RS-232↔IEEE 488
Interface Converter

EUROPEAN UNION DECLARATION OF CONFORMITY

To maintain safety, emission, and immunity standards of this declaration, the following conditions must be met.

- Serial and IEEE cables must have a braided shield connected circumferentially to their connectors' metal shells.

- All cable screw locks must be tightened at both ends of the cable.

- The host computer must be properly grounded.

- Some inaccuracy is to be expected when I/O leads are exposed to RF fields or transients.

- The operator must observe all safety cautions and operating conditions specified in the documentation for all hardware used.

- The host computer, peripheral equipment, power sources, and expansion hardware must be CE compliant.

- All power must be off to the device and externally connected equipment before internal access to the device is permitted.

- An external power supply is provided with this product. Its input is 105 to 125 VAC or 210 to 250 VAC, 50-60 Hz, 10 VA maximum power draw. Its 9-VDC output connects to the power input of the unit (marked 10VDC MAX @ 500 mA).

- The RS-232/422 terminal is meant to be connected only to devices with serial-communications-level signals. The IEEE 488 terminal is meant to be used only with non-isolated IEEE 488 systems. The common mode voltage (cable shell to earth) must be zero.

- Terminal Installation Category for CE Compliance is Category 1.

- Operating environment for CE compliance is: Indoor use at altitudes below 2000 m, 0 to 40°C, 80% maximum RH up to 31°C decreasing linearly 4%RH/°C to 40°C.

- Regarding DC power input: Please note that the power input is marked 10VDC MAX @ 600 mA. This is just something to check; check your equipment's power input labels for "600 mA" (or even 500 mA).

WARNING!

Noted conditions pertain to potential safety hazards. When you see a WARNING!, CAUTION!, or IMPORTANT! note, carefully read the information and be alert to the possibility of personal injury.

Failure to follow these directives voids emission and immunity compliance.

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AND

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RADIO FREQUENCY INTERFERENCE STATEMENTS

This equipment generates, uses, and can radiate radio frequency energy and if not installed and used properly, that is, in strict accordance with the manufacturer's instructions, may cause interference to radio communication. It has been tested and found to comply with the limits for a Class A computing device in accordance with the specifications in Subpart J of Part 15 of FCC rules, which are designed to provide reasonable protection against such interference when the equipment is operated in a commercial environment. Operation of this equipment in a residential area is likely to cause interference, in which case the user at his own expense will be required to take whatever measures may be necessary to correct the interference.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

This digital apparatus does not exceed the Class A limits for radio noise emission from digital apparatus set out in the Radio Interference Regulation of Industry Canada.

Le présent appareil numérique n'émet pas de bruits radioélectriques dépassant les limites applicables aux appareils numériques de classe A prescrites dans le Règlement sur le brouillage radioélectrique publié par Industrie Canada.

NORMAS OFICIALES MEXICANAS (NOM)
ELECTRICAL SAFETY STATEMENT

INSTRUCCIONES DE SEGURIDAD

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

18. Servicio por personal calificado deberá ser provisto cuando:

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

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

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

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

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

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1. Specifications

IEEE-488 Interface

Implementation —   C1, C2, C3, C4, and C28 controller subsets. Serial to IEEE: SH1, AH1, T6, TE0, L4, LE0, SR1, RL0, PP0, DC1, DT0, E1.

Terminators —   Selectable CR, LF, LF-CR, and CR-LF with EOI

Connector —   Standard IEEE 488 connector with metric studs

Serial Interface

EIA RS-232C —   AB, BA, BB, CA, CB

EIA RS-422A —   Balanced voltage on TxD and RxD

Character Set —   Asynchronous bit serial

Output Voltage —   ±5 volts min. (RS-232C); 5 volts typical (RS-422A)

Input Voltage —   ±3 volts min.; q15v max.

Baud Rate —   Selectable 110, 300, 600, 1200, 1800, 2400, 3600, 4800, 7200, 9600, 19,200, and 57,600

Data Format —   Selectable 7 or 8 data bits; 1 or 2 stop bits; odd, even, mark, space, and no parity on transmit

Duplex —   Full with Echo/No Echo

Serial Control —   Selectable CTS/RTS or XON/XOFF

Terminators —   Selectable CR, LF, LF-CR, and CR-LF

Connector —   25-pin sub-D male, DCE configured

General

Data Buffer —	32,000 characters dynamically allocated
Indicators —	LEDs for IEEE Talk and Listen, Serial Send and Receive, and Power
Power —	105-125V or 210-250V; 50-60 Hz, 10 VA max.
Size —	2.7"H x 5.5"W x 7.4"D (6.9 x 14 x 18.8 cm)
Weight —	3.6 lb. (1.6 kg)
Environment —	0 to 50°C; 0 to 70% R.H. to 35°C. Linearly derate 3% R.H./degrees Centigrade from 35 to 50°C
Controls —	Power Switch (external), IEEE and Serial parameter switches (internal). Jumper selection of RS-232 or RS-422 operation (internal)
Certification —	FCC, CE

WARNING!

Do not use this interface outdoors. The interface is intended for indoor use only. Using this equipment outdoors could result in equipment failure, bodily injury, or death.

CAUTION

Do not connect AC line power directly to the RS-232↔IEEE 488 Interface Converter. Direct AC connection will damage equipment.

2. Introduction

2.1 Description

The RS-232↔488 Interface Converter provides transparent communication from a serial computer to an IEEE 488 printer, plotter, or other device. It also can be used to control a serial device, such as a printer or terminal, from an IEEE 488 host computer.

As a serial-to-IEEE-488 converter, the interface converter receives data from a serial host then automatically performs the bus sequences necessary to send this data to the IEEE 488 device. If desired, data can be requested from the IEEE 488 device and returned to the host.

As an IEEE 488 to serial converter the interface converter is a peripheral to an IEEE 488 controller. Data received from the controller is sent to the serial device, and the data received from the serial device is buffered for transmission to the IEEE 488 controller. The interface converter can inform the host, by the serial poll-status byte, that it has received data from the serial device.

2.2 Abbreviations

The IEEE 488 abbreviations listed below are used throughout this manual.

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

3. Getting Started

3.1 Inspection

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

Every interface converter is shipped with the following:

• RS-232↔IEEE 488 Interface Converter

• This instruction manual

• Power supply

3.2 Configuration

Three DIP switches internal to the interface converter set the configuration of the interface.

NOTE

Selectable functions are read *only* at power-on and should only be set prior to applying power to the interface. The following figures illustrate the factory-default conditions, which are:

Serial Port:	**IEEE:**
9600 Baud	Mode = IEEE 488 Controller
8 Data Bits	Address = 10
2 Stop Bits	Bus Terminator = LF; EOI Disabled
No Parity	Talk-Back on Terminator Enabled
Serial Terminator = LF	Talk-Back on Timeout Enabled
Echo Disabled	
RTS/CTS Handshake	

SW3

DOT
Switch Side View

1 2 3 4 5 6 7 8
OPEN

IEEE Addr **10**
IEEE Term **LF**
EOI **Disabled**

SW2

DOT
Switch Side View

1 2 3 4 5 6 7 8
OPEN

Mode **C**
Talk-Back on Timeout **Enabled**
Serial Term **LF**
Echo **No Echo**
Parity **No Parity**

SW1

DOT
Switch Side View

1 2 3 4 5 6 7 8
OPEN

Baud Rate **9600**
Handshake **RTS/CTS**
Word Length **8 Data Bits**
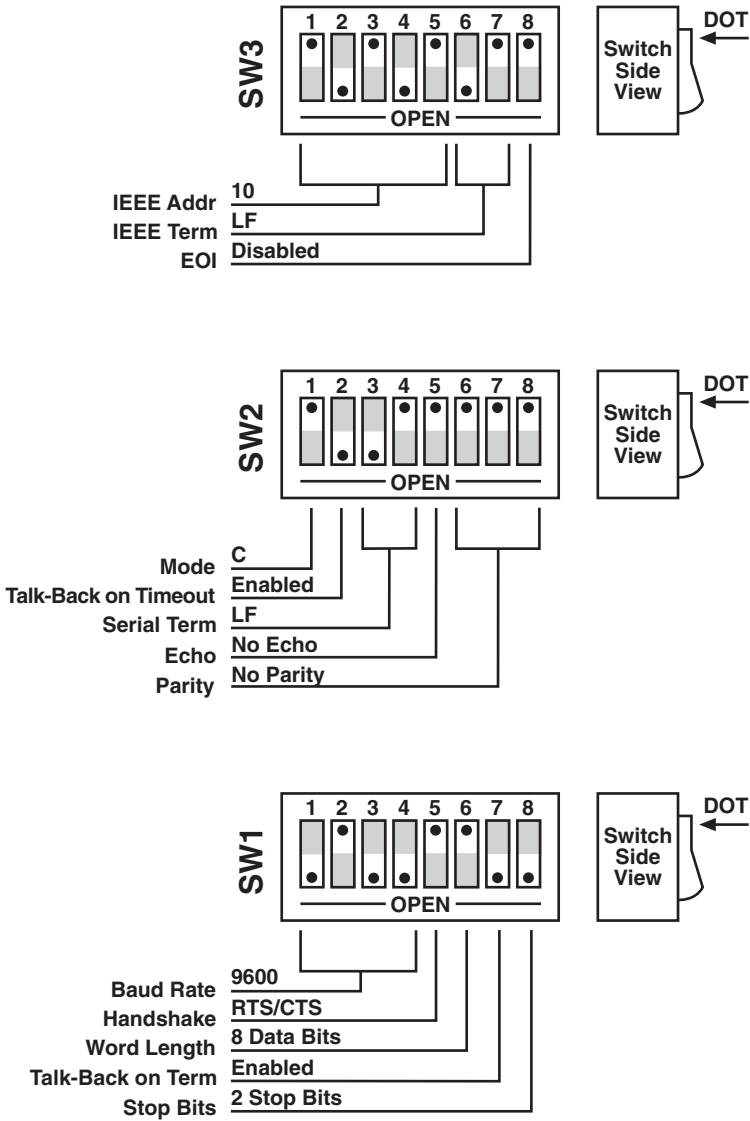Talk-Back on Term **Enabled**
Stop Bits **2 Stop Bits**

Figure 3-1. Factory-Default Settings.

Note that the interface converter comes configured as an IEEE controller. In this mode, the interface converter is designed to allow an RS-232 computer to communicate with an IEEE peripheral such as a plotter. This controller mode is described in detail in **Chapter 4**.

The interface converter may also be configured as an IEEE peripheral. As an IEEE peripheral, it allows an IEEE controller to communicate with an RS-232 device. The peripheral mode of operation is described in detail in **Chapter 5**.

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

1. Disconnect the power supply from the AC line and from the interface. Also disconnect any IEEE or serial cables.

WARNING

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

2. Place the interface converter upside down on a flat surface. Remove the four screws located near the rubber feet.

3. Return the interface converter to the upright position and carefully remove the top cover.

4. Change whichever DIP-switch settings you need to change.

5. When you have made all your changes, reverse this procedure to reassemble the interface converter.

3.3 Serial Port Settings

The first parameters to configure are those that correspond to the RS-232 port. These include baud rate, word length, number of stop bits, parity selection and type of RS-232 handshake. Each of these are described in the following sections.

3.3.1 SERIAL BAUD RATE

The "baud rate" is the number of serial data bits per second transferred into and out of the RS-232 interface. SW1-1 through SW1-4 determine the serial baud rate. The factory-default baud rate is 9600 baud. Baud rates may be selected from 110 to 57,600 baud. Refer to the following diagram for specific baud rates.
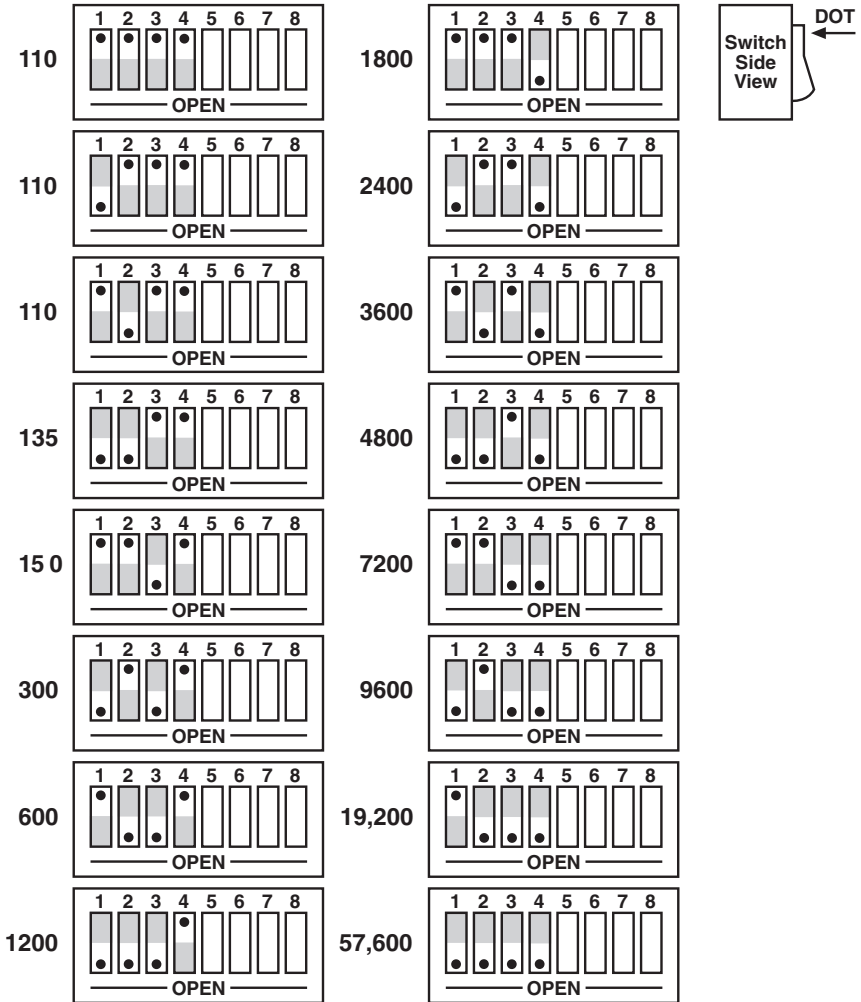
Figure 3-2. Switch SW1: Selecting the Serial Baud Rate.

3.3.2 SERIAL WORD LENGTH (DATA BITS)

SW1-6 determines the number of data bits, often referred to as word length, for each serial character transmitted or received. The factory default is 8 data bits.
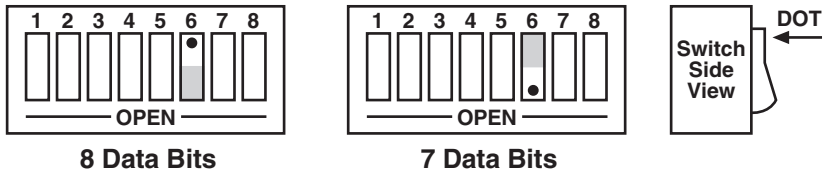
Figure 3-3. Switch SW1: Selecting the Serial Word Length (Data Bits).

3.3.3 SERIAL STOP BITS

Switch SW1-8 determines the number of stop bits contained in each serial character transmitted and received. The factory default is 2 stop bits.
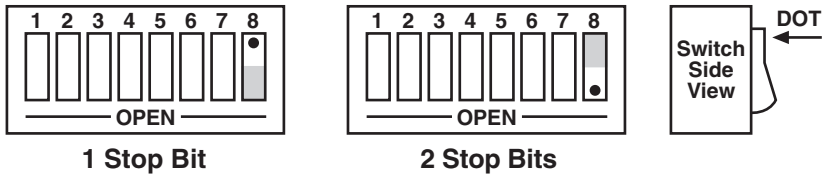
Figure 3-4. Switch SW1: Selecting the Serial Stop Bits.

3.3.4 SERIAL PARITY

Serial Parity is selected with S2-6 through S2-8. The interface converter generates the selected parity during serial transmissions but it does not check parity on data that is received. The factory default is parity disabled.

Odd Parity   **Mark Parity**   **Switch Side View**   **DOT**

Even Parity   **Space Parity**
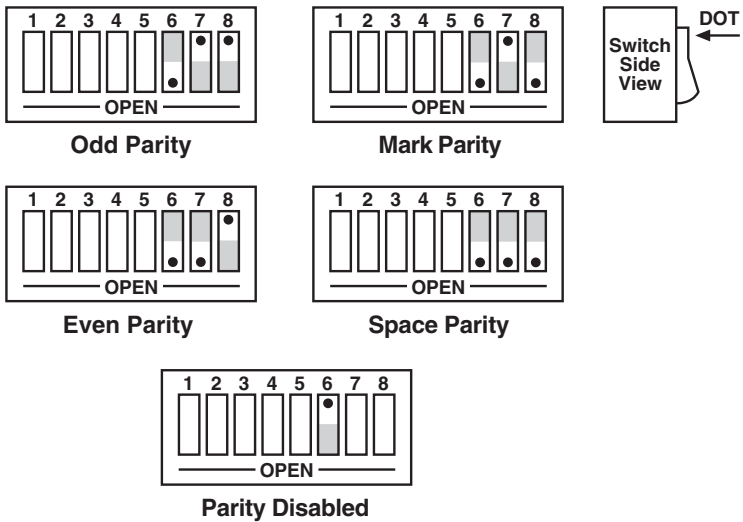
Parity Disabled

Figure 3-5. Switch SW2: Selecting the Serial Parity.

3.3.5 SERIAL ECHO

Serial data sent to the interface converter will be echoed back to the serial host if SW2-5 is set to the open position. The factory default is Echo Disabled.

Echo Disabled   **Echo Enabled**   **Switch Side View**   **DOT**
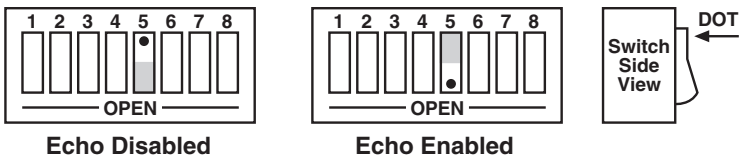
Figure 3-6. Switch SW2: Enabling or Disabling Echo.

3.3.6 SERIAL HANDSHAKE

Switch SW1-5 is used to select hardware [RTS/CTS] or software [Xon/Xoff] serial handshake control.

With X-ON/X-OFF, the interface converter issues an X-OFF character [ASCII value of $13] when its buffer memory is near full. When the X-OFF character is sent, there are still more than 1000 character locations remaining to protect against buffer overrun. When it is able to accept more information, the interface converter issues an Xon character [ASCII value of $11]. The interface converter also accepts X-ON/X-OFF on transmit from the serial host it is communicating with. RTS/CTS serial control becomes inactive when X-ON/X-OFF is enabled. The RTS output is, however, set to an active high state. The CTS input is not used for this handshake and may be left floating (unconnected).

With RTS/CTS, the interface converter un-asserts RTS (sets RTS low) when its buffer memory is near full. When RTS is un-asserted, there are still more than 1000 character locations remaining to protect against buffer overrun. When it is able to accept more information, the interface converter asserts RTS (sets RTS high). The interface converter will not transmit data to the serial host if it detects the CTS input un-asserted (low) when configured for this hardware handshake.

The factory-default serial control is hardware, RTS/CTS.
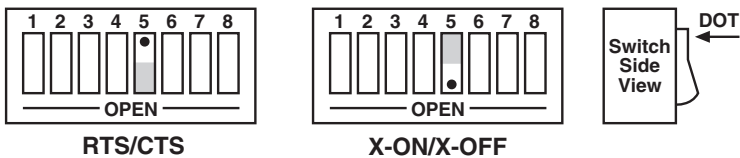
Figure 3-7. Switch SW1: Selecting the Serial Handshake.

3.4 Selecting Terminator Substitution

The interface converter can be configured to provide RS-232-to-IEEE-488 and IEEE-488-to-RS-232 terminator substitution. This is useful when interfacing an RS-232 device which only issues carriage return [CR] as an output terminator to an IEEE controller which expects a carriage return followed by a line feed [CR-LF].

In a case like that, the serial terminator should be selected for CR Only while the IEEE terminator is set to CR-LF. When a serial CR character is received, it is discarded, and an IEEE CR-LF is substituted for it. In the IEEE-to-RS-232 direction, the IEEE CR is unconditionally discarded. Upon receipt of the IEEE LF, a serial CR is substituted.

The interface converter can be made totally data transparent by setting both the serial and IEEE terminators to be CR Only or LF Only.

3.4.1 SERIAL TERMINATOR

SW2-3 and SW2-4 select the serial terminators for the serial input and output. The factory default is LF Only.
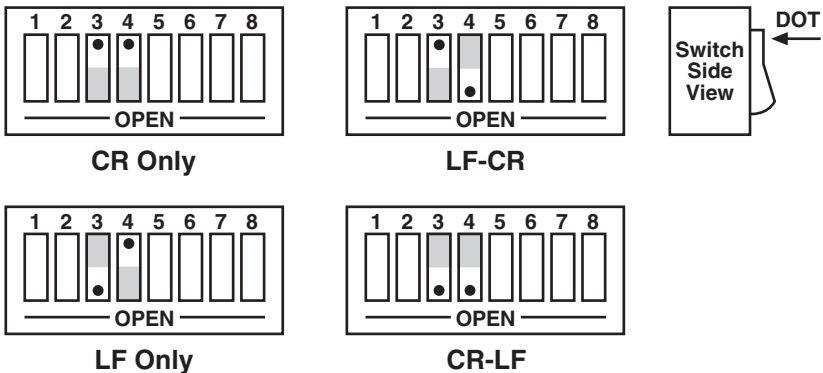
Figure 3-8. Switch SW2: Selecting the Serial Terminator.

3.4.2 IEEE BUS TERMINATOR

SW3-6 through SW3-8 set the IEEE bus terminators used for data sent or received by the interface converter. EOI, a line used to signal the end of a multiple character bus transfer, may also be enabled. If enabled, EOI is asserted when the last selected bus terminator is sent. Factory default is LF Only with EOI disabled.
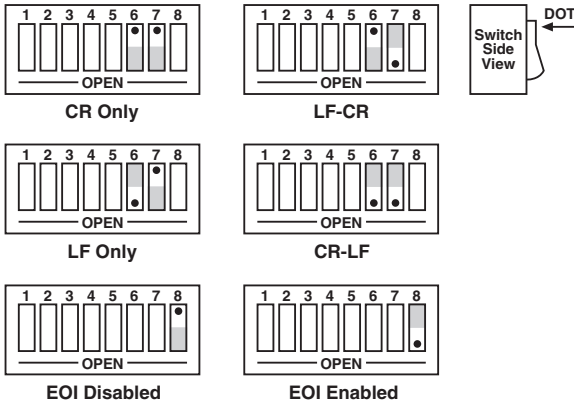
Figure 3-9. Switch SW3: Selecting the IEEE Bus Terminator.

3.5 Selecting the Mode

SW2-1 sets the major operating mode of the interface converter. The IEEE Controller (RS-232-to-IEEE converter) mode allows a serial host device to send data to a single IEEE bus peripheral. Applications include interfacing a listen-only or addressable IEEE printer/plotter to a serial printer port. Refer to **Chapter 4** for more detailed information on the controller mode of operation.

The Peripheral mode is used when interfacing a serial device to an IEEE controller. Data which is sent by the IEEE controller to the interface converter is transmitted out its serial port. Data received from the serial device is buffered by the interface converter until read by the IEEE controller. Refer to **Chapter 5** for more detailed information on the peripheral mode of operation.

The factory default is the IEEE Controller mode, an RS-232-to-IEEE converter.
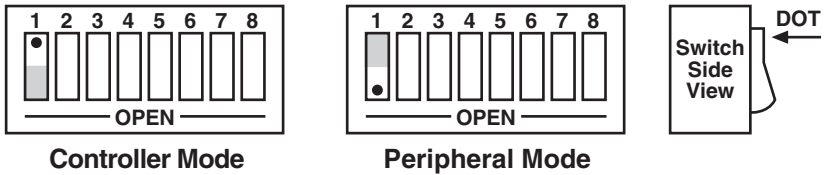
Figure 3-10. Switch SW2: Selecting the Mode.

3.6 Selecting the IEEE Address

SW3-1 through SW3-5 select the IEEE bus address of the interface converter when in the IEEE Peripheral mode. These same switches are used in the IEEE Controller mode to select the address of the device that will be controlled. [Refer to **Chapters 5** and **4** respectively for additional information]. The address is selected by simple binary weighting, with SW3-1 being the least significant bit and SW3-5 the most significant. The factory default is address 10.

Listen Only is a special type of Peripheral operation. In the Listen Only mode the interface converter accepts all data transmitted on the bus, ignoring any bus addressing, and transfers it out its serial port. The interface converter is set to Listen Only mode by setting its address to 31. If the IEEE address is set to 31 in the peripheral mode, it is adjusted to 30.
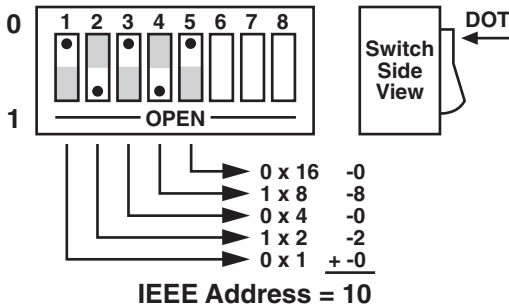
Figure 3-11. Switch SW3: Selecting the IEEE Address.

3.7 Feature Selections

The functions of the remaining switches are dependent on the mode selected. A brief description of each of these features follows. You should refer to the listed sections for additional information.

3.7.1 CONTROLLER FEATURES

In the IEEE Controller (RS-232-to-IEEE 488 Converter) mode, SW1-7 is used to determine whether the interface should, after sending the IEEE bus terminators, address the attached bus device to talk. The factory default is Talk-Back On Terminator enabled.

SW2-2 selects whether the interface converter should address the attached bus device to talk when the interface converter has nothing more to send to that device. The factory default is Talk-Back On Timeout enabled.

Refer to **Chapter 4** for complete details on these features.

**Talk-Back on
Terminator Disabled**

**Talk-Back on
Terminator Enabled**
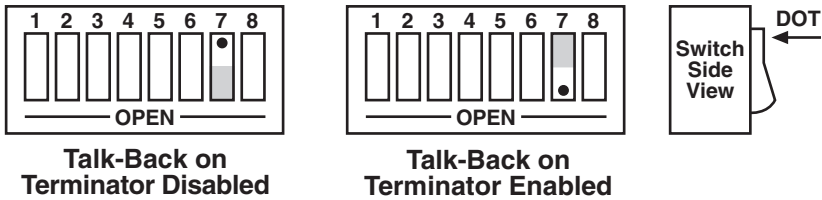
Figure 3-12. Switch SW1: Enabling or Disabling "Talk Back on Terminator" in Controller Mode.

**Talk-Back on
Timeout Disabled**

**Talk-Back on
Timeout Enabled**
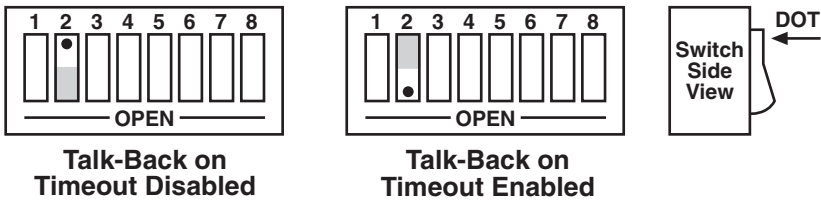
Figure 3-13. Switch SW2: Enabling or Disabling "Talk Back on Timeout" in Controller Mode.

3.7.2 PERIPHERAL FEATURES

In the IEEE Peripheral (IEEE 488 to RS-232 converter) mode, SW1-7 enables the interface to assert the SRQ IEEE bus interface line to indicate that it has received the last switch selected serial terminator character from the serial device.
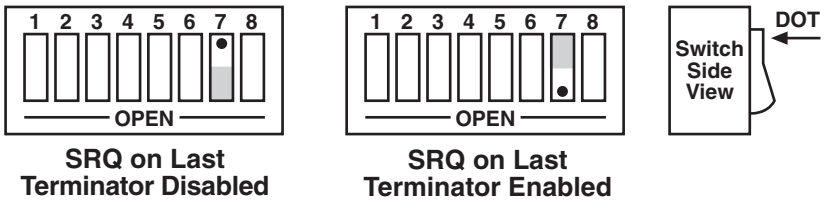
Figure 3-14. Switch SW1: Enabling or Disabling SRQ on Last Serial Terminator in Peripheral Mode.

3.8 Serial Interface

The interface converter has the ability to output signal levels that are compatible with either RS-232 or RS-422. An internal DIP shorting plug determines which electrical specification is chosen. If the interface is to be connected to an IBM® PC or compatible, the RS-232 level should be selected. If it will be connected to a Macintosh®, the RS-422 level should be used. For connection to other computers, refer to the manufacturer's manual to determine which levels are supported.

3.8.1 RS-232/RS-422 Signal Level Selection

The interface converter's factory default signal levels are compatible with RS-232. To select RS-422 levels, carefully remove the 8-position shorting plug with a small flat blade screwdriver from J106. Install the DIP jumper into J205 making certain that all of the pins on the shorting plug are inserted correctly.
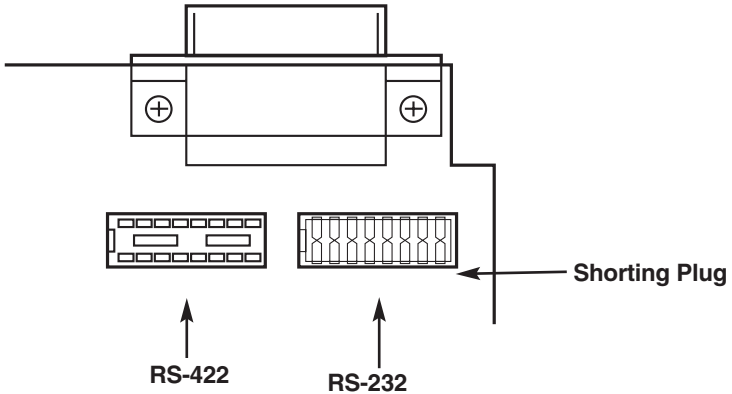
Figure 3-15. Selecting RS-232 or RS-422 Signal Levels.

3.8.2 Serial Signal Descriptions

The interface converter is equipped with a standard DB25 female connector on its rear panel and requires a standard DB25 male mating connector. The interface converter's connector is configured as DCE type equipment for RS-232 communications, which means the interface converter always transmits data on Pin 3 and receives the data on Pin 2. The following lists and describes the RS-232 and RS-422 signals provided on the interface converter.
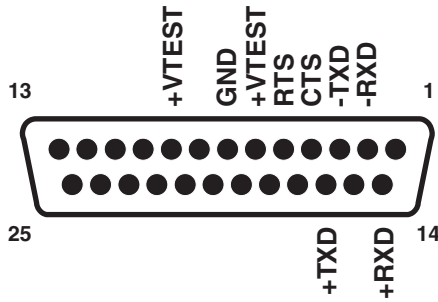
Figure 3-16. Rear View of the Interface Converter's Serial Connector.

-RxD   Receive Data—Input—Pin 2

This pin accepts serial data sent by the RS-232 or RS-422 host. The serial data is expected with the word length, baud rate, stop bits, and parity selected by the internal switches. The signal level is low true.

-TxD   Transmit Data—Output—Pin 3

This pin transmits serial data to the RS-232 or RS-422 host. The serial data is sent with the word length, baud rate, stop bits, and parity selected by the internal switches. The signal level is low true.

CTS   Clear To Send—Input—Pin 4

The CTS input is used as a hardware-handshake line to prevent the interface converter from transmitting serial data when the RS-232 host is not ready to accept it. When RTS/CTS handshake is selected on the internal switches, the interface converter will not transmit data out -TxD while this line is un-asserted (lowered). If the RS-232 host is not capable of driving this line it can be connected to the Vtest output (Pin 6) of the interface converter. If X-ON/X-OFF handshake is selected, the CTS line is not tested to determine if it can transmit data.

RTS   Request To Send—Output—Pin 5

The RTS output is used as a hardware handshake line to prevent the RS-232/RS-422 host from transmitting serial data if the interface converter is not ready to accept it. When RTS/CTS handshake is selected on the internal switches, the interface converter will drive the RTS output high when there are more than 1,000 character locations available in its internal buffer. If the number of available locations drops to less than 1,000, the interface converter will unassert (lower) this output. If Xon/Xoff handshake is selected, the RTS line will be permanently driven active (high).

Vtest   Test Voltage—Output—Pin 6

This pin is connected to +5 volts through a 1K resistor. It is also common to Vtest on Pin 9.

Gnd   Ground—Pin 7

This pin sets the ground reference point for the other RS-232 inputs and outputs.

Vtest   Test Voltage—Output—Pin 9

This pin is connected to +5 volts through a 1K resistor. It is also common to Vtest on Pin 6.

+RxD   Receive Data Plus—Input—Pin 14

This pin accepts serial data sent by the RS-422 host. The serial data is expected with the word length, baud rate, stop bits, and parity selected by the internal switches. The signal level is high true and only connected to this pin when RS-422 operation is selected. It is 180 degrees out of phase with -RxD.

+TxD   Transmit Data Plus—Output—Pin 16

This pin transmits serial data to the RS-422 host. The serial data is sent with the word length, baud rate, stop bits, and parity selected by the internal switches. The signal level is high true and only connected to this pin when RS-422 operation is selected. It is 180 degrees out of phase with -TxD.

3.8.3 SERIAL-CABLE WIRING DIAGRAMS

If a cable was not purchased with the interface, the following diagrams will be helpful in making your own cable. Simple soldering skills and an attention to detail will ensure successful construction.

```
Mini DINs Male                    DB25 Male
RTS  1 ──────────────────────▶  4  CTS
CTS  2 ◀──────────────────────  5  RTS
-TxD 3 ──────────────────────▶  2  -RxD
Gnd  4 ◀──────────────────────▶ 7  Gnd
-RxD 5 ◀──────────────────────  3  -TxD
+TxD 6 ◀──────────────────────▶ 14 +RxD
+RxD 8 ◀──────────────────────  16 +TxD
```
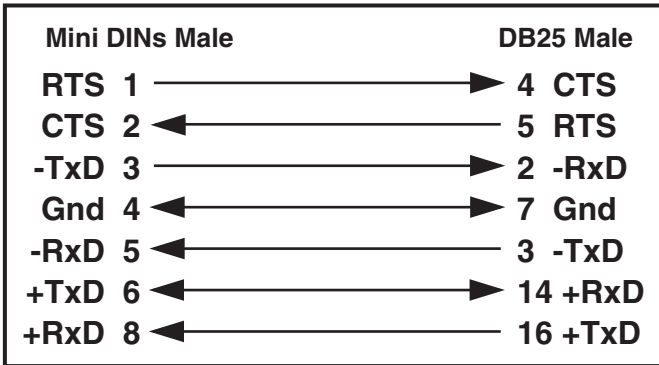
Figure 3-17. Wiring Diagram:
Macintosh to Interface Converter (RS-422).

```
DB25 Female                       DB25 Male
-TxD 2 ──────────────────────▶  2  -RxD
-RxD 3 ◀──────────────────────  3  -TxD
RTS  4 ──────────────────────▶  4  CTS
CTS  5 ◀──────────────────────  5  RTS
DSR  6 ◀──────────────────────  3  V test
Gnd  7 ◀──────────────────────▶ 7  Gnd
```
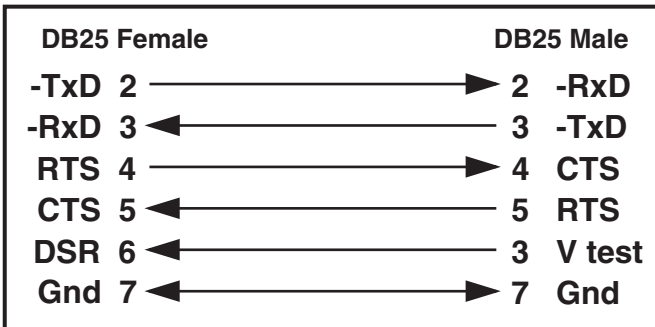
Figure 3-18. Wiring Diagram: IBM PC or Compatible with
DB25 Serial Connector to Interface Converter (RS-232).

```
DB9 Female                    DB25 Male
DCD  1  ◄─────────┐
-RxD  2  ◄────────┤        3  -TxD
-TxD  3  ─────────┼─────►  2  -RxD
DTR  4  ──────────●
Gnd  5  ◄─────────────────►  7  Gnd
DSR  6  ◄─────────┘
RTS  7  ────────────────►  4  CTS
CTS  8  ◄────────────────  5  RTS
```
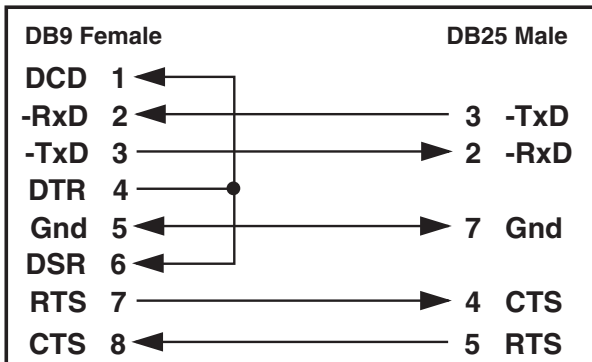
Figure 3-19. Wiring Diagram: IBM AT or Compatible with DB9 Serial Connector to Interface Converter (RS-232).

NOTE

Standard AT 9-pin-to-25-pin adapter cables are not wired as shown above and will not work with the interface converter.

3.9 General

Refer to the following sections for specific operational modes. This sub-section gives a general test of functionality. After setting the power-on defaults and reassembling the interface converter, plug the power-supply connector into the rear jack on the interface.

CAUTION

Never plug the power supply into the interface while it is connected to AC line power. If you do, you could damage the interface converter.

WARNING

The power supply provided with the interface converter is intended for INDOOR USE ONLY. Using it outdoors could result in equipment failure, personal injury, or death.

After plugging the power-supply connector into the interface, plug the power supply into AC line power. Turn the rear-panel power switch ON (the "1" position). All the front-panel indicators should light momentarily while the interface converter performs an internal ROM and RAM self-check. At the end of this self-check, all indicators except POWER should turn off.

If there is an error in the ROM checksum, all of the LEDs will remain on. Flashing LEDs indicate a RAM failure. Should such an error occur, turn the rear-panel switch to the OFF [0] position and retry the above procedure.

If the front-panel indicators do not flash and the POWER indicator does not remain lit, there may not be any power supplied to the interface. In this event, check the AC line and the rear-panel connection of the power supply. If the problem is unresolved, call your supplier.

If proper operation is obtained, connect an interface cable to the DB25 port on the rear of the interface converter. Connect the other end to the host's serial port. Except for connecting IEEE bus instruments, the interface converter is installed and ready to use.

WARNING

The interface converter makes its earth-ground connection through the serial interface cable. It should only be connected to the IEEE host. Failure to do so may allow the interface converter to float to a bus-device test voltage. This could result in damage to the interface, personal injury, or death.

4. Controller Operation

4.1 Controller-Mode (Serial to IEEE) Operation

The IEEE Controller mode allows a serial RS-232 or RS-422 host device to send data to a single IEEE bus peripheral or to multiple peripherals if they occupy the same bus address. Applications include interfacing a listen-only or addressable IEEE printer/plotter to a serial printer port.

Once the interface converter has initialized itself after power-on, it waits for serial input data. When received, it addresses the selected IEEE device to listen with the following bus sequence:

ATNUNL,MTA,LAG,*ATN

The data received from the serial host is placed into a circular serial input buffer. Simultaneously, characters are removed from that buffer and sent to the IEEE bus device. The serial terminator(s), if present, are not sent. Instead, the IEEE terminators are substituted and sent in their place.

As long as the serial input buffer is not empty, the interface converter will continue to send data from it to the IEEE bus device. If the serial input buffer becomes emptied, the interface converter will command the IEEE bus device to talk if one of the talk-back features is enabled. This allows the interface converter to be used as a controller with devices, such as plotters or instruments, that return status and other information to the host computer.

When the interface converter addresses the IEEE bus device to talk it uses the following bus sequence:

ATNUNL,MLA,TAG,*ATN

The interface converter then accepts data from the IEEE device and returns it to the host until the last selected IEEE terminator is detected. The IEEE bus terminators are replaced by the serial terminators, and these are then sent to the serial host.

If the IEEE device has been addressed to talk but does not respond or finish transmission by the time additional characters are received in the circular serial-input buffer, the talk sequence will be aborted to allow additional serial information to be sent to the IEEE device.

4.2 Serial and IEEE Terminator Substitution

The interface converter can be configured to provide serial-to-IEEE-488 and IEEE-488-to-serial terminator substitution. This is useful when interfacing a serial host which only issues carriage return [CR] as an output terminator to an IEEE peripheral which expects a carriage return followed by a line feed [CR-LF].

In this case, the serial terminator should be selected for CR Only while the IEEE terminator is set for CR-LF. When a serial CR character is received, it is discarded and replaced with an IEEE CR followed by an IEEE LF. In the IEEE to serial direction, the IEEE CR is unconditionally discarded. Upon receipt of the IEEE LF a serial CR is substituted.

The interface converter can be made totally data-transparent by setting both the serial and IEEE terminators to be CR Only or LF Only. Refer to **Chapter 3** for the proper switch settings for both the IEEE and serial terminators.

4.3 IEEE Address Selection

SW3-1 through SW3-5 select the IEEE bus address of the IEEE peripheral the interface converter will be communicating with. These switches set the address of the IEEE device that will be controlled, not the address of the interface converter. The address of the interface converter is automatically adjusted so that address conflicts will not occur. The address is selected by simple binary weighting with SW3-1 being the least significant bit and SW3-5 the most significant. If address 31 (reserved on the IEEE bus) is selected in the controller mode, address 30 is assigned as the device it will be communicating with. The following figure shows the IEEE address selection of 10.
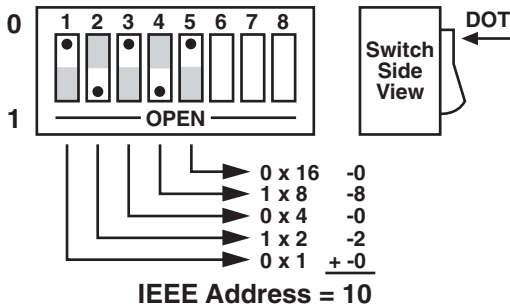
Figure 4-1. Switch SW3: Selecting the IEEE Address.

4.4 Talk-Back Features

Two different switch-selectable talk-back features are included to provide bi-directional communication with the IEEE device. Whether either talk-back feature should be enabled depends on the application.

4.4.1 TALK-BACK ON TERMINATOR

SW1-7 is used to determine whether the interface should address the attached bus device to talk after sending the selected IEEE bus terminator(s). This feature is commonly used to provide bidirectional communication with a single IEEE instrument. Talk-back will only occur if there is no serial data to output to the IEEE device. The factory default is Talk-Back On Terminator enabled.

Talk-Back on Terminator Disabled

Talk-Back on Terminator Enabled

Figure 4-2. Switch SW1: Enabling or Disabling "Talk-Back on Terminator."

When the serial input buffer becomes empty, the interface converter checks the last characters sent to the IEEE bus device. If these were the IEEE bus terminators and Talk-Back on Terminator is enabled, the IEEE bus device is addressed to talk. Any data received by the interface converter from the bus device is sent to the serial host.

When the last IEEE bus terminator is detected from the IEEE device, the interface converter disables the device from sending additional information by asserting Attention (ATN) on the bus.
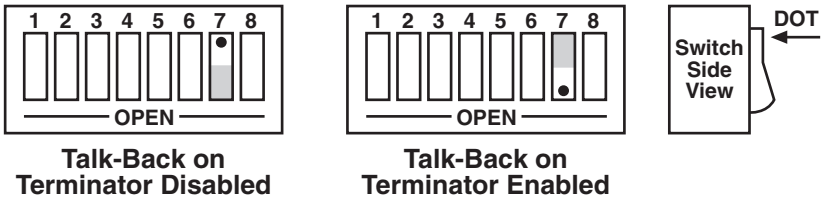
If the IEEE device does not responded or finish transmission by the time additional characters are received into the serial input buffer, the talk sequence will be aborted to allow additional serial information to be sent to the IEEE device.

The program example on the next page shows how this feature can be used to communicate with a single IEEE instrument. The program example is written in BASIC on an IBM PC or compatible and communicates with a Keithley Model 196 DMM.

```
10        '
20        '        Example Program using interface converter with
25        '        the Talk-Back on Terminator feature enabled to
30        '        communicate with a Keithley Model 196 DMM
40        '
50        '        Open BASIC's serial communications port
60        OPEN "COM1: 9600, N, 8, 2" AS 1
70        '        Set the Model 196 DMM to the 30VDC range
80        PRINT #1, "F0R3X"; ' The ; suppresses terminators
90        '        Request 10 Readings from 196"
100       FOR N=1 to 10
110            PRINT #1," " ' Output terminator
120            LINE INPUT #1, A$ ' Get reading from 196
130            PRINT A$ ' print it on the screen
140       NEXT N
150       END
```

4.4.2 TALK-BACK ON TIMEOUT

SW2-2 selects whether the interface converter should address the attached bus device to talk when the interface converter has no more serial data to send. This feature relies on time and not on terminators. Its use is primarily for simulating a serial plotter from an IEEE 488 (HP-IB) plotter. The factory default is Talk-Back On Timeout enabled.
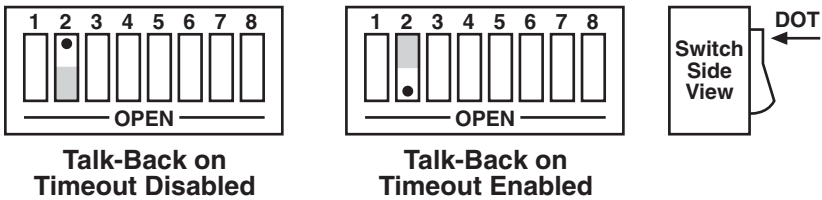

Talk-Back on Timeout Disabled   **Talk-Back on Timeout Enabled**

Figure 4-3. Switch SW2: Enabling or Disabling "Talk-Back on Timeout."

If Talk-Back on Timeout is enabled, the interface converter waits approximately 100 milliseconds after it detects that its serial input buffer is empty. If no serial character has been received by the end of this time, the IEEE bus device is addressed to talk. The choice of talk-back modes depends strongly on the type of device and software being used. For most plotter applications, the Talk-Back on Timeout feature should be enabled.

When the last IEEE bus terminator is detected from the IEEE device, the interface converter disables the device from sending additional information by asserting Attention (ATN) on the bus. If the IEEE device does not respond or finish transmission by the time additional characters are received into the serial input buffer, the talk sequence will be aborted to allow additional serial information to be sent to the IEEE device.

Most IEEE 488 plotters will not respond to the talk address sequence with output data unless there has been a specific device dependent command sent to tell them what to say. If they have not been told what to say, they say nothing.

The following is an example of how this feature can be used to communicate with an IEEE plotter. The program example is written in BASIC on an IBM PC or compatible. It turns the PC into a dumb serial terminal. When a key is pressed on the keyboard, the character is transmitted out of the serial (COM1) port. Any serial data which is received from the port is printed on the display.

```
10 ' Dumb Terminal Program for the interface converter
20 ' This program allows direct interaction between
30 '   the IBM PC and an IEEE plotter through the
40 ' interface converter. The interface converter must have Talk-Back
50 '        on Timeout enabled.
60 'Open the serial communications port
70 OPEN "COM1: 9600,n,8,2,cs,ds" AS 1
80 ' Display any data received from the COM1 port
90 IF LOC(1) THEN PRINT INPUT$(LOC(1),1);: GOTO 90
100 ' Transmit key presses to the COM1 port and screen
110 K$=INKEY$
120 PRINT #1, K$; : PRINT K$;
130 GOTO 90 ' Do it again
```

Enter the program into the computer and run it. The example below shows how to test the interface converter's operation with a Hewlett-Packard® 7470A plotter. Other IEEE plotters are similar, but you should refer to the plotter's programming manual for the proper command syntax. Notice the interface converter's front-panel LEDs as you type the plotter commands.
Type the following HP-GL® output-identify command on the keyboard...

OI;

The plotter (HP® 7470A) should immediately respond with.....

7470A

When you type the following HP-GL command on the keyboard, the plotter should respond by retrieving its pen, drawing a line and returning the pen.

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

4.5 Plotter Applications

To use the interface converter to interface an HP-IB plotter to a serial computer port, you will need the following information about your system:

1) The serial data format that the application (plotting or graphics) program expects the plotter to communicate with. These parameters include baud rate, word length, stop bits, parity and serial control.

   Some programs allow these parameters to be selected by the user. Other graphics programs depend on the RS-232 version of the plotter defaults. Usually, Hewlett-Packard plotters use 9600 baud, 7 data bits, 1 stop bit, even parity, and X-ON/X-OFF serial control. Since these plotters are available with serial interfaces, the operator's manual of your IEEE plotter should contain this information.

2) The IEEE bus address of your plotter. This address is usually set by a DIP switch located on the rear of the plotter. The first five switches set the address, which, for Hewlett-Packard plotters, is usually address 5. Refer to the plotter's operator's manual for exact information.

Set the interface converter's internal DIP switches to match the parameters determined above. Other parameters which should be selected include:

1. Talk-Back on Terminator Enabled.

2. Talk-Back on Timeout Enabled.

3. Serial Terminators set to CR Only.

4. IEEE Terminators set to CR Only with EOI enabled.
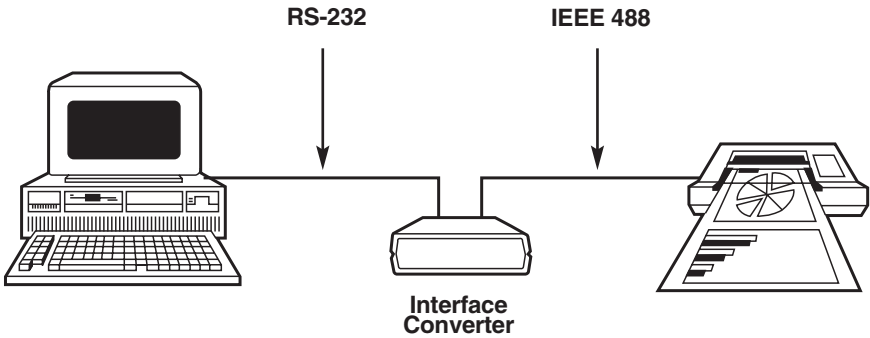
Figure 4-4. A PC-Based Graphics System.

The following shows the interface converter's internal switch settings required to use a Hewlett-Packard 7580A plotter with AutoCAD® from AUTODESK on an IBM PC or compatible. Because PCs and compatibles output RS-232 levels, the shorting DIP jumper should be set to the RS-232 position (J206).
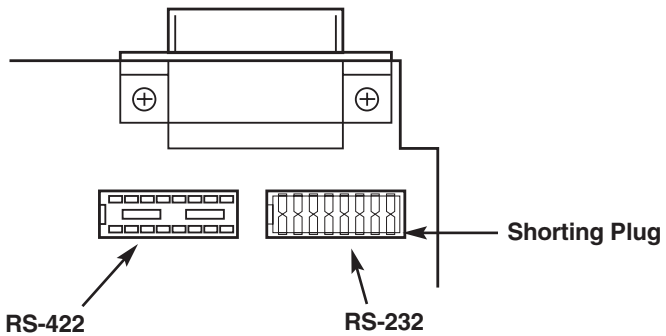

Figure 4-5. Selecting RS-232 Signal Levels.

SW3

1 2 3 4 5 6 7 8

OPEN

Switch Side View

DOT

IEEE Addr **5**
IEEE Term **CR Only**
EOI **Enabled**

SW2

1 2 3 4 5 6 7 8

OPEN

Switch Side View

DOT

Mode **C**
Talk-Back on Timeout **Enabled**
Serial Term **CR**
Echo **No Echo**
Parity **Even**

SW1

1 2 3 4 5 6 7 8

OPEN

Switch Side View

DOT

Baud Rate **9600**
Handshake **X-ON/X-OFF**
Word Length **7 Data Bits**
Talk-Back on Terminator **Enabled**
Stop Bits **1 Stop Bit**
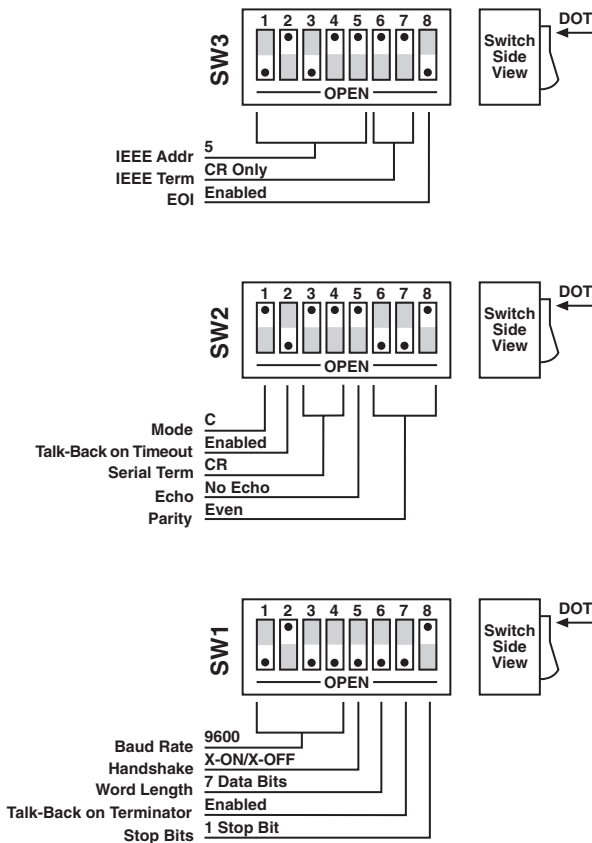
Figure 4-6. Interface Converter Settings for Use with HP 7580A Plotter on an IBM PC.

When using the interface converter with plotting programs on the Macintosh computer with graphic drivers such as MacPlot®, some serial data format parameters are user-modifiable. The following is a partial MacPlot configuration screen which allows selection of baud rate, stop bits, and parity. With this driver, the word length is fixed to 7 data bits with X-ON/X-OFF serial control. These non-modifiable defaults are plotter dependent. Refer to the plotter or driver manual for the defaults of the specific plotter. For this example, 57600 baud with one stop bit and no parity has been chosen for the serial data format.

ᜒ	File	Edit	Windows

Settings for HP 7500A

Baud Rate:	57600	Stop Bits:	1	Parity:	None	Paper Si

- ○ Apple Plotter
- ○ Calcomp 104x/7x,9x5
- ○ Calcomp 81
- ○ Colorwriter 6200DS10
- ○ Colorwriter 6310
- ○ Colorwriter 6320
- ○ Epson HI-80
- ○ Facit 4551
- ○ Graphtec FP5301

- ○ Graphic MP31 / 2 / 300
- ○ H.P. 7220
- ○ H.P. 7440A ColorPro
- ○ H.P. 7470A
- ○ H.P. 7475
- ○ H.P. 7550A
- ○ H.P. 7570A DraftPro
- ◉ H.P. 7580B
- ○ H.P. 7585B

- ○ Houst
- ○ Houst
- ○ Houst
- ○ Houst
- ○ Houst
- ○ Houst
- ○ Houst
- ○ Houst
- ○ Houst

Figure 4-7. MacPlot Configuration Screen.

RS-422   IEEE 488

Interface
Converter

Figure 4-8. A Macintosh Based Graphics System.

The Macintosh computer outputs RS-422 levels. Because of this, the internal DIP shorting jumper is set to the RS-422 position (J205).

Figure 4-9. Setting the Internal DIP Shorting Jumper for RS-422.

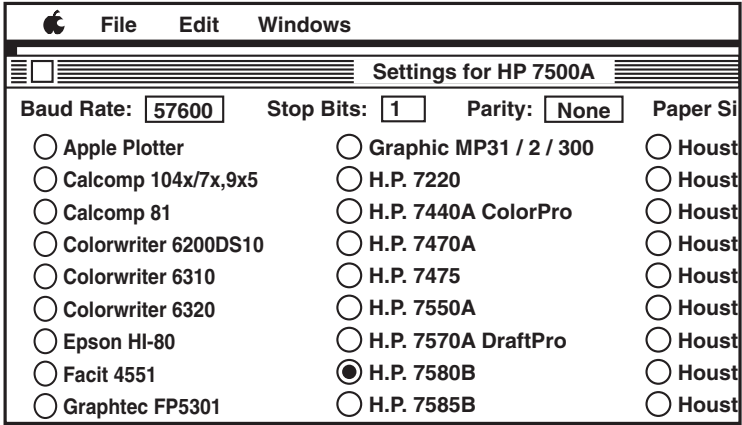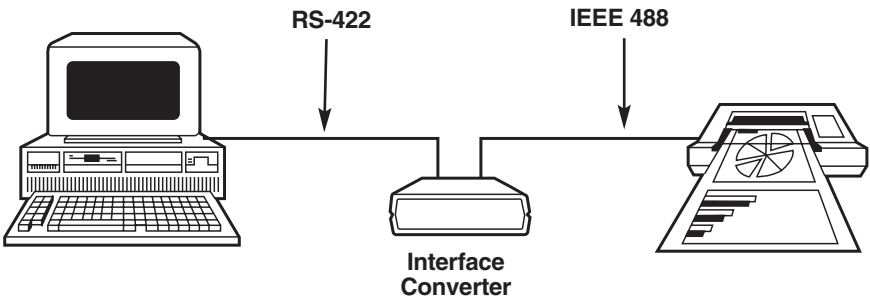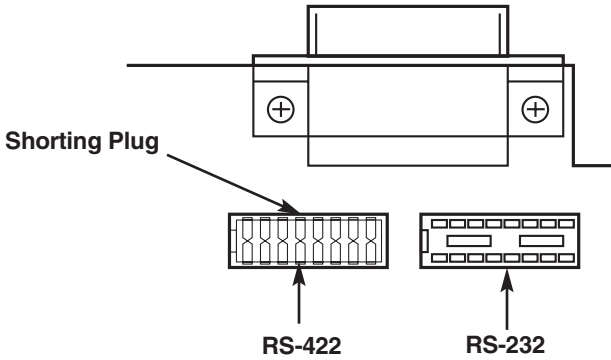The following illustrates the interface converter's internal switch settings for use with MacPlot, using the previously described format.
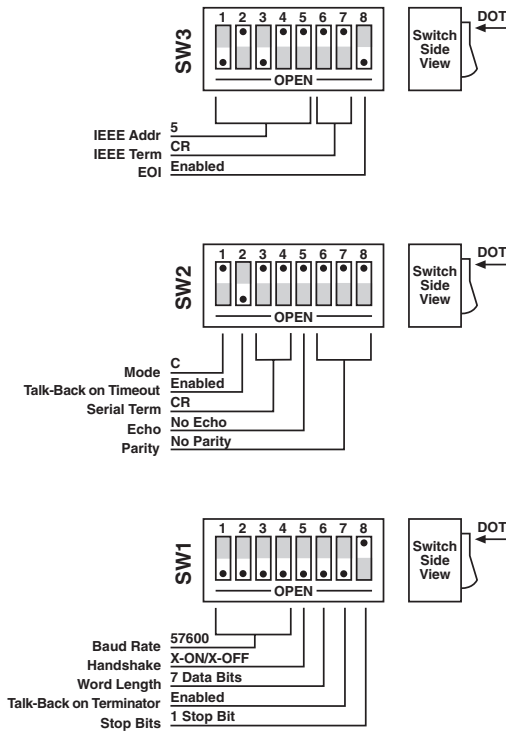
Figure 4-10. Interface Converter Settings for Use with HP 7580A Plotter on a Macintosh.

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

When the serial host begins to send the interface converter data, the Receive LED will flash. If it does not, this indicates that the interface is not receiving data from the serial host. Verify the cables are connected properly and the serial cable wiring. Verify the serial data format, word length, stop bits and parity.

4.6 Printer Applications

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

5. Peripheral Operation

5.1 Peripheral-Mode Operation

This mode of operation is useful in interfacing a serial device, such as a serial printer, plotter or instrument, to an IEEE controller. Data which is sent by the IEEE controller to the interface converter is buffered and transmitted out its serial port. Data received from the serial device is buffered by the interface converter until read by the IEEE controller. The interface converter can buffer approximately 32,000 bytes of data from both the IEEE input and the serial input.

The interface converter will refuse to accept more data from the IEEE controller when its buffer memory is full. It does this by preventing completion of the bus handshaking sequences. It will also request that additional serial data not be sent by negating its Request To Send (RTS) output or by transmitting the X-OFF ASCII character. The serial handshake used depends on the handshake selection (see **Chapter 3**).

5.2 Serial and IEEE Input Buffers

Memory in the interface converter is dynamically allocated for the serial input and IEEE input buffers. This allows for the most efficient partitioning of memory for any given application.

At power on, or device clear, each buffer is allocated a 128-byte mini-buffer or queue. When the serial input (or IEEE input) requires more buffer space, additional queues are allocated. When a queue is empty, it is released from the input buffers so that it may be re-allocated wherever it is required.

There are approximately 250 available queues for a total of 32,000 bytes of buffer (character) space. Queues are continually allocated and released as required by the serial and IEEE input. Of the 250 available queues, 240 are issued without regard to controlling the receipt of additional serial or IEEE input data.

When the serial input buffer requests one of the last 10 queues (in other words, when there are 1280 character locations left), it signals the serial host that it should stop sending data. This is accomplished by either unasserting RTS or issuing "X-OFF," depending on which serial handshake control has been switch selected.

When more than 10 queues become available, it asserts RTS or issues "X-ON."

The IEEE bus input signals that the IEEE input (or serial output) buffer is full when the number of queues available drops below 10 (1280 character locations left). When the number of available queues drops to 4 or less (512 character locations left), the IEEE interface of the interface converter stops accepting data from the bus. This bus hold-off will only occur until additional queues (more than 4) become available. Then the interface will resume accepting bus data.

5.3 IEEE Data Transfers

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

5.3.1 BLIND BUS DATA TRANSFERS

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

To illustrate how this would appear, let's assume the interface converter is connected to a serial device which will accept data at 1200 baud or 110 bytes per second. The IEEE bus controller is capable of sending data to the interface converter at a rate of 5000 bytes per second. The data would be transferred on the bus at 5000 characters per second for slightly over six seconds, filling over 31,000 locations. At that time, the IEEE input would hold off additional data transfers until 128 characters are sent out the serial port at rate of 110 characters per second. This 110 cps would then become the average bus data acceptance rate of the interface converter.

If the controller is set to detect a data time-out error, then it will do so if the interface converter holds off IEEE input data transfers for too long. The error can be used to alert the operator to the problem, such as a printer out of paper, so that it can be corrected. If the controller then restarts transmission exactly where it left off, no data will be lost.
If data is requested by the controller and no serial input data is available in the interface converter, the bus will hang until serial data is received. If no serial data is received, it will hang forever until the controller times out.

5.3.2 CONTROLLED BUS DATA TRANSFERS

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

When serial-polled, the interface converter provides eight bits of status information to the controller. The most significant bit (DIO8) of the interface converter's serial poll byte is set to a logic "1" when the IEEE input buffer is NOT EMPTY. The term NOT EMPTY is used to signify that not all of the previous data sent to the interface has been transmitted to the serial device. If it is NOT EMPTY, the controller may avoid sending any more data to the interface converter. If this bit is a logic "0," then the serial device has accepted all previous data and the IEEE controller may send more.

Another bit (DIO4) of the Serial Poll byte is used to indicate additional information concerning the IEEE input buffer. This bit is set to a logic "1" when there is 1280 or less locations in the buffer for data. It is cleared, set to a logic "0", when there is greater than 1280 locations available. This bit is referred to as the IEEE input buffer FULL bit.

When serial data is received, DIO5 of the Serial Poll byte is set to "1", to indicate to the IEEE controller that the serial input buffer is NOT EMPTY. If this bit is set, it indicates that at least one character is available in the serial input buffer to be read by the IEEE controller. Once all of the serial input data is read by the IEEE controller this bit is reset.

The interface converter can generate a request for service on the bus when it receives the last serial terminator. To enable this feature, the Peripheral SRQ switch, located on the internal switch bank of SW1, must be enabled. When SRQ is enabled, the interface converter will assert the IEEE bus SRQ line and set serial poll status bits DIO7 and DIO3 when the last serial terminator is detected. The IEEE controller must perform a serial poll on the interface to clear the SRQ. If the Peripheral SRQ switch is in the disabled position, there will not be any indication in the serial-poll status byte that a serial terminator has been received.
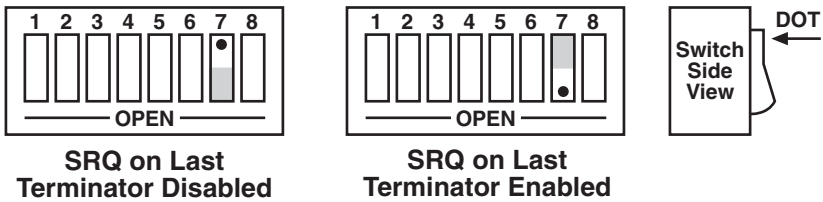
SRQ on Last Terminator Disabled

SRQ on Last Terminator Enabled

Figure 5-1. Switch SW1: Enabling or Disabling "SRQ on Last Terminator."

5.4 Serial-Poll Status-Byte Register

The following shows and describes the serial-poll status information provided by the interface converter.

DIO8   **IEEE Input Buffer NOT Empty**

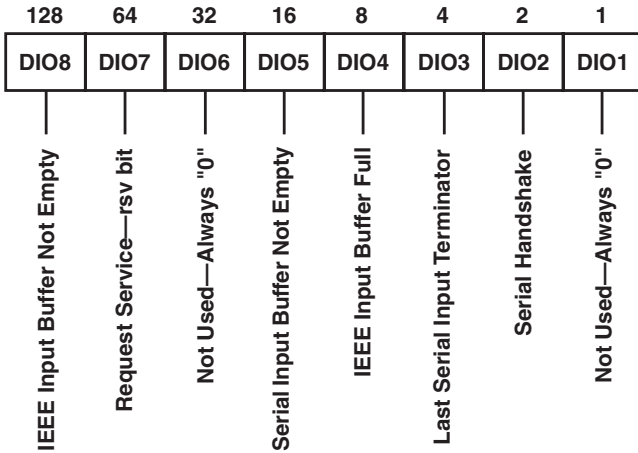This bit is set when the IEEE input buffer contains one or more data bytes.

Figure 5-2. Serial Poll Status Byte.

DIO7　　　　**rsv**
serial-poll status information

> This bit is defined by the IEEE 488 Specification and is used to indicate to the bus controller that the interface converter is the bus device that requested service. It is cleared when the interface is serial polled by the controller.

DIO6　　　　**Not Defined—Always "0"**

DIO5　　　　**Serial Input Buffer NOT EMPTY**

> This bit is set when the serial input buffer contains one or more data bytes which have not been sent out the IEEE bus. It is cleared, set to "0," when the buffer is empty.

DIO4　　　　**IEEE Input Buffer Full**

> When this bit is set, it indicates that the interface converter may hold off the controller on subsequent data transfers. The interface may continue to accept an additional 512 characters, depending on the size of the serial input buffer.

DIO3　　　　**Received Last Serial Terminator**

> If the **Peripheral SRQ** feature is enabled, the interface converter will issue a request for service by asserting the **SRQ** line and setting this bit along with the **rsv** bit (DIO7). It is cleared, along with **rsv**, when serial polled by the controller. If this feature is not enabled, this bit is always "0."

DIO2　　　　**Serial Handshake**

> This bit indicates the present state of the serial handshake. If it is set to "1," the serial device connected to the interface converter is capable of accepting serial data. If "0," the RTS line is unasserted, if configured for hardware handshake, or the "X-OFF" character has been received, if configured for X-ON/X-OFF software handshake.

DIO1　　　　**Not Used—Always "0"**

5.5 Use of Serial and Bus Terminators

The interface converter can be configured to provide RS-232-to-IEEE-488 and IEEE-488-to-RS-232 terminator substitution. This is useful when interfacing a serial device that only issues carriage return [CR] as an output terminator to an IEEE controller that expects a carriage return followed by a line feed [CR-LF].

In this previous example, the serial terminator should be selected for CR Only while the IEEE terminator is set to CR-LF. When a serial CR character is received it is discarded and substituted with an IEEE CR followed by an IEEE LF. In the IEEE to serial direction, the IEEE CR is unconditionally discarded. Upon receipt of the IEEE LF a serial CR is substituted.

The interface converter can be made totally data-transparent by setting both the serial and IEEE terminators to be CR Only or LF Only. The choice of appropriate terminators may be determined by inspection of the serial device and IEEE controller's instruction manuals. See **Chapter 3** of this manual for instructions on selecting the interface converter's serial and bus terminals.

5.6 IEEE 488 Bus Implementation

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

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

5.6.1 MY TALK ADDRESS (MTA)

When the interface converter is addressed to talk, it retrieves data from the serial input buffer and outputs it to the IEEE 488 bus. It substitutes the selected IEEE bus terminators for the received serial terminators. The interface converter will continue to output serial input buffer data as long as the IEEE controller allows.

5.6.2 MY LISTEN ADDRESS (MLA)

When the interface converter is addressed to listen, it accepts data from the active talker and outputs this data through the serial interface. It substitutes the selected serial terminators for the received IEEE bus terminators.

5.6.3 DEVICE CLEAR (DCL AND SDC)

Device Clear resets the interface converter's IEEE input and serial input buffers. Any pending data and Service Requests (SRQ), including the information they convey, are lost.

5.6.4 INTERFACE CLEAR (IFC)

IFC places the interface converter in the Talker/Listener Idle State. It clears any pending requests for service (SRQ). The condition which caused the SRQ remains unmodified.

5.6.5 SERIAL POLL ENABLE (SPE)

When Serial-Poll-Enabled, the interface 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 interface converter will continue to try to output its serial-poll response until it is "Serial-Poll-Disabled" by the controller.

5.6.6 SERIAL POLL DISABLE (SPD)

Disables the interface converter from responding to serial polls by the controller.

5.6.7 UNLISTEN (UNL)

UNL places the interface converter in the Listener Idle State.

5.6.8 UNTALK (UNT)

UNT places the interface converter in the Talker Idle State.

5.7 IEEE Address Selection

SW3-1 through SW3-5 select the IEEE bus address of the interface converter when in the IEEE Peripheral mode. The address is selected by simple binary weighting with SW3-1 being the least significant bit and SW3-5 the most significant. The following figure shows the IEEE address of the interface converter set to 10.
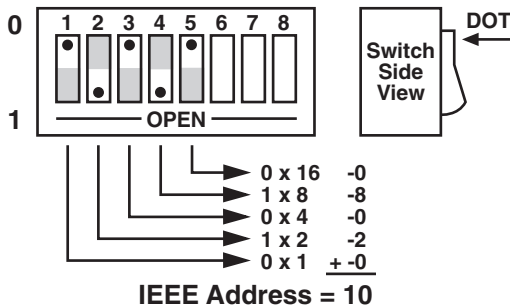

Figure 5-3. SW3 View for IEEE Address Selection.

Listen Only Mode
Listen Only is a special type of Peripheral operation. In the Listen Only Mode the interface converter accepts all data transmitted on the bus and transfers it out its serial port. The interface converter is set to Listen Only mode by setting its address to 31 (switches SW3-1 through SW3-5 all open).

NOTE

The 232-488 Converter does not support all of these functions. Refer back to controller mode (Section 4.1) and peripheral mode (Section 5.1) for more information about operation of this particular device.

6. IEEE 488 Primer

6.1 History

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

Before this standard was adopted most instrumentation manufacturers offered their own versions of computer interfaces. This placed the burden of system hardware design on the end user. If your application required the products of several different manufacturers, then you might need to design several different hardware and software interfaces.

The popularity of the IEEE 488 interface (sometimes called the General Purpose Interface Bus or GPIB) is due to the total specification of the electrical and mechanical interface as well as the data transfer and control protocols. The use of the IEEE 488 standard has moved the responsibility of the user from design of the interface to design of the high-level software that is specific to the measurement application.

6.2 General Structure

The main purpose of the GPIB is to transfer information between two or more devices. A device can either be an instrument or a computer. Before any information transfer can take place, it 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 the Active Controller at power-on.

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 that is recognized to speak is the Active Talker. There can only be one Talker at a time if the information transferred is to be clearly understood by all. The act of "giving the floor" to that device is called Addressing to Talk. If the committee chairman cannot attend the meeting, or if other matters require his attention, he can appoint an acting chairman to take control of the proceedings. For the GPIB, this device becomes the Active Controller.

At a committee meeting, everyone present usually listens. This is not the case with the GPIB. The Active Controller selects which devices will listen and commands all other devices to ignore what is being transmitted. A device is instructed to listen by being Addressed to Listen. This device is then referred to as an Active Listener. Devices that 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. The students are told to raise their hands 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.
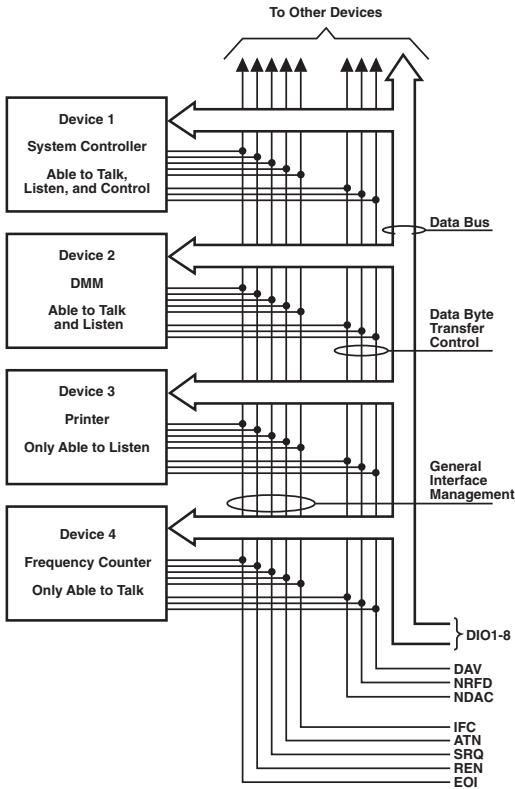
Figure 6-1. IEEE 488 Bus Structure.

6.3 Send It to My Address

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

The IEEE 488 standard permits up to 15 devices to be configured within one system. Each of these devices must have a unique address to avoid confusion. In a similar fashion, every building in town has a unique address to prevent one home from receiving another home's mail. Exactly how each device's address is set is specific to the device's manufacturer. Some are set by DIP switches in hardware, others by software. Consult the manufacturer's instructions to determine how to set the address.
Addresses are sent with universal (multiline) commands from the Active Controller. These commands include My Listen Address (MLA), My Talk Address (MTA), Talk Address Group (TAG), and Listen Address Group (LAG).

6.4 Bus Management Lines

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

6.4.1 ATTENTION (ATN)

ATN is one of the most important lines for bus management. If Attention is asserted, then the information contained on the data lines is to be interpreted as a multiline command. If it 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.

6.4.2 INTERFACE CLEAR (IFC)

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

6.4.3 REMOTE ENABLE (REN)

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

6.4.4 END OR IDENTIFY (EOI)

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

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

6.4.5 SERVICE REQUEST (SRQ)

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

6.5 Handshake Lines

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

6.5.1 DATA VALID (DAV)

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

6.5.2 NOT READY FOR DATA (NRFD)

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

6.5.3 NOT DATA ACCEPTED (NDAC)

The NDAC line is also controlled by the Listeners. This line indicates to the Talker that each device addressed to listen has accepted the information. Each device releases NDAC (high) at its own rate, but the NDAC will not go high until the slowest Listener has accepted the data byte.
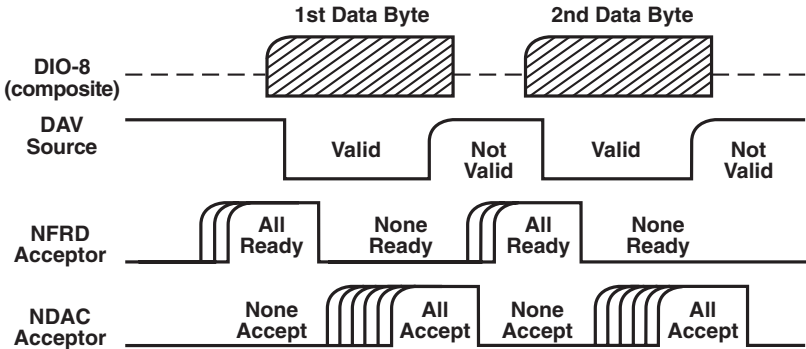
Figure 6-2. IEEE Bus Handshaking.

6.6 Data Lines

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

6.7 Multiline Commands

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

6.7.1 GO TO LOCAL (GTL)

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

6.7.2 LISTEN ADDRESS GROUP (LAG)

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

6.7.3 UNLISTEN (UNL)

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

6.7.4 TALK ADDRESS GROUP (TAG)

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

6.7.5 UNTALK (UNT)

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

6.7.6 LOCAL LOCKOUT (LLO)

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

6.7.7 DEVICE CLEAR (DCL)

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

6.7.8 SELECTED DEVICE CLEAR (SDC)

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

6.7.9 SERIAL POLL DISABLE (SPD)

The SPD command disables all devices from sending their Serial Poll status byte. ($l9)

6.7.10 SERIAL POLL ENABLE (SPE)

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

6.7.11 GROUP EXECUTE TRIGGER (GET)

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

6.7.12 TAKE CONTROL (TCT)

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

6.7.13 SECONDARY COMMAND GROUP (SCG)

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

6.7.14 PARALLEL POLL CONFIGURE (PPC)

For devices capable of performing a Parallel Poll, this command determines which data bit they are to assert in response to a Parallel Poll ($05)

6.7.15 PARALLEL POLL UNCONFIGURE (PPU)

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

6.8 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.

6.8.1 SERIAL POLL

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

6.8.2 PARALLEL POLL

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

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

7. Theory of Operation and Board Layout

7.1 Theory of Operation

The heart of the interface converter is a 6809 microprocessor (U101) supported by 8K bytes of firmware EPROM [U102 (2764)] and 32K bytes of static RAM [U103 (58256)]. A Versatile Interface Adapter [U104 (65B22)] is used to generate real-time interrupts for the firmware operating system.

The front-panel annunciators are also driven by U104 through an inverter [U113 (74LS04)]. The IEEE 488 bus interface is accomplished by a TMS9914A [U106] controller with drivers U107 and U108. The serial interface is provided by the UART [6551 (U105)]. If RS-232 levels are chosen, they are provided by the RS-232 transceiver (U209). If RS-422 levels are selected, the differential driver [26LS30 (U207)] and receiver [26LS33 (U208)] are used.

The internal DIP switches [SW1, SW2, and SW3] are read via 74HCT244 tri-state buffers [U201, U202 and U203]. Power is supplied by an external unregulated 9-volt wallmount supply. Regulation to the required +5 volts is provided by U206 [7805].

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

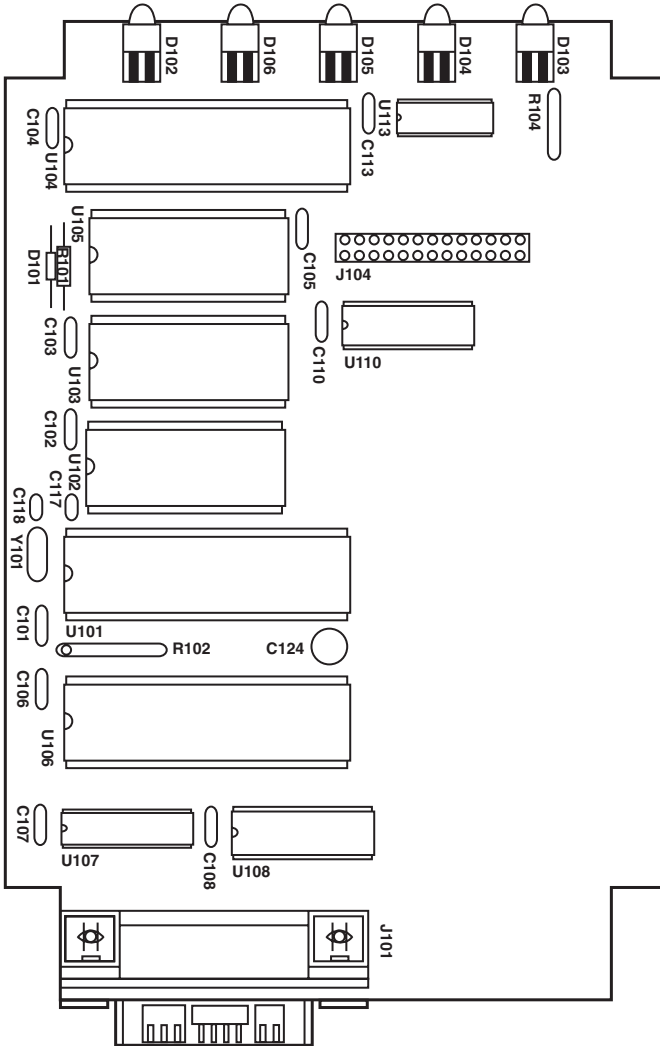| Address	Device	Part Number	Function
$0000-$7FFF	U103	58258	Static RAM
$A000-$A007	U106	9914A	IEEE Controller
$A800-$A807	U105	6551	UART
$B000-$B00F	U104	65B22	VIA
$B800	U201	74HCT244	SW1 (S201)
$B801	U202	74HCT244	SW2 (S202)
$B802	U203	74HCT244	SW3 (S203)
$E000-$FFFF	U102	2764	Programmed EPROM

7.2 Board Layout

**Figure 7-1. Component Layout of the
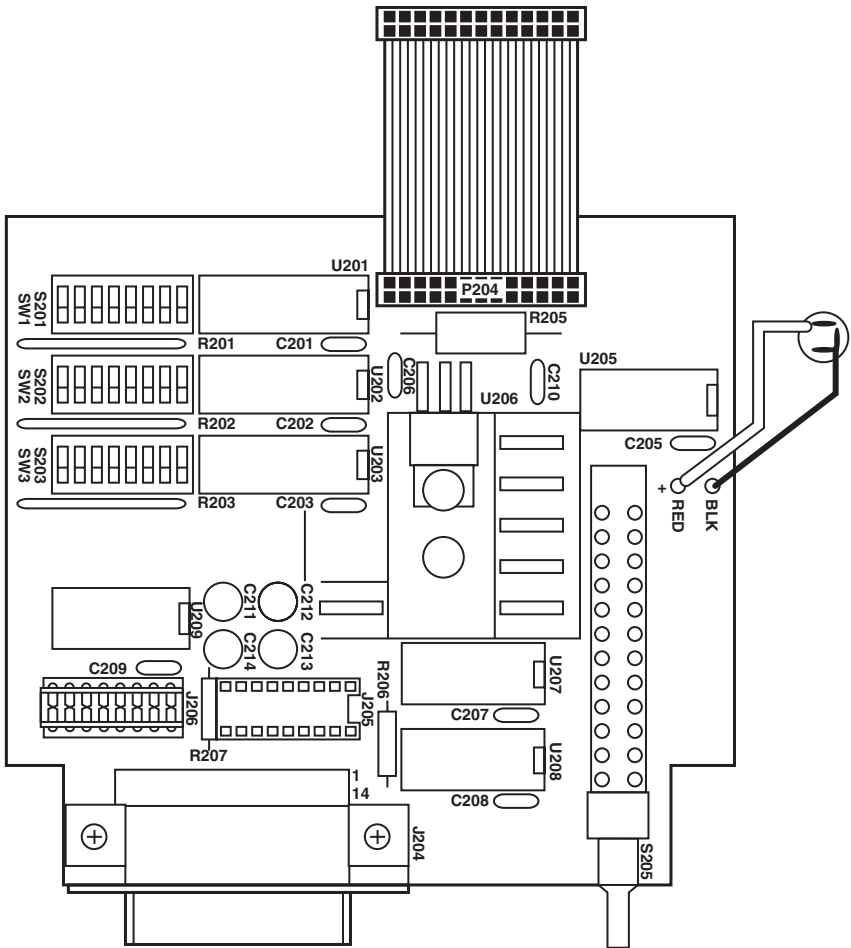Interface Converter's Motherboard.**

**Figure 7-2. Component Layout of the
Interface Converter's Serial I/O board.**

Appendix A. Sample Dumb-Terminal Program

```
10      REM ***      DUMB-TERMINAL PROGRAM FOR THE interface
                     converter
20      REM ***                      Running under IBM BASIC
30      REM ***      This Program allows direct interaction between the
40      REM ***      IBM PC and an IEEE bus device through the interface
                     converter.
50      REM ***      The interface converter must be configured as the
                     IEEE bus
60      REM ***      controller and have Talk-Back on Terminator enabled.
70      REM ***
80      REM ***
90      REM ***
100            CLS
110     ' Open the serial communications port and set the serial parameters
120            OPEN "COM1: 9600,n,8,2,cs,ds" AS 1
130     ' Display any characters received from the COM1 port
140            IF LOC(1) THEN PRINT INPUT$ (LOC(1) ,1);
150     ' Transmit any key presses from keyboard to the COM1 port and to
           the screen
160     K$=INKEY$
170     PRINT #1,K$;  :  PRINT K$;
180     GOTO 140 ' Do it again
```

Appendix B. Character Codes and IEEE Multiline Messages

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

Group ranges: |——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

How To Read the Chart

Hexadecimal **Equivalent**	**Decimal** **Equivalent**
ASCII Character	
Address or Command	

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