

**Paroscientific, Inc.**  
**Digiquartz® Pressure Instrumentation**

**User's Manual**  
**for**  
**Intelligent RS-232 Instruments Only**

**PS-2 Water Stage Sensor**

**Model 760 Portable Field Standard**

**Series 8DP/ 8WD / 8B Intelligent Depth Sensors**

**Series 1000 / 6000 / 9000 Intelligent Transmitters**

**MET3 and MET3A Meteorological Measurement Systems**

**“The standard by which other standards are measured”**



**Technology**



# **DIGIQUARTZ®**

## **PRECISION PRESSURE INSTRUMENTS**

### **USER'S MANUAL FOR INTELLIGENT RS-232 INSTRUMENTS ONLY**

- \* PS-2 WATER STAGE SENSOR (RS-232)
- \* MODEL 760 PORTABLE FIELD STANDARD
- \* SERIES 8DP / 8WD / 8B INTELLIGENT DEPTH SENSOR
- \* SERIES 1000 / 6000 / 9000 INTELLIGENT TRANSMITTER
- \* MET3 AND MET3A METEOROLOGICAL MEASUREMENT SYSTEMS

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# 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 760 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 other RS-232 serial host device.

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 E.

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.

## **SPECIFICATIONS**

1. 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	$\pm 5$ 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 Quiescent

14 mA at 1 sample/s

25 mA Max

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



## **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	$\pm 5$ 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:

3 mA In Sleep Mode

17 mA Quiescent

38 mA Max

### **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/XP 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® Assistant 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 C 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>
<b>P3</b>	Make one pressure measurement and send it to the computer.
<b>P5</b>	Make one pressure measurement hold value until requested.
<b>DB or DS</b>	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: **\*ddsscc\_\_<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**<sup>1</sup> 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**<sup>2</sup> Sets transmitter parity. Must be global.
- EW** Enable EEPROM write for one command.

---

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

<sup>2</sup> 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 <sub>2</sub> O |

**UF** Read/enter user definable units.

**MD** Reads or sets power-up mode.

## **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**

**MC**<sup>3</sup> Memory check. Checks program PROM.

**CS** Check stack of microprocessor.

**CT**<sup>3</sup> Check counter timebase.

**CX** Check crystal of microprocessor clock.

---

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

## **CALIBRATION COMMANDS**

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

**SN<sup>4</sup>** Read/enter transmitter serial number.

**PA** Read/enter pressure adder.

**PM** Read/enter pressure multiplier.

**TC<sup>4</sup>** 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

---

<sup>4</sup> 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: \*0001555.444

- 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

**DS**<sup>5</sup> 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

## CONFIGURATION CONTROL COMMANDS

---

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

- 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

**PT**<sup>6</sup> 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

---

<sup>6</sup> PARAMETER IS READ-ONLY, PROTOCOL IS FIXED AT 8 DATA BITS, NO PARITY, AND 1 STOP BIT IN TRANSMITTERS AND DEPTH SENSORS SHIPPED AFTER 10 /1/01.

**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 PSI BY</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 <sub>2</sub> 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<sup>2</sup>

**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>
<b>MD = 0</b>	off	off
<b>MD = 1</b>	on	off
<b>MD = 2</b>	off	on
<b>MD = 3</b>	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 760 portable pressure standard resets 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

## 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 760 pressure standard.

### **BP** Beep.

ACTION: Causes the overpressure warning beeper to sound for approximately one second. (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 of the Model 760 is similar, except that overpressure triggers a warning beeper instead of a logic output level. Also, on the Model 760, **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 of the Model 760 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 760.)

**TYPICAL COMMAND:** \*0100ZL

**TYPICAL REPLY:** \*0001ZL = 1      Taring disabled



## SPECIAL DIAGNOSTIC COMMANDS

- MC<sup>7</sup>**    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
- CT<sup>7</sup>**    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

---

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

## 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.*

**SN**<sup>8</sup> 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

**TC**<sup>8</sup> Read/enter timebase correction factor.  
ACTION: Same as other coefficients. **TC** = 10 MHz/TCXO freq.

TYPICAL COMMAND: \*0100TC  
TYPICAL REPLY:     \*0001TC = .6666667  
TYPICAL COMMAND: \*0100EW \*0100TC = .6666666  
TYPICAL REPLY:     \*0001TC = .6666666

---

<sup>8</sup> 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:

$$\begin{array}{lll}
 \text{Resolution/f.s.} & = & \frac{1}{150 * PR * P_{per}} \\
 \\ 
 \text{Pressure Sensor} & = & \frac{PR * P_{per}}{10,000} \quad \text{sec.} \\
 \text{Integration Time} & & \\
 \\ 
 \text{P2 command} & = & \frac{10,000}{PR * P_{per}} \\
 \text{Max Samples/s} & & \\
 \\ 
 \text{P4 Command} & = & \frac{10,000}{PR * P_{per} + (TR + 1) * T_{per}} \\
 \text{Max Sample/s} & & 
 \end{array}$$

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 E. 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**.



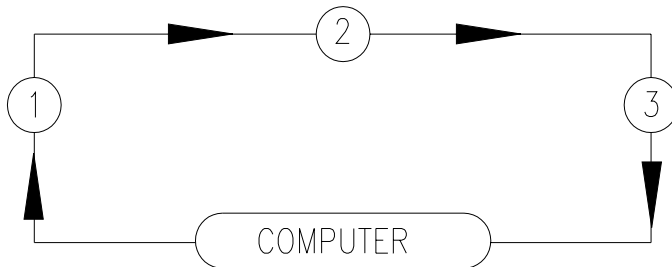
## MULTIPLE TRANSMITTERS ON THE RS-232 BUS

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.

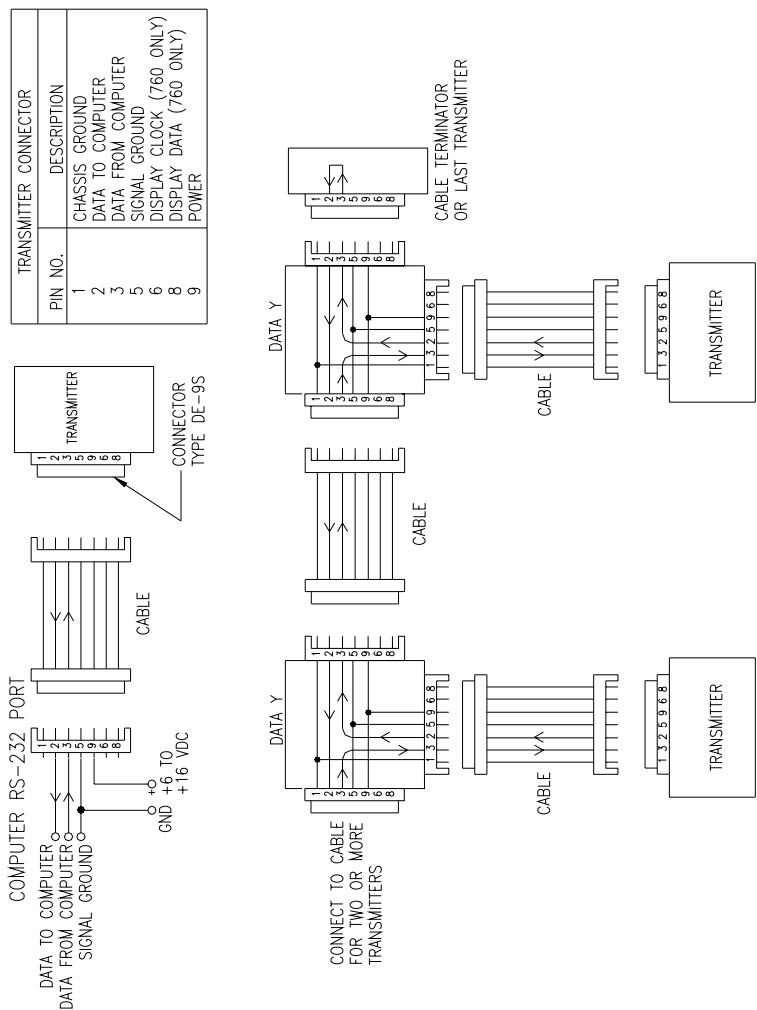
When setting up a loop:

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.

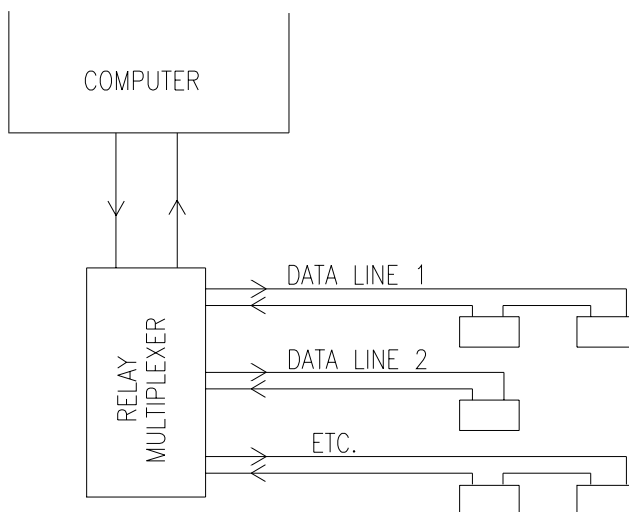
## SERIAL LOOP CONNECTIONS

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



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.

## 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, and Model 760.

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

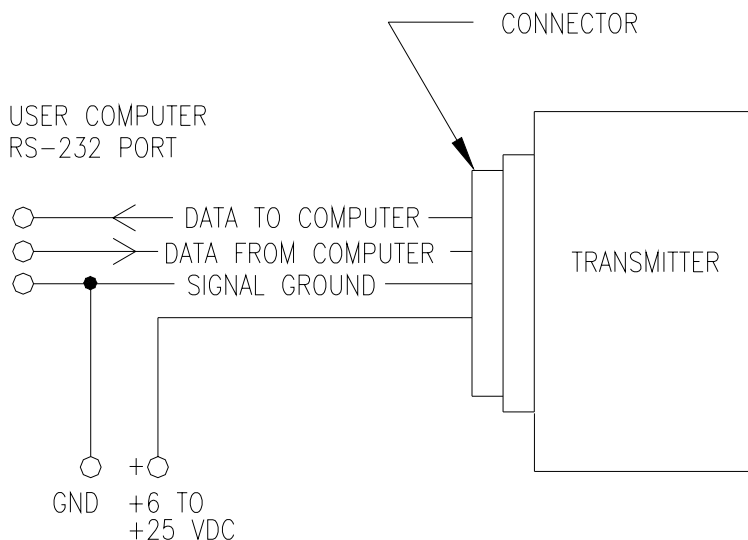
On some 9-pin versions of the RS-232C Serial Interface Board (NOT MODEL 760), Tare Request, Tare Indicator, and Overpressure Warning can be brought out on unused pins of the 9-pin output connector. Contact Paroscientific for details.

## 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

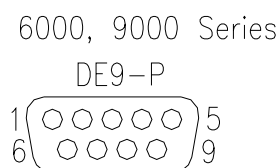
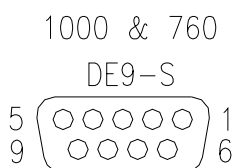
### CONNECTOR PIN ASSIGNMENTS

#### 9-PIN D CONNECTOR

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

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 (Model 760 Only)
	PIN 7	not used
	PIN 8	DISPLAY DATA (Model 760 Only)
	PIN 9	POWER (SEE SCD)

Connector Diagram:



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

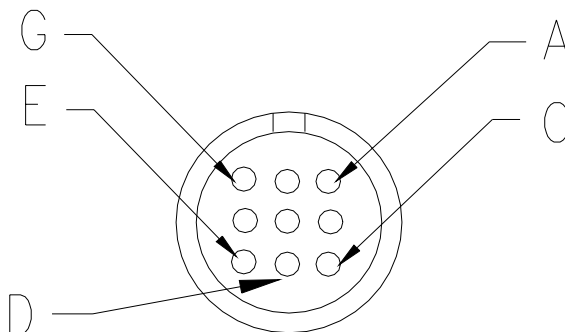


## 9-PIN BENDIX MS CONNECTOR

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

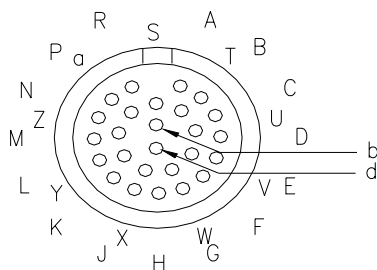
## 26-PIN BENDIX MS CONNECTOR

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

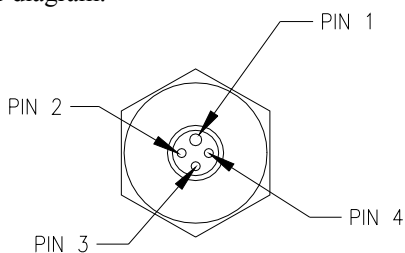
MATING CONNECTOR: MS3106A28-12S

## 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)

Connector diagram:



CONNECTOR PART NO.: XSG-4-BCL

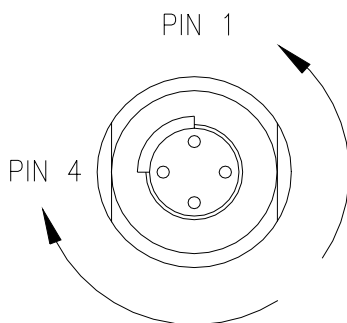
MATING CONNECTOR: XSG-4-CCP

## 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

### 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 B 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 D

### SAMPLING COMMANDS

		APPROX. MAX SAMPLES PER SEC.
--	--	------------------------------------

#### STANDARD SAMPLING COMMANDS

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

#### PERIOD SAMPLING COMMANDS

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

#### BURST SAMPLING COMMANDS

PRESSURE BURST	<b>P7</b> Continuous sample and send	90
PERIOD BURST	<b>Q1, P2, Q1</b> Command sequence	130

## APPENDIX E

### 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:

$$\text{Temperature} = Y_1 U + Y_2 U^2 + Y_3 U^3 \text{ deg C}$$

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

where: Tau = pressure period in microseconds

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

$$C = C_1 + C_2 U + C_3 U^2$$

$$D = D_1 + D_2 U$$

$$T_0 = T_1 + T_2 U + T_3 U^2 + T_4 U^3 + T_5 U^4$$

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 F

### 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 G

### 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, 6000, and 9000 series transmitter products 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: <b>MD, DV, DC.</b> Hardware change: display driving.
4.00	Refinements to display capability, parity, sequential dump. Commands added: <b>DP, DR, DS, MC, PT.</b> No hardware changes.
4.04	Commands <b>BL, DD, IM, IC</b> added.
4.05	Hardware change: Input select circuit.
7.00	Commands added: <b>ZL, ZS, ZV, OP.</b> Hardware change: Tare request indicator. <b>OP</b> 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
R2.01	Support for S3 Processor

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

<u>VERSION</u>	<u>MODEL</u>
60.xx	Model 760

## APPENDIX H            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**<sup>9</sup> 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**<sup>10</sup> Sets transmitter parity. Must be global.
- EW** Enable EEPROM write for one command.

*REMAINING COMMANDS CANNOT BE GLOBAL*

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

---

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

<sup>10</sup> 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).

**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 <sub>2</sub> O |

**UF** Read/enter user definable units.

**MD** Reads or sets power-up mode.

## **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**

**MC**<sup>11</sup> Memory check. Checks program PROM.

**CS** Check stack of microprocessor.

**CT**<sup>11</sup> Check counter timebase.

**CX** Check crystal of microprocessor clock.

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

## **CALIBRATION COMMANDS**

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

**SN**<sup>12</sup> Read/enter transmitter serial number.

**PA** Read/enter pressure adder.

**PM** Read/enter pressure multiplier.

**TC**<sup>12</sup> 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.

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

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