Parallel488 Bus Converter

INSTRUCTION MANUAL

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Parallel488

User's Manual

138-0920

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Introduction

1.1 Description

The Parallel488 is an intellegent 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-in to the Parallel488, allowing the computer to unload an entire document, and proceed to another task while the Parallel488 spools data to the receiving device. The Parallel488 spools characters to the receiving device until the Parallel488's buffer is empty. Also included in the Parallel488 is the capability to automatically insert a line-feed character upon receipt of carriage-return character. This is useful in assuring compatability with a wide variety of computers, instruments, printers, and plotters.

1.2 Specifications

IEEE 488-1978 Implementation: subsets.(Parallel to IEEE)	C1, C2, C3, C4 and C28 controller
	SH0, AH1, T0, TE0, L4, LE0, SR0, RL0, PP0, DC1, DT0, E1.
Connector:	Standard IEEE 488 connector with metric studs.
Parallel	(Centronics)
Terminator:	Selectable Auto-LF (IEEE to Parallel).
Connector:	Standard 36-pin male Centronics style
General	
Data Buffer:	24,000 characters
Indicators:	LEDs for IEEE Talk and Listen, Parallel Send and Receive, and Power.
Power:	105-125V or 210-250V; 50-60 Hz, 10 VA Max.
Dimensions:	188mm deep x 140mm wide x 68mm high 7.39" x 5.5" x2.68").
Weight:	1.55 kg. (3.6 lbs).
Environment:	0¡ - 50¡C; 0 to 70% R.H. to 35¡C. Linearly derate 3% R.H./¡C from 35¡ to 50¡C.
Controls:	Power Switch (external), IEEE and parallel parameter switches (internal).

Specifications subject to change without notice.

1.3 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

Getting Started

2.1 Inspection

The Parallel488 was carefully inspected, both mechanically and electrically, prior to shipment. When you receive the interface, carefully unpack all items from the shipping carton and check for any obvious signs of physical damage which may have occurred during shipment. Immediately report any damage found to the shipping agent. Remember to retain all shipping materials in the event that shipment back to the factory becomes necessary.

Every Parallel488 is shipped with the following....

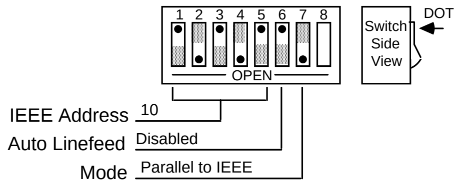
- Parallel488 Bus Converter Interface
- 138-0920 Instruction Manual
- TR-2 Power Supply [110v] or
- TR-2E Power Supply [220/230v]

Note: Other accessories ordered may be packaged and shipped separately.

2.2 Configuration

The Parallel488 has two modes of operation; as a parallel to IEEE 488 converter, or as an IEEE 488 to parallel converter. A DIP switch internal to the Parallel488 determines which one of these modes the product will assume. 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). On the following page are the Parallel488 factory default settings.

SW1 Factory Default Settings



To modify any of these defaults, follow this simple procedure:

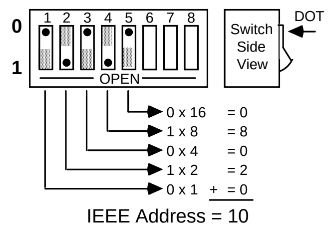
Disconnect the power supply from the AC line and from the interface. Disconnect any IEEE or parallel cables prior to dissassembly.

WARNING

Never open the Parallel488 case while it is connected to the AC line. Failure to observe this warning may result in equipment failure, personal injury or death.

Remove the four 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 those parameters which are appropriate for your installation and reassemble the unit. Slide the main circuit board into the previously noted slot and finish reassembly by tightening the four screws into the rear panel.

SW1 View for IEEE Bus Address Selection



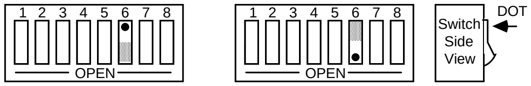
When all switches are in the "open" position (address 31), the Parallel488 is in the `Listen Only` mode. This mode enables a `TALK ONLY` device, such as an digital voltmeter or data logger, to send data directly to the Parallel488 without requiring a controller.

2.2.2 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 Parallel488 automatically inserts a linefeed 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 linefeeds upon receipt of a carriage-return.

This feature is functional in both operating modes of the Parallel488. The factory default condition is auto-linefeed disabled. It will become immediately evident that this feature should be enabled if your printed material all appears on one line.

SW1 View for Auto-Linefeed Selection

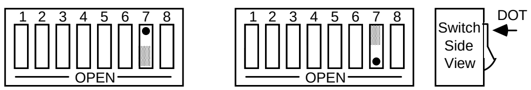


Auto-Linefeed Disabled Auto-Linefeed Enabled

2.2.3 Mode Selection

The Parallel488 mode is selected with SW1-7 in either the parallel to IEEE mode (described in Section 3), or the IEEE to parallel mode (described in Section 4). 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.

SW1 View for Mode Selection



IEEE to Parallel Mode Parallel to IEEE Mode

2.3 Operation

After setting the Parallel488 to the proper switch selections and reassembling the unit, plug the power supply connector into the rear jack on the interface.

CAUTION

Never install the power supply into the interface while it is connected to AC line power. Failure to observe this caution may result in damage to the Parallel488.

WARNING

The power supply provided with the interface is intended for INDOOR USE ONLY. Failure to observe this warning could result in equipment failure, personal injury or death.

After installing the power supply connector into the interface, 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 Parallel488 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 following LED conditions 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 symptons occur, cycle the power switch on the Parallel488 to be sure of the problem. If the problem is unresolved, refer to the Service Information section of this manual.

If proper operation is obtained, turn-off the Parallel488 power switch, and connect a parallel interface cable to the rear of the Parallel488. Connect the other end of the cable to the device having the parallel interface. Now connect the IEEE cable to the rear of the Parallel488, and the other end to the IEEE device.

Now apply power to both the IEEE device and the parallel device. The Parallel488 is now ready to perform the data transfer between both devices.

WARNING The Parallel488 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 the Parallel488 to float to a voltage away from ground. This could result in damage to the interface, personal injury or death.

Parallel To IEEE Operation

3.1 Parallel to IEEE 488 Mode Operation

The Parallel To IEEE mode allows a parallel (Centronics) host device to send data to single or multiple IEEE bus peripherals. The Parallel488 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 Parallel488 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 Parallel488 also has the capability 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.

3.2 Parallel Data Transfers

At power on, the Parallel488 sends an Interface Clear command on the IEEE bus for greater than 100 microseconds. It then sends the following IEEE command sequence ofÉ

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 Parallel488'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 Parallel488 on the parallel bus.

After all devices have received their listen address, the Parallel488 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 32,000 data buffer stores the characters until the IEEE bus can accept them. In the event the buffer fills up entirely, the Parallel488 will hold off from accepting data on the parallel port until sufficient buffer space is available to proceed.

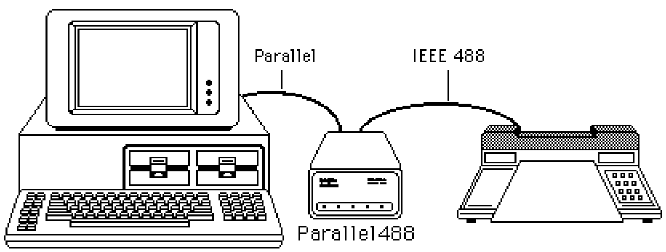
3.3 IEEE Address Selection

It is not necessary to match the IEEE address on your printer or plotter to an address on the Parallel488. The interface addresses all IEEE 488 devices to listen. The address of the Parallel488 is automatically adjusted so that address conflicts will not occur.

3.4 Plotter Applications

Some applications programs, such as Lotus 1-2-3ª, allow a graphics output to a plotter via the PC's parallel (LPT) port. The Parallel488 can be used to interface an IEEE 488 (HP-IB) plotter to the PC.

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 Parallel488 using a standard printer interface cable. Using a standard IEEE 488 cable, connect the Parallel488's IEEE output to the plotter's IEEE input.

After configuration, turn on the plotter followed by the Parallel488. The Parallel488'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 Parallel488 has detected the plotter on the IEEE bus and has addressed it to listen.

When the parallel host begins to send the Parallel488 data, the Receive LED will flash. If it does not, this indicates that the interface is not receiving data from the parallel host. Verify the cables are connected properly and the parallel cable wiring.

The following is an example of how the Parallel488 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 Parallel488
20    ' This Program allows direct interaction between
30    ' the IBM-PC and an IEEE plotter through the
Parallel488.
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 Parallel488'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 Parallel488'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;
```

3.5 Printer Applications

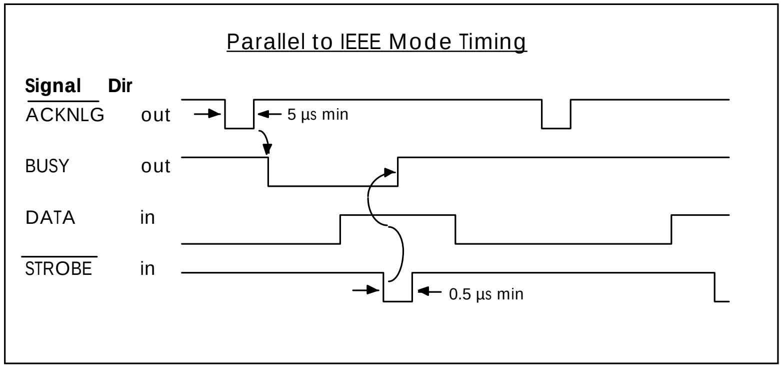
Most of the information given for plotter applications applies to applications for interfacing IEEE 488 printers to a parallel host. Some high end printers have a secondary command setting which must be disabled for the Parallel488 to control them. The Parallel488 does not use secondary commands to control IEEE peripherals, such as printers or plotters. Refer to the printer's instruction manual if the is a question as to whether the printer requires secondary commands.

3.6 Parallel Interface Description and Timing

As a parallel to IEEE converter, the Parallel488 controls the following signals (designated as `out` in the following table) 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 Parallel488 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 Parallel488 pulses this line low for >5 µs after it has accepted a character from the parallel device.
11	BUSY	out	The Parallel488 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 Parallel488 will add a linefeed character to the IEEE data stream.
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

IEEE to Parallel Operation

4.1 IEEE to Parallel Mode Operation

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 Parallel488 is buffered and transmitted out its parallel port. The Parallel488 can buffer approximately 24,000 bytes of data from the IEEE input.

The Parallel488 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 Parallel488 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 Parallel488, it will pulse the `INIT` line on the parallel interface for approximately 50 microseconds. This is used to reset the parallel device.

4.2 IEEE Data Transfers

The following methods may be used by the IEEE controller when sending data to the Parallel488:

4.2.1 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 Parallel488. This is referred to as blind data transfers because the IEEE controller is blind as to whether or not the Parallel488 is capable of accepting data. In this case, the bus controller's output data transfer will be held off by the Parallel488 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 Parallel488 is connected to a parallel printer which will accept data at 120 characters per second. The IEEE bus controller is capable of sending data to the Parallel488 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 devices 120 cps 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 Parallel488 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.

4.2.2 Controlled Bus Data Transfers

If the controller must avoid waiting for the parallel device, it can 'serial poll' the Parallel488. 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.

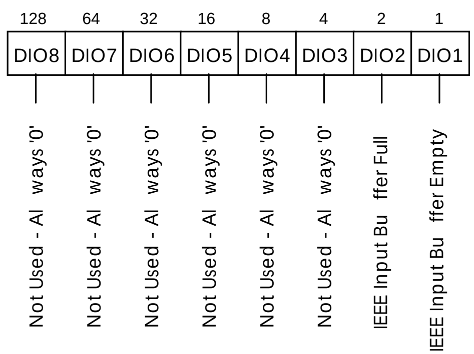
When serial polled, the Parallel488 provides eight bits of status information to the controller. One of the bits [DIO1] of the Parallel488's serial poll byte is set to a logic "1" when the IEEE input buffer is EMPTY. The term EMPTY is used to signify that all of the previous data sent to the interface has been transmitted to the parallel device. If it is NOT EMPTY, the controller may avoid sending any more data to the Parallel488. 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 is greater than 2048 locations available. This bit is referred to as the IEEE input buffer FULL bit.

4.3 Serial Poll Status Byte Register

The following shows and describes the serial poll status information provided by the Parallel488.

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 Parallel488.

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 Parallel488 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 Parallel488.

4.4 IEEE 488 Bus Implementation

The Parallel488 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 Parallel488 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)

4.4.1 My Talk Address (MTA)

The Parallel488 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.

4.4.2 **My Listen Address** (MLA)

When the Parallel488 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.

4.4.3 **Device Clear** (DCL and SDC)

Device Clear resets the Parallel488's IEEE input buffer and pulses the parallel interface `INIT` line. Any pending data is lost.

4.4.4 **Interface Clear** (IFC)

IFC places the Parallel488 in the Talker/Listener Idle State.

4.4.5 **Serial Poll Enable** (SPE)

When Serial Poll Enabled, the Parallel488 sets itself to respond to a serial poll with its serial poll status byte if addressed to talk. The Parallel488 will continue to try to output its serial poll response until it is 'Serial Poll Disabled' by the controller.

4.4.6 **Serial Poll Disable** (SPD)

Disables the Parallel488 from responding to serial polls by the controller.

4.4.7 **Unlisten** (UNL)

UNL places the Parallel488 in the Listener Idle State.

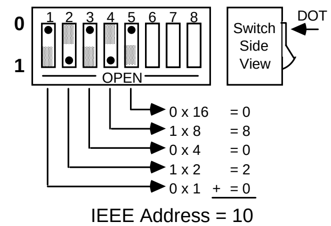
4.4.8 **Untalk** (UNT)

UNT places the Parallel488 in the Talker Idle State.

4.5 IEEE Address Selection

SW1-1 through SW1-5 select the IEEE bus address of the Parallel488 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 Parallel488 set to 10.

SW1 View for IEEE Address Selection



4.5.1 Listen Only Mode

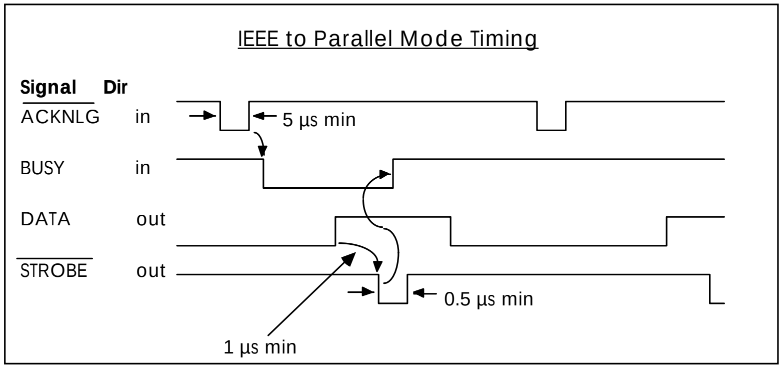
Listen Only is a special type of IEEE to Parallel operation. In the Listen Only mode the Parallel488 accepts all data transmitted on the bus and transfers it out its parallel port. The Parallel488 is set to Listen Only mode by setting its address to 31 (switches SW1-1 through SW1-5 all open).

4.6 Parallel Interface Description and Timing

As an IEEE to parallel converter, the Parallel488 controls the following signals (designated as `out` in the following table) and responds to the signals (designated as `in`).

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 Parallel488 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.
16	Logic GND		Signal return.
19-30	Logic GND		Signal return.

31	/INIT	out	The Parallel488 pulses this line low for approx. 50 µs upon receipt of an IEEE 488 Device Clear, 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 488 Primer

5.1 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 Parallel488 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.

5.2 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 is 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 can not 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.

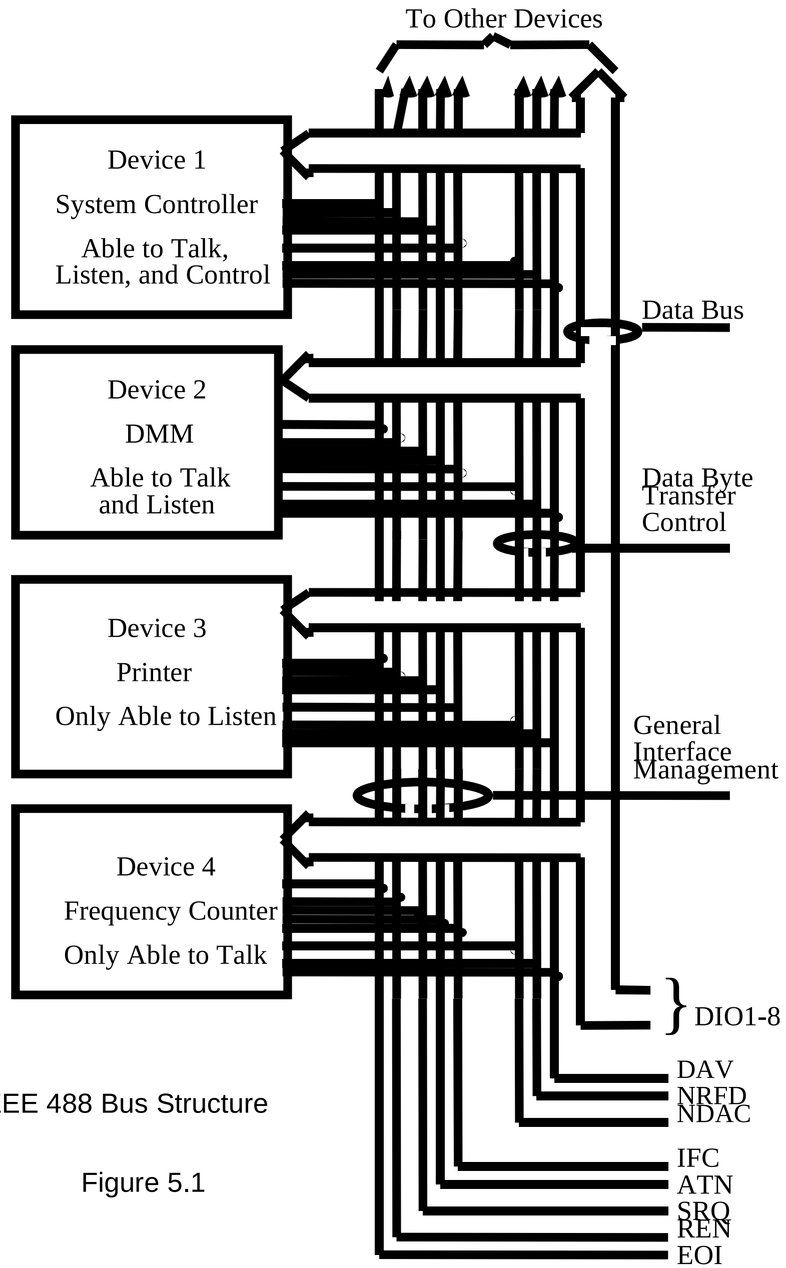
At a committee meeting, everyone present usually listens. This is not the case with the GPIB. The Active Controller selects which devices will listen and commands all other devices to ignore what is being transmitted. A device is instructed to listen by being Addressed to Listen. This device is then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

For data transfer on the IEEE 488, the Active Controller mustÉ

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.



IEEE 488 Bus Structure

Figure 5.1

5.3 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).

5.4 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, i.e. a low voltage represents a logic "1" (asserted), and a high voltage represents a logic "0" (unasserted).

5.4.1 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 is not, 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.

5.4.2 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).

5.4.3 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.

5.4.4 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.

5.4.5 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.

5.5 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.

5.5.1 Data Valid (DAV)

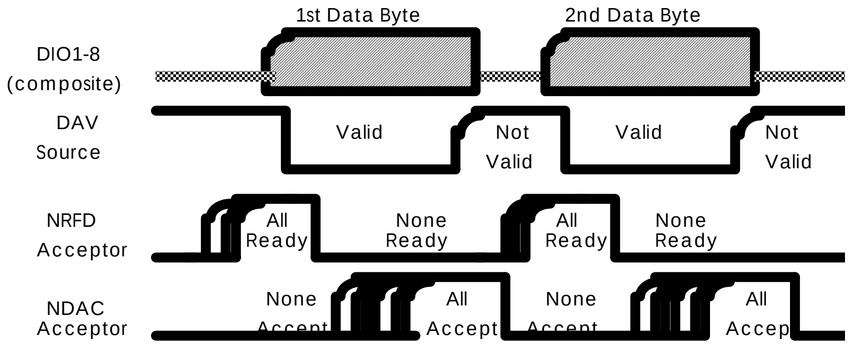
The DAV line is controlled by the Talker. The Talker verifies that NDAC is asserted (active low) which indicates that all Listeners have accepted the previous data byte transferred. The Talker then outputs data on the bus and waits until NRFD is unasserted (high) which indicates that all Addressed Listeners 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.

5.5.2 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.

5.5.3 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.



IEEE Bus Handshaking

5.6 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.

5.7 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.

5.7.1 Go To Local (GTL)

This command allows the selected devices to be manually controlled. ($01)

5.7.2 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.

5.7.3 Unlisten (UNL)

This command tells all bus devices to Unlisten. The same as Unaddressed to Listen. ($3F)

5.7.4 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.

5.7.5 Untalk (UNT)

This command tells bus devices to Untalk. The same as Unaddressed to Talk. ($5F)

5.7.6 Local Lockout (LLO)

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

5.7.7 Device Clear (DCL)

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

5.7.8 Selected Device Clear (SDC)

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

5.7.9 Serial Poll Disable (SPD)

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

5.7.10 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. ($18)

5.7.11 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. ($08)

5.7.12 Take Control (TCT)

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

5.7.13 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. ($60 to $7F)

5.7.14 Parallel Poll Configure (PPC)

This configures devices capable of performing a Parallel Poll as to which data bit they are to assert in response to a Parallel Poll. ($05)

5.7.15 Parallel Poll Unconfigure (PPU)

This disables all devices from responding to a Parallel Poll. ($15)

5.8 More On 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 happen 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 is very important to the test system and the software designer has easy access to this line by 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 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.

5.8.1 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 times 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.

5.8.2 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.

Service Information

6.1 Factory Service

IOtech maintains a factory service center in Cleveland, Ohio. If problems are encountered in using the Parallel488, you should first telephone the factory. Many problems can be resolved through discussions with our applications department. If the problem cannot be solved by this method, you will be instructed as to the proper return procedure.

6.2 Theory of Operation

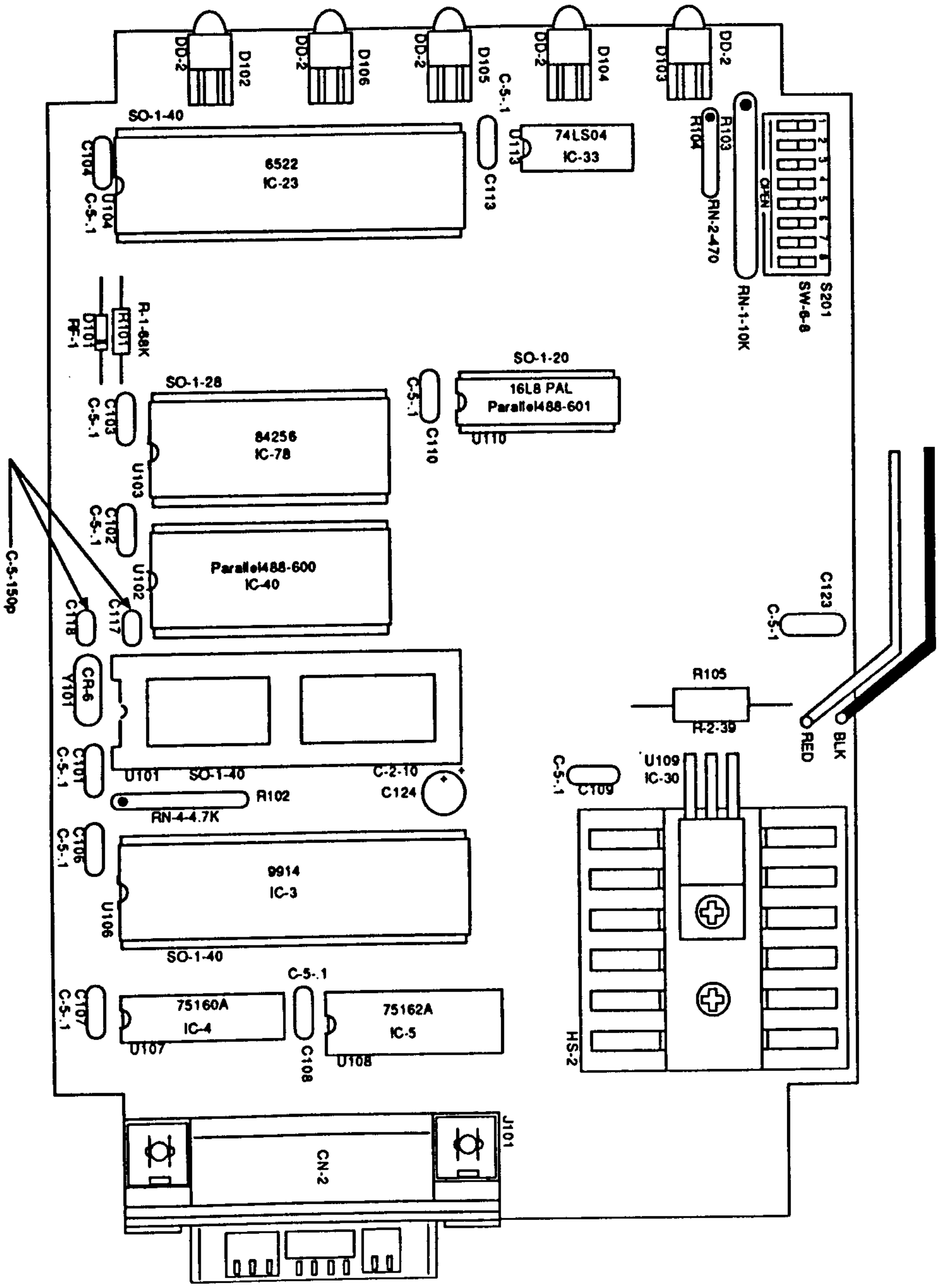
At the heart of the Parallel488 is a 6809 microprocessor [U201] supported by 8K bytes of firmware EPROM [U102 (2764)] and 32K bytes of Static RAM [U103 (84256)]. A Versatile Interface Adapter [U104 (R65C22)] is used to generate real time interrupts for the firmware operating system. The front panel annunciators 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.

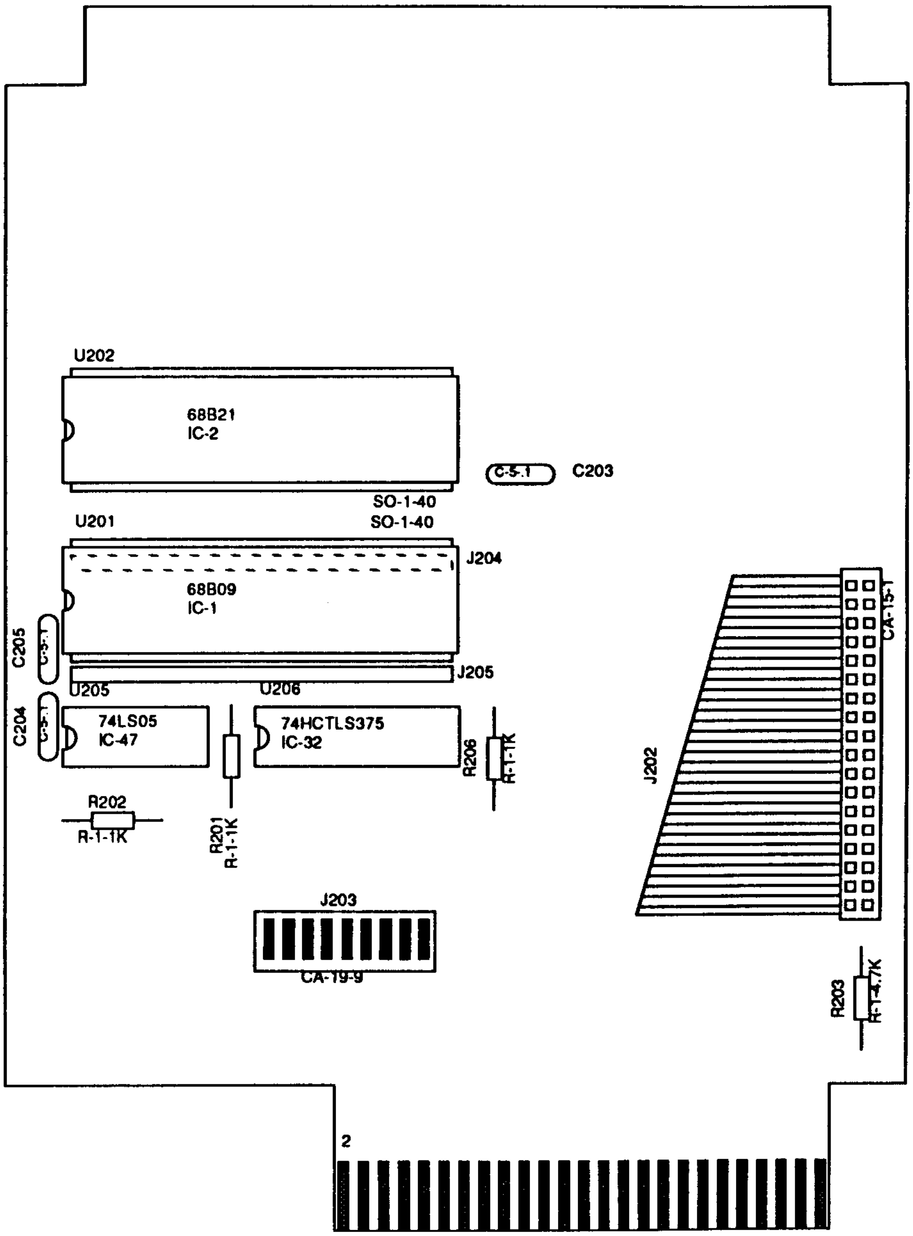
Decoding of the microprocessor address space is accomplished with a Programmable Logic Array [U110 (16L8)]. Below is the memory space allocation.

Address	Device	Part Number	Function
$2000-$7FFF	U103	84256	Static RAM
$8000	U206	74LS373	Parallel data receiver
$9200	U202	6821	Parallel handshake/data out
$A000	U106	9914A	IEEE Controller
$B000	U104	R65C22	LED Driver
$E000-$FFFF	U102	2764	Programmed EPROM

6.3 Parallel488 Component Layout (Mother board)



6.4 Parallel488 Component Layout (I/O board)



6.5 Parallel488 Replaceable Parts List

Schematic	Part Number	Description
C101	C-5-.1	0.1uF, 25v ceramic
C102	C-5-.1	0.1uF, 25v ceramic
C103	C-5-.1	0.1uF, 25v ceramic
C104	C-5-.1	0.1uF, 25v ceramic
C105		Not Used
C106	C-5-.1	0.1uF, 25v ceramic
C107	C-5-.1	0.1uF, 25v ceramic
C108	C-5-.1	0.1uF, 25v ceramic
C109	C-5-.1	0.1uF, 25v ceramic
C110	C-5-.1	0.1uF, 25v ceramic
C111		Not Used
C112		Not Used
C113	C-5-.1	0.1uF, 25v ceramic
C114		Not Used
C115		Not Used
C116		Not Used
C117	C-4-150p	150pF,1kv ceramic
C118	C-4-150p	150pF,1kv ceramic
C119		Not Used
C120		Not Used
C121		Not Used
C122		Not Used
C123	C-5-1	1uF, 25v ceramic
C201		Not Used
C202		Not Used
C203	C-5-.1	0.1uF,25v ceramic
C204	C-5-.1	0.1uF,25v ceramic
C205	C-5-.1	0.1uF,25v ceramic
D101	RF-1	1N914 diode
D102	DD-2	LED, Dialight #550-2406
D103	DD-2	LED, Dialight #550-2406
D104	DD-2	LED, Dialight #550-2406
D105	DD-2	LED, Dialight #550-2406
D106	DD-2	LED, Dialight #550-2406
J101	CN-11	Pwr Connector SWCR #712A
J102		Not Used
J103	CN-2	IEEE Connector
J104		Not Used
J105		Not Used
J202	CA-15-1	Centronics Cable Assembly
J203	CA-19-9	9 Position DIP Jumper
J204	CA-20	20 Conductor Ribbon Assembly
J205	CA-20	20 Conductor Ribbon Assembly

Schematic	Part Number	Description
R101	R-1-68K	68K½, 1/4w, 10% carbon
R102	RN-4-4.7K	4.7K½ x 7 SIP Network
R103	RN-1-10K	10K½ x 9 SIP Network
R104	RN-2-470	470½ X 5 SIP Network
R105	R-2-39	39½, 1 W, 10% carbon
R106		Not Used
R107		Not Used
R201	R-1-1K	1K½, 1/4w, 10% carbon
R202	R-1-1K	1K½, 1/4w, 10% carbon
R203	R-1-4.7K	4.7K½, 1/4w, 10% carbon
R204		Not Used
R205		Not Used
R206	R-1-1K	1K½, 1/4w, 10% carbon
S101	SW-8	Power Switch
S104	SW-6-8	8 Pole Dip
S201		Not Used
S202		Not Used
U101		Not Used
U102	IC-40	MBM2764-45 EPROM
U103	IC-78	84256-15 32K x 8 CMOS
SRAM		
U104	IC-23	R65C22 Versatile Interface
Adapter		
U105		Not Used
U106	IC-3	TMS9914ANL IEEE Controller
U107	IC-4	SN75160AN Driver
U108	IC-5	SN75162N Driver
U109	IC-30	LM7805CT +5v Regulator
U110	Parallel488-601	Programming Equation - 16L8
PAL		
U111		Not Used
U112		Not Used
U113	IC-33	74LS04 Hex Inverter
U114		Not Used
U115		Not Used
U116		Not Used
U201	IC-1	MC6809B Microprocessor
U202	IC-2	6821 PIA
U203		Not Used
U204		Not Used
U205	IC-47	74LS05 Hex Inverter/OC
outputs		
U206	IC-32	SN74LS373 Octal Latch
Y101	CR-6	8.0000 MHz Oscillator
	TR-2	Power Supply ; 115 volts AC
	TR-2E	Power Supply ; 220 volts AC

B7 B6 B5 →	0 0 0	0 0 1	0 1 0	0 1 1	1 0 0	1 0 1	1 1 0	1 1 1
BITS	CONTROL		NUMBERS SYMBOLS		UPPER CASE		LOWER CASE	
B4 B3 B2 B1								
0 0 0 0	0 NUL 0 0	20 DLE 10 16	40 SP 20 32	60 0 30 48	100 @ 40 64	120 P 50 80	140 ` 60 96	160 p 70 112
0 0 0 1	1 GTL SOH 1 1	21 LLO DC1 11 17	41 ! 21 33	61 1 31 49	101 A 41 65	121 Q 51 81	141 a 61 97	161 q 71 113
0 0 1 0	2 STX 2 2	22 DC2 12 18	42 " 22 34	62 2 32 50	102 B 42 66	122 R 52 82	142 b 62 98	162 r 72 114
0 0 1 1	3 ETX 3 3	23 DC3 13 19	43 # 23 35	63 3 33 51	103 C 43 67	123 S 53 83	143 c 63 99	163 s 73 115
0 1 0 0	4 SDC EOT 4 4	24 DCL DC4 14 20	44 $ 24 36	64 4 34 52	104 D 44 68	124 T 54 84	144 d 64 100	164 t 74 116
0 1 0 1	5 PPC ENQ 5 5	25 PPU NAK 15 21	45 % 25 37	65 5 35 53	105 E 45 69	125 U 55 85	145 e 65 101	165 u 75 117
0 1 1 0	6 ACK 6 6	26 SYN 16 22	46 & 26 38	66 6 36 54	106 F 46 70	126 V 56 86	146 f 66 102	166 v 76 118
0 1 1 1	7 BEL 7 7	27 ETB 17 23	47 ' 27 39	67 7 37 55	107 G 47 71	127 W 57 87	147 g 67 103	167 w 77 119
1 0 0 0	10 GET BS 8 8	30 SPE CAN 18 24	50 (28 40	70 8 38 56	110 H 48 72	130 X 58 88	150 h 68 104	170 x 78 120
1 0 0 1	11 TCT HT 9 9	31 SPD EM 19 25	51) 29 41	71 9 39 57	111 I 49 73	131 Y 59 89	151 i 69 105	171 y 79 121
1 0 1 0	12 LF A 10	32 SUB 1A 26	52 * 2A 42	72 : 3A 58	112 J 4A 74	132 Z 5A 90	152 j 6A 106	172 z 7A 122
1 0 1 1	13 VT B 11	33 ESC 1B 27	53 + 2B 43	73 ; 3B 59	113 K 4B 75	133 [5B 91	153 k 6B 107	173 { 7B 123
1 1 0 0	14 FF C 12	34 FS 1C 28	54 , 2C 44	74 < 3C 60	114 L 4C 76	134 \ 5C 92	154 l 6C 108	174 ¦ 7C 124
1 1 0 1	15 CR D 13	35 GS 1D 29	55 - 2D 45	75 = 3D 61	115 M 4D 77	135] 5D 93	155 m 6D 109	175 } 7D 125
1 1 1 0	16 SO E 14	36 RS 1E 30	56 . 2E 46	76 > 3E 62	116 N 4E 78	136 ∧ 5E 94	156 n 6E 110	176 ~ 7E 126
1 1 1 1	17 SI F 15	37 US 1F 31	57 / 2F 47	77 ? 3F 63	117 O 4F 0	137 _ 5F 95	157 o 6F 111	177 RUBOUT (DEL) 7F 127
	ADDRESSED COMMANDS	UNIVERSAL COMMANDS	LISTEN ADDRESSES		TALK ADDRESSES		SECONDARY ADDRESSES OR COMMANDS	

KEY:

octal	25 PPU	Message Mnemonic
	NAK	ASCII/ISO character
hex	15 21	decimal

ASCII 7-bit Code Chart