		0,13	03	032 .5222
16	3300	1160	321	0,23	0,11		0,08	04	033 .5332
16	4700	1430	455	0,25	0,09		0,06	05	033 .5472
16	6800	1460	657	0,36	0,08		0,06	05	033 .5682
25	3,3	13	5	0,18	86,9	27		1	030 .6338
25	10	36	13	0,14	22,3	9		2	030 .6109
25	22	43	28	0,14	10,2	4,1		2	030 .6229
25	47	83	12	0,14	4,80	1,9		3	030 .6479
25	100	120	19	0,14	2,23	0,90		5a	030 .6101
25	100	120	19	0,14	2,23	0,90		4	031 .6101
25	150	190	27	0,14	1,49	0,60		5	031 .6151
25	220	280	37	0,14	1,02	0,41		6	031 .6221
25	330	350	54	0,14	0,68	0,27		7	031 .6331
25	470	360	75	0,14	0,47	0,19		00	032 .6471
25	680	500	106	0,14	0,32	0,13		01	032 .6681
25	1000	660	154	0,14	0,22	0,09		02	032 .6102
25	1500	810	229	0,17	0,18		0,15	03	032 .6152
25	2200	1060	334	0,18	0,13		0,10	04	033 .6222
25	3300	1340	499	0,21	0,10		0,07	05	033 .6332
25	4700	1370	709	0,28	0,10		0,06	05	033 .6472

* Replace dot in catalogue number by:
1 for style 1, case sizes 00 to 05, supplied in box;
2 for style 1 on bandoliers on reel (preferred for case sizes 1 to 4) } case sizes 1 to 7
3 for style 1 on bandoliers in box (preferred for case sizes 5a to 7) } case sizes 1 to 7
→ 4 for style 2, case sizes 02 to 05;
8 for style 3, case sizes 1 to 02.

U_R V	nom. cap. µF	max. r.m.s. ripple current at 85 °C mA	max. d.c. leakage current at U_R after 1 min. µA	max. tan δ	max. ESR Ω	max. impedance Ω at 10 kHz	max. impedance Ω at 1 kHz	case size	catalogue number * 2222 followed by
40	2,2	13	5	0,15	109	32		1	030 .7228
40	6,8	36	14	0,11	25,8	10		2	030 .7688
40	10	38	20	0,11	17,6	7		2	030 .7109
40	15	43	30	0,11	11,7	4,7		2	030 .7159
40	22	61	9	0,11	8,0	3,2		3	030 .7229
40	33	83	12	0,11	5,31	2,1		3	030 .7339
40	47	120	16	0,11	3,73	1,5		5a	030 .7479
40	47	120	16	0,11	3,73	1,5		4	031 .7479
40	100	190	28	0,11	1,75	0,70		5	031 .7101
40	150	280	40	0,11	1,17	0,47		6	031 .7151
40	220	430	57	0,11	0,80	0,32		7	031 .7221
40	220	260	57	0,12	0,86	0,32		00	032 .7221
40	330	370	84	0,12	0,58	0,21		01	032 .7331
40	470	440	117	0,12	0,40	0,15		01	032 .7471
40	680	580	167	0,12	0,28	0,10		02	032 .7681
40	1000	780	244	0,12	0,19	0,07		03	032 .7102
40	1500	970	364	0,15	0,16		0,13	04	033 .7152
40	2200	1220	532	0,16	0,12		0,09	05	033 .7222
40	3300	1284	796	0,24	0,11		0,07	05	033 .7332
63	0,33	5	5	0,09	435	167		2	030 .8337
63	0,47	8	5	0,09	305	117		2	030 .8477
63	0,68	10	5	0,09	211	81		2	030 .8687
63	1,0	12	5	0,09	143	55		2	030 .8108
63	1,5	12	5	0,09	95,6	37		2	030 .8158
63	2,2	21	7	0,09	65,2	25		2	030 .8228
63	3,3	25	11	0,09	46,5	17		2	030 .8338
63	4,7	31	15	0,09	30,5	12		2	030 .8478
63	6,8	35	22	0,09	21,1	8,1		2	030 .8688
63	10	51	7	0,08	12,8	5,5		3	030 .8109
63	15	61	10	0,08	8,5	3,7		3	030 .8159
63	22	90	13	0,08	5,79	2,5		5a	030 .8229
63	22	90	13	0,08	5,79	2,5		4	031 .8229
63	47	120	22	0,08	2,71	1,2		5	031 .8479
63	68	200	30	0,08	1,88	0,81		6	031 .8689
63	100	260	42	0,08	1,28	0,55		7	031 .8101
63	150	260	61	0,08	0,90	0,37		00	032 .8151
63	220	350	88	0,08	0,61	0,25		01	032 .8221
63	330	480	129	0,08	0,41	0,17		02	032 .8331
63	470	570	182	0,08	0,29	0,15		02	032 .8471
63	680	770	261	0,08	0,20	0,08		03	032 .8681
63	1000	1140	382	0,08	0,14	0,06		05	033 .8102
63	1500	1110	571	0,12	0,15		0,15	05	033 .8152

* See footnote on the opposite page.

U_R V	nom. cap. µF	max. r.m.s. ripple current at 85 °C mA	max. d.c. leakage current at U_R after 1 min. µA	max. tan δ	max. ESR Ω	max. impedance Ω at 10 kHz	max. impedance Ω at 1 kHz	case size	catalogue number * 2222 followed by
100	1,0	14	5	0,08	128	45		2	030 .9108
100	2,2	25	11	0,08	57,9	21		2	030 .9228
100	3,3	35	17	0,08	38,6	14		2	030 .9338
100	4,7	38	22	0,07	23,7	9,6		3	030 .9478
100	6,8	61	34	0,07	16,4	6,6		3	030 .9688
100	10	90	50	0,07	11,2	4,5		5a	030 .9109
100	10	90	50	0,07	11,2	4,5		4	031 .9109
100	22	120	80	0,07	5,07	2,1		5	031 .9229
100	33	200	119	0,07	3,38	1,4		6	031 .9339
100	47	260	33	0,07	2,37	0,96		7	031 .9479
100	68	130	45	0,15	3,53	2,0		00	032 .9689
100	100	190	64	0,15	2,40	1,2		01	032 .9101
100	150	250	94	0,15	1,60	0,85		02	032 .9151
100	220	330	136	0,15	1,09	0,60		03	032 .9221
100	330	460	202	0,15	0,73	0,50		04	033 .9331
100	470	600	286	0,15	0,51	0,35		05	033 .9471
100	680	650	412	0,15	0,42	0,35		05	033 .9681

* Replace dot in catalogue number by:
1 for style 1, case sizes 00 to 05, supplied in box;
2 for style 1 on bandoliers on reel (preferred for case sizes 1 to 4) } case sizes 1 to 7
3 for style 1 on bandoliers in box (preferred for case sizes 5a to 7) } case sizes 1 to 7
→ 4 for style 2, case sizes 02 to 05;
8 for style 3, case sizes 1 to 02.

Capacitance

Nominal capacitance at 100 Hz and T_{amb} = 20 °C	see Table 2
Tolerance on nominal capacitance at 100 Hz	−10 to +50%

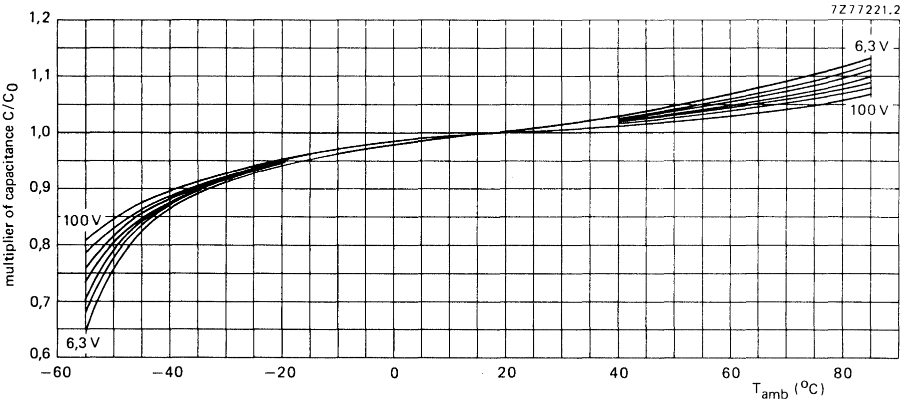


Fig. 4 Multiplier of capacitance as a function of ambient temperature; **case sizes 1 to 7;** C_0 = capacitance at 20 °C, 100 Hz.

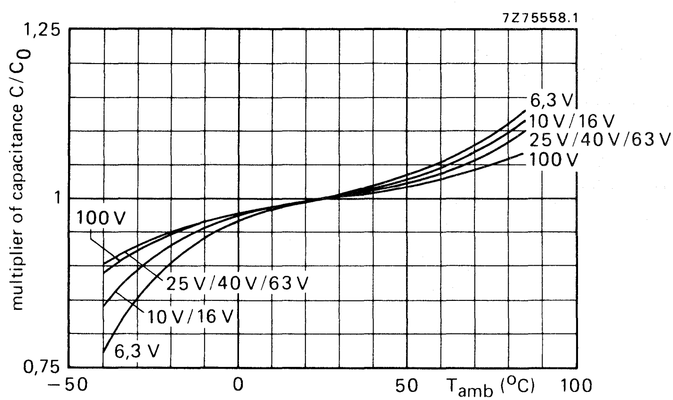


Fig. 5 Multiplier of capacitance as a function of ambient temperature; **case sizes 00 to 05;** C_0 = capacitance at 25 °C, 100 Hz.

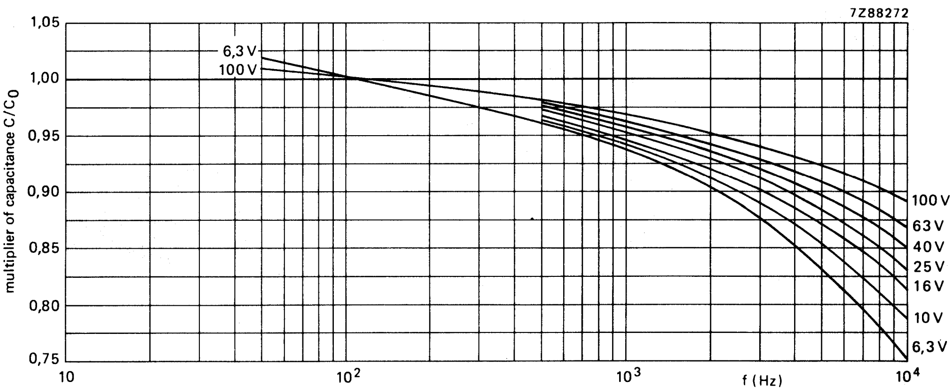


Fig. 6 Multiplier of capacitance as a function of frequency; **case sizes 1 to 7;** C_0 = capacitance at 20 °C, 100 Hz.

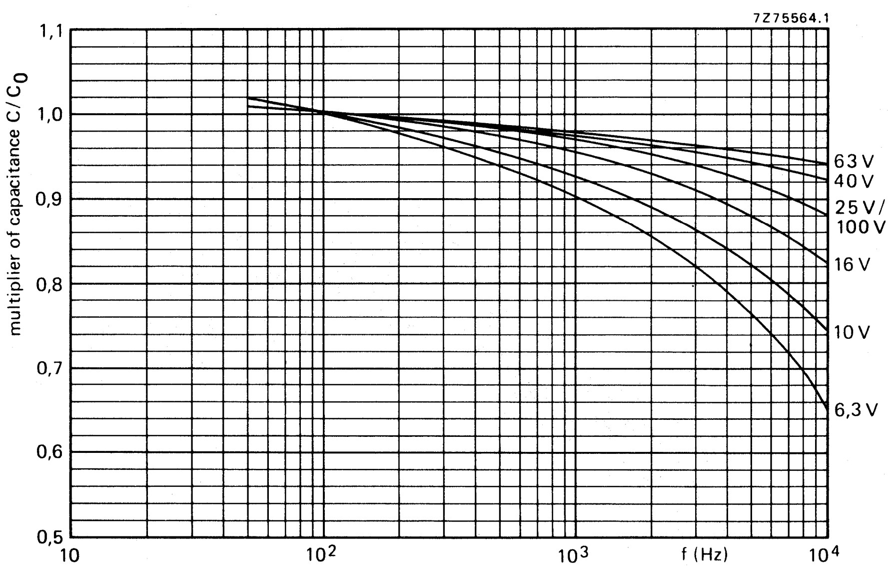


Fig. 7 Multiplier of capacitance as a function of frequency; **case sizes 00 to 05;** C_0 = capacitance at 25 °C, 100 Hz.

Voltage

	core temperature ▲ < 60 °C	60 to 95 °C
Rated voltage = max. permissible voltage	1,1 x U_R	U_R
Ripple voltage* = max. permissible a.c. voltage providing the following three conditions are met:		
a) max. (d.c. + peak a.c.) voltage	1,1 x U_R	U_R
b) max. peak a.c. voltage without d.c. voltage applied	1 V	
c) momentary value of applied voltage	between U_R and −1 V	
Surge voltage = max. permissible voltage for short periods	1,15 x U_R	
Reverse voltage = max. d.c. voltage applied in the reverse polarity at the maximum category temperature for short periods	1 V	

Ripple current **

Maximum permissible r.m.s. ripple current at

100 Hz and T_{amb} = 85 °C	see Table 2
100 Hz and T_{amb} = 40 °C	2,24 x values stated in Table 2

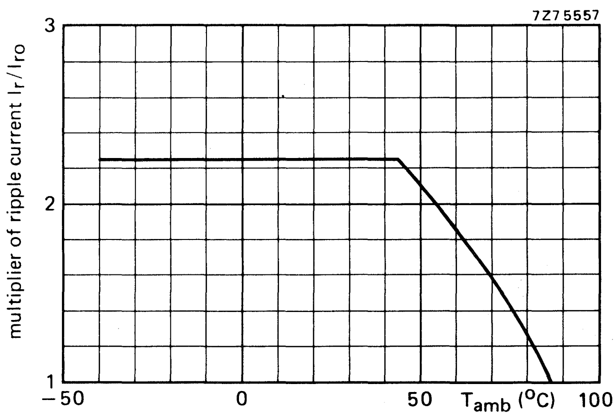


Fig. 8 Multiplier of ripple current as a function of ambient temperature; I_{r0} = ripple current at 85 °C, 100 Hz.

▲ See Introduction, section 5, "Ripple current".

* Ripple voltages are not applicable if the maximum permissible ripple current is exceeded. In that case the ripple current is decisive.

** Ripple currents are not applicable if the maximum permissible ripple voltage is exceeded. In that case the ripple voltage is decisive.

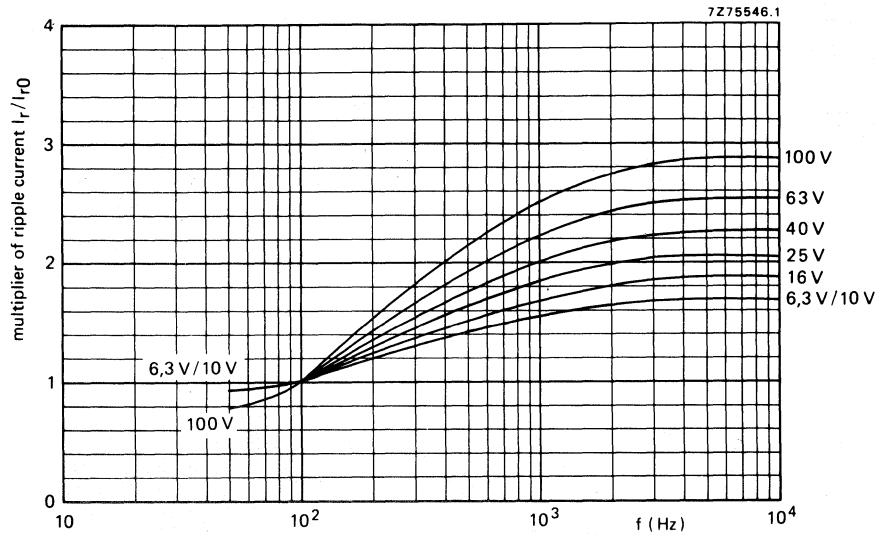


Fig. 9 Multiplier of ripple current as a function of frequency, **case sizes 1 to 7;** I_{r0} = ripple current at 85 °C, 100 Hz.

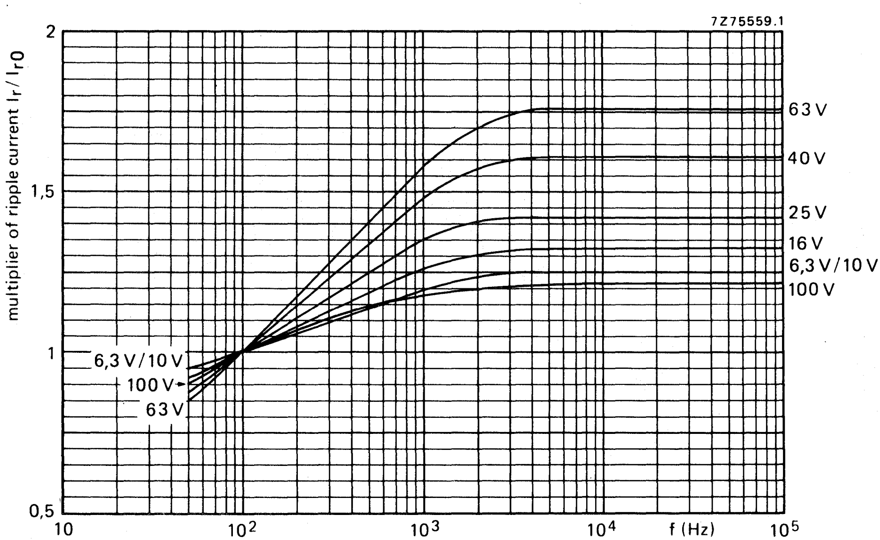


Fig. 10 Multiplier of ripple current as a function of frequency, **case sizes 00 to 03;** I_{r0} = ripple current at 85 °C, 100 Hz.

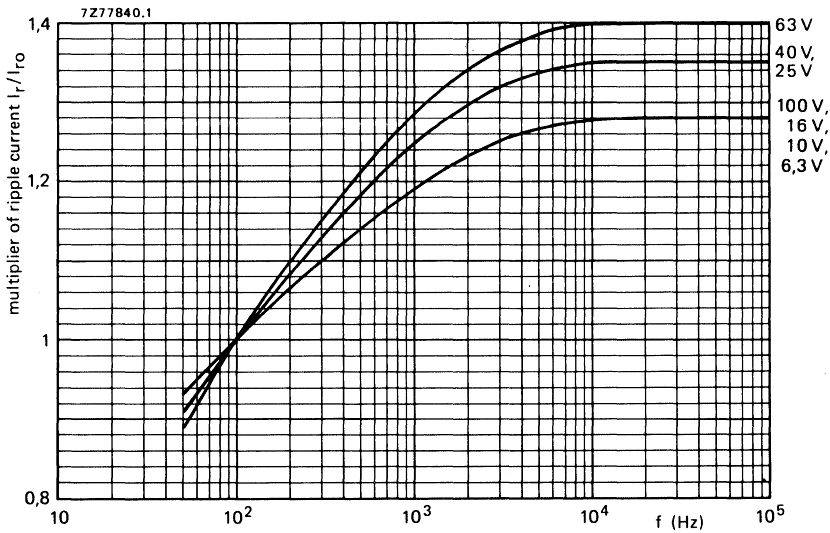


Fig. 11 Multiplier of ripple current as a function of frequency, **case sizes 04 and 05;** I_{r0} = ripple current at 85 °C, 100 Hz.

Non-sinusoidal ripple currents have to be analyzed into a number of sinusoidal currents and the following requirements shall then be satisfied:

$$\sum_n \frac{I_n^2}{r_n} \leqslant I_{r\,max}^2$$

$I_{r\,max}$ = maximum ripple current at 100 Hz and applicable ambient temperature;

I_n = ripple current at a certain frequency;

$\sqrt{r_n} = I_r/I_{r0}$ = multiplying factor at a same frequency.

Charge and discharge current

The capacitors may be charged from a source without internal resistance and they may be discharged by short-circuiting. If the capacitors are charged and discharged continuously at a rate of several times per minute, the charge and discharge currents have to be considered as ripple currents flowing through the capacitor. The r.m.s. value of these currents should be determined and the value thus found must not exceed the applicable limit.

D.C. leakage current

Maximum d.c. leakage current 1 min after application of U_R, at T_{amb} = 20 °C.	
case sizes 1 and 2	see Table 2 (0,05 CU or 5 μA, whichever is greater)
case sizes 3 to 7 and 00 to 05	see Table 2 (0,006 CU + 4 μA for CU > 1000 μC; 0,01 CU or 1 μA, whichever is greater for CU ⩽ 1000 μC)
D.C. leakage current during continuous operation at U_R	
at T_{amb} = 20 °C, case sizes 1 to 7	approx. 0,1 x values of Table 2
at T_{amb} = 20 °C, case sizes 00 to 05	approx. 0,01 x values of Table 2
at T_{amb} = 85 °C	⩽ values of Table 2

If owing to prolonged storage and/or storage at an excessive temperature (> 40 °C) the d.c. leakage current is too high, application of the rated voltage for some hours will cause the d.c. leakage current to fall to a value lower than specified in Table 2.

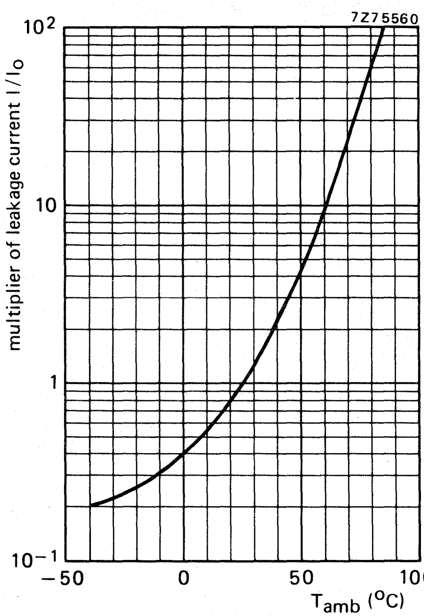


Fig. 12 Multiplier of d.c. leakage current as a function of ambient temperature, **cases sizes 00 to 05;** I_0 = d.c. leakage current during continuous operation at 25 °C and U_R.

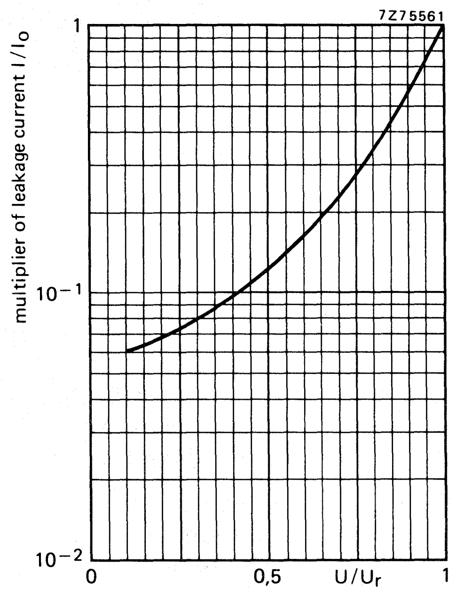


Fig. 13 Multiplier of d.c. leakage current as a function of U/U_R, **case sizes 00 to 05;** I_0 = d.c. leakage current during continuous operation at 25 °C and U_R.

Tan δ (dissipation factor)

Maximum tan δ at 100 Hz and T_{amb} = 25 °C, measured by means of a four-terminal circuit (Thomson circuit) — see Table 2

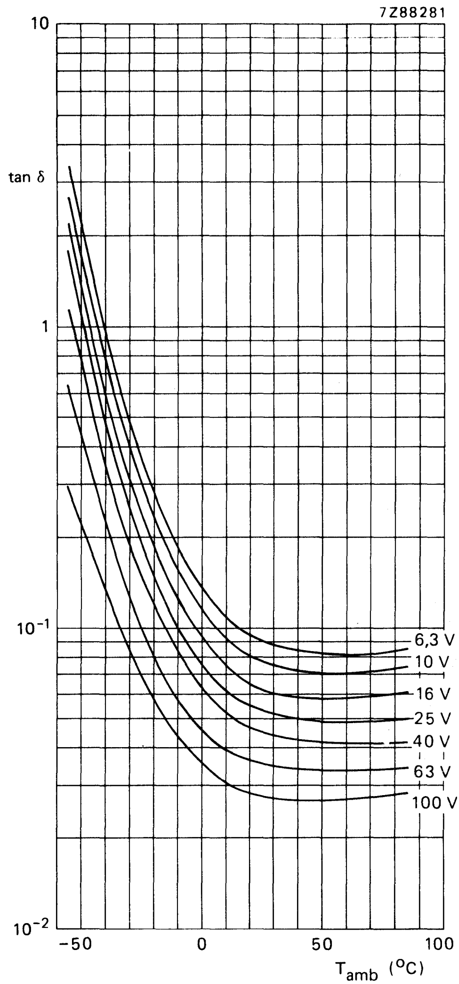


Fig. 14 Typical tan δ as a function of ambient temperature at 100 Hz; **case sizes 1 to 7.**

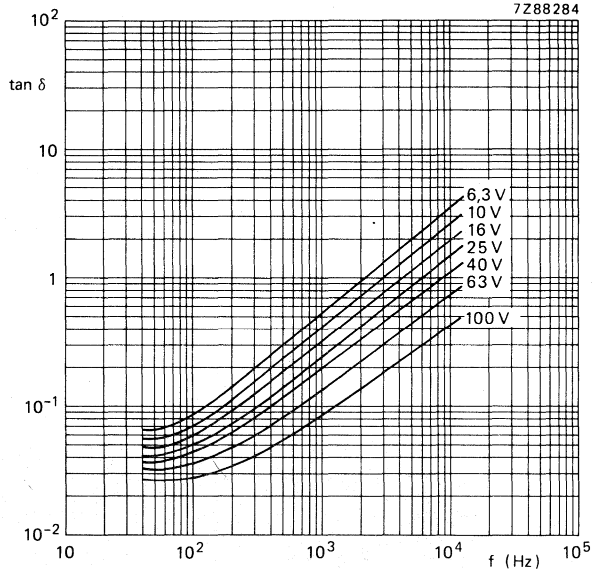


Fig. 15 Typical tan δ as a function of frequency at 25 °C, **case sizes 1 to 7.**

Equivalent series resistance (ESR)

Maximum ESR at 100 Hz and T_{amb} = 25 °C, measured by means of a four-terminal circuit (Thomson Circuit) (ESR = tan $\delta/\omega C$) — see Table 2

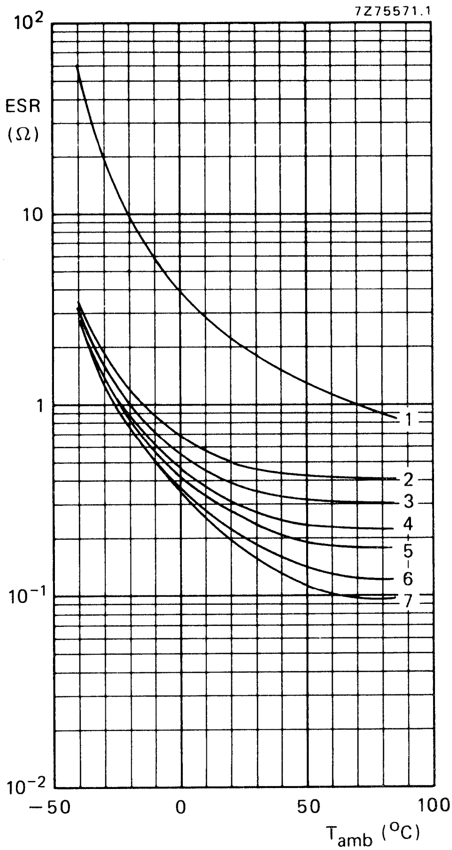


Fig. 16 Typical ESR as a function of ambient temperature at 100 Hz.

Case size 00:
curve 1 = 68 μF, 100 V;
curve 2 = 150 μF, 63 V;
curve 3 = 220 μF, 40 V;
curve 4 = 470 μF, 25 V;
curve 5 = 680 μF, 16 V;
curve 6 = 1000 μF, 10 V;
curve 7 = 1500 μF, 6,3 V.

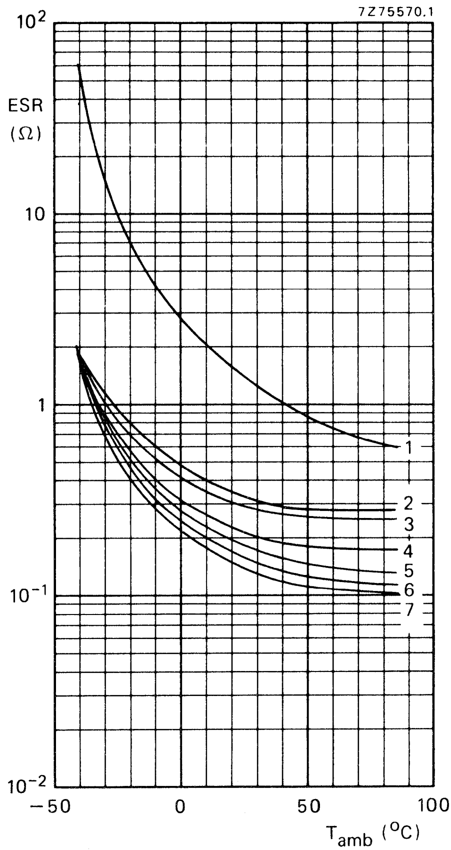


Fig. 17 Typical ESR as a function of ambient temperature at 100 Hz.

Case size 01:
curve 1 = 100 μF, 100 V;
curve 2 = 220 μF, 63 V;
curve 3 = 330 μF, 40 V;
curve 4 = 470 μF, 40 V;
curve 5 = 680 μF, 25 V;
curve 6 = 1000 μF, 16 V;
curve 7 = 1500 μF, 10 V and 2200 μF, 6,3 V.

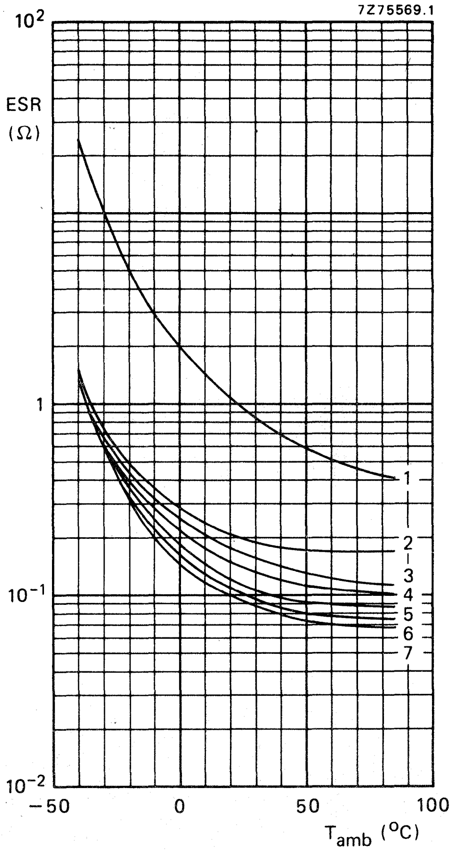


Fig. 18 Typical ESR as a function of ambient temperature at 100 Hz.

Case size 02:
curve 1 = 150 μF, 100 V;
curve 2 = 330 μF, 63 V;
curve 3 = 470 μF, 63 V;
curve 4 = 680 μF, 40 V;
curve 5 = 1000 μF, 25 V;
curve 6 = 1500 μF, 16 V;
curve 7 = 2200 μF, 10 V and 3300 μF, 6,3 V.

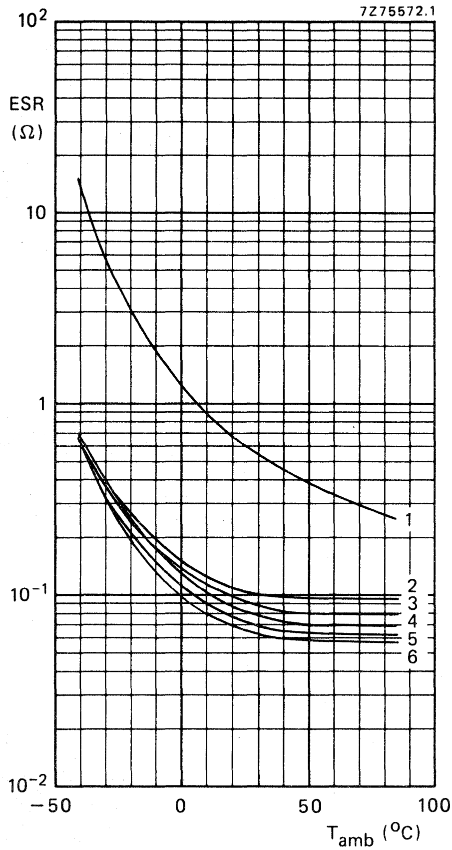


Fig. 19 Typical ESR as a function of ambient temperature at 100 Hz.

Case size 03:
curve 1 = 220 μF, 100 V;
curve 2 = 680 μF, 63 V;
curve 3 = 1000 μF, 40 V;
curve 4 = 1500 μF, 25 V;
curve 5 = 2200 μF, 16 V;
curve 6 = 3300 μF, 10 V and 4700 μF, 6,3 V.

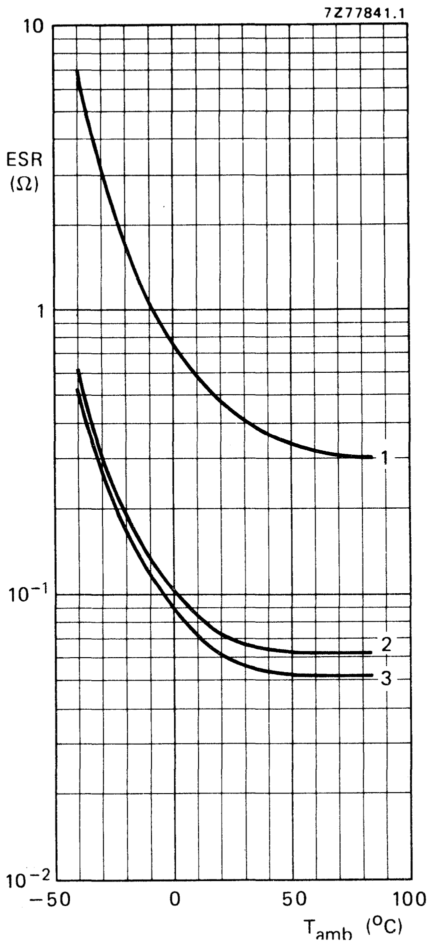


Fig. 20 Typical ESR as a function of ambient temperature at 100 Hz.

Case size 04:
curve 1 = 330 μF, 100 V;
curve 2 = 1500 μF, 40 V and 2200 μF, 25 V;
curve 3 = 3300 μF, 16 V, 4700 μF, 10 V and 6800 μF, 6,3 V.

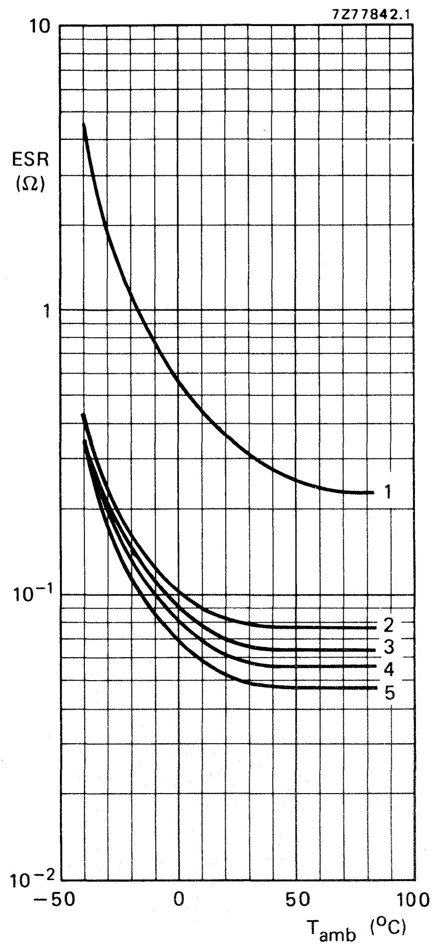


Fig. 21 Typical ESR as a function of ambient temperature at 100 Hz.

case size 05:
curve 1 = 470 μF, 100 V and 680 μF, 100 V;
curve 2 = 1000 μF, 63 V;
curve 3 = 1500 μF, 63 V;
curve 4 = 2200 μF, 40 V and 3300 μF, 25 V;
curve 5 = 4700 μF, 16 V, 6800 μF, 10 V, 10 000 μF, 6,3 V and 15 000 μF, 6,3 V.

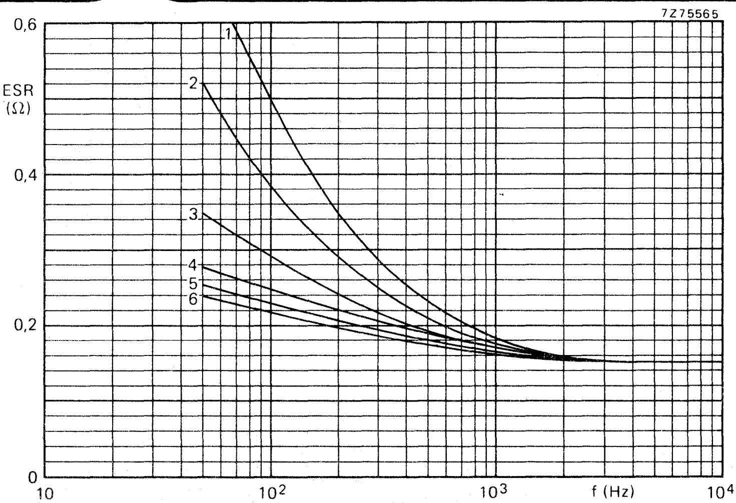


Fig. 22 Typical ESR as a function of frequency at 25 °C. 6,3 to 63 V versions, **case size 00:**

curve 1 = 150 μF, 63 V;
curve 2 = 220 μF, 40 V;
curve 3 = 470 μF, 25 V;
curve 4 = 680 μF, 16 V;
curve 5 = 1000 μF, 10 V;
curve 6 = 1500 μF, 6,3 V.

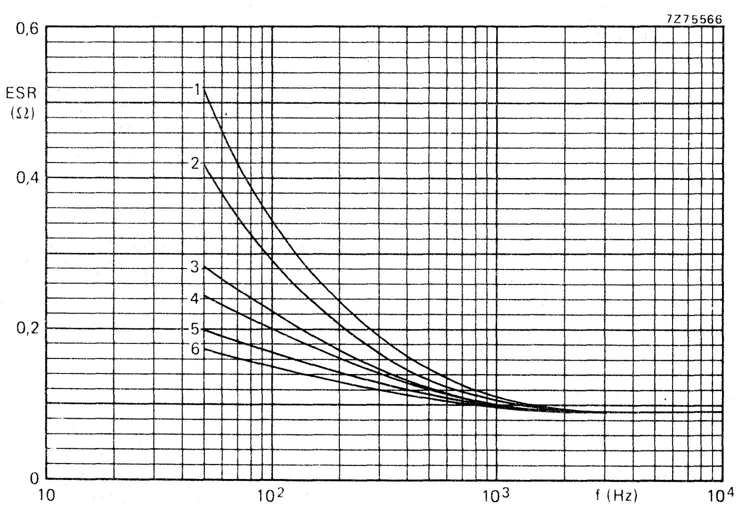


Fig. 23 Typical ESR as a function of frequency at 25 °C. 6,3 to 63 V versions, **case size 01:**

curve 1 = 220 μF, 63 V;
curve 2 = 330 μF, 40 V;
curve 3 = 470 μF, 40 V;
curve 4 = 680 μF, 25 V;
curve 5 = 1000 μF, 16 V;
curve 6 = 1500 μF, 10 V; and 2200 μF, 6,3 V.

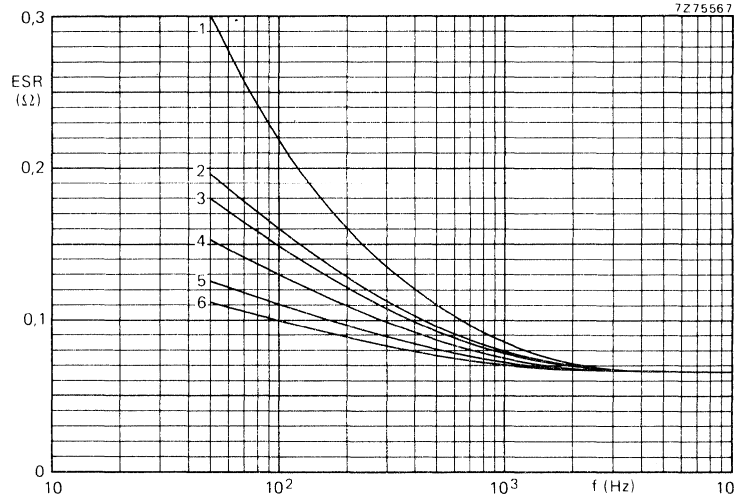


Fig. 24 Typical ESR as a function of frequency at 25 °C. 6,3 to 63 V versions, **case size 02:**

curve 1 = 330 μF, 63 V;
curve 2 = 470 μF, 63 V;
curve 3 = 680 μF, 40 V;
curve 4 = 1000 μF, 25 V;
curve 5 = 1500 μF, 16 V;
curve 6 = 2200 μF, 10 V; and 3300 μF, 6,3 V.

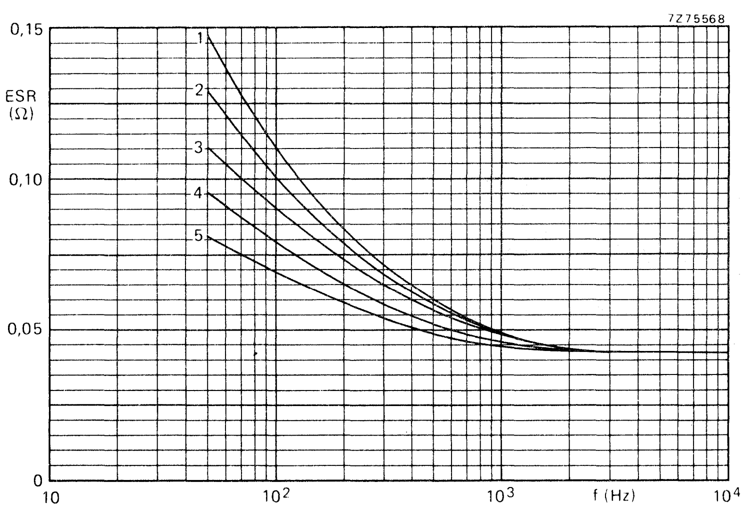


Fig. 25 Typical ESR as a function of frequency at 25 °C. 6,3 to 63 V versions, **case size 03:**

curve 1 = 680 μF, 63 V;
curve 2 = 1000 μF, 40 V;
curve 3 = 1500 μF, 25 V;
curve 4 = 2200 μF, 16 V;
curve 5 = 3300 μF, 10 V; and 4700 μF, 6,3 V.

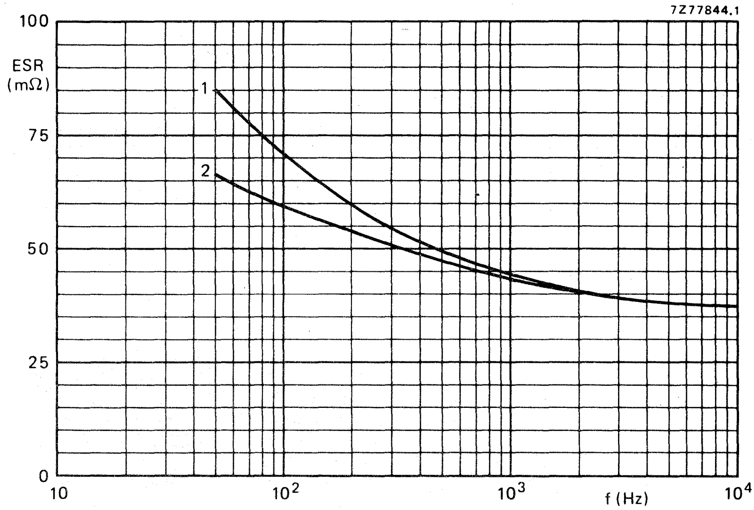


Fig. 26 Typical ESR as a function of frequency at 25 °C. **Case size 04:** curve 1 = 1500 μF, 40 V and 2200 μF, 25 V; curve 2 = 3300 μF, 16 V, 4700 μF, 10 V and 6800 μF, 6,3 V.

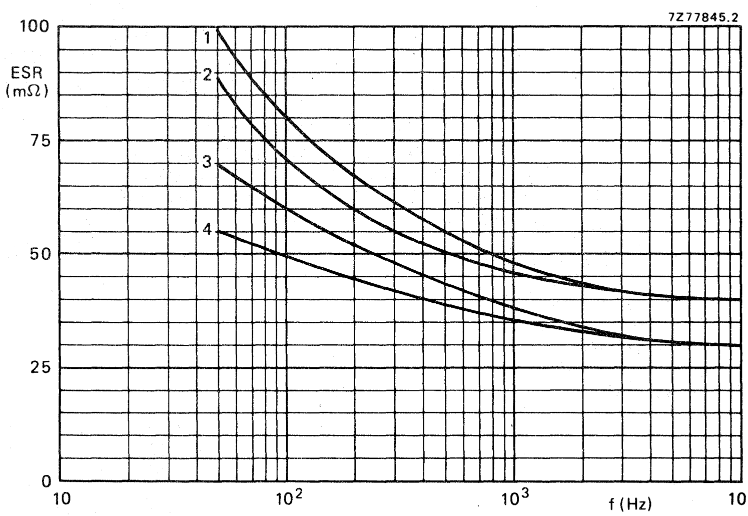


Fig. 27 Typical ESR as a function of frequency at 25 °C. **Case size 05:** curve 1 = 1000 μF, 63 V; curve 2 = 1500 μF, 63 V; curve 3 = 2200 μF, 40 V and 3300 μF, 25 V; curve 4 = 4700 μF, 16 V, 6800 μF, 10 V, 10 000 μF and 15 000 μF, 6,3 V.

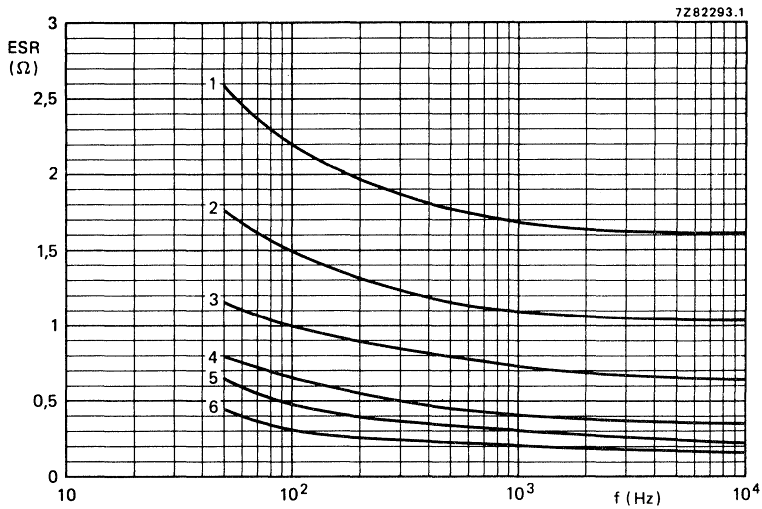


Fig. 28 Typical ESR as a function of frequency at 25 °C; 100 V version:
curve 1 = 68 μF, case size 00;
curve 2 = 100 μF, case size 01;
curve 3 = 150 μF, case size 02;
curve 4 = 220 μF, case size 03;
curve 5 = 330 μF, case size 04;
curve 6 = 470 μf and 680 μF, case size 05.

Impedance (Z)

Maximum impedance at T_{amb} = 20 °C and 1 kHz or 10 kHz, measured by means of a four-terminal circuit (Thomson circuit) — see Table 2

$z = Z \times C_{nom}$, at 10 kHz — see Table 3

$z = Z \times C_{nom}$, at 1 kHz — see Table 4

Table 3

T_{amb}	$z = Z \times C_{nom}$ (Ω μF) at U_R; at 10 kHz						
	6,3 V	10 V	16 V	25 V	40 V	63 V	100 V
+20 °C	⩽ 200	⩽ 160	⩽ 120	⩽ 90	⩽ 70	⩽ 55	⩽ 45
−25 °C	⩽ 1200	⩽ 750	⩽ 560	⩽ 400	⩽ 300	⩽ 180	⩽ 130
−40 °C	⩽ 3200	⩽ 2000	⩽ 1500	⩽ 1100	⩽ 900	⩽ 500	⩽ 350
−55 °C*	typ. 6500	typ. 5000	typ. 3300	typ. 2400	typ. 1500	typ. 850	typ. 500

Table 4

T_{amb}	$z = Z \times C_{nom}$ (Ω μF) at U_R; at 1 kHz						
	6,3 V	10 V	16 V	25 V	40 V	63 V	100 V
+20 °C	⩽ 350	⩽ 300	⩽ 250	⩽ 220	⩽ 200	⩽ 180	⩽ 175
−25 °C	⩽ 1700	⩽ 1100	⩽ 800	⩽ 570	⩽ 430	⩽ 330	⩽ 300
−40 °C	⩽ 4500	⩽ 2800	⩽ 2000	⩽ 1400	⩽ 1100	⩽ 800	⩽ −

* For case sizes 1 to 7 only.

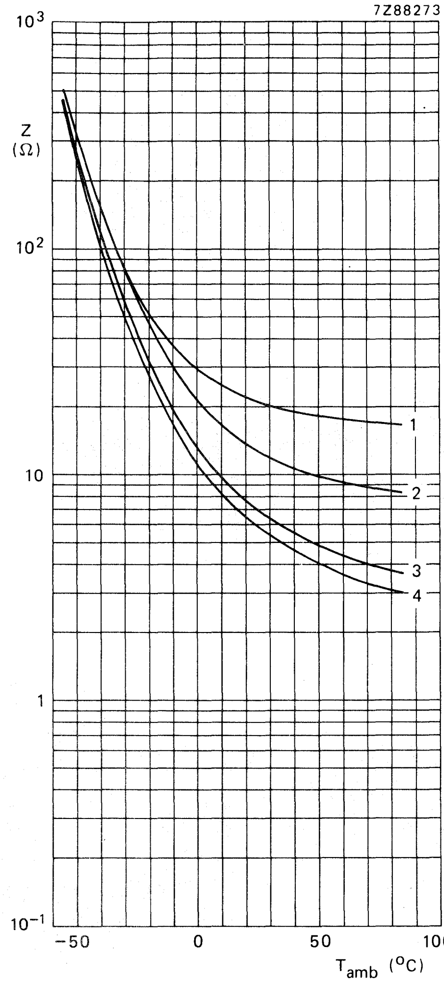


Fig. 29 Typical impedance as a function of ambient temperature at 10 kHz; **case size 1:**

curve 1 = 1 μF, 63 V;
curve 2 = 2,2 μF, 40 V;
curve 3 = 4,7 μF, 16 V;
curve 4 = 10 μF, 6,3 V.

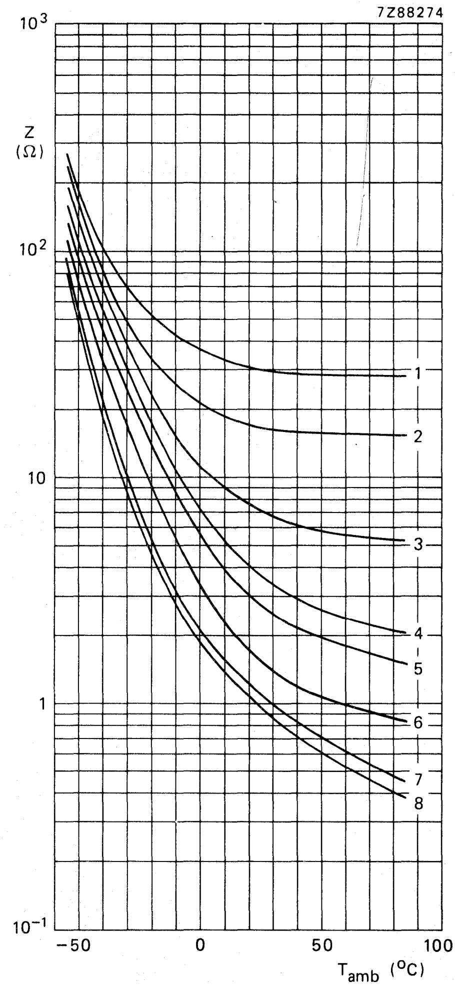


Fig. 30 Typical impedance as a function of ambient temperature at 10 kHz; **case size 2:**

curve 1 = 0,47 μF, 63 V;
curve 2 = 1 μF, 63 V;
curve 3 = 3,3 μF, 63 V;
curve 4 = 6,8 μF, 63 V;
curve 5 = 10 μF, 25 V;
curve 6 = 22 μF, 25 V;
curve 7 = 47 μF, 10 V;
curve 8 = 68 μF, 6,3 V.

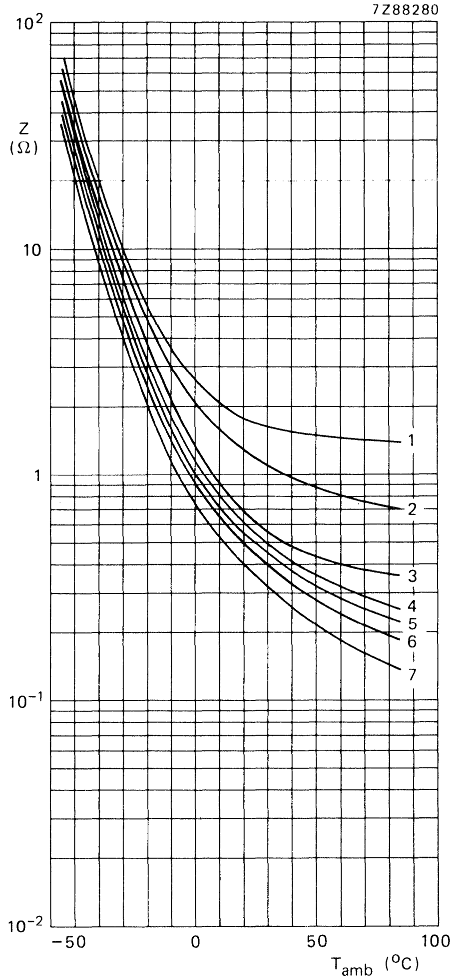


Fig. 31 Typical impedance as a function of ambient temperature at 10 kHz; **case size 3:**

curve 1 = 4,7 μF, 100 V;
curve 2 = 10 μF, 63 V;
curve 3 = 22 μF, 40 V;
curve 4 = 47 μF, 25 V;
curve 5 = 68 μF, 16 V;
curve 6 = 100 μF, 10 V;
curve 7 = 150 μF, 6,3 V.

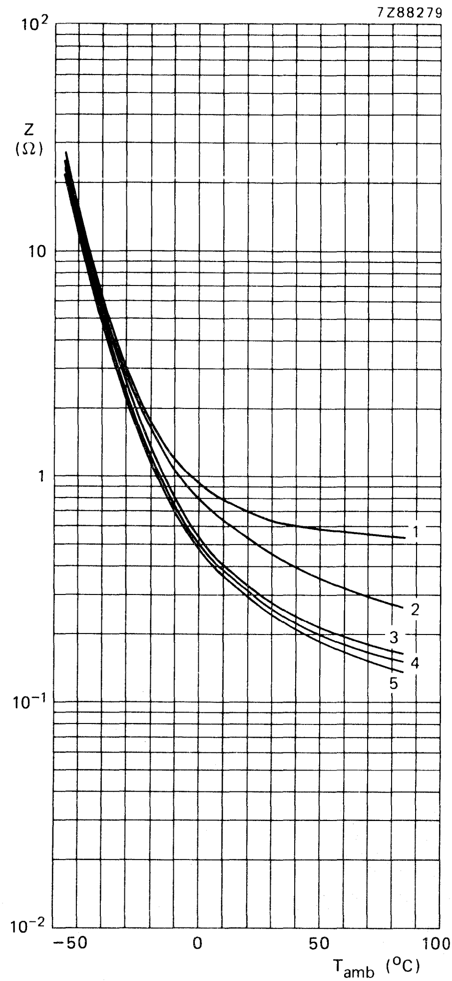


Fig. 32 Typical impedance as a function of ambient temperature at 10 kHz; **case size 5a:**

curve 1 = 22 μF, 63 V;
curve 2 = 47 μF, 40 V;
curve 3 = 100 μF, 25 V;
curve 4 = 150 μF, 16 V;
curve 5 = 220 μF, 10 V.

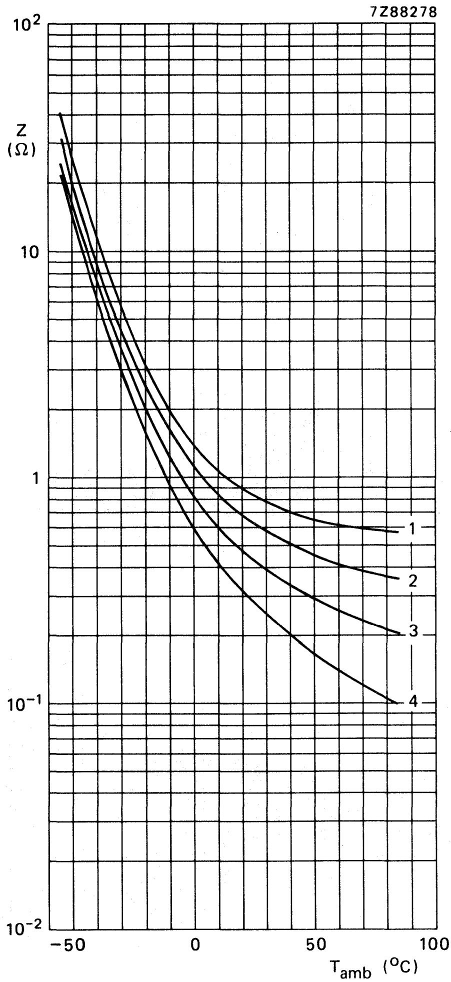


Fig. 33 Typical impedance as a function of ambient temperature at 10 kHz; **case size 4:**

curve 1 = 22 μF, 63 V;
curve 2 = 47 μF, 40 V;
curve 3 = 100 μF, 25 V;
curve 4 = 220 μF, 10 V.

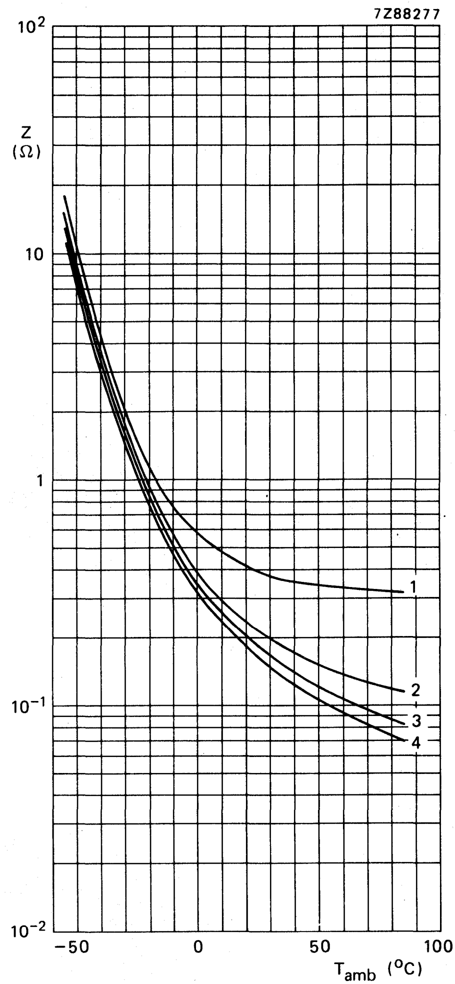


Fig. 34 Typical impedance as a function of ambient temperature at 10 kHz; **case size 5:**

curve 1 = 47 μF, 63 V;
curve 2 = 150 μF, 25 V;
curve 3 = 330 μF, 10 V;
curve 4 = 470 μF, 6,3 V.

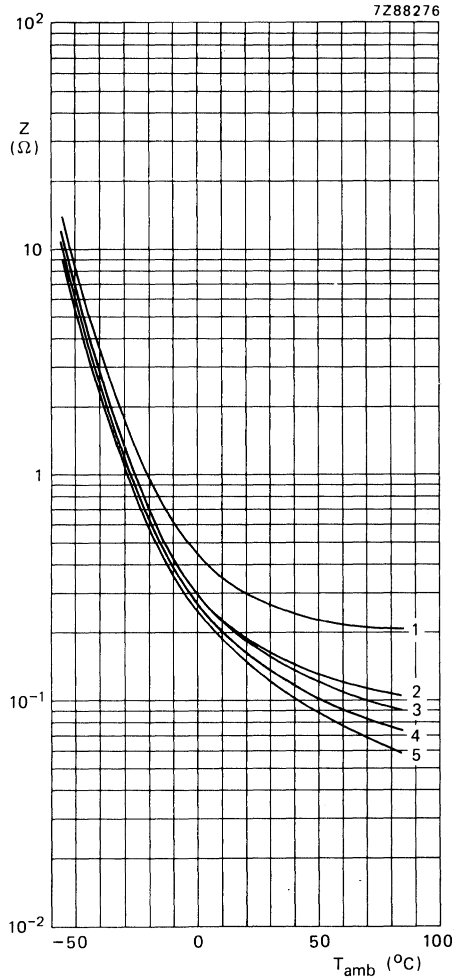


Fig. 35 Typical impedance as a function of ambient temperature at 10 kHz; **case size 6:**

curve 1 = 68 μF, 63 V;
curve 2 = 150 μF, 40 V;
curve 3 = 220 μF, 25 V;
curve 4 = 330 μF, 16 V;
curve 5 = 680 μF, 6,3 V.

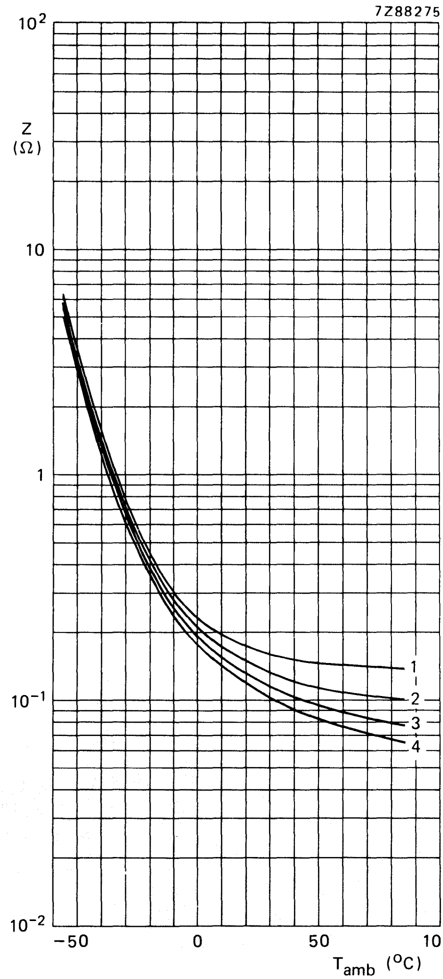


Fig. 36 Typical impedance as a function of ambient temperature at 10 kHz; **case size 7:**

curve 1 = 100 μF, 63 V;
curve 2 = 220 μF, 40 V;
curve 3 = 470 μF, 16 V;
curve 4 = 1000 μF, 6,3 V.

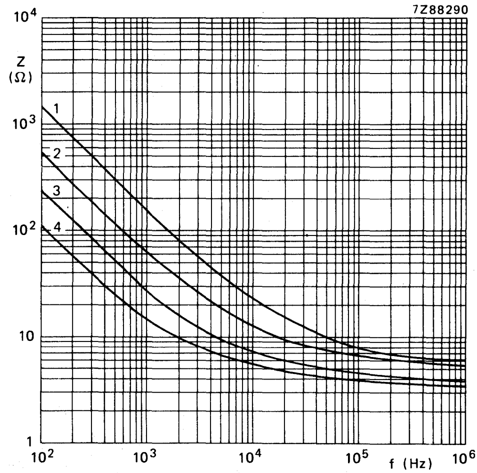


Fig. 37 Typical impedance as a function of frequency at T_{amb} = 20 °C; **case size 1:**
curve 1 = 1 μF, 63 V;
curve 2 = 2,2 μF, 40 V;
curve 3 = 4,7 μF, 16 V;
curve 4 = 10 μF, 6,3 V.

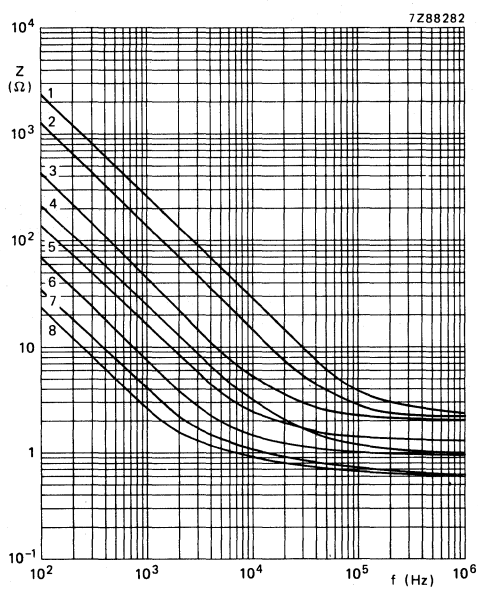


Fig. 38 Typical impedance as a function of frequency at T_{amb} = 20 °C; **case size 2:**
curve 1 = 0,47 μF, 63 V;
curve 2 = 1 μF, 63 V/100 V;
curve 3 = 3,3 μF, 63 V/100 V;
curve 4 = 6,8 μF, 63 V;
curve 5 = 10 μF, 25 V;
curve 6 = 22 μF, 25 V;
curve 7 = 47 μF, 10 V;
curve 8 = 68 μF, 6,3 V.

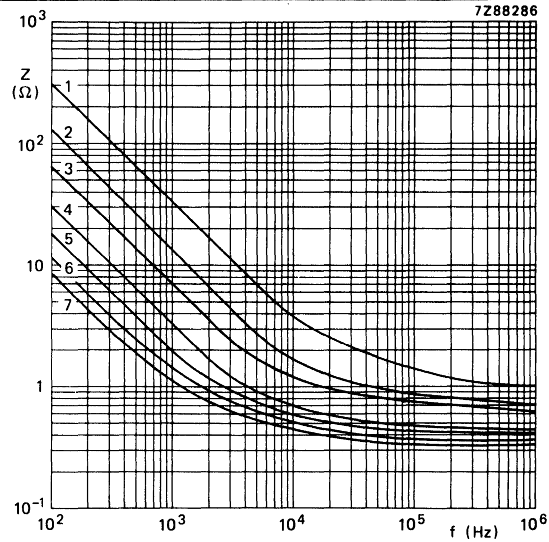


Fig. 39 Typical impedance as a function of frequency at T_{amb} = 20 °C; **case size 3:**
curve 1 = 4,7 μF, 100 V;
curve 2 = 10 μF, 63 V;
curve 3 = 22 μF, 40 V;
curve 4 = 47 μF, 25 V;
curve 5 = 68 μF, 16 V;
curve 6 = 100 μF, 10 V;
curve 7 = 150 μF, 6,3 V.

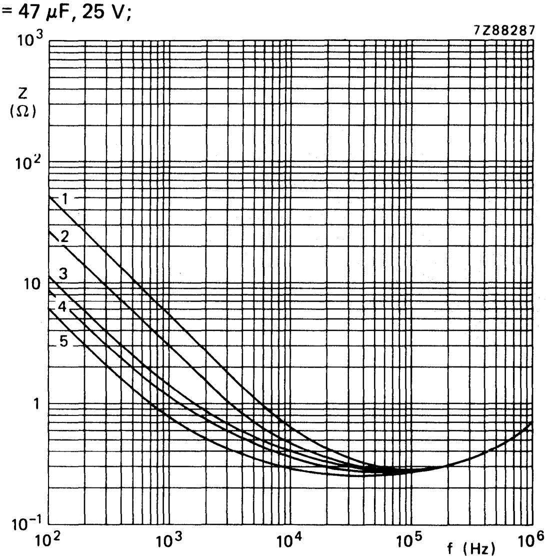


Fig. 40 Typical impedance as a function of frequency at T_{amb} = 20 °C; **case size 5a:**
curve 1 = 22 μF, 63 V;
curve 2 = 47 μF, 40 V;
curve 3 = 100 μF, 25 V;
curve 4 = 150 μF, 16 V;
curve 5 = 220 μF, 10 V.

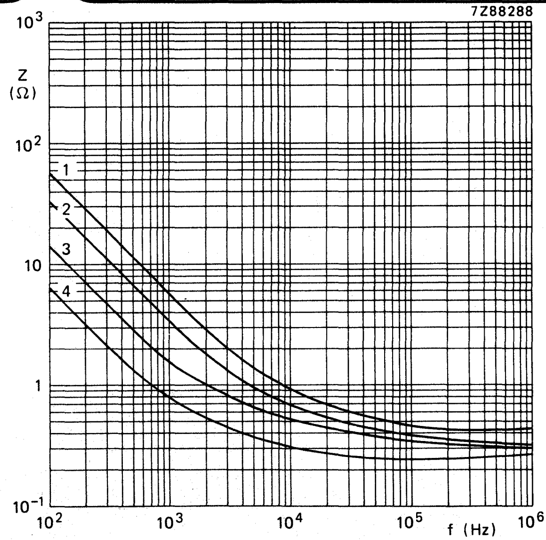


Fig. 41 Typical impedance as a function of frequency at T_{amb} = 20 °C; **case size 4:**
curve 1 = 22 μF, 63 V;
curve 2 = 47 μF, 40 V;
curve 3 = 100 μF, 25 V;
curve 4 = 220 μF, 10 V.

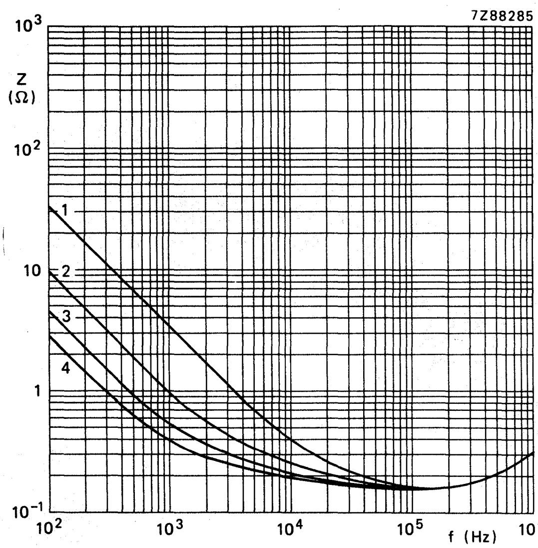


Fig. 42 Typical impedance as a function of frequency at T_{amb} = 20 °C; **case size 5:**
curve 1 = 47 μF, 63 V;
curve 2 = 150 μF, 25 V;
curve 3 = 330 μF, 10 V;
curve 4 = 470 μF, 6,3 V.

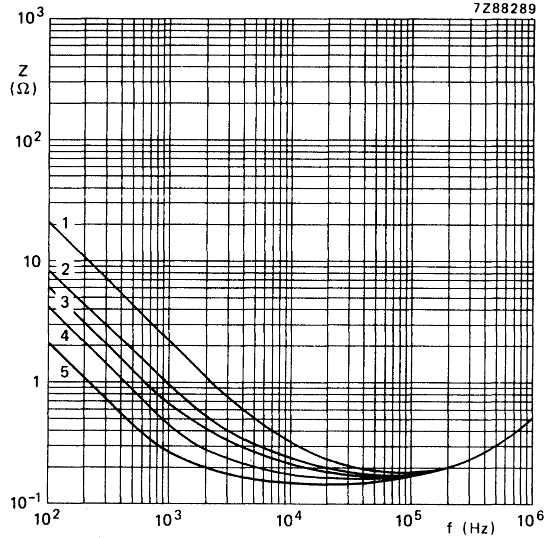


Fig. 43 Typical impedance as a function of frequency at T_{amb} = 20 °C; **case size 6:**
curve 1 = 68 μF, 63 V;
curve 2 = 150 μF, 40 V;
curve 3 = 220 μF, 25 V;
curve 4 = 330 μF, 16 V;
curve 5 = 680 μF, 6,3 V.

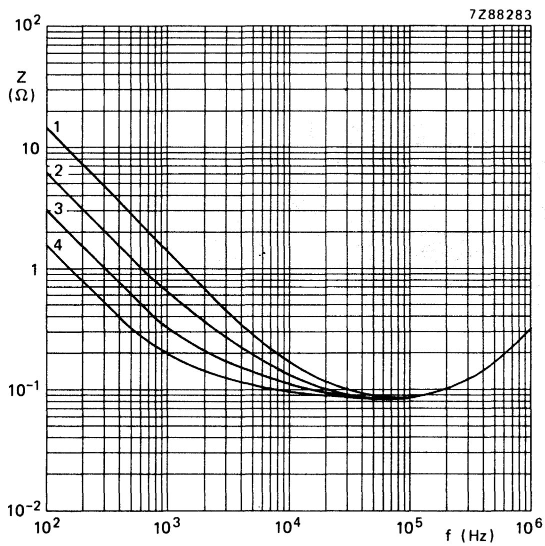


Fig. 44 Typical impedance as a function of frequency at T_{amb} = 20 °C; **case size 7:**
curve 1 = 100 μF, 63 V;
curve 2 = 220 μF, 40 V;
curve 3 = 470 μF, 16 V;
curve 4 = 1000 μF, 6,3 V.

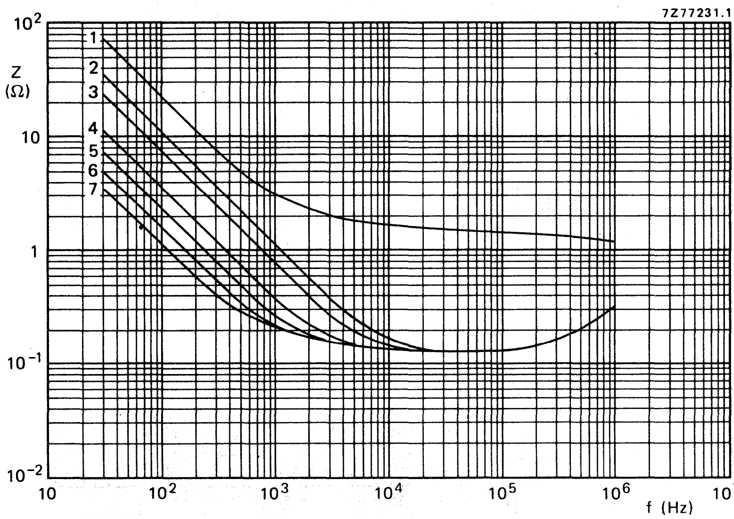


Fig. 45 Typical impedance as a function of frequency at 20 °C. **Case size 00:**
curve 1 = 68 μF, 100 V;
curve 2 = 150 μF, 63 V;
curve 3 = 220 μF, 40 V;
curve 4 = 470 μF, 25 V;
curve 5 = 680 μF, 16 V;
curve 6 = 1000 μF, 10 V;
curve 7 = 1500 μF, 6,3 V.

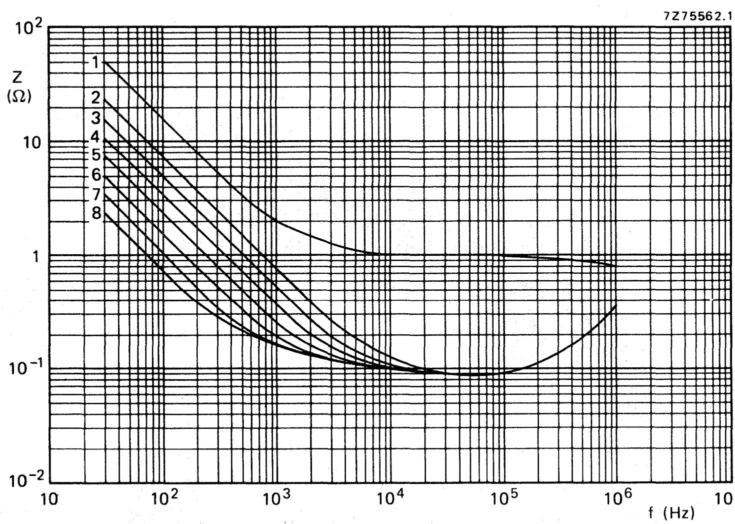


Fig. 46 Typical impedance as a function of frequency at 20 °C. **Case size 01:**
curve 1 = 100 μF, 100 V;
curve 2 = 220 μF, 63 V;
curve 3 = 330 μF, 40 V;
curve 4 = 470 μF, 40 V;
curve 5 = 680 μF, 25 V;
curve 6 = 1000 μF, 16 V;
curve 7 = 1500 μF, 10 V;
curve 8 = 2200 μF, 6,3 V.

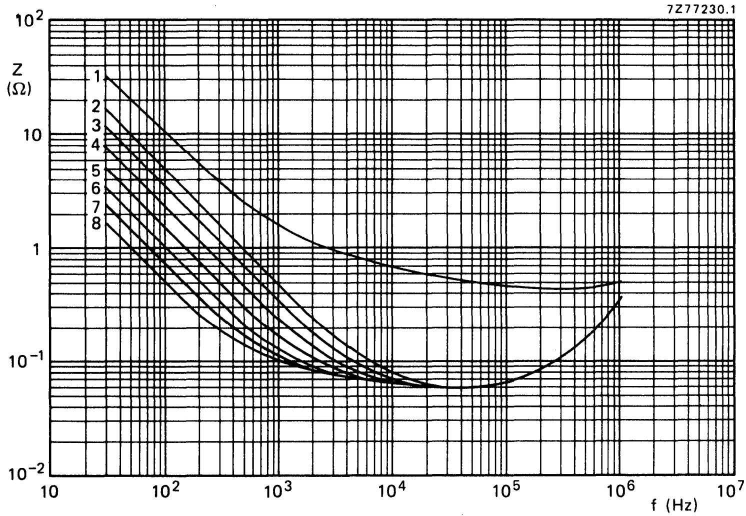


Fig. 47 Typical impedance as a function of frequency at 20 °C. **Case size 02:**
curve 1 = 150 μF, 100 V;
curve 2 = 330 μF, 63 V;
curve 3 = 470 μF, 63 V;
curve 4 = 680 μF, 40 V;
curve 5 = 1000 μF, 25 V;
curve 6 = 1500 μF, 16 V;
curve 7 = 2200 μF, 10 V;
curve 8 = 3300 μF, 6,3 V.

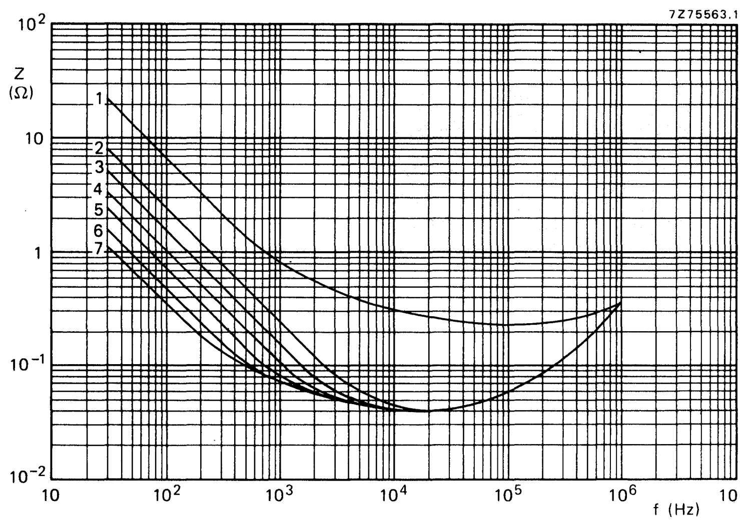


Fig. 48 Typical impedance as a function of frequency at 20 °C. **Case size 03:**
curve 1 = 220 μF, 100 V;
curve 2 = 680 μF, 63 V;
curve 3 = 1000 μF, 40 V;
curve 4 = 1500 μF, 25 V;
curve 5 = 2200 μF, 16 V;
curve 6 = 3300 μF, 10 V;
curve 7 = 4700 μF, 6,3 V.

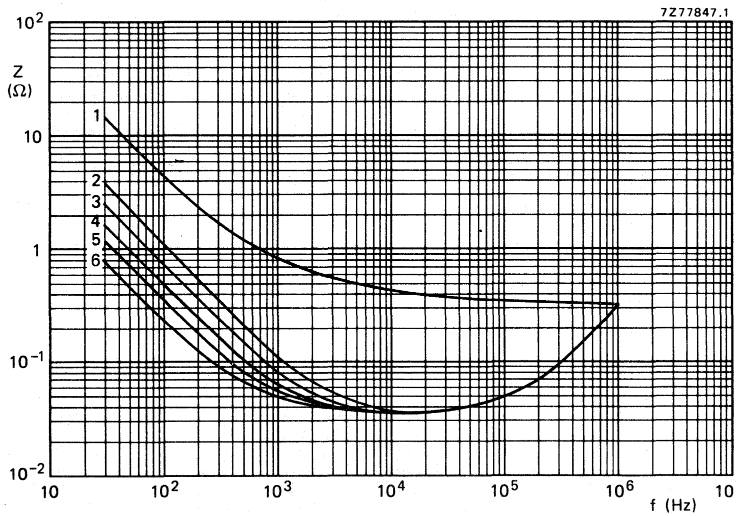


Fig. 49 Typical impedance as a function of frequency at 20 °C. **Case size 04:**
curve 1 = 330 μF, 100 V; curve 3 = 2200 μF, 25 V; curve 5 = 4700 μF, 10 V;
curve 2 = 1500 μF, 40 V; curve 4 = 3300 μF, 16 V; curve 6 = 6800 μF, 6,3 V.

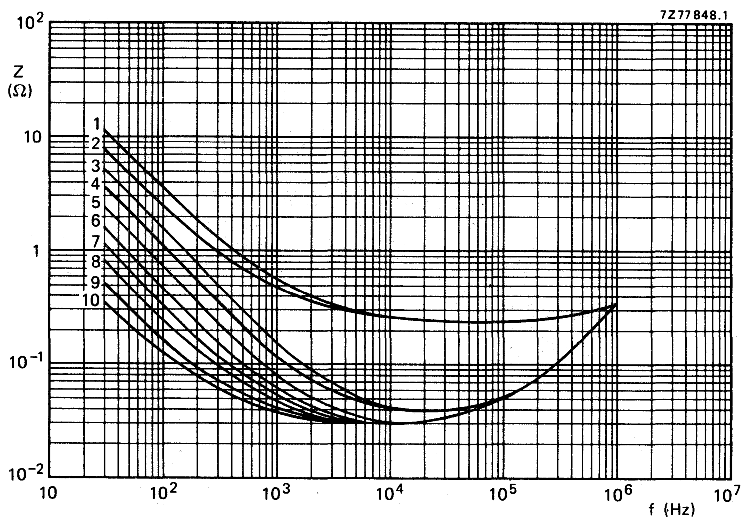


Fig. 50 Typical impedance as a function of frequency at 20 °C. **Case size 05:**
curve 1 = 470 μF, 100 V; curve 4 = 1500 μF, 63 V; curve 7 = 4700 μF, 16 V;
curve 2 = 680 μF, 100 V; curve 5 = 2200 μF, 40 V; curve 8 = 6800 μF, 10 V;
curve 3 = 1000 μF, 63 V; curve 6 = 3300 μF, 25 V; curve 9 = 10 000 μF, 6,3 V;
curve 10 = 15 000 μF, 6,3 V.

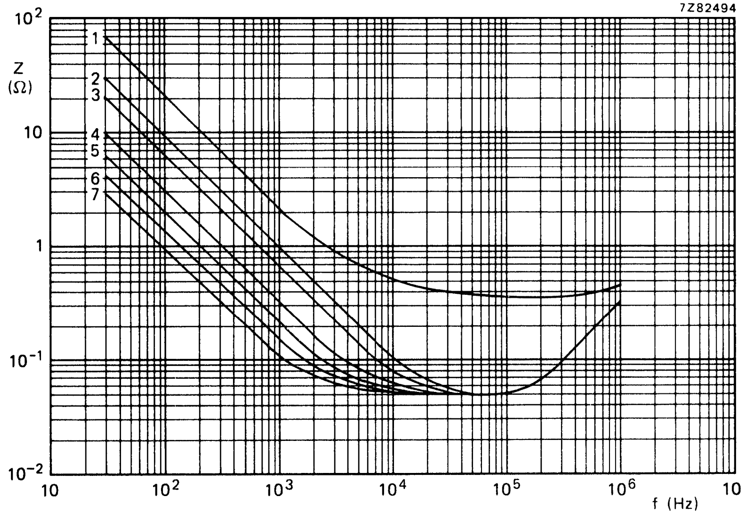


Fig. 51 Typical impedance as a function of frequency at 85 °C. **Case size 00:**
curve 1 = 68 μF, 100 V;
curve 2 = 150 μF, 63 V;
curve 3 = 220 μF, 40 V;
curve 4 = 470 μF, 25 V;
curve 5 = 680 μF, 16 V;
curve 6 = 1000 μF, 10 V;
curve 7 = 1500 μF, 6,3 V.

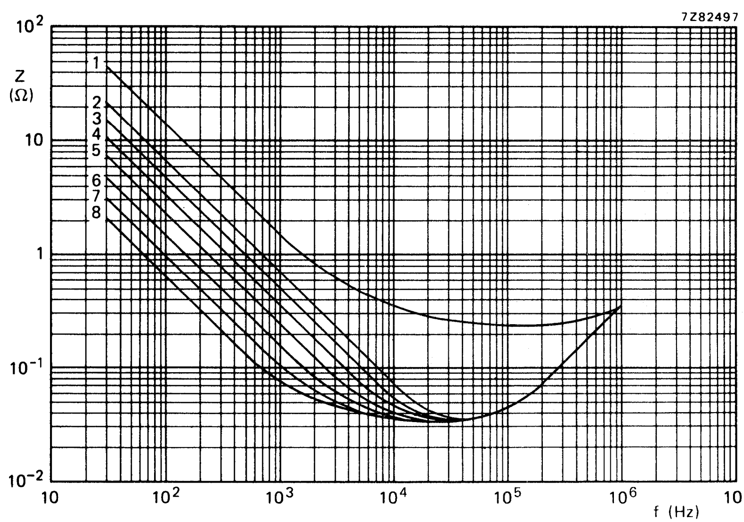


Fig. 52 Typical impedance as a function of frequency at 85 °C. **Case size 01:**
curve 1 = 100 μF, 100 V;
curve 2 = 220 μF, 63 V;
curve 3 = 330 μF, 40 V;
curve 4 = 470 μF, 40 V;
curve 5 = 680 μF, 25 V;
curve 6 = 1000 μF, 16 V;
curve 7 = 1500 μF, 10 V;
curve 8 = 2200 μF, 6,3 V.

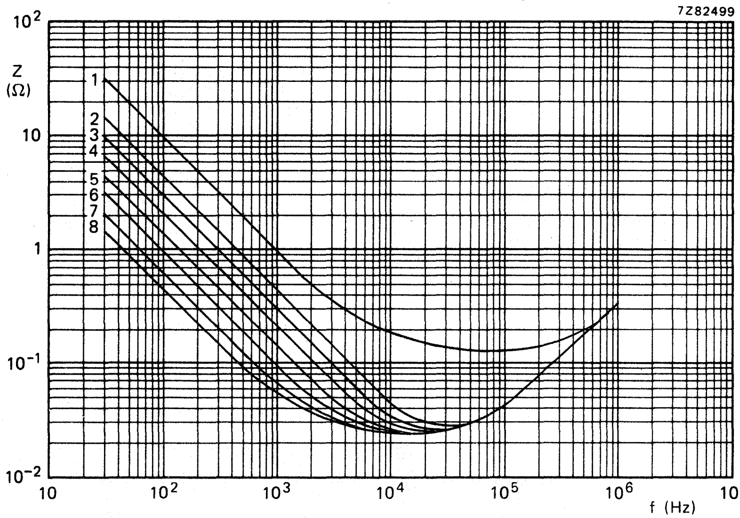


Fig. 53 Typical impedance as a function of frequency at 85 °C. **Case size 02:**
curve 1 = 150 μF, 100 V;
curve 2 = 330 μF, 63 V;
curve 3 = 470 μF, 63 V;
curve 4 = 680 μF, 40 V;
curve 5 = 1000 μF, 25 V;
curve 6 = 1500 μF, 16 V;
curve 7 = 2200 μF, 10 V;
curve 8 = 3300 μF, 6,3 V.

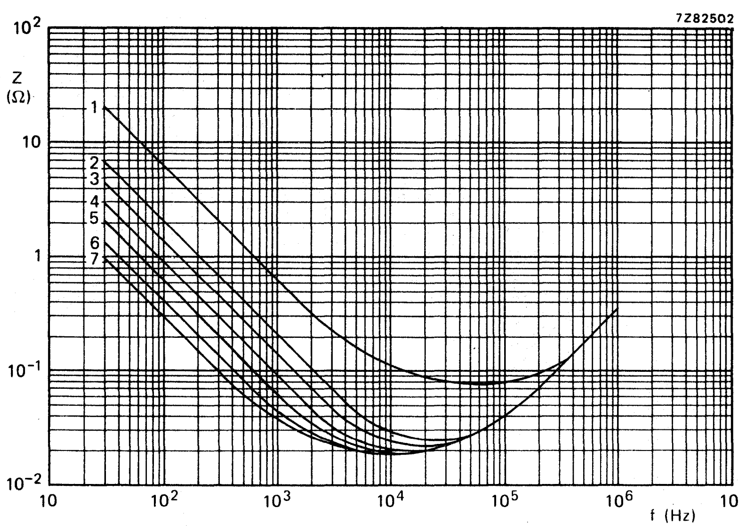


Fig. 54 Typical impedance as a function of frequency at 85 °C. **Case size 03:**
curve 1 = 220 μF, 100 V;
curve 2 = 680 μF, 63 V;
curve 3 = 1000 μF, 40 V;
curve 4 = 1500 μF, 25 V;
curve 5 = 2200 μF, 16 V;
curve 6 = 3300 μF, 10 V;
curve 7 = 4700 μF, 6,3 V.

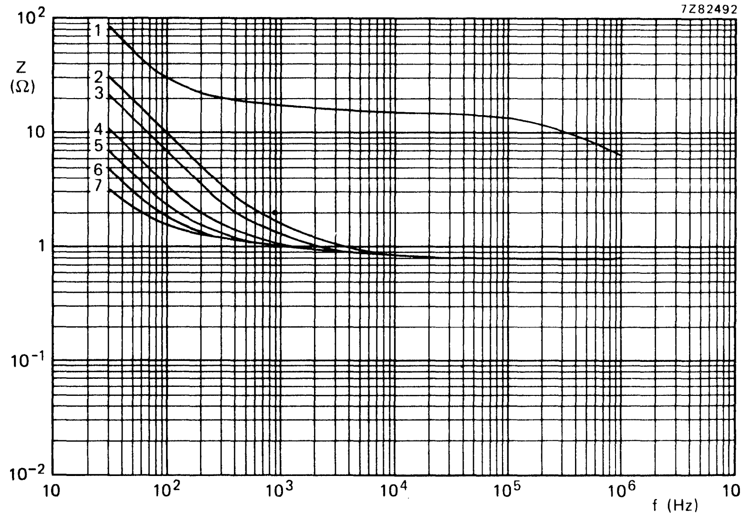


Fig. 55 Typical impedance as a function of frequency at −25 °C. **Case size 00:**
curve 1 = 68 μF, 100 V;
curve 2 = 150 μF, 63 V;
curve 3 = 220 μF, 40 V;
curve 4 = 470 μF, 25 V;
curve 5 = 680 μF, 16 V;
curve 6 = 1000 μF, 10 V;
curve 7 = 1500 μF, 6,3 V.

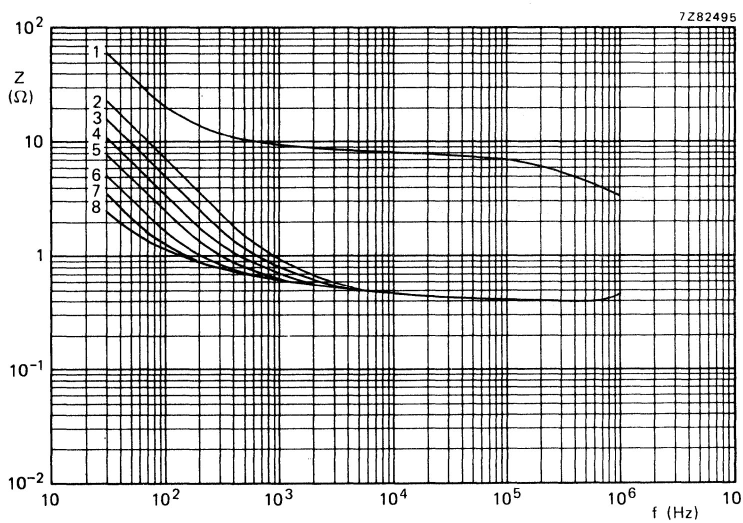


Fig. 56 Typical impedance as a function of frequency at −25 °C. **Case size 01:**
curve 1 = 100 μF, 100 V;
curve 2 = 220 μF, 63 V;
curve 3 = 330 μF, 40 V;
curve 4 = 470 μF, 40 V;
curve 5 = 680 μF, 25 V;
curve 6 = 1000 μF, 16 V;
curve 7 = 1500 μF, 10 V;
curve 8 = 2200 μF, 6,3 V.

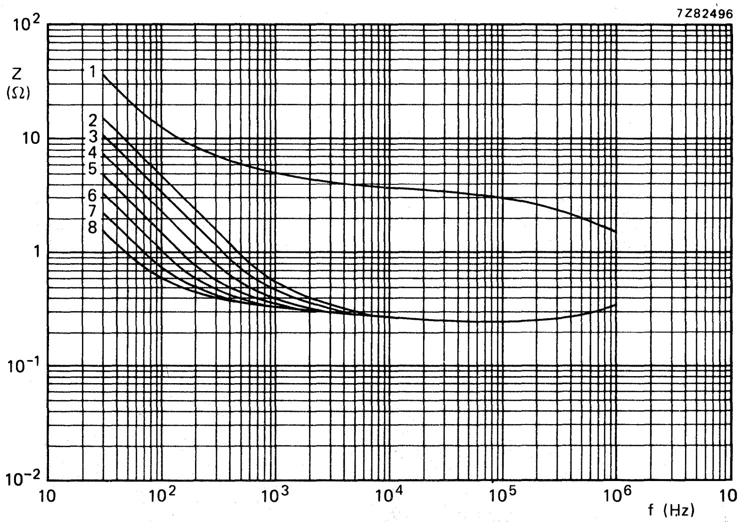


Fig. 57 Typical impedance as a function of frequency at −25 °C. **Case size 02:**
curve 1 = 150 μF, 100 V;
curve 2 = 330 μF, 63 V;
curve 3 = 470 μF, 63 V;
curve 4 = 680 μF, 40 V;
curve 5 = 1000 μF, 25 V;
curve 6 = 1500 μF, 16 V;
curve 7 = 2200 μF, 10 V;
curve 8 = 3300 μF, 6,3 V.

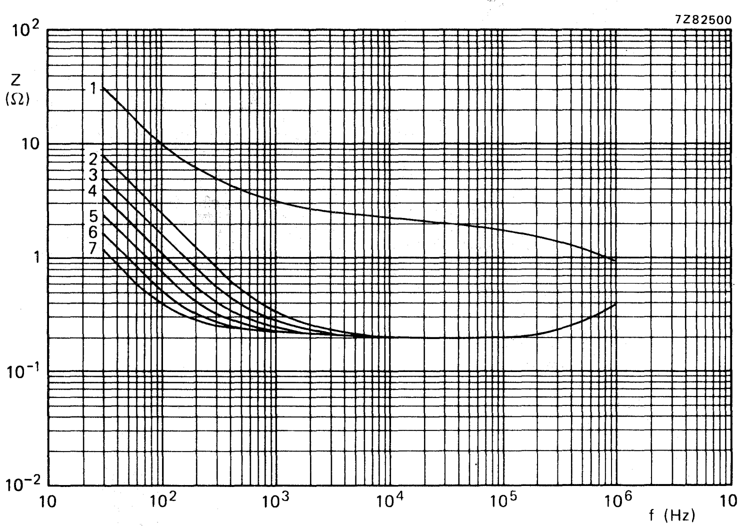


Fig. 58 Typical impedance as a function of frequency at −25 °C. **Case size 03:**
curve 1 = 220 μF, 100 V;
curve 2 = 680 μF, 63 V;
curve 3 = 1000 μF, 40 V;
curve 4 = 1500 μF, 25 V;
curve 5 = 2200 μF, 16 V;
curve 6 = 3300 μF, 10 V;
curve 7 = 4700 μF, 6,3 V.

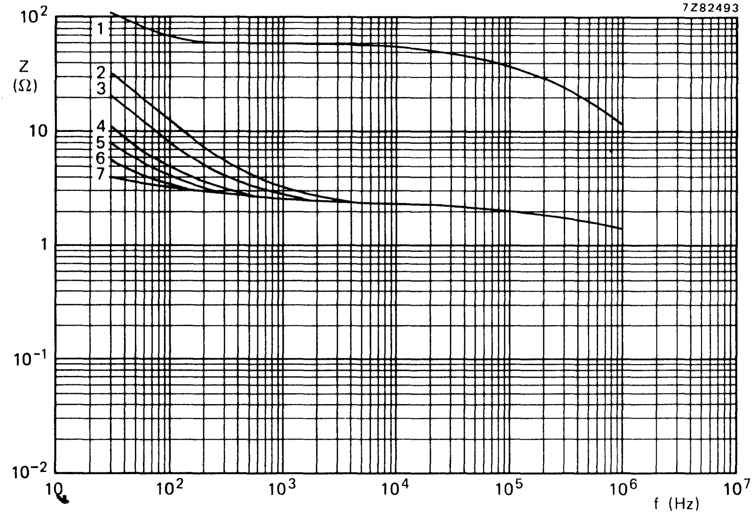


Fig. 59 Typical impedance as a function of frequency at −40 °C. **Case size 00:**
curve 1 = 68 μF, 100 V;
curve 2 = 150 μF, 63 V;
curve 3 = 220 μF, 40 V;
curve 4 = 470 μF, 25 V;
curve 5 = 680 μF, 16 V;
curve 6 = 1000 μF, 10 V;
curve 7 = 1500 μF, 6,3 V.

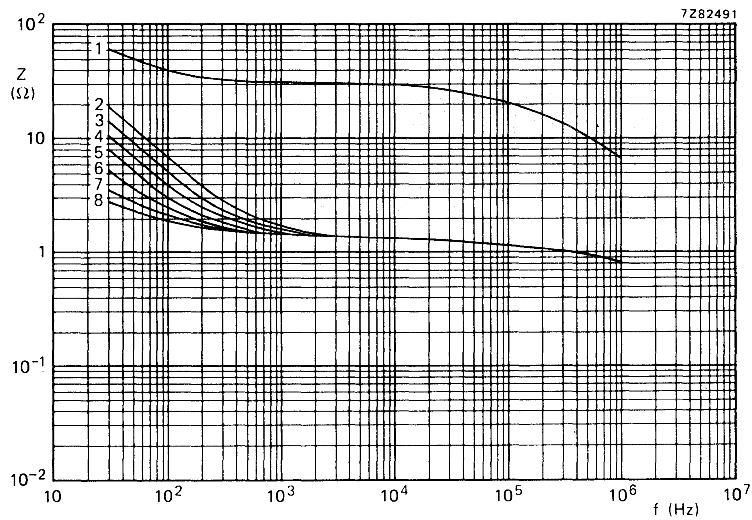


Fig. 60 Typical impedance as a function of frequency at −40 °C. **Case size 01:**
curve 1 = 100 μF, 100 V;
curve 2 = 220 μF, 63 V;
curve 3 = 330 μF, 40 V;
curve 4 = 470 μF, 40 V;
curve 5 = 680 μF, 25 V;
curve 6 = 1000 μF, 16 V;
curve 7 = 1500 μF, 10 V;
curve 8 = 2200 μF, 6,3 V.

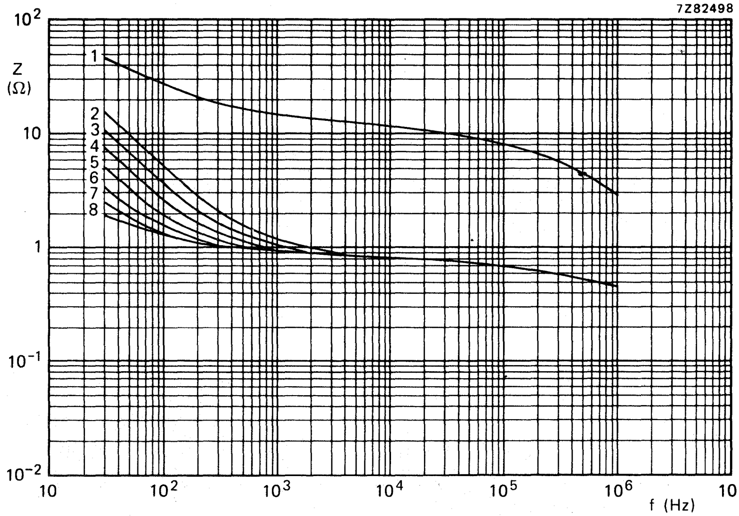


Fig. 61 Typical impedance as a function of frequency at −40 °C. **Case size 02:**
curve 1 = 150 μF, 100 V;
curve 2 = 330 μF, 63 V;
curve 3 = 470 μF, 63 V;
curve 4 = 680 μF, 40 V;
curve 5 = 1000 μF, 25 V;
curve 6 = 1500 μF, 16 V;
curve 7 = 2200 μF, 10 V;
curve 8 = 3300 μF, 6,3 V.

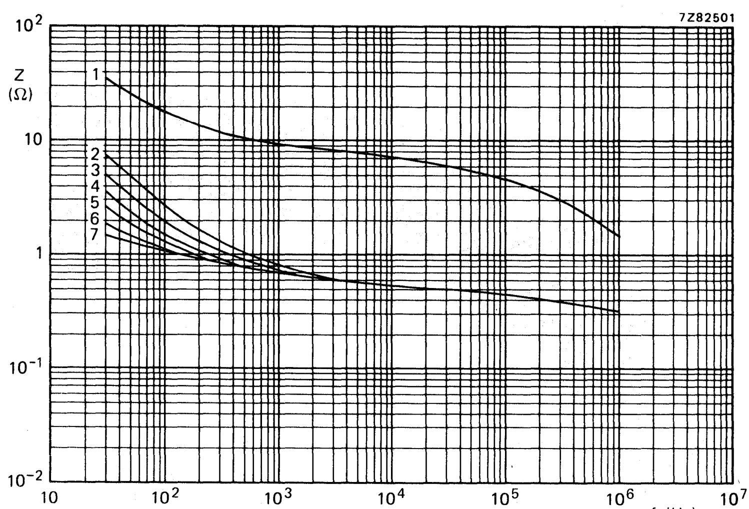


Fig. 62 Typical impedance as a function of frequency at −40 °C. **Case size 03:**
curve 1 = 220 μF, 100 V;
curve 2 = 680 μF, 63 V;
curve 3 = 1000 μF, 40 V;
curve 4 = 1500 μF, 25 V;
curve 5 = 2200 μF, 16 V;
curve 6 = 3300 μF, 10 V;
curve 7 = 4700 μF, 6,3 V.

Equivalent series inductance (ESL)

Case size 1	typ.	15 nH
Case size 2	typ.	17 nH
Case sizes 3 and 4	typ.	30 nH
Case size 5a	typ.	85 nH
Case size 5	typ.	50 nH
Case sizes 6 and 7	typ.	65 nH
Case sizes 00 and 01	typ.	50 nH
Case size 02	typ.	55 nH
Case sizes 03, 04 and 05	typ.	60 nH

OPERATIONAL DATA

Category temperature range
- case sizes 1 to 7: −55 to +85 °C
- case sizes 00 to 05: −40 to +85 °C

Typical life time	T_{amb} = 85 °C	T_{amb} = 40 °C
case size 1	1500 h	35 000 h
case sizes 2 to 7	3000 h	70 000 h
case sizes 00 to 05	10 000 h	> 200 000 h

Shelf life at 0 V and T_{amb} = 85 °C: 500 h

PACKING

All capacitors are supplied in boxes, except case sizes 1 to 7 of style 1, which are on bandoliers in boxes or on reels. The number of capacitors per box or per reel is shown in Table 5.

Table 5

case size	number of capacitors				
	style 1 on bandoliers per reel	style 1 on bandoliers per box	style 1 per box	style 2 per box	style 3 per box
1	4000	1000			1000
2	3000	1000			1000
3	1000	1000			1000
5a	500	500			1000
4	1000	1000			1000
5	500	500			1000
6	500	500			1000
7	500	500			500
00			200		200
01			200		200
02			200		200
03			200	200	
04			100	100	
05			100	100	

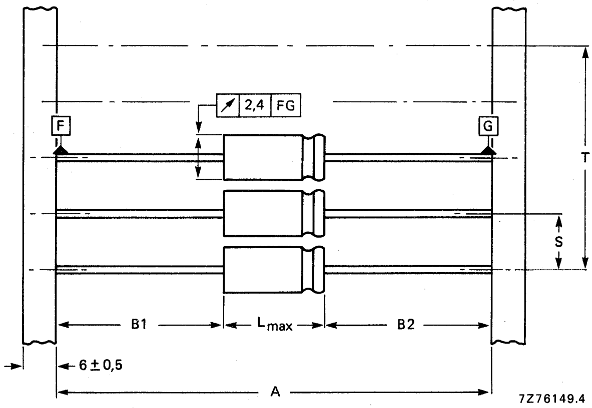


Fig. 63 Style 1 capacitors (case sizes 1 to 7) on bandoliers: the bandolier to which the negative capacitor terminals are connected is blue. See Table 6 for dimensions A, S, T and L.
|B1 − B2| = max. 1,4 mm.

Table 6

Dimensions in mm

case size	A	S	T for number (n) of capacitors		L_{max}
			n < 50	50 < n < 100	
→ 1	63,5 ± 1,5	5 ± 0,4	5 (n-1) ± 2	5 (n-1) ± 4	12,0
2	63,5 ± 1,5	5 ± 0,4	5 (n-1) ± 2	5 (n-1) ± 4	10,5
3	63,5 ± 1,5	10 ± 0,4	10 (n-1) ± 2	10 (n-1) ± 4	10,5
5a	63,5 ± 1,5	10 ± 0,4	10 (n-1) ± 2	10 (n-1) ± 4	11,5
4	73 ± 1,6	10 ± 0,4	10 (n-1) ± 2	10 (n-1) ± 4	18,5
5	73 ± 1,6	10 ± 0,4	10 (n-1) ± 2	10 (n-1) ± 4	18,5
6	73 ± 1,6	15 ± 0,75	15 (n-1) ± 2	15 (n-1) ± 4	18,5
7	73 ± 1,6	15 ± 0,75	15 (n-1) ± 2	15 (n-1) ± 4	25,0

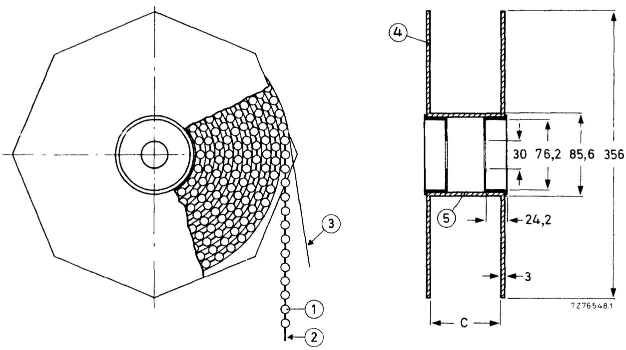


Fig. 64 Style 1 capacitors (case sizes 1 to 7) on bandoliers on reel; dimension C is 83,5 mm for case sizes 1, 2, 3 and 5a, and 88,5 mm for case sizes 4, 5, 6 and 7; the overall width of the reel is 94,5 mm and 99,5 mm respectively.

1 = capacitor
2 = bandolier
3 = paper
4 = flange
5 = cylinder

TESTS AND REQUIREMENTS

See Introduction, section 9, under aluminium electrolytic capacitors, with the following addition for **case sizes 1 to 7**.

After *endurance test, 2000 h (1000 h for case size 1), 85 °C,* the capacitors meet the following requirements:

$\Delta C/C \leqslant \pm$ 15%, for U_R = 10 to 100 V;

$\Delta C/C \leqslant +$ 15%, −25% for U_R = 6,3 V;

tan $\delta \leqslant$ 130% of specified value;

d.c. leakage current $\leqslant$ specified value;

impedance at 10 kHz $\leqslant$ 200% of specified value.

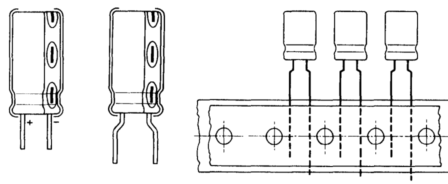
After *shelf life test, 500 h, 85 °C,* the capacitors meet the same requirements as after endurance test. The rated voltage shall be applied to the capacitors for minimum 30 min, at least 24 h and not more than 48 h before measurements.

Note:

Capacitors 2222 030, case size 1 are miniature types, general-purpose grade.
Capacitors 2222 030 and 2222 031, case sizes 2 to 7, are miniature types, long-life grade.
Capacitors 2222 032 and 2222 033 are small types, long-life grade.

ALUMINIUM ELECTROLYTIC CAPACITORS

- **Miniature and small types**
- **Single ended**
- **General applications**



QUICK REFERENCE DATA

Nominal capacitance range (E6 series):	0,10 to 4700 μF
Tolerance on nominal capacitance:	−20 to +20%*
Rated voltage range, U_R (R5 series):	6,3 to 100 V
Category temperature range:	−40 to +85 °C
Endurance test at 85 °C:	1000 h
Shelf life at 0 V, 85 °C:	500 h
Basic specifications: IEC 384-4, G.P. grade; DIN 41332/DIN 41259	
Climatic category:	
IEC 68:	40/085/56
DIN 40040:	GPF

* ± 10% to special order.

Selection chart for C_{nom} − U_R and relevant case sizes.

C_{nom} μF	U_R (V) 6,3	10	16	25	35	40	50	63	100
0,10								11	
0,15								11	
0,22								11	11
0,33								11	
0,47								11	11
0,68								11	
1								11	11
1,5								11	11
2,2								11	11
3,3								11	11
4,7								11	12
6,8								11	12
10							11	12	13
15						11		12	13
22					11	12	12	13	14
33			11			12		13	15
47		11		12			13	14	16
68			12			13	14	15	17
100		12		13	14		15	16	18
150	12		13	14		15	16	17	18
220		13	14	15		16	17	18	19
330	13	14	15	16		17	18	19	20
470		15	16	17		18		19	
680	15	16	17	18		19	19	20	
1000	16	17	18	19	19		20		
1500	17	18	19	20					
2200	18		19	20					
3300	19		20						
4700	20								

case size	nominal dimensions (mm)
11	ϕ 5 x 11
12	ϕ 6 x 11
13	ϕ 8 x 12
14	ϕ 10 x 12
15	ϕ 10 x 16
16	ϕ 10 x 20
17	ϕ 12,5 x 20
18	ϕ 12,5 x 25
19	ϕ 16 x 25
20	ϕ 16 x 31

APPLICATION

These capacitors with high CU-product per unit volume are mainly used for smoothing, coupling and decoupling purposes in consumer applications, such as audio and television circuits. Other applications are in timing and delay circuits. The taped versions are suitable for automatic insertion and for cutting and forming equipment.

DESCRIPTION

The capacitor has etched and oxidized aluminium foil electrodes rolled up with a paper strip impregnated with an electrolyte. The capacitor is in an insulated aluminium case.

MECHANICAL DATA

Dimensions in mm

The capacitor is available in 5 styles:
style 1: long leads; in boxes;
style 2: straight short leads; non preferred, in boxes;
style 3: bent short leads only case sizes 11, 12 and 13; non preferred, in boxes;
style 4: long leads; on tape on reel, positive leading; only case sizes 11 to 13;
style 5: long leads; on tape in ammunition pack; only case sizes 11 to 13.

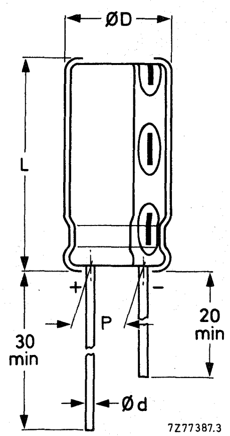


Fig. 1 Style 1; see Table 1 for dimensions d, D, L and P.

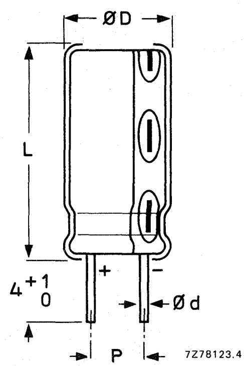


Fig. 2 Style 2; non preferred, see Table 1 for dimensions d, D, L and P.

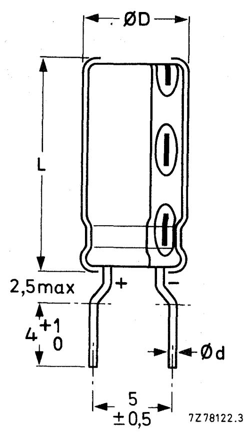
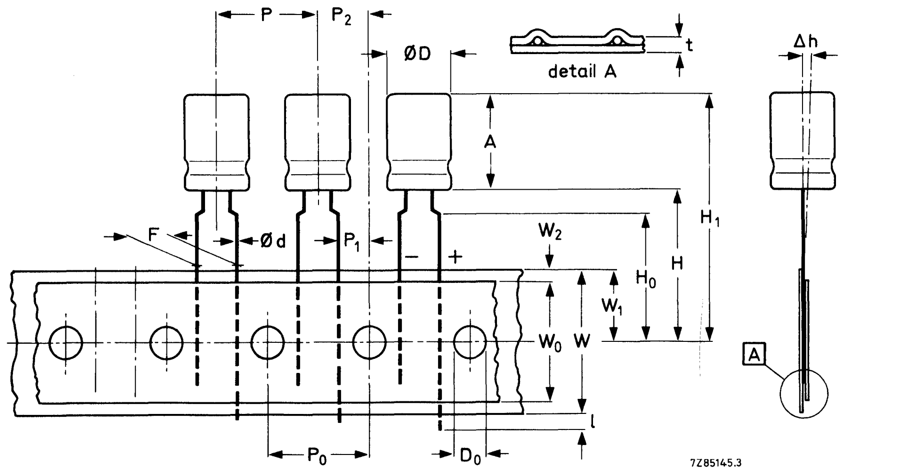


Fig. 3 Style 3, case sizes 11, 12 and 13; non preferred, see Table 1 for dimensions d, D and L.

Table 1

case size	d	D_{max}	L_{max}	P		mass g
11	0,5*	5,5	12,0	2,0		0,4
12	0,6	6,5	12,0	2,5		0,6
13	0,6	8,5	12,5	3,5	± 0,5	1,1
14	0,6	10,5	12,5	5,0		1,6
15	0,6	10,5	17,0	5,0		1,9
16	0,6	10,5	21,0	5,0		2,2
17	0,6	13,0	21,0	5,0		4,0
18	0,6	13,0	26,0	5,0	± 0,5	5,0
19	0,8	16,5	26,0	7,5		8,0
20	0,8	16,5	32,0	7,5		9,0

* 0,6 mm under consideration.



→ direction of tape transport (positive leading) ←

Fig. 4 Styles 4 and 5, case sizes 11 to 13; see Table 2 for dimensions.
Negative-leading tapes are available to special order.

Table **2**

	symbol	case size			tol.
		11	12	13	
Body diameter	D	5,5	6,5	8,5	max.
Body height	A	12,0	12,0	12,5	max.
Lead-wire diameter	d	0,5*	0,6	0,6	± 0,05
Pitch of component	P	12,7	12,7	12,7	± 1,0
Feed-hole pitch	P_0	12,7	12,7	12,7	± 0,2**
Hole centre to lead	P_1	3,85	3,85	3,85	± 0,5
Feed hole centre to component centre	P_2	6,35	6,35	6,35	± 1,0
Lead-to-lead distance	F	5,0	5,0	5,0	+ 0,6/−0
Component alignment	Δh	0	0	0	± 1,0
Tape width	W	18,0	18,0	18,0	± 0,5
Hold-down tape width	W_0	12,5	12,5	12,5	min. ***
Hole position	W_1	9,0	9,0	9,0	± 0,5
Hold-down tape position	W_2	2,5	2,5	2,5	max.
Height of component from tape centre	H	18,0	18,0	18,0	+ 1,5/−0
Lead-wire clinch height	H_0	16,0	16,0	16,0	± 0,5
Component height	H_1	32,0	32,0	32,0	max.
Lead-wire protrusion	l	2,0	2,0	2,0	max.
Feed-hole diameter	D_0	4,0	4,0	4,0	± 0,2
Total tape thickness	t	0,9	0,9	0,9	max.

* 0,6 mm under consideration.
** Cumulative pitch error: ± 1 mm/20 pitches.
*** Other widths under consideration.

Marking

The capacitors are marked with: nominal capacitance, rated voltage, a symbol to identify the negative terminal, group number (035), code for factory of origin, name of manufacturer and date code (year and month) according to IEC 62.

Minimum atmospheric pressure 8,5 kPa

PRODUCT SAFETY

Non-solid electrolytic capacitors may contain chemicals which can be regarded as hazardous if incorrectly handled. Caution is necessary should the outer case be fractured.

ELECTRICAL DATA

Unless otherwise specified all electrical values in Table 3 apply at an ambient temperature of 20 to 25 ^{o}C, a frequency of 100 Hz, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 45 to 75%.

Table 3

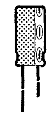
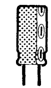
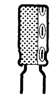
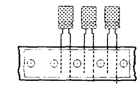
U_R	nom. cap.	max. r.m.s. ripple current at T_{amb} = 85 °C	max. d.c. leakage current at U_R after 1 min	max. tan δ	max. impedance (Ω) at T_{amb} = 20 °C		case size	catalogue number 2222 035 followed by				
					at 1 kHz	at 10 kHz		 style 1	 style 2	 style 3	 on reel style 4	in ammopack style 5
V	μF	mA	μA									
6,3	150	260	22	0,24		1,33	12	53151	83151	63151	23151	33151
	330	320	45	0,24		0,61	13	53331	83331	63331	23331	33331
	680	460	89	0,24		0,29	15	53681	63681			
	1000	530	129	0,24		0,20	16	53102	63102			
	1500	640	192	0,24	0,23	0,13	17	53152	63152			
	2200	800	280	0,24	0,16	0,09	18	53222	63222			
	3300	850	419	0,24	0,11	0,06	19	53332	63332			
	4700	960	595	0,24	0,07	0,04	20	53472	63472			
10	47	100	12	0,20		3,40	11	54479	84479	64479	24479	34479
	100	160	23	0,20		1,60	12	54101	84101	64101	24101	34101
	220	250	47	0,20		0,73	13	54221	84221	64221	24221	34221
	330	340	69	0,20		0,48	14	54331	64331			
	470	400	97	0,20		0,34	15	54471	64471			
	680	480	139	0,20		0,24	16	54681	64681			
	1000	580	203	0,20		0,16	17	54102	64102			
	1500	720	303	0,20	0,2	0,11	18	54152	64152			
16	33	90	14	0,16		3,64	11	55339	85339	65339	25339	35339
	68	180	25	0,16		1,76	12	55689	85689	65689	25689	35689
	150	270	51	0,16		0,80	13	55151	85151	65151	25151	35151
	220	320	73	0,16		0,55	14	55221	65221			
	330	405	109	0,16		0,36	15	55331	65331			
	470	480	153	0,16		0,26	16	55471	65471			
	680	590	221	0,16		0,18	17	55681	65681			
	1000	700	323	0,16		0,12	18	55102	65102			
	1500	820	483	0,16	0,17	0,08	19	55152	65152			
	2200	1000	707	0,16	0,11	0,05	19	55222	65222			
	3300	1200	1059	0,16	0,08	0,04	20	55332	65332			

Table 3 (continued)

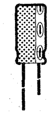
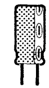
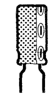
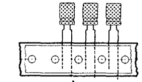
U_R	nom. cap.	max. r.m.s. ripple current at T_{amb} = 85 °C	max. d.c. leakage current at U_R after 1 min	max. tan δ	max. impedance (Ω) at T_{amb} = 20 °C		case size	catalogue number 2222 035 followed by				
					at 1 kHz	at 10 kHz		 style 1	 style 2	 style 3	 on reel style 4	in ammopack style 5
V	µF	mA	µA									
25	47	140	27	0,14		1,91	12	56479	86479	66479	26479	36479
	100	230	53	0,14		0,90	13	56101	86101	66101	26101	36101
	150	330	78	0,14		0,60	14	56151	66151			
	220	400	113	0,14		0,41	15	56221	66221			
	330	500	168	0,14		0,27	16	56331	66331			
	470	600	238	0,14		0,19	17	56471	66471			
	680	710	343	0,14		0,13	18	56681	66681			
	1000	850	503	0,14		0,09	19	56102	66102			
	1500	1000	753	0,14	0,15	0,06	20	56152	66152			
	2200	1200	1103	0,14	0,10	0,04	20	56222	66222			
35	22	90	18	0,12		3,41	11	90003	90004	90005	90034	90085
	100	280	73	0,12		0,75	14	90059	90081			
	1000	1050	703	0,12		0,08	19	90006	90007			
40	15	70	15	0,12		4,67	11	57159	87159	67159	27159	37159
	22	90	21	0,12		3,18	12	57229	87229	67229	27229	37229
	33	140	29	0,12		2,12	12	57339	87339	67339	27339	37339
	68	200	57	0,12		1,03	13	57689	87689	67689	27689	37689
	150	320	123	0,12		0,47	15	57151	67151			
	220	470	179	0,12		0,32	16	57221	67221			
	330	590	267	0,12		0,21	17	57331	67331			
	470	800	379	0,12		0,15	18	57471	67471			
	680	960	547	0,12		0,10	19	57681	67681			
50	10	60	13	0,10		6,00	11	90008	90009	90011	90035	90087
	22	100	25	0,10		2,73	12	90012	90013	90014	90036	90088
	47	180	50	0,10		1,28	13	90015	90016	90033	90037	90038
	68	260	71	0,10		0,88	14	90017	90018			
	100	320	103	0,10		0,60	15	90019	90021			
	150	410	153	0,10		0,40	16	90022	90023			
	220	500	223	0,10		0,27	17	90024	90025			
	330	650	333	0,10		0,18	18	90026	90027			
	680	980	683	0,10		0,09	19	90028	90029			
	1000	1100	1003	0,10		0,06	20	90031	90032			

Table 3 (continued)

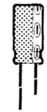
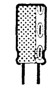
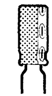
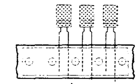
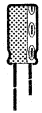
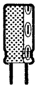
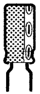
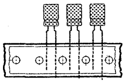
U_R	nom. cap.	max. r.m.s. ripple current at T_{amb} = 85 °C	max. d.c. leakage current at U_R after 1 min	max. tan δ	max. impedance (Ω) at T_{amb} = 20 °C		case size	catalogue number 2222 035 followed by				
					at 1 kHz	at 10 kHz		 style 1	 style 2	 style 3	 on reel style 4	in ammopack style 5
V	µF	mA	µA									
63	0,10	3,5	3	0,08		550	11	58107	88107	68107	28107	38107
	0,15	4,5	3	0,08		367	11	58157	88157	68157	28157	38157
	0,22	6	3	0,08		250	11	58227	88227	68227	28227	38227
	0,33	7	3	0,08		167	11	58337	88337	68337	28337	38337
	0,47	8	4	0,08		117	11	58477	88477	68477	28477	38477
	0,68	10	4	0,08		81	11	58687	88687	68687	28687	38687
	1,0	12	4	0,08		55,0	11	58108	88108	68108	28108	38108
	1,5	16	5	0,08		36,7	11	58158	88158	68158	28158	38158
	2,2	22	6	0,08		25,0	11	58228	88228	68228	28228	38228
	3,3	32	7	0,08		16,7	11	58338	88338	68338	28338	38338
	4,7	40	9	0,08		11,7	11	58478	88478	68478	28478	38478
	6,8	55	12	0,08		8,09	11	58688	88688	68688	28688	38688
	10	70	16	0,08		5,50	12	58109	88109	68109	28109	38109
	15	98	22	0,08		3,67	12	58159	88159	68159	28159	38159
	22	120	31	0,08		2,50	13	58229	88229	68229	28229	38229
	33	160	45	0,08		1,67	13	58339	88339	68339	28339	38339
	47	200	62	0,08		1,17	14	58479	68479			
	68	280	89	0,08		0,81	15	58689	68689			
	100	360	129	0,08		0,55	16	58101	68101			
	150	480	192	0,08		0,37	17	58151	68151			
	220	600	280	0,08		0,25	18	58221	68221			
	330	750	419	0,08		0,17	19	58331	68331			
	470	900	595	0,08		0,12	19	58471	68471			
	680	1040	860	0,08		0,08	20	58681	68681			

Table 3 (continued)

U_R	nom. cap.	max. r.m.s. ripple current at T_{amb} = 85 °C	max. d.c. leakage current at U_R after 1 min	max. tan δ	max. impedance (Ω) at T_{amb} = 20 °C		case size	catalogue number 2222 035 followed by				
					at 1 kHz	at 10 kHz		 style 1	 style 2	 style 3	 on reel style 4	in ammopack style 5
V	μF	mA	μA									
100	0,22	10	3	0,07		205	11	59227	89227	69227	29227	39227
	0,47	12	4	0,07		95,7	11	59477	89477	69477	29477	39477
	1,0	15	5	0,07		45,0	11	59108	89108	69108	29108	39108
	1,5	20	6	0,07		30,0	11	59158	89158	69158	29158	39158
	2,2	27	7	0,07		20,5	11	59228	89228	69228	29228	39228
	3,3	35	10	0,07		13,6	11	59338	89338	69338	29338	39338
	4,7	45	12	0,07		9,57	12	59478	89478	69478	29478	39478
	6,8	59	17	0,07		6,62	12	59688	89688	69688	29688	39688
	10	80	23	0,07		4,50	13	59109	89109	69109	29109	39109
	15	105	33	0,07		3,00	13	59159	89159	69159	29159	39159
	22	140	47	0,07		2,05	14	59229	69229			
	33	180	69	0,07		1,36	15	59339	69339			
	47	240	97	0,07		0,96	16	59479	69479			
	68	340	139	0,07		0,66	17	59689	69689			
	100	440	203	0,07		0,45	18	59101	69101			
	150	630	303	0,07		0,30	18	59151	69151			
	220	800	443	0,07		0,20	19	59221	69221			
	330	900	663	0,07		0,14	20	59331	69331			

Capacitance

Nominal capacitance at 100 Hz and T_{amb} = 20 °C	see Table 3
Tolerance on nominal capacitance at 100 Hz	−20 to +20%

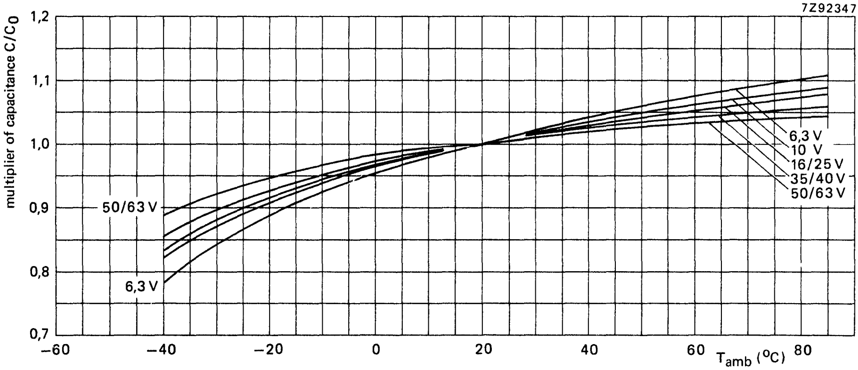


Fig. 5 Typical multiplier of capacitance as a function of ambient temperature; C_0 = capacitance at 20 °C, 100 Hz.

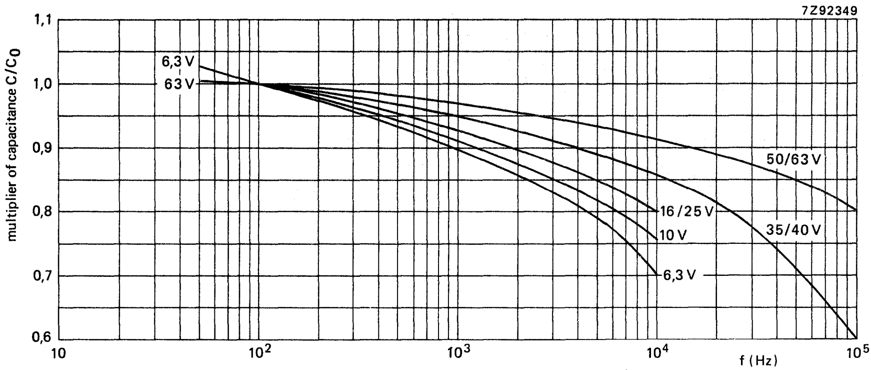


Fig. 6 Typical multiplier of capacitance as a function of frequency; C_0 = capacitance at 20 °C, 100 Hz.

Voltage

→

	core temperature ▲ $< 50\ ^{o}C$	50 to 95 ^{o}C
Rated voltage = max. permissible voltage	1,15 x U_R	U_R
Ripple voltage* = max. permissible a.c. voltage providing the following three conditions are met:		
a) max. (d.c. + peak a.c.) voltage	1,15 x U_R	U_R
b) max. peak a.c. voltage without d.c. voltage applied	2 V	
c) momentary value of applied voltage	between U_R and −2 V	
Surge voltage = max. permissible voltage for short periods	1,15 x U_R	
Reverse voltage = max. d.c. voltage applied in the reverse polarity for short periods	2 V	

Ripple current**

Maximum permissible r.m.s. ripple current at 100 Hz and T_{amb} = 85 ^{o}C — see Table 3

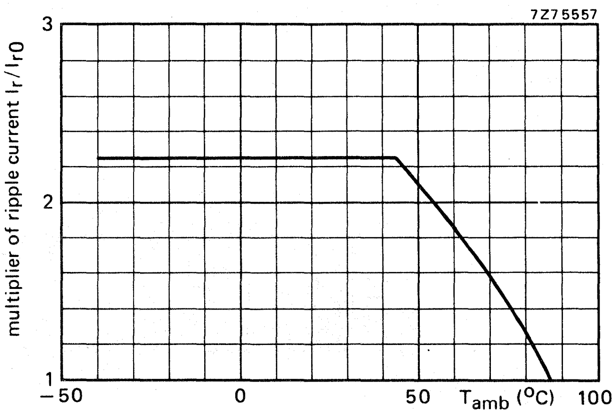


Fig. 7 Typical multiplier of ripple current as a function of ambient temperature; I_{r0} = ripple current at 85 ^{o}C, 100 Hz.

▲ See Introduction, section 5, "Ripple current".

* Ripple voltages are not applicable if the maximum permissible ripple current is exceeded. In that case the ripple current is decisive.

** Ripple currents are not applicable if the maximum permissible ripple voltage is exceeded. In that case the ripple voltage is decisive.

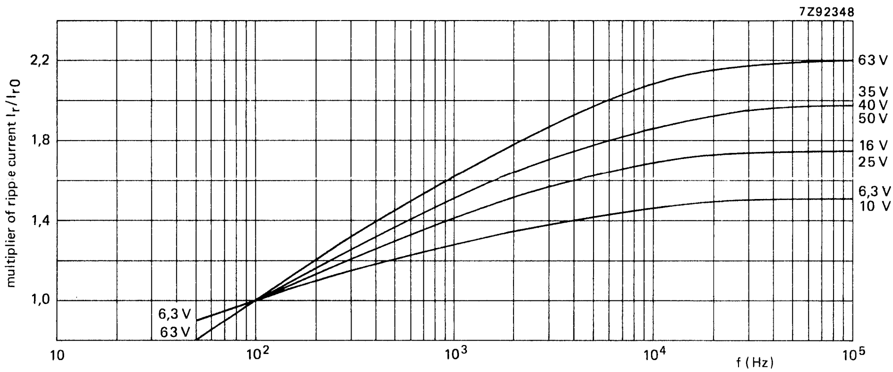


Fig. 8 Typical multiplier of ripple current as a function of frequency;
I_{r0} = ripple current at 85 °C; 100 Hz.

Non-sinusoidal ripple currents have to be analyzed into a number of sinusoidal currents and the following requirements shall then be satisfied:

$$\sum_n \frac{I_n^2}{r_n} \leq I_{r\,max}^2$$

$I_{r\,max}$ = maximum ripple current at 100 Hz and applicable ambient temperature;
I_n = ripple current at a certain frequency;
$\sqrt{r_n} = I_r/I_{r0}$ = multiplying factor at a same frequency.

Charge and discharge current

The capacitors may be charged from a source without internal resistance and they may be discharged by short-circuiting. If the capacitors are charged and discharged continuously several times per minute, the charge and discharge currents have to be considered as ripple currents flowing through the capacitor. The r.m.s. value of these currents should be determined and the value thus found must not exceed the applicable limit. (See also Tests and requirements.)

D.C. leakage current ←

Maximum d.c. leakage current 1 min after application of U_R at T_{amb} = 20 °C	see Table 3 (0,02 CU + 3 μA)
D.C. leakage current during continuous operation at U_R,	
at T_{amb} = 25 °C	approx. 0,1 x value stated in Table 3
at T_{amb} = 85 °C	$\leq$ value stated in Table 3

If owing to prolonged storage and/or storage at an excessive temperature (> 40 °C) the d.c. leakage current is too high, application of the rated voltage for some hours will cause the d.c. leakage current to fall to a value lower than specified in Table 3.

Tan δ (dissipation factor)

Maximum tan δ at 100 Hz and T_{amb} = 25 °C, measured by means of a four-terminal circuit (Thomson circuit) — see Table 3

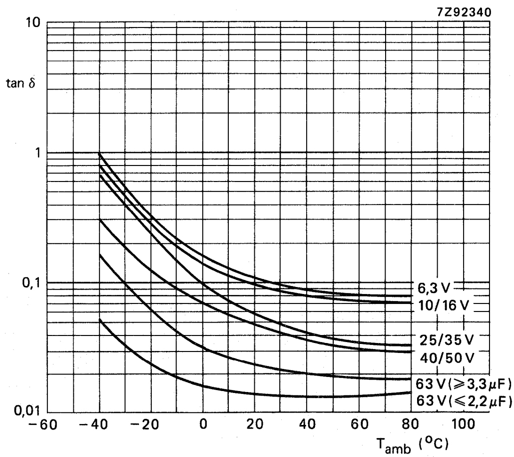


Fig. 9 Typical tan δ at 100 Hz as a function of ambient temperature.

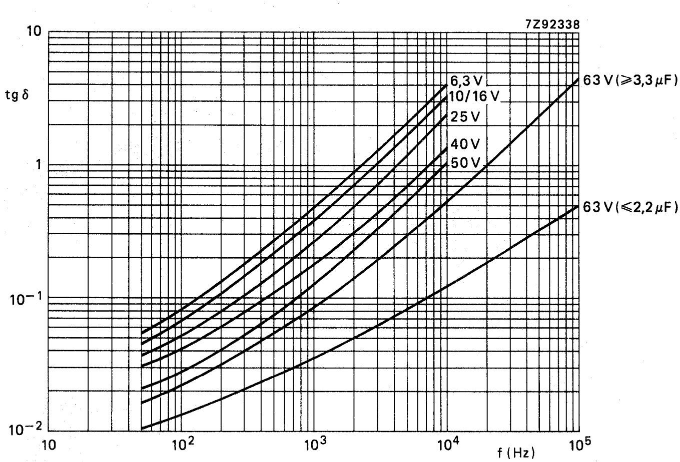


Fig. 10 Typical tan δ as a function of frequency at T_{amb} = 20 °C.

Equivalent series resistance (ESR)

ESR = tan $\delta/\omega C$
Maximum tan δ and C at 100 Hz and T_{amb} = 25 °C — see Table 3

Equivalent series inductance (ESL)

Case sizes 11, 12, 13	typ. 13 nH
Case sizes 14, 15, 16	typ. 16 nH
Case sizes 17, 18, 19, 20	typ. 18 nH

Impedance (Z)

Maximum impedance at T_{amb} = 20 °C and 10 kHz and 1 kHz ($C_{nom} > 1000\ \mu F$), measured by means of a four-terminal circuit (Thomson circuit) — see Table 3

$z = Z \times C_{nom}$ — see Table 4

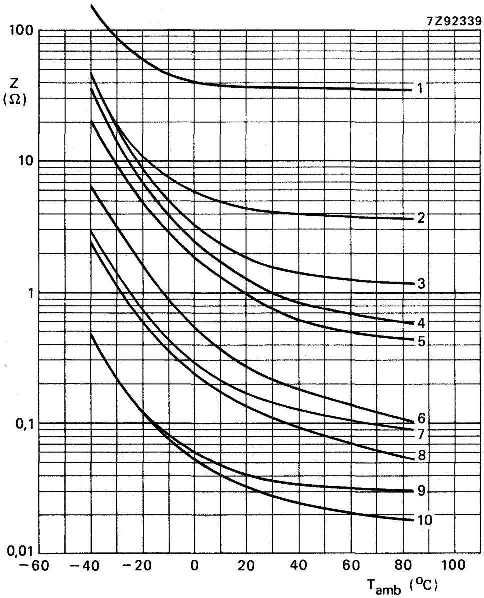
Maximum ratio between impedances at T_{amb} = −25 °C and + 20 °C, and at T_{amb} = −40 °C and + 20 °C, at 100 Hz measured by means of a four-terminal circuit (Thomson circuit) — see Table 5

Table 4

	T_{amb}	$z = Z \times C_{nom}$ ($\Omega\ \mu F$) at U_R								
		6,3 V	10 V	16 V	25 V	35 V	40 V	50 V	63 V	100 V
$C_{nom} > 1000\ \mu F$, measured at 1 kHz	+20 °C	350	300	250	220	–	200	–	180	175
	−25 °C	1700	1100	800	570	–	430	–	330	300
	−40 °C	4500	2800	2000	1400	–	1100	–	800	700
$C_{nom} \leqslant 1000\ \mu F$, measured at 10 kHz	+20 °C	200	160	120	90	75	70	60	55	45
	−25 °C	1200	750	560	400	330	300	220	180	130
	−40 °C	3200	2000	1500	1100	950	900	700	500	350

Table 5

	maximum impedance ratio at U_R and 100 Hz								
	6,3 V	10 V	16 V	25 V	35 V	40 V	50 V	63 V	100 V
$\frac{Z \text{ at } -25\,°C}{Z \text{ at } +20\,°C}$	4	3	2	2	2	2	2	2	2
$\frac{Z \text{ at } -40\,°C}{Z \text{ at } +20\,°C}$	7	5	5	4	4	4	4	4	4



Curve 1 = 0,47 μF; 63 V;
curve 2 = 4,7 μF; 63 V;
curve 3 = 15 μF; 40 V;
curve 4 = 47 μF; 10 V;
curve 5 = 47 μF; 25 V;
curve 6 = 330 μF; 6,3 V;
curve 7 = 150 μF; 6,3 V;
curve 8 = 680 μF; 6,3 V;
curve 9 = 680 μF; 50 V;
curve 10 = 4700 μF; 6,3 V.

Fig. 11 Typical impedance at 10 kHz as a function of ambient temperature.

Curve 1 = 0,47 μF; 6,3 V;
curve 2 = 4,7 μF; 63 V;
curve 3 = 15 μF; 40 V;
curve 4 = 47 μF; 10 V;
curve 5 = 47 μF; 25 V;
curve 6 = 47 μF; 63 V;
curve 7 = 330 μF; 6,3 V.

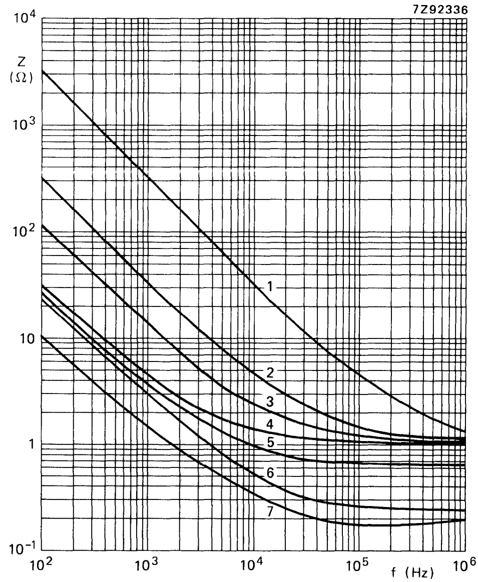


Fig. 12 Typical impedance as a function of frequency at T_{amb} = 20 °C.

Curve 1 = 150 μF; 63 V;
curve 2 = 680 μF; 6,3 V;
curve 3 = 680 μF; 50 V;
curve 4 = 4700 μF; 6,3 V.

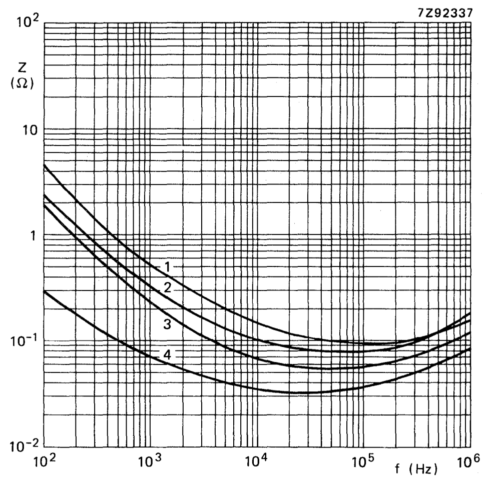


Fig. 13 Typical impedance as a function of frequency at T_{amb} = 20 °C.

OPERATIONAL DATA

Category temperature range	−40 to +85 °C
Typical life time	
at T_{amb} = 40 °C	50 000 h
at T_{amb} = 85 °C	2000 h
at T_{amb} = 95 °C	1000 h
at T_{amb} = 105 °C	500 h
Shelf life at 0 V and T_{amb} = 85 °C	500 h

PACKING

Capacitors of styles 1, 2 and 3 are supplied in boxes, those of styles 4 and 5 on tape on reel and in ammunition pack respectively. The numbers per box, per reel and per ammunition pack are given in Table 6.

Table 6

case size	number of capacitors				
	style 1 per box	style 2 per box	style 3 per box	style 4 per reel	style 5 per ammunition pack
11	1000	1000	1000	1000	2000
12	1000	1000	1000	1000	2000
13	1000	1000	1000	500	1000
14	1000	1000			
15	500	500			
16	500	500			
17	200	200			
18	200	200			
19	200	200			
20	200	200			

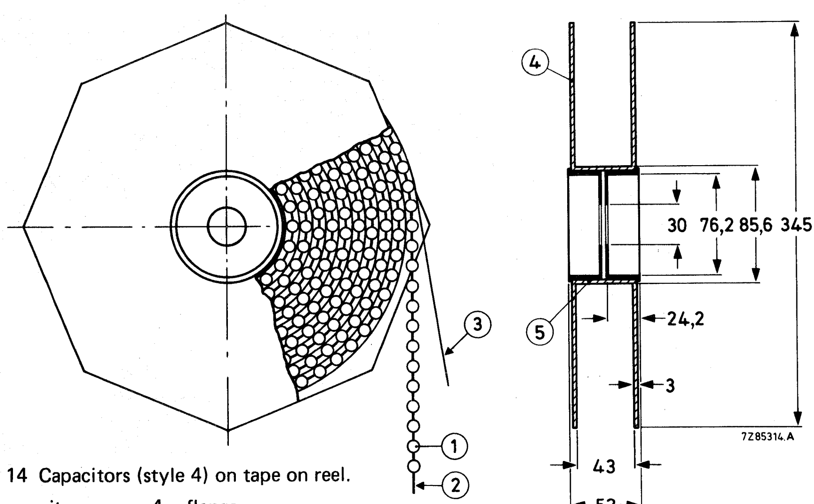


Fig. 14 Capacitors (style 4) on tape on reel.

1 = capacitor
2 = tape
3 = paper
4 = flange
5 = cylinder

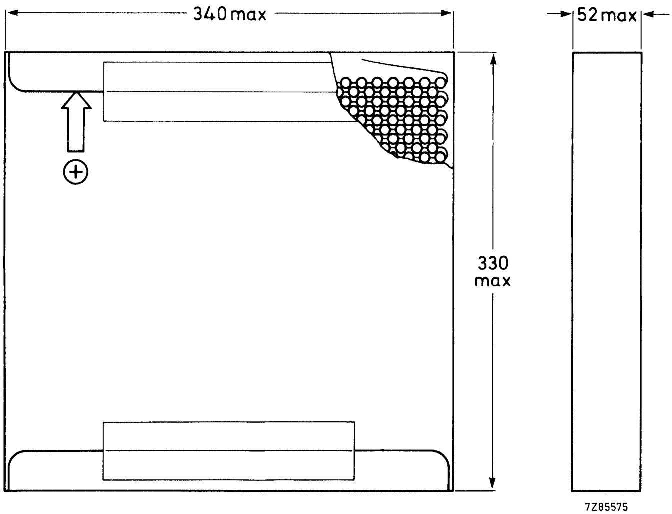


Fig. 15 Capacitors (style 5) on tape in ammunition pack.

TESTS AND REQUIREMENTS

See Introduction, section 9, under aluminium electrolytic capacitors.

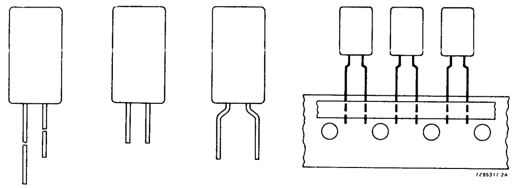
After *shelf life test, 500 h, 85 °C,* the capacitors meet the same requirements as after endurance test, except for d.c. leakage current of the 100 V range: ≤200% of specified value. The rated voltage shall be applied to the capacitors for minimum 30 min, at least 24 h and not more than 48 h before measurements.

Note: Capacitors 2222 035 are miniature and small, general-purpose grade.

For low-leakage version, see 2222 013; for high-temperature version, see 2222 116.

ALUMINIUM ELECTROLYTIC CAPACITORS

- **Miniature type**
- **Single ended**
- **Long life**
- **General and industrial applications**



QUICK REFERENCE DATA

Nominal capacitance range (E6 series)	0,15 to 470 µF
Tolerance on nominal capacitance	−20 to + 20%*
Rated voltage range, U_R (R5 series)	6,3 to 63 V
Category temperature range	−55 to + 85 °C
Endurance test at 85 °C	2000 h
Shelf life at 0 V, 85 °C	500 h
Basic specification	IEC384-4, long-life grade DIN41332/DIN41259
Climatic category	
IEC68	55/085/56
DIN40040	FPF

Selection chart for C_{nom}-U_R and relevant case sizes.

C_{nom} µF	U_R (V) 6,3	10	16	25	35	40	50	63
0,15								11
0,22								11
0,33								11
0,47								11
0,68								11
1								11
1,5								11
2,2								11
3,3								11
4,7								11
6,8								11
10							11	11
15						11		
22					11			11
33			11				11	13
47		11			11		13	13
68		11		11		13		13
100	11		11	13			13	
150		11	13		13			
220		13	13	13				
330	13		13					
470		13						

case size	nominal dimensions (mm)
11	φ 5 x 11
13	φ 8,2 x 11

* ± 10% to special order.

APPLICATION

These capacitors with extremely high CV product to volume ratio are mainly used for smoothing, coupling and decoupling purposes in consumer applications, such as audio and television circuits, and in industrial applications, such as measuring and regulating circuits. Other applications are timing and delay circuits. The taped versions are suitable for automatic insertion and for cutting and forming equipment.

DESCRIPTION

The capacitor has etched and oxidised aluminium foil electrodes rolled up with a paper strip impregnated with an electrolyte. The capacitor is in all-insulated aluminium case.

MECHANICAL DATA

Dimensions in mm

The capacitor is available in 5 styles:
style 1: long leads; in boxes;
style 2: straight short leads; non preferred, in boxes;
style 3: bent short leads (only case size 11); non preferred, in boxes;
style 4: long leads; on tape on reel, positive leading;
style 5: long leads; on tape in ammunition pack.

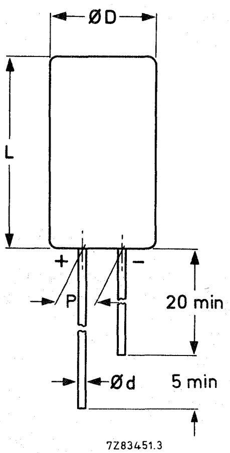


Fig. 1 Style 1; see Table 1 for dimensions d, D, L and P.

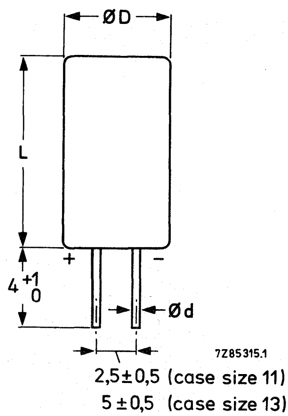


Fig. 2 Style 2; non preferred, see Table 1 for dimensions d, D and L.

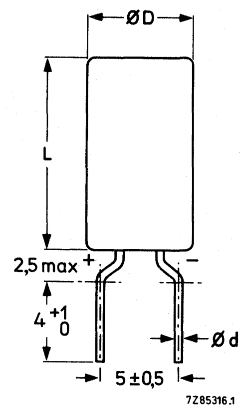
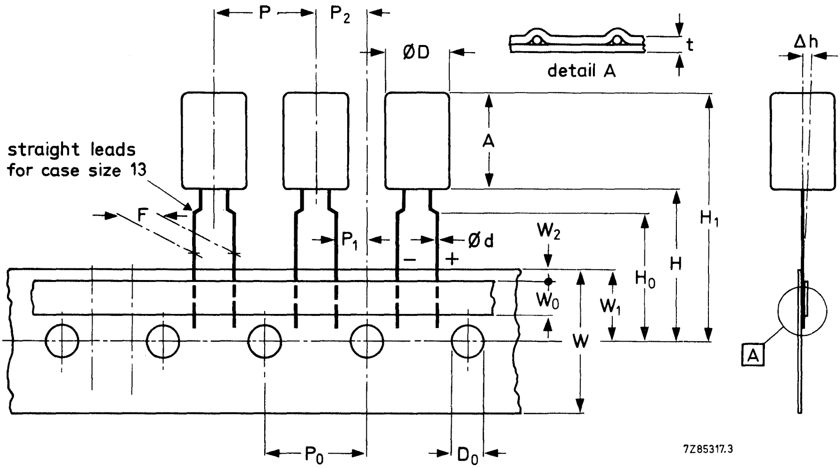


Fig. 3 Style 3; case size 11 only; non preferred, see Table 1 for dimensions d, D and L.

Table 1

case size	dimensions				mass approx. g
	d	D_{max}	L_{max}	P	
11	0,5*	5,5	12,0	2,5	0,4
13	0,6	8,7	12,0	5,0	1,1

* 0,6 mm under consideration.



→ direction of tape transport (positive leading) ←

Fig. 4 Styles 4 and 5; see Table 2 for dimensions.
Negative-leading tapes are available to special order.

Table 2

	symbol	case size		tol.
		11	13	
Body diameter	D	5,5	8,7	max.
Body height	A	12,0	12,0	max.
Lead-wire diameter	d	0,5*	0,6	± 0,05
Pitch of component	P	12,7	12,7	± 1,0
Feed-hole pitch	P_0	12,7	12,7	± 0,2**
Hole centre to lead	P_1	3,85	3,85	± 0,5
Feed hole centre to component centre	P_2	6,35	6,35	± 0,7
Lead-to-lead distance	F	5,0	5,0	+ 0,6/–0
Component alignment	Δh	0	0	± 1,0
Tape width	W	18,0	18,0	± 0,5
Hold-down tape width	W_0	6,0	6,0	min.
Hole position	W_1	9,0	9,0	± 0,5
Hold-down tape position	W_2	2,5	2,5	max.
Height of component from tape centre	H	18,0	18,0	+ 1,5/–0
Lead-wire clinch height	H_0	16,0	–	± 0,5
Component height	H_1	32,0	32,0	max.
Feed-hole diameter	D_0	4,0	4,0	± 0,2
Total tape thickness	t	0,9	0,9	max.

* 0,6 mm under consideration.
** Cumulative pitch error: ± 1 mm/20 pitches.

Marking

The capacitors are marked as follows:

on the top

- nominal capacitance;
- code letter for tolerance on nominal capacitance, according to IEC62;
- rated voltage;
- polarity identification.

on the circumference

- name of manufacturer;
- group number (036);
- code letter of manufacturer;
- date code (year and month) according to IEC 62.

Minimum atmospheric pressure 8,5 kPa

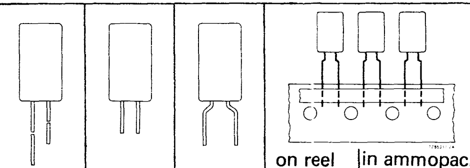
PRODUCT SAFETY

Non-solid electrolytic capacitors may contain chemicals which can be regarded as hazardous if incorrectly handled. Caution is necessary should the outer case be fractured.

ELECTRICAL DATA

Unless otherwise specified all electrical values in Table 3 apply at an ambient temperature of 20 to 25 °C, a frequency of 100 Hz, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 45 to 75%.

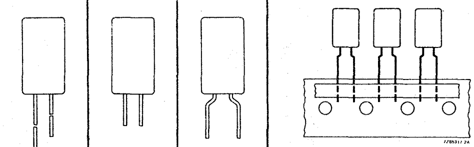
Table 3



U_R V	nom. cap. µF	max. r.m.s. ripple current at T_{amb} = 85 °C mA	max. d.c. leakage current at U_R after 1 min. µA	max. tan δ	case size*	catalogue number 2222 036 followed by				
						style 1	style 2	style 3	on reel style 4	in ammopack style 5
6,3	100	80	7	0,20	11	53101	83101	63101	23101	33101
	330	180	16	0,20	13	53331	63331		23331	33331
10	47	60	6	0,16	11	54479	84479	64479	24479	34479
	68	70	7	0,16	11	54689	84689	64689	24689	34689
	150	95	12	0,20	11	54151	84151	64151	24151	34151
	220	170	17	0,16	13	54221	64221		24221	34221
	470	230	31	0,20	13	54471	64471		24471	34471
16	33	55	7	0,14	11	55339	85339	65339	25339	35339
	100	90	13	0,16	11	55101	85101	65101	25101	35101
	150	150	18	0,14	13	55151	65151		25151	35151
	220	180	24	0,14	13	55221	65221		25221	35221
	330	210	35	0,16	13	55331	65331		25331	35331
25	68	80	13	0,14	11	56689	86689	66689	26689	36689
	100	130	18	0,12	13	56101	66101		26101	36101
	220	180	36	0,14	13	56221	66221		26221	36221
35	22	50	8	0,10	11	90001	90002	90003	90016	90027
	47	70	13	0,12	11	90094	90095	90096	90097	90098
	150	160	35	0,12	13	90099	90101		90102	90103
40	15	45	7	0,10	11	57159	87159	67159	27159	37159
	68	120	20	0,10	13	57689	67689		27689	37689
50	10	40	6	0,08	11	90004	90005	90006	90017	90028
	33	65	13	0,10	11	90104	90105	90106	90107	90108
	47	110	18	0,08	13	90011	90012		90019	90031
	100	150	33	0,10	13	90109	90111		90112	90113

* Case size 11: ϕ5 mm x 11 mm; case size 13; ϕ8,2 mm x 11 mm (nominal dimensions).

Table 3 (continued)



U_R V	nom. cap. µF	max. r.m.s. ripple current at T_{amb} = 85 °C mA	max. d.c. leakage current at U_R after 1 min. µA	max. tan δ	case size*	catalogue number 2222 036 followed by				
						style 1	style 2	style 3	on reel style 4	in ammopack style 5
63	0,15	5	4	0,08	11	58157	88157	68157	28157	38157
	0,22	6,5	4	0,06	11	58227	88227	68227	28227	38227
	0,33	8	4	0,06	11	58337	88337	68337	28337	38337
	0,47	9,5	4	0,06	11	58477	88477	68477	28477	38477
	0,68	11	4	0,06	11	58687	88687	68687	28687	38687
	1,0	13,5	4	0,06	11	58108	88108	68108	28108	38108
	1,5	16,5	4	0,06	11	58158	88158	68158	28158	38158
	2,2	20	4	0,06	11	58228	88228	68228	28228	38228
	3,3	25	5	0,06	11	58338	88338	68338	28338	38338
	4,7	30	5	0,06	11	58478	88478	68478	28478	38478
	6,8	40	6	0,06	11	58688	88688	68688	28668	38688
	10	45	7	0,06	11	58109	88109	68109	28109	38109
	22	55	11	0,08	11	58229	88229	68229	28229	38229
	33	110	16	0,06	13	58339	68339		28339	38339
	47	120	21	0,07	13	58479	68479		28479	38479
	68	140	29	0,08	13	58689	68689		28689	39689

* Case size 11: ϕ5 mm x 11 mm; case size 13: ϕ8,2 mm x 11 mm (nominal dimensions).

Capacitance

Nominal capacitance at 100 Hz and T_{amb} = 20 °C	see Table 3
Tolerance on nominal capacitance at 100 Hz	–20 to + 20%

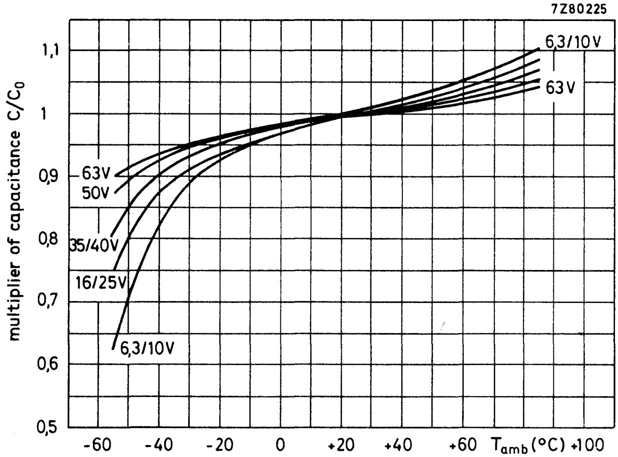


Fig. 5 Typical multiplier of capacitance as a function of ambient temperature; C_0 = capacitance at 20 °C, 100 Hz.

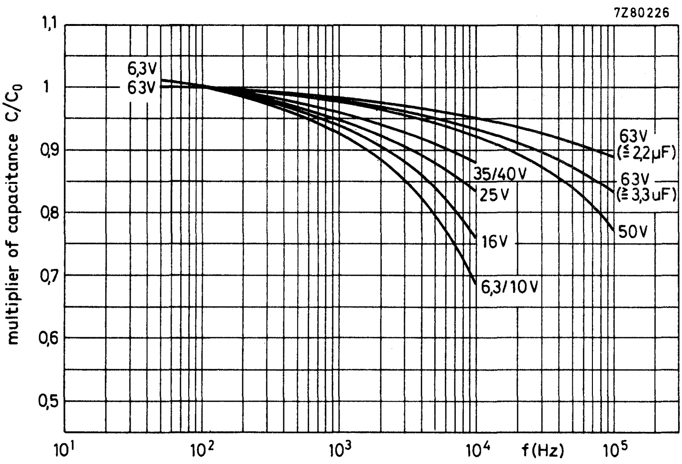


Fig. 6 Typical multiplier of capacitance as a function of frequency; C_0 = capacitance at 20 °C, 100 Hz.

Voltage

	core temperature▲ < 50 °C	core temperature▲ 50 to 95 °C
Rated voltage = max. permissible voltage	1,15 x U_R	U_R
Ripple voltage* = max. permissible a.c. voltage providing the following three conditions are met:		
(a) max. (d.c. + peak a.c.) voltage	1,15 x U_R	U_R
(b) max. peak a.c. voltage without d.c. voltage applied	2 V	
(c) momentary value of applied voltage	between U_R and −2 V	
Surge voltage = max. permissible voltage for short periods	1,2 x U_R	1,15 x U_R
Reverse voltage = max. d.c. voltage applied in the reverse polarity for short periods	2 V	

Ripple current**

Maximum permissible r.m.s. ripple current at 100 Hz and T_{amb} = 85 °C — see Table 3

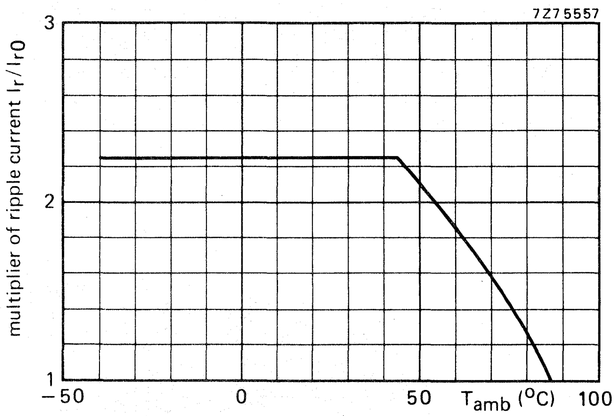


Fig. 7 Typical multiplier of ripple current as a function of ambient temperature; I_{r0} = ripple current at 85 °C, 100 Hz.

▲ See Introduction, section 5, "Ripple current".

* Specified ripple voltages are not applicable if the maximum permissible ripple current is exceeded. In that case the ripple current is decisive.

** Specified ripple currents are not applicable if the maximum permissible ripple voltage is exceeded. In that case the ripple voltage is decisive.

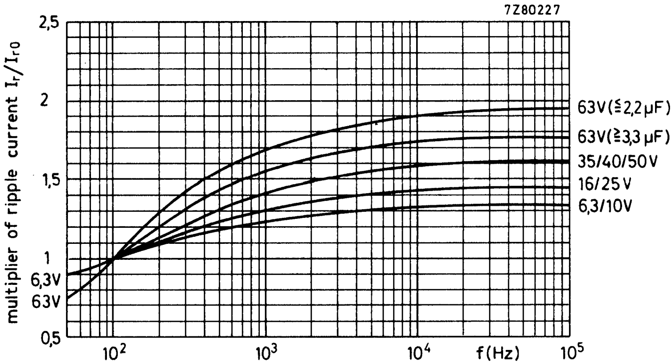


Fig. 8 Typical multiplier of ripple current as a function of frequency;
I_{r0} = ripple current at 85 °C, 100 Hz.

Non-sinusoidal ripple currents have to be analyzed into a number of sinusoidal currents. The following requirements must then be satisfied:

$$\sum_n \frac{I_n^2}{r_n} \leqslant I_{r\,max}^2$$

$I_{r\,max}$ = maximum ripple current at 100 Hz and applicable ambient temperature;
I_n = ripple current at a certain frequency;
$\sqrt{r_n} = I_r/I_{r0}$ = multiplying factor at a same frequency.

Charge and discharge current

There is no limit on the charge or discharge rate. If the capacitors are charged and discharged continuously several times per minute, the charge and discharge currents have to be considered as ripple currents flowing through the capacitor. The r.m.s. value of these currents should be determined and the value thus found must not exceed the applicable limit. (See also Tests and requirements.)

D.C. leakage current

Maximum d.c. leakage current 1 min after application of U_R at T_{amb} = 20 °C	see Table 3 (0,006 CU + 3 μA)
D.C. leakage current during continuous operation at U_R,	
at T_{amb} = 25 °C	approx. 0,1 x value stated in Table 3
at T_{amb} = 85 °C	⩽ value stated in Table 3

If owing to prolonged storage and/or storage at an excessive temperature (> 40 °C) the d.c. leakage current is too high, application of the rated voltage for some hours will cause the d.c. leakage current to fall to a value lower than specified in Table 3.

Tan δ (dissipation factor)

Maximum tan δ at 100 Hz and T_{amb} = 25 °C, measured by a four-terminal circuit (Thomson circuit) — see Table 3

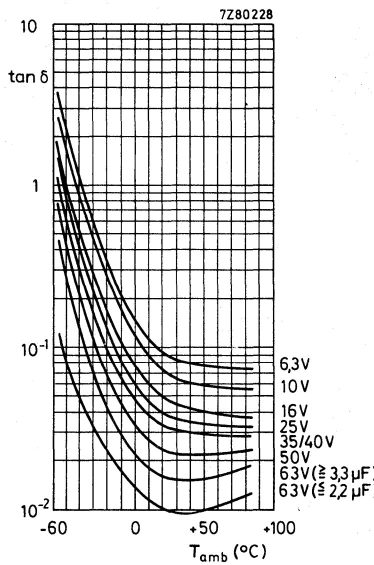


Fig. 9 Typical tan δ at 100 Hz as a function of ambient temperature.

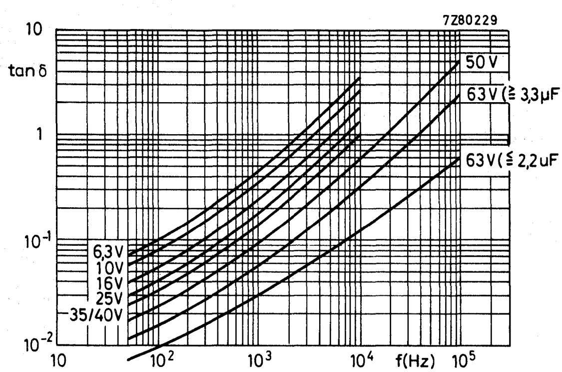


Fig. 10 Typical tan δ as a function of frequency at T_{amb} = 20 °C.

Equivalent series resistance (ESR)

ESR = tan $\delta/\omega C$	
Maximum tan δ and C at 100 Hz and T_{amb} = 25 °C	see Table 3

Equivalent series inductance (ESL)

Case size 11	typ. 13 nH
Case size 13	typ. 16 nH

Impedance (Z)

Maximum impedance at T_{amb} = 20 °C, −25 °C and −40 °C and 10 kHz, measured by a four-terminal circuit (Thomson circuit)	see Table 4
Maximum ratio between impedances at T_{amb} = −25 °C and +20 °C, at T_{amb} = −40 °C and +20 °C, and at T_{amb} = −55 °C and +20 °C, at 100 Hz measured by a four-terminal circuit (Thomson circuit)	see Table 4

Table 4

U_R V	nom. cap. µF	case size*	max. impedance at 10 kHz T_{amb} = 20 °C Ω	T_{amb} = −25 °C Ω	T_{amb} = −40 °C Ω	maximum impedance ratio at U_R and 100 Hz $\frac{Z \text{ at } -25\ °C}{Z \text{ at } +20\ °C}$	$\frac{Z \text{ at } -40\ °C}{Z \text{ at } +20\ °C}$	$\frac{Z \text{ at } -55\ °C}{Z \text{ at } +20\ °C}$
6,3	100	11	1,7	9,0	25,0	2	3	7
	330	13	0,52	2,7	7,6	2	3	7
10	47	11	2,8	11,9	31,9	2	3	5
	68	11	1,9	8,2	22,1	2	3	5
	150	11	1,3	8,0	21,3	2	3	8
	220	13	0,59	2,6	6,8	2	3	5
	470	13	0,43	2,6	6,8	2	3	8
16	33	11	2,7	12,1	33,1	1,5	2	5
	100	11	1,6	7,5	20,0	1,5	2	6
	150	13	0,60	2,7	7,3	1,5	2	5
	220	13	0,55	2,5	6,8	1,5	2	5
	330	13	0,48	2,3	6,1	1,5	2	6
25	68	11	1,8	8,2	22,1	1,5	2	5
	100	13	0,70	3,0	9,0	1,5	2	4
	220	13	0,55	2,6	6,8	1,5	2	5
35	22	11	2,7	11,4	34,1	1,5	2	4
	47	11	1,9	8,5	23,4	1,5	2	4
	150	13	0,60	2,7	7,3	1,5	2	4
40	15	11	3,7	14,7	46,7	1,5	2	3
	68	13	0,81	3,2	10,3	1,5	2	3
50	10	11	4,5	16,0	58,0	1,5	2	3
	33	11	2,1	9,1	27,3	1,5	2	3
	47	13	0,96	3,4	12,3	1,5	2	3
	100	13	0,70	3,0	9,0	1,5	2	3
63	0,15	11	267	867	2670	1,3	1,5	2
	0,22	11	182	591	1818	1,3	1,5	2
	0,33	11	121	394	1212	1,3	1,5	2
	0,47	11	85,1	277	851	1,3	1,5	2
	0,68	11	58,1	191	588	1,3	1,5	2
	1,0	11	40	130	400	1,3	1,5	2
	1,5	11	26,7	86,7	267	1,3	1,5	2
	2,2	11	18,2	59,1	182	1,3	1,5	2
	3,3	11	12,1	39,4	121	1,5	2	3
	4,7	11	8,5	27,2	85,1	1,5	2	3
	6,8	11	5,9	19,1	58,8	1,5	2	3
	10	11	4,0	13,0	40,0	1,5	2	3
	22	11	2,7	10,0	31,8	1,5	2	3
	33	13	1,2	3,9	12,1	1,5	2	3
	47	13	1,0	3,5	11,2	1,5	2	3
	68	13	0,88	3,2	10,3	1,5	2	3

* Case size 11: ϕ5 mm x 11 mm; case size 13: ϕ8,2 mm x 11 mm (nominal dimensions).

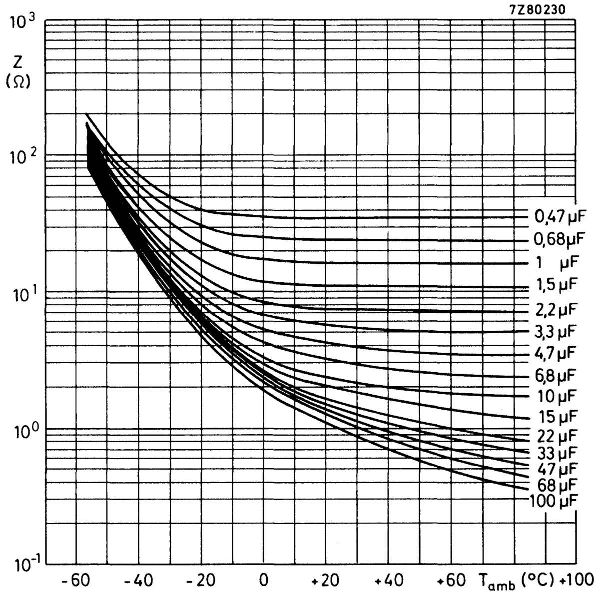


Fig. 11 Typical impedance at 10 kHz as a function of ambient temperature, case size 11.

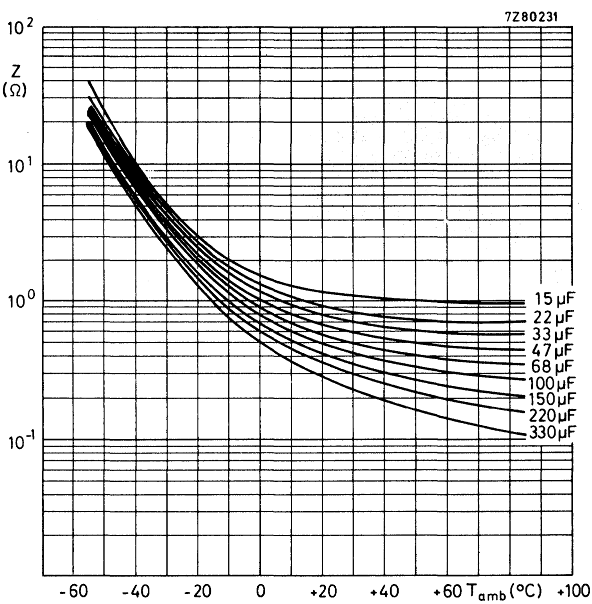


Fig. 12 Typical impedance at 10 kHz as a function of ambient temperature, case size 13.

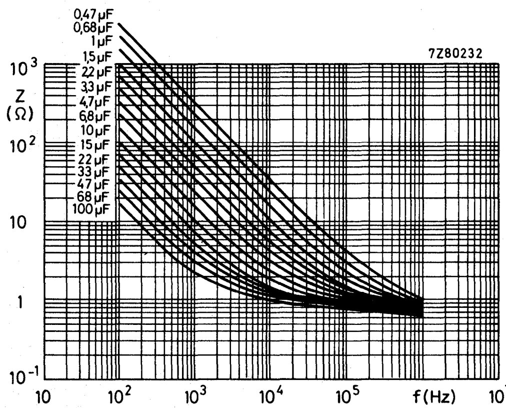


Fig. 13 Typical impedance as a function of frequency at T_{amb} = 20 °C, case size 11.

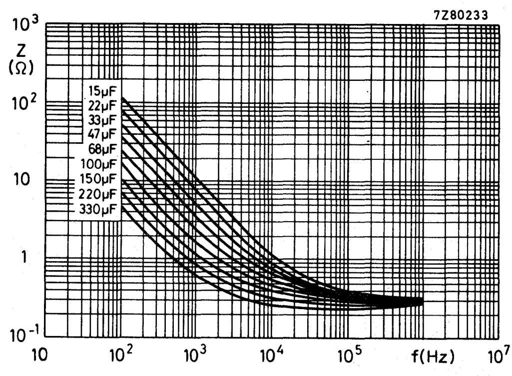


Fig. 14 Typical impedance as a function of frequency at T_{amb} = 20 °C, case size 13.

OPERATIONAL DATA

Category temperature range	−55 to +85 °C
Typical life time	
at T_{amb} = 40 °C	70 000 h
at T_{amb} = 85 °C	3000 h
at T_{amb} = 95 °C	1500 h
at T_{amb} = 105 °C	750 h
Shelf life at 0 V and T_{amb} = 85 °C	500 h

PACKING

Capacitors of styles 1, 2 and 3 are supplied in boxes, those of styles 4 and 5 on tape on reel and in ammunition pack respectively. The numbers per box, per reel and per ammunition pack are given in Table 5.

Table 5

case size	number of capacitors				
	style 1 per box	style 2 per box	style 3 per box	style 4 per reel (min.)	style 5 per ammunition pack
11	1000	1000	1000	1000	2000
13	1000	1000	1000	500	1000

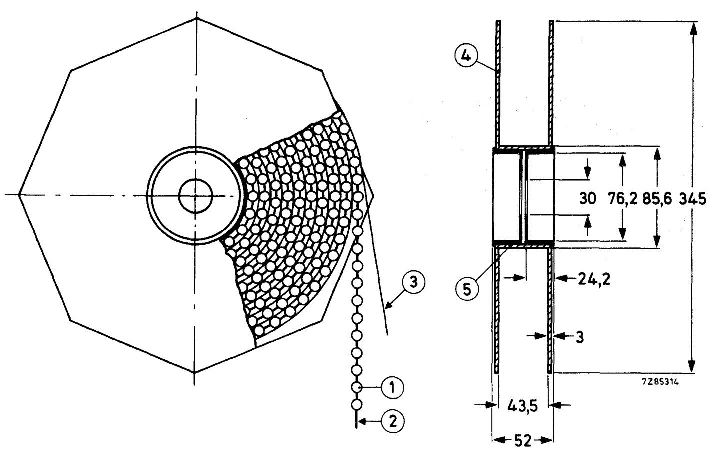


Fig. 15 Capacitors (style 4) on tape on reel.

1 = capacitor
2 = tape
3 = paper
4 = flange
5 = cylinder

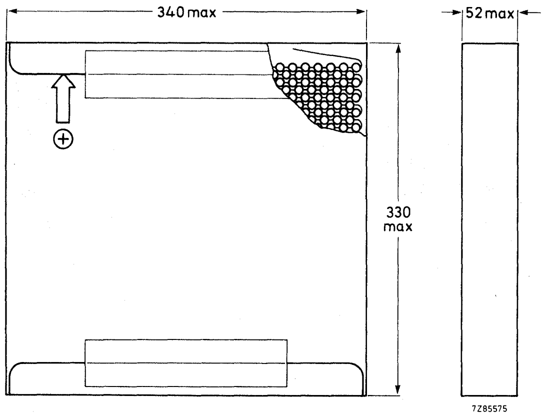


Fig. 16 Capacitors (style 5) on tape in ammunition pack.

TESTS AND REQUIREMENTS

See Introduction, section 9, under aluminium electrolytic capacitors, with the following addition.

After *endurance test, 2000 h, 85 °C,* the capacitors meet the following requirements:

$\Delta C/C \leqslant \pm 15\%$, for U_R = 10 to 63 V,

$\Delta C/C \leqslant +15\%, -25\%$ for U_R = 6,3 V;

tan $\delta \leqslant 130\%$ of specified value;

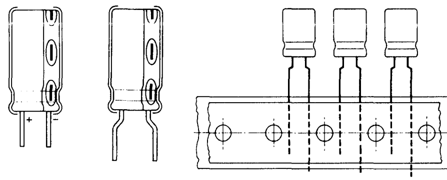
d.c. leakage current $\leqslant$ specified value.

After *shelf life test, 500 h, 85 °C,* the capacitors meet the same requirements. The rated voltage shall be applied to the capacitors for minimum 30 min, at least 24 h and not more than 48 h before measurements.

Note- Capacitors 2222 036 are miniature, long-life grade.

ALUMINIUM ELECTROLYTIC CAPACITORS

- **Miniature and small types**
- **Single ended**
- **Very high CU-product per unit volume**
- **General applications**



QUICK REFERENCE DATA

Nominal capacitance range (E6 series)	0,10 to 10 000 μF
Tolerance on nominal capacitance	−20 to + 20%*
Rated voltage range, U_R (R5 series)	6,3 to 100 V
Category temperature range	−40 to + 85 °C
Endurance test at 85 °C	
U_R = 6,3 to 16 V	1000 h**
U_R = 25 to 100 V	2000 h
Shelf life at 0 V, 85 °C	500 h
Basic specifications	
IEC 384-4, G.P. grade	
DIN 41332/DIN 41259	
Climatic category	
IEC 68	40/085/56
DIN 40040	GPF

* ± 10% to special order.
** 2000 h under development.

case size	nominal dimensions (mm)
11	Ø 5 x 11
12	Ø 6 x 11
13	Ø 8 x 12
14	Ø 10 x 12
15	Ø 10 x 16
16	Ø 10 x 20
17	Ø 12,5 x 20
18	Ø 12,5 x 25
19	Ø 16 x 25
20	Ø 16 x 31

Selection chart for C_{nom} - U_R and relevant case sizes.

C_{nom}	U_R (V)								
μF	6,3	10	16	25	35	40	50	63	100
0,10								11	
0,15								11	
0,22								11	11
0,33								11	
0,47								11	11
0,68								11	
1								11	11
1,5								11	11
2,2								11	11
3,3								11	11
4,7								11	11
6,8								11	11
10							11	11	12
15						11		11	13
22					11	11	12	12	13
33			11		11	12	12	13	14
47		11		11		12	13	13	15
68	11		11	12		13	13	14	15
100		11	12	13		13		14	16
150	12	12	13	13		14		15	17
220	12	13	13		14		15	16	18
330	13	13	14		15	16		17	19
470	13		14		16	17	17	18	20
680		14	15		17	18	18	19	
1000		15	16	17	18	19	19	20	
1500	16		17	18	19	20			
2200	17		18	19	20				
3300		18	19	20					
4700		19	20						
6800	19	20							
10 000	20								

APPLICATION

These capacitors with very high CU-product per unit volume are mainly used for smoothing, coupling and decoupling purposes in consumer applications, such as audio and television circuits.
Other applications are in timing and delay circuits. The taped versions are suitable for automatic insertion and for cutting and forming equipment.

DESCRIPTION

The capacitors have etched and oxidized aluminium foil electrodes rolled up with a paper strip impregnated with an electrolyte. The capacitors are in an insulated aluminium case.

MECHANICAL DATA

Dimensions in mm

The capacitor is available in 6 styles:
style 1: long leads; in boxes;
style 2: straight short leads; non preferred, in boxes;
style 3: bent short leads only case sizes 11, 12 and 13; non preferred, in boxes;
style 4: long leads; on tape on reel, positive leading; only case sizes 11 to 13;
style 5: long leads; on tape in ammunition pack; only case sizes 11 to 13;
style 6: long leads; on tape on reel, negative leading; only case sizes 11 to 13.

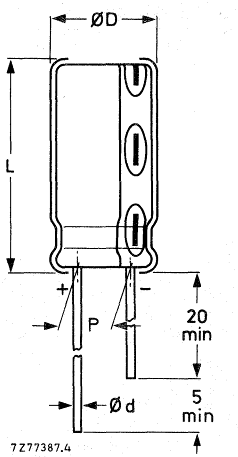


Fig. 1 Style 1; see Table 1 for dimensions d, D, L and P.

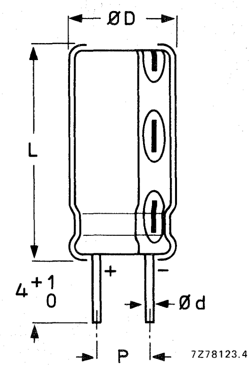


Fig. 2 Style 2; non preferred, see Table 1 for dimensions d, D, L and P.

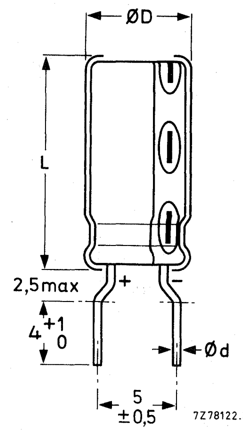


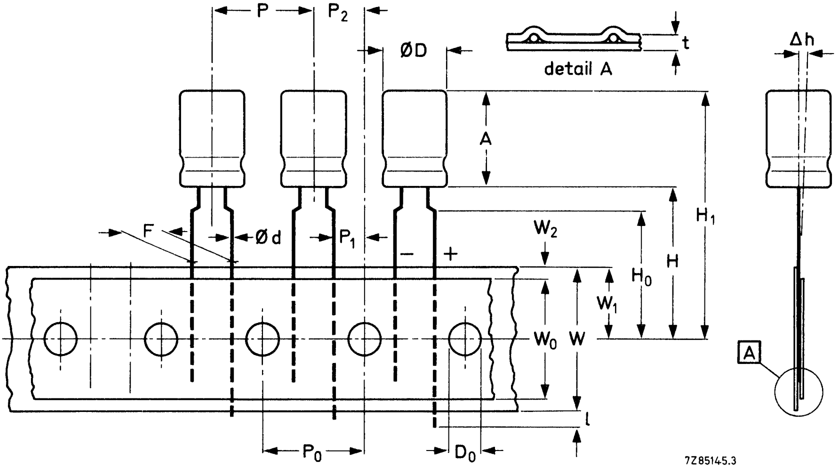
Fig. 3 Style 3, case sizes 11, 12 and 13; non preferred, see Table 1 for dimensions d, D and L.

Table 1

case size	dimensions					mass g
	d	D_{max}	L_{max}	P		
11	0,5*	5,5	12,0	2,0	± 0,5	0,4
12	0,6	6,5	12,0	2,5	± 0,5	0,6
13	0,6	8,5	12,5	3,5	± 0,5	1,1
14	0,6	10,5	12,5	5,0	± 0,5	1,6
15	0,6	10,5	17,0	5,0	± 0,5	1,9

case size	dimensions					mass g
	d	D_{max}	L_{max}	P		
16	0,6	10,5	21,0	5,0	± 0,5	2,2
17	0,6	13,0	21,0	5,0	± 0,5	4,0
18	0,6	13,0	26,0	5,0	± 0,5	5,0
19	0,8	16,5	26,0	7,5	± 0,5	8,0
20	0,8	16,5	32,0	7,5	± 0,5	9,0

* 0,6 mm under consideration.



→ direction of tape transport (positive leading)

Fig. 4 Styles 4, 5 and 6, case sizes 11 to 13; see Table 2 for dimensions. For style 6 the tape transport is in opposite direction (negative leading).

Table 2

	symbol	case size			tol.
		11	12	13	
Body diameter	D	5,5	6,5	8,5	max.
Body height	A	12,0	12,0	12,5	max.
Lead-wire diameter	d	0,5*	0,6	0,6	± 0,05
Pitch of component	P	12,7	12,7	12,7	± 1,0
Feed-hole pitch	P_0	12,7	12,7	12,7	± 0,2**
Hole centre to lead	P_1	3,85	3,85	3,85	± 0,5
Feed hole centre to component centre	P_2	6,35	6,35	6,35	± 1,0
Lead-to-lead distance	F	5,0	5,0	5,0	+ 0,6/–0
Component alignment	Δh	0	0	0	± 1,0
Tape width	W	18,0	18,0	18,0	± 0,5
Hold-down tape width	W_0	12,5	12,5	12,5	min. ***
Hole position	W_1	9,0	9,0	9,0	± 0,5
Hold-down tape position	W_2	2,5	2,5	2,5	max.
Height of component from tape centre	H	18,0	18,0	18,0	+ 1,5/–0
Lead-wire clinch height	H_0	16,0	16,0	16,0	± 0,5
Component height	H_1	32,0	32,0	32,0	max.
Lead-wire protrusion	l	2,0	2,0	2,0	max.
Feed-hole diameter	D_0	4,0	4,0	4,0	± 0,2
Total tape thickness	t	0,9	0,9	0,9	max.

* 0,6 mm under consideration.
** Cumulative pitch error: ± 1 mm/20 pitches.
*** Other widths under consideration.

Marking

The capacitors are marked with: nominal capacitance, rated voltage, a symbol ot identify the negative terminal, group number (037), code for factory of origin, name of manufacturer and date code (year and month) according to IEC 62.

Minimum atmospheric pressure 8,5 kPa

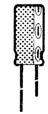
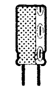
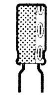
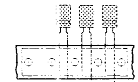
PRODUCT SAFETY

Non-solid electrolytic capacitors may contain chemicals which can be regarded as hazardous if incorrectly handled. Caution is necessary should the outer case be fractured.

ELECTRICAL DATA

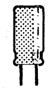
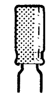
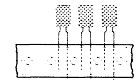
Unless otherwise specified all electrical values in Table 3 apply at an ambient temperature of 20 to 25 ^{o}C, a frequency of 100 Hz, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 45 to 75%.

Table 3

U_R	nom. cap.	max. r.m.s. ripple current at T_{amb} = 85 °C	max. d.c. leakage current at U_R after 1 min	max. tan δ	max. impedance (Ω) at T_{amb} = 20 °C		case size	catalogue number 2222 037 followed by					
					at 1 kHz	at 10 kHz		 style 1	 style 2	 style 3	on reel* style 4	 in ammopack style 5	on reel** style 6
V	μF	mA	μA										
6,3	68	57	7,3	0,24		8,8	11	53689	83689	63689	23689	33689	43689
	150	92	12	0,24		4,0	12	53151	83151	63151	23151	33151	43151
	220	110	17	0,24		2,7	12	53221	83221	63221	23221	33221	43221
	330	160	24	0,24		1,8	13	53331	83331	63331	23331	33331	43331
	470	200	33	0,24		1,3	13	53471	83471	63471	23471	33471	43471
	1 500	480	98	0,25	0,44		16	53152	63152				
	2 200	640	140	0,26	0,31		17	53222	63222				
	6 800	1200	430	0,35	0,12		19	53682	63682				
	10 000	1500	630	0,42	0,10		20	53103	63103				
10	47	51	7,7	0,20		9,6	11	54479	84479	64479	24479	34479	44479
	100	75	13	0,20		4,5	11	54101	84101	64101	24101	34101	44101
	150	100	18	0,20		3,0	12	54151	84151	64151	24151	34151	44151
	220	150	25	0,20		2,0	13	54221	84221	64221	24221	34221	44221
	330	180	36	0,20		1,4	13	54331	84331	64331	24331	34331	44331
	680	300	71	0,20		0,66	14	54681	64681				
	1 000	400	100	0,20		0,45	15	54102	64102				
	3 300	900	330	0,24	0,18		18	54332	64332				
	4 700	1100	470	0,28	0,13		19	54472	64472				
	6 800	1400	680	0,32	0,10		20	54682	64682				

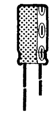
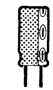
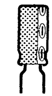
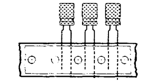
* Positive leading.
** Negative leading.

Table 3 (continued)

U_R	nom. cap.	max. r.m.s. ripple current at T_{amb} = 85 °C	max. d.c. leakage current at U_R after 1 min	max. tan δ	max. impedance (Ω) at T_{amb} = 20 °C		case size	catalogue number 2222 037 followed by					
					at 1 kHz	at 10 kHz		 style 1	 style 2	 style 3	 on reel* style 4	in ammopack style 5	on reel** style 6
V	μF	mA	μA										
16	33	48	8,3	0,16		9,7	11	55339	85339	65339	25339	35339	45339
	68	69	14	0,16		4,7	11	55689	85689	65689	25689	35689	45689
	100	92	19	0,16		3,2	12	55101	85101	65101	25101	35101	45101
	150	140	27	0,16		2,1	13	55151	85151	65151	25151	35151	45151
	220	160	38	0,16		1,5	13	55221	85221	65221	25221	35221	45221
	330	230	56	0,16		0,97	14	55331	65331				
	470	270	78	0,16		0,68	14	55471	65471				
	680	370	110	0,16		0,47	15	55681	65681				
	1000	490	160	0,16		0,32	16	55102	65102				
	1500	650	240	0,17	0,29		17	55152	65152				
	2200	840	360	0,18	0,21		18	55222	65222				
	3300	1100	530	0,20	0,15		19	55332	65332				
	4700	1300	760	0,24	0,11		20	55472	65472				
25	47	62	15	0,14		4,7	11	56479	86479	66479	26479	36479	46479
	68	81	20	0,14		3,2	12	56689	86689	66689	26689	36689	46689
	100	120	28	0,14		2,2	13	56101	86101	66101	26101	36101	46101
	150	140	41	0,14		1,5	13	56151	86151	66151	26151	36151	46151
	1000	590	250	0,14		0,22	17	56102	66102				
	1500	760	380	0,15	0,24		18	56152	66152				
	2200	1000	550	0,16	0,17		19	56222	66222				
	3300	1300	830	0,18	0,12		20	56332	66332				

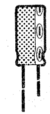
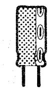
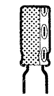
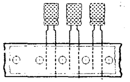
* Positive leading.
** Negative leading.

Table 3 (continued)

U_R	nom. cap.	max. r.m.s. ripple current at T_{amb} = 85 °C	max. d.c. leakage current at U_R after 1 min	max. tan δ	max. impedance (Ω) at T_{amb} = 20 °C		case size	catalogue number 2222 037 followed by					
					at 1 kHz	at 10 kHz		 style 1	 style 2	 style 3	 on reel* style 4	in ammopack style 5	on reel** style 6
V	μF	mA	μA										
35	22	45	11	0,12		6,8	11	50229	80229	60229	20229	30229	40229
	33	56	15	0,12		4,5	11	50339	80339	60339	20339	30339	40339
	220	220	80	0,12		0,68	14	50221	60221				
	330	300	120	0,12		0,45	15	50331	60331				
	470	390	170	0,12		0,32	16	50471	60471				
	680	520	240	0,12		0,22	17	50681	60681				
	1000	690	250	0,12		0,15	18	50102	60102				
	1500	940	530	0,13	0,21		19	50152	60152				
	2200	1200	770	0,14	0,14		20	50222	60222				
40	15	38	9	0,12		8,7	11	57159	87159	67159	27159	37159	47159
	22	45	12	0,12		5,9	11	57229	87229	67229	27229	37229	47229
	33	61	16	0,12		3,9	12	57339	87339	67339	27339	37339	47339
	47	73	22	0,12		2,8	12	57479	87479	67479	27479	37479	47479
	68	100	30	0,12		1,9	13	57689	87689	67689	27689	37689	47689
	100	130	43	0,12		1,3	13	57101	87101	67101	27101	37101	47101
	150	180	63	0,12		0,87	14	57151	67151				
	330	320	140	0,12		0,39	16	57331	67331				
	470	440	190	0,12		0,28	17	57471	67471				
	680	570	280	0,12		0,19	18	57681	67681				
	1000	870	400	0,12		0,13	19	57102	67102				
	1500	1000	600	0,13	0,18		20	57152	67152				

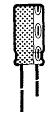
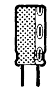
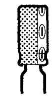
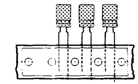
* Positive leading.
** Negative leading.

Table 3 (continued)

U_R	nom. cap.	max. r.m.s. ripple current at T_{amb} = 85 °C	max. d.c. leakage current at U_R after 1 min	max. tan δ	max. impedance (Ω) at T_{amb} = 20 °C		case size	catalogue number 2222 037 followed by					
					at 1 kHz	at 10 kHz		 style 1	 style 2	 style 3	 on reel* style 4	in ammopack style 5	on reel** style 6
V	μF	mA	μA										
50	10	34	8	0,10		9,5	11	51109	81109	61109	21109	31109	41109
	22	54	14	0,10		4,3	12	51229	81229	61229	21229	31229	41229
	33	67	20	0,10		2,9	12	51339	81339	61339	21339	31339	41339
	47	96	27	0,10		2,0	13	51479	81479	61479	21479	31479	41479
	68	120	37	0,10		1,4	13	51689	81689	61689	21689	31689	41689
	220	260	110	0,10		0,43	15	51221	61221				
	470	480	240	0,10		0,20	17	51471	61471				
	680	630	340	0,10		0,14	18	51681	61681				
	1000	680	500	0,10		0,10	19	51102	61102				

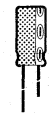
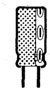
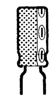
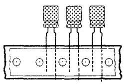
* Positive leading.
** Negative leading.

Table 3 (continued)

U_R	nom. cap.	max. r.m.s. ripple current at T_{amb} = 85 °C	max. d.c. leakage current at U_R after 1 min	max. tan δ	max. impedance (Ω) at T_{amb} = 20 °C		case size	catalogue number 2222 037 followed by					
					at 1 kHz	at 10 kHz		 style 1	 style 2	 style 3	 on reel* style 4	in ammopack style 5	on reel** style 6
V	µF	mA	µA										
63	0,10	3,5	3,1	0,09		800	11	58107	88107	68107	28107	38107	48107
	0,15	4,3	3,1	0,09		530	11	58157	88157	68157	28157	38157	48157
	0,22	5,2	3,1	0,09		360	11	58227	88227	68227	28227	38227	48227
	0,33	6,4	3,2	0,09		240	11	58337	88337	68337	28337	38337	48337
	0,47	7,7	3,3	0,09		170	11	58477	88477	68477	28477	38477	48477
	0,68	9,2	3,4	0,09		120	11	58687	88687	68687	28687	38687	48687
	1,0	11	3,6	0,09		80	11	58108	88108	68108	28108	38108	48108
	1,5	14	3,9	0,09		53	11	58158	88158	68158	28158	38158	48158
	2,2	17	4,4	0,09		36	11	58228	88228	68228	28228	38228	48228
	3,3	20	5,1	0,09		24	11	58338	88338	68338	28338	38338	48338
	4,7	24	6,0	0,09		17	11	58478	88478	68478	28478	38478	48478
	6,8	29	7,3	0,09		12	11	58688	88688	68688	28688	38688	48688
	10	35	9,3	0,09		8,0	11	58109	88109	68109	28109	38109	48109
	15	43	12	0,09		5,3	11	58159	88159	68159	28159	38159	48159
	22	57	17	0,09		3,6	12	58229	88229	68229	28229	38229	48229
	33	85	24	0,09		2,4	13	58339	88339	68339	28339	38339	48339
	47	100	33	0,09		1,7	13	58479	88479	68479	28479	38479	48479
	68	140	46	0,09		1,2	14	58689	68689				
	100	170	66	0,09		0,80	14	58101	68101				
	150	230	98	0,09		0,53	15	58151	68151				
	220	300	140	0,09		0,36	16	58221	68221				
	330	420	210	0,09		0,24	17	58331	68331				
	470	550	300	0,09		0,17	18	58471	68471				
	680	760	430	0,09		0,12	19	58681	68681				
	1000	1000	630	0,09		0,08	20	58102	68102				

* Positive leading.
** Negative leading.

Table 3 (continued)

U_R	nom. cap.	max. r.m.s. ripple current at T_{amb} = 85 °C	max. d.c. leakage current at U_R after 1 min	max. tan δ	max. impedance (Ω) at T_{amb} = 20 °C		case size	catalogue number 2222 037 followed by					
					at 1 kHz	at 10 kHz		 style 1	 style 2	 style 3	 on reel* style 4	in ammopack style 5	on reel** style 6
V	μF	mA	μA										
100	0,22	5,9	3,2	0,07		270	11	59227	89227	69227	29227	39227	49227
	0,47	8,7	3,5	0,07		130	11	59477	89477	69477	29477	39477	49477
	1,0	13	4	0,07		60	11	59108	89108	69108	29108	39108	49108
	1,5	16	4,5	0,07		40	11	59158	89158	69158	29158	39158	49158
	2,2	19	5,2	0,07		27	11	59228	89228	69228	29228	39228	49228
	3,3	23	6,3	0,07		18	11	59338	89338	69338	29338	39338	49338
	4,7	27	7,7	0,07		13	11	59478	89478	69478	29478	39478	49478
	6,8	33	9,8	0,07		8,8	11	59688	89688	69688	29688	39688	49688
	10	44	13	0,07		6,0	12	59109	89109	69109	29109	39109	49109
	15	65	18	0,07		4,0	13	59159	89159	69159	29159	39159	49159
	22	78	25	0,07		2,7	13	59229	89229	69229	29229	39229	49229
	33	110	36	0,07		1,8	14	59339	69339				
	47	150	50	0,07		1,3	15	59479	69479				
	68	180	71	0,07		0,88	15	59689	69689				
	100	230	100	0,07		0,60	16	59101	69101				
	150	320	150	0,07		0,40	17	59151	69151				
	220	430	220	0,07		0,27	18	59221	69221				
	330	600	330	0,07		0,18	19	59331	69331				
	470	780	470	0,07		0,13	20	59471	69471				

* Positive leading.
** Negative leading.

Capacitance

Nominal capacitance at 100 Hz and T_{amb} = 20 °C	see Table 3
Tolerance on nominal capacitance at 100 Hz	−20 to + 20%

Voltage

	core temperature▲	
	< 50 °C	50 to 95 °C
Rated voltage = max. permissible voltage	1,15 x U_R	U_R
Ripple voltage* = max. permissible a.c. voltage providing the following three conditions are met:		
a) max. (d.c. + peak a.c.) voltage	1,15 x U_R	U_R
b) max. peak a.c. voltage without d.c. voltage applied	1 V	
c) momentary value of applied voltage	between U_R and −1 V	
Surge voltage = max. permissible voltage for short periods	1,15 x U_R	
Reverse voltage = max. d.c. voltage applied in the reverse polarity for short periods	1 V	

Ripple current **

Maximum permissible r.m.s. ripple current at 100 Hz and T_{amb} = 85 °C	see Table 3

DEVELOPMENT DATA

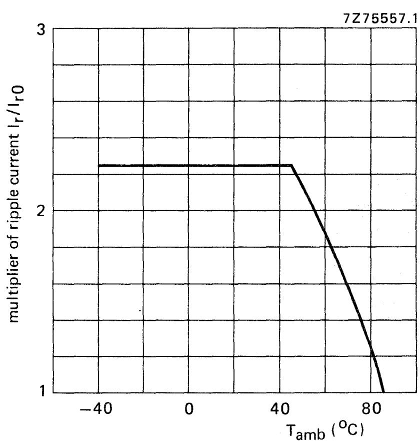


Fig. 5 Typical multiplier of ripple current as a function of ambient temperature; I_{r0} = ripple current at 85 °C, 100 Hz.

▲ See Introduction, section 5, "Ripple current".

* Ripple voltages are not applicable if the maximum permissible ripple current is exceeded. In that case the ripple current is decisive.

** Ripple currents are not applicable if the maximum permissible ripple voltage is exceeded. In that case the ripple voltage is decisive.

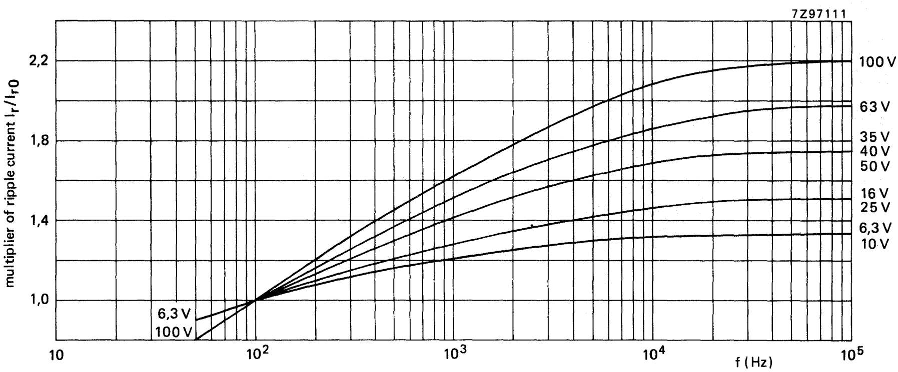


Fig. 6 Typical multiplier of ripple current as a function of frequency;
I_{r0} = ripple current at 85 °C; 100 Hz.

Non-sinusoidal ripple currents have to be analyzed into a number of sinusoidal currents and the following requirements shall then be satisfied:

$$\sum_n \frac{I_n^2}{r_n} \leqslant I_{r\,max}^2$$

$I_{r\,max}$ = maximum ripple current at 100 Hz and applicable ambient temperature;
I_n = ripple current at a certain frequency;
$\sqrt{r_n} = I_r/I_{r0}$ = multiplying factor at a same frequency.

Charge and discharge current

The capacitors may be charged from a source without internal resistance and they may be discharged by short-circuiting. If the capacitors are charged and discharged continuously several times per minute, the charge and discharge currents have to be considered as ripple currents flowing through the capacitor. The r.m.s. value of these currents should be determined and the value thus found must not exceed the applicable limit. (See also Tests and requirements).

D.C. leakage current

Maximum d.c. leakage current 1 min after application of U_R at T_{amb} = 20 °C — see Table 3 (0,01 CU + 3 μA)

D.C. leakage current during continuous operation at U_R,
at T_{amb} = 25 °C — approx. 0,1 x value stated in Table 3
at T_{amb} = 85 °C — ⩽ value stated in Table 3

If owing to prolonged storage and/or storage at an excessive temperature (> 40 °C) the d.c. leakage current is too high, application of the rated voltage for some hours will cause the d.c. leakage current to fall to a value lower than specified in Table 3.

Tan δ (dissipation factor)

Maximum tan δ at 100 Hz and T_{amb} = 25 °C, measured by means of a four-terminal circuit (Thomson circuit) — see Table 3

Equivalent series resistance (ESR)

ESR = tan δ/ωC

Maximum tan δ and C at 100 Hz and T_{amb} = 25 °C — see Table 3

Equivalent series inductance (ESL)

Case sizes 11, 12, 13	typ. 13 nH
Case sizes 14, 15, 16	typ. 16 nH
Case sizes 17, 18, 19, 20	typ. 18 nH

Impedance (Z)

Maximum impedance at T_{amb} = 20 °C and 10 kHz ($C_{nom} \leqslant$ 1000 μF) and 1 kHz ($C_{nom} >$ 1000 μF), measured by means of a four-terminal circuit (Thomson circuit) — see Table 3

z = Z x C_{nom} — see Table 4

Maximum ratio between impedances at T_{amb} = −25 °C and + 20 °C, and at T_{amb} = −40 °C and + 20 °C, at 100 Hz measured by means of a four-terminal circuit (Thomson circuit) — see Table 5

DEVELOPMENT DATA

Table 4

	T_{amb}	z = Z x C_{nom} (Ω μF) at U_R								
		6,3 V	10 V	16 V	25 V	35 V	40 V	50 V	63 V	100 V
$C_{nom} >$ 1000 μF, measured at 1 kHz*	+ 20 °C	650	530	430	350	300	270	260	250	240
	−25 °C	5500	4000	2700	1700	1200	1000	700	550	500
$C_{nom} \leqslant$ 1000 μF, measured at 10 kHz	+ 20 °C	600	450	320	220	150	130	95	80	60
	−25 °C	5500	4000	2700	1700	1200	950	650	500	450

Table 5

	maximum impedance ratio at U_R and 100 Hz								
	6,3 V	10 V	16 V	25 V	35 V	40 V	50 V	63 V	100 V
$\frac{Z \text{ at } -25\,°C}{Z \text{ at } +20\,°C}$	4	3	2	2	2	2	2	2	2
$\frac{Z \text{ at } -40\,°C}{Z \text{ at } +20\,°C}$	8	6	5	4	4	4	3	3	3

* Values shall be increased by 5% per 1000 μF.

OPERATIONAL DATA

Category temperature range	−40 to + 85 °C	
Typical life time	U_R = 25 to 100 V	U_R = 6,3 to 16 V
at T_{amb} = 40 °C	70 000 h	35 000 h
at T_{amb} = 85 °C	3000 h	1500 h
at T_{amb} = 95 °C	1500 h	750 h
at T_{amb} = 105 °C	750 h	400 h
Shelf life at 0 V and T_{amb} = 85 °C	500 h	500 h

PACKING

Capacitors of styles 1, 2 and 3 are supplied in boxes, those of styles 4, 6 and 5 on tape on reel and in ammunition pack respectively. The numbers per box, per reel and per ammuniation pack are given in Table 6.

Table 6

case size	number of capacitors				
	style 1 per box	style 2 per box	style 3 per box	styles 4 and 6 per reel	style 5 per ammuniation pack
11	1000	1000	1000	1000	2000
12	1000	1000	1000	1000	2000
13	1000	1000	1000	500	1000
14	1000	1000			
15	500	500			
16	500	500			
17	200	200			
18	200	200			
19	200	200			
20	200	200			

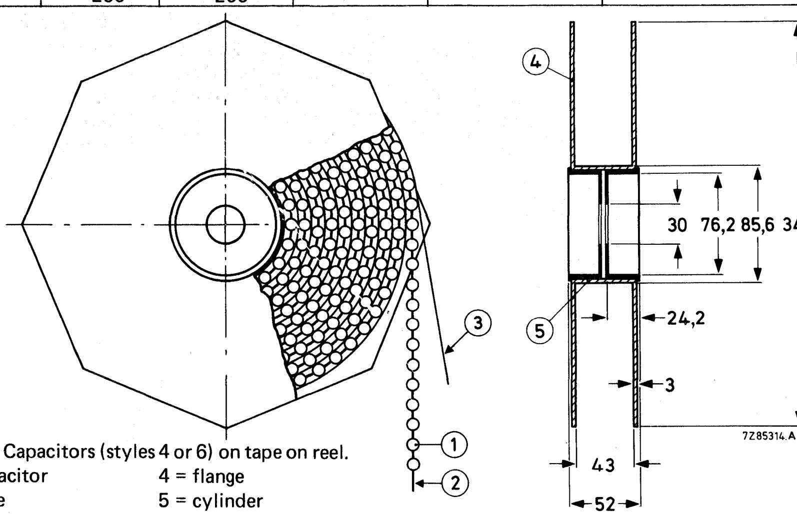


Fig. 7 Capacitors (styles 4 or 6) on tape on reel.
1 = capacitor
2 = tape
3 = paper
4 = flange
5 = cylinder

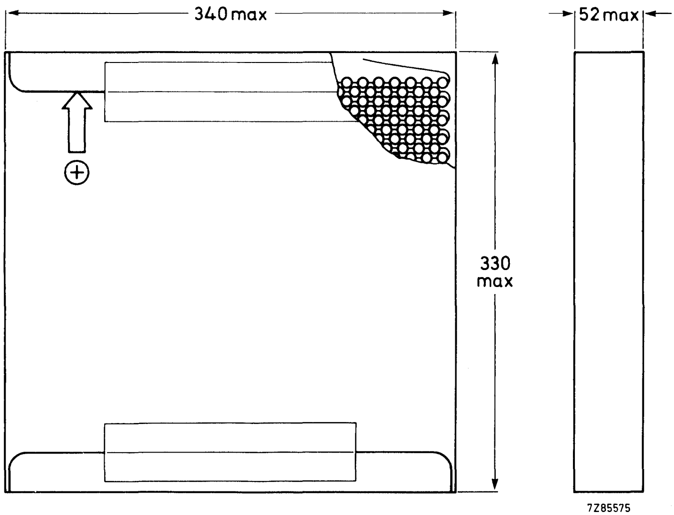


Fig. 8 Capacitors (style 5) on tape in ammunition pack.

TESTS AND REQUIREMENTS

See Introduction, section 9, under aluminium electrolytic capacitors, with the following addition.

After *endurance test, 1000 h (U_R = 6,3 to 16 V) or 2000 h (U_R = 25 to 100 V), 85 °C,* the capacitors meet the following requirements:

$\Delta C/C \leqslant \pm 20\%$,

tan $\delta \leqslant 1,5$ x specified value,

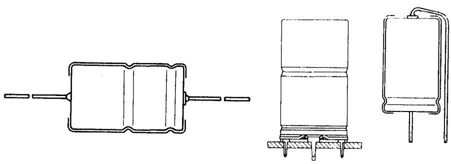
d.c. leakage current $\leqslant$ specified value.

After *shelf life test, 500 h, 85 °C,* the capacitors meet the same requirements as after endurance test, except for leakage current of the 100 V range: $\leqslant$ 200% of specified value. The rated voltage shall be applied to the capacitors for minimum 30 min, at least 24 h and not more than 48 h before measurements.

Note: Capacitors 2222 037 are miniature and small, general-purpose grade.

ALUMINIUM ELECTROLYTIC CAPACITORS

- **Miniature and small types**
- **Axial leads and single ended**
- **Long life**
- **General and industrial applications**



QUICK REFERENCE DATA

Nominal capacitance range	1 to 220 μF
Tolerance on nominal capacitance	−10 to + 50%
Rated voltage range, U_R (R5 series)	160 to 385 V
Category temperature range	−40 to + 85 °C
Endurance test at 85 °C	
case sizes 4 to 7	2000 h
case sizes 00 to 05	5000 h
Shelf life at 0 V, 85 °C	500 h
Basic specifications	IEC 384-4, type 1, long-life grade DIN 41240
Climatic category	
IEC 68	40/085/56
DIN 40040	GPF

Selection chart for C_{nom}-U_R and relevant case sizes.

C_{nom} μF	U_R (V) 160	250	350	385
1				4
2,2		4		5
4,7	4	5	6	7
6,8			00	00
10	5	00/7	01	01
15		01	01	02
22	00/7	01	02	03
33	01	02	03	04
47	02	03	04	04
68	02	04	05	05
100	03	05		
150	04			
220	05			

case size	nominal dimensions (mm)	series number	
4 5 6 7	Ø 6,5 x 18 Ø 8 x 18 Ø 10 x 18 Ø 10 x 25	041	miniature
00 01 02 03	Ø 10 x 30 Ø 12,5 x 30 Ø 15 x 30 Ø 18 x 30	042	small
04 05	Ø 18 x 40 Ø 21 x 40	043	

APPLICATION

For smoothing, coupling and decoupling purposes in circuits where a high voltage is required. The bandoliered version is extremely suitable for automatic insertion and for cutting and forming equipment.

DESCRIPTION

The capacitor has etched and oxidized aluminium foil electrodes rolled up with a paper strip impregnated with an electrolyte. The capacitor is in an aluminium case, which is insulated with a blue plastic sleeve.

The capacitors are available in 3 styles, all with soldered-copper leads.

Style 1: axial leads; all case sizes; case sizes 4 to 7 are supplied on bandoliers.
Style 2: single ended; with mounting ring with printed-wiring pins; especially for use in applications with severe shocks and vibrations; case sizes 02 to 05.
Style 3: single ended; case sizes 4 to 7 and 00 to 02.

MECHANICAL DATA

Dimensions in mm

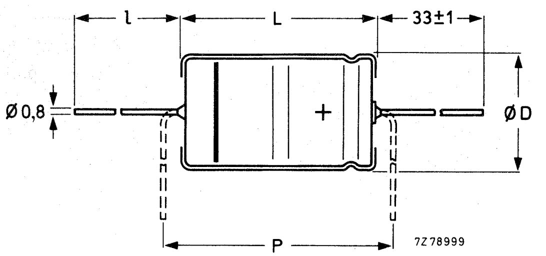


Fig. 1 Style 1; see Table 1a for dimensions D, L, l and P.

Table 1a

case size	style 1						mass approx. g
	l	D_{nom}	L_{nom}	D_{max}	L_{max}	P_{min}	
4	*	6,5	18,0	6,9	18,5	25	1,3
5	*	8,0	18,0	8,5	18,5	25	1,7
6	*	10,0	18,0	10,5	18,5	25	2,5
7	*	10,0	25,0	10,5	25,0	30	3,3
00	55 ± 1	10,0	30,0	10,5	30,5	35,0	4,0
01	55 ± 1	12,5	30,0	13,0	30,5	35,0	6,3
02	55 ± 1	15,0	30,0	15,5	30,5	35,0	8,2
03	55 ± 1	18,0	30,0	18,5	30,5	35,0	10,9
04	34 ± 1	18,0	40,0	18,5	41,5	45,0	14
05	34 ± 1	21,0	40,0	21,5	41,5	45,0	19

* Case sizes 4 to 7 are supplied on bandoliers in boxes or on reels (see PACKING).

Table 1b

case size	style 2						mass approx. g
	d_1	d_2	D1	$D2_{max}$	D3	L	
02	0,8	1 + 0,1	15,0	17,5	16,5 ± 0,2	31 ± 1	8,6
03	0,8	1 + 0,1	18,0	19,5	18,5 ± 0,2	31 ± 1	11,5
04	1,0	1,3 + 0,1	18,0	19,5	18,5 ± 0,2	42 ± 1	14,5
05	1,0	1,3 + 0,1	21,0	22,5	21,5 ± 0,2	42 ± 1	19,7

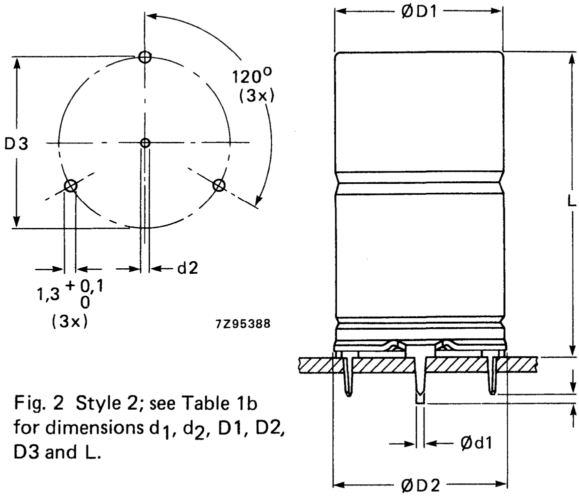


Fig. 2 Style 2; see Table 1b for dimensions d_1, d_2, D1, D2, D3 and L.

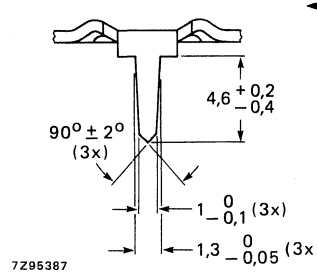


Table 1c

case size	d	style 3			mass approx. g
		D_{max}	L_{max}	P	
4	0,8	6,9	21,5	5 -10	1,2
5	0,8	8,5	21,5	5 -10	1,6
6	0,8	10,5	21,5	7,5-12,5	2,3
7	0,8	10,5	28,0	7,5-12,5	3,1
00	0,8	10,5	34,0	7,5-12,5	3,8
01	0,8	13,0	34,0	7,5-12,5	6,1
02	0,8	15,5	34,0	10,0-15,0	8,0

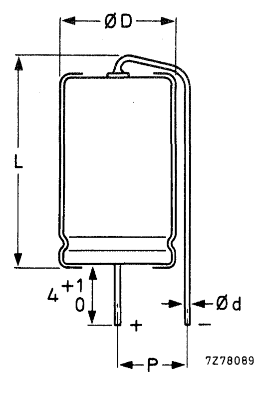


Fig. 3 Style 3 see Table 1c for dimensions d, D, L and P.

Marking

The capacitors are marked with:

- nominal capacitance;
- tolerance on nominal capacitance;
- rated voltage;
- group number; code of origin;
- name of manufacturer;
- date code (year and month) according to IEC 62;
- band to identify the negative terminal;
- + signs to identify the positive terminal.

Mounting

The diameter of the holes in the printed-wiring board for styles 1 and 3 is 1 + 0,1 mm.

→ The hole diameter for style 2 is 1,3 + 0,1 mm, except that for the anode pin of case sizes 02 and 03: 1 + 0,1 mm.

Minimum atmospheric pressure 8,5 kPa

PRODUCT SAFETY

Non-solid electrolytic capacitors may contain chemicals which can be regarded as hazardous if incorrectly handled. Caution is necessary should the outer case be fractured.

ELECTRICAL DATA

Table 2

Unless otherwise specified all electrical values in Table 2 apply at an ambient temperature of 20 to 25 °C, a frequency of 100 Hz, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 45 to 75%. (See also the relevant paragraphs.)

U_R V	nom. cap. µF	max. r.m.s. ripple current at T_{amb} = 85 °C mA	max.d.c.leakage current at U_R after 1 min µA	max. ESR Ω	max. tan δ	typ. impedance at 10 kHz Ω	case size	catalogue number* 2222 followed by
160	4,7	26	38	53,2	0,15	26	4	041 .1478
	10	41	68	25,0	0,15	12	5	041 .1109
	22	77	126	11,4	0,15	5,5	7	041 .1229
	22	106	42	6,8	0,10	1,3	00	042 .1229
	33	146	58	4,5	0,10	1,0	01	042 .1339
	47	194	78	3,2	0,10	0,66	02	042 .1479
	68	233	108	2,2	0,10	0,48	02	042 .1689
	100	313	154	1,5	0,10	0,37	03	042 .1101
	150	433	226	1,0	0,10	0,21	04	043 .1151
	220	571	327	0,7	0,10	0,18	05	043 .1221
250	2,2	18	28	132	0,18	35	4	041 .3228
	4,7	29	55	61,7	0,18	18	5	041 .3478
	10	55	95	29	0,18	7	7	041 .3109
	10	72	33	15	0,10	4,2	00	042 .3109
	15	100	44	10	0,10	2,8	01	042 .3159
	22	120	60	6,8	0,10	2,2	01	042 .3229
	33	162	84	4,5	0,10	1,4	02	042 .3339
	47	215	116	3,2	0,10	0,75	03	042 .3479
	68	291	163	2,2	0,10	0,4	04	043 .3689
	100	385	235	1,5	0,10	0,28	05	043 .3101
350	4,7	32	69	68,1	0,20	12	6	041 .5478
	6,8	60	32	22	0,10	5,0	00	042 .5688
	10	81	42	15	0,10	4,2	01	042 .5109
	15	100	57	10	0,10	2,8	01	042 .5159
	22	133	79	6,8	0,10	2,1	02	042 .5229
	33	162	114	4,5	0,10	0,9	03	042 .5339
	47	242	158	3,2	0,10	0,7	04	043 .5479
	68	317	224	2,2	0,10	0,4	05	043 .5689
385	1	12	19	335	0,20	40	4	041 .8108
	2,2	23	42	152	0,20	20	5	041 .8228
	4,7	43	71	71,3	0,20	8	7	041 .8478
	6,8	60	34	22	0,10	5,0	00	042 .8688
	10	81	45	15	0,10	4,2	01	042 .8109
	15	110	62	10	0,10	2,3	02	042 .8159
	22	147	86	6,8	0,10	2,0	03	042 .8229
	33	203	124	4,5	0,10	0,8	04	043 .8339
	47	242	173	3,2	0,10	0,7	04	043 .8479
	68	317	246	2,2	0,10	0,4	05	043 .8689

* Note is on the next page.

* Replace dot in catalogue number by:
1 for style 1, case sizes 00 to 05, supplied in box;
2 for style 1 on bandoliers on reel (preferred for case size 4) } case sizes 4 to 7
3 for style 1 on bandoliers in box (preferred for case sizes 5 to 7) } case sizes 4 to 7
→ 4 for style 2, case sizes 02 to 05;
8 for style 3.

Capacitance

Nominal capacitance at 100 Hz and T_{amb} = 20 °C	see Table 2
Tolerance on nominal capacitance at 100 Hz	−10 to + 50%

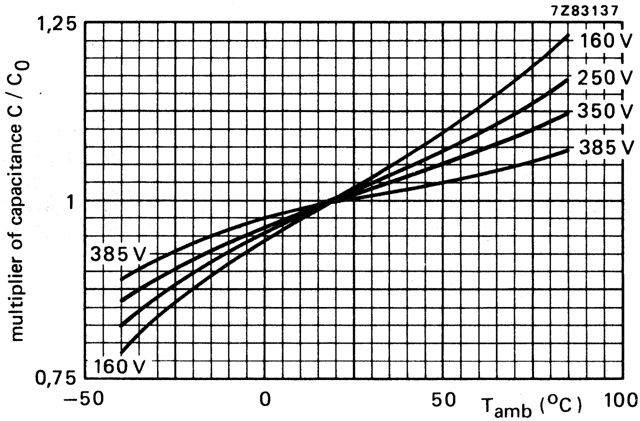


Fig. 4 Multiplier of capacitance as a function of ambient temperature; **case sizes 4 to 7**; C_0 = capacitance at 20 °C, 100 Hz.

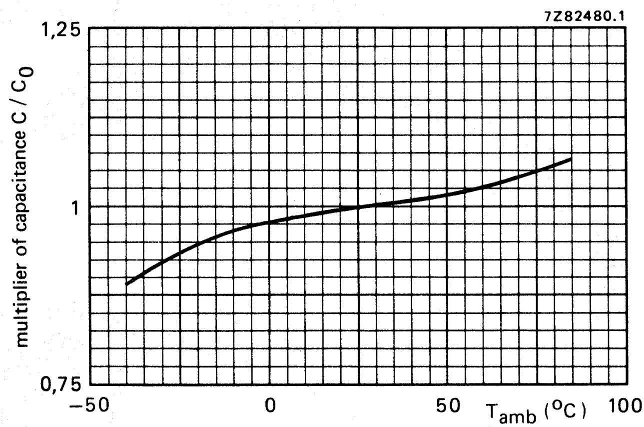


Fig. 5 Multiplier of capacitance as a function of ambient temperature; **case sizes 00 to 05**; C_0 = capacitance at 25 °C, 100 Hz.

Voltage

Rated voltage = max. permissible voltage at core temperature▲	
< 60 °C	1,1 x U_R
60 to 95 °C	U_R
Ripple voltage* = max. permissible a.c. voltage providing the following three conditions are met:	
a) max. (d.c. + peak a.c.) voltage	U_R
b) max. peak a.c. voltage without d.c. voltage applied	1 V
c) momentary value of applied voltage	between U_R and −1 V
Surge voltage = max. permissible voltage for short periods	
for U_R = 160 V or 250 V	1,15 x U_R
for U_R = 350 V or 385 V	1,1 x U_R
Reverse voltage = max. d.c. voltage applied in the reverse polarity at 85 °C for short periods	1 V

Ripple current **

Maximum permissible r.m.s. ripple current at 100 Hz and T_{amb} = 85 °C	see Table 2

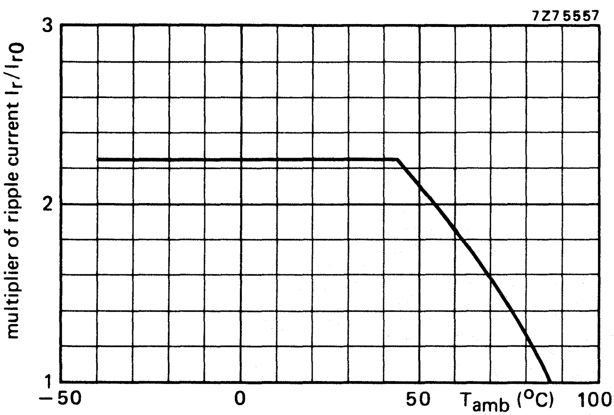


Fig. 6 Multiplier of ripple current as a function of ambient temperature; I_{r0} = ripple current at 85 °C, 100 Hz.

▲ See Introduction, section 5, "Ripple current".

* Ripple voltages are not applicable if the maximum permissible ripple current is exceeded. In that case the ripple current is decisive.

** Ripple currents are not applicable if the maximum permissible ripple voltage is exceeded. In that case the ripple voltage is decisive.

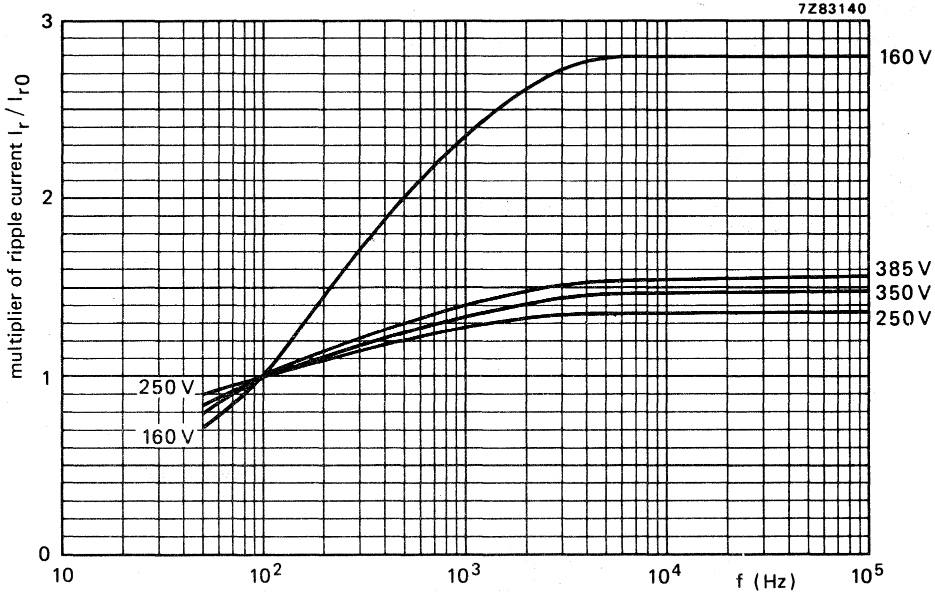


Fig. 7 Multiplier of ripple current as a function of frequency; **case sizes 4 to 7**; I_{r0} = ripple current at 85 °C, 100 Hz.

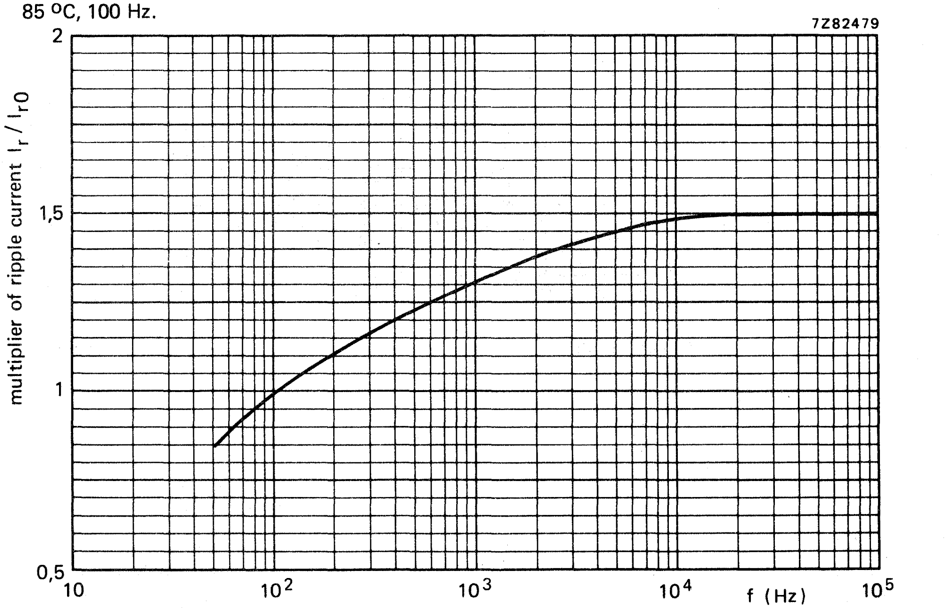


Fig. 8 Multiplier of ripple current as a function of frequency; **case sizes 00 to 05**: I_{r0} = ripple current at 85 °C, 100 Hz.

Non-sinusoidal ripple currents have to be analyzed into a number of sinusoidal currents and the following requirements shall then be satisfied:

$$\sum_n \frac{I_n^2}{r_n} \leqslant I_{r\,max}^2$$

$I_{r\,max}$ = maximum ripple current at 100 Hz and applicable ambient temperature;
I_n = ripple current at a certain frequency;
$\sqrt{r_n} = I_r/I_{r0}$ = multiplying factor at a same frequency.

Charge and discharge current

The capacitors may be charged from a source without internal resistance and they may be discharged by short-circuiting. If the capacitors are charged and discharged continuously several times per minute, the charge and discharge currents have to be considered as ripple currents flowing through the capacitors. The r.m.s. value of these currents should be determined and the value thus found must not exceed the applicable limit.

D.C. leakage current

Maximum d.c. leakage current **1 min** after application of the rated voltage at T_{amb} = 20 °C	
case sizes 4 to 7	see Table 2 (0,05 CU or 5 μA, whichever is greater for CU ⩽ 1000 μC; 0,03 CU + 20 μA for CU > 1000 μC)
case sizes 00 to 05	see Table 2 (0,009 CU + 10 μA)
Maximum d.c. leakage current **5 min** after application of the rated voltage at T_{amb} = 20 °C; all case sizes	0,01 CU or 1 μA (whichever is greater) for CU ⩽ 1000 μC; 0,006 CU + 4 μA for CU > 1000 μC CU > 1000 μC

If owing to prolonged storage and/or storage at an excessive temperature (> 40 °C) the d.c. leakage current is too high, application of the rated voltage for some hours will cause the d.c. leakage current to fall to a value lower than specified in Table 2.

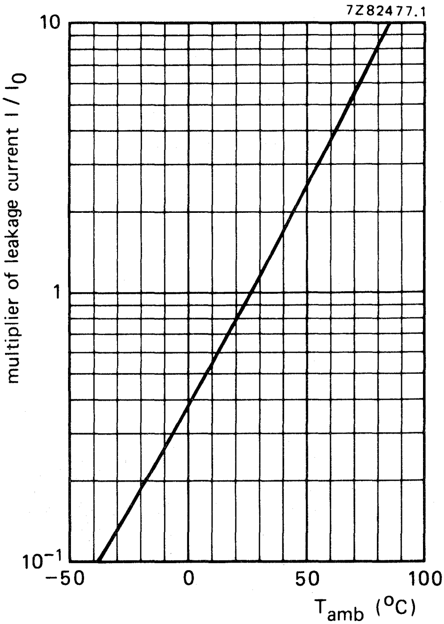


Fig. 9 Multiplier of d.c. leakage current as a function of ambient temperature; I_0 = d.c. leakage current during continuous operation at 25 °C and U_R.

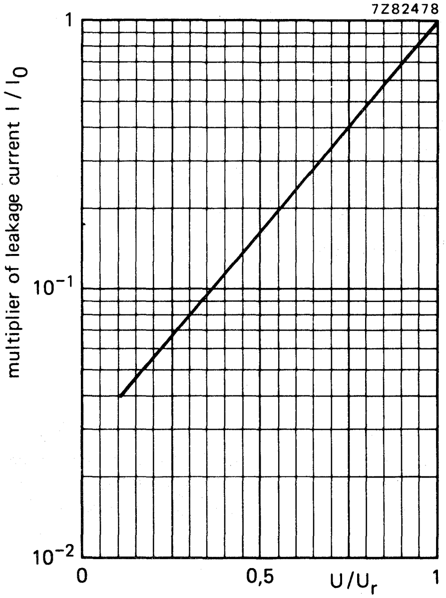


Fig. 10 Multiplier of d.c. leakage current as a function of U/U_R; I_0 = d.c. leakage current during continuous operation at 25 °C and U_R.

Tan δ (dissipation factor)

Maximum tan δ at 100 Hz and T_{amb} = 25 °C, measured by means of a four-terminal circuit (Thomson circuit) — see Table 2

Equivalent series resistance (ESR)

Maximum ESR at 100 Hz and T_{amb} = 25 °C, measured by means of a four-terminal circuit (Thomson circuit)

see Table 2

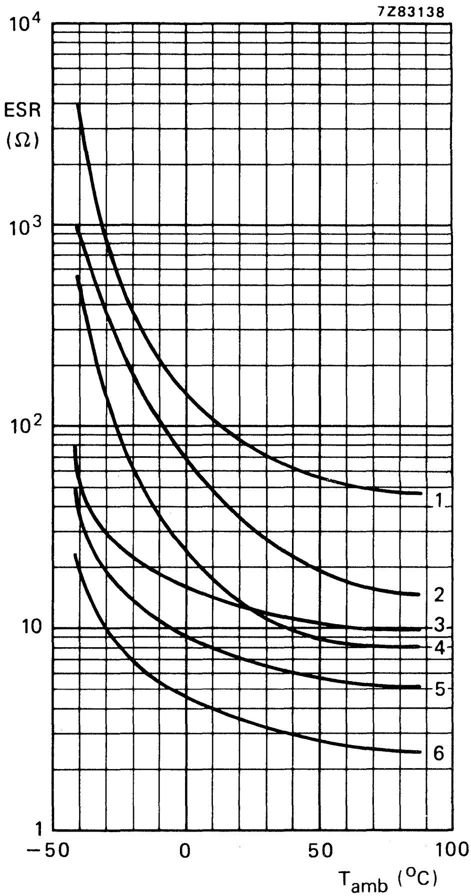


Fig. 11 Typical ESR as a function of ambient temperature at 100 Hz; **case sizes 4 to 7.**
Curve 1 = case size 4, 385 V;
curve 2 = case size 5, 385 V;
curve 3 = case size 4, 160 V;
curve 4 = case size 7, 385 V;
curve 5 = case size 5, 160 V;
curve 6 = case size 7, 160 V.

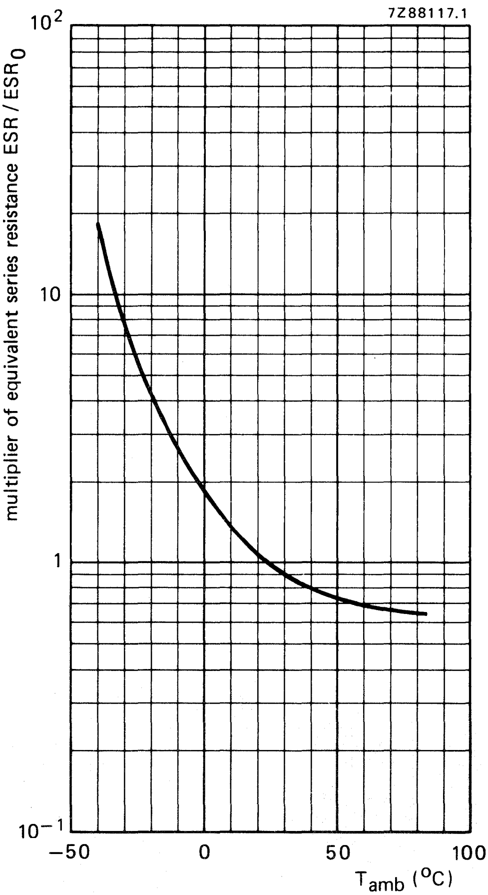


Fig. 12 Multiplier of ESR as a function of ambient temperature; **case sizes 00 to 05**; ESR_0 = typ. ESR at 25 °C, 100 Hz.

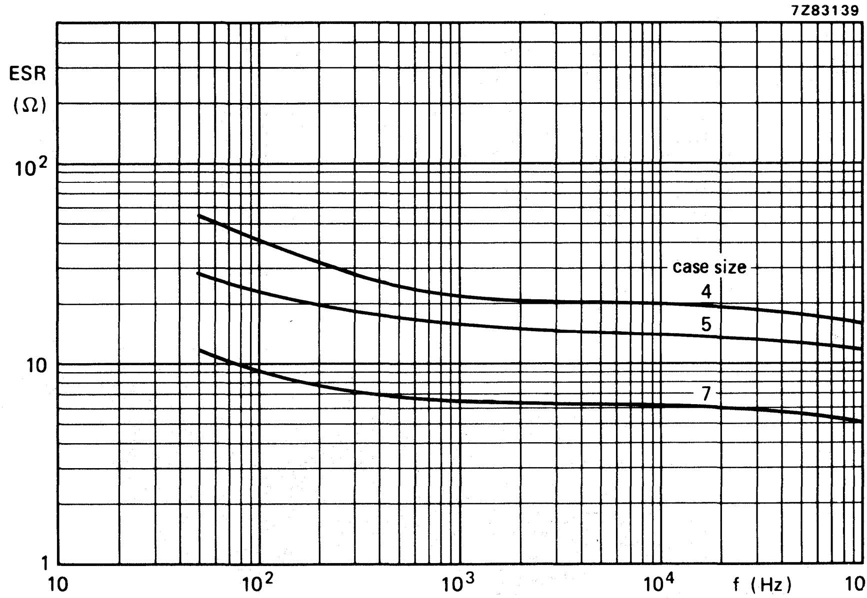


Fig. 13 Typical ESR as a function of frequency at 20 °C; U_R = 250 V; **case sizes 4 to 7.**

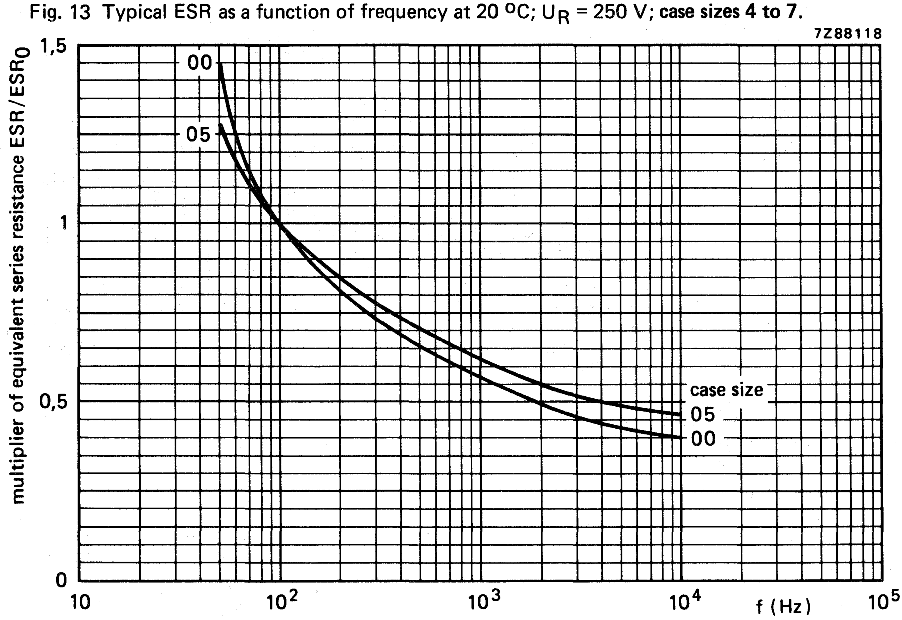


Fig. 14 Multiplier of ESR as a function of frequency; **case sizes 00 to 05**; ESR_0 = typ. ESR at 25 °C, 100 Hz.

Impedance

Typical impedance at 10 kHz, measured by a four-terminal circuit (Thomson circuit)

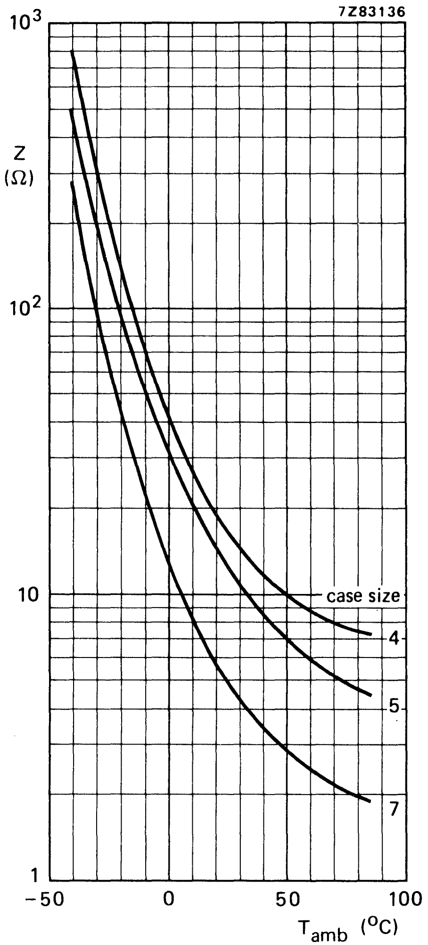


Fig. 15 Typical impedance as a function of ambient temperature at 10 kHz; U_R = 250 V; **case sizes 4 to 7.**

see Table 2

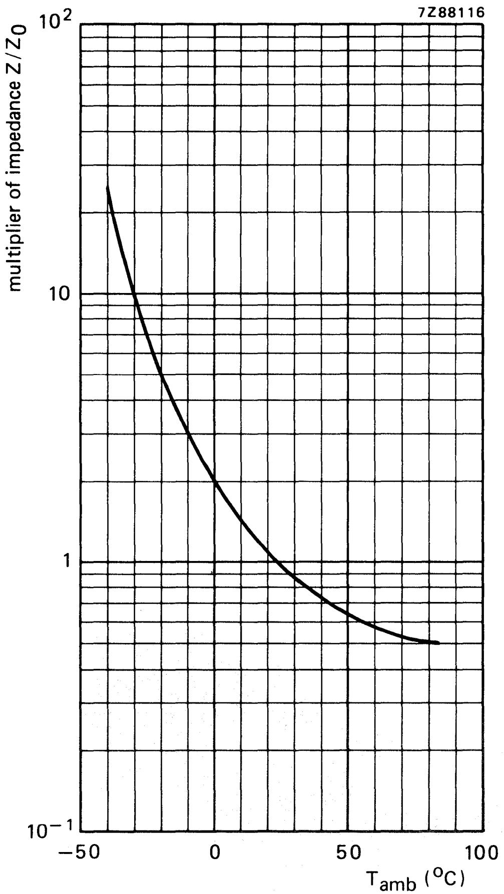


Fig. 16 Multiplier of impedance as a function of ambient temperature; **case sizes 00 to 05**; Z_0 = typ. impedance at 25 °C, 10 kHz (see Table 2).

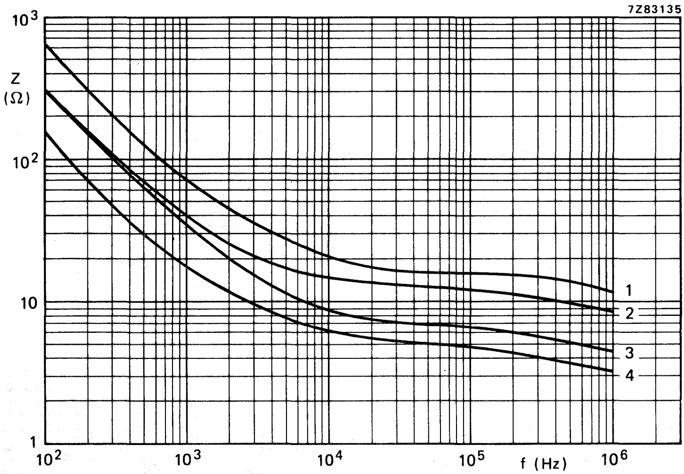


Fig. 17 Typical impedance as a function of frequency at 20 °C. **Case sizes 4 to 7.**

Curve 1 = case size 4, 250 V;
curve 2 = case size 5, 250 V;
curve 3 = case size 6, 350 V;
curve 4 = case size 7, 250 V.

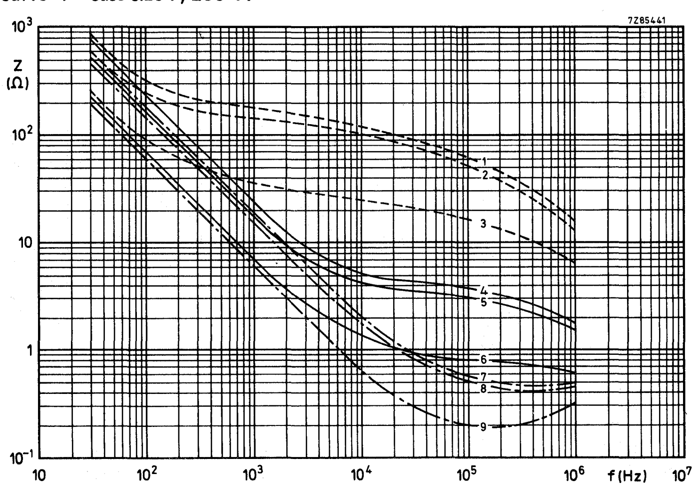


Fig. 18 Typical impedance as a function of frequency at different temperatures. **Case size 00.**

Curve 1 = 6,8 μF, 350/385 V; –40 °C;
curve 2 = 10 μF, 250 V; –40 °C;
curve 3 = 22 μF, 160 V; –40 °C;
curve 4 = 6,8 μF, 350/385 V; + 20 °C;
curve 5 = 10 μF, 250 V; + 20 °C;
curve 6 = 22 μF, 160 V; + 20 °C;
curve 7 = 6,8 μF, 350/385 V; + 85 °C;
curve 8 = 10 μF, 250 V; + 85 °C;
curve 9 = 22 μF, 160 V; + 85 °C.

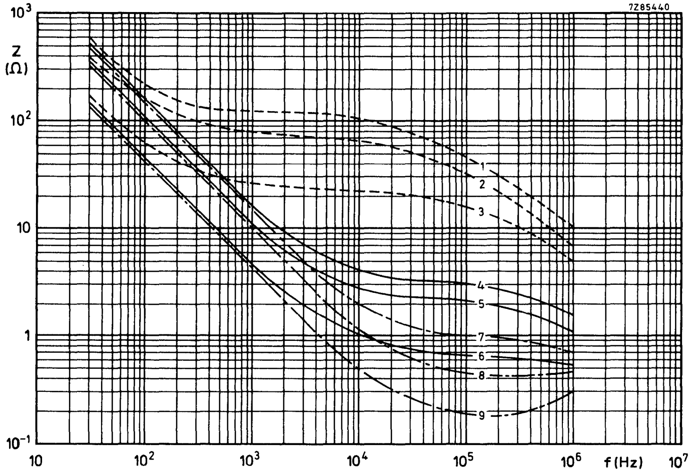


Fig. 19 Typical impedance as a function of frequency at different temperatures. **Case size 01.**

Curve 1 = 10 μF, 350/385 V; –40 °C;
curve 2 = 15 μF, 250 V; –40 °C;
curve 3 = 33 μF, 160 V; –40 °C;
curve 4 = 10 μF, 350/385 V; + 20 °C;
curve 5 = 15 μF, 250 V; + 20 °C;
curve 6 = 33 μF, 160 V; + 20 °C;
curve 7 = 10 μF, 350/385 V; + 85 °C;
curve 8 = 15 μF, 250 V; + 85 °C;
curve 9 = 33 μF, 160 V; + 85 °C.

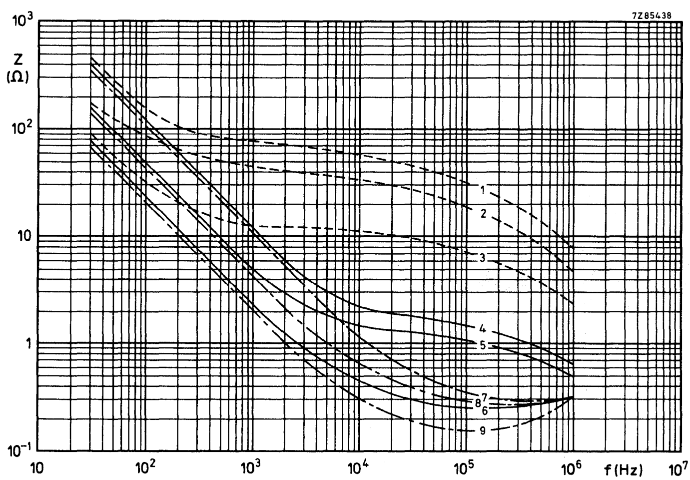


Fig. 20 Typical impedance as a function of frequency at different temperatures. **Case size 02.** ←

Curve 1 = 15 μF, 385 V; –40 °C;
curve 2 = 22 μF, 350 V; –40 °C;
curve 3 = 68 μF, 160 V; –40 °C;
curve 4 = 15 μF, 385 V; +20 °C;
curve 5 = 22 μF, 350 V; +20 °C;
curve 6 = 68 μF, 160 V; + 20 °C;
curve 7 = 15 μF, 385 V; + 85 °C;
curve 8 = 22 μF, 350 V; + 85 °C;
curve 9 = 68 μF, 160 V; + 85 °C.

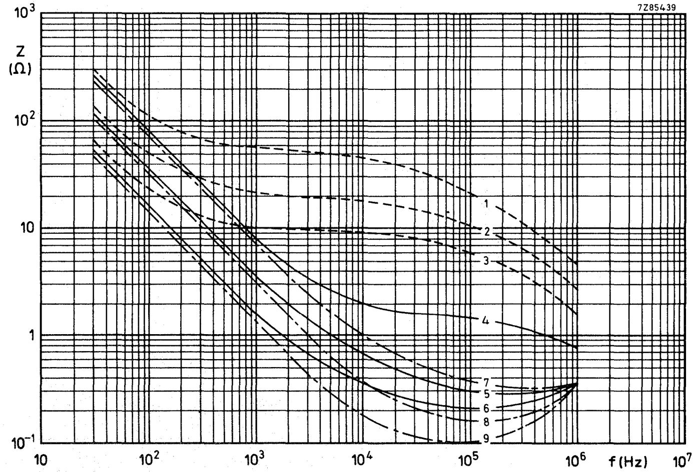


Fig. 21 Typical impedance as a function of frequency at different temperatures. **Case size 03.**

Curve 1 = 22 μF, 385 V; –40 °C;
curve 2 = 47 μF, 250 V; –40 °C;
curve 3 = 100 μF, 160 V; –40 °C;
curve 4 = 22 μF, 385 V; + 20 °C;
curve 5 = 47 μF, 250 V; + 20 °C;
curve 6 = 100 μF, 160 V; + 20 °C;
curve 7 = 22 μF, 385 V; + 85 °C;
curve 8 = 47 μF, 250 V; + 85 °C;
curve 9 = 100 μF, 160 V; + 85 °C.

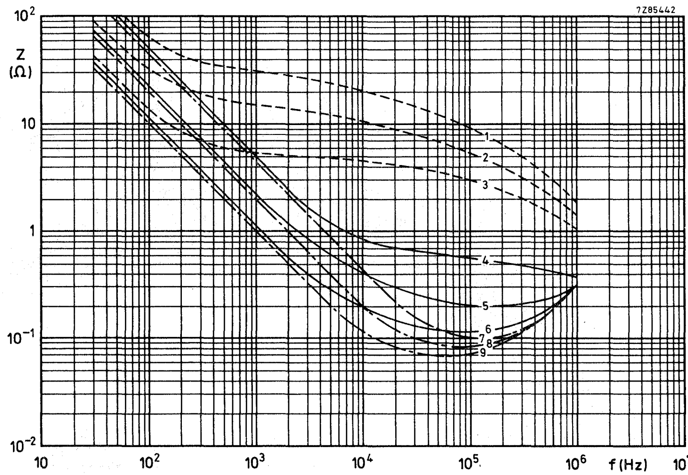


Fig. 22 Typical impedance as a function of frequency at different temperatures. **Case size 04.**

Curve 1 = 33 μF, 385 V; –40 °C;
curve 2 = 68 μF, 250 V; –40 °C;
curve 3 = 150 μF, 160 V; –40 °C;
curve 4 = 33 μF, 385 V; + 20 °C;
curve 5 = 68 μF, 250 V; + 20 °C;
curve 6 = 150 μF, 160 V; + 20 °C;
curve 7 = 33 μF, 385 V; + 85 °C;
curve 8 = 68 μF, 250 V; + 85 °C;
curve 9 = 150 μF, 160 V; + 85 °C.

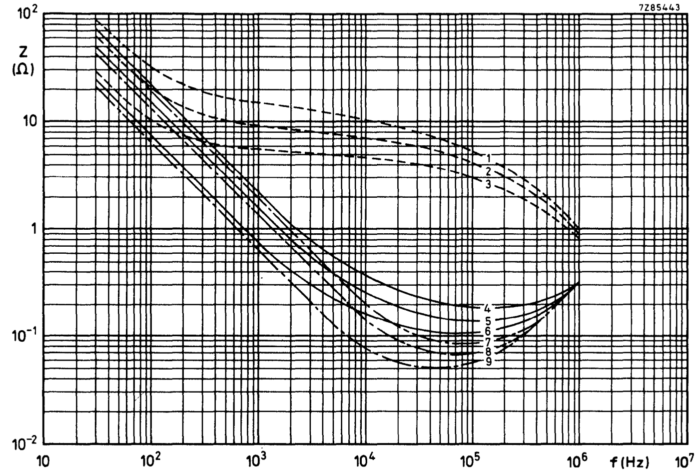


Fig. 23 Typical impedance as a function of frequency at different temperatures. **Case size 05.**

Curve 1 = 68 μF, 350/385 V; –40 °C;
curve 2 = 100 μF, 250 V; –40 °C;
curve 3 = 220 μF, 160 V; –40 °C;
curve 4 = 68 μF, 350/385 V; + 20 °C;
curve 5 = 100 μF, 250 V; + 20 °C;
curve 6 = 220 μF, 160 V; + 20 °C;
curve 7 = 68 μF, 350/385 V; + 85 °C;
curve 8 = 100 μF, 250 V; + 85 °C;
curve 9 = 220 μF, 160 V; + 85 °C.

Inductance (ESL)

Case size 4	30 nH	typical values
Case size 5	50 nH	
Case sizes 6 and 7	65 nH	
Case sizes 00 and 01	50 nH	
Case size 02	55 nH	
Case sizes 03, 04 and 05	60 nH	

OPERATIONAL DATA

Category temperature range	–40 to + 85 °C	
Typical life time	T_{amb} = 85 °C	T_{amb} = 40 °C
case sizes 4 to 7	5000 h	> 100 000 h
case sizes 00 to 05	10 000 h	> 200 000 h
Shelf life at 0 V and T_{amb} = 85 °C	500 h	

PACKING

All capacitors are supplied in boxes, case sizes 4 to 7 of style 1 are on bandoliers in boxes or on reels. The number of capacitors per box or per reel is shown in Table 3.

Table 3

case size	number of capacitors		
	style 1 per reel	style 1 per box	styles 2 and 3 per box
4	1000	1000	1000
5	500	500	1000
6	500	500	1000
7	500	500	500
00		200	200
01		200	200
02		200	200
03		200	200
04		100	100
05		100	100

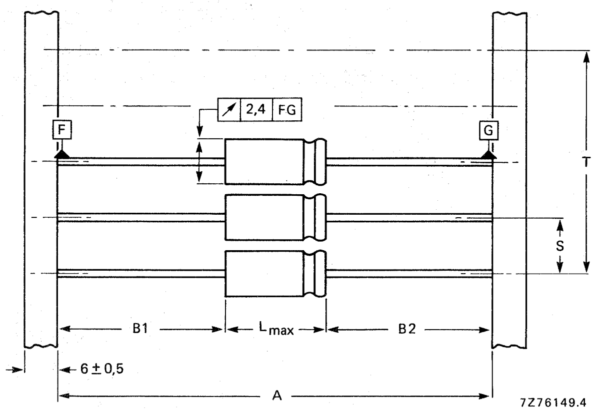


Fig. 24 Style 1 capacitors (case sizes 4 to 7) on bandoliers: the bandolier to which the negative capacitor terminals are connected is blue. See Table 4 for dimensions A, S, T and L. |B1 − B2| = max. 1,4 mm.

Table 4

Dimensions in mm

case size	A	S	T for number (n) of capacitors		L_{max}
			$n < 50$	$50 < n < 100$	
4	73 ± 1,6	10 ± 0,4	10 (n-1) ± 2	10 (n-1) ± 4	18,5
5	73 ± 1,6	10 ± 0,4	10 (n-1) ± 2	10 (n-1) ± 4	18,5
6	73 ± 1,6	15 ± 0,75	15 (n-1) ± 2	15 (n-1) ± 4	18,5
7	73 ± 1,6	15 ± 0,75	15 (n-1) ± 2	15 (n-1) ± 4	25,0

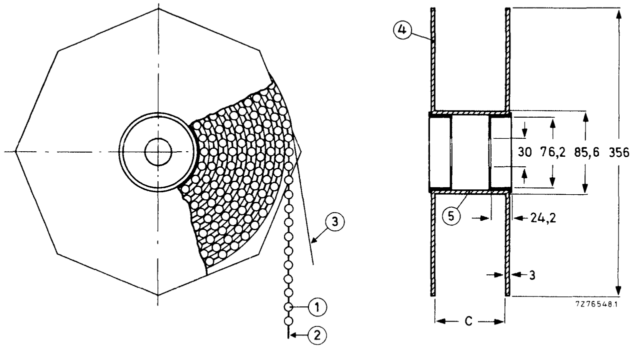


Fig. 25 Style 1 capacitors (case sizes 4 to 7) on bandoliers on reel; dimension C is 88,5 mm; the overall width of the reel is 99,5 mm.

1 = capacitor
2 = bandolier
3 = paper
4 = flange
5 = cylinder

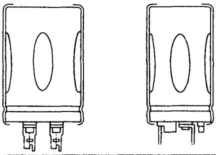
TESTS AND REQUIREMENTS

See Introduction, section 9, under aluminium electrolytic capacitors.

After *shelf life test, 500 h, 85 °C,* the capacitors meet the same requirements as after endurance test, except for d.c. leakage current: $\leqslant$ 200% of specified value. The rated voltage shall be applied to the capacitors for minimum 30 min, at least 24 h and not more than 48 h before measurements.

Note: Capacitors 2222 041 are miniature types, long-life grade.
Capacitors 2222 042 and 2222 043 are small types, long-life grade.

ALUMINIUM ELECTROLYTIC CAPACITORS



- **Large type with solder tags or printed-wiring pins**
- **Long life**
- **Industrial applications**

QUICK REFERENCE DATA

Nominal capacitance range (E6 series)	47 to 68 000 μF
Tolerance on nominal capacitance	−10 to + 30%
Rated voltage, U_R	10 to 385 V
Category temperature range	−40 to + 85 °C
Endurance test at 85 °C, at U_R	2000 h
Shelf life at 0 V, 85 °C	500 h
Basic specification	IEC 384-4, long-life grade; DIN 41240
Dimensional specification	DIN 41238
Climatic category, IEC 68 DIN 40040	40/085/56 GPF (56 days)
Approval	CECC 30 301-033

Selection chart for C_{nom}-U_R and relevant case sizes.

C_{nom}	U_R (V)							
μF	10	16	25	40	63	100	250	385
47								1
68								2
100							1	3
150							2	4
220							3	5/6
330							4	7
470						1	5/6	8
680						2	7	
1 000					1	3	8	
1 500				1	2	4		
2 200			1	2	3	5/6		
3 300		1	2	3	4	7		
4 700	1	2	3	4	5/6	8		
6 800	2	3	4	5/6	7	9		
10 000	3	4	5/6	7	8			
15 000	4	5/6	7	8	9			
22 000	5/6	7	8	9				
33 000	7	8	9					
47 000	8	9						
68 000	9							

case size	nominal dimensions (mm) versions with solder tags	nominal dimensions (mm) versions with printed-wiring pins
1	ϕ 25 x 35	ϕ 25 x 35
2	ϕ 25 x 45	ϕ 25 x 45
3	ϕ 30 x 45	ϕ 30 x 45
4	ϕ 35 x 45	ϕ 35 x 45
5	ϕ 35 x 55	ϕ 35 x 55
6		ϕ 40 x 45
7	ϕ 40 x 55	ϕ 40 x 55
8	ϕ 40 x 75	ϕ 40 x 75
9	ϕ 40 x 105	ϕ 40 x 105

APPLICATION

These capacitors have low ESR and ESL values and a high resistance to shock and vibration which render them suitable for application such as:

- switched-mode power supplies;
- power supplies in digital equipment;
- energy storage in pulse systems;
- filters in measuring and control apparatus.

DESCRIPTION

The resistance to shock and vibration is achieved by a special internal construction.
The capacitors are completely cold welded and charge/discharge proof. The aluminium case is fully insulated. The solder tag versions have a safety vent in the discs, the printed-wiring versions have a safety vent in the case bottom.

MECHANICAL DATA

Dimensions in mm

Capacitors with solder tags

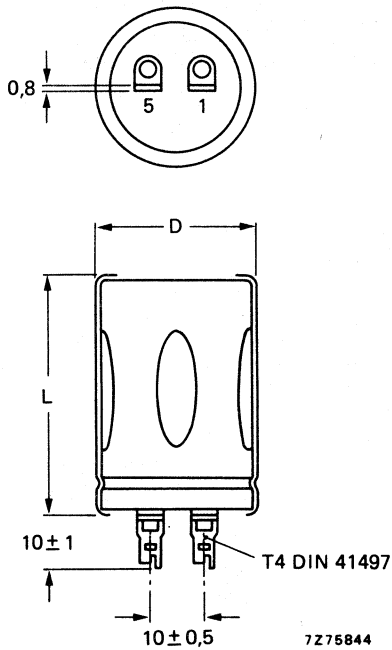


Fig. 1.

1 = positive terminal;
5 = negative terminal.

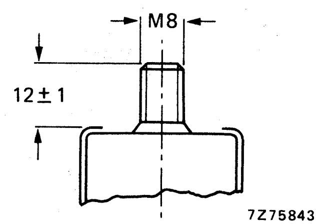


Fig. 2 Bolt version.

Table 1a

case size	D		L		mass approx. g
1	25	+ 0,6	35	+ 1,3	25
2	25		45		30
3	30		45		40
4	35		45		55
5	35		55		65
7	40		55		85
8	40		75		115
9	40		105		160

Capacitors with printed-wiring pins

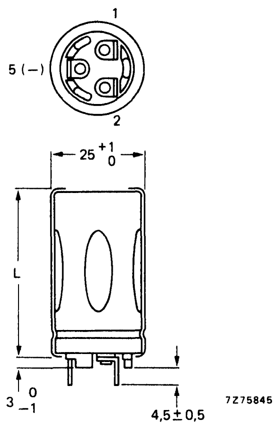


Fig. 3a.

1 = positive terminal;
5 = negative terminal.

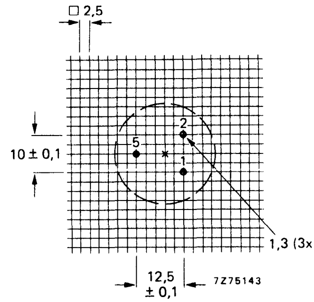


Fig. 3b Piercing diagram viewed from component side.

Table 1b

case size	L	mass approx. g
1	35 } + 1,3	25
2	45	30

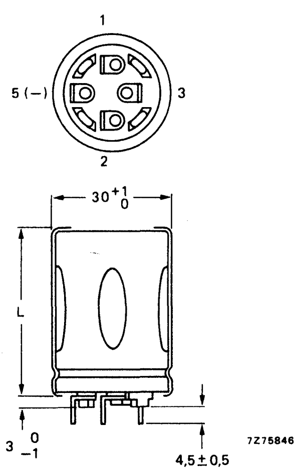


Fig. 4a.

1 = positive terminal;
5 = negative terminal.

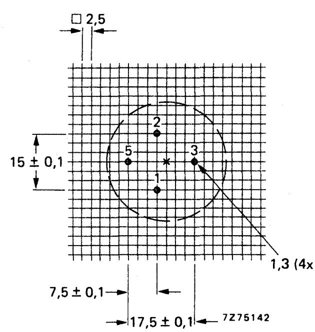


Fig. 4b Piercing diagram viewed from component side.

Table 1c

case size	L	mass approx. g
3	45 + 1,3	40

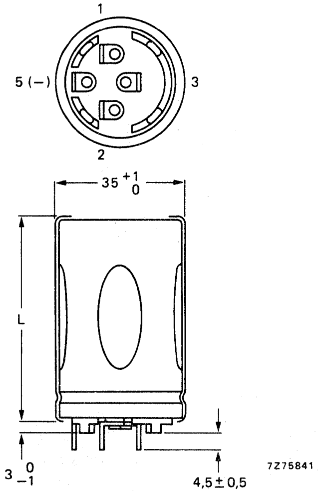


Fig. 5a.

1 = positive terminal;
5 = negative terminal.

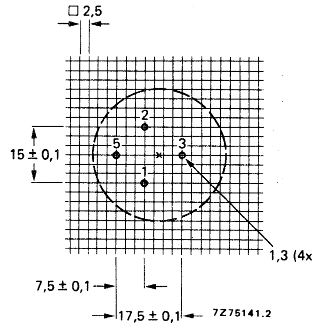


Fig. 5b Piercing diagram viewed from component side.

Table 1d

case size	L	mass approx. g
4	45 + 1,3	55
5	55 + 1,3	65

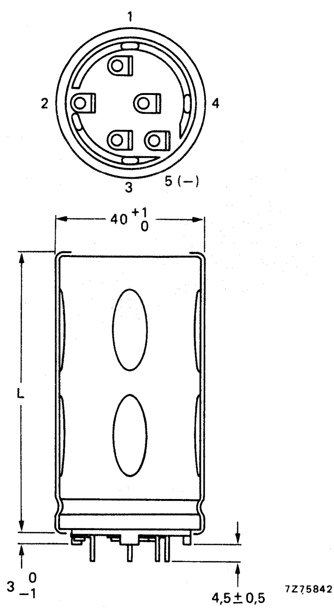


Fig. 6a.

1 = positive terminal;
5 = negative terminal.

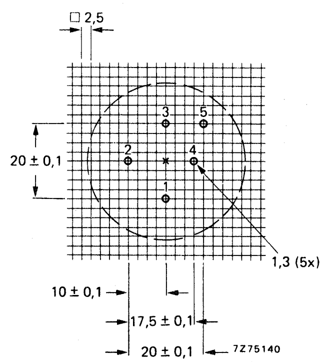


Fig. 6b Piercing diagram viewed from component side.

Table 1e

case size	L	mass approx. g
6	45 + 1,3	70
7	55 + 1,3	85
8	75 + 1,3	115
9	105 + 1,3	160

Marking

The capacitors are marked with: nominal capacitance, tolerance on capacitance, rated voltage, temperature range, IEC grade, catalogue number, date code (year, week) according to IEC 62, name of manufacturer, indication of production centre, polarity of the terminals and CECC specification BS. CECC 30 301-033.

The terminals are marked as shown in the dimensional figures.

Mounting

The capacitors may be mounted in any position with or without a mounting clamp. When a number of capacitors are connected in a bank, they must not be closer together than 15 mm, when no derating of ripple current and/or temperature is applied.
If the case has to be at a specified potential, it should be connected to the negative terminal only.

Minimum atmospheric pressure 8,5 kPa

PRODUCT SAFETY

Non-solid electrolytic capacitors may contain chemicals which can be regarded as hazardous if incorrectly handled. Caution is necessary should the outer case be fractured.

ELECTRICAL DATA

Unless otherwise specified all electrical values apply at an ambient temperature of 20 °C, a frequency of 100 Hz, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 45 to 75%.

Table 2 (note is at the end of the table)

U_R V	nom. cap. µF	max. r.m.s. ripple current (A) at 100 Hz, 85 °C	max. r.m.s. ripple current (A) at 20 kHz, 70 °C	max. d.c. leakage current at U_R after 1 min (mA)	typ. tan δ	max. ESR mΩ	max. impedance at 10 kHz mΩ	case size	catalogue number* 2222 followed by
10	4 700	2,4	4,6	0,28	0,19	74	50	1	050 . 4472
	6 800	3,2	6,1	0,41	0,18	51	37	2	. 4682
	10 000	3,8	7,2	0,60	0,24	39	29	3	. 4103
	15 000	4,1	7,8	0,90	0,33	35	26	4	. 4153
	22 000	5,0	9,5	1,32	0,37	27	21	5	. 4223
	22 000	4,2	8,0	1,32	0,48	36	27	6	. 4223
	33 000	5,0	9,5	1,98	0,58	29	22	7	. 4333
	47 000	6,8	12,9	2,82	0,58	20	17	8	. 4473
	68 000	9,2	17,5	4,08	0,62	15	14	9	. 4683
16	3 300	2,4	4,6	0,32	0,13	75	50	1	. 5332
	4 700	3,1	5,9	0,45	0,14	52	37	2	. 5472
	6 800	3,7	7,0	0,65	0,17	40	30	3	. 5682
	10 000	4,1	7,8	0,96	0,22	36	27	4	. 5103
	15 000	5,0	9,5	1,44	0,25	28	21	5	. 5153
	15 000	4,2	8,0	1,44	0,33	36	27	6	. 5153
	22 000	5,0	9,5	2,12	0,38	29	22	7	. 5223
	33 000	6,7	12,7	3,17	0,41	20	17	8	. 5333
	47 000	9,1	17,3	4,51	0,42	15	14	9	. 5473
25	2 200	2,3	4,4	0,33	0,10	78	52	1	. 6222
	3 300	3,1	5,9	0,49	0,11	53	38	2	. 6332
	4 700	3,7	7,0	0,70	0,12	42	31	3	. 6472
	6 800	4,1	7,8	1,02	0,15	37	28	4	. 6682
	10 000	5,0	9,5	1,50	0,17	28	21	5	. 6103
	10 000	4,2	8,0	1,50	0,22	36	27	6	. 6103
	15 000	5,0	9,5	2,25	0,26	29	22	7	. 6153
	22 000	6,8	12,9	3,30	0,27	20	17	8	. 6223
	33 000	9,2	17,5	4,95	0,30	15	14	9	. 6333
40	1 500	2,0	3,8	0,36	0,085	112	68	1	. 7152
	2 200	2,7	5,1	0,53	0,087	76	51	2	. 7222
	3 300	3,3	6,3	0,79	0,10	57	41	3	. 7332
	4 700	3,8	7,2	1,13	0,12	48	35	4	. 7472
	6 800	4,7	8,9	1,64	0,13	36	27	5	. 7682
	6 800	4,1	7,8	1,64	0,17	45	33	6	. 7682
	10 000	4,9	9,3	2,40	0,19	35	27	7	. 7103
	15 000	6,6	12,5	3,60	0,21	25	20	8	. 7153
	22 000	9,0	17,1	5,28	0,22	18	16	9	. 7223

Table 2 (continued)

U_R V	nom cap. μF	max. r.m.s. ripple current (A) at 100 Hz, 85 °C	20 kHz, 70 °C	max. d.c. leakage current at U_R after 1 min (mA)	typ. tan δ	max. ESR mΩ	max. impedance at 10 kHz mΩ	case size	catalogue number* 2222 followed by
63	1 000	1,8	3,4	0,38	0,064	122	74	1	050 . 8102
	1 500	2,5	4,7	0,57	0,065	83	54	2	. 8152
	2 200	3,1	5,9	0,83	0,076	57	41	3	. 8222
	3 300	3,6	6,8	1,25	0,094	48	35	4	. 8332
	4 700	4,4	8,3	1,78	0,10	36	27	5	. 8472
	4 700	3,8	7,2	1,78	0,13	45	33	6	. 8472
	6 800	4,7	8,9	2,57	0,14	35	27	7	. 8682
	10 000	6,2	11,8	3,78	0,15	25	20	8	. 8103
	15 000	8,5	16,1	5,67	0,16	18	16	9	. 8153
100	470	1,2	2,3	0,28	0,086	429	300	1	. 9471
	680	1,7	3,2	0,41	0,087	297	210	2	. 9681
	1 000	2,2	4,2	0,60	0,092	208	150	3	. 9102
	1 500	2,6	4,9	0,90	0,10	152	120	4	. 9152
	2 200	3,2	6,1	1,32	0,11	109	90	5	. 9222
	2 200	3,0	5,7	1,32	0,12	124	110	6	. 9222
	3 300	3,6	6,8	1,98	0,14	91	75	7	. 9332
	4 700	5,0	9,5	2,82	0,13	63	55	8	. 9472
	6 800	6,9	13,1	4,08	0,14	44	40	9	. 9682
250	100	0,6	1,15	0,15	0,085	1800	1300	1	052 . 3101
	150	0,8	1,5	0,23	0,08	1100	850	2	. 3151
	220	1,0	1,9	0,33	0,08	750	550	3	. 3221
	330	1,4	2,65	0,49	0,08	500	400	4	. 3331
	470	1,8	3,4	0,70	0,08	360	290	5	. 3471
	470	1,8	3,4	0,70	0,095	420	350	6	. 3471
	680	2,3	4,4	1,02	0,08	250	190	7	. 3681
	1 000	3,0	5,7	1,50	0,08	170	140	8	. 3102
385	47	0,4	0,75	0,11	0,065	2800	2200	1	. 8479
	68	0,6	1,15	0,16	0,055	1700	1350	2	. 8689
	100	0,8	1,5	0,23	0,055	1100	850	3	. 8101
	150	1,0	1,9	0,34	0,055	725	525	4	. 8151
	220	1,3	2,45	0,50	0,055	500	350	5	. 8221
	220	1,3	2,45	0,50	0,065	600	420	6	. 8221
	330	1,7	3,2	0,75	0,055	340	230	7	. 8331
	470	2,8	5,3	1,06	0,055	240	160	8	. 8471

* To complete the catalogue number, replace dot (8th digit) by:
1 = solder tag version;
4 = printed-wiring version, case size 6 only;
5 = printed-wiring version, except case size 6;
6 = solder tag, bolt version.

Capacitance

Nominal capacitance values at 100 Hz and T_{amb} = 20 °C	see Table 2
Tolerance on nominal capacitance at 100 Hz	−10 to + 30%

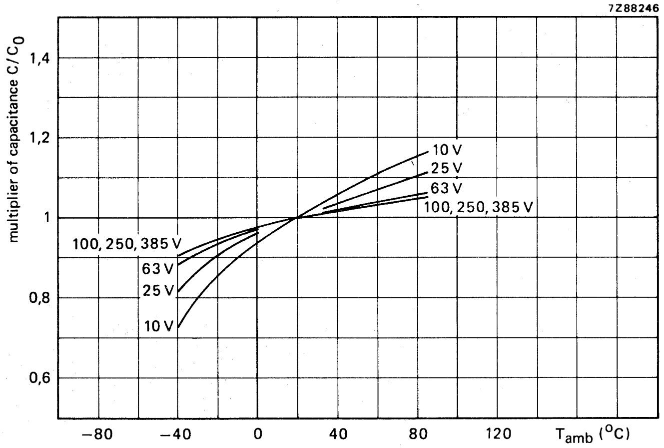


Fig. 7 Multiplier of capacitance as a function of ambient temperature; C_0 = capacitance at 25 °C, 100 Hz.

Voltage

	core temperature ▲ < 60 °C	core temperature ▲ 60 to 95 °C
Rated voltage = max. permissible voltage	1,1 x U_R	U_R
Ripple voltage* = max. permissible a.c. voltage providing the following conditions are met:		
(a) max. positive voltage on anode (d.c. + peak a.c.)	⩽ 1,1 x U_R	⩽ U_R
(b) max. positive voltage on cathode (reverse voltage)	2 V	2 V
Surge voltage = max. permissible voltage at the maximum category temperature for short periods		
10 to 100 V versions	1,25 x U_R	1,15 x U_R
250 V version	1,15 x U_R	1,15 x U_R
385 V version	1,1 x U_R	1,1 x U_R
Reverse voltage = max. d.c. voltage applied in the reverse polarity at the maximum category temperature for short periods	2 V	2 V

▲ See Introduction, section 5, "Ripple current".

* Ripple voltages are not applicable if the maximum permissible ripple current is exceeded. In that case the ripple current is decisive.

Ripple current*

Maximum permissible r.m.s. ripple current

at 100 Hz and T_{amb} = 85 °C	see Table 2
at 20 kHz and T_{amb} = 70 °C	see Table 2
at 100 Hz and other temperatures	see Table 3
at other frequencies and T_{amb} = 85 °C	see Table 4

Table 3

ambient temperature °C	multiplier of max. ripple current
85	1,00
80	1,22
75	1,41
70	1,58
65	1,73
60	1,87
55	2,00
50	2,12
45	2,24
⩽ 40	2,35

Table 4

frequency Hz	multiplier of max. ripple current, $\sqrt{r}$
50	0,83
100	1,00
200	1,10
400	1,15
1000	1,19
⩾ 2000	1,20

Non-sinusoidal ripple currents have to be analyzed into a number of sinusoidal currents and the following requirements shall then be satisfied:

$$\sum_n \frac{I_n^2}{r_n} \leqslant I_{r\,max}^2$$

$I_{r\,max}$ = maximum ripple current at 100 Hz and applicable ambient temperature

I_n = ripple current at a certain frequency

$\sqrt{r_n}$ = multiplying factor at same frequency (Table 4).

Charge and discharge current

The capacitors may be charged from a source without internal resistance and they may be discharged by short-circuiting. If the capacitors are charged and discharged continuously, the charge and discharge currents have to be considered as ripple currents flowing through the capacitor. The r.m.s. value of these currents should be determined and the value thus found must not exceed the applicable limit.

* Ripple currents are not applicable if the maximum permissible ripple voltage is exceeded. In that case the ripple voltage is decisive.

D.C. leakage current

Maximum d.c. leakage current 1 min after application of the rated voltage at T_{amb} = 20 °C	see Table 2 (0,006 CU + 4 μA)
Maximum d.c. leakage current 15 min after application of the rated voltage	
at T_{amb} = 20 °C	0,125 x value stated in Table 2
at T_{amb} = 85 °C	0,625 x value stated in Table 2

If owing to prolonged storage and/or storage at an excessive temperature the d.c. leakage current is too high, application of the rated voltage for some hours will cause the d.c. leakage current to fall to a value lower than specified in Table 2.

Tan δ (dissipation factor)

Tan δ at 100 Hz and T_{amb} = 20 °C, measured by means of a four-terminal circuit (Thomson circuit)	see Table 2

Equivalent series inductance (ESL)

Case sizes 1 and 2	max. 25 nH
Case sizes 3, 4 and 5	max. 30 nH
Case sizes 6, 7 and 8	max. 35 nH

Equivalent series resistance (ESR)

Maximum ESR at 100 Hz and T_{amb} = 20 °C	see Table 2

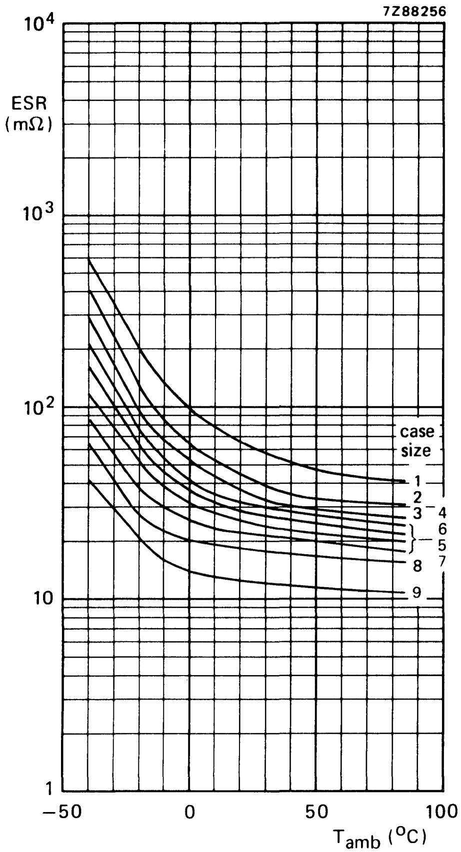


Fig. 8 Typical ESR as a function of temperature at 100 Hz, U_R = 10 V.

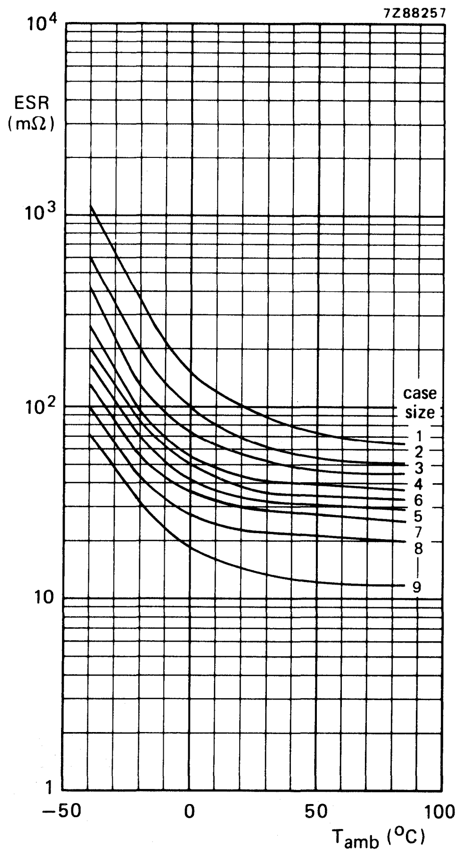


Fig. 9 Typical ESR as a function of temperature at 100 Hz, U_R = 63 V.

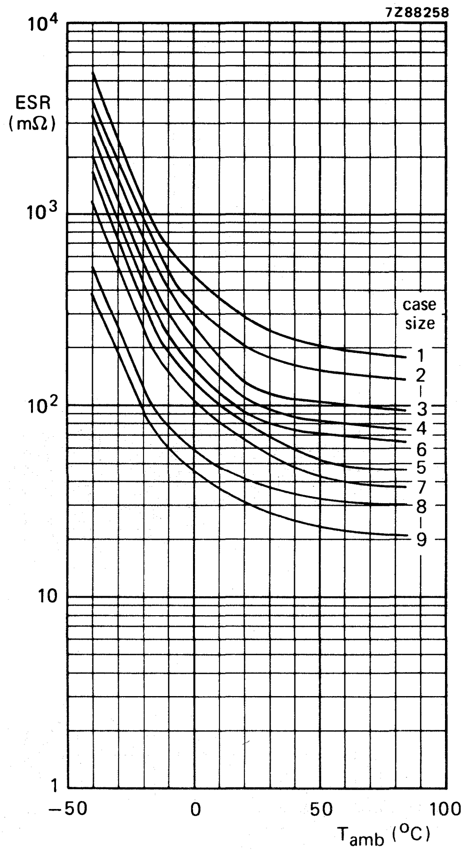


Fig. 10 Typical ESR as a function of temperature at 100 Hz, U_R = 100 V.

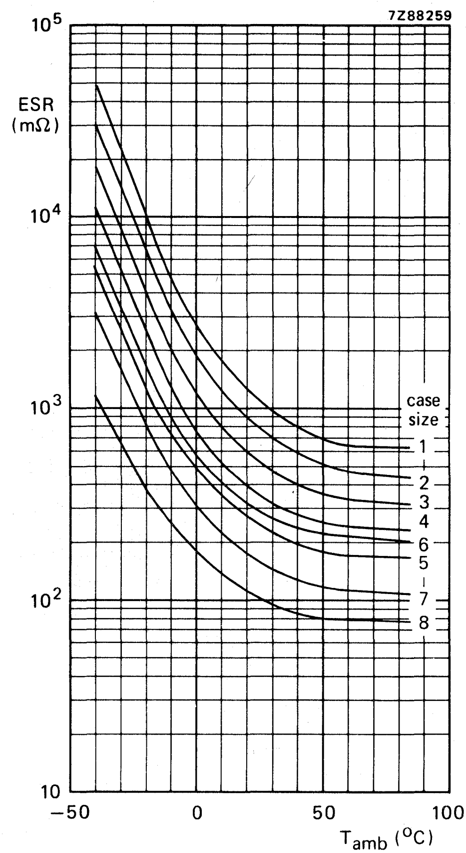


Fig. 11 Typical ESR as a function of temperature at 100 Hz, U_R = 250 V.

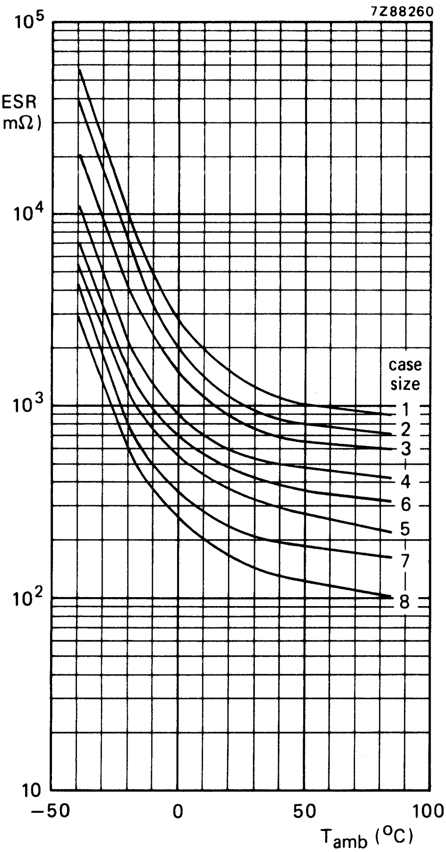


Fig. 12 Typical ESR as a function of temperature at 100 Hz, U_R = 385 V.

Impedance

Maximum impedance at 10 kHz and T_{amb} = 20 °C, measured by means of a four-terminal circuit (Thomson circuit) — see Table 2

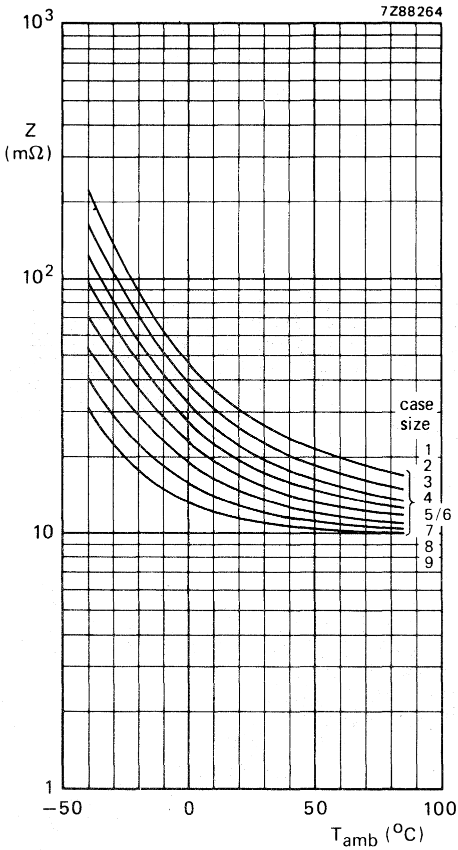


Fig. 13 Typical impedance as a function of temperature at 10 kHz, U_R = 10 V.

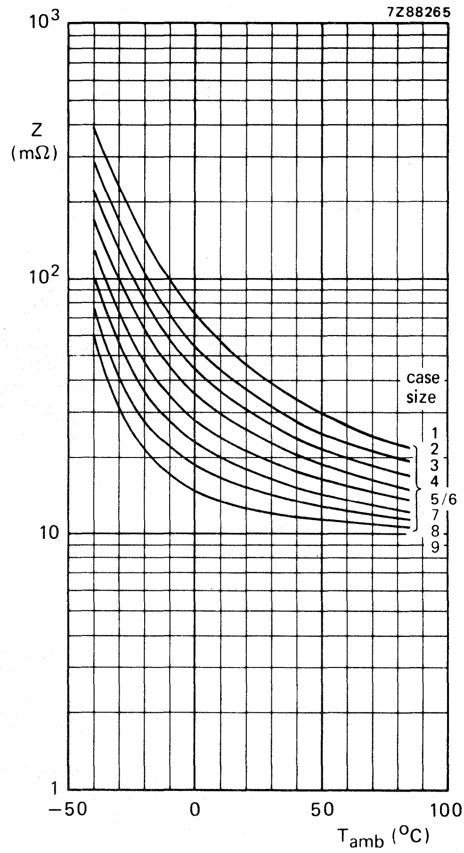


Fig. 14 Typical impedance as a function of temperature at 10 kHz, U_R = 63 V.

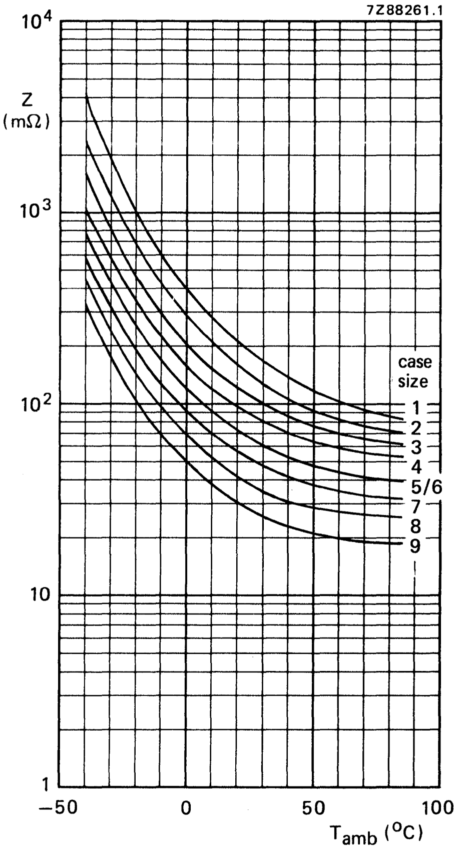


Fig. 15 Typical impedance as a function of temperature at 10 kHz, U_R = 100 V.

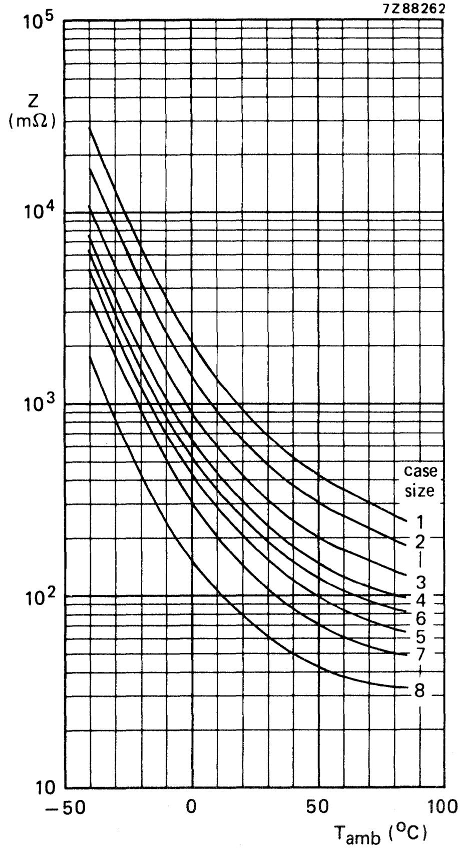


Fig. 16 Typical impedance as a function of temperature at 10 kHz, U_R = 250 V.

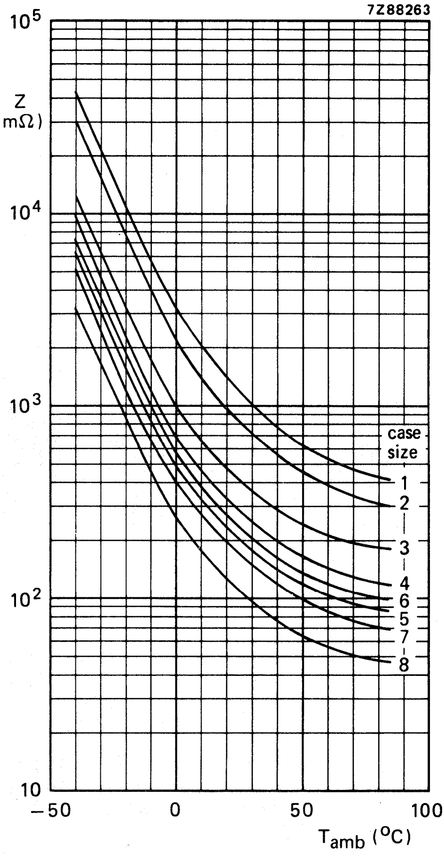


Fig. 17 Typical impedance as a function of temperature at 10 kHz, U_R = 385 V.

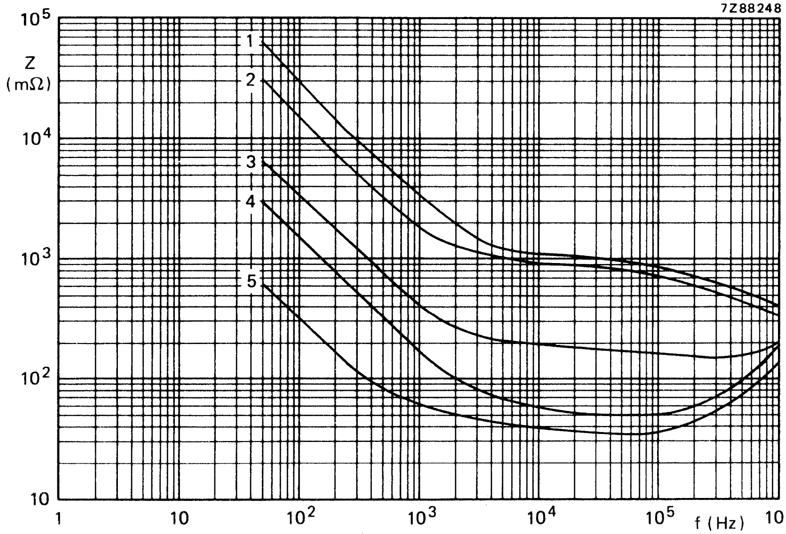


Fig. 18 Typical impedance as a function of frequency at T_{amb} = 20 °C; **case size 1:**
curve 1 = 47 μF, 385 V;
curve 2 = 100 μF, 250 V;
curve 3 = 470 μF, 100 V;
curve 4 = 1000 μF, 63 V;
curve 5 = 4700 μF, 10 V.

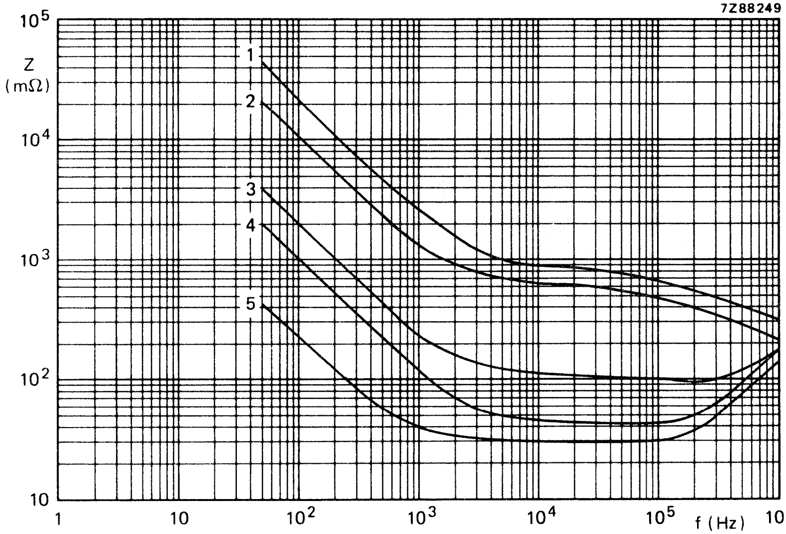


Fig. 19 Typical impedance as a function of frequency at T_{amb} = 20 °C; **case size 2:**
curve 1 = 68 μF, 385 V;
curve 2 = 150 μF, 250 V;
curve 3 = 680 μF, 100 V;
curve 4 = 1500 μF, 63 V;
curve 5 = 6800 μF, 10 V.

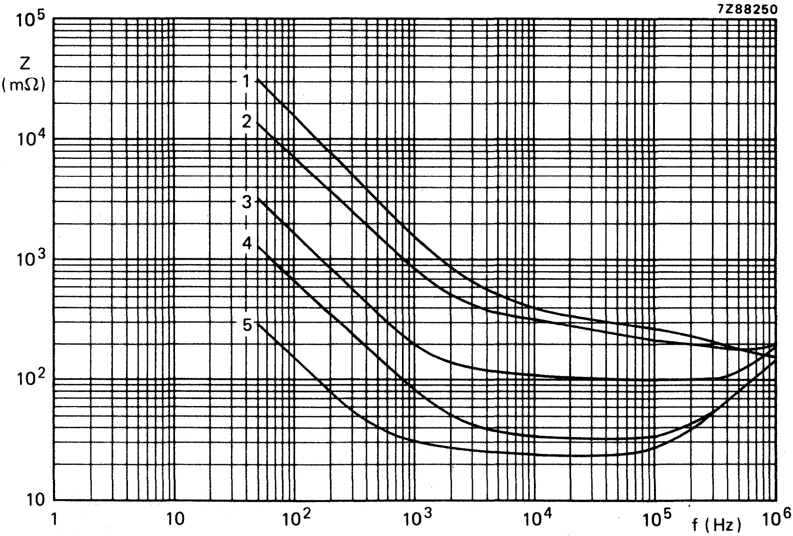


Fig. 20 Typical impedance as a function of frequency at T_{amb} = 20 °C; **case size 3:**
curve 1 = 100 μF, 385 V;
curve 2 = 220 μF, 250 V;
curve 3 = 1000 μF, 100 V;
curve 4 = 2200 μF, 63 V;
curve 5 = 10 000 μF, 10 V.

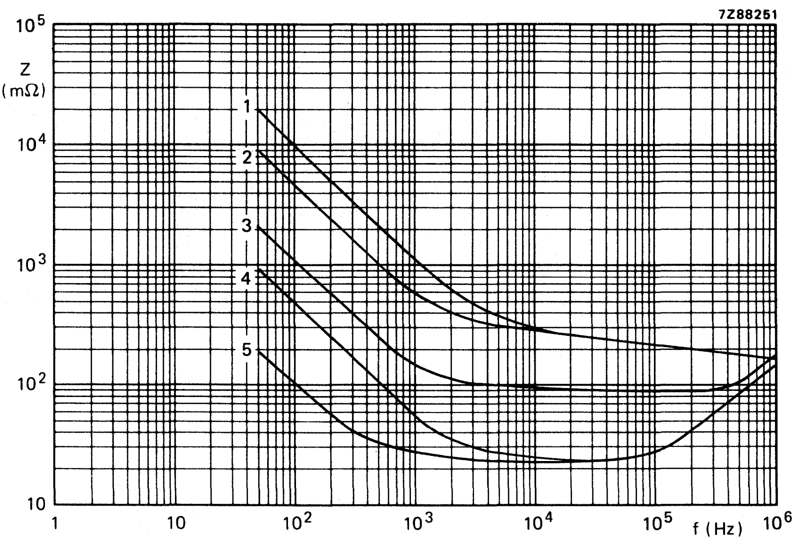


Fig. 21 Typical impedance as a function of frequency at T_{amb} = 20 °C; **case size 4:**
curve 1 = 150 μF, 385 V;
curve 2 = 330 μF, 250 V;
curve 3 = 1500 μF, 100 V;
curve 4 = 3300 μF, 63 V;
curve 5 = 15 000 μF, 10 V.

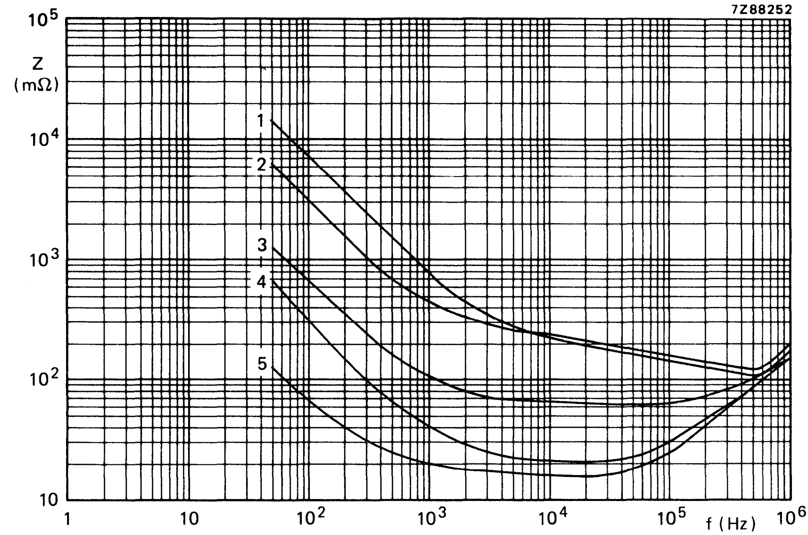


Fig. 22 Typical impedance as a function of frequency at T_{amb} = 20 °C; **case size 5:**
curve 1 = 220 μF, 385 V;
curve 2 = 470 μF, 250 V;
curve 3 = 2200 μF, 100 V;
curve 4 = 4700 μF, 63 V;
curve 5 = 22 000 μF, 10 V.

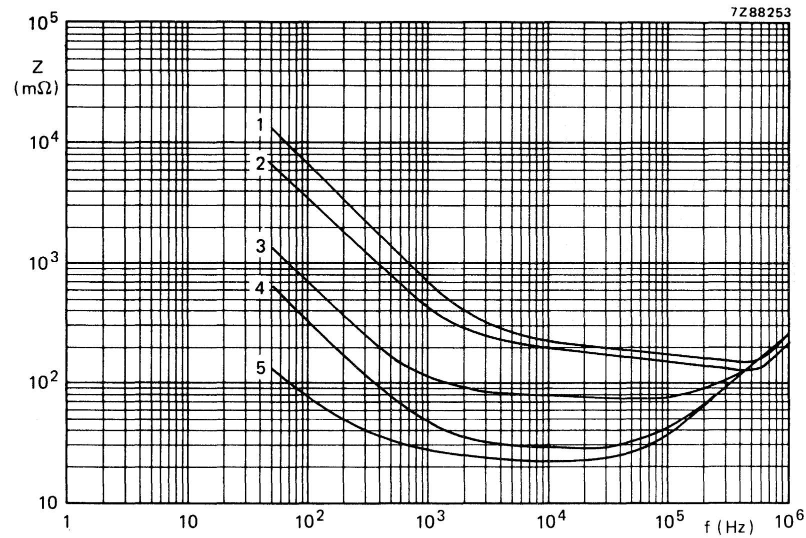


Fig. 23 Typical impedance as a function of frequency at T_{amb} = 20 °C; **case size 6:**
curve 1 = 220 μF, 385 V;
curve 2 = 470 μF, 250 V;
curve 3 = 2200 μF, 100 V;
curve 4 = 4700 μF, 63 V;
curve 5 = 22 000 μF, 10 V.

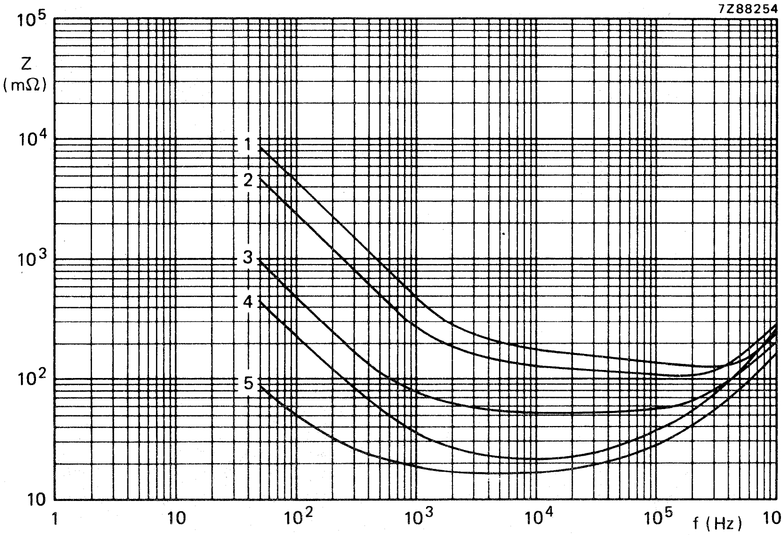


Fig. 24 Typical impedance as a function of frequency at T_{amb} = 20 °C; **case size 7:**
curve 1 = 330 μF, 385 V;
curve 2 = 680 μF, 250 V;
curve 3 = 3300 μF, 100 V;
curve 4 = 6800 μF, 63 V;
curve 5 = 33 000 μF, 10 V.

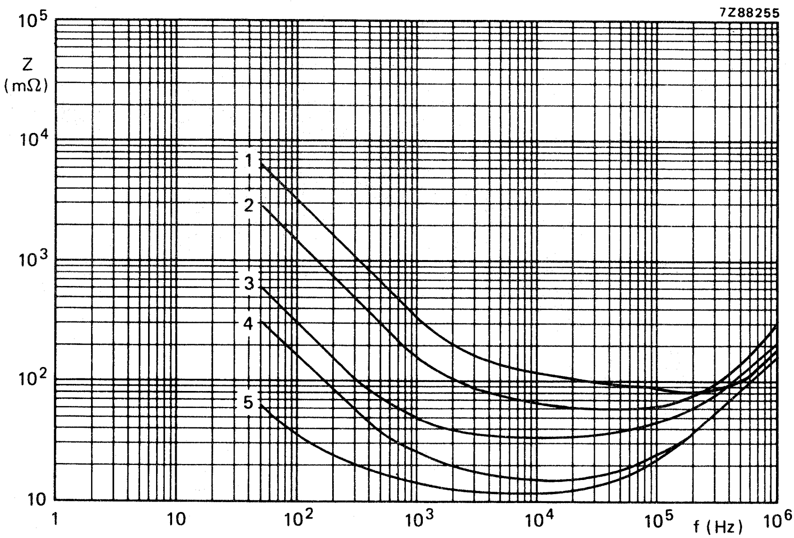


Fig. 25 Typical impedance as a function of frequency at T_{amb} = 20 °C; **case size 8:**
curve 1 = 470 μF, 385 V;
curve 2 = 1000 μF, 250 V;
curve 3 = 4700 μF, 100 V;
curve 4 = 10 000 μF, 63 V;
curve 5 = 47 000 μF, 10 V.

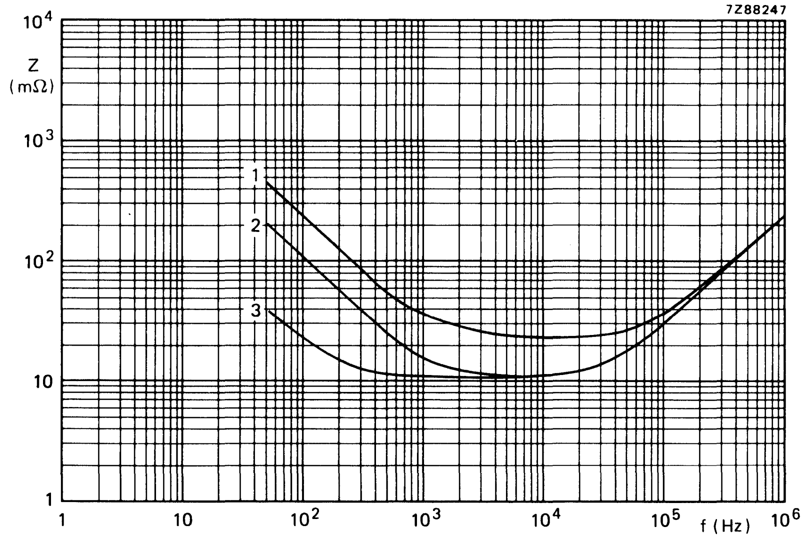


Fig. 26 Typical impedance as a function of frequency at T_{amb} = 20 °C; **case size 9:**
curve 1 = 6800 μF, 100 V;
curve 2 = 15 000 μF, 63 V;
curve 3 = 68 000 μF, 10 V.

OPERATIONAL DATA

Category temperature range	–40 to + 85 °C
Life expectancy	
Typical life time	
at T_{amb} = 85 °C	> 5000 h
at T_{amb} = 40 °C	> 100 000 h
Shelf life at 0 V and T_{amb} = 85 °C	500 h
Failure rate	
Failure rate, catastrophic, at rated voltage, T_{amb} = 40 °C and confidence level 60%	< 0,5 x 10^{-7}

PACKING

The capacitors are packed in boxes containing 100 pieces.

TESTS AND REQUIREMENTS

See Introduction, section 9, under aluminium electrolytic capacitors.
For the 385 V version the d.c. leakage current and tan δ measurements of the reverse voltage test (sub clause 9. 16 IEC 384-4) should be carried out after 250 h, U_R in forward polarity.

After *shelf life test, 500 h, 85 °C,* the capacitors meet the same requirements as after endurance test. The rated voltage shall be applied to the capacitors for minimum 30 min., at least 24 h and not more than 48 h before measurements.

Note: Capacitors 2222 050 and 2222 052 are large types, long-life grade.

MOUNTING ACCESSORIES

Dimensions in mm

Clamps

To facilitate vertical mounting, a series of rigid clamps made of cadmium-plated steel are available. They can easily be slid over the capacitor and then fixed to it with a nut and bolt. The clamps have two mounting lugs. Four types are available, one for each case diameter of the capacitor range. They are delivered without nuts or bolts.

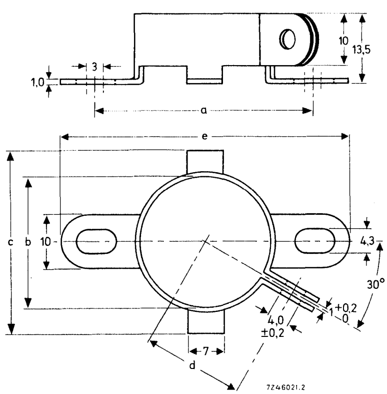


Fig. 27 Clamp for case sizes 1, 2, 3, 7, 8 and 9.

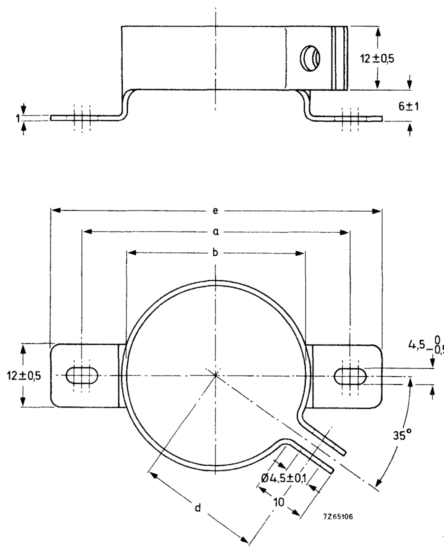


Fig. 28 Clamp for case sizes 4 and 5.

case size	dimensions (mm)					catalogue number
	a	b	c	d	e	
1, 2	41,5 ± 0,2	25	35	18,5	56	4322 043 03301
3	46,5 ± 0,2	30	40	21	61	03311
4, 5	51,5 ± 0,2	35	–	23,5	63	04272
7, 8, 9	56,5 ± 0,2	40	50	26	71	03331

Bolt/nut

When mounting by means of the bolt, which is an integral part of the case, standard metal M8 nuts and washers can be used; the maximum permissible torque is 7Nm.
If insulated mounting is required synthetic nuts and rubber washers are available; for these nuts the maximum permissible torque is 4Nm.

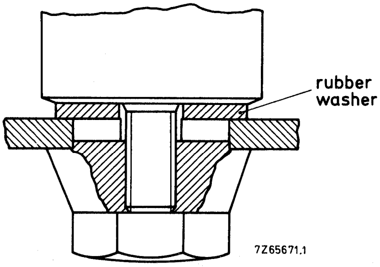


Fig. 29.

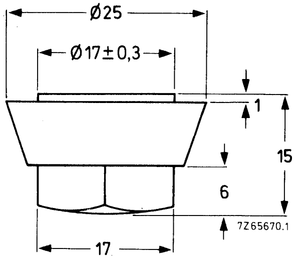


Fig. 30 Synthetic cap nut M8, threaded depth min 11,5 mm. Catalogue number 4322 043 05561.

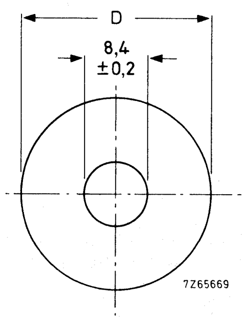
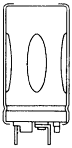


Fig. 31 Rubber washer (thickness 2 mm).

D mm	catalogue number
24	4322 043 05611
29	4322 043 05601
34	4322 043 05591
39	4322 043 05581

ALUMINIUM ELECTROLYTIC CAPACITORS

- Very high CU-product per unit volume
- Large type with printed-wiring pins
- Long life
- Industrial applications



QUICK REFERENCE DATA

Nominal capacitance range (E6 series)	68 to 150 000 μF
Tolerance on nominal capacitance	± 20%
Rated voltage range, U_R	10 to 385 V
Category temperature range	
for $U_R \leqslant 63$ V	−55 to + 85 °C
for $U_R > 63$ V	−40 to + 85 °C
Endurance test at 85 °C	2000 h
Shelf life at 0 V, 85 °C	500 h
Basic specification	IEC 384-4, long-life grade
Climatic category, IEC 68	40/085/56

Selection chart for C_{nom}—U_R and relevant case sizes

C_{nom} μF	U_R (V) 10	16	25	40	63	100	200	385
68								1
100								2
150							1	3
220							2	4
330							3	5/6
470							4	7
680						1	5/6	8
1 000						2	7	9
1 500						3	8	
2 200					1	4	9	
3 300				1	2	5/6		
4 700			1	2	3	7		
6 800		1	2	3	4	8		
10 000	1	2	3	4	5/6	9		
15 000	2	3	4	5/6	8			
22 000	3	4	5/6	7	9			
33 000	4	5/6	7	8				
47 000	5/6	7	8	9				
68 000	7	8	9					
100 000	8	9						
150 000	9							

case size	nominal dimensions mm
1	Ø 25 x 35
2	Ø 25 x 45
3	Ø 30 x 45
4	Ø 35 x 45
5	Ø 35 x 55
6	Ø 40 x 45
7	Ø 40 x 55
8	Ø 40 x 75
9	Ø 40 x 105

APPLICATION

These capacitors have low ESR and ESL values and feature extremely small dimensions which render them suitable for applications such as:

- switched-mode power supplies;
- power supplies in digital equipment;
- energy storage in pulse systems;
- filters in measuring and control equipment.

DESCRIPTION

The capacitors have deeply etched anode foil electrodes, which achieves extremely small dimensions for a given CU-product. They are completely cold welded and charge/discharge proof. The aluminium case is fully insulated. A safety vent is located in the case bottom.

MECHANICAL DATA

Capacitors with printed-wiring pins

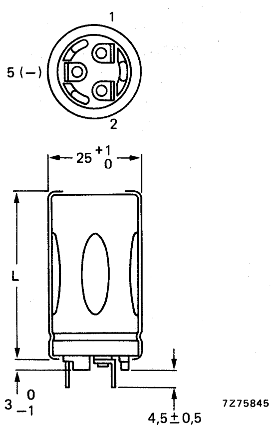


Fig. 1a.

1 = positive terminal;
5 = negative terminal.

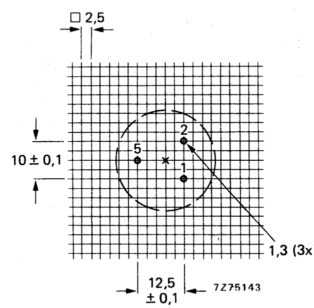


Fig. 1b Piercing diagram viewed from component side.

Table 1a

case size	L		mass approx. g
1	35	+ 1,3	25
2	45	+ 1,3	30

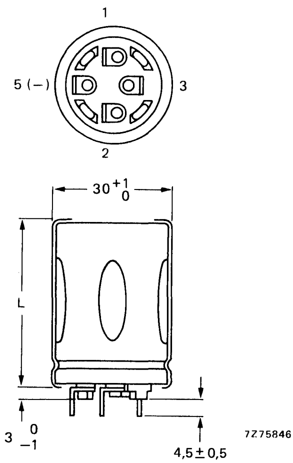


Fig. 2a.

1 = positive terminal;
5 = negative terminal.

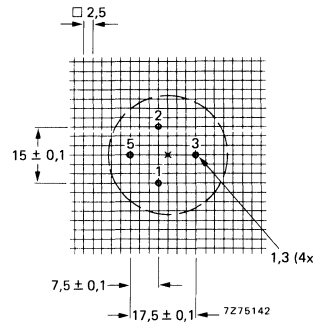


Fig. 2b Piercing diagram viewed from component side.

Table 1b

case size	L	mass approx. g
3	45 + 1,3	40

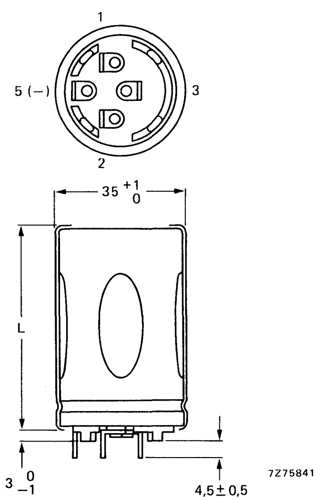


Fig. 3a.

1 = positive terminal;
5 = negative terminal.

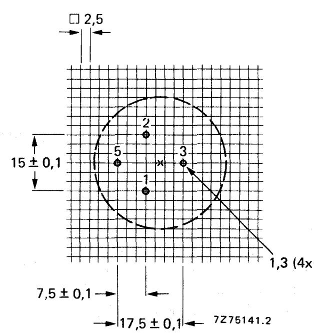


Fig. 3b Piercing diagram viewed from component side.

Table 1c

case size	L	mass approx. g
4	45 } + 1,3	55
5	55 } + 1,3	65

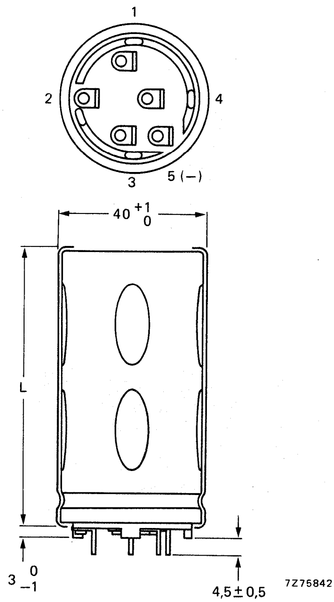


Fig. 4a.

1 = positive terminal;
5 = negative terminal.

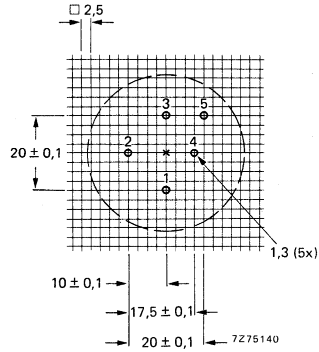


Fig. 4b Piercing diagram viewed from component side.

Table 1d

case size	L		mass approx. g
6	45	+ 1,3	70
7	55		85
8	75		115
9	105		160

Marking

The capacitors are marked with: nominal capacitance, tolerance on capacitance, rated voltage, temperature range, data code (year and week) according to IEC62, name of manufacturer,indication of production centre, polarity of the terminals and rill to identify the negative terminal.

Mounting

The capacitors may be mounted in any position with or without a mounting clamp. Where a number of capacitors are connected to form a capacitor bank, the proximity to one another must not be less than 15 mm, when no derating of ripple current and/or temperature is applied. If the case has to be at a specified potential, it should be connected to the negative terminal only.

Minimum atmospheric pressure 8,5 kPa

PRODUCT SAFETY

Non-solid electrolytic capacitors may contain chemicals which can be regarded as hazardous if incorrectly handled. Caution is necessary should the outer case be fractured.

ELECTRICAL DATA

Unless otherwise specified all electrical values apply at an ambient temperature of 20 °C, a frequency of 100 Hz, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 45 to 75%.

Table 2 (see also corresponding paragraphs)

U_R	nom. cap.	max. r.m.s. ripple current at		max.d.c.leakage current at	max. ESR	max. impedance at 10 kHz	case size	catalogue number 2222 followed by
		100 Hz/85 °C	20 kHz/70 °C	U_R after 1 min				
V	µF	A	A	mA	mΩ	mΩ		
10	10 000	3,1	5,9	0,60	51	40	1	051 54103
	15 000	4,1	7,8	0,90	37	30	2	54153
	22 000	5,0	9,5	1,32	30	25	3	54223
	33 000	5,5	10,4	1,98	28	24	4	54333
	47 000	6,8	12,9	2,82	23	20	5	54473
	47 000	5,8	10,4	2,82	29	22	6	44473
	68 000	7,1	13,5	4,08	24	20	7	54683
	100 000	9,2	17,4	6,00	19	16	8	54104
	150 000	12,0	22,7	9,00	16	14	9	54154
16	6 800	3,1	5,9	0,65	53	42	1	55682
	10 000	4,0	7,6	0,96	39	34	2	55103
	15 000	5,0	9,5	1,44	31	27	3	55153
	22 000	5,5	10,4	2,12	29	26	4	55223
	33 000	6,7	12,7	3,17	23	21	5	55333
	33 000	5,7	10,8	3,17	30	24	6	45333
	47 000	7,0	13,3	4,52	24	20	7	55473
	68 000	9,2	17,4	6,53	19	16	8	55683
	100 000	12,0	22,7	9,60	16	14	9	55104
25	4 700	2,9	5,5	0,71	60	42	1	56472
	6 800	3,9	7,4	1,02	42	34	2	56682
	10 000	4,8	9,1	1,50	34	27	3	56103
	15 000	5,3	10,0	2,25	30	26	4	56153
	22 000	6,5	12,3	3,30	24	21	5	56223
	22 000	5,7	10,8	3,30	31	24	6	46223
	33 000	7,0	13,3	4,95	25	20	7	56333
	47 000	9,2	17,4	7,05	19	16	8	56473
	68 000	12,0	22,7	10,20	16	14	9	56683
40	3 300	2,9	5,5	0,80	87	63	1	57332
	4 700	3,8	7,2	1,13	62	47	2	57472
	6 800	4,7	8,9	1,64	49	38	3	57682
	10 000	5,2	9,8	2,40	48	37	4	57103
	15 000	6,3	11,9	3,60	37	28	5	57153
	15 000	5,6	10,6	3,60	50	35	6	47153
	22 000	5,8	11,0	5,28	39	28	7	57223
	33 000	7,8	14,8	7,92	28	21	8	57333
	47 000	10,4	19,7	11,28	22	17	9	57473

Table 2 (continued)

U_R V	nom. cap. µF	max. r.m.s. ripple current at 100 Hz/85 °C A	max. r.m.s. ripple current at 20 kHz/70 °C A	max. d.c. leakage current at U_R after 1 min mA	max. ESR mΩ	max. impedance at 10 kHz mΩ	case size	catalogue number 2222 followed by
63	2 200	2,5	4,7	0,84	83	62	1	051 58222
	3 300	3,3	6,2	1,25	58	42	2	58332
	4 700	4,1	7,8	1,78	49	38	3	58472
	6 800	4,5	8,5	2,57	48	37	4	58682
	10 000	5,4	10,2	3,78	37	28	5	58103
	10 000	4,6	8,7	3,78	52	37	6	48103
	15 000	7,5	14,2	5,67	29	24	8	58153
	22 000	10	19	8,32	22	19	9	58223
100	680	1,74	3,30	0,41	190	130	1	59681
	1 000	2,34	4,44	0,60	130	90	2	59102
	1 500	2,95	5,59	0,90	95	67	3	59152
	2 200	3,69	7,00	1,32	71	53	4	59222
	3 300	4,37	8,29	1,98	55	41	5	59332
	3 300	4,16	7,89	1,98	64	48	6	49332
	4 700	5,21	9,88	2,82	49	38	7	59472
	6 800	6,97	13,22	4,08	35	28	8	59682
	10 000	9,50	18,00	6,00	26	21	9	59103
200	150	0,70	1,33	0,18	1000	770	1	053 52151
	220	0,94	1,78	0,26	680	525	2	52221
	330	1,27	2,41	0,40	460	360	3	52331
	470	1,66	3,15	0,57	320	250	4	52471
	680	2,19	4,15	0,82	220	170	5	52681
	680	2,17	4,11	0,82	220	170	6	42681
	1 000	2,86	5,42	1,20	150	115	7	52102
	1 500	3,81	7,22	1,80	110	85	8	52152
	2 200	5,20	9,86	2,64	80	60	9	52222
385	68	0,47	0,89	0,16	2200	1400	1	58689
	100	0,64	1,21	0,23	1500	940	2	58101
	150	0,90	1,71	0,35	1000	620	3	58151
	220	1,15	2,18	0,51	680	420	4	58221
	330	1,53	2,90	0,77	450	270	5	58331
	330	1,52	2,88	0,77	450	270	6	48331
	470	1,96	3,72	1,09	320	190	7	58471
	680	2,70	5,12	1,58	220	135	8	58681
	1 000	3,70	7,02	2,31	180	125	9	58102

Capacitance

Nominal capacitance values at 100 Hz and T_{amb} = 20 °C	see Table 2
Tolerance on nominal capacitance at 100 Hz	± 20%

Voltage

	core temperature ▲ < 60 °C	core temperature ▲ 60 to 95 °C
Rated voltage = max. permissible voltage	1,1 x U_R	U_R
Ripple voltage* = max. permissible a.c. voltage providing the following conditions are met:		
(a) max. positive voltage on anode (d.c. + peak a.c.)	⩽ 1,1 x U_R	⩽ U_R
(b) max. positive voltage on cathode (reverse voltage)	1 V	1 V
Surge voltage = max. permissible voltage for short periods	1,25 x U_R	1,15 x U_R (⩽ 100 V) 1,15 x U_R (200 V version) 1,1 x U_R (385 V version)
Reverse voltage = max. d.c. voltage applied in the reverse polarity at the maximum category temperature for short periods	1 V	1 V

Ripple current **

Maximum permissible r.m.s. ripple current

at 100 Hz and T_{amb} = 85 °C or 20 kHz and T_{amb} = 70 °C	see Table 2
at 100 Hz and other temperatures	see Table 3
at other frequencies and T_{amb} = 85 °C	see Table 4

Table 3

ambient temperature °C	multiplier of max. ripple current
85	1,00
80	1,22
75	1,41
70	1,58
65	1,73
60	1,87
55	2,00
50	2,12
45	2,24
⩽ 40	2,35

Table 4

frequency Hz	multiplier of max. ripple current $\sqrt{r}$
50	0,83
100	1,00
200	1,10
400	1,15
1000	1,19
⩾ 2000	1,20

▲ See Introduction, section 5, "Ripple current".

* Ripple voltages are not applicable if the maximum permissible ripple current is exceeded. In that case the ripple current is decisive.

** Ripple currents are not applicable if the maximum permissible ripple voltage is exceeded. In that case the ripple voltage is decisive.

Non-sinusoidal ripple currents have to be analyzed into a number of sinusoidal currents and the following requirements shall then be satisfied:

$$\sum_n \frac{I_n^2}{r_n} \leqslant I_{r\,max}^2$$

$I_{r\,max}$ = maximum ripple current at 100 Hz and applicable ambient temperature

I_n = ripple current at a certain frequency

$\sqrt{r_n}$ = multiplying factor at same frequency (Table 4).

Charge and discharge current

The capacitors may be charged from a source without internal resistance and they may be discharged by short-circuiting. If the capacitors are charged and discharged continuously, the charge and discharge currents have to be considered as ripple currents flowing through the capacitor. The r.m.s. value of these currents should be determined and the value thus found must not exceed the applicable limit.

D.C. leakage current

Maximum d.c. leakage current 1 min after application of the rated voltage at T_{amb} = 20 °C	see Table 2 (0,006 CU + 4 μA)

If owing to prolonged storage and/or storage at an excessive temperature the d.c. leakage current is too high, application of the rated voltage for some hours will cause the d.c. leakage current to fall to a value lower than specified in Table 2.

Impedance

Maximum impedance at 10 kHz and T_{amb} = 20 °C measured by means of a four-terminal circuit (Thomson circuit)	see Table 2

Equivalent series resistance (ESR)

Maximum ESR at 100 Hz and T_{amb} = 20 °C	see Table 2

Inductance (ESL)

Case sizes 1 and 2	max. 25 nH
Case sizes 3, 4 and 5	max. 30 nH
Case sizes 6, 7, 8 and 9	max. 35 nH

OPERATIONAL DATA

Category temperature range

For $U_R \leqslant 63$ V	−55 to + 85 °C
For $U_R > 63$ V	−40 to + 85 °C

Life expectancy

Typical life time	
at T_{amb} = 85 °C	> 5000 h
at T_{amb} = 40 °C	> 100 000 h
Shelf life at 0 V and T_{amb} = 85 °C	500 h

Failure rate

Failure rate, catastrophic, at rated voltage, T_{amb} = 40 °C and confidence level 60%	$< 10^{-7}$

PACKING

The capacitors are packed in boxes containing 100 pieces.

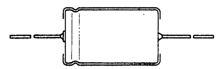
TESTS AND REQUIREMENTS

See Introduction, section 9, under aluminium electrolytic capacitors.
After *shelf life test, 500 h, 85 °C,* the capacitors meet the same requirements as after endurance test.
The rated voltage shall be applied to the capacitors for minimum 30 min., at least 24 h and not more than 48 h before measurements.
For the 385 V version the d.c. leakage current and tan δ measurements of the reverse voltage test (sub clause 9. 16 IEC 384-4) should be carried out after 250 h, U_R in forward polarity.

Note: Capacitors 2222 051 and 2222 053 are large types, long-life grade.

ALUMINIUM ELECTROLYTIC CAPACITORS

- **Low-leakage version of 2222 030/031 series**
- **Miniature type**
- **Axial leads**
- **Long life**
- **General and industrial applications**
- **Alternative for tantalum capacitors**



QUICK REFERENCE DATA

Nominal capacitance range (E6 series)	0,33 to 68 μF
Tolerance on nominal capacitance	−10 to + 50%
Rated voltage range, U_R (R5 series)	6,3 to 25 V
Leakage current after 2 min	0,002 CU or 0,7 μA
Category temperature range	−55 to + 85 °C
Endurance test at 85 °C	2000 h
Shelf life at 0 V, 85 °C	500 h
Basic specification	IEC 384-4, long-life grade; DIN41316
Climatic category	
IEC 68	55/085/56
DIN 40040	FPF

Selection chart for C_{nom}-U_R and relevant case sizes.

C_{nom}	U_R(V)			
μF	6,3	10	16	25
0,33				2
0,47				2
0,68				2
1				2
1,5				2
2,2				2
3,3				2
4,7				2
6,8			2	2
10		2	2	3
15	2		2	3
22		2	3	
33	2		3	
47		3		
68	3			

case size	nominal dimensions (mm)
2	Ø 4,5 x 10
3	Ø 6 x 10

APPLICATION

These capacitors are suited for those applications where a low leakage current is required. In many cases they are a cost-effective substitute for tantalum capacitors.
The capacitors are mainly used for high impedance coupling and decoupling purposes in consumer applications, such as audio and television circuits, and in industrial applications such as measuring and regulating circuits. Other applications are in timing and delay circuits with large time constant. The taped versions are extremely suitable for automatic insertion and for cutting and forming equipment.

DESCRIPTION

The capacitors have etched and oxidized aluminium foil electrodes rolled up with a paper strip impregnated with an electrolyte. The capacitors are in an aluminium case, which is insulated with a blue plastic sleeve.
They have axial soldered-copper leads, and are supplied on bandoliers on reels.

MECHANICAL DATA

Dimensions in mm

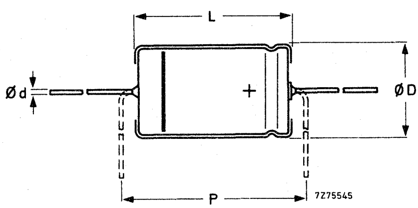


Fig. 1 See Table 1 for dimensions d, D, L and P.

Table 1

case size	dimensions						mass approx. g
	d	D_{nom}	L_{nom}	D_{max}	L_{max}	P_{min}	
2	0,6	4,5	10,0	5,0	10,5	15	0,50
3	0,6	6,0	10,0	6,3	10,5	15	0,70

Marking

The capacitors are marked with:
- nominal capacitance;
- tolerance on nominal capacitance;
- rated voltage;
- group number; code of origin;
- name of manufacturer;
- date code (year and month) according to IEC 62;
- band to identify the negative terminal.

Mounting

The capacitors are suitable for mounting on printed-wiring boards; the required hole diameter is 0,8 + 0,1 mm.

Minimum atmospheric pressure 8,5 kPa

PRODUCT SAFETY

Non-solid electrolytic capacitors may contain chemicals which can be regarded as hazardous if incorrectly handled; caution is necessary should the outer case be fractured.

ELECTRICAL DATA

Table 2

Unless otherwise specified all electrical values in Table 2 apply at an ambient temperature of 20 to 25 °C, a frequency of 100 Hz, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 45 to 75%.

U_R V	nom. cap. μF	max. r.m.s. ripple current at T_{amb} = 85 °C mA	max. d.c leakage current at U_R after 2 min. μA	max. tan δ	max. impedance at 10 kHz Ω	case size	catalogue number 2222 065 followed by
6,3	15	26,5	0,7	0,16	8	2	23159
	33	39	0,7	0,16	3,6	2	23339
	68	67	0,9	0,16	1,8	3	23689
10	10	23	0,7	0,14	9	2	24109
	22	34	0,7	0,14	4,1	2	24229
	47	60	0,9	0,14	1,9	3	24479
16	6,8	21	0,7	0,12	10	2	25688
	10	25	0,7	0,12	7	2	25109
	15	31	0,7	0,12	4,7	2	25159
	22	44	0,7	0,12	3,2	3	25229
	33	54	1,1	0,12	2,1	3	25339
25	0,33	5,6	0,7	0,08	170	2	26337
	0,47	6,6	0,7	0,08	120	2	26477
	0,68	8,0	0,7	0,08	81	2	26687
	1,0	9,7	0,7	0,08	55	2	26108
	1,5	11,2	0,7	0,09	37	2	26158
	2,2	13,5	0,7	0,09	25	2	26228
	3,3	16,6	0,7	0,09	17	2	26338
	4,7	20	0,7	0,09	12	2	26478
	6,8	24	0,7	0,09	8,1	2	26688
	10	34	0,7	0,09	5,5	3	26109
	15	42	0,8	0,09	3,7	3	26159

Capacitance

Nominal capacitance at 100 Hz and T_{amb} = 20 °C	see Table 2
Tolerance on nominal capacitance at 100 Hz	−10 to + 50%

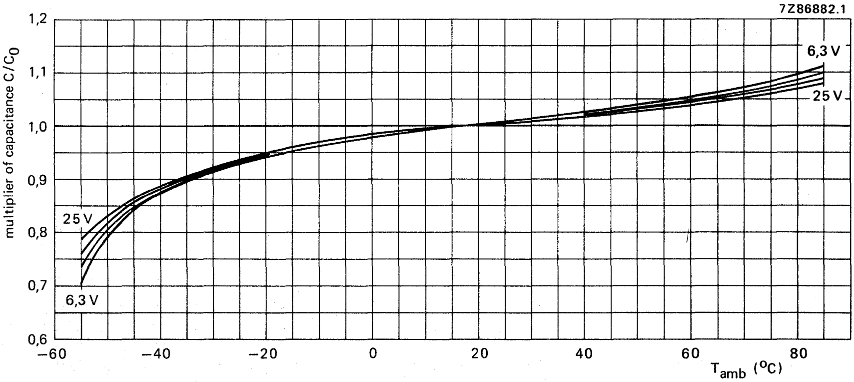


Fig. 2 Multiplier of capacitance as a function of ambient temperature; C_0 = capacitance at 20 °C, 100 Hz.

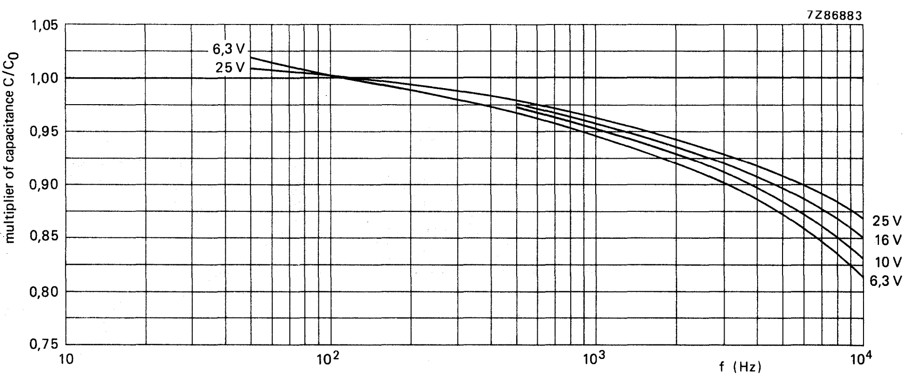


Fig. 3 Multiplier of capacitance as a function of frequency; C_0 = capacitance at 20 °C, 100 Hz.

Voltage

Max. permissible voltage at core temperature ⩽ 95 °C▲	1,6 x U_R
Ripple voltage* = max. permissible a.c. voltage providing the following three conditions are met:	
(a) max. (d.c. + peak a.c.) voltage	1,6 x U_R
(b) max. peak a.c. voltage without d.c. voltage applied	2 V
(c) momentary value of applied voltage	between 1,6 x U_R and −2 V
Surge voltage = max. permissible voltage for short periods	1,6 x U_R
Reverse voltage = max. d.c. voltage applied in the reverse polarity for short periods	2 V

Ripple current**

Maximum permissible r.m.s. ripple current at	
100 Hz and T_{amb} = 85 °C	see Table 2
100 Hz and T_{amb} = 40 °C	2,24 x values stated in Table 2

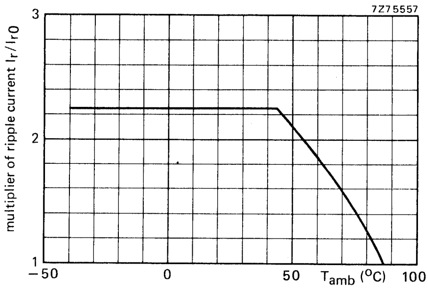


Fig. 4 Multiplier of ripple current as a function of ambient temperature; I_{r0} = ripple current at 85 °C, 100 Hz.

▲ See Introduction, section 5, "Ripple current".

* Specified ripple voltages are not applicable if the maximum permissible ripple current is exceeded. In that case the ripple current is decisive.

** Specified ripple currents are not applicable if the maximum permissible ripple voltage is exceeded. In that case the ripple voltage is decisive.

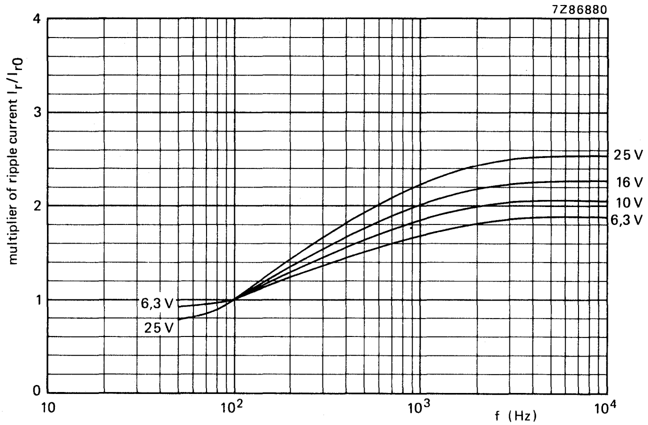


Fig. 5 Multiplier of ripple current as a function of frequency; I_{r0} = ripple current at 85 °C, 100 Hz.

Non-sinusoidal ripple currents have to be analyzed into a number of sinusoidal currents and the following requirements shall then be satisfied:

$$\sum_n \frac{I_n^2}{r_n} \leqslant I_{r\,max}^2$$

$I_{r\,max}$ = maximum ripple current at 100 Hz and applicable ambient temperature;

I_n = ripple current at a certain frequency;

$\sqrt{r_n} = I_r/I_{r0}$ = multiplying factor at a same frequency.

Charge and discharge current

The capacitors may be charged from a source without internal resistance and they may be discharged by short-circuiting. If the capacitors are charged and discharged continuously at a rate of several times per minute, the charge and discharge currents have to be considered as ripple currents flowing through the capacitor. The r.m.s. value of these currents should be determined and the value thus found must not exceed the applicable limit.

D.C. leakage current

Maximum d.c. leakage current 2 min after application of U_R, at T_{amb} = 20 °C — see Table 2 (0,002 CU or 0,7 µA, whichever is greater)

If owing to prolonged storage and/or storage at an excessive temperature (> 40 °C) the d.c. leakage current is too high, application of the rated voltage for some hours will cause the d.c. leakage current to fall to a value lower than specified in Table 2.

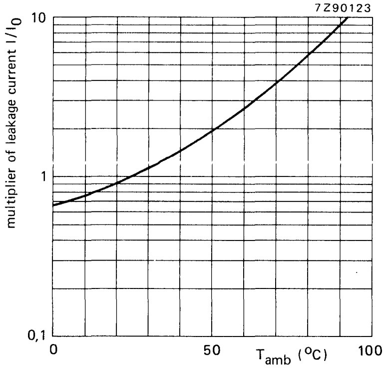


Fig. 6 Multiplier of d.c. leakage current as a function of ambient temperature; I_0 = d.c. leakage current during continuous operation at 25 °C and U_R.

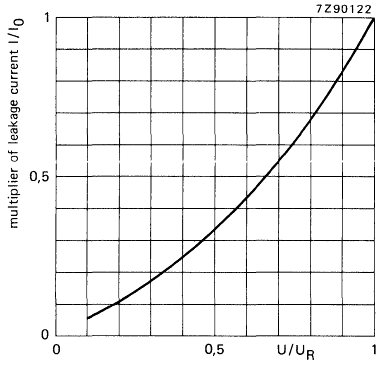


Fig. 7 Multiplier of d.c. leakage current as a function of U/U_R; I_0 = d.c. leakage current during continuous operation at 25 °C and U_R.

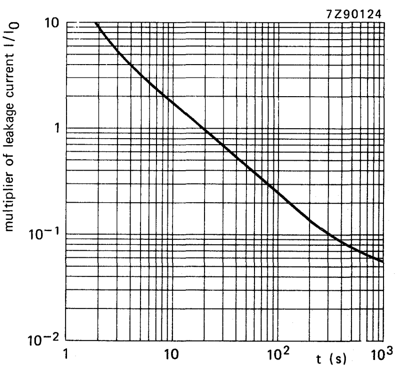


Fig. 8 Multiplier of typical d.c. leakage current as a function of time; I_0 = d.c. leakage current value as specified in Table 2.

Tan δ (dissipation factor)

Maximum tan δ at 100 Hz and T_{amb} = 25 °C, measured by means of a four-terminal circuit (Thomson circuit) — see Table 2

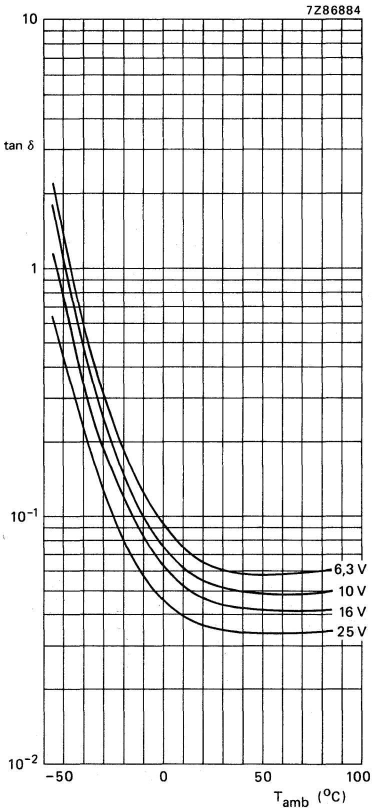


Fig. 9 Typical tan δ as a function of ambient temperature at 100 Hz.

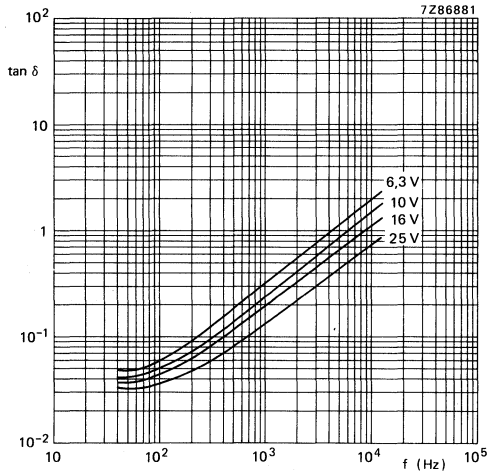


Fig. 10 Typical tan δ as a function of frequency at 25 °C.

Equivalent series resistance (ESR)

ESR = tan $\delta/\omega C$
Maximum tan δ and C at 100 Hz and T_{amb} = 25 °C — see Table 2

Equivalent series inductance (ESL)

Case size 2 — typ. 17 nH
Case size 3 — typ. 30 nH

Impedance (Z)

Maximum impedance at T_{amb} = 20 °C and 10 kHz, measured by means of a four-terminal circuit (Thomson circuit) — see Table 2

z = Z x C_{nom}, at 10 kHz — see Table 3

Table 3

T_{amb}	$z = Z \times C_{nom}$ (Ω µF) at U_R; at 10 kHz			
	6,3 V	10 V	16 V	25 V
+20 °C	⩽ 120	⩽ 90	⩽ 70	⩽ 55
−25 °C	⩽ 560	⩽ 400	⩽ 300	⩽ 180
−40 °C	⩽ 1500	⩽ 1100	⩽ 900	⩽ 500
−55 °C	typ. 3300	typ. 2400	typ. 1500	typ. 850

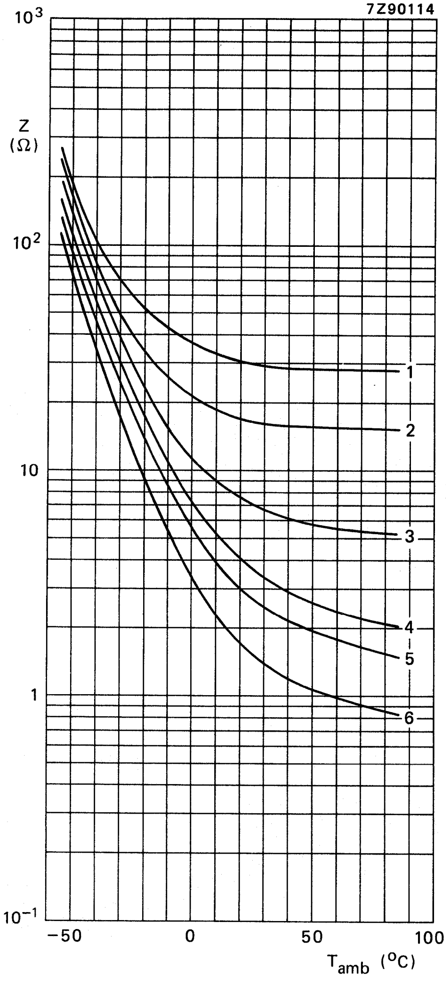


Fig. 11 Typical impedance as a function of ambient temperature at 10 kHz; **case size 2:**

curve 1 = 0,47 μF, 25 V;
curve 2 = 1 μF, 25 V;
curve 3 = 3,3 μF, 25 V;
curve 4 = 6,8 μF, 25 V;
curve 5 = 10 μF, 10 V;
curve 6 = 22 μF, 10 V.

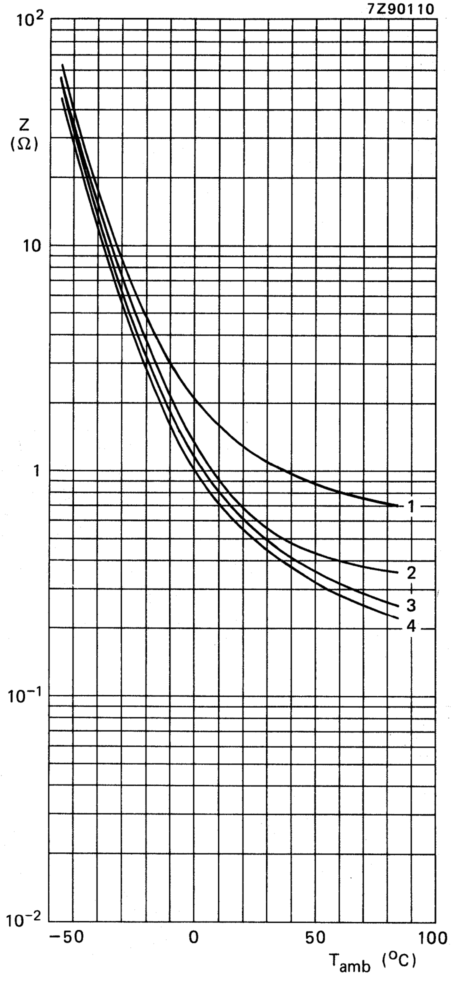


Fig. 12 Typical impedance as a function of ambient temperature at 10 kHz; **case size 3:**

curve 1 = 10 μF, 25 V;
curve 2 = 22 μF, 16 V;
curve 3 = 47 μF, 10 V;
curve 4 = 68 μF, 6,3 V.

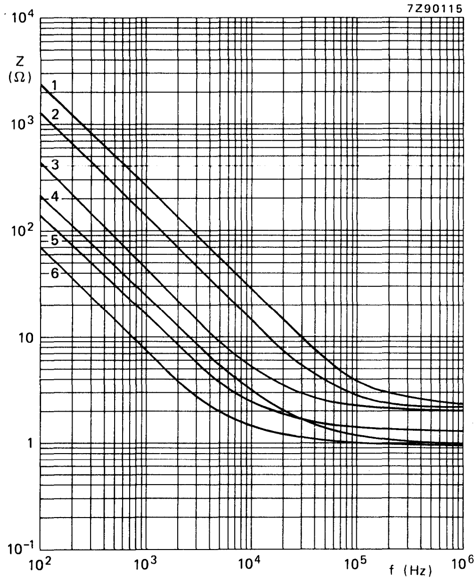


Fig. 13 Typical impedance as a function of frequency at 20 °C; **case size 2:**

curve 1 = 0,47 μF, 25 V;
curve 2 = 1 μF, 25 V;
curve 3 = 3,3 μF, 25 V;
curve 4 = 6,8 μF, 25 V;
curve 5 = 10 μF, 10 V;
curve 6 = 22 μF, 10 V.

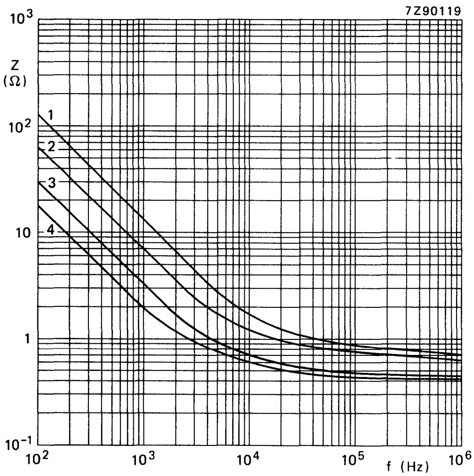


Fig. 14 Typical impedance as a function of frequency at 20 °C; **case size 3:**

curve 1 = 10 μF, 25 V;
curve 2 = 22 μF, 16 V;
curve 3 = 47 μF, 10 V;
curve 4 = 68 μF, 6,3 V.

OPERATIONAL DATA

Category temperature range	−55 to + 85 °C
Typical life time	
at T_{amb} = 85 °C	3000 h
at T_{amb} = 40 °C	70 000 h
Shelf life at 0 V and T_{amb} = 85 °C	500 h

PACKING

The capacitors are supplied on bandoliers on reels. The number of capacitors per reel is 3000 for case size 2, and 1000 for case size 3.

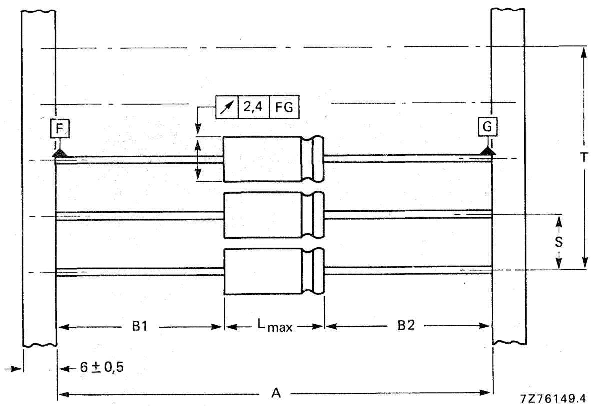


Fig. 15 Capacitors on bandoliers: the bandolier to which the negative capacitor terminals are connected is blue. See Table 4 for dimensions A, S, T and L.
|B1−B2| = max. 1,4 mm.

Table 4

Dimensions in mm

case size	A	S	T for number (n) of capacitors		L_{max}
			n < 50	50 < n < 100	
2	63,5 ± 1,5	5 ± 0,4	5 (n-1) ± 2	5 (n-1) ± 4	10,5
3	63,5 ± 1,5	10 ± 0,4	10 (n-1) ± 2	10 (n-1) ± 4	10,5

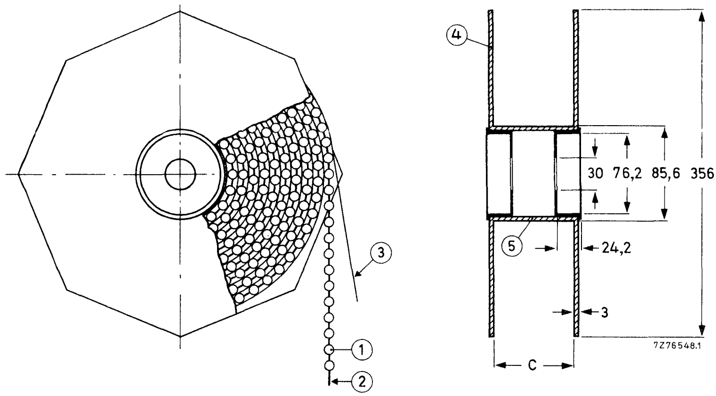


Fig. 16 Capacitors on bandoliers on reel; dimension C is 83,5 mm; the overall width of the reel is 94,5 mm.

1 = capacitor
2 = bandolier
3 = paper
4 = flange
5 = cylinder

TESTS AND REQUIREMENTS

See Introduction, section 9, under aluminium electrolytic capacitors, with the following addition.

After *endurance test, 2000 h, 85 °C,* the capacitors meet the following requirements:

$\Delta C/C \leqslant \pm$ 15%, for U_R = 10 to 25 V;

$\Delta C/C \leqslant +$ 15%, −25% for U_R = 6,3 V;

tan $\delta \leqslant$ 130% of specified value;

d.c. leakage current $\leqslant$ specified value;

impedance at 10 kHz $\leqslant$ 200% of specified value.

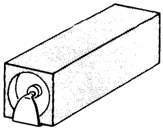
After *shelf life test, 500 h, 85 °C,* the capacitors meet the same requirements, except for d.c. leakage current: $\leqslant$ 200% of specified value. The rated voltage shall be applied to the capacitors for minimum 30 min., at least 24 h and not more than 48 h before measurements.

Note:

Capacitors 2222 065 are miniature types, long-life grade.

ALUMINIUM ELECTROLYTIC CAPACITORS

- **Surface mounted type**
- **Supplied in rail or in blister tape**
- **General applications**



QUICK REFERENCE DATA

Nominal capacitance range (E6 series	0,1 to 22 μF
Tolerance on nominal capacitance	−10 to + 50% or ± 20%
Rated voltage range, U_R (R5 series)	6,3 to 63 V
Category temperature range	−40 to + 85 °C
Endurance test at 85 °C	1000 h
Shelf life at 0 V, 85 °C	500 h
Resistance to soldering heat	260 °C, 10 s; immersion in solder permitted
Basic specifications	IEC 384-4, G.P. grade
	DIN 41332, type II
Climatic category	
IEC 68	40/085/56
DIN 40040	GPF

Selection chart for C_{nom}-U_R and relevant case sizes.

C_{nom} μF	U_R (V) 6,3	10	16	25	40	63
0,1						1a
0,15						1a
0,22						1a
0,33						1a
0,47						1a
0,68						1a
1						1a
1,5						1a
2,2					1a	1
3,3				1a		1
4,7			1a		1	
6,8		1a		1		
10	1a		1			
15		1				
22	1					

case size	maximum dimensions (mm) length x width x height
1a	9 x 4 x 4
1	12 x 4 x 4

APPLICATION

These capacitors with high CU-product per unit volume are for surface mounted assembly. They are mainly used for smoothing, coupling and decoupling purposes in consumer applications, such as audio and television circuits. Other applications are in timing and delay circuits.
The capacitors are suitable for automatic placement.

DESCRIPTION

The capacitors have highly etched and oxidized aluminium foil electrodes rolled up with a paper strip impregnated with an electrolyte. The capacitors are in a rectangular plastic case with flat soldered-copper tags.

The capacitors are supplied in rails in boxes or in blister tape on reel.

MECHANICAL DATA

Dimensions in mm

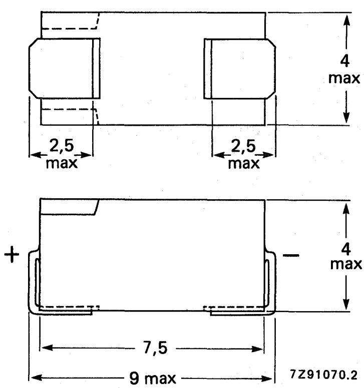


Fig. 1a Case size 1a.

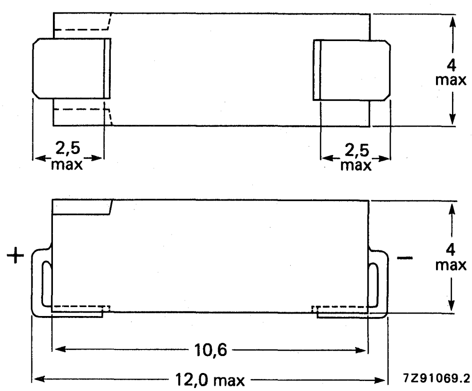


Fig. 1b Case size 1.

Marking

The capacitors are marked on the top with nominal capacitance, "−" sign to identify the cathode, and code for rated voltage, see Table 1. The numerals are those of the capacitance in μF, and the position of the letter indicating the rated voltage, marks the position of the decimal point in the capacitance value.
Example: 3H3 indicates 3,3 μF, 63 V.
Bevelled edges identify the anode end.

Table 1

rated voltage V	code letter
6,3	C
10	D
16	E
25	F
40	G
63	H

Mounting

The capacitors can be placed and soldered on to printed-circuit boards or on to hybrid circuits. Suitable mounting methods include those where the device is totally immersed in a solder bath (260 °C, 10 s), as in wave soldering, and reflow methods where the solder and device are heated together, as in vapour phase soldering.

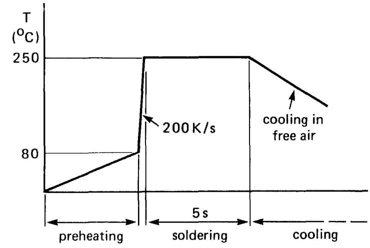


Fig. 2 Typical temperature-time curve for wave soldering.

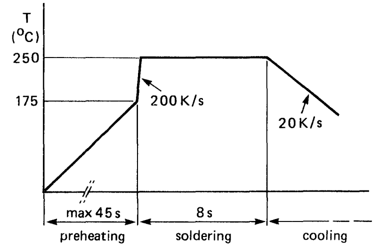


Fig. 3 Typical temperature-time curve for reflow soldering.

In both soldering processes, the capacitors reach the actual soldering temperature. The temperature rise caused by preheating and immersion in solder has no adverse effects on the life of the capacitors, provided the restrictions indicated by Fig. 4 are observed. This curve indicates the acceptable combination of temperature and time. The conditions indicated by the solid parts of the curve can be applied once to each capacitor: a preheating stage at or below one of the temperature-time points on part A, and a soldering stage at or below one of the temperature-time points on part B. Furthermore, the time in part B can be split into two, for double soldering. Typically, an example might be a preheating stage at 165 °C for 60 s followed by a first soldering stage for 4 s at 260 °C and directly followed by a second soldering stage for 6 s at 260 °C (total soldering 10 s at 260 °C).

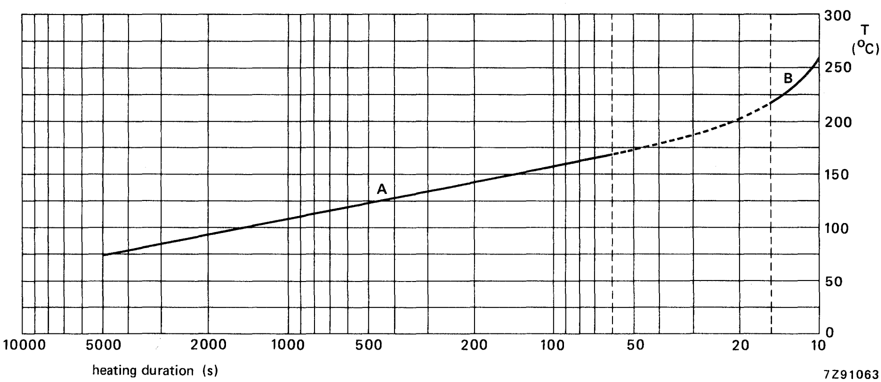


Fig. 4 Preheating (A) and soldering (B) limits for undiminished life expectancy.

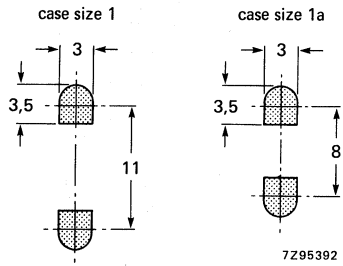


Fig. 5 Recommended dimensions of metal connection pads on printed-circuit board or substrate surface.

Minimum atmospheric pressure 8,5 kPa

PRODUCT SAFETY

Non-solid electrolytic capacitors may contain chemicals which can be regarded as hazardous if incorrectly handled; caution is necessary should the outer case be fractured.

ELECTRICAL DATA

Table 2

Unless otherwise specified all electrical values in Table 2 apply at an ambient temperature of 20 to 25 °C, a frequency of 100 Hz, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 45 to 75%.

U_R V	nom. cap. μF	max. r.m.s. ripple current at T_{amb} = 85 °C mA	max. d.c. leakage current at U_R after 1 min μA	max. tan δ	max. ESR Ω	max. impedance at 10 kHz Ω	case size*	catalogue number 2222 085 followed by			
								−10/+ 50% in tape	−10/+ 50% in rail	± 20% in tape	± 20% in rail
6,3	10	11	4	0,30	48	20	1a	23109	33109	63109	73109
	22	20	6	0,30	22	9	1	23229	33229	63229	73229
10	6,8	10	4	0,25	59	24	1a	24688	34688	64688	74688
	15	18	6	0,25	27	11	1	24159	34159	64159	74159
16	4,7	9	5	0,20	68	26	1a	25478	35478	65478	75478
	10	16	6	0,20	32	12	1	25109	35109	65109	75109
25	3,3	8	5	0,18	87	27	1a	26338	36338	66338	76338
	6,8	14	6	0,18	42	13	1	26688	36688	66688	76688
40	2,2	7	5	0,16	116	32	1a	27228	37228	67228	77228
	4,7	13	7	0,16	54	15	1	27478	37478	67478	77478
63	0,1	2	4	0,10	1590	550	1a	28107	38107	68107	78107
	0,15	3	4	0,10	1060	367	1a	28157	38157	68157	78157
	0,22	3	4	0,10	723	250	1a	28227	38227	68227	78227
	0,33	4	4	0,10	482	167	1a	28337	38337	68337	78337
	0,47	4	4	0,10	339	117	1a	28477	38477	68477	78477
	0,68	5	4	0,10	234	81	1a	28687	38687	68687	78687
	1	6	4	0,12	191	55	1a	28108	38108	68108	78108
	1,5	7	5	0,14	149	37	1a	28158	38158	68158	78158
	2,2	11	6	0,14	87	25	1	28228	38228	68228	78228
	3,3	13	7	0,14	68	17	1	28338	38338	68338	78338

* Case size 1a: 9 mm x 4 mm x 4 mm (max. dimensions).
Case size 1 : 12 mm x 4 mm x 4 mm (max. dimensions).

Capacitance

Nominal capacitance at 100 Hz and T_{amb} = 20 °C	see Table 2
Tolerance on nominal capacitance at 100 Hz	−10 to + 50% or ± 20%

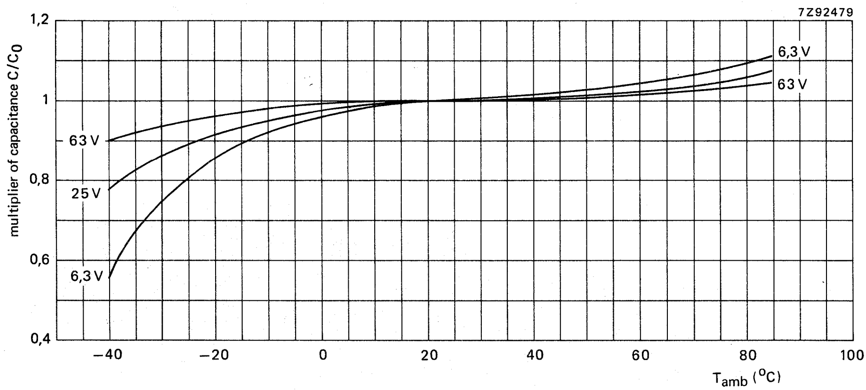


Fig. 6 Multiplier of capacitance as a function of ambient temperature; C_0 = capacitance at T_{amb} = 20 °C, 100 Hz.

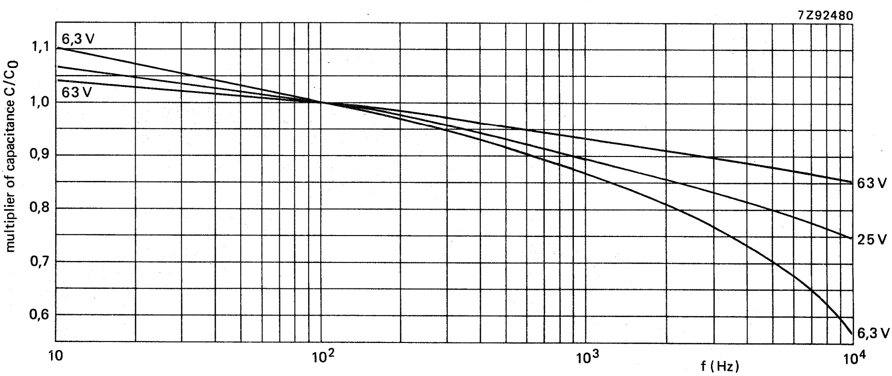


Fig. 7 Multiplier of capacitance as a function of frequency; C_0 = capacitance at T_{amb} = 20 °C, 100 Hz.

Voltage

	core temperature▲ < 60 °C	core temperature▲ 60 to 95 °C
Rated voltage = max. permissible voltage	1,1 x U_R	U_R
Ripple voltage* = max. permissible a.c. voltage providing the following three conditions are met:		
a) max. (d.c. + peak a.c.) voltage	1,1 x U_R	U_R
b) max. peak a.c. voltage without d.c. voltage applied	2 V	
c) momentary value of applied voltage	between U_R and −2 V	
Surge voltage = max. permissible voltage for short periods	1,2 x U_R	1,15 x U_R
Reverse voltage = max. d.c. voltage applied in the reverse polarity for short periods	2 V	

Ripple current**

Maximum permissible r.m.s. ripple current at 100 Hz and T_{amb} = 85 °C — see Table 2

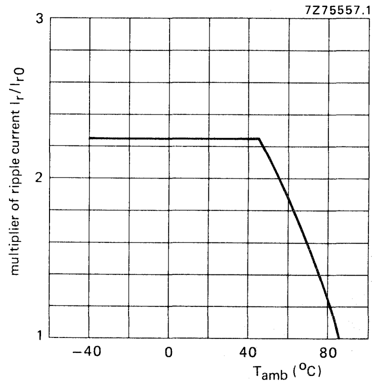


Fig. 8 Multiplier of ripple current as a function of ambient temperature; I_{r0} = ripple current at T_{amb} = 85 °C, 100 Hz.

▲ See Introduction, section 5, "Ripple current".

* Specified ripple voltages are not applicable if the maximum permissible ripple current is exceeded. In that case the ripple current is decisive.

** Specified ripple currents are not applicable if the maximum permissible ripple voltage is exceeded. In that case the ripple voltage is decisive.

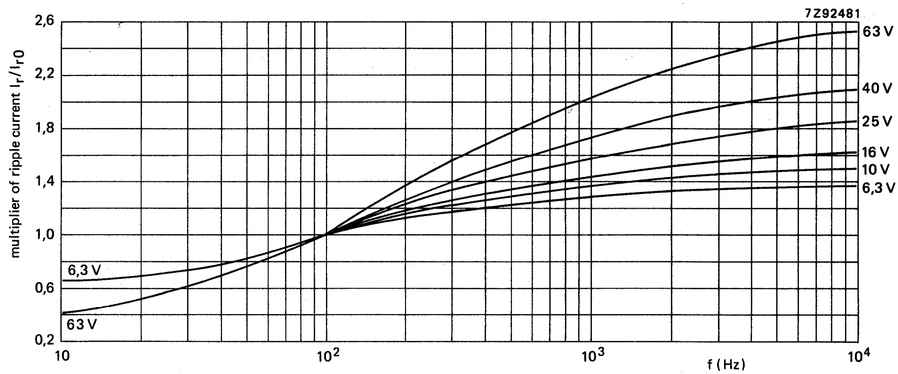


Fig. 9 Multiplier of ripple current as a function of frequency; I_{r0} = ripple current at T_{amb} = 85 °C, 100 Hz.

Non-sinusoidal ripple currents have to be analyzed into a number of sinusoidal currents and the following requirements shall then be satisfied:

$$\sum_n \frac{I_n^2}{r_n} \leqslant I_{r\,max}^2$$

$I_{r\,max}$ = maximum ripple current at 100 Hz and applicable ambient temperature;

I_n = ripple current at a certain frequency;

$\sqrt{r_n} = I_r/I_{r0}$ = multiplying factor at a same frequency.

Charge and discharge current

The capacitors may be charged from a source without internal resistance and they may be discharged by short-circuiting. If the capacitors are charged and discharged continuously at a rate of several times per minute, the charge and discharge currents have to be considered as ripple currents flowing through the capacitor. The r.m.s. value of these currents should be determined and the value thus found must not exceed the applicable limit.

D.C. leakage current

Maximum d.c. leakage current 1 min after application of U_R at T_{amb} = 20 °C — see Table 2 (0,02 CU + 3 μA)

If owing to prolonged storage and/or storage at an excessive temperature (> 40 °C) the d.c. leakage current is too high, application of the rated voltage for some hours will cause the d.c. leakage current to fall to a value lower than specified in Table 2.

Tan δ

Maximum tan δ at 100 Hz and T_{amb} = 20 °C see Table 2

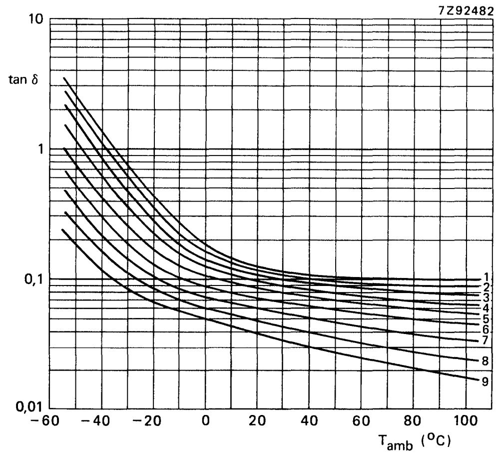


Fig. 10 Typical tan δ as a function of ambient temperature at 100 Hz.

Curve 1 = 6,3 V;
curve 2 = 10 V;
curve 3 = 16 V;
curve 4 = 25 V;
curve 5 = 40 V;
curve 6 = 1,5 to 3,3 μF, 63 V;
curve 7 = 0,68 and 1 μF, 63 V;
curve 8 = 0,22 to 0,47 μF, 63 V;
curve 9 = 0,1 and 0,15 μF, 63 V.

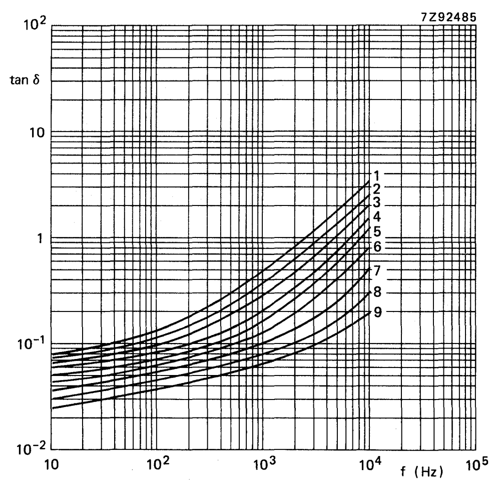


Fig. 11 Typical tan δ as a function of frequency at T_{amb} = 20 °C.

Curve 1 = 6,3 V;
curve 2 = 10 V;
curve 3 = 16 V;
curve 4 = 25 V;
curve 5 = 40 V;
curve 6 = 1,5 to 3,3 μF, 63 V;
curve 7 = 0,68 and 1 μF, 63 V;
curve 8 = 0,22 to 0,47 μF, 63 V;
curve 9 = 0,1 and 0,15 μF, 63 V.

Equivalent series resistance (ESR)

Maximum ESR at 100 Hz and T_{amb} = 20 °C — see Table 2

Impedance (Z)

Maximum impedance at 10 kHz and T_{amb} = 20 °C, measured by means of a four-terminal circuit (Thomson circuit) — see Table 2

$z = Z \times C_{nom}$, at 10 kHz — see Table 3

Table 3

T_{amb}	$z = Z \times C_{nom}$ (Ω μF) at U_R; at 10 kHz					
	6,3 V	10 V	16 V	25 V	40 V	63 V
+ 20 °C	⩽ 200	⩽ 160	⩽ 120	⩽ 90	⩽ 70	⩽ 55
−25 °C	⩽ 1200	⩽ 750	⩽ 560	⩽ 400	⩽ 300	⩽ 180
−40 °C	⩽ 3200	⩽ 2000	⩽ 1500	⩽ 1100	⩽ 900	⩽ 500

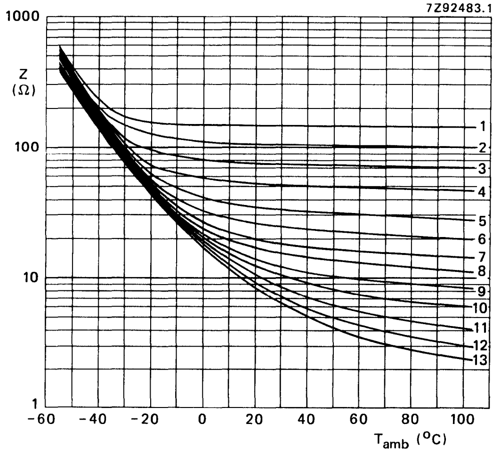


Fig. 12 Typical impedance as a function of ambient temperature at 10 kHz; case size 1a.

Curve 1 = 0,1 μF, 63 V;
curve 2 = 0,15 μF, 63 V;
curve 3 = 0,22 μF, 63 V;
curve 4 = 0,33 μF, 63 V;
curve 5 = 0,47 μF, 63 V;
curve 6 = 0,68 μF, 63 V;
curve 7 = 1 μF, 63 V;
curve 8 = 1,5 μF, 63 V;
curve 9 = 2,2 μF, 40 V;
curve 10 = 3,3 μF, 25 V;
curve 11 = 4,7 μF, 16 V;
curve 12 = 6,8 μF, 10 V;
curve 13 = 10 μF, 6,3 V.

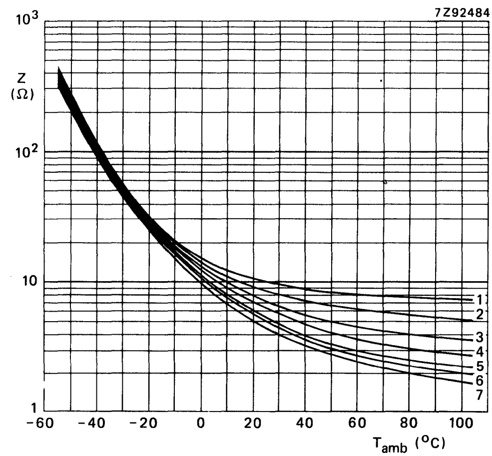


Fig. 13 Typical impedance as a function of ambient temperature at 10 kHz; case size 1.

Curve 1 = 2,2 μF, 63 V;
curve 2 = 3,3 μF, 63 V;
curve 3 = 4,7 μF, 40 V;
curve 4 = 6,8 μF, 25 V;
curve 5 = 10 μF, 16 V;
curve 6 = 15 μF, 10 V;
curve 7 = 22 μF, 6,3 V.

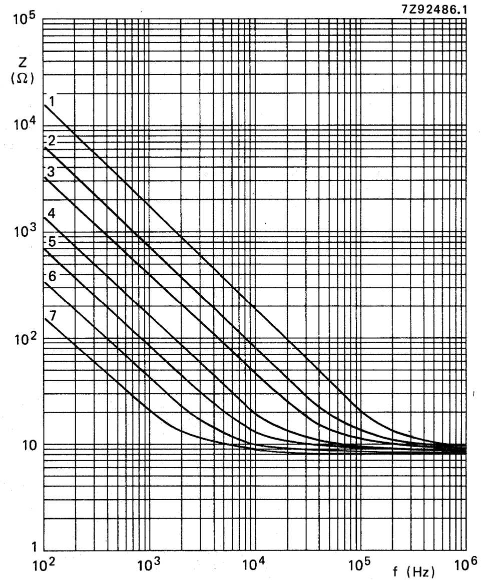


Fig. 14 Typical impedance as a function of frequency at T_{amb} = 20 °C; case size 1a.

Curve 1 = 0,1 μF, 63 V;
curve 2 = 0,22 μF, 63 V;
curve 3 = 0,47 μF, 63 V;
curve 4 = 1 μF, 63 V;
curve 5 = 2,2 μF, 40 V;
curve 6 = 4,7 μF, 16 V;
curve 7 = 10 μF, 6,3 V;

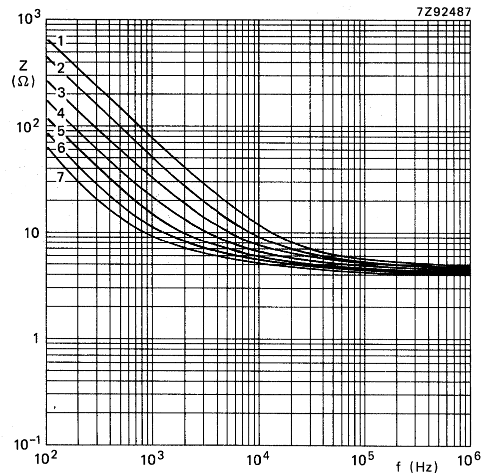


Fig. 15 Typical impedance as a function of frequency at T_{amb} = 20 °C; case size 1.

Curve 1 = 2,2 μF, 63 V;
curve 2 = 3,3 μF, 63 V;
curve 3 = 4,7 μF, 40 V;
curve 4 = 6,8 μF, 25 V;
curve 5 = 10 μF, 16 V;
curve 6 = 15 μF, 10 V;
curve 7 = 22 μF, 6,3 V.

Equivalent series inductance (ESL)

case size 1a	typ. 13 nH
case size 1	typ. 15 nH

OPERATIONAL DATA

Category temperature range — −40 to + 85 °C

PACKING

Dimensions in mm

The capacitors are supplied in rail (100 per rail, 5000 per inner box, 20 000 per outer box), and in 16 mm blister tape of 2000 on reel.

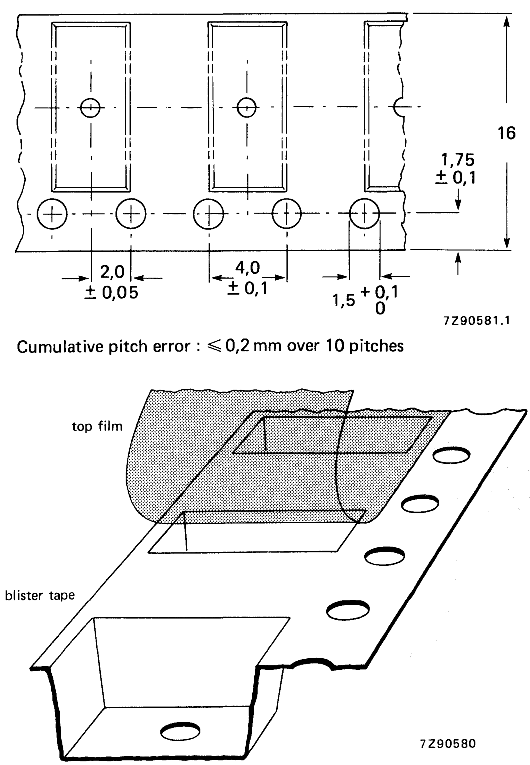


Fig. 16 Blister tape.

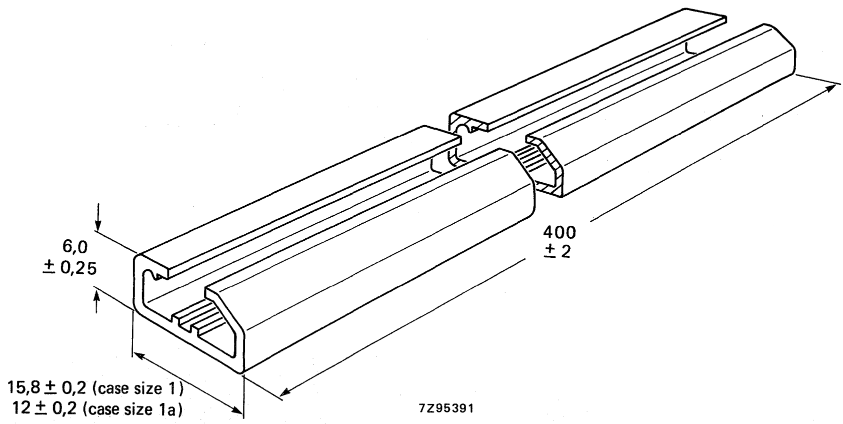


Fig. 17 Rail.

TESTS AND REQUIREMENTS

See Introduction, section 9, under aluminium electrolytic capacitors, with the following addition.

After *endurance test, 1000 h, 85 °C,* the capacitors meet the following requirements:

- $\Delta C/C \leqslant \pm 20\%$,
- tan $\delta \leqslant 200\%$ of specified value,
- d.c. leakage current ⩽ specified value.

After *shelf life test, 500 h, 85 °C,* the capacitors meet the same requirements as after endurance test, except for d.c. leakage current: ⩽ 200% of specified value. The rated voltage shall be applied to the capacitors for minimum 30 min, at least 24 h and not more than 48 h before measurements.

Resistance to soldering heat: 260 ± 5 °C, 10 ± 1 s.

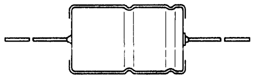
After soldering test, the capacitors meet the following requirements:

- $\Delta C/C \leqslant \pm 10\%$,
- tan $\delta \leqslant$ specified value,
- d.c. leakage current ⩽ 200% of specified value,
- no visible damage.

Note: Capacitors 2222 085 are miniature types, general purpose grade.

ALUMINIUM ELECTROLYTIC CAPACITORS

- Miniature and small types
- Axial leads
- Long life
- Industrial applications



QUICK REFERENCE DATA

Nominal capacitance range (E6 series)	2,2 to 2200 μF
Tolerance on nominal capacitance	−10 to + 50%
Rated voltage range (U_R) (R5 series)	6,3 to 100 V
Category temperature range	−40 to + 85 °C
Endurance test	
at 85 °C	5000 h
at 105 °C	1000 h*
Shelf life at 0 V, 85 °C	500 h
Basic specification	IEC 384—4, long-life grade DIN 41240 (IA) NF C93—110 (type 1)
Climatic category	
IEC 68	40/085/56
DIN 40040	GPF (56 days)
NF C93—001	554
Approval	CECC 30 301-027*

* Not applicable to 100 V range.

Selection chart for C—U_R and relevant case sizes.

C_{nom} μF	U_R (V) 6,3	10	16	25	40	63	100
2,2						5	
3,3						5	
4,7						5	5
6,8						5	5
10						5	5
15					5	6	6
22					5	6	6
33				5	6	00	00
47				5	6	00	00
68			5		00	01	01
100		5		6	01	02	02
150	5		6	00	01	03	03
220		6	00	01	02		
330	6	00			03		
470	00		01	02			
680		01	02	03			
1000	01	02	03				
1500	02	03					
2200	03						

case size	nominal dimensions (mm)
5	Ø 8 x 18
6	Ø 10 x 18
00	Ø 10 x 30
01	Ø 12,5 x 30
02	Ø 15 x 30
03	Ø 18 x 30

APPLICATION

These axial-type capacitors are especially designed for those applications where extreme requirements have to be met concerning reliability and long lifetime both at high and low temperatures, such as in computer, telecommunication and telephony equipment.

DESCRIPTION

The capacitor has etched and oxidized aluminium foil electrodes rolled up with a porous paper spacer, which separates the anode and the cathode. The spacer is impregnated with an electrolyte which retains its good characteristics both at low and high temperatures. The capacitor is housed in an aluminium case with axial soldered-copper leads, sealed with a synthetic disc and is insulated with a blue synthetic sleeve. The all-welded construction, the built-in voltage derating, and the close quality control during manufacture ensure a reliability and a life expectancy far superior to normal grade electrolytic capacitors.

MECHANICAL DATA

Dimensions in mm

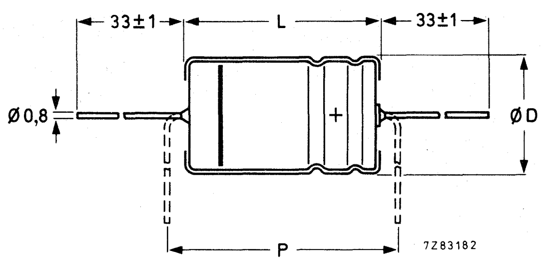


Fig. 1 Case sizes 5 and 6. For dimensions D, L and P, see Table 1.

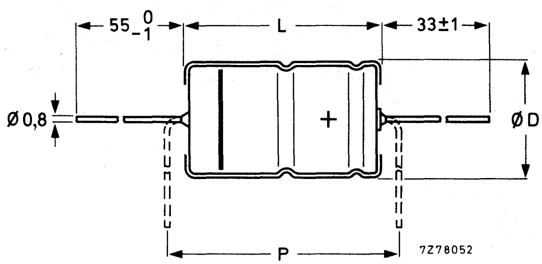


Fig. 2 Case sizes 00, 01, 02 and 03. For dimensions D, L and P, see Table 1.

Table 1

case size	dimensions					approx. mass g
	D		L		P_{min}	
5	8,0	+ 0,5	18,0	+ 0,5	25	1,8
6	10,0		18,0		25	2,5
00	10,0		30,0		35	4,3
01	12,5		30,0		35	6,6
02	15,0		30,0		35	8,5
03	18,0		30,0		35	11,2

Marking

The capacitors are marked with: nominal capacitance, rated voltage, tolerance on capacitance, group number 108.3, maximum temperature, code of origin, date code, a band to identify the negative terminal and "+" signs for positive terminal.

Mounting

The capacitors may be mounted in any position by their leads (see also Tests and requirements in the Introduction).

Minimum atmospheric pressure 8,5 kPa

PRODUCT SAFETY

Non-solid electrolytic capacitors may contain chemicals which can be regarded as hazardous if incorrectly handled. Caution is necessary should the outer case be fractured.

ELECTRICAL DATA

Table 2

Unless otherwise specified all electrical values in Table 2 apply at an ambient temperature of 20 to 25 °C, a frequency of 100 Hz, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 45 to 75%.

U_R V	nom. cap. µF	max. r.m.s. ripple current at T_{amb} = 85 °C (mA) *	max. d.c. leakage current at U_R after 1 min µA	max. tan δ *	typ. ESR * Ω	impedance at 100 kHz Ω max.	impedance at 100 kHz Ω typ.	case size	catalogue number
6,3	150	130	10	0,20	1,06	1,60	0,70	5	2222 108 33151
	330	220	17	0,20	0,49	0,84	0,36	6	33331
	470	325	22	0,20	0,34	0,42	0,18	00	33471
	1000	470	42	0,20	0,16	0,30	0,13	01	33102
	1500	630	60	0,20	0,11	0,22	0,10	02	33152
	2200	920	85	0,20	0,09	0,19	0,09	03	33222
10	100	120	10	0,15	1,27	1,60	0,70	5	34101
	220	205	17	0,15	0,57	0,84	0,36	6	34221
	330	325	24	0,15	0,38	0,42	0,18	00	34331
	680	470	45	0,15	0,19	0,30	0,13	01	34681
	1000	630	65	0,15	0,13	0,22	0,10	02	34102
	1500	920	95	0,15	0,09	0,19	0,09	03	34152
16	68	110	11	0,12	1,40	1,60	0,70	5	35689
	150	190	18	0,12	0,63	0,84	0,36	6	35151
	220	270	25	0,12	0,44	0,42	0,18	00	35221
	470	360	50	0,12	0,21	0,30	0,13	01	35471
	680	500	70	0,12	0,14	0,22	0,10	02	35681
	1000	650	100	0,12	0,10	0,19	0,09	03	35102
25	33	85	8	0,10	2,41	1,60	0,70	5	36339
	47	100	11	0,10	1,70	1,60	0,70	5	36479
	100	170	19	0,10	0,80	0,84	0,36	6	36101
	150	270	26	0,10	0,53	0,42	0,18	00	36151
	220	360	37	0,10	0,36	0,30	0,13	01	36221
	470	500	75	0,10	0,17	0,22	0,10	02	36471
	680	650	105	0,10	0,12	0,19	0,09	03	36681
40	15	65	6	0,08	4,24	1,60	0,70	5	37159
	22	80	9	0,08	2,89	1,60	0,70	5	37229
	33	110	12	0,08	1,93	0,84	0,36	6	37339
	47	130	15	0,08	1,36	0,84	0,36	6	37479
	68	195	20	0,08	0,93	0,42	0,18	00	37689
	100	245	28	0,08	0,63	0,30	0,13	01	37101
	150	280	40	0,08	0,43	0,30	0,13	01	37151
	220	360	55	0,08	0,34	0,22	0,10	02	37221
	330	495	85	0,08	0,20	0,19	0,09	03	37331
63	2,2	25	1,5**	0,08	28,9	1,60	0,70	5	38228
	3,3	30	2**	0,08	19,3	1,60	0,70	5	38338
	4,7	35	3**	0,08	13,5	1,60	0,70	5	38478
	6,8	45	4**	0,08	9,36	1,60	0,70	5	38688
	10	50	6	0,08	6,37	1,60	0,70	5	38109
	15	75	10	0,08	2,90	0,84	0,36	6	38159
	22	90	12	0,08	4,25	0,84	0,36	6	38229
	33	125	17	0,08	1,93	0,42	0,18	00	38339
	47	150	22	0,08	1,36	0,42	0,18	00	38479
	68	195	30	0,08	0,93	0,30	0,13	01	38689
	100	275	42	0,08	0,63	0,22	0,10	02	38101
	150	355	60	0,08	0,43	0,19	0,09	03	38151

* See also corresponding paragraph.
** Measured after 5 min.

U_R V	nom. cap. μF	max. r.m.s. ripple current at T_{amb} = 85 °C (mA)*	max. d.c. leakage current at U_R after 1 min μA	max. tan δ*	typ. ESR* Ω	impedance at 100 kHz Ω max.	impedance at 100 kHz Ω typ.	case size	catalogue number
100	4,7	40	5**	0,07	8,5	1,6	0,8	5	2222 108 39478
	6,8	50	7**	0,07	5,9	1,6	0,8	5	39688
	10	60	10	0,07	4,0	1,6	0,8	5	39109
	15	80	13	0,07	2,7	0,84	0,4	6	39159
	22	90	17	0,07	1,8	0,84	0,4	6	39229
	33	105	24	0,15	4,8	1,9	0,9	00	39339
	47	125	33	0,15	3,4	1,9	0,9	00	39479
	68	165	45	0,15	2,4	1,6	0,7	01	39689
	100	225	64	0,15	1,6	1,3	0,5	02	39101
	150	300	94	0,15	1,1	0,9	0,3	03	39151

Capacitance

Nominal capacitance at 100 Hz at T_{amb} = 20 °C — see Table 2

Tolerance on nominal capacitance at 100 Hz — −10 to + 50%

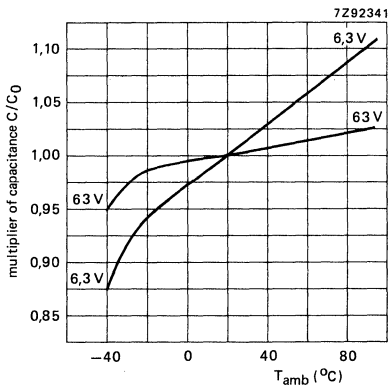


Fig. 3 Typical capacitance as a function of temperature, U_R = 6,3 to 63 V; C_o = capacitance at 20 °C, 100 Hz.

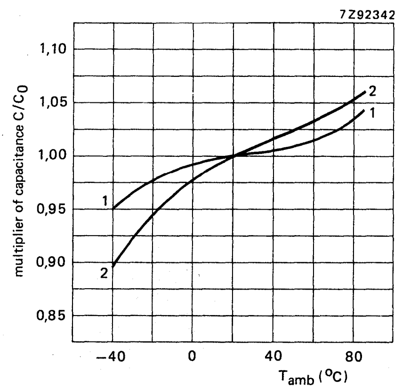


Fig. 4 Typical capacitance as a function of temperature, U_R = 100 V; C_o = capacitance at 20 °C, 100 Hz.
curve 1 = case sizes 5 and 6;
curve 2 = case sizes 00 to 03.

* See also corresponding paragraph.
** Measured after 5 min.

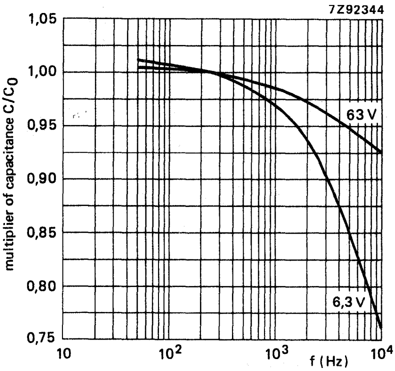


Fig. 5 Typical capacitance as a function of frequency, U_R = 6,3 to 63 V;
C_o = capacitance at 20 °C, 100 Hz.

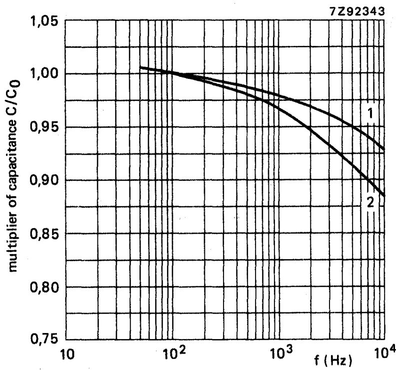


Fig. 6 Typical capacitance as a function of frequency, U_R = 100 V;
C_o = capacitance at 20 °C, 100 Hz.
curve 1 = case sizes 5 and 6;
curve 2 = case sizes 00 to 03.

Voltage

Max. permissible voltage	1,1 x U_R
Ripple voltage * = max. permissible a.c. voltage providing the following three conditions are met:	
a) max. (d.c. + peak a.c.) voltage	1,1 x U_R
b) max. peak a.c. voltage, without d.c. voltage applied	1 V
c) momentary value of applied voltage	between 1,1 x U_R and −1 V
Surge voltage = max. permissible voltage for short periods (see also Tests and requirements in the Introduction)	1,15 x U_R
Reverse voltage = max. d.c. voltage applied in the reverse polarity at 85 °C	1 V

Ripple current**

Maximum permissible r.m.s. ripple current at 100 Hz and

T_{amb} = 85 °C	see Table 2
T_{amb} = 75 °C	1,7 x values of Table 2
$T_{amb} \leqslant$ 65 °C	2,2 x values of Table 2

* Ripple voltages are not applicable if the max. permissible ripple current is exceeded. In that case the ripple current is decisive.

** Ripple currents are not applicable if the max. permissible ripple voltage is exceeded. In that case the ripple voltage is decisive.

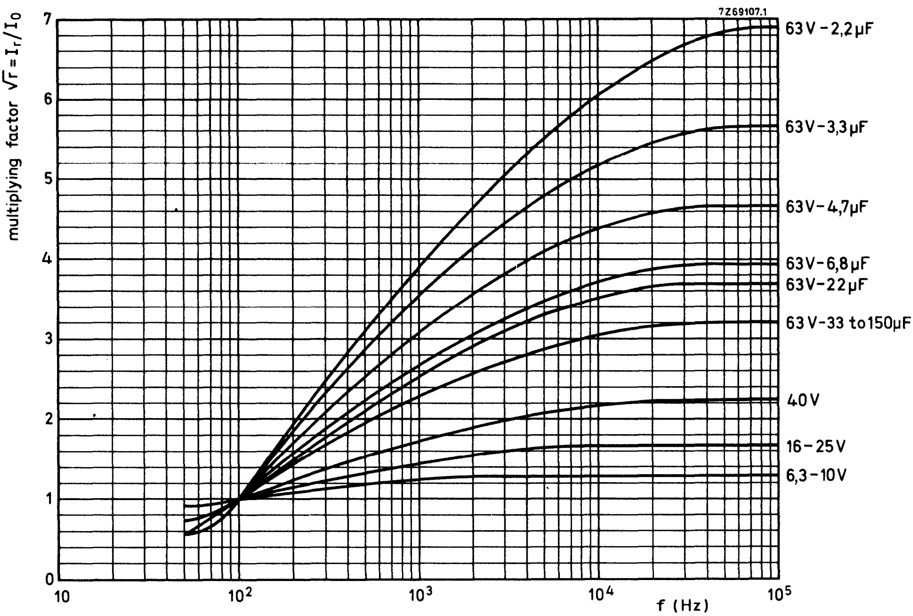


Fig. 7 Multiplying factor as a function of frequency, U_R = 6,3 to 63 V; I_0 = maximum ripple current at 85 °C, 100 Hz.

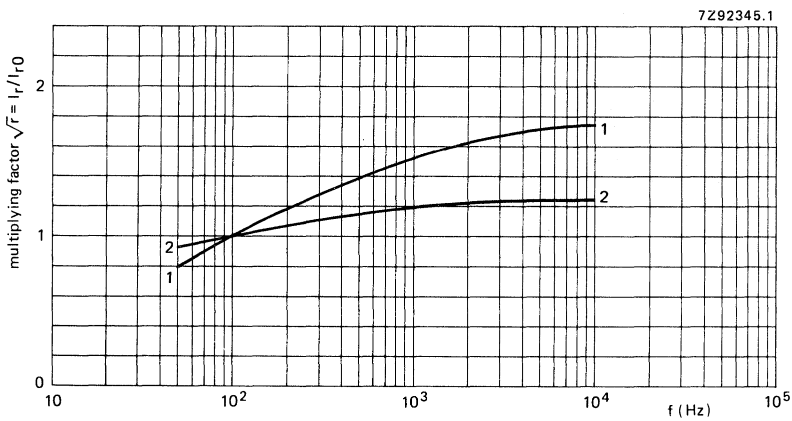


Fig. 8 Multiplying factor as a function of frequency, U_R = 100 V; I_0 = maximum ripple current at 85 °C, 100 Hz.
Curve 1 = case sizes 5 and 6;
Curve 2 = case sizes 00 to 03.

Non-sinusoidal ripple currents have to be analyzed into a number of sinusoidal currents and the following requirements shall then be satisfied:

$$\sum_n \frac{I_n^2}{r_n} \leqslant I_r^2 \text{ max}$$

$I_{r\,max}$ = max. ripple current at 100 Hz and applicable ambient temperature;
I_n = ripple current at a certain frequency;
$\sqrt{r_n}$ = multiplying factor at same frequency.

Note
These ripple currents are not applicable if the max. permissible ripple voltage is exceeded. In that case the ripple voltage is decisive (see Ripple voltage).

Charge and discharge current

The capacitors may be charged from a source with a source impedance of 0 Ω, and they may be discharged by short-circuiting. If the capacitors are charged and discharged continuously at a rate of several times per minute, the charge and discharge currents have to be considered as ripple currents flowing through the capacitor. The r.m.s. value of these currents should be determined and the value thus found must not exceed the applicable limit.

D.C. leakage current

Maximum d.c. leakage current 1 min* after application of U_R, at T_{amb} = 20 °C	see Table 2
D.C. leakage current during continuous operation at U_R	
at 20 °C	approx. 0,2 x values stated in Table 2
at 85 °C	⩽ values stated in Table 2

* For capacitors < 10 μF the d.c. leakage current shall be measured 5 min after application of U_R.

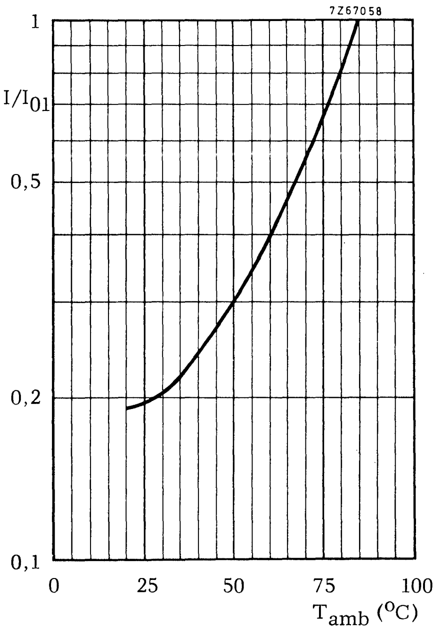


Fig. 9 Multiplier I/I_{01} as a function of temperature. I_{01} = d.c. leakage current during continuous operation at T_{amb} = 85 °C at U_R.

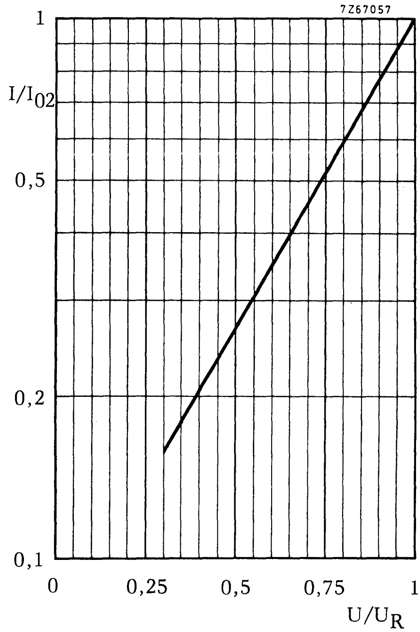


Fig. 10 Multiplier I/I_{02} as a function of U/U_R. I_{02} = d.c. leakage current at U_R at a discrete constant temperature within category temperature range.

If owing to prolonged storage and/or storage at an excessive temperature (> 40 °C) the d.c. leakage current is too high, application of the rated voltage for some hours will cause the d.c. leakage current to fall to a value lower than specified in Table 2.

Tan δ (dissipation factor)

Maximum tan δ at 100 Hz and T_{amb} = 20 °C, measured by means of a four-terminal circuit (Thomson circuit) — see Table 2

Equivalent series resistance (ESR = tan δ/ωC)

Typical ESR at 100 Hz and T_{amb} = 20 °C — see Table 2

Impedance

Impedance at 100 kHz and T_{amb} = 20 °C, measured by means of a four-terminal circuit (Thomson circuit) — see Table 2

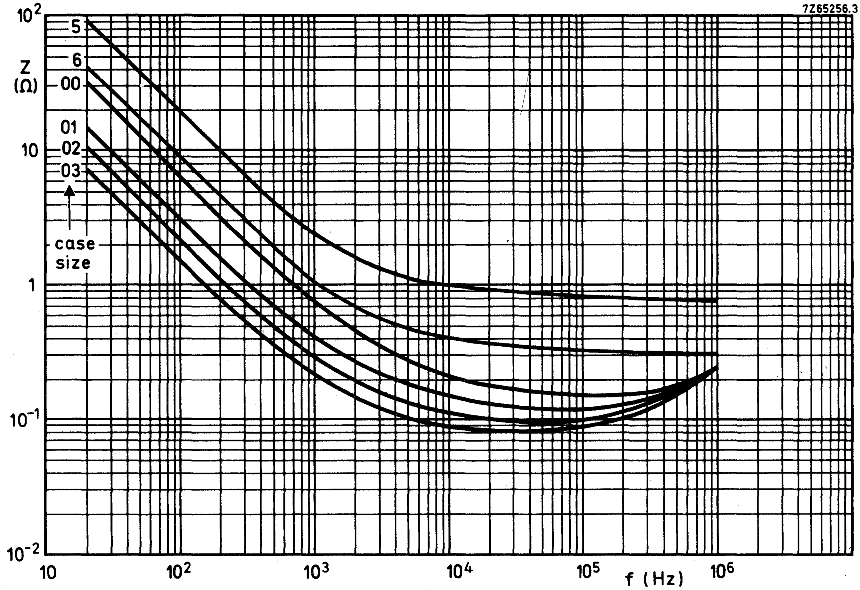


Fig. 11 Typical impedance as a function of frequency at 20 °C, U_R = 16 V.

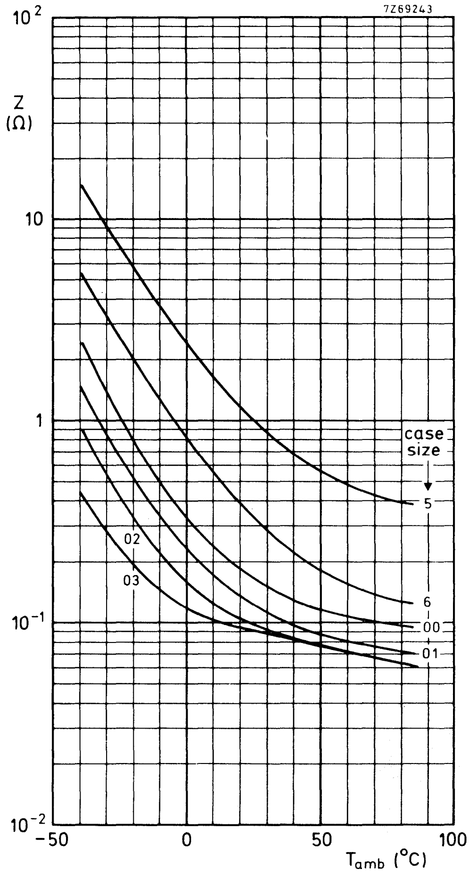


Fig. 12 Typical impedance as a function of temperature at 100 kHz, U_R = 6,3 to 63 V.

Equivalent series inductance (ESL)

Case size 5	typ. 40 nH
Case size 6	typ. 50 nH
Case sizes 00 and 01	typ. 50 nH
Case size 02	typ. 55 nH
Case size 03	typ. 60 nH

OPERATIONAL DATA

Category temperature range

for rated voltage	−40 to + 85 °C	
Typical lifetime	case sizes 5 and 6	case sizes 00 to 03
at + 40 °C	> 120 000 h	> 200 000 h
at + 85 °C	> 6 000 h	> 10 000 h
at + 105 °C	> 1 200 h	> 2 000 h*
Shelf life at 0 V and T_{amb} = 85 °C	500 h	

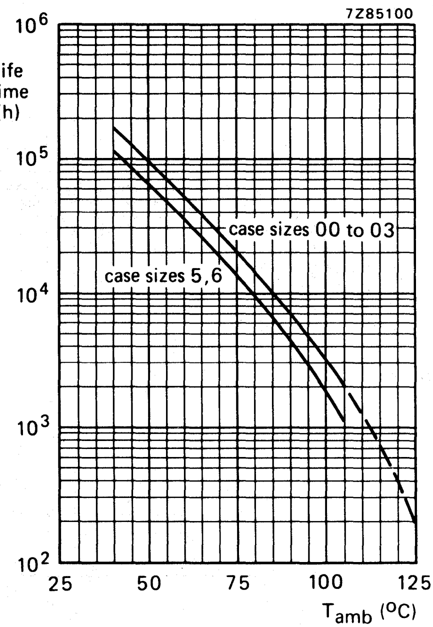


Fig. 13 Typical lifetime as a function of temperature.

* Not applicable to 100 V range.

PACKING

Capacitors with case sizes 00 to 03 are supplied in boxes of 200. Capacitors with case sizes 5 and 6 are supplied on bandoliers in boxes of 500.

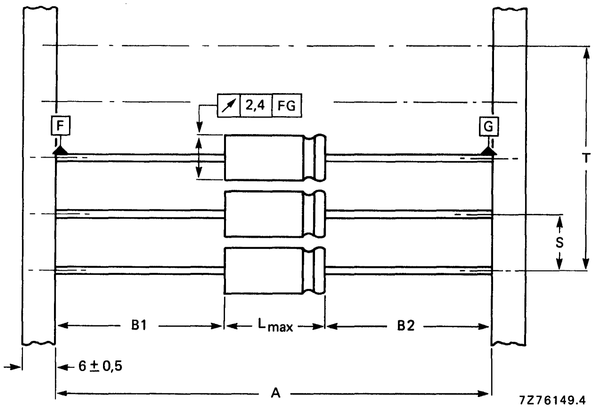


Fig. 14 Capacitors (case size 5 or 6) on bandoliers: the bandolier to which the negative capacitor terminals are connected is blue. See Table 3 for simendions A, S, T and L.

|B1–B2| = max. 1,4 mm.

Table 3

Dimensions in mm

case size	A	S	T for number (n) of capacitors		L_{max}
			n < 50	50<n<100	
5	73 ± 1,6	10 ± 0,4	10 (n-1) ± 2	10 (n-1) ± 4	18,5
6	73 ± 1,6	15 ± 0,75	15 (n-1) ± 2	15 (n-1) ± 4	18,5

TESTS AND REQUIREMENTS

See Introduction, section 9, under aluminium electrolytic capacitors, with the exception of IEC 384–4 sub clause 9. 14, for which the following is valid.

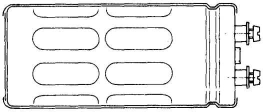
IEC 384–4 sub clause 9. 14.
IEC 68–2 test method: no reference.
Name of test: Endurance.
Procedure: 5000 h at 85 ^{o}C, rated voltage and ripple current applied.
Requirements: No visible damage, no leakage of electrolyte, insulation resistance $>$ 100 MΩ, no breakdown or flashover, d.c. leakage current $\leqslant$ stated limit, tan $\delta \leqslant$ 1,3 x stated limit, impedance at 100 kHz $\leqslant$ 2 x stated limit, ΔC/C $\leqslant$ 15%.

After *shelf life test, 500 h, 85 ^{o}C,* the capacitors meet the same requirements as after endurance test. The rated voltage shall be applied to the capacitors for minimum 30 min., at least 24 h and not more than 48 h before measurements.

Note:
Capacitors 2222 108 are miniature and small types, long-life grade.

ALUMINIUM ELECTROLYTIC CAPACITORS

- Large type with screw terminals
- Long life
- Industrial applications



QUICK REFERENCE DATA

Nominal capacitance range (E6 series)	150 to 220 000 μF
Tolerance on nominal capacitance	−10 to + 30%
Rated voltage range, U_R	10 to 385 V
Category temperature range	−40 to + 85 °C
Endurance test at 85 °C	5000 h
Shelf life at 0 V, 85 °C	500 h
Basic specifications	IEC 384-4, long-life grade
	DIN 41240
Detail specification	DIN 41248
Climatic category	
IEC 68	40/085/56
DIN 40040	GPF (56 days)
NF C93-001	554

Selection chart for C_{nom}-U_R and relevant case sizes.

C_{nom} μF	U_R (V)								
	10	16	25	40	63	100	250	350	385
150									10
220									11
330							10		12a
470							11		14
680							12a	14	15a
1 000						10	14	15a	16a
1 500						10	15a		16a
2 200					10	11	16a		17
3 300				10	10	12a	16a		
4 700			10	10	11	14	17		
6 800			10	11	12a	15a			
10 000		10	11	12a	14	16a			
15 000	10	11	12a	14	15a	16a			
22 000	11	12a	14	15a	16a	17			
33 000	12a	14	15a	16a	16a				
47 000	14	15a	16a	16a	17				
68 000	15a	16a	16a	17					
100 000	16a	16a	17						
150 000	16a	17							
220 000	17								

case size	nominal dimensions (mm)
10	Ø 35 x 60
11	Ø 35 x 80
12a	Ø 35 x 105
14	Ø 50 x 80
15a	Ø 50 x 105
16a	Ø 65 x 105
17	Ø 75 x 105

APPLICATION

These capacitors have extremely low impedance and inductance values and high resistance to shock and vibration which render them very suitable for applications such as:

- switched-mode power supplies;
- power supplies in digital equipment;
- energy storage in pulse systems;
- filters in measuring and control apparatus.

DESCRIPTION

The low impedance and inductance are achieved by a special construction with multiple internal anode and cathode connections. The high resistance to shock and vibration is achieved by the longitudinal rills and special internal construction. The capacitors are completely cold-welded and there are no limitations on charge/discharge rate (see paragraph "Charge and discharge current"). The aluminium cases are fully insulated and sealed by a synthetic disc with a vent. The capacitors are delivered with screws and washers.

MECHANICAL DATA

Dimensions in mm

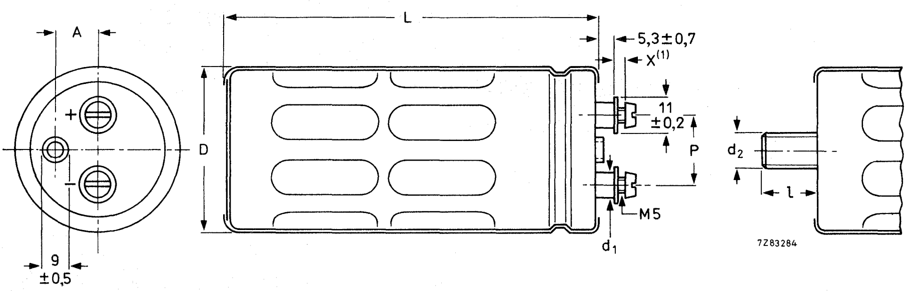


Fig. 1 See Table 1 for dimensions D, L, P, A, d_1, d_2, and l.

(1) Maximum permissible torque which may be applied to the termination screws at various heights (dimension x in drawing):

x	max. permissible torque (Nm)
2	1,5
4	1
6	0,5

Table 1

case size	D		L		P		A	d1		$d_2 \times l$
10	35	+ 1,5	60	+ 3	13,0	± 0,1	8,4	8	± 0,2	M8 x 12
11	35		80		13,0		8,4	8		M8 x 12
12a	35		105		13,0		8,4	8		M8 x 12
14	50		80		22,0		14,3	8		M12 x 16
15a	50		105		22,0		14,3	8		M12 x 16
16a	65		105		28,5		19,0	11		M12 x 16
17	75		105		32,0		21,0	11		M12 x 16

Marking

The capacitors are marked with: nominal capacitance, tolerance on nominal capacitance, rated voltage, temperature range, IEC grade, maximum r.m.s. ripple current at 70 °C and 20 kHz, catalogue number, date code (year/week), name of manufacturer. ←

Mounting

The capacitor may be mounted vertically or horizontally, with or without mounting clamp. For proper functioning the vent should be on the upper side, whether the capacitor is mounted horizontally or vertically. When a number of capacitors are connected in a bank, they must not be closer together than 15 mm when no derating of ripple current and/or temperature is applied. See also Mounting Accessories, at the end of this data sheet.

Minimum atmospheric pressure 8,5 kPa

PRODUCT SAFETY

Non-solid electrolytic capacitors may contain chemicals which can be regarded as hazardous if incorrectly handled. Caution is necessary should the outer case be fractured.

ELECTRICAL DATA

Unless otherwise specified all electrical values in Table 2 apply at an ambient temperature of 20 °C, a frequency of 100 Hz, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 45 to 75%.

Table 2

U_R	nom. cap.	max. r.m.s.* ripple current (A)		max.d.c.leakage current at U_R after 1 min	typ.* ESR	max. tan δ*	impedance at 20 kHz* mΩ		case size	catalogue number**
		at T_{amb} = 85 °C 100 Hz	at T_{amb} = 70 °C 20 kHz							
V	μF			mA	mΩ		typ.	max.		
10	15 000	6	11,4	0,90	20	0,32	13	20	10	2222 114 14153
	22 000	7,5	14,2	1,32	14	0,33	9,5	14	11	14223
	33 000	10	19	1,98	10	0,35	7,5	10	12a	14333
	47 000	14	26,5	2,82	7,5	0,36	5,0	9,5	14	14473
	68 000	18	34	4,08	5,5	0,38	4,0	8,0	15a	14683
	100 000	30	50	6,00	3,5	0,34	3,0	5,0	16a	14104
	150 000	30	50	9,00	3,0	0,45	3,0	5,0	16a	14154
	220 000	37	50	13,20	2,0	0,45	2,5	4,0	17	14224
16	10 000	6	11,4	0,96	22	0,22	13	20	10	15103
	15 000	7,5	14,2	1,44	15	0,23	9,5	14	11	15153
	22 000	10	19	2,12	11	0,25	7,0	10	12a	15223
	33 000	13	24,6	3,17	7,5	0,26	5,0	9,5	14	15333
	47 000	18	34	4,52	5,5	0,27	4,0	8,0	15a	15473
	68 000	28	50	6,53	3,5	0,24	3,0	5,0	16a	15683
	100 000	28	50	9,60	3,0	0,31	3,0	5,0	16a	15104
	150 000	37	50	14,40	2,0	0,31	2,5	4,0	17	15154
25	4 700	5,2	10	0,71	30	0,14	15	23	10	16472
	6 800	5,2	10	1,02	25	0,18	14	21	10	16682
	10 000	6,7	12,7	1,50	18	0,18	10	15	11	16103
	15 000	9,7	18,4	2,25	12	0,19	7,5	11	12a	16153
	22 000	12,5	23,7	3,30	8,5	0,19	5,5	9,5	14	16223
	33 000	18	34	4,95	6,0	0,21	4,0	8,0	15a	16333
	47 000	27	50	7,05	4,0	0,18	3,0	5,0	16a	16473
	68 000	27	50	10,20	3,5	0,23	3,0	5,0	16a	16683
	100 000	37	50	15,00	2,5	0,23	2,5	4,0	17	16104
40	3 300	4,5	8,5	0,80	37	0,13	21	32	10	17332
	4 700	4,5	8,5	1,13	35	0,17	22	33	10	17472
	6 800	6	11,4	1,64	25	0,17	15	23	11	17682
	10 000	7,5	14,2	2,40	17	0,18	11	17	12a	17103
	15 000	10	19	3,60	11	0,17	7,5	13	14	17153
	22 000	15	28,5	5,28	8,0	0,18	5,5	10,5	15a	17223
	33 000	21	40	7,92	5,0	0,16	3,5	6,0	16a	17333
	47 000	22	42	11,28	4,5	0,21	3,5	6,0	16a	17473
	68 000	30	50	16,32	3,0	0,21	3,0	4,5	17	17683

* See also corresponding paragraph.
** Replace 8th digit by 5 for bolt version.

U_R	nom. cap.	max. r.m.s.* ripple current (A)		max.d.c.leakage current at U_R after 1 min	typ.* ESR	max. tan δ*	impedance at 20 kHz* mΩ		case size	catalogue number**
		at T_{amb} = 85 °C 100 Hz	at T_{amb} = 70 °C 20 kHz				typ.	max.		
V	μF			mA	mΩ					
63	2 200	3,7	7	0,84	39	0,09	22	33	10	2222 114 18222
	3 300	3,7	7	1,25	32	0,11	20	30	10	18332
	4 700	5,2	10	1,78	23	0,11	14	21	11	18472
	6 800	7,5	14,2	2,57	17	0,11	10	15	12a	18682
	10 000	9,5	18	3,78	12	0,12	7,5	14	14	18103
	15 000	13,5	25,6	5,67	8,5	0,13	5,5	10,5	15a	18153
	22 000	21	40	8,32	5,0	0,11	3,5	6,0	16a	18223
	33 000	22	42	12,48	4,5	0,14	3,5	6,0	16a	18333
	47 000	30	50	17,77	3,0	0,14	3,0	4,5	17	18473
100	1 000	2,2	4,2	0,60	220	0,22	160	240	10	19102
	1 500	2,2	4,2	0,90	220	0,33	160	240	10	19152
	2 200	3,3	6,3	1,32	150	0,33	110	165	11	19222
	3 300	4,5	8,5	1,98	100	0,33	75	115	12a	19332
	4 700	5,7	10,8	2,82	70	0,33	55	85	14	19472
	6 800	8,0	15,2	4,08	50	0,33	35	55	15a	19682
	10 000	13,5	25,6	6,00	22	0,22	16	25	16a	19103
	15 000	13,5	25,6	9,00	22	0,33	16	25	16a	19153
	22 000	15,0	28,5	13,20	15	0,33	11	17	17	19223
250	330	1,8	3,4	0,50	300	0,15	275	500	10	2222 115 13331
	470	2,5	4,7	0,71	250	0,15	140	375	11	13471
	680	3,5	6,6	1,02	180	0,15	125	300	12a	13681
	1 000	4,2	8	1,50	110	0,15	60	130	14	13102
	1 500	6,3	12	2,25	60	0,15	40	100	15a	13152
	2 200	8,8	16,7	3,30	45	0,15	30	60	16a	13222
	3 300	10,5	20	4,95	30	0,15	25	50	16a	13332
	4 700	14	26,5	7,05	25	0,15	20	40	17	13472
350	680	2,7	5,1	1,47	140	0,10	60	130	14	15681
	1 000	4,8	9,1	2,14	65	0,10	50	100	15a	15102
385	150	1,2	2,3	0,34	425	0,10	250	500	10	18151
	220	1,6	3	0,50	275	0,10	200	380	11	18221
	330	2,2	4,2	0,75	175	0,10	140	300	12a	18331
	470	2,7	5,1	1,06	110	0,10	75	130	14	18471
	680	4,8	9,1	1,53	90	0,10	60	130	15a	18681
	1 000	7	13,3	2,25	70	0,10	45	60	16a	18102
	1 500	7	13,3	3,38	45	0,10	30	50	16a	18152
	2 200	9	17	4,95	35	0,10	20	45	17	18222

* See also corresponding paragraph.
** Replace 8th digit by 5 for bolt version.

Capacitance

Nominal capacitance at 100 Hz and T_{amb} = 20 °C	see Table 2
Tolerance on nominal capacitance at 100 Hz	−10 to + 30%

Voltage

	core temperature* < 60 °C	core temperature* 60 to 95 °C
Rated voltage = max. permissible voltage	1,1 x U_R	U_R
Ripple voltage = max. permissible a.c. voltage providing the following three conditions are met:		
(a) max. positive voltage on anode (d.c. + peak a.c.)	1,1 x U_R	U_R
(b) max. positive voltage on cathode (reverse voltage)	1 V	1 V
(c) max. ripple current is not exceeded		
Surge voltage = max. permissible voltage for short periods (see also "Tests and requirements")		
U_R = 10 to 100 V	1,25 x U_R	1,15 x U_R
U_R = 250 V	1,15 x U_R	1,15 x U_R
U_R = 350 V and 385 V	1,1 x U_R	1,1 x U_R
Reverse voltage = max. d.c. voltage applied in the reverse polarity at the maximum category temperature (for short periods)	1 V	1 V

* See Introduction, section 5, "Ripple current".

Ripple current

Maximum permissible r.m.s. ripple current

at 100 Hz and T_{amb} = 85 °C	see Table 2
at 20 kHz and T_{amb} = 70 °C	see Table 2
at other frequencies and temperatures	see Tables 3 and 4*

Table 3

ambient temperature °C	multiplier of max. ripple current
85	1,00
80	1,22
75	1,41
70	1,58
65	1,73
60	1,87
55	2,00
50	2,12
45	2,24
≤ 40	2,35

Table 4

frequency Hz	multiplier of max. ripple current ($\sqrt{r}$)
50	0,83
100	1,00
200	1,10
400	1,15
1000	1,19
≥ 2000	1,20

*With an absolute maximum of 50 A.

Non-sinusoidal ripple currents have to be analyzed into a number of sinusoidal currents and the following requirements shall then be satisfied:

$$\sum_n \frac{I_n^2}{r_n} \leq I_r^2 \text{max.}$$

$I_{r\,max}$ = max. ripple current at 100 Hz and applicable ambient temperature;

I_n = ripple current at a certain frequency;

$\sqrt{r_n}$ = multiplying factor at same frequency (Table 4)

Note

Ripple currents are not applicable if the maximum permissible ripple voltage is exceeded. In that case the ripple voltage is decisive.

Charge and discharge current

The capacitors may be charged from a source without internal resistance and they may be discharged by short-circuiting. If the capacitors are charged and discharged continuously at a rate of several times per minute, the charge and discharge currents have to be considered as ripple currents flowing through the capacitor. The r.m.s. value of these currents should be determined and the value thus found must not exceed the applicable limit.

D.C. leakage current

Maximum d.c. leakage current 1 min after application of the rated voltage at T_{amb} = 20 °C	see Table 2 (0,006 CU + 4 μA)
D.C. leakage current after 15 min at U_R,	
at T_{amb} = 20 °C	0,125 x value stated in Table 2
at T_{amb} = 85 °C	0,625 x value stated in Table 2

If owing to prolonged storage and/or storage at an excessive temperature the d.c. leakage current is too high, application of the rated voltage for some hours will cause the d.c. leakage current to fall to a value lower than specified in Table 2.

Tan δ (dissipation factor)

Maximum tan δ at 100 Hz and T_{amb} = 20 °C, measured by means of a four-terminal circuit (Thomson circuit) — see Table 2

Equivalent series resistance (ESR)

Typical ESR at 100 Hz and T_{amb} = 20 °C — see Table 2

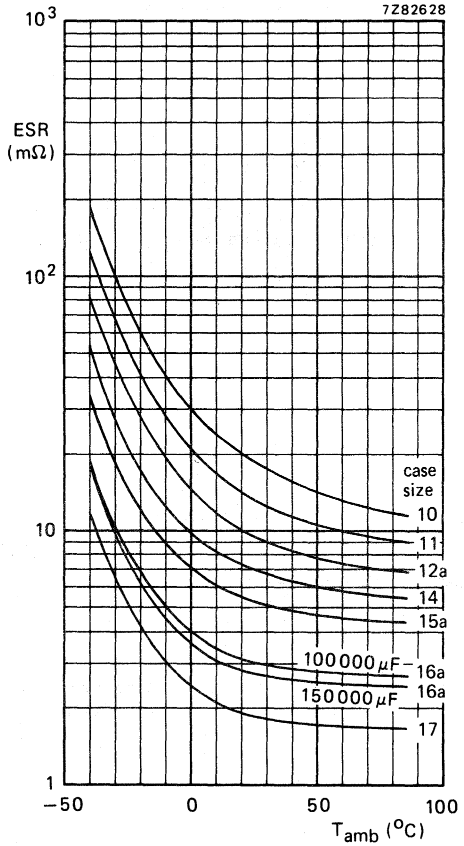


Fig. 2 Typical ESR as a function of temperature at 100 Hz, U_R = 10 V.

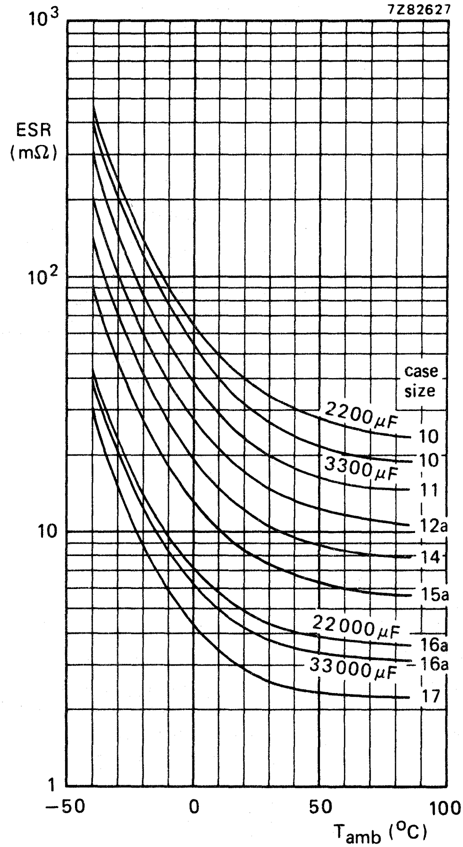


Fig. 3 Typical ESR as a function of temperature at 100 Hz, U_R = 63 V.

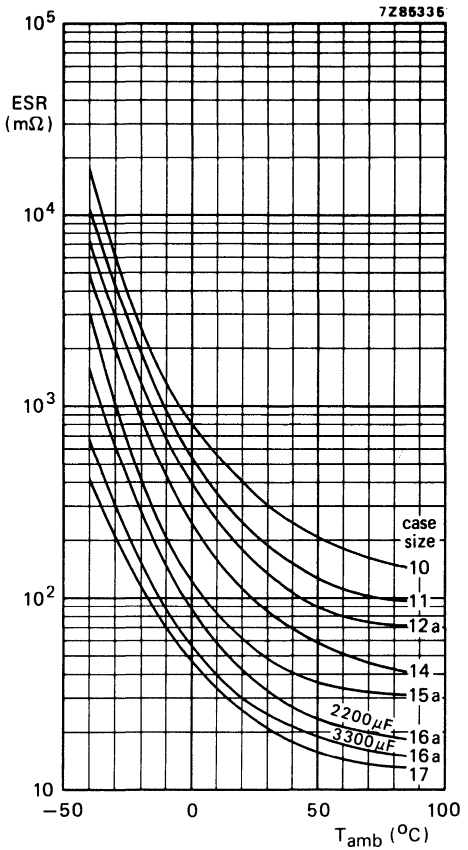


Fig. 4 Typical ESR as a function of temperature at 100 Hz, U_R = 250 V.

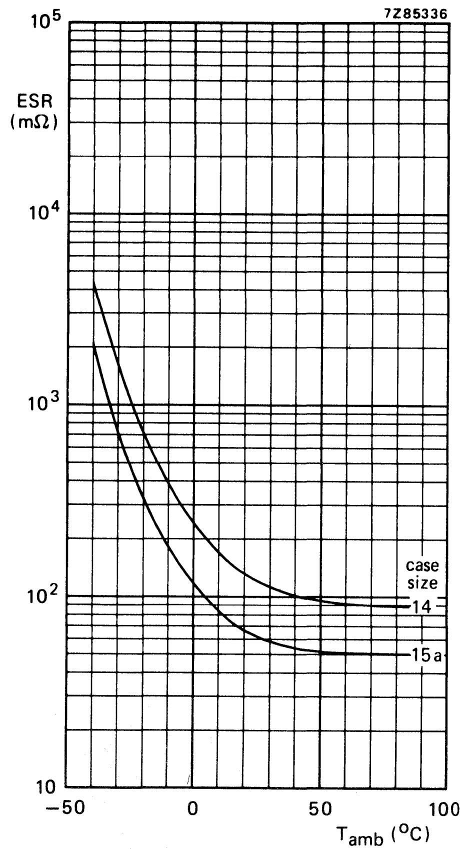


Fig. 5 Typical ESR as a function of temperature at 100 Hz, U_R = 350 V.

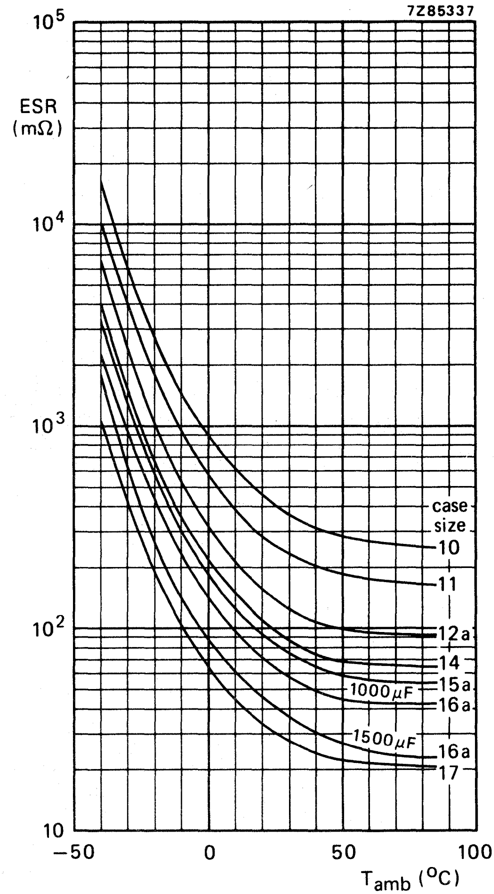


Fig. 6 Typical ESR as a function of temperature at 100 Hz, U_R = 385 V.

Impedance

Impedance at 20 kHz and T_{amb} = 20 °C, measured by means of a four-terminal circuit (Thomson circuit) — see Table 2

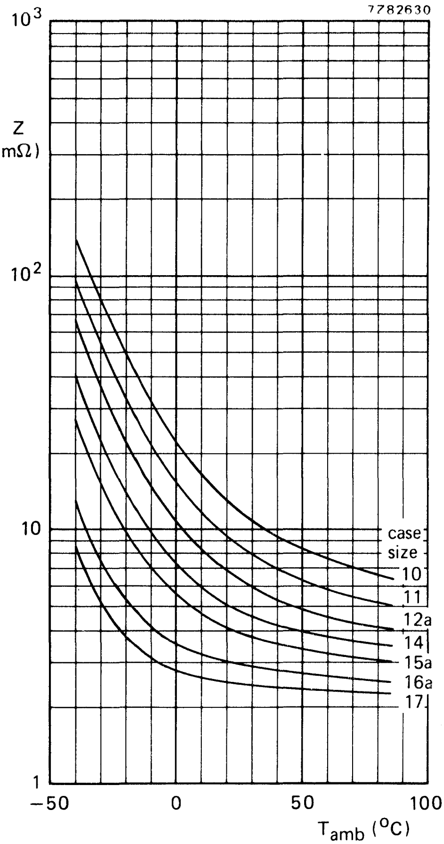


Fig. 7 Typical impedance as a function of temperature at 20 kHz, U_R = 10 V.

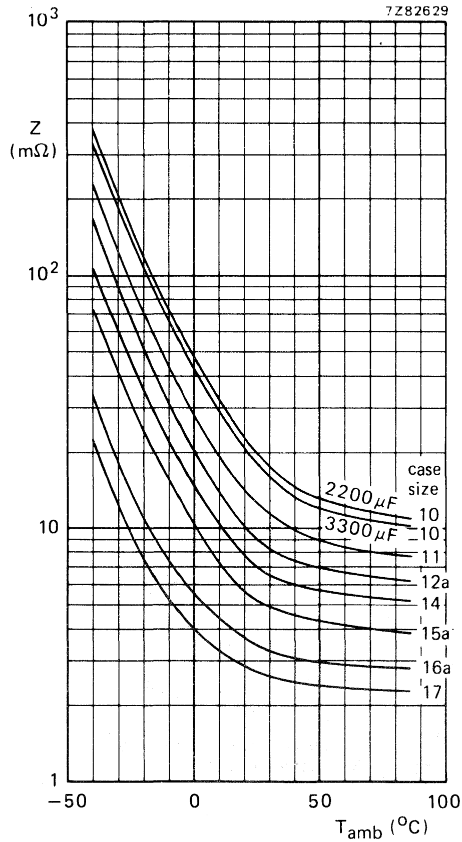


Fig. 8 Typical impedance as a function of temperature at 20 kHz, U_R = 63 V.

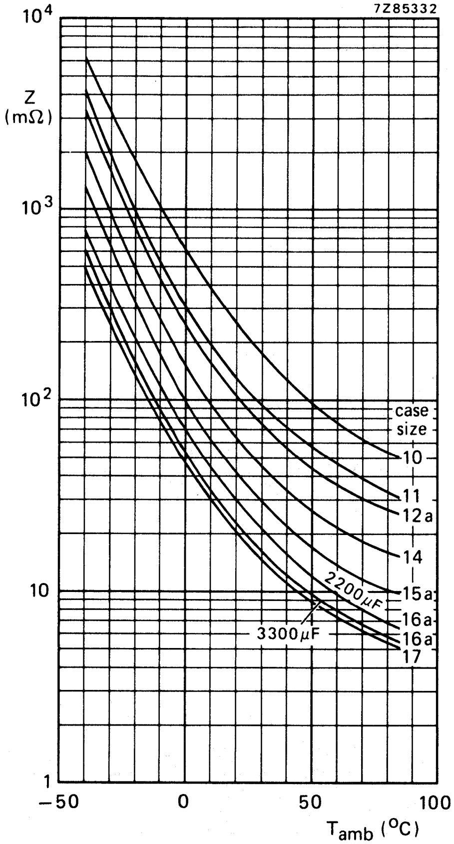


Fig. 9 Typical impedance as a function of temperature at 20 kHz, U_R = 250 V.

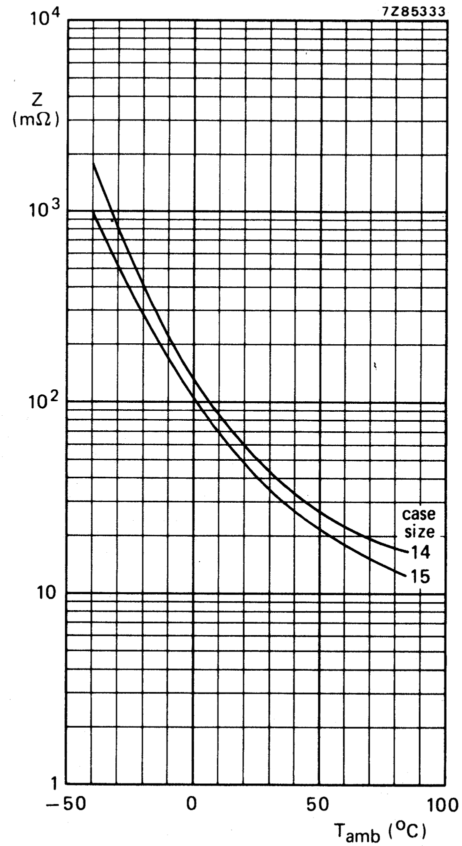


Fig. 10 Typical impedance as a function of temperature at 20 kHz, U_R = 350 V.

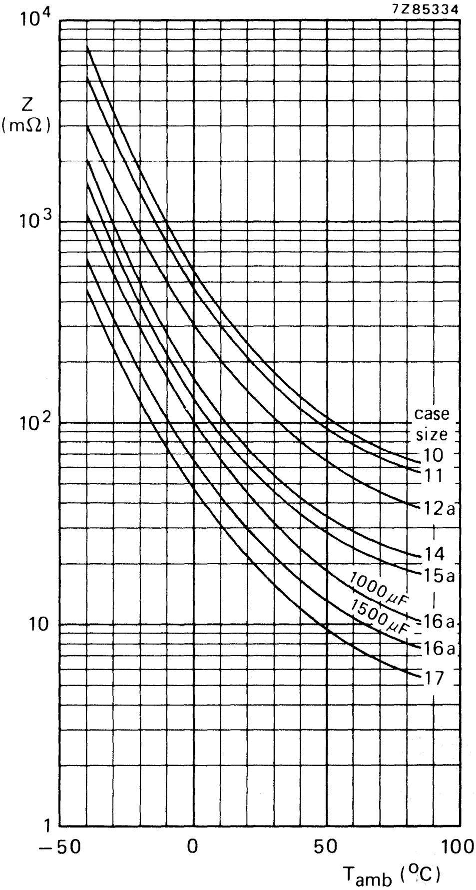


Fig. 11 Typical impedance as a function of temperature at 20 kHz, U_R = 385 V.

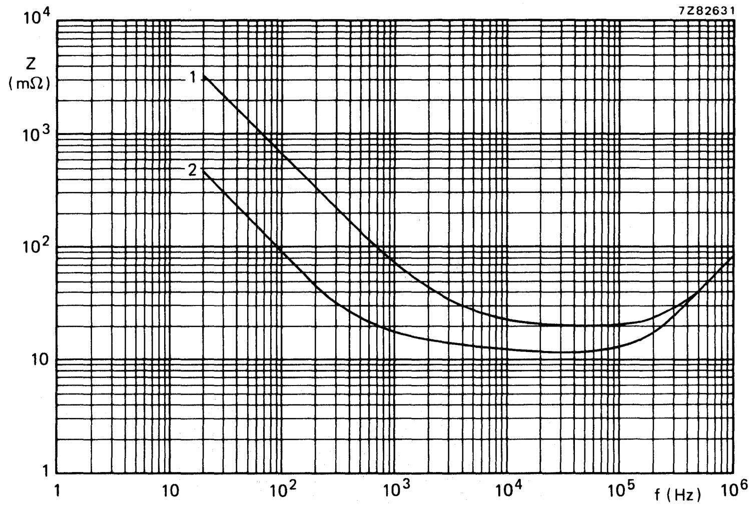


Fig. 12 Typical impedance as a function of frequency at T_{amb} = 20 °C; **case size 10:**
curve 1 = 2200 μF, 63 V; curve 2 = 15 000 μF, 10 V.

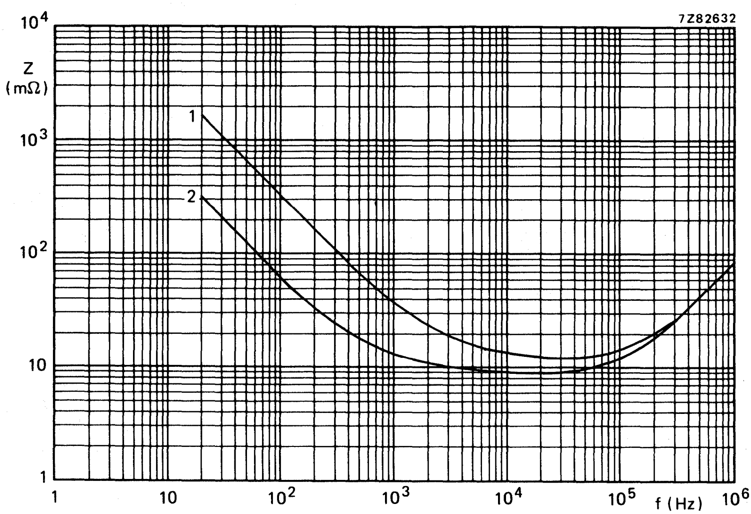


Fig. 13 Typical impedance as a function of frequency at T_{amb} = 20 °C; **case size 11:**
curve 1 = 4700 μF, 63 V; curve 2 = 22 000 μF, 10 V.

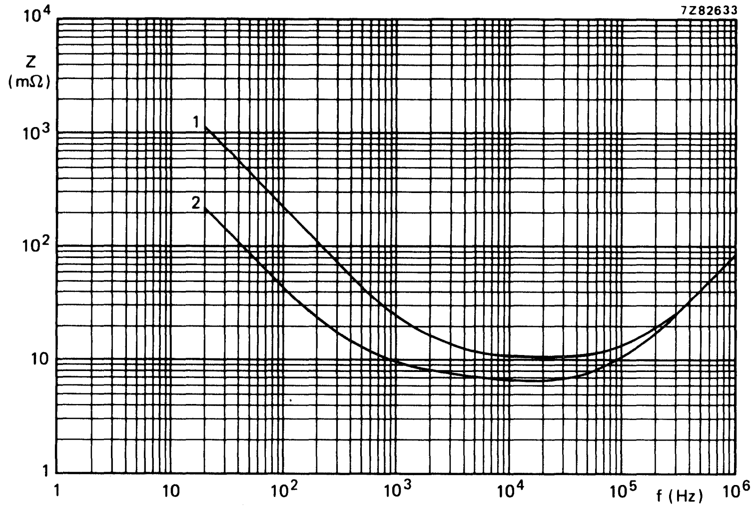


Fig. 14 Typical impedance as a function of frequency at T_{amb} = 20 °C; **case size 12a:**
curve 1 = 6800 μF, 63 V; curve 2 = 33 000 μF, 10 V.

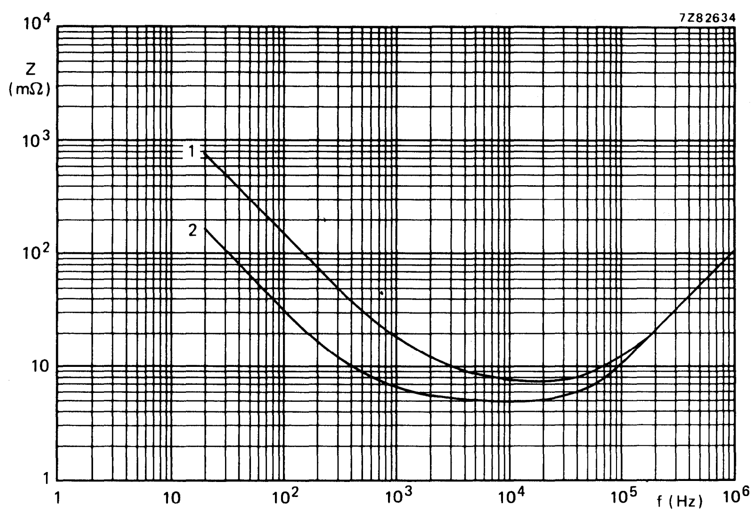


Fig. 15 Typical impedance as a function of frequency at T_{amb} = 20 °C; **case size 14:**
curve 1 = 10 000 μF, 63 V; curve 2 = 47 000 μF, 10 V.

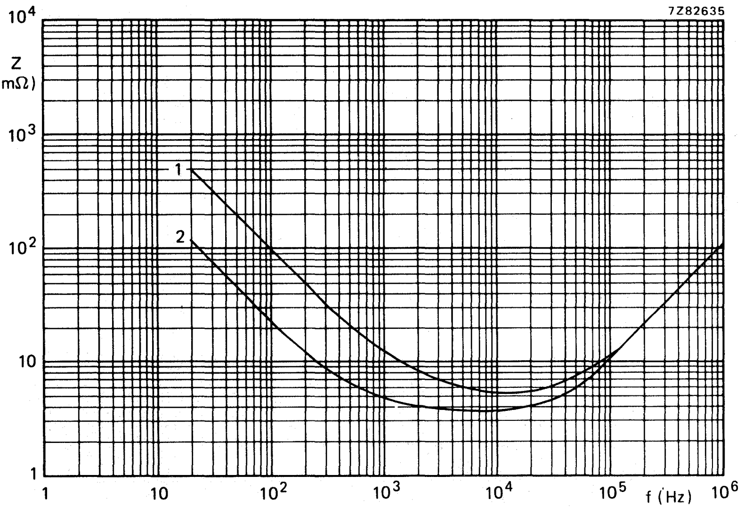


Fig. 16 Typical impedance as a function of frequency at T_{amb} = 20 °C; **case size 15a:**
curve 1 = 15 000 μF, 63 V; curve 2 = 68 000 μF, 10 V.

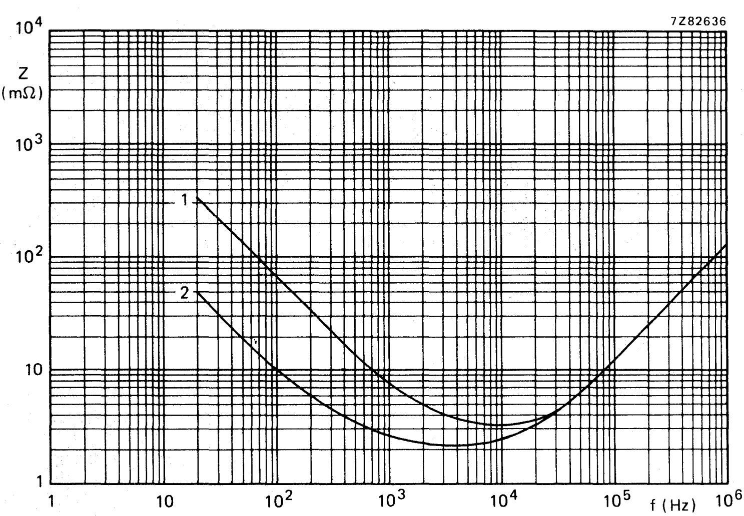


Fig. 17 Typical impedance as a function of frequency at T_{amb} = 20 °C; **case size 16a:**
curve 1 = 22 000 μF, 63 V; curve 2 = 150 000 μF, 10 V.

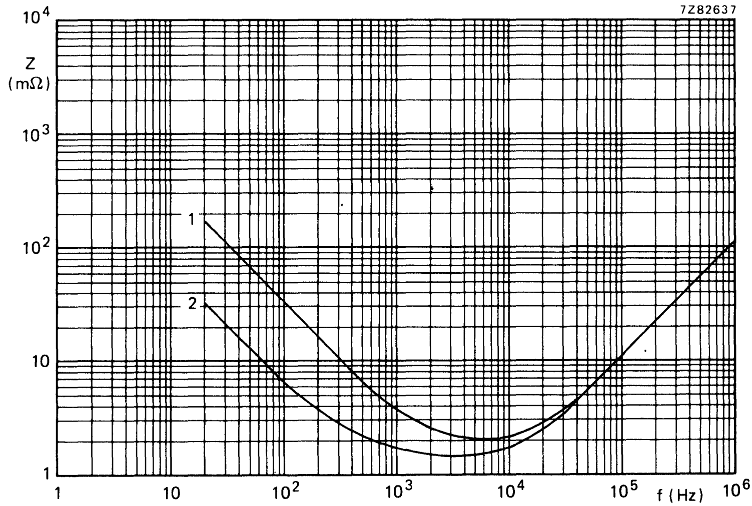


Fig. 18 Typical impedance as a function of frequency at T_{amb} = 20 °C; **case size 17:**
curve 1 = 47 000 μF, 63 V; curve 2 = 220 000 μF, 10 V.

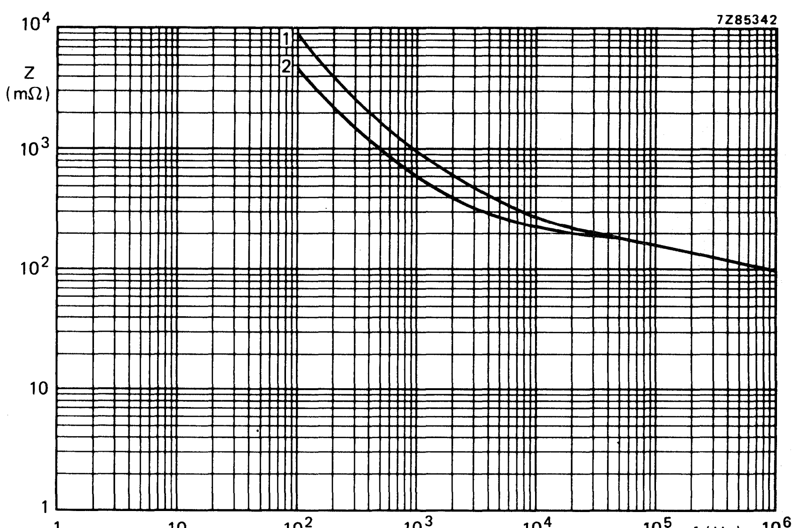


Fig. 19 Typical impedance as a function of frequency at T_{amb} = 20 °C; **case size 10:**
curve 1 = 150 μF, 385 V; curve 2 = 330 μF, 250 V.

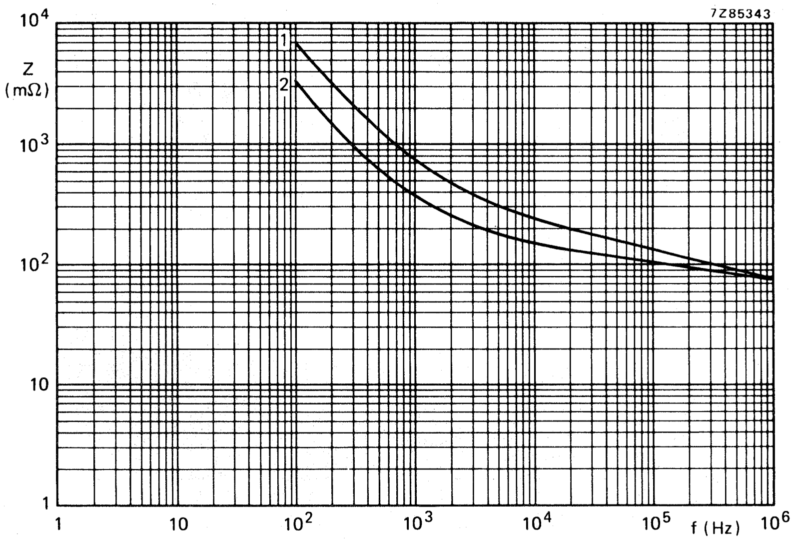


Fig. 20 Typical impedance as a function of frequency at T_{amb} = 20 °C; **case size 11:**
curve 1 = 220 μF, 385 V; curve 2 = 470 μF, 250 V.

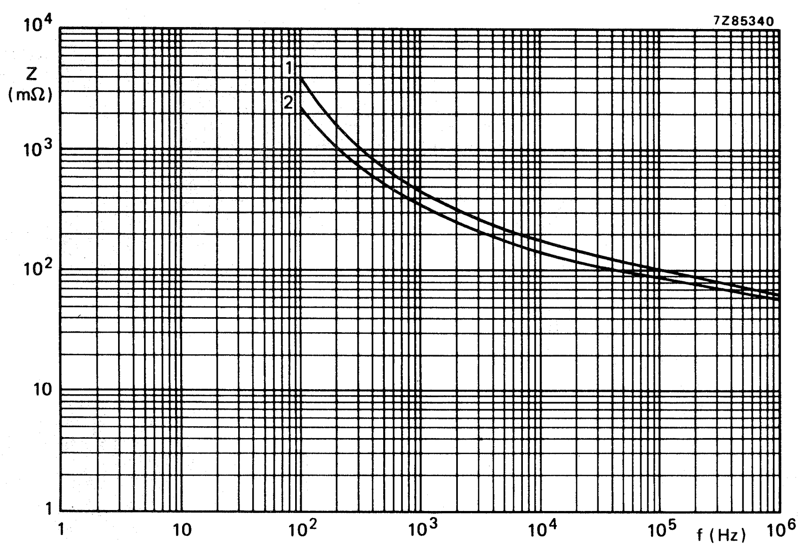


Fig. 21 Typical impedance as a function of frequency at T_{amb} = 20 °C; **case size 12a:**
curve 1 = 330 μF, 385 V; curve 2 = 680 μF, 250 V.

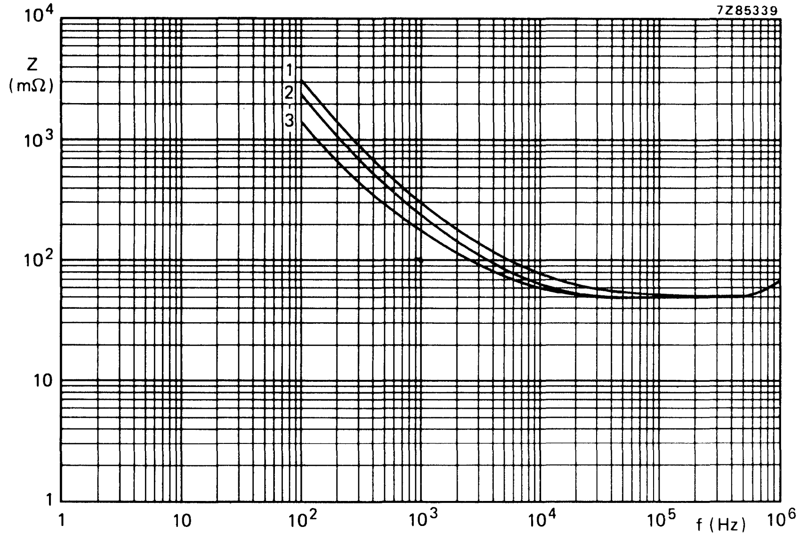


Fig. 22 Typical impedance as a function of frequency at T_{amb} = 20 °C; **case size 14**:
curve 1 = 470 μF, 385 V; curve 2 = 680 μF, 350 V;
curve 3 = 1000 μF, 250 V.

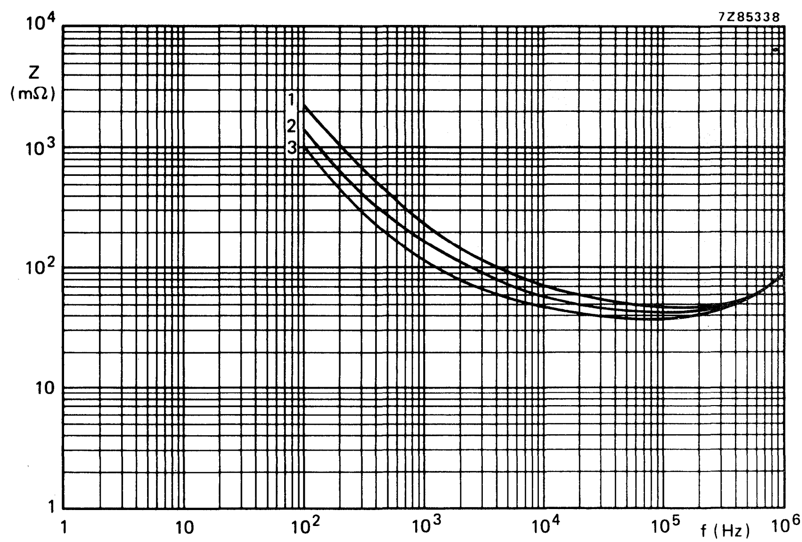


Fig. 23 Typical impedance as a function of frequency at T_{amb} = 20 °C; **case size 15a**:
curve 1 = 680 μF, 385 V; curve 2 = 1000 μF, 350 V;
curve 3 = 1500 μF, 250 V.

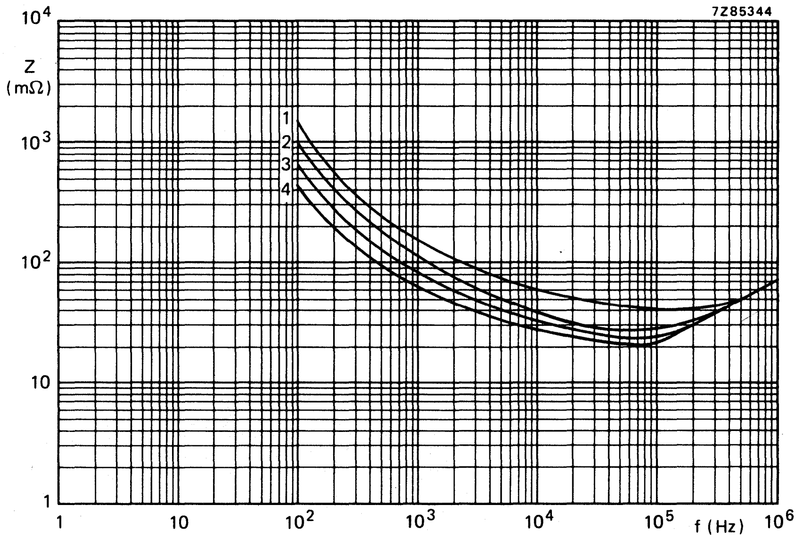


Fig. 24 Typical impedance as a function of frequency at T_{amb} = 20 °C; **case size 16a:**
curve 1 = 1000 μF, 385 V; curve 2 = 1500 μF, 385 V;
curve 3 = 2200 μF, 250 V; curve 4 = 3300 μF, 250 V.

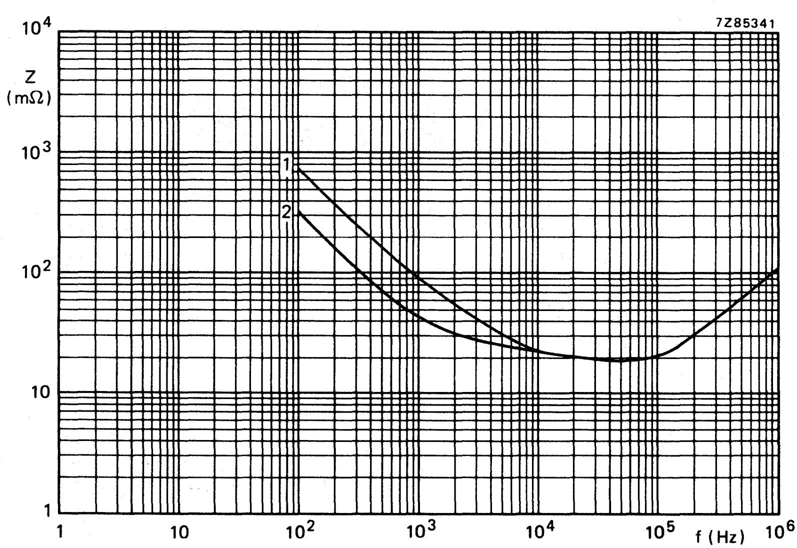


Fig. 25 Typical impedance as a function of frequency at T_{amb} = 20 °C; **case size 17:**
curve 1 = 2200 μF, 385 V; curve 2 = 4700 μF, 250 V.

Equivalent series inductance (ESL)

case size	typ. inductance
10, 11 and 12a	13 nH
14 and 15a	16 nH
16a	19 nH
17	20 nH

OPERATIONAL DATA

Category temperature range (for rated voltage) —40 to + 85 °C

Life expectancy

Typical life time
at T_{amb} = 85 °C > 10 000 h
at T_{amb} = 40 °C > 200 000 h **(25 years)**
Shelf life at 0 V and T_{amb} = 85 °C 500 h

Failure rate

Failure rate, catastrophic, at rated voltage, T_{amb} = 40 °C, confidence level 60% < 10^{-7} ←

PACKING

The capacitors are packed in boxes.
Case sizes 10, 11, 12a, 14 and 15a: 50 capacitors per box;
case sizes 16a and 17: 25 capacitors per box.

TESTS AND REQUIREMENTS

See Introduction, section 9, under aluminium electrolytic capacitors.

After *shelf life test, 500 h, 85 °C,* the capacitors meet the same requirements as after endurance test. The rated voltage shall be applied to the capacitors for minimum 30 min., at least 24 h and not more than 48 h before measurements.

Note: Capacitors 2222 114 and 2222 115 are large types with screw terminals, long-life grade.

MOUNTING ACCESSORIES

Clamps

To facilitate vertical mounting, a series of rigid clamps made of cadmium-plated steel are available. They can easily be slipped over the capacitor and then clamped with a nut and bolt. The clamps have either two or three mounting lugs. Four types of clamp are available, one for each case diameter. They are delivered without nuts or bolts.

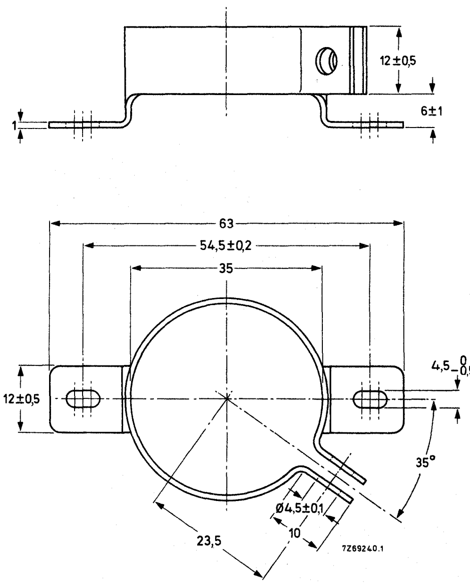


Fig. 26 Clamp for case diameter of 35 mm.
Catalogue number: 4322 043 04272.

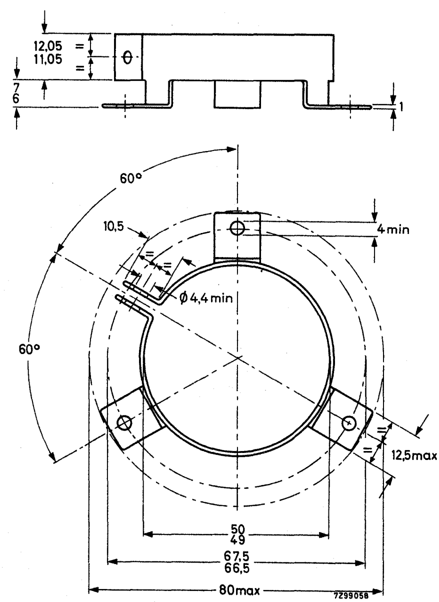


Fig. 27 Clamp for case diameter of 50 mm.
Catalogue number: 4322 043 04281.

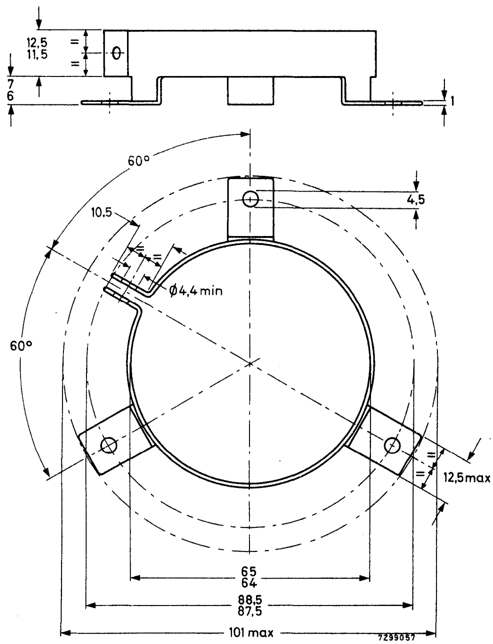


Fig. 28 Clamp for case diameter of 65 mm.
Catalogue number: 4322 043 04291.

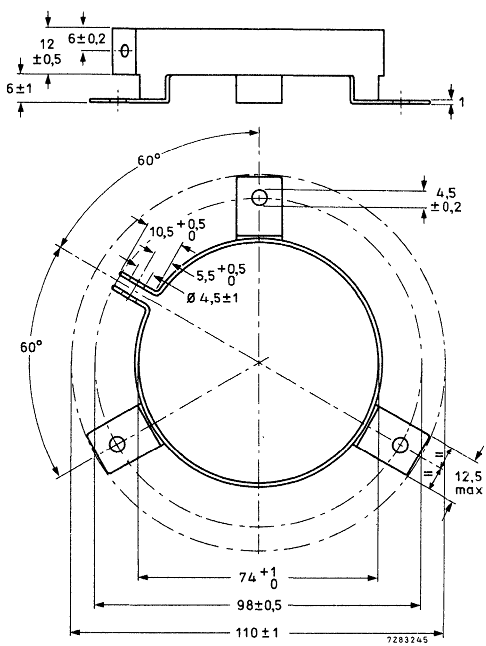


Fig. 29 Clamp for case diameter of 75 mm.
Catalogue number: 4322 043 12990.

Bolt/nut

When mounting with the bolt, which is an integral part of the case, standard metal M8 and M12 nuts and washers can be used; the maximum permissible torque is 7Nm for M8 nuts, and 19Nm for M12 nuts.
If insulated mounting is required, synthetic nuts and rubber washers are available; for these nuts the maximum permissible torque is 4Nm (M8) and 11Nm (M12).

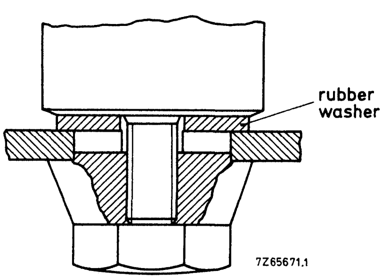


Fig. 30 Insulated mounting.

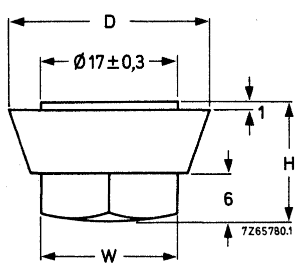
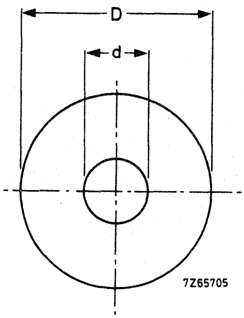


Fig. 31 Synthetic cap nut; see Table 5 (next page) for dimensions D, H and W.

Table 5

thread	D	H	W*	min. threaded depth	catalogue number
M8	25	15	17	11,5	4322 043 05561
M12	30	20	19	15,5	4322 043 05571



dimensions in mm

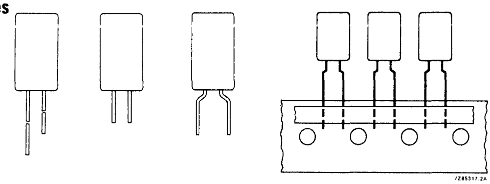
D	d	catalogue number
34	8,4	4322 043 05591
49	13	4322 043 05531
64	13	4322 043 05521
74	13	4322 043 13000

Fig. 32 Rubber washer; thickness 2 mm.

* W measured across flats.

ALUMINIUM ELECTROLYTIC CAPACITORS

- **High-temperature version of 2222 036 series**
- **Miniature type**
- **Single ended**
- **Long life**
- **Industrial applications**
- **High CU product per unit volume**



QUICK REFERENCE DATA

Nominal capacitance range (E6 series)	0,47 to 470 μF
Tolerance on nominal capacitance	−20 to + 20%
Rated voltage range, U_R (R5 series)	6,3 to 50 V
Category temperature range	−55 to + 105 °C
Endurance test	1500 h at 105 °C/5000 h at 85 °C
Shelf life at 0 V	1500 h at 105 °C/5000 h at 85 °C
Basic specification	IEC 384-4, long-life grade DIN 41332/DIN 41259
Climatic category	
IEC 68	55/105/56
DIN 40040	FPF

Selection chart for C_{nom}-U_R and relevant case sizes.

C_{nom} μF	U_R (V)					
	6,3	10	16	25	35	50
0,47						11
0,68						11
1						11
1,5						11
2,2						11
3,3						11
4,7						11
6,8						11
10						11
15						11
22						11
33					11	13
47				11		13
68			11			13
100		11			13	
150	11			13		
220			13			
330		13				
470	13					

case size	nominal dimensions (mm)
11	Ø 5 x 11
13	Ø 8,2 x 11

APPLICATION

These capacitors with extremely high CU product to volume ratio are mainly used for smoothing, coupling and decoupling purposes in industrial applications, where high reliability and/or a wide temperature range is required. Other applications are timing and delay circuits. The taped versions are suitable for automatic insertion and for cutting and forming equipment.

DESCRIPTION

The capacitor has etched and oxidized aluminium foil electrodes rolled up with a paper strip impregnated with an electrolyte. The capacitor is in an all-insulated aluminium case.

MECHANICAL DATA

Dimensions in mm

The capacitor is available in 6 styles:
style 1: long leads; in boxes;
style 2: straight short leads; non preferred, in boxes;
style 3: bent short leads (only case size 11); non preferred, in boxes;
style 4: long leads; on tape on reel, positive leading;
style 5: long leads; on tape in ammunition pack;
style 6: long leads; on tape on reel, negative leading.

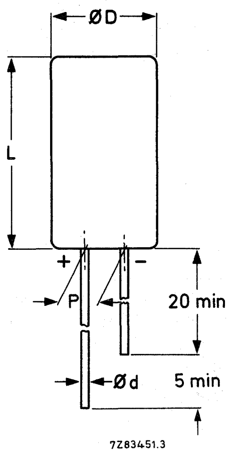


Fig. 1. Style 1; see Table 1 for dimensions d, D, L and P.

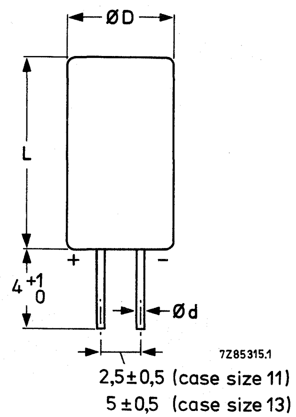


Fig. 2 Style 2; non preferred, see Table 1 for dimensions d, D and L.

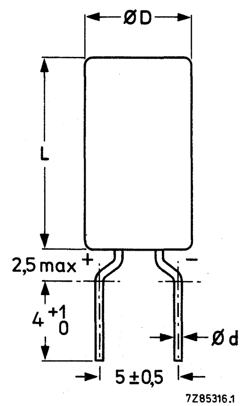
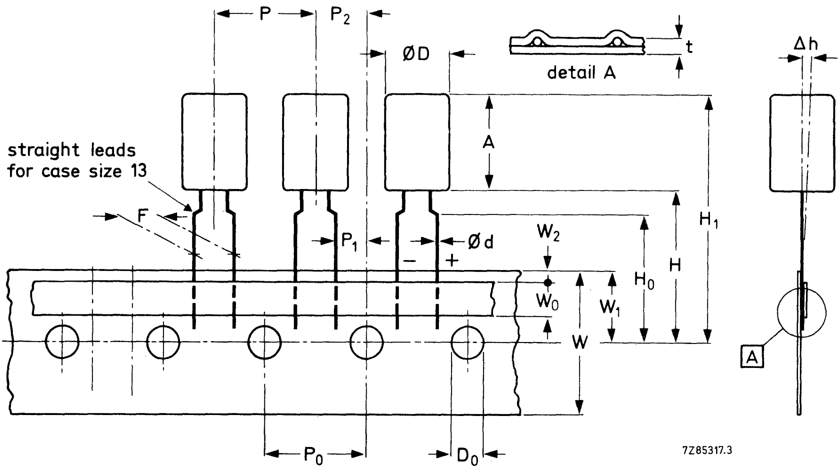


Fig. 3 Style 3; case size 11 only; non preferred, see Table 1 for dimensions d, D and L.

Table 1

case size	dimensions				mass approx. g
	d	D_{max}	L_{max}	P	
11	0,5*	5,5	12,0	2,5	0,4
13	0,6	8,7	12,0	5,0	1,1

* 0,6 mm under consideration.



→ direction of tape transport (positive leading)

Fig. 4 Styles 4, 5 and 6; see Table 2 for dimensions. For style 6 the tape transport is in opposite direction (negative leading).

Table 2

	symbol	case size 11	case size 13	tol.
Body diameter	D	5,5	8,7	max.
Body height	A	12,0	12,0	max.
Lead-wire diameter	d	0,5*	0,6	± 0,05
Pitch of component	P	12,7	12,7	± 1,0
Feed-hole pitch	P_0	12,7	12,7	± 0,2**
Hole centre to lead	P_1	3,85	3,85	± 0,5
Feed hole centre to component centre	P_2	6,35	6,35	± 0,7
Lead-to-lead distance	F	5,0	5,0	+ 0,6/–0
Component alignment	Δh	0	0	± 1,0
Tape width	W	18,0	18,0	± 0,5
Hold-down tape width	W_0	6,0	6,0	min.
Hole position	W_1	9,0	9,0	± 0,5
Hold-down tape position	W_2	2,5	2,5	max.
Height of component from tape centre	H	18,0	18,0	+ 1,5/–0
Lead-wire clinch height	H_0	16,0	–	± 0,5
Component height	H_1	32,0	32,0	max.
Feed-hole diameter	D_0	4,0	4,0	± 0,2
Total tape thickness	t	0,9	0,9	max.

* 0,6 mm under consideration.

** Cumulative pitch error: ± 1 mm/20 pitches.

Marking

The capacitors are marked as follows:

on the top

- nominal capacitance;
- code letter for tolerance on nominal capacitance, according to IEC 62;
- rated voltage;
- polarity identification.

on the circumference

- name of manufacturer;
- group number (116); code for long-life grade (LL);
- code letter of manufacturer;
- date code (year and month) according to IEC 62.

Minimum atmospheric pressure 8,5 kPa

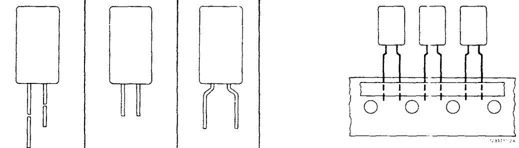
PRODUCT SAFETY

Non-solid electrolytic capacitors may contain chemicals which can be regarded as hazardous if incorrectly handled; caution is necessary should the outer case be fractured.

ELECTRICAL DATA

Unless otherwise specified all electrical values in Table 3 apply at an ambient temperature of 20 to 25 °C, a frequency of 100 Hz, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 45 to 75%.

Table 3



U_R V	nom. cap. μF	max. r.m.s. ripple current mA at T_{amb} = 85 °C	max. r.m.s. ripple current mA at T_{amb} = 105 °C	max. d.c. leakage current at U_R after 1 min μA	max. tan δ	case size*	catalogue number 2222 116 followed by: style 1	style 2	style 3	on reel** style 4	in ammopack style 5	on reel▲ style 6
6,3	150	81	47	8,7	0,25	11	53151	83151	63151	23151	33151	43151
	470	190	110	21	0,25	13	53471	63471		23471	33471	43471
10	100	74	43	9	0,2	11	54101	84101	64101	24101	34101	44101
	330	180	105	23	0,2	13	54331	64331		24331	34331	44331
16	68	69	40	9,5	0,16	11	55689	85689	65689	25689	35689	45689
	220	165	95	24	0,16	13	55221	65221		25221	35221	45221
25	47	61	35	10	0,14	11	56479	86479	66479	26479	36479	46479
	150	145	83	26	0,14	13	56151	66151		26151	36151	46151
35	33	55	32	9,9	0,12	11	50339	80339	60339	20339	30339	40339
	100	130	74	24	0,12	13	50101	60101		20101	30101	40101
50	0,47	7,6	4,4	3,1	0,09	11	51477	81477	61477	21477	31477	41477
	0,68	9,1	5,3	3,2	0,09	11	51687	81687	61687	21687	31687	41687
	1	11	6,4	3,3	0,09	11	51108	81108	61108	21108	31108	41108
	1,5	13,5	7,8	3,5	0,09	11	51158	81158	61158	21158	31158	41158
	2,2	16,5	9,5	3,7	0,09	11	51228	81228	61228	21228	31228	41228
	3,3	20	11,5	4	0,09	11	51338	81338	61338	21338	31338	41338
	4,7	24	14	4,4	0,09	11	51478	81478	61478	21478	31478	41478
	6,8	29	16,5	5	0,09	11	51688	81688	61688	21688	31688	41688
	10	35	20	6	0,09	11	51109	81109	61109	21109	31109	41109
	15	43	25	7,5	0,09	11	51159	81159	61159	21159	31159	41159
	22	52	30	9,6	0,09	11	51229	81229	61229	21229	31229	41229
	33	85	49	13	0,09	13	51339	61339		21339	31339	41339
	47	100	58	17	0,09	13	51479	61479		21479	31479	41479
	68	120	70	23	0,09	13	51689	61689		21689	31689	41689

* Case size 11: ϕ 5 mm x 11 mm; case size 13: ϕ 8,2 mm x 11 mm (nominal dimensions).

** Positive leading.

▲ Negative leading.

Capacitance

Nominal capacitance at 100 Hz and T_{amb} = 20 °C	see Table 3
Tolerance on nominal capacitance at 100 Hz	−20 to + 20%

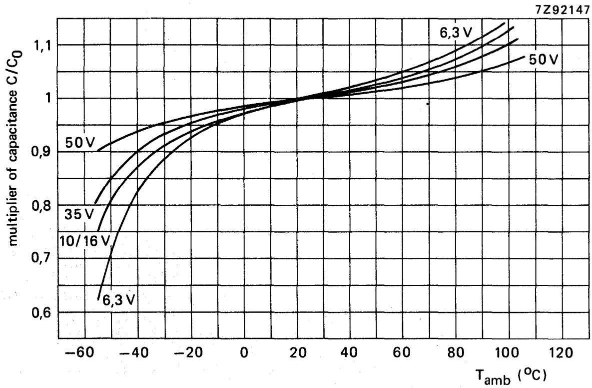


Fig. 5 Typical multiplier of capacitance as a function of ambient temperature; C_0 = capacitance at 20 °C, 100 Hz.

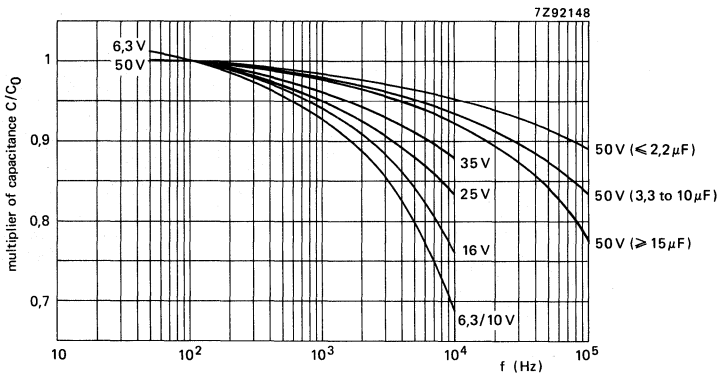


Fig. 6 Typical multiplier of capacitance as a function of frequency; C_0 = capacitance at 20 °C, 100 Hz.

Voltage

Voltage	core temperature▲ < 95 °C	95 to 115 °C
Rated voltage = max. permissible voltage	1,3 x U_R	U_R
Ripple voltage* = max. permissible a.c. voltage providing the following three conditions are met:		
(a) max. (d.c. + peak a.c.) voltage	1,3 x U_R	U_R
(b) max. peak a.c. voltage without d.c. voltage applied	2 V	
(c) momentary value of applied voltage	between U_R and −2 V	
Surge voltage = max. permissible voltage for short periods	1,5 x U_R	1,3 x U_R
Reverse voltage = max. d.c. voltage applied in the reverse polarity for short periods	2 V	

Ripple current**

Maximum permissible r.m.s. ripple current at 100 Hz and T_{amb} = 85 °C and 105 °C — see Table 3

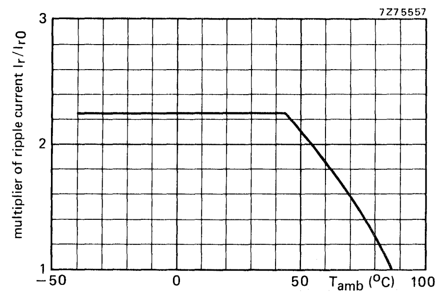


Fig. 7 Typical multiplier of ripple current as a function of ambient temperature; I_{r0} = ripple current at 85 °C, 100 Hz.

▲ See Introduction, section 5, "Ripple current".

* Specified ripple voltages are not applicable if the maximum permissible ripple current is exceeded. In that case the ripple current is decisive.

** Specified ripple currents are not applicable if the maximum permissible ripple voltage is exceeded. In that case the ripple voltage is decisive.

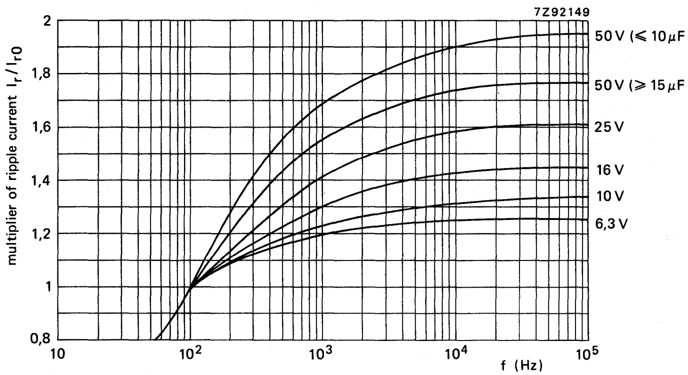


Fig. 8 Typical multiplier of ripple current as a function of frequency;
I_{r0} = ripple current at 85 °C, 100 Hz.

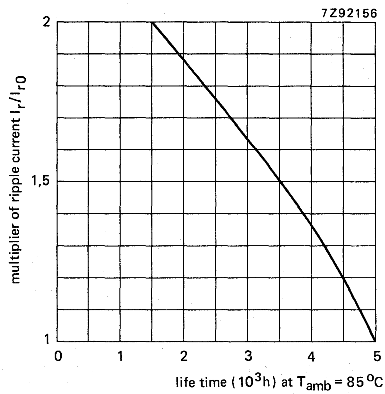


Fig. 9 Typical multiplier of ripple current as a function of life time at 85 °C;
I_{r0} = ripple current at 85 °C, 100 Hz.

Non-sinusoidal ripple currents have to be analyzed into a number of sinusoidal currents. The following requirements must then be satisfied:

$$\sum_n \frac{I_n^2}{r_n} \leqslant I_{r\,max}^2$$

$I_{r\,max}$ = maximum ripple current at 100 Hz and applicable ambient temperature;
I_n = ripple current at a certain frequency;
$\sqrt{r_n} = I_r/I_{r0}$ = multiplying factor at a same frequency.

Charge and discharge current

There is no limit on the charge or discharge rate. If the capacitors are charged and discharged continuously several times per minute, the charge and discharge currents have to be considered as ripple currents flowing through the capacitor. The r.m.s. value of these currents should be determined and the value thus found must not exceed the applicable limit. (See also Tests and requirements.)

D.C. leakage current

Maximum d.c. leakage current 1 min after application of U_R at T_{amb} = 20 °C	see Table 3 (0,006 CU + 3 μA)
D.C. leakage current during continuous operation at U_R,	
at T_{amb} = 25 °C	approx. 0,05 x value stated in Table 3
at T_{amb} = 85 °C	⩽ value stated in Table 3

If owing to prolonged storage and/or storage at an excessive temperature (> 40 °C) the d.c. leakage current is too high, application of the rated voltage for some hours will cause the d.c. leakage current to fall to a value lower than specified in Table 2.

Tan δ (dissipation factor)

Maximum tan δ at 100 Hz and T_{amb} = 25 °C, measured by a four-terminal circuit (Thomson circuit)	see Table 3

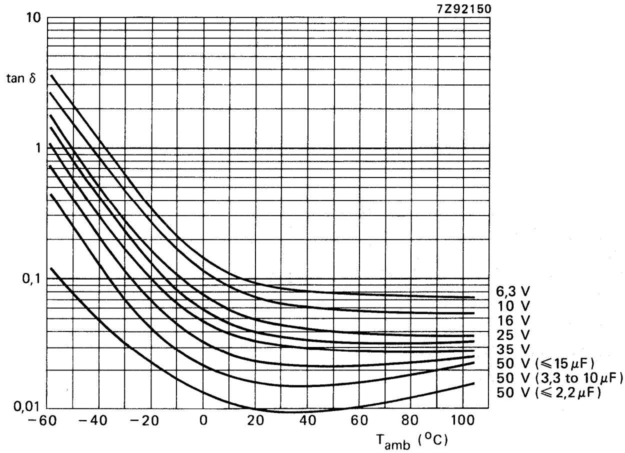


Fig. 10 Typical tan δ at 100 Hz as a function of ambient temperature.

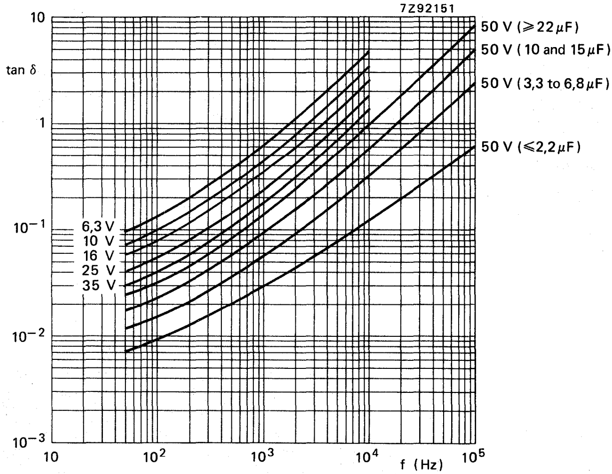


Fig. 11 Typical tan δ as a function of frequency at T_{amb} = 20 °C.

Equivalent series resistance (ESR)

ESR = tan $\delta/\omega C$

Maximum tan δ and C at 100 Hz and T_{amb} = 25 °C — see Table 3

Equivalent series inductance (ESL)

Case size 11	typ. 13 nH
Case size 13	typ. 16 nH

Impedance (Z)

Maximum impedance at T_{amb} = 20 °C, −25 °C and −40 °C and 10 kHz, measured by a four-terminal circuit (Thomson circuit) — see Table 4

Maximum ratio between impedances at T_{amb} = −25 °C and + 20 °C, at T_{amb} = −40 °C and + 20 °C, and at T_{amb} = −55 °C and + 20 °C, at 100 Hz measured by a four-terminal circuit (Thomson circuit) — see Table 4

Table 4

U_R	nom. cap.	case size*	max. impedance at 10 kHz			maximum impedance ratio at U_R and 100 Hz		
			T_{amb} = 20 °C	T_{amb} = −25 °C	T_{amb} = −40 °C	$\frac{Z \text{ at } -25\ °C}{Z \text{ at } +20\ °C}$	$\frac{Z \text{ at } -40\ °C}{Z \text{ at } +20\ °C}$	$\frac{Z \text{ at } -55\ °C}{Z \text{ at } +20\ °C}$
V	μF		Ω	Ω	Ω			
6,3	150	11	2	12	32	2	3	8
	470	13	0,64	3,8	10	2	3	8
10	100	11	2	12	32	1,5	2	6
	330	13	0,61	3,6	9,7	1,5	2	6
16	68	11	2,4	11	29	1,5	2	5
	220	13	0,73	3,4	9,1	1,5	2	5
25	47	11	2,6	12	32	1,5	2	4
	150	13	0,8	3,7	10	1,5	2	4
35	33	11	2,7	12	33	1,5	2	3
	100	13	0,9	4	11	1,5	2	3
50	0,47	11	150	640	1900	1,3	1,5	2
	0,68	11	105	440	1300	1,3	1,5	2
	1	11	70	300	900	1,3	1,5	2
	1,5	11	47	200	600	1,3	1,5	2
	2,2	11	32	135	410	1,3	1,5	2
	3,3	11	21	91	270	1,5	2	3
	4,7	11	15	64	190	1,5	2	3
	6,8	11	10,5	44	130	1,5	2	3
	10	11	7	30	90	1,5	2	3
	15	11	4,7	20	60	1,5	2	3
	22	11	3,2	13,5	41	1,5	2	3
	33	13	2,1	9,1	27	1,5	2	3
	47	13	1,5	6,4	19	1,5	2	3
	68	13	1,05	4,4	13	1,5	2	3

* Case size 11: ϕ 5 mm x 11 mm; case size 13: ϕ 8,2 x 11 mm (nominal dimensions).

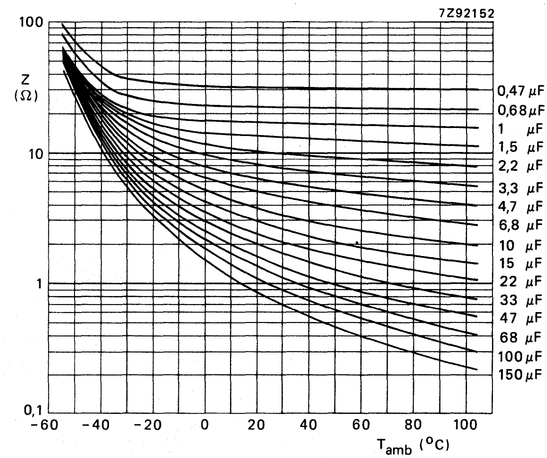


Fig. 12 Typical impedance at 10 kHz as a function of ambient temperature, case size 11.

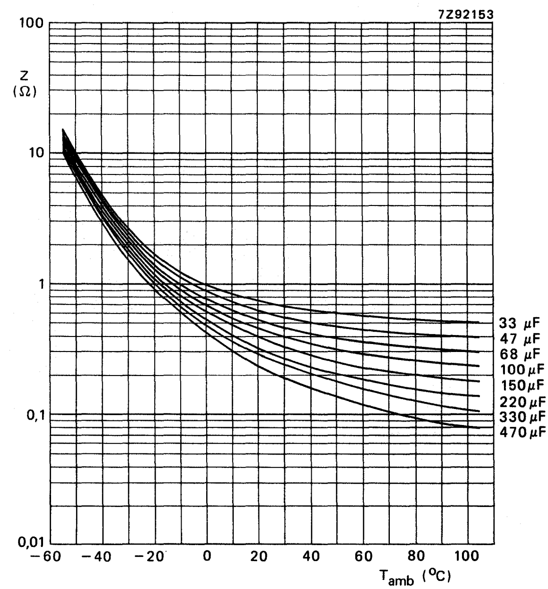


Fig. 13 Typical impedance at 10 kHz as a function of ambient temperature, case size 13.

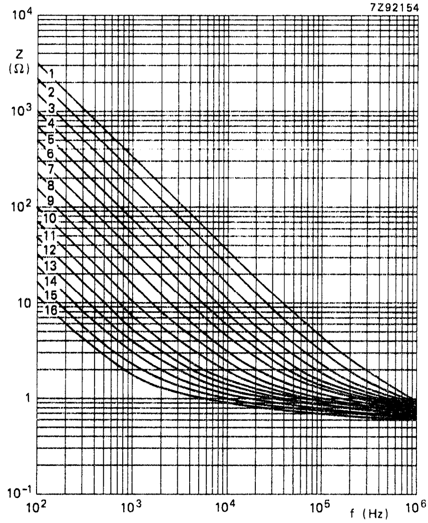


Fig. 14 Typical impedance as a function of frequency at T_{amb} = 20 °C, **case size 11:**
curve 1 = 0,47 μF;
curve 2 = 0,68 μF;
curve 3 = 1 μF;
curve 4 = 1,5 μF;
curve 5 = 2,2 μF;
curve 6 = 3,3 μF;
curve 7 = 4,7 μF;
curve 8 = 6,8 μF;
curve 9 = 10 μF;
curve 10 = 15 μF;
curve 11 = 22 μF;
curve 12 = 33 μF;
curve 13 = 47 μF;
curve 14 = 68 μF;
curve 15 = 100 μF;
curve 16 = 150 μF.

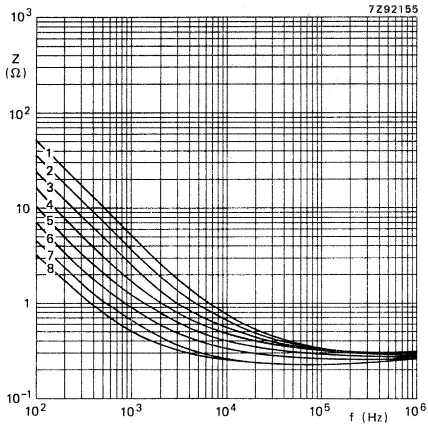


Fig. 15 Typical impedance as a function of frequency at T_{amb} = 20 °C, **case size 13:**
curve 1 = 33 μF;
curve 2 = 47 μF;
curve 3 = 68 μF;
curve 4 = 100 μF;
curve 5 = 150 μF;
curve 6 = 220 μF;
curve 7 = 330 μF;
curve 8 = 470 μF.

OPERATIONAL DATA

Category temperature range	−55 to + 105 °C
Typical life time	
at T_{amb} = 40 °C	120 000 h
at T_{amb} = 85 °C	6000 h
at T_{amb} = 105 °C	2000 h
Shelf life at 0 V	
at T_{amb} = 85 °C	5000 h
at T_{amb} = 105 °C	1500 h

PACKING

Capacitors of styles 1, 2 and 3 are supplied in boxes, those of styles 4, 6 and 5 on tape on reel and in ammunition pack respectively. The numbers per box, per reel and per ammunition pack are given in Table 5.

Table 5

case size	number of capacitors				
	style 1 per box	style 2 per box	style 3 per box	styles 4 and 6 per reel (min.)	style 5 per ammunition pack
11	1000	1000	1000	1000	2000
13	1000	1000	1000	500	1000

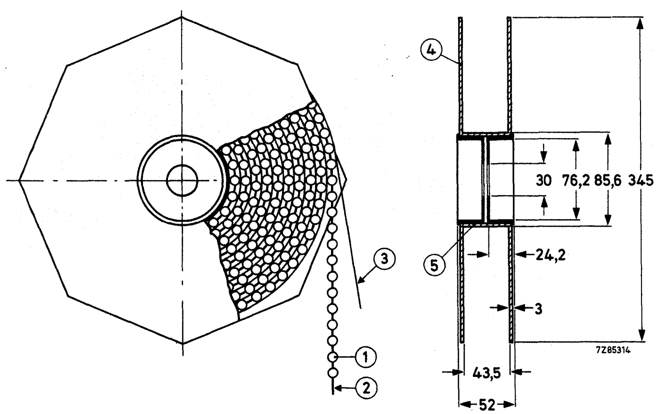


Fig. 16 Capacitors (style 4) on tape on reel.
1 = capacitor
2 = tape
3 = paper
4 = flange
5 = cylinder

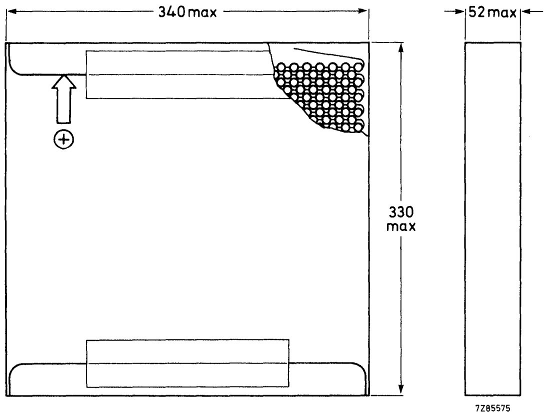


Fig. 17 Capacitors (style 5) on tape in ammunition pack.

TESTS AND REQUIREMENTS

See Introduction, section 9, under aluminium electrolytic capacitors, with the following addition.

After *endurance test, at U_R, 1500 h, 105 °C or 5000 h, 85 °C,* the capacitors meet the following requirements:

$\Delta C/C \leqslant \pm 20\%$, for U_R = 10 to 50 V;

$\Delta C/C \leqslant +20\%, -30\%$ for U_R = 6,3 V;

tan $\delta \leqslant 130\%$ of specified value;

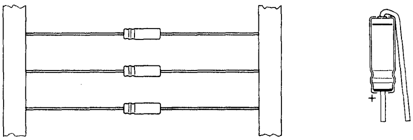
d.c. leakage current ⩽ specified value

After *shelf life test, at 0 V,* the capacitors meet the same requirements, except for d.c. leakage current: ⩽ 200% of specified value. The rated voltage shall be applied to the capacitors for minimum 30 min, at least 24 h and not more than 48 h before measurements.

Note: Capacitors 2222 116 are miniature, long-life grade.

ALUMINIUM ELECTROLYTIC CAPACITORS

- Ultra miniature type
- Axial leads or single ended
- Very high CU-product per unit volume
- General applications



QUICK REFERENCE DATA

Nominal capacitance range (E6 series)	0,1 to 22 μF
Tolerance on nominal capacitance	−10 to + 50% (± 20% to special order)
Rated voltage range, U_R (R5 series)	6,3 to 63 V
Category temperature range	−40 to + 85 °C
Endurance test at 85 °C	1500 h
Shelf life at 0 V, 85 °C	500 h
Basic specification	IEC 384-4, G.P. grade DIN 41332, type II
Climatic category	
IEC 68	40/085/56
DIN 40040	GPF

Selection chart for C_{nom}-U_R and relevant case sizes.

C_{nom} μF	U_R (V) 6,3	10	16	25	40	63
0,1						1a
0,15						1a
0,22						1a
0,33						1a
0,47						1a
0,68						1a
1						1a
1,5						1a
2,2					1a	1
3,3				1a		1
4,7			1a		1	
6,8		1a		1		
10	1a		1			
15		1				
22	1					

case size	nominal dimensions (mm)
1a	ϕ 3,3 x 8
1	ϕ 3,3 x 11

APPLICATION

These capacitors have extremely high CU-product per unit volume, which render them very suitable for applications, where high requirements are imposed on size and mass, e.g. portable and mobile high density electronic equipment. They are mainly used for smoothing, coupling and decoupling purposes in consumer applications, such as audio and video circuits, and in other applications such as measuring, regulating, timing and delay circuits. The bandoliered version is extremely suitable for automatic insertion and for cutting and forming equipment.

DESCRIPTION

The capacitors have highly etched and oxidized aluminium foil electrodes rolled up with a paper strip impregnated with an electrolyte. The capacitors are in an aluminium case, which is insulated with a blue plastic sleeve.

The capacitors are available in 2 styles, both with soldered-copper leads.

Style 1: axial leads; supplied on bandoliers.
Style 3: single ended.

MECHANICAL DATA

Dimensions in mm

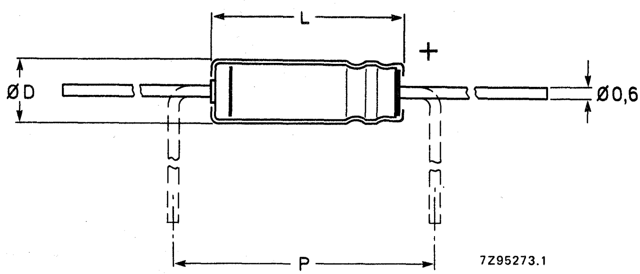


Fig. 1 Style 1; see Table 1a for dimensions D, L and P.

Table 1a

case size	style 1					mass approx. g
	D_{nom}	L_{nom}	D_{max}	L_{max}	P_{min}	
→ 1a	3,3	8	3,5	9	12,5	0,30
→ 1	3,3	11	3,5	12	15	0,35

Table 1b

case size	style 3			mass approx. g
	D_{max}	L_{max}	P	
1a	3,5	11	2 – 5	0,20
1	3,5	14	2 – 5	0,25

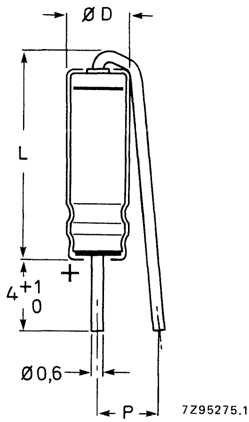


Fig. 2 Style 3: see Table 1b for dimensions D, L and P.

Marking

The capacitors are marked with:
- nominal capacitance;
- rated voltage;
- group number; code of origin;
- name of manufacturer;
- date code (year and month) according to IEC 62;
- band to identify the negative terminal.

DEVELOPMENT DATA

Mounting

The capacitors are suitable for mounting on printed-wiring boards; the required hole diameter is 0,8 + 0,1 mm.

Minimum atmospheric pressure 8,5 kPa

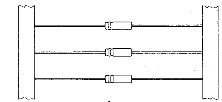
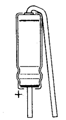
PRODUCT SAFETY

Non-solid electrolytic capacitors may contain chemicals which can be regarded as hazardous if incorrectly handled; caution is necessary should the outer case be fractured.

ELECTRICAL DATA

Table 2

Unless otherwise specified all electrical values in Table 2 apply at an ambient temperature of 20 to 25 °C, a frequency of 100 Hz, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 45 to 75%.

U_R	nom. cap.	max. r.m.s. ripple current at T_{amb} = 85 °C	max. d.c. leakage current at U_R after 1 min	max. tan δ	max. ESR	max. impedance (Ω) at 10 kHz, at T_{amb} =			case size*	catalogue number 2222 117 followed by		
V	μF	mA	μA		Ω	20 °C	−25 °C	−40 °C		 on reel style 1	in box style 1	 style 3
6,3	10	11	4	0,30	48	20	120	320	1a	23109	33109	83109
	22	20	6	0,30	22	9	55	145	1	23229	33229	83229
10	6,8	10	4	0,25	59	24	110	294	1a	24688	34688	84688
	15	18	6	0,25	27	11	50	133	1	24159	34159	84159
16	4,7	9	5	0,20	68	26	119	319	1a	25478	35478	85478
	10	16	6	0,20	32	12	56	150	1	25109	35109	85109
25	3,3	8	5	0,18	87	27	121	333	1a	26338	36338	86338
	6,8	14	6	0,18	42	13	59	162	1	26688	36688	86688
40	2,2	7	5	0,16	116	32	136	409	1a	27228	37228	87228
	4,7	13	7	0,16	54	15	64	191	1	27478	37478	87478
63	0,1	2	4	0,10	1590	550	1800	5000	1a	28107	38107	88107
	0,15	3	4	0,10	1060	367	1200	3330	1a	28157	38157	88157
	0,22	3	4	0,10	723	250	818	2270	1a	28227	38227	88227
	0,33	4	4	0,10	482	167	545	1520	1a	28337	38337	88337
	0,47	4	4	0,10	339	117	383	1060	1a	28477	38477	88477
	0,68	5	4	0,10	234	81	265	735	1a	28687	38687	88687
	1	6	4	0,12	191	55	180	500	1a	28108	38108	88108
	1,5	7	5	0,14	149	37	120	333	1a	28158	38158	88158
	2,2	11	6	0,14	87	25	82	227	1	28228	38228	88228
	3,3	13	7	0,14	68	17	55	152	1	28338	38338	88338

* Case size 1a: φ 3,3 mm x 8 mm.
Case size 1 : φ 3,3 mm x 11 mm.

Capacitance

Nominal capacitance at 100 Hz and T_{amb} = 20 °C	see Table 2
Tolerance on nominal capacitance at 100 Hz	−10 to + 50% (± 20% to special order)

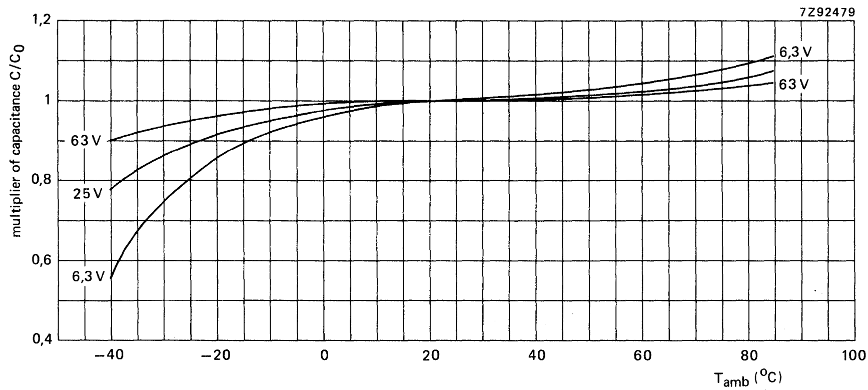


Fig. 3 Multiplier of capacitance as a function of ambient temperature; C_0 = capacitance at T_{amb} = 20 °C, 100 Hz.

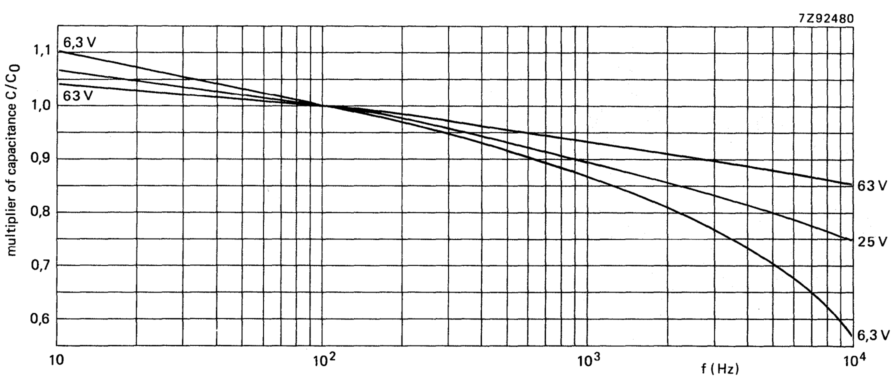


Fig. 4 Multiplier of capacitance as a function of frequency; C_0 = capacitance at T_{amb} = 20 °C, 100 Hz.

Voltage

→

	core temperature▲	
	< 60 °C	60 to 95 °C
Rated voltage = max. permissible voltage	1,1 x U_R	U_R
Ripple voltage* = max. permissible a.c. voltage providing the following three conditions are met:		
a) max. (d.c. + peak a.c.) voltage	1,1 x U_R	U_R
b) max. peak a.c. voltage without d.c. voltage applied	2 V	
c) momentary value of applied voltage	between U_R and −2 V	
Surge voltage = max. permissible voltage for short periods	1,2 x U_R	1,15 x U_R
Reverse voltage = max. d.c. voltage applied in the reverse polarity for short periods	2 V	

Ripple current**

Maximum permissible r.m.s. ripple current at 100 Hz and T_{amb} = 85 °C — see Table 2

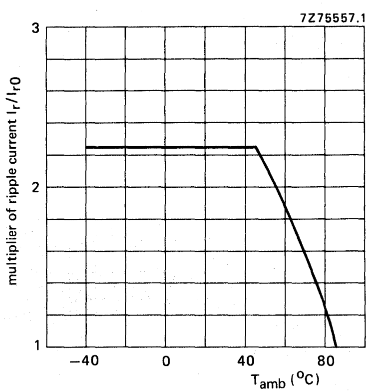


Fig. 5 Multiplier of ripple current as a function of ambient temperature; I_{r0} = ripple current at T_{amb} = 85 °C, 100 Hz.

▲ See Introduction, section 5, "Ripple current".

* Specified ripple voltages are not applicable if the maximum permissible ripple current is exceeded. In that case the ripple current is decisive.

** Specified ripple currents are not applicable if the maximum permissible ripple voltage is exceeded. In that case the ripple voltage is decisive.

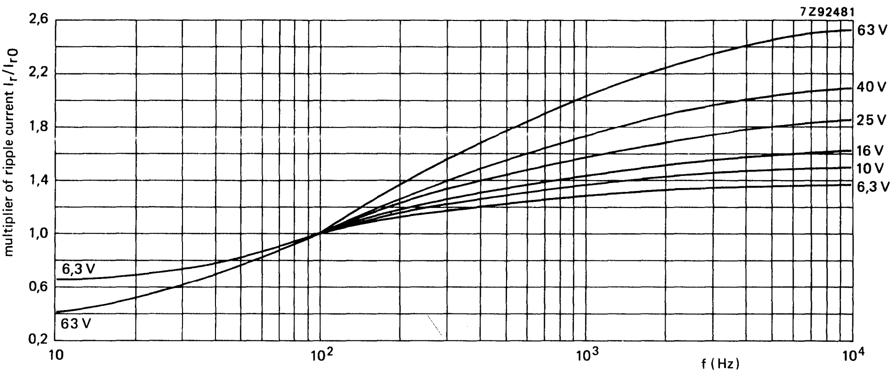


Fig. 6 Multiplier of ripple current as a function of frequency; I_{r0} = ripple current at T_{amb} = 85 °C, 100 Hz.

Non-sinusoidal ripple currents have to be analyzed into a number of sinusoidal currents and the following requirements shall then be satisfied:

$$\sum_n \frac{I_n^2}{r_n} \leqslant I_{r\,max}^2$$

$I_{r\,max}$ = maximum ripple current at 100 Hz and applicable ambient temperature;

I_n = ripple current at a certain frequency;

$\sqrt{r_n} = I_r/I_{r0}$ = multiplying factor at a same frequency.

Charge and discharge current

The capacitors may be charged from a source without internal resistance and they may be discharged by short-circuiting. If the capacitors are charged and discharged continuously at a rate of several times per minute, the charge and discharge currents have to be considered as ripple currents flowing through the capacitor. The r.m.s. value of these currents should be determined and the value thus found must not exceed the applicable limit. (See also Tests and Requirements).

D.C. leakage current

Maximum d.c. leakage current 1 min after application of U_R
at T_{amb} = 20 °C — see Table 2 (0,02 CU + 3 μA)

If owing to prolonged storage and/or storage at an excessive temperature (> 40 °C) the d.c. leakage current is too high, application of the rated voltage for some hours will cause the d.c. leakage current to fall to a value lower than specified in Table 2.

Tan δ

Maximum tan δ at 100 Hz and T_{amb} = 20 °C | see Table 2

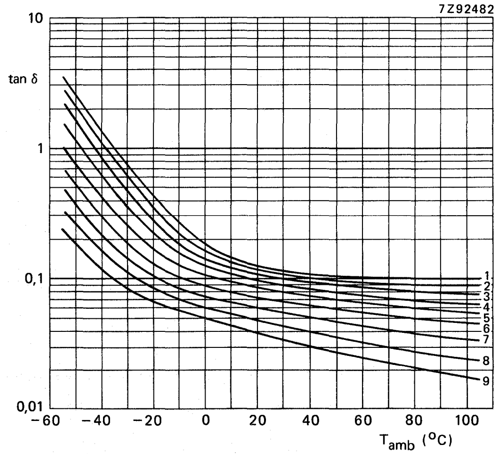


Fig. 7 Typical tan δ as a function of ambient temperature at 100 Hz.
Curve 1 = 6,3 V;
curve 2 = 10 V;
curve 3 = 16 V;
curve 4 = 25 V;
curve 5 = 40 V;
curve 6 = 1,5 to 3,3 μF, 63 V;
curve 7 = 0,68 and 1 μF, 63 V;
curve 8 = 0,22 to 0,47 μF, 63 V;
curve 9 = 0,1 and 0,15 μF, 63 V.

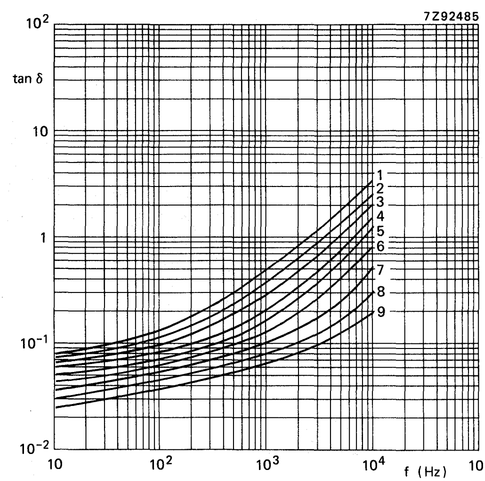


Fig. 8 Typical tan δ as a function of frequency at T_{amb} = 20 °C.
Curve 1 = 6,3 V;
curve 2 = 10 V;
curve 3 = 16 V;
curve 4 = 25 V;
curve 5 = 40 V;
curve 6 = 1,5 to 3,3 μF, 63 V;
curve 7 = 0,68 and 1 μF, 63 V;
curve 8 = 0,22 to 0,47 μF, 63 V;
curve 9 = 0,1 and 0,15 μF, 63 V.

Equivalent series resistance (ESR)

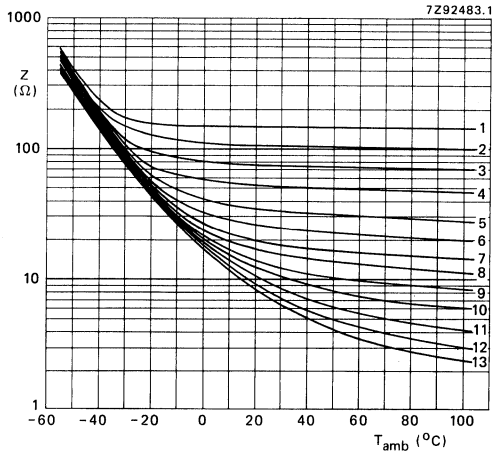
Maximum ESR at 100 Hz and T_{amb} = 20 °C — see Table 2

Impedance (Z)

Maximum impedance at 10 kHz and T_{amb} = 20 °C, −25 °C and −40 °C, measured by means of a four-terminal circuit (Thomson circuit) — see Table 2

Fig. 9 Typical impedance as a function of ambient temperature at 10 kHz; case size 1a.

Curve 1 = 0,1 μF, 63 V;
curve 2 = 0,15 μF, 63 V;
curve 3 = 0,22 μF, 63 V;
curve 4 = 0,33 μF, 63 V;
curve 5 = 0,47 μF, 63 V;
curve 6 = 0,68 μF, 63 V;
curve 7 = 1 μF, 63 V;
curve 8 = 1,5 μF, 63 V;
curve 9 = 2,2 μF, 40 V;
curve 10 = 3,3 μF, 25 V;
curve 11 = 4,7 μF, 16 V;
curve 12 = 6,8 μF, 10 V;
curve 13 = 10 μF, 6,3 V.



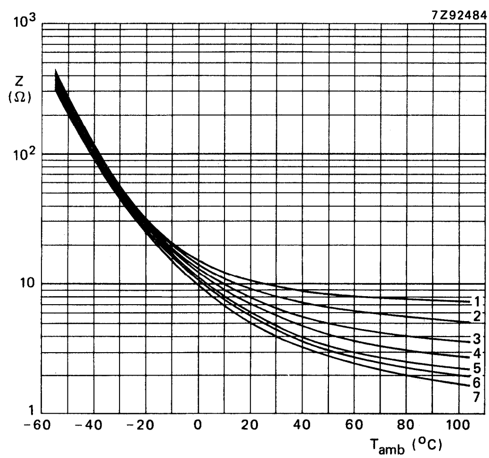


Fig. 10 Typical impedance as a function of ambient temperature at 10 kHz; case size 1.

Curve 1 = 2,2 μF, 63 V;
curve 2 = 3,3 μF, 63 V;
curve 3 = 4,7 μF, 40 V;
curve 4 = 6,8 μF, 25 V;
curve 5 = 10 μF, 16 V;
curve 6 = 15 μF, 10 V;
curve 7 = 22 μF, 6,3 V.

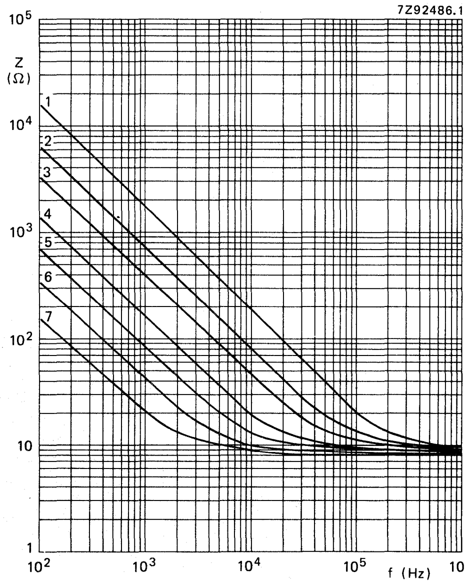


Fig. 11 Typical impedance as a function of frequency at T_{amb} = 20 °C; case size 1a.

Curve 1 = 0,1 μF, 63 V;
curve 2 = 0,22 μF, 63 V;
curve 3 = 0,47 μF, 63 V;
curve 4 = 1 μF, 63 V;
curve 5 = 2,2 μF, 40 V;
curve 6 = 4,7 μF, 16 V;
curve 7 = 10 μF, 6,3 V.

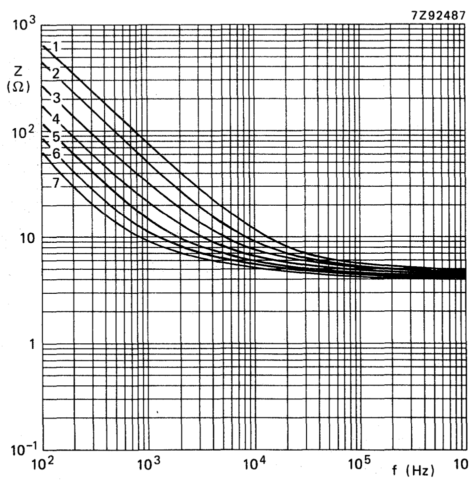


Fig. 12 Typical impedance as a function of frequency at T_{amb} = 20 °C; case size 1.

Curve 1 = 2,2 μF, 63 V;
curve 2 = 3,3 μF, 63 V;
curve 3 = 4,7 μF, 40 V;
curve 4 = 6,8 μF, 25 V;
curve 5 = 10 μF, 16 V;
curve 6 = 15 μF, 10 V;
curve 7 = 22 μF, 6,3 V.

Equivalent series inductance (ESL)

case size 1a	typ. 13 nH
case size 1	typ. 15 nH

OPERATIONAL DATA

Category temperature range	−40 to + 85 °C
Typical life time	
at T_{amb} = 40 °C	50 000 h
at T_{amb} = 85 °C	2000 h
Shelf life at 0 V and T_{amb} = 85 °C	500 h

PACKING

Capacitors of style 3 are supplied in boxes; capacitors of style 1 are supplied on bandoliers in boxes or on reels. The number of capacitors per box or per reel is shown in Table 3.

Table 3

case size	number of capacitors		
	style 1 per reel	style 1 per box	style 3 per box
1a	4000	1000	1000
1	4000	1000	1000

DEVELOPMENT DATA

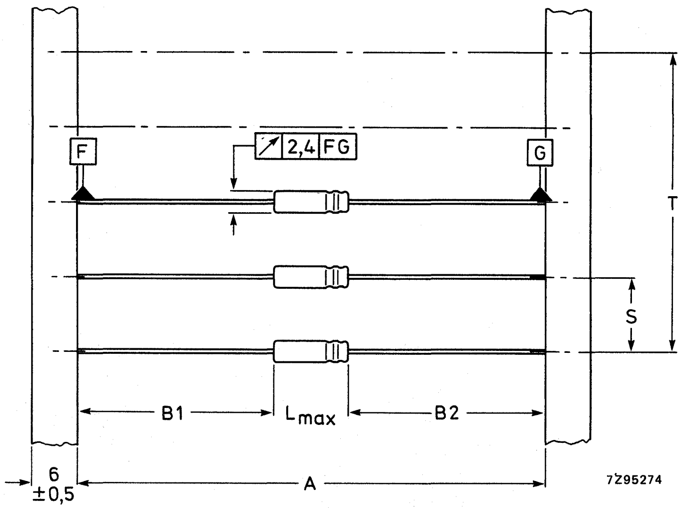


Fig. 13 Style 1 capacitors on bandoliers; the bandolier to which the negative capacitor terminals are connected is blue. See Table 4 for dimensions A, S, T and L.
|B1–B2| = max. 1,4 mm.

Table 4 (Dimensions in mm)

case size	A	S	T for number (n) of capacitors		L_{max}
			n < 50	50 < n < 100	
→ 1a	63,5 ± 1,5	5 ± 0,4	5(n-1) ± 2	5(n-1) ± 4	9
→ 1	63,5 ± 1,5	5 ± 0,4	5(n-1) ± 2	5(n-1) ± 4	12

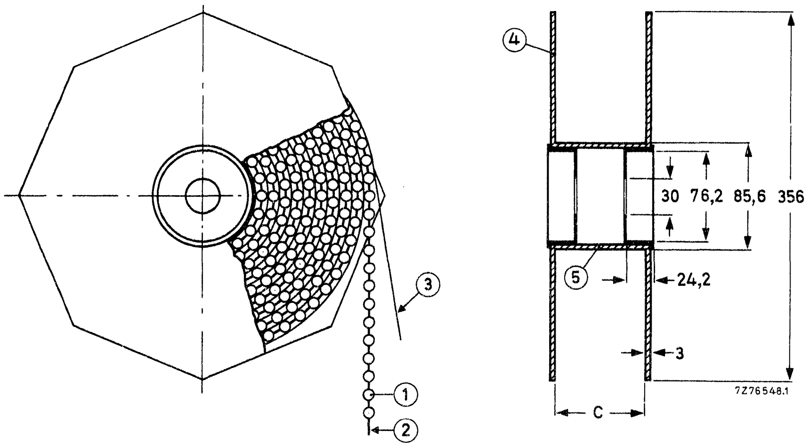


Fig. 14 Style 1 capacitors on bandoliers on reel; dimension C = 83,5 mm; the overall width of the reel is 94,5 mm.

1 = capacitor
2 = bandolier
3 = paper
4 = flange
5 = cylinder

DEVELOPMENT DATA

TESTS AND REQUIREMENTS

See Introduction, section 9, under aluminium electrolytic capacitors, with the following addition.

After *endurance test, 1500 h, 85 °C,* the capacitors meet the following requirements:

$\Delta C/C \leqslant \pm 20\%$,

tan $\delta \leqslant 200\%$ of specified value,

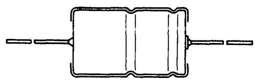
d.c. leakage current ⩽ specified value.

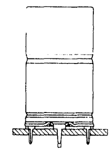
After *shelf life test, 500 h, 85 °C,* the capacitors meet the same requirements as after endurance test, except for d.c. leakage current: ⩽ 200% of specified value. The rated voltage shall be applied to the capacitors for minimum 30 min, at least 24 h and not more than 48 h before measurements.

Note: Capacitors 2222 117 are miniature types, general purpose grade.

ALUMINIUM ELECTROLYTIC CAPACITORS

- Miniature and small types
- Axial leads
- Extended temperature range
- Very long life, high stability
- Very high CU-product per unit volume
- Industrial and military applications





QUICK REFERENCE DATA

Nominal capacitance range (E6 series):	1 to 15 000 μF
Tolerance on nominal capacitance:	± 20%
Rated voltage range, U_R (R5 series):	6,3 to 200 V
Category temperature range	
case sizes 4 to 7:	–40 to +125 °C
case sizes 00 to 05:	–55 to +125 °C
Endurance test	
at 125 °C, with max. ripple current:	2000 h
at 150 °C, without ripple current:	500 h
Shelf life at 0 V, 125 °C:	500 h
Basic specifications:	IEC 384-4, long-life grade; DIN 41257; DIN 41240, type 1
Climatic category	
IEC 68, case sizes 4 to 7	40/125/56
case sizes 00 to 05	55/125/56
DIN 40040, case sizes 4 to 7	GKD
case sizes 00 to 05	FKD

case size	nominal dimensions (mm)	
4	Ø 6,5 x 18	miniature
5	Ø 8 x 18	miniature
6	Ø 10 x 18	miniature
7	Ø 10 x 25	miniature
00	Ø 10 x 30	small
01	Ø 12,5 x 30	small
02	Ø 15 x 30	small
03	Ø 18 x 30	small
04	Ø 18 x 40	small
05	Ø 21 x 40	small

Selection chart for C_{nom}-U_R and relevant case sizes.

C_{nom} μF	U_R (V) 6,3	10	16	25	40	63	100	200
1						4		
1,5						4		
2,2						4		
3,3						4		
4,7						4		
6,8						4		
10						4		
15						4		00
22						4		01
33						5		02
47					4	5	00	03
68					5	6	01	04
100				4	5	7/00	01	05
150			4	5	6	01	02	
220		4	5	6	7/00	01	03	
330	4	5	6	7	01	02	04	
470		6	6	7/00	01	03	05	
680		6	7/00	01	02	04		
1 000	6	7/00	01	01	03	05		
1 500	7/00	01	01	02	04			
2 200	01	01	02	03	05			
3 300	01	02	03	04				
4 700	02	03	04	05				
6 800	03	04	05					
10 000	04	05						
15 000	05							

*

Case sizes 4 to 7 (miniature types) are still under development; information on these capacitors are derived from development samples, and does not necessarily imply that they will go into regular production.

APPLICATION

These capacitors are especially designed for those applications where extreme ambient temperatures exist. They are very suitable for applications where very high requirements have to be met concerning reliability and long lifetime over a wide temperature range, such as in automotive, computer, telecommunication and telephony equipment.
The high CU-product per unit volume offers additional advantages in applications where high requirements are imposed on size and mass, e.g. automotive equipment. They are mainly used for energy storage, smoothing, coupling and decoupling purposes, as well as for timing and delay circuits. The bandoliered version is extremely suitable for automatic insertion and for cutting and forming equipment.

DESCRIPTION

The capacitors have deeply etched and oxidized aluminium foil electrodes rolled up with a porous paper spacer, which separates the anode and the cathode. The spacer is impregnated with an electrolyte which retains its good characteristics at extreme temperatures. The capacitors are housed in an aluminium case with axial soldered-copper terminations, sealed with a synthetic disc. The all-welded construction, the built-in voltage derating, and the close quality control during manufacture ensure a reliability and a life expectancy far superior to normal grade electrolytic capacitors.

The capacitors are available in 2 styles:

style 1 : axial leads, case insulated with a blue synthetic sleeve; all case sizes; case sizes 4 to 7 are supplied on bandoliers;

style 2 : single ended; with mounting ring with printed-wiring pins; especially for use in applications with severe shocks and vibrations; case sizes 02 to 05.

MECHANICAL DATA

Dimensions in mm

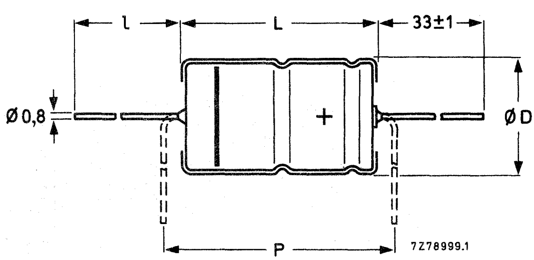


Fig. 1 Style 1; see Table 1a for dimensions D, L, l and P.

Table 1a

case size	l	style 1					mass approx. g
		D_{nom}	L_{nom}	D_{max}	L_{max}	P_{min}	
4	*	6,5	18,0	6,9	18,5	25	1,3
5	*	8,0	18,0	8,5	18,5	25	1,7
6	*	10,0	18,0	10,5	18,5	25	2,5
7	*	10,0	25,0	10,5	25,0	30	3,3
00	55 ± 1	10,0	30,0	10,5	30,5	35,0	4,3
01	55 ± 1	12,5	30,0	13,0	30,5	35,0	6,6
02	55 ± 1	15,0	30,0	15,5	30,5	35,0	8,5
03	55 ± 1	18,0	30,0	18,5	30,5	35,0	11,2
04	34 ± 1	18,0	40,0	18,5	41,5	45,0	14
05	34 ± 1	21,0	40,0	21,5	41,5	45,0	19

* Case sizes 4 to 7 are supplied on bandoliers in boxes or on reels (see Packing).

Table 1b

case size	style 2						mass approx. g
	d_1	d_2	D1	$D2_{max}$	D3	L	
02	0,8	1 + 0,1	15,0	17,5	16,5 ± 0,2	31 ± 1	8,6
03	0,8	1 + 0,1	18,0	19,5	18,5 ± 0,2	31 ± 1	11,5
04	1,0	1,3 + 0,1	18,0	19,5	18,5 ± 0,2	42 ± 1	14,5
05	1,0	1,3 + 0,1	21,0	22,5	21,5 ± 0,2	42 ± 1	19,7

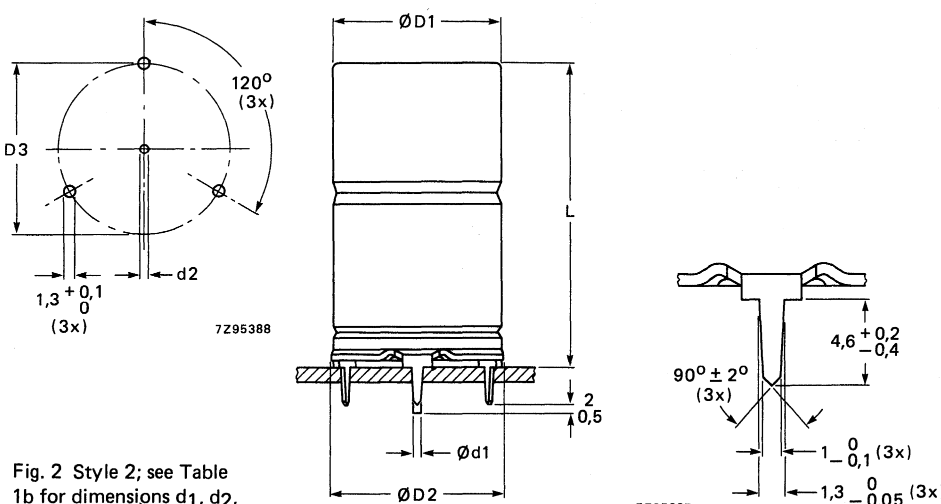


Fig. 2 Style 2; see Table 1b for dimensions d_1, d_2, D1, D2, D3 and L.

Marking

The capacitors are marked with:
- nominal capacitance;
- tolerance on nominal capacitance according to IEC 62;
- rated voltage at 125 °C and 85 °C;
- group number 118;
- maximum temperature; grade reference LL;
- name of manufacturer; code of origin;
- date code (year and month) according to IEC 62;
- band to identify the negative terminal;
- + signs to identify the positive terminal.

Mounting

The capacitors may be mounted in any position by their leads.

Minimum atmospheric pressure 8,5 kPa

PRODUCT SAFETY

Non-solid electrolytic capacitors may contain chemicals which can be regarded as hazardous if incorrectly handled. Caution is necessary should the outer case be fractured.

ELECTRICAL DATA

Table 2

Unless otherwise specified all electrical values apply at an ambient temperature of 20 to 25 °C, a frequency of 100 Hz, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 45 to 75%.

U_R V	nom. cap. µF	max. r.m.s. ripple current at T_{amb} = 125 °C mA	max.d.c.leakage current at U_R after 1 min µA	max. tan δ	max. ESR Ω	max. impedance at 10 kHz Ω	case size	catalogue number* 2222 118 followed by
6,3	330	112	20	0,50	2,41	2,1	4	. 3331
	1000	251	42	0,50	0,79	0,8	6	. 3102
	1500	352	61	0,50	0,53	0,53	7	**
	1500	416	61	0,46	0,485	0,45	00	. 3152
	2200	590	87	0,46	0,305	0,28	01	. 3222
	3300	648	129	0,58	0,280	0,27	01	. 3332
	4700	826	182	0,58	0,185	0,18	02	. 3472
	6800	1040	261	0,66	0,155	0,15	03	. 3682
	10 000	1417	382	0,66	0,098	0,10	04	. 3103
	15 000	1707	571	0,77	0,082	0,10	05	. 3153
10	220	109	20	0,35	2,53	2,1	4	. 4221
	330	150	24	0,35	1,69	1,4	5	. 4331
	470	179	32	0,35	1,19	1,0	5	. 4471
	680	247	45	0,35	0,82	0,81	6	. 4681
	1000	343	64	0,35	0,56	0,55	7	**
	1000	409	64	0,32	0,505	0,45	00	. 4102
	1500	590	94	0,32	0,285	0,28	01	. 4152
	2200	634	136	0,40	0,290	0,27	01	. 4222
	3300	826	202	0,40	0,190	0,18	02	. 4332
	4700	1035	286	0,46	0,155	0,15	03	. 4472
	6800	1395	412	0,53	0,100	0,10	04	. 4682
	10 000	1674	604	0,53	0,084	0,10	05	. 4103
16	150	106	20	0,25	2,65	2,2	4	. 5151
	220	145	25	0,25	1,81	1,5	5	. 5221
	330	204	36	0,25	1,21	1,2	6	. 5331
	470	243	49	0,25	0,85	0,83	6	. 5471
	680	335	69	0,25	0,58	0,57	7	**
	680	389	69	0,22	0,525	0,45	00	. 5681
	1000	557	100	0,22	0,345	0,28	01	. 5102
	1500	609	148	0,29	0,305	0,27	01	. 5152
	2200	790	215	0,29	0,205	0,18	02	. 5222
	3300	1008	321	0,34	0,165	0,15	03	. 5332
	4700	1363	455	0,34	0,105	0,10	04	. 5472
	6800	1627	657	0,38	0,088	0,10	05	. 5682

* Replace dot in catalogue number by:
1 for style 1, case sizes 00 to 05, supplied in box;
2 for style 1 on bandoliers on reel } case sizes 4 to 7
3 for style 1 on bandoliers in box } case sizes 4 to 7
4 for style 2; case sizes 02 to 05.

** See Table 3.

U_R V	nom. cap. μF	max. r.m.s. ripple current at T_{amb} = 125 °C mA	max.d.c.leakage current at U_R after 1 min μA	max. tan δ	max. ESR Ω	max. impedance at 10 kHz Ω	case size	catalogue number* 2222 118 followed by
25	100	102	20	0,18	2,86	2,3	4	. 6101
	150	141	27	0,18	1,91	1,55	5	. 6151
	220	196	37	0,18	1,30	1,25	6	. 6221
	330	274	54	0,18	0,87	0,82	7	. 6331
	470	327	75	0,18	0,61	0,57	7	**
	470	366	75	0,18	0,62	0,50	00	. 6471
	680	515	106	0,18	0,38	0,30	01	. 6681
	1000	531	154	0,24	0,375	0,28	01	. 6102
	1500	691	229	0,25	0,263	0,22	02	. 6152
	2200	919	334	0,26	0,185	0,17	03	. 6222
	3300	1280	499	0,26	0,120	0,11	04	. 6332
	4700	1464	709	0,28	0,095	0,10	05	. 6472
40	47	89,8	20	0,11	3,72	2,8	4	. 7479
	68	121	20	0,11	2,57	1,9	5	. 7689
	100	147	28	0,11	1,75	1,3	5	. 7101
	150	207	40	0,11	1,17	1,0	6	. 7151
	220	287	57	0,11	0,80	0,68	7	**
	220	338	57	0,10	0,695	0,55	00	. 7221
	330	484	83	0,10	0,430	0,33	01	. 7331
	470	522	117	0,11	0,380	0,30	01	. 7471
	680	695	167	0,11	0,255	0,23	02	. 7681
	1000	852	244	0,13	0,205	0,18	03	. 7102
	1500	1196	364	0,13	0,130	0,11	04	. 7152
	2200	1403	532	0,15	0,105	0,10	05	. 7222
63	1	16,4	20	0,07	111	22	4	. 8108
	1,5	20,1	20	0,07	74,3	18	4	. 8158
	2,2	24,3	20	0,07	50,6	14,5	4	. 8228
	3,3	29,8	20	0,07	33,8	11,2	4	. 8338
	4,7	35,6	20	0,07	23,7	8,9	4	. 8478
	6,8	42,8	20	0,07	16,4	7,2	4	. 8688
	10	51,9	20	0,07	11,1	5,6	4	. 8109
	15	63,6	20	0,07	7,43	4,2	4	. 8159
	22	77,0	20	0,07	5,06	3,2	4	. 8229
	33	106	20	0,07	3,38	2,1	5	. 8339
	47	126	22	0,07	2,37	1,5	5	. 8479
	68	175	30	0,07	1,64	1,05	6	. 8689
	100	243	42	0,07	1,14	0,7	7	**
	100	262	42	0,07	1,15	1,0	00	. 8101
	150	415	61	0,07	0,645	0,61	01	. 8151
	220	454	87	0,08	0,610	0,56	01	. 8221
	330	544	129	0,09	0,420	0,40	02	. 8331
	470	695	182	0,09	0,310	0,33	03	. 8471
	680	971	261	0,09	0,195	0,18	04	. 8681
	1000	1161	382	0,10	0,160	0,15	05	. 8102

* See note on the next page.

** See Table 3.

U_R V	nom. cap. µF	max. r.m.s. ripple current at T_{amb} = 125 °C mA	max.d.c.leakage current at U_R after 1 min µA	max. tan δ	max. ESR Ω	max. impedance at 10 kHz Ω	case size	catalogue number* 2222 118 followed by
100	47	178	33	0,08	2,60	2,0	00	. 9479
	68	278	45	0,08	1,78	1,2	01	. 9689
	100	303	64	0,09	1,37	1,15	01	. 9101
	150	368	94	0,10	0,94	0,78	02	. 9151
	220	481	136	0,10	0,66	0,55	03	. 9221
	330	644	202	0,10	0,45	0,37	04	. 9331
	470	833	282	0,10	0,33	0,28	05	. 9471
200	15	129	22	0,046	4,76	3,75	00	92159
	22	198	31	0,046	3,17	2,22	01	92229
	33	242	44	0,046	2,11	1,11	02	**
	47	317	61	0,046	1,48	0,60	03	**
	68	428	86	0,046	1,02	0,42	04	**
	100	551	124	0,046	0,96	0,39	05	**

Table 3

U_R V	nom. cap. µF	case size	catalogue number: capacitors on bandoliers on reel	catalogue number: capacitors on bandoliers in box
6,3	1500	7	2222 118 90502	2222 118 90503
10	1000	7	90504	90505
16	680	7	90506	90507
25	470	7	90508	90509
40	220	7	90511	90512
63	100	7	90513	90514

Table 4

U_R V	nom. cap. µF	case size	catalogue number: style 1	catalogue number: style 2
200	33	02	2222 118 92339	2222 118 90002
	47	03	92479	90003
	68	04	92689	90004
	100	05	92101	90005

* Replace dot in catalogue number by:
1 for style 1, case sizes 00 to 05, supplied in box;
2 for style 1 on bandoliers on reel } case sizes 4 to 7
3 for style 1 on bandoliers in box } case sizes 4 to 7
4 for style 2; case sizes 02 to 05.

** See Table 4.

Capacitance

Nominal capacitance at 100 Hz and T_{amb} = 25 °C	see Table 2
Tolerance on nominal capacitance at 100 Hz	± 20%

Voltage

Note: For applications at capacitor core temperatures ▲ of ⩽ 95 °C the rated voltage (U_R) may be raised according to Table 5.

Table 5

U_R at > 95 to 130 °C	6,3 V	10 V	16 V	25 V	40 V	63 V	100 V	200 V
U_{R2} at ⩽ 95 °C	10 V	16 V	25 V	40 V	63 V	100 V	125 V	250 V

	core temperature ▲		
	⩽ 60 °C	> 60 to ⩽ 95 °C	> 95 to ⩽ 130 °C
Max. permissible voltage	1,1 x U_{R2}	U_{R2}	U_R
Ripple voltage* = max. permissible a.c. voltage providing the following three conditions are met:			
a. max. (d.c. + peak a.c.) voltage	1,1 x U_{R2}	U_{R2}	U_R
b. max. peak a.c. voltage without d.c. voltage applied	2 V	2 V	2 V
c. momentary value of applied voltage	between U_{R2} and −2 V	between U_{R2} and −2 V	between U_R and −2 V
Surge voltage = max. permissible voltage for short periods	1,2 x U_{R2}	1,15 x U_{R2}	1,1 x U_R
Reverse voltage = max. d.c. voltage applied in the reverse polarity for short periods	2 V	2 V	2 V

Ripple current**

Maximum permissible r.m.s. ripple current at 100 Hz and T_{amb} = 125 °C — see Table 2

Charge and discharge current

The capacitors may be charged from a source without internal resistance and they may be discharged by short-circuiting. If the capacitors are charged and discharged continuously at a rate of several times per minute, the charge and discharge currents have to be considered as ripple currents flowing through the capacitors. The r.m.s. value of these currents should be determined and the value thus found must not exceed the applicable limit.

▲ See Introduction, section 5, "Ripple current".

* Ripple voltages are not applicable if the max. permissible ripple current is exceeded. In that case the ripple current is decisive.

** Ripple currents are not applicable if the max. permissible ripple voltage is exceeded. In that case the ripple voltage is decisive.

D.C. leakage current

Maximum d.c. leakage current 1 min after application of U_R at T_{amb} = 25 °C	see Table 2 (0,006 CU + 4 μA or 20 μA, whichever is greater)

If owing to prolonged storage and/or storage at an excessive temperature (> 40 °C) the d.c. leakage current is too high, application of the rated voltage for some hours will cause the d.c. leakage current to fall to a value lower than specified in Table 2.

Tan δ (dissipation factor)

Maximum tan δ at 100 Hz and T_{amb} = 20 °C, measured by a four-terminal circuit (Thomson circuit)	see Table 2

Equivalent series resistance (ESR)

Maximum ESR at 100 Hz and T_{amb} = 20 °C, measured by a four-terminal circuit (Thomson circuit)	see Table 2

Impedance

Maximum impedance at 10 kHz, measured by a four-terminal circuit (Thomson circuit)	see Table 2

Equivalent series inductance (ESL)

Case size 4	typ. 25 nH
Case size 5	typ. 40 nH
Case sizes 6, 7, 00 and 01	typ. 50 nH
Case size 02	typ. 55 nH
Case sizes 03, 04 and 05	typ. 60 nH

OPERATIONAL DATA

Category temperature range	
case sizes 4 to 7	−40 to +125 °C
case sizes 00 to 05	−55 to +125 °C
Typical life time, at max. ripple current according to Table 2	
at T_{amb} = 40 °C	450 000 h (approx. 50 years)
at T_{amb} = 85 °C	20 000 h
at T_{amb} = 125 °C	3000 h
Shelf life at 0 V and T_{amb} = 125 °C	500 h

PACKING

All capacitors are supplied in boxes, except case sizes 4 to 7 of style 1, which are on bandoliers in boxes or on reels. The number of capacitors per box or per reel is shown in Table 6.

Table 6

case size	number of capacitors per box or per reel
4	1000
5	500
6	500
7	500
00	200
01	200
02	200
03	200
04	100
05	100

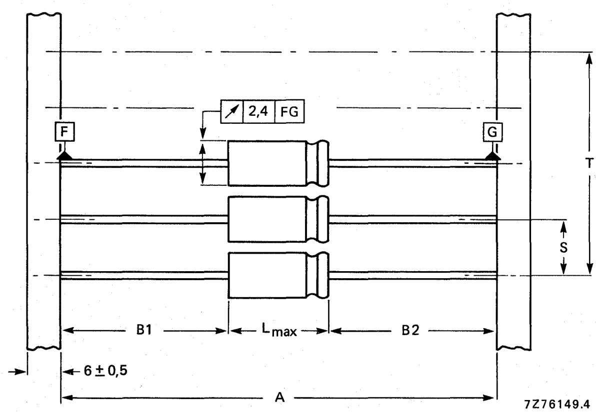


Fig. 3 Capacitors (case sizes 4 to 7) on bandoliers; the bandolier to which the negative capacitor terminals are connected is blue. See Table 7 for dimensions A, S, T and L_{max}.
$|B1 - B2| = 1,4 + (L_{max} - L)$ mm max.

Table 7

Dimensions in mm

case size	A	S	T for number (n) of capacitors		
			$n \leq 50$	$50 < n < 100$	
4	73 ± 1,6	10 ± 0,4	10 (n-1) ± 2	10 (n-1) ± 4	18,5
5	73 ± 1,6	10 ± 0,4	10 (n-1) ± 2	10 (n-1) ± 4	18,5
6	73 ± 1,6	15 ± 0,75	15 (n-1) ± 2	15 (n-1) ± 4	18,5
7	73 ± 1,6	15 ± 0,75	15 (n-1) ± 2	15 (n-1) ± 4	25,0

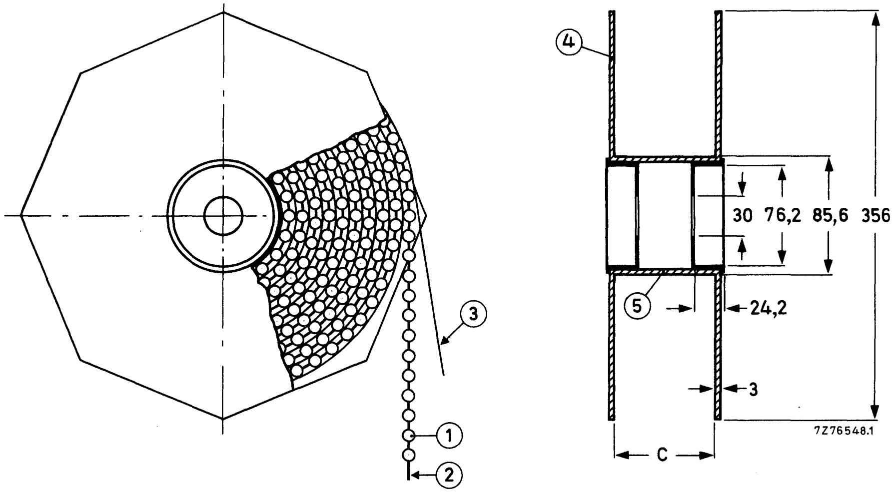


Fig. 4 Capacitors (case sizes 4 to 7) on bandoliers on reel; dimension C is 88,5 mm; the overall width of the reel is 99,5 mm.

1 = capacitor
2 = bandolier
3 = paper
4 = flange
5 = cylinder

TESTS AN REQUIREMENTS

See Introduction, section 9, under aluminium electrolytic capacitors, with the following addition.

After *shelf life test, 500 h, 125 °C,* the capacitors meet the same requirements as after endurance test, except for d.c. leakage current: ⩽ 200% of specified value. The rated voltage shall be applied to the capacitors for minimum 30 min, at least 24 h and not more than 48 h before measurements.

After *reverse voltage test, 125 °C (IEC 384-4, sub clause 9.16),* the capacitors meet the following requirements:

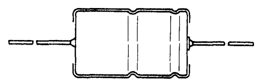
d.c. leakage current	⩽ stated limit,
tan δ	⩽ stated limit,
$\Delta C/C$	⩽ 20%

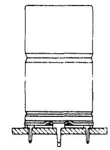
Note

Capacitors 2222 118 are miniature and small types, long-life grade.

ALUMINIUM ELECTROLYTIC CAPACITORS

- Miniature and small types
- Axial leads
- Long life
- Industrial applications





QUICK REFERENCE DATA

Nominal capacitance range (E6 series)	1 to 4700 μF
Tolerance on nominal capacitance	−10 to +50%
Rated voltage, U_R (R5 series)	10 to 350 V
Category temperature range	
case sizes 4 to 7	−40 to + 85 °C
case sizes 00 to 05 ($U_R \leqslant 100$ V)	−55 to + 85 °C
case sizes 00 to 05 ($U_R \geqslant 160$ V)	−40 to + 85 °C
Endurance test at 85 °C	
case sizes 4 and 5	6000 h
case sizes 6 to 05	8000 h
Shelf life at 0 V, 85 °C (case sizes 5 to 05)	500 h
Basic specifications	IEC 384-4, long-life grade DIN 41257 UTE C031/C033 (case sizes 00 to 05)

Climatic category	IEC 68	DIN 40040
case sizes 4 to 7	40/085/56	GPF
case sizes 00 to 05 ($U_R \leqslant 100$ V)	55/085/56	FPF
case sizes 00 to 05 ($U_R \geqslant 160$ V)	40/085/56	GPF

Selection chart for C_{nom}-U_R and relevant case sizes.

C_{nom} μF	U_R (V) 10	16	25	40	63	100	160	250	350
1						4			4
1,5						4		4	5
2,2						4	4	5	5
3,3						4	5		6
4,7					4	4	5	6	6
6,8					4	5	6	7	*
10					4	5	6	7	01
15				4	5	6	7		
22			4		5	6	7 /00	01	02
33			4	5	6	7			
47		4		5	6	7/00	02	03	04
68		4	5	6	7/00	01			
100		5		6	00	02	03	05	
150		5	6	7/01	02	03			
220	5	6	7/01	01	02	04	05		
330		7/01	01	02	03	04			
470	01	7/01	01	02	04	05			
680	01	02	03	03	05				
1000	02	02	03	04	05				
1500	03	03	04	05					
2200	03	04	05	05					
3300	04	05							
4700	05	05							

case size	nominal dimensions (mm)	
4	Ø 6,5 x 18	miniature
5	Ø 8 x 18	
6	Ø 10 x 18	
7	Ø 10 x 25	
00	Ø 10 x 30	small
01	Ø 12,5 x 30	
02	Ø 15 x 30	
03	Ø 18 x 30	
04	Ø 18 x 40	
05	Ø 21 x 40	

* Case sizes 4 to 7 ($U_R \geqslant 160$ V) are still under development; information on these capacitors is derived from development samples, and may change in any manner without notice.

APPLICATION

These capacitors are especially designed for those applications where extreme requirements have to be met concerning reliability and long lifetime both at high and low temperatures, such as in computer, telecommunication and telephony equipment.

They are mainly used for energy storage, smoothing, coupling and decoupling purposes, as well as for timing and delay circuits. The bandoliered version is extremely suitable for automatic insertion and for cutting and forming equipment.

DESCRIPTION

The capacitors have etched and oxidized aluminium foil electrodes rolled up with a porous paper spacer, which separates the anode and the cathode. The spacer is impregnated with an electrolyte which retains its good characteristics both at low and high temperatures. The capacitors are housed in an aluminium case with axial soldered-copper terminations, sealed with a synthetic disc. The all-welded construction, the built-in voltage derating, and the close quality control, during manufacture ensure a reliability and a life expectancy far superior to normal grade electrolytic capacitors.

The capacitors are available in 2 styles:

style 1: axial leads, case insulated with a blue synthetic sleeve; all case sizes; case sizes 4 to 7 are supplied on bandoliers;

style 2: single ended; with mounting ring with printed-wiring pins; especially for use in applications with severe shocks and vibrations; case sizes 02 to 05.

MECHANICAL DATA

Dimensions in mm

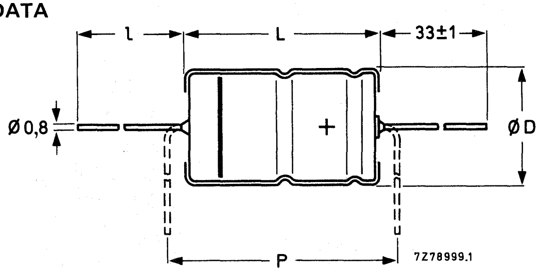
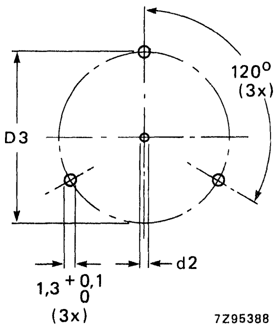


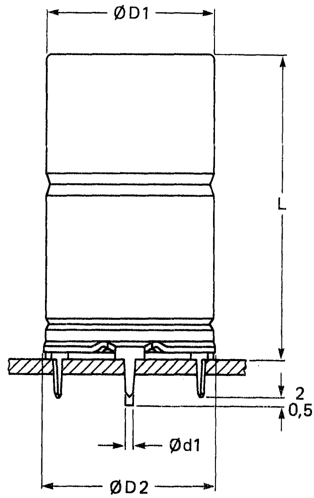
Fig. 1a See Table 1a for dimensions D, L, l and P.

Table 1a

case size	l	D_{nom}	L_{nom}	D_{max}	L_{max}	P_{min}	mass approx. g
4	*	6,5	18,0	6,9	18,5	25	1,3
5	*	8,0	18,0	8,5	18,5	25	1,7
6	*	10,0	18,0	10,5	18,5	25	2,5
7	*	10,0	25,0	10,5	25,0	30	3,3
00	55 ± 1	10,0	30,0	10,5	30,5	35,0	4,3
01	55 ± 1	12,5	30,0	13,0	30,5	35,0	6,6
02	55 ± 1	15,0	30,0	15,5	30,5	35,0	8,5
03	55 ± 1	18,0	30,0	18,5	30,5	35,0	11,2
04	34 ± 1	18,0	40,0	18,5	41,5	45,0	14
05	34 ± 1	21,0	40,0	21,5	41,5	45,0	19

* Case sizes 4 to 7 are supplied on bandoliers in boxes or on reels (see Packing).





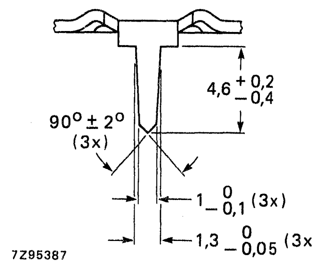


Fig 1b Style 2; see Table 1b for dimensions d_1, d_2, D1, D2, D3 and L.

Table 1b

case size	style 2						mass approx. g
	d_1	d_2	D1	$D2_{max}$	D3	L	
02	0,8	1 +0,1	15,0	17,5	16,5 ± 0,2	31 ± 1	8,6
03	0,8	1 +0,1	18,0	19,5	18,5 ± 0,2	31 ± 1	11,5
04	1,0	1,3 + 0,1	18,0	19,5	18,5 ± 0,2	42 ± 1	14,5
05	1,0	1,3 + 0,1	21,0	22,5	21,5 ± 0,2	42 ± 1	19,7

Marking

The capacitors are marked with:
- nominal capacitance;
- tolerance on nominal capacitance according to IEC 62;
- rated voltage;
- group number 132 or 133;
- maximum temperature; grade reference LL;
- name of manufacturer; code of origin;
- date code (year and month) according to IEC 62;
- band to identify the negative terminal;
- + signs to identify the positive terminal.

Mounting

The capacitors may be mounted in any position by their leads (see also Tests and Requirements in the Introduction).

Minimum atmospheric pressure 8,5 kPa

PRODUCT SAFETY

Non-solid electrolytic capacitors may contain chemicals which can be regarded as hazardous if incorrectly handled. Caution is necessary should the outer case be fractured.

ELECTRICAL DATA

Table 2

Unless otherwise specified all electrical values apply at an ambient temperature of 20 to 25 °C, a frequency of 100 Hz, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 45 to 75%.

U_R V	nom. cap. μF	max. r.m.s. ripple current at T_{amb} = 85 °C mA	max.d.c.leakage current at U_R after 5 min μA	max. tan δ	max. ESR Ω ·	max. impedance Ω at 10 kHz	at 100 kHz	case size	catalogue number* 2222 followed by
10	220	190	8,4	0,18		0,73	0,70	5	132 .4221
	470	350	9,4	0,18	0,77	0,26	0,60	01	132 .4471
	680	460	13,6	0,18	0,53	0,20	0,40	01	132 .4681
	1000	640	20	0,18	0,36	0,12		02	132 .4102
	1500	800	30	0,22	0,29	0,10		03	132 .4152
	2200	1100	44	0,22	0,20	0,09		03	132 .4222
	3300	1300	66	0,27	0,16	0,05		04	132 .4332
	4700	1800	94	0,27	0,12	0,05		05	132 .4472
16	47	95	5,5	0,14		2,6	2,2	4	132 .5479
	68	110	6,2	0,14		1,8	1,6	4	132 .5689
	100	150	7,2	0,14		1,2	1,1	5	132 .5101
	150	190	8,8	0,14		0,80	0,80	5	132 .5151
	220	250	11	0,14		0,55	0,55	6	132 .5221
	330	320	14,6	0,14		0,36	0,36	7	**
	330	320	10,6	0,14	0,80	0,36	0,60	01	132 .5331
	470	450	19	0,14	0,55	0,26	0,26	7	**
	470	450	15	0,14	0,55	0,26	0,40	01	132 .5471
	680	550	22	0,14	0,39	0,14		02	132 .5681
	1000	780	32	0,14	0,26	0,12		02	132 .5102
	1500	950	48	0,15	0,19	0,10		03	132 .5152
	2200	1300	70	0,15	0,12	0,06		04	132 .5222
	3300	1600	106	0,15	0,09	0,05		05	132 .5332
	4700	2300	150	0,15	0,08	0,05		05	132 .5472
25	22	60	5,1	0,11		4,1	2,9	4	132 .6229
	33	80	5,7	0,11		2,7	2,3	4	132 .6339
	68	140	7,4	0,11		1,3	1,1	5	132 .6689
	150	230	11,5	0,11		0,60	0,60	6	132 .6151
	220	340	15	0,11		0,40	0,40	7	**
	220	340	11	0,11	1,0	0,40	0,60	01	132 .6221
	330	410	16,5	0,11	0,63	0,30	0,40	01	132 .6331
	470	560	24	0,11	0,47	0,20		01	132 .6471
	680	700	34	0,11	0,32	0,10		03	132 .6681
	1000	1000	50	0,11	0,22	0,10		03	132 .6102
	1500	1100	75	0,12	0,16	0,06		04	132 .6152
	2200	1850	110	0,13	0,12	0,05		05	132 .6222

* Replace dot in catalogue number by:
1 for style 1, case sizes 00 to 05, supplied in box;
2 for style 1 on bandoliers on reel } case sizes 4 to 7
3 for style 1 on bandoliers in box } case sizes 4 to 7
4 for style 2; case sizes 02 to 05.

** See Table 3.

U_R V	nom. cap. μF	max. r.m.s. ripple current at T_{amb} = 85 °C mA	max.d.c.leakage current at U_R after 5 min μA	max. tan δ	max. ESR Ω	max. impedance Ω at 10 kHz	at 100 kHz	case size	catalogue number* 2222 followed by
40	15	60	5,2	0,09		5	3,2	4	132 . 7159
	33	100	6,6	0,09		2,3	1,9	5	132 . 7339
	47	120	7,8	0,09		1,6	1,4	5	132 . 7479
	68	170	9,4	0,09		1,1	1,0	6	132 . 7689
	100	210	12	0,09		0,75	0,75	6	132 . 7101
	150	310	16	0,09		0,50	0,50	7	**
	150	310	12	0,09	1,27	0,50	0,60	01	132 . 7151
	220	410	17,5	0,09	0,86	0,34	0,40	01	132 . 7221
	330	550	26	0,09	0,58	0,20		02	132 . 7331
	470	700	38	0,09	0,40	0,16		02	132 . 7471
	680	900	54	0,09	0,28	0,10		03	132 . 7681
	1000	1200	80	0,09	0,19	0,08		04	132 . 7102
	1500	1500	120	0,10	0,14	0,06		05	132 . 7152
	2200	1900	176	0,10	0,10	0,05		05	132 . 7222
63	4,7	38	4,6	0,07		12	5	4	132 . 8478
	6,8	45	4,9	0,07		8,1	4	4	132 . 8688
	10	64	5,3	0,07		5,5	3,3	4	132 . 8109
	15	80	5,9	0,07		3,7	2,5	5	132 . 8159
	22	100	6,8	0,07		2,5	2,1	5	132 . 8229
	33	140	8,2	0,07		1,7	1,5	6	132 . 8339
	47	170	9,9	0,07		1,2	1,1	6	132 . 8479
	68	210	12,6	0,07		0,81	0,60	7	**
	68	210	8,6	0,07	1,9	0,80	0,60	00	132 . 8689
	100	300	12,6	0,07	1,3	0,60	0,40	00	132 . 8101
	150	350	19	0,07	0,87	0,37		02	132 . 8151
	220	520	28	0,07	0,58	0,25		02	132 . 8221
	330	600	42	0,07	0,40	0,15		03	132 . 8331
	470	970	59	0,07	0,27	0,12		04	132 . 8471
	680	1000	86	0,07	0,19	0,08		05	132 . 8681
	1000	1600	126	0,07	0,13	0,06		05	132 . 8102
100	1	20	4,2	0,06		45	6	4	132 . 9108
	1,5	25	4,3	0,06		30	6	4	132 . 9158
	2,2	30	4,4	0,06		20	5	4	132 . 9228
	3,3	37	4,7	0,06		14	5	4	132 . 9338
	4,7	48	4,9	0,06		9,6	4	4	132 . 9478
	6,8	60	5,4	0,06		6,6	3,5	5	132 . 9688
	10	73	6	0,06		4,5	2,8	5	132 . 9109
	15	100	7	0,06		3	1,8	6	132 . 9159
	22	130	8,4	0,06		2	1,3	6	132 . 9229
	33	170	10,6	0,06		1,4	1,1	7	132 . 9339
	47	220	13,4	0,06		1	0,90	7	**
	47	220	9,4	0,06	2,4	1	0,90	00	132 . 9479
	68	250	13,5	0,06	1,7	0,80		01	132 . 9689
	100	380	20	0,06	1,1	0,50		02	132 . 9101
	150	400	30	0,06	0,75	0,35		03	132 . 9151
	220	660	44	0,06	0,5	0,20		04	132 . 9221
	330	700	66	0,06	0,34	0,15		04	132 . 9331
	470	1200	94	0,06	0,24	0,10		05	132 . 9471

Table 2 (continued)

U_R V	nom. cap. µF	max. r.m.s. ripple current at T_{amb} = 85 °C mA	max.d.c.leakage current at U_R after 5 min µA	max. tan δ	max. ESR Ω	max. impedance Ω at 10 kHz	at 100 kHz	case size	catalogue number* 2222 followed by
160	2,2	22	7	0,10		55	30	4	133 . 1228
	3,3	30	7	0,10		36	25	5	133 . 1338
	4,7	37	7	0,10		26	20	5	133 . 1478
	6,8	50	7	0,10		18	16	6	133 . 1688
	10	61	7	0,10		12	10	6	133 . 1109
	15	85	9	0,10		8	6	7	133 . 1159
	22	120	11	0,10		5,5	2,5	7	**
	22	120	7	0,10	6,8	5,5	2,5	00	133 . 1229
	47	180	15	0,10	3,2	2,6		02	133 . 1479
	100	350	32	0,10	1,5	1,2		03	133 . 1101
	220	610	70	0,10	0,7	0,60		05	133 . 1221
250	1,5	18	7	0,10		73	35	4	133 . 3158
	2,2	25	7	0,10		50	30	5	133 . 3228
	4,7	37	7	0,10		23	16	6	133 . 3478
	6,8	55	7,4	0,10		16	12	7	133 . 3688
	10	66	9	0,10		11	9	7	133 . 3109
	22	130	11	0,10	6,8	5		01	133 . 3229
	47	200	24	0,10	3,2	2,3		03	133 . 3479
	100	370	50	0,10	1,5	1,1		05	133 . 3101
350	1	15	7	0,10		100	40	4	133 . 5108
	1,5	20	7	0,10		67	32	5	133 . 5158
	2,2	25	7	0,10		45	28	5	133 . 5228
	3,3	34	7	0,10		30	20	6	133 . 5338
	4,7	43	7,3	0,10		21	15	6	133 . 5478
	10	90	7	0,10	15	10		01	133 . 5109
	22	140	15,5	0,10	6,8	4,5		02	133 . 5229
	47	270	33	0,10	3,2	2,1		04	133 . 5479

* Replace dot in catalogue number by:
1 for style 1, case sizes 00 to 05, supplied in box;
2 for style 1 on bandoliers on reel } case sizes 4 to 7
3 for style 1 on bandoliers in box } case sizes 4 to 7
4 for style 2; case sizes 02 to 05.

** See Table 3.

Table 3

U_R V	nom. cap. µF	case size	catalogue number: capacitors on bandoliers on reel	catalogue number: capacitors on bandoliers in box
16	330	7	2222 132 90508	2222 132 90509
	470	7	90507	90502
25	220	7	90503	90504
40	150	7	90511	90512
63	68	7	90513	90514
100	47	7	90505	90506
160	22	7	2222 133 90502	2222 133 90503

Capacitance

Nominal capacitance at 100 Hz and T_{amb} = 20 °C — see Table 2

Tolerance on nominal capacitance at 100 Hz — −10 to +50%

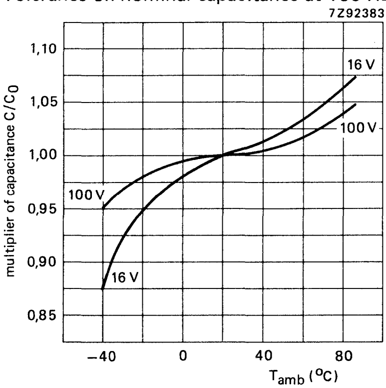


Fig. 2 Multiplier of capacitance as a function of ambient temperature, **case sizes 4 to 7;** C_0 = capacitance at 20 °C, 100 Hz.

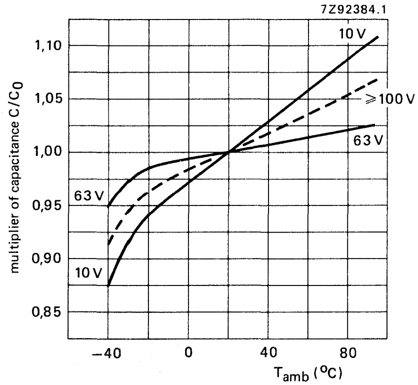


Fig. 3 Multiplier of capacitance as a function of ambient temperature, **case sizes 00 to 05;** C_0 = capacitance at 20 °C, 100 Hz.

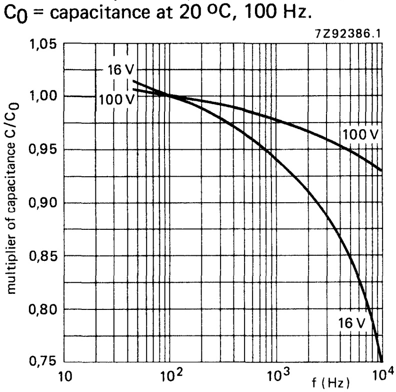


Fig. 4 Multiplier of capacitance as a function of frequency, **case sizes 4 to 7;** C_0 = capacitance at 20 °C, 100 Hz.

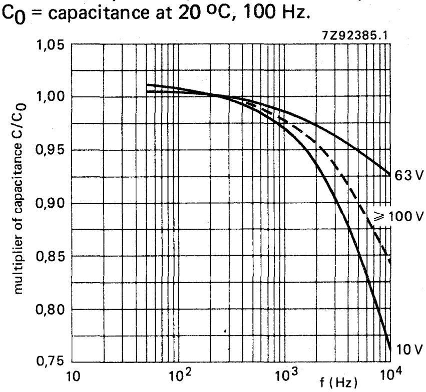


Fig. 5 Multiplier of capacitance as a function of frequency, **case sizes 00 to 05;** C_0 = capacitance at 20 °C, 100 Hz.

Voltage

Max. permissible voltage		$1{,}1 \times U_R$
Ripple voltage* =	max. permissible a.c. voltage providing the following three conditions are met:	
	a. max. (d.c. + peak a.c.) voltage	$1{,}1 \times U_R$
	b. max. peak a.c. voltage without d.c. voltage applied	1 V
	c. momentary value of applied voltage	between $1{,}1 \times U_R$ and −1 V
Surge voltage =	max. permissible voltage for short periods (see also Tests and Requirements in the Introduction)	$1{,}15 \times U_R$
Reverse voltage =	max. d.c. voltage applied in the reverse polarity at 85 °C	1 V

Ripple current**

Maximum permissible r.m.s. ripple current at 100 Hz and T_{amb} = 85 °C — see Table 2

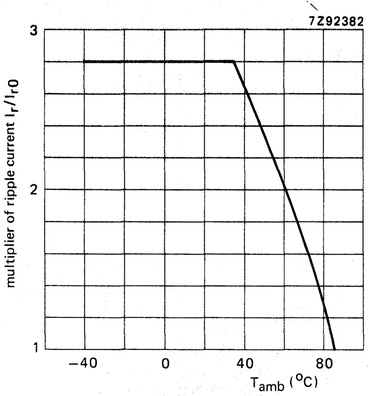


Fig. 6 Multiplier of ripple current as a function of ambient temperature, **case sizes 4 to 7;** I_{r0} = ripple current at 85 °C and 100 Hz.

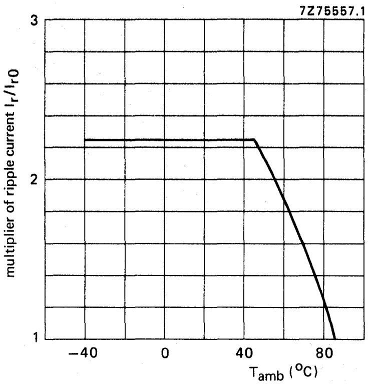


Fig. 7 Multiplier of ripple current as a function of ambient temperature, **case sizes 00 to 05;** I_{r0} = ripple current at 85 °C and 100 Hz.

* Ripple voltages are not applicable if the max. permissible ripple current is exceeded. In that case the ripple current is decisive.

** Ripple currents are not applicable if the max. permissible ripple voltage is exceeded. In that case the ripple voltage is decisive.

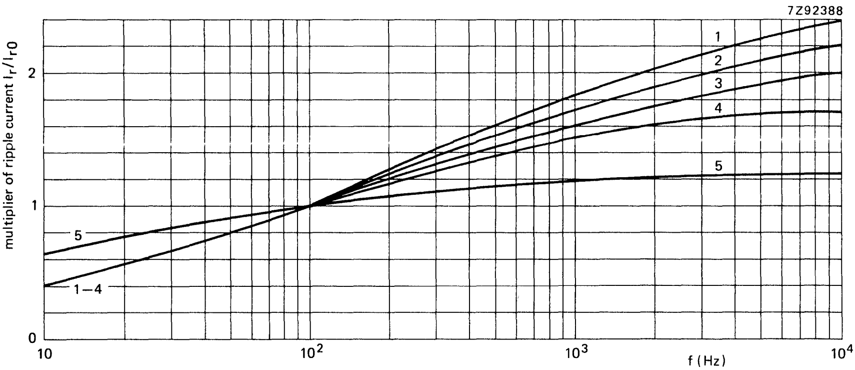


Fig. 8 Multiplier of ripple current as a function of frequency, **case sizes 4 to 7;** I_{r0} = ripple current at 85 °C and 100 Hz.

Curve 1 = 1 μF, 100 V; curve 2 = 1,5 μF, 100 V; curve 3 = 2,2 μF, 100 V; curve 4 = ≥ 3,3 μF, 100 V; curve 5 = 16 V.

Non-sinusoidal ripple currents have to be analyzed into a number of sinusoidal currents and the following requirements shall then be satisfied:

$$\sum_n \frac{I_n^2}{r_n} \leqslant I_r^2{}_{max}$$

$I_{r\,max}$ = maximum ripple current at 100 Hz and applicable ambient temperature;

I_n = ripple current at a certain frequency;

$\sqrt{r_n}=I_r/I_{r0}$ = multiplying factor at a same frequency.

Charge and discharge current

The capacitors may be charged from a source without internal resistance and they may be discharged by short-circuiting. If the capacitors are charged and discharged continuously at a rate of several times per minute, the charge and discharge currents have to be considered as ripple currents flowing through the capacitors. The r.m.s. value of these currents should be determined and the value thus found must not exceed the applicable limit.

D.C. leakage current

Case sizes 4 to 7

Maximum d.c. leakage current 1 min after application of U_R at T_{amb} = 20 °C,	
U_R = 10 to 100 V	0,01 CU + 3 μA
U_R = 160 to 350 V	(0,01 CU + 3 μA) or 20 μA, whichever is greater
Maximum d.c. leakage current 5 min after application of U_R at T_{amb} = 20 °C	
U_R = 10 to 100 V	see Table 2 (0,002 CU + 4 μA)
U_R = 160 to 350 V	(0,002 CU + 4 μA) or 7 μA, whichever is greater
D.C. leakage current during continuous operation at U_R	
at T_{amb} = 20 °C	0,001 CU + 1 μA
at T_{amb} = 85 °C	0,002 CU + 4 μA

Case sizes 00 to 05

Maximum d.c. leakage current 1 min after application of U_R at T_{amb} = 20 °C	0,006 CU + 4 μA
Maximum d.c. leakage current 5 min after application of U_R at T_{amb} = 20 °C	see Table 2 (0,002 CU)
D.C. leakage current during continuous operation at U_R	
at T_{amb} = 20 °C	$<$ 0,0005 CU
at T_{amb} = 85 °C	0,002 CU

If owing to prolonged storage and/or storage at an excessive temperature ($>$ 40 °C) the d.c. leakage current is too high, application of the rated voltage for some hours will cause the d.c. leakage current to fall to a value lower than specified in Table 2.

Tan δ (dissipation factor)

Maximum tan δ at 100 Hz and T_{amb} = 20 °C, measured by a four-terminal circuit (Thomson circuit) — see Table 2

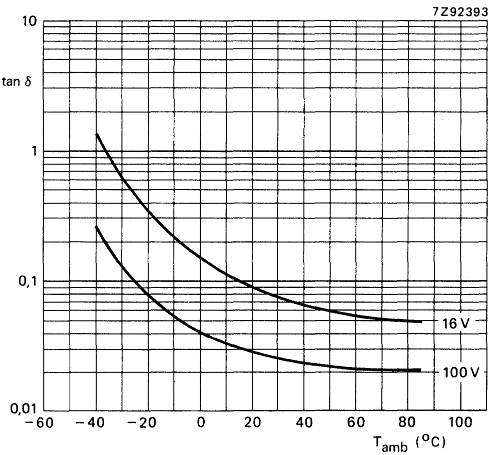


Fig. 9 Typical tan δ as a function of ambient temperature at 100 Hz, **case sizes 4 to 7.**

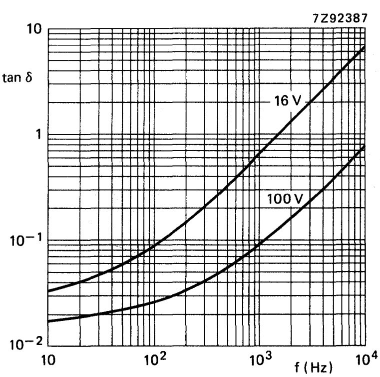


Fig. 10 Typical tan δ as a function of frequency at 20 °C, **case sizes 4 to 7.**

Impedance (Z)

Maximum impedance at T_{amb} = 20 °C and 10 kHz or 100 kHz, measured by a four-terminal circuit (Thomson circuit) — see Table 2

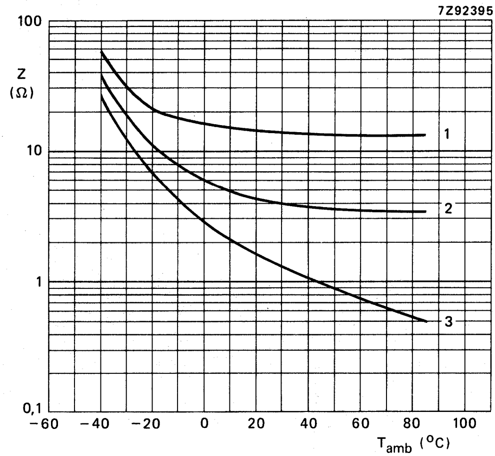


Fig. 11 Typical impedance as a function of ambient temperature at 10 kHz, **case size 4.**
Curve 1 = 1 μF, 100 V; curve 2 = 4,7 μF, 100 V; curve 3 = 47 μF, 16 V.

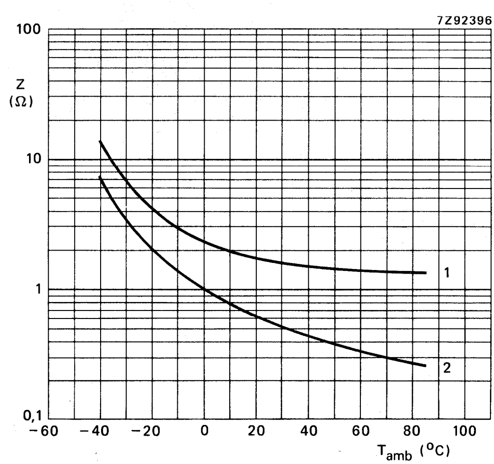


Fig. 12 Typical impedance as a function of ambient temperature at 10 kHz, **case size 5.**
Curve 1 = 10 μF, 100 V; curve 2 = 150 μF, 16 V.

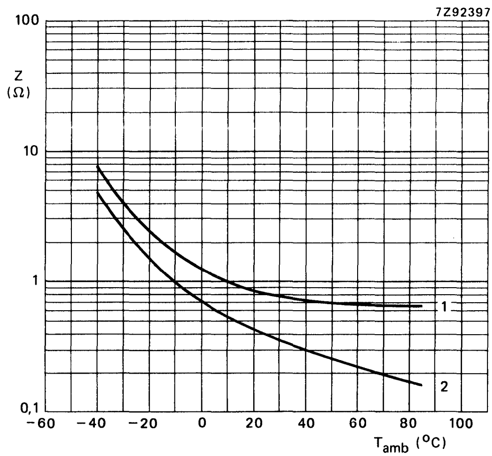


Fig. 13 Typical impedance as a function of ambient temperature at 10 kHz, **case size 6.**
Curve 1 = 22 μF, 100 V; curve 2 = 220 μF, 16 V.

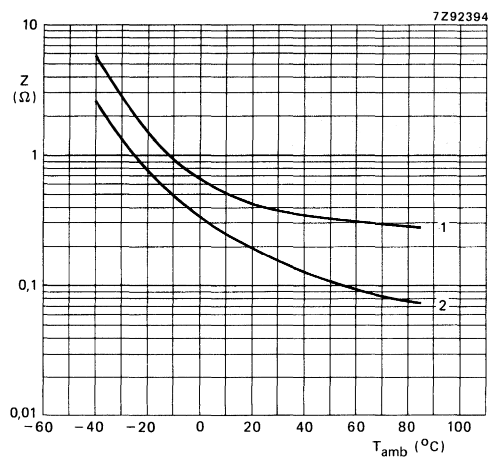


Fig. 14 Typical impedance as a function of ambient temperature at 10 kHz, **case size 7.**
Curve 1 = 47 μF, 100 V; curve 2 = 470 μF, 16 V.

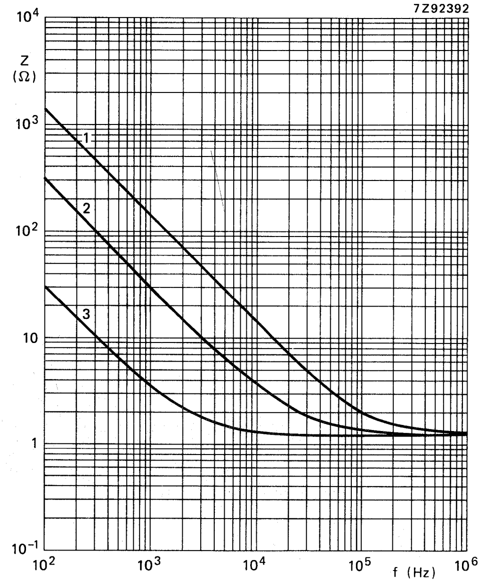


Fig. 15 Typical impedance as a function of frequency at 20 °C, **case size 4.**
Curve 1 = 1 μF, 100 V; curve 2 = 4,7 μF, 100 V; curve 3 = 47 μF, 16 V.

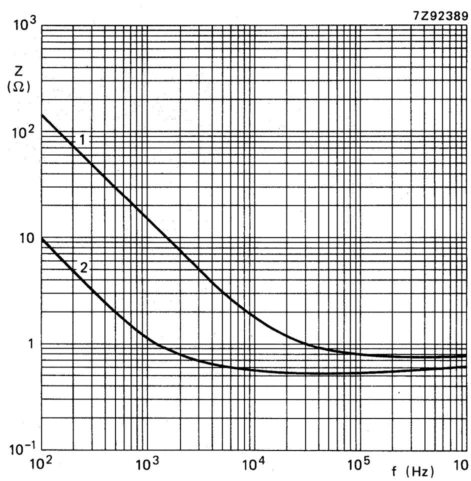


Fig. 16 Typical impedance as a function of frequency at 20 °C, **case size 5.**
Curve 1 = 10 μF, 100 V; curve 2 = 150 μF, 16 V.

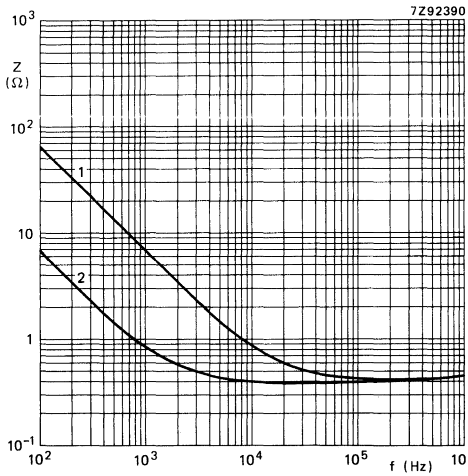


Fig. 17 Typical impedance as a function of frequency at 20 °C, **case size 6.**
Curve 1 = 22 μF, 100 V; curve 2 = 220 μF, 16 V.

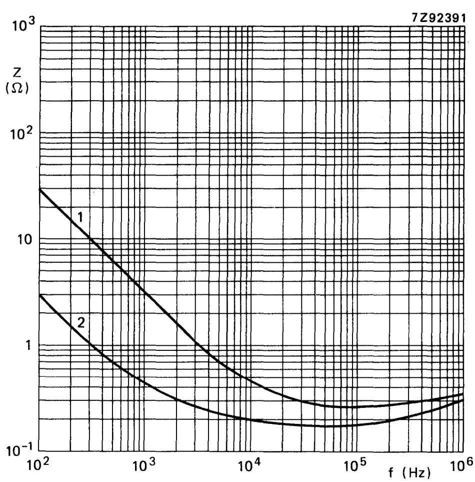


Fig. 18 Typical impedance as a function of frequency at 20 °C, **case size 7.**
Curve 1 = 47 μF, 100 V; curve 2 = 470 μF, 16 V.

Equivalent series resistance (ESR)

Maximum ESR at 100 Hz and T_{amb} = 20 °C, measured by a four-terminal circuit (Thomson Circuit)	see Table 2

Equivalent series inductance (ESL)

Case size 4	typ. 25 nH
Case size 5	typ. 40 nH
Case sizes 6, 7, 00 and 01	typ. 50 nH
Case size 02	typ. 55 nH
Case sizes 03, 04 and 05	typ. 60 nH

OPERATIONAL DATA

Category temperature range	
case sizes 4 to 7	−40 to + 85 °C
case sizes 00 to 05, $U_R \leqslant 100$ V	−55 to + 85 °C
case sizes 00 to 05, $U_R \geqslant 160$ V	−40 to + 85 °C

Typical life time	T_{amb} = 85 °C	T_{amb} = 40 °C
case sizes 4 and 5	⩾ 10 000 h	⩾ 200 000 h
case sizes 6 to 05	⩾ 15 000 h	⩾ 300 000 h (approx. 40 years)

Shelf life at 0 V and T_{amb} = 85 °C	500 h

PACKING

All capacitors are supplied in boxes, case sizes 4 to 7 are on bandoliers in boxes or on reels. The number of capacitors per box or per reel is shown in Table 4.

Table 4

case size	number of capacitors per box or per reel
4	1000
5	500
6	500
7	500
00	200
01	200
02	200
03	200
04	100
05	100

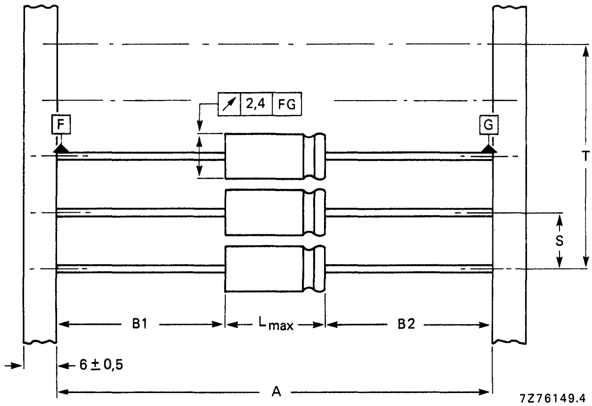


Fig. 19 Capacitors (case sizes 4 to 7) on bandoliers; the bandolier to which the negative capacitor terminals are connected is blue. See Table 5 for dimensions A, S, T and L_{max}.
$|B1 - B2| = 1,4 + (L_{max} - L)$ mm max.

Table 5

Dimensions in mm

case size	A	S	T for number (n) of capacitors		L_{max}
			$n < 50$	$50 < n < 100$	
4	73 ± 1,6	10 ± 0,4	10 (n-1) ± 2	10 (n-1) ± 4	18,5
5	73 ± 1,6	10 ± 0,4	10 (n-1) ± 2	10 (n-1) ± 4	18,5
6	73 ± 1,6	15 ± 0,75	15 (n-1) ± 2	15 (n-1) ± 4	18,5
7	73 ± 1,6	15 ± 0,75	15 (n-1) ± 2	15 (n-1) ± 4	25,0

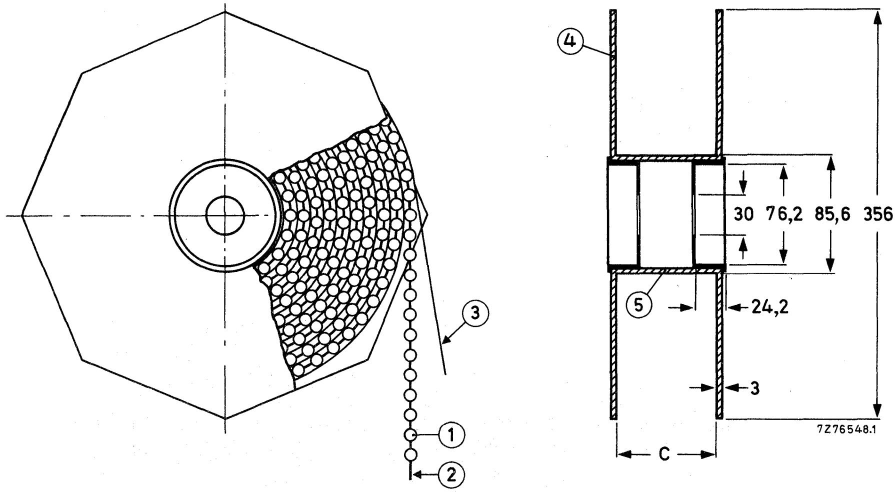


Fig. 20 Capacitors (case sizes 4 to 7) on bandoliers on reel; dimension C is 88,5 mm; the overall width of the reel is 99,5 mm.

1 = capacitor
2 = bandolier
3 = paper
4 = flange
5 = cylinder

TESTS AND REQUIREMENTS

See Introduction, section 9, under aluminium electrolytic capacitors, with the exception of IEC 384-4 subclause 9.14, for which the following is valid.
IEC 384-4 subclause 9.14.
IEC 68-2 test method: no reference.
Name of test: Endurance.
Procedure: 6000 h at U_R and 85 °C for case sizes 4 and 5;
8000 h at U_R and 85 °C for case sizes 6 to 05.

Requirements: No visible damage, no leakage of electrolyte, insulation resistance > 100 MΩ, no breakdown or flashover, d.c. leakage current ⩽ stated limit, tan $\delta \leqslant$ 1,3 x stated limit, impedance at 10 kHz ⩽ 2 x stated limit, $\Delta C/C \leqslant 15\%$.

After *shelf life test, 500 h, 85 °C,* the capacitors meet the same requirements as after endurance test. The rated voltage shall be applied to the capacitors for minimum 30 min, at least 24 h and not more than 48 h before measurements.

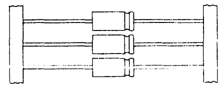
Note

Capacitors 2222 132 and 2222 133 are miniature and small types, long-life grade.

SOLID ALUMINIUM CAPACITORS

SOLID ALUMINIUM CAPACITORS

- **Small type**
- **Axial leads; metal case; ceramic seal**
- **Very long life**
- **High reliability**
- **Industrial and military applications**



QUICK REFERENCE DATA

Nominal capacitance range (E6 series)	2,2 to 330 μF
Tolerance on nominal capacitance	−20 to +20% *
Rated voltage range, U_R (R5 series)	6,3 to 50 V
Category temperature range	−55 to +125 °C
Usable temperature range	−80 to +200 °C
Endurance test	
at T_{amb} = 125 °C	5000 h
at T_{amb} = 150 °C	2000 h
Basic specification	IEC 384-4, long-life grade
Climatic category, IEC 68; 6,3 V to 40 V ranges	55/125/56
Climatic category, IEC 68; 50 V range	
at 50 V	55/085/56
at 40 V	55/125/56
DIN 40040	EHC/JQ/TW
NF C20-600	434
Approvals; 6,3 V to 40 V ranges	CECC 30 302-001
	U.K. : Post Office; Ministry of Defence DEF 59-44
	Sweden: FOA/FTL
	ESA : SCC Arcao AR C121 (Ariane)
	France : Liste LNZ 44-04 COS-A

Selection chart for C_{nom}-U_R and relevant case sizes.

C_{nom} μF	U_R (V) 6,3	10	16	25	40	50
2,2					1	1
3,3					1	
4,7				1	2A	2A
6,8					2A	2A
10			1	2A	2A	
15		1	2A			4
22	1			2A	4	5
33		2A	2A	4	5	6
47	2A	2A	4	5	6	
68	2A		5	6		
100		4	6			
150	4	5				
220	5	6				
330	6					

case size	nominal dimensions (mm)
1	Ø 6,5 x 15
2A	Ø 7,5 x 20
4	Ø 9 x 22,5
5	Ø 10 x 31,5
6	Ø 12,5 x 31,5

* ± 10% to special order.

APPLICATION

These capacitors utilize advanced technology to achieve long life, high stability, excellent reliability, very high ripple current rating and low temperature dependence. The capacitors are not subject to a limitation on charge or discharge currents and they will function in circuits where voltage reversal may occur.
The taped versions are suitable for automatic insertion and for cutting and forming equipment.

DESCRIPTION

The capacitors have etched aluminium foil electrodes separated by a layer of glassfabric and filled with solid semiconductive, pyrolitically formed manganese dioxide. The capacitors are housed in an aluminium case with soldered-copper axial leads and are sealed by a ceramic disc. The cathode lead is welded to the case, which is insulated with a blue transparent plastic sleeve.

The capacitors are supplied on bandoliers in boxes and on reels.

Note: A special version is available, which is partly epoxy-filled, withstanding severe shock and vibration tests; see also "Tests and requirements".

MECHANICAL DATA

Dimensions in mm

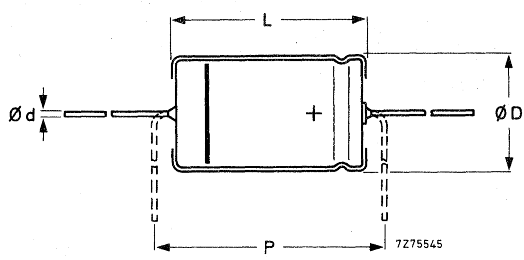


Fig. 1 For dimensions d, D, L and P, see Table 1a.

Table 1a

case size	d*		D_{nom}	L_{nom}	D_{max}	L_{max}	P_{min}	mass** approx. g
1	0,6	+0,06 / −0,05	6,5	15	6,7	15,3	20	1,2
2A	0,6		7,5	20	7,6	20,4	22,5	2,4
4	0,6		9	22,5	9,3	23,3	25	3,3
5	0,8	+0,08 / −0,05	10	31,5	10,3	32	35	4,5
6	0,8		12,5	31,5	12,9	32	35	6,3

* Tolerance according to IEC 301; not applicable to a length of 2 mm from the lead ends, which is covered by the bandoliers.

** Add 10% for epoxy-filled version.

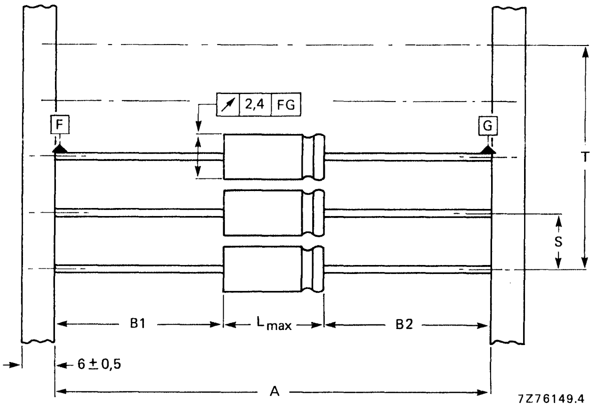


Fig. 2 Capacitors on bandoliers; the bandolier to which the negative capacitor terminals are connected is blue. See Table 1b for dimensions A, S, T and L_{max}.
$|B1-B2| = 1,4 + (L_{max}-L)$ mm max.

Table 1b

case size	A	S	T for number (n) of capacitors		L_{max}
			n < 50	50 < n < 100	
1	73 ± 1,6	10 ± 0,4	10 (n-1) ± 2	10 (n-1) ± 4	15,3
2A	73 ± 1,6	10 ± 0,4	10 (n-1) ± 2	10 (n-1) ± 4	20,4
4	73 ± 1,6	10 ± 0,4	10 (n-1) ± 2	10 (n-1) ± 4	23,3
5	73 ± 1,6	15 ± 0,75	10 (n-1) ± 2	10 (n-1) ± 4	32
6	73 ± 1,6	15 ± 0,75	10 (n-1) ± 2	10 (n-1) ± 4	32

Marking

The capacitors are marked with: group number (121), capacitance, tolerance, rated and derated voltages at corresponding maximum temperatures, date code, a band to identify the negative terminal, "+" signs for the positive terminal and name of manufacturer.

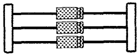
Mounting

No special provisions are required for soldering to the tinned leads. (2 mm of the anode lead nearest the body are not solderable).

ELECTRICAL DATA

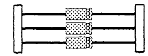
Unless otherwise specified all electrical values in Table 2 apply at an ambient temperature of 20 to 25 °C, a frequency of 100 Hz, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 45 to 75%.
See also the corresponding paragraphs.

Table 2

U_R	nom. cap.	max. r.m.s. ripple current at T_{amb} = 125 °C, no d.c. voltage applied	max. d.c. leakage current at U_R after 1 min*	max. tan δ	max. ESR	max. impedance at 100 kHz*	case size	catalogue number 2222 121 followed by 		
V	µF	mA	µA		Ω	Ω		in box	on reel	epoxy-filled version**
6,3	22	60	10	0,18	16,5	1,2	1	13229	23229	63229
	47	100	21	0,18	7,6	1,0	2A	13479	23479	63479
	68	130	30	0,18	5,3	0,75	2A	13689	23689	63689
	150	220	66	0,18	2,4	0,4	4	13151	23151	63151
	220	320	97	0,18	1,6	0,3	5	13221	23221	63221
	330	430	146	0,18	1,1	0,2	6	13331	23331	63331
10	15	50	11	0,16	21,5	2,5	1	14159	24159	64159
	33	85	23	0,16	9,6	1,25	2A	14339	24339	64339
	47	115	33	0,16	6,8	0,75	2A	14479	24479	64479
	100	190	70	0,16	3,2	0,5	4	14101	24101	64101
	150	280	105	0,16	2,1	0,4	5	14151	24151	64151
	220	380	154	0,16	1,4	0,4	6	14221	24221	64221
16	10	45	16	0,14	28	2,5	1	15109	25109	65109
	15	60	24	0,14	19	1,25	2A	15159	25159	65159
	33	105	53	0,14	8,4	1,25	2A	15339	25339	65339
	47	140	75	0,14	5,9	0,5	4	15479	25479	65479
	68	200	109	0,14	4,1	0,4	5	15689	25689	65689
	100	270	160	0,14	2,8	0,4	6	15101	25101	65101

* Capacitors with lower values of max. d.c. leakage current or max. impedance are available to special order.
** Withstands severe shock and vibration.

Table 2 (continued)

U_R	nom. cap.	max. r.m.s. ripple current at T_{amb} = 125 °C, no d.c. voltage applied	max. d.c. leakage current at U_R after 1 min*	max. tan δ	max. ESR	max. impedance at 100 kHz*	case size	catalogue number 2222 121 followed by 		
V	μF	mA	μA		Ω	Ω		in box	on reel	epoxy-filled version**
25	4,7	30	12	0,14	60	5	1	16478	26478	66478
	10	50	25	0,14	28	2,5	2A	16109	26109	66109
	22	85	55	0,14	13	2,5	2A	16229	26229	66229
	33	120	83	0,14	8,4	1	4	16339	26339	66339
	47	160	118	0,14	5,9	0,8	5	16479	26479	66479
	68	220	170	0,14	4,1	0,5	6	16689	26689	66689
40	2,2	20	9	0,12	109	7,5	1	17228	27228	67228
	3,3	30	13	0,12	73	7,5	1	17338	27338	67338
	4,7	35	19	0,12	51	2,5	2A	17478	27478	67478
	6,8	45	27	0,12	35	2,5	2A	17688	27688	67688
	10	60	40	0,12	24	2,5	2A	17109	27109	67109
	22	100	88	0,12	11	1	4	17229	27229	67229
	33	150	132	0,12	7,3	0,8	5	17339	27339	67339
	47	200	188	0,12	5,1	0,5	6	17479	27479	67479
50	2,2	15	11	0,25	230	20	1	18228	28228	68228
	4,7	25	24	0,25	106	10	2A	18478	28478	68478
	6,8	35	34	0,25	74	6	2A	18688	28688	68688
	15	60	75	0,25	34	4	4	18159	28159	68159
	22	85	110	0,25	23	3,2	5	18229	28229	68229
	33	110	165	0,25	15,5	2	6	18339	28339	68339

* Capacitors with lower values of max. d.c. leakage current or max. impedance are available to special order.
** Withstands severe shock and vibration.

Capacitance

Nominal capacitance values at 100 Hz and T_{amb} = 25 °C	see Table 2
Tolerance on nominal capacitance at 100 Hz	± 20%; ± 10% to special order

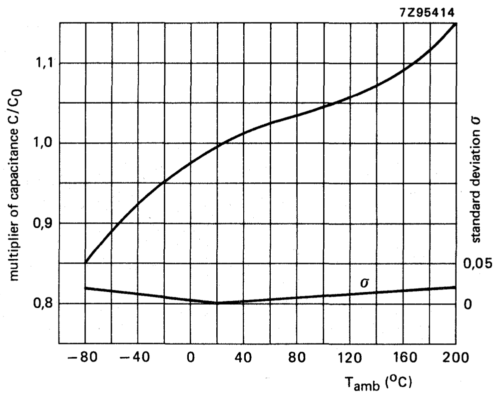


Fig. 3 Typical multiplier of capacitance as a function of ambient temperature.
C_0 = capacitance at T_{amb} = 25 °C, 100 Hz.

Voltage

Rated voltage	
6,3 V to 40 V ranges = max. permissible voltage at $T_{amb} \leqslant 125$ °C	U_R
50 V range = max. permissible voltage at $T_{amb} \leqslant 85$ °C	U_R*
Derated voltage	
6,3 V to 40 V ranges = max. permissible voltage at T_{amb} from 125 °C to 200 °C	0,63 x U_R
50 V range = max. permissible voltage at T_{amb} from 85 °C to 125 °C	40 V
Ripple voltage	
Max. permissible a.c. voltage providing the following four conditions are met:	
a) Max. a.c. voltage, with negative d.c. voltage applied	2 V

* 63 V is permissible for max. 500 h at T_{amb} = 85 °C.

b) Max. peak a.c. voltage, without d.c. voltage applied

	$T_{amb} \leqslant 85\ ^oC$	$85\ ^oC < T_{amb} \leqslant 125\ ^oC$*
at $f \leqslant 0,1$ Hz	$0,30 \times U_R$	$0,15 \times U_R$
at $0,1\ Hz < f \leqslant 1$ Hz	$0,45 \times U_R$	$0,22 \times U_R$
at $1\ Hz < f \leqslant 10$ Hz	$0,60 \times U_R$	$0,30 \times U_R$
at $10\ Hz < f \leqslant 50$ Hz	$0,65 \times U_R$	$0,32 \times U_R$
at $f > 50$ Hz	$0,80 \times U_R$	$0,40 \times U_R$

c) Momentary value of applied voltage, with positive d.c. voltage applied: between U_R (in the positive half wave) and the limits mentioned under b) (in the negative half wave)

d) Ripple voltage limits are not applicable if the maximum ripple current is exceeded. In that case the ripple current is decisive. Whichever is in practice decisive, depends on the actual impedance of the capacitor. Table 3 should be considered as an aid only in establishing whether the ripple voltage or the ripple current is decisive.

Table 3

frequency	decisive factor	
	at $T_{amb} \leqslant 85\ ^oC$	$T_{amb} > 85\ ^oC$
$f \leqslant 50$ Hz	voltage	voltage, if actual capacitor impedance is high; current, if actual capacitor impedance is low
$50\ Hz < f \leqslant 1$ kHz	voltage, if actual capacitor impedance is high; current, if actual capacitor impedance is low	current
$f > 1$ kHz	current	current

Surge voltage

		$T_{amb} \leqslant 85\ ^oC$	$85\ ^oC < T_{amb} \leqslant 125\ ^oC$
6,3 V to 40 V ranges	= max. permissible voltage for short periods (see also "Tests and requirements")	$1,15 \times U_R$	
50 V range	= max. permissible voltage for max. 500 h	63 V	45 V

* For 50 V range, $U_R = 40$ V.

Reverse voltage	$T_{amb} \leqslant 85\ ^oC$	$85\ ^oC < T_{amb} \leqslant 125\ ^oC$
6,3 V to 40 V ranges = max. d.c. voltage continuously (2000 h) applied in the reverse polarity,		
at $T_{amb} \leqslant 85\ ^oC$	0,30 x U_R	
at $85\ ^oC < T_{amb} \leqslant 125\ ^oC$	0,15 x U_R	
50 V range = max. d.c. voltage applied in the reverse polarity at the maximum category temperature for short periods (see also "Tests and requirements")	7,5 V	6 V

Ripple current

Maximum permissible r.m.s. ripple current at 100 Hz and $T_{amb} = 125\ ^oC$ — see Table 2

Maximum permissible r.m.s. ripple current at other frequencies, temperatures and conditions — see Table 4 to 6, and Fig. 4

Table 4 Temperature multiplier of ripple current ($\sqrt{k}$), at 100 Hz

T_{amb} ^oC	$\sqrt{k}$
25	2,6
35	2,5
45	2,4
55	2,25
65	2,2
70	2,15
75	2,1
80	2,05
85	2,0
90	1,9
95	1,8
100	1,7
105	1,6
110	1,45
115	1,35
120	1,2
125	1,0

Table 5 Frequency multiplier of ripple current ($\sqrt{r}$) at 25 ^oC

frequency kHz	$\sqrt{r}$
0,05	0,8
0,1	1,0
0,2	1,2
0,5	1,4
1	1,55
2	1,70
5	1,80
10	1,95
20	2,05
50	2,15
100	2,20
200	2,25
500	2,30
1000	2,35

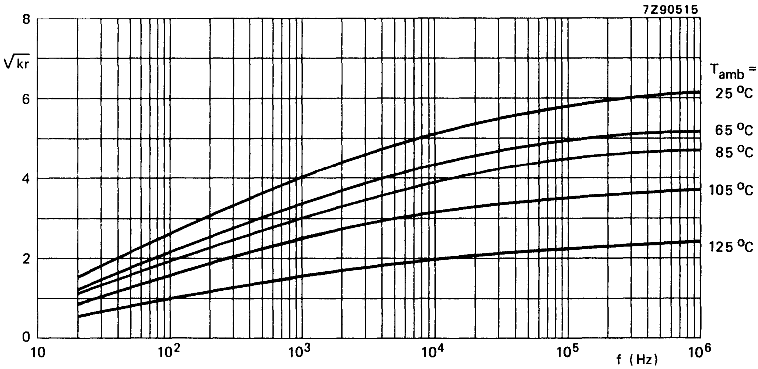


Fig. 4 Combined temperature/frequency multiplier of ripple current ($\sqrt{kr}$) as a function of frequency. $I_{r\,max} = I_{r0}\sqrt{kr}$.

Table 6 Multiplier of ripple current for various application conditions

condition	multiplier
A. Capacitor insulated with a blue sleeve, mounted horizontally on a thermally non-conducting printed-circuit board, in free flowing air and in a surrounding that allows the absorption of radiation heat.	1,0
B. As under A but capacitor is not insulated	0,9
C. As under A but capacitor is mounted vertically.	0,7
D. As under A but capacitor is mounted on a good thermally conducting printed-circuit board.	1,25
E. As under A but the surrounding walls etc. have a temperature higher than 125 °C and therefore prevent the absorption of heat by radiation.	0,6
F. Capacitor has an ESR value lower than the maximum ESR.	$\sqrt{\frac{ESR_{max}}{ESR_{actual}}}$
G. As under A but capacitor is epoxy-filled (for severe shock and vibration resistance).	1,05
H. As under G but capacitor is mounted on a good thermally conducting printed-circuit board.	1,5

Note: Neither the maximum permissible ripple current nor the maximum permissible ripple voltage values are to be exceeded. Refer to Table 3 to find whichever factor will be decisive.

Calculation of ripple currents

The maximum permissible ripple current ($I_{r\,max}$) is a function of temperature and frequency:

$I_{r\,max} = I_{r0}\sqrt{kr}$,

where I_{r0} = max. ripple current at 100 Hz and 125 °C (see Table 2);

$\sqrt{k}$ = temperature multiplier (neglecting the frequency dependence) = $\sqrt{P_{max}/P_{125}}$;

$\sqrt{r}$ = frequency multiplier (neglecting the temperature dependence) = $\sqrt{ESR_{100}/ESR_{max}}$;

(for $\sqrt{k}$ and $\sqrt{r}$, see Tables 4 and 5, for $\sqrt{kr}$, see Fig. 4);

while P_{max} = max. permissible power dissipation, temperature dependent;

P_{125} = max. permissible power dissipation at 125 °C = $I^2_{r0}\,ESR_{100}$;

ESR_{max} = max. equivalent series resistance, frequency dependent;

ESR_{100} = max. equivalent series resistance at 100 Hz.

The formula is derived for any temperature and frequency as follows:

$$I^2_{r\,max} = P_{max}/ESR_{max}$$
$$= kr\,P_{125}/ESR_{100}$$
$$= kr\,I^2_{r0}\,ESR_{100}/ESR_{100}$$

Thus $I_{r\,max} = I_{r0}\sqrt{kr}$.

The values of the temperature multiplier $\sqrt{k}$ and of P125 have been calculated allowing a capacitor temperature of 138 °C and assuming the values of ESR_{max} at 138 °C to be 0,8 times the ESR_{max} at 25 °C at all frequencies.

The values of the frequency multiplier $\sqrt{r}$ have been measured at 25 °C assuming it to be the same at all temperatures.

The power dissipation (P_{max}) has been calculated assuming it to be governed by the simplified relation:

$P_{max} = \beta \times S \times \Delta T$,

where β = heat transfer coefficient, taken as 9,0 W/m²K;

S = capacitor outer surface;

ΔT = temperature difference between capacitor surface and the ambient atmosphere, taken as 13 °C at T_{amb} = 125 °C.

Charge and discharge current

The capacitors may be charged from a source without internal resistance and they may be discharged by short-circuiting. If the capacitors are charged and discharged continuously at a rate of several times per minute, the charge and discharge currents have to be considered as ripple currents flowing through the capacitor. The r.m.s. value of these currents should be determined and the value thus found must not exceed the applicable limit.

D.C. leakage current

Maximum d.c. leakage current 1 min after application of U_R, at T_{amb} = 25 °C	see Table 2 (max. 0,1 CU)
D.C. leakage current during continuous operation at U_R,	
at T_{amb} = 25 °C	approx. 0,5 x value stated in Table 2
at T_{amb} = 85 °C	approx. 2 x value stated in Table 2
at T_{amb} = 125 °C	approx. 7 x value stated in Table 2
D.C. leakage current during continuous operation at 40 V, T_{amb} = 125 °C (only applicable to 50 V range)	approx. 2 x value stated in Table 2

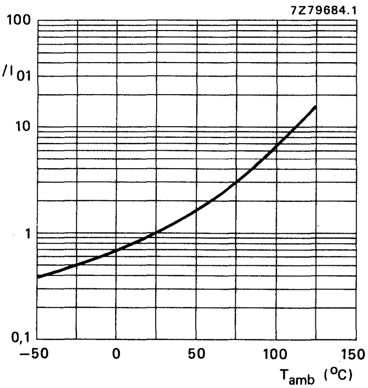


Fig. 5 Multiplier I/I_{01} as a function of ambient temperature. I_{01} = d.c. leakage current during continuous operation at U_R, T_{amb} = 25 °C.

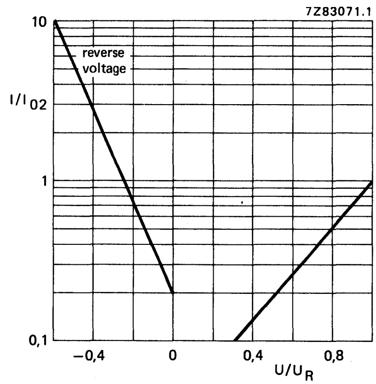


Fig. 6 Multiplier I/I_{02} as a function of U/U_R. I_{02} = d.c. leakage current at U_R at a discrete constant temperature.

Tan δ (dissipation factor)

Maximum tan δ at 100 Hz and T_{amb} = 25 °C, measured by means of a four-terminal circuit (Thomson circuit)	see Table 2
Typical tan δ at 100 Hz and T_{amb} = 25 °C	approx. 0,6 x value stated in Table 2

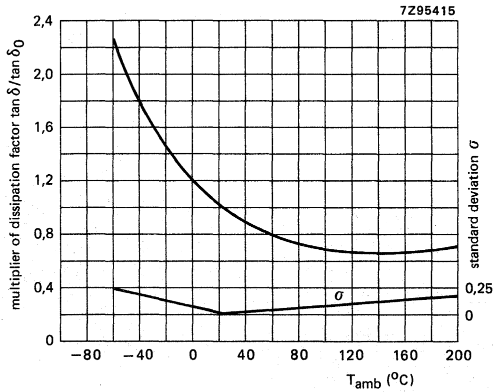


Fig. 7 Multiplier of dissipation factor as a function of ambient temperature; tan δ_0 = dissipation factor at 25 °C, 100 Hz.

Equivalent series resistance (ESR = tan $\delta/\omega C$)

Maximum ESR at 100 Hz and T_{amb} = 25 °C (calculated from maximum tan δ and 0,8 x nominal capacitance)	see Table 2

Impedance

Maximum impedance at 100 kHz, and T_{amb} = 25 °C, measured by means of a four-terminal circuit (Thomson circuit)	see Table 2

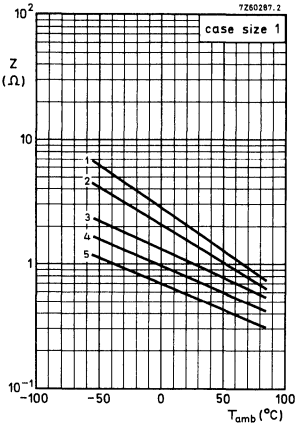


Fig. 8 Typical impedance as a function of temperature at 100 kHz.

Curve 1 = 2,2 μF, 40 V;
curve 2 = 4,7 μF, 25 V;
curve 3 = 10 μF, 16 V;
curve 4 = 15 μF, 10 V;
curve 5 = 22 μF, 6,3 V.

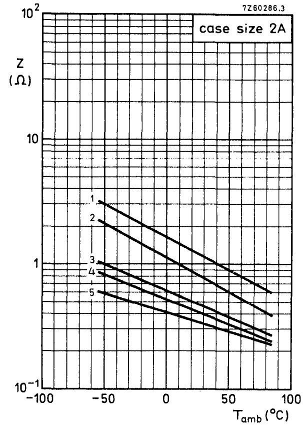


Fig. 9 Typical impedance as a function of temperature at 100 kHz.

Curve 1 = 4,7 μF, 40 V;
curve 2 = 10 μF, 25 V;
curve 3 = 15 μF, 16 V;
curve 4 = 33 μF, 10 V;
curve 5 = 47 μF, 6,3 V.

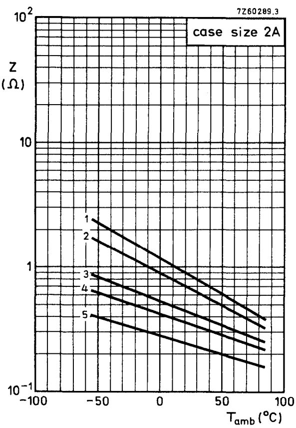


Fig. 10 Typical impedance as a function of temperature at 100 kHz.

Curve 1 = 10 μF, 40 V;
curve 2 = 22 μF, 25 V;
curve 3 = 33 μF, 16 V;
curve 4 = 47 μF, 10 V;
curve 5 = 68 μF, 6,3 V.

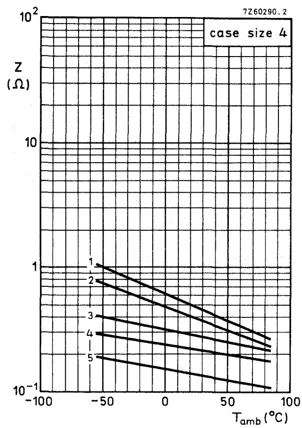


Fig. 11 Typical impedance as a function of temperature at 100 kHz.

Curve 1 = 22 μF, 40 V;
curve 2 = 33 μF, 25 V;
curve 3 = 47 μF, 16 V;
curve 4 = 100 μF, 10 V;
curve 5 = 150 μF, 6,3 V.

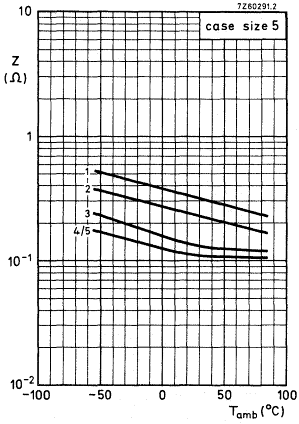


Fig. 12 Typical impedance as a function of temperature at 100 kHz.

Curve 1 = 33 μF, 40 V;
curve 2 = 47 μF, 25 V;
curve 3 = 68 μF, 16 V;
curve 4 = 150 μF, 10 V;
curve 5 = 220 μF, 6,3 V.

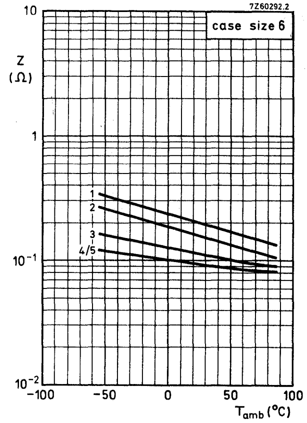


Fig. 13 Typical impedance as a function of temperature at 100 kHz.

Curve 1 = 47 μF, 40 V;
curve 2 = 68 μF, 25 V;
curve 3 = 100 μF, 16 V;
curve 4 = 220 μF, 10 V;
curve 5 = 330 μF, 6,3 V.

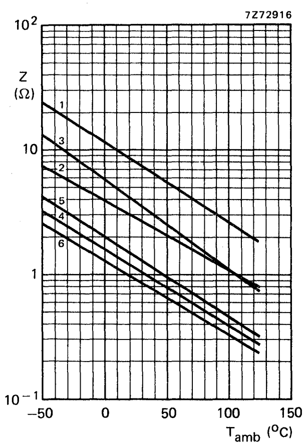


Fig. 14 Typical impedance as a function of temperature at 100 kHz.

Curve 1 = 2,2 μF, 50 V;
curve 2 = 4,7 μF, 50 V;
curve 3 = 6,8 μF, 50 V;
curve 4 = 15 μF, 50 V;
curve 5 = 22 μF, 50 V;
curve 6 = 33 μF, 50 V.

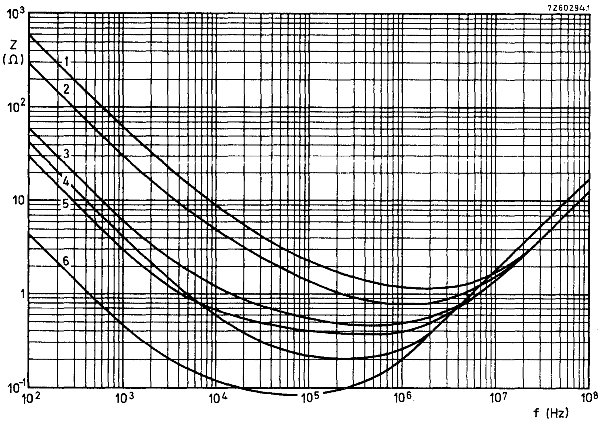


Fig. 15 Typical impedance as a function of frequency at T_{amb} = 25 °C.

Curve 1 = 2,2 μF, 40 V;
curve 2 = 4,7 μF, 40 V;
curve 3 = 22 μF, 6,3 V;
curve 4 = 47 μF, 40 V;
curve 5 = 47 μF, 6,3 V;
curve 6 = 330 μF, 6,3 V.

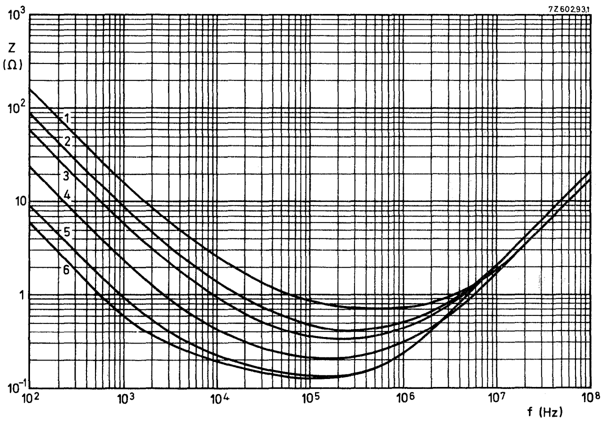


Fig. 16 Typical impedance as a function of frequency at T_{amb} = 25 °C.

Curve 1 = 10 μF, 40 V;
curve 2 = 22 μF, 40 V;
curve 3 = 33 μF, 40 V;
curve 4 = 68 μF, 6,3 V;
curve 5 = 150 μF, 6,3 V;
curve 6 = 220 μF, 6,3 V.

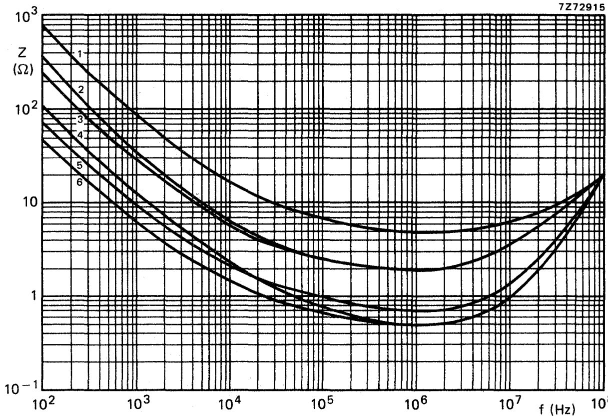


Fig. 17 Typical impedance as a function of frequency at T_{amb} = 25 °C.
Curve 1 = 2,2 μF, 50 V;
curve 2 = 4,7 μF, 50 V;
curve 3 = 6,8 μF, 50 V;
curve 4 = 15 μF, 50 V;
curve 5 = 22 μF, 50 V;
curve 6 = 33 μF, 50 V.

Equivalent series inductance (ESL)

Equivalent series inductance, measured by means of a four-terminal circuit (Thomson circuit), at 10 MHz; the capacitor leads bent to the pitch as indicated

	pitch	max. ESL	typ. ESL
case size 1	20,3 mm	30 nH	15 to 23 nH
case size 2A	25,4 mm	30 nH	16 to 24 nH
case size 4	27,9 mm	35 nH	20 to 27 nH
case size 5	35,6 mm	40 nH	26 to 33 nH
case size 6	35,6 mm	55 nH	41 to 49 nH

OPERATIONAL DATA

Category temperature range, 6,3 V to 40 V ranges	−55 to + 125 °C
Category temperature range, 50 V range	
for rated voltage	−55 to + 85 °C
for derated voltage (40 V)	−55 to + 125 °C
Usable temperature range	−80 to + 200 °C
Typical life time, 6,3 V to 40 V ranges	
at T_{amb} = 125 °C and U_R	> 20 000 h
at T_{amb} = 150 °C and U_R	> 5 000 h
at T_{amb} = 175 °C and U_R	> 2 000 h
Typical life time, 50 V range	
at T_{amb} = 85 °C and U_R	> 10 000 h
at T_{amb} = 125 °C and derated voltage (40 V)	> 10 000 h
Field failure rate	$< 1 \times 10^{-9}$/h
Typical parameter change after endurance test at T_{amb} = 125 °C	see Figs. 18, 19 and 20

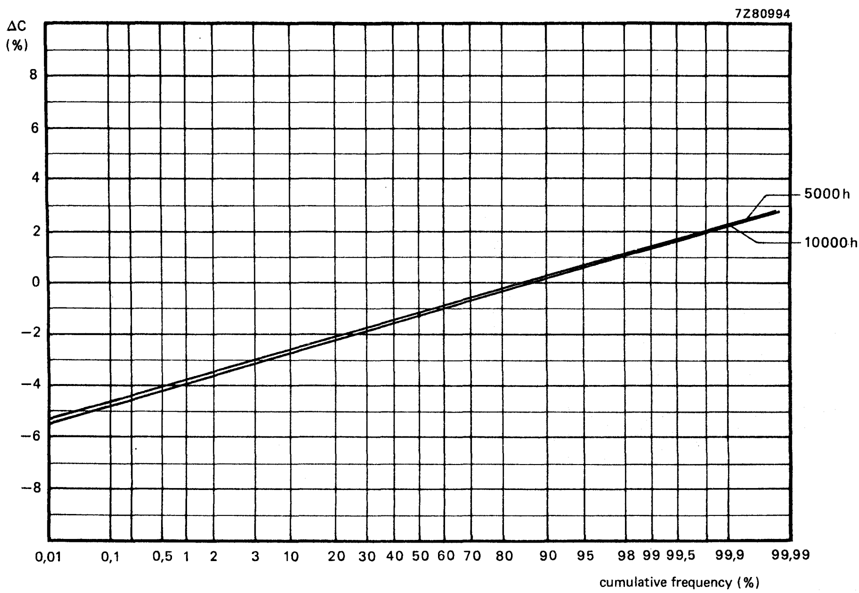


Fig. 18 Change of capacitance after endurance test.

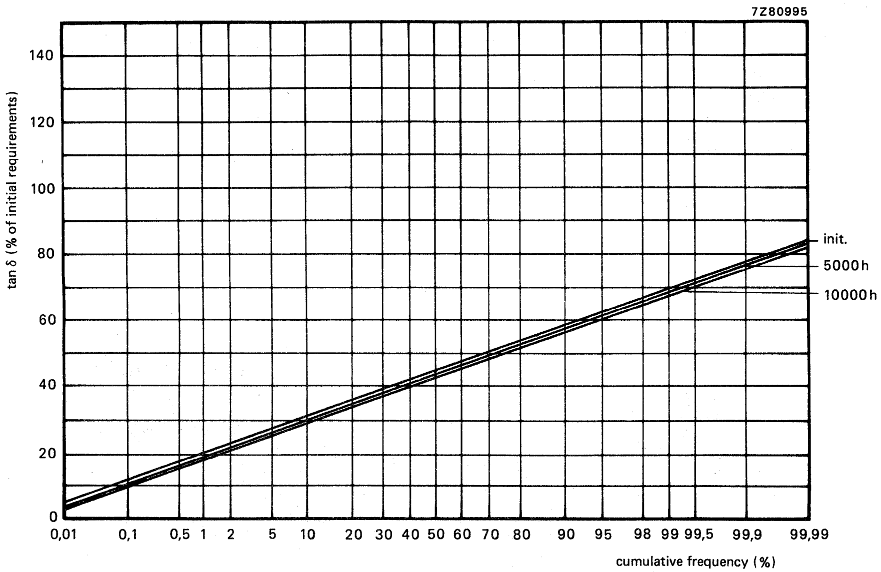


Fig. 19 Tan δ after endurance test.

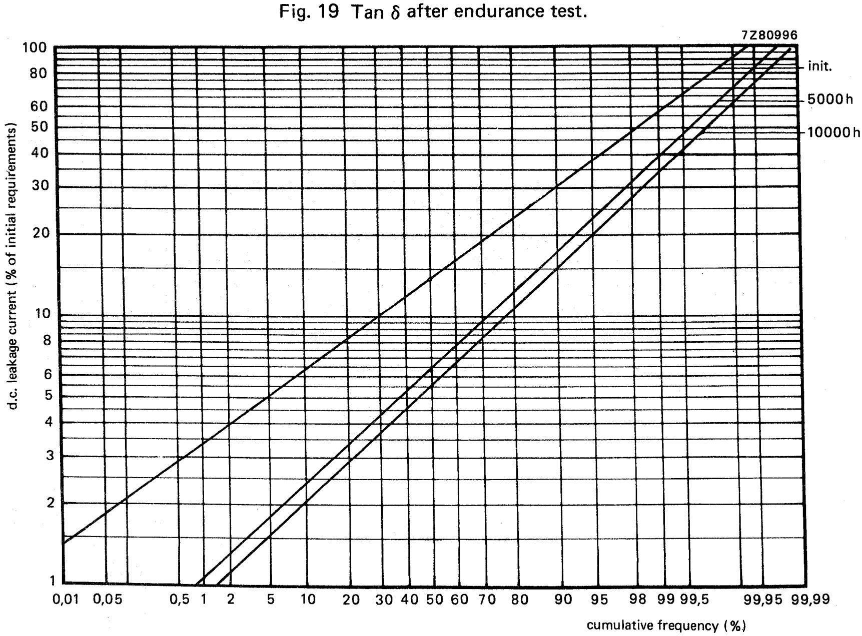


Fig. 20 D.C. leakage current after endurance test.

PACKING

The capacitors are supplied on bandoliers in boxes or on reels, (according to IEC 286-1). The number of capacitors per box or per reel is shown in Table 7.

Table 7

case size	number of capacitors	
	per box	per reel
1	100	1000
2A	100	1000
4	100	500
5	100	500
6	100	400

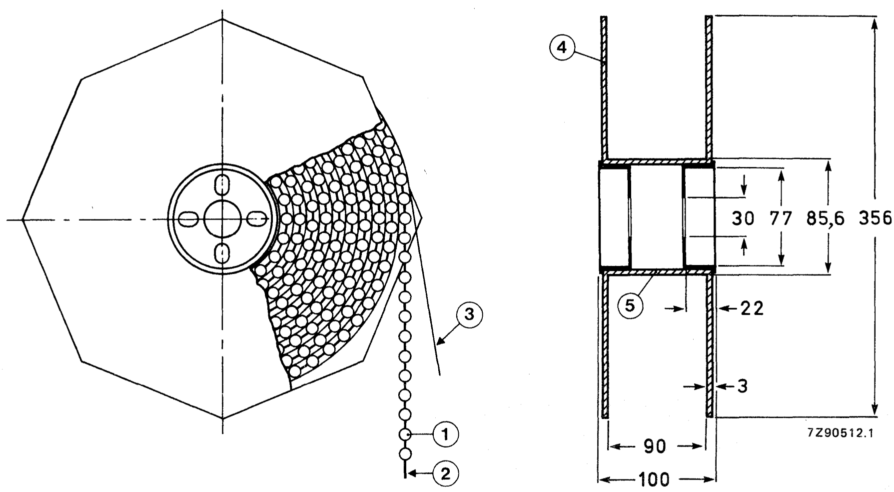


Fig. 21 Capacitors on bandoliers on reel.

1 = capacitor
2 = bandolier
3 = paper
4 = flange
5 = cylinder

TESTS AND REQUIREMENTS

See Introduction, section 9, under solid aluminium capacitors, with the addition of the following tests.

Severe rapid change of temperature test: 100 cycles of 15 min at −40 °C and + 125 °C.

Requirements: d.c. leakage current ⩽ stated limit,
tan δ ⩽ 1,6 x stated limit,
impedance ⩽ 1,6 x stated limit,
ΔC/C ⩽ 10%.

Solvent resistance tests:

Severity 1, according to MIL-STD-202, method 215, including brushing of all portions of the specimens.

Solvents:
- deionized water (50 ± 5 °C);
- 1.1.1. trichloro-ethane;
- mixture of 25 vol.% 2-propanol (isopropanol) and 75 vol.% mineral spirits.

Severity 2, according to IEC 68-2-45, and IEC 653, test XA with the following details and additions.

Conditions: immersion time of samples 5 min., at ambient temperature, at boiling temperature, in vapour of boiling solvent, and ultrasonic (40 kHz).

Solvents:
- deionized water (50 ± 5 °C);
- calgonite solution (20 g/l, 70 ± 5 °C), a dishwasher detergent;
- mixture of 4,5% 2-butoxyethanol, 4,5% 2-amino-ethanol, and 91% water (70 ± 5 °C);
- 1.1.1. trichloro-ethane;
- mixtures of 1.1.2-trichloro- 1.2.2-trifluoro-ethane (fluorocarbon 113) and the following solvents in the respective mass percentage ratios of these solvents to fluorocarbon:
  - 2-propanol (isopropanol), 25%: 75% (Arklone K*); up to the ratio 35%: 65%;
  - ethanol, 4,5%: 95,5% (e.g. Arklone A*, Freon TE**);
  - methanol and nitromethane, 5,7%: 0,3%: 94% (Freon TMS**).

Requirement: visual appearance not affected.

Note: Tests are carried out using non-contaminated solvents.

* Trade mark of I.C.I.

** Trade mark of Dupont de Nemours.

Severe vibration tests (for epoxy-filled version only): according to IEC68-2-6 and MIL-STD-202, method 204, letters E and F, with the following details and additions.

a. Method of mounting: clamping both the body and the leads.

b. Severity:
1. frequency range : 10 - 3000 Hz;
   temperature : 20 - 25 °C;
2. frequency range : 50 - 2000 Hz;
   temperature : 125 °C.

1 and 2. vibration amplitude: 50g or 3,5 mm, whichever is less.

c. Direction and duration motion:

Severity 1 : 1 octave/min, 3 directions (mutually perpendicular), 20 sweeps per direction (total 60 sweeps or 18 h);

Severity 2: 1 octave/min, 2 directions (longitudinal and transversal), 3 sweeps per direction (total 6 sweeps or 1 h).

d. Functioning:
severity 1 : rated voltage applied;
severity 2 : no voltage applied.

e. Requirements:
$\Delta C/C$: $\leqslant$ 10%
tan δ : $\leqslant$ 1,2 x stated limit
impedance : $\leqslant$ 1,4 x stated limit
d.c. leakage current : $\leqslant$ stated limit
general : no intermittent contacts;
no indication of breakdown;
no open circuiting;
no evidence of mechanical damage.

f. Typical capability: up to 80g at 10 to 3000 Hz (also at 125 °C).

Severe shock tests (for epoxy-filled version only): according to IEC68-2-27 and MIL-STD-202, method 213, letter F, with the following details and additions.

a. Method of mounting: clamping both the body and the leads.

b. Pulse shape: half-sine or sawtooth.

c. Severity:
1. 1500g, 0,5 ms (MIL-STD-202, method 213, letter F);
2. 3000g, 0,2 ms;
3. 10000g, 0,1 ms;

d. Direction and number of shocks:

severity 1 and 2: 3 successive shocks in each direction of 3 mutually perpendicular axes (total 18 shocks);

severity 3: 1 shock, any direction.

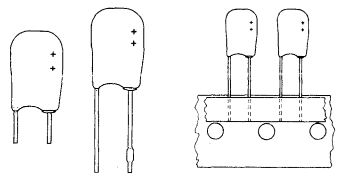
e. Functioning: rated voltage applied.

f. Requirements: see "Severe vibration tests" par. e.

g. Typical capability: $\geqslant$ 100000g; these shock tests can be preceded by severe vibration tests on the same samples.

SOLID ALUMINIUM CAPACITORS

- Miniature type
- Single ended
- Resin dipped
- Long life
- No derating at maximum temperature
- General and industrial applications



QUICK REFERENCE DATA

Nominal capacitance range (E6 series)	0,1 to 68 μF
Tolerance on nominal capacitance	± 20% (± 10% to special order)
Rated voltage range, U_R (R5 series)	6,3 to 40 V
Category temperature range	−55 to + 125 °C
Usable temperature range	−55 to + 175 °C
Endurance test	
at 85 °C	5000 h
at 125 °C	2000 h
Basic specification	IEC 384-4, long-life grade
Climatic category, IEC 68	55/125/56
DIN 40040	FKD/KQ/SV
NF C20-600	434
Approvals	CECC 30 302-002
	Liste LNZ 44-04 COS-B
	Gam-t-1

Selection chart for C_{nom}—U_R and relevant case sizes.

C_{nom} μF	U_R (V) 6,3	10	16	25	35	40*
0,1						1
0,15						1
0,22						1
0,33						1
0,47						2
0,68				1		2
1				1	2	3
1,5				1		4
2,2			1	2		4
3,3			1	2		
4,7		1	2	3		
6,8		1	2	4		
10	1	2	3	4		
15	2	2	4			
22	2	3				
33	3	4				
47	4					
68	4					

case size	maximum dimensions (mm)
1	12,5 x 8 x 3,5
2	12,5 x 8 x 4,5
3	12,5 x 8 x 5
4	12,5 x 8 x 6

* Up to 85 °C; from 85 to 125 °C this value is 25 V.

APPLICATION

Especially for filtering, smoothing, coupling and decoupling purposes in general and industrial applications. These capacitors utilize advanced technology to achieve long life, high reliability, high stability and low temperature dependence.

The capacitors have a very low and stable leakage current, small dimensions and a fixed pitch of 5 mm.
→ The taped versions are suitable for automatic insertion and for cutting and forming equipment.

DESCRIPTION

This capacitor is of a construction with a highly etched aluminium plate anode, aluminium oxide as a dielectric and a solid cathode. The capacitor is coated with an orange synthetic resin. The terminal leads are brought out on one side.

→ The capacitor is available in four styles, all with soldered-copper leads:
style 1: with short leads,
style 2: with long leads of which the anode lead has a flattened area at the end,
style 3: with long leads (without flattened area) on tape on reel, positive leading,
style 4: with long leads (without flattened area) on tape in ammunition pack.

MECHANICAL DATA

Dimensions in mm*

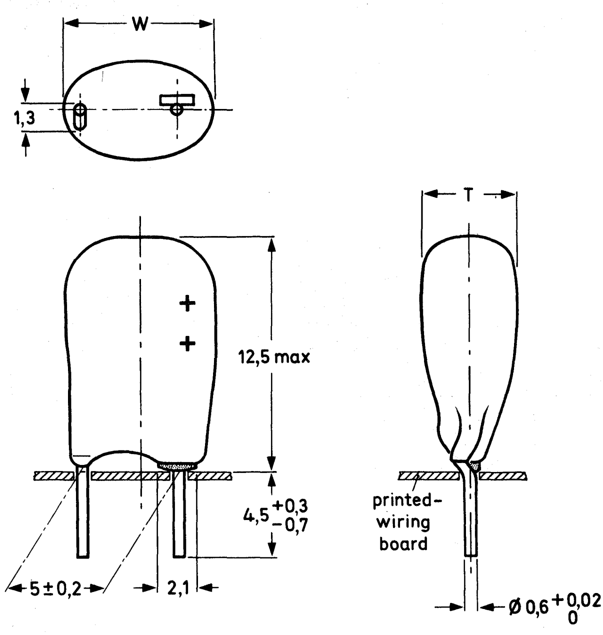


Fig. 1 Style 1; see Table 1a for dimensions T and W.
Note: Capacitors with other lead lengths are available to special order.

* Measured according to IEC 717.

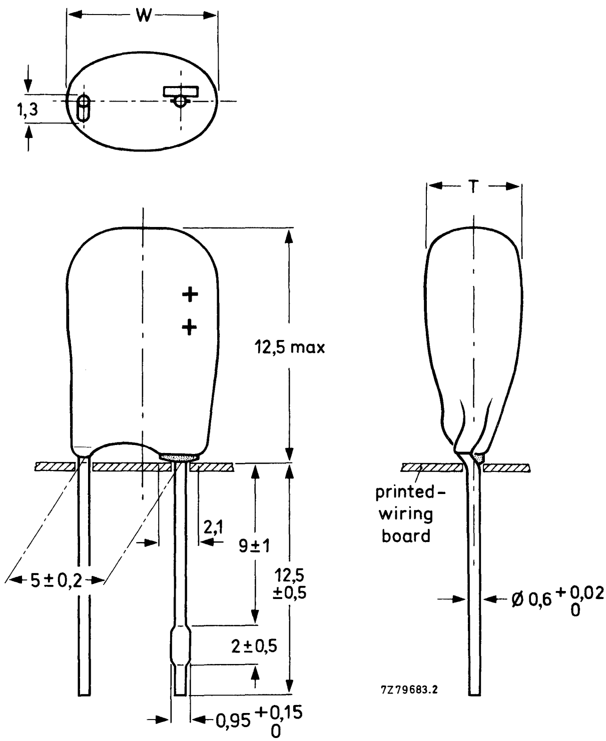


Fig. 2 Style 2; see Table 1a for dimensions T and W.

Table 1a

case size	T_{max}	W_{max}	mass g
1	3,5	8	0,30
2	4,5	8	0,35
3	5	8	0,50
4	6	8	0,60

Note: A kink in the cathode lead avoids solder wetting problems of the lacquer dipped leads. The lacquer is so applied that it cannot pass beyond the centre of the kink, thus ensuring a clean surface of the part of the lead in the printed-wiring board hole. (Also suitable for use in plated-through holes).

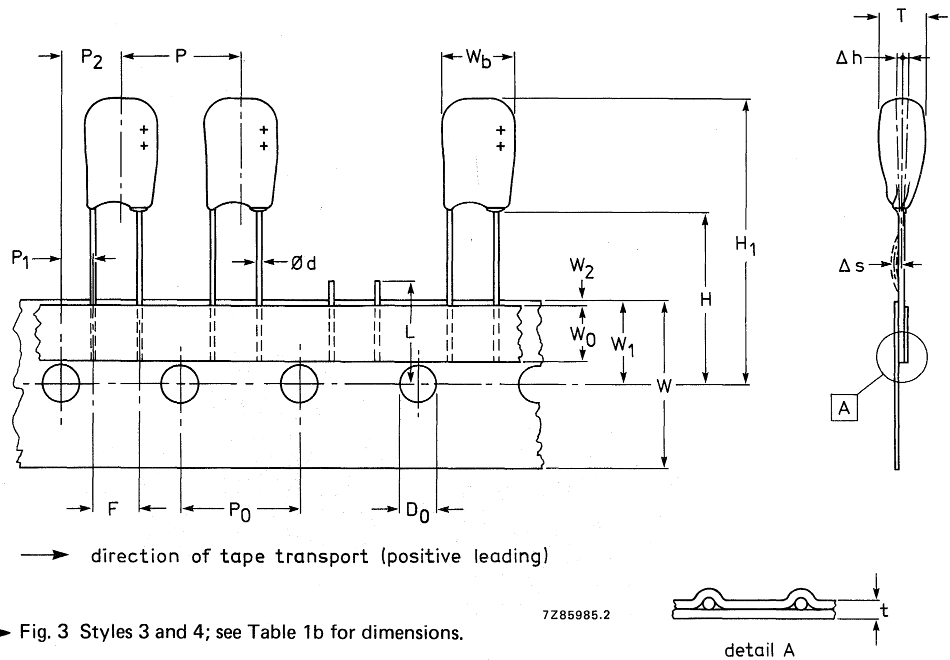


Fig. 3 Styles 3 and 4; see Table 1b for dimensions.

Table 1b

	symbol	value	tolerance	remarks
Body thickness	T	3,5-4,5-5-6	max.	for case sizes 1, 2, 3 and 4 respectively
Body width	W_b	8	max.	
Component alignment	Δh	0	± 1	
Lead-wire diameter	d	0,6	+ 0,02/—0	
Lead straightness	Δs	0	± 0,2	
Length of snipped leads	L	11	max.	
Lead-to-lead distance	F	5	+ 0,4/—0,2	
Pitch of components	P	12,7	± 1	
Feed-hole pitch	P_0	12,7	± 0,2	*
Feed-hole centre to lead	P_1	3,85	± 0,5	
Feed-hole centre to component centre	P_2	6,35	± 1	
Feed-hole diameter	D_0	4	± 0,2	
Height of component from tape centre	H	18,5	± 0,5	
Component height	H_1	32	max.	
Tape width	W	18	± 0,5	
Hold-down tape width	W_0	6	± 0,5	Feed hole shall be free
Hole position	W_1	9	+ 0,5/—0,2	
Hold-down tape position	W_2	0,5	+ 0,5/—0,2	
Total tape thickness	t	0,9	max.	

* Cumulative pitch error: ± 0,5 mm/4 pitches, and ± 1 mm/20 pitches.

Marking

The capacitors are marked with: nominal capacitance, rated voltage, "+" signs to identify the anode terminal, tolerance code (M = ± 20%, K = ± 10%), date code (year and month) and name of manufacturer.

Mounting

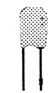
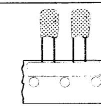
The diameter of the mounting holes in the printed-wiring board is 0,8 ± 0,1 mm, except that of the hole for the anode lead of style 2 capacitors: 1,3–0,2 mm.

When bending, cutting or straightening the leads, ensure that the capacitor body is relieved of stress.

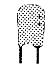
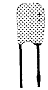
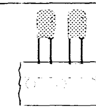
ELECTRICAL DATA

Unless otherwise specified all electrical values in Table 2 apply at an ambient temperature of 20 to 25 °C, a frequency of 100 Hz, an atmospheric pressure of 93 to 106 kPa and a relative humidity of 45 to 75%.
See also the corresponding paragraphs.

Table 2

U_R*	nom. cap.	max. r.m.s. ripple current at T_{amb} = 125 °C, no d.c. voltage applied	max. d.c. leakage current (μA)** at U_R after		max. tan δ	max. ESR	max. impedance at 100 kHz**	case size	catalogue number 2222 122 followed by			
												
											on reel	in ammopack
V	μF	mA	15 s	1 min		Ω	Ω		style 1	style 2	style 3	style 4
6,3	10	9	1,6	0,6	0,15	30	5	1	53109	73109	23109	33109
	15	13	2,4	0,9	0,15	20	3	2	53159	73159	23159	33159
	22	20	3,5	1,4	0,15	14	1,3	2	53229	73229	23229	33229
	33	30	5,2	2,1	0,15	9	0,9	3	53339	73339	23339	33339
	47	42	7,4	3,0	0,15	6,4	0,7	4	53479	73479	23479	33479
	68	61	10,7	4,3	0,15	4,4	0,5	4	53689	73689	23689	33689
10	4,7	7	1,2	0,5	0,15	64	7	1	54478	74478	24478	34478
	6,8	10	1,7	0,7	0,15	44	5	1	54688	74688	24688	34688
	10	14	2,5	1,0	0,15	30	1,5	2	54109	74109	24109	34109
	15	21	3,8	1,5	0,15	20	1	2	54159	74159	24159	34159
	22	31	5,5	2,2	0,15	14	0,7	3	54229	74229	24229	34229
	33	47	8,3	3,3	0,15	9	0,5	4	54339	74339	24339	34339
16	2,2	5	0,9	0,4	0,10	91	10	1	55228	75228	25228	35228
	3,3	8	1,3	0,5	0,10	61	7	1	55338	75338	25338	35338
	4,7	11	1,9	0,8	0,10	43	2	2	55478	75478	25478	35478
	6,8	16	2,7	1,1	0,10	29,5	1,5	2	55688	75688	25688	35688
	10	23	4,0	1,6	0,10	20	1	3	55109	75109	25109	35109
	15	34	6,0	2,4	0,10	13,5	0,7	4	55159	75159	25159	35159

* Up to T_{amb} = 125 °C.
** Versions with lower values of max. d.c. leakage current or max. impedance are available to special order.

U_R*	nom. cap.	max. r.m.s. ripple current at T_{amb} = 125 °C, no d.c. voltage applied	max. d.c. leakage current (μA)** at U_R after		max. tan δ	max. ESR	max. impedance at 100 kHz**	case size	catalogue number 2222 122 followed by			
											 on reel	in ammopack
V	μF	mA	15 s	1 min		Ω	Ω		style 1	style 2	style 3	style 4
25	0,68	2	0,4	0,2	0,10	295	30	1	56687	76687	26687	36687
	1,0	4	0,6	0,3	0,10	200	20	1	56108	76108	26108	36108
	1,5	5	0,9	0,4	0,10	135	15	1	56158	76158	26158	36158
	2,2	8	1,4	0,6	0,10	91	10	2	56228	76228	26228	36228
	3,3	12	2,1	0,8	0,10	61	7	2	56338	76338	26338	36338
	4,7	17	2,9	1,2	0,10	43	5	3	56478	76478	26478	36478
	6,8	24	4,2	1,7	0,10	29,5	3	4	56688	76688	26688	36688
	10	35	6,2	2,5	0,15	20	2	4	56109	76109	26109	36109
35	1,0	3	0,9	0,4	0,10	200	15	2	50108	70108	20108	30108
40▲	0,1	0,4	0,1	0,04	0,10	1990	70	1	57107	77107	27107	37107
	0,15	0,5	0,15	0,06	0,10	1330	50	1	57157	77157	27157	37157
	0,22	0,8	0,22	0,88	0,10	910	30	1	57227	77227	27227	37227
	0,33	1	0,33	0,13	0,10	610	30	1	57337	77337	27337	37337
	0,47	2	0,5	0,2	0,10	430	20	2	57477	77477	27477	37477
	0,68	2	0,7	0,3	0,10	295	15	2	57687	77687	27687	37687
	1,0	4	1,0	0,4	0,10	200	10	3	57108	77108	27108	37108
	1,5	5	1,5	0,6	0,10	135	7	4	57158	77158	27158	37158
	2,2	8	2,2	0,9	0,10	91	5	4	57228	77228	27228	37228

* Up to T_{amb} = 125 °C.

** Versions with lower values of max. d.c. leakage current or max. impedance are available to special order.

▲ Up to T_{amb} = 85 °C; at T_{amb} from 85 °C to 125 °C this value is 25 V.

Capacitance

Nominal capacitance values at 100 Hz and T_{amb} = 25 °C	see Table 2
Tolerance on nominal capacitance at 100 Hz	± 20% (± 10% to special order)

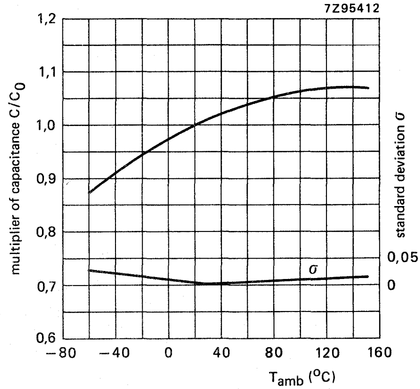


Fig. 4 Typical multiplier of capacitance as a function of ambient temperature.
C_0 = capacitance at 25 °C, 100 Hz.

Voltage

Rated voltage

6,3 V to 25 V ranges	= max. permissible voltage at $T_{amb} \leqslant$ 125 °C	U_R
40 V range	= max. permissible voltage at $T_{amb} \leqslant$ 85 °C	U_R

Derated voltage

6,3 V to 25 V ranges	= max. permissible voltage at T_{amb} from 125 °C to 175 °C	0,63 x U_R
40 V range	= max. permissible voltage at T_{amb} from 85 °C to 175 °C	0,63 x U_R

Surge voltage = max. permissible voltage for short periods (see also Tests and requirements)	$1{,}15 \times U_R$
Reverse voltage = max. d.c. voltage applied in the reverse polarity at the maximum category temperature for short periods (see also Tests and requirements)	$0{,}30 \times U_R$

Ripple voltage

Max. permissible a.c. voltage providing the following four conditions are met:

a) Max. a.c. voltage, with negative d.c. voltage applied — 2 V

b) Max. peak a.c. voltage, without d.c. voltage applied

	$T_{amb} \leq 85\ ^oC$	$85\ ^oC < T_{amb} \leq 125\ ^oC$
at $f \leq 0{,}1$ Hz	$0{,}30 \times U_R$	$0{,}15 \times U_R$
at $0{,}1\ Hz < f \leq 1$ Hz	$0{,}45 \times U_R$	$0{,}22 \times U_R$
at $1\ Hz < f \leq 10$ Hz	$0{,}60 \times U_R$	$0{,}30 \times U_R$
at $10\ Hz < f \leq 50$ Hz	$0{,}65 \times U_R$	$0{,}32 \times U_R$
at $f > 50$ Hz	$0{,}80 \times U_R$	$0{,}40 \times U_R$

c) Momentary value of applied voltage, with positive d.c. voltage applied — between U_R (in the positive half wave) and the limits mentioned under b) (in the negative half wave)

d) Ripple voltage limits are not applicable if the maximum ripple current is exceeded. In that case the ripple current is decisive. Whichever is in practice decisive, depends on the actual impedance of the capacitor. In the survey at the end of this data sheet the ripple current and ripple voltage limits can be found for each capacitor. ←

Ripple current

Maximum permissible r.m.s. ripple current at 100 Hz and $T_{amb} = 125\ ^oC$	see Table 2
Maximum permissible r.m.s. ripple current at other frequencies and temperatures	see survey at the end of this data sheet ←
Maximum permissible r.m.s. ripple current at 100 Hz and $T_{amb} = 125\ ^oC$ for capacitors with lower ESR value than the maximum ESR	$\sqrt{ESR_{max}/ESR_{actual}}$ x value stated in Table 2

Calculation of ripple currents

The maximum permissible ripple current ($I_{r\,max}$) is a function of temperature and frequency:

$I_{r\,max} = I_{r0}\sqrt{kr}$,

where I_{r0} = max. ripple current at 100 Hz and 125 °C (see Table 2);

$\sqrt{k}$ = temperature multiplier (neglecting the frequency dependence) = $\sqrt{P_{max}/P_{125}}$;

$\sqrt{r}$ = frequency multiplier (neglecting the temperature dependence) = $\sqrt{ESR_{100}/ESR_{max}}$;

while P_{max} = max. permissible power dissipation, temperature dependent;

P_{125} = max. permissible power dissipation at 125 °C = $I^2_{r0}\,ESR_{100}$;

ESR_{max} = max. equivalent series resistance, frequency dependent;

ESR_{100} = max. equivalent series resistance at 100 Hz.

The formula is derived for any temperature and frequency as follows:

$$I^2_{r\,max} = P_{max}/ESR_{max} = kr\,P_{125}/ESR_{100} = kr\,I^2_{r0}\,ESR_{100}/ESR_{100}$$

Thus $I_{r\,max} = I_{r0}\sqrt{kr}$.

The values of the temperature multiplier $\sqrt{k}$ and of P_{125} have been calculated allowing a capacitor temperature of 138 °C and assuming the values of ESR_{max} at 138 °C to be 0,8 x or 1,05 x the ESR_{max} at 25 °C at all frequencies for case sizes 1 to 3 or case size 4 respectively.

The values of the frequency multiplier $\sqrt{r}$ have been measured at 25 °C assuming it to be the same at all temperatures.

The power dissipation (P_{max}) has been calculated assuming it to be governed by the simplified relation:

$P_{max} = \beta \times S \times \Delta T$,

where β = heat transfer coefficient, taken as 18 W/m²K (capacitor mounted on a thermally well-conducting printed-circuit board, in free flowing air, the board being in vertical position);

S = capacitor outer surface;

ΔT = temperature difference between capacitor surface and the ambient atmosphere, taken as 13 °C at T_{amb} = 125 °C.

→ For case sizes 1 to 3 P_{125} = 45 mW, for case size 4 P_{125} = 65 mW.

Charge and discharge current

The capacitors may be charged from a source without internal resistance and they may be discharged by short-circuiting. If the capacitors are charged and discharged continuously at a rate of several times per minute, the charge and discharge currents have to be considered as ripple currents flowing through the capacitor. The r.m.s. value of these currents should be determined and the value thus found must not exceed the applicable limit. (See also Tests and Requirements).

D.C. leakage current

Maximum d.c. leakage current 15 s after application of U_R, at T_{amb} = 25 °C	see Table 2 (0,025 CU or 0,1 μA whichever is greater)
Maximum d.c. leakage current 1 min after application of U_R, at T_{amb} = 25 °C	see Table 2 (0,01 CU or 0,04 μA whichever is greater)
Typical d.c. leakage current 15 s or 1 min after application of U_R, at T_{amb} = 25 °C	
6,3 V to 16 V ranges	approx. 0,2 x value stated in Table 2
25 V to 40 V ranges	approx. 0,1 x value stated in Table 2
Typical d.c. leakage current during continuous operation at U_R	
at T_{amb} = 25 °C	approx. 0,02 x 15 s-value stated in Table 2
at T_{amb} = 85 °C	approx. 0,1 x 15 s-value stated in Table 2
at T_{amb} = 125 °C	approx. 0,3 x 15 s-value stated in Table 2

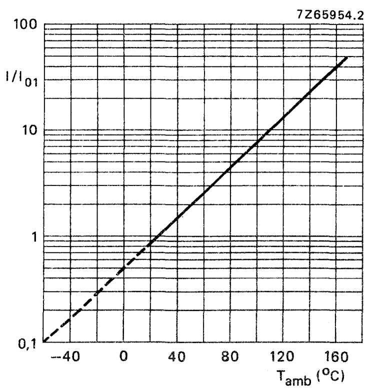


Fig. 5 Typical multiplier I/I_{01} as a function of ambient temperature; I_{01} = d.c. leakage current during continuous operation at U_R, T_{amb} = 25 °C.

Tan δ (dissipation factor)

Maximum tan δ at 100 Hz and T_{amb} = 25 °C, measured by means of a four-terminal circuit (Thomson circuit)	see Table 2
Typical tan δ at 100 Hz and T_{amb} = 25 °C	0,05

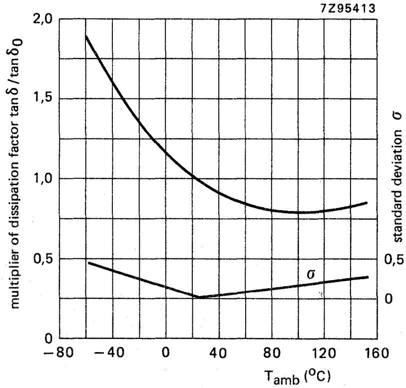


Fig. 6 Typical multiplier of dissipation factor as a function of temperature; tan δ_0 = dissipation factor at T_{amb} = 25 °C, 100 Hz.

Equivalent series resistance (ESR = tan $\delta/\omega C$)

Maximum ESR at 100 Hz and T_{amb} = 25 °C (calculated from maximum tan δ and 0,8 x nominal capacitance)	see Table 2
Maximum ESR at 100 kHz and T_{amb} = 25 °C	equal to values of max. impedance at 100 kHz, see Table 2 ←

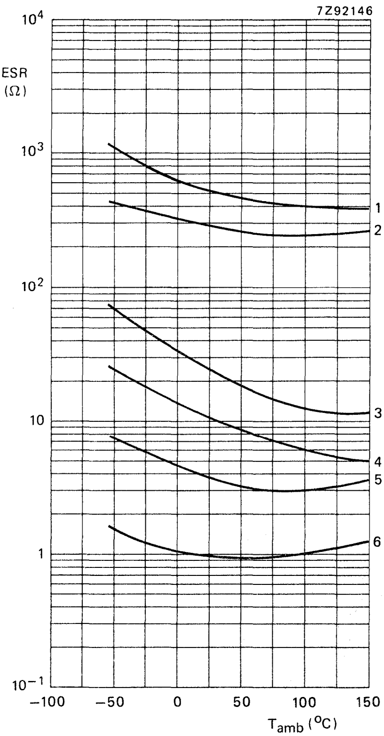


Fig. 7 Typical ESR as a function of ambient temperature at 100 Hz.

Curve 1 = 0,1 μF, 40 V;
curve 2 = 1,5 μF, 40 V;
curve 3 = 3,3 μF, 25 V;
curve 4 = 10 μF, 6,3 V;
curve 5 = 22 μF, 10 V;
curve 6 = 68 μF, 6,3 V.

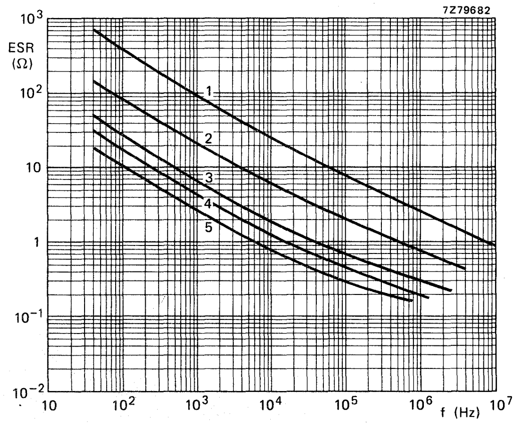


Fig. 8 Typical ESR as a function of frequency at T_{amb} = 25 °C; **case size 1.**

Curve 1 = 0,33 μF, 40 V;
curve 2 = 1 μF, 25 V;
curve 3 = 3,3 μF, 16 V;
curve 4 = 4,7 μF, 10 V;
curve 5 = 10 μF, 6,3 V.

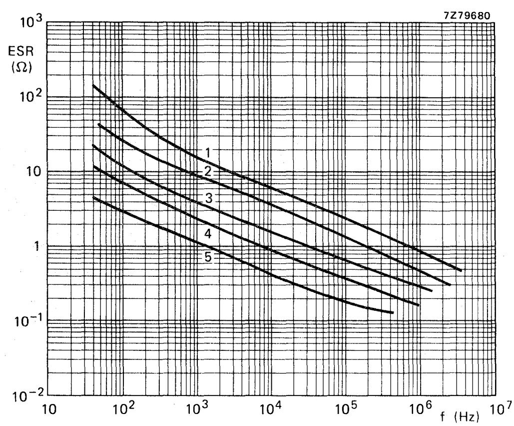


Fig. 9 Typical ESR as a function of frequency at T_{amb} = 25 °C; **case size 2.**

Curve 1 = 0,47 μF, 40 V;
curve 2 = 2,2 μF, 25 V;
curve 3 = 4,7 μF, 16 V;
curve 4 = 10 μF, 10 V;
curve 5 = 22 μF, 6,3 V.

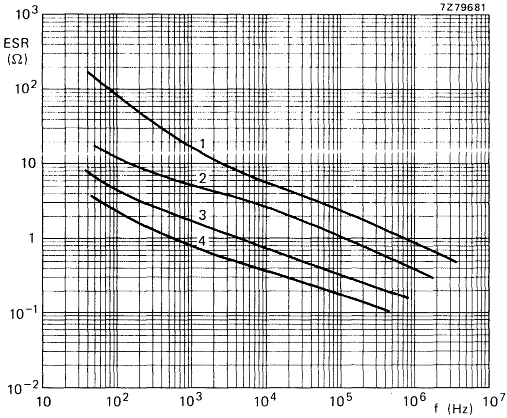


Fig. 10 Typical ESR as a function of frequency at T_{amb} = 25 °C; **case size 3.**

Curve 1 = 1 μF, 40 V;
curve 2 = 4,7 μF, 25 V;
curve 3 = 10 μF, 16 V;
curve 4 = 33 μF, 6,3 V.

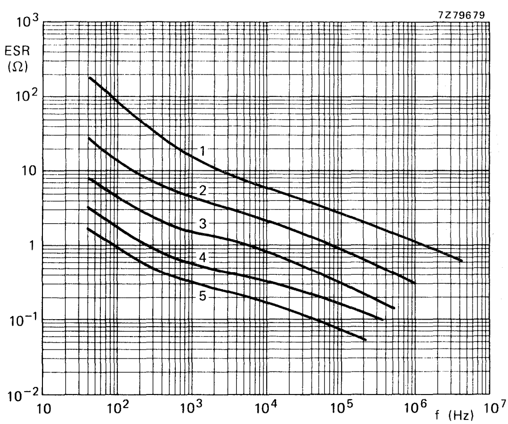


Fig. 11 Typical ESR as a function of frequency at T_{amb} = 25 °C; **case size 4.**

Curve 1 = 1,5 μF, 40 V;
curve 2 = 6,8 μF, 25 V;
curve 3 = 15 μF, 16 V;
curve 4 = 33 μF, 10 V;
curve 5 = 68 μF, 6,3 V.

Impedance

Maximum impedance at 100 kHz and T_{amb} = 25 °C, measured by means of a four-terminal circuit (Thomson circuit) — see Table 2

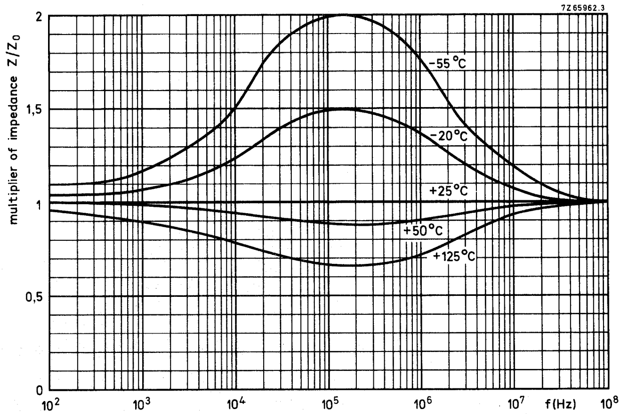


Fig. 12 Typical multiplier of impedance Z/Z_0 as a function of frequency at different temperatures; Z_0 = impedance initial value at T_{amb} = 25 °C.

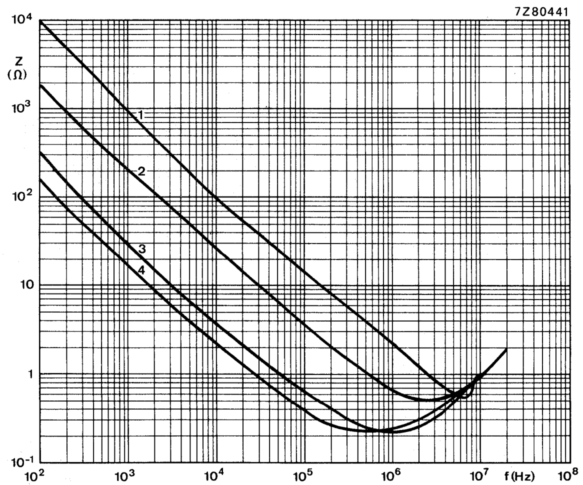


Fig. 13 Typical impedance as a function of frequency at T_{amb} = 25 °C; **case size 1.**

Curve 1 = 0,15 µF, 40 V;
curve 2 = 0,68 µF, 25 V;
curve 3 = 4,7 µF, 10 V;
curve 4 = 10 µF, 6,3 V.

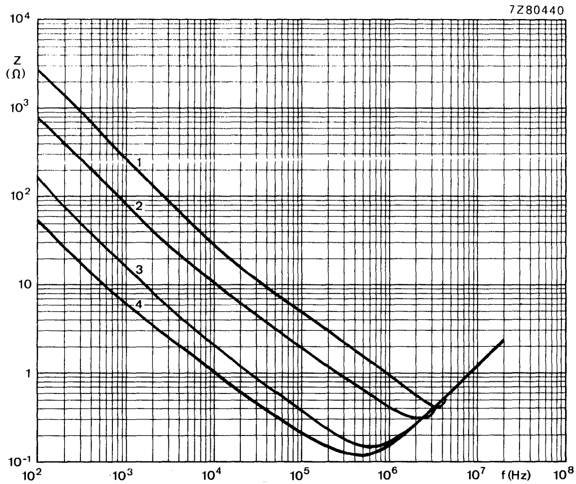


Fig. 14 Typical impedance as a function of frequency at T_{amb} = 25 °C; **case size 2.**

Curve 1 = 0,47 μF, 40 V;
curve 2 = 2,2 μF, 25 V;
curve 3 = 10 μF, 10 V;
curve 4 = 22 μF, 6,3 V.

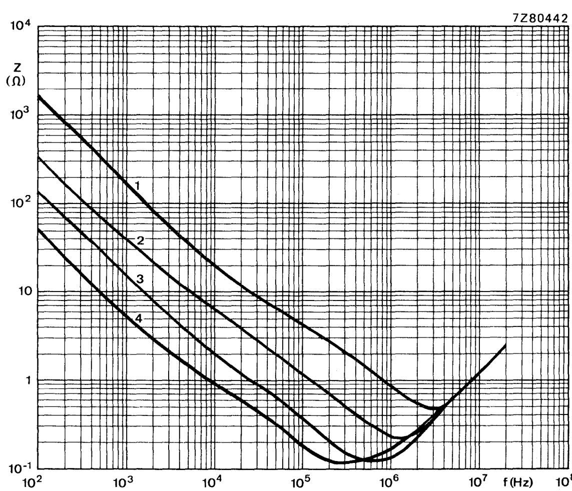


Fig. 15 Typical impedance as a function of frequency at T_{amb} = 25 °C; **case size 3.**

Curve 1 = 1 μF, 40 V;
curve 2 = 4,7 μF, 25 V;
curve 3 = 10 μF, 16 V;
curve 4 = 33 μF, 6,3 V.

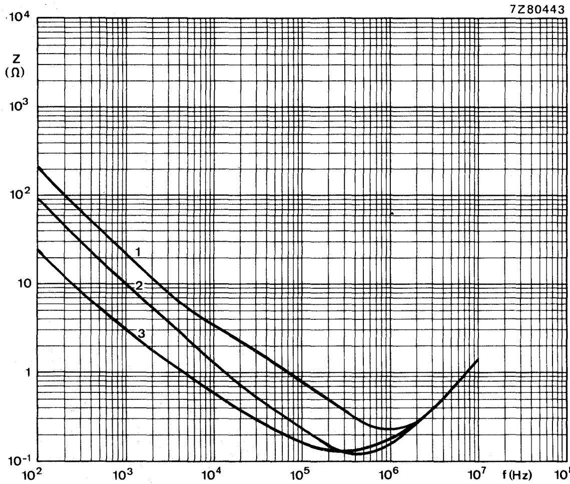


Fig. 16 Typical impedance as a function of frequency at T_{amb} = 25 °C; **case size 4.**

Curve 1 = 6,8 μF, 25 V;
curve 2 = 15 μF, 16 V;
curve 3 = 68 μF, 6,3 V.

Equivalent series inductance (ESL)

Equivalent series inductance, measured by means of a four-terminal circuit (Thomson circuit), at 10 MHz; capacitor leads bent to a pitch of 5,1 mm

case sizes 1 and 2	max. 20 nH; typ. 9 to 14 nH
case sizes 3 and 4	max. 20 nH; typ. 11 to 16 nH

OPERATIONAL DATA

Category temperature range	
for rated voltage, 6,3 V to 25 V range	−55 to + 125 °C
for rated voltage, 40 V range	−55 to + 85 °C
for derated voltage, 40 V range	−55 to + 125 °C
Usable temperature range	−55 to + 175 °C
Typical life time	
at T_{amb} = 85 °C	> 20 000 h
at T_{amb} = 125 °C	> 10 000 h
at T_{amb} = 175 °C	> 2 000 h
Field failure rate	< 1 x 10^{-8}/h
Typical parameter change after endurance test at T_{amb} = 125 °C	see Figs. 17, 18 and 19

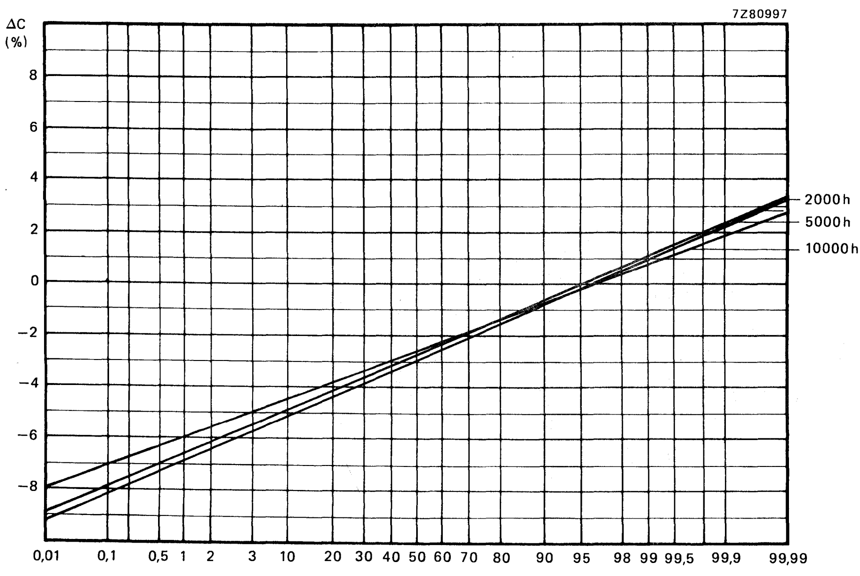


Fig. 17 Change of capacitance after endurance test.

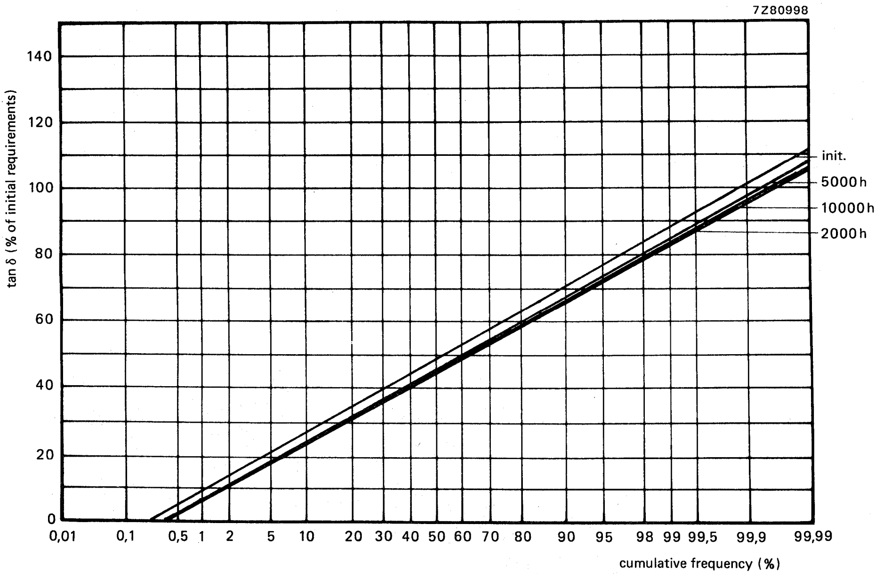


Fig. 18 Tan δ after endurance test.

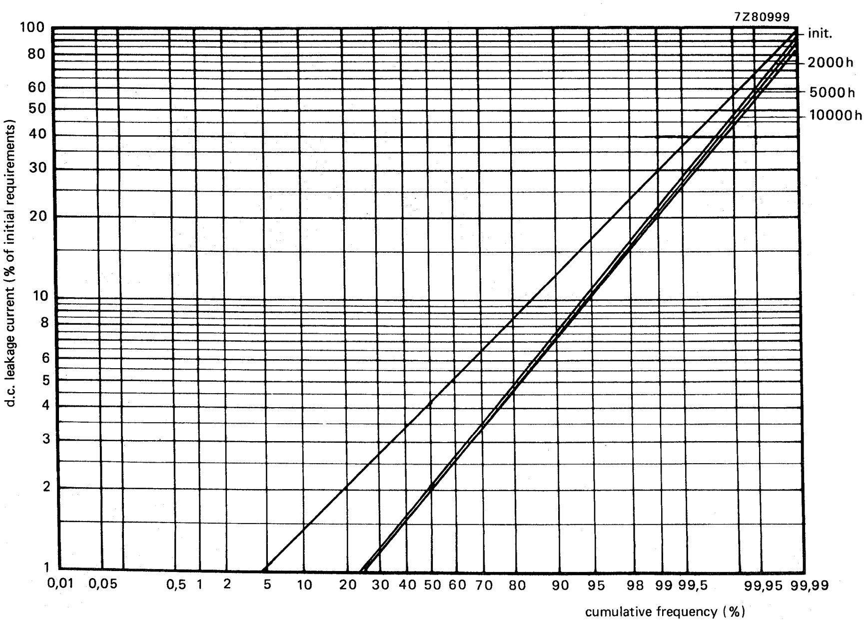


Fig. 19 D.C. leakage current after endurance test.

PACKING

Capacitors of styles 1 and 2 are supplied in boxes, those of styles 3 and 4 on tape on reel and in ammunition packing resp. The number of capacitors per box, per reel or per ammunition packing is:

style 1, all case sizes	: 1000 capacitors per box; 200 per plastic bag, 5 bags per box;
style 2, case sizes 1, 2 and 3	: 1000 capacitors per box, 200 per plastic bag, 5 bags per box;
style 2, case size 4	: 800 capacitors per box, 200 per plastic bag, 4 bags per box;
style 3, case sizes 1 and 2	: 2000 capacitors per reel;
style 3, case sizes 3 and 4	: 1000 capacitors per reel;
style 4, case sizes 1 and 2	: 2000 capacitors per ammunition packing;
style 4, case sizes 3 and 4	: 1000 capacitors per ammunition packing.

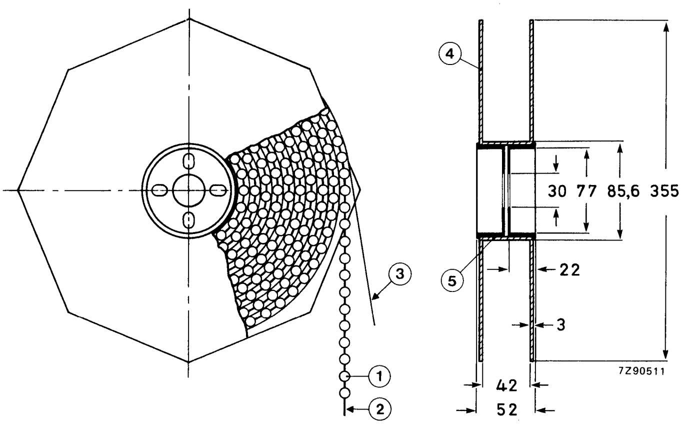


Fig. 20 Style 3 capacitors on tape on reel.
1 = capacitor
2 = tape
3 = paper
4 = flange
5 = cylinder

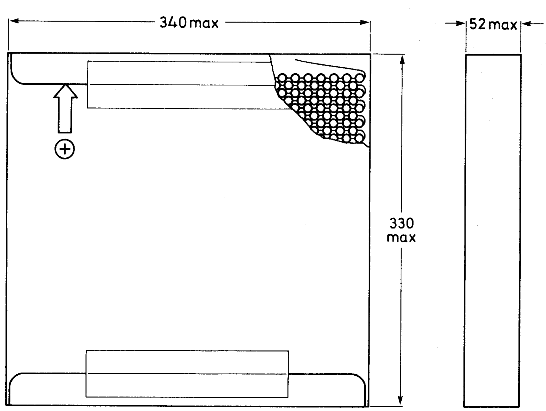


Fig. 21 Style 4 capacitors on tape in ammunition packing.

→ TESTS AND REQUIREMENTS

See Introduction, section 9, under solid aluminium capacitors, with the addition of the following tests.

Solvent resistance tests:

Severity 1, according to MIL-STD-202, method 215, including brushing of all portions of the specimens.

Solvents:
- deionized water (50 ± 5 °C);
- 1.1.1. trichloro-ethane;
- mixture of 25 vol. % 2-propanol (isopropanol) and 75 vol. % mineral spirits.
- mixture of 50,5 mass % 1.1.2-trichloro-1.2.2-trifluoroethane (fluorocarbon 113) and 49,5 mass % dichloromethane (methylene chloride, Freon TMC**).

Severity 2, according to IEC 68-2-45, and IEC 653, test XA with the following details and additions.

Conditions: immersion time of samples 5 min., at ambient temperature, at boiling temperature, in vapour of boiling solvent, and ultrasonic (40 kHz).

Solvents:
- deionized water (50 ± 5 °C);
- calgonite solution (20 g/l, 70 ± 5 °C);
- mixture of 4,5% 2-butoxyethanol, 4,5% 2-amino-ethanol, and 91% water (70 ± 5 °C);
- 1.1.1. trichloro-ethane;
- mixtures of 1.1.2-trichloro-1.2.2.-trifluoro-ethane (fluorocarbon 113) and the following solvents in the respective mass percentage ratios of these solvents to fluorocarbon;
  - 2-propanol (isopropanol), 25%: 75% (Arklone K*); up to the ratio 35%: 65%;
  - dichloromethane (methylene chloride), 49,5%: 50,5% (Freon TMC**);
  - ethanol, 4,5%: 95,5% (e.g. Arklone A*, Freon TE**);
  - methanol and nitromethane, (5,7%: 0,3%: 94% (Freon TMS**).

Requirement: visual appearance not affected.

Note: Tests are carried out using non-contaminated solvents.

Extended vibration test, according to IEC 68-2-6, test Fc: 10 to 2000 Hz, 1,5 mm or 20 g (whichever is less), 1 octave/min, 3 directions (mutually perpendicular), 1 sweep per direction, no voltage applied.

Requirements: no intermittent contacts; no breakdown; no open circuiting; no mechanical damage;
$\Delta C/C \leqslant 5\%$;
tan δ and h.f. impedance $\leqslant$ 1,2 x stated limit;
d.c. leakage current $\leqslant$ 1,5 x stated limit;
typical capability: up to 50 g (clamping both the body and the leads).

Shock test, according to IEC 68-2-27, test Ea: half sine or sawtooth pulse shape, 50 g, 11 ms, 3 successive shocks in each direction of 3 mutually perpendicular axes, no voltage applied.

Requirements: no intermittent contacts; no breakdown; no open circuiting; no mechanical damage;
$\Delta C/C \leqslant 5\%$;
tan δ and h.f. impedance $\leqslant$ 1,2 x stated limit;
d.c. leakage current $\leqslant$ 1,5 x stated limit;
typical capability: up to 100 g, also in combination with extended vibration test.

Passive flammability test, according to IEC 695-2-2, capacitor mounted to a vertical printed-wiring board, one flame on capacitor body, T_{amb} = 20 to 25 °C, test duration = 20 s.

Requirements: after removing the test flame from the capacitor, the capacitor must not continue to burn for more than 15 s; no burning particles must drop from the sample.

* Trade mark of I.C.I.
** Trade mark of Dupont de Nemours.

Survey of maximum permissible ripple voltage and ripple current values at various ambient temperatures and frequencies

Notes

- Zero d.c. voltage is assumed; at non-zero d.c. voltage the values in the tables can be adapted according to paragraphs "Ripple voltage" and "Ripple current".
- If the limiting current value given in the tables is applied, the voltage limit mentioned in "Ripple voltage, b", is not exceeded; if the limiting voltage value given in the tables is applied, the current limit calculated as in "Calculation of ripple currents" is not exceeded.

		frequency (Hz)																	
		1		50		100		300		600		1500		10^4		10^5		10^6	
C μF	T_{amb} ^oC	I_{ac} mA	V_P V	I_{ac} mA	V_P V	I_{ac} mA	V_P V	I_{ac} mA	V_P V	I_{ac} mA	V_P V	I_{ac} mA	V_P V	I_{ac} mA	V_P V	I_{ac} mA	V_P V	I_{ac} mA	V_P V
U_R = 6,3 V																			
10	25	0,1	3	9	5	18	5	54	5	108	5	166	3	203	0,6	229	0,1	244	0
	45	0,1	3	9	5	18	5	54	5	108	5	154	3	187	0,5	211	0,1	226	0
	65	0,1	3	9	5	18	5	54	5	108	5	141	2,5	172	0,5	194	0,1	207	0
	85	0,1	3	9	5	18	5	54	5	108	5	128	2,5	156	0,4	176	0,1	188	0
	125	0	1,5	5	2,5	9	2,5	27	2,5	54	2,5	64	1	78	0,2	88	0	94	0
15	25	0,2	3	13	5	27	5	81	5	161	5	208	2,5	254	0,5	286	0,1	306	0
	45	0,2	3	13	5	27	5	81	5	161	5	192	2,5	234	0,4	264	0,1	282	0
	65	0,2	3	13	5	27	5	81	5	160	5	176	2	215	0,4	242	0	259	0
	85	0,2	3	13	5	27	5	81	5	145	4,5	160	2	195	0,4	220	0	235	0
	125	0,1	1,5	7	2,5	13	2,5	40	2,5	73	2,5	80	1	98	0,2	110	0	118	0
22	25	0,2	3	20	5	39	5	118	5	226	5	250	2	304	0,4	343	0	367	0
	45	0,2	3	20	5	39	5	118	5	209	4,5	230	2	281	0,4	317	0	338	0
	65	0,2	3	20	5	39	5	118	5	191	4	211	2	257	0,3	290	0	310	0
	85	0,2	3	20	5	39	5	118	5	174	3,5	192	1,5	234	0,3	264	0	282	0
	125	0,1	1,5	10	2,5	20	2,5	59	2,5	87	2	96	0,8	117	0,2	132	0	141	0
33	25	0,3	3	30	5	59	5	177	5	283	4	312	2	380	0,3	429	0	458	0
	45	0,3	3	30	5	59	5	177	5	261	3,5	288	1,5	351	0,3	396	0	423	0
	65	0,3	3	30	5	59	5	177	5	239	3,5	264	1,5	322	0,3	363	0	388	0
	85	0,3	3	30	5	59	5	177	5	218	3	240	1,5	293	0,2	330	0	353	0
	125	0,2	1,5	15	2,5	30	2,5	89	2,5	109	1,5	120	0,7	146	0,1	65	0	176	0
47	25	0,5	3	42	5	84	5	253	5	358	3,5	395	1,5	482	0,3	543	0	581	0
	45	0,5	3	42	5	84	5	253	5	331	3,5	365	1,5	445	0,3	502	0	536	0
	65	0,5	3	42	5	84	5	253	5	303	3	334	1,5	408	0,2	460	0	491	0
	85	0,5	3	42	5	84	5	247	5	276	2,5	304	1	371	0,2	418	0	447	0
	125	0,2	1,5	21	2,5	42	2,5	124	2,5	138	1,5	152	0,6	185	0,1	209	0	223	0
68	25	0,7	3	61	5	122	5	365	5	434	3	478	1,5	583	0,2	658	0	703	0
	45	0,7	3	61	5	122	5	359	5	400	3	442	1	538	0,2	607	0	649	0
	65	0,7	3	61	5	122	5	329	4,5	367	2,5	405	1	493	0,2	557	0	595	0
	85	0,7	3	61	5	122	5	266	4	334	2,5	368	1	449	0,2	506	0	541	0
	125	0,3	1,5	31	2,5	61	2,5	150	2	167	1	814	0,5	224	0,1	253	0	270	0

C µF	T_{amb} °C	1 I_{ac} mA	1 V_P V	50 I_{ac} mA	50 V_P V	100 I_{ac} mA	100 V_P V	300 I_{ac} mA	300 V_P V	600 I_{ac} mA	600 V_P V	1500 I_{ac} mA	1500 V_P V	10^4 I_{ac} mA	10^4 V_P V	10^5 I_{ac} mA	10^5 V_P V	10^6 I_{ac} mA	10^6 V_P V
U_R = 10 V																			
4,7	25	0,1	4,5	7	8	13	8	40	8	80	8	125	5	152	0,9	172	0,1	183	0
	45	0,1	4,5	7	8	13	8	40	8	80	8	115	4,5	140	0,8	158	0,1	169	0
	65	0,1	4,5	7	8	13	8	40	8	80	8	106	4	129	0,8	145	0,1	155	0
	85	0,1	4,5	7	8	13	8	40	8	80	8	96	4	117	0,7	132	0,1	141	0
	125	0	2	3	4	7	4	20	4	40	4	48	2	59	0,4	66	0	71	0
6,8	25	0,1	4,5	10	8	19	8	58	8	116	8	146	4	178	0,7	200	0,1	214	0
	45	0,1	4,5	10	8	19	8	58	8	116	8	134	3,5	164	0,7	185	0,1	197	0
	65	0,1	4,5	10	8	19	8	58	8	112	7,5	123	3,5	150	0,6	169	0,1	181	0
	85	0,1	4,5	10	8	19	8	58	8	102	7	112	3	137	0,6	154	0,1	165	0
	125	0,1	2	5	4	10	4	29	4	51	3,5	56	1,5	68	0,3	77	0	82	0
10	25	0,2	4,5	14	8	28	8	85	8	151	7	166	3	203	0,6	229	0,1	244	0
	45	0,2	4,5	14	8	28	8	85	8	139	6,5	154	3	187	0,5	211	0,1	226	0
	65	0,2	4,5	14	8	28	8	85	8	128	6	141	2,5	172	0,5	194	0,1	207	0
	85	0,2	4,5	14	8	28	8	85	8	116	5,5	128	2,5	156	0,4	176	0,1	188	0
	125	0,1	2	7	4	14	4	43	4	58	2,5	64	1	78	0,2	88	0	94	0
15	25	0,2	4,5	21	8	43	8	128	8	189	6	208	2,5	254	0,5	286	0,1	306	0
	45	0,2	4,5	21	8	43	8	128	8	174	5,5	192	2,5	234	0,4	264	0,1	282	0
	65	0,2	4,5	21	8	43	8	128	8	160	5	176	2	215	0,4	242	0	259	0
	85	0,2	4,5	21	8	43	8	128	8	145	4,5	160	2	195	0,4	220	0	235	0
	125	0,1	2	11	4	21	4	64	4	73	2,5	80	1	98	0,2	110	0	118	0
22	25	0,4	4,5	31	8	63	8	188	8	116	5	250	2	304	0,4	343	0	367	0
	45	0,4	4,5	31	8	63	8	187	8	209	4,5	230	2	281	0,4	317	0	338	0
	65	0,4	4,5	31	8	63	8	172	7,5	191	4	211	2	257	0,3	290	0	310	0
	85	0,4	4,5	31	8	63	8	156	6,5	174	3,5	192	1,5	234	0,3	264	0	282	0
	125	0,2	2	16	4	31	4	78	3,5	87	2	96	0,8	117	0,2	132	0	141	0
33	25	0,5	4,5	47	8	94	8	270	7,5	302	4,5	333	2	406	0,3	458	0	489	0
	45	0,5	4,5	47	8	94	8	250	7	278	4	307	1,5	374	0,3	422	0	451	0
	65	0,5	4,5	47	8	94	8	229	6,5	255	3,5	282	1,5	343	0,3	387	0	414	0
	85	0,5	4,5	47	8	94	8	208	6	232	3,5	256	1,5	312	0,3	352	0	376	0
	125	0,3	2	24	4	47	4	104	3	116	1,5	128	0,7	156	0,1	176	0	188	0

Column groups: frequency (Hz).

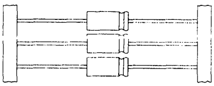
		frequency (Hz)																	
		1		50		100		300		600		1500		10^4		10^5		10^6	
C μF	T_{amb} °C	I_{ac} mA	V_P V	I_{ac} mA	V_P V	I_{ac} mA	V_P V	I_{ac} mA	V_P V	I_{ac} mA	V_P V	I_{ac} mA	V_P V	I_{ac} mA	V_P V	I_{ac} mA	V_P V	I_{ac} mA	V_P V
U_R = 16 V																			
2,2	25	0,1	7	5	13	10	13	30	13	60	13	104	9	127	1,5	143	0,2	153	0
	45	0,1	7	5	13	10	13	30	13	60	13	96	8	117	1,5	132	0,2	141	0
	65	0,1	7	5	13	10	13	30	13	60	13	88	7,5	107	1,5	121	0,2	129	0
	85	0,1	7	5	13	10	13	30	13	60	13	80	7	98	1	110	0,1	118	0
	125	0	3,5	3	6,5	5	6,5	15	6,5	30	6,5	40	3,5	49	0,6	55	0,1	59	0
3,3	25	0,1	7	8	13	15	13	45	13	90	13	125	7	152	1,5	172	0,1	183	0
	45	0,1	7	8	13	15	13	45	13	90	13	115	6,5	140	1	158	0,1	169	0
	65	0,1	7	8	13	15	13	45	13	90	13	106	6	129	1	145	0,1	155	0
	85	0,1	7	8	13	15	13	45	13	87	12,5	96	5,5	117	1	132	0,1	141	0
	125	0	3,5	4	6,5	8	6,5	23	6,5	44	6	48	2,5	59	0,5	66	0,1	71	0
4,7	25	0,1	7	11	13	21	13	64	13	128	13	146	6	178	1	200	0,1	214	0
	45	0,1	7	11	13	21	13	64	13	122	12	134	5,5	164	1	185	0,1	197	0
	65	0,1	7	11	13	21	13	64	13	112	11	123	5	150	0,9	169	0,1	181	0
	85	0,1	7	11	13	21	13	64	13	102	10	112	4,5	137	0,8	154	0,1	165	0
	125	0,1	3,5	5	6,5	11	6,5	32	6,5	51	5	56	2	68	0,4	77	0	82	0
6,8	25	0,2	7	16	13	31	13	93	13	151	10,5	166	4,5	203	0,8	229	0,1	244	0
	45	0,2	7	16	13	31	13	93	13	139	9,5	154	4	187	0,8	211	0,1	226	0
	65	0,2	7	16	13	31	13	93	13	128	9	141	4	172	0,7	194	0,1	207	0
	85	0,2	7	16	13	31	13	93	13	116	8	128	3,5	156	0,6	176	0,1	188	0
	125	0,1	3,5	8	6,5	16	6,5	46	6,5	58	4	64	2	78	0,3	88	0	94	0
10	25	0,3	7	23	13	46	13	137	13	189	9	208	4	254	0,7	286	0,1	306	0
	45	0,3	7	23	13	46	13	137	13	174	8	192	3,5	234	0,7	264	0,1	282	0
	65	0,3	7	23	13	46	13	137	13	160	7,5	176	3,5	215	0,6	242	0,1	259	0
	85	0,3	7	23	13	46	13	130	12	145	7	160	3	195	0,5	220	0,1	235	0
	125	0,1	3,5	11	6,5	23	6,5	65	6	73	3,5	80	1,5	98	0,3	110	0	118	0
15	25	0,4	7	34	13	68	13	205	13	245	7,5	270	3,5	330	0,6	372	0,1	397	0
	45	0,4	7	34	13	68	13	203	12,5	226	7	250	3	304	0,6	343	0,1	367	0
	65	0,4	7	34	13	68	13	186	11,5	207	6,5	229	3	279	0,5	315	0,1	336	0
	85	0,4	7	34	13	68	13	169	10,5	189	6	208	2,5	254	0,5	286	0,1	306	0
	125	0,2	3,5	17	6,5	34	6,5	85	5,5	94	3	104	1,5	127	0,2	143	0	153	0

		frequency (Hz)																	
		1		50		100		300		600		1500		10^4		10^5		10^6	
C μF	T_{amb} °C	I_{ac} mA	V_P V	I_{ac} mA	V_P V	I_{ac} mA	V_P V	I_{ac} mA	V_P V	I_{ac} mA	V_P V	I_{ac} mA	V_P V	I_{ac} mA	V_P V	I_{ac} mA	V_P V	I_{ac} mA	V_P V
U_R = 25 V																			
0,68	25	0	11	2	20	5	20	15	20	29	20	58	16	71	3	80	0,3	86	0
	45	0	11	2	20	5	20	15	20	29	20	54	15	66	2,5	74	0,3	79	0
	65	0	11	2	20	5	20	15	20	29	20	49	13,5	60	2,5	68	0,3	72	0
	85	0	11	2	20	5	20	15	20	29	20	45	12,5	55	2,5	62	0,3	66	0
	125	0	5,5	1	10	2	10	7	10	15	10	22	6	27	1	31	0,1	33	0
1	25	0	11	4	20	7	20	21	20	43	20	67	12,5	81	2,5	92	0,3	98	0
	45	0	11	4	20	7	20	21	20	43	20	61	11,5	75	2	85	0,2	90	0
	65	0	11	4	20	7	20	21	20	43	20	56	10,5	69	2	77	0,2	83	0
	85	0	11	4	20	7	20	21	20	43	20	51	9,5	62	2	70	0,2	75	0
	125	0	5,5	2	10	4	10	11	10	21	10	26	5	31	0,9	35	0,1	38	0
1,5	25	0,1	11	5	20	11	20	32	20	64	20	83	10,5	101	2	114	0,2	122	0
	45	0,1	11	5	20	11	20	32	20	64	20	77	9,5	94	2	106	0,2	113	0
	65	0,1	11	5	20	11	20	32	20	64	20	70	9	86	1,5	97	0,2	103	0
	85	0,1	11	5	20	11	20	32	20	58	18	64	8	78	1,5	88	0,2	94	0
	125	0	5,5	3	10	5	10	16	10	29	9	32	4	39	0,7	44	0,1	47	0
2,2	25	0,1	11	8	20	16	20	47	20	94	20	104	9	127	1,5	143	0,2	153	0
	45	0,1	11	8	20	16	20	47	20	87	18,5	96	8	117	1,5	132	0,2	141	0
	65	0,1	11	8	20	16	20	47	20	80	17	88	7,5	107	1,5	121	0,2	129	0
	85	0,1	11	8	20	16	20	47	20	73	15,5	80	7	98	1	110	0,1	118	0
	125	0	5,5	4	10	8	10	24	10	36	7,5	40	3,5	49	0,6	55	0,1	59	0
3,3	25	0,1	11	12	20	24	20	70	20	113	16	125	7	152	1,5	172	0,1	183	0
	45	0,1	11	12	20	24	20	70	20	104	15	115	6,5	140	1	158	0,1	169	0
	65	0,1	11	12	20	24	20	70	20	96	13,5	106	6	129	1	145	0,1	155	0
	85	0,1	11	12	20	24	20	70	20	87	12,5	96	5,5	117	1	132	0,1	141	0
	125	0,1	5,5	6	10	12	10	35	10	44	6	48	2,5	59	0,5	66	0,1	71	0
4,7	25	0,2	11	17	20	33	20	100	20	132	13	146	6	178	1	200	0,1	214	0
	45	0,2	11	17	20	33	20	100	20	122	12	134	5,5	164	1	185	0,1	197	0
	65	0,2	11	17	20	33	20	100	20	112	11	123	5	150	0,9	169	0,1	181	0
	85	0,2	11	17	20	33	20	91	18	102	10	112	4,5	137	0,8	154	0,1	165	0
	125	0,1	5,5	8	10	17	10	46	9	51	5	56	2	68	0,4	77	0	82	0
6,8	25	0,3	11	24	20	48	20	145	20	170	11,5	187	5	228	0,9	257	0,1	275	0
	45	0,3	11	24	20	48	20	140	19,5	157	11	173	5	211	0,9	238	0,1	254	0
	65	0,3	11	24	20	48	20	129	17,5	144	10	158	4,5	193	0,8	218	0,1	233	0
	85	0,3	11	24	20	48	20	117	16	131	9	144	4	176	0,7	198	0,1	212	0
	125	0,1	5,5	12	10	24	10	59	8	65	4,5	72	2	88	0,4	99	0	106	0

C	T_{amb}	frequency (Hz) 1		10		100		300		600		1500		10^4		10^5		10^6	
		I_{ac}	V_P	I_{ac}	V_P	I_{ac}	V_P	I_{ac}	V_P	I_{ac}	V_P	I_{ac}	V_P	I_{ac}	V_P	I_{ac}	V_P	I_{ac}	V_P
μF	°C	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
U_R = 40 V																			
0,1	25	0	18	0,6	32	1	32	3	32	7	32	17	32	25	7	29	0,8	31	0,1
	45	0	18	0,6	32	1	32	3	32	7	32	17	32	23	6,5	26	0,7	28	0,1
	65	0	18	0,6	32	1	32	3	32	7	32	17	32	22	6	24	0,7	26	0,1
	85	0	18	0,6	32	1	32	3	32	7	32	16	30	20	5,5	22	0,6	24	0,1
	125	0	9	0,2	10	0,4	10	1	10	2	10	5	10	10	3	11	0,3	12	0
0,15	25	0	18	0,9	32	2	32	5	32	10	32	25	31,5	30	5,5	34	0,6	37	0,1
	45	0	18	0,9	32	2	32	5	32	10	32	23	29	28	5,5	32	0,6	34	0,1
	65	0	18	0,9	32	2	32	5	32	10	32	21	26,5	26	5	29	0,5	31	0,1
	85	0	18	0,9	32	2	32	5	32	10	32	19	24	23	4,5	26	0,5	28	0,1
	125	0	9	0,3	10	0,5	10	2	10	3	10	8	10	12	2	13	0,2	14	0
0,22	25	0	18	1	32	3	32	8	32	15	32	33	28,5	41	5	46	0,6	49	0,1
	45	0	18	1	32	3	32	8	32	15	32	31	26	37	5	42	0,5	45	0,1
	65	0	18	1	32	3	32	8	32	15	32	28	24	34	4,5	39	0,5	41	0,1
	85	0	18	1	32	33	32	8	32	15	32	26	22	31	4	35	0,5	38	0
	125	0	9	0,4	10	0,8	10	2	10	5	10	12	10	16	2	18	0,2	19	0
0,33	25	0	18	2	32	4	32	11	32	23	32	42	23,5	51	4,5	57	0,5	61	0,1
	45	0	18	2	32	4	32	11	32	23	32	38	22	47	4	53	0,5	56	0
	65	0	18	2	32	4	32	11	32	23	32	35	20	43	3,5	48	0,4	52	0
	85	0	18	2	32	4	32	11	32	23	32	32	18	39	3,5	44	0,4	47	0
	125	0	9	0,6	10	1	10	4	10	7	10	16	9	20	1,5	22	0,2	24	0
0,47	25	0	18	3	32	5	32	16	32	32	32	50	20	61	3,5	69	0,4	73	0
	45	0	18	3	32	5	32	16	32	32	32	46	18,5	56	3,5	63	0,4	68	0
	65	0	18	3	32	5	32	16	32	32	32	42	17	52	3	58	0,3	62	0
	85	0	18	3	32	5	32	16	32	32	32	38	15,5	47	3	53	0,3	56	0
	125	0	9	0,8	10	2	10	5	10	10	10	19	7,5	23	1,5	26	0,2	28	0
0,68	25	0	18	4	32	8	32	23	32	46	32	58	16	71	3	80	0,3	86	0
	45	0	18	4	32	8	32	23	32	46	32	54	15	66	2,5	74	0,3	79	0
	65	0	18	4	32	8	32	23	32	45	31	49	13,5	60	2,5	68	0,3	72	0
	85	0	18	4	32	8	32	23	32	41	28	45	12,5	55	2,5	62	0,3	66	0
	125	0	9	1	10	2	10	7	10	15	10	22	6	27	1	31	0,1	33	0
1	25	0,1	18	6	32	11	32	34	32	60	28,5	67	12,5	81	2,5	92	0,3	98	0
	45	0,1	18	6	32	11	32	34	32	56	26	61	11,5	75	2	85	0,2	90	0
	65	0,1	18	6	32	11	32	34	32	51	24	56	10,5	69	2	77	0,2	83	0
	85	0,1	18	6	32	11	32	34	32	46	22	51	9,5	62	2	70	0,2	75	0
	125	0	9	2	10	4	10	11	10	21	10	26	5	31	0,9	35	0,1	38	0
1,5	25	0,1	18	9	32	17	32	51	32	75	23,5	83	10,5	101	2	114	0,2	122	0
	45	0,1	18	9	32	17	32	51	32	70	22	77	9,5	94	2	106	0,2	113	0
	65	0,1	18	9	32	17	32	51	32	64	20	70	9	86	1,5	97	0,2	103	0
	85	0,1	18	9	32	17	32	51	32	58	18	64	8	78	1,5	88	0,2	94	0
	125	0	9	3	10	5	10	16	10	29	9	32	4	39	0,7	44	0,1	47	0
2,2	25	0,1	18	13	32	25	32	75	32	94	20	104	9	127	1,5	143	0,2	153	0
	45	0,1	18	13	32	25	32	75	32	87	18,5	96	8	117	1,5	132	0,2	141	0
	65	0,1	18	13	32	25	32	72	30,5	80	17	88	7,5	107	1,5	121	0,2	129	0
	85	0,1	18	13	32	25	32	65	27,5	73	15,5	80	7	98	1	110	0,1	118	0
	125	0,1	9	4	10	8	10	24	10	36	7,5	40	3,5	49	0,6	55	0,1	59	0

SOLID ALUMINIUM CAPACITORS

- **Enhanced capacitance**
- **Small type**
- **Axial leads; metal case; ceramic seal**
- **Long life**
- **High reliability**
- **Industrial and military applications**



QUICK REFERENCE DATA

Nominal capacitance range (E6 series)	2,2 to 2200 μF
Tolerance on nominal capacitance	± 20% (± 10% to special order)
Rated voltage range, U_R	4 to 40 V
Category temperature range	−55 to + 125 °C
Usable temperature range	−80 to + 200 °C
Endurance test	5000 h at 125 °C 2000 h at 150 °C
Basic specification	IEC 384-4, long-life grade
Climatic category, IEC 68	55/125/56
DIN 40040	EHC/JQ/TW
NF C20-600	434
Approval	Liste LNZ 44-04 COS-C gam-t-1

Selection chart for C_{nom}-U_R and relevant case sizes.

C_{nom}	U_R (V)							
	4	6,3	10	16	20	25	35	40
2,2							1	1
3,3							1	1
4,7							1	1
6,8							1	1
10				1	1	1	2A	2A
15				1	1	1	2A	2A
22				1		2A	2A	4
33			1	2A		2A	4	4
47		1	1	2A	2A	2A*	4	5
68	1	1	2A	2A		4	5	5
100	1		2A	4	4	4	6	6
150		2A	4	4	5	5	6*	
220	2A		4	5	5	6		
330		4	5	5	6	6		
470	4		5	6	6			
680		5	6	6				
1000	5	6	6					
1500	6	6						
2200	6							

case size	nominal dimensions (mm)
1	Ø 6,5 x 15
2A	Ø 7,5 x 20
4	Ø 9 x 22,5
5	Ø 10 x 31,5
6	Ø 12,5 x 31,5

* Available to special order.

APPLICATION

These capacitors with high CU-product per unit volume, utilize advanced technology to achieve long life, high stability, excellent reliability, high ripple current rating and low temperature dependence. The capacitors are not subject to a limitation on charge or discharge currents and they will function in circuits where voltage reversal may occur.
The taped versions are suitable for automatic insertion and for cutting and forming equipment.

DESCRIPTION

The capacitors have highly etched aluminium foil electrodes separated by a layer of glass fabric and filled with solid, semiconductive, pyrolitically formed manganese dioxide. The capacitors are housed in an aluminium case and are sealed by a ceramic disc. The cathode lead is welded to the case.

The capacitors are available in 4 styles, all with soldered-copper leads;
- style 1: axial leads, case insulated with a blue transparant plastic sleeve; supplied on bandoliers in box;
- style 2: as style 1, however supplied on bandoliers on reel;
- style 3: single-ended, case insulated with a blue transparant plastic sleeve;
- style 4: single-ended, case fitted in a yellow plastic foot; available to special order.

Note: A special version is available, which is partly epoxy-filled, withstanding severe shock and vibration tests; see also paragraph "Tests and requirements".

MECHANICAL DATA

Dimensions in mm

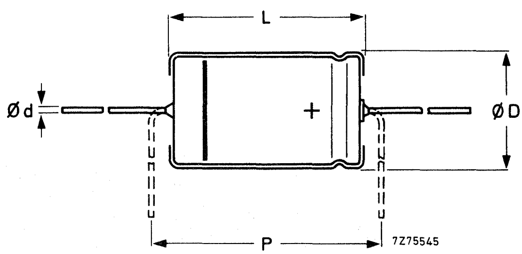


Fig. 1a Styles 1 and 2; for dimensions d, D, L and P, see Table 1a.

Table 1a

case size	d*		D_{nom}	L_{nom}	D_{max}	L_{max}	P_{min}	mass** approx. g
1	0,6	+0,06 −0,05	6,5	15	6,7	15,3	20	1,2
2A	0,6		7,5	20	7,6	20,4	22,5	2,4
4	0,6		9	22,5	9,3	23,3	25	3,3
5	0,8	+0,08 −0,05	10	31,5	10,3	32	35	4,5
6	0,8		12,5	31,5	12,9	32	35	6,3

* Tolerance according to IEC 301; not applicable to a length of 2 mm from the lead ends, which is covered by the bandoliers.

** Add 10% for epoxy-filled version.

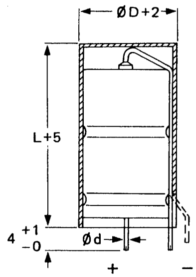


Fig. 1b Style 3; for dimensions d, D and L see Table 1a. Available to special order.

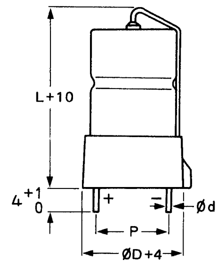


Fig. 1c Style 4; for dimensions d, D, L and P see Table 1a. Available to special order.

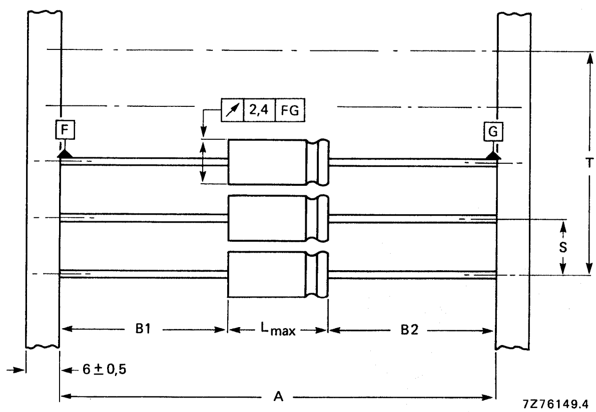


Fig. 2 Capacitors (style 1 and 2) on bandoliers; the bandoliers to which the negative capacitor terminals are connected is blue. See Table 1b for dimensions A, S, T and L_{max}.
$|B1-B2| = 1,4 + (L_{max}-L)$ mm max.

Table 1b

case size	A	S	T for number (n) of capacitors		L_{max}
			n < 50	50 < n < 100	
1	73 ± 1,6	10 ± 0,4	10 (n-1) ± 2	10 (n-1) ± 4	15,3
2A	73 ± 1,6	10 ± 0,4	10 (n-1) ± 2	10 (n-1) ± 4	20,4
4	73 ± 1,6	10 ± 0,4	10 (n-1) ± 2	10 (n-1) ± 4	23,3
5	73 ± 1,6	15 ± 0,75	10 (n-1) ± 2	10 (n-1) ± 4	32
6	73 ± 1,6	15 ± 0,75	10 (n-1) ± 2	10 (n-1) ± 4	32

Marking

The capacitors are marked with: group number (123), capacitance, tolerance, rated voltage at corresponding maximum temperature, date code, a band to identify the negative terminal, "+" signs for the positive terminal and name of manufacturer.

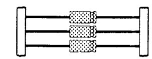
Mounting

No special provisions are required for soldering to the tinned leads.
(2 mm of the anode lead nearest the body are not solderable).

ELECTRICAL DATA

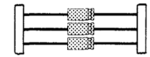
Unless otherwise specified all electrical values in Table 2 apply at an ambient temperature of 20 to 25 °C, a frequency of 100 Hz, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 45 to 75%.
See also the corresponding paragraphs.

Table 2



U_R*	nom. cap.	max. r.m.s. ripple current at T_{amb} = 125 °C, no d.c. voltage applied	max. d.c. leakage current at U_R after 1 min**	max. tan δ	max. ESR	max. impedance at 100 kHz**	case size	catalogue number▲ 2222 123 followed by: style 1	style 2	epoxy-filled version
V	μF	mA	μA		Ω	Ω				
4	68	53	19	0,25	7,3	1,2	1	12689	22689	62689
	100	77	28	0,25	5,0	1,2	1	12101	22101	62101
	220	160	60	0,25	2,3	1,0	2A	12221	22221	62221
	470	300	130	0,25	1,1	0,4	4	12471	22471	62471
	1000	630	280	0,25	0,50	0,3	5	12102	22102	62102
	1500	950	420	0,25	0,33	0,2	6	12152	22152	62152
	2200	1250	610	0,25	0,23	0,2	6	12222	22222	62222
6,3	47	58	21	0,18	7,6	1,2	1	13479	23479	63479
	68	83	30	0,18	5,3	1,2	1	13689	23689	63689
	150	160	65	0,18	2,4	1,0	2A	13151	23151	63151
	330	330	150	0,18	1,1	0,4	4	13331	23331	63331
	680	680	300	0,18	0,55	0,3	5	13681	23681	63681
	1000	940	440	0,18	0,36	0,2	6	13102	23102	63102
	1500	1220	660	0,18	0,24	0,2	6	13152	23152	63152

* Up to T_{amb} = 125 °C.
** Capacitors with lower values of max. d.c. leakage current or max. impedance are available to special order.
▲ Catalogue numbers are given for capacitors with tolerance ± 20%; for ± 10% tolerance replace the first digits in the columns by 4 (style 1), 7 (epoxy-filled version) or 8 (epoxy-filled version, level S certified).

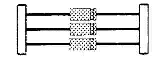


U_R*	nom. cap.	max. r.m.s. ripple current at T_{amb} = 125 °C, no d.c. voltage applied	max. d.c. leakage current at U_R after 1 min**	max. tan δ	max. ESR	max. impedance at 100 kHz**	case size	catalogue number▲ 2222 123 followed by		
								style 1	style 2	epoxy-filled version
V	μF	mA	μA		Ω	Ω				
10	33	63	23	0,18	11	1,2	1	14339	24339	64339
	47	83	35	0,18	7,6	1,2	1	14479	24479	64479
	68	110	50	0,18	5,3	1,0	2A	14689	24689	64689
	100	160	70	0,18	3,6	1,0	2A	14101	24101	64101
	150	240	100	0,18	2,4	0,4	4	14151	24151	64151
	220	350	150	0,18	1,7	0,4	4	14221	24221	64221
	330	490	230	0,18	1,1	0,3	5	14331	24331	64331
	470	570	330	0,18	0,8	0,3	5	14471	24471	64471
	680	760	480	0,18	0,55	0,2	6	14681	24681	64681
	1000	1000	700	0,18	0,36	0,2	6	14102	24102	64102
16	10	31	16	0,14	28	2,5	1	15109	25109	65109
	15	47	24	0,14	19	2,5	1	15159	25159	65159
	22	63	35	0,14	13	2,5	1	15229	25229	65229
	33	89	55	0,14	8,4	2,0	2A	15339	25339	65339
	47	120	75	0,14	5,9	2,0	2A	15479	25479	65479
	68	180	110	0,14	4,1	2,0	2A	15689	25689	65689
	100	260	160	0,14	2,8	0,8	4	15101	25101	65101
	150	310	240	0,16	2,1	0,8	4	15151	25151	65151
	220	420	350	0,16	1,5	0,6	5	15221	25221	65221
	330	510	500	0,16	1,0	0,6	5	15331	25331	65331
	470	680	750	0,16	0,7	0,4	6	15471	25471	65471
	680	850	870	0,16	0,5	0,4	6	15681	25681	65681

* Up to T_{amb} = 125 °C.

** Capacitors with lower values of max. d.c. leakage current or max. impedance are available to special order.

▲ Catalogue numbers are given for capacitors with tolerance ± 20%; for ± 10% tolerance replace the first digits in the columns by 4 (style 1), 7 (epoxy-filled version) or 8 (epoxy-filled version, level S certified).

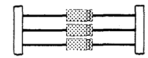
U_R*	nom. cap.	max. r.m.s. ripple current at T_{amb} = 125 °C, no d.c. voltage applied	max. d.c. leakage current at U_R after 1 min**	max. tan δ	max. ESR	max. impedance at 100 kHz**	case size	catalogue number▲ 2222 123 followed by 		
V	μF	mA	μA		Ω	Ω		style 1	style 2	epoxy-filled version
20	10	39	20	0,14	28	2,5	1	see Table 2a	see Table 2a	see Table 2a
	15	52	30	0,14	19	2,5	1			
	47	150	95	0,14	5,9	2,0	2A			
	100	270	200	0,14	2,8	0,8	4			
	150	350	300	0,16	2,1	0,6	5			
	220	420	440	0,16	1,5	0,6	5			
	330	570	660	0,16	1,0	0,4	6			
	470	720	940	0,16	0,7	0,4	6			
25	10	43	25	0,14	28	5	1	16109	26109	66109
	15	60	35	0,14	19	5	1	16159	26159	66159
	22	88	55	0,14	13	2,5	2A	16229	26229	66229
	33	130	85	0,14	8,4	2,5	2A	16339	26339	66339
	47▲▲	160	100	0,14	5,9	2,5	2A	16479	26479	66479
	68	230	170	0,14	4,1	1,0	4	16689	26689	66689
	100	250	250	0,16	3,1	1,0	4	16101	26101	66101
	150	350	400	0,16	2,1	0,8	5	16151	26151	66151
	220	460	550	0,16	1,5	0,6	6	16221	26221	66221
	330	600	800	0,16	1,0	0,6	6	16331	26331	66331

* Up to T_{amb} = 125 °C.

** Capacitors with lower values of max. d.c. leakage current or max. impedance are available to special order.

▲ Catalogue numbers are given for capacitors with tolerance ± 20%; for ± 10% tolerance replace the first digits in the columns by 4 (style 1), 7 (epoxy-filled version) or 8 (epoxy-filled version, level S certified).

▲▲ Available to special order.

U_R*	nom. cap.	max. r.m.s. ripple current at T_{amb} = 125 °C, no d.c. voltage applied	max. d.c. leakage current at U_R after 1 min**	max. tan δ	max. ESR	max. impedance at 100 kHz**	case size	catalogue number▲ 2222 123 followed by 		
V	μF	mA	μA		Ω	Ω		style 1	style 1	epoxy-filled version
35	2,2	10	5	0,12	109	7,5	1	97228	20228	60228
	3,3	14	7	0,12	73	7,5	1	97338	20338	60338
	4,7	20	10	0,12	51	7,5	1	97478	20478	60478
	6,8	27	15	0,12	35	7,5	1	97688	20688	60688
	10	37	20	0,12	24	2,5	2A	97109	20109	60109
	15	53	30	0,12	16	2,5	2A	97159	20159	60159
	22	78	45	0,12	11	2,5	2A	97229	20229	60229
	33	120	65	0,12	7,2	1,0	4	97339	20339	60339
	47	140	95	0,12	5,1	1,0	4	97479	20479	60479
	68	170	135	0,16	4,7	0,8	5	97689	20689	60689
	100	220	200	0,16	3,2	0,6	6	97101	20101	60101
	150▲▲	290	300	0,16	2,1	0,6	6	97151	20151	60151
40	2,2	11	9	0,12	109	7,5	1	17228	27228	67228
	3,3	16	13	0,12	73	7,5	1	17338	27338	67338
	4,7	22	19	0,12	51	7,5	1	17478	27478	67478
	6,8	28	27	0,12	35	7,5	1	17688	27688	67688
	10	41	40	0,12	24	2,5	2A	17109	27109	67109
	15	61	60	0,12	16	2,5	2A	17159	27159	67159
	22	89	90	0,12	11	1,5	4	17229	27229	67229
	33	120	130	0,12	7,2	1,0	4	17339	27339	67339
	47	160	190	0,12	5,1	1,0	5	17479	27479	67479
	68	170	270	0,16	4,7	0,8	5	17689	27689	67689
	100	220	400	0,16	3,2	0,6	6	17101	27101	67101

* Up to T_{amb} = 125 °C.

** Capacitors with lower values of max. d.c. leakage current or max. impedance are available to special order.

▲ Catalogue numbers are given for capacitors with tolerance ± 20%; for ± 10% tolerance replace the first digits in the columns by 4 (style 1), 7 (epoxy-filled version) or 8 (epoxy-filled version, level S certified).

▲▲ Available to special order.

Table 2a

U_R* V	case size	catalogue number 2222 123 followed by style 1 tol. ± 20%	style 1 tol. ± 10%	style 2 tol. ± 20%	style 2 tol. ± 10%	epoxy-filled version tol. ± 20%	epoxy-filled version tol. ± 10%	epoxy-filled version level S certified
20	1	90037	90137	90057	90157	90077	90177	90277
	1	90038	90138	90058	90158	90078	90178	90278
	2A	90042	90142	90062	90162	90082	90182	90282
	4	90044	90144	90064	90164	90084	90184	90284
	5	90045	90145	90065	90165	90085	90185	90285
	5	90046	90146	90066	90166	90086	90186	90286
	6	90047	90147	90067	90167	90087	90187	90287
	6	90048	90148	90068	90168	90088	90188	90288

* Up to T_{amb} = 125 °C.

Capacitance

Nominal capacitance values at 100 Hz and T_{amb} = 25 °C	see Table 2
Tolerance on nominal capacitance at 100 Hz	± 20% (± 10% to special order)

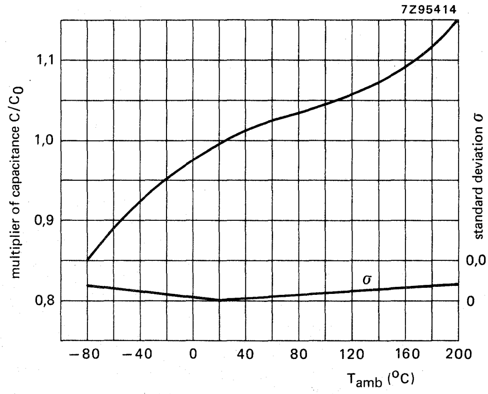


Fig. 3 Typical multiplier of capacitance as a function of ambient temperature.
C_0 = capacitance at 25 °C, 100 Hz.

Voltage

Rated voltage = max. permissible voltage	U_R
Derated voltage = max. permissible voltage at T_{amb} from 125 °C to 200 °C	0,63 x U_R
Surge voltage = max. permissible voltage for short periods at T_{amb} = 125 °C (see also "Test and requirements")	1,15 x U_R
Reverse voltage = max. d.c. voltage continuously (2000 h) applied in the reverse polarity,	
at $T_{amb} \leq 85$ °C	0,30 x U_R
at 85 °C $< T_{amb} \leq 125$ °C	0,15 x U_R

Ripple voltage =
max. permissible a.c. voltage providing the following four conditions are met:

a) Max. a.c. voltage, with negative d.c. voltage applied — 2 V

b) Max. peak a.c. voltage, without d.c. voltage applied — $U_R \times M_F \times M_T$
M_F = frequency multiplier, see Table below,
M_T = capacitor core temperature multiplier;
M_T = 1 for core temperatures ⩽ 85 °C,
$M_T = 1100/(T_{core} + 273) - 2{,}06$ for core temperatures > 85 °C.

frequency (Hz)	M_F
⩽ 0,1	0,30 x U_R
> 0,1 to 1	0,45 x U_R
> 1 to 10	0,60 x U_R
> 10 to 50	0,65 x U_R
> 50	0,80 x U_R

c) Momentary value of applied voltage, with positive d.c. voltage applied — between U_R (in the positive half wave) and the limits mentioned under b) (in the negative half wave)

d) Ripple voltage limits are not applicable if the maximum ripple current is exceeded. In that case the ripple current is decisive. Whichever is in practice decisive, depends on the actual impedance of the capacitor. In the Survey at the end of this data sheet the ripple current and ripple voltage limits can be found for each capacitor.

Ripple current

Maximum permissible r.m.s. ripple current at 100 Hz and T_{amb} = 125 °C — see Table 2

Maximum permissible r.m.s. ripple current at other frequencies and temperatures, at standard condition* — see Survey at the end of this data sheet

Maximum permissible r.m.s. ripple current at various application conditions — see Table 3

* See Table 3, condition A.

Table 3 Multiplier of ripple current for various application conditions

condition	multiplier
A. Standard condition: capacitor insulated with a blue sleeve, mounted horizontally on a vertical printed-circuit board with thermal conductivity of 0,4 $Wm^{-1}K^{-1}$, in free flowing air and in a surrounding that allows the absorption of radiation heat at 125 °C.	1,0
B. As under A but capacitor is not insulated.	0,83
C. As under A but capacitor is mounted horizontally at the bottom of a horizontal printed-circuit board	0,96
D. As under A but capacitor is mounted on a thermally well-conducting printed-circuit board.	1,08
E. As under A but capacitor is mounted on a thermally non-conducting printed-circuit board.	0,90
F. As under A but the surrounding walls etc. have a temperature higher than 125 °C and therefore prevent the absorption of heat by radiation	0,86
G. Capacitor has an ESR value lower than the maximum ESR.	$\sqrt{\frac{ESR_{max}}{ESR_{actual}}}$
H. As under A but capacitor is applied in low-density air, in particular at 10 km height.	0,94
J. As under A but capacitor is epoxy-filled (for severe shock and vibration resistance).	1,16

Notes

- If required the various multiplying factors can be multiplied together, e.g. if conditions B and C apply the multiplier is 0,83 x 0,96.
- Neither the maximum permissible ripple current nor the maximum permissible ripple voltage values are to be exceeded. Refer to the Tables at the end of this data sheet to find whether a current increase is permissible by the voltage limits.

Calculation of ripple currents

The maximum permissible ripple current ($I_{r\,max}$) is a function of temperature and frequency:

$I_{r\,max} = I_{r0}\sqrt{kr}$,

where I_{r0} = max. ripple current at 100 Hz and 125 °C (see Table 2);

$\sqrt{k}$ = temperature multiplier (neglecting the frequency dependence) = $\sqrt{P_{max}/P_{125}}$;

$\sqrt{r}$ = frequency multiplier (neglecting the temperature dependence) = $\sqrt{ESR_{100}/ESR_{max}}$;

while P_{max} = max. permissible power dissipation, temperature dependent;

P_{125} = max. permissible power dissipation at 125 °C = $I^2_{r0}\,ESR_{100}$;

ESR_{max} = max. equivalent series resistance, frequency dependent;

ESR_{100} = max. equivalent series resistance at 100 Hz.

The formula is derived for any temperature and frequency as follows:

$$I_{r\,max}^2 = P_{max}/ESR_{max}$$
$$= kr\,P_{125}/ESR_{100}$$
$$= kr\,I^2_{r0}\,ESR_{100}/ESR_{100}$$

Thus $I_{r\,max} = I_{r0}\sqrt{kr}$.

The values of the temperature multiplier $\sqrt{k}$ and P_{125} have been calculated allowing a capacitor core temperature of 145 °C and assuming the values of ESR_{max} to be independent of temperature at all frequencies.

The values of the frequency multiplier $\sqrt{r}$ have been measured at 25 °C and 125 °C assuming to be the same at all temperatures.

The power dissipation (P_{max}) has been calculated assuming it to be governed by the simplified relation:

$P_{max} = (\beta S + \gamma)\,\Delta T$;

where β = total heat transfer coefficient, comprising internal and external heat transfer, with exception of case ends and leads;

S = capacitor outer surface;

γ = correction factor covering the heat conduction through case end and leads;

ΔT = temperature difference between capacitor core and the ambient atmosphere, taken as 20 °C at T_{amb} = 125 °C.

For this calculation the standard condition (A, Table 3) has been assumed; in that case the following numerical values apply:

case	β ($Wm^{-2}K^{-1}$)	γ (WK^{-1})	P_{max} (W) = P_{125}
1	6,2	0,0042	0,13
2A	7,2	0,0042	0,16
4	8,5	0,0042	0,21
5	8,0	0,0042	0,26
6, low cap.	7,7	0,0042	0,32
6, high cap.	9,2	0,0042	0,36

The results for all combinations of ESR and case size are shown in Fig. 4.

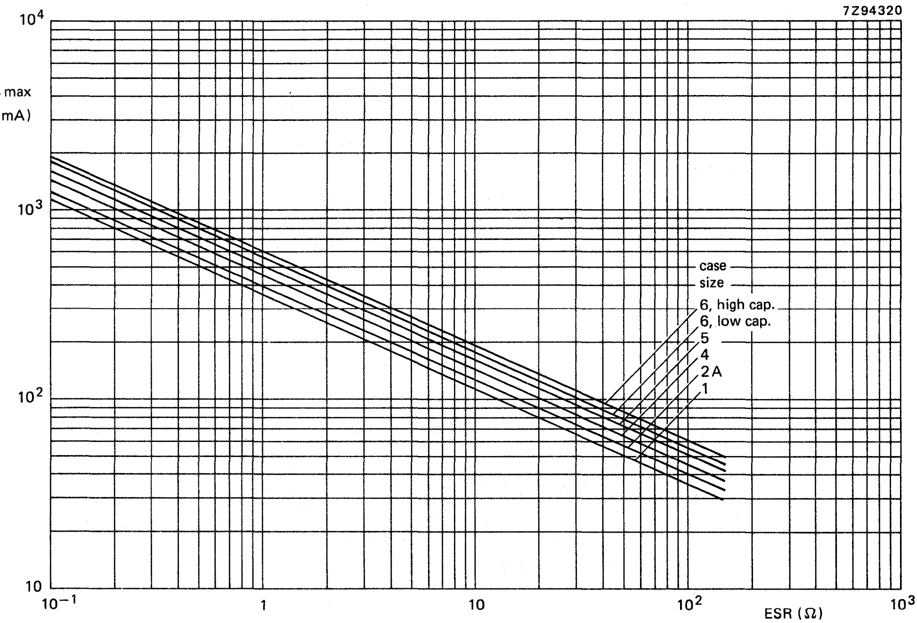


Fig. 4 Maximum permissible r.m.s. ripple current at T_{amb} = 125 °C as a function of ESR, at standard condition (A, Table 3).

As the ripple current and the ripple voltage depend on the capacitor impedance, which has a certain spread, one of the following situations occur:
– only the current is limiting;
– only the voltage is limiting;
– both current and voltage are limiting.

The tables at the end of this data sheet show the worst-case calculation: if the limiting current value given in the tables is applied, the voltage limit mentioned in "Ripple voltage, b", is not exceeded; if the limiting voltage value given in the tables is applied, the current limit calculated as in "Calculation of ripple currents" is not exceeded.

Charge and discharge current

The capacitors may be charged from a source without internal resistance and they may be discharged by short-circuiting. If the capacitors are charged and discharged continuously at a rate of several times per minute, the charge and discharge currents have to be considered as ripple currents flowing through the capacitor. The r.m.s. value of these currents should be determined and the value thus found must not exceed the applicable limit.

D.C. leakage current

Maximum d.c. leakage current 1 min after application of U_R, at T_{amb} = 25 °C	see Table 2 (max. 0,1 CU)
Maximum d.c. leakage current during continuous operation at U_R,	
at T_{amb} = 25 °C	approx. 0,5 x value stated in Table 2
at T_{amb} = 85 °C	approx. 2 x value stated in Table 2
at T_{amb} = 125 °C	approx. 7 x value stated in Table 2

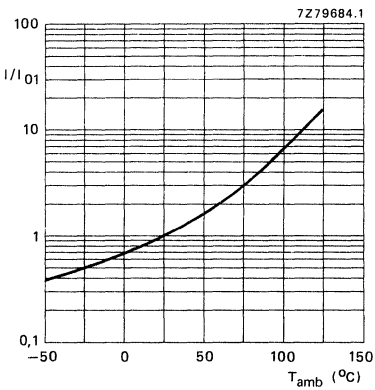


Fig. 5 Multiplier I/I_{01} as a function of temperature. I_{01} = d.c. leakage current during continuous operation at U_R, T_{amb} = 25 °C.

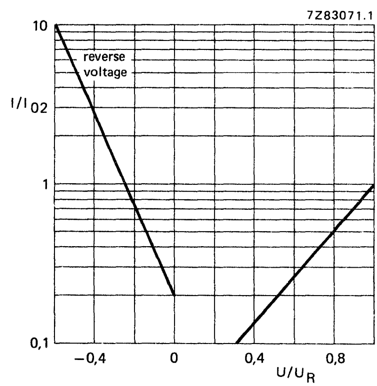


Fig. 6 Multiplier I/I_{02} as a function of U/U_R. I_{02} = d.c. leakage current at U_R at a discrete constant temperature

Tan δ (dissipation factor)

Maximum tan δ at 100 Hz and T_{amb} = 25 °C, measured by means of a four-terminal circuit (Thomson circuit)	see Table 2
Typical tan δ at 100 Hz and T_{amb} = 25 °C	0,6 x value stated in Table 2

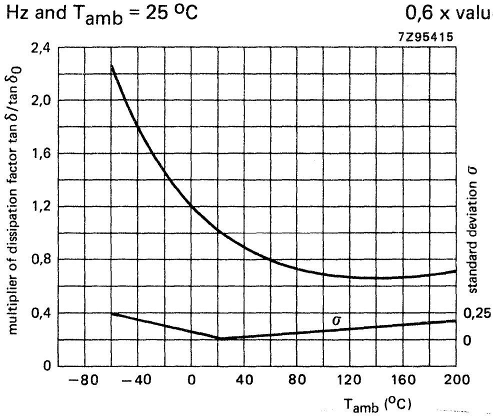
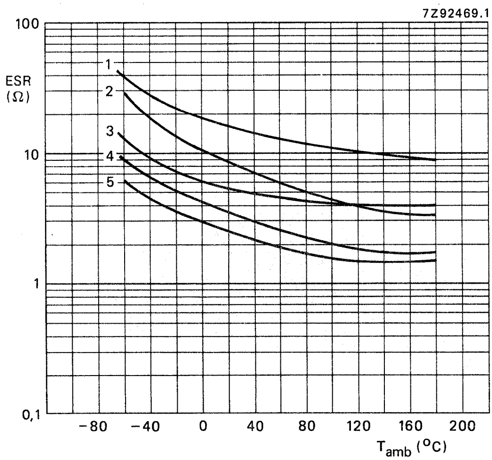


Fig. 7 Multiplier of dissipation factor as a function of ambient temperature; tan δ_0 = dissipation factor at 25 °C, 100 Hz.

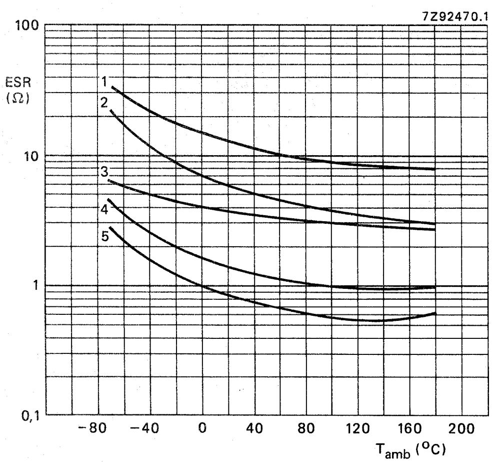
Equivalent series resistance (ESR = tan $\delta/\omega C$)

Maximum ESR at 100 Hz and T_{amb} = 25 °C (calculated from maximum tan δ and 0,8 x nominal capacitance)	see Table 2
Maximum ESR at 100 kHz and T_{amb} = 25 °C	equal to values of max. impedance at 100 kHz, see Table 2
Typical ESR	see graphs below; the standard deviation is 20% of each value



Curve 1 = 10 μF, 20 V and 25 V, and 6,8 μF, 35 V and 40 V;
curve 2 = 10 μF, 16 V;
curve 3 = 22 μF, 16 V;
curve 4 = 33 μF, 10 V;
curve 5 = 47 μF, 6,3 V and 10 V, and 68 μF, 4 V and 6,3 V.

Fig. 8 Typical ESR as a function of ambient temperature at 100 Hz, **case size 1.**



Curve 1 = 10 μF, 35 and 40 V;
curve 2 = 33 μF, 25 V;
curve 3 = 47 μF, 20 V and 25 V;
curve 4 = 68 μF, 10 V and 150 μF, 6,3 V;
curve 5 = 100 μF, 10 V.

Fig. 9 Typical ESR as a function of ambient temperature at 100 Hz, **case size 2A.**

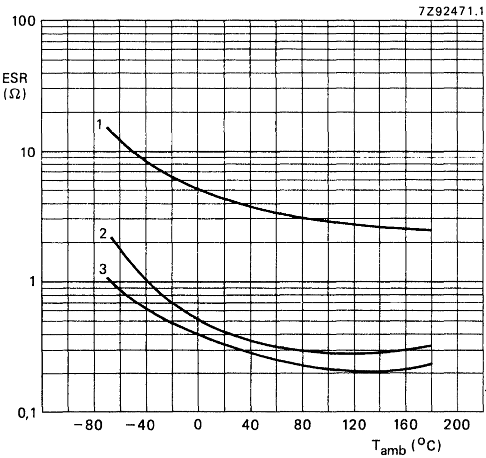


Fig. 10 Typical ESR as a function of ambient temperature at 100 Hz, **case size 4.**
Curve 1 = 33 μF, 35 V and 40 V;
curve 2 = 220 μF, 10 V and 330 μF, 6,3 V;
curve 3 = 470 μF, 4 V.

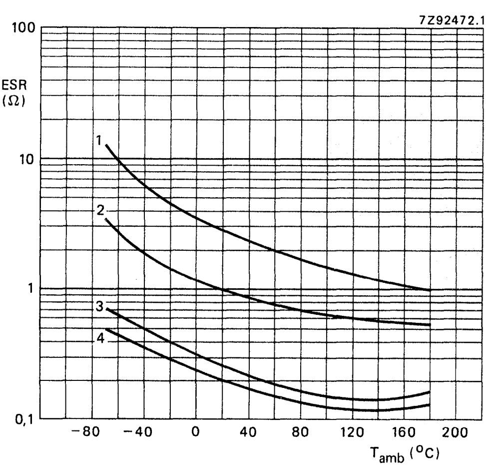


Fig. 11 Typical ESR as a function of ambient temperature at 100 Hz, **case size 5.**
Curve 1 = 68 μF, 35 V and 40 V;
curve 2 = 150 μF, 20 V and 25 V;
curve 3 = 330 μF, 10 V;
curve 4 = 470 μF, 10 V.

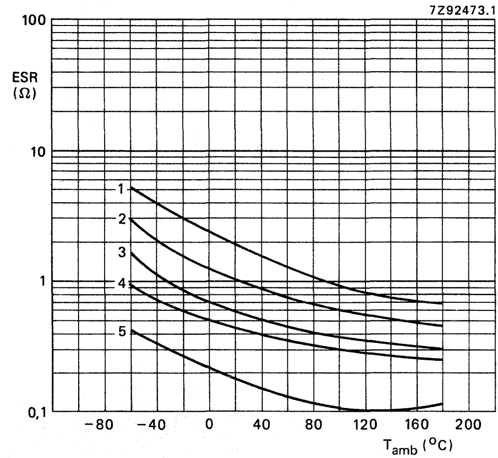


Fig. 12 Typical ESR as a function of ambient temperature at 100 Hz, **case size 6.**

Curve 1 = 100 μF, 35 and 40 V;
curve 2 = 150 μF, 35 V;
curve 3 = 220 μF, 25 V;
curve 4 = 470 μF, 16 V;
curve 5 = 1000 μF, 6,3 V and
680 μF, 10 V.

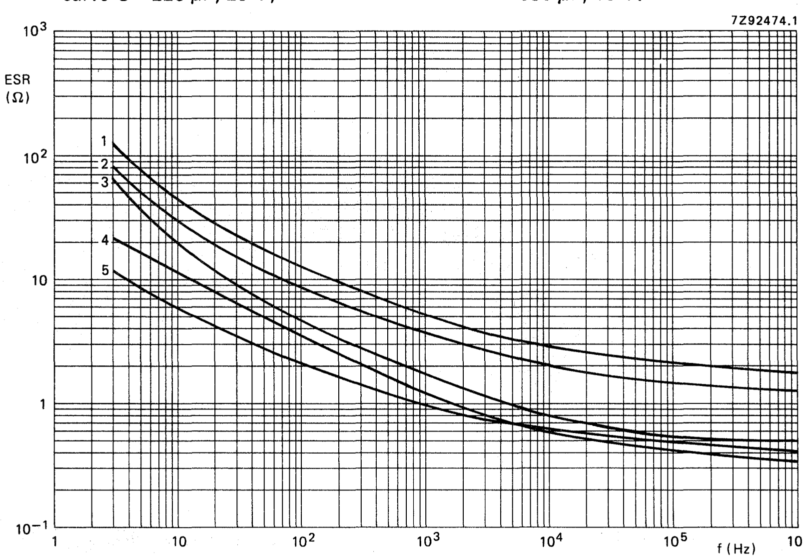


Fig. 13 Typical ESR as a function of frequency at T_{amb} = 25 °C, **case size 1.**

Curve 1 = 10 μF, 20 V and 25 V, and
6,8 μF, 35 V and 40 V;
curve 2 = 10 μF, 16 V;
curve 3 = 22 μF, 16 V;
curve 4 = 33 μF, 10 V;
curve 5 = 68 μF, 4 V and 6,3 V, and
47 μF, 6,3 V and 10 V.

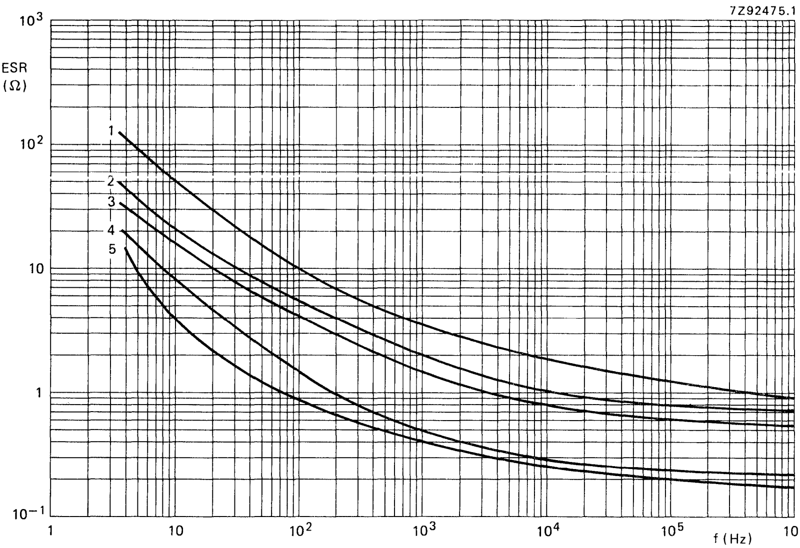


Fig. 14 Typical ESR as a function of frequency at T_{amb} = 25 °C, **case size 2A.**

Curve 1 = 10 μF, 35 V and 40 V;
curve 2 = 33 μF, 25 V;
curve 3 = 47 μF, 20 V and 25 V;
curve 4 = 68 μF, 10 V, and 150 μF, 6,3 V;
curve 5 = 100 μF, 10 V.

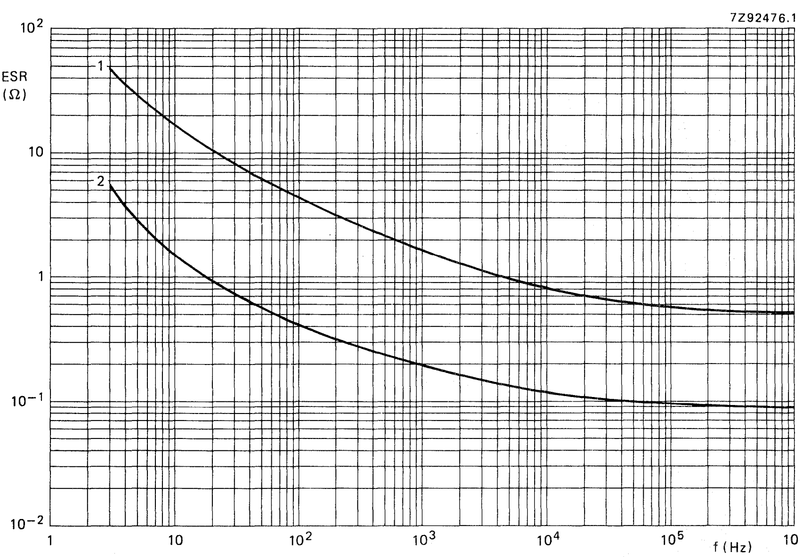


Fig. 15 Typical ESR as a function of frequency at T_{amb} = 25 °C, **case size 4.**

Curve 1 = 33 μF, 35 V and 40 V;
curve 2 = 220 μF, 10 V, 330 μF, 6,3 V and 470 μF, 4 V.

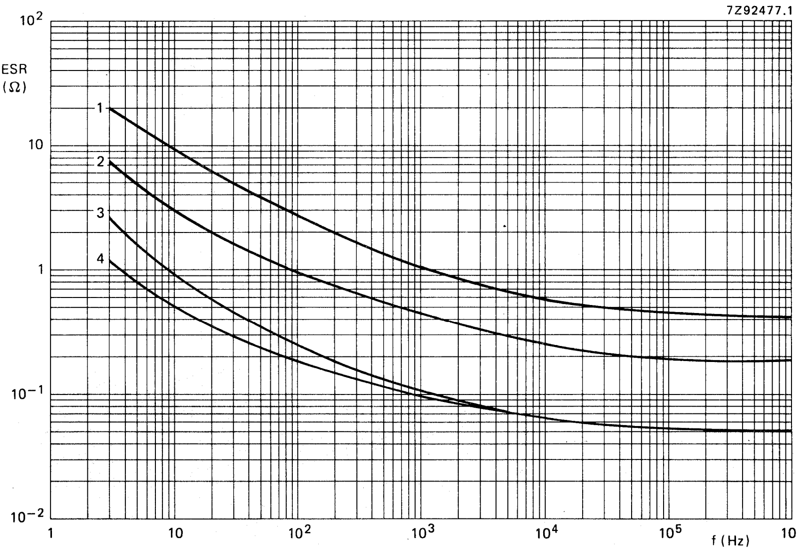


Fig. 16 Typical ESR as a function of frequency at T_{amb} = 25 °C, **case size 5.**

Curve 1 = 68 μF, 35 V and 40 V;
curve 2 = 150 μF, 20 V and 25 V;
curve 3 = 330 μF, 10 V;
curve 4 = 470 μF, 10 V.

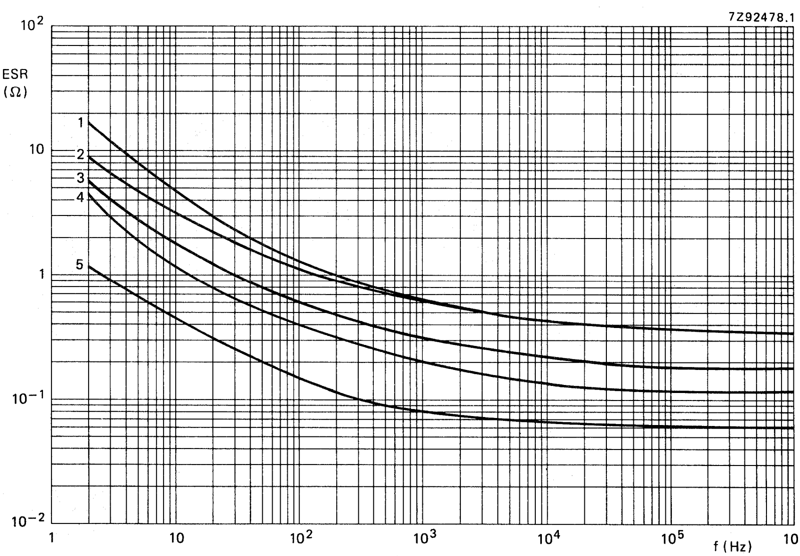


Fig. 17 Typical ESR as a function of frequency at T_{amb} = 25 °C, **case size 6.**

Curve 1 = 100 μF, 35 V and 40 V;
curve 2 = 150 μF, 35 V;
curve 3 = 220 μF, 25 V;
curve 4 = 470 μF, 16 V;
curve 5 = 1000 μF, 6,3 V and 680 μF, 10 V.

Impedance

Maximum impedance at 100 kHz and T_{amb} = 25 °C, measured by means of a four-terminal circuit (Thomson circuit) — see Table 2

Typical impedance at 100 kHz, and T_{amb} = 25 °C — 0,5 x value stated in Table 2

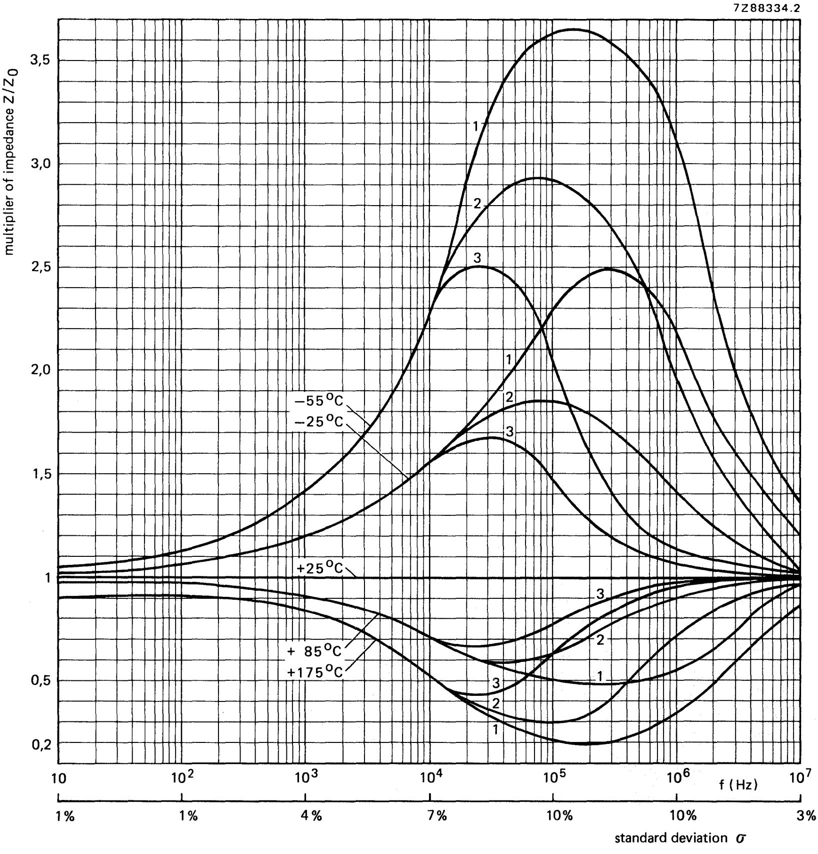


Fig. 18 Typical multiplier of impedance as a function of frequency at different ambient temperatures; Z_0 = initial impedance value at any frequency and T_{amb} = 25 °C.

Curves 1 = case sizes 1 and 2A, 16 to 40 V;
curves 2 = case sizes 1 and 2A, 4 to 10 V;
curves 3 = case sizes 4, 5 and 6.

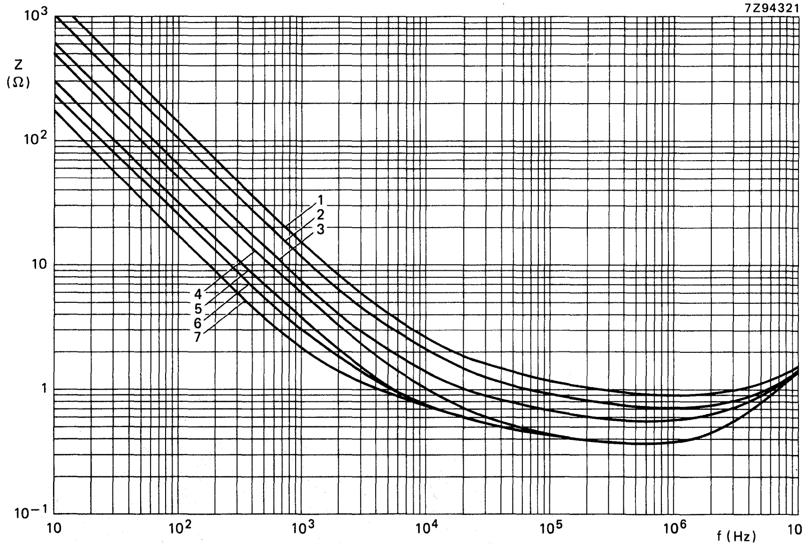


Fig. 19 Typical impedance as a function of frequency at T_{amb} = 25 °C, **case size 1, U_R = 4 to 16 V.**

Curve 1 = 10 µF; 16 V;
curve 2 = 15 µF; 16 V;
curve 3 = 22 µF; 16 V;
curve 4 = 33 µF; 10 V;
curve 5 = 47 µF, 6,3 V and 10 V;
curve 6 = 68 µF, 4 V and 6,3 V;
curve 7 = 100 µF, 4 V.

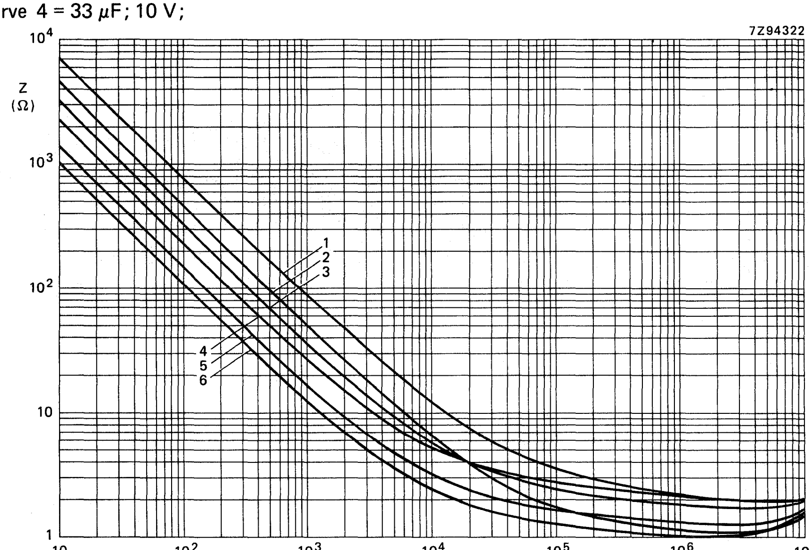


Fig. 20 Typical impedance as a function of frequency at T_{amb} = 25 °C, **case size 1, U_R = 20 to 40 V.**

Curve 1 = 2,2 µF, 35 V and 40 V;
curve 2 = 3,3 µF, 35 V and 40 V;
curve 3 = 4,7 µF, 35 V and 40 V;
curve 4 = 6,8 µF, 35 V and 40 V;
curve 5 = 10 µF, 20 V and 25 V;
curve 6 = 15 µF, 20 V and 25 V.

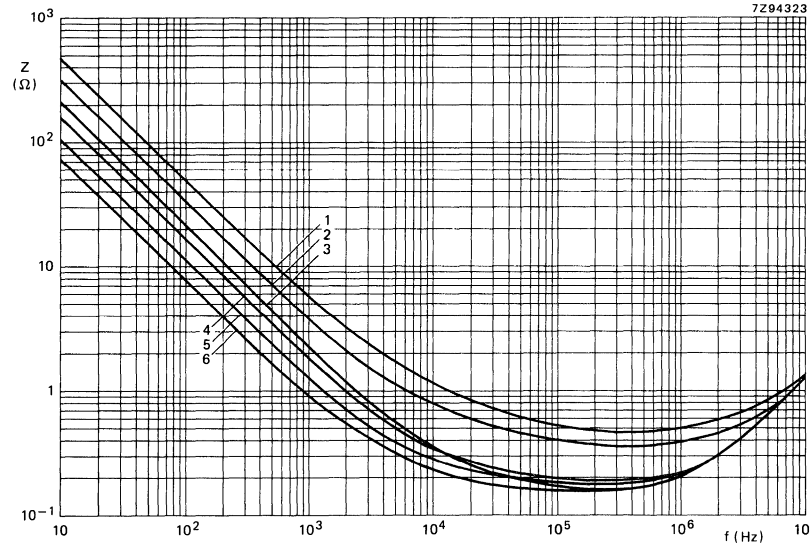


Fig. 21 Typical impedance as a function of frequency at T_{amb} = 25 °C, **case size 2A, U_R = 4 to 16 V.**

Curve 1 = 33 μF, 16 V;
curve 2 = 47 μF, 16 V;
curve 3 = 68 μF, 10 V;
curve 4 = 100 μF, 10 V;
curve 5 = 150 μF, 6,3 V;
curve 6 = 220 μF, 4 V.

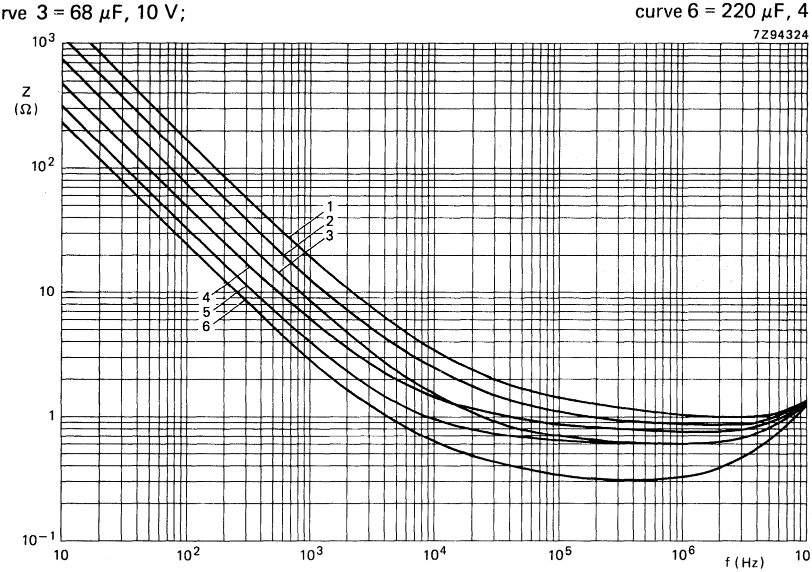


Fig. 22 Typical impedance as a function of frequency at T_{amb} = 25 °C, **case size 2A, U_R = 16 to 40 V.**

Curve 1 = 10 μF, 35 V and 40 V;
curve 2 = 15 μF, 35 V and 40 V;
curve 3 = 22 μF, 25 V and 35 V;
curve 4 = 33 μF, 25 V;
curve 5 = 47 μF, 20 V and 25 V;
curve 6 = 68 μF, 16 V.

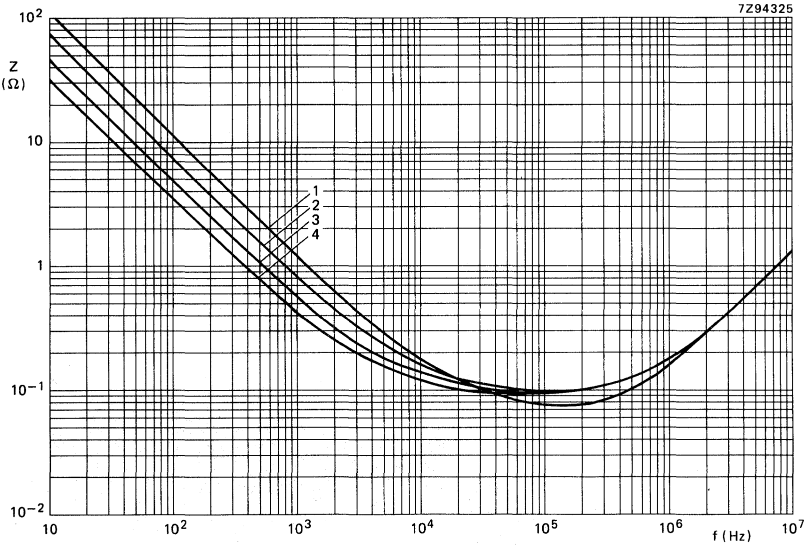


Fig. 23 Typical impedance as a function of frequency at T_{amb} = 25 °C, **case size 4, U_R = 4 to 10 V.**
Curve 1 = 150 μF, 10 V;
curve 2 = 220 μF, 10 V;
curve 3 = 330 μF, 6,3 V;
curve 4 = 470 μF, 4 V.

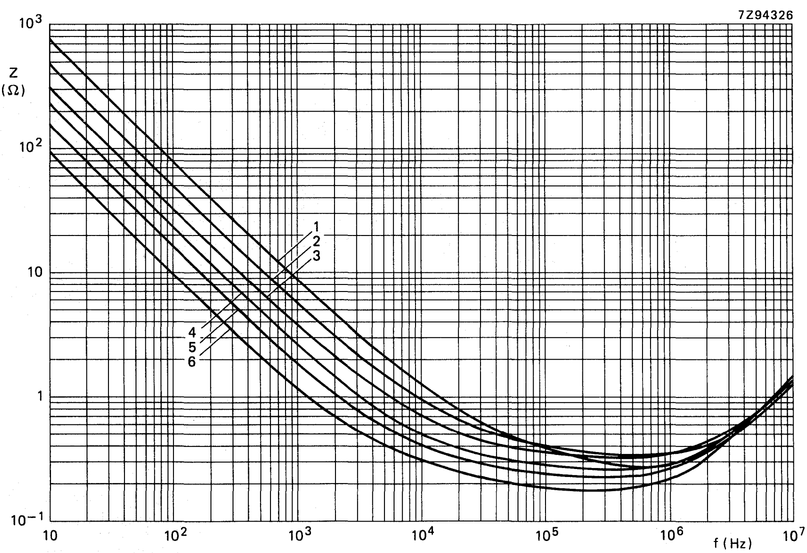


Fig. 24 Typical impedance as a function of frequency at T_{amb} = 25 °C, **case size 4, U_R = 16 to 40 V.**
Curve 1 = 22 μF, 40 V;
curve 2 = 33 μF, 35 V and 40 V;
curve 3 = 47 μF, 35 V;
curve 4 = 68 μF, 25 V;
curve 5 = 100 μF, 16 V, 20 V and 25 V;
curve 6 = 150 μF, 16 V.

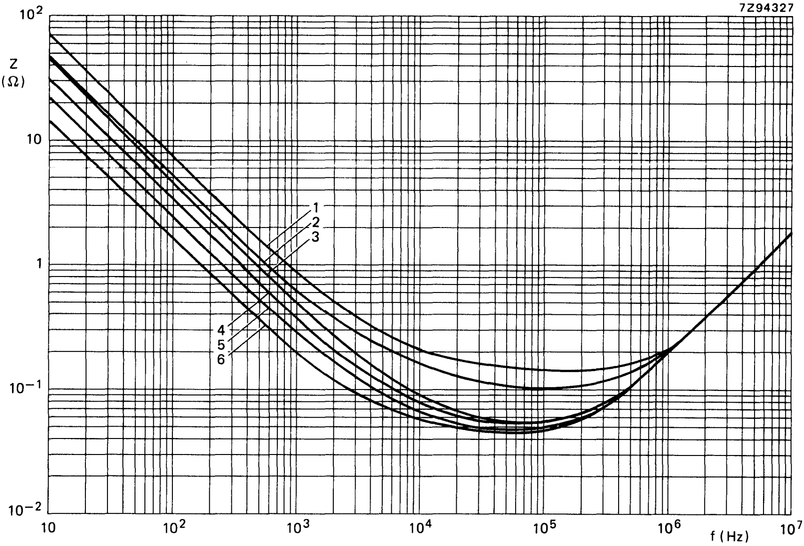


Fig. 25 Typical impedance as a function of frequency at T_{amb} = 25 °C, **case size 5, U_R = 4 to 16 V.**
Curve 1 = 220 μF, 16 V;
curve 2 = 330 μF, 16 V;
curve 3 = 330 μF, 10 V;
curve 4 = 470 μF, 10 V;
curve 5 = 680 μF, 6,3 V;
curve 6 = 1000 μF, 4 V.

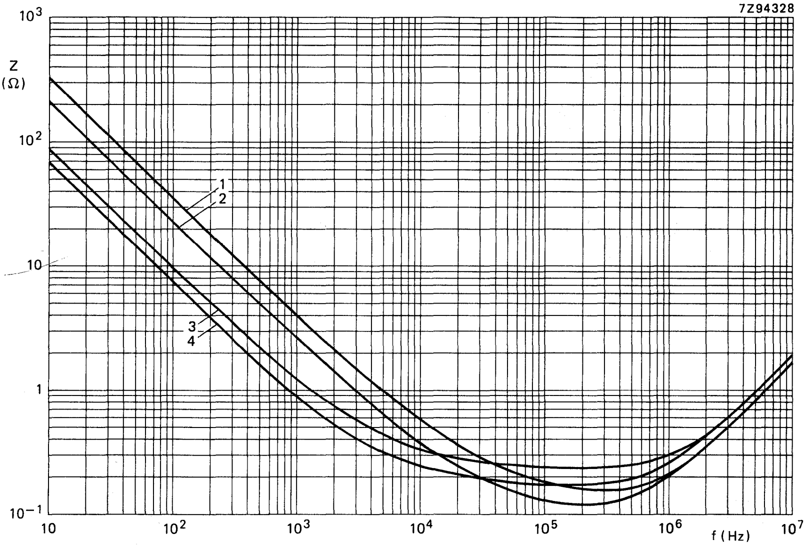


Fig. 26 Typical impedance as a function of frequency at T_{amb} = 25 °C, **case size 5, U_R = 20 to 40 V.**
Curve 1 = 47 μF, 40 V;
curve 2 = 68 μF, 35 V and 40 V;
curve 3 = 150 μF, 20 V and 25 V;
curve 4 = 220 μF, 20 V.

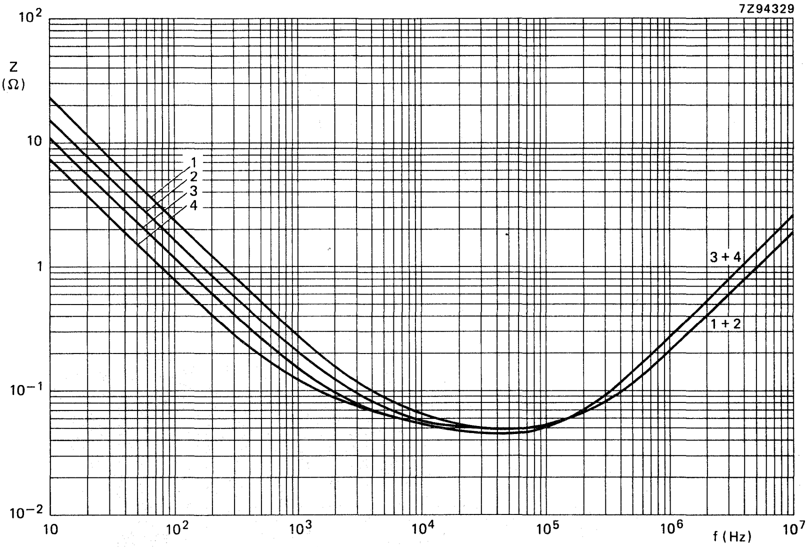


Fig. 27 Typical impedance as a function of frequency at T_{amb} = 25 °C, **case size 6, U_R = 4 to 10 V.**
Curve 1 = 680 μF, 10 V;
curve 2 = 1000 μF, 6,3 V;
curve 3 = 1500 μF, 6,3 V;
curve 4 = 2200 μF, 4 V.

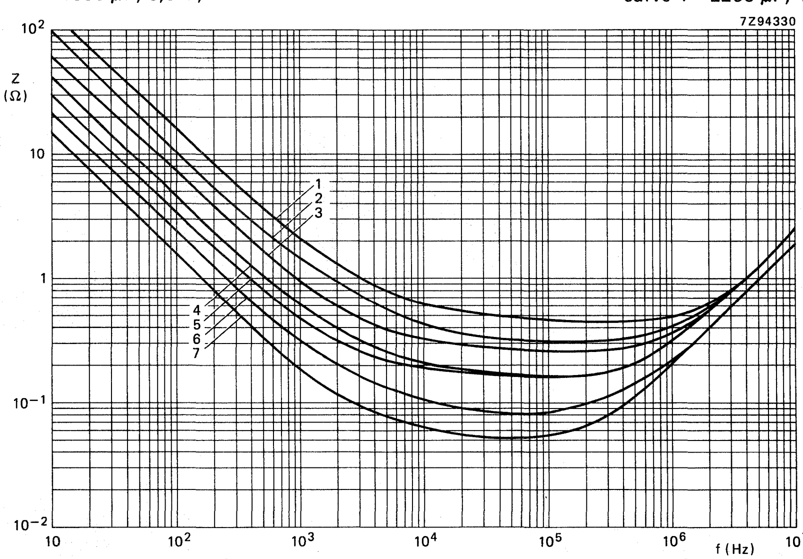


Fig. 28 Typical impedance as a function of frequency at T_{amb} = 25 °C, **case size 6, U_R = 10 to 40 V.**
Curve 1 = 100 μF, 35 V and 40 V;
curve 2 = 150 μF, 35 V;
curve 3 = 220 μF, 25 V;
curve 4 = 330 μF, 20 V;
curve 5 = 470 μF, 16 V and 20 V;
curve 6 = 680 μF, 16 V;
curve 7 = 1000 μF, 10 V.

Equivalent series inductance (ESL)

Equivalent series inductance, measured by means of a four-terminal circuit (Thomson circuit), at 10 MHz; the capacitor leads bent to the pitch as indicated

	pitch	max. ESL	typ. ESL
case size 1	20,3 mm	30 nH	15 to 23 nH
case size 2A	25,4 mm	30 nH	16 to 24 nH
case size 4	27,9 mm	35 nH	20 to 27 nH
case size 5	35,6 mm	40 nH	26 to 33 nH
case size 6, lower capacitance	35,6 mm	55 nH	41 to 49 nH
case size 6, higher capacitance	35,6 mm	50 nH	32 to 42 nH

OPERATIONAL DATA

Category temperature range	−55 to + 125 °C
Usable temperature range	−80 to + 200 °C
Typical life time at T_{amb} = 125 °C and U_R	$>$ 20 000 h
Field failure rate	$< 1 \times 10^{-9}$/h

PACKING

Capacitors of style 1 are supplied on bandoliers in boxes, those of style 2 are on bandoliers on reels (according to IEC 286–1).
The number of capacitors per box or per reel is shown in Table 4.

Table 4

case size	number of capacitors	
	style 1 per box	style 2 per reel
1	100	1000
2A	100	1000
4	100	500
5	100	500
6	100	400

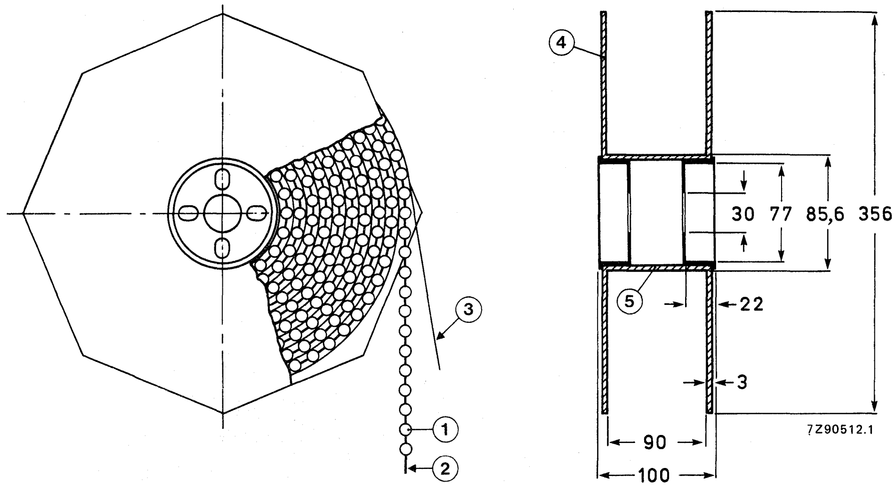


Fig. 29 Style 2 capacitors on bandoliers on reel.

1 = capacitor
2 = bandolier
3 = paper
4 = flange
5 = cylinder

TESTS AND REQUIREMENTS

See Introduction, section 9, under solid aluminium capacitors, with the addition of the following tests.

Severe rapid change of temperature test: 100 cycles of 15 min at –40 °C and + 125 °C.

Requirements: d.c. leakage current ⩽ stated limit,
tan δ ⩽ 1,6 x stated limit,
impedance ⩽ 1,6 x stated limit,
$\Delta C/C$ ⩽ 10%.

Solvent resistance tests:

Severity 1, according to MIL-STD-202, method 215, including brushing of all portions of the specimens.

Solvents:
- deionized water (50 ± 5 °C);
- 1.1.1. trichloro-ethane;
- mixture of 25 vol. % 2-propanol (isopropanol) and 75 vol. % mineral spirits.

Severity 2, according to IEC 68-2-45, and IEC 653, test XA with the following details and additions.

Conditions: immersion time of samples 5 min., at ambient temperature, at boiling temperature, in vapour of boiling solvent, and ultrasonic (40 kHz).

Solvents:
- deionized water (50 ± 5 °C);
- calgonite solution (20 g/l, 70 ± 5 °C), a dishwasher detergent;
- mixture of 4,5% 2-butoxyethanol, 4,5% 2-amino-ethanol, and 91% water (70 ± 5 °C);
- 1.1.1. trichloro-ethane;
- mixtures of 1.1.2-trichloro-1.2.2-trifluoro-ethane (fluorocarbon 113) and the following solvents in the respective mass percentage ratios of these solvents to fluorocarbon:
  - 2-propanol (isopropanol), 25%: 75% (Arklone K*); up to the ratio 35%: 65%;
  - ethanol, 4,5%: 95,5% (e.g. Arklome A*, Freon TE**);
  - methanol and nitromethane, 5,7%: 0,3%: 94% (Freon TMS**).

Requirement: visual appearance not affected.

Note: Tests are carried out using non-contaminated solvents.

Severe vibration tests (for epoxy-filled version only): according to IEC 68-2-6 and MIL-STD-202, method 204, letters E and F, with the following details and additions.

a. Method of mounting: clamping both the body and the leads.
b. Severity 1: frequency range temperature: 10 – 3000 Hz; 20 – 25 °C;
2: frequency range temperature: 50 – 2000 Hz; 125 °C.
1 and 2: vibration amplitude: 50g or 3,5 mm, whicever is less.
c. Direction and duration of motion:
severity 1: 1 octave/min, 3 directions (mutually perpendicular), 20 sweeps per direction (total 60 sweeps or 18 h);
2: 1 octave/min, 2 directions (longitudinal and transversal), 3 sweeps per direction (total 6 sweeps or 1 h).
d. Functioning:
severity 1: rated voltage applied;
2: no voltage applied.
e. Requirements:

	ΔC/C:	⩽ 10%
	tan δ:	⩽ 1,2 x stated limit
	impedance:	⩽ 1,4 x stated limit
	d.c. leakage current:	⩽ stated limit
	general:	no intermittent contacts;
		no indication of breakdown;
		no open circuiting;
		no evidence of mechanical damage.

f. Typical capability: up to 80g at 10 to 3000 Hz (also at 125 °C).

Severe shock tests (for epoxy-filled version only): according to IEC 68-2-27 and MIL-STD-202, method 213, letter F, with the following details and additions.

a. Method of mounting: clamping both body and the leads.
b. Pulse shape: half-sine or sawtooth.
c. Severity 1: 1500g, 0,5 ms (MIL-STD-202, method 213, letter F);
2: 3000g, 0,2 ms;
3: 10 000g, 0,1 ms.
d. Direction and number of shocks:
severity 1 and 2: 3 successive shocks in each direction of 3 mutually perpendicular axes (total 18 shocks);
3: 1 shock, any direction.
e. Functioning: rated voltage applied.
f. Requirements: see "Severe vibration tests" par. e.
g. Typical capability: ⩾ 100000g; these shock tests can be preceded by severe vibration tests on the same samples.

Survey of maximum permissible ripple voltage and ripple current values at various ambient temperatures and frequencies

Notes

- Zero d.c. voltage is assumed; at non-zero d.c. voltage the values in the tables can be adapted according to paragraphs "Ripple voltage" and "Ripple current".
- If the limiting current value given in the tables is applied, the voltage limit mentioned in "Ripple voltage, b", is not exceeded; if the limiting voltage value given in the tables is applied, the current limit calculated as in "Calculation of ripple currents" is not exceeded.
- 1E + 04 to be read as 10^4 Hz;
  1E + 05 to be read as 10^5 Hz;
  1E + 06 to be read as 10^6 Hz.

68 μF – 4 V – case size 1

	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
Freq	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	0	1.80	0	1.80	0	1.80	0	1.80	0	1.50	0	1.30
10	6	2.40	6	2.40	6	2.40	6	2.40	5	2.00	4	1.70
50	32	2.60	32	2.60	32	2.60	32	2.60	27	2.20	22	1.80
100	75	3.20	75	3.20	75	3.20	75	3.20	63	2.70	53	2.20
300	230	3.20	230	3.20	210	3.00	180	2.60	150	2.10	130	1.50
600	330	2.20	270	2.00	250	1.80	250	1.50	250	1.30	190	0.89
1000	360	1.70	360	1.50	360	1.40	360	1.20	290	0.97	210	0.68
1500	520	1.20	470	1.10	420	0.96	370	0.83	300	0.68	210	0.48
1E+04	630	0.28	580	0.26	520	0.23	450	0.20	370	0.16	260	0.12
1E+05	710	0.12	650	0.11	580	0.10	500	0.09	410	0.07	290	0.05
1E+06	760	0.13	700	0.12	620	0.11	540	0.09	440	0.08	310	0.05

100 μF – 4 V – case size 1

	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
Freq	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	1	1.80	1	1.80	1	1.80	1	1.80	1	1.50	0	1.30
10	9	2.40	9	2.40	9	2.40	9	2.40	7	2.00	6	1.70
50	47	2.60	47	2.60	47	2.60	47	2.60	40	2.20	33	1.80
100	110	3.20	110	3.20	110	3.20	110	3.20	93	2.70	77	2.20
300	330	3.00	300	2.80	260	2.50	220	2.10	190	1.70	190	1.20
600	370	1.80	370	1.60	370	1.50	370	1.30	320	1.00	230	0.73
1000	530	1.40	530	1.30	500	1.10	430	0.97	350	0.79	250	0.56
1500	630	0.97	570	0.89	510	0.79	440	0.69	360	0.56	260	0.40
1E+04	760	0.23	700	0.21	620	0.19	540	0.16	440	0.13	310	0.10
1E+05	860	0.15	790	0.13	700	0.12	610	0.10	500	0.08	350	0.06
1E+06	920	0.16	840	0.14	750	0.13	650	0.11	530	0.09	380	0.06

220 μF – 4 V – case size 2A

	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
Freq	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	1	1.80	1	1.80	1	1.80	1	1.80	1	1.50	1	1.30
10	19	2.40	19	2.40	19	2.40	19	2.40	16	2.00	13	1.70
50	100	2.60	100	2.60	100	2.60	100	2.60	88	2.20	73	1.80
100	240	3.20	240	3.20	240	3.20	240	3.20	200	2.70	160	2.20
300	580	2.30	480	2.10	420	1.80	420	1.60	420	1.30	330	0.93
600	820	1.30	820	1.20	750	1.10	650	0.95	530	0.77	370	0.55
1000	1000	1.00	910	0.94	820	0.84	710	0.73	580	0.60	410	0.42
1500	1030	0.73	940	0.66	840	0.59	730	0.51	600	0.42	420	0.30
1E+04	1260	0.17	1150	0.16	1030	0.14	890	0.12	730	0.10	510	0.07
1E+05	1420	0.14	1300	0.13	1160	0.11	1010	0.10	820	0.08	580	0.06
1E+06	1520	0.16	1390	0.14	1240	0.13	1070	0.11	880	0.09	620	0.06

470 μF – 4 V – case size 4

	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
Freq	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	3	1.80	3	1.80	3	1.80	3	1.80	3	1.50	2	1.30
10	40	2.40	40	2.40	40	2.40	40	2.40	34	2.00	28	1.70
50	220	2.60	220	2.60	220	2.60	220	2.60	190	2.20	150	1.80
100	520	3.20	520	3.20	520	3.20	480	3.00	390	2.40	300	1.70
300	900	1.80	900	1.60	900	1.40	900	1.20	760	1.00	540	0.72
600	1510	1.00	1380	0.94	1230	0.84	1070	0.73	870	0.60	620	0.42
1000	1650	0.80	1510	0.73	1350	0.65	1170	0.56	950	0.46	670	0.33
1500	1700	0.56	1560	0.51	1390	0.46	1210	0.40	980	0.32	700	0.23
1E+04	2080	0.13	1900	0.12	1700	0.11	1470	0.10	1200	0.08	850	0.06
1E+05	2340	0.10	2140	0.09	1910	0.08	1660	0.07	1350	0.06	960	0.04
1E+06	2500	0.13	2290	0.12	2040	0.11	1770	0.09	1450	0.08	1020	0.05

1000 μF – 4 V – case size 5

	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
Freq	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	6	1.80	6	1.80	6	1.80	6	1.80	5	1.50	4	1.30
10	85	2.40	85	2.40	85	2.40	85	2.40	72	2.00	60	1.70
50	470	2.60	470	2.60	470	2.60	470	2.60	400	2.20	330	1.80
100	1100	3.20	1060	3.10	940	2.70	820	2.40	670	1.90	630	1.40
300	1910	1.40	1910	1.30	1800	1.10	1560	0.97	1270	0.79	900	0.56
600	2530	0.81	2310	0.74	2060	0.66	1790	0.57	1460	0.47	1030	0.33
1000	2760	0.62	2520	0.57	2250	0.51	1950	0.44	1590	0.36	1130	0.25
1500	2850	0.44	2600	0.40	2330	0.36	2010	0.31	1640	0.25	1160	0.18
1E+04	3470	0.11	3170	0.10	2830	0.09	2450	0.07	2000	0.06	1420	0.04
1E+05	3920	0.11	3570	0.10	3200	0.09	2770	0.08	2260	0.06	1600	0.05
1E+06	4030	0.19	3820	0.17	3420	0.16	2960	0.13	2410	0.11	1710	0.08

1500 μF — 4 V — case size 6

	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
Freq	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	10	1.80	10	1.80	10	1.80	10	1.80	8	1.50	7	1.30
10	130	2.40	130	2.40	130	2.40	130	2.40	110	2.00	90	1.70
50	710	2.60	710	2.60	710	2.60	710	2.60	590	2.20	480	1.80
100	1660	3.00	1490	2.80	1280	2.50	1100	2.10	950	1.70	950	1.20
300	2870	1.20	2730	1.10	2440	1.00	2110	0.88	1730	0.72	1220	0.51
600	3430	0.73	3130	0.67	2800	0.60	2420	0.52	1980	0.42	1400	0.30
1000	3740	0.66	3410	0.60	3050	0.54	2640	0.47	2160	0.38	1530	0.27
1500	3860	0.53	3520	0.49	3150	0.44	2730	0.38	2230	0.31	1580	0.22
1E+04	4700	0.14	4290	0.12	3840	0.11	3330	0.10	2720	0.08	1920	0.06
1E+05	5310	0.15	4840	0.14	4330	0.12	3750	0.11	3060	0.09	2170	0.06
1E+06	3240	0.32	3240	0.29	3240	0.26	3240	0.23	3240	0.18	2310	0.13

2200 μF — 4 V — case size 6

	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
Freq	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	14	1.80	14	1.80	14	1.80	14	1.80	12	1.50	10	1.30
10	190	2.40	190	2.40	190	2.40	190	2.40	160	2.00	130	1.70
50	1040	2.60	1040	2.60	1040	2.60	1030	2.60	850	2.10	640	1.60
100	2290	2.60	1920	2.40	1620	2.10	1410	1.90	1390	1.50	1250	1.10
300	3800	1.10	3470	0.98	3100	0.88	2690	0.76	2190	0.62	1550	0.44
600	4350	0.63	3970	0.58	3550	0.52	3080	0.45	2510	0.37	1780	0.26
1000	4750	0.57	4340	0.52	3880	0.47	3360	0.40	2740	0.33	1940	0.23
1500	4900	0.46	4480	0.42	4000	0.38	3470	0.33	2830	0.27	2000	0.19
1E+04	5980	0.12	5460	0.11	4880	0.10	4230	0.08	3450	0.07	2440	0.05
1E+05	6470	0.19	6150	0.17	5500	0.16	4770	0.13	3890	0.11	2750	0.08
1E+06	3470	0.38	3470	0.35	3470	0.31	3470	0.27	3470	0.22	2940	0.15

47 μF — 6,3 V — case size 1

	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
Freq	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	1	2.80	1	2.80	1	2.80	1	2.80	0	2.40	0	2.00
10	6	3.80	6	3.80	6	3.80	6	3.80	5	3.20	4	2.60
50	35	4.10	35	4.10	35	4.10	35	4.10	30	3.50	25	2.90
100	83	5.00	83	5.00	83	5.00	83	5.00	70	4.30	58	3.50
300	250	5.00	240	4.70	210	4.20	180	3.60	150	3.00	140	2.10
600	300	3.00	280	2.80	280	2.50	280	2.10	260	1.80	180	1.20
1000	390	2.30	390	2.10	390	1.90	350	1.70	280	1.30	200	0.95
1500	510	1.60	460	1.50	420	1.30	360	1.20	290	0.95	210	0.67
1E+04	620	0.40	570	0.36	510	0.32	440	0.28	360	0.23	250	0.16
1E+05	700	0.12	640	0.11	570	0.10	490	0.08	400	0.07	290	0.05
1E+06	750	0.13	680	0.12	610	0.10	530	0.09	430	0.07	300	0.05

68 μF — 6,3 V — case size 1

Freq	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	1	2.80	1	2.80	1	2.80	1	2.80	1	2.40	1	2.00
10	9	3.80	9	3.80	9	3.80	9	3.80	8	3.20	6	2.60
50	51	4.10	51	4.10	51	4.10	51	4.10	43	3.50	36	2.90
100	120	5.00	120	5.00	120	5.00	120	5.00	100	4.30	83	3.50
300	350	4.30	290	3.90	250	3.50	220	3.00	210	2.50	190	1.70
600	400	2.50	400	2.30	400	2.10	380	1.80	310	1.50	220	1.00
1000	570	1.90	540	1.80	480	1.60	420	1.40	340	1.10	240	0.79
1500	610	1.40	560	1.20	500	1.10	430	0.97	350	0.79	250	0.56
1E+04	740	0.33	680	0.30	610	0.27	520	0.23	430	0.19	300	0.13
1E+05	840	0.14	760	0.13	680	0.12	590	0.10	480	0.08	340	0.06
1E+06	890	0.15	820	0.14	730	0.13	630	0.11	520	0.09	370	0.06

150 μF — 6,3 V — case size 2A

Freq	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	2	2.80	2	2.80	2	2.80	2	2.80	1	2.40	1	2.00
10	20	3.80	20	3.80	20	3.80	20	3.80	17	3.20	14	2.60
50	110	4.10	110	4.10	110	4.10	110	4.10	96	3.50	79	2.90
100	260	5.00	260	5.00	260	5.00	260	5.00	220	4.20	160	3.10
300	530	3.20	470	2.90	460	2.60	460	2.30	450	1.90	320	1.30
600	890	1.90	820	1.70	730	1.50	640	1.30	520	1.10	370	0.77
1000	980	1.50	890	1.30	800	1.20	690	1.00	570	0.84	400	0.60
1500	1010	1.00	920	0.94	830	0.84	720	0.73	580	0.59	410	0.42
1E+04	1230	0.25	1130	0.23	1010	0.20	870	0.17	710	0.14	500	0.10
1E+05	1390	0.14	1270	0.13	1140	0.11	980	0.10	800	0.08	570	0.06
1E+06	1490	0.15	1360	0.14	1210	0.12	1050	0.11	860	0.09	610	0.06

330 μF — 6,3 V — case size 4

Freq	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	3	2.80	3	2.80	3	2.80	3	2.80	3	2.40	2	2.00
10	45	3.80	45	3.80	45	3.80	45	3.80	38	3.20	31	2.60
50	250	4.10	250	4.10	250	4.10	250	4.10	210	3.50	170	2.90
100	580	5.00	580	5.00	560	4.90	490	4.20	400	3.40	330	2.40
300	1010	2.50	1010	2.20	1010	2.00	930	1.70	760	1.40	540	1.00
600	1510	1.40	1380	1.30	1230	1.20	1070	1.00	870	0.84	620	0.59
1000	1650	1.10	1510	1.00	1350	0.91	1170	0.79	950	0.64	670	0.46
1500	1700	0.79	1560	0.72	1390	0.64	1210	0.56	980	0.45	700	0.32
1E+04	2080	0.19	1900	0.17	1700	0.15	1470	0.13	1200	0.11	850	0.08
1E+05	2340	0.10	2140	0.09	1910	0.08	1660	0.07	1350	0.06	960	0.04
1E+06	2500	0.13	2290	0.12	2040	0.11	1770	0.09	1450	0.08	1020	0.05

680 μF — 6,3 V — case size 5

Freq	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	7	2.80	7	2.80	7	2.80	7	2.80	6	2.40	5	2.00
10	93	3.80	93	3.80	93	3.80	93	3.80	78	3.20	65	2.60
50	510	4.10	510	4.10	510	4.10	510	4.10	430	3.40	340	2.70
100	1200	4.60	1050	4.20	900	3.80	780	3.30	680	2.70	680	1.90
300	2070	1.90	1920	1.70	1720	1.60	1490	1.30	1210	1.10	860	0.78
600	2410	1.10	2200	1.00	1970	0.92	1700	0.79	1390	0.65	980	0.46
1000	2630	0.86	2400	0.79	2150	0.71	1860	0.61	1520	0.50	1070	0.35
1500	2720	0.61	2480	0.56	2220	0.50	1920	0.43	1570	0.35	1110	0.25
1E+04	3310	0.15	3020	0.13	2700	0.12	2340	0.10	1910	0.08	1350	0.06
1E+05	3730	0.11	3410	0.10	3050	0.09	2640	0.07	2160	0.06	1520	0.04
1E+06	3990	0.18	3640	0.17	3260	0.15	2820	0.13	2300	0.10	1630	0.07

1000 μF — 6,3 V — case size 6

Freq	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	10	2.80	10	2.80	10	2.80	10	2.80	9	2.40	7	2.00
10	140	3.80	140	3.80	140	3.80	140	3.80	120	3.20	95	2.60
50	750	4.10	750	4.10	750	4.10	750	4.10	630	3.40	480	2.60
100	1730	4.30	1440	3.90	1220	3.50	1060	3.00	1010	2.50	940	1.80
300	2860	1.80	2610	1.60	2340	1.40	2020	1.20	1650	1.00	1170	0.72
600	3280	1.00	2990	0.95	2680	0.85	2320	0.73	1890	0.60	1340	0.42
1000	3580	0.93	3270	0.85	2920	0.76	2530	0.66	2070	0.54	1460	0.38
1500	3700	0.76	3370	0.69	3020	0.62	2610	0.53	2130	0.44	1510	0.31
1E+04	4500	0.19	4110	0.18	3680	0.16	3180	0.14	2600	0.11	1840	0.08
1E+05	5080	0.14	4640	0.13	4150	0.12	3590	0.10	2930	0.08	2070	0.06
1E+06	5100	0.31	4950	0.28	4430	0.25	3840	0.22	3130	0.18	2220	0.13

1500 μF — 6,3 V — case size 6

Freq	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	15	2.80	15	2.80	15	2.80	15	2.80	13	2.40	11	2.00
10	200	3.80	200	3.80	200	3.80	200	3.80	170	3.20	140	2.60
50	1130	4.10	1130	4.10	1130	4.10	1070	3.90	880	3.20	650	2.30
100	2210	3.70	1820	3.40	1590	3.00	1510	2.60	1510	2.10	1220	1.50
300	3720	1.50	3400	1.40	3040	1.20	2630	1.10	2150	0.88	1520	0.62
600	4260	0.90	3890	0.82	3480	0.73	3010	0.63	2460	0.52	1740	0.37
1000	4650	0.81	4240	0.74	3800	0.66	3290	0.57	2680	0.47	1900	0.33
1500	4800	0.65	4380	0.60	3920	0.53	3390	0.46	2770	0.38	1960	0.27
1E+04	5850	0.17	5340	0.15	4780	0.14	4140	0.12	3380	0.10	2390	0.07
1E+05	6600	0.19	6020	0.17	5390	0.15	4670	0.13	3810	0.11	2690	0.08
1E+06	5470	0.37	5470	0.34	5470	0.30	4990	0.26	4070	0.21	2880	0.15

33 μF — 10 V — case size 1

	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
Freq	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	1	4.50	1	4.50	1	4.50	1	4.50	1	3.80	0	3.20
10	7	6.00	7	6.00	7	6.00	7	6.00	6	5.10	5	4.20
50	39	6.50	39	6.50	39	6.50	39	6.50	33	5.50	28	4.60
100	92	8.00	92	8.00	92	8.00	92	8.00	78	6.70	63	5.50
300	240	6.10	200	5.60	170	5.00	160	4.30	160	3.50	130	2.50
600	310	3.60	310	3.30	310	2.90	270	2.50	220	2.10	150	1.50
1000	410	2.80	370	2.50	330	2.30	290	2.00	240	1.60	170	1.10
1500	420	2.00	390	1.80	350	1.60	300	1.40	240	1.10	170	0.80
1E+04	520	0.47	470	0.43	420	0.38	360	0.33	300	0.27	210	0.19
1E+05	580	0.10	530	0.09	470	0.08	410	0.07	340	0.06	240	0.04
1E+06	620	0.11	570	0.10	510	0.09	440	0.08	360	0.06	250	0.04

47 μF — 10 V — case size 1

	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
Freq	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	1	4.50	1	4.50	1	4.50	1	4.50	1	3.80	1	3.20
10	10	6.00	10	6.00	10	6.00	10	6.00	9	5.10	7	4.20
50	56	6.50	56	6.50	56	6.50	56	6.50	48	5.50	39	4.60
100	130	8.00	130	8.00	130	8.00	130	8.00	110	6.60	83	5.00
300	270	5.10	230	4.70	230	4.20	230	3.60	230	3.00	160	2.10
600	440	3.00	410	2.80	370	2.50	320	2.10	260	1.80	180	1.20
1000	490	2.30	450	2.10	400	1.90	350	1.70	280	1.30	200	0.95
1500	510	1.60	460	1.50	420	1.30	360	1.20	290	0.95	210	0.67
1E+04	620	0.40	570	0.36	510	0.32	440	0.28	360	0.23	250	0.16
1E+05	700	0.12	640	0.11	570	0.10	490	0.08	400	0.07	290	0.05
1E+06	750	0.13	680	0.12	610	0.10	530	0.09	430	0.07	300	0.05

68 μF — 10 V — case size 2A

	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
Freq	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	1	4.50	1	4.50	1	4.50	1	4.50	1	3.80	1	3.20
10	15	6.00	15	6.00	15	6.00	15	6.00	12	5.10	10	4.20
50	81	6.50	81	6.50	81	6.50	81	6.50	69	5.50	57	4.60
100	190	8.00	190	8.00	190	8.00	190	7.80	150	6.40	110	4.70
300	350	4.80	330	4.30	330	3.90	330	3.40	300	2.70	220	1.90
600	600	2.80	550	2.60	490	2.30	430	2.00	350	1.60	250	1.10
1000	660	2.20	600	2.00	540	1.80	470	1.50	380	1.20	270	0.88
1500	680	1.50	620	1.40	560	1.20	480	1.10	390	0.88	280	0.62
1E+04	830	0.37	760	0.33	680	0.30	590	0.26	480	0.21	340	0.15
1E+05	940	0.09	850	0.08	760	0.08	660	0.07	540	0.05	380	0.04
1E+06	1000	0.10	910	0.09	820	0.08	710	0.07	580	0.06	410	0.04

100 μF — 10 V — case size 2A

	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
Freq	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	2	4.50	2	4.50	2	4.50	2	4.50	1	3.80	1	3.20
10	22	6.00	22	6.00	22	6.00	22	6.00	18	5.10	15	4.20
50	120	6.50	120	6.50	120	6.50	120	6.50	100	5.50	83	4.50
100	280	8.00	280	8.00	270	7.80	230	6.70	190	5.50	160	3.90
300	480	3.90	480	3.60	480	3.20	450	2.80	370	2.30	260	1.60
600	730	2.30	670	2.10	600	1.90	520	1.60	420	1.30	300	0.95
1000	800	1.80	730	1.60	650	1.50	570	1.30	460	1.00	330	0.73
1500	830	1.30	750	1.10	670	1.00	580	0.89	480	0.73	340	0.51
1E+04	1010	0.30	920	0.28	820	0.25	710	0.21	580	0.17	410	0.12
1E+05	1140	0.11	1040	0.10	930	0.09	800	0.08	660	0.06	460	0.05
1E+06	1210	0.12	1110	0.11	990	0.10	860	0.09	700	0.07	500	0.05

150 μF — 10 V — case size 4

	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
Freq	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	2	4.50	2	4.50	2	4.50	2	4.50	2	3.80	2	3.20
10	32	6.00	32	6.00	32	6.00	32	6.00	27	5.10	23	4.20
50	180	6.50	180	6.50	180	6.50	180	6.50	150	5.50	130	4.50
100	420	8.00	420	8.00	380	7.20	330	6.30	270	5.10	240	3.60
300	730	3.70	730	3.30	730	3.00	630	2.60	520	2.10	370	1.50
600	1020	2.20	930	2.00	840	1.80	720	1.50	590	1.20	420	0.88
1000	1120	1.70	1020	1.50	910	1.40	790	1.20	650	0.96	460	0.68
1500	1150	1.20	1050	1.10	940	0.96	820	0.83	670	0.68	470	0.48
1E+04	1410	0.28	1280	0.26	1150	0.23	990	0.20	810	0.16	570	0.11
1E+05	1590	0.07	1450	0.06	1300	0.05	1120	0.05	920	0.04	650	0.03
1E+06	1690	0.09	1550	0.08	1380	0.07	1200	0.06	980	0.05	690	0.04

220 μF — 10 V — case size 4

	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
Freq	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	4	4.50	4	4.50	4	4.50	4	4.50	3	3.80	2	3.20
10	48	6.00	48	6.00	48	6.00	48	6.00	40	5.10	33	4.20
50	260	6.50	260	6.50	260	6.50	260	6.50	220	5.50	170	4.30
100	610	7.20	530	6.60	450	5.90	390	5.10	350	4.20	350	3.00
300	1060	3.00	970	2.70	870	2.40	750	2.10	610	1.70	430	1.20
600	1220	1.70	1110	1.60	990	1.40	860	1.20	700	1.00	500	0.71
1000	1330	1.30	1210	1.20	1080	1.10	940	0.95	770	0.78	540	0.55
1500	1370	0.95	1250	0.87	1120	0.78	970	0.67	790	0.55	560	0.39
1E+04	1670	0.23	1530	0.21	1360	0.19	1180	0.16	960	0.13	680	0.09
1E+05	1880	0.08	1720	0.07	1540	0.07	1330	0.06	1090	0.05	770	0.03
1E+06	2010	0.11	1840	0.10	1640	0.09	1420	0.07	1160	0.06	820	0.04

330 μF — 10 V — case size 5

	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
Freq	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	5	4.50	5	4.50	5	4.50	5	4.50	5	3.80	4	3.20
10	71	6.00	71	6.00	71	6.00	71	6.00	60	5.10	50	4.20
50	390	6.50	390	6.50	390	6.50	390	6.50	330	5.40	250	4.10
100	900	6.80	750	6.20	640	5.50	550	4.80	530	3.90	490	2.80
300	1490	2.80	1360	2.50	1210	2.30	1050	2.00	860	1.60	610	1.10
600	1700	1.60	1560	1.50	1390	1.30	1200	1.20	980	0.94	700	0.67
1000	1860	1.30	1700	1.10	1520	1.00	1320	0.89	1070	0.73	760	0.51
1500	1920	0.89	1750	0.81	1570	0.72	1360	0.63	1110	0.51	780	0.36
1E+04	2340	0.21	2140	0.19	1910	0.17	1650	0.15	1350	0.12	960	0.09
1E+05	2640	0.07	2410	0.07	2160	0.06	1870	0.05	1520	0.04	1080	0.03
1E+06	2820	0.13	2570	0.12	2300	0.10	1990	0.09	1630	0.07	1150	0.05

470 μF — 10 V — case size 5

	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
Freq	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	8	4.50	8	4.50	8	4.50	8	4.50	6	3.80	5	3.20
10	100	6.00	100	6.00	100	6.00	100	6.00	86	5.10	71	4.20
50	560	6.50	560	6.50	560	6.50	510	5.90	420	4.80	320	3.50
100	1010	5.60	840	5.10	750	4.50	750	3.90	750	3.20	570	2.30
300	1740	2.30	1590	2.10	1420	1.90	1230	1.60	1010	1.30	710	0.93
600	2000	1.30	1820	1.20	1630	1.10	1410	0.95	1150	0.78	820	0.55
1000	2180	1.00	1990	0.95	1780	0.85	1540	0.73	1260	0.60	890	0.42
1500	2250	0.73	2060	0.67	1840	0.60	1590	0.52	1300	0.42	920	0.30
1E+04	2740	0.18	2500	0.16	2240	0.14	1940	0.12	1580	0.10	1120	0.07
1E+05	3100	0.09	2830	0.08	2530	0.07	2190	0.06	1790	0.05	1260	0.04
1E+06	3310	0.15	3020	0.14	2700	0.12	2340	0.11	1910	0.09	1350	0.06

680 μF — 10 V — case size 6

	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
Freq	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	11	4.50	11	4.50	11	4.50	11	4.50	9	3.80	8	3.20
10	150	6.00	150	6.00	150	6.00	150	6.00	120	5.10	100	4.20
50	810	6.50	810	6.50	790	6.30	680	5.50	560	4.40	460	3.20
100	1260	5.10	1110	4.70	1090	4.20	1090	3.60	1080	3.00	760	2.10
300	2320	2.10	2110	1.90	1890	1.70	1640	1.50	1340	1.20	950	0.85
600	2650	1.20	2420	1.10	2170	1.00	1880	0.87	1530	0.71	1080	0.50
1000	2900	1.10	2640	1.00	2360	0.91	2050	0.78	1670	0.64	1180	0.45
1500	2990	0.90	2730	0.82	2440	0.73	2110	0.64	1730	0.52	1220	0.37
1E+04	3640	0.23	3330	0.21	2970	0.19	2580	0.16	2100	0.13	1490	0.09
1E+05	4110	0.12	3750	0.11	3360	0.09	2910	0.08	2370	0.07	1680	0.05
1E+06	4390	0.25	4010	0.23	3590	0.20	3100	0.18	2530	0.14	1790	0.10

1000 μF – 10 V – case size 6

	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
Freq	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	16	4.50	16	4.50	16	4.50	16	4.50	14	3.80	11	3.20
10	220	6.00	220	6.00	220	6.00	220	6.00	180	5.10	150	4.20
50	1200	6.50	1160	6.30	1040	5.60	900	4.90	730	4.00	680	2.80
100	1600	4.60	1600	4.20	1600	3.70	1600	3.20	1410	2.60	1000	1.90
300	3040	1.90	2770	1.70	2480	1.50	2150	1.30	1750	1.10	1240	0.76
600	3480	1.10	3180	1.00	2840	0.90	2460	0.78	2010	0.63	1420	0.45
1000	3800	0.99	3470	0.90	3100	0.81	2680	0.70	2190	0.57	1550	0.40
1500	3920	0.80	3580	0.73	3200	0.65	2770	0.57	2260	0.46	1600	0.33
1E+04	4780	0.20	4360	0.19	3900	0.17	3380	0.14	2760	0.12	1950	0.08
1E+05	5390	0.15	4920	0.14	4400	0.12	3810	0.11	3110	0.09	2200	0.06
1E+06	5760	0.30	5250	0.28	4700	0.25	4070	0.21	3320	0.18	2350	0.12

10 μF – 16 V – case size 1

	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
Freq	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	0	7.20	0	7.20	0	7.20	0	7.20	0	6.10	0	5.00
10	3	9.60	3	9.60	3	9.60	3	9.60	3	8.10	2	6.70
50	19	10.40	19	10.40	19	10.40	19	10.40	16	8.80	13	7.30
100	45	12.80	45	12.80	45	12.80	45	12.80	38	10.80	31	8.90
300	140	12.50	130	11.40	110	10.20	94	8.80	78	7.20	78	5.10
600	150	7.40	150	6.70	150	6.00	150	5.20	140	4.30	96	3.00
1000	210	5.70	210	5.20	210	4.60	180	4.00	150	3.30	100	2.30
1500	260	4.00	240	3.70	220	3.30	190	2.80	150	2.30	110	1.60
1E+04	320	0.96	290	0.88	260	0.79	230	0.68	190	0.56	130	0.39
1E+05	360	0.13	330	0.12	300	0.11	260	0.09	210	0.07	150	0.05
1E+06	390	0.14	360	0.13	320	0.11	280	0.10	220	0.08	160	0.06

15 μF – 16 V – case size 1

	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
Freq	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	0	7.20	0	7.20	0	7.20	0	7.20	0	6.10	0	5.00
10	5	9.60	5	9.60	5	9.60	5	9.60	4	8.10	4	6.70
50	29	10.40	29	10.40	29	10.40	29	10.40	24	8.80	20	7.30
100	68	12.80	68	12.80	68	12.80	68	12.80	57	10.80	47	8.80
300	190	10.10	150	9.20	130	8.30	120	7.20	120	5.90	100	4.10
600	230	6.00	230	5.50	230	4.90	200	4.20	160	3.50	120	2.40
1000	310	4.60	280	4.20	250	3.80	220	3.30	180	2.70	130	1.90
1500	320	3.20	290	3.00	260	2.70	230	2.30	190	1.90	130	1.30
1E+04	390	0.78	360	0.71	320	0.64	280	0.55	230	0.45	160	0.32
1E+05	440	0.16	400	0.14	360	0.13	310	0.11	260	0.09	180	0.06
1E+06	470	0.17	430	0.15	390	0.14	330	0.12	270	0.10	190	0.07

22 μF – 16 V – case size 1

Freq Hz	T 25 degC Irms mA	T 25 degC Vpeak V	T 45 degC Irms mA	T 45 degC Vpeak V	T 65 degC Irms mA	T 65 degC Vpeak V	T 85 degC Irms mA	T 85 degC Vpeak V	T 105 degC Irms mA	T 105 degC Vpeak V	T 125 degC Irms mA	T 125 degC Vpeak V
1	1	7.20	1	7.20	1	7.20	1	7.20	1	6.10	0	5.00
10	8	9.60	8	9.60	8	9.60	8	9.60	6	8.10	5	6.70
50	42	10.40	42	10.40	42	10.40	42	10.40	36	8.80	30	7.30
100	99	12.80	99	12.80	99	12.80	99	12.70	82	10.60	63	8.10
300	210	8.40	180	7.60	170	6.80	170	5.90	170	4.80	120	3.40
600	330	4.90	320	4.50	280	4.00	240	3.50	200	2.80	140	2.00
1000	380	3.80	340	3.50	310	3.10	270	2.70	220	2.20	150	1.60
1500	390	2.70	360	2.40	320	2.20	270	1.90	220	1.50	160	1.10
1E+04	470	0.64	430	0.59	390	0.53	340	0.45	270	0.37	190	0.26
1E+05	530	0.19	490	0.17	440	0.15	380	0.13	310	0.11	220	0.08
1E+06	570	0.20	520	0.18	470	0.17	400	0.14	330	0.12	230	0.08

33 μF – 16 V – case size 2A

Freq Hz	T 25 degC Irms mA	T 25 degC Vpeak V	T 45 degC Irms mA	T 45 degC Vpeak V	T 65 degC Irms mA	T 65 degC Vpeak V	T 85 degC Irms mA	T 85 degC Vpeak V	T 105 degC Irms mA	T 105 degC Vpeak V	T 125 degC Irms mA	T 125 degC Vpeak V
1	1	7.20	1	7.20	1	7.20	1	7.20	1	6.10	1	5.00
10	11	9.60	11	9.60	11	9.60	11	9.60	10	8.10	8	6.70
50	64	10.40	64	10.40	64	10.40	64	10.40	54	8.80	45	7.30
100	150	12.80	150	12.80	150	12.80	150	12.50	120	10.40	89	7.60
300	270	7.70	260	7.10	260	6.30	260	5.50	240	4.50	170	3.20
600	480	4.60	440	4.20	390	3.70	340	3.20	280	2.60	200	1.90
1000	520	3.50	480	3.20	430	2.90	370	2.50	300	2.00	210	1.40
1500	540	2.50	490	2.30	440	2.00	380	1.80	310	1.40	220	1.00
1E+04	660	0.60	600	0.54	540	0.49	470	0.42	380	0.34	270	0.24
1E+05	740	0.16	680	0.14	610	0.13	530	0.11	430	0.09	300	0.06
1E+06	790	0.17	730	0.16	650	0.14	560	0.12	460	0.10	320	0.07

47 μF – 16 V – case size 2A

Freq Hz	T 25 degC Irms mA	T 25 degC Vpeak V	T 45 degC Irms mA	T 45 degC Vpeak V	T 65 degC Irms mA	T 65 degC Vpeak V	T 85 degC Irms mA	T 85 degC Vpeak V	T 105 degC Irms mA	T 105 degC Vpeak V	T 125 degC Irms mA	T 125 degC Vpeak V
1	1	7.20	1	7.20	1	7.20	1	7.20	1	6.10	1	5.00
10	16	9.60	16	9.60	16	9.60	16	9.60	14	8.10	11	6.70
50	91	10.40	91	10.40	91	10.40	91	10.40	77	8.80	63	7.20
100	210	12.80	210	12.80	210	12.80	180	11.10	150	9.10	120	6.50
300	370	6.50	370	5.90	370	5.30	350	4.60	290	3.70	200	2.60
600	570	3.80	520	3.50	470	3.10	410	2.70	330	2.20	230	1.60
1000	630	2.90	570	2.70	510	2.40	440	2.10	360	1.70	260	1.20
1500	650	2.10	590	1.90	530	1.70	460	1.50	370	1.20	260	0.85
1E+04	790	0.50	720	0.46	640	0.41	560	0.35	450	0.29	320	0.20
1E+05	890	0.15	810	0.14	720	0.12	630	0.11	510	0.09	360	0.06
1E+06	950	0.16	870	0.15	770	0.13	670	0.12	550	0.09	390	0.07

68 μF — 16 V — case size 2A

	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
Freq	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	2	7.20	2	7.20	2	7.20	2	7.20	2	6.10	1	5.00
10	24	9.60	24	9.60	24	9.60	24	9.60	20	8.10	17	6.70
50	130	10.40	130	10.40	130	10.40	130	10.40	110	8.80	90	7.20
100	310	12.80	290	12.00	260	10.70	220	9.20	180	7.60	180	5.40
300	530	5.40	530	4.90	490	4.40	420	3.80	350	3.10	240	2.20
600	690	3.20	630	2.90	560	2.60	490	2.20	400	1.80	280	1.30
1000	750	2.40	680	2.20	610	2.00	530	1.70	430	1.40	310	1.00
1500	770	1.70	710	1.60	630	1.40	550	1.20	450	1.00	320	0.70
1E+04	940	0.41	860	0.38	770	0.34	670	0.29	540	0.24	390	0.17
1E+05	1060	0.18	970	0.16	870	0.15	750	0.13	610	0.10	430	0.07
1E+06	1140	0.20	1040	0.18	930	0.16	800	0.14	660	0.11	460	0.08

100 μF — 16 V — case size 4

	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
Freq	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	3	7.20	3	7.20	3	7.20	3	7.20	2	6.10	2	5.00
10	35	9.60	35	9.60	35	9.60	35	9.60	29	8.10	24	6.70
50	190	10.40	190	10.40	190	10.40	190	10.40	160	8.80	130	7.10
100	450	12.30	410	11.30	350	10.10	310	8.70	260	7.10	260	5.00
300	780	5.00	760	4.60	680	4.10	590	3.60	480	2.90	340	2.10
600	950	3.00	870	2.70	770	2.40	670	2.10	550	1.70	390	1.20
1000	1030	2.30	940	2.10	840	1.90	730	1.60	600	1.30	420	0.94
1500	1070	1.60	980	1.50	870	1.30	760	1.10	620	0.93	440	0.66
1E+04	1300	0.39	1190	0.35	1060	0.32	920	0.27	750	0.22	530	0.16
1E+05	1470	0.17	1340	0.15	1200	0.14	1040	0.12	850	0.10	600	0.07
1E+06	1570	0.18	1430	0.17	1280	0.15	1110	0.13	910	0.11	640	0.08

150 μF — 16 V — case size 4

	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
Freq	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	4	7.20	4	7.20	4	7.20	4	7.20	3	6.10	3	5.00
10	52	9.60	52	9.60	52	9.60	52	9.60	44	8.10	36	6.70
50	290	10.40	290	10.40	290	10.40	270	9.90	230	8.10	160	5.90
100	570	9.50	470	8.70	410	7.80	390	6.70	390	5.50	310	3.90
300	960	3.90	870	3.60	780	3.20	680	2.80	550	2.20	390	1.60
600	1090	2.30	1000	2.10	890	1.90	770	1.60	630	1.30	450	0.94
1000	1190	1.80	1090	1.60	980	1.40	840	1.30	690	1.00	490	0.72
1500	1230	1.20	1130	1.10	1010	1.00	870	0.88	710	0.72	500	0.51
1E+04	1500	0.30	1370	0.27	1230	0.24	1060	0.21	870	0.17	610	0.12
1E+05	1700	0.19	1550	0.18	1380	0.16	1200	0.14	980	0.11	690	0.08
1E+06	1810	0.21	1650	0.19	1480	0.17	1280	0.15	1050	0.12	740	0.09

220 μF — 16 V — case size 5

	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
Freq	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	6	7.20	6	7.20	6	7.20	6	7.20	5	6.10	4	5.00
10	76	9.60	76	9.60	76	9.60	76	9.60	65	8.10	53	6.70
50	420	10.40	420	10.40	420	10.40	370	9.20	300	7.50	240	5.40
100	720	8.70	610	7.90	560	7.10	560	6.10	560	5.00	420	3.50
300	1270	3.50	1160	3.20	1040	2.90	900	2.50	740	2.00	520	1.40
600	1460	2.10	1330	1.90	1190	1.70	1030	1.50	840	1.20	600	0.85
1000	1590	1.60	1450	1.50	1300	1.30	1130	1.10	920	0.93	650	0.66
1500	1640	1.10	1500	1.00	1340	0.93	1160	0.80	950	0.66	670	0.46
1E+04	2000	0.27	1830	0.25	1640	0.22	1420	0.19	1160	0.16	820	0.11
1E+05	2260	0.13	2060	0.12	1850	0.10	1600	0.09	1310	0.07	920	0.05
1E+06	2410	0.16	2200	0.15	1970	0.13	1710	0.11	1390	0.09	990	0.07

330 μF — 16 V — case size 5

	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
Freq	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	9	7.20	9	7.20	9	7.20	9	7.20	7	6.10	6	5.00
10	110	9.60	110	9.60	110	9.60	110	9.60	97	8.10	80	6.70
50	630	10.40	600	9.80	530	8.80	460	7.60	380	6.20	360	4.40
100	850	7.10	850	6.50	850	5.80	850	5.00	730	4.10	510	2.90
300	1560	2.90	1420	2.60	1270	2.40	1100	2.00	900	1.70	640	1.20
600	1790	1.70	1630	1.60	1460	1.40	1260	1.20	1030	0.99	730	0.70
1000	1950	1.30	1780	1.20	1590	1.10	1380	0.93	1130	0.76	800	0.54
1500	2010	0.93	1840	0.85	1640	0.76	1420	0.66	1160	0.54	820	0.38
1E+04	2450	0.22	2240	0.20	2000	0.18	1740	0.16	1420	0.13	1000	0.09
1E+05	2770	0.16	2530	0.14	2260	0.13	1960	0.11	1600	0.09	1130	0.06
1E+06	2960	0.20	2700	0.18	2410	0.16	2090	0.14	1710	0.11	1210	0.08

470 μF — 16 V — case size 6

	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
Freq	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	12	7.20	12	7.20	12	7.20	12	7.20	10	6.10	9	5.00
10	160	9.60	160	9.60	160	9.60	160	9.60	140	8.10	110	6.70
50	900	9.90	820	9.10	700	8.10	610	7.00	520	5.70	520	4.10
100	1210	6.50	1210	6.00	1210	5.30	1170	4.60	960	3.80	680	2.70
300	2050	2.70	1870	2.40	1680	2.20	1450	1.90	1190	1.50	840	1.10
600	2350	1.60	2150	1.40	1920	1.30	1660	1.10	1360	0.91	960	0.64
1000	2570	1.40	2340	1.30	2100	1.20	1820	1.00	1480	0.82	1050	0.58
1500	2650	1.10	2420	1.00	2160	0.94	1870	0.81	1530	0.66	1080	0.47
1E+04	3230	0.29	2950	0.27	2640	0.24	2280	0.21	1860	0.17	1320	0.12
1E+05	3640	0.21	3330	0.19	2970	0.17	2580	0.15	2100	0.12	1490	0.08
1E+06	3890	0.29	3550	0.27	3180	0.24	2750	0.21	2250	0.17	1590	0.12

680 μF – 16 V – case size 6

	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
Freq	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	18	7.20	18	7.20	18	7.20	18	7.20	15	6.10	12	5.00
10	240	9.60	240	9.60	240	9.60	240	9.60	200	8.10	160	6.70
50	1240	8.60	1040	7.90	880	7.00	760	6.10	750	5.00	680	3.50
100	1740	5.70	1740	5.20	1700	4.60	1470	4.00	1200	3.30	850	2.30
300	2580	2.30	2350	2.10	2100	1.90	1820	1.60	1490	1.30	1050	0.95
600	2950	1.40	2690	1.20	2410	1.10	2090	0.97	1700	0.79	1200	0.56
1000	3220	1.20	2940	1.10	2630	1.00	2280	0.87	1860	0.71	1320	0.50
1500	3330	1.00	3040	0.91	2720	0.81	2350	0.71	1920	0.58	1360	0.41
1E+04	4050	0.26	3700	0.23	3310	0.21	2870	0.18	2340	0.15	1650	0.10
1E+05	4570	0.19	4170	0.18	3730	0.16	3230	0.14	2640	0.11	1870	0.08
1E+06	4880	0.30	4460	0.27	3990	0.24	3450	0.21	2820	0.17	1990	0.12

10 μF – 20 V – case size 1

	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
Freq	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	0	9.00	0	9.00	0	9.00	0	9.00	0	7.60	0	6.30
10	4	12.00	4	12.00	4	12.00	4	12.00	4	10.20	3	8.40
50	24	13.00	24	13.00	24	13.00	24	13.00	20	11.00	17	9.10
100	56	16.00	56	16.00	56	16.00	56	16.00	47	13.50	39	11.00
300	150	12.50	130	11.40	110	10.20	98	8.90	98	7.20	84	5.10
600	190	7.40	190	6.70	190	6.00	170	5.20	140	4.30	96	3.00
1000	260	5.70	230	5.20	210	4.60	180	4.00	150	3.30	100	2.30
1500	260	4.00	240	3.70	220	3.30	190	2.80	150	2.30	110	1.60
1E+04	320	0.96	290	0.88	260	0.79	230	0.68	190	0.56	130	0.39
1E+05	360	0.13	330	0.12	300	0.11	260	0.09	210	0.07	150	0.05
1E+06	390	0.14	360	0.13	320	0.11	280	0.10	220	0.08	160	0.06

15 μF – 20 V – case size 1

	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
Freq	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	1	9.00	1	9.00	1	9.00	1	9.00	0	7.60	0	6.30
10	7	12.00	7	12.00	7	12.00	7	12.00	6	10.20	5	8.40
50	36	13.00	36	13.00	36	13.00	36	13.00	31	11.00	25	9.10
100	84	16.00	84	16.00	84	16.00	84	15.90	70	13.20	52	9.90
300	170	10.10	150	9.20	150	8.30	150	7.20	140	5.90	100	4.10
600	280	6.00	260	5.50	230	4.90	200	4.20	160	3.50	120	2.40
1000	310	4.60	280	4.20	250	3.80	220	3.30	180	2.70	130	1.90
1500	320	3.20	290	3.00	260	2.70	230	2.30	190	1.90	130	1.30
1E+04	390	0.78	360	0.71	320	0.64	280	0.55	230	0.45	160	0.32
1E+05	440	0.16	400	0.14	360	0.13	310	0.11	260	0.09	180	0.06
1E+06	470	0.17	430	0.15	390	0.14	330	0.12	270	0.10	190	0.07

47 μF — 20 V — case size 2A

Freq Hz	T 25 degC Irms mA	T 25 degC Vpeak V	T 45 degC Irms mA	T 45 degC Vpeak V	T 65 degC Irms mA	T 65 degC Vpeak V	T 85 degC Irms mA	T 85 degC Vpeak V	T 105 degC Irms mA	T 105 degC Vpeak V	T 125 degC Irms mA	T 125 degC Vpeak V
1	2	9.00	2	9.00	2	9.00	2	9.00	1	7.60	1	6.30
10	20	12.00	20	12.00	20	12.00	20	12.00	17	10.20	14	8.40
50	110	13.00	110	13.00	110	13.00	110	13.00	95	11.00	78	8.90
100	260	15.80	250	14.50	210	12.90	180	11.20	150	9.10	150	6.50
300	460	6.50	460	5.90	410	5.30	350	4.60	290	3.70	200	2.60
600	570	3.80	520	3.50	470	3.10	410	2.70	330	2.20	230	1.60
1000	630	2.90	570	2.70	510	2.40	440	2.10	360	1.70	260	1.20
1500	650	2.10	590	1.90	530	1.70	460	1.50	370	1.20	260	0.85
1E+04	790	0.50	720	0.46	640	0.41	560	0.35	450	0.29	320	0.20
1E+05	890	0.25	810	0.23	720	0.20	630	0.18	510	0.14	360	0.10
1E+06	950	0.27	870	0.25	770	0.22	670	0.19	550	0.16	390	0.11

100 μF — 20 V — case size 4

Freq Hz	T 25 degC Irms mA	T 25 degC Vpeak V	T 45 degC Irms mA	T 45 degC Vpeak V	T 65 degC Irms mA	T 65 degC Vpeak V	T 85 degC Irms mA	T 85 degC Vpeak V	T 105 degC Irms mA	T 105 degC Vpeak V	T 125 degC Irms mA	T 125 degC Vpeak V
1	3	9.00	3	9.00	3	9.00	3	9.00	3	7.60	2	6.30
10	44	12.00	44	12.00	44	12.00	44	12.00	37	10.20	30	8.40
50	240	13.00	240	13.00	240	13.00	230	12.60	190	10.40	140	7.60
100	500	12.30	410	11.30	350	10.10	320	8.70	320	7.10	270	5.00
300	830	5.00	760	4.60	680	4.10	590	3.60	480	2.90	340	2.10
600	950	3.00	870	2.70	770	2.40	670	2.10	550	1.70	390	1.20
1000	1030	2.30	940	2.10	840	1.90	730	1.60	600	1.30	420	0.94
1500	1070	1.60	980	1.50	870	1.30	760	1.10	620	0.93	440	0.66
1E+04	1300	0.39	1190	0.35	1060	0.32	920	0.27	750	0.22	530	0.16
1E+05	1470	0.17	1340	0.15	1200	0.14	1040	0.12	850	0.10	600	0.07
1E+06	1570	0.18	1430	0.17	1280	0.15	1110	0.13	910	0.11	640	0.08

150 μF — 20 V — case size 5

Freq Hz	T 25 degC Irms mA	T 25 degC Vpeak V	T 45 degC Irms mA	T 45 degC Vpeak V	T 65 degC Irms mA	T 65 degC Vpeak V	T 85 degC Irms mA	T 85 degC Vpeak V	T 105 degC Irms mA	T 105 degC Vpeak V	T 125 degC Irms mA	T 125 degC Vpeak V
1	5	9.00	5	9.00	5	9.00	5	9.00	4	7.60	3	6.30
10	65	12.00	65	12.00	65	12.00	65	12.00	55	10.20	46	8.40
50	360	13.00	360	13.00	360	13.00	310	11.40	260	9.30	210	6.70
100	610	10.70	520	9.80	480	8.80	480	7.60	480	6.20	350	4.40
300	1080	4.40	980	4.00	880	3.60	760	3.10	620	2.50	440	1.80
600	1230	2.60	1130	2.40	1010	2.10	870	1.80	710	1.50	500	1.10
1000	1350	2.00	1230	1.80	1100	1.60	950	1.40	780	1.20	550	0.81
1500	1390	1.40	1270	1.30	1130	1.10	980	0.99	800	0.81	570	0.57
1E+04	1690	0.34	1550	0.31	1380	0.28	1200	0.24	980	0.19	690	0.14
1E+05	1910	0.16	1740	0.15	1560	0.13	1350	0.11	1100	0.09	780	0.07
1E+06	2040	0.19	1860	0.17	1670	0.15	1440	0.13	1180	0.11	830	0.08

220 μF — 20 V — case size 5

Freq	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	7	9.00	7	9.00	7	9.00	7	9.00	6	7.60	5	6.30
10	95	12.00	95	12.00	95	12.00	95	12.00	81	10.20	67	8.40
50	530	13.00	500	12.00	430	10.70	380	9.30	310	7.60	300	5.40
100	710	8.70	710	7.90	710	7.10	710	6.10	590	5.00	420	3.50
300	1270	3.50	1160	3.20	1040	2.90	900	2.50	740	2.00	520	1.40
600	1460	2.10	1330	1.90	1190	1.70	1030	1.50	840	1.20	600	0.85
1000	1590	1.60	1450	1.50	1300	1.30	1130	1.10	920	0.93	650	0.66
1500	1640	1.10	1500	1.00	1340	0.93	1160	0.80	950	0.66	670	0.46
1E+04	2000	0.27	1830	0.25	1640	0.22	1420	0.19	1160	0.16	820	0.11
1E+05	2260	0.19	2060	0.18	1850	0.16	1600	0.14	1310	0.11	920	0.08
1E+06	2410	0.22	2200	0.20	1970	0.18	1710	0.16	1390	0.13	990	0.09

330 μF — 20 V — case size 6

Freq	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	11	9.00	11	9.00	11	9.00	11	9.00	9	7.60	8	6.30
10	140	12.00	140	12.00	140	12.00	140	12.00	120	10.20	100	8.40
50	790	11.80	690	10.80	590	9.70	510	8.40	450	6.80	450	4.80
100	1060	7.80	1060	7.10	1060	6.40	980	5.50	800	4.50	570	3.20
300	1720	3.20	1570	2.90	1400	2.60	1210	2.30	990	1.80	700	1.30
600	1970	1.90	1800	1.70	1610	1.50	1390	1.30	1140	1.10	800	0.77
1000	2150	1.70	1960	1.50	1750	1.40	1520	1.20	1240	0.98	880	0.69
1500	2220	1.40	2020	1.30	1810	1.10	1570	0.97	1280	0.79	910	0.56
1E+04	2700	0.35	2470	0.32	2210	0.29	1910	0.25	1560	0.20	1100	0.14
1E+05	3050	0.17	2780	0.16	2490	0.14	2160	0.12	1760	0.10	1240	0.07
1E+06	3260	0.24	2970	0.22	2660	0.20	2300	0.17	1880	0.14	1330	0.10

470 μF — 20 V — case size 6

Freq	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	15	9.00	15	9.00	15	9.00	15	9.00	13	7.60	11	6.30
10	200	12.00	200	12.00	200	12.00	200	12.00	170	10.20	140	8.40
50	1050	10.50	870	9.60	740	8.60	640	7.40	640	6.10	570	4.30
100	1510	6.90	1510	6.30	1430	5.70	1240	4.90	1010	4.00	720	2.80
300	2180	2.80	1990	2.60	1780	2.30	1540	2.00	1260	1.60	890	1.20
600	2490	1.70	2280	1.50	2040	1.40	1760	1.20	1440	0.97	1020	0.68
1000	2720	1.50	2490	1.40	2220	1.20	1930	1.10	1570	0.87	1110	0.61
1500	2810	1.20	2570	1.10	2290	1.00	1990	0.86	1620	0.70	1150	0.50
1E+04	3430	0.31	3130	0.28	2800	0.25	2420	0.22	1980	0.18	1400	0.13
1E+05	3860	0.22	3530	0.20	3160	0.18	2730	0.15	2230	0.13	1580	0.09
1E+06	4130	0.30	3770	0.27	3370	0.24	2920	0.21	2380	0.17	1690	0.12

10 μF – 25 V – case size 1

Freq	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	0	11.20	0	11.20	0	11.20	0	11.20	0	9.50	0	7.90
10	5	15.00	5	15.00	5	15.00	5	15.00	5	12.70	4	10.50
50	30	16.20	30	16.20	30	16.20	30	16.20	25	13.80	21	11.40
100	70	20.00	70	20.00	70	20.00	70	19.80	58	16.50	43	12.30
300	140	12.50	120	11.40	120	10.20	120	8.90	120	7.20	84	5.10
600	240	7.40	210	6.70	190	6.00	170	5.20	140	4.30	96	3.00
1000	260	5.70	230	5.20	210	4.60	180	4.00	150	3.30	100	2.30
1500	260	4.00	240	3.70	220	3.30	190	2.80	150	2.30	110	1.60
1E+04	320	0.96	290	0.88	260	0.79	230	0.68	190	0.56	130	0.39
1E+05	360	0.26	330	0.24	300	0.21	260	0.18	210	0.15	150	0.11
1E+06	390	0.28	360	0.25	320	0.22	280	0.19	220	0.16	160	0.11

15 μF – 25 V – case size 1

Freq	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	1	11.20	1	11.20	1	11.20	1	11.20	1	9.50	0	7.90
10	8	15.00	8	15.00	8	15.00	8	15.00	7	12.70	6	10.50
50	45	16.20	45	16.20	45	16.20	45	16.20	38	13.80	31	11.30
100	110	20.00	110	20.00	110	20.00	91	17.30	75	14.10	60	10.10
300	180	10.10	180	9.20	180	8.30	180	7.20	140	5.90	100	4.10
600	290	6.00	260	5.50	230	4.90	200	4.20	160	3.50	120	2.40
1000	310	4.60	280	4.20	250	3.80	220	3.30	180	2.70	130	1.90
1500	320	3.20	290	3.00	260	2.70	230	2.30	190	1.90	130	1.30
1E+04	390	0.78	360	0.71	320	0.64	280	0.55	230	0.45	160	0.32
1E+05	440	0.31	400	0.29	360	0.26	310	0.22	260	0.18	180	0.13
1E+06	470	0.33	430	0.31	390	0.27	330	0.24	270	0.19	190	0.14

22 μF – 25 V – case size 2A

Freq	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	1	11.20	1	11.20	1	11.20	1	11.20	1	9.50	1	7.90
10	12	15.00	12	15.00	12	15.00	12	15.00	10	12.70	8	10.50
50	66	16.20	66	16.20	66	16.20	66	16.20	56	13.80	46	11.30
100	150	20.00	150	20.00	140	18.50	120	16.00	100	13.10	88	9.30
300	270	9.30	270	8.50	270	7.60	240	6.60	190	5.40	140	3.80
600	390	5.50	350	5.00	320	4.50	270	3.90	220	3.20	160	2.20
1000	420	4.20	380	3.90	340	3.50	300	3.00	240	2.50	170	1.70
1500	430	3.00	400	2.70	360	2.40	310	2.10	250	1.70	180	1.20
1E+04	530	0.72	480	0.66	430	0.59	370	0.51	310	0.42	220	0.29
1E+05	600	0.21	550	0.19	490	0.17	420	0.15	350	0.12	240	0.09
1E+06	640	0.23	580	0.21	520	0.18	450	0.16	370	0.13	260	0.09

33 μF – 25 V – case size 2A

	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
Freq	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	1	11.20	1	11.20	1	11.20	1	11.20	1	9.50	1	7.90
10	18	15.00	18	15.00	18	15.00	18	15.00	15	12.70	13	10.50
50	99	16.20	99	16.20	99	16.20	99	16.20	83	13.60	67	11.00
100	230	18.90	210	17.30	180	15.40	150	13.30	130	10.90	130	7.70
300	400	7.70	380	7.10	340	6.30	300	5.50	240	4.50	170	3.20
600	480	4.60	440	4.20	390	3.70	340	3.20	280	2.60	200	1.90
1000	520	3.50	480	3.20	430	2.90	370	2.50	300	2.00	210	1.40
1500	540	2.50	490	2.30	440	2.00	380	1.80	310	1.40	220	1.00
1E+04	660	0.60	600	0.54	540	0.49	470	0.42	380	0.34	270	0.24
1E+05	740	0.26	680	0.24	610	0.21	530	0.19	430	0.15	300	0.11
1E+06	790	0.28	730	0.26	650	0.23	560	0.20	460	0.16	320	0.11

47 μF – 25 V – case size 2A

	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
Freq	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	2	11.20	2	11.20	2	11.20	2	11.20	2	9.50	1	7.90
10	26	15.00	26	15.00	26	15.00	26	15.00	22	12.70	18	10.50
50	140	16.20	140	16.20	140	16.20	140	16.00	110	13.20	84	9.70
100	300	15.80	250	14.50	210	12.90	190	11.20	190	9.10	160	6.50
300	500	6.50	460	5.90	410	5.30	350	4.60	290	3.70	200	2.60
600	570	3.80	520	3.50	470	3.10	410	2.70	330	2.20	230	1.60
1000	630	2.90	570	2.70	510	2.40	440	2.10	360	1.70	260	1.20
1500	650	2.10	590	1.90	530	1.70	460	1.50	370	1.20	260	0.85
1E+04	790	0.50	720	0.46	640	0.41	560	0.35	450	0.29	320	0.20
1E+05	890	0.31	810	0.29	720	0.26	630	0.22	510	0.18	360	0.13
1E+06	950	0.34	870	0.31	770	0.27	670	0.24	550	0.19	390	0.14

68 μF – 25 V – case size 4

	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
Freq	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	3	11.20	3	11.20	3	11.20	3	11.20	2	9.50	2	7.90
10	37	15.00	37	15.00	37	15.00	37	15.00	31	12.70	26	10.50
50	200	16.20	200	16.20	200	16.20	200	15.60	160	12.80	120	9.30
100	410	15.00	340	13.70	290	12.20	270	10.60	270	8.70	230	6.10
300	680	6.10	620	5.60	560	5.00	480	4.30	390	3.50	280	2.50
600	780	3.60	720	3.30	640	3.00	550	2.60	450	2.10	320	1.50
1000	860	2.80	780	2.50	700	2.30	600	2.00	490	1.60	350	1.10
1500	880	2.00	810	1.80	720	1.60	620	1.40	510	1.10	360	0.80
1E+04	1080	0.47	980	0.43	880	0.39	760	0.33	620	0.27	440	0.19
1E+05	1210	0.17	1110	0.16	990	0.14	860	0.12	700	0.10	500	0.07
1E+06	1300	0.19	1180	0.17	1060	0.15	920	0.13	750	0.11	530	0.08

100 μF – 25 V – case size 4

Freq Hz	T 25 degC Irms mA	T 25 degC Vpeak V	T 45 degC Irms mA	T 45 degC Vpeak V	T 65 degC Irms mA	T 65 degC Vpeak V	T 85 degC Irms mA	T 85 degC Vpeak V	T 105 degC Irms mA	T 105 degC Vpeak V	T 125 degC Irms mA	T 125 degC Vpeak V
1	4	11.20	4	11.20	4	11.20	4	11.20	3	9.50	3	7.90
10	54	15.00	54	15.00	54	15.00	54	15.00	46	12.70	38	10.50
50	300	16.20	300	16.00	260	14.30	230	12.40	190	10.10	170	7.20
100	410	11.60	400	10.60	400	9.40	400	8.20	360	6.70	250	4.70
300	770	4.70	710	4.30	630	3.90	550	3.30	450	2.70	320	1.90
600	890	2.80	810	2.50	720	2.30	630	2.00	510	1.60	360	1.10
1000	970	2.20	880	2.00	790	1.80	680	1.50	560	1.20	400	0.88
1500	1000	1.50	910	1.40	820	1.20	710	1.10	580	0.88	410	0.62
1E+04	1220	0.36	1110	0.33	990	0.30	860	0.26	700	0.21	500	0.15
1E+05	1370	0.19	1250	0.18	1120	0.16	970	0.14	790	0.11	560	0.08
1E+06	1470	0.21	1340	0.19	1200	0.17	1040	0.15	850	0.12	600	0.09

150 μF – 25 V – case size 5

Freq Hz	T 25 degC Irms mA	T 25 degC Vpeak V	T 45 degC Irms mA	T 45 degC Vpeak V	T 65 degC Irms mA	T 65 degC Vpeak V	T 85 degC Irms mA	T 85 degC Vpeak V	T 105 degC Irms mA	T 105 degC Vpeak V	T 125 degC Irms mA	T 125 degC Vpeak V
1	6	11.20	6	11.20	6	11.20	6	11.20	5	9.50	4	7.90
10	81	15.00	81	15.00	81	15.00	81	15.00	69	12.70	57	10.50
50	450	16.20	420	14.90	370	13.30	320	11.50	260	9.40	260	6.70
100	600	10.70	600	9.80	600	8.80	600	7.60	500	6.20	350	4.40
300	1080	4.40	980	4.00	880	3.60	760	3.10	620	2.50	440	1.80
600	1230	2.60	1130	2.40	1010	2.10	870	1.80	710	1.50	500	1.10
1000	1350	2.00	1230	1.80	1100	1.60	950	1.40	780	1.20	550	0.81
1500	1390	1.40	1270	1.30	1130	1.10	980	0.99	800	0.81	570	0.57
1E+04	1690	0.34	1550	0.31	1380	0.28	1200	0.24	980	0.19	690	0.14
1E+05	1910	0.22	1740	0.20	1560	0.18	1350	0.15	1100	0.12	780	0.09
1E+06	2040	0.24	1860	0.22	1670	0.20	1440	0.17	1180	0.14	830	0.10

220 μF – 25 V – case size 6

Freq Hz	T 25 degC Irms mA	T 25 degC Vpeak V	T 45 degC Irms mA	T 45 degC Vpeak V	T 65 degC Irms mA	T 65 degC Vpeak V	T 85 degC Irms mA	T 85 degC Vpeak V	T 105 degC Irms mA	T 105 degC Vpeak V	T 125 degC Irms mA	T 125 degC Vpeak V
1	9	11.20	9	11.20	9	11.20	9	11.20	8	9.50	6	7.90
10	120	15.00	120	15.00	120	15.00	120	15.00	100	12.70	84	10.50
50	660	14.50	570	13.20	480	11.80	420	10.20	380	8.40	370	5.90
100	880	9.50	880	8.70	880	7.80	800	6.70	650	5.50	460	3.90
300	1400	3.90	1280	3.60	1150	3.20	990	2.80	810	2.30	570	1.60
600	1610	2.30	1470	2.10	1310	1.90	1140	1.60	930	1.30	660	0.94
1000	1750	2.10	1600	1.90	1430	1.70	1240	1.50	1010	1.20	720	0.84
1500	1810	1.70	1650	1.50	1480	1.40	1280	1.20	1050	0.97	740	0.68
1E+04	2210	0.43	2010	0.39	1800	0.35	1560	0.30	1270	0.25	900	0.18
1E+05	2490	0.21	2270	0.19	2030	0.17	1760	0.15	1440	0.12	1020	0.09
1E+06	2660	0.26	2430	0.24	2170	0.21	1880	0.18	1540	0.15	1090	0.11

330 μF — 25 V — case size 6

Freq Hz	T 25 degC Irms mA	T 25 degC Vpeak V	T 45 degC Irms mA	T 45 degC Vpeak V	T 65 degC Irms mA	T 65 degC Vpeak V	T 85 degC Irms mA	T 85 degC Vpeak V	T 105 degC Irms mA	T 105 degC Vpeak V	T 125 degC Irms mA	T 125 degC Vpeak V
1	13	11.20	13	11.20	13	11.20	13	11.20	11	9.50	9	7.90
10	180	15.00	180	15.00	180	15.00	180	15.00	150	12.70	120	10.50
50	870	12.50	720	11.50	620	10.20	570	8.90	570	7.20	480	5.10
100	1320	8.30	1320	7.50	1200	6.70	1040	5.80	850	4.80	600	3.40
300	1820	3.40	1660	3.10	1490	2.80	1290	2.40	1050	2.00	740	1.40
600	2090	2.00	1910	1.80	1700	1.60	1480	1.40	1200	1.20	850	0.81
1000	2280	1.80	2080	1.60	1860	1.50	1610	1.30	1320	1.00	930	0.73
1500	2350	1.50	2150	1.30	1920	1.20	1660	1.00	1360	0.84	960	0.59
1E+04	2870	0.37	2620	0.34	2340	0.30	2030	0.26	1650	0.21	1170	0.15
1E+05	3230	0.18	2950	0.17	2640	0.15	2290	0.13	1870	0.11	1320	0.07
1E+06	3450	0.25	3150	0.23	2820	0.20	2440	0.18	1990	0.14	1410	0.10

2,2 μF — 35 V — case size 1

Freq Hz	T 25 degC Irms mA	T 25 degC Vpeak V	T 45 degC Irms mA	T 45 degC Vpeak V	T 65 degC Irms mA	T 65 degC Vpeak V	T 85 degC Irms mA	T 85 degC Vpeak V	T 105 degC Irms mA	T 105 degC Vpeak V	T 125 degC Irms mA	T 125 degC Vpeak V
1	0	9.90	0	9.90	0	9.90	0	9.90	0	8.40	0	6.90
10	1	13.20	1	13.20	1	13.20	1	13.20	1	11.20	1	9.30
50	6	14.30	6	14.30	6	14.30	6	14.30	5	12.10	4	10.00
100	14	17.60	14	17.60	14	17.60	14	17.60	12	14.90	10	12.40
300	41	17.60	41	17.60	39	16.50	34	14.30	27	11.60	24	8.30
600	60	12.00	50	10.90	46	9.80	46	8.50	46	6.90	34	4.90
1000	65	9.20	65	8.40	65	7.50	65	6.50	53	5.30	38	3.80
1500	95	6.50	87	6.00	78	5.30	67	4.60	55	3.80	39	2.70
1E+04	120	1.60	110	1.40	95	1.30	82	1.10	67	0.90	47	0.64
1E+05	130	0.14	120	0.13	110	0.11	92	0.10	75	0.08	53	0.06
1E+06	140	0.15	130	0.14	110	0.12	99	0.10	81	0.09	57	0.06

3,3 μF — 35 V — case size 1

Freq Hz	T 25 degC Irms mA	T 25 degC Vpeak V	T 45 degC Irms mA	T 45 degC Vpeak V	T 65 degC Irms mA	T 65 degC Vpeak V	T 85 degC Irms mA	T 85 degC Vpeak V	T 105 degC Irms mA	T 105 degC Vpeak V	T 125 degC Irms mA	T 125 degC Vpeak V
1	0	9.90	0	9.90	0	9.90	0	9.90	0	8.40	0	6.90
10	2	13.20	2	13.20	2	13.20	2	13.20	1	11.20	1	9.30
50	9	14.30	9	14.30	9	14.30	9	14.30	7	12.10	6	10.00
100	21	17.60	21	17.60	21	17.60	21	17.60	17	14.90	14	12.30
300	62	16.60	56	15.10	48	13.50	41	11.70	36	9.60	36	6.80
600	69	9.80	69	8.90	69	8.00	69	6.90	59	5.60	42	4.00
1000	98	7.50	98	6.90	92	6.10	79	5.30	65	4.30	46	3.10
1500	120	5.30	110	4.80	95	4.30	82	3.80	67	3.10	47	2.20
1E+04	140	1.30	130	1.20	120	1.00	100	0.90	82	0.74	58	0.52
1E+05	160	0.17	150	0.15	130	0.14	110	0.12	92	0.10	65	0.07
1E+06	170	0.18	160	0.17	140	0.15	120	0.13	98	0.10	70	0.07

4,7 μF — 35 V — case size 1

Freq	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	0	9.90	0	9.90	0	9.90	0	9.90	0	8.40	0	6.90
10	2	13.20	2	13.20	2	13.20	2	13.20	2	11.20	2	9.30
50	13	14.30	13	14.30	13	14.30	13	14.30	11	12.10	9	10.00
100	29	17.60	29	17.60	29	17.60	29	17.60	25	14.90	20	12.20
300	80	13.90	67	12.70	57	11.30	51	9.80	51	8.00	44	5.70
600	98	8.20	98	7.50	98	6.70	87	5.80	71	4.70	50	3.40
1000	130	6.30	120	5.80	110	5.20	95	4.50	78	3.70	55	2.60
1500	140	4.50	130	4.10	110	3.60	98	3.20	80	2.60	57	1.80
1E+04	170	1.10	150	0.98	140	0.87	120	0.76	98	0.62	69	0.44
1E+05	190	0.20	170	0.18	160	0.17	130	0.14	110	0.12	78	0.08
1E+06	200	0.22	190	0.20	170	0.18	140	0.15	120	0.12	83	0.09

6,8 μF — 35 V — case size 1

Freq	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	0	9.90	0	9.90	0	9.90	0	9.90	0	8.40	0	6.90
10	3	13.20	3	13.20	3	13.20	3	13.20	3	11.20	2	9.30
50	18	14.30	18	14.30	18	14.30	18	14.30	15	12.10	13	10.00
100	42	17.60	42	17.60	42	17.60	42	17.60	35	14.70	27	11.30
300	89	11.60	77	10.60	73	9.50	73	8.20	73	6.70	53	4.70
600	140	6.80	140	6.30	120	5.60	110	4.80	86	4.00	61	2.80
1000	160	5.30	150	4.80	130	4.30	110	3.70	94	3.00	66	2.20
1500	170	3.70	150	3.40	140	3.00	120	2.60	97	2.10	68	1.50
1E+04	200	0.89	190	0.82	170	0.73	140	0.63	120	0.52	83	0.36
1E+05	230	0.24	210	0.22	190	0.20	160	0.17	130	0.14	94	0.10
1E+06	250	0.26	220	0.24	200	0.21	170	0.18	140	0.15	100	0.11

10 μF — 35 V — case size 2A

Freq	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	0	9.90	0	9.90	0	9.90	0	9.90	0	8.40	0	6.90
10	5	13.20	5	13.20	5	13.20	5	13.20	4	11.20	3	9.30
50	27	14.30	27	14.30	27	14.30	27	14.30	23	12.10	19	10.00
100	62	17.60	62	17.60	62	17.60	61	17.30	51	14.30	37	10.50
300	110	10.70	110	9.70	110	8.70	110	7.50	100	6.20	72	4.40
600	200	6.30	180	5.70	160	5.10	140	4.40	120	3.60	82	2.60
1000	220	4.80	200	4.40	180	4.00	160	3.40	130	2.80	89	2.00
1500	230	3.40	210	3.10	180	2.80	160	2.40	130	2.00	92	1.40
1E+04	280	0.82	250	0.75	230	0.67	200	0.58	160	0.47	110	0.34
1E+05	310	0.11	280	0.10	250	0.09	220	0.08	180	0.06	130	0.04
1E+06	330	0.12	300	0.11	270	0.10	230	0.08	190	0.07	140	0.05

15 μF – 35 V – case size 2A

	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
Freq	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	1	9.90	1	9.90	1	9.90	1	9.90	1	8.40	0	6.90
10	7	13.20	7	13.20	7	13.20	7	13.20	6	11.20	5	9.30
50	40	14.30	40	14.30	40	14.30	40	14.30	34	12.10	28	10.00
100	93	17.60	93	17.60	91	17.20	79	14.90	64	12.20	53	8.70
300	160	8.70	160	7.90	160	7.10	150	6.20	120	5.00	88	3.60
600	250	5.10	220	4.70	200	4.20	170	3.60	140	3.00	100	2.10
1000	270	4.00	250	3.60	220	3.20	190	2.80	160	2.30	110	1.60
1500	280	2.80	250	2.50	230	2.30	200	2.00	160	1.60	110	1.10
1E+04	340	0.67	310	0.61	280	0.55	240	0.47	200	0.39	140	0.27
1E+05	380	0.13	350	0.12	310	0.11	270	0.10	220	0.08	160	0.05
1E+06	410	0.14	370	0.13	330	0.12	290	0.10	230	0.08	170	0.06

22 μF – 35 V – case size 2A

	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
Freq	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	1	9.90	1	9.90	1	9.90	1	9.90	1	8.40	1	6.90
10	11	13.20	11	13.20	11	13.20	11	13.20	9	11.20	7	9.30
50	59	14.30	59	14.30	59	14.30	59	14.30	49	12.10	40	9.80
100	140	17.50	130	16.00	110	14.30	96	12.40	78	10.10	78	7.10
300	240	7.20	240	6.50	210	5.80	180	5.10	150	4.10	110	2.90
600	300	4.20	270	3.90	240	3.40	210	3.00	170	2.40	120	1.70
1000	320	3.30	300	3.00	260	2.70	230	2.30	190	1.90	130	1.30
1500	330	2.30	310	2.10	270	1.90	240	1.60	190	1.30	140	0.94
1E+04	410	0.55	370	0.50	330	0.45	290	0.39	240	0.32	170	0.22
1E+05	460	0.16	420	0.15	380	0.13	320	0.11	270	0.09	190	0.07
1E+06	490	0.17	450	0.16	400	0.14	350	0.12	280	0.10	200	0.07

33 μF – 35 V – case size 4

	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
Freq	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	1	9.90	1	9.90	1	9.90	1	9.90	1	8.40	1	6.90
10	16	13.20	16	13.20	16	13.20	16	13.20	13	11.20	11	9.30
50	88	14.30	88	14.30	88	14.30	88	14.30	74	12.00	59	9.60
100	210	16.40	180	15.00	160	13.40	130	11.60	120	9.50	120	6.70
300	360	6.70	330	6.10	300	5.50	260	4.80	210	3.90	150	2.70
600	420	4.00	380	3.60	340	3.20	300	2.80	240	2.30	170	1.60
1000	460	3.10	420	2.80	370	2.50	320	2.20	260	1.80	190	1.20
1500	470	2.20	430	2.00	380	1.80	330	1.50	270	1.20	190	0.88
1E+04	570	0.52	520	0.47	470	0.42	410	0.37	330	0.30	230	0.21
1E+05	650	0.09	590	0.08	530	0.07	460	0.06	370	0.05	260	0.04
1E+06	690	0.10	630	0.09	560	0.08	490	0.07	400	0.06	280	0.04

47 μF — 35 V — case size 4

Freq	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	2	9.90	2	9.90	2	9.90	2	9.90	1	8.40	1	6.90
10	23	13.20	23	13.20	23	13.20	23	13.20	19	11.20	16	9.30
50	130	14.30	130	14.30	130	14.30	120	14.00	100	11.50	73	8.40
100	260	13.70	220	12.50	190	11.20	170	9.70	170	7.90	140	5.60
300	430	5.60	400	5.10	350	4.60	310	4.00	250	3.20	180	2.30
600	500	3.30	450	3.00	410	2.70	350	2.30	290	1.90	200	1.40
1000	540	2.50	490	2.30	440	2.10	380	1.80	310	1.50	220	1.00
1500	560	1.80	510	1.60	460	1.50	400	1.30	320	1.00	230	0.73
1E+04	680	0.43	620	0.39	560	0.35	480	0.31	390	0.25	280	0.18
1E+05	770	0.11	700	0.10	630	0.09	540	0.08	440	0.06	310	0.04
1E+06	820	0.12	750	0.11	670	0.10	580	0.08	470	0.07	340	0.05

68 μF — 35 V — case size 5

Freq	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	2	9.90	2	9.90	2	9.90	2	9.90	2	8.40	2	6.90
10	33	13.20	33	13.20	33	13.20	33	13.20	28	11.20	23	9.30
50	180	14.30	180	14.30	170	13.80	150	11.90	120	9.70	100	6.90
100	270	11.20	240	10.20	240	9.10	240	7.90	240	6.50	170	4.60
300	510	4.60	460	4.20	420	3.70	360	3.20	290	2.60	210	1.90
600	580	2.70	530	2.50	480	2.20	410	1.90	340	1.60	240	1.10
1000	640	2.10	580	1.90	520	1.70	450	1.50	370	1.20	260	0.85
1500	660	1.50	600	1.30	540	1.20	460	1.00	380	0.85	270	0.60
1E+04	800	0.35	730	0.32	650	0.29	570	0.25	460	0.20	330	0.14
1E+05	900	0.09	820	0.08	740	0.07	640	0.06	520	0.05	370	0.04
1E+06	960	0.10	880	0.09	790	0.08	680	0.07	560	0.06	390	0.04

100 μF — 35 V — case size 6

Freq	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	4	9.90	4	9.90	4	9.90	4	9.90	3	8.40	3	6.90
10	48	13.20	48	13.20	48	13.20	48	13.20	41	11.20	34	9.30
50	260	14.30	260	14.00	230	12.50	200	10.80	160	8.90	150	6.30
100	360	10.10	350	9.30	350	8.30	350	7.20	320	5.90	220	4.10
300	680	4.20	620	3.80	550	3.40	480	2.90	390	2.40	280	1.70
600	780	2.40	710	2.20	640	2.00	550	1.70	450	1.40	320	1.00
1000	850	2.20	780	2.00	690	1.80	600	1.60	490	1.30	350	0.90
1500	880	1.80	800	1.60	720	1.50	620	1.30	510	1.00	360	0.73
1E+04	1070	0.46	970	0.42	870	0.37	760	0.32	620	0.26	440	0.19
1E+05	1200	0.10	1100	0.09	980	0.08	850	0.07	700	0.06	490	0.04
1E+06	1290	0.13	1180	0.12	1050	0.10	910	0.09	740	0.07	530	0.05

150 μF — 35 V — case size 6

	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
Freq	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	5	9.90	5	9.90	5	9.90	5	9.90	5	8.40	4	6.90
10	72	13.20	72	13.20	72	13.20	72	13.20	61	11.20	50	9.30
50	400	13.50	360	12.30	300	11.00	260	9.50	230	7.80	230	5.50
100	530	8.90	530	8.10	530	7.20	510	6.30	410	5.10	290	3.60
300	890	3.60	810	3.30	730	3.00	630	2.60	510	2.10	360	1.50
600	1020	2.10	930	2.00	830	1.70	720	1.50	590	1.20	420	0.87
1000	1110	1.90	1010	1.80	910	1.60	790	1.40	640	1.10	450	0.78
1500	1150	1.60	1050	1.40	940	1.30	810	1.10	660	0.90	470	0.64
1E+04	1400	0.40	1280	0.36	1140	0.33	990	0.28	810	0.23	570	0.16
1E+05	1580	0.13	1440	0.12	1290	0.11	1120	0.09	910	0.08	640	0.05
1E+06	1690	0.16	1540	0.15	1380	0.13	1190	0.11	970	0.09	690	0.07

2,2 μF — 40 V — case size 1

	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
Freq	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	0	11.30	0	11.30	0	11.30	0	11.30	0	9.60	0	7.90
10	1	15.10	1	15.10	1	15.10	1	15.10	1	12.80	1	10.60
50	7	16.40	7	16.40	7	16.40	7	16.40	6	13.90	5	11.50
100	16	20.20	16	20.20	16	20.20	16	20.20	13	17.10	11	14.10
300	47	20.20	44	18.60	39	16.50	34	14.30	28	11.70	27	8.30
600	55	12.00	53	11.00	53	9.80	53	8.50	49	6.90	34	4.90
1000	75	9.20	75	8.40	75	7.50	65	6.50	53	5.30	38	3.80
1500	95	6.50	87	6.00	78	5.30	67	4.60	55	3.80	39	2.70
1E+04	120	1.60	110	1.40	95	1.30	82	1.10	67	0.90	47	0.64
1E+05	130	0.14	120	0.13	110	0.11	92	0.10	75	0.08	53	0.06
1E+06	140	0.15	130	0.14	110	0.12	99	0.10	81	0.09	57	0.06

3,3 μF — 40 V — case size 1

	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
Freq	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	0	11.30	0	11.30	0	11.30	0	11.30	0	9.60	0	7.90
10	2	15.10	2	15.10	2	15.10	2	15.10	2	12.80	1	10.60
50	10	16.40	10	16.40	10	16.40	10	16.40	8	13.90	7	11.50
100	23	20.20	23	20.20	23	20.20	23	20.20	20	17.00	16	14.00
300	67	16.60	56	15.10	48	13.50	41	11.70	41	9.60	37	6.80
600	79	9.80	79	8.90	79	8.00	73	6.90	59	5.60	42	4.00
1000	110	7.50	100	6.90	92	6.10	79	5.30	65	4.30	46	3.10
1500	120	5.30	110	4.80	95	4.30	82	3.80	67	3.10	47	2.20
1E+04	140	1.30	130	1.20	120	1.00	100	0.90	82	0.74	58	0.52
1E+05	160	0.17	150	0.15	130	0.14	110	0.12	92	0.10	65	0.07
1E+06	170	0.18	160	0.17	140	0.15	120	0.13	98	0.10	70	0.07

4,7 μF — 40 V — case size 1

Freq	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	0	11.30	0	11.30	0	11.30	0	11.30	0	9.60	0	7.90
10	3	15.10	3	15.10	3	15.10	3	15.10	2	12.80	2	10.60
50	14	16.40	14	16.40	14	16.40	14	16.40	12	13.90	10	11.50
100	33	20.20	33	20.20	33	20.20	33	20.20	28	16.90	22	13.40
300	77	13.90	64	12.70	58	11.40	58	9.80	58	8.00	44	5.70
600	110	8.20	110	7.50	100	6.70	87	5.80	71	4.70	50	3.40
1000	130	6.30	120	5.80	110	5.20	95	4.50	78	3.70	55	2.60
1500	140	4.50	130	4.10	110	3.60	98	3.20	80	2.60	57	1.80
1E+04	170	1.10	150	0.98	140	0.87	120	0.76	98	0.62	69	0.44
1E+05	190	0.20	170	0.18	160	0.17	130	0.14	110	0.12	78	0.08
1E+06	200	0.22	190	0.20	170	0.18	140	0.15	120	0.12	83	0.09

6,8 μF — 40 V — case size 1

Freq	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	0	11.30	0	11.30	0	11.30	0	11.30	0	9.60	0	7.90
10	4	15.10	4	15.10	4	15.10	4	15.10	3	12.80	3	10.60
50	21	16.40	21	16.40	21	16.40	21	16.40	18	13.90	14	11.50
100	48	20.20	48	20.20	48	20.20	46	19.30	38	15.90	28	11.50
300	85	11.60	84	10.60	84	9.50	84	8.20	75	6.70	53	4.70
600	150	6.80	140	6.30	120	5.60	110	4.80	86	4.00	61	2.80
1000	160	5.30	150	4.80	130	4.30	110	3.70	94	3.00	66	2.20
1500	170	3.70	150	3.40	140	3.00	120	2.60	97	2.10	68	1.50
1E+04	200	0.89	190	0.82	170	0.73	140	0.63	120	0.52	83	0.36
1E+05	230	0.24	210	0.22	190	0.20	160	0.17	130	0.14	94	0.10
1E+06	250	0.26	220	0.24	200	0.21	170	0.18	140	0.15	100	0.11

10 μF — 40 V — case size 2A

Freq	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	0	11.30	0	11.30	0	11.30	0	11.30	0	9.60	0	7.90
10	6	15.10	6	15.10	6	15.10	6	15.10	5	12.80	4	10.60
50	30	16.40	30	16.40	30	16.40	30	16.40	26	13.90	21	11.50
100	71	20.20	71	20.20	71	20.20	64	18.20	52	14.80	41	10.60
300	120	10.70	120	9.70	120	8.70	120	7.50	100	6.20	72	4.40
600	200	6.30	180	5.70	160	5.10	140	4.40	120	3.60	82	2.60
1000	220	4.80	200	4.40	180	4.00	160	3.40	130	2.80	89	2.00
1500	230	3.40	210	3.10	180	2.80	160	2.40	130	2.00	92	1.40
1E+04	280	0.82	250	0.75	230	0.67	200	0.58	160	0.47	110	0.34
1E+05	310	0.11	280	0.10	250	0.09	220	0.08	180	0.06	130	0.04
1E+06	330	0.12	300	0.11	270	0.10	230	0.08	190	0.07	140	0.05

15 μF – 40 V – case size 2A

Freq Hz	T 25 degC Irms mA	T 25 degC Vpeak V	T 45 degC Irms mA	T 45 degC Vpeak V	T 65 degC Irms mA	T 65 degC Vpeak V	T 85 degC Irms mA	T 85 degC Vpeak V	T 105 degC Irms mA	T 105 degC Vpeak V	T 125 degC Irms mA	T 125 degC Vpeak V
1	1	11.30	1	11.30	1	11.30	1	11.30	1	9.60	0	7.90
10	8	15.10	8	15.10	8	15.10	8	15.10	7	12.80	6	10.60
50	46	16.40	46	16.40	46	16.40	46	16.40	38	13.80	32	11.40
100	110	20.20	100	19.40	92	17.30	79	15.00	65	12.20	61	8.70
300	180	8.70	180	7.90	180	7.10	150	6.20	120	5.00	88	3.60
600	250	5.10	220	4.70	200	4.20	170	3.60	140	3.00	100	2.10
1000	270	4.00	250	3.60	220	3.20	190	2.80	160	2.30	110	1.60
1500	280	2.80	250	2.50	230	2.30	200	2.00	160	1.60	110	1.10
1E+04	340	0.67	310	0.61	280	0.55	240	0.47	200	0.39	140	0.27
1E+05	380	0.13	350	0.12	310	0.11	270	0.10	220	0.08	160	0.05
1E+06	410	0.14	370	0.13	330	0.12	290	0.10	230	0.08	170	0.06

22 μF – 40 V – case size 4

Freq Hz	T 25 degC Irms mA	T 25 degC Vpeak V	T 45 degC Irms mA	T 45 degC Vpeak V	T 65 degC Irms mA	T 65 degC Vpeak V	T 85 degC Irms mA	T 85 degC Vpeak V	T 105 degC Irms mA	T 105 degC Vpeak V	T 125 degC Irms mA	T 125 degC Vpeak V
1	1	11.30	1	11.30	1	11.30	1	11.30	1	9.60	1	7.90
10	12	15.10	12	15.10	12	15.10	12	15.10	10	12.80	8	10.60
50	67	16.40	67	16.40	67	16.40	67	16.40	56	13.80	46	11.20
100	160	19.90	150	18.20	130	16.20	110	14.00	89	11.50	89	8.10
300	270	8.20	270	7.50	240	6.70	210	5.80	170	4.70	120	3.30
600	340	4.80	310	4.40	280	3.90	240	3.40	200	2.80	140	2.00
1000	370	3.70	340	3.40	300	3.00	260	2.60	210	2.10	150	1.50
1500	380	2.60	350	2.40	310	2.10	270	1.90	220	1.50	160	1.10
1E+04	460	0.63	420	0.57	380	0.51	330	0.44	270	0.36	190	0.26
1E+05	520	0.11	480	0.10	430	0.09	370	0.08	300	0.06	210	0.05
1E+06	560	0.12	510	0.11	460	0.10	400	0.08	320	0.07	230	0.05

33 μF – 40 V – case size 4

Freq Hz	T 25 degC Irms mA	T 25 degC Vpeak V	T 45 degC Irms mA	T 45 degC Vpeak V	T 65 degC Irms mA	T 65 degC Vpeak V	T 85 degC Irms mA	T 85 degC Vpeak V	T 105 degC Irms mA	T 105 degC Vpeak V	T 125 degC Irms mA	T 125 degC Vpeak V
1	1	11.30	1	11.30	1	11.30	1	11.30	1	9.60	1	7.90
10	18	15.10	18	15.10	18	15.10	18	15.10	15	12.80	13	10.60
50	100	16.40	100	16.40	100	16.40	99	16.20	83	13.50	62	10.00
100	220	16.40	180	15.00	160	13.40	130	11.60	130	9.50	120	6.70
300	370	6.70	330	6.10	300	5.50	260	4.80	210	3.90	150	2.70
600	420	4.00	380	3.60	340	3.20	300	2.80	240	2.30	170	1.60
1000	460	3.10	420	2.80	370	2.50	320	2.20	260	1.80	190	1.20
1500	470	2.20	430	2.00	380	1.80	330	1.50	270	1.20	190	0.88
1E+04	570	0.52	520	0.47	470	0.42	410	0.37	330	0.30	230	0.21
1E+05	650	0.09	590	0.08	530	0.07	460	0.06	370	0.05	260	0.04
1E+06	690	0.10	630	0.09	560	0.08	490	0.07	400	0.06	280	0.04

47 μF – 40 V – case size 5

	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
Freq	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	2	11.30	2	11.30	2	11.30	2	11.30	2	9.60	1	7.90
10	26	15.10	26	15.10	26	15.10	26	15.10	22	12.80	18	10.60
50	140	16.40	140	16.40	140	16.40	140	15.90	110	13.10	83	9.50
100	290	15.40	240	14.10	210	12.60	190	10.90	190	8.90	160	6.30
300	490	6.30	450	5.80	400	5.20	350	4.50	280	3.60	200	2.60
600	560	3.70	510	3.40	460	3.00	400	2.60	320	2.20	230	1.50
1000	610	2.90	560	2.60	500	2.30	430	2.00	350	1.70	250	1.20
1500	630	2.00	580	1.80	510	1.70	450	1.40	360	1.20	260	0.83
1E+04	770	0.49	700	0.44	630	0.40	540	0.34	440	0.28	310	0.20
1E+05	870	0.09	790	0.08	710	0.07	610	0.06	500	0.05	350	0.04
1E+06	930	0.10	850	0.09	760	0.08	650	0.07	530	0.06	380	0.04

68 μF – 40 V – case size 5

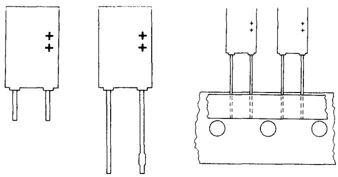
	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
Freq	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	3	11.30	3	11.30	3	11.30	3	11.30	2	9.60	2	7.90
10	37	15.10	37	15.10	37	15.10	37	15.10	31	12.80	26	10.60
50	210	16.40	200	15.50	170	13.80	150	12.00	120	9.80	120	6.90
100	270	11.20	270	10.20	270	9.10	270	7.90	240	6.50	170	4.60
300	510	4.60	460	4.20	420	3.70	360	3.20	290	2.60	210	1.90
600	580	2.70	530	2.50	480	2.20	410	1.90	340	1.60	240	1.10
1000	640	2.10	580	1.90	520	1.70	450	1.50	370	1.20	260	0.85
1500	660	1.50	600	1.30	540	1.20	460	1.00	380	0.85	270	0.60
1E+04	800	0.35	730	0.32	650	0.29	570	0.25	460	0.20	330	0.14
1E+05	900	0.08	820	0.07	740	0.06	640	0.05	520	0.04	370	0.03
1E+06	960	0.09	880	0.08	790	0.07	680	0.06	560	0.05	390	0.04

100 μF – 40 V – case size 6

	T 25 degC		T 45 degC		T 65 degC		T 85 degC		T 105 degC		T 125 degC	
Freq	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak	Irms	Vpeak
Hz	mA	V	mA	V	mA	V	mA	V	mA	V	mA	V
1	4	11.30	4	11.30	4	11.30	4	11.30	3	9.60	3	7.90
10	55	15.10	55	15.10	55	15.10	55	15.10	46	12.80	38	10.60
50	300	15.40	270	14.10	230	12.60	200	10.90	170	8.90	170	6.30
100	400	10.10	400	9.30	400	8.30	390	7.20	320	5.90	220	4.10
300	680	4.20	620	3.80	550	3.40	480	2.90	390	2.40	280	1.70
600	780	2.40	710	2.20	640	2.00	550	1.70	450	1.40	320	1.00
1000	850	2.20	780	2.00	690	1.80	600	1.60	490	1.30	350	0.90
1500	880	1.80	800	1.60	720	1.50	620	1.30	510	1.00	360	0.73
1E+04	1070	0.46	970	0.42	870	0.37	760	0.32	620	0.26	440	0.19
1E+05	1200	0.10	1100	0.09	980	0.08	850	0.07	700	0.06	490	0.04
1E+06	1290	0.13	1180	0.12	1050	0.10	910	0.09	740	0.07	530	0.05

SOLID ALUMINIUM CAPACITORS

- **Miniature type**
- **Single ended**
- **Epoxy potted**
- **Long life**
- **General and industrial applications**



QUICK REFERENCE DATA

Nominal capacitance range (E6 series)	0,1 to 68 μF
Tolerance on nominal capacitance	± 20% (± 10% to special order)
Rated voltage range, U_R (R5 series)	6,3 to 40 V
Category temperature range	−55 to + 85 °C
Endurance test at 85 °C	5000 h
Basic specification	IEC 384-4, long-life grade
Climatic category, IEC 68	55/085/56

Selection chart for C_{nom}-U_R and relevant case sizes.

C_{nom} μF	U_R (V) 6,3	10	16	25	35	40
0,1						1
0,15						1
0,22						1
0,33						1
0,47						1
0,68						1
1				1	1	2*
1,5				1		2
2,2				1		2
3,3			1	1*		
4,7			1	2*		
6,8			1	2		
10		1	2	2*		
15		1	2			
22	1	2				
33		2				
47	2					
68	2					

case size	maximum dimensions (mm)
1	12,5 x 8,5 x 4,5
2	12,5 x 8,5 x 6

* Available to special order.

APPLICATION

These capacitors are for filtering, smoothing, coupling and decoupling purposes in general and industrial applications. They utilize advanced technology to achieve long life, high reliability, high stability and low temperature dependence.

The capacitors have a very low and stable leakage current, small dimensions and a fixed pitch of 5 mm. Thanks to the potted execution they are particularly suited to withstand severe shock and vibration tests.

The taped version is suitable for automatic insertion and for cutting and forming equipment.

DESCRIPTION

The capacitor is of a construction with a highly etched aluminium plate anode, aluminium oxide as a dielectric and a solid cathode. The capacitor is potted with epoxy resin in a blue case.

The capacitor is available in three styles, all with soldered-copper radial leads:

style 1 : with short leads;
style 2 : with long leads of which the anode lead has a flattened area at the end;
style 3 : with long leads (without flattened area) on tape on reel, positive leading.

MECHANICAL DATA

Dimensions in mm

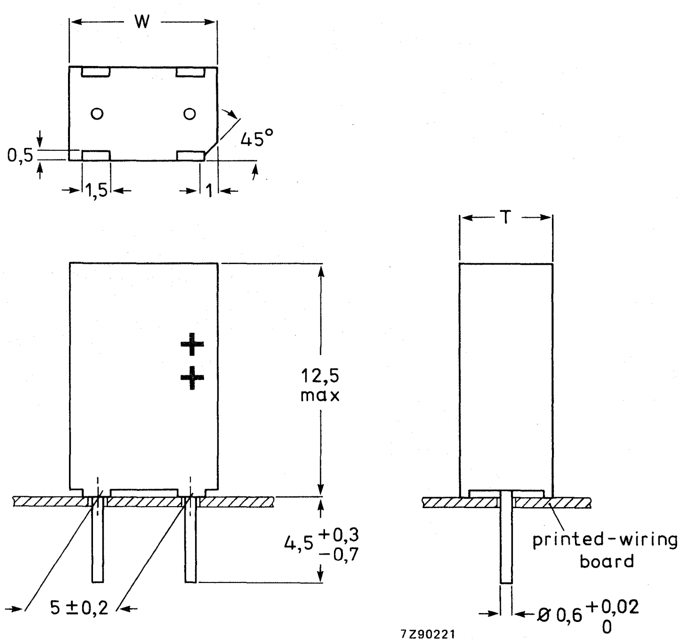


Fig. 1 Style 1; see Table 1a for dimensions T and W.
Note: Capacitors with other lead lengths are available to special order.

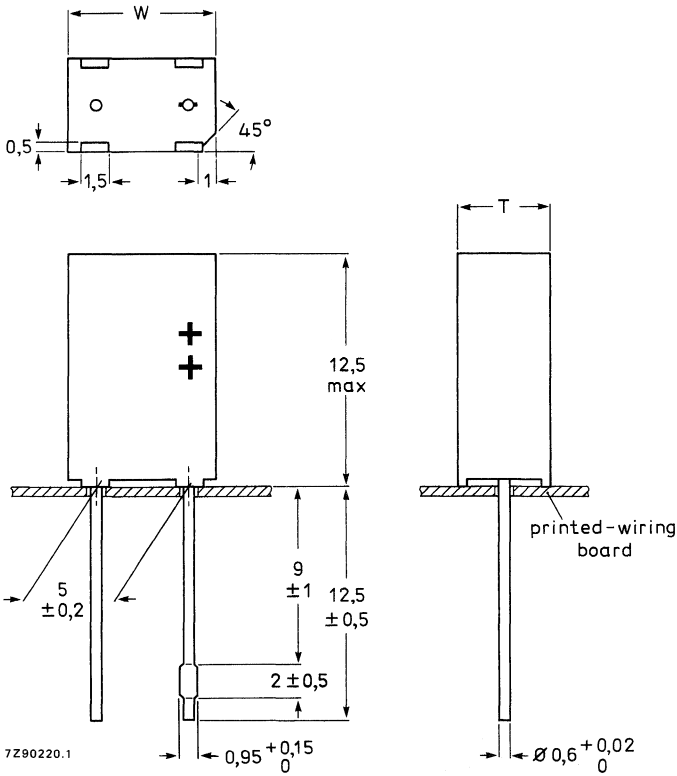


Fig. 2 Style 2; see Table 1a for dimensions T and W.

Table 1a

case size	T_{max}	W_{max}	mass g
1	4,5	8,5	0,4
2	6	8,5	0,7

DEVELOPMENT DATA

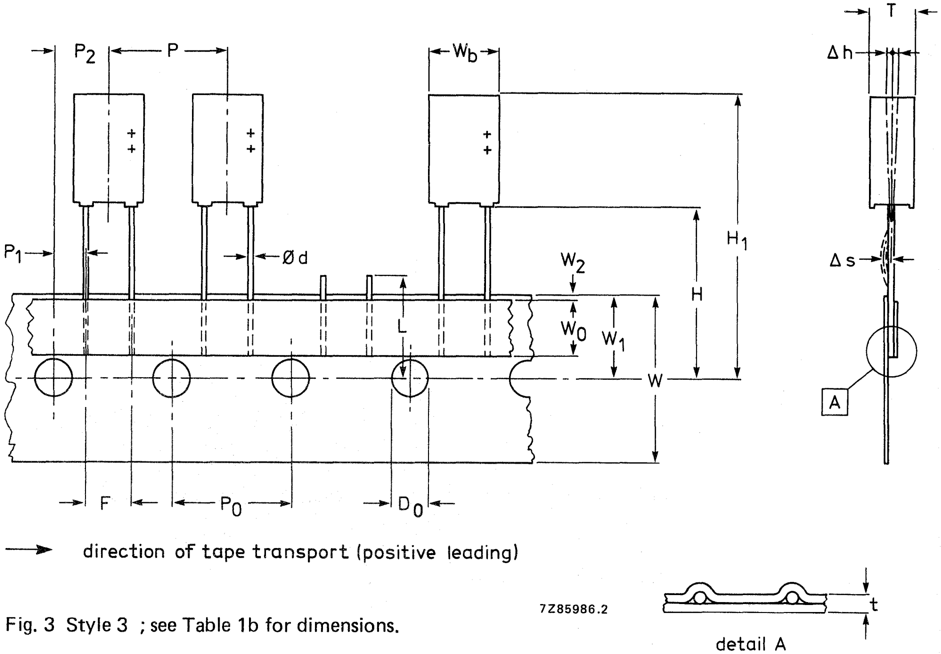


Fig. 3 Style 3 ; see Table 1b for dimensions.

Table 1b

	symbol	value	tolerance	remarks
Body thickness	T	4,5-6	max.	for case sizes 1 and 2 resp.
Body width	W_b	8	max.	
Component alignment	Δh	0	± 1	
Lead-wire diameter	d	0,6	+ 0,02/−0	
Lead straightness	Δs	0	± 0,5	
Length of snipped leads	L	11	max.	
Lead-to-lead distance	F	5	+ 0,4/−0,2	
Pitch of components	P	12,7	± 1	
Feed-hole pitch	P_0	12,7	± 0,2	*
Feed-hole centre to lead	P_1	3,85	± 0,5	
Feed-hole centre to component centre	P_2	6,35	± 1	
Feed-hole diameter	D_0	4	± 0,2	
Height of component from tape centre	H	18,5	± 0,5	
Component height	H_1	32	max.	
Tape width	W	18	± 0,5	
Hold-down tape width	W_0	6	± 0,5	Feed hole shall be free
Hole position	W_1	9	+ 0,5/−0,2	
Hold-down tape position	W_2	0,5	+ 0,5/−0,2	
Total tape thickness	t	0,9	max.	

* Cumulative pitch error: ± 0,5 mm/4 pitches, and ± 1 mm/20 pitches.

Marking

The capacitors are marked with: nominal capacitance, rated voltage, "+" signs to identify the anode terminal, tolerance code (M = ± 20%, K = ± 10%), date code (year and month) and name of manufacturer.

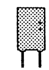
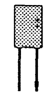
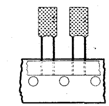
Mounting

The diameter of the mounting holes in the printed-wiring boards is 0,8 ± 0,1 mm, except that of the hole for the anode lead of style 2 capacitors: 1,3–0,2 mm.

ELECTRICAL DATA

Unless otherwise specified all electrical values in Table 2 apply at an ambient temperature of 20 to 25 °C, a frequency of 100 Hz, an atmospheric pressure of 93 to 106 kPa and a relative humidity of 45 to 75%. See also the corresponding paragraphs.

Table 2

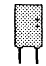
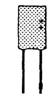
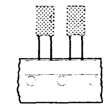
U_R	nom. cap.	max. r.m.s. ripple current at T_{amb} = 85 °C*	max. d.c. leakage current (μA) ** at U_R after		max. tan δ	max. ESR	max. impedance at 100 kHz**	case size	catalogue number 2222 124 followed by		
											
V	μF	mA	15 s	1 min		Ω	Ω		style 1	style 2	style 3
6,3	22	20	3,5	1,4	0,15	14	1,3	1	53229	73229	23229
	47	42	7,4	3,0	0,15	6,4	0,7	2	53479	73479	23479
	68	61	10,7	4,3	0,15	4,4	0,5	2	53689	73689	23689
10	10	14	2,5	1,0	0,15	30	1,5	1	54109	74109	24109
	15	21	3,8	1,5	0,15	20	1	1	54159	74159	24159
	22	31	5,5	2,2	0,15	14	0,7	2	54229	74229	24229
	33	47	8,3	3,3	0,15	9	0,5	2	54339	74339	24339
16	3,3	8	1,3	0,5	0,10	61	7	1	55338	75338	25338
	4,7	11	1,9	0,8	0,10	43	2	1	55478	75478	25478
	6,8	16	2,7	1,1	0,10	29,5	1,5	1	55688	75688	25688
	10	23	4,0	1,6	0,10	20	1	2	55109	75109	25109
	15	34	6,0	2,4	0,10	13,5	0,7	2	55159	75159	25159
25	1	4	0,6	0,3	0,10	200	20	1	56108	76108	26108
	1,5	5	0,9	0,4	0,10	135	15	1	56158	76158	26158
	2,2	8	1,4	0,6	0,10	91	10	1	56228	76228	26228
	3,3▲	12	2,1	0,8	0,10	61	7	1	56338	76338	26338
	4,7▲	17	2,9	1,2	0,10	43	5	2	56478	76478	26478
	6,8	24	4,2	1,7	0,10	29,5	3	2	56688	76688	26688
	10▲	35	6,3	2,5	0,15	20	2	2	56109	76109	26109

* For calculation of the max. ripple current at these and other frequencies and temperatures, see paragraphs "Voltage" and "Ripple current".

** Versions with lower values of max. d.c. leakage current or max. impedance are available to special order.

▲ Available to special order.

Table 2 (continued)

U_R	nom. cap.	max. r.m.s. ripple current at T_{amb} = 85 °C*	max. d.c. leakage current (μA) ** at U_R after		max. tan δ	max. ESR	max. impedance at 100 kHz**	case size	catalogue number 2222 124 followed by		
											
V	μF	mA	15 s	1 min		Ω	Ω		style 1	style 2	style 3
35	1	3	0,9	0,4	0,10	200	15	1	50108	70108	20108
40	0,1	0,4	0,1	0,04	0,10	1990	70	1	57107	77107	27107
	0,15	0,5	0,15	0,06	0,10	1330	50	1	57157	77157	27157
	0,22	0,8	0,22	0,08	0,10	910	30	1	57227	77227	27227
	0,33	1	0,33	0,13	0,10	610	30	1	57337	77337	27337
	0,47	2	0,5	0,2	0,10	430	20	1	57477	77477	27477
	0,68	2	0,7	0,3	0,10	295	15	1	57687	77687	27687
	1,0▲	4	1,0	0,4	0,10	200	10	2	57108	77108	27108
	1,5	5	1,5	0,6	0,10	135	7	2	57158	77158	27158
	2,2	8	2,2	0,9	0,10	91	5	2	57228	77228	27228

* For calculation of the max. ripple current at these and other frequencies and temperatures, see paragraphs "Voltage" and "Ripple current".
** Versions with lower values of max. d.c. leakage current or max. impedance are available to special order.
▲ Available to special order.

Capacitance

Nominal capacitance values at 100 Hz and T_{amb} = 25 °C	see Table 2
Tolerance on nominal capacitance at 100 Hz	± 20% (± 10% to special order)

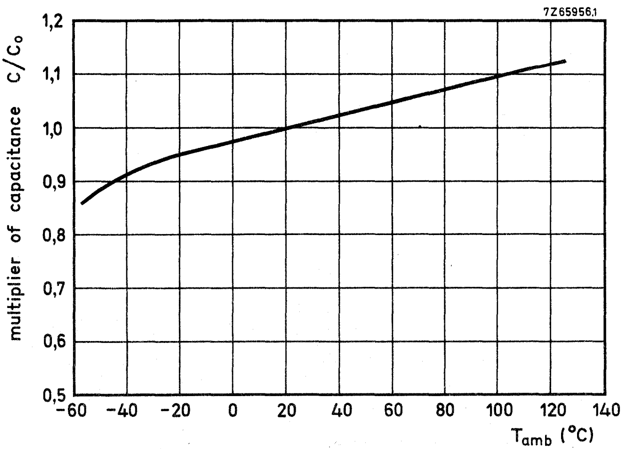


Fig. 4 Multiplier of capacitance as a function of temperature; C_o = capacitance at T_{amb} = 25 °C, 100 Hz.

Voltage

Rated voltage = max. permissible voltage at $T_{amb} \leqslant 85$ °C	U_R
Ripple voltage = max. permissible a.c. voltage providing the following four conditions are met:	
a) Max. a.c. voltage, with negative d.c. voltage applied	2 V
→ b) Max. peak a.c. voltage, without d.c. voltage applied	
at $f \leqslant 0,1$ Hz	0,15 x U_R
at 0,1 Hz $< f \leqslant$ 1 Hz	0,22 x U_R
at 1 Hz $< f \leqslant$ 10 Hz	0,30 x U_R
at 10 Hz $< f \leqslant$ 50 Hz	0,32 x U_R
at $f >$ 50 Hz	0,40 x U_R
c) Momentary value of applied voltage, with positive d.c. voltage applied	between U_R (in the positive half wave) and the limits mentioned under b) (in the negative half wave)

d) Ripple voltage limits are not applicable if the maximum ripple current is exceeded. In that case the ripple current is decisive. Whichever is in practice decisive, depends on the actual impedance of the capacitor. Table 3 should be considered as an aid only in establishing whether the ripple voltage or the ripple current is decisive.

Table 3

frequency	decisive factor
$f \leq 50$ Hz	voltage
50 Hz $< f \leq 1$ kHz	voltage, if actual capacitor impedance is high; current, if actual capacitor impedance is low
$f > 1$ kHz	current

Surge voltage =
max. permissible voltage for short periods (see also Tests and requirements) — $1{,}15 \times U_R$

Reverse voltage =
max. d.c. voltage applied in the reverse polarity at the maximum category temperature for short periods(see also Tests and requirements) — $0{,}30 \times U_R$

DEVELOPMENT DATA

Ripple current

Maximum permissible r.m.s. ripple current at 100 Hz and T_{amb} = 85 °C	see Table 2
Maximum permissible r.m.s. ripple current at other frequencies and temperatures	see Tables 4 and 5, and Fig. 5
Maximum permissible r.m.s. ripple current at 100 Hz and T_{amb} = 85 °C for capacitors with lower ESR value than the maximum ESR	$\sqrt{ESR_{max}/ESR_{actual}}$ x value stated in Table 2

Table 4 Temperature multiplier of ripple current ($\sqrt{k}$), at 100 Hz

T_{amb} °C	$\sqrt{k}$
25	2,2
30	2,15
35	2,1
40	2,05
45	2,0
50	1,9
55	1,8
60	1,7
65	1,6
70	1,45
75	1,35
80	1,2
85	1,0

Table 5 Frequency multiplier of ripple current ($\sqrt{r}$) at 25 °C

frequency kHz	$\sqrt{r}$
0,05	0,8
0,1	1,0
0,2	1,2
0,5	1,4
1	1,55
2	1,70
5	1,80
10	1,95
20	2,05
50	2,15
100	2,20
200	2,25
500	2,30
1000	2,35

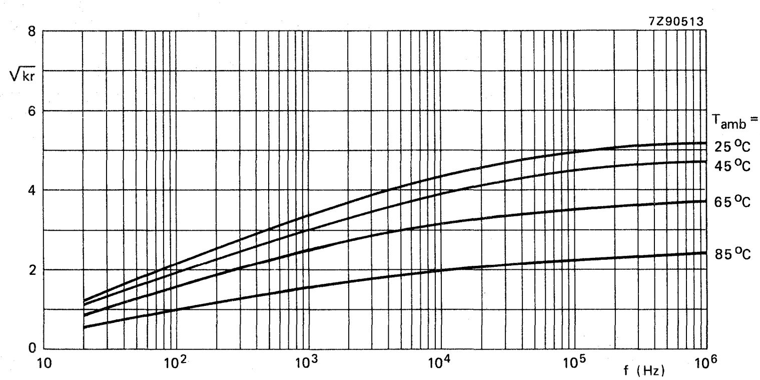


Fig. 5 Combined temperature/frequency multiplier of ripple current ($\sqrt{kr}$) as a function of frequency. $I_{r\,max} = I_{r0}\sqrt{kr}$.

Note: Neither the maximum permissible ripple current nor the maximum permissible ripple voltage values are to be exceeded. Refer to Table 3 (paragraph "Voltage") to find whichever factor will be decisive.

Calculation of ripple currents

The maximum permissible ripple current ($I_{r\ max}$) is a function of temperature and frequency:

$I_{r\ max} = I_{r0}\sqrt{kr}$,

where I_{r0} = max. ripple current at 100 Hz and 85 °C (see Table 2);

$\sqrt{k}$ = temperature multiplier (neglecting the frequency dependence) = $\sqrt{P_{max}/P_{85}}$;

$\sqrt{r}$ = frequency multiplier (neglecting the temperature dependence) = $\sqrt{ESR_{100}/ESR_{max}}$;

(for $\sqrt{k}$ and $\sqrt{r}$, see Tables 4 and 5, for $\sqrt{kr}$, see Fig. 5);

while P_{max} = max. permissible power dissipation, temperature dependent;

P_{85} = max. permissible power dissipation at 85 °C = $I^2_{r0}\ ESR_{100}$;

ESR_{max} = max. equivalent series resistance, frequency dependent;

ESR_{100} = max. equivalent series resistance at 100 Hz.

The formula is derived for any temperature and frequency as follows:

$$I^2_{r\ max} = P_{max}/ESR_{max}$$
$$= kr\ P_{85}/ESR_{100}$$
$$= kr\ I^2_{r0}\ ESR_{100}/ESR_{100}$$

Thus $I_{r\ max} = I_{r0}\sqrt{kr}$.

The values of the temperature multiplier $\sqrt{k}$ and of P_{85} have been calculated allowing a capacitor temperature of 98 °C and assuming the values of ESR_{max} at 98 °C to be 0,8 times the ESR_{max} at 25 °C at all frequencies.

The values of the frequency multiplier $\sqrt{r}$ have been measured at 25 °C assuming it to be the same at all temperatures.

The power dissipation (P_{max}) has been calculated assuming it to be governed by the simplified relation:

$P_{max} = \beta \times S \times \Delta T$,

where β = heat transfer coefficient, taken as 18 W/m²K (capacitor mounted on a thermally well-conducting printed-circuit board, in free flowing air, the board being in vertical position);

S = capacitor outer surface;

ΔT = temperature difference between capacitor surface and the ambient atmosphere, taken as 13 °C at T_{amb} = 85 °C.

Charge and discharge current

The capacitors may be charged from a source without internal resistance and they may be discharged by short-circuiting. If the capacitors are charged and discharged continuously at a rate of several times per minute, the charge and discharge currents have to be considered as ripple currents flowing through the capacitor. The r.m.s. value of these currents should be determined and the value thus found must not exceed the applicable limit.

D.C. leakage current

Maximum d.c. leakage current 15 s after application of U_R,
at T_{amb} = 25 °C — see Table 2 (0,025 CU or 0,1 µA whichever is greater)

Maximum d.c. leakage current 1 min after application of U_R,
at T_{amb} = 25 °C — see Table 2 (0,01 CU or 0,04 µA whichever is greater)

Typical d.c. leakage current during continuous operation at U_R,

at T_{amb} = 25 °C	approx. 0,02 x 15 s-value stated in Table 2
at T_{amb} = 85 °C	approx. 0,1 x 15 s-value stated in Table 2
at T_{amb} = 125 °C	approx. 0,3 x 15 s-value stated in Table 2

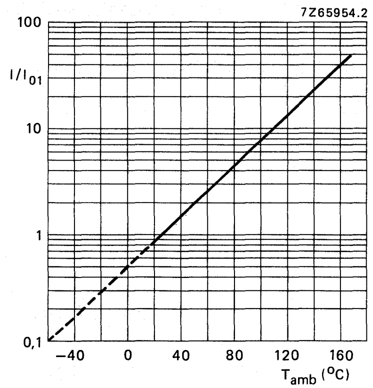


Fig. 6 Multiplier I/I_{01} as a function of ambient temperature; I_{01} = d.c. leakage current during continuous operation at U_R, T_{amb} = 25 °C.

Tan δ (dissipation factor)

Maximum tan δ at 100 Hz and T_{amb} = 25 ^{o}C, measured by means of a four-terminal circuit (Thomson circuit) — see Table 2

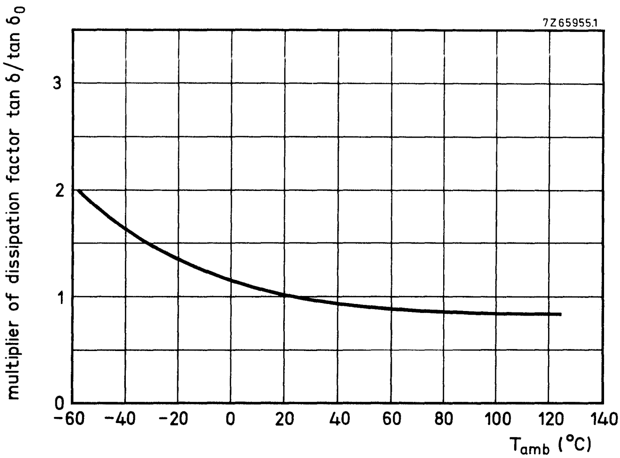


Fig. 7 Typical multiplier of dissipation factor as a function of temperature; tan δ_0 = dissipation factor at T_{amb} = 25 ^{o}C, 100 Hz.

DEVELOPMENT DATA

Equivalent series resistance (ESR = tan $\delta/\omega C$)

Maximum ESR at 100 Hz and T_{amb} = 25 °C (calculated from maximum tan δ and 0,8 x nominal capacitance) — see Table 2

→ Maximum ESR at 100 kHz and T_{amb} = 25 °C — equal to values of max. impedance at 100 kHz, see Table 2

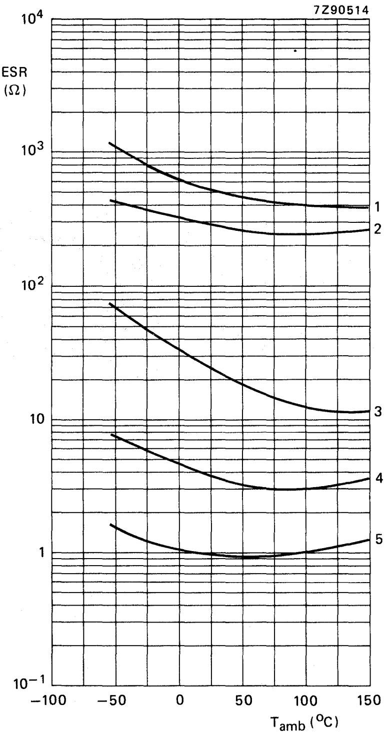


Fig. 8 Typical ESR as a function of ambient temperature at 100 Hz.

Curve 1 = 0,1 μF, 40 V;
curve 2 = 1,5 μF, 40 V;
curve 3 = 3,3 μF, 25 V;
curve 4 = 22 μF, 10 V;
curve 5 = 68 μF, 6,3 V.

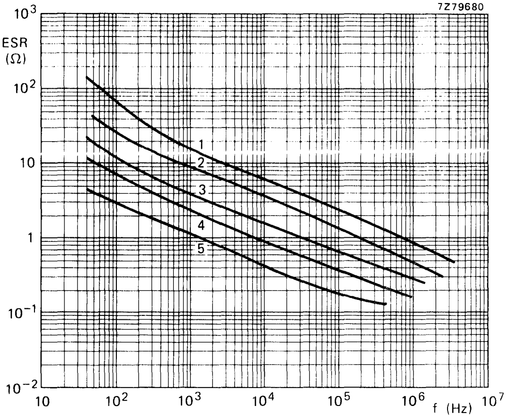


Fig. 9 Typical ESR as a function of frequency at T_{amb} = 25 °C; case size 1.

Curve 1 = 0,47 μF, 40 V;
curve 2 = 2,2 μF, 25 V;
curve 3 = 4,7 μF, 16 V;
curve 4 = 10 μF, 10 V;
curve 5 = 22 μF, 6,3 V.

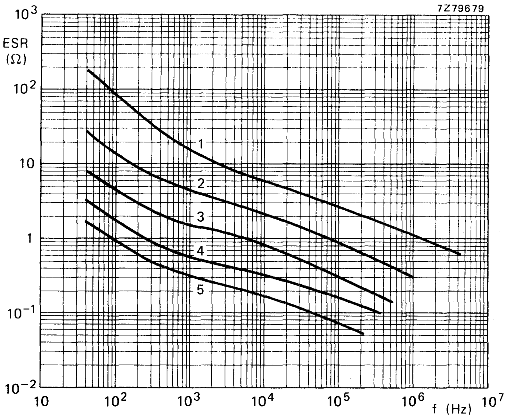


Fig. 10 Typical ESR as a function of frequency at T_{amb} = 25 °C; case size 2.

Curve 1 = 1,5 μF, 40 V;
curve 2 = 6,8 μF, 25 V;
curve 3 = 15 μF, 16 V;
curve 4 = 33 μF, 10 V;
curve 5 = 68 μF, 6,3 V.

Impedance

Maximum impedance at 100 kHz and T_{amb} = 25 °C, measured by means of a four-terminal circuit (Thomson circuit) — see Table 2

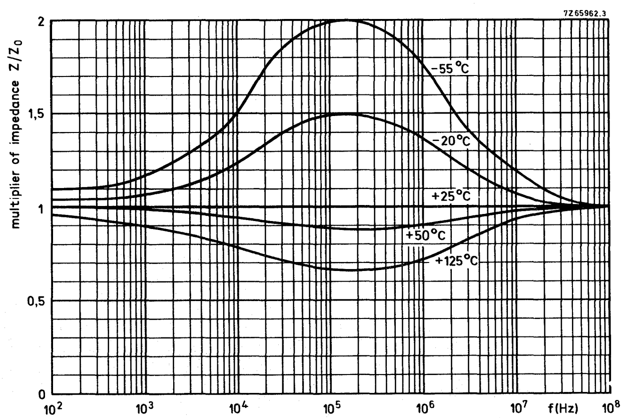


Fig. 11 Typical multiplier of impedance Z/Z_0 as a function of frequency at different temperatures; Z_0 = impedance initial value at T_{amb} = 25 °C.

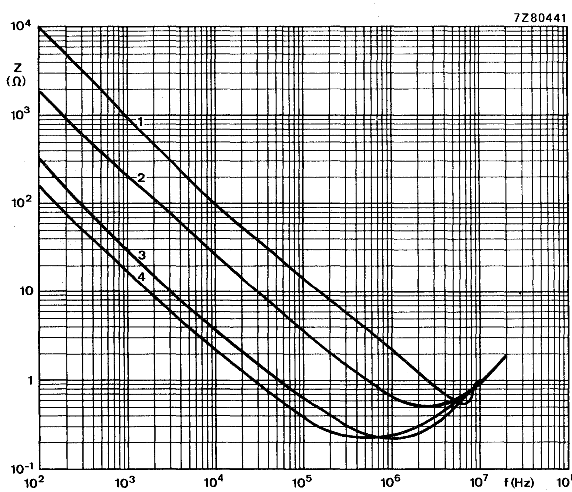


Fig. 12 Typical impedance as a function of frequency at T_{amb} = 25 °C, **case size 1.**

Curve 1 = 0,47 μF, 40 V;
curve 2 = 2,2 μF, 25 V;
curve 3 = 10 μF, 10 V;
curve 4 = 22 μF, 6,3 V.

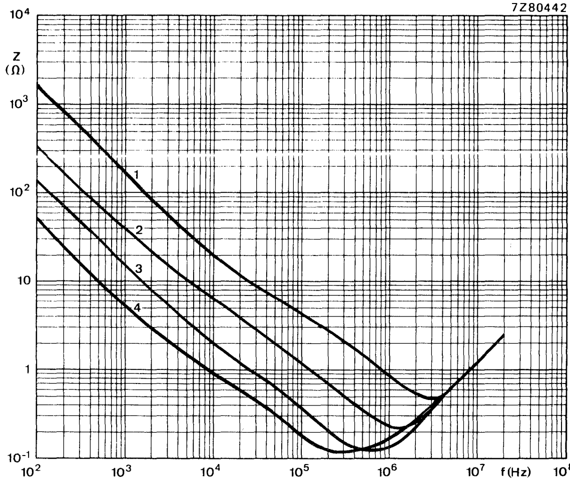


Fig. 13 Typical impedance as a function of frequency at T_{amb} = 25 °C; **case size 2.**

Curve 1 = 1 μF, 40 V;
curve 2 = 4,7 μF, 25 V;
curve 3 = 10 μF, 16 V;
curve 4 = 47 μF, 6,3 V.

DEVELOPMENT DATA

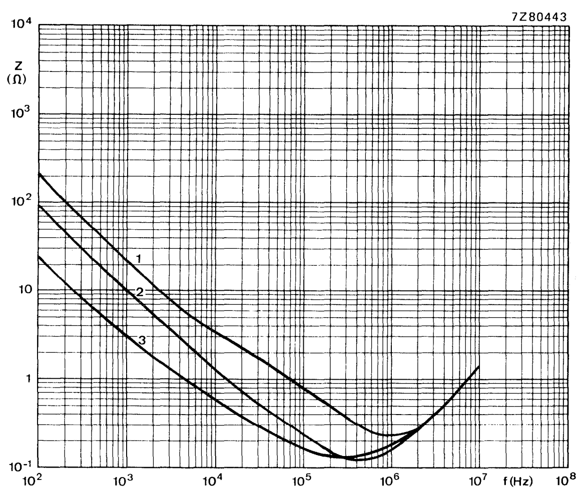


Fig. 14 Typical impedance as a function of frequency at T_{amb} = 25 °C; **case size 2.**

Curve 1 = 6,8 μF, 25 V;
curve 2 = 15 μF, 16 V;
curve 3 = 68 μF, 6,3 V.

Equivalent series inductance (ESL)

Equivalent series inductance, measured by means of a four-terminal circuit (Thomson-circuit), at 10 MHz; capacitor leads bent to a pitch of 5,1 mm

case size 1	max. 20 nH; typ. 9 to 14 nH
case size 2	max. 20 nH; typ. 11 to 16 nH

OPERATIONAL DATA

Category temperature range	–55 to + 85 °C
Typical life time at T_{amb} = 85 °C	> 20 000 h

PACKING

Capacitors of styles 1 and 2 are supplied in boxes, those of style 3 on tape on reel.
The number of capacitors per box or per reel is:

styles 1 and 2 : 500 capacitors per box; 100 per plastic bag, 5 bags per box;
style 3 : 1000 capacitors per reel.

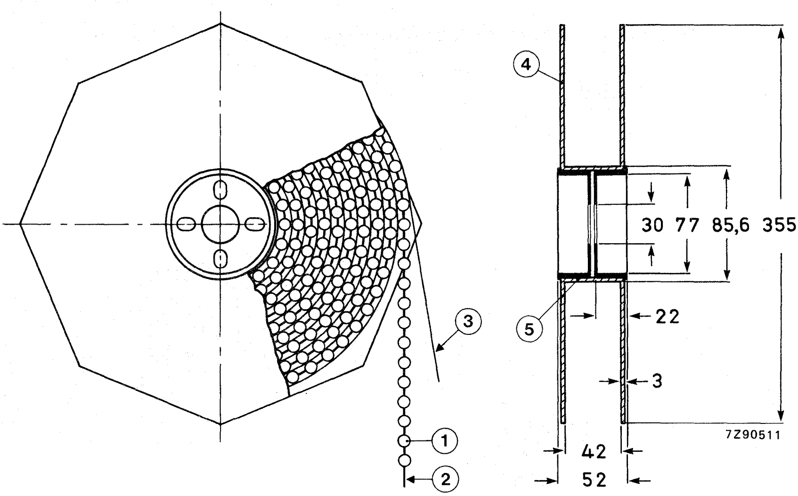


Fig. 15 Style 3 capacitors on tape on reel.
1 = capacitor
2 = tape
3 = paper
4 = flange
5 = cylinder

TESTS AND REQUIREMENTS

See Introduction, section 9, under solid aluminium capacitors, with the addition of the following tests.

Solvent resistance tests: immersion time of samples 5 min., at ambient temperature, at boiling temperature, in vapour of boiling solvent, and ultrasonic (40 kHz).

Solvents :
- deionized water (50 ± 5 °C);
- calgonite solution (20 g/l, 70 ± 5 °C);
- mixture of 4,5% 2-butoxyethanol, 4,5% 2-amino-ethanol, and 91% water (70 ± 5 °C);
- 1.1.1. trichloro-ethane;
- mixtures of 1.1.2-trichloro-1.2.2-trifluoro-ethane (fluorocarbon 113) and the following solvents in the respective mass percentage ratios of these solvents to fluorocarbon:
  - 2-propanol (isopropanol), 25%: 75% (Arklone K*); up to ratio 35% : 65%;
  - dichloromethane (methylene chloride), 49,5%: 50,5% (Freon TMC**);
  - ethanol, 4,5%: 95,5% (e.g. Arklone A*, Freon TE**);
  - methanol and nitromethane, (5,7%: 0,3%: 94% (Freon TMS**).

Requirement : visual appearance not affected.

Note: Tests are carried out using non-contaminated solvents.

Extended vibration test, according to IEC 68-2-6, test FC: 10 to 2000 Hz, 1,5 mm or 10 g (whichever is less), 1 octave/min, 3 directions (mutually perpendicular), 1 sweep per direction, no voltage applied. ←

Requirements : no intermittent contacts; no breakdown; no open circuiting; no mechanical damage;
$\Delta C/C \leqslant 5\%$;
tan δ and h.f. impedance $\leqslant$ 1,2 x stated limit;
d.c. leakage current $\leqslant$ 1,5 x stated limit;
typical capability: up to 50 g.

Shock test, according to IEC 68-2-27, test Ea: half sine or sawtooth pulse shape, 50g, 11 ms, 3 successive shocks in each direction of 3 mutually perpendicular axes, no voltage applied. ←

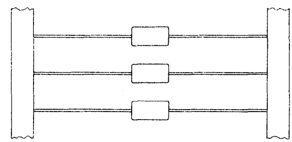
Requirements : no intermittent contacts; no breakdown; no open circuiting; no mechanical damage;
$\Delta C/C \leqslant 5\%$;
tan δ and h.f. impedance $\leqslant$ 1,2 x stated limit;
d.c. leakage current $\leqslant$ 1,5 x stated limit;
typical capability: up to 100 g, also in combination with extended vibration test.

DEVELOPMENT DATA

* Trade mark of I.C.I.
** Trade mark of Dupont de Nemours.

SOLID ALUMINIUM CAPACITORS

- Enhanced CU-product per unit volume
- Miniature type, equivalent to solid tantalum types
- Axial leads; metal case; epoxy seal
- Long life
- High reliability
- Industrial and military applications
- Pitch equal to that of tantalum case sizes A and B



QUICK REFERENCE DATA

Nominal capacitance range (E6 series)	0,22 to 68 μF
Tolerance on nominal capacitance	± 20%
Rated voltage range, U_R	4 to 35 V
Category temperature range	−55 to + 125 °C
Endurance test at 125 °C	2000 h
Basic specification	IEC 384-4, long-life grade
Climatic category, IEC 68	55/125/56

Selection chart for C_{nom}-U_R and relevant case sizes.

C_{nom} μF	U_R (V) 4	6,3	10	16	20	25	35
0,22							A2
0,33							A2
0,47							A2
0,68							A2
1,0							A2
1,5							A2
2,2							A2
3,3							A2
4,7						A2	A3/B
6,8					A2		A3/B
10				A2		A3/B	
15			A2		A3/B		
22		A2		A3/B			
33	A2		A3/B				
47		A3/B					
68	A3/B						

case size	nominal dimensions (mm)
A2	Ø 5,0 x 10
A3	Ø 6,0 x 10
B	Ø 5,0 x 15

APPLICATION

These capacitors with high CU-product per unit volume, utilize advanced technology to achieve long life, high stability and reliability, high ripple current rating and low temperature dependence.
The capacitors are not subject to a limitation on charge or discharge currents and they will function in circuits where voltage reversal may occur.
The minimum pitch corresponds to that of tantalum capacitors, case sizes A and B. The capacitors are on bandoliers; they are extremely suitable for automatic insertion and for cutting and forming equipment.

DESCRIPTION

The capacitors have etched and oxidized aluminium foil electrodes separated by a layer of semiconductive material. The electrolyte is pyrolitically formed manganese dioxide. The capacitors are housed in an aluminium case with axial leads and are sealed with epoxy resin. The cathode lead is welded to the case, which is insulated with a blue transparent plastic sleeve.

The capacitors are supplied on bandoliers in boxes and on reels.

MECHANICAL DATA

Dimensions in mm

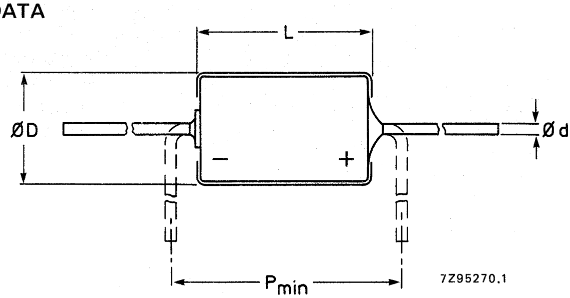


Fig. 1 For dimensions d, D, L and P, see Table 1.

Table 1

case size	d	D_{nom}	L_{nom}	D_{max}	L_{max}	P_{min}	mass approx. g
A2	0,6 ± 0,05	5	10	5,1	10,2	12,5	0,55
A3	0,6 ± 0,05	6	10	6,3	10,2	12,5	0,75
B	0,6 ± 0,05	5	15	5,1	15,3	17,5	0,8

Marking

The capacitors are marked with: group number (125), capacitance, tolerance, rated voltage, date code, a band to identify the negative terminal, and name of manufacturer.

Mounting

No special provisions are required for soldering to the tinned leads.
(2 mm of the anode lead nearest the body are not solderable).

ELECTRICAL DATA

Unless otherwise specified all electrical values in Table 2 apply at an ambient temperature of 20 to 25 °C, a frequency of 100 Hz, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 45 to 75%. See also the corresponding paragraphs.

Table 2

U_R V	nom. cap. μF	max. r.m.s. ripple current at T_{amb} = 125 °C mA	max. d.c. leakage current at U_R after 1 min μA	max. tan δ	max. ESR Ω	max. impedance at 100 kHz Ω	case size	catalogue number 2222 125 followed by: on reel	in box
4	33	40	9,6	0,25	15	5	A2	22339	32339
	68	70	17	0,25	7,3	2,5	A3	90502	90503
	68	70	17	0,25	7,3	2,5	B	22689	32689
6,3	22	40	9,9	0,18	16,5	5	A2	23229	33229
	47	70	18	0,18	7,6	2,5	A3	90504	90505
	47	70	18	0,18	7,6	2,5	B	23479	33479
10	15	35	11	0,16	21	5	A2	24159	34159
	33	60	20	0,16	9,6	2,5	A3	90506	90507
	33	60	20	0,16	9,6	2,5	B	24339	34339
16	10	30	11	0,14	28	10	A2	25109	35109
	22	50	21	0,14	12,5	5	A3	90508	90509
	22	50	21	0,14	12,5	5	B	25229	35229
20	6,8	25	9,8	0,14	41	10	A2	90511	90512
	15	40	18	0,14	18,5	5	A3	90513	90514
	15	40	18	0,14	18,5	5	B	90515	90516
25	4,7	20	8,9	0,12	51	10	A2	26478	36478
	10	35	16	0,12	24	5	A3	90518	90519
	10	35	16	0,12	24	5	B	26109	36109
35	0,22	5	3,4	0,09	810	30	A2	20227	30227
	0,33	6	3,6	0,09	540	25	A2	20337	30337
	0,47	7	3,8	0,09	380	20	A2	20477	30477
	0,68	8,5	4,2	0,09	260	10	A2	20687	30687
	1	10	4,8	0,09	180	10	A2	20108	30108
	1,5	13	5,6	0,09	120	10	A2	20158	30158
	2,2	15	6,9	0,12	110	10	A2	20228	30228
	3,3	19	8,8	0,12	72	10	A2	20338	30338
	4,7	25	11	0,12	51	5	A3	90522	90523
	4,7	25	11	0,12	51	5	B	20478	30478
	6,8	30	15	0,12	35	5	A3	90524	90525
	6,8	30	15	0,12	35	5	B	20688	30688

DEVELOPMENT DATA

Capacitance

Nominal capacitance values at 100 Hz and T_{amb} = 25 °C	see Table 2
Tolerance on nominal capacitance at 100 Hz	± 20%

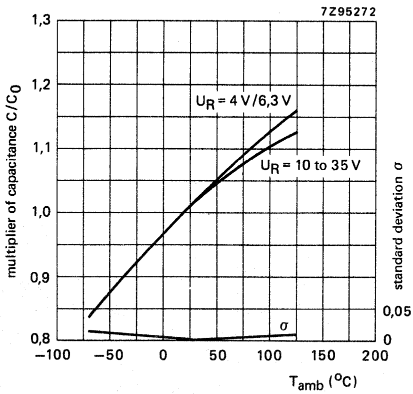


Fig. 2 Typical capacitance as a function of ambient temperature.
C_0 = capacitance at 25 °C, 100 Hz.

Voltage

Rated voltage = max. permissible voltage: U_R

Ripple voltage = max. permissible a.c. voltage providing the following four conditions are met:

a) Max. a.c. voltage, with negative d.c. voltage applied: 2 V

b) Max. peak a.c. voltage, without d.c. voltage applied

	$T_{amb} \leqslant 85$ °C	85 °C $< T_{amb} \leqslant 125$ °C
at $f \leqslant 0,1$ Hz	0,30 x U_R	0,15 x U_R
at 0,1 Hz $< f \leqslant 1$ Hz	0,45 x U_R	0,22 x U_R
at 1 Hz $< f \leqslant 10$ Hz	0,60 x U_R	0,30 x U_R
at 10 Hz $< f \leqslant 50$ Hz	0,65 x U_R	0,32 x U_R
at $f > 50$ Hz	0,80 x U_R	0,40 x U_R

c) Momentary value of applied voltage, with positive d.c. voltage applied: between U_R (in the positive half wave) and the limits mentioned under b) (in the negative half wave)

d) Ripple voltage limits are not applicable if the maximum ripple current is exceeded. In that case the ripple current is decisive. Whichever is in practice decisive, depends on the actual impedance of the capacitor. Table 3 should be considered as an aid only in establishing whether the ripple voltage or the ripple current is decisive.

Table 3

frequency	decisive factor	
	at $T_{amb} \leqslant 85\ ^{o}C$	$T_{amb} > 85\ ^{o}C$
$f \leqslant 50$ Hz	voltage	voltage, if actual capacitor impedance is high; current, if actual capacitor impedance is low
$50\ Hz < f \leqslant 1\ kHz$	voltage, if actual capacitor impedance is high; current, if actual capacitor impedance is low	current
$f > 1$ kHz	current	current

Surge voltage =
max. permissible voltage for short periods
(see also "Test and requirements") $1{,}15 \times U_R$

Reverse voltage =
max. d.c. voltage continuously (2000 h)
applied in the reverse polarity,
at $T_{amb} \leqslant 85\ ^{o}C$ $0{,}30 \times U_R$
at $85\ ^{o}C < T_{amb} \leqslant 125\ ^{o}C$ $0{,}15 \times U_R$

Ripple current

Maximum permissible r.m.s. ripple current at 100 Hz and T_{amb} = 125 °C — see Table 2

Maximum permissible r.m.s. ripple current at other frequencies, temperatures and conditions — see Tables 4 to 6, and Fig. 3

Table 4 Temperature multiplier of ripple current ($\sqrt{k}$), at 100 Hz

T_{amb} °C	$\sqrt{k}$
25	2,6
35	2,5
45	2,4
55	2,25
65	2,2
70	2,15
75	2,1
80	2,05
85	2,0
90	1,9
95	1,8
100	1,7
105	1,6
110	1,45
115	1,35
120	1,2
125	1,0

Table 5 Frequency multiplier of ripple current ($\sqrt{r}$) at 25 °C

frequency kHz	$\sqrt{r}$
0,05	0,8
0,1	1,0
0,2	1,2
0,5	1,4
1	1,55
2	1,70
5	1,80
10	1,95
20	2,05
50	2,15
100	2,20
200	2,25
500	2,30
1000	2,35

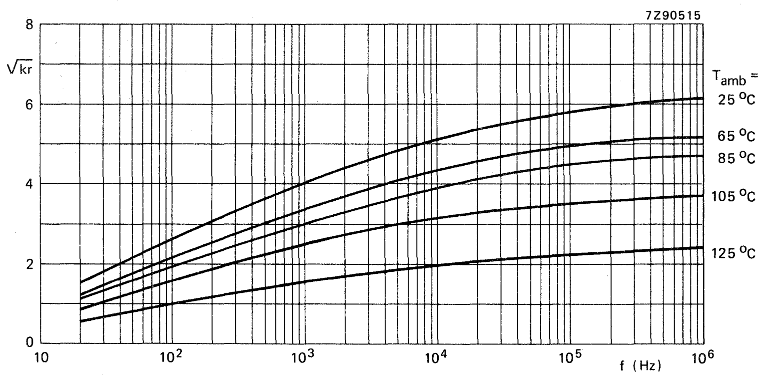


Fig. 3 Combined temperature/frequency multiplier of ripple current ($\sqrt{kr}$) as a function of frequency. $I_{r\,max} = I_{r0}\sqrt{kr}$.

Table 6 Multiplier of ripple current for various application conditions

condition	multiplier
A. Capacitor insulated with a blue sleeve, mounted horizontally on a thermally non-conducting printed-circuit board, in free flowing air and in a surrounding that allows the absorption of radiation heat.	1,0
B. As under A but capacitor is not insulated.	0,9
C. As under A but capacitor is mounted vertically	0,7
D. As under A but capacitor is mounted on a thermally well-conducting printed-circuit board.	1,25
E. As under A but the surrounding walls etc. have a temperature higher than 125 °C and therefore prevent the absorption of heat by radiation	0,6
F. Capacitor has an ESR value lower than the maximum ESR.	$\sqrt{\frac{ESR_{max}}{ESR_{actual}}}$
G. As under A but capacitor is epoxy-filled (for severe shock and vibration resistance).	1,05
H. As under G but capacitor is mounted on a thermally well-conducting printed-circuit board.	1,5

DEVELOPMENT DATA

Note: Neither the maximum permissible ripple current nor the maximum permissible ripple voltage values are to be exceeded. Refer to Table 3 (paragraph "Voltage") to find whichever factor will be decisive.

Calculation of ripple currents

The maximum permissible ripple current ($I_{r\,max}$) is a function of temperature and frequency:

$I_{r\,max}$ = $I_{r0}\sqrt{kr}$,

whre I_{r0} = max. ripple current at 100 Hz and 125 °C (see Table 2);

$\sqrt{k}$ = temperature multiplier (neglecting the frequency dependence) = $\sqrt{P_{max}/P_{125}}$;

$\sqrt{r}$ = frequency multiplier (neglecting the temperature dependence) = $\sqrt{ESR_{100}/ESR_{max}}$;

(for $\sqrt{k}$ and $\sqrt{r}$, see Tables 4 and 5, for $\sqrt{kr}$, see Fig. 3);

while P_{max} = max. permissible power dissipation, temperature dependent;

P_{125} = max. permissible power dissipation at 125 °C = $I^2_{r0}\,ESR_{100}$;

ESR_{max} = max. equivalent series resistance, frequency dependent;

ESR_{100} = max. equivalent series resistance at 100 Hz.

The formula is derived for any temperature and frequency as follows:

$$I_{r\,max}{}^2 = P_{max}/ESR_{max}$$
$$= kr\,P_{125}/ESR_{100}$$
$$= kr\,I^2{}_{r0}\,ESR_{100}/ESR_{100}$$

Thus $I_{r\,max} = I_{r0}\sqrt{kr}$.

The values of the temperature multiplier $\sqrt{k}$ and of P_{125} have been calculated allowing a capacitor temperature of 138 °C and assuming the values of ESR_{max} at 138 °C to be 0,8 times the ESR_{max} at 25 °C at all frequencies.

The values of the frequency multiplier $\sqrt{r}$ have been measured at 25 °C assuming it to be the same at all temperatures.

The power dissipation (P_{max}) has been calculated assuming it to be governed by the simplified relation:

$$P_{max} = \beta \times S \times \Delta T,$$

where β = heat transfer coefficient, taken as 9,0 W/m²K;

S = capacitor outer surface;

ΔT = temperature difference between capacitor surface and the ambient atmosphere, taken as 13 °C at T_{amb} = 125 °C.

Charge and discharge current

The capacitors may be charged from a source without internal resistance and they may be discharged by short-circuiting. If the capacitors are charged and discharged continuously at a rate of several times per minute, the charge and discharge currents have to be considered as ripple currents flowing through the capacitor. The r.m.s. value of these currents should be determined and the value thus found must not exceed the applicable limit.

DEVELOPMENT DATA

D.C. leakage current

Maximum d.c. leakage current 1 min after application of U_R, at T_{amb} = 25 °C	see Table 2 (max. 0,05 CU + 3 μA)
D.C. leakage current during continuous operation at U_R,	
at T_{amb} = 25 °C	approx. 0,5 x value stated in Table 2
at T_{amb} = 85 °C	approx. 2 x value stated in Table 2
at T_{amb} = 125 °C	approx. 7 x value stated in Table 2

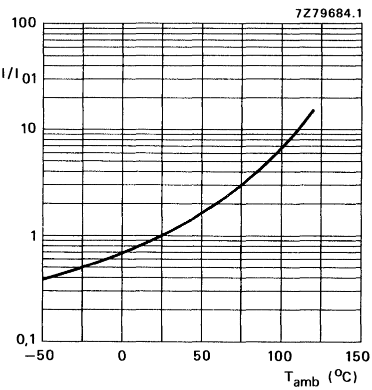


Fig. 4 Multiplier I/I_{01} as a function of temperature. I_{01} = d.c. leakage current during continuous operation at U_R, T_{amb} = 25 °C.

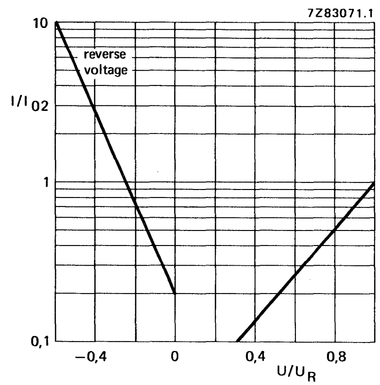


Fig. 5 Multiplier I/I_{02} as a function of U/U_R. I_{02} = d.c. leakage current at U_R at a discrete constant temperature.

Tan δ (dissipation factor)

Maximum tan δ at 100 Hz and T_{amb} = 25 °C, measured by means of a four-terminal circuit (Thomson circuit)	see Table 2
Typical tan δ at 100 Hz and T_{amb} = 25 °C	0,6 x value stated in Table 2

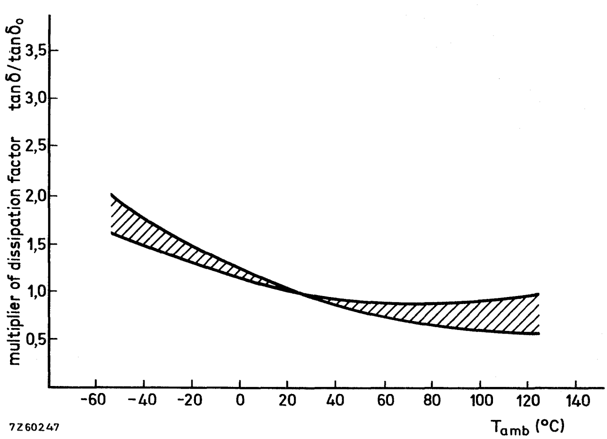


Fig. 6 Multiplier of dissipation factor as a function of ambient temperature; tan δ_0 = dissipation factor at 25 °C, 100 Hz.

Equivalent series resistance (ESR = tan $\delta/\omega C$)

Maximum ESR at 100 Hz and T_{amb} = 25 °C (calculated from maximum tan δ and 0,8 x nominal capacitance)	see Table 2
Maximum ESR at 100 kHz and T_{amb} = 25 °C	equal to values of max. impedance at 100 kHz, see Table 2

Impedance

Maximum impedance at 100 kHz and T_{amb} = 25 °C, measured by means of a four-terminal circuit (Thomson circuit)	see Table 2
Typical impedance at 100 kHz, and T_{amb} = 25 °C	0,5 x value stated in Table 2

Equivalent series inductance (ESL)

Equivalent series inductance, measured by means of a four-terminal circuit (Thomson circuit), at 10 MHz; the capacitor leads bent to the pitch as indicated

	pitch	typ. ESL
case size A2	12,5 mm	12 nH
case size A3	12,5 mm	25 nH
case size B	17,5 mm	15 nH

OPERATIONAL DATA

Category temperature range	−55 to + 125 °C
Typical life time at T_{amb} = 125 °C and U_R	> 5000 h

PACKING

The capacitors are supplied on bandoliers in boxes and on reels. The number of capacitors per box and per reel is 1000.

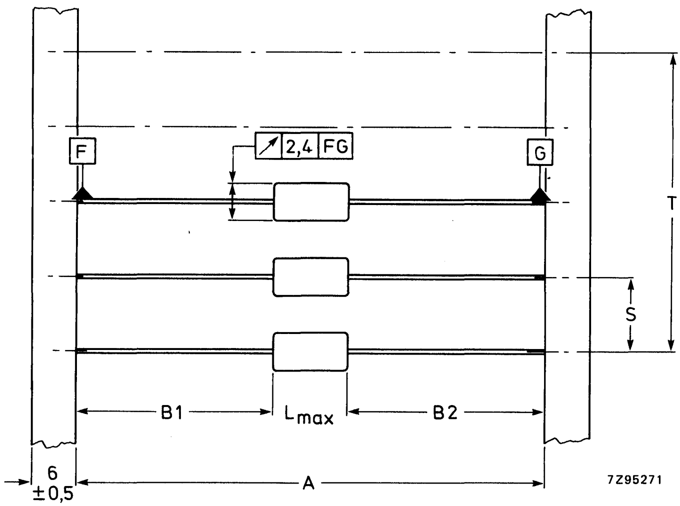


Fig. 7 Capacitors on bandoliers; the bandolier to which the negative capacitor terminals are connected is blue. See Table 7 for dimensions A, S, T and L_{max}.
$|B1-B2| = 1,4 + (L_{max}-L)$ mm max.

Table 7 (Dimensions in mm)

case size	A	S	T for number (n) of capacitors		L_{max}
			$n < 50$	$50 < n < 100$	
A2	63,5 ± 1,5	10 ± 0,4	10 (n-1) ± 2	10 (n-1) ± 4	10,2
A3	63,5 ± 1,5	10 ± 0,4	10 (n-1) ± 2	10 (n-1) ± 4	10,2
B	63,5 ± 1,5	10 ± 0,4	10 (n-1) ± 2	10 (n-1) ± 4	15,3

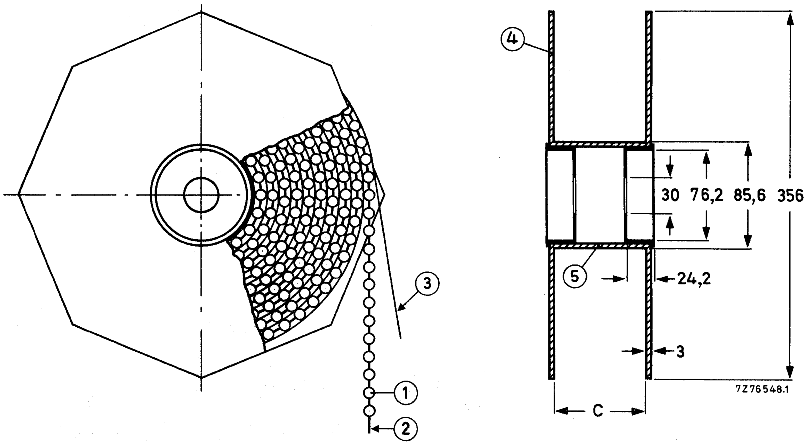


Fig. 8 Capacitors on bandoliers on reel; dimension C = 83,5 mm; the overall width of the reel is 94,5 mm.

1 = capacitor
2 = bandolier
3 = paper
4 = flange
5 = cylinder

TESTS AND REQUIREMENTS

See Introduction, section 9, under solid aluminium capacitors 123, with deviations of requirements of the following tests:

Climatic sequence *Damp heat, steady state* *Surge* *Storage at upper category temperature*	$\Delta C/C \leqslant 10\%$; 1 min value of d.c. leakage current measured after 5 min.

Additional test:

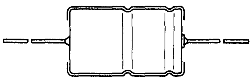
Severe rapid change of temperature test: 100 cycles of 15 min at −40 °C and + 125 °C.

Requirements: d.c. leakage current ⩽ stated limit,
tan $\delta \leqslant 1{,}6$ x stated limit,
impedance ⩽ 1,6 x stated limit,
$\Delta C/C \leqslant 10\%$.

MAINTENANCE TYPES

ALUMINIUM ELECTROLYTIC CAPACITORS

- **Small type**
- **Bipolar**
- **Long life**
- **General and industrial applications**



QUICK REFERENCE DATA

Nominal capacitance range (E6 series)	1 to 47 μF
Tolerance on nominal capacitance	–20 to +20%
Rated voltage U_R (a.c.), frequency > 15 Hz	63 V peak (40 V r.m.s.), provided ripple current remains within specified limits
Rated voltage U_R (d.c.)	63 V (in both directions)
Category temperature range	–40 to +85 °C
Endurance test at 85 °C	5000 h
Shelf life at 0 V, 85 °C	500 h
Basic specification	IEC384-4, long-life grade
Climatic category, IEC68	40/085/56

Selection chart for C-U_R and relevant case sizes

U_R V	C_{nom} μF	case size	nom. dimensions mm
63	1	00	ϕ 10 x 30
	1,5	00	ϕ 10 x 30
	2,2	00	ϕ 10 x 30
	3,3	00	ϕ 10 x 30
	4,7	00	ϕ 10 x 30
	6,8	00	ϕ 10 x 30
	10	01	ϕ 12,5 x 30
	15	01	ϕ 12,5 x 30
	22	02	ϕ 15 x 30
	33	02	ϕ 15 x 30
	47	03	ϕ 18 x 30

APPLICATION

These capacitors are especially designed for those applications where a low impedance, small dissipation and an excellent temperature constancy over the audio frequency range is required such as crossover filters in loudspeaker boxes and intercom systems.

DESCRIPTION

The capacitor has etched aluminium-foil electrodes rolled up with a porous paper spacer which separates the two anodes. The spacer is impregnated with an electrolyte which is the electrical connection between the two anode foils and retains its good characteristics both at low and at high temperatures. The capacitor is housed in an aluminium case. It has soldered-copper leads.

MECHANICAL DATA

Dimensions in mm

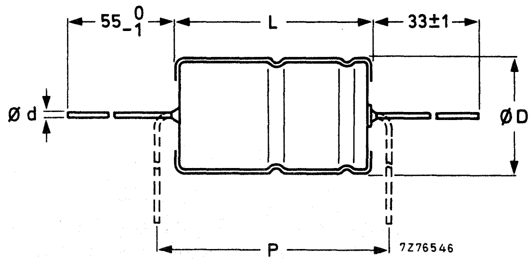


Fig. 1 For dimensions d, D, L and P, see Table 1.

Table 1

case size	d	D_{nom}	L_{nom}	D_{max}	L_{max}	P_{min}	mass approx. g
00	0,8	10	30	10,5	30,5	35	4,0
01	0,8	12,5	30	13,0	30,5	35	6,3
02	0,8	15	30	15,5	30,5	35	8,2
03	0,8	18	30	18,5	30,5	35	10,9

Marking

The capacitors are marked with:
- nominal capacitance;
- tolerance on nominal capacitance;
- rated voltage;
- group number 039;
- name of manufacturer;
- date code (year and month) according to IEC62;
- bipolar.

Mounting

The diameter of the mounting holes in the printed-wiring board is 1 + 0,1 mm.

Minimum atmospheric pressure 8,5 kPa

PRODUCT SAFETY

Non-solid electrolytic capacitors may contain chemicals which can be regarded as hazardous if incorrectly handled. Caution is necessary should the outer case be fractured.

ELECTRICAL DATA

Table 2

Unless otherwise specified all electrical values in Table 2 apply at an ambient temperature of 20 to 25 °C, a frequency of 100 Hz, an atmospheric pressure of 93 to 106 kPa and a relative humidity of 45 to 75%.

U_R V	nom. cap. μF	max r.m.s. ripple current at T_{amb} = 85 °C mA*	max. d.c. leakage current at U_R after 5 min μA*	typ ESR Ω*	max ESR Ω*	case size	catalogue number
63	1	14	57	260	570	00	2222 039 18108
	1,5	19	57	140	290	00	18158
	2,2	25	57	80	135	00	18228
	3,3	35	60	38	85	00	18338
	4,7	42	65	26	59	00	18478
	6,8	51	71	18	41	00	18688
	10	70	81	12	28	01	18109
	15	84	97	8,5	19	01	18159
	22	121	111	5	11	02	18229
	33	147	132	3,1	7	02	18339
	47	213	159	1,9	4,3	03	18479

Capacitance

The nominal capacitance values at 100 Hz are given in Table 2. The tolerance on nominal capacitance at 100 Hz is –20 to +20%.

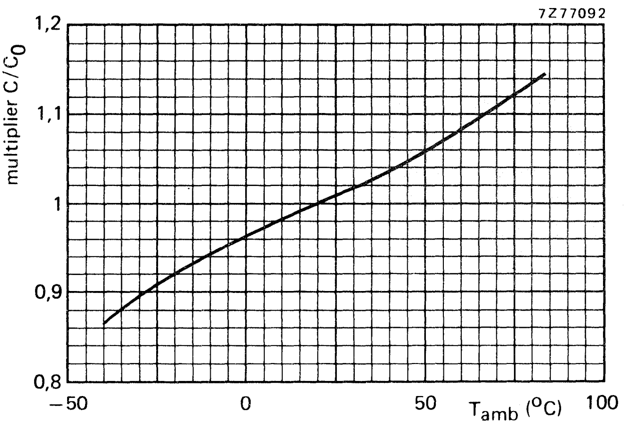


Fig. 2 Typical capacitance as a function of ambient temperature; C_0 = capacitance at 20 °C and 100 Hz.

* See also corresponding paragraph.

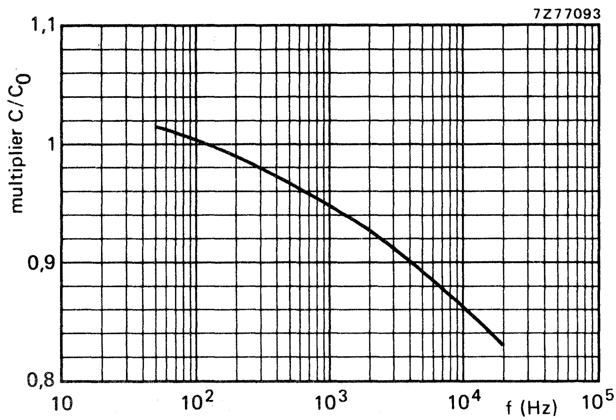


Fig. 3 Typical capacitance as a function of frequency; C_0 = capacitance at 20 °C and 100 Hz.

Voltage

The rated voltage U_R (a.c.) in the temperature range −40 to +85 °C is 63 V peak (40 V r.m.s.), provided the ripple current remains below the specified values in Table 2.

The rated voltage U_R (d.c.) in the temperature range −40 to +85 °C is 63 V, independent of polarity.

Ripple current

The maximum permissible r.m.s. ripple current at 100 Hz and T_{amb} = 85 °C is given in Table 2.

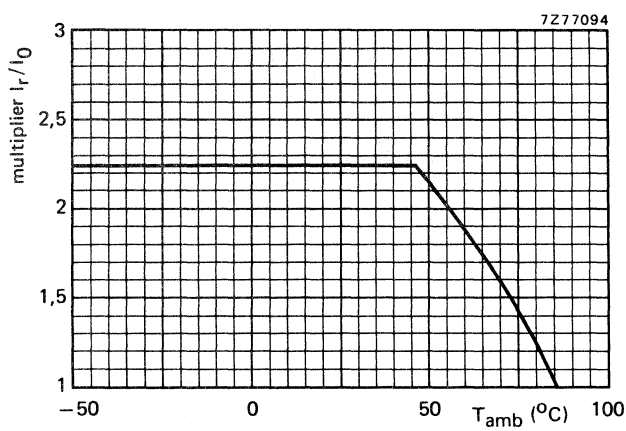


Fig. 4 Typical ripple current as a function of ambient temperature; I_0 = ripple current at 85 °C and 100 Hz.

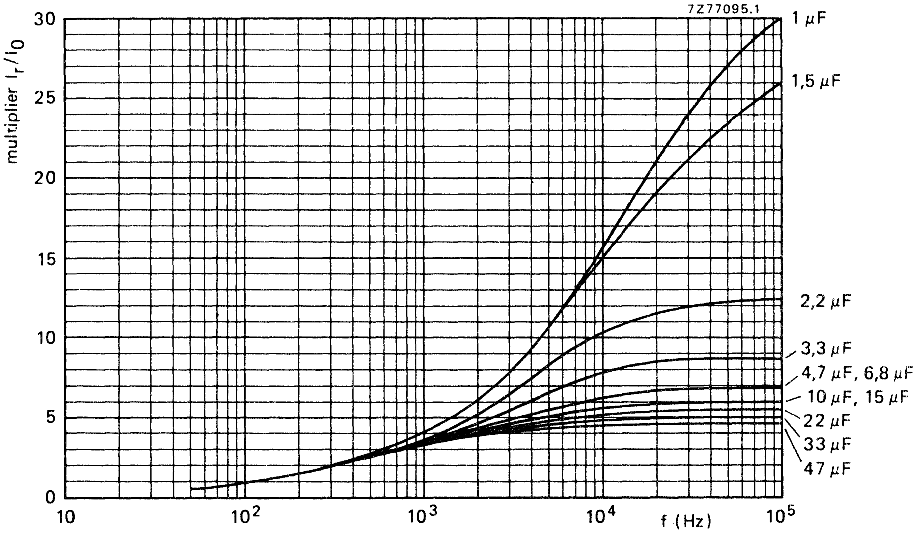


Fig. 5 Typical ripple current as a function of frequency; I_0 = ripple current at 85 °C and 100 Hz.

D.C. leakage current

The maximum d.c. leakage current, when the case is at negative potential with respect to the other connection, 5 min after application of the rated voltage at T_{amb} = 20 to 25 °C is given in Table 2.

The maximum d.c. leakage current, when the case is at positive potential with respect to the other connection, may be up to 50 μA higher than the values given in Table 2.

If the d.c. leakage current is too high, owing to prolonged storage and/or storage at an excessive temperature, application of the rated voltage for some hours will cause the d.c. leakage current to fall to a value lower than specified in Table 2.

Equivalent series resistance (ESR)

The ESR at 100 Hz and T_{amb} = 25 °C, measured by means of a four-terminal circuit (Thomson circuit) is given in Table 2.

For ESR at different frequencies, see graphs on the next page.

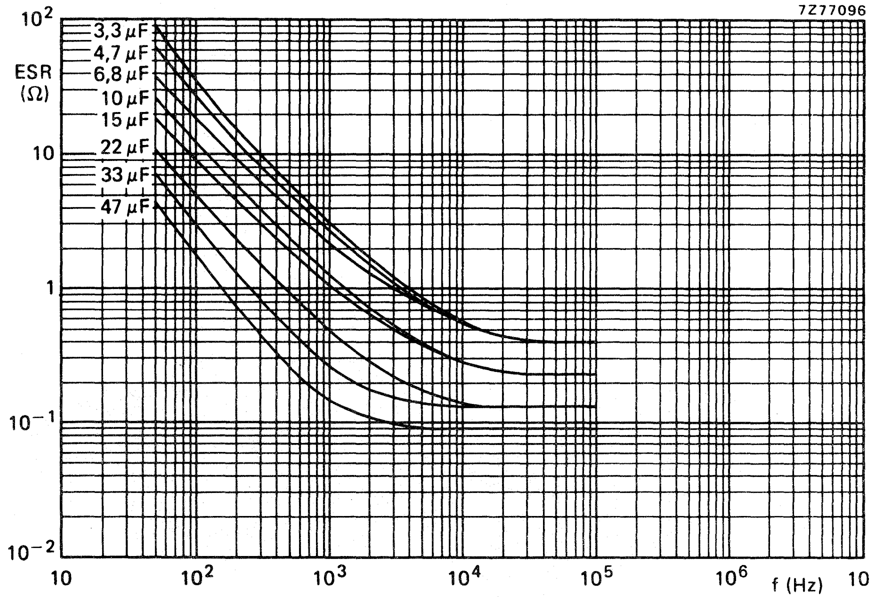


Fig. 6 Typical ESR as a function of frequency at 25 °C.

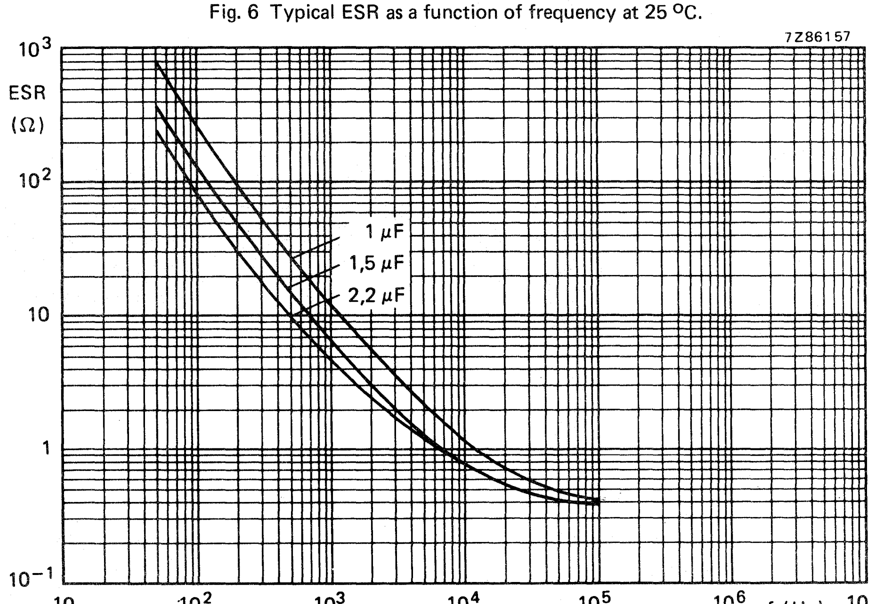


Fig. 7 Typical ESR as a function of frequency at 25 °C.

Impedance

Impedance at T_{amb} = 25 °C measured by means of a four-terminal circuit (Thomson circuit).

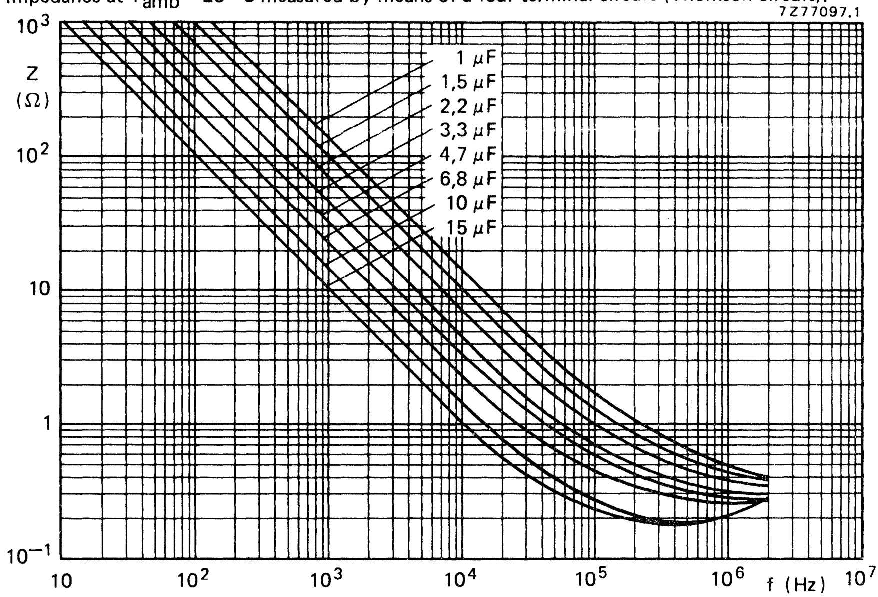


Fig. 8 Typical impedance as a function of frequency at 25 °C.

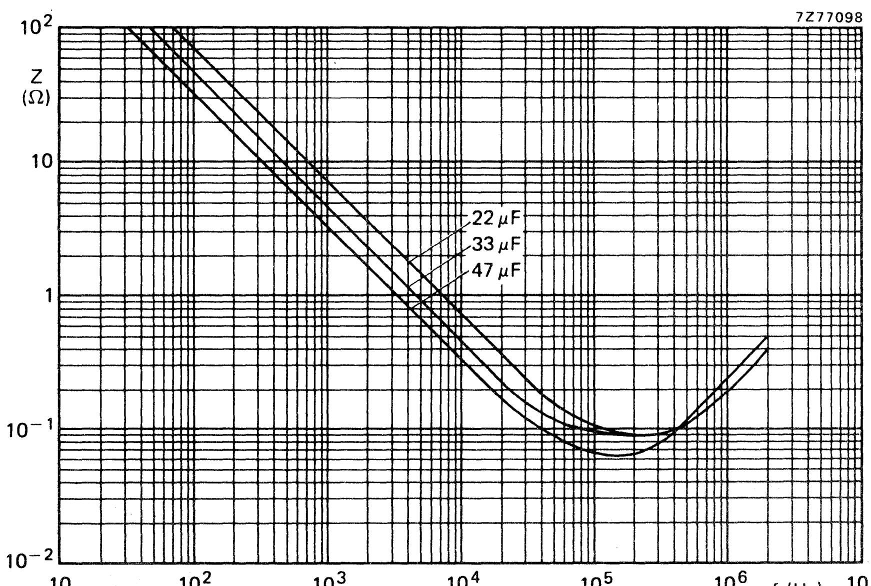


Fig. 9 Typical impedance as a function of frequency at 25 °C.

OPERATIONAL DATA

Category temperature range	−40 to + 85 °C
Typical life time	
at T_{amb} = 85 °C	10 000 h
at T_{amb} = 40 °C	> 200 000 h
Shelf life at 0 V and T_{amb} = 85 °C	500 h

PACKING

The capacitors are packed in boxes of 200.

TEST AND REQUIREMENTS

See Introduction, section 9, under aluminium electrolytic capacitors, with the exception of IEC384-4 sub clause 9.14, and the figures of tan δ, for which the following is valid.

IEC384-4 sub clause 9.14.
IEC68-2 test method: no reference.
Name of test: Endurance

Procedure a:	5000 h at 85 °C, rated d.c. voltage applied in anv direction.
Requirements:	no visible damage, no leakage of electrolyte, d.c. leakage current at applied d.c. voltage in applied direction $\leqslant$ stated limit, ESR $\leqslant$ 1,3 x stated limit, $\Delta C/C \leqslant 15\%$, ratio of impedances at 10 kHz before and after test $\leqslant$ 2, insulation resistance > 100 MΩ, no breakdown or flashover.
Procedure b:	5000 h at 85 °C, rated ripple current applied, no d.c. voltage applied.
Requirements:	no visible damage, no leakage of electrolyte, ESR $\leqslant$ 2 x stated limit, $\Delta C/C \leqslant 15\%$, ratio of impedances at 10 kHz before and after test $\leqslant$ 2, insulation resistance > 100 MΩ, no breakdown or flashover.

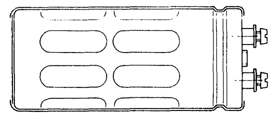
After *shelf life test,* 500 h, 85 °C, the capacitors meet the same requirements as after endurance test. The rated voltage shall be applied to the capacitors for minimum 30 min., at least 24 h and not more than 48 h before measurements.

In this data sheet no value is given for tan δ; where in the tests and requirements tan δ is mentioned, ESR must be read instead.

Note: Capacitors 2222 039 are small types, long-life grade.

ALUMINIUM ELECTROLYTIC CAPACITORS

- **Large type with screw terminals**
- **Long life**
- **Military and industrial applications**



QUICK REFERENCE DATA

Nominal capacitance range (E6 series)	1500 to 150 000 μF
Tolerance on nominal capacitance	−10 to +50%
Rated voltage range, U_R (R5 series)	6,3 to 100 V
Category temperature range	
2222 106	−40 to +85 °C
2222 107	−25 to +85 °C
Typical life time at 85 °C	>5000 h
Basic specification	IEC 384-4, long-life grade
Climatic category	
IEC 68 (2222 106)	40/085/56
DIN 40040 (2222 106)	GPF (56 days)
NF C93-001 (2222 106)	554
IEC 68 (2222 107)	25/085/56
DIN 40040 (2222 107)	GPF (56 days)
NF C93-001 (2222 107)	654
Approvals	U.K. Post Office D 2186 Ministry of Defence (Navy) DEF5134-1 FOA/FTL (Sweden)

Selection chart for C_{nom}-U_R and relevant case sizes.

C_{nom} μF	U_R (V)						
	6,3	10	16	25	40	63	100
1500							11
2200						11	12
3300						12	14
4700					11	14	15
6800				11	12	15	
10 000			11	12	14		16
15 000		11	12	14	15	16	
22 000	11	12	14	15			
33 000	12	14	15		16		
47 000	14	15		16			
68 000	15		16				
100 000		16					
150 000	16						

case size	nominal dimensions (mm)
11	Ø 35 x 80
12	Ø 35 x 112
14	Ø 50 x 80
15	Ø 50 x 112
16	Ø 65 x 112

APPLICATION

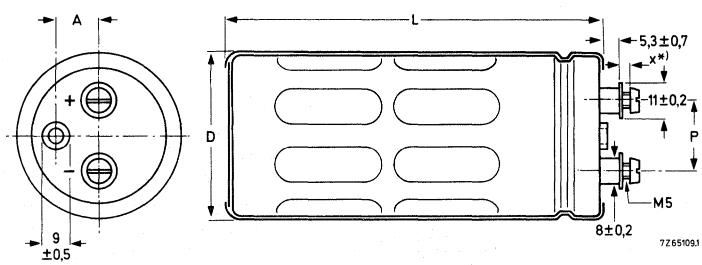
Because of their high reliability and long service life these capacitors are recommended not only for industrial but also for military applications. Their extremely low resistance and inductance values and high resistance to shock and vibration render them very suitable for applications such as:
- switched-mode power supplies;
- power supplies in digital equipment;
- energy storage in pulse systems;
- filters in measuring and control apparatus.

DESCRIPTION

The low values of impedance and inductance are achieved by a special construction with multiple internal anode and cathode connections.
The high resistance to shock and vibration is achieved by the longitudinal rills and special internal construction.
The capacitors are completely cold-welded and charge/discharge proof.
The aluminium cases are fully insulated and sealed by a synthetic resin disc with a vent. In the case of over-pressure the vent releases this pressure and closes again; the proper operation of the capacitor remains guaranteed.
The capacitors are delivered with screws and washers.

MECHANICAL DATA

Dimensions in mm



See Table 1 for dimensions D, L, P and A.

*) Maximum permissible torque which may be applied to the termination screws at various heights (X in drawing):

2	4	6	X (mm)
1,5	1	0,5	max. permissible torque (Nm)

Table 1

case size	D + 1,5	L + 3	P ± 0,1	A ± 0,2	approx. mass (g)
11	35	80	15	8,4	105
12	35	112	15	8,4	140
14	50	80	22	14,3	200
15	50	112	22	14,3	280
16	65	112	31	19,0	480

Marking

The capacitors are marked with: nominal capacitance, tolerance on nominal capacitance, rated voltage, temperature range, IEC type, maximum permissible ripple current at 50 °C, catalogue number and date code.

Mounting

The capacitor may be mounted vertically or horizontally, with or without mounting clamp. For proper functioning the vent should be on the upper side, whether the capacitor is mounted horizontally or vertically. When a number of capacitors are connected in a bank, they must not be closer than 15 mm when no derating of ripple current and/or temperature is applied. See also Mounting Accessories, at the end of this data sheet.

Minimum atmospheric pressure 8,5 kPa

PRODUCT SAFETY

Non-solid electrolytic capacitors may contain chemicals which can be regarded as hazardous if incorrectly handled. Caution is necessary should the outer case be fractured.

ELECTRICAL DATA

Table 2

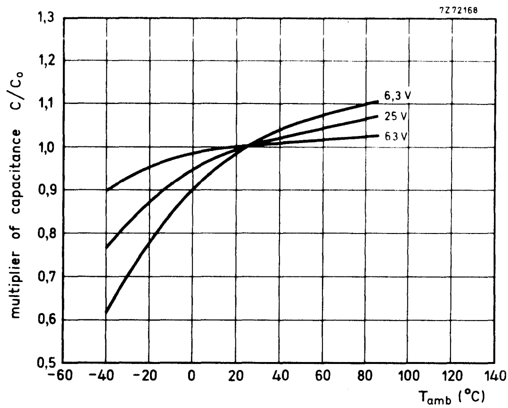
Unless otherwise specified all electrical values in Table 2 apply at an ambient temperature of 20 to 25 °C, a frequency of 100 Hz, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 45 to 75%.

U_R	nom. cap.	max. r.m.s. ripple current at T_{amb} = 85 °C	max. d.c. leakage current at U_R after 5 min	typ. ESR	max. tan δ	impedance at 20 kHz (mΩ) [1]		case size	catalogue number
(V)	(μF)	(A) [1]	(mA) [1]	(mΩ) [1]	[1]	typ.	max.		
6,3	22000	5,5	0,9	13,0	0,32	8,5	13,0	11	2222 106 33223
	33000	7,9	1,3	8,5	0,32	7,0	10,5	12	33333
	47000	9,4	1,8	6,5	0,35	5,5	8,0	14	33473
	68000	13,2	2,6	4,5	0,35	4,0	6,0	15	33683
	150000	21,3	5,7	2,5	0,45	3,5	5,5	16	33154
10	15000	5,3	0,9	14,0	0,23	8,5	13,0	11	34153
	22000	7,5	1,4	9,5	0,23	7,0	10,5	12	34223
	33000	9,1	2,0	7,0	0,25	5,5	8,0	14	34333
	47000	12,8	2,9	5,0	0,25	4,0	6,0	15	34473
	100000	20,5	6,0	2,5	0,27	3,5	5,5	16	34104
16	10000	5,0	1,0	16,0	0,16	8,5	13,0	11	35103
	15000	7,1	1,5	10,5	0,16	7,0	10,5	12	35153
	22000	8,6	2,2	8,0	0,18	5,5	8,0	14	35223
	33000	12,4	3,2	5,0	0,18	4,0	6,0	15	35333
	68000	19,7	6,6	2,5	0,19	3,5	5,5	16	35683
25	6800	4,7	1,1	18,0	0,12	8,5	13,0	11	36682
	10000	6,7	1,5	12,0	0,12	7,0	10,5	12	36103
	15000	8,2	2,3	8,5	0,13	5,5	8,0	14	36153
	22000	11,6	3,3	6,0	0,13	4,0	6,0	15	36223
	47000	18,7	7,1	3,0	0,14	3,5	5,5	16	36473
40	4700	4,3	1,2	21,0	0,10	11,5	17,0	11	37472
	6800	6,0	1,7	14,5	0,10	8,5	13,0	12	37682
	10000	7,4	2,4	10,5	0,10	6,0	9,0	14	37103
	15000	10,6	3,6	7,0	0,10	4,5	7,0	15	37153
	33000	17,6	8,0	3,5	0,11	3,5	5,5	16	37333
63	2200	3,6	0,9	30,0	0,065	11,5	17,0	11	38222
	3300	5,2	1,3	20,0	0,065	8,5	13,0	12	38332
	4700	6,3	1,8	14,5	0,070	6,0	9,0	14	38472
	6800	8,8	2,6	10,0	0,070	4,5	7,0	15	38682
	15000	14,8	5,7	5,0	0,075	3,5	5,5	16	38153
100	1500	3,1	0,9	270	0,40	200	300	11	2222 107 30152
	2200	4,5	1,4	180	0,40	130	200	12	30222
	3300	5,4	2,0	120	0,40	90	140	14	30332
	4700	7,7	2,9	80	0,40	60	90	15	30472
	10000	12,6	6,0	40	0,40	40	60	16	30103

[1] See also corresponding paragraph.

Capacitance

Nominal capacitance values at 100 Hz and T_{amb} = 25 °C	see Table 2
Tolerance on nominal capacitance at 100 Hz	−10 to +50%



Typical capacitance as a function of ambient temperature;
C_0 = capacitance at T_{amb} = 25 °C, 100 Hz.

Voltage

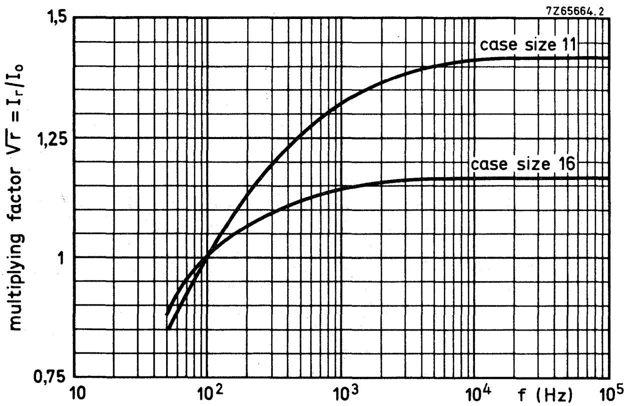
		core temperature* < 60 °C	core temperature* 60 to 95 °C
Rated voltage	= max. permissible voltage	1,1 x U_R	U_R
Ripple voltage**	= max. permissible a.c. voltage providing the following three conditions are met:		
	a) max. (d.c. + peak a.c.) voltage	1,1 x U_R	U_R
	b) max. peak a.c. voltage, with d.c. voltage applied	applied d.c. voltage + 1 V	
	c) max. peak a.c. voltage, without d.c. voltage applied	1 V	
Surge voltage	= max. permissible voltage for short periods (see also "Tests and requirements")	1,15 x U_R	
Reverse voltage	= max. d.c. voltage applied in the reverse polarity at the maximum category temperature (for short periods)	1 V	

* See Introduction, section 5, "Ripple current".

** Ripple voltages are not applicable if the maximum permissible ripple current is exceeded. In that case the ripple current is decisive.

Ripple current

Maximum permissible r.m.s. ripple current at 100 Hz and T_{amb} = 85 °C	see Table 2
at T_{amb} = 80 °C	1,4 x values stated in Table 2
at T_{amb} = 75 °C	1,7 x values stated in Table 2 [1])
at $T_{amb} \leq$ 65 °C	2,2 x values stated in Table 2 [1])



Multiplying factor as a function of frequency, for calculation of max. ripple current [1]).
I_0 = maximum ripple current at 85 °C, 100 Hz.

Non-sinusoidal ripple currents have to be analyzed into a number of sinusoidal currents and the following requirements shall then be satisfied:

$$\sum_n \frac{I_n^2}{r_n} \leq I_r^2 \text{max.}$$

$I_{r\ max}$ = max. ripple current at 100 Hz and applicable ambient temperature;

I_n = ripple current at a certain frequency;

$\sqrt{r_n}$ = multiplying factor at same frequency.

Note

Ripple currents are not applicable if the maximum permissible ripple voltage is exceeded. In that case the ripple voltage is decisive.

[1]) With a maximum of 30 A.

Charge and discharge current

The capacitors may be charged from a source without internal resistance and they may be discharged by short-circuiting.
If the capacitors are charged and discharged continuously at a rate of several times per minute, the charge and discharge currents have to be considered as ripple currents flowing through the capacitor. The r.m.s. value of these currents should be determined and the value thus found must not exceed the applicable limit.

D.C. leakage current

Maximum d.c. leakage current 5 min after application of the rated voltage at T_{amb} = 20 °C	see Table 2 (0,006 CU + 4 μA)
D.C. leakage current during continuous operation at U_R, at T_{amb} = 20 °C	approx. 0,125 of value stated in Table 2
at T_{amb} = 85 °C	≤ value stated in Table 2

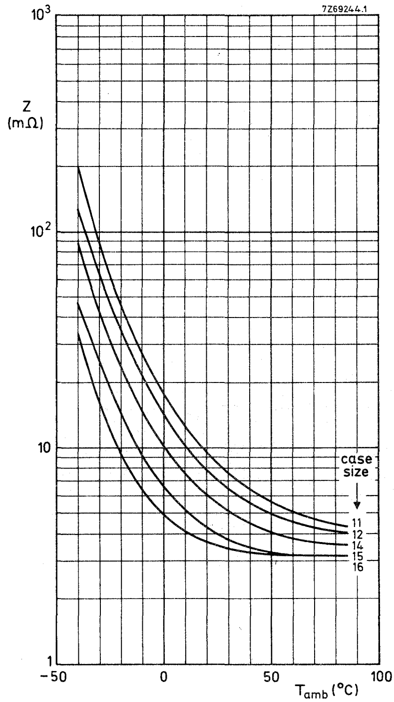
If owing to prolonged storage and/or storage at an excessive temperature the d.c. leakage current is too high, application of the rated voltage for some hours will cause the d.c. leakage current to fall to a value lower than specified in Table 2.

Tan δ (dissipation factor)

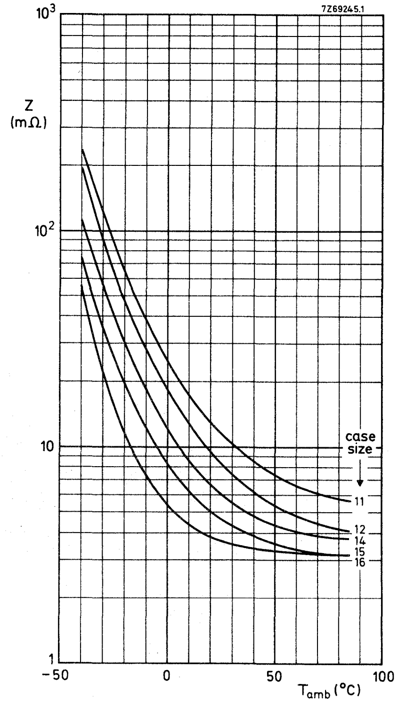
Tan δ at 100 Hz and T_{amb} = 25 °C, measured by means of a four-terminal circuit (Thomson circuit)	see Table 2

Impedance

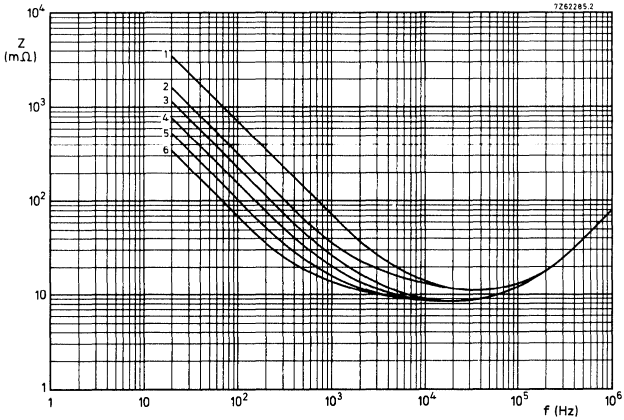
Impedance at 20 kHz and T_{amb} = 25 °C, measured by means of a four-terminal circuit (Thomson circuit)	see Table 2



Typical impedance as a function of temperature at 20 kHz for 6,3 V to 25 V types.



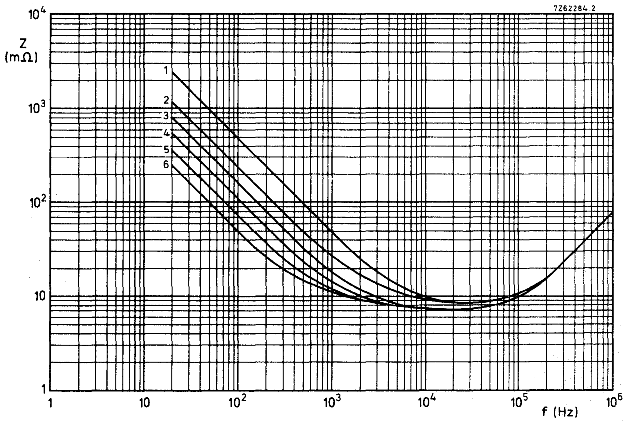
Typical impedance as a function of temperature at 20 kHz for 40 V and 63 V types.



Typical impedance as a function of frequency at T_{amb} = 25 °C.

case size 11

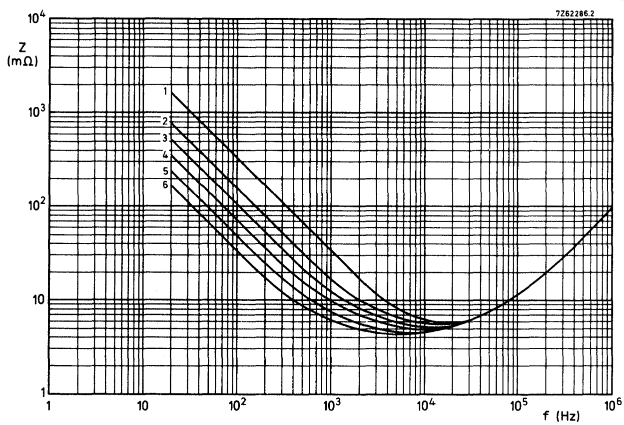
curve 1 = 2200 μF, 63 V
2 = 4700 μF, 40 V
3 = 6800 μF, 25 V
4 = 10 000 μF, 16 V
5 = 15 000 μF, 10 V
6 = 22 000 μF, 6,3 V



Typical impedance as a function of frequency at T_{amb} = 25 °C.

case size 12

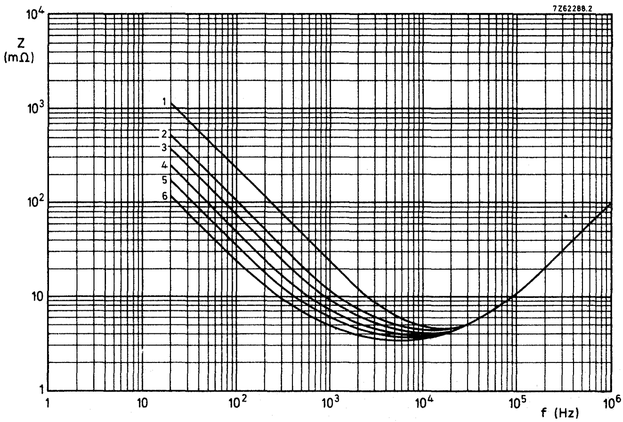
curve 1 = 3300 μF, 63 V
2 = 6800 μF, 40 V
3 = 10 000 μF, 25 V
4 = 15 000 μF, 16 V
5 = 22 000 μF, 10 V
6 = 33 000 μF, 6,3 V



Typical impedance as a function of frequency at T_{amb} = 25 °C.

case size 14

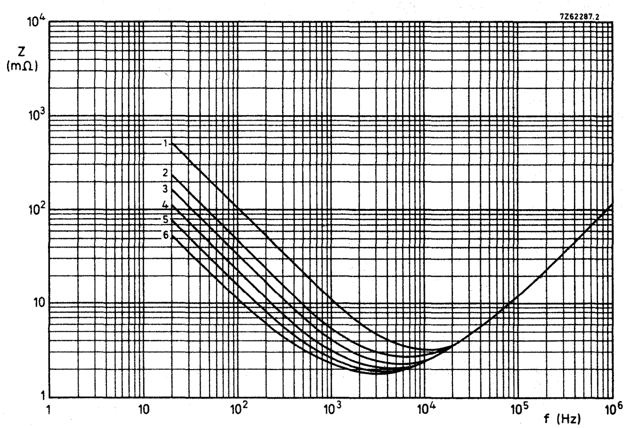
curve 1 = 4700 μF, 63 V
2 = 10 000 μF, 40 V
3 = 15 000 μF, 25 V
4 = 22 000 μF, 16 V
5 = 33 000 μF, 10 V
6 = 47 000 μF, 6,3 V



Typical impedance as a function of frequency at T_{amb} = 25 °C.

case size 15

curve 1 = 6800 µF, 63 V
2 = 15 000 µF, 40 V
3 = 22 000 µF, 25 V
4 = 33 000 µF, 16 V
5 = 47 000 µF, 10 V
6 = 68 000 µF, 6,3 V



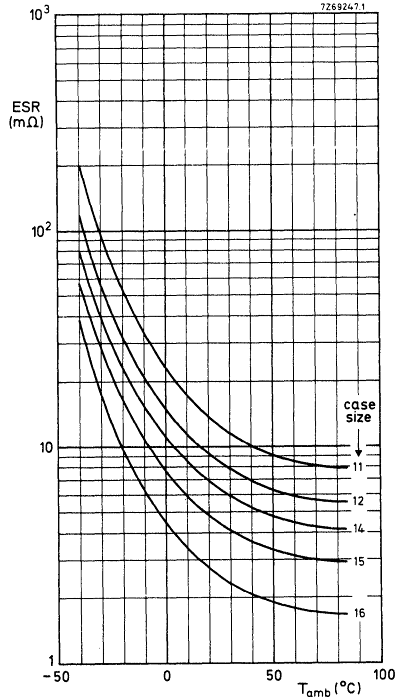
Typical impedance as a function of frequency at T_{amb} = 25 °C.

case size 16

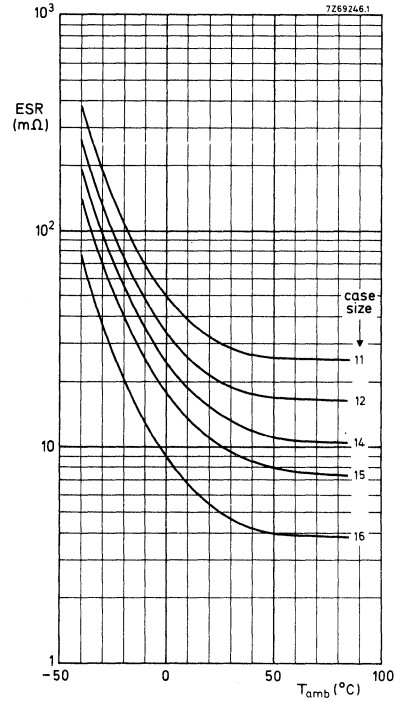
curve 1 = 15 000 µF, 63 V
2 = 33 000 µF, 40 V
3 = 47 000 µF, 25 V
4 = 68 000 µF, 16 V
5 = 100 000 µF, 10 V
6 = 150 000 µF, 6,3 V

Equivalent series resistance (ESR = tan $\delta/\omega C$)

ESR at 100 Hz and T_{amb} = 25 °C — see Table 2



Typical ESR as a function of temperature at 100 Hz for 6,3 V types.



Typical ESR as a function of temperature at 100 Hz for 63 V types.

Inductance

case size	typical inductance
11 and 12	12 nH
14 and 15	15 nH
16	18 nH

OPERATIONAL DATA

Category temperature range

for rated voltage, 2222 106	−40 to +85 °C
for rated voltage, 2222 107	−25 to +85 °C

Life expectancy

Typical lifetime

at T_{amb} = 85 °C	>5000 h
at T_{amb} = 25 °C	>15 years

PACKING

Case sizes 11, 12, 14 and 15: 50 pieces per box.
Case size 16: 25 pieces per box.

TESTS AND REQUIREMENTS

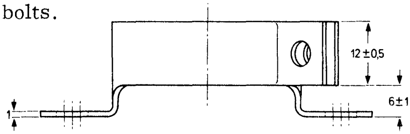
See Introduction, section 9, under aluminium electrolytic capacitors.

Note: Capacitors 2222 106 and 2222 107 belong to the large types with screw terminals, long-life grade.

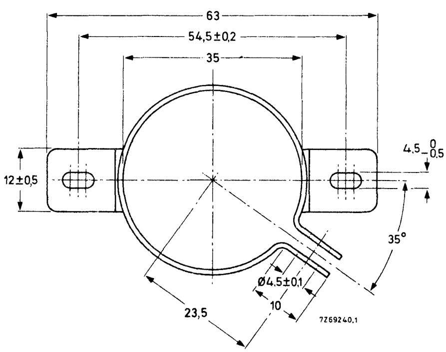
MOUNTING ACCESSORIES

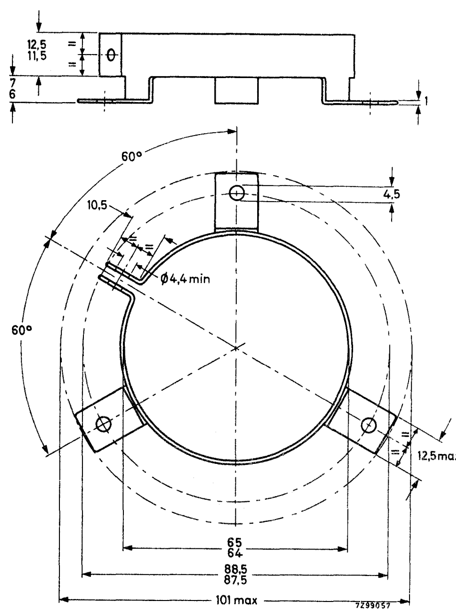
Clamps

To facilitate vertical mounting, a series of rigid clamps made of cadmium-plated steel are available. They can easily be slid over the capacitor and then fixed to it with a nut and bolt. They are provided with two or three mounting lugs. Three types are available, one for each case diameter of the capacitor range. They are delivered without nuts or bolts.

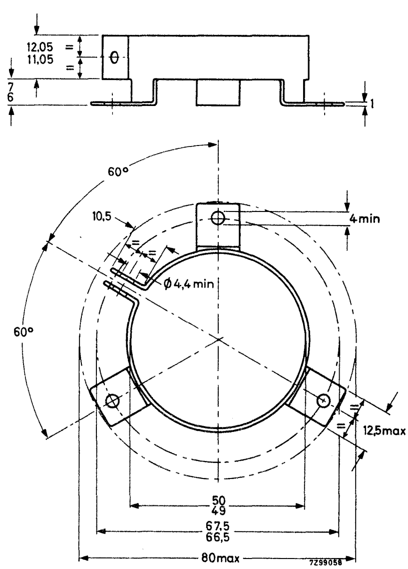


Clamp for case diameter of 35 mm.
Catalogue number: 4322 043 04272.





Clamp for case diameter of 65 mm.
Catalogue number 4322 043 04291.



Clamp for case diameter of 50 mm.
Catalogue number 4322 043 04281.

NOTES

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STANDARD SERIES OF VALUES IN A DECADE

for resistances and capacitances

according to IEC publication 63

E192	E96	E48	E192	E96	E48	E192	E96	E48	E192	E96	E48	E192	E96	E48
100	100	100	169	169	169	287	287	287	487	487	487	825	825	825
101			172			291			493			835		
102	102		174	174		294	294		499	499		845	845	
104			176			298			505			856		
105	105	105	178	178	178	301	301	301	511	511	511	866	866	866
106			180			305			517			876		
107	107		182	182		309	309		523	523		887	887	
109			184			312			530			898		
110	110	110	187	187	187	316	316	316	536	536	536	909	909	909
111			189			320			542			920		
113	113		191	191		324	324		549	549		931	931	
114			193			328			556			942		
115	115	115	196	196	196	332	332	332	562	562	562	953	953	953
117			198			336			569			965		
118	118		200	200		340	340		576	576		976	976	
120			203			344			583			988		
121	121	121	205	205	205	348	348	348	590	590	590			
123			208			352			597					
124	124		210	210		357	357		604	604				
126			213			361			612					
127	127	127	215	215	215	365	365	365	619	619	619			
129			218			370			626					
130	130		221	221		374	374		634	634				
132			223			379			642					
133	133	133	226	226	226	383	383	383	649	649	649			
135			229			388			657					
137	137		232	232		392	392		665	665				
138			234			397			673					
140	140	140	237	237	237	402	402	402	681	681	681			
142			240			407			690					
143	143		243	243		412	412		698	698				
145			246			417			706					
147	147	147	249	249	249	422	422	422	715	715	715			
149			252			427			723					
150	150		255	255		432	432		732	732				
152			258			437			741					
154	154	154	261	261	261	442	442	442	750	750	750			
156			264			448			759					
158	158		267	267		453	453		768	768				
160			271			459			777					
162	162	162	274	274	274	464	464	464	787	787	787			
164			277			470			796					
165	165		280	280		475	475		806	806				
167			284			481			816					

E24	E12	E6	E3
10	10	10	10
11			
12	12		
13			
15	15	15	
16			
18	18		
20			
22	22	22	22
24			
27	27		
30			
33	33	33	
36			
39	39		
43			
47	47	47	47
51			
56	56		
62			
68	68	68	
75			
82	82		
91			

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