Paroscientific, Inc.
Digiquartz® Pressure Instrumentation

User's Manual
For
Intelligent RS-232 Only Instruments

Series 1000 / 6000 / 9000 Intelligent Transmitters

Model 760 Portable Field Standard

Series 8DP / 8WD / 8B Intelligent Depth Sensor

MET3 And MET3A Broadband Meteorological Measurements Systems

PS-2 Water Stage Sensor

"The standard by which other standards are measured"

Digiquartz®
Technology

DIGIQUARTZ®
PRECISION PRESSURE INSTRUMENTS

USER'S MANUAL
FOR
INTELLIGENT RS-232 ONLY INSTRUMENTS

- ❖ SERIES 1000 / 6000 / 9000 INTELLIGENT TRANSMITTER

- ❖ MODEL 760 PORTABLE FIELD STANDARD

- ❖ SERIES 8DP / 8WD / 8B INTELLIGENT DEPTH SENSOR

- ❖ MET3 AND MET3A BROADBAND METEOROLOGICAL MEASUREMENT SYSTEMS

- ❖ PS-2 WATER STAGE SENSOR

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Please visit www.paroscientific.com
for the latest manual revisions.

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1. INTRODUCTION

This manual describes the programming and operation of Paroscientific's line of intelligent instruments with the RS-232 interfaces only. These instruments have a common instruction set except for the Model 760 where noted throughout this manual. Please visit our website at www.paroscientific.com for the latest manual revision.

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.

Although the following sections apply to the pressure sensor of MET3 and MET3A Broadband Meteorological Measurement System, please read the MET3/MET3A section for more specific information.

LATEST FEATURES

Starting with firmware revision R5.10 or later, it is now possible to achieve parts-per-billion resolution (nano-resolution) as opposed to parts-per-million resolution in standard mode. This feature can be easily enabled/disabled via software commands. Please refer to Section 8 for additional information on this new feature.

2. HARDWARE DESCRIPTION

Digiquartz$^{\circledR}$ Intelligent Transmitters, Portable Pressure Standards, Intelligent Depth Sensors, MET stations, and Water Stage Sensors 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 unit 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.

3. SPECIFICATIONS

See MET3/3A section for specifications for these products.

NOTE: 710 Display is only supported by older instruments with display clock and display data outputs.

RS-232 BUS:

Baud Rates	User selectable from 300 to 19200 baud
Input levels	Any RS-232C compatible level
Output levels	± 5 VDC nominal
Data framing	8 data bits, no parity, one stop bit
Handshaking	Not required.

POWER REQUIREMENTS:

- TRANSMITTERS AND DEPTH SENSORS SHIPPED PRIOR TO 10/01/2001:

    +6 TO +16 VDC

    Typical current drain:
    12 mA Quiescent
    14 mA at 1 sample/s
    25 mA Max
    25 mA Peak Instantaneous Current

- TRANSMITTERS AND DEPTH SENSORS SHIPPED AFTER 10/01/2001 WITH FIRMWARE VERSION R1.00 – R3.00):

    +6 TO +16 VDC

    Typical current drain:
    3   mA In Sleep Mode
    17 mA Quiescent
    38 mA Max

- TRANSMITTERS AND DEPTH SENSORS SHIPPED WITH
  FIRMWARE VERSION R4.00 AND LATER:

  +6 TO +16 VDC

  Typical current drain:
  - 7   mA In Sleep Mode
  - 12 mA Quiescent
  - 16 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.

4. HOW TO GET STARTED

This section concentrates on items a first time user needs to know.

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.

Download the latest Digiquartz Interactive software (DQI) from www.paroscientific.com. Once download is complete, run executable and follow on-screen instructions to install on a Windows PC (must be equipped with at least one RS-232 serial port).

Download and install 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 Paroscientific website. 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.

INSTALLATION

Digiquartz Intelligent Transmitters can generally be mounted in any orientation. Mounting hole patterns for units so equipped can be found on the Specification Control Drawing (SCD) supplied with the unit.

CAUTION Pressure head effects vary with transducer orientation, and result in zero offsets. These effects are more pronounced when liquid-filled pressure lines are being used. These effects can be minimized by keeping the transducer pressure port and the pressure source at the same elevation, or by making an offset correction to compensate for the pressure head.

PRESSURE PORTS AND BUFFER TUBES

Digiquartz Intelligent Transmitters include a nylon or stainless steel buffer tube that is an integral part of the mechanical shock protection system of the transmitter. For Series 1000 and 9000 devices, the buffer tube is located within the transducer housing. For Series 6000 devices, it is externally attached.

WARNING For 6000 Series units, DO NOT REMOVE THE EXTERNAL COILED BUFFER TUBE FROM TRANSMITTER. Disconnecting the buffer tube from the transmitter pressure fitting may cause irreversible damage to the unit. Only make connections to the buffer tube fitting and avoid coupling directly to the transmitter pressure fitting. If the transmitter pressure fitting becomes flared, stripped or damaged, it will be necessary to return the unit to Paroscientific for repairs.

For additional information, see the application note "The Use and Handling of Buffer Tubes" at www.paroscientific.com.

Parker A-Lok or equivalent nut and ferrule fittings are used on most Digiquartz Intelligent Transmitters. Series 1000 and 6000 devices use the 1/8" OD configuration. Series 9000 transmitters are equipped with a modified ¼" HIP or equivalent fitting.

CAUTION It is recommended that all pressure fittings are installed finger tight, then tightened an additional ¾ turn to complete the pressure seal.

Two 7/16" wrenches are required when making or breaking any 1/8-inch pressure fitting. The first wrench is used to stabilize the stationary fitting, and the second wrench is used to turn the other fitting. For the modified ¼" HIP fitting, one 5/8" wrench and one 3/4" wrench are required to make and break the connections.

OIL FILLED VS. NON-OIL FILLED UNITS

OIL FILLED TRANSMITTERS

Transmitters that are to be used to measure liquid media pressures are oil filled at Paroscientific. Transmitters that are oil filled should never be used in gas media applications.

Oil fill and bleed all pressure lines that are to be connected to an oil filled transmitter. The same oil used to fill the transmitter should be used to fill the pressure lines; consult the transmitter Specification Control Drawing for details.

CAUTION If your transmitter and buffer tube are oil filled, do not pull a vacuum or apply pressurized gas to the unit. Doing so could allow bubbles to form in the pressure lines and transmitter, which will adversely affect the accuracy of the unit.

CAUTION Pressure head effects result in zero offsets. These effects are more pronounced when liquid filled pressure lines are being used. These effects can be minimized by keeping the transmitter pressure port and the pressure source at the same elevation, or by making an offset correction to compensate for the pressure head.

NON-OIL FILLED TRANSMITTERS

Non-oil filled transmitters are intended for use in gas media applications, and should never be used in liquid media applications.

WARNING If your transmitter and buffer tube are not oil-filled, do not apply pressurized liquid media to the unit. Liquid may contaminate the unit, and may adversely affect the accuracy of the unit. It is not possible to completely remove most liquids from the transmitter once they have been introduced.

For additional information, see the application note "Oil Filled Transducers Accuracy, Performance, and Handling" at www.paroscientific.com.

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.

Command	Transmitter Response
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: ***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 PROGRAMS

For programming examples in Visual Basic and Visual C, see the website http://www.paroscientific.com under the software menu option.

5. COMMAND LIST

SAMPLE COMMANDS
 (May be used as global 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 COMMANDS

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 TRANMITTERS AND DEPTH SENSORS SHIPPED WITH
     FIRMWARE VERSIONS R1.00 - R2.01.
[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

PI Set or read the pressure measurement integration time
TI Set or read the temperature measurement integration time
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_2O

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.

TIME REFERENCE STAMP COMMAND

TS Enables and disables the time reference stamp feature.

SPECIAL DIAGNOSTIC COMMANDS

MC[3] Memory check. Checks program PROM.
CS Check stack of microprocessor.
CT[3] Check counter timebase.
CX Check crystal of microprocessor clock.

NANO-RESOLUTION COMMANDS

XM Resolution mode.
IA IIR mode cut-off frequency.
XN Number of significant digits.

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[3] 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[4] Read/enter transmitter serial number.
PA   Read/enter pressure adder.
PM Read/enter pressure multiplier.
TC[4] 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).

6. COMMAND DESCRIPTIONS

(For commands specific to nano-resolution, please refer to Section 8**.)**

SAMPLING COMMANDS (may be used as global 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[5] 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 FOR TRANMITTERS AND DEPTH SENSORS SHIPPED WITH FIRMWARE VERSIONS R1.00 - R2.01.

MEASUREMENT INTEGRATION TIME COMMANDS

Digiquartz Intelligent devices sample the transducer's pressure and temperature signals for a length of time specified by the measurement integration time commands. The measurement integration time has a direct affect on sampling rate and measurement resolution. See Section 9 for details.

PI and **TI** are the primary integration time commands for pressure and temperature signal measurement. The legacy commands **PR** and **TR** may also be used. The advantage of **PI** and **TI** is that the specified integration time is expressed directly in milliseconds.

NOTE: The legacy commands **PR** and **TR** traditionally specified the number of signal periods to sample. This integration scheme has been replaced by integration over a fixed length of time. For backward compatibility, values input using **PR** and **TR** are converted to an equivalent time using nominal pressure and temperature period values.

PRIMARY INTEGRATION TIME COMMANDS

PI   Set or read the pressure measurement integration time

Units: Milliseconds

Range: 1 to 290000 when **XM** = 0

1 to 72500 when **XM** = 1

Default: 666

Typical set command: *0100EW*0100PI=1000

Typical set response: *0001PI=1000

Typical read command: *0100PI

Typical read response: *0001PI=1000

NOTE: Whenever the value of **PI** is changed, **TI** is automatically updated with the same value.

TI   Set or read the temperature measurement integration time

Units: Milliseconds

Range: 1 to 290000 when **XM** = 0

1 to 72500 when **XM** = 1

Default: 666

Typical set command: *0100EW*0100TI=1000

Typical set response: *0001TI=1000

Typical read command: *0100TI

Typical read response: *0001TI=1000

NOTE: Changing **TI** has no effect on **PI**.

NOTE: It is usually recommended that **TI** and **PI** be set to the same value.

NOTE: Do not set **PI** to a value of less that 10 when using a Model 715 display. Doing so may result in an inconsistent display.

LEGACY INTEGRATION TIME COMMANDS

PR   Set or read pressure measurement integration time

Units: None

Range: 1 to 16383, integer values only

Default: 238

Typical set command: *0100EW*0100PR=200

Typical set response: *0001PR=200

Typical read command: *0100PR

Typical read response: *0001PR=200

NOTE: Whenever the value of **PR** is changed, **TR** is automatically updated with the value of **PR** times 4.

NOTE: Whenever the value of **PR** is changed, **PI** is automatically updated to reflect the equivalent pressure integration time.

TR   Set or read temperature measurement integration time

Units: None

Range: 1 to 65535, integer values only

Default: 952

Typical set command: *0100EW*0100TR=800

Typical set response: *0001TR=800

Typical read command: *0100TR

Typical read response: *0001TR=800

NOTE: Changing **TR** has no effect on **PR**.

NOTE: Whenever the value of **TR** is changed, **II** is automatically updated to reflect the equivalent temperature integration time.

CONFIGURATION CONTROL COMMANDS

BR   Enter baud rate. Must be a global command.

> $\boxed{\textbf{CAUTION}}$ *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 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[6]   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 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 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 following commands cannot be global commands.*

UN   Read/enter choice of pressure units.
ACTION: Selects unit 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**.

UN	UNITS	MULTIPLY PSI BY
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

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[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 /1/01.

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	

*   For fresh water applications only. For sea water applications, consult the application note "Digiquartz Depth Sensor Ocean Depth Conversion" at http:\\www.paroscientific.com.

UF   Read/enter user defined unit 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

Pressure to Depth Conversions

	1 psi=
m of H$_2$O d=1	0.7030696
cm of H$_2$O d=1	70.30696
in. of H$_2$O d=1	27.67991
ft. of H$_2$O d=1	2.306659
m of sea water d=1.0281	0.683853
ft of sea water d=1.0281	2.243613
m of air d=0.00117	600.9143
in. of air d=0.00117	23658.04

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.

	Display	Continuous RS-232
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 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 display
TYPICAL REPLY:	*0001MD = 1	Display active

POWER MANAGEMENT COMMANDS

Digiquartz Intelligent devices can be commanded to enter a low-power "sleep" mode during periods of serial port inactivity. The unit "awakens" 0.6 seconds after a single serial character is received on either port. Since the unit is "asleep" when the wake-up character is received, that character will be lost, and will not be interpreted as being part of a command. It is therefore necessary to send a character and wait at least 0.6 seconds before sending a command to an intelligent device that is "asleep."

CAUTION Power management features are not available if **MD** is set for continuous pressure data output or display data output.

SL[7]   Set or read the sleep mode enable state.

ACTION: Allows sleep mode to be enabled or disabled. When sleep mode is enabled, the device will enter sleep mode when both serial ports have received no characters for the number of seconds specified by the value of **ST**. When sleep mode is disabled, the device cannot enter sleep mode.

RANGE: 0 = sleep mode disabled
                        1 = sleep mode enabled

DEFAULT: 0

TYPICAL COMMAND: *0100EW*0100SL=1
TYPICAL RESPONSE: *0001SL=1
TYPICAL COMMAND: *0100SL
TYPICAL RESPONSE: *0001SL=1

NOTE: If **MD** is set for continuous pressure data output or display data output, the device will never enter sleep mode regardless of the values of **SL** or **ST**.

---

[7] SUPPORTED IN TRANSMITTERS AND DEPTH SENSORS SHIPPED AFTER 10/1/01 (FIRMWARE VERSION R1.00 AND LATER).

ST[7]   Set or read the sleep mode timeout length.

  ACTION: When **SL**=1, the device enters sleep mode if both serial
             ports have received no characters for **ST** seconds.

  UNITS: Seconds

  RANGE: 5 to 255, integer values only.

  DEFAULT: 10
  TYPICAL COMMAND: *0100EW*0100ST=5
  TYPICAL RESPONSE: *0001ST=5
  TYPICAL COMMAND: *0100ST
  Typical response: *0001ST=5

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). 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

TIME REFERENCE STAMP COMMAND

> **NOTE:** The time reference stamp feature is available in firmware version 4.10 or later.

A time reference stamp can be appended to pressure and temperature measurement data to help you determine when the pressure or period measurement was taken, relative to the transmission of the measurement command response. The time reference value reported is the time interval between the midpoint of the integration period and the start of the transmission of the first ASCII character of the response data.

TS   Enables and disables the time reference stamp feature. The **TS** command affects the following measurement commands: **P1**, **P2**, **P3**, **P4**, **P5**, **P6**, **P7**, **Q1**, **Q2**, **Q3**, **Q4**, **Q5**, and **Q6**.

ACTION: When is enabled, a comma delimited time reference stamp is appended to the measurement values returned by the aforementioned commands, expressed in microseconds.

RANGE: 0 = Time reference stamp disabled
1 = Time reference stamp enabled

TYPICAL SET COMMAND: *0100EW*0100TS=1
TYPICAL SET RESPONSE: *0001TS=1
TYPICAL READ COMMAND: *0100TS
TYPICAL READ RESPONSE: *0001TS=1

The time reference value reported is the time interval between the midpoint of the integration period and the start of the transmission of the first ASCII character of the response data, expressed in microseconds. **DL**=1 pads the time reference stamp value to 9 digits.

Examples:
(Pressure = 14.74638, time reference stamp = 500637 microseconds)

P3 response, **DL**=0:   *000114.74638,500637
P3 response, **DL**=1:   *0001+14.746380000,000500637

Transmission delay

The response data as seen by the serial host is delayed by the time it takes to transmit the data. For high accuracy applications, it is necessary to compensate for this delay. The formula for calculating the transmission delay time is as follows:

$$T = (N * 10) (1E6/BR)$$

Where: T = transmission delay in microseconds
         N = number of characters transmitted
         BR = baud rate

Don't forget to consider the carriage return and line feed characters when determining the number of characters transmitted.

Processing delay
For high accuracy applications, it is also necessary to compensate for any delay by the serial host in acknowledging the first character of the response data.

SPECIAL DIAGNOSTIC COMMANDS

MC[8]   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[8]   Check counter timebase.
      Supported on all transmitters having a separate timebase 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[8]   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

---

[8]   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 commands.

SN[9]   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 $P = PM * (Pcalc + PA)$, where Pcalc 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[9]   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

---

[9]   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.

7. 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**

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.

8. NANO-RESOLUTION FEATURES & FUNCTIONS

INTRODUCTION

With firmware revision R5.10, it is now possible to achieve parts-per-billion resolution. This feature can be enabled by software command. When disabled, the sensor is backward compatible and works in the standard mode with typical parts-per-million resolution. Nano-resolution is achieved by sub-sampling the pressure at a much higher rate (typically 8 kHz) and applying digital signal processing techniques. Because of the much higher processing requirements, more input power is required. In general, the nano-resolution feature is only useful if pressure is stable enough over effective sampling period and the data acquisition system can handle additional digits. The practical bandwidth of interest is in the infrasound and deep infrasound (10 to 0.001 Hz).

The digital signal processing technique utilizes the infinite impulse response (IIR) filter available with firmware R5.10 and later. It consists of a 5-stage digital low-pass filter acting on the sub-samples. It filters all frequencies with a roll-off of -100 dB/decade above a user selectable cutoff frequency. It is an effective anti-aliasing filter. The inherent resolution depends on the cutoff frequency and not on the sampling period. Typically the sampling rate is set at the Nyquist limit, or twice the cutoff frequency.

ENABLING NANO-RESOLUTION

Nano-resolution can be enabled and disabled by the **XM** serial command.

XM   Set or read the resolution mode.

Range: 0 = Standard Resolution (backward compatible)
                1 = Nano-resolution, IIR Filter

Default: 0

Typical set command:	*0100EW*0100XM=1
Typical set response:	*0001XM=1
Typical read command:	*0100XM
Typical read response:	*0001XM=1

CONFIGURING IIR FILTER MODE

SETTING RESOLUTION

Resolution is a function of the cutoff frequency when operating in IIR mode. The cutoff frequency is user-selectable and is set by the **IA** command.

IA   Set or read the cutoff frequency setting.

Range: 0 - 16

Default: 11

Typical set command:	*0100EW*0100IA=11
Typical set response:	*0001IA=11
Typical read command:	*0100IA
Typical read response:	*0001IA=11

Refer to the following table for a list of ranges for **IA** values, cutoff frequencies, measurement resolution, and the number of digits reported.

IA	Cutoff Frequency[a] (Hz)	Effective Time Interval[b] (ms)	Period Resolution[c] (dB)	Measurand Resolution[d] (dB)			Pressure & Temp. Digits[e]
0	1400	0.1	-82	-62	790	ppm	6
1	700	1	-94	-74	200	ppm	7
2	350	2	-105	-85	56	ppm	7
3	175	3	-117	-97	14	ppm	8
4	88	6	-127	-107	4.5	ppm	8
5	44	11	-140	-120	1.0	ppm	8
6	22	22	-149	-129	0.35	ppm	9
7	11	44	-157	-137	0.14	ppm	9
8	5.5	89	-167	-147	45	ppb	10
9	2.8	178	-177	-157	14	ppb	10
10	1.4	350	-186	-167	4.5	ppb	11
11	0.7	700	-196	-176	1.6	ppb	11
12	0.35	1400	-203	-183	0.7	ppb	12
13	0.18	2800	-206	-186	0.5	ppb	12
14	0.09	5600	-207	-187	0.4	ppb	12
15	0.045	11200	-207	-187	0.4	ppb	12
16	0.023	22400	-207	-187	0.4	ppb	12

[a] *Cutoff Frequency* is the -3dB point of the low-pass IIR filter.

[b] *Effective Time Interval* is the recommended maximum time interval between measurements that ensures sampling up to the specified cutoff frequency. The time interval is set using the **PI** command.

[c] *Period Resolution* is the resolution of pressure and temperature period measurements.

[d] *Measurand Resolution* is the resolution of pressure and temperature measurements.

[e] *Pressure and Temperature Digits* is the total number of digits used to report pressure and temperature measurements. Pressure and temperature period measurements contain one additional digit.

DEFAULT NUMERIC FORMAT FOR IIR FILTER

The default numeric formats used to report period, pressure, and temperature measurement values are as follows, where N = the number of significant digits shown in the resolution tables.

PRESSURE

The sensor full-scale pressure defines the number of digits reserved for the integer portion of the pressure value. For example, a 1000 psi full-scale unit would have 4 digits reserved (but not necessarily used) for the integer portion of the pressure value, leaving N-4 digits for the fractional portion.

TEMPERATURE

Three digits are reserved (but not necessarily used) for the integer portion of the temperature value, leaving N-3 digits for the fractional portion. Negative temperature values include a sign but the numeric format is otherwise unaffected.

PRESSURE PERIOD

Two digits are used for the integer portion of the pressure period value, leaving N-2 digits for the fractional portion.

TEMPERATURE PERIOD

One digit is used for the integer portion of the pressure period value, leaving N-1 digits for the fractional portion.

CONTROLLING THE NUMERIC FORMAT

The **XN** command sets the number of significant digits used to report period, pressure, and temperature measurement values. The **XN** command overrides the default numeric format.

XN   Set or read the number of significant digits.

Range: 0 - 13
Default: 0
Typical set command: *0100EW*0100XN=10
Typical set response: *0001XN=10
Typical read command: *0100XN
Typical read response: *0001XN=10

When **XN** is set to 0, the default numeric formats are used. When non-zero, **XN** specifies the number of significant digits used to report

period, pressure, and temperature measurement values. With the exception of the total number of digits, all default format characteristics apply. The integer portion is never expressed with fewer digits than required regardless of the value of **XN**. The fractional portion is rounded or padded with zeros as required to fit the specified format. The **XN** command works with and without IIR Filter enabled.

9. 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.

PR	Pressure Resolution fs (ppm)	Pressure Signal Integration Time (s)	P2 (period) max (samples/s)	P4 (pressure) max (samples/s)
10000	0.05	28.0	0.036	0.02
2380	0.1	6.7	0.15	0.08
1190	0.2	3.3	0.30	0.16
476	0.5	1.3	0.75	0.40
238	1	0.67	1.5	0.80
119	2	0.33	3.0	1.6
48	5	0.13	7.3	4.0
24	10	0.07	14	8.0
12	20	0.033	28	15
6	40	0.017	55	30
4	60	0.011	85	46
3	80	0.0084	115	61
1	240	0.0028	274	159

NOTE: The reference values shown above are for a transmitter in standard resolution mode only, 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 when **PR/TR** are used to set integration time.

Data rates are somewhat slower than the integration time would suggest due to processing overhead. This effect becomes more pronounced as the data rate increases. The baud rate may need to be increased to achieve high data rates.

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.

10. 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.

BAUD RATE	MAXIMUM SAMPLES/SEC
300	2.1
600	4.3
1200	8.6
2400	17.0
4800	34.0
9600	69.0
19200	137.0

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

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 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.
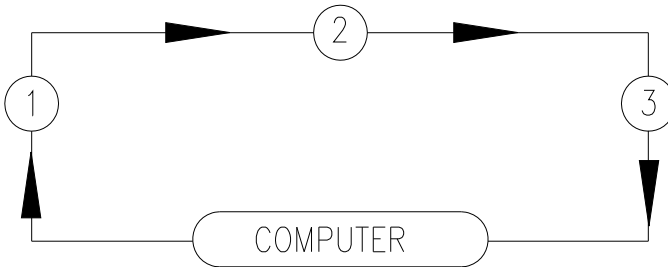
11. MULTIPLE TRANSMITTERS ON THE RS-232 BUS

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 10). 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.
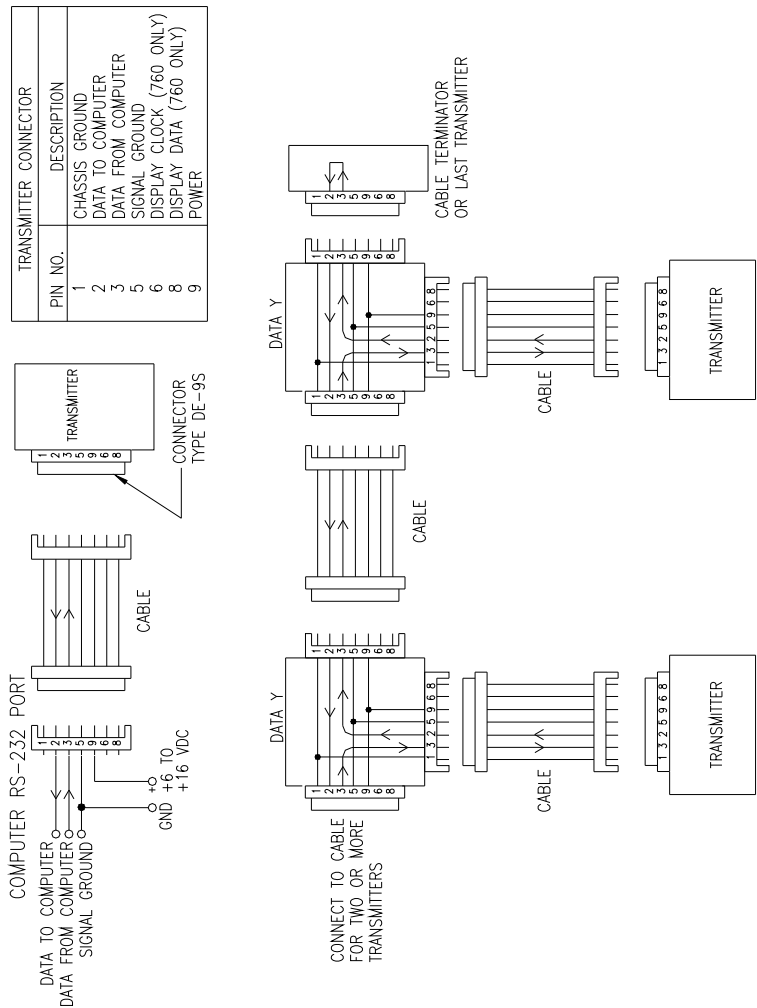
When setting up a loop:

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-adapter and plugging the two extension cables together.
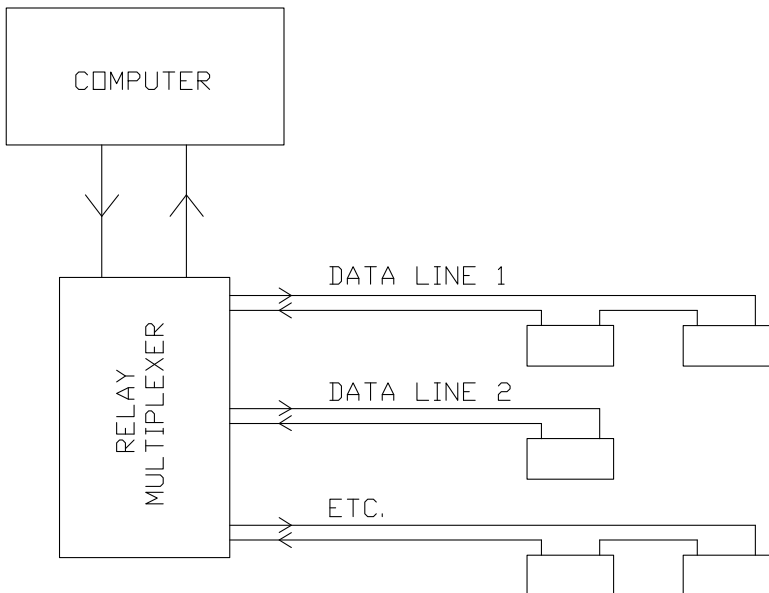
SERIAL LOOP CONNECTIONS
Pin-outs are shown for transmitters and interface boards with 9-pin connectors.

TRANSMITTER CONNECTOR	
PIN NO.	DESCRIPTION
1	CHASSIS GROUND
2	DATA TO COMPUTER
3	DATA FROM COMPUTER
5	SIGNAL GROUND
6	DISPLAY CLOCK (760 ONLY)
8	DISPLAY DATA (760 ONLY)
9	POWER

CONNECTOR TYPE DE-9S

TRANSMITTER

CABLE

COMPUTER RS-232 PORT

DATA TO COMPUTER
DATA FROM COMPUTER
SIGNAL GROUND

GND
+6 TO +16 VDC

CABLE TERMINATOR OR LAST TRANSMITTER

DATA Y

CABLE

CABLE

TRANSMITTER

DATA Y

CONNECT TO CABLE FOR TWO OR MORE TRANSMITTERS

CABLE

TRANSMITTER

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.

12. 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.

13. MET3/MET3A INSTALLATION, OPERATION, & MAINTENANCE

INTRODUCTION

The Paroscientific MET3/MET3A Meteorological Measurement System is a precision instrument that measures barometric pressure, temperature, and relative humidity. The MET3/MET3A may be interfaced to a variety of instruments including personal computers, GPS receivers, and data loggers. The MET3/MET3A is packaged in a rugged, weather-resistant housing with a waterproof connector to provide reliable operation under adverse field conditions.

PERFORMANCE SPECIFICATIONS

PRESSURE (DIGIQUARTZ BAROMETRIC STANDARD)

Range:	620 to 1100hPa (9 to 16 psia)
Resolution:	Better than 0.001 hPa
Accuracy, including pressure hysteresis, repeatability, linearity & temperature conformance:	Better than ±0.08 hPa
Stability:	Better than 0.1 hPa per year

TEMPERATURE (PLATINUM RESISTANCE TEMPERATURE PROBE)

Range:	-50 to +60 °C
Resolution:	Better than 0.01 °C
Accuracy:	MET3A: Better than ±0.1 °C
	MET3: Better than ± 0.5 °C
Stability:	Better than 0.1 °C per year

RELATIVE HUMIDITY (CAPACITANCE PROBE)

Range:	0 to 100%
Accuracy:	Better than ±2% RH at 25 °C
Saturation recovery time (not applicable for MET3):	2 minutes or less

HARDWARE DESCRIPTION

Required Test And Installation Components

1. MET3/MET3A Meteorological Measurement System

2. MET3/MET3A Interface Cable (P/N 2319-XXX)

3. Digiquartz CD Library *

4. Power Breakout / Supply Kit*

    - 9 to 12 VDC from 110 VAC (P/N 1727-001) or

    - 9 to 12 VDC from 220 VAC (P/N 1727-002)

    * These items may be optional for your field installation. To verify the operation of the device with a PC you will require an external power source and breakout as the PC serial port does not supply power to the MET3/MET3A. Paroscientific Power Supply Kit will simplify this process.

Status Indicators

In early 2002, a status indicator panel was added to the MET3/MET3A. These status indicators allow you to determine whether input power is applied to the unit, and to monitor RS-232 serial activity. The status indicator panel is located on the bottom of the of the unit, adjacent to the electrical connector.

The following table explains the function of the status indicators:

Indicator Color	Function
Red	ON: Input power on OFF: Input power off
Green	FLICKERING: Activity on RS-232 receive line OFF: No activity on RS-232 receive line
Yellow	FLICKERING: Activity on RS-232 transmit line OFF: No activity on RS-232 transmit line

FIELD INSTALLATION

This section discusses physical installation of the MET3/MET3A. For information on connecting the MET3/MET3A to a PC or GPS receiver, please review our GPS-MET support site: "Integrating Digiquartz MET3 and MET3A Broadband Meteorological System with a GPS Receiver" found at http:\\www.paroscientific.com/pdf/GPSMETIntegration.pdf.
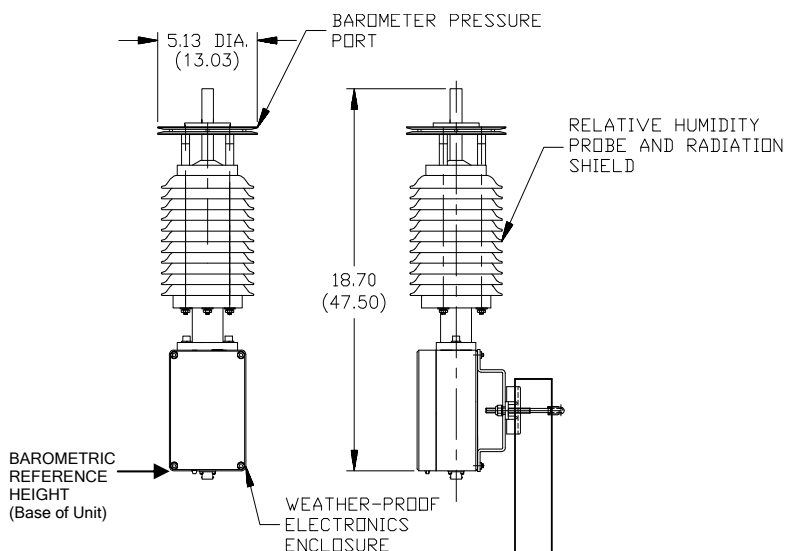
MET3/3A Physical Installation / Mounting

The MET3/MET3A is packaged to withstand adverse field conditions and no additional shielding or protection is required. We recommend that the MET3 interface cable used to connect to the recording device be protected from long-term exposure to the elements. A typical installation will include placing the cable in conduit to ensure extended cable life and reliable data transmission. Proper cable strain relief will minimize cable and connector damage.

Install the mounting bracket on a pole of not more than 2 inches in diameter. (An optional flat monument mounting plate is available.) Be sure the mounting fixture and structure are capable of supporting the weight of the MET3/MET3A under adverse weather conditions.

The mounting hardware supplied with the MET3/MET3A provides ground isolation from the mounting pole. No other ground connection should be made except at the recording device through the cable shield and connector shells (as shown in Connector Diagram section).
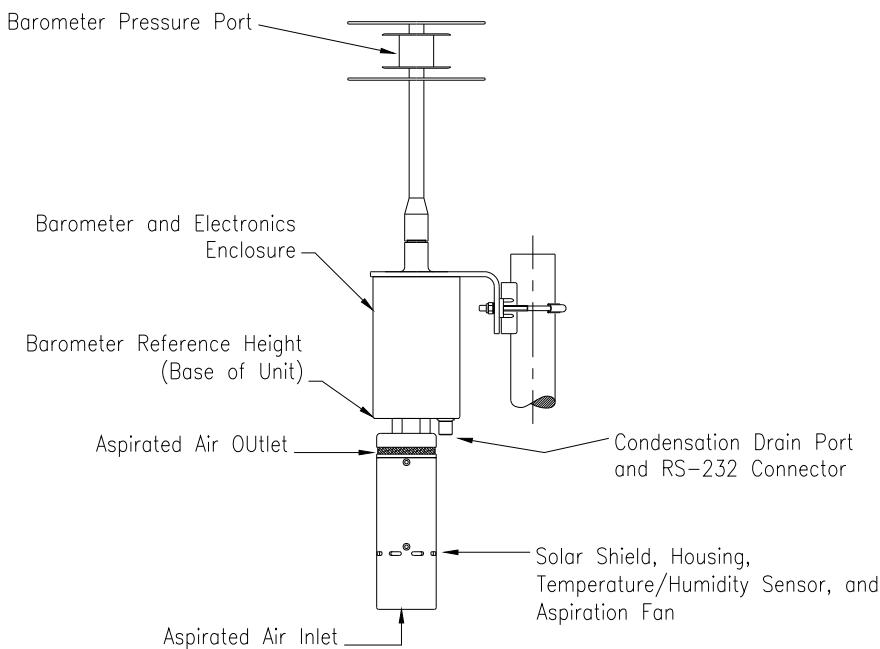
The MET3 should be installed vertically with the sun-shield and barometric port assembly facing upwards (on the top-side). This position will assure optimum performance of the sensors.

MET3

The MET3A must be installed with the barometric port assembly vertical as shown below. MET3A units that are delivered with the barometer port dismounted from the main body should be assembled in the following manner:

❑ Apply at least three wraps of Teflon pipe tape (supplied with unit) to the ¾" male pipe thread on the top of the main body of the instrument. Ensure that the entire thread is adequately covered with the tape.

❑ Carefully mate the female thread at the base of the barometer port with the taped male thread and screw the two together *HAND TIGHT*. Do not over-tighten these threads. Over-tightening could cause damage to the threads and impede future disassembly.

MET3A

Install the unit in a location where the ports remain unobstructed. There should be at least one foot of clearance in all directions and at least four feet of clearance from the ground. The ports are designed to minimize effects caused by solar radiation and wind, and obstruction of the ports could result in erratic performance. For GPS Meteorology applications we recommend that the MET3A be installed with the barometer port at the GPS antenna height.

BENCH TEST AND GPS RECEIVER INTERFACE INFORMATION

Please also review our GPS-MET support site: "Integrating Digiquartz MET3 and MET3A Broadband Meteorological Systems with a GPS Receiver" found at http:\\www.paroscientific.com/pdf/GPSMETIntegration.pdf.

Digiquartz MET3 and MET3A Compatible GPS Receivers

- Thales Navigation (Ashtech)
- Javad Navigation Systems
- Novatel
- Trimble
- Leica

MET3/3A Data Cable & Power Adapter Kit

The MET3/3A Data Cable & Power Adapter Kit is an optional accessory provided to integrate a MET station with a data acquisition system such as a GPS receiver, PC, or a data logger. This kit includes a data cable, a power adapter, and power break out. All these items are needed when connecting a MET station to a data acquisition system. Paroscientific recommends the data cable and power adapter kit for diagnostics purposes.

The power adapter and power breakout are used to provide power to a MET station on pin 9. Some GPS receivers, such as Thales, may provide power to MET stations. In this case, you don't have to use the power adapter and the breakout to power up the MET station.

For instructions on connecting your GPS receiver, see the website http://www.paroscientific.com under the manuals menu option.
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COMMANDS

MET3/MET3A Command Descriptions

The MET3/MET3A intelligent interface supports a variety of commands that may be used to configure the unit and retrieve data.

With the exception of the EW command, the following commands are unique to the MET3/MET3A. Refer to Appendix-H for other valid commands. These commands supplement the commands listed in the Programming and Operations Manual for other Paroscientific products.

EW   Permits the modification of a parameter value. It must be sent with any command that modifies a parameter value.

        Example 1: (To change a Z1 coefficient value)

        Command: *0100EW*0100Z1=#####

        Response: *0001Z1=#####

        Example 2: (To change a G2 coefficient value)

        Command: *0100EW*0100G2=#####

        Response: *0001G2=#####

P9   Description: Read unified data word containing Pressure, Temperature and Humidity measurement values based on the NMEA specification.

        NOTE: This command only functions with single devices and cannot be used in a serial loop.

        The instrument only responds to P9 commands when the engineering units are set to Bar (UN=3).

        Command: *0100P9

        Typical Response:

$WIXDR,P,<[P]>,B,<SN>,C,<[T]>,C,<SN>,H, <[H]>,P,<SN><CR><LF>

                Pressure   Temperature   Humidity

Transducer	Field	Units
Pressure	P	B=Bar
Temperature	C	C=Celsius
Humidity	H	P=Percent

<SN>= Transducer Serial Number (Typically- DQ#####)

L1   Provides pressure, temperature, and RH measurement data in a unified, fixed field length format. This format simplifies the parsing of the individual measurement values, and enhances the MET3/MET3A's compatibility with commercial data loggers, such as the Handar 555 Data Collection Platform.

> **NOTE:** The L1 command is only supported by MET3/MET3A firmware revision 1.02 and above. The **L1** command only functions with single devices and cannot be used in a serial loop.

Typical command: *0100L1

Typical response: *098765,+00.995874,+23.45,+045.7,1<cr><lf>

The **L1** data record is formatted as follows:

Field	Character position (1-based)
Start character " * " (asterisk)	1
Serial Number field	2-7
Comma	8
Pressure field	9 – 18
Comma	19
Temperature field	20 – 25
Comma	26
RH field	27 – 32
Comma	33
Fan Status field	34
Termination characters	35 – 36

Pressure, temperature, and RH values are padded with leading and trailing zeroes as required to maintain a fixed field width. The serial number field is padded with leading zeroes as required to maintain a fixed field width. The decimal point always appears in the same character position within each field. The pressure, temperature, and RH fields have explicit signs. If the MET3A fan is operational, a "1" is returned in the Fan Status field, otherwise a "0" is returned.

To determine which firmware version is loaded, activate the **VR** command. **VR** returns the firmware version number stored in the program EPROM.

Example:
Command: *0100VR
Response: *0001VR=01.01

NH   Read or set NMEA header used in the P9 command response.

By default, the NH (NMEA Header) string is set to produce the generic NMEA header "$WI". The default P9 output looks like this:

$WIXDR,P,<Pres Value>,B,<SN>,C,<Temp value>,C,<SN>,H,<Hum value>,P,<SN><CR><LF>

To change the header string to "$PASHS,", use the following NH (NMEA Header) command.

Command: *0100EW *0100NH=$PASHS,

Response: *0001NH=$PASHS,

The P9 response will now look like this…

$PASHS,XDR,P,<Pres   Value>,B,<SN>,C,<Temp value>,C,<SN>,H,<Hum value>,P,<SN><CR><LF>

Remember to add a comma to the end of the string if a comma is to appear before XDR.

The maximum string length is 7 characters.

Unused characters to be "null" not spaces.

ASCII characters 32 through 90 are valid, except "*" and "=".

TT or A1

Read an external temperature sensor measurement in degrees Celsius

Command: *0100TT   (*0100A1)

Response: *0001#.## or *0001##.##

*0001-#.## or *0001-##.##   (for negative temperature
                                                      values)

NOTE: See **MD** command for fan status indication.

RH or A2

Read an external humidity sensor measurement in percent.

Command: *0100RH   (*0100A2)

Response: *0001#.# or *0001##.#

N1   Read raw analog to digital converter value for the temperature input.

Command: *0100N1

Response: *0001######

N2   Read raw analog to digital converter value for the humidity input.
Command: *0100N2
Response: *0001######

AR   Read or set current analog resolution
If **AR** = 0 then output resolution is 0.1 degrees C, 0.1% RH.
If **AR** = 1 then output resolution is 0.01 degrees C, 0.1% RH.
Command: *0100AR
Response: *0001AR=0

To change AR value:
Command: *0100EW*0100AR=1
Response: *0001AR=1

Z1   Read or set zero adjustment coefficient for calculated temperature value.
Command: *0100Z1
Response: *0001Z1= ######
NOTE: Changing this parameter affects temperature calibration!

Z2   Read or set zero adjustment coefficient for calculated humidity value.
Command: *0100Z2
Response: *0001Z2= ######
NOTE*: Changing this parameter affects humidity calibration!

M1   Read or set span adjustment coefficient for calculated temperature value.
Command: *0100M1
Response: *0001M1= ######
NOTE: Changing this parameter affects temperature calibration!

M2   Read or set span adjustment coefficient for calculated humidity value.

Command: *0100M2

Response: *0001M2= ######

NOTE: Changing this parameter affects temperature calibration!

E1, E2, F1, F2, G1, G2, H1, H2, K1, K2

Read or set temperature and humidity calibration coefficients.

Channel 1: **E1, F1, G1, H1, K1** (temperature)

Channel 2: **E2, F2, G2, H2, K2** (humidity)

Example:

Command: *0100E1

Response: *0001E1=######

NOTE: Changing these parameters affects the temperature and/or humidity calibration!

Aspiration Fan Status Indicator- MET3A Only

A warning character can be added to the temperature data to indicate the operational status of the aspiration fan. This indication may be toggled on and off by using the Mode (**MD**) command. When the Mode is set to **MD** = 4, a plus (+) sign will be appended to temperature measurement data if the fan is not operating properly.

Example: Read or set the Mode (**MD**) parameter.

Read the Mode setting

Command: *0100MD

Response: *0001MD= 04   - The mode is set to report fan status.

Set the Mode setting

Command: *0100EW*0100MD=4

Response: *0001MD= 04   - The mode is set to report fan status.

Example: Read a temperature reading with the fan status indication. (**MD** = 4, fan OK)

Command: *0100TT

Response: *000122.23

Example: Read a temperature measurement with the fan status indication. (MD=4, fan not working)

Command: *0100TT

Response: *000122.23+

                  *0001-22.23+ (example of negative temperature values).

NOTE: The fan status indication applies to the **TT**, **A1** and **P9** commands.

Digiquartz Intelligent Interface Commands Not Supported by the MET3/MET3A.

The following commands are not supported in the MET3/MET3A. Refer to Digiquartz Programming and Operations manual for descriptions.
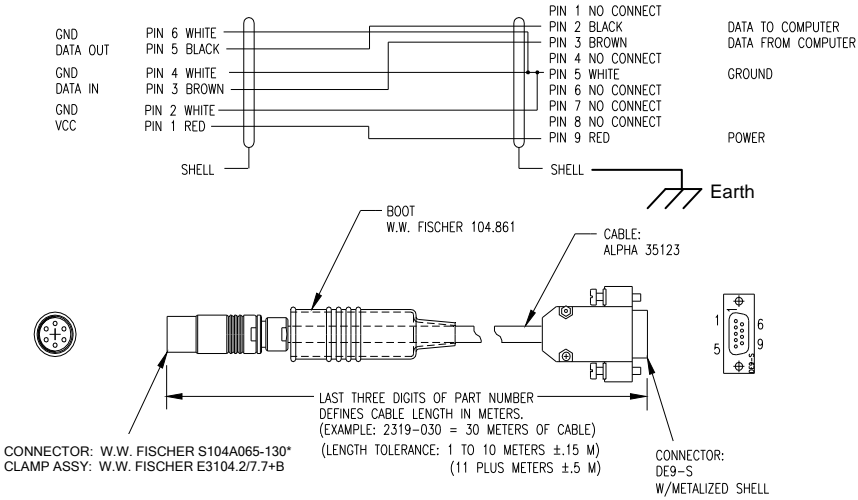
Display Commands: **DC, DD, DP, DR, DV**

Tare Commands: **BP, OP, ZS, ZV, ZL**
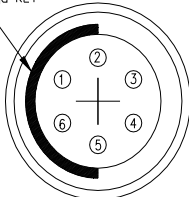
16 Bit Interface Commands: **LL, LH, IM, IC**
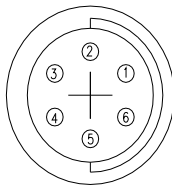
CONNECTOR DIAGRAM

Double check that the power to the MET3/MET3A unit is correct in voltage requirements (MET3: +7Vdc to +16Vdc @ 20mA nominal, 200mA maximum; MET3A: 7Vdc to +16Vdc @ 105mA nominal, 200mA maximum) and that the communication pin-outs to the MET3/ MET3A connector are correct.
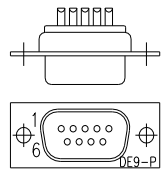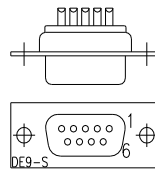
MAINTENANCE

The MET3/MET3A Meteorological Measurement System is a highly accurate, reliable instrument that is intended to operate for a long period of time without need of maintenance or calibration. For critical installations, yearly checks of temperature, humidity, and barometric pressure may be appropriate. Transfer standards, such as the Paroscientific Model 760-16B (for pressure), or a newly calibrated MET3/MET3A unit would be suitable for field verification of installed units.

Ensuring that the MET3/MET3A package remains clean and debris-free will improve the overall performance. The electronics package is environmentally sealed, requires no cleaning or maintenance, and **contains no customer serviceable parts. Opening of the sealed enclosure may affect the Paroscientific warranty.**
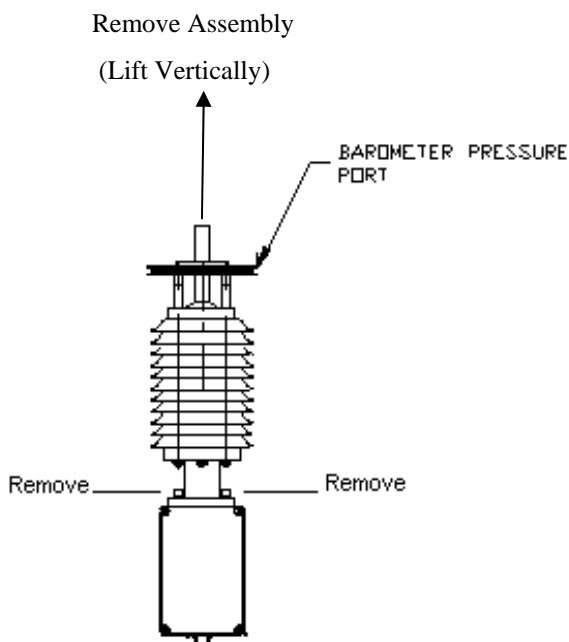
MET3 Maintenance Procedures

Periodic cleaning of the solar shield and barometer port inlet is the only recommended physical maintenance for the unit. The cleaning procedure consists of removing the solar shield and barometer port assembly, cleaning the port inlet, and re-installing the assembly.

Solar Shield and Barometer Port Removal

The solar shield and barometer port assembly has been designed for easy removal so that the user may clean the temperature / humidity probe. Using a 3/16" Allen wrench, dismount the shield/port assembly by removing the two socket head cap screws that attach the assembly to the electronics enclosure. Carefully lift the shield assembly upwards to expose the probe.

Cleaning the Temperature / Humidity Probes

Remove the heat sink from the RH probe and clean the sensor screen with distilled water. Sensors that become heavily contaminated in field use can be cleaned off with a soft brush and distilled water. Replace the heat sink before re-assembling.

Remove Assembly

(Lift Vertically)

BAROMETER PRESSURE
PORT

Remove _____   _____ Remove

MET3

Solar Shield and Barometer Port Replacement

The solar shield and barometer port assembly should be replaced in its original
orientation. The base of the shield/port assembly has a gasket seal between it
and the electronics enclosure to prevent any moisture from entering the
electronics. Be sure that the gasket is in good condition and properly seated
when replacing the port. Hand-torque the cap screws to 25 in-lbs. This torque
will compress the gasket approximately 50 percent; over tightening may distort
the gasket or strip the threads within the electronics enclosure.
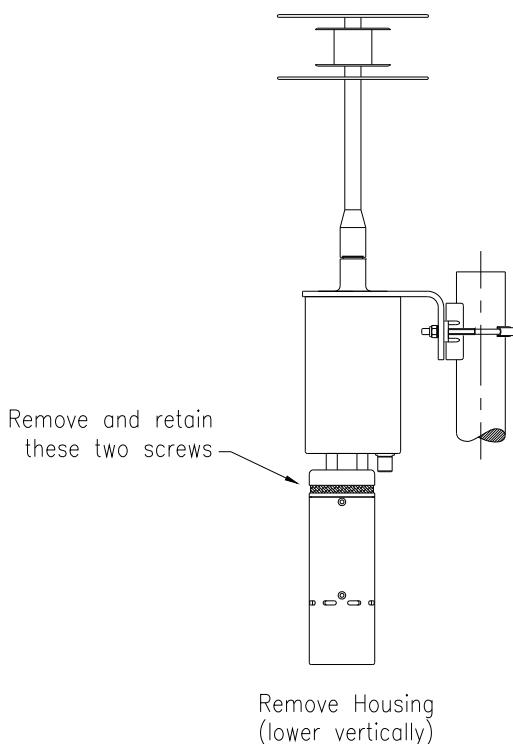
MET3A Maintenance Procedures

Periodic cleaning of the housing, barometer port inlet and temperature / humidity sensor is the only recommended physical maintenance of the unit.

Barometer Port Removal

The cleaning procedure consists of unscrewing the barometer port in a counterclockwise direction, cleaning out any debris from between the upper and lower plates and the adjacent orifice plates and checking for unobstructed flow through the port assembly. If flow is still obstructed, the upper plate and upper orifice plate may be removed by unscrewing the ½-20UNF flat head socket screw on top of the port. Use a 5/16" Allen hex wrench. This allows access to both the orifice plates and the interior of the upper end of the column. Remove any debris from the various orifices and reassemble, applying a small amount of Loctite 609 to the screw. Torque the screw to 25 ft/lbs to secure the assembly. Prior to re-installation of the pressure port it is recommended that the Teflon pipe tape on the male ¾" thread be removed and replaced with at least three wraps of fresh tape. Carefully re-mate the barometer port to the main body of the instrument and screw the two together, *HAND TIGHT*. Do not over-tighten these threads. Over-tightening could cause damage to the threads and impede future disassembly. **Do not permit water to enter the exposed port on the electronics enclosure.**

Cleaning the Barometer Condensation Drain

The condensation drain is the brass fitting with a sintered stainless steel screen, located on the underside of the upper body adjacent to the electrical connector. Inspect the screen for contamination and if necessary, clean the screen with a nylon brush and distilled water.

Remove and retain
these two screws

Remove Housing
(lower vertically)

MET3A

Cleaning the Temperature / Humidity Sensor

You may visually check the aspirated portion of the enclosure for contamination. Prior to any cleaning activity, turn off the power. The screens are intended to prevent large particles from entering the system. Clean these with a nylon brush. It is necessary to remove the lower portion of the MET3A aspirated temperature / humidity system to access the sensor. Locate the two hex head screws found just below the upper screen and remove using a 3/32" Allen hex wrench. Carefully slide the outer housing down. You may encounter a small amount of resistance while removing this housing due to the O-ring seals. Do not force the housing off the assembly. Once removed, you will see the temperature / RH sensor mounted within the isothermal block. Clean the sensor screen with distilled water. Sensors which have become heavily contaminated may be scrubbed off with a nylon brush and distilled water. Inspect or replace and lubricate the O-rings with any silicone-based O-ring lubricant. Carefully re-assemble the outer housing.

Aspiration Fan Replacement

The internal fan used to provide airflow for the temperature and humidity probe is a highly reliable weather-hardened device requiring little or no maintenance. In the unlikely event of a failure do not replace it with a standard fan assembly. It is recommended that you contact Paroscientific to obtain all the appropriate replacement parts and instructions for performing this procedure.

CALIBRATION OF MET3/MET3A SENSORS

Pressure Sensor

The MET3A uses a Digiquartz Barometric Standard that offers ±0.08 hPa accuracy and a 3-year stability warranty of better than 0.1 hPa per year.

Pressure Calibration Overview

All Digiquartz Barometric Standard transducers are calibrated and conformance tested over their operational pressure and temperature ranges against NIST-traceable standards.

Transducer output and applied pressure are recorded at test pressures that span the transducer range over a minimum of at least six different temperatures. These measurements are used to derive calibration coefficients for the best fit for each individual transducer. The differences between the indicated pressures and the applied pressures from the primary standard are less than ±0.08 hPa for Digiquartz barometers.

Temperature Sensor

The temperature sensor is a precision thin-film platinum 1000-ohm resistance element (RTD). The sensor was chosen for its accuracy and long-term stability. The resolution of the sensor is better than 0.01 degree C and the accuracy is better than ±0.1 degree C over the full temperature range from –50 to + 60 degrees C.

MET3 Only: The temperature probe is surrounded by a Gill multi-plate solar shield, which greatly reduces the effects of direct and reflected solar radiation. When placed in full sunlight and still air, the temperature rise at the sensor is approximately 1 degree C. This effect decreases rapidly with wind speed, and is less than 0.4 degrees C at a wind speed of 3 m/s.

MET3A Only: The time constant of the fully packaged sensor is approximately 15 minutes, and the self-heating of the sensor in still air is less than 0.07 degree C. The temperature probe is surrounded by a fan-aspirated solar shield, which greatly reduces the effects of direct and reflected solar radiation.

Temperature Calibration Overview

MET3 Only: The MET3 electronics and temperature sensors are separately calibrated against a NIST traceable temperature reference standard over the entire operational temperature range. The resulting coefficients for the electronics and the temperature sensor are combined into a single set of system-level coefficients. Each MET3 is then conformance tested over the entire operational temperature range to ensure specified temperature measurement accuracy.

MET3A Only: The MET3A incorporates a precision thin-film RTD to sense temperature. A thermal chamber is used to control environmental temperature, and an independently calibrated, NIST traceable thermistor is used as a temperature reference.

The MET3A humidity/temperature sensor is enclosed in a small isothermal block that includes a bore designed to accept a standard 0.125" diameter temperature reference probe. The bore terminates in close proximity to the humidity/temperature sensor, assuring good isothermal contact between it and the temperature reference probe. The MET3A RTD sensor and electronics are simultaneously calibrated by taking reference probe temperature and MET3A temperature measurements at various stable points over the range of –50 to +60°C, and adjusting the MET3A temperature coefficients to correct for combined temperature sensor and electronics nonlinearity. This process yields system temperature measurement accuracies of ±0.1°C or better over the temperature range of –50 to +60°C.

Relative Humidity Sensor

The humidity sensor uses a polymer capacitance element. It was selected for its accuracy, stability, and resistance to contamination. Its output is corrected for temperature effects over a wide temperature range.

MET3 Only: The time constant of the RH sensor in slowly moving air is approximately 5 minutes (longer for high humidity). Very large steps in humidity can require considerably longer for full equilibrium. A step change of 75% RH settles within 5% of final value in 10 minutes and within 1% of final value in 2.5 hours. In addition, there can be hysteresis effects of a few percent after prolonged exposure to humidity above 90% RH. Exposure of the humidity sensor to condensing conditions can lead to humidity readings in excess of 100%, however, the probe will recover after several hours return to reduced humidity atmospheric conditions.

MET3A Only: The recovery time of the aspirated RH sensor is typically less than 2 minutes. Very large steps in humidity can take longer to reach full equilibrium. A step change of 75% RH settles within 5% of final value in 2 minutes and within 1% of final value in 5 minutes. In addition, there can be hysteresis effects of a few percent after prolonged exposure to humidity above 90% RH.

Relative Humidity Calibration

The MET3/MET3A humidity sensor is a standard humidity probe characterized by the manufacturer. All MET3/MET3A units are conformance tested against a transfer standard to ensure proper performance.

MET3/3A INTELLIGENT INTERFACECOMMAND SUMMARY

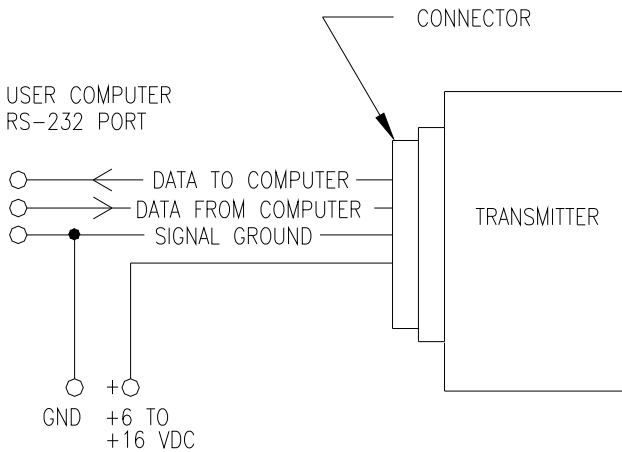| COMMAND	DESCRIPTION	INPUT COMMAND	OUTPUT RESPONSE
P9	Sample and respond with NMEA formatted data values	*0100P9	$WI,XDR,....
NH	Return User Defined NMEA header ($WI, - default)	*0100NH	*0001NH=$WI,
TT or A1	Sample & return external temperature measurement in °C	*0100TT (*0100A1)	*0001##.##
RH or A2	Sample & return an external humidity measurement in percentage	*0100RH (*0100A2)	*0001##.#
N1	Sample & return an analog integer count for analog channel 1 (T)	*0100N1	*0001######
N2	Sample & return an analog integer count for analog channel 2 (RH)	*0100N2	*0001######
AR	Return current analog resolution; AR=0 then output resolution is 0.1 °C, 0.1% RH; AR=1 then output resolution is 0.01 °C, 0.1% RH	*0100AR	*0001AR=0 *0001AR=1
Z1	Set/Return zero adjustment coefficient for analog channel 1 (T)	*0100Z1	*0001Z1=######
Z2	Set/Return zero adjustment coefficient for analog channel 2 (RH)	*0100Z2	*0001Z2=######
M1	Set/Return the span adjustment coefficient for analog channel 1 (T)	*0100M1	*0001M1=#######
M2	Set/Return the span adjustment coefficient for analog channel 2 (RH)	*0100M2	*0001M2=#######
E1	Set/Return temperature coefficient E1	*0100E1	*0001E1=######
F1	Set/Return temperature coefficient F1	*0100F1	*0001F1=######
G1	Set/Return temperature coefficient G1	*0100G1	*0001G1=#######
H1	Set/Return temperature coefficient H1	*0100H1	*0001H1=#######
K1	Set/Return temperature coefficient K1	*0100K1	*0001K1=######
E2	Set/Return humidity coefficient E2	*0100E2	*0001E2=######
F2	Set/Return humidity coefficient F2	*0100F2	*0001F2=######
G2	Set/Return humidity coefficient G2	*0100G2	*0001G2=#######
H2	Set/Return humidity coefficient H2	*0100H2	*0001H2=#######
K2	Set/Return humidity coefficient K2	*0100K2	*0001K2=######
EW	Enable EPROM write for one command string. May be a global command. Example: Change E1 temperature coefficient to 0.1	*0100EW....(cmd) *0100EW *0100E1=0.1	Cmd Response *0001E1=.1000000

14. SUPPLIMENTAL INFORMATION

APPENDIX A

HOOKUP FOR RS-232 ONLY DIGIQUARTZ SENSORS

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 enabling jumper pins on the computer connector. If messages cannot be retrieved from the transmitter, ensure 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

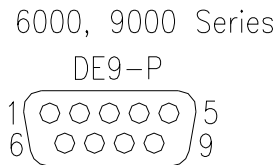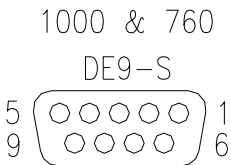**CONNECTOR PIN ASSIGNMENTS**

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:

```
   1000 & 760                 6000, 9000 Series
     DE9-S                        DE9-P
5 ( O O O O O ) 1          1 ( O O O O O ) 5
9 (  O O O O  ) 6          6 (  O O O O  ) 9
```
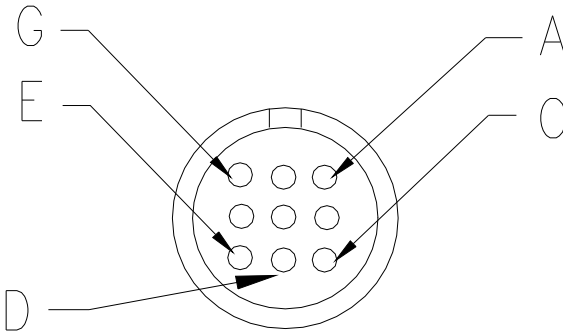
CONNECTOR PART NO.:   Type DE9-S
MATING CONNECTOR: Type DE9-P

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
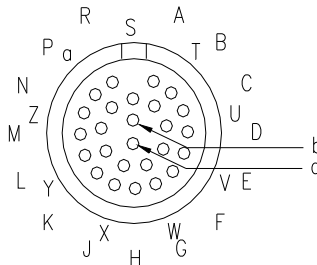
26-PIN BENDIX MS CONNECTOR

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   DO
        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
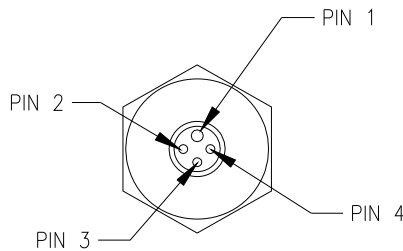
Connector Diagram:

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
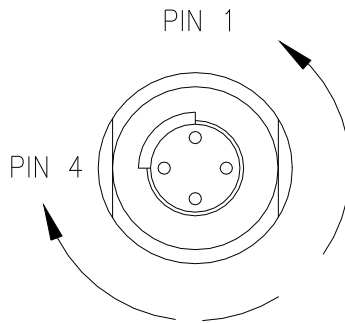   PIN 4   POWER (SEE SCD)

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.

APPENDIX D

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 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:

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

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

where: Tau = pressure period in microseconds

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

Temperature coefficients: $U_0 \ Y_1 \ Y_2 \ Y_3$

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

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:

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

where **P** is the pressure calculated using the original calibration coefficients and the selected unit 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: **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
R1.01	General maintenance revision
R2.00	Support for S3 Processor
R2.01	General maintenance revision
R3.00	Added power-saving features
R4.00	General maintenance revision
R4.01	General maintenance revision
R4.02	General maintenance revision

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

VERSION	MODEL
60.xx	Model 760
M1.02	MET3/MET3A

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[10] Dump sequential. Sends stored values in sequential order.

CONFIGURATION CONTROL COMMANDS

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[11] Sets transmitter parity. Must be global.
EW Enable EEPROM write for one command.

---

[10] NOT SUPPORTED FOR TRANMITTERS AND DEPTH SENSORS SHIPPED WITH FIRMWARE VERSIONS R1.00 - R2.01.

[11] 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

PI   Set or read the pressure measurement integration time
TI   Set or read the temperature measurement integration time
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_2O

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.

TIME REFERENCE STAMP COMMAND

TS   Enables and disables the time reference stamp feature.

SPECIAL DIAGNOSTIC COMMANDS

MC[12] Memory check. Checks program PROM.
CS   Check stack of microprocessor.
CT[12] Check counter timebase.
CX[12] Check crystal of microprocessor clock.

NANO-RESOLUTION COMMANDS

XM   Resolution mode.
IA   IIR mode cut-off frequency.
XN   Number of significant digits.

---

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

CALIBRATION COMMANDS

*WARNING!! THE FOLLOWING COMMANDS AFFECT PRESSURE
        TRANSDUCER ACCURACY.*

SN[13] Read/enter transmitter serial number.
PA   Read/enter pressure adder.
PM   Read/enter pressure multiplier.
TC[13] 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.

---

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

NOTES: