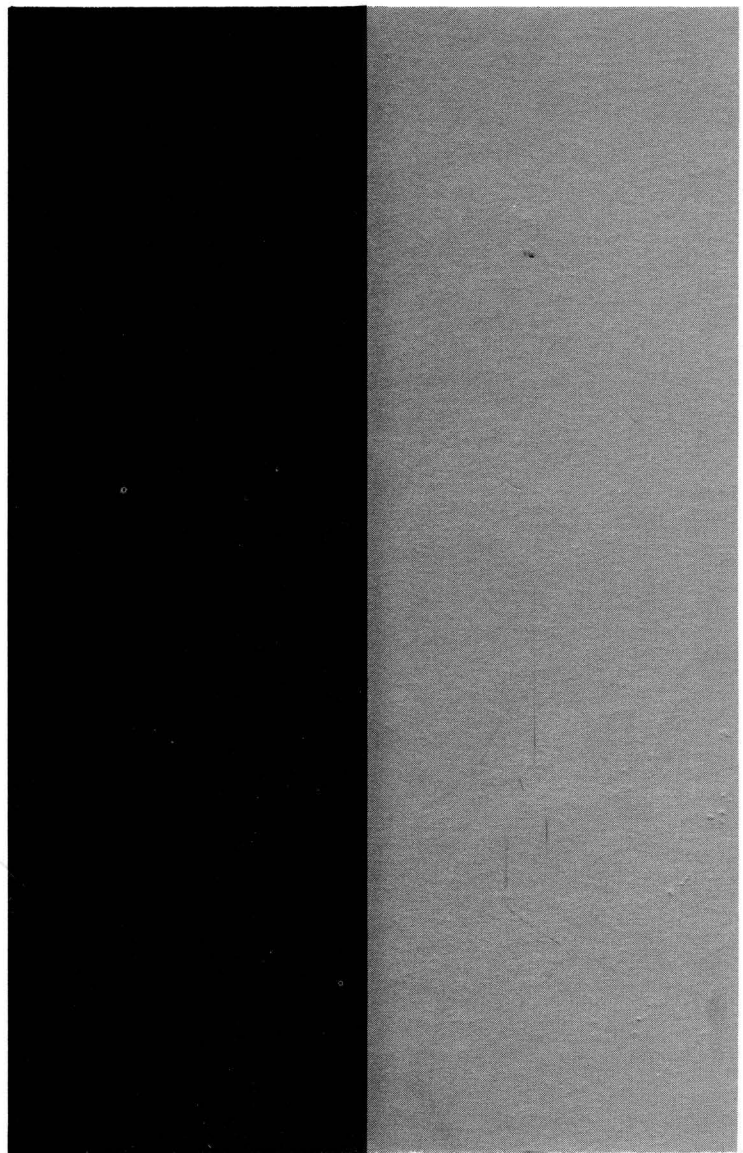
SPERRY RAND

UNIVAC

1106 SYSTEM

1108 MULTI PROCESSOR SYSTEM

UNITIZED CHANNEL STORAGE SUBSYSTEM



PROGRAMMER REFERENCE

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1. INTRODUCTION

This manual contains information for the programming of the UNIVAC Unitized Channel Storage Subsystem for the UNIVAC 1106 and 1108 Multi-Processor Systems (hereafter referred to as the UNIVAC 1106/1108 Systems).

It is assumed that the programmer is already capable at the system level and needs only to be instructed in the use of the subsystem. Therefore, material already covered in the system manuals will not be duplicated here.

This manual is divided into two basic sections:

- Subsystem Description
- Programming

Referencing the programming section within this manual on a regular basis is unnecessary when appropriate software is available as an interface to the UNIVAC Unitized Channel Storage Subsystem.

2. SUBSYSTEM DESCRIPTION

2.1 GENERAL

The UNIVAC Unitized Channel Storage Subsystem is used to provide the UNIVAC 1106/1108 Systems with a large capacity, word-addressable, zero latency, random access storage medium. The subsystem consists of one or two Type 5031 Control Units used with two to eight unitized storage units. Because of its very high transfer rate, a control unit is usually connected to a normal I/O channel of the input/output controller (UNIVAC 1108 System). The subsystem can be connected to a compatible channel of a 1108 CPU, as explained in 2.5.

A control unit performs the following functions:

- receives function words from the processor and translates them into commands for the storage;
- assembles and disassembles data and control words for acceptance by the processor and the storage units;
- controls the orderly addressing of storage locations;
- synchronizes the flow of data between the processor and the storage units; and
- interprets signals from the storage units and notifies the processor of storage unit conditions.

A storage unit performs the following functions:

- receives commands (and a storage address, if a Read, Write, or Search function word has been issued) from the control unit;
- receives data to be written in a storage location from the control unit;
- sends data that has been read from a storage location to the control unit; and
- signals the control unit when abnormal or error conditions exist.

The subsystem provides a nonvolatile mass storage medium having a nominal maximum transfer rate of 445,000 words (36-bits) per second, a read access time as low as 2.0 microseconds, a write access time as low as 0.6 microseconds, and a storage capacity as great as 1,048,576 data words when eight unitized storage units are used. Subsystem performance characteristics are summarized in Table 2-1.

PARAMETER	SPECIFICATION
Storage capacity	Maximum
Words	1,048,576 (in 262 K increments)
Characters	6,291,456 (in 786 K increments)
Access time	
Average	2.0 microseconds
Minimum	0.6 microseconds
Nominal maximum transfer rate	
Words	445,000 words/sec (max.)
Characters	2,670,000 char/sec (max.)
Processor I/O channels required	One for each control unit

Table 2-1. Subsystem Performance Characteristics

All functions of the subsystem, once initiated, operate independently of the processor, except for data word transfers. In addition to the usual functions of reading and writing at known addresses, the subsystem provides the ability to search offline through a storage area. This ability is limited by the number of continuously addressable words on the same subsystem and by the occurrence of an end-of-block word in a Block-Search function. Once a Search function has been initiated and an identifier word transferred, the subsystem performs all required comparisons for the search without intervention from the processor.

The accuracy of storage data in the unitized storage unit is verified by odd parity checking. When data is stored, two parity bits per word are generated by the control unit and stored with the word. When data is read from the storage unit, parity is checked automatically. Should a parity error occur, a status word is generated and the processor is notified of the address of the word in which the error was detected.

2.2 CONFIGURATIONS

Figure 2-1 defines the possible configurations of the Unitized Channel Storage Subsystem. The left half of the figure represents the maximum single-access (nonsimultaneous) subsystem with the shaded portion showing the minimum components necessary for operation. By adding the components in the right half of the figure, subsystem capabilities are increased to a dual-access (simultaneous) operation. Minimum configuration for a dual-access operation is shown by the combined shaded areas.

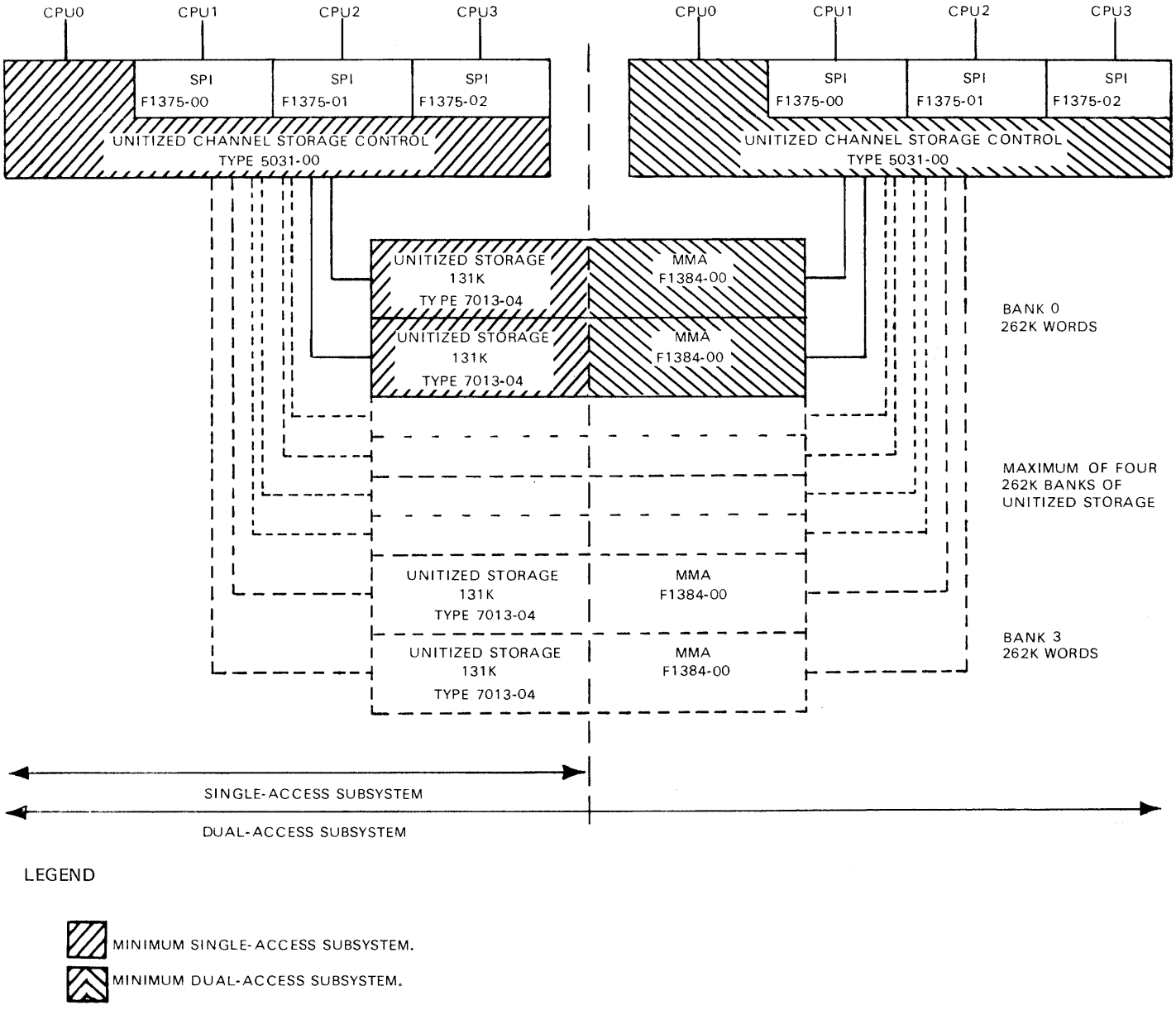

Figure 2-1. Unitized Channel Storage Sybsystem Configuration

The components used in a nonsimultaneous operation are listed in Table 2-2. Table 2-3 lists the simultaneous operation components.

SUBSYSTEM COMPONENTS NAME	TYPE NUMBER 60 Hz	TYPE NUMBER 50 Hz	MINIMUM REQUIRED	MAXIMUM PERMITTED
Control Unit	5031-00	5031-01	1	1
SPI Features*	F1375-00 F1375-01 F1375-02		0	3
Storage Unit	7013-04	7013-05	2	8

NOTE: *One F1375 is required for each additional processor that is connected to the control unit.

Table 2-2. Nonsimultaneous Operation Components

SUBSYSTEM COMPONENTS NAME	TYPE NUMBER 60 Hz	TYPE NUMBER 50 Hz	MINIMUM REQUIRED	MAXIMUM PERMITTED
Control unit	5031-00	5031-01	2	2
SPI Features*	F1375-00 F1375-01 F1375-02		0	6
Storage Unit	7013-04	7013-05	2	8
MMA Features**	F1384-00		2	8

NOTE: *One F1375 is required for each additional processor that is connected to the control unit.
**One F1384 is required for each 131K of storage.

Table 2-3. Simultaneous Operation Subsystem

The nonsimultaneous operation subsystem is used for serial operation; that is, when one operation (read, write, or search) on any storage unit is completed, another operation on any storage unit can be initiated. Should a storage unit fail because of a circuit failure, the design of the storage units and of their connections to the control unit is such that continued subsystem operation is permitted through use of all remaining components.

The simultaneous operation subsystem permits concurrent operation of any two storage units by using two control units. A minimum of two storage units is required. An additional interface channel is required for each storage unit used with the second control unit. This channel is provided by adding the MMA Feature F1384 to the storage unit. In a dual-channel operation, either control unit can initiate an operation. Should a subsystem component fail because of a circuit failure, the design of the components and interconnections used in a simultaneous operation subsystem allows this component to be disconnected so the remaining subsystem components can continue operation. If a storage unit or its MMA Interface Feature fails, continued operation of the simultaneous operation subsystem excluding the affected storage unit, is permitted. If either control unit fails, operation as a nonsimultaneous subsystem, excluding the affected control unit, is permitted.

2.3 SUBSYSTEM COMPONENTS

The following paragraphs describe the Type 5031 Control Unit, its optional features, and the Type 7013 Storage Unit. These components make up the Unitized Channel Storage Subsystem.

2.3.1 CONTROL UNIT

The Type 5031-00 Control Unit is shown in Figure 2-2. One unit is required for nonsimultaneous operation of the subsystem. A second control unit is required for dual-channel fully simultaneous operation of the subsystem. A control unit can be connected to either a normal I/O channel (UNIVAC 1106/1108 Systems) or a compatible I/O channel (UNIVAC 1108 System) of the processor by way of cables containing 36 input data lines, 36 output data lines, and 7 control signal lines.

The control unit contains three 36-bit registers. Two registers hold the function words, data words, and status words, and the third, which interfaces with the unitized storage units, is used to assemble and disassemble the data words.

The control unit receives and interprets function words from the processor, selects the storage unit, and handles the data transfers and required checking. At the end of the process called for by a function word, the control unit sends a status word (to the processor) containing a report that the process was completed without error detection. If an error or abnormal condition is detected, it is reported to the processor by means of the appropriate status word.

During execution of a Write function, the control unit receives data words from the processor and sends them to the specified storage unit.

During execution of a Read function, the storage unit reads the data word, checks to see if a parity error exists, and makes each word available to the control unit; provided there is no parity error, the control unit makes the data word available to the processor. If a parity error is detected, the control unit will send the appropriate status word to the processor instead of the data word.

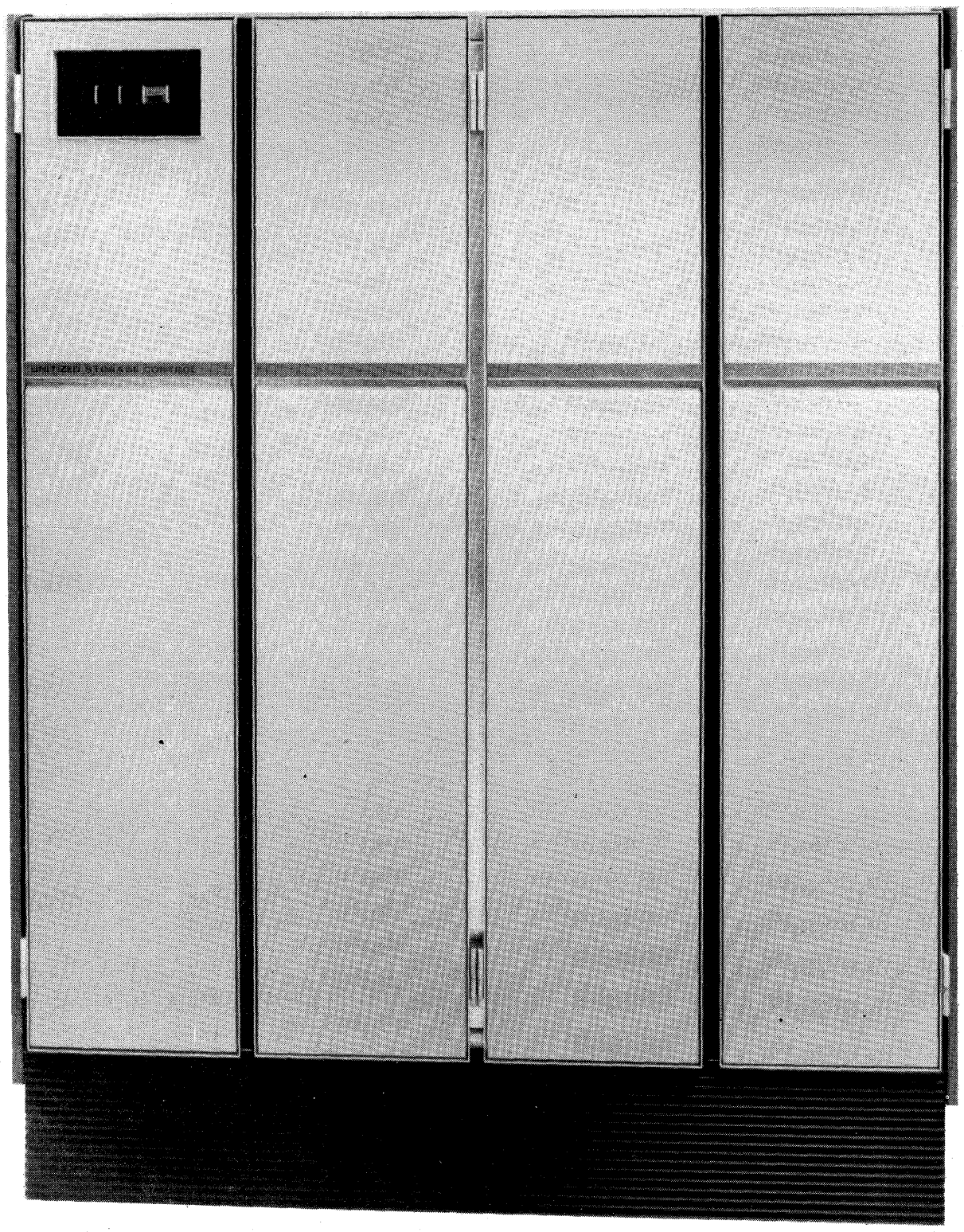

Figure 2-2. Type 5031 Control Unit

A second control unit is required for dual-access fully simultaneous operation of the subsystem. In a simultaneous operation subsystem, it is possible for the two control units to be actively engaged in performing functions which need concurrent references to the same storage unit. In this case, the storage unit will grant priority to each control unit on a first come, first served basis for the transfer of one word. After the transfer is completed, priority will be given to the second control unit for a one word transfer. Priority will continue to alternate between the two controls in this manner as long as both actively reference the same storage unit. This will effectively reduce the data transfer rate, if the control units are connected to a normal I/O channel of the processor. Similarly, if address incrementation for a function being performed by one control unit leads to switching from one storage unit to the next higher storage unit, and this storage unit is being used under the control of the other control unit, the data transfer rate of both control units is decreased.

2.3.2 SHARED PERIPHERAL INTERFACE OPTIONAL FEATURES

The basic Type 5031 Control Unit can interface with only one processor I/O channel. Shared peripheral interface (SPI) features can be added which permit the control unit to communicate with two, three, or four processors or I/O channels as listed below.

FEATURE	NUMBER
Second Processor Interface	F1375-00
Third Processor Interface	F1375-01
Fourth Processor Interface	F1375-02

Installation of the Second Processor Interface feature is a prerequisite for installation of the Third Processor Interface feature. In like manner, installation of the Third Processor Interface feature is a prerequisite for installation of the Fourth Processor Interface feature. These control unit features are designed for the Unitized Channel Storage Subsystem and are contained in the Type 5031 Control Unit.

When two or more processors are connected to a control unit by way of the SPI features, the individual processors are automatically assigned priorities on the basis of which control unit connectors are used to attach the I/O cabling from each processor. When the control unit is in a cleared condition, it normally presents an Output Request (ODR) signal to each processor to which it is connected. If two or more processors simultaneously send a function word to the control unit, the control unit responds to the highest priority processor. However, the control unit captures the function word from each lower priority processor and holds each word until the function specified by the higher priority processor is completed. Similarly, if a control unit receives a function word from one or more processors while one of the other processors is being serviced, that control unit holds the function word(s) until completion of the function specified by the processor being serviced.

The completion of a function is signalled to the control unit by receipt of either an Input Acknowledge signal in response to an External Interrupt signal or a Terminate-Without-Interrupt function following a read or search operation.

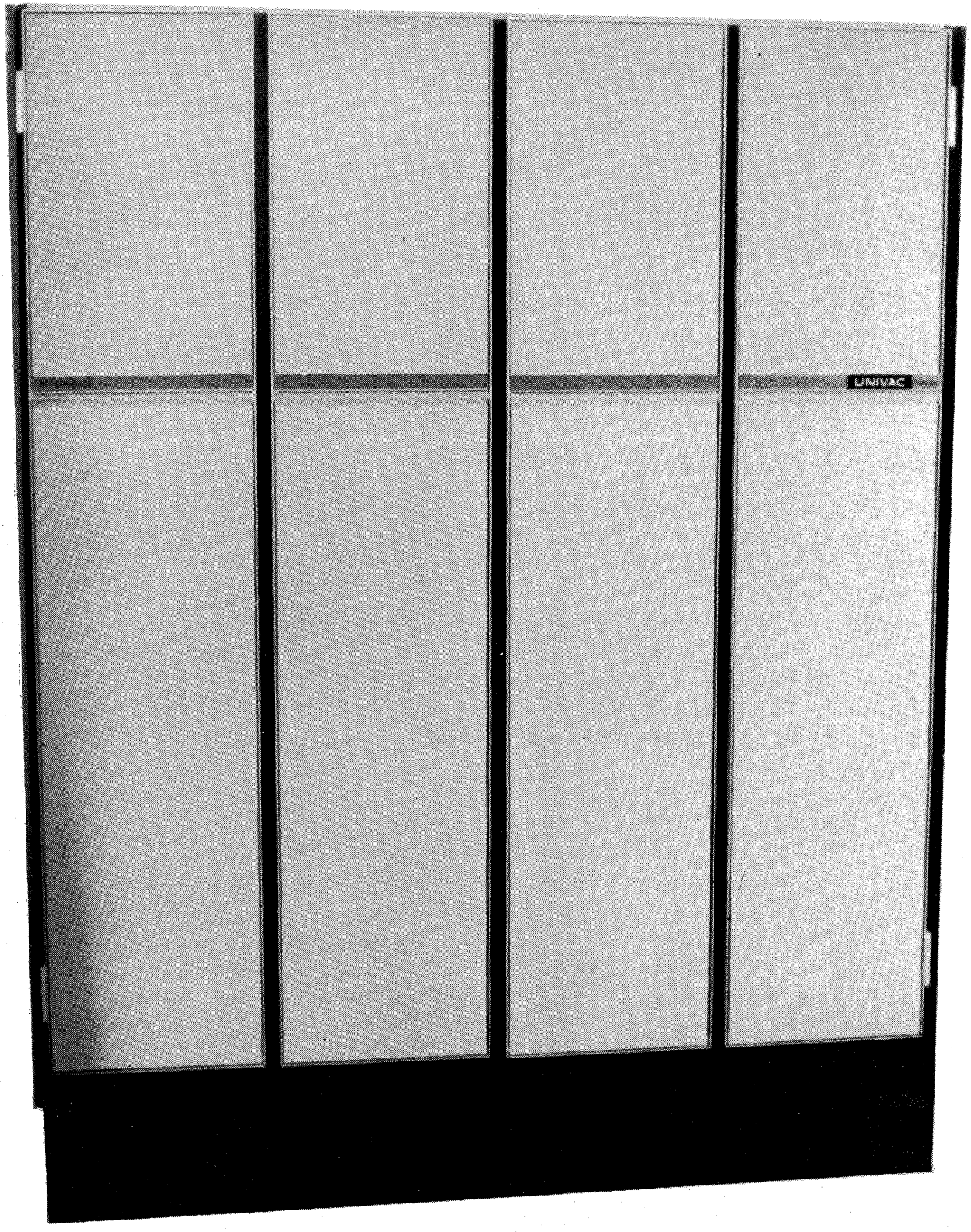

Figure 2-3. Unitized Storage Unit

When a function is completed, the control unit scans its registers for a function word previously received from one or more processors. If a register is holding a function word, the function specified by the highest priority processor having a pending function word is initiated. The control unit continues to hold any function word from a lower priority processor until priority permits servicing that processor.

When two or more processors are connected to a control unit, the control unit is normally cabled to an Availability Control Unit, as explained in 2.5.

2.3.3 UNITIZED STORAGE UNIT

The unitized storage unit, shown in Figure 2-3, provides the UNIVAC 1106/1108 Processing Systems with a rapid access, zero latency, high capacity storage medium. These units are designed for complete compatibility within the subsystem.

The unitized storage unit is a random access, ferrite core storage with a 1.5 microsecond cycle time and a storage capacity of 131,072 36-bit words. The storage unit has a single-channel interface that can be expanded to a two-channel interface for dual-control operation. Functional characteristics are listed in Table 2-4.

The data word received by the control unit is transferred in parallel to the storage unit through two holding registers. Odd parity bits are generated in the storage unit and are stored with the data word. Data read from the storage is checked for correct parity in the storage unit and transmitted through two holding registers in the control unit to the processor.

Simultaneous operation of the storage unit requires an additional interface channel. This channel is provided with the MMA Feature F1384. One MMA Feature is required for each 131K unit that is used with two control units in a dual-access subsystem.

	STORAGE UNIT
PARAMETER	SPECIFICATION
Data Handling Capabilities (Processor Word Length)	36-bits
Storage Capacity	
Data Words	131,072
Data Bits	3,718,592
Address Mode	By Word
Storage Data Interface	Word Parallel
Parity Checking	Odd, two bits per word

Table 2-4. Storage Unit Functional Characteristics

2.4 ADDRESSING

Word locations on a storage unit in the subsystem are individually addressable. A storage unit address includes the following parts:

- Logical storage unit number.
- Matrix address of the word in the specified storage unit.

Figure 2-4 shows the word address format of the storage unit. The 17 bits of matrix address allows a range of 131,072 words (the word capacity of one unitized storage unit). The 3 bits for logical storage unit number selection will permit operation with up to eight storage units. The total address range for the 20-bit address register is 1,048,576 addresses.

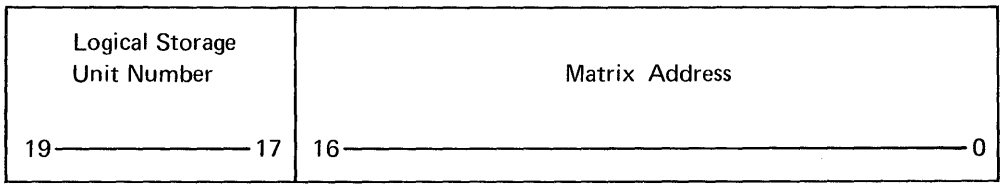

Figure 2-4. Word Address Format for the Unitized Storage Unit

2.5 SUBSYSTEM INTERFACES

Control units are used to provide the interface between the subsystem and other components. The simultaneous operation subsystem, which includes two control units, provides two separate and independent interfaces, one at each control unit. The following paragraphs explain the interface between the control unit of a nonsimultaneous operation subsystem and the other system components. This description also applies to each of the control units of a simultaneous operation subsystem.

If the control unit does not include any of the shared peripheral interface (SPI) features, it interfaces with an I/O channel of one processor (1106/1108 CPU or 1108 IOC) only. If the control unit interfaces with a compatible I/O channel of a UNIVAC 1108 CPU or normal channel of a UNIVAC 1106 CPU, an interlace of 3 or 4 (see 3.3 on timing) must be used.

The interface includes 36 output data lines from the processor, 36 input data lines to the processor, and 7 control signal lines. The name, origin, meaning, and effect of each of the seven control signals are given in Table 2-5.

If the control unit includes one or more of the SPI features (see 2.3.2.2) to interface with two or more processors, it provides an interface with each processor. This interface is identical to that provided for the single processor. The control unit also provides an interface with the Availability Control Unit (ACU) of the UNIVAC 1106/1108 Multi-Processor System.

The control unit/ACU interface consists of up to four Disable signal lines, one for each processor connected to the control unit. When the ACU turns on the Disable signal associated with a processor, that processor is logically

SIGNAL NAME	ORIGIN	MEANING	EFFECT
Output Request (ODR)	Control unit	The control unit can accept an output data word or a function word.	The processor sends an output data word or the next function word if the I/O channel is active in the output mode or function mode.
External Function (EF)	Processor	The word on the output data lines is a function word.	The control unit accepts the function word, turns off the ODR signal if it is on, and initiates the operation specified in the function word.
Output Acknowledge (OA)	Processor	The word on the output data lines is a data word to be written in a storage unit. Sent only in response to an ODR signal.	If the control unit is active in a write operation, it accepts the data word and turns off the ODR signal. If the control unit is not active in a write operation and had turned on the ODR signal to indicate it could accept a function word, it ignores the word on the output data lines and does not turn off the ODR signal.
Input Data Request (IDR)	Control unit	The word on the input data lines is a data word.	The processor accepts and stores the data word if the channel is active in the input mode.
External Interrupt (EI)	Control unit	The word on the input data lines is a status word.	The processor accepts and stores the status word.
Input Acknowledge (IA)	Processor	The processor has accepted and stored the word on the input data lines. Sent only in response to an IDR signal or EI signal.	The control unit turns off the signal (IDR or EI) which caused the processor to send the IA signal.
Master Clear	Processor	The control unit is cleared and conditioned to accept a function word.	Any operation in progress by way of the control unit is aborted, and any control signals to the processor are turned off. The control unit is conditioned to accept a function word, and the ODR signal is turned on.

Table 2-5. Control Signals of Control Unit/Processor Interface

disconnected from the control unit. An EF, OA, IA, or Master Clear signal received from that processor while the Disable signal is present is ignored. The control unit inhibits any signal (ODR, IDR, or EI) to that processor while the Disable signal is present . If that processor has previously sent a function word to the control unit but the control unit is still holding the function word because the SPI priority circuitry has not permitted the servicing of that processor, the register holding the function word is cleared. If the control unit is in the midst of an operation initiated by that processor, any operation other than a write operation is immediately aborted; the control unit scans its registers for a function word from another processor and proceeds accordingly.

If the control unit is in the midst of a write operation for that processor, any data words received from that processor before the disable signal was turned on are written, the function is aborted, and the control unit scans its registers associated with the other processors.

When the Disable signal associated with a processor is turned off, that processor is logically connected to the control unit. The control unit turns on the ODR signal to that processor. If a Master Clear signal is received from any processor logically connected to the control unit by way of the shared peripheral interface, the control unit and the word register associated with each of the processors are cleared, the ODR signal is sent to each of the processors logically connected to the control unit, and the control unit is conditioned to accept a function word.

3. PROGRAMMING

3.1 GENERAL

The UNIVAC Unitized Channel Storage Subsystem is used to provide the UNIVAC 1106/1108 Systems with a means of transferring blocks of data to and from a magnetic storage medium. The processor sends one or more function words to the control unit in initiating a read, search, or write operation to actuate the subsystem. While the specified operation is performed, the storage unit checks or generates parity for each data word, read or written, and notifies the control unit of any abnormal condition or error it detects. The control unit then notifies the processor of the error condition.

3.2 WORD FORMATS

The Unitized Channel Storage Subsystem accommodates six types of processor input/output words. The various types of words are:

- Function word
  The function word specifies the operation to be performed and the starting storage address.

- Identifier word
  The identifier word is used in search operations to specify the bit configuration of the word being sought and is transferred to the subsystem after the function word.

- End-of-block word
  The end-of-block word is a word of all 1 bits used to separate files or groups of records in the storage units.

- Overflow word
  The overflow word, which is the word stored in the location immediately following an end-of-block word, can be used to indicate the storage address of the first word of a group of related records.

- Status word
  The status word, which is generated by the control unit and transferred to the processor, indicates the subsystem condition that caused an external interrupt.

- Data word
  The data word contains the information to be written in or read from the storage unit.

These types of words are described in detail in the following paragraphs.

3.2.1 FUNCTION WORD

The function word is used to instruct the control unit to initiate a subsystem operation. Bits 35 through 30 specify the operation to be performed. Bits 29 through 24 are ignored by the subsystem. Bits 23 through 20 must be zeros.

For most function words, the contents of bit positions 19 through 0 specify the address of the first word to be read from or written in a storage unit, as explained in 2.4. However, some of these bits or all of them are ignored for the Terminate Without Interrupt, Terminate With Interrupt, and Bootstrap functions (see 3.2.1.3, 3.2.1.4, and 3.2.1.5, respectively). The function word format is shown in Figure 3-1.

FUNCTION CODE		IGNORED BY CONTROL UNIT		ZEROS*		WORD ADDRESS	
35	30	29	24	23	20	19	0

*A 1 bit will result in an Invalid Address status word.

Figure 3-1. Function Word Format

The 12 functions listed in Table 3-1 are used to instruct the subsystem to perform various operations. A function word other than a terminate function should never be forced out to the control unit while the control unit is performing a previous function; otherwise, the results are unpredictable.

FUNCTION	FUNCTION CODE (OCTAL)
Continuous Write (without interrupt)	02
Write With Interrupt	22
Terminate Without Interrupt	23
Terminate With Interrupt	33
Bootstrap (without interrupt)	40
Continuous Read (without interrupt)*	(41), 42, (43)
Search	45
Search Read	46
Block Read	52
Block Search	55
Block Search Read	56
Read With Interrupt	62

*The Read Early function (41) and the Read Late function (43) as used in the Type 5012 Control Unit in the FH 432/1782 Subsystem, are decoded as a Continuous Read function (42).

Table 3-1. Function Repertoire Summary

Detailed descriptions of the 12 functions are given in the following paragraphs.

3.2.1.1 CONTINUOUS WRITE (WITHOUT INTERRUPT) FUNCTION

Function Code: 02_8

The Continuous Write function is used to instruct the control unit to accept output data words from the processor and to record them in consecutive storage addresses beginning at the address specified in the function word. This function continues until concluded by one of the following:

- Terminate With Interrupt function
- Status codes
  - End-of-File
  - Invalid Address
  - Fault

Invalid Address (see 3.2.5.9) and Fault (see 3.2.5.5) are both error conditions; End-of-File (see 3.2.5.6) is treated as an abnormal condition. If any of these conditions occurs, the writing operation is stopped, the appropriate status word is generated, and the External Interrupt signal is turned on. After the External Interrupt signal is acknowledged by the processor, the control unit is conditioned to accept a new function word.

If neither an error nor an abnormal condition is detected, the writing operation continues until the processor output buffer has been exhausted. At this point, the control unit is still conditioned for writing, so the buffer can be extended if desired. After all required data words have been transferred, a Terminate With Interrupt (33_8) function should be sent to the subsystem; a Terminate Without Interrupt (23_8) function should not be used. If an error is detected, the processor is informed of the error condition by the status code for the Terminate function. If no error is detected, the processor is informed by a Normal Completion status code when the write operation has been successfully completed.

The process of writing is not initiated until a dat word is received by the control unit following receipt of a Continuous Write (02_8) function word. After the first data word is received, the nominal transfer rate can be achieved only if the processor responds to each ODR signal by sending another data word to the control unit within the timing limitations specified in 3.3.

3.2.1.2 WRITE WITH INTERRUPT FUNCTION

Function Code: 22_8

The Write With Interrupt function is used to instruct the control unit to accept output data words from the processor and to record them in consecutive storage unit addresses (beginning at the address specified in the function word). The function continues until concluded by one of the following:

- Terminate With Interrupt function

- Status code

  - Normal Completion (timeout)
  - End-of-File
  - Invalid Address
  - Fault
  - Late Acknowledge

Invalid Address (see 3.2.5.9) and Fault are error conditions; End-of-File (see 3.2.5.5) and Late Acknowledge (see 3.2.5.1) are abnormal conditions. If any of these conditions occur, the writing operation is stopped, the appropriate status word is generated, and the External Interrupt signal is turned on. After the External Interrupt signal is acknowledged by the processor, the control unit is conditioned to accept a new function word.

If neither an error nor an abnormal condition is detected, the writing operation continues until the processor output buffer has been exhausted. At this point the control unit is still conditioned for writing, so the buffer can be extended if desired. If the next data word is not received in time to write in the next consecutive address, the control unit initiates a stop-delay operation. If a data word is received during the stop-delay period, it is not written. Instead, a status word containing a Late Acknowledge (02_8) is generated, and the External Interrupt signal is turned on. If a data word is not received during the stop-delay period, a Normal Completion (40_8) status code is generated, and the External Interrupt signal is turned on. It is not necessary to use a Terminate function to conclude the operation because of the timeout feature which used the stop-delay. However, the Terminate With Interrupt (33_8) function can be used.

The process of writing is not initiated until a data word is received by the subsystem following receipt of a Write With Interrupt (22_8) function word. After the first data word is received, the nominal transfer rate can be achieved only if the processor responds to each ODR signal by sending another data word to the subsystem within the timing limitations specified in 3.3.

3.2.1.3 TERMINATE WITHOUT INTERRUPT FUNCTION

Function Code: 23_8

The Terminate Without Interrupt function is used to instruct the control unit to conclude the function currently being performed under its control. The contents of bit positions 19 through 0 of this function word are ignored by the control unit. Input operations are terminated immediately upon receipt of a Terminate Without Interrupt function by the control unit.

All input and output functions that are not concluded by an external interrupt must be concluded by a Terminate function, either with or without interrupt, in order to free the control unit to perform another function. Therefore, in the absence of an error causing an external interrupt, a Terminate function must be sent to the subsystem following completion of a Continuous Write (02_8), Bootstrap (40_8), Read Early (41_8), Continuous Read (42_8), Read Late (43_8), or Search Read (46_8) function, since none of these functions normally result in an external

interrupt. The Block Read (52$_8$) and the Block Search Read (56$_8$) functions, which involve input data transfer, may or may not require a Terminate function. If the function is concluded by an End-of-Block interrupt, the subsystem is cleared following acknowledgment of the interrupt. However, if the input buffer is filled before an End-of-Block is detected, a Terminate function is necessary to clear the control unit, unless the buffer is to be extended.

If the control unit receives a Terminate Without Interrupt function at a time when the External Interrupt signal is present (as a result of a previous function), the control unit disregards the Terminate function.

The Terminate Without Interrupt (23$_8$) function is commonly used where necessary to conclude all operations except writing operations. The Terminate With Interrupt (33$_8$) function must be used to conclude a Continuous Write (02$_8$) function.

3.2.1.4 TERMINATE WITH INTERRUPT FUNCTION

Function Code: 33$_8$

The Terminate With Interrupt function is used to instruct the control unit to conclude the function currently being performed under its control and to inform the processor of its conclusion by means of an external interrupt. The contents of bit positions 19 through 0 of this function word are ignored by the control unit. Input operations are terminated immediately upon receipt of a Terminate With Interrupt function by the control unit; however, output operations continue until all data words previously received by the subsystem have been written in the storage unit at which time the termination becomes effective. When the previous function has been successfully terminated, the status word presented to the processor along with the External Interrupt signal contains a Normal Completion (40$_8$) status code.

The Terminate With Interrupt function is needed to conclude a Continuous Write (02$_8$) function so that the processor is informed when the function has been completed. As noted previously, the termination of a Continuous Write (02$_8$) function is effected only after all data words received by the subsystem have been written into the storage unit. Therefore, an error condition can occur between the time the Terminate With Interrupt function is received by the control unit and the time the Continuous Write function is effectively concluded. If such an error occurs, the status code in the status word accompanying the External Interrupt signal is governed by the nature of the error. A fault condition occurring during this interval takes precedence over normal completion and leads to generation of a status word containing the Fault (14$_8$) status code. An End-of-File (34$_8$) can take precedence over Normal Completion (40$_8$), as explained in 3.2.5.7.

If the control unit receives a Terminate With Interrupt function at a time when the External Interrupt signal is present (as a result of a previous function), the control unit disregards the Terminate function.

3.2.1.5 BOOTSTRAP (WITHOUT INTERRUPT) FUNCTION

Function Code: 40$_8$

The Bootstrap function is used to instruct the subsystem to perform a continuous read operation (identical to

function code 42$_8$) starting with address 0 of logical storage unit 0. The address portion of a Bootstrap function word is ignored by the control unit. All methods of termination that apply to the Continuous Read (42$_8$) function except End-of-File apply to the Bootstrap function as well. An End-of-File status code is never generated in response to a Bootstrap function because if the last word on the bootstrap drum is read for a Bootstrap function, the first word in that storage unit is the next word read rather than the first word in the next storage unit.

The subsystem must be in a cleared condition (no other function in progress) before the Bootstrap function can be initiated. If a Bootstrap function is used as part of a programmed recovery procedure in a situation where the current condition of the subsystem is unknown to the recovery program, two consecutive Terminate Without Interrupt (23$_8$) functions must be sent to the subsystem before the Bootstrap function. If this precaution is neglected and a Bootstrap function is sent when the control unit is not in a cleared condition, the results are unpredictable.

3.2.1.6 CONTINUOUS READ (WITHOUT INTERRUPT) FUNCTION

Function Code: 42$_8$

The Continuous Read function is used to instruct the subsystem to read data words from consecutive storage addresses and transfers these words to the processor. These transfers begin at the storage address specified in the function word and continue until concluded by one of the following:

- Function codes
  - Terminate Without Interrupt
  - Terminate With Interrupt

- Status codes
  - End-of-File
  - Parity Error
  - Invalid Address
  - Fault

The Continuous Read function must be concluded by a Terminate function unless a condition which causes an external interrupt occurs. The Terminate Without Interrupt (23$_8$) function is commonly programmed as a response to a monitor interrupt to indicate that the input buffer has been filled, provided that all required data words have been received by the processor. The buffer area can be extended, of course, if more words are required than those provided for in the original buffer area.

During a read operation, the processor must respond to each successive IDR signal within the timing limitations specified in 3.3 in order to maintain the nominal transfer rate of the equipment. If the processor fails to respond in time, the input data word and the next two data words remain available in a fullword, assembly-disassembly register and two fullword registers in the control unit. Transfers will not be aborted by the hardware unless a Terminate With Interrupt or a Terminate Without Interrupt function code is received.

The Read Early and Read Late functions, as used in the 5012 Drum Subsystem, are decoded as a Continuous Read function.

3.2.1.7 SEARCH FUNCTION

Function Code: 45_8

The Search function is used to instruct the subsystem to read data words from storage (starting at the storage address specified in the Search function word) and to compare them with the identifier word which contains the bit pattern being sought.

The identifier word following the Search function word is supplied to the control unit with an External Function signal. The normal ending of a search operation is a search-find condition when identical comparison is achieved between the identifier word and a word in storage. When this condition occurs, the control unit assembles a status word containing both the Search Find (05_8) status code and the address of the found word and turns on the External Interrupt signal. If in the course of the search, a word which matches the identifier word is not found in storage, the searching operation continues until an End-of-File is reached or until the occurrence of either a Terminate function or an error. The Search function is concluded by one of the following:

- Function codes
  - Terminate Without Interrupt
  - Terminate With Interrupt

- Status codes
  - Search Find
  - End-of-File
  - Parity Error
  - Invalid Address
  - Fault

Since no input data transfers are associated with this function, no input buffer area need be specified.

It should be noted that the control unit, after receiving a Search function word, always interprets the next word received with an External Function signal as the identifier word. Thus, if a Terminate function is sent to a control unit after a Search function and before an identifier word is sent, the control unit does not recognize the Terminate function word as such but rather interprets it as an identifier word and begins the searching operation. In such a case, a second Terminate function word is needed to clear the control unit.

The conditions stated in the preceding paragraph are true of all Search functions (Search, Search Read, Block Search, and Block Search Read). Therefore, a function access control word with a word count of 2 should be used to initiate the search operation: the first word for the Search function itself and the second for the identifier word.

3.2.1.8 SEARCH READ FUNCTION

Function Code: 46_8

The Search Read function is used to instruct the subsystem to read data words from consecutive storage addresses (starting at the address specified in the function word) and to compare each word with the identifier word containing the bit pattern being sought. The identifier word is supplied to the control unit as a second function word following the Search Read function word. When identical comparison is achieved between a word in storage and the identifier word, the control unit changes from a searching operation to a reading operation which is identical to a Continuous Read (42_8) operation and transfers input data starting with the word that matches the identifier word. When the input buffer has been filled, data transfer ceases, but the subsystem is still in an active condition. At this point the buffer may be extended if additional words are to be read; otherwise, a Terminate function (either form) must be sent to the subsystem to clear the control unit before a new function can be initiated. If, in the course of the search, a word which matches the identifier word is not found in the storage unit, the searching operation continues until an end of file is reached or until the occurrence of either a terminate function or an error. The Search Read function may be concluded by one of the following:

- Function codes
  - Terminate Without Interrupt
  - Terminate With Interrupt

- Status codes
  - End-of-File
  - Parity Error
  - Invalid Address
  - Fault

Similar to other Search functions, the control unit interprets the next word received with an External Function signal after the Search function word as the identifier word.

3.2.1.9 BLOCK READ FUNCTION

Function Code: 52_8

The Block Read function is used to instruct the subsystem to read data words from the storage unit and to perform input data transfers starting at the storage address specified in the function word and continuing until an end-of-block word (defined as a word of all 1 bits) and the word following it (called the overflow word) have been read.

Following the transfer of all preceding data words, the end-of-block word is transferred to the processor as the last word to enter the input buffer. When the processor acknowledges receipt of the end-of-block word, the control unit assembles a status word consisting of the End-of-Block (04_8) status code in the upper 6-bit positions and the 30 low-order bits of the overflow word for presentation to the processor along with an External Interrupt signal. The Block Read function can be concluded by one of the following:

- Function codes
  - Terminate Without Interrupt
  - Terminate With Interrupt

- Status codes
  - End-of-Block
  - End-of-File
  - Parity Error
  - Invalid Address
  - Fault

If the input buffer is filled before an end-of-block word is detected, data transfer ceases, but the subsystem is still in an active condition. If more data words are required by the processor, the input buffer may be extended; otherwise, a Terminate function must be programmed to clear the control unit before a new function can be initiated.

3.2.1.10 BLOCK SEARCH FUNCTION

Function Code: 55_8

The Block Search function is used to instruct the subsystem to read data words from the storage unit (starting at the storage address specified in the Block Search function word) and to compare them with the identifier word which contains the bit pattern being sought. The identifier word is supplied to the control unit as a second function word following the Block Search function word. If identical comparison is achieved between the identifier word and a word in storage before an end-of-block word is detected, the control unit assembles a status word containing both the Search Find (05_8) status code and the address of the found word and turns on the External Interrupt signal. If an end-of-block word is detected before a find is made, the control unit assembles a status word containing the End-of-Block (04_8) status code in the upper 6-bit positions and the 30 low-order bits of the overflow word. It should be noted that if the identifier word is an end-of-block word and it is read from the storage unit, the status word assembled contains the Search Find (05_8) status code rather than the End-of-Block (04_8) status code. The 30 low-order bit positions of the status word include the 20-bit address of the end-of-block word rather than the 30 low-order bits of the overflow word.

The Block-Search function is concluded by one of the following:

- Function codes
  - Terminate Without Interrupt
  - Terminate With Interrupt

- Status codes
  - Search Find
  - End-of-Block
  - End-of-File
  - Overflow Parity
  - Invalid Address

- Fault
- Parity Error

Since no input data transfers are associated with this function, no input buffer area need be specified.

Similar to other Search functions, the control unit interprets the next word received with an External Function signal after the Block Search function word as the identifier word.

3.2.1.11 BLOCK SEARCH READ FUNCTION

Function Code: 56_8

The Block Search Read function is used to instruct the subsystem to read data words from the storage unit (starting with the storage address specified in the function word) and to compare each word with the identifier word which contains the bit pattern being sought. The identifier word following the Block Search Read function word is supplied to the control unit as another function word. This searching operation continues until one of the following occurs:

- An end-of-block word is detected. One more word, the overflow word, is read from the storage unit. The control unit assembles a status word containing the End-of-Block (04_8) status code and the 30 low-order bits of the overflow word and then turns on the External Interrupt signal.

- A condition which is detected results in an external interrupt. Possible conditions are end-of-file, parity error, invalid address, and fault.

- Identical comparison is achieved between a word read from storage and the identifier word. When this condition occurs, the control unit changes from a searching operation to a reading and data-transferring operation identical with the Block Read (52_8) function. All conditions relating to the Block Read function, described in 3.2.1.9, apply to a Block Search Read function after a find has been made.

If the identifier word for a Block Search Read function is an end-of-block word, the search find condition causes the end-of-block word to be the only word transferred to the input buffer. The status word accompanying the External Interrupt contains the End-of-Block (04_8) status code and the 30 low-order bits of the overflow word.

The same principle governs the transfer of the identifier word as that previously described in connection with the Search (45_8) function (see 3.2.1.7).

3.2.2.12 READ WITH INTERRUPT FUNCTION

Function Code: 62_8

The Read With Interrupt function is used to instruct the subsystem to read data from consecutive storage addresses (starting at the address specified by the function word). The data read from the storage unit is transferred to the

processor by way of the control unit. If the processor does not accept word n in time to free a control unit register so that word n + 2 can be read, reading from the storage unit is halted, and a stop-delay operation (see 3.2.1.2) is initiated by the control unit. The control unit makes words n, and n + 1 available in sequence to the processor during this interval. At the end of the delay, an External Interrupt signal is turned on by the control unit and sent to the processor. If word n is accepted by the processor during the stop-delay period, the Late Acknowledge (02_8) status code is sent with the External Interrupt signal to the processor at the end of the interval. If word n is not accepted during the stop-delay period, the Normal Completion (40_8) status code is sent to the processor.

A stop-delay operation is also initiated when the control unit detects a potential end-of-file condition. However, in this instance the delay is used solely to determine when the status code should be generated. The acceptance of one or more words by the processor during this stop-delay interval does not cause generation of the Late Acknowledge status.

The Read With Interrupt function is concluded by one of the following:

- Function codes
  - Terminate Without Interrupt
  - Terminate With Interrupt

- Status codes
  - Normal Completion (timeout)
  - End-of-File
  - Parity Error
  - Invalid Address
  - Fault
  - Late Acknowledge

Because of the timeout (stop-delay) feature, a Terminate function is not needed to conclude the operation. However, either Terminate function may be used.

3.2.2 IDENTIFIER WORD

Following the transfer of any of the Search functions (Search, Search Read, Block Search, Block Search Read), the identifier word is transferred with an External Function signal from the processor to the control unit. The identifier word has no fixed format and may contain any bit configuration representing the data word being sought.

After a Search function word is received and decoded, the control unit remains inactive until the identifier word is received. The control unit requests the identifier word within two microseconds after the search function word is received.

3.2.3 END-OF-BLOCK WORD

The end-of-block word, which is a full 36-bit word containing all 1 bits, is used to separate files or groups of records

stored in the storage unit. The control unit recognizes an end-of-block word only during block operations (Block Read, Block Search, and Block Search Read functions). In those block operations having input data transfers, no data words are transferred to the processor following the transfer of the end-of-block word. A word of all 1 bits has no special significance during execution of either write function.

3.2.4 OVERFLOW WORD

The overflow word is the designation given to the word recorded in the address immediately following an end-of-block word. The 30 low-order bits of the overflow word are presented to the processor as part of the status word along with a status code of 04_8 at the normal conclusion of all block functions except when a find occurs in a block-search operation. The 24 low-order bits of the overflow word can be programmed to indicate the starting address of the next portion of a nonconsecutive file.

3.2.5 STATUS WORD

The status word is generated by the control unit to indicate conditions within the subsystem. The status word, which is made available to the processor over the 36 input data lines, is accompanied by a signal on the External Interrupt line to inform the processor that a status word rather than a data word is on the data lines.

The status code always occupies the six upper bit positions of the status word; the remainder of the status word can also contain significant information. The status word can take one of four possible formats, depending upon the nature of the condition being indicated. The four formats of the status word are shown in Figure 3-2.

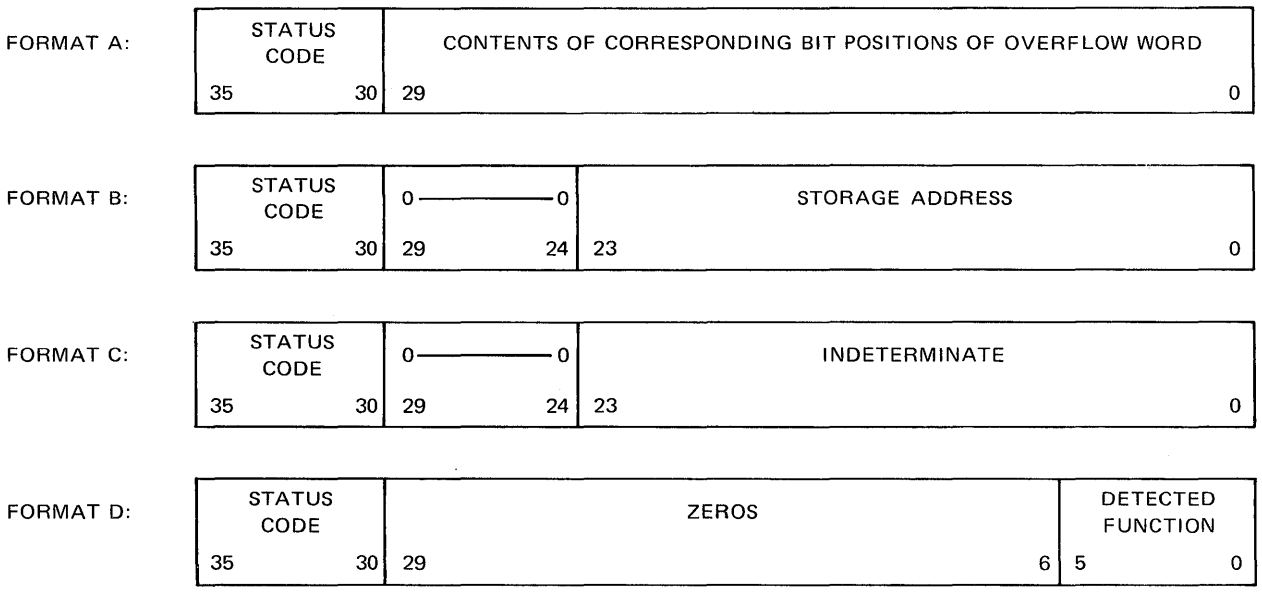

Figure 3-2. Status Word Formats

The Unitized Channel Storage Subsystem can generate any of 10 status codes listed in Table 3-2.

Some of the status codes represent error conditions, while other codes simply represent the normal conclusion of the subsystem operations. In general, error conditions take precedence over normal conditions if the two occur simultaneously. The action to be taken by the program when the external interrupt occurs depends on the function being executed and the nature of the condition which caused the interrupt. For example, parity error indications logically suggest that one or more attempts be made to re-read the error word, as a recovery procedure. On the other hand, a Search Find status code is normal condition indication to the program that the desired information has been located in the storage unit so use of this information depends entirely on the nature of the program.

Not all status codes can occur in response to all function codes. Table 3-3 indicates the possible status code responses to each of the function codes in the subsystem repertoire.

The status codes and their significance are discussed in detail in the following paragraphs.

3.2.5.1 LATE ACKNOWLEDGE STATUS

Status Code: 02_8 Status Word Format: B

The Late Acknowledge status code, which is received only in response to a Write With Interrupt (22_8) or Read With Interrupt (62_8) function, is used to indicate that the processor was too slow in responding to a request (ODR or IDR) signal (see 3.3). When a Late Acknowledge status code is received in response to a Write With Interrupt function, all words received prior to the late word have been written without error detection. The late word is not written. The control unit can accept no more than three words following the late word (two words before the External Interrupt signal is turned on and one word after the External Interrupt signal is acknowledged). The address in the status word is normally the address of the last word written. However, if the 13 low-order bits of the status word are all 1 bits, bit positions 23 through 13 of the status word contain a value which is one greater than the value in the corresponding bit positions of the address of the last word written.

When a Late Acknowledge status code is received in response to a Read With Interrupt function, all data words accepted by the processor are valid data words. The processor can receive a maximum of two data words following the word acknowledged with a late Input Acknowledge signal. The address in the status word is normally the address of the second word following the word acknowledged with a late Input Acknowledge signal.

When the processor acknowledges receipt of a Late Acknowledge status word, the control unit turns on the ODR signal to the processor and is ready to accept the next function word.

3.2.5.2 END-OF-BLOCK STATUS

Status Code: 04_8 Status Word Format: A

A status word, containing an End-of-Block status code and the 30 low-order bits of the overflow word, is generated during execution of any of three Block functions: Block Read, Block Search, and Block Search Read. The status

STATUS WORD	STATUS CODE (OCTAL)	STATUS WORD FORMAT (See Figure 3-2)
Late Acknowledge	02	B
End-of-Block	04	A
Search Find	05	B
Overflow Parity Error	06	B
Fault	14	C
End-of-File	34	B
Normal Completion	40	B
Invalid Function	50	D
Invalid Address	54	B
Parity Error	64	B

Table 3-2. Summary of Status Codes

FUNCTION CODE	DESCRIPTION	Late Acknowledge (02)	End-of-Block (04)	Search Find (05)	Overflow Parity Error (06)	Fault (14)	End-of-File (34)	Normal Completion (40)	Invalid Function (50)	Invalid Address (54)	Storage Parity Error (64)
02	Continuous Write Without Interrupt					X	X			X	
22	Continuous Write With Interrupt	X				X	X	X		X	
23	Terminate Without Interrupt*					X					
33	Terminate With Interrupt*					X		X			
40	Automatic Bootstrap					X	X			X	X
45	Search			X		X	X			X	X
46	Search Read					X	X			X	X
52	Block Read		X		X	X	X			X	X
55	Block Search		X	X	X	X	X			X	X
56	Block Search Read		X		X	X	X			X	X
62	Continuous Read With Interrupt	X				X	X	X		X	X
	All Other Function Codes								X		
	Format (see Figure 3-2)	B	A	B	B	C	B	B	D	B	B
	Priority	4	9	7	5	1	8	10	2	3	6

*The possible status codes in response to a Terminate function code also include those of the previous function.

NOTE: The addresses returned with the Status Codes are included in the Status Code definitions.

Table 3-3. Possible Status Code Responses to Function Codes

word is generated by the control unit, and the External Interrupt signal is turned on if the end-of-block and overflow words are read without parity error detection and one of the following conditions is satisfied.

- The input buffer for a Block Read function is large enough to accept the end-of-block word.
- The identifier word for a Block Search function or Block Search Read function is not an end-of-block word, and a find is not made by the time an end-of-block word is read from the storage unit.
- The identifier word for a Block Search Read function is not an end-of-block word, a find is made before an end-of-block word is read, the input buffer is large enough to accept the end-of-block word, and an end-of-block word is not the last word preceding an address gap.
- The identifier word for a Block Search Read function is an end-of-block word, and the program defines an input buffer of at least one word.

An End-of-Block status word is not generated for a Block function in any of the following special cases:

- if a parity error is detected when an end-of-block word is read, a Parity Error status code is generated (see 3.2.5.11);
- if a parity error is detected when the overflow word is read, an Overflow Parity Error status code is generated (see 3.2.5.4);
- if the identifier word for a Block Search function is an end-of-block word and an end-of-block word is read from storage without parity error detection, a Search Find status code is generated (see 3.2.5.3);
- if the last word in a storage unit is an end-of-block word and the next consecutive address is for a nonexistent or unavailable storage unit, the overflow word cannot be read and an End-of-File status code is generated (see 3.2.5.7).

3.2.5.3 SEARCH FIND STATUS

Status Code: 05_8 Status Word Format: B

The Search Find status code is used to indicate to the processor that a word which is identical to the identifier word has been found in the storage unit during a Search (45_8) or Block Search (55_8) function. The 24 low-order bits of the status word contain the storage address of the found word. A search find condition is not reported if a parity error is detected in a word read from a storage unit even if the data bits read are identical to the bits of the identifier word. In such a case, a parity error is reported.

3.2.5.4 OVERFLOW PARITY ERROR STATUS

Status Code: 06_8 Status Word Format: B

The Overflow Parity Error status code is used to inform the processor that a parity error was detected by the control unit during a reading of the overflow word at the conclusion of a Block function. The 24 low-order bits of the status word contain the storage address of the overflow word in which the error was detected.

A status word containing the Overflow Parity Error status code is generated if an only if all conditions for generation of a status word containing an End-of-Block status code are met, except for detection of proper parity for the overflow word when it is read from the storage units.

3.2.5.5 FAULT STATUS

Status Code: 14_8 Status Word Format: C

The fault status code is used to inform the processor that a hardware malfunction has occurred in the subsystem. Conditions which can cause a fault indication are:

- More than one storage unit has acknowledged a storage request.
- A storage unit in use during the function operation became unavailable.

The storage unit will become unavailable if any of the following conditions exist:

- If any of the STOP ON PARITY switches are set when an error occurs.
- If the storage unit is powered down.
- If the storage unit is switched to OFF-LINE.

The contents of the 20 low-order bits of this status word are indeterminate and should be ignored.

3.2.5.6 END-OF-FILE STATUS

Status Code: 34_8 Status Word Format: B

The end-of-file status code is used to inform the processor that the next sequential address is outside the set of legitimate storage addresses of the particular subsystem, or is in an inoperable storage unit. This status code is generated only through incrementation of the storage unit address during the performance of a function; however, specifying such an address in the function word results in an External Interrupt signal accompanied by an Invalid Address status code rather than an End-of-File status code.

A status word containing an End-of-File status code is generated in response to any of the following functions:

- Continuous Write (without interrupt) function or Write With Interrupt function after a word is written in the last word position (in a storage unit) preceding an address gap.
- Terminate With Interrupt function following either Write function for which a status word has not been generated by the control unit, if one or more data words are received for the Write function following the data word written at the highest address preceding an address gap. The end-of-file status code is not generated until after the word has been written at the last address.
- Search Read or Block Search Read function for which a find has been made and any Read function after the processor acknowledges receipt of the last word (in a storage unit) preceding an address gap.
- Any Search function for which a find has not been made after the last word preceding an address gap has been read and found to be not identical to the identifier word.

An End-of-File status code is not generated in response to a Terminate With Interrupt function following either Write function if there were no data words received following the word written at the highest address preceding an address gap. In this case, a status word containing a Normal Completion status code is generated.

An End-of-File status code is never generated in response to the Terminate Without Interrupt function.

With the exception of Search functions, the contents of the 21 low-order bit positions of the status word are indeterminate.

When an End-of-File status word is generated in response to any Search function (Search, Search Read, Block Search, and Block Search Read), the contents of the 21 low-order bit positions of the status word are significant. Within bit positions 20 through 17, the logical storage unit number is specified for the unit following the last searched storage unit which there was no search find. Bit positions 16 through 1 contain zeros. But position 0 may be a 0 or 1. The contents of the 21 low-order bit positions of an End-of-File status word generated in response to any Search function are shown in Table 3-4.

Logical Storage Unit Number	Last Address Referenced Before End-of-File (Octal)	21 Low-order Bits of End-of-File Status Word (Octal)*
0	0377777	040000X
1	0777777	100000X
2	1377777	140000X
3	1777777	200000X
4	2377777	240000X
5	2777777	300000X
6	3377777	340000X
7	3777777	400000X

*The X is either a 1 or a 0.

Table 3-4. The 21 Low-Order Bits of the End-of-File Status Word in Response to Any Function.

3.2.5.7 NORMAL COMPLETION STATUS

Status Code: 40_8 Status Word Format: B

The Normal Completion status code can be generated only in response to a Terminate With Interrupt, a Write With Interrupt or a Read With Interrupt function. If a Normal Completion status code is generated in response to a Terminate With Interrupt function sent to a control unit following a function for which no status word has been received, then the previous function was completed without error detection.

When a Terminate With Interrupt function is sent to a control unit following completion of the data transfers for a Continuous Write function, a fault or an end-of-file can be detected between the time the last data word to be written is received, and the time the Terminate function is received or the time the last data word which can be written is written, whichever occurs later. In these cases, a Fault status takes precedence over normal completion status. Normal Completion takes precedence over End-of-File if all data words sent to the subsystem can be written. An End-of-File takes precedence over Normal Completion if the last data word received by the control unit cannot be written because of an address gap following the last word which is written.

If Normal Completion is generated in response to a Terminate With Interrupt function sent to a control unit at a time when there is no previously unanswered function word, then the control unit is in a cleared condition and is ready to accept the next function word.

If Normal Completion is generated in response to a Write With Interrupt function, all data words sent to the control unit have been written without an error detected and a data word was not sent to the control unit during an interval of 100 microseconds (interlace of 1) following the writing of the last data word received on a timely basis by the control unit.

If Normal Completion is generated in response to a Read With Interrupt function, then the processor did not accept a data word from the control unit during an interval of 100 microseconds (interlace of 1) following initiation of the stop-delay, and the processor did not accept the last word from the storage unit following detection of a potential end-of-file condition.

3.2.5.8 INVALID FUNCTION STATUS

Status Code: 50_8 Status Word Format: D

The Invalid Function status code is used to inform the processor that the function word sent to the control unit specifies a function code that is not included in the subsystem repertoire. No function is initiated in this case, and the External Interrupt signal is presented to the processor immediately. The 24 low-order bits of the status word are indeterminate and should be ignored.

If both an Invalid Function code and an Invalid Address code are specified in the same function word, the Invalid Function status code takes precedence.

3.2.5.9 INVALID ADDRESS STATUS

Status Code: 54_8 Status Word Format: B

The Invalid Address status code is used to inform the processor that the storage address in the function word can not be used for that function.

An invalid address is defined as an address specified in any Read, Write, or Search function word which is not within the set of normally legitimate addresses for the subsystem or which is in an inoperable storage unit. If a function word specifies an invalid address, the function is not initiated, and the External Interrupt signal is sent to the processor immediately. It should be noted that this status code is generated only as a result of the receipt of an unusable address in a function word. If such an address is developed by incrementation while some operation is being performed, an End-of-File status code, rather than an Invalid Address, is generated. When an illegal address is detected for a search function, the Invalid Address status code is not sent to the processor until the identifier word is received.

3.2.5.10 PARITY ERROR STATUS

Status Code: 64_8 Status Word Format: B

The Parity Error status code is used to inform the processor that the control unit detected a parity error during a read or search operation. The 21 low-order bits of the status word contain an address one greater than the address of the word in which the error was detected. If bit 20 of the status code is set, a one bit was detected within bit positions 20 through 23 of the function word.

The parity bits are generated by the unitized storage unit during a write operation and are checked by the storage unit during a read operation. The Parity Error data word will be rewritten with incorrect parity. Rereading will check for the continued existence of the parity error.

If a data parity error is detected, the status word is made available to the processor, and the External Interrupt signal is turned on only after the processor has accepted all parity-correct data words read for input to the processor before the error was detected. When the External Interrupt signal is acknowledged, the control unit is cleared to receive a new function. The error word is not made available to the processor.

3.2.6 DATA WORD

Data words contain the information which is read from or written into the storage unit. After each Read or Write function word is received and acted upon by the control unit, data words are transferred between the processor and subsystem. The data word is a 36-bit processor word with no fixed format. No data words are transferred when either form of a Terminate function, a Search function, or a Block Search function is sent to the subsystem.

3.3 TIMING

The data transfer rates stated in Table 3-5 are available to the subsystem. These rates can be selected by a patch card in the control unit. In order to maintain a data transfer rate, the processor must respond to each IDR or ODR signal within a required interval.

During a normal input data transfer, the IDR signal is maintained on the line until an Input Acknowledge signal is received. There is no maximum limit on the time the IDR may stay up before being acknowledged. The data lines will remain stable as long as the IDR is up.

For an input function, the response interval is defined as the time interval between the initiation of an IDR signal at the control unit end of the I/O cable and the arrival of an Input Acknowledge signal at the same end of the cable. If an I/O transfer of 1 is used, the processor must respond to each IDR signal with an Input Acknowledge signal within 2.5 microseconds for the data transfer to proceed at the selected rate.

The Input Acknowledge signal will be set for a fixed time only, no less than 375 nanoseconds (1108). The subsystem can detect an Input Acknowledge signal which may exist in a stable "one" state for as little as 250 nanoseconds, allowing for a rise-time no greater than 75 nanoseconds. When the Input Acknowledge is sensed, the IDR may be dropped to the "zero" state at any time, but it will remain in the zero state at least 200 nanoseconds before another IDR can be initiated.

On non-interrupting read functions, an infinite response time is tolerated, (IDR to IA), and a terminate function is necessary to conclude the operation if no error occurs. The Continuous Read With Interrupt function code, however, will tolerate only the maximum response times listed in Table 3-5 without automatic termination of the operation. After the maximum response time has elapsed for a Continuous Read With Interrupt function, a 100 microsecond stop-delay is initiated by the control and the IDR signal is dropped. The last word remains on the I/O lines; however, any Input Acknowledge during stop-delay will cause a Late Acknowledge status word to be generated. At the end of the stop-delay a Normal Completion status word is generated.

During a normal output data transfer the subsystem presents an ODR signal to the processor indicating that it is in a condition to accept data. This is necessary because the data is available to the subsystem for a fixed time only, nominally 950 nanoseconds (1108). There is no requirement that the data lines be returned to the "zero" state before being reset to the "one" state. The time which may elapse between the request and the time the data is placed on the line is not fixed, but may vary depending on the priority of the particular requesting channel and the data rates of the other peripheral units. The processor puts the Output Acknowledge signal on the line from 50 to 125 nanoseconds after placing data on the line.

The response times stated in Table 3-5 are based on the maximum transfer rate of 445,000 words per second. It is possible to operate the subsystem at any of the slower transfer rates by inserting the patch-card in the control unit that selects the I/O rate. If any I/O transfer other than the first is selected by a patch-card in the control unit, the processor must respond within a time equal to the difference between the time of the selected rate and the maximum control unit turnaround time of 400 nanoseconds (including an assumed cable delay of 200 nanoseconds) to maintain the selected rate. However, the maximum response times listed in Table 3-5 are still required to avoid a termination of the self interrupting functions.

A maximum transfer rate of 445,000 words per second is for an I/O transfer interlace of 1 and is obtained by allowing the processor to control the I/O timing. The control unit establishes the slower transfer rates by furnishing intervals between the successive words transferred and increasing the available response time. For example, if an I/O transfer interlace of 2 is used, the IDR/ODR is presented at 4.0 microsecond intervals.

INTERLACE**	NOMINAL TRANSFER RATE (words/sec)	MINIMUM TIME BETWEEN WORDS (μs)	ARBITRARY STOP-DELAY* (μs)	PERMITTED RESPONSE TIME (μs) ONE-TIME MAXIMUM
1	440,000	2.25	100	7.0
2	250,000	4.0	100	12.0
3	125,000	8.0	100	18.6
4	62,000	16.0	100	24.0

*The stop-delay is adjustable to any nominal value from 35 microseconds to 350 microseconds.

**Any of the interlaces shown may be used when the subsystem is operating in an 1108 Multi-Processor System; an interlace of 2 or greater should be used when the subsystem is operating in an 1106 System.

Table 3-5. Transfer Rates With Various Interlaces

3.4 PROGRAMMING FOR OPTIONAL SHARED PERIPHERAL INTERFACE

When the shared peripheral interface SPI is master cleared, it turns on the ODR signal to each processor logically connected to it. When a processor sends a function word to the shared peripheral interface, it turns off the ODR signal to that processor. When a processor gains control of the data path to the control unit, the shared peripheral interface turns the ODR signal on and off to that processor in agreement with the status of the ODR signal from the control unit to the shared peripheral interface.

When a processor sends a function word to the shared peripheral interface, it is held in a word register associated with that processor until that processor is given control of the data path. The processor should not force another function word out to the shared peripheral interface until the control unit gives control of the data path to that processor and accepts the function word in the word register. If a function word is forced out to the shared peripheral interface when this register is still holding a preceding function word, the contents of the register are not disturbed. The new function word is ignored by the shared peripheral interface.

Additional details concerning the shared peripheral interface are included in 2.3.2 and 2.5.