IEEE 488 Parallel Converter

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NORMAS OFICIALES MEXICANAS (NOM)
ELECTRICAL SAFETY STATEMENT

INSTRUCCIONES DE SEGURIDAD

1. Todas las instrucciones de seguridad y operación deberán ser leídas antes de que el aparato eléctrico sea operado.

2. Las instrucciones de seguridad y operación deberán ser guardadas para referencia futura.

3. Todas las advertencias en el aparato eléctrico y en sus instrucciones de operación deben ser respetadas.

4. Todas las instrucciones de operación y uso deben ser seguidas.

5. El aparato eléctrico no deberá ser usado cerca del agua—por ejemplo, cerca de la tina de baño, lavabo, sótano mojado o cerca de una alberca, etc..

6. El aparato eléctrico debe ser usado únicamente con carritos o pedestales que sean recomendados por el fabricante.

7. El aparato eléctrico debe ser montado a la pared o al techo sólo como sea recomendado por el fabricante.

8. Servicio—El usuario no debe intentar dar servicio al equipo eléctrico más allá a lo descrito en las instrucciones de operación. Todo otro servicio deberá ser referido a personal de servicio calificado.

9. El aparato eléctrico debe ser situado de tal manera que su posición no interfiera su uso. La colocación del aparato eléctrico sobre una cama, sofá, alfombra o superficie similar puede bloquea la ventilación, no se debe colocar en libreros o gabinetes que impidan el flujo de aire por los orificios de ventilación.

10. El equipo eléctrico deber ser situado fuera del alcance de fuentes de calor como radiadores, registros de calor, estufas u otros aparatos (incluyendo amplificadores) que producen calor.

11. El aparato eléctrico deberá ser connectado a una fuente de poder sólo del tipo descrito en el instructivo de operación, o como se indique en el aparato.

12. Precaución debe ser tomada de tal manera que la tierra fisica y la polarización del equipo no sea eliminada.

13. Los cables de la fuente de poder deben ser guiados de tal manera que no sean pisados ni pellizcados por objetos colocados sobre o contra ellos, poniendo particular atención a los contactos y receptáculos donde salen del aparato.

14. El equipo eléctrico debe ser limpiado únicamente de acuerdo a las recomendaciones del fabricante.

15. En caso de existir, una antena externa deberá ser localizada lejos de las lineas de energia.

16. El cable de corriente deberá ser desconectado del cuando el equipo no sea usado por un largo periodo de tiempo.

17. Cuidado debe ser tomado de tal manera que objectos liquidos no sean derramados sobre la cubierta u orificios de ventilación.

18. Servicio por personal calificado deberá ser provisto cuando:

    A: El cable de poder o el contacto ha sido dañado; u

    B: Objectos han caído o líquido ha sido derramado dentro del aparato; o

    C: El aparato ha sido expuesto a la lluvia; o

    D: El aparato parece no operar normalmente o muestra un cambio en su desempeño; o

    E: El aparato ha sido tirado o su cubierta ha sido dañada.

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1. Specifications

IEEE 488-1978
Implementation —   C1, C2, C3, C4, and C28 controller subsets; Parallel to IEEE: SH0, AH1, T0, TE0, L4, LE0, SR0, RL0, PP0, DC1, DT0, E1

Parallel (Centronics)
Termination Character —   Selectable Auto-LF (IEEE to Parallel)

Data Buffer —   24,000 characters

Controls —   Power Switch (external), IEEE and parallel parameter switches (internal)

Connectors —   (1) Standard IEEE 488 connector with metric studs, (1) Standard 36-pin male Centronics

Indicators —   IEEE 488 Talk and Listen, Parallel Send and Receive, Power

Operating Temperature —   32 to 122°F (0 to 50°C)

Humidity Tolerance —   Up to 70% relative humidity

Power —   105 to 125V or 210 to 250V; 50–60 Hz, 10 VA maximum

Size —   2.7"H x 5.4"W x 7.5"D (6.9 x 13.7 x 19.1 cm)

Weight —   2.1 lb. (1 kg)

2. Introduction

2.1 Description

The IEEE 488 Parallel Converter is an intelligent bus converter that provides transparent conversion from an IEEE 488 device to a parallel (Centronics®) device, or from a parallel device to an IEEE 488 device. Common applications include interfacing an IBM® PC's parallel port to the IEEE port on an HP® plotter, or interfacing an IEEE controller to a parallel printer.

A buffer capable of storing 24,000 characters is built into the IEEE 488 Parallel Converter, allowing the computer to unload an entire document and move on to another task while the IEEE 488 Parallel Converter spools data to the receiving device. The IEEE 488 Parallel Converter spools characters to the receiving device until the Converter's buffer is empty. The IEEE 488 Parallel Converter can also automatically insert a line-feed character upon receipt of a carriage-return character. This is useful in assuring compatibility with a wide variety of computers, instruments, printers, and plotters.

2.2 Abbreviations

The following IEEE 488 abbreviations are used throughout this manual.

addr n	IEEE bus address "n"
ATN	Attention line
CA	Controller Active
CO	Controller
CR	Carriage Return
data	Data String
DCL	Device Clear
GET	Group Execute Trigger
GTL	Go To Local
LA	Listener Active
LAG	Listen Address Group
LF	Line Feed
LLO	Local Lock Out
MLA	My Listen Address
MTA	My Talk Address
PE	Peripheral
PPC	Parallel Poll Configure
PPU	Parallel Poll Unconfigure
SC	System Controller
SDC	Selected Device Clear
SPD	Serial Poll Disable
SPE	Serial Poll Enable
SRQ	Service Request
TA	Talker Active
TAD	Talker Address
TCT	Take Control
term	Terminator
UNL	Unlisten
UNT	Untalk
*	Unasserted

2.3 What's Included

The IEEE 488 Parallel Converter was carefully inspected prior to shipment. Once you've unpacked all items from the shipping carton, check for any obvious signs of physical damage which may have occurred during shipping. Immediately report any damage found. Remember to retain all shipping materials in case shipment back to Black Box is necessary.

Every IEEE 488 Parallel Converter is shipped with:

- IEEE 488 Parallel Converter

- This user's manual

- A power supply (either 110V or 220/230V)

3. Configuration and Operation

The IEEE 488 Parallel Converter has two modes of operation: as a parallel-to-IEEE-488 converter or as an IEEE-488-to-parallel converter. A DIP switch in the IEEE 488 Parallel Converter determines the mode. Also selectable is the automatic insertion of a line-feed character after receipt of a carriage return, and the IEEE address (for the IEEE to parallel mode only). Listed below are the Converter's factory-default settings.
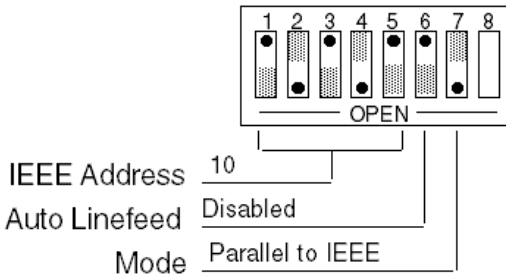
Figure 3-1. SW1 Factory-Default Settings.

To modify any of these defaults, disconnect the power supply from the AC line and from the interface. Disconnect any IEEE or parallel cables prior to disassembly.

WARNING

Never open the IEEE 488 Parallel Converter's case while it is connected to the AC line. Doing so may result in equipment failure, personal injury, or death.

Remove the screws located in each corner of the rear panel. Hold the case firmly and pull the rear panel outward, noting the slot location of the main circuit board. Modify the parameters appropriate for your installation and reassemble the unit. Slide the main circuit board into the previously noted slot and tighten the four screws into the rear panel.

3.1 IEEE Address Selection

Switches SW1-1 through SW1-5 select the Converter's IEEE address when it's in the IEEE-to-parallel mode. They have no significance when the parallel-to-IEEE mode is selected. Each switch is weighted with a number from 1 to 16. The sum of the switches in the "open" position is equal to the IEEE address. The factory-default address is 10.
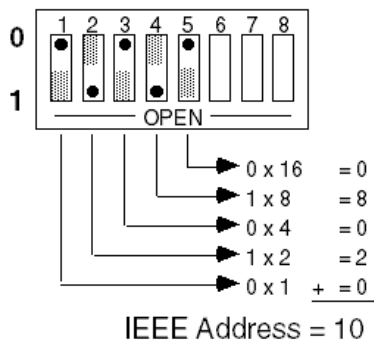
Figure 3-2. SW1 View for IEEE Bus Address Selection.

When all switches are in the "open" position (address 31), the IEEE 488 Parallel Converter is in the Listen Only mode. This mode enables a TALK ONLY device, such as a digital voltmeter or data logger, to send data directly to the IEEE 488 Parallel Converter without requiring a controller.

3.1.1 AUTO-LINEFEED SELECTION

Switch SW1-6 selects whether auto-linefeed is selected. When SW1-6 is in the "closed" position, no extra characters are added to received data. When SW1-6 is in the "open" position, the IEEE 488 Parallel Converter automatically inserts a line-feed character into the data stream after receiving a carriage return. This feature is necessary when both the data source does not send line feeds with each carriage return, and the receiving device does not insert line feeds upon receipt of a carriage return.

This feature is functional in both operating modes of the IEEE 488 Parallel Converter. The factory-default condition is auto-linefeed disabled. This feature should be enabled if all your printed material appears on one line.

Auto-Linefeed Disabled   Auto-Linefeed Enabled
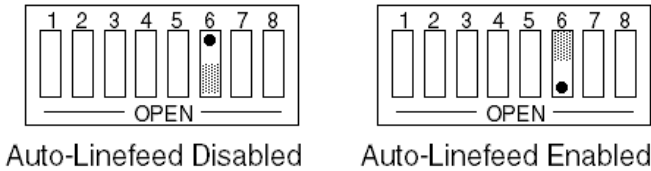
Figure 3-3. SW1 View for Auto-Linefeed Selection.

3.1.2 MODE SELECTION

SW1-7 selects either the parallel-to-IEEE mode (described in **Chapter 4**) or the IEEE-to-parallel mode (described in **Chapter 5**). The product operates in only one of two modes, and cannot communicate in both modes simultaneously. The factory default is the parallel-to-IEEE mode.

IEEE to Parallel Mode   Parallel to IEEE Mode
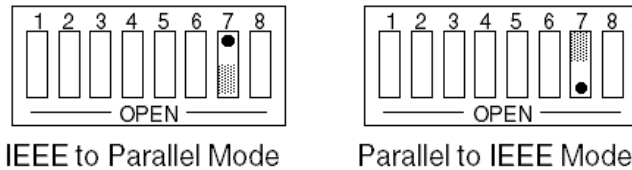
Figure 3-4. SW1 View for Mode Selection.

3.2 Operation

After setting the IEEE 488 Parallel Converter to the proper switch selections and reassembling the unit, plug the power-supply connector into the rear jack on the interface.

CAUTION

Always connect the power supply to the Converter first, then to the AC line power. Connecting it to the power first may result in damage to the IEEE 488 Parallel Converter.

WARNING

The power supply provided with the interface is intended for indoor use only. Using it outdoors could result in equipment failure, personal injury, or death.

After connecting the power supply to the Converter, plug the power supply into the AC line power. Place the rear-panel power switch in the ON [1] position. All front-panel indicators should light for approximately one second while the IEEE 488 Parallel Converter performs an internal ROM and RAM self-check. At the end of this self-check all indicators except POWER should turn off. If any of the LED conditions listed below exist after power-on, a failure has occurred.

Symptom	Failure
All lights remain on.	ROM test has failed.
All lights blink continually.	RAM test has failed.
An LED does not blink.	LED has failed.
No LEDs blink.	Power supply has failed.

If any of the above symptoms occur, cycle the power switch on the IEEE 488 Parallel Converter to be sure of the problem. If the problem is unresolved, refer to **Chapter 7** for additional information.

If the Converter is operating properly, turn off the Converter's power switch and connect a parallel interface cable to the rear. Connect the other end of the cable to the device having the parallel interface. Now connect the IEEE cable to the rear of the IEEE 488 Parallel Converter and the other end to the IEEE device.

Apply power to both the IEEE device and the parallel device. The IEEE 488 Parallel Converter is now ready to perform the data transfer between both devices.

WARNING

The IEEE 488 Parallel Converter makes its earth-ground connection through the parallel interface cable. The unit should only be connected to an IEEE bus device after first being connected to the parallel device. Failure to do so may allow dangerous voltages to build up. This could result in damage to the interface, personal injury, or death.

4. Parallel-to-IEEE Operation

4.1 Introduction to Parallel-to-IEEE Mode

The Parallel-to-IEEE mode allows a parallel (Centronics) host device to send data to single or multiple IEEE bus peripherals. The IEEE 488 Parallel Converter accepts characters on its parallel port and outputs them to the IEEE port. The interface can buffer approximately 24,000 bytes of data from the parallel port. Applications include interfacing a listen-only or addressable IEEE printer/plotter to a parallel printer port.

The IEEE 488 Parallel Converter will refuse to accept more data from the parallel port when its buffer memory is full. It does this by preventing completion of the parallel-bus handshaking sequence.

The Converter also has the ability to automatically insert a line-feed character after receiving a carriage-return character. This is necessary if the sending parallel device does not automatically send a line feed and the receiving IEEE device does not automatically insert a line feed. It will become immediately evident that this feature should be enabled if your printed material all appears on one line.

4.2 Parallel Data Transfers

At power on, the IEEE 488 Parallel Converter sends an Interface Clear command on the IEEE bus for greater than 100 microseconds. It then sends the following IEEE command sequence:

```
ATN•UNL,UNT,LAG,*ATN
```

In this sequence, LAG includes all listen addresses from 0 to 30. This guarantees that any printer or plotter attached to the IEEE 488 Parallel Converter's IEEE port will be in the listen mode, ready to accept characters. A device on the IEEE port which is in the LISTEN ONLY or LISTEN ALWAYS mode will also be ready to accept characters. The power-on sequence is also initiated when the INIT line is detected by the IEEE 488 Parallel Converter on the parallel bus.

After all devices have received their listen address, the IEEE 488 Parallel Converter will accept characters on its parallel port and output them to the IEEE port. If characters are received at a rate faster than can be output, the built-in 24,000-byte data buffer stores the characters until the IEEE bus can accept them. In the event the buffer fills up entirely, the IEEE 488 Parallel Converter will hold off from accepting data on the parallel port until sufficient buffer space is available to proceed.

4.3 IEEE Address Selection

It is not necessary to match the IEEE address on your printer or plotter to an address on the IEEE 488 Parallel Converter. The interface addresses all IEEE 488 devices to listen. The address of the IEEE 488 Parallel Converter is automatically adjusted so that address conflicts will not occur.

4.4 Plotter Applications

Some applications, such as Lotus® 1-2-3®, allow a graphics output to a plotter via the PC's parallel (LPT) port. The IEEE 488 Parallel Converter can be used to interface an IEEE 488 (HP-IB) plotter to the PC.
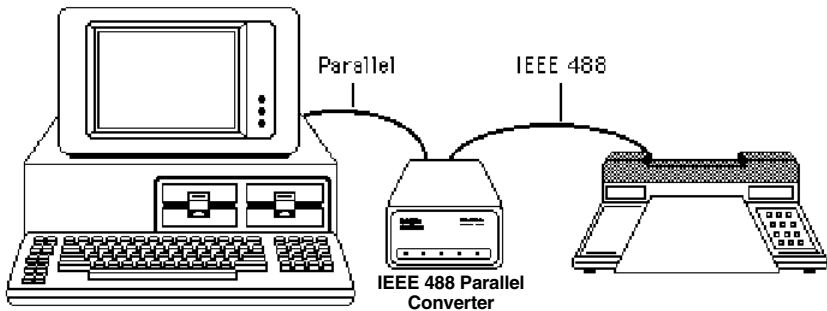
Figure 4-1. An IBM PC-based Graphics System.

To configure the PC graphics system, connect the LPT output of the PC to the parallel input connector on the IEEE 488 Parallel Converter using a standard printer interface cable. Using a standard IEEE 488 cable, connect the IEEE 488 Parallel Converter's IEEE output to the plotter's IEEE input.

After configuration, turn on the plotter followed by the IEEE 488 Parallel Converter. The IEEE 488 Parallel Converter's front panel LEDs should all light momentarily while it performs an internal ROM and RAM test. All LEDs should go out except for the Power and Talk LED. The Talk LED indicates that the IEEE 488 Parallel Converter has detected the plotter on the IEEE bus and has addressed it to listen.

When the parallel host begins to send the IEEE 488 Parallel Converter data, the Receive LED will flash. If it does not, this indicates that the interface is not receiving data from the parallel host. Verify that the cables are connected properly and the parallel cable is wired correctly.

The following is an example of how the IEEE 488 Parallel Converter can be used to communicate with an IEEE plotter through the PC's LPT port. The program example is written in BASIC on an IBM PC or compatible. It turns the PC into a dumb parallel terminal. When a key is pressed on the keyboard, the character is transmitted out of the parallel (LPT1) port.

```
10    '   Terminal Program for the IEEE 488 Parallel
Converter
20    ' This Program allows direct interaction between
30    ' the IBM PC and an IEEE plotter through the IEEE 488
      Parallel Converter.
40    '
50    'Open the parallel communications port
60    OPEN "LPT1:" AS 1
70    ' Transmit key presses to the LPT1 port and screen
80    K$=INKEY$
90    PRINT #1,K$; : PRINT K$;
100   GOTO 90 ' Do it again
```

Enter the program into the computer and run it. The example below shows how to test the IEEE 488 Parallel Converter's operation with a Hewlett-Packard® 7470A plotter. Other IEEE plotters are similar, but you should refer to the plotter's programming manual for the proper command syntax. Notice the IEEE 488 Parallel Converter's front-panel LEDs as you type the plotter commands.

By typing the following HPGL command on the keyboard, the plotter should respond by retrieving its pen, drawing a line, and returning the pen.

SP1;PA1000,1000;PD;PA1000,6000;PU;SP0;

4.5 Printer Applications

Most of the information given for plotter applications applies to applications for interfacing IEEE 488 printers to a parallel host. Some high-end printers have a secondary command setting which must be disabled for the IEEE 488 Parallel Converter to control them. The IEEE 488 Parallel Converter does not use secondary commands to control IEEE peripherals, such as printers or plotters. Refer to the printer's instruction manual if there is a question as to whether the printer requires secondary commands.

4.6 Parallel Interface Description and Timing

As a parallel-to-IEEE converter, the IEEE 488 Parallel Converter controls the signals designated as "out" in this chart and responds to the signals designated as "in."

Pin	Signal	Direction	Description
1	STROBE	in	When a low pulse is sent by the parallel device (>0.5 µs), the IEEE 488 Parallel Converter reads the character on the data lines and places it in the IEEE output buffer.
2	DATA0	in	Least significant data bit 0 (high=logic "1")
3	DATA1	in	Data bit 1
4	DATA2	in	Data bit 2
5	DATA3	in	Data bit 3
6	DATA4	in	Data bit 4
7	DATA5	in	Data bit 5
8	DATA6	in	Data bit 6
9	DATA7	in	Most significant data bit 7
10	ACKNLG	out	The IEEE 488 Parallel Converter pulses this line low for >5 µs after it has accepted a character from the parallel device.
11	BUSY	out	The IEEE 488 Parallel Converter sets this line low when it can accept another parallel character. If the buffer is full, this line is set high until the buffer again has space.
12	PE	out	Out of Paper signal. Not used. Always low.
13	SLCT	out	Printer Select signal. Not used. Always high.
14	/AUTO FEED	in	When this line is low and the present parallel character is a carriage-return, the IEEE 488 Parallel Converter will add a line-feed character to the IEEE data stream.

Pin	Signal	Direction	Description
16	Logic GND		Signal return.
19-30	Logic GND		Signal return.
31	/INIT	in	When a low pulse is received (>50 µs), the buffer is cleared, Interface Clear (IFC) is asserted for 100 µs, and the Listener Address Group is sent on the IEEE bus.
32	/ERROR	out	Off-Line signal. Not used. Always high.
33	Logic GND		Signal return.
36	/SLCT IN	in	Printer Select Input. Not used.

Parallel to IEEE Mode Timing

Signal	Dir	
ACKNLG	out	5 µs min
BUSY	out	
DATA	in	
STROBE	in	0.5 µs min
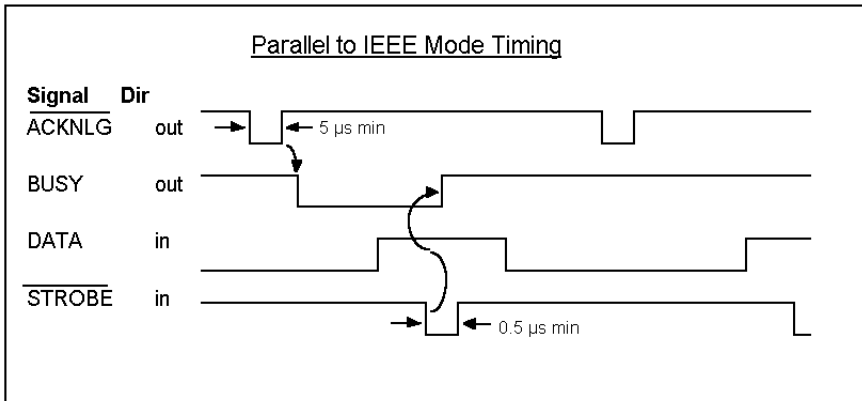
5. IEEE-to-Parallel Operation

5.1 Introduction to IEEE-to-Parallel Mode

This mode of operation is useful in interfacing a parallel device, such as a Centronics printer, to an IEEE controller or Talk Only device. Data which is sent by the IEEE controller to the IEEE 488 Parallel Converter is buffered and transmitted out its parallel port. The IEEE 488 Parallel Converter can buffer approximately 24,000 bytes of data from the IEEE input.

The IEEE 488 Parallel Converter will refuse to accept more data from the IEEE controller when its buffer memory is full. It does this by preventing completion of the bus handshaking sequences.

The IEEE 488 Parallel Converter also has the capability to automatically insert a line-feed character after receiving a carriage-return character. This is necessary if the sending IEEE device does not automatically send a line feed and the receiving parallel device does not automatically insert a line feed. It will become immediately evident that this feature should be enabled if your printed material all appears on one line.

When power is applied to the IEEE 488 Parallel Converter, it will pulse the INIT line on the parallel interface for approximately 50 microseconds. This is used to reset the parallel device.

5.2 IEEE Data Transfers

The methods listed in this section may be used by the IEEE controller when sending data to the IEEE 488 Parallel Converter.

5.2.1 BLIND BUS DATA TRANSFERS

If the IEEE controller does not mind waiting an indefinite time for data space in the buffer to become available, the data can simply be sent to the IEEE 488 Parallel Converter. This is referred to as blind data transfer because the IEEE controller is blind as to whether or not the IEEE 488 Parallel Converter is capable of accepting data. In this case, the bus controller's output data transfer will be held off by the IEEE 488 Parallel Converter if it is unable to buffer the data. It will resume accepting IEEE input data when memory becomes available. This type of control might be appropriate in a single-user environment.

To illustrate how this would appear, let's assume the IEEE 488 Parallel Converter is connected to a parallel printer which will accept data at 120 bytes per second. The IEEE bus controller is capable of sending data to the IEEE 488 Parallel Converter at a rate of 5000 bytes per second. The data would be transferred on the bus at 5000 characters per second for slightly over five seconds, filling over 24,000 locations. At that time, the IEEE input would hold off additional data transfers until memory becomes available to buffer more data. The parallel printer's 120 bytes per second would then become the average IEEE-bus data-acceptance rate.

If the controller is set to detect a data time-out error, then it will do so if the IEEE 488 Parallel Converter holds off IEEE input data transfers for too long. The error can be used to alert the operator to the problem, such as a printer out of paper, so that it can be corrected. If the controller then restarts transmission exactly where it left off, no data will be lost.
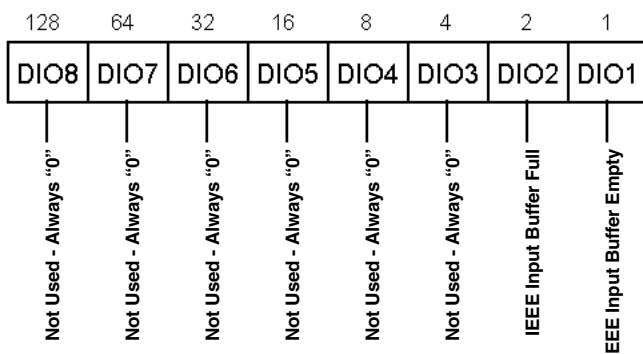
5.2.2 CONTROLLED BUS DATA TRANSFERS

If the controller must avoid waiting for the parallel device, it can "serial-poll" the IEEE 488 Parallel Converter. Serial poll is a method by which the controller can inquire the internal status of the interface without disturbing any data being transferred, slowing data transfers, or locking up the bus. You should refer to the programming manual of your controller to determine the method of performing serial polls.

When serial-polled, the IEEE 488 Parallel Converter provides eight bits of status information to the controller. One of the bits [DIO1] of the IEEE 488 Parallel Converter's serial-poll byte is set to a logic "1" when the IEEE input buffer is EMPTY. The term EMPTY is used to signify that all of the previous data sent to the interface has been transmitted to the parallel device. If it is NOT EMPTY, the controller may avoid sending any more data to the IEEE 488 Parallel Converter. If this bit is a logic "1," then the parallel device has accepted all previous data and the IEEE controller may send more.

Another bit [DIO2] of the Serial Poll byte is used to indicate additional information concerning the IEEE input buffer. This bit is set to a logic "1" when there is 1024 or less locations in the buffer for data. It is cleared (set to a logic "0") when there are more than 2048 locations available. This bit is referred to as the IEEE input buffer FULL bit.

5.3 Serial-Poll Status Byte Register

The following shows and describes the serial-poll status information provided by the IEEE 488 Parallel Converter.

128	64	32	16	8	4	2	1
DIO8	DIO7	DIO6	DIO5	DIO4	DIO3	DIO2	DIO1
Not Used - Always "0"	Not Used - Always "0"	Not Used - Always "0"	Not Used - Always "0"	Not Used - Always "0"	Not Used - Always "0"	IEEE Input Buffer Full	IEEE Input Buffer Empty

Figure 5-1. Serial Poll Status Byte.

DIO8   Not Defined - Always "0"

DIO7   rsv - Always "0"
             This bit is defined by the IEEE 488 Specification and is used to indicate to the bus controller which device requires service. This bit is not supported by the IEEE 488 Parallel Converter.

DIO6   Not Defined - Always "0"

DIO5   Not Defined - Always "0"

DIO4   Not Defined - Always "0"

DIO3   Not Defined - Always "0"

DIO2   IEEE Input Buffer Full
             When this bit is set, it indicates that the IEEE 488 Parallel Converter may hold off the controller on subsequent data transfers. The interface may continue to accept an additional 512 characters.

    DIO1   IEEE Input Buffer Empty
                When this bit is set, it indicates that the parallel device has accepted
                all previous data sent to the IEEE 488 Parallel Converter.

5.4 IEEE 488 Bus Implementation

The IEEE 488 Parallel Converter implements many of the capabilities defined by
the IEEE 488 1978 specification. These are discussed in the following sections. The
bus uniline and multiline commands that the IEEE 488 Parallel Converter does not
support or respond to include:

> Remote Enable (REN)
>
> Go to Local (GTL)
>
> Group Execute Trigger (GET)
>
> Local Lockout (LLO)
>
> Take Control (TCT)
>
> Parallel Poll (PP)
>
> Parallel Poll Configure (PPC)
>
> Parallel Poll Unconfigure (PPU)
>
> Parallel Poll Disable (PPD)

5.4.1 MY TALK ADDRESS (MTA)

The IEEE 488 Parallel Converter does not support the transfer of data from the
parallel port to the IEEE controller except as it pertains to serial polls. This is due
to the unidirectional data transfer of the parallel interface.

5.4.2 MY LISTEN ADDRESS (MLA)

When the IEEE 488 Parallel Converter is addressed to listen, it accepts data from
the active talker, buffers it, and outputs this data through the parallel interface. It
will issue a line-feed character upon detection of a carriage return if the Auto
Linefeed feature is enabled.

5.4.3 DEVICE CLEAR (DCL AND SDC)

Device Clear resets the IEEE 488 Parallel Converter's IEEE input buffer and pulses
the parallel-interface INIT line. Any pending data is lost.

5.4.4 INTERFACE CLEAR (IFC)

IFC places the IEEE 488 Parallel Converter in the Talker/Listener Idle State.

5.4.5 SERIAL POLL ENABLE (SPE)

When in Serial Poll Enabled, the IEEE 488 Parallel Converter sets itself to respond to a serial poll with its serial-poll status byte if addressed to talk. The IEEE 488 Parallel Converter will continue to try to output its serial poll response until it is "Serial Poll Disabled" by the controller.

5.4.6 SERIAL POLL DISABLE (SPD)

Disables the IEEE 488 Parallel Converter from responding to serial polls by the controller.

5.4.7 UNLISTEN (UNL)

UNL places the IEEE 488 Parallel Converter in the Listener Idle State.

5.4.8 UNTALK (UNT)

UNT places the IEEE 488 Parallel Converter in the Talker Idle State.

5.5 IEEE Address Selection

SW1-1 through SW1-5 select the IEEE bus address of the IEEE 488 Parallel Converter when in the IEEE to Parallel mode. The address is selected by simple binary weighting with SW1-1 being the least significant bit and SW1-5 the most significant. The following figure shows the IEEE address of the IEEE 488 Parallel Converter set to 10.
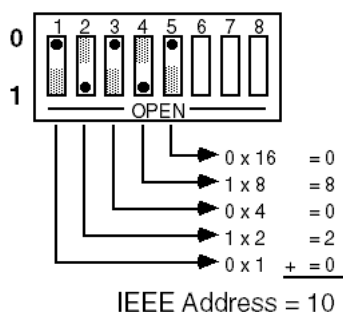
Figure 5-2. SW1 View for IEEE Address Selection.

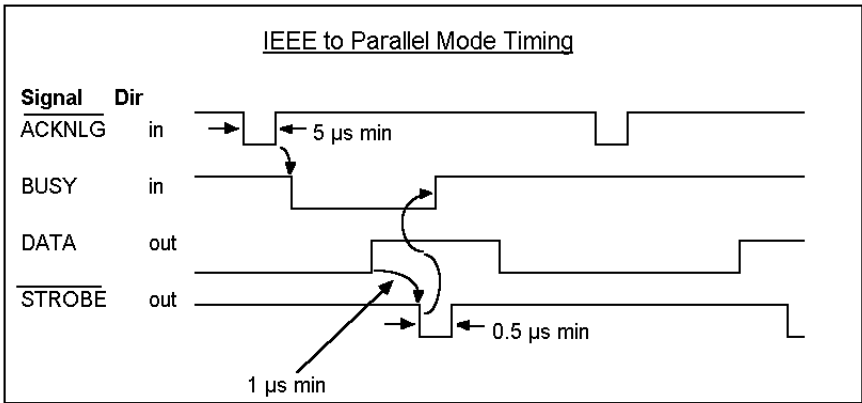Listen Only is a special type of IEEE to Parallel operation. In the Listen Only mode the IEEE 488 Parallel Converter accepts all data transmitted on the bus and transfers it out its parallel port. The IEEE 488 Parallel Converter is set to Listen Only mode by setting its address to 31 (switches SW1-1 through SW1-5 all open).

5.6 Parallel Interface Description and Timing

As an IEEE-to-parallel converter, the IEEE 488 Parallel Converter controls the signals designated as "out" and responds to the signals designated as "in" on the parallel interface.

Pin	Signal	Direction	Description
1	STROBE	out	After presenting a new character on the parallel data lines (>1µs), this line is pulsed low for >0.5 µs.
2	DATA0	out	Least significant data bit 0 (high=logic "1").
3	DATA1	out	Data bit 1.
4	DATA2	out	Data bit 2.
5	DATA3	out	Data bit 3.
6	DATA4	out	Data bit 4.
7	DATA5	out	Data bit 5.
8	DATA6	out	Data bit 6.
9	DATA7	out	Most significant data bit 7.
10	ACKNLG	in	Low input indicates the parallel device has accepted the character.
11	BUSY	in	Low input indicates the parallel device is ready to accept a new character. The IEEE 488 Parallel Converter will not output a character until this line is low.
12	PE	in	Out of Paper signal. Not used.
13	SLCT	in	Printer Select signal. Not used.
14	/AUTO FEED	out	Always high.

Pin	Signal	Direction	Description
16	Logic GND		Signal return.
19-30	Logic GND		Signal return.
31	/INIT	out	The IEEE 488 Parallel Converter pulses this line low for approx. 50 µs upon receipt of an IEEE 488 Device Clear or Selected Device Clear, or at power on.
32	/ERROR	in	Off-Line signal. Not used.
33	Logic GND		Signal return.
36	/SLCT IN	out	Always low. Selects the external parallel device.

IEEE to Parallel Mode Timing

Signal	Dir
ACKNLG	in
BUSY	in
DATA	out
STROBE	out

5 µs min

0.5 µs min

1 µs min

6. IEEE 488 Primer

6.1 History

The IEEE 488 bus is an instrumentation communication bus adopted by the Institute of Electrical and Electronic Engineers in 1975 and revised in 1978. The IEEE 488 Parallel Converter conforms to this most recent revision, designated IEEE 488-1978.

Prior to the adoption of this standard, most instrumentation manufacturers offered their own versions of computer interfaces. This placed the burden of system hardware design on the end user. If his application required the products of several different manufacturers, then he might need to design several different hardware and software interfaces. The popularity of the IEEE 488 interface (sometimes called the General Purpose Interface Bus or GPIB) is due to the total specification of the electrical and mechanical interface as well as the data transfer and control protocols. The use of the IEEE 488 standard has moved the responsibility of the user from design of the interface to design of the high-level software that is specific to the measurement application.

6.2 General Structure

The main purpose of the GPIB is to transfer information between two or more devices. A device can either be an instrument or a computer. Before any information transfer can take place, it's first necessary to specify which will do the talking (send data) and which devices will be allowed to listen (receive data). The decision of who will talk and who will listen usually falls on the System Controller, which is, at power-on, the Active Controller.

The System Controller is similar to a committee chairman. On a well-run committee, only one person may speak at a time and the chairman is responsible for recognizing members and allowing them to have their say. On the bus, the device which is recognized to speak is the Active Talker. There can only be one Talker at a time if the information transferred is to be clearly understood by all. The act of "giving the floor" to that device is called Addressing to Talk. If the committee chairman cannot attend the meeting, or if other matters require his attention, he can appoint an acting chairman to take control of the proceedings. For the GPIB, this device becomes the Active Controller.

At a committee meeting, everyone present usually listens. This is not the case with the GPIB. The Active Controller selects which devices will listen and commands all other devices to ignore what is being transmitted. A device is instructed to listen by

being Addressed to Listen. This device is then referred to as an Active Listener. Devices which are to ignore the data message are instructed to Unlisten.

The reason some devices are instructed to Unlisten is quite simple. Suppose a college instructor is presenting the day's lesson. Each student is told to raise their hand if the instructor has exceeded their ability to keep up while taking notes. If a hand is raised, the instructor stops his discussion to allow the slower students time to catch up. In this way, the instructor is certain that each and every student receives all the information he is trying to present. Since there are a lot of students in the classroom, this exchange of information can be very slow. In fact, the rate of information transfer is no faster than the rate at which the slowest note-taker can keep up. The instructor, though, may have a message for one particular student. The instructor tells the rest of the class to ignore this message (Unlisten) and tells it to that one student at a rate which he can understand. This information transfer can then happen much quicker, because it need not wait for the slowest student.

The GPIB transfers information in a similar way. This method of data transfer is called handshaking. Handshaking is discussed in more detail in **Section 6.5**.

For data transfer on the IEEE 488, the Active Controller must…

a) Unlisten all devices to protect against eavesdroppers.

b) Designate who will talk by addressing a device to talk.

c) Designate all the devices who are to listen by addressing those devices to listen.

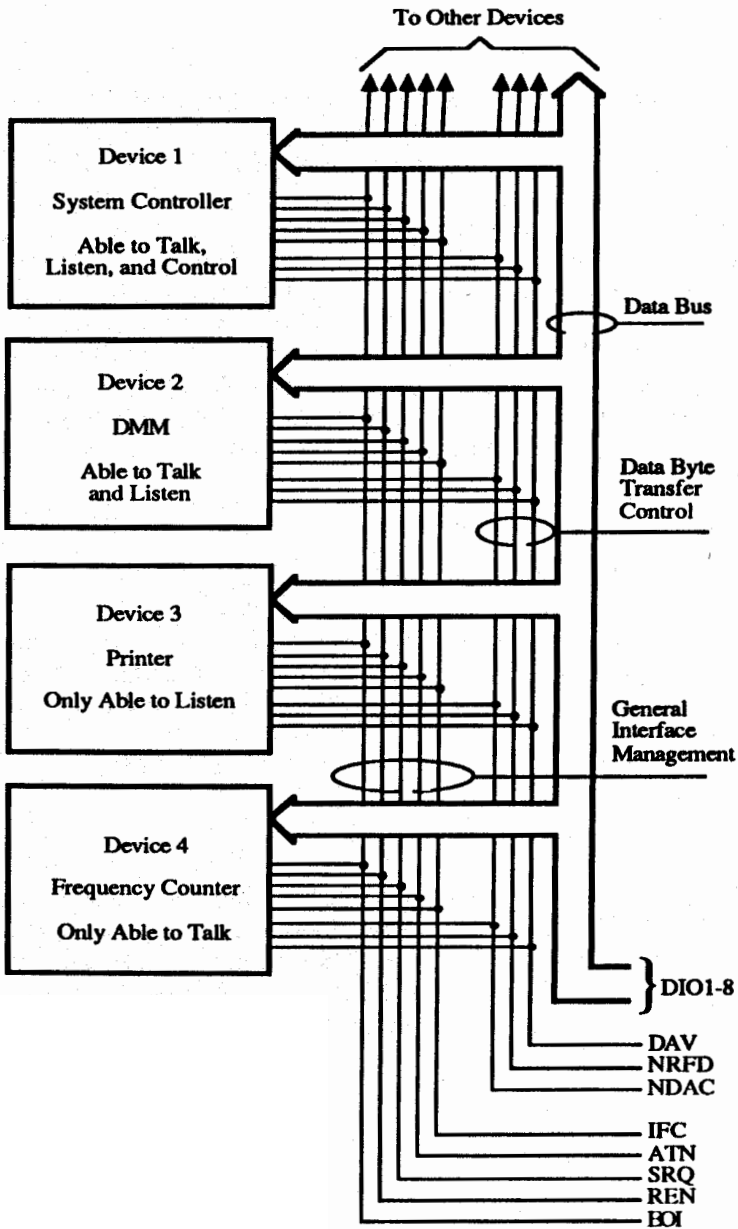d) Indicate to all devices that the data transfer can take place.

Figure 6-1. IEEE 488 Bus Structure.

6.3 Send It to My Address

In the previous discussion, the terms Addressed to Talk and Addressed to Listen were used. These terms require some clarification.

The IEEE 488 standard permits up to 15 devices to be configured within one system. Each of these devices must have a unique address to avoid confusion. In a similar fashion, every building in town has a unique address to prevent one home from receiving another home's mail. Exactly how each device's address is set is specific to the product's manufacturer. Some are set by DIP switches in hardware, others by software. Consult the manufacturer's instructions to determine how to set the address.

Addresses are sent with universal (multiline) commands from the Active Controller. These commands include My Listen Address (MLA), My Talk Address (MTA), Talk Address Group (TAG), and Listen Address Group (LAG).

6.4 Bus Management Lines

Five hardware lines on the GPIB are used for bus management. Signals on these lines are often referred to as uniline (single-line) commands. The signals are active low—that is, a low voltage represents a logic "1" (asserted), and a high voltage represents a logic "0" (unasserted).

6.4.1 ATTENTION (ATN)

ATN is one of the most important lines for bus management. If Attention is asserted, then the information contained on the data lines is to be interpreted as a multiline command. If it isn't, then that information is to be interpreted as data for the Active Listeners. The Active Controller is the only bus device that has control of this line.

6.4.2 INTERFACE CLEAR (IFC)

The IFC line is used only by the System Controller. It is used to place all bus devices in a known state. Although device configurations vary, the IFC command usually places the devices in the Talk and Listen Idle states (neither Active Talker nor Active Listener).

6.4.3 REMOTE ENABLE (REN)

When the System Controller sends the REN command, bus devices will respond to remote operation. Generally, the REN command should be issued before any bus programming is attempted. Only the System Controller has control of the Remote Enable line.

6.4.4 END OR IDENTIFY (EOI)

The EOI line is used to signal the last byte of a multibyte data transfer. The device that is sending the data asserts EOI during the transfer of the last data byte. The EOI signal is not always necessary, as the end of the data may be indicated by some special character such as carriage return.

The Active Controller also uses EOI to perform a Parallel Poll by simultaneously asserting EOI and ATN.

6.4.5 SERVICE REQUEST (SRQ)

When a device desires the immediate attention of the Active Controller it asserts SRQ. It is then the Controller's responsibility to determine which device requested service. This is accomplished with a Serial Poll or a Parallel Poll.

6.5 Handshake Lines

The GPIB uses three handshake lines in an "I'm ready—Here's the data—I've got it" sequence. This handshake protocol assures reliable data transfer, at the rate determined by the slowest Listener. One line is controlled by the Talker, while the other two are shared by all Active Listeners. The handshake lines, like the other IEEE 488 lines, are active low.

6.5.1 DATA VALID (DAV)

The DAV line is controlled by the Talker. The Talker verifies that NDAC is asserted (active low), which indicates that all Listeners have accepted the previous data byte transferred. The Talker then outputs data on the bus and waits until NRFD is unasserted (high), which indicates that all Addressed Listeners are ready to accept the information. When NRFD and NDAC are in the proper state, the Talker asserts DAV (active low) to indicate that the data on the bus is valid.

6.5.2 NOT READY FOR DATA (NRFD)

This line is used by the Listeners to inform the Talker when they are ready to accept new data. The Talker must wait for each Listener to unassert this line (high), which they will do at their own rate when they are ready for more data. This assures that all devices that are to accept the information are ready to receive it.

6.5.3 NOT DATA ACCEPTED (NDAC)

The NDAC line is also controlled by the Listeners. This line indicates to the Talker that each device addressed to listen has accepted the information. Each device releases NDAC (high) at its own rate, but the NDAC will not go high until the slowest Listener has accepted the data byte.
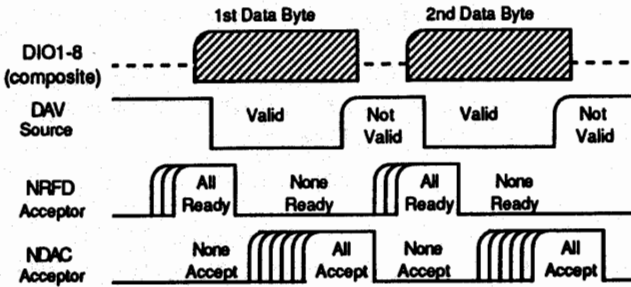

Figure 6-2. IEEE Bus Handshaking.

6.6 Data Lines

The GPIB provides eight data lines for a bit parallel/byte serial data transfer. These eight data lines use the convention of DIO1 through DIO8 instead of the binary designation of D0 to D7. The data lines are bidirectional and are active low.

6.7 Multiline Commands

Multiline (bus) commands are sent by the Active Controller over the data bus with ATN asserted. These commands include addressing commands for talk, listen, Untalk, and Unlisten.

6.7.1 GO TO LOCAL (GTL)

This command allows the selected devices to be manually controlled. (IEEE 488 command code: $01.)

6.7.2 LISTEN ADDRESS GROUP (LAG)

There are 31 (0 to 30) listen addresses associated with this group. The 3 most significant bits of the data bus are set to 001 while the 5 least significant bits are the address of the device being told to listen.

6.7.3 UNLISTEN (UNL)

This command tells all bus devices to Unlisten. This is the same as Unaddressed to Listen. (IEEE 488 command code: $3F.)

6.7.4 TALK ADDRESS GROUP (TAG)

There are 31 (0 to 30) talk addresses associated with this group. The 3 most significant bits of the data bus are set to 010 while the 5 least significant bits are the address of the device being told to talk.

6.7.5 UNTALK (UNT)

This command tells bus devices to Untalk. This is the same as Unaddressed to Talk. (IEEE 488 command code: $5F.)

6.7.6 LOCAL LOCKOUT (LLO)

Issuing the LLO command prevents manual control of the instrument's functions. (IEEE 488 command code: $11.)

6.7.7 DEVICE CLEAR (DCL)

This command causes all bus devices to be initialized to a pre-defined or power-up state. (IEEE 488 command code: $14.)

6.7.8 SELECTED DEVICE CLEAR (SDC)

This causes a single device to be initialized to a pre-defined or power-up state. (IEEE 488 command code: $04.)

6.7.9 SERIAL POLL DISABLE (SPD)

The SPD command disables all devices from sending their Serial Poll status byte. (IEEE 488 command code: $19.)

6.7.10 SERIAL POLL ENABLE (SPE)

A device which is Addressed to Talk will output its Serial Poll status byte after SPE is sent and ATN is unasserted. (IEEE 488 command code: $18.)

6.7.11 GROUP EXECUTE TRIGGER (GET)

This command usually signals a group of devices to begin executing a triggered action. This allows actions of different devices to begin simultaneously. (IEEE 488 command code: $08.)

6.7.12 TAKE CONTROL (TCT)

This command passes bus-control responsibilities from the current Controller to another device which has the ability to control. (IEEE 488 command code: $09.)

6.7.13 SECONDARY COMMAND GROUP (SCG)

These are any one of the 32 possible commands (0 to 31) in this group. They must immediately follow a talk or listen address. (IEEE 488 command codes: $60 to $7F.)

6.7.14 PARALLEL POLL CONFIGURE (PPC)

This tells devices capable of performing a Parallel Poll which data bit they are to assert in response to a Parallel Poll. (IEEE 488 command code: $05.)

6.7.15 PARALLEL POLL UNCONFIGURE (PPU)

This disables all devices from responding to a Parallel Poll. (IEEE 488 command code: $15.)

6.8 More About Service Requests

Most of the commands covered, both uniline and multiline, are the responsibility of the Active Controller to send and the bus devices to recognize. Most of these are taken care of routinely by the interface and are totally transparent to the system programmer. Other commands are used directly by the user to provide optimum system control.

Of the uniline commands, SRQ (Service Request) is very important to the test system, so the software designer has easy access to this line from most devices. Service Request is the method by which a bus device can signal to the Controller that an event has occurred. It is similar to an interrupt in a microprocessor-based system.

Most intelligent bus peripherals have the ability to assert SRQ. A DMM might assert it when its measurement is complete, if its input is overloaded, or for any of an assortment of reasons. A power supply might assert SRQ if its output has current limited. This is a powerful bus feature that removes the burden from the System

Controller to periodically inquire, "Are you done yet?" Instead, the Controller says, "Do what I told you to do and let me know when you're done," or "Tell me when something is wrong."

Since SRQ is a single-line command, there is no way for the Controller to determine which device requested the service without additional information. This information is provided by the multiline commands for Serial Poll and Parallel Poll.

6.8.1 SERIAL POLL

Suppose the Controller receives a service request. For this example, let's assume there are several devices which could assert SRQ. The Controller issues an SPE (Serial Poll enable) command to each device sequentially. If any device responds with DIO7 asserted, it indicates to the Controller that it was the device that asserted SRQ. Often the other bits will indicate why the device wanted service. This Serial Polling sequence, and any resulting action, is under control of the software designer.

6.8.2 PARALLEL POLL

The Parallel Poll is another way the Controller can determine which device requested service. It provides the who but not necessarily the why. When bus devices are configured for Parallel Poll, they are assigned one bit on the data bus for their response. By using the Status bit, the logic level of the response can be programmed to allow logical OR/AND conditions on one data line by more than one device. When SRQ is asserted, the Controller (under user's software) conducts a Parallel Poll. The Controller must then analyze the eight bits of data received to determine the source of the request. Once the source is determined, a Serial Poll might be used to determine the why.

Of the two polling types, the Serial Poll is the most popular due to its ability to determine the who and why. In addition, most devices support Serial Poll only.

7. Service Information

7.1 Theory of Operation

At the heart of the IEEE 488 Bus Extender is a 6809 microprocessor (U201) supported by 8 KB of firmware EPROM (U102 [2764]) and 32 KB of static RAM (U103 [84256]). A Versatile Interface Adapter (U104 [R65C22]) is used to generate real-time interrupts for the firmware operating system. The front-panel annunciators are also driven by U104 through an inverter (U113 [74LS04]).

Handshake lines for the parallel port are controlled by a programmable interface adapter (PIA) (U202 [6821]). In the IEEE to parallel mode, this same PIA is used to output 8 bits of data to the parallel port. In the parallel to IEEE mode, an 8-bit latch (U206 [74LS373]) reads data from the parallel port.

To decode the microprocessor address space, use a Programmable Logic Array (U110 [16L8]). The memory-space allocation is shown below.

Address	Device	Function
$2000-$7FFF	U103	Static RAM
$8000	U206	Parallel data receiver
$9200	U202	Parallel handshake/data out
$A000	U106	IEEE controller
$B000	U104	LED driver
$E000-$FFFF	U102	Programmed EPROM

7.2 IEEE 488 Parallel Converter Motherboard
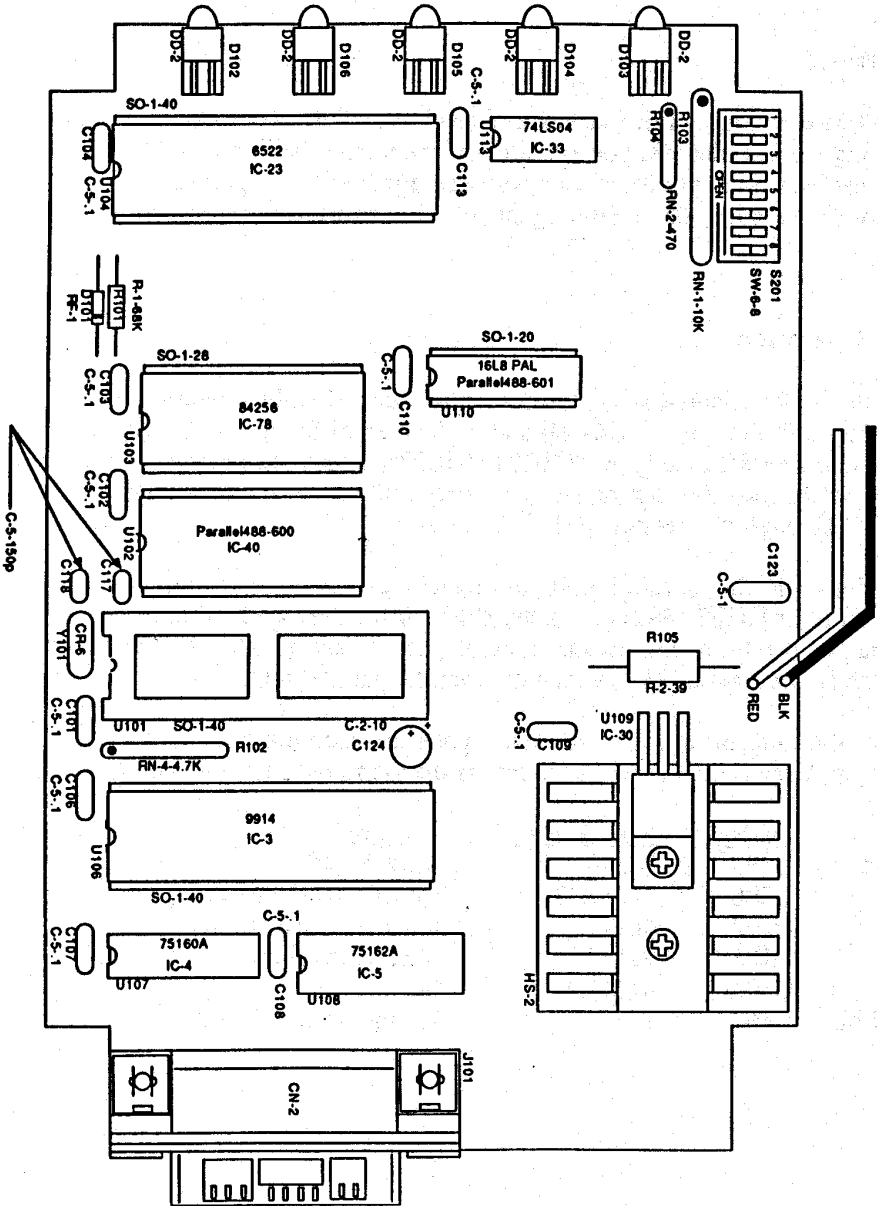
7.3 IEEE 488 Parallel Converter I/O Board
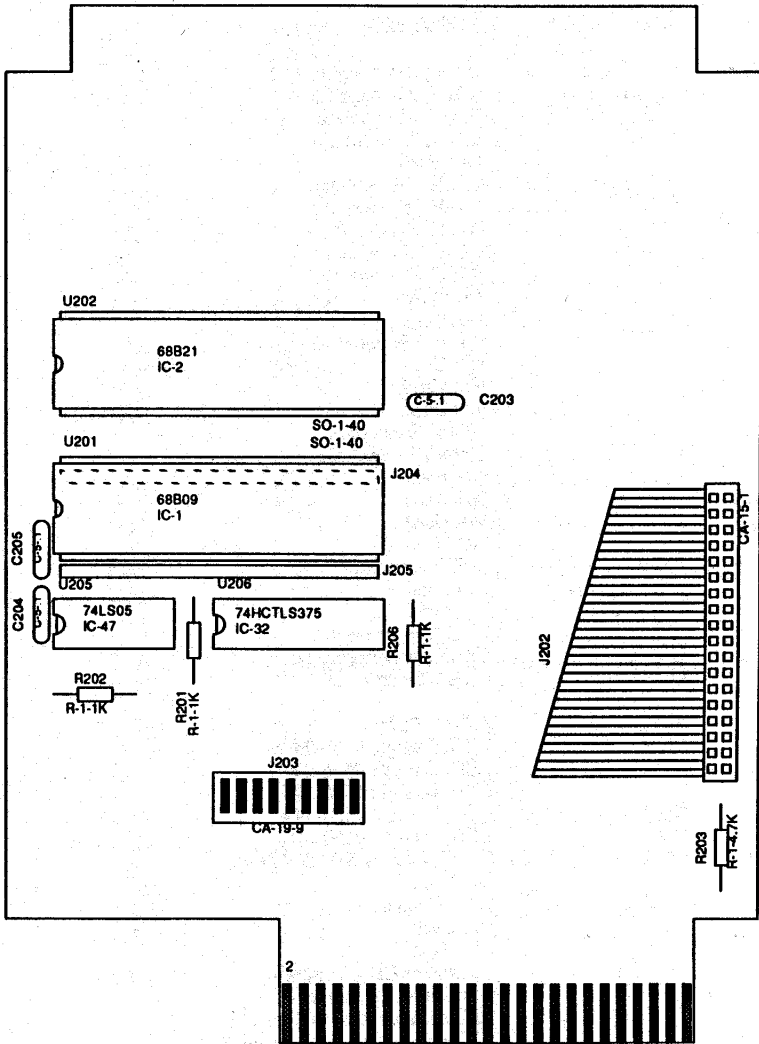
7.4 Calling Black Box

If you determine that your Extender is malfunctioning, do not attempt to alter or repair the unit. It contains no user-serviceable parts. Contact Black Box at 724-746-5500.

Before you do, make a record of the history of the problem. We will be able to provide more efficient and accurate assistance if you have a complete description, including:

- the nature and duration of the problem.

- when the problem occurs.

- the components involved in the problem.

- any particular application that, when used, appears to create the problem or make it worse.

7.5 Shipping and Packaging

If you need to transport or ship your Extender:

- Package it carefully. We recommend that you use the original container.

- If you are shipping the Extender for repair, make sure you include everything that came in the original package. Before you ship, contact Black Box to get a Return Authorization (RA) number.

Appendix: Character Codes and IEEE Multiline Messages

When reading this table, note that the codes listed in the upper-left corners are IEEE 488 command codes, the codes in the upper right corners are the ASCII representations, and the actual message is shown in the center of each block.

S00 / 0 NUL	S10 / 16 DLE	S20 / 32 SP (00)	S30 / 48 0 (16)	S40 / 64 @ (00)	S50 / 80 P (16)	S60 / 96 ` (SCG)	S70 / 112 p (SCG)
S01 / 1 SOH (GTL)	S11 / 17 DC1 (LLO)	S21 / 33 ! (01)	S31 / 49 1 (17)	S41 / 65 A (01)	S51 / 81 Q (17)	S61 / 97 a (SCG)	S71 / 113 q (SCG)
S02 / 2 STX	S12 / 18 DC2	S22 / 34 " (02)	S32 / 50 2 (18)	S42 / 66 B (02)	S52 / 82 R (18)	S62 / 98 b (SCG)	S72 / 114 r (SCG)
S03 / 3 ETX	S13 / 19 DC3	S23 / 35 # (03)	S33 / 51 3 (19)	S43 / 67 C (03)	S53 / 83 S (19)	S63 / 99 c (SCG)	S73 / 115 s (SCG)
S04 / 4 EOT (SDC)	S14 / 20 DC4 (DCL)	S24 / 36 $ (04)	S34 / 52 4 (20)	S44 / 68 D (04)	S54 / 84 T (20)	S64 / 100 d (SCG)	S74 / 116 t (SCG)
S05 / 5 ENQ (PPC)	S15 / 21 NAK (PPU)	S25 / 37 % (05)	S35 / 53 5 (21)	S45 / 69 E (05)	S55 / 85 U (21)	S65 / 101 e (SCG)	S75 / 117 u (SCG)
S06 / 6 ACK	S16 / 22 SYN	S26 / 38 & (06)	S36 / 54 6 (22)	S46 / 70 F (06)	S56 / 86 V (22)	S66 / 102 f (SCG)	S76 / 118 v (SCG)
S07 / 7 BEL	S17 / 23 ETB	S27 / 39 ' (07)	S37 / 55 7 (23)	S47 / 71 G (07)	S57 / 87 W (23)	S67 / 103 g (SCG)	S77 / 119 w (SCG)
S08 / 8 BS (GET)	S18 / 24 CAN (SPE)	S28 / 40 ((08)	S38 / 56 8 (24)	S48 / 72 H (08)	S58 / 88 X (24)	S68 / 104 h (SCG)	S78 / 120 x (SCG)
S09 / 9 HT (TCT)	S19 / 25 EM (SPD)	S29 / 41) (09)	S39 / 57 9 (25)	S49 / 73 I (09)	S59 / 89 Y (25)	S69 / 105 i (SCG)	S79 / 121 y (SCG)
S0A / 10 LF	S1A / 26 SUB	S2A / 42 * (10)	S3A / 58 : (26)	S4A / 74 J (10)	S5A / 90 Z (26)	S6A / 106 j (SCG)	S7A / 122 z (SCG)
S0B / 11 VT	S1B / 27 ESC	S2B / 43 + (11)	S3B / 59 ; (27)	S4B / 75 K (11)	S5B / 91 [(27)	S6B / 107 k (SCG)	S7B / 123 { (SCG)
S0C / 12 FF	S1C / 28 FS	S2C / 44 , (12)	S3C / 60 < (28)	S4C / 76 L (12)	S5C / 92 \ (28)	S6C / 108 l (SCG)	S7C / 124 | (SCG)
S0D / 13 CR	S1D / 29 GS	S2D / 45 - (13)	S3D / 61 = (29)	S4D / 77 M (13)	S5D / 93] (29)	S6D / 109 m (SCG)	S7D / 125 } (SCG)
S0E / 14 SO	S1E / 30 RS	S2E / 46 . (14)	S3E / 62 > (30)	S4E / 78 N (14)	S5E / 94 ^ (30)	S6E / 110 n (SCG)	S7E / 126 ~ (SCG)
S0F / 15 SI	S1F / 31 US	S2F / 47 / (15, UNL)	S3F / 63 ? (UNL)	S4F / 79 O (15, UNT)	S5F / 95 _ (UNT)	S6F / 111 o (SCG)	S7F / 127 DEL (SCG)

— ACG — · · UCG · · ——— LAG ——— TAG ——— SCG ———

ACG = Addressed Command Group
UCG = Universal Command Group
LAG = Listen Address Group

TAG = Talk Address Group
SCG = Secondary Command Group

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