LINEAR TECHNOLOGY CORPORATION

INTERFACE PRODUCT HANDBOOK 1993

LINEAR TECHNOLOGY

This handbook presents Linear Technology Corporation's (LTC's) diverse and innovative family of Interface products. Included are application notes and design notes which provide information and assistance in solving interface design problem.

LTC's RS232/RS562 Interface products contain state-of-the-art devices with the industry's highest ESD rating, lowest power dissipation and best reliability. Standard features include 5V and 3.3V only operation with 0.1µF charge pump capacitors, 10kV ESD protection on the RS232 bus pins, and full compliance with the RS232 speacifications, including over-voltage conditions. LTC's flow-through pinout on all of its RS232 devices enables simplified printed circuit layout.

Configurations range from 2 driver, 2 receiver parts to 5 driver, 5 receiver devices suitable for personal computer serial ports and other RS232 DTE/DCE ports. Low power shutdown modes are available along with single receiver keep-alive for monitoring wake-up signals.

LTC RS485/RS422 Interface products offer the industry's lowest power dissipation by implementing a CMOS Schottky process which allows full compliance with RS485 specifications. LTC's devices have supply currents as low as 300µA and support data rates up to 10MBit/s. Configurations available include single transceivers for half and full-duplex communications, as well as drivers and receivers all in industry standard pinouts. These differential Interface devices also support protocols such as RS449, RS530 or V.35.

Special Interface devices include the LTC1320 for combined single-ended and differential applications such as LocalTalk®. The LTC1145 and LTC1146 are integrated isolation circuits with quiescent currents well below those of opto-isolators but with comparable speed.

All of LTC's Interface products are available in surface mount SOIC packaging. We are continuing to expand our surface mount capabilities and now offer Shrink Small Outline Packages (SSOP) for some of our Interface devices. Contact the factory or your local sales representative for more information.

If you require additional information on device characteristics or device reliability, please contact LTC Marketing at (408) 432-1900, or contact your local LTC Sales Representative. Thank you for your interest in LTC Interface products. We look forward to continuing to serve your interface needs in the future.

LocalTalk is a registered trademark of Apple Computer, Inc.

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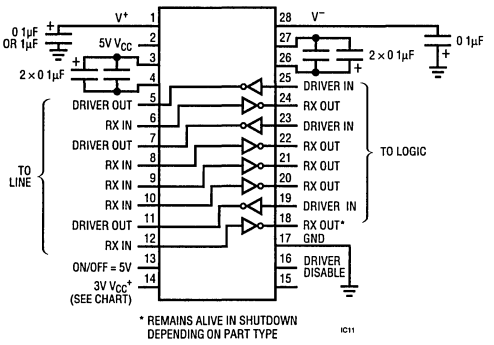
AppleTalk is a registered trademark of Apple Computer, Inc.

Complete RS232 PC Serial Ports: 3 Drivers, 5 Receivers

- 10kV ESD Immunity
- 3V Logic Compatible
- Receiver Keep-Alive in Shutdown
- SOIC Packages (Ask about SSOP)
- Ultra Low Power (LTC1337: 1.5mW)
- Flow-Through Architecture
- 0.1µF Capacitors
- Low Power Shutdown
- 120k Baud Operation
- Capable of Mouse Driving
- 3.3V or 5V Powered

SUPPLY VOLTAGE	3V OR 5V LOGIC	TYP POWER DISS(mW)	1 RECEIVER ACTIVE IN SHUTDOWN	I_Q IN SHDN (µA)	DRIVER DISABLE	10kV ESD	0.1µF CAPS	DEVICE TYPE
5	5	85		1				LT1137
5	5	60		1	X	X	X	LT1137A
5	5	30	X	60	X	X	X*	LT1237
5 & 3	3	30	X	60	X	X	X*	LT1330
3	3	42	X	60	X	X	X	LT1331
5 & 3	3	34	X	60	X	X	X*	LT1331
5	5	1.5		1		X	X	LTC1337
5	5	60	X	60	X	X	X	LT1341
5 & 3	3	60		1	X	X	X	LT1342

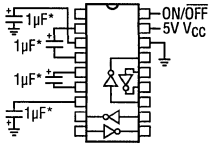
*Requires one 1µF capacitor



5V Powered RS232 2 Driver/2 Receiver Circuits

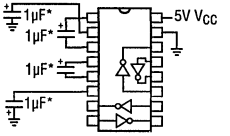
- Rugged Bipolar Construction
- 10kV ESD Immunity (LT1180A, LT1181A)
- 0.1µF Charge Pump Capacitors
- Immune to Latch-Up
- Low Power Shutdown
- 3-State Outputs When Shut Down

SHUTDOWN/ RS232 AND TTL THREE-STATE OUTPUTS	FAULT TOLERANT TO ±25V	REQ'D CHARGE PUMP CAP SIZE	COMMENTS	PART NUMBER
Yes	Yes	1µF	General Purpose Interface	LT1080
No	Yes	1µF	Rugged MAX232 Replacement	LT1081
Yes	Yes	0.1µF	Ideal for Surface Mount, 10kV ESD	LT1180A
No	Yes	0.1µF	Replaces MAX202, 232A, 10kV ESD	LT1181A
Yes	Yes	1µF	Low Power LT1080	LT1280
No	Yes	1µF	Low Power LT1081	LT1281



*0.1µF FOR LT1180A

LT1080, LT1180A, LT1280
2 Dx, 2 Rx



*0.1µF FOR LT1181A

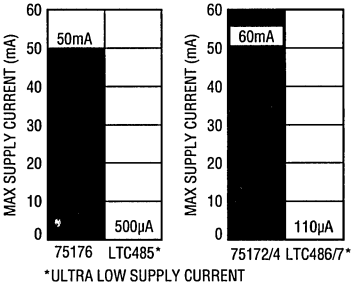
LT1081, LT1181A, LT1281
2 Dx, 2 RX

More RS232 Driver/Receiver Combinations Inside!

RS485 Family Features

- Ultra Low Power
- CMOS Schottky Process
- Designed for RS485 and RS422 Applications
- Three-State RS485 Outputs When Shutdown
- Power-Up/Down Glitch Free Outputs
- 10MB Operation (LTC486-489, LTC1485)
- Industry Standard Pinouts
- SOIC Available

The LTC RS485 Advantage: Low Power



RS485/RS422 Interface

DRIVERS	RECEIVERS	SUPPLIES REQUIRED	MAX DATA RATE	MAX SUPPLY CURRENT	INDUSTRY STANDARD PINOUT	COMMENTS	PART NUMBER
1	1	5V	2.5MB	500µA	75176	Half Duplex 2-Wire RS485	LTC485
4	0	5V	10MB	150µA	75172	Good For RS449, RS530, V.35 Interface	LTC486
4	0	5V	10MB	150µA	75174	Good For RS449, RS530, V.35 Interface	LTC487
0	4	5V	10MB	10mA	75173	Good For RS449, RS530, V.35 Interface	LTC488
0	4	5V	10MB	10mA	75175	Good For RS449, RS530, V.35 Interface	LTC489
1	1	5V	2.5MB	500µA	75179	Full Duplex 4-Wire RS485	LTC490
1	1	5V	2.5MB	500µA	75ALS180	Full Duplex 4-Wire RS485	LTC491
1	1	5V	10MB	3.5mA	75ALS176B	High Speed/Half Duplex	LTC1485

Other RS232 Driver/Receiver Combinations

DRIVERS	RECEIVERS	SUPPLIES REQUIRED	SHUTDOWN/ RS232 and TTL THREE-STATE OUTPUTS	FAULT TOLERANT to ±25V	REQ'D CHARGE PUMP CAP SIZE	COMMENTS	PART NUMBER
4	0	±12 V	Yes	Yes	N/A	Low Power 1488 Upgrade	LT1030
4	0	±12 V	Yes	Yes	N/A	Low Power 1488 Upgrade Also Supports RS423	LT1032
3	3	5V, ±12 V	Yes	Yes	N/A	One Receiver Active in Shutdown	LT1039
3	3	5V, ±12 V	No	Yes	N/A	Rugged MC145406 Replacement	LT1039-16
5	5	5V	No	Yes	0.1µF	Synchronous Communications, 10kV ESD	LT1130A
5	4	5V	Yes	Yes	0.1µF	Synchronous Modem/DCE Interface, 10kV ESD	LT1131A
5	3	5V	No	Yes	0.1µF	Modem/DCE Interface, 10kV ESD	LT1132A
3	5	5V	No	Yes	0.1µF	PC/DTE Interface, 10kV ESD	LT1133A
4	4	5V	No	Yes	0.1µF	5V Only 1488/1489 Replacement, 10kV ESD	LT1134A
5	3	5V, ±12 V	No	Yes	N/A	Modem/DCE Interface, 10kV ESD	LT1135A
4	5	5V	Yes	Yes	0.1µF	Synchronous PC/DTE Interface, 10kV ESD	LT1136A
5	3	5V	Yes	Yes	0.1µF	Modem/DCE Interface, 10kV ESD	LT1138A
4	4	5V, 12 V	Yes	Yes	0.1µF	1488/1489 Replacement, 10kV ESD	LT1139A
5	3	5V, ±12 V	Yes	Yes	N/A	Modem/DCE Interface, 10kV ESD	LT1140A
3	5	5V, ±12 V	Yes	Yes	N/A	PC/DTE Interface, 10kV ESD	LT1141A

CHAPTER 1: NEW PRODUCTS

Chapter 1: New Products

Advanced Low Power 5V RS232 Drivers/Receivers with Small Capacitors

FEATURES

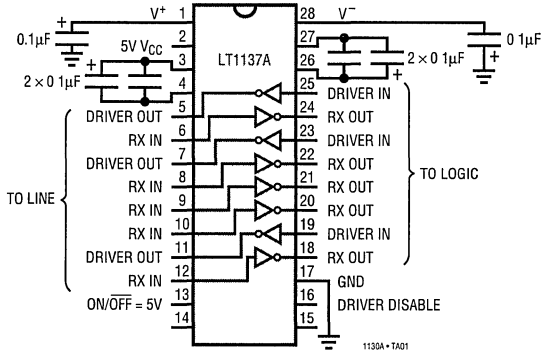
- ESD Protection over ±**10kV**
- Uses Small Capacitors: 0.1µF, 0.2µF
- 1µA Supply Current in SHUTDOWN
- Operates to 120k Baud
- CMOS Comparable Low Power
- Operates from a Single 5V Supply
- Easy PC Layout: Flowthrough Architecture
- Rugged Bipolar Design: Absolutely No Latch-Up
- Outputs Assume a High Impedance State When Off or Powered Down
- Improved Protection: RS232 I/O Lines Can be Forced to ±30V Without Damage
- Output Overvoltage Does Not Force Current Back Into Supplies
- Available in SO and SSOP Packages

DESCRIPTION

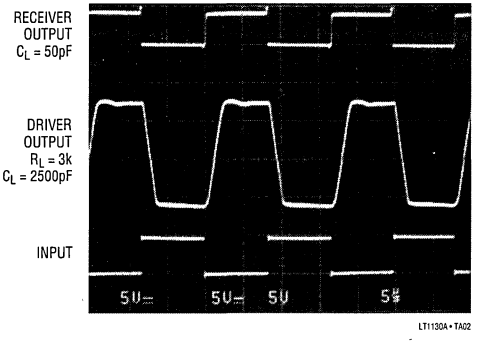
The LT1130A/LT1140A series of RS232 drivers/receivers features special bipolar construction techniques which protect the drivers and receivers beyond the fault conditions stipulated for RS232. Driver outputs and receiver inputs can be shorted to ±30V without damaging the device or the power supply generator. In addition, the RS232 I/O pins are resilient to multiple ±10kV ESD strikes. An advanced driver output stage operates up to 120kBaud while driving heavy capacitive loads. Supply current is typically 12mA, competitive with CMOS devices.

Several members of the series include flexible operating mode controls. The Driver Disable pin disables the drivers and the charge pump, the ON/$\overline{\text{OFF}}$ pin shuts down all circuitry. While shut down, the drivers and receivers assume high impedance output states.

Basic Operation



Output Waveforms



LT1130A 5-Driver/5-Receiver RS232 Transceiver
LT1131A 5-Driver/4-Receiver RS232 Transceiver w/Shutdown
LT1132A 5-Driver/3-Receiver RS232 Transceiver
LT1133A 3-Driver/5-Receiver RS232 Transceiver
LT1134A 4-Driver/4-Receiver RS232 Transceiver
LT1135A 5-Driver/3-Receiver RS232 Transceiver w/o Charge Pump
LT1136A 4-Driver/5-Receiver RS232 Transceiver w/Shutdown
LT1137A 3-Driver/5-Receiver RS232 Transceiver w/Shutdown
LT1138A 5-Driver/3-Receiver RS232 Transceiver w/Shutdown
LT1139A 4-Driver/4-Receiver RS232 Transceiver w/Shutdown
LT1140A 5-Driver/3-Receiver RS232 Transceiver w/o Charge Pump
LT1141A 3-Driver/5-Receiver RS232 Transceiver w/o Charge Pump

ABSOLUTE MAXIMUM RATINGS (Note 1)

Supply Voltage (V_{CC}) 6V
V^+ 13.2V
V^- ..... −13.2V
Input Voltage
Driver ..... V^- to V^+
Receiver ..... −30V to 30V
On/Off Pin ..... −0.3V to 12V
Driver Disable Pin ..... −0.3V to V_{CC} + 0.3V
Output Voltage
Driver ..... −30V to 30V
Receiver ..... −0.3V to V_{CC} + 0.3V

Short-Circuit Duration
V^+ ..... 30 sec
V^- ..... 30 sec
Driver Output ..... Indefinite
Receiver Output ..... Indefinite
Operating Temperature Range
LT113XAC/LT114XAC ..... 0°C to 70°C
Storage Temperature Range ..... −65°C to 150°C
Lead Temperature (Soldering, 10 sec) ..... 300°C

PRODUCT SELECTION TABLE

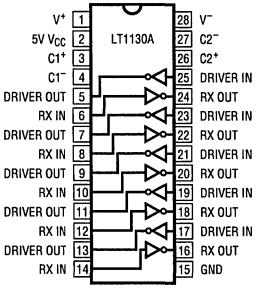
Part Number	Power Supply Voltages*	Shutdown	Driver Disable	Drivers	Receivers	External Components
LT1130A	5	No	No	5	5	4 Capacitors
LT1131A	5	Yes	Yes	5	4	4 Capacitors
LT1132A	5	No	No	5	3	4 Capacitors
LT1133A	5	No	No	3	5	4 Capacitors
LT1134A	5	No	No	4	4	4 Capacitors
LT1135A	5, 12, −12	No	No	5	3	None
LT1136A	5	Yes	Yes	4	5	4 Capacitors
LT1137A	5	Yes	Yes	3	5	4 Capacitors
LT1138A	5	Yes	Yes	5	3	4 Capacitors
LT1139A	5, 12	Yes	No	4	4	2 Capacitors
LT1140A	5, 12, −12	Yes	Yes	5	3	None
LT1141A	5, 12, −12	Yes	Yes	3	5	None

*The LT1130A, LT1131A, LT1132A, LT1134A, LT1136A, LT1137A and LT1138A can operate with 5V and 12V supplies and two external capacitors.

PACKAGE/ORDER INFORMATION

5-DRIVER/5-RECEIVER

TOP VIEW



N PACKAGE 28-LEAD PLASTIC DIP (600" WIDE)
S PACKAGE 28-LEAD PLASTIC SOL (300" WIDE)

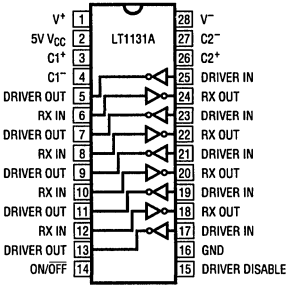
T_{JMAX} = 150°C, θ_{JA} = 56°C/W (N)
T_{JMAX} = 150°C, θ_{JA} = 68°C/W (S)

ORDER PART NUMBER

LT1130ACN
LT1130ACS

5-DRIVER/4-RECEIVER WITH SHUTDOWN

TOP VIEW



N PACKAGE 28-LEAD PLASTIC DIP (600" WIDE)
S PACKAGE 28-LEAD PLASTIC SOL (300" WIDE)

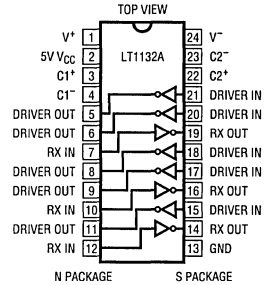
T_{JMAX} = 150°C, θ_{JA} = 56°C/W (N)
T_{JMAX} = 150°C, θ_{JA} = 68°C/W (S)

ORDER PART NUMBER

LT1131ACN
LT1131ACS

PACKAGE/ORDER INFORMATION

5-DRIVER/3-RECEIVER



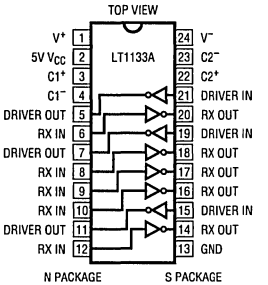
N PACKAGE 24-LEAD PLASTIC DIP (300" WIDE)
S PACKAGE 24-LEAD PLASTIC SOL (300" WIDE)

T_{JMAX} = 150°C, θ_{JA} = 58°C/W (N)
T_{JMAX} = 150°C, θ_{JA} = 80°C/W (S)

ORDER PART NUMBER

LT1132ACN
LT1132ACS

3-DRIVER/5-RECEIVER



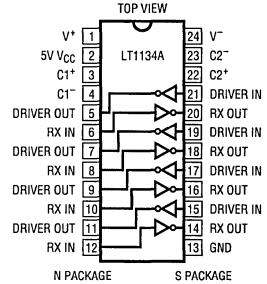
N PACKAGE 24-LEAD PLASTIC DIP (300" WIDE)
S PACKAGE 24-LEAD PLASTIC SOL (300" WIDE)

T_{JMAX} = 150°C, θ_{JA} = 58°C/W (N)
T_{JMAX} = 150°C, θ_{JA} = 80°C/W (S)

ORDER PART NUMBER

LT1133ACN
LT1133ACS

4-DRIVER/4-RECEIVER



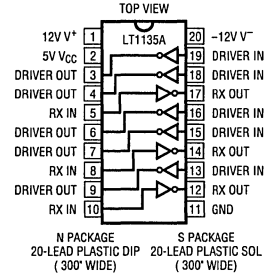
N PACKAGE 24-LEAD PLASTIC DIP (300" WIDE)
S PACKAGE 24-LEAD PLASTIC SOL (300" WIDE)

T_{JMAX} = 150°C, θ_{JA} = 58°C/W (N)
T_{JMAX} = 150°C, θ_{JA} = 80°C/W (S)

ORDER PART NUMBER

LT1134ACN
LT1134ACS

5-DRIVER/3-RECEIVER WITHOUT CHARGE PUMP



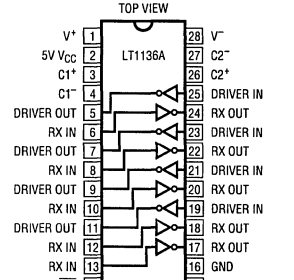
N PACKAGE 20-LEAD PLASTIC DIP (300" WIDE)
S PACKAGE 20-LEAD PLASTIC SOL (300" WIDE)

T_{JMAX} = 150°C, θ_{JA} = 79°C/W (N)
T_{JMAX} = 150°C, θ_{JA} = 85°C/W (S)

ORDER PART NUMBER

LT1135ACN
LT1135ACS

4-DRIVER/5-RECEIVER WITH SHUTDOWN



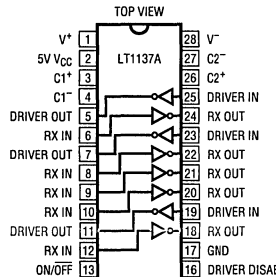
N PACKAGE 28-LEAD PLASTIC DIP (600" WIDE)
S PACKAGE 28-LEAD PLASTIC SOL (300" WIDE)

T_{JMAX} = 150°C, θ_{JA} = 56°C/W (N)
T_{JMAX} = 150°C, θ_{JA} = 68°C/W (S)

ORDER PART NUMBER

LT1136ACN
LT1136ACS

3-DRIVER/5-RECEIVER WITH SHUTDOWN



G PACKAGE 28-LEAD PLASTIC SSOP (300" WIDE)
N PACKAGE 28-LEAD PLASTIC DIP (600" WIDE)
S PACKAGE 28-LEAD PLASTIC SOL (300" WIDE)

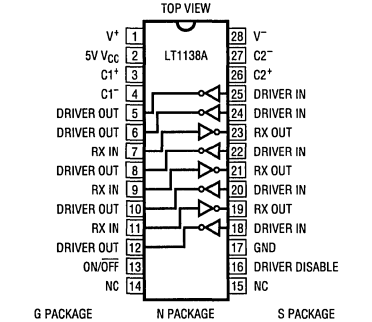
T_{JMAX} = 150°C, θ_{JA} = 96°C/W (G)
T_{JMAX} = 150°C, θ_{JA} = 56°C/W (N)
T_{JMAX} = 150°C, θ_{JA} = 68°C/W (S)

ORDER PART NUMBER

LT1137ACG
LT1137ACN
LT1137ACS

PACKAGE/ORDER INFORMATION

5-DRIVER/3-RECEIVER WITH SHUTDOWN



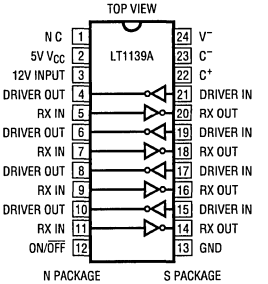
G PACKAGE 28-LEAD PLASTIC SSOP (300" WIDE)
N PACKAGE 28-LEAD PLASTIC DIP (600" WIDE)
S PACKAGE 28-LEAD PLASTIC SOL (300" WIDE)

T_{JMAX} = 150°C, θ_{JA} = 96°C/W (G)
T_{JMAX} = 150°C, θ_{JA} = 56°C/W (N)
T_{JMAX} = 150°C, θ_{JA} = 68°C/W (S)

ORDER PART NUMBER

LT1138ACG
LT1138ACN
LT1138ACS

4-DRIVER/4-RECEIVER WITH SHUTDOWN WITH 12V AND 5V SUPPLIES



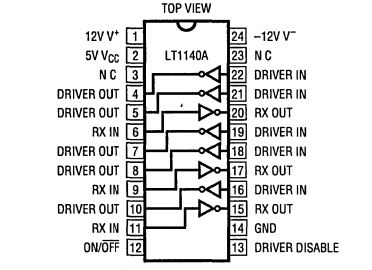
N PACKAGE 24-LEAD PLASTIC DIP (300" WIDE)
S PACKAGE 24-LEAD PLASTIC SOL (300" WIDE)

T_{JMAX} = 150°C, θ_{JA} = 58°C/W (N)
T_{JMAX} = 150°C, θ_{JA} = 80°C/W (S)

ORDER PART NUMBER

LT1139ACN
LT1139ACS

5-DRIVER/3-RECEIVER WITH SHUTDOWN WITHOUT CHARGE PUMP



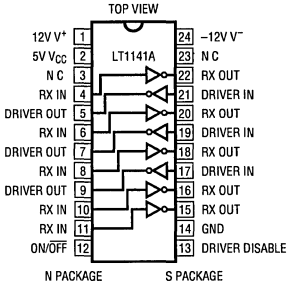
N PACKAGE 24-LEAD PLASTIC DIP (300" WIDE)
S PACKAGE 24-LEAD PLASTIC SOL (300" WIDE)

T_{JMAX} = 150°C, θ_{JA} = 58°C/W (N)
T_{JMAX} = 150°C, θ_{JA} = 80°C/W (S)

ORDER PART NUMBER

LT1140ACN
LT1140ACS

3-DRIVER/5-RECEIVER WITH SHUTDOWN WITHOUT CHARGE PUMP



N PACKAGE 24-LEAD PLASTIC DIP (300" WIDE)
S PACKAGE 24-LEAD PLASTIC SOL (300" WIDE)

T_{JMAX} = 150°C, θ_{JA} = 58°C/W (N)
T_{JMAX} = 150°C, θ_{JA} = 80°C/W (S)

ORDER PART NUMBER

LT1141ACN
LT1141ACS

ELECTRICAL CHARACTERISTICS (Note 2)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Power Supply Generator						
V^+ Output				8.6		V
V^- Output				–7.8		V
5V V_{CC} Supply Current: LT1130A, LT1131A, LT1132A, LT1133A, LT1134A, LT1136A, LT1138A	(Note 3)	O		15	25	mA
5V V_{CC} Supply Current: LT1135A, LT1140A, LT1141A	(Note 3), V^+ = 12V, V^- = –12V	O		8	15	mA
5V V_{CC} Supply Current: LT1137A	(Note 3)	O		12	17	mA
5V V_{CC} Supply Current: LT1139A	(Note 3), V^+ = 12V	O		8	15	mA

ELECTRICAL CHARACTERISTICS (Note 2)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
12V V^+ Supply Current: LT1135A, LT1140A, LT1141A	(Note 3), $V^- = -12V$	●		1	4	mA
12V V^+ Supply Current: LT1139A	(Note 3)	●		6	10	mA
–12V V^- Supply Current: LT1135A, LT1140A, LT1141A	(Note 3) $V^+ = 12V$	●		2	6	mA
Supply Current when OFF (V_{CC})	SHUTDOWN (Note 4) DRIVER DISABLE	●		1 4	10	µA mA
Supply Rise Time SHUTDOWN to Turn-On	C1, C2, C^+, C^- = 1.0µF C^+, C^- = 0.1µF, C1, C2 = 0.2µF			2.0 0.2		ms ms
ON/$\overline{\text{OFF}}$ Pin Thresholds	Input Low Level (Device SHUTDOWN) Input High Level (Device Enabled)	● ●	 2.4	1.4 1.4	0.8	V V
ON/$\overline{\text{OFF}}$ Pin Current	$0V \le V_{ON/\overline{OFF}} \le 5V$	●	–15		80	µA
DRIVER DISABLE Pin Thresholds	Input Low Level (Drivers Enabled) Input High Level (Drivers Disabled)	● ●	 2.4	1.4 1.4	0.8	V V
DRIVER DISABLE Pin Current	$0V \le V_{DRIVER\ DISABLE} \le 5V$	●	–10		500	µA
Oscillator Frequency				130		kHz
Any Driver						
Output Voltage Swing	Load = 3k to GND Positive Negative	● ●	5	7.3 –6.5	 –5	V V
Logic Input Voltage Level	Input Low Level (V_{OUT} = High) Input High Level (V_{OUT} = Low)	● ●	 2	1.4 1.4	0.8	V V
Logic Input Current	$0.8V \le V_{IN} \le 2V$	●		5	20	µA
Output Short-Circuit Current	$V_{OUT} = 0V$			±17		mA
Output Leakage Current	SHUTDOWN $V_{OUT} = \pm 30V$ (Note 4)	●		10	100	µA
Slew Rate	R_L = 3k, C_L = 51pF R_L = 3k, C_L = 2500pF			15 6	30	V/µs V/µs
Propagation Delay	Output Transition t_{HL} High-to-Low (Note 5) Output Transition t_{LH} Low-to-High			0.6 0.5	1.3 1.3	µs µs
Any Receiver						
Input Voltage Thresholds	Input Low Threshold (V_{OUT} = High) Input High Threshold (V_{OUT} = Low)	● ●	0.8	1.3 1.7	 2.4	V V
Hysteresis		●	0.1	0.4	1	V
Input Resistance			3	5	7	kΩ
Output Voltage	Output Low, $I_{OUT} = -1.6mA$ Output High, $I_{OUT} = 160\mu A$ (V_{CC} = 5V)	● ●	 3.5	0.2 4.2	0.4	V V
Output Leakage Current	SHUTDOWN (Note 4) $0 \le V_{OUT} \le V_{CC}$	●		1	10	µA
Output Short-Circuit Current	Sinking Current, $V_{OUT} = V_{CC}$ Sourcing Current, $V_{OUT} = 0V$		 10	–20 20	–10	mA mA
Propagation Delay	Output Transition t_{HL} High-to-Low (Note 6) Output Transition t_{LH} Low-to-High			250 350	600 600	ns ns

The ● denotes specifications which apply over the operating temperature range ($0°C \le T_A \le 70°C$ for commercial grade and $-40°C \le T_A \le 85°C$ for industrial grade).

Note 1: Absolute Maximum Ratings are those values beyond which the life of the device may be impaired.

Note 2: Testing done at V_{CC} = 5V and $V_{ON/\overline{OFF}}$ = 3V.

Note 3: Supply current is measured with driver and receiver outputs unloaded and the driver inputs tied high.

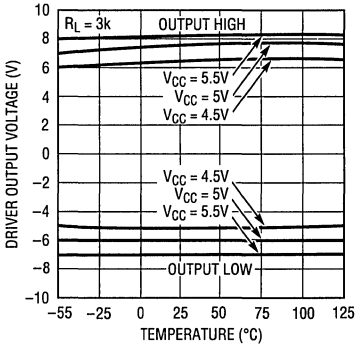
Note 4: Supply current and driver leakage current measurements in SHUTDOWN are performed with $V_{ON/\overline{OFF}}$ = 0.1V. Supply current measurements using DRIVER DISABLE are performed with $V_{DRIVER\ DISABLE}$ = 3V. For LT1135, LT1139, LT1140 and LT1141 with 12V supplies, V_{OUT} leakage is 200µA for V_{OUT} forced to ±25V.

Note 5: For driver delay measurements, R_L = 3k and C_L = 51pF. Trigger points are set between the driver's input logic threshold and the output transition to the zero crossing (t_{HL} = 1.4V to 0V and t_{LH} = 1.4V to 0V).

Note 6: For receiver delay measurements, C_L = 51pF. Trigger points are set between the receiver's input logic threshold and the output transition to standard TTL/CMOS logic threshold (t_{HL} = 1.3V to 2.4V and t_{LH} = 1.7V to 0.8V).

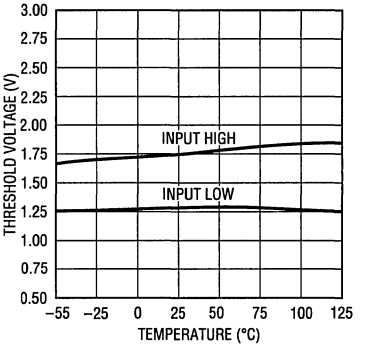
TYPICAL PERFORMANCE CHARACTERISTICS

Driver Output Voltage



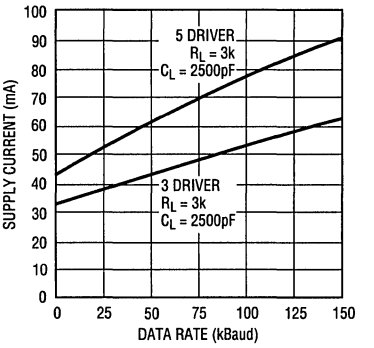
LT1130A • TPC01

Receiver Input Thresholds



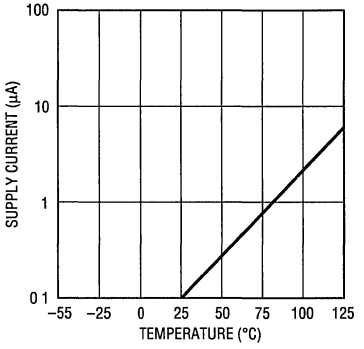
LT1137A • TPC02

Supply Current vs Data Rate



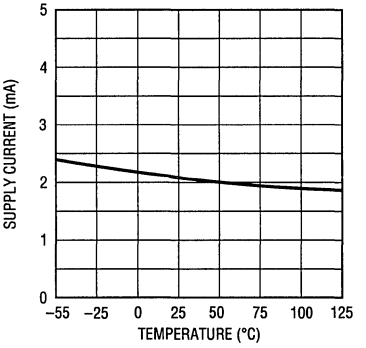
LT1130A • TPC03

Supply Current in SHUTDOWN



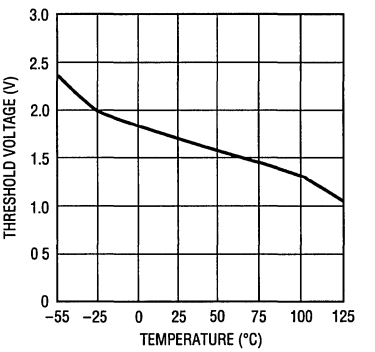
LT1137A • TPC04

Supply Current in DRIVER DISABLE



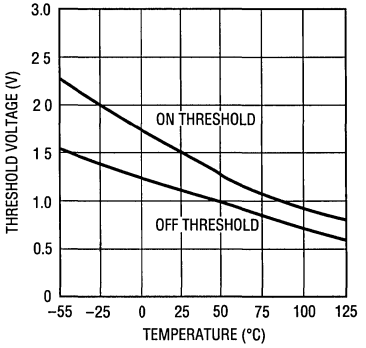
LT1137A • TPC05

DRIVER DISABLE Threshold



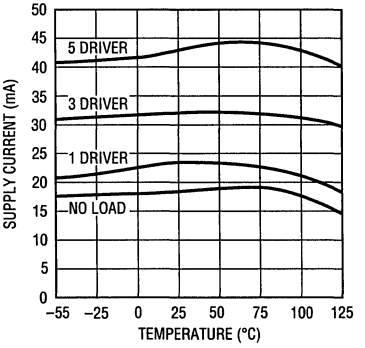
LT1137A • TPC06

ON/$\overline{\text{OFF}}$ Thresholds



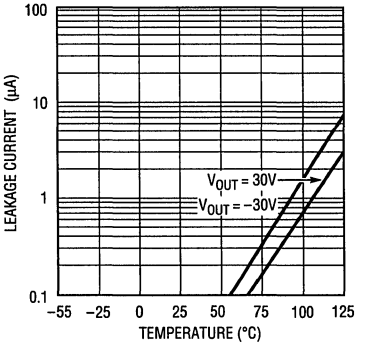
LT1137A • TPC07

Supply Current



LT1130A • TPC08

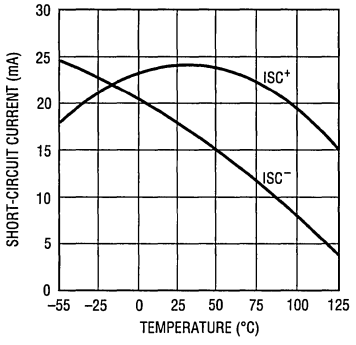
Driver Leakage in SHUTDOWN



LT1137A • TPC09

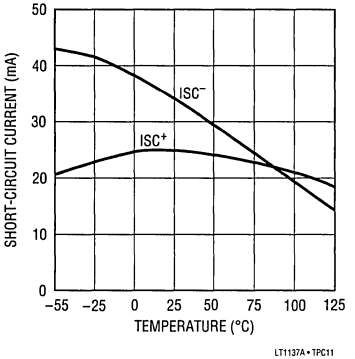
TYPICAL PERFORMANCE CHARACTERISTICS

Driver Short-Circuit Current



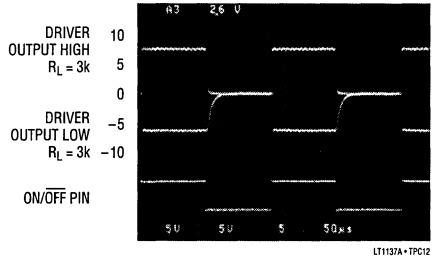
LT1137A • TPC10

Receiver Short-Circuit Current



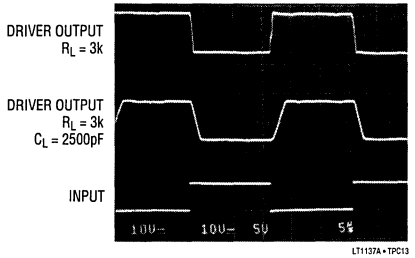
LT1137A • TPC11

SHUTDOWN to Driver Output



LT1137A • TPC12

Driver Output Waveforms



LT1137A • TPC13

PIN FUNCTIONS

V_{CC}: 5V Input Supply Pin. Supply current drops to zero in the SHUTDOWN mode. This pin should be decoupled with a 0.1µF ceramic capacitor close to the package pin. Insufficient supply bypassing can result in low output drive levels and erratic charge pump operation.

GND: Ground Pin.

ON/$\overline{OFF}$: Control the operation mode of the device and is TTL/CMOS compatible. A logic low puts the device in the SHUTDOWN mode which reduces input supply curent to zero and places all of the drivers and receivers in high impedance state. A logic high fully enables the transceiver.

DRIVER DISABLE: This pin provides an alternate control for the charge pump and RS232 drivers. A logic high on this pin shuts down the charge pump and places all drivers in a high impedance state. Receivers remain active under these conditions. Floating the driver disable pin or driving it to a logic low level fully enables the transceiver. A logic low on the ON/$\overline{OFF}$ pin supersedes the state of the Driver Disable pin. Supply current drops to 4mA when in DRIVER DISABLE mode.

V^+: Positive Supply Output (RS232 Drivers). $V^+ \approx 2V_{CC} - 1.5V$. This pin requires an external charge storage capacitor $C \geq 1.0\mu F$, tied to ground or V_{CC}. Larger value capacitors may be used to reduce supply ripple. With multiple transceivers, the V^+ and V^- pins may be paralleled into common capacitors. For large numbers of transceivers, increasing the size of the shared common storage capacitors is recommended to reduce ripple.

PIN FUNCTIONS

V^-: Negative Supply Output (RS232 Drivers). $V^- \approx -(2V_{CC} - 2.5V)$. This pin requires an external charge storage capacitor $C \geq 0.1\mu F$. V^- is short-circuit proof for 30 seconds.

$C1^+$, $C1^-$, $C2^+$, $C2^-$: Commutating Capacitor Inputs. These pins require two external capacitors $C \geq 0.2\mu F$: one from $C1^+$ to $C1^-$, and another from $C2^+$ to $C2^-$. To maintain charge pump efficiency, the capacitor's effective series resistance should be less than 2Ω. For $C \geq 1\mu F$, low ESR tantalum capacitors work well in this application, although small value ceramic capacitors may be used with a minimal reduction in charge pump compliance. In applications where larger positive voltages are available, such as 12V, C1 may be omitted and the positive voltage may be connected directly to the $C1^+$ pin. In this mode of operation, the V^+ pin should be decoupled with a $0.1\mu F$ ceramic capacitor.

DRIVER IN: RS232 Driver Input Pins. These inputs are TTL/CMOS compatible. Inputs should not be allowed to float. Tie unused inputs to V_{CC}.

DRIVER OUT: Driver Outputs at RS232 Voltage Levels. Driver output swing meets RS232 levels for loads up to 3k. Slew rates are controlled for lightly loaded lines. Output current capability is sufficient for load conditions up to 2500pF. Outputs are in a high impedance state when in SHUTDOWN mode, V_{CC} = 0V, or when the driver disable pin is active. Outputs are fully short-circuit protected from V^- + 30V to V^+ – 30V. Applying higher voltages will not damage the device if the overdrive is moderately current limited. Short circuits on one output can load the power supply generator and may disrupt the signal levels of the other outputs. The driver outputs are protected against ESD to ±10kV for human body model discharges.

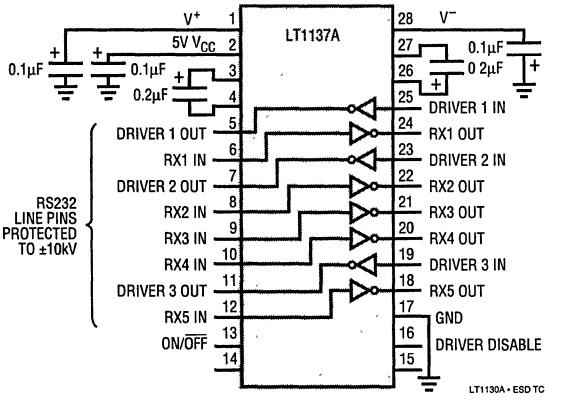
RX IN: Receiver Inputs. These pins accept RS232 level signals (±30V) into a protected 5k terminating resistor. The receiver inputs are protected against ESD to ±10kV for human body model discharges. Each receiver provides 0.4V of hysteresis for noise immunity. Open receiver inputs assume a logic low state.

RX OUT: Receiver Outputs with TTL/CMOS Voltage Levels. Outputs are in a high impedance state when in SHUTDOWN mode to allow data line sharing. Outputs are fully short-circuit protected to ground or V_{CC} with the power on, off, or in SHUTDOWN mode.

ESD PROTECTION

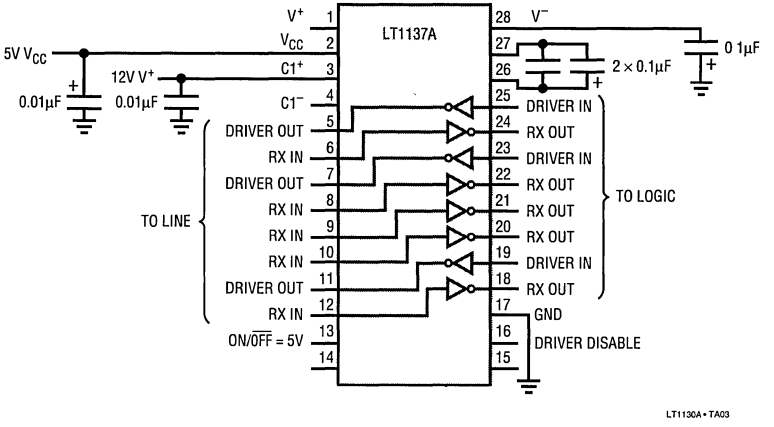
The RS232 line inputs of the LT1130A/LT1140A series of RS232 Driver/Receivers have on-chip protection from ESD transients up to ±10kV. The protection structures act to divert the static discharge safely to system ground. In order for the ESD protection to function effectively, the power supply and ground pins of the LT1130A/LT1140A must be connected to ground through low impedances. The power supply decoupling capacitors and charge pump storage capacitors provide this low impedance in normal application of the circuit. The only constraint is that low ESR capacitors must be used for bypassing and charge storage. ESD testing must be done with pins V_{CC}, V^+, V^- and GND shorted to ground or connected with low ESR capacitors.

ESD Test Circuit

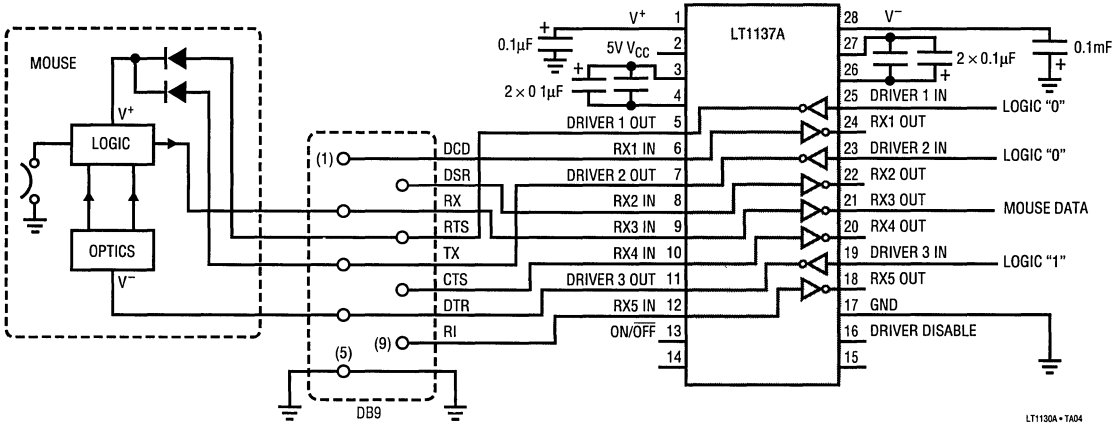


TYPICAL APPLICATIONS

Operation Using 5V and 12V Power Supplies

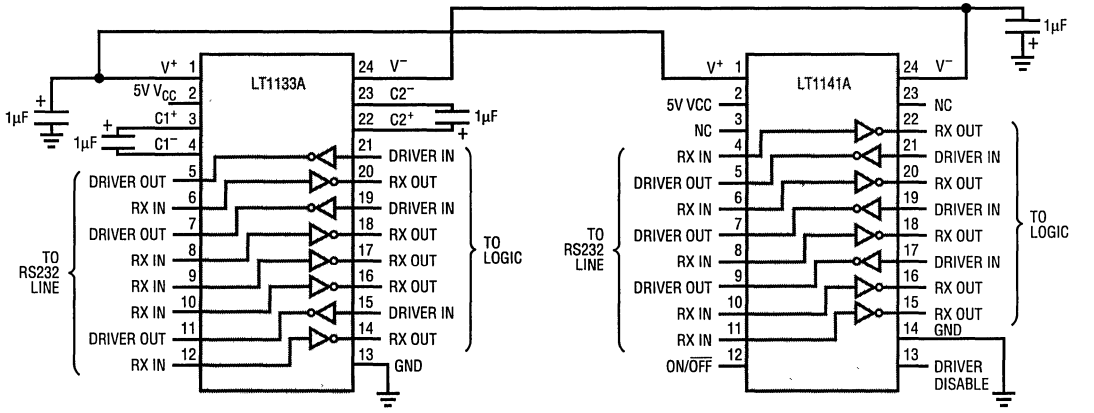


Typical Mouse Driving Application



TYPICAL APPLICATIONS

Sharing Power Supply Generator with a Second Transceiver



Advanced Low Power 5V RS232 Transceiver with Small Capacitors

FEATURES

- ESD Protection over ±**10kV**
- Uses Small Capacitors: 0.1µF, 0.2µF
- 1µA Supply Current in SHUTDOWN
- Pin Compatible with LT1137
- Operates to 120k Baud
- CMOS Comparable Low Power: 60mW
- Operates from a Single 5V Supply
- Easy PC Layout: Flowthrough Architecture
- Rugged Bipolar Design
- Outputs Assume a High Impedance State When Off or Powered Down
- Improved Protection: RS232 I/O Lines Can Be Forced to ±30V without Damage
- Output Overvoltage Does Not Force Current Back into Supplies
- Absolutely No Latch-up
- Available in SO and SSOP Packages

APPLICATIONS

- Notebook Computers
- Palmtop Computers

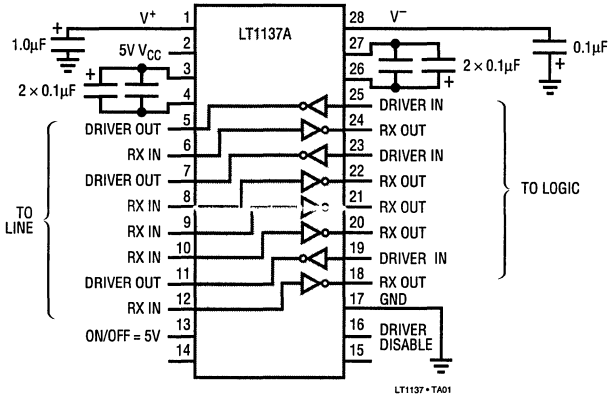
DESCRIPTION

The LT1137A is a three-driver, five-receiver RS232 transceiver, pin compatible with the LT1137, offering performance improvements and two SHUTDOWN modes. The LT1137A's charge pump is designed for extended compliance, and can deliver over 40mA of load current. Supply current is typically 12mA, competitive with similar CMOS devices. An advanced driver output stage operates up to 120k baud while driving heavy capacitive loads.

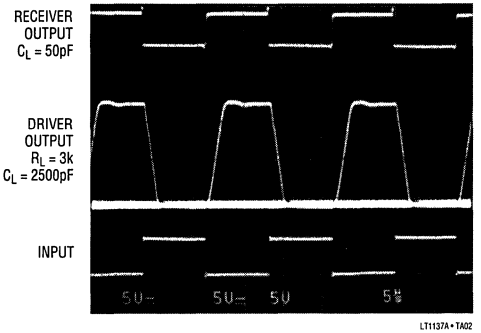
The LT1137A is fully compliant with all EIA-RS232 specifications. Special bipolar construction techniques protect the drivers and receivers beyond the fault conditions stipulated for RS232. Driver outputs and receiver inputs can be shorted to ±30V without damaging the device or the power supply generator. In addition, the RS232 I/O pins are resilient to multiple ±10kV ESD strikes.

The transceiver has two SHUTDOWN modes. One mode disables the drivers and the charge pump, the other shuts down all circuitry. While shut down, the drivers and receivers assume high impedance output states.

TYPICAL APPLICATION



Output Waveforms

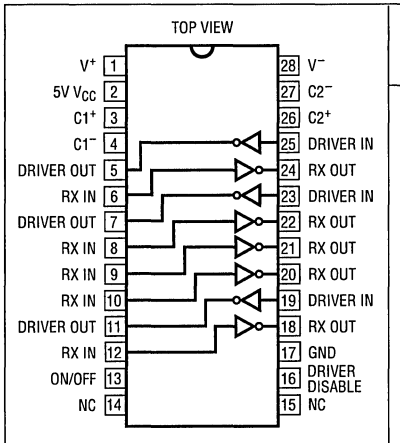


ABSOLUTE MAXIMUM RATINGS

(Note 1)

Supply Voltage (V_{CC}) 6V
V^+ 13.2V
V^- ..... –13.2V
Input Voltage
  Driver ..... V^- to V^+
  Receiver ..... –30V to 30V
Output Voltage
  Driver ..... –30V to 30V
  Receiver ..... –0.3V to V_{CC} + 0.3V
Short Circuit Duration
  V^+ ..... 30 sec
  V^- ..... 30 sec
  Driver Output ..... Indefinite
  Receiver Output ..... Indefinite
Operating Temperature Range
  LT1137AC ..... 0°C to 70°C
Storage Temperature Range ..... –65°C to 150°C
Lead Temperature (Soldering, 10 sec) ..... 300°C

PACKAGE/ORDER INFORMATION



N PACKAGE
28-LEAD PLASTIC DIP

S PACKAGE
28-LEAD SOL

G PACKAGE
28-LEAD SSOP

T_{JMAX} = 150°C, θ_{JA} = 56°C/W (N)
T_{JMAX} = 150°C, θ_{JA} = 85°C/W (S)
T_{JMAX} = 150°C, θ_{JA} = 96°C/W (G)

ORDER PART NUMBER

LT1137ACN
LT1137ACS
LT1137ACG

ELECTRICAL CHARACTERISTICS (Note 2)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Power Supply Generator						
V^+ Output				8.6		V
V^- Output				–7.8		V
Supply Current (V_{CC})	(Note 3)	O		12	17	mA
Supply Current When OFF (V_{CC})	SHUTDOWN (Note 4) DRIVER DISABLE	O		1 4	10	µA mA
Supply Rise Time SHUTDOWN to Turn-On	C1, C2, C^+, C^- = 1µF, C^+, C^- = 0.1µF, C1, C2 = 0.2µF			2.0 0.2		ms ms
ON/OFF Pin Thresholds	Input Low Level (Device SHUTDOWN) Input High Level (Device Enabled)	O O	 2.4	1.4 1.4	0.8	V V
ON/OFF Pin Current	$0V \le V_{ON/OFF} \le 5V$	O	–15		80	µA
Driver Disable Pin Thresholds	Input Low Level (Drivers Enabled) Input High Level (Drivers Disabled)	O O	 2.4	1.4 1.4	0.8	V V
Driver Disable Pin Current	$0V \le V_{DRIVER\ DISABLE} \le 5V$	O	–10		500	µA
Oscillator Frequency				130		kHz

ELECTRICAL CHARACTERISTICS (Note 2)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Any Driver						
Output Voltage Swing	Load = 3k to GND	Positive o	5.0	7.5		V
		Negative o		−6.3	−5.0	V
Logic Input Voltage Level	Input Low Level (V_{OUT} = High)	o		1.4	0.8	V
	Input High Level (V_{OUT} = Low)	o	2.0	1.4		V
Logic Input Current	$0.8V \le V_{IN} \le 2V$	o		5	20	µA
Output Short-Circuit Current	V_{OUT} = 0V			±17		mA
Output Leakage Current	SHUTDOWN V_{OUT} = ±25V (Note 4)	o		10	100	µA
Slew Rate	R_L = 3k, C_L = 51pF			15	30	V/µs
	R_L = 3k, C_L = 2500pF		4	15		V/µs
Propagation Delay	Output Transition t_{HL} High to Low (Note 5)			0.6	1.3	µs
	Output Transition t_{LH} Low to High			0.5	1.3	µs
Any Receiver						
Input Voltage Thresholds	Input Low Threshold (V_{OUT} = High)	o	0.8	1.3		V
	Input High Threshold (V_{OUT} = Low)	o		1.7	2.4	V
Hysteresis		o	0.1	0.4	1.0	V
Input Resistance			3	5	7	kΩ
Output Voltage	Output Low, I_{OUT} = −1.6mA	o		0.2	0.4	V
	Output High, I_{OUT} = 160µA (V_{CC} = 5V)	o	3.5	4.2		V
Output Leakage Current	SHUTDOWN (Note 4) $0 \le V_{OUT} \le V_{CC}$	o		1	10	µA
Output Short-Circuit Current	Sinking Current, $V_{OUT} = V_{CC}$			−20	−10	mA
	Sourcing Current, V_{OUT} = 0V		10	20		mA
Propagation Delay	Output Transition t_{HL} High to Low (Note 6)			250	600	ns
	Output Transition t_{LH} Low to High			350	600	ns

The o denotes specifications which apply over the operating temperature range ($0°C \le T_A \le 70°C$ for commercial grade, and $-40°C \le T_A \le 85°C$ for industrial grade).

Note 1: Absolute Maximum Ratings are those values beyond which the life of the device may be impaired.

Note 2: Testing done at V_{CC} = 5V and $V_{ON/OFF}$ = 3V.

Note 3: Supply current is measured with driver and receiver outputs unloaded and the driver inputs tied high.

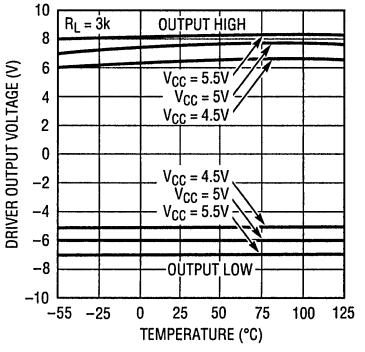
Note 4: Supply current and leakage current measurements in SHUTDOWN are performed with $V_{ON/OFF}$ = 0.1V. Supply current measurements using DRIVER DISABLE are performed with $V_{DRIVER\ DISABLE}$ = 3V.

Note 5: For driver delay measurements, R_L = 3k and C_L = 51pF. Trigger points are set between the driver's input logic threshold and the output transition to the zero crossing (t_{HL} = 1.4V to 0V and t_{LH} = 1.4V to 0V).

Note 6: For receiver delay measurements, C_L = 51pF. Trigger points are set between the receiver's input logic threshold and the output transition to standard TTL/CMOS logic threshold (t_{HL} = 1.3V to 2.4V and t_{LH} = 1.7V to 0.8V).

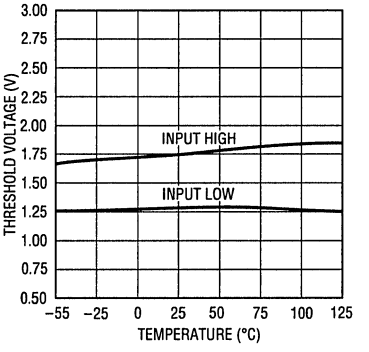
TYPICAL PERFORMANCE CHARACTERISTICS

Driver Output Voltage



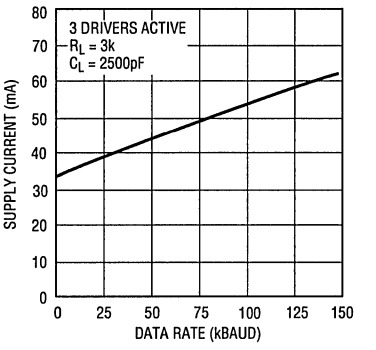
LT1137A • TPC01

Receiver Input Thresholds



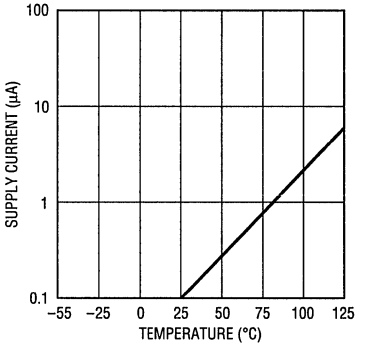
LT1137A • TPC02

Supply Current vs Data Rate



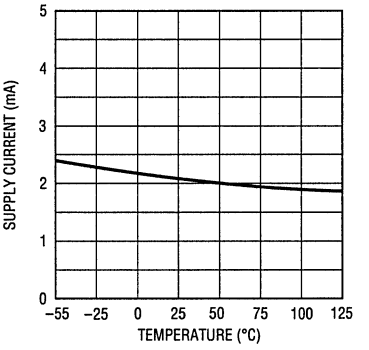
LT1137A • TPC03

Supply Current in SHUTDOWN



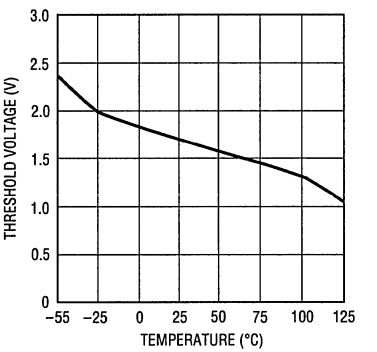
LT1137A • TPC04

Supply Current in DRIVER DISABLE



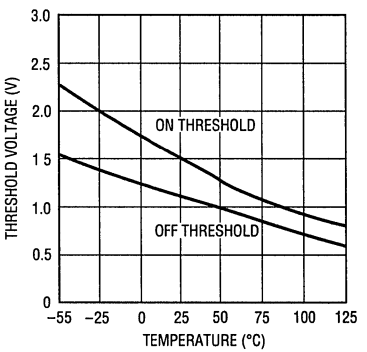
LT1137A • TPC05

Driver Disable Threshold



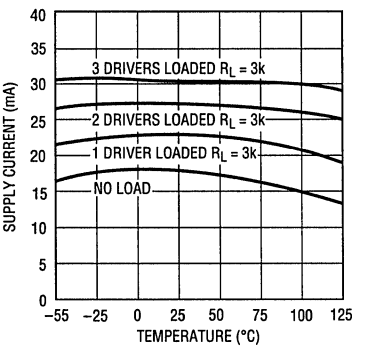
LT1137A • TPC06

On/Off Thresholds



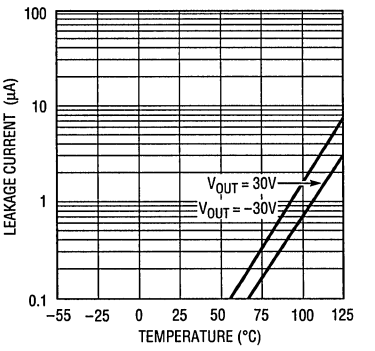
LT1137A • TPC07

Supply Current



LT1137A • TPC08

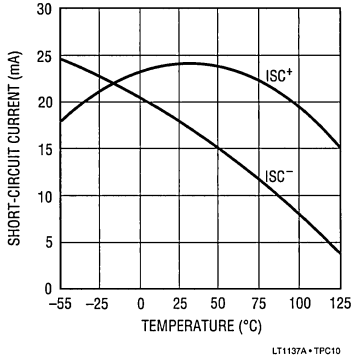
Driver Leakage in SHUTDOWN



LT1137A • TPC09

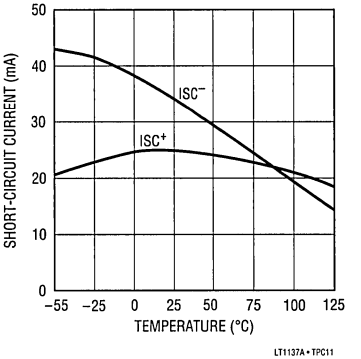
TYPICAL PERFORMANCE CHARACTERISTICS

Driver Short-Circuit Current



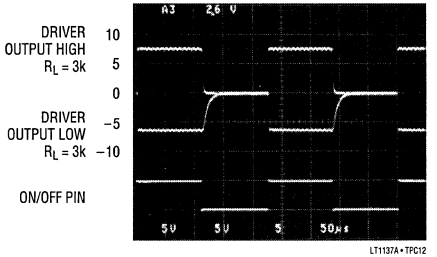
LT1137A • TPC10

Receiver Short-Circuit Current



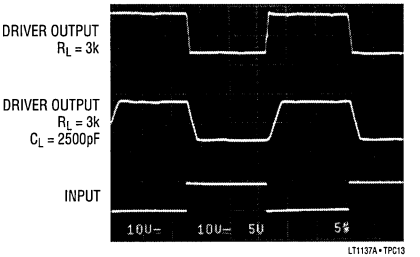
LT1137A • TPC11

SHUTDOWN to Driver Output



LT1137A • TPC12

Driver Output Waveforms



LT1137A • TPC13

PIN FUNCTIONS

V_{CC}: 5V Input Supply Pin. Supply current drops to zero in the SHUTDOWN mode. This pin should be decoupled with a 0.1µF ceramic capacitor close to the package pin. Insufficient supply bypassing can result in low output drive levels and erratic charge pump operation.

GND: Ground Pin.

ON/OFF: TTL/CMOS Compatible Operating Mode Control. A logic low puts the device in the SHUTDOWN mode which reduces input supply current to zero and places all of the drivers and receivers in high impedance state. A logic high fully enables the transceiver.

DRIVER DISABLE: This pin provides an alternate control for the charge pump and RS232 drivers. A logic high on this pin shuts down the charge pump and places all drivers in a high impedance state. Receivers remain active under these conditions. Floating the driver disable pin or driving it to a logic low level fully enables the transceiver. A logic low on the On/Off pin supersedes the state of the Driver Disable pin. Supply current drops to 4mA when in DRIVER DISABLE mode.

V^+: Positive Supply Output (RS232 Drivers). $V^+ \approx 2V_{CC} - 1.5V$. This pin requires an external charge storage capacitor $C \geq 0.1\mu F$, tied to ground or V_{CC}. Larger value capacitors may be used to reduce supply ripple. With multiple transceivers, the V^+ and V^- pins may be paralleled into common capacitors. For large numbers of transceivers, increasing the size of the shared common storage capacitors is recommended to reduce ripple.

PIN FUNCTIONS

V^-: Negative Supply Output (RS232 Drivers). $V^- \approx -(2V_{CC} - 2.5V)$. This pin requires an external charge storage capacitor $C \geq 0.1\mu F$. V^- is short-circuit proof for 30 seconds.

$C1^+$, $C1^-$, $C2^+$, $C2^-$: Commutating Capacitor Inputs. These pins require two external capacitors $C \geq 0.2\mu F$: one from $C1^+$ to $C1^-$, and another from $C2^+$ to $C2^-$. To maintain charge pump efficiency, the capacitor's effective series resistance should be less than 2Ω. For $C \geq 1\mu F$, low ESR tantalum capacitors work well in this application, although small value ceramic capacitors may be used with a minimal reduction in charge pump compliance. In applications where larger positive voltages are available, such as 12V, C1 may be omitted and the positive voltage may be connected directly to the $C1^+$ pin. In this mode of operation, the V^+ pin should be decoupled with a 0.1μF ceramic capacitor.

DRIVER IN: RS232 Driver Input Pins. These inputs are TTL/CMOS compatible. Inputs should not be allowed to float. Tie unused inputs to V_{CC}.

DRIVER OUT: Driver Outputs at RS232 Voltage Levels. Driver output swing meets RS232 levels for loads up to 3k. Slew rates are controlled for lightly loaded lines. Output current capability is sufficient for load conditions up to 2500pF. Outputs are in a high impedance state when in SHUTDOWN mode, V_{CC} = 0V, or when the driver disable pin is active. Outputs are fully short-circuit protected from V^- + 30V to V^+ – 30V. Applying higher voltages will not damage the device if the overdrive is moderately current limited. Short circuits on one output can load the power supply generator and may disrupt the signal levels of the other outputs. The driver outputs are protected against ESD to ±10kV for human body model discharges.

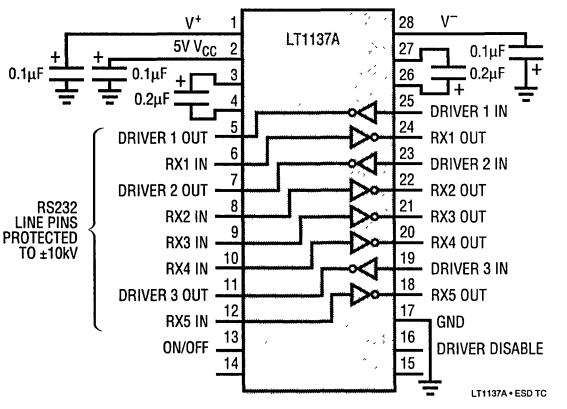
RX IN: Receiver Inputs. These pins accept RS232 level signals (±30V) into a protected 5k terminating resistor. The receiver inputs are protected against ESD to ±10kV for human body model discharges. Each receiver provides 0.4V of hysteresis for noise immunity. Open receiver inputs assume a logic low state.

RX OUT: Receiver Outputs with TTL/CMOS Voltage Levels. Outputs are in a high impedance state when in SHUTDOWN mode to allow data line sharing. Outputs are fully short-circuit protected to ground or V_{CC} with the power on, off, or in SHUTDOWN mode.

ESD PROTECTION

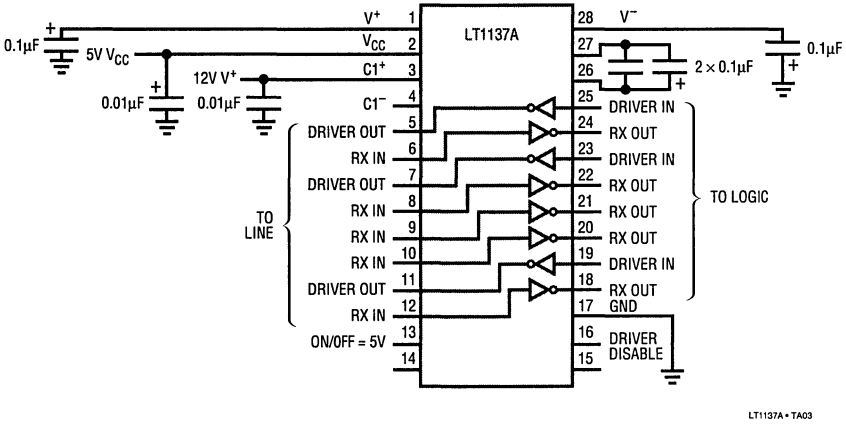
The RS232 line inputs of the LT1137A have on-chip protection from ESD transients up to ±10kV. The protection structures act to divert the static discharge safely to system ground. In order for the ESD protection to function effectively, the power supply and ground pins of the LT1137A must be connected to ground through low impedances. The power supply decoupling capacitors and charge pump storage capacitors provide this low impedance in normal application of the circuit. The only constraint is that low ESR capacitors must be used for bypassing and charge storage. ESD testing must be done with pins V_{CC}, V^+, V^- and GND shorted to ground or connected with low ESR capacitors.

ESD Test Circuit

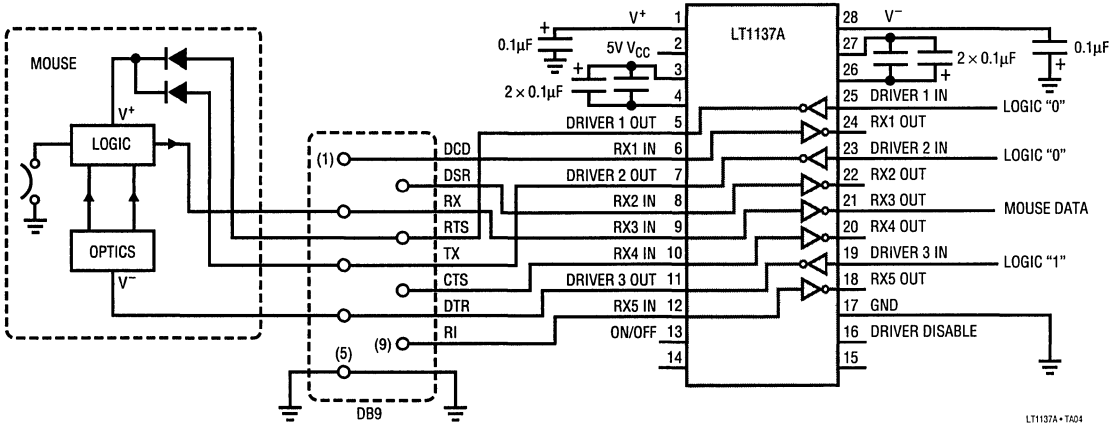


TYPICAL APPLICATIONS

Operation Using 5V and 12V Power Supplies



Typical Mouse Driving Application



LTC1145/LTC1146

Low Power Digital Isolator

February 1993

FEATURES

- Greater Than 2500V Isolation
- Higher Voltage Options Available
- Low Input Current
  - LTC1145: 600µA
  - LTC1146: 60µA
- Maximum Input Frequency
  - LTC1145: 200kbps
  - LTC1146: 20kbps
- TTL Level Output
- Noise Filter Prevents Glitches at the Output
- Output Can Be Synchronized to an External Clock

APPLICATIONS

- Low Power Opto-Isolator Replacement
- Isolated Serial Data Interfaces
- Isolated Power MOSFET Drivers

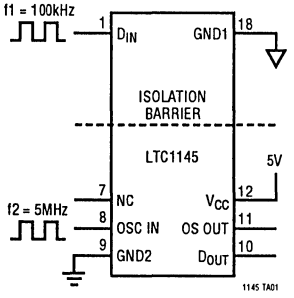
DESCRIPTION

The LTC1145/LTC1146 provide 2500V of input to output isolation for TTL digital/CMOS signals. But unlike opto-isolators, the input current is a mere 60µA for the LTC1146 which can handle frequencies up to 20kbps. The faster LTC1145 will handle frequencies up to 200kbps while only drawing 600µA.

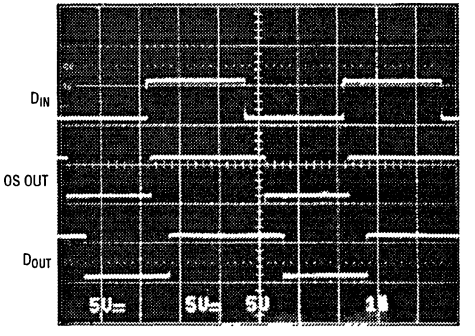
The output signal is in phase with the input, and swings between GND2 and V_{CC} providing a TTL/CMOS compatible signal without any pull-up resistors. An on-chip noise filter helps prevent glitches and data errors at the output, and a pin is provided for synchronizing the output signal to an external system clock.

TYPICAL APPLICATION

Digital Isolation Interface
Data Rate Up to 200kbps



LTC1145 Typical Waveforms



OS OUT AND D_{OUT} LOADED WITH 15pF SCOPE PROBE
f1 AND f2 SYNCHRONIZED FOR PHOTO

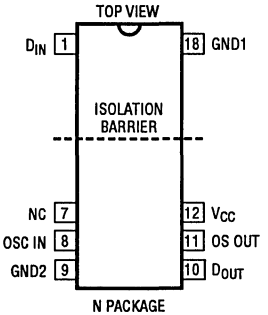
1145/6 TA02

ABSOLUTE MAXIMUM RATINGS

Supply Voltage 12V
Input Voltage
D_{IN} ..... 12V to (GND1 – 0.3V)
OSC IN ..... (V_S + 0.3V) to (GND2 – 0.3V)
Output Voltage
OS OUT, D_{OUT} ..... (V_S + 0.3V) to (GND2 – 0.3V)

Operating Temperature Range ..... –40°C to 85°C
Storage Temperature Range ..... –65°C to 150°C
Lead Temperature (Soldering, 10 sec) ..... 300°C

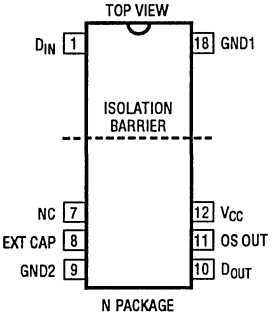
PACKAGE/ORDER INFORMATION



N PACKAGE
18-LEAD PLASTIC DIP

ORDER PART NUMBER

LTC1145CN
LTC1145IN



N PACKAGE
18-LEAD PLASTIC DIP

ORDER PART NUMBER

LTC1146CN
LTC1146IN

ELECTRICAL CHARACTERISTICS

V_{CC} = 4.5V to 5.5V, T_A = 25°C, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
LTC1145						
V_{OL}	Output Low Voltage	OS OUT, D_{OUT} at 4mA			0.4	V
V_{OH}	Output High Voltage	OS OUT, D_{OUT} at 4mA	3.5			V
V_{IL}	Input Low Voltage	OSC IN			0.8	V
V_{IH}	Input High Voltage	OSC IN	2.4			V
I_{IN}	Input Current	OSC IN			10	µA
		D_{IN} at 3V		400		µA
		D_{IN} at 5V		600		µA
		D_{IN} at 10V		900		µA
I_{CC}	Supply Current	V_{CC} = 5V, OSC IN at 0V		2		mA
t_{PLH1}	D_{IN} to OS OUT Low to High	C_L = 15pF		100		ns
t_{PHL1}	D_{IN} to OS OUT High to Low	C_L = 15pF		600		ns
t_{PLH2}	D_{IN} to D_{OUT} Low to High	C_L = 15pF		600		ns
t_{PHL2}	D_{IN} to D_{OUT} High to Low	C_L = 15pF		1.2		µs
SR	Input Signal Slew Rate	D_{IN}	1		500	V/µs
T_{CM}	Common-Mode Slew	D_{IN} = GND1 Connected to V_{CM}			1000	V/µs
V_{INH}	Input High Voltage	D_{IN}	3			V
V_{INL}	Input Low Voltage	D_{IN}			1	V

ELECTRICAL CHARACTERISTICS

V_{CC} = 4.5V to 5.5V, T_A = 25°C, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
LTC1146						
V_{OL}	Output Low Voltage	OS OUT, D_{OUT} at 4mA			0.4	V
V_{OH}	Output High Voltage	OS OUT, D_{OUT} at 4mA	3.5			V
V_{IL}	Input Low Voltage	D_{IN}			0.8	V
V_{IH}	Input High Voltage	D_{IN}	3			V
I_{IN}	Input Current	D_{IN} at 3V D_{IN} at 5V D_{IN} at 10V		40 60 100		µA µA µA
I_{CC}	Supply Current	V_{CC} = 5V		2		mA
t_{PLH1}	D_{IN} to OS OUT Low to High	C_L = 15pF		100		ns
t_{PHL1}	D_{IN} to OS OUT High to Low	C_L = 15pV		6		µs
t_{PLH2}	D_{IN} to D_{OUT} Low to High	C_L = 15pF, C_{EXT} = 50pF		4		µs
t_{PHL2}	D_{IN} to D_{OUT} High to Low	C_L = 15pF, C_{EXT} = 50pF		10		µs
SR	Input Signal Slew Rate	D_{IN}	1		500	V/µs
T_{CM}	Common-Mode Slew	D_{IN} = GND1 Connected to V_{CM}			1000	V/µs

PIN FUNCTIONS

Pin 1 (D_{IN}): Data Input.

Pin 7 (NC): Not Connected.

Pin 8 (LTC1145) (OSC IN): External Frequency Input. The signal on this pin overrides the internal oscillator frequency.

Pin 8 (LTC1146) (C_{EXT}): External Capacitor. Connecting a capacitor at this pin allows the internal oscillator frequency to be slowed down.

Pin 9 (GND2): The Gground Connection of the Receiver Die.

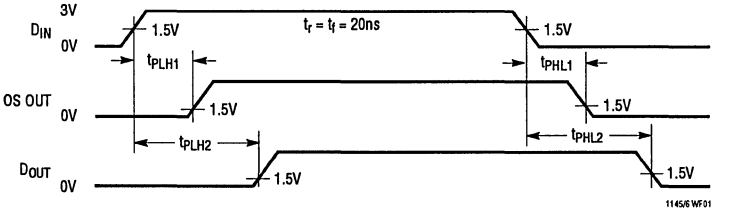
Pin 10 (D_{OUT}): Data Output. The output signal has gone through the internal filter. The output level is TTL compatible.

Pin 11 (OS OUT): One-Shot Output. The output signal that does not go through the internal filter. The output level is TTL compatible.

Pin 12 (V_{CC}): Positive Supply of the Receiver Die, 4.5V < V_{CC} < 5.5V.

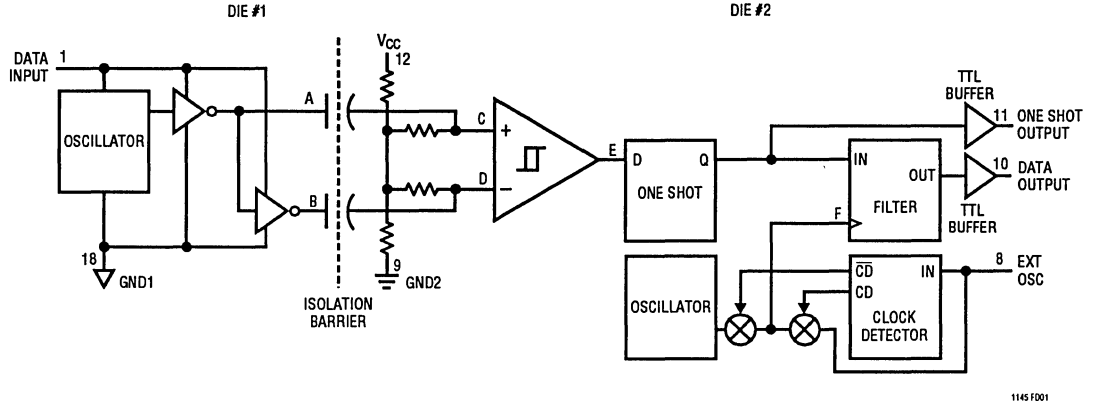
Pin 18 (GND1): The Ground Connection of the Driver Die.

SWITCHING TIME WAVEFORMS

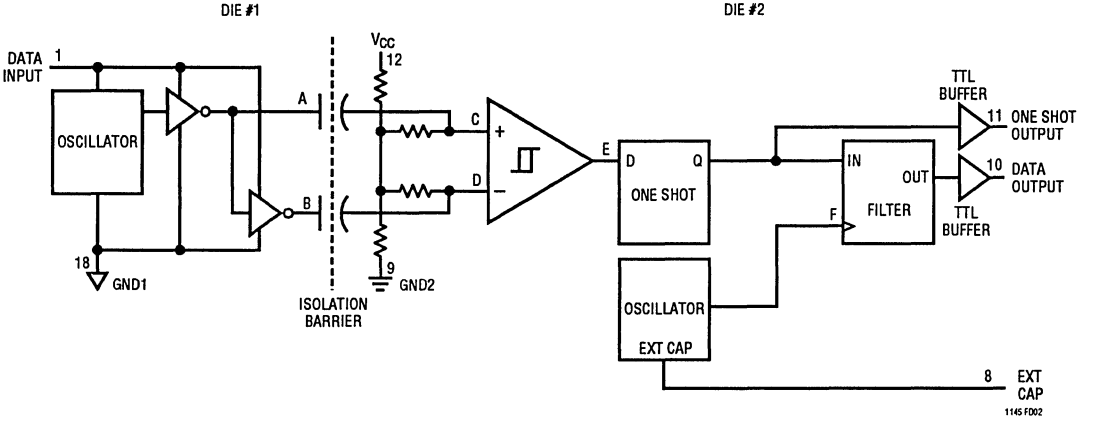


FUNCTIONAL DIAGRAMS

LTC1145



LTC1146



Low Power 5V RS232 Dual Driver/Receiver with 0.1µF Capacitors

FEATURES

- ESD Protection over ±**10kV**
- Uses Small Capacitors: 0.1µF
- Operates to 120k Baud
- Outputs Withstand ±30V Without Damage
- CMOS Comparable Low Power: 40mW
- Operates from a Single 5V Supply
- Rugged Bipolar Design
- Outputs Assume a High Impedance State When Off or Powered Down
- Meets All RS232 Specifications
- Available With or Without Shutdown
- Absolutely No Latch-up
- Available in SO Package

APPLICATIONS

- Portable Computers
- Battery-Powered Systems
- Power Supply Generator
- Terminals
- Modems

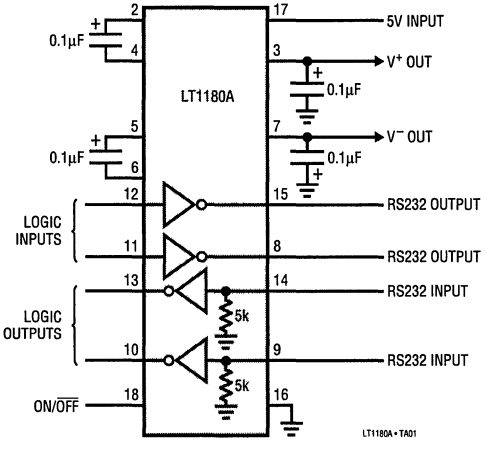
DESCRIPTION

The LT1180A/LT1181A are dual RS232 driver/receiver pairs with integral charge pump to generate RS232 voltage levels from a single 5V supply. These circuits feature rugged bipolar design to provide operating fault tolerance and ESD protection unmatched by competing CMOS designs. Using only 0.1µF external capacitors, these circuits consume only 40mW of power, and can operate to 120k baud even while driving heavy capacitive loads. New ESD structures on the chip allow the LT1180A/LT1181A to survive multiple ±10kV strikes, eliminating the need for costly TransZorbs® on the RS232 line pins. The LT1180A/LT1181A are fully compliant with EIA RS232 standards. Driver outputs are protected from overload, and can be shorted to ground or up to ±30V without damage. During SHUTDOWN or power-off conditions, driver and receiver outputs are in a high impedance state, allowing line sharing.

The LT1181A is available in 16-pin DIP and SO packages. The LT1180A is supplied in 18-pin DIP and SO packages for applications which require SHUTDOWN.

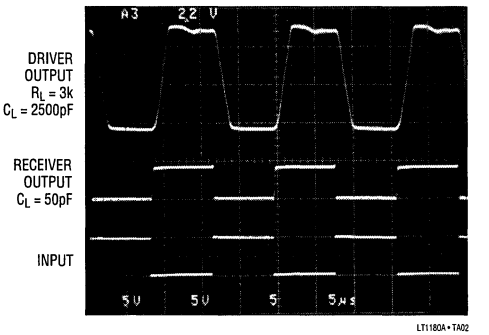
TransZorb is a registered trademark of General Instruments, GSI

TYPICAL APPLICATION



LT1180A • TA01

Output Waveforms



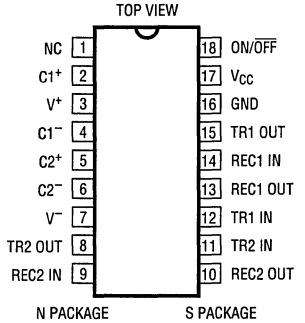
LT1180A • TA02

ABSOLUTE MAXIMUM RATINGS

Supply Voltage (V_{CC}) 6V
V^+ 13.2V
V^- ..... −13.2V
Input Voltage
  Driver ..... V^- to V^+
  Receiver ..... −30V to 30V
  ON/$\overline{OFF}$ ..... −0.3V to 12V
Output Voltage
  Driver ..... V^+ − 30V to V^- + 30V
  Receiver ..... −0.3V to V_{CC} + 0.3V

Short-Circuit Duration
  V^+ ..... 30 sec
  V^- ..... 30 sec
  Driver Output ..... Indefinite
  Receiver Output ..... Indefinite
Operating Temperature Range
  LT1180AI/LT1181AI ..... −40°C to 85°C
  LT1180AC/LT1181AC ..... 0°C to 70°C
Storage Temperature Range ..... −65°C to 150°C
Lead Temperature (Soldering, 10 sec) ..... 300°C

PACKAGE/ORDER INFORMATION

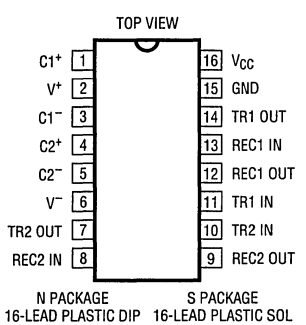


N PACKAGE 18-LEAD PLASTIC DIP
S PACKAGE 18-LEAD PLASTIC SOL

T_{JMAX} = 125°C, θ_{JA} = 80°C/W, θ_{JC} = 36°C/W (N)
T_{JMAX} = 125°C, θ_{JA} = 90°C/W, θ_{JC} = 26°C/W (S)

ORDER PART NUMBER

LT1180AIN
LT1180ACN
LT1180ACS



N PACKAGE 16-LEAD PLASTIC DIP
S PACKAGE 16-LEAD PLASTIC SOL

T_{JMAX} = 125°C, θ_{JA} = 90°C/W, θ_{JC} = 46°C/W (N)
T_{JMAX} = 125°C, θ_{JA} = 95°C/W, θ_{JC} = 27°C/W (S)

ORDER PART NUMBER

LT1181AIN
LT1181ACN
LT1181ACS

ELECTRICAL CHARACTERISTICS (Note 2)

PARAMETER	CONDITIONS			MIN	TYP	MAX	UNITS
Power Supply Generator							
V^+ Output					7.9		V
V^- Output					−7.0		V
Supply Current (V_{CC})	(Note 3), T_A = 25°C				9	13	mA
			O			16	mA
Supply Current When OFF (V_{CC})	SHUTDOWN (Note 4) LT1180A Only		O		1	10	µA
Supply Rise Time	C1 = C2 = C3 = C4 = 0.1µF				0.2		ms
SHUTDOWN to Turn-On	LT1180A Only				0.2		ms
ON/$\overline{OFF}$ Pin Thresholds	Input Low Level (Device SHUTDOWN)		O	0.8	1.2		V
	Input High Level (Device Enabled)		A		1.6	2.4	V
ON/$\overline{OFF}$ Pin Current	0V ≤ $V_{ON/\overline{OFF}}$ ≤ 5V		A	−15		80	µA
Oscillator Frequency					130		kHz
Driver							
Output Voltage Swing	Load = 3k to GND	Positive	A	5.0	7.5		V
		Negative	A		−6.3	−5.0	V

ELECTRICAL CHARACTERISTICS (Note 2)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Logic Input Voltage Level	Input Low Level (V_{OUT} = High) Input High Level (V_{OUT} = Low)	o o	 2.0	1.4 1.4	0.8	V V
Logic Input Current	$0.8V \le V_{IN} \le 2.0V$	o		5	20	µA
Output Short-Circuit Current	V_{OUT} = 0V			17		mA
Output Leakage Current	SHUTDOWN V_{OUT} = ±30V (Note 4)	o		10	100	µA
Slew Rate	R_L = 3k, C_L = 51pF R_L = 3k, C_L = 2500pF		 4	15 7	30	V/µs V/µs
Propagation Delay	Output Transition t_{HL} High-to-Low (Note 5) Output Transition t_{LH} Low-to-High			0.6 0.5	1.3 1.3	µs µs
Receiver						
Input Voltage Thresholds	Input Low Threshold (V_{OUT} = High) Input High Threshold (V_{OUT} = Low)		0.8	1.3 1.7	 2.4	V V
Hysteresis		o	0.1	0.4	1.0	V
Input Resistance			3	5	7	kΩ
Output Leakage Current	SHUTDOWN (Note 4) $0 \le V_{OUT} \le V_{CC}$	o		1	10	µA
Output Voltage	Output Low, I_{OUT} = −1.6mA Output High, I_{OUT} = 160µA (V_{CC} = 5V)	o o	 3.5	0.2 4.2	0.4	V V
Output Short-Circuit Current	Sinking Current, $V_{OUT} = V_{CC}$ Sourcing Current, V_{OUT} = 0V		 10	−20 20	−10	mA mA
Propagation Delay	Output Transition t_{HL} High-to-Low (Note 6) Output Transition t_{LH} Low-to-High			250 350	600 600	ns ns

The o denotes specifications which apply over the operating temperature range (0°C ≤ T_A ≤ 70°C for commercial grade, and −40°C ≤ T_A ≤ 85°C for industrial grade.

Note 1: Absolute Maximum Ratings are those values beyond which the life of the device may be impaired.

Note 2: Testing done at V_{CC} = 5V and $V_{ON/\overline{OFF}}$ = 3V, unless otherwise specified.

Note 3: Supply current is measured as the average over several charge pump cycles. $C^+ = C^- = C1 = C2 = 0.1\mu F$. All outputs are open, with all driver inputs tied high.

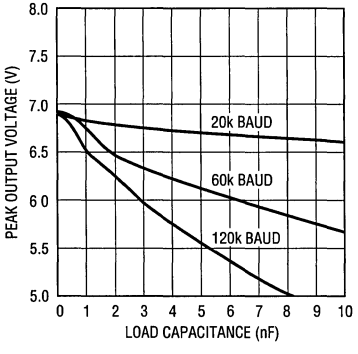
Note 4: Supply current measurements in SHUTDOWN are performed with $V_{ON/\overline{OFF}} \le 0.1V$.

Note 5: For driver delay measurements, R_L = 3k and C_L = 51pF. Trigger points are set between the driver's input logic threshold and the output transition to the zero crossing (t_{HL} = 1.4V to 0V and t_{LH} = 1.4V to 0V).

Note 6: For receiver delay measurements, C_L = 51pF. Trigger points are set between the receiver's input logic threshold and the output transition to standard TTL/CMOS logic threshold (t_{HL} = 1.3V to 2.4V and t_{LH} = 1.7V to 0.8V).

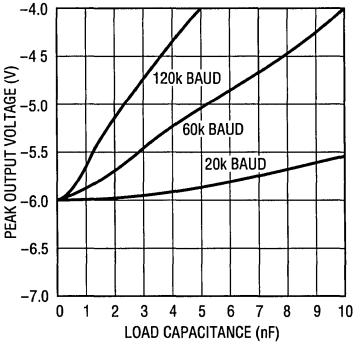
TYPICAL PERFORMANCE CHARACTERISTICS

Driver Maximum Output Voltage vs Load Capacitance



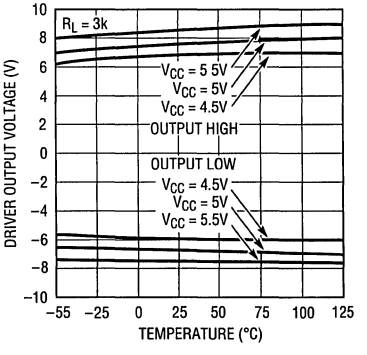
LT1180A • TPC01

Driver Minimum Output Voltage vs Load Capacitance



LT1180A • TPC02

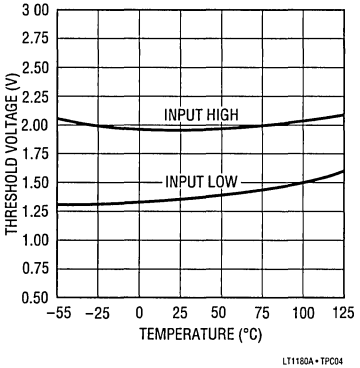
Driver Output Voltage



LT1180A • TPC03

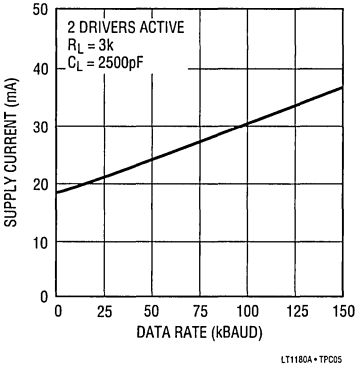
TYPICAL PERFORMANCE CHARACTERISTICS

Receiver Input Thresholds



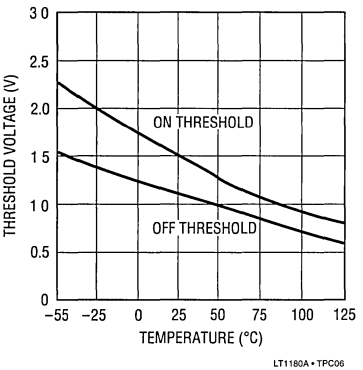
LT1180A • TPC04

Supply Current vs Data Rate



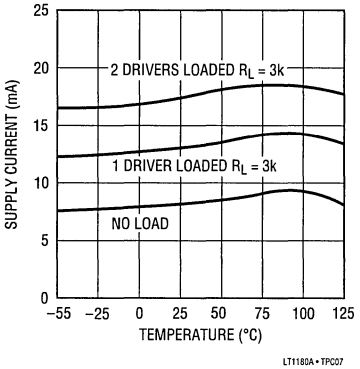
LT1180A • TPC05

ON/$\overline{\text{OFF}}$ Thresholds



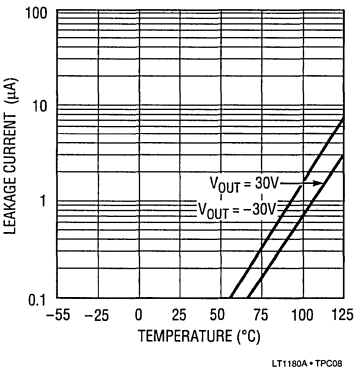
LT1180A • TPC06

Supply Current



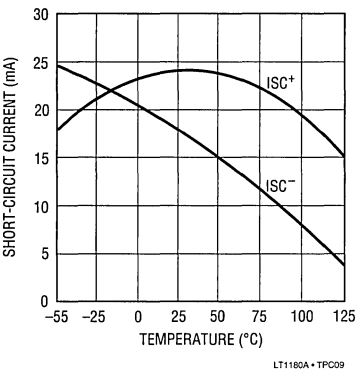
LT1180A • TPC07

Driver Leakage in Shutdown



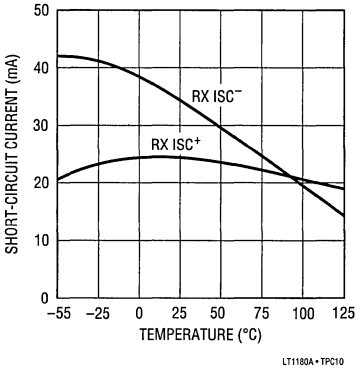
LT1180A • TPC08

Driver Short-Circuit Current



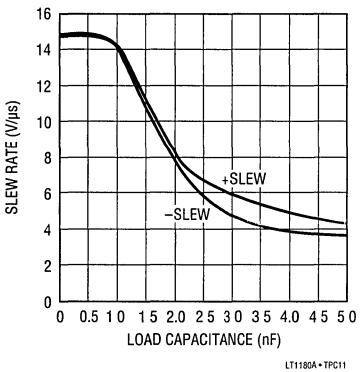
LT1180A • TPC09

Receiver Short-Circuit Current



LT1180A • TPC10

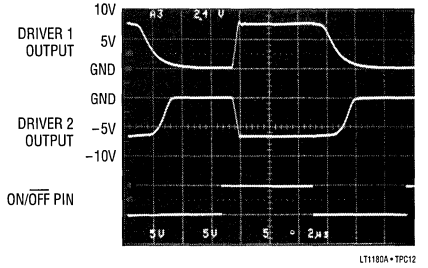
Slew Rate vs Load Capacitance



LT1180A • TPC11

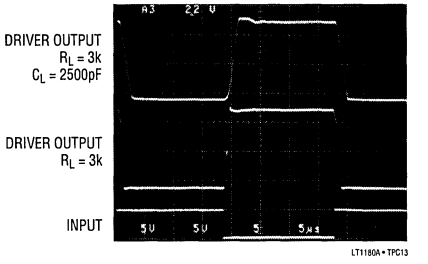
TYPICAL PERFORMANCE CHARACTERISTICS

Shutdown to Driver Outputs



LT1180A • TPC12

Driver Output Waveforms



LT1180A • TPC13

PIN FUNCTIONS

V_{CC}: 5V Input Supply Pin. This pin should be decoupled with a 0.1µF ceramic capacitor close to the package pin. Insufficient supply bypassing can result in low output drive levels and erratic charge pump operation.

GND: Ground Pin.

ON/$\overline{OFF}$: A TTL/CMOS Compatible Operating Mode Control. A logic low puts the LT1180A in SHUTDOWN mode. Supply current drops to zero and both driver and receiver outputs assume a high impedance state. A logic high fully enables the device.

V^+: Positive Supply Output (RS232 Drivers). $V^+ \approx 2V_{CC} - 1.5V$. This pin requires an external charge storage capacitor $C \geq 0.1\mu F$, tied to ground or V_{CC}. Larger value capacitors may be used to reduce supply ripple. With multiple transceivers, the V^+ and V^- pins may be paralleled into common capacitors.

V^-: Negative Supply Output (RS232 Drivers). $V^- \approx -(2V_{CC} - 2.5V)$. This pin requires an external charge storage capacitor $C \geq 0.1\mu F$. Larger value capacitors may be used to reduce supply ripple. With multiple transceivers, the V^+ and V^- pins may be paralleled into common capacitors.

TR1 IN, TR2 IN: RS232 Driver Input Pins. These inputs are TTL/CMOS compatible. Inputs should not be allowed to float. Tie unused inputs to V_{CC}.

TR1 OUT, TR2 OUT: Driver Outputs at RS232 Voltage Levels. Driver output swing meets RS232 levels for loads up to 3k. Slew rates are controlled for lightly loaded lines. Output current capability is sufficient for load conditions up to 2500pF. Outputs are in a high impedance state when in SHUTDOWN mode, V_{CC} = 0V, or when the driver disable pin is active. Outputs are fully short-circuit protected from V^- + 30V to V^+ – 30V. Applying higher voltages will not damage the device if the overdrive is moderately current limited. Short circuits on one output can load the power supply generator and may disrupt the signal levels of the other outputs. The driver outputs are protected against ESD to ±10kV for human body model discharges.

REC1 IN, REC2 IN: Receiver Inputs. These pins accept RS232 level signals (±30V) into a protected 5k terminating resistor. The receiver inputs are protected against ESD to ±10kV for human body model discharges. Each receiver provides 0.4V of hysteresis for noise immunity. Open receiver inputs assume a logic low state.

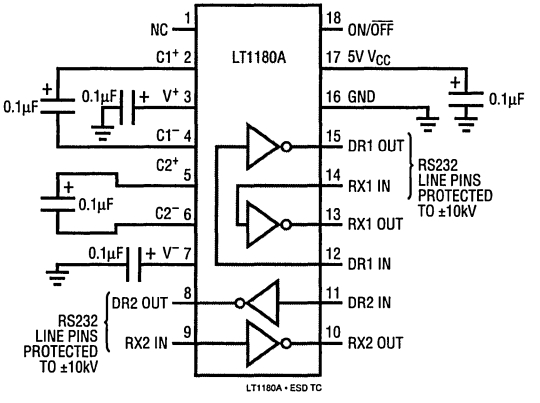
REC1 OUT, REC2 OUT: Receiver outputs with TTL/CMOS Voltage Levels. Outputs are in a high impedance state when in SHUTDOWN mode to allow data line sharing. Outputs are fully short-circuit protected to ground or V_{CC} with the power ON, OFF or in the SHUTDOWN mode.

$C1^+$, $C1^-$, $C2^+$, $C2^-$: Commutating Capacitor Inputs. These pins require two external capacitors $C \geq 0.1\mu F$: one from $C1^+$ to $C1^-$ and another from $C2^+$ to $C2^-$. C1 should be deleted if a separate 12V supply is available and connected to pin $C1^+$. Similarly, C2 should be deleted if a separate –12V supply is connected to pin V^-.

ESD PROTECTION

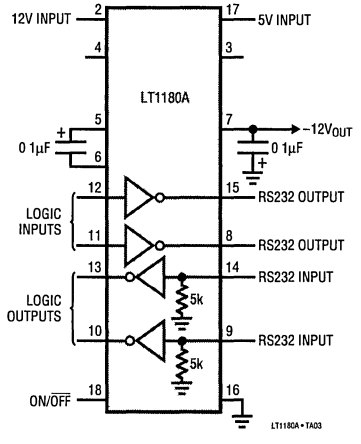
The RS232 line inputs of the LT1180A/LT1181A have on-chip protection from ESD transients up to ±10kV. The protection structures act to divert the static discharge safely to system ground. In order for the ESD protection to function effectively, the power supply and ground pins of the circuit must be connected to ground through low impedances. The power supply decoupling capacitors and charge pump storage capacitors provide this low impedance in normal application of the circuit. The only constraint is that low ESR capacitors must be used for bypassing and charge storage. ESD testing must be done with pins V_{CC}, V_L, V^+, V^-, and GND shorted to ground or connected with low ESR capacitors.

ESD Test Circuit

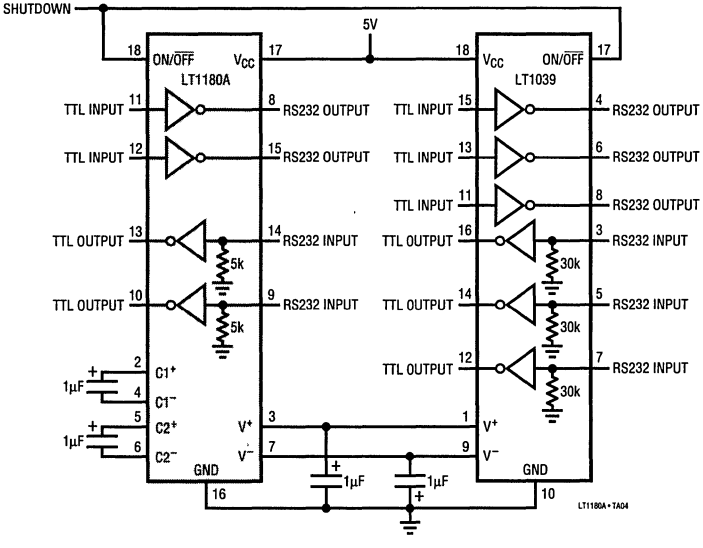


TYPICAL APPLICATIONS

Operation Using 5V and 12V Power Supplies



Supporting an LT1039 (Triple Driver/Receiver)



5V RS232 Transceiver with Advanced Power Management and One Receiver Active in SHUTDOWN

FEATURES

- One Receiver Remains Active While in SHUTDOWN
- ESD Protection over ±**10kV**
- Uses Small Capacitors: 0.1µF, 0.2µF, 1.0µF
- 60µA Supply Current in SHUTDOWN
- Pin-Compatible with LT1137A
- Operates to 120k Baud
- CMOS Comparable Low Power 30mW
- Operates from a Single 5V Supply
- Easy PC Layout – Flowthrough Architecture
- Rugged Bipolar Design
- Outputs Assume a High Impedance State When Off or Powered Down
- Absolutely No Latchup
- Available in SO and SSOP Packages

APPLICATIONS

- Notebook Computers
- Palmtop Computers

DESCRIPTION

The LT1237 is an advanced low power three driver, five receiver RS232 transceiver. Included on the chip is a shutdown pin for reducing supply current near zero. During SHUTDOWN one receiver remains active to detect incoming RS232 signals, for example, to wake up a system.

The LT1237 is fully compliant with all EIA RS232 specifications. New ESD structures on the chip allow the LT1237 to survive multiple ±10kV strikes, eliminating the need for costly TransZorbs® on the RS232 line pins.

The LT1237 operates in excess of 120k baud even driving heavy capacitive loads. Two SHUTDOWN modes allow the driver outputs to be shut down separately from the receivers for more versatile control of the RS232 interface. During SHUTDOWN, drivers and receivers assume a high impedance state.

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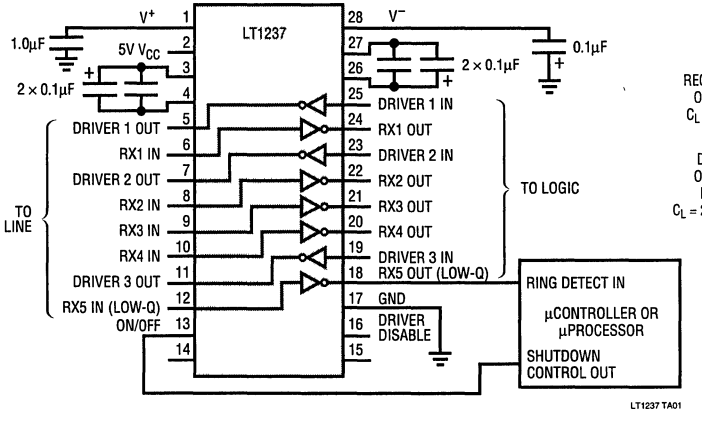
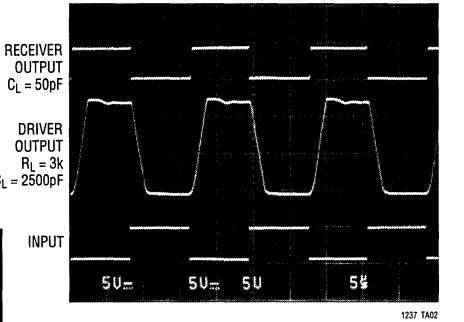
TYPICAL APPLICATION



LT1237 TA01

Output Waveforms



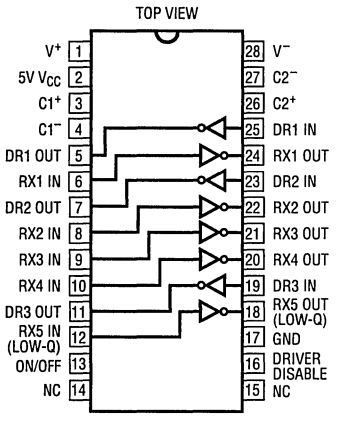
1237 TA02

ABSOLUTE MAXIMUM RATINGS

(Note 1)

Supply Voltage (V_{CC}) 6V
V^+ 13.2V
V^- ..... –13.2V
Input Voltage
  Driver ..... V^- to V^+
  Receiver ..... –30V to 30V
Output Voltage
  Driver ..... –30V to 30V
  Receiver ..... –0.3V to V_{CC} + 0.3V
Short Circuit Duration
  V^+ ..... 30 sec
  V^- ..... 30 sec
  Driver Output ..... Indefinite
  Receiver Output ..... Indefinite
Operating Temperature Range
  LT1237I ..... –40°C to 85°C
  LT1237C ..... 0°C to 70°C
Storage Temperature Range ..... –65°C to 150°C
Lead Temperature (Soldering, 10 sec) ..... 300°C

PACKAGE/ORDER INFORMATION



J PACKAGE
28-LEAD CERAMIC DIP

N PACKAGE
28-LEAD PLASTIC DIP

S PACKAGE
28-LEAD SOL

G PACKAGE
28-LEAD SSOP

T_{JMAX} = 150°C, θ_{JA} = 62°C/W (J)
T_{JMAX} = 150°C, θ_{JA} = 56°C/W (N)
T_{JMAX} = 150°C, θ_{JA} = 85°C/W (S)
T_{JMAX} = 150°C, θ_{JA} = 96°C/W (G)

ORDER PART NUMBER
LT1237IJ
LT1237IN
LT1237CJ
LT1237CN
LT1237CS
LT1237CG

ELECTRICAL CHARACTERISTICS (Note 2)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Power Supply Generator						
V^+ Output				7.9		V
V^- Output				–7		V
Supply Current (V_{CC})	T_A = 25°C (Note 3)			6	12	mA
		❹		6	14	mA
Supply Current when OFF (V_{CC})	SHUTDOWN (Note 4)	❺		0.06	0.15	mA
	DRIVER DISABLE			3.00		mA
Supply Rise Time SHUTDOWN to Turn-On	C1 = C2 = 0.2µF, C^+ = 1.0µF, C^- = 0.1µF			2		ms
ON/OFF Pin Thresholds	Input Low Level (Device SHUTDOWN)	❻	0.8	1.2		V
	Input High Level (Device Enabled)	❼		1.6	2.4	V
ON/OFF Pin Current	0V ≤ $V_{ON/OFF}$ ≤ 5V	❽	–15		80	µA
Driver Disable Pin Thresholds	Input Low Level (Drivers Enabled)	❾	0.8	1.4		V
	Input High Level (Drivers Disabled)	❿		1.4	2.4	V
Driver Disable Pin Current	0V ≤ $V_{DRIVER\ DISABLE}$ ≤ 5V	⓫	–10		500	µA
Oscillator Frequency	Driver Outputs Loaded R_L = 3k			130		kHz

ELECTRICAL CHARACTERISTICS (Note 2)

PARAMETER	CONDITIONS			MIN	TYP	MAX	UNITS
Any Driver							
Output Voltage Swing	Load = 3k to GND	Positive	o	5.0	7.5		V
		Negative	o		−6.3	−5.0	V
Logic Input Voltage Level	Input Low Level (V_{OUT} = High)		o		1.4	0.8	V
	Input High Level (V_{OUT} = Low)		o	2.0	1.4		V
Logic Input Current	$0.8V \le V_{IN} \le 2V$		o		5	20	µA
Output Short-Circuit Current	V_{OUT} = 0V				17		mA
Output Leakage Current	SHUTDOWN V_{OUT} = ±30V (Note 4)		o		10	100	µA
Slew Rate	R_L = 3k, C_L = 51pF				15	30	V/µs
	R_L = 3k, C_L = 2500pF			4	7		V/µs
Propagation Delay	Output Transition t_{HL} High to Low (Note 5)				0.6	1.3	µs
	Output Transition t_{LH} Low to High				0.5	1.3	µs
Any Receiver							
Input Voltage Thresholds	Input Low Threshold (V_{OUT} = High)			0.8	1.3		V
	Input High Threshold (V_{OUT} = Low)				1.7	2.4	V
Hysteresis			o	0.1	0.4	1.0	V
Input Resistance				3	5	7	kΩ
Output Leakage Current	SHUTDOWN (Note 4) $0 \le V_{OUT} \le V_{CC}$		o		1	10	µA
Receivers 1, 2, 3, 4							
Output Voltage	Output Low, I_{OUT} = −1.6mA		o		0.2	0.4	V
	Output High, I_{OUT} = 160µA (V_{CC} = 5V)		o	3.5	4.2		V
Output Short-Circuit Current	Sinking Current, $V_{OUT} = V_{CC}$			−10	−20		mA
	Sourcing Current, V_{OUT} = 0V			10	20		mA
Propagation Delay	Output Transition t_{HL} High to Low (Note 6)				250	600	ns
	Output Transition t_{LH} Low to High				350	600	ns
Receiver 5 (LOW I_{SUPPLY} RX)							
Output Voltage	Output Low, I_{OUT} = −500µA		o		0.2	0.4	V
	Output High, I_{OUT} = 160µA (V_{CC} = 5V)		o	3.5	4.2		V
Output Short-Circuit Current	Sinking Current, $V_{OUT} = V_{CC}$			−2	−4		mA
	Sourcing Current, V_{OUT} = 0V			2	4		mA
Propagation Delay	Output Transition t_{HL} High to Low (Note 6)				1.0	3	µs
	Output Transition t_{LH} Low to High				0.6	3	µs

The o denotes specifications which apply over the operating temperature range ($0°C \le T_A \le 70°C$ for commercial grade, and $-40°C \le T_A \le 85°C$ for industrial grade).

Note 1: Absolute Maximum Ratings are those values beyond which the life of the device may be impaired.

Note 2: Testing done at V_{CC} = 5V and $V_{ON/OFF}$ = 3V, unless otherwise specified.

Note 3: Supply current is measured as the average over several charge pump burst cycles. C^+ = 1.0µF, C^- = 0.1µF, C1 = C2 = 0.2µF. All outputs are open, with all driver inputs tied high.

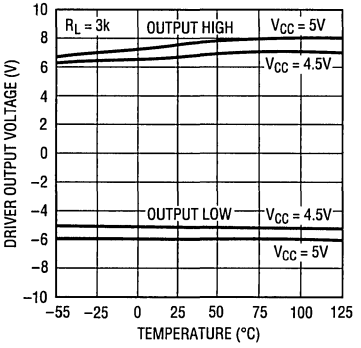
Note 4: Measurements in SHUTDOWN are performed with $V_{ON/OFF} \le 0.1V$. Supply current measurements using DRIVER DISABLE are performed with $V_{DRIVER\ DISABLE} \ge 3V$.

Note 5: For driver delay measurements, R_L = 3k and C_L = 51pF. Trigger points are set between the driver's input logic threshold and the output transition to the zero crossing (t_{HL} = 1.4V to 0V and t_{LH} = 1.4V to 0V).

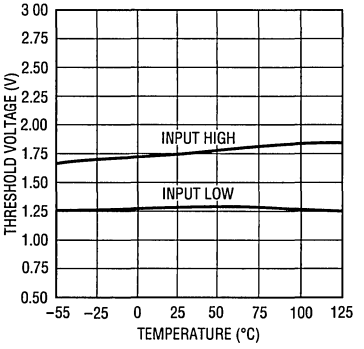
Note 6: For receiver delay measurements, C_L = 51pF. Trigger points are set between the receiver's input logic threshold and the output transition to standard TTL/CMOS logic threshold (t_{HL} = 1.3V to 2.4V and t_{LH} = 1.7V to 0.8V).

TYPICAL PERFORMANCE CHARACTERISTICS

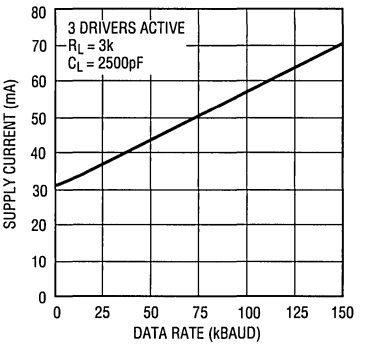
Driver Output Voltage



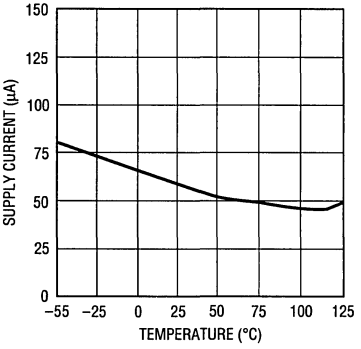
Receiver Input Thresholds



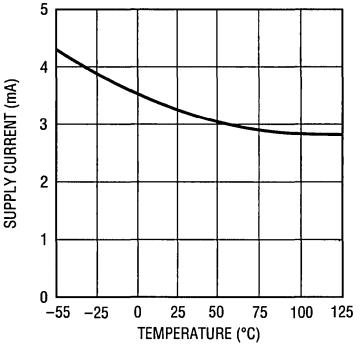
Supply Current vs Data Rate



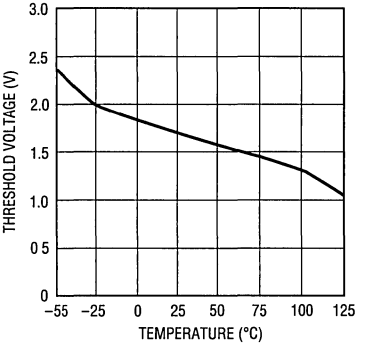
Supply Current in SHUTDOWN



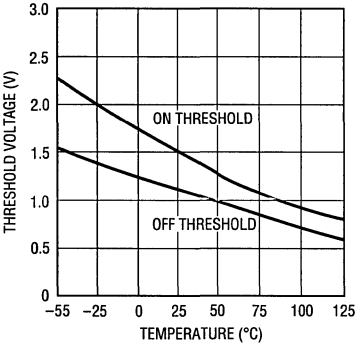
Supply Current in DRIVER DISABLE



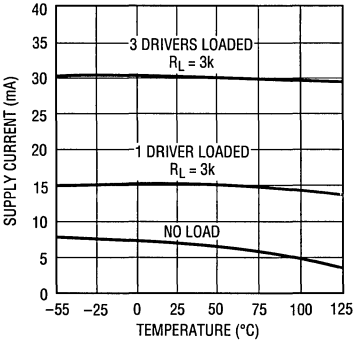
Driver Disable Threshold



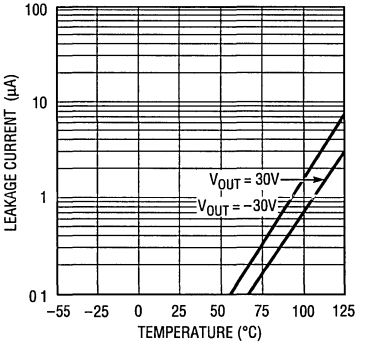
On/Off Thresholds



Supply Current

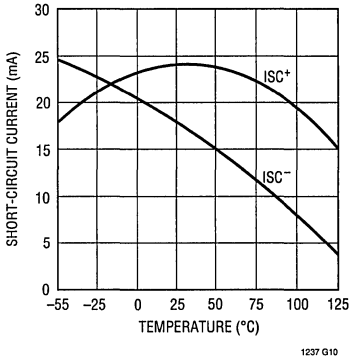


Driver Leakage in SHUTDOWN

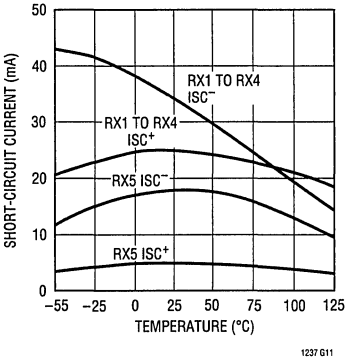


TYPICAL PERFORMANCE CHARACTERISTICS

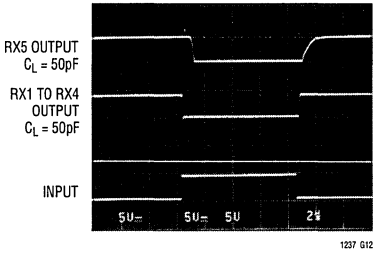
Driver Short-Circuit Current



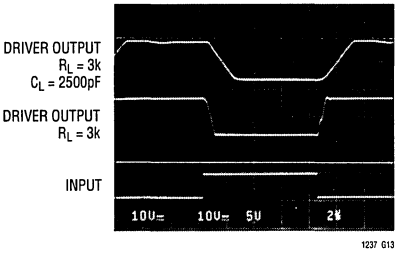
Receiver Short-Circuit Current



Receiver Output Waveforms



Driver Output Waveforms



PIN FUNCTIONS

V_{CC}: 5V Input Supply Pin. This pin should be decoupled with a 0.1µF ceramic capacitor close to the package pin. Insufficient supply bypassing can result in low output drive levels and erratic charge pump operation.

GND: Ground Pin.

ON/OFF: TTL/CMOS Compatible Operating Mode Control. A logic low puts the device in the low power SHUTDOWN mode. All three drivers and four receivers (RX1, RX2, RX3, and RX4) assume a high impedance output state in SHUTDOWN. Only receiver RX5 remains active while the transceiver is in SHUTDOWN. The transceiver consumes only 60µA of supply current while in SHUTDOWN. A logic high fully enables the transceiver.

DRIVER DISABLE: This pin provides an alternate control for the charge pump and RS232 drivers. A logic high on this pin shuts down the charge pump and places all driver outputs in a high impedance state. All five receivers remain active under these conditions. Floating the driver disable pin or driving it to a logic low level fully enables the transceiver. A logic low on the On/Off pin supersedes the state of the Driver Disable pin. Supply current drops to 3mA when in DRIVER DISABLE mode.

V^+: Positive Supply Output (RS232 Drivers). $V^+ \approx 2V_{CC} - 1.5V$. This pin requires an external charge storage capacitor $C \geq 1.0\mu F$, tied to ground or V_{CC}. Larger value capacitors may be used to reduce supply ripple. The ratio of the capacitors on V^+ and V^- should be greater than 5 to 1.

PIN FUNCTIONS

V^-: Negative Supply Output (RS232 Drivers). $V^- \approx -(2V_{CC} - 2.5V)$. This pin requires an external charge storage capacitor $C \geq 0.1\mu F$. See the Applications Information section for guidance in choosing filter capacitors for V^+ and V^-.

$C1^+$, $C1^-$, $C2^+$, $C2^-$: Commutating Capacitor Inputs, require two external capacitors $C \geq 0.2\mu F$: one from $C1^+$ to $C1^-$, and another from $C2^+$ to $C2^-$. The capacitor's effective series resistance should be less than 2Ω. For $C \geq 1\mu F$, low ESR tantalum capacitors work well in this application, although small value ceramic capacitors may be used with a minimal reduction in charge pump compliance.

DRIVER IN: RS232 Driver Input Pins. These inputs are TTL/CMOS compatible. Inputs should not be allowed to float. Tie unused inputs to V_{CC}.

DRIVER OUT: Driver Outputs at RS232 Voltage Levels. Driver output swing meets RS232 levels for loads up to 3k. Slew rates are controlled for lightly loaded lines. Output current capability is sufficient for load conditions up to 2500pF. Outputs are in a high impedance state when in SHUTDOWN mode, V_{CC} = 0V, or when the driver disable pin is active. Outputs are fully short-circuit protected from V^- + 30V to V^+ – 30V. Applying higher voltages will not damage the device if the overdrive is moderately current limited. Short circuits on one output can load the power supply generator and may disrupt the signal levels of the other outputs. The driver outputs are protected against ESD to ±10kV for human body model discharges.

RX IN: Receiver Inputs. These pins accept RS232 level signals (±30V) into a protected 5k terminating resistor. The receiver inputs are protected against ESD to ±10kV for human body model discharges. Each receiver provides 0.4V of hysteresis for noise immunity. Open receiver inputs assume a logic low state.

RX OUT: Receiver Outputs with TTL/CMOS Voltage Levels. Outputs RX1, RX2, RX3, and RX4 are in a high impedance state when in SHUTDOWN mode to allow data line sharing. Outputs, including LOW-Q RX OUT, are fully short-circuit protected to ground or V_{CC} with the power on, off, or in SHUTDOWN mode.

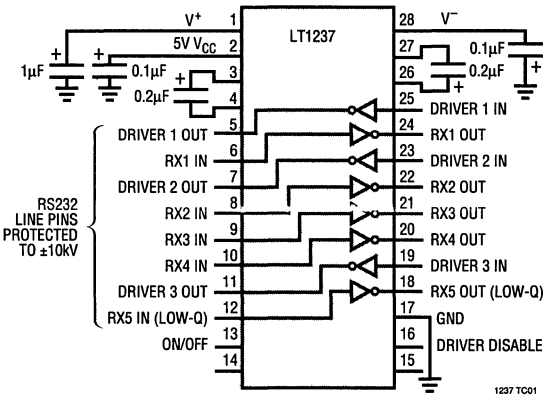
LOW Q-CURRENT RX IN: Low Power Receiver Input. This special receiver remains active when the part is in SHUTDOWN mode, consuming typically 60µA. This receiver has the same 5k input impedance and ±10kV ESD protection characteristics as the other receivers.

LOW Q-CURRENT RX OUT: Low Power Receiver Output. This pin produces the same TTL/CMOS output voltage levels as receivers RX1, RX2, RX3, and RX4 with slightly decreased speed and short-circuit current. Data rates to 120k baud are supported by this receiver.

ESD PROTECTION

The RS232 line inputs of the LT1237 have on-chip protection from ESD transients up to ±10kV. The protection structures act to divert the static discharge safely to system ground. In order for the ESD protection to function effectively, the power supply and ground pins of the LT1237 must be connected to ground through low impedances. The power supply decoupling capacitors and charge pump storage capacitors provide this low impedance in normal application of the circuit. The only constraint is that low ESR capacitors must be used for bypassing and charge storage. ESD testing must be done with pins V_{CC}, V_L, V^+, V^-, and GND shorted to ground or connected with low ESR capacitors.

ESD Test Circuit



APPLICATIONS INFORMATION

Storage Capacitor Selection

The V^+ and V^- storage capacitors must be chosen carefully to insure low ripple and stable operation. The LT1237 charge pump operates in a power efficient Burst Mode™. When storage capacitor voltage drops below a preset threshold, the oscillator is gated on until V^+ and V^- are boosted up to levels exceeding a second threshold. The oscillator then turns off, and current is supplied from the V^+ and V^- storage capacitors.

The V^- potential is monitored to control charge pump operation. It is therefore important to insure lower V^+ ripple than V^- ripple, or erratic operation of the charge pump will result. Proper operation is insured in most applications by choosing the V^+ filter capacitor to be at least 5 times the V^- filter capacitor value. If V^+ is more heavily loaded than V^-, a larger ratio may be needed.

The V^- filter capacitor should be selected to obtain low ripple when the drivers are loaded, forcing the charge pump into continuous mode. A minimum value 0.1µF is suggested.

Do not attempt to reduce V^- ripple when the charge pump is in discontinuous Burst Mode™ operation. The ripple in this mode is determined by internal comparator thresholds. Larger storage capacitor values increase the burst period, and do not reduce ripple amplitude.

Power Saving Operational Modes

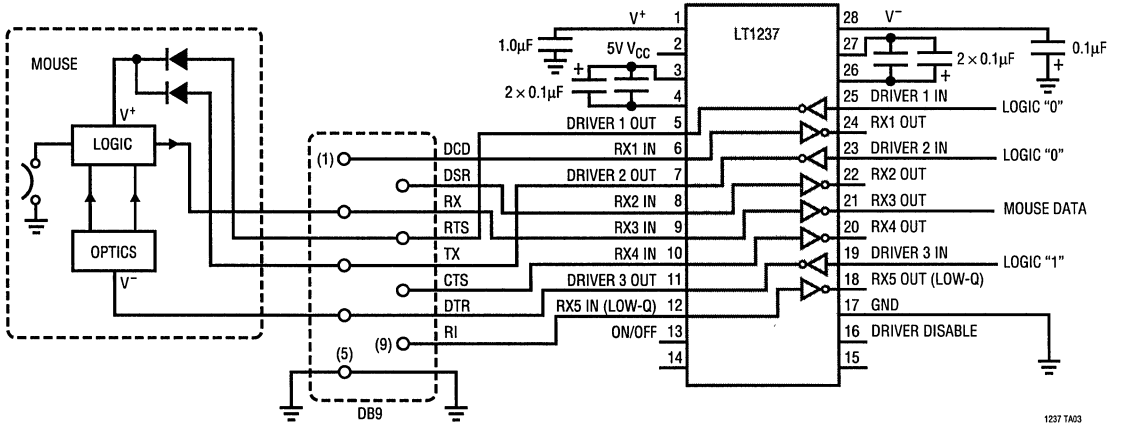
The LT1237 has both SHUTDOWN and DRIVER DISABLE operating modes. These operating modes can optimize power consumption based upon applications needs.

The On/Off shutdown control turns off all circuitry except for Low-Q RX5. When RX5 detects a signal, this information can be used to wake up the system for full operation.

If more than one line must be monitored, the DRIVER DISABLE mode provides a power efficient operating option. The DRIVER DISABLE mode turns off the charge pump and RS232 drivers, but keeps all five receivers active. Power consumption in DRIVER DISABLE mode is 3mA from V_{CC}.

Burst Mode is a trademark of Linear Technology Corporation

Typical Mouse Driving Application



AppleTalk® Transceiver

FEATURES

- Single Chip Provides Complete LocalTalk®/AppleTalk® Port
- Low Power: I_{CC} = 1.2mA Typ
- Shutdown Pin Reduces I_{CC} to 30µA Typ
- Drivers Maintain High Impedance in Three-State or with Power Off
- 30ns Driver Propagation Delay Typ
- 5ns Driver Skew Typ
- Thermal Shutdown Protection
- Drivers are Short-Circuit Protected

APPLICATIONS

- LocalTalk Peripherals
- Notebook/Palmtop Computers
- Battery-Powered Systems
- RS232/562 to RS422 Conversion

LocalTalk and AppleTalk are registered trademarks of Apple Computer, Inc.

DESCRIPTION

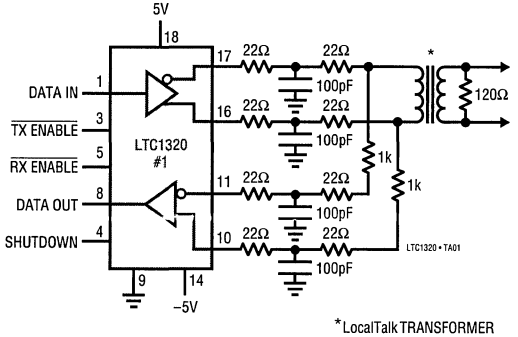
The LTC1320 is an RS422/RS562 line transceiver designed to operate on LocalTalk networks. It provides one differential RS422 driver, one single-ended RS562 driver, two single-ended RS562 receivers, and one differential RS422 receiver. The LTC1320 draws only 1.2mA quiescent current when active and 30µA in shutdown, making it ideal for use in battery-powered devices and other systems where power consumption is a primary concern.

The LTC1320 drivers are specified to drive ±2V into 100Ω. Additionally, the driver outputs three-state when disabled, during shutdown, or when the power is off; they maintain high impedance even with output common-mode voltages beyond the power supply rails. Both the driver outputs and receiver inputs are protected against ESD damage to beyond 5kV.

The LTC1320 is available in the 18-pin SOL package.

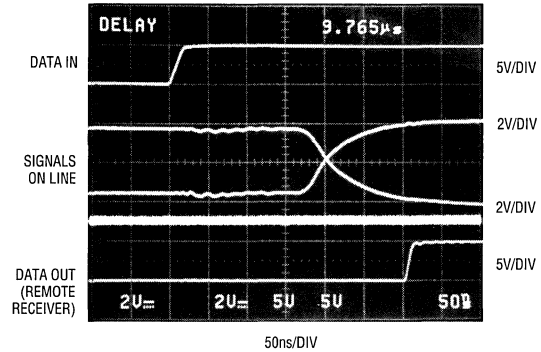
TYPICAL APPLICATION

Typical LocalTalk Connection



*LocalTalk TRANSFORMER

Output Waveforms

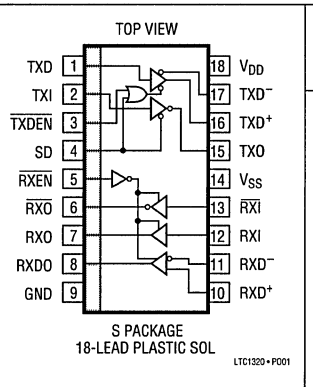


50ns/DIV

ABSOLUTE MAXIMUM RATINGS

Supply Voltage (V_{DD}) 7V
Supply Voltage (V_{SS}) ..... −7V
Input Voltage (Logic Inputs) ..... −0.3V to V_{DD} + 0.3V
Input Voltage (Receiver Inputs) ..... ±15V
Driver Output Voltage (Forced) ..... ±15V
Output Short-Circuit Duration ..... Indefinite
Operating Temperature Range ..... 0°C ot 70°C
Storage Temperature Range ..... −65°c to 150°C
Lead Temperature (Soldering, 10 sec) ..... 300°C

PACKAGE/ORDER INFORMATION



T_{JMAX} = 150°C, θ_{JA} = 100°C/W

ORDER PART NUMBER
LTC1320CS

DC ELECTRICAL CHARACTERISTICS

V_S = ±5V ±5%, T_A = 0°C to 70°C (Notes 2, 3)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V_{OD}	Differential Driver Output Voltage	No Load R_L = 100Ω (Figure 1)	O O	8.0 2.0			V V
	Change in Magnitude of Driver Differential Output Voltage	R_L = 100Ω (Figure 1)			0.2		V
V_{OC}	Driver Common-Mode Output Voltage	R_L = 100Ω (Figure 1)			3		V
	Output Common-Mode Range	SD = 5V or Power Off	O			±10	V
	Single-Ended Driver Output Voltage	No Load R_L = 400Ω	O O	±4.0 ±3.4			V V
	Input High Voltage	All Logic Input Pins	O	2.0			V
	Input Low Voltage	All Logic Input Pins	O			0.8	V
	Input Current	All Logic Input Pins	O		±1	±20	µA
	Three-State Output Current	SD = 5V or Power Off, −10V < V_O < 10V	O		±2	±100	µA
	Driver Short-Circuit Current	−5V < V_O < 5V	O	35	350	500	mA
	Receiver Input Resistance	−7V < V_{IN} < 7V	O	12			kΩ
V_{OH}	Receiver Output High Voltage	I_O = −4mA	O	3.5			V
V_{OL}	Receiver Output Low Voltage	I_O = 4mA	O			0.4	V
	Receiver Output Short-Circuit Current	0V < V_O < 5V	O	7		85	mA
	Receiver Output Three-State Current	0V < V_O < 5V	O		±2	±100	µA
	Differential Receiver Threshold Voltage	−7V < V_{CM} < 7V	O	−200		200	mV
	Differential Receiver Input Hysteresis	−7V < V_{CM} < 7V			70		mV
	Single-Ended Receiver Input Low Voltage		O			0.8	V
	Single-Ended Receiver Input High Voltage		O	2			V
I_{DD}	Supply Current	No Load, SD = 0V No Load, SD = 5V	O O		1.2 30	3.0 350	mA µA
I_{SS}	Supply Current	No Load, SD = 5V	O		2	350	µA

SWITCHING CHARACTERISTICS $V_S = \pm5V \pm5\%$, $T_A = 0°C$ to $70°C$ (Notes 2, 3)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
$t_{PLH, HL}$	Differential Driver Propagation Delay	$R_L = 100\Omega$, $C_L = 100pF$ (Figures 2, 8)	O		40	120	ns
t_{SKEW}	Differential Driver Output to Output	$R_L = 100\Omega$, $C_L = 100pF$ (Figures 2, 8)	O		10	50	ns
$t_{r, f}$	Differential Driver Rise/Fall Time	$R_L = 100\Omega$, $C_L = 100pF$ (Figures 2, 8)	O		15	80	ns
$t_{ENH, L}$	Driver Enable to Output Active	$C_L = 100pF$ (Figures 3, 4, 10)	O		50	150	ns
$t_{H, Ldis}$	Driver Output Active to Disable	$C_L = 15pF$ (Figures 3, 4, 10)	O		50	150	ns
$t_{PLH, HL}$	Single-Ended Driver Propagation Delay	$R_L = 450\Omega$, $C_L = 100pF$ (Figures 5, 11)	O		40	120	ns
$t_{r, f}$	Single-Ended Driver Rise/Fall Time	$R_L = 450\Omega$, $C_L = 100pF$ (Figures 5, 12)	O		15	80	ns
$t_{PLH, HL}$	Receiver Propagation Delay	$C_L = 15pF$ (Figures 13, 14)	O		60	160	ns
$t_{ENH, L}$	Receiver Enable to Output Active	$C_L = 100pF$ (Figures 6, 7, 15)	O		30	100	ns
$t_{H, Ldis}$	Receiver Output Active to Disable	$C_L = 15pF$ (Figures 6, 7, 15)	O		30	100	ns

The O denotes specifications which apply over the full operating temperature range.

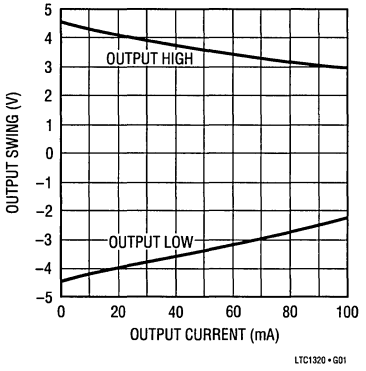
Note 1: Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

Note 2: All currents into device pins are positive; all currents out of device pins are negative. All voltages are referenced to ground unless otherwise specified.

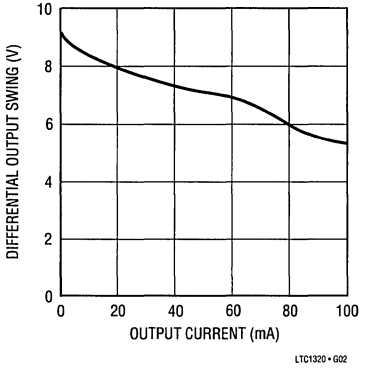
Note 3: All typicals are given at $V_S = \pm5V$, $T_A = 25°C$.

TYPICAL PERFORMANCE CHARACTERISTICS

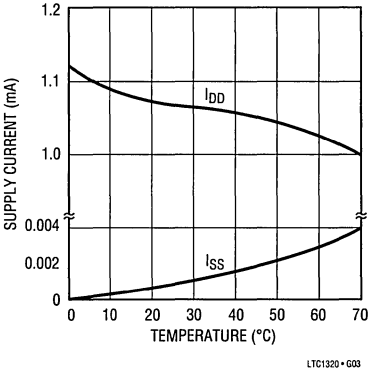
Output Swing vs Load Current



Differential Output Swing vs Load Current



Supply Current vs Temperature



PIN FUNCTIONS

TXD (Pin 1): RS422 Differential Driver Input (TTL Compatible).

TXI (Pin 2): RS562 Single-Ended Driver Input (TTL compatible.

$\overline{\text{TXDEN}}$ (Pin 3): RS422 Differential Driver Output Enable (TTL Compatible). A high level on this pin forces the RS422 driver into three-state; a low level enables the driver. This input does not affect the RS562 single-ended driver.

SD (Pin 4): Shutdown Input (TTL Compatible). When this pin is high, the chip is shut down: all driver outputs three-state and the supply current drops to 30μA. A low on this pin allows normal operation.

PIN FUNCTIONS

$\overline{\text{RXEN}}$ (Pin 5): Receiver Enable (TTL Compatible). A high level on this pin disables the receivers and three-states the logic outputs; a low level allows normal operation. To prevent erratic behavior at the receiver outputs during shutdown, $\overline{\text{RXEN}}$ should be pulled high along with SD.

$\overline{\text{RXO}}$ (Pin 6): Inverting RS562 Single-Ended Receiver Output.

RXO (Pin 7): Noninverting RS562 Single-Ended Receiver Output.

RXDO (Pin 8): RS422 Differential Receiver Output.

GND (Pin 9): Ground Pin.

RXD$^+$ (Pin 10): RS422 Differential Receiver Noninverting Input. When this pin is ≥200mV above RXD$^-$, RXDO will be high; when this pin is ≥200mV below RXD$^-$, RXDO will be low.

RXD$^-$ (Pin 11): RS422 Differential Receiver Inverting Input.

RXI (Pin 12): Noninverting RS562 Receiver Input. This input controls the RXO output; it has no effect on the $\overline{\text{RXO}}$ output.

$\overline{\text{RXI}}$ (Pin 13): Inverting RS562 Receiver Input. This input controls the $\overline{\text{RXO}}$ output; it has no effect on the RXO output.

V_{SS} (Pin 14): Negative Supply. $-4.75 \geq V_{SS} \geq -5.25V$. The voltage on this pin must never exceed ground on power up or power-down.

TXO (Pin 15): RS562 Single-Ended Driver Output.

TXD$^+$ (Pin 16): RS422 Differential Driver Noninverting Output.

TXD$^-$ (Pin 17): RS422 Differential Driver Inverting Output.

V_{DD} (Pin 18): Positive Supply. $4.75V \leq V_{DD} \leq 5.25V$.

TEST CIRCUITS

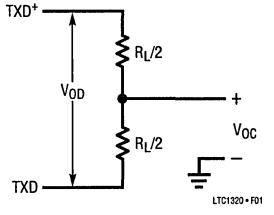


Figure 1

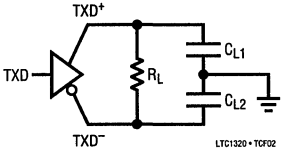


Figure 2

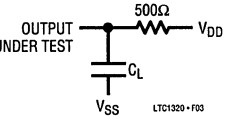


Figure 3

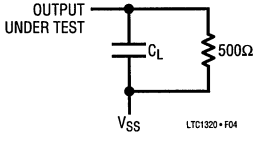


Figure 4

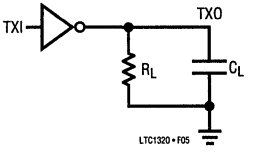


Figure 5

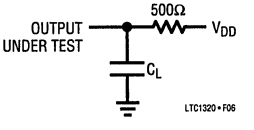


Figure 6

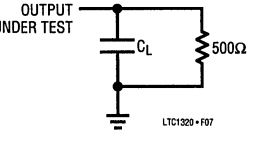


Figure 7

SWITCHING WAVEFORMS

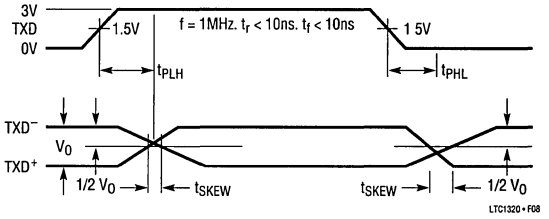


Figure 8

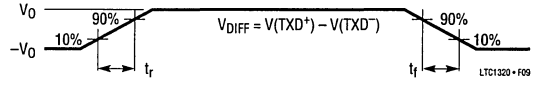


Figure 9

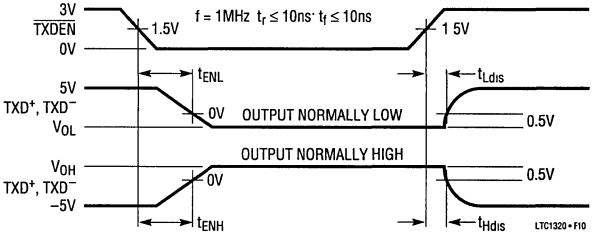


Figure 10

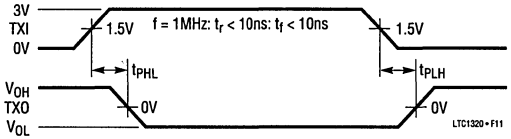


Figure 11

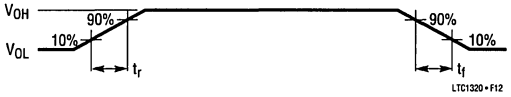


Figure 12

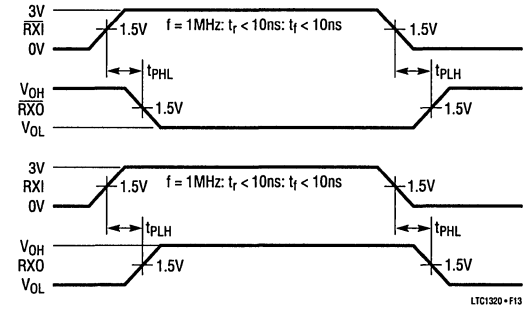


Figure 13

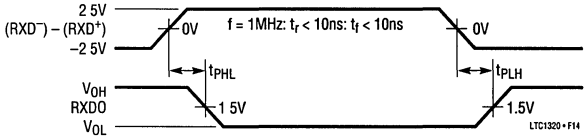


Figure 14

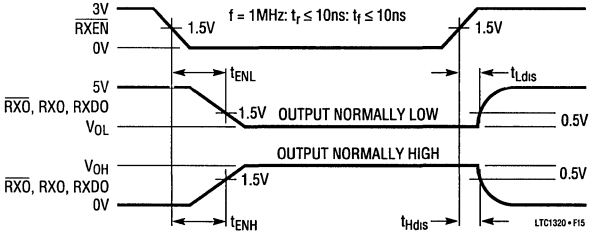


Figure 15

APPLICATIONS INFORMATION

Thermal Shutdown Protection

The LTC1320 includes a thermal shutdown circuit which protects the part against prolonged shorts at the driver outputs. If any driver output is shorted to another output or to the power supply, the current will be initially limited to 450mA max. The die temperature will rise to about 150°C, at which point the thermal shutdown circuit turns off the driver outputs. When the die cools to about 130°C, the outputs re-enable. If the shorted condition still exists, the part will heat again and the cycle will repeat. When the short is removed, the part will return to normal operation. This oscillation occurs at about 10Hz and prevents the part from being damaged by excessive power dissipation.

Power Shutdown

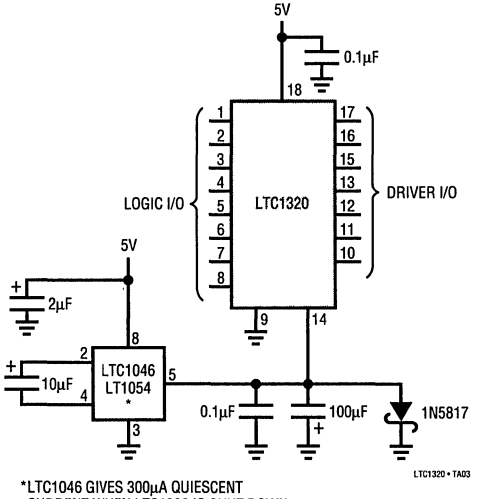
The power shutdown feature of the LTC1320 is designed primarily for battery-powered systems. When SD (pin 4) is forced high, the part enters shutdown mode. In shutdown, the supply current drops from 1.2mA to 30µA typ. The driver outputs are three-stated and the power to the receivers is removed. The receiver outputs are not automatically three-stated in shutdown, and can toggle erroneously due to feedthrough from the inputs. This can be prevented by pulling $\overline{RXEN}$ high along with SD; this will three-state the receiver outputs and prevent the generation of spurious data.

Supply Bypassing

The LTC1320 requires that both V_{DD} and V_{SS} are well bypassed; data errors can result from inadequate bypassing. Bypass capacitor values of 0.1µF to 1µF from V_{DD} to ground and from V_{SS} to ground are adequate. Lead lengths and trace lengths between the capacitors and the chip should be short to minimize lead inductance.

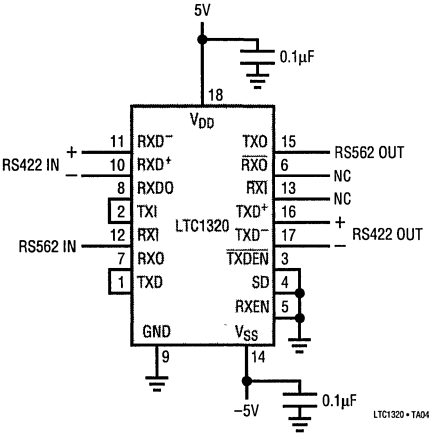
TYPICAL APPLICATIONS

Single 5V Supply



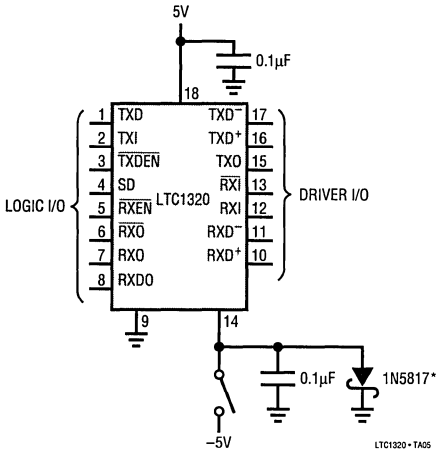
*LTC1046 GIVES 300µA QUIESCENT CURRENT WHEN LTC1320 IS SHUT DOWN
LT1054 PROVIDES HIGHER OUTPUT DRIVE

RS422 to RS562/RS562 to RS422 Converter



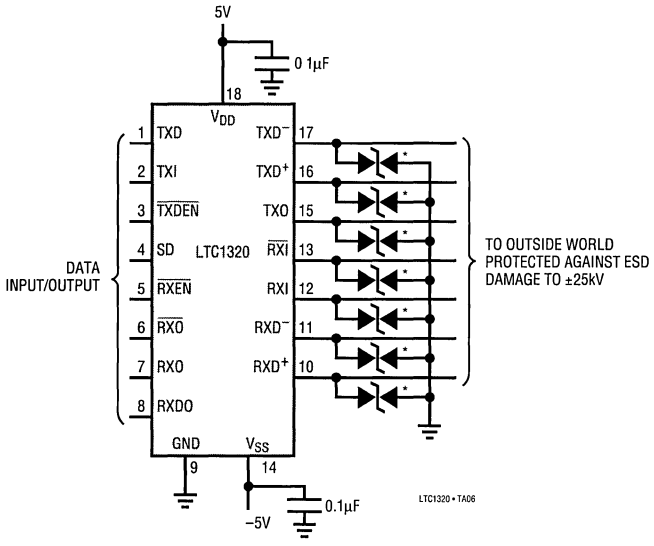
TYPICAL APPLICATIONS

Switched Negative Supply



*SCHOTTKY DIODE PREVENTS V_{SS} FROM EXCEEDING GND ON POWER-UP OR POWER-DOWN

≥25k ESD Protection



*GENERAL SEMICONDUCTOR ICTE-22C OR EQUIVALENT

3.3V Micropower EIA/TIA-562 Driver/Receiver

April 1993

FEATURES

- Low Supply Current **300μA**
- 1μA Supply Current in SHUTDOWN
- ESD Protection ±10kV
- Operates From a Single 3.3V Supply
- Uses Small Capacitors 0.1μF
- Operates To 120k Baud
- Three-State Outputs are High Impedance When Off
- Output Overvoltage Does Not Force Current Back Into Supplies
- EIA/TIA-562 I/O Lines Can Be Forced to ±25V Without Damage
- Meet All EIA/TIA-562 Specifications
- Flowthrough Architecture

APPLICATIONS

- Notebook Computers
- Palmtop Computers

DESCRIPTION

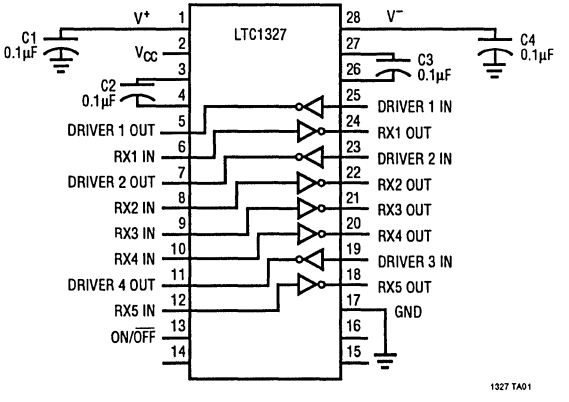
The LTC1327 is an advanced low power, three-driver/five-receiver EIA/TIA-562 transceiver. In the no load condition, the supply current is only **300μA**. In the shutdown mode, the supply current is further reduced to 1μA. The charge pump only requires four 0.1μF capacitors and can supply up to 5mA of extra current to power external circuitry.

In SHUTDOWN mode, the supply current is further reduced to 1μA. All EIA/TIA-562 outputs assume a high impedance state in SHUTDOWN and with the power off.

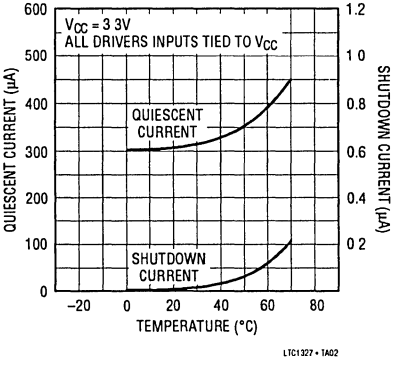
The LTC1327 is fully compliant with all EIA/TIA-562 specifications. The transceiver can operate up to 120k Baud with a 1000pF//3kΩ load. Both driver outputs and receiver inputs can be forced to ±25V without damage, and can survive multiple ±10k ESD strikes.

TYPICAL APPLICATION

3-Drivers/5-Receivers with SHUTDOWN



Supply Current



ABSOLUTE MAXIMUM RATINGS

Supply Voltage (V_{CC}) 5V
Input Voltage
- Driver ..... −0.3V to (V_{CC} + 0.3V)
- Receiver ..... −25V to 25V
- On/$\overline{Off}$ Pin ..... −0.3V to (V_{CC} + 0.3V)

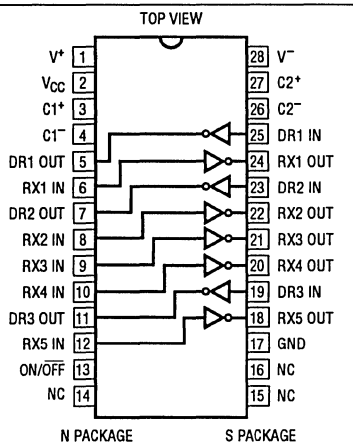
Output Voltage
- Driver ..... −25V to 25V
- Receiver ..... −0.3V to (V_{CC} + 0.3V)

Short-Circuit Duration
- V^+ ..... 30 sec
- V^- ..... 30 sec
- Driver Output ..... Indefinite
- Receiver Output ..... Indefinite

Operating Temperature Range
- Commercial LTC1327C ..... 0°C to 70°C

Storage Temperature Range ..... −65°C to 150°C
Lead Temperature (Soldering, 10 sec) ..... 300°C

PACKAGE/ORDER INFORMATION



N PACKAGE
28-LEAD PLASTIC DIP

S PACKAGE
28-LEAD PLASTIC SOL

G PACKAGE
28-LEAD SSOP

ORDER PART NUMBER
LTC1327CN LTC1327CG LTC1327CS

ELECTRICAL CHARACTERISTICS

V_{CC} = 3.3V, C1 to C4 = 0.1µF, unless otherwise noted.

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
DC PERFORMANCE						
Any Driver						
Output Voltage Swing	Positive Negative (3k to GND)	● ●	3.7 −3.7	4.5 −4.5		V V
Logic Input Voltage Level	Input Low Level (V_{OUT} = High) Input High Level (V_{OUT} = Low)	● ●	 2	1.4 1.4	0.8 	V V
Logic Input Current	V_{IN} = 3.3 V_{IN} = 0	● ●	 	 	5 −5	µA µA
Output Short-Circuit Current	V_{OUT} = 0V			±10		mA
Output Leakage Current	SHUTDOWN (Note 3), V_{OUT} = ±20V			10	100	µA
Any Receiver						
Input Voltage Thresholds	Input Low Threshold Input High Threshold	● ●	0.8 	1.3 1.7	 2.4	V V
Hysteresis		●	0.1	0.4	1	V
Input Resistance			3	5	7	kΩ
Output Voltage	Output Low, I_{OUT} = −1.6mA (V_{CC} = 3.3V) Output High, I_{OUT} = 160µA (V_{CC} = 3.3V)	● ●	 3	0.2 3.2	0.4 	V V
Output Short-Circuit Current	Sinking Current, V_{OUT} = V_{CC}		−5	−20		mA
Output Leakage Current	SHUTDOWN (Note 3), 0 ≤ V_{OUT} ≤ V_{CC}	●		1	10	µA
Power Supply Generator						
V^+ Output Voltage	I_{OUT} = 0mA I_{OUT} = 5mA	● ●	5.2 5.0	5.7 5.5	 	V V
V^- Output Voltage	I_{OUT} = 0mA I_{OUT} = −5mA	● ●	−4.7 −4.5	−5.3 −5.0	 	V V
Supply Rise Time	SHUTDOWN to Turn-On				0.2	ms

ELECTRICAL CHARACTERISTICS

V_{CC} = 3.3V, C1 to C4 = 0.1µF, unless otherwise noted.

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Power Supply						
V_{CC} Supply Current	No Load (Note 2)	●		0.3	0.5	mA
Supply Leakage Current (V_{CC})	SHUTDOWN (Note 3)	●		1	10	µA
On/$\overline{\text{Off}}$ Threshold Low		●		1.4	0.8	V
On/$\overline{\text{Off}}$ Threshold High		●	2	1.4		V
AC CHARACTERISTICS						
Slew Rate	R_L = 3k, C_L = 51pF R_L = 3k, C_L = 2500pF		 2	6.5 4	30	V/µs V/µs
Driver Propagation Delay	t_{HLD}	●		2	3	µs
(TTL to RS232)	t_{LHD}	●		2	3	µs
Receiver Propagation Delay	t_{HLR}	●		0.3	0.6	µs
(RS232 to TTL)	t_{LHR}	●		0.2	0.6	µs

The ● denotes specifications which apply over the operating temperature ($0°C \le T_A \le 70°C$).

Note 1: Absolute Maximum Ratings are those values beyond which the life of the device may be impaired.

Note 2: Supply current is measured with driver and receiver output unloaded and driver inputs tied high.

Note 3: Supply current measurement in SHUTDOWN is performed with V_{ON} = 0V.

PIN FUNCTIONS

V_{CC}: 3.3V Input Supply Pin. Supply current less than 1µA in the SHUTDOWN mode. This pin should be decoupled with a 0.1µF ceramic capacitor.

GND: Ground Pin.

ON/$\overline{\text{OFF}}$: TTL/CMOS Compatible Shutdown Pin. A logic low puts the device in SHUTDOWN mode which reduces input supply current to less than 1µA and places all drivers and receivers in high impedance state.

V^+: Positive Supply Output (EIA/TIA-562 Drivers). $V^+ \cong 2V_{CC} - 0.5V$. This pin requires an external capacitor C = 0.1µF for charge storage. The capacitor may be tied to ground or 3.3V. With multiple devices, the V^+ and V^- pins may be paralleled into common capacitors. For large numbers of devices, increasing the size of the shared common storage capacitors is recommended to reduce ripple.

V^-: Negative Supply Output (EIA/TIA-562 Drivers). $V^- \cong -(2V_{CC} - 1)$. This pin requires an external capacitor C = 0.1µF for a charge storage.

$C1^+$, $C1^-$, $C2^+$, $C2^-$: Commutating Capacitor Inputs. These pins require two external capacitors C = 0.1µF. One from $C1^+$ to $C1^-$, and another from $C2^+$ to $C2^-$. To maintain charge pump efficiency, the capacitor's effective series resistance should be less than 20Ω.

DRIVER IN: EIA/TIA-562 Driver Input Pins. Inputs are TTL/CMOS compatible. Inputs should not be allowed to float. Tie unused inputs to V_{CC}.

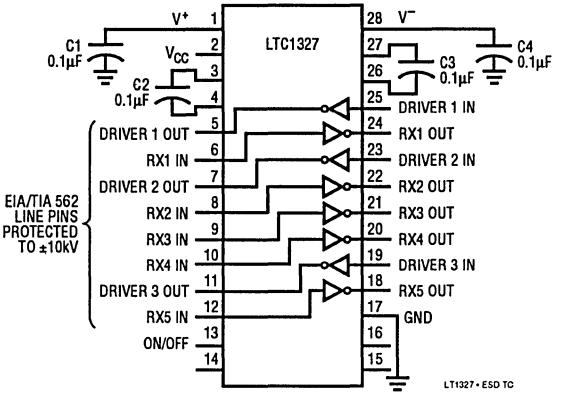
DRIVER OUT: Driver Outputs at EIA/TIA-562 Voltage Levels. Outputs are in a high impedance state when in SHUTDOWN mode or V_{CC} = 0V. The driver outputs are protected against ESD to ±10kV for human body model discharges.

RX IN: Receiver Inputs. These pins accept EIA/TIA-562 level signals (±25V) into a protected 5kΩ terminating resistor. The receiver inputs are protected against ESD to ±10kV for human body model discharges. Each receiver provides 0.4V of hysteresis for noise immunity.

RX OUT: Receiver Outputs With TTL/CMOS Voltage Levels. Outputs are in a high impedance stage when in SHUTDOWN mode to allow data line sharing.

TEST CIRCUIT

ESD Test Circuit



APPLICATIONS INFORMATION

The LT1327 is compatible with RS232 parts. This table shows some devices and thresholds.

MANUFACTURER	PART NUMBER	COMPATIBLE	MIN	TYP	MAX	MIN	TYP	MAX
Linear Technology	LT1080	√	0.8	1.3	–	–	1.7	2.4
	LT1137A	√	0.8	1.3	–	–	1.7	2.4
	LT1330	√	0.8	1.3	–	–	1.7	2.4
	LT1281	√	0.8	1.3	–	–	1.7	2.4
	All Others	√						
Texas Instruments	SN75189	√	0.65	1	1.25	0.9	1.3	1.6
	SN75189A	√	0.65	1	1.25	1.55	1.9	2.25
	MAX232	√	0.8	1.2	–	–	1.7	2.4
	SN75C185	√	0.65	1	1.25	1.6	2.1	2.55
Maxim	MAX232A	√	0.8	1.3	–	–	1.8	2.4
	MAX241	√	0.6	1.2	–	–	1.5	2.4
Sipex	SP232	√	0.8	1.2	–	–	1.7	2.4
	SP301	√	0.75	–	1.35	1.75	2.5	
Motorola	MC1489	√	0.75	–	1.25	1	–	1.5
	MC1489A	√	0.75	0.8	1.25	1.75	1.95	2.25
National	DS1489	√	0.75	1	1.25	1	1.25	1.5
	DS14C89A	√	0.5	–	1.9	1.3	–	2.7

5V RS232 Transceiver with 3V Logic Interface and One Receiver Active in SHUTDOWN

FEATURES

- **3V Logic Interface**
- ESD Protection over **±10kV**
- Uses Small Capacitors: 0.1µF, 0.2µF, 1.0µF
- One Low Power Receiver Remains Active While in SHUTDOWN
- Pin Compatible with LT1137A and LT1237
- Operates to 120k Baud
- CMOS Comparable Low Power: 30mW
- Easy PC Layout – Flowthrough Architecture
- Rugged Bipolar Design
- Outputs Assume a High Impedance State When Off or Powered Down
- Absolutely No Latchup
- 60µA Supply Current in SHUTDOWN
- Available in SO and SSOP Packages

APPLICATIONS

- Notebook Computers
- Palmtop Computers

DESCRIPTION

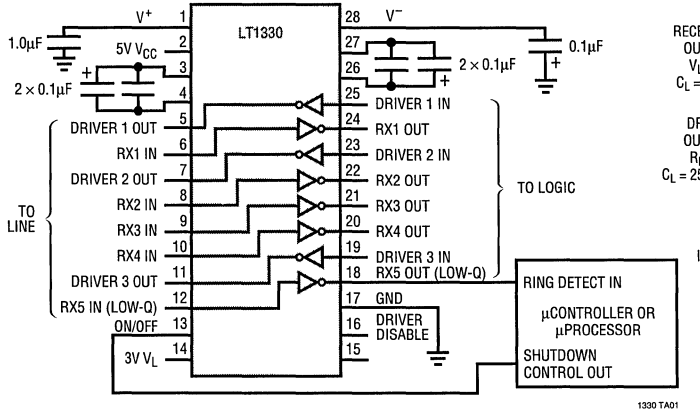
The LT1330 is a three driver, five receiver RS232 transceiver with low supply current. Designed to interface with new 3V logic, the LT1330 operates with both a 5V power supply and a 3V logic power supply. The chip may be shut down to micropower operation with one receiver remaining active to monitor RS232 inputs such as ring detect from a modem.

The LT1330 is fully compliant with all EIA RS232 specifications. Additionally, the RS232 line input and output pins are resilient to multiple ±10kV ESD strikes. This eliminates the need for costly TransZorbs® on line pins for the RS232 part.

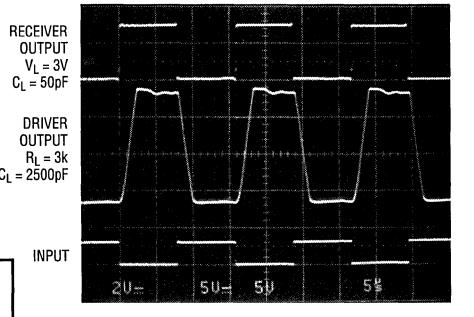
The LT1330 operates to 120k baud even driving high capacitive loads. During SHUTDOWN, driver and receiver outputs are at a high impedance state allowing devices to be paralleled.

TransZorb is a registered trademark of General Instruments, GSI

TYPICAL APPLICATION



Output Waveforms

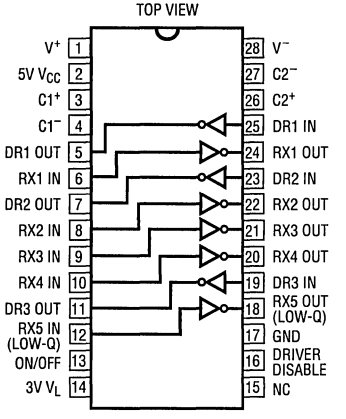


ABSOLUTE MAXIMUM RATINGS

(Note 1)

Supply Voltage (V_{CC}) 6V
Supply Voltage (V_L) 6V
V^+ 13.2V
V^- ..... –13.2V
Input Voltage
  Driver ..... V^- to V^+
  Receiver ..... –30V to 30V
Output Voltage
  Driver ..... –30V to 30V
  Receiver ..... –0.3V to V_L + 0.3V
Short Circuit Duration
  V^+ ..... 30 sec
  V^- ..... 30 sec
  Driver Output ..... Indefinite
  Receiver Output ..... Indefinite
Operating Temperature Range
  LT1330I ..... –40°C to 85°C
  LT1330C ..... 0°C to 70°C
Storage Temperature Range ..... –65°C to 150°C
Lead Temperature (Soldering, 10 sec) ..... 300°C

PACKAGE/ORDER INFORMATION



J PACKAGE
28-LEAD CERAMIC DIP

N PACKAGE
28-LEAD PLASTIC DIP

S PACKAGE
28-LEAD SOL

G PACKAGE
28-LEAD SSOP

T_{JMAX} = 150°C, θ_{JA} = 62°C/W (J)
T_{JMAX} = 150°C, θ_{JA} = 56°C/W (N)
T_{JMAX} = 150°C, θ_{JA} = 85°C/W (S)
T_{JMAX} = 150°C, θ_{JA} = 96°C/W (G)

ORDER PART NUMBER
LT1330IJ
LT1330CJ
LT1330CN
LT1330CS
LT1330CG

ELECTRICAL CHARACTERISTICS (Note 2)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Power Supply Generator						
V^+ Output				7.9		V
V^- Output				–7		V
Supply Current (V_{CC})	T_A = 25°C (Note 3)			6	12	mA
		O		6	14	mA
Supply Current (V_L)	(Note 4)			0.1	1	mA
Supply Current When OFF (V_{CC})	SHUTDOWN (Note 5)	O		0.06	0.15	mA
	DRIVER DISABLE			3.00		mA
Supply Rise Time SHUTDOWN to Turn-On	C1 = C2 = 0.2µF, C^+ = 1.0µF, C^- = 0.1µF			0.2		ms
ON/OFF Pin Thresholds	Input Low Level (Device SHUTDOWN)	O	0.8	1.4		V
	Input High Level (Device Enabled)	O		1.4	2.4	V
ON/OFF Pin Current	0V ≤ $V_{ON/OFF}$ ≤ 5V	O	–15		80	µA
Driver Disable Pin Thresholds	Input Low Level (Drivers Enabled)	O	0.8	1.4		V
	Input High Level (Drivers Disabled)	O		1.4	2.4	V
Driver Disable Pin Current	0V ≤ $V_{DRIVER\ DISABLE}$ ≤ 5V	O	–10		500	µA
Oscillator Frequency	Driver Outputs Loaded R_L = 3k			130		kHz

ELECTRICAL CHARACTERISTICS (Note 2)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Any Driver						
Output Voltage Swing	Load = 3k to GND	Positive o	5.0	7.5		V
		Negative o		−6.3	−5.0	V
Logic Input Voltage Level	Input Low Level (V_{OUT} = High)	o		1.4	0.8	V
	Input High Level (V_{OUT} = Low)	o	2.0	1.4		V
Logic Input Current	$0.8V \le V_{IN} \le 2V$	o		5	20	µA
Output Short-Circuit Current	V_{OUT} = 0V			17		mA
Output Leakage Current	SHUTDOWN V_{OUT} = ±30V (Note 5)	o		10	100	µA
Slew Rate	R_L = 3k, C_L = 51pF			15	30	V/µs
	R_L = 3k, C_L = 2500pF		4	15		V/µs
Propagation Delay	Output Transition t_{HL} High to Low (Note 6)			0.6	1.3	µs
	Output Transition t_{LH} Low to High			0.5	1.3	µs
Any Receiver						
Input Voltage Thresholds	Input Low Threshold (V_{OUT} = High)		0.8	1.3		V
	Input High Threshold (V_{OUT} = Low)			1.7	2.4	V
Hysteresis		o	0.1	0.4	1.0	V
Input Resistance			3	5	7	kΩ
Output Leakage Current	SHUTDOWN (Note 5) $0 \le V_{OUT} \le V_{CC}$	o		1	10	µA
Receivers 1, 2, 3, 4						
Output Voltage	Output Low, I_{OUT} = −1.6mA	o		0.2	0.4	V
	Output High, I_{OUT} = 160µA (V_L = 3V)	o	2.7	2.9		V
Output Short-Circuit Current	Sinking Current, $V_{OUT} = V_{CC}$		−10	−20		mA
	Sourcing Current, V_{OUT} = 0V		10	20		mA
Propagation Delay	Output Transition t_{HL} High to Low (Note 7)			250	600	ns
	Output Transition t_{LH} Low to High			350	600	ns
Receiver 5 (LOW Q-Current RX)						
Output Voltage	Output Low, I_{OUT} = −500µA	o		0.2	0.4	V
	Output High, I_{OUT} = 160µA (V_L = 3V)	o	2.7	2.9		V
Output Short-Circuit Current	Sinking Current, $V_{OUT} = V_{CC}$		−2	−4		mA
	Sourcing Current, V_{OUT} = 0V		2	4		mA
Propagation Delay	Output Transition t_{HL} High to Low (Note 7)			1	3	µs
	Output Transition t_{LH} Low to High			1	3	µs

The o denotes specifications which apply over the operating temperature range ($0°C \le T_A \le 70°C$ for commercial grade, and $-40°C \le T_A \le 85°C$ for industrial grade).

Note 1: Absolute Maximum Ratings are those values beyond which the life of the device may be impaired.

Note 2: Testing done at V_{CC} = 5V and $V_{ON/OFF}$ = 3V.

Note 3: Supply current is measured as the average over several charge pump burst cycles. C^+ = 1.0µF, C^- = 0.1µF, C1 = C2 = 0.2µF. All outputs are open, with all driver inputs tied high.

Note 4: V_L supply current is measured with all receiver outputs low.

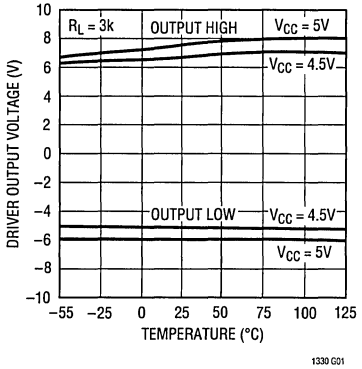
Note 5: Measurements in SHUTDOWN are performed with $V_{ON/OFF} \le 0.1V$. Supply current measurements using DRIVER DISABLE are performed with $V_{DRIVER\ DISABLE} \ge 3V$.

Note 6: For driver delay measurements, R_L = 3k and C_L = 51pF. Trigger points are set between the driver's input logic threshold and the output transition to the zero crossing (t_{HL} = 1.4V to 0V and t_{LH} = 1.4V to 0V).

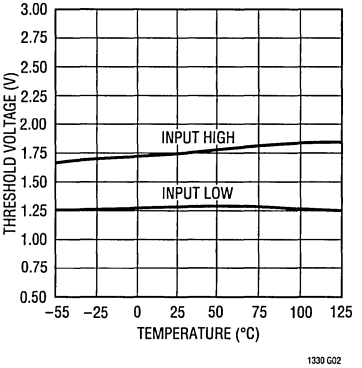
Note 7: For receiver delay measurements, C_L = 51pF. Trigger points are set between the receiver's input logic threshold and the output transition to standard TTL/CMOS logic threshold (t_{HL} = 1.3V to 2.4V and t_{LH} = 1.7V to 0.8V).

TYPICAL PERFORMANCE CHARACTERISTICS

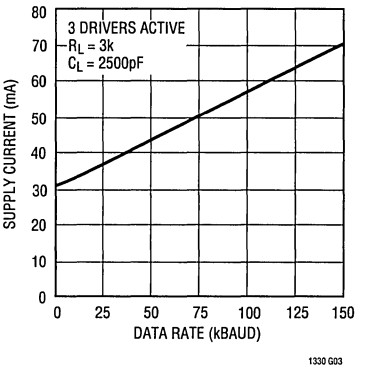
Driver Output Voltage



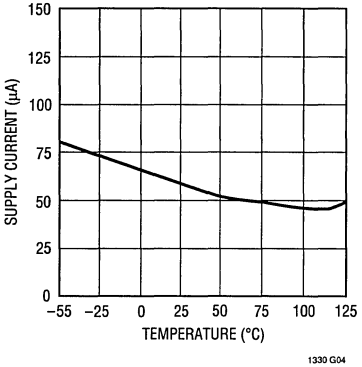
Receiver Input Thresholds



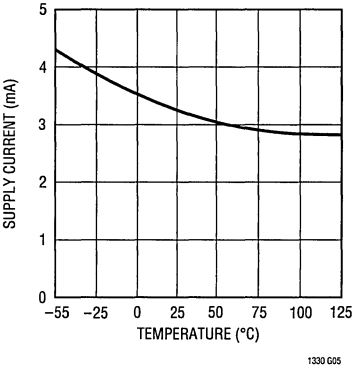
Supply Current vs Data Rate



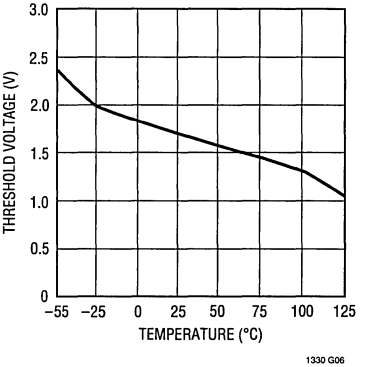
V_{CC} Supply Current in SHUTDOWN



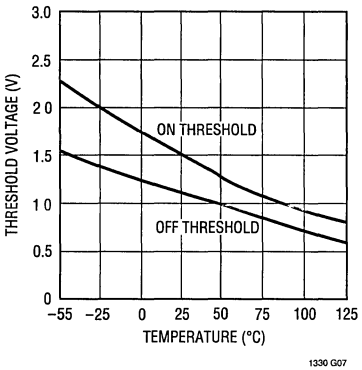
V_{CC} Supply Current in DRIVER DISABLE



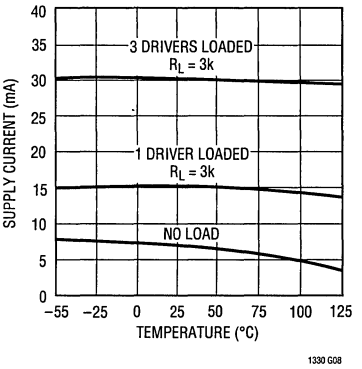
Driver Disable Threshold



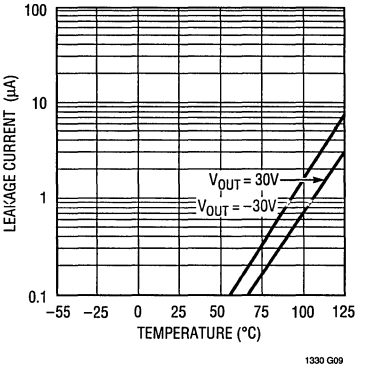
On/Off Thresholds



V_{CC} Supply Current

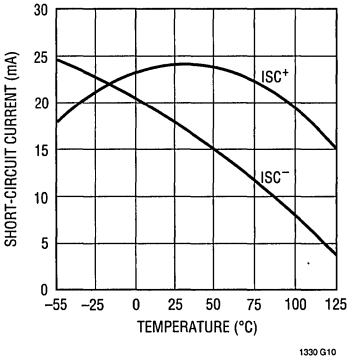


Driver Leakage in SHUTDOWN

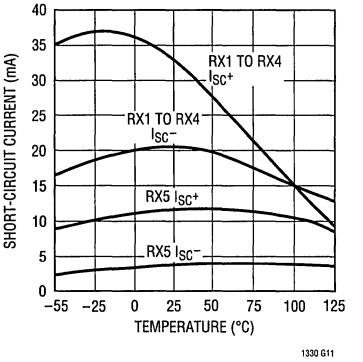


TYPICAL PERFORMANCE CHARACTERISTICS

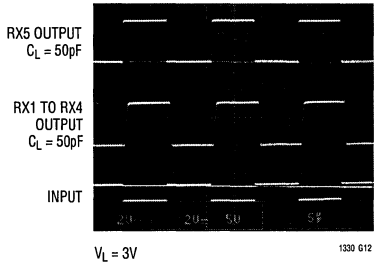
Driver Short-Circuit Current



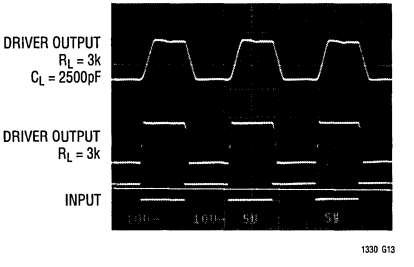
Receiver Short-Circuit Current



Receiver Output Waveforms



Driver Output Waveforms



PIN FUNCTIONS

V_{CC}: 5V Input Supply Pin. This pin should be decoupled with a 0.1µF ceramic capacitor close to the package pin. Insufficient supply bypassing can result in low output drive levels and erratic charge pump operation.

V_L: 3V Logic Supply Pin for all RS232 Receivers. Like V_{CC}, the V_L input should be decoupled with a 0.1µF ceramic capacitor. This pin may also be connected to 5V.

GND: Ground Pin.

ON/OFF: TTL/CMOS Compatible Operating Mode Control. A logic low puts the device in the low power SHUTDOWN mode. All three drivers and four receivers (RX1, RX2, RX3, and RX4) assume a high impedance output state in SHUTDOWN. Only receiver RX5 remains active while the transceiver is in SHUTDOWN. The transceiver consumes only 60µA of supply current while in SHUTDOWN. A logic high fully enables the transceiver.

DRIVER DISABLE: This pin provides an alternate control for the charge pump and RS232 drivers. A logic high on this pin shuts down the charge pump and places all driver outputs in a high impedance state. All five receivers remain active under these conditions. Floating the driver disable pin or driving it to a logic low level fully enables the transceiver. A logic low on the On/Off pin supersedes the state of the Driver Disable pin. Supply current drops to 3mA when in DRIVER DISABLE mode.

V^+: Positive Supply Output. $V^+ \approx 2V_{CC} - 1.5V$. This pin requires an external charge storage capacitor, $C \geq 1.0\mu F$, tied to ground or 5V. Larger value capacitors may be used

PIN FUNCTIONS

to reduce supply ripple. The ratio of the capacitors on V^+ and V^- should be greater than 5 to 1.

V^-: Negative Supply Output. $V^- \approx -(2V_{CC} - 2.5V)$. This pin requires an external charge storage capacitor, $C \geq 0.1\mu F$. See the Applications Information section for guidance in choosing filter capacitors for V^+ and V^-.

$C1^+$, $C1^-$, $C2^+$, $C2^-$: Commutating Capacitor Inputs require two external capacitors, $C \geq 0.2\mu F$: one from $C1^+$ to $C1^-$, and another from $C2^+$ to $C2^-$. The capacitor's effective series resistance should be less than 2Ω. For $C \geq 1\mu F$, low ESR tantalum capacitors work well, although ceramic capacitors may be used with a minimal reduction in charge pump compliance.

DRIVER IN: RS232 Driver Input Pins. These inputs are TTL/CMOS compatible. Unused inputs should be connected to V_{CC}.

DRIVER OUT: Driver Outputs at RS232 Voltage Levels. Driver output swing meets RS232 levels for loads up to 3k. Slew rates are controlled for lightly loaded lines. Output current capability is sufficient for load conditions up to 2500pF. Outputs are in a high impedance state when in SHUTDOWN mode, V_{CC} = 0V, or when the driver disable pin is active. Outputs are fully short-circuit protected from V^- + 30V to V^+ – 30V. Applying higher voltages will not damage the device if the overdrive is moderately current limited. Short circuits on one output can load the power supply generator and may disrupt the signal levels of the other outputs. The driver outputs are protected against ESD to ±10kV for human body model discharges.

RX IN: Receiver Inputs. These pins accept RS232 level signals (±30V) into a protected 5k terminating resistor. The receiver inputs are protected against ESD to ±10kV for human body model discharges. Each receiver provides 0.4V of hysteresis for noise immunity. Open receiver inputs assume a logic low state.

RX OUT: Receiver Outputs with TTL/CMOS Voltage Levels. Outputs are in a high impedance state when in SHUTDOWN mode to allow data line sharing. Outputs, including LOW-Q RX OUT, are fully short-circuit protected to ground or V_{CC} with the power on, off, or in SHUTDOWN mode.

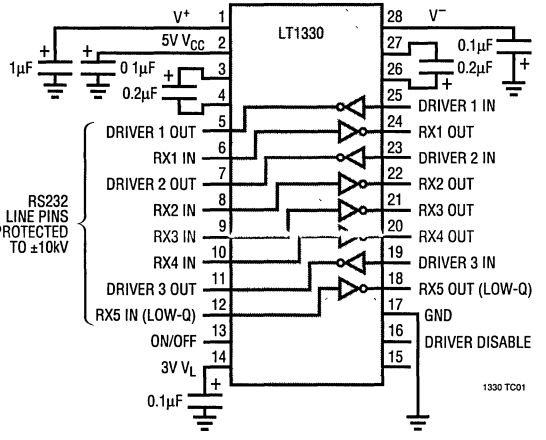
LOW Q-CURRENT RX IN: Low Power Receiver Input. This special receiver remains active when the part is in SHUTDOWN mode, consuming typically 60µA. This receiver has the same 5k input impedance and ±10kV ESD protection characteristics as the other receivers.

LOW Q-CURRENT RX OUT: Low Power Receiver Output. This pin produces the same TTL/CMOS output voltage levels as receivers RX1, RX2, RX3, and RX4 with slightly decreased speed and short-circuit current. Data rates to 120k baud are supported by this receiver.

ESD PROTECTION

The RS232 line inputs of the LT1330 have on-chip protection from ESD transients up to ±10kV. The protection structures act to divert the static discharge safely to system ground. In order for the ESD protection to function effectively, the power supply and ground pins of the LT1330 must be connected to ground through low impedances. The power supply decoupling capacitors and charge pump storage capacitors provide this low impedance in normal application of the circuit. The only constraint is that low ESR capacitors must be used for bypassing and charge storage. ESD testing must be done with pins V_{CC}, V_L, V^+, V^-, and GND shorted to ground or connected with low ESR capacitors.

ESD Test Circuit



APPLICATIONS INFORMATION

Storage Capacitor Selection

The V^+ and V^- storage capacitors must be chosen carefully to insure low ripple and stable operation. The LT1330 charge pump operates in a power efficient Burst Mode™. When storage capacitor voltage drops below a preset threshold, the oscillator is gated on until V^+ and V^- are boosted up to levels exceeding a second threshold. The oscillator then turns off, and current is supplied from the V^+ and V^- storage capacitors.

The V^- potential is monitored to control charge pump operation. It is therefore important to insure lower V^+ ripple than V^- ripple, or erratic operation of the charge pump will result. Proper operation is insured in most applications by choosing the V^+ filter capacitor to be at least 5 times the V^- filter capacitor value. If V^+ is more heavily loaded than V^-, a larger ratio may be needed.

The V^- filter capacitor should be selected to obtain low ripple when the drivers are loaded, forcing the charge pump into continuous mode. A minimum value 0.1µF is suggested.

Do not attempt to reduce V^- ripple when the charge pump is in discontinuous Burst Mode™ operation. The ripple in this mode is determined by internal comparator thresholds. Larger storage capacitor values increase the burst period, and do not reduce ripple amplitude.

Power Saving Operational Modes

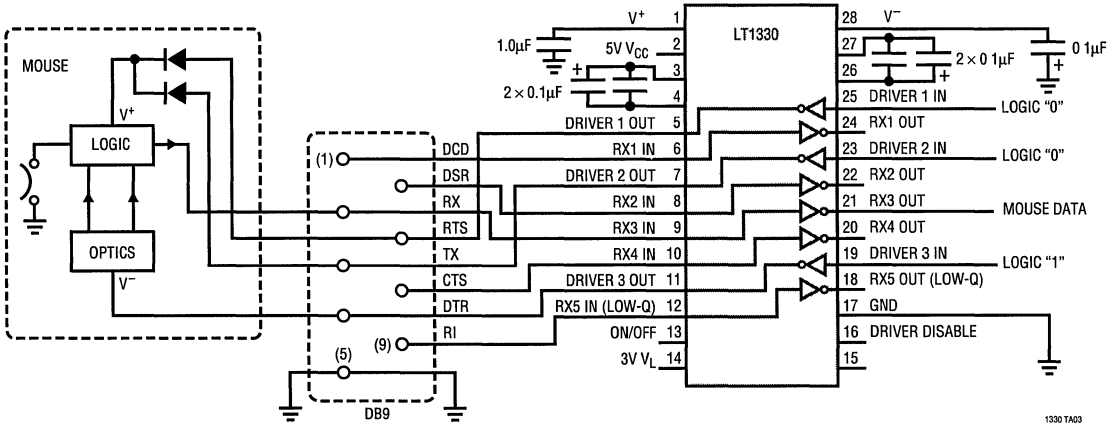
The LT1330 has both SHUTDOWN and DRIVER DISABLE operating modes. These operating modes can optimize power consumption based upon applications needs.

The On/Off shutdown control turns off all circuitry except for Low-Q RX5. When RX5 detects a signal, this information can be used to wake up the system for full operation.

If more than one line must be monitored, the DRIVER DISABLE mode provides a power efficient operating option. The DRIVER DISABLE mode turns off the charge pump and RS232 drivers, but keeps all five receivers active. Power consumption in DRIVER DISABLE mode is 3mA from V_{CC}.

Burst Mode is a trademark of Linear Technology Corporation

Typical Mouse Driving Application



3V RS562 or 5V/3V RS232 Transceiver with One Receiver Active in SHUTDOWN

February, 1993

FEATURES

- **RS232 Compatible 3 Volt Operation**
- **3V Logic Interface**
- **ESD Protection Over ±10kV**
- One Low Power Receiver Remains Active While in SHUTDOWN
- 60μA Supply Current in SHUTDOWN
- Low Power Driver Disable Mode
- Uses Small Capacitors (0.1μF, 0.2μF, 1.0μF)
- Operates to 120k Baud
- CMOS Comparable Low Power: 60mW
- Easy PC Layout Flow-Through Architecture
- Rugged Bipolar Design
- Outputs Assume a High Impedance State When Off or Powered Down

APPLICATIONS

- Notebook Computers
- Palmtop Computers

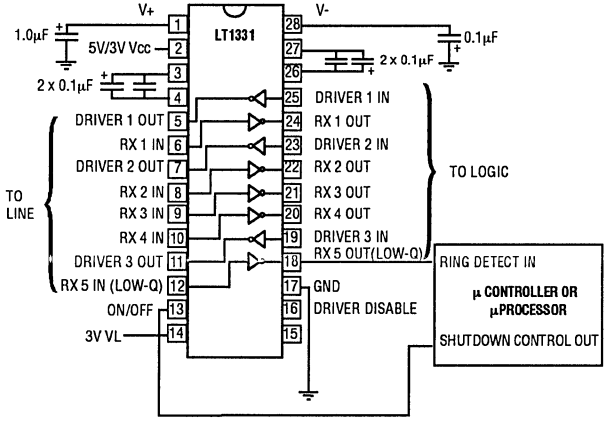
DESCRIPTION

The LT1331 is a 3 driver, 5 receiver RS232 transceiver designed for 3V and mixed 3V/5V systems. Receivers operate from 3V supply V_L, while the on-board charge pump and drivers operate from 5V or 3V supply V_{CC}.

The transceiver has two shutdown modes. One mode disables the drivers and the charge pump, the other shuts down all circuitry except for one low power receiver which can be used for ring detection. The V_{CC} supply may be shut down while in ring detection mode. While shut down, the drivers and receivers assume high impedance output states.

The LT1331 is fully compliant with all EIA-RS232 specifications when V_{CC}=5V. If V_{CC}=3V, output drive levels are compatible with all known interface circuits. Special bipolar construction techniques protect the drivers and receivers beyond the fault conditions stipulated for RS232. The RS232 I/O pins are resilient to multiple ±10kV ESD strikes. An advanced driver output stage operates up to 120k baud while driving heavy capacitive loads.

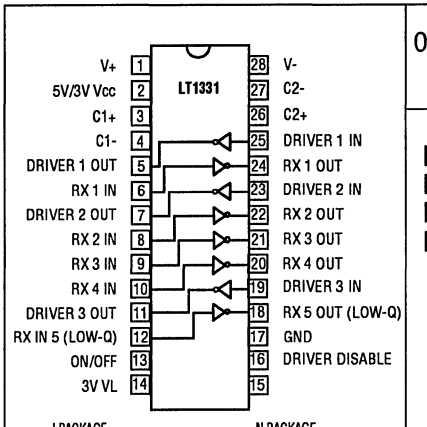
Typical Application



ABSOLUTE MAXIMUM RATINGS

Supply Voltage (V_{CC}) 6V
Supply Voltage (V_L) 6V
V+ 13.2V
V- ..... -13.2V
Input Voltage
  Driver ..... V+ to V-
  Receiver ..... 30V to -30V
  ON/OFF ..... -0.3V to V_{CC}+0.3V
  Driver Disable ..... -0.3V to V_{CC}+0.3V
Output Voltage
  Driver ..... -30V to 30V
  Receiver ..... -0.3V to V_L+0.3V
Short Circuit Duration
  V+ 30s
  V- 30s
  Driver Output ..... Indefinite
  Receiver Output ..... Indefinite
Operating Temperature Range
  LT1331C ..... 0°C to 70°C

PACKAGE/ORDER INFORMATION



ORDER PART NUMBER

LT1331CJ
LT1331CN
LT1331CS
LT1331CG

ELECTRICAL CHARACTERISTICS (Note 1)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Power Supply Generator						
V+ Output	V_{CC}=5V V_{CC}=3.3V			8.6 5.5		V V
V- Output	V_{CC}=5V V_{CC}=3.3V			-7.0 -4.8		V V
Supply Current (V_{CC})	V_{CC}=5V (Note 2) V_{CC}=3.3V			12 12	17 17	mA mA
Supply Current (V_L)	(Note 3)			3	5	mA
Supply Current When OFF (V_{CC})	SHUTDOWN (Note 4) DRIVER DISABLE	● 		2 0.1	50 1	µA mA
Supply Current When OFF (V_L)	SHUTDOWN (Note 4) DRIVER DISABLE	● 		60 3	100 5	µA mA
Supply Rise Time, SHUTDOWN to Turn On	C1=C2=0.2uF, C+=1.0µF, C-=0.1µF			2		msec
ON/OFF Pin Thresholds	Input Low Level (Device SHUTDOWN) Input High Level (Device Enabled)	● ●	 2.4	1.4 1.4	0.8 	V V
ON/OFF Pin Current	0V ≤ $V_{ON/OFF}$ ≤ 5V	●	-15		80	µA
Driver Disable Pin Thresholds	Input Low Level (Drivers Enabled) Input High Level (Drivers Disabled)	● ●	 2.4	1.4 1.4	0.8 	V V
DRIVER DISABLE Pin Current	0V ≤ $V_{DRIVER\ DISABLE}$ ≤ 5V	●	-10		500	µA

ELECTRICAL CHARACTERISTICS (Note 2)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Any Driver						
Output Voltage Swing, Positive	V_{CC}=5V, R_L=3k V_{CC}=3.3V, R_L=3k	● 	5.0 3.7	6.5 4.0		V V
Output Voltage Swing, Negative	V_{CC}=5V, R_L=3k V_{CC}=3.3V, R_L=3k	● 		- 6.0 - 3.3	- 5.0 - 2.7	V V
Logic Input Voltage Level	Input Low Level (V_{OUT}=High) Input High Level (V_{OUT}=Low)	● ●	 2.0	1.4 1.4	0.8 	V V
Logic Input Current	0.8V ≤ V_{IN} ≤ 2.0V	●		5	20	µA
Output Short Circuit Current	V_{OUT} = 0V			17		mA
Output Leakage Current	SHUTDOWN Vout = ±30V (Note 4)	●		10	100	µA
Slew Rate	R_L=3K, C_L=51pF R_L=3K, C_L=2500pF			15 6	30 	V/µs V/µs
Propagation Delay	Output Transition t_{HL} High to Low (Note 5) Output Transition t_{LH} Low to High			0.6 0.5	1.3 1.3	µS µS
Any Receiver						
Input Voltage Thresholds	Input Low Threshold (V_{OUT}=High) Input High Threshold (V_{OUT}=Low)		0.8 	1.3 1.7	 2.4	V V
Hysteresis		●	0.1	0.4	1.0	V
Input Resistance			3	5	7	kΩ
Receivers 1 Through 4						
Output Voltage	Output Low, i_{OUT} = -1.6mA Output High, i_{OUT} = 160µA (V_L = 3.3)	● ●	 2.0	0.2 2.4	0.4 	V V
Output Short Circuit Current	Sinking Current, V_{OUT} = V_{CC} Sourcing Current, V_{OUT} = 0V		 10	- 20 20	- 10 	mA mA
Propagation Delay	Output Transition t_{HL} High to Low (Note 6) Output Transition t_{LH} Low to High			250 350	600 600	nS nS
Ouput Leakage Current	SHUTDOWN (Note 4) 0 ≤ V_{OUT} ≤ V_{CC}	●		1	10	µA
Receiver 5 (LOW Q-CURRENT RX)						
Output Voltage	Output Low, i_{OUT} = -500µA Output High, i_{OUT} = 160µA (V_L = 3V)	● ●	 2.0	0.2 2.4	0.4 	V V
Output Short Circuit Current	Sinking Current, V_{OUT} = Vcc Sourcing Current, V_{OUT} = 0V		 2	- 4 4	- 2 	mA mA
Propagation Delay	Output Transition t_{HL} High to Low (Note 6) Output Transition t_{LH} Low to High			1.0 1.0	3 3	µS µS

The ● denotes specifications which apply over the operating temperature range. (0 °C ≤ T_A ≤ 70° C for commercial grade, -40°C ≤ T_A ≤ 85°C for industrial grade, and -55°C ≤ T_A ≤ 125°C for military grade.)

Note 1: Testing done at V_{CC} = 5V, V_L = 3.3V, and $V_{ON/OFF}$ = 3V.

Note 2: Supply current is measured as the average over several charge pump burst cycles. C+=1.0µF, C-=0.1µF, C1=C2=0.2µF. All outputs are open, with all driver inputs tied high.

Note 3: V_L supply current is measured with all receiver outputs high.

Note 4: Supply current and leakage current measurements in SHUTDOWN are performed with $V_{ON/OFF}$ ≤ 0.1V. Supply current measurements using DRIVER DISABLE are performed with $V_{DRIVER\ DISABLE}$ ≥ 3V.

Note 5: For driver delay measurements, R_L = 3K and C_L = 51pF. Trigger points are set between the driver's input logic threshold and the output transition to the zero crossing. (t_{HL} = 1.4V to 0V and t_{LH} = 1.4V to 0V)

Note 6: For receiver delay measurements, C_L = 51pF. Trigger points are set between the receiver's input logic threshold and the output transition to standard TTL/CMOS logic threshold. (t_{HL} = 1.3V to 2.0V and t_{LH} = 1.7V to 0.8V)

PIN FUNCTIONS

V_{CC}: 3V or 5V power supply for charge pump and drivers. This supply is not used by keep alive receiver RX5, so V_{CC} may be powered down when in the SHUTDOWN mode for system power savings. The V_{CC} pin should be decoupled with a 0.1µF ceramic capacitor.

V_L: 3V power supply for receivers. The V_L pin should be decoupled with a 0.1µF ceramic capacitor.

GND: Ground.

ON/OFF: A TTL/CMOS compatible operating mode control. A logic low puts the device in the SHUTDOWN mode. All drivers and four of the receivers go to a high impedance state, and the V_{CC} supply may be turned off. A logic high fully enables the transceiver.

DRIVER DISABLE: This pin provides an alternate operating mode control. A logic high shuts down the charge pump, placing all drivers in a high impedance state. All receivers remain active. Floating the pin, or driving it to a logic low, fully enables the transceiver.

V^+: Positive supply output. $V^+ \cong 2Vcc - 1.5V$. The V^+ output is short circuit proof for 30 seconds. This pin requires an external capacitor for charge storage. With V_{CC}=3V, the V^+ charge storage capacitor should be chosen to minimize ripple to acceptable levels. A minimum size of 0.1µF is recommended for 3V operation. With V_{CC}=5V, the capacitor must be at least 5X the value chosen for the V^- storage capacitor. The recommended minimum value of C^+ for 5V operation is 1µF. (Units shipped with date code after 9326 may use 0.1µF filter capacitors on V^+).

V^-: Negative supply output. $V^- \cong -(2Vcc-2.5V)$. V^- is short circuit proof for 30 seconds. This pin requires an external charge storage capacitor. The V^- storage capacitor should be chosen to minimize ripple on V^-. A minimum value of 0.1µF is recommended. When V_{CC}=5V, ripple must be measured with the outputs loaded to insure continuous mode operation of the charge pump. See Applications Information for additional guidance in choosing storage capacitors.

$C1^+$;$C1^-$;$C2^+$;$C2^-$: Commutating capacitor inputs. These pins require two external capacitors $C \geq 0.2\mu F$. One from $C1^+$ to $C1^-$, and another from $C2^+$ to $C2^-$. To maintain charge pump efficiency, the capacitor's effective series resistance should be less than 2 Ohms. Low ESR tantalum capacitors work well in this application, although small value ceramic capacitors may be used with minimal reduction in charge pump compliance.

DRIVER IN: RS232 driver inputs. Inputs are TTL/CMOS compatible. Tie unused inputs to V_{CC}.

DRIVER OUT: RS232 Driver outputs. Outputs are in a high impedance state when in SHUTDOWN , Driver Disable, or V_{CC} = 0V. Outputs are fully short circuit protected from V^- + 30V to V^+ - 30V. Although the outputs are protected, short circuits on one output can load the power supply generator and may disrupt the signal levels of the other outputs. The driver outputs are protected against ESD to ±10kV for human body model discharges. Output levels of -3.3V to 4V are achieved when the circuit is operated with V_{CC} = 3.3V.

RX IN: Receiver inputs. These pins accept RS232 level signals (±30V) into a protected 5k Ohm terminating resistor. The receiver inputs are protected against ESD to ±10kV for human body model discharges. Each receiver provides 0.4V of hysteresis for noise immunity.

RX OUT: Receiver outputs. Outputs are in a high impedance state when in SHUTDOWN mode to allow data line sharing. Outputs, including LOW-Q RXOUT, are fully short circuit protected to ground, V_{CC}, or V_L.

LOW Q RX IN: Low power receiver input. This receiver remains active in SHUTDOWN mode, consuming only 60µA from supply V_L. This receiver has the same input and protection characteristics as the other receivers.

LOW Q RX OUT: Low power receiver output. This pin produces the same output levels as standard receivers, with slightly decreased speed and short circuit current.

APPLICATIONS INFORMATION

POWER SAVING OPERATIONAL MODES

The LT1331 has both Shutdown and Driver Disable operating modes. These operating modes can optimize power consumption based upon applications needs.

The Shutdown control turns off all circuitry except for Low-Q RX5. RX5 operates entirely from the V_L power supply, so the power consumption from V_{CC} drops to zero. The V_{CC} power supply may be turned off while in shutdown, which may allow greater power savings in some systems. When RX5 detects a signal, this information can be used to wake up the system for full operation.

If more than one line must be monitored, the Driver Disable mode provides a power efficient operating option. The Driver Disable mode turns off the charge pump and RS232 drivers, but keeps all five receivers active. Power consumption in Driver Disable mode is 3mA from V_L and less than 100µA from V_{CC}.

Shutdown and Driver Disable operating modes are available in both mixed 5V/3V or 3V only power supply operation.

MIXED 5V/3V OPERATION

Driver Outputs

When operated with V_{CC}=5V and V_L=3.3V supplies, the RS232 Drivers meet or exceed all RS232 or V.28 communication interface standards. Data rates up to 120k baud are supported, and all standard RS232 compatible mice may be driven by the LT1331.

Driver outputs are protected from line shorts to ground or power supplies. Overvoltage conditions to +/-30V are tolerated in operational , SHUTDOWN or power off modes. Outputs of other drivers may be adversely affected during the fault conditions however.

Storage Capacitor Selection

The V^+ and V^- storage capacitors must be chosen carefully to insure low ripple and stable operation of the LT1331. The V^- filter capacitor should be selected to obtain low ripple when the drivers are loaded, forcing the charge pump into continuous operating mode. A minimum value 0.1µF is suggested.

Do not attempt to reduce V^- ripple when the charge pump is in discontinuous operation. The ripple in this mode is determined by internal comparator thresholds. Larger storage capacitor values increase the burst period, and do not reduce ripple amplitude.

V+ filter capacitor selection must insure lower V^+ ripple than V^- ripple, or erratic operation of the charge pump will result. Proper operation is insured in most applications by choosing the V^+ filter capacitor to be at least 5X the V^- filter capacitor value. If V^+ is more heavily loaded than V^-, a larger ratio may be needed. (The requirement for larger V+ filter capacitance will not be needed on units with date code 9326 or later, 0.1µF will be acceptable.)

+3V OPERATION

Driver Outputs

The LT1331 is not fully compliant with RS232 or V.28 standards when operated from 3V supplies, however there is sufficient output voltage swing to interface with nearly all RS232 receivers and transceivers. The driver output swing, when operated with V_{CC}=3.3V, is guaranteed to be at least -2.7V to 3.7V, with typical swing being -3.3 to 4.0V. This insures compatibility with all commonly used RS232 and RS562 interface circuits. Table 1. summarizes the receiver input threshold specifications for RS232 circuits from many manufacturers. Only a few receivers with negative thresholds are not fully compatible with the LT1331 driver outputs.

Storage Capacitor Selection

V^+ and V^- storage capacitor selection is less critical for V_{CC}=3V operation. The charge pump always operates continuously with V_{CC}=3V, so interaction between C^+ and C^- does not occur. Each capacitor may be chosen independently to reduce ripple to an acceptable level. The only constraint is that each capacitor should be ≥ 0.1µF.

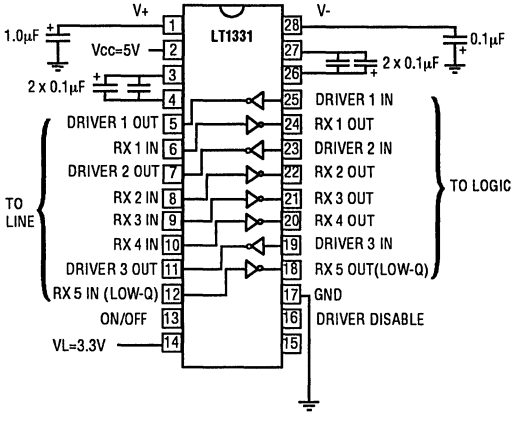
APPLICATIONS INFORMATION

Table 1. Commonly Used RS232 Interface Circuit Receiver Thresholds

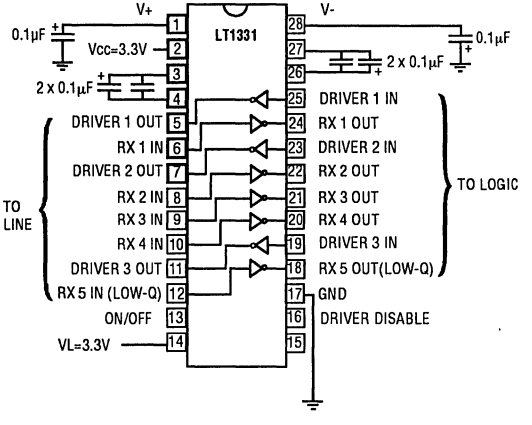
MANUFACTURER	PART NUMBER	COMPATIBLE	INPUT LOW THRESHOLD			INPUT HIGH THRESHOLD		
			MIN	TYP	MAX	MIN	TYP	MAX
LINEAR TECHNOLOGY	LT1080	√	0.8	1.3	-	-	1.7	2.4
	LT1137A	√	0.8	1.3	-	-	1.7	2.4
	LT1330	√	0.8	1.3	-	-	1.7	2.4
	LT1281	√	0.8	1.3	-	-	1.7	2.4
	ALL OTHERS	√						
TEXAS INSTRUMENTS	SN75189	√	0.65	1.0	1.25	0.9	1.3	1.6
	SN75189A	√	0.65	1.0	1.25	1.55	1.9	2.25
	MAX232	√	0.8	1.2	_	-	1.7	2.4
	SN75C185	√	0.65	1.0	1.25	1.6	2.1	2.55
MAXIM	MAX232A	√	0.8	1.3	-	-	1.8	2.4
	MAX241	√	0.6	1.2	-	-	1.5	2.4
SIPEX	SP232	√	0.8	1.2	-	-	1.7	2.4
	SP301	√	0.75	-	1.35	1.75	-	2.5
MOTOROLA	MC1489	√	0.75	-	1.25	1	-	1.5
	MC1489A	√	0.75	0.8	1.25	1.75	1.95	2.25
NATIONAL	DS1489	√	0.75	1.0	1.25	1.0	1.25	1.5
	DS14C89A	√	0.5	-	1.9	1.3	-	2.7

TYPICAL APPLICATIONS

Basic Mixed 5V/3V Supply Operation

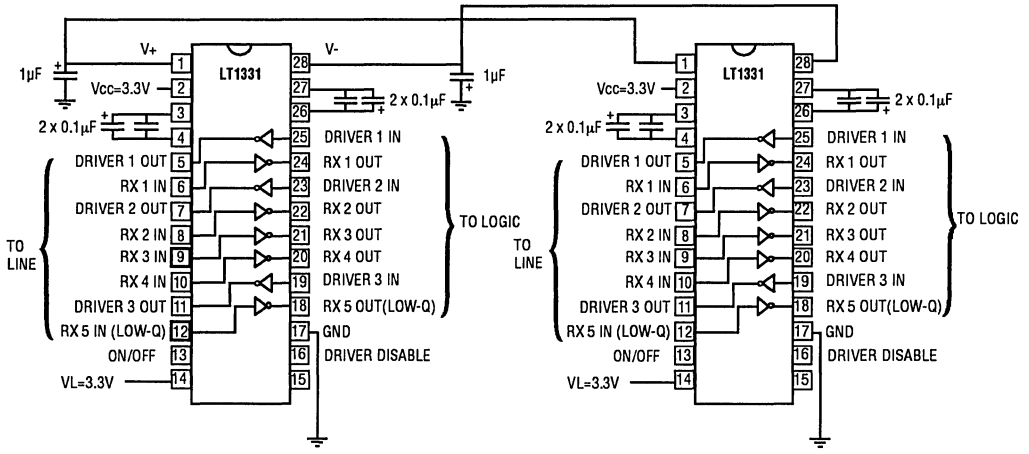


Basic 3V Supply Operation



TYPICAL APPLICATIONS

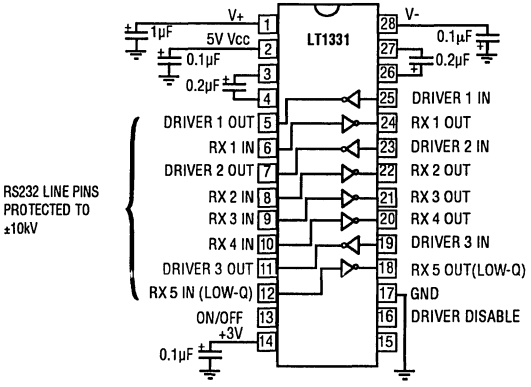
+3.3V Parallel Operation with Shared Storage Capacitors



ESD PROTECTION

The RS232 line inputs of the LT1331 have on-chip protection from ESD transients up to ±10kV. The protection structures act to divert the static discharge safely to system ground. In order for the ESD protection to function effectively, the power supply and ground pins of the LT1331 must be connected to ground through low impedances. The power supply decoupling capacitors and charge pump storage capacitors provide this low impedance in normal application of the circuit. The only constraint is that low ESR capacitors must be used for bypassing and charge storage. ESD testing must be done with pins V_{CC}, V_L, V^+, V^-, and GND shorted to ground or connected with low ESR capacitors.

ESD Test Circuit



PRELIMINARY

LT1332

Wide Supply Range Low Power RS232 Transceiver With 12V Vpp Output for FLASH Memory

February, 1993

FEATURES

- Generates Full RS232 Signal Levels from **3V Supply**
- 12V Vpp Output Available for FLASH Memory
- Useful with a Wide Variety of Switching Regulators
- Low Supply Current, I(Vcc) = 1mA
- Wide Supply Range , 2 ≤ Vcc ≤ 6
- **ESD Protection to ±10kV**
- Operates to 120kbaud
- Outputs Assume a High Impedance States When Off or Powered Down
- One µPower Receiver Remains Active while in SHUTDOWN
- Flow Through Architecture Eases PC Board Layout
- 60µA Supply Current in SHUTDOWN
- Absolutely No Latchup
- Available in SO and SSOP Packages

APPLICATIONS

- Notebook and Palmtop Computers
- Mouse Driver Circuits

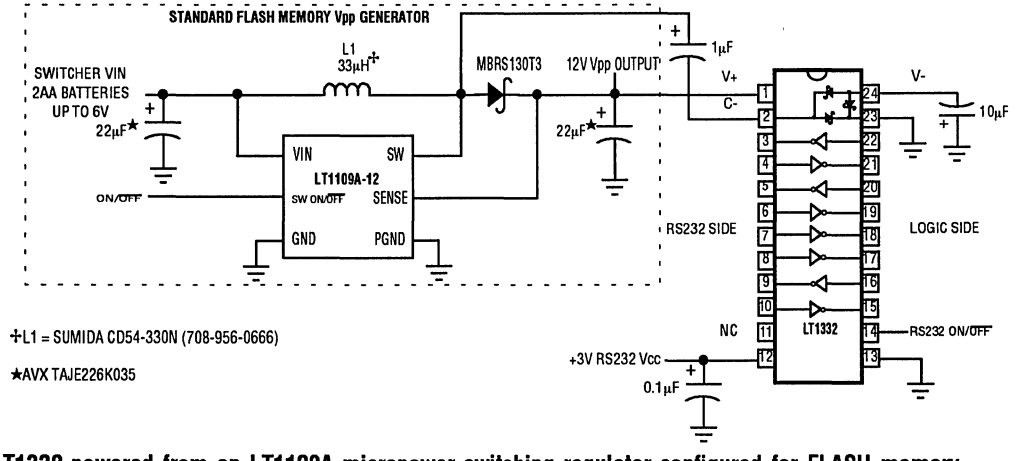
DESCRIPTION

The LT1332 is a 3 driver, 5 receiver RS232 transceiver, designed to be used in conjunction with a switching regulator. The LT1332 shares the regulator's positive output, while charge is capacitively pumped from the regulator's switch pin to the negative supply. Schottky rectifiers built into the LT1332 simplify the charge pump design.

The LT1332/Switcher combination generates fully compliant RS232 signal levels from as little as 2V of input supply. The switcher can deliver greater than 100mA of ouput current, making the LT1332 an excellent choice for mouse driver circuits.

Advanced driver output stages operate up to 120Kbaud while driving heavy capacitive loads. New ESD structures on chip make the LT1332 resilient to multiple ±10kV strikes, eliminating costly transient supressors.

A shutdown pin disables the transceiver except for one receiver which remains active for detecting incoming RS232 signals. When shutdown, the drivers and receivers assume high impedance output states.



LT1332 powered from an LT1109A micropower switching regulator configured for FLASH memory.

LTC1337

5V Micropower RS232 3-Driver/5-Receiver Transceiver

January 1993

FEATURES

- Low Supply Current **300μA**
- 1μA Supply Current in SHUTDOWN
- ESD Protection Over ±10kV
- Operates from a Single 5V Supply
- Uses Small Capacitors 0.1μF
- Operates to 120k Baud
- Three-State Outputs Are High Impedance When Off
- Output Overvoltage Does Not Force Current Back into Supplies
- RS232 I/O Lines Can Be Forced to ±25V without Damage
- Pin Compatible with LT1137A and LT1237
- Flowthrough Architecture

APPLICATIONS

- Notebook Computers
- Palmtop Computers

DESCRIPTION

The LT1337 is a 3-driver/5-receiver RS232 transceiver with very low supply current. In the no load condition, the supply current is only **300μA**. The charge pump only requires four 0.1μF capacitors and can supply up to 12mA of extra current to power external circuitry.

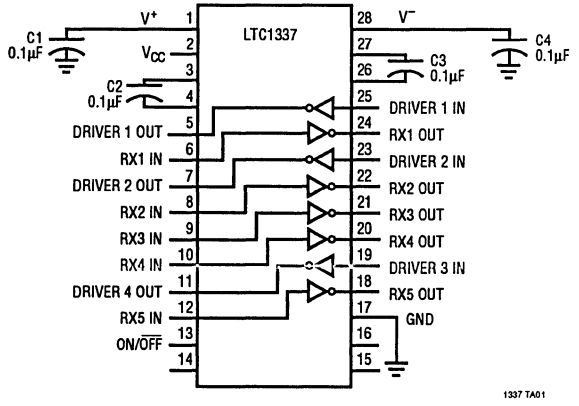
In SHUTDOWN mode, the supply current is further reduced to 1μA. All RS232 outputs assume a high impedance state in SHUTDOWN and with the power off.

The LTC1337 is fully compliant with all RS232 specifications. The transceiver can operate up to 120k baud with a 1000pF//3kΩ load. Both driver outputs and receiver inputs can be forced to ±25V without damage, and can survive multiple ±10kV ESD strikes.

The LTC1337 is the first of LTC's new micropower interface products. Other driver/receiver combination versions will be available shortly. Call factory for newest released products.

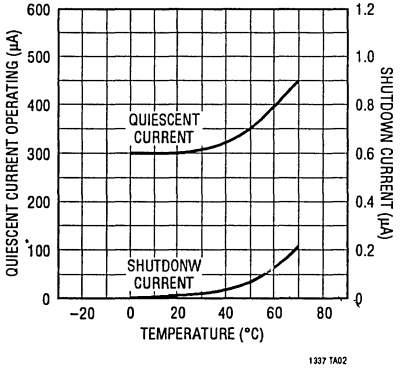
TYPICAL APPLICATION

3-Drivers/5-Drivers with SHUTDOWN



1337 TA01

Supply Current

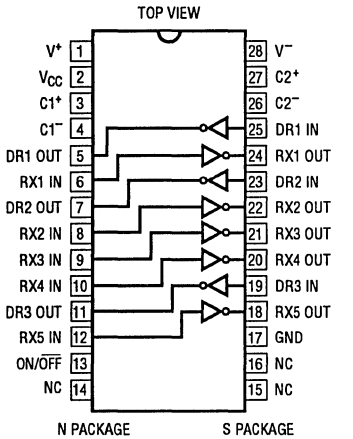


1337 TA02

ABSOLUTE MAXIMUM RATINGS

Supply Voltage (V_{CC}) 6V
Input Voltage
  Driver ..... −0.3V to V_{CC} + 0.3V
  Receiver ..... −25V to 25V
  On/$\overline{Off}$ Pin ..... −0.3V to V_{CC} + 0.3V
Output Voltage
  Driver .....−25V to 25V
  Receiver..... −0.3V to V_{CC} + 0.3V
Short Circuit Duration
  V^+ ..... 30 sec
  V^- ..... 30 sec
  Driver Output ..... Indefinite
  Receiver Output ..... Indefinite
Operating Temperature Range
  Commercial (LTC1337C) ..... 0°C to 70°C
Storage Temperature Range..... −65°C to 150°C
Lead Temperature (Soldering, 10 sec) ..... 300°C

PACKAGE/ORDER INFORMATION



N PACKAGE
28-LEAD PLASTIC DIP

S PACKAGE
28-LEAD PLASTIC SOL

G PACKAGE
28-LEAD SSOP

ORDER PART NUMBER

LTC1337CN
LTC1337CS
LTC1337CG

DC ELECTRICAL CHARACTERISTICS

V_{CC} = 5V, C1 = C2 = C3 = C4 = 0.1µF, unless otherwise noted.

PARAMETER	CONDITIONS			MIN	TYP	MAX	UNITS
Any Driver							
Output Voltage Swing	3k to GND	Positive	●	5.0	7.0		V
		Negative	●	−5.0	−6.5		V
Logic Input Voltage Level	Input Low Level (V_{OUT} = High)		●		1.4	0.8	V
	Input High Level (V_{OUT} = Low)		●	2.0	1.4		V
Logic Input Current	V_{IN} = 5V		●			5	µA
	V_{IN} = 0		●			−5	µA
Output Short-Circuit Current	V_{OUT} = 0V				±10		mA
Output Leakage Current	SHUTDOWN, V_{OUT} = ±20V (Note 3)		●		10	100	µA
Any Receiver							
Input Voltage Thresholds	Input Low Threshold		●	0.8	1.3		V
	Input High Threshold		●		1.7	2.4	V
Hysteresis			●	0.1	0.4	1	V
Input Resistance				3	5	7	kΩ
Output Voltage	Output Low, I_{OUT} = −1.6mA (V_{CC} = 5V)		●		0.2	0.4	V
	Output High, I_{OUT} = 160µA (V_{CC} = 5V)		●	3.5	4.8		V
Output Short-Circuit Current	Sinking Current, V_{OUT} = V_{CC}			−15	−40		mA
Output Leakage Current	SHUTDOWN, 0 ≤ V_{OUT} ≤ V_{CC} (Note 3)		●		1	10	µA
Power Supply Generator							
V^+ Output Voltage	I_{OUT} = 0mA		●	7.0	8.0		V
	I_{OUT} = 12mA		●	6.8	7.5		V
V^- Output Voltage	I_{OUT} = 0mA		●	−7.0	−8.0		V
	I_{OUT} = 12mA		●	−6.3	−7.0		V
Supply Rise Time	SHUTDOWN to Turn-On					0.2	ms

DC ELECTRICAL CHARACTERISTICS

V_{CC} = 5V, C1 = C2 = C3 = C4 = 0.1µF, unless otherwise noted.

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Power Supply						
V_{CC} Supply Current	No Load (Note 2)	●		0.3	0.5	mA
Supply Leakage Current (V_{CC})	SHUTDOWN (Note 3)	●		1	10	µA
On/$\overline{Off}$ Threshold Low		●		1.4	0.8	V
On/$\overline{Off}$ Threshold High		●	2.0	1.4		V

AC CHARACTERISTICS

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Slew Rate	R_L = 3k, C_L = 51pF			8	30	V/µs
	R_L = 3k, C_L = 2500pF		2	4		V/µs
Driver Propagation Delay	t_{HLD} (Figure 1)	●		2	3	µs
(TTL to RS232)	t_{LHD} (Figure 1)	●		2	3	µs
Receiver Propagation Delay	t_{HLR} (Figure 2)	●		0.3	0.6	µs
(RS232 to TTL)	t_{LHR} (Figure 2)	●		0.2	0.6	µs

The ● denotes specifications which apply over the operating temperature range (0°C ≤ T_A ≤ 70°C).

Note 1: Absolute Maximum Ratings are those values beyond which the life of the device may be impaired.

Note 2: Supply current is measured with driver and receiver outputs unloaded and driver inputs tied high.

Note 3: Supply current measurement in SHUTDOWN is performed with V_{ON} = 0V.

SWITCHING TIME WAVEFORMS

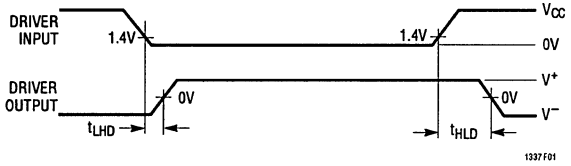


Figure 1. Driver Propagation Delay Timing

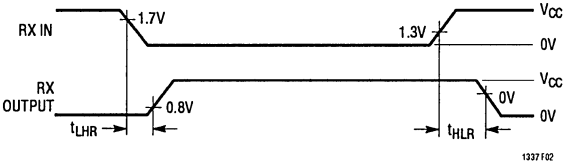


Figure 2. Receiver Propagation Delay Timing

TEST CIRCUITS

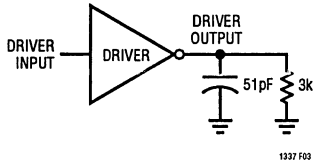


Figure 3. Driver Timing Test Load

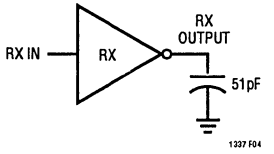


Figure 4. Receiver Timing Test Load

PIN FUNCTIONS

V_{CC}: 5V Input Supply Pin. Supply current less than 1µA in the SHUTDOWN mode. This pin should be decoupled with a 0.1µF ceramic capacitor.

GND: Ground Pin.

ON/$\overline{OFF}$: TTL/CMOS Compatible Shutdown Pin. A logic low puts the device in the SHUTDOWN mode which reduces input supply current to less than 1µA and places all drivers and receivers in high impedance state.

V^+: Positive Supply Output (RS232 Drivers). $V^+ \cong 2V_{CC} - 1V$. This pin requires an external capacitor C = 0.1µF for charge storage. The capacitor may be tied to ground or 5V. With multiple devices, the V^+ and V^- pins may be paralleled into common capacitors. For large numbers of devices, increasing the size of the shared common storage capacitors is recommended to reduce ripple.

V^-: Negative Supply Output (RS232 Drivers). $V^+ \cong 2V_{CC} - 1.5V$). This pin requires an external capacitor C = 0.1µF for charge storage.

$C1^+$, $C1^-$, $C2^+$, $C2^-$: Commutating Capacitor Inputs. These pins require two external capacitors C = 0.1µF. One from $C1^+$ to $C1^-$, and another from $C2^+$ to $C2^-$. To maintain charge pump efficiency, the capacitor's effective series resistance should be less than 50Ω.

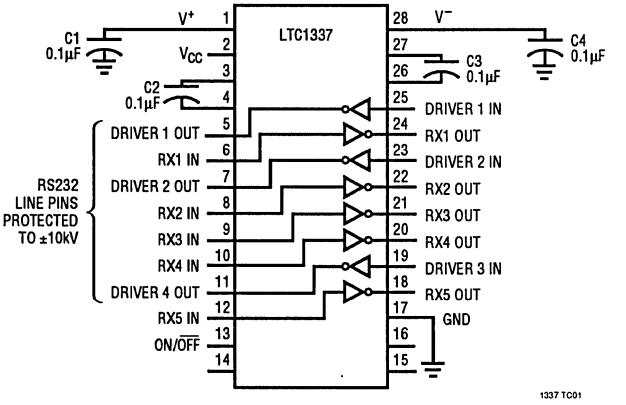
DRIVER IN: RS232 Driver Input Pins. Inputs are TTL/CMOS compatible. Inputs should not be allowed to float. Tie unused inputs to V_{CC}.

DRIVER OUT: Driver Outputs at RS232 Voltage Levels. Outputs are in a high impedance state when in SHUTDOWN mode or V_{CC} = 0V. The driver outputs are protected against ESD to ±10kV for human body model discharges.

RX IN: Receiver Inputs. These pins accept RS232 level signals (±25V) into a protected 5k terminating resistor. The receiver inputs are protected against ESD to ±10kV for human body model discharges. Each receiver provides 0.4V of hysteresis for noise immunity.

RX OUT: Receiver Outputs with TTL/CMOS Voltage Levels. Outputs are in a high impedance state when in SHUTDOWN mode to allow data line sharing.

ESD Test Circuit



5V RS232 Transceiver with One Receiver Active in SHUTDOWN

January, 1993

FEATURES

- One Receiver Remains Active While in SHUTDOWN
- ESD Protection Over **±10kV**
- Uses Small Capacitors (0.1μF, 0.2μF)
- 60μA Supply Current in SHUTDOWN
- Pin Compatible with LT1137A
- Operates to 120k baud
- CMOS Comparable Low Power - 60mW
- Operates From a Single 5V Supply
- Easy PC Layout-Flow Through Architecture
- Rugged Bipolar Design
- Outputs Assume a High Impedance State When Off or Powered Down
- Absolutely No Latchup
- Available in SO and SSOP Packages

APPLICATIONS

- Notebook Computers
- Palmtop Computers

DESCRIPTION

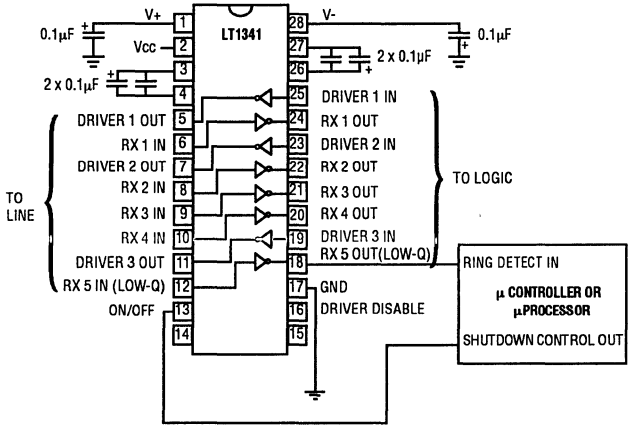
The LT1341 is an advanced low power three driver, five receiver RS232 transceiver. Included on the chip is a shutdown pin for reducing supply current to near zero. During shutdown one receiver remains active to detect incoming RS232 signals, for example, to wake up a system. All other receivers and the drivers assume high impedance states during SHUTDOWN.

The DRIVER DISABLE function provides additional control of operating mode. When DRIVER DISABLE is high the charge pump and drivers turn off. Receivers continue to operate during DRIVER DISABLE.

New ESD structures on the chip allow the LT1341 to survive multiple ±10kV strikes, eliminating the need for costly TranZorbs on the RS232 line pins.

The LT1341 is fully compliant with all EIA RS232 specifications and operates in excess of 120 kilobaud even driving heavy capacitive loads.

Typical Application

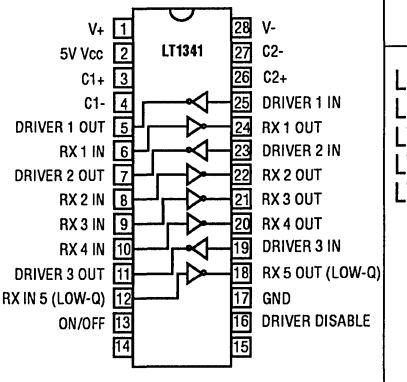


ABSOLUTE MAXIMUM RATINGS

(Note 1)

Supply Voltage (V_{CC}) 6V
V^+ 13.2V
V^- ..... -13.2V
Input Voltage
  Driver ..... V^+ to V^-
  Receiver ..... 30V to -30V
Output Voltage
  Driver ..... -30V to 30V
  Receiver ..... -0.3V to V_{CC}+0.3V
Short Circuit Duration
  V^+ 30s
  V^- 30s
  Driver Output ..... Indefinite
  Receiver Output ..... Indefinite
Operating Temperature Range
  LT1341I ..... -40°C to 85°C
  LT1341C ..... 0°C to 70°C
Storage Temperature Range ..... -65°C to 150°C
Lead Temperature (Soldering, 10 sec.) ..... 300°C

PACKAGE/ORDER INFORMATION



J PACKAGE
28-LEAD CERAMIC DIP

N PACKAGE
28-LEAD PLASTIC DIP

S PACKAGE
28-LEAD PLASTIC SOL

G PACKAGE
28-LEAD PLASTIC SSOP

ORDER PART NUMBER

LT1341IJ
LT1341CJ
LT1341CN
LT1341CS
LT1341CG

ELECTRICAL CHARACTERISTICS (Note 2)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Power Supply Generator						
V+ Output				8.6		V
V- Output				-7.0		V
Supply Current (V_{CC})	(Note 3)			14	17	mA
Supply Current when OFF (V_{CC})	SHUTDOWN (Note 4) DRIVER DISABLE	● 		0.06 3	0.150 	mA mA
Supply Rise Time SHUTDOWN to Turn On	C1=C2=0.2µF, C^+=C^-=0.1µF			2		ms
ON/OFF Pin Thresholds	Input Low Level (Device SHUTDOWN) Input High Level (Device Enabled)	● ●	 2.0	1.4 1.4	0.8 	V V
ON/OFF Pin Current	0V ≤ $V_{ON/OFF}$ ≤ 5V	●	-15		80	µA
Driver Disable Pin Thresholds	Input Low Level (Drivers Enabled) Input High Level (Drivers Disabled)	● ●	 2.0	1.4 1.4	0.8 	V V
DRIVER DISABLE Pin Current	0V ≤ $V_{DRIVER\ DISABLE}$ ≤ 5V	●	-10		500	µA
Oscillator Frequency				130		kHz

ELECTRICAL CHARACTERISTICS (Note 2)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Any Driver						
Output Voltage Swing	Load = 3k to GND Positive	●	5.0	7.3		V
	Negative	●	-5.0	-6.5		V
Logic Input Voltage Level	Input Low Level (V_{OUT}=High)	●		1.4	0.8	V
	Input High Level (V_{OUT}=Low)	●	2.0	1.4		V
Logic Input Current	0.8V ≤ V_{IN} ≤ 2.0V	●		5	20	µA
Output Short Circuit Current	V_{OUT} = 0V			17		mA
Output Leakage Current	SHUTDOWN V_{OUT} = ±30V (Note 4)	●		10	100	µA
Slew Rate	R_L=3k, C_L=51pF			15	30	V/µs
	R_L=3k, C_L=2500pF		4	15		V/µs
Propagation Delay	Output Transition t_{HL} High to Low (Note 5)			0.6	1.3	µS
	Output Transition t_{LH} Low to High			0.5	1.3	µS
Any Receiver						
Input Voltage Thresholds	Input Low Threshold (V_{OUT} = High)		0.8	1.3		V
	Input High Threshold (V_{OUT} = Low)			1.7	2.4	V
Hysteresis		●	0.1	0.4	1.0	V
Input Resistance			3	5	7	kΩ
Ouput Leakage Current	SHUTDOWN (Note) 0 ≤ V_{OUT} ≤ V_{CC}	●		1	10	µA
Receivers 1 Through 4						
Output Voltage	Output Low, I_{OUT} = -1.6mA	●		0.2	0.4	V
	Output High, I_{OUT} = 160µA (V_{CC}= 5V)	●	3.5	4.2		V
Output Short Circuit Current	Sinking Current, V_{OUT} = V_{CC}		-10	-20		mA
	Sourcing Current, V_{OUT} = 0V		10	20		mA
Propagation Delay	Output Transition t_{HL} High to Low (Note 6)			250	600	nS
	Output Transition t_{LH} Low to High			350	600	nS
Receiver 5 (LOW-I_Q RX)						
Output Voltage	Output Low, I_{OUT} = -500µA	●		0.2	0.4	V
	Output High, I_{OUT} = 160µA (V_{CC} = 5V)	●	3.5	4.2		V
Output Short Circuit Current	Sinking Current, V_{OUT} = V_{CC}		-2	-4		mA
	Sourcing Current, V_{OUT} = 0V		2	4		mA
Propagation Delay	Output Transition t_{HL} High to Low (Note 6)			1.0	3	µS
	Output Transition t_{LH} Low to High			1.0	3	µS

The ● denotes specifications which apply over the operating temperature range. (0°C ≤ T_A ≤ 70°C for commercial grade, -40°C ≤ T_A ≤ 85°C for industrial grade, and -55°C ≤ T_A ≤ 125°C for military grade.)

Note 1: Absolute Maximum Ratings are those values beyond which the life of the device may be impaired.

Note 2: Testing done at V_{CC} = 5V and $V_{ON/OFF}$=3V.

Note 3: Supply current is measured as the average over several charge pump burst cycles. C^+=C^-=0.1µF, C1=C2=0.2µF. All outputs are open, with all driver inputs tied high.

Note 4: Supply current measurements in SHUTDOWN are performed with $V_{ON/OFF}$ ≤ 0.1V. Supply current measurements using DRIVER DISABLE are performed with $V_{DRIVER\ DISABLE}$ ≥ 3V.

Note 5: For driver delay measurements, R_L = 3k and C_L = 51pF. Trigger points are set between the driver's input logic threshold and the output transition to the zero crossing. (t_{HL} = 1.4V to 0V and t_{LH} = 1.4V to 0V)

Note 6: For receiver delay measurements, C_L = 51pF. Trigger points are set between the receiver's input logic threshold and the output transition to standard TTL/CMOS logic threshold. (t_{HL} = 1.3V to 2.4V and t_{LH} = 1.7V to 0.8V)

PIN FUNCTIONS

V_{CC}: 5V Input supply pin. This pin should be decoupled with a 0.1uF ceramic capacitor.

GND: Ground Pin.

On/Off: A TTL/CMOS logic low puts the device in the low power SHUTDOWN mode. All of the drivers and four receivers go to a high impedance state. A logic high fully enables the transceiver.

DRIVER DISABLE: This pin provides an alternate control for the charge pump and RS232 drivers. A logic high on this pin shuts down the charge pump and places all drivers in a high impedance state. All receivers remain active under these conditions. Floating the driver disable pin or driving it to a logic low level fully enables the transceiver.

V^+: Positive supply output (RS232 drivers). $V^+ \approx 2V_{CC}$ - 1.5V. This pin requires an external charge storage capacitor C ≥0.1μF, tied to ground or V_{CC}. Larger value capacitors may be used to reduce supply ripple.

V^-: Negative supply output (RS232 drivers). $V^- \approx -(2V_{CC}$-2.5V). This pin requires an external charge storage capacitor C ≥ 0.1μF. To reduce supply ripple, increase the size of the storage capacitor.

$C1^+$;$C1^-$;$C2^+$;$C2^-$: Commutating capacitor inputs, require two external capacitors C ≥ 0.2μF. One from $C1^+$ to $C1^-$, and another from $C2^+$ to $C2^-$. The capacitor's effective series resistance should be less than 2Ω. For C ≥1μF, low ESR tantalum capacitors work well in this application, although small value ceramic capacitors may be used with a minimal reduction in charge pump compliance.

DRIVER IN: RS232 driver input pins. These inputs are TTL/CMOS compatible. Tie unused inputs to Vcc.

DRIVER OUT: Driver outputs at RS232 voltage levels. Outputs are in a high impedance state when in SHUTDOWN mode, V_{CC} = 0V, or when the driver disable pin is active. Outputs are fully short circuit protected from $V_{OUT}=V^-$ + 30V to $V_{OUT}=V^+$ - 30V. Applying higher voltages will not damage the device if the overdrive is moderately current limited. Short circuits on one output can load the power supply generator and may disrupt the signal levels of the other outputs. The driver outputs are protected against ESD to ±10kV for human body model discharges.

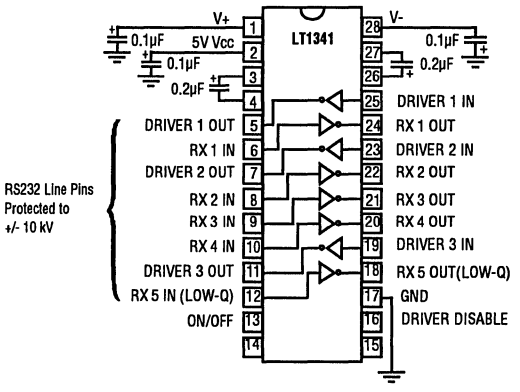
RX IN: Receiver inputs. These pins accept RS232 level signals (±30V) into a protected 5kΩ terminating resistor. The receiver inputs are protected against ESD to ±10kV for human body model discharges. Each receiver provides 0.4V of hysteresis for noise immunity.

RX OUT: Receiver outputs with TTL/CMOS voltage levels. Outputs are in a high impedance stage when in SHUTDOWN mode to allow data line sharing. Outputs, including LOW-Q RXOUT, are fully short circuit protected to ground or V_{CC} with the power on, off, or in SHUTDOWN mode.

LOW Q-CURRENT RX IN: Low power receiver input. This special receiver remains active when the part is in SHUTDOWN mode, consuming typically 60μA. This receiver has the same input and protection characteristics as the other receivers.

LOW Q-CURRENT RX OUT: Low power receiver output. This pin produces the same TTL/CMOS output voltage levels with slightly decreased speed and short circuit current.

ESD Test Circuit



5V RS232 Transceiver with 3V Logic Interface

January, 1993

FEATURES

- ESD Protection Over **±10kV**
- 3 Volt Logic Interface
- Uses Small Capacitors (0.1μF, 0.2μF)
- 1μA Supply Current in SHUTDOWN
- Low Power Driver Disable Operating Mode
- Pin Compatible with LT1137A
- Operates to 120k baud
- CMOS Comparable Low Power - 60mW
- Operates From a 5V Supply and 3V Logic Suppy
- Easy PC Layout: Flowthrough Architecture
- Rugged Bipolar Design
- Outputs Assume a High Impedance State When Off or Powered Down
- Absolutely No Latchup

APPLICATIONS

- Notebook Computers
- Palmtop Computers

DESCRIPTION

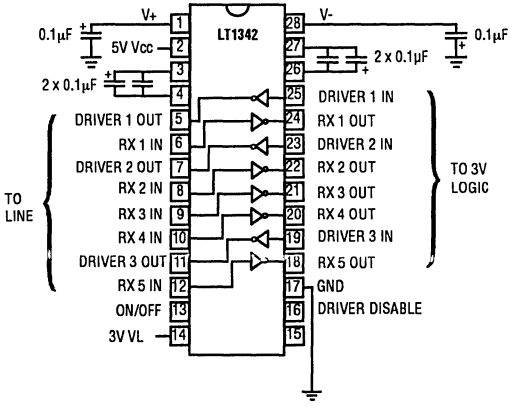
The LT1342 is an advanced low power three driver, five receiver RS232 transceiver. The LT1342 operates from a 5V supply and a 3V logic supply. Receiver outputs can interface directly to 3V logic circuits. Included on the chip is a shutdown pin for reducing supply current to near zero. All receivers and drivers assume high impedance states during SHUTDOWN.

The DRIVER DISABLE function provides additional control of operating mode. When DRIVER DISABLE is high the charge pump and drivers turn off. Receivers continue to operate during DRIVER DISABLE.

New ESD structures on the chip allow the LT1342 to survive multiple ±10kV strikes, eliminating the need for costly TranZorbs on the RS232 line pins.

The LT1342 is fully compliant with all EIA RS232 specifications and operates in excess of 120 kilobaud even driving heavy capacitive loads.

Basic Operation

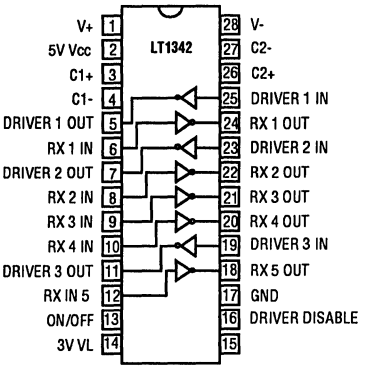


ABSOLUTE MAXIMUM RATINGS

(Note 1)

Supply Voltage (V_{CC}) 6V
Supply Voltage (V_L) 6V
V^+ 13.2V
V^- ..... -13.2V
Input Voltage
  Driver ..... V^- to V^+
  Receiver ..... -30V to 30V
Output Voltage
  Driver ..... -30V to 30V
  Receiver ..... -0.3V to V_{CC}+0.3V
Short Circuit Duration
  V^+ 30s
  V^- 30s
  Driver Output ..... Indefinite
  Receiver Output ..... Indefinite
Operating Temperature Range
  LT1342I ..... -40°C to 85°C
  LT1342C ..... 0°C to 70°C
Storage Temperature Range ..... -65°C to 150°C
Lead Temperature (Soldering, 10 sec.) ..... 300°C

PACKAGE/ORDER INFORMATION



J PACKAGE
28-LEAD CERAMIC DIP

N PACKAGE
28-LEAD PLASTIC DIP

S PACKAGE
28-LEAD PLASTIC SOL

G PACKAGE
28-LEAD PLASTIC SSOP

ORDER PART NUMBER
LT1342IJ
LT1342CJ
LT1342CN
LT1342CS
LT1342CG

ELECTRICAL CHARACTERISTICS (Note 2)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Power Supply Generator						
V+ Output				8.6		V
V- Output				-7.0		V
Supply Current (V_{CC})	(Note 3)			12	17	mA
Logic Supply Current (V_L)	(Note 4)			0.1	1	mA
Supply Current when OFF (V_{CC})	SHUTDOWN (Note 5) DRIVER DISABLE	● 		1 0.1	10 	µA mA
Logic Supply Current (V_L) when OFF	SHUTDOWN (Note 5) DRIVER DISABLE	● 		1 0.1	10 1	µA mA
Supply Rise Time SHUTDOWN to Turn On	C1=C2=0.2µF, C^+=C^-=0.1µF			0.2		ms
ON/OFF Pin Thresholds	Input Low Level (Device SHUTDOWN) Input High Level (Device Enabled)	● ●	 2.0	1.4 1.4	0.8 	V V
ON/OFF Pin Current	0V ≤ $V_{ON/OFF}$ ≤ 5V	●	-15		80	µA
Driver Disable Pin Thresholds	Input Low Level (Drivers Enabled) Input High Level (Drivers Disabled)	● ●	 2.0	1.4 1.4	0.8 	V V
DRIVER DISABLE Pin Current	0V ≤ $V_{DRIVER\ DISABLE}$ ≤ 5V	●	-10		500	µA
Oscillator Frequency				130		kHz

ELECTRICAL CHARACTERISTICS (Note 2)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Any Driver						
Output Voltage Swing	Load = 3k to GND Positive	●	5.0	7.3		V
	Negative	●	-5.0	-6.5		V
Logic Input Voltage Level	Input Low Level (V_{OUT}=High)	●		1.4	0.8	V
	Input High Level (V_{OUT}=Low)	●	2.0	1.4		V
Logic Input Current	0.8V ≤ V_{IN} ≤ 2.0V	●		5	20	µA
Output Short Circuit Current	V_{OUT}=0V			17		mA
Output Leakage Current	SHUTDOWN V_{OUT} = ±30V (Note 5)	●		10	100	µA
Slew Rate	R_L=3k, C_L=51pF			15	30	V/µs
	R_L=3k, C_L=2500pF		4	15		V/µs
Propagation Delay	Output Transition t_{HL} High to Low (Note 6)			0.6	1.3	µS
	Output Transition t_{LH} Low to High			0.5	1.3	µS
Any Receiver						
Input Voltage Thresholds	Input Low Threshold (V_{OUT}=High)		0.8	1.3		V
	Input High Threshold (V_{OUT}=Low)			1.7	2.4	V
Hysteresis		●	0.1	0.4	1.0	V
Input Resistance			3	5	7	kΩ
Ouput Leakage Current	SHUTDOWN (Note) 0 ≤ V_{OUT} ≤ V_{CC}	●		1	10	µA
Receivers 1 Through 4						
Output Voltage	Output Low, I_{OUT} = -1.6mA	●		0.2	0.4	V
	Output High, I_{OUT} = 160µA	●	2.7	2.9		V
Output Short Circuit Current	Sinking Current, V_{OUT} = V_{CC}		-10	-20		mA
	Sourcing Current, V_{OUT} = 0V		10	20		mA
Propagation Delay	Output Transition t_{HL} High to Low (Note 7)			250	600	nS
	Output Transition t_{LH} Low to High			350	600	nS
Receiver 5						
Output Voltage	Output Low, I_{OUT} = -500µA	●		0.2	0.4	V
	Output High, I_{OUT} = 160µA	●	2.7	2.9		V
Output Short Circuit Current	Sinking Current, V_{OUT} = V_{CC}		-2	-4		mA
	Sourcing Current, V_{OUT} = 0V		2	4		mA
Propagation Delay	Output Transition t_{HL} High to Low (Note 7)			1.0	3	µS
	Output Transition t_{LH} Low to High			1.0	3	µS

The ● denotes specifications which apply over the operating temperature range. (0°C ≤ T_A ≤ 70°C for commercial grade, -40°C ≤ T_A ≤ 85°C for industrial grade, and -55°C ≤ T_A ≤ 125°C for military grade.)

Note 1: Absolute Maximum Ratings are those values beyond which the life of the device may be impaired.

Note 2: Testing done at V_{CC} = 5V, V_L=3.3V and $V_{ON/OFF}$=3V.

Note 3: Supply current is measured as the average over several charge pump burst cycles. C^+=C^-=0.1µF, C1=C2=0.2µF. All outputs are open, with all driver inputs tied high.

Note 4: V_L supply current is measured with all receiver outputs low.

Note 5: Supply current measurements in SHUTDOWN are performed with $V_{ON/OFF}$ ≤ 0.1V. Supply current measurements using DRIVER DISABLE are performed with $V_{DRIVER\ DISABLE}$ ≥ 3V.

Note 6: For driver delay measurements, R_L = 3k and C_L = 51pF. Trigger points are set between the driver's input logic threshold and the output transition to the zero crossing. (t_{HL} = 1.4V to 0V and t_{LH} = 1.4V to 0V)

Note 7: For receiver delay measurements, C_L = 51pF. Trigger points are set between the receiver's input logic threshold and the output transition to standard TTL/CMOS logic threshold. (t_{HL} = 1.3V to 2.4V and t_{LH} = 1.7V to 0.8V)

PIN FUNCTIONS

V_{CC}: 5V Input supply pin. This pin should be decoupled with a 0.1uF ceramic capacitor close to the package pin. Insufficient supply bypassing can result in low output drive levels and erratic charge pump operation.

V_L: 3V Logic supply pin. Provides power to the receiver outputs. Decouple with a 0.1uF ceramic capacitor.

GND: Ground Pin.

On/Off: A TTL/CMOS compatible operating mode control. A logic low puts the device in the low power SHUTDOWN mode. Drivers and receivers assume a high impedance state in shutdown. The transceiver consumes almost no supply current while in Shutdown. A logic high fully enables the transceiver.

DRIVER DISABLE: This pin provides an alternate control for the charge pump and RS232 drivers. A logic high on this pin shuts down the charge pump and places all drivers in a high impedance state. All five receivers remain active under these conditions. Floating the driver disable pin or driving it to a logic low level fully enables the transceiver. A logic low on the On/Off pin supercedes the state of the Driver Disable pin. Supply current drops to 3mA when in DriverDisable mode.

V^+: Positive supply output (RS232 drivers). $V^+ \approx 2V_{CC}$ - 1.5V. This pin requires an external charge storage capacitor C $\geq$0.1μF, tied to ground or V_{CC}. Larger value capacitors may be used to reduce supply ripple.

V^-: Negative supply output (RS232 drivers). $V^- \approx -(2V_{CC}$-2.5V). This pin requires an external charge storage capacitor C $\geq$ 0.1μF. To reduce supply ripple, increase the size of the storage capacitor.

$C1^+$;$C1^-$;$C2^+$;$C2^-$: Commutating capacitor inputs, require two external capacitors C $\geq$ 0.2μF. One from $C1^+$ to $C1^-$, and another from $C2^+$ to $C2^-$. The capacitor's effective series resistance should be less than 2Ω. For C $\geq$1μF, low ESR tantalum capacitors work well in this application, although small value ceramic capacitors may be used with a minimal reduction in charge pump compliance.

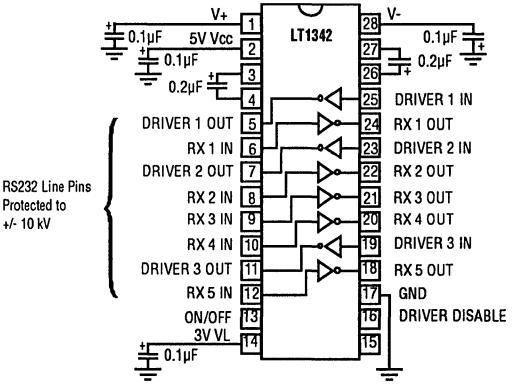
DRIVER IN: RS232 driver input pins. These inputs are compatible with TTLor CMOS logic. Tie unused inputs to Vcc or V_L.

DRIVER OUT: Driver outputs at RS232 voltage levels. Driver output swing meets RS232 levels for loads up to 3k. Slew rates are controlled for lightly loaded lines. Output current capability is sufficient for load conditions up to 2500pF. Outputs are in a high impedance state when in SHUTDOWN mode, V_{CC} = 0V, or when the driver disable pin is active. Outputs are fully short circuit protected from V- + 30V to V+ - 30V. Applying higher voltages will not damage the device if the overdrive is moderately current limited. Short circuits on one output can load the power supply generator and may disrupt the signal levels of the other outputs. The driver outputs are protected against ESD to ±10kV for human body model discharges.

RX IN: Receiver inputs. These pins accept RS232 level signals (±30V) into a protected 5k terminating resistor. The receiver inputs are protected against ESD to ±10kV for human body model discharges. Each receiver provides 0.4V of hysteresis for noise immunity. Open receiver inputs assume a logic low state.

RX OUT: Receiver outputs with TTL/CMOS voltage levels. Outputs are in a high impedance state when in SHUTDOWN mode to allow data line sharing. Outputs are fully short circuit protected to ground or V_{CC} with the power on, off, or in SHUTDOWN mode.

ESD Test Circuit



CHAPTER 2: RS485 PRODUCTS

Chapter 2: RS485 Products

RS485 Applications Information

Typical Applications

A typical half duplex interface is shown in Figure 1. A twisted pair of wires connect up to 32 drivers and receivers for half duplex data transmission. There are no restrictions on where the chips are connected to the wires, and it isn't necessary to have the chips connected at the ends. However, the wires must be terminated only at the ends with a resistor equal to their characteristic impedance, typically 120Ω. The optional shields around the twisted pair help reduce unwanted noise, and are connected to GND at one end.

A typical full duplex interface is shown in Figure 2. Two twisted pair wires connect up to 32 driver/receiver pairs for full duplex data transmission. There are no restrictions on where the chips are connected to the wires, and it isn't necessary to have the chips connected at the ends. However, the wires must be terminated only at the ends with a resistor equal to their characteristic impedance, typically 120Ω. The input impedance of a receiver is typically 20kΩ to GND, or 0.6 unit RS-485 load, so in practice 50 to 60

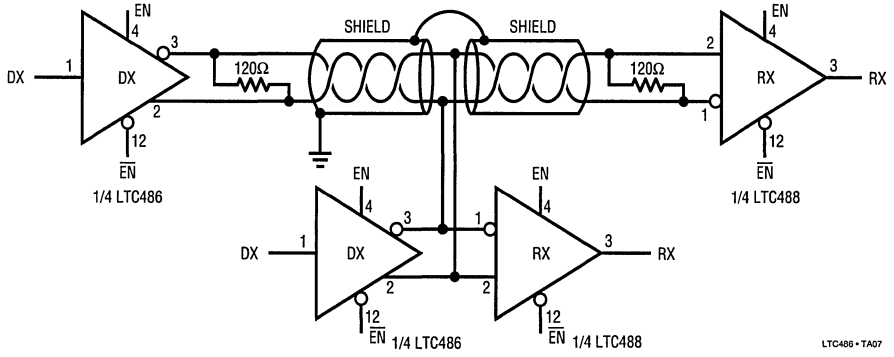


Figure 1. Typical Connection

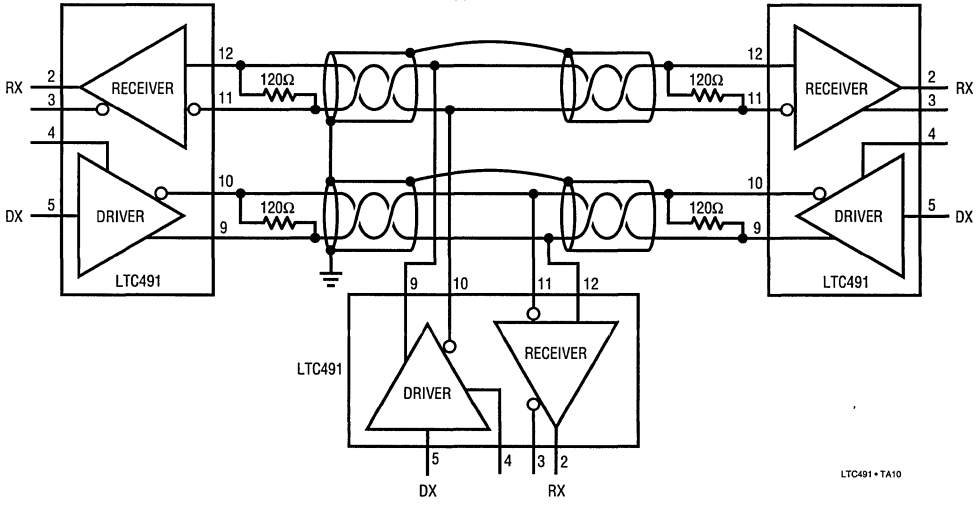


Figure 2. Typical Connection

transceivers can be connected to the same wires. The optional shields around the twisted pair help reduce unwanted noise, and are connected to GND at one end.

The LTC490 and LTC491 can also be used as line repeaters as shown in Figure 3. If the cable length is longer than 4000 feet, the device is inserted in the middle of the cable with the receiver output connected back to the driver input.

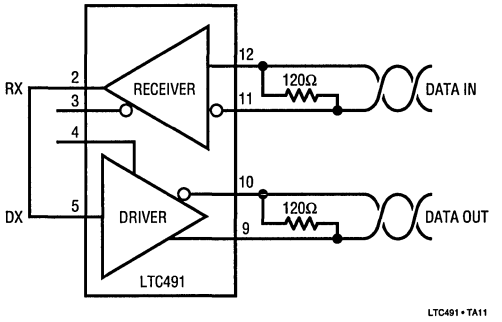


Figure 3. Line Repeater

Thermal Shutdown

All of LTC's RS485 devices have a thermal shutdown feature which protects the part from excessive power dissipation. If the outputs of the driver are accidently shorted to a power supply or low impedance source, up to 250mA can flow through the part. The thermal shutdown circuit disables the driver outputs when the internal temperature reaches 150°C and turns them back on when the temperature cools to 130°C. If the outputs of two or more LTC491 drivers are shorted directly, the driver outputs can not supply enough current to activate the thermal shutdown. Thus, the thermal shutdown circuit will not prevent contention faults when two drivers are active on the bus at the same time.

Cables and Data Rate

The transmission line of choice for RS485 applications is a twisted pair. There are coaxial cables (twinaxial) made for this purpose that contain straight pairs, but these are less flexible, more bulky, and more costly than twisted pairs. Many cable manufacturers offer a broad range of 120Ω cables designed for RS485 applications.

Losses in a transmission line are a complex combination of DC conductor loss, AC losses (skin effect), leakage and AC losses in the dielectric. In good polyethylene cables such as the Belden 9841, the conductor losses and dielectric losses are of the same order of magnitude, leading to relatively low over all loss (Figure 4).

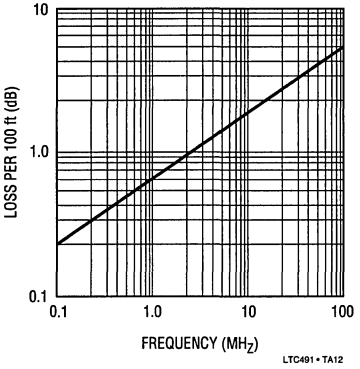


Figure 4. Attenuation vs Frequency for Belden 9481

When using low loss cables, Figure 5 can be used as a guideline for choosing the maximum line length for a given data rate. With lower quality PVC cables, the dielectric loss factor can be 1000 times worse. PVC twisted pairs have terrible losses at high data rates (>100kBs), and greatly reduce the maximum cable length. At low data rates however, they are acceptable and much more economical.

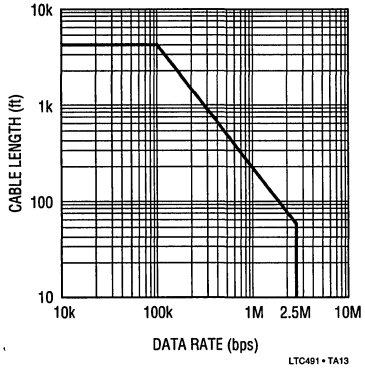


Figure 5. Cable Length vs Data Rate

Cable Termination

The proper termination of the cable is very important. If the cable is not terminated with it's characteristic impedance, distorted waveforms will result. In severe cases, distorted (false) data and nulls will occur. A quick look at the output of the driver will tell how well the cable is terminated. It is best to look at a driver connected to the end of the cable, since this eliminates the possibility of getting reflections from two directions. Simply look at the driver output while transmitting square wave data. If the cable is terminated properly, the waveform will look like a square wave (Figure 6).

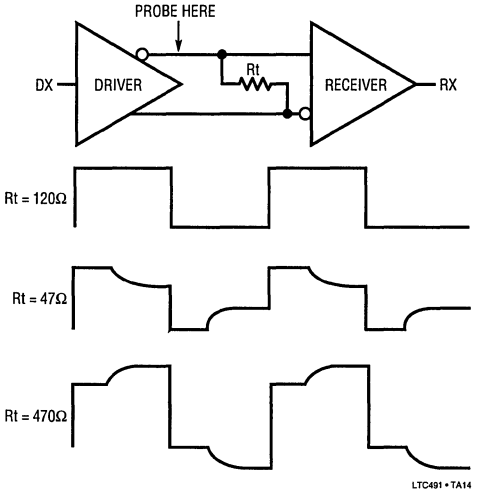


Figure 6. Termination Effects

If the cable is loaded excessively (47Ω), the signal initially sees the surge impedance of the cable and jumps to an initial amplitude. The signal travels down the cable and is reflected back out of phase because of the mistermination. When the reflected signal returns to the driver, the amplitude will be lowered. The width of the pedestal is equal to twice the electrical length of the cable (about 1.5ns/foot).

If the cable is lightly loaded (470Ω), the signal reflects in phase and increases the amplitude at the driver output. An input frequency of 30kHz is adequate for tests out to 4000 feet of cable.

AC Cable Termination

Cable termination resistors are necessary to prevent unwanted reflections, but they consume power. The typical differential output voltage of the driver is 2V when the cable is terminated with two 120Ω resistors, causing 33mA of DC current to flow in the cable when no data is being sent. This DC current is about 60 times greater than the supply current of the LTC491. One way to eliminate the unwanted current is by AC coupling the termination resistors as shown in Figure 7.

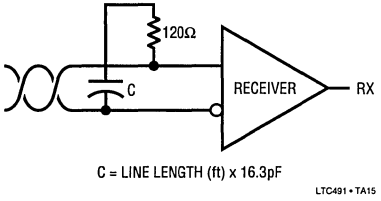


Figure 7. AC Coupled Termination

The coupling capacitor must allow high-frequency energy to flow to the termination, but block DC and low frequencies. The dividing line between high and low frequency depends on the length of the cable. The coupling capacitor must pass frequencies above the point where the line represents an electrical one-tenth wavelength. The value of the coupling capacitor should therefore be set at 16.3pF per foot of cable length for 120Ω cables. With the coupling capacitors in place, power is consumed only on the signal edges, and not when the driver output is idling at a 1 or 0 state. A 100nF capacitor is adequate for lines up to 4000 feet in length. Be aware that the power savings start to decrease once the data rate surpasses $1/(120\Omega \times C)$.

Receiver Open-Circuit Fail-Safe

Some data encoding schemes require that the output of the receiver maintains a known state (usually a logic 1) when the data is finished transmitting and all drivers on the line are forced into three-state. The receiver of the LTC491 has a fail-safe feature which guarantees the output to be in a logic 1 state when the receiver inputs are left floating (open-circuit). However, when the cable is terminated with 120Ω, the differential inputs to the receiver are shorted together, not left floating. Because the receiver has about 70mV of hysteresis, the receiver output will maintain the last data bit received.

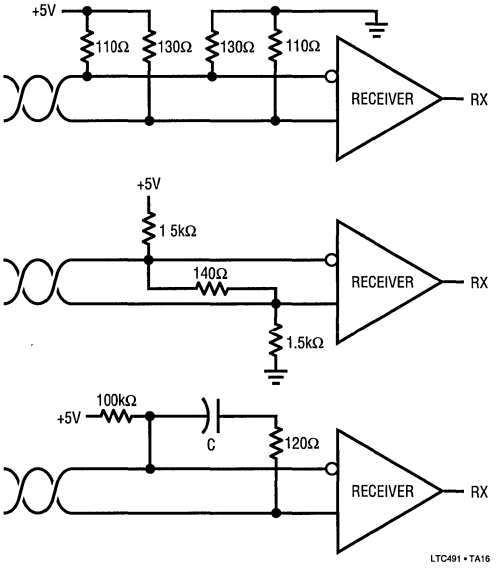


Figure 8. Forcing "0" When All Drivers are Off

The termination resistors are used to generate a DC bias which forces the receiver output to a known state, in this case a logic 0. The first method consumes about 208mW and the second about 8mW. The lowest power solution is to use an AC termination with a pull-up resistor. Simply swap the receiver inputs for data protocols ending in logic 1.

Fault Protection

All of LTC's RS485 products are protected against ESD transients up to 2kV using the human body model (100pF, 1.5kΩ). However, some applications need more protection. The best protection method is to connect a bidirectional TransZorb® from each line side pin to ground (Figure 9).

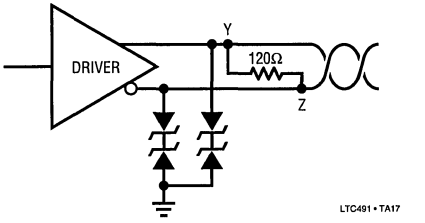


Figure 9. ESD Protection with TransZorbs

A TransZorb is a silicon transient voltage suppressor that has exceptional surge handling capabilities, fast response time, and low series resistance. They are available from General Semiconductor Industries and come in a variety of breakdown voltages and prices. Be sure to pick a breakdown voltage higher than the common mode voltage required for your application (typically 12V). Also, don't forget to check how much the added parasitic capacitance will load down the bus.

Typical Applications

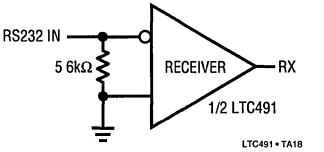


Figure 10. RS232 Receiver

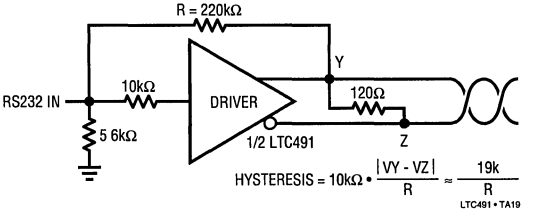


Figure 11. RS232 to RS485 Level Transistor with Hysteresis

TransZorb is a registered trademark of General Instruments, GSI

LINEAR TECHNOLOGY

DESIGN NOTES

Number 39 in a series from Linear Technology Corporation *September, 1990*

Low Power CMOS RS485 Transceiver

Robert Reay

Introduction

The EIA RS485 data transmission standard has become popular because it allows for balanced data transmission in a party line configuration. Users are able to configure inexpensive local area networks and multi-drop communication links using twisted pair wire and the protocol of their choice.

Previous RS485 transceivers have been designed using bipolar technology because the common mode range of the device must extend beyond the supplies and be immune to ESD damage and latchup. Unfortunately, the bipolar devices draw a large amount of supply current and are unacceptable for low power applications. The LTC485 is the first CMOS RS485 transceiver featuring ultra low power consumption (I_{CC} = 500µA max.) without sacrificing ESD and latchup immunity.

Proprietary Output Stage

The LTC485 driver output stage of Figure 1 features a common mode range that extends beyond the supplies while virtually eliminating latchup and providing excellent ESD protection. Two Schottky diodes SD3 and SD4 are added to a conventional CMOS inverter output stage. The Schottky diodes are fabricated by a proprietary modification to a standard N-well CMOS process. When the output stage is operating normally, the Schottky diodes are forward biased and have a small voltage drop across them. When the output is in the high impedance state and is driven above V_{CC} or below ground by another driver on the party line, the parasitic diode D1 or D2 will forward bias, but SD3 or SD4 will reverse bias and prevent current from flowing into the N-well or substrate. Thus, the high impedance state is maintained even with the output voltage beyond the supplies. With no current flow into the N-well or substrate, latchup is virtually eliminated.

Propagation Delay

Using the test circuit of Figure 4 with only one foot of twisted pair wire, Figures 2 and 3 show the typical propagation delays.

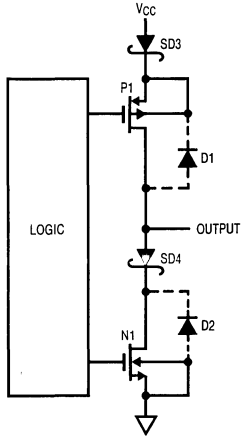


Figure 1. LTC485 Output Stage

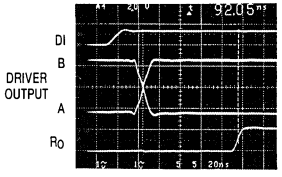


Figure 2. LTC485 System Waveforms

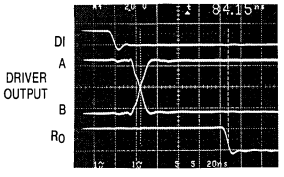


Figure 3. LTC485 System Waveforms

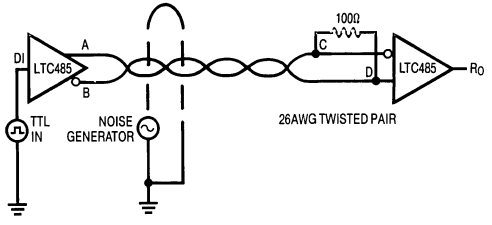


Figure 4. LTC485 System Test Circuit

LTC485 Line Length vs Data Rate

The maximum line length allowable for the RS422/RS485 standard is 4000 feet. Using the test circuit of Figure 4 with 4000 feet of twisted pair wire, Figure 5 and 6 show that with ≈20Vp-p common mode noise injected on the line, the LTC485 is able to reconstruct the data stream at the end of the wire.

Figures 7 and 8 show that the LTC485 is able to comfortably drive 4000 feet of wire at 110kHz.

When specifying line length vs maximum data rate the curve in Figure 9 should be used:

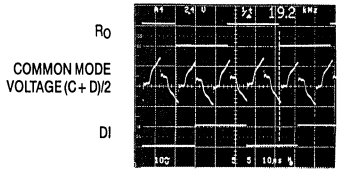


Figure 5. System Common Mode Voltage @19.2kHz

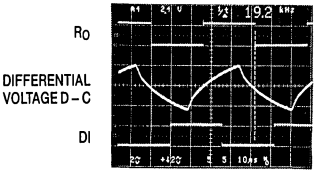


Figure 6. System Differential Voltage @19.2kHz

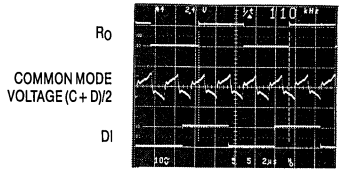


Figure 7. System Common Mode Voltage @110kHz

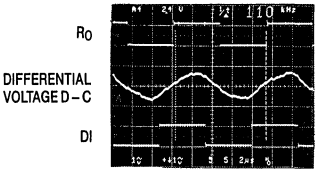


Figure 8. System Differential Voltage @110kHz

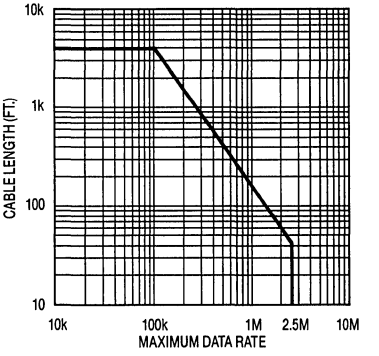


Figure 9. Cable Length vs Maximum Data Rate

For literature of our Low Power Transceivers call **(800) 637-5545.** For applications help, call (408) 432-1900, Ext. 456.

Low Power RS485 Interface Transceiver

FEATURES

- Low Power: I_{CC} = 300μA Typ
- Designed for RS485 Interface Applications
- Single +5V Supply
- –7V to +12V Bus Common Mode Range Permits ±7V Ground Difference Between Devices on the Bus
- Thermal Shutdown Protection
- Power Up/Down Glitch-Free Driver Outputs Permit Live Insertion or Removal of Transceiver
- Driver Maintains High Impedance in Three-State or With the Power Off
- Combined Impedance of a Driver Output and Receiver Allows Up to 32 Transceivers on the Bus
- 70mV Typical Input Hysteresis
- 30ns Typical Driver Propagation Delays with 5ns Skew
- Pin Compatible with the SN75176A, DS75176A and μA96176

APPLICATIONS

- Low Power RS485/RS422 Transceiver
- Level Translator

The LTC485 is a low power differential bus/line transceiver designed for multipoint data transmission standard RS485 applications with extended common mode range (+12V to –7V). It also meets the requirements of RS422.

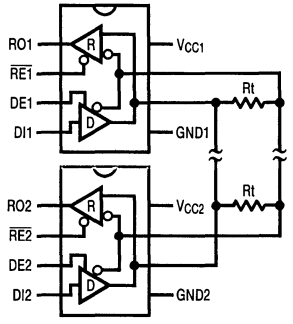
The CMOS design offers significant power savings over its bipolar counterpart without sacrificing ruggedness against overload of ESD damage.

The driver and receiver feature three-state outputs, with the driver outputs maintaining high impedance over the entire common mode range. Excessive power dissipation caused by bus contention or faults is prevented by a thermal shutdown circuit which forces the driver outputs into a high impedance state.

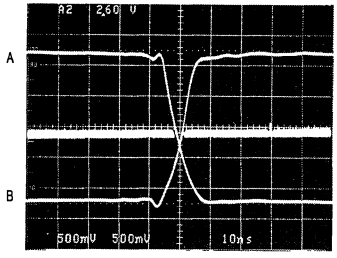
The receiver has a fail safe feature which guarantees a high output state when the inputs are left open.

The LTC485 is fully specified over the commercial and extended industrial temperature range.

TYPICAL APPLICATION



Driver Outputs

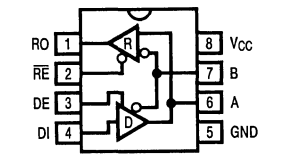


ABSOLUTE MAXIMUM RATINGS

(Note 1)

Supply Voltage (V_{CC}) 12V
Control Input Voltages ..... −0.5V to V_{CC} + 0.5V
Driver Input Voltage ..... −0.5V to V_{CC} + 0.5V
Driver Output Voltages ..... ±14V
Receiver Input Voltages ..... ±14V
Receiver Output Voltage ..... −0.5V to V_{CC} + 0.5V
Operating Temperature Range
LTC485I ..... −40°C ≤ T_A ≤ 85°C
LTC485C ..... 0°C ≤ T_A ≤ 70°C
LTC485M ..... −55°C ≤ T_A ≤ 125°C

PACKAGE/ORDER INFORMATION



J8 PACKAGE
8-LEAD CERAMIC DIP

N8 PACKAGE
8-LEAD PLASTIC DIP

S8 PACKAGE
8-LEAD PLASTIC SOIC

T_{JMAX} = 155°C, θ_{JA} = 100°C/W (J)
T_{JMAX} = 100°C, θ_{JA} = 130°C/W (N)
T_{JMAX} = 100°C, θ_{JA} = 170°C/W (S)

ORDER PART NUMBER
LTC485CN8
LTC485IN8
LTC485CS8
LTC485IS8
LTC485CJ8
LTC485MJ8
S8 PART MARKING
485
485I

DC ELECTRICAL CHARACTERISTICS

V_{CC} = 5V ± 5% (Notes 2 and 3)

SYMBOL	PARAMETER	CONDITIONS			LTC485C, LTC485I MIN	TYP	MAX	UNITS
V_{OD1}	Differential Driver Output Voltage (Unloaded)	I_O = 0		○			5	V
V_{OD2}	Differential Driver Output Voltage (with Load)	R = 50Ω; (RS422)		○	2			V
		R = 27Ω; (RS485), Figure 1		○	1.5		5	
ΔV_{OD}	Change in Magnitude of Driver Differential Output Voltage for Complementary Output States	R = 27Ω or R = 50Ω, Figure 1		●			0.2	V
V_{OC}	Driver Common Mode Output Voltage	R = 27Ω or R = 50Ω, Figure 1		○			3	V
$\Delta \lvert V_{OC} \rvert$	Change in Magnitude of Driver Common Mode Output Voltage for Complementary Output States	R = 27Ω or R = 50Ω, Figure 1		○			0.2	V
V_{IH}	Input High Voltage	DE, DI, $\overline{RE}$		○	2.0			V
V_{IL}	Input Low Voltage	DE, DI, $\overline{RE}$		○			0.8	V
I_{IN1}	Input Current	DE, DI, $\overline{RE}$		○			±2	µA
I_{IN2}	Input Current (A, B)	DE = 0, V_{CC} = 0 or 5.25	V_{IN} = 12V	●			+1.0	mA
			V_{IN} = −7V	○			−0.8	
V_{TH}	Differential Input Threshold Voltage for Receiver	−7V ≤ V_{CM} ≤ +12V		○	−0.2		+0.2	V
ΔV_{TH}	Receiver Input Hysteresis	V_{CM} = 0V		●		70		mV
V_{OH}	Receiver Output High Voltage	I_O = −4mA, V_{ID} = +200mV		○	3.5			V
V_{OL}	Receiver Output Low Voltage	I_O = +4mA, V_{ID} = −200mV		○			0.4	V
I_{OZR}	Three-State (High Impedance) Output Current at Receiver	V_{CC} = Max, 0.4 ≤ V_O ≤ 2.4		○			±1	µA
R_{IN}	Receiver Input Resistance	−7V ≤ V_{CM} ≤ +12V		●	12			kΩ
I_{CC}	Supply Current	No Load, Pins 2, 3, 4 = 0V or 5V	Outputs Enabled	●		500	900	µA
			Outputs Disabled	●		300	500	
I_{OSD1}	Driver Short-Circuit Current, V_{OUT} = HIGH	−7V ≤ V_O ≤ +12V		○	35		250	mA
I_{OSD2}	Driver Short-Circuit Current, V_{OUT} = LOW	−7V ≤ V_O ≤ +10V		○	35		250	mA
I_{OSR}	Receiver Short-Circuit Current	0V ≤ V_O ≤ V_{CC}		○	7		85	mA

SWITCHING CHARACTERISTICS V_{CC} = 5V ± 5% (Notes 2 and 3)

SYMBOL	PARAMETER	CONDITIONS		LTC485C, LTC485I MIN	TYP	MAX	UNITS
t_{PLH}	Driver Input to Output	R_{DIFF} = 54Ω, C_{L1} = C_{L2} = 100pF, (Figures 3 and 5)	O	10	30	60	ns
t_{PHL}	Driver Input to Output		O	10	30	60	
t_{SKEW}	Driver Output to Output		O		5	10	
t_R, t_F	Driver Rise or Fall Time		O	3	15	40	
t_{ZH}	Driver Enable to Output High	C_L = 100pF (Figures 4 and 6) S2 Closed	O		40	70	ns
t_{ZL}	Driver Enable to Output Low	C_L = 100pF (Figures 4 and 6) S1 Closed	O		40	70	ns
t_{LZ}	Driver Disable Time from Low	C_L = 15pF (Figures 4 and 6) S1 Closed	O		40	70	ns
t_{HZ}	Driver Disable Time from High	C_L = 15pF (Figures 4 and 6) S2 Closed	O		40	70	ns
t_{PLH}	Receiver Input to Output	R_{DIFF} = 54Ω, C_{L1} = C_{L2} = 100pF, (Figures 3 and 7)	O	30	90	200	ns
t_{PHL}	Receiver Input to Output		O	30	90	200	ns
t_{SKD}	$\lvert t_{PLH} - t_{PHL} \rvert$ Differential Receiver Skew		O		13		ns
t_{ZL}	Receiver Enable to Output Low	C_{RL} = 15pF (Figures 2 and 8) S1 Closed	O		20	50	ns
t_{ZH}	Receiver Enable to Output High	C_{RL} = 15pF (Figures 2 and 8) S2 Closed	O		20	50	ns
t_{LZ}	Receiver Disable from Low	C_{RL} = 15pF (Figures 2 and 8) S1 Closed	O		20	50	ns
t_{HZ}	Receiver Disable from High	C_{RL} = 15pF (Figures 2 and 8) S2 Closed	O		20	50	ns

The O denotes specifications which apply over the full operating temperature range.

Note 1: "Absolute Maximum Ratings" are those beyond which the safety of the device cannot be guaranteed.

Note 2: All currents into device pins are positive; all currents out of device pins are negative. All voltages are referenced to device ground unless otherwise specified.

Note 3: All typicals are given for V_{CC} = 5V and T_A = 25°C.

TEST CIRCUITS

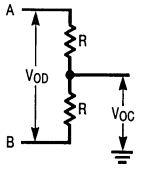


Figure 1. Driver DC Test Load

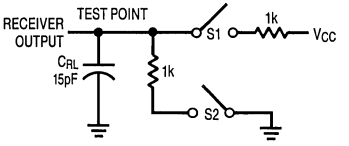


Figure 2. Receiver Timing Test Load

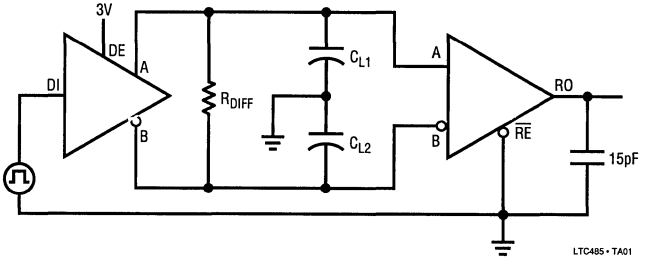


Figure 3. Driver/Receiver Timing Test Circuit

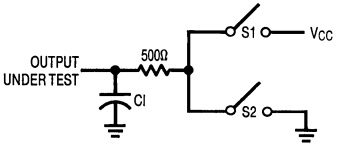


Figure 4. Driver Timing Test Load #2

SWITCHING TIME WAVEFORMS

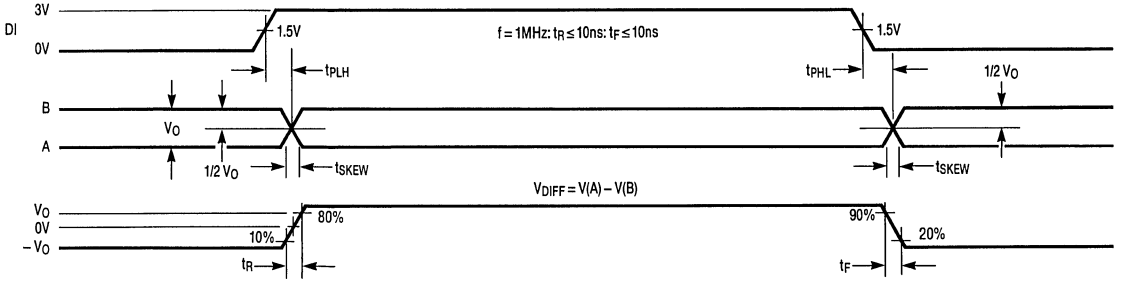


Figure 5. Driver Propagation Delays

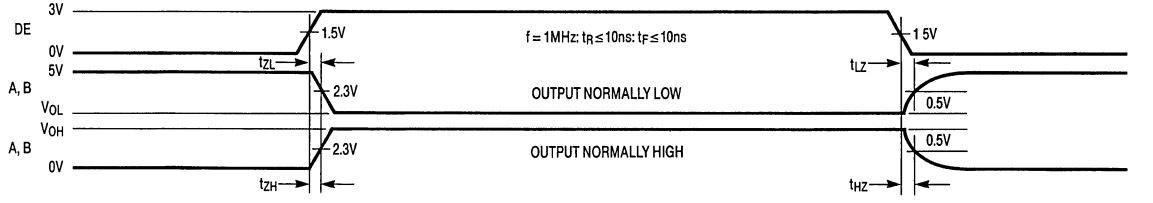


Figure 6. Driver Enable and Disable Times

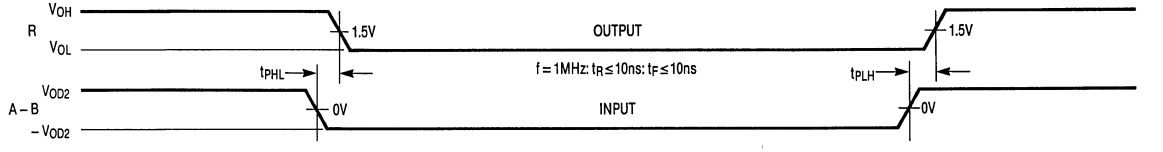


Figure 7. Receiver Propagation Delays

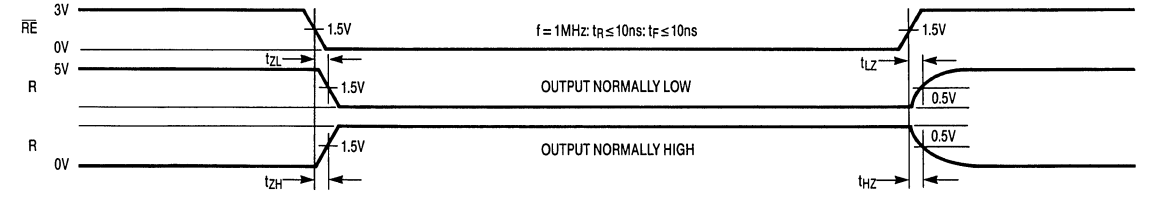


Figure 8. Receiver Enable and Disable Times

FUNCTION TABLES

LTC485 Transmitting

INPUTS			LINE CONDITION	OUTPUTS	
$\overline{RE}$	DE	DI		B	A
X	1	1	No Fault	0	1
X	1	0	No Fault	1	0
X	0	X	X	Z	Z
X	1	X	Fault	Z	Z

LTC485 Receiving

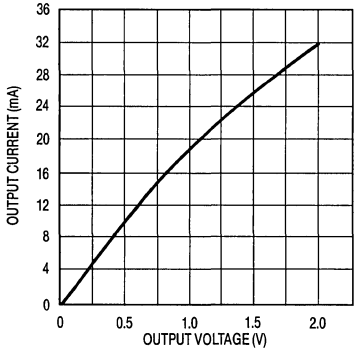
INPUTS			OUTPUTS
$\overline{RE}$	DE	A – B	R
0	0	≥ +0.2V	1
0	0	≤ –0.2V	0
0	0	Inputs Open	1
1	0	X	Z

PIN FUNCTIONS

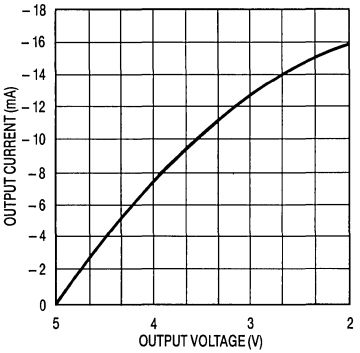
PIN #	NAME	DESCRIPTION
1	RO	Receiver Output. If the receiver output is enabled ($\overline{RE}$ low), then if A > B by 200mV, RO will be high. If A < B by 200mV, then RO will be low.
2	$\overline{RE}$	Receiver Output Enable. A low enables the receiver output, RO. A high input forces the receiver output into a high impedance state.
3	DE	Driver Outputs Enable. A high on DE enables the driver output. A and B, and the chip will function as a line driver. A low input will force the driver outputs into a high impedance state and the chip will function as a line receiver.
4	DI	Driver Input. If the driver outputs are enabled (DE high), then a low on DI forces the outputs A low and B high. A high on DI with the driver outputs enabled will force A high and B low.
5	GND	Ground Connection.
6	A	Driver Output/Receiver Input.
7	B	Driver Output/Receiver Input.
8	V_{CC}	Positive Supply; 4.75 < V_{CC} < 5.25

TYPICAL PERFORMANCE CHARACTERISTICS

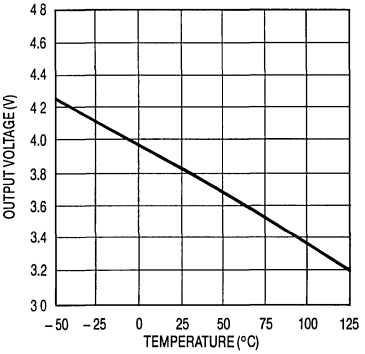
Receiver Output Low Voltage vs Output Current T_A = 25°C



Receiver Output High Voltage vs Output Current T_A = 25°C

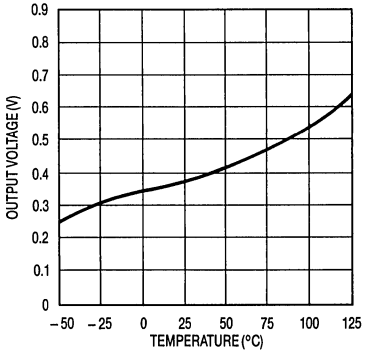


Receiver Output High Voltage vs Temperature @I = 8mA

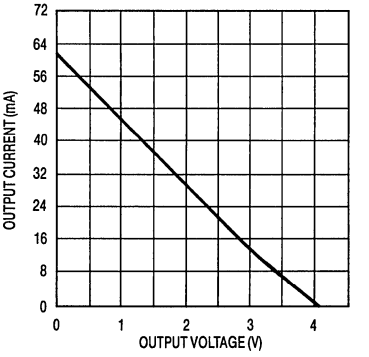


TYPICAL PERFORMANCE CHARACTERISTICS

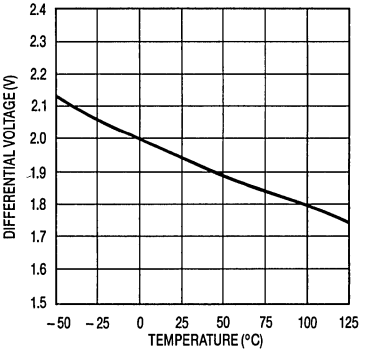
Receiver Output Low Voltage vs Temperature @I = 8mA



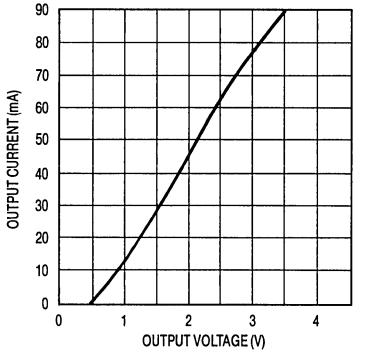
Driver Differential Output Voltage vs Output Current $T_A = 25°C$



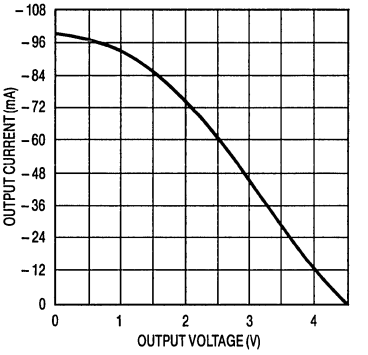
Driver Differential Output Voltage vs Temperature RI = 54Ω



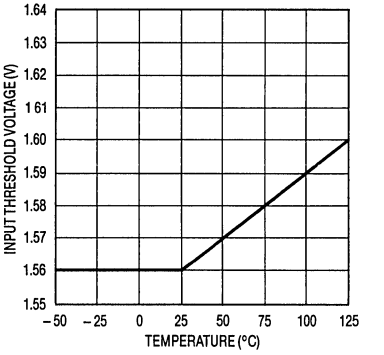
Driver Output Low Voltage vs Output Current $T_A = 25°C$



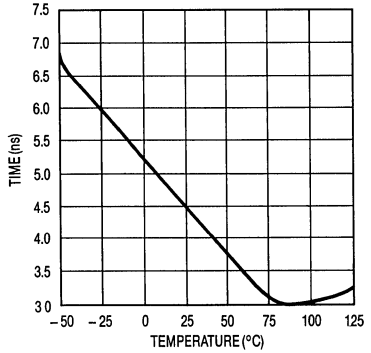
Driver Output High Voltage vs Output Current $T_A = 25°C$



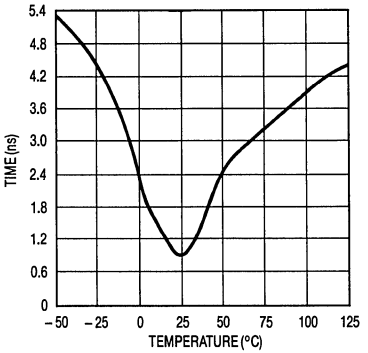
TTL Input Threshold vs Temperature



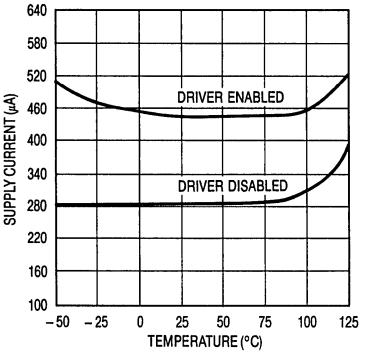
Receiver $|t_{PLH} - t_{PHL}|$ vs Temperature



Driver Skew vs Temperature



Supply Current vs Temperature



Quad Low Power RS485 Driver

FEATURES

- Very Low Power: I_{CC} = 110µA Typ.
- Designed for RS485 or RS422 Applications
- Single +5V Supply
- –7V to +12V Bus Common Mode Range Permits ±7V GND Difference Between Devices on the Bus
- Thermal Shutdown Protection
- Power-Up/Down Glitch-Free Driver Outputs Permit Live Insertion/Removal of Package
- Driver Maintains High Impedance in Three-State or with the Power Off
- 28ns Typical Driver Propagation Delays with 5ns Skew
- Pin Compatible with the SN75172, DS96172, µA96172, and DS96F172

APPLICATIONS

- Low Power RS485/RS422 Drivers
- Level Translator

DESCRIPTION

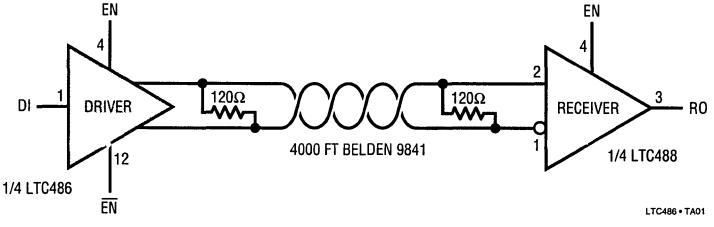
The LTC486 is a low power differential bus/line driver designed for multipoint data transmission standard RS485 applications with extended common mode range (+12V to –7V). It also meets RS422 requirements.

The CMOS design offers significant power savings over its bipolar counterpart without sacrificing ruggedness against overload or ESD damage.

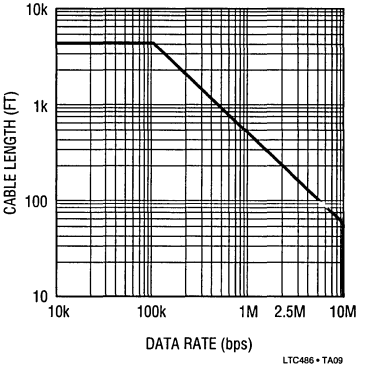
The driver features three-state outputs, with the driver outputs maintaining high impedance over the entire common mode range. Excessive power dissipation caused by bus contention or faults is prevented by a thermal shutdown circuit which forces the driver outputs into a high impedance state.

Both AC and DC specifications are guaranteed from 0°C to 70°C and over the 4.75V to 5.25V supply voltage range.

TYPICAL APPLICATION



RS485 Cable Length Specification*



* APPLIES FOR 24 GAUGE, POLYETHYLENE DIELECTRIC TWISTED PAIR

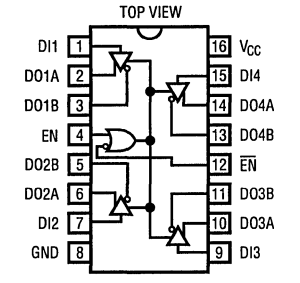
ABSOLUTE MAXIMUM RATINGS

(Note 1)

Supply Voltage (V_{CC}) 12V
Control Input Voltages ..... −0.5V to V_{CC} + 0.5V
Driver Input Voltages ..... −0.5V to V_{CC} + 0.5V
Driver Output Voltages ..... ±14V
Control Input Currents ..... ±25mA
Driver Input Currents ..... ±25mA
Operating Temperature Range ..... 0°C to 70°C
Storage Temperature Range ..... −65°C to 150°C
Lead Temperature (Soldering, 10 sec.) ..... 300°C

T_{JMAX} = 125°C, θ_{JA} = 70°C/W (N)
T_{JMAX} = 150°C, θ_{JA} = 95°C/W (S)

PACKAGE/ORDER INFORMATION



ORDER PART NUMBER
LTC486CN
LTC486CS

DC ELECTRICAL CHARACTERISTICS

V_{CC} = 5V ±5%, 0°C ≤ Temperature ≤ 70°C (Note 2, 3)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V_{OD1}	Differential Driver Output Voltage (Unloaded)	I_O = 0				5	V
V_{OD2}	Differential Driver Output Voltage (With Load)	R = 50Ω; (RS422)		2			V
		R = 27Ω; (RS485) (Figure 1)		1.5		5	V
V_{OD}	Change in Magnitude of Driver Differential Output Voltage for Complementary Output States	R = 27Ω or R = 50Ω (Figure 1)				0.2	V
V_{OC}	Driver Common Mode Output Voltage					3	
$\lvert V_{OC}\rvert$	Change in Magnitude of Driver Common Mode Output Voltage for Complementary Output States					0.2	
V_{IH}	Input High Voltage	DI, EN, $\overline{EN}$		2.0			V
V_{IL}	Input Low Voltage					0.8	V
I_{IN1}	Input Current					±2	µA
I_{CC}	Supply Current	No Load	Output Enabled		110	200	µA
			Output Disabled		110	200	
I_{OSD1}	Driver Short Circuit Current, V_{OUT} = High	−7V ≤ V_O ≤ +12V				250	mA
I_{OSD2}	Driver Short Circuit Current, V_{OUT} = Low	−7V ≤ V_O ≤ +12V				250	mA
I_{OZ}	High Impedance State Output Current	V_O = −7V to 12V			±2	±200	µA

SWITCHING CHARACTERISTICS

V_{CC} = 5V ±5%, 0°C ≤ Temperature ≤ 70°C (Note 2, 3)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
t_{PLH}	Driver Input to Output	R_{DIFF} = 54Ω, C_{L1} = C_{L2} = 100pF (Figures 2, 4)	20	28	60	ns
t_{PHL}	Driver Input to Output		20	28	60	
t_{SKEW}	Driver Output to Output			5	15	
t_r, t_f	Driver Rise or Fall Time		5	15	71	
t_{ZH}	Driver Enable to Output High	C_L = 100pF (Figures 3, 5) S2 Closed		35	70	ns
t_{ZL}	Driver Enable to Output Low	C_L = 100pF (Figures 3, 5) S1 Closed		44	75	ns
t_{LZ}	Driver Disable Time from Low	C_L = 15pF (Figures 3, 5) S1 Closed		55	92	ns
t_{HZ}	Driver Disable Time from High	C_L = 15pF (Figures 3, 5) S2 Closed		45	75	ns

Note 1: "Absolute Maximum Ratings" are those beyond which the safety of the device cannot be guaranteed.

Note 2: All currents into device pins are positive; all currents out of device pins are negative. All voltages are referenced to device ground unless otherwise specified.

Note 3: All typicals are given for V_{CC} = 5V and Temperature = 25°C.

FUNCTION TABLE

INPUT	ENABLES		OUTPUTS	
DI	EN	$\overline{EN}$	OUTA	OUTB
H	H	X	H	L
L	H	X	L	H
H	X	L	H	L
L	X	L	L	H
X	L	H	Z	Z

H: High Level
L: Low Level
X: Irrelevant
Z: High Impedance (Off)

PIN FUNCTIONS

DI1 (Pin 1): Driver 1 input. If Driver 1 is enabled, then a low on DI1 forces the driver outputs DO1A low and DO1B high. A high on DI1 with the driver outputs enabled will force DO1A high and DO1B low.

DO1A (Pin 2): Driver 1 output.

DO1B (Pin 3): Driver 1 output.

EN (Pin 4): Driver outputs enabled. See Function Table for details.

DO2B (Pin 5): Driver 2 output.

DO2A (Pin 6): Driver 2 output.

DI2 (Pin 7): Driver 2 input. Refer to DI1.

GND (Pin 8): Ground connection.

DI3 (Pin 9): Driver 3 input. Refer to DI1.

DO3A (Pin 10): Driver 3 output.

DO3B (Pin 11): Driver 3 output.

$\overline{EN}$ (Pin 12): Driver outputs disenabled. See Function Table for details.

DO4B (Pin 13): Driver 4 output.

DO4A (Pin 14): Driver 4 output.

DI4 (Pin 15): Driver 4 input. Refer to DI1.

V_{CC} (Pin 16): Positive supply; $4.75 < V_{CC} < 5.25$.

TEST CIRCUITS

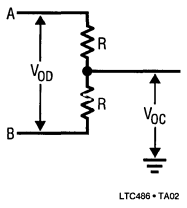


Figure 1. Driver DC Test Load

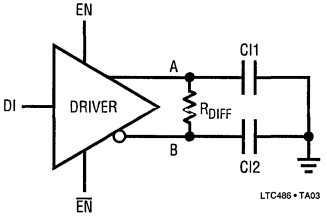


Figure 2. Driver Timing Test Circuit

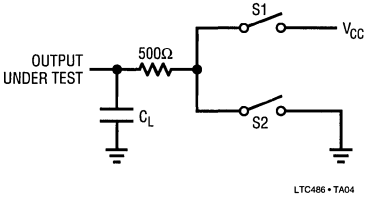


Figure 3. Driver Timing Test Load #2

SWITCHING TIME WAVEFORMS

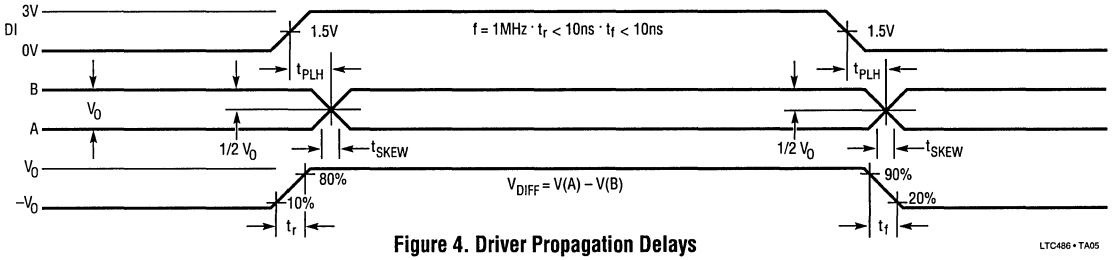


Figure 4. Driver Propagation Delays

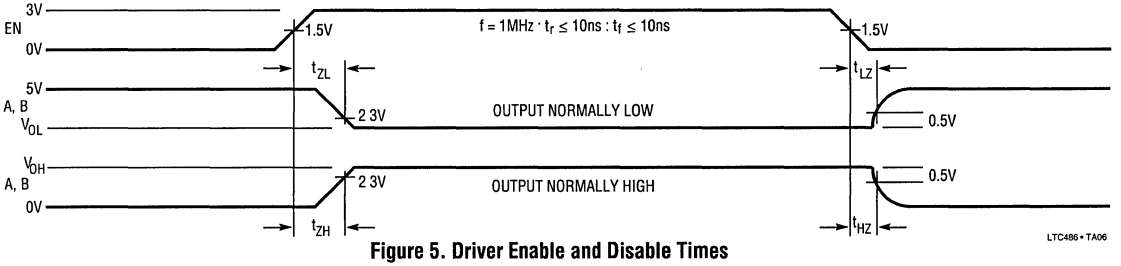
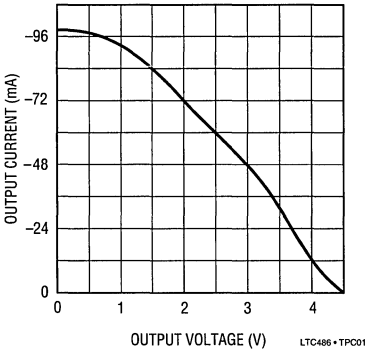


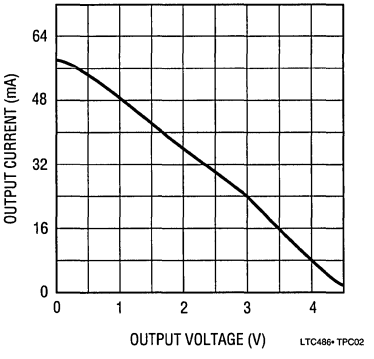
Figure 5. Driver Enable and Disable Times

TYPICAL PERFORMANCE CHARACTERISTICS

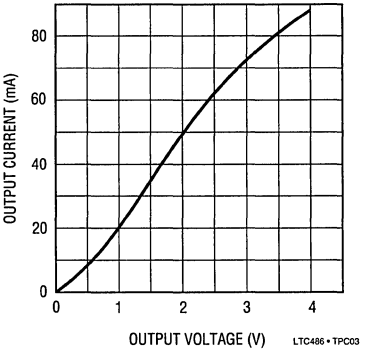
Driver Output High Voltage vs Output Current T_A = 25°C



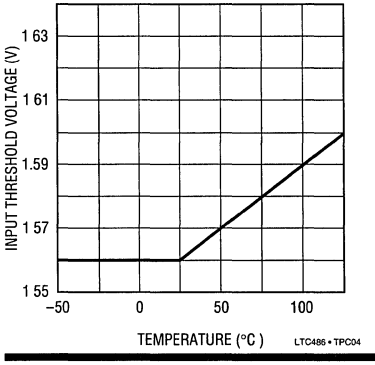
Driver Differential Output Voltage vs Output Current T_A = 25°C



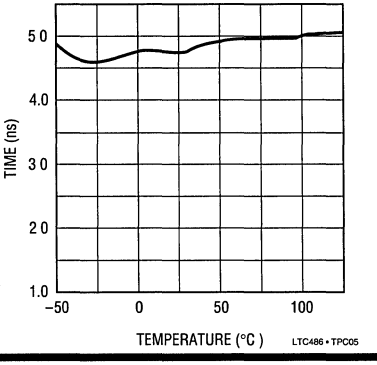
Driver Output Low Voltage vs Output Current T_A = 25°C



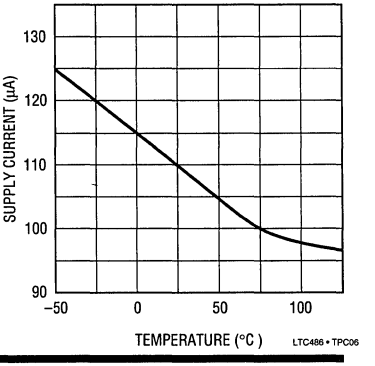
TTL Input Threshold vs Temperature



Driver Skew vs Temperature

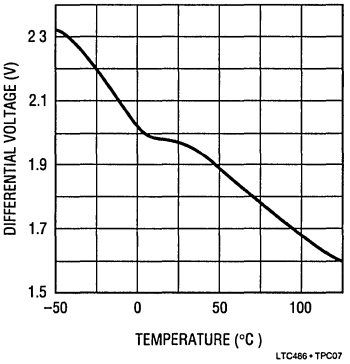


Supply Current vs Temperature



TYPICAL PERFORMANCE CHARACTERISTICS

Driver Differential Output Voltage vs Temperature $R_O = 54\Omega$



Quad Low Power RS485 Driver

FEATURES

- Very Low Power: I_{CC} = 110µA Typ.
- Designed for RS485 or RS422 Applications
- Single +5V Supply
- –7V to +12V Bus Common Mode Range Permits ±7V GND Difference Between Devices on the Bus
- Thermal Shutdown Protection
- Power-Up/Down Glitch-Free Driver Outputs Permit Live Insertion/Removal of Package
- Driver Maintains High Impedance in Three-State or with the Power Off
- 28ns Typical Driver Propagation Delays with 5ns Skew
- Pin Compatible with the SN75174, DS96174, µA96174, and DS96F174

APPLICATIONS

- Low Power RS485/RS422 Drivers
- Level Translator

DESCRIPTION

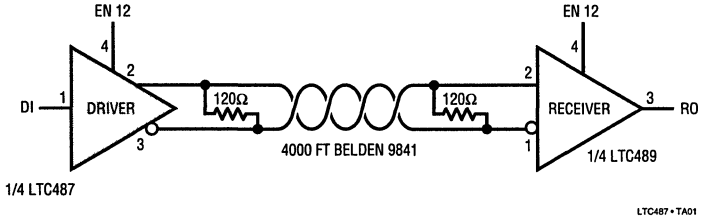
The LTC487 is a low power differential bus/line driver designed for multipoint data transmission standard RS485 applications with extended common mode range (+12V to –7V). It also meets RS422 requirements.

The CMOS design offers significant power savings over its bipolar counterpart without sacrificing ruggedness against overload or ESD damage.

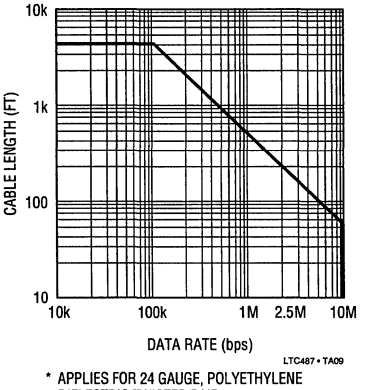
The driver features three-state outputs, with the driver outputs maintaining high impedance over the entire common mode range. Excessive power dissipation caused by bus contention or faults is prevented by a thermal shutdown circuit which forces the driver outputs into a high impedance state.

Both AC and DC specifications are guaranteed from 0°C to 70°C and over the 4.75V to 5.25V supply voltage range.

TYPICAL APPLICATION



RS485 Cable Length Specification*



* APPLIES FOR 24 GAUGE, POLYETHYLENE DIELECTRIC TWISTED PAIR

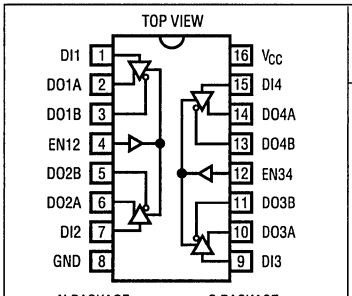
ABSOLUTE MAXIMUM RATINGS

(Note 1)

Supply Voltage (V_{CC}) 12V
Control Input Voltages ..... –0.5V to V_{CC} + 0.5V
Driver Input Voltages ..... –0.5V to V_{CC} + 0.5V
Driver Output Voltages ..... ±14V
Control Input Currents ..... ±25mA
Driver Input Currents ..... ±25mA
Operating Temperature Range ..... 0°C to 70°C
Storage Temperature Range ..... –65°C to 150°C
Lead Temperature (Soldering, 10 sec.) ..... 300°C

T_{JMAX} = 125°C, θ_{JA} = 70°C/W (N)
T_{JMAX} = 150°C, θ_{JA} = 95°C/W (S)

PACKAGE/ORDER INFORMATION



ORDER PART NUMBER
LTC487CN
LTC487CS

DC ELECTRICAL CHARACTERISTICS

V_{CC} = 5V ±5%, 0°C ≤ Temperature ≤ 70°C (Note 2, 3)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V_{OD1}	Differential Driver Output Voltage (Unloaded)	I_O = 0				5	V
V_{OD2}	Differential Driver Output Voltage (With Load)	R = 50Ω; (RS422)		2			V
		R = 27Ω; (RS485) (Figure 1)		1.5		5	V
V_{OD}	Change in Magnitude of Driver Differential Output Voltage for Complementary Output States	R = 27Ω or R = 50Ω (Figure 1)				0.2	V
V_{OC}	Driver Common Mode Output Voltage					3	
$\lvert V_{OC}\rvert$	Change in Magnitude of Driver Common Mode Output Voltage for Complementary Output States					0.2	
V_{IH}	Input High Voltage	DI, EN12, EN34		2.0			V
V_{IL}	Input Low Voltage					0.8	V
I_{IN1}	Input Current					±2	µA
I_{CC}	Supply Current	No Load	Output Enabled		110	200	µA
			Output Disabled		110	200	
I_{OSD1}	Driver Short Circuit Current, V_{OUT} = High	–7V ≤ V_O ≤ +12V				250	mA
I_{OSD2}	Driver Short Circuit Current, V_{OUT} = Low	–7V ≤ V_O ≤ +12V				250	mA
I_{OZ}	High Impedance State Output Current	V_O = –7V to 12V			±2	±200	µA

SWITCHING CHARACTERISTICS

V_{CC} = 5V ±5%, 0°C ≤ Temperature ≤ 70°C (Note 2, 3)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
t_{PLH}	Driver Input to Output	R_{DIFF} = 54Ω, C_{L1} = C_{L2} = 100pF (Figures 2, 4)	20	28	60	ns
t_{PHL}	Driver Input to Output		20	28	60	
t_{SKEW}	Driver Output to Output			5	15	
t_r, t_f	Driver Rise or Fall Time		5	20	71	
t_{ZH}	Driver Enable to Output High	C_L = 100pF (Figures 3, 5) S2 Closed		35	70	ns
t_{ZL}	Driver Enable to Output Low	C_L = 100pF (Figures 3, 5) S1 Closed		44	75	ns
t_{LZ}	Driver Disable Time from Low	C_L = 15pF (Figures 3, 5) S1 Closed		55	92	ns
t_{HZ}	Driver Disable Time from High	C_L = 15pF (Figures 3, 5) S2 Closed		45	75	ns

Note 1: "Absolute Maximum Ratings" are those beyond which the safety of the device cannot be guaranteed.

Note 2: All currents into device pins are positive; all currents out of device pins are negative. All voltages are referenced to device GND unless otherwise specified.

Note 3: All typicals are given for V_{CC} = 5V and Temperature = 25°C.

FUNCTION TABLE

INPUT	ENABLES	OUTPUTS	
DI	EN12 or EN34	OUTA	OUTB
H	H	H	L
L	H	L	H
X	L	Z	Z

H: High Level
L: Low Level
X: Irrelevant
Z: High Impedance (Off)

PIN FUNCTIONS

DI1 (Pin 1): Driver 1 input. If Driver 1 is enabled, then a low on DI1 forces the driver outputs DO1A low and DO1B high. A high on DI1 with the driver outputs enabled will force DO1A high and DO1B low.

DO1A (Pin 2): Driver 1 output.

DO1B (Pin 3): Driver 1 output.

EN12 (Pin 4): Driver 1 and 2 outputs enabled. See Function Table for details.

DO2B (Pin 5): Driver 2 output.

DO2A (Pin 6): Driver 2 output.

DI2 (Pin 7): Driver 2 input. Refer to DI1.

GND (Pin 8): GND connection.

DI3 (Pin 9): Driver 3 input. Refer to DI1.

DO3A (Pin 10): Driver 3 output.

DO3B (Pin 11): Driver 3 output.

EN34 (Pin 12): Driver 3 and 4 outputs enabled. See Function Table for details.

DO4B (Pin 13): Driver 4 output.

DO4A (Pin 14): Driver 4 output.

DI4 (Pin 15): Driver 4 input. Refer to DI1.

V_{CC} (Pin 16): Positive supply; $4.75 < V_{CC} < 5.25$.

TEST CIRCUITS

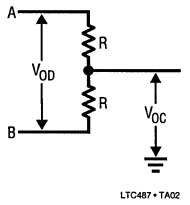


Figure 1. Driver DC Test Load

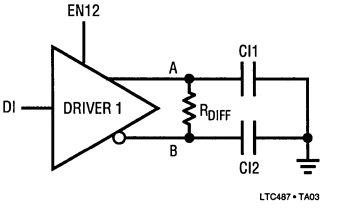


Figure 2. Driver Timing Test Circuit

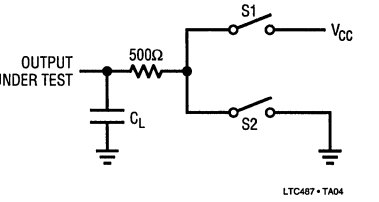


Figure 3. Driver Timing Test Load #2

SWITCHING TIME WAVEFORMS

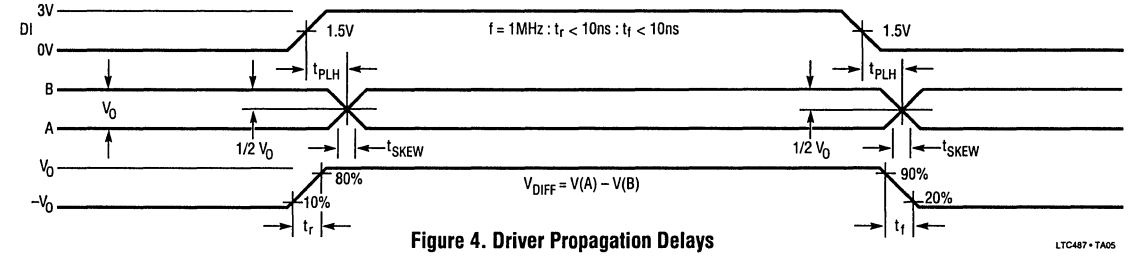


Figure 4. Driver Propagation Delays

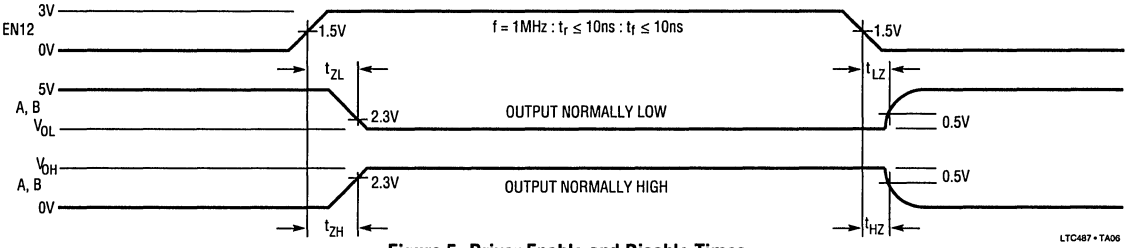
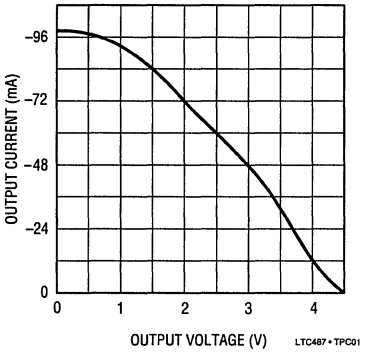


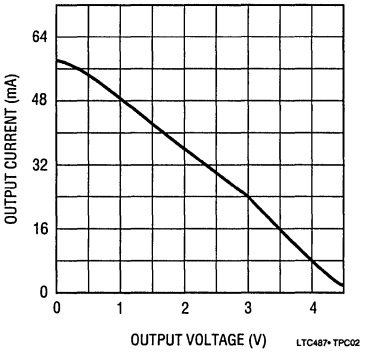
Figure 5. Driver Enable and Disable Times

TYPICAL PERFORMANCE CHARACTERISTICS

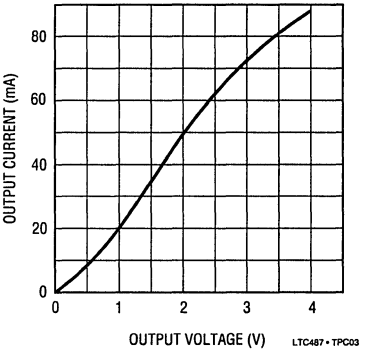
Driver Output High Voltage vs Output Current T_A = 25°C



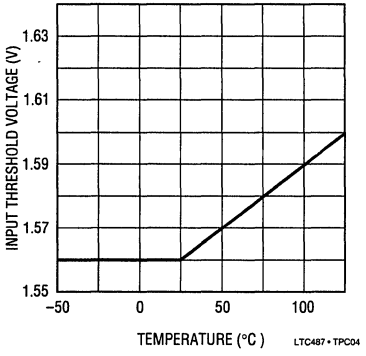
Driver Differential Output Voltage vs Output Current T_A = 25°C



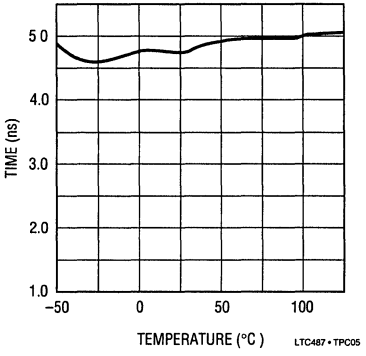
Driver Output Low Voltage vs Output Current T_A = 25°C



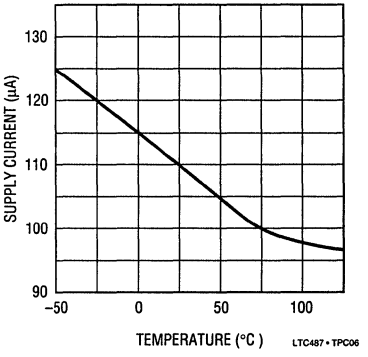
TTL Input Threshold vs Temperature



Driver Skew vs Temperature

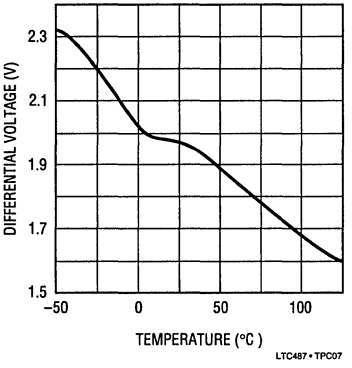


Supply Current vs Temperature



TYPICAL PERFORMANCE CHARACTERISTICS

Driver Differential Output Voltage vs Temperature $R_O = 54\Omega$



FEATURES

- Low Power: I_{CC} = 7mA Typ.
- Designed for RS485 or RS422 Applications
- Single 5V Supply
- –7V to 12V Bus Common Mode Range Permits ±7V Ground Difference Between Devices on the Bus
- 60mV Typical Input Hysteresis
- Receiver Maintains High Impedance in Three-State or with the Power Off
- 28ns Typical Receiver Propagation Delay
- Pin Compatible with the SN75173 (LTC488)
- Pin Compatible with the SN75175 (LTC489)

APPLICATIONS

- Low Power RS485/RS422 Receivers
- Level Translator

DESCRIPTION

The LTC488 and LTC489 are low power differential bus/line receivers designed for multipoint data transmission standard RS485 applications with extended common mode range (12V to –7V). They also meet the requirements of RS422.

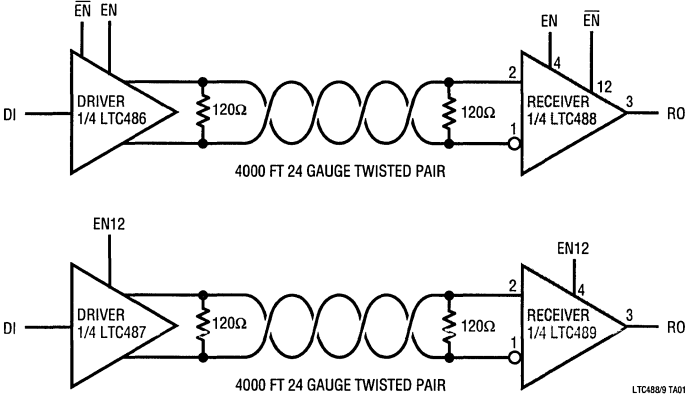
The CMOS design offers significant power savings over its bipolar counterpart without sacrificing ruggedness against overload or ESD damage.

The receiver features three-state outputs, with the receiver output maintaining high impedance over the entire common mode range.

The receiver has a fail-safe feature which guarantees a high output state when the inputs are left open.

Both AC and DC specifications are guaranteed 4.75V to 5.25V supply voltage range.

TYPICAL APPLICATION



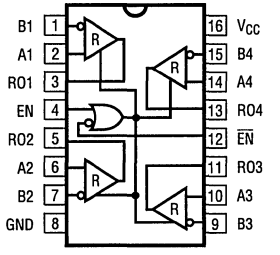
ABSOLUTE MAXIMUM RATINGS (Note 1)

Supply Voltage (V_{CC}) 12V
Control Input Currents ..... – 25mA to 25mA
Control Input Voltages ..... –0.5V to V_{CC} + 0.5V
Receiver Input Voltages ..... ±14V
Receiver Output Voltages ..... –0.5V to V_{CC} + 0.5V

Operating Temperature Range
LTC488C/LTC489C ..... 0°C to 70°C
LTC488I/LTC489I ..... –40°C to 85°C
Storage Temperature Range ..... –65°C to 150°C
Lead Temperature (Soldering, 10 sec.) ..... 300°C

PACKAGE/ORDER INFORMATION

TOP VIEW



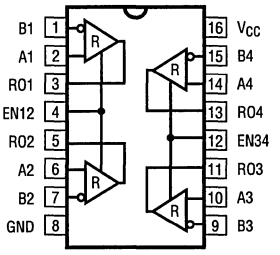
N PACKAGE 16-LEAD PLASTIC DIP
S PACKAGE 16-LEAD PLASTIC SOL

T_{JMAX} = 150°C, θ_{JA} = 70°C/W (N PKG)
T_{JMAX} = 150°C, θ_{JA} = 90°C/W (S PKG)

ORDER PART NUMBER

LTC488CN
LTC488CS
LTC488IN
LTC488IS

TOP VIEW



N PACKAGE 16-LEAD PLASTIC DIP
S PACKAGE 16-LEAD PLASTIC SOL

T_{JMAX} = 150°C, θ_{JA} = 70°C/W (N PKG)
T_{JMAX} = 150°C, θ_{JA} = 90°C/W (S PKG)

ORDER PART NUMBER

LTC489CN
LTC489CS
LTC489IN
LTC489IS

DC ELECTRICAL CHARACTERISTICS V_{CC} = 5V ± 5% (Notes 2 and 3), unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V_{INH}	Input High Voltage	EN, $\overline{EN}$, EN12, EN34	O	2.0			V
V_{INL}	Input Low Voltage	EN, $\overline{EN}$, EN12, EN34	O			0.8	V
I_{IN1}	Input Current	EN, $\overline{EN}$, EN12, EN34	O			±2	µA
I_{IN2}	Input Current (A, B)	V_{CC} = 0V or 5.25V, V_{IN} = 12V V_{CC} = 0V or 5.25V, V_{IN} = –7V	O O			1.0 –0.8	mA mA
V_{TH}	Differential Input Threshold Voltage for Receiver	–7V ≤ V_{CM} ≤ 12V	O	–0.2		0.2	V
ΔV_{TH}	Receiver Input Hysteresis	V_{CM} = 0V			60		mV
V_{OH}	Receiver Output High Voltage	I_O = –4mA, V_{ID} = 0.2V	O	3.5			V
V_{OL}	Receiver Output Low Voltage	I_O = 4mA, V_{ID} = –0.2V	O			0.4	V
I_{OZR}	Three-State Output Current at Receiver	V_{CC} = Max 0.4V ≤ V_O ≤ 2.4V	O			±1	µA
I_{CC}	Supply Current	No Load	O		7	10	mA
R_{IN}	Receiver Input Resistance	–7V ≤ V_{CM} ≤ 12V, V_{CC} = 0V	O	12			kΩ
I_{OSR}	Receiver Short-Circuit Current	0V ≤ V_O ≤ V_{CC}	O	7		85	mA
t_{PLH}	Receiver Input to Output	C_L = 15pF (Figures 1, 3)	O	12	28	55	ns
t_{PHL}	Receiver Input to Output	C_L = 15pF (Figures 1, 3)	O	12	28	55	ns
t_{SKD}	$\lvert t_{PLH} - t_{PHL} \rvert$ Differential Receiver Skew	C_L = 15pF (Figures 1, 3)			4		ns

DC ELECTRICAL CHARACTERISTICS

V_{CC} = 5V ±5% (Notes 2 and 3), unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
t_{ZL}	Receiver Enable to Output Low	C_L = 15pF (Figures 2, 4) S1 Closed	O		30	45	ns
t_{ZH}	Receiver Enable to Output High	C_L = 15pF (Figures 2, 4) S2 Closed	O		30	45	ns
t_{LZ}	Receiver Disable from Low	C_L = 15pF (Figures 2, 4) S1 Closed	O		30	45	ns
t_{HZ}	Receiver Disable from High	C_L = 15pF (Figures 2, 4) S2 Closed	O		30	45	ns

The O denotes specifications which apply over the operating temperature range.

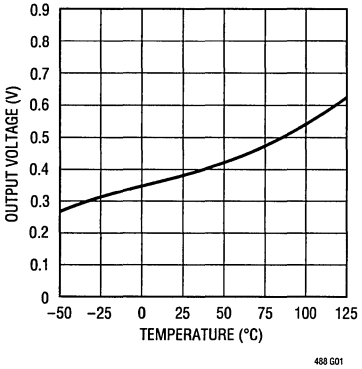
Note 1: "Absolute Maximum Ratings" are those beyond which the safety of the device cannot be guaranteed.

Note 2: All currents into device pins are positive; all currents out of device pins are negative. All voltages are referenced to device ground unless otherwise specified.

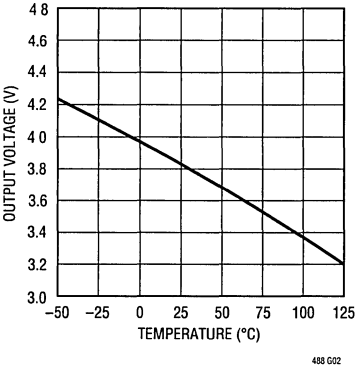
Note 3: All typicals are given for V_{CC} = 5V and T_A = 25°C.

TYPICAL PERFORMANCE CHARACTERISTICS

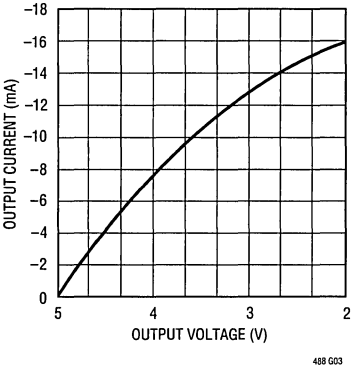
Receiver Output Low Voltage vs Temperature at I = 8mA



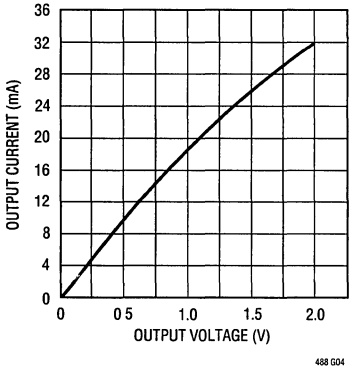
Receiver Output High Voltage vs Temperature at I = 8mA



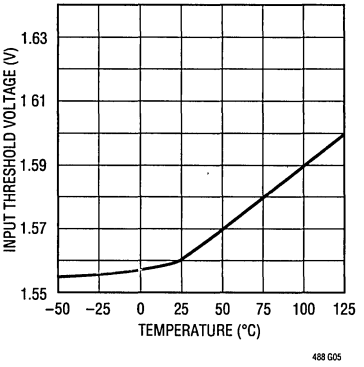
Receiver Output High Voltage vs Output Current at T_A = 25°C



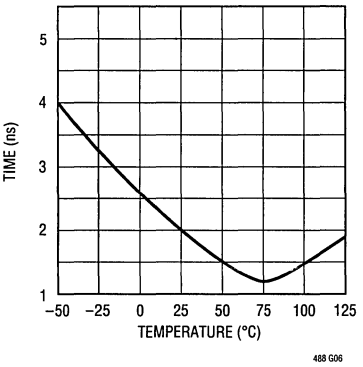
Receiver Output Low Voltage vs Output Current at T_A = 25°C



TTL Input Threshold vs Temperature

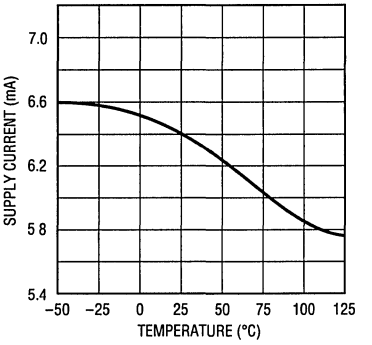


Receiver $|t_{PLH} - t_{PHL}|$ vs Temperature



TYPICAL PERFORMANCE CHARACTERISTICS

Supply Current vs Temperature



PIN FUNCTIONS

PIN 1 (B1) Receiver 1 input.

PIN 2 (A1) Receiver 1 input.

PIN 3 (RO1) Receiver 1 output. If the receiver output is enabled, then if A > B by 200mV, RO1 will be high. If A < B by 200mV, then RO1 will be low.

PIN 4 (EN)(LTC488) Receiver output enabled. See Function Table for details.

PIN 4 (EN12)(LTC489) Receiver 1, Receiver 2 output enabled. See Function Table for details.

PIN 5 (RO2) Receiver 2 output. Refer to RO1.

PIN 6 (A2) Receiver 2 input.

PIN 7 (B2) Receiver 2 input.

PIN 8 (GND) Ground connection.

PIN 9 (B3) Receiver 3 input.

PIN 10 (A3) Receiver 3 input.

PIN 11 (RO3) Receiver 3 output. Refer to RO1.

PIN 12 ($\overline{EN}$)(LTC488) Receiver output disabled. See Function Table for details.

PIN 12 (EN34)(LTC489) Receiver 3, Receiver 4 output enabled. See Function Table for details.

PIN 13 (RO4) Receiver 4 output. Refer to RO1.

PIN 14 (A4) Receiver 4 input.

PIN 15 (B4) Receiver 4 input.

PIN 16 (V_{CC}) Positive Supply; $4.75V \leq V_{CC} \leq 5.25V$

FUNCTION TABLES

LTC488

DIFFERENTIAL	ENABLES		OUTPUT
A – B	EN	$\overline{EN}$	RO
$V_{ID} \geq 0.2V$	H	X	H
	X	L	H
$-0.2V < V_{ID} < 0.2V$	H	X	?
	X	L	?
$V_{ID} \leq 0.2V$	H	X	L
	X	L	L
X	L	H	Z

LTC489

DIFFERENTIAL	ENABLES	OUTPUT
A – B	EN12 or EN34	RO
$V_{ID} \geq 0.2V$	H	H
$-0.2V < V_{ID} < 0.2V$	H	?
$V_{ID} \leq 0.2V$	H	L
X	L	Z

H: High Level
L: Low Level
X: Irrelevant
?: Indeterminate
Z: High Impedance (Off)

TEST CIRCUITS

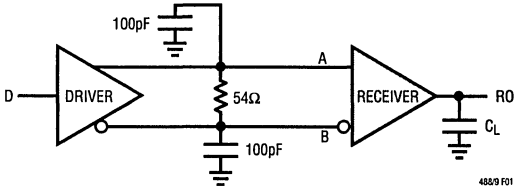


Figure 1. Receiver Timing Test Circuit

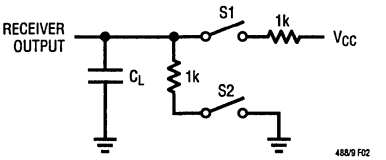


Figure 2. Receiver Enable and Disable Timing Test Circuit

Note: The input pulse is supplied by a generator having the following characteristics: f = 1MHz, Duty Cycle = 50%, t_r < 10ns, $t_f \leq$ 10ns, Z_{OUT} = 50Ω

SWITCHING TIME WAVEFORMS

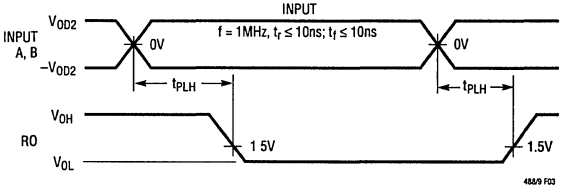


Figure 3. Receiver Propagation Delays

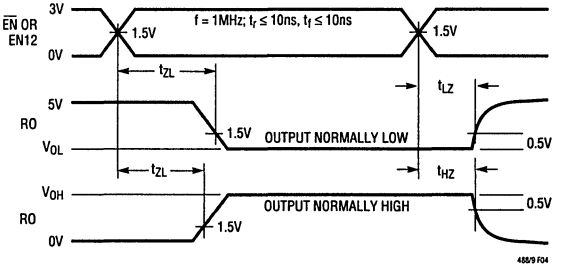


Figure 4. Receiver Enable and Disable Times

APPLICATIONS INFORMATION

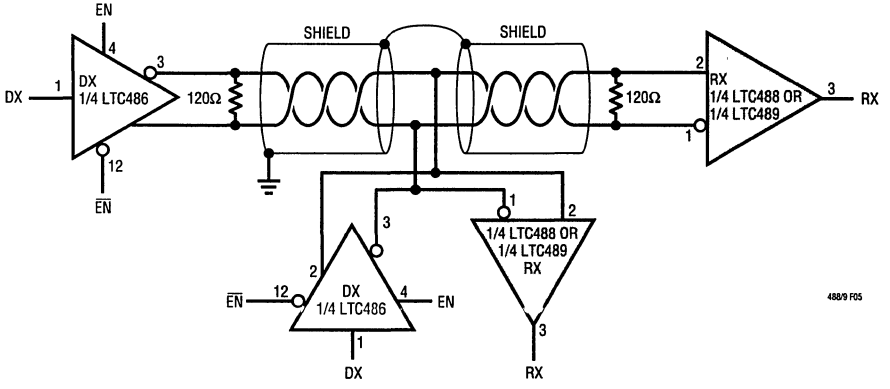


Figure 5. Typical Connection

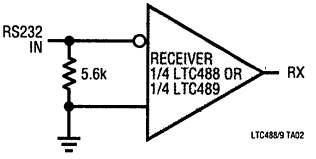
APPLICATIONS INFORMATION

Typical Application

A typical connection of the LTC488/LTC489 is shown in Figure 5. Two twisted-pair wires connect up to 32 driver/receiver pairs for half-duplex data transmission. There are no restrictions on where the chips are connected to the wires, and it isn't necessary to have the chips connected at the ends. However, the wires must be terminated only at the ends with a resistor equal to their characteristic impedance, typically 120Ω. The input impedance of a receiver is typically 20k to GND, or 0.5 unit RS485 load, so in practice 50 to 60 transceivers can be connected to the same wires. The optional shields around the twisted-pair help reduce unwanted noise, and are connected to GND at one end.

TYPICAL APPLICATIONS

RS232 Receiver



Differential Driver and Receiver Pair

FEATURES

- Low Power: I_{CC} = 300μA Typical
- Designed for RS485 or RS422 Applications
- Single +5V Supply
- –7V to +12V Bus Common Mode Range Permits ±7V Ground Difference Between Devices on the Bus
- Thermal Shutdown Protection
- Power-Up/Down Glitch-Free Driver Outputs Permit Live Insertion or Removal of Package
- Driver Maintains High Impedance in Three-State or with the Power Off
- Combined Impedance of a Driver Output and Receiver Allows up to 32 Transceivers on the Bus
- 70mV Typical Input Hysteresis
- 28ns Typical Driver Propagation Delays with 5ns Skew
- Pin Compatible with the SN75179

APPLICATIONS

- Low Power RS485/RS422 Transceiver
- Level Translator

DESCRIPTION

The LTC490 is a low power differential bus/line transceiver designed for multipoint data transmission standard RS485 applications with extended common mode range (+12V to –7V). It also meets the requirements of RS422.

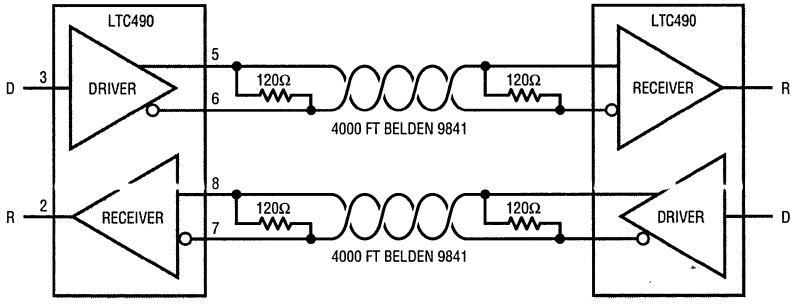
The CMOS design offers significant power savings over its bipolar counterpart without sacrificing ruggedness against overload or ESD damage.

The driver and receiver feature three-state outputs, with the driver outputs maintaining high impedance over the entire common mode range. Excessive power dissipation caused by bus contention or faults is prevented by a thermal shutdown circuit which forces the driver outputs into a high impedance state.

The receiver has a fail safe feature which guarantees a high output state when the inputs are left open.

Both AC and DC specifications are guaranteed from 0°C to 70°C and 4.75V to 5.25V supply voltage range.

TYPICAL APPLICATION



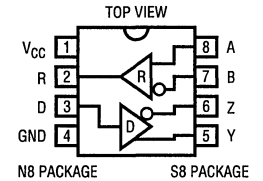
LTC490 • TA01

ABSOLUTE MAXIMUM RATINGS

(Note 1)

Supply Voltage (V_{CC}) 12V
Driver Input Currents ..... –25mA to 25mA
Driver Input Voltages ..... –0.5V to V_{CC} +0.5V
Driver Output Voltages ..... ±14V
Receiver Input Voltages ..... ±14V
Receiver Output Voltages ..... –0.5V to V_{CC} +0.5V
Operating Temperature Range ..... 0°C to 70°C
Storage Temperature Range ..... –65°C to 150°C
Lead Temperature (Soldering, 10 sec.) ..... 300°C

PACKAGE/ORDER INFORMATION



N8 PACKAGE 8-LEAD PLASTIC DIP
S8 PACKAGE 8-LEAD PLASTIC SOIC

T_{JMAX} = 125°C, θ_{JA} = 100°C/W (N)
T_{JMAX} = 150°C, θ_{JA} = 150°C/W (S)

ORDER PART NUMBER
LTC490CN8 LTC490CS8 LTC490IN8 LTC490IS8
S8 PART MARKING
490 490I

DC ELECTRICAL CHARACTERISTICS

V_{CC} = 5V ±5%, 0°C ≤ Temperature ≤ 70°C (Notes 2 and 3) unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V_{OD1}	Differential Driver Output Voltage (Unloaded)	I_O = 0				5	V
V_{OD2}	Differential Driver Output Voltage (With load)	R = 50Ω; (RS422)		2			V
		R = 27Ω; (RS485) (Figure 1)		1.5		5	V
ΔV_{OD}	Change in Magnitude of Driver Differential Output Voltage for Complementary Output States	R = 27Ω or R = 50Ω (Figure 1)				0.2	V
V_{OC}	Driver Common Mode Output Voltage					3	V
$\Delta \lvert V_{OC} \rvert$	Change in Magnitude of Driver Common Mode Output Voltage for Complementary Output States					0.2	V
V_{IH}	Input High Voltage (D)			2.0			V
V_{IL}	Input Low Voltage (D)					0.8	V
I_{IN1}	Input Current (D)					±2	µA
I_{IN2}	Input Current (A, B)	V_{CC} = 0V or 5.25V	V_{IN} = 12V			+1.0	mA
			V_{IN} = –7V			–0.8	mA
V_{TH}	Differential Input Threshold Voltage for Receiver	–7V ≤ V_{CM} ≤ 12V		–0.2		+0.2	V
ΔV_{TH}	Receiver Input Hysteresis	V_{CM} = 0V			70		mV
V_{OH}	Receiver Output High Voltage	I_O = –4mA, V_{ID} = +0.2V		3.5			V
V_{OL}	Receiver Output Low Voltage	I_O = +4mA, V_{ID} = –0.2V				0.4	V
I_{OZR}	Three-State Output Current at Receiver	V_{CC} = Max 0.4V ≤ V_O ≤ 2.4V				±1	µA
I_{CC}	Supply Current	No Load; D = GND, or V_{CC}			300	500	µA
R_{IN}	Receiver Input Resistance	–7V ≤ V_{CM} ≤ +12V		12			kΩ
I_{OSD1}	Driver Short Circuit Current, V_{OUT} = High	–7V ≤ V_O ≤ +12V				250	mA
I_{OSD2}	Driver Short Circuit Current, V_{OUT} = Low	–7V ≤ V_O ≤ +12V				250	mA
I_{OSR}	Receiver Short-Circuit Current	0V ≤ V_O ≤ V_{CC}		7		85	mA
I_{OZ}	Driver Three-State Output Current	V_O = –7V to 12V			±2	±200	µA

SWITCHING CHARACTERISTICS

V_{CC} = 5V ±5%, 0°C ≤ Temperature ≤ 70°C (Notes 2 and 3) unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
t_{PLH}	Driver Input to Output	R_{DIFF} = 54Ω, C_{L1} = C_{L2} = 100pF (Figures 2, 3)	10	28	60	ns
t_{PHL}	Driver Input to Output		10	28	60	ns
t_{SKEW}	Driver Output to Output			5		ns
t_r, t_f	Driver Rise or Fall Time		5	15	25	ns
t_{PLH}	Receiver Input to Output	R_{DIFF} = 54Ω, C_{L1} = C_{L2} = 100pF (Figures 2, 4)	40	70	150	ns
t_{PHL}	Receiver Input to Output		40	70	150	ns
t_{SKD}	$\lvert t_{PLH} - t_{PHL} \rvert$ Differential Receiver Skew			13		ns

Note 1: "Absolute Maximum Ratings" are those beyond which the safety of the device cannot be guaranteed.

Note 2: All currents into device pins are positive; all currents out of device pins are negative. All voltages are referenced to device ground unless otherwise specified.

Note 3: All typicals are given for V_{CC} = 5V and Temperature = 25°C.

PIN FUNCTIONS

V_{CC} (Pin 1): Positive supply; 4.75V ≤ V_{CC} ≤ 5.25V.

R (Pin 2): Receiver output. If A > B by 200mV, R will be high. If A < B by 200mV, then R will be low.

D (Pin 3): Driver input. A low on D forces the driver outputs A low and B high. A high on D will force A high and B low.

GND (Pin 4): Ground Connection.

Y (Pin 5): Driver output.

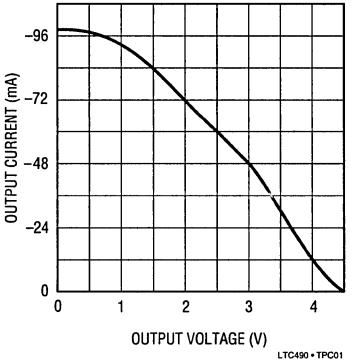
Z (Pin 6): Driver output.

B (Pin 7): Receiver input.

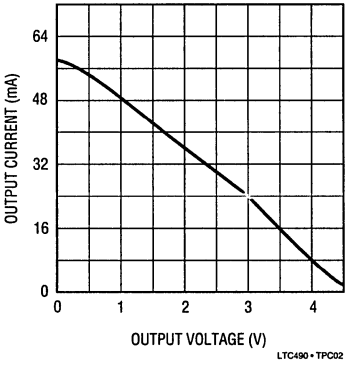
A (Pin 8): Receiver input.

TYPICAL PERFORMANCE CHARACTERISTICS

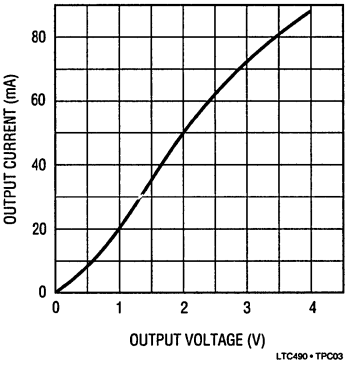
Driver Output High Voltage vs Output Current T_A = 25°C



Driver Differential Output Voltage vs Output Current T_A = 25°C

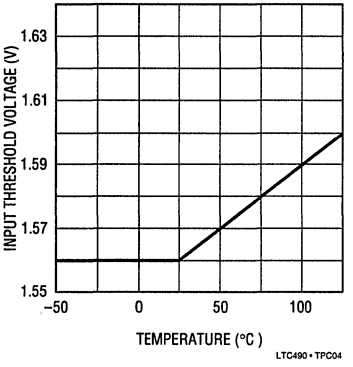


Driver Output Low Voltage vs Output Current T_A = 25°C

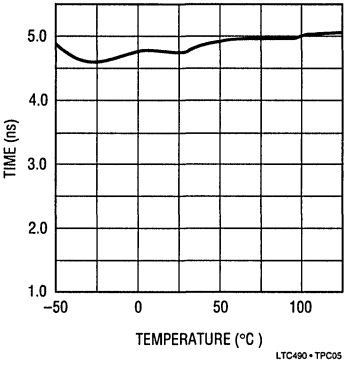


TYPICAL PERFORMANCE CHARACTERISTICS

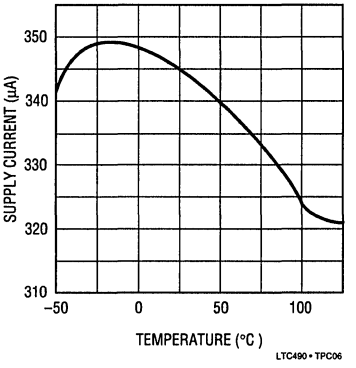
TTL Input Threshold vs Temperature



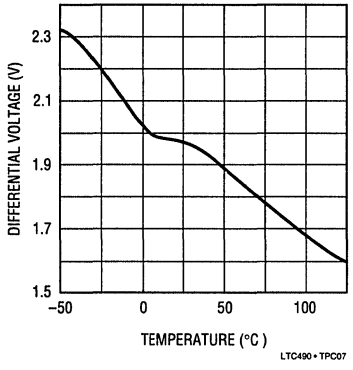
Driver Skew vs Temperature



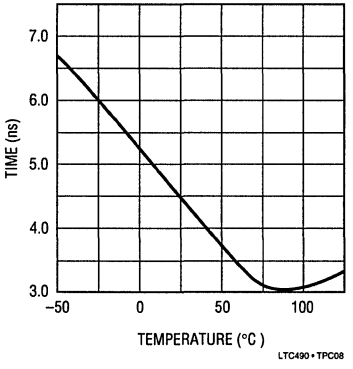
Supply Current vs Temperature



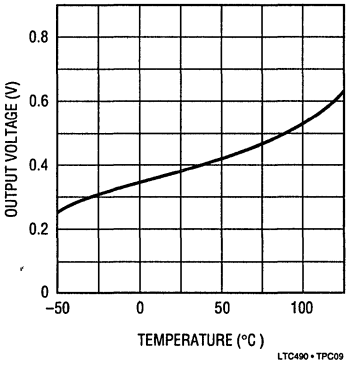
Driver Differential Output Voltage vs Temperature R_O = 54Ω



Receiver $|t_{PLH}-t_{PHL}|$ vs Temperature



Receiver Output Low Voltage vs Temperature at I = 8mA



TEST CIRCUITS

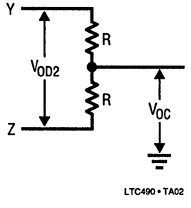


Figure 1. Driver DC Test Load

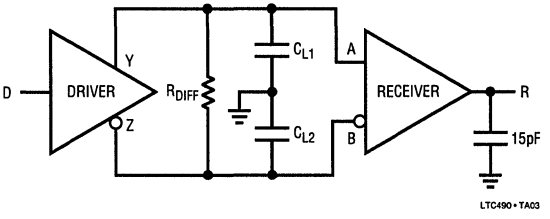


Figure 2. Driver/Receiver Timing Test Circuit

SWITCHING TIME WAVEFORMS

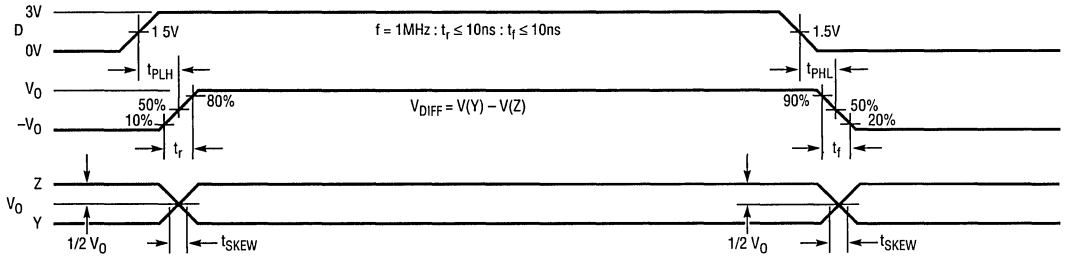


Figure 3. Driver Propagation Delays

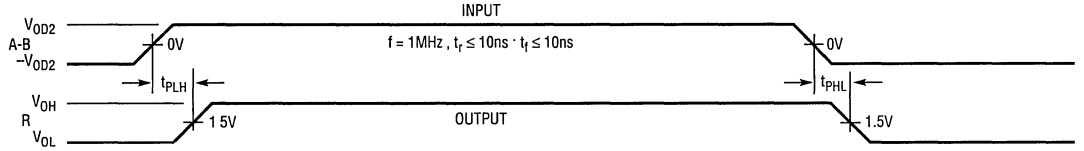


Figure 4. Receiver Propagation Delays

APPLICATIONS INFORMATION

Typical Application

A typical connection of the LTC490 is shown in Figure 5. Two twisted pair wires connect two driver/receiver pairs for full duplex data transmission. Note that the driver and receiver outputs are always enabled. If the outputs must be disabled, use the LTC491.

There are no restrictions on where the chips are connected, and it isn't necessary to have the chips connected at the ends of the wire. However, the wires must be terminated only at the ends with a resistor equal to their characteristic impedance, typically 120Ω. Because only

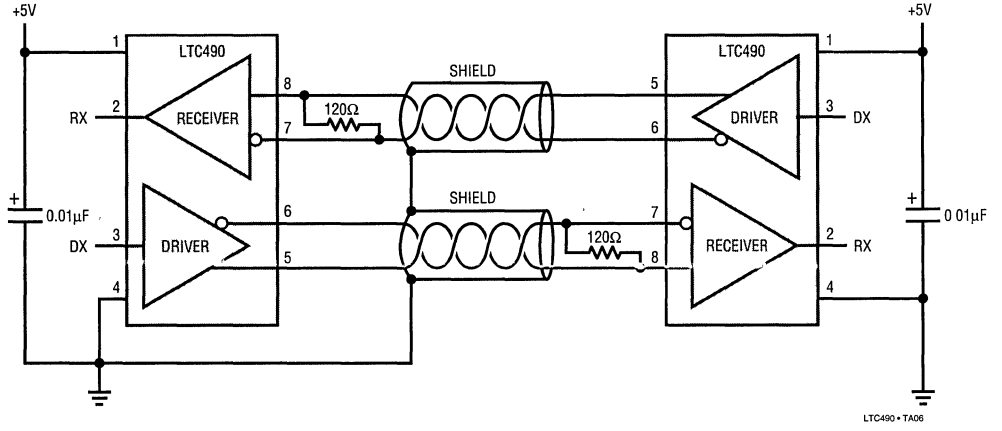


Figure 5. Typical Connection

APPLICATIONS INFORMATION

one driver can be connected on the bus, the cable can be terminated only at the receiving end. The optional shields around the twisted pair help reduce unwanted noise, and are connected to GND at one end.

The LTC490 can also be used as a line repeater as shown in Figure 6. If the cable length is longer than 4000 feet, the LTC490 is inserted in the middle of the cable with the receiver output connected back to the driver input.

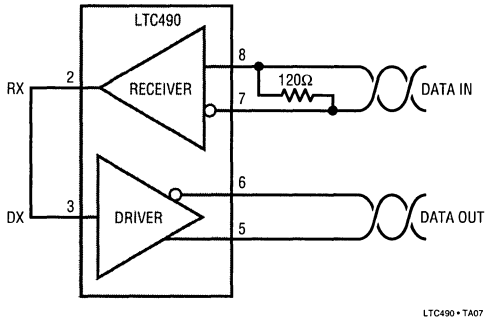


Figure 6. Line Repeater

Thermal Shutdown

The LTC490 has a thermal shutdown feature which protects the part from excessive power dissipation. If the outputs of the driver are accidently shorted to a power supply or low impedance, source, up to 250mA can flow through the part. The thermal shutdown circuit disables the driver outputs when the internal temperature reaches 150°C and turns them back on when the temperature cools to 130°C. If the outputs of two or more LTC490 drivers are shorted directly, the driver outputs can not supply enough current to activate the thermal shutdown. Thus, the thermal shutdown circuit will not prevent contention faults when two drivers are active on the bus at the same time.

Differential Driver and Receiver Pair

FEATURES

- Low Power: I_{CC} = 300μA Typical
- Designed for RS485 or RS422 Applications
- Single +5V Supply
- –7V to +12V Bus Common Mode Range Permits ±7V Ground Difference Between Devices on the Bus
- Thermal Shutdown Protection
- Power-Up/Down Glitch-Free Driver Outputs Permit Live Insertion or Removal of Package
- Driver Maintains High Impedance in Three-State or with the Power Off
- Combined Impedance of a Driver Output and Receiver Allows up to 32 Transceivers on the Bus
- 70mV Typical Input Hysteresis
- 28ns Typical Driver Propagation Delays with 5ns Skew
- Pin Compatible with the SN75180

APPLICATIONS

- Low Power RS485/RS422 Transceiver
- Level Translator

DESCRIPTION

The LTC491 is a low power differential bus/line transceiver designed for multipoint data transmission standard RS485 applications with extended common mode range (+12V to –7V). It also meets the requirements of RS422.

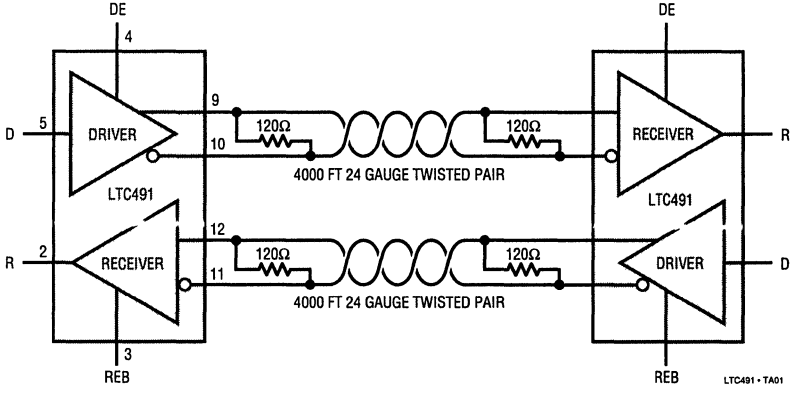
The CMOS design offers significant power savings over its bipolar counterpart without sacrificing ruggedness against overload or ESD damage.

The driver and receiver feature three-state outputs, with the driver outputs maintaining high impedance over the entire common mode range. Excessive power dissipation caused by bus contention or faults is prevented by a thermal shutdown circuit which forces the driver outputs into a high impedance state.

The receiver has a fail safe feature which guarantees a high output state when the inputs are left open.

Both AC and DC specifications are guaranteed from 0°C to 70°C and 4.75V to 5.25V supply voltage range.

TYPICAL APPLICATION

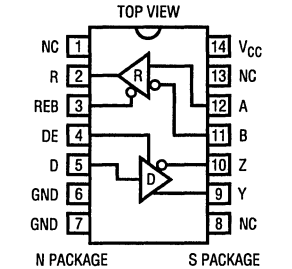


ABSOLUTE MAXIMUM RATINGS

(Note 1)

Supply Voltage (V_{CC}) 12V
Control Input Voltages ..... −0.5V to V_{CC} +0.5V
Control Input Currents ..... −50mA to 50mA
Driver Input Voltages ..... −0.5V to V_{CC} +0.5V
Driver Input Currents ..... −25mA to 25mA
Driver Output Voltages ..... ±14V
Receiver Input Voltages ..... ±14V
Receiver Output Voltages ..... −0.5V to V_{CC} +0.5V
Operating Temperature Range ..... 0°C to 70°C
Storage Temperature Range ..... −65°C to 150°C
Lead Temperature (Soldering, 10 sec.) ..... 300°C

PACKAGE/ORDER INFORMATION



N PACKAGE
14-LEAD PLASTIC DIP

S PACKAGE
14-LEAD PLASTIC SOIC

LTC491 • POI01

ORDER PART NUMBER
LTC491CN
LTC491CS
LTC491IN
LTC491IS

T_{JMAX} = 100°C, θ_{JA} = 90°C/W (N)
T_{JMAX} = 100°C, θ_{JA} = 110°C/W (S)

DC ELECTRICAL CHARACTERISTICS

V_{CC} = 5V ±5%, 0°C ≤ Temperature ≤ 70°C (Notes 2 and 3) unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V_{OD1}	Differential Driver Output Voltage (Unloaded)	I_O = 0				5	V
V_{OD2}	Differential Driver Output Voltage (With load)	R = 50Ω; (RS422)		2			V
		R = 27Ω; (RS485) (Figure 1)		1.5		5	V
ΔV_{OD}	Change in Magnitude of Driver Differential Output Voltage for Complementary Output States	R = 27Ω or R = 50Ω (Figure 1)				0.2	V
V_{OC}	Driver Common Mode Output Voltage					3	V
$\Delta \lvert V_{OC} \rvert$	Change in Magnitude of Driver Common Mode Output Voltage for Complementary Output States					0.2	V
V_{IH}	Input High Voltage	D, DE, REB		2.0			V
V_{IL}	Input Low Voltage					0.8	V
I_{IN1}	Input Current					±2	µA
I_{IN2}	Input Current (A, B)	V_{CC} = 0V or 5.25V	V_{IN} = 12V			+1.0	mA
			V_{IN} = −7V			−0.8	mA
V_{TH}	Differential Input Threshold Voltage for Receiver	−7V ≤ V_{CM} ≤ 12V		−0.2		+0.2	V
ΔV_{TH}	Receiver Input Hysteresis	V_{CM} = 0V			70		mV
V_{OH}	Receiver Output High Voltage	I_O = −4mA, V_{ID} = +0.2V		3.5			V
V_{OL}	Receiver Output Low Voltage	I_O = +4mA, V_{ID} = −0.2V				0.4	V
I_{OZR}	Three-State Output Current at Receiver	V_{CC} = Max 0.4V ≤ V_O ≤ 2.4V				±1	µA
I_{CC}	Supply Current	No Load; D = GND,	Outputs Enabled		300	500	µA
		or V_{CC}	Outputs Disabled		300	500	µA
R_{IN}	Receiver Input Resistance	−7V ≤ V_{CM} ≤ +12V		12			kΩ
I_{OSD1}	Driver Short Circuit Current, V_{OUT} = High	−7V ≤ V_O ≤ +12V				250	mA
I_{OSD2}	Driver Short Circuit Current, V_{OUT} = Low	−7V ≤ V_O ≤ +12V				250	mA
I_{OSR}	Receiver Short Circuit Current	0V ≤ V_O ≤ V_{CC}		7		85	mA
I_{OZ}	Driver Three-State Output Current	V_O = −7V to 12V			±2	±200	µA

SWITCHING CHARACTERISTICS

V_{CC} = 5V ±5%, 0°C ≤ Temperature ≤ 70°C (Notes 2 and 3) unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
t_{PLH}	Driver Input to Output	R_{DIFF} = 54Ω, C_{L1} = C_{L2} = 100pF (Figures 2, 5)	10	28	60	ns
t_{PHL}	Driver Input to Output		10	28	60	ns
t_{SKEW}	Driver Output to Output			5		ns
t_r, t_f	Driver Rise or Fall Time		5	15	25	ns
t_{ZH}	Driver Enable to Output High	C_L = 100pF (Figures 4, 6) S2 Closed		40	70	ns
t_{ZL}	Driver Enable to Output Low	C_L = 100pF (Figures 4, 6) S1 Closed		40	70	ns
t_{LZ}	Driver Disable Time From Low	C_L = 15pF (Figures 4, 6) S1 Closed		40	70	ns
t_{HZ}	Driver Disable Time From High	C_L = 15pF (Figures 4, 6) S2 Closed		40	70	ns
t_{PLH}	Receiver Input to Output	R_{DIFF} = 54Ω, C_{L1} = C_{L2} = 100pF (Figures 2, 7)	40	70	150	ns
t_{PHL}	Receiver Input to Output		40	70	150	ns
t_{SKD}	$\lvert t_{PLH} - t_{PHL} \rvert$ Differential Receiver Skew			13		ns
t_{ZL}	Receiver Enable to Output Low	C_L = 15pF (Figures 3, 8) S1 Closed		20	50	ns
t_{ZH}	Receiver Enable to Output High	C_L = 15pF (Figures 3, 8) S2 Closed		20	50	ns
t_{LZ}	Receiver Disable From Low	C_L = 15pF (Figures 3, 8) S1 Closed		20	50	ns
t_{HZ}	Receiver Disable From High	C_L = 15pF (Figures 3, 8) S2 Closed		20	50	ns

Note 1: "Absolute Maximum Ratings" are those beyond which the safety of the device cannot be guaranteed.

Note 2: All currents into device pins are positive; all currents out of device pins are negative. All voltages are referenced to device ground unless otherwise specified.

Note 3: All typicals are given for V_{CC} = 5V and Temperature = 25°C.

PIN FUNCTIONS

NC (Pin 1): Not Connected.

R (Pin 2): Receiver output. If the receiver output is enabled (REB low), then if A > B by 200mV, R will be high. If A < B by 200mV, then R will be low.

REB (Pin 3): Receiver output enable. A low enables the receiver output, R. A high input forces the receiver output into a high impedance state.

DE (Pin 4): Driver output enable. A high on DE enables the driver outputs, A and B. A low input forces the driver outputs into a high impedance state.

D (Pin 5): Driver input. If the driver outputs are enabled (DE high), then A low on D forces the driver outputs A low and B high. A high on D will force A high and B low.

GND (Pin 6): Ground Connection.

GND (Pin 7): Ground Connection.

NC (Pin 8): Not Connected.

Y (Pin 9): Driver output.

Z (Pin 10): Driver output.

B (Pin 11): Receiver input.

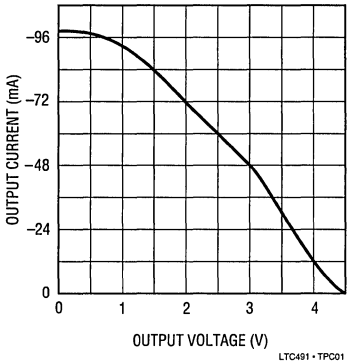
A (Pin 12): Receiver input.

NC (Pin 13): Not Connected.

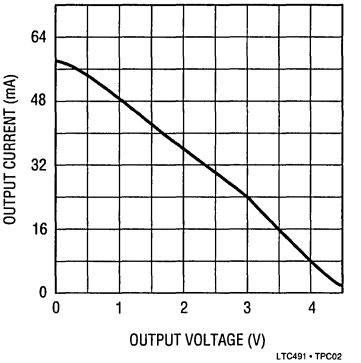
V_{CC} (Pin 14): Positive supply; 4.75V ≤ V_{CC} ≤ 5.25V.

TYPICAL PERFORMANCE CHARACTERISTICS

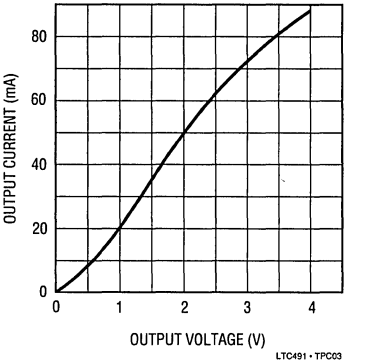
Driver Output High Voltage vs Output Current T_A = 25°C



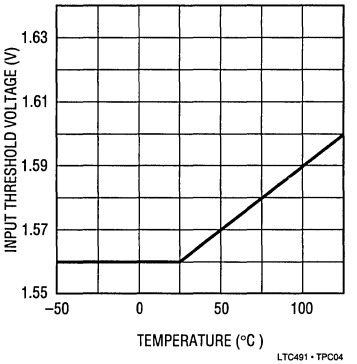
Driver Differential Output Voltage vs Output Current T_A = 25°C



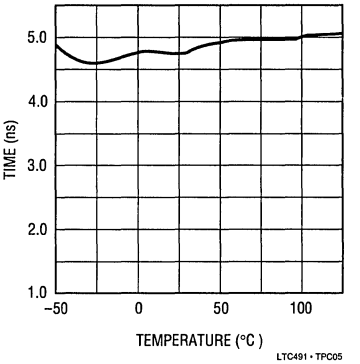
Driver Output Low Voltage vs Output Current T_A = 25°C



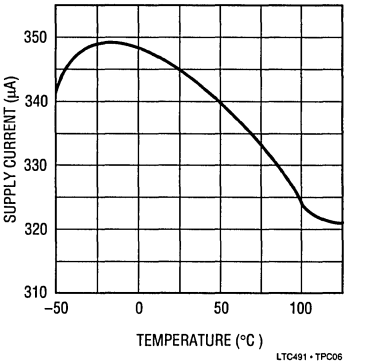
TTL Input Threshold vs Temperature



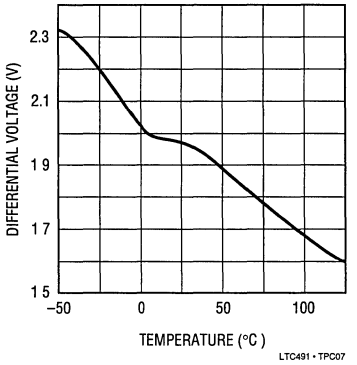
Driver Skew vs Temperature



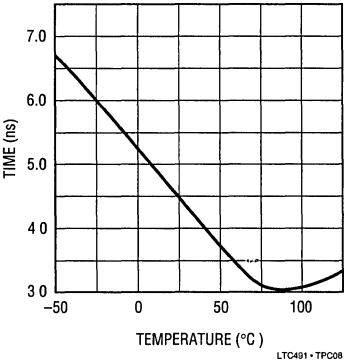
Supply Current vs Temperature



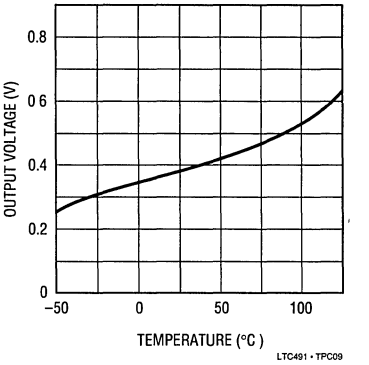
Driver Differential Output Voltage vs Temperature R_O = 54Ω



Receiver $|t_{PLH}\ t_{PHL}|$ vs Temperature



Receiver Output Low Voltage vs Temperature at I = 8mA



TEST CIRCUITS

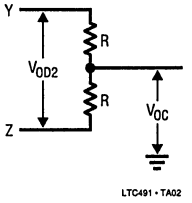


Figure 1. Driver DC Test Load

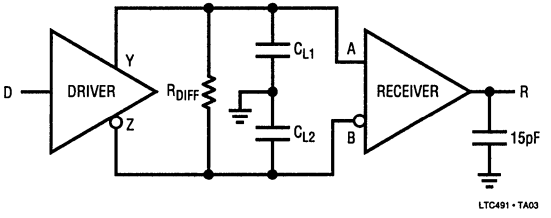


Figure 2. Driver/Receiver Timing Test Circuit

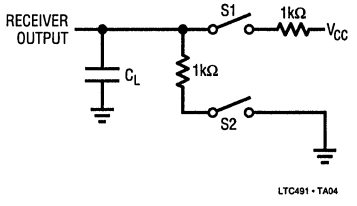


Figure 3. Receiver Timing Test Load

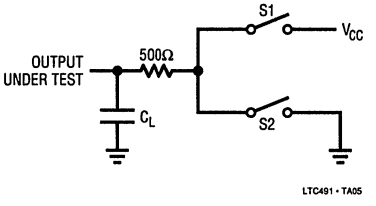


Figure 4. Driver Timing Test Load

SWITCHING TIME WAVEFORMS

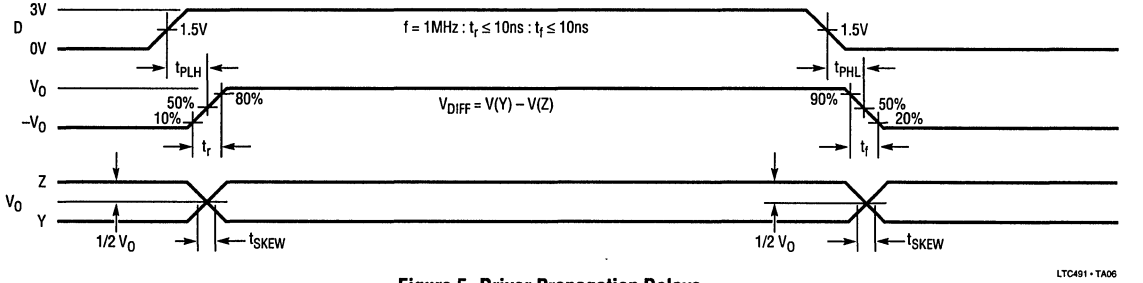


Figure 5. Driver Propagation Delays

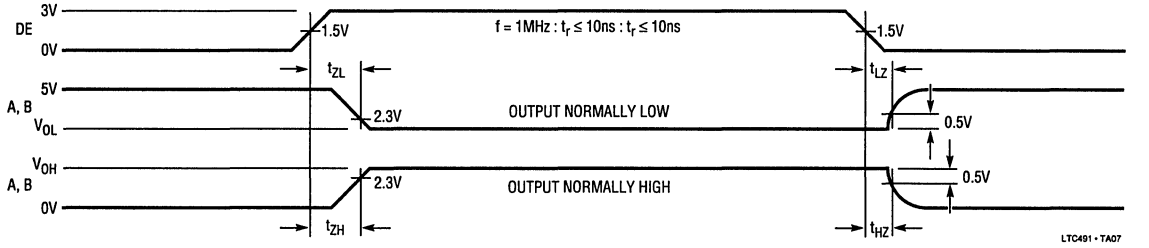


Figure 6. Driver Enable and Disable Times

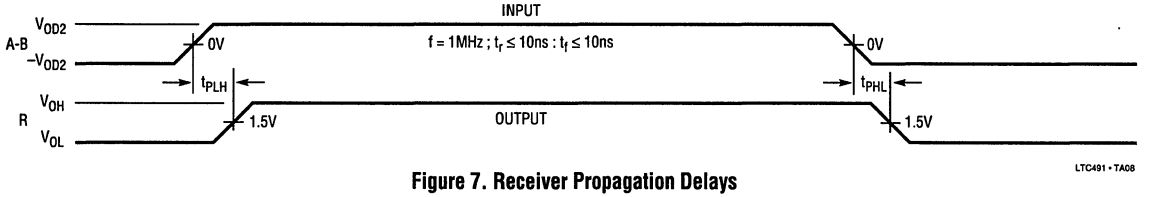


Figure 7. Receiver Propagation Delays

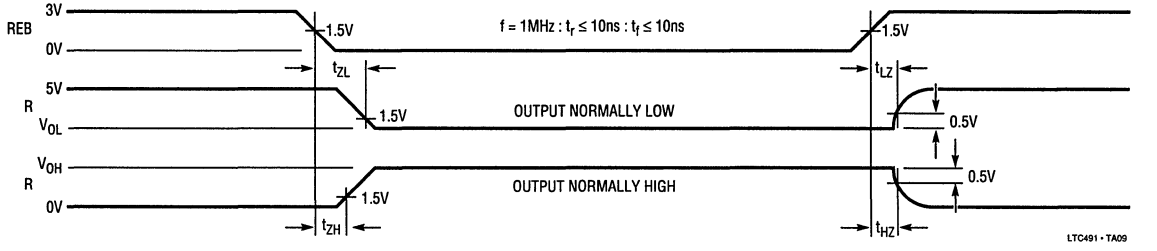


Figure 8. Receiver Enable and Disable Times

APPLICATIONS INFORMATION

Typical Application

A typical connection of the LTC491 is shown in Figure 9. Two twisted pair wires connect up to 32 driver/receiver pairs for full duplex data transmission. There are no restrictions on where the chips are connected to the wires, and it isn't necessary to have the chips connected at the ends. However, the wires must be terminated only at the ends with a resistor equal to their characteristic impedance, typically 120Ω. The input impedance of a receiver is typically 20kΩ to GND, or 0.6 unit RS-485 load, so in practice 50 to 60 transceivers can be connected to the same wires. The optional shields around the twisted pair help reduce unwanted noise, and are connected to GND at one end.

The LTC491 can also be used as a line repeater as shown in Figure 10. If the cable length is longer than 4000 feet, the LTC491 is inserted in the middle of the cable with the receiver output connected back to the driver input.

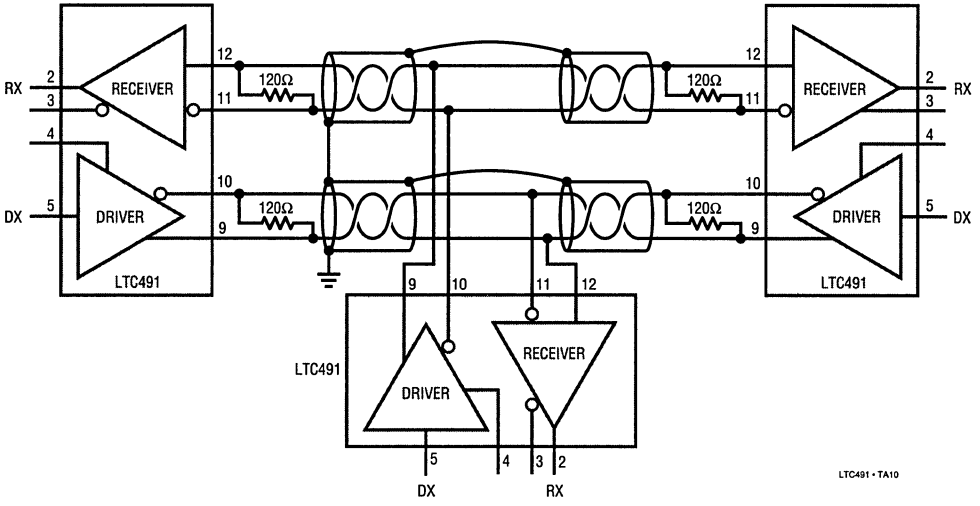


Figure 9. Typical Connection

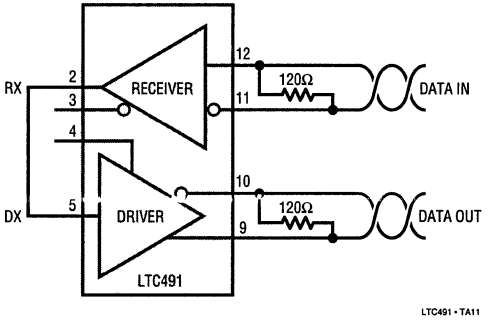


Figure 10. Line Repeater

FEATURES

- Low Power: I_{CC} = 1.8mA Typ.
- 28ns Typical Driver Propagation Delays with 4ns Skew
- Designed for RS485 or RS422 Applications
- Single 5V Supply
- –7V to 12V Bus Common Mode Range Permits ±7V Ground Difference Between Devices on the Bus
- Thermal Shutdown Protection
- Power-Up/Down Glitch-Free Driver Outputs
- Driver Maintains High Impedance in Three-State or with the Power Off
- Combined Impedance of a Driver Output and Receiver Allows up to 32 Transceivers on the Bus
- 60mV Typical Input Hysteresis
- Pin-Compatible with the SN75176A, DS75176A, and SN75LBC176

APPLICATIONS

- Low Power RS485/RS422 Transceiver
- Level Translator

DESCRIPTION

The LTC1485 is a low power differential bus/line transceiver designed for multipoint data transmission standard RS485 applications with extended common mode range (12V to –7V). It also meets the requirements of RS422.

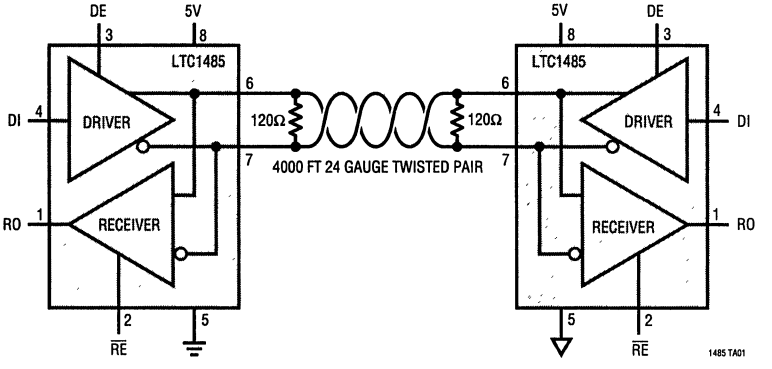
The CMOS with Schottky design offers significant power savings over its bipolar counterpart without sacrificing ruggedness against overload or ESD damage.

The driver and receiver feature three-state outputs, with the driver outputs maintaining high impedance over the entire common mode range. Excessive power dissipation caused by bus contention or faults is prevented by a thermal shutdown circuit which forces the driver outputs into a high impedance state.

The receiver has a fail-safe feature which guarantees a high output state when the inputs are left open.

Both AC and DC specifications are guaranteed from –40°C to 85°C and 4.75V to 5.25V supply voltage range.

TYPICAL APPLICATION

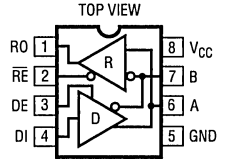


ABSOLUTE MAXIMUM RATINGS

(Note 1)

Supply Voltage (V_{CC}) 12V
Control Input Voltages ..... $-0.5V$ to $V_{CC} + 0.5V$
Control Input Currents ..... $-50mA$ to $50mA$
Driver Input Voltages ..... $-0.5V$ to $V_{CC} + 0.5V$
Driver Input Currents ..... $-25mA$ to $25mA$
Driver Output Voltages ..... $\pm14V$
Receiver Input Voltages ..... $\pm14V$
Receiver Output Voltages ..... $-0.5V$ to $V_{CC} + 0.5V$
Operating Temperature Range
LTC1485C ..... 0°C to 70°C
LTC1485I ..... $-40°C$ to 85°C
Storage Temperature Range ..... $-65°C$ to 150°C
Lead Temperature (Soldering, 10 sec.) ..... 300°C

PACKAGE/ORDER INFORMATION



N8 PACKAGE
8-LEAD PLASTIC DIP

S8 PACKAGE
8-LEAD PLASTIC SOIC

$T_{JMAX} = 125°C$, $\theta_{JA} = 100°C/W$ (N)
$T_{JMAX} = 150°C$, $\theta_{JA} = 150°C/W$ (S)

ORDER PART NUMBER
LTC1485CN8 LTC1485IN8 LTC1485CS8 LTC1485IS8
S8 PART MARKING
1485 1485I

DC ELECTRICAL CHARACTERISTICS

V_{CC} = 5V ±5% (Notes 2 and 3), unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V_{OD1}	Differential Driver Output Voltage (Unloaded)	$I_O = 0$;	O		5	V	
V_{OD2}	Differential Driver Output Voltage (With Load)	R = 50Ω; (RS422)	O	2			V
		R = 27Ω; (RS485) (Figure 1)	O	1.5		5	V
ΔV_{OD}	Change in Magnitude of Driver Differential Output Voltage for Complementary Output States	R = 27Ω or R = 50Ω (Figure 1)	O			0.2	V
V_{OC}	Driver Common Mode Output Voltage	R = 27Ω or R = 50Ω (Figure 1)	O			3	V
$\Delta\lvert V_{OC}\rvert$	Change in Magnitude of Driver Common Mode Output Voltage for Complementary Output States	R = 27Ω or R = 50Ω (Figure 1)	O			0.2	V
V_{INH}	Input High Voltage	DI, DE, $\overline{RE}$	O	2.0			V
V_{INL}	Input Low Voltage	DI, DE, $\overline{RE}$	O			0.8	V
I_{IN1}	Input Current	DI, DE, $\overline{RE}$	O			±2	µA
I_{IN2}	Input Current (A, B)	V_{CC} = 0V or 5.25V, V_{IN} = 12V	O			1.0	mA
		V_{CC} = 0V or 5.25V, V_{IN} = −7V	O			−0.8	mA
V_{TH}	Differential Input Threshold Voltage for Receiver	$-7V \le V_{CM} \le 12V$	O	−0.2		0.2	V
ΔV_{TH}	Receiver Input Hysteresis	V_{CM} = 0V	O		60		mV
V_{OH}	Receiver Output High Voltage	$I_O = -4mA$, $V_{ID} = 0.2V$	O	3.5			V
V_{OL}	Receiver Output Low Voltage	$I_O = 4mA$, $V_{ID} = -0.2V$	O			0.4	V
I_{OZR}	Three-State Output Current at Receiver	V_{CC} = Max 0.4V ≤ V_O ≤ 2.4V	O			±1	µA
I_{CC}	Supply Current	No Load; DI = GND or V_{CC}					
		Outputs Enabled	O		1.8	2.3	mA
		Outputs Disabled	O		1.7	2.3	mA
R_{IN}	Receiver Input Resistance	$-7V \le V_{CM} \le 12V$	O	12			kΩ
I_{OSD1}	Driver Short-Circuit Current, V_{OUT} = High	$-7V \le V_O \le 12V$	O			250	mA
I_{OSD2}	Driver Short-Circuit Current, V_{OUT} = Low	$-7V \le V_O \le 12V$	O			250	mA
I_{OSR}	Receiver Short-Circuit Current	$0V \le V_O \le V_{CC}$	O	7		85	mA

SWITCHING CHARACTERISTICS

V_{CC} = 5V ±5% (Notes 2 and 3), unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
t_{PLH}	Driver Input to Output	R_{DIFF} = 54Ω, C_{L1} = C_{L2} = 100pF (Figures 2 and 5)	O	13	28	50	ns
t_{PHL}	Driver Input to Output	R_{DIFF} = 54Ω, C_{L1} = C_{L2} = 100pF (Figures 2 and 5)	O	13	28	50	ns
t_{SKEW}	Driver Output to Output	R_{DIFF} = 54Ω, C_{L1} = C_{L2} = 100pF (Figures 2 and 5)	O		4	10	ns
t_r, t_f	Driver Rise or Fall Time	R_{DIFF} = 54Ω, C_{L1} = C_{L2} = 100pF (Figures 2 and 5)	O	5	15	25	ns
t_{ZH}	Driver Enable to Output High	C_L = 100pF (Figures 4 and 6) S2 Closed	O		40	60	ns
t_{ZL}	Driver Enable to Output Low	C_L = 100pF (Figures 4 and 6) S1 Closed	O		40	70	ns
t_{LZ}	Driver Disable Time from Low	C_L = 15pF (Figures 4 and 6) S1 Closed	O		40	65	ns
t_{HZ}	Driver Disable Time from High	C_L = 15pF (Figures 4 and 6) S2 Closed	O		40	60	ns
t_{PLH}	Receiver Input to Output	R_{DIFF} = 54Ω, C_{L1} = C_{L2} = 100pF (Figures 2 and 7)	O	15	25	50	ns
t_{PHL}	Receiver Input to Output	R_{DIFF} = 54Ω, C_{L1} = C_{L2} = 100pF (Figures 2 and 7)	O	20	30	55	ns
t_{SKEW}	$\lvert t_{PLH} - t_{PHL} \rvert$ Differential Receiver Skew	R_{DIFF} = 54Ω, C_{L1} = C_{L2} = 100pF (Figures 2 and 7)	O		5	15	ns
t_{ZL}	Receiver Enable to Output Low	C_L = 15pF (Figures 3 and 8) S1 Closed	O		30	45	ns
t_{ZH}	Receiver Enable to Output High	C_L = 15pF (Figures 3 and 8) S2 Closed	O		30	45	ns
t_{LZ}	Receiver Disable from Low	C_L = 15pF (Figures 3 and 8) S1 Closed	O		30	45	ns
t_{HZ}	Receiver Disable from High	C_L = 15pF (Figures 3 and 8) S2 Closed	O		30	45	ns

The O denotes specifications which apply over the operating temperature range.

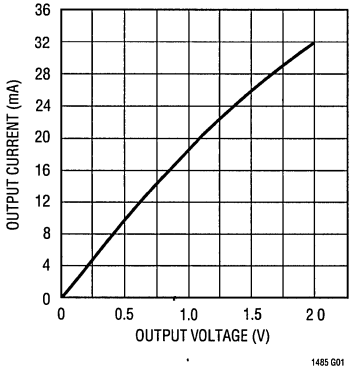
Note 1: "Absolute Maximum Ratings" are those beyond which the safety of the device cannot be guaranteed.

Note 2: All currents into device pins are positive; all currents out of device pins are negative. All voltages are referenced to device ground unless otherwise specified.

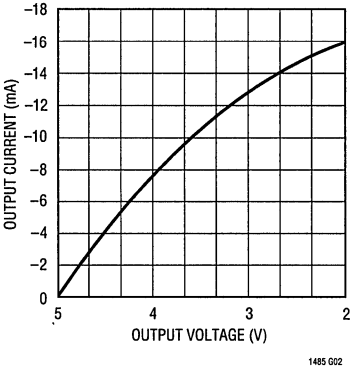
Note 3: All typicals are given for V_{CC} = 5V and T_A = 25°C.

TYPICAL PERFORMANCE CHARACTERISTICS

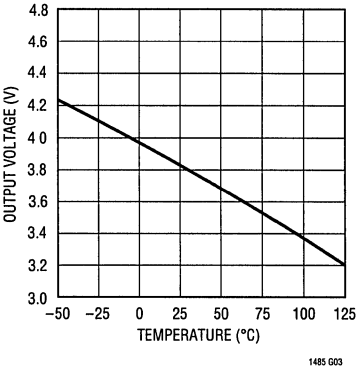
Receiver Output Low Voltage vs Output Current at TA = 25°C



Receiver Output High Voltage vs Output Current at T_A = 25°C

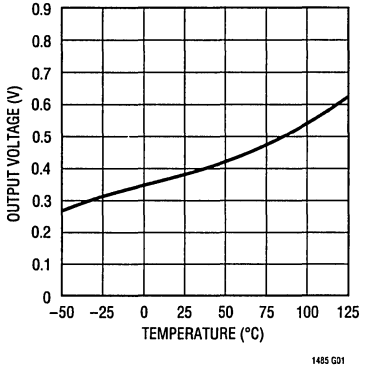


Receiver Output High Voltage vs Temperature at I = 8mA

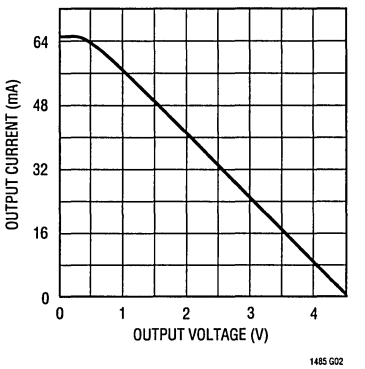


TYPICAL PERFORMANCE CHARACTERISTICS

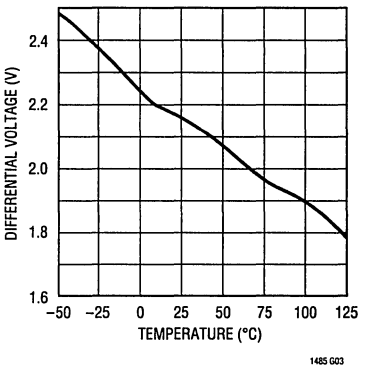
Receiver Output Low Voltage vs Temperature at I = 8mA



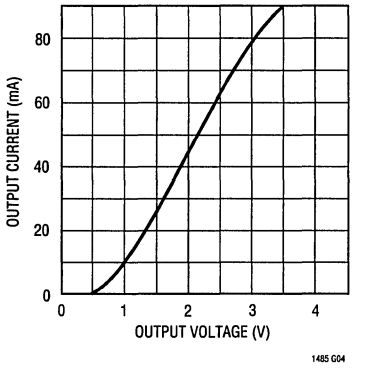
Driver Differential Output Voltage vs Output Current at T_A = 25°C



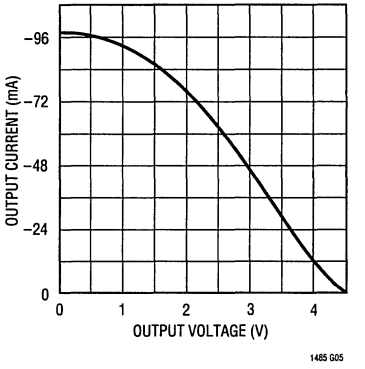
Driver Differential Output Voltage vs Temperature at R_L = 54Ω



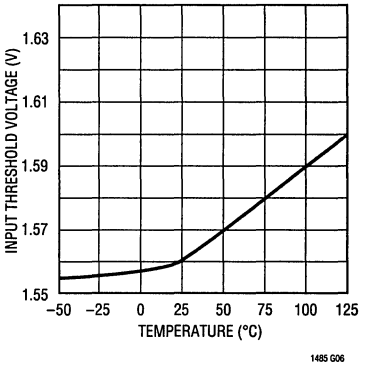
Driver Output Low Voltage vs Output Current at T_A = 25°C



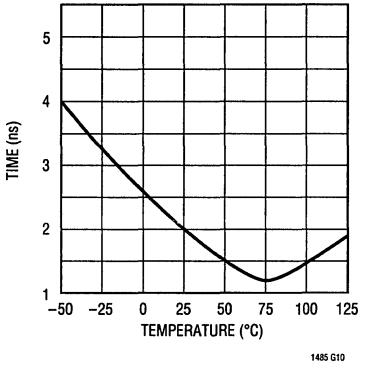
Driver Output High Voltage vs Output Current at T_A = 25°C



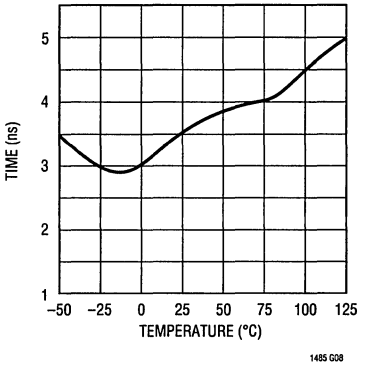
TTL Input Threshold vs Temperature



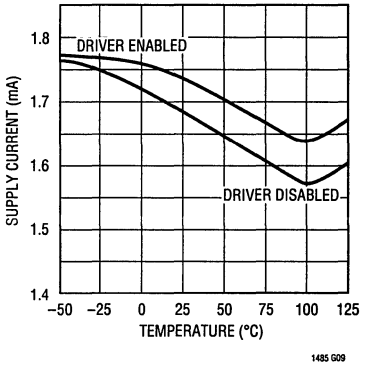
Receiver $|t_{PLH} - t_{PHL}|$ vs Temperature



Driver Skew vs Temperature



Supply Current vs Temperature



PIN FUNCTIONS

PIN 1 (RO) Receiver Output: If the receiver output is enabled ($\overline{RE}$ low), then if A > B by 200mV, RO will be high. If A < B by 200mV, then RO will be low.

PIN 2 ($\overline{RE}$) Receiver Output Enable: A low enables the receiver output, RO. A high input forces the receiver output into a high impedance state.

PIN 3 (DE) Driver Output Enable: A high on DE enables the driver outputs, A and B. A low input will force the driver outputs into a high impedance state.

PIN 4 (DI) Driver Input: If the driver outputs are enabled (DE high), then a low on DI forces the driver outputs A low and B high. A high on DI will force A high and B low.

PIN 5 (GND) Ground Connection

PIN 6 (A) Driver Output/Receiver Input

PIN 7 (B) Driver Output/Receiver Input

PIN 8 (V_{CC}) Positive Supply; $4.75V \leq V_{CC} \leq 5.25V$

TEST CIRCUITS

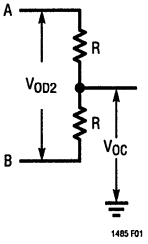


Figure 1. Driver DC Test Load

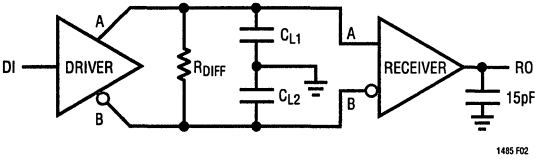


Figure 2. Driver/Receiver Timing Test Circuit

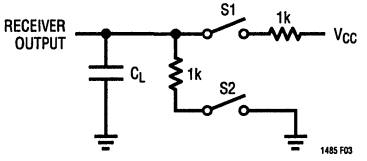


Figure 3. Receiver Timing Test Load

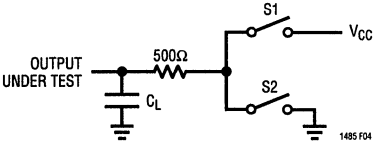


Figure 4. Driver Timing Test Load

SWITCHING TIME WAVEFORMS

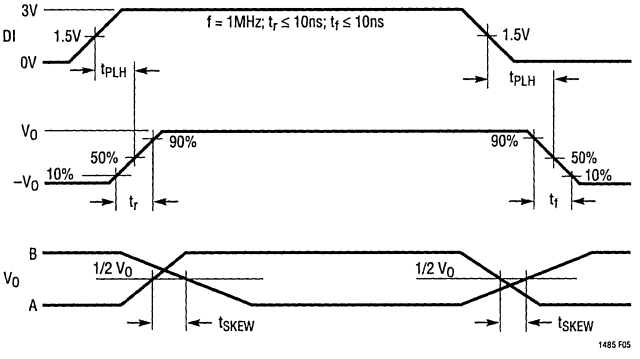


Figure 5. Driver Propagation Delays

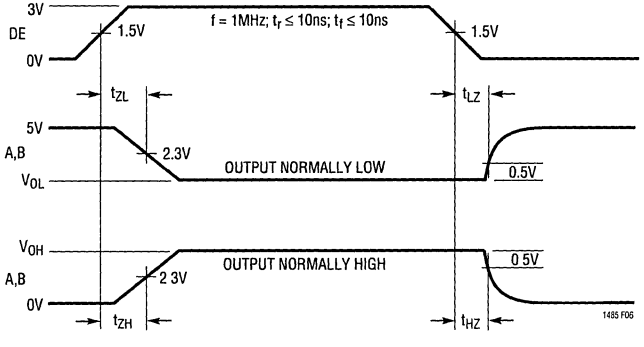


Figure 6. Driver Enable and Disable Times

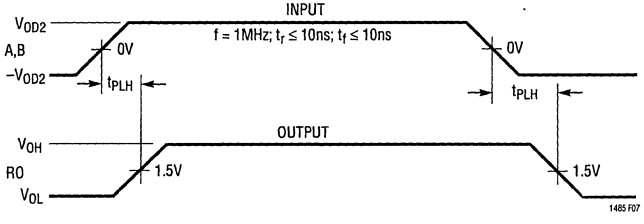


Figure 7. Receiver Propagation Delays

SWITCHING TIME WAVEFORMS

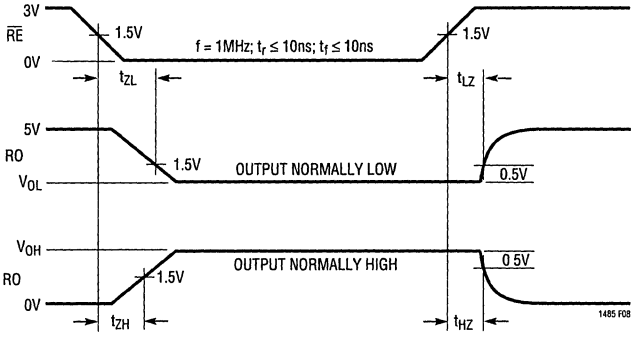


Figure 8. Receiver Enable and Disable Times

CHAPTER 3: RS232 PRODUCTS

Chapter 3: RS232 Products

LINEAR TECHNOLOGY

DESIGN NOTES

Number 4 in a series from Linear Technology Corporation *November, 1987*

New Developments in RS232 Interfaces

Robert Dobkin

New RS232 interface chips have been developed that offer significant advantages over older devices such as the 1488 and 1489. The new RS232 interface ICs improve speed, power, voltage supply requirements, and protection over older devices. Further, the new chips are easier to use, requiring fewer external components and may be turned off to a "zero" power supply current condition for use in battery powered systems.

The new RS232 drivers are implemented in a monolithic bipolar technology. A unique output stage was designed that provides large output swings, minimizing power supply voltage requirements, while retaining outstanding overload protection features. The outputs can be driven beyond the power supply voltage without drawing excessive current or forcing current back into the power supplies. Of course, current limiting is included to protect against short circuit conditions.

Initial consideration of technologies for implementing RS232 interfacing might include CMOS as a possible technology for this type of application. Power supply requirements are low, output voltage swing is high, and higher voltage CMOS technologies are available to allow operation up to ±15V. Consideration of some of the problems associated with CMOS decreases its attractiveness for RS232 drivers.

Inherent in the CMOS structure, are diodes between the drain and source of the CMOS devices and the power supplies as is shown in Figure 1. A requirement of RS232 interfaces is the ability to withstand voltage applied to the output pins. With a CMOS output stage this is achieved with the inclusion of a 300Ω resistor in series with the output. (The resistor is similar to the resistors included in older drivers.) It protects the interface chip, but still allows damage to other devices powered by the same supply.

A problem occurs when the output of a driver which is powered from the 5V logic supply is connected to an external 12V or 15V source as is allowed by the RS232 specification. External current flows through the 300Ω limiting resistor, through the diodes, which are a part of the CMOS structure, and into the power supply. This forces the power supply to 12V or 15V damaging the 5V logic that is connected to the supplies. This problem can even cause latchup if the logic supply is off when external RS232 signals feed voltage into the supply. This problem did not usually exist in the past, because the RS232 interfaces were powered by separate ±12V supplies.

ESD damage is probably the most frequent cause of failure of interface chips. Bipolar devices are relatively rugged but still can be damaged by ESD. System requirements for ESD may be as high as 20kV. No IC can withstand that much voltage without external protection.

A requirement of the RS232 specification is the ability to withstand ±25V input signals. The CMOS LTC1045 which is used as an RS232 receiver has been designed to operate with external resistors in series with the input. These resistors allow very large voltage swings at the input pins and provide ESD protection to the IC. Using on-chip resistors precludes the use of the optimum ESD protection structures, so CMOS devices may be more sensitive to ESD destruction at their inputs.

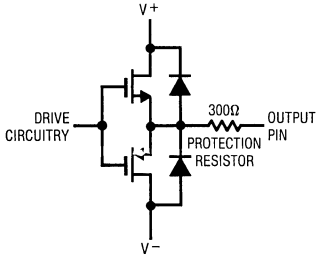


Figure 1. CMOS Line Driver Showing Parasitic Diodes to the Power Supplies

The output stage of the bipolar drivers is shown in Figure 2. Opposed collector NPN and PNP transistors give the widest possible output swings. The PNP transistor will swing to within 200mV of the positive supply while the NPN transistor with its associated Schottky diode will swing within about 900mV of the negative supply. If the output voltage is forced above the positive supply the emitter base junction of the PNP transistor reverse biases, and no current flows into the supply. The device is unaffected by external voltage up to the breakdown voltage of the transistor. If the output is forced below the negative supply, the Schottky diode reverse biases and prevents external current flow into the chip. Capacitor C1 is used to control the output slew rate so that no frequency compensation components are required to meet the RS232 specification of 4V/μs to 30V/μs.

Typically the slew rate of these drivers is about 8-10V/μs. This allows them to be used successfully up to about 64k baud. The output slew rate of the bipolar drivers is well controlled by an internal capacitor and relatively independent of load resistance or capacitance. The bipolar receiver is relatively straightforward utilizing a level detector with hysteresis to set the trip point. Nominally the trip point is set at about 1.5V with 200mV of hysteresis. The receivers go into a high output state with an open input. The receivers outputs are both TTL and CMOS compatible.

A recent advance in the drivers and receivers is on-chip power supply generation. Devices like the LT1080 and LT1081 include an oscillator, capacitive voltage doubler, and capacitive inverter to generate ±9V from the 5V power supply. The charge-pump power supply generator requires only four 1μF capacitors to generate RS232 communication levels from a 5V logic supply. Figure 3 shows a typical hook-up for the LT1080. The on-chip power supply generators generate excess power over the LT1080 requirements, so another RS232 communication device such as the LT1039 can be powered from the same power supply generator. Table 1 gives typical performance of all Linear Technology driver/receiver devices for RS232 communication.

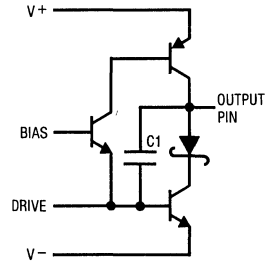


Figure 2. New Bipolar Driver Output Stage

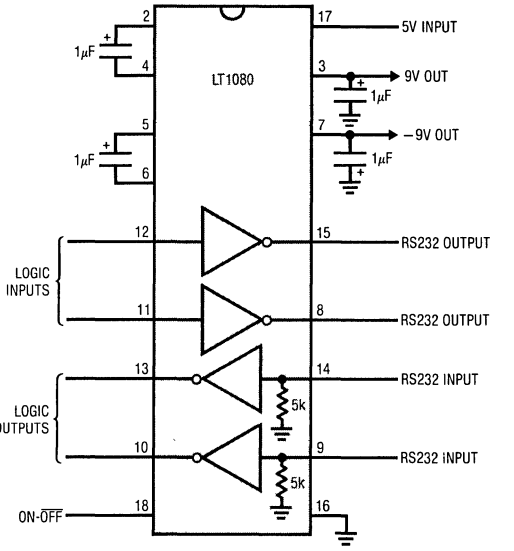


Figure 3. 5V Powered RS232 Driver/Receiver

Table 1. New Drivers and Receivers

DEVICE	DRVS	RECS	SHUT-DOWN	SUPPLY GENERATOR	REMARKS
LT1030	4		X		Low Cost
LT1032	4		X		RS423 Compatible
LT1039	3	3	X		
LT1039N16	3	3			MC145406 Compatible
LTC1045		6	X		Micropower
LT1080	2	2	X	X	
LT1081	2	2		X	MAX232 Compatible
LT1130	5	5		X	
LT1131	5	4	X	X	
LT1132	5	3		X	
LT1133	3	5		X	
LT1134	4	4		X	
LT1135	5	3			
LT1136	4	5	X	X	
LT1180	2	2	X		0.1μF Caps
LT1181	2	2			0.1μF Caps

LINEAR TECHNOLOGY

DESIGN NOTES

Number 14 in a series from Linear Technology Corporation *September, 1988*

Extending the Applications of 5V Powered RS232 Transceivers

High Speed Operation

Although the EIA RS232 specification is for a relatively slow communications protocol, many applications require RS232 transceivers to operate at higher frequencies. Devices such as the LT1080, LT1081, and the LT1130 series share a common design for the drivers and receivers and are capable of operating over 100 kilobaud.

Although the slew rate is controlled for all of the Linear Technology series of RS232 communications devices, for output levels limited to ±6V the transition time is fast enough to allow high baud rates. With a slew rate of approximately 10V per microsecond, it only takes 1.2 microseconds for a 12V excursion. The two photos (Figure 1 and Figure 2) show the output waveform and delay associated with a 75kHz square wave input and a 100kHz square wave. Delay times are in the order of 0.5 microseconds and the total slew time is approximately 1.2 microseconds. Output load is 3k. Receivers are much faster and can handle these baud rates with no problem. For higher communication rates, a differential signal is recommended.

Power Supply Tricks

The power supply generator on 5V powered devices is a charge pump circuit which generates approximately ±9V from a single 5V supply. Parallel operation of the supply charge pumps for 5V powered transceivers is easily achieved to minimize component count. The positive and negative supply have approximately 1μF of holding capacitance for energy storage. If several devices with charge pumps are used in the same system, the output supplies may be paralleled into a single pair of common energy storage capacitors.

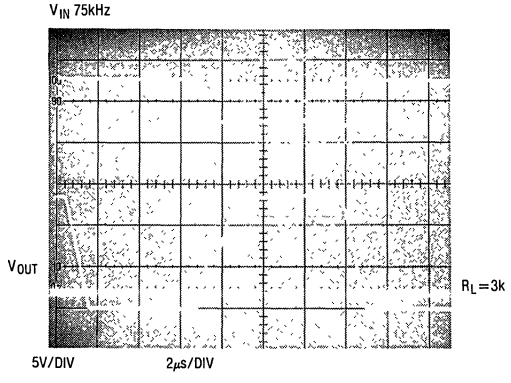


Figure 1. Operation at 75kHz

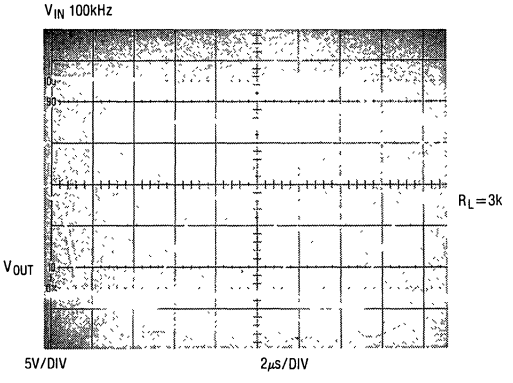


Figure 2. Operation at 100kHz

Figure 3 shows two LT1080's with common power supply capacitors for energy storage. Twice the output current is available for external use. This eliminates two capacitors from the system. Individual charge pump capacitors are still needed on each of the devices.

Operation with +5V and +12V Supplies

The charge pump circuitry takes the input 5V and doubles it. The doubled voltage is then inverted to obtain a negative output. The only reason for doubling the input is to ensure adequate positive and negative output voltage to meet RS232 specifications. In PC systems, where +12V is available, the internal voltage doubler does not need to be used. The device may be connected directly to a +5V and a +12V supply. The +12V is then inverted to obtain approximately −11V. This eliminates one charge pump capacitor and one holding capacitor for the 12V output. Figure 4 shows an LT1080 connected to a 12V and 5V power supply. The +12V is connected into one of the charge pump capacitor pins rather than the 12V output pin. Supply current also decreases to about 9mA.

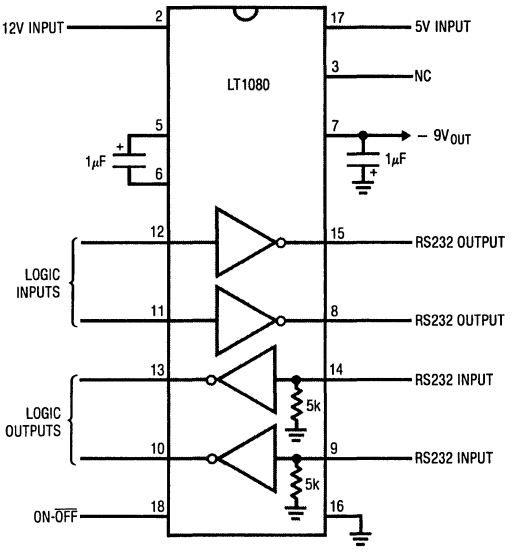


Figure 4. Operation with +12V and +5V Supplies

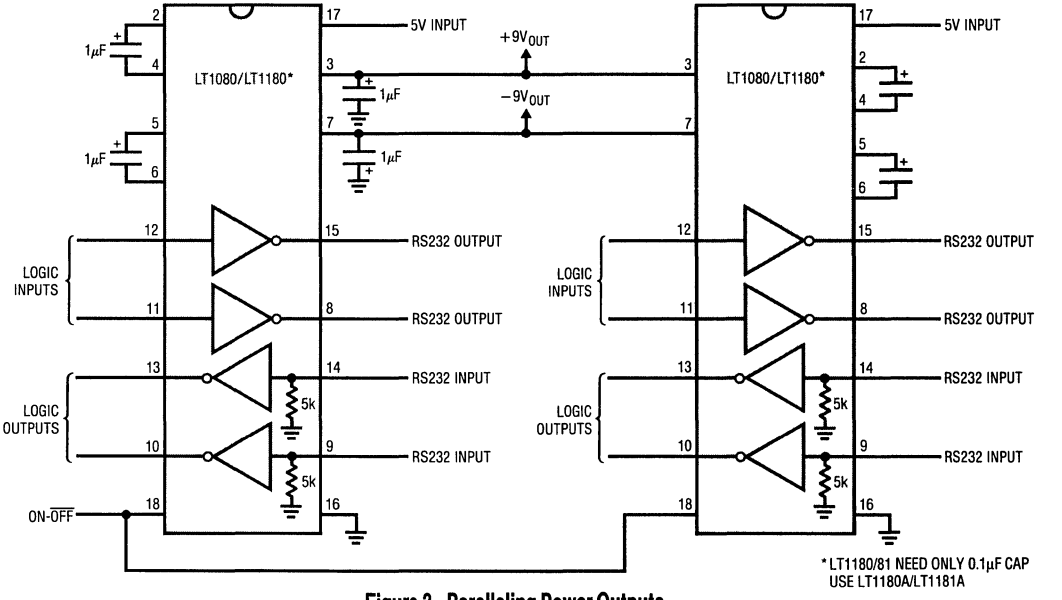


Figure 3. Paralleling Power Outputs

For literature about our complete line of RS232 products, call **800-637-5545**. For help with an application, call (408) 432-1900, Ext. 357.

LINEAR TECHNOLOGY

DESIGN NOTES

Number 20 in a series from Linear Technology Corporation *February, 1989*

Hex Level Shift Shrinks Board Space

Brian Huffman

Although simple in concept, interfacing digital levels between different logic families usually requires many parts and appreciable board space. Other applications that require some form of level shifting of the output swing have solutions just as complicated. A logic to CMOS analog switch (Figure 1) is just one example where a level shift must occur. A new device, the LTC1045, solves this and other level shift related problems conveniently. The LTC1045 is a hex level translator with a linear comparator on the front end. A latch and three-state output buffer are at the back. These features make it useful in other applications as a hex comparator or in interfacing to a data bus. Almost any input and output voltage requirements can be accommodated by simply setting the level of the appropriate power supply voltages.

The LTC1045 consists of six high speed comparators with output latches and three-state capability (see Figure 2). Each comparator's non-inverting input is brought out separately. The inverting inputs of comparators 1-4 are tied to V_{TRIP1} and 5-6 are tied to V_{TRIP2}. With these inputs the switching point of the comparators can be set anywhere within the common-mode range of V^- to (V^+ – 2V). There are four power supply pins on the LTC1045: V^+, V^-, V_{OH} and V_{OL}. V^+ and V^- power the comparator's front end, and V_{OH} and V_{OL} power the output drivers. Almost any combination of power supply voltages can be used. There are three restrictions: V_{OH} must be less than or equal to V^+; there must be a minimum differential voltage of 4.5V between V^+ and V^- and 3V between V_{OH} and V_{OL}. The maximum voltage between any two pins must not exceed the 18V absolute maximum.

The supply current is programmed with an external resistor. The R_{SET} resistor allows trade-offs between speed and power consumption. The propagation delay, with the I_{SET} pin at V^- and a single 5V supply, is typically 100ns with a total supply current of 4.5mA. The quiescent current can be brought down to 100μA (15 microamps per comparator) with an R_{SET} of 1M and a propagation delay of only 1.2μs. In addition, the I_{SET} pin completely shuts off power and latches the translator output voltages. The DISABLE input sets the six outputs to a high impedance state allowing the LTC1045 to be interfaced to a data bus.

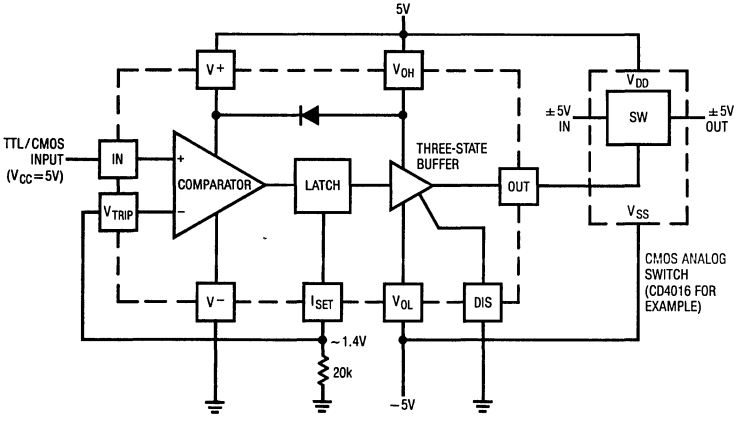


Figure 1. TTL/CMOS Logic Levels to ± 5V Analog Switch Driver

Figure 3 shows a simple way to build a battery powered RS232 receiver. The input voltage may be driven ±30V without adverse effects because the 100k resistor prevents device damage. With a 1M R_{SET} the hex RS232 line receiver draws only 100μA of quiescent current and has a propagation delay of 1.2μs. Only a single supply is needed for operation.

Board space can be saved by using the LTC1045 level translator as a hex comparator — even though both comparator inputs are not available. Figure 4 shows the LTC1045 used as a power supply monitor. The outputs of three power supplies are tied to the positive inputs through an appropriate resistive voltage divider. The divider ratio is set so that the voltage into the comparator equals the reference on the inverting input when the power supply voltage is at a critical level.

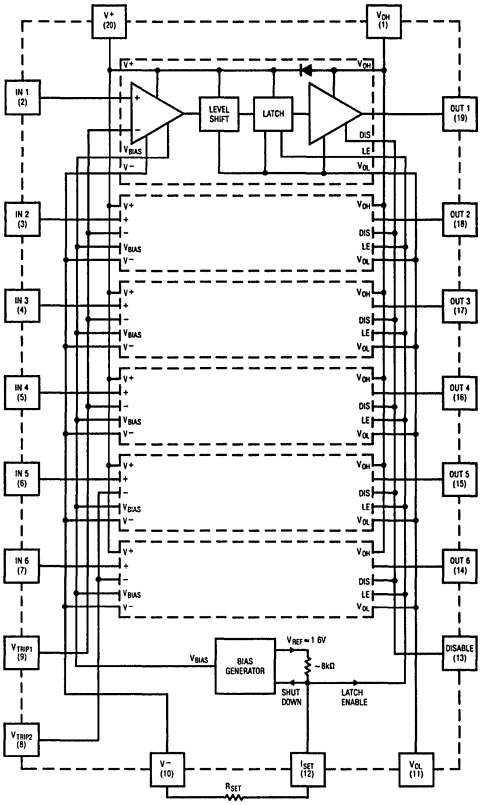


Figure 2. LTC1045 Block Diagram

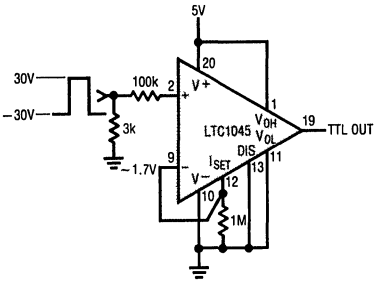


Figure 3. RS232 Receiver

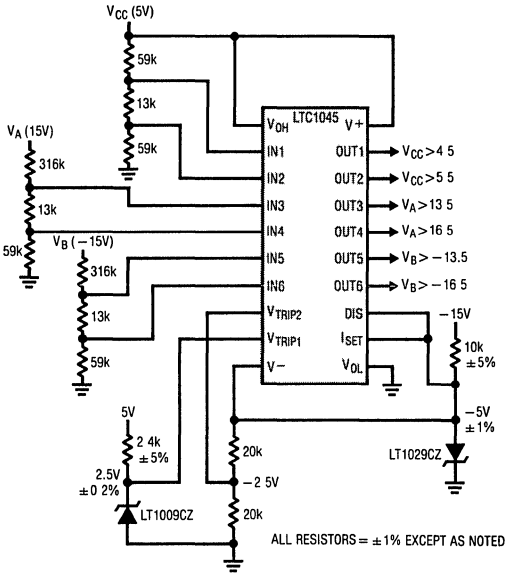


Figure 4. Power Supply Monitor

For literature on the LTC1045, call **800-637-5545.**
For applications help, call (408) 432-1900, Ext. 361.

LINEAR TECHNOLOGY

DESIGN NOTES

Number 27 in a series from Linear Technology Corporation *October, 1989*

Design Considerations for RS-232 Interfaces

Sean Gold

Introduction

When designing an RS-232 interface, it is necessary to conform to standards published by the Electronics Industry Association, EIA RS-232.V28. Some key specifications are summarized in Table 1. However, the EIA specifications are often just the beginning of the design. Practical problems such as generating RS-232 signal levels, providing sufficient load drive, and ensuring protection against fault conditions must also be considered.

Table 1. Key RS-232 Transceiver Specifications (EIA RS232C.V28)

SPECIFICATION	VALUE	UNITS
Signal Levels	±15 Max; ±5 Min	V
Cable Length	50 Max	Ft
Load Capacitance	2500 Max	pF
Cable Termination	3k<R<7k	Ω
Data Rate	20k Max	Baud
Slew Rate	3<SR<30	V/μs
Fault Conditions	Drivers Must Tolerate:	
	* Conductor to Conductor Shorts	—
	* Line Open Circuit	—
	* ±25V Line Overvoltage	—

Power Supply Generators

Creating the separate RS-232 voltage levels is a common problem in systems which have only a 5V logic supply. Linear Technology has developed a family of transceivers that include an on-chip charge pump to generate the RS-232 supplies. These transceivers are available in a wide variety of configurations incorporating up to 5 drivers and 5 receivers. Some transceivers have a SHUTDOWN control which turns off the charge pump and places the drivers in a "zero" power—high impedance state.

The charge pump consists of a relaxation oscillator, a capacitive voltage doubler, and a capacitive voltage inverter. The oscillator is designed to operate at a frequency well above the signal frequencies to avoid supply degradation as charge is rapidly removed from the storage capacitors.

The LT1180/LT1181's charge pump oscillator operates at approximately 200kHz, which is two times the frequency of the LT1080 and LT1130 series transceivers. The faster oscillator permits the use of low value capacitors (C>0.1μF), and shortens the turn-on time from power off or SHUTDOWN state to less than 200μs. The LT1080 and LT1130 start up in approximately 2ms.

Load Driving

It is often desirable to exceed the 20kHz data rate or drive loads greater than 2500pF, e.g. long cables. Slew rate control in the drivers makes this objective possible without compromising the remaining specifications. When lightly loaded, the slew rate is set by an internal bias current and compensation capacitor. When heavily loaded, slew rate is limited by the output stage short circuit current and the load capacitance. The plot in Figure 1 shows the maximum load capacitance for a given data rate.

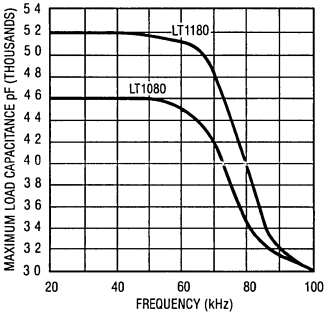


Figure 1. Max Load Capacitance vs Data Rate. Both Transceivers Use 1.0μF Storage Capacitors.

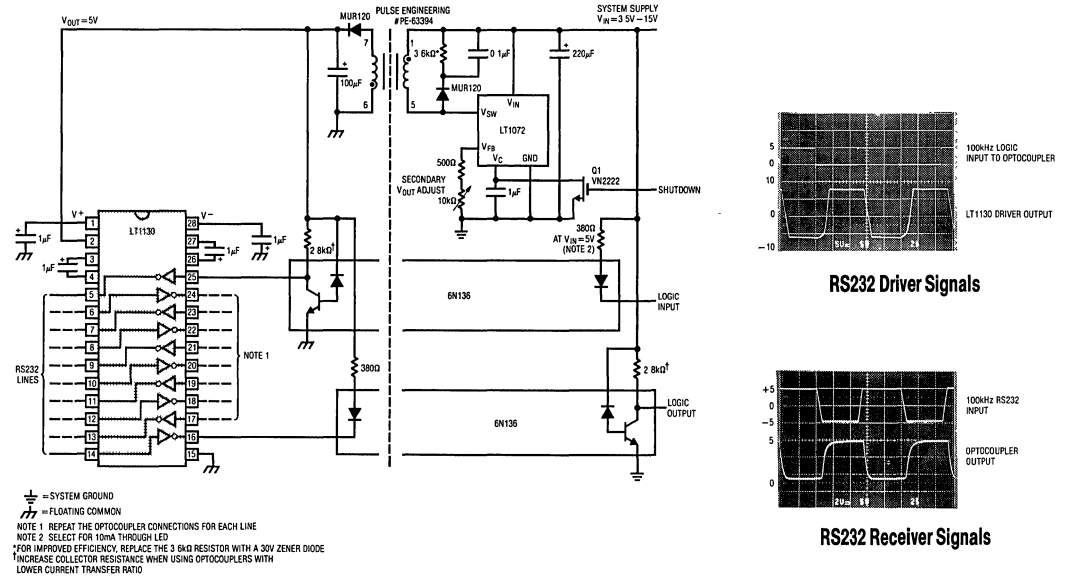


Figure 2. 2500V Isolated 5-Driver/5-Receiver RS232 Transceiver

Fault Conditions

In addition to protecting against all of the fault conditions described in Table 1, LTC transceivers are guaranteed for latchup free operation. When the drivers are turned off or SHUTDOWN, the output stage becomes a high impedance; even when the output is pulled beyond the supply rails. The small current produced by overvoltage is not directed back into the supplies. High impedance on the driver outputs also eliminates signal feedthrough between the logic inputs and the RS-232 lines.

When the device is turned on, overvoltage can, at most, pull the limited short circuit current from the supplies. The receivers are also short circuit current limited to prevent damage to unprotected logic circuitry.

Isolated Transceiver

The most frequent cause of failure in interface chips is exposure to extreme fault conditions. Protection against large differences in ground potential, high ground loop currents, or accidental high voltage connections mandates a fully isolated transceiver.

The circuit in Figure 2 provides 2500V isolation with optically coupled data lines and an isolated 5V supply. A powered transceiver eliminates the need for three supplies on both sides of the isolation transformer. High speed 6N136 optocouplers permit the LT1130 to operate at its full 100kHz bandwidth. However, slower, less expensive optoisolators, such as the 4N28, may be used when the data rate is less than 20k baud. The 5V power supply is generated with an isolated LT1072 switching regulator. The LT1072 has no electrical connection to the load; instead, the circuit derives its feedback from the transformers flyback voltage. This technique is often referred to as an isolated flyback regulator[1]. The regulator needs to deliver only modest current levels (200mA max), allowing a physically small isolation transformer. The circuit accepts 3.5V to 15V unregulated inputs which are readily available in most systems. Load regulation is 5% over a 200mA range of output current (50mA–250mA), and efficiency reaches 60% under maximum load conditions. Efficiency may be improved by 10% if the 3.6kΩ snubber resistor is replaced with a 30V Zener diode. Q1 provides shutdown control, which disables the interface to a low power state.

Note 1: Refer to Linear Technology's Application Note 19, pp. 30–34.

For literature on RS-232 products, call **(800) 637-5545.**
For applications help, call (408) 432-1900, Ext. 453.

LINEAR TECHNOLOGY

DESIGN NOTES

Number 29 in a series from Linear Technology Corporation *December, 1989*

A Single Supply RS232 Interface for Bipolar A to D Converters

Sean Gold

Designing circuitry for single supply operation is often an attractive simplification for reducing production costs. Yet many applications call for just a few additional supplies to solve simple interface problems. The example presented here describes how an advanced RS232 interface can simplify an A to D converter which processes bipolar signals.

The LT1180 RS232 transceiver includes a charge pump which produces low ripple supplies with sufficient surplus current to drive a CMOS A to D converter and precision voltage reference. The circuit in Figure 1 operates from a single 5V supply, and draws a total quiescent current of only 37mA. These features make the circuit ideal for applications which must process bipolar signals with minimal support electronics.

The LTC1094 serial A to D converter requires both a low noise supply and reference voltage for accurate operation.[1] These design problems are solved with an LT1021 precision reference, which delivers a stable, low noise, 5V signal from the LT1180's V^+ output. Relatively large storage and filter capacitors must be used with the LT1180 to reduce the noise in the system below 1mV for a 12 bit system. Construction also requires close attention to the layout of the system grounds and other aspects of circuit board design to avoid noise problems.[2]

To accommodate bipolar inputs ($-5 < V_{IN} < 5$), the LTC1094's negative rail must be biased beyond the extreme signal swing, but below absolute maximum ratings for the supplies. A 5.6V Zener diode, D1, provides a sufficient bias because the V^- pin draws very little current.

The A to D converter communicates with a remote controller via three wires, which carry the clock, the configuration word, and the output data. The chip select signal, $\overline{CS}$, is generated from the incoming clock with a peak detector, constructed with a single PNP transistor. R and C are designed to hold the $\overline{CS}$ pin low for at least one clock period. Assuming the logic

Note 1: Refer to the data sheets for the LTC1094/LTC1294.
Note 2: An excellent reference on the subject of grounding and low noise circuit design is: "An IC Amplifier User's Guide to Decoupling, Grounding, and Making Things Go Right for A Change," by Paul Brokaw, Analog Devices Application Note.

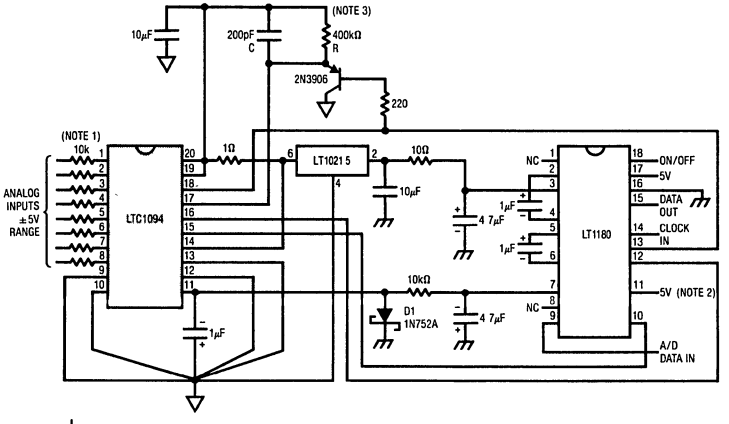


Figure 1. A/D Converter Interface

threshold in the LTC1094 is 1.4V, two useful rules of thumb for selecting R and C are: Design RC to be at least four times the clock period. And select C as small as possible to start the converter quickly. Minor aberrations in the $\overline{CS}$ signal are unimportant because the $\overline{CS}$ pin is level sensitive. The PNP is biased from the clean reference supply so very little noise is coupled into the A to D. Additional buffers are unnecessary because the peak detector drives a CMOS input.

The operating sequence for the LTC1094 is shown in Figure 2. The $\overline{CS}$ signal switches to a low state less than 1μs after receiving the system clock, and the configuration word may be transmitted after one clock cycle. After the 18 clock cycles required to complete the conversion, the clock must shut off to allow $\overline{CS}$ to switch to a high state for at least 2μs — the minimum time between conversions. The operating sequence may then be repeated.

A single conversion cycle is shown in Figure 3. The LT1180's maximum data rate limits the clock speed to 100k baud. The input voltage is 3.33V which generates a bit pattern of alternating 1's and 0's. Trace B shows the Chip Select signal, and Trace C shows the gating pulse for the system clock. The complete conversion cycle for a 12-bit converter using an LTC1294 is listed in Figure 4. For this example, the gating signals are adjusted to allow for the two extra bits of data.[3]

Note 3: The LTC1094 in Figure 1 was directly replaced with an LTC1294, with no changes to the circuit.

MSB First Data (MSBF = 1)

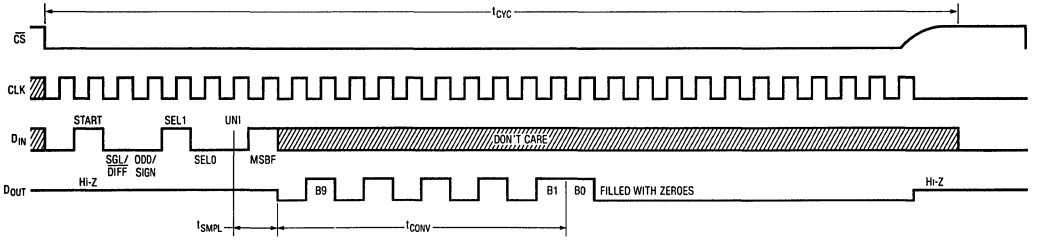


Figure 2. LTC1093/4 Operating Sequence Example: Differential Inputs (CH4 +, CH5 –), Bipolar Mode

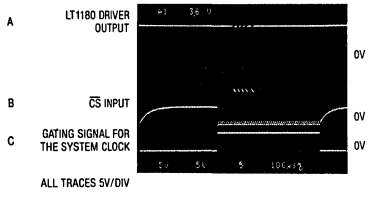


Figure 3. 10 Bit Converter Interface

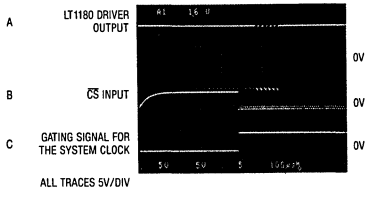


Figure 4. 12 Bit Converter Interface

For literature on RS232 products, call **(800) 637-5545.**
For applications help, call (408) 432-1900, Ext. 456.

LINEAR TECHNOLOGY

DESIGN NOTES

Number 30 in a series from Linear Technology Corporation *January, 1990*

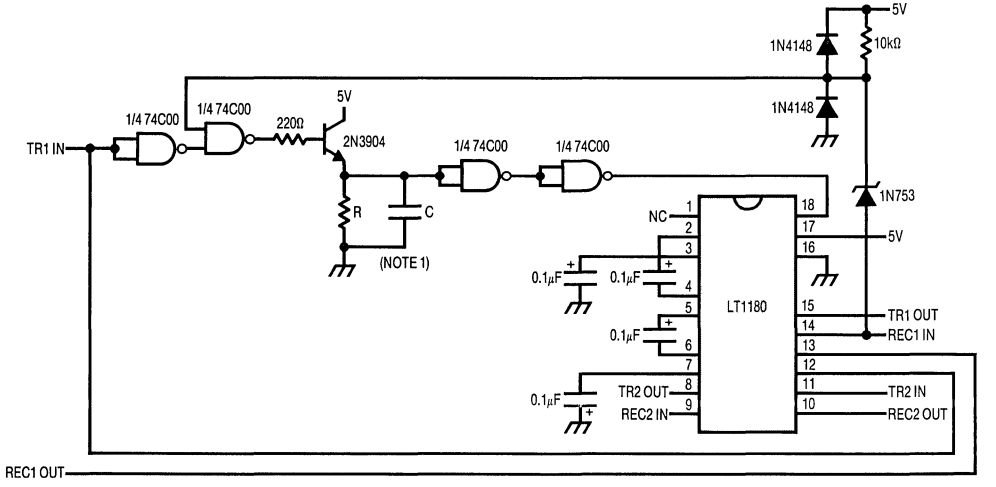
RS232 Transceiver with Automatic Power Shutdown Control

Sean Gold

The LT1180/81 RS232 transceivers with on-chip charge pumps offer some unique features that greatly enhance serial interface performance. Like the LT1080 and LT1130 series transceivers, the LT1180 is fully compliant with all RS232 specifications. The LT1180 is unique since it utilizes a charge pump which oscillates at 150kHz to 200kHz — about twice the frequency of the standard transceivers. In addition to providing excellent current delivery capability, the high speed charge pump can operate with storage capacitors as small as 0.1μF.

Reducing storage capacitor size to 0.1μF shrinks board space, thereby lowering production costs. Small capacitors also shorten the transceiver turn-on time to less than 200μs, which makes the LT1180 ideal for applications which must address the RS232 transceiver quickly. The interface described here takes advantage of fast turn-on to reduce power dissipation.

The circuit shown in Figure 1 automatically shuts down when there is no data flow through the interface. A data stream on either the RS232 or logic inputs activates the transceiver. The data must begin with a logic 1 preamble, and the data stream must contain a sufficient number of 1's to keep the transceiver active. The preamble may be as short as 50μs. Alternatively, the input to the Automatic SHUTDOWN circuit could be an RS232 handshake signal, such as Data Set Ready (DSR) or Clear to Send (CTS), which remain high during the data transfer. The LT1180's 200μs turn-on delay does not limit the data rate in the transceiver. Once the LT1180 is active, it can process data at the maximum 100k baud data rate.



NOTE 1: SELECT RC BASED ON CLOCK SPEED AND REQUIRED DROP OUT TIME
$T = RC \approx 2 \bullet T_{DROP\ OUT}$ FOR THIS EXAMPLE, R = 100KΩ AND C = 1μF.
C SHOULD NOT EXCEED 1μF UNLESS THE 2N3904 CURRENT LIMITED WITH A COLLECTOR RESISTOR

Figure 1. Fast Turn-On Transceiver with Automatic SHUTDOWN Control

A peak detector senses data flow. The extra CMOS gates are buffers which ensure the time constant is relatively independent of input signal level. The drop out time, i.e. the duration of inactivity prior to SHUTDOWN, is approximately 0.5RC. More specifically, drop out occurs when the voltage on the peak detector decays from $V_{CC}-0.7V$ to the logic switch point of $V_{CC}/2$. The RS232 input to the control circuit is clamped to protect the logic inputs. The zener diode, D3, forces the turn-on threshold on the RS232 side to $-3.5V$, which prevents the transceiver from turning on when the cable is grounded.

Figures 2 through 4 demonstrate the automatic SHUTDOWN control's response to logic and RS232 signals, as well as zero data flow. The minimum pulse width is 50μs and the drop out time is set to 50ms. The power supply outputs — the lower two traces in Figures 2 and 3 — become active in less than 200μs. When active, the circuit consumes 16mA of quiescient current. In SHUTDOWN state, the Q-current drops to 50μA.

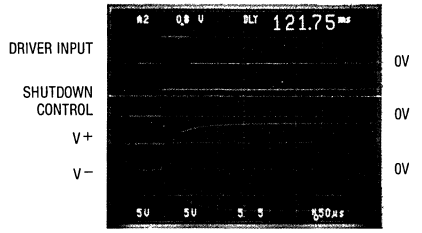


Figure 2. Transceiver Turn-On Via Logic Input

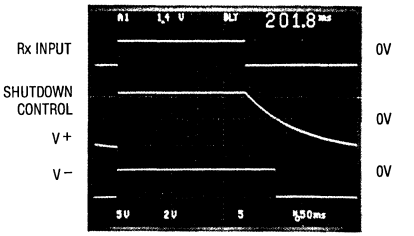


Figure 3. Transceiver Turn-On Via Receiver Input

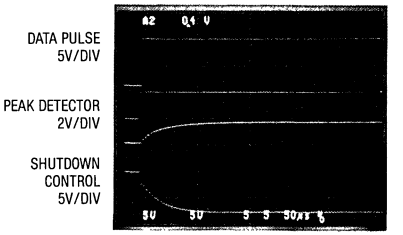


Figure 4. SHUTDOWN After 50ms Without Data Transmission

For literature on our interface products, call **(800) 637-5545.** For help with an application, call (408) 432-1900, Ext. 445.

LINEAR TECHNOLOGY

DESIGN NOTES

Number 34 in a series from Linear Technology Corporation *May, 1990*

Active Termination for SCSI-2 Bus

Sean Gold

Overview of SCSI-2

The SCSI-2 bus[1] is an interface for computers and instrumentation that communicate over small distances — often within the same cabinet. Like GPIB (IEEE 488), SCSI's hardware and software specifications are designed to coordinate independent resources such as disk and tape drives, file servers, printers, and other computers. SCSI-2 is a bidirectional bus, which must be terminated at both ends to 2.85V (Figure 1). The terminators are needed because SCSI-2 uses simple open collector output drivers in its transceivers. Terminators link communicating devices to the supplies, and roughly match the transmission line's characteristic impedance. When the load to the bus increases, the role of the termination network becomes more important for maintaining signal integrity at high data rates. An active termination design is now a part of the SCSI-2 standard and is presented here in-depth.

The single ended SCSI-2 bus is limited to six meters in length, and supports variable speed communication up to 5M transfers/sec. The bus nominally uses 18 data lines which defines the loading requirements for the terminators, because each output driver can sink at most 48mA. Up to eight SCSI devices can access the bus at regular distances along the cable. Any two devices can terminate the cable, but bit error rates are minimized with the terminators attached only at the ends. Local capacitive loading is low under these conditions, making the transmission line more consistent with fewer discontinuities.

SCSI-2's key specifications are repeated from the ANSI standard in Table 1.

Table 1. Single Ended SCSI-2

PARAMETER	VALUE	COMMENTS
Termination Supply	$4.25 < TERMPWR < 5.25$	0.9A Typical 1.5A Worst Case
Logic Supply	$V_{OUT} = 2.85V @ 0.5A$ $2.6 < V_{OUT} < 2.9$	Per Terminator
Data Rate	5M Transfers/Sec.	Six Meters Max.
Cable Impedance	110Ω $80 < Z_O < 140$	Nominal
Transceivers	TTL Compatible	Negative True Logic 5V = 0, 0V = 1
Signal Levels	$0 < V_{OL} < 0.5$ $2.5 < V_{OH} < 5.25$ $V_{IL} < 0.8$ $2.0 < V_{IH}$ $0.2 <$ Hysteresis	 $-0.4mA < I_{IL} < 0mA$ $0.0mA < I_{IH} < 0.1mA$
Short Circuit Current	48mA/Transceiver	Based on Old TTL Spec

Note 1: SCSI-2 = Small Computer System Interface Version 2, pronounced "Scuzy-2." The complete specifications standard is available through ANSI #X3T9.2.

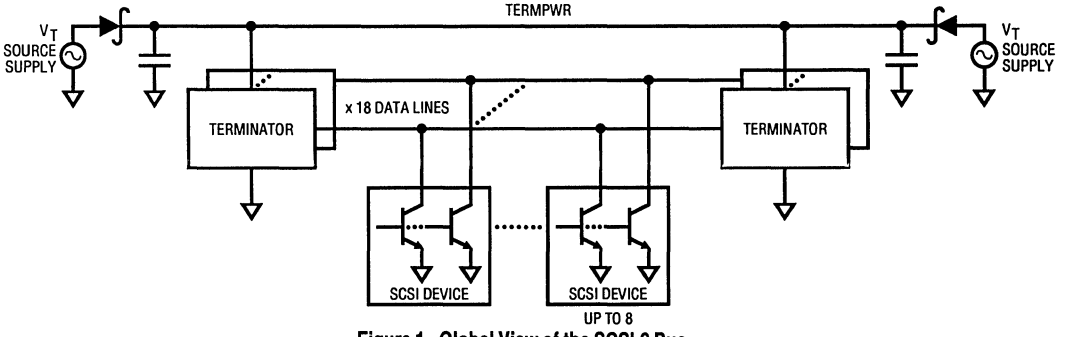


Figure 1. Global View of the SCSI-2 Bus

Shortcomings of Passive Terminators

The resistive voltage divider shown in Figure 2 is commonly used to terminate the SCSI bus. Multiple power sources are allowed to connect to the SCSI cable. Each source is protected with a Schottky diode to prevent damage from reverse currents. The resulting termination power signal, TERMPWR, is not well regulated — subject to variations in source supplies and protection diodes, as well as ohmic losses. Unfortunately, these changes in TERMPWR translate directly to the bus through the resistive divider, which degrades noise margins.

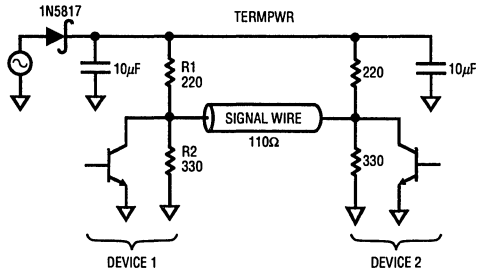


Figure 2. Passive Termination

The low values for R1 and R2 reflect a compromise between driver sink current and impedance matching the signal lines. Normally, high resistances would be desirable to minimize driver sink current. Yet, the terminator should match the signal line's 110Ω characteristic impedance, and the bus's quiescent state must be above the TTL logic threshold. It is not possible to meet all of these objectives simultaneously. The SCSI standard suggests R1 = 220Ω and R3 = 330Ω. The resulting bus voltage is 3V with 132Ω impedance, which is mismatched to the nominal 110Ω cable impedance. The Schottky diode aggravates the mismatch because it presents a poor AC ground. In addition to these problems, the small resistors draw 300mA Q-current fromTERMPWR, assuming 18 signal lines with the bus inactive.

Active Terminators

The active terminator shown in Figure 3 uses an LT1117-2.85 low dropout regulator to control the logic supply. The LT1117's line regulation makes the output immune to variations in TERMPWR. After accounting for resistor tolerances and variations in the LT1117's reference, the absolute variation in the 2.85V output is only 4 percent over temperature. When the regulator drops out at TERMPWR –2.85V = 1.25V, the output linearly tracks the input with a slope of 1V/V. Signal quality is quite good because the 110Ω series resistor closely matches the transmission line's characteristic impedance, and the regulator provides a good AC ground.

In contrast to the passive circuit, two LT1117s require only 20mA quiescent current. For the power levels in this application, the LT1117 does not need a heat sink, and is available in low cost, space saving, SOT-223 surface mount packages. Beyond solving basic signal conditioning problems, the LT1117 handles fault conditions with short circuit current limiting, thermal shutdown, and on-chip ESD protection circuitry.

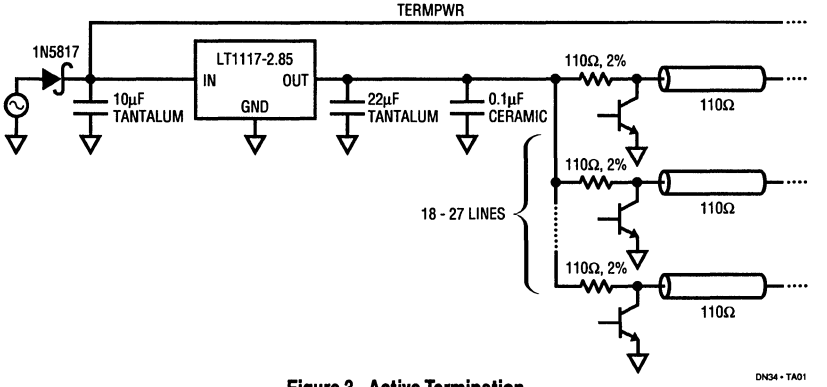


Figure 3. Active Termination

For literature on linear regulators, call **(800) 637-5545.**
For applications help, call (408) 432-1900, Ext. 209.

LINEAR TECHNOLOGY

DESIGN NOTES

RS232 Transceivers for Hand Held Computers Withstand 10kV ESD – Design Note 64

Sean Gold

Battery-powered computers and instrumentation are often subjected to severe electrical stress which imposes some stringent demands on serial communication interfaces. As always, operating from a battery mandates minimal power consumption. Transceivers must also tolerate repetitive Electrostatic Discharge (ESD) pulses because cable connections frequently come in contact with humans and other charged bodies.

Linear Technology's LT1237 addresses the above requirements. The LT1237 is a complete RS232 port, with three drivers, five receivers and a regulated charge pump. Supply current is typically 6mA, but the device can be shut down with two separate logic controls. The driver disable pin shuts off the charge pump and the drivers – leaving all receivers active, I_{SUPPLY} = 4mA. The ON/$\overline{OFF}$ pin shuts down all circuitry except for one micropower receiver, I_{SUPPLY} = 60µA. The active receiver is useful for detecting start-up signals. The LT1237 operates up to 120kBaud and is fully compliant with all RS232 specifications. Connections to the RS232 cable are protected with internal ESD structures that can withstand repetitive ±10kV human body model ESD pulses.

Figure 1 shows a typical application circuit. The LT1237's flow through pinout and its ability to use small surface mount capacitors, helps reduce the interface's overall footprint.

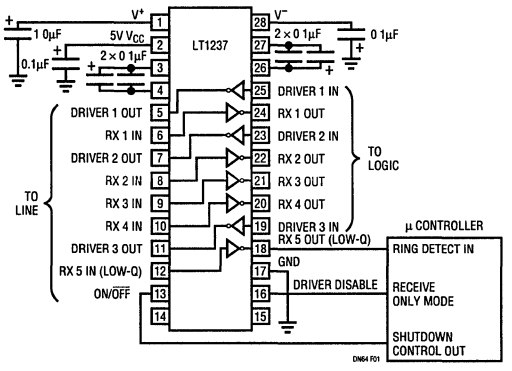


Figure 1. LT1237 Application Circuit

Interfacing with 3V Logic

Hand held computers are rapidly moving to 3V logic to save power. Yet higher voltage buses are still utilized elsewhere in the system for display driving and other functions. The LT1330 is functionally equivalent to the LT1237 but operates from 5V with a separate logic supply to interface directly with 3V logic. (Figure 2)

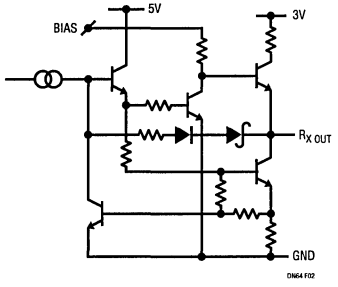


Figure 2. Receiver Output Stages in the LT1330 are Biased From a Separate Logic Supply to Easily Interface with 3V Systems

ESD Protection Techniques

Even though the I/O pins on the LT1237 and LT1330 are protected, a basic understanding of electrostatic discharge, its causes and its remedies, is helpful when designing with these circuits.

ESD generated by triboelectric charging of the human body is often the most troublesome problem for portable computers.[1] Energy imparted during a discharge is usually in the form of a rapidly rising high voltage pulse with a slow exponential tail. ESD pulses can be modeled with the switching circuit shown in Figure 3. ESD contributes frequency components well into the GHz range. At such frequencies, nearby cables and PC board traces look like receiving antennas for ESD noise.

1. Triboelectricity is the charge created as a result of friction between bodies.

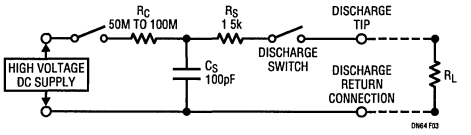


Figure 3. Human Body Circuit Model for ESD Pulses

Circuit damage from ESD can occur as a result of three effects: (1) High current heating, which destroys junctions or metallization. (2) Intense electromagnetic fields, which break down junctions or thin oxides. (3) Radiated noise, which drives the circuit into invalid or locked up states.

Any action which eliminates the charge generator, circumvents charge transfer, or enhances the circuit's ability to absorb energy, will increase a circuit's tolerance of ESD. Eliminating the ubiquitous charge generators and disrupting charge transfer are difficult tasks because they demand strict control of the circuit's operating environment. A more practical approach is to limit ESD entry points by shielding the circuit's enclosure and covering the RS232 port's connector when it is not in use.

Another practical remedy is to increase a transceiver's ability to absorb energy by clamping the RS232 line to ground with fast acting avalanche diodes or dedicated transient suppressors (Figure 4). Discrete suppressors are widely available and are extremely effective. Designers are often reluctant to use discrete suppressors because they are expensive. Costing up to $0.40/pin, they can sometimes exceed the cost of the transceiver.

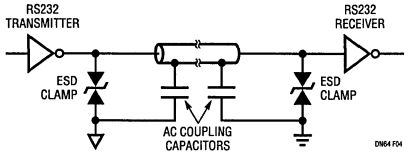


Figure 4. Older Interface Designs Used External ESD Clamps

The LT1237 and LT1330 incorporate the clamps for diverting ESD energy on chip. These active structures quickly respond to positive or negative signals at threshold voltages higher than RS232 signals, yet below destructive levels for the device. The path of high current flow is through large pn junctions which increases the capacity to absorb energy.

When a discharge occurs, the resulting current flow is insignificant when the transceiver is turned off or powered down. When operating, the resulting current may debias internal circuitry and lock up the circuit. Observations have shown these nondestructive errors to be highly dependent upon the logical state of the transceiver. Cycling the power clears the circuit.

When very high levels of ESD protection are required, an external LC filter (Figure 5) can be used to drop ESD energy into a range that can be safely dissipated within the transceiver.

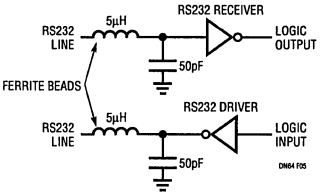


Figure 5. External LC Filters Provide Protection From Very High Levels of ESD Yet Cost Less Than Discrete Supressors

PC Board Layout

Energy shunted through an ESD clamp can still cause problems if the impedance of the return path is large enough to create a sizable voltage drop. Such voltage drops may damage unprotected components that share the common return line. Including a low inductance ground plane in the PC board is therefore essential for good ESD protection. For the LT1237 and LT1330, the AC path to ground through V^- must also be low impedance. Adding a few hundred picofarads of low ESR capacitance in parallel with the primary storage capacitor provides a good AC ground.

When using discrete transient suppressors or filters, place components as close as possible to the connector with short paths to the return plane. Make the spacing between the circuit board traces as wide as possible. ESD pulses can easily arc from one trace to another when the spacing between traces is narrow. Arcing occurs slowly compared with ESD rise time, so air spark gaps alone will not protect circuitry from ESD. Dedicated spark gaps are effective for limiting ESD energy when used with additional suppression devices.

Do not float the cable shield with respect to local ground. Designers may feel inclined to do this to avoid circulating current due to differences in ground potential. Instead, AC couple the grounds so they are shorted at ESD frequencies.

Conclusion

The techniques described here cannot entirely eliminate ESD problems, but understanding ESD's nature and using careful circuit design, will help protect against its intrusion.

For literature on our family of RS232 transceivers, call **(800) 637-5545**. For applications help, call (408) 432-1900, Ext. 456

Quad Low Power Line Driver

FEATURES

- Low Operating Voltage ±5V to ±15V
- 500μA Supply Current
- Zero Supply Current when Shut Down
- Outputs Can Be Driven ±30V
- Output "Open" when Off (3-State)
- 10mA Output Drive
- Pinout Similar to 1488*
- Output of Several Devices can be Paralleled
- Available in SO Package

APPLICATIONS

- RS232 Driver
- Micropower Interface
- Level Translator

* Check compatibility, some pins different

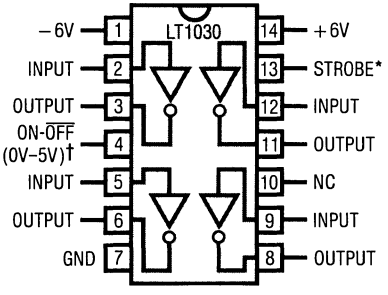
DESCRIPTION

The LT1030 is an RS232 line driver that operates over a ±5V to ±15V range on low supply current and can be shut down to zero supply current. Outputs are fully protected from externally applied voltages of ±30V by current limiting. Since the output swings to within 200mV of the positive supply and 1V of the negative supply, power supply needs are minimized.

A major advantage of the LT1030 is the high impedance output state when off or powered down, which allows several different drivers on the same bus.

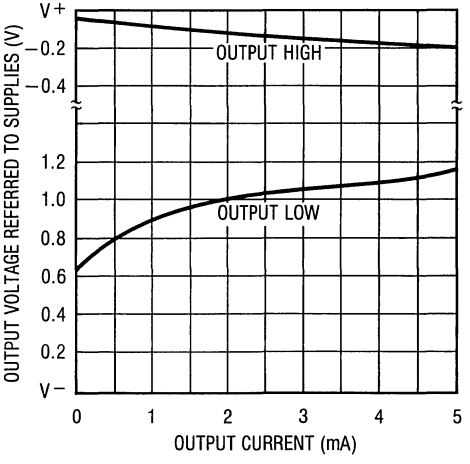
Our RS232 product line includes other high-performance devices. The LT1039 is a triple low-power driver/receiver with shutdown that can be powered from a 5V supply. The LT1080 is a 5V powered dual driver/receiver with on-chip ±9V power generator, and shutdown.

RS232 Line Driver



*NO CONNECTION NEEDED WHEN NOT USED.
†5V=ON.

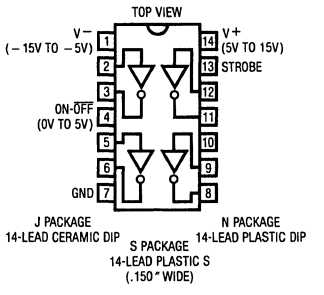
Output Swing vs Output Current



ABSOLUTE MAXIMUM RATINGS

Supply Voltage ..... ±15V
Logic Input Pins ..... V^- to 25V
On-$\overline{\text{Off}}$ Pin ..... GND to 12V
Output (Forced) ..... V^- +30V, V^+ −30V
Short Circuit Duration (to ±30V) ..... Indefinite
Operating Temperature Range
LT1030C ..... 0°C to 70°C
Guaranteed Functional by Design ... −25°C to 85°C
Storage Temperature ..... −65°C to 150°C
Lead Temperature (Soldering, 10 sec) ..... 300°C

PACKAGE/ORDER INFORMATION



T_{JMAX} = 150°C, θ_{JA} = 80°C/W (J)
T_{JMAX} = 110°C, θ_{JA} = 130°C/W (N)
T_{JMAX} = 110°C, θ_{JA} = 100°C/W (S)

ORDER PART NUMBER
LT1030CJ LT1030CN LT1030CS FOR MILITARY APPLICATIONS USE LT1032MJ

ELECTRICAL CHARACTERISTICS (Supply Voltage = ±5V to ±15V)

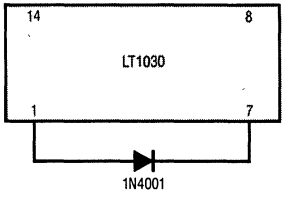
PARAMETER	CONDITIONS			MIN	TYP	MAX	UNITS
Supply Current	$V_{ON-\overline{OFF}} \geq 2.4V$, $I_{OUT} = 0$, All Outputs Low		O		500	1000	µA
Power Supply Leakage Current	$V_{ON-\overline{OFF}} \leq 0.4V$				1	10	µA
	$V_{ON-\overline{OFF}} \leq 0.1V$		O		10	150	µA
Output Voltage Swing	Load = 2mA	Positive		$V^+ - 0.3V$	$V^+ - 0.1V$		V
		Negative			$V^- + 0.9V$	$V^- + 1.4V$	V
Output Current	V_{SUPPLY} ±5V to ±15V			5	12		mA
Output Overload Voltage (Forced)	Operating or Shutdown		O	$V^+ - 30V$		$V^- + 30V$	V
Output Current	Shutdown V_{OUT} = ±30V				2	100	µA
Input Overload Voltage (Forced)	Operating or Shutdown		O	V^-		15	V
Logic Input Levels	Low Input (V_{OUT} = High)		O		1.4	0.8	V
	High Input (V_{OUT} = Low)		O	2	1.4		V
Logic Input Current	$V_{IN} > 2.0V$				2	20	µA
	$V_{IN} < 0.8V$				10	20	µA
On-$\overline{\text{Off}}$ Pin Current	$0 \leq V_{IN} \leq 5V$			−10	30	65	µA
Slew Rate				4	15	30	V/µS

The O denotes specifications which apply over the operating temperature range.

Note 1: 3V applied to the strobe pin will force all outputs low. Strobe pin input impedance is about 2k to ground. Leave open when not used.

PIN FUNCTIONS

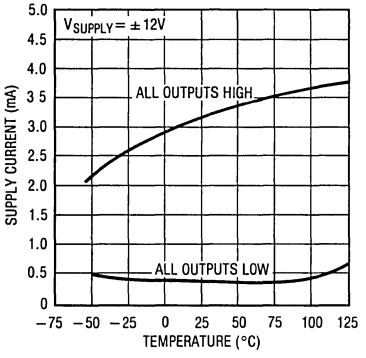
PIN	FUNCTION	COMMENT
1	Minus Supply	Operates −2V to −15V
2,5,9,12	Logic Input	Operates properly on TTL or CMOS levels. Output valid from $(V^- + 2V) \leq V_{IN} \leq 15V$. Connect to 5V when not used.
3,6,8,11	Output	Line drive output.
4	On-$\overline{\text{Off}}$	Shuts down entire circuit. Cannot be left open. For "normally on" operation, connect between 5V-10V.
7	Ground	Ground must be more positive than V^-
13	Strobe	Forces all outputs low. Drive with 3V.
14		Positive supply 5V to 15V.



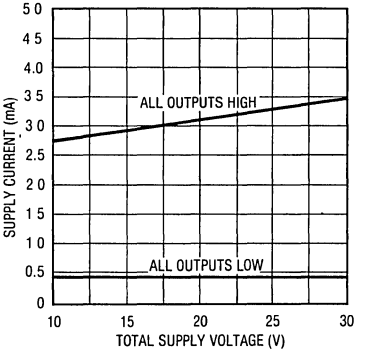
Note: As with other bipolar ICs, forward biasing the substrate diode can cause problems. The LT1030 will draw high current from V^+ to ground if the V^- pin is open circuited or pulled above ground. If this is possible, connecting a diode from V^- to ground will prevent the high current state. Any low cost diode can be used.

TYPICAL PERFORMANCE CHARACTERISTICS

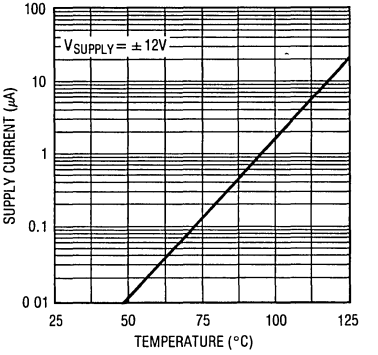
On Supply Current vs Temperature



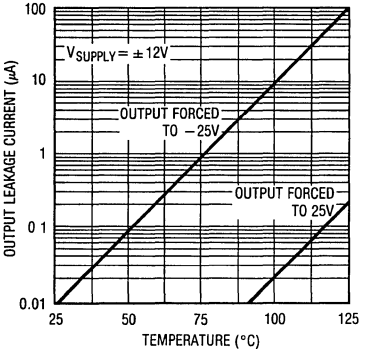
On Supply Current vs Supply Voltage



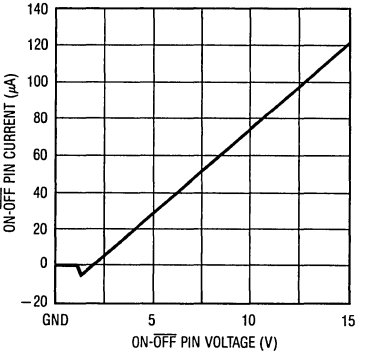
Off Supply Current vs Temperature



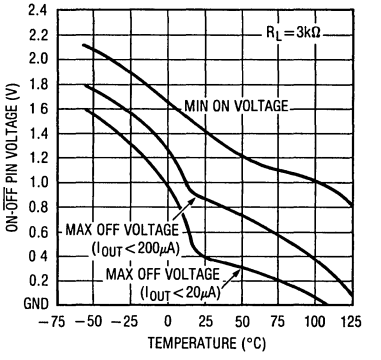
Off Output Leakage vs Temperature



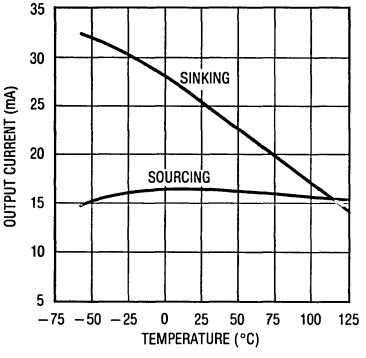
On-$\overline{\text{Off}}$ Pin Current vs Voltage



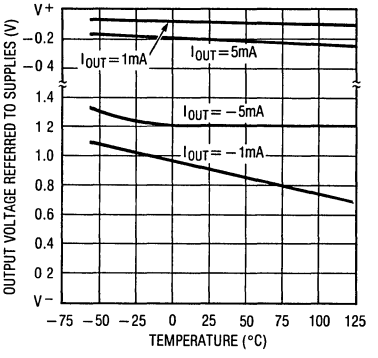
Shutdown Voltage vs Temperature



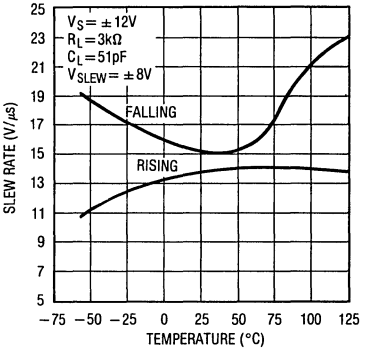
Current Limit vs Temperature



Output Swing vs Temperature

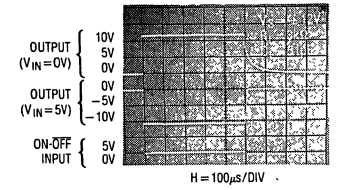


Slew Rate vs Temperature

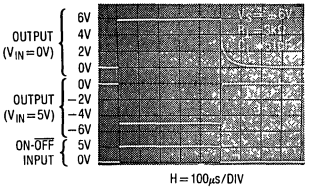


TYPICAL PERFORMANCE CHARACTERISTICS

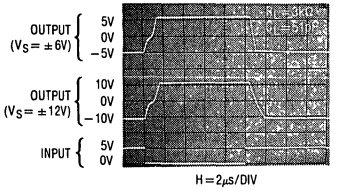
On-$\overline{\text{Off}}$ Response Time



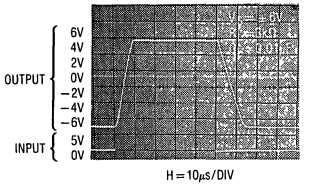
On-$\overline{\text{Off}}$ Response Time



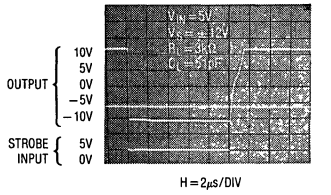
Output Waveform



Output Waveform Driving Capacitive Load



Strobe Pin Response Time



Quad Low Power Line Driver

FEATURES

- Low Operating Voltage ±5V to ±15V
- 500μA Supply Current
- Zero Supply Current when Shut Down
- Outputs Can Be Driven ±30V
- Thermal Limiting
- Output "Open" when Off (Three-State)
- 10mA Output Drive
- Pinout Similar to 1488 (See Diagram)*

APPLICATIONS

- RS232 Driver
- Power Supply Inverter
- Micropower Interface
- Level Translator

* Check compatibility, some pins different

DESCRIPTION

The LT1032 is a RS232 and RS423 line driver that operates over a ±5V to ±15V range on low supply current and can be shut down to zero supply current. Outputs are fully protected from externally applied voltages of ±30V by both current and thermal limiting. Since the output swings to within 200mV of the positive supply and 600mV of the negative supply, power supply needs are minimized.

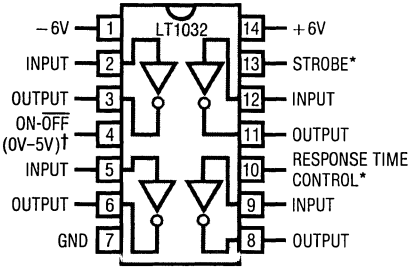
Also included is a strobe pin to force all outputs low independent of input or shutdown conditions. Further, slew rate can be adjusted with a resistor connected to the supply.

A major advantage of the LT1032 is the high impedance output state when off or powered down.

For applications requiring dual or triple RS232 driver/receiver devices, see the LT1080 (dual) or LT1039 (triple) datasheets.

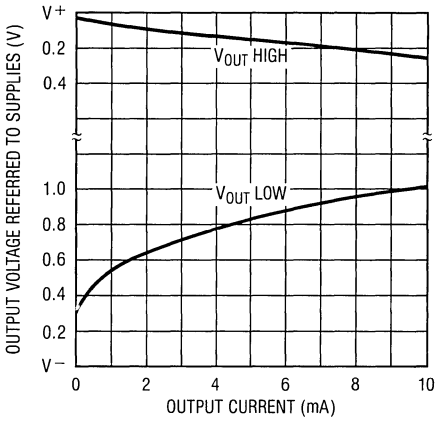
TYPICAL APPLICATION

RS232 Line Driver



*NO CONNECTION NEEDED WHEN NOT USED
†5V = ON.

Output Swing vs Output Current

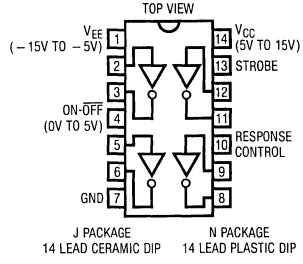


ABSOLUTE MAXIMUM RATINGS

Supply Voltage ..... ±15V
Logic Input Pins ..... V^- to 25V
On-$\overline{\text{Off}}$ Pin ..... GND to 15V
Output (Forced) ..... V^- + 30V, V^+ − 30V
Response Pin ..... ±6V
Short Circuit Duration (to ±30V) ..... Indefinite

Operating Temperature Range
LT1032M ..... −55°C to 125°C
LT1032C ..... 0°C to 70°C
Guaranteed Functional by Design ... −25°C to 85°C
Lead Temperature (Soldering, 10 sec) ..... 300°C

PACKAGE/ORDER INFORMATION

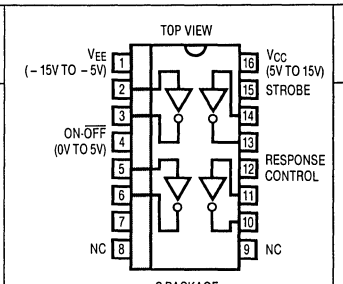


J PACKAGE
14 LEAD CERAMIC DIP

N PACKAGE
14 LEAD PLASTIC DIP

T_{JMAX} = 150°C, θ_{JA} = 100°C/W, θ_{JC} = 60°C/W (MJ)
T_{JMAX} = 85°C, θ_{JA} = 100°C/W, θ_{JC} = 60°C/W (CJ)
T_{JMAX} = 85°C, θ_{JA} = 100°C/W, θ_{JC} = 60°C/W (N)

ORDER PART NUMBER
LT1032MJ
LT1032CJ
LT1032CN



S PACKAGE
16-LEAD PLASTIC SOL

T_{JMAX} = 85°C, θ_{JA} = 95°C/W, θ_{JC} = 27°C/W (S)

ORDER PART NUMBER
LT1032CS

ELECTRICAL CHARACTERISTICS

(Supply Voltage = ±5V to ±15V)

PARAMETER	CONDITIONS			MIN	TYP	MAX	UNITS
Supply Current	$V_{ON-\overline{OFF}} \geq 2.4V$, $I_{OUT} = 0$, All Outputs Low		o		500	1000	µA
Power Supply Leakage Current	$V_{ON-\overline{OFF}} \leq 0.4V$				1	10	µA
	$V_{ON-\overline{OFF}} \leq 0.1V$, $T_A = 125°C$		o		10	50	µA
Output Voltage Swing	Load = 2mA	Positive		$V^+ - 0.3V$	$V^+ - 0.1V$		V
		Negative			$V^- + 0.7V$	$V^- + 0.9V$	V
Output Current	V_{SUPPLY} ±5V to ±15V			10	22		mA
Output Overload Voltage (Forced)	Operating or Shutdown		o	$V^+ - 30V$		$V^- + 30V$	V
Output Current	Shutdown $V_{OUT} = \pm 30V$				2	100	µA
Input Overload Voltage (Forced)	Operating or Shutdown		o	V^-		30V	V
Logic Input Levels	Low Input (V_{OUT} = High)		o		1.4	0.8	V
	High Input (V_{OUT} = Low)		o	2	1.4		V
Logic Input Current	$V_{IN} > 2.0V$				2	20	µA
	$V_{IN} < 0.8V$				10	20	µA
On-$\overline{\text{Off}}$ Pin Current	$0 \leq V_{IN} \leq 5V$		o	−10	3	50	µA
Slew Rate	$I_{RESPONSE} = 0$			4	15	30	V/µS
Change in Slew Rate (Note 2)	$I_{RESPONSE} = +50\mu A$				+50		%
	$I_{RESPONSE} = -50\mu A$				−50		%
Response Pin Leakage	$V_{SUPPLY} = \pm 6V$, $V_{ON/OFF} \leq 0.4V$, $V_{RESPONSE} = \pm 6V$				1		µA

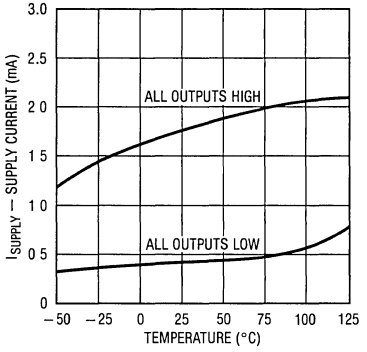
The o denotes specifications which apply over the operating temperature range

Note 1: 3V applied to the strobe pin will force all outputs low. Strobe pin input impedance is about 2k to ground. Leave open when not used

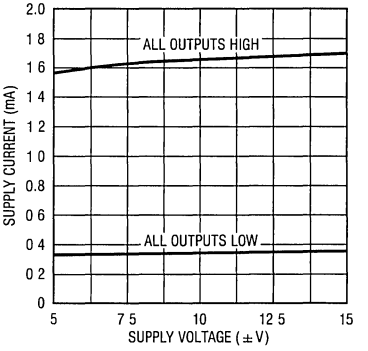
Note 2: Response can be changed by connecting a resistor to the supply. For supplies less than ± 6V this current is disconnected when shut down. Leave open when not used.

TYPICAL PERFORMANCE CHARACTERISTICS

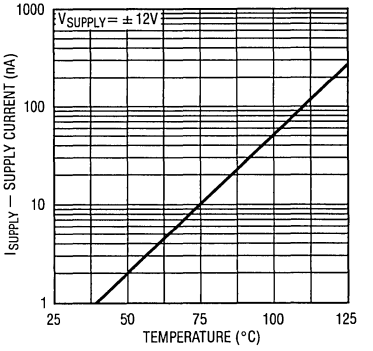
On Supply Current vs Temperature



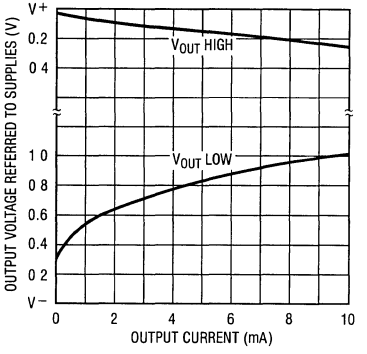
Supply Current vs Supply Voltage



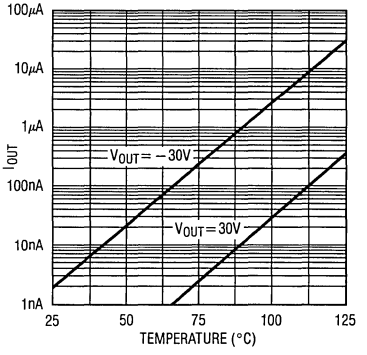
Off Supply Current vs Temperature



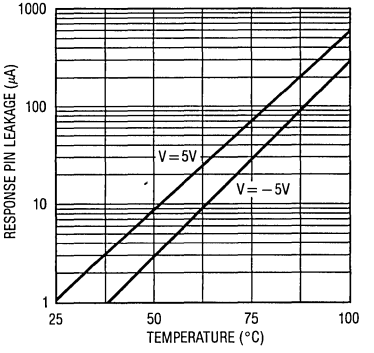
Output Swing vs Output Current



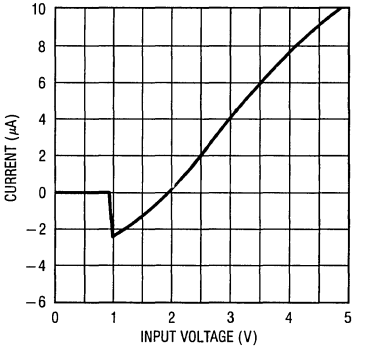
Output Leakage vs Temperature



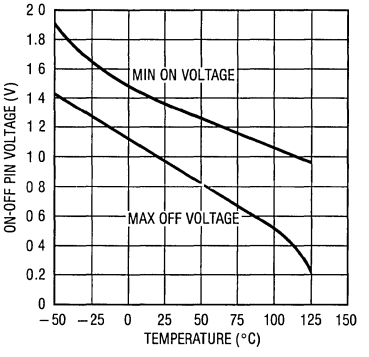
Response Pin Leakage vs Temperature (Device Off)



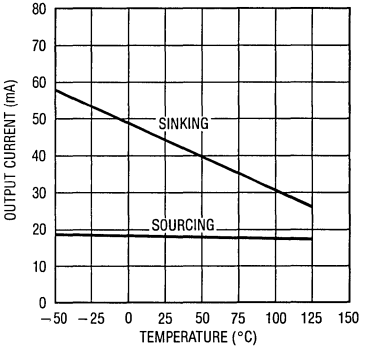
On-$\overline{\text{Off}}$ Pin Current vs Voltage



Shutdown Pin Voltage vs Temperature

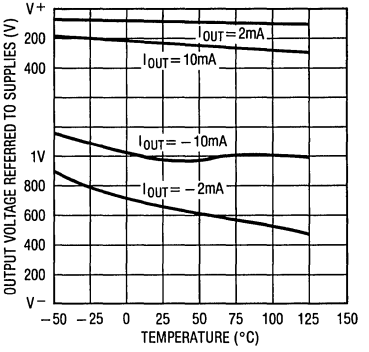


Current Limit vs Temperature

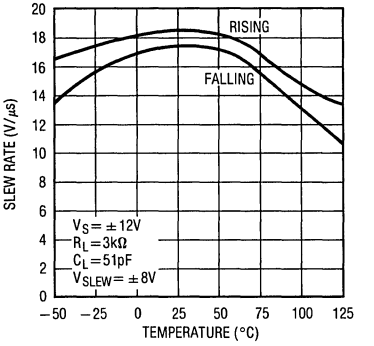


TYPICAL PERFORMANCE CHARACTERISTICS

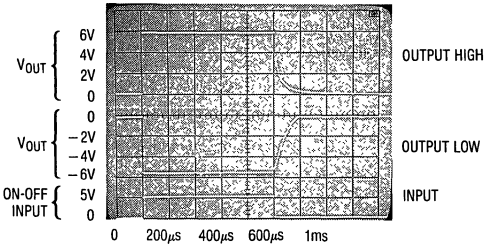
Output Swing vs Temperature



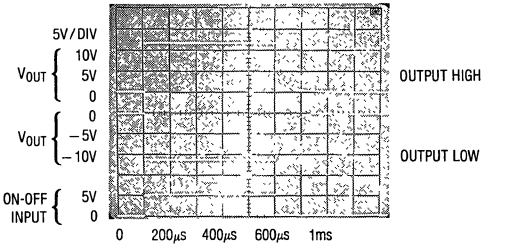
Slew Rate vs Temperature



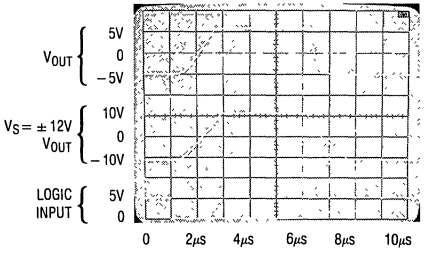
On-$\overline{\text{Off}}$ Response Time



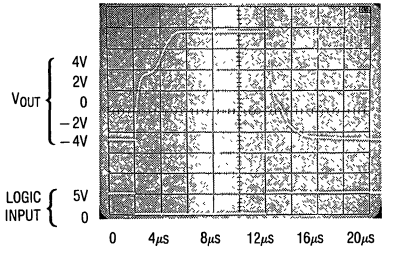
On-$\overline{\text{Off}}$ Response Time



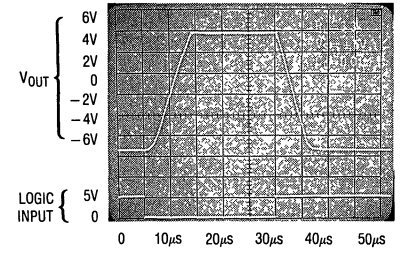
Output Waveform



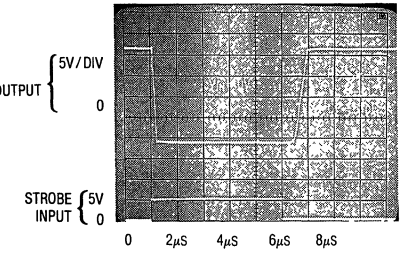
Output Waveform



Output Waveform Driving Capacitive Load



Strobe Pin Response



APPLICATIONS INFORMATION

Application Hints

The LT1032 is exceptionally easy to use when compared to older drivers. Operating supply voltage can be as low as ±3V or as high as ±15V. Input levels are referred to ground.

The logic inputs are internally set at TTL levels. Outputs are valid for input voltages from 1V above V^- to 25V. Driving the logic inputs to V^- turns off the output stage. The "on-off" control completely turns off all supply current of the LT1032. The levels required to drive the device on or off are set by internal emitter-base voltages. Since the current into the "on-$\overline{\text{off}}$" pin is so low, TTL or CMOS drivers have no problem controlling the device.

The strobe pin is not fully logic compatible. The impedance of the strobe pin is about 2kΩ to ground. Driving the strobe pin positive forces the output stages low—even if the device is shut off. Under worst-case conditions, 3V minimum at 2mA are needed driving the strobe pin to insure strobing.

The response pin can be used to make some adjustment in slew rate. A resistor can be connected between the response pin and the power supplies to drive 50μA to 100μA into the pin. The response pin is a low impedance point operating at about 0.75V above ground. For supply voltage up to ±6V, current is turned off when the device is turned off. For higher supply voltages, a zener should be connected in series with the resistor to limit the voltage applied to the response pin to 6V. Also, for temperatures above 100°C, using the response pin is not recommended. The leakage current into the response pin at high temperatures is excessive.

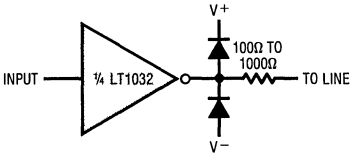
Outputs are well protected against shorts or externally applied votlage. Tested limits are ±30V, but the device can withstand external voltages up to the breakdown of the transistors (typically about 50V). The LT1032 is usually immune to ESD up to 2500V on the outputs with no damage (limit of LTC tester).

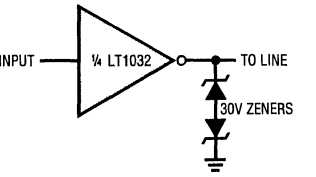
PIN FUNCTION

PIN	FUNCTION	COMMENT
1	Minus Supply	Operates −2V to −15V
2,5,9,12	Logic Input	Operates properly on TTL or CMOS levels. Output valid from $(V^- + 2V) \leq V_{IN} \leq 15V$. Connect to ground when not used.
3,6,8,11	Output	Line drive output.
4	On-$\overline{\text{Off}}$	Shuts down entire circuit. Cannot be left open. For "normally on" operation, connect to V+.
7	Ground	Ground must be more positive than V^-
10	Response Control	Allows limited change of slew rate. Leave open when not used.
13	Strobe	Forces all outputs low. Drive with 3V.
14	Positive Supply	Operates 5V to 15V

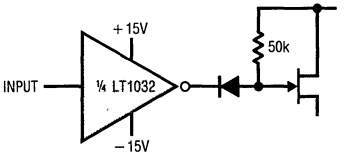
TYPICAL APPLICATIONS

Protecting Against More than ±30V Output Overload

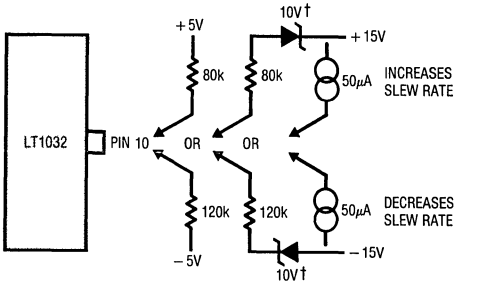




FET Driver

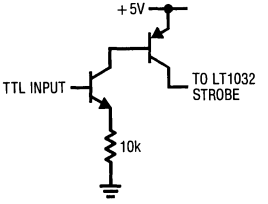


Slew Rate Adjustment*

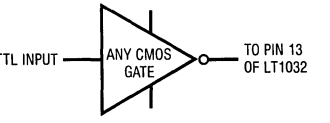


*ABOUT 4V/μs CHANGE
†ZENERS PREVENT LEAKAGE
DURING SHUT DOWN

TTL/CMOS Compatible Strobe



Strobing with CMOS



RS232 Driver/Receiver with Shutdown

FEATURES

- Operates from ±5V to ±15V Supplies
- Fully Protected Against Overload
- Outputs can be Driven ±30V without Damage
- Three-State Outputs; Outputs Open when Off
- Bipolar Circuit—No Latch Up
- ±30V Input Range
- Triple Driver/Receiver
- No Supply Current in Shutdown
- 30kΩ Input Impedance
- Meets All RS232 Specifications
- 16 Pin Version—Pin Compatible with MC145406
- Available in SO Package

APPLICATIONS

- RS232 Interface
- Terminals
- Modems

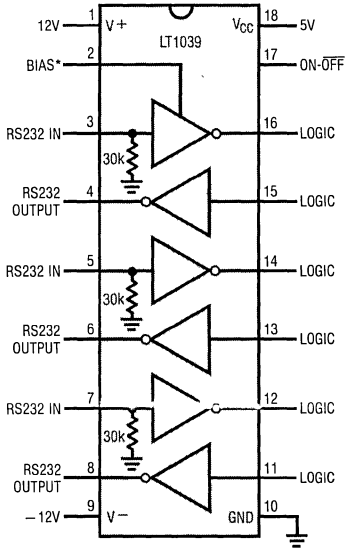
The LT1039 is a triple RS232 driver/receiver which includes SHUTDOWN. Each receiver will accept up to ±30V input and can drive either TTL or CMOS logic. The RS232 drivers accept TTL logic inputs and output RS232 voltage levels. The outputs are fully protected against overload and can be shorted to ground or up to ±30V without damage to the drivers. Additionally, when the system is shut down or power is off, the outputs are in a high impedance state allowing data line sharing. Bipolar circuitry makes this driver/receiver exceptionally rugged against overloads or **ESD** damage.

A bias pin allows one receiver to be kept on while the rest of the part is shut down.

The LT1039 is also available in the 16 pin version, without shutdown or bias pin functions.

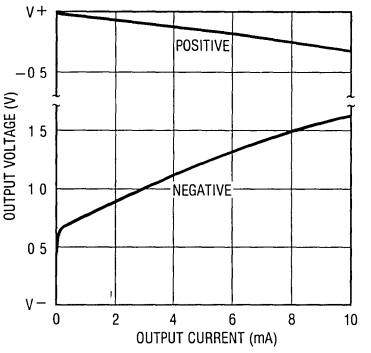
For applications requiring operation from a single 5V supply, see LT1080/81, LT1180/81 and LT1130 data sheets.

TYPICAL APPLICATION



*BIAS PIN USED TO KEEP THE RECEIVER ON WHILE IN SHUTDOWN

Driver Output Swing



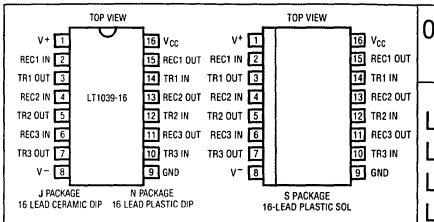
ABSOLUTE MAXIMUM RATINGS

Supply Voltage
- Driver (V^+, V^-) ..... ± 16V
- Receiver (V_{CC}) 7V

Logic Inputs ..... V^- to 25V
Receiver Inputs ..... ± 30V
On-$\overline{Off}$ Input ..... GND to 12V
Driver Outputs ..... V^- + 30V to V^+ – 30V
Short Circuit Duration ..... Indefinite
Operating Temperature Range
- LT1039M ..... –55°C to 125°C
- LT1039C ..... 0°C to 70°C
- Guaranteed Functional by Design ..... –40°C to 85°C

Lead Temperature (Soldering, 10 sec.) ..... 300°C

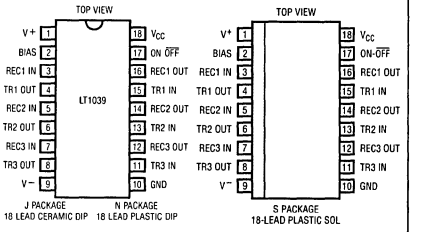
PACKAGE/ORDER INFORMATION



T_{JMAX} = 150°C, θ_{JA} = 105°C/W, θ_{JC} = 30°C/W (J)
T_{JMAX} = 125°C, θ_{JA} = 90°C/W, θ_{JC} = 50°C/W (N)
T_{JMAX} = 125°C, θ_{JA} = 95°C/W, θ_{JC} = 27°C/W (S)

ORDER PART NUMBER

LT1039CN16
LT1039CJ16
LT1039MJ16
LT1039CS16



T_{JMAX} = 150°C, θ_{JA} = 88°C/W, θ_{JC} = 22°C/W (J)
T_{JMAX} = 125°C, θ_{JA} = 79°C/W, θ_{JC} = 36°C/W (N)
T_{JMAX} = 125°C, θ_{JA} = 90°C/W, θ_{JC} = 26°C/W (S)

ORDER PART NUMBER

LT1039CN
LT1039CJ
LT1039MJ
LT1039CS

ELECTRICAL CHARACTERISTICS

PARAMETER	CONDITIONS			MIN	TYP	MAX	UNITS
Driver V^+ =12V; V^- = –12V; $V_{ON-\overline{OFF}}$ = 2.5V (Note 1)							
Output Voltage Swing	Load = 3k to Ground	Positive	○	V^+ – 0.4	V^+ – 0.1		V
		Negative	●	V^- + 1.5	V^- + 1		V
Logic Input Voltage Levels	Input Low Level (V_{OUT} = High)		○		1.4	0.8	V
	Input High Level (V_{OUT} = Low)		○	2.0	1.4		V
Logic Input Current	$V_{IN} \geq 2.0V$				1	20	μA
	$V_{IN} \leq 0.8V$				5	20	μA
Output Short Circuit Current	Sourcing Current, V_{OUT} = 0V			5	15		mA
	Sinking Current, V_{OUT} = 0V			–5	–15		mA
Output Leakage Current	SHUTDOWN (Note 2 and 3); V_{OUT} = ± 18V, V_{IN} = 0		○		10 (25°C)	200	μA
Supply Leakage Current	SHUTDOWN (Note 2)		●		1 (25°C)	100	μA
Slew Rate	R_L = 3kΩ; C_L = 51pF			4	15	30	V/μs
Supply Current	V_{OUT} = Low				4	8	mA
Receiver V_{CC} = 5V; $V_{ON-\overline{OFF}}$ = 2.5V (Note 1)							
Input Voltage Thresholds	Input Low (V_{OUT} = High)		○	0.5	1.3		V
	Input High (V_{OUT} = Low)		●		1.7	2.8	V
Hysteresis			○	0.1	0.4	1.0	V
Input Resistance			○		30		kΩ
Output Voltage	Output Low, I_{OUT} = –1.6mA		○		0.4	0.5	V
	Output High, I_{OUT} = 160μA		○	3.5	4.8		V
Output Short Circuit Current	Sinking Current, V_{OUT} = V_{CC}		●	–10			mA
	Sourcing Current, V_{OUT} = 0V (Note 4)		●	0.5	1		mA
Output Leakage Current	SHUTDOWN (Note 1); $0V \leq V_{OUT} \leq V_{CC}$, V_{IN} = 0		●		1	10	μA
Supply Current			●		4	7	mA

ELECTRICAL CHARACTERISTICS

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Supply Leakage Current	SHUTDOWN (Note 2)	O		1 (25°C)	100	μA
On-$\overline{\text{Off}}$ Pin Current	$0V \le V_{ON\ \overline{OFF}} \le 5V$	O	–15		80	μA

The O denotes the specifications which apply over the full operating temperature range.

Note 1: $V_{ON\ -\ \overline{OFF}}$ = 5.0V for LT1039M grade devices.

Note 2: $V_{ON\ -\ \overline{OFF}}$ = 0.4V for $-55°C \le T_A \le 100°C$, and $V_{ON-\overline{OFF}}$ = 0.2V for $100°C \le T_A \le 125°C$. Does not apply to LT1039-16 part.

Note 3: For $T_A \ge 100°C$, leakage current is 350μA max.

Note 4: For $T_A \le -25°C$, output souce current is 0.4mA.

PIN FUNCTIONS (Pin numbers listed are for 18 pin device).

V+, V– (Pins 1, 9): Driver supply pins. Supply current drops to zero in SHUTDOWN mode. Driver outputs are in a high impedance state when V+ and V– = 0V.

V_{CC} (Pin 18): 5V power for receivers.

GND (Pin 10): Ground pin.

TR IN (Pins 11, 13, 15): RS232 driver input pins. Inputs are TTL/CMOS compatible. Inputs should not be allowed to float. Tie unused inputs to V_{CC}.

TR OUT (Pins 4, 6, 8): Driver outputs with RS232 voltage levels. Outputs are in a high impedance state when in the SHUTDOWN mode or when power is off (V+ and V– = 0V) to allow data line sharing. Outputs are fully short circuit protected from V– +30V to V+ –30V with power on, off, or in the SHUTDOWN mode. Typical output breakdowns are greater than ±45V and higher applied voltages will not damage the device if moderately current limited.

REC IN (Pins 3, 5, 7): Receiver input pins. Accepts RS232 voltage levels (±30V) and has 0.4V of hysteresis to provide noise immunity. Input impedance is nominally 30kΩ.

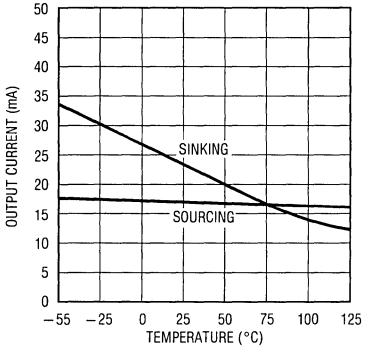
REC OUT (Pins 12, 14, 16): Receiver outputs with TTL/CMOS voltage levels. Outputs are in a high impedance state when in the SHUTDOWN mode to allow data line sharing. Outputs are fully short circuit protected to ground or V_{CC} with power on, off, or in the SHUTDOWN mode.

ON-$\overline{\text{OFF}}$ (Pin 17): Controls the operation mode of the LT1039 and is TTL/CMOS compatible. A logic low puts the device in the SHUTDOWN mode which reduces input supply current to zero and places both driver and receiver outputs in a high impedance state.

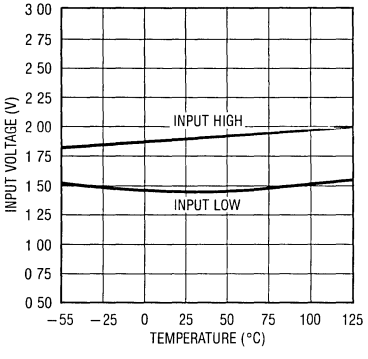
BIAS (Pin 2): Keeps receiver 1 on while the LT1039 is in the SHUTDOWN mode. Leave BIAS pin open when not in use. See Application Hints for proper use.

TYPICAL PERFORMANCE CHARACTERISTICS

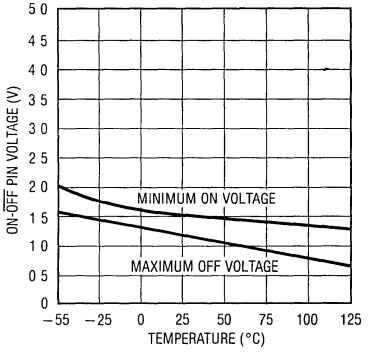
Driver Output Short Circuit Current



Receiver Input Thresholds

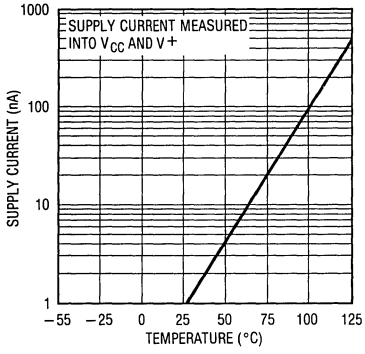


On-$\overline{\text{Off}}$ Pin Thresholds

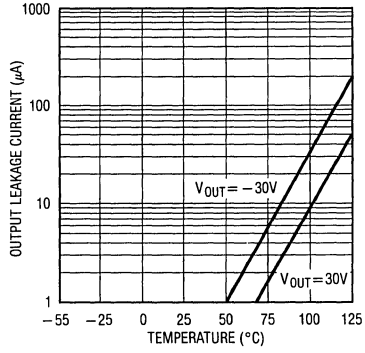


TYPICAL PERFORMANCE CHARACTERISTICS

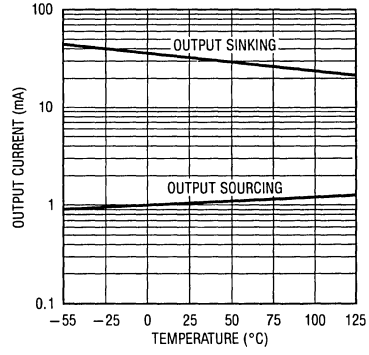
Supply Current in SHUTDOWN



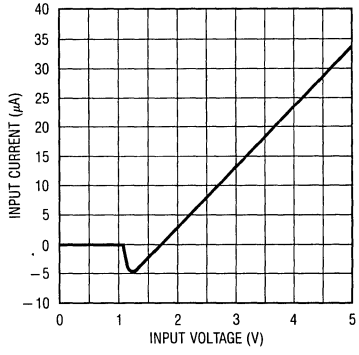
Driver Output Leakage in SHUTDOWN



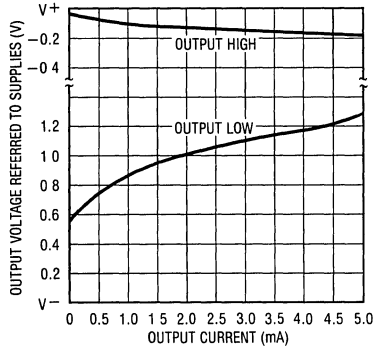
Receiver Output Short Circuit Current



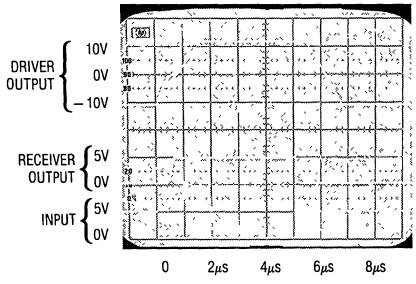
On-$\overline{\text{Off}}$ Pin Current vs Voltage



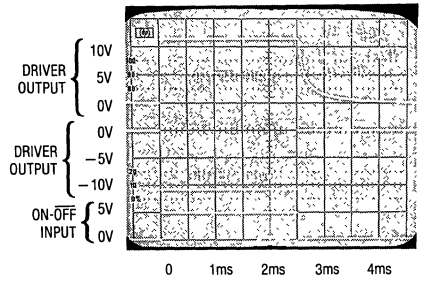
Driver Output Swing vs Current



Output Waveforms

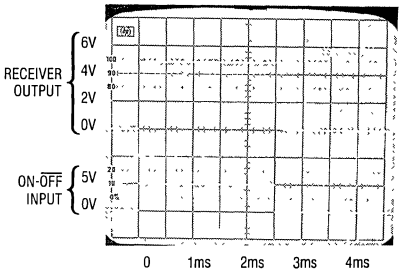


SHUTDOWN to Driver Output

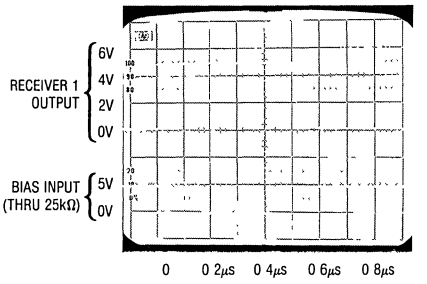


TYPICAL PERFORMANCE CHARACTERISTICS

SHUTDOWN to Receiver Output

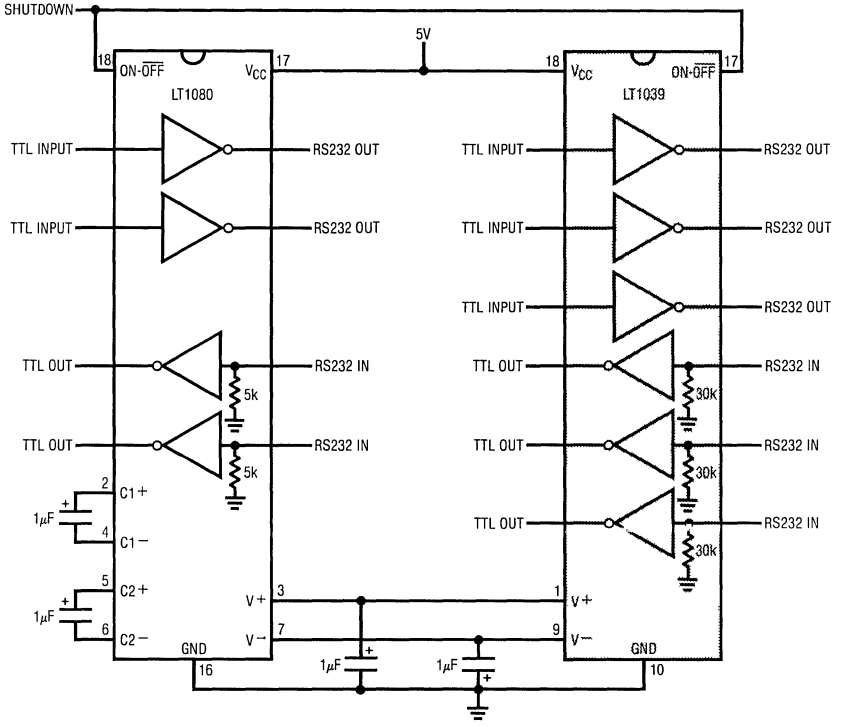


Bias Pin Response Time



TYPICAL APPLICATION

LT1080 (Driver/Receiver with Power Supply) Driving an LT1039



APPLICATION HINTS

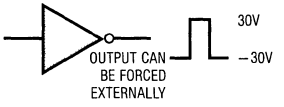
The driver output stage of the LT1039 offers significantly improved protection over older bipolar and CMOS designs. In addition to current limiting, the driver output can be externally forced to ±30V with no damage or excessive current flow, and will not disrupt the supplies. Some drivers have diodes connected between the outputs and the supplies, so externally applied voltages can cause excessive supply voltage to develop.

Placing the LT1039 in the SHUTDOWN mode (Pin 17 low) puts both the driver and receiver outputs in a high impedance state. This allows data line sharing and transceiver applications.

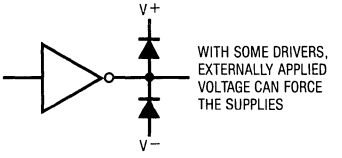
The SHUTDOWN mode also drops all supply currents (V_{CC}, V^+, V^-) to zero for power-conscious systems.

When driving CMOS logic from a receiver that will be used in the SHUTDOWN mode and there is no other active receiver on the line, a 51k resistor can be placed from the logic input to V_{CC} to force a definite logic level when the receiver output is in a high impedance state.

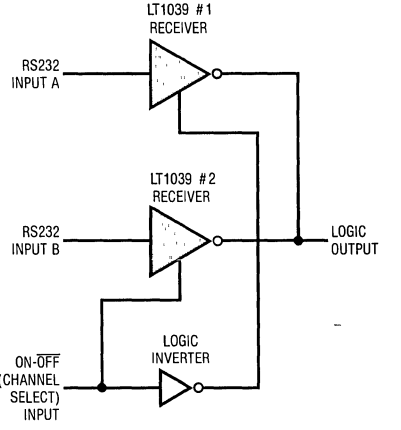
LT1039 Driver



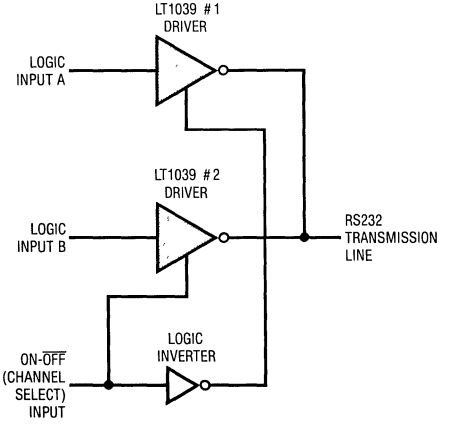
Older RS232 Drivers and Other CMOS Drivers



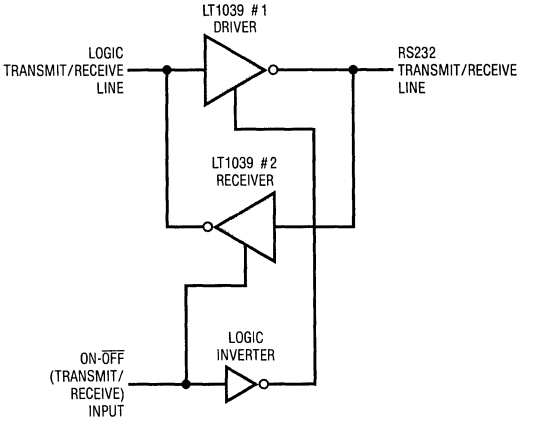
Sharing a Receiver Line



Sharing a Transmitter Line



Transceiver

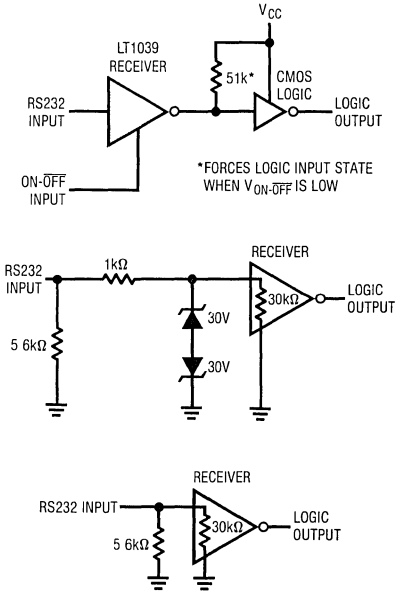


APPLICATION HINTS

To protect against receiver input overloads in excess of ±30V, a voltage clamp can be placed on the data line and still maintain RS232 compatibility.

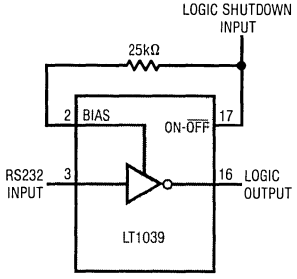
The receiver input impedance of the LT1039 is nominally 30kΩ. For applications requiring a 5kΩ input impedance, a 5.6kΩ resistor can be connected from the receiver input to ground.

Driver inputs should not be allowed to float. Any unused inputs should be tied to V_{CC}.

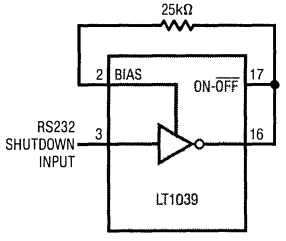


The bias pin is used to "keep alive" one receiver while in the SHUTDOWN mode (all other circuitry being inactive). This allows a system to be in SHUTDOWN and still have one active receiver for transferring data. It can also be used to make an RS232 compatible SHUTDOWN control line. Driving the bias pin low through a resistance of 24kΩ to 30kΩ keeps the receiver active. Do not drive the bias pin directly from a logic output without the series resistor. An unused bias pin should be left open.

Keeping Alive One Receiver while in SHUTDOWN



RS232 Compatible SHUTDOWN Control Line



Programmable Micropower Hex Translator / Receiver / Driver

FEATURES

- Efficiently Translate Voltage Levels
- Internal Hysteresis for Noise Immunity
- Output Latches Included
- Three-State Outputs
- Programmable Power/Speed
- Power can be Completely Shut Off
- ±50V on Inputs with External 100kΩ Limit Resistor
- 1.2μs Response at 100μA Supply Current

APPLICATIONS

- TTL/CMOS to ±5V Analog Switch Drive
- TTL to CMOS (3V to 15V V_{CC})
- ECL to CMOS (3V to 15V V_{CC})
- Ground Isolation Buffer
- Low Power RS232 Line Receiver

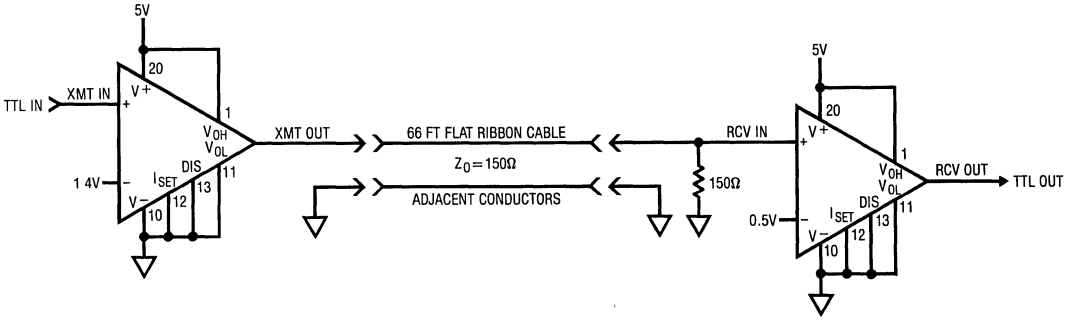
DESCRIPTION

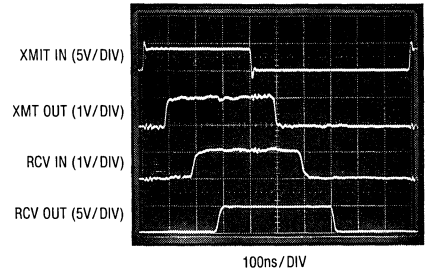
The LTC1045 is a hex level translator manufactured using Linear Technology's enhanced LTCMOS™ silicon gate process. It consists of six high speed comparators with output latches and three-state capability. Each comparator's plus input is brought out separately. The minus inputs of comparators 1-4 are tied to V_{TRIP1} and 5-6 are tied to V_{TRIP2}.

The I_{SET} pin has several functions. When taken to V^+ the outputs are latched and power is completely shut off. Power/speed can be programmed by connecting I_{SET} to V^- through an external resistor.

LTCMOS™ is a trademark of Linear Technology Corp.

Flat Ribbon Cable Driver/Receiver



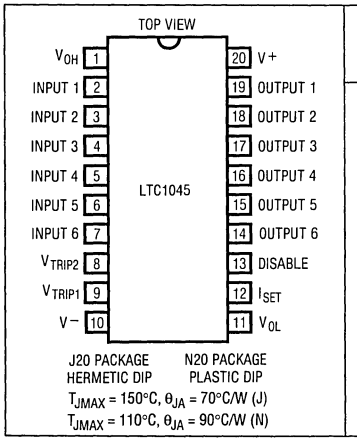


ABSOLUTE MAXIMUM RATINGS

(Notes 1 and 2)

Total Supply Voltage (V^+, V_{OH} to V^-, V_{OL})..... 18V
Output High Voltage (V_{OH}) ..... $\leq V^+$
Input Voltage ..... 18V to V^- – 0.3V
Operating Temperature Range
LTC1045C..... – 40°C to 85°C
LTC1045M ..... – 55°C to 125°C
Storage Temperature Range..... – 55°C to 150°C
Lead Temperature (Soldering, 10 sec) ..... 300°C
Output Short Circuit Duration
($V_{OH} - V_{OL} \leq 10V$)..... Continuous
ESD (MIL-STD-883, Method 3015.1)..... 2000V

PACKAGE/ORDER INFORMATION



J20 PACKAGE HERMETIC DIP — N20 PACKAGE PLASTIC DIP

T_{JMAX} = 150°C, θ_{JA} = 70°C/W (J)
T_{JMAX} = 110°C, θ_{JA} = 90°C/W (N)

ORDER PART NUMBER
LTC1045MJ LTC1045CJ LTC1045CN

ELECTRICAL CHARACTERISTICS

(Note 3) $V^+ = V_{OH} = 5V$, $V^- = V_{OL} = 0V$, $T_A = 25°C$ unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS		LTC1045M MIN	LTC1045M TYP	LTC1045M MAX	LTC1045C MIN	LTC1045C TYP	LTC1045C MAX	UNITS
I_B	Input Bias Current	$V^- \leq V_{IN} \leq V^+$	o		±1			±1		nA
			o			1.0			0.5	μA
	Trip Voltage Range (Pin 8 and Pin 9)		o	V^-		$V^+ - 2$	V^-		$V^+ - 2$	V
I_S	V^+ to V^- Supply Current	DISABLE = V^+, R_{SET} = 10k			2.5	3.5		2.5	3.5	mA
			o			5.0			4.5	mA
I_{OFF}	V^+ to V^- Supply Current in Shutdown	DISABLE = $I_{SET} = V^+$			10			10		nA
			o			5			1	μA
V_{REF}	Voltage on I_{SET} (Pin 12)	R_{SET} = 10k			0.9			0.9		V
			o	0.5		1.4	0.6		1.25	V
V_{OH}	TTL Output High Voltage	$I_{OUT} = -360\mu A$, $V^+ = 4.5V$	o	2.4	4.4		2.4	4.4		V
V_{OL}	TTL Output Low Voltage	$I_{OUT} = 1.6mA$, $V^+ = 4.5V$	o		0.2	0.4		0.2	0.4	V
I_{SINK}	Output Short Circuit Sink Current	$V_{IN} = V_{TRIP} - 100mV$, $V_{OUT} = V^+$		8.5	15		7.5	15		mA
			o	5.5			5.5			mA
I_{SOURCE}	Output Short Circuit Source Current	$V_{IN} = V_{TRIP} + 100mV$, $V_{OUT} = V^-$		4.5	8.0		4.0	8.0		mA
			o	3.2			3.2			mA
I_{OZ}	Three-State Leakage Current	DISABLE = V^+ $V_{OL} \leq V_{OUT} \leq V_{OH}$			0.005			0.005		μA
			o			1			1	μA
R_{OH}	Output Resistance to V_{OH}	$\lvert I_{OUT} \rvert \leq 100\mu A$			260	400		260	475	Ω
			o			600			600	Ω
R_{OL}	Output Resistance to V_{OL}	$\lvert I_{OUT} \rvert \leq 100\mu A$			100	150		100	180	Ω
			o			250			250	Ω
	I_{SET} Voltage for Shutdown		o	$V^+ - 0.5$			$V^+ - 0.5$			V
V_{IH}	DISABLE Input Logic Levels	$V^+ = 4.5V$, $V^- = 0V$	o	2.0			2.0			V
V_{IL}		$V^+ = 5.5V$, $V^- = 0V$	o			0.8			0.8	V
	Input Supply Differential ($V^+ - V^-$) (Note 3)		o	4.5		15	4.5		15	V
	Output Supply Differential ($V_{OH} - V_{OL}$) (Note 3)		o	3		15	3		15	V

AC ELECTRICAL CHARACTERISTICS

$V^+ = V_{OH} = 5V$, $V^- = V_{OL} = 0V$, $T_A = 25°C$ unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS		LTC1045M MIN	LTC1045M TYP	LTC1045M MAX	LTC1045C MIN	LTC1045C TYP	LTC1045C MAX	UNITS
t_d	Response Time	Test Circuit Figure 1 $R_{SET} = 10k$, ± 100mV Drive	o			200 350			250 350	ns ns
t_{SETUP}	Time Before Rising Edge of I_{SET} that Data Must be Present	Test Circuit Figure 2			80			80		ns
t_{HOLD}	Time After Rising Edge of I_{SET} that Data Must be Present	Test Circuit Figure 2			0			0		ns
t_{ACC}	Falling Edge of DISABLE to Logic Level (from Hi-Z State)	Test Circuit Figure 3			165			165		ns
t_{IH}, t_{OH}	Rising Edge of DISABLE to Hi-Z State	Test Circuit Figure 3			200			200		ns

The o denotes the specifications which apply over the full operating temperature range.

Note 1: Absolute Maximum Ratings are those values beyond which the life of the device may be impaired.

Note 2: The maximum differential voltage between any two power pins (V^+, V^-, V_{OH} and V_{OL}) must not exceed 18V. The maximum recommended operating differential is 15V.

Note 3: During operation near the maximum supply voltage limit, care should be taken to avoid or suppress power supply turn-on and turn-off transients, power supply ripple, or ground noise; any of these conditions must not cause a supply differential to exceed the absolute maximum rating.

TEST CIRCUITS

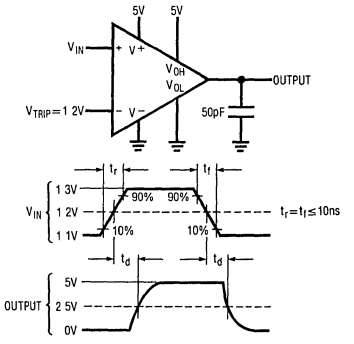


Figure 1. Response Time Test Circuit

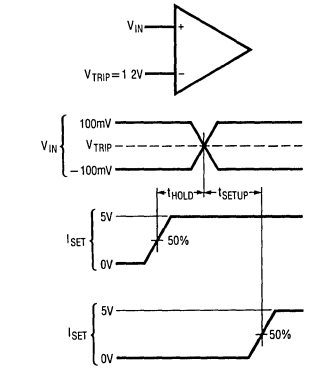


Figure 2. Latch Test Circuit

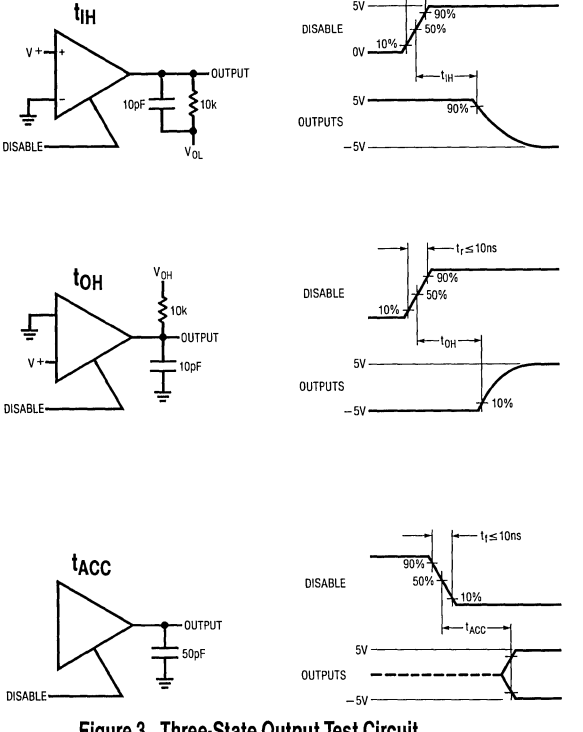
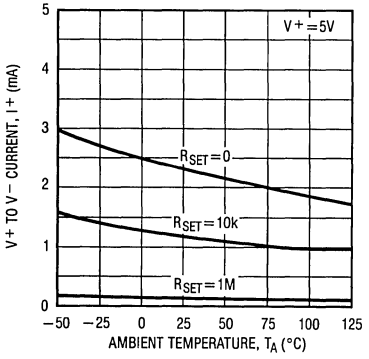


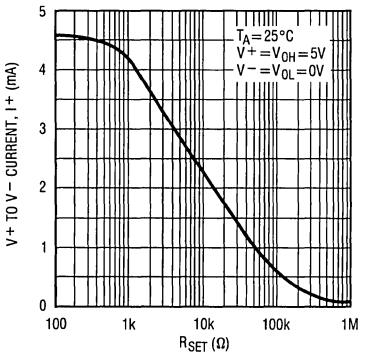
Figure 3. Three-State Output Test Circuit, Conditions: $V^+ = 5V$, $V^- = 0V$, $V_{OH} = 5V$, $V_{OL} = 0V$

TYPICAL PERFORMANCE CHARACTERISTICS

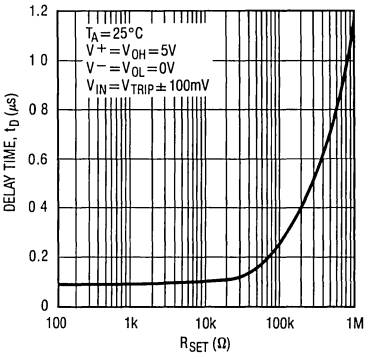
I^+ vs Temperature



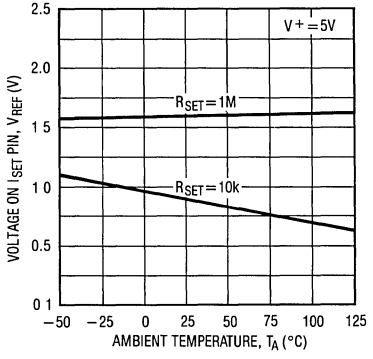
I^+ vs R_{SET}



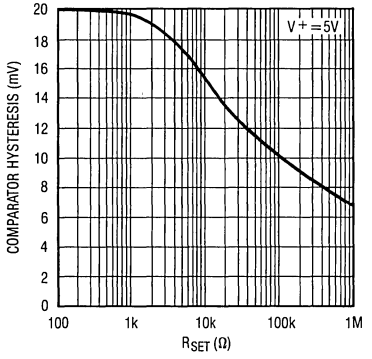
Delay Time vs R_{SET}



V_{REF} vs Temperature



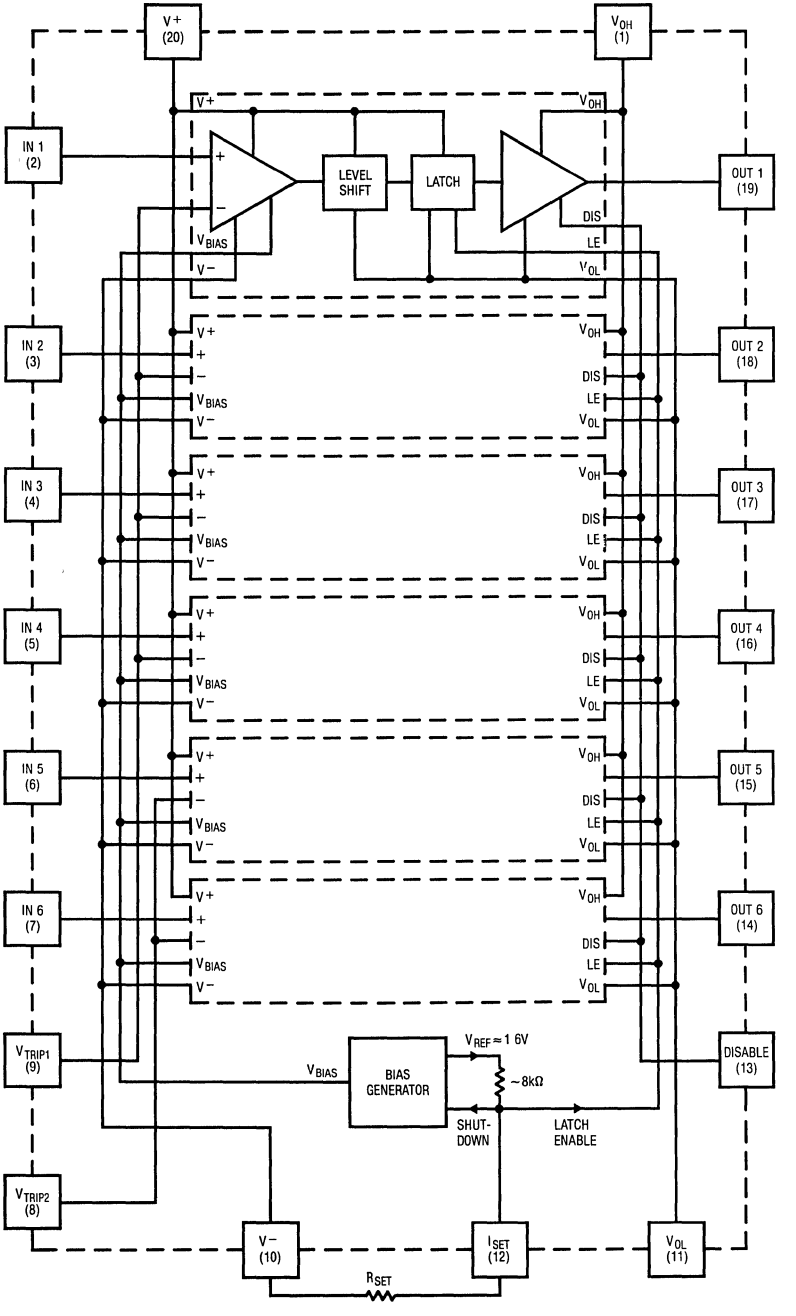
Hysteresis vs R_{SET}



PIN DESCRIPTION

Pin	Name	Description
1	V_{OH}	High level to which the output switches
2-7	INPUT	Six comparator inputs; voltage range = V^- to $V^- + 18V$
8	V_{TRIP2}	Trip point for first four comparators (inputs 1-4); voltage range = V^- to $V^+ - 2V$
9	V_{TRIP1}	Trip point for last two comparators (inputs 5-6); voltage range = V^- to $V^+ - 2V$
10	V^-	Low level to which the output switches
11	V_{OL}	Comparator negative supply
12	I_{SET}	This pin has three functions 1) R_{SET} from this pin to V^- sets bias current 2) When forced to V^+ power is shut off completely 3) When forced to V^+ outputs are latched
13	DISABLE	When high outputs are Hi-Z
14-19	OUTPUT	Six driver outputs
20	V^+	Comparator positive supply

BLOCK DIAGRAM



APPLICATIONS INFORMATION

The LTC1045 consists of six voltage translators and associated control circuitry, see Block Diagram. Each translator has a linear comparator input stage with the positive input brought out separately. The negative inputs of the first four comparators are tied in common to V_{TRIP1} and the negative inputs of the last two comparators are tied in common to V_{TRIP2}. With these inputs the switching point of the comparators can be set anywhere within the common-mode range of V^- to $V^+ - 2V$. To improve noise immunity each comparator has a small built-in hysteresis. Hysteresis varies with bias current from 7mV at low bias current to 20mV at high bias current (see typical curve of Hysteresis vs R_{SET}).

Setting the Bias Current

Unlike CMOS logic, any linear CMOS circuit must draw some quiescent current. The bias generator (Block Diagram) allows the quiescent current of the comparators to be varied. Bias current is programmed with an external resistor (see typical curve of I^+ vs R_{SET}). As the bias current is decreased, the LTC1045 slows down (see typical curve of Delay Time vs R_{SET}).

Shutting Power Off and Latching the Outputs

In addition to setting the bias current, the I_{SET} pin shuts power completely off and latches the translator outputs. To do this, the I_{SET} pin must be forced to $V^+ - 0.5V$. As shown in Figure 4, a CMOS gate or a TTL gate with a resistor pull-up does this quite nicely. Even though power is turned off to the linear circuitry, the CMOS output logic is powered and maintains the output state. With no DC load on the output, power dissipation, for all practical purposes, is zero.

Latching the output is fast—typically 80ns from the rising edge of I_{SET}. Going from the latched to flow through state is much slower—typically 1.5μs from the falling edge of I_{SET}. This time is set by the comparator's power up time. During the power up time, the output can assume false states. To avoid problems, the output should not be considered valid until 2μs to 5μs after the falling edge of I_{SET}.

Putting the Outputs in Hi-Z State

A DISABLE input sets the six outputs to a high impedance state. This allows the LTC1045 to be interfaced to a data bus. When DISABLE = "1" the outputs are high impedance and when DISABLE = "0" they are active. With TTL supplies, $V^+ = 4.5V$ to 5.5V and $V^- = GND$, the DISABLE input is TTL compatible.

Power Supplies

There are four power supplies on the LTC1045: V^+, V^-, V_{OH} and V_{OL}. They can be connected almost arbitrarily, but there are a few restrictions. A minimum differential must exist between V^+ and V^- and V_{OH} and V_{OL}. The V^+ to V^- differential must be at least 4.5V and the V_{OH} to V_{OL} differential must be at least 3.0V. Another restriction is caused by the internal parasitic diode D1 (see Figure 5).

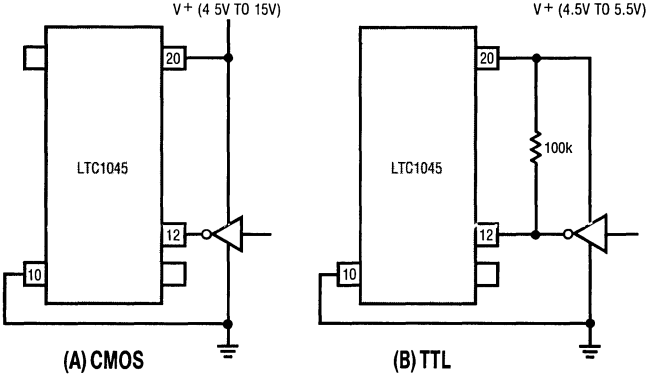


Figure 4. Driving the I_{SET} Pin with Logic

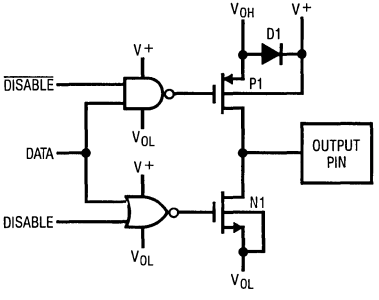


Figure 5. Output Driver

APPLICATIONS INFORMATION

Because of this diode, V_{OH} must not be greater than V^+. Lastly the maximum voltage between any two power supply pins must not exceed 15V operating or 18V absolute maximum. For example, if $V^+ = 5V$, V^- or V_{OL} should be no more negative than $-10V$. Note that V_{OL} should not be more negative than $-10V$ even if the V_{OH} to V_{OL} differential does not exceed the 15V maximum. In this case the V^+ to V_{OL} differential sets the limit.

Input Voltage

The LTC1045 has no upper clamp diodes as do conventional CMOS circuits. This allows the inputs to exceed the V^+ supply. The inputs will break down approximately 30V above the V^- supply. If the input current is limited with 100kΩ, the input voltage can be driven to at least ±50V with no adverse effects for any combination of allowed power supply voltages. Output levels will be correct even under these conditions (i.e., if the input voltage is above the trip point, the output will be high and if it is below, the output will be low).

Output Drive

Output drive characteristics of the LTC1045 will vary with the power supply voltages that are chosen. Output impedance is affected by V^+, V_{OH} and V_{OL}. V^- has no effect on output impedance. Guaranteed drive characteristics are specified in the table of electrical characteristics for $V^+ = V_{OH} = 5V$ and $V^- = V_{OL} = 0V$. Figures 6 and 7 show relative output impedance for other supply combinations. In general, output impedance is minimized if V^+ to V_{OH} is minimized and V_{OH} to V_{OL} is maximized.

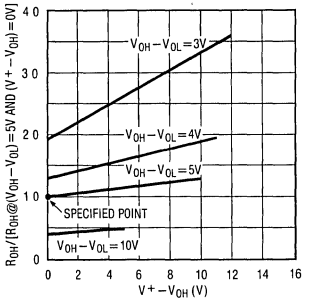


Figure 6. Relative Output Sourcing Resistance (R_{OH}) vs $V^+ - V_{OH}$

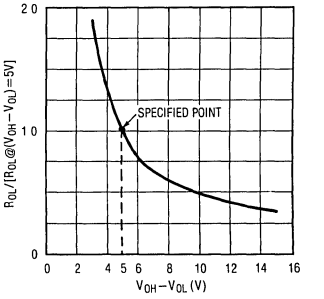
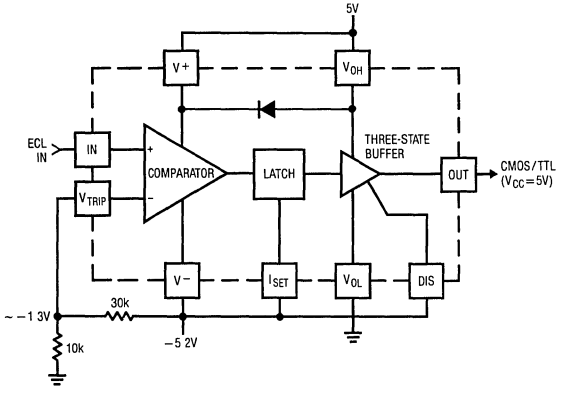


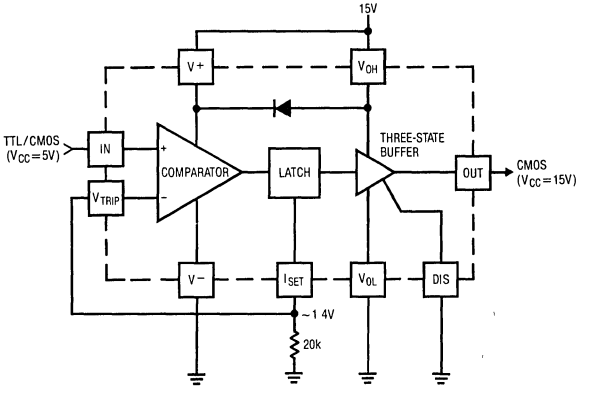
Figure 7. Relative Output Sinking Resistance (R_{OL}) vs $V_{OH} - V_{OL}$

TYPICAL APPLICATIONS

ECL to CMOS/TLL Logic

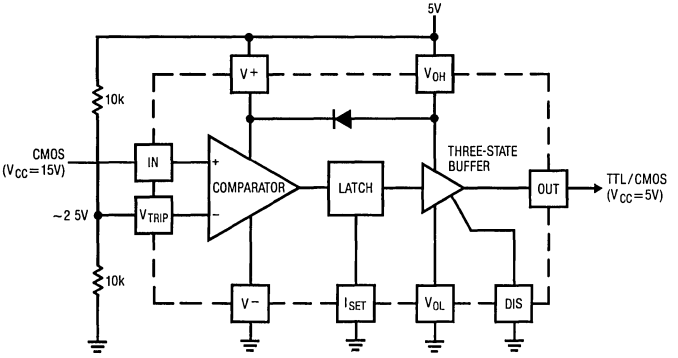


TTL/CMOS (V_{CC} = 5V) to High Voltage CMOS (V_{CC} = 15V)

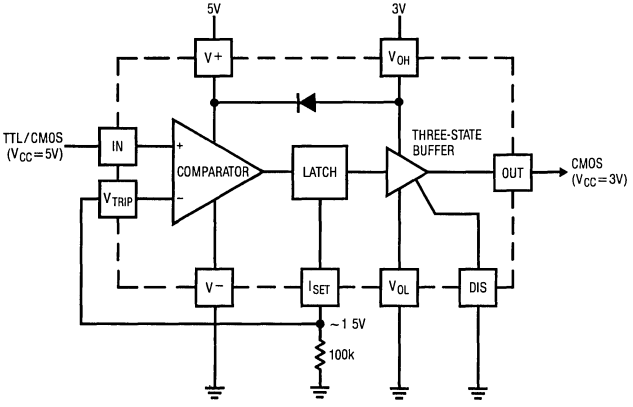


TYPICAL APPLICATIONS

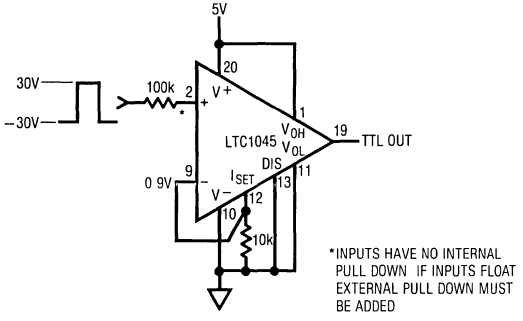
High Voltage CMOS (V_{CC} = 15V) to TTL/CMOS (V_{CC} = 5V)



TTL/CMOS (V_{CC} = 5V) to Low Voltage CMOS (V_{CC} = 3V)



RS232 Receiver



Advanced Low Power 5V RS232 Dual Driver/Receiver

FEATURES

- Absolutely No Latchup
- CMOS Comparable Low Power — 60mW
- **Superior to CMOS**
  - Improved Speed — Operates Over 64K Baud
  - Improved Protection — Outputs Can be Forced to ±30V Without Damage
  - Three-State Outputs are High Impedance When Off
  - Only Needs 1μF Capacitors
- Can Power Additional RS232 Drivers — 10mA
- 1μA Supply Current in Shutdown
- Available in SO Package
- Available With or Without Shutdown

APPLICATIONS

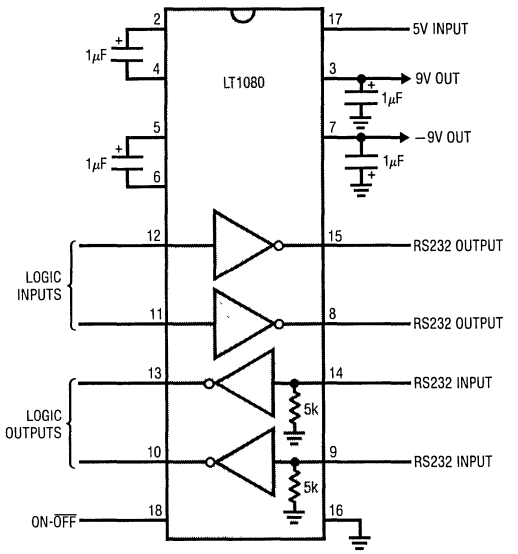
- Portable Computers
- Battery Powered RS232 Systems
- Power Supply Generator
- Terminals
- Modems

DESCRIPTION

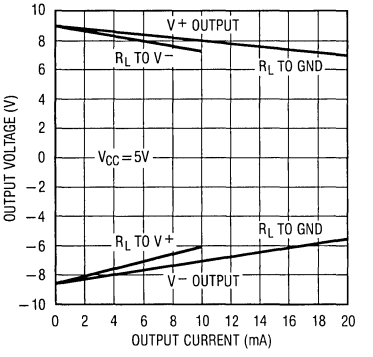
The LT1080 and LT1081 are the only dual RS232 driver/receiver with charge pump to guarantee absolutely no latchup. These interface optimized devices provide a realistic balance between CMOS levels of power dissipation and real world requirements for ruggedness. The driver outputs are fully protected against overload and can be shorted to ±30V. Unlike CMOS, the advanced architecture of the LT1080/LT1081 does not load the signal line when "shut down" or when power is off. Both the receiver and RS232 outputs are put into a high impedance state. An advanced output stage allows driving higher capacitive loads at higher speeds with exceptional ruggedness against ESD.

For applications requiring up to 5 drivers and 5 receivers with charge pump in one package see the LT1130 Series data sheet. A version of the LT1080/81, the LT1180 and LT1181 which use only 0.1μF capacitors is also available. All of Linear Technology's RS232 IC's are available in standard surface mount packages.

TYPICAL APPLICATION



Supply Generator Outputs



Advanced Low Power 5V RS232 Drivers/Receivers with Charge Pump

FEATURES

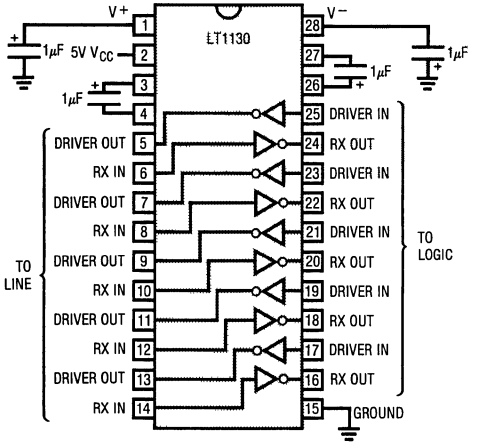
- Absolutely No Latchup
- CMOS Comparable Low Power — 80mW
- Operates from a **Single 5V Supply**
- **Superior to CMOS**
  - **Easy PC Layout** — Flow Through Architecture
  - Improved Speed — Operates Over 64K Baud
  - Improved Protection — Outputs Can be Forced to ±30V Without Damage
  - Three-State Outputs are High Impedance When Off
  - Only Needs 1μF Capacitors
  - Output Overvoltage Does Not Force Current Back Into Supplies
- 1μA Supply Current in Shutdown
- Available in SO Package

DESCRIPTION

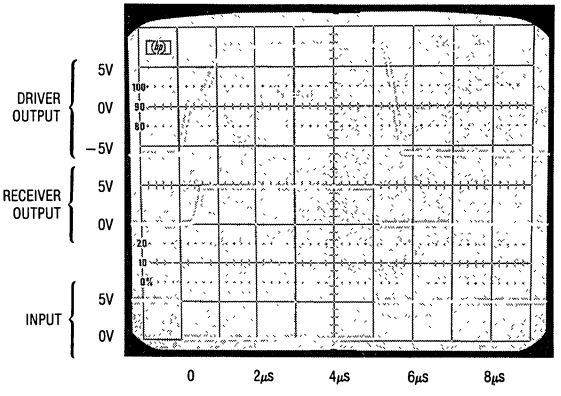
The LT1130 Series are the only RS232 drivers/receivers with charge pump to guarantee absolutely no latchup. These interface optimized devices provide a realistic balance between CMOS levels of power dissipation and real world requirements for ruggedness. The driver outputs are fully protected against overload and can be shorted to ±30V. Unlike CMOS, the advanced architecture of the LT1130 does not load the signal line when "shut down" or when power is off. Both the receiver and RS232 outputs are put into a high impedance state. An advanced output stage allows driving higher capacitive loads at higher speeds with exceptional ruggedness.

For applications requiring only 2 drivers and 2 receivers with charge pump in one package see the LT1180 Series data sheet. All of Linear Technology's RS232 IC's are available in standard surface mount packages.

Basic Operation



Output Waveform



LT1130 5-Driver/5-Receiver RS232 Transceiver
LT1131 5-Driver/4-Receiver RS232 Transceiver w/Shutdown
LT1132 5-Driver/3-Receiver RS232 Transceiver
LT1133 3-Driver/5-Receiver RS232 Transceiver
LT1134 4-Driver/4-Receiver RS232 Transceiver
LT1135 5-Driver/3-Receiver RS232 Transceiver w/o Charge Pump
LT1136 4-Driver/5-Receiver RS232 Transceiver w/Shutdown
LT1137 3-Driver/5-Receiver RS232 Transceiver w/Shutdown
LT1138 5-Driver/3-Receiver RS232 Transceiver w/Shutdown
LT1139 4-Driver/4-Receiver RS232 Transceiver w/Shutdown
LT1140 5-Driver/3-Receiver RS232 Transceiver w/o Charge Pump
LT1141 3-Driver/5-Receiver RS232 Transceiver w/o Charge Pump

Advanced Low Power 5V RS232 Dual Driver/Receiver with Small Capacitors

FEATURES

- 0.1μF Capacitors
- Absolutely No Latchup
- CMOS Comparable Low Power — 70mW
- **Superior to CMOS**
  - Improved Speed — Operates Over 64K Baud
  - Improved Protection — Outputs Can be Forced to ±30V Without Damage
  - Three-State Outputs are High Impedance When Off
  - Smaller Board Area Required
- 1μA Supply Current in Shutdown
- Available in SO Package
- Available With or Without Shutdown

APPLICATIONS

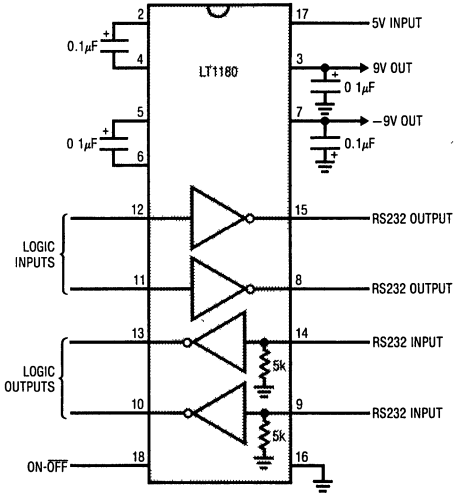
- Portable Computers
- Battery Powered RS232 Systems
- Power Supply Generator
- Terminals
- Modems

DESCRIPTION

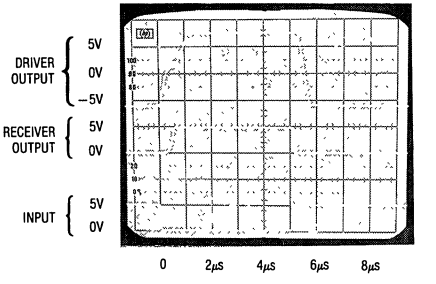
The LT1180 and LT1181 are the only dual RS232 driver/receiver with charge pump to guarantee absolutely no latchup. Requiring only 0.1μF charge pump capacitors, these interface optimized devices provide a realistic balance between CMOS levels of power dissipation and real world requirements for ruggedness. Small capacitors reduce cost as well as board size. The driver outputs are fully protected against overload and can be shorted to ±30V. Unlike CMOS, the advanced architecture of the LT1180/LT1181 does not load the signal line when "shut down" or when power is off. Both the receiver and RS232 outputs are put into a high impedance state. An advanced output stage allows driving higher capacitive loads at higher speeds with exceptional ruggedness against ESD.

For applications requiring up to 5 drivers and 5 receivers with charge pump in one package see the LT1130 Series data sheet. A version of the LT1180/81, the LT1080 and LT1081 is available for applications requiring extra current from the charge pump to power other circuitry. All of Linear Technology's RS232 IC's are available in standard surface mount packages.

TYPICAL APPLICATION



Output Waveforms



Advanced Low Power 5V RS232 Dual Driver/Receiver

FEATURES

- 10mA Max Supply Current
- Absolutely No Latchup
- CMOS Comparable Low Power — 35mW Typ
- **Superior to CMOS**
  - Improved Speed — Operates Over 64K Baud
  - Improved Protection — Outputs Can be Forced to ±30V Without Damage
  - Three-State Outputs are High Impedance When Off
  - Smaller Board Area Required
- 1μA Supply Current in Shutdown
- Available in SO Package
- Available With or Without Shutdown

APPLICATIONS

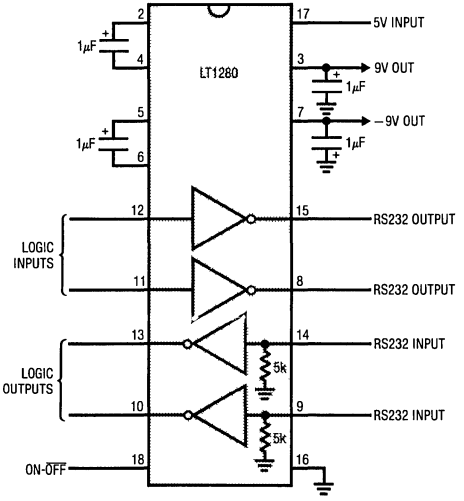
- Portable Computers
- Battery Powered RS232 Systems
- Power Supply Generator
- Terminals
- Modems

DESCRIPTION

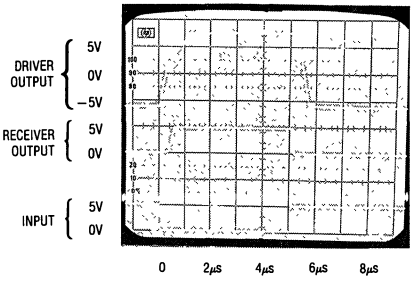
The LT1280 and LT1281 are the only dual RS232 driver/receiver with charge pump to guarantee absolutely no latchup. Requiring only 1μF charge pump capacitors, these interface optimized devices provide a realistic balance between CMOS levels of power dissipation and real world requirements for ruggedness. Small capacitors reduce cost as well as board size. The driver outputs are fully protected against overload and can be shorted to ±30V. Unlike CMOS, the advanced architecture of the LT1280/LT1281 does not load the signal line when "shutdown" or when power is off. Both the receiver and RS232 outputs are put into a high impedance state. An advanced output stage allows driving higher capacitive loads at higher speeds with exceptional ruggedness against ESD.

For applications requiring small 0.1μF capacitors, the LT1280A/LT1281A will be released by June 1993. In addition to meeting all LT1280/LT1281 specifications, including 10mA max. supply current, the LT1280A/LT1281A provides ±10kV ESD protection for the RS232 line pins.

TYPICAL APPLICATION



Output Waveforms

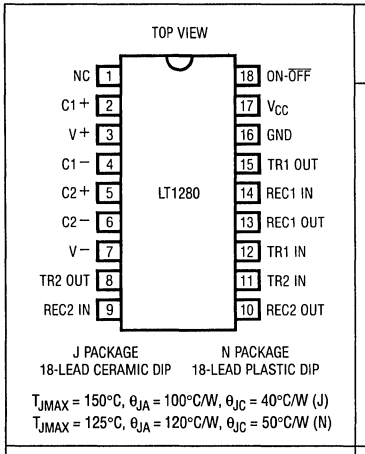


ABSOLUTE MAXIMUM RATINGS

Supply Voltage (V_{CC}) 6V
V+ 13.2V
V– ..... –13.2V
Input Voltage
Driver ..... V– to V+
Receiver ..... –30V to 30V
On-$\overline{\text{Off}}$ Pin ..... GND to 12V
Output Voltage
Driver ..... V– +30V to V+ –30V
Receiver ..... –0.3V to V_{CC} +0.3V

Short Circuit Duration
V+ ..... 30 Seconds
V– ..... 30 Seconds
Driver Output ..... Indefinite
Receiver Output ..... Indefinite
Operating Temperature Range
LT1280M/LT1281M ..... –55°C to 125°C
LT1280I/LT1281I ..... –40°C to 85°C
LT1280C/LT1281C ..... 0°C to 70°C
Lead Temperature (Soldering, 10 sec.) ..... 300°C

PACKAGE/ORDER INFORMATION



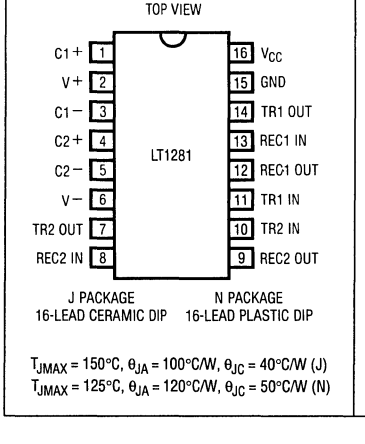
J PACKAGE
18-LEAD CERAMIC DIP

N PACKAGE
18-LEAD PLASTIC DIP

T_{JMAX} = 150°C, θ_{JA} = 100°C/W, θ_{JC} = 40°C/W (J)
T_{JMAX} = 125°C, θ_{JA} = 120°C/W, θ_{JC} = 50°C/W (N)

ORDER PART NUMBER

LT1280MJ
LT1280IJ
LT1280IN
LT1280CJ
LT1280CN



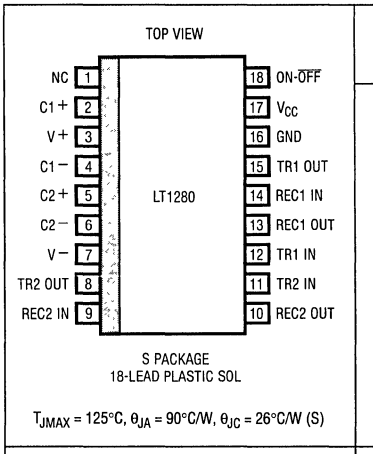
J PACKAGE
16-LEAD CERAMIC DIP

N PACKAGE
16-LEAD PLASTIC DIP

T_{JMAX} = 150°C, θ_{JA} = 100°C/W, θ_{JC} = 40°C/W (J)
T_{JMAX} = 125°C, θ_{JA} = 120°C/W, θ_{JC} = 50°C/W (N)

ORDER PART NUMBER

LT1281MJ
LT1281IJ
LT1281IN
LT1281CJ
LT1281CN

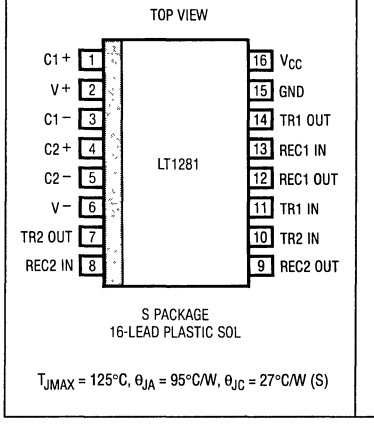


S PACKAGE
18-LEAD PLASTIC SOL

T_{JMAX} = 125°C, θ_{JA} = 90°C/W, θ_{JC} = 26°C/W (S)

ORDER PART NUMBER

LT1280IS
LT1280CS



S PACKAGE
16-LEAD PLASTIC SOL

T_{JMAX} = 125°C, θ_{JA} = 95°C/W, θ_{JC} = 27°C/W (S)

ORDER PART NUMBER

LT1281IS
LT1281CS

ELECTRICAL CHARACTERISTICS (Note 1)

PARAMETER	CONDITIONS			MIN	TYP	MAX	UNITS
Driver							
Output Voltage Swing	Load = 3k to GND Both Outputs.	Positive Negative	o o	5.0 −5.0	7.3 −6.5		V V
Logic Input Voltage Level	Input Low Level (V_{OUT} = High) Input High Level (V_{OUT} = Low)		o o	 2.0	1.4 1.4	0.8	V V
Logic Input Current	$V_{IN} \geq 2.0V$ $V_{IN} \leq 0.8V$		o o	 	5 5	20 20	μA μA
Output Short Circuit Current	Sourcing Current, V_{OUT} = 0V Sinking Current, V_{OUT} = 0V		 	7 −7	12 −12		mA mA
Output Leakage Current	SHUTDOWN (Note 2), V_{OUT} = ±30V (Note 4)		o		10	25	μA
Slew Rate	R_L = 3kΩ, C_L = 51pF			4	15	30	V/μs
Receiver							
Input Voltage Thresholds	Input Low Threshold, LT1280C/LT1281C LT1280I, M/LT1281I, M		o o	0.8 0.2	1.3 1.3		V V
	Input High Threshold, LT1280C/LT1281C LT1280I, M/LT1281I, M		o o	 	1.7 1.7	2.4 3.0	V V
Hysteresis			o	0.1	0.4	1.0	V
Input Resistance				3	5	7	kΩ
Output Voltage	Output Low, I_{OUT} = −1.6mA Output High, I_{OUT} = 160μA (V_{CC} = 5V)		o o	 3.5	0.2 4.8	0.4	V V
Output Short Circuit Current	Sinking Current, $V_{OUT} = V_{CC}$ Sourcing Current, V_{OUT} = 0V		 	−10 0.3	−20 0.6		mA mA
Output Leakage Current	SHUTDOWN (Note 2), $0V \leq V_{OUT} \leq V_{CC}$		o		1	10	μA
Supply Current	(Note 3)		 o		7	10 14	mA mA
Supply Leakage Current (V_{CC})	SHUTDOWN (Note 2) (LT1280 Only) (Note 4)		o		1	25	μA
On-$\overline{\text{Off}}$ Pin Current	$0V \leq V_{ON\text{-}\overline{OFF}} \leq 5V$ (LT1280 Only)		o	−15		80	μA

The o denotes specifications which apply over the operating temperature range ($0°C \leq T_A \leq 70°C$ for commercial grade, $-40°C \leq T_A \leq 85°C$ for industrial grade or $-55°C \leq T_A \leq 125°C$ for military grade devices).

Note 1: These parameters apply for $V_{ON\text{-}\overline{OFF}}$ = 3V, V_{CC} = 5V and C = 1.0μF unless otherwise specified.

Note 2: $V_{ON\text{-}\overline{OFF}}$ = 0.4V for $-55°C \leq T_A \leq 100°C$, and $V_{ON\text{-}\overline{OFF}}$ = 0.2V for $100°C \leq T_A \leq 125°C$ (LT1280 only).

Note 3: Unless otherwise specified, V_{CC} = 5V, external loading of V^+ and V^- equals zero and the driver outputs are low (inputs high).

Note 4: Leakage current at 125°C = 100μA max.

PIN FUNCTIONS (Pin numbers refer to LT1280)

V_{CC} (Pin 17): Input supply pin. Supply current drops to zero in the SHUTDOWN mode.

GND (Pin 16): Ground pin.

On-$\overline{Off}$ (Pin 18): Controls the operation mode of the LT1280 and is TTL/CMOS compatible. A logic low puts the device in the SHUTDOWN mode which reduces input supply current to zero and places both driver and receiver outputs in a high impedance state. A logic high fully enables the device.

V+ (Pin 3): Positive supply for RS232 drivers. $V+ \approx 2V_{CC} - 1.5V$. Requires an external capacitor ($\geq 0.1\mu F$) for charge storage. Capacitor may be tied to ground or +5V input supply. With multiple transceivers, the V+ and V− pins may be paralleled into common capacitors.

V− (Pin 7): Negative supply for RS232 drivers. $V- \approx -(2V_{CC} - 2.5V)$. Requires an external capacitor ($\geq 0.1\mu F$) for charge storage. With multiple transceivers, the V+ and V− pins may be paralleled into common capacitors.

TR1 IN; TR2 IN (Pins 12, 11): RS232 driver input pins. Inputs are TTL/CMOS compatible. Inputs should not be allowed to float. Tie unused inputs to V_{CC}.

TR1 OUT; TR2 OUT (Pins 15, 8): Driver outputs with RS232 voltage levels. Outputs are in a high impedance state when in the SHUTDOWN mode or when power is off ($V_{CC} = 0V$) to allow data line sharing. Outputs are fully short circuit protected from V− +30V to V+ −30V with power on, off, or in the SHUTDOWN mode. Typical output breakdowns are greater than ±45V and higher applied voltages will not damage the device if moderately current limited. Shorting one output will affect output from the other.

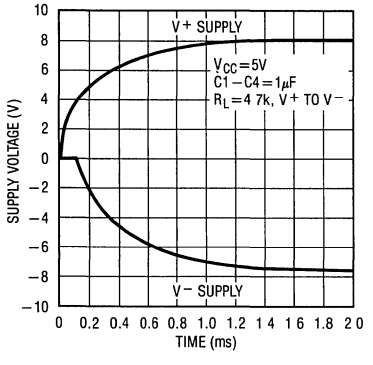
REC1 IN; REC2 IN (Pins 14, 9): Receiver inputs. Accepts RS232 voltage levels (±30V) and has 0.4V of hysteresis to provide noise immunity. Input impedance is nominally 5kΩ.

REC1 OUT; REC2 OUT (Pins 13, 10): Receiver outputs with TTL/CMOS voltage levels. Outputs are in a high impedance state when in the SHUTDOWN mode to allow data line sharing. Outputs are fully short circuit protected to ground or V_{CC} with power on, off, or in the SHUTDOWN mode.

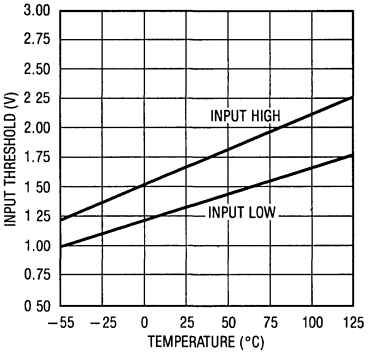
C1+; C1−; C2+; C2− (Pins 2, 4, 5, 6): Requires an external capacitor ($\geq 0.1\mu F$) from C1+ to C1− and another from C2+ to C2−. Pin 2 can be used for connecting a second positive supply. When a separate positive supply is used, C1 can be deleted.

TYPICAL PERFORMANCE CHARACTERISTICS

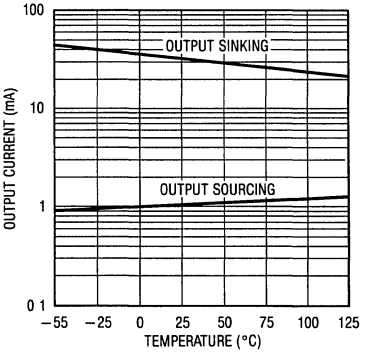
Supply Generation from V_{CC} or Shutdown



Receiver Input Thresholds

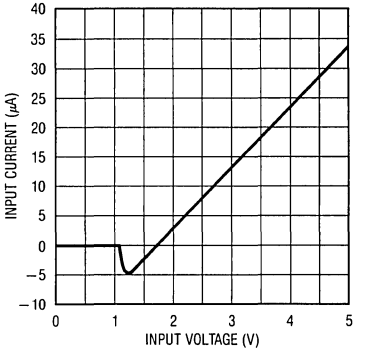


Receiver Output Short Circuit Current

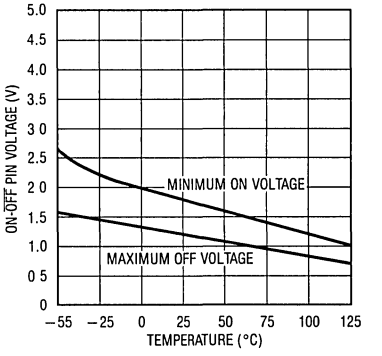


TYPICAL PERFORMANCE CHARACTERISTICS

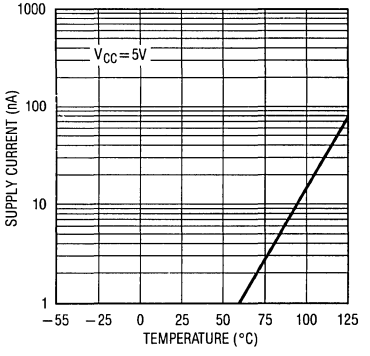
On-$\overline{\text{Off}}$ Pin Current vs Voltage



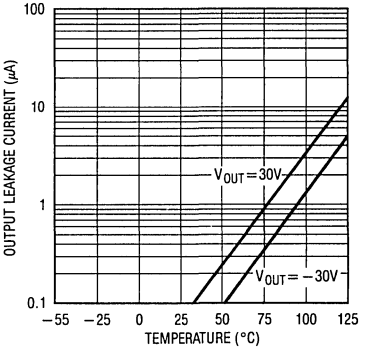
On-$\overline{\text{Off}}$ Pin Thresholds



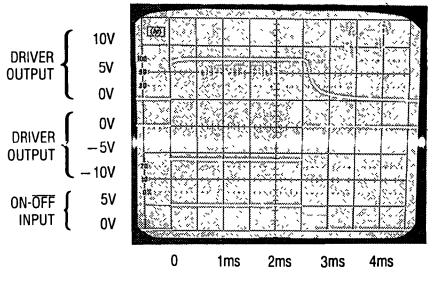
Supply Current in Shutdown



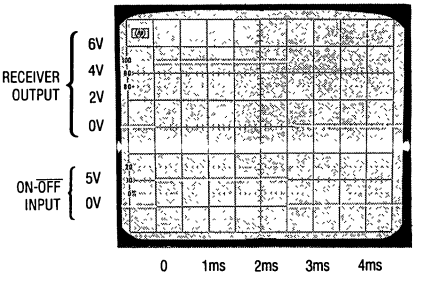
Driver Output Leakage in Shutdown



Shutdown to Driver Output



Shutdown to Receiver Output



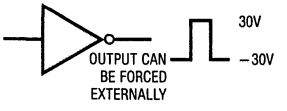
APPLICATION HINTS

The driver output stage of the LT1280 offers significantly improved protection over older bipolar and CMOS designs. In addition to current limiting, the driver output can be externally forced to ±30V with no damage or excessive current flow, and will not disrupt the supplies. Some drivers have diodes connected between the outputs and the supplies, so externally applied voltages can cause excessive supply voltage to develop.

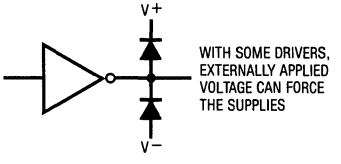
Placing the LT1280 in the SHUTDOWN mode (Pin 18 low) puts both the driver and receiver outputs in a high impedance state. This allows data line sharing and transceiver applications.

The SHUTDOWN mode also drops input supply current (V_{CC}; Pin 17) to zero for power-conscious systems.

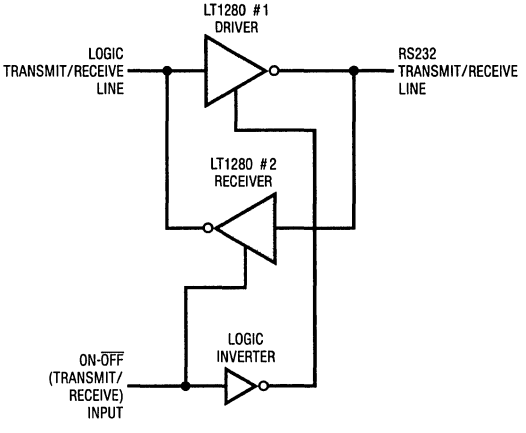
LT1280/LT1281 Driver



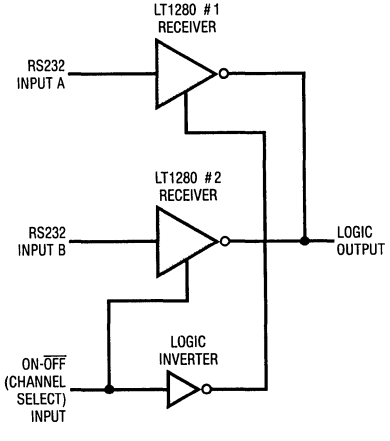
Older RS232 Drivers and CMOS Drivers



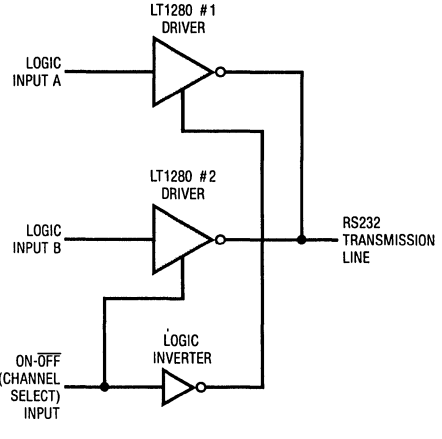
Transceiver



Sharing a Receiver Line



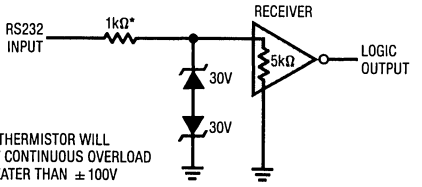
Sharing a Transmitter Line

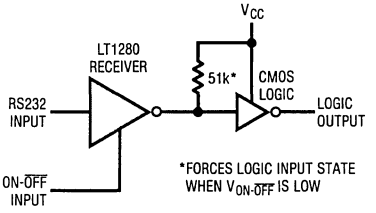


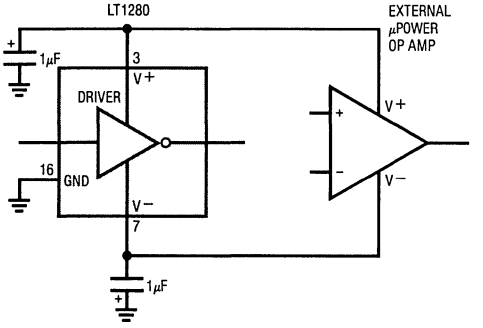
APPLICATION HINTS

When driving CMOS logic from a receiver that will be used in the SHUTDOWN mode and there is no other active receiver on the line, a 51k resistor can be placed from the logic input to V_{CC} to force a definite logic level when the receiver output is in a high impedance state.

To protect against receiver input overloads in excess of ±30V, a voltage clamp can be placed on the data line and still maintain RS232 compatibility.

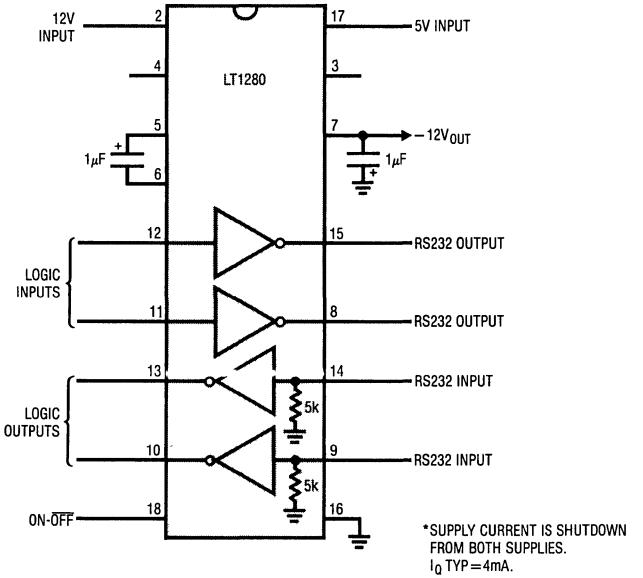






TYPICAL APPLICATION

Operating with 12V and 5V Supplies*



*SUPPLY CURRENT IS SHUTDOWN FROM BOTH SUPPLIES. I_Q TYP = 4mA.

CHAPTER 4: APPENDICES

Chapter 4: Appendices

INTERFACE STANDARDS

SPECIFICATION			RS232	RS423	RS422	RS485	RS562
Mode of Operation			Single-Ended	Single-Ended	Differential	Differential	Single-Ended
Number of Drivers and Receivers Allowed on One Line			1 Driver, 1 Receiver	1 Driver, 10 Receivers	1 Driver, 10 Receivers	32 Drivers, 32 Receivers	1 Driver, 1 Receiver
Maximum Cable Length			50 feet*	4000 feet	4000 feet	4000 feet	50 feet*
Maximum Data Rate			20kb/s	100kb/s	10Mb/s	10Mb/s	64kb/s
Maximum Voltage Applied to Driver Output			±25V	±6V	−0.25V to 6V	−7V to 12V	±25V
Driver Output Signal	Min Loaded		±5V	±3.6V	±2V	±1.5V	±3.7V
	Max Unloaded		±15V	±6V	±5V	±5V	±13.2V
Driver Load			3kΩ to 7kΩ	450Ω (Min)	100Ω	54Ω	3kΩ to 7kΩ
Maximum Driver Output Current		Power ON	–	–	–	–	60mA
(High Impedance State)		Power OFF	V_{MAX}/300Ω	±100µA	±100µA	±100µA	V_{MAX}/300Ω
Output Slew Rate			30V/µs (Max)	Controls Provided	–	–	30V/µs (Max)
Receiver Input Voltage Range			±15V (±25V Max)	±12V	±7V	−7V to 12V	±15V (±25V Max)
Receiver Input Sensitivity			±3V	±200mV	±200mV	±200mV	±3
Receiver Input Resistance			3kΩ to 7kΩ	4kΩ (Min)	4kΩ (Min)	12kΩ (Min)	3kΩ to 7kΩ

* For 2500pF cable capacitance, as per EIA 232D for data rates less than 20k baud. For data rates greater than 20k baud, C_{Load} = 1000pF.

Complete standards can be obtained from Global Engineering Documents, 2805 McGraw Avenue, Irvine, CA 92714

INTERFACE GLOSSARY

ASCII – American Standard Code for Information Interchange—a 7-bit code for sending data. See page 8.

asynchronous – Transmission in which character synchronization is established by use of start and stop bits. Also called start/stop transmission.

auxiliary channel – A secondary channel whose transmission direction is independent of the primary channel.

backward channel – A secondary channel whose direction of transmission is the opposite of the primary channel.

baud – The number of discrete signal elements transmitted per second. Many encoding methods allow transmission rates (bits per second) which are a multiple of baud rate.

BPS – Bits per second transmitted or received.

DCE – Data communications equipment. For example, a modem.

DTE – Data terminal equipment. For example, a computer or terminal.

frame – A group of bits transmitted as a unit. In asynchronous transmission a frame consists of a start bit, data bits, an optional parity bit, and one or more stop bits.

full-duplex – Simultaneous two-way independent transmission in both directions.

half-duplex – A circuit designed for transmission in either direction but not both directions simultaneously.

modem – Stands for MODulator-DEModulator, a device that converts digital signals to analog signals and vice versa. Analog signals can be transmitted over communications links such as telephone lines.

primary channel – The data channel having the higher signaling line.

protocol – Rules that define how two or more communications devices will "talk" to each other.

secondary channel – The data channel having the lower signaling rate of the interface. There are two classes of secondary channels: auxiliary and backward.

simplex – A circuit capable of operating in only one direction.

synchronous – Transmission method in which the data is transmitted at a fixed rate with the transmitter and receiver synchronized.

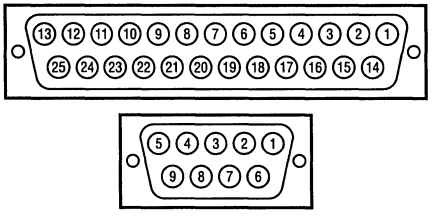
CONNECTOR INFORMATION

SIGNAL PINOUT

PIN	NAME	ABBR.	DTE/DCE	AT
1	Frame Ground	FG		
2	Transmit Data	TD	⇒	3
3	Receive Data	RD	⇐	2
4	Request to Send	RTS	⇒	7
5	Clear to Send	CTS	⇐	8
6	Data Set Ready	DSR	⇐	6
7	Signal Ground	SG		5
8	Data Carrier Detect	DCD	⇐	1
9	(Reserved)			
10	(Reserved)			
11	Unassigned			
12	Sec. Carrier Detect	(S)CD	⇐	
13	Sec. Clear to Send	(S)CTS	⇐	
14	Sec. Transmit Data	(S)TD	⇒	
15	Transmitter Clock	TC	⇐	
16	Sec. Receive Data	(S)RD	⇐	
17	Receiver Clock	RC	⇐	
18	Local Loopback		⇒	
19	Sec. Request to Send	(S)RTS	⇒	
20	Data Terminal Ready	DTR	⇒	4
21	Remote Loopback		⇒	
	Signal Quality Detect	SQ	⇐	
22	Ring Indicator	RI	⇐	9
23	Data Rate Select			
24	Transmitter Clock	(E)TC	⇒	
25	Test Mode		⇐	

- The DTE/DCE column indicates data direction.
- The AT column indicates the pin numbers used on IBM-PC/AT 9-pin connectors.
- Pin numbers in bold indicate commonly used signals.
- Data rate select (pin 23) can be from DTE or DCE.

CONNECTORS



VIEWS ARE FROM THE PIN SIDE OF THE FEMALE (DCE) CONNECTOR OR THE WIRE SIDE OF THE MALE (DTE) CONNECTOR.

RS232•01

CONNECTOR SIGNAL DESCRIPTIONS

Frame Ground – Chassis ground of equipment.

Transmit Data – Data sent by the DTE. The DTE holds the transmit data line in the mark condition when not transmitting.

Receive Data – Data received by the DCE. The DCE holds the receive data line in the mark condition when Data Carrier Detect is off.

Request to Send – Used by DTE to tell DCE it wants to send data.

Clear to Send – Used by DCE to indicate it is ready to accept data.

Data Set Ready (DCE Ready) – Indicates DCE is ready for operation.

Signal Ground – Common ground for all signals.

Data Carrier Detect (Received Line Signal Detector) – DCE indicates it is receiving a signal.

Transmitter Clock (Transmitter Signal Element Timing) – Used to supply signal timing. Note that there are two of these signals: one supplied by the DCE and one by the DTE. Used for synchronous transmission.

Receiver Clock (Receiver Signal Element Timing) – Used by the DCE to provide receive signal timing (clock) to the DTE. Used for synchronous transmission.

Local Loopback – Used to control the local loopback test condition in the local DCE.

Data Terminal Ready – Used by the DTE to tell the DCE to switch to the communications channel. Turning off DTR will cause a modem to hang up a connection.

Remote Loopback – Used to control the remote loopback test condition in the remote DCE. An ON condition causes the local DCE to signal the remote DCE to establish remote loopback.

Signal Quality Detect – An OFF condition indicates a high probability of error. (Not recommended for new designs.)

Ring Indicator – DCE turns this signal ON when it receives a ringing signal.

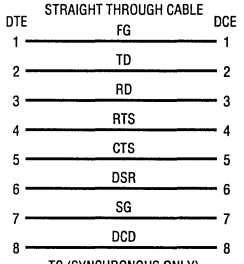
Data Rate Select – Used to select one of two data rates (synchronous DCE) or one of two ranges of data rates (asynchronous DCE).

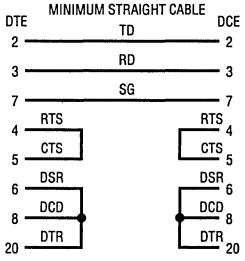
Test Mode – Used by DCE to indicate that it is in test mode.

Note: All secondary (Sec.) signals have the same meaning as the primary signals of the same name but apply to the secondary channel. The secondary channel is not available in many systems.

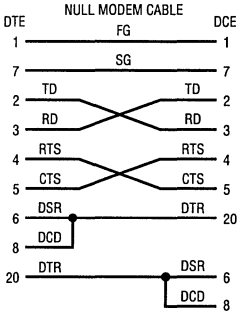
CABLE INFORMATION

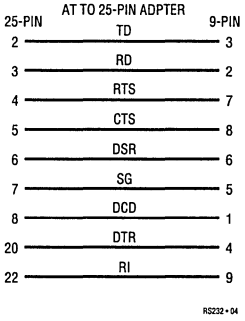
CABLES AND ADAPTERS





A MINIMUM NULL MODEM CABLE IS THE SAME AS A MINIMUM STRAIGHT CABLE EXCEPT THAT RD AND TD (PINS 2 AND 3) ARE CROSS-CONNECTED AS IN THE NULL MODEM CABLE.





RS232 • 04

CABLE RUN LENGTH

Within the standard, cable lengths are limited by the signal characteristics. In practice, however, these limits are exceeded. The following chart offers some reasonable guidelines for 24-gauge wire under average conditions.

Information from the data sheets on standard driver integrated circuits indicates that these guidelines may be conservative and suggests lengths of up to 10,000 feet at data rates in excess of 20,000 bits per second are possible.

The external environment will have a large effect on lengths for unshielded cables. In electrically noisy environments, even very short cables can pick up stray signals.

Rate	Shielded	Unshielded
110	5000	1000
300	4000	1000
1200	3000	500
2400	2000	500
4800	500	250
9600	250	100

PROTOCOL INFORMATION

PARITY

Parity is the use of a check bit, appended to each frame of data, for error checking purposes. The following parity types are possible.

None – No parity bit is sent.

Odd – The parity bit is set to ensure an odd number of bits are set within the frame.

Even – The parity bit is set to ensure an even number of bits are set within the frame.

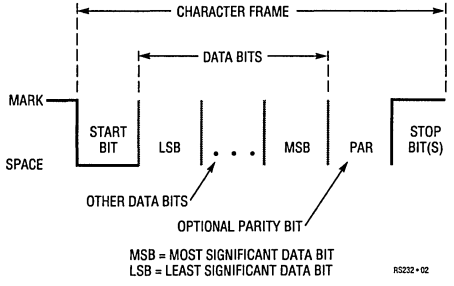
Mark – The parity bit is always set to the marking signal condition.

Space – The parity bit is always set to the spacing signal condition.

Examples of Common Formats

8N1 – 8 data bits, 1 stop bit, no parity bit. (10-bit frame)
7N1 – 7 data bits, 1 stop bit, no parity bit. (9-bit frame)
8E1 – 8 data bits, 1 stop bit, even parity. (11-bit frame)

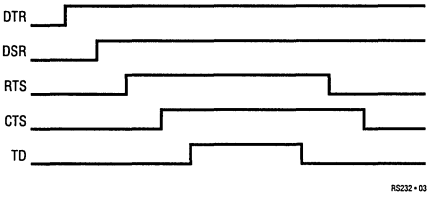
CHARACTER FRAME



RS232 • 02

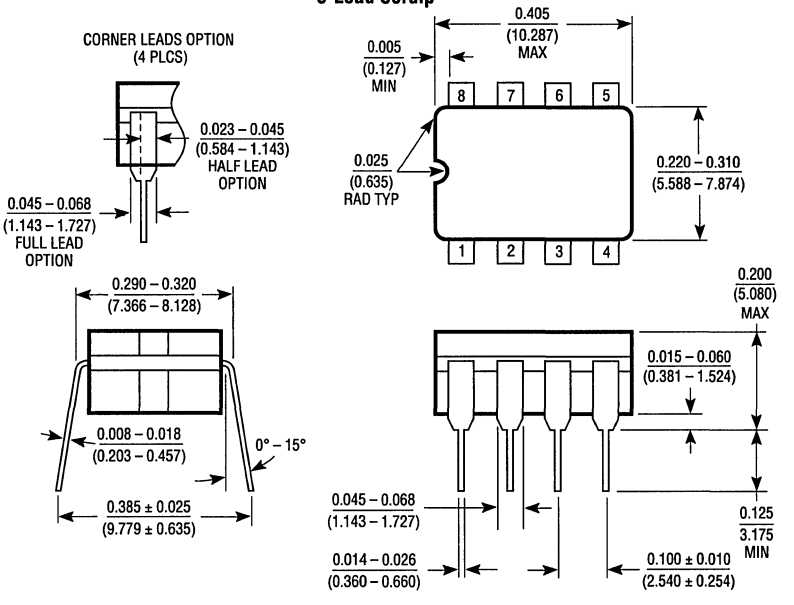
RELATIVE SIGNAL TIMING

NORMAL TIMING SEQUENCES DURING ESTABLISHMENT OF COMMUNICATIONS ARE SHOWN BELOW ON HALF-DUPLEX CIRCUITS, RTS IS DROPED AS SOON AS THE DATA IS SENT. THIS IS TO SIGNAL A TURNAROUND OF THE CIRCUIT



RS232 • 03

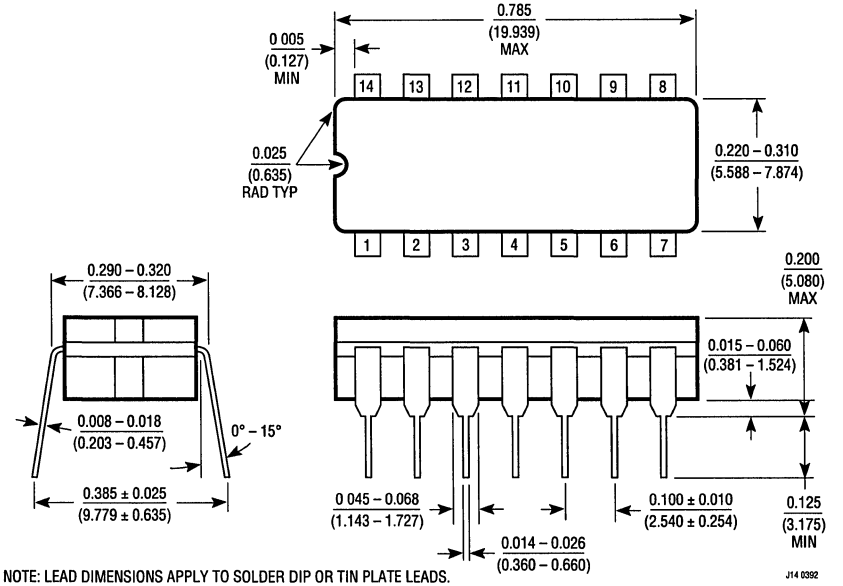
J Package
8-Lead Cerdip



NOTE: LEAD DIMENSIONS APPLY TO SOLDER DIP OR TIN PLATE LEADS.

J8 0293

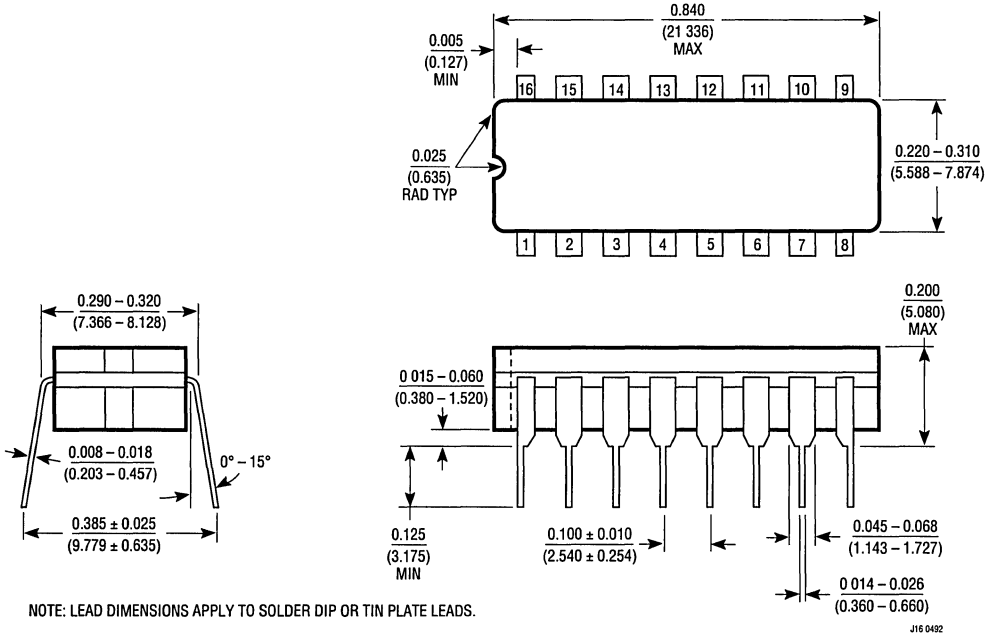
J Package
14-Lead Cerdip



NOTE: LEAD DIMENSIONS APPLY TO SOLDER DIP OR TIN PLATE LEADS.

J14 0392

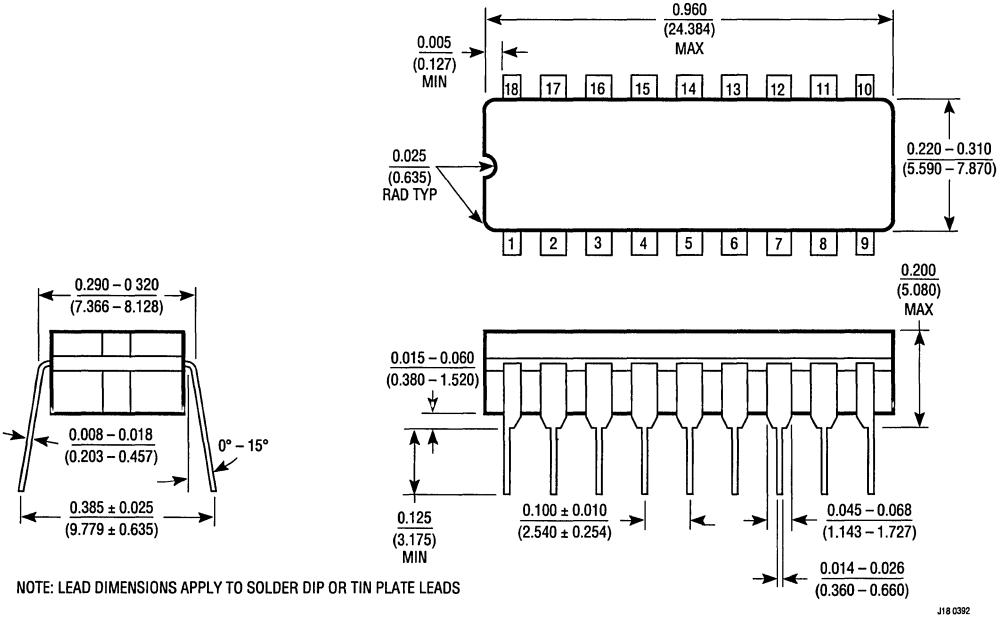
J Package
16-Lead Cerdip



NOTE: LEAD DIMENSIONS APPLY TO SOLDER DIP OR TIN PLATE LEADS.

J16 0492

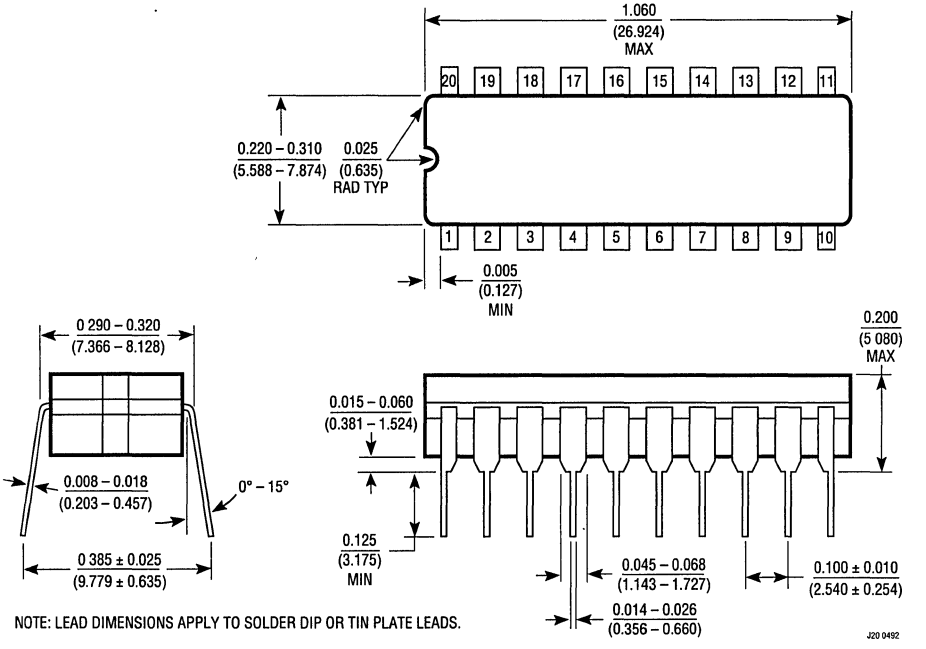
J Package
18-Lead Cerdip



NOTE: LEAD DIMENSIONS APPLY TO SOLDER DIP OR TIN PLATE LEADS

J18 0392

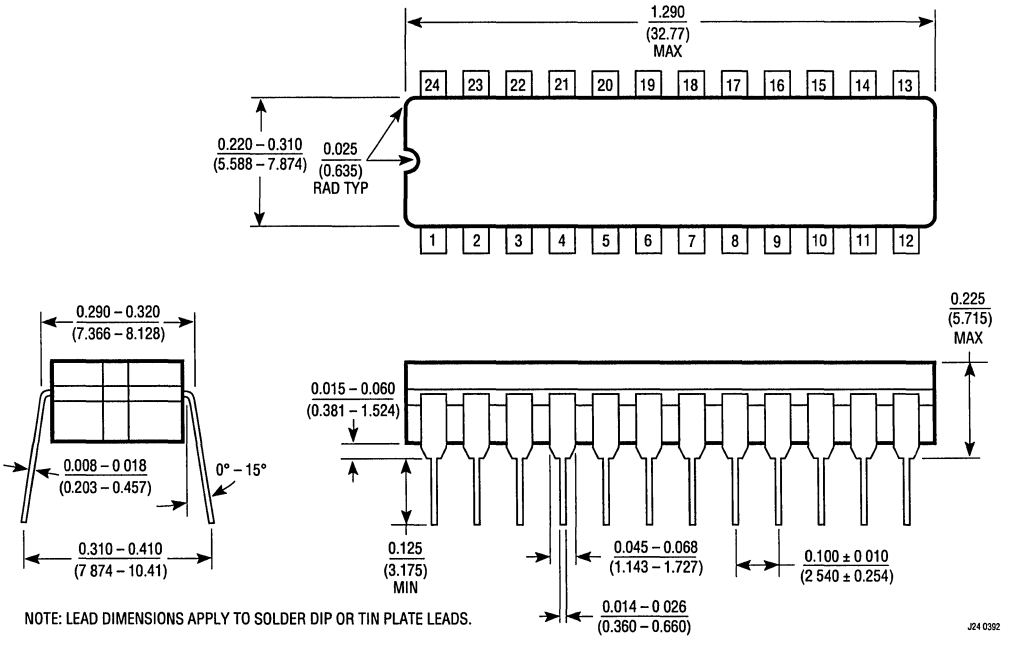
J Package
20-Lead Cerdip



NOTE: LEAD DIMENSIONS APPLY TO SOLDER DIP OR TIN PLATE LEADS.

J20 0492

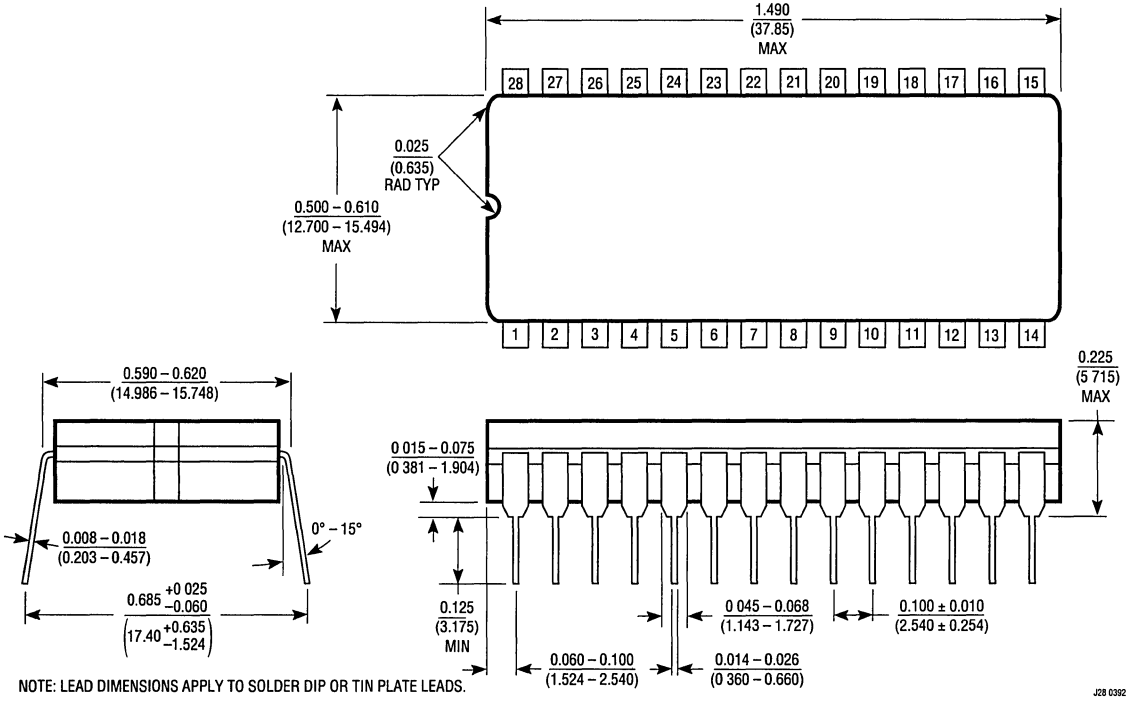
J Package
24-Lead Cerdip



NOTE: LEAD DIMENSIONS APPLY TO SOLDER DIP OR TIN PLATE LEADS.

J24 0392

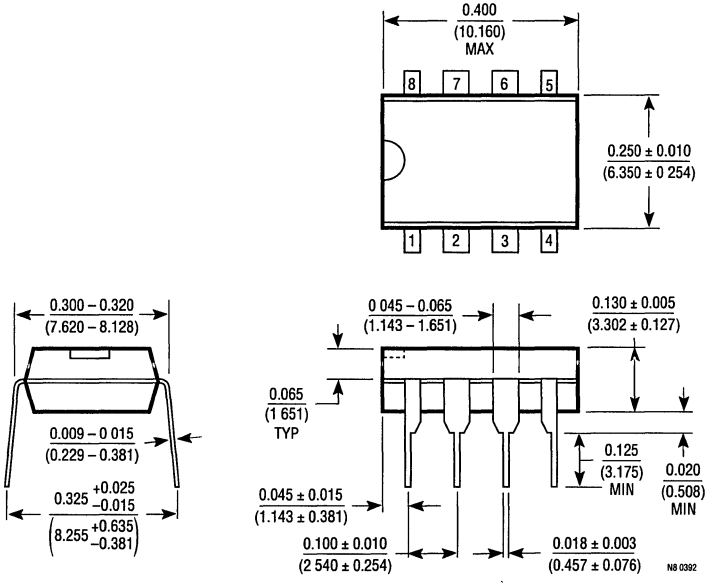
J Package
28-Lead Cerdip



NOTE: LEAD DIMENSIONS APPLY TO SOLDER DIP OR TIN PLATE LEADS.

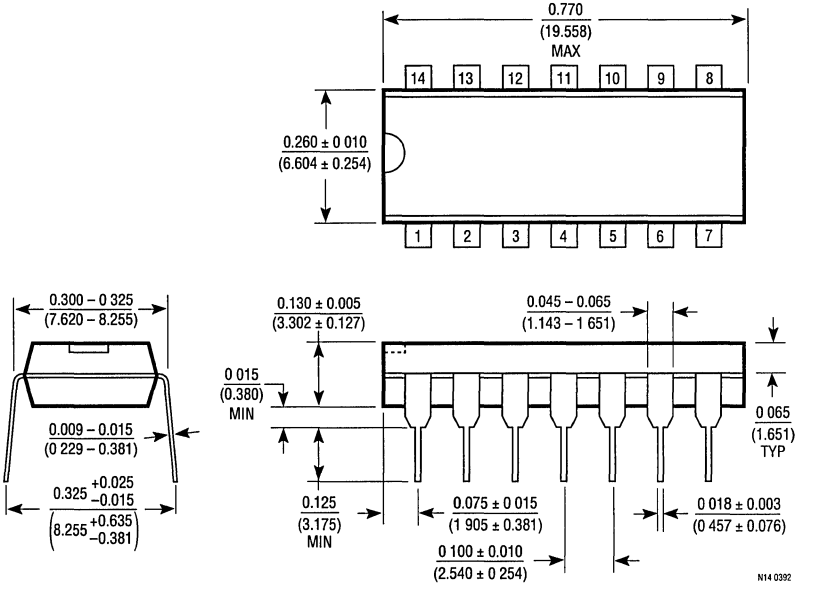
J28 0392

N Package
8-Lead Molded DIP



N8 0392

N Package
14-Lead Molded DIP



N Package
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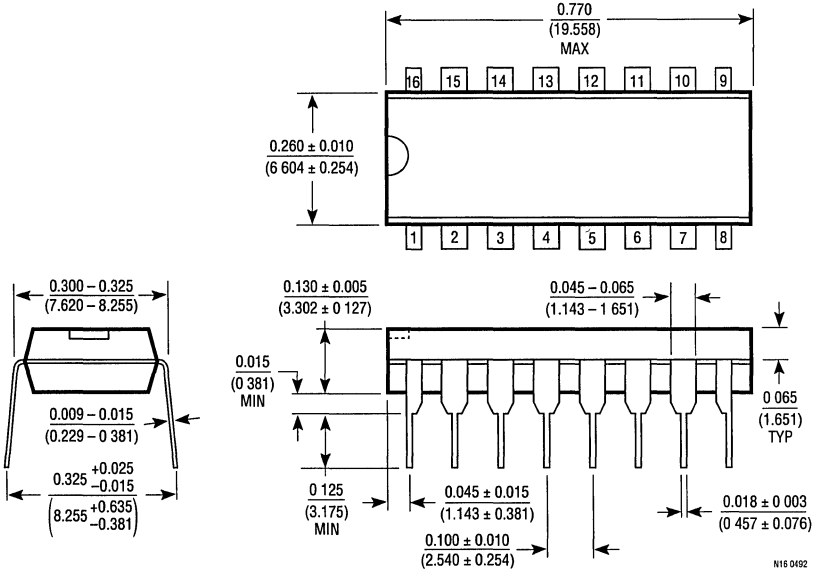
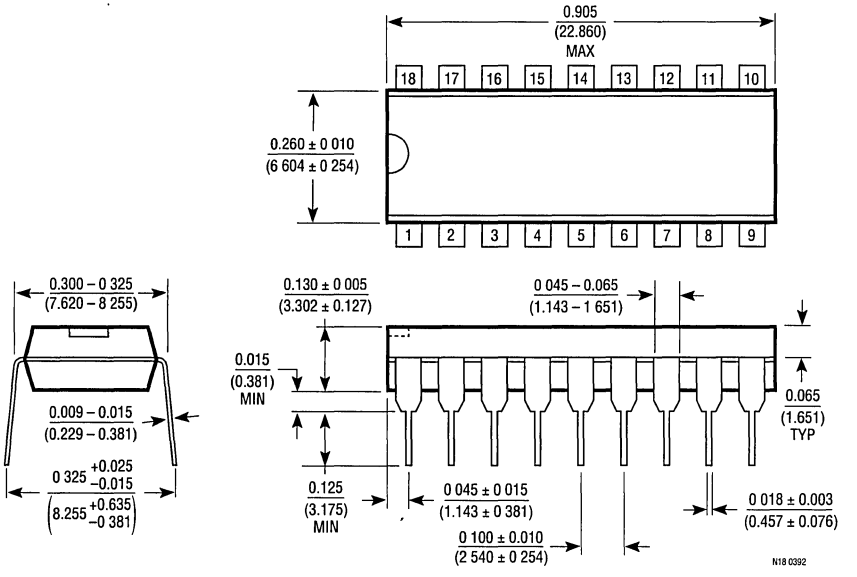
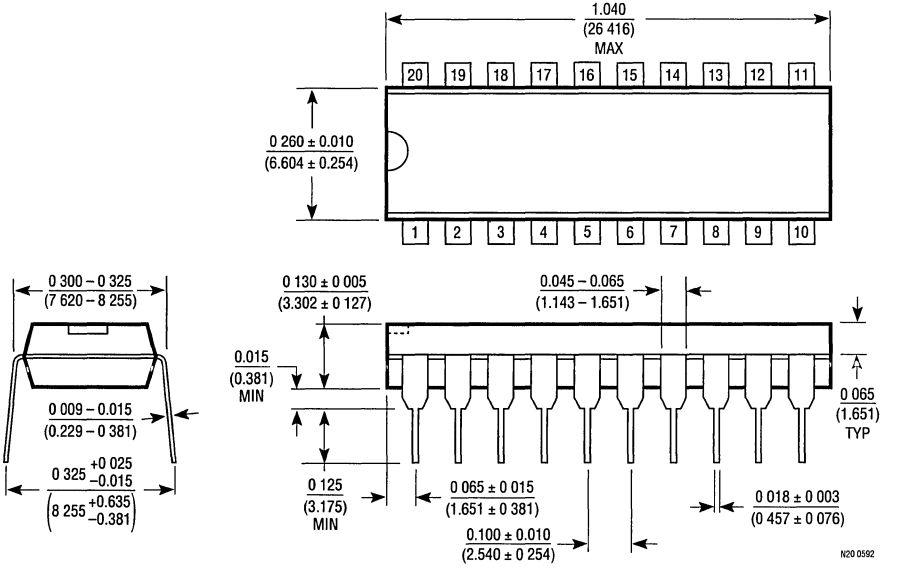


N Package
18-Lead Molded DIP



N Package
20-Lead Molded DIP



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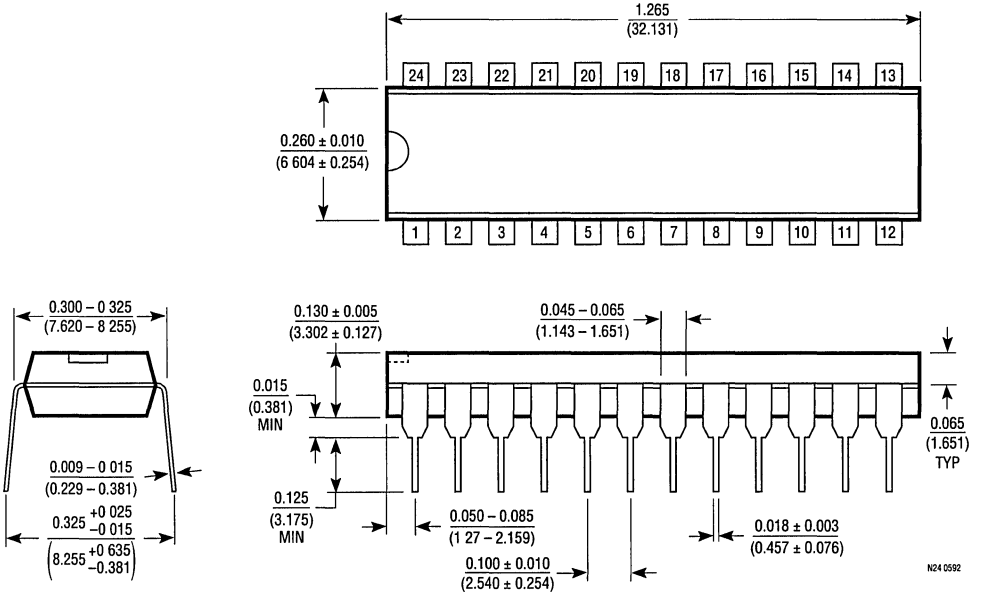

N Package
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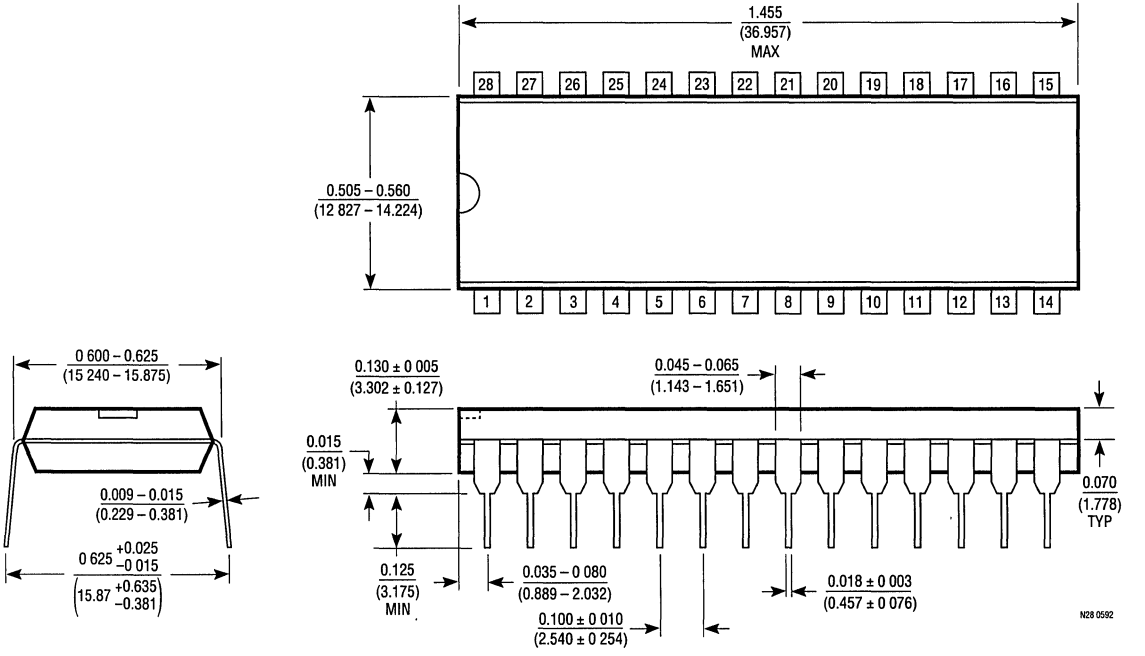
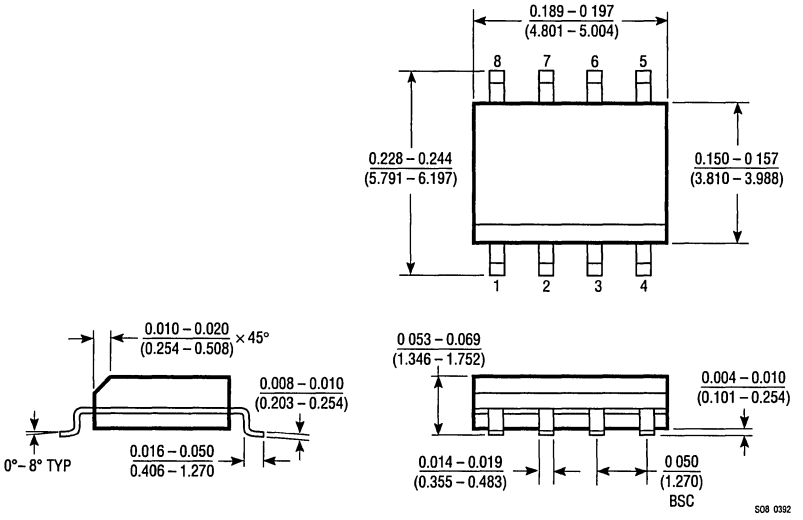


SO Package
8-Lead Small Outline



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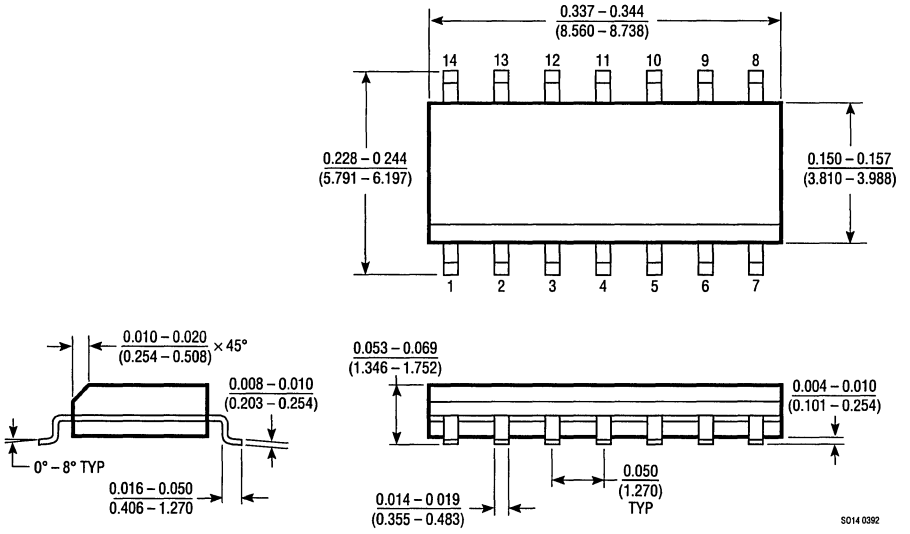

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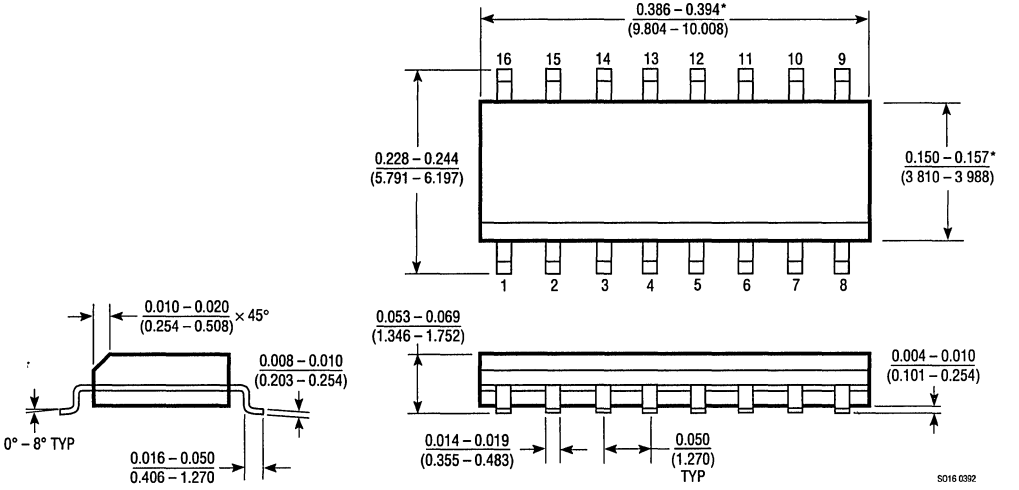
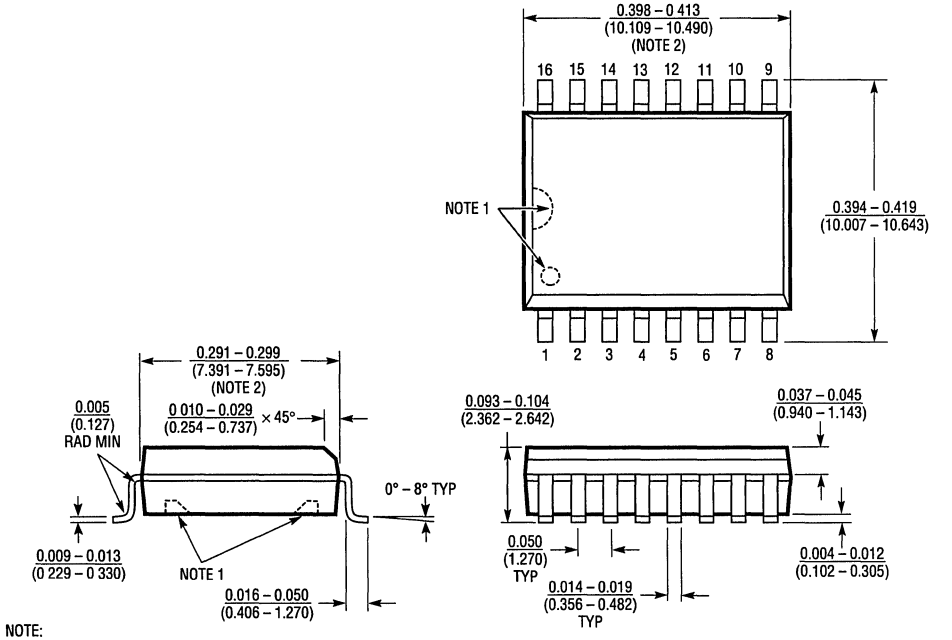


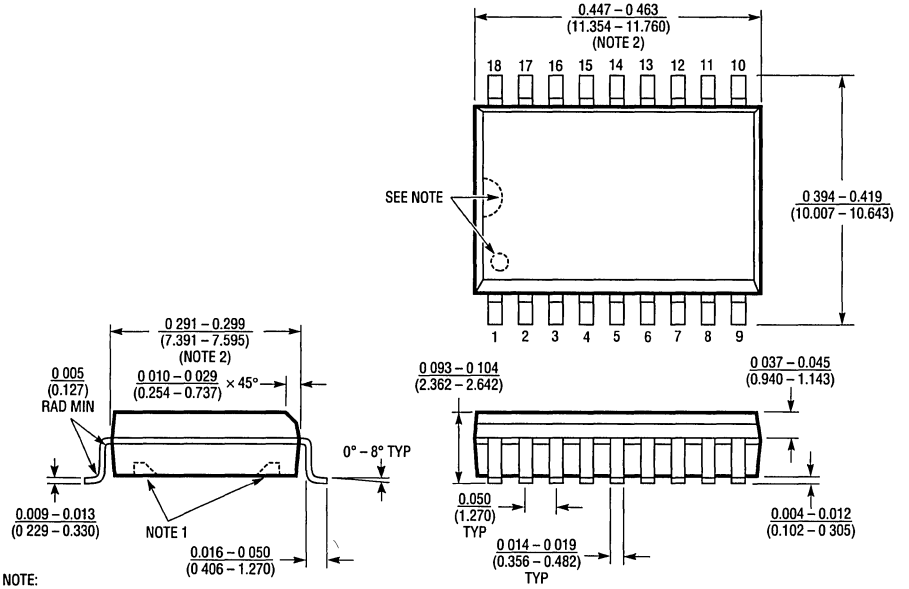
*THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.
MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0.006 INCH (0.15mm).

SOL Package
16-Lead Small Outline (Wide)



NOTE:
1. PIN 1 IDENT, NOTCH ON TOP AND CAVITIES ON THE BOTTOM OF PACKAGES ARE THE MANUFACTURING OPTIONS. THE PART MAY BE SUPPLIED WITH OR WITHOUT ANY OF THE OPTIONS.
2. THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS. MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0 006 INCH (0.15mm).

SOL Package
18-Lead Small Outline (Wide)



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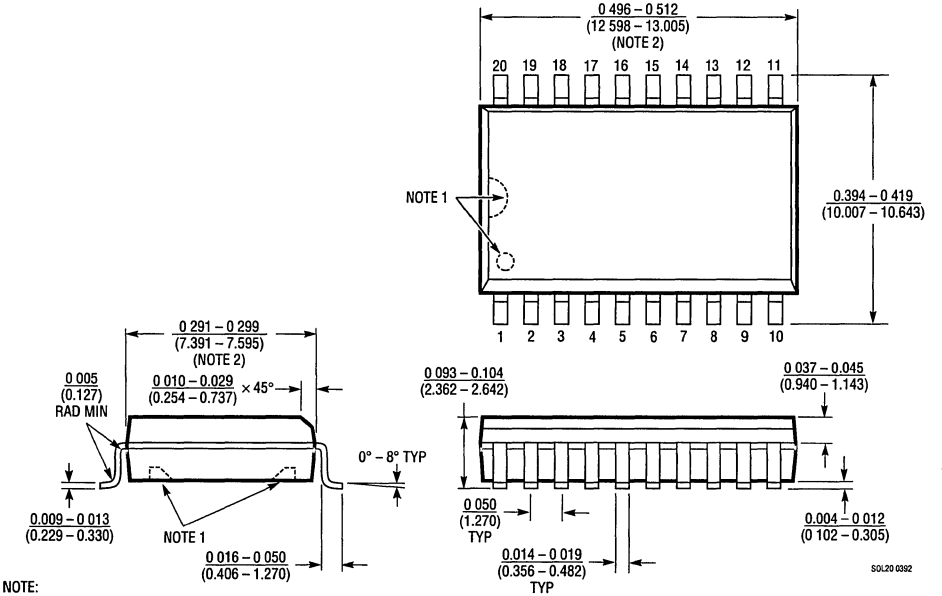
1. PIN 1 IDENT, NOTCH ON TOP AND CAVITIES ON THE BOTTOM OF PACKAGES ARE THE MANUFACTURING OPTIONS. THE PART MAY BE SUPPLIED WITH OR WITHOUT ANY OF THE OPTIONS.
2. THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS. MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0.006 INCH (0.15mm).

SOL Package
20-Lead Small Outline (Wide)



NOTE:
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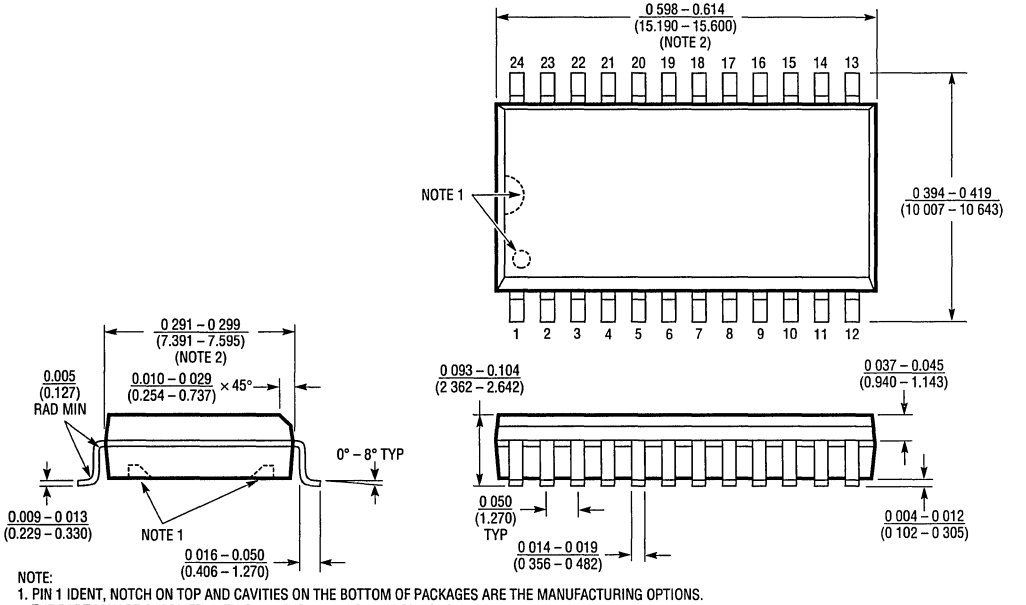
2. THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS. MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0 006 INCH (0.15mm).

SOL Package
24-Lead Small Outline (Wide)

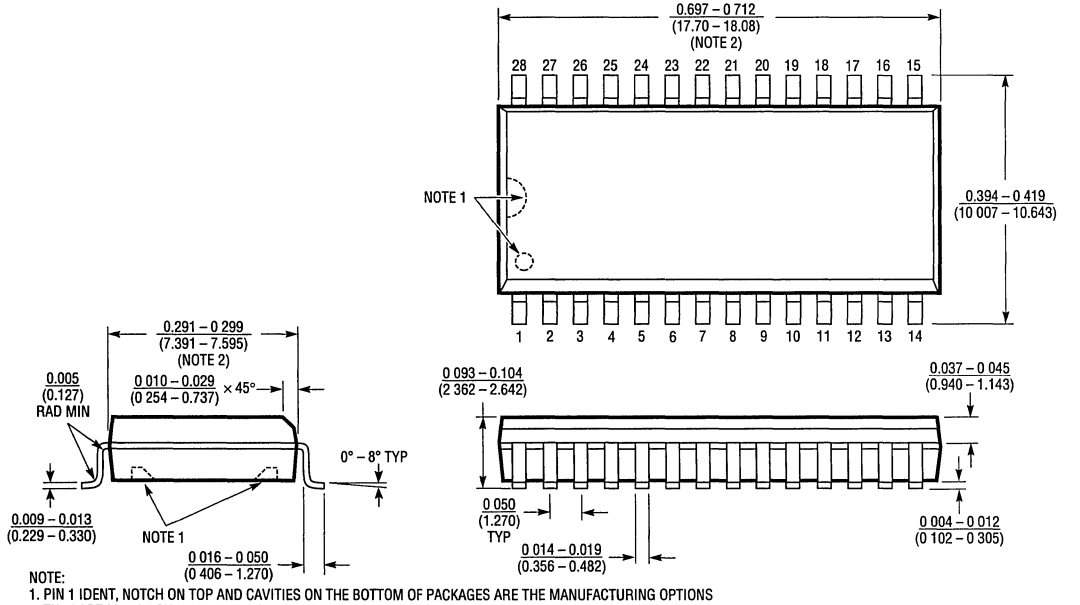


NOTE:
1. PIN 1 IDENT, NOTCH ON TOP AND CAVITIES ON THE BOTTOM OF PACKAGES ARE THE MANUFACTURING OPTIONS. THE PART MAY BE SUPPLIED WITH OR WITHOUT ANY OF THE OPTIONS.

SOL24 0392

2. THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS. MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0.006 INCH (0 15mm).

SOL Package
28-Lead Small Outline (Wide)

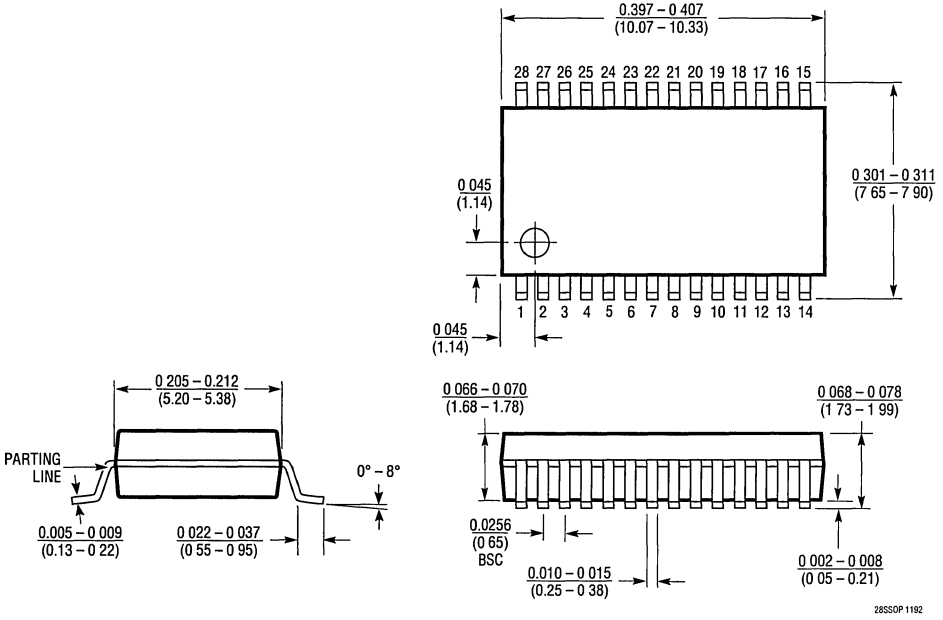


NOTE:
1. PIN 1 IDENT, NOTCH ON TOP AND CAVITIES ON THE BOTTOM OF PACKAGES ARE THE MANUFACTURING OPTIONS THE PART MAY BE SUPPLIED WITH OR WITHOUT ANY OF THE OPTIONS.

SOL28 0392

2. THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0 006 INCH (0.15mm).

G Package
28-Lead Shink Small Outline



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