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Digital488/80
Instruction Manual

Part No. Digital488/80-901

Revision 1.0

August 1988

IOtech, Inc. • 25971 Cannon Road • Cleveland, Ohio 44146 • (21

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Introduction

1.1 General Description

The Digital488/80 is a digital input and output interface to the IE unit has 80 TTL level digital I/O lines which are divided into two 40 b Channel is divided into five eight-bit Ports. Each port is software p input or output. Thus, a configuration can range from 80 input lines or any combination in between in multiples of 8 bits. As an added fe lines can be configured as high current high voltage outputs to allow solenoids, relays or other high voltage high current devices.

The Digital488/80 has several features which give it versatile int A trigger output signal is asserted on the Group Execute Trigger (GE Edge-triggered inputs can generate a Service Request on the bus. Six software programmable, including ASCII hexadecimal, ASCII d binary, binary, high speed binary and ASCII decimal. There are also and bit clear commands. Programmable terminators are provi interfacing to various controllers.

A Status command enables the controller to interrogate the prog the Digital488/80 at any time. Additionally, all Digital488/80 comma (?) option which allows the user to build user-defined status command only that status information which is needed for a given applicatio initiated at power-on which checks for proper RAM and ROM operati

When addressed to talk, the Digital 488/80 will output data fro the selected Channel or a selected 8 bit Port. When addressed to lis accept input data and programming information from the controller an to the appropriate I/O port.

Two addressing modes are available allowing communi Digital488/80 using either Dual Primary or Secondary addressing addressing modes, the two Channels may reside at two consecut addresses or at the same primary bus address with two consecutive sec

Up to 100 preset configurations for each Channel may be save RAM for later use allowing easy configuration of the device f applications. A power-on configuration can also be created and automatically configuring the device upon upon power on.

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1.2 Available Accessories

Additional accessories that can be ordered for the Digital488/80 include:

CA-7-1	1.5 foot IEEE 488 Cable
CA-7-2	6 foot IEEE 488 Cable
CA-7-3	6 foot shielded IEEE 488 Cable
CA-7-4	6 foot reverse entry IEEE 488 Cable
CA-8-50	6 foot, 50 conductor ribbon cable with a card edge connector on one end, the other end un-terminated.
CN-6-50	50 Pin solder tab edge connector.
CN-20	Right Angle IEEE 488 adapter, male and female
CN-22	IEEE 488 Multi-tap bus strip, four female connectors
CN-23	IEEE 488 panel mount feed-through connector, male and female
Digital488/80 -901	Additional Instruction Manual

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1.3 Specifications

Digital488/80

Digital I/O Interface

Configuration:	Dual channels each with five 8-bit ports, programm outputs. Also included per channels are programm lines, data latching capability, clear and trigger outp request input.
Logic Levels:	Outputs will drive 2 TTL loads.
Connector:	Two 50 pin card edge. Mating connectors supplied.
High-Current Outputs:	Up to forty lines of channel 1 can be configured outputs. These are selected in 8 bit groups by pos internal to the Digital488/80. Each high-current out sinking up to 200mA at 50VDC max.
IEEE 488-1978 Implementation:	SH1, AH1, T4, TE8, L4, LE4, SR1, RL0, PP0, DC1
Terminators:	Selectable CR, LF, LF-CR and CR-LF with EOI.
Connector:	Standard IEEE 488 connector with metric studs.
Programmable:	IEEE Terminators, EOI, SRQ Mask, Port Data, Handshake lines, Format and configuration.

General

Indicators:	LEDs for Talk, Listen, SRQ, Error, Test and Powe
Power:	105-125V or 210-250V; 50-60 Hz, 20 VA Max.
Dimensions:	425mm wide x 45mm high x 203mm deep (16.75" x
Weight:	2 kg. (4.5 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 dip switch for IEEE addre IEEE address, and channel 1 configuration jumpers

Specifications subject to change without notice.

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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
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
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

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Getting Started

2.1 Inspection

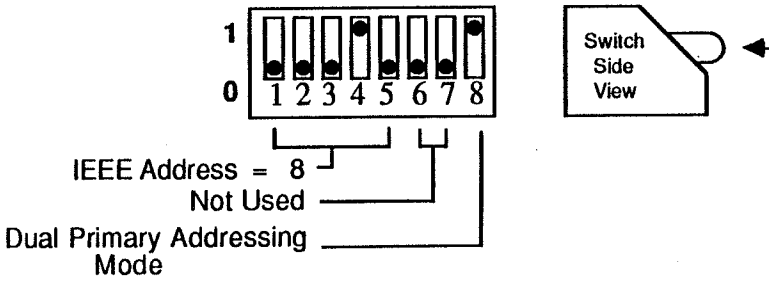
The Digital488/80 was carefully inspected, both mechanically prior to shipment. When you receive the interface, carefully unpack shipping carton and check for any obvious signs of physical damage occurred during shipment. Report any such damage found to th immediately. Remember to retain all shipping materials in the event t to the factory becomes necessary. Every Digital488/80 is shipped v items:

• Digital488/80	IEEE Digital I/O Converter
• CN-6-50	50 Pin Card Edge Connectors (2)
• Digital488/80-901	Instruction Manual
• CA-1	Power Cable
• HA-41-6	Screws (4)
• FE-1	Rubber Feet (4)
• HA-31	Rack Ears (2)
• FU-1-.25	1/4 Amp Fuse

2.2 Configuration

The Digital488/80 has one internal 8 position switch (SW1) a rear panel. This switch determines the unit's IEEE address and its The switch is read only when the unit is powered on, and should be s power. The following figure illustrates the factory default setting for

SW1 Factory Default Settings



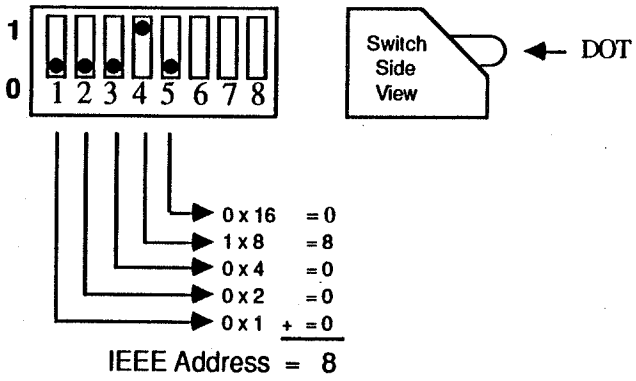
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To modify any of these defaults, disconnect the power cord from th change the switch settings using a small screwdriver. SW1 is accessib rear panel of the device. The enclosure does not need to be opened t switch settings.

2.2.1 IEEE 488 Address Selection

The IEEE 488 bus address is set by SW1-1 through SW1-5 (lo rear of unit). The address can be set from 0 through 30 and is rea power on. The address is selected by simple binary weighting with being the least significant bit and Switch 5 the most significant factory default is address 8. If address 31 is selected, it defaults to ad because the IEEE 488 standard has reserved address 31.

SW1 View for IEEE Bus Address Selection

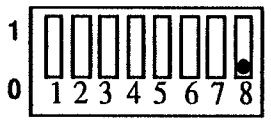


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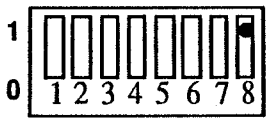
2.2.2 Digital488/80 Addressing Modes

The Digital488/80 can be thought of as two identical I
Digital I/O interfaces. Each interface occupies one bus address
I/O channel. Therefore the Digital488/80 occupies two bus ad
IEEE 488 system. To allow communication with each in
addressing modes are available: Dual Primary and Secondary
The addressing mode is selected by SW1-8 located on the rea
The switch settings for both modes are shown below.

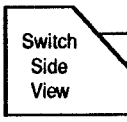
SW1 View for Addressing Mode Selection



Secondary Addressing Mode



Dual Primary Addressing Mode



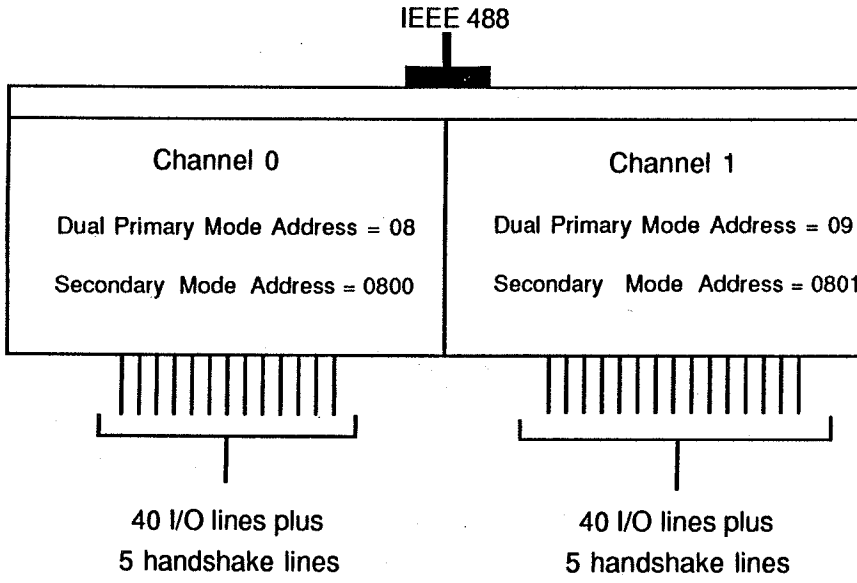
When Dual Primary addressing is selected, SW1-1 (the
address is ignored. The Channel 0 interface resides at an eve
bus address while the Channel 1 interface resides at the next
For example, if the address switches are set for bus address 6, th
interface will reside at bus address 6 and the Channel 1 interfac
at bus address 7. Note: if address 30 is selected in Dual Primary
mode, the Digital488/80 will default to address 28 for Channel 0
29 for Channel 1.

When Secondary addressing is used, both interfaces reside
primary bus address selected by SW1-1 through SW1-5. To c
with Channel 0, secondary address 00 must be used along with
address. To communicate with Channel 1, secondary address
used. Note: if address 31 is selected in Secondary Addressing
Digital488/80 will default to address 3000 for Channel 0 and a
for Channel 1.

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The picture below shows the relationship between the channels two addressing modes. For this example, the address switches are set address 8.

Pictorial View of the Digital488/80



To illustrate the differences between the two Channels and h communicate with the Digital488/80 using the two addressing m several programming examples are given at the end of this section.

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2.2.3 IEEE 488 Bus Output Terminator Selection

The terminating characters sent on output by the Digital4 by using the Terminator command. Upon power on, the uni bus terminators are determined by the Power-On Configurat factory default terminator selection is Y0 (CR LF). The pow terminators can be changed to any of the four available option the Terminator command in the following Command Descri The four available terminator options, and the commands ass them are : Y0 - CR LF, Y1 - LF CR, Y2 - CR only, and Y3 - L is desired to have particular power on default termir terminator(s) may be selected using the Terminator Comm selection can be saved as part of Configuration O0 which is configuration.

The Digital488/80 ignores all terminators received f controller. Only the Execute command (X) is used t Digital488/80 that a command string has been completed.

2.3 Digital Input/Output Ports

The Digital488/80 has 40 data lines per channel which can groups of 8 as either input or output. At power on, the configuratio ports is determined by the options saved as Configuration configuration). Therefore, in order to set the unit to a particular c power on, the Save Configuration (S0) command must be desired options have been selected.

2.3.1 Logic Levels

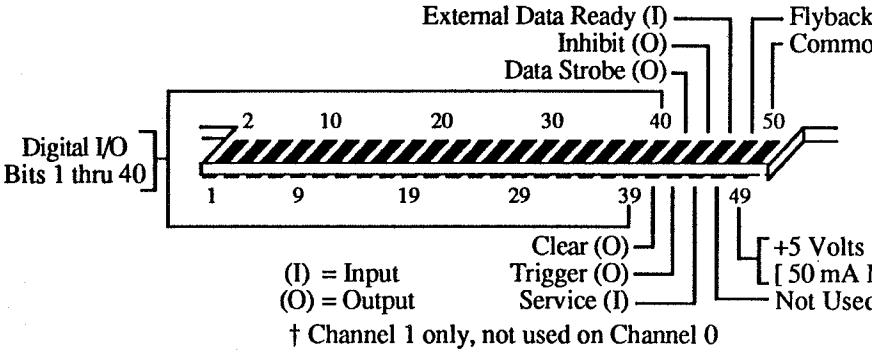
The data and handshake output lines will drive two T addition, ports 1 and 2 on each Channel can function as 5 compatible outputs. All input lines are less than 1.5 TTL load are protected against damage due to high static voltages. Norma should be taken to limit the input voltages to -0.3 to +7.0 volts. are referenced to COMMON (Pin 50).

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2.3.2 Digital I/O Port Pin Outs

The following diagram illustrates one of the digital I/O edge co as view from the rear of the Digital488/80. Both edge connec identical with the exception of pin 48 which is used as a FL connection for Channel 1 but is unused on Channel 0.

Digital488/80 Rear Panel I/O Connector Pin Out



Pin	Description
1 thru 8	DATA PORT1 (Input or Output). Pin 1 is bit 1 (LSB), Pin 8 is bit 8 (MSB). Least Significant Port
9 thru 16	DATA PORT2 (Input or Output). Pin 9 is bit 1 (LSB), Pin 16 is bit 8 (MSB).
17 thru 24	DATA PORT3 (Input or Output). Pin 17 is bit 1 (LSB), Pin 24 is bit 8 (MSB).
25 thru 32	DATA PORT4 (Input or Output). Pin 25 is bit 1 (LSB), Pin 32 is bit 8 (MSB).
33 thru 40	DATA PORT5 (Input or Output). Pin 33 is bit 1 (LSB), Pin 40 is bit 8 (MSB). Most Significant Port

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41	CLEAR (Output).
42	DATA STROBE (Output).
43	TRIGGER (Output).
44	INHIBIT (Output).
45	SERVICE INPUT (Input).
46	EXTERNAL DATA READY [EDR] (Input).
47	Not used.
48	Channel 0 - Not used Channel 1 - FLYBACK
49	+5 Volts (Do not exceed 50 mA load).
50	I/O COMMON (Gnd).

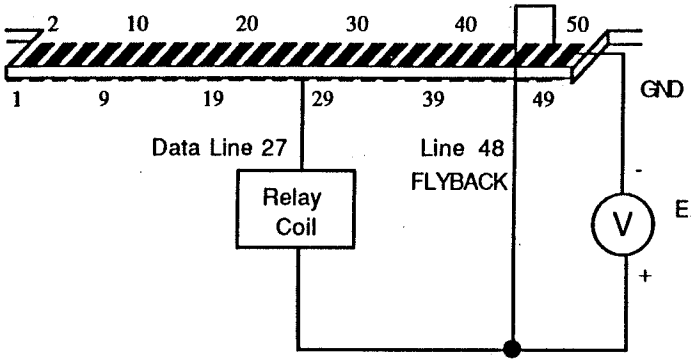
2.3.2.1 High Voltage, High Current Outputs - Chan

In addition to interfacing with TTL and CMOS logic lev lines of Channel 1 can be configured as high voltage high curre groups of 8. Lines configured in this manner can only be use These outputs can sink up to 200mA at up to 50VDC through th collector drivers with integral diodes for inductive lo suppression. This allows for interfacing with relays, and soleno

When used with relays or solenoids, the FLYBACK pin card connector should be connected to the positive supply lead supply used with the external devices being driven.

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View of Edge Connector Showing use of FLYBACK Lin



To configure the channel 1 data lines for this purpose, it is nec
open the enclosure and reposition the configuration jumpers acc
the following instructions. Disconnect the power cord from the AC
from the interface. Disconnect any IEEE or digital I/O cables
disassembly.

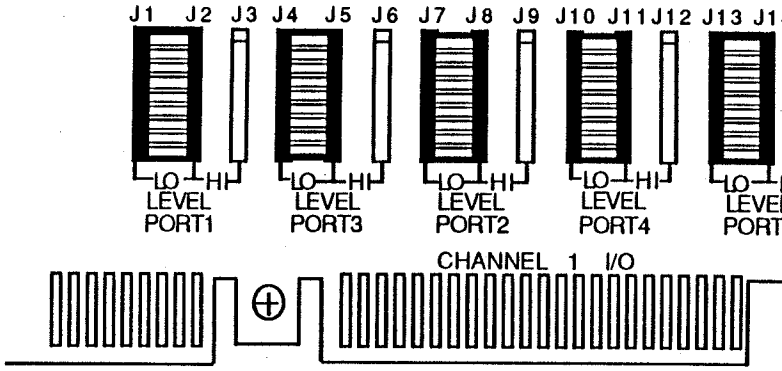
WARNING

Never open the Digital488/80 case while it is connected to the AC line. Internal voltage potentials exist which could cause personal injury or death.

Place the interface on a flat surface. Remove the four screws
the case and remove the top cover. Located in front of the ca
connectors, there are five sets of connectors with configuration j
These are factory set to configure the channel 1 data lines for low le
logic levels.

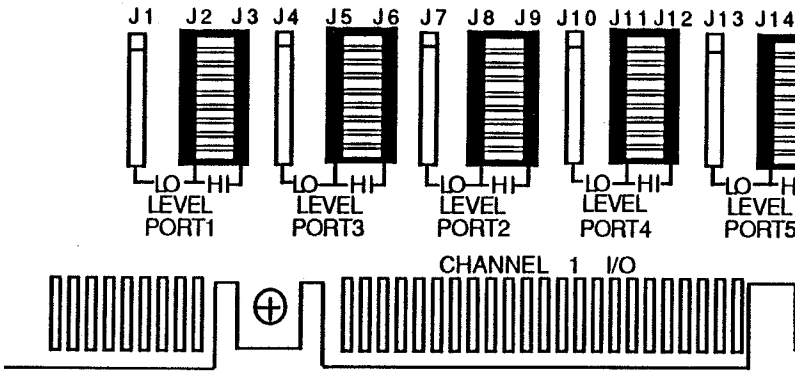
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View of Configuration Jumpers - Factory Settin
All Ports configured as Low Level Inputs or Outp



To configure data lines as high voltage high current outp
the configuration jumpers for the ports which are to be used for
and reinsert them so that the center socket is now connected
socket.

View of Configuration Jumpers
All Ports configured as High Level Outputs



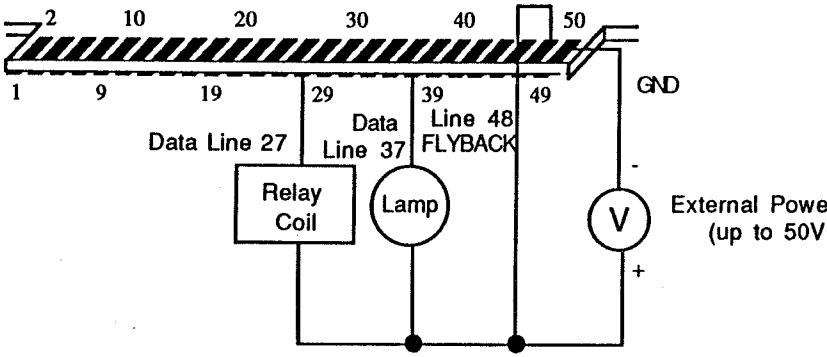
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Once the jumper(s) have been repositioned for your p application, make note of the new jumper settings for later refer carefully re-assemble the unit.

2.3.2.2 Using the High Voltage High Current Outputs

Once the Channel 1 port(s) are configured for high level o they can be used to drive devices such as relays, solenoids and disp example, a typical application may require a lamp and a relay to b by the Digital488/80. The relay is connected to data line 28 (port 4 lamp is connected to data line 38 (port 5). These two ports configured as high level outputs. These devices would be connected below.

View of Channel 1 Edge Card Connector
Using High Level Outputs to Drive a Relay and Lam



CAUTION

Never connect external high level devices to a Channel 1 port which has not first been configured for this purpose. Failure to do so may result in damage to the Digital488/80.

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CAUTION

Never connect external high level devices to port on Channel 0. Failure to do so may resu damage to the Digital488/80.

Since a relay is used for this application, the flybac connected to the positive terminal of the external power supp that the Ground lead of the power supply should be connec (GND) on the edge card connector. Remember that ports conf level outputs can only be used as outputs.

2.3.3 Control Lines

Five control lines on each channel enable handshaking data transfer to the Digital488/80. They are automatically acti corresponding I/O activity and can also be independently acti `Handshake` (`Hn`) command. For all descriptions that follow on the function and action of a given line is true for both cha where noted.

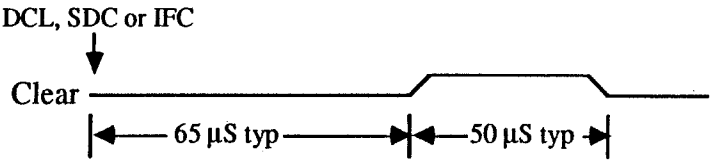
2.3.3.1 Clear (Pin 41)

The Clear output can be pulsed for approxima microseconds after a Device Clear (DCL), Selected Devi (SDC), or Interface Clear (IFC) command has been sent or depending on the `Format` (`Fn`) mode of each channel. W an SDC to either channel or a DCL is executed, both char affected. The effect depends on whether either channel High Speed Binary (`F5`) mode. If in the `F5` mode, the ch in the `F5` mode will have their command interpreter re- and are returned to the ASCII Hexadecimal (`F0`) mode. parameters remain unchanged. In addition, the CLEAR both channels are not pulsed. If neither channel is in the `F5` an SDC to either channel or a DCL will return both Cha their power-up configuration and pulse both CLEAR l approximately 50 microseconds.

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The Clear line is normally active high. The Invert comma (I8) will program it active low. The `Handshake` command (H can pulse the Clear line of either channel, independent of any I operations.

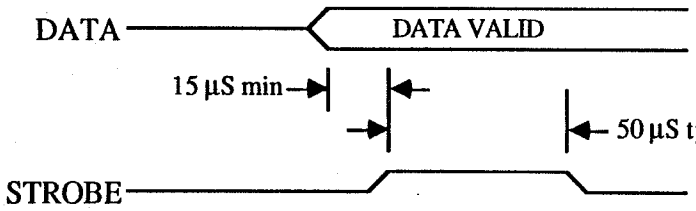
Timing Diagram for Clear Output



2.3.3.2 Data Strobe (Pin 42)

The Data Strobe output is pulsed for approximately microseconds after new data is output on the I/O port. The Da Strobe line is normally active high but may be programmed act low by the `Invert` command (`I4`). The `Handshake` comma (`H1`) can pulse the Data Strobe line, independent of any I operations. The Data Strobe output is not pulsed when `Bit S` (`An`) and `Bit Clear (Bn)` commands are executed.

Timing Diagram for Strobe Output



† 15 µS typ in F5 Format

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2.3.3.3 External Data Ready [EDR] (Pin 46)

The External Data Ready [EDR] line is an edge s
input which is used to latch input data. It is used in con
with the `Data Ready` command (`R1` or `R2`). The EDF
must be at least 1 microsecond wide and must have a rise
time of less than one microsecond. The EDR line is n
rising-edge sensitive but can be programmed with the I
command (`I32`) to be falling-edge sensitive. Refer
following diagram for timing relationships.

When using the EDR line with the `R1` command, da
read when the Digital488/80 is addressed to talk as with
Digital488/80 will only output data when the EDR line tran

When using the EDR line with the `R2` command, dat
and stored in an internal data buffer each time the EI
transitions. The Digital488/80 will only output data when
data in the buffer to output.

EDR is not functional in the high speed binary (`F5`) f

2.3.3.4 Inhibit (Pin 44)

The Inhibit output is asserted while data on the selec
port is being read into the I/O port buffer. This line is n
active high but may be programmed active low by the I
command (`I1`). The Inhibit line can be programmed inde
of any I/O operations with the Inhibit command (`Qn`). Refe
following diagram for timing relationships.

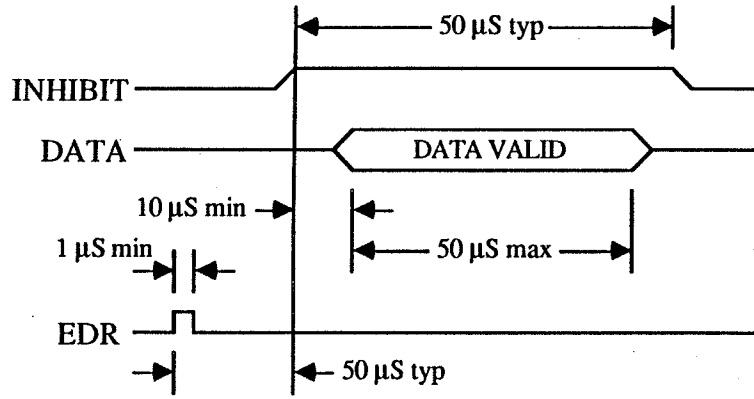
The Inhibit line is asserted once for each data read op
for all `Format` (`Fn`) modes except high speed binary (`F5`)
mode, it is asserted for the first data read after the Digital4
addressed to talk. On the last data byte transfer, the data
again with Inhibit asserted in anticipation of another data t
If Inhibit is used to sequence external hardware, you sh
aware that this line will pulse N+1 times; where N is the nu

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total (5 byte) data transfers.

The Inhibit Line is not pulsed when reading a particular status using the `Status` (`Un`) command.

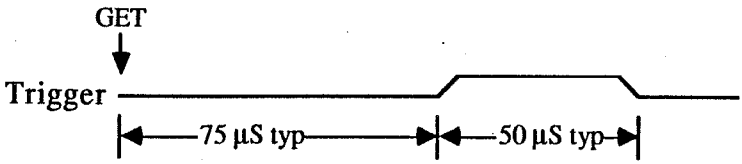
Timing Diagram for EDR Input and Inhibit Output



2.3.3.5 Trigger (Pin 43)

The Trigger output is pulsed for approximately microseconds after a GET (Group Execute Trigger) command received from the bus controller. The trigger pulse is normally active high, but can be made active low with the `Invert` command (`I2`). The `Handshake` command (`H2`) can independently pulse the Trigger line, independent of any bus activity.

Timing Diagram for Trigger Output



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2.3.3.6 Service (Pin 45)

The Service input is an edge sensitive input ca
generating a bus Service Request (SRQ). It is enabled
`Service Request Mask` (`M1`) command and de
rising-edge sensitive. The `Invert` command (`I64`) can
to program it to be falling-edge sensitive.

2.4 IEEE 488 Bus Implementation

The Digital488/80 implements many of the capabilities d
IEEE 488 1978 specification. These are discussed in the follov
Those bus uniline and multiline commands that the Digital48
support or respond to include:

Remote Enable (REN)	Parallel Poll (PP)
Go to Local (GTL)	Parallel Poll Configu
Local Lockout (LLO)	Parallel Poll Unconfi
Take Control (TCT)	Parallel Poll Disable

2.4.1 My Talk Address (MTA)

In `R0` mode, when the Digital488/80 is addressed to ta
Inhibit, reads the data from all ports, un-asserts Inhibit and ou
to the bus in the format as defined by the `Format (Fn)`, `Po`
`Bus Input/Output (Gn)` commands. The output bus ter
appended to the output with the exception of the `F4` and `F5` for
not append terminators. The output format of `F5` will
separately. After output in the `F0` through `F4` formats, the D
must be re-addressed to talk to perform subsequent reads. If the

In `R1` mode, the Digital488/80 will wait for the selected E
before reading the data and formatting it for output. If the E
changed state prior to being addressed to talk, the data read a
EDR will be buffered for output when next addressed to t

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changes again before the previous EDR buffered data has been outp
Digital488/80 will generate an EDR Overrun error and ignore th
read request. After output in the F0 through F4 formats, the Digital
must be re-addressed to talk to perform subsequent buffered output o
captured data.

In R2 mode, the Digital488/80 will wait for the selected EDR tra
before reading the data and storing it in the internal data buffer. Up t
readings may be latched and stored. The EDR and Inhibit lines func
the same manner as in the R1 mode. If an attempt is made to store mo
2000 readings, the Digital488/80 will generate an Overrun error.
output in the F0 through F4 formats, the Digital488/80/80 m
re-addressed to talk to perform subsequent buffered output of EDR ca
data.

In any Rn mode, the Digital488/80 can request status using the S
(Un) command without affecting the data ports or the Inhibit line. Af
requested status is output, the presently programmed Rn mode returns

EDR cannot be used to capture data in the high speed binary
(F5). When addressed to talk in this format it asserts Inhibit, reads th
from all ports, un-asserts Inhibit and outputs the binary data to the bu
EOI asserted on the fifth byte. When the last data byte is transferred, t
is read again in anticipation of another data transfer. If Inhibit is u
sequence external hardware, this line will pulse N+1 times; where N
number of total (5 byte) data transfers. In this format the Digital488/8
not have to be re-addressed to talk to read the ports multiple times.

With all Fn formats, the data is output in a PORT5, PORT4, P
PORT2, PORT1 sequence.

2.4.2 My Listen Address (MLA)

When the Digital488/80 is addressed to listen in the F0 throu
format, it accepts characters from the active talker and interprets
characters as commands and command parameters. These comman
explained in Section 3.

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In the high speed binary format (F5), the command
disabled. The Digital488/80 treats all bytes received as data
the Digital I/O ports. Each time it receives five bytes or detect
the Data Strobe for approximately 15 microseconds. Data is
PORT5, PORT4, PORT3, PORT2, PORT1 sequence.

If only two bytes are received, with EOI asserted on the
the Digital488/80 will update PORT5 with the first byte rec
with the second and pulse the Data Strobe. Since the inter
received characters as data, the Status (Un) command
recognized.

2.4.3 Device Clear (DCL and SDC)

only way to exit from F5!

In the F0 thru F4 formats, Device Clear resets the Dig
power on defaults and pulses the Clear output line for appr
microseconds.

If either Channel is in the high speed binary data format (
SDC to either Channel will enable the command interpreter o
in the F5 mode and then change the format to F0. All oth
remain unchanged. In addition, the Clear output line is not puls
SDC when the either Channel is in the F5 mode. This
programmable method to exit the F5 format.

2.4.4 Group Execute Trigger (GET)

When the Digital488/80 recognizes a GET on either cha
the Trigger output lines on both channels for appro
microseconds. If it is desired to pulse only one handsh
Handshake (H2) command should be issued to the desired cha

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2.4.5 Interface Clear (IFC)

IFC places the Digital488/80 in the Talker/Listener Idle State an the Clear output line for approximately 50 microseconds.

2.4.6 Serial Poll Enable (SPE)

When Serial Poll Enabled, the Digital488/80 sets itself to respo serial poll with its serial poll status byte if addressed to talk. When th poll byte is accepted by the controller, any pending SRQs are clear Digital488/80 will continue to try to output its serial poll response u serial poll disabled by the controller.

2.4.7 Serial Poll Disable (SPD)

Disables the Digital488/80 from responding to serial polls controller.

2.4.8 Unlisten (UNL)

UNL places the Digital488/80 in the Listener Idle State.

2.4.9 Untalk (UNT)

UNT places the Digital488/80 in the Talker Idle State.

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2.4.10 Serial Poll Response

Whenever the Digital488/80 generates an SRQ, a serial poll of return a serial poll status byte of at least 64 (decimal) showing tha generated by the Digital488/80. In order to determine which cha SRQ, use the `Service Request Mask` command (with the `Qu` recall what SRQ conditions are selected. The Digital488/80 will ret disabled or a response between either `M1` through `M7` or `M16` through what SRQ conditions are selected. The following BASIC progr approach for handling service requests:

```
PRINT#1,"SPOLL08"                          Serial poll channel 0
INPUT#2,SRQ08
PRINT#1,"SPOLL09"                          Serial poll channel 1
INPUT#2,SRQ09
PRINT#1,"OUTPUT08;M?"                      Get SRQ selection(s)
PRINT#1,"ENTER08"
INPUT#2,M08$
PRINT#1,"OUTPUT09;M?"                      Get SRQ selection(s)
PRINT#1,"ENTER09"
INPUT#2,M09$
IF M08$="M0" THEN GOTO 500                 SRQs disabled Chann
IF M08$="M1" AND SRQ08 = 65 THEN GOTO 600
                                           Service input transiti
IF M08$="M2" AND SRQ08 = 66 THEN GOTO 700
                                           EDR input transition
IF M08$="M4" AND SRQ08 = 70 THEN GOTO 800
                                           Bus Error routine, Cl
```

Note: To allow the Digital488/80 to detect each of the above conditi `Request Mask` (`Mn`) command must be executed for each conditio comparisons of the Serial Poll Status Byte and the `M?` response are SRQ conditions are selected.

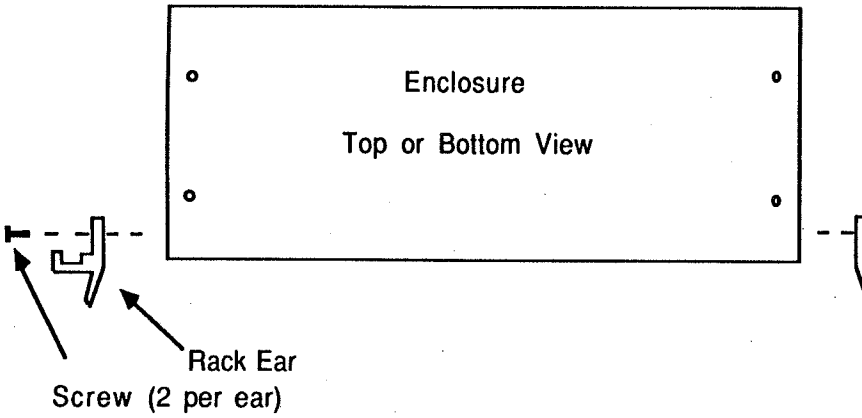
The unit may be programmed to generate an SRQ on power-on b option (SRQ on Ready) of the `Service Request Mask` (`Mn`) co this selection as part of the power-on configuration (configuration 0

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2.5 Hardware Installation

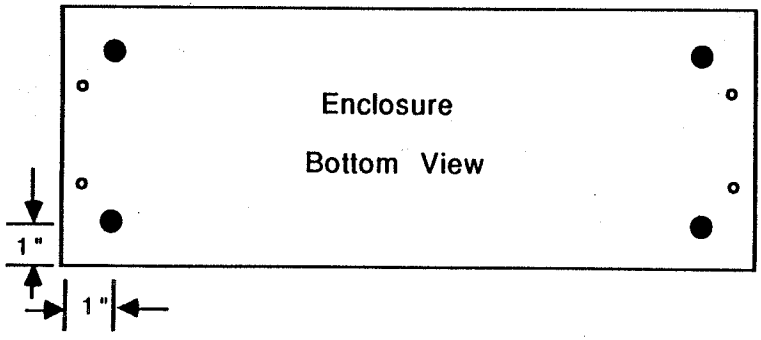
Included with the Digital488/80 are accessories for rack or bench
mount installation is required, install the two rack ears using the encl
These ears can be installed so either the front or the rear of the unit face
the rack fixture.

View of Enclosure showing Rack Hardware Installatio



If bench installation is required, the rubber feet can be installed on the
the unit approximately one inch from each corner.

View of Enclosure Showing Feet Placement



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2.6 Operation

Before operating the Digital488/80, note that the interface ma
110 or 220 volts AC. The operation voltage is set by an internal sw
next to the power supply transformer. The factory setting of SW
operation. To change the operation voltage, it is necessary to oper
change the setting of SW-4 according to the following instructior
power cord from the AC line and from the interface. Disconnect a
I/O cables prior to disassembly.

WARNING

**Never open the Digital488/80 case while i
connected to the AC line. Internal vol
potentials exist which could cause personal in
or death.**

Place the interface on a flat surface. Remove the four screws on
remove the top cover. Located next to the transformer is SW-
screwdriver, insert the tip of the screwdriver into the slot of the sw
switch to the left or right so that the desired line voltage selection app
Make note of the new setting for later reference and carefully re-asse

WARNING

**The interface is intended for INDOOR U
ONLY. Failure to observe this warning co
result in equipment failure, personal injury
death.**

After plugging in the power cord, turn on the Digital488/80 by
panel power switch. All the front panel LEDs should light for a
second while the Digital488/80 performs an internal ROM and RAM
end of this self check all indicators should turn off except POWER.

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If you obtain the above response then your Digital488/80 is alive ar
LEDs remain on, then a ROM error has occurred. If all LEDs (except th
flash continuously, then a RAM error has occurred. Try cycling the
Digital488/80 to determine that the error is repeatable.

If all LEDs except the Power and Error LEDs go out, there was a ch
on non-volatile RAM and the saved configurations may be lost. The ch
condition may be cleared by doing a save of a configuration usin
`Configuration (Sn)` command.

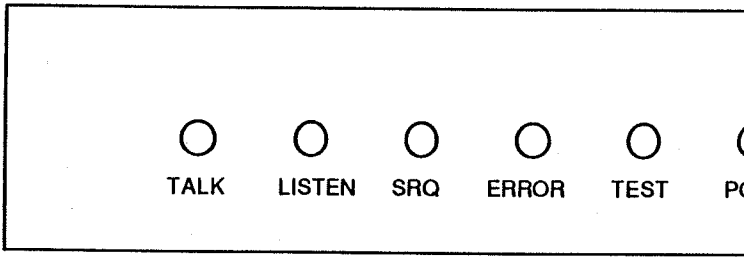
If the LEDs do not flash and the POWER indicator does not light, the
any power supplied to the interface. In this event, check to make sure the
supplied to the unit. If the problem persists, refer to the Service Informat
this manual.

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2.6.1 Front Panel Indicators

Six LEDs on the front panel of the Digital488/80 display the sta
The function of each indicator is described below.

View of Digital488/80 Front Panel Indicators



TALK	ON when the Digital488/80 is in the Talker sta Digital488/80 is in the Idle or Listener state
LISTEN	ON when the Digital488/80 is in the Listener sta Digital488/80 is in the Idle or Talker state
SRQ	ON when the Digital488/80 has generated a serv when no SRQ is pending. (see `Service R` Command for more information)
ERROR	ON when an error has occured, OFF when no erro (see `Error` command for more information)
TEST	Used in conjunction with the `TEST` comman communication has been established wtih the Digita
POWER	ON when power is applied to the Digital488/80 and on the back panel is in the on position (depressed) C present or the internal fuse or power supply is faulty

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2.7 Programming Examples

These examples use the IOtech Personal488 and the BASIC Keyboa program listed in appendix C. The Keyboard Controller program a communication with the Digital488/80 (or any IEEE device on the bus) ar convenient method of exercising the Digital488/80 and becoming fami commands and their actions.

First, set SW1 for Dual Primary addressing mode and bus address 8. IEEE cable from the Digital488/80 to the IEEE connector on the Person on the Digital488/80 by depressing the rear panel power switch. All of th LEDs should light for approximately one second while the Digital488/80 internal ROM and RAM self test. At the end of this self test all indicator off except power. Run the Keyboard Controller program and verify th prompt appears on the screen. The following is a listing of commands Digital488/80 and the response received. Responses are separated by e space for clarity although these spaces will not actually appear when using

```
CMD>                          Command prompt from Keyboard Contro
CMD>OUTPUT08;T1X              Turn on the Test LED (Test LED should li
CMD>OUTPUT08;T0X              Turn off the Test LED (Test LED should t
CMD>CLEAR                     Reset the Digital488/80
CMD>OUTPUT08;U0X              Get status of Channel 0
CMD>ENTER08
1.0C0E0F0G0I000K0L0000M000P0R0Y0

                              Status message shows all default options ar
CMD>OUTPUT09;U0X              Get status of Channel 1
CMD>ENTER09
1.0C0E0F0G0I000K0M000P0R0Y0

                              Status message shows all default options ar
CMD>OUTPUT08;C?               Request Port Configuration Mode for Char
CMD>ENTER08
C0                            C0 is returned showing default port config
CMD>OUTPUT08;C5X              Configure all Channel 0 Ports as outputs
CMD>OUTPUT08;C?               Request Port Configuration Mode for Char
```


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```
CMD>ENTER08
C5                          C5 is returned showing that our C
                            executed
CMD>OUTPUT09;C?             Request Port Configuration Mode fo
CMD>ENTER09
C0                          C0 is returned since we didn't ch
                            configuration of the Ports on Channe
CMD>OUTPUT08;G2R0X          Send output data when addressed to ta
CMD>OUTPUT08;D123ZX         Send '123' to Channel 0
CMD>ENTER08                 Read data from Channel 0
0000000123
CMD>OUTPUT08;A37X           Set bit 37 on Channel 0
CMD>ENTER08                 Read data from Channel 0
1000000123                  Display shows bit 37 set and also the p
```

The above examples may also be repeated using Secondary addre turn off the Digital488/80, set SW1 for Secondary addressing mo above commands substituting 0800 for 08 and 0801 for 09 in all co

2.8 Data Transfer Speed Specifications

The Digital488/80 has been measured to perform at the speeds l testing was done in such a way that the limiting factor was the Digital4 IEEE contrtroller driving it. All explanations discuss only one cha specifications given are valid for either channel.

2.8.1 Collection and Storage of Data

The Digital488/80 has an internal data buffer cap storing 2000 readings of 40 bit data per channel. When op in the R2 mode (data is latched and stored on an EDR transi transition on the External Data Ready input caus Digital488/80 to collect the current value of all 40 bits an the reading in the buffer. This collection and storage of 40 data can occur at a maximum rate of once every 140 micros

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2.8.2 Output of Data to Ports

When sending data to the outputs on a channel of t Digital488/80, the fastest `Format` mode is high-speed bina mode (`F5`). In this mode, five bytes of binary data are accept from the bus and sent directly to the Digital488/80 outputs (all bits). This constitutes one data transfer. The data transfer rate this mode is approximately 1400 transfers per second.

2.8.3 IEEE 488 Bus Communication

The fastest data transfer rate across the IEEE bus to t IEEE 488 controller is approximately 1 byte every 1 microseconds whether reading data from the internal data buff or accepting commands or data from the bus.

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Command Descriptions

Control of the Digital 488/80 is implemented with 23 bus com here in detail. Examples are given for the commands using a PC IEEE 488 controller by using the IOtech Personal488 PC/IEE associated driver software. All examples are given using GWBASIC Digital488/80 bus address should be set to 8 for all examples.

In order to establish communication with DVR488 from GWB the following sequence must be used:

```
OPEN "\DEV\IEEEOUT" FOR OUTPUT AS #1
IOCTL#1,"BREAK"
PRINT#1,"RESET"
OPEN "\DEV\IEEEIN" FOR INPUT AS #2
```

All of the command examples that follow assume that the driver opened and reset by the above sequence.

Most of the instructions offer a query (?) option. This opti determine the present configuration or mode of a command previous number of these query commands may be combined into one string t construct a specialized status command requesting the Digital488/80 t information which is of interest for a given application.

Attention!

It is necessary that the **EXECUTE** command (X) foll all command strings sent to the **Digital488/80.** commands are executed until an **X** is received by **Digital488/80.** The only exception to this rule are query commands. Any query commands do not have to followed by an **X**.

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Bit Set

The `Bit Set` command programs a logic one output to a bit descr argument 'n'. Setting a bit may represent either a +5 volt or 0 volt output on whether an `Invert` command (`I16`) has been sent. If data is active h condition), then `Bit Set` outputs +5 volts. If multiple bits are to be set with command string, an `Execute` command (`X`) must be included after ever command.

The bit which is being set must have been configured as an outpu `Configure` command to be valid. The Strobe output line is not pulsed wh `Set` command is sent.

`An`	Bit `n` (1 thru 40) is set to logic one
`A?`	Return `n` (1 thru 40) of last bit set

Examples:

Using Dual Primary Addressing Mode
to communicate with channel 0:

```
PRINT#1,"CLEAR08"                reset the Digital488/80
PRINT#1,"OUTPUT08;C5P0X"         configure all ports as output, sele
PRINT#1,"OUTPUT08;A22X"          set bit 22 to a logic one
PRINT#1,"OUTPUT08;A23XA24X"      set bits 23 and 24 to a logic one
```

Using Secondary Addressing Mode
to communicate with channel 0:

```
PRINT#1,"CLEAR0800"              reset the Digital488/80
PRINT#1,"OUTPUT0800;C5P0X"       configure all ports as output, sele
PRINT#1,"OUTPUT0800;A22X"        set bit 22 to a logic one
PRINT#1,"OUTPUT0800;A23XA24X"    set bits 23 and 24 to a logic one
```


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Bit Clear

The `Bit Clear` command will clear to a logic zero an output b argument 'n'. Clearing a bit may represent either a 0 volt or +5 volt on whether an `Invert` command (`I16`) has been sent. If data is a condition), then `Bit Clear` outputs 0 volts. When multiple `Bit C` are used in the same command string, an `Execute` command (`X`) command.

The bit which is being cleared must have been defined as `Configure` (`Cn`) command in order to be valid. The Strobe output when the `Bit Clear` command is sent.

`Bn`	Bit `n` (1 thru 40) is cleared to a logic 0
`B?`	Return `n` (1 thru 40) of last bit cleared

Example:

```
PRINT#1,"CLEAR08"                    reset the Digital488/80
PRINT#1,"OUTPUT08;C5P0X"             configure all ports as outpu
PRINT#1,"OUTPUT08;A7XA8XA9X"         set bits 7, 8, and 9 to +5 vol
PRINT#1,"OUTPUT08;B7X"               clear bit 7 to zero volts
PRINT#1,"OUTPUT08;B8XB9X"            clear bits 8 and 9 to zero vo
```


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Configure

Ports 1 through 5 are configured as inputs or outputs with the Co command. Each port is eight bits wide. At power-on, all ports are initialize The Configure command is usually the first command to be sent after pov ports programmed as outputs will be set to a logic zero after receiving the command. The actual output level is dependent on the Invert command (I

Cn Mode n (0 thru 5) defines which ports are input and output

		Port				
		5	4	3	2	1
	C0	in	in	in	in	in
	C1	in	in	in	in	out
Command	C2	in	in	in	out	out
	C3	in	in	out	out	out
	C4	in	out	out	out	out
	C5	out	out	out	out	out

in = programmed as an input port
out = programmed as an output port

C? Return present port configuration

Examples:

```
PRINT#1,"CLEAR08"
PRINT#1,"OUTPUT08;C1X"
PRINT#1,"OUTPUT08;C?"
PRINT#1,"ENTER08"
INPUT#2,A$
PRINT A$
```

reset the Digital488/80
select port 1 as output, ports 2 thru as inputs
request present port configuration
display shows C1

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Data

The Data command outputs up to 40 bits of data to the output p
channel. The number of bits which can be sent with the Data comma
number of bits programmed as outputs. For formats F0 through F3
data sent is less than the the number of bits programmed as outputs, th
bits will contain the data sent and the most-significant bits will be cle
If a single port is selected with the Port command, only eight bits ma
Data command. The Data Strobe output of the selected chan
approximately 50 microseconds after new data is output on the sele
channel.

For formats F0 through F3, data sent by the controller is contain
(D) and a suffix (Z). In format F4, the five bytes immediately followi
interpreted as data and the suffix (Z) is not used. For the high speed
all bytes received are treated as data and the prefix and suffix are not
Format (Fn) command for additional details.

Dn...Z n... represents the data to be outputted, terminated b
(note: in the F4 mode, the Z terminator is not allowed)

Examples:

```
PRINT#1,"CLEAR08"                    reset the Digital488/8
PRINT#1,"OUTPUT08;C5P1G2R0X"         all ports are output, s
PRINT#1,"OUTPUT08;D55ZX"             send 55 to port 1
PRINT#1,"ENTER08"
INPUT#2,A$                           read data from port 1
PRINT A$                             display shows 55
PRINT#1,"OUTPUT08;P0X"               select all ports
PRINT#1,"OUTPUT08;D1234567890ZX"     send data to all 40 dat
PRINT#1,"ENTER08"
INPUT#2,A$                           read data from the D
PRINT A$                             display shows 12345
```


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```
PRINT#1,"CLEAR08"                reset the Digital488/80
PRINT#1,"OUTPUT08;C5P1G2R0X"     all ports are output, select port 1
PRINT#1,"OUTPUT08;D123ZX"        send 12 bits of data to the least sig
PRINT#1,"ENTER08"
INPUT#2,A$                       read data from the Digital488/80
PRINT A$                         display shows 0000000123
PRINT#1,"OUTPUT08;P5D21ZX"       select port 5 only
PRINT#1,"OUTPUT08;P0X"           select all ports
PRINT#1,"ENTER08"
INPUT#2,A$                       read data from the Digital488/80
PRINT A$                         display shows 2100000123
```


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Error

The Error command is used to determine the present erro selected channel of the Digital488/80. After execution of the Err present error condition is cleared. The error condition is also cleare Status (U0) command. When an error has occurred, the Error panel of the Digital488/80 will turn on. The Error light will stay c (E?) or Status (U0) command is executed.

If a Non-Volatile RAM Checksum Failure (E5) occurs, this er only be cleared by doing a save of a configuration using the Save C (Sn) command. Executing this command updates the checksum to a clears the E5 error condition.

E?	Return and clear present error condition

After execution of the Error command, the Digital488/80 wil following error codes:

E0	No Error has occurred
E1	Unrecognized command (W4X, J5 etc.)
E2	Invalid Command Parameter (A62X, C10X etc.)
E3	Conflict Error (outputting data to an input port, sendin
E4	Not used
E5	Non-Volatile RAM Checksum Failure
E6	Internal Data Buffer Overrun (attempting to store data

Examples:

```
PRINT#1,"CLEAR08"          reset the Digital488/80
PRINT#1,"OUTPUT08;E?"      request error status
PRINT#1,"ENTER08"
INPUT#2,A$
PRINT A$                   display shows E0, no erro
```


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```
PRINT#1,"OUTPUT08;W5X"
PRINT#1,"OUTPUT08;E?"
PRINT#1,"ENTER08"
INPUT#2,A$
PRINT A$

PRINT#1,"OUTPUT08;E?"
PRINT#1,"ENTER08"
INPUT#2,A$
PRINT A$


PRINT#1,"OUTPUT08;C8X"
PRINT#1,"OUTPUT08;E?"
PRINT#1,"ENTER08"
INPUT#2,A$
PRINT A$


PRINT#1,"OUTPUT08;G0C5P1X"
PRINT#1,"OUTPUT08;D123456ZX"
PRINT#1,"OUTPUT08;E?"
PRINT#1,"ENTER08"
INPUT#2,A$
PRINT A$
```

send an illegal command to the I
request error status (Note: error
be on)

display shows E1-Unrecognized
(Error light should be off)
request error status

display shows E0 since error c
been cleared after reading error

send a command with an invalid
request error status (Note: error
be on)

display shows E2-Invalid Para
(Error light should be off)

configure all ports as outputs, se
send too much data for 1 port
request error status (Note: error
be on)

display shows E3-Conflict Erro
(Error light should be off)

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Format

The `Format` command determines the method by which input ar be described. Six data formats are available.

`F0`	ASCII Hexadecimal (4 bits per character)
`F1`	ASCII Character (4 bits per character)
`F2`	ASCII Binary (1 bit per character)
`F3`	ASCII Decimal (8 bits per number)
`F4`	Binary (each byte represents 8 bits)
`F5`	High Speed Binary (each byte represents 8 bits
`F?`	Return present data format

F0 Format - ASCII Hexadecimal

In the default `F0` format, the data is described in ASCII hexade character having a value from 0 thru 9 or A thru F. Each ASCII cha bits of data.

F0 Character	Decimal Equiv	F0 Character	Decimal Equi
0	0	8	8
1	1	9	9
2	2	A	10
3	3	B	11
4	4	C	12
5	5	D	13
6	6	E	14
7	7	F	15

Data received for output to the digital ports must be contained w and a suffix (`Z`). If the amount of data sent is less than the number of as outputs, the least-significant bits will contain the data sent and the bits will be cleared to logic zero. If the data sent is greater than th programmed for output or selected by the `Port (Pn)` command, the generate a conflict error (`E3`) and ignore the entire command string The Data Strobe output is pulsed for approximately 50 microseconds output on the selected port(s).

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When the Digital488/80 is addressed to talk (in Data Ready mode R
Inhibit, reads the data from all ports, unasserts Inhibit and outputs the
characters determined by the Bus Input/Output (Gn) and Port (Pn)
Leading zeros are not suppressed and the bus terminators are appended to
After output the Digital488/80 must be re-addressed to talk to perform
reads. EDR (in R1 or R2 mode) may also be used to capture data in this for

Example:

```
PRINT#1,"CLEAR08"                reset the Digital488/80
PRINT#1,"OUTPUT08;R0P0C2G2X"     configure ports 1 & 2 as output
PRINT#1,"OUTPUT08;F0X"           select ASCII Hexadecimal format
PRINT#1,"OUTPUT08;D4E6BZX"       output hexadecimal 4E6B to ports
PRINT#1,"ENTER08"
INPUT#2,A$                       read data from the Digital488/80
PRINT A$                         display shows 4E6B
```

F1 Format - ASCII Character

In the F1 format, the data is coded and transmitted in ASCII Characte
four least significant bits of each ASCII character representing four bits of d

F1 Character	Decimal Equiv	F1 Character	Decimal Equiv
0	0	8	8
1	1	9	9
2	2	:	10
3	3	;	11
4	4	<	12
5	5	=	13
6	6	>	14
7	7	?	15

Data received for output to the digital ports must be contained within
and a suffix (Z). If the amount of data sent is less than the number of bits p
as outputs, the least-significant bits will contain the data sent and the most
bits will be cleared to logic zero. If the data sent is greater than the num
programmed for output or selected by the Port (Pn) command, the Digital

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generate a conflict error (E3) and ignore the entire command string
The Data Strobe output is pulsed for approximately 50 microsecond
output on the selected port(s).

When the Digital488/80 is addressed to talk (in R0 mode) it ass
the data from all ports, unasserts Inhibit and outputs the numb
determined by the Gn and Pn commands. Leading zeros are not suppr
terminators are appended to the output. After output the Digita
re-addressed to talk to perform subsequent reads. EDR (in R1 or R2 r
used to capture data in this format.

Example:

```
PRINT#1,"CLEAR08"                reset the Digital488/80
PRINT#1,"OUTPUT08;C5G2R0P0X"     all ports are outputs, select
PRINT#1,"OUTPUT08;F1X"           select ASCII Character for
PRINT#1,"OUTPUT08;D4>6ZX"        send 4>6 to the Digital488/
PRINT#1,"ENTER08"
INPUT#2,A$                       read data from the Digital4
PRINT A$                         display shows 00000004>
PRINT#1,"OUTPUT08;D1??2ZX"       send 1??2 to the Digital48
PRINT#1,"ENTER08"
INPUT#2,A$                       read data from the Digital4
PRINT A$                         display shows 0000001??
```


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F2 Format - ASCII Binary

In the F2 format, the each data bit is described with an ASCII 0 or 1. formatted in two 4-bit multiples separated by semicolons.

F2 String	Decimal Equiv	F2 String	Decimal Equiv
0000;0000	0	0000;1001	9
0000;0001	1	0000;1010	10
0000;0010	2	0000;1011	11
0000;0011	3	0000;1100	12
0000;0100	4	0000;1101	13
0000;0101	5	0000;1110	14
0000;0110	6	0000;1111	15
0000;0111	7	1000;0001	129
0000;1000	8	1111;1111	255

Data received for output to the digital ports must be contained with (D) and a suffix (Z) and each 4-bit quantity must be separated by se Leading zeros are not required. If the amount of data sent is less than the bits programmed as outputs, the least-significant bits will contain the da the most-significant bits will be cleared to logic zero. If the data sent is g the number of bits programmed for output or selected by the Pn com Digital488/80 will generate a conflict error (E3) and ignore the entire string up to the next X. The Data Strobe output is pulsed for approxi microseconds after new data is output on the selected port(s).

When the Digital488/80 is addressed to talk (in R0 mode) it asse reads the data from all ports, unasserts Inhibit and outputs the number of determined by the Gn and Pn commands. Leading zeros are not suppress bus terminators are appended to the output. After output the Digital488/8 re-addressed to talk to perform subsequent reads. EDR (in R1 or R2 mode be used to capture data in this format.

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Example:

```
PRINT#1,"CLEAR08"                    reset the Digital488/80
PRINT#1,"OUTPUT08;C5G2R0P1X"         all ports are outputs, sel
PRINT#1,"OUTPUT08;F2X"               select ASCII/binary mo
PRINT#1,"OUTPUT08;D1;1011ZX"

                                     send binary data
PRINT#1,"ENTER08"
INPUT#2,A$                           read data from the Digit
PRINT A$                             display shows 0001;10
```

F3 Format - ASCII Decimal

In the F3 format, the data is described in decimal 8 bit multipl in ASCII. Each decimal number (0 to 255) to be output must semicolons.

F3 Number	Decimal Equiv	F3 Number	Decimal Equiv
000	0	008	8
001	1	009	9
002	2	010	10
003	3	020	20
004	4	100	100
005	5	200	200
006	6	210	210
007	7	255	255

Data received for output to the digital ports must be contained v and a suffix (Z). If the amount of data sent is less than the number of as outputs, the least-significant bits will contain the data sent and the bits will be cleared to logic zero. If the data sent is greater than th programmed for output or selected by the Pn command, the Di generate a conflict error (E3) and ignore the entire command string The Data Strobe output is pulsed for approximately 50 microseconds output on the selected port(s).

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When the Digital488/80 is addressed to talk (in R0 mode) it asserts Inh the data from all ports, unasserts Inhibit and outputs the number of determined by the Gn and Pn commands. Leading zeros are not suppressed a terminators are appended to the output. After output the Digital488/80 re-addressed to talk to perform subsequent reads. EDR (in R1 or R2 mode) m used to capture data in this format.

Examples:

```
PRINT#1,"CLEAR08"                    reset the Digital488/80
PRINT#1,"OUTPUT08;F3X"               select decimal mode
PRINT#1,"OUTPUT08;C5G2R0P0X"         all ports are outputs, select all port
PRINT#1,"OUTPUT08;D240;165ZX"        send data to the Digital488/80
PRINT#1,"ENTER08"                    read data from the Digital488/80
INPUT#2,A$
PRINT A$                             display shows 000;000;000;24
```

F4 Format - Binary

In the F4 binary format, no error checking is performed and caution exercised when using this mode to avoid locking the IEEE bus.

When addressed to listen, the Digital488/80 expects the "D" prefix fo five bytes of data beginning with PORT5 without the "Z" suffix. If any digita is configured as an input, the data to that input port will be ignored.

When the Digital488/80 is addressed to talk (in R0 mode) it asserts Inh the data from all ports, unasserts Inhibit and outputs 5 bytes beginning wit with EOI asserted on the last bye. Bus terminators, with the exception of EO appended to the output. After output the Digital488/80 must be re-addressed perform subsequent reads. EDR (in R1 or R2 mode) may also be used to captu this format.

F5 Format - High Speed Binary

In the F5 high speed binary format, the command interpreter is disabl

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addressed to listen, the Digital488/80 treats all bytes received as data
Digital I/O ports. Each time it receives five bytes or detects EOI asse
Data Strobe for approximately 15 microseconds. Data is expected in a
PORT3, PORT2, PORT1 sequence. If only two bytes are received,
on the second byte, the Digital488/80 will update PORT5 with the f
PORT4 with the second and pulse the Data Strobe. Since the interface
characters as data, no commands will be recognized.

To place the Digital488/80 in the F5 format, the 3 character str
be the last command sent to the interface without terminators. Any ch
to this command, such as carriage return or line feed, will be consid
output ports will reflect those character values. (see the following pro

When addressed to talk in this format it asserts Inhibit, reads
ports, unasserts Inhibit and outputs the binary data to the bus with E
fifth byte. When the last data byte is transferred, the data is read again
another data transfer. If Inhibit is used to sequence external hardw
pulse N+1 times; where N is the number of total (5 byte) data transf
the Digital488/80 does not have to be re-addressed to talk to read
times. EDR cannot be used to capture data in the F5 high speed binary

The only programmable method to exit the F5 high speed binar
clear (DCL) or Selected Device Clear (SDC). When received, it enab
interpreter and changes the format to F0. All other parameters rema
addition, the Clear output line is not pulsed by DCL or SDC when the

When either channel (or both) is in the F5 mode, a DCL or
channel will clear the F5 mode. It will not reset the interface. It will
out of the F5 mode and place it in the F0 mode.

Example:

```
PRINT#1,"OUTPUT08#3F5X"          put Channel 0 in F5 mode
PRINT#1,CHR$(255),CHR$(125)      send data
```

Note: The #3 tells DRVR488 to send only the 3 bytes F5X without te
was not done, the first data bytes to appear at the output of the Digita
CR LF or whatever terminators were selected.

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Bus Input/Output

The Bus Output command determines whether input port data, outp both input and output port data, or buffered data will be transmitted on the Digital488/80 is addressed to talk. The amount of data sent is dependen command.

The G0 default mode causes all input and output port data to be controller when addressed to talk. The G1 mode causes only data fro programmed as inputs to be returned when addressed to talk. The G2 mod data from ports programmed as outputs to be returned when addressed to t

The G3 mode causes data in the data buffer to be returned when addre Both input and output data (all 40 bits) are returned in this mode. If readings in the buffer is 0, the Digital488/80 will hold off the bus u transition of EDR and another reading has been collected and buffered. A transition, it will then return that newly collected reading.

If all ports are programmed as outputs with G1 selected and the Dig addressed to talk, nothing will be transmitted and the bus will hang. The c also cause the bus to hang with all ports programmed as inputs and G2 selec

G0	Input and output port data is sent when addressed to talk
G1	Only input port data is sent when addressed to talk
G2	Only output port data is sent when addressed to talk
G3	Buffered input and output data sent when addressed to talk
G?	Return present Bus Input/Output mode

Examples:

```
PRINT#1,"CLEAR08"
PRINT#1,"OUTPUT08;P0C1R0X"
PRINT#1,"OUTPUT08;G1X"
PRINT#1,"ENTER08"
INPUT#2,A$
PRINT A$
```

reset the Digital488/80
port1 as output, ports 2-5 as inpu
select only input ports for data

read data from the input ports
display shows FFFFFFFF (data
dependent on what is connected).

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Handshake

The Handshake control command enables software control of the independent of any other I/O operations. When the Digital488/80 command, the respective handshake line is pulsed for approximately It returns to its steady-state condition after pulsing. The `Invert (In` be used to change the active state of any of the handshake lines.

`H0`	The Clear line is pulsed
`H1`	The Strobe line is pulsed
`H2`	The Trigger line is pulsed
`H?`	Return last Handshake command executed

Example:

```
PRINT#1,"OUTPUT08;H1X"
```

pulse the Strobe line on Cha

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Invert

The `Invert` command is used to change the polarity of the handsh lines. At power up all handshake and control lines are active high (log volts). The `Invert` command can selectively change the polarity of handshake lines, and of the data lines. If multiple `Invert` commands a within the same string, then an `Execute` command (`X`) should be inclu each `Invert` command. An alternative is to add the values of each `Inver` desired, and send one command with the sum of the desired commands. T commands are ORed together as received. To delete any one command, it to program the default mode `I0`, then reprogram the desired commands.

`I0`	All control lines are active high, all data lines are high true
`I1`	Inhibit output is active low
`I2`	Trigger output is active low
`I4`	Data Strobe output is active low
`I8`	Clear output is active low
`I16`	Data is low true
`I32`	EDR input is falling-edge sensitive
`I64`	Service input is falling-edge sensitive
`I?`	Return last `Invert` command executed

Example:

`PRINT#1,"CLEAR08"`	reset the Digital488/80
`PRINT#1,"OUTPUT08;I32XI64X"`	select EDR and Service input as falling-edge sensitive

Note:

`PRINT#1,"OUTPUT08;I96X"`	performs the same function as abo

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End or Identify (EOI)

The EOI line is one of five interface management lines on the II used by a talker to indicate the end of a multiple byte transfer sequen can change the EOI mode by programming the Digital488/80 from t mode, the EOI line is asserted by the Digital488/80 on the last byte o string. In the `K1` mode the EOI function is disabled (except when modes [`F4` and `F5`]).

`K0`	EOI enabled, assert EOI on last byte transferred
`K1`	EOI disabled, do not assert EOI on last byte transferred
`K?`	Return present EOI selection

Examples:

```
PRINT#1,"OUTPUT08;K1X"
```
disables EOI on last byte

```
PRINT#1,"OUTPUT08;K?"
PRINT#1,"ENTER08"
INPUT#2,A$
PRINT A$
```
request EOI selection from

display shows K1

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Buffer

The Buffer command is used to clear the internal data buffer or to d number of readings in the buffer. It is used primarily with the Buffered D command (R2) although it may be used at any time to determine the buffer s

L0	Clear the internal data buffer
L?	Return number of port readings in the internal data buffer

Examples:

```
PRINT#1,"OUTPUT08;C0P0R2G3X"
```
buffer data to be sent when addressed to talk

collect some data

```
PRINT#1,"OUTPUT08;L?X"
PRINT#1,"ENTER08"
INPUT#2,COUNT$
COUNT$ = RIGHT$(COUNT$,4)
COUNT = VAL(COUNT$)
PRINT COUNT
```
request buffer status of Chan

display shows 24 (24 port readings in buffer)

```
DIM B(100)
FOR I = 1 TO COUNT
PRINT#1,"ENTER08"
INPUT#2,A$
B(I) = VAL(RIGHT$(A$,4))
NEXT I
```
store readings in an array

readings are stored as integer

```
PRINT#1,"OUTPUT08;L?X"
PRINT#1,"ENTER08"
INPUT#2,COUNT$
PRINT COUNT$
```
request buffer status

display shows L000 since a been read

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Service Request Mask (SRQ)

The Service Request (SRQ) Mask command is used by th alert the controller to one of several conditions described below. Request conditions can be enabled simultaneously by issuing then combining them in one command string. If multiple Mn comma within the same command string, each command should be followe (X) command. The programmed SRQ modes will remain enabled u disabled) command is sent, or the controller sends a Device Clear (Device Clear (SDC).

M0	SRQ is disabled
M1	SRQ on Service input transition
M2	SRQ on EDR input transition
M4	SRQ on bus error
M16	SRQ on Ready

M0 default mode disables the SRQ function, preventing the Di generating a Service Request.

M1 enables the Digital488/80 to generate a Service Request when line makes a transition. Refer to the Invert (I64) command programming the polarity of the Service input line.

M2 enables the Digital488/80 to generate a Service Request wh makes a transition. Refer to the Invert (I32) command programming the polarity of the EDR input line.

M4 enables the Digital488/80 to generate a Service Request occurs. The most common bus error is sending an invalid Digital488/80. For example, selecting an 'F6' format will cause the generate a Service Request when the M4 mode is selected.

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M16 enables the Digital488/80 to generate a Service Request w completed the execution of a set of commands from the bus controller. T used by the controller to assure the completion of a set of commands befo subsequent set of commands.

Like the Invert (In) commands, the Service Request Mask are also ORed together as received. To delete any one command, it is n program the default mode M0, then reprogram the desired commands.

Example:

```
PRINT#1,"CLEAR08"          reset the Digital488/80
PRINT#1,"OUTPUT08;M4X"     select SRQ on Bus error
PRINT#1,"OUTPUT08;F7X"     send an invalid command.

                           Note: ERROR and SRQ LEDs should i

PRINT#1,"CLEAR08"          reset the Digital488/80
PRINT#1,"OUTPUT08;M1XM4X"  select SRQ on Bus Error and
                           SRQ on Service Input Transition.

PRINT#1,"OUTPUT08;M5X"     This has the same effect as the comman
                           where M1X plus M4X equals M5X.
```


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Recall Configuration

The `Recall Configuration` command is used to load a p configuration from non-volatile RAM and use it as the present con argument of the command (`n`) may range from `0` to `100`. As ment `Save Configuration` command, configuration `0` is the power-o Any load of a configuration not previously saved with the `Save Co` command will configure the channel with the default setting for each `Format F0, Terminator Y0` etc.) Issuing an `O?` command configuration number last recalled.

`On`	Load configuration `n` for use as present channel configu
`O?`	Return present channel configuration number (`n`)

Example:

```
PRINT#1,"CLEAR08"
PRINT#1,"OUTPUT08;O5X"
```

reset the Digital488/80
load configuration 5 from non-vol for use as present configuration

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Port

The `Port` command determines which port is selected for data input/o default mode (`P0`), all ports are selected. The `P1` thru `P5` commands sele eight bit port.

It is recommended that the `Bus Input/Output (Gn)` command be u `P0` mode to select which type of port data (input or output) will be se Digital488/80 is addressed to talk. Data in modes `P1` throuth `P5` will be in in groups of eight bits.

`P0`	All five ports are selected
`P1`	Port 1 is selected
`P2`	Port 2 is selected
`P3`	Port 3 is selected
`P4`	Port 4 is selected
`P5`	Port 5 is selected
`P?`	Return present port selection

Example:

```
PRINT#1,"CLEAR08"          reset the Digital488/80
PRINT#1,"OUTPUT08;P4X"     select port 4
```


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Inhibit

The `Inhibit` control command allows software control of independent of any other I/O activities. The 'set' and 'clear' levels of th determined by the `Invert` (`In`) command.

`Q0`	Clear the Inhibit line (return to unasserted state)
`Q1`	Set the Inhibit line (place in the asserted state)
`Q?`	Return the last Inhibit command executed

Example:

```
PRINT#1,"CLEAR08"                reset the Digital488/80
PRINT#1,"OUTPUT08;Q1X"           set the Inhibit line on Chann
```


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Data Ready

The Data Ready command enables digital input port data to be la used in conjunction with the Service Request Mask (M2) command, Data Ready line can both latch the input data and generate an SRQ controller that new data is available.

In the default mode (R0) data is read when the Digital488/80 is addr In the R1 mode, it will wait for the selected External Data Ready (ED before reading the data and formatting it for output. If the Digital488/80 to talk before EDR is asserted, the bus will hang up until the EDR pulse EDR is asserted the data will remain latched until the interface is addresse the data is read by the controller. If EDR transitions again before the p buffered data has been read, the Digital488 will generate a Buffer Overr and ignore the EDR read request. The Inhibit line is asserted once for e operation for all format (Fn) modes except high speed binary (F5).

In the R2 mode, successive readings (up to 2000) may be latched and internal data buffer. The number of readings in the buffer may be found command. The EDR and Inhibit lines function in the same manner as in t If an attempt is made to store more than 2000 readings in the interna Digital488/80 will generate a Buffer Overrun error (E6).

After output in the F0 through F4 formats, the Digital488 must be re- talk to perform subsequent buffered output of EDR captured data. EDR ca to capture data in the F5 high speed binary format

The EDR signal must be at least 1 microsecond wide and should have time of less than 1.0 microsecond. The EDR line defaults to rising-edge s can be changed to falling-edge sensitive with the Invert command (I32).

R0	Data is not latched, and is read whenever the D is addressed to talk
R1	Data is latched on an EDR transition
R2	Data is latched and buffered on an EDR transition
R?	Return present programmed Data Ready mode

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Examples:

```
PRINT#1,"CLEAR08"
PRINT#1,"OUTPUT08;R1X"
```

reset the Digital488/80
data is read only after a risi
signal is applied to the EDR
(only 1 reading is stored in
be read before another
taken)

```
PRINT#1,"CLEAR08"
DIM B$(100)
PRINT#1,"OUTPUT08;C0P0X"
PRINT#1,"OUTPUT08;R2X"

PRINT#1,"OUTPUT08;G3X"
```

reset the Digital488/80
dimension an array to store
all ports are inputs, select a
data is latched and buffered
on EDR transition
buffered I/O data sent when

50 readings (1 reading per
transition) are taken an
internal buffer

```
FOR I = 1 TO 50

PRINT#1,"ENTER08"
INPUT#2,B$(I)
NEXT I
```

read the internal buffer and
the array

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Save Configuration

The Save Configuration command is used to save a non-volatile present channel configuration for later recall with the Recall Confi (On) command. The argument (n) for this command may range fron allowing 101 different configurations to be saved in battery-backed-up R power on, the default configuration will be the S0 configuration. The pre all output bits is read before saving. When the configuration is restore Recall Configuration (On) command, the outputs will be set to the they had at the time the Sn command was executed. If it is desired that the o to a specific state as part of a configuration, then the Data (Dn...Z) comm be used just prior to the Save Configuration command to insure that are set to the proper state upon retrieval of the configuration.

Sn	Save present configuration as configuration n (n = 0 to 100
S?	Return the last configuration number (n) saved. (not configuration loaded)

Example:

PRINT#1,"CLEAR08"	reset the Digital488/80
PRINT#1,"OUTPUT08;C5X"	configure all ports as outputs
PRINT#1,"OUTPUT08;F3X"	select ASCII Decimal data format
PRINT#1,"OUTPUT08;P4X"	select port 4
PRINT#1,"OUTPUT08;S57X"	save present channel configuration as configuration 57.

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Test

The Test command is used to verify that communication has been the Digital488/80. If the `T1` command is executed, the front panel TI light. If the `T0` command is then executed, the TEST LED should command can be used to test the connection between the IEEE Co Digital488/80.

`T1`	Turn on Test LED
`T0`	Turn off Test LED

Example:

```
PRINT#1,"CLEAR08"                reset the Digital488/80
PRINT#1,"OUTPUT08;T1X"           turn on the TEST LED
                                 TEST LED should illuminate
PRINT#1,"OUTPUT08;T0X"           turn off the TEST LED
                                 TEST LED should extinguish
```


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Status

The Status (U0) command will cause the Digital488/80 to send message when next addressed to talk. The status of the Digital488/80 may any time without interfering with normal operation. Any error conditions after the status string is read by the controller. The Status (Un) command controller to read any single bit from the I/O ports (n = 1 through 40).

U0	Send the Digital488/80 status when next addressed to talk
Un	Send the status of bit n (n = 1 through 40) when next addressed to
U?	Return last status command executed

The format of the status byte returned by the Digital488/80 after rece command is as follows:

```
*.*C#E#F#G#I###K#L####M###P#R#Y#
```

where each # equals the number corresponding to that command. T information *.* is the revision level of the Digital488/80 firmware.

Example:

```
PRINT#1,"CLEAR08"                reset the Digital488/80
PRINT#1,"OUTPUT08;U0X"           request the status of the Digital488/8
PRINT#1,"ENTER08"
INPUT#2,A$                       read the status byte
PRINT A$                         display =
                        1.0C0E0F0G0I000K0L0000M000P0R0S0
```

The status returned after receiving a U1 through U40 is an ASCII characte depending on the level of the line, and the state of the Invert (I16) comma

```
PRINT#1,"CLEAR08"                reset the Digital488/80
PRINT#1,"OUTPUT08;U22X"          request the status of bit 22
INPUT#2,A$                       read the status
PRINT A$                         display shows a 0 (dependent on the
                                 applied to the input)
```


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Below is a summary of the Status (U0) information.

C#	Configuration
C0	All ports are inputs
C1	Port 1 is an output, ports 2 thru 5 are inputs
C2	Ports 1 and 2 are outputs, ports 3 thru 5 are inputs
C3	Ports 1 thru 3 are outputs, ports 4 and 5 are inputs
C4	Ports 1 thru 4 are outputs, port 5 is an input
C5	All ports are outputs

E#	Error Message
0	No error
1	Unrecognized command (ex. W3)
2	Invalid command option (ex. F8)
3	Conflict (ex. attempting to output data to an input p
4	Not used
5	Non-Volatile RAM checksum error
6	Buffer Overrun error

F#	Data Format
F0	Hexadecimal
F1	ASCII
F2	Binary
F3	Decimal
F4	High Speed Binary

G#	Bus Input/Output mode
G1	Only Input port data sent when addressed to talk
G2	Only Output port data sent when addressed to talk
G3	Buffered port data sent when addressed to talk

I###	Invert Control Lines
I0	All control and data lines are active high
I1	Inhibit output is active low
I2	Trigger output is active low
I4	Data Strobe output is active low
I8	Clear output is active low

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I16	Data is active low
I32	EDR input is fallling edge sensitive
I64	Service input is falling edge sensitive

Note: the status indication reflects the sum of all received Invert commands.

K#	End Or Identify
K0	EOI enabled
K1	EOI disabled

L####	Buffer Status #### = number of readings in the buffer (

M##	Service Request
M0	SRQ is disabled
M1	SRQ on Service input transition
M2	SRQ on EDR input transition
M4	SRQ on Bus error
M16	SRQ on Ready

Note:the status indication reflects the sum of all received Service Request Mas

P#	Selected Port
P0	All ports selected
P1	Port 1 selected
P2	Port 2 selected
P3	Port 3 selected
P4	Port 4 selected
P5	Port 5 selected

R#	Data Ready
R0	Data is not latched, but is read when Digital 488 is addressed to talk
R1	Data is latched on EDR transition
R2	Data is latched and buffered on EDR transition

Y#	Terminator
Y0	CR LF
Y1	LF CR
Y2	CR only
Y3	LF only

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View Configuration

The View Configuration command is used to look at a configu saved without loading it for use as the present configuration. In command, the Digital488/80 will return a string in the following form

```
S###C#F#G#I###K#M###P#R#Y#D0000000000Z
```

where each # equals the option for that command saved configuration. Data in between the D and Z is depende the I/O lines at the time the configuration was saved.

Example:

```
PRINT#1,"CLEAR08"                reset the Digital488/80
PRINT#1,"OUTPUT08;V12X"          view configuration 12
PRINT#1,"ENTER08"
INPUT#2,A$
PRINT A$                         display shows
                        S018C5F2G2I000K1M016P0R1Y2
```

This message is interpreted as follows:

S018	Configuration 18
C5	All ports are outputs
F2	ASCII Binary data format
G2	Only output port data sent when addres
I0	Data lines are active high
K1	EOI disabled
M16	SRQ on Ready
P0	All ports are selected
R1	Data is latched on EDR transition
Y2	Terminator is CR only
D0000000000Z	All I/O lines are low

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View Version

The `View Version` command is used to look at the firmware revis
the ROM. In response to this command, the Digital488/80 will return a nu
following format *.* where each * is a 1 digit number. The `Execute` (X
is not needed since the `View Version` command is a query command.

Examples:

`PRINT#1,"CLEAR08"`	reset the Digital488/80
`PRINT#1,"OUTPUT08;V?"`	request firmware revision level
`PRINT#1,"ENTER08"`	read data from the Digital488/80
`INPUT#2,A$`	
`PRINT A$`	display shows `1.0` (or higher)

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Execute

Commands sent to the Digital488/80 will result in no actio instructed to execute these commands. This is done by sending an X, character of a command string. Commands sent without an X are st buffer until an X is received. Any number of Execute commands m the same command string. Certain commands, such as Bit Set (An) each command in a string if more than one of that command is within

Examples:

`PRINT#1,"CLEAR08"`	reset the Digital488/80
`PRINT#1,"OUTPUT08;F2"`	send "F2" to the Digital48 input buffer
`PRINT#1,"OUTPUT08;X"`	instruct the Digital488/80 command input buffer
`PRINT#1,"OUTPUT08;A1XA2X"`	two Bit Set (An) comma same string, requiring an X command.

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Terminator

The IEEE 488 bus terminator defaults at power-on to the Terminat saved in configuration 0 (the power-on configuration). It also may be p for any combination of Carriage Return (CR) and Line Feed (LF). The Y0 most commonly accepted terminator, CR-LF. Y1 reverses the sequence to s Y2 sends CR only and Y3 sends LF only.

Y0	CR LF
Y1	LF CR
Y2	CR only
Y3	LF only
Y?	Return present Terminator selection

Example:

```
PRINT#1,"OUTPUT08;Y3X"
```

select line feed terminator

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Query

All Digital488/80 commands offer a `Query` (`?`) option which determine the present configuration or mode of a command previous use this option, the first letter of the command is used followed by a q Any number of these query commands may be combined into one st user to construct a specialized status command requesting the Digital only that information which is of interest for a given application. Th command is not needed when using the `Query` option.

`?` Return the present configuration or mode of the command

Examples:

```
PRINT#1,"CLEAR08"          reset the Digital488/80
PRINT#1,"OUTPUT08;M4X"     select SRQ on Bus error
PRINT#1,"OUTPUT08;M?"      determine last M command executed
PRINT#1,"ENTER08"          read data from the Digital488/80
INPUT#2,A$
PRINT A$                   display shows M4


PRINT#1,"OUTPUT08;U0X"     request the status of Channel 1
PRINT#1,"ENTER08"          read data from the Digital488/80
INPUT#2,A$
PRINT A$                   display shows status message
                          *.*C#E#F#G#I###K#L####M###
```

Using the `Query` command to return the same status mess

```
PRINT#1,"OUTPUT08;V?C?E?F?G?I?K?L?M?P?R?S?Y?X"
                           request the status of Channel 1
PRINT#1,"ENTER08"          read data from the Digital488/80
INPUT#2,A$
PRINT A$                   display shows status message
                             *.*C#E#F#G#I###K#L####M###
```


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Serial Poll Status Byte

The Serial Poll Status byte is sent upon receiving the serial po command from the controller. Refer to the Service Request Mask (Mr description for details on how the Serial Poll byte is affected. To enable reflect the true status of the device, the appropriate Mn command must be Below is a description of the significance of each bit in the Serial Poll Status

Bit Location	Value	(SRQ Bit Value if set to logic 1)
DIO1 (LSB)	1	Service Input transition
DIO2	2	EDR input transition
DIO3	4	Bus error
DIO4	8	Not used,always 0
DIO5	16	Ready for more commands
DIO6	32	Not used, always 0
DIO7	64	Service Request bit
DIO8 (MSB)	128	not assigned, always 0

Serial Poll Bit Description

DIO1 When enabled by the M1 command, DIO1 is set by a transition on Input line (active transition state determined by the Inver command. DIO1 is cleared after the controller serial polls the Digi

DIO2 When enabled by the M2 command, DIO2 is set on an EDR trans transition state determined by the Invert (I32) command). DIO after the controller serial polls the Digital488/80.

DIO3 DIO3 is set when an invalid command is sent to the Digital488/8 command will enable a Service Request to occur when an invalid received. The bit is cleared after the controller sends a Sta command and reads the status string from the Digital488/80.

DIO4 DIO4 is not used, and is always a logic zero.

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DIO5 The DIO5 bit is set after an entire command string has b processed by the Digital488/80. The bit is cleared while the processing commands which have been received from the used with the M16 command, a Service Request will also be g DIO5 bit is set. An Execute (X) command must be receive bit can be cleared.

DIO6 DIO6 is not used, and is always a logic zero.

DIO7 When the Digital488/80 generates a Service Request, the DIO This is used by the controller to determine that the Serv generated by the Digital488/80.

DIO8 DIO8 is not used, and is always a logic zero.

Example:

```
PRINT#1,"CLEAR08"          reset the Digital488/80
PRINT#1,"OUTPUT08;M4X"     select SRQ on Bus error
PRINT#1,"OUTPUT08;F7X"     send an invalid bus comman
                           ERROR and SRQ LEDs sho
PRINT#1,"SPOLL08"          display should be 84 (64+16
```

64 denotes the Digital488/80 was the source of the SRQ. 16 denotes the READY for more commands. 4 denotes a Bus error.

When serial polled,the SRQ LED will turn off.

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IEEE 488 Primer

4.1 HISTORY

The **IEEE 488** bus is an instrumentation communication bus Institute of Electrical and Electronic Engineers in 1975 and revise **Digital488** conforms to this most recent revision designated **IEEE**

Prior to the adoption of this standard, most instrumentation offered their own versions of computer interfaces. This placed the b hardware design on the end user. If his application required the pro different manufacturers, then he might need to design several differe software interfaces. The popularity of the **IEEE 488** interface (some **General Purpose Interface Bus** or **GPIB**) is due to the total spec electrical and mechanical interface as well as the data transfer and c The use of the **IEEE 488** standard has moved the responsibility c design of the interface to design of the high level software that is measurement application.

4.2 GENERAL STRUCTURE

The main purpose of the **GPIB** is to transfer information betwe devices. A device can either be an instrument or a computer. Before transfer can take place, it is first necessary to specify which will do t data) and which devices will be allowed to listen (receive data). The will talk and who will listen usually falls on the **System Controller** w on, the **Active Controller**.

The **System Controller** is similar to a committee chairman. committee, only one person may speak at a time and the chairman is recognizing members and allowing them to have their say. On the which is recognized to speak is the **Active Talker**. There can only be time if the information transferred is to be clearly understood by all. T the floor" to that device is called **Addressing to Talk**. If the committ not attend the meeting, or if other matters require his attention, he can a chairman to take control of the proceedings. For the **GPIB**, this dev **Active Controller**.

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At a committee meeting, everyone present usually listens. This is not th the **GPIB**. The **Active Controller** selects which devices will listen and co other devices to ignore what is being transmitted. A device is instructed being **Addressed to Listen**. This device is then referred to as an **Active** Devices which are to ignore the data message are instructed to **Unlisten**.

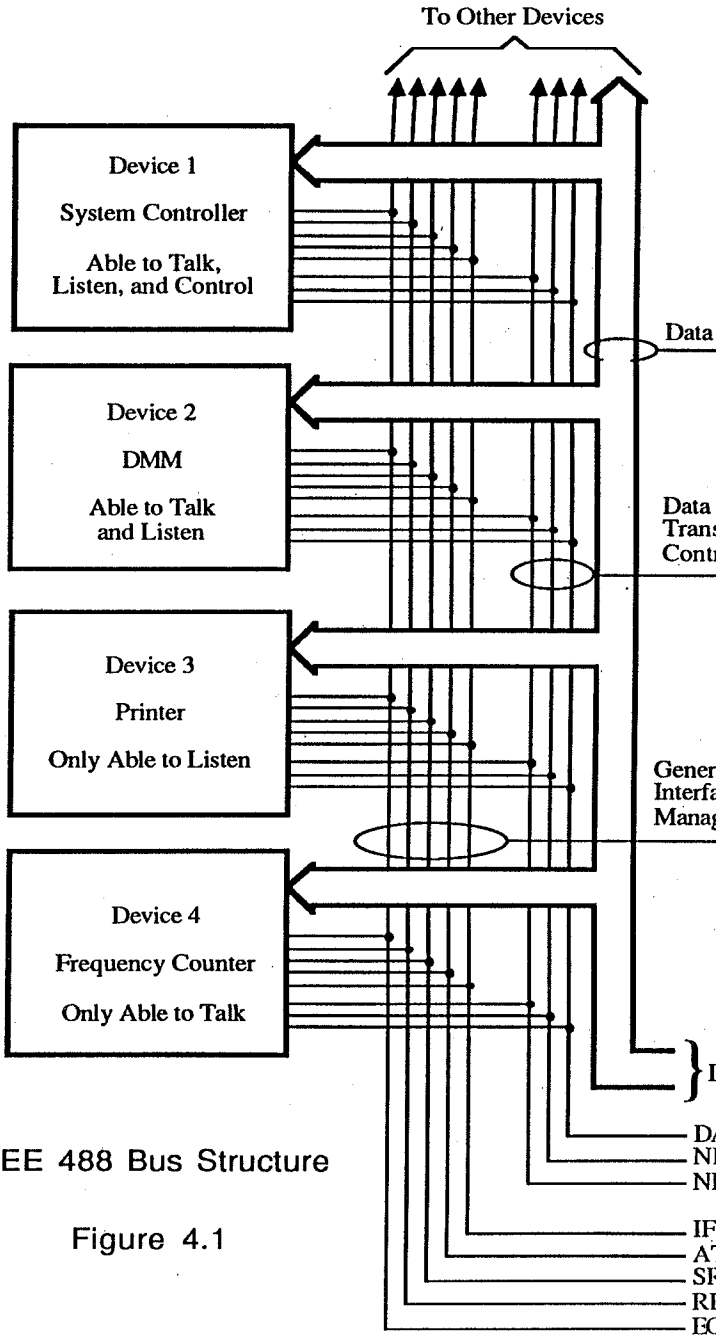
The reason some devices are instructed to **Unlisten** is quite simple. college instructor is presenting the day's lesson. Each student is told to raise if the instructor has exceeded their ability to keep up while taking notes. raised, the instructor stops his discussion to allow the slower students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

The **GPIB** transfers information in a similar way. This method of data called **handshaking**. More on this later.

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.

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IEEE 488 Bus Structure

Figure 4.1

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4.3 SEND IT TO MY ADDRESS

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

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

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

4.4 BUS MANAGEMENT LINES

Five hardware lines on the **GPIB** are used for bus management. Signa lines are often referred to as **uniline** (single line) commands. The signals low, i.e. a low voltage represents a logic "1" (asserted), and a high voltage r logic "0" (unasserted).

4.4.1 Attention (ATN)

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

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4.4.2 Interface Clear (IFC)

The **IFC** line is used only by the **System Controller**. It is all bus devices in a known state. Although device configurations command usually places the devices in the Talk and Listen Idle s **Active Talker** nor **Active Listener**).

4.4.3 Remote Enable (REN)

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

4.4.4 End or Identify (EOI)

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

The **Active Controller** also uses **EOI** to perform a **Par** simultaneously asserting **EOI** and **ATN**.

4.4.5 Service Request (SRQ)

When a device desires the immediate attention of **Controller** it asserts **SRQ**. It is then the Controller's resp determine which device requested service. This is accomplished **Poll** or a **Parallel Poll**.

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4.5 HANDSHAKE LINES

The **GPIB** uses three handshake lines in an "I'm ready - Here's the da it" sequence. This handshake protocol assures reliable data transfer, determined by the slowest Listener. One line is controlled by the Talke other two are shared by all Active Listeners. The handshake lines, like the **488** lines, are active low.

4.5.1 Data Valid (DAV)

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

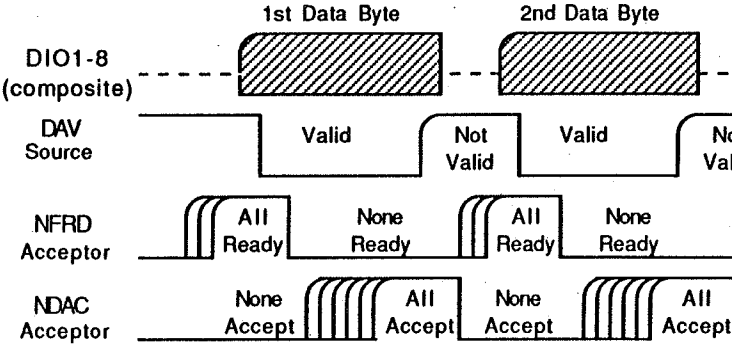
4.5.2 Not Ready for Data (NRFD)

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

4.5.3 Not Data Accepted (NDAC)

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

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IEEE Bus Handshaking

4.6 DATA LINES

The **GPIB** provides eight data lines for a bit parallel/byte ser
These eight data lines use the convention of **DIO1** through **DIO8** inst
designation of **D0** to **D7**. The data lines are bidirectional and are active

4.7 MULTILINE COMMANDS

Multiline (bus) commands are sent by the **Active Controller** c
with **ATN** asserted. These commands include addressing command
Untalk and Unlisten.

4.7.1 Go To Local (GTL)

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

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4.7.2 Listen Address Group (LAG)

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

4.7.3 Unlisten (UNL)

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

4.7.4 Talk Address Group (TAG)

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

4.7.5 Untalk (UNT)

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

4.7.6 Local Lockout (LLO)

Issuing the **LLO** command prevents manual control of the instrum functions. ($11)

4.7.7 Device Clear (DCL)

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

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4.7.8 Selected Device Clear (SDC)

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

4.7.9 Serial Poll Disable (SPD)

The **SPD** command disables all devices from sending thei status byte. ($19)

4.7.10 Serial Poll Enable (SPE)

A device which is Addressed to Talk will output its Serial Po after **SPE** is sent and **ATN** is unasserted. ($18)

4.7.11 Group Execute Trigger (GET)

This command usually signals a group of devices to begin triggered action. This allows actions of different device simultaneously. ($08)

4.7.12 Take Control (TCT)

This command passes bus control responsibilities from **Controller** to another device which has the ability to control. ($0

4.7.13 Secondary Command Group (SCG)

These are any one of the 32 possible commands (0 to 31) i They must immediately follow a talk or listen address. ($60 to $7F

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4.7.14 Parallel Poll Configure (PPC)

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

4.7.15 Parallel Poll Unconfigure (PPU)

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

4.8 MORE ON SERVICE REQUESTS

Most of the commands covered, both uniline and multiline, are the res of the **Active Controller** to send and the bus devices to recognize. Mo happen routinely by the interface and are totally transparent to the system pr Other commands are used directly by the user to provide optimum system c the uniline commands, **SRQ** is very important to the test system and th designer has easy access to this line by most devices. Service Request is the which a bus device can signal to the **Controller** that an event has occu similar to an interrupt in a microprocessor based system.

Most intelligent bus peripherals have the ability to assert **SRQ**. A D assert it when its measurement is complete, if its input is overloaded or fo assortment of reasons. A power supply might **SRQ** if its output has curre This is a powerful bus feature that removes the burden from the **System** to periodically inquire, "Are you done yet?". Instead, the **Controller** says, told you to do and let me know when you're done" or "Tell me when so wrong."

Since **SRQ** is a single line command, there is no way for the **Con** determine which device requested the service without additional informa information is provided by the multiline commands for **Serial Poll** and **Poll**.

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4.8.1 Serial Poll

Suppose the **Controller** receives a service request. For t
let's assume there are several devices which could assert
Controller issues an **SPE** (Serial Poll enable) command to
sequentially. If any device responds with DIO7 asserted it ind
Controller that it was the device that asserted **SRQ**. Often tim
bits will indicate why the device wanted service. This **Ser**
sequence, and any resulting action, is under control of the softwa

4.8.2 Parallel Poll

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

Of the two polling types, the **Serial Poll** is the most popular du
determine the who and why. In addition, most devices support **Serial**

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Service Information

5.1 Factory Service

IOtech maintains a factory service center in Cleveland, Ohio. encountered in using the **Digital488/80** you should first telephone th problems can be resolved by discussing the problems with our applicat If the problem cannot be solved by this method, you will be instructed return procedure.

5.2 Theory of Operation

The Heart of the **Digital488/80** is a 6809 microprocessor [U10 8K bytes of firmware EPROM [U102] and 32K bytes of battery-b [U103]. Interface to the IEEE 488 bus is accomplished by a 9914 interfa A 65C22 [U104] generates real-time interrupts for the firmware opera also drives the front panel LEDs.

The digital I/O prts are controlled through 6821 interface chips High-voltage, high-current output capability is optionally provided through 74HCTLS240s and ULN2803A peripheral drivers [U116 - U1

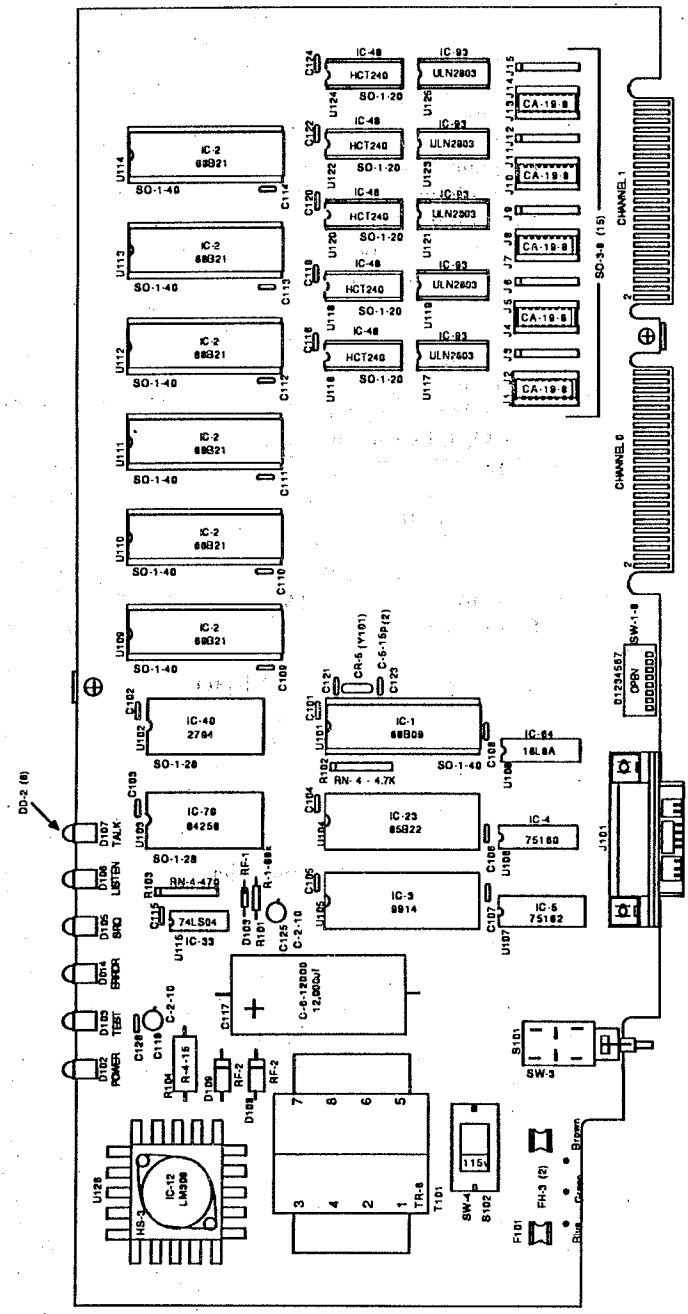
Power is supplied by an on-board transformer and full-wave recti to the required +5 volts is provided by an LM309K [U126].

The Memory space allocation on the Digital488/80 is...

Address	Device	Part Number	Function
$0000-$7FFF	U103	84256	32K x 8 R/
$8010-$8014	U109	6821	Digital I/C
$8020-$8024	U110	6821	Digital I/C
$8040-$8044	U111	6821	Digital I/C
$8080-$8084	U112	6821	Digital I/C
$8100-$8104	U113	6821	Digital I/C
$8200-$8204	U114	6821	Digital I/C
$8800-$8810	U104	65C22	Timer, Dig
$9000-$9907	U105	TMS9914A	IEEE488 I
$E000-$FFFF	U102	2764	Programm

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5.3 Digital488/80 Component Layout



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5.4 Digital488/80 Replaceable Parts List

Schematic	Part Number	Description
C101-C116	C-5-.1	Ceramic, 25v
C118,C124	C-5-.1	Ceramic, 25v
C120-C122	C-5-.1	Ceramic, 25v
C126	C-5-.1	Ceramic, 25v
C121,C123	C-5-15p	Ceramic, 25v
C119,C125	C-2-10	Electrolytic, 25v
C117	C-6-12000	Electrolytic, 25v
Not shown	CN-35	Power Connector
D103	RF-1	Small Signal Diode
D108-D109	RF-2	3A Diode
D102-D107	DD-2	Red PC Mount
F101	FH-3	Fuse Clip
Not shown	FH-4	Fuse Holder
J101	CN-2	IEEE 488 Connector
R101	R-1-68K	68KΩ, 1/4w carbon
R104	R-4-15	15 Ω, 2W
R102	RN-4-4.7K	4.7KΩ x 7 SIP
R103	RN-2-470	470Ω x 5 SIP
S101	SW-3	DPDT Push-Push
S102	SW-4	DPDT Slide 110/220
T101	TR-6	Transformer 10v @1.2A
SW-1-8	SW-1-8	8 Pole Piano Switch
U108	Digital488/80-600	Programmed EPROM
U104	IC-23	65B22 Versitile Interface Adapter
U106	IC-4	SN75160BN IEEE Driver
U107	IC-5	SN75162BN IEEE Driver
U113	IC-33	74LS04 Hex Inverter
U101	IC-1	MC68B09P Microprocessor
U126	IC-12	LM309 Regulator, + 5v
U109-U114	IC-2	68B21 PIA
U105	IC-3	TMS9914ANL IEEE Controller
U115	IC-33	74LS04
U116,U118	IC-48	74LS240 Octal Buffer
U120,U122	IC-48	74LS240 Octal Buffer
U124	IC-48	74LS240 Octal Buffer
U117,U119	IC-93	ULN2803 Relay Drivers
U121,U123	IC-93	ULN2803 Relay Drivers
U125	IC-93	ULN2803 Relay Drivers
Y101	CR-5	8.0000 MHz Crystal

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Command	Code	Description
Bit Set	**An**	Set bit n (n = 1 thru 40) of selected cha
	A?	Return n (1 thru 40) of last bit set of se
Bit Clear	**Bn**	Clear bit n (1 thru 40) of selected char
	B?	Return n (1 thru 40) of last bit cleared channel
Buffer	**L0**	Clear data buffer
	L?	Return number of readings in the data
Bus Input/Output	**G0**	Input and Output port data sent when a
	G1	Only Input port data sent when addre
	G2	Only Output port data sent when addr
	G3	Buffered data sent when addressed to
	G?	Return present Bus Output mode
Configure	**C0**	All ports of selected channel (0 or 1)
	C1	Port 1 is an output, ports 2 thru 5 are i
	C2	Ports 1 and 2 are outputs, ports 3 thru
	C3	Ports 1 thru 3 are outputs, ports 4 and
	C4	Ports 1 thru 4 are outputs, port 5 is an
	C5	All ports of selected channel are outpu
	C?	Return present port configuration of s
Data	**Dn..Z**	Data to be output on selected channel (entered after "D" and terminated by "Z
Data Ready	**R0**	Data is read when system is addressed
	R1	Data is latched on EDR transition
	R2	Data is latched and buffered on EDR
	R?	Return present Data Ready mode
EOI	**K0**	EOI enabled
	K1	EOI disabled
	K?	Return present EOI selection
Error	**E?**	Return and clear present error conditio

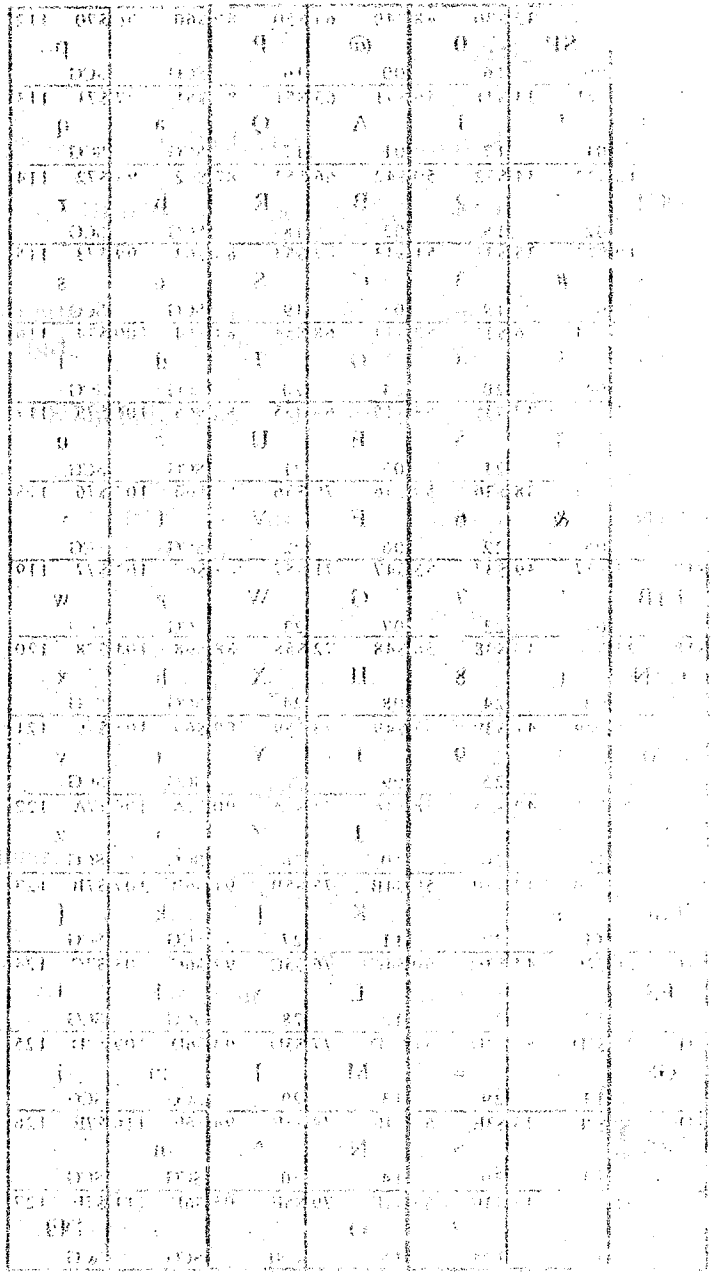
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Command	Code	Description
Execute	**X**	Execute preceding command string
Format	**F0**	ASCII Hexadecimal
	F1	ASCII Character
	F2	ASCII Binary
	F3	ASCII Decimal
	F4	Binary
	F5	High Speed Binary
	F?	Return present data format
Handshake	**H0**	Pulse the Clear line of selected channel (0
	H1	Pulse the Strobe line of selected channel
	H2	Pulse the Trigger line of selected channel
	H?	Return last handshake command executed
Inhibit	**Q0**	Clear Inhibit line of selected channel (0 or
	Q1	Set Inhibit line of selected channel
	Q?	Return last Inhibit command executed
Invert	**I0**	All control line outputs of selected channel are active high data lines are high true
	I1	Inhibit output is active low
	I2	Trigger output is active low
	I4	Data Strobe output is active low
	I8	Clear output is active low
	I16	Data is low true
	I32	EDR input is falling-edge sensitive
	I64	Service input is falling-edge sensitive
	I?	Return last Invert command executed
Port	**P0**	All ports selected on channel m (m = 0 or 1
	P1	Port 1 selected of channel m
	P2	Port 2 selected of channel m
	P3	Port 3 selected of channel m
	P4	Port 4 selected of channel m
	P5	Port 5 selected of channel m
	P?	Return present port selection of channel m

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Command	Code	Description
Query	?	Request command selection or device
Recall Configuration	On	Load configuration n (n = 0 to 100) f present configuration
View Configuration	Vn	Return configuration n for examinatio loading it for use as the current config
View Version	V?	Return revision level of Digital488/80
Save Configuration	Sn	Save present configuration as configuration n (n = 0 to 100)
	S?	Return last configuration (n) saved
SRQ Mask	M0	SRQ is disabled
	M1	SRQ on Service Input transition
	M2	SRQ on EDR input transition
	M4	SRQ on bus error
	M16	SRQ on Ready
	M?	Return present SRQ configuration
Status	U0	Send Status information of selected ch when next addressed to talk (*.*C#E#F#G#I###K#L####M###P#
	Un	Read state of bit n (1 through 40) of se
	U?	Return last Status command executed
Terminator	Y0	CR LF
	Y1	LF CR
	Y2	CR only
	Y3	LF only
	Y?	Return present Terminator mode
Test	T0	Turn off Test LED
	T1	Turn on Test LED

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

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Keyboard Controller Program

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Keyboard Controller Progra

The Keyboard Controller Program is a simple BASIC progra commands from the keyboard and sends them to Personal488. It th responses from Personal488 on the screen. The Keyboard Controll convenient method of exercising the Digital488/80 and becoming fa commands and their actions.

```
10 ' Personal488 Keyboard Controller Program
20 '
30 ' For use with the IOtech Personal488
40 ' IEEE 488 interface
50 '
100 OPEN "\DEV\IEEEOUT" FOR OUTPUT AS #1
110 IOCTL#1,"BREAK"
120 PRINT#1,"RESET"
130 OPEN "\DEV\IEEEIN" FOR INPUT AS #2
140 '
150 ON ERROR GOTO 300
160 PRINT#1,"ERROR OFF"
170 '
180 LINE INPUT "CMD> ",CMD$
190 PRINT#1,CMD$
200 '
210 IF IOCTL$(2)<>"1" THEN 180
220 PRINT INPUT$(1,2);
230 GOTO 210
290 '
300 ' Error Handler
310 '
320 IOCTL#1,"BREAK"
330 PRINT#1,"STATUS"
340 INPUT#2,ST$
350   PRINT   CHR$(7);"Error   #";MID$(ST
";MID$(ST$,27)
360 RESUME NEXT
```


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