GPIB-LPT
User Manual

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This equipment generates and uses radio frequency energy and, if not installed and used in strict accordance with the instructions in this manual, may cause interference to radio and television reception. This equipment has been tested and found to comply with (1) the limits for a Class B computing device, in accordance with the specifications in Subpart J of Part 15 of U.S. Federal Communications Commission (FCC) Rules, and (2) the limits for radio noise emissions from digital apparatus set out in the Radio Interference Regulations of the Canadian Department of Communication (DOC). These regulations are designed to provide reasonable protection against interference from the equipment to radio and television reception in commercial areas.

There is no guarantee that interference will not occur in a particular installation. However, the chances of interference are much less if the equipment is used according to this instruction manual.

If the equipment does cause interference to radio or television reception, which can be determined by turning the equipment on and off, one or more of the following suggestions may reduce or eliminate the problem.

- Operate the equipment and the receiver on different branches of your AC electrical system.

- Move the equipment away from the receiver with which it is interfering.

- Relocate the equipment with respect to the receiver.

- Reorient the receiver's antenna.

- Be sure that the equipment is plugged into a grounded outlet and that the grounding has not been defeated with a cheater plug.

If necessary, consult National Instruments or an experienced radio/television technician for additional suggestions. The following booklet prepared by the FCC may also be helpful: *How to Identify and Resolve Radio-TV Interference Problems.* This booklet is available from the U.S. Government Printing Office, Washington, DC 20402, Stock Number 004-000-00345-4.

Preface

This manual is divided into the following sections.

Section One, *Introduction*, contains a brief description of the GPIB-LPT including its features, components, and accessories.

Section Two, *Configuration and Installation*, describes how to configure and install the GPIB-LPT into your system.

Section Three, *Function Description*, shows a block diagram of the GPIB-LPT and describes the functional components of the GPIB-LPT.

Section Four, *Running Diagnostic Tests*, describes how to run the diagnostic tests that are shipped with the GPIB-LPT.

Section Five, *Programming the GPIB-LPT*, contains specific information about the GPIB-LPT registers along with software examples.

Appendix A, *Operation of the GPIB*, describes GPIB terminology and protocol for users unfamiliar with the GPIB.

Appendix B, *Multiline Interface Messages*, contains an ASCII chart and a list of the corresponding GPIB messages.

Abbreviations Used in This Manual

The following abbreviations are used in the text of this manual.

A	ampere
hex	hexadecimal
kbytes	1,000 bytes
m	meter
Mbytes	1,000,000 bytes
μsec	microsecond
sec	second
V	volt
VDC	Volts direct current

Related Documents

The following documents are references that cover in greater detail specific topics introduced in this manual:

- *ANSI/IEEE Standard 488-1978, IEEE Standard Digital Interface for Programmable Instrumentation*

- *IBM Options Adapters Manual*

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Section One
Introduction

The National Instruments GPIB-LPT is a high-performance talk-only interface that converts data sent to a standard parallel port into an IEEE-488 General Purpose Interface Bus (GPIB) format for use with IEEE-488 printers and plotters. The GPIB-LPT looks like a standard parallel port for the IBM PC operating system and software. It can be used to communicate with GPIB printers and plotters with PC application programs, such as AutoCAD, that use parallel ports for printer and plotter output.

Features

The GPIB-LPT has the following hardware features:

- emulates the standard PC parallel printer interface so that no additional software is needed

- can be configured as either LPT1 (PRN), LPT2, or LPT3

- compatible with any software using the parallel ports on the IBM PC compatibles

- small dimensions so that it fits into any slot of a personal computer

- transparent addressing of unaddressed listeners

- interrupt synchronization circuitry which holds off interrupts until the GPIB handshake is complete

- choice of REN mode which operates an instrument in the remote mode

- choice of SRQ enable which monitors of asynchronous service requests

- choice of IFC mode which sends an interface clear when the computer is powered on

Figure 1-1 shows the GPIB-LPT interface board.
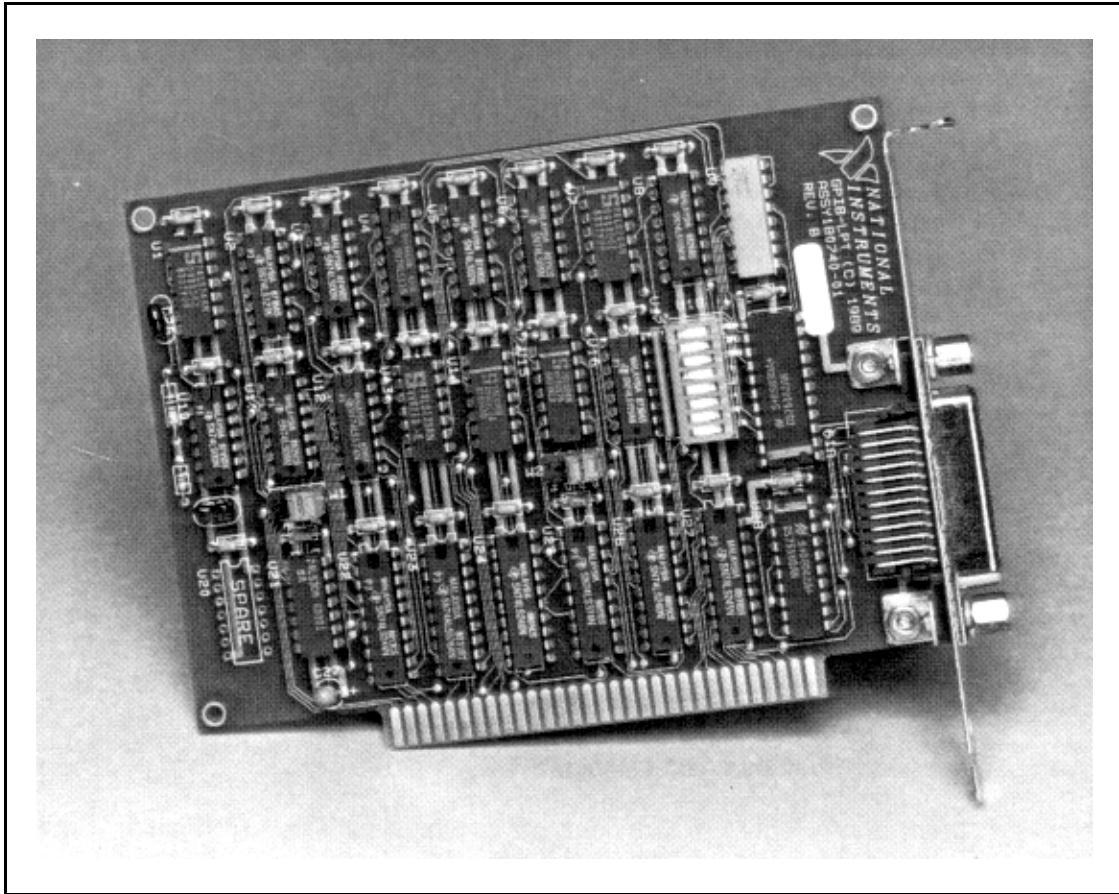
Figure 1-1. GPIB-LPT Board

The GPIB-LPT works in most true IBM-compatible computers. It does not work in the TI Professional Computer because it uses a different Basic Input Output System (BIOS) than the IBM compatibles.

What Your Kit Should Contain

Your kit should contain the following components:

Item	Part Number
GPIB-LPT interface board	180742-01
GPIB-LPT User Manual	320161-01
GPIB-LPT Diagnostic Package Diskette	420211-43

Note: The GPIB-LPT Diagnostic Package Diskette contains the *lpt.exe* diagnostic test that is described in Section Four, *Running Diagnostic Tests*.

Make sure each of these items is in your kit. If any item is missing, contact National Instruments.

Optional Equipment

Item	Part Number
Double Shielded Cables*:	
GPIB Type X2 Cable - 1 m	763061-01
GPIB Type X2 Cable - 2 m	763061-02
GPIB Type X2 Cable - 4 m	763061-03

* In order to meet FCC emission limits for a Class B device, you must use a double shielded (Type X2) GPIB cable. Operating this equipment with a single shielded (Type X1) cable may cause interference to radio and television reception in residential areas.

Section Two
Configuration and Installation

Figure 2-1 shows the locations of the GPIB-LPT configuration jumpers and switches.
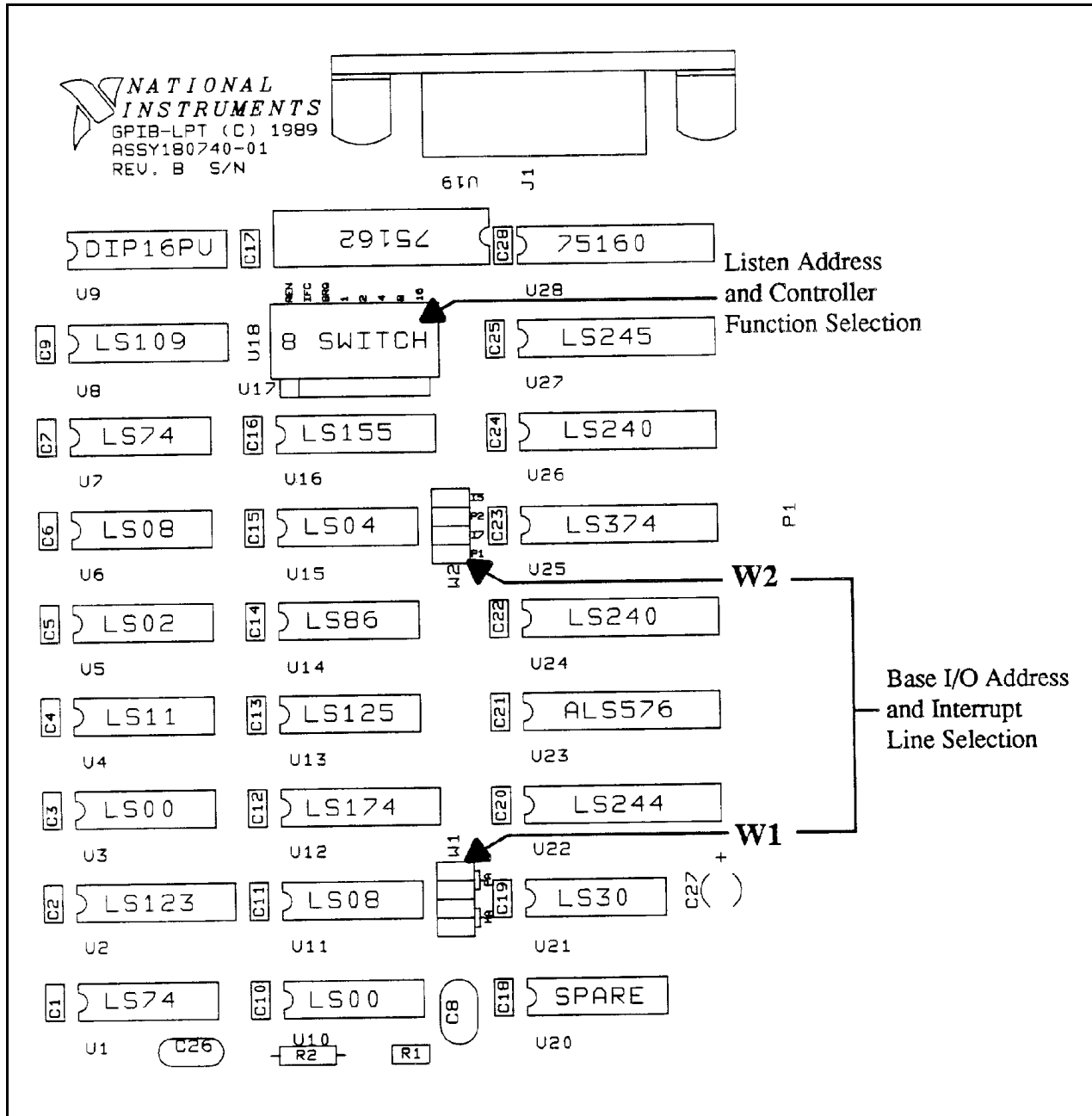
Figure 2-1. GPIB-LPT Parts Locator Diagram

Configuration

When installing the GPIB-LPT you must determine which IBM PC parallel port adapter the GPIB-LPT board will respond to and select the appropriate base address and interrupt level. The GPIB-LPT can be configured to one of three base addresses:

- 3BC Monochrome adapter

- 378/37C Parallel Port 1

- 278/27C Parallel Port 2

It is shipped from the factory set to 278/27C. The GPIB-LPT needs to be reconfigured if there is another device (such as a printer adapter card or a built-in parallel port) at the same address.

DOS has reserved device names for the parallel ports it finds in the system: LPT1 or PRN, LPT2, and LPT3. The parallel port adapters are named in the order in which they are found. Whenever the computer is turned on, it searches all three parallel port addresses for installed adapters. It first searches 3BC (LPT1), then 378 (LPT2), then 278 (LPT3). If only one device is installed, that device is named LPT1 regardless of what its I/O address is. If there is more than one parallel device installed, the first one found is assigned LPT1, the second one found is assigned LPT2, and so on.

The GPIB-LPT may need to be reconfigured if its interrupt level conflicts with another device. If the base I/O address of the GPIB-LPT does not conflict with any other device in your computer and the GPIB-LPT still does not work with your software package, reconfigure the GPIB-LPT to a different interrupt level.

Table 2-1 shows the standard base I/O address and interrupt level for each parallel port.

Table 2-1. IBM PC Parallel Port Adapters

Name of Port	Base I/O Address (hex)	Interrupt Level
Monochrome Display and Printer Adapter	3BC	7
Parallel Port 1	378 or 37C	7
Parallel Port 2	278 or 27C	5

The GPIB-LPT is shipped from the factory configured to operate as Parallel Port 2 (base I/O address 278 or 27C). If your PC already has a device responding to Parallel Port 2, it is necessary to reconfigure the GPIB-LPT board to another parallel port by changing the base I/O address and interrupt level.

Switch and Jumper Settings

Table 2-2 lists the factory settings and optional configurations for the switches and jumpers on the GPIB-LPT.

Table 2-2. Factory Default Settings and Optional Configurations

GPIB-LPT	Default	Optional
Base I/O Address	278/27C	3BC and 378/37C
Interrupt Level	5	7

If you need to change the factory settings, continue on. If you do not need to change the factory settings, skip to *Installation* later in this section.

Base I/O Address and Interrupt Selection

The base I/O address and interrupt line used by the GPIB-LPT are determined by the jumpers located at positions W1 and W2. The jumpers are set at the factory for base I/O address 278/27C hex and interrupt level 5.

Figure 2-2 shows the three possible combinations of jumper settings.

Note: PA stands for Parallel Adapter and MA stands for Monochrome Adapter.

a. Jumpers Set to Base I/O Address 3BC hex and Interrupt Level 7.
(Monochrome Display and Printer Adapter)

b. Jumpers Set to Base I/O Address 378/37C hex and Interrupt Level 7.
(Parallel Port 1)

c. Jumpers Set to Default Setting.
(Base I/O Address 278/27C hex and Interrupt Level 5)
(Parallel Port 2)
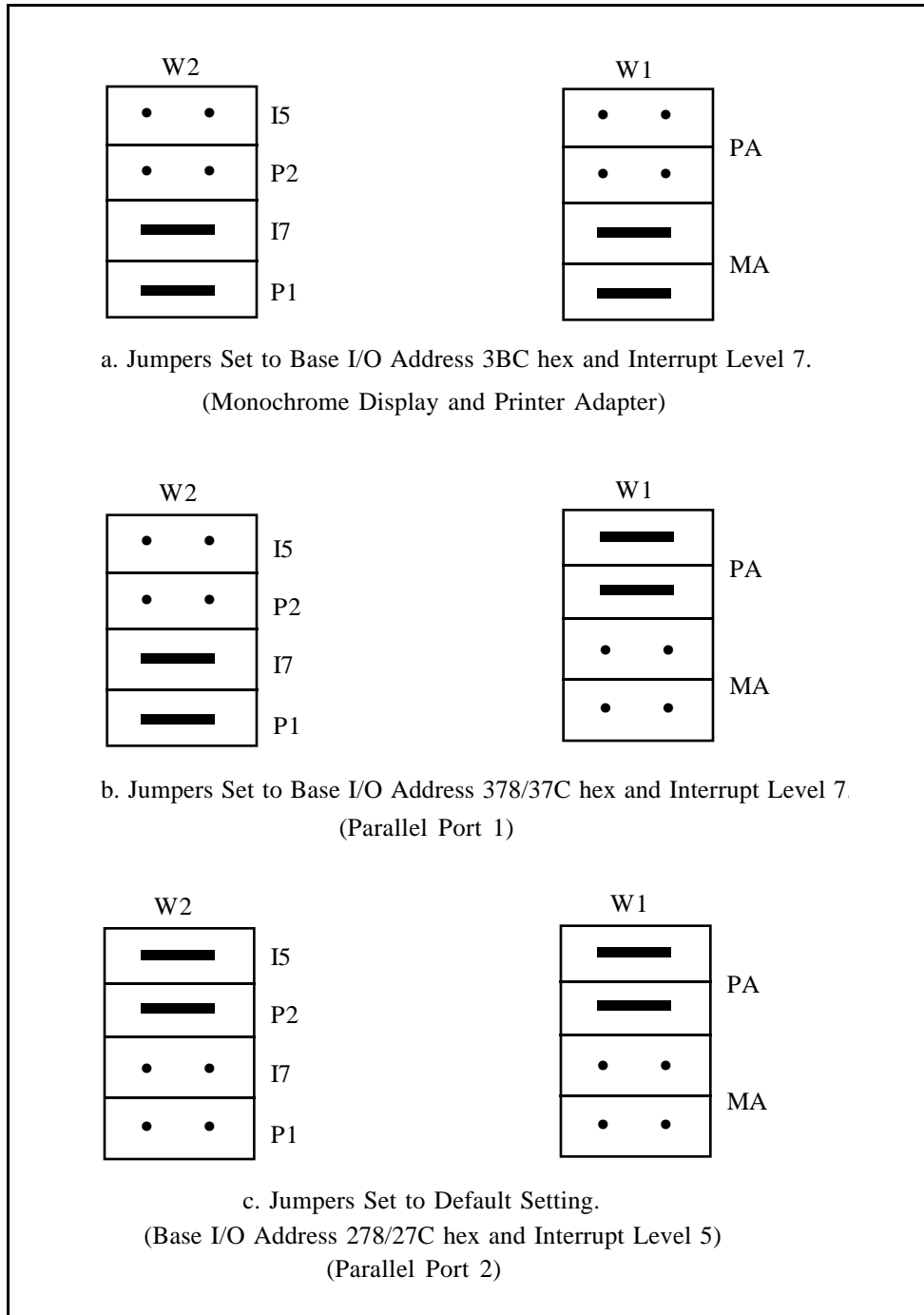
Figure 2-2. Possible Settings for GPIB-LPT Jumpers

Listen Address and Control Function Selection

The GPIB-LPT interface board has eight onboard switches you can use to configure the GPIB controller responsibilities. The lower five switches set the listen address of the external device(s) that will be attached to the GPIB-LPT. This address is used to send a GPIB listen address to the device(s) whenever the device(s) indicates that it is not a Listener. The three remaining switches (REN, IFC, and SRQ) have the following special functions:

Note: An asterisk (*) after a signal name indicates that the signal is inverted (negative logic).

*   REN*   Asserts/unasserts the Remote Enable (REN) line that places an instrument in remote mode. The ON position enables REN. The OFF position disables REN.

*   IFC*   Enables/disables the Interface Clear (IFC) option on the GPIB-LPT. If enabled, the GPIB-LPT issues an IFC when it is initialized. The ON position enables IFC on initialization. The OFF position holds IFC unasserted.

*   SRQ*   Enables/disables the Service Request (SRQ) option. If enabled, the GPIB-LPT monitors the SRQ line through the Paper Error (PE) bit in the GPIB-LPT status register. When the switch is positioned ON, the PE bit reflects the status of the SRQ line. When the switch is positioned OFF, the PE bit is always low.

The GPIB-LPT factory default switch configuration is for device address 5, REN OFF, IFC ON, and SRQ ON. Figure 2-3 shows the factory default switch settings for the GPIB-LPT.
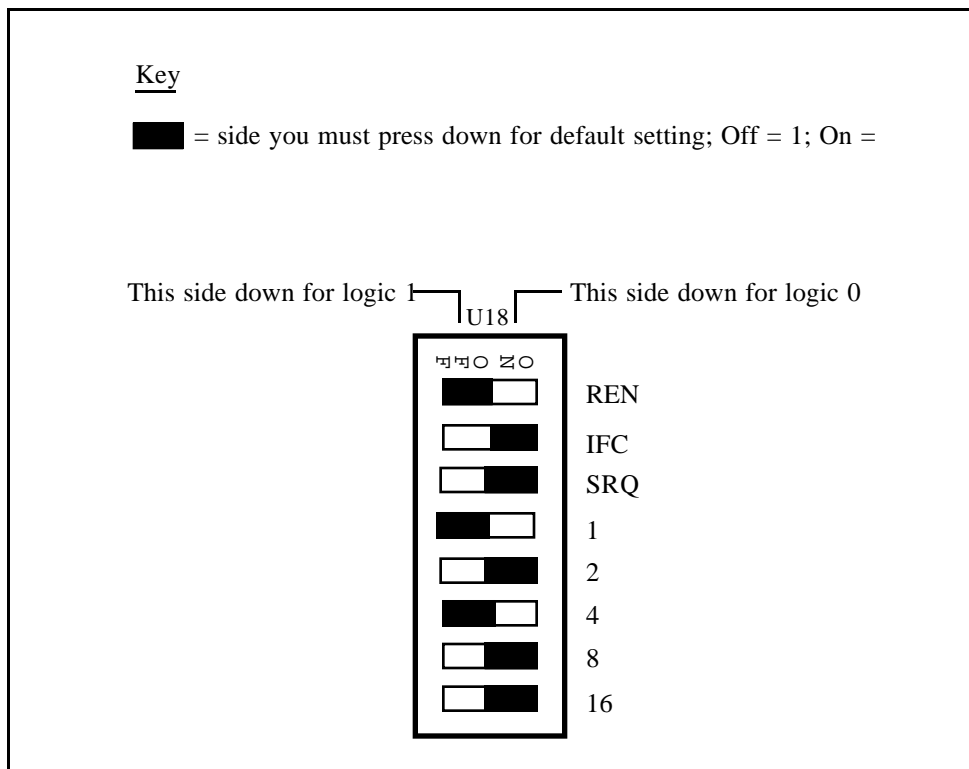
Figure 2-3. Switch Setting for REN OFF, IFC ON, SRQ ON, and Address 5
(Default Setting)

Figure 2-4 shows the switch configuration when using a device with address 6 hex.   The address varies with each device so check the address of your device and set these lower five bits.
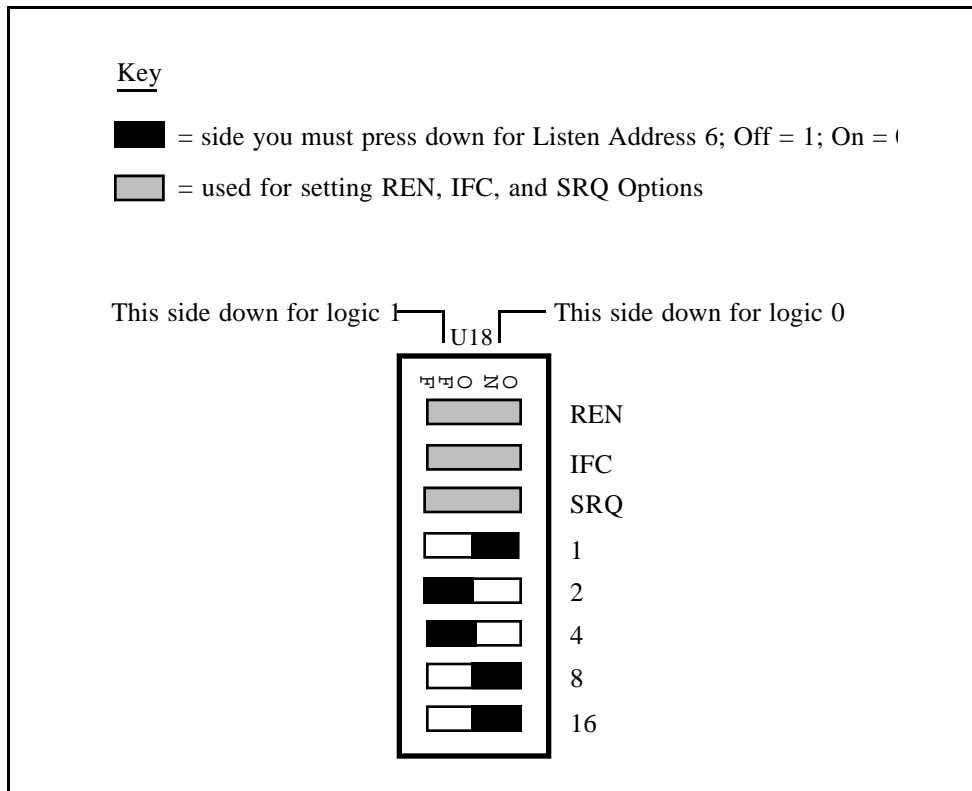
Figure 2-4. Setting for Address 6 hex

Figure 2-5 shows the switch configuration for REN* always asserted, IFC* enabled on GPIB-LPT initialization, and PE always low.

Key

= side you must press down for REN ON, IFC ON, and SRQ OFF; Off = 1; On = 0

= used for setting Listen Address

This side down for logic 1 ⌐ U18 ⌐ This side down for logic 0

OFF ON

REN
IFC
SRQ
1
2
4
8
16
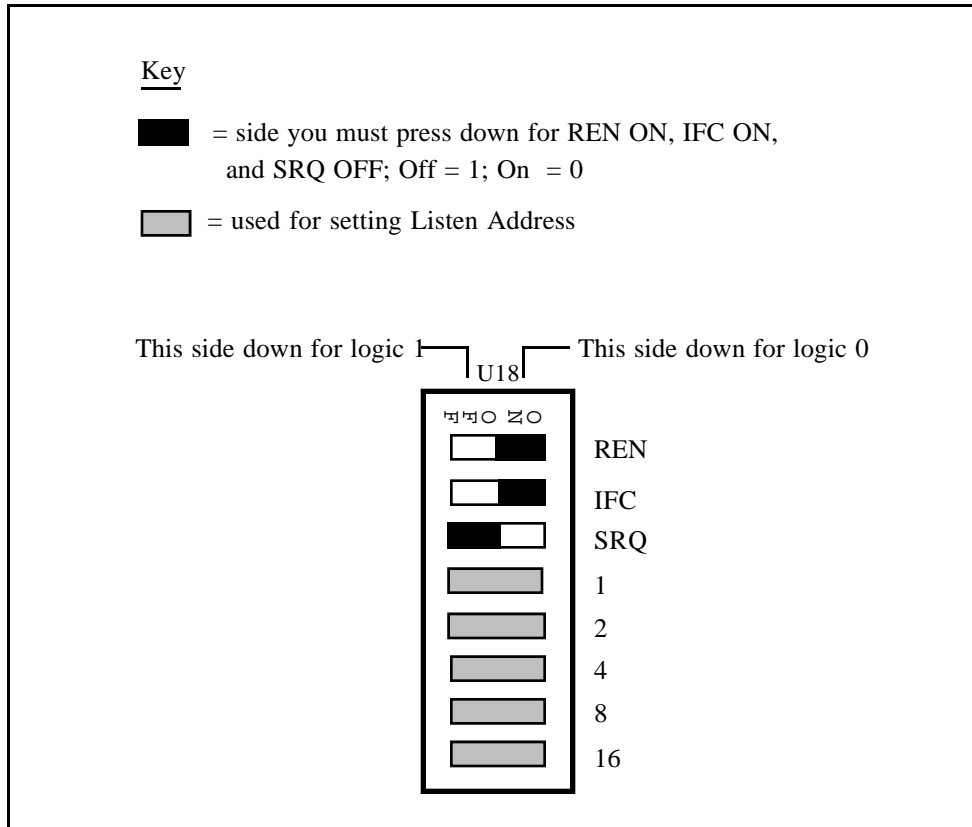
Figure 2-5. Switch Setting for REN ON, IFC ON, and SRQ OFF

In the space provided here, record the new settings for your GPIB-LPT so that you will have them handy for future reference.

GPIB-LPT	**New Setting**
Base I/O Address	_____
Interrupt Level	_____
REN Option	_____
IFC Option	_____
SRQ Option	_____
Listen Address	_____

Installation

The GPIB-LPT can be installed in any unused expansion slot in your computer. Once you have changed, verified, and recorded the switch and jumper settings, you are ready to install the GPIB-LPT.

The following steps are general installation instructions. Consult the user manual or technical reference manual of your personal computer for specific instructions and warnings.

1. Turn off your computer.

2. Remove the plug from its power source.

3. Remove the top cover or access port to the I/O channel.

4. Remove the expansion slot cover on the back panel of your computer.

5. Insert the GPIB-LPT in an unused slot with the IEEE-488 receptacle sticking out of the opening of the back panel. It may be a tight fit, but do not force the board into place.

    Note: The GPIB-LPT cannot be used in slot J8 of the IBM PC XT.

6. Screw the right angle mounting bracket of the GPIB-LPT to the back panel rail of your computer.

7. Check the installation.

8. Replace the expansion slot cover of your computer.

Section Three
Function Description

Figure 3-1 shows a block diagram of the GPIB-LPT.
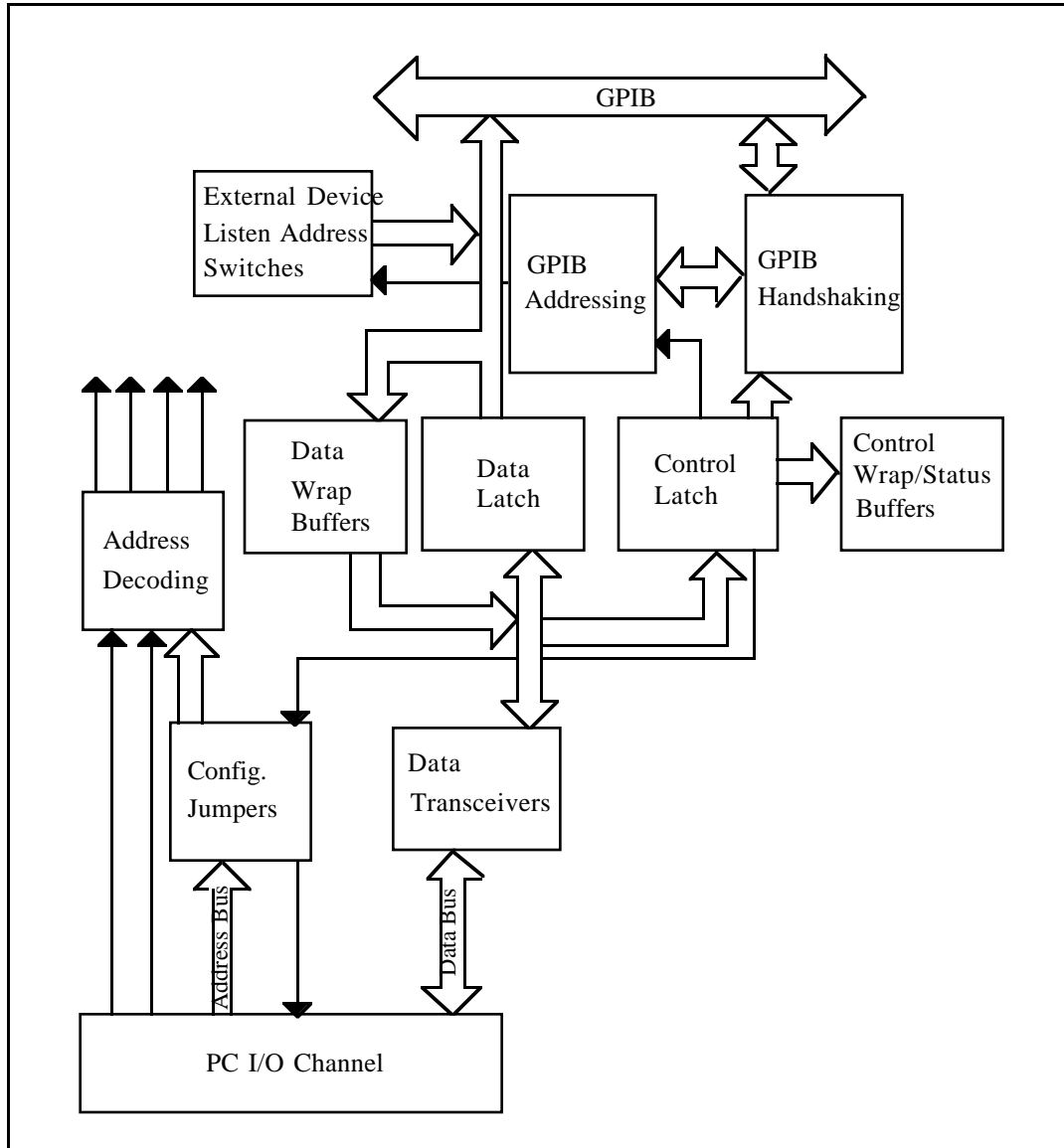
Figure 3-1. GPIB-LPT Block Diagram

The interface consists of the following functional components:

- Address Decoding

- Configuration Jumpers

- Data and Control Latches

- Data Transceivers

- Data Wrap, Control Wrap and Status Buffers

- External Device Listen Address Switch

- GPIB Handshaking

- GPIB Addressing

Address Decoding

Address decoding monitors the PC address bus to recognize when a GPIB-LPT address is present and sends a read and/or write to the GPIB-LPT registers.

Configuration Jumpers

The configuration jumpers determine the base I/O address and the corresponding interrupt request line of the GPIB-LPT.

Data and Control Latches

Data and control latches emulate the data and control registers of the standard IBM PC parallel port adapter. Writing to these latches controls output to the printer/plotter.

Data Transceivers

Data transceivers interface the GPIB-LPT local data bus to the IBM PC data bus.

Data Wrap, Control Wrap and Status Buffers

Data wrap, control wrap and status buffers, and the data and control latches make the GPIB-LPT compatible with the standard PC parallel port software. When the data and control wrap buffers are read by software, the data previously written to the data and control latches is returned; the status buffers emulate the PC parallel port read-only status register.

External Device Listen Address Switch

The external device listen address switch sets the listen address of the GPIB external device(s) attached to the GPIB-LPT. This listen address is sent to address the external device to listen.

GPIB Handshaking

GPIB handshaking converts PC parallel port handshaking into GPIB handshaking protocol. This process is transparent to you.

GPIB Addressing

On printer/plotter initialization, the GPIB-LPT checks to see if the printer/plotter is listening; if not, the GPIB-LPT addresses it as a listener using the GPIB listen address on the onboard switches.

Section Four
Running Diagnostic Tests

The GPIB-LPT Test Commands

The GPIB-LPT Diagnostic Tests can be used to verify the configuration of the GPIB-LPT and its connection to a GPIB printer or plotter.

To run a GPIB-LPT diagnostic test, connect a printer or plotter to the GPIB and run the program `LPT.EXE` from the GPIB-LPT diagnostic package disk. The following message will appear on the screen:

```
NATIONAL INSTRUMENTS GPIB-LPT DIAGNOSTIC TESTS

This program assumes the GPIB-LPT is configured at base address
278 (Parallel adapter 2).

If you reconfigured your GPIB-LPT you must change the address
that this program uses.  To do this, enter command c from the
menu.

Enter one of the following commands:

   -1 printer test

   -2 plotter test

   -c change LPT configuration

   -q quit

?
```

A short explanation of each command is given in the following paragraphs.

-1 printer test

Select this test to verify the configuration of the GPIB-LPT when connecting it to a GPIB ASCII printer. This test will send characters to the printer.

Entering this command returns the prompt:

```
Starting printer test.

Press any key to stop printing.
```

The printer should begin printing a string of characters. To stop the test, press any key. The
following message then appears:

```
Printer test finished.

Please check output to printer with user manual instructions.
```

The output on the printer should read:

```
NATIONAL INSTRUMENTS GPIB-LPT DIAGNOSTIC TEST!"#$%&'()*+,-.
/0123456789:;<=>?@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]_'abcdefghijkl
mnopqrstuvwxyz{|}~ !"#$%&'()*+,./0123456789:;<=>?@ABCDEFGHI
JKLMNOPQRSTUVWXY  Z[\]_'abcdefghijklmnopqrstuvwxyz{|}~ !"#$%&'
()*+,./0123456789:;<=>?@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]_'abcdefghi
jklmnopqrstuvwxyz{|}~ !"#$%&'()*+,./0123456789:;<=>?@ABCDEFG
HIJKLMNOPQRSTUVWXYZ[\]_'abcdefghijklmnopqrstuvwxyz{|}~
```

If the printer does not respond, an error message appears on the screen along with a message
telling you to recheck all of your connections and jumper settings. If the test still fails after
everything has been checked, write down the error message, if any, and call National Instruments.

-2 plotter test

Select this test to verify the configuration of the GPIB-LPT when connecting it to a GPIB HP-GL
plotter. This test will send output to the plotter.

When this command is selected, the computer prints the following message:

```
Starting plotter test.
```

As illustrated in Figure 4-1, the plotter begins to draw four ovals.
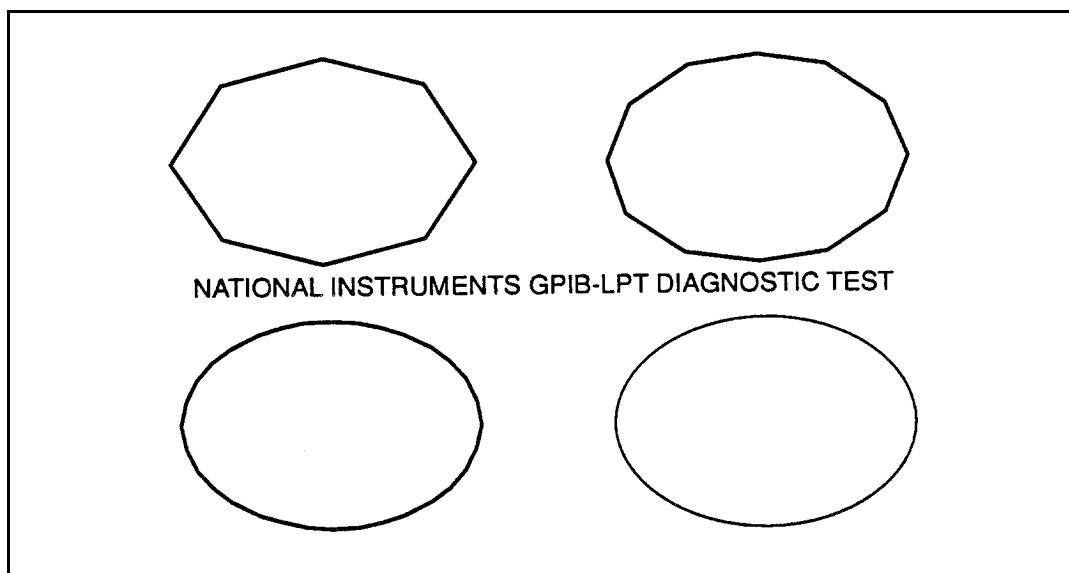
Figure 4-1. Plotter Output

When it is finished, the following message appears on the screen:

```
Plotter test finished.

Please check output to plotter with user manual instructions.
```

If the plotter does not respond or the output on the plotter does not match Figure 4-1, check again to be sure that all of the connections are tight and the jumpers are all set correctly. Try the test again. If it still does not work, write down any error messages that appear and call National Instruments.

-c change LPT configuration

This command is used to change the base address of the GPIB-LPT to match the actual board settings. If you have changed the jumper settings to something different than the default settings, you must run this command.

When this command is selected, the following menu appears:

```
This program assumes the GPIB-LPT is configured at base address
278 (Parallel adapter 2).

Enter the number of the correct address.

1) base address 3bc (Monochrome adapter)
2) base address 378 (Parallel adapter 1)
3) base address 278 (Parallel adapter 2)

Enter 1, 2, 3, or <return> for no change?
```

Type in the number of the address that you have configured the board to. The computer prints out your choice and returns to the main menu.

-q quit

This command ends the test program and returns to DOS.

Section Five
Programming the GPIB-LPT

This section presents specific information about the GPIB-LPT Parallel Port Emulator registers along with software examples.

The GPIB-LPT Registers

The GPIB-LPT has three onboard registers that are required for parallel port adapters: The DATA register, the STAT register, and the CTRL register.

Data Register (DATA)

PC Address: Base I/O Address + 0 (hex)

Attributes: Read/Write

7	6	5	4	3	2	1	0	
D7	D6	D5	D4	D3	D2	D1	D0	R/W
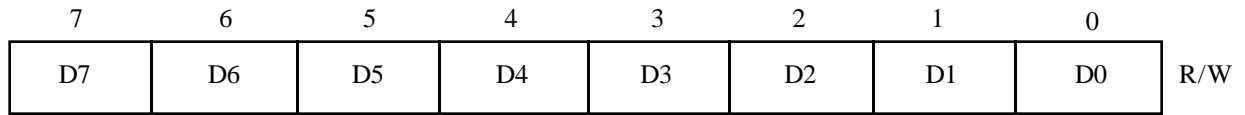
Writing to this address causes data to be latched in the GPIB-LPT DATA register. Reading this address sends the contents of the DATA register to the system microprocessor.

Bit	**Mnemonic**	**Description**
7 - 0r/w	D(7-0)	Data Bits 7 through 0

Status Register (STAT)

PC Address: Base I/O Address + 1 (hex)

Attributes: Read Only

7	6	5	4	3	2	1	0	R
BUSY*	ACK*	PE	SLCT	ERROR*	X	X	X	

Printer status is stored at this address to be read by the microprocessor.

Bit	Mnemonic	Description
7r	BUSY*	Device is Busy Bit

This signal is active when the printer is busy and cannot accept data or when the GPIB printer is being listen-addressed and is asserting the Not Ready For Data (NRFD) GPIB handshake line.

| 6r | ACK* | Acknowledge Bit |

This bit emulates the ACK* signal generated by the external parallel port device, indicating that the device has received a character. It is a 5 μsec (minimum) pulse triggered when the Not Data Accepted (NDAC) GPIB handshake line is unasserted by the external GPIB device.

| 5r | PE | Paper Error Bit |

This bit indicates to the parallel port adapter that a paper error has occurred (a logical 1 means end of paper has been detected). The GPIB-LPT can be configured to use this bit to monitor the current state of the GPIB SRQ line. If the GPIB-LPT switch is set to enable the Service Request (SRQ) option, PE is a logical 1 when the SRQ is asserted.

| 4r | SLCT | Select Bit |

This bit indicates to the parallel port adapter that the printer is selected (a logical 1 means the printer is selected). The GPIB-LPT automatically addresses the external GPIB device to listen when the first data byte is sent. The GPIB-LPT asserts the SLCT bit (makes it a logical 1) whenever the GPIB line Attention (ATN) is not being asserted; the SLCT bit is a logical 0 when ATN is being asserted (when the printer is being listen-addressed).

Bit	Mnemonic	Description
3r	ERROR*	Error Bit
		This bit indicates Paper End state, Off line state, and Error state (a logical 0 indicates one of these states). This bit is not used by the GPIB-LPT and is held logical 1.
2 - 0r	X	Don't Care Bits 2 through 0
		Can be read as a 0 or 1.

Control Register (CTRL)

PC Address: Base I/O Address + 2 (hex)

Attributes: Write Only

7	6	5	4	3	2	1	0
X	X	X	IRQEN	SLCTIN	INIT*	AUTOFD	STROBE

W

Printer control signals are stored at this address to be read by the system microprocessor.

Bit	Mnemonic	Description
7 - 5w	X	Don't Care Bits 7 through 5.
		Can be written as a 0 or 1.
4w	IRQEN	Interrupt Request Enable Bit
		When this bit is set, an interrupt will occur when ACK* changes from active to inactive.
3w	SLCTIN	Select In Bit
		When this bit is set, the GPIB-LPT can source data onto the GPIB data lines.
2w	INIT*	Initialize Bit
		Setting and then clearing this bit initializes the GPIB-LPT.
1w	AUTOFD	Automatic Linefeed Bit
		When this bit is set to one, a linefeed is automatically set after each line is sent to the printer. This bit is not used by the GPIB-LPT because there is no analogous signal for GPIB printers.
0w	STROBE	Data Strobe Bit
		Pulsing this bit from low to high clocks the contents of the DATA register into the secondary data latch of the GPIB-LPT and initiates a GPIB Source Handshake. If the printer is offline, the GPIB-LPT first sends the listen address of the printer.

Programming Considerations

The GPIB-LPT works transparently with any program that uses the parallel port for hardcopy output. No programming is required. However, you can write your own driver routines. The following paragraphs explain how to use the GPIB-LPT with the DOS operating system and with the C and BASIC programming languages. Considerations for programming your own printer/plotter adapter driver are also discussed. In all examples, the GPIB-LPT is the second parallel adapter in the system and has been assigned the DOS device name `LPT2`. Since `LPT2` is a reserved DOS device name, the standard output can be redirected to the GPIB-LPT.

Using the GPIB-LPT with the DOS Operating System

The following DOS command sends the file `example.txt` to the GPIB device connected to the GPIB-LPT.

```
type example.txt >lpt2
```

Note: You press your RETURN or ENTER key to execute these commands.

Similarly, the following DOS command sends the string `"Hello, world"`, along with a carriage return (`0Dh`), followed by a line feed (`0Ah`), to the GPIB device connected to the GPIB-LPT.

```
echo Hello, world>lpt2
```

The DOS `PRINT` command is an interrupt-driven print routine (however, it is interrupted by the internal clock, not by the printer adapter) that can be used to send a file to the GPIB device connected to the GPIB-LPT. The following command:

```
print example.txt
```

will cause DOS to respond with:

```
Name of list device [PRN]:
```

Typing `lpt2` (when the board is configured for LPT2) starts sending the file `example.txt` to the printer. All successive invocations of `PRINT` assume device `LPT2` is to be used; the prompt only occurs the first time. See your DOS manual for more information about the `PRINT` command.

Using the GPIB-LPT with C and BASIC

The following examples show how to access the parallel port in the C and BASIC programming languages, respectively.

Accessing the Parallel Port in C

```
#include <stdio.h>
        .
        .
FILE    *fopen(), *fp;
char    *gpib_dev= "LPT2";
fp=fopen(gpib_dev,"w");
fprintf(fp, "Hello, world");
fflush(fp);
```

These lines send the string `"Hello, world"` to the GPIB device connected to the GPIB-LPT.

Accessing the Parallel Port in BASIC

```
10  OPEN "LPT2" FOR OUTPUT AS #1
20  PRINT #1, "Hello, world"
```

This program sends the string `"Hello, world"` to the GPIB device. The BASIC commands `LPRINT` and `LLIST` always send data to the first parallel printer adapter in the system (`LPT1`); these will only send data to the GPIB device if the GPIB-LPT is `LPT1`.

Writing a GPIB-LPT Driver

When you use an IBM BIOS driver, it performs the following steps to send a character out to the parallel port:

1. Writes the character to the DATA Register.

2. Waits for the signal BUSY* to equal 1; if the timeout period expires, exits the routine. If the timeout period does not expire, continues the routine.

3. Sets the signal STROBE equal to 1.

4. Waits 1 to 5 μsec.

5. Sets the signal STROBE equal to 0.

6. Returns from the routine with the status information from the STAT Register.

Although the IBM BIOS driver is sufficient, a higher performance driver can be implemented by taking advantage of the GPIB-LPT's interrupt capability. Writing a GPIB-LPT driver to send a character out to the parallel port requires two parts: a setup and initialization routine, and an interrupt handler routine.

Setup and Initialization Routine

The setup and initialization routine initializes the interrupt vector (for interrupt level 5 or 7, depending on configuration), sends out the first data byte to the GPIB-LPT, and unmasks the interrupt. The ACK* pulse from this byte interrupts the processor so the next byte can be sent by the interrupt handler. You must complete the following steps to set up and initialize an interrupt vector:

a. Put the address of the interrupt handler routine at the appropriate interrupt vector address (5 or 7).

b. Unmask the interrupts for level 5 or 7 by clearing the appropriate bit in the PC interrupt controller chip.

c. Set the bit IRQEN equal to 0 (initially disabling the GPIB-LPT interrupt).

d. Initialize a data pointer to the data being sent.

e. Return from the routine.

Interrupt Handler Routine

The interrupt handler routine is called every time an ACK* pulse (interrupt) is seen by the processor. It disables the GPIB-LPT interrupt, calls the PRINT subroutine, and re-arms the 8259A Interrupt Controller chip. You must complete the following steps for the interrupt handler routine:

a. Set the bit IRQEN equal 0.

b. Call the PRINT routine (the steps of the PRINT routine follow this routine).

c. Write the End Of Interrupt command to the PC interrupt controller chip.

d. Rearm the interrupt.

e. Return from the routine.

PRINT Routine

To send a character to the printer, use a PRINT routine which includes the following steps:

a. Have the character variable equal the data referenced by the data pointer.

b. If the character variable equals the terminator character, re-mask interrupt 5 or 7 and exit. If it does not equal the terminator character, continue.

c. Write the character variable to the DATA Register.

d. Wait for the signal BUSY* to equal 1; if the timeout period expires, exit the routine. If the timeout period does not expire, continue the routine.

e. Set the signals STROBE and IRQEN equal to 1.

f. Wait 1 to 5 μsec.

g. Set the signal STROBE equal to 0.

h. Increment the data pointer.

i. Return from the routine.

Timing Constraints

When writing to or from a driver, it is important to meet all timing constraints. The only constraint for the GPIB-LPT is the length of the STROBE pulse. The following sequence guarantees a pulse width between 1 and 5 μsec:

```
mov al,0Dh   ;STROBE mask
mov dx,CTRL  ;dx points to the CTRL register
cli          ;disable interrupts to prevent
             ;stretching of the pulse
out dx,al    ;set STROBE=1
jmp $+2      ;delay to meet timing
jmp $+2      ;requirement
mov al,0Ch   ;normal mask
out dx,al    ;set STROBE=0
sti          ;interrupts back on
```

Note: Interrupts are turned off so that the pulse is not interrupted and stretched.

Appendix A
Operation of the GPIB

History of the GPIB

The *GPIB* is a link, bus, or interface system through which interconnected electronic devices communicate. Hewlett-Packard invented the GPIB, which they call the *HP-IB*, to connect and control programmable instruments manufactured by them. Because of its high system data rate ceilings of from 250 kbytes/sec to 1 Mbyte/sec, the GPIB quickly became popular in other applications such as intercomputer communication and peripheral control. It was later accepted as the industry standard IEEE-488. The versatility of the system prompted the name General Purpose Interface Bus.

Types of Messages

Devices on the GPIB communicate by passing messages through the interface system. There are two types of messages:

- Device-dependent messages, often called data or data messages, contain device-specific information such as programming instructions, measurement results, machine status, and data files.

- Interface messages manage the bus itself. They are usually called commands or command messages. Interface messages perform such functions as initializing the bus, addressing and unaddressing devices, and setting devices for remote or local programming.

Note: The term *command* as used here should not be confused with some device instructions which are also called commands. Such device-specific instructions are actually data messages.

Talkers, Listeners, and Controllers

There are three types of GPIB communicators. A Talker sends data messages to one or more Listeners. The Controller manages the flow of information on the GPIB by sending commands to all devices.

Devices can be Talkers, Listeners, and/or Controllers. A digital multimeter, for example, is a Talker and may also be a Listener. A printer or plotter is usually only a Listener. A computer on the GPIB often combines all three roles to manage the bus and communicate with other devices. The GPIB is a bus like a typical computer bus except that the computer has its circuit cards interconnected via a backplane bus whereas the GPIB has standalone devices interconnected via a cable bus.

The role of the GPIB Controller can also be compared to the role of the computer's CPU, but a better analogy is to the switching center of a city telephone system.

The switching center (Controller) monitors the communications network (GPIB). When the center (Controller) notices that a party (device) wants to make a call (send a data message), it connects the caller (Talker) to the receiver (Listener).

The Controller usually addresses a Talker and a Listener before the Talker can send its message to the Listener. After the message is transmitted, the Controller usually unaddresses both devices.

Some bus configurations do not require a Controller. For example, one device may only be a Talker (called a Talk-only device) and there may be one or more Listen-only devices.

A Controller is necessary when the active or addressed Talker or Listener must be changed. The Controller function is usually handled by a computer.

System Controller and Active Controller

Although there can be multiple Controllers on the GPIB, only one Controller at a time is Active Controller or Controller-in-Charge (CIC). Active control can be passed from the current Active Controller to an idle Controller. Only one device on the bus, the System Controller, can make itself the Active Controller.

GPIB Signals

The interface bus consists of 16 signal lines and eight ground return or shield drain lines. The 16 signal lines are divided into three groups:

• eight data lines

• three handshake lines

• five interface management lines

Figure A-1 shows the arrangement of these signals on the GPIB cable connector.

DIO1*	1	13	DIO5*
DIO2*	2	14	DIO6*
DIO3*	3	15	DIO7*
DIO4*	4	16	DIO8*
EOI*	5	17	REN*
DAV*	6	18	GND (TW PAIR W/DAV*)
NRFD*	7	19	GND (TW PAIR W/NRFD*)
NDAC*	8	20	GND (TW PAIR W/NDAC*)
IFC*	9	21	GND (TW PAIR W/IFC*)
SRQ*	10	22	GND (TW PAIR W/SRQ*)
ATN*	11	23	GND (TW PAIR W/ATN*)
SHIELD	12	24	SIGNAL GROUND
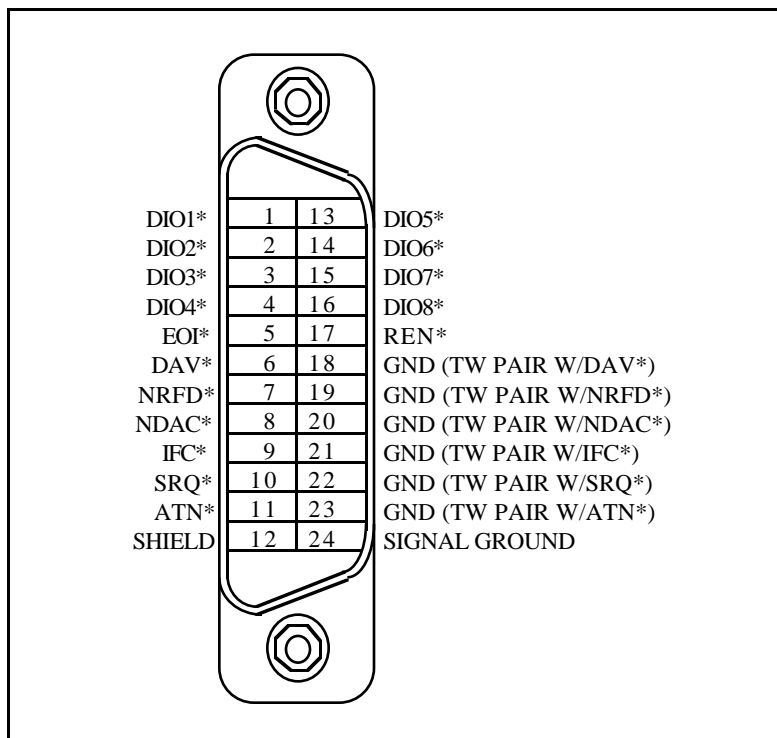
Figure A-1. GPIB Cable Connector

Data Lines

The eight data lines, DIO1 through DIO8, carry both data and command messages. All commands and most data use the 7-bit ASCII or ISO code set, in which case the eighth bit, DIO8, is unused or used for parity.

Handshake Lines

Three lines asynchronously control the transfer of message bytes among devices. The process is called a three-wire interlocked handshake and it guarantees that message bytes on the data lines are sent and received without transmission error.

NRFD (not ready for data)

NRFD indicates when a device is ready or not ready to receive a message byte. The line is driven by all devices when receiving commands and by Listeners when receiving data messages.

NDAC (not data accepted)

NDAC indicates when a device has or has not accepted a message byte. The line is driven by all devices when receiving commands and by Listeners when receiving data messages.

DAV (data valid)

DAV tells when the signals on the data lines are stable (valid) and can be accepted safely by devices. The Controller drives DAV when sending commands, and the Talker drives it when sending data messages.

The way in which NRFD and NDAC are used by the receiving device is called the Acceptor Handshake. Likewise, the sending device uses DAV in the Source Handshake.

Interface Management Lines

Five lines are used to manage the flow of information across the interface.

ATN (attention)

The Controller drives ATN true when it uses the data lines to send commands and false when it allows a Talker to send data messages.

IFC (interface clear)

The System Controller drives the IFC line to initialize the bus to become Controller-In-Charge.

REN (remote enable)

The System Controller drives the REN line, which is used to place devices in remote or local program mode.

SRQ (service request)

Any device can drive the SRQ line to asynchronously request service from the Active Controller.

EOI (end or identify)

The EOI line has two purposes. The Talker uses the EOI line to mark the end of a message string. The Active Controller uses the EOI line to tell devices to identify their responses in a parallel poll.

Physical and Electrical Characteristics

Devices are usually connected with a cable assembly consisting of a shielded 24-conductor cable with both a plug and receptacle at each end. This design allows devices to be connected in either a linear or a star configuration, or a combination of the two. See Figures A-2 and A-3.
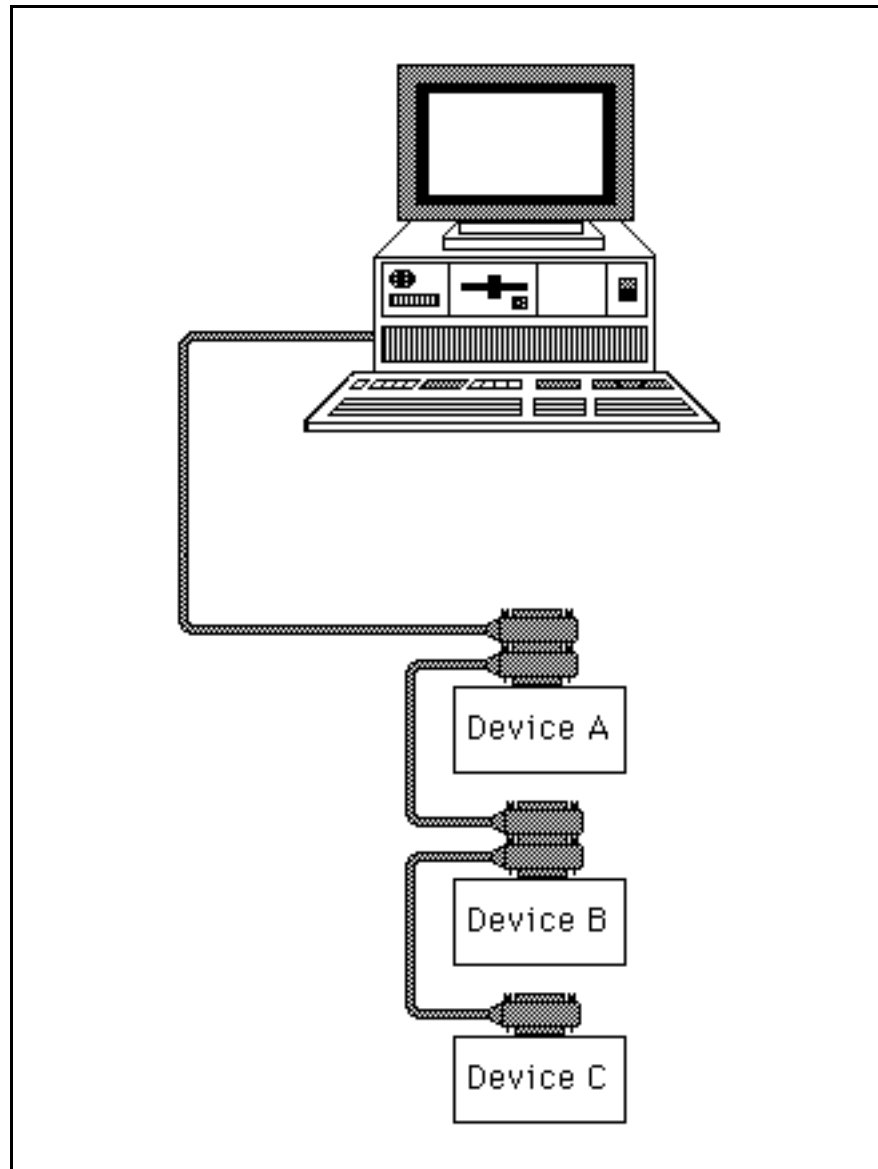
Figure A-2. Linear Configuration of GPIB Devices
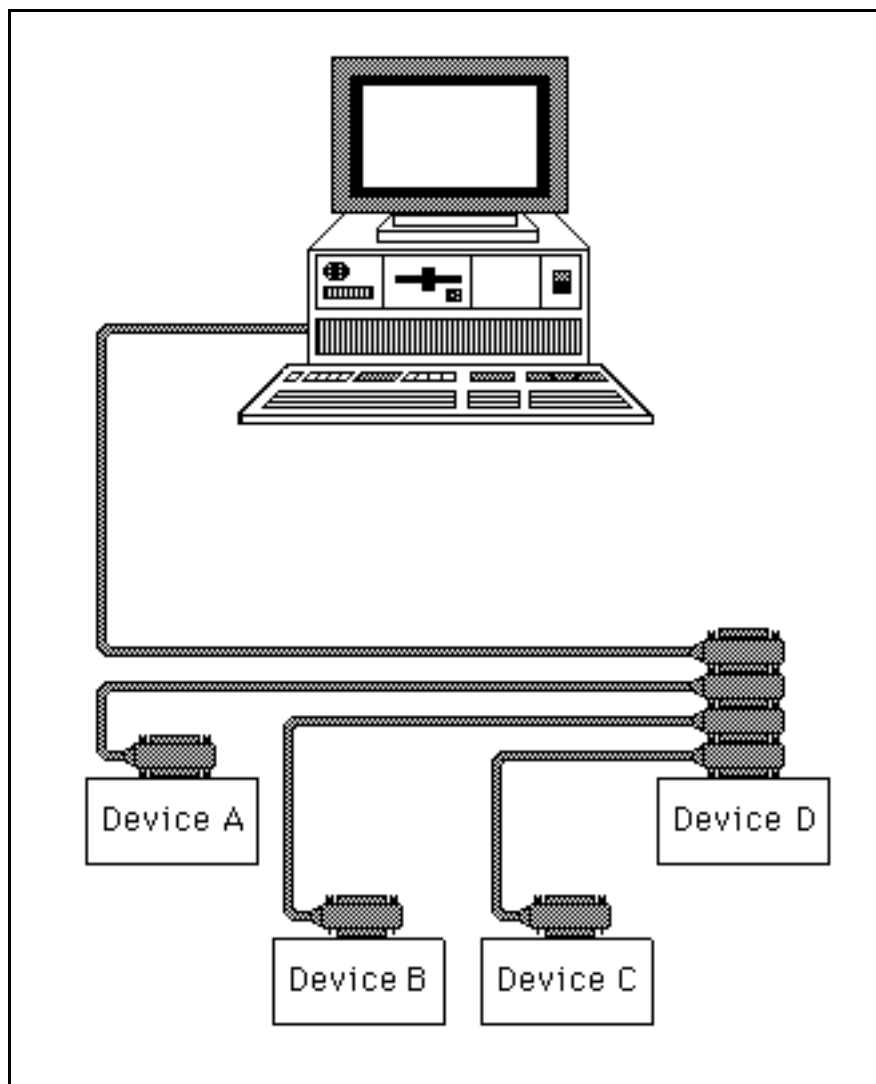
Figure A-3. Star Configuration of GPIB Devices

The standard connector is the Amphenol or Cinch Series 57 MICRORIBBON or AMP CHAMP type. An adapter cable using non-standard cable and/or connector is used for special interconnect applications.

The GPIB uses negative logic with standard TTL logic levels. When DAV is true, for example, it is a TTL low level (≤ 0.8 V), and when DAV is false, it is a TTL high level (≥ 2.0 V).

Configuration Restrictions

To achieve the high data transfer rate that the GPIB is designed for, the physical distance between devices and the number of devices on the bus is limited.

The following restrictions are typical:

- A maximum separation of 4 m between any two devices and an average separation of less than 2 m over the entire bus.

- A maximum total cable length of 20 m.

- No more than 15 devices connected to each bus, with at least two-thirds powered-on.

Appendix B
Multiline Interface Messages

The following tables are multiline interface messages (sent and received with ATN TRUE).

Multiline Interface Messages

Hex	Oct	Dec	ASCII	Msg	Hex	Oct	Dec	ASCII	Msg
00	000	0	NUL		20	040	32	SP	MLA0
01	001	1	SOH	GTL	21	041	33	!	MLA1
02	002	2	STX		22	042	34	"	MLA2
03	003	3	ETX		23	043	35	#	MLA3
04	004	4	EOT	SDC	24	044	36	$	MLA4
05	005	5	ENQ	PPC	25	045	37	%	MLA5
06	006	6	ACK		26	046	38	&	MLA6
07	007	7	BEL		27	047	39	'	MLA7
08	010	8	BS	GET	28	050	40	(	MLA8
09	011	9	HT	TCT	29	051	41	)	MLA9
0A	012	10	LF		2A	052	42	*	MLA10
0B	013	11	VT		2B	053	43	+	MLA11
0C	014	12	FF		2C	054	44	,	MLA12
0D	015	13	CR		2D	055	45	–	MLA13
0E	016	14	SO		2E	056	46	.	MLA14
0F	017	15	SI		2F	057	47	/	MLA15
10	020	16	DLE		30	060	48	0	MLA16
11	021	17	DC1	LLO	31	061	49	1	MLA17
12	022	18	DC2		32	062	50	2	MLA18
13	023	19	DC3		33	063	51	3	MLA19
14	024	20	DC4	DCL	34	064	52	4	MLA20
15	025	21	NAK	PPU	35	065	53	5	MLA21
16	026	22	SYN		36	066	54	6	MLA22
17	027	23	ETB		37	067	55	7	MLA23
18	030	24	CAN	SPE	38	070	56	8	MLA24
19	031	25	EM	SPD	39	071	57	9	MLA25
1A	032	26	SUB		3A	072	58	:	MLA26
1B	033	27	ESC		3B	073	59	;	MLA27
1C	034	28	FS		3C	074	60	<	MLA28
1D	035	29	GS		3D	075	61	=	MLA29
1E	036	30	RS		3E	076	62	>	MLA30
1F	037	31	US		3F	077	63	?	UNL

Message Definitions

DCL	Device Clear		PPU	Parallel Poll Unconfigure
GET	Group Execute Trigger		SDC	Selected Device Clear
GTL	Go To Local		SPD	Serial Poll Disable
LLO	Local Lockout		SPE	Serial Poll Enable
MLA	My Listen Address		TCT	Take Control
PPC	Parallel Poll Configure		UNL	Unlisten

Multiline Interface Messages

Hex	Oct	Dec	ASCII	Msg	Hex	Oct	Dec	ASCII	Msg
40	100	64	@	MTA0	60	140	96	`	MSA0,PPE
41	101	65	A	MTA1	61	141	97	a	MSA1,PPE
42	102	66	B	MTA2	62	142	98	b	MSA2,PPE
43	103	67	C	MTA3	63	143	99	c	MSA3,PPE
44	104	68	D	MTA4	64	144	100	d	MSA4,PPE
45	105	69	E	MTA5	65	145	101	e	MSA5,PPE
46	106	70	F	MTA6	66	146	102	f	MSA6,PPE
47	107	71	G	MTA7	67	147	103	g	MSA7,PPE
48	110	72	H	MTA8	68	150	104	h	MSA8,PPE
49	111	73	I	MTA9	69	151	105	i	MSA9,PPE
4A	112	74	J	MTA10	6A	152	106	j	MSA10,PPE
4B	113	75	K	MTA11	6B	153	107	k	MSA11,PPE
4C	114	76	L	MTA12	6C	154	108	l	MSA12,PPE
4D	115	77	M	MTA13	6D	155	109	m	MSA13,PPE
4E	116	78	N	MTA14	6E	156	110	n	MSA14,PPE
4F	117	79	O	MTA15	6F	157	111	o	MSA15,PPE
50	120	80	P	MTA16	70	160	112	p	MSA16,PPD
51	121	81	Q	MTA17	71	161	113	q	MSA17,PPD
52	122	82	R	MTA18	72	162	114	r	MSA18,PPD
53	123	83	S	MTA19	73	163	115	s	MSA19,PPD
54	124	84	T	MTA20	74	164	116	t	MSA20,PPD
55	125	85	U	MTA21	75	165	117	u	MSA21,PPD
56	126	86	V	MTA22	76	166	118	v	MSA22,PPD
57	127	87	W	MTA23	77	167	119	w	MSA23,PPD
58	130	88	X	MTA24	78	170	120	x	MSA24,PPD
59	131	89	Y	MTA25	79	171	121	y	MSA25,PPD
5A	132	90	Z	MTA26	7A	172	122	z	MSA26,PPD
5B	133	91	[	MTA27	7B	173	123	{	MSA27,PPD
5C	134	92	\	MTA28	7C	174	124	|	MSA28,PPD
5D	135	93	]	MTA29	7D	175	125	}	MSA29,PPD
5E	136	94	^	MTA30	7E	176	126	~	MSA30,PPD
5F	137	95	_	UNT	7F	177	127	DEL	

Message Definitions

PPD	Parallel Poll Disable	MTA	My Talk Address
PPE	Parllel Poll Enable	SPE	Serial Poll Enable
MSA	My Secondary Address	UNT	Untalk

Appendix C
Specifications

This appendix has the specifications for the GPIB-LPT board.

Power Requirement

+5 VDC (±5%)	0.40 A typical

Physical

Dimensions	4.2 in. x 5.5 in.
I/O Connector	IEEE-488 Standard 24-pin

Operation Environment

Component Temperature	0° to 70°C
Relative humidity	5% to 90%, noncondensing
Emissions	FCC Class B

Storage Environment

Temperature	-55° to 125°C
Relative humidity	5% to 90%, noncondensing

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