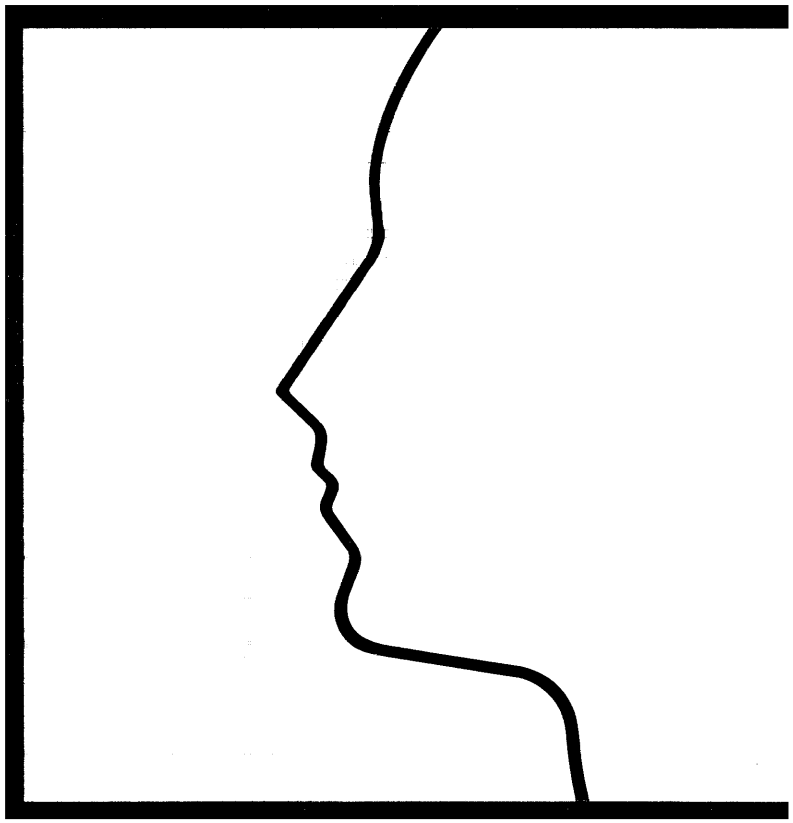
TEXAS INSTRUMENTS

EXPLORER™

NuBus™ PERIPHERAL

INTERFACE GENERAL

DESCRIPTION



EXPLORER™ NUBUS™ PERIPHERAL INTERFACE GENERAL DESCRIPTION

MANUAL REVISION HISTORY

Explorer™ NuBus™ Peripheral Interface General Description
(2243146-0001)

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The system-defined windows shown in this manual are examples of the software as this manual goes into production. Later changes in the software may cause the windows on your system to be different from those in the manual.

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THE EXPLORER™ SYSTEM HARDWARE MANUALS

System Level Hardware Publications	Explorer 7-Slot System Installation	2243140-0001
	Explorer System Field Maintenance	2243141-0001
	Explorer NuBus™ System Architecture General Description	2537171-0001
System Enclosure Hardware Publications	Explorer 7-Slot System Enclosure General Description	2243143-0001
	Explorer Memory General Description	2533592-0001
	Explorer Processor General Description	2243144-0001
	Explorer Display Unit General Description	2243151-0001
	Explorer System Interface General Description	2243145-0001
Mass Storage Hardware Publications	Explorer Mass Storage Enclosure General Description	2243148-0001
	Explorer Winchester Disk Formatter (ADAPTEC) Supplement to Explorer Mass Storage Enclosure General Description	2243149-0001
	Explorer Winchester Disk Drive (Maxtor) Supplement to Explorer Mass Storage Enclosure General Description	2243150-0001
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	Explorer Cable Interconnect Board (2236120-0001) Supplement to Explorer Mass Storage Enclosure General Description	2243177-0001
	Explorer NuBus Peripheral Interface General Description (NUPI board)	2243146-0001
Mass Storage Hardware Vendor Publications	Series 540 Cartridge Tape Drive Product Description, Cipher Data Products, Inc., Bulletin Number 01-311-0284-1K (1/4-inch tape drive)	2249997-0001
	MT01 Tape Controller Technical Manual, Emulex Corporation, part number MT0151001 (formatter for the 1/4-inch tape drive)	2243182-0001
	XT-1000 Service Manual, 5 1/4-inch Fixed Disk Drive, Maxtor Corporation, part number 20005 (5 1/4-inch Winchester disk drive, 112 megabytes)	2249999-0001
	ACB-5500 Winchester Disk Controller User's Manual, Adaptec, Inc., (formatter for the 5 1/4-inch Winchester disk drive)	2249933-0001
Optional Equipment Hardware Publications	Explorer NuBus Ethernet® Controller General Description	2243161-0001
	Model 855 Printer Operator's Manual	2225911-0001
	Model 855 Printer Technical Reference Manual	2232822-0001
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THE EXPLORER™ SYSTEM SOFTWARE MANUALS

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	Explorer TCP/IP User's Guide	2537150-0001
System Software Internals	Explorer System Software Design Notes	2243208-0001

CONTENTS

Tables

ABOUT THIS MANUAL

Purpose

This document provides a general description of the Texas Instruments (TI) NuBus Peripheral Interface (NUPI) board (TI part number 2238040-0001). The information in this document is intended to be used by system designers, value added retailers (VARs), maintenance personnel, system users, and operators. This manual is divided into five sections and three appendixes.

Contents of This Manual

Section 1: Introduction — Provides general information on the NUPI board and its usage in the Explorer computer systems.

Section 2: Installation — Provides installation procedures and information for the NUPI board.

Section 3: Operating Instructions — Provides general information on NUPI board self-test operation.

Section 4: Hardware Design Information — Provides a block diagram description of the NUPI board and a general description of NUPI data transfer operations.

Section 5: Programming Information — Provides information that a programmer would need to prepare a custom device driver routine. TI provides device driver routines as part of system software.

Appendix A: SCSI Commands and Messages — Provides information about the SCSI commands and messages and their relationship to NUPI commands and operations.

Appendix B: Memory Maps — Provides maps of the NUPI read-only memory (ROM) address space.

Appendix C: NUPI LED Settings — Provides a list of conditions which result in the NUPI firmware setting the NUPI LEDs.

NOTE: The > symbol indicates hexadecimal throughout this manual.

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1 INTRODUCTION

General

1.1 This section contains information on the following topics:

- NUPI general information
- NUPI key features
- NUPI specifications
- Mass storage subsystem overview

The Texas Instruments (TI) NuBus Peripheral Interface (NUPI) board (Figure 1–1) provides a means for TI Explorer computer products to support mass storage subsystems. It uses the industry standard Small Computer Systems Interface (SCSI) to move data between mass storage devices and the NuBus.

The NUPI is assembled on a triple-height Eurocard. The Eurocard is a European standard card assembly that measures 122.2 by 280 millimeters (4.8 by 11 inches) and has one standard DIN (Deutsches Institut fuer Normung*) connector. The expression *triple-height* indicates that the 122.2-millimeter dimension is multiplied by 3. That is, the NUPI board measures 366.7 by 280 millimeters (14.4 by 11 inches) and has three standard DIN connectors. A DIN connector is a European standard 96-pin connector organized into 3 rows of 32 pins each.

Figure 1-2 shows the Explorer computer system. The Explorer computer is an advanced, symbolic processing workstation that uses the Lisp (list processing) computer language. Its main bus is the NuBus. The NuBus is a multiple-use, high-speed, synchronous bus that multiplexes 32-bit data words and 32-bit addresses. A simple communications protocol allows circuit boards on the bus to operate as either bus-master or bus-slave devices.

In general, the NUPI board can be inserted in any chassis slot in which the NuBus is connected to P1, and P3 is open for input/output (I/O) data and control. Exceptions to this are slots that are dedicated to specific boards. A hard-wired identification (ID) code on the backplane becomes a part of the board address. This allows the processor to identify the board without any special switch or jumper configurations. The system enclosure general description manuals provide information on slot restrictions and board ID codes.

* German Institute for Standards.

Figure 1–1 NuBus Peripheral Interface Board

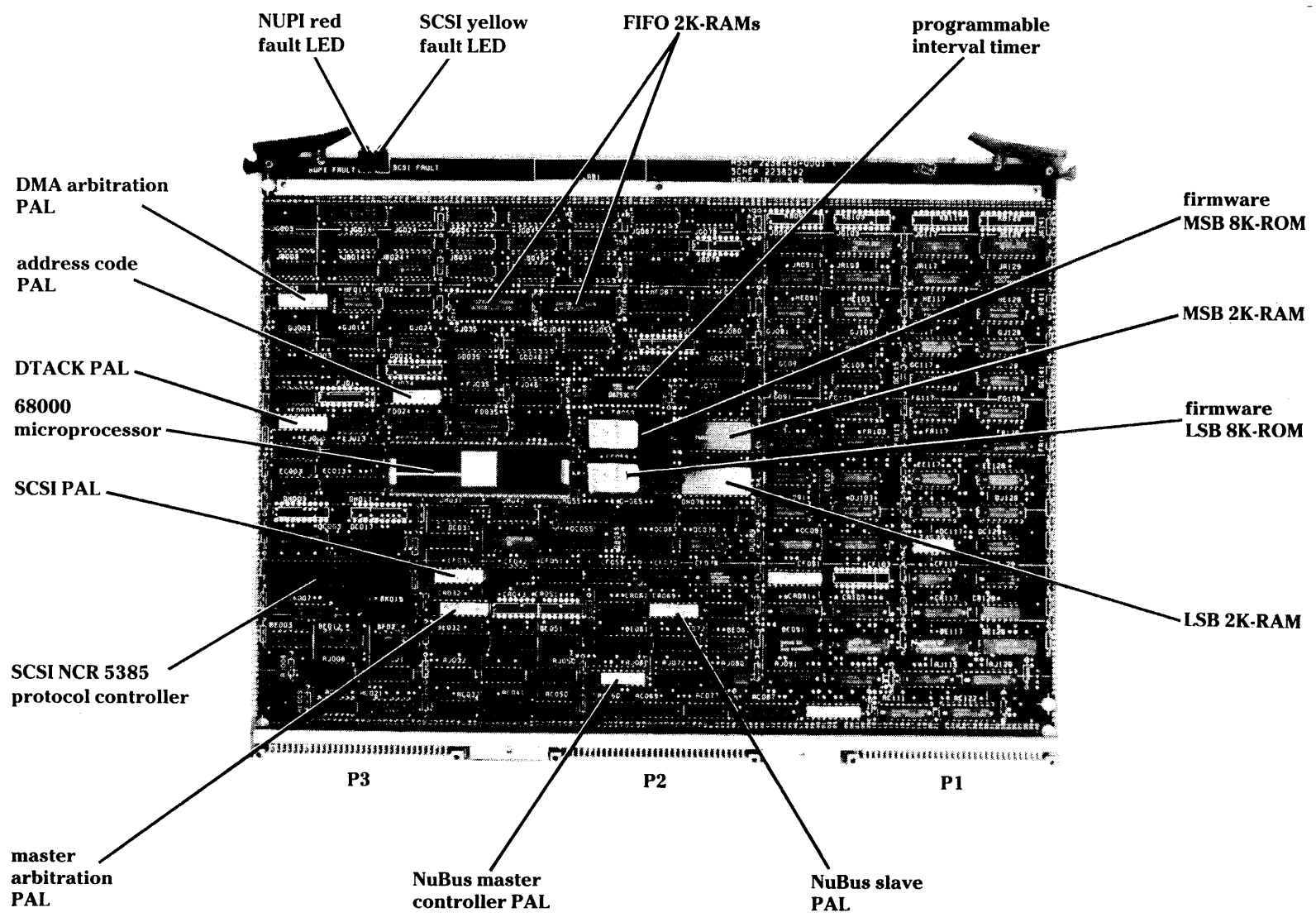
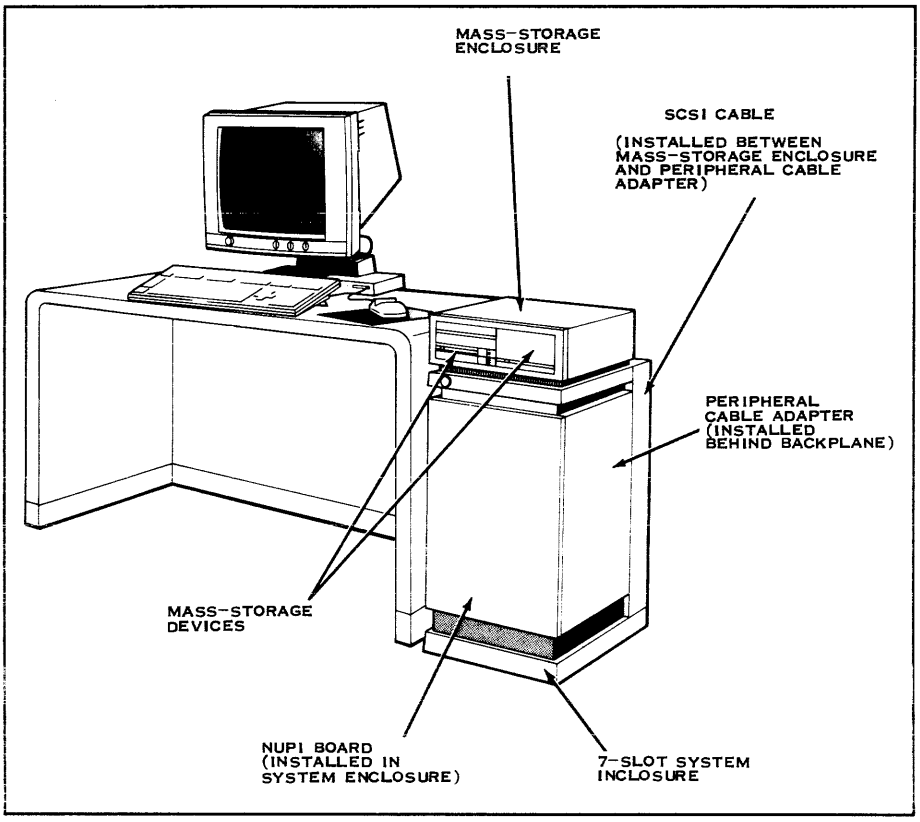


Figure 1-2 **Explorer Computer System Components**



Features

1.2 The following key features characterize the NUPI board:

- Provides a single-board interface between the NuBus and the SCSI bus.
- Uses a European standard triple-height Eurocard assembly.
- Is controlled by an MC68000 microprocessor unit (MPU) running at a frequency of 10 megahertz.
- Provides data transfers of up to 1.5 megabytes per second between the NuBus and the SCSI bus.
- Has extensive on-board self-test diagnostic capability.

Specifications

1.3 The NUPI board changes operating system (OS) commands residing in NuBus memory to SCSI operations for the appropriate mass storage device formatter. NuBus and SCSI protocols allow the transfer of data, commands, and status between NuBus memory and the mass storage devices. Table 1-1 lists the general specifications for the NUPI board assembly.

Table 1-1 **NUPI Board Specifications**

Item	Specifications
Power usage:	
Voltage	5.0 Vdc ±5 percent
Current	5.6 A
Power	30.0 watts (maximum)
Temperature limits:	
Operating	4 to 45 degrees C (40 to 113 degrees F)
Nonoperating	-40 to 65 degrees C (-40 to 149 degrees F)
Maximum change	Less than 10 degrees C (18 degrees F) per hour
Relative humidity (noncondensing) range:	
Operating	8 to 80 percent
Nonoperating	5 to 95 percent
Altitude limits:	
Operating	-300 to 3 000 meters (-990 to 10 000 feet)
Nonoperation	-300 to 12 000 meters (-990 to 40 000 feet)
Mechanical shock (in 3 axes):	
Operating	15 g
Nonoperating	25 g
Mechanical vibration (in 3 axes):	
Operating	0.5 g
Nonoperating	1.0 g
Dimensions:	
Width	366.7 mm (14.437 in)
Depth	280 mm (11.024 in)
Thickness (with components):	18.11 mm (0.714 in) maximum

Mass Storage Subsystem Overview

1.4 Figure 1-3 is a block diagram of a typical Explorer computer mass storage subsystem. The mass storage subsystem provides data and program storage as well as backup and transportable media. The subsystem uses a distributed intelligence scheme to perform the required data transfer operations between NuBus memory and the mass storage intelligent formatters. These formatters provide device-level control for the mass storage devices connected to them. The following paragraphs provide an overview of the mass storage subsystem.

NuBus Peripheral Interface (NUPI)

1.4.1 The NUPI receives command blocks from the processor via the NuBus. These command blocks contain requests that are destined for either the NUPI itself or one of the mass storage formatters.

SCSI Cable

1.4.2 The SCSI cable is a 50-pin cable that connects the NUPI I/O port to the mass storage enclosure. A peripheral cable adapter (PCA) connects the 50-pin connector on the SCSI cable to the 96-pin I/O connector at the rear of the computer backplane. Optional daisy chain SCSI cables connect one or more additional mass storage enclosures to allow mass storage expansion. This expansion is limited to a maximum total cable length of 19.68 feet (6.00 meters).

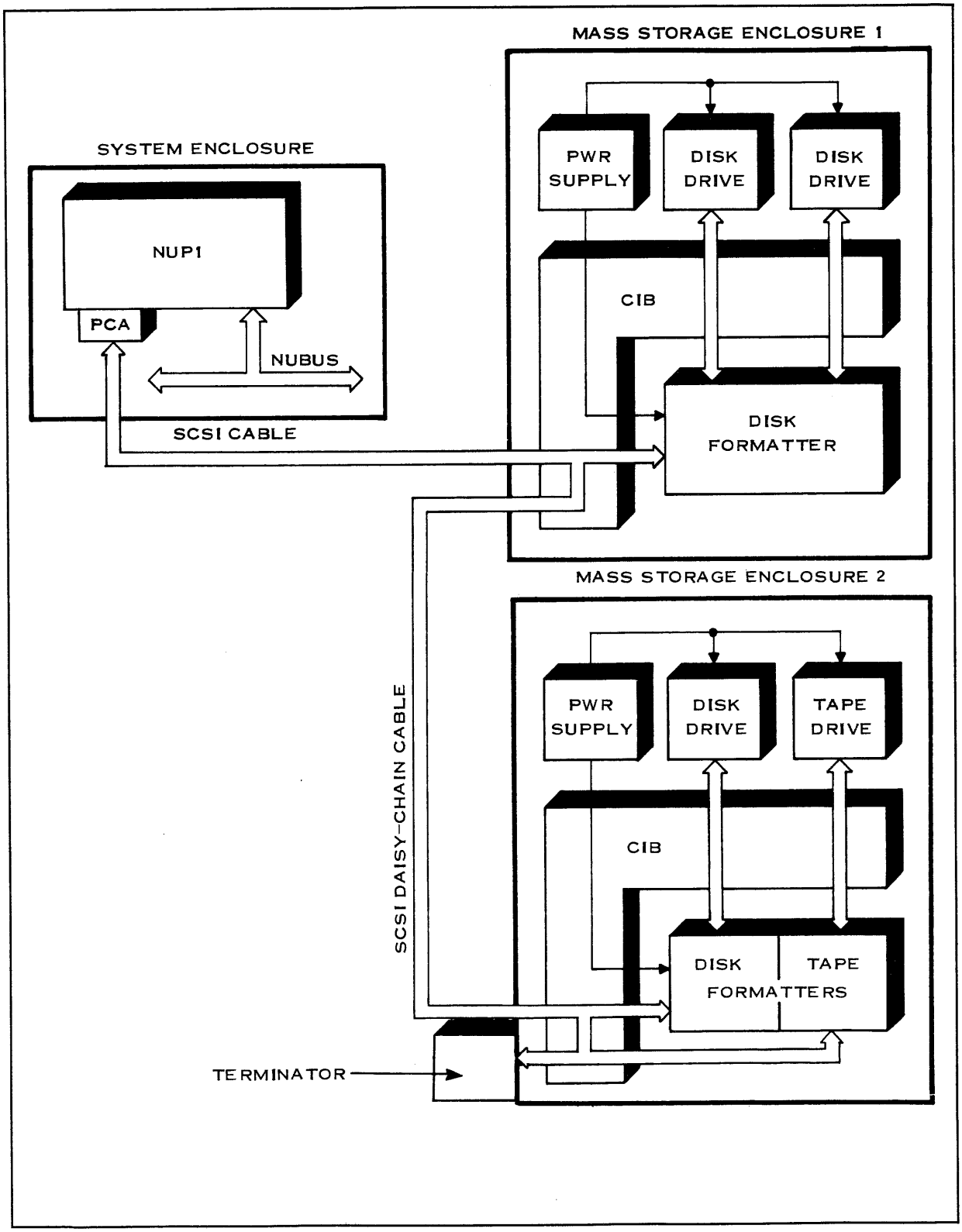
Mass Storage Enclosure

1.4.3 The mass storage enclosure houses the mass storage subsystem power supply and cooling fan, one or two mass storage devices, and one or two device formatters. The enclosure also houses a cable interconnect board (CIB) which facilitates interconnections within the enclosure and connection to the computer system and/or other mass storage enclosures. A single computer system can support up to four mass storage enclosures.

Formatters

1.4.4 Each mass storage enclosure can house either one or two formatters. Thus, a single computer system can support up to eight disk devices or eight tape devices, or any combination of eight devices.

Figure 1–3 Typical Explorer Mass Storage Subsystem



Mass Storage Devices

1.4.5 The 5 1/4-inch Winchester disk is the primary mass storage device for the computer system. This type of mass storage device provides the capacity and performance level required by a workstation or file server system. Optional 5 1/4-inch cartridge tapes provide system mass storage backup.

1/2-Inch Tape Drive

1.4.6 The NUPI (TI part number 2238040-0001, Rev P) has the internal logic and ROM code required to support a 1/2-inch tape drive. The 1/2-inch tape drive connects to the SCSI bus over a SCSI daisy-chain cable from one of the mass storage enclosures. Refer to the *Explorer 7-Slot System Installation* manual for details on the installation of a 1/2-inch tape drive.

2 INSTALLATION

Introduction

2.1 This section provides installation instructions for the NuBus peripheral interface (NUPI) board. The NUPI board can be installed in various chassis of the Explorer computer family.

CAUTION: The NUPI board contains static-sensitive electronic components. To avoid damage to these components, ensure that you are well grounded before removing or handling the board.

The recommended method is to use a static-control system consisting of a static-control floor or table mat and a static-control wrist strap. These are commercially available. If you do not have a static-control system, you can discharge any accumulated static charge by touching a grounded object prior to handling a board. Then, as a further precaution, place the board on a grounded work surface after removing it from the assembly or its protective package.

Before storing or transporting the NUPI board, return it to its protective package or to the assembly.

Installation

2.2 To install the NUPI board in the system enclosure, perform the following steps:

NOTE: The general description manuals for the system enclosures contain details on slot usage and operating control locations for the applicable systems.

---

1. Set the power switch on the system enclosure to the off position.
2. Open the front door or remove the trim panel from the system enclosure.
3. Release the latches on the internal metal door to gain access to the board slots.
4. Orient the board to align the male NuBus connector with the corresponding backplane NuBus connector. Ensure that the component side of the board faces the right side of the cabinet.

5. Slide the board into the selected slot and ensure that the DIN connectors engage the backplane connectors. Use the two injectors to lock the board into the slot.

6. Fully close and latch the internal metal door. This door must be in place before the system is returned to operation.

7. Close the front door or replace the trim panel.

8. Open the rear door or remove the rear trim panel.

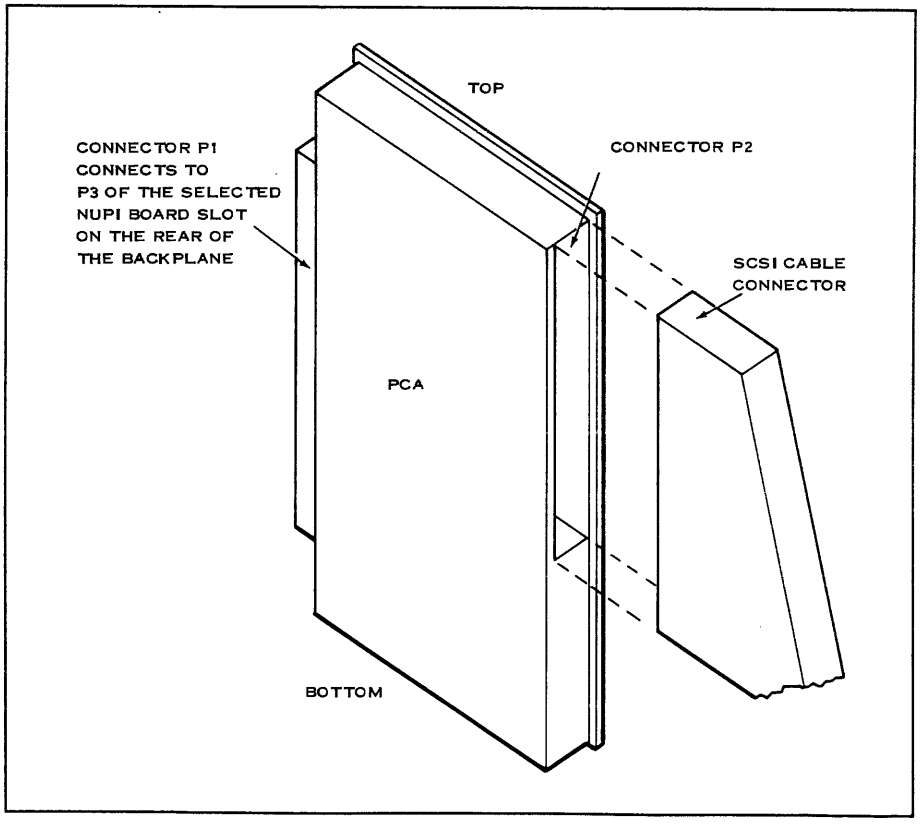
9. Install the printed circuit adapter (PCA) on the appropriate I/O connector (P3) at the rear of the backpanel. The I/O connectors are the bottom row. Figure 2-1 shows the PCA.

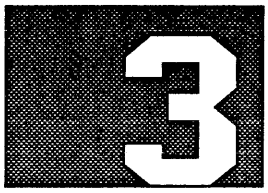
10. Install the SCSI cable and the mass storage enclosure. Ensure that the SCSI cable connector is positioned as shown in Figure 2-1. Refer to the appropriate system enclosure manual for cable routing from the PCA to the mass storage enclosure.

11. Close the rear door or replace the rear trim panel.

12. Perform the NUPI self-test to verify proper system operation. (Refer to Section 3.)

Figure 2–1 **Peripheral Cable Adapter and SCSI Cable Installation**





OPERATING INSTRUCTIONS

Introduction

3.1 This section provides self-test operation information for the NuBus peripheral interface (NUPI) board installed in an Explorer computer system. Refer to your system enclosure general description manual for the locations of operating controls.

Reset, Power-Up Sequence, and Self-Test Execution

3.2 Any one of the following conditions resets the NUPI board and initiates the NUPI self-tests:

- Completion of a power-up sequence
- Recognition of a NuBus reset condition
- Execution of a Self-Test All command
- Generation of a software reset

Successful completion of the NUPI self-test initiates the SCSI self-test. After successful completion of both the NUPI and the SCSI self-tests, the NUPI waits to be enabled as a NuBus master. The first time the NUPI is enabled as a NuBus master, it runs a short self-test of the NuBus slave logic and the NuBus transceiver.

The NUPI board has two self-test fault indicator light-emitting diodes (LEDs). The red LED is for the NUPI board and the yellow LED is for the SCSI bus. Failure of either of these LEDs to extinguish following self-test indicates a self-test failure. In the case of the SCSI bus, a failure can be either in the NUPI on-board SCSI interface logic, the SCSI bus cable, or a device in the mass storage enclosure.

Failure of the red LED to extinguish following self-test can indicate either a NUPI fault or a fault on one of the other NuBus devices that precludes successful self-test completion. For example, this could indicate a defective processor or memory board. However, in this case, more than one fault LED should remain on.

Either a self-test failure or an active test-LED bit in the configuration register prohibits the NUPI from processing any commands.

NUPI Board Self-Test Procedure

3.3 Perform the following test procedure after a new NUPI board has been installed in an Explorer computer system:

1. Set the power switches on the mass storage enclosure and system enclosure to the on position.

2. Open the front door or remove the front trim panel to gain access to the inner metal door. Do not open the metal door because doing so will turn off the enclosure power. View slots in the metal door allow visual access to the on-board fault LEDs.

3. Check that the red LED on each of the circuit boards in the enclosure is on to indicate that the self-test for that board is operating. Figure 3-1 shows the location of these fault LEDs.

4. If the NUPI fault LED fails to go out following self-test completion, and all other fault LEDs are out, replace the NUPI board and execute the test again.

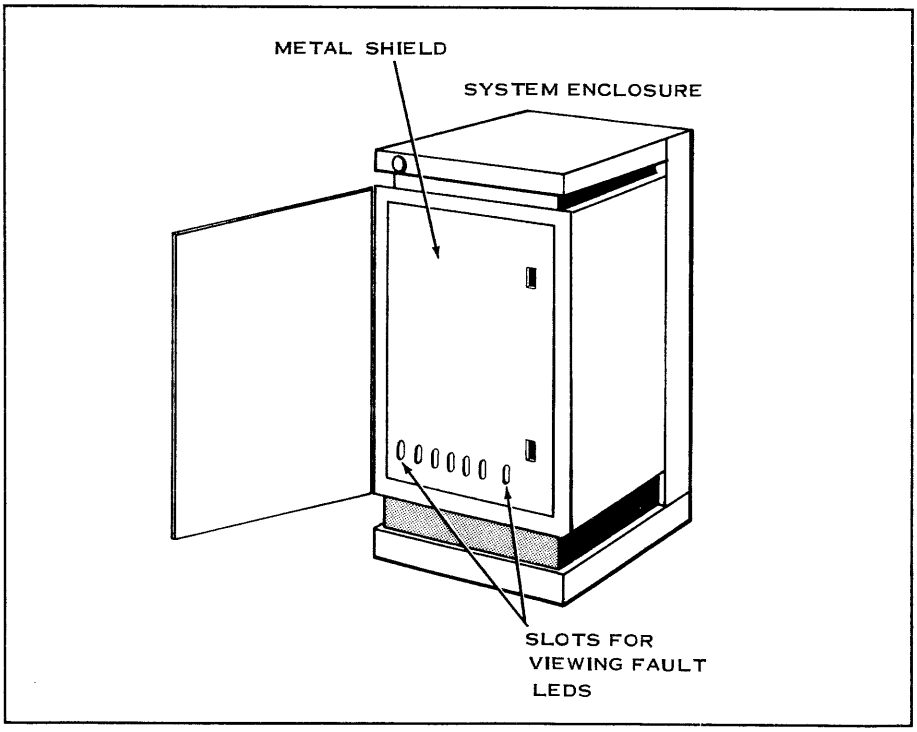
5. If the SCSI bus fault LED fails to go out following self-test completion, verify that all mass storage enclosures are properly connected and powered up. If this does not reveal the source of the SCSI fault, perform the following steps:

   a. Set the system enclosure power switch to the off position and disconnect the SCSI cable.

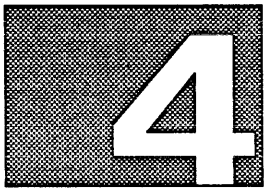
   b. Set the system enclosure power switch to the on position and wait for self-test completion.

   c. If the SCSI fault LED still does not go out, replace the NUPI board and/or PCA. Otherwise, replace the SCSI cable and/or mass storage enclosure.

Figure 3–1 **Example of Fault LED Locations**



HARDWARE DESIGN INFORMATION



Introduction

4.1 This section contains information on the following topics:

- NUPI operation as a master or slave
- NUPI functions
- NUPI bus structure
- Data transfer operations
- Functional block diagram

The NuBus peripheral interface (NUPI) board provides an interface between the Explorer computer system and both disk and tape mass storage devices. It receives command blocks from the processor via the NuBus and interprets these command blocks to determine the quantity of data to be transferred, as well as the transfer direction and destination. Thus, the NUPI coordinates the transfer of data, command, and status information between system memory and the mass storage devices.

The NUPI arbitrates with other system devices for control of the NuBus and can operate as either a NuBus slave or a NuBus master device. The following paragraphs describe NUPI slave and master operations.

NUPI Slave Operations

4.1.1 When operating as a NuBus slave device, the NUPI responds to commands from NuBus master devices. The following paragraphs describe the functions of the NUPI as a NuBus slave device.

NUPI Configuration and Status Information

4.1.1.1 The on-board NUPI read-only memory (ROM) stores configuration parameters that identify the board as a NUPI. These parameters provide such information as board type, buffer size, and board part number. During system initialization, the processor reads these configuration parameters to determine the NUPI slot location and other identifying characteristics of the board. Section 5 lists the NUPI configuration parameters.

The NUPI contains an eight-bit flag register that stores information concerning NUPI and Small Computer Systems Interface (SCSI) self-test status. These self-tests are implemented in the NUPI on-board ROM and are executed during system initialization. Completion of these self-tests returns status information to the flag register. The system processor can then read the contents of this register to determine whether or not the self-tests completed successfully. Section 5 defines the individual bits of the flag register.

Command Block Starting Address and NUPI Configuration

4.1.1.2 Commands destined for the NUPI or the mass storage devices reside in NuBus memory as blocks of 32-bit registers containing all necessary command information. During system initialization or prior to the execution of any NUPI or mass storage command, the system processor writes the physical memory starting address into the NUPI command address register. This command address register resides in the on-board NUPI RAM.

The NUPI RAM also contains a configuration register. This configuration register contains NuBus enable, fault LED state, NuBus test, and other system information. The system processor supplies this information during system initialization before issuing a command to the NUPI.

NUPI Master Operations

4.1.2 The NUPI is under the control of the on-board microprocessor (MPU) during NUPI master operations. After being enabled as a NuBus master and receiving the command block starting address, the MPU gains access to the NuBus and requests the command block designated by the command block starting address. The MPU and DMA control logic then proceed with command execution.

NuBus to SCSI Bus Interface

4.1.3 The 32-bit NuBus handles all communications between the NUPI and the system whereas all communications between the NUPI and the mass storage enclosure are via the 8-bit SCSI bus. This communication scheme requires that the NUPI be able to translate between 32-bit words for the NuBus and 8-bit bytes for the SCSI bus. The following paragraphs provide an overview of these buses.

SCSI Bus

4.1.3.1 The SCSI bus is a low-active bus that transfers addresses, data, parity, control, and status information between the NUPI and the mass storage devices. A bus arbitration scheme allows the bus to be under the control of the NUPI SCSI logic or any one of up to eight mass storage devices at any given time. All information transfers over the SCSI bus are asynchronous and follow a request/acknowledge handshake protocol. Each handshake operation allows the transfer of one 8-bit byte of data.

Communication via the SCSI is allowed between only two SCSI devices at any given time. The NUPI is the SCSI bus initiator, and the mass storage formatter is the target. The initiator is the device that originates an operation, and the target is the device that performs the operation.

SCSI Phases The SCSI architecture includes eight distinct phases. The SCSI bus can never be in more than one of these phases at any given time. These phases are as follows:

- Bus-free phase — This phase indicates that no SCSI device is actively using the SCSI bus and that the SCSI bus is available for subsequent users.

- Arbitration phase — This phase allows a SCSI device to gain control of the SCSI bus and to assume the functions of either an initiator or a target device.

- Selection phase — This phase allows the initiator to select a target for the purpose of initiating some operation within the target.

- Reselection phase — This phase allows a target device to reselect an initiator for the purpose of continuing some previously initiated operation that has been suspended by the target.

NOTE: All of the following phases are collectively termed the *information transfer phases*. All data and control information transfers occur during these phases.

- Command phase — This phase allows the target device to request command information from the initiator.

- Data phase — This phase consists of the data-in phase and the data-out phase as follows:

  - During the data-in phase, the target sends data from the target to the initiator.

  - During the data-out phase, the target requests data from the initiator.

- Status phase — In this phase, the target sends status information to the initiator.

- Message phase — This phase consists of the message-out phase and the message-in phase as follows:

  - During the message-out phase, the initiator sends messages to the target.

  - During the message-in phase, the target requests messages from the initiator.

SCSI Signal Definitions The SCSI bus uses nine control signals for transferring control information, eight data signals for transferring address and data information, and a parity signal for transferring bus parity information. Table 4-1 lists and defines these SCSI signals.

Table 4-1 SCSI Bus Signal Definitions

Signal	Definition
BBSY–	Bus busy. When active, this signal indicates that the SCSI bus is being used.
BSEL–	Bus select. This signal can be under the control of either the initiator or the target device. The initiator uses BSEL– to select a target, and the target uses the signal to reselect the initiator.
BCD–	Bus control/data. The target device drives this signal low to indicate that the bus is carrying control information and high to indicate that it is carrying data.
BIO–	Bus input/output. The target device drives this signal to indicate the data transfer direction. Low indicates a target-to-initiator transfer; high indicates an initiator-to-target transfer.
BMSG–	Bus message. The target activates this signal during the message phase of an information transfer. Activation during the message-out phase indicates that a message is to be sent from the initiator to the target. Activation during the message-in phase indicates that a message is to be sent from the target to the initiator.
BREQ–	Bus request. The target activates this signal to initiate a request for a data byte transfer.
BACK–	Bus acknowledge. The initiator activates this signal to acknowledge a request for a data byte transfer.
BATN–	Bus attention. The initiator activates this signal to indicate that it has a message ready for the target and that the target can receive this message at its convenience by performing a message-out phase.
BRST–	Bus reset. The NUPI activates this signal to clear all SCSI devices.
BDB7– ↓ BDB0–	Data bus. The data bus transfers addresses, data, and parity between the SCSI devices. BDB7– is the most significant bit, and BDB0– is the least significant bit.
BDBP–	Data parity bit. The SCSI bus uses odd parity, and all SCSI devices can generate this bit.

NuBus

4.1.3.2 The NuBus is a synchronous, low-active bus that links the NUPI to the system processor, system memory, and other system devices. All transitions and signal samplings are synchronized to the 10-megahertz system clock.

NuBus Structure The NuBus is a multiplexed 32-bit bus that carries both addresses and data between the NUPI and other system devices. The bus also carries control and status information. The NUPI is allocated a 16-megabyte block in the NuBus address space. This memory block is used for all NUPI slave operations and its location in memory is determined by the slot in which the NUPI is installed.

Figure 4-1 shows the organization of NuBus bits. These bits are designated as bits 0 through 31, where bit 0 is the least significant bit and bit 31 is the most significant bit. The NuBus can perform 32-bit word, 16-bit halfword, or 8-bit byte operations.

Figure 4-2 shows the data paths for bytes, halfwords, and words over the NuBus. Any given data byte is always carried on the same set of NuBus lines regardless of the transfer mode. The address lines are allocated as follows:

- Byte 0 — AD0– through AD7–
- Byte 1 — AD8– through AD15–
- Byte 2 — AD16– through AD23–
- Byte 3 — AD24– through AD31–

This data path approach allows straight-forward connection of either 8-bit, 16-bit, or 32-bit devices.

Figure 4-1 **NuBus Bit Organization**

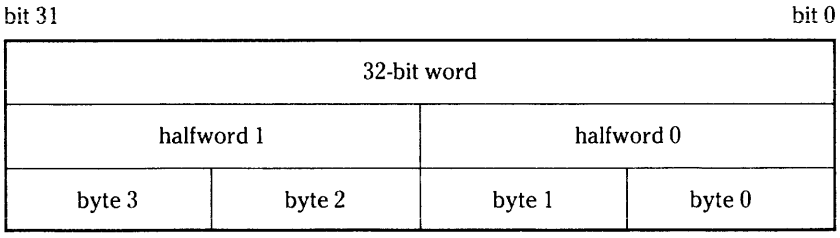
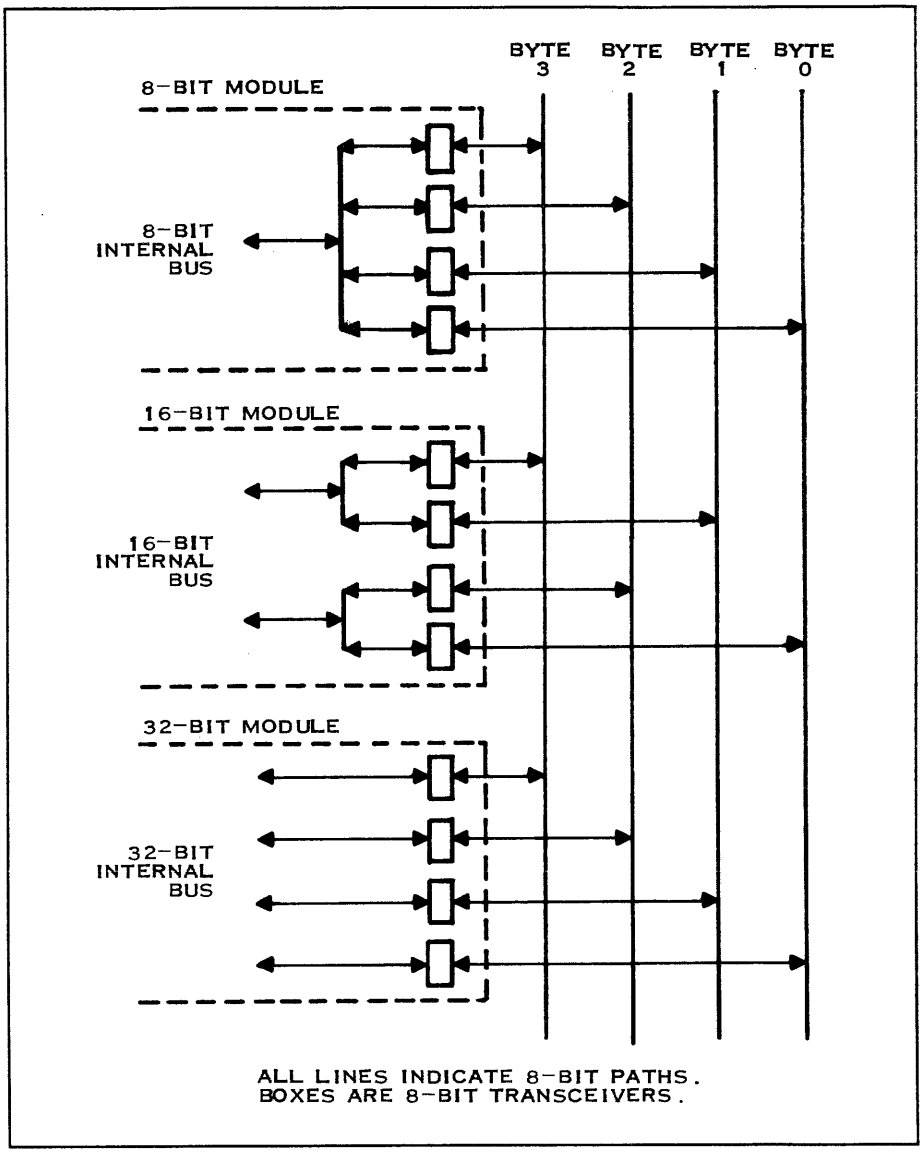


Figure 4-2 **Data Paths for 8-Bit, 16-Bit, and 32-Bit Devices**



NuBus Slot ID The NUPI board base physical address depends on the backplane slot in which the board is installed. Each NuBus backplane slot has a unique 4-bit slot identification code (ID0- through ID3-). These ID code bits are located at backplane connector P1 pins 90, 26, 91, and 27, respectively. The level on each of these pins is fixed for any given slot location.

The NUPI board base physical address as it appears on the NuBus is defined as follows:

>FSXXXXXX

where:

>F equals binary 1111. These are the four most significant bits (AD28– through AD31–) of the address.

S is a 4-bit binary code in the range of 0000 through 1111 that corresponds to the NUPI board slot number and forms address bits AD24– through AD27–.

XXXXXX represents the hexadecimal equivalent of address bits AD0– through AD23–.

NuBus Signal Definitions The NuBus provides 32 multiplexed lines for address and data transfers, 4 control signals, and 5 arbitration signals. In addition, the bus also supports a group of utility signals including the system clock, system reset, and 4 slot identification signals. Table 4-2 lists and defines these NuBus signals.

Table 4-2 NuBus Signal Definitions

Signal	Definition
AD31– ↓ AD0–	Address/data signals. These lines are multiplexed to carry 32-bit addresses at the beginning of each transaction and up to 32 bits of data later in the transaction. AD1– and AD0– also serve as part of the data transfer mode code.(See the definition for TM1– and TM0–.)
START–	Transfer start. This signal is activated for one clock cycle at the beginning of a transaction to indicate that the address/data lines are carrying a valid address. This clock cycle is called the start cycle.
ACK–	Transfer acknowledge. The addressed slave device activates this signal for one clock cycle to indicate the completion of a transaction. This clock cycle is called the acknowledge cycle.
TM1– ↓ TM0–	Transfer mode signals. These signals, along with AD1– and AD0–, form a 4-bit binary code that specifies, during the start cycle, the type of data transfer (word, halfword, or byte) to be performed. The addressed slave drives these signals during the acknowledge cycle to indicate the status of the transfer operation.
CLK–	System clock. The system clock is a 10-megahertz clock that synchronizes bus arbitration and data transfers between system devices on the NuBus. The clock has an asymmetric duty cycle of 75 percent. In general, signal changes occur on the rising edge of CLK– and are sampled on the falling edge.

Table 4-2 NuBus Signal Definitions (Continued)

Signal	Definition
RESET–	Reset signal. This signal serves two functions, depending on its duration. When active for a single clock period (bus reset), the signal causes a NuBus interface initialization for all devices on the NuBus. When active for more than one clock period (system reset), the signal returns all NuBus devices to the initial power-up state.
ID3– ↓ ID1–	Board slot identification signals. These signals are binary coded to specify the physical location of a device on the NuBus. The distributed arbitration logic uses these ID numbers to uniquely identify NuBus devices for arbitration contests.
ARB3– ↓ ARB0–	Arbitrate signals. These signals are driven by contenders for the NuBus to determine which NuBus device becomes the NuBus master.
RQST–	NuBus request. During arbitration, NuBus devices contending for control of the bus must first activate RQST– and then place their slot ID codes on the arbitrate lines. In the case of more than one contender, the contender with the highest slot ID becomes the NuBus master.

NUPI Functional Overview

4.2 Figure 4-3 shows the functional organization of the NUPI. The four functional areas of the board are the NuBus interface logic, the SCSI controller, the DMA logic, and the MPU control logic. All board functions, including data transfers, are under the control of the MPU control logic.

Each NuBus cycle to the NUPI board begins with a write operation to the on-board RAM. This write operation informs the MPU that a command is pending and specifies the system memory address at which the command is located. The MPU, in response to an interrupt, reads the command block from the specified memory address. It then proceeds to execute the command.

After determining the nature of the command, the MPU sets up the SCSI controller for the specified operation. This causes the SCSI controller to arbitrate for access to the SCSI bus. After SCSI bus access is granted, the SCSI controller communicates with the mass storage device formatter to obtain a request for the data transfer to begin. During this period, the MPU continues to process the command block to determine the quantity of data to be transferred, the transfer direction, and the destination addresses.

Using the parameters specified in the command block, the MPU initializes all transfer counts and sets up the DMA control logic to handle the data transfer. The MPU then starts the DMA operation.

If the specified operation is a read from mass storage operation, the DMA logic receives the data via the SCSI controller in the form of 8-bit bytes. The DMA control logic performs the following operations:

1. Loads the data bytes into the first-in-first-out (FIFO) RAM as the two bytes of a 16-bit halfword

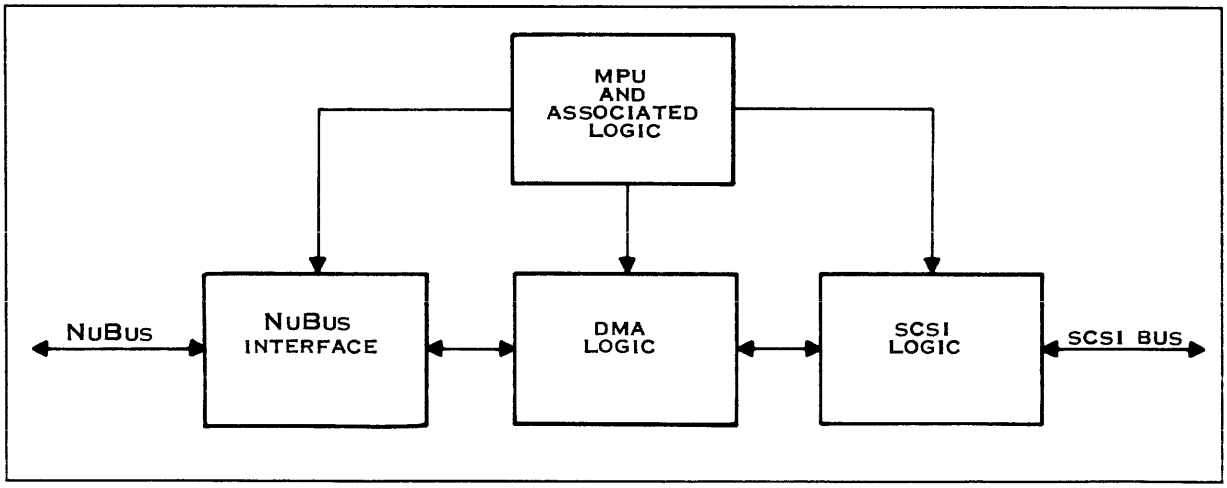
2. Reads the halfwords from the FIFO RAM into the NuBus interface logic as the two halfwords of a 32-bit word

3. Generates a request to the NuBus arbitration logic for access to the NuBus

After gaining access to the NuBus, the DMA logic places the previously determined destination address on the NuBus and completes the transfer by placing the 32-bit data word on the bus. This process continues for subsequent data bytes until the entire block of data has been transferred.

The process for writing to a mass storage device is identical to the read operation except that all steps are reversed.

Figure 4–3 NUPI Functional Organization



NUPI Bus Structure

4.3 The NUPI internal buses maximize data throughput and minimize command processing time. These buses facilitate orderly communication of addresses, data, and control information between the various functional areas of the NUPI. The following paragraphs describe the NUPI internal bus structure.

MPU Address Bus

4.3.1 The MPU address bus is a 23-bit, unidirectional, three-state bus (MAB0 through MAB22) that provides addresses for all MPU bus cycles. During normal operation, the MPU generates addresses on the MPU address bus. During NuBus slave cycles, the NuBus master device generates these addresses and places them on the bus via the NuBus interface logic. Address decode logic on the NUPI board decodes certain address bits to generate control signals needed for processing the specified command.

MPU Data Bus

4.3.2 The MPU data bus is a 16-bit, bidirectional, three-state bus (MB0 through MB15) that transfers data, control, and status information between the MPU (in some cases), the NuBus, and various associated logic devices. During NUPI slave operations, the NuBus master uses the MPU data bus to read data from the NUPI ROM or RAM and to write to the NUPI RAM. The MPU uses the data bus to write to the NUPI RAM, the interval timer, the DMA bus, and the NuBus, or to read from all of these locations and the NUPI ROM.

Data transfers on the MPU data bus can be either halfword or byte operations, depending on the states of the upper data strobe (UDS–) and the lower data strobe (LDS–). These MPU control signals determine whether the data transfer is a 16-bit halfword, or the upper or lower 8-bit byte.

Input/Output (I/O) Bus

4.3.3 The I/O bus (IOB0 through IOB31) is a 32-bit bidirectional bus that carries addresses and data for all NuBus cycles. During NUPI self-test operations, the I/O bus carries loopback data.

DMA Bus

4.3.4 The DMA bus (DMA0 through DMA15) is the principal internal bus for data transfers between the NuBus and the SCSI bus. During mass storage read operations, the DMA bus transfers data from the SCSI bus to the FIFO RAM and from the FIFO RAM to the NuBus. During mass storage write operations, the bus transfers data from the NuBus to the FIFO RAM and from the FIFO RAM to the SCSI bus.

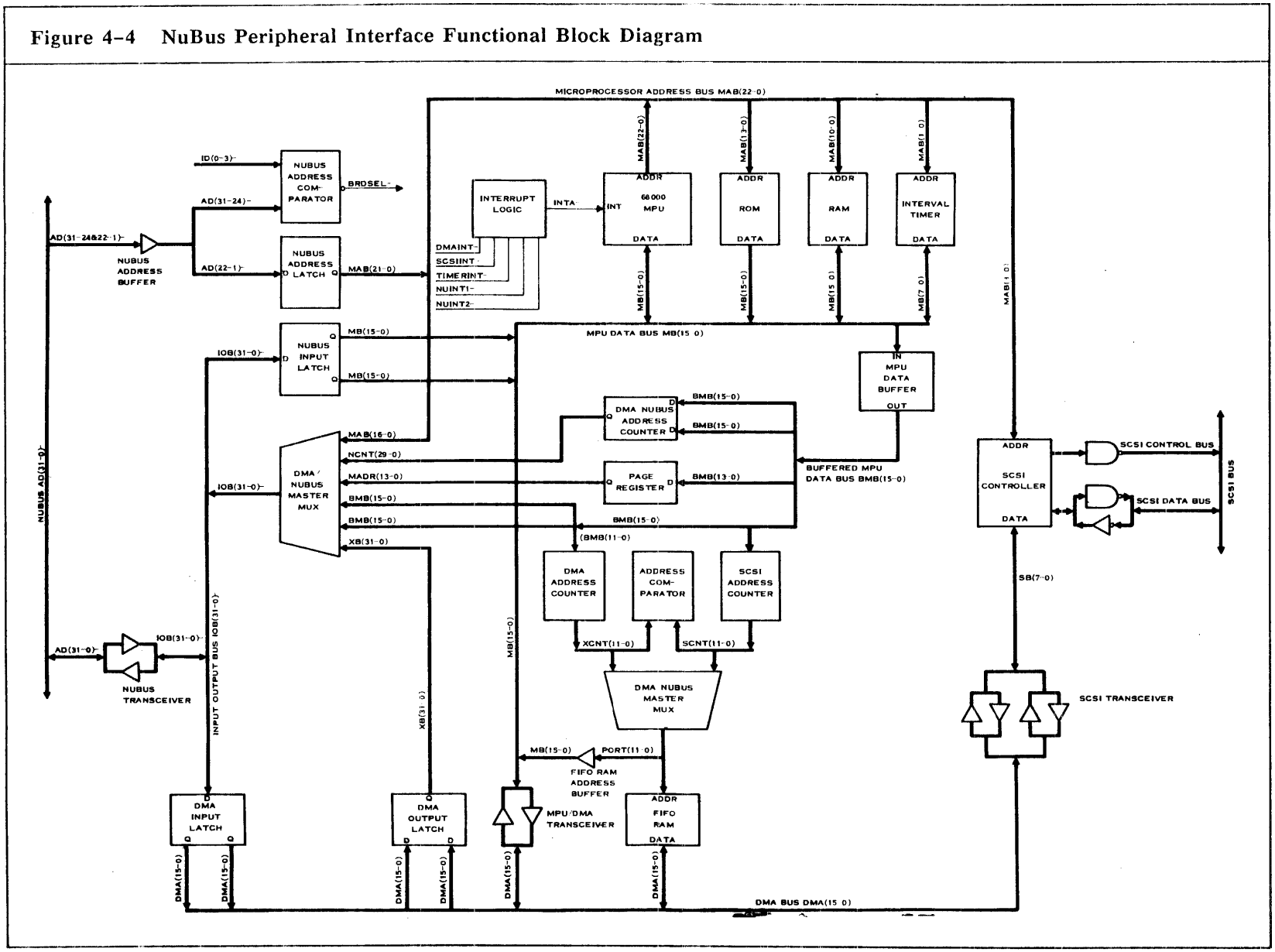
Basic Data Flow for Mass Storage Operations

4.4 The NUPI handles all data transfers between the 32-bit, synchronous NuBus and the 8 bit, asynchronous SCSI bus. A FIFO data transfer scheme on the NUPI compensates for the differences between the two buses. The following paragraphs describe a complete mass storage read operation in which data is transferred from a mass storage device to the NuBus via the NUPI. (Refer to Figure 4-4.)

NUPI Command Initialization

4.4.1 The NuBus master initializes the command by placing address >FSE00004 on the NuBus. >FSE00004 is the NUPI address for the command address register. The NuBus address receiver passes the upper 8-bits (>FS) of the address to the NuBus address comparator and the remaining bits to the NuBus address latch. The NuBus address latch stores these bits for later placement on the MPU address bus.

Figure 4–4 NuBus Peripheral Interface Functional Block Diagram



The NuBus address comparator decodes the upper eight address bits by comparing them to the fixed NUPI slot ID (>FS). Since the address is intended for the NUPI, the upper eight address bits are identical to this slot ID, resulting in the generation of the NUPI board select signal.

The NUPI slave logic senses the received slot ID code and generates a request for access to the MPU address and data buses. After the MPU completes its current cycle, the slave logic gains access to the MPU data bus and enables the NuBus address latch to place the address on the MPU address bus.

The NuBus I/O control logic enables the NuBus transceiver to transfer the NuBus data (the command address) from the NuBus to the I/O bus and latches it into the NuBus input latch. The command address is then enabled through the NuBus input latch to the MPU data bus. The MPU address decode and control logic selects the NUPI RAM, and the NuBus slave logic writes the two consecutive halfwords from the MPU data bus into the RAM.

On cycle completion, the NuBus master relinquishes control of the MPU address and data buses back to the MPU. The NuBus slave logic generates an interrupt to the MPU to indicate that the NuBus has written to the NUPI. The MPU then reads the command address register to determine the address of the command, then initializes the NUPI internal logic to receive the command block. This initialization of the NUPI logic is as follows:

- The MPU places the 14 most significant address bits from the command address in the page register.
- The MPU initiates a cycle to the NuBus.
- Internal arbitration between the MPU and the DMA control logic grants the MPU access to the NuBus. The NuBus address is formed by concatenating the lower 17 bits of the MPU address with the bits previously latched into the page register.

The NuBus master logic generates a NuBus start cycle to initiate the transfer of the first word of the command block from system memory to the NUPI RAM. The command block consists of eight 32-bit words. Therefore, the NUPI must perform eight complete data transfer operations in order to transfer the entire command block.

After the entire command block has been read from the NuBus to the NUPI RAM, the MPU interprets it to determine what operation is to be performed. The MPU then generates an access request to the SCSI bus by issuing a command to the SCSI controller via the DMA bus and SCSI transceiver.

After the SCSI selects a formatter, the formatter requests the command information. After receiving the command information, the formatter requests the start of the data transfer operation. During the period between the SCSI bus selection request and the request for the data transfer, the MPU continues to process the command block and completes the NUPI initialization as follows:

- Sets up the byte transfer count in the SCSI controller's internal counter.
- Initializes the DMA/SCSI address counter to the FIFO RAM starting addresses.
- Initializes the DMA/NuBus address counter to the NuBus starting address.
- Initializes one section of the interval timer with the number of 32-bit words to be transferred (data transfer count) to the NuBus.
- Initializes the DMA transfer direction.

After the SCSI controller generates an interrupt to the MPU indicating that it is ready to begin the data transfer operation and after the initialization is complete, the MPU then begins the DMA operation.

Data Transfer Operation

4.4.2 DMA data transfer operations can be either read or write operations between the NuBus and the mass storage devices. These operations are identical in every respect except that the steps involved in a write operation are the reverse of those for a read operation. The following paragraphs describe a mass storage read operation.

The mass storage device sends 8-bit data bytes over the SCSI bus to the SCSI controller. The SCSI controller transfers these bytes via the SCSI transceiver and the DMA bus to the FIFO RAM where they are assembled into 16-bit halfwords. After two consecutive bytes have been transferred to the FIFO RAM and assembled into a halfword, the DMA controller transfers the halfword to the DMA output latch.

After two consecutive halfwords have been transferred to the DMA output latch, the DMA controller generates a NuBus request to the NuBus master arbitration logic. The NuBus master arbitration logic grants the DMA controller access to the NuBus. The NuBus master controller then transfers the previously loaded NuBus address from the DMA/NuBus counter onto the NuBus via the DMA/NuBus master multiplexer and the NuBus transceiver. This address transfer occurs during the NuBus start cycle.

After completion of the NuBus start cycle, the 32-bit word is transferred from the DMA output latch to the NuBus via the DMA/NuBus master multiplexer and the NuBus transceiver. NuBus cycle completion updates the DMA/NuBus address counter to the next NuBus address, and the process continues until the entire data block has been transferred from the mass storage device to the destination address.

NUPI Command Completion

4.4.3 After completing a data transfer operation, the SCSI controller notifies the MPU that the transfer is complete, and the interval timer signals the MPU that the NuBus transfer count has expired. The MPU then completes the transaction by posting completion status to the NuBus.

Detailed Functional Block Diagram Description

4.5 Figure 4-4 shows a detailed functional block diagram of the NUPI board. The major functional blocks of the board are as follows:

- MPU and associated logic
- MPU/NuBus interface
- DMA logic
- SCSI logic

The following paragraphs describe the NUPI board functional blocks and internal bus structure.

MPU and Associated Logic

4.5.1 All NUPI operations are under the control of the on-board MPU and its associated logic. The following paragraphs describe this logic.

MC68000 MPU

4.5.1.1 The MC68000 MPU is the on-board processor for the NUPI. The MPU monitors and controls all NUPI operations, processes NuBus commands, issues SCSI commands, and executes NUPI and SCSI self-tests. The MPU initiates commands to the SCSI bus via the SCSI controller. It responds to interrupts and executes interrupt service routines.

NUPI ROM

4.5.1.2 The NUPI on-board ROM stores information in the form of 16-bit halfwords in two 8192 by 8-bit ROMs. These ROMs contain the MPU firmware, the NUPI configuration data, the NUPI and SCSI self-test firmware, and the NUPI device service routine (DSR) boot code. Refer to Section 5 for more information about the ROM contents.

NUPI RAM

4.5.1.3 The NUPI on-board RAM stores information in the form of 16-bit halfwords in two 2048 by 8-bit RAMs. These RAMs contain the NUPI command address register, the NUPI configuration register, various control and status registers, and internal control data structures for all active commands. Refer to Section 5 for more information about the RAM contents.

Interval Timer

4.5.1.4 The interval timer contains the NuBus data transfer count during DMA operations. The MPU initializes this count prior to a DMA data transfer operation and decrements the count after each 32-bit NuBus word has been transferred. An expired count signals the end of the data transfer operation. The interval timer also provides on-board event generation for polling and time-outs.

MPU Interrupt Logic

4.5.1.5 The MPU responds to five interrupt levels on the NUPI. On-board interrupt logic latches these interrupts and encodes them into a 3-bit binary code for the MPU interrupt inputs. The five interrupt levels are as follows:

- Level 1 — DMA complete interrupt (DMAINT–). The DMA control logic generates this interrupt to indicate the completion of a DMA operation.
- Level 2 — SCSI interrupt (SCSIINT–). The SCSI controller generates this interrupt to indicate a SCSI event.

- Level 3 — Timer interrupt (TIMERINT–). The interval timer generates this interrupt.
- Level 4 — NuBus interrupt 2 (NUINT2–). The NuBus master logic generates this interrupt to indicate that a NuBus error has occurred during a NuBus master operation.
- Level 5 — NuBus interrupt 1 (NUINT1–). The NuBus master slave logic generates this interrupt to indicate that a write operation has occurred to the most significant byte (bits 24 through 31) of a 32-bit word.

MPU/NuBus Interface

4.5.1.6 The MPU cannot address the 32-bit NuBus directly because its address bus is limited to 23 address bits. Thus, the NUPI board uses the following scheme to generate addresses to the NuBus:

1. The MPU loads the page register with the lower 14 bits of the MPU data bus. These bits are to be used as the upper 14 bits of the NuBus address.
2. The MPU master multiplexer develops the NuBus address by concatenating UDS– and the lower 17 bits of the MPU address bus with the page register.

The data flow from the NuBus to the MPU data bus is as follows:

1. The NuBus I/O control logic enables the NuBus transceiver to transfer 32-bit data words from the NuBus to the I/O bus, then latches the data into the NuBus input latch.
2. The MPU control logic enables the NuBus input latch to place the 32-bit data words on the MPU data bus as two consecutive 16-bit halfwords.

The data flow from the MPU data bus to the NuBus is as follows:

1. The NuBus I/O control logic enables the 16-bit halfword through both the upper and lower half of the MPU master multiplexer.
2. The NuBus I/O control logic enables the 32-bit data words onto the NuBus via the NuBus transceiver.

NuBus Interface Logic

4.5.2 The NuBus interface logic consists of the NuBus transceiver, the NuBus slave logic, and the NuBus master logic. The following paragraphs describe this logic.

NuBus Transceiver

4.5.2.1 The NuBus transceiver passes 32-bit data and address words bidirectionally between the NuBus and the I/O bus. The transfer direction is under the control of the NuBus I/O control logic.

NuBus Slave Logic

4.5.2.2 The NuBus slave logic consists of the NuBus address buffer, the NuBus address latch, and the NuBus address comparator. This logic monitors the NuBus continuously for read or write cycles destined for the NUPI.

The NuBus address comparator determines when the NUPI is being addressed by comparing >F and the NUPI slot ID to the eight most significant bits of the NuBus address. If these bits correspond to each other, the comparator activates the NUPI board select signal and control signals in the NuBus I/O control logic and the NuBus slave logic.

The NuBus address buffer and latch isolate the NUPI's internal address bus from the NuBus. The buffer passes all NuBus addresses to the latch and, if an address is destined for the NUPI, the NuBus slave logic requests access to the MPU address bus. After gaining bus access, the NuBus slave logic enables the NuBus address latch to place the address on the bus.

NuBus Master Logic

4.5.2.3 A request from either the MPU or the DMA control logic causes the NuBus master logic to generate a NuBus cycle request. After generating the request, the NuBus master logic arbitrates for control of the NuBus, and after becoming the NuBus master, the NuBus master logic initiates data transfers to or from the NuBus.

NuBus arbitration is accomplished by the NuBus arbitration logic. After the NuBus master activates the NuBus arbitration request line, the NuBus arbitration logic places the NUPI slot ID code on the NuBus arbitration lines. If no device with a higher slot ID is contending for NuBus control, the NuBus arbitration logic grants NuBus control to the NUPI's NuBus master logic.

SCSI Logic

4.5.3 The SCSI logic consists of the SCSI controller chip, the SCSI bus driver/receiver, and the DMA to SCSI transceivers. After being initiated by the MPU, the SCSI logic handles all data transfers between the 8-bit SCSI bus and the 16-bit FIFO RAM.

SCSI Controller Chip

4.5.3.1 The MPU controls the operation of the SCSI controller by writing to and reading from the chip's internal registers. The SCSI controller provides handshake signals for data transfers between the SCSI to DMA transceiver and the SCSI bus. On completion of a data transfer operation or on occurrence of any SCSI bus condition that requires servicing, the controller generates an interrupt to the MPU.

SCSI Driver/Receiver

4.5.3.2 The SCSI driver/receiver, under control of the SCSI controller, inverts and transfers data and control information from the SCSI controller chip to the SCSI bus during mass storage write operations. During mass storage read operations, the driver/receiver inverts and transfers data and status information from the SCSI bus to the SCSI controller.

SCSI to DMA Transceiver

4.5.3.3 During mass storage read operations, the SCSI to DMA transceiver transfers 8-bit data bytes from the SCSI controller to the DMA bus and assembles them into 16-bit halfwords in the FIFO RAM. During mass storage write operations, the transceiver transfers 16-bit halfwords as two consecutive 8-bit bytes from the FIFO RAM to the SCSI controller. The DMA control logic determines the transfer direction and enables the SCSI to DMA transceiver to transfer the data.

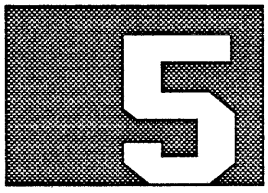
DMA Logic

4.5.4 The DMA logic consists of the FIFO RAM and the DMA/SCSI address counters. This logic, under control of the DMA control logic, is the principal element in the transfer of data between the 8-bit asynchronous SCSI bus and the 32-bit synchronous NuBus.

The FIFO RAM provides temporary storage of 16-bit data halfwords in two 1024 by 8-bit RAMs during transfers between the NuBus and the SCSI. The input and output addresses are independently generated by the DMA/SCSI address counters so that the input addresses are always ahead of the output addresses. The DMA controller ensures that this condition prevails by continuously comparing the addresses and stopping the appropriate counter when the addresses become equal. This prevents attempts to remove data from the RAM before data is available.

During the initialization stage of a data transfer operation, the MPU loads the FIFO RAM base addresses into the counters. As the transfer progresses, the DMA control logic increments the counts. For transfers from the NuBus to the SCSI bus, the DMA address counter controls the input addresses, and the SCSI address counter controls the output addresses. For transfers from the SCSI bus to the NuBus, the roles of these two counters are reversed.

PROGRAMMING INFORMATION



Introduction

5.1 This section contains information on the following topics:

- NuBus data transfer operations
- NUPI configuration ROM
- NUPI registers
- NUPI command structures
- NUPI command execution
- NUPI command descriptions
- Error and status information

The NUPI responds to command blocks from the NuBus that determine the type of operations to perform and carries out these operations by executing the specified command. This section provides information required for accessing and issuing commands to the NUPI.

The programming information in this section is useful in writing custom mass storage driver routines. Most users will prefer to use TI standard system software, which includes efficient and thoroughly tested mass storage driver routines. The standard software also includes standardized file manipulation schemes that are essentially independent of device type.

NuBus Data Transfer Modes

5.2 The NuBus uses a data transfer mode code to specify the type and direction of any given data transfer. This code consists of the two transfer mode signals (TM1- and TM0-) and the two least significant NuBus address bits (AD1- and AD0-). TM1- and TM0- determine the transfer type and direction, and the address bits specify the data boundary. The data transfer mode code is active during each NuBus start. Table 5-1 defines the NuBus data transfer mode codes.

Table 5-1 **NuBus Data Transfer Mode Codes**

TM1-	TM0-	AD1-	AD0-	Data Transfer Type
L	L	L	L	Write byte 3
L	L	L	H	Write byte 2
L	L	H	L	Write byte 1
L	L	H	H	Write byte 0
L	H	L	L	Write halfword 1
L	H	L	H	Write block*
L	H	H	L	Write halfword 0
L	H	H	H	Write word
H	L	L	L	Read byte 3
H	L	L	H	Read byte 2
H	L	H	L	Read byte 1
H	L	H	H	Read byte 0
H	H	L	L	Read halfword 1
H	H	L	H	Read block*
H	H	H	L	Read halfword 0
H	H	H	H	Read word

NOTE:

*The NUPI does not support the write block and read block transfer modes.

NUPI Control Space

5.3 The NUPI control space is a 16-megabyte NuBus memory block in the address range of >FS000000 through >FSFFFFFF where S is a hexadecimal number corresponding to the number of the slot in which the NUPI is installed. This control space allocates specific NUPI board locations that can be accessed by the NuBus. Appendix B provides a map of the control space allocations, and the following paragraphs describe the allocated locations.

NUPI ROM

5.3.1 The NUPI ROM occupies a NuBus address range of >FSFFC000 through >FSFFFFFF and contains the following information:

- NUPI configuration data
- MPU firmware
- NUPI self-test firmware
- NUPI device driver boot code

The NUPI configuration data occupies a NuBus address range of >FSFFFF00 through >FSFFFFFF and contains specific information about the NUPI board. Some of this information, such as the board part number, does not vary from one NUPI board to another. Other information, such as the board serial number, is unique for each board. The configuration data is available on the NuBus as the least significant byte of each NuBus word. The other three bytes of each word have undetermined values. Table 5-2 lists and defines the configuration data.

Table 5-2 **Configuration ROM Field Bit Definitions**

Address Range	Data Value	Definition
>FSFFFF00	>02	Resource type. This is a one-byte binary field that allows the initial program loader to determine the resources required to perform the initial program load (IPL). In the case of the NUPI, bit 1 is set to indicate that this board is a disk controller that can be used as a load device.
>FSFFFF04	>C3	Test byte.
>FSFFFF08	>01	Test time.
>FSFFFF0C	>03	ROM layout. The value >03 indicates that the current NUPI ROM layout conforms to the Explorer system specification. Each revision of the document that affects the ROM will increment this value.
>FSFFFF10	>23	ROM flags. This one-byte field reports certain system information that is inherent to the NUPI board. The current value (0010 0011) indicates that the NUPI performs self-tests, participates in the NuBus system test, cannot be a system test master, does not support NuBus block moves, contains no accessible system memory, and requires a power failure event in case of a system power failure.
>FSFFFF14 >FSFFFF18 >FSFFFF1C	>02 >00 >D4	Flag register offset. This three-byte field indicates the offset between the start of the NUPI control space and the NUPI flag register address.
>FSFFFF20 >FSFFFF24 >FSFFFF28	>58 >FB >FF	Diagnostic offset. This three-byte field indicates the offset between the start of the NUPI control space and the lowest address of the NUPI diagnostic code.
>FSFFFF2C >FSFFFF30 >FSFFFF34	>58 >FB >FF	Device driver offset. This three-byte field indicates the offset between the start of the NUPI control space and the lowest address of the NUPI device-driven routine.
>FSFFFF38 >FSFFFF3C >FSFFFF40	>0B >00 >E0	Configuration register offset. This three-byte field indicates the offset between the start of the NUPI control space and the lowest address of the NUPI configuration register.

Table 5-2 **Configuration ROM Field Bit Definitions (Continued)**

Address Range	Data Value	Definition
>FSFFFF44	>30	NUPI board part number. This is the ASCII code for the NUPI board part number (2238040-0001).
>FSFFFF48	>30	
>FSFFFF4C	>30	
>FSFFFF50	>30	
>FSFFFF54	>32	
>FSFFFF58	>32	
>FSFFFF5C	>33	
>FSFFFF60	>38	
>FSFFFF64	>30	
>FSFFFF68	>34	
>FSFFFF6C	>30	
>FSFFFF70	>2D	
>FSFFFF74	>30	
>FSFFFF78	>30	
>FSFFFF7C	>30	
>FSFFFF80	>31	
>FSFFFF84	>4E	Board type and buffer size. The first three addresses contain the ASCII code NPI, indicating that this is a NUPI board. The next address contains >1A, the hexadecimal value of the logarithm of 1024 to the base 2. This value represents a buffer size of 1024 bytes. The remaining addresses are set to 0.
>FSFFFF88	>50	
>FSFFFF8C	>49	
>FSFFFF90	>1A	
>FSFFFF94	>00	
>FSFFFF98	>00	
>FSFFFF9C	>00	
>FSFFFFA0	>00	
>FSFFFFA4	>54	Vendor identification. These four addresses contain the ASCII code for TIAU, indicating that the board was manufactured by Texas Instruments Data Systems Group, Austin. This code can vary, depending on the manufacturing site.
>FSFFFFA8	>49	
>FSFFFFAC	>41	
>FSFFFFB0	>55	
>FSFFFFB4	>06	ROM size.
>FSFFFFB8		Cyclic redundancy check (CRC) signature. This signature is the result of a cyclic redundancy check of the ROM contents. The method is transparent but should always yield the same signature, indicating that the ROM contents are correct.
>FSFFFFBC		

Table 5-2 **Configuration ROM Field Bit Definitions (Continued)**

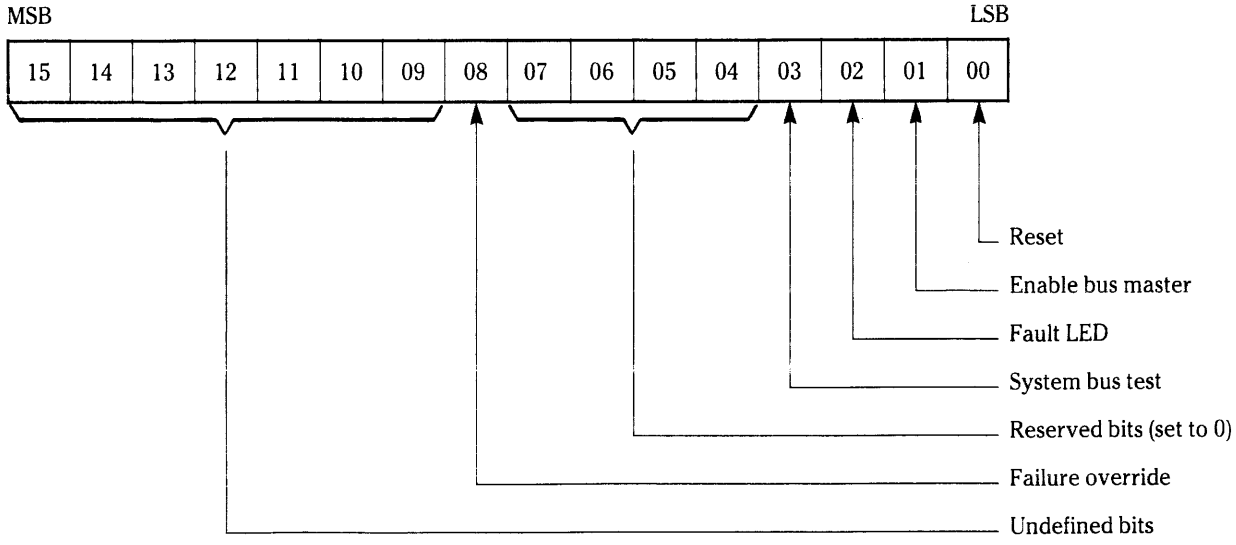
Address Range	Data Value	Definition
>FSFFFFC0 >FSFFFFC4 >FSFFFFC8 >FSFFFFCC >FSFFFFD0 >FSFFFFD4 >FSFFFFD8		Revision level. This is the ASCII code that indicates the current revision level (*) of the board. The asterisk indicates an unrevised board. The next revision level will be A, and each subsequent revision level will increment this value.
>FSFFFFDC >FSFFFFE0 >FSFFFFE4 >FSFFFFE8 >FSFFFFEC >FSFFFFF0 >FSFFFFF4 >FSFFFFF8 >FSFFFFFC		Serial number. These addresses contain codes indicating the week and year of manufacture, the manufacturing site, and a serial number.

The NUPI ROMs revision E (part numbers 2238056-0006 and 2238057-0006) have firmware that supports fixed block mode and variable block mode data transfers for 1/2-inch tape drives.

Configuration Register

5.3.2 Figure 5-1 shows the NUPI configuration register. The configuration register is a 16-bit register that contains parameters that are initialized at power-up or when required. These parameters determine the operating status of the board and can be read from or written to via the NuBus. The configuration register resides in the NUPI's on-board RAM at an address specified by the configuration register offset field of the configuration ROM.

Figure 5-1 NUPI Configuration Register



The individual bits and fields of the configuration register are defined as follows:

- Reset (bit 0) — Activating this bit resets both the NUPI and the SCSI bus and causes all NUPI power-up self-tests to be executed. Then, after a processing-overhead delay, all configuration register bits are deactivated.

- Enable bus master (bit 1) — Activating this bit enables the NUPI to become a NuBus master in order to process NuBus commands.

- Fault LED (bit 2) — When active, this bit activates the NUPI fault LED and self-test failure status. This bit overrides the result of any self-test operation. Therefore, self-test status must be determined prior to a configuration register update operation.

- System bus test (bit 3) — When active, this bit causes the NUPI to write the contents of the configuration ROM to a NuBus address specified by the direct memory access (DMA) test register and to read the data back for verification. This is repeated three times.

- Failure override (bit 8) — When active, this bit enables the NUPI to process commands even though either a self-test failure has occurred or the fault LED is on. When inactive, this bit prevents any command processing in the event that a self-test has failed.

The on-board microprocessor software interprets each bit of the configuration register. Therefore, in the event of a catastrophic self-test failure, the operation of these bits may be undefined. This condition also implies a delay between the writing of the register and the completion of its bit functions.

A configuration register update operation allows normal execution of ongoing commands, provided that the enable bus master bit is active and that the following bits are inactive:

- Reset

- Fault LED

- System bus test

An active system bus test bit allows any ongoing data transfer operation to continue but bars the initiation of any other command until all functions of this bit are complete.

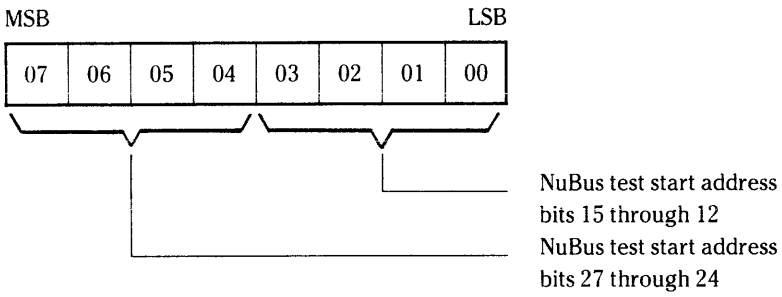
Activation of the fault LED and/or the reset bit terminates all ongoing NUPI or SCSI bus formatter commands and prevents both event generation and status updates for any pending inactive commands. Any command that is in progress when these bits are activated results in the generation of a command-aborted event. Disabling the NUPI as a NuBus master suspends all NuBus transactions but does not abort any ongoing command operation except those that are time dependent. Restoring the NUPI as a NuBus master allows normal completion of the command.

NuBus DMA Test Register

5.3.3 Figure 5-2 shows the NuBus DMA test register. This register occupies the least significant byte of the address following the configuration address. It is used by the NUPI when participating in the system NuBus test. This is a test of the NUPI's capability to communicate with NuBus memory and other NuBus devices.

The NuBus DMA register contains an encoded version of the beginning NuBus address for NuBus test transfer operations. That is, it contains bits 27 through 24 and bits 15 through 12 of the NuBus test start address. Bit 1 of the ROM flags field in the NUPI configuration register indicates that the NUPI is capable of participating in the system NuBus test.

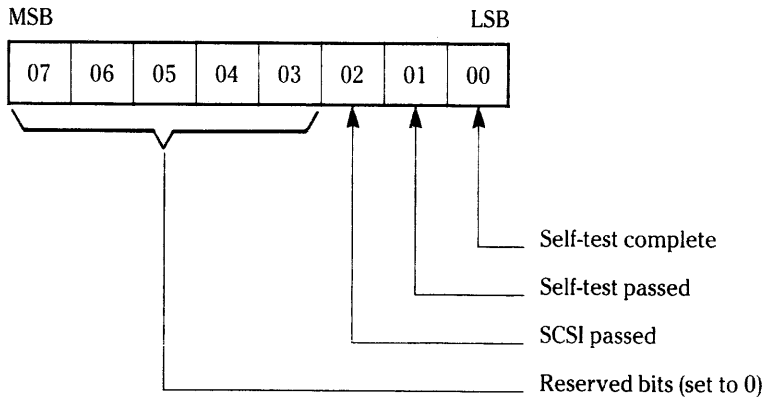
Figure 5-2 **NuBus DMA Test Register**



Flag Register

5.3.4 Figure 5-3 shows the NUPI flag register. The flag register is an 8-bit register that contains the NUPI and SCSI bus flag bits. These bits provide information regarding self-test status. The flag register resides in the NUPI's on-board RAM at an address specified by the flag register offset field of the configuration ROM.

Figure 5-3 **NUPI Flag Register**



The individual bits and fields of the flag register are as follows:

- Self-test complete (bit 0) — When active (low), this bit indicates completion of all NUPI self-tests except the NuBus transceiver and slave test. When inactive, this bit indicates either that a self-test is in progress or that a self-test has failed.

- Self-test passed (bit 1) — When active (low), this bit indicates successful completion of all NUPI self-tests. A configuration register update operation sets (or resets) this bit to reflect the condition of the configuration register's fault LED bit.

- SCSI passed (bit 2) — When active (low), this bit indicates successful completion of the SCSI bus or mass storage device formatters self-test. When inactive, this bit bars all SCSI bus operations unless the failure override bit of the configuration register is active.

Command Address Register

5.3.5 The command address register is a 32-bit register that contains the NuBus memory address of the NUPI command block (Figure 5-4). Writing the most significant byte of the starting physical NuBus address to the most significant byte of this register initiates command processing. The address can be written with four individual byte operations, two individual halfword operations, or as a single word operation. However, since writing of the most significant byte initiates command processing, the three least significant bytes must be written prior to or simultaneously with the most significant byte. Although write operations to the register can be done in any transfer mode, read operations are limited to either the halfword or byte transfer mode. A word read operation transfers the contents of halfword 0 to both halves of the word.

Diagnostic Window

5.3.6 The diagnostic window is a block of NuBus addresses that allows another NuBus master device to read certain on-board NUPI addresses. These include the following:

CAUTION: Writing to these addresses can adversely affect the NUPI, causing an event generation and resetting the NUPI and the SCSI bus.

- Microprocessor RAM — This is a 4-kilobyte block beginning at address >FSE00000.

- Microprocessor ROM — This is a 16-kilobyte block beginning at address >FSFFC000.

- NUPI board status inputs — This is a 2-byte block beginning at address >FSD40000.

- NuBus master status inputs — This is a single byte at address >FSCC0000.

- SCSI control logic — This is a 16-byte block beginning at address >FSAA8000.
- FIFO RAM port — This is a 2-byte block beginning at address >FSB80000.

Diagnostic window access operations inhibit NuBus master cycle generation and input/output (I/O) bus loopback operations. All other operations remain uninhibited.

Power Failure Event Address

5.3.7 NUPI self-test operations clear the power failure event address. During processor idle time, the microcode monitors this address and, if the least significant bit is set, prevents processing of any new command. However, changing the state of this bit does not affect any currently executing command. Once command processing has been suspended by setting this bit, it can only be resumed by either issuing a NuBus reset, activating the reset bit in the configuration register, or clearing the event byte.

NUPI Board Programming

5.4 All data transactions and command information reside in NuBus memory. Commands are issued to the NUPI board by establishing a command block in NuBus memory and writing the address of this block into the NUPI command address register. The NUPI acknowledges receipt of the command block by setting the busy bit in the command block status register. On completion of the command, the NUPI updates the command block status register, resets the busy bit, and sets the command complete bit.

If the issued command block includes an active event bit, command completion causes an event to be posted to the event generation address specified by the command block. Command completion can be determined by either polling the command block for completion status or by enabling event generation and receiving the event.

The NUPI can accept only one active command for each attached peripheral device. Commands issued to devices that already have an active command will have an error status posted. No internal record of the command is kept by the NUPI.

The NUPI supports SCSI devices with fixed block sizes that are integral powers of two between four and ten, inclusive. Illegal block size errors are posted when NUPI commands are issued to SCSI devices with fixed block sizes that are not powers of two or are powers of two not in the supported range. SCSI devices that are in variable block mode may have any block size allowed by SCSI.

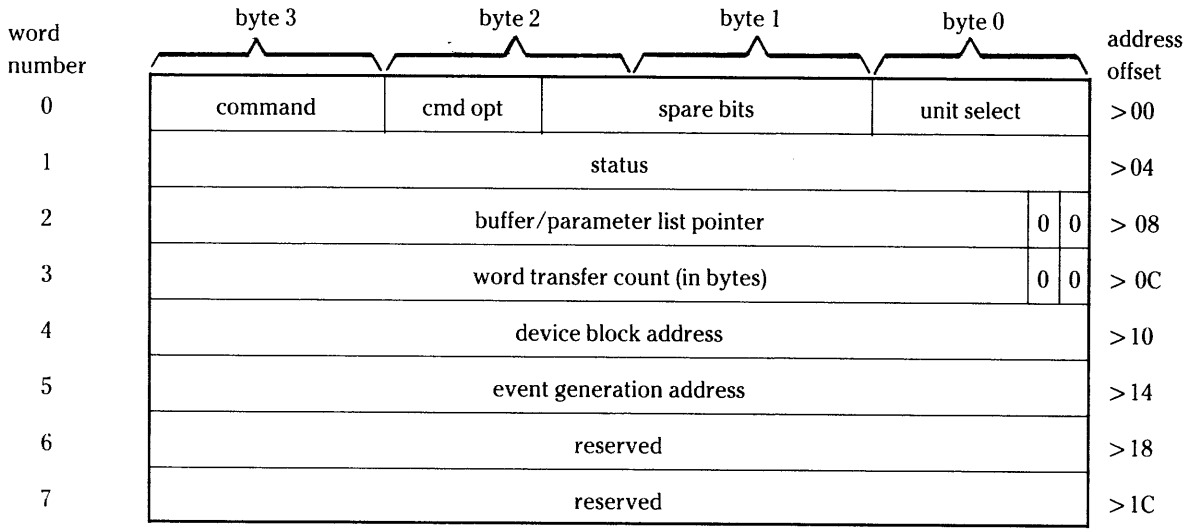
Command Block Format

5.4.1 Figure 5-4 shows the NUPI command block format. The command block is a group of 32-bit words containing control and status information for the NUPI board and/or mass storage device formatters. The address of each register in memory is the command address from the NUPI command address register offset by the value shown at the right of each register. The indicated bytes consist of the following bits:

- Byte 3 — Bits 31 through 24
- Byte 2 — Bits 23 through 16
- Byte 1 — Bits 15 through 8
- Byte 0 — Bits 7 through 0

The following illustrations and paragraphs describe the command block fields.

Figure 5-4 NUPI Command Block Format



Command Word 0

5.4.1.1 Figure 5-5 shows command word 0, which contains the command description field and other bits and fields that determine the command's destination and how the command is to be handled. The following paragraphs describe the bits and fields of command word 0.

Command Description Field The command description field is an 8-bit field (bits 31 through 24) that defines the operation to be performed and determines whether the command is destined for the NUPI or for the formatter of the mass storage device specified by the unit select field. Bits 31 and 30 are the destination bits for the NUPI and the mass storage device formatter, respectively. Setting either of these bits active determines the destination of the command. If neither is active, the command is destined for the selected mass storage device. The remaining 6 bits define the command to be executed.

Tables 5-3 through 5-6 list the NUPI command codes in hexadecimal. These hexadecimal values can be translated to determine the destination of any given command as shown by the following examples:

- Request Device Status >02 — The binary value of this command code is 0000 0010. In this case, since neither of the destination bits is set, the command is destined for the mass storage device currently specified by the unit select field.

- Request Formatter Status >42 — The binary value of this command code is 0100 0010. In this case, bit 30 is set to indicate that this command is destined for the formatter of the selected mass storage device.

- Request NUPI Status >82 — The binary value of this command code is 1000 0010. In this case, bit 31 is set to indicate that this command is destined for the NUPI board.

Notice that the last six bits (00 0010) are identical for all of these commands. That is, all request status commands have identical command definition fields.

All NUPI commands fall into one of the following categories:

- Utility and status commands — These commands perform NUPI or formatter setup operations and status checking.

- General device and disk commands — These commands perform general device-oriented operations and NUPI/NuBus data transfer operations.

- Tape-specific commands — These commands perform tape control operations.

- Self-test and diagnostic commands — These commands control self-test and diagnostic operations for the NUPI board and the various formatters and/or peripheral devices.

Figure 5–5 Command Word 0

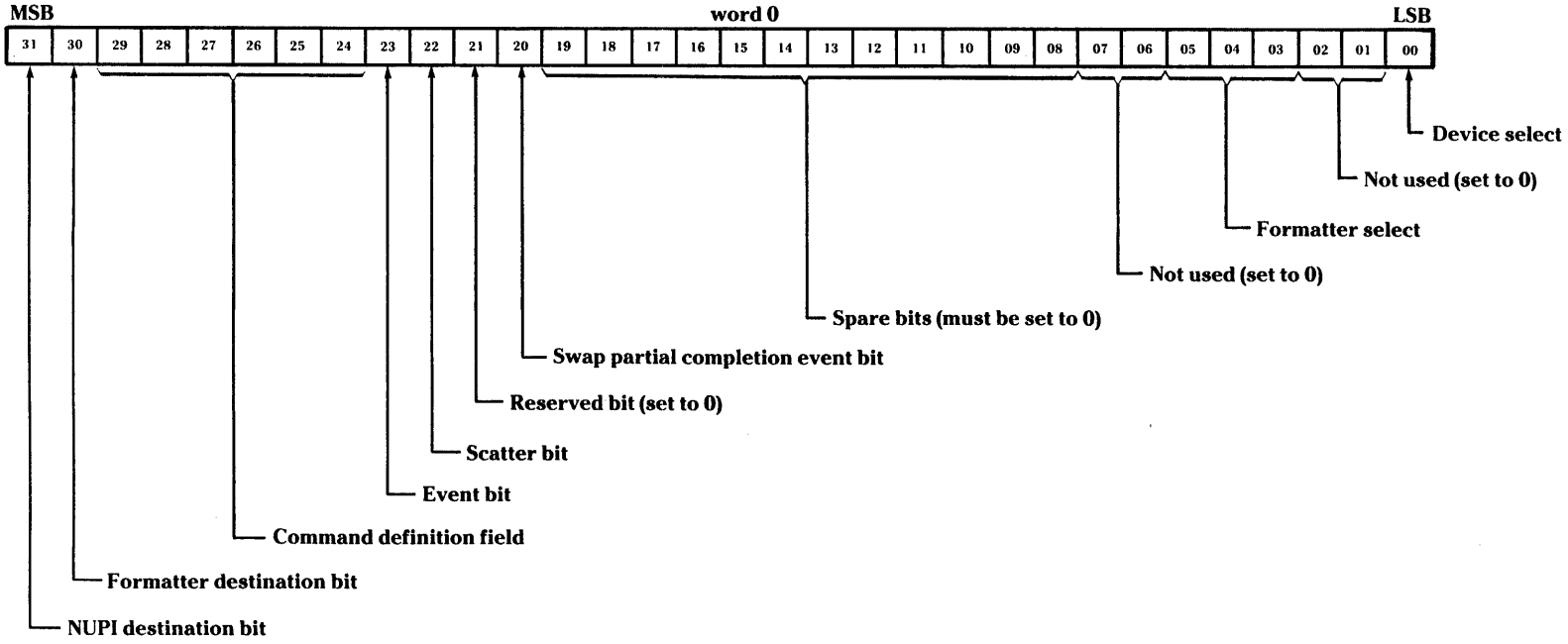


Table 5-3 **Utility and Status Commands**

Command Code	Command Name
>00	Illegal
>02	Request Device Status
>41	Formatter Setup
>42	Request Formatter Status
>81	NUPI Setup
>82	Request NUPI Status

Table 5-4 **General Device and Disk Commands**

Command Code	Command Name
>10	Restore Device
>11	Seek
>12	Read
>13	Write
>14	Format Unit

Table 5-5 **Tape-Specific Commands**

Command Code	Command Name
>20	Rewind Tape
>21	Unload Tape
>22	Erase Tape
>23	Space Forward by Blocks
>24	Space Reverse by Blocks
>25	Write File Mark

Table 5-5 **Tape-Specific Commands (Continued)**

Command Code	Command Name
>26	Tape Re-tension
>27	Space Forward by File Marks
>28	Space Reverse by File Marks
>29	Space Forward to End of Data
>2A	Load

Table 5-6 **Self-Test and Diagnostic Commands**

Command Code	Command Name
>30	NUPI Device Self-Tests
>70	Formatter Self-Test
>71	SCSI Pass Through Read
>72	SCSI Pass Through Write
>B0	NUPI Self-Test

Command Options Field The command options field (Figure 5-5) is a 16-bit field (bits 23 through 8) that defines various command options, such as information about event generation and extension blocks. Either of the following conditions causes illegal command processing, resulting in error status or special event generation:

- Spare bits (17 through 8) are *not* set to 0.
- The scatter bit is active for any command other than Read, Write, Format Unit, or Request NUPI Status.

The individual bits of the command options field are defined as follows:

- Variable mode/device blocks (bit 18) — For Read and Write commands, this bit (if set) specifies variable block mode. For Space by Blocks commands, this bit (when set) specifies that the parameter is in device blocks rather than 1024 byte NuBus blocks.
- Block mode (bit 19) — Reserved for NuBus block mode.

- Scatter (bit 22) — When active, this bit initiates a NuBus memory scatter operation. It converts the data address value in the NuBus address field of the command block to an address extension block pointer. Scatter operations are valid only for Read, Write, Format Unit, and Request NUPI Status.

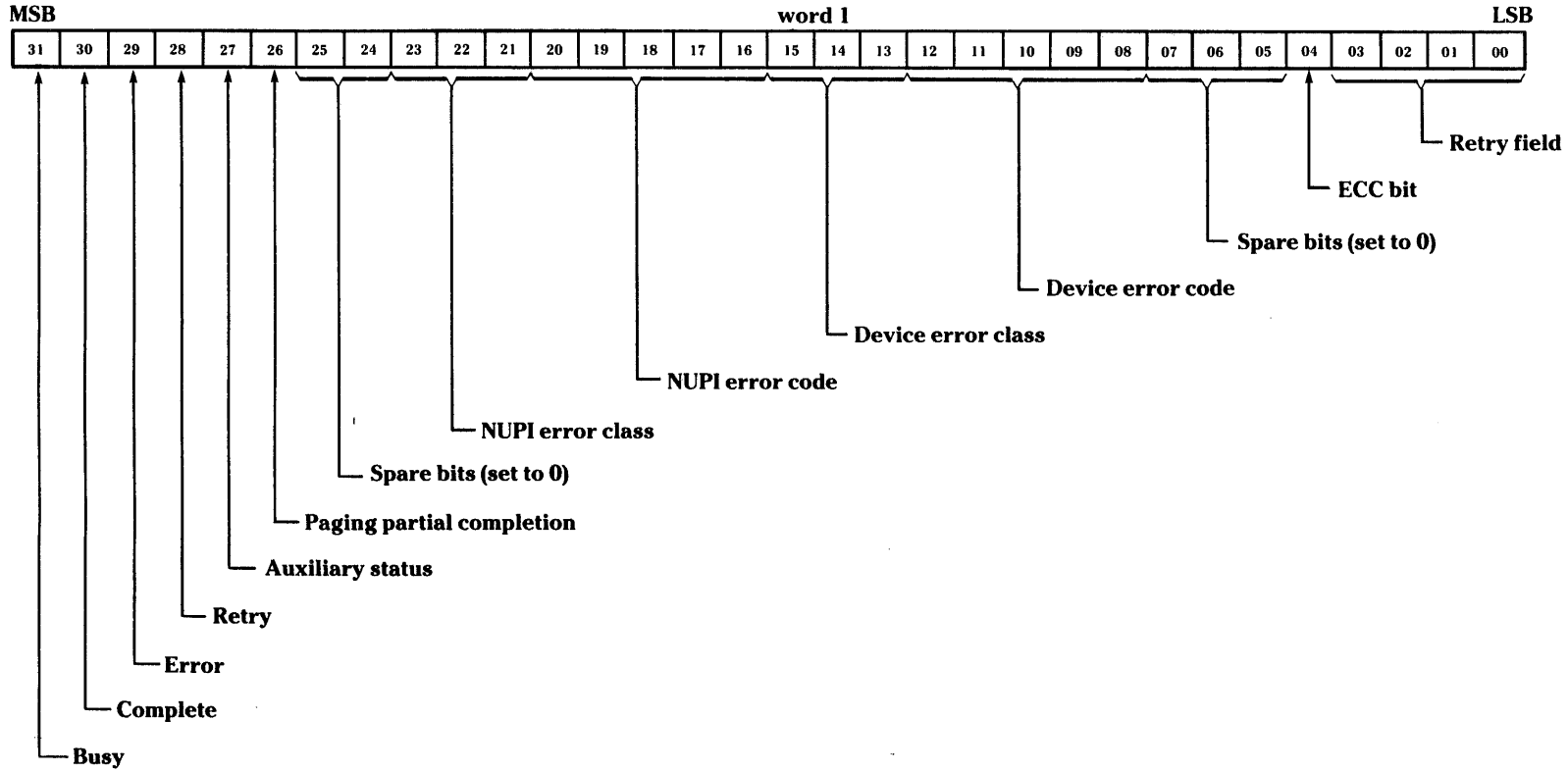
- Event (bit 23) — When active, this bit causes command completion to post an event to the event generation address specified by the command block.

Unit Select Field The unit select field (Figure 5-4) is an 8-bit field (bits 7 through 0) whose binary-coded value can specify 1 of up to 255 mass storage devices for command execution. The current mapping uses bits 5 through 3 to define 1 of 7 formatters and bit 0 to define 1 of 2 devices on the specified formatter. Thus, the current possible number of mass storage devices is 14.

NUPI Status Word

5.4.1.2 Figure 5-6 shows the NUPI command block status word (command word 1). The status word is a 32-bit word that contains 4 bytes of command block status and command completion status. Host processor command block initialization must set the word to 0 to prevent later misinterpretation of its bits. Failure to initialize the word to 0 causes the NUPI to treat the current command as illegal. The following paragraphs describe the individual status word bytes.

Figure 5-6 NUPI Command Block Status Word



Current and Completion Status Field The current and completion status field is an 8-bit field (bits 31 through 24) that shows the status of a currently executing command and the status of a completed command. This field contains the following bits:

- Auxiliary status (bit 27) — When active, this bit indicates that additional status, such as power failure detection, overtemperature detection, or command abortion without status update, is available. This bit is set only if a special event has occurred and the special event address has not been initialized. The host should issue a Request NUPI Status command in response to this bit.

- Retry (bit 28) — When active, this bit indicates that retries have been performed in an effort to execute the command. If the error bit is also set, this indicates that the retries were unsuccessful. Status word bits 3 through 0 contain the number of retries, including any error-correction attempt that is required to perform the operation.

  The NUPI retries commands for the following reasons:

  - When a NuBus error occurs during DMA to a direct access device.
  - For SCSI parity errors to commands to a direct access device.
  - For receiving busy SCSI status from a formatter.
  - When an invalid SCSI mode occurs on a command to a direct access device.

  The NUPI attempts to retry the last operation for the following reasons:

  - When a NuBus error occurs during DMA to a sequential access device.
  - When an invalid SCSI mode occurs on a command to a sequential access device.
  - When NuBus errors occur during accesses to NuBus memory for command parameters.

- Error (bit 29) — When active, this bit indicates that an unrecoverable error has occurred.

- Complete (bit 30) — When active, this bit indicates completion of command execution. During command block initialization, this bit must be inactive.

- Busy (bit 31) — The NUPI activates this bit to acknowledge receipt of a command and to indicate that it is currently processing the command. After completion of command processing, the NUPI deactivates the busy bit. This bit indicates to the software that the NUPI is available to receive commands for other devices without the possibility of receiving NuBus retries.

Error Handling and Reporting Errors occurring during command execution are classified as follows:

- Recoverable errors — These errors are indicated by a retry count in the status register. Excessive retry attempts can indicate a hardware or medium problem even though the data is probably correct. Recoverable errors do not set the error bit but can place an error code in either the NUPI error-detected field or the device error-detected field.

- Unrecoverable NUPI errors — These errors appear as hexadecimal codes in the NUPI error-detected field and are divided into 7 classes (bits 23 through 21) with 31 possible error codes (bits 20 through 16) per class. Table 5-7 lists and defines these error codes.

- Unrecoverable formatter or device errors — These errors appear as hexadecimal codes in the device error-detected field and are divided into 7 classes (bits 15 through 13) with 31 possible error codes (bits 12 through 8) per class. Table 5-8 lists and defines these error codes.

NUPI Error Code and Classification Field The NUPI error code and classification field (Figure 5-6) is an 8-bit field (bits 23 through 16) that contains a 4-bit NUPI error code and a 3-bit NUPI error classification code. These two fields form a complete error code that defines NUPI error status.

Table 5-7 lists and defines the NUPI error codes. The error classifications are as follows:

- Error class code >1 — Self-test error

- Error class code >2 — Attention errors requiring operator intervention

- Error class code >3 — Errors related to the NuBus or the SCSI bus

- Error class code >4 — Command errors (invalid parameter)

- Error class code >5 — Hardware errors related to specific mass storage devices

- Error class code >6 — Media errors (probably a media problem, but can indicate a hardware problem)

- Error class code >7 — Reserved

  The first command issued to a device which goes offline and comes back online (such as media changes for tapes) will be flagged with a "Unit Attention" (>45) error unless it is a status command in which case it receives Unit Attention Status. This forces user notification of device state changes that may have occurred without user knowledge.

NOTE: The complete error codes listed in Table 5-7 and Table 5-8 are composites of the 3-bit error class codes and the 5-bit error codes. For example, error class code >3 (011) and error code >06 (00110) together form complete error code 01100110 (>66).

Table 5-7 NUPI Error Code Definitions

Complete Error Code	Error Class	Error Code	Definition
>21 ↓ >3F	>1	>01 ↓ >1F	Self-test failure (the error code bits represent the failing test number)
>41 ↓ >5F	>2	>01 ↓ >1F	Reserved
>61	>3	>01	NuBus time-out error
>62	>3	>02	NuBus error
>63	>3	>03	SCSI bus parity error
>64	>3	>04	Formatter busy
>65	>3	>05	Rate error
>66	>3	>06	Bus error trap
>67 ↓ >7F	>3	>07 ↓ >1F	Reserved
>81	>4	>01	Command aborted
>82	>4	>02	Invalid command
>83	>4	>03	Invalid parameter
>84	>4	>04	SCSI command completed with no data transfer

Table 5-7 NUPI Error Code Definitions (Continued)

Complete Error Code	Error Class	Error Code	Definition
>85	>4	>05	Multiple active commands or new command queue overflow
>86 ↓ >9F	>4	>06 ↓ >1F	Reserved*
>A1	>5	>01	Illegal interrupt
>A2	>5	>02	SCSI function-complete interrupt without cause
>A3	>5	>03	Time-out while waiting for the SCSI controller data register to fill
>A4	>5	>04	Invalid SCSI controller command interrupt
>A5	>5	>05	Software error trap
>A6	>5	>06	Hardware error trap
>A7	>5	>07	Queue overflow trap
>A8	>5	>08	Address error trap
>A9	>5	>09	Illegal instruction trap
>AA	>5	>0A	NuBus DMA locked up (may need hardware reset)
>AB ↓ >BF	>5	>0B ↓ >1F	Reserved
>C1 ↓ >DF	>6	>01 ↓ >1F	Reserved

*No internal record of commands issued to devices that already have active commands will be kept by the NUPI.

Device Error Code and Classification Field The device error code and classification field (Figure 5-6) is an 8-bit field (bits 15 through 8) that defines the error code status for a mass storage device or formatter in the same manner as does the NUPI error code and classification field. The classification codes are identical to those listed for the NUPI. Table 5-8 lists and defines the device and formatter error codes.

NOTE: As indicated in the table, some of these codes are status codes that do not indicate an error condition.

Table 5-8 **Formatter and Mass Storage Device Error Code Definitions**

Complete Error Code	Error Class	Error Code	Definition
>21 ↓ >3F	>1	>01 ↓ >1F	Self-test failure (the error code represents the failing test number).
>41	>2	>01	No selected unit.
>42	>2	>02	Medium not loaded.
>43	>2	>03	Write protected.
>44	>2	>04	Medium change or offline device now online (status code).
>45	>2	>05	Unit attention.
>46	>2	>06	Temperature fault.
>47	>2	>07	Invalid medium type.
>48	>2	>08	SCSI sense data is available (status code).
>49	>2	>09	Tape incorrect length indication (ILI) (status code).
>4A	>2	>0A	Tape end of media (EOM) reflects an error for an attempt to read more data, other than 0, than is available and indicates status for all other conditions.

Table 5-8 **Formatter and Mass Storage Device Error Code Definitions (Continued)**

Complete Error Code	Error Class	Error Code	Definition
>4B	>2	>0B	Tape ILI and EOM set (status code).
>4C	>2	>0C	Tape file mark (FM) encountered (status code).
>4D	>2	>0D	Tape ILI and FM set (status code).
>4E	>2	>0E	Tape EOM and FM set (status code).
>4F	>2	>0F	Tape ILI, EOM, and FM set (status code).
>50	>2	>10	SCSI bus hung, hardware reset required.
>51	>2	>11	SCSI device failed to reconnect before end of time-out period.
>52	>2	>12	SCSI device failed to complete its operation before end of time-out period.
>53	>2	>13	Nonextended error code is 0 (status code).
>54	>2	>14	Device has multiple block descriptors.
>55	>2	>15	Device has undefined block length.
>56 ↓ >5F	>2	>16 ↓ >1F	Reserved.
>61	>3	>01	SCSI bus parity error.
>62	>3	>02	Mass storage device not ready.
>63	>3	>03	Rate error
>64	>3	>04	Target selected NUPI as a target.
>65	>3	>05	Offline.
>66	>3	>06	Invalid SCSI testability interrupt.
>67	>3	>07	Invalid SCSI bus disconnect.
>68	>3	>08	Invalid mode for SCSI status.

Table 5-8 **Formatter and Mass Storage Device Error Code Definitions (Continued)**

Complete Error Code	Error Class	Error Code	Definition
>69	>3	>09	Invalid mode for SCSI command byte request.
>6A	>3	>0A	Sequence error: SCSI completion address.
>6B	>3	>0B	Sequence error: SCSI requested data.
>6C	>3	>0C	Sequence error: SCSI DMA start/stop address.
>6D ↓ >6F	>3	>0D ↓ >1F	Reserved.
>70	>3	>10	Unknown message received from target.
>71	>3	>11	Invalid mode on input SCSI message.
>72	>3	>12	Excess SCSI status.
>73	>3	>13	Excess SCSI command bytes requested.
>74	>3	>14	Expected SCSI Restore message not received.
>75	>3	>15	Reconnect to unit not awaiting reconnect.
>76	>3	>16	Expected SCSI Command Complete message not received.
>77	>3	>17	Illegal SCSI message for reconnect state.
>78	>3	>18	Reselected without valid SCSI identification.
>79	>3	>19	Invalid mode on SCSI message out.
>7A	>3	>1A	Invalid mode on SCSI data transfer.
>7B	>3	>1B	Target tried to transfer more data than was requested.

Table 5-8 **Formatter and Mass Storage Device Error Code Definitions (Continued)**

Complete Error Code	Error Class	Error Code	Definition
>7C ↓ >7F	>3	>1C ↓ >1F	Reserved.
>81	>4	>01	Command aborted.
>82	>4	>02	Invalid command.
>83	>4	>03	Invalid parameter.
>84	>4	>04	Illegal block address.
>85	>4	>05	Volume overflow.
>86 ↓ >89	>4	>06 ↓ >09	Reserved.
>8A	>4	>0A	Formatter failed to connect to SCSI bus.
>8B ↓ >8D	>4	>0B ↓ >0D	Reserved.
>8E	>4	>0E	Unknown error code returned from formatter.
>8F	>4	>0F	Formatter busy.
>90 ↓ >9F	>4	>10 ↓ >1F	Reserved.
>A1	>5	>01	Missing index signal.
>A2	>5	>02	Seek incomplete.
>A3	>5	>03	Write fault.
>A4	>5	>04	Track 0 not found.
>A5	>5	>05	Multiple units selected.
>A6	>5	>06	Seek error.
>A7	>5	>07	Formatter hardware error.

Table 5-8 **Formatter and Mass Storage Device Error Code Definitions (Continued)**

Complete Error Code	Error Class	Error Code	Definition
>A8 ↓ >BF	>5	>08 ↓ >1F	Reserved.
>C1	>6	>01	ID error.
>C2	>6	>02	Uncorrectable data error.
>C3	>6	>03	ID address mark not found.
>C4	>6	>04	Data address mark not found.
>C5	>6	>05	Block not found (sector address).
>C6	>6	>06	Bad block not found.
>C7	>6	>07	Format error.
>C8	>6	>08	Correctable data check.
>C9	>6	>09	Interleave error.
>CA	>6	>0A	Media error.
>CB ↓ >DF	>6	>0B ↓ >1F	Reserved.

Retry and Error Correction Status Field The retry and error correction status field (Figure 5-6) is an 8-bit field (bits 7 through 0) that indicates error and/or retry attempts. This field contains the following bits and fields:

- Retry (bits 3 through 0) — This field contains a binary coded number indicating the number of NUPI retries performed. The binary number 1111 indicates 15 or more retries, and 0000 indicates none.
- ECC (bit 4) — Error correcting code (ECC) was applied to some part of the data.

NOTE: The following paragraphs describe the buffer/parameter list pointer (word 2) and the word transfer count (word 3).

Since the NUPI does not support byte or halfword data transfer operations, bits 0 and 1 of the buffer/parameter list pointer must be set to 0 (inactive). Note that an inactive (low) state in these bit positions corresponds to the inactive (high) state of bits AD0- and AD1- on the NuBus. As shown in Table 5-1, this is the condition required for word transfer operations.

All word transfer counts specified by command block word 3 are in hexadecimal bytes. These byte counts must be expressed in multiples of 4 bytes in order to support word counts. Therefore, bits 0 and 1 of the word transfer count must also be set to 0.

Buffer/Parameter List Pointer

5.4.1.3 Some commands, such as the Format Unit command and those involving scatter operations, require a parameter list. The 32-bit buffer/parameter list pointer (Figure 5-7) indicates the NuBus physical address of the parameter list. During data transfers that do not use the scatter operation, the pointer indicates the NuBus physical address of the read or write data. As indicated in the foregoing note, bits 0 and 1 must be set to 0 to avoid illegal command detection and processing.

Word Transfer Count

5.4.1.4 Figure 5-8 shows the word transfer count. This 32-bit register contains a hexadecimal value that indicates the total number of bytes to be transferred during a read or write operation. As indicated in the foregoing note, bits 0 and 1 must be set to 0. If they are not set to 0, the NUPI will treat the command block as an illegal command, unless the target SCSI device is in variable block mode.

The NUPI supports odd byte data transfers to a SCSI device in variable block mode; however, for read commands that do not have multiples of four transfer counts, the system must provide memory space for the number of bytes in the transfer count rounded up to the next multiple of four. A transfer count of zero is not supported for read or write commands.

Figure 5-7 Buffer/Parameter List Pointer

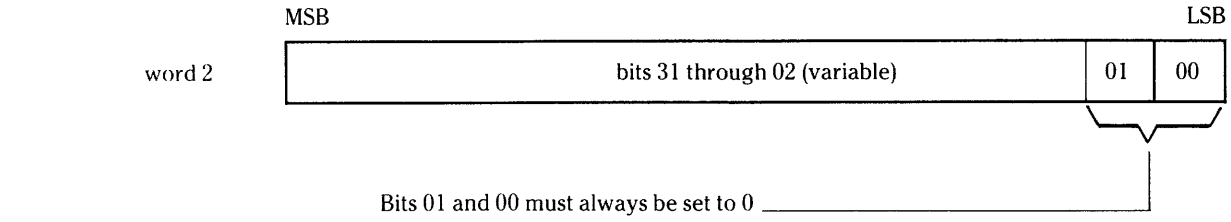
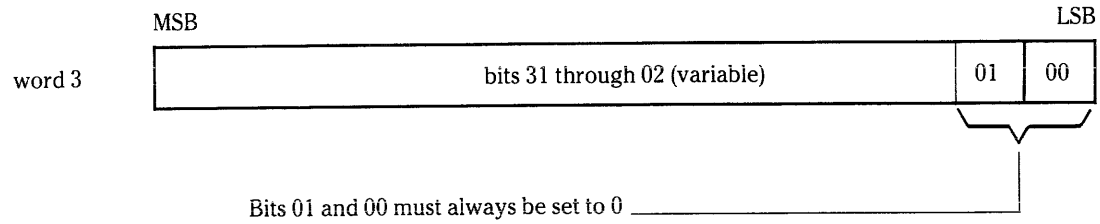


Figure 5-8 Word Transfer Count



Device Block Address

5.4.1.5 The Device Block Address (word 4) specifies the logical starting address of the block to be accessed on the selected mass storage device. For a mass storage write operation, the data bytes are stored sequentially starting at the device block address. For mass storage read operations, the device block starting address specifies the device address from which the first data byte is to be read.

Event Generation Address

5.4.1.6 An active event bit in the command options field enables an event to be posted on completion of each command, indicating that the command has completed. The event generation address (word 5) represents the 32-bit physical NuBus memory location to which an all-ones data byte is to be written. This data byte can occupy any one of the four byte positions in the NuBus word.

NOTE: The Explorer computer system uses an event-reporting scheme in which each device or action that is capable of generating an event has a unique NuBus memory address reserved for posting the particular event. Event generation is accomplished by writing an all-ones byte to the assigned event generation address. The Explorer processor polls the event generation address periodically to determine if one or more events have been posted and to identify the posting device.

Special Event Reporting

5.4.2 Sometimes the NUPI requires special attention that is not provided by normal status reporting on command completion. In these cases, special event reporting notifies the processor of the NUPI's special attention requirement. These special events are as follows:

- An unrecoverable NuBus error occurs while fetching the command block.
- An overtemperature condition occurs in one of the mass storage devices.
- A command abortion occurs with no NuBus command block update.

- An illegal command or command block is issued.
- Loss of power occurs.
- An illegal write to NUPI control space is attempted.

The NUPI Setup command (paragraph 5.5.2.1) specifies a special event address to which any one of the special event conditions generates a NuBus event. If the command is not received or a reset condition occurs after the command is received, no action occurs until completion of the next valid command. At that time, the auxiliary status bit is set, and the NUPI status command returns the cause of the special event.

Once a special event condition has been issued, no further notification occurs until after completion of a Request NUPI Status command. This is true whether the special event condition is issued as a result of posting an event or setting the auxiliary status bit. Thus, the returned special event field can contain multiple special event conditions that could have occurred at different times.

Scattered Memory Operations

5.4.3 Scattered memory operations allow the use of two or more physically noncontiguous memory blocks for storing a single logical section of data, thus supporting the logical addressing capabilities of the Explorer processor. A special table area (the scatter table) in NuBus memory makes these operations possible.

Scattered memory operations are valid for Read, Write, Format Unit, or Request NUPI Status commands. Refer to paragraph 5.5 for descriptions of these commands.

Figure 5-9 shows an example of a scattered memory operation in which a section of data (Figure 5-10) is transferred from a mass storage device and stored in noncontiguous blocks in NuBus memory. The scatter table contains two words (the address pointer and the word count) for each noncontiguous memory block to be used. The address pointer specifies the starting address of the memory block, and the word count specifies the length of the block in hexadecimal bytes. Bits 0 and 1 of this word count value must always be set to 0 to ensure that the transfer operation starts on a word boundary.

When a command is issued with an active scatter bit in the command options field (Figure 5-9), the buffer/parameter list pointer of the NUPI command block contains the address of the first address pointer in the scatter table.

During a read operation, as shown in Figure 5-9 and Figure 5-10, the data is read sequentially from the mass storage device and stored in the scattered memory locations specified by the scatter table address pointers. During a write operation, the data from these scattered memory locations is stored sequentially on the mass storage device. The word transfer count in the NUPI command block specifies the total number of bytes (the sum of all scatter table word count entries) to be transferred. The word counts in the scatter table specify the number of words for each noncontiguous memory location.

For fixed block devices, the transfer count must be a multiple of four long words. If bits 0 and 1 are not 0s, an illegal command error is posted. For variable block devices, this parameter can specify odd byte transfer counts, but the memory space should be reserved for the next higher multiple of four bytes for read commands.

The last scatter table entry can specify odd byte transfers for variable block devices. For read commands, the system must reserve NuBus memory space sufficient for the next higher multiple of four bytes.

NOTE: Although it is possible to handle contiguous memory blocks in the same manner as scattered blocks, handling them as contiguous blocks (scatter bit not set) improves performance.

NUPI Commands

5.5 Command initiation is accomplished by writing the command block starting address into the NUPI command address register (paragraph 5.3.5). The NUPI then starts command processing by reading the command block, verifying that it is valid, and setting the busy bit (Figure 5-6) of the command block status word. On completion of command execution, the NUPI resets the busy bit, sets the complete bit, and returns the appropriate status information to the command block.

The NUPI can simultaneously support active commands for itself, every odd-numbered mass storage device, and either the formatter or device 0 of all formatters. Any command issued to a device having a command in progress is treated as an illegal command.

After the most significant byte of the command starting address has been written, the NUPI saves the entire command address prior to accepting another slave cycle. This ensures the integrity of the command address register. Also, during this time NuBus retries are issued for both read and write operations to the NUPI.

The operating system software can monitor the busy bit to determine when the NUPI has sufficiently processed the current command block to allow another command to be issued. This prevents the occurrence of NuBus retry operations while the NUPI copies the command address register for its internal use. When the operating system monitors the busy bit during polling operations, it must also monitor the completion bit to ensure that command completion does not occur prior to recognition of the busy bit. If either the busy bit or the completion bit is active, the NUPI can begin processing another command without the occurrence of NuBus retry operations.

The NUPI and/or the formatters perform all available retry operations in an attempt to recover from an error condition and, if all retry operations fail, set the error status bit. The system software must monitor the retry status bits to determine if a correctable hardware or medium problem requires attention and, if so, must report it. This allows the problem to receive the necessary attention before it becomes uncorrectable.

A command time-out feature deactivates any command that does not complete within its allotted time-out period. These time-out periods vary from one command to another. In general, however, they are set to allow sufficient time for all operations specified by the command to complete.

Figure 5-9 Example of Scattered Memory Operations

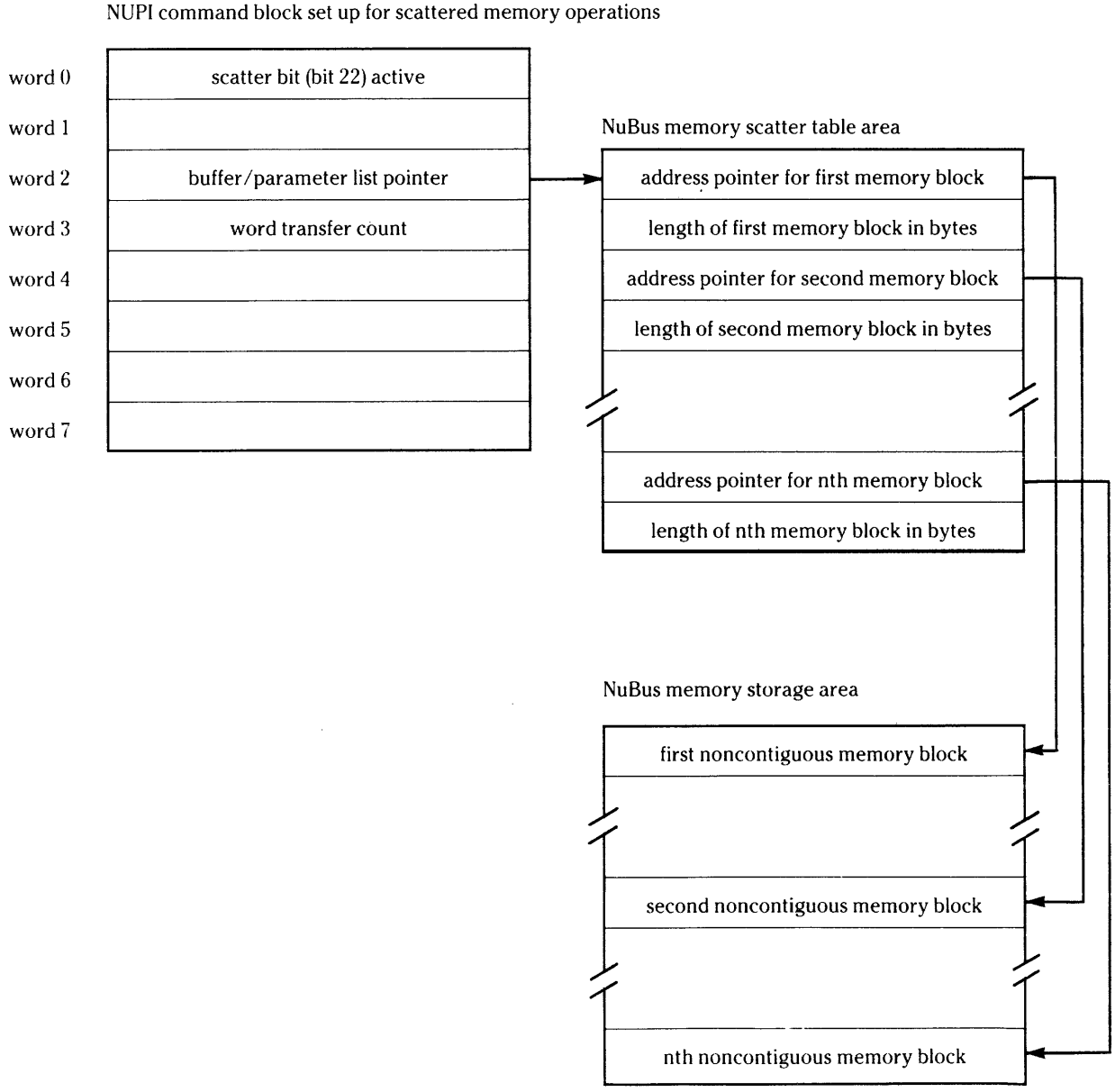
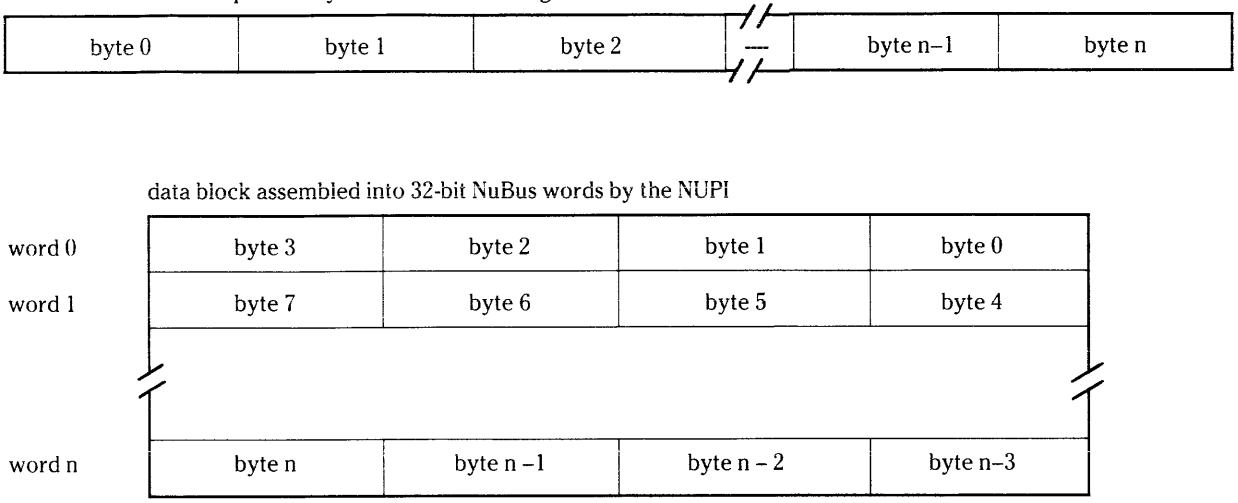


Figure 5-10 Example of a Mass Storage/NuBus Data Transfer



Illegal Commands

5.5.1 Command code >00 is an illegal command that results in neither modification nor execution of the command block. If a NUPI Setup command has been issued, a special event is generated. Otherwise, no action occurs until completion of the next valid command. Completion of the next valid command sets the auxiliary status bit.

All unimplemented commands or invalid command blocks are also treated as illegal commands.

Setup Commands

5.5.2 A setup command sets initial parameters in either the NUPI or a selected formatter as indicated by the two most significant bits of the command. The following paragraphs describe the NUPI Setup and Formatter Setup commands.

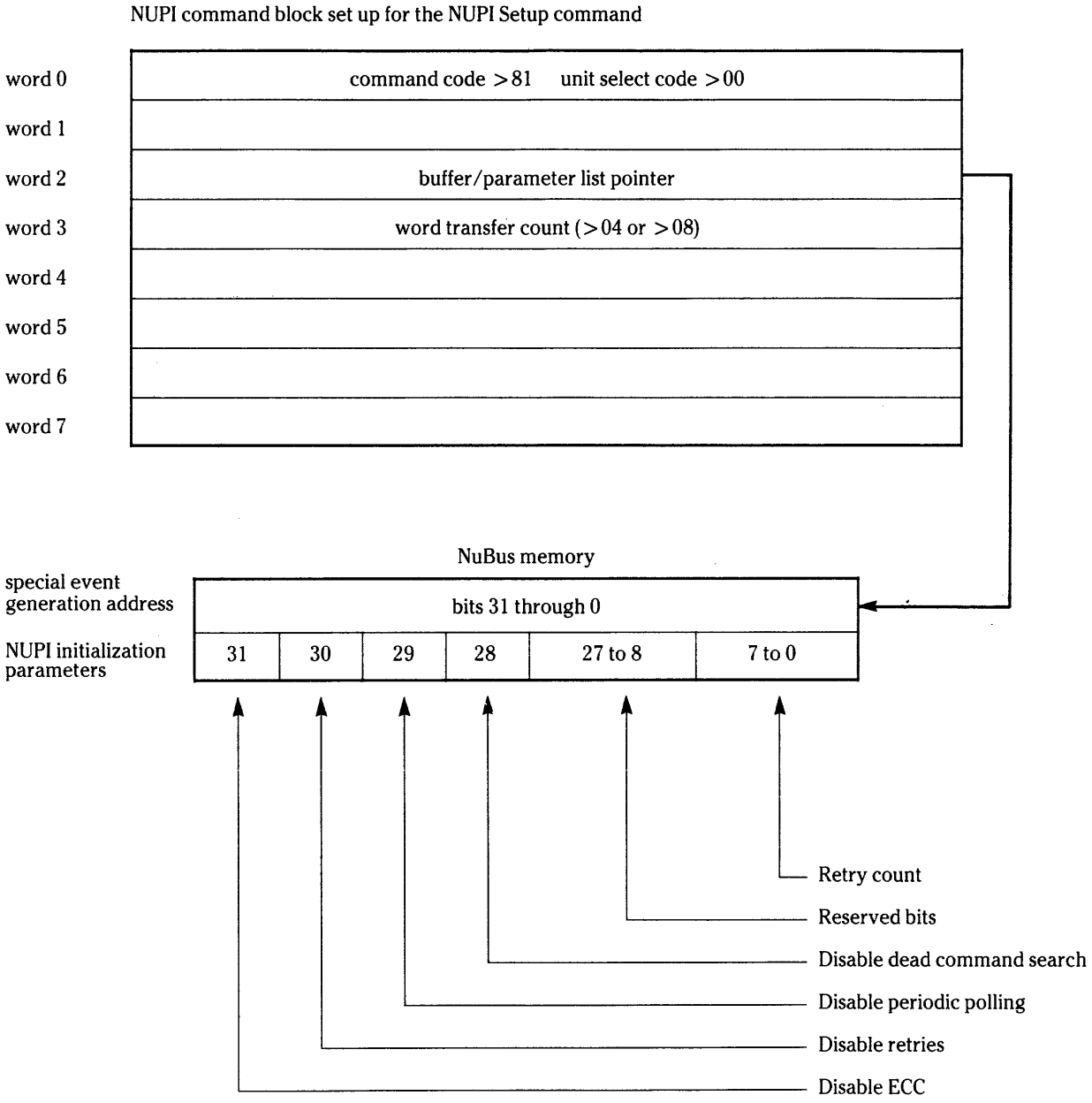
NUPI Setup Command

5.5.2.1 The command code for the NUPI Setup command is >81. This command sets up the special event generation address pointer and the NUPI initialization parameters (provided by the system software) in NuBus memory. Figure 5-11 shows how the command is executed.

During command execution, the buffer/parameter list pointer indicates the NuBus memory address for the 32-bit special event generation address. The word transfer count of the NUPI command block specifies the number of bytes to transfer.

A word transfer count of >04 (4 bytes) updates the special event generation address and leaves the NUPI initialization parameters unchanged. A word transfer count of >08 (8 bytes) updates both the special event generation address and the NUPI initialization parameters. A word transfer count that exceeds >08 causes the command to be treated as an illegal command. Also, the unit selection byte must contain >00 to avoid illegal command processing.

Figure 5-11 NUPI Setup Command Execution



The NUPI initialization parameters (Figure 5-11) are as follows:

- Retry count (bits 7 through 0) — This field contains a hexadecimal value for the total number of retries to be performed. A value of 0 in this field causes the default value to be used.

- Disable dead command search (bit 28) — When active, this bit disables the dead command search feature. Under normal conditions, this bit is held inactive, thus allowing a search for commands that have exceeded their specified time-out period without normal completion (dead commands).

- Disable periodic polling (bit 29) — When active, this bit disables the NUPI's periodic polling operations.

- Disable retries (bit 30) — When active, this bit disables NUPI retry operations.

- Disable ECC (bit 31) — This bit is not applicable to NUPI initialization. It should be set to 0.

Formatter Setup Command

5.5.2.2 The command code for the Formatter Setup command is >41. This command provides formatter-specific operational parameters and mode-select parameters to the selected formatter. A word transfer count of >00 for this command causes the formatter to return an invalid parameter error. Thus the word transfer count must be nonzero.

The associated parameter list for the Formatter Setup command is a block of NuBus words that can vary from one formatter or mass storage device to another. A typical parameter list contains the following information:

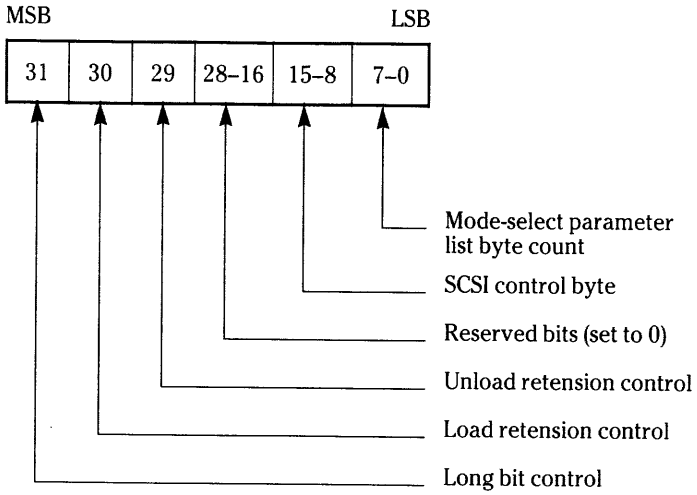
- A NuBus word (Figure 5-12) that contains the formatter-specific parameters, the SCSI command control byte, and the number of bytes in the mode-select parameter list.

- A NuBus word that contains the mode-select header. A typical mode-select header specifies the type of disk and the number of block descriptor bytes in the remaining words of the list.

- Two or more NuBus words that contain the block descriptor bytes of the mode-select parameter list. A typical block descriptor specifies the density characteristics of the disk, the number of data blocks to be transferred to or from the disk, and the data block length.

NOTE: In addition to the above data, the parameter list can also contain bytes that specify vendor-unique parameters.

Figure 5-12 **Word 0 of the Formatter Setup Command Parameter List**



The individual bits and fields of parameter list word 0 are defined as follows:

- Mode-select parameter list byte count (bits 7 through 0) — This field contains the number of mode-select bytes to be transferred.

- SCSI control byte (bits 15 through 8) — The SCSI control byte is the last byte of each SCSI command descriptor block. It contains the flag and link bits that are used for linked command operations. Since the NUPI does not support linked command operations, this entire byte must be set to 0.

- Unload re-tension control (bit 29) — When active, this bit sets the re-tension bit in the SCSI Load/Unload command to perform a re-tensioning operation during the Unload command execution. This bit is valid for tape formatters only. For disk formatters, it is reserved and should be set to 0.

- Load re-tension control (bit 30) — When active, this bit sets the re-tension bit in the SCSI Load/Unload command to perform a re-tensioning operation during the Load command execution. This bit is valid for tape formatters only. For disk formatters, it is reserved and should be set to 0.

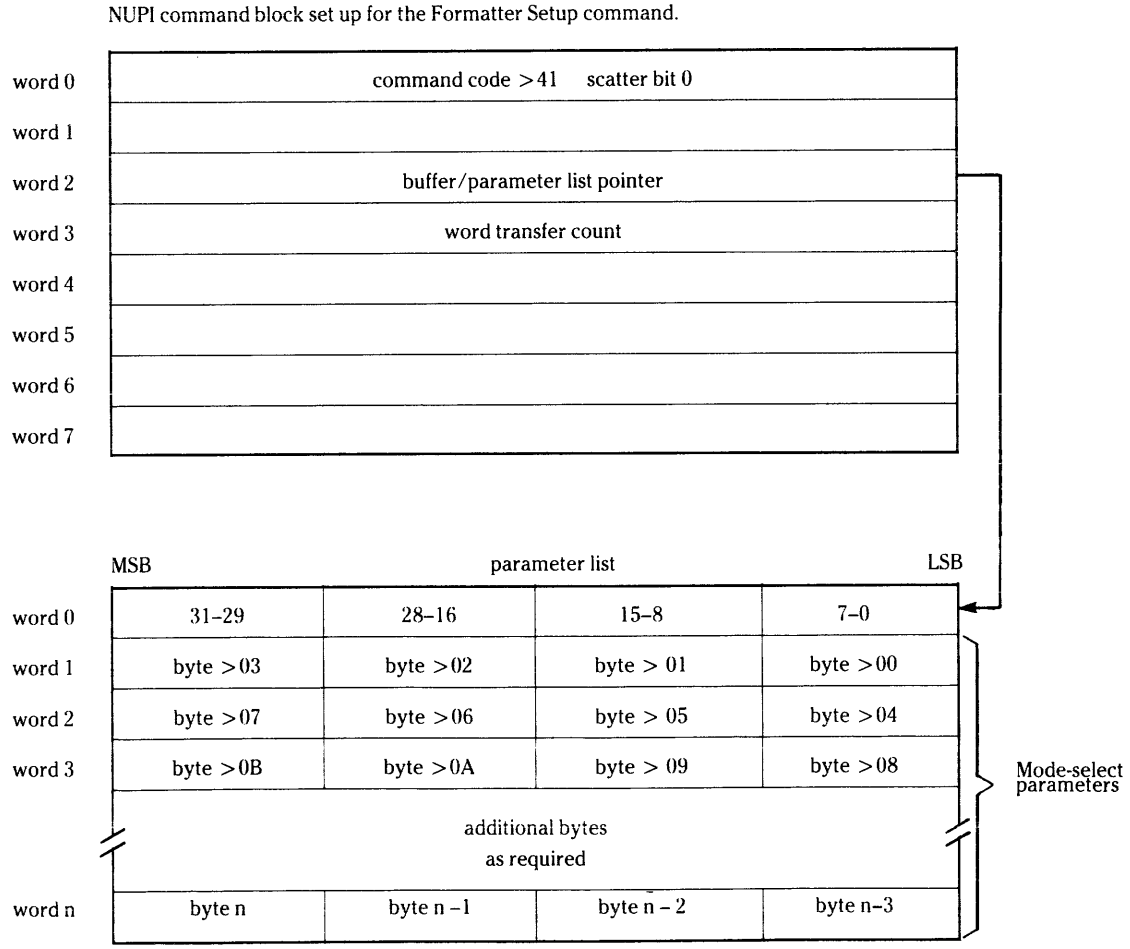
- Long bit control (bit 31) — When active, this bit *resets* the long bit of the SCSI Erase command. The SCSI Erase command long bit controls the distance to be erased and its default condition is active (set), which causes an erasure from the current tape position to the EOT. Resetting the bit causes an erasure of a length of tape, which is dependent on the particular tape drive. The long bit control bit is valid for tape formatters only. For disk formatters, it is reserved and should be set to 0.

Figure 5-13 shows how the Formatter Setup command is executed. The buffer/parameter list pointer of the NUPI command block contains the NuBus address of parameter list word 0. The word transfer count specifies the total number of bytes in the parameter list. Setting this count to >04 sends parameter list word 0 only. If the complete parameter list is required, the word transfer count must be set to the appropriate value, depending on the number of bytes in the mode-select parameter list.

Notice that the first byte of the mode-select parameter list occupies the lowest byte address of the first word (word 1) of the list, the second byte occupies the next higher byte address, and so on. The SCSI Mode Select command passes the parameters to the formatter one byte at a time, starting with byte >00. These bytes are passed to the addressed formatter until the byte count specified in word 1 is exhausted. Attempts to pass a formatter block size not supported by the NUPI causes an invalid parameter error to be posted.

Setting the scatter bit in the command options field invalidates the Formatter Setup command.

Figure 5-13 Formatter Setup Command Execution



Request Status Commands

5.5.3 The command codes for the request status commands are >02, >42, and >82. These commands return the current status to the host from the NUPI or a selected formatter or mass storage device. The buffer/parameter list pointer specifies the NuBus memory address at which this status information is to be stored, and the word transfer count indicates the maximum number of words available for status storage.

Status returned in response to the request status commands is formatted as follows:

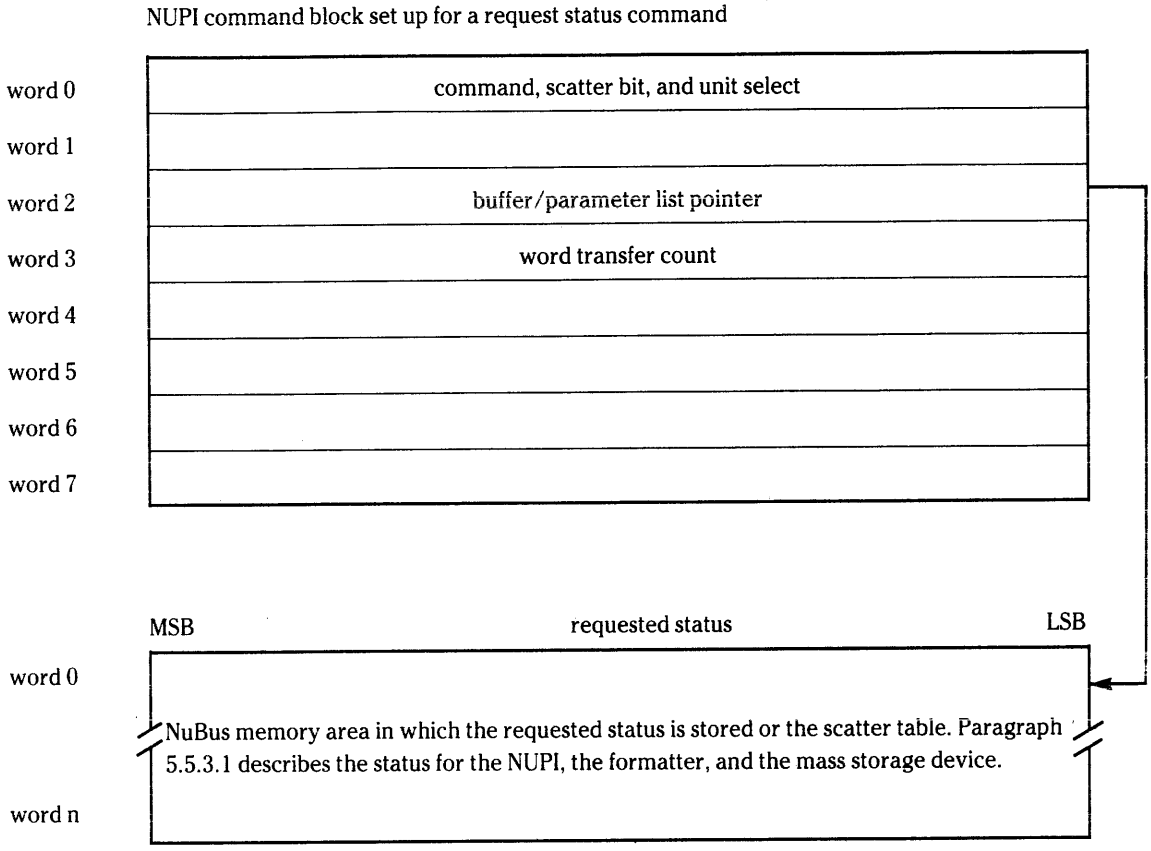
1. NUPI parameters for a Request NUPI Status command.
2. Formatter and/or device general status as required.
3. Sixteen bytes of the last SCSI Request Sense command (Appendix A).
4. A listing of the last eight commands and their associated error status. These errors can be any of the NUPI and/or device errors described in Tables 5-7 and 5-8. Paragraph 5.5.3.1 provides more details about this command and error information.
5. A NuBus word in which the least significant byte is the SCSI status byte for the last issued command.
6. Disk capacity (applicable to device status only).
7. Tape maximum block size (device status only).
8. Tape minimum block size (device status only).
9. NUPI RAM contents, including firmware revision level.

Figure 5-14 shows how the request status commands are executed. Word 0 specifies the command (>02, >42, or >82) and the selected device. The scatter bit must be set to 0 except for the Request NUPI Status command. The word transfer count specifies (in hexadecimal bytes) the number of status words to be transferred to NuBus memory. The buffer/parameter list pointer indicates the beginning NuBus memory address at which the status information is to be stored.

NOTE: For scattered memory operations, the buffer/parameter list pointer indicates the NuBus location of the scatter table to be used.

The following paragraphs describe the request status commands and the status returned by each of them.

Figure 5-14 Request Status Command Execution



Request NUPI Status Command

5.5.3.1 The command code for the Request NUPI Status command is >82. This command returns the number of status words specified by the word transfer count to the NuBus memory location indicated by the buffer/parameter list pointer. However, if the scatter bit of the command options field is active, the buffer/parameter list pointer contains the address of the scatter table. The operation is then performed as a scattered memory operation as described in paragraph 5.4.3.

NOTE: The scatter option is valid for this command only if both the word transfer count and the length of the first memory block are equal to or greater than >84 (Figure 5-9). Also, the unit select field must be set to 0 for this command. Any other unit select value results in illegal command processing.

For a transfer count of 4 or 8 bytes, the NUPI returns a request count without executing polling commands, which update formatter and device status words.

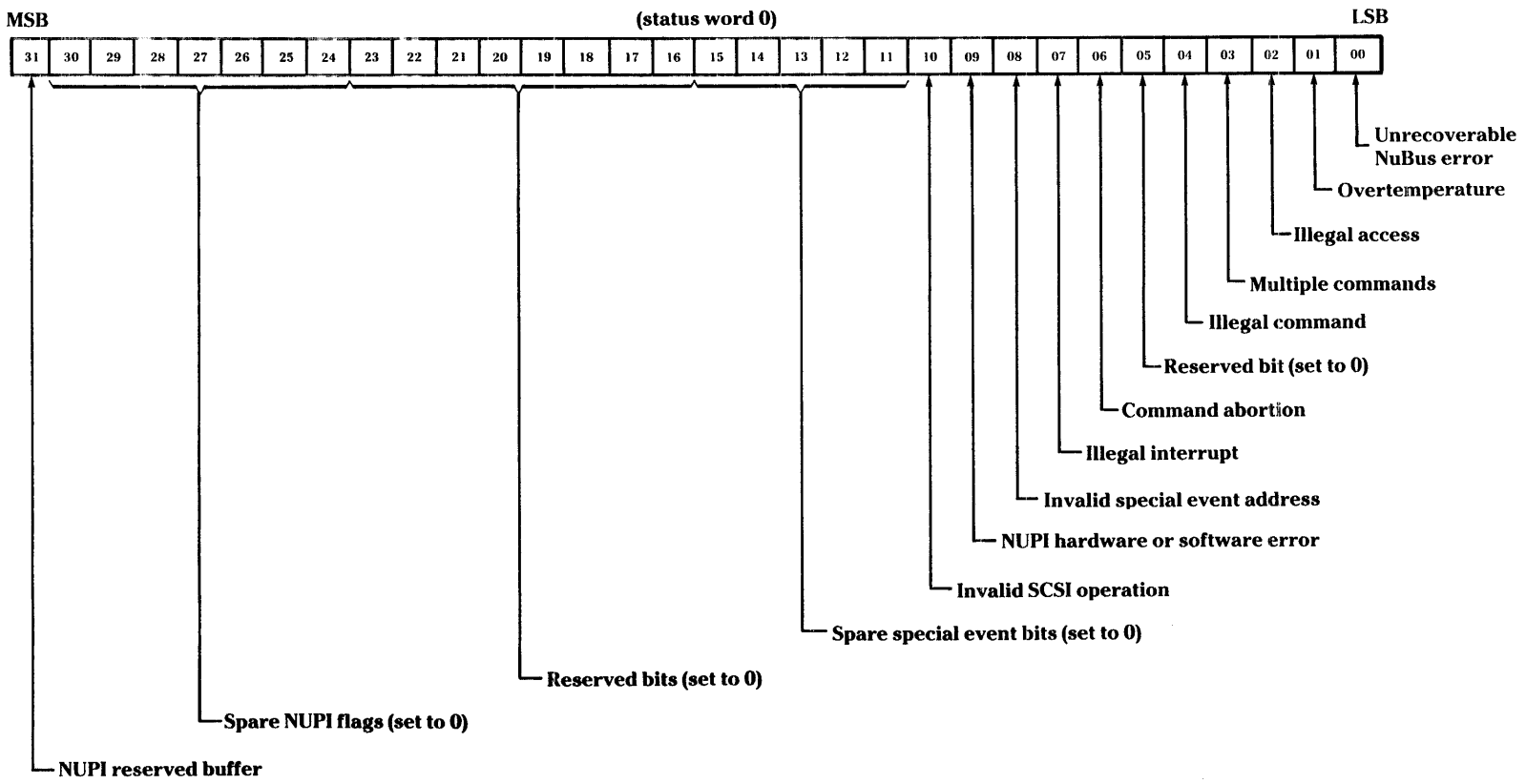
Values returned to NuBus memory in response to the Request NUPI Status command contain NUPI status and special event information, self-test information, formatter and/or mass storage device information, command status information, and the NUPI RAM contents. The NUPI RAM contents include the firmware revision level and the last NuBus address accessed for occurrences of special events 0, 3, 4, or 6. The following paragraphs describe this status information.

NUPI Flags and Special Events Figure 5-15 shows the contents of the first status word (word 0) returned in response to the Request NUPI Status command. This word contains information about NUPI status and special events.

Status word 0 contains the following bits and fields:

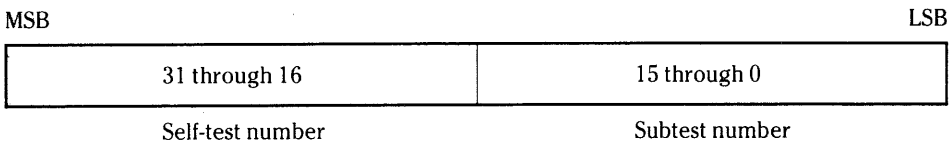
- Unrecoverable NuBus error (bit 0) — When active, this bit indicates that an unrecoverable NuBus error has occurred while fetching the command block.
- Overtemperature (bit 1) — When active, this bit indicates the first occurrence of an overtemperature condition in one of the mass storage devices that currently has no active command.
- Illegal access (bit 2) — When active, this bit indicates an illegal attempt to access the NUPI control space from the NuBus.
- Multiple commands (bit 3) — The NUPI firmware revision -0006 changes the method of handling the error of issuing a command to a device which already has an active command. Before revision -0006, a special event (bit 3) is posted. With revision -0006, error code >85 is posted (without a special event).
- Illegal command (bit 4) — When active, this bit indicates that an illegal command or command block has been issued.
- Command abortion (bit 6) — When active, this bit indicates that a command was aborted with no NuBus updates.
- Illegal interrupt (bit 7) — When active, this bit indicates that an illegal interrupt has occurred during an attempted NuBus access operation.
- Invalid special event address (bit 8) — When active, this bit indicates that an invalid special event address has been specified.
- NUPI hardware or software error (bit 9) — When active, this bit indicates that either a hardware or a software error has occurred on the NUPI.
- Invalid SCSI operation (bit 10) — When active, this bit indicates an attempt to execute an invalid SCSI operation.
- Spare special event field (bits 15 through 11) — These are spare special event bits that are set to 0.
- Reserved (bits 23 through 16) — These bits are set to 0.
- Spare NUPI flags (bits 30 through 24) — These are spare NUPI flags that are set to 0.

Figure 5–15 NUPI Flags and Special Event Bits (Status Word 0)



Self-Test Status Information Figure 5-16 shows the contents of the second status word (word 1) returned in response to the Request NUPI Status command. This word contains the self-test and subtest numbers of the last self-test executed. Halfword 1 (bits 31 through 16) contains the self-test number, and halfword 0 (bits 15 through 0) contains the subtest number (0 for a successful self-test). For multiple self-test execution, the self-test number is that of the last self-test executed.

Figure 5-16 Self-Test Status Information (Status Word 1)



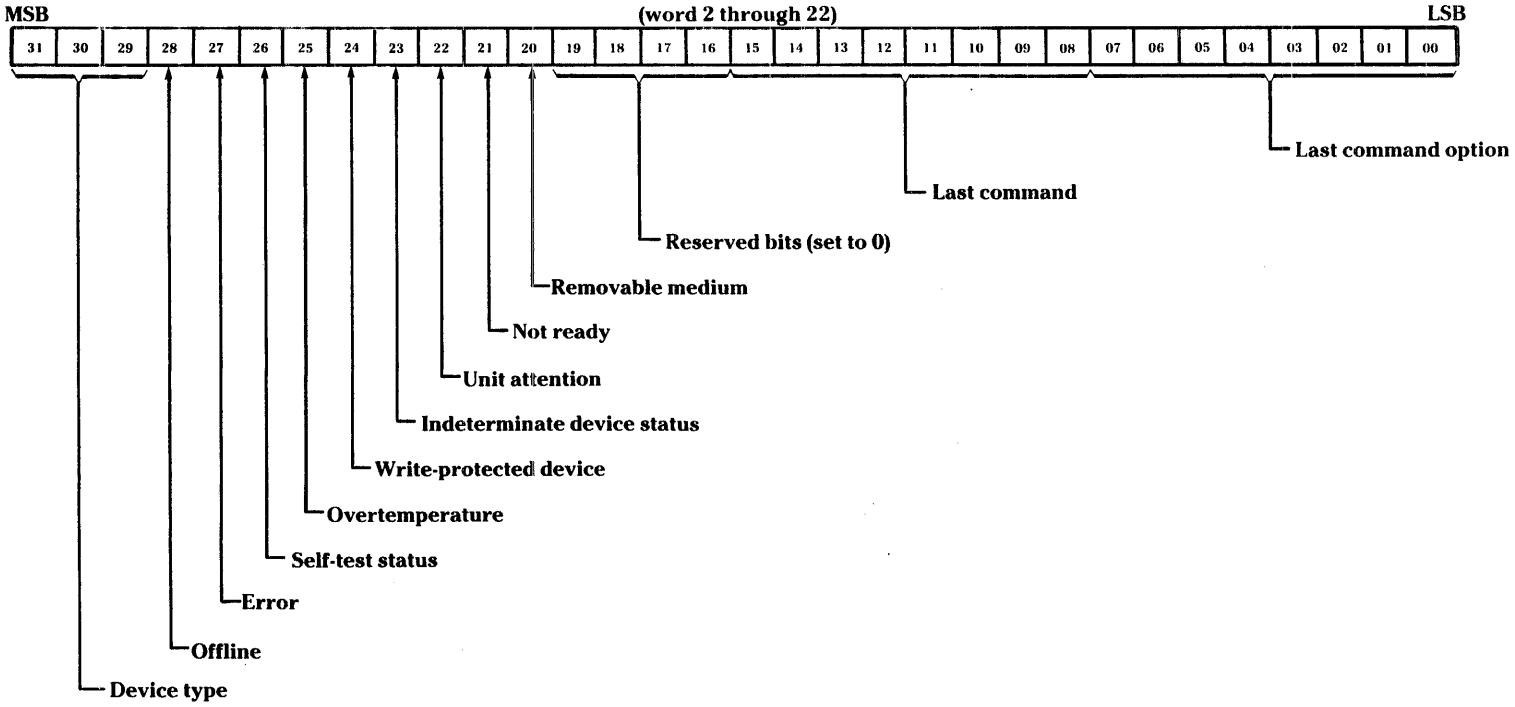
Formatter and Mass Storage Device Information Figure 5-17 shows the contents of a formatter or device status word. The status returned in response to the Request NUPI Status command contains one of these status words for each formatter and one for each mass storage device in the mass storage subsystem. These status words are listed sequentially as follows:

- Words 2 through 6 — These words contain the status information for formatters 0 through 4.
- Words 7 and 8 — These words contain the status information for formatters 6 and 7.

NOTE: Each device on the SCSI bus has a unique address. Thus, the formatter SCSI addresses are 0, 1, 2, 3, 4, 6 and 7, and the NUPI SCSI address is 5.

- Words 9 and 10 — These words contain status information for devices 0 and 1 of formatter 0.
- Words 11 and 12 — These words contain status information for devices 0 and 1 of formatter 1.
- Words 13 and 14 — These words contain status information for devices 0 and 1 of formatter 2.
- Words 15 and 16 — These words contain status information for devices 0 and 1 of formatter 3.
- Words 17 and 18 — These words contain status information for devices 0 and 1 of formatter 4.

Figure 5–17 Formatter and Device Status (Words 2 Through 22)



- Words 19 and 20 — These words contain status information for devices 0 and 1 of formatter 6.

- Words 21 and 22 — These words contain status information for devices 0 and 1 of formatter 7.

NOTE: The next two words following the last device status word are undefined for the Request NUPI Status command.

The individual bits and fields of the formatter and device status word are defined as follows:

- Last command option (bits 7 through 0) — This byte contains the condition of the option bits for the last command issued.

- Last command (bits 15 through 8) — This byte contains the command code for the last command issued.

- Removable medium (bit 20) — When active, this bit indicates that the mass storage device has a removable recording medium (cartridge, removable disk, and so forth).

- Not ready (bit 21) — When active, this bit indicates that although the mass storage device may be powered up, it is not yet ready to accept a command.

- Unit attention (bit 22) — When active, this bit indicates that the device has just come online or that a medium change has been detected.

- Indeterminate device status (bit 23) — When active, this bit indicates that the status of the device cannot be determined.

- Write-protected device (bit 24) — When active, this bit indicates that a device is write-protected and cannot be written to.

- Overtemperature (bit 25) — When active, this bit indicates that the formatter has detected an overtemperature condition in one of the mass storage enclosures.

- Self-test status (bit 26) — When active, this bit indicates that the formatter or device has failed a self-test. When inactive, it indicates that either the device has passed the last self-test or that no test is available for the device.

- Error (bit 27) — When active, this bit indicates that an error occurred during the execution of the last command and that status is available for the command.

- Offline (bit 28) — When active, this bit indicates that the formatter or device is offline.

- Device type (bits 31 through 29) — This field contains a 3-bit binary code that specifies the device type for this status word. The device types specified are as follows:
  - 001: Device type 1 is a magnetic tape.
  - 010: Device type 2 is a disk unit.
  - 011: Device type 3 is a printer.
  - 100: Device type 4 is a write-once, read-multiple optical disk unit.
  - 101: Device type 5 is a read-only optical disk unit.
  - 110: Device type 6 is an undefined device.
  - 111: Device type 7 is an undefined device.

NOTE: For formatter status, the device type bits are reserved and are returned as a 0 value. If the device status is offline, not ready, or indeterminate, these bits may be invalid.

SCSI Sense Information Some errors occurring during the execution of SCSI commands (issued by the NUPI to formatters and mass storage devices) generate status data called SCSI sense information. On receiving notification from a formatter that sense information is available, the NUPI issues a Request Sense command to the formatter, causing the sense data to be returned and stored in the NUPI RAM. The NUPI returns this sense information to NuBus memory as status words 23 through 26 in response to any request for status. For more information about SCSI sense data, refer to the *Explorer Winchester Disk Formatter (ADAPTEC) Supplement to Explorer Mass Storage Enclosure General Description* or the *Explorer Cartridge Tape Drive (Cipher) Supplement to Explorer Mass Storage Enclosure General Description.*

List of Commands and Errors The last eight halfwords (status words 27 through 30) of the returned status contain a list of the last NUPI commands issued and the errors (if any) associated with them.

Figure 5-18 shows a listing of the last commands issued in which no errors were found. The numbers in parentheses indicate the sequential order of the commands. In this case, since all commands were error-free, a total of eight commands (the last eight commands issued) are listed. The letters XX represent the command codes, and FF is a hexadecimal delimiting value.

Figure 5-18 **List of Last Eight Error-Free Commands**

halfword 1	halfword 0
(2) >XXFF	(1) >XXFF
(4) >XXFF	(3) >XXFF
(6) >XXFF	(5) >XXFF
(8) >XXFF	(7) >XXFF

If one or more errors are found during command execution, they are listed as shown in Figure 5-19 and the actual number of commands listed is limited by the number of errors found. In this example, the first command (listed in the halfword 0 position) has one associated error (listed in the halfword 1 position). The third command has two associated errors (listed in the next two available halfword positions). Thus, since each error requires one halfword of space, it reduces the number of listed commands by 1.

If the byte count has not expired, the remaining data constitutes a dump of the NUPI's RAM structures as follows:

1. The first 16-bit word is the ROM revision level in ASCII.

2. The next 32-bit word is the last physical NuBus address accessed for the most recent occurrence of special event numbers, 0, 3, 4, or 6.

NOTE: This information should be accessed as soon as a special event is posted to avoid the possibility that a different special event will overwrite the last address accessed for the first event.

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3. The remaining data are NUPI RAM locations.

NUPI RAM Contents The remaining information returned in response to the Request NUPI Status command is a dump of the NUPI RAM contents. This information is requested by setting the word transfer count in the command to a value greater than is required for the status information. A number of bytes corresponding to the remaining word transfer count (bytes remaining after the status has been transferred) is then dumped from the NUPI RAM into NuBus memory.

Request Formatter Status Command

5.5.3.2 The command code for the Request Formatter Status command is >42. The unit select field specifies the formatter for which the status is requested. Values returned in response to the command indicate current status information and a list of errors for the selected formatter and for each mass storage device attached to it. Figure 5-17 shows this status information. The first word contains formatter status. The second and third words contain status information for devices 0 and/or 1, respectively. The next 16 halfwords contain the SCSI sense status and the last commands issued, along with any associated errors (Figures 5-18 and 5-19).

Figure 5-19 **Command List Containing Three Errors**

halfword 1	halfword 0
error	(1) > XXFF
(3) > XXFF	(2) > XXFF
error	error
(5) > XXFF	(4) > XXFF

Execution of the Request Formatter Status command is identical to that of the Request NUPI command with the following exceptions:

- The NUPI flags and special event bits and the self-test status are not returned.
- The scatter option is not valid.
- The NUPI RAM dump is not executed.
- Formatter and device status is for the selected formatter and its associated mass storage devices only.
- A maximum of 11 status words are returned.

Request Device Status Command

5.5.3.3 The command code for the Request Device Status command is >02. The unit select field specifies the mass storage device for which the status is requested. Status information returned in response to this command pertains only to the selected mass storage device.

The maximum length of this returned status for the Request Device Status command is 14 words. These words contain the following information:

- The first word contains the device status (Figure 5-17).
- The next 16 halfwords contain the SCSI sense status and the command codes of the last 8 issued commands or any errors that occurred for these commands (paragraph 5.5.3.1).

- The next word contains the SCSI status byte for the last command issued to the selected device.
- The next word contains the capacity (in disk blocks) of the disk device or -1 (>FFFFFFFF) if the device is not a disk.
- The next word contains the device formatter block size in hexadecimal.
- The next word contains the maximum tape block size (-1 if not the size of the device formatter).
- The last word contains the minimum tape block size (-1 if not a tape).

Execution of the Request Device Status command is identical to that of the Request Formatter Status command except that no formatter status is returned.

Restore Device Command

5.5.4 The command code for the Restore Device command is >10, and its purpose is to cause self-reinitialization of the selected mass storage device. For a disk unit, this positions the read/write heads over the beginning sector of track 0 and clears any latched faults, provided that they no longer exist. For a tape unit, the Restore Device command positions the tape at the beginning of tape (BOT).

A system power-up operation activates the reset bit in the NUPI configuration register (paragraph 5.3.2). This causes a NUPI and a SCSI reinitialization, which also restores the mass storage devices.

NOTE: Since a restore operation requires more time to complete than a seek to track 0, the Restore Device command should not be used for the seek operation.

Seek Command

5.5.5 The command code for the Seek command is >11 and its function is to position the disk read/write heads over the data block specified by the device block address parameter (command word 4). Since this command is valid only for disk units, an attempt to issue it to a tape unit returns an invalid parameter error. Command completion occurs after correct head positioning or the occurrence of an uncorrectable error.

Read Command

5.5.6 The command code for a Read command is >12. Its function is to transfer data from the selected device to the NuBus memory address specified by the buffer/parameter list pointer. The word transfer count specifies (in bytes) the total number of words to be transferred. If the word transfer count exceeds the number of words in a given mass storage data block, the command automatically crosses block boundaries to transfer the total number of bytes specified.

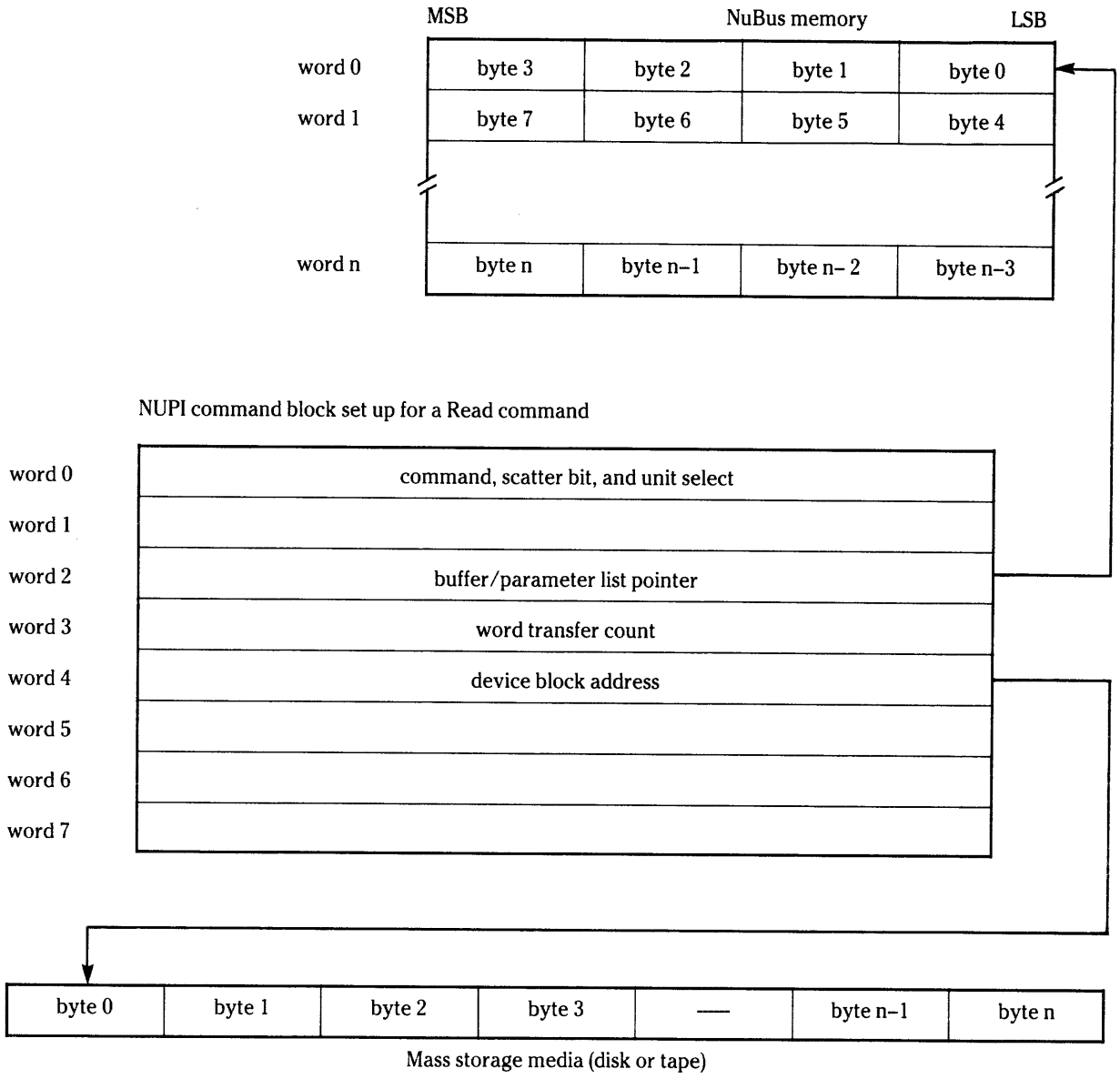
For disk operations, the device block address parameter of the NUPI command block specifies the starting block address. For tape operations, the command ignores this address and starts at the current tape position.

For scatter operations, the parameter list pointer contains the address of the scatter table. In this case, each scatter table entry specifies the NuBus address and the number of bytes to be written to that address. After the first table entry, if the word transfer count has not expired, the next entry is obtained, and the read operation continues until the table is exhausted. Occurrence of an uncorrectable error during the transfer stores the failing block address and the word count in the command block. Refer to paragraph 5.4.3 for more information about scattered memory operations.

Figure 5-20 shows how the Read command is executed for a nonscatter read operation. Command word 0 contains the Read command code (>12), the scatter bit, and the unit select number. Word 2 contains the NuBus starting address to which the data is to be transferred if the scatter bit is not set. Word 3 specifies (in bytes) the number of words to be transferred, and word 4 specifies the mass storage device starting block address.

When the variable blocks bit (bit 18) is set in the command options field, the command transfers one block of data from the addressed device to NuBus memory. If the device has not previously been set to variable block mode (via the Formatter Setup command or as the default mode of the device), an illegal parameter error is posted.

Figure 5-20 Read Command Execution



Command execution is initiated by writing the NuBus address of the NUPI command block to the NUPI's command address register. The NUPI then performs the following sequence of operations:

1. Copies the command address register in NUPI RAM for the purpose of saving the command.

2. Re-enables slave operations to allow the NUPI to accept the next command.

3. Fetches the command block, and verifies it as far as possible.

4. Sets the busy status bit to indicate that the NUPI is executing a command.

5. Initializes the command in the NUPI RAM.

6. Issues the SCSI command to the appropriate formatter and mass storage device.

NOTE: If the formatter operation involves a large waiting period, the formatter disconnects from the SCSI bus to free the bus for other use. It then reconnects on completion of the operation.

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7. Starts assembling bytes from the SCSI bus into words.

8. Performs a NuBus transfer following the availability of each word. This continues until the number of bytes specified by the word transfer count have been transferred.

9. For a scatter operation, fetches and sets up the next entry from NuBus memory while SCSI transfers continue. This continues until the scatter table is exhausted.

10. Terminates the command and performs internal cleanup.

11. Sets up the command block for ending status. The device block address and the buffer/parameter list pointer indicate the device and memory location, respectively, of any unrecoverable error. The word transfer count indicates the error length.

12. Sets the final status in the command block (word 1) with the busy bit off and the complete bit on.

Write Command

5.5.7 The command code for the Write command is >13. Its function is to transfer data to the selected device from the NuBus memory address specified by the buffer/parameter list pointer. The NUPI command block parameters for the Write command are identical to those for the Read command except for the command code in word 0. Also, command execution is identical to that of the Read command (Figure 5-20) except for the following:

- The direction of transfer is reversed.
- The NUPI accepts 32-bit words from the NuBus, disassembles them into bytes, and places them on the SCSI bus.

The scatter option is also valid for the Write command.

When the variable blocks bit (bit 18) is set in the command options field, the command transfers one block of data from NuBus memory to the addressed device. If the device has not previously been set to variable block mode (via the Formatter Setup command or as the default mode of the device), an illegal parameter error is posted.

Format Unit Command

5.5.8 The command code for the Format Unit command is >14, and its function is to initialize the disk medium. This command places an initial format on the selected disk unit, thus destroying any previously recorded data. Medium defects supplied with the command or found by the formatter are deallocated to spare disk sectors reserved for that purpose. Any future read or write operations to the disk ignore the defective sectors. Thus, execution of the Format Unit command results in an apparently error-free disk.

Figure 5-21 shows the Format Unit command parameter list. This list resides in NuBus memory and contains the required formatter initialization parameters.

Figure 5-21 Format Unit Command Parameter List

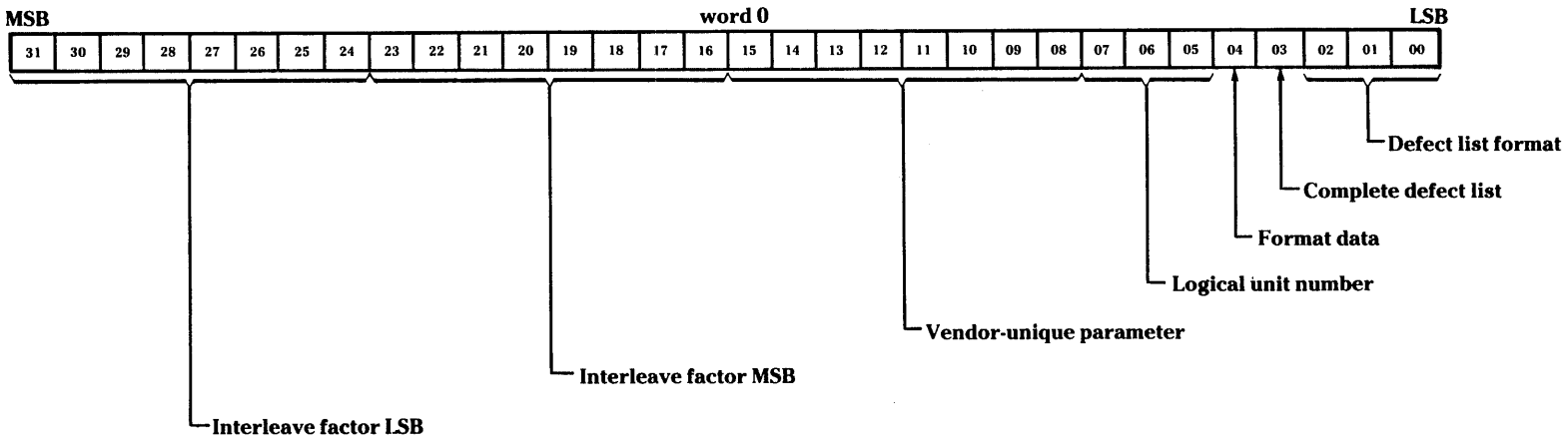
word 0	SCSI Format command bytes 1 through 4
word 1	SCSI Format command parameter list pointer
word 2	SCSI Format command parameter list word length
word 3	reserved for surface analysis parameter buffer pointer
word 4	reserved for surface analysis parameter buffer length
word 5	reserved
word 6	reserved
word 7	reserved
word 8	reserved

The formatter initialization parameters are defined as follows:

- Word 0 (Figure 5-22) — This word contains the following disk parameters:
  - Defect list format (byte 0, bits 2 through 0) — This field contains a code that specifies whether the disk defect list location is to be specified by cylinder, head, or bytes from the index.
  - Complete defect list (byte 0, bit 3) — When active, this bit indicates that the existing disk defect list contains all known defects and is to replace any previous defect list. When inactive, this bit indicates that any new defects are to be added to the existing list.
  - Format data (byte 0, bit 4) — When active, this bit indicates that the formatter is to supply disk defect data during formatting. When inactive, this bit indicates that no disk defect data is available and that the disk is to be formatted without defect data.
  - Logical unit number (byte 0, bits 7 through 5) — This field specifies the logical unit number of the disk drive to be formatted.
  - Vendor-unique parameters (byte 1) — This byte contains parameters that are unique to the specific type of disk unit.
  - Interleave factor (bytes 3 and 2) — The interleave factor is a whole number that specifies the relationship between the physical sector order and the logical sector order on the disk. For an interleave factor of *n*, logically sequential sectors fall on every *nth* physical sector.

NOTE: The least significant byte and the most significant byte of the interleave factor occupy bytes 3 and 2, respectively, of word 0.

Figure 5-22 SCSI Format Parameters (Word 0)



- Word 1 — This word contains the SCSI format parameter list pointer. This pointer indicates the NuBus location of the disk defect list.

- Word 2 — This word contains the SCSI format parameter list length. This list length specifies (in hexadecimal bytes) the number of words in the disk defect list. If no defect list is available, word 2 and bit 4 of word 0 must be set to 0.

NOTE: For scattered memory operations, word 1 contains the scatter table address and word 2 contains the total length (in hexadecimal bytes) of the defect list described by the scatter table. Refer to paragraph 5.4.3 for more information about scattered memory operations.

- Words 3 and 4 — These are reserved for future use as a NuBus address pointer and a parameter list length for surface analysis parameters.

- Words 5 through 8 — These words are reserved and must be set to 0.

Tape Commands

5.5.9 Tape operations often return nonerror status to a command block. This nonerror status sets the appropriate command block status bits but does not set the error bit unless an error condition also exists. Refer to Table 5-8 for more information about the nonerror status codes.

After one of the nonerror status conditions has been returned, further status can be obtained by issuing the Device Status command and processing the returned SCSI sense data. Most of this data varies from one formatter to another.

Although some of the tape commands do not require a word transfer count or a buffer/parameter list pointer value, valid command decoding requires that the two least significant bits of these parameters be set to 0 to avoid illegal command detection and processing. Also, an attempt to issue any of these commands to a disk unit returns an invalid parameter error to the host.

Rewind Tape Command

5.5.9.1 The command code for the Rewind Tape command is >20, and its function is to cause a selected tape unit to rewind to the BOT position. This command does not require a block address, a word transfer count, or a NuBus buffer address.

Unload Tape Command

5.5.9.2 The command code for the Unload Tape command is >21, and its function is to cause a selected tape unit to move to the unload position. This command issues the SCSI Load/Unload command to the tape device. If the unload re-tension control bit of the formatter-specific parameter field (paragraph 5.5.2.2) is set, this command also performs a tape re-tension operation. The Unload Tape command does not require a block address, a word transfer count, or a NuBus buffer address.

NOTE: The SCSI command set uses the same command (Load/Unload) for loading or unloading tape. A load bit in the SCSI command block causes a load operation when high and an unload operation when low.

Erase Tape Command

5.5.9.3 The command code for the Erase Tape command is >22. This command erases the tape on a selected tape unit starting at the current position unless the long bit control bit (paragraph 5.5.2.2) is active. Having this bit active causes the formatter to erase a vendor-specified length of tape. This command does not require a block address, a word transfer count, or a NuBus buffer address.

Space Commands

5.5.9.4 Three space forward commands facilitate tape operations by allowing specified portions of tape to be skipped without affecting the data. The following paragraphs describe these commands.

Space Forward by Blocks Command The command code for the Space Forward by Blocks command is >23. This command functions similarly to the Read command except that no data is transferred to the NuBus or retained in the NUPI buffer. Its function is to move the tape forward by a specified number of blocks. The buffer/parameter list pointer contains the NuBus address of a word transfer parameter that specifies the number of NuBus blocks to skip up to a maximum of >7FFFFF (8 388 607). This method of specifying the block count avoids the limitation imposed by the requirement of setting to 0 the two least significant bits of command word 4. A NuBus block is equivalent to 1024 bytes, whereas the length of a tape block depends on the tape device used.

If the Device Blocks command option bit (bit 18) is set, the command's parameter is interpreted as device blocks rather than 1024 byte NuBus blocks. This option requires the tape device be previously set to variable block mode. If not previously set to variable block mode, an invalid parameter status is reported.

Space Reverse by Blocks Command The command code for the Space Reverse by Blocks command is >24. This command moves the tape backward the hexadecimal number of blocks (maximum FFFFFFH) specified in a long word parameter pointed to by the buffer/parm pointer of the command block. If the Device Blocks command option bit (bit 18) is set, the command's parameter is interpreted as device blocks rather than 1024 byte NuBus blocks. This option requires that the device be previously set to variable block mode. If previously set to variable block mode, an invalid parameter status is reported. This command also reports invalid command status if it is issued to a disk drive, a formatter, or the NUPI. Since the block addresses and NuBus buffer addresses are not used, the two least significant bits of the NuBus address must be set to zero for valid command decoding. If these two bits are not set to zero, the command block is not executed, and an illegal command will be processed.

Space Forward by File Marks Command The command code for the Space Forward by File Marks command is >27. This command is similar to the Space Forward by Blocks command except that its function is to move the tape forward by a specified number of file marks. The buffer/parameter list pointer contains the NuBus address of a word transfer parameter that specifies the number of file marks to skip.

Space Reverse by File Marks The command code for the Space Reverse by File Marks is >28. This command operates similar to the Space Forward by File Marks command except that spacing is done in reverse (toward BOT). This command moves the tape backwards the hexadecimal number of file marks (maximum FFFFFFH) specified in a long word parameter pointed to by the buffer/parm pointer of the command block. This command reports an invalid command status if it is issued to a disk drive, a formatter, or the NUPI. Since the block addresses and NuBus Buffer addresses are not used, it is necessary to guarantee that the two least significant bits of the NuBus address are set to zero for valid command decoding. If these two bits are not set to zero, the command block is not executed, and an illegal command is processed.

Space Forward to End of Data Command The command code for the Space Forward to End of Data command is >29. This command is similar to the Space Forward by Blocks command except that its function is to move the tape forward to the end of the recorded data. This command does not use the buffer/parameter list pointer or the word transfer count.

Write File Mark Command

5.5.9.5 The command code for the Write File Mark command is >25. This command writes a file mark at the current position on a selected tape unit and a leader gap whose length is determined by the tape unit or formatter. This command does not require a block address, a word transfer count, or a NuBus buffer address.

Tape Re-tension Command

5.5.9.6 The command code for the Tape Re-tension command is >26. This command issues the SCSI Load/Unload command with the load and re-tension bits set. The purpose of tape re-tensioning is to ensure that the tension is uniform throughout the reel.

Load Command

5.5.9.7 The command code for the Load command is >2A, and its function is to move the tape to the load position (BOT) so it is ready for use. This command issues the SCSI Load/Unload command to the tape device. If the load re-tension control bit of the formatter-specific parameter field (paragraph 5.5.2.2) is set, this command also performs a tape re-tension operation.

Individual Self-Test Commands

5.5.10 The individual self-test command codes are >30 (NUPI devices), >70 (formatter), and >B0 (NUPI). These commands ignore the parameter list pointer and word transfer count. The device address field contains the list of self-tests to be performed by the selected device. Each active bit in this field enables the self-test corresponding to the bit position. For example, a code of >92 (10010010) executes self-tests 2, 5, and 8 in that order. An active bit for which no self-test exists results in a no-operation (NOP). Bit 31 (if set) causes looping on the specified self-test until the NUPI is reset.

Table 5-9 lists the NUPI self-tests. Some of these tests are categorized as potentially fatal. That is, failure of any one of these tests results in an inability of the NUPI to reliably access the NuBus for command block updates or reporting of command completion status. Therefore, if the self-test fails to complete execution within the time specified in the configuration ROM, it is treated as a failure.

CAUTION: An attempt to execute any self-test while any other command is in progress can result in serious adverse effects. For example, a self-test command directed to the NUPI generates a SCSI bus reset, aborting all ongoing mass storage commands in the middle of their operations.

Table 5-9 NUPI Self-Tests

Self-Test Code	Name
X X X X X X X X X X X X X 1	Short microprocessor check (FATAL)
X X X X X X X X X X X X 1 X	ROM CR check (FATAL)
X X X X X X X X X X X 1 X X	Full RAM test (FATAL)
X X X X X X X 1 X X X X X	Interval timer test
X X X X X X 1 X X X X X X	Board control test (discrete lines, XCNT, and SCNT)
X X X X X 1 X X X X X X X	Page address register and MPU address loopback test (FATAL)
X X X X 1 X X X X X X X X	DMA FIFO RAM, IOB latch, and NuBus/DMA address counter tests
X X X 1 X X X X X X X X X	SCSI controller chip test
X X 1 X X X X X X X X X X	Internal DMA operation test
X 1 X X X X X X X X X X X	DMA/NuBus loopback test
1 X X X X X X X X X X X X	SCSI loopback test (with Texas Instruments formatters only)

Note:

X = irrelevant

SCSI Pass Through Read Command

5.5.11 The command code for the SCSI Pass Through Read command is >71. This command allows execution of a SCSI command block in NuBus memory to be processed for the formatter specified by the unit select field. This enables execution of SCSI commands from the host with data transferred back to NuBus memory. The NUPI handles all SCSI handshake operations. The system software must ensure that the device for which the command is intended is not active and that it receives no standard command until this command is complete.

During the execution of the SCSI Pass Through Read command, the NUPI performs no retry or error recovery operations. Also, NUPI status information returned to the command block during this time contains no SCSI command status. This status is placed in the NuBus SCSI status block.

The parameter list pointer indicates the NuBus address of a block of data that contains the following information:

- Word 1 — NuBus data pointer. This word contains the NuBus address for the information transfer phase of the SCSI command. For a read pass-through operation, this address is the location where the information is to be placed. For a write pass-through operation, this is the address of the buffer from which the information is to be passed to the SCSI device. This information is packed in NuBus memory, four bytes per NuBus word, with byte 0 at the lowest NuBus byte address, byte 1 at the second NuBus byte address, and so on.

- Word 2 — NuBus data buffer length. This word specifies the length in hexadecimal bytes of the buffer area defined in word 1. During a read pass-through or write pass-through operation, data in excess of this buffer length is lost, and an illegal parameter error is returned to the command block.

- Word 3 — NuBus SCSI status pointer. This word specifies the NuBus address at which status information resulting from the SCSI command is placed.

- Word 4 — NuBus SCSI status pointer length. This word specifies the length in hexadecimal bytes of the status buffer. Status information in excess of this buffer length results in command abortion and rate-error status.

- Word 5 — NuBus SCSI command block pointer. This word contains the NuBus address of the SCSI command block to be executed. The SCSI command block consists of the number of bytes required by the SCSI command's group code. These bytes are packed in NuBus memory, four bytes per NuBus word, with byte 0 at the lowest NuBus byte address, byte 1 at the second NuBus byte address, and so on.

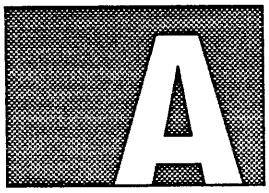
- Word 6 — NuBus SCSI command block length. This word contains the length in hexadecimal bytes of the SCSI command block to be executed. If this entry is of insufficient size for the specified command block, an invalid parameter error is returned.

The word transfer count specifies, in hexadecimal notation, the length of the indicated data block. This block must be exactly >18 (24) bytes long in order to contain all required data. Otherwise, an invalid parameter error is reported.

SCSI Pass Through Write Command

5.5.12 The command code for the SCSI Pass Through Write command is >72. This command allows execution of a SCSI command block in NuBus memory to be processed for the formatter and mass storage device specified by the unit select field. This enables execution of SCSI commands from the host, with data transferred from NuBus memory to the SCSI device. The NUPI handles all SCSI handshake operations. The system software must ensure that the device for which the command is intended is not active and that it receives no standard command until this command is complete.

Execution of the SCSI Pass Through Write command is identical to that of the SCSI Pass Through Read command.



SCSI COMMANDS AND MESSAGES

Introduction

A.1 The mass storage subsystem uses a set of commands and messages to handle communications between the NUPI and the mass storage formatters. This appendix summarizes these commands and messages.

SCSI Commands

A.2 The NUPI, in response to commands from the host, establishes a connection and transfers the appropriate SCSI commands to the specified formatter. On completion of command execution, the formatter returns a status byte and a message byte to the NUPI to indicate either successful completion or that error information is available for reading. Table A-1 lists the SCSI commands and describes the conditions under which they are issued.

Table A-1 SCSI Command

Command	Command Code	Disk/Tape	Description
Test Unit Ready	>00	Both	The NUPI issues this command during power-up or during polling operations. The selected formatter responds to this command by returning a status byte that indicates whether or not the mass storage device is powered up and ready.
Restore	>01	Disk	The NUPI issues this command in response to a Restore Device command from the host. The Restore command causes the selected disk unit to move its head assembly to cylinder >00 and to return a status byte to the NUPI.
Rewind	>01	Tape	The NUPI issues this command in response to a Rewind Tape command from the host. This command repositions the tape to the beginning of tape.
Request Sense	>03	Both	The NUPI issues this command during error processing. The Request Sense command allows the NUPI to read the sense bytes of the formatter following an error condition. The sense bytes define the error.
Format Unit	>04	Disk	The NUPI issues this command in response to a Format Unit command from the host. This command causes the selected formatter to format the selected disk for reading and writing. This command also marks defective sectors for defect skipping during normal read/write operations.

Table A-1 SCSI Command (Continued)

Command	Command Code	Disk/Tape	Description
Read Block Limits	>05	Tape	The NUPI issues this command during polling operations to determine the data block length of the tape devices.
Read	>08 >28	Both Disk	The NUPI issues this command in response to a Read command from the host. This command allows a specified number of data blocks to be transferred from the mass storage media to the host via the NUPI, starting at a block address specified by the command.
Write	>0A >2A	Both Disk	The NUPI issues this command in response to a Write command from the host. This command allows the host to write a specified number of data blocks to the mass storage media, starting at a block address specified by the command.
Seek	>0B	Disk	The NUPI issues this command in response to a Seek command from the host. This command causes the selected disk device to seek to a particular cylinder where a requested data block resides. The Seek command does not transfer data.
Write File Mark	>10	Tape	The NUPI issues this command in response to a Write File Mark command from the host. This command causes a file mark to be written to the tape.
Space	>11	Tape	The NUPI issues this command in response to a Space Forward by Blocks, Space Forward by File Marks, or Space Forward to End of Data command from the host. This command causes the tape to move forward a distance specified by the command.
Inquiry	>12	Both	The NUPI issues this command at power-up and during polling to identify the type of mass storage device.
Mode Select	>15	Both	The NUPI issues this command in response to the Formatter Setup command. This command provides a means for the NUPI to specify disk or tape drive parameters to the formatter.

Table A-1 SCSI Commands (Continued)

Command	Command Code	Disk/Tape	Description
Erase	>19	Tape	The NUPI issues this command in response to an Erase Tape command from the host. This command erases the tape on a selected tape unit starting at the current position unless the long bit control bit (paragraph 5.5.2.2) is active.
Mode Sense	>1A	Both	The NUPI issues this command during power-up and polling. This command allows the NUPI to determine the block size established by the last Mode Select or Format Unit command.
Load/Unload	>1B	Tape	The NUPI issues this command in response to either a Load, Unload, or Tape Re-tension command from the host. Two bits (re-tension and load) in the command descriptor block define the operation as follows: ■ Load bit high — Command execution moves the tape to the load position. ■ Load bit low — Command execution moves the tape to the unload position. ■ Re-tension bit high — Command execution performs a tape re-tension operation. ■ Re-tension bit low — Command execution does not perform a tape re-tension operation.
Read Capacity	>25	Disk	The NUPI issues this command during polling operations to determine the data block length of the disk devices.

SCSI Messages

A.3 The NUPI and the mass storage formatters use SCSI messages to establish a physical link between the NUPI and the desired mass storage device. Once the connection is made, these messages are used to convey protocol control information during normal operation. Table A-2 lists and describes the SCSI messages.

Table A-2 SCSI Messages

SCSI Message	Message Code	Received/ Issued	Description
Command Complete	>00	Received	The formatter sends this message to the NUPI to indicate that the current command is complete.
Save Data Pointer	>02	Received	The formatter sends this message to the NUPI prior to a disconnect message to direct it to save a copy of the currently active data pointer for the selected mass storage device.
Restore Pointers	>03	Received	The formatter sends this message to the NUPI to direct it to recall the last data pointer saved. Since reconnection implies a data pointer restore operation, this message is used only for error recovery procedures.
Disconnect	>04	Received	The formatter sends this message to the NUPI to request a bus disconnect during a command execution. This feature allows other bus devices to share the SCSI bus during time-consuming operations that do not transfer data.
Initiator Detected Error	>05	Issued	The NUPI sends this message to the formatter to indicate the detection of a retryable error since the last data pointer save.
Abort	>06	Issued	The NUPI sends this message to the formatter to request termination of any I/O activity for the selected mass storage device.
Message Reject	>07	Both	Either the NUPI or the formatter sends this message to indicate that the last message received was either inappropriate or was not implemented.
No Operation	>08	Both	If the NUPI has no other valid message to send, it sends this message to the formatter in response to a request for a message.
Message Parity Error	>09	Both	Either the NUPI or the formatter sends this message to indicate that the last message received contains a bus parity error.

Table A-2 SCSI Messages (Continued)

SCSI Message	Message Code	Received/ Issued	Description
Bus Device Reset	>0C	Issued	The NUPI sends this message to direct the formatter to terminate any operations in progress and to return to the bus-free state.
Identify	>80 ↓ >83	Both	The NUPI sends this message during the physical path connection phase to indicate that the NUPI can support bus sharing and to notify the selected mass storage device that the NUPI wants to communicate with it. The formatter sends this message during reselection.
	>C0 ↓ >C3	Issued	

MEMORY MAPS

This appendix contains the memory maps for the NUPI's on-board ROM.

Figure B-1 NUPI Configuration ROM (Sheet 1 of 2)

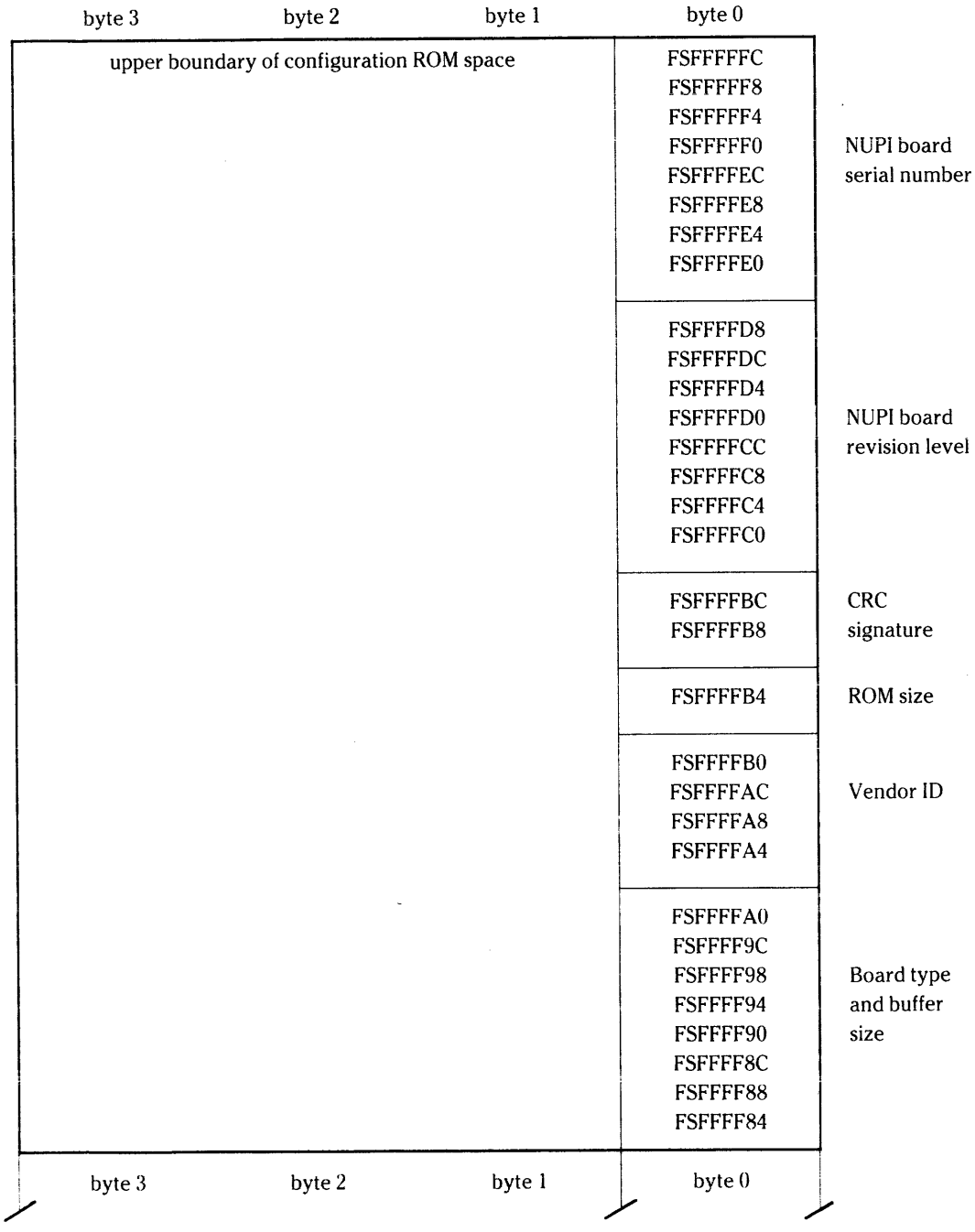


Figure B-1 NUPI Configuration ROM (Sheet 2 of 2)

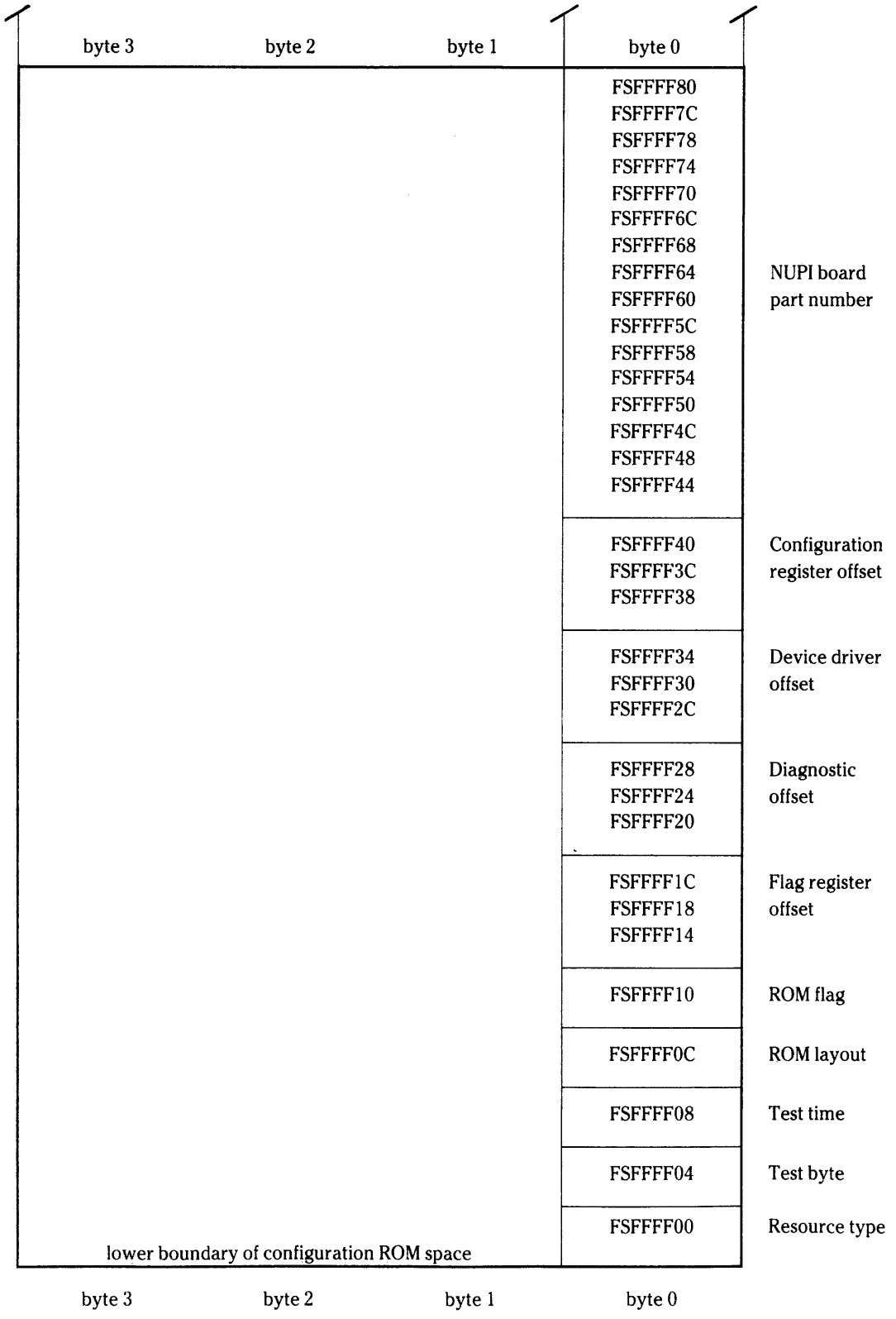
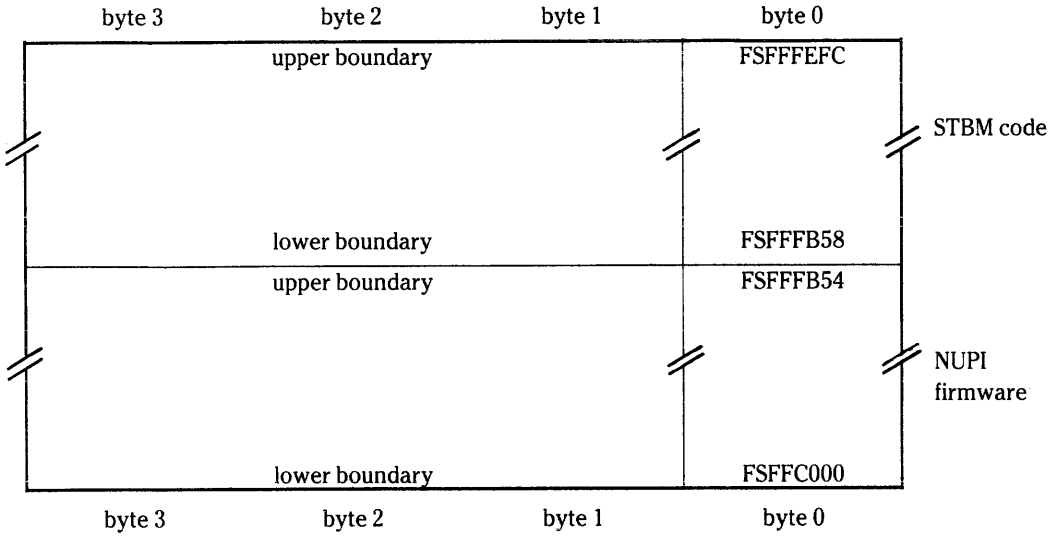
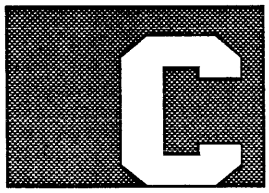


Figure B-2 NUPI Firmware and STBM Code





NUPI LED SETTINGS

This appendix lists the conditions under which the NUPI firmware sets the NUPI LEDs. The NUPI has red and yellow LEDs. The red LED indicates a NUPI board fault; the yellow LED indicates a SCSI bus fault.

LED	Conditions
Red	1. Self-test failure 2. Bus test failure 3. 68000 hardware error trap 4. 68000 software error trap 5. Occurrence of unused NCR5385 testability or invalid command interrupts. 6. Set by operating system (configuration register bit 2)
Yellow	1. Self-test failure 2. Selected interrupt from NCR5385 3. Received an NCR function complete interrupt with no apparent cause 4. Illegal message for reconnect phase 5. Reconnection to a device not waiting for reconnection 6. Reselection without a valid SCSI ID 7. A command time-out for a SCSI bus hung condition

GLOSSARY

a

acknowledge cycle — The last period of a NuBus transaction (one clock period long) during which the ACK- signal is asserted.

address cycle — The first period of a NuBus transaction (one clock period long) during which the START- signal is active and the NuBus address is on AD0- through AD31-. Address cycle is the same as start cycle.

address space — The space set aside in memory for a specific group of addresses.

arbitration — The process of selecting between the different circuit boards that are available on a bus using a priority system.

auxiliary status bit — A bit in the NUPI status word that indicates to the host that status other than that reported in the status word is available and that the host should request this additional status.

b

backplane — A circuit board that connects all the circuit board slot connectors together in a chassis to make a bus connection.

block transfer — The movement of groups of consecutive 32-bit words over the NuBus.

buffer/parameter list pointer — A NUPI command word that indicates the NuBus physical address of a parameter list for commands that require such a list. For data transfers that do not involve scatter operations, the pointer indicates the NuBus address of the read or write data.

bus — A group of one or more signal lines that transfers information from one or more sources to one or more destinations.

busy bit — A bit in the NUPI status word that, when active, indicates to the host that the NUPI has received and is currently executing a command.

byte — A group of eight parallel bits of data.

c

chip — An integrated circuit device containing a large number of electronic elements in a single package.

command abortion bit — A special event bit that the NUPI returns in response to a Request NUPI Status command to indicate to the host that the NUPI has aborted a command without updating the NuBus.

command address register — A register in NUPI RAM to which the starting NuBus address of the NUPI command block is written.

command description field — An eight-bit field in the NUPI command block that defines the operation to be performed and determines whether it is to be performed by the NUPI or by a selected formatter.

command error bit — A formatter/mass storage device status bit that the NUPI returns in response to any one of the request status commands to indicate to the host that an error occurred during the execution of the last command and that status is available.

command options field — A 16-bit field in the NUPI command block that defines various command options.

complete bit — A bit in the NUPI status word that, when active, indicates to the host that the NUPI has completed command execution.

complete defect list bit — A bit in the Format Unit command block that indicates that the current disk defect list contains all known defects and is to replace the existing defect list on the disk.

CRC — Cyclic redundancy check. A system of error checking for data transfer operations.

current and completion status field — An eight-bit field in the NUPI status word that shows the status of a completed command.

cycle — A periodically repeated sequence of operations.

d

device block address — A NUPI command block word that specifies the logical starting address of a block of data to be accessed on the selected mass storage device.

device not ready bit — A mass storage device status bit that the NUPI returns in response to any one of the request status commands to indicate to the host that the selected device is not yet ready to accept a command.

device offline bit — A formatter/mass storage device status bit that the NUPI returns in response to any one of the request status commands to indicate to the host that either the selected formatter or the selected device is offline.

device overtemperature bit — A formatter status bit that the NUPI returns in response to any one of the request status commands to indicate to the host that a formatter has detected an overtemperature condition in its associated mass storage enclosure.

device removable medium bit — A mass storage device status bit that the NUPI returns in response to a Request NUPI Status command to indicate to the host that the selected device has a removable recording medium.

device select bit — A bit in the NUPI command block that indicates the mass storage device for which the current command is intended. This bit is used in conjunction with the formatter select field.

device unit attention bit — A mass storage device status bit that the NUPI returns in response to any one of the request status commands to indicate to the host that the selected device has just come online or that the medium has just been changed on the selected device.

DMA bus — Direct memory access bus. A 16-bit bus that handles all internal NUPI data transfer operations between the NuBus and the mass storage subsystem.

e

ECC bit — A bit in the NUPI status word that indicates to the host that error correcting code has been applied to some part of the previously transferred data.

ejector — A mechanical device on a circuit board that provides leverage to help remove a circuit board from the connectors on the backplane.

enable bus master bit — A bit in the NUPI configuration register that, when active, enables the NUPI to become a NuBus master in order to process NuBus commands.

error bit — A bit in the NUPI status word that indicates to the host that an unrecoverable error has occurred.

event bit — A bit in the NUPI command block that, when active, causes the NUPI to post an event to the specified event generation address.

event generation address — A NuBus address to which an event is posted. Each device or action that can post an event has a unique event generation address.

f

failure override bit — A bit in the NUPI configuration register that, when active, allows the NUPI to override a self-test failure in order to process a command.

fault LED bit — A bit in the NUPI configuration register that, when active, overrides the result of any NUPI self-test operation and activates the NUPI fault LED and self-test failure status.

FIFO RAM — First-in-first-out random-access memory.

format data bit — A bit in the SCSI format command parameter list that, when active, indicates that the formatter is to supply disk defect data during formatting.

format parameter list pointer — A word in the format command parameter list that indicates the NuBus location of the disk defect list.

formatter destination bit — A bit in the NUPI command block that, when active, indicates that the current command is intended for the selected formatter.

formatter or device self-test status bit — A formatter/mass storage device status bit that the NUPI returns in response to any one of the request status commands to indicate to the host that either the selected formatter or the selected device has failed a self-test.

formatter select field — A three-bit field in the NUPI command block that specifies the formatter for which a command is intended.

h

halfword — A group of 16 parallel bits of data.

hard-wired — A term describing wires that are permanently connected to terminals.

i

illegal access bit — A special event bit that the NUPI returns in response to the Request NUPI Status command to indicate to the host that an illegal attempt to access the NUPI control space has occurred.

illegal command bit — A special event bit that the NUPI returns in response to a Request NUPI Status command to indicate to the host that an illegal command or command block has been issued.

illegal interrupt bit — A special event bit that the NUPI returns in response to a Request NUPI Status command to indicate to the host that an illegal interrupt has occurred during an attempted NuBus access operation.

indeterminate device status bit — A mass storage device status bit that the NUPI returns in response to any one of the request status commands to indicate to the host that the status of the selected device cannot be determined.

injector — A mechanical device on a circuit board that provides leverage to help insert a circuit board into the connectors on the backplane.

invalid SCSI operation bit — A special event bit that the NUPI returns in response to any one of the request status commands to indicate to the host that an invalid SCSI operation has been attempted.

invalid special event address bit — A special event bit that the NUPI returns in response to any one of the request status commands to indicate to the host that an invalid special event address has been specified.

IOB — Input/output bus. A 32-bit, bidirectional bus on the NUPI that carries addresses and data for all NuBus cycles in which the NUPI is involved. It also carries loopback data for self-test operations.

l

last command field — A status byte that the NUPI returns in response to any one of the request status commands. This byte contains the command code for the last command issued.

last command option field — A status byte that the NUPI returns in response to any one of the request status commands to indicate to the host the condition of the option bits for the last command issued.

LED — An acronym for light-emitting diode.

Lisp — A high-level computer programming language used for symbolic processing.

load re-tension control bit — A bit in the Formatter Setup command parameter list that causes a selected tape device to adjust the tape tension during a load operation.

logical unit number field — A three-bit field in the Format Unit command block that specifies the disk device to be formatted.

long bit control bit — A bit in the Formatter Setup command parameter list that controls the amount of tape to be erased on a selected tape device.

m

master — The controlling circuit in a master/slave communication protocol over a bus.

MPU — Microprocessor unit.

MPU address bus — A 23-bit bus on the NUPI that provides addresses for all MPU cycles.

MPU data bus — A 16-bit, bidirectional bus that transfers data, control, and status information between the NUPI MPU, the NuBus, and various associated logic devices.

multiple commands bit — A special event bit that the NUPI returns in response to any one of the request status commands to indicate to the host that an attempt has been made to issue multiple commands to either the NUPI, a selected formatter, or a selected device.

n

NuBus — A high-speed synchronous bus that multiplexes 32-bit data words with 32-bit address words and uses master/slave communication protocols.

NUPI — NuBus peripheral interface.

NUPI destination bit — A bit in the NUPI command block that, when active, indicates that the current command is intended for the NUPI.

NUPI flag register — An eight-bit register in NUPI RAM that provides information regarding self-test status.

NUPI hardware or software error bit — A special event bit that the NUPI returns in response to any one of the request status commands to indicate to the host that either a hardware or software error has occurred on the NUPI.

NUPI status word — A word in the NUPI command block that reports command block status and command completion status to the host.

---

o

overtemperature bit — A special event bit that the NUPI returns in response to any one of the request status commands to indicate to the host that an overtemperature condition has occurred in one of the mass storage devices that currently has no active command.

---

p

paging partial completion status bit — A bit in the NUPI status word that, when active, indicates to the host that the NuBus operation portion of a Swap NUPI Buffer and Write command is complete, even though a SCSI operation may still be active.

period — One cycle of the NuBus clock.

power failure event — An event that is posted to indicate the occurrence of a power failure.

---

r

reset bit — A bit in the NUPI configuration register that, when activated, resets both the NUPI and the SCSI bus and causes all power-up self-tests to be executed.

retry bit — A bit in the NUPI status word that, when active, indicates to the host that retry operations have been performed in an effort to execute a command.

S

scatter bit — A bit in the NUPI command block that, when active, initiates a NuBus memory scatter operation.

SCSI — Small Computer System Interface. The principal interface between the NUPI and the mass storage formatters in the Explorer mass storage subsystem.

SCSI passed bit — A bit in the NUPI flag register that, when active, indicates successful completion of either the SCSI bus or formatter self-test.

SCSI sense information — Status information that is generated by the mass storage formatters during the execution of mass storage commands. The formatters report to the NUPI that the sense information is available, and the NUPI obtains the information by issuing a Request Sense command.

self-test complete bit — A bit in the NUPI flag register that, when active, indicates that all NUPI self-tests, except the NuBus transceiver and slave tests, have completed.

self-test passed bit — A bit in the NUPI flag register that, when active, indicates that all NUPI self-tests have completed successfully.

slave — The device that is controlled by a master device in a master/slave communication arrangement over a bus.

slot — A physical channel in a chassis into which a circuit board is inserted.

slot ID — A binary code that identifies the slot into which a circuit board is inserted.

static-sensitive — Capable of being damaged by static electricity.

synchronous bus — A bus that has a separate clock line to provide synchronization for information that is transferred over the bus.

system bus test bit — A bit in the NUPI configuration register that, when active, causes the NUPI to write the contents of the configuration ROM to a NuBus address specified by the DMA test register and to read the data back for verification.

t

tape re-tension — A method of adjusting the tension of the tape on a tape reel to ensure that the tension is uniform throughout the reel.

transaction — A complete bus operation; for example, a read or write operation.

u

unit select field — An eight-bit field in the NUPI command block that specifies both the formatter and the mass storage device for which the command is intended.

unload re-tension control bit — A bit in the Formatter Setup command parameter list that causes a selected tape device to adjust the tape tension during an unload operation.

unrecoverable NuBus error bit — A special event bit that the NUPI returns in response to any one of the request status commands to indicate to the host that an unrecoverable NuBus error has occurred while fetching the NUPI command block.

w

word — A group of 32 parallel bits of data.

word transfer count — A NUPI command block word that contains a hexadecimal value that indicates the total number of bytes to be transferred during a read or write operation.

write-protected device bit — A mass storage device status bit that the NUPI returns in response to any one of the request status commands to indicate to the host that the selected device is write-protected and cannot be written to.

INDEX

a

b

C

d

e

f

g

i

l

m

n

Explorer NuBus Peripheral Interface General Description
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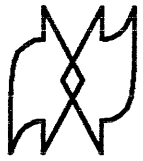

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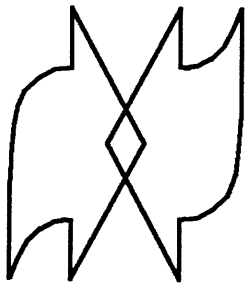

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