

# Four Channel IEEE 488/Serial Converter Instruction Manual

Part No. GE390-901

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## Introduction

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### 1.1 General Description

The Four Channel IEEE 488/Serial Converter is a four port serial RS-232 or RS-422 interface to the IEEE 488 bus. Each port can be independently programmed for baud rate, stop bits, data bits, parity and handshaking. The Converter can inform the bus controller that it has received data through the use of the SRQ facility or by direct inquiry of the number of serial input bytes available.

The Converter uses a command address in which the serial port parameters may be specified and serial port or command status is returned. The serial data is then sent and received on a separate address or addresses, providing data transparency between the serial device and host controller.

The Converter serial port configuration may be saved in non-volatile RAM to be used as the default settings when next powered on, allowing a once only configuration of the device for many applications.

### 1.2 Specifications

#### Each Serial Interface:

EIA RS-232C:	AB, BA, BB, CA, CB
EIA RS-422:	Balanced Voltage
Character Set:	Asynchronous bit serial
Duplex:	Full
Word Length:	7 or 8 data bits
Stop Bits:	1 or 2
Parity:	None, odd, or even
Baud Rates:	110, 300, 600, 1200, 1800, 2400, 3600, 4800, 7200, 9600, 19200, or 16x external clock. The sum of all four channel baud rates not to exceed 38,400 bits/second.
Terminator:	Any 8 bit value
Handshaking:	Clear to Send/Request to Send (CTS/RTS), XON/XOFF, none
I/O buffers:	56,000 characters - dynamically allocated
Output Voltage:	$\pm 5$ volts minimum (RS-232C) 5 volts typical (RS-422A)
Input Voltage:	$\pm 3.0$ volts minimum: $\pm 15$ volts maximum
Connector:	9-pin sub-D male.

**IEEE 488-1978**

**Implementation:** SH1, AH1, T6, TE8, L4, LE4, SR1, RL0, PP0, DC1, DT0, C0, E1  
**Terminators:** Selectable CR, LF, LF-CR and CR-LF with EOI  
**Connector:** Standard IEEE 488 connector with metric studs  
**Programmable:** IEEE Terminators, Serial Terminator, EOI, SRQ Mask, Data Port, Baud Rate, Word Length, Parity, Stop Bits, Handshake Type, Handshake Control

**General**

**Indicators:** LEDs for Talk, Listen, SRQ, Error, Send, and Receive for each Port, and Power  
**Power:** 105-125V or 210-250V; 50-60 Hz, 20 VA Max.  
**Dimensions:** 425mm wide x 45mm high x 203mm deep  
(16.75 in x 1.75 in x 8 in )  
**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 addressing mode and IEEE address, and serial port configuration jumpers (internal).

Specifications subject to change without notice.

### 1.3 Abbreviations

The following IEEE 488 abbreviations are used throughout this manual.

addr n	IEEE bus address "n"
ATN	Attention line
CA	Controller Active
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

## Getting Started

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### 2.1 Inspection

Your Four Channel IEEE 488/Serial Converter was carefully inspected, both mechanically and electrically, prior to shipment. When you receive the Converter, carefully unpack all items from the shipping carton and check for any obvious signs of physical damage which may have occurred during shipment. Report any such damage to the shipping agent immediately. Retain all shipping materials in the event that shipment back to the factory becomes necessary.

Every Converter is shipped with the following....

- Four Channel IEEE 488/Serial Converter
- Instruction Manual
- Accessory Kit which includes:
  - Power Cable
  - Spare 1/4 amp Fuse
  - Rubber Feet (4)
  - Rack Ears (2)
  - Rack Ear Screws (4)
  - 9 Pin Female Connector (4)
  - Hood for Female Connector (4)

### 2.2 Front and Rear Panels

Pictured in Figure 2.1 are the front and rear panels of the Converter. The front panel houses thirteen LED indicators which display the status of the Converter. The function of each indicator is described below.

**SEND (1-4)** ON when the designated port is transmitting data to the serial interface, OFF when the designated port transmitter is idle.

**RECEIVE (1-4)** ON when the designated port is receiving data from the serial interface, OFF when the port 1 receiver is idle.



TALK	ON when the Converter is in the Talker active state, OFF when the Converter is in the Idle or Listener active state
LISTEN	ON when the Converter is in the Listener active state, OFF when the Converter is in the Idle or Talker active state
SRQ	ON when the Converter has generated a service request, OFF when no SRQ is pending. (See Section 3 for more information.)
ERROR	ON when an error has occurred, OFF when no error condition exists. (See Section 3 for more information.)
POWER	ON when power is applied to the Converter and the power switch on the back panel is in the ON position (depressed). OFF when power is not present or the internal fuse or power supply is faulty.

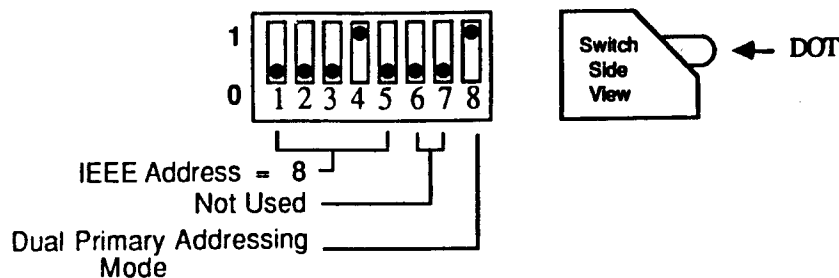
Mounted on the rear panel of the Converter are the power cable connector, the power on/off switch, the IEEE 488 bus connector, the addressing mode/address switch and four 9 pin Sub-D male connectors, one for each serial port.

### 2.3 IEEE 488 Bus Configuration

The Converter must be user-configured for proper operation over the IEEE 488 bus. Bus configuration includes selection of addressing mode, bus address, and bus terminator. Each of these configuration selections are described below.

The Converter bus addressing mode and bus address are determined by the eight position switch located on the rear panel (see Figure 2-1). Switch positions SW1-1 through SW1-5 determine the IEEE address (0 - 30); SW1-6 and SW1-7 are not used; SW1-8 determines the addressing mode (dual primary or secondary). SW1 is set at the factory for IEEE address 8 and dual primary addressing mode as shown in Figure 2-2. SW1 switch settings are read only when the Converter is powered on and should only be set before power is applied. If it is necessary to change the switch setting, first be sure the power cord is disconnected from AC line. Then, with a small flat blade screwdriver, slide each switch into the position desired. Refer to Sections 2.3.1 and 2.3.2 for a discussion of the various mode and address selections.

Figure 2-2. SW1 Factory Default Setting

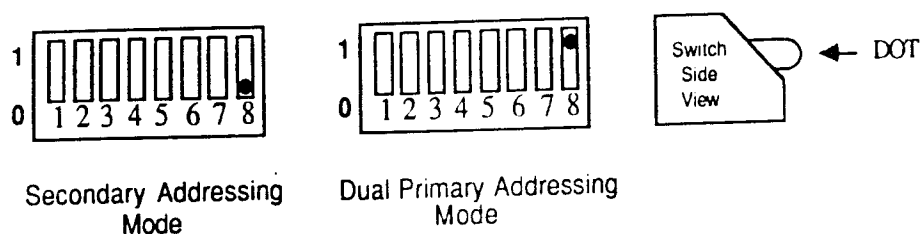


The bus terminator is determined by the last Bus Terminator ( $Y_n$ ) command sent to the bus as described in Section 3. The bus terminator can be set to any of four available options: CR only ( $Y_0$ ), LF only ( $Y_1$ ), CR LF ( $Y_2$ ), and LF CR ( $Y_3$ ). On initial power-up, the default value is ( $Y_2$ ) CR LF. To change the power-up default terminator, first set the terminator using the  $Y_n$  command. Then save the selection using the Save Configuration ( $S_1$ ) command as described in Section 3. Refer to section 2.3.3 for a discussion of the bus terminator.

### 2.3.1 Converter Addressing Modes

To provide transparent serial data communications, the Converter occupies either 1 or 2 primary addresses on the IEEE 488 bus, dependent upon the addressing mode used. The two available addressing modes are secondary and dual primary. One address is used for sending commands to and receiving status from the Converter. The other addresses are used exclusively for serial data transfer. The addressing mode is determined by position 8 of SW1 (located on the rear panel). Switch position SW1-8 for each mode is shown in Figure 2-4.

Examples are given at the end of this section to illustrate the differences between the two modes and how each is used to communicate with the Converter.

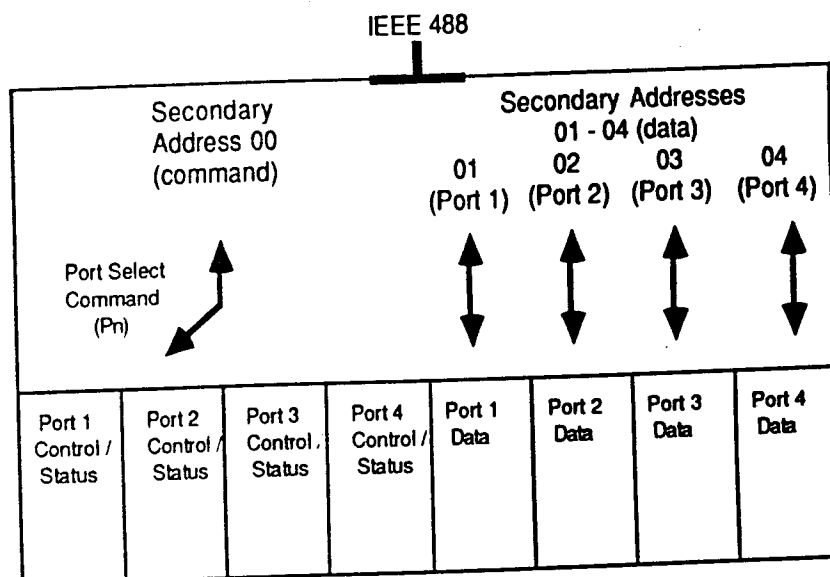
**Figure 2-3. SW1 View for Addressing Mode Selection**

### 2.3.1.1 Secondary Addressing Mode

When Secondary addressing mode is selected, communications with the Converter is accomplished by using the primary bus address selected by SW1-1 through SW1-5 and an additional secondary bus address. Secondary address 00 is used in transferring command and status information while secondary addresses 01 through 04 are used for serial data transfers with serial ports 1 through 4 respectively. In this mode, control of the serial ports are multiplexed through secondary address 00, the command/status address, with the Port (P<sub>n</sub>) command selecting the desired port. Data transfers, however, are not multiplexed as each serial data port has its own unique secondary address.

Figure 2-4 illustrates the relationship between the command/status and serial data addresses when using the secondary addressing mode.

Figure 2-4. Pictorial View of the Secondary Addressing Mode

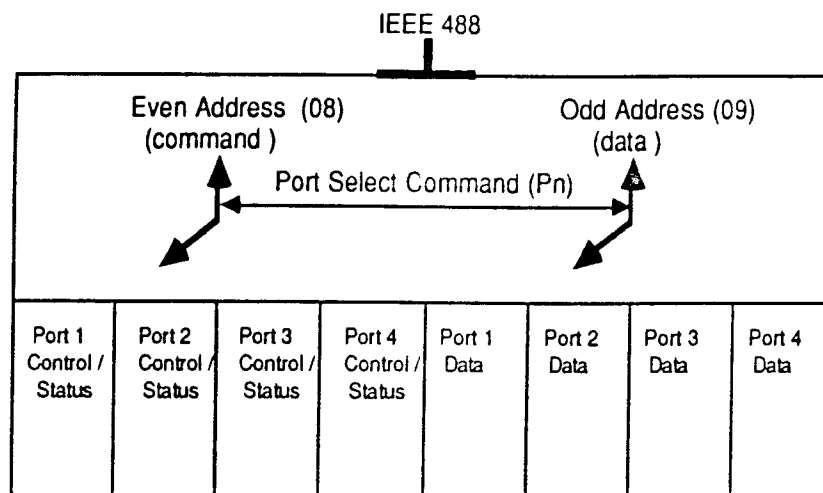


### 2.3.1.2 Dual Primary Addressing Mode

When Dual Primary addressing mode is selected, communications with the Converter is accomplished by using two consecutive primary IEEE bus addresses. These addresses are selected by SW-2 through SW1-5, SW1-1 (the LSB) of the address is ignored. Of the two addresses specified, the even address is used in transferring command and status information and the odd address is used for serial data transfers. In this mode, control of the serial ports is multiplexed through the even or command/status address, with the Port (Pn) command selecting the desired port. Serial data transfers are multiplexed through the odd or data address, again with the Port (Pn) command selecting the desired port.

Figure 2-5 illustrates the relationship between the command/status and serial data addresses when using the dual primary addressing mode.

**Figure 2-5 Pictorial View of the Dual Primary Addressing Mode**

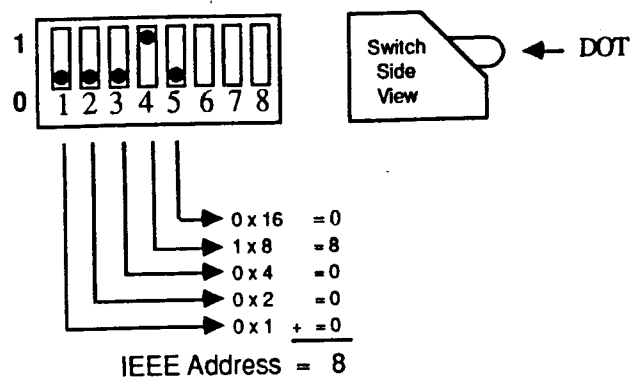


### 2.3.2 IEEE 488 Address Selection

The IEEE 488 bus address is set by SW1-1 through SW1-5 (located on rear panel). The address is read only at power on and can be set from 0 through 30 when using the secondary addressing mode, or 0 to 28 using the dual primary addressing mode. The address is selected by simple binary weighting with SW1-1 being the least significant bit and SW1-5 the most significant bit (see Figure 2-6). SW1 switch positions for IEEE addresses 0 through 30 are listed in Table 2-1. The factory default is address 8.

**NOTE:** If address 30 / 31 is selected, when using dual primary addressing mode, it defaults to address 28 / 29 because the IEEE 488 standard has reserved address 31. Similarly if address 31 is selected, when using the secondary addressing mode, it defaults to address 30.

Figure 2-6. SW1 View for IEEE Bus Address Selection

Table 2-1. SW1 Switch Positions  
(IEEE Address Selection)

IEEE Bus Address	SW1 setting 1 2 3 4 5	IEEE Bus Address	SW1 setting 1 2 3 4 5
0	00000	16	00001
1	10000	17	10001
2	01000	18	01001
3	11000	19	11001
4	00100	20	00101
5	10100	21	10101
6	01100	22	01101
7	11100	23	11101
8	00010	24	00011
9	10010	25	10011
10	01010	26	01011
11	11010	27	11011
12	00110	28	00111
13	10110	29	10111
14	01110	30	01111
15	11110	31	11111

### 2.3.3 IEEE 488 Bus Terminator Selection

The terminating characters sent when status is output by the Converter are set by using the Terminator (Yn) command. As shipped from the factory, the unit's power on IEEE 488 bus terminators are CR LF. The power on default terminators can be changed to any of the four available options discussed in detail in the Command Description section. The four available terminator command options are: CR only (Y0), LF only (Y1), CR LF (Y2), and LF CR (Y3). If it is desired to have particular power on default terminators, the terminators are set using the Terminator Command and then saved using the Save Configuration command (S1).

The Converter ignores all terminators received from the host controller on the command address. Only the Execute command (X) is used to signal the Converter that a command string has been completed.

The Converter ignores all terminators sent to the serial data address(es), but will monitor the serial data it receives for the character specified with the Serial Terminator command (Tn). If enabled by the Data EOI command (Ln), EOI will be asserted when the serial terminator character is sent to the host controller. Each serial port may use a separate serial terminator.

## 2.4 Memory Usage

Memory in the Converter is dynamically allocated for the serial input and output buffers. This allows for the most efficient utilization of memory for any given application. This memory is kept in the USER 'heap' (a vernacular for heap of memory) until required by the system.

At power on each serial port is allocated two 127 byte mini-buffers or queues, one for input and the other for output. When the serial port requires more buffer space, additional queues are allocated. When a queue is emptied, it is released from the serial port so that it may be reallocated when, and where required.

There are approximately 430 queues available for a total of over 54,000 bytes of buffer (character) space. Of the available queues, 398 are issued without regard to controlling the receipt of additional serial input data (handshaking).

When one of the last 32 queues is allocated the Converter signals the serial devices that they should stop sending serial data. This is accomplished by either unasserting RTS or sending the 'XOFF' control character depending upon how the individual serial ports are programmed. Also the Converter sets a bit in its serial poll status byte and optionally issues an SRQ to inform the host bus controller of the 'low memory' condition. When more than 32 queues become available the serial devices are signaled to allow more serial input data by asserting RTS or issuing the 'XON' control character as appropriate. The 'low memory' bit of the serial poll status byte is also cleared by more than 32 queues becoming available, however if SRQs were enabled the bit will remain set until at least one serial poll request is received after the original 'low memory' warning.

When one of the last 16 queues is allocated the Converter will stop accepting serial output data from the host bus controller. In this situation the host bus controller should read any available serial input data or wait for the existing serial output data to be sent to the serial devices before continuing.

## 2.5 Serial Port Configuration

The Converter has four separate serial ports, each of which can be configured independently of the others. Complete serial port configuration is accomplished by using both hardware jumpers and software commands. Hardware jumpers, located on the main board behind each serial connector, are used to configure the port electrically as either RS-232 or RS-422. Software configuration consists of various commands for setting baud rate, stop bits, parity, and other asynchronous communications characteristics.



### 2.5.1 RS-232/422 Configuration Jumpers

Each serial port is capable of operating with either RS-232 or RS-422 electrical characteristics. This selection is done via a set of hardware jumpers located on the main board behind each serial connector. A twelve position jumper plug must be inserted in one of the two available positions for proper operation. These jumpers are factory set to configure all ports for RS-232 levels as illustrated in figure 2.7.

If configured for RS-422, each port's Receive Data (RxD) and Clear to Send (CTS) input lines may optionally be terminated with a 100 ohm resistor. Termination resistors are selected by positioning the two flea clips located behind each serial connector towards the front panel, or upper position. These jumpers are factory set to the unterminated position, towards the rear panel. The jumpers associated with each port are: port 1 JP104 & JP105, port 2 JP109 & JP110, port 3 JP114 & JP115, and port 4 JP119 & JP120.

Figure 2.8 illustrates port 1 jumpered in RS-232, RS-422 unterminated, and RS-422 terminated with 100 ohm resistor (left to right).

**NOTE:**

When using RS-422 in a single ended configuration ports must be unterminated for proper operation.

**NOTE:**

Termination jumpers have no effect when ports are configured for RS-232 operation.

**WARNING**

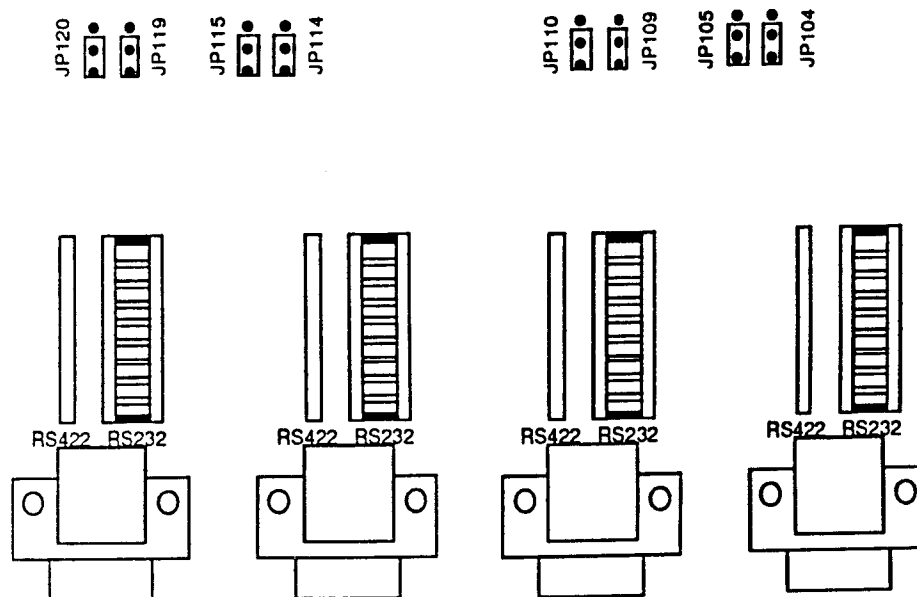
Never open the Converter case while it is connected to the AC line. Internal voltage potentials exist which could cause personal injury or death.

To open the Converter place it on a flat surface then remove the four screws on top of the case and remove the top cover. Located in front of the four serial port connectors, are four sets of connectors with configuration jumpers, one set per serial port.

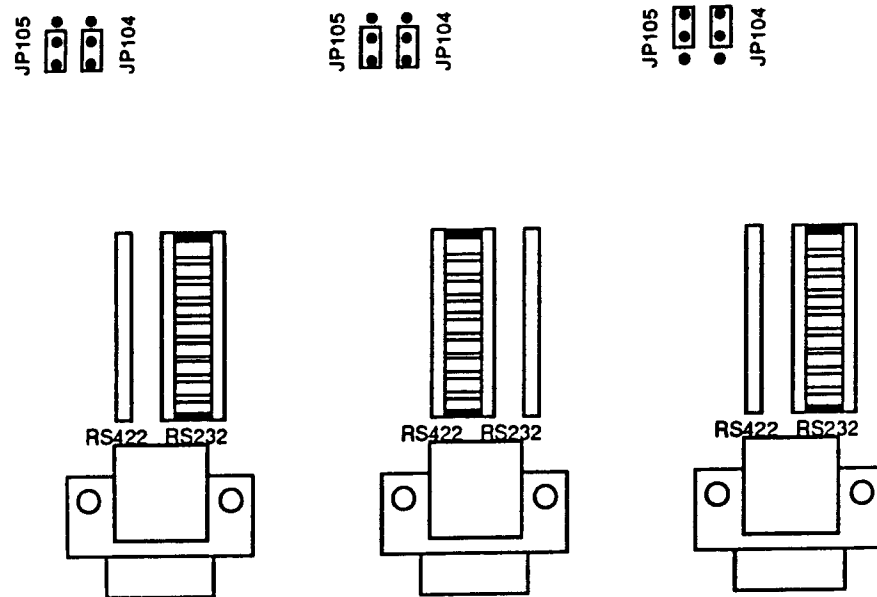
To reconfigure a serial port for RS-422 operation, remove the twelve position configuration jumper and reinsert it so that the center socket is now connected to the left socket as viewed from the rear of the unit. If single ended operation is desired move the two flea clips to the position farthest from the serial port connectors.

Once the jumper(s) have been repositioned for your particular application, make note of the new jumper settings for later reference and carefully reassemble the unit.

**Figure 2-7. View of Configuration Jumpers - Factory Setting**  
All Ports configured as RS-232



**Figure 2-8. View of Alternate Port 1 Configurations  
RS-232, RS-422 Unterminated, & RS-422 Terminated**



### 2.5.2 Asynchronous Communications Setup

Associated with each serial port are a number of parameters which control the the transfer of serial data. These parameters, and the commands used to set them, are listed in Table 2-4.

**Table 2-4. Serial Port Configuration Parameters**

Stop Bits	An	Number of stop bits; 1 or 2.
Baud Rate	Bn	Baud rate; 110 - 19200, or external.
Parity	Cn	Parity; even, odd, or none.
Data Bits	Dn	Number of data bits; 7 or 8.
Handshake Type	Gn	Handshake type; RTS/CTS, XON/XOFF, or none
Handshake Control	Nn	Handshake control; automatic, hold-off, or accept.

Configuration of the serial ports may be accomplished at any time by sending one or more command strings to the Converter command/status address. Configuration commands may be sent individually or grouped together to fully setup a port using only one message. Furthermore all four serial ports may be configured using only one message so long as each port setup begins with a Port (Pn) command and ends with an Execute (X) command. Several examples are presented below to illustrate different configuration methods.

Example 1: Configure all ports using dual primary addressing mode.

PRINT#1, "CLEAR08"	reset the Converter
PRINT#1, "OUTPUT08;P1X"	Select port 1
PRINT#1, "OUTPUT08;A0B3C1D0X"	Specify 1 stop bit, 1200 baud, odd parity, and 7 data bits
PRINT#1, "OUTPUT08;P2X"	Select port 2
PRINT#1, "OUTPUT08;A1B9C0D1X"	Specify 2 stop bits, 9600 baud, no parity, and 8 data bits
PRINT#1, "OUTPUT08;P3X"	Select port 3
PRINT#1, "OUTPUT08;A0B7C2D1X"	Specify 1 stop bit, 4800 baud, even parity, and 8 data bits
PRINT#1, "OUTPUT08;P4X"	Select port 4
PRINT#1, "OUTPUT08;A0B10C1D1X"	Specify 1 stop bit 19200 baud, no parity, and 8 data bits

Example 2: Configure all ports using secondary addressing mode.

PRINT#1, "CLEAR0800"	Reset the Converter
PRINT#1, "OUTPUT0800;P1A0B3C1D0X"	Select port 1, 1 stop bit, 1200 baud, odd parity, and 7 data bits.
PRINT#1, "OUTPUT0800;P2A1B9C0D1X"	Select port 2, 2 stop bits, 9600 baud, no parity, and 8 data bits
PRINT#1, "OUTPUT0800;P3A0B7C2D1X"	Select port 3, 1 stop bit, 4800 baud, even parity, and 8 data bits
PRINT#1, "OUTPUT0800;P4A1B10C1D1X"	Select port 4, 2 stop bits 19200 baud, no parity, and 8 data bits

### 2.5.3 Handshake Configuration

The Converter uses handshaking to prevent loss of data while both transmitting and receiving serial data. The function of handshaking is to prevent a sender from transmitting more data than a receiver can accept. The Converter accomplishes this in one of two ways, by using hardware or software handshaking.

Hardware handshaking utilizes the Request to Send (RTS) line of the serial interface to inform the connected device that the Converter is able to accept data. Inversely the Clear to Send (CTS) line of the serial interface is monitored by the Converter to determine whether or not the connected device is able to accept data. The Converter may be configured to use the hardware (RTS/CTS) handshaking method with the G0 command. In addition the automatic handshaking control option (N0) is normally used. This option will negate and assert the RTS line depending on the amount of memory available for receiving serial data. The manual handshake control options, N1 and N2, may be used in special circumstances to unassert and assert the RTS line under program control if desired. The clock output handshake control option (N3) is not allowed when hardware handshaking is being used and will generate a command conflict error if attempted.

The software handshaking method uses special control characters, transmitted along with the serial data, to prevent loss of serial data. The XOFF character (&H11) is transmitted to inform the connected device that the Converter is no longer able to accept data. The XON character (&H13) is transmitted to inform the connected device that the Converter is again able to accept data. Similarly the Converter monitors the serial data it receives for the occurrence of XON/XOFF control characters and stops or starts the transmission of data to the connected device accordingly. The Converter may be configured for software (XON/XOFF) handshaking by using the G1 command. In addition the automatic handshaking control option (N0) is normally used. This option will cause the Converter to send XOFF and XON control characters depending on the amount of memory available for receiving serial data. The manual handshake control options (N1 and N2) may be used in special circumstances to send XOFF and XON characters under program control if desired.

The clock output handshake control option (N3) operates the same as the automatic handshake option, but will also cause the serial baud clock x 16 signal to be output on the RTS line.

In addition to software and hardware handshaking the Converter provides a No Handshaking mode which may be used in special circumstances where handshaking is not desired. This mode is selected by using the G2 command. In the no handshake mode the RTS line may be manually unasserted or asserted using the N1 and N0 or N2 handshake control commands, or the serial baud clock x 16 may be output on the RTS line if the N3 command is used.

#### 2.5.4 Serial Signal Descriptions

The Converter is equipped with four DB-9S connectors on its rear panel and requires DB-9P mating connectors. The Converter's connector is configured as an IBM AT when RS-232 levels are selected and Macintosh II/SE/Plus when RS-422 levels are selected. Tables 2.2 and 2.3 list the RS-232 and RS-422 pin connections. Each of these signals are described below.

**RxD- Receive Data (input)**

This pin accepts serial data sent by an RS-232 or RS-422 device. The serial data received is expected to match the word length, baud rate, stop bits, and parity configuration of the particular port. This signal is low true.

**RxD+ Receive Data (input)**

This pin accepts serial data sent by an RS-422 device. It functions identically to RxD- except that its polarity is inverted. This signal is high true.

**TxD- Transmit Data (output)**

This pin transmits serial data to an RS-232 or RS-422 device. The serial data received is sent with the word length, baud rate, stop bits, and parity configured for the particular port. This signal is low true.

**TxD+ Transmit Data (output)**

This pin transmits serial data to an RS-422 device. The pin functions identically to TxD- except that its polarity is inverted. This signal is high true.

**CTS+ Clear To Send (input) / 16 x Baud Clock (input)**

The CTS+ input is used as a hardware handshake line to prevent the Converter from transmitting serial data to an RS-232 or RS-422 device when it is not able to accept it. When RTS/CTS handshaking is selected using the (G0) command, the Converter will not transmit data out TxD± while this signal is unasserted (low). If XON/XOFF (G1) or no handshaking (G2) is selected, the CTS+ line is ignored when transmitting data.

If XON/XOFF (G1) or no handshaking (G2) is selected the CTS line may be used to input a clock signal which is sixteen times the desired baud rate. This mode is selected using the Baud Rate command (B11).

**CTS- Clear To Send (input) / 16 x Baud Clock (input)**

The CTS- input is used as a hardware handshake line with RS-422 devices. The pin functions identically to CTS+ except that its polarity is inverted. This signal is low true.

**RTS+ Request To Send (output) / 16 x Baud Clock (output)**

The RTS+ output is used as a hardware handshake line to prevent an RS-232 device from transmitting serial data to the Converter when it is not able to accept it. When automatic RTS/CTS handshaking is selected using the (G0) and (N0) commands, the Converter will assert (high) the RTS+ signal when greater than 4096 memory locations are available in its internal buffers. If available memory drops below 4096 bytes, the Converter unasserts (low) the RTS+ signal. With RTS/CTS handshaking selected, the RTS+ signal may also be asserted and unasserted under program control by using the (N2) and (N1) handshake control commands respectively.

If XON/XOFF handshaking (G1) is selected, the RTS+ line may either be programmed as either permanently asserted (high) or to output sixteen times the baud rate clock. These options are selected using the handshake control command (Nn).

If No handshaking (G2) is selected, the RTS+ line may either be programmed as either permanently asserted (high), permanently unasserted (low), or to output a signal sixteen times the baud rate clock. These options are selected using the handshake control command (Nn).

**RTS Request To Send (output) / 16 x Baud Clock (output)**

The RTS- output is used as a hardware handshake line with RS-422 devices. The pin functions identically to RTS+ except that its polarity is inverted. This signal is low true.

**GND Ground**

This signal sets the ground reference point for the other RS-232 input and output signals.



## 2.6 IEEE 488 Bus Implementation

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

Remote Enable (REN)  
Go to Local (GTL)  
Local Lockout (LLO)  
Take Control (TCT)  
Group Execute Trigger (GET)

Parallel Poll (PP)  
Parallel Poll Configure (PPC)  
Parallel Poll Unconfigure (PPU)  
Parallel Poll Disable (PPD)

### 2.6.1 My Talk Address (MTA), My Secondary Address (MSA)

The Converter is addressed to talk in one of two ways dependent upon the addressing mode selected. When dual primary addressing mode is selected, the Converter is addressed to talk upon receipt of MTA. If secondary addressing mode is selected the Converter is addressed to talk upon receipt of an MTA and MSA sequence.

When the Converter is addressed to talk on its command/status address, it outputs either a U0, Un, or query (?) response message depending on which was last requested. The status output bus terminators are then appended to the output and EOI is asserted if the status EOI option was enabled. The Converter must be readdressed to talk to perform subsequent reads.

When the Converter is addressed to talk on a serial data address, it retrieves data from the associated serial input buffer and outputs it to the IEEE bus. If the serial terminator character is encountered and the data EOI option is enabled (L0), EOI is asserted on that character. EOI may also be asserted on the last character in the serial data buffer if this data EOI option is enabled (L2).

**Table 2-2. RS-232 Serial Port Pin Connections**

<u>Pin</u>	<u>Description</u>	<u>Input/Output</u>
1	No connection	
2	Receive data (RxD-)	Input
3	Transmit data (TxD-)	Output
4	No connection	
5	Ground	
6	No connection	
7	Request to send (RTS+) or 16 x baud clock	Output Output
8	Clear to send (CTS+) or 16 x baud clock	Input Input
9	No connection	

**Table 2-3. RS-422 Serial Port Pin Connections**

<u>Pin</u>	<u>Description</u>	<u>Input/Output</u>
1	Ground	
2	Clear to send positive (CTS +) or 16 x baud clock	Input Input
3	Clear to send negative (CTS -) or 16 x baud clock	Input Input
4	Transmit data positive (TxD +)	Output
5	Transmit data negative (TxD -)	Output
6	Request to send positive (RTS +) or 16 x baud clock	Output Output
7	Request to send negative (RTS -) or 16 x baud clock	Output Output
8	Receive data positive (RxD +)	Input
9	Receive data negative (RxD -)	Input

### **2.6.2 My Listen Address (MLA), My Secondary Address (MSA)**

The Converter is addressed to listen in one of two ways dependent upon the addressing mode selected. When dual primary addressing mode is selected, the Converter is addressed to listen upon receipt of MLA. If secondary addressing mode is selected the Converter is addressed to listen upon receipt of an MLA and MSA sequence.

When the Converter is addressed to listen on its command/status address it accepts characters from the active talker and interprets these characters as commands and command parameters. These commands are fully explained in Section 3.

When the Converter is addressed to listen on a serial data address it accepts data from the active talker and places this data into the appropriate serial output buffer, to be transmitted verbatim.

### **2.6.3 Device Clear (DCL and SDC)**

Device Clear resets the Converter to power on defaults and empties all the serial input and output buffers. Any pending data and Service Requests (SRQ), including the information they convey are lost.

### **2.6.4 Interface Clear (IFC)**

IFC places the Converter in the Talker/Listener Idle State and clears any pending request from service (SRQ). The condition which caused the SRQ, however, remains unchanged.

### **2.6.5 Serial Poll Enable (SPE)**

When Serial Poll Enabled, the Converter sets itself to respond to a serial poll with its serial poll status byte if addressed to talk. When the serial poll byte is accepted by the controller, any pending SRQs are cleared. The Converter will continue to try to output its serial poll response until it is serial poll disabled by the controller.

### 2.6.6 Serial Poll Disable (SPD)

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

### 2.6.7 Serial Poll Response

Whenever the Converter generates an SRQ, a serial poll of either the command/status address or a serial data address will return a serial poll status byte of at least 64 decimal showing that an SRQ has been generated by the Converter. The status byte returned can be used to determine the cause of the Service Request. These responses are explained in detail in Section 3.

### 2.6.8 Unlisten (UNL)

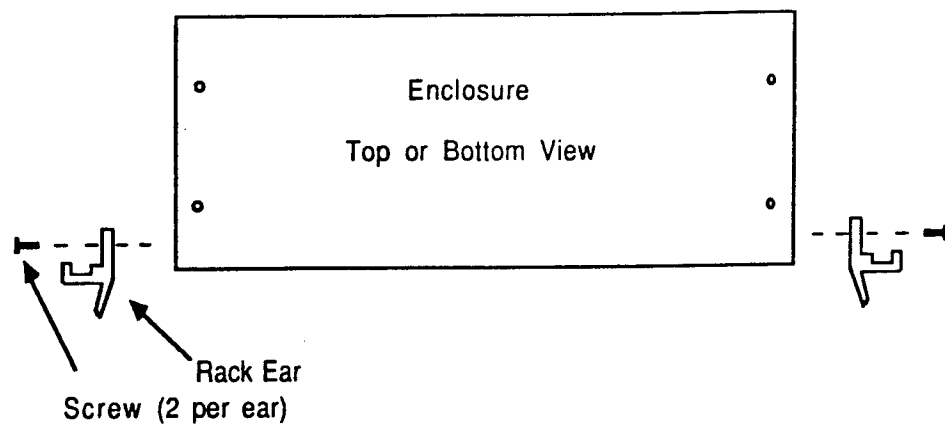
UNL places the Converter in the Listener Idle State.

### 2.6.9 Untalk (UNT)

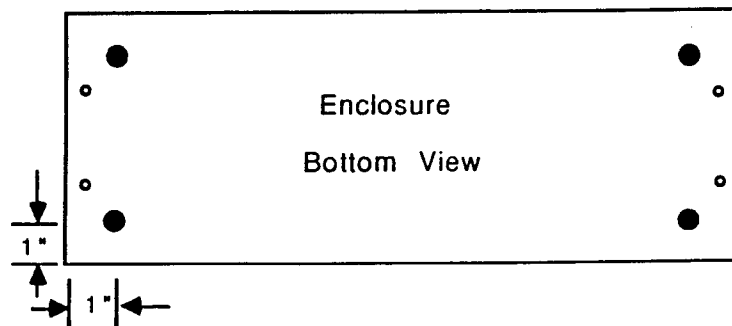
UNT places the Converter in the Talker Idle State.

## 2.7 Hardware Installation

Included with the Converter are accessories for rack or bench use. If rack mount installation is required, install the two rack ears using the enclosed screws, as shown in Figure 2-6. These ears can be installed so either the front or the rear of the unit faces the front of the rack fixture.

**Figure 2-6. View of Enclosure showing Rack Hardware Installation**

If bench installation is required, the rubber feet can be installed on the underside of the unit approximately one inch from each corner as shown in Figure 2-7.

**Figure 2-7. View of Enclosure Showing Feet Placement**

## 2.8 Power Up

To begin operating the Converter, plug the power cord into an AC outlet.

### WARNING

The Converter is intended for **INDOOR USE ONLY**. Failure to observe this warning could result in equipment failure, personal injury or death.

After plugging in the power cord, turn on the Converter by depressing the rear panel power switch (Figure 2-1). All the front panel LEDs should light for approximately two seconds while the Converter performs an internal ROM and RAM self check. At the end of this self check all indicators should turn off except POWER.

If you obtain the above response then your Converter is alive and well. If all LEDs remain on, then a ROM error has occurred. If all LEDs (except the power LED) flash continuously, then a RAM error has occurred. Try cycling the power to the Converter to determine that the error is repeatable.

If the LEDs do not flash and the POWER indicator does not remain lit, there may not be any power supplied to the Converter. In this event, check to make sure the AC power is supplied to the unit. If the problem persists, refer to the Service Information section of this manual.

## 2.9 Programming Examples

These examples use the IOtech Personal488 and the BASIC Keyboard Controller program listed in appendix D. The Keyboard Controller program allows direct communication with the Converter (or any IEEE device on the bus) and is the most convenient method of exercising the Converter and becoming familiar with the commands and their actions.

First, set SW1 for Dual Primary addressing mode and bus address 8. Connect an IEEE cable from the Converter to the IEEE connector on the Personal488. Turn on the Converter by depressing the rear panel power switch. All of the front panel LEDs should light for approximately one second while the Converter performs an internal ROM and RAM self test. At the end of this self test all indicators should turn off except Power.

## Section 2

## Getting Started

Run the Keyboard Controller program and verify that the CMD> prompt appears on the screen. The following is a listing of commands given to the Converter and the response received. Responses are separated by extra vertical space for easier reading although these spaces will not actually appear when using the program.

CMD>	Command prompt from Keyboard Controller
program	
CMD>OUTPUT08;S0X	Restore configuration to factory default values
CMD>CLEAR	Reset the Converter
CMD>ENTER08	
1.3C0E0F0G0I000K0M000P0R0Y0Z55880	
CMD>OUTPUT08;P1U1X	Status message shows all default options are in use
CMD>ENTER08	select port 1 and port 1 status
1.3A0B009C0D1G0I00000L1N0000000T010U1	
CMD>OUTPUT08;a1b7d0x	Status message shows all default options are in use
CMD>ENTER08	Change the configuration of port 1
1.3A1B007C0D0G0I00000L1N0000000T010U1	
CMD>OUTPUT08;P3U3X	Status message shows new options are in use
CMD>ENTER08	select port 3 and port 3 status
1.3A0B009C0D1G0I00000L1N0000000T010U3	
CMD>OUTPUT08;C2X	Status message shows all default options are in use
CMD>OUTPUT08;C?X	Change parity option for port 3
CMD>ENTER08	Request current parity option
C2	C2 is returned since we changed the default
CMD>OUTPUT09;hello message	
	send "hello message" out port 3
CMD>OUTPUT08;P1X	select port 1
CMD>OUTPUT09;hello message	
	send "hello message" out port 1

CMD>ENTER08  
1.3A0B009C2D1G0I00000L1N000000T010U3  
port 3 status is returned since U3 has not changed

CMD>ENTER09  
???  
port 3 serial data is returned if any has been received

The above examples may also be repeated using Secondary addressing. To do this, turn off the Converter, set SW1 for Secondary addressing mode. The session would then appear as presented below.

CMD>  
program  
CMD>OUTPUT0800;S0X      Command prompt from Keyboard Controller  
Restore configuration to factory default values  
CMD>CLEAR                Reset the Converter  
CMD>ENTER0800  
1.3C0E0F0G0I000K0M000P0R0Y0Z55880

CMD>OUTPUT0800;P1U1X      Status message shows all default options are in use  
select port 1 and port 1 status  
CMD>ENTER0800  
1.3A0B009C0D1G0I00000L1N000000T010U1

CMD>OUTPUT0800;a1b7d0x      Status message shows all default options are in use  
Change the configuration of port 1

CMD>ENTER0800  
1.3A1B007C0D0G0I00000L1N000000T010U1

CMD>OUTPUT0800;P3U3X      Status message shows new options are in use  
select port 3 and port 3 status  
CMD>ENTER0800  
1.3A0B009C0D1G0I00000L1N000000T010U3

CMD>OUTPUT0800;C2X      Status message shows all default options are in use  
Change parity option for port 3  
CMD>OUTPUT0800;C?X      Request current parity option  
CMD>ENTER0800  
C2  
C2 is returned since we changed the default



## Section 2

## Getting Started

CMD>OUTPUT0803;hello message  
send "hello message" out port 3

CMD>OUTPUT0801;hello message  
send "hello message" out port 1

CMD>ENTER0800  
1.3A0B009C2D1G0I00000L1N0O00000T010U3  
port 3 status is returned since U3 has not changed

CMD>ENTER0801  
???  
port 1 serial data is returned if any has been received

CMD>ENTER0803  
???  
port 3 serial data is returned if any has been received

---

## Command Descriptions

---

Control of the Four Channel IEEE 488/Serial Converter is implemented with 22 bus commands, described here in detail. Examples are given for the commands using a PC functioning as an IEEE 488 controller by using an IOtech GP488B board and associated driver software, Driver488. All examples are given using GWBASIC or BASICA. The Converter bus address is assumed to be set to 8 for all examples.

In order to establish communication with Driver488 from GWBASIC or BASICA, the following sequence must be used:

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

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

All commands may be entered in upper or lower case. Each command offers a query (?) option. This option can be used to determine the present configuration or mode of a command previously executed. In addition, there are four commands that are query only ( i.e., they are used as status commands and have no set options). Any number of query commands may be combined into one string to allow the user to construct a specialized status command requesting the Converter to return only that information which is of interest .

---

### Attention!

It is necessary that the Execute command (X) follow all command strings sent to the Converter. No commands are executed until an X is received by the Converter. The only exception to this rule are the query commands. Query commands do not have to be followed by an X.

---

## Stop Bits

**An**

The Stop Bits command programs the number of stop bits contained in each character transmitted and received by the selected serial port. The Port Select command (Pn) is used to select the serial port regardless of addressing mode in use. The factory default setting as set by the Save Configuration command (S0) is A0, 1 stop bit.

- A0 One stop bit selected.
- A1 Two stop bits selected.
- A? Return current stop bit setting.

Example 1: Set stop bits for ports 1 and 3 using dual primary addressing mode

PRINT#1, "CLEAR08"	reset the Converter
PRINT#1, "OUTPUT08;P1X"	select port 1 as the current port
PRINT#1, "OUTPUT08;A0X"	select 1 stop bit
PRINT#1, "OUTPUT08;P3A1X"	select 2 stop bits for port 3

Example 2: Set stop bits for ports 1 and 3 using secondary addressing mode

PRINT#1, "CLEAR0800"	reset the Converter
PRINT#1, "OUTPUT0800;P1X"	select port 1 as the current port
PRINT#1, "OUTPUT0800;A0X"	select 1 stop bit
PRINT#1, "OUTPUT0800;P3A1X"	select 2 stop bits for port 3

## Baud Rate

**Bn**

The Baud Rate command programs the speed at which serial data is transmitted and received by the selected serial port. The Port Select command (Pn) is used to select the serial port regardless of addressing mode in use. Additionally the CTS line may be used to input a clock signal which is sixteen times the desired baud rate if B11 is selected. The factory default setting as set by the Save Configuration command (S0) is B9, 9600 baud.

**NOTE:** The sum of the baud rates for all four ports cannot exceed 38,400 baud or data may be lost.

B0	110 baud selected
B1	300 baud selected
B2	600 baud selected
B3	1200 baud selected
B4	1800 baud selected
B5	2400 baud selected
B6	3600 baud selected
B7	4800 baud selected
B8	7200 baud selected
B9	9600 baud selected
B10	19200 baud selected
B11	16 x External clock selected
B?	Return current baud setting

**Example 1:** Set baud rates for ports 1 and 2 using dual primary addressing mode

PRINT#1, "CLEAR08"	reset the Converter
PRINT#1, "OUTPUT08;P1X"	select port 1 as the current port
PRINT#1, "OUTPUT08;B3X"	select 1200 baud
PRINT#1, "OUTPUT08;P2B10X"	select 19200 baud on port 2

**Example 2:** Set baud rates for ports 1 and 2 using secondary addressing mode

PRINT#1, "CLEAR0800"	reset the Converter
PRINT#1, "OUTPUT0800;P1B3X"	select 1200 baud for port 1
PRINT#1, "OUTPUT0800;P3b10X"	select 19200 baud for port 3

## Parity

**Cn**

The Parity command specifies the parity, if any, to be transmitted and received with each character of the selected serial port. The Port Select command (Pn) is used to select the serial port regardless of addressing mode in use. If even or odd parity is enabled the Converter will append a bit of the correct parity to each character transmitted. However, the Converter does not check parity on characters received. The factory default setting as set by the Save Configuration command (S0) is C0, parity disabled.

- C0 Parity disabled.
- C1 Odd parity enabled.
- C2 Even parity enabled.
- C? Return current parity setting.

Example 1: Set parity for port 2 using dual primary addressing mode.

```
PRINT#1, "CLEAR08"          reset the Converter
PRINT#1, "OUTPUT08;P2C1X"   select odd parity for port 2
```

Example 2: Set parity for port 4 using secondary addressing mode.

```
PRINT#1, "CLEAR0800"        reset the Converter
PRINT#1, "OUTPUT0800;P4C2X" select even parity for port 4
```

## Data Bits

**Dn**

The Data Bits command programs the number of data bits contained in each character transmitted and received by the selected serial port. The Port Select command (Pn) is used to select the serial port regardless of addressing mode in use. The factory default setting as set by the Save Configuration command (S0) is D1, eight data bits.

- D0 Seven data bits selected.
- D1 Eight data bits selected.
- D? Return current data bits setting

Example1: Set data bits for ports 1 and 3 using dual primary addressing mode.

PRINT#1, "CLEAR08"	reset the Converter
PRINT#1, "OUTPUT08;P1X"	select port 1 as the current port
PRINT#1, "OUTPUT08;D0X"	select 7 data bits
PRINT#1, "OUTPUT08;P3D1X"	select 8 data bits for port 3

Example 2: Set data bits for ports 1 and 3 using secondary addressing mode.

PRINT#1, "CLEAR0800"	reset the Converter
PRINT#1, "OUTPUT0800;P1X"	select port 1 as the current port
PRINT#1, "OUTPUT0800;d0X"	select 7 data bits
PRINT#1, "OUTPUT0800;P3d1X"	select 8 data bits for port 3

## Error Query

**E?**

The Error Query is used to determine the present error condition of the Converter. After execution of the Error Query, the present error condition is cleared. The error condition is also returned and cleared by the status Un command.

E?      Return and clear present error condition

Example1: Query the error status using dual primary addressing mode.

PRINT#1, "OUTPUT08;E?"	request error status
PRINT#1, "ENTER08"	
INPUT#2, A\$	
PRINT A\$	display shows E0, No errors

Example2: Query the error status using secondary addressing mode.

PRINT#1, "OUTPUT0800;W5X"	send an illegal command to the Converter
PRINT#1, "OUTPUT0800;E?"	request error status
PRINT#1, "ENTER0800"	
INPUT#2, A\$	
PRINT A\$	display shows E1, unrecognized command
PRINT#1, "OUTPUT0800;E?"	request error status again
PRINT#1, "ENTER0800"	
INPUT#2, A\$	
PRINT A\$	display shows E0, error condition has been cleared after reading error status

## Flush

**Fn**

The Flush command is used to discard serial data for a selected port. The Port Select command (Pn) is used to select the serial port regardless of addressing mode in use. Data waiting to be read over the IEEE bus, transmitted out the serial port, or both, may be flushed.

- F0 Flush serial input data.
- F1 Flush serial output data.
- F2 Flush both serial input and output data.
- F? Return last F command executed.

Example 1: Flush serial input data for port 1 using dual primary addressing mode.

PRINT#1, "CLEAR08"	reset the Converter
PRINT#1, "OUTPUT08;P1X"	select port 1 as the current port
PRINT#1, "OUTPUT08;F0X"	flush serial input data

Example 2: Flush serial output data for port 2 using secondary addressing mode.

PRINT#1, "CLEAR0800"	reset the Converter
PRINT#1, "OUTPUT0800;P2X"	select port 2 as the current port
PRINT#1, "OUTPUT0800;f1X"	flush serial output data



## Handshake Type

**Gn**

The Handshake Type command determines the flow control method to be used in serial data transfers for the selected serial port. The Port Select command (Pn) is used to select the serial port regardless of addressing mode in use.

The hardware handshake method uses the RTS and CTS signals of the serial interface to prevent data overruns by asserting the RTS line when the Converter is able to accept data and requiring the CTS signal to be asserted before transmitting data.

The software handshake method uses two special serial characters, XON (11 hex) and XOFF (&H13) to control data flow. The XOFF character is sent to stop data transmission and the XON character is sent to resume data transmission. It should be noted that the software method is not compatible with binary data as the data itself may contain XON and XOFF characters.

If no handshaking is desired, handshaking may be disabled entirely. The factory default setting as set by the Save Configuration command (S0) is G0, hardware handshaking (RTS/CTS).

- |    |  |
|----|--|
| G0 | Hardware handshaking (RTS/CTS) is selected.  |
| G1 | Software handshaking (XON/XOFF) is selected. |
| G2 | No handshaking is selected.                  |
| G? | Return present handshaking method.           |

Example 1: Select software handshaking on port 1 using dual primary addressing mode.

PRINT#1, "OUTPUT08;P1X"	select port 1 as the current port
PRINT#1, "OUTPUT08;G1X"	select software handshaking

Example 2: Select hardware handshaking on port 2 using secondary addressing mode.

PRINT#1, "OUTPUT0800;P2G0X"	select hardware handshaking for port 2
-----------------------------	--

## Input Query

**I?**

The Input Query command returns the number of characters available to be read on the the IEEE bus from the selected serial port ( i.e. the port's serial input buffer ). The Port Select command (Pn) is used to select the serial port regardless of addressing mode in use.

I?      Return number of characters in the input buffer.

Example 1: Find the number of input characters available on port 1 using dual primary addressing mode.

PRINT#1, "OUTPUT08;P1x"	select port 1
PRINT#1, "OUTPUT08;I?"	request number of serial input characters
PRINT#1, "ENTER08"	
INPUT#2, A\$	read the response
PRINT A\$	display shows I00010, 10 characters

Example 2: Find number of input characters available on port 1 using secondary addressing mode.

PRINT#1, "OUTPUT0800;P1xI?"	select port 1 and request number of input
PRINT#1, "ENTER0800"	characters available
INPUT#2, A\$	read the response
PRINT A\$	display shows I00033, 33 characters

## Status EOI

**Kn**

The EOI line is one of five interface management lines of the IEEE 488 bus. It is used to indicate the end of a multiple byte message. The Status EOI command specifies how this line will be used when the Converter sends port and command status messages to the addressed listener, usually the bus controller. In the K0 mode, the EOI line is asserted by the Converter on the last byte of every status message. In the K1 mode the EOI line is not used. The factory default setting as set by the Save Configuration command (S0) is K1, EOI is disabled.

- |    |  |
|----|--|
| K0 | Assert EOI on last byte of status message. |
| K1 | EOI is disabled.                           |
| K? | Return last EOI command received.          |

Example 1: Select EOI on last byte of message using dual primary addressing mode.

```
PRINT#1, "OUTPUT08;k0X"
```

Example 2: Disable EOI on status messages using secondary addressing mode.

```
PRINT#1, "OUTPUT0800;K1X"
```

## Data EOI

**Ln**

The Data EOI command specifies how the IEEE 488 EOI line will be used when the Converter sends serial port data to the addressed listener, usually the bus controller, for the selected serial port. The Port Select command (Pn) is used to select the serial port regardless of addressing mode in use. In the L0 mode, the EOI line is asserted by the Converter when the data byte matches the selected serial terminator (Txxx). In the L1 mode the EOI line is not used. If the L2 mode is selected, the EOI line is asserted when the last serial input character is sent over the IEEE bus. In the L3 mode the EOI line is asserted on either a match with the serial terminator or the last serial character sent. The factory default setting as set by the Save Configuration command (S0) is L1, EOI is disabled.

- L0      Assert EOI on serial terminator character.
- L1      EOI is disabled.
- L2      Assert EOI on last serial input character.
- L3      Assert EOI on serial terminator character or last serial character.
- L?      Returns last Data EOI command selected.

Example 1: Select EOI on serial terminator using dual primary addressing mode.

PRINT#1, "OUTPUT08;P1X"	select port 1 as the current port
PRINT#1, "OUTPUT08;LOX"	select data EOI on serial terminator

Example 2: Disable EOI on selected port using secondary addressing mode.

PRINT#1, "OUTPUT0800;p1L1X"	disable EOI on port 1
-----------------------------	-----------------------

## Service Request (SRQ) Mn

The Service Request (SRQ) mode is used by the Converter to alert the controller to one of several conditions described below. Multiple SRQ conditions can be enabled simultaneously by issuing them separately or by combining them in one command. If multiple SRQ commands are contained within the same command string, each SRQ command should be followed by an Execute command (X). The programmed SRQ modes will remain enabled until the M0 command is sent, or the controller sends a Device Clear (DCL) or Selected Device Clear (SDC). The factory default setting as set by the Save Configuration command (S0) is M0, SRQ is disabled.

M0	SRQ is disabled
M1	SRQ on receipt of data on serial port 1
M2	SRQ on receipt of data on serial port 2
M4	SRQ on receipt of data on serial port 3
M8	SRQ on receipt of data on serial port 4
M16	SRQ on Ready
M32	SRQ on Error condition
M128	SRQ on Memory low condition
M?	Returns current SRQ mask

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

M1, M2, M4 and M8 will generate a Service Request when the data is received on serial ports 1, 2, 3, and 4 respectively.

M16 will generate a Service Request when the Converter has completed the execution of a set of commands from the bus controller. This is used by the controller to assure the completion of a set of commands before sending a subsequent set of commands.

M32 will generate a Service Request when an error occurs. The most common bus error is sending an invalid command to the Converter. For example, attempting to select an 'B15' baud rate when no 'B15' baud rate exists will generate a Service Request when the M32 mode is selected.

M128 will generate a Service Request when the Converter has used up most of its available memory. This provides an indication that no further data should be sent to the serial ports until data is freed. Data may be freed either by reading serial input data from the Converter, waiting for serial output data to finish being transmitted, or by flushing a serial port if data is not moving as expected.

Example 1: Enable SRQ on serial data or low memory using dual primary addressing mode.

PRINT#1, "OUTPUT08;M0X"	clear SRQ mask
PRINT#1, "OUTPUT08;M1X"	select SRQ on serial port 1 data
PRINT#1, "OUTPUT08;M2X"	select SRQ on serial port 2 data
PRINT#1, "OUTPUT08;M4X"	select SRQ on serial port 3 data
PRINT#1, "OUTPUT08;M8X"	select SRQ on serial port 4 data
PRINT#1, "OUTPUT08;M128X"	select SRQ memory low

Example 2: Enable SRQ on serial data or low memory using dual primary addressing mode. This example has the same effect as example 1.

PRINT#1, "OUTPUT08;M132X"	select SRQ on serial data or memory low
---------------------------	---

Example 3: Enable SRQ on error using secondary addressing mode.

PRINT#1, "OUTPUT0800;M0X"	clear SRQ mask
PRINT#1, "OUTPUT0800;M32X"	select SRQ on command error

## Handshake Control

**Nn**

The Handshake Control, in conjunction with the Handshake Type command, determines what flow control method is to be used in serial data transfers for the selected port. The Port Select command (Pn) is used to select the serial port regardless of addressing mode in use. If the hardware handshake method (G0) is being used, the handshake control command will effect the serial port's RTS line. Handshaking control may be selected to asserted and un-asserted the RTS line automatically as memory is available, asserted the RTS line continually or un-asserted RTS line continually.

When the software handshake method (G0) is used, the handshake control command will effect the sending of the handshake characters XON and XOFF. Handshaking control may be selected to enable the automatic output of XON/XOFF serial characters as memory dictates, cause the XOFF character to be issued, or cause the XON character to be issued. Additionally this command may be used to enable the output of sixteen times the baud rate clock on the RTS line.

If the no handshake method (G2) is in use, the Handshake Control command controls the assertion, un-assertion, or output of a signal sixteen times baud clock output on the RTS line.

The factory default setting as set by the Save Configuration command (S0) is N0, automatic handshaking.

- |    |   |
|----|---|
| N0 | Automatic handshaking, RTS/CTS or XON/XOFF.   |
| N1 | Hold off serial input, un-assert RTS or send XOFF.  |
| N2 | Release holdoff of serial input, assert RTS, or send XON.   |
| N3 | Automatic XON/XOFF handshake with 16 x baud clock output on RTS line, or no handshaking and 16 x baud clock output on RTS line. |
| N? | Return present handshaking control selection.   |

Example 1: Select automatic hardware handshaking using dual primary addressing mode.

PRINT#1, "CLEAR08"	reset the Converter
PRINT#1, "OUTPUT08;P1X"	select port 1 as the current port
PRINT#1, "OUTPUT08;G0N0X"	select automatic hardware handshaking

Example 2: Select software handshaking with baud clock output using secondary addressing mode.

PRINT#1, "CLEAR0800"	reset the Converter
PRINT#1, "OUTPUT0800;P2X"	select port 2 as the current port
PRINT#1, "OUTPUT0800;g1n3X"	select software handshaking with baud clock output



## Output Query

**O?**

The Output Query command returns the number of characters waiting to be transmitted out on the selected serial port ( i.e. the port's serial output buffer ). The Port Select command (Pn) is used to select the serial port regardless of addressing mode in use.

O?      Return number of characters in the serial output buffer.

Example 1: Find number of output characters on port 1 using dual primary addressing mode.

PRINT#1, "OUTPUT08;P1x"	select port 1
PRINT#1, "OUTPUT08;O?"	request number of serial output characters
PRINT#1, "ENTER08"	
INPUT#2, A\$	read the response
PRINT A\$	display shows 000010, 10 characters

Example 2: Find number of output characters on port 1 using secondary addressing mode.

PRINT#1, "OUTPUT0800;P1xO?"	select port 1 and request number of output
PRINT#1, "ENTER0800"	characters waiting to be sent
INPUT#2, A\$	read the response
PRINT A\$	display shows 000033, 33 characters

## Port Select

**Pn**

The Port Select command determines which port is selected for execution of serial setup commands and for data input/output when using the Dual Primary addressing mode. The factory default setting as set by the Save Configuration command (S0) is P1, port 1 selected.

P1	Port 1 is selected
P2	Port 2 is selected
P3	Port 3 is selected
P4	Port 4 is selected
P?	Return present port selection

Example 1: Select port 1, then send a message using dual primary addressing mode.

PRINT#1, "OUTPUT08;P1X"	select port 1 as the current port
PRINT#1, "OUTPUT08;a0b5c1d1X"	select 1 stop bit, 2400 baud, odd parity 8 data bits
PRINT#1, "OUTPUT08;g1n0t13X"	select Xon/Xoff, automatic handshaking, terminator CR
PRINT#1, "OUTPUT09;Startup message"	send a startup message out port 1

Example 2: Select port 1, then send a message using secondary addressing mode.

PRINT#1, "OUTPUT0800;P1X"	select port 1 as the current port
PRINT#1, "OUTPUT0800;a0b5c1d1X"	select 1 stop bit, 2400 baud, odd parity, 8 data bits
PRINT#1, "OUTPUT0800;g1n0t13X"	select Xon/Xoff, automatic handshaking, terminator CR
PRINT#1, "OUTPUT0801;Startup message"	send a startup message out port 1

## Break

**Qn**

The Break command enables or disables the sending of break (a constant stream of '0' bits) by the selected port. While a port is sending break no characters can be transmitted. When sending break is subsequently disabled, normal character transmission will resume. The factory default setting as set by the Save Configuration command (S0) is Q0, disable sending break.

- Q0     Disable sending break.
- Q1     Enable sending break.
- Q?     Return current break setting.

**NOTE:** The programmer must ensure the break command is enabled for more than one character time before issuing the disable sending break command to ensure that break is recognized.

**NOTE:** Sending a break while a port is transmitting data may cause the character currently being transmitted to become corrupted. The Output Query (O?) may be used to verify that the serial output buffer is empty. Once the serial output buffer is empty a delay of two character times is required to ensure that all serial data has been transmitted and will not be corrupted by sending break.

Example 1: Program port 1 to send a break using dual primary addressing mode

PRINT#1, "CLEAR08"	reset the Converter
PRINT#1, "OUTPUT08;P1X"	select port 1 as the current port
PRINT#1, "OUTPUT08;Q1X"	send break
FOR LUP = 1 to 100:NEXT LUP	delay a short while
PRINT#1, "OUTPUT08;Q0X"	stop sending break

Example 2: Program port 3 to send a break using secondary addressing mode

PRINT#1, "CLEAR0800"	reset the Converter
PRINT#1, "OUTPUT0800;P3X"	select port 3 as the current port
PRINT#1, "OUTPUT0800;Q1X"	send break
FOR LUP = 1 to 100:NEXT LUP	delay a short while
PRINT#1, "OUTPUT0800;Q0X"	stop sending break

## Save Configuration

Sn

The Save Configuration command is used to save a non-volatile copy of the present configuration for the Converter to be used as the power-up configuration. Note that this command is independent of port selection; it saves all Converter port and command settings. The S0 command is used to restore the factory default configuration.

- S0 Save the default configuration in non-volatile RAM.
- S1 Save the current configuration in non-volatile RAM.
- S? Return the last Save configuration command.

Example 1: Configure each port; save settings using dual primary addressing mode.

```
PRINT#1, "OUTPUT08;k0m16u0y2X" select EOI with last bus terminator, SRQ on
                                ready, command status, terminator CR LF
PRINT#1, "OUTPUT08;P1X"        select port 1 as the current port
PRINT#1, "OUTPUT08;a0b5c1d1X"  select 1 stop bit, 2400 baud, odd parity,
                                8 data bits
PRINT#1, "OUTPUT08;g1n0t13X"  select Xon/Xoff, automatic handshaking,
                                terminator CR
PRINT#1, "OUTPUT08;P2X"        select port 2 as the current port
PRINT#1, "OUTPUT08;a1b3c0d0X"  select 2 stop bits, 1200 baud, no parity,
                                7 data bits
PRINT#1, "OUTPUT08;g0n0t10X"  select RTS/CTS, automatic handshaking,
                                terminator LF
PRINT#1, "OUTPUT08;P3X"        select port 3 as the current port
PRINT#1, "OUTPUT08;a0b10c2d1X" select 1 stop bit, 19200 baud, even parity,
                                8 data bits
PRINT#1, "OUTPUT08;g1n0t13X"  select Xon/Xoff, automatic handshaking,
                                terminator CR
PRINT#1, "OUTPUT08;P4X"        select port 4 as the current port
PRINT#1, "OUTPUT08;a1b1c0d0X"  select 2 stop bit, 300 baud, no parity,
                                8 data bits
PRINT#1, "OUTPUT08;g1n3t13X"  select Xon/Xoff, automatic handshaking,
                                output baud clock, terminator CR
PRINT#1, "OUTPUT08;S1x"        save the configuration
```

### Section 3

### Command Descriptions

**Example 2: Restore the default configuration using secondary addressing mode.**

PRINT#1, "OUTPUT0800;S0x"  
PRINT#1, "CLEAR0800"

restore the factory default configuration  
reset the Converter to re-configure

## Serial Terminator

**Tn**

The Serial Terminator command is used in conjunction with the Data EOI (Ln) command to specify which character to assert EOI on for the selected serial port. The Port Select command (Pn) is used to select the serial port regardless of addressing mode in use. The terminator value may range from 0 to 255 allowing any 7 bit ASCII character or 8 bit data value to be used. The factory default setting as set by the Save Configuration command (S0) is T010, the line feed character.

Tn     Select serial terminator where n is a value in the range 0 thru 255  
T?     Return the currently selected serial terminator.

Example 1: Set terminators for ports 1 and 3 using dual primary addressing mode.

PRINT#1, "CLEAR08"	reset the Converter
PRINT#1, "OUTPUT08;P1X"	select port 1 as the current port
PRINT#1, "OUTPUT08;T13X"	select CR terminator
PRINT#1, "OUTPUT08;P3X"	select port 3 as the current port
PRINT#1, "OUTPUT08;T0X"	select NUL character terminator

Example 2: Set terminators for ports 1 and 3 using secondary addressing mode.

PRINT#1, "OUTPUT0800;P1X"	select port 1 as the current port
PRINT#1, "OUTPUT0800;T13X"	select CR terminator
PRINT#1, "OUTPUT0800;P3X"	select port 3 as the current port
PRINT#1, "OUTPUT0800;T0X"	select NUL terminator

## Status

Un

The Status command selects the type of status message the Converter will send when addressed to talk on the command address. The U0 selection causes the command status to be selected. The U1 thru U4 selections cause a serial port status to be selected. The status of the Converter may be read at any time without interfering with normal operation. Any error conditions are cleared after the command status string is read by the controller. The factory default setting as set by the Save Configuration command (S0) is U0, command status is selected.

**NOTE:** The Status selected is independent of the serial port selected via the Port command (Pn).

- U0 Send the Converter command status when addressed to talk
- U1 Send the status of serial port 1 when next addressed to talk
- U2 Send the status of serial port 2 when next addressed to talk
- U3 Send the status of serial port 3 when next addressed to talk
- U4 Send the status of serial port 4 when next addressed to talk
- U? Return the current status command selection

The format of the status byte returned by the Converter after receiving a U0 command is as follows:

\*.\*E#K#M###P#U#Y#Z#####

where each # equals the number corresponding to that command. The leading information \*.\* is the revision level of the Converter firmware.

**Example 1:** Read Converter command status using dual primary addressing mode.

DIM A\$(50)	dimension A\$
PRINT#1,"CLEAR08"	reset the Converter
PRINT#1,"OUTPUT08;U0X"	send U0 to the Converter
PRINT#1,"ENTER08"	
INPUT#2,A\$	read the status byte
PRINT A\$	shows 1.0E0K1M000P1Y2

The format of the status byte returned by the Converter after receiving a U1 through U4 command is as follows:

\*.\*A#B#C#D##G#I#####L#N#O#####Q#T###U#

where each # equals the number corresponding to that command. The leading information \*.\* is the revision level of the Converter firmware.

Example 2: Read Converter command status using secondary addressing mode.

DIM A\$(50)	dimension A\$
PRINT#1, "OUTPUT0800;S0X"	restore Converter defaults
PRINT#1, "CLEAR0800"	reset the Converter
PRINT#1, "OUTPUT0800;U1X"	send U1 to the Converter
PRINT#1, "ENTER0800"	
INPUT#2, A\$	read the port 1 status message
PRINT A\$	shows
1.0A0B009C0D1G0I00000L1N0000000Q0T010U1	

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

E#	Error Message
E0	No error
E1	Unrecognized command (ex. W3)
E2	Illegal command option (ex. F8)
E3	Conflict (handshake type, handshake control, baud select)
K#	End Or Identify
K0	EOI enabled on last byte of status message
K1	EOI disabled
M###	Service Request
M0	SRQ is disabled
M1	SRQ on serial port #1 data in
M2	SRQ on serial port #2 data in
M4	SRQ on serial port #3 data in



### Section 3

### Command Descriptions

M8	SRQ on serial port #4 data in
M16	SRQ on Ready
M32	SRQ on error condition
M128	SRQ on memory low condition

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

P#	Selected Port
P1	Port 1 selected
P2	Port 2 selected
P3	Port 3 selected
P4	Port 4 selected

U#	Status message
U0	Command status

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

Z##### Free buffer memory available for serial data

Below is a summary of the Serial Port Status (U1-4) information.

A#	Stop Bits
A0	1 stop bit
A1	2 stop bits

B###	Baud Rate
B0	110 Baud selected
B1	300 Baud selected
B2	600 Baud selected
B3	1200 Baud selected
B4	1800 Baud selected
B5	2400 Baud selected

B6	3600 Baud selected
B7	4800 Baud selected
B8	7200 Baud selected
B9	9600 Baud selected
B10	19200 Baud selected
B11	16 x External clock selected
C#	Parity
C0	Parity is disabled.
C1	Odd parity is enabled.
C2	Even parity is enabled.
D#	Data Bits
D0	Seven data bits selected.
D1	Eight data bits selected.
G#	Handshake Type
G0	Hardware handshaking (RTS/CTS) is selected.
G1	Software handshaking (XON/XOFF) is selected.
G2	No handshaking is selected.
I#####	Serial input bytes available to read
L#	Data EOI
L0	Assert EOI on serial terminator character.
L1	EOI is disabled.
L2	Assert EOI on last serial input character.
L3	Assert EOI on serial terminator character or last serial character.
N#	Handshake Control
N0	Automatic handshaking, RTS/CTS or XON/XOFF
N1	Hold off serial input, un-assert RTS or send XOFF.
N2	Release holdoff of serial input, assert RTS or Send XON.
N3	Automatic XON/XOFF handshake with Baud Clock x 16 output on RTS line, or no handshaking and Baud Clock x 16 output on RTS line.
O#####	Serial output bytes not yet transmitted out the serial port

### Section 3

### Command Descriptions

Q#	Break
Q0	Stop sending break characters.
Q1	Send break characters.
T###	Current Serial Terminator character
U#	Selected Serial Port Status
U1	Serial port 1 status
U2	Serial port 2 status
U3	Serial port 3 status
U4	Serial port 4 status

## Version Query

**V?**

The Version Query command returns the Converter firmware revision number.

V?    Return Converter firmware revision number.

Example 1: Get Converter firmware revision using dual primary addressing mode.

PRINT#1, "OUTPUT08;V?"

ask for version information

PRINT#1, "ENTER08"

read the response

INPUT#2, A\$

PRINT A\$

display shows    1.3 (or higher)

## Execute

**X**

Commands sent to the Converter will result in no action until the unit is instructed to execute these commands. This is done by sending an X, usually as the last character of a command string. Commands sent without an X are stored in the internal buffer until an X is received. Any number of Execute commands may be inserted into the same command string.

X      Execute previous Converter command(s).

Example 1: Execute a Converter command using dual primary addressing mode.

PRINT#1, "CLEAR08"  
PRINT#1, "OUTPUT08;P1F2"

PRINT#1, "OUTPUT08;X"

reset the Converter  
send "F2" to the Converter command  
Flush port 1 input and output buffers  
instruct the Converter to execute its  
command input buffer

## Bus Terminator

Yn

The IEEE 488 bus terminator command selects the characters sent at the end of status messages returned by the Converter. The terminator may be programmed for any combination of Carriage Return (CR) and Line Feed (LF). Y0 sends CR only and Y1 sends LF only. The Y2 mode, the most commonly accepted terminator, sends CR-LF. Y3 reverses the sequence to send LF-CR. The factory default setting as set by the Save Configuration command (S0) is Y2, CR-LF.

Y0	CR only
Y1	LF only
Y2	CR LF
Y3	LF CR
Y?	Return current bus terminator selection.

Example 1: Set terminator to linefeed carriage return using dual primary addressing mode.

```
PRINT#1, "CLEAR08"
```

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

select line feed carriage return terminator

## Memory Query

**Z?**

The Memory Query command returns the number of characters which may be written to the serial ports without causing a 'low memory' condition. This command may be used to for determining how many more characters can be safely written to the Converter before handshaking will attempt to stop serial input data because of a 'low memory' condition.

**Z?**      Return the number of characters which may be written to the serial ports

**Example 1:** Find the amount of free memory remaining in the Converter using dual primary addressing mode.

PRINT#1, "OUTPUT08; Z?"	request amount of free memory
PRINT#1, "ENTER08"	
INPUT#2, A\$	read the response
PRINT A\$	display shows Z23456

**Example 2:** Find the amount of free memory remaining in the Converter using secondary addressing mode.

PRINT#1, "OUTPUT0800; Z?"	request amount of free memory
PRINT#1, "ENTER0800"	
INPUT#2, A\$	read the response
PRINT A\$	display shows Z23456

## Serial Poll Status Byte

The Serial Poll Status byte is sent upon receiving the serial poll command from the controller. Refer to the SRQ description for details on how the Serial Poll Status byte is affected. Below is a description of the significance of each bit in the Serial Poll Status byte.

<u>Bit Location</u>	<u>Value</u>	(SRQ Bit Value if set to logic 1)
DIO1(LSB)	1	serial data available on port 1
DIO2	2	serial data available on port 2
DIO3	4	serial data available on port 3
DIO4	8	serial data available on port 4
DIO5	16	Ready for more commands
DIO6	32	Command Error
DIO7	64	Service Request bit
DIO8 (MSB)	128	Memory low warning

### Serial Poll Bit Description

- DIO1 The DIO1 bit is set by the receipt of serial data on port 1. When enabled by the M1 command this condition will also generate a Service Request. DIO1 is cleared when no more data is available to be read on port 1.
- DIO2 The DIO2 bit is set by the receipt of serial data on port 2. When enabled by the M2 command this condition will also generate a Service Request. DIO2 is cleared when no more data is available to be read on port 2.
- DIO3 The DIO3 bit is set by the receipt of serial data on port 3. When enabled by the M4 command this condition will also generate a Service Request. DIO3 is cleared when no more data is available to be read on port 3.
- DIO4 The DIO4 bit is set by the receipt of serial data on port 4. When enabled by the M8 command this condition will also generate a Service Request. DIO4 is cleared when no more data is available to be read on port 4.
- DIO5 The DIO5 bit is set after an entire command string has been received and processed by the Converter. The bit is cleared while the Converter is processing commands which have been received from the controller. When used with the M16 command, a Service Request will also be generated when



### Section 3

### Command Descriptions

the DIO5 bit is set. An Execute command (X) must be received before the DIO5 bit can be cleared.

- DIO6 DIO6 is set when an invalid command is sent to the Converter. The M32 command will enable a Service Request to occur when an invalid command is received. This bit is cleared after the controller sends a Status (U0), or Error Query (E?) command and reads the status string from the Converter.
- DIO7 When the Converter generates a Service Request, the DIO7 bit will be set to a logic one. This is used by the controller to determine that the Service Request was generated by the Converter.
- DIO8 DIO8 is when the Converter memory is low. The M128 command enables a Service Request to occur when the memory low condition is encountered. This bit is cleared when a memory low condition no longer exists.

#### Example:

PRINT#1, "CLEAR08"	reset the Converter
PRINT#1, "OUTPUT08;M32X"	select SRQ on Bus error
PRINT#1, "OUTPUT08;F7X"	send an invalid bus command.
	ERROR and SRQ LEDs should illuminate
PRINT#1, "SPOLL08"	display should be 112 (64+16+32)

64 denotes the Converter was the source of the SRQ. 16 denotes the Converter is READY for more commands. 32 denotes a Command error. When serial polled, the SRQ LED will turn off.

## IEEE 488 Primer

---

### 4.1 History

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

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

### 4.2 General Structure

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

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

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

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

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

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

- a) Unlisten all devices to protect against eavesdroppers.
- b) Designate who will talk by addressing a device to talk.
- c) Designate all the devices who are to listen by addressing those devices to listen.
- d) Indicate to all devices that the data transfer can take place.

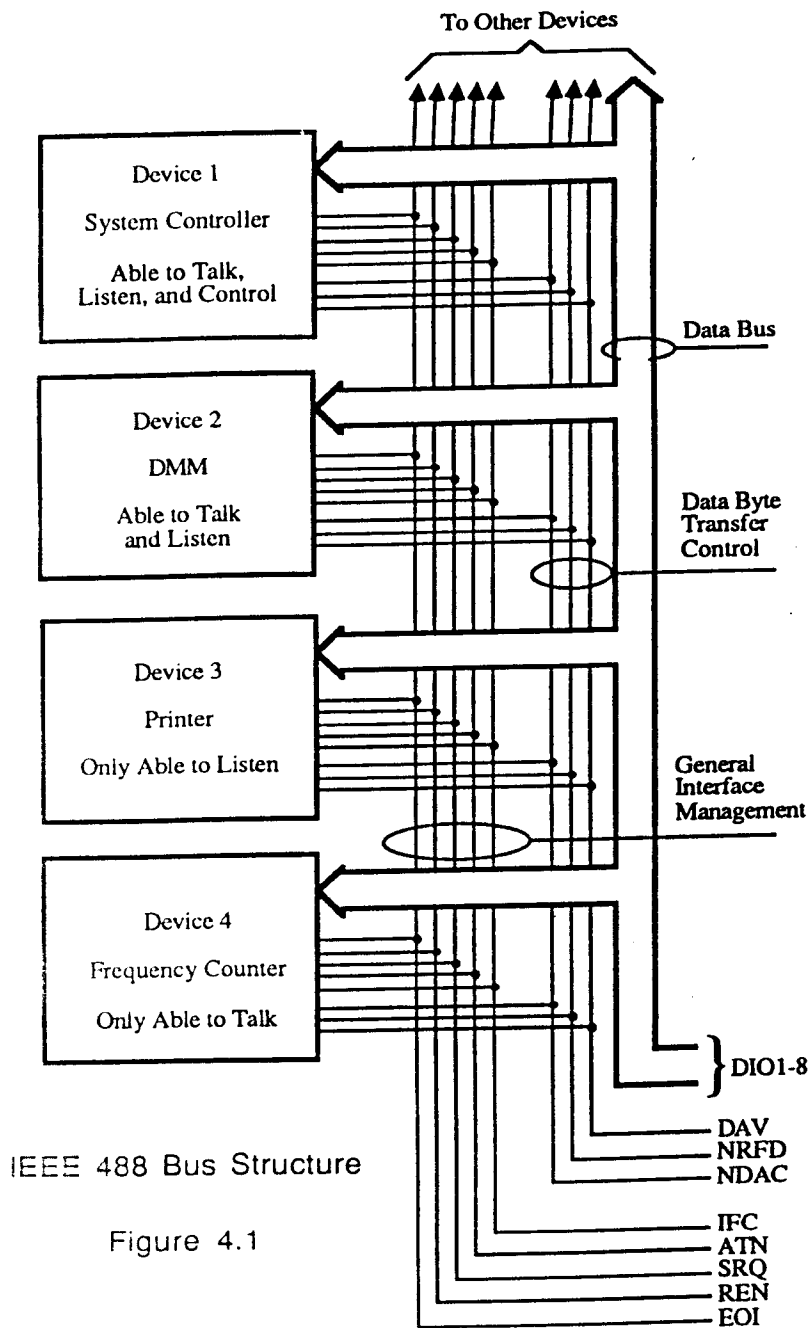


Figure 4.1

### 4.3 Send it to My Address

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

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

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

### 4.4 Bus Management Lines

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

#### 4.4.1 Attention (ATN)

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

#### 4.4.2 Interface Clear (IFC)

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

#### 4.4.3 Remote Enable (REN)

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

#### 4.4.4 End or Identify (EOI)

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

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

#### 4.4.5 Service Request (SRQ)

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

## 4.5 Handshake Lines

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

### 4.5.1 Data Valid (DAV)

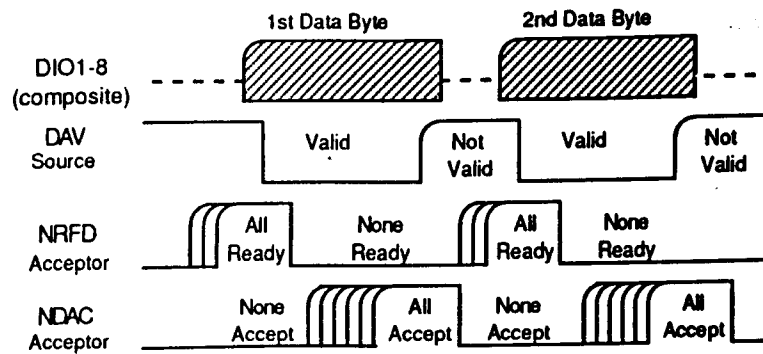
The DAV line is controlled by the Talker. The Talker verifies that NDAC is asserted (active low) which indicates that all Listeners have accepted the previous data byte transferred. The Talker then outputs data on the bus and waits until NRFD is unasserted (high) which indicates that all Addressed Listeners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

### 4.5.2 Not Ready for Data (NRFD)

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

### 4.5.3 Not Data Accepted (NDAC)

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



IEEE Bus Handshaking

#### 4.6 Data Lines

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

#### 4.7 Multiline Commands

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

##### 4.7.1 Go To Local (GTL)

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



#### **4.7.2 Listen Address Group (LAG)**

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

#### **4.7.3 Unlisten (UNL)**

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

#### **4.7.4 Talk Address Group (TAG)**

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

#### **4.7.5 Untalk (UNT)**

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

#### **4.7.6 Local Lockout (LLO)**

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

#### **4.7.7 Device Clear (DCL)**

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

#### **4.7.8 Selected Device Clear (SDC)**

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

#### **4.7.9 Serial Poll Disable (SPD)**

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

#### **4.7.10 Serial Poll Enable (SPE)**

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

#### **4.7.11 Group Execute Trigger (GET)**

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

#### **4.7.12 Take Control (TCT)**

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

#### **4.7.13 Secondary Command Group (SCG)**

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

#### **4.7.14 Parallel Poll Configure (PPC)**

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

#### **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 responsibility of the Active Controller to send and the bus devices to recognize. Most of these happen routinely by the interface and are totally transparent to the system programmer. Other commands are used directly by the user to provide optimum system control. Of the uniline commands, SRQ is very important to the test system and the software designer has easy access to this line by most devices. Service Request is the method by which a bus device can signal to the Controller that an event has occurred. It is similar to an interrupt in a microprocessor based system.

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

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

#### 4.8.1 Serial Poll

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

#### 4.8.2 Parallel Poll

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

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

## Theory of Operation

### Theory of Operation

The Heart of the Four Channel IEEE 488/Serial Converter is a 2 Mhz 6809 microprocessor [U101] supported by 8K bytes of firmware EPROM [U102 (27128)] and 64k bytes of static RAM [U103 & U104 (58256)]. A Versatile Interface Adapter [U104 (65B22)] is used to generate real-time interrupts for the firmware operating system and drive the front panel LED annunciators through inverters [U112 & U113 (74LS04)].

The IEEE 488 bus interface is accomplished by a TMS9914A [U105] controller with drivers [U106 (75160) and U107(75162)]. The four serial interfaces use two Z8530 [U119 & U120] Serial Communications Controllers with four RS232 drivers [U121, U122, U123, & U124 (LT1081)], two RS422 drivers [U126 & U127 (26LS31)], and two RS422 receivers [U128 & U129 (26LS33)].

Decoding of the microprocessor address space is accomplished with two Programmable Logic Array [U108 & U111 (16L8)]. The Memory space allocation is...

<u>Address</u>	<u>Device</u>	<u>Part Number</u>	<u>Function</u>
\$0000-\$7FFF	U103	58256	Static RAM
\$8000-\$E6FF	U104	58256	Static RAM
\$E700-\$E70F	U106	TMS9914A	IEEE Controller
\$E710-\$E71F	U114	74HCT240	SW1
\$E760-\$E76F	U120	Z8530	Serial Controller
\$E770-\$E77F	U119	Z8530	Serial Controller
\$E780-\$E7FF	U110	R65C22	VIA
\$E800-\$FFFF	U102	27128	Programmed EPROM

<u>Command</u>	<u>Code</u>	<u>Description</u>
Stop Bit(s)	A0	Selects 1 stop bit for selected port
	A1	Selects 2 stop bits for selected port
	A?	Returns current stop bits setting
Baud Rate	B0	Baud rate = 110
	B1	Baud rate = 300
	B2	Baud rate = 600
	B3	Baud rate = 1200
	B4	Baud rate = 1800
	B5	Baud rate = 2400
	B6	Baud rate = 3600
	B7	Baud rate = 4800
	B8	Baud rate = 7200
	B9	Baud rate = 9600
	B10	Baud rate = 19200
	B11	Baud rate = 16 x external
Parity	B?	Returns current baud rate setting
	C0	No parity enabled
	C1	Odd parity
	C2	Even parity
Data Bits	C?	Returns current parity setting
	D0	Sets number of data bits to 7
	D1	Sets number of data bits to 8
	D?	Returns current data bit setting
Error Query	E?	Returns error status
Flush	F0	Flushes serial input buffer
	F1	Flushes serial output buffer
	F2	Flushes both input and output buffers
	F?	Returns last flush command executed

## Appendix A

## Interface Command Summary

<u>Command</u>	<u>Code</u>	<u>Description</u>
<b>HandshakeType</b>	G0	Sets handshake to Rts/Cts (hardware)
	G1	Sets handshake to Xon/Xoff (software)
	G2	Sets handshake to none
	G?	Returns current handshake type selected
<b>Input Query</b>	I?	Returns number of characters in serial input queue
<b>Status EOI</b>	K0	Assert EOI with last terminator
	K1	EOI disabled
	K?	Returns current status EOI selected
<b>Data EOI</b>	L0	Assert EOI on serial terminator
	L1	EOI disabled
	L2	Assert EOI on last character in buffer
	L3	Assert EOI on terminator or last character
	L?	Returns current data EOI selected
<b>Service Request Mask</b>	M0	Disable bus SRQ
	M1	SRQ on Serial port 1 input
	M2	SRQ on Serial port 2 input
	M4	SRQ on Serial port 3 input
	M8	SRQ on Serial port 4 input
	M16	SRQ on Ready for next command
	M32	SRQ on Command error
	M128	SRQ on Memory low
<b>Handshake Control</b>	M?	Returns current SRQ mask
	N0	Automatic
	N1	Holdoff data
	N2	Accept data
	N3	Output 16 x baud clock on RTS line
<b>Output Query</b>	N?	Returns current handshake control setting
	O?	Returns number of characters in serial output queue

<u>Command</u>	<u>Code</u>	<u>Description</u>
Port Select	P1	Select serial port 1
	P2	Select serial port 2
	P3	Select serial port 3
	P4	Select serial port 4
	P?	Returns currently selected serial port
Break	Q0	Disable sending break
	Q1	Enable sending break
	Q?	Returns current break setting
Save Configuration	S0	Save default setup in non-volatile RAM
	S1	Save current setup in non-volatile RAM
	S?	Returns last save configuration command executed
Serial Terminator	Tn	Select n (0 - 255) as serial terminator
	T?	Returns currently selected serial terminator
Status	U0	Send command status on talk
	U1	Send serial port 1 status on talk
	U2	Send serial port 2 status on talk
	U3	Send serial port 3 status on talk
	U4	Send serial port 4 status on talk
	U?	Returns current status select setting
Version Query	V?	Returns the Converter firmware revision
Execute	X	Execute Command String
Bus Terminator	Y0	CR
	Y1	LF
	Y2	CR LF
	Y3	LF CR
	Y?	Returns current bus terminator setting
Memory Query	Z?	Returns the amount of serial data memory available



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

- ACG - UCG - LAG - TAG - SCG -

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

TAG = Talk Address Group  
SCG = Secondary Command Group