

DIGIQUARTZ^â

PRECISION PRESSURE INSTRUMENTS

PROGRAMMING AND
OPERATION MANUAL

FOR

- * SERIES 1000 / 6000/ 9000
INTELLIGENT TRANSMITTER
- * SERIES 8DP / 8WD / 8B
INTELLIGENT DEPTH SENSOR
- * MODEL 760 PORTABLE FIELD STANDARD
- * MODEL 740 PORTABLE LABORATORY STANDARD
- * MODEL 730 INTELLIGENT DISPLAY
- * MODEL 710 DISPLAY
- * RS-232C SERIAL INTERFACE BOARD
- * 16-BIT BINARY INTERFACE BOARD
- * PS-2 WATER STAGE SENSOR (RS-232)
- * MET 3 (Reference Doc# T8360-001)

DOCUMENT NO. 8107-001

REVISION N

April 2002

COPYRIGHT 2002 PAROSCIENTIFIC, INC.



TABLE OF CONTENTS

SECTION	PAGE
1 INTRODUCTION	1-1
2 HARDWARE DESCRIPTION.....	2-1
3 SPECIFICATIONS	3-1
All Products Shipped Prior to October 1, 2001	3-1
Transmitters and Depth Sensors Shipped After October 1, 2001	3-3
4 HOW TO GET STARTED.....	4-1
Types of Measurements	4-1
Types of Sampling	4-2
Command Format.....	4-3
Set-up Commands	4-3
Standard Configuration Setup	4-3
Sample Program for Single Measurements	4-4
Sample Program for Continuous Measurements	4-7
5 COMMAND LIST.....	5-1
6 COMMAND DESCRIPTIONS	6-5
Sampling Commands.....	6-5
Configuration Control Commands.....	6-9
Special Commands To Control Display	6-13
Tare And Overpressure Commands.....	6-15
Special Diagnostic Commands.....	6-18
Optional 16-Bit Binary Output Commands.....	6-19
Calibration Commands.....	6-21
7 GLOBAL COMMANDS.....	7-1
8 RESOLUTION, INTEGRATION TIME, AND SAMPLING SPEED.....	8-1
9 HIGH SPEED SAMPLING	9-1
10 MULTIPLE TRANSMITTERS ON THE RS-232 BUS	10-1

SECTION	PAGE
11 DIGIQUARTZ^â MODEL 710 DIGITAL DISPLAY	11-1
12 16-BIT SERIAL BINARY OUTPUT	12-1
13 16-BIT PARALLEL BINARY OUTPUT (available as an option)	13-1
14 TARING AND OVERPRESSURE WARNING	14-1
APPENDIX A HOOKUP	15-1
APPENDIX B CONNECTOR PIN ASSIGNMENTS	15-3
APPENDIX C DISPLAY HOOKUP	15-10
APPENDIX D PROGRAMMING HINTS	15-11
APPENDIX E SAMPLING COMMANDS	15-13
APPENDIX F USEFUL IBM BASIC INSTRUCTIONS	15-14
APPENDIX G CALCULATION OF PRESSURE	15-15
APPENDIX H ZERO AND SPAN ADJUSTMENTS	15-16
APPENDIX I SOFTWARE VERSIONS	15-17
APPENDIX J COMMAND LIST	15-19

INTRODUCTION

This manual describes the programming and operation of Paroscientific's line of intelligent instruments with the RS-232 interfaces. These instruments have a common instruction set with some variation in the Model 740, Model 760 and 16-bit board as noted.

The Intelligent Transmitter, Portable Pressure Standards and RS-232C serial interface boards each provide direct digital pressure output, in the user's choice of engineering units, to a computer or optional stand-alone readout display.

The intelligent devices receive commands and data requests via a two way RS-232 port and return data via the same bus. Up to 98 transmitters can be attached to a single RS-232 port.

Powerful, easy to use program commands allow the user to address any or all transmitters on the bus and control data sampling rates, sample integration time, baud rate, and other operating parameters.

Pressure values are output in any of eight standard sets of engineering units or in user definable units.

Output pressure data is fully compensated for temperature effects over the calibrated temperature range.

The different models can easily be mixed on the same RS-232C bus. The same basic commands are used with all models. A few additional commands control special features unique to some models.

HARDWARE DESCRIPTION

The Digiquartz[®] Intelligent Transmitters and Portable Pressure Standards consist of a standard Paroscientific pressure transducer and a digital interface board in an integral package. The digital interface boards are also available separately for customer systems where separate packaging of the transducer and interface board is desired. Programming and operation are the same in all configurations.

The digital board has a microprocessor-controlled counter and RS-232 port. The microprocessor operating program is stored in permanent memory (EPROM). User controllable parameters are stored in user writable memory (EEPROM). The user interacts with the transmitter via the two-way RS-232 interface.

The pressure transducer provides two continuous frequency output signals: one corresponds to the pressure and the other to sensor internal temperature. The digital board uses these two signals to calculate fully temperature-compensated pressure. The equations used are described in Appendix G.

The microprocessor monitors incoming commands from the computer. When a sampling command is received, the microprocessor selects the appropriate frequency signal source and makes a period measurement using a 14.74 MHz timebase counter. The counter integration time is user selectable. Some commands require measurements of both temperature and pressure signals. In that case, the temperature period is measured first, followed by the pressure period. When the period measurement is completed, the microprocessor makes the appropriate calculations and loads the data onto the RS-232 bus.

An optional version of the transmitter and digital interface board is available which provides 16-bit serial binary output in addition to RS-232 output. (Refer to Section 12.)

SPECIFICATIONS

1. ALL 740/760 PORTABLE STANDARDS
2. TRANSMITTERS AND DEPTH SENSORS SHIPPED BEFORE OCTOBER 1, 2001

RS-232 BUS:

Baud Rates	User selectable from 150 to 19200 baud
Input levels	Any RS-232C compatible level
Output levels	± 5 VDC nominal
Data framing	User selectable choices: 8 data bits, no parity, one stop bit 7 data bits, odd parity, one stop bit 7 data bits, even parity, one stop bit
Handshaking	Not required.

POWER REQUIREMENTS:

+6 TO +16 VDC

Typical current drain:

12 mA r.m.s. quiescent

14 mA r.m.s. at 1 sample/s

25 mA r.m.s. max at high speed

25 mA peak instantaneous current

SAMPLING MODES:

Single sample and send

Synchronized sample and hold

Continuous sample and send

Special burst sampling modes

SAMPLE INTEGRATION TIME:

User selectable in approximately 3 ms steps from 3 ms to 30 s.

SAMPLE SPEED:

Depends on integration time
Up to 50 samples/ s in normal modes
Up to 135 samples/ s in burst sampling modes

RESOLUTION:

Depends on integration time
User selectable in 15000 steps
Typically: 100 ppm full scale at 70 samples/ s
 10 ppm at 8 samples/ s
 1 ppm at approximately 1 sample/ s
 0.1 ppm once every 15 s

PRESSURE UNITS:

User selectable

Choice of psi, hPa, mbar, bar, kPa, MPa, inches of Hg, Torr,
meters of water or user definable

OPTIONAL OUTPUTS:

16-bit parallel binary output is available as an option.
16-bit serial binary output is standard on some models.

SPECIFICATIONS

TRANSMITTERS AND DEPTH SENSORS SHIPPED AFTER OCTOBER 1, 2001
(FIRMWARE VERSION R1.00 AND LATER)

NOTE:

710 Display is not supported.

RS-232 BUS:

Baud Rates	User selectable from 150 to 19200 baud
Input levels	Any RS-232C compatible level
Output levels	± 5 VDC nominal
Data framing	User selectable choices: 8 data bits, no parity, one stop bit 7 data bits, odd parity, one stop bit 7 data bits, even parity, one stop bit
Handshaking	Not required.

POWER REQUIREMENTS:

+6 TO +16 VDC

Typical current drain:

18 mA r.m.s. quiescent

32 mA r.m.s. max at high speed

SAMPLING MODES:

Single sample and send
Synchronized sample and hold
Continuous sample and send
Special burst sampling modes

SAMPLE INTEGRATION TIME:

User selectable in approximately 3 ms steps from 3 ms
to 30 s.

SAMPLE SPEED:

Depends on integration time
Up to 50 samples/ s in normal modes
Up to 135 samples/ s in burst sampling modes

RESOLUTION:

Depends on integration time
User selectable in 15000 steps
Typically: 100 ppm full scale at 70 samples/ s
 10 ppm at 8 samples/ s
 1 ppm at approximately 1 sample/ s
 0.1 ppm once every 15 s

PRESSURE UNITS:

User selectable

Choice of psi, hPa, mbar, bar, kPa, MPa, inches of Hg, Torr,
meters of water or user definable

HOW TO GET STARTED

This section concentrates on things a first time user needs to know. It includes simple sample programs written in BASIC.

Hook up the transmitter as described in Appendices A and B. Then read through Sections 1 and 2 to get an overview of the capabilities of the transmitter.

The Digiquartz® CD-ROM Library included in your shipment contains programs that allow you to configure and log data from your instrument. These programs will run on any PC with an RS-232 port and the Windows 95/98/NT operating system. To install the programs, insert the CD-ROM into your drive. A menu will appear on the screen allowing you to select the program you would like to install.

Run the Digiquartz® Interactive program to verify that your hookup is correct and that the instrument is operating properly. Run the Digiquartz® Assistance program to log data from the instrument. Context sensitive help is also available while running each program.

There are a variety of other useful programs that may be found on the CD-ROM. You may also use a standard terminal emulation program to interact with your instrument. If trouble is encountered, check the programming hints in Appendix D of this manual.

TYPES OF MEASUREMENTS

The transmitter can make four types of measurements:

1. **Pressure** - Pressure measurements are the most frequently used.
2. **Temperature** (internal sensor temperature) - The sensor internal temperature measurement is intended for thermal compensation of pressure. Because the sensor is thermally isolated, the internal temperature changes slowly and might be read only occasionally.

The period measuring commands are used mainly for calibration or diagnostic tests. They also can be used for high speed burst sampling.

3. **Period of the pressure sensor**
4. **Period of the temperature sensor**

TYPES OF SAMPLING

There are four types of sampling:

1. Single measurement sample and send, (e.g., command **P3**)
2. Single measurement sample and hold, (e.g., command **P5**)
3. Continuous sample and send, (e.g., command **P4**)
4. Special high speed burst sampling, (e.g., command **P7**)

The simplest commands to use are the single sample commands, and beginners should start with them.

<u>Command</u>	<u>Transmitter Response</u>
P3	Make one pressure measurement and send it to the computer.
P5	Make one pressure measurement hold value until requested.
DB or DS	Send value being held to computer.

The difference is that **P3** sends data as soon as it is available, while **P5** holds the data until a **DB** (dump buffer) or **DS** (dump sequential) request is received.

P5 is intended primarily for sampling simultaneously with several transmitters and then reading them out one by one.

The continuous and burst sampling procedures are described later. They are more complicated to use because data keeps coming in and user programs must keep up with it.

COMMAND FORMAT

All commands have the form: ***ddscc_<cr><lf>**

Data framing is 8 data bits, no parity, with one stop bit or 7 data bits with even or odd parity, one stop bit. Set by command **PT**.

1. Each line starts with an asterisk (*).
2. The next 2 digits, **dd** are the destination for the command (**00-99**).

The controller (IBM PC, etc.) is address **00**, and the transmitters can be **01** through **98**. Address **99** is for "global".

A transmitter responds only to its own address or **99**.

3. The next 2 digits, **ss**, are the source of the message (**00-98**).
4. The next 2 characters, **cc**, specify the type of message, and may be followed by more characters in some messages. Characters must be upper case. Reply messages may substitute data for the **cc** characters.
5. Each message line is terminated by a carriage return **<cr>** and a line feed **<lf>**.
6. Undefined commands are absorbed.
7. A command arriving before a previous command is completed cancels the previous command.

A typical message from the PC to transmitter #1 asking for pressure:

***0100P3 <cr> <lf>**

A typical reply from the transmitter to the PC:

***000114.573 <cr> <lf>**

SET-UP COMMANDS

Before a computer can talk to the transmitter, its baud rate (**BR**), parity (**PT**), and identification (**ID**) number must be known. Transmitters are normally shipped set to **BR = 9600, PT = N, and ID = 1**. Users may change these parameters but should record the new values. If the baud rate and parity of a transmitter are not known, the computer will have to search all values to reestablish communication.

The command **PR** sets the counter integration time in multiples of about 0.003 seconds. This command determines the Pressure Resolution.

The transmitters are shipped set to **PR = 238**, which gives a pressure resolution of about 1 ppm and a counter integration time of about 0.7 seconds. Users may select the value best suited for their applications. Larger values give higher resolution but take longer.

Once these parameters are set, you are ready to take data. The transmitter retains these parameters in EEPROM even if turned off. The sample programs on the following pages will help you to get started.

STANDARD CONFIGURATION SETUP

The intelligent devices are shipped with a data sheet of the configuration setup. It shows the settings of all the configuration parameters and calibration coefficients. The user should safeguard this data sheet for future reference.

SAMPLE PROGRAM FOR SINGLE MEASUREMENTS

(The following program is written in BASIC)

```
10 REM ***SINGLE SAMPLE PROGRAM
20 CLS
    Clear screen.

30 ON ERROR GOTO 130
    Set up exit in case of errors.

40 OPEN "COM1:9600,N,8,1,CS,DS,LF" FOR RANDOM AS #1
    Set up computer RS-232 port #1. 9600 baud, no parity, 8 data bits,
    1 stop bit, no handshaking, send line feed.

50 PRINT #1, "*0100VR"
    Send a command to stop any commands in progress.

60 CLOSE #1
    Close channel to clear out buffer.

70 OPEN "COM1:9600,N,8,1,CS,DS,LF" FOR RANDOM AS #1
    Reopen channel, ready to go.

80 PRINT #1, "*0100P3"
    Ask for one pressure reading.

90 INPUT #1, A$
    Read the data.

100 PRINT "DATA RECEIVED: "; A$
    Print the data.

110 CLOSE #1
    Close channel.

120 END

130 PRINT "ERROR NR"; ERR; "ON LINE"; ERL
    Error exit. Print message.

140 RESUME 120
```

Lines **40-60** clear the transmitter of previous commands. They halt any continuous data from the transmitter and clear out the computer input buffer.

In lines **40** and **70**, **COM1** can be changed to **COM2** to use RS-232 port #2 instead of port #1. Specify the baud rate for which the transmitter is set.

Now try substituting the **P1** or **Q3** command for **P3** in line **80**.

Try adding the following to get continuous output:

```
105 GOTO 80
```

Press **CTRL BREAK** to halt the program.

Now add the following to strip off the address block *0001 from the reply:

```
95 A$ = MID$(A$,6)
```

For additional programming examples in Visual Basic, Visual C, and LabView, see the website <http://www.paroscientific.com> under software

SAMPLE PROGRAM FOR CONTINUOUS MEASUREMENTS

```
10 REM ***CONTINUOUS SAMPLE PROGRAM
20 CLS
    Clear screen.

30 ON ERROR GOTO 130
    Set up exit in case of errors.

40 OPEN "COM1:9600,N,8,1,CS,DS,LF" FOR RANDOM AS #1
    Set up computer RS-232 port #1. 9600 baud, no parity, 8 data bits,
    1 stop bit, no handshaking, send line feed.

50 PRINT #1, "*0100VR"
    Send a command to stop any commands in progress.

60 CLOSE #1
    Close channel to clear out buffer.

70 OPEN "COM1:9600,N,8,1,CS,DS,LF" FOR RANDOM AS #1
    Reopen channel, ready to go.

80 PRINT #1, "*0100P4"
    Ask for continuous pressure readings.

90 INPUT #1, A$
    Read the data.

95 A$ = MID$(A$,6)
    Strip off address block.

100 PRINT "DATA: "; A$: GOTO 90
    Print the data. Loop to get more.

130 PRINT "ERROR NR"; ERR; "ON LINE"; ERL
    Error exit. Print message.

140 CLOSE #1: END
    Close file.
```

COMMAND LIST

SAMPLE COMMANDS

(May be used as global 99 commands)

- P1** Sample and send one pressure sensor period.
- P2** Continuously sample and send pressure periods.
- P3** Sample and send one pressure.
- P4** Continuously sample and send pressure.
- P5** Sample and hold one pressure.
- P6** Sample and hold one pressure period.
- P7** Burst and sample pressure: read temperature once; then continuously send pressure compensated using original temperature.

- Q1** Sample and send one temperature period.
- Q2** Continuously sample and send temperature periods.
- Q3** Sample and send one temperature.
- Q4** Continuously sample and send temperature.
- Q5** Sample and hold one temperature.
- Q6** Sample and hold one temperature period.

- DB** Dump buffer. Sends values being stored.
- DS**¹ Dump sequential. Sends stored values in sequential order.

CONFIGURATION CONTROL

- BR** Enter baud rate. Must be global command.
- BL** Locks baud rate and parity to prevent change.
Must be global command.
- ID** Auto-number transmitters in a loop. Must be global command.
- PT**² Sets transmitter parity. Must be global.
- EW** Enable EEPROM write for one command.

¹ NOT SUPPORTED FOR TRANSMITTERS AND DEPTH SENSORS SHIPPED AFTER 10/1/01 (FIRMWARE VERSION R1.00 AND LATER).

² PARAMETER IS READ-ONLY, FIXED AT 8 DATA BITS, NO PARITY, AND 1 STOP BIT IN TRANSMITTERS AND DEPTH SENSORS SHIPPED AFTER 10/1/01 (FIRMWARE VERSION R1.00 AND LATER).

REMAINING COMMANDS CANNOT BE GLOBAL

- PR** Read/enter pressure resolution.
- TR** Read/enter temperature resolution.
- UN** Read/enter choice of pressure units.

- | | | |
|-----------------|--------|-----------------------|
| 0. user defined | 3. bar | 6. in Hg |
| 1. psi | 4. kPa | 7. Torr or mm Hg |
| 2. mbar or hPa | 5. MPa | 8. m H ₂ O |

- UF** Read/enter user definable units.
- MD** Reads or sets power-up mode.

SPECIAL COMMANDS TO CONTROL DISPLAY

- DC** Display check.
- DD** Display distance.
- DP** Reads or sets number of display decimal places.
- DR** Display right-adjusted data from computer.
- DV** Display value from computer, left-adjusted.

TARE AND OVERPRESSURE COMMANDS

- BP** Sound overpressure beeper.
- OP** Read/enter the overpressure alarm setting.
- ZS** Read the position of the zero set switch.
- ZV** Zero value. Read the zero offset value.
- ZL** Zero lock. Enable or disable taring.

SPECIAL DIAGNOSTIC COMMANDS

- MC³** Memory check. Checks program PROM.
- CS** Check stack of microprocessor.
- CT³** Check counter timebase.
- CX** Check crystal of microprocessor clock.

³ NOT SUPPORTED FOR TRANSMITTERS AND DEPTH SENSORS SHIPPED AFTER 10/1/01 (FIRMWARE VERSION R1.00 AND LATER).

OPTIONAL 16-BIT BINARY OUTPUT COMMANDS

- LL** Limit low. Reads or sets pressure corresponding to binary 0.
- LH** Limit high. Reads or sets pressure for binary 65535.
- IM** Interface mode. Turns 16-bit binary interface on or off.
- IC** Inhibit control. Controls operation of data inhibit line.

CALIBRATION COMMANDS

WARNING!! THE FOLLOWING COMMANDS CAN CHANGE THE CALIBRATION COEFFICIENTS.

- SN⁴** Read/enter transmitter serial number.
- PA** Read/enter pressure adder.
- PM** Read/enter pressure multiplier.
- TC⁴** Read/enter timebase correction factor.

- C1** Read/enter C1 pressure coefficient.
- C2** Read/enter C2 pressure coefficient.
- C3** Read/enter C3 pressure coefficient.

- D1** Read/enter D1 pressure coefficient.
- D2** Read/enter D2 pressure coefficient.

- T1** Read/enter T1 pressure coefficient.
- T2** Read/enter T2 pressure coefficient.
- T3** Read/enter T3 pressure coefficient.
- T4** Read/enter T4 pressure coefficient.
- T5** Read/enter T5 pressure coefficient.

- U0** Read/enter U0 temperature coefficient.

- Y1** Read/enter Y1 temperature coefficient.
- Y2** Read/enter Y2 temperature coefficient.
- Y3** Read/enter Y3 temperature coefficient

⁴ READ-ONLY FOR TRANSMITTERS AND DEPTH SENSORS SHIPPED AFTER 10/1/01 (FIRMWARE VERSION R1.00 AND LATER).

COMMAND DESCRIPTIONS

SAMPLING COMMANDS (may be used as global 99 commands.)

P1 Sample and send one period measurement of the pressure signal in microseconds.

ACTION: Start pressure count, read count when done, calculate period using timebase and integration time, send reading, await next command.

TYPICAL COMMAND: *0100P1

TYPICAL REPLY: *000129.12345

P2 Continuously sample and send pressure signal periods.

ACTION: Start pressure count, read count when done, restart count, calculate period using timebase and integration time, send reading, read next count when available and loop until stopped.

TYPICAL COMMAND: *0100P2

TYPICAL REPLY: *000129.12345

*000129.12346

*000129.12344, etc.

P3 Sample and send one compensated pressure.

ACTION: Start temperature count, read count when done, start pressure count, correct temperature count for timebase and integration time, compute temperature compensated pressure coefficients, read pressure count when done, correct pressure count for timebase and integration time, calculate pressure, send reading, await next command.

TYPICAL COMMAND: *0100P3

TYPICAL REPLY: *000155.444

- P4** Continuously sample and send compensated pressure.
ACTION: Start temperature count, read count when done, start pressure count, correct temperature count for timebase and integration time, compute temperature compensated pressure coefficients, read pressure count when done, restart temperature count, correct pressure count for timebase and integration time, calculate pressure, send reading, loop until stopped.
- TYPICAL COMMAND: *0100P4
TYPICAL REPLY: *0001555.444
*0001555.447
*0001555.444, etc.
- P5** Sample and hold one compensated pressure.
ACTION: Same as **P3** except save reading and await **DB** command.
- TYPICAL COMMAND: *0100P5
TYPICAL REPLY: None until **DB** or **DS** command received.
- P6** Sample and hold one pressure signal period.
ACTION: Same as **P1** except save reading and await **DB** command.
- TYPICAL COMMAND: *0100P6
TYPICAL REPLY: None until **DB** or **DS** command received.
- P7** Burst sample pressure: read temperature once; then continuously send pressure compensated with original temperature reading.
ACTION: Start temperature count, read count when done, start pressure count, compute temperature compensated pressure coefficients and save for repeated use, read pressure count when done, restart pressure count, correct pressure count for timebase and integration time, calculate pressure, send reading, wait for next pressure count, and loop until stopped.
- TYPICAL COMMAND: *0100P7
TYPICAL REPLY: *0001555.444
*0001555.447
*0001555.444, etc.

- Q1** Sample and send one temperature signal period.
ACTION: Start temperature count, read count when done, correct for timebase and integration time, send reading, await next command.
- TYPICAL COMMAND: *0100Q1
TYPICAL REPLY: *00015.812345
- Q2** Continuously sample and send temperature signal period.
ACTION: Start temperature count, read count when done, restart count, correct count for timebase and integration time, send reading, get next count, and loop until stopped.
- TYPICAL COMMAND: *0100Q2
TYPICAL REPLY: *00015.812345
*00015.812346
*00015.812347, etc.
- Q3** Sample and send one temperature in degrees C.
ACTION: Start temperature count, read count when done, correct count for timebase and integration time, compute temperature and send, await next command.
- TYPICAL COMMAND: *0100Q3
TYPICAL REPLY: *000122.1234
- Q4** Continuously sample and send temperature.
ACTION: Start temperature count, read count when done, restart count, correct for timebase and integration time, compute temperature and send, wait for next count, and loop until stopped.
- TYPICAL COMMAND: *0100Q4
TYPICAL REPLY: *000122.1234
*000122.1235
*000122.1234, etc.
- Q5** Sample and hold one temperature.
ACTION: Same as **Q3** except save reading and await **DB** command.
- TYPICAL COMMAND: *0100Q5
TYPICAL REPLY: None until **DB** or **DS** command received.

Q6 Sample and hold one temperature period.
ACTION: Same as **Q1** except save reading and await **DB** or **DS** command.

TYPICAL COMMAND: *0100Q6

TYPICAL REPLY: None until **DB** or **DS** command received

DB Dump buffer. Send reading being stored.
ACTION: Send reading saved during **P5**, **P6**, **Q5**, or **Q6** command.
The **DB** command must be the next command addressed to the transmitter after a sample and hold. If the **DB** command arrives before the sample is ready, data are sent when ready.

TYPICAL COMMAND: *0100DB

TYPICAL REPLY: *0001555.444

DS⁵ Dump sequential. Usually a global command.
ACTION: Similar to **DB** command except it guarantees that the data from multiple transducers comes back in sequential order. Sends reading saved during a **P5**, **P6**, **Q5**, or **Q6** sample and hold command and then sends a global **DS** command to trigger the next transmitter in the loop. The **DS** command must be the next command addressed to the transmitter after the sample and hold. If the **DS** command arrives before the sample is ready, data are sent when ready.

TYPICAL COMMAND: *9900DS

TYPICAL REPLY: *000114.576 First transmitter
*000214.577 Second transmitter
*9900DS

⁵ NOT SUPPORTED IN TRANSMITTERS AND DEPTH SENSORS SHIPPED AFTER 10/1/01 (FIRMWARE VERSION R1.00 AND LATER).

CONFIGURATION CONTROL COMMANDS

BR Enter baud rate. Must be a global **99** command.

CAUTION: *Think carefully before changing the baud rate.*

ACTION: Sets baud rate. Does not require an **EW** command. Choices are 150, 300, 600, 1200, 2400, 4800, 9600, 19200 baud.

TYPICAL COMMAND: *9900BR = 2400 set BR = 2400

TYPICAL REPLY: *9900BR = 2400

NOTE: When the baud rate is changed, the confirming reply is sent at the original baud rate but all subsequent commands should be at the new baud rate.

BL Baud lock. Must be global command.

ACTION: Locks or unlocks baud rate and parity to prevent accidentally changing them. **BL = 0** is unlocked and allows values to be changed. **BL = 1** is locked. When modems are used, it is wise to lock the baud rate at a value compatible with the modem.

TYPICAL COMMAND: *9900BL

TYPICAL REPLY: *0100BL = 0 not locked

*9900BL

TYPICAL COMMAND: *9900EW *9900BL = 1 lock all

TYPICAL REPLY: *9900EW

*0001BL = 1

*9900BL = 1

ID Auto-number transmitters in a loop. Must be a global **99** command.

ACTION: Causes units to auto-number around a loop. Command begins at the PC with ***9900ID**. The first unit sees that the previous unit was "00" and numbers itself "01" and stores the value in EEPROM. Unit sends out ***9901ID** which causes the next unit to number itself "02". The PC eventually will receive the message ***99nnID**, where nn is the number of units in the loop.

TYPICAL COMMAND: *9900ID

TYPICAL REPLY: *9901ID

PT⁶ Sets transmitter parity. Must be a global **99** command. Parameter **PT** controls parity sent by the transmitter. Parity on incoming messages is ignored. Choices are:

- N** 8 data bits, no parity, one stop bit
- E** 7 data bits, even parity, one stop bit
- O** 7 data bits, odd parity, one stop bit.

TYPICAL COMMAND: *9900PT = N Set to 8 data bits, no parity
TYPICAL REPLY: *9900PT = N

VR Read software version. May be a global **99** command.
ACTION: Unit sends the software version number stored in the program EPROM.

TYPICAL COMMAND: *0100VR
TYPICAL REPLY: *0001VR = 01.00

EW Enable EEPROM write for one command. May be a global **99** command.
ACTION: Set flag allowing EEPROM write on next command. Flag is cleared after next command is received.

TYPICAL COMMAND: *0100EW
TYPICAL REPLY: None

NOTE: *The remaining commands cannot be global 99 commands.*

PR Read/enter pressure resolution.
ACTION: Same as other coefficients. PR = 1 to 16383. Pressure integration time = 100 * PR * period of pressure oscillator. TR is automatically set to 4 * PR when PR is changed.

TYPICAL COMMAND: *0100PR
TYPICAL REPLY: *0001PR = 00100
TYPICAL COMMAND: *0100EW *0100PR = 200
TYPICAL REPLY: *0001PR = 00200

⁶ PARAMETER IS READ-ONLY, PROTOCOL IS FIXED AT 8 DATE BITS, NO PARITY, AND 1 STOP BIT IN TRANSMITTERS AND DEPTH SENSORS SHIPPED AFTER 10 /1/02.

TR Read/enter temperature resolutions.
 ACTION: Same as other coefficients. TR = 1 to 65535. Temperature integration time = 100 *TR * period of temperature oscillator. TR is automatically set to 4 * PR when PR is changed, but is overwritten by this command.

TYPICAL COMMAND: *0100TR
 TYPICAL REPLY: *0001TR = 00400
 TYPICAL COMMAND: *0100EW *0100TR = 800
 TYPICAL REPLY: *0001TR = 00800

UN Read/enter choice of pressure units.
 ACTION: Selects units conversion factor by which all computed pressures are multiplied before output. UN = 1 to 8 selects from eight standard sets of units. UN = 0 chooses the user defined multiplier which is set with command UF.

<u>UN</u>	<u>UNITS</u>	<u>MULTIPLY PSIBY</u>
1	psi	1.0000000
2	mbar or hPa	68.94757
3	bar	.06894757
4	kPa	6.894757
5	MPa	.00689476
6	in Hg	2.036021
7	mm Hg or torr	51.71493
8	m H ₂ O	.7030696
0	user defined	set by UF command

TYPICAL COMMAND: *0100UN What are units?
 TYPICAL REPLY: *0001UN = 4 Units are kPa
 TYPICAL COMMAND: *0100EW *0100UN = 2 Set to mbar
 TYPICAL REPLY: *0001UN = 2

UF Read/enter user defined units conversion factor.
ACTION: Allows users to convert pressure to any desired set of units by defining a conversion factor. Then, when UN = 0 is selected, the output pressure will be psi * UF.

TYPICAL COMMAND:	*0100UF	Present
factor?		
TYPICAL REPLY:	*0001UF = 1.000000	
TYPICAL COMMAND:	*0100EW *0100UF = 144.0000	Define units
TYPICAL REPLY:	*0001UF = 144.0000	lb/ft ²

MD Read or set the mode parameter **MD**.
ACTION: This parameter controls the power-up state of the transmitter. The transmitter always responds to user commands, but it can also drive a remote display and send data continuously on the RS-232 bus in a background mode. These background tasks are turned on and off by the **MD** command.

	<u>Display</u>	<u>Continuous RS-232</u>
MD = 0	off	off
MD = 1	on	off
MD = 2	off	on
MD = 3	on	on

Whenever the transmitter calculates pressure in response to a user request, the data are also sent to any active background tasks. In addition, whenever the transmitter is not servicing user requests, it measures pressure and sends it to any active background tasks. Background tasks are temporarily interrupted whenever the higher priority computer requests require attention. Users requiring maximum sample speed or minimum current drain should turn off any unnecessary background tasks.

Model 740 and Model 760 portable pressure standards reset to MD = 1 when power is applied. Other models do not.

TYPICAL COMMAND:	*0100MD	What mode?
TYPICAL REPLY:	*0001MD = 0	No background tasks
TYPICAL COMMAND:	*0100EW *0100MD = 1	Turn on background display
TYPICAL REPLY:	*0001MD = 1	Display active

SPECIAL COMMANDS TO CONTROL DISPLAY

DC Display check command.

ACTION: Causes display to cycle through all display segments to check display. Does not generate any reply.

TYPICAL COMMAND: *0100DC

TYPICAL REPLY: None

DD Display distance.

ACTION: Reads or sets the display driving distance. The **DD** parameter controls the display clocking rate. **DD** = 0 is usually adequate for displays located within 100 to 200 feet of the transmitter using shielded cable for the display lines. For longer distances or if noisy readings appear on the display, change to **DD** = 1. Slower clocking of the display allows longer cables but slows the data sampling rate by a slight amount. The extra time to clock the display is not usually significant for **PR** values greater than about 30. The default setting is **DD** = 0.

TYPICAL COMMAND: *0100DD

TYPICAL REPLY: *0001DD = 0 short distance

TYPICAL COMMAND: *0100EW *0100DD = 1 set for long distance

TYPICAL REPLY: *0001DD = 1

Note: DD does not apply to Model 730, 740, 760, 790

DP Decimal point command.

ACTION Reads or sets the number of decimal places shown on the display. If **DP** = 6, the display automatically shows all significant digits, right-adjusted. If a user requests more decimal places than there is room to show, display will shift the decimal point so that the 6 most significant digits are shown. Values greater than 999999 or less than -99999 are shown as OF (overflow).

TYPICAL COMMAND: *0100DP How may decimal places?

TYPICAL REPLY: *0001DP = 2 Display shows 14.57

TYPICAL COMMAND: *0100EW *0100DP = 3

TYPICAL REPLY: *0001DP = 3 Display shows 14.573

DR Display right-adjusted.

ACTION: Displays any number specified by the computer on the display. Messages are right-adjusted and may be up to six characters plus a decimal point. Legal characters are **. - 1 2 3 4 5 6 7 8 9**. Decimal point position is determined by the **DP** command. The **DR** command does not generate any reply on the RS-232 bus.

TYPICAL COMMAND: *0100DR = 14.543 Displays 14.543
(depends on **DP**)

TYPICAL REPLY: None

DV Display value.

ACTION: Puts any value specified by the computer on the display. Messages are left-adjusted and may be up to six characters plus a decimal point. Legal characters are **. - 0 1 2 3 4 5 6 7 8 9** and upper case letters **A B C D E F**. Decimal point position is not affected by the **DP** command. The **DV** command does not generate any reply on the RS-232 bus.

TYPICAL COMMAND: *0100DV = 14.543 Displays 14.543
*0100DV = 23.25 F Displays 23.25 F

For a special display with colons, try sending six characters followed by 0 or 1.

TYPICAL COMMAND: *0100DV = 1234560 Displays 12:34:56
*0100DV = 1234561 Displays 12:34:56

TARE AND OVERPRESSURE COMMANDS

NOTE: These commands are supported only on Intelligent Transmitters and RS-232C Serial Interface Boards with 9-pin connectors and on the Model 740 and Model 760 pressure standards.

BP Beep.

ACTION: Causes the overpressure warning beeper to sound for approximately one second. (Model 740 and Model 760 only.)

TYPICAL COMMAND: *0100BP

TYPICAL REPLY: None.

OP Overpressure.

ACTION: Read or set the value of the overpressure limit. Any pressure reading greater than this value triggers an overpressure warning.

On intelligent transmitters and RS-232 interface cards, overpressure causes the overpressure indicator line to go high (+5 volts). See Section 14. The indicator line goes low again if measured pressure drops below the limit. For purposes of determining overpressure, untared pressure with no **PA** is used.

Operation on the Model 740 and Model 760 is similar, except that overpressure triggers a warning beeper instead of a logic output level. Also, on these models, **OP** must be entered in psi.

TYPICAL COMMAND: *0100OP

TYPICAL REPLY: *0100OP = 10200.0

TYPICAL COMMAND: *0100EW *0100OP = 17.00

TYPICAL REPLY: *0001OP = 17.00000

ZS Zero set.

ACTION: Read or set the value of the zero switch.

On intelligent transmitters and RS-232 interface cards, **ZS** is a logic switch stored in RAM which controls taring, the subtraction of some initial value. It has three states:

ZS = 0 when tare is off

ZS = 1 when taring has been requested

ZS = 2 when taring is in effect

ZS is set to 0 on power up. Once the taring commands have been activated by setting ZL = 0, taring can be requested either with ZS = 1 command or by toggling a contact closure line. At the first pressure reading following a tare request, the measured pressure is stored in RAM parameter ZV, parameter ZS is automatically set to 2 to indicate that taring is in effect, and the value ZV is subtracted from all subsequent pressure readings until taring is turned off. Changing the value of ZS by software command requires an EW command, even though ZS is stored in RAM rather than in EEPROM.

NOTE: If taring is already in effect when a ZS = 1 command is issued, a new zero value is initialized at the next pressure reading and taring continues using the new value.

Operation with some Model 740's and all Model 760's is somewhat different. On these models, taring can be initiated only by a mechanical switch closure. The ZS command returns value 0 or 1 depending on whether the zero set switch is off or on.

TYPICAL COMMAND:	*0100ZS	
TYPICAL REPLY:	*0001ZS = 0	No taring
TYPICAL COMMAND:	*0100EW *0100ZS = 1	Initiate taring
TYPICAL REPLY:	*0001ZS = 1	
TYPICAL COMMAND:	*0100P3	Measure pressure
TYPICAL REPLY:	*0001.0000	
TYPICAL COMMAND:	*0100ZS	
TYPICAL REPLY:	*0001ZS = 2	

ZV Zero value.

ACTION: Reads or sets the pressure value that is subtracted from reading when taring is activated. **ZV** is stored in RAM. Users may force a specific value to be used if taring is presently in effect (**ZS** = 2) by setting **ZV** to any desired value. Note, however, that if taring is subsequently requested either by a **ZS** = 1 command or by contact closure, a new **ZV** will overwrite the value you have set. Changing the value of **ZV** by software command requires an **EW** command, even though **ZV** is stored in RAM rather than in EEPROM. The value of **ZV** is lost if power is turned off.

Operation is similar on the Model 740 and Model 760 except taring can only be initiated by mechanical switch closure and a command to set **ZV** to a specific value will be interpreted as being in psi, regardless of the pressure units selected. Commands to read the value of **ZV** show it in whatever pressure units are selected.

TYPICAL COMMAND: *01000ZV
TYPICAL REPLY: *0001ZV = 14.592

ZL Zero lock.

ACTION: If **ZL** is set to 1, the taring feature is locked out. If **ZL** is set to 0, the tare contact closure and **ZS** =1 commands are enabled. (Not supported on Model 740 and Model 760.)

TYPICAL COMMAND: *0100ZL
TYPICAL REPLY: *0001ZL = 1 Taring disabled

SPECIAL DIAGNOSTIC COMMANDS

- MC⁷** Memory check.
ACTION: Checks integrity of PROM program. Returns "Y" if correct, "N" if error.
- TYPICAL COMMAND: *0100MC
TYPICAL REPLY: *0001MC = Y Program correct
- CS** Check stack.
ACTION: Returns number of unused bytes in microprocessor operations stack since power was last applied.
- TYPICAL COMMAND: *0100CS
TYPICAL REPLY: *0001CS = 5
- CT⁷** Check counter timebase.
Supported on all transmitters which have separate timebases for the microprocessor and the counter.
ACTION: Puts counter timebase divided by 512 onto display clock line (pin 6 on 9-pin connector or pin 11 on 25-pin connector). Cancelled by next command. The counter timebase is very stable; however, several microseconds of jitter appear on the output waveform because the microprocessor interrupts which generate the divided output are asynchronous relative to the counter timebase.
- TYPICAL COMMAND: *0100CT
TYPICAL REPLY: None
- CX** Check crystal.
ACTION: Puts microprocessor clock divided by 480 onto display clock line (pin 6 on 9-pin connector or pin 11 on 25-pin connector). Cancelled by next command.
- TYPICAL COMMAND: *0100CX
TYPICAL REPLY: None

⁷ COMMANDS ARE NOT SUPPORTED FOR TRANSMITTERS AND DEPTH SENSORS SHIPPED AFTER 10/1/01 (FIRMWARE VERSION R1.00 AND LATER).

OPTIONAL 16-BIT BINARY OUTPUT COMMANDS

16-BIT BINARY OUTPUT IS NOT SUPPORTED FOR TRANSMITTERS AND DEPTH SENSORS SHIPPED AFTER 10/1/01.

LL Limit low.

ACTION: Controls scaling of the 16-bit binary output. Reads or sets the pressure to be converted to binary output 0. If pressure units are changed, **LL** must be re-entered in the new units.

LH Limit high.

ACTION: Controls scaling of the 16-bit binary output. Reads or sets pressure to be converted to binary output 65535. If pressure units are changed, **LH** must be re-entered in the new units.

IM Interface mode.

ACTION: Reads or sets the value of the **IM** parameter which controls whether interface is on or off and whether the binary output pegs or wraps around at the upper and lower limits. Choices are:

IM = 0 Binary interface off.

IM = 1 Binary interface on.

Supported on both serial binary and parallel binary interfaces.

Values above **LH** peg at 65535.

Values below **LL** peg at binary 0.

IM = 2 Parallel binary interface on.

Supported only on 16-bit *parallel* binary interface.

Binary output wraps around at limits.

IC Inhibit control.

Supported only on 16-bit *parallel* binary interface.

ACTION: Controls use the data inhibit signal. The user may provide a data inhibit pulse or gate to prevent updating of the parallel output during a fixed time interval. Activation of this feature and polarity of the gating signal are selected by the **IC** (Inhibit Control) parameter. As shipped, the boards are configured with **IC = 0**.

IC = 0 Device ignores inhibit line.

IC = 1 Inhibit active. +5 volts to enable. Ground to inhibit.

IC = 2 Inhibit active. Ground to enable. +5 volts to inhibit.

The inhibit pulse must have a minimum width of 3.5 microseconds and may be any longer width. A transition from enable to inhibit generates an internal gating signal which begins within 3.5 microseconds of the transition and has a nominal width of 250-500 microseconds. Parallel output is not updated during the time interval from 3.5 microseconds after the transition until both the internally generated gating signal and the customer provided inhibit signal have ended.

CALIBRATION COMMANDS

NOTE: *CHANGING THESE VALUES PERMANENTLY ALTERS THE CALIBRATION.*

The commands below are used to read or change the transmitter calibration coefficients. Altering values requires a prior **EW** command.

NOTE: *These commands cannot be global 99 commands.*

SN⁸ Read/enter transmitter serial number.

ACTION: Same as other coefficients. **SN** is 6 digits long.

TYPICAL COMMAND: *0100SN Read present
value

TYPICAL REPLY: *0001SN = 004876

TYPICAL COMMAND: *0100EW *0100SN = 004444 Change value

TYPICAL REPLY: *0001SN = 004444

PA Read/enter pressure adder in units selected by **UN** setting.

PM Read/enter pressure multiplier.

ACTION: Same as for other coefficients. Intended for offset and span adjustments to calibration. Output $P = PM * (P_{calc} + PA)$, where P_{calc} is pressure calculated using original calibration data and **UN**.

TYPICAL COMMAND: *0100PA

TYPICAL REPLY: *0001PA = .0000000

TYPICAL COMMAND: *0100EW *0100PM = 1.00002

TYPICAL REPLY: *0001PM = 1.000020

TC⁸ Read/enter timebase correction factor.

ACTION: Same as other coefficients. $TC = 10 \text{ MHz/TCXO freq.}$

TYPICAL COMMAND: *0100TC

TYPICAL REPLY: *0001TC = .6666667

TYPICAL COMMAND: *0100EW *0100TC = .6666666

TYPICAL REPLY: *0001TC = .6666666

⁸ COMMANDS ARE READ-ONLY FOR TRANSMITTERS AND DEPTH SENSORS SHIPPED AFTER 10/1/01 (FIRMWARE VERSION R1.00 AND LATER).

C1 Read/enter C1 pressure coefficient, as above.
C2 Read/enter C2 pressure coefficient, as above.
C3 Read/enter C3 pressure coefficient, as above.

D1 Read/enter D1 pressure coefficient, as above.
D2 Read/enter D2 pressure coefficient, as above.

T1 Read/enter T1 pressure coefficient, as above.
T2 Read/enter T2 pressure coefficient, as above.
T3 Read/enter T3 pressure coefficient, as above.
T4 Read/enter T4 pressure coefficient, as above.
T5 Read/enter T5 pressure coefficient, as above.

U0 Read/enter U0 pressure coefficient, as above.

Y1 Read/enter Y1 pressure coefficient, as above.
Y2 Read/enter Y2 pressure coefficient, as above.
Y3 Read/enter Y3 pressure coefficient, as above.

GLOBAL COMMANDS

Sometimes it is convenient to have a single command affect all transmitters in a loop. For certain instructions, using the destination address **99** causes all the transmitters in the loop to respond.

Some commands can only be sent with a global address. They are:

BR
BL
ID
PT

The global address is often used with the sample and hold commands when there are multiple transmitters in a loop. The global address synchronizes the transmitters to take measurements at the same time. The sample and hold commands are:

P5 and P6
Q5 and Q6

All of the sampling commands and a few other commands may be either individually or globally addressed.

P1 through P7
Q1 through Q6
DB
DS
VR
EW

NOTE: *The remaining commands should not be sent as global commands.*

When a transmitter recognizes a global command, it relays it to the next transmitter in the loop before acting on it. The result is that the global command echoes around the loop and comes back to the computer in addition to the transmitter responses. For all global commands except the **VR** and **DS** commands, the echoed command precedes the responses.

RESOLUTION, INTEGRATION TIME, AND SAMPLING SPEED

The resolution of the transmitter is determined by the counter integration time. Users can adjust the integration time to optimize resolution, noise rejection, and sample rate for a wide variety of applications by using the **PR** command. Transmitters are shipped with the value **PR** = 238 stored in EEPROM.

The relationship between **PR**, pressure resolution, integration time, and maximum sampling rate is shown in the table below.

<u>PR</u>	<u>pressure resolution fs</u>	<u>pressure signal integration time</u>	<u>P2(period) max samples/s</u>	<u>P4(press) max samples/s</u>
10000	0.05 ppm	28.0 s	0.036	0.02
2380	0.1 ppm	6.7 s	0.15	0.08
1190	0.2 ppm	3.3 s	0.30	0.16
476	0.5 ppm	1.3 s	0.74	0.40
238	1 ppm	0.67 s	1.5	0.8
119	2 ppm	0.33 s	3.0	1.6
48	5 ppm	0.13 s	7.3	4.0
24	10 ppm	0.07 s	14.3	8.0
12	20 ppm	0.033 s	28	16
6	40 ppm	0.017 s	58	31
4	60 ppm	0.011 s	87	43
3	80 ppm	0.0084 s	116	47
1	240 ppm	0.0028 s	135	50

The values above are for a typical transmitter with a pressure signal period (Pper) of 28 microseconds and a temperature signal period (Tper) of 5.8 microseconds. Values may vary by about 20% for different transmitters of the same model and by up to 35% for different models.

Resolution, integration time, and maximum samples rates may be calculated for all models using the equation below, where sensor periods are in microseconds:

$$\text{Resolution/f.s.} = \frac{1}{150 * PR * Pper}$$

$$\text{Pressure Sensor Integration Time} = \frac{PR * Pper}{10,000} \text{ sec.}$$

$$\text{P2 command Max Samples/s} = \frac{10,000}{PR * Pper}$$

$$\text{P4 Command Max Sample/s} = \frac{10,000}{PR * Pper + (TR + 1) * Tper}$$

At very short counter integration times, sample rates are limited by microprocessor speed or baud rate rather than by integration time.

HIGH SPEED SAMPLING

High speed sampling requires special attention to baud rate, sample integration time, and programming. Assuming a typical message at high speed of 14 characters, the maximum number of data values/second at various baud rates is tabulated below.

<u>BAUD RATE</u>	<u>MAXIMUM SAMPLES/SEC</u>
300	2.1
600	4.3
1200	8.6
2400	17
4800	34
9600	69
19200	137

Thus, high baud rates must be used for fast sampling.

At very high speeds, programs written in BASIC may not be able to keep up with incoming data, particularly if they try to do many calculations or screen display while data are coming in. If programs are limiting your speed, possible ways to speed them up are:

Avoid calculations while data are coming in. Store it for later processing.

Increase the size of the communications RS-232 input buffer in the computer. (For example, on an IBM PC, use the /C option when loading BASIC.)

Use a basic compiler.

Use a faster language such as C, Pascal or Fortran.

Assuming that the baud rate and computer are fast enough, the transmitter operating parameters which affect speed are the **PR** command and the sampling mode chosen. For large values of **PR**, the sample rate is limited by the counter integration time. As **PR** is made smaller, the sample rate increases. Somewhere around 40 samples/s, the speed begins to be limited by the microprocessor calculation speed. Generally, the continuous send commands are somewhat faster than repeated individual commands because counting of the next sample proceeds while the previous one is being calculated.

Two special burst sampling procedures can be used to obtain faster sample rates.

The **P7** command allows up to about 90 samples/s. With this command, temperature is measured once and that value is used for the temperature correction of all subsequent pressure measurements. This is faster because time is saved by not having to count the temperature signal on every reading and because many of the temperature correction terms are calculated only once and then stored. This command is intended for relatively short bursts. If internal sensor temperature changes rapidly during the data run (more than about 0.3 degrees C), small errors will be introduced in the data because all temperature corrections are being made with the temperature measured at the start of the run. In more rapidly changing thermal environments, errors can be minimized by reissuing the **P7** command periodically to force an update of the temperature being used.

The fastest sampling method uses period measurement commands **Q1** and **P2** and can achieve sample rates up to 135 samples/s. The transmitter reports period data directly, and calculation of pressure is done in the user's computer. Typically, the user takes a single temperature period with command **Q1**, a burst of pressure periods with command **P2**, and then another temperature with **Q1**. The user interpolates the before and after temperature periods to get a temperature period corresponding to each pressure period measurement and uses this pair of periods to calculate the corrected pressure using the equation in Appendix G. Note that the transmitter calibration coefficients needed can be obtained via bus commands.

The mode parameter **MD** can affect sampling speed. When doing high speed sampling at greater than about 20 samples per second, sample rates using commands **P3**, **P4**, or **P7** will be slightly slower in mode **MD = 1** or **MD = 3** than in mode **MD = 0** or **MD = 2** because of the extra time required for the display. The extra time required is approximately 6 milliseconds per sample for **DD = 0** and 36 milliseconds per sample for **DD = 1**. Other commands are not affected. For example, a **P4** command that gives 19 samples/s for **MD = 0** will run about 5% slower for **MD = 1**, and a **P7** command giving 45 samples/s for **MD = 0** will run about 20% slower for **MD = 1**.

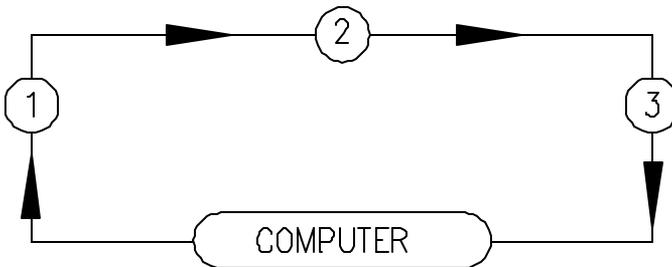
MULTIPLE TRANSMITTERS ON THE RS-232 BUS

There are three ways to attach multiple transmitters to a single computer: (1) a serial loop of several transmitters on a single RS-232 port, (2) a relay or logic multiplexer switching a single port sequentially among a number of transmitters, and (3) multiple RS-232 ports. These are discussed in the following paragraphs.

1. SERIAL LOOPS

The addressable command structure allows use of up to 98 transmitters simultaneously in a loop on a single RS-232 port. Global commands (destination address **99**) allow all transmitters to be addressed with a single command. Keep in mind that the maximum number of messages per second on the bus is limited by the baud rate (see Section 9). For loops with multiple transmitters, the higher baud rates are recommended.

Logically, the structure of the bus is a one way circle. A typical three transmitter loop is shown below:



All messages move clockwise around the loop, relayed from transmitter to transmitter. Each transmitter picks off the messages addressed to it and relays responses or other messages onward.

When setting up a loop:

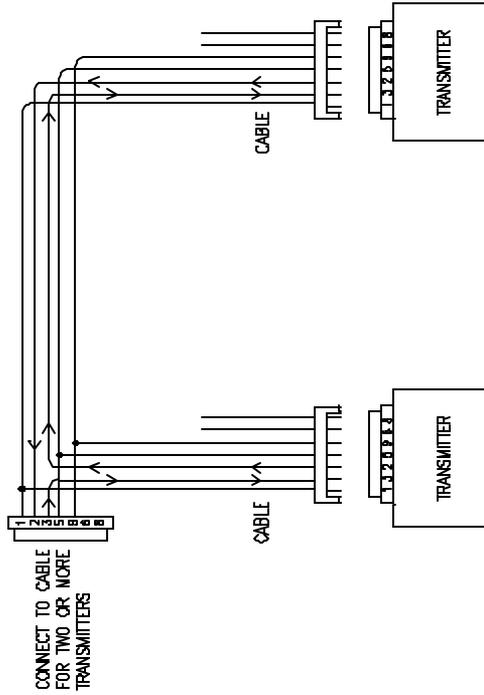
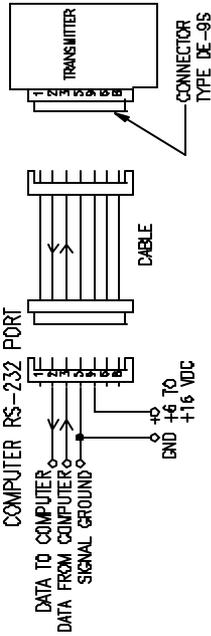
1. Set all transmitters to the same baud rate before installing them in the loop. Two transmitters at different baud rates cannot communicate. When all transmitters are at the same baud rate, a new baud rate can be chosen with a global **BR** command.

2. Use the global **ID** command ***9900ID** to auto-number units around the loop and find out how many there are (from the source address of the command coming back to the computer.)
3. The serial number of each transmitter can be checked by polling it with the **SN** command.
4. The easiest way to take data is with a global sample and hold ***9900P5** followed by a global dump command ***9900DS**. This keeps samples synchronized and keeps the data sorted out at the computer.
5. It is possible to have several transmitters simultaneously in continuous send mode, but because exact integration time varies from unit to unit, the data can come back in a chaotic order and must be sorted out according to address.
6. The wiring diagram for loop interconnections is shown on the next page. Pin connections shown are for 9-pin D connectors, but an analogous system could be used for any connector type. Note that only 4-wire cabling is required, or only 3-wire cabling if transmitter power is not bussed. The terminator block after the last transmitter wraps the transmit data line back to the computer input. With this arrangement, any transmitter can be removed from the loop either by unplugging the transmitter and replacing it with a terminator jumper or by removing the y-adaptor and plugging the two extension cables together.

SERIAL LOOP CONNECTIONS

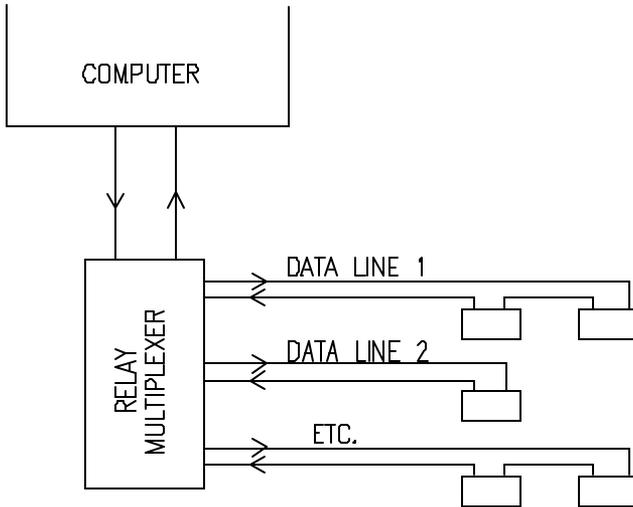
Pin-outs are shown for transmitters and interface boards with 9-pin connectors.

TRANSMITTER CONNECTOR	
PIN NO.	DESCRIPTION
1	CHASSIS GROUND
2	DATA TO COMPUTER
3	DATA FROM COMPUTER
5	SIGNAL GROUND
8	DISPLAY CLOCK
9	DISPLAY DATA
9	POWER



2. MULTIPLEXER SYSTEM

For high security applications with a large number of transmitters, it may be desirable to use a relay multiplexer as a switching hub to select separate data lines running out to the individual transmitters or clusters of transmitters in the system. Loss of any one data line through accident or failure will affect only the cluster on that data line.

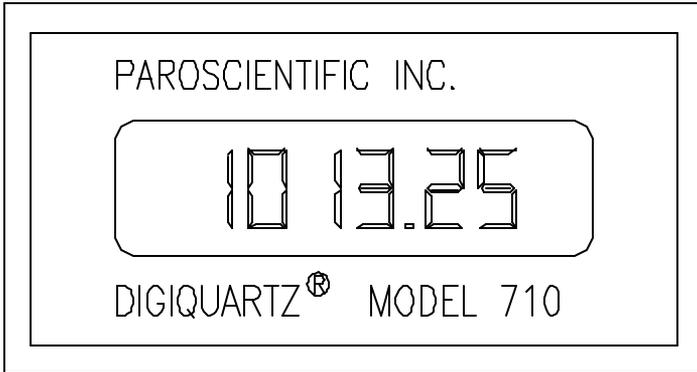


3. MULTIPLE RS-232 PORTS.

Transmitters or clusters of transmitters can be assigned to individual serial ports. This approach can provide simultaneous very high speed sampling of large numbers of transmitters. Expansion cards are available for PCs which provide up to 32 serial ports per card. Some versions with on-board IO processors and dual ported RAM can transfer data at 19200 baud to and from all ports simultaneously. These boards can provide data at 100 samples per second from each of 32 transmitters. This approach also offers good system integrity in the sense that failure of any transducer or cable does not affect the rest of the system.

DIGIQUARTZ[®] MODEL 710 DISPLAY

MODEL 710 DISPLAY IS NOT SUPPORTED WITH TRANSMITTERS AND DEPTH SENSORS SHIPPED AFTER 10/1/01.



INTRODUCTION

The Model 710 is a six digit LCD display in a standard 1/8 DIN size panel mount enclosure. It displays pressure data from intelligent transmitters, intelligent depth sensors, and portable standards. The display operates either as a stand-alone device with a transmitter or with a computer on-line. Extra commands (**MD**, **DD**, **DP**, **DR**, **DV**, and **DC**) have been added to control the display.

For stand-alone operation, the display shows pressure whenever power is applied to the transmitter. The display mode parameter stored in the transmitter EEPROM must be set to **MD = 1** or **MD = 3**.

When a computer is on-line, the Model 710 can also be used to display other data calculated in the computer (filtered data values, time, temperature, error messages, etc.) using commands **DR** and **DV**. These functions work for all values of the mode parameter **MD**.

The display distance command **DD** controls the clocking rate to the display. Normally **DD** is set to 0 for optimum speed. However, for cable lengths greater than 200 feet, or if the display is noisy, users should set **DD = 1**.

A single transmitter can drive several displays in parallel.

Installation instructions are given in Appendix C.

DISPLAY MODES

On transmitters which support a 16-bit serial binary output, this output must be turned off by setting **IM=0** before the display can be used. The mode parameter **MD** then controls operation of the display and other background tasks. It is stored in EEPROM in the transmitter and can be changed by user command over the R-232 data bus.

For most users, mode **MD = 1** is the standard mode. When powered up in this mode, the transmitter resets and begins displaying pressure. In this mode, the transmitter gives priority attention to computer requests, but supports the display as secondary or background task. Whenever the transmitter sends a pressure measurement to the computer in response to a user request, the transmitter also sends the value to the display. In addition, whenever the transmitter is not occupied servicing user requests, it measures pressure and sends the value to the display. The display update rate depends upon the **PR** parameter. These background measurements are interrupted whenever the higher priority computer requests require attention. Under all normal conditions, this protocol assures frequent display update.

When in **MD = 0** or **MD = 2**, the display is controlled only by an on-line user computer. The value displayed is changed only in response to specific user requests via the **DV** ("Display Value") or **DR** ("Display Right-adjusted") commands. These commands send data calculated in the host computer to the intelligent transmitter, which in turn sends it to the display. Elaborate user programs are possible which collect data from the pressure transmitter and other sources, calculate derived quantities, and send them to the display. Modes **MD = 0** and **MD = 2** are used primarily for special purposes in computer-based data acquisition systems.

DISPLAY INTERRUPTION BY A USER COMPUTER

Because computer requests have priority, there are three unusual special situations when display updating can be interrupted for significant amounts of time by host computer requests:

1. If an on-line computer keeps the transmitter fully occupied carrying out commands other than pressure measurements (for example, rapidly repeated

period measurements with a **P1** command). This would not normally be done except for diagnostic checks. While this occurs, the display is frozen at the last value sent and no warning is given.

2. If a display and hold command is issued (**P5, P6, Q5, Q6**), data are held and display is suspended until a **DB** or **DS** command to send the data is received. If no **DB** or **DS** command arrives within 2 seconds, the transmitter displays "-----" to warn that the display is not current. Normal operation resumes when the next command arrives or power is interrupted. When using sample and hold commands, it is good programming practice to set up an error exit routine to issue a command (such as ***9900VR**) that restores normal display operation upon exit.
3. If the continuous period measuring commands (**P2** or **Q2**) or continuous temperature measuring commands (**Q4**) are executed, the transmitter displays "-----" to warn that the display is not being updated. Normal operation is restored when the next command is received or power is interrupted. Again, it is good programming practice to set up an error exit to restore normal display operation upon exit.

If the display does not show pressure when power is first applied, it is probably because a user computer program has set the display mode to **MD = 0**. Reset the mode to **MD = 1** with the **MD** command.

On-line user computer programs which issue sample and hold commands (**P5, P6, Q5, Q6**) and exit without a **DB** or **DS** command or which issue continuous sampling commands (**P2, P7, Q2, Q4**) and exit without terminating them can leave the display in the "-----" state. Users should set up error exit routines to avoid exiting in undefined states. Normal operation is restored when the next command is received or power is interrupted.

16-BIT SERIAL BINARY OUTPUT

16-BIT BINARY OUTPUT IS NOT SUPPORTED FOR TRANSMITTERS AND DEPTH SENSORS SHIPPED AFTER 10/1/01.

Some transmitters can be configured by the user to provide both an RS-232C bus and a separate 16-bit serial binary output bus. The 16-bit output data stream is sent MSB first, pulse width modulated, with a 4 kHz bit rate and is available on Pin 8 of the transmitter connector. This feature is supported on all software versions (VR command) which begin with the letter "S". Special commands, **IM**, **LH**, and **LL**, are sent over the RS-232C bus to configure the 16-bit interface and control scaling. Once configured, pressure data are sent continuously on the 16-bit serial interface whenever power is applied. The update rate depends on the integration time parameters **PR** and **TR**. Pressure and temperature data can also be read via the RS-232C bus.

1. Transmitter pin-outs:

<u>PIN</u>	<u>SIGNAL</u>
2	DATA TO COMPUTER
3	DATA FROM COMPUTER
5	SIGNAL AND POWER GROUND
6	DISPLAY CLOCK
8	DISPLAY DATA <u>OR</u> 16-BIT SERIAL BINARY
9	POWER (+6 TO +16 VDC)

2. 16- bit serial interface characteristics:

Output signal: 16-bit serial data stream
MSB first

Bit rate: 4 kHz

Output data levels: $V_{OL} = -3$ to -5 VDC
 $V_{OH} = 3$ to 5 VDC

Between samples, data line is set to V_{OH} .

A binary "0" bit is output by setting the data line to V_{OL} for 125 microseconds and then to V_{OH} for 125 microseconds.

A binary "1" bit is output by setting the data line to V_{OL} for 50 microseconds and then to V_{OH} for 200 microseconds.

3. RS-232C Control Bus.

The RS-232C bus is the control bus for the transmitter. The unit is not designed simultaneously to respond to user commands while providing continuous serial binary output. User commands via the RS-232C bus have priority. Data from the serial binary output may be interrupted or may be invalid while the depth sensor is responding to a command sent by a user on the RS-232C bus. Normal operation of the 16-bit serial output automatically resumes as soon as the command has been completed.

4. Output scaling: Two user settable parameters control the scaling of the 16-bit binary serial output. These are set using commands **LL** and **LH**.

LL (for limit low)
Sets the pressure to be converted to binary output 0.
Pressures less than **LL** will peg at binary 0.

LH (for limit high)
Sets the pressure to be converted to binary full scale 65535.
Pressures greater than **LH** will peg at 65535.

Users may set these parameters to any value. Once scaling is set, any binary number **N** can be converted to pressure using the equation:

$$P = LL + (LH - LL) * N / 65535$$

If pressure units are changed, **LL** and **LH** must be re-entered in the new units.

5. Interface Mode Command. Both the display and 16-bit serial binary outputs use the same driver and output pin. Therefore, before activating the 16-bit serial output, the display output must be turned off by setting MD=0 or MD=2. The serial binary output interface may then be activated by using the interface mode command **IM**.

IM = 0 Binary interface off
IM = 1 Binary interface on.
Values above **LH** peg at 65535.
Values below **LL** peg at 0

16-BIT PARALLEL BINARY OUTPUT

An optional 16-bit parallel binary output is available (Series 1000 products only). Transmitters and interface cards with the parallel binary output option have 25-pin output connectors and support both 16-bit parallel binary output and RS-232C serial output. The RS-232C bus is used to configure the interface and to control output scaling. Special commands, **IC**, **IM**, **LH**, and **LL**, configure the binary interface. Once configured, pressure data are continuously available on the binary interface whenever power is on. Pressure and temperature data can also be read via the RS-232C bus.

1. Transducer pin-outs:

<u>PIN</u>	<u>SIGNAL</u>	<u>PIN</u>	<u>SIGNAL</u>
1	CHASSIS GROUND	14	D0 LSB
2	DATA FROM COMPUTER	15	D4
3	DATA TO COMPUTER	16	D5
4	INHIBIT/TRIGGER	17	D6
5	D7	18	DISPLAY DATA
6	D3	19	D2
7	GROUND	20	D1
8	D9	21	D8
9	D10	22	D11
10	D12	23	D13
11	DISPLAY CLOCK	24	DATA VALID
12	D14	25	POWER (SEE SCD)
13	D15 MSB		

- Output levels: binary 1 = +5 volts
 binary 0 = ground
- Output scaling: Two user settable parameters control the scaling of the parallel output.

LL (for limit low)
 Sets the pressure to be converted to binary output 0.

LH (for limit high)
 Sets the pressure to be converted to binary full scale 65535.

Once scaling is set, any binary number **N** can be converted to pressure using the equation:

$$P = LL + (LH-LL) * N/65535$$

If pressure units are changed, **LL** and **LH** must be re-entered in the new units.

4. The parallel output binary interface is turned on and off by the interface mode parameter **IM**. The normal mode is **IM = 1**.

IM = 0	Binary interface off
IM = 1	Binary interface on. Values above LH peg at 65535. Values below LL peg at 0
IM = 2	Binary interface on. Binary wraps around at P = LH .

5. Handshaking: Parallel output continuously has the most recent pressure value except for about 30 nanoseconds while latching new data. Update rate is controlled by user selectable integration time. Maximum update rate to the parallel output is approximately 13 samples/sec. The data valid line goes to ground just before latching new data and remains low for 5 microseconds. The best way to assure data integrity is to read the data twice in quick succession. If the readings agree, the data is correct. If not, reread data.
6. Data Inhibit Signal: The user may provide a data inhibit pulse or gate to prevent updating of the parallel output during a fixed time interval. Activation of this feature and polarity of the gating signal are selected by the **IC** (Inhibit Control) parameter. As shipped, the boards are configured with **IC = 0**.

IC = 0	Device ignores inhibit line
IC = 1	Inhibit active. +5 volts to enable. Ground to inhibit.
IC = 2	Inhibit active. Ground to enable. +5 volts to inhibit.

The inhibit pulse must have a minimum length of 3.5 microseconds and may be any longer length. A transition from enable to inhibit generates an internal gating signal, which begins within 3.5 microseconds of the transition, and has a nominal length of 250 - 500 microseconds. Parallel output is not updated during the time interval from 3.5 microseconds after the transition until both the internally generated gating signal and the customer provided inhibit signal have ended.

TARING AND OVERPRESSURE WARNING

Taring and overpressure warning capabilities are supported in slightly different ways on 9-pin version of the Intelligent Transmitter, RS-232C Serial Interface Board, Model 740 and Model 760. These features are not available on the 16-bit Parallel Binary Output Board.

OVERPRESSURE WARNING

Paroscientific pressure transducers can be damaged by the application of pressure greater than 1.2 times their rated full scale pressure. Users should protect the transducer with overpressure relief valves in applications where overpressure could be applied. The software command **OP** sets the overpressure warning level. Pressure in excess of this limit triggers a 5 volt logic level on the RS-232C Serial Interface Board and triggers a warning beeper on the Model 740 and Model 760.

TARING

Taring is the subtraction of an initial value from pressure readings. This feature is activated and used with software commands **ZS**, **ZV** and **ZL** (as described in Section 6).

On some Model 740, taring is initiated by shorting two terminals available on the rear panel. Taring remains in effect as long as the terminals are connected.

On the Model 760, taring is initiated by a front panel switch and remains in effect as long as the switch remains closed.

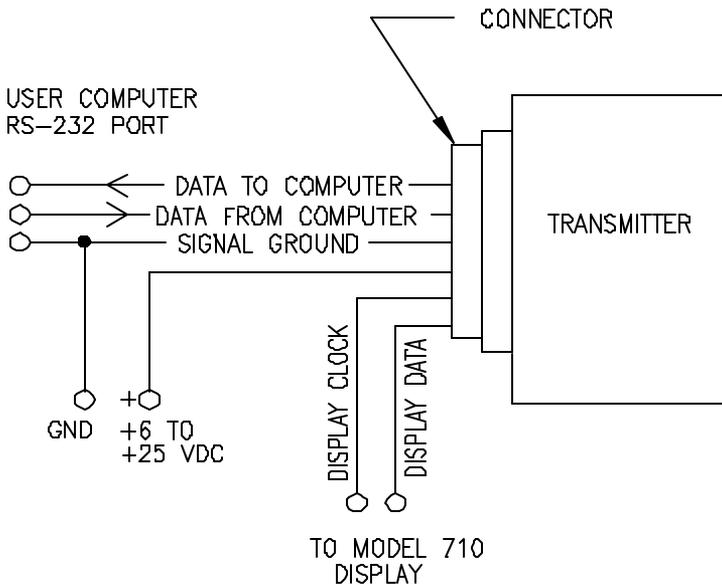
On some 9-pin versions of the RS-232C Serial Interface Board (NOT MODEL 740 or 760), Tare Request, Tare Indicator, and Overpressure Warning can be brought out on unused pins of the 9-pin output connector. Contact Paroscientific for details.

APPENDIX A

HOOKUP

GENERAL DESCRIPTION

Hookup consists of providing power to the transmitter and running receive, transmit, and signal ground lines from the transmitter to the computer RS-232 output connector. The required connections are shown schematically in the figure below.



Proper connection requires identifying the correct output pins on the computer RS-232 port and on our transmitter output connector.

CONNECTING TO THE TRANSMITTER ELECTRICAL CONNECTOR

Because our equipment is used in many different applications, a number of different output connectors are used. The most common is a 9-pin D connector. Output connector diagrams and pin assignments for all of our products are given in Appendix B. The user should locate the "data to computer", "data from computer", and "signal ground" pins on the appropriate diagram. These must be connected to the computer serial port.

CONNECTING TO THE COMPUTER RS-232 PORT

Most computer RS-232 ports have either male or female 25-pin or 9-pin connectors. The most common computer pin connections are tabulated below. Check your computer manual to verify pin assignments.

IBM PC AT 9-pin	STANDARD RS-232 25-pin
3 Data from computer	2 Data from computer
2 Data to computer	3 Data to computer
5 Signal ground	7 Signal ground
4 DTR	20 DTR
8 CTS	5 CTS
6 DSR	6 DSR
1 CD	8 CD
	1 Frame ground

Our transmitter requires only connections for data from computer, data to computer, and signal ground. However, depending on the user computer and how a program opens up the RS-232 port, the user may need to provide handshaking signal levels by jumpering pins on the computer connector. If you cannot seem to get any messages back from the transmitter, first make sure that the baud rate is correct and that the communications channel is set up for 8 data bits, no parity, 1 stop bit. Then try a global command (***9900VR**) to make sure the **ID** is correct. If that does not work, the computer may be waiting for handshake signals (**CTS**, **DSR**, **CD**) which the transmitter does not provide.

On the IBM PC and most other computers, you can choose to ignore these signals when you open up the communications channel. See the programming examples in the text. If your computer insists on these signals, you can provide them by jumpering back the **DTR** signal to the **CTS**, **DSR**, and **CD** pins on the same connector.

APPENDIX B

CONNECTOR PIN ASSIGNMENTS

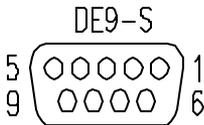
9-PIN D CONNECTOR

Models: Intelligent Transmitter (RS-232)
Digital Barometer
Model 740 Portable Laboratory Standard
Model 760 Portable Field Standard
Model 730 Intelligent Display

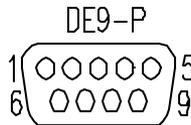
Pin-outs:	PIN 1	CHASSIS GROUND
	PIN 2	DATA TO COMPUTER
	PIN 3	DATA FROM COMPUTER
	PIN 4	not used
	PIN 5	SIGNAL AND POWER GROUND
	PIN 6	DISPLAY CLOCK
	PIN 7	not used
	PIN 8	DISPLAY DATA
	PIN 9	POWER (SEE SCD)

Connector Diagram:

1000, 740, 730, 710, 760



6000, 9000 Series



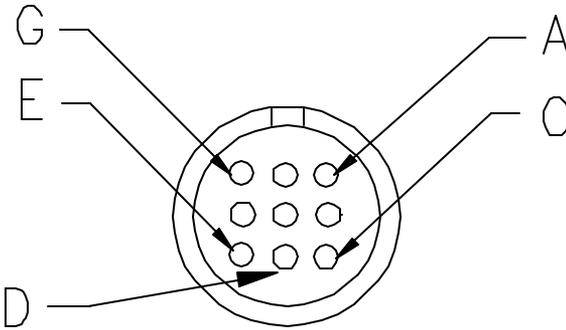
CONNECTOR PART NO.: Type DE9-S
MATING CONNECTOR: Type DE9-P

9-PIN BENDIX MS CONNECTOR

Models: Model PS-2 Water Level Sensor (RS-232)

Pin-outs:	PIN A	CHASSIS GROUND
	PIN B	DATA TO COMPUTER
	PIN C	DATA FROM COMPUTER
	PIN D	not used
	PIN E	SIGNAL AND POWER GROUND
	PIN F	DISPLAY CLOCK
	PIN G	not used
	PIN H	DISPLAY DATA
	PIN J	POWER (SEE SCD)

Connector Diagram:



CONNECTOR PART NO.: MS3102A22-20P

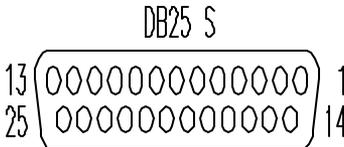
MATING CONNECTOR: MS3106A22-20S

25 PIN D CONNECTOR

Model: Inteligent Transmitter with 16 Bit Parallel Output

Pin-out:	PIN 1	CHASSIS GROUND
	PIN 2	DATA FROM COMPUTER
	PIN 3	DATA TO COMPUTER
	PIN 4	INHIBIT/TRIGGER
	PIN 5	D7
	PIN 6	D3
	PIN 7	SIGNAL AND POWER GROUND
	PIN 8	D9
	PIN 9	D10
	PIN 10	D12
	PIN 11	DISPLAY CLOCK
	PIN 12	D14
	PIN 13	D15 MSB
	PIN 14	DO LSB
	PIN 15	D4
	PIN 16	D5
	PIN 17	D6
	PIN 18	DISPLAY DATA
	PIN 19	D2
	PIN 20	D1
	PIN 21	D8
	PIN 22	D11
	PIN 23	D13
	PIN 24	DATA VALID
	PIN 25	POWER (SEE SCD)

Connector Diagram:



CONNECTOR PART NO.: DB25-S

MATING CONNECTOR: DB25-P

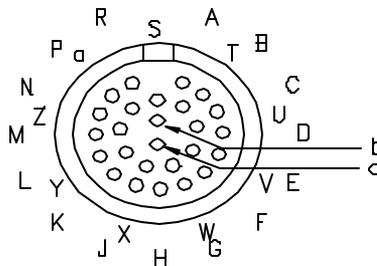
26-PIN BENDIX MS CONNECTOR

Models: Model PS-2 Water Level Sensor (16-bit parallel output)

Pin-outs:

PIN A	CHASSIS GROUND
PIN B	DATA FROM COMPUTER
PIN C	DATA TO COMPUTER
PIN D	INHIBIT/TRIGGER
PIN E	D7
PIN F	D3
PIN G	SIGNAL AND POWER GROUND
PIN H	D9
PIN J	D10
PIN K	D12
PIN L	DISPLAY CLOCK
PIN M	D14
PIN N	D15
PIN P	D0
PIN R	D4
PIN S	D5
PIN T	D6
PIN U	DISPLAY DATA
PIN V	D2
PIN W	D1
PIN X	D0
PIN Y	D11
PIN Z	D13
PIN a	DATA VALID
PIN b	POWER (SEE SCD)
PIN d	not used

Connector Diagram:



CONNECTOR PART NO.: MS3102A28-12P
MATING CONNECTOR: MS3106A28-12S

DEPTH SENSORS

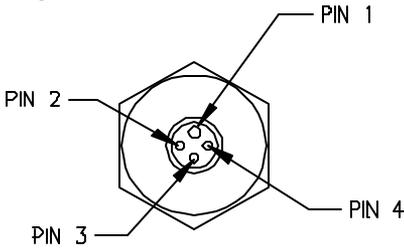
Model: 8B, 8DP 8WD, with RS-232 interface

Pin-outs: PIN 1 DATA TO COMPUTER
 PIN 2 DATA FROM COMPUTER
 PIN 3 SIGNAL AND POWER GROUND
 PIN 4 POWER (SEE SCD)

Model: 8DP RS-232 with Modem

Pin-outs: PIN 1 MODEM SIGNAL
 PIN 2 MODEM SIGNAL
 PIN 3 SIGNAL AND POWER GROUND
 PIN 4 POWER (SEE SCD)

Connector diagram:



CONNECTOR PART NO.: XSG-4-BCL

MATING CONNECTOR: XSG-4-CCP

DEPTH SENSORS

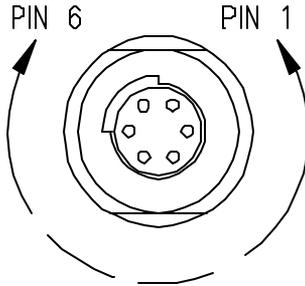
Model: 8DP with Display and Modem

Pin-outs:	PIN 1	SIGNAL AND POWER GROUND
	PIN 2	MODEM SIGNAL
	PIN 3	DISPLAY CLOCK
	PIN 4	MODEM SIGNAL
	PIN 5	POWER (SEE SCD)
	PIN 6	DATA DISPLAY

Model: 8DP with Display and Intelligent Card

Pin-outs:	PIN 1	SIGNAL AND POWER GROUND
	PIN 2	DATA TO COMPUTER
	PIN 3	DISPLAY CLOCK
	PIN 4	DATA FROM COMPUTER
	PIN 5	POWER (SEE SCD)
	PIN 6	DISPLAY DATA

Connector Diagram:



CONNECTOR PART NO.: XSE-6-BCR

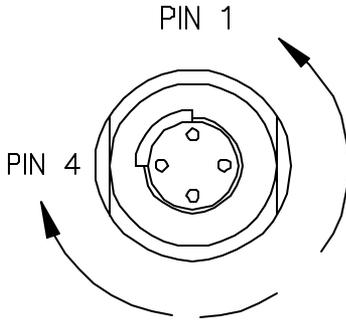
MATING CONNECTOR: 6492-0XX

DEPTH SENSORS

Model: 8DP with Intelligent Card

Pin-outs:	PIN 1	DATA TO COMPUTER
	PIN 2	DATA FROM COMPUTER
	PIN 3	SIGNAL AND POWER GROUND
	PIN 4	POWER (SEE SCD)

Connector Diagram:



CONNECTOR PART NO.: XSE-4-BCR
MATING CONNECTOR: XSE-4-CCP

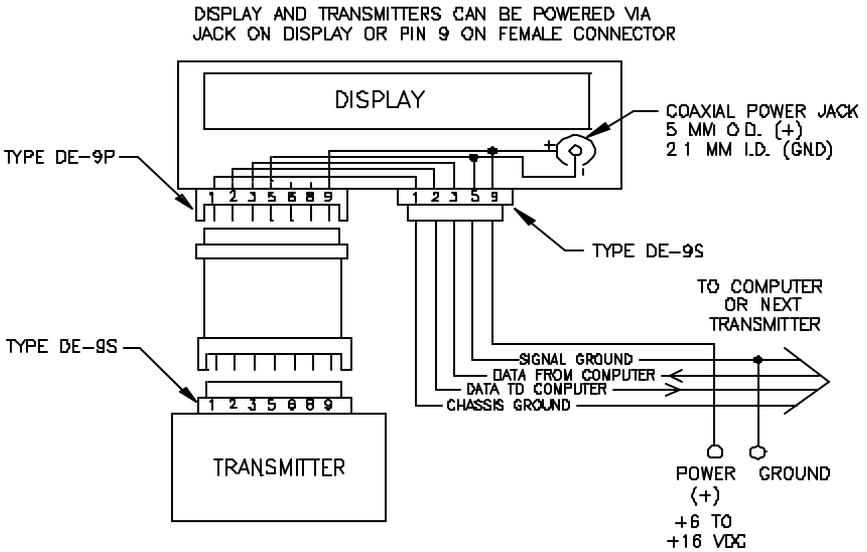
APPENDIX C

DISPLAY HOOKUP

The display uses separate clock and serial data lines from the transmitter, rather than the RS-232 bus. Any wiring arrangement which provides these signals to the display is satisfactory. Power may be obtained from the transmitter power supply or from a separate supply.

Commonly, the transmitter plugs into the 9-pin male connector on the display and a computer plugs into the 9-pin female connector. Power, ground, and RS-232 data lines pass through from one connector to the other. A DC power jack on the display serves as a convenient way to supply power to all displays and transmitters on the loop. Equivalently, at the user's option, wires may be run directly to the transmitter connector from both the computer and the display.

Pin-outs shown are for transmitters and interface boards with 9-pin connectors.



APPENDIX D

PROGRAMMING HINTS

Sometimes it is difficult to be sure exactly what your computer is sending out. One trick is to disconnect the transmitter and replace it with a connector which wraps the computer transmitted data back to the computer receive line. Then by looking at the data in the receive buffer, you can find out exactly what was sent.

1. **MESSAGES NOT COMING BACK FROM TRANSMITTER** - If you cannot seem to get any messages back from the transmitter, first make sure that the baud rate is correct and the communications channel is set up for 8 data bits, no parity, 1 stop bit. Then try a global command (***9900VR**) to make sure the ID is correct. If that does not work, the computer may be waiting for handshake signals (**CTS, DSR, CD**) which the transmitter does not provide. On the IBM PC and most other computers, you can choose to ignore these signals when you open up the communications channel. See the programming examples in the text. If your computer insists on these signals, you can provide them by jumpering back the **DTR** signals to the **CTS, DSR,** and **CD** pins on the same connector. See APPENDIX A for common pin-outs.
2. **UNREQUESTED CONTINUOUS DATA** - If the transmitter sends data continuously without being asked whenever powered up, check the setting of the **MD** parameter.
3. **REPLY DELAY** - Almost all commands generate a reply, but for long integration times some replies may take several seconds.
Exceptions:
 - a) An undefined (garbage) command addressed to a specific sensor will be absorbed.
Example: ***0100ZQ**
 - b) Sample and hold commands generate no response.
4. **GLOBAL COMMAND ECHO** - Global commands echo back the command in addition to whatever response they produce. The reason is that each transmitter passes on the command to the next transmitter in the loop before acting on the command.
Example: COMMAND: ***9900P1**
 REPLY: ***9900P1**
 ***000128.12345**
5. **GARBAGE CHARACTERS IN INPUT BUFFER** - The computer receive buffer should be cleared after applying power to the transmitter. Turning on

power to the transmitter causes the output lines to go from zero to defined voltage levels. This produces a garbage character in the input buffer of some computers. Alternatively, when getting data from the input buffer, throw away leading characters until you come to an * . All legitimate transmitter replies begin with *.

6. **CLEAR TRANSMITTER** - At the start of all programs, send a command (*9900VR is a good choice) to terminate whatever the transmitter may have been doing and then clear out the RS-232 receive buffer on your computer. Remember that when a "continuous send" command is given, the transmitter continues to send data even after the computer is halted. If you restart the program, the transmitter will still be sending data whether it is expected or not.
7. **REWRITING EEPROM** - Do not routinely rewrite EEPROM at the start of every program. Check the values and change only what needs changing. A given register in EEPROM is guaranteed only for 10,000 rewrites.
8. **WRITING CONTROL PARAMETERS IN EEPROM** - When writing control parameters in EEPROM, (e.g. BR =, PR =, UN =, etc.), always wait for the reply before sending other commands addressed to the same transmitter. The sensor ignores commands addressed to it until its EEPROM write is completed (about 0.1 seconds). Commands for other transmitters are relayed properly. No wait is required when reading EEPROM.
9. **NUMBER OF BYTES IN RECEIVE BUFFER** - In IBM BASIC, the function LOC (file number) will tell how many bytes are in receive buffer.
10. **19200 BAUD SUPPORT** - Some early versions of IBM BASIC did not officially support 19200 baud.

APPENDIX E

SAMPLING COMMANDS

APPROX. MAX
SAMPLES
PER SEC.

STANDARD SAMPLING COMMANDS

PRESSURE	P3 Single sample and send	30
	P4 Continuous sample and send	50
	P5 Single sample and hold	30
	DB Send stored value	
TEMPERATURE	Q3 Single sample and send	45
	Q4 Continuous sample and send	100
	Q5 Single sample and hold	45
	DB Send stored value	

PERIOD SAMPLING COMMANDS

P PERIOD	P1 Single sample and send	50
	P2 Continuous sample and send	135
	P6 Single sample and hold	50
	DB Send stored value	
T PERIOD	Q1 Single sample and send	58
	Q2 Continuous sample and send	145
	Q6 Single sample and hold	55
	DB Send stored value	

BURST SAMPLING COMMANDS

PRESSURE BURST	P7 Continuous sample and send	90
PERIOD BURST	Q1, P2, Q1 Command sequence	130

APPENDIX F

USEFUL IBM BASIC INSTRUCTIONS

References: IBM BASIC REFERENCE MANUAL, especially Appendix C
IBM BASIC HANDBOOK, Chapter 2

When calling BASIC from the system, the communications buffer size can be changed using the /C option. For example: **BASICA/C:2048** sets buffer to 2048 bytes.

In BASIC, the following instructions are useful:

OPEN "COMn"	opens communications file n
CLOSE n	closes file n
LOC(n)	function to find out how many characters are in the input buffer for file n
INPUT#	input up to <cr> or comma
LINE INPUT#	input up to <cr>
INPUT\$	input a specified number of characters
PRINT#	send data from computer
WRITE#	send data from computer
	NOT RECOMMENDED
	<i>Inserts quotes around strings</i>
GET	get specific number of characters from buffer
PUT	put specific number of bytes into output buffer
ON COM(n)	detects activity on communications port

STRING MANIPULATION INSTRUCTIONS:

INSTR	find specific character of string
LEFT\$	
RIGHT\$	
MID\$	
VAL	convert a string to a numeric value
STR\$	convert a numeric value to a string

APPENDIX G

CALCULATION OF PRESSURE

The transmitter calculates temperature and pressure from period measurements of two frequency signals. The equations used in the calculations are given below:

$$\text{Temperature} = Y_1U + Y_2U^2 + Y_3U^3 \text{ deg C}$$

$$P = C(1 - T_0^2/\text{Tau}^2)[1 - D(1 - T_0^2/\text{Tau}^2)] \text{ psi}$$

where: Tau = pressure period in microseconds

$$U = (\text{temp period}) - U_0 \text{ microseconds}$$

$$C = C_1 + C_2U + C_3U^2$$

$$D = D_1 + D_2U$$

$$T_0 = T_1 + T_2U + T_3U^2 + T_4U^3 + T_5U^4$$

These equations express temperature and pressure in terms of the transducer calibration coefficients:

$$\text{Temperature coefficients: } U_0 \ Y_1 \ Y_2 \ Y_3$$

$$\text{Pressure coefficients: } C_1 \ C_2 \ C_3 \ D_1 \ D_2 \ T_1 \ T_2 \ T_3 \ T_4 \ T_5$$

These coefficients are stored in EEPROM and can be obtained from the transmitter via the RS-232 bus.

Final output pressure is computed from the above using the following equation:

$$P_{\text{output}} = \text{PM} [(\text{units multiplier}) \times P + \text{PA}]$$

When units are changed using the **UN** command, **PA** is automatically recalculated to be correct in the new units.

APPENDIX H

ZERO AND SPAN ADJUSTMENTS

Commands **PA** and **PM** can be used for minor transmitter zero and span adjustments. Normally the pressure adder **PA** is set to zero and the pressure multiplier **PM** is set to 1.0.

Adjusted pressure is calculated using the equation:

$$P_{\text{adjusted}} = PM \times (P + PA)$$

where **P** is the pressure calculated using the original calibration coefficients and the selected units factor. The user enters **PA** in the selected units. The transmitter converts the entered value to psi before storing it. Whenever the transmitter is asked to send the value of **PA**, it will be reconverted and sent in the units in effect at the time of the request.

The **PA** parameter can also be used to offset absolute pressure readings to read gauge pressure.

WARNING: Be very careful when using the **PA** and **PM** commands because they directly affect the transmitter calibration. Inaccurate values will result in inaccurate data.

APPENDIX I

SOFTWARE VERSIONS

A number of evolutionary improvements have been made to the hardware and software in the intelligent transmitter to add display capability and extra commands and features. We have maintained full forward compatibility, so that user programs written for one version operate properly with all later versions, and different versions can be mixed on the same loop.

The hardware and software version of any transmitter can be determined with the **VR** command. If desired, any transmitter can be upgraded to support all of the latest features. Design changes for all standard 1000 series transmitter products except 16-Bit, Model 740, and Model 760 are summarized below:

VERSION

1.00	Original series.
2.00	Commands added: none. Hardware change: Input selection modified.
3.00	Display capability added. Commands added: MD, DV, DC . Hardware change: display driving.
4.00	Refinements to display capability, parity, sequential dump. Commands added: DP, DR, DS, MC, PT . No hardware changes.
4.04	Commands BL, DD, IM, IC added.
4.05	Hardware change: Input select circuit.
7.00	Commands added: ZL, ZS, ZV, OP . Hardware change: Tare request indicator. OP indicator.
7.10	Software change. Faster math package.
S2.00	Surface-mount revision, transzorbs, faster clock
S2.01	More significant figures at UN=0

- S2.02 Minor reset improvements after changes in configuration
- S2.03 Multi-drop capability added
- R1.00 Hardware and Firmware revision

Different versions of the software are used for other models as follows:

<u>VERSION</u>	<u>MODEL</u>
5.xx	16-bit parallel binary output
40.xx	Model 740
60.xx	Model 760

APPENDIX J COMMAND LIST

SAMPLE COMMANDS

(May be used as global 99 commands)

- P1** Sample and send one pressure sensor period.
- P2** Continuously sample and send pressure periods.
- P3** Sample and send one pressure.
- P4** Continuously sample and send pressure.
- P5** Sample and hold one pressure.
- P6** Sample and hold one pressure period.
- P7** Burst and sample pressure: read temperature once; then continuously send pressure compensated using original temperature.

- Q1** Sample and send one temperature period.
- Q2** Continuously sample and send temperature periods.
- Q3** Sample and send one temperature.
- Q4** Continuously sample and send temperature.
- Q5** Sample and hold one temperature.
- Q6** Sample and hold one temperature period.

- DB** Dump buffer. Sends values being stored.
- DS⁹** Dump sequential. Sends stored values in sequential order.

CONFIGURATION CONTROL

- BR** Enter baud rate. Must be global command.
- BL** Locks baud rate and parity to prevent change.
Must be global command.
- ID** Auto-number transmitters in a loop. Must be global command.
- PT¹⁰** Sets transmitter parity. Must be global.
- EW** Enable EEPROM write for one command.

REMAINING COMMANDS CANNOT BE GLOBAL

⁹ NOT SUPPORTED FOR TRANSMITTERS AND DEPTH SENSORS SHIPPED AFTER 10/1/01 (FIRMWARE VERSION R1.00 AND LATER).

¹⁰ PARAMETER IS READ-ONLY, FIXED AT 8 DATA BITS, NO PARITY, AND 1 STOP BIT IN TRANSMITTERS AND DEPTH SENSORS SHIPPED AFTER 10/1/01 (FIRMWARE VERSION R1.00 AND LATER).

PR Read/enter pressure resolution.
TR Read/enter temperature resolution.

UN Read/enter choice of pressure units.

0. user defined	3. bar	6. in Hg
1. psi	4. kPa	7. Torr or mm Hg
2. mbar or hPa	5. MPa	8. m H ₂ O

UF Read/enter user definable units.

MD Reads or sets power-up mode.

SPECIAL COMMANDS TO CONTROL DISPLAY

DC Display check.

DD Display distance.

DP Reads or sets number of display decimal places.

DR Display right-adjusted data from computer.

DV Display value from computer, left-adjusted.

TARE AND OVERPRESSURE COMMANDS

BP Sound overpressure beeper.

OP Read/enter the overpressure alarm setting.

ZS Read the position of the zero set switch.

ZV Zero value. Read the zero offset value.

ZL Zero lock. Enable or disable taring.

SPECIAL DIAGNOSTIC COMMANDS

MC¹¹Memory check. Checks program PROM.

CS Check stack of microprocessor.

CT¹¹ Check counter timebase.

CX Check crystal of microprocessor clock.

OPTIONAL 16-BIT BINARY OUTPUT COMMANDS

LL Limit low. Reads or sets pressure corresponding to binary 0.

LH Limit high. Reads or sets pressure for binary 65535.

IM Interface mode. Turns 16-bit binary interface on or off.

¹¹ NOT SUPPORTED FOR TRANSMITTERS AND DEPTH SENSORS SHIPPED AFTER 10/1/01 (FIRMWARE VERSION R1.00 AND LATER).

IC Inhibit control. Controls operation of data inhibit line.

CALIBRATION COMMANDS

WARNING!! THE FOLLOWING COMMANDS CAN CHANGE THE CALIBRATION COEFFICIENTS.

SN¹² Read/enter transmitter serial number.

PA Read/enter pressure adder.

PM Read/enter pressure multiplier.

TC¹² Read/enter timebase correction factor.

C1 Read/enter C1 pressure coefficient.

C2 Read/enter C2 pressure coefficient.

C3 Read/enter C3 pressure coefficient.

D1 Read/enter D1 pressure coefficient.

D2 Read/enter D2 pressure coefficient.

T1 Read/enter T1 pressure coefficient.

T2 Read/enter T2 pressure coefficient.

T3 Read/enter T3 pressure coefficient.

T4 Read/enter T4 pressure coefficient.

T5 Read/enter T5 pressure coefficient.

U0 Read/enter U0 temperature coefficient.

Y1 Read/enter Y1 temperature coefficient.

Y2 Read/enter Y2 temperature coefficient.

Y3 Read/enter Y3 temperature coefficient.

¹² READ-ONLY FOR TRANSMITTERS AND DEPTH SENSORS SHIPPED AFTER 10/1/01 (FIRMWARE VERSION R1.00 AND LATER).