Paroscientific, Inc.
Digiquartz® Pressure Instrumentation

Digiquartz Broadband Intelligent Instruments with M7 Processor for RS-232/RS-485 Interfaces

Series 1000 / 6000 / 9000
Intelligent Pressure Transmitter

Series 8000 Intelligent Depth Sensor

Intelligent Seismic Sensors

RS-232 / RS-485 Serial Interface Board

User Manual

"The standard by which other standards are measured"

Digiquartz®
Technology

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Digiquartz® Broadband Intelligent Instruments with M7 Processor for RS-232 and RS-485 Interfaces

User Manual

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1 Introduction

Thank you for your recent Digiquartz® Intelligent Transmitter, Depth Sensor, Triaxial Accelerometer or Tiltmeter purchase. This manual describes operation of the entire line of Paroscientific Digiquartz Intelligent devices that feature the M7 Intelligent Board (firmware version KX.XX) and also equipped with single RS-232 or dual RS-232/RS-485 ports. Note that this document does not apply to previous generation instruments with firmware versions QX.XX, RX.XX or SX.XX. For the latest updates, information, and legacy product support, please visit our website at www.paroscientific.com.

NOTE: To determine if your Digiquartz Intelligent device supports dual RS-232/RS-485 or RS-232 only serial interface, please refer to product documentation.

1.1 Latest Features

The new board using the M7 processor and is backward compatible with most older commands used in previous generations of boards (see manuals 8819-001 and 8820-001 on our website). It also has several new features that are described below.

Butterworth Filter Setting - The M7 board uses 6th order Butterworth filters as the anti-aliasing filters, which allow a signal response that is as flat as possible in the passband. The filter corner frequency can be set using the **BC** parameter; refer to Section 6.3.1, page 64 for more information.

Power Optimization Setting - In certain applications where available power is limited, the power consumption of the board can be reduced by sacrificing high frequency counting capability (counting noise). This can be set using the **VP** command; refer to Section 5.10, page 45 for details.

Resonance Correction Setting - The seismic sensors are open loop sensors, some with low resonant frequencies (in 5-30 Hz range). The response of the sensor at resonance can be electronically compensated with the M7 board. This feature can be enabled/disabled using the **NE** command; refer to Section 5.17, page 58 for details.

Data Logging - The M7 board has the capability of locally logging around 50,000 to 100,000 samples (output lines) depending on the type of output, when the board is supplied with power. The commands **LZ**, **LR**, **LX** and **LS** are supported. Refer to Section 5.16, page 56 for more information on data logging commands.

Sleep Mode - As before, the **SL** command enables/disables sleep mode, while the **ST** command sets the timeout parameter for the sleep mode. A new command, **SO**, is used with the M7 board to immediately command the board to sleep. Refer to Section 5.10, page 45 for more information on sleep mode commands.

Higher Baud Rate Support - The M7 board can support higher baud rates of up to 230400 while still using the same command format as before. For baud rates greater than 115200, the user must issue the **VR** command (using the higher baud rate) within 15 sec to confirm the new baud rate. Refer to page 27 for more information on managing baud rates.

GPS Receivers and PPS Input - Digiquartz Intelligent Transmitters with a pulse-per second (PPS) input and firmware KX.XX can interface with compatible GPS receivers. An optional timestamp can be included with measurement command responses. The timestamps can be used with or without a GPS receiver or PPS input signal. The timestamp has several formatting options, and can be positioned just after the address header or at the end of the measurement command response. Please refer to Section 9 beginning on page 79 for additional information on using GPS receivers.

Unsupported Features - Some previously available features are not supported with the M7 processor:

- The **FM**, **OI, P7**, **PS**, **PR** and **TR** commands are not supported.
- The relative timestamp is not supported. M7 instruments instead utilize absolute timestamps, with the option of time/date data and PPS timing signal provided by a GPS receiver.

1.2 Conventions Used In This Manual

The following conventions are used throughout this manual:

Digiquartz Intelligent Device - Any Series 1000, 6000, or 9000 Intelligent Transmitter, or Series 8000 Intelligent Depth Sensor.

Digiquartz Intelligent Transmitter - Any model from the Series 1000, 6000, or 9000 product lines.

Digiquartz Intelligent Depth Sensor - Any model from the Series 8000 product line with RS-232 and/or RS-485 capabilities.

Digiquartz Seismic Sensor - Any model from the Accelerometer or Tilt Meter product line with RS-232 and/or RS-485 capabilities.

CAUTION

is used to draw your attention to a situation that may result in an undesirable outcome, but will not damage an Intelligent device.

WARNING

is used to draw your attention to a situation that may result in permanent damage to an Intelligent device.

DANGER

is used to draw your attention to a situation that may result in injury.

1.3 Warnings and Safety Precautions

Digiquartz Pressure Transmitters and Depth Sensors are precision devices, and as such, they should be operated with a certain degree of care to ensure optimum performance.

WARNING

It is recommended that the input pressure typically not exceed 1.2 times the rated full-scale pressure. Calibration can be affected if this limit is exceeded, and permanent damage can result if the unit is sufficiently over-pressured. Certain custom products may have lower requirements; please refer to the product SCD for actual safe pressure rating.

WARNING

Excessive mechanical shock may cause irreparable damage. Do not drop an Intelligent device, or allow tools to fall on the unit or its pressure port.

1.4 Hardware Descriptions

1.4.1 Intelligent Transmitters (Series 1000 / 6000 / 9000)

Digiquartz Intelligent Transmitters consist of a pressure transducer and a serial interface board in an integral package. Commands are sent and measurement data is received via one RS-232 and one RS-485 serial port. Measurement data is provided directly in user-selectable engineering units with a typical total accuracy of 0.01% or better over a wide temperature range. Pressure measurements are fully temperature compensated using a precision quartz crystal temperature sensor. Each intelligent transmitter is preprogrammed with calibration coefficients for full plug-in interchangeability.

1.4.2 Intelligent Depth Sensors (Series 8000)

Digiquartz Intelligent Depth Sensors consist of a pressure transducer and a serial interface board in a rugged waterproof package. Commands are sent and measurement data are received via one RS-232 and one RS-485 serial port. Measurement data is provided directly in user-selectable engineering units with a typical total accuracy of 0.01% or better over a wide temperature range. Pressure measurements are fully temperature compensated using a precision quartz crystal temperature sensor. Each intelligent depth sensor is preprogrammed with calibration coefficients for full plug-in interchangeability.

1.4.3 Intelligent Seismic Sensors

The Paroscientific seismic sensor product line offers the unique advantages of resonant quartz crystal technology for seismic and geodetic measurements. The sensors are inherently digital, ultra compact and consume low levels of power, while at the same time offer large sensing ranges, extremely low self noise and market leading stability. The remarkable performance of these sensors is achieved through the use of a precision quartz crystal resonator whose frequency of oscillation varies with induced stress. The devices are thermally compensated to achieve a high degree of accuracy over a broad range of temperatures.

Traditional broadband seismometers do not have the range to measure strong seismic events, and traditional strong motion sensors lack the sensitivity or stability to make good long-term measurements. In order to achieve this for events such as earthquake shaking, tilt, Earth tides, slow slip events and geodesy, high resolution measurements are required over a time span ranging from fractions of a second to years.

Triaxial Accelerometer (Series QA15 / QA30) - Digiquartz Intelligent Triaxial Accelerometers consist of a 3-axis seismic sensor and attached serial interface board. Commands are sent and measurement data is received via one RS-232/RS-485 serial port. Measurement data is provided directly and has a full-scale range of 1.5 g's and 3g's respectively. The QA-30 is highly compact and has a high resonant frequency (>150 Hz). The QA-15 offers an order of magnitude lower noise level than the QA-30 and has a resonant frequency close to 25 Hz. Both sensors have an internal alignment matrix that uses the invariance of the Earth's gravity vector as a reference to measure seismic events and the resultant earth movements. With these features, improved high-resolution measurements of earthquakes, tilt, slow-slip and other long-term events can be reliably made.

Dual-Axis Tiltmeter (Model QT2) - Digiquartz Intelligent Tiltmeters consist of a 2-axis seismic sensor and attached serial interface board. Commands are sent and measurement data is received via one RS-232/RS-485 serial port. Measurement data is provided directly, with a typical resolution exceeding 0.2 nanoradian and a shelf noise that is very low. Coupled with low intrinsic temperature sensitivity and high stability, the Tiltmeter is the perfect tool for making highly sensitive long-term tilt measurements in applications such as borehole monitoring, seafloor movement, volcanic studies, and more.

2 Features and Functions

The following features and capabilities are common to all Digiquartz Intelligent Transmitters and Depth Sensors except as noted. For the added benefits of nano-resolution signal processing, please refer to Section 6, page 63 for details.

2.1 Measurement Basics

The outputs from Digiquartz transducers are two square wave signals whose period is proportional to the applied input signal and internal transducer temperature. This signal may be pressure for pressure transducers, acceleration for accelerometers, and so forth. In the rest of this manual for convenience, the standard convention will be to use "pressure" as the default input signal. The Intelligent electronics measures these signals using a technique similar to that of a common laboratory frequency counter. Like the frequency counter, a signal must be integrated, or sampled, for a specified period of time to measure its period. The time over which the signal is sampled determines the resolution of the measurement. Longer sampling times increase resolution, but result in a slower sampling rate.

Digiquartz Intelligent devices with the M7 processor allow one to set the integration time between 0.001 and 85 seconds in 0.001 second increments. Pressure and temperature integration times can be set independently. Measurements can be continuously taken in the background, or can be initiated when a measurement command is received. These features can be used to configure the intelligent device according to the data acquisition and resolution requirements of your application. Refer to Section 7.1, page 69 for more information about integration time, resolution, and sampling rate.

> **NOTE:** For convenience in the rest of this manual, the standard convention will be to use "pressure" as the default input signal. For Accelerometer and Tiltmeter users note that your output signal will not be in pressure units.

2.2 Measurement Descriptions

The pressure and temperature signals of the transducer are sampled, or integrated, and different types of outputs are provided depending on the measurement requested.

PRESSURE MEASUREMENTS

Pressure measurements are by far the most common. Pressure measurements are fully temperature-compensated, and therefore require an internal temperature measurement.

When a pressure measurement is made, the following sequence occurs:

1. The temperature and pressure signal periods are measured simultaneously.
2. A temperature-compensated pressure value is calculated using the pressure period, temperature period, and the calibration coefficients.
3. The pressure value is output.

INTERNAL SENSOR TEMPERATURE MEASUREMENTS

Internal sensor temperature is normally only used for temperature compensation of pressure, but can be requested independently (or along with pressure) for diagnostic purposes.

When an internal sensor temperature measurement is made, the following sequence occurs:

1. The temperature signal period is measured.
2. The temperature value is calculated using the temperature period and the calibration coefficients.
3. The temperature values are output.

PRESSURE AND TEMPERATURE PERIOD MEASUREMENTS

Period measurements are used mainly for calibration and diagnostic purposes, but may be useful in high-speed sampling applications. For more details on using measurement commands, please refer to Section 5.3 beginning on page 30.

NANO-RESOLUTION

With nano-resolution enabled it is possible to achieve parts-per-billion resolution as opposed to parts-per-million resolution in standard mode. This feature can be easily enabled/disabled via serial commands. Please refer to Section 6 beginning on page 63 for additional information on using this feature.

2.3 Sampling Types

Options available for measurement sampling are listed below. Refer to Section 5.3, page 30 for detailed measurement command descriptions.

Single Measurement Sampling - These commands will output a single measurement value each time the command is received.

Continuous Measurement Sampling - These commands will repeatedly output measurement data until commanded to stop.

Sample and Hold Measurement Sampling - These commands are similar to single measurement sampling, but the measurement value is not output until a separate command is sent. This type of sampling is useful when you need to simultaneously trigger measurements from multiple units, and then read them one by one in a particular order.

2.4 Engineering Units

Pressure values can be expressed in the following engineering units:

- psi
- hPa (mbar)
- bar
- kPa
- MPa
- in Hg
- mm Hg (torr)
- m H_20
- user-defined units

Acceleration values can be expressed in meters per second squared (m/s^2) or g-force (g). Tilt values are expressed in radians (rad). For details on how to change the units of measurement using the **UN** command, refer to page 44.

Internal temperature values can be expressed in units of Celsius or Fahrenheit (°C or °F). Refer to the **TU** command on page 45 for details.

2.5 Serial Data Output Modes

In addition to the sampling types described in Section 2.3, Digiquartz Intelligent devices can also be configured to provide continuous pressure measurement data whenever power is applied. Refer to Section 5.8, page 42 for details.

2.6 Power Management

You can configure a Digiquartz Intelligent device to automatically switch to a low power "sleep" state after a user-defined period of serial inactivity, thus conserving power. When serial activity resumes, the unit will "awaken", allowing normal operation. With the M7 processor, sleep mode is also now available to use with continuous pressure output or nano-resolution.

The power consumption of the board is dependent on the microcontroller system clock and counting clock frequencies. Faster clock frequencies enable faster processing of the quartz resonator period, in turn reducing jitter or counting noise. However, not all applications require fast sampling and low counting noise. In such cases, the user might prefer to lower the power consumption by reducing clock frequencies. The **VP** command provides a simplified control for optimizing power consumption versus performance.Refer to Section 5.10, page 45 for details.

2.7 Tare and Overpressure

You can configure the Digiquartz Intelligent device to subtract a value from each subsequent pressure measurement. This process is referred to as 'taring.' You can tare to the current pressure value, or to any value you specify. Taring can be initiated by contact closure via a dedicated digital input line, or by serial command. A dedicated digital output and/or a special character in the measurement data can be used to indicate whether taring is in effect. Refer to Section 5.11, page 47 and Section 10, page 91 for details.

You can configure the Digiquartz Intelligent device to indicate whether the measured pressure exceeds a user-specified setpoint. This indication is provided via a dedicated digital output line. Refer to sections cited in previous paragraph for details.

> **NOTE:** Tare and overpressure I/O lines are not available for RS-232 only instruments, Digiquartz Intelligent Depth Sensors, Accelerometers, or Tiltmeters.

2.8 Measurement Data Formatting

Several serial data formatting options have been provided, and are listed below. Refer to Section 5 beginning on page 27 for details on using the commands discussed below.

User-Defined Commands - Lets you create your own custom measurement commands, containing any combination of measurement values and text strings. See the **OF** and **OM** commands for details.

Engineering Unit Suffix - Appends the engineering unit to pressure and temperature measurement data. See the **US** command for details.

Underscore Separator - Adds underscore(s) to pressure and temperature measurement data to separate the measurement value from the address header and optional engineering unit. See the **SU** command for details.

Tare Indicator - Adds an uppercase 'T' character to pressure measurement data to indicate a tared value. See the **ZI** command for details.

Fixed Field Data Format - Converts measurement data to a predictable fixed-length and fixed-position format to simplify parsing by data loggers and other programmable serial hosts. See the **DL** command for details.

User-Defined Unit Label - Lets you define the 4-character unit label to be used when the user-defined pressure unit is selected. See the **UM** command for details.

2.9 RS-232 and RS-485 Serial Communications

Commands for Digiquartz Intelligent devices are sent via serial communications. Response data, if any, will be output from the port that received the command. Common baud rates between 300 and 230400 baud are fully supported. Higher baud rates up to 460800 are possible but have not been fully tested. The serial protocol is fixed at 8 data bits, no parity, and 1 stop bit.

Up to 98 units and an RS-232 serial host can be interconnected to form a serial loop network. Additionally, up to 98 units and an RS-485 serial host can be interconnected to form a 2-wire or 4-wire RS-485 multi-drop network. Refer to Sections 5.1, 8.3, 8.4 and 11 for more details on networking.

Communication with a specific Digiquartz Intelligent device occurs by sending commands to its ID number. You can also send certain commands to all devices on a network by sending the command to the global address. Refer to Sections 4.3, 4.4 and 5.15 for details.

2.10 Differences Between RS-232 and RS-485 Ports

Generally, Digiquartz Intelligent devices respond identically to commands received on either port, with the following exceptions:

- Global commands received by the RS-232 port are re-transmitted. This enables a global command to be relayed to each device in an RS-232 serial loop network. Refer to Section 8.4, page 76 for more information about RS-232 serial loop networking.
- Commands received by the RS-232 port that are addressed for other devices are re-transmitted. This behavior is necessary to support RS-232 serial loop networking. Refer to Section 8.4, page 76 for more information about RS-232 serial loop networking.
- Global commands received by the RS-485 port never generate a response. This prevents a data collision from occurring if all devices on a multi-drop network were to respond simultaneously. Refer to Section 8.3, page 74 for details.

2.11 Calibration

Digiquartz Intelligent devices are shipped fully calibrated. Calibration data is shipped with the unit in printed form, and is also stored within the device in non-volatile memory. These values should not be modified unless it is absolutely necessary to do so, and then only with extreme caution.Refer to Section 13, page 105 for details.

2.12 Instrument Identification

Digiquartz Intelligent devices are shipped with several instrument identification values stored in non-volatile memory. These read-only values include:

- Serial and model numbers
- Full-scale pressure
- Transducer type.

Refer to Section 5.13, page 52 for details.

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3 Installation and Quick Start

3.1 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 transmitter 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 transmitter pressure port and the pressure source at the same elevation, or by making an offset correction to compensate for the pressure head.

3.1.1 Pressure Ports and Buffer Tubes

Digiquartz Intelligent Transmitters typically include a nylon or stainless steel buffer tube. The buffer tube is an integral part of the mechanical shock protection system of the device.

Parker A-Lok or equivalent nut and ferrule compression tube fittings are used on most Digiquartz Intelligent Transmitters. The Series 1000 devices use 1/8" diameter tube fittings for installation. 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.

The Series 9000 transmitters use a 1/4" Modified HIP or equivalent fitting. A 5/8" wrench and 3/4" wrench are required to make and break these connections.

CAUTION

It is recommended that new pressure fittings are installed finger tight, then wrench-tightened an additional ¾ turn to complete the pressure seal. To remake an existing pressure fitting, install finger-tight and wrench-tighten just enough to achieve a seal. Over-tightening an existing fitting may cause irreversible damage to the connector seat.

WARNING

Avoid making connections directly to the transmitter pressure fitting. Make connections to the buffer tube fitting wherever possible. If the transmitter pressure fitting becomes flared, stripped or damaged, it will be necessary to return the unit to Paroscientific for repairs.

WARNING

Do not remove the buffer tube. It is an integral part of the mechanical shock protection system of the transmitter.

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

3.1.2 Oil Filled vs. Non-Oil Filled Units

OIL FILLED TRANSMITTERS

Transmitters intended for liquid media pressure measurements 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 dry 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.

3.2 Quick Start

This section will help you to quickly connect your Digiquartz Intelligent device to the RS-232 serial port of a standard PC, establish communications, and take your first pressure measurements.

This process will be much simpler and easier if you have purchased a Power Module Kit. The kit specific to your device see below:

FOR DUAL RS-232 / RS-485

P/N 1294-003 universal kit:

- Power adapter module, P/N 6671-003
- Universal power supply, P/N 6024-003
- 9-pin serial cable, P/N 6409-014

FOR RS-232 ONLY

P/N 1291-003 universal kit:

- Power adapter module, P/N 6671-001
- Universal power supply, P/N 6377-009
- 9-pin serial cable, P/N 6409-014

Additionally, Digiquartz Intelligent instruments with a pulse-per second (PPS) input and firmware KX.XX (M7 processor) or QX.XX (M3 processor) can interface with compatible GPS receivers. To use this feature, the following kit is available:

GPS INTERFACE KIT

P/N 1055-005 kit for M7/M3 processor:

- Power adapter module, P/N 2378-002
- Universal power supply, P/N 6024-003
- 9-pin serial cable, P/N 6409-014

3.2.1 Connect Up the System

IF YOU HAVE THE POWER MODULE KIT:

- Connect up the system as shown in Figure 11-12 on page 99.
- Plug in the wall power supply.

IF YOU DON'T HAVE THE POWER MODULE KIT:

- Connect up the system as shown in Figure 11-13 on page 99.

IF YOU HAVE THE GPS INTERFACE KIT:

- Interface with the GPS using instructions and figures found in Section 9.3 beginning on page 83.

3.2.2 Run Digiquartz Interactive 3 (DQI3)

- Install Digiquartz Interactive 3 (DQI3) on your Windows-based PC. DQI3 can be found at www.paroscientific.com. DQI3 is compatible with both 32 and 64-bit Windows operating systems.
- Connect the RS-232 port of your instrument to the serial communications port on your PC, and power up the instrument.
- Run DQI3, the start-up screen will be displayed as default.
- Select the *Configuration and Monitoring* option, then select the COM port if known, otherwise select *All*.
- Click *Find Devices*. DQI3 will attempt to detect the instrument, and if successful, will display its serial number and communications parameters.

NOTE: For users with multiple networked devices, select a single device under *Devices Detected* before proceeding. If the search ends and your instrument is not located, close DQI3 and ensure that your instrument is powered and properly connected to the PC serial communications port before running DQI3 again.

- Once all instruments have been located, select the desired instrument and click *Select Device* to set up parameters and begin taking measurements.

Congratulations, you are now ready to take your first pressure measurement! We encourage you to use DQI3 to explore the remaining functions of your Digiquartz Intelligent device. Please refer to the Help function in DQI3 and Section 4.6, page 25 for more information.

NOTE: For optional data-logging capabilities, please refer to document 8822-001 on using the Paroscientific Serial DataLogger, kit PN 1886-001.

4 Operation

4.1 Compatible Serial Hardware

Digiquartz Intelligent devices are compatible with any equipment that conforms to the EIA RS-232 and/or RS-485 specifications. They are also backward compatible with earlier Intelligent devices that support RS-232 only, and can be used together in RS-232 serial loop networks.

4.2 Serial and Power Connections

Serial and power connections are made via a 15-pin high-density D-Sub connector for dual RS-232/485 devices, or 9-pin D-Sub connector for RS-232 only devices. Refer to Section 11.1, page 93 for connector pin details, and Section 11.2, page 98 for detailed system wiring diagrams.

It is recommended that you establish communications and verify transmitter operation prior to permanently installing the device. The Power Module Kit simplifies the task of powering the transmitter and making serial connections to a PC or other serial host. Refer to Section 3.2, page 21 for details.

> **NOTE:** The Power Module Kits are intended for use with Digiquartz Intelligent transmitters, and are not compatible with Intelligent depth sensor products.

4.3 Communications

Digiquartz Intelligent devices are initially configured for RS-232/RS-485 communications at 9,600 baud. The serial protocol is fixed at 8 data bits, no parity, and 1 stop bit. Each Intelligent device has an ID number, and will only respond to commands sent to its ID number or 99. ID number 99 is reserved as a global address, which can be used to send a single command to multiple devices at once. The ID number is initially configured to 01, but you can set the ID number to any value between 01 and 98.

It is recommended that Digiquartz Interactive 3 (DQI3) software be used to establish initial communications with your transmitter. Refer to Section 3.2, page 21 for details.

You may also use any terminal program that is configured for the proper baud rate and serial protocol. Your terminal program must also send a line-feed character (ASCII 10) with each carriage return.

4.4 Command and Response Basics

ASCII text commands are used to communicate remotely with the device.

The following basic tasks can be performed by sending the appropriate command:

- Take a measurement
- Perform a control function, such as changing the baud rate
- Set or read the value of an operating parameter, such as integration time

Measurement commands typically generate a response that contains the measurement data. Parameter-set commands typically generate a response that reports the updated parameter value. Parameter-read commands report the current parameter value.

When setting virtually all parameter values, you must precede the command with an **EW** command. This reduces the likelihood of accidental alteration of stored parameter values.

In general, when a command is being processed and another command is received, the device will abort the command in process and begin processing the second command, regardless of whether the commands are received via RS-232 or RS-485.

> **NOTE:** Due to internal resource limitations, commands sent simultaneously to both RS-232 and RS-485 ports may occasionally not generate a response. It is recommended that the serial host retry the command should this occur.

4.5 Command and Response Format

Commands sent to and responses received from the device are very similar, and are made up of the following:

START CHARACTER

The start character is an asterisk (ASCII 42 decimal).

DESTINATION ID

This is the Unit ID number of the device that is to receive the command or response. It is a two-digit integer between 00 and 99. ID 00 is reserved for the serial host, usually a PC. The factory default Unit ID number is 01.

SOURCE ID

This is the Unit ID number of device that is sending the command or the response. It is a two-digit integer between 00 and 98. ID 00 is reserved for the serial host, usually a PC.

COMMAND AND RESPONSE DATA

A wide variety of commands and resulting response data are possible, depending on the particular command used. Refer to Section 5 beginning on page 27 for more information on using commands.

TERMINATION CHARACTERS

All commands must terminate with a carriage return (ASCII 13 decimal) followed by a linefeed (ASCII 10 decimal). All command responses are terminated in the same manner.

COMMAND FORMAT

Commands are typically sent in the following format. The **P3** command is used in this example:

*0100P3CrLf

Where:

* = Start character	Asterisk, ASCII 42 decimal
01 = Destination ID	Unit ID of the device that is to receive the command.
00 = Source ID	Unit ID of the device that is sending the command (Serial host is ID 00)
P3 = Command	**P3** is an example. Refer to Section 5 for descriptions of the entire command set.
Cr = Carriage return	ASCII 13 decimal
Lf = Linefeed char.	ASCII 10 decimal

RESPONSE FORMAT

Responses are typically received in the following format:

*000114.4567CrLf

Where:

* = Start character	Asterisk, ASCII 42 decimal
00 = Destination ID	Unit ID of serial host that is to receive the response
01 = Source ID	Unit ID of device that is responding.
14.4567 = Data	Data sent in response to the prior command
Cr = Carriage return	ASCII 13 decimal
Lf = Linefeed char.	ASCII 10 decimal

These examples are typical, but other response forms exist. Refer to Section 5 for specific details regarding each available command.

4.6 Digiquartz Software

Paroscientific provides several software programs that simplify common measurement and configuration tasks. The latest versions of these and other software programs are available at the Paroscientific web site at www.paroscientific.com.

4.6.1 Digiquartz Interactive 3 (DQI3)

OVERVIEW

Digiquartz Interactive 3 (DQI3) is a Windows-based program that makes it easy to communicate with and configure Digiquartz Intelligent devices. We encourage you to install and use DQI3 to verify proper operation, configure your device, take measurements, and experiment with its functions. DQI3 supports both 32 and 64-bit operating systems.

DQI3 consists of two main sections: Configuration and Monitoring and Digiquartz Terminal.

CONFIGURATION AND MONITORING SECTION

The Configuration and Monitoring section allows one to set up a device and display measurement values without previous knowledge of device commands, as well as provide the advanced user with a powerful set of configuration tools.

With Configuration and Monitoring, you can:

- Establish communications with a device on any available com port, at any supported Unit ID and baud rate value.
- Perform common configuration functions.
- Store current configuration settings for future restoration needs.
- Save or print a configuration report.
- Save or print a diagnostic report.
- Take measurements and display measurement data.
- Plot measurement data and print graphs.
- Log timestamp measurement data to a file for analysis.

DIGIQUARTZ TERMINAL SECTION

The Digiquartz Terminal section allows one to communicate directly with the device at the most fundamental level using native commands. All possible configuration and measurement functions are available via the terminal interface. Digiquartz Terminal is designed especially for communication with Digiquartz Intelligent devices.

HOW TO USE DQI3

Refer to Section 3.2.2, page 22 for basic installation instructions. For additional information on using the program, one can also access the help function in DQI3.

5 Command Instructions

NOTE: For commands related to GPS, PPS, and timestamp please refer to Section 9. For commands related to Seismic applications, please refer to Section 5.17.

5.1 Enable Write Command

When setting virtually all parameter values, you must precede the parameter set command with an **EW** (enable write) command. Parameter set commands will usually be ignored unless they are preceded with this **EW** command.

EW **Enable the next parameter set command to write a new value into non-volatile memory.**

EW can be issued as a separate command by terminating it with a carriage return/line feed, or you can string the **EW** and parameter set commands together as shown below.

Typical Syntax:	*0100EW*0100UN=2
Alternate Syntax:	*0100EW
	*0100UN=800

NOTE: **EW** is only necessary when using commands to set a parameter value. It is not necessary to use **EW** to read a parameter value, or when using measurement commands.

5.2 Serial Communications Commands

The serial communications commands enable the baud rate and device ID to be set via the RS-232 or RS-485 ports.

BR **Set the baud rate for both ports**

Action:	Set both serial ports to the same baud rate.
Default:	9600
Typical Command:	*9900BR=19200
Typical Response:	*9900BR=19200

BR is a set-only command. It is not possible to read the value of **BR. BR** must be sent to the global Unit ID 99. **BR** cannot be sent to an individual Unit ID. Standard supported baud rates are 300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, and 115200 baud. Higher baud rates can be set but must be followed up by the **VR** command within 15 seconds, or unit will revert to previous baud rate.

NOTE: Under certain conditions, communication problems may occur at higher baud rates. If the problem persists, consider changing the baud rate to a lower setting.

M7 instruments also support baud rates unique to each RS-232 and RS-485 port. This feature is particularly useful when high-speed host communications occur on one port, and a GPS receiver is being used on the other port.

BR1 Set the baud rate for RS-232 port

Action:	Sets the baud rate for the RS-232 port only.
Typ. Set Command:	*9900BR1=19200
Typical Response:	*9900BR1=19200

BR2 Set the baud rate for RS-485 port

Action:	Sets the baud rate for the RS-485 port only.
Typ. Set Command:	*9900BR2=4800
Typical Response:	*9900BR2=4800

BL Lock or unlock the baud rate.

Typical Command:	*9900EW*9900BL=1
Typical Response:	*9900EW
	*0001BL=1
	*9900BL=1

BL can be read using either the global ID 99 or an individual unit ID. **BL** can only be set using the global ID 99. If the global command was successful, the responses on the RS-232 port include the **EW** command echo and a **BL** command response for each unit - this is due to the nature of the serial loop networking protocol. If the command was unsuccessful, the response will only be the command sent.

NOTE: Since **BL** set commands are sent to the global ID, they produce no response on the RS-485 port.

DA RS-485 2-wire delay compensating for serial converters.

Action:	Sets the minimum delay between a command and its response, ensuring adequate time for the RS-485 transceiver to switch.
Range:	0 - 1,000,000 µs
Default:	1500
Typ. Set Command:	*0100EW*0100DA=1500
Typ. Read Command:	*0100DA
Typical Response:	*0001DA=1500.000

PC RS-485 communications often involve USB/RS-485 or RS-232/RS-485 converters. When converters are used in RS-485 2-wire configurations, care must be taken to avoid data collisions by ensuring the target device does not respond to commands before the converter has a chance to switch the RS-485 transceiver from transmit to receive mode.

The **DA** command sets the minimum delay between a command and its response, ensuring adequate time for the RS-485 transceiver to switch. is

If you are experiencing garbled or missing serial data on a 2-wire RS-485 system with a serial converter, try increasing the **DA** value until proper command responses are received. Since different serial converter brands and models operate differently, it may be necessary to experiment with different **DA** values to find a setting that prevents data collisions but does not cause excessive delay.

ID **Set the Unit ID. ID must be sent to the global ID 99.**

Typical Command: *9900ID
Typical Response: *9901ID

RS-232 USAGE - With a single unit, **ID** sets the Unit ID of the unit to the source ID + 1. When used with a serial loop network, **ID** sets the Unit ID of the first unit to the source ID + 1. The unit then responds by incrementing the source ID. This behavior enables **ID** to set all units on the serial loop network to unique Unit ID values in ascending order, starting with the command source ID + 1. See Section 8.4, page 76 for more information on serial loop networking.

RS-485 USAGE - Use of the **ID** command is not recommended in RS-485 multi-drop networks, since all the units on the network would be set to the same Unit ID. To set a unique Unit ID for each unit to be used in a multi-drop network, set them one at a time prior to installing them in the network. Refer to Section 8.3, page 74 for more information on RS-485 networking.

XX **Reports the number of transducers and mode of operation.**

Action: This is a read only command that reports back a value that represents the number of transducers and modes of operation. Please refer to the table below for details.
Range: 1 to 8
Default: 1
Typ. Read Command: *0100EZ*0100XX
Typ. Read Response: *0001XX=5

NOTE: For the **XX** table below, "Press" refers to pressure transducer, "Temp" is temperature sensor, "Accel" is accelerometer, and "Tilt" is Tiltmeter.

TABLE 5-1: XX Mode Description

XX Value	Transducer Operation Mode	Description of Signals
1	Single Transducer	default
2	Two Pressure Transducers	2 Press, 2 Temp
3	Triax Accelerometer	3 Accel, 1 Temp, where the AX, AY, AZ axial alignment matrix correction is applied
4	Dual-axis Tiltmeter	2 Tilt, 1 Temp where the SX, SY axial alignment matrix correction is applied
5	Single-axis Accelerometer	1 Accel, 1 Temp
7	Four Pressure Transducers	4 Press, 4 Temp
8	SOS Mode	3 Accel, 2 Press, 3 Temp (Sets VP=5, XC=99)

For non-pressure sensors the relationship between XX and UN is as follows:

- When **XX**=3, 4 or 5 and **UN**=1, the unit of measurement = m/s^2
- When **XX**=4 and **UN**=2, the unit of measurement = radians, where radians = asin(m/s^2)/g), and g = 9.80708 m/s^2.
- When **XX**=4 and **UN**=3, the unit of measurement = degrees, where degrees = 180/Pi*asin((m/s^2/g), and g = 9.80708 m/s^2.
- Refer to page 44 for more information on using the **UN** command.

NOTE: **XX**=6 is currently not a user option.

5.3 Measurement Commands

The following commands are used to initiate measurements, and to control measurement integration time.

5.3.1 Single Measurement Commands

The following commands are used to initiate single measurements. They return the resulting measurement value as soon as it is available when in Integration Mode, or immediately if in Nano-Resolution.

P3 **Sample and send one pressure measurement.**

Action:	Measure pressure sensor temperature period and pressure period, calculate temperature-compensated pressure, send pressure value, and await next command.
Units:	As specified by **UN**
Typical Command:	*0100P3
Typical Response:	*00114.71234 (Value: 14.71234)

NOTE: Refer to Section 5.17, page 58 for additional information on using **P3** with seismic sensors.

THE FOLLOWING ARE LOW-LEVEL MEASUREMENT COMMANDS GENERALLY USED FOR DIAGNOSTIC PURPOSES:

Q3 **Sample and send one pressure sensor temperature measurement.**

Action:	Measure internal pressure sensor temperature period, calculate pressure sensor temperature, send pressure sensor temperature value, and await next command.
Units:	°F or °C, as selected by **TU**
Typical Command:	*0100Q3
Typical Response:	*000122.345 (Value: 22.345)

NOTE: **Q3** is the internal pressure sensor temperature, and is mainly used for diagnostic purposes.

P1 Sample and send one pressure period measurement.

Action:	Measure pressure period, send pressure period value, and await next command.
Typical Command:	*0100P1
Typical Response:	*000128.123456 (Value: 28.123456)

NOTE: Refer to Section 5.17, page 58 for additional information on using **P1** with seismic sensors.

Q1 Sample and send one pressure sensor temperature period measurement.

Action:	Measure internal pressure sensor temperature period, send pressure sensor temperature period value, and await next command.
Units:	Microseconds
Typical Command:	*0100Q1
Typical Response:	*00015.1234567 (Value: 5.1234567)

5.3.2 Continuous Measurement Commands

The following commands are used to initiate and control continuous measurements. Continuous measurement commands repeatedly take measurement samples and return measurement values until commanded to stop (or power is interrupted). Continuous measurements are canceled by sending any valid command.

P4 Continuously sample and send pressure measurement values.

Action:	Continuously sample and send pressure measurement values, and repeat until commanded to stop.
Units:	As specified by **UN**
Typical Command:	*0100P4
Typical Response:	*000114.71234 (Value: 14.71234) *000114.71235 (Value: 14.71235) *000114.71234... (Value: 14.71234)

NOTE: Refer to Section 5.17, page 58 for additional information on using **P4** with seismic sensors.

THE FOLLOWING ARE LOW-LEVEL MEASUREMENT COMMANDS GENERALLY USED FOR DIAGNOSTIC PURPOSES:

P2 Continuously sample and send pressure period measurement values.

Action:	Measure pressure period, send pressure period value, and repeat until commanded to stop.
Units:	Microseconds
Typical Command:	*0100P2
Typical Response:	*000128.123456 (Value: 28.123456) *000128.123457 (Value: 28.123457) *000128.123456 …(Value: 28.123456)

NOTE: Refer to Section 5.17, page 58 for additional information on using **P2** with seismic sensors.

Q2 Continuously sample and send temperature period measurement values.

Action:	Measure internal pressure sensor temperature period, send temperature period value, and repeat until commanded to stop.
Units:	Microseconds
Typical Command:	*0100Q2
Typical Response:	*00015.1234567 (Value: 5.1234567) *00015.1234568 (Value: 5.1234568) *00015.1234567…(Value: 5.1234567)

Q4 Continuously sample and send temperature measurement values.

Action:	Measure internal pressure sensor temperature period, calculate temperature, send temperature value, and repeat until commanded to stop.
Units:	°F or °C, as selected by **TU**
Typical Command:	*0100Q4
Typical Response:	*000122.345 (Value: 22.345) *000122.346 (Value: 22.346) *000122.345 … (Value: 22.345)

5.3.3 Compound Measurement Commands

Compound measurement commands return multiple measurement values. They ensure the measurement values are acquired simultaneously, and are more efficient and convenient than taking the measurements separately.

Three compound measurements are available:

- Pressure and temperature
- Pressure period and temperature period
- Pressure, pressure period, and temperature period

Compound measurements can be either polled, continuous initiated by a command, or continuous whenever power is applied. Refer to the **MD** command on page 42 for compound commands that produce data whenever power is applied.

> **NOTE:** For **E1** through **E6** commands, refer to Section 5.17, page 58 for additional information on using these commands with seismic sensors.

E1 **Sample and send one compound pressure period and temperature period measurement. Measurement values are formatted identically to P1 and Q1 commands.**

Action:	Take simultaneous pressure and temperature period measurements, send pressure and temperature period measurements, await next command.
Typical Command:	*0100E1
Typical Response:	*0001,30.142801,5.8120589

E2 **Continuously sample and send compound pressure period and temperature period measurements. Response data is formatted identically to E1.**

Action:	Take simultaneous pressure and temperature period measurements, send pressure and temperature period measurements, continue until commanded to stop.
Typical Command:	*0100E2
Typical Response:	*0001,30.142801,5.8120589 *0001,30.142802,5.8120588 *0001,30.142803,5.8120587…

E3 **Sample and send one compound pressure and temperature measurement. Measurement values are formatted identically to P3 and Q3 commands.**

Action:	Take simultaneous pressure and temperature period measurements, calculate temperature and temperature-compensated pressure value, send pressure and temperature values, await next command.
Typical Command:	*0100E3
Typical Response:	*0001,14.50629, 21.514

E4 **Continuously sample and send compound pressure and temperature measurements. Response data is formatted identically to E3.**

Action:	Take simultaneous pressure and temperature period measurements, calculate temperature and temperature-compensated pressure value, send pressure and temperature values, continue until commanded to stop.
Typical Command:	*0100E4
Typical Response:	*0001,14.50629, 21.514 *0001,14.50630, 21.513 *0001,14.50631, 21.512…

E5 **Sample and send one compound pressure, pressure period, and temperature period measurement. Measurement values are formatted identically to P3, P1, and Q1 commands.**

Action:	Take simultaneous pressure and temperature period measurements, calculate temperature-compensated pressure value, send pressure, pressure period, and temperature period values, await next command.
Typical Command:	*0100E5
Typical Response:	*0001,14.63820, 30.167999,5.8125361

E6 **Continuously sample and send compound pressure, pressure period, and temperature period measurements. Response data is formatted identically to E5.**

Action:	Take simultaneous pressure and temperature period measurements, calculate temperature-compensated pressure value, send pressure, pressure period, and temperature period values, continue until commanded to stop.
Typical Command:	*0100E6
Typical Response:	*0001,14.63820, 30.167999,5.8125361 *0001,14.63821, 30.167998,5.8125362 *0001,14.63822, 30.167997,5.8125363…

5.3.4 Sample and Hold Measurement Commands

The following commands are used to initiate and send single sample and hold measurements. Measurement values are held until the next command is received. If the next command is a **DB** or **DS** command, the measurement value is sent; if it is any other command, the measurement value is lost. If a **DB** or **DS** command is received before the measurement command is complete, the measurement value will be sent as soon as it is available.

P5 **Sample and hold one pressure measurement.**

Action:	Measure temperature period, measure pressure period, calculate temperature-compensated pressure, save pressure value, and await **DB** or **DS** command.
Units:	As specified by **UN**
Typical Command:	*0100P5
Typical Response:	No response until **DB** or **DS** command is received

NOTE: Refer to Section 5.17, page 58 for additional information on using **P5** with seismic sensors.

DB **Dump Buffer. Send a held measurement value.**

Action:	If a measurement value is being held, send it - otherwise do nothing.
Typical Command:	*0100DB
Typical Response:	*000114.12345 (Value: 14.12345)

NOTE: The **DB** command can also be used globally on the RS-232 port. The device will not respond to a global **DB** command on the RS-485 port.

DS **Dump Sequential. Sequentially send a held measurement value.**

Action:	If a measurement value is being held, send it - otherwise do nothing.	
Typical Command:	*9900DS	
Typical Response:	*000114.12345	(From unit 1)
	*000214.54321	(From unit 2)
	*9900DS	(Echoed **DS** command)

DS is useful only when acquiring measurement data from two or more units in an RS-232 serial loop network. **DS** ensures that measurements are returned in the order that units appear in the serial loop network. See Section 8.4, page 76 for more information about RS-232 serial loop networking.

THE FOLLOWING ARE LOW-LEVEL MEASUREMENT COMMANDS GENERALLY USED FOR DIAGNOSTIC PURPOSES:

P6 **Sample and hold one pressure period measurement.**

Action:	Measure pressure period, save pressure period value, and await **DB** or **DS** command.
Units:	Microseconds
Typical Command:	*0100P6
Typical Response:	No response until **DB** or **DS** command is received

NOTE: Refer to Section 5.17, page 58 for additional information on using **P6** with seismic sensors.

Q5 Sample and hold one pressure sensor temperature measurement.

Action:	Measure internal pressure sensor temperature period, calculate pressure sensor temperature, save value, and await **DB** or **DS** command.
Units:	°F or °C, as selected by **TU**
Typical Command:	*0100Q5
Typical Response:	No response until **DB** or **DS** command is received

Q6 Sample and hold one pressure sensor temperature period measurement.

Action:	Measure pressure sensor temperature period, save value, and await **DB** or **DS** command.
Units:	Microseconds
Typical Command:	*0100Q6
Typical Response:	No response until **DB** or **DS** command is received

5.4 Measurement Integration Time Commands

Digiquartz Intelligent devices support time-based pressure integration only. This means that the unit's pressure and temperature signals are sampled for a user-specified period of time. In the past, period-based integration was also supported, which sampled the pressure and temperature signals for a user-specified number of periods.

See Section 7.1, page 69 for information regarding the relationships between integration time, resolution, and sampling rate.

TIME-BASED INTEGRATION

PI and **TI** are the time-based integration time commands for pressure and temperature signal integration. The advantage of **PI** and **TI** is that the integration time is not a function of measured period, and is consistent from unit to unit. This will allow the user to better synchronize measurements from two or more Digiquartz Intelligent devices that support time-based integration. The resolution of **PI** and **TI** is approximately 1ms.

TIME-BASED INTEGRATION TIME COMMANDS

PI Set or read time-based pressure measurement integration time.

Units:	Milliseconds (Resolution = 1 millisecond)
Range:	(see table below)
Default:	666
Typ. Set Command:	*0100EW*0100PI=1000
Typ. Read Command:	*0100PI
Typical Response:	*0001PI=1000

TI **Set or read time-based temperature measurement integration time.**

Units:	Milliseconds (Resolution = 1 millisecond)
Range:	(see table below)
Default:	666
Typ. Set Command:	*0100EW*0100TI=1000
Typ. Read Command:	*0100TI
Typical Response:	*0001TI=1000

Whenever the value of **PI** is changed, **TI** is automatically updated with the same value. Changing **TI** has no effect on **PI**. **TI** should be set to the same value as **PI** for optimum performance in most applications.

TABLE 5-2: PI or TI Settings For Different VP Values

VP Value	PI or TI Set Range (milliseconds)	Conversion (seconds)
1	1 to 85000	0.001 to 85
2	1 to 42000	0.001 to 42
3	1 to 28000	0.001 to 28
4	1 to 21000	0.001 to 21
5	1 to 15000	0.001 to 15

5.5 Precise Measurement Rate Command

The **TH** command is used in conjunction with the continuous measurement commands to produce measurements at precise data rates. This can be useful in many applications, such as when measurements are to be analyzed in the frequency domain, or whenever the time between measurements must be known and consistent.

TH is an alternative to the **PI** command. **TH** specifies data rate rather than integration time, and results in a more accurate and consistent data rate compared to **PI**. The value of **TH** specifies the data rate in Hertz, up to a maximum rate set by the baud rate and command type. If data rates less than 1 Hz are required, **PI** must be used.

The function of the **TH** command differs slightly depending on whether Standard or Nano-Resolution is selected:

Standard Resolution - In Standard Resolution mode, **TH** controls both resolution and data rate. When **TH** is nonzero, the data rate in Hz is specified by the value of **TH**, and **PI** is automatically optimized for the maximum resolution available at the specified data rate. When **TH** is set to 0, control of integration time and data rate revert back to **PI**.

Nano-Resolution - In Nano-Resolution mode, **TH** controls data rate only - resolution is set using the **BC** (or legacy **IA**) command. When **TH** is nonzero, the data rate in Hz is specified by the value of **TH**. When **TH** is set to 0, control of data rate reverts back to **PI**.

NOTE: See Section 6 for more information on using Nano-Resolution.

TH works only with the following continuous measurement commands: **P2, P4, Q2, Q4, E2, E4, E6, MD**=2**, MD**=3**, MD**=6, **MD**=7, **MD**=14**,** and **MD**=15. **TH** has no effect on polled and sample-and-hold measurement commands in standard resolution mode; they use **PI** to set the integration time regardless of the **TH** value.

Whether the desired data rate is attainable depends on serial baud rate and the number of characters in the measurement command response. When **TH** is set, the user specifies the intended measurement command. The unit then checks various parameter settings that affect data rate, and reports whether the specified data rate can be attained. For this reason, it is important that the unit be set to the desired baud rate and configured for the desired measurement prior to setting **TH**. It is also important to set **TH** again if a different measurement command is to be used, or if a configuration change results in a greater number of characters in the serial response.

TH Set or read measurement data rate.

Units:	Hertz (Hz)
Range:	1 to maximum set by baud rate and command type
Default:	0 (TH off; control reverts to PI)
Typ. Set Command:	*0100EW*0100TH=20,P4
Typ. Set Response:	*0001TH=20,P4;>OK
Typ. Read Command:	*0100TH
Typ. Read Response:	*0001TH=20

Example 1: Successfully setting data rate

For the Typical Set Command above, we will assume the user wants to acquire continuous pressure data (**P4**) at 20 Hz. The baud rate is currently set to 9,600 baud.

The >OK in the typical set response indicates the desired 20Hz data rate is attainable under the current conditions. Now, when the **P4** command is used, measurement data will be sent at 0.05 second intervals, or 20Hz.

Example 2: Unsuccessfully setting data rate

For this example, we will assume the user wants to acquire continuous pressure data (**P4**) at 40Hz. The baud rate is currently set to 9,600 baud.

Command:	*0100EW*0100TH=40,P4
Response:	*0001TH=40,P4;>ERROR

The >ERROR in the response indicates the desired 40Hz data rate is not attainable under the current conditions, and the value of **TH** was not updated. Generally, to correct the problem, one would either reduce the desired data rate or increase the baud rate.

Example 3: **Returning control of integration time to PI**

For this example, we will assume the user no longer requires precise measurement intervals and wishes to return control of integration time to **PI**. Note that it is not necessary to specify the measurement command when setting **TH** to zero.

Command: *0100EW*0100TH=0
Response: *0001TH=0

NOTE: **PI/TI** control the data rate when using the **OFR** command, regardless of the **TH** value.

5.6 User-Defined Commands

The user-defined commands enable the user to define custom commands. All measurement options are available. Any combination of measurement options and text can be specified, and measurement values can be formatted per your specifications.

User-defined commands consist of an output mask command to define the command behavior, and an associated command to execute the output mask. Three independent user-defined commands are available. To use a user-defined command, the output mask must be defined using the **OM** command. The output mask typically contains some combination of command codes, text strings, and numeric format specifiers, each separated by a comma. The **OF** command is used to execute the command defined by **OM**.

COMMAND CODES

Command codes are used in the output mask to produce measurement or text output when executed. The available command codes are listed in Table 5-3.

NOTE: To work with a serial loop network, the output mask must begin with a STAR command code, and the second and third characters of the resulting response data must not match the address of any intelligent devices on the serial loop network.

TEXT STRINGS

Text strings are literal text delimited by quote characters. They can be inserted at any location within the output mask. The most common use of text strings is to annotate command code outputs.

Example: "This is my text" will output "This is my text" (less the quote characters) when executed.

NUMERIC FORMAT SPECIFIERS

Numeric format specifiers are used to control the format of measurement value outputs. Command codes used with numeric format specifiers are identified in Table 5-3. Numeric format specifiers are placed immediately after the command code to which they apply.

Numeric format specifiers have syntax “x.y” where ‘x’ is any number between 0 and 9, and ‘y’ is any number between 0 and 13.

The 'x' value specifies the number of digits to the left of the decimal point that will be output. All digits to the left of the decimal point are always output regardless of the 'x' value. If the 'x' value is greater than the number of digits to the left of the decimal point, the output will be padded with leading zeros.

The 'y' value specifies the number of digits to the right of the decimal point that will be output. If the 'y' value is less than the number of digits to the right of the decimal point, the output will be rounded to the number of digits specified. If the 'y' value is greater than the number of digits to the right of the decimal point, the output will be padded with trailing zeros. Refer to Table 5-4 for examples.

TABLE 5-3: Command Codes For User-Defined Commands

Command Code	Description	Format Specifier?
P	Pressure	Y
P+	Add sign character to pressure value	Y
MINP	Minimum pressure	Y
MAXP	Maximum pressure	Y
TV	Tare value	N
ST	Sensor temperature	Y
PPER	Pressure period	Y
TPER	Temperature period	Y
PU	Pressure unit	N
TU	Sensor temperature unit	N
UA	Destination ID	N
HA	Source ID	N
HEAD	Same as STAR,UA,HA	N
CR	Carriage return	N
LF	Line feed	N
CRLF, END, E	Carriage return/line feed	N
STAR	Asterisk	N
SPACE, SPC	Space character	N
COMMA	Comma character	N
RESET	Set mask to default (must be used alone)	N

NOTE: Command codes in Table 5-3 are not case sensitive.

TABLE 5-4: User-Defined Numeric Formatting Examples

Value	Output Mask	Output
14.56789	P1.5	14.56789
14.56789	MIN5.5	00014.56789
14.56789	MAX2.2	14.57
14.56789	P2.7	14.5678900
14.56789	P5.7	00014.5678900

OM Set or read the user-defined command output mask.

Three output masks can be defined - **OM1**, **OM2**, and **OM3**. The number is optional - if no number is specified, **OM1** is assumed.

Range:	200 characters maximum.
Default:	OM1=STAR,HA,UA,P,CRLF
	OM2=HEAD,SPC,P,SPC,PU,CRLF
	OM3=S,"Pressure:",P,SPC,PU,";PPeriod:",PPER,"; Temp:",ST,SPC,TU,";TPeriod:",TPER,CRLF
Typ. Set Command:	*0100EW*0100OM="Pressure:",P,CRLF
Typ. Read Command:	*0100OM
Typical Response:	*0001OM="Pressure:",P,CRLF

When the **OM** command is sent, the output mask is checked for syntax errors. If a syntax error is detected, an error code is returned, along with the output mask up to the point where the error was detected. The syntax error will be between the last comma and the end of the returned output mask. Refer to Table 5-5 for list of **OM** error codes and their descriptions.

TABLE 5-5: OM Command Error Codes

OM Error Code3	Description
O1	Unrecognized command
O2	Missing quote character
O3	Output mask too long
O4	RESET mixed with other command codes
O5	Bad format specifier

OF Executes the associated user-defined command output mask.

OF1, **OF2**, and **OF3** execute output masks defined by **OM1**, **OM2**, and **OM3**, respectively. The number is optional - if no number is specified **OF1** is assumed. **OFR** will execute **OM** repeatedly until canceled by any valid command. See **MD** to automatically execute **OM** on start-up.

Typical Command:	*0100OF
Typical Response:	Pressure: 14.12345

The **OF** command processes command codes in the order that they appear in the output mask. The output for each command code is sent as it is processed.

TABLE 5-6: Single Response, OM /OF Examples

OM Output Mask	OF Command Result
OM = STAR,HA,UA,P,”psi”	*000114.5678 psi
OM = HEAD,P,END	*000114.5678<CRLF>
OM = HEAD,P2.2,END	*000114.57<CRLF>
OM = “Min:”,MINP,SPACE,”Max:”,MAXP	Min: 14.5678 Max: 14.5687

TABLE 5-7: Continuous Response OM / OFR Examples

OM Output Mask	OFR Command Result
OM = STAR,HA,UA,P,"psi",CRLF	*000114.5678psi<CRLF> *000114.5678psi<CRLF> *000114.5678psi<CRLF>... ... ...

NOTE: **PI/TI** control the data rate when using the **OFR** command, regardless of the **TH** value.

5.7 Minimum/Maximum Pressure Commands

The Minimum/Maximum Pressure Commands return the minimum and maximum pressure measurement values.

M1 Return minimum pressure measurement value

Units: Current pressure unit
Typ. Read Command: *0100M1
Typ. Read Response: *0001M1=14.12345 (Value: 14.12345)

M3 Return maximum pressure measurement value

Units: Current pressure unit
Typ. Read Command: *0100M3
Typ. Read Response: *0001M3=14.12345 (Value: 14.12345)

MR Reset the minimum and maximum pressure measurement values

Units: Current pressure unit
Typical Command: *0100MR
Typical Response: *0001MR>OK

When the **MR** command is received, the minimum and maximum pressure values will be set to the next pressure measurement value.

NOTE: **M1** and **M3** also reset to the next pressure measurement value whenever power is cycled, tare is initiated or disabled, or coefficients parameters that effect the pressure value are changed (**C1**, **C2**, **C3**, **D1**, **D2**, **PA**, **PM**, **TC**, **T1**, **T2**, **T3**, **T4**, **T5**, **U0**, **Y1**, **Y2**, **Y3**).

5.8 Serial Data Output Mode Command

The following command controls whether pressure data is continuously output, and whether display data are produced.

MD Set or read the data output mode.

Action: **MD** configures the Intelligent Device for continuous pressure measurement output whenever power is applied.

Range:	0 - 15 (refer to Table 5-8 below)
Default:	1
Typ. Set Command:	*0100EW*0100MD=1
Typ. Read Command:	*0100MD
Typical Response:	*0001MD=1

TABLE 5-8: MD Command Options

MD Value	Continuous Serial Data Command Output
0	None
1	None
2	P4
3	P4
8	OM1
10	OM2
12	OM3
14	E4
15	E6

CAUTION

Do not configure any device on a 2-wire RS-485 network for continuous pressure data output from the RS-485 port on power-up (**MD**=2, 3, 8, 10, 12, 14, or 15). If you do this, it is unlikely that you will be able to reconfigure the unit over the network, since any command is likely to collide with the pressure data being continuously sent. To recover, you will need to remove the device from the network and reconfigure it individually via the RS-232 port.

When **MD** is set to a non-zero value, the specified serial data output mode will be preempted under the following conditions:

- When the intelligent device is running in a continuous pressure data output mode, continuous data output is suspended when a measurement command is received. Continuous data output resumes when the measurement command is complete.
- Continuous pressure data output is suspended when a continuous measurement command (**P2, P4, Q2, Q4**) is received, and resumes when the continuous measurement command is canceled.
- Once **MD** is set, the specified function will remain in effect until **MD** is set to a different value, even through a power cycle. Therefore, the Intelligent device will generally perform the specified function whenever power is applied.

5.9 Unit Commands

Unit commands are used to specify the engineering unit to be used when calculating pressure or sensor temperature values, and to configure the user-defined pressure unit.

UN **Set or read the pressure unit.**

Action:	Sets or reads the unit of all pressure values displayed and delivers via the serial ports.
Range:	0 to 8 (refer to Table 5-9)
Default:	1
Typ. Set Command:	*0100EW*0100UN=2
Typ. Read Command:	*0100UN
Typical Response:	*0001UN=2

NOTE: Refer to Section 5.17, page 58 for additional information on using **UN** with seismic sensors.

TABLE 5-9: Measurement Units and Conversion Factors

UN Value	Measurement Unit	Conversion Factor
0	User -defined	Value of UF
1	psi	1.0000000
2	hPa (mbar)	68.94757
3	bar	0.06894757
4	kPa	6.894757
5	MPa	0.00689476
6	in Hg	2.036021
7	mmHg (Torr)	51.71493
8	m H_20	0.7030696

Setting **UN** to a non-zero value selects one of eight standard pressure units. Setting **UN** to 0 selects a user-defined unit whose conversion factor is specified by the **UF** command.

The native pressure unit of the device is psi. When a different pressure unit is specified, the pressure value in psi is first calculated, and then converted to the desired unit by multiplying by the appropriate conversion factor.

UF **Set or read the user-defined pressure unit conversion factor.**

Action:	When **UN**=0, calculated pressure values in psi are multiplied by the value of **UF** before being output, thus scaling pressure values in the desired user-defined pressure unit.
Range:	-9999999 to 9999999
Default:	1.000000
Typ. Set Command:	*0100EW*0100UF=2
Typ. Read Command:	*0100UF
Typical Response:	*0001UF=2.000000

TU **Set or read the sensor temperature unit.**

Action:	Specifies temperature units for **E3**, **E4**, **Q3**, **Q4**, **Q5**.
Range:	0 = °C 1 = °F
Default:	0
Typ. Set Command:	*0100EW*0100TU=1
Typ. Read Command:	*0100TU
Typical Response:	*0001TU=1

NOTE: Temperature is always calculated in °C but converted to °F when **TU** = 1.

5.10 Power Management Commands

Digiquartz Intelligent devices can be commanded to enter a reduced-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 in Sleep Mode.

CAUTION

Power management features are not available if **MD** is set for continuous output (**MD**>0).

SL **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
Typ. Set Command:	*0100EW*0100SL=1
Typ. Read Command:	*0100SL
Typical Response:	*0001SL=1

NOTE: **SL** is not available with continuous pressure output or nano-resolution.

ST **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
Typ. Set Command:	*0100EW*0100ST=5
Typ. Read Command:	*0100ST
Typical Response:	*0001ST=5

SO **Force sleep mode immediately**

Action:	Tells the unit to enter sleep mode until it detects any activity on the RS-232/485 COM ports. Any COM port activity or power cycle will reawaken the unit.
Range:	1 = enables sleep mode
Typ. Set Command:	*0100LW*0100SO=1

VP **Set system and counting clock frequencies to reduce power consumption**

Action:	Reduce board power consumption by sacrificing high frequency counting capability (counting noise). Use this in applications where available power is limited.
Range:	5 (max. power/performance) to 1 (least)
Default:	1
Typ. Set Command:	*0100EW*0100VP=3
Typ. Read Command:	*0100VP
Typical Response:	*0001VP=3

NOTE: Not all transducer operation modes are fully supported at all **VP** settings. **XX**=6 is currently not a user option. See table below.

TABLE 5-10: Using the VP Command

XX	Mode	Sleep Mode (mA)	Active VP Setting VP=1 (mA)	VP=2 (mA)	VP=3 (mA)	VP=4 (mA)	VP=5 (mA)
1	Single Transducer	7.2	17.9	22.3	25.7	32.5	47.0
2	Two Transducers	7.2	-	23.8	27.4	34.4	49.1
3	Triax Accelerometer	7.2	-	23.2	29.1	36.9	52.3
4	Dual-axis Tiltmeter	7.2	-	22.2	26.9	33.9	48.6
5	Single-axis Accelerometer	7.2	18.0	22.3	25.8	32.7	47.2
7	Four Pressure Transducers	7.2	-	-	28.0	35.9	51.0
8	SOS Mode	7.2	-	-	-	-	50.1

5.11 Tare and Overpressure Commands

Tare is the process of subtracting a specified value from pressure measurements. You may use the current measured pressure as the tare value, or you may specify any desired value. Tare can also be enabled, disabled, and locked out through the use of serial commands. Serial pressure measurement data can be formatted to include an indication when tare is in effect. Refer to page 51 for more information on using the **ZI** command.

The overpressure command can be used to specify the overpressure alarm set-point. When the overpressure set point is exceeded, the overpressure I/O line changes from logic low (0 VDC) to logic high (3.3 VDC). Refer to Section 10, page 91 for more information.

Available tare options include:

Standard Tare - The default tare mode defaults the tare value to zero on power-up.

Non-Volatile Tare - Tare can optionally default to the last tare value on power-up, effectively retaining the tare value through a power cycle.

ZE **Set or read the tare mode**

Action:	**ZE**=0, tare value of **ZV** is set to zero on power-up. **ZE**=1, tare value of **ZV** is restored to the last tare value on power-up.
Range:	0 or 1
Default:	0
Typ. Set Command:	*0100EW*0100ZE=1
Typ. Read Command:	*0100ZE
Typical Response:	*0001ZE=1

ZL **Set or read the tare lockout parameter value.**

Action:	**ZL**=0, tare is unlocked (**ZS** can be modified) **ZL**=1, tare is locked (**ZS** cannot be modified)
Range:	0 or 1
Default:	0
Typ. Set Command:	*0100EW*0100ZL=1
Typ. Read Command:	*0100ZL
Typical Response:	*0001ZL=1

If **ZS**=1 and a **ZL**=1 command is issued, tare will be in effect when the next pressure measurement is taken, but you cannot turn tare off until **ZL** is set to 0. The value of **ZL** is set to 0 on power-up.

ZS **Set or read the tare state parameter value.**

Action:	The three states of **ZS** are: **ZS**=0, tare function is turned off. **ZS**=1, tare requested, but is not yet in effect. **ZS**=2, tare is in effect
Range:	0 to 2
Default:	0
Typ. Set Command:	*0100EW*0100ZS=1
Typ. Read Command:	*0100ZS
Typical Response:	*0001ZS=1

ZS is set to 0 on power-up. If **ZL**=0 (tare is not locked out), tare can be requested by setting the **ZS** to 1.

At the first pressure measurement following a tare request, the following sequence occurs:
1. Pressure value is stored in the **ZV** parameter.
2. Value of **ZS** is set to 2 to indicate that tare is in effect.
3. Value of **ZV** is subtracted from all subsequent pressure values until tare is turned off.

If tare is already in effect when a **ZS**=1 command is issued, the sequence described above occurs at the next pressure measurement, and tare continues using a new value of **ZV**.

ZV **Set or read the tare value.**

Action:	Sets or reads the value that is subtracted from pressure measurements when tare is activated.
Range:	-9999999 to 9999999
Default:	0
Typ. Set Command:	*0100EW*0100ZV=14.7123
Typ. Read Command:	*0100ZV
Typical Response:	*0001ZV=14.7123

ZV can be set to any desired value when tare is in effect (**ZS**=2). Note, however, that if tare is subsequently requested, a new value will overwrite the **ZV** value you have set. The value of **ZV** = 0 on power-up.

OP **Set or read the overpressure alarm set-point value.**

Action:	When a pressure measurement value is less than the value of **OP**, the Overpressure I/O line is at logic low (0 VDC); if it is greater or equal to the value of **OP**, the Overpressure I/O line is set to logic high (3.3 V DC). Refer to Section 10, page 91 for more information. **OP** is set in the current pressure units, and is scaled accordingly if the engineering units are changed.

Range:	-9999999 to 9999999
Default:	Maximum rated device pressure
Typ. Set Command:	*0100EW*0100OP=15
Typ. Set Response:	*0001OP=15.00000
Typ. Read Command:	*0100OP
Typ. Read Response:	*0001OP=15.00000

NOTE: Command **OP** only checks for overpressure when **MD** is not = 0 or during pressure readings (**P3** or **P4**). Refer to Section 5.8, page 42 for more on using the **MD** command.

5.12 Measurement Data Formatting Commands

These commands are used to alter the format of serial measurement data. The following data formatting functions are available:

- Append an engineering unit label to measurement data.
- Append an tare indication to tare pressure measurement data.
- Add underscores to separate the measurement data from the rest of the serial output data string to improve readability.
- Add trailing zeros to the measurement data to create a fixed-length data string to simplify parsing.

Formatting commands can be used separately or in any combination.

US **Set or read the engineering units suffix parameter value. The US command only supports single transducer mode where XX = 1.**

Action:	**US**=1, a unit label is appended to measurement data.
	US=0, no unit label is appended.
Range:	0 or 1
Default:	0
Typ. Set Command:	*0100EW*0100US=1
Typ. Read Command:	*0100US
Typical Response:	*0001US =1

Examples:

*000114.71234psia	(Pressure measurement, **US**=1)
*000121.123C	(Temp measurement, **US**=1)

NOTE: Refer to Section 5.17, page 58 for additional information regarding seismic sensors.

When **US**=1, a pressure unit label is appended to pressure measurement values according to the value of **UN**:

TABLE 5-11: Appended Pressure Measurement Labels

UN value	Label
0	Defined by UM
1	psia, psig, or psid
2	hPa
3	bar
4	kPa
5	MPa
6	inHg
7	mmHg
8	mH2O

When **US**=1, a temperature unit label is appended to temperature measurement values according to the value of **TU**:

TABLE 5-12: Appended Temperature Measurement Labels

TU value	Label
0	C
1	F

SU **Set or read the underscore separator parameter value.**

Action:	**SU**=1, an underscore separates the measurement data from the address header and the optional unit suffix. **SU**=0, no underscore separators appear.
Range:	0 or 1
Default:	0
Typ. Set Command:	*0100EW*0100SU=1
Typ. Read Command:	*0100SU
Typical Response:	*0001SU=1

Examples:	*000114.71234	(**SU**=0)
	*0001_14.71234	(**SU**=1)
	*0001_14.71234_psia	(**SU**=1, **US**=1)

ZI **Set or read the tare indication parameter value.**

Action:	**ZI**=1, a “T” is appended to pressure measurement values when tare is in effect. **ZI**=0, no tare indication appears, whether tare is in effect or not.
Range:	0 or 1
Default:	0
Typ. Set Command:	*0100EW*0100ZI=1
Typ. Read Command:	*0100ZI
Typical Response:	*0001ZI=1

Examples:	*000114.71234	(**ZI**=0)
	*000114.71234T	(**ZI**=1)
	*0001_14.71234T	(**ZI**=1, **SU**=1)
	*000114.71234Tpsia	(**ZI**=1, **US**=1)
	*0001_14.71234T_psia	(**ZI**=1,**US**=1, **SU**=1)

DL **Set or read the fixed field data format parameter.**

Action:	When **DL**=1, measurement data is formatted in a fixed field format. When **DL**=0, measurement data is given in the standard format. The fixed field format is specified as follows: *AAAASDDDDDDDDDD (**XM**=0) *AAAASDDDDDDDDDDDDDDD (**XM**=1), where * = the asterisk character A = destination and source address characters S = sign of measurement data, either + or – D = numeric representation of measurement data, either digits or a decimal point
Range:	0 or 1
Default:	0
Typ. Set Command:	*0100EW*0100DL=1
Typ. Set Response:	*0001DL=1
Typ. Read Command:	*0100DL
Typ. Read Response:	*0001DL=1

Examples:	*000114.71234	(Pressure, **DL**=0)
	*0001+14.7123400	(Pressure, **DL**=1)
	*000121. 123	(Temperature, **DL**=0)
	*0001+21.1230000	(Temperature, **DL**=1)

NOTE: Period measurement data will contain no sign.

NOTE: The format specification and examples shown above assume that the other formatting commands are disabled. If other formatting commands are used in combination with **DL**, a fixed field format will still result, but the format will vary slightly from the one described above.

UM **Set or read the user-defined unit label parameter.**

Action:	When **UN**=0 and **US**=1, the text value of **UM** is appended to pressure measurements.
Range:	Any text up to four characters, consisting of ASCII 32 to ASCII 127.
Default:	user
Typ. Set Command:	*0100EW*0100UM=test
Typ. Read Command:	*0100UM
Typical Response:	*0001UM=test

Examples:	*000114.71234	(**UN**=0, **US**=0)
	*000114.71234user	(**UN**=0,**US**=1, **UM**=user)

KH **Disable Header in Data Outputs**

Action:	Determines whether the normal header is applied to the serial data output or not.
Range:	0 = Normal header output (example: *HHUU) 1 = Removes header from serial data output
Default:	0
Typ. Set Command:	*0100EW*0100KH=1
Typ. Read Command:	*0100KH
Typical Response:	*0001KH=1

NOTE: “HH” is the host address in ASCII decimal while “UU” is the user address.

5.13 Unit Identification Commands

The Unit Identification commands read various unit-specific parameters. These parameters are factory-set, and cannot be modified.

SN **Read the serial number.**

Action:	The **SN** parameter contains the device serial number. **SN** is a read-only command.
Typ. Read Command:	*0100SN
Typ. Read Response:	*0001SN=12345

VR **Read the firmware version number.**

Action: The **VR** parameter contains the device firmware version number. **VR** is a read-only command.

Typ. Read Command: *0100VR

Typ. Read Response: *0001VR=R5.10

NOTE: For RS-232 only, a global **VR** command can be issued as *9900VR.

CF **Read the firmware checksum.**

Action: The **CF** parameter contains the firmware checksum. The value of **CF** is always 4 characters. **CF** is a read-only command.

Typ. Read Command: *0100CF

Typ. Read Response: *0001CF=A1B2

MN **Read the model number.**

Action: The **MN** parameter contains the device model number as a text string. The value of **MN** always contains 24 characters. If the model number is less than 24 characters, the string will be padded with trailing spaces to a length of 24 characters. **MN** is a read-only command.

Typ. Read Command: *0100MN

Typ. Read Response: *0001MN=6030A

PF **Read the full-scale pressure value.**

Action: The **PF** parameter contains the full-scale pressure value in the current pressure units. If the units are changed, the value of **PF** is scaled accordingly. **PF** is a read-only command.

Typ. Read Command: *0100PF

Typ. Read Response: *0001PF=16.00000

PO **Read the pressure transducer type.**

Action: The **PO** parameter contains the pressure transducer type. **PO** is a read-only command.

Typ. Read Command: *0100PO

Typ. Read Response: *0001PO=0

TABLE 5-13: PO Value

PO value	Transducer type
0	Absolute
1	Gauge

5.14 Calibration Commands

The calibration commands set and read several parameters that directly affect the measurement accuracy of the device. Refer to Sections 7.2 and 13 for more information regarding the use of the calibration parameters.

⚠ **CAUTION**

Calibration values should be modified only when absolutely necessary, and then with extreme caution. Calibration value adjustments should only be performed by a qualified metrology lab. Calibration coefficients are unique to each product and should never be modified or transferred to another unit.

ZERO AND SPAN ADJUSTMENT COMMANDS

The **PA** command is used to make zero offset adjustments to the indicated pressure value. The **PM** command is used to make span adjustments to the indicated pressure value.

PA and **PM** are used in the following formula to calculate final output pressure:

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

Where: P = Pressure calculated using original calibration coefficients in the current pressure unit.
PM = the current value of the **PM** parameter
PA = the current value of the **PA** parameter

PA **Set or read the pressure adder parameter.**

Action:	The pressure adder parameter is used to make zero adjustments to the calibration. **PA** can also be used to offset absolute pressure measurements by atmospheric pressure to obtain gauge pressure.
Range:	-9999999 to 9999999
Default:	0.0
Typ. Set Command:	*0100EW*0100PA=.0000123
Typ. Read Command:	*0100PA
Typical Response:	*0001PA=.0000123

NOTE: The value of **PA** is entered in the current pressure units but is converted to psi prior to being stored.

PM **Set or read the pressure multiplier parameter.**

Action:	The pressure multiplier parameter is used to make span adjustments to the calibration.
Range:	-9999999 to 9999999
Default:	1
Typ. Set Command:	*0100EW*0100PM=1.000123
Typ. Read Command:	*0100PM
Typical Response:	*0001PM=1.000123

NOTE: The value of **PM** is dimensionless, and is therefore not scaled if the units are changed.

TA Temperature adder for zero adjust

Action:	This parameter is used to make zero adjustments to the calibration.
Default:	0
Typ. Set Command:	*0100LW*0100TA=.0000123
Typ. Read Command:	*0100TA
Typical Response:	*0001TA=.0000123

CALIBRATION COEFFICIENT COMMANDS

These commands contain the calibration coefficients for the Digiquartz pressure device.

C1, C2, C3, D1, D2, T1, T2, T3, T4, T5, U0, Y1, Y2, Y3

Set or read the calibration coefficients.

Default:	Device-specific
Typ. Set Command:	*0100EW*0100C1=228.1234
Typ. Read Command:	*0100C1
Typical Response:	*0001C1=228.1234

Refer to Section 13, page 105 for more information on calibration.

TIMEBASE CALIBRATION COMMANDS

TC is used to normalize the nominal reference crystal frequency to compensate for the natural variation in reference crystal frequency.

TC Read the factory-set crystal timebase correction factor.

Action:	Read the **TC** value. **TC** is a read-only command.
Typ. Read Command:	*0100TC
Typ. Read Response:	*0001TC=1.0000009

5.15 Global Commands

Under certain circumstances, it may be necessary to send a single command to multiple Intelligent devices on a serial loop or multi-drop network. The ID 99 has been reserved for such global addressing. When an Intelligent device receives a supported command addressed to ID 99, the device reacts to that command regardless of its assigned ID value.

To support the unique requirements of RS-232 serial loop and RS-485 multi-drop networking, Intelligent devices react to global commands differently depending on which port received the command. When a global command is received via RS-232, the global command is re-transmitted before acting on the command. This ensures that all devices on a serial loop will receive the global command. When a global command is received via RS-485, the Intelligent device acts on the command but does not send a response. This prevents multiple devices on a multi-drop network from transmitting simultaneously, which would result in data collisions and unintelligible data.

SUPPORTED GLOBAL COMMANDS

All commands that affect serial communication must be globally addressed. Those commands are: **BR**, **BL**, and **ID**.

Global addressing is often used with sample and hold measurement commands to synchronize measurements from multiple devices. The sample and hold measurement commands are: **P5**, **P6, Q5**, and **Q6.**

Most sampling commands and certain other commands may be either individually or globally addressed: **E1** through **E6, P1** through **P6, Q1** through **Q6, DB, DS, VR,** and **EW.**

The remaining commands should not be sent as global commands.

CAUTION

Global sampling commands sent to multiple units on an RS-485 multi-drop network may result in data collisions when multiple devices respond simultaneously.

5.16 Data Logging Commands

The M7 board has the capability of locally logging around 50,000 - 100,000 samples (output lines) depending on the type of output, as long as the board is powered. Once logging is enabled (**LZ** command), and a continuous output is requested, the board will log the output until it runs out of memory. The appropriate sampling time should be set using **TH** (output rate) or **PI** (integration time) command, and the right anti-aliasing filter corner frequency should be set using the **BC** command. Note that enabling log forces the timestamp (**TS**) to be ON. The following commands are supported:

LI **Report Logger Address**

Action:	Reports logging start address, end address, and pointer checksum.
Typ. Read Command:	*0100LI
Typ. Read Response:	*0001LI=0,0,0,0

LQ **Log Storage Mode Select**

Action:	Specifies the type of data log storage. Select binary to minimize memory storage per record, select ASCII to maximize potential data content per record.
Range:	0 = Binary 1 = ASCII
Default:	0
Typ. Set Command:	*0100EW*0100LQ=1
Typ. Read Command:	*0100LQ
Typical Response:	*0001LQ=1

LR **Print out stored log from the first record**

Action:	Outputs the data log from memory. Each record includes a sequentially numbered header prefix.
Typ. Read Command:	*0100LR
Typ. Read Response:	

* 000001: V,01/01/70 06:53:01.250
* 000002: PM,2.5449414353,-.7260193382,19.5081209
* 000003: V,01/01/70 06:53:01.500
* 000004: PM,2.5449414641,-.7260207413,19.5081217

LS **Report number of stored log records**

Action:	The number of records stored in the SPI log memory can be queried using this read only command.
Typ. Read Command:	*0100LS
Typ. Read Response:	*0001LS=550

LW **Enable/Stop data-logging wrapping**

Action:	Directs how to proceed when EEPROM log memory is all used.
Range:	0 = Terminate logging and save log pointers. 1 = Enable WRAP function where the oldest log entries become overwritten.
Default:	0
Typ. Set Command:	*0100LW*0100LW=0
Typ. Read Command:	*0100LW
Typical Response:	*0001LW=0

LX **Clears out the stored log**

Action:	When LX=X, log memory pointers are reset and the entire EEPROM log memory is erased.
Typ. Set Command:	*0100EW*0100LX=X
Typ. Set Response:	*0001LX>Log memory reset. :Successful

LZ **Enable/Disable Data Logging**

Action:	Is used to enable or disable data logging to EEPROM memory.
Range:	0 = Disable logging; the log pointers are saved to non-volatile I2C EEPROM memory 1 = Enables logging to the 4MB SPI EEPROM
Default:	0
Typ. Set Command:	*0100EW*0100LZ=1
Typ. Read Command:	*0100LZ
Typical Response:	*0001LZ=1

NOTE: It is important to disable logging in order to commit all recorded data to permanent memory. If the unit is simply powered off without disabling logging, some data could be lost.

5.17 Seismic Sensor Commands

Seismic sensor commands are specific to instruments such as the Triaxial Accelerometer and Tiltmeter, devices that have multiple sensing channels.Their measurement command responses contain values for all channels separated by commas. Seismic sensor commands are not applicable to devices such as depth sensors or transmitters that measure single-channel pressure.

In addition to the coefficients described on page 55, seismic sensors also use one or more of the following coefficients: G1, G1s, E, F, N2, N3, N4, N5 and N6. Refer to Section 13, page 105 for more information on calibration.

EV Enable G-vector

Action:	Enables the G-vector (Root of Sum of Squares, or RSS) on to the end on E3, E4, E5 and E6 command outputs.
Range:	0 = Disabled 1= Enabled
Default:	0
Typ. Set Command:	*0100EW*0100EV=1
Typ. Read Command:	*0100EV
Typical Response:	*0001EV=1

GL Sets Local Gravity Constant in m/s^2

Action:	Will set the local gravity constant, including factory default.
Typ. Set Command:	*0100EW*0100GL=DEFAULT
Typ. Read Command:	*0100GL
Typical Response:	*001GL=9.807080

KE Orientation sensitivity correction of APGs in SOS mode

Range:	0 = Correction is Disabled 1= Enables orientation sensitivity correction
Default:	1
Typ. Set Command:	*0100EW*0100KE=1
Typ. Read Command:	*0100KE
Typical Response:	*0001KE=1

NOTE: The **KE** command is only applicable for **XX**=8 (SOS Mode)

NE **Resonance Correction Setting**

Action:	The seismic sensors are open loop sensors, some with low resonant frequencies (in 5-30 Hz range). The response of the sensor at resonance can be electronically compensated in the M7 board. This feature can be enabled/disabled using the NE command (1/0) as follows:
Range:	0 = Resonance correction is Disabled 1= Enables resonance correction
Default:	1
Typ. Set Command:	*0100EW*0100NE=1
Typ. Read Command:	*0100NE
Typical Response:	*0001NE=1

NOTE: When resonance correction is enabled the anti-aliasing filter becomes 4th order instead of 6th order. The compensation is approximate, and a small residual response may still be present in the output.

Some commands are used on both single channel (pressure transducers) and multi-channel (Tiltmeter, for example) instruments. These multi-channel instruments will have additional measurement values for each additional channel as described below.

NOTE: The number of digits in your measurement values may differ from the examples below depending on your configuration settings.

P1, P2, P6 Command Response

Example 1: Triax Accelerometer
*0001,29.9607973,30.1039107,29.3032095
Example 2: Tiltmeter
*0001,55.1234567,55,7654321

TABLE 5-14: Seismic Sensor P1/P2/P6 Response

Field	Description	Value (Accelerometer)	Value (Tiltmeter)
1	Header	*0001	*0001
2	X-axis period value	29.9607973	55.1234567
3	Y-axis period value	30.1039107	55.7654321
4	Z-axis period value	29.3032095	N/A

P3, P4, P5 Command Response

Example 1: Triax Accelerometer
*0001,.272655867,.052456071,9.800600040
Example 2: Tiltmeter
*0001,.0123456,.0654321

TABLE 5-15: Seismic Sensor P3/P4/P5 Response

Field	Description	Value (Accelerometer)	Value (Tiltmeter)
1	Header	*0001	*0001
2	X-axis period value	.272655867	.0123456
3	Y-axis period value	.052456071	.0654321
4	Z-axis period value	9.800600040	N/A

E1, E2 Command Response

Example 1: Triax Accelerometer
*0001,29.9607076,30.1041443,29.3031453,5.765203193253
Example 2: Tiltmeter
*0001,55.1234567,55,7654321,5.7954321

TABLE 5-16: Seismic Sensor E1/E2 Response

Field	Description	Value (Accelerometer)	Value (Tiltmeter)
1	Header	*0001	*0001
2	X-axis period value	29.9607076	55.1234567
3	Y-axis period value	30.1041443	55.7654321
4	Z-axis period value	29.3031453	N/A
5	Temperature period value	5.765203193253	5.7954321

E3, E4 Command Response

Example 1: Triax Accelerometer
*0001,.272787363,.052234540,9.800605917,22.0423467,9.804540670
Example 2: Tiltmeter
*0001,.0123456,.0654321,22.0123456

TABLE 5-17: Seismic Sensor E3/E4 Response

Field	Description	Value (Accelerometer)	Value (Tiltmeter)
1	Header	*0001	*0001
2	X-axis value	.272787363	.0123456
3	Y-axis value	.052234540	.0654321
4	Z-axis value	9.800605917	N/A
5	Temperature value	22.0423467	22.0123456
6	Acceleration Vector	9.804540670	N/A

E5, E6 Command Response

Example 1: Triax Accelerometer
*0001,.272739416,.052754335,9.800680555,22.0245525,30.2872269825,30.1887436141,31.2056120846,5.87016297036,9.804616726
Example 2: Tiltmeter
*0001,.0123456,.0654321,22.0123456,55.1234567,55.7654321,5.7954321

TABLE 5-18: Seismic Sensor E5/E6 Response

Field	Description	Value (Accelerometer)	Value (Tiltmeter)
1	Header	*0001	*0001
2	X-axis value	.272739416	.0123456
3	Y-axis value	.052754335	.0654321
4	Z-axis value	9.800680555	N/A
5	Temperature value	22.0245525	22.0123456
6	X-axis period value	30.2872269825	55.1234567
7	Y-axis period value	30.1887436141	55.7654321
8	Z-axis period value	31.2056120846	N/A
9	Temperature period value	5.87016297036	5.7954321
10	Acceleration vector	9.804616726	N/A

Setting Units for the Triax Accelerometer and Tiltmeter

Setting the **UN** value sets the units for all acceleration channels.

The native unit for the Triax Accelerometer is m/s^2. Available options are:
UN=0 (used-defined unit)
UN=1 (m/s^2).

For the Tiltmeter, the available options are:
UN=0 (user-defined unit)
UN=1 (m/s^2)
UN=2 (radians)
UN=3 (degrees)

Acceleration Vector

The Triax Accelerometer **E3/E4/E5/E6** command response includes an optional acceleration vector magnitude value as the last field in the response string. The acceleration vector is the square root of the sum of squares of the x, y and z accelerations.

The acceleration vector field can be enabled/disabled by the **EV** command. When disabled, the acceleration vector value and its preceding comma delimiter will not appear in the measurement command response.

TABLE 5-19: EV Command Options

EV Value	Effect
0	Acceleration vector value disabled
1	Acceleration vector value enabled

Axis Alignment Matrix

The axis alignment matrix aligns the three accelerometer axes with the Triax Accelerometer mounting surface. Axis alignment is provided by correcting raw acceleration values using a set of factory-derived coefficients. As the alignment coefficients are part of the instrument calibration, modifying them is generally not recommended.

Triax Accelerometer Coefficient commands:
AX1, AX2, AX3, AY1, AY2, AY3, AZ1, AZ2, AZ3

Axis alignment formulas:
Corrected X axis acceleration = (AX1 * RawX) + (AX2 * RawY) + (AX3 * RawZ)
Corrected Y axis acceleration = (AY1 * RawX) + (AY2 * RawY) + (AY3 * RawZ)
Corrected Z axis acceleration = (AZ1 * RawX) + (AZ2 * RawY) + (AZ3 * RawZ)

Tiltmeter Coefficient commands:
SX1, SX2, SY1, SY2

Axis alignment formulas:
Corrected X axis tilt = (SX1 * RawX) + (SX2 * RawY)
Corrected Y axis tilt = (SY1 * RawX) + (SY2 * RawY)

6 Nano-Resolution Features & Functions

6.1 Introduction

Nano-resolution mode utilizes the inherent advantage of frequency/period measurement of the quartz resonator technology to the full extent. It is capable of parts-per-billion resolution in less than a second and is available starting with firmware versions R5.10, Q1.00, and K1.00. In older firmwares, it is enabled by a serial command, and can be used with all measurement commands. In K1.00 or newer, it is the default measurement mode.

Nano-Resolution has higher processing requirements and therefore consumes more power. Consult the SCD for your product for details regarding power consumption. In firmware K1.00 or newer, power consumption can be traded off against performance, if desired, using the **VP** command described on page 46.

6.2 Technical Information

Nano-resolution is achieved by sampling the pressure at a high rate and applying digital signal processing via an infinite impulse response (IIR) filter. In firmwares R5.10, and Q1.00 and Q1.04 it consists of a 5-stage digital low-pass filter acting on the sub-samples. It filters all frequencies with a -100 dB/decade roll-off 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 approximately 3 times the cutoff frequency when **VP** = 1.

A drawback with the above technique is that the cutoff frequency and group delay of the filter depends on the crystal frequency. Since the crystal frequency can vary by +/-10% of the nominal value, there exists some variability in the precise filter response and delay. With firmware Q2.00 and K1.00, a two stage filtering is employed to address this problem. A first anti-aliasing stage filters the crystal period counts at a sampling rate proportional to the crystal frequency. This filtered data is then resampled at a fixed rate set by the reference clock on the intelligent board. The resampled period data is then further filtered at the cutoff frequency set by **BC** using 6th order butterworth filters and down-sampled at the rate set by **TH**. This scheme enables a fixed response and delay independent of the crystal frequency.

6.3 Resolution and Data Rate

The intrinsic resolution of a sensor is the size of a signal resolvable within a measurement time window or bandwidth, when it is limited by intrinsic sensor noise alone. It is the area under the sensor noise spectral density plot between two frequency points corresponding to the bandwidth. To simplify practical usage, we define the resolution of the sensor at a specified cutoff frequency as the product of the noise amplitude spectral density at that frequency and the square root of the cutoff frequency. This is equivalent to the root mean square (rms) amplitude of the signal, or the point-to-point fluctuation observed in the output at the specified cutoff frequency.

The resolution of the sensor at the specified corner frequency (**BC** value) can be queried by using the **FR** command. Unlike standard resolution mode, data rate and resolution are independent in nano-resolution mode and are selected using separate commands. It is recommended that resolution is selected first. Data rate is then selected based on the resolution setting. A data rate of approximately 3 times the cutoff frequency is generally recommended to avoid aliasing.

6.3.1 Enable and Set Nano-Resolution

Nano-resolution can be enabled and disabled by the **XM** serial command. Resolution is a function of the cutoff frequency when nano-resolution is enabled. The M7 board uses 6th order Butterworth filters as the anti-aliasing filters. The filter's corner frequency is set by the **BC** command.

XM **Set or read the resolution mode.**

Range:	0 = Standard Resolution 1 = Nano-resolution
Default:	0
Typ. Set Command:	*0100EW*0100XM=1
Typ. Read Command:	*0100XM
Typical Response:	*0001XM=1

BC **Set or read the filter corner frequency in Hz.**

Action:	Used to set corner frequency for pressure and seismic sensors (acceleration, tilt, angle).
Range:	0.02 to 100 Hz
Default:	0.2
Typ. Set Command:	*0100EW*0100BC=1
Typ. Read Command:	*0100BC
Typical Response:	*0001BC=1.000000

BC can be set between 0.02 Hz up to 100 Hz. To avoid aliasing, the corner frequency should be kept 1/3rd or smaller than the sampling rate (set by **TH** or **PI**).

NOTE: Previous **IA** commands can also be used to set the corner frequency (refer to the Nano-Resolution section in the 8819-001 manual). However, the filter used is still the 6th order Butterworth filter, not the previous IIR filter.

FD **Current SSP/Butterworth Filter Delay in Seconds**

Action:	Outputs the calculated value of the total filter delay from the anti-aliasing filters.
Typ. Set Command:	*0100EW*0100FD=.0260
Typ. Read Command:	*0100FD
Typical Response:	*0001FD=.0260

Filter delay accuracy is specified in seconds as +/- (0.001+0.3% of delay).

FR **Read Resolution of Pressure**

Action:	Outputs the resolution of pressure in engineering units, ppm, or dB relative to full-scale.
Typ. Read Command:	*0100FR
Typ. Read Response:	*0001FR=.1659519,.0000024893,-135.6

NOTE: The **FR** command works regardless of **XM** status.

6.3.2 Setting Data Rate

The method for controlling data rate in nano-resolution mode differs depending on whether continuous measurements (**P4**, **P2**, etc.) or polled measurements (**P3**, **P1**, etc.) are being taken. Continuous measurements are usually recommended since it is much simpler to control data rate.

Continuous Commands - Timing of continuous measurements in nano-resolution mode is determined by **TH** or **PI**. **TH** specifies the measurement rate in Hz, and is the preferred method. **PI** sets the approximate measurement interval in milliseconds, and is in effect when **TH**=0.

Polled Commands - The concept of integration time does not apply in nano-resolution mode, and as a result, polled commands such as **P3** return a measurement value immediately, regardless of **TH** and **PI** settings. Measurement timing must be controlled by the serial host that issues the measurement commands. Continuous measurement commands are recommended instead whenever consistent measurement timing is desired.

To avoid aliasing, it is generally recommended to select a data rate that is approximately 3 times the cutoff frequency. Refer to page 38 for instructions on using the **TH** command.

6.4 Filter Options for Nano-Resolution

TABLE 6-1: Example Filter Settings When VP = 1

IA	Filter Delay[a] (sec)	Cutoff Frequency[b] (Hz)	Minimum Measurement Rate[c] (Hz)	Measurand Resolution[d] (dB)	(ppb)
4	0.0288	34	170	-124	632
5	0.0444	16	80	-134	204
6	0.0830	8	40	-143	72
7	0.1603	4	20	-152	26
8	0.3147	2	10	-161	9
9	0.6295	1	5	-170	3
10	1.259	0.5	2.5	-177	1.4
11	2.518	0.25	1.25	-182	0.8
12	5.036	0.125	0.63	-182	0.8
13	9.836	0.064	0.32	-183	0.7
14	19.671	0.032	0.16	-183	0.7

a. *Filter Delay* is a time constant associated with each value of **IA** that describes the time needed for a pressure event to propagate through the IIR filter. Allow five time constants for a pressure event to propagate fully through the IIR filter.
b. *Cutoff Frequency* is the -3dB point of the low-pass IIR filter.
c. *Minimum Measurement Rate (MMR)* is the recommended minimum sampling rate to avoid aliasing. The measurement rate is set using the **TH** command (R5.20 and later) or the **PI** command (versions prior to R5.20). Values for MMR are approximately 3 times that of Cutoff Frequency.
d. *Measurand Resolution* is the resolution of pressure and temperature measurements.

NOTE: The resolution is measured at the corner frequency of the IIR filter, while the duration of the measurement is assumed to be the inverse of the corner frequency. For more information, please refer to the application note “Noise Floor of Quartz Crystals” found on the Paroscientific website.

6.5 Nano-Resolution Application Example

This example gives the steps required to configure an intelligent device for nano-resolution pressure measurements, according to the requirements of a particular application.

STEP 1: Enable Nano-Resolution mode

- Issue the command **0100EW*0100XM=1* to enable nano-resolution mode.

STEP 2: Determine the frequency range of interest

- For this example, let us assume the measured pressure data will contain information of interest at 1Hz and below.

STEP 3: Set the IIR filter cutoff frequency

- Since the pressure information of interest is expected to be at or below 1Hz, the cutoff frequency **BC** should be set above this value.
- Issue the command **0100EW*0100BC=2* to set the IIR cutoff frequency to 2 Hz.

STEP 4: Set the measurement rate

- The recommended minimum measurement sampling rate is approximately 3 times the IIR filter cutoff frequency. Sampling below this recommended rate can introduce aliasing and produce erroneous results. Since we have specified an IIR cutoff frequency of 2Hz, the recommended sampling rate is 3 times 2 Hz, or 6 Hz.
- Issue the command **0100EW*0100TH=6*,P4 to set the measurement rate to 6 Hz.

STEP 5: Begin taking pressure measurements

- Issue the command **0100P4* to begin acquiring continuous pressure measurements at the rate set by the **TH** command. Other continuous pressure measurement commands may also be used instead of **P4**.

6.6 Numeric Format For Nano-Resolution

6.6.1 Default Format

The default numeric formats used to report period, pressure, and temperature measurement values are as follows, where N = the number of significant digits set by **XN**.

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.

6.6.2 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
Typ. Set Command: *0100EW*0100XN=10
Typ. Read Command: *0100XN
Typical Response: *0001XN=10

When **XN**=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.

The integer portion of the measurement value is never altered regardless of the value of **XN**. Only the fractional portion of the measurement value is rounded as required to conform to the format specified by **XN**.

The number of digits in the integer portion of the full-scale pressure (**PF**) is used to determine the number of digits reserved but not necessarily used for the integer portion of pressure values.

Example:
If the full-scale pressure is 1000 psi, four digits are reserved for the integer portion, leaving **XN** minus 4 digits available for the fractional portion. If the pressure value is 14.12345678 and **XN**=8, the value would be formatted as 14.1235. Four digits were reserved for the integer portion but only two were needed, leaving 4 digits available for the fractional portion.

The **XN** command works in both standard resolution and nano-resolution modes.

Refer to Table 6-2 for examples of formatted measurement values for **XN**. The examples assume a transducer full-scale pressure (**PF**) of 16 psi.

TABLE 6-2: Examples of Formatted Measurement Value Using XN

XN	Measurement Value	Formatted Measurement Value
0	14.12345678901	14.12345678901
1	14.12345678901	14
2	14.12345678901	14
3	14.12345678901	14.1
4	14.12345678901	14.12
5	14.12345678901	14.123
6	14.12345678901	14.1235
7	14.12345678901	14.12346
8	14.12345678901	14.123457
9	14.12345678901	14.1234568
10	14.12345678901	14.12345679
11	14.12345678901	14.123456789
12	14.12345678901	14.1234567890
13	14.12345678901	14.12345678901

7 Pressure Measurement Concepts

7.1 Calculations and Formulas

Internal sensor temperature and applied pressure are calculated from period measurements of the two transducer output signals. The equations and coefficients used to perform these calculations are described below. Refer to the Calibration Coefficient Sheet for the actual coefficient values for your transducer.

7.1.1 Pressure Calculation

The following equation is used to calculate pressure:

$$P = C(1 - T_0^2/Tau^2)[1 - D(1 - T_0^2/Tau^2)]$$

Where:
P = pressure
Tau = pressure signal period (microseconds)
U = temperature signal period (microseconds) – U_0 (microseconds)
$C = C_1 + C_2U + C_3U^2$
$D = D_1 + D_2U$
$T_0 = T_1 + T_2U + T_3U^2 + T_4U^3 + T_5U^4$
Pressure Coefficients: C_1 C_2 C_3 D_1 D_2 T_1 T_2 T_3 T_4 T_5

NOTE: Certain seismic sensors also use an ‘E’ and ‘F’ coefficient as shown here:

$$P = C(1 - T_0^2/Tau^2)[1 - D(1 - T_0^2/Tau^2) + E(1 - T_0^2/Tau^2)^2 + F(1 - T_0^2/Tau^2)^3]$$

7.1.2 Temperature Calculation

The following equation is used to calculate internal sensor temperature:

$$T = Y_1U + Y_2U^2 + Y_3U^3$$

Where:
T = Temperature (°C)
U_0 = temperature signal period (microseconds) at 0° C
U = temperature signal period (microseconds) – U_0 (microseconds)
Temperature coefficients: U_0 Y_1 Y_2 Y_3

7.1.3 Final Output Pressure Calculation

The following equation is used with the pressure value calculated above to calculate the final output pressure value:

P_{output} = **PM**[(units multiplier) x P + **PA**]

Where: P_{output} = Final output pressure value (psi)
P = raw pressure value (from pressure equation above)
PM = Value stored in the **PM** parameter
PA = Value stored in the **PA** parameter
Units multiplier =Value used to convert psi to the current pressure unit.

The **PM** and **PA** commands allow for minor zero and span adjustments to the raw pressure value. Normally, **PM** (pressure multiplier) is set to 1.0, and **PA** (pressure adder) is set to 0.0. Refer to Sections 5.14, 13 and 7.2 below for more information related to the **PA** and **PM** commands.

7.2 Zero and Span Adjustments

Adjusted pressure is calculated using the following equation:

$P_{adjusted}$ = **PM** x (P + **PA**)

Where: P = Pressure calculated using original calibration coefficients, in the current pressure units
PM = the current value of PM
PA = the current value of PA

CAUTION

Use extreme caution when modifying **PA** or **PM** because they directly affect calibration. Inaccurate values will result in inaccurate pressure measurements.

7.3 Resolution, Integration Time, and Sampling Rate

NOTE: This section applies to standard resolution mode only.

The outputs from Digiquartz pressure transducers are two square wave signals whose period is proportional to applied pressure and internal transducer temperature. The Intelligent electronics measures these signals using a technique similar to that of a common laboratory frequency counter. Like the frequency counter, a signal must be integrated for a specified time to measure its period.

The time over which the signal is integrated determines the resolution of the measurement. Longer integration times increase resolution, but reduce the sampling rate. Conversely, shorter integration times decrease resolution, but increase the sampling rate.

Another factor that influences sampling rate is the serial baud rate. For short integration times, faster baud rates enable faster sampling. As integration times increase, the benefit of faster baud rates quickly diminishes.

Table 7-1 illustrates the relationship between integration time, resolution, and sampling rate for the **P4** command in Simultaneous Integration and Sequential Integration Simulation modes at various baud rates.

TABLE 7-1: Relationship of Sampling Time, Resolution, and Sampling Rate for P4 Command in Standard Resolution Mode

PI[a] (ms)	Pressure Resolution (ppm)	Sampling Rate [b,c] 9600 Baud (Hz)	57600/115200 Baud (Hz)
1	200.0000	106.70	418.00
3	66.6667	106.70	232.00
8	25.0000	87.30	106.00
11	18.1818	80.00	80.00
17	11.7647	54.00	54.00
34	5.8824	28.00	28.00
67	2.9851	14.60	14.60
134	1.4925	7.38	7.38
333	0.6006	2.99	2.99
666	0.3003	1.50	1.50
1333	0.1500	0.75	0.75
3332	0.0600	0.30	0.30
6664	0.0300	0.15	0.15
13328	0.0150	0.08	0.08
26656	0.0075	0.04	0.04
45872	0.0044	0.02	0.02

a. Data in this table assumes **TI** = **PI**.
b. The measurement time interval (seconds) is equal to 1 / Sampling Rate (Hz).
c. Data rates are approximations only and may vary slightly for different firmware versions.

7.4 High-Speed Sampling

Use one or more of the techniques shown in Table 7-2 to increase sampling rate:

TABLE 7-2: Sampling Rate Techniques

To try one of the following actions:	Use Command	On Page:
Increase baud rate	**BR**	27
Reduce integration time	**PI**, **TI**	36
Use a continuous pressure measurement command, such as **P4**	**P4**	31
Use the continuous pressure period command, and post-process data to convert to pressure	**P2**	32

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8 Networking Multiple Intelligent Devices

Digiquartz Intelligent devices support RS-232 serial loop and RS-485 multi-drop networking. Networking allows you to communicate with up to 98 Digiquartz Intelligent devices from a single RS-232 or RS-485 serial host.

8.1 Networking Basics

WHEN SETTING UP A NETWORK, THE FOLLOWING MUST BE OBSERVED:

- Verify proper operation of each Digiquartz Intelligent device before installing it in a network.
- If your network includes older Digiquartz Intelligent devices using SX.XX series firmware, set the older devices to **PT** = N to assure compatibility with the newer devices.
- Set all Digiquartz Intelligent devices to the same baud rate before installing them in a network. Once your network is up and running, you can change the baud rate to any supported value.
- Each Digiquartz Intelligent device on the network requires a unique Unit ID.
  - If you are setting up an RS-232 serial loop network, you can automatically set all devices to a unique ID value by issuing a single **ID** command.
  - If you are setting up an RS-485 multi-drop network, you must isolate each device from the network, and set the ID of each device individually.
  - See page 28 for more information on using the **ID** command.

8.2 Choosing a Network Type

RS-232 and RS-485 networks have unique benefits, as described below. Carefully consider your system requirements before selecting a network type.

BENEFITS OF RS-485 MULTI-DROP NETWORKS:

- RS-485 transmission distance is up to 4,000 feet, compared to 50 feet for RS-232 serial loop networking.
- Improved data integrity in electrically noisy environments, as compared to RS-232 serial loop networks.
- Can take synchronized measurements from any or all devices on the network. This is not possible with RS-232 serial loop network due to the delays that occur as the measurement command propagates through the network.
- Can wake up all sleeping devices with a single character. Each device must be awakened individually on an RS-232 serial loop network.
- Improved system reliability. It is less likely that a failure in a single unit will affect the entire network, as compared to RS-232 serial loop networks.

BENEFITS OF RS-232 SERIAL LOOP NETWORKS:

- RS-232 serial loop networks are compatible with most standard PCs, and most other control devices. RS-485 may not be available or may require additional hardware, depending on the serial host you have selected.
- Unique device IDs can be assigned to all devices on the network with a single command. With an RS-485 multi-drop network, you must isolate each unit and assign its unique ID individually.
- Can directly communicate with up to 98 devices. You can address up to 98 devices with RS-485, but you must use a repeater if you have more than 32 devices (including the host) on the network.

8.3 RS-485 Multi-drop Networks

As described in Section 8.2, page 73, RS-485 multi-drop offers several significant benefits over RS-232 serial loop networking. It is recommended that RS-485 multi-drop networks be used whenever possible.

RS-485 multi-drop networks can be wired as a 2-wire or 4-wire system. All Digiquartz Intelligent devices are compatible with either system. Refer to Section , page 100 for multi-drop network wiring diagrams.

RS-485 MULTI-DROP NETWORK CONSIDERATIONS

When setting up and operating an RS-485 multi-drop network, please be aware that up to 98 devices can be addressed on an RS-485 multi-drop network, but a maximum of 31 devices can be driven by any single transmitter. If you intend to build a network that exceeds 31 Digiquartz Intelligent devices, you must use one or more RS-485 repeaters to ensure that no device is driving more than a maximum of 31 receivers.

CAUTION

Do not attempt to set Unit ID values over a multi-drop network. Doing so will set all devices on the network to the same Unit ID value. To set each device to a unique Unit ID, isolate each device from the network, and individually set its Unit ID value.

CAUTION

Use caution when sending continuous measurement commands (**P2**, **P4**, **Q2**, **Q4**) to any device on a 2-wire multi-drop network. If you do this, you may need to cycle power to stop the continuous transmission of measurement data, since the command from the host to stop continuous measurement will likely collide with the measurement data coming from the device. This is especially true if your device is set for a short integration time.

CAUTION

Use caution when configuring any device on a 2 -wire RS-485 network for continuous pressure data output from the RS-485 port on power-up (**MD**=2 or **MD**=3). If you do this, it is unlikely that you will be able to reconfigure the unit over the network, since any command is likely to collide with the pressure data being continuously sent. To recover, you will need to remove the device from the network and reconfigure it individually via the RS-232 port.

2-WIRE RS-485 MULTI-DROP NETWORKS

Digiquartz Intelligent devices support half-duplex, primary-secondary communications with serial hosts. This means that the secondary device will only transmit if it has been commanded to do so by the serial host, or primary. This feature enables the Intelligent devices to be used in 2-wire RS-485 systems, where commands sent from the host and responses sent by the Intelligent devices are sent on the same pair of wires.

Figure 11-17 on page 100 illustrates a two-wire RS-485 multi-drop network consisting of a host and multiple Digiquartz Intelligent devices. Notice that the TX+ and RX+ signals and the TX- and RX- signals are tied together at each device, forming a 2-wire interface. The 2-wire half duplex configuration can reduce wiring costs, but the system designer must take precautions as described above to ensure reliable communications.

Data collisions occur on 2-wire RS-485 systems when two or more secondary devices transmit simultaneously, or when the primary and one or more secondary devices transmit simultaneously. The result of a data collision is that both transmissions become unintelligible and are lost. In a primary-secondary network, it is the responsibility of the serial host to ensure that data collisions do not occur. Normally, this requires that the host wait an appropriate length of time for a response before sending another command.

Since multiple transmitters share common wiring in 2-wire RS-485 multi-drop systems, it is necessary that all devices on a network have the ability to disable their transmitters when not actively transmitting. Digiquartz Intelligent devices perform this task automatically, but the serial host must also enable its transmitter only when transmitting. Some RS-485 devices, particularly low-cost RS-232 to RS-485 converters, tend to leave their transmitters enabled for a period of time after RS-485 data has been transmitted. If this time is sufficiently long, some or all of the response data from a Digiquartz Intelligent device will not be received by the serial host, since the host will still be in the transmit mode when the response is being sent. If you plan to use such a device, reliable two-wire RS-485 communications may not be possible, and you will need to use a 4-wire system instead.

4-WIRE RS-485 MULTI-DROP NETWORKS

Figure 11-18 on page 101 illustrates a 4-wire RS-485 multi-drop network consisting of a host and three Digiquartz Intelligent devices. In this system, there is no need for the host to disable its transmitter, since it is connected to the receive lines of the Intelligent devices via a dedicated pair of wires, enabling full-duplex operation.

8.4 RS-232 Serial Loop Networks

In an RS-232 serial loop network, the transmit output of the RS-232 host is connected to the receive input of the first device in the loop (see Figure 8-1). The transmit output of the first device is connected to the receive input of the next device. The remaining devices are connected similarly, with their receive input connected to the transmit output of the previous device, and their transmit output connected to the receive input of the next device. The transmit output of the last device is connected to the receive input of the RS-232 host.

The host sends commands to the first device in the loop. If a command is addressed to that device, the command is carried out; if not, the command is resent to the next device. Globally addressed commands are carried out by each device, and are also resent to the next device. When a device responds to a command, the response is addressed to the host, and is therefore resent by each device that receives it until it eventually makes it way to the serial host.

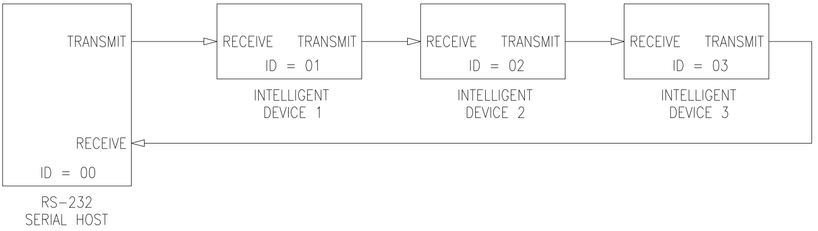

FIGURE 8-1: Serial Loop Network Block Diagram

Keep these points in mind when designing an RS-232 serial loop network:

- As previously described, each device will resend any command or response that is addressed to another device. Since each device considers resending to be a higher priority than sending its own response, it is possible that a device can spend all its time resending, and never have an opportunity to send its own response. This occurs only when one or more upstream devices are continuously transmitting. To prevent this situation:
  - Operate your network at 9,600 or 19,200 baud.
  - Avoid continuous transmission (**P2**, **P4**, **Q2**, and **Q4** commands) at extremely low integration times.
- Do not operate a serial loop network above 19,200 baud.
- A single **ID** command will automatically set all devices on the serial loop to unique sequential IDs.
- It is not possible to precisely synchronize measurements from two or more devices by sending a global measurement command. This is a result of the delay that occurs as the measurement command propagates through the serial loop. If precise measurement synchronization is required, consider an RS-485 multi-drop network instead.

- When a global command is sent, it propagates through the serial loop, eventually making its way back to the host. Therefore, the data received by the host in response to a global command includes the command itself, followed by the individual responses from all devices on the network.
- Sleeping devices on a serial loop network must be awakened individually, and in sequence, by sending a complete command to each device, starting with the first device. Keep in mind that a serial loop network will not be fully operational unless all devices on the network are awake, since response data will not be resent by sleeping devices downstream.
- Digiquartz Interactive software (DQI3) is not capable of waking multiple sleeping devices on a serial loop network. If you intend to use DQI3 to communicate with units on a serial loop network, please ensure that all devices have the sleep mode disabled.

8.5 Other Networking Methods

MULTIPLE SERIAL PORTS

PC expansion boards are available which provide up to 32 individual RS-232 serial ports. Using such a board, it would be possible to design a system whereby each Intelligent device would be connected to the serial host via its own RS-232 port. This type of a system would ensure that any communications port, cable, or transmitter failure would not affect the rest of the system.

RELAY MULTIPLEXER SYSTEM

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

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9 GPS Receiver Interfacing

Digiquartz Intelligent instruments with a pulse-per second (PPS) input and firmware KX.XX (M7 processor) or QX.XX (M3 processor) can interface with compatible GPS receivers. Instruments with older firmware RX.XX or SX.XX are not compatible with GPS interfacing.

An optional timestamp can be included with measurement command responses. The timestamps can be used with or without a GPS receiver or PPS input signal. The timestamp has several formatting options, and can be positioned just after the address header or at the end of the measurement command response. The benefits to interfacing with a GPS receiver include:

- Measurements can be synchronized with GPS time
- Absolute time-stamping of measurement data
- Precise synchronization of measurements between multiple instruments
- Internal real-time clock synchronized with GPS time

At this time, the following Garmin GPS receivers have been qualified for use with Paroscientific instrumentation:

- Garmin GPS 24xd HVS
- Garmin GPS 16x HVS

NOTE: The Garmin 19x HVS and 17x HVS are also qualified for use but have been discontinued by Garmin.

9.1 Timestamp and Time/Date Format

An optional timestamp can be included with measurement command responses.The timestamps can be used with or without a GPS receiver or pulse-per-second (PPS) input signal. The timestamp has several formatting options, and can be positioned just after the address header or at the end of the measurement command response.

Example: Triax Accelerometer **P3** measurement response with timestamp enabled:
*0001,A,09/16/21 12:42:36.744,.271049445,.051840849,9.800686949

TABLE 9-1: Triax Accelerometer P3 Example with Timestamp

Field	Value	Description
1	*0001	Address Header
2	A	GPS/PPS status (see Section 9.4)
3	09/16/21 12:42:36.744	Timestamp
4	.271049445	X axis acceleration
5	.051840849	Y axis acceleration
6	9.800686949	Z axis acceleration

When starting a measurement sequence with timestamps enabled, measurements commence at the top of the next second, and the first response will have a timestamp one sampling interval later.

Example: If a measurement command is issued at 09:59:59.500AM and **TH**=40 (40 Hz data rate), the first measurement will be time-stamped 10:00:00.025AM.

TS Enable Timestamp

Action:	Issue the TS command to enable timestamps.
Range:	0 or 1
Default:	0
Typ. Set Command:	*0100EW*0100TS=1
Typ. Read Command:	*0100TS
Typical Response:	*0001TS=1

When the GPS interface is enabled (**GE**=1), timestamps are derived from GPS date and time data. When the GPS interface is disabled (**GE**=0), timestamps are derived from the internal real-time clock. The real-time clock is volatile and must be set whenever the M7 instrument is reset, either by a command or by a power cycle.

Any measurement command can be used to test the timestamp. For example, *0100P3 should produce a single timestamped pressure/acceleration measurement response. If no timestamp is produced, ensure that **TS**=1 (timestamp enabled).

TJ Timestamp Format

Action:	Sets the desired timestamp format
Range:	0 to 5
Default:	0
Typ. Set Command:	*0100EW*0100TJ=1
Typ. Read Command:	*0100TJ
Typ. Set Response:	*0001TJ=1

The **TJ** parameter sets the timestamp format as shown in the table below.

For **TJ** = 0, 1, 2 or 3 the timestamp is date and time expressed in ASCII decimal. For **TJ** = 4 or 5 the timestamp is UTC time in seconds expressed in hexadecimal format.

TABLE 9-2: Timestamp Formats

TJ	Format Mode	Resolution	Output Format
0	Standard	millisecond	MM/DD/YY HH:MM:SS.sss
1	Standard	microsecond	MM/DD/YY HH:MM:SS.ssssss
2	GSE	millisecond	YYYY/MM/DD HH:MM:SS.sss
3	GSE	microsecond	YYYY/MM/DD HH:MM:SS.ssssss

TABLE 9-2: Timestamp Formats

TJ	Format Mode	Resolution	Output Format
4	NTP	microsecond	AAAAAAAA.aaaaaaaa (‘AA’ = seconds, ‘aa’ = fractional seconds)
5	NTP	232ps (1/2^32 sec.)	BBBBBBBB.bbbbbbbb (‘BB’ = seconds, ‘bb’ = fractional seconds)

NOTE: **TJ** = 4 is UNIX epoch based (number of seconds since 1/1/1970). **TJ** = 5 is NTP epoch based (number of seconds since 1/1/1900).

TF Offset GPS time to match local

Action: Offsets GPS time to match your local UTS time zone.
Range: -12 to 14
Default: 0
Typ. Set Command: *0100EW*0100TF=5
Typ. Read Command: *0100TF
Typical Response: *0001TF=5

TF has no effect on GSE and NTP format timestamps, and is only in effect when time and date are provided by a GPS receiver (**GE**=1).

TP Timestamp Position

Action: Offsets GPS time to match your local UTS time zone.
Range: 0 or 1
Default: 0
Typ. Set Command: *0100EW*0100TP=0
Typ. Read Command: *0100TP
Typical Response: *0001TP=0

TABLE 9-3: Timestamp Position

TP	Timestamp Position	Examples
0	BEFORE data	*0001A,11/26/13 09:26:21.005 AM,14.63821
1	AFTER data	*000114.63821,A, 11/26/13 09:26:21.005 AM

GT Time Format

Action: Sets 12 hour or 24 hour time format.
Range: 0 or 1
Default: 0
Typ. Set Command: *0100EW*0100GT=0
Typ. Read Command: *0100GT
Typical Response: *0001GT=0

TABLE 9-4: Time Format

GT	Time Format	Examples
0	12 hour	*0001A,11/26/13 01:33:57.201 PM,14.63887
1	24 hour	*0001A,11/26/13 13:33:57.201,14.63887

GD Date Format

Action:	Sets the MM/DD/YY or DD/MM/YY date format
Range:	0 or 1
Default:	0
Typ. Set Command:	*0100EW*0100GD=0
Typ. Read Command:	*0100GD
Typical Response:	*0001GD=0

TABLE 9-5: Date Format

GD	Date Format	Example
0	MM/DD/YY	*0001A,11/26/13 13:33:57.201,14.63887
1	DD/MM/YY	*0001A,26/11/13 13:33:57.201,14.63887

GR Time/Date in current form

Action:	Sets and reports the current date and time using the current date (**GD**) and time (**GT**) format settings.
Typ. Set Command:	*0100EW*0100GR=01/12/23 11:45:53 PM
Typ. Read Command:	*0100GR
Typical Response:	*0001GR=01/12/23 11:45:53 PM

This example assumes MM/DD/YY date (**GD**=0) and 12-hour time (**GT**=0). The date and time format used to create a **GR** command must conform to the current **GT** and **GD** settings.

NOTE: When connected to a GPS receiver, the internal real-time clock is synchronized with GPS date and time. It is only necessary to set the date and time when not using a GPS receiver. The real-time clock must be set each time the unit is powered on or reset by a command.

GC Writes only time/date at the top of the next second

Action:	Writes time/date at the top of the next second. Time/date must be written in the current date (**GD**) and time (**GT**) format.
Typ. Set Command:	*0100EW*0100GC=01/12/23 11:45:53 PM
Example:	12/02/25 08:01:09.750 AM,27.8193026458

This example assumes MM/DD/YY date (**GD**=0) and 12-hour time (**GT**=0). The date and time format used to create a **GC** command must conform to the current **GT** and **GD** settings.

9.2 Synchronizing Measurements

When an M7 instrument is integrated with a GPS receiver, continuous measurement commands (**P4**, **E4**, etc.) produce measurements synchronized with GPS time, enabling precise measurement synchronization between multiple instruments.

For most applications, the most effective synchronization occurs when all instruments are set up identically. The following operating parameters should be identical for all instruments used in synchronous measurement applications:

SERIAL PORT BAUD RATE

Set all instruments to the same baud rate (**BR** command). For details on using the **BR** command , refer to page 27.

DATA RATE

Setting the data rate with the **TH** command provides precise data intervals and consistent data rates. Refer to page 38 for additional information on using the **TH** command. Setting the data rate with the **PI** and **TI** commands is not recommended in synchronous applications.

MEASUREMENT MODE

Set all instruments to Standard Resolution, or set them all to Nano Resolution mode (**XM** command). If using Nano Resolution, set all instruments to the same corner frequency (**IA** or **BC** command). Refer to Section 6 of this document for details on using Nano Resolution.

MEASUREMENT TYPE

Continuous measurement commands (**P4**, **E4**, etc.) used in conjunction with the **TH** command will produce measurements at consistent intervals and with identical timestamps.

TIME STAMP PARAMETERS

Set up all units to the same timestamp and date/time formats.

9.3 Interfacing with a GPS Receiver

As noted earlier, Digiquartz Intelligent instruments with a pulse-per second (PPS) input and firmware KX.XX or QX.XX can interface with compatible GPS receivers. To enable and configure a GPS receiver the following commands are used:

GE Enable GPS functionality

Action:	This will enable the GPS interface between the instrument and GPS receiver.
Range:	0 = GPS disabled 1 = GPS enabled with PPS signal 2 = PPS signal only (no GPS tracking)
Typ. Set Command:	*0100EW*0100GE=1
Typ. Read Command:	*0100GE
Typical Response:	*0001GE=1

GI Configure Garmin GPS 16x/17x/19x/24x devices

Action:	This command is used to configure compatible GPS devices for use with Paroscientific instruments.
Range:	0 to 5 (see below for settings)
Default:	1
Typ. Set Command:	*0100EW*0100GI=1
Typ. Read Command:	*0100GI
Typical Response:	*0001GI=1

0 = defaults GPS to Garmin factory settings (PPS disabled)
1 = Configures GPS to work with Paroscientific instruments (PPS enabled)
2 = Enable all data sentences (for troubleshooting only)
3 = Force GPS to reset
4 = Force GPS to a cold start
5 = Only GPRMC enabled (minimum requirement)

To interface with a GPS receiver, please follow the steps below:

STEP 1: Connect GPS to the M7 instrument

- Depending on the Garmin GPS model that is being connected, refer to the figures below to connect the Garmin GPS receiver to the M7 instrument.
- If using the Garmin GPS 24xd HVS or GPS 19x HVS, ensure that its Rate Change Cable is installed per Figure 9-6. The function of the Rate Change Cable is to set the GPS default baud rate to 4800 and serial data rate to 1Hz. When the Rate Change Cable is installed, the GPS 24xd HVS or GPS 19x HVS defaults to the same baud rate and serial data rate as the GPS 17x and GPS 16x.

STEP 2: Set up the M7 instrument to enable the GPS interface

- Issue the command **0100EW*0100GE=1* to enable the GPS interface.

STEP 3: Set the M7 instrument GPS port baud rate to 4,800 baud.

- If using the Garmin GPS 17x HVS, GPS 19x HVS, or GPS 24xd HVS (RS-485), issue the command **9900BR2=4800*.
- If using the Garmin GPS 16x HVS (RS-232), issue the command **9900BR1=4800*.

STEP 4: Configure the GPS receiver for use with the M7 instrument.

- Issue the command **0100EW*0100GI=1*. The unit should respond with >*OK: GPS ready for operation, cycle power.* For both the GPS receiver and the M7 instrument, cycle power to establish communications between the two. If an error message is received, please refer to GPS troubleshooting in Section 9.6.

STEP 5: Enable Timestamps

- If timestamps are desired, issue the command **0100EW*0100TS=1*. Refer to Section 9.1 for timestamp details and formatting options.

STEP 6: Test to verify successful interface with the GPS receiver

- Issue the command **0100GP* to get the status of the GPS interface. The unit should respond with ">1: GPS is functioning properly" once the GPS receiver acquires a sufficient number of satellites. For any other response, please refer to GPS troubleshooting in Section 9.6.

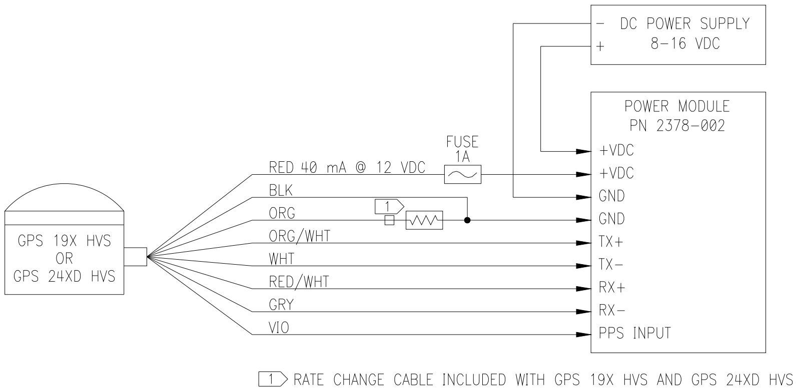

FIGURE 9-6: Garmin GPS Models 19x-HVS and 24xd-HVS Wiring Diagram

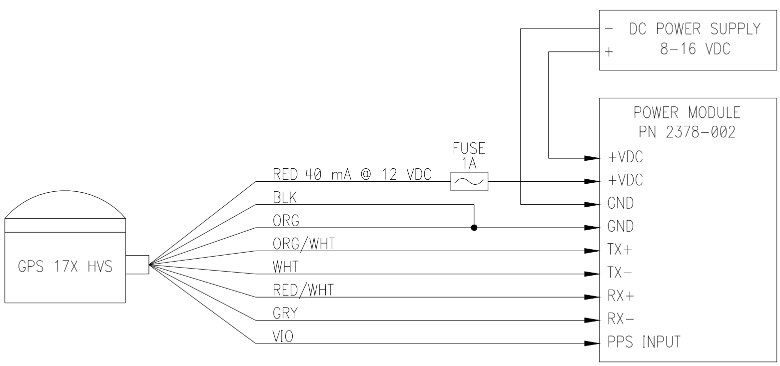

FIGURE 9-7: Garmin GPS Model 17x Wiring Diagram

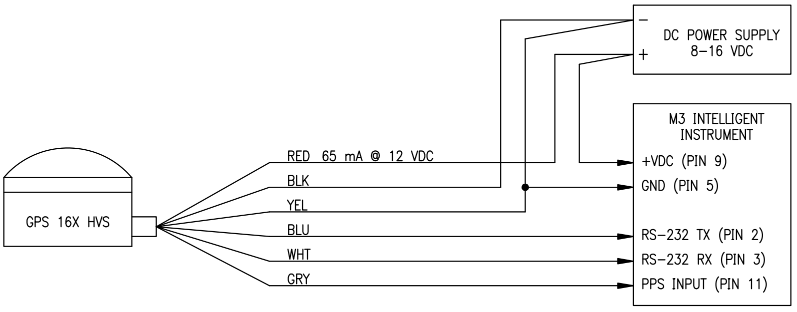

FIGURE 9-8: Garmin GPS Model 16x Wiring Diagram

9.4 GPS Status Indication

A GPS status indication is shown in the optional timestamp included with each measurement command response. Refer back to Section 9.1 for details on using timestamps.

TABLE 9-9: Status When Using GPS Mode (GE = 1)

Status	Description
V	GPS mode not enabled, GPS not yet locked, or a problem with the GPS integration
A	GPS mode enabled and GPS integration functioning properly

9.5 Instrument Behavior When GPS is Interrupted

GPS DATA AND PPS INTERRUPTED

If the GPS serial data or the PPS signal is interrupted, the GPS status indicator becomes the character "V", and the M7 instrument will continue to trigger measurements and generate time stamps based on the internal real-time clock. When GPS serial data and PPS signal are restored, the GPS status indicator becomes the character "A", the M7 instrument immediately synchronizes with any resulting GPS timing change, and measurements will continue uninterrupted.

GPS POSITION LOCK INTERRUPTED

If the GPS loses position lock due to acquisition of insufficient satellites, the GPS status indicator becomes the character "V", and the M7 instrument will continue to trigger measurements and generate time stamps based on GPS time and PPS. When the GPS regains position lock, the GPS status indicator becomes the character "A", the M7 instrument immediately synchronizes with any resulting GPS timing change, and measurements will continue uninterrupted.

9.6 GPS/PPS Troubleshooting

The GP command reports the status of the GPS and PPS. Whenever a problem is encountered with the GPS/PPS interface, issue the command **0100GP* to help diagnose and correct the problem.

GP Report GPS connection status for PPS

Action:	Diagnostic command to help resolve problems.
Typ. Read Command:	*0100GP
Typ. Read Response:	*0001GP>0:GPS Functions are disabled

The **GP** command produces the following responses when in GPS is enabled (**GE**=1). If a problem is reported, take the corrective action recommended for the response received and issue the **GP** command again to see if the problem has been resolved.

>0: GPS Functions are disabled

Corrective Action: Enable GPS functions by issuing command **0100EW*0100GE=1 for GPS or *0100EW*0100GE=2* for PPS only.

>1: GPS is functioning properly

No corrective action needed.

>2: PPS signal not detected yet

GPS serial data is being received, but PPS signal has not yet been detected.

Corrective Action: Allow time for the GPS receiver to achieve position lock and produce a PPS signal. Ensure that the GPS receiver has been configured to work with M7 instrument by issuing the command **0100EW*0100GI=1*. Check wiring to ensure the PPS signal is properly wired to the M7 instrument.

>3: Lost GPS serial communications

GPS serial data is no longer being received but the PPS signal is still being received.

Corrective Action: Ensure the GPS serial port is still at the correct baud rate, typically 4800 baud. Ensure that GPS serial wiring is correct.

>4: Lost PPS and GPS serial communications

GPS serial data and PPS are no longer being received.

Corrective Action: Verify that GPS is still being powered properly and GPS wiring is correct.

>5: Acquiring more GPS satellites

Corrective Action: Wait for GPS to acquire sufficient satellites for position lock. The GPS status indicator will change from V to A when sufficient satellites have been acquired. If this status never clears, ensure that GPS is in an appropriately unobstructed location.

>6: GPS port baud rate greater than 38400

Corrective Action: Do not attempt to set the baud rate of the com port used for GPS communications to greater than 38,400 baud. It is almost never necessary to use anything other than the default baud rate of 4,800 baud.

>7: GPS serial communications not received

Corrective Action: Check GPS power, GPS port baud rate, and GPS wiring.

>8: PPS signal not detected

GPS serial data being received with position lock achieved, but no PPS signal detected.

Corrective Action: Ensure that the GPS receiver has been configured to work with the M7 instrument by issuing the command **0100EW*0100GI=1*. Check that PPS signal is wired correctly.

>11: Update date/time

When connected to a GPS receiver, the internal real-time clock must be set each time the unit is powered on or reset by a command.

Corrective Action: Update the date/time using the **GC** or **GR** command.

The **GP** command produces the following responses when PPS mode is enabled (**GE**=2). If a problem is reported, take the corrective action recommended for the response received, then issue the **GP** command again to see if the problem has been resolved.

>9: PPS signal detected

Unit configured for PPS mode and a proper PPS signal is detected. No corrective action needed.

>10: PPS signal not detected

Unit configured for PPS mode and PPS signal is not detected.

Corrective Action: Ensure that the GPS receiver has been configured to work with the M7 instrument by issuing the command **0100EW*0100GI=1*. Check PPS signal source and wiring, and ensure the PPS signal meets the requirements in the product SCD.

9.7 Synchronizing an M7 Instrument to a PPS Signal

M7 instruments can accept a pulse per second (PPS) signal alone, without GPS data. In this configuration, the internal real-time clock is synchronized to the PPS signal. Measurements can also be synchronized to PPS when **TH** is used to set the measurement rate.

Benefits

- Measurements can be synchronized with GPS time
- Absolute time-stamping of measurement data
- Precise synchronization of measurements between multiple M7 instruments

NOTE: For PPS signal requirements, please refer to the instrument SCD.

9.7.1 Configuring Instruments for PPS operation

To configure M7 instruments for PPS operation, please follow the steps below:

STEP 1: Connect PPS signal to M7 instrument

- If using the Power Module P/N 2378-002: Connect the PPS signal from the signal source to the Power Module PPS terminal, and connect the ground from the PPS signal source to a Power Module ground terminal.
- If not using the Power Module P/N 2378-002: Connect the PPS signal from the signal source to the M7 instrument pin 11, and connect the ground from the PPS signal source to M7 instrument pin 5.

STEP 2: Configure the M7 instrument for PPS mode

- Issue the command **0100EW*0100GE=2* to enable PPS mode

STEP 3: Test the PPS interface

- Issue the command **0100GP*. The instrument should respond with *>9:PPS signal detected*. If any other response is received, refer to the PPS troubleshooting section.

9.7.2 Key Points Regarding PPS Mode

PPS STATUS INDICATION

A PPS status indication is shown in the optional timestamp included with each measurement command response.

TABLE 9-10: Status When Using PPS Only (GE = 2)

Status	Description
V	PPS mode not enabled or PPS signal not detected
X	PPS signal detected but real-time clock has not been set since power-up. See **GR** command
P	PPS functioning properly

DATA AND TIME INFORMATION

Date and time information used to create timestamps is provided by the M7 instrument's real-time clock. The real-time clock is volatile and must be set whenever the unit is powered up or reset. To set the real-time clock using the **GR** command, refer to page 82.

CONTINUOUS MEASUREMENTS

Continuous measurements are only synchronized with the PPS signal when **TH** is used to set the data rate. When **TH**=0, measurements are not synchronized to the PPS signal. Refer to page 38 for using the **TH** command.

9.8 RS-485 Command Response Delay

PC RS-485 communications often involve USB/RS-485 or RS-232/RS-485 converters. When converters are used in RS-485 2-wire configurations, care must be taken to avoid data collisions by ensuring the target device does not respond to commands before the converter has a chance to switch the RS-485 transceiver from transmit to receive mode.

The **DA** command sets the minimum delay between a command and its response, ensuring adequate time for the RS-485 transceiver to switch.

If you are experiencing garbled or missing serial data on a 2-wire RS-485 system with a serial converter, try increasing the **DA** value until proper command responses are received. Since different serial converter brands and models operate differently, it may be necessary to experiment with different **DA** values to find a setting that prevents data collisions but does not cause excessive delay.

DA RS-485 Command Response Delay

Action:	Sets the minimum delay between a command and its response, ensuring adequate time for the RS-485 transceiver to switch.
Range:	0 - 1,000,000 µs
Default:	1500
Typ. Set Command:	*0100EW*0100DA=5000
Typ. Set Response:	*0001DA=5000

10 I/O Lines

Digiquartz Intelligent Transmitters feature discrete digital I/O lines that may be used to control and monitor tare and overpressure alarm functions. See Section 5.11, page 47 for more information regarding tare and overpressure functions.

> **NOTE:** Some Digiquartz Intelligent Devices do not support the I/O lines described in this section. Refer to the SCD for the specific device in-use.

10.1 Input

TARE INPUT

Activated by a momentary contact closure to ground. When taring is not in effect and Tare Input is activated, taring is enabled on the next pressure measurement. When taring is in effect and Tare Input is activated, taring is disabled, and the next pressure measurement taken will not be tared.

WARNING

To prevent possible damage, do not connect the Tare Input to anything other than the DC power ground from the voltage source. The Tare line is pulled to 3.3V internally and should NEVER have voltages higher than 5VDC applied to it.

10.2 Output

TARE OUTPUT

Indicates whether the most recent pressure measurement was tared. The tare output is set to logic high when taring is in effect, is set to logic low when taring is not in effect.

OVERPRESSURE OUTPUT

Indicates whether the most recent pressure measurement exceeds the user-specified overpressure setpoint. The overpressure output is set to logic high if overpressure setpoint is exceeded, and is set to logic low otherwise. See the **OP** command on page 48 for more information.

- Logic low:< 0.1 VDC
- Logic high:3.3 VDC
- Maximum output drive current: 300μA (microamps)

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11 Connector and Wiring Diagrams

11.1 Connector Diagrams

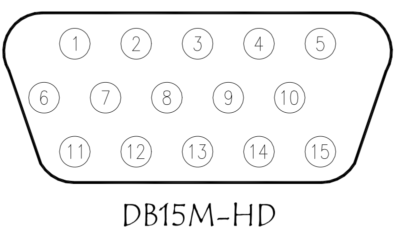
This section provides pin assignment diagrams for Digiquartz Intelligent devices and standard PCs. PC pin assignments are typical; if in doubt, consult the hardware manual that came with your PC.

NOTE: All connector diagrams are as viewed from the mating end of the device.

WARNING

Pin-outs shown are based on standard product configurations. For custom configurations, always consult the SCD for the specific electrical pin-outs and voltage requirements.

11.1.1 Intelligent Device - RS-232/485

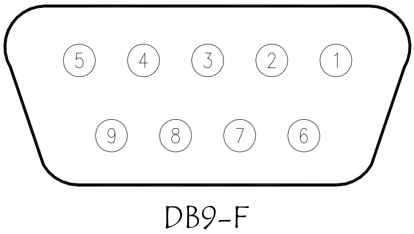


Pin	Connection
1	Chassis ground
2	RS-232 TX
3	RS-232 RX
4	Not used
5	Power / Signal ground
6	Tare output
7	Tare switch input
8	Overpressure output
9	Power (consult SCD)
10	Not used
11	Not used / PPS Input[a]
12	RS-485 RX+
13	RS-485 RX-
14	RS-485 TX+
15	RS-485 TX-

a. Some configurations may have PPS input, see unit SCD for details.

FIGURE 11-1: Intelligent Transmitter - 15-Pin Connector Pinout

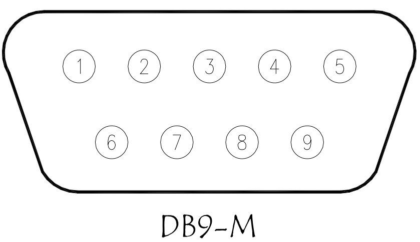
11.1.2 Intelligent Device - RS-232 Only



Pin	Connection
1	Chassis ground
2	RS-232 TX
3	RS-232 RX
4	not used
5	Power / Signal ground
6	not used[a]
7	not used
8	not used[b]
9	Power (consult SCD)

a. Display clock, obsolete Model 760.
b. Display data, obsolete Model 760.

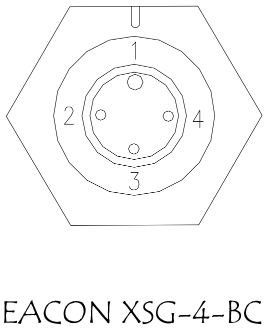
FIGURE 11-2: Model 1000 Intelligent Transmitter and Model 765 Portable Field Standard - 9-Pin Connector



Pin	Connection
1	not used
2	RS-232 TX
3	RS-232 RX
4	not used
5	Power / Signal ground
6	not used
7	Tare Output
8	not used
9	Power (consult SCD)

FIGURE 11-3: Model 6000 Intelligent Barometer, Model 9000 Intelligent Transmitter - 9-pin Connector

11.1.3 Depth Sensor - RS-232 Only

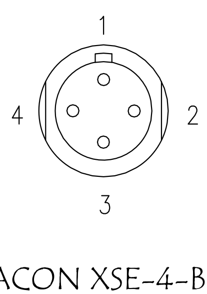


INTELLIGENT DEVICE	
Pin	Connection
1	RS-232 TX
2	RS-232 RX
3	Power/Signal ground
4	Power (consult SCD)

NON-INTELLIGENT DEVICE	
Pin	Connection
1	Temperature Signal[a]
2	Pressure Signal
3	Power/Signal ground
4	Power (consult SCD)

a. For non-temperature compensated units PIN 1 is not used.

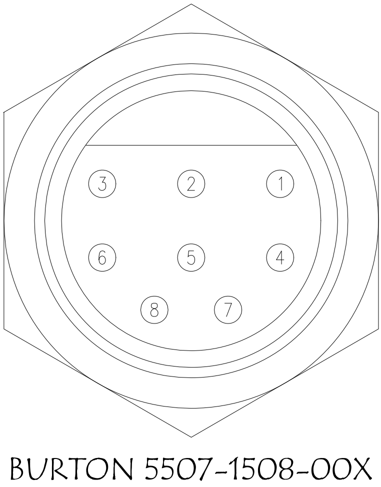
FIGURE 11-4: 8B, 8DP, 8WD Depth Sensor - Seacon BCL Connector Pinout



Pin	Connection
1	RS-232 TX
2	RS-232 RX
3	Power/ Signal ground
4	Power (consult SCD)

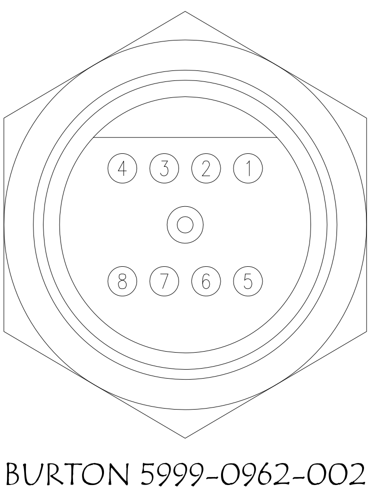
FIGURE 11-5: 8DP Intelligent Depth Sensor - Seacon BCR Connector Pinout

11.1.4 Intelligent Depth Sensor - RS-232/485



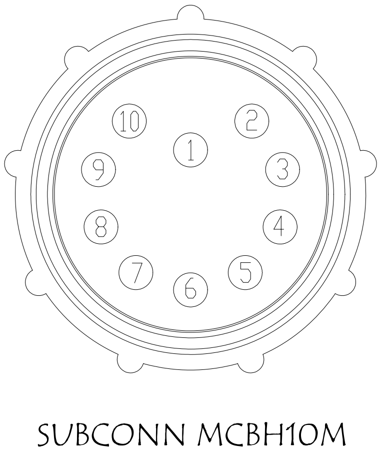
Pin	Connection
1	RS-232 TX
2	RS-232 RX
3	Power/ Signal ground
4	Power (consult SCD)
5	RS-485 RX+
6	RS-485 RX-
7	RS-485 TX+
8	RS-485 TX-

FIGURE 11-6: Intelligent Absolute Depth Sensor - Burton Connector Pinout



Pin	Connection
1	RS-232 TX
2	RS-232 RX
3	Power / Signal ground
4	Power (consult SCD)
5	RS-485 RX+
6	RS-485 RX-
7	RS-485 TX+
8	RS-485 TX-

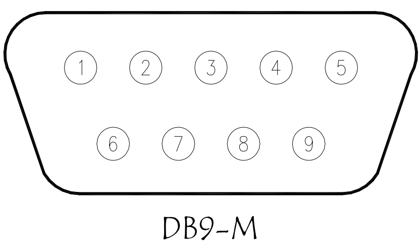
FIGURE 11-7: Intelligent Gauge Depth Sensor - Burton Connector Pinout



Pin	Connection
1	RS-232 TX
2	RS-232 RX
3	Power / Signal ground
4	Power
5	RS-485 RX+
6	RS-485 RX-
7	RS-485 TX+
8	RS-485 TX-
9	PPS
10	not used

FIGURE 11-8: Intelligent Absolute Depth Sensor - SubConn MCBH Connector Pinout

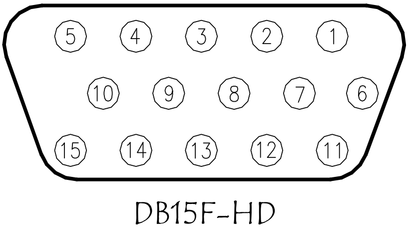
11.1.5 PC RS-232 Port: 9-pin Male D-Sub Connector



Pin	Connection
1	Data Carrier detect (DCD)
2	RS-232 RX
3	RS-232 TX
4	Data Terminal Ready (DTR)
5	Signal ground
6	Data Set Ready (DSR)
7	Request To Send (RTS)
8	Clear To Send (CTS)
9	Ring Indicator (RI)

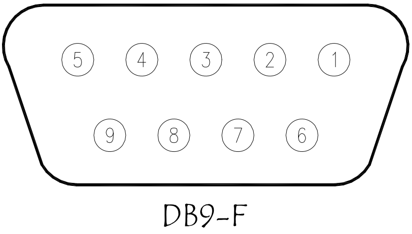
FIGURE 11-9: Typical PC RS-232 - 9-Pin Connector Pinout

11.1.6 Power Adapter Module Connectors



Pin	Connection
1	Not used
2	RS-232 TX
3	RS-232 RX
4	Not used
5	Power / Signal ground
6	Not used
7	Not used
8	Not used
9	Power (consult SCD)
10	Not used
11	Not used
12	RS-485 RX+
13	RS-485 RX-
14	RS-485 TX+
15	RS-485 TX-

FIGURE 11-10: P/N 6671-003 Power Module - 15-Pin Connector Pinout



Pin	Connection
1	Not used
2	RS-232 TX
3	RS-232 RX
4	Not used
5	Power / Signal ground
6	Not used
7	Not used
8	Not used
9	Power (consult SCD)

FIGURE 11-11: P/N 6671-003 Power Module - 9-Pin Connector Pinout

11.2 Serial Wiring Diagrams

The diagrams in this section show the various ways in which Digiquartz Intelligent devices can be connected to RS-232 and RS-485 serial hosts. The pin numbers given are for Digiquartz Intelligent devices with 15-pin high-density D-sub miniature connectors. Refer to Section 11.1, page 93 for pin assignments of other connectors. PC serial port pin numbers assume a typical 9-pin RS-232 port; consult the documentation that came with your PC to verify your RS-232 port pin assignments.

11.2.1 RS-232 Wiring Diagrams

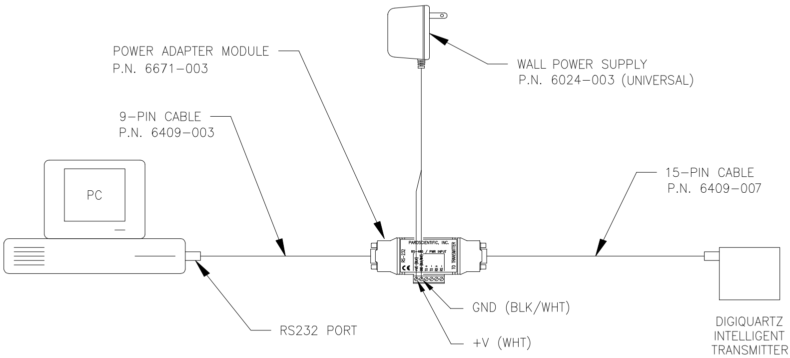


FIGURE 11-12: RS-232 Wiring Diagram Using Optional RS232/RS485 Power Module Kit

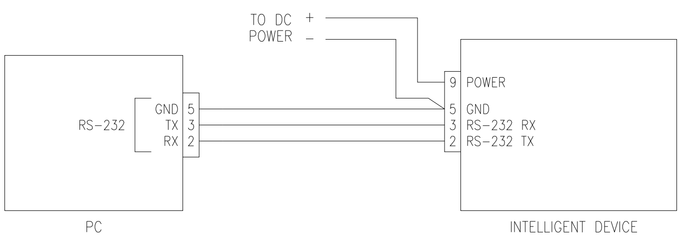


FIGURE 11-13: Simple RS-232 Wiring Diagram

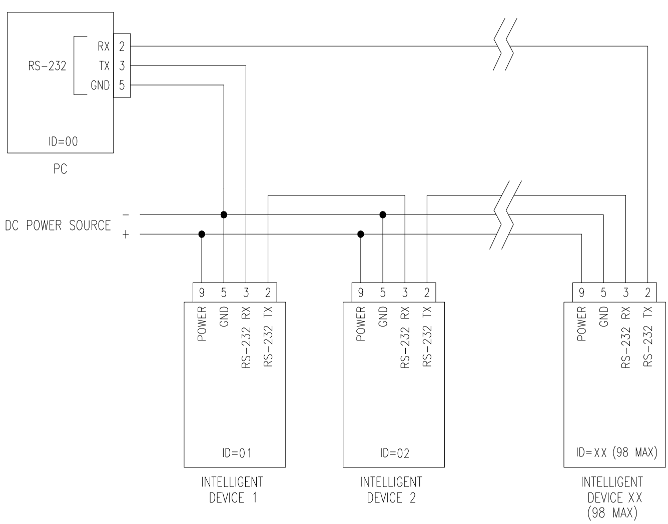


FIGURE 11-14: RS-232 Serial Loop Network Wiring Diagram

11.2.2 RS-485 Wiring Diagrams

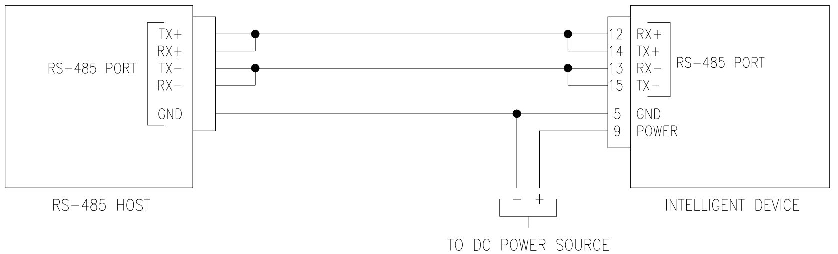


FIGURE 11-15: 2-Wire RS-485 System, Single Device

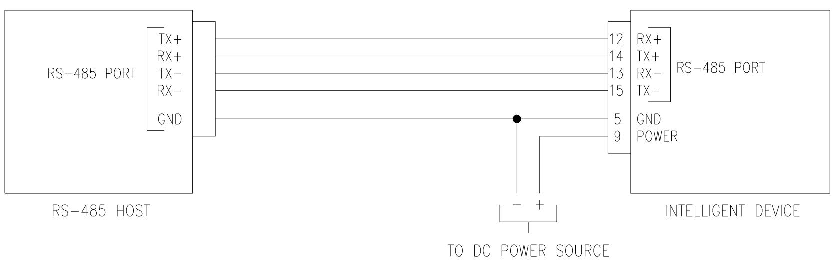


FIGURE 11-16: 4-Wire RS-485 System, Single Device

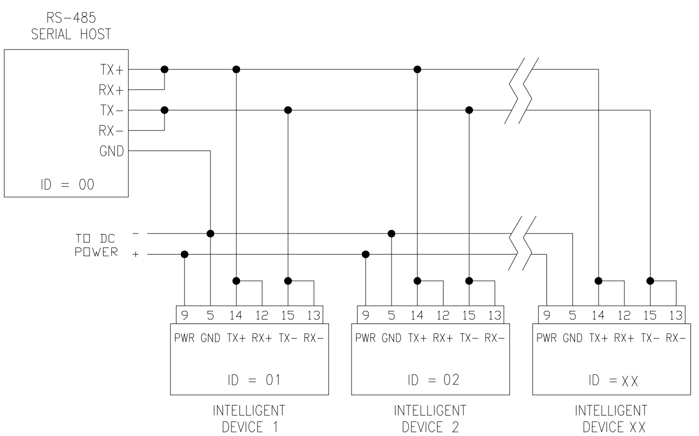


FIGURE 11-17: 2-Wire RS-485 Multi-Drop Network Wiring Diagram

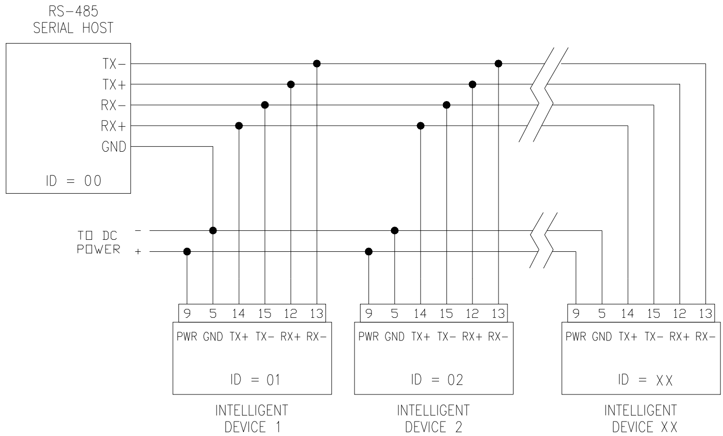


FIGURE 11-18: 4-Wire RS-485 Multi-Drop Network Wiring Diagram

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12 Troubleshooting

12.1 Troubleshooting

The following are solutions to frequently encountered problems. If you are experiencing difficulty with a Digiquartz Intelligent device, it is likely that the solution can be found below.

> **NOTE:** For troubleshooting GPS related issues, please refer directly to Section 9.6, page 87.

NO RESPONSE FROM DEVICE

Check your connections:

- Check your connections to ensure that your system is hooked up properly.
- Check your power source to ensure that the proper voltage is supplied to the device.
- If you believe that your system is wired and powered properly, but you still cannot communicate with your device(s), try using a PC and Digiquartz Interactive software (DQI3) to verify operation and configuration of each device individually. To do this, you will need to connect each device one at a time to the PC RS-232 port. DQI3 will allow you to establish communications with Digiquartz Intelligent devices regardless of baud rate or ID settings. If your device(s) work properly with DQI3, but you are still unable to communicate with them in your system, the problem is almost certainly caused by your serial host hardware/software settings or your connections.
- If you are networking your devices, make sure that all are set to the same baud rate, and that any earlier-generation (RS-232 only) devices are set to PT=N (8 data bits, no parity, 1 stop bit). Also ensure that each device is set to a unique ID value.

Check your serial host:

- Make sure your serial host is configured for the proper baud rate, and 8 data bits, no parity, and 1 stop bit.
- Make sure your commands are terminated with a carriage return and line feed (ASCII 13 and 10). Your serial host hardware or software may need to be configured to provide proper command termination.
- Make sure that you are sending commands to the proper ID. If you are unsure which ID to use, try sending a global **SN** command (*9900SN), and check the response(s) to see which ID(s) responded.

INTELLIGENT DEVICE DOES NOT RESPOND TO A COMMAND, BUT RESPONDS TO SUBSEQUENT COMMANDS

- The Intelligent device is probably asleep when the first command is received, but is awake when the second command arrives. Therefore, the first command is ignored, and the second command is acted upon. To avoid this, either wake up the device before attempting a command, or disable sleep mode. Refer to the **SL** command for more information.

DEVICE REPORTS INCORRECT PRESSURE VALUES

- Check that the calibration coefficients are correct. Digiquartz Interactive (DQI3) software can be used for this purpose. The proper calibration coefficients are listed in the calibration data sheet that was provided with your Intelligent device. If you are unable to locate the calibration data sheet, contact Paroscientific for the calibration coefficients specific to your unit.

12.2 Frequently Asked Questions (FAQ)

How do I change the RS-232 / RS-485 baud rate?
Refer to Section 5.1 “Enable Write Command” beginning on page 27.

How do I configure my instrument?
Refer to Section 3 “Installation and Quick Start” beginning on page 19, and Section 4 “Operation” beginning on page 23.

How do I change the pressure unit?
Refer to Section 5.9 “Unit Commands” beginning on page 43.

How do I change the pressure sampling rate?
Refer to Section 5.4 “Measurement Integration Time Commands” beginning on page 36.

What are the RS-232 and RS-485 commands?
Refer to Section 5 “Command Instructions” beginning on page 27.

How do I tare the unit?
Refer to Section 5.11 “Tare and Overpressure Commands” beginning on page 47.

How do I change the Unit ID?
Refer to Section 5.1 “Enable Write Command” beginning on page 27.

What firmware revision is supported by this manual?
This manual is specifically for instruments delivered with firmware KX.XX. For earlier models using firmware QX.XX, RX.XX or SX.XX, refer to documents 8819-001, 8820-001 and our website for more information.

13 Calibration

13.1 Pressure Calibration Procedure

13.1.1 Overview

Paroscientific transducers measure pressure with a force sensitive quartz crystal whose output period (or frequency) changes with applied load. For a given temperature, true applied pressure will generate a specific crystal period. Therefore, a measure of the crystal period will indicate what pressure is applied, provided the relationship between crystal period and pressure is known. This relationship is usually expressed as the C, D, T_0 equation. C, D, and T_0 are coefficients that are unique to Paroscientific transducers, and are different for each transducer. In addition, these coefficients are characterized for thermal effects. For each temperature, they are expressed as polynomial expansions with coefficients **C1**, **C2**, **C3**, **D1**, **D2**, **T1**, **T2**, **T3**, **T4**, and **T5**. Typically, it takes between 7 and 10 coefficients to fully describe the relationship, also called the "CD thermal model", between crystal output, temperature, and pressure.

Recalibration is necessary if a user decides that the agreement between true and indicated pressure is outside tolerances set for the particular application. Please see the documents entitled "Recalibration of Paroscientific Transducers - Doc 8140-001" and "Calibration of Digiquartz Sensors" at www.paroscientific.com for recalibration procedures and calibration software support.

Because the recalibration period of Digiquartz Instruments depends on specific applications and user requirements, we do not recommend a typical interval between calibrations. Some customers never recalibrate their instruments, while others do periodically every 1 to 3 years.

13.1.2 Zero and Span Adjustments

The Paroscientific pressure transducer measures a force that is generated by external pressure. Since the quartz crystal is extremely sensitive, any other small force that is transmitted to the sensing element will be added to the pressure measurement. A pressure offset generated in this way is purely additive and is the same at all pressure values. In principle, checking accuracy at a single applied pressure is sufficient to determine an offset. Of course, the offset can be calculated as the average offset of many pressure points.

Span is defined here as the pressure difference from minimum pressure to full-scale pressure. A span error is the difference between the indicated pressure span as measured by the transducer and the true pressure span. If a transducer is carefully adjusted at minimum pressure, the span error is simply the difference between indicated and true applied pressure at full scale.

The span of a Paroscientific transducer is rarely adjusted since the scale factor of the sensing element is very stable. Differences are sometimes due to different calibration standards. The span of a dead weight tester used as a primary standard depends directly on the piston area and the value of local gravity. Any apparent change of span in a Paroscientific transducer should be carefully checked to ascertain that the pressure is correctly applied and calculated with the correct piston area and gravity constant, and that the piston is vertical. We recommend recording several pressure points over the entire pressure range to establish any span error. The Paroscientific calibration software program RECAL calculates the best span by a least-squares fit optimization.

Please refer to the document entitled "Recalibration of Paroscientific Transducers - Doc 8140-001" at www.paroscientific.com for details regarding offset and span adjustment.

Calibration should only be performed by a skilled operator.

The **PA** and **PM** commands allow you to make zero and span adjustments. Normally, **PA** (pressure adder) is set to 0.0, and **PM** (pressure multiplier) is set to 1.0.

Adjusted pressure is calculated using the following equation:

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

Where: P = Pressure calculated using original calibration coefficients, in the current pressure units
PM=the current value of PM
PA = the current value of PA

Refer to Section 5.14, page 54 for more information on using the **PA** and **PM** commands.

CAUTION

PA and **PM** directly affect calibration. Use extreme caution when modifying **PA** or **PM**. Improper **PA** and/or **PM** values will result in inaccurate pressure measurements.

14 Pressure Unit Conversion Table

To use this table:

- Determine original pressure unit and desired pressure unit.
- Using the table, identify the appropriate pressure conversion factor.
- Multiply the original pressure value by the conversion factor to convert it to the desired pressure unit.

TABLE 14-1: Pressure Unit Conversion Table

Original Pressure Unit	**Desired Pressure Unit**						
	Grams/cm^3	Pounds/in^2	Inches of mercury	Millimeters of mercury or Torr	Grams/cm^2	Millibar or Hectopascal	Pascal or Newton/m^2
	g/cm^3	psi	in Hg	mm Hg or Torr	g/cm^2	mbar or hPa	Pa or N/m^2
g/cm^3	1	1.422334	2.895903	73.5592	100.0000	98.06650	9806.650
psi	.7030696	1	2.036021	51.71493	70.30696	68.94757	6894.757
in Hg	.3453155	.4911541	1	25.40000	34.53155	33.86388	3386.388
mm Hg or Torr	.01359510	.01933678	.03937008	1	1.359510	1.333224	133.3224
g/cm^2	.01000000	.01422334	.02895903	.7355592	1	.9806650	98.06650
mbar or hPa	.01019716	.01450377	.02952999	.75000617	1.019716	1	100.0000
Pa or N/m^2	1.019716x10-4	1.450377x10-4	2.952999x10-4	7.500617x10-3	.01019716	.01000000	1

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15 Command and Parameter Index

TABLE 15-1: Action Commands

COMMAND	DESCRIPTION	PAGE
BC	Set Butterworth corner frequency in Hz.	64
BL	Lock baud rate	28
BR	Set baud rate	27
DA	RS-485 2-wire delay (us) compensating for serial converters	28
DB	Dump buffer	35
DS	Dump buffer sequential	35
E1	Sample and send one compound period per P1/Q1 format	33
E2	Sample and send continuous compound period per E1 format	33
E3	Sample and send one compound measurement per P3/Q3 format	33
E4	Sample and send continuous compound period per E3 format	34
E5	Sample and send one compound value per P3/P1/Q1 format	34
E6	Sample and send continuous compound values per E5 format	34
EV*	Enable G-vector (For XX=3, Accelerometer Mode only)	58
ID	Set unit ID	28
KE*	Orientation sensitivity correction of APGs in XX=8, SOS mode	58
M1	Output timestamp for minimum pressure value	42
M3	Output timestamp for maximum pressure value	42
MR	Reset minimum and maximum pressure value	42
NE*	Accelerometer/Tiltmeter resonance correction	59
OF	Execute user-defined command	41
P1	Output single pressure period value	31
P2	Output continuous pressure period values	32
P3	Output single pressure values	30
P4	Output continuous pressure values	31
P5	Sample and hold a pressure value	35
P6	Sample and hold a pressure period value	35
Q1	Output single temperature period value	31
Q2	Output continuous temperature period values	32
Q3	Output single temperature value	30
Q4	Output continuous temperature values	32
Q5	Sample and hold a temperature value	36
Q6	Sample and hold a temperature period value	36

NOTE: The commands noted with an asterisk (*) in Tables 15-1 and 15-2 can only be used with seismic sensors.

TABLE 15-2: Parameter Commands

COMMAND	DESCRIPTION	PAGE
C1	C1 coefficient	55
C2	C2 coefficient	55
C3	C3 coefficient	55
CF	Firmware checksum	53
D1	D1 coefficient	55
D2	D2 coefficient	55
DL	Fixed field data format	51
FD	Current SSP/Butterworth filter delay in seconds	65
FR	Read resolution of force channels	65
GC	Write only time/date on next top of second	82
GD	Date format	82
GE	Enable GPS functions	83
GI	Configure Garmin GPS 17x/16x/19x device	84
GL*	Local gravity constant in m/s2	58
GP	Report GPS connection status for PPS and serial communications	87
GR	Command to enter time/date in current form	82
GT	Time format (12hr/24hr)	81
IA	IIR mode cutoff frequency	64
KH	Disable header in data outputs	52
LI	Report logging start address, end address, and pointer checksum	56
LQ	Log storage mode select	56
LR	Prints out the stored log starting from the first record	57
LS	Reports number of stored log record	57
LW	Enable/Stop data logging wrap function	57
LX	Clears out the stored log	57
LZ	Enable/Disable data logging, save log pointers	57
MD	Serial data model	42
MN	Model number	53
OM	User-defined command definition	41
OP	Overpressure alarm setpoint	48
PA	Pressure adder	54
PF	Full-scale pressure	53
PI	Pressure integration time-based)	36
PM	Pressure multiplier	54
PO	Pressure transducer type	53
SL	Sleep mode enable / disable	45
SN	Serial number	52
SO	Force sleep mode immediately	46
ST	Sleep timeout	46
SU	Data separation character enable/disable	50
T1	T1 coefficient	55
T2	T2 coefficient	55
T3	T3 coefficient	55
T4	T4 coefficient	55
T5	T5 coefficient	55

TABLE 15-2: Parameter Commands

COMMAND	DESCRIPTION	PAGE
TA	Temperature adder for zero adjust	55
TC	Timebase correction factor	55
TF	UTC time zone offset (+/-) in hours	81
TH	Pressure measurement data rate	38
TI	Temperature integration time (time-based)	37
TJ	Time stamping format	80
TP	Time stamping position relative to data	81
TS	Time stamping mode	80
TU	Sensor temperature unit (^{o}C/^{o}F)	45
U0	U0 coefficient	55
UF	User-defined unit factor	44
UM	User-defined pressure unit label	52
UN	Pressure unit	44
US	Serial data unit suffix enable/disable	49
VP	Sets system and counting clock frequencies	46
VR	Firmware version	53
XM	Resolution mode	64
XN	Number of significant digits	68
Y1	Y1 coefficient	55
Y2	Y2 coefficient	55
Y3	Y3 coefficient	55
ZE	Set or read tare mode	46
ZI	Tare serial indication enable/disable	51
ZL	Tare lock	47
ZS	Tare switch state	47
ZV	Tare offset value	48

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