

Manual Supplement

Digiquartz M3 Broadband Intelligent Instruments

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Manual Supplement for Paroscientific M3 Intelligent Instruments

Reference

Paroscientific Intelligent Instruments Manual, document number 8819-001.

Scope

This document is a supplement to the Paroscientific Intelligent Instruments Manual. It covers the unique features of intelligent instruments that feature the Paroscientific M3 Intelligent Board. These instruments can be identified by firmware version QX.XX, and will be referred to as M3 instruments in this document. This document does not apply to previous-generation instruments with firmware version RX.XX or SX.XX.

Conventions

The examples shown in the document assume a device ID of 01. If ID is set to some other value, use that ID value instead when sending commands, and expect that ID value to appear in the response in place of 01.

Unsupported Features

Some features covered in the Paroscientific Intelligent Instruments Manual are not supported by M3 instruments.

- The Model 715 display and associated commands DM, DP, DT, PL, and UL are not supported.
- The DL command is not supported.
- The OI command is not supported. Signal integration timing is as though OI=0.
- The FM command is not supported.
- The OP command is not supported.
- The P7 and PS commands are not supported.
- Legacy PR and TR integration time commands are not supported.
- The Tare Input, Tare Output, and Overpressure output are not supported. The tare function is still supported by serial commands.
- The relative timestamp feature is not supported. M3 instruments instead support absolute timestamps, with the option of time/date data and PPS timing signal provided by a GPS receiver.

Measurement Command Responses

M3 instruments support all measurement commands covered in the Intelligent Instruments manual, with the exception of P7 and the associated PS command.

Some M3 instruments (the Triax Accelerometer, for example) have multiple sensor channels. Their measurement command responses contain measurement values for all sensor channels, separated by commas.

The number of digits in your measurement values may differ from the examples depending on your configuration settings. Refer to the 8819-001 manual for additional information.

P1, P2, P6 Command Response

Triax Accelerometer example:

*0001,29.9607973,30.1039107,29.3032095

Table 1: Triax Accelerometer P1/P2/P6 Response

Field	Description	Value
1	Header	*0001
2	X-axis acceleration period value	29.9607973
3	Y-axis acceleration period value	30.1039107
4	Z-axis acceleration period value	29.3032095

P3, P4, P5 Command Response

Triax Accelerometer example:

*0001,.272655867,.052456071,9.800600040

Table 2: Triax Accelerometer P3/P4/P5 Response

Field	Description	Value
1	Header	*0001
2	X-axis acceleration value	.272655867
3	Y-axis acceleration value	.052456071
4	Z-axis acceleration value	9.800600040

E1, E2 Command Response

Triax Accelerometer example:

*0001,29.9607076,30.1041443,29.3031453,5.765203193253

Table 3: Triax Accelerometer E1/E2 Response

Field	Description	Value
1	Header	*0001
2	X-axis acceleration period value	29.9607076
3	Y-axis acceleration period value	30.1041443
4	Z-axis acceleration period value	29.3031453
5	Temperature period value	5.765203193253

E3, E4 Command Response

Triax Accelerometer example:

*0001,.272787363,.052234540,9.800605917,22.0423467,9.804540670

Table 4: Triax Accelerometer E3/E4 Response

Field	Description	Value
1	Header	*0001
2	X-axis acceleration value	.272787363
3	Y-axis acceleration value	.052234540
4	Z-axis acceleration value	9.800605917
5	Temperature value	22.0423467
6	Acceleration vector (see Measurement Settings section)	9.804540670

E5, E6 Command Response

Triax Accelerometer example:

*0001,.272739416,.052754335,9.800680555,22.0245525,30.2872269825,30.1887436141,31.2056120846,5.87016297036,9.804616726

Table 5: Triax Accelerometer E5/E6 Response

Field	Description	Value
1	Header	*0001
2	X-axis acceleration value	.272739416
3	Y-axis acceleration value	.052754335
4	Z-axis acceleration value	9.800680555
5	Temperature value	22.0245525
6	X-axis acceleration period value	30.2872269825
7	Y-axis acceleration period value	30.1887436141
8	Z-axis acceleration period value	31.2056120846
9	Temperature period value	5.87016297036
10	Acceleration vector (see Measurement Settings section)	9.804616726

Measurement Settings

Nano-resolution

Refer to Nano-Resolution section of the Intelligent Instruments Manual for details regarding nano-resolution configuration settings. The IIR filter settings table in the 8819-001 manual (Table 6-1) does not apply to M3 instruments. The table shown here should be used instead.

Table 6: M3 IA Settings and Filter Characteristics

IA value	Cutoff Frequency ^a	Filter Delay ^b	Minimum Measurement Rate ^c	Measurand Resolution ^d	
	(Hz)	(s)	(Hz)	(dB)	ppb
6	25.1	0.032	138	-139	114
7	12.3	0.063	68	-148	39
8	6.2	0.13	34	-157	15
9	3.14	0.25	17	-166	5.2
10	1.57	0.51	9	-174	2.0
11	0.78	1.01	4	-180	1.0
12	0.39	2.03	2	-184	0.61
13	0.195	4.06	1	-184	0.65
14	0.099	8.11	0.5	-183	0.68

- Cutoff Frequency is the -3dB point of the low-pass IIR filter.
- Filter Delay is a time constant that describes the time needed for a pressure/acceleration event to propagate through the IIR filter. Allow five time constants for a pressure/acceleration event to propagate fully through the IIR filter.
- Minimum Measurement Rate (MMR) is the recommended minimum sampling rate to avoid aliasing. The measurement rate is set using the TH (fixed sampling rate) or PI (fixed integration time) command. Values for MMR are approximately a factor of 5.5 times the cutoff frequency.
- Measurand Resolution is the resolution of pressure/acceleration and temperature measurements. The resolution is measured at the corner frequency of the IIR filter and the duration of measurement is assumed to be the inverse of the corner frequency. For more information, refer to the Application note “Noise floor of Quartz crystals” on the Paroscientific website.

Units

Setting units for the Triax Accelerometer

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

The native unit for the Triax Accelerometer is m/s². Available options are:

- UN=0 (used-defined unit)
- UN=1 (m/s²).

Variants of the UN command set the units for individual acceleration channels.

Table 7: UN Command Variants

UN command	Triax Accelerometer
UNA	Sets units for X axis acceleration
UNB	Sets units for Y axis acceleration
UNC	Sets units for Z axis acceleration

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 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.

The acceleration vector is the square root of the sum of squares of the x, y and z accelerations.

Table 8: 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)

Timestamp

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 of Triax Accelerometer P3 measurement response with timestamp enabled:

*0001,A,09/16/21 12:42:36.744,.271049445,.051840849,9.800686949

Table 9: Triax Accelerometer P3 Example with Timestamp

Field	Value	Description
1	*0001	Address header
2	A	GPS/PPS status. See Table 14 and Table 15
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

Configuring an M3 Instrument to Include Timestamps

1. Enable Timestamp

Issue the command *0100EW*0100TS=1 to enable timestamps. 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 M3 instrument is reset, either by a command or by a power cycle.

2. Test the Timestamp

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).

Timestamp Options

Timestamp Format

The TJ parameter selects from six available timestamp formats. Set TJ to the value associated with the desired timestamp format. Example: To select the standard format with millisecond resolution, issue the command *0100EW*0100TJ=0.

Table 10: Timestamp formats

TJ	Timestamp format
0	Standard format, millisecond resolution. Format: MM/DD/YY HH:MM:SS.sss
1	Standard format, microsecond resolution. Format: MM/DD/YY HH:MM:SS.ssssss
2	GSE format, millisecond resolution. Format: YYYY/MM/DD HH:MM:SS.sss
3	GSE format, microsecond resolution. Format: YYYY/MM/DD HH:MM:SS.ssssss
4	NTP format, hexadecimal, microsecond resolution. Seconds from 1/1/1970. Format: AAAAAAAAA.aaaaaaa, where AAAAAAAAA=seconds, aaaaaaa=fractional seconds
5	NTP format, hexadecimal, 232ps (1/2 ³² second) resolution. Seconds from 1/1/1900. Format: AAAAAAAAA.aaaaaaa, where AAAAAAAAA=seconds, aaaaaaa=fractional seconds

Time Zone Offset

The TF parameter offsets GPS time to match your local time zone. TF can be set within a range of -12 to 14. Example command: To set the UTC offset to -8 hours, set TF to -8 with the command *0100EW*0100TF=-8.

NOTE: 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).

Time Stamp Position

The TP command positions the timestamp either before or after the measurement data. Set TP to the value associated with the desired position. Example command: *0100EW*0100TP=0

Table 11: Timestamp position relative to measurement data

TP	Timestamp position
0	Timestamp positioned before data. Example: *0001A,11/26/13 09:26:21.005 AM,14.63821
1	Timestamp positioned after data. Example: *000114.63821,A, 11/26/13 09:26:21.005 AM

Time Format

The GT command selects 12 hour or 24 hour time format. Set GT to the value associated with the desired format. Example command: *0100EW*0100GT=0

Table 12: Time formats

GT	Time format
0	12-hour time format. Example: *0001A,11/26/13 01:33:57.201 PM,14.63887
1	24-hour time format. Example: *0001A,11/26/13 13:33:57.201,14.63887

Date Format

The GD command selects MM/DD/YY or DD/MM/YY date format. Set GD to the value associated with the desired format. Example command: *0100EW*0100GD=0

Table 13: Date formats

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

Current Date and Time

The GR command sets and reports the current date and time. Date and time are reported according to the current date and time format settings. When setting date and time, the values must be entered according to the current date and time format settings.

- To report current date and time, issue the command *0100GR.
- To set date and time, issue the command *0100EW*0100GR=01/25/13 11:45:53 PM, substituting current date and time. This example assumes MM/DD/YY date (GD=0) and 12-hour time (GT=0). The date and time format used to form 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.

Starting a Measurement Sequence with Timestamps Enabled

When a measurement command is issued, 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

Synchronizing Measurements

When an M3 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 M3 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). Refer to the Baud Rate section in this document for BR command details.

Data Rate

Setting the data rate with the TH command provides precise data intervals and consistent data rates. Refer to the Intelligent Instruments Manual for TH command details. 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 command). Refer to the Nano-Resolution section of this document and the Intelligent Instruments Manual for details.

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. Refer to the Intelligent Instruments Manual for measurement command details.

Time stamp parameters

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

Interfacing a GPS receiver with M3 instruments

Benefits

- Measurements can be synchronized with GPS time
- Absolute time-stamping of measurement data
- Precise synchronization of measurements between multiple M3 instruments
- Internal real-time clock synchronized with GPS time

Compatible GPS Receivers

These Garmin GPS receivers have been qualified for use with M3 instruments:

- Garmin GPS 24xd HVS
- Garmin GPS 19x HVS (Discontinued, replaced by the Garmin GPS 24xd HVS)
- Garmin GPS 17x HVS (Discontinued, replaced by the Garmin GPS 19x HVS)
- Garmin GPS 16x HVS

Interfacing a GPS receiver to an M3 instrument

1. Connect GPS to the M3 instrument

Refer to Figure 1, Figure 2, and Figure 3 to connect the GPS receiver to the M3 instrument.

If using the Garmin GPS 24xd HVS or GPS 19x HVS, ensure that its Rate Change Cable is installed per Figure 1. 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.

2. Set up the M3 instrument to enable the GPS interface

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

3. Set the M3 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`.

4. Configure the GPS receiver for use with the M3 instrument.

Issue the command `*0100EW*0100GI=1`. The unit should respond with `>OK: GPS ready for operation, cycle power`. Cycle power to establish communications between the GPS receiver and the M3 instrument. If an error message is received, please refer to the GPS troubleshooting section.

5. Enable Timestamps

If timestamps are desired, issue the command `*0100EW*0100TS=1`. Refer to the Timestamp section for timestamp details and format options.

6. Test the M3 instrument 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. If you receive any other response, please refer to the GPS troubleshooting section.

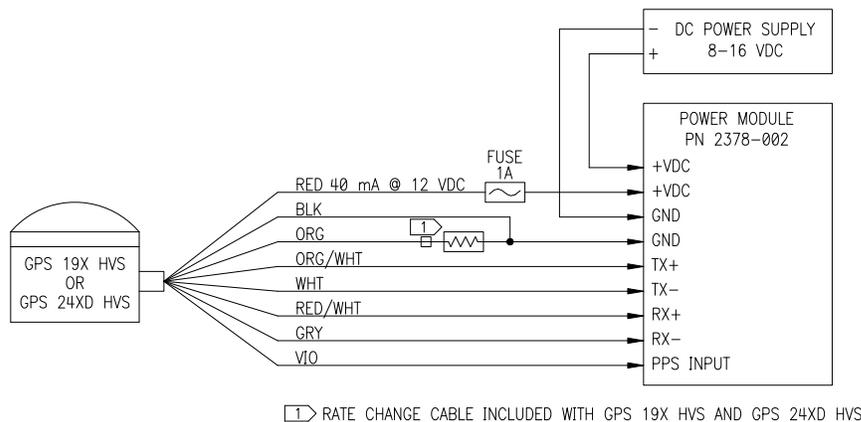


Figure 1: Garmin GPS 19x HVS and GPS 24xd HVS Wiring Diagram

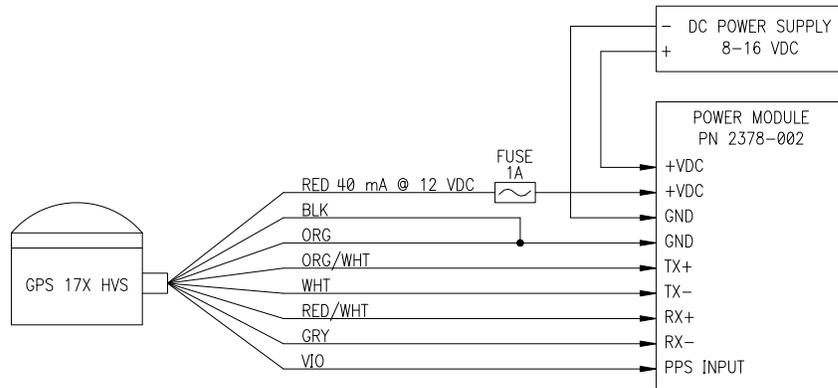


Figure 2: Garmin GPS 17x Wiring Diagram

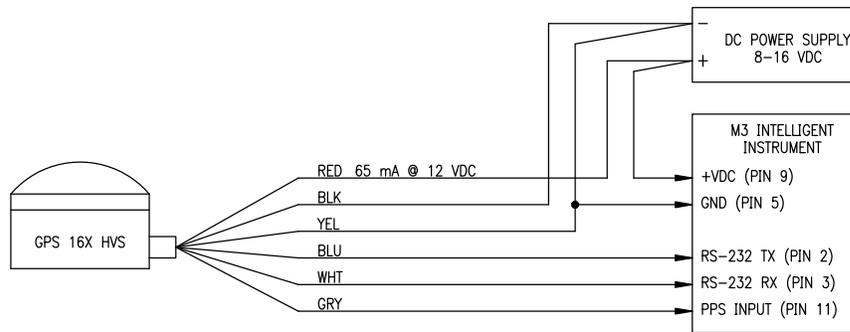


Figure 3: Garmin GPS 16x Wiring Diagram

GPS Status Indication

A GPS status indication is shown in the optional timestamp included with each measurement command response. See the Timestamp section for details.

Table 14: GPS Status Indications

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

M3 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 M3 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 M3 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 M3 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 M3 instrument immediately synchronizes with any resulting GPS timing change, and measurements will continue uninterrupted.

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.

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 the 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 M3 instrument by issuing the command *0100EW*0100GI=1. Check wiring to ensure the PPS signal is properly wired to the M3 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 M3 instrument by issuing the command *0100EW*0100GI=1. Check that PPS signal is wired correctly.

Synchronizing an M3 Instrument to a PPS Signal

M3 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 M3 instruments

PPS Signal Requirements

Please refer to the M3 instrument SCD for PPS signal requirements.

Configuring M3 instruments for PPS operation

1. Connect PPS signal to M3 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 M3 instrument pin 11, and connect the ground from the PPS signal source to M3 instrument pin 5.

2. Configure the M3 instrument for PPS mode

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

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.

PPS Status Indication

A PPS status indication is shown in the optional timestamp included with each measurement command response. See the Timestamp section for details.

Table 15: PPS Status Indications

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

Key points regarding PPS mode

- Date and time information used to create timestamps is provided by the M3 instrument's real-time clock. The real-time clock is volatile and must be set whenever the unit is powered up or reset. Refer to the GR command to set the real-time clock.
- 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.

PPS Troubleshooting

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

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 and 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 M3 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.

Baud Rate

M3 instruments support unique baud rates for the RS-232 and RS-485 ports. 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.

Setting both ports to the same baud rate

The standard BR command as shown in the Intelligent Instruments Manual sets both the RS-232 and RS-485 ports to the specified baud rate.

Setting ports to different baud rates

Variants of the standard BR command are used to set the baud rate for an individual serial port.

The BR1 command sets the baud rate for the RS-232 port only.

Example command: *9900BR1=9600

Example response: *9900BR1=9600

The BR2 command sets the baud rate for the RS-485 port only.

Example command: *9900BR2=4800

Example response: *9900BR2=4800

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 range: 0 – 1,000,000 μ s

DA default value: 1500

Example command: *0100EW*0100DA=5000

Example response: *0001DA=5000