the smart approach to instrumentation ™

IOtech, Inc.
25971 Cannon Road Cleveland, OH 44146
Phone: (440) 439-4091 Fax: (440) 439-4093
E-mail: sales@iotech.com Internet: http://www.iotech.com

Digital232 User's Manual

p/n DIGITAL232-901 Rev 2.0

Warranty Information

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

Limitation of Liability

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

Copyright, Trademark, and Licensing Notice

FCC Statement

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

CE Notice

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

Warnings, Cautions, Notes, and Tips

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

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

Specifications and Calibration

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

Quality Notice

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

Table of Contents

Table of Contents

Introduction

1.1 General Description

The **Digital232** is a digital input and output interface to the RS-232 standard. The unit has 40 TTL level digital I/O lines, divided into five 8-bit ports. Each port is software programmable as input or output.

The **Digital232** has several features which give it versatile interface capability. A trigger output signal can be asserted on a Trigger command. Edge-triggered inputs can generate a Service Request to the RS-232 host. Five data formats are software programmable, including hexadecimal, ASCII, binary, high speed binary and decimal. There are also individual bit set and bit clear commands.

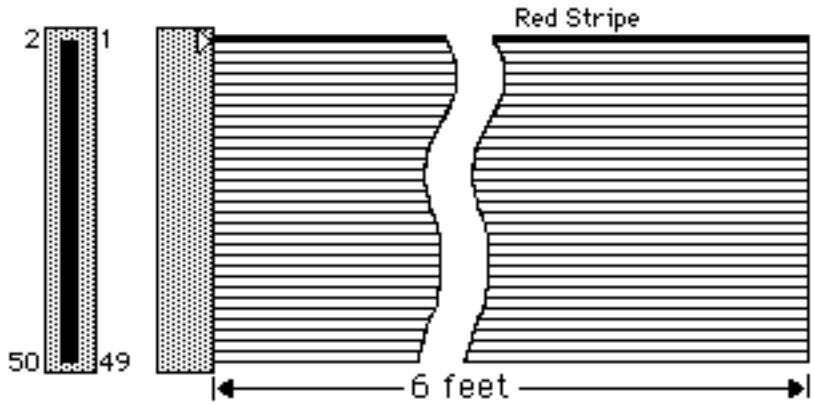
A status mode enables the host to interrogate the programmed status of the **Digital232** at any time. A self-test is initiated at power-on which checks for proper RAM and ROM operation.

When data is requested, the **Digital232** will output from all forty bits, all input ports, all output ports, or from a specific 8 bit port. When being programmed, the unit will input data and programming information from the host, and output the data to the selected I/O port.

1.2 Available Accessories

Additonal accessories that can be ordered for the **Digital232** include...

CN-6-50	50 Pin solder tab edge connector.
109-0920	Instruction Manual
CA-11	12 ft. RS-232 cable, compatible with IBM PCs or similar computers.
CA-8-50	6 foot, 50 conductor ribbon cable with a card edge connector on one end, the other end unterminated.



CA-8-50

1.3 Specifications

DIGITAL I/O:

Configuration:	Five 8 bit ports, programmable as inputs or outputs. Also included are programmable handshake lines, data latching capability, and trigger output.
Logic Levels:	Outputs will drive 2 TTL loads.
Connector:	I/O Port: One 50 pin card-edge. Mating connector supplied.

SERIAL INTERFACE:

EIA RS-232C:	AB, BA, BB, CA, CB
Duplex:	Full with switch selectable echo/no-echo
Data Bits:	7 or 8 (switch selectable)
Stop bits:	1 or 2 (switch selectable)
Parity:	Switch selectable on transmit for odd, even, mark, space or disabled. No parity test on receive
Baud Rates:	110, 135, 150, 300, 600, 1200, 1800, 2400, 3600, 4800, 7200, 9600, and 19200 (switch selectable)
Terminator:	Switch selectable CR, LF, CR-LF, or LF-CR
Control:	Supports Clear To Send (CTS), Request To Send (RTS) and switch selectable XON/XOFF
Serial I/O Buffers:	3500 Characters each
Serial Connectors:	Mates with a 25-Pin Sub-D male: DCE configured.

GENERAL:

Indicators:	LEDs for Send, Receive, Test, Error, and Power
Power:	105-125V or 210-250V,50, 60 Hz; 15 VA MAX.
Environment:	0 to 50 deg C; 0 to 70% RH
Dimensions:	188mm deep x 140mm wide x 68mm high. (7.39" x 5.5" x 2.68")
Weight:	1.55 kg (3.6 lbs)
Controls:	Power switch, internal dip switch for RS-232 parameters
Supplied Accessories:	I/O port connector, power supply and manual.

Specifications are subject to change without notice.

GETTING STARTED

2.1 INSPECTION

The **Digital232** was carefully inspected, both mechanically and electrically, prior to shipment. When you receive the interface, carefully unpack all items from the shipping carton and check for any obvious signs of physical damage which may have occurred during shipment. Immediately report any such damage found to the shipping agent. Remember to retain all shipping materials in the event that shipment back to the factory becomes necessary.

Every **Digital232** is shipped with the following....

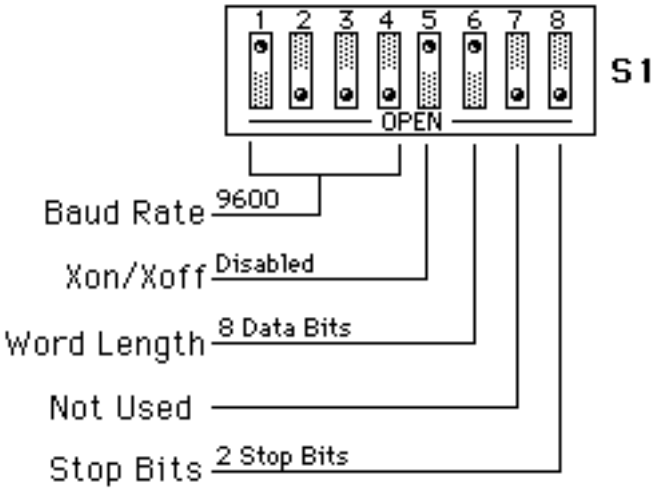
• **Digital232**	Digital I/O Interface
• **109-0920**	Instruction Manual
• **CN-6-50**	50 pin card edge connector
• **TR-2**	115 volt Power Supply or
TR-2E	220 volt Power Supply

2.2 CONFIGURATION

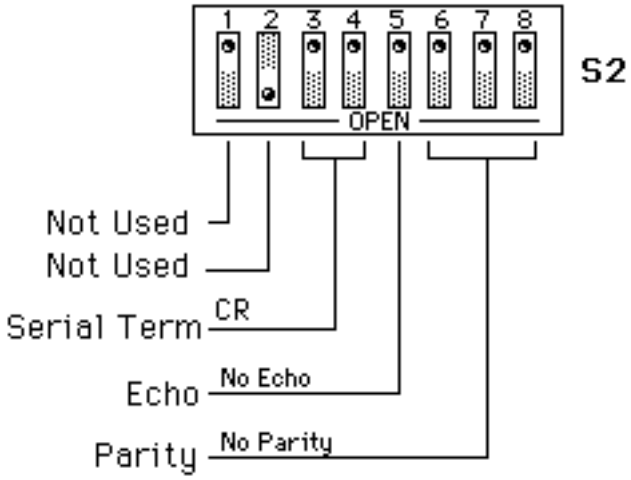
Two DIP switches internal to the **Digital232** set the configuration of the interface. NOTE: Most selectable functions are read ONLY at power-on and should only be set prior to applying power to the interface. The following figures illustrate the factory default conditions which are:

9600 Baud
8 Data Bits
2 Stop Bits
No Parity
Xon/Xoff Disabled
Echo Disabled
Serial Terminator = CR Only

S1 Factory Default Settings



S2 Factory Default Settings



Switch S1 is the 8-position dip switch close to the front of the unit. Switch S2 is near the rear power switch. To modify any of these defaults, follow this simple procedure:

Disconnect the power supply from the AC line and from the interface. Disconnect any digital I/O or serial cables prior to disassembly.

WARNING

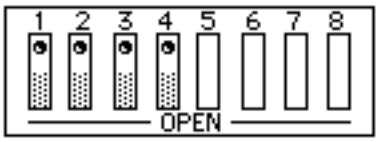
Never open the **Digital232** case while it is connected to the AC line. Failure to observe this warning may result in equipment failure, personal injury or death.

Remove the four screws located in each corner of the rear panel. Hold the case firmly and pull the rear panel outward, noting the slot location of the main circuit board. Modify those parameters which are appropriate for your installation and reassemble the unit. Slide the main circuit board into the previously noted slot and finish reassembly by tightening the four screws into the rear panel.

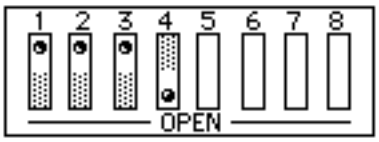
2.2.1 Serial Baud Rate Selection

S1-1 through S1-4 determine the serial baud rate. The factory default is 9600 baud. The baud rate may be selected from 110 to 19200. (Switch S1 is located near the front of the interface)

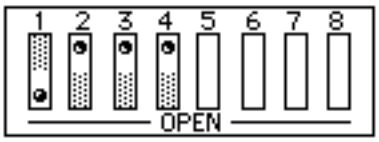
S1 View for Serial Baud Rate Selection



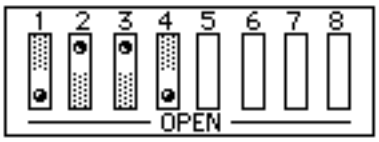
110



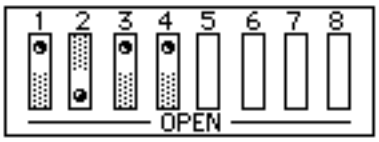
1200



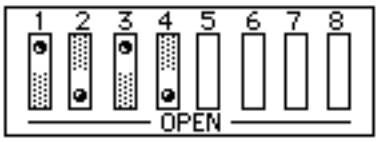
110



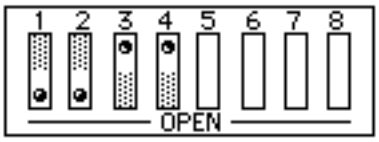
1800



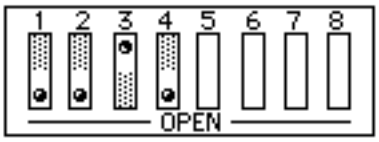
110



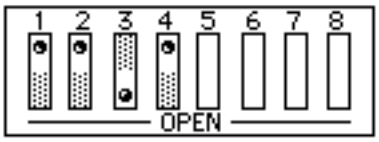
2400



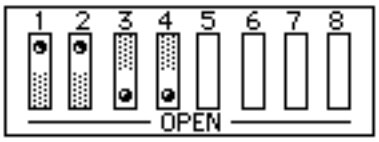
110



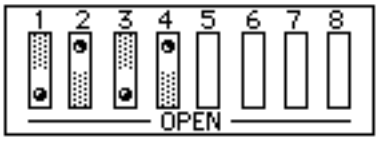
3600



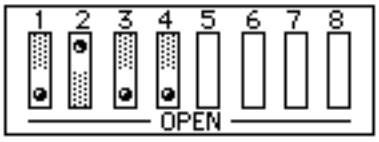
135



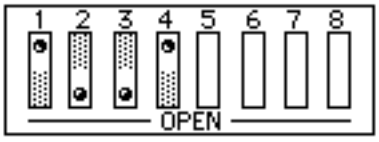
4800



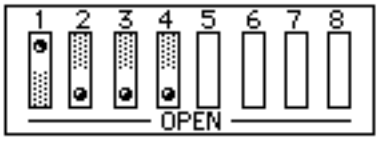
150



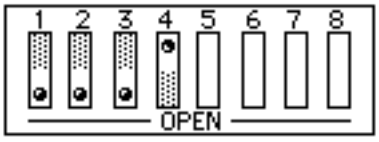
7200



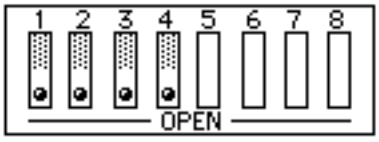
300



9600



600



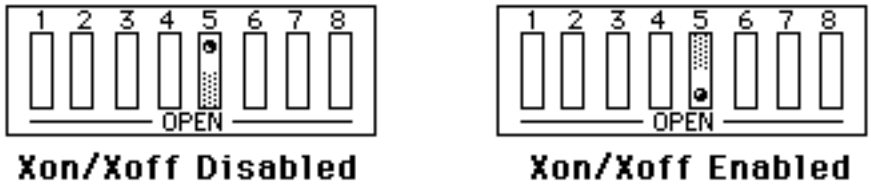
19200

2.2.2 Xon/Xoff Serial Control Selection

Switch S1-5 is used to enable **Xon/Xoff** serial control. When enabled, the **Digital232** issues **Xoff** when its serial input buffer is near full. When it is able to accept more information, it issues **Xon**. The **Digital232** also accepts **Xon/Xoff** on transmit from the serial device it is communicating with.

When the **Xon/Xoff** mode is enabled, the **RTS** output from the **Digital232** is set to +5 volts, and the **CTS** input is ignored. However, the **CTS** input to the **Digital232** should be wired to the **+Vtest** to avoid any problems. The factory default is **Xon/Xoff** disabled.

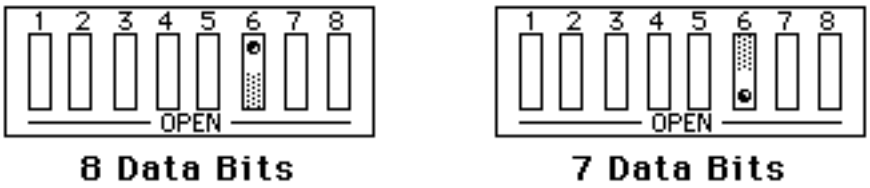
S1 View for Xon/Xoff Serial Control



2.2.3 Serial Word Length Selection

S1-6 determines the number of bits per each serial character transmitted or received. The factory default is 8 data bits.

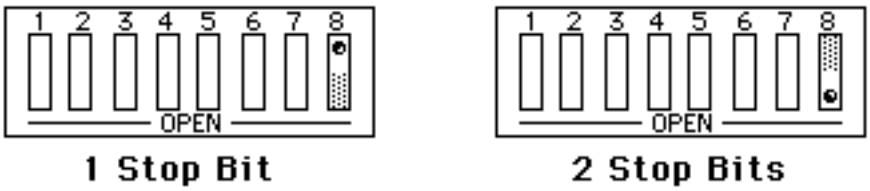
S1 View of Serial Word Length (Data Bits)



2.2.4 Serial Stop Bit Selection

Switch SW1-8 determines the number of stop bits contained in each serial character transmitted and received. The factory default is 2 stop bits.

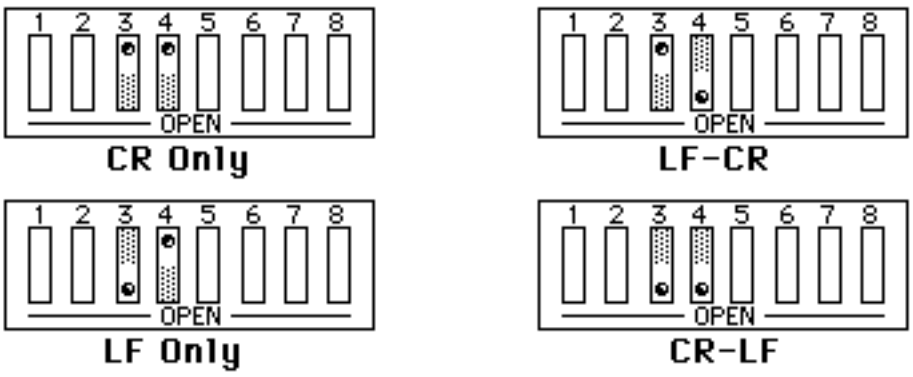
SW1 View for Serial Stop Bit Selection



2.2.5 Serial Terminator Selection

S2-3 and S2-4 select the serial terminators for the serial input and output. The factory default is **CR**. (switch S2 is located near the rear power switch).

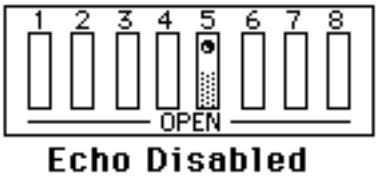
S2 View for Serial Terminator



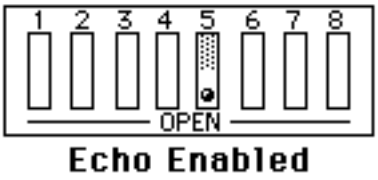
2.2.6 Serial Echo Selection

Serial data sent to the **Digital232** will be echoed back to the serial host if S2-5 is set to the open position. Factory default is Echo Disabled.

S2 View for Echo



Echo Disabled



Echo Enabled

2.2.7 Serial Parity Selection

Serial Parity is selected with S2-6 through S2-8. The **Digital232** generates the selected parity during serial transmissions but it does not check parity on data received. The factory default is parity disabled.

S2 View for Serial Parity Selection

Odd Parity

Mark Parity

Even Parity

Space Parity

Parity Disabled

2.3 Digital Input/Output Ports

The **Digital232** has 40 data lines which can be programmed in groups of 8 as

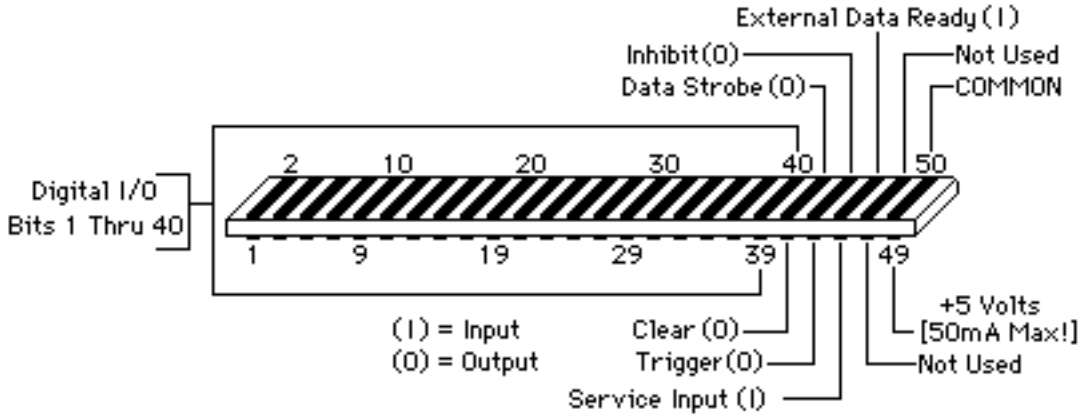
either input or output. At power on, all 40 bits are in the input mode. Each 8 bit group is one port, beginning with **Port 1** as the least significant 8 bits, and **Port 5** as the most significant 8 bits.

2.3.1 Logic Levels

The data and handshake output lines will drive two TTL loads. In addition, ports 3, 4, and 5 outputs are 5 Volt CMOS compatible. All input lines are less than 1.5 TTL loads. All inputs are protected against damage due to high static voltages. Normal precautions should be taken to limit the input voltages to -0.3 to +7.0 volts. All I/O lines are referenced to **COMMON** (Pin 50).

2.3.2 Digital I/O Port Pinout (rear view)

The following diagram illustrates the digital I/O edge connector as view from the rear of the **Digital232**



Pin	Description
1 thru 8	**DATA PORT1** (Input or Output). Pin 1 is bit 1 (LSB), Pin 8 is bit 8 (MSB). Least Significant Port
9 thru 16	**DATA PORT2** (Input or Output). Pin 9 is bit 1 (LSB), Pin 16 is bit 8 (MSB).
17 thru 24	**DATA PORT3** (Input or Output). Pin 17 is bit 1 (LSB), Pin 24 is bit 8 (MSB).
25 thru 32	**DATA PORT4** (Input or Output). Pin 25 is bit 1 (LSB), Pin 32 is bit 8 (MSB).
33 thru 40	**DATA PORT5** (Input or Output). Pin 33 is bit 1 (LSB), Pin 40 is bit 8 (MSB). Most Significant Port
41	**CLEAR** (Output).
42	**DATA STROBE** (Output).
43	**TRIGGER** (Output).
44	**INHIBIT** (Output).
45	**SERVICE INPUT** (Input).
46	**EXTERNAL DATA READY [EDR]** (Input).
47,48	Not used.
49	**+5 Volts** (**Do not exceed 50 mA load**).
50	**I/O COMMON.**

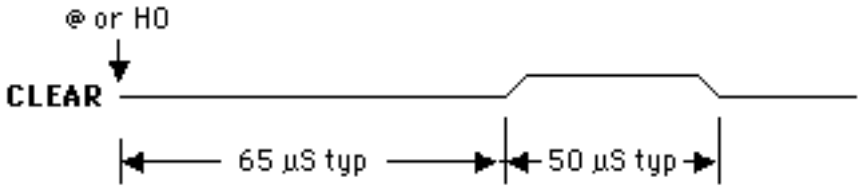
2.3.3 Control Lines

Five control lines enable handshaking of digital I/O data transfer to the **Digital232**. They are automatically activated with the corresponding I/O activity and can also be independently activated with the **Handshake** (**Hn**) command.

2.3.3.1 **Clear** (Pin 41)

The **Clear** output is pulse for approximately 50 microseconds at power-on, or upon receipt of the **RESET** (**@**) command. The **Clear** line is normally active high. The **Invert** command (**I8**) will program it active low. The **Handshake** command **(H0)** can pulse the **Clear** line, independent of any I/O operations.

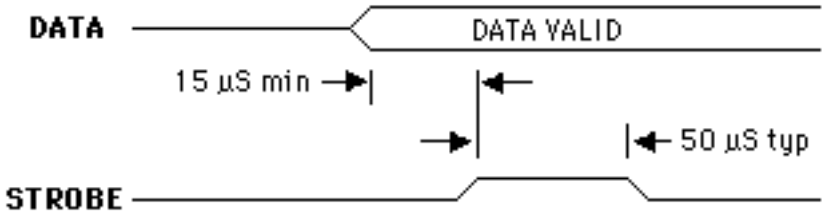
TIMING DIAGRAM FOR CLEAR OUTPUT



2.3.3.2 **Data Strobe** (Pin 42)

The **Data Strobe** output is pulse for approximately 50 microseconds after new data is output on the I/O port. The **Data Strobe** line is normally active high but may be programmed active low by the **Invert** command (**I4**). The **Handshake** command **(H1)** can pulse the **Data Strobe** line, independent of an I/O operations.

TIMING DIAGRAM FOR STROBE OUTPUT



2.3.3.3 External Data Ready [EDR] (Pin 46)

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

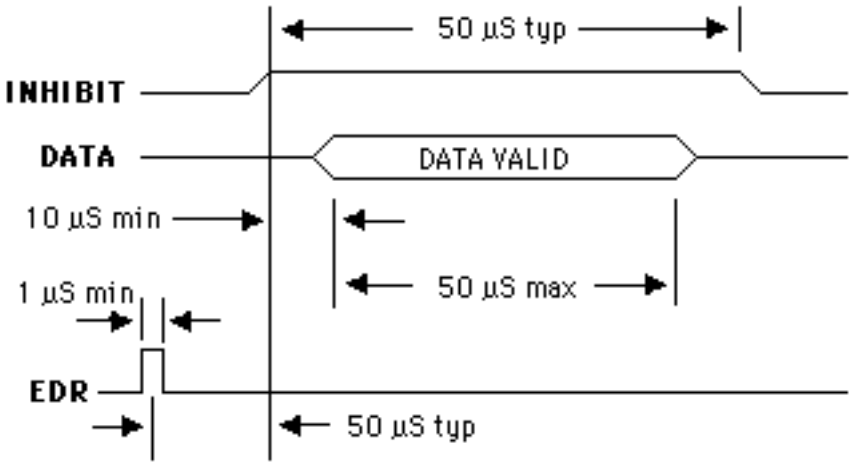
When using the **EDR** line the **Digital232** will only output data when the **EDR** line transitions.

2.3.3.4 Inhibit (Pin 44)

The **Inhibit** output is asserted while data on the selected I/O port is being read into the I/O port buffer. This line is normally active high but may be programmed active low by the **Invert** command (**I1**). The **Inhibit** line can be programmed independent of any I/O operations with the **Inhibit** command (**Qn**). Refer to the following diagram for timing relationships.

The **Inhibit** line is asserted once for each data read operation for all format [**Fn**] modes.

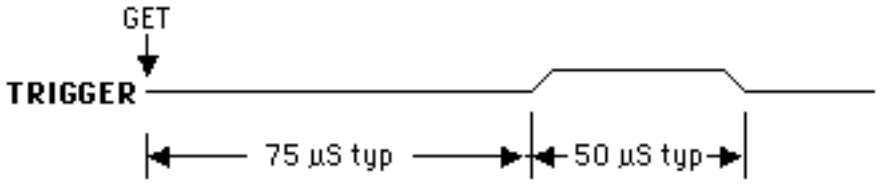
TIMING DIAGRAM FOR EDR AND INHIBIT



2.3.3.5 **Trigger** (Pin 43)

The **Trigger** output is pulse for approximately 50 microseconds after the **Handshake** command (**H2**) is received. The trigger pulse is normally active high, but can be made active low with the **Invert** command (**I2**).

TIMING DIAGRAM FOR TRIGGER OUTPUT



2.3.3.6 **Service** (Pin 45)

The **Service** input is an edge sensitive input capable of generating a **Service Request** (**SRQ**)**.** It is enabled with the **SRQ** command (**M1**) and defaults to rising-edge sensitive. The **Invert** command (**I64**) can be used to program it to be falling-edge sensitive.

2.4 INSTALLATION

To begin operating the **Digital232,** plug the external power supply into the rear jack on the interface.

CAUTION

Never install the power supply into the interface while it is connected to AC line power. Failure to observe this caution may result in damage to the **Digital232.**

WARNING

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

After installing the power supply connector into the interface, turn on the **Digital232** by depressing the rear panel power switch. All the front panel LEDs should light for approximately one second while the **Digital232** 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 **Digital232** is alive and well. If all LEDs remain on, then a ROM error has occurred. If all LEDs continue to flash (except the power LED), then a RAM error has occurred. Try cycling the power to the **Digital232** 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 interface. In this event, check to make sure the AC power is supplied to the power supply, and that the supply is properly installed

into the unit. If the problem is unresolved, refer to the **Service Information** section of this manual.

Connect a serial cable to the DB-25 connector on the rear of the **Digital232**. Connect the other end of the cable to the serial host. Running a dumb terminal program similar to that shown in Appendix C, type the following....

@	Reset the **Digital232**
R0	Request data from the **Digital232**
	The **Digital232** should respond with '**FFFFFFFFF**'

2.5 Errors

The **Digital232** has built-in error checking, to ensure that it has received valid commands and data, and to alert the user if an inappropriate situation has occurred. The front panel **Error** LED will illuminate when an error condition occurs, and will remain lit until the status command **U0** is received. The **Digital232** will continue to operate after an error has occurred, but in the instance of an invalid command, the command will not be executed and must be re-sent.

The **Service Request** command **M4** can be used to automatically send an SRQ message to the host whenever an error occurs. This is particularly helpful when first configuring the system using a 'dumb terminal' program, as described for the IBM PC in Appendix C. Refer to the **Status** command (**U0**) for more information on error codes.

COMMAND DESCRIPTIONS

Control of the **Digital232** is implemented with 17 commands, described here in detail. Examples are given for many of the commands using an IBM PC and the "dumb terminal" program described in Appendix C. The underlined portion of the example refers to text which is typed into the PC when the program is running. It is implied that each command is terminated by the "RETURN' key on the PC in order to execute the command.

When the **Digital232** receives multiple commands before receiving a terminator or **Execute** command, the accumulated commands are executed in the following order:

Command	**Code**	
Reset	@	(executed immediately)
Invert	I	
Configure	C	
Format	F	
Data	D	
Bit Set	A	
Bit Clear	B	
Inhibit	Q	
Handshake	H	
Service Request	M	
Status	U	
Terminator	Y	
Test	T	
Data Ready	R	(executed last)

RESET @

The **Reset** command returns the **Digital232** to its power-on conditions. It does not require an **Execute** command or terminator to be executed. To be sure that the **Reset** command is not confused with the argument of a previous command it is a good practice to precede it with an **Execute (X)** command.

@ Reset the **Digital232** to its power-on conditions

Example:

X@ reset the **Digital232**

BIT SET An

The **Bit Set** command programs a logic one output to a bit described by the argument '**n**'. Setting a bit may represent either a +5 volt or 0 volt output, depending on whether an **Invert** command (**I16**) has been sent. If data is active high (default condition), **Bit Set** outputs +5 volts. If multiple bits are to be set within the same command string, an **Execute** command (**X**) must be included after every **Bit Set** command.

The bit which is being set must have been configured as an output bit by the **Configure** command to be valid, otherwise the **Digital232** will generate a Conflict Error.

The **Strobe** and **Inhibit** output lines are not pulsed when the **Bit Set** command is sent.

An	Bit **n** (1 thru 40) is set to logic one

Example:

@	reset the **Digital232**
C5	configure all ports as output
A22	set bit 22 to a logic one
A23XA24	set bits 23 and 24 to a logic one

BIT CLEAR Bn

The **Bit Clear** command will clear to a logic zero an output bit described by the argument '**n**'. Clearing a bit may represent either a 0 volt or +5 volt output, depending on whether an **Invert** command (**I16**) has been sent. If data is active high (default condition), then **Bit Clear** outputs 0 volts. When multiple **Bit Clear** commands are used in the same command string, an **Execute** command (**X**) must follow each command.

The bit which is being cleared must have been defined as an output by the **Configure** command in order to be valid, otherwise the **Digital232** will generate a Conflict Error.

The **Strobe** and **Inhibit** output lines are not pulsed when the **Bit Clear** command is sent.

Bn	Bit n (1 thru 40) is cleared to a logic 0

Example:

@	reset the **Digital232**
C5	configure all ports as output
A7XA8XA9	set bits 7, 8, and 9 to +5 volts
B7	clear bit 7 to zero volts
B8XB9	clear bits 8 and 9 to zero volts

CONFIGURE Cn

Ports 1 thru 5 are configured as inputs or outputs with the **Configure** command. Each port is eight bits wide. At power-on, all ports are initialized as inputs. The **Configure** command is usually the first command to be sent after power on. All ports programmed as outputs will be set to a logic zero after receiving the **Configure** command. The actual output level is dependent on the **Invert** command (**I16**).

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

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

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

Example:

@	reset the **Digital232**
C1	select port 1 as output, ports 2 thru 5 as inputs

DATA Dn....Z

The **Data** command outputs up to 40 bits of data to the output ports. The number of bits which can be sent with the **Data** command is limited by the number of bits programmed as outputs. For formats **F0** through **F3**, if the amount of data sent is less than the the number of bits programmed as outputs, the least-significant bits will contain the data sent and the most-significant bits will be cleared to logic zero. If a single port is selected with the **Port** command, only eight bits may sent with the **Data** command. The **Data Strobe** output is pulse for approximately 50 microseconds after new data is output on the selected ports.

For formats **F0** through **F3**, data sent by the controller is contained within a prefix (**D**) and a suffix (**Z**). In format **F4**, the five bytes immediately following the prefix (**D**) is interpreted as data and the suffix (**Z**) is not used. Refer to the **Fn** command for additional details.

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

Example:

@	reset the **Digital232**
C5P1	configure all ports as output, select port 1
D55Z	send "55" to port 1
R0	read data from port 1, display shows 55
P0	select all ports
D1234567890Z	send data to all 40 bits
R0	read data from the **Digital232**, display shows 1234567890

FORMAT Fn

The **Format** command determines the method by which input and output data will be described. Five data formats are available and are described in detail in the following paragraphs.

F0	ASCII Hexadecimal (4 bits per character)
F1	ASCII Character (4 bits per character)
F2	ASCII Binary (1 bit per character)
F3	ASCII Decimal (8 bits per number)
F4	Binary (each byte represents 8 bits)

When data is requested from the **Digital232** (**R0**) it asserts **Inhibit**, reads the data from all ports, unasserts **Inhibit** and outputs the number of characters determined by the **Gn** and **Pn** commands. Leading zeros are not suppressed and the serial terminators are appended to the output. After output the **Digital232** must be requested to perform subsequent reads. **EDR** (**R1**) may also be used to capture data in these formats.

F0 Format- ASCII Hexadecimal

In the default **F0** format, the data is described in ASCII hexadecimal, with each character having a value from 0 thru 9 or A thru F. Each ASCII character describes 4 bits of data.

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

Data received for output to the digital ports must be contained within a prefix (**D**) and a suffix (**Z**). If the amount of data sent is less than the number of bits programmed as outputs, the least-significant bits will contain the data sent and the most-significant bits will be cleared to logic zero. If the data sent is greater than the number of bits programmed for output or selected by the **Pn** command, the **Digital232** will generate a conflict error and ignore the entire command string. The **Data Strobe** output is pulse for approximately 50 microseconds after new data is output on the selected port(s).

Example:

@	reset the **Digital232**
C2G2	configure ports 1 & 2 as output
D4E6BZ	output hexadecimal '4E6B' to ports 1 & 2
R0	read data from the **Digital232**
	display shows 4E6B

F1 Format - ASCII Character

In the **F1** format, the data is coded and transmitted in ASCII Characters with the four least significant bits of each ASCII character representing four bits of data.

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

Data received for output to the digital ports must be contained within a prefix (**D**) and a suffix (**Z**). If the amount of data sent is less than the number of bits programmed as outputs, the least-significant bits will contain the data sent and the most-significant bits will be cleared to logic zero. If the data sent is greater than the number of bits programmed for output or selected by the **Pn** command, the **Digital232** will generate a conflict error and ignore the entire command string. The **Data Strobe** output is pulse for approximately 50 microseconds after new data is output on the selected port(s).

Example:

F1	select ASCII mode
R0	read data from the **Digital232**, display shows 4>6;
D1??2Z	send 1??2 to the **Digital232**
R0	read data from the **Digital232**, display shows 1??2

F2 Format - ASCII Binary

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

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

Data received for output to the digital ports must be contained within a prefix (**D**) and a suffix (**Z**) and each 4-bit quantity must be separated by semicolons. Leading zeros are not required. If the amount of data sent is less than the number of bits programmed as outputs, the least-significant bits will contain the data sent and the most-significant bits will be cleared to logic zero. If the data sent is greater than the number of bits programmed for output or selected by the **Pn** command, the **Digital232** will generate a conflict error and ignore the entire command string. The **Data Strobe** output is pulse for approximately 50 microseconds after new data is output on the selected port(s).

Example:

F2	select ASCII/binary mode
R0	read data from the **Digital232**, display shows 0001;1111;1111;0001
D1111;0;1010;0101Z	
R0	read data from the **Digital232**, display shows 1111;0000;1010;0101

F3 Format - ASCII Decimal

In the **F3** format, the data is described in decimal 8 bit multiples and transmitted in ASCII. Each decimal number (0 to 255) to be output must be separated by semicolons.

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

Data received for output to the digital ports must be contained within a

prefix (**D**) and a suffix (**Z**). If the amount of data sent is less than the number of bits programmed as outputs, the least-significant bits will contain the data sent and the most-significant bits will be cleared to logic zero. If the data sent is greater than the number of bits programmed for output or selected by the **Pn** command, the **Digital232** will generate a conflict error and ignore the entire command string. The **Data Strobe** output is pulse for approximately 50 microseconds after new data is output on the selected port(s).

Example:

F3	select decimal mode
R0	read data from the **Digital232**, display shows 240;165
D100;200Z	output 100 & 200 to the **Digital232**
R0	read data from the **Digital232**, display shows 100;200

F4 Format - Binary

In the **F4** binary format the **Digital232** expects the "**D**" prefix followed by five bytes of data beginning with PORT5 without the "**Z**" suffix. If any digital I/O port is configured as an input, the data to that input port will be ignored and no error will be generated.

When data is requested from the **Digital232** (**R0**) it asserts **Inhibit**, reads the data from all ports, unasserts **Inhibit** and outputs 5 bytes beginning with PORT5. Serial terminators are appended to the output. After output the **Digital232** must be requested to perform subsequent reads. **EDR** (**R1**) may also be used to capture data in this format.

Example:

F4	select the binary mode
D!&Jg(Z	the binary representation of the characters **!&Jg(** will be output to the digital I/O port

OUTPUT SELECT Gn

The **Output Select** command determines the I/O port from which data will be transmitted when the **Digital232** outputs data to its serial port. The amount of data sent is dependent on the **Pn** command. In any port mode other than **P0,** only the 8 bits selected by the **Port** command will be output from the **Digital232** serial port.

The default mode, **G0** causes all 40 bits to be sent when data is requested. The **G1** mode causes only data from the ports programmed as inputs to be sent when data is requested. The **G2** mode causes only data from ports programmed as outputs to be returned when data is requested.

If all ports are programmed as outputs with **G1** selected and data is requested, nothing will be transmitted. Conversely, nothing will be transmitted with all ports programmed as inputs and **G2** selected.

G0	Input and output port data is output
G1	Only input port data is output
G2	Only output port data is output

Example:

@	reset the **Digital232**
P0C1	configure port 1 as input, ports 2-5 as output
G1	select only input ports when data is requested
R0	read data from the **Digital232** input ports display shows 000000FF (data is dependent on what is connected to the input)
G2	select output ports when data is requested
R0	read data from the **Digital232** input ports display shows 00 (outputs default to 0)

HANDSHAKE Hn

The **Handshake** control command enables software control of the handshake lines, independent of any other I/O operations. When the **Digital232** receives an **Hn** command, the respective handshake line is pulsed for approximately 50 microseconds. It returns to its steady-state condition after pulsing. The **Invert** command may be used to change the active state of any of the handshake lines.

H0 The **Clear** line is pulsed
H1 The **Strobe** line is pulsed
H2 The **Trigger** line is pulsed

Example:

H1 The **Strobe** line is pulsed

Invert In

The **Invert** command is used to change the polarity of the handshake and data lines. At power up all handshake and control lines are active high (logic one = + 5 volts). The **Invert** command can selectively change the polarity of each of the handshake lines, and of the data lines. If multiple **Invert** commands are contained within the same string, then an **Execute** command (X) should be included between each **Invert** command. An alternative is to add the values of each **Invert** command desired, and send one command with the sum of the desired commands. The **Invert** commands are Ored together as received. To delete any one command, it is necessary to program the default mode **I0**, then re-program the desired commands.

I0	All control lines are active high, all data lines are high true.
I1	Inhibit **output** is active low
I2	Trigger **output** is active low
I4	Data Strobe **output** is active low
I8	Clear **output** is active low
I16	Data **is low** true
I32	EDR **input** is falling-edge sensitive
I64	Service **input** is falling-edge sensitive

Example:

@	reset the Digital 232
I32XI64	select EDR and Service **input** as falling-edge sensitive
note:	
I96	performs the same function as above

Service Request (SRQ) Mn

The **Service Request (SRQ**) mode is used by the **Digital232** to alert the host computer to one of several conditions described below. When a service request condition occurs, the string "**SRQ n**" will automatically be sent to the host computer, where "n" is a number from 1 through 7. The number "n" is determined by the conditions which have caused the service request, and is the sum of M1, M2, and M4.

Multiple **SRQ** conditions can be enabled simultaneously. If multiple **SRQ** commands are contained within the same command string, each **SRQ** command should be followed by an **Execute** command (X). An alternative is to add the values of each **SRQ** command desired, and send one command with the sum of the desired commands. The **SRQ** commands are ORed together as received. The programmed **SRQ** modes will remain enabled until the **M0** command is sent, or a **Reset (@)** command is received.

M0 default mode disables the SRQ function, preventing the Digital232 from generating a Service Request

M1 will generate a Service Request when the Service Input line makes a transition. Refer to the Invert command (I64) description for programming the polarity of the Service input line.

M2 will generate a Service Request when the EDR input makes a transition. Refer to the Invert command (I32) description for programming the polarity of the EDR input line.

M4 will generate a Service Request when a programming error occurs. For example, attempting to select an 'F6' format when no 'F6' format exists will generate a Service Request when the M4 mode is selected.

Example:

@ reset the **Digital232**
M4 select **SRQ** on error
F7 send an invalid command.
ERROR LED should illuminate and "SRQ" is sent to the host

Port Pn

The **Port** command determines which port is selected for output and input data. In the default mode (P0), all ports are selected. The **P1** thru **P5** commands select a specific eight bit port.

The Output Select (Gn) command is used to determine whether input or output port data is sent out the serial port when requested. Data in modes P1 through P5 is input or output in groups of eight bits.

P0	All five ports are selected
P1	Port 1 is selected
P2	Port 2 is selected
P3	Port 3 is selected
P4	Port 4 is selected
P5	Port 5 is selected

Example:

@	reset the Digital 232
P4	select port 4

INHIBIT Qn

The **Inhibit** control command allows software control of the **Inhibit** line, independent of any other I/O activities. The 'set' and 'clear' levels of the **Inhibit** line are determined by the **Invert** command.

Q0 Clear the **Inhibit** line (return to unasserted state)
Q1 Set the **Inhibit** line (place in the asserted state)

Example:

@ reset the **Digital232**
Q1 set the **Inhibit** line

Data Ready Rn

The **Data Ready** command enables digital input data to be latched and transmitted out the serial port. When used in conjunction with the **Service Request** function, the **External Data Ready** line can both latch the input data and signal the host computer that new data is available.

In the default mode (R0) data is read and transmitted out the serial port when the Digital232 receives an R0 command. In R1 mode, data on an input port is latched on the transition of a signal applied to the **External Data Ready** (**EDR**) line. At that same time, the latched data is transmitted out the Digital232's serial port to the host computer. If EDR transitions again before the previous **EDR** buffered data has been formatted for output and sent to an internal serial output queue, the Digital232 will generate an **EDR Overrun** error and ignore the **EDR** read request.

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

In the R2 mode, serial data is sent to the host every time the last serial terminator is received. If, for example, the serial terminators selected are CR and LF then data is read and transmitted on receipt of the LF.

R0	Data is read and transmitted to the serial host computer.
R1	Data is latched on an EDR transition and transmitted to the host.
R2	Data is sent to the host computer after every receipt of the last serial terminator from the host

Example:

@	reset the **Digital232**
R1	request digital I/O data to be sent to the serial host

Test Tn

The **Test** command is used to verify hardware and LED operation. The **T0** command will turn-off the front panel **Test LED**. The **T1** command will turn-on the **Test LED**. The **T2** command will cause the Digital232 to initiate a ROM/RAM test. If the test is successful, all LEDs will flash for one-half second. If a test fails, the **Error** LED will remain illuminated. Use the **Status** command to determine the cause of the self test error.

Example:

@	reset the **Digital232**
T0	turn-off the front panel Test LED
T1	turn-on the Test LED

Status Un

The **Status** command (U0) will cause the Digital232 to send its status message to the host computer. The status of the Digital232 may be read at any time without interfering with normal operation. Any error conditions are cleared after the status string is read by the host. The **Status** command (Un) also enables the controller to read any single bit from the I/O ports (U1 through U40).

U0	Send the Digital232 status and clear any error conditions
Un	Send the status of bit n (1 thru 40)

The format of the status byte returned by the Digital232 after receiving a U0 command is as follows….

1.0C#E#F#G#I###M#P#R#Y#

where each "#" equals the number corresponding to that command. The leading information "1.0" is the revision level of the Digital232 software.

Example:

@@	reset the **Digital232**
U0	send U0 to the Digital232
	read the status byte
	display = *.*C0E0F0G0I000M0P0R0Y*

The status returned after receiving a U1 through U40 is an ASCII character '1' or '0', depending on the level of the line, and the state of the Invert command (I16).

Example:

U22	request the status of bit 22, display shows, a 0 (dependent on the signal applied to the input)

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

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

E#	**Error Message**
E0	No error
E1	Unrecognized command (ex. W3)
E2	Illegal command option (ex. F8)
E3	Conflict (attempt to output data to an input port)
E4	EDR overrun (EDR pulses occurred faster than data should be transmitted to the host)
E5	ROM error (a bit or bits in the ROM have changed state, consult the factory for further action)
E6	RAM error (a bit or bits in the RAM are not working properly, consult the factory for further action)

F#	**Data Format**
F0	ASCII Hexadecimal
F1	ASCII Character
F2	ASCII Binary
F3	ASCII Decimal
F4	Binary

G#	**Output Select**
G0	Input and Output port data is output
G1	Only Input port data is output
G2	Only Output port data is output

I###	**Invert Control Lines**
I0	All control and data lines are active high
I1	Inhibit output is active low
I2	Trigger output is active low
I4	Data Strobe Output is active low
I8	Clear output is active low
I16	Data is active low
I32	EDR input is falling edge sensitive
I64	Service input is falling edge sensitive

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

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

R#	**Data Ready**
R0	Data is sent to the host immediately
R1	Data is latched on EDR transition, and sent to the host
R2	Data is sent to the host upon receipt of the serial terminator.

Y#	**Serial Terminator**
Y0	CR
Y1	LF
Y2	LF-CR
Y3	CR-LF

EXECUTE X

Commands sent to the **Digital232** will result in no action until the unit is instructed to execute these commands. This is done by sending an **X** command or a serial terminator, which is usually the last character of a command string. Commands sent without an **X** are stored in the internal buffer until an **X** or a serial terminator is received. Any number of **Execute** commands may be inserted into the same command string. Certain commands, such as **Bit Set** require an **X** after each command in a string if more than one of that command is within the same string.

Example:

@	reset the **Digital232**
A1XA2	two **Bit Set** commands are within the same string, requiring an **X** after each command (unless separated by a terminator)

Terminator Yn

The serial terminator(s) defaults at power-on to the settings on Switch S1. It also may be programmed for any combination of Carriage Return (CR) and Line Feed (LF). The Y0 mode is the most commonly accepted terminator, CR.

Y0	CR Only
Y1	LF Only
Y2	LF-CR
Y3	CR-LF

Example:

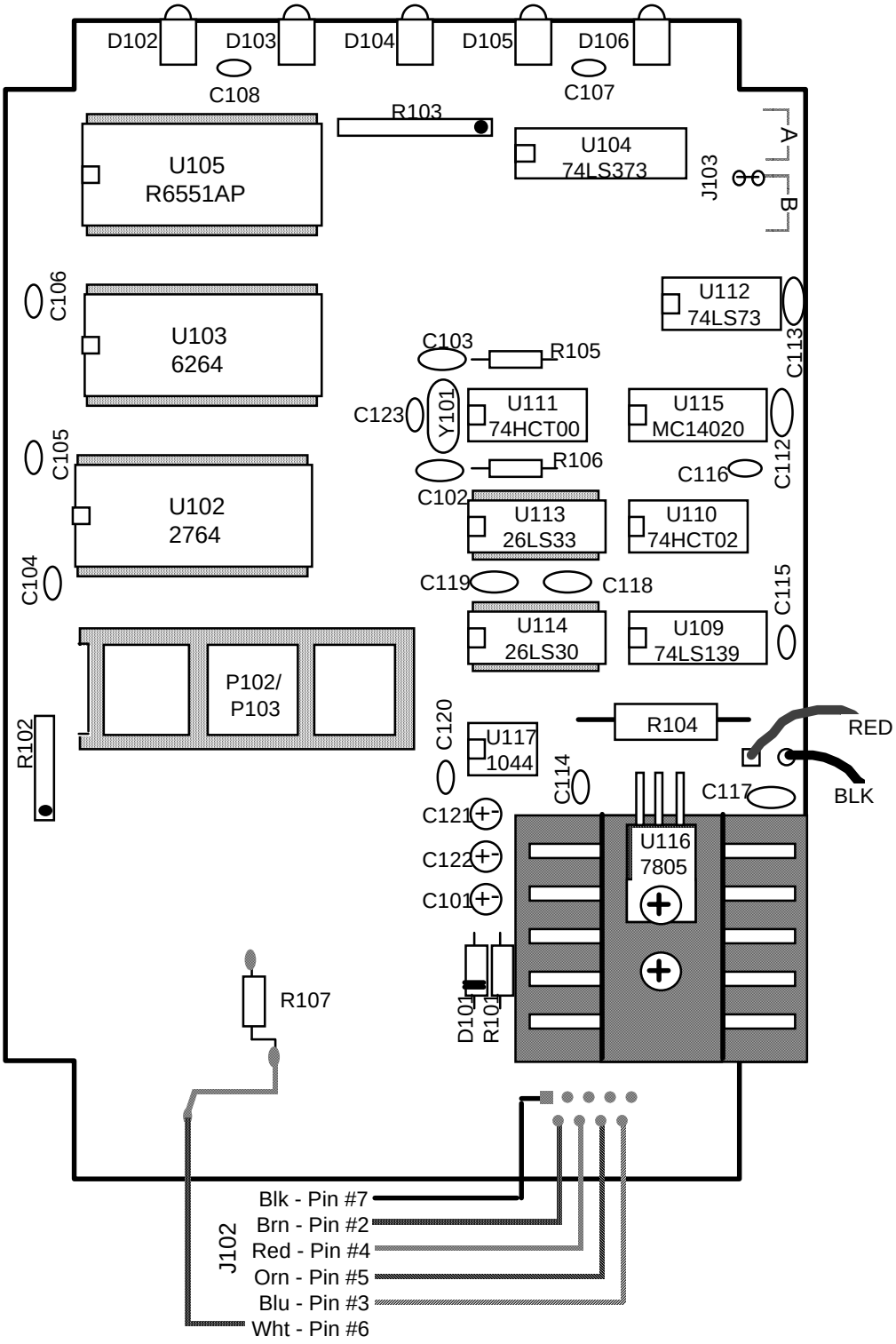
@	reset the **Digital232**
Y3	select line feed terminator
U0	send status to the host
	status byte indicates Y3 selected

Service Information

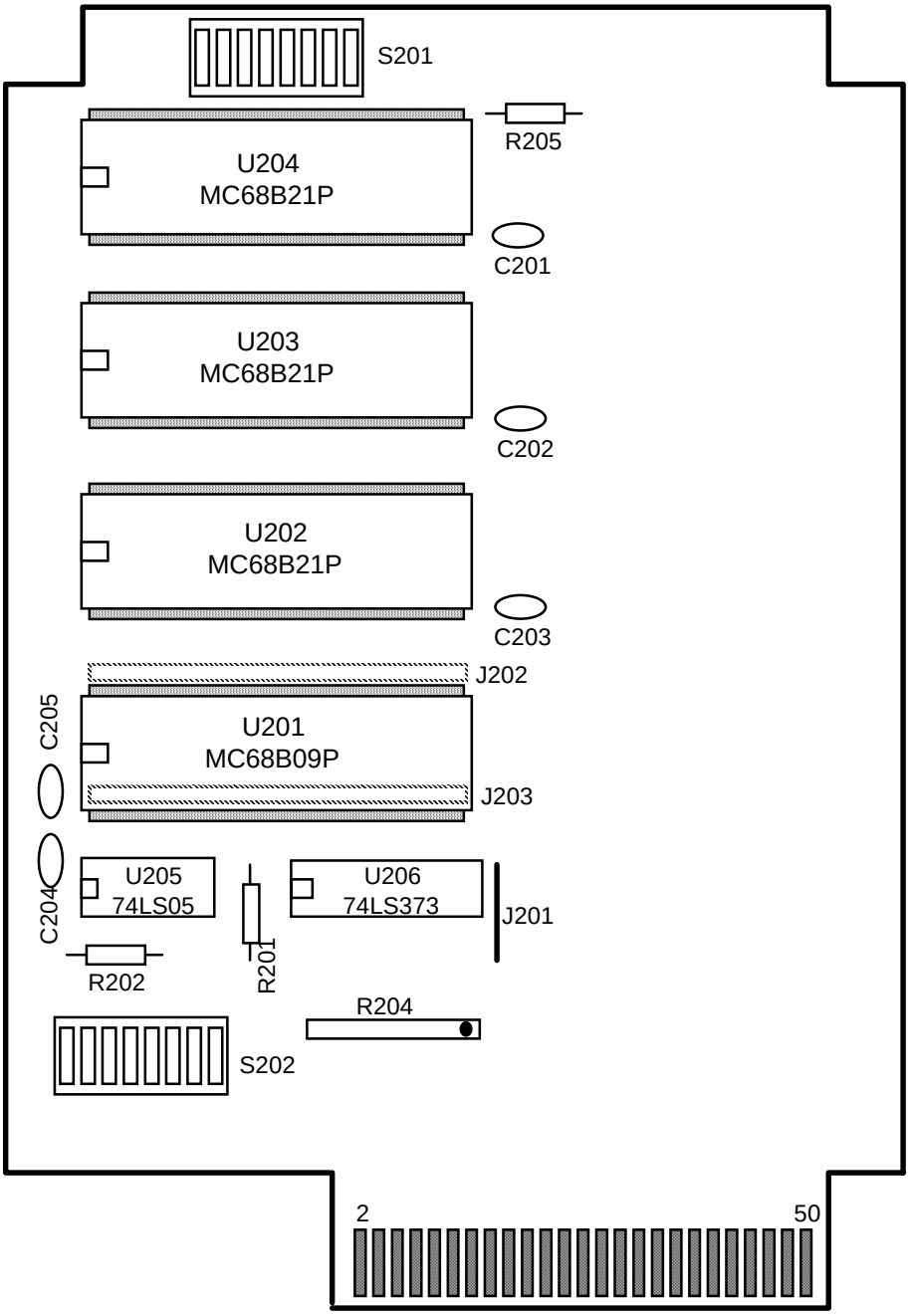
4.1 FACTORY SERVICE

IOtech maintains a factory service center in Cleveland, Ohio. If problems are encountered in using the **Digital232** you should first telephone the factory. Many problems can be resolved by discussing the problems with our applications department. If the problem cannot be solved by this method, you will be instructed as to the proper return procedure.

4.2 Digital232 Component Layout (Mother Board)



4.3 Digital232 Component Layout (I/O Board)



Digital 232 Command Summary

Command	Code	Description
Bit Set	**An**	Set bit n (1 thru 40)
Bit Clear	**Bn**	Clear bit n (1 thru 40)
Output	**G0**	Input and Output port data is output
	G1	Only Input port data is output
	G2	Only Output port data is output
Configure	**C0**	All ports are inputs
	C1	Port 1 is an output, ports 2 thru 5 are inputs
	C2	Ports 1 and 2 are outputs, ports 3 thru 5 are inputs
	C3	Ports 1 thru 3 are outputs, ports 4 and 5 are inputs
	C4	Ports 1 thru 4 are outputs, port 5 is an input
	C5	All ports are outputs
Data	**Dn..Z**	Data to be outputted is entered after "D" and terminated by "Z"
Data Ready	**R0**	Data is transmitted to the host computer via the serial port upon receipt of an **R0** command
	R1	Data is latched on an EDR transition, and transmitted to the host via the serial port
	R2	Data is transmitted to the host via the serial port after receipt of a serial terminator
Execute	**X**	Execute preceding command string
Format	**F0**	ASCII Hexadecimal
	F1	ASCII Charater
	F2	ASCII Binary
	F3	ASCII Decimal
	F4	Binary

Handshake	**H0**	Pulse the Clear line
	H1	Pulse the Strobe line
	H2	Pulse the Trigger line
Inhibit	**Q0**	Clear Inhibit line
	Q1	Set Inhibit line
Invert	**I0**	All control line outputs are active high
	I1	Inhibit output is active low
	I2	Trigger output is active low
	I4	Data Strobe output is active low
	I8	Clear output is active low
	I16	Data is low true
	I32	EDR input is falling-edge sensitive
	I64	Service input is falling-edge sensitive
Port	**P0**	All ports selected
	P1	Port 1 selected
	P2	Port 2 selected
	P3	Port 3 selected
	P4	Port 4 selected
	P5	Port 5 selected
Reset	**@**	Reset the **Digital232** to power-on conditions
SRQ	**M0**	SRQ is disabled
	M1	SRQ on Service Input transition
	M2	SRQ on EDR input transition
	M4	SRQ on command error
Status	**U0**	Send Status information when next addressed to talk (*.*C#E#F#G#I###M#P#R#Y#)
	Un	Read state of bit n (1 thru 40)
Terminator	**Y0**	CR LF
	Y1	LF CR
	Y2	CR only
	Y3	LF only

Test	**T0**	Turn off the TEST LED
	T1	Turn on the TEST LED
	T2	Perform a RAM and ROM test

ASCII Character Codes

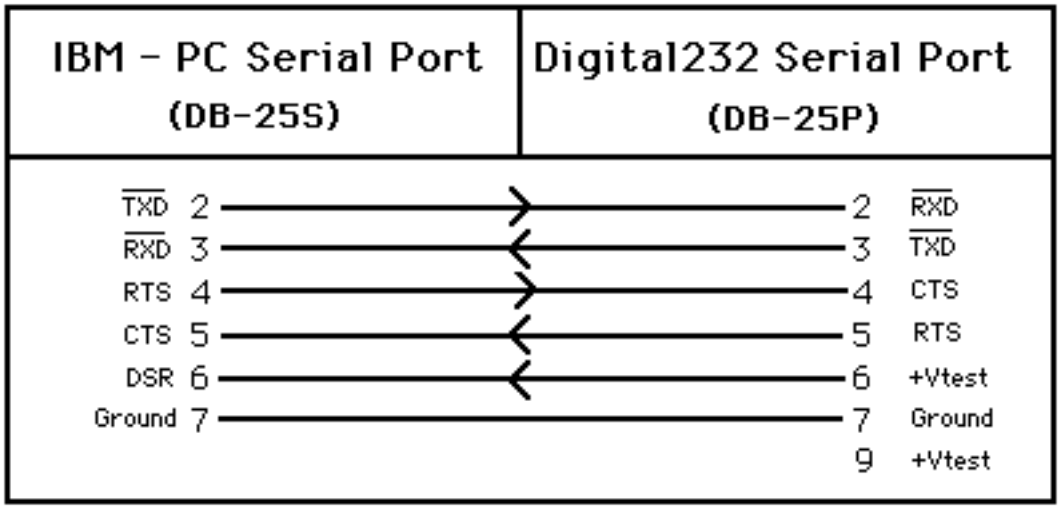
Dec	Hex	CHR	Dec	Hex	CHR	Dec	Hex	CHR	Dec	Hex	CHR
00	00	NUL	32	20	SPACE	64	40	@	96	60	'
01	01	SOX	33	21	!	65	41	A	97	61	a
02	02	STX	34	22	"	66	42	B	98	62	b
03	03	ETX	35	23	#	67	43	C	99	63	c
04	04	EOT	36	24	$	68	44	D	100	64	d
05	05	ENQ	37	25	%	69	45	E	101	65	e
06	06	ACK	38	26	&	70	46	F	102	66	f
07	07	BEL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

Dec = decimal Hex = hexadecimal CHR = character
LF = Line Feed CR = Carrage Return FF = Form Feed
DEL = Rubout

IMB PC Interfacing

```
10      REM ***      DUMB TERMINAL PROGRAM FOR THE Digital232
15      REM ***            Running under IBM basica
20      REM ***  This program allows direct interaction between the
25      REM ***  IBM-PC and digital I/O devices through the Digital232.
30      REM ***  Make sure the Digital232 is configured for its factory
35      REM ***  default conditions, described in Section 2 of this manual.
40      REM ***
45      REM ***            IOtech, Inc., P.O.Box 21204,
50      REM ***         Cleveland, Ohio 44121 (440) 439-4091
60          CLS
70      REM ***  Set communications parameters of COM1 port
80          OPEN "COM1:9600,N,8,2,cs,ds" AS 1
90      REM ***   Display characters from COM1
100         IF LOC(1) THEN PRINT INPUT$(LOC(1),1);
110     REM ***   Transmit any available characters from the keyboard
120         K$=INKEY$
130         PRINT #1,K$;: PRINT K$;
140         GOTO 100
```

Wiring Diagram for interfacing the Digital232 to an IBM PC



note: if the **Xon/Xoff** mode is enabled, then CTS pin 4 of the **Digital232** must be connected to +Vtest pin 9.