



IOtech, Inc.

25971 Cannon Road Cleveland, OH 44146

Phone: (440) 439-4091 Fax: (440) 439-4093

E-mail: sales@iotech.com Internet: <http://www.iotech.com>

Extender 488HS User's Manual

p/n EXT488/HS-901, Rev. 2.0

©1996-1997 by IOtech, Inc. Part No.EXT488/HS-901, Rev. 2.0
Printed in the United States of America

Warranty Information

Your IOtech warranty is as stated on the *product warranty card*. You may contact IOtech by phone, fax machine, or e-mail in regard to warranty-related issues.
Phone: (440) 439-4091, fax: (440) 439-4093, e-mail: sales@iotech.com

Limitation of Liability

IOtech, Inc. cannot be held liable for any damages resulting from the use or misuse of this product.

Copyright, Trademark, and Licensing Notice

All IOtech documentation, software, and hardware are copyright with all rights reserved. No part of this product may be copied, reproduced or transmitted by any mechanical, photographic, electronic, or other method without IOtech's prior written consent. IOtech product names are trademarked; other product names, as applicable, are trademarks of their respective holders. All supplied IOtech software (including miscellaneous support files, drivers, and sample programs) may only be used on one installation. You may make archival backup copies.

FCC Statement



IOtech devices emit radio frequency energy in levels compliant with Federal Communications Commission rules (Part 15) for Class A devices. If necessary, refer to the FCC booklet *How To Identify and Resolve Radio-TV Interference Problems* (stock # 004-000-00345-4) which is available from the U.S. Government Printing Office, Washington, D.C. 20402.

CE Notice



Many IOtech products carry the CE marker indicating they comply with the safety and emissions standards of the European Community. As applicable, we ship these products with a Declaration of Conformity stating which specifications and operating conditions apply.

Warnings, Cautions, Notes, and Tips



Refer all service to qualified personnel. This caution symbol warns of possible personal injury or equipment damage under noted conditions. Follow all safety standards of professional practice and the recommendations in this manual. Using this equipment in ways other than described in this manual can present serious safety hazards or cause equipment damage.



This ESD caution symbol urges proper handling of equipment or components sensitive to damage from electrostatic discharge. Proper handling guidelines include the use of grounded anti-static mats and wrist straps, ESD-protective bags and cartons, and related procedures.

Specifications and Calibration

Specifications are subject to change without notice. Significant changes will be addressed in an addendum or revision to the manual. As applicable, IOtech calibrates its hardware to published specifications. Periodic hardware calibration is not covered under the warranty and must be performed by qualified personnel as specified in this manual. Improper calibration procedures may void the warranty.

Quality Notice



IOtech has maintained ISO 9001 certification since 1996. Prior to shipment, we thoroughly test our products and review our documentation to assure the highest quality in all aspects. In a spirit of continuous improvement, IOtech welcomes your suggestions.

Table of Contents

Section 1	Introduction	1.1
1.1	Description	1.1
1.2	Available Accessories	1.2
1.3	Specifications	1.2
1.4	Abbreviations	1.4
Section 2	Getting Started	2.1
2.1	Inspection	2.1
2.2	Extender488/HS Configuration	2.1
2.3	Front Panel Indicators	2.3
2.4	Line Voltage Selection	2.4
2.5	Hardware Installation	2.6
2.6	Operation	2.7
2.7	Speed Considerations	2.8
Section 3	IEEE 488 Primer	3.1
3.1	History	3.1
3.2	General Structure	3.1
3.3	Send It To My Address	3.4
3.4	Bus Management Lines	3.4
3.4.1	Attention (ATN)	3.4
3.4.2	Interface Clear (IFC)	3.4
3.4.3	Remote Enable (REN)	3.5
3.4.4	End or Identify (EOI)	3.5
3.4.5	Service Request (SRQ)	3.5
3.5	Handshake Lines	3.5
3.5.1	Data Valid (DAV)	3.5
3.5.2	Not Ready for Data (NRFD)	3.6
3.5.3	Not Data Accepted (NDAC)	3.6
3.6	Data Lines	3.7
3.7	Multiline Commands	3.7
3.7.1	Go To Local (GTL)	3.7
3.7.2	Listen Address Group (LAG)	3.7
3.7.3	Unlisten (UNL)	3.7
3.7.4	Talk Address Group (TAG)	3.7
3.7.5	Untalk (UNT)	3.7
3.7.6	Local Lockout (LLO)	3.8
3.7.7	Device Clear (DCL)	3.8
3.7.8	Selected Device Clear (SDC)	3.8
3.7.9	Serial Poll Disable (SPD)	3.8
3.7.10	Serial Poll Enable (SPE)	3.8
3.7.11	Group Execute Trigger (GET)	3.8
3.7.12	Take Control (TCT)	3.8
3.7.13	Secondary Command Group (SCG)	3.9
3.7.14	Parallel Poll Configure (PPC)	3.9
3.7.15	Parallel Poll Unconfigure (PPU)	3.9
3.8	More On Service Requests	3.9
3.8.1	Serial Poll	3.10
3.8.2	Parallel Poll	3.10

Table of Contents

Section 4	Service Information	4.1
4.1	Factory Service	4.1
4.2	Theory of Operation	4.1
4.3	Extender488/HS Cable Construction.....	4.1
	4.3.1 Cable Wiring Diagram	4.2
Appendix A	Character Codes and IEEE Multiline Messages	A.1

Introduction

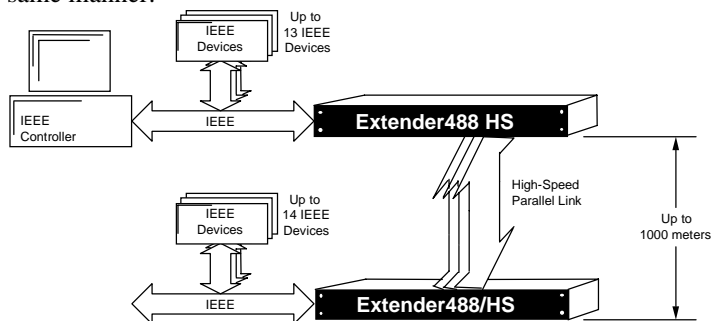
1.1 Description

The Extender488/HS High Speed IEEE 488 Bus Extender enables IEEE 488 devices to be controlled at a distance of up to 1,000 meters from a host computer. The Extender488/HS overcomes the limit imposed by the IEEE 488 specification of 2 meters between any two devices. In addition, the Extender488/HS Bus Extender allows up to 27 devices to be on the bus (plus the controller and the two Extender488/HS Bus Extenders), versus the 14 device limit imposed by the IEEE standard.

Two bus extenders are required to perform bus extension. The bus connected to the host computer, or controller, is the "local" bus. The bus to which control is extended is the "remote" bus. One Extender488/HS Bus Extender is required on each bus to accomplish IEEE bus extension.

Communication between bus extenders is accomplished with parallel data transmission, using RS-422 data drivers and receivers within the Extender488/HS Bus Extender. This differential parallel data format provides high noise immunity, high speed, and long-distance capability using a special cable.

Operation of the Extender488/HS Bus Extender is completely transparent to the system. The controller can access both local and remote devices in exactly the same manner.



1.2 Available Accessories

The following accessories are available from IOtech for use with the Extender488/HS Bus Extender:

CA-7-1	1.5 foot IEEE 488 cable
CA-7-2	6 foot IEEE 488 cable
CA-7-3	6 foot IEEE 488 cable; shielded
CA-7-2	6 foot IEEE 488 cable; reverse entry
CA-56-30	30 m. Shielded parallel cable with mating connectors for the Extender488/HS
CA-56-10	10 m. Shielded parallel cable with mating connectors for the Extender488/HS
CN-20	Right angle IEEE 488 adapter
CN-48	Extender488/HS cable adapter
CN-22	IEEE 488 multi-tap bus strip; 4 connectors in parallel
CN-23	IEEE 488 panel mount feed-thru connector
MAN-116-0015	Additional Manual

Refer to the IOtech catalog for those accessories not listed here.

1.3 Specifications

IEEE 488-1978

Implementation:	Proprietary transparent control and data transfers. PASS CONTROL is not supported.
Connector:	Standard IEEE 488 connector with metric studs.

Parallel Interface

EIA RS-422A:	Balanced voltage on all signal lines.
Connector:	50-pin Centronics female.
Max. Cable Length:	1000 meters.

General

Data Rates: Specifications apply to data transfers after addressing has been established.

<u>Cable Length m. (ft.)</u>	<u>Data Rate (kB/s, avg) *</u>
10 (32.8)	800
20 (65.6)	700
50 (164)	450
100 (328.1)	300
200 (656.2)	150
500 (1640.5)	75
1000 (3281.0)	40

* using a 500ns data settling delay

Indicators: LEDs for IEEE Talk, Listen, Local Extender,
Remote Extender, Connect, and Power.

Power: 105-125V or 210-250V; 50-60 Hz, 30 VA Max.

Dimensions: 425mm wide x 45mm high x 208mm deep
(16.75" x 1.75" x 8.20").

Weight: 2.1 kg. (4.6 lbs).

Environment: 0° - 50°C; 0 to 90% R.H. Non-Condensing

Controls: Power Switch (external),
Configuration switch (external).

Specifications subject to change without notice.

1.4 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

Your Extender488/HS IEEE 488 Bus Extender was carefully inspected, both mechanically and electrically, prior to shipment. When you receive the Extender488/HS Bus Extender, 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 Extender488/HS Bus Extender is shipped with the following:

- **Extender488/HS** High Speed IEEE 488 Bus Extender Interface
- **MAN-116-0015** Instruction Manual
- **A-116-0001** Accessory Kit (includes power cable, fuse, and rack mounting hardware)

Note: accessories ordered may be packaged and shipped separately

2.2 Extender488/HS Configuration

Two Extender488/HS IEEE Bus Extenders are required to accomplish bus extension, with one connected directly to the Local IEEE 488 bus, and the other connected to the Remote IEEE 488 bus.

CAUTION

Make sure that the Extender488/HS Bus Extender that is connected to the controller is set for Local Extender mode and the other Extender488/HS Bus Extender is set to Remote Extender mode before applying power. Failure to observe this caution will result in damage to both Extender488/HS Bus Extenders.

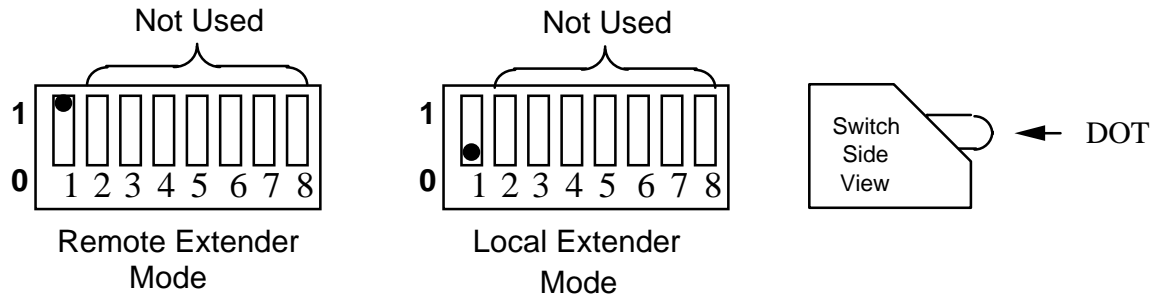
Both local and remote bus extenders are identical. Before either unit is powered on, switch #1 of the rear panel configuration DIP switch must be set to Local Extender Mode

(for the Extender488/HS Bus Extender connected to the Local bus) or Remote Extender Mode (for the Extender488/HS Bus Extender connected to the Remote bus).

When both units are on, the Local bus extender will monitor all local bus activity and transmit this activity to the Remote bus extender. All activity detected by the Remote bus extender is also communicated back to the Local bus extender.

WARNING

Never open the Extender488/HS Bus Extender case while it is connected to the AC line. Failure to observe this warning may result in equipment failure, personal injury or death.

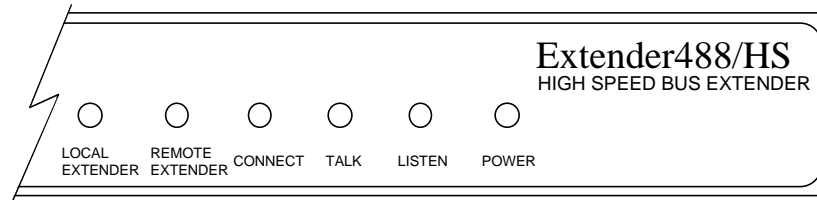


Extender488/HS Configuration Selection

Note: Factory default setting is REMOTE.

2.3 Front Panel Indicators

Six LEDs on the front panel of the Extender488/HS display the status of the bus extender. The function of each indicator is described below.



Front Panel Indicators

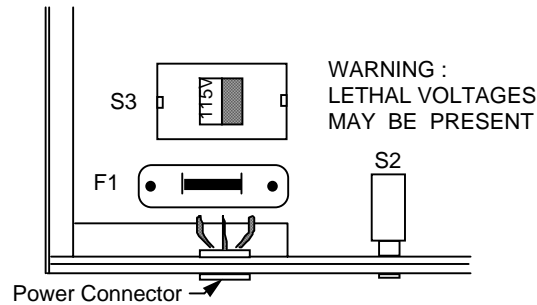
LOCAL	ON when the Extender488/HS is configured as the Local EXTENDER Extender.
REMOTE	ON when the Extender488/HS is configured as the EXTENDER Remote Extender.
CONNECT	ON if both Extender488/HS Bus Extenders are powered on and the interconnecting cable is functional.
TALK	Remote Extender - On when a device on the Local bus (or the controller) is talking to device(s) on the Remote bus. Local Extender - On except when a device on the Local bus (or the controller) is talking to device(s) on the Remote bus.
LISTEN	Local Extender - On when a device on the Local bus (or the controller) is talking to device(s) on the Remote bus. Remote Extender - On except when a device on the Local bus (or the controller) is talking to device(s) on the Remote bus.
POWER	ON when power is applied to the Extender488/HS and the power switch on the rear panel is in the ON position (depressed). OFF otherwise.

2.4 Line Voltage Selection

The line voltage is set by an internal switch (S3) located near the rear panel power supply connector, next to the power switch. To change the operating voltage, it is necessary to open the enclosure

and change the setting of S3. The 1/2 Amp fuse (IOtech part number FU-1-.5) that is used for 115 Volt operation must be replaced with a 1/4 Amp fuse (IOtech part number FU-1-.25) for 230 Volt operation..

Disconnect the power cord from the AC line and from the Extender488/HS Bus Extender. Disconnect any IEEE cables prior to disassembly.



Extender488/HS Fuse and Line Voltage Switch Locations

WARNING

Never open the Extender488/HS Bus Extender case while it is connected to the AC line. Internal voltage potentials exist which could cause personal injury or death.

1. Place the Extender488/HS on a flat surface. Remove the six screws on top of the case and remove the top cover. Located next to the rear panel power connector is switch S3 and fuse F1.
2. Using a small screwdriver, insert the tip of the screwdriver into the slot of the switch and move the switch to the left or right so that the desired line voltage selection appears on the switch. Make note of the new setting for later reference.

CAUTION

Use the 1/2 Amp fuse, FU-1-.5 for 115 volt operation. Use the 1/4 Amp fuse, FU-1-.25 for 230 volt operation. Failure to use the correct fuse could result in damage to the Extender488/HS Bus Extender.

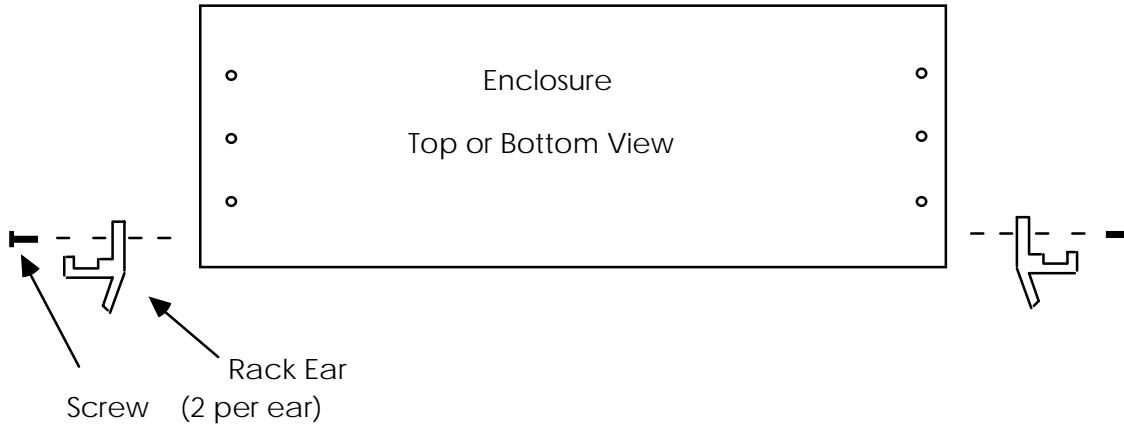
3. Replace the 1/2 Amp fuse, FU-1-.5 (115 volt operation), with the 1/4 Amp fuse (230 volt operation), part number FU-1-.25, that is included in the Extender488/HS-004 Accessory Kit.
4. Carefully reassemble the unit.

WARNING

The Extender88/HS Bus Extender is intended for INDOOR USE ONLY. Failure to observe this warning could result in equipment failure, personal injury or death.

2.5 Hardware Installation

Included with the Extender488/HS Bus Extender are accessories for rack or bench use. If rack mount installation is required, install the two rack ears using the enclosed screws. These ears can be installed so either the front or the rear of the unit faces the front of the rack fixture.



View of Enclosure showing Rack Hardware Installation

If bench installation is required, the rubber feet can be installed on the underside of the unit near each corner.



View of Enclosure Bottom Showing Feet Placement

2.6 Operation

After configuring the Extender488/HS IEEE 488 Bus Extenders and connecting the Extender488/HS cable, plug the power cable connector into the rear jack on the bus extender.

WARNING

The Extender488/HS Bus Extender is intended for INDOOR USE ONLY. Failure to observe this warning could result in equipment failure, personal injury or death.

The Extender488/HS Bus Extender makes its earth ground connection through the IEEE interface cable. Each bus extender must be connected to at least one IEEE device which is earth ground referred. Failure to do so may allow the Extender488/HS Bus Extender to float to a voltage away from ground. This could result in damage to the Extender488/HS Bus Extender, personal injury, or death.

CAUTION

Make sure that the Extender488/HS Bus Extender that is connected to the controller is set for Local Extender mode and the other Extender488/HS Bus Extender is set to Remote Extender mode before applying power. Failure to observe this caution will result in damage to both Extender488/HS Bus Extenders

After installing the power cable into the bus extender, plug the power cable into the AC line power. Place the rear panel power switches on both units in the ON [depressed] position. The CONNECT and POWER LEDs should light on both units. The REMOTE EXTENDER LED should be lit on the unit set for REMOTE EXTENDER operation and the LOCAL EXTENDER LED should be lit on the unit set for LOCAL EXTENDER operation. If the LOCAL unit is connected to an IEEE 488 controller and the controller is on, the LISTEN LED should be lit on the LOCAL unit and the TALK LED should be lit on the REMOTE unit. If any of the following LED conditions exist after power-on, a failure has occurred:

SYMPTOM

CONNECT LED off

No LEDs on

FAILUREExtender488/HS cable defective
or not properly installed
Power not connected

If the CONNECT LED is not lit on either unit, make sure that the Extender488/HS cable is firmly seated in the rear panel connector. If the problem is unresolved, refer to the Service Information section of this manual.

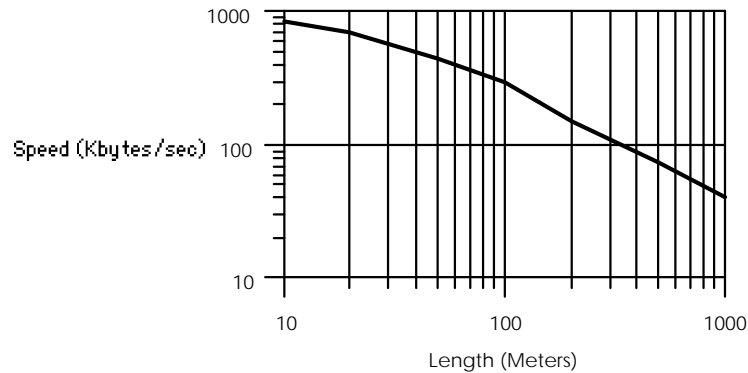
If proper operation is obtained, turn-off the Extender488/HS power switch and connect the other IEEE devices to each of the Extender488/HS IEEE ports. Apply power to all devices in the system.

Once all IEEE devices have been connected and powered on, the Extender488/HS will allow the system controller to command up to 13 IEEE devices on its local bus (in addition to itself and the local bus extender), and up to 14 IEEE devices on the remote bus (in addition to the remote bus extender). The bus extenders have no address of their own, and therefore will operate completely transparent to the system. Be careful not to have two IEEE devices with the same address connected to either remote or local buses. Failure to do so will result in the bus 'locking up' when one of the devices is accessed.

2.7 Speed Considerations

The Extender488/HS bus extenders operate transparently to most IEEE 488 applications. However, since there is an inverse relationship between the data transfer rate and the cable length, the response time for bus transactions may be affected. The following information is provided so that you can determine if some modifications may be needed to your application.

As the length of the cable linking the two bus extenders is increased, the data transfer rate will decrease. A graph showing the typical data transfer rate as a function of distance is shown on the next page.



Extender488/HS Data Rate vs Cable Length

Since the IEEE 488 handshake is maintained across the entire link from the Local bus to the Remote bus, it is highly unlikely that data will be lost. The only IEEE 488 transaction that could be affected by long cable lengths is parallel poll (PPOL). If your application uses parallel polling, you should be aware of the time delays that are introduced into your system when any type of bus extender (including the Extender488/HS) is installed.

In a system that does not use a bus extender, the following events occur when the controller conducts a parallel poll:

1. Controller conducts parallel poll (asserts EOI and ATN).
2. Devices detect parallel poll state and respond by asserting a data line.
3. Controller reads parallel poll response from data bus.

In a system that uses bus extenders, the following delays are present when the controller conducts a parallel poll:

1. Controller conducts parallel poll (asserts EOI and ATN)
2. Local extender detects parallel poll state and sends the message to the link port.
3. Message travels through the link cable and arrives at the remote extender after an amount of time that depends on the length of the interconnecting cable.
4. Remote unit receives parallel poll state and sends it to the remote IEEE 488 bus.
5. Devices on the remote bus detect the parallel poll state and respond by asserting a data line.
6. Response travels through remote extender to its link port.
7. Response travels through the link cable and arrives at the local extender after an amount of time that depends on the length of the interconnecting cable.

8. Local extender receives parallel poll response on the link port and sends it to the local IEEE 488 bus.
9. Controller reads parallel poll response.

Since most controllers read the parallel poll response shortly after asserting EOI and ATN (within 2 μ s), the use of a bus extender may not provide the parallel poll response back to the controller in the allotted time. For applications that use the parallel poll command, the interconnecting cable length should be such that time delays will not affect the parallel poll response. The following example may be used to help determine the response time to a parallel poll in your system.

If a cable length of 10 m. is used, the parallel poll response time would be calculated as shown below (from the previous parallel poll delay explanation):

<u>Step</u>	<u>Time Delay (approximate)</u>
1	0
2	20 ns
3	59 ns (5.9 ns/meter) X (Interconnecting cable length)
4	20 ns
5	140 ns (device dependent)
6	20 ns
7	59 ns (5.9 ns/meter) X (Interconnecting cable length)
8	20 ns
<hr/>	
Total	338 ns Total parallel poll response time

Since the IEEE 488 controller will wait 2 μ s before reading the parallel poll response, the 338 ns response time is well within the required 2 μ s response time. For distances greater than 150 meters, the parallel poll response may not be returned to the controller in the allotted time. The time is dependent on the response time of the instruments on the remote bus.

IEEE 488 Primer

3.1 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 **Digital488** 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.

3.2 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**.

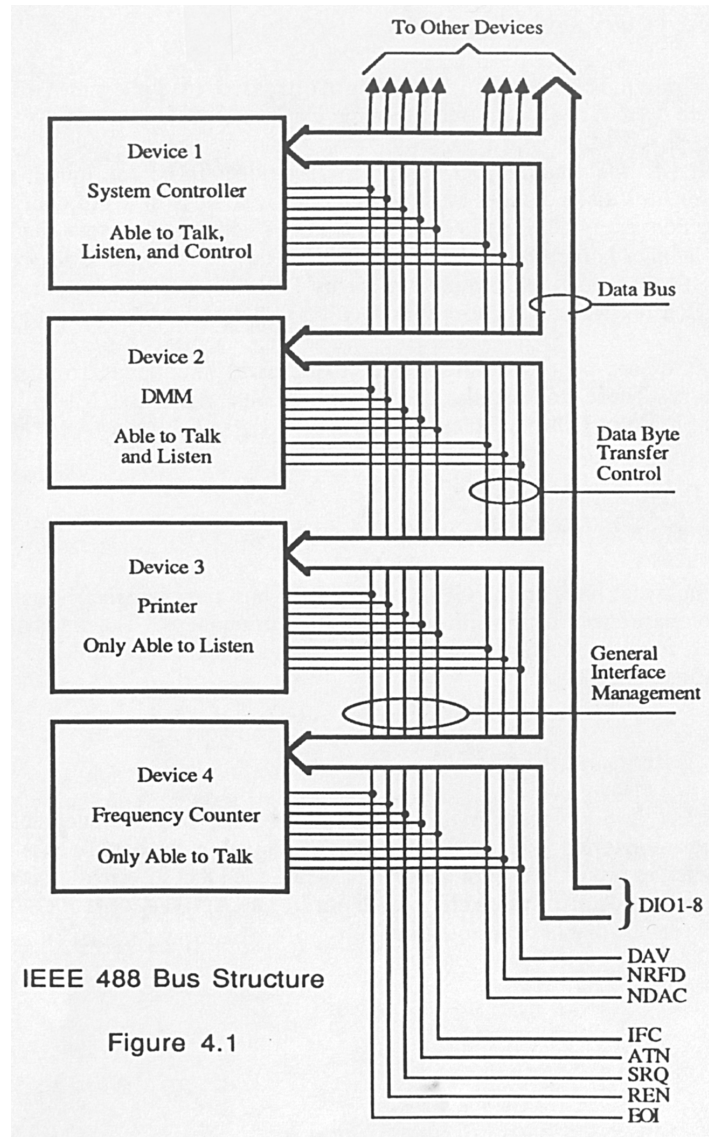
At a committee meeting, everyone present usually listens. This is not the case with the **GPIB**. The **Active Controller** selects which devices will listen and commands all other devices to ignore what is being transmitted. A device is instructed to listen by being **Addressed to Listen**. This device 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 388**, 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.



3.3 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)**.

3.4 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).

3.4.1 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.

3.4.2 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**).

3.4.3 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.

3.4.4 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**.

3.4.5 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**.

3.5 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.

3.5.1 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

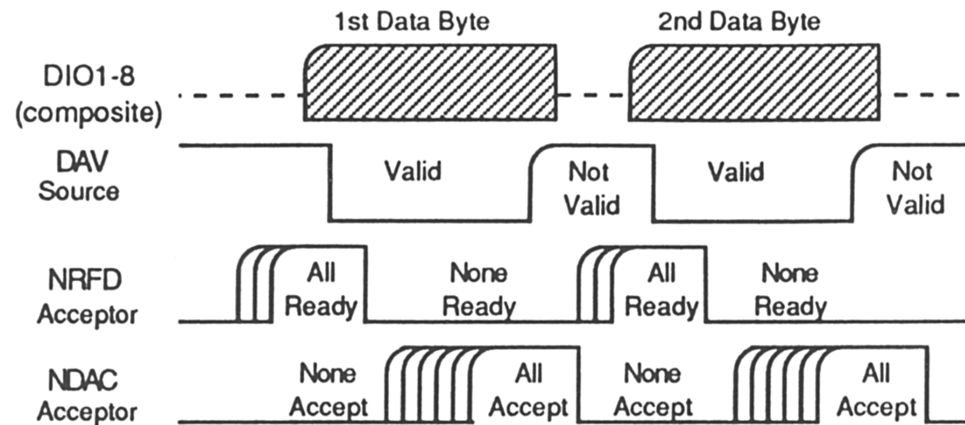
waits until **NRF**D is unasserted (high) which indicates that all Addressed Listeners are ready to accept the information. When **NRF**D and **NDAC** are in the proper state, the **Talker** asserts **DAV** (active low) to indicate that the data on the bus is valid.

3.5.2 Not Ready for Data (NRF

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.

3.5.3 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

3.6 DATA LINES

The **GPB** 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.

3.7 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.

3.7.1 Go To Local (GTL)

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

3.7.2 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.

3.7.3 Unlisten (UNL)

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

3.7.4 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.

3.7.5 Untalk (UNT)

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

3.7.6 Local Lockout (LLO)

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

3.7.7 Device Clear (DCL)

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

3.7.8 Selected Device Clear (SDC)

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

3.7.9 Serial Poll Disable (SPD)

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

3.7.10 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)

3.7.11 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)

3.7.12 Take Control (TCT)

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

3.7.13 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)

3.7.14 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)

3.7.15 Parallel Poll Unconfigure (PPU)

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

3.8 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**.

3.8.1 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.

3.8.2 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

4.1 Factory Service

IOtech maintains a factory service center in Cleveland, Ohio. If problems are encountered in using the Extender488/HS Bus Extender, you should first telephone the factory. Many problems can be resolved by discussing the problem with our applications department. If the problem cannot be solved by this method, you will be instructed as to the proper return procedure.

4.2 Theory of Operation

The Extender488/HS Bus Extender is controlled by two programmable array logic integrated circuits. Each Extender488/HS monitors the control and handshake lines on each bus and the internal logic determines the correct direction for all data transceivers.

Communication between each Extender488/HS is accomplished using RS-422 transceivers. These transceivers as well as the IEEE 488 transceivers are controlled by the internal logic.

4.3 Extender488/HS Cable Construction

The following information is provided for users that want to make their own interconnecting cable for Extender488/HS. Shielded twisted pair cable must be used and the pairs must be connected as shown in the cable wiring diagram.

Shielded Male Connector:	AMP 554953-2 (or equivalent)
Cover:	AMP 554946-2 (or equivalent)
Cable:	24 AWG., 50 conductor shielded cable (25 twisted pairs). Nominal capacitance between conductors for each pair must be less than 13 pF per foot.

4.3.1 Extender488/HS Cable Wiring Diagram

Pair	Shielded Male Connector	Shielded Male Connector
1	1	1
	26	26
2	2	2
	27	27
3	3	3
	28	28
4	4	4
	29	29
5	5	5
	30	30
6	6	6
	31	31
7	7	7
	32	32
8	8	8
	33	33
9	9	9
	34	34
10	10	10
	35	35
11	11	11
	36	36
12	12	12
	37	37
13	13	13
	38	38
14	14	14
	39	39
15	15	15
	40	40

Extender488/HS Wiring Diagram - Continued

Pair	Shielded Male Connector	Shielded Male Connector
16	16	16
	41	41
17	17	17
	42	42
18	18	18
	43	43
19	19	19
	44	44
20	20	20
	45	45
21	21	21
	46	46
22	22	22
	47	47
23	23	23
	48	48
24	24	24
	49	49
25	25	25
	50	50

\$00	0	\$10	16	\$20	32	\$30	48	\$40	64	\$50	80	\$60	96	\$70	112
NUL		DLE		SP	0	@		P		`		p			
\$01	1	\$11	17	\$21	33	\$31	49	\$41	65	\$51	81	\$61	97	\$71	113
SOH		DC1		!	1	A		Q		a		q			
GTL		LLO			17	01		17		SCG		SCG			
\$02	2	\$12	18	\$22	34	\$32	50	\$42	66	\$52	82	\$62	98	\$72	114
STX		DC2		"	2	B		R		b		r			
					18	02		18		SCG		SCG			
\$03	3	\$13	19	\$23	35	\$33	51	\$43	67	\$53	83	\$63	99	\$73	115
ETX		DC3		#	3	C		S		c		s			
					19	03		19		SCG		SCG			
\$04	4	\$14	20	\$24	36	\$34	52	\$44	68	\$54	84	\$64	100	\$74	116
EOT		DC4		\$	4	D		T		d		t			
SDC		DCL			20	04		20		SCG		SCG			
\$05	5	\$15	21	\$25	37	\$35	53	\$45	69	\$55	85	\$65	101	\$75	117
ENQ		NAK		%	5	E		U		e		u			
PPC		PPU			21	05		21		SCG		SCG			
\$06	6	\$16	22	\$26	38	\$36	54	\$46	70	\$56	86	\$66	102	\$76	118
ACK		SYN		&	6	F		V		f		v			
					22	06		22		SCG		SCG			
\$07	7	\$17	23	\$27	39	\$37	55	\$47	71	\$57	87	\$67	103	\$77	119
BEL		ETB		'	7	G		W		g		w			
					23	07		23		SCG		SCG			
\$08	8	\$18	24	\$28	40	\$38	56	\$48	72	\$58	88	\$68	104	\$78	120
BS		CAN		(	8	H		X		h		x			
GET		SPE			24	08		24		SCG		SCG			
\$09	9	\$19	25	\$29	41	\$39	57	\$49	73	\$59	89	\$69	105	\$79	121
HT		EM		)	9	I		Y		i		y			
TCT		SPD			25	09		25		SCG		SCG			
\$0A	10	\$1A	26	\$2A	42	\$3A	58	\$4A	74	\$5A	90	\$6A	106	\$7A	122
LF		SUB		*	:	J		Z		j		z			
					26	10		26		SCG		SCG			
\$0B	11	\$1B	27	\$2B	43	\$3B	59	\$4B	75	\$5B	91	\$6B	107	\$7B	123
VT		ESC		+	;	K		[		k		{			
					27	11		27		SCG		SCG			
\$0C	12	\$1C	28	\$2C	44	\$3C	60	\$4C	76	\$5C	92	\$6C	108	\$7C	124
FF		FS		,	<	L		\		l		|			
					28	12		28		SCG		SCG			
\$0D	13	\$1D	29	\$2D	45	\$3D	61	\$4D	77	\$5D	93	\$6D	109	\$7D	125
CR		GS		-	=	M		]		m		}			
					29	13		29		SCG		SCG			
\$0E	14	\$1E	30	\$2E	46	\$3E	62	\$4E	78	\$5E	94	\$6E	110	\$7E	126
SO		RS		.	>	N		^		n		~			
					30	14		30		SCG		SCG			
\$0F	15	\$1F	31	\$2F	47	\$3F	63	\$4F	79	\$5F	95	\$6F	111	\$7F	127
SI		US		/	?	O		_		o		DEL			
					31	15		31		SCG		SCG			
					UNL			UNT							
					LAG			TAG							

ACG = Addressed Command Group TAG = Talk Address Group
 UCG = Universal Command Group SCG = Secondary Command Group
 LAG = Listen Address Group