

JDx Series User Manual



Contact us: Jewell Instruments, LLC
850 Perimeter Road
Manchester, NH 03103
Phone: 603-669-6400
Fax: 603-622-2690
Website: www.jewellinstruments.com
Email: sales@jewellinstruments.com



Copyright © 2021 by Jewell Instruments LLC. All rights reserved.

REVISION HISTORY

Revision	Date	Change Description
A12	1/12/2021	Preliminary release, JDI, updated from original user guide
A14	7/14/2021	Preliminary release, added Moving Average Filter commands, updated baud rate/streaming table
B	7/21/2021	New Release to Production, Compatible with SW879838 V1.8 Rev B

TABLE OF TABLES AND FIGURES	iii
MANUAL ACRONYMS & NOTATIONS	iv
1 OVERVIEW	1
2 INSTALLATION	2
2.1 Power Requirements	2
2.2 Mechanical Connections	2
2.3 Mechanical Installation	8
2.4 RS-485 Installation	10
2.5 Galvanic Isolation, JDx Grounding & Transient Protection	10
3 JDx COMMUNICATION PROTOCOL	11
3.1 Default Communication Settings	11
3.2 Firmware Commands and Parameters	11
3.2.1 General Command Formats	12
3.2.2 Get Value	13
3.2.3 Streaming	14
3.2.4 Sensor Node ID, Address	15
3.2.5 Bandwidth	16
3.2.6 Change Baud Rate	17
3.2.7 (Enable/Disable) Moving Average Filter	18
3.2.8 Configure Length of Moving Average Filter	19
3.2.9 Clear Fault Condition	20
3.2.10 Decimation (Averaging)	21
3.2.11 Non-Volatile Save	22
3.2.12 Non-Volatile Restore	23
3.2.13 Query	24
3.2.14 RS-485 Termination	32
3.2.15 Data FIFO Query	32
3.2.16 Data FIFO Dump	33
3.2.17 Data FIFO Flush	33
3.2.18 Bus Scan	34
3.2.19 Soft Reset	34

3.2.20	Relative Zero	35
3.3	Data Integrity, CRC	35
3.4	Shared RS-485 Bus	35
APPENDIX A: WARRANTY & LIMITATION OF LIABILITY		36

TABLE OF TABLES AND FIGURES

Table 1: Power Requirements	2
Table 2: JDx Series DB9 Pinout	3
Table 3: JDx Series M12 Pinout	4
Table 4: JDx Series C06 Pinout	5
Table 5: JDx Series Deutsch 4-Pin Pinout	6
Table 6: JDx Series Unterminated cable (Flying Leads)	7
Figure 1: JDx DB9 Outline & Dimensions	8
Figure 2: JDx M12 Outline & Dimensions	8
Figure 3: JDx C06 Outline & Dimensions	9
Figure 4: JDx Flying Leads, Deutsch 4P Outline & Dimensions (cable omitted for clarity)	9

MANUAL ACRONYMS & NOTATIONS

JDI	Jewell Digital Inclinator
JDA	Jewell Digital Accelerometer
JDx	JDI or JDA Sensor
0x__	0x indicates hexadecimal notation
CR	Carriage Return, hexadecimal 0x0D
LF	Line Feed, hexadecimal 0x0A (also known as a new line)
CRLF	Abbreviation for the line termination sequence “Carriage Return & “Line Feed”
CRC16	16-bit cyclic redundancy check
	“pipe” is used to separate parameters in a list of options in the firmware commands. The user should select one parameter only.

1 OVERVIEW

This quick start guide covers the installation and operation of all models of the Jewell Digital Inclinometer. The inclinometer provides continuous dual axis measurements of inclination via ASCII over RS-485 over the sensor's linear range with resolution down to 0.001 degree. Power is supplied through two pins on the connector.

The sensors are shipped with generic settings and the intention is that the user will reconfigure the sensor to meet the needs of their RS-485 bus if the sensor will co-exist with other RS-485 devices. For large quantity orders we are happy to reconfigure the sensors to your particular needs (additional programming charges may apply).

2 INSTALLATION

Some general information for the installation of the JDx sensor is included here. Please refer to the product-specific datasheet or product drawing for connector pinout, mechanical dimensions and mounting patterns. These are also shipped with the product and are available by contacting Jewell Instrument's Customer Support at 1-800-227-5955 or sensors@jewellinstruments.com.

2.1 POWER REQUIREMENTS

The inclinometer's minimum, maximum, and typical power requirements are shown in the following Table 1.

Power Supply Voltage, Minimum	5V DC
Power Supply Voltage, Typical	9V – 36V DC
Power Supply Voltage, Maximum	38V DC
Power, Maximum	800 mW

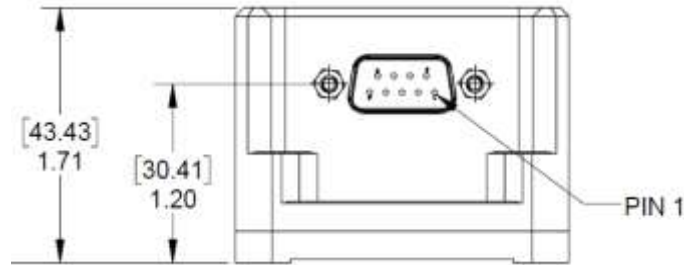
Table 1: Power Requirements

2.2 MECHANICAL CONNECTIONS

The sensor is available in several models with various connectors, including an IP67 rated male DB9 connector. In order to achieve the full IP67 rating, an appropriate mating connector with an IP67 rated backshell must be employed and fully engaged. IP67 backshells are readily available from suppliers such as NorComp, Conec and Digi-Key.

The power & communication information for the various JDx sensor models are provided below.

Table 2: JDx Series DB9 Pinout



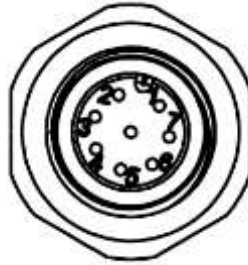
DB9 CONNECTOR RS-485 VERSION	
COLOR	ASSIGNMENT
1	DATA-
2	DATA+
3	N/C
4	N/C
5	GND
6	N/C
7	N/C
8	POWER-
9	POWER+

DB9 CONNECTOR RS-232 VERSION	
COLOR	ASSIGNMENT
1	N/C
2	RXD
3	TXD
4	N/C
5	GND
6	N/C
7	N/C
8	POWER-
9	POWER+

Pins 1 and 2 are polarity specific and are used for the half-duplex RS-485 communication lines. Take note of the polarity. Pin 5 contains the ground reference for the RS-485 lines and depending on installation may not be required. This GND reference IS needed for proper operation of the RS-232 models, as the RS-232 standard requires a Ground reference.

Pins 8 and 9 are the power pins for the JDx sensor. Reverse polarity protection (via a diode bridge) has been implemented internal to the sensors. This means either power or ground can be applied to either pin 8 or 9 without causing electrical damage. **APPLY DC VOLTAGE ONLY.**

Table 3: JDx Series M12 Pinout



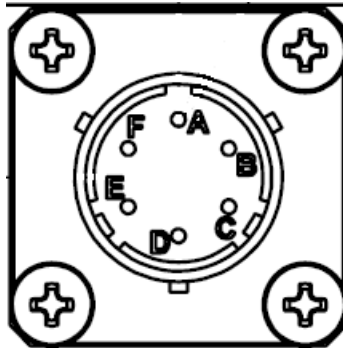
M12 CONNECTOR RS-485 VERSION	
COLOR	ASSIGNMENT
1	N/C
2	POWER+
3	POWER-
4	DATA-
5	GND
6	DATA+
7	N/C
8	GND

M12 CONNECTOR RS-232 VERSION	
COLOR	ASSIGNMENT
1	TXD
2	POWER+
3	POWER-
4	N/C
5	GND
6	N/C
7	RXD
8	GND

Pins 4 and 6 are polarity specific for the half-duplex RS-485 communication lines. Take note of the polarity. Pin 5 contains the ground reference for the RS-485 lines and depending on installation may not be required. This Pin 5 GND reference IS needed for proper operation of the RS-232 models, as the RS-232 standard requires a Ground reference.

Pins 2 and 3 are the power pins for the JDx sensor. Reverse polarity protection (via a diode bridge) has been implemented internal to the sensors. This means either power or ground can be applied to either pin 2 or 3 without causing electrical damage. **APPLY DC VOLTAGE ONLY.**

Table 4: JDx Series C06 Pinout



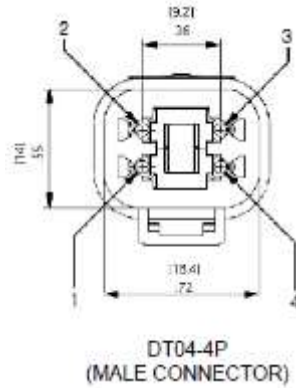
6-PIN CIRCULAR (C06) CONNECTOR RS-485 VERSION	
COLOR	ASSIGNMENT
A	POWER+
B	POWER-
C	N/C
D	DATA+
E	DATA-
F	GND

6-PIN CIRCULAR (C06) CONNECTOR RS-232 VERSION	
COLOR	ASSIGNMENT
A	POWER+
B	POWER-
C	N/C
D	RXD
E	TXD
F	GND

Pins D and E are polarity specific for the half-duplex RS-485 communication lines. Take note of the polarity. Pin F contains the ground reference for the RS-485 lines and depending on installation may not be required. This Pin F GND reference IS needed for proper operation of the RS-232 models, as the RS-232 standard requires a Ground reference.

Pins A and B are the power pins for the JDx sensor. Reverse polarity protection (via a diode bridge) has been implemented internal to the sensors. This means either power or ground can be applied to either pin A or B without causing electrical damage. **APPLY DC VOLTAGE ONLY.**

Table 5: JDx Series Deutsch 4-Pin Pinout



4-PIN DEUTSCH (MALE) CONNECTOR RS-485 VERSION ONLY	
PIN	ASSIGNMENT
1	POWER+
2	POWER-
3	DATA+
4	DATA+

Pins 3 and 4 are polarity specific for the half-duplex RS-485 communication lines. Take note of the polarity.

Pins 1 and 2 are the power pins for the JDx sensor. Reverse polarity protection (via a diode bridge) has been implemented internal to the sensors. This means either power or ground can be applied to either pin 1 or 2 without causing electrical damage. **APPLY DC VOLTAGE ONLY.**

Table 6: JDx Series Unterminated cable (Flying Leads)

RS-485 VERSION	
COLOR	ASSIGNMENT
RED	POWER+
BLACK	POWER-
GREEN	DATA+
BLUE	DATA-
WHITE	GND

RS-232 VERSION	
COLOR	ASSIGNMENT
RED	POWER+
BLACK	POWER-
GREEN	RXD
BLUE	TXD
WHITE	GND

Green and Blue wires are polarity specific for the half-duplex RS-485 communication lines. Take note of the polarity. White wire contains the ground reference for the RS-485 lines and depending on installation may not be required. This White GND wire reference IS needed for proper operation of the RS-232 models, as the RS-232 standard requires a Ground reference.

Red and Black wires are the power connections for the JDx sensor. Reverse polarity protection (via a diode bridge) has been implemented internal to the sensors. This means either power(+) or power(-)/ground can be applied to either Red or Black without causing electrical damage. **APPLY DC VOLTAGE ONLY.**

2.3 MECHANICAL INSTALLATION

The figures below show the hole pattern required to mount the JDx sensor. The figures also provide the dimensions of the inclinometer. Dimensions are provided in Imperial units of inches, shown without brackets, and SI units of millimeters, shown within brackets.

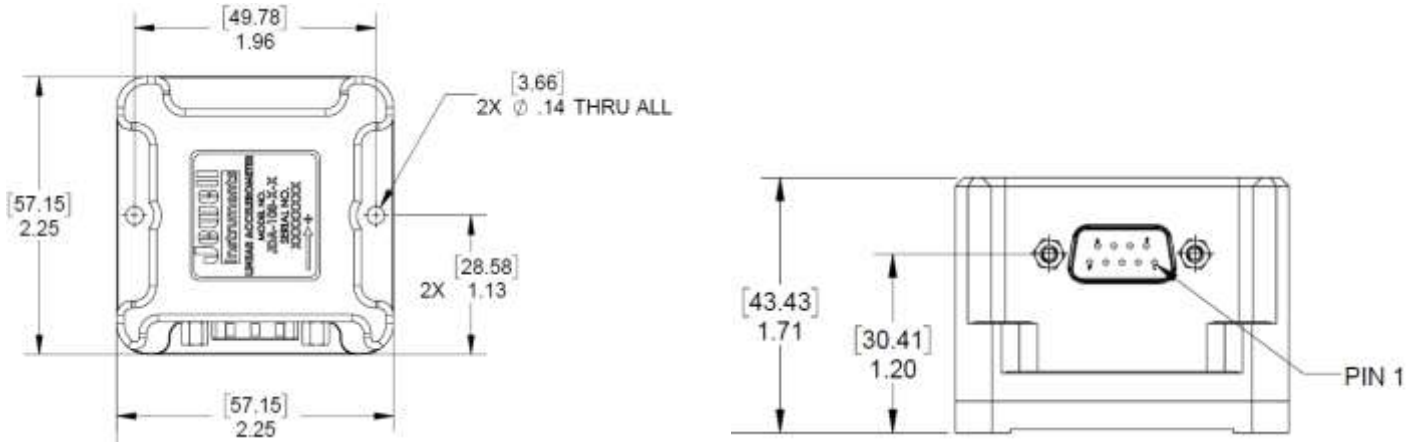


Figure 1: JDx DB9 Outline & Dimensions

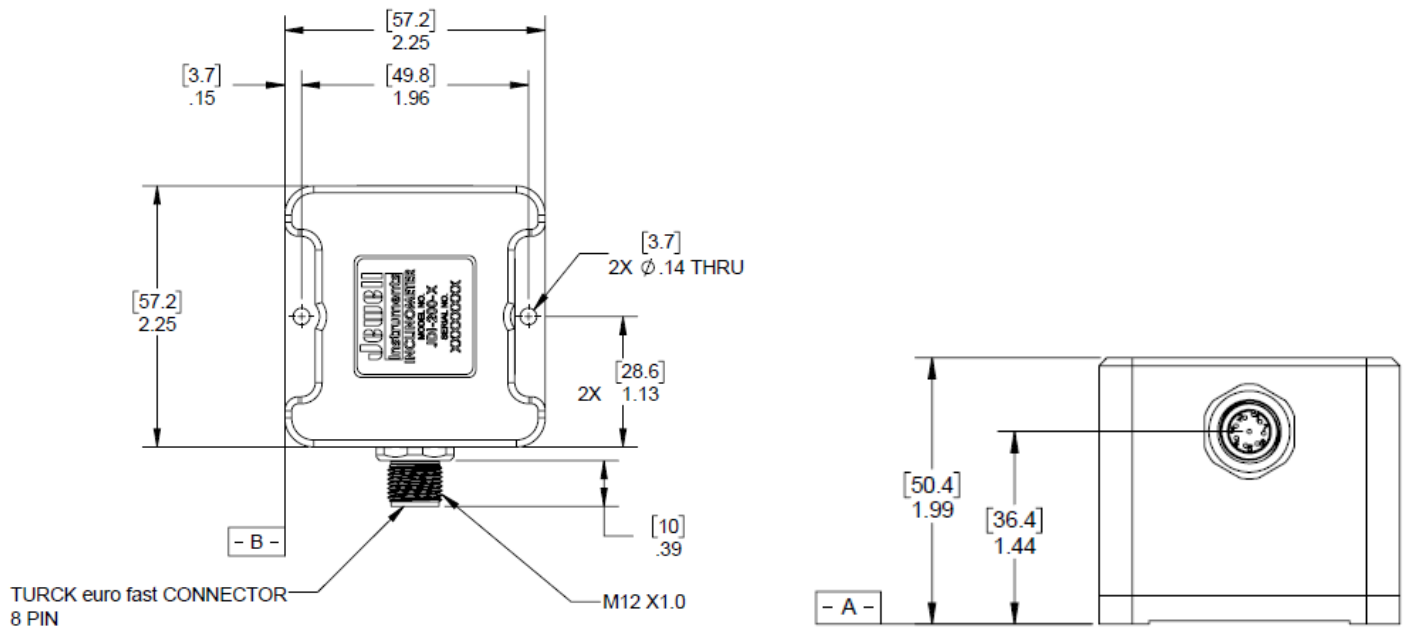


Figure 2: JDx M12 Outline & Dimensions

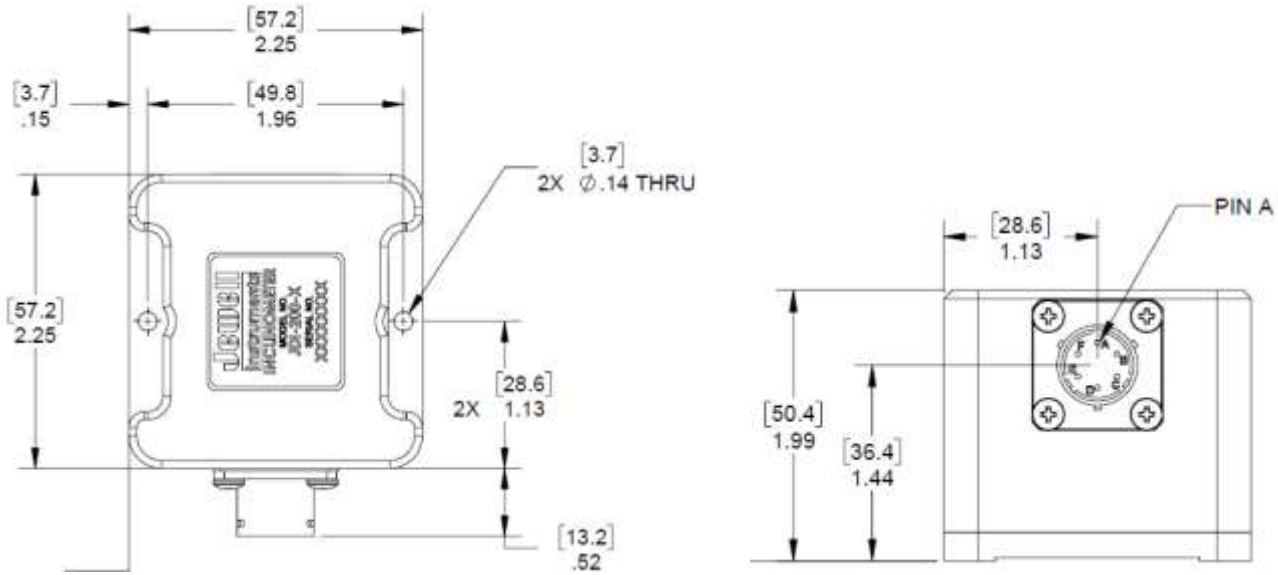


Figure 3: JDx C06 Outline & Dimensions

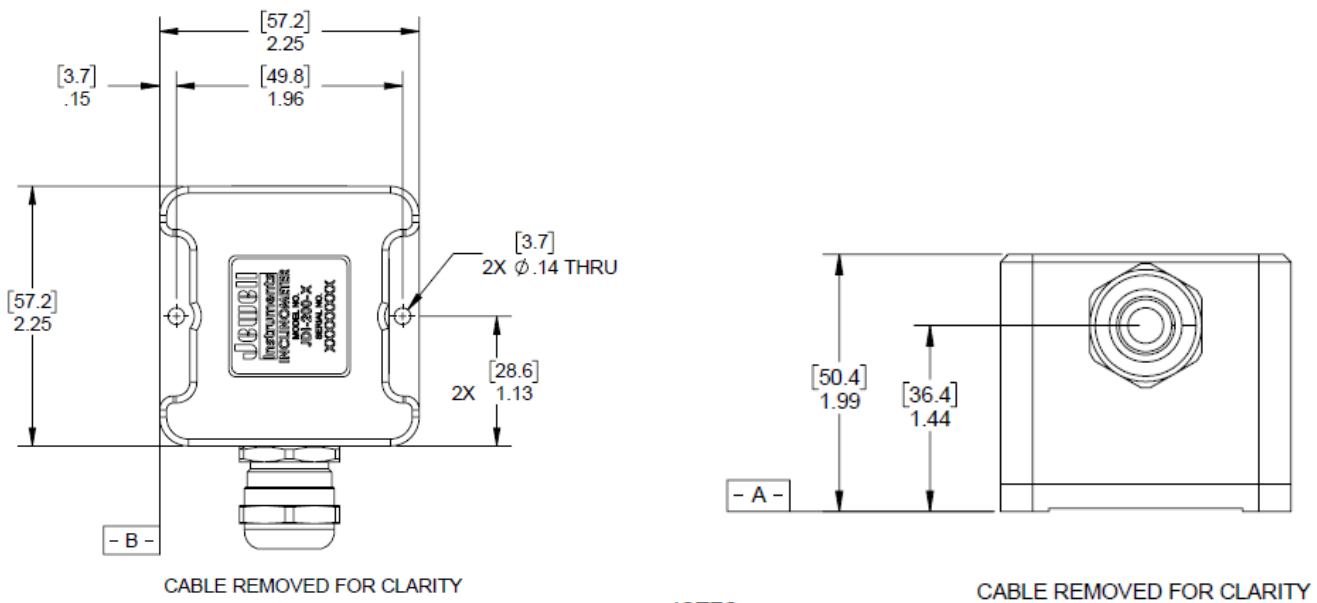


Figure 4: JDx Flying Leads, Deutsch 4P Outline & Dimensions

2.4 RS-485 INSTALLATION

The JDx sensor may be installed on an RS-485 bus. Jewell recommends that the sensor installer review appropriate guidelines for multiple devices on a bus. The JDx sensor contains a 120 Ω termination resistor at the PCB level near the internal RS-485 transceiver. The JDx sensor is shipped with the termination resistor disabled, though the termination may be enabled via software commands at the customer's preference. Enabling and disabling of the termination resistor is accomplished through firmware commands.

2.5 GALVANIC ISOLATION, JDx GROUNDING & TRANSIENT PROTECTION

Both the power connections and RS-485 connections are galvanically isolated from the internal sensor. This ensures that common mode noise which may develop over long cable lengths will not adversely affect the sensitive measurements of the device. The power and RS-485 signals are separated from each other, but their separation is not rated at a specific galvanic isolation voltage.

The shell of the DB9, M12, and C06 connectors have a low impedance path to the baseplate of the sensor. This ensures that cable noise is diverted through the aluminum enclosure and into the mounting structure of the sensor.

To further protect the JDx sensor in the harshest electrical environments, all inputs and outputs have bi-directional transorbs and gas discharge tubes to dissipate any transient energy to its local ground. Further, all inputs and outputs have differential transorbs between wire pairs.

3 JDx COMMUNICATION PROTOCOL

The JDx sensor data is easy to retrieve from the sensor via simple commands. To obtain this data, a typical terminal emulation program¹ (or equivalent) may be used on the system/computer side. The following sections outline the communication settings, and command protocol. The JDx sensor supports a proprietary Jewell ASCII interface protocol.

3.1 DEFAULT COMMUNICATION SETTINGS

The defaults for the communication settings are listed below. Of the settings shown below, only the baud and parity may be changed.

Table 6: JDx Series Default Communication Settings

Baud	19200
Data Bits	8
Parity	Even
Stop Bits	1
Flow Control	None

3.2 FIRMWARE COMMANDS AND PARAMETERS

The Jewell protocol commands and sensor parameters are detailed in the following sections.

¹ RealTerm Terminal Emulator Program, or HyperTerminal are example programs.

3.2.1 GENERAL COMMAND FORMATS

Jewell ASCII command protocol conforms to a basic format as described in the following section(s).

3.2.1.1 PROPRIETARY ASCII

Commands are packets transmitted from the “master” to the “slave.” The slave is always the JDx sensor – it provides the response. For the JDx sensor to acknowledge a command, the data packet must either start with a : (colon) or ; (semicolon) and end with a CR (0x0D) and LF (0x0A). Without the “:”, “;”, or CRLF², the JDx sensor will not respond. Very generically, the commands must have the following syntax:

```
;<NodeID>,<Command>,<Parameter> CRLF
```

```
:<NodeID>,<Command>,<Parameter>,<CRC16> CRLF
```

Please take note that above there are two commands shown. One begins with a colon, and the other begins with a semicolon. Commands which begin with a semicolon will not invoke the 16-bit CRC check within the device. Commands which begin with a colon must include a 16-bit CRC and the JDx will enforce CRC checking to validate the command. The latter implementation allows the JDx sensor to check data packet integrity in noisy environments. It is up to the discretion of the user to utilize one or the other.

Please also take note of the commas and the NodeID. The commas allow packets to be easily parsed and each packet must contain a NodeID. If the NodeID transmitted by the master does not match the NodeID of the target JDx sensor, then the target sensor will ignore the command³.

All commands in the following sections must be issued using ASCII text only.

³ The JDx will also respond to the broadcast address of “000”. This is intended for ease of recovery, configuration and setup and is not intended for general use in the field. If multiple units are on the same bus their responses to a broadcast command will generally have a data collision. So, usage of broadcast address messages on daisy-chained sensors should be generally avoided.

3.2.2 GET VALUE

This command obtains the most recent sample from the JDx sensor. This command is useful when the JDx sensor is installed on a shared RS-485 bus and the user wishes to implement the JDx sensor as a true slave device. The last parameter before the CRC is a 16-bit sequence number. Every time a data point is generated by the sensor the sequence number is incremented. This will allow downstream software to know if it has read the same data point twice, or if it has missed a data point. (See also FIFO commands, specifically section 3.2.16)

Command Syntax	;<NodeID>,V CRLF	or
	:<NodeID>,V,<CRC16> CRLF	

Response Syntax Varies per “sample type”, reflecting the sensor configuration purchased⁴.

```

<NodeID>,V,41,<X G’s >,<Temperature>,<seq>,<CRC16> CRLF
<NodeID>,V,42,<X G’s>,<Y G’s >,<Temperature>,<seq>,<CRC16> CRLF
<NodeID>,V,43,<X G’s>,<Y G’s >,<Z G’s >,<Temperature>,<seq>,<CRC16> CRLF
<NodeID>,V,51,<X angle>,<Temperature>,<seq>,<CRC16> CRLF
<NodeID>,V,52,<X angle>,<Y angle>,<Temperature>,<seq>,<CRC16> CRLF

```

Example Command ;001,V CRLF

Example Response 001,V,52,+16.0396,+0.0117,+22.050,2559,E007 CRLF

Notes Sample type for the JDI-200-5/5-5293 was “7”, this has been promoted to “52” to align with our standard part offerings. X and Y angular values are in degrees, Temperature is in degrees Celsius and <CRC16> is reported in hexadecimal.
Sequence number is an unsigned 16-bit number and will rollover from 65535 to 0.

3.2.3 STREAMING

This command enables the JDx sensor to continuously transmit data out to the RS-485 bus at the bandwidth specified in section 3.2.5. A value of 0 or 1 must be provided. The value of 0 turns off data streaming, while the value 1 enables data streaming. This command is useful if the user wishes to not actively interrogate the JDx sensor for samples. Care should be taken using this command when the JDx sensor is installed on a shared RS-485 bus.

Command Syntax	<pre>;<NodeID>,S,<1 0> CRLF :<NodeID>,S,<1 0>,<CRC16> CRLF</pre>	or
Response Syntax	<pre><NodeID>,S,<0=OFF, 1=ON>,Streaming,<CRC16> CRLF</pre> <p>(Subsequent data points will adhere to the “V” command’s syntax, see section Get Value</p>	
Example Command	<pre>;100,S,1CRLF</pre>	
Example Response	<pre>100,S,1,Streaming,5EF2CRLF 100,V,52,+0.1582,-0.8087,+20.327,1124,4769CRLF 100,V,52,+0.1580,-0.8085,+20.327,1125,AF73CRLF 100,V,52,+0.1582,-0.8085,+20.325,1126,E6C9CRLF</pre>	

Notes A Non-Volatile Save command is required to save the streaming setting to non-volatile memory. This will ensure the parameter is recalled after a power cycle. Responses to the commands are the same as the responses to the Get Value command.

Changing the baud or the output data rate of the device may interrupt the stream. If this occurs, simply re-issue the command to start streaming with the new settings.

The sensor firmware will not allow Streaming to be enabled if the current communication baud rate is too low (<9600 bps).

3.2.4 SENSOR NODE ID, ADDRESS

This command changes the NodeID, or bus address of the JDx sensor. Each JDx sensor is shipped from the factory with a default NodeID, corresponding to the last two digits of the specific sensor's serial number. Changing the address is very simple if the user wishes to assign something other than the factory default. Any integer value from 1 to 250 is accepted.

Command Syntax ;<NodeID>,A,<New_NodeID> CRLF or
 :<NodeID>,A,<New_NodeID>,<CRC16> CRLF

Response Syntax <NodeID>,A,<New_NodeID>,Address,<CRC16> CRLF

Example Command ;001,A,2 CRLF

Example Response 002,A,002,Address,<CRC16> CRLF

Notes A Non-Volatile Save command is required to save the new NodeID to non-volatile memory. This will ensure the parameter is recalled after a power cycle. <CRC16> is reported in hexadecimal.

The default ID is generally the last two digits of the serial number. As zero is disallowed, sensors with a serial number ending in "00" will be programmed to have an ID of "100" instead.

3.2.5 BANDWIDTH

This command changes the output data rate (data sample rate) of the JDx sensor. The table below shows the combinations which are allowed vs the communications baud rate. Care must be taken in selecting the bandwidth of the sensor and the baudrate of the sensor’s communication link. For obvious reasons, the user should not select the highest output data rate and lowest baudrate settings.

Table 7: JDx Bandwidth vs Baud⁵

Baud	Bandwidth (Output Sample Rate)					
	3.9	7.8	15.6	31.2	62.5	125
2400	X	X	X	X	X	X
9600	OK	OK*	X	X	X	X
19200	OK	OK	OK*	X	X	X
38400	OK	OK	OK*	X	X	X
57600	OK	OK	OK	OK*	X	X
115200	OK	OK	OK	OK	OK*	X
230400	OK	OK	OK	OK	OK	OK*
460800	OK	OK	OK	OK	OK	OK*
500000	OK	OK	OK	OK	OK	OK*

Command Syntax ;<NodeID>,B,<3.9|7.8|15.6|31.2|62.5|125> CRLF or
 :<NodeID>,B,<3.9|7.8|15.6|31.2|62.5|125>,<CRC16> CRLF

Response Syntax <NodeID>,B,<NewDataRate>,Data rate,<NewBW>,-3dB,<CRC16> CRLF

Example Command ;001,B,15.6 CRLF

Example Response 001,B,15.6,Data rate,3.9,-3dB,2258 CRLF

Notes A Non-Volatile Save command is required to save the new New_Bandwidth to non-volatile memory. This will ensure the parameter is recalled after a power cycle. The sensor will round to the nearest data rate that it is capable of providing. The filter’s -3dB point is ¼ of the sample rate and is also echoed for clarity. <CRC16> is reported in hexadecimal.

Output data rate may be reduced by the “Decimation(Averaging)” setting, see that section for more details.

*** This command forces reconfiguration of the MEMs accelerometer and various communication FIFOs maintaining synchronized data transfer with the device. It is strongly recommended to allow approximately 1.5 seconds of time after receiving the response to this command before issuing other commands to the sensor, so that internal processing can complete.

3.2.6 CHANGE BAUD RATE

This command changes the baud rate of the JDx sensor. Each JDx sensor is shipped from the factory with a default Baud rate of 19200 bps. The baud value must be an integer between 2400 and 500,000. Please note that the streaming feature is only supported above 9600 baud. Parity may be set with the case-insensitive first letter of the parity desired, e.g., ‘e’ven, ‘n’one, or ‘o’dd. Supported baud rates are 500000, 460800, 230400, 115200, 57600, 38400, 19200, 9600, 4800, and 2400 bps. These baud rates all have less than 1.6% baud error.

Command Syntax ;<NodeID>,C,B,<2400|4800|9600|19200|38400|57600|115200|230400|460800|500000>,<E|N|O> CRLF
 :<NodeID>,C,B,<2400|4800|9600|19200|38400|57600|115200|230400|460800|500000>,<E|N|O>,<CRC16> CRLF

Response Syntax <NodeID>,C,B,<New_Baud>,8<parity>1,1 sec delayed baud change,<CRC16> CRLF
 <NodeID>,C,B,<New_Baud>,8<parity>1,New baud,<CRC16> CRLF

Example Command ;001,C,B,115200,n CRLF

Example Response 001,C,B,116279,8n1,1 sec delayed baud change,D35ACRLF

Notes A Non-Volatile Save command is required to save the new “New_Baud” baud to non-volatile memory. This will ensure the parameter is recalled after a power cycle. The first response line is sent at the old baud rate, the second line is sent at the new baud rate. There is a 1.0 ±0.2 second delay from the start of the first line’s transmission to the start of the second line’s transmission. <CRC16> is reported in hexadecimal.

Other Notes

Switching from baud rates below 9600, the first line may not completely print before the 1.0 sec time expires. The JDx will respond with the closest achievable baud to your requested rate from the supported list, or default to 19200 bps if the requested rate is unachievable with one of the standard bauds in the list.

This command forces reconfiguration of the communications hardware. It is strongly recommended to allow approximately 1.5 seconds of time after issuing this command before issuing other commands to the sensor, so that internal processing can complete.

Beginning with the firmware releases V2.5 and V1.5 revisions, the baud rate selection is enforced differently than in prior (V1.3 and earlier) firmware. Earlier firmware allowed the user to set ANY baud rate value between 300 bps and 500,000 bps regardless of its exact value, or achievability within 2% of baud rate standards. As this could lead to problems with interoperability, or even setting the device to an unattainable standard baud rate, this was changed. The new firmware provides more standard baud rates which it can achieve with 2% or better baud error. If a value is specified which is more than 2% from a supported value, the unit will default to using a standard value of 19200 bps.

⁵ Combinations with a “*” denote configurations that are possible, but subsequent communications will likely need to be retried as the bus bandwidth is nearly full.

3.2.7 (ENABLE/DISABLE) MOVING AVERAGE FILTER

This command is used to enable or disable the Moving Average Filter (“Boxcar” filter) in the sensor. When disabled, the sensor’s microcontroller reads measurement data samples from the embedded accelerometer without averaging them. When enabled, the sensor’s microcontroller reads measurement data from the embedded accelerometer and performs a moving average (average of the last “N” data samples) and computes an accelerometer output measurement.

The Moving Average Filter does not change the rate of inclination measurements output from the sensor as defined by using the Bandwidth (“B”) command. It computes the moving average of the last “N” accelerometer data samples, discarding the oldest sample from the filter buffer with each new one that it adds to the buffer. When the Moving Average Filter is enabled, it will output NON-AVERAGED output measurements until it has accumulated “N” accelerometer samples, at which point it will begin to output AVERAGED measurements. Disabling/enabling, or changing the configured length of the Moving Average Filter will cause the filter to be reset and its buffer cleared. If Enabled, the filter will resume output of NON-AVERAGED data samples until the filter buffer of “N” samples has been filled, at which point it will send AVERAGED data samples. This is to avoid the scaling error (1/N, 1/N-1, etc.) of the first N-1 output samples, which could otherwise be interpreted as significant movement.

The length, N (number of samples to average) of the Moving Average Filter is configured with the “Configure Length (Moving Average Filter) Command”. See that section of the manual for more details.

The sensor’s rate of output for the inclination angles can also be affected by the “D” (Decimation) configuration parameter – refer to the section on “**Decimation (Averaging)**” for more details on that command. The Moving Average Filter is implemented before the Decimation Filter in the data flow processing in the sensor’s firmware.

Command Syntax	;<NodeID>,C,A,<0 1>CRLF :<NodeID>,C,A,<0 1>,<CRC16> CRLF
Response Syntax	<NodeID>,C,A,<0 1>,MA Filter <Enabled Disabled>,<CRC16> CRLF
Example Command	;001,C,A,1CRLF
Example Response	001,C,A,1,MA Filter Enabled,0E75CRLF
Notes	To ENABLE the filter, use the “C,A,1” form of the command. To DISABLE the filter, use the “C,A,0” form. Non-Volatile Save command is required to save the new Moving Average Filter setting to non-volatile memory. This will ensure the parameter is recalled after a power cycle. <CRC16> is reported in hexadecimal.

3.2.8 CONFIGURE LENGTH OF MOVING AVERAGE FILTER

This command is used to configure the Sample Length, N, of Moving Average Filter (“Boxcar” filter) in the sensor. When disabled, the sensor’s microcontroller reads measurement data samples from the embedded accelerometer without averaging them. When enabled, the sensor’s microcontroller reads measurement data from the embedded accelerometer and performs a moving average (average of the last “N” data samples) and computes an accelerometer output measurement. The valid range of values for N are “3” through “32”. If a value outside of this range is specified, the configured value will remain at the previous setting.

The Moving Average Filter does not change the rate of inclination measurements output from the sensor as defined by using the Bandwidth (“B”) command. It computes the moving average of the last “N” accelerometer data samples, discarding the oldest sample from the filter buffer with each new one that it adds to the buffer. When the Moving Average Filter is enabled, it will output NON-AVERAGED output measurements until it has accumulated “N” accelerometer samples, at which point it will begin to output AVERAGED measurements. Disabling/enabling, or changing the configured length of the Moving Average Filter will cause the filter to be reset and its buffer cleared. If Enabled, the filter will resume output of NON-AVERAGED data samples until the filter buffer of “N” samples has been filled, at which point it will send AVERAGED data samples. This is to avoid the scaling error (1/N, 1/N-1, etc.) of the first N-1 output samples, which could otherwise be interpreted as significant movement.

The sensor’s rate of output for the inclination angles can also be affected by the “D” (Decimation) configuration parameter – refer to the section on “**Decimation (Averaging)**” for more details on that command. The Moving Average Filter is implemented before the Decimation Filter in the data flow processing in the sensor’s firmware.

Command Syntax	;<NodeID>,C,L,<New Length>CRLF :<NodeID>,C,L,<New Length>,<CRC16> CRLF
Response Syntax	<NodeID>,C,L,<New Length>,MA Filter Sample Length,<CRC16> CRLF
Example Command	;001,C,L,10CRLF
Example Response	001,C,L,10,MA Filter Sample Length,5CC3CRLF
Notes	The <New Length> parameter should be an integer value [3 – 32]. Non-Volatile Save command is required to save the new Moving Average Filter setting to non-volatile memory. This will ensure the parameter is recalled after a power cycle. <CRC16> is reported in hexadecimal.

3.2.9 CLEAR FAULT CONDITION

This command is used to clear any fault condition bits from the device's STATUS REGISTER0 and STATUS REGISTER1 (STS0, STS1). If a fault condition persists (such as over or under temperature, over or under range) the fault bit will be asserted again with the next output value update. Refer to the Query Fault Condition Registers command for information on the individual fault condition bits.

Command Syntax	<code>;<NodeID>,C,F CRLF</code> or <code>;<NodeID>,C,F,<CRC16> CRLF</code>
Response Syntax	<code><NodeID>,F,STS0:<decimal value>,<hex value>,STS1:<decimal value>,<hex value>,<CRC16> CRLF</code> <code><NodeID>, F,STS0:<decimal value>,<hex value>,STS1:<decimal value>,<hex value>,<CRC16> CRLF</code>
Example Command	<code>;065,C,F CRLF</code>
Example Response	<code>;065,F,STS0:0,0x0000,STS1:0,0x0000,9027 CRLF</code>

3.2.10 DECIMATION (AVERAGING)

This command changes the output data rate by averaging multiple input samples per output data value. Each JDx sensor is shipped from the factory with a default averaging of 1 sample, meaning no averaging is performed and the rate of output measurements matches the configured rate from the Bandwidth (B) command. The JDx sensor will average the specified number (“D”) of samples prior to transmitting data on the RS-485 bus. When changing to new values, the value must be an integer and be in the range of 1 to 4096 samples. Note that setting values which are > 1 will result in slowing the effective output rate of new measurements. For example, with an ODR=3.9, (set with “B” command) and Averaging OFF (D = 1), the sample output rate is nearly 4 measurements per second. Setting the parameter D to the value of “24” slows the output of new measurements to approximately 1 every six seconds ($24/3.9 = 6.15$). Therefore, while this implements software averaging, it also implements a decimation, or changing of the output data rate from the sensor.

The Decimation(Average) Filter is implemented after the Moving Average Filter in the data flow processing in the sensor.

The output of the Decimation (Averaging) Filter is converted into a temperature-compensated output data value for transmission on the sensor’s communications port.

Command Syntax	<pre>;<NodeID>,D,<New_Average> CRLF ;<NodeID>,D,<New_Average>,<CRC16> CRLF</pre>	or
Response Syntax	<pre><NodeID>,D,<New_Average>,Samples to average,<CRC16> CRLF</pre>	
Example Command	<pre>;065,D,25 CRLF</pre>	
Example Response	<pre>065,D,0025,Samples to average,4B5DCRLF</pre>	
Notes	<p>A Non-Volatile Save command is required to save the new New_Average to non-volatile memory. This will ensure the parameter is recalled after a power cycle. Sample data rate will be affected by this value. <CRC16> is reported in hexadecimal.</p>	
***	<p>This command forces reconfiguration of internal FIFO data buffers. It is strongly recommended to allow approximately 1.5 seconds of time after issuing this command before issuing other commands to the sensor, so that internal processing can complete.</p>	

3.2.11 NON-VOLATILE SAVE

This command saves the current settings of the JDx sensor to non-volatile memory. The non-volatile save command should be issued when the user wishes to save the changed parameters to ensure those settings are recalled upon power up. If this command is not issued after parameters are changed, the JDx sensor will revert back to its previous settings on the next power cycle OFF-> ON or when issued a Reset Command.

Command Syntax	;<NodeID>,N,S CRLF	or	
	:<NodeID>,N,S,<CRC16> CRLF		
Response Syntax	<NodeID>,N,S,Settings stored in EEPROM,<EEPROM CRC>,<CRC16> CRLF		
Example Command	;001,N,S CRLF		
Example Response	001,N,S,Settings stored in EEPROM,0xB97C,6290CRLF		
Notes	EEPROM CRC is reported for informational use only, the communication CRC is not preceded by "0x". < EEPROM CRC > & <CRC16> are reported in hexadecimal.		

3.2.12 NON-VOLATILE RESTORE

This command restores the JDx sensor to its last saved settings from within the non-volatile memory. The non-volatile restore command should be issued when the user wishes to recall the previously saved settings.

Command Syntax	<code>;<NodeID>,N,R CRLF</code> or <code>;<NodeID>,N,R,<CRC16> CRLF</code>
Response Syntax	<code><NodeID>,N,R,Settings loaded OK,<Calc'ed CRC>,<ROM CRC>,<CRC16> CRLF</code>
Example Command	<code>;001,N,R CRLF</code>
Example Response	<code>001,N,R,Settings loaded OK,0xB97C,0xB97C,92C3 CRLF</code>
Notes	If there is a CRC failure, the sensor will still try to load certain values, but the baud rate will be overridden to 19200. Calculated CRC and the CRC retrieved from the EEPROM are reported for informational use. <code><Calc'ed CRC></code> , <code><ROM CRC></code> & <code><CRC16></code> are reported in hexadecimal.

3.2.13 QUERY

This command queries the settings of the JDx sensor and transmits it for the user to review how the JDx sensor is configured.

Command Syntax ;<NodeID>,Q,<Q|B|BE|BL|C|D|S|T|X|Z> CRLF or
 :<NodeID>,Q,<Q|B|BE|BL|C|D|S|T|X|Z><CRC16> CRLF
 where <Q|B|BE|BL|C|D|S|T|X|Z> is one of the following (select one only):
 Q = full report, B = bandwidth, BE= MA Filter Enable, BL = MA Filter Length, C = status
 code, D = data samples to average, S = Streaming status, T = Test Mode Status, X =
 Termination status, Z=Relative Zero

Response Syntax Varies with query request.

Example Command ;001,Q,B CRLF

Example Response 001,Q,B,3.9,Data rate,1.0,-3dB,D042CRLF

Notes The query command is intended to allow access to the responses from other commands without having to write over the current values, e.g., “;001,Q,BCRLF” allows the user to access the response from the ‘B’ command without writing anything to the device. A summary of many sensor settings is available via a “;001,Q,QCRLF” command. <CRC16> is reported in hexadecimal.

3.2.13.1 QUERY SUMMARY

A simple method to retrieve the state of most of the sensor’s settings is to issue a “Query Summary” command.

Command Syntax	;<NodeID>,Q,Q CRLF or :<NodeID>,Q,Q,<CRC16> CRLF
Response Syntax	<NodeID>,Q,Q,<ISO encoding and copyright statement>,<model>,<serial number>,<Software Revision>,<SVNMODS>,<SW build date>,<Calibration due date>,<Manufactureddate>,<Address>,<Outputstyle>,<Reserved>,<Streaming>,<Reserved>,<Bus termination>,<Relative zero>,<Reserved>,<Reserved>,<Datarate>,<Decimation>,<Baud rate>,<Reserved>,<Reserved>,<CRC16> CRLF
Example Command	;000,Q,Q CRLF
Example Response ⁶	095,Q,Q,(c) 2020 Jewell Instruments,JDI-200-14.5 ,3047795,FW_Rev 1.7.0 SVN_Rev=1222,Modified,Built=2020/05/13 21:37:02 UTC,CalDue=2022JUL14,Manufactured=2021JAN12,A=95,O=52,R=2,S=0,T=0,X=0,Z=0,GC =-9.169,OC=2024.657,ODR=3.906,D=1,baud=19230,I=0,BL=1.3,(128),AA29

3.2.13.2 QUERY BANDWIDTH

A method to retrieve the sensor’s bandwidth or sample rate is to issue a “Query Bandwidth” command.

Command Syntax	;<NodeID>,Q,B CRLF or :<NodeID>,Q,B,<CRC16> CRLF
Response Syntax	<NodeID>,Q,B,Output Data Rate, “Data rate”, -3dB filter bandwidth, “-3dB”,<CRC16> CRLF
Example Command	;000,Q,Q CRLF
Example Response ⁷	001,Q,B,3.9,Data rate,1.0,-3dB,D042CRLF

The response indicates the output data rate or output sample rate (assuming no averaging is enabled) and the effective sensor bandwidth (-3dB frequency).

3.2.13.3 QUERY MOVING AVERAGE FILTER ENABLE

A method to retrieve the sensor’s setting for whether the Moving Average Filter (also called a Boxcar Filter) is Enabled or Disabled.

Command Syntax	;<NodeID>,Q,BECRLF	or
	:<NodeID>,Q,BE,<CRC16> CRLF	
Response Syntax	<NodeID>,Q,BE,<0 1>,MA Filter Enable,<CRC16> CRLF	
Example Command	;001,Q,BECRLF	
Example Response ⁸	001,Q,BE,0,MA Filter Enable,FFF2CRLF	

The response indicates the state of the MA Filter Enable bit, 0=Disabled, 1=Enabled. If the MA Filter is disabled, no Moving Average of the accelerometer’s data samples are computed.

3.2.13.4 QUERY MOVING AVERAGE FILTER LENGTH

A method to retrieve the sensor’s setting for the Moving Average Filter (also called a Boxcar Filter) Length configuration. This defines the filter length, N, the number of accelerometer data samples to process.

Command Syntax	;<NodeID>,Q,BLCRLF	or
	:<NodeID>,Q,BL,<CRC16> CRLF	
Response Syntax	<NodeID>,Q,BL,<MA Filter Length>,MA Filter Length,<CRC16> CRLF	
Example Command	;001,Q,BLCRLF	
Example Response	001,Q,BL,10,MA Filter Length,69FACRLF	

The response indicates the configured length (number of samples to average) of the Moving Average Filter.

3.2.13.5 QUERY FAULT CONDITION REGISTERS

A simple method to check the sensor for fault status conditions is to issue a “Query Fault Condition” command.

Command Syntax	<pre>;<NodeID>,Q,C CRLF ;<NodeID>,Q,C,<CRC16> CRLF</pre>	or
Response Syntax	<pre><NodeID>,Q,C,STS0:<decimal value>,<hex value>,STS1:<decimal value>,<hex value>s,<CRC16> CRLF</pre>	
Example Command	<pre>;000,Q,C CRLF</pre>	
Example Response	<pre>065,Q,C,STS0:8208,0x2010,STS1:0,0x0000,B3F3 CRLF</pre>	

This example shows that bit 13 (0x2000) and bit 4 (0x0010) are set, indicating that the sensor has powered up or been reset by a power cycle or brownout (bit 13), and that it is being operated above its highest calibrated range(bit 4).

Refer to the following table for the Fault Condition bit descriptions.

The “Behavior” column indicates whether the fault condition bit is “latching” (L) in behavior or “unlatched” (U) in behavior.

L = Latching, the bit is set upon the first detection of the condition and remains set until the unit is reset or a “Clear Fault Condition” (C,F) command is received, which can clear the bit(s). If a condition persists, the bits will be set again.

U = Unlatching, the bit is set while the condition persists, but will clear automatically when the condition is resolved. An example of this is the measured internal temperature being above the maximum calibrated limit (typically 60C) and then cooling to below the calibrated limit. In this case the bit will be set, and then clear automatically when the temperature is within calibrated operational values (Bit 2). Any bits not documented here are reserved for future use.

Table 7: JDx Fault Condition Register Bit Definitions

STS0: Fault Condition Bit	Behavior	Decimal / Hex Value
Bit 0: COM Port Parity Error	L	1 / 0x0001
Bit 1: COM Port Framing and/or Overrun Error	L	2 / 0x0002
Bit 2: Measured temperature is above the maximum calibrated range of the device	U	4 / 0x0004
Bit 3: Measured temperature is below the minimum calibrated range of the device	U	8 / 0x0008
Bit 4: Measured value (angle, acceleration) is above the maximum calibrated range of the device	U	16 / 0x0010
Bit 5: Measured value (angle, acceleration) is below the minimum calibrated range of the device	U	32 / 0x0020
Bit 6: Failure to load Calibration data from Flash	L	64 / 0x0040
Bit 7: Failure to load Nonvolatile Settings data from EEPROM - using default configuration settings	L	128 / 0x0080
Bit 8: Failure to ID, configure, or self test Accelerometer IC	L	256 / 0x0100
Bit 11: Test Mode Active in Accelerometer IC	U	2048 / 0x0800
Bit 12: The system has been reset due to a software fault/Watchdog timeout error - operational stability may or may not be maintained.	L	4096 / 0x1000
Bit 13: BrownOut/Power Cycle Detect. System has been reset from power brownout condition or has just been powered up	L	8192 / 0x2000

3.2.13.6 QUERY DECIMATION

A simple method to retrieve the Decimation value (number of samples to average) is to issue a “Q,D” command.

Command Syntax	;<NodeID>,Q,D CRLF	or
	:<NodeID>,Q,D,<CRC16> CRLF	
Response Syntax	<NodeID>,Q,D,<value>,Samples to average,<CRC16> CRLF	
Example Command	;000,Q,D CRLF	
Example Response	065,Q,D,0002,Samples to average, E761 CRLF	

3.2.13.7 QUERY STREAMING

A simple method to retrieve the Streaming status (Enabled (1) or Disabled (0)) is to issue a “Q,S” command.

Command Syntax	;<NodeID>,Q,S CRLF	or
	:<NodeID>,Q,S,<CRC16> CRLF	
Response Syntax	<NodeID>,Q,S,<value>,Streaming,<CRC16> CRLF	
Example Command	;000,Q,S CRLF	
Example Response	095,Q,S,0,Streaming,40EF CRLF	

3.2.13.8 QUERY TEST MODE

A simple method to retrieve the Test Mode status of the sensor’s accelerometer is to issue a “Q,T” command.

Command Syntax	;<NodeID>,Q,T CRLF	or
	:<NodeID>,Q,T,<CRC16> CRLF	

Response Syntax <NodeID>,Q,T,<value>,<CRC16> CRLF

Example Command ;000,Q,T CRLF

Example Response 067,Q,T,0,0AF8 CRLF

Notes The accelerometer should never be put into test mode unless directed to do so by Jewell Customer support for diagnostic purposes. Test mode applies test mass forces to the MEMs device and will result in erroneous readings while it is enabled. A response value of “0” indicates the accelerometer is NOT in test mode, but a response value of any non-0 value could indicate a test mode is engaged and readings are not accurate. If for any reason, you observe seemingly erroneous readings from the sensor, you can issue this command to see if it has been switched into test mode (<value> != 0). If this happens, try to disable test mode by issuing the following command:

	;<NodeID>,T,0 CRLF	or
	:<NodeID>,T,0,<CRC16> CRLF	

Example Command ;000,T,0 CRLF

Example Response 067,T,0,B944 CRLF

3.2.13.9 QUERY RS-485 TERMINATION

A simple method to retrieve the state of a sensor’s RS-485 termination resistor status is to issue a “Q,X” command. An additional caveat of the RS-485 termination commands is that the sensor’s specific unit address MUST be specified in the NodeID field. Otherwise, an error response will be issued and no action taken. This is to prevent a broadcast message from enabling the termination resistors on many JDI sensors in an RS-485 chain simultaneously, which would totally disrupt communications. A returned value of “0” indicates termination is “OFF”, while a value of “1” indicates termination is “ON”.

Command Syntax	;<NodeID>,Q,X CRLF :<NodeID>,Q,X<CRC16> CRLF	or
Response Syntax	<NodeID>,Q,X,<0 1>, RS-485 Termination<CRC16> CRLF	
Example Command	;018,Q,X CRLF	
Example Response	018,Q,X,0,RS-485 termination,FE65CRLF	

3.2.13.10 QUERY RELATIVE ZERO

A simple method to retrieve the sensor’s Relative Zero settings is to issue a “Q,Z” command. If you have enabled the User Relative Zero function in the sensor and wish to know the axis offset values it has set, or simply wish to know if the function is enabled or not, you can use this command to display the status.

Command Syntax	;<NodeID>,Q,Z CRLF :<NodeID>,Q,Z<CRC16> CRLF	or
Response Format	<NodeID>,Q,Z,<RelZeroEnable>, <X_Offset>, <Y_Offset>, Software zero,<CRC16> CRLF	
Response Syntax	<NodeID>,Q,Z,<0 1>, <+ -> x.xxxx, <+ ->y.yyyy, Software zero,<CRC16> CRLF	
Example Command	;095,Q,Z CRLF	
Example Response	095,Q,Z,0,+0.0000,+0.0000,Software zero,C7B7CRLF	

3.2.14 RS-485 TERMINATION

This command enables or disables the 120 Ω termination resistor within the JDx sensor. Each JDx sensor is shipped from the factory with the termination resistor disabled. The value of 0 disables the termination resistor, while the value of 1 enables the resistor. The user must ensure that on a shared RS-485 bus that only one termination resistor is installed and that it is implemented at the distant end of the RS-485 network. Please reference section 3.4 for additional information regarding RS-485 networks.

Command Syntax	;<NodeID>,X,<1 0> CRLF	or
	:<NodeID>,X,<1 0>,<CRC16> CRLF	
Response Syntax	<NodeID>,X,1,RS-485 termination ,<CRC16> CRLF	
Example Command	;001,X,1 CRLF	
Example Response	001,X,1,RS-485 termination,E8D6 CRLF	
Notes	<CRC16> is reported in hexadecimal.	

3.2.15 DATA FIFO QUERY

In an effort to support downstream DSP efforts, the JDx has a FIFO of up to 64 of the latest data points. As an alternative to streaming, the FIFO may be accessed to burst data out of the sensor without needing to access it in a real-time fashion to recover all data that it generates. The Data FIFO Query command reports the number of entries currently residing in the FIFO. The count is accurate as of the point in time that the command was received. During the generation of the ASCII response string and its conveyance across the physical RS-485 link, more data may have been generated.

Command Syntax	;<NodeID>,F,Q CRLF	or
	:<NodeID>,F,Q,<CRC16> CRLF	
Response Syntax	<NodeID>,F,Q,<FIFO_size>,<CRC16> CRLF	
Example Command	;000,F,Q CRLF	
Example Response	001,F,Q,27,D1C1 CRLF	

3.2.16 DATA FIFO DUMP

This command will create a short stream of data similar to the streaming function, but it will cease once it has emptied the FIFO.

Command Syntax	;<NodeID>,F,D CRLF :<NodeID>,F,D,<CRC16> CRLF	or
Response Syntax	<NodeID>,F,D,Dumping <N>+ entries,<CRC16> CRLF	
Example Command	;000,F,D CRLF	
Example Response	250,F,D,Dumping 2+ entries,85D0 CRLF 250,V,R,-393,-1333,+255300,+1697,1032,2478 CRLF 250,V,R,-383,-1329,+255303,+1697,1033,9105 CRLF	

3.2.17 DATA FIFO FLUSH

This command will re-initialize the FIFO. Not only will the existing data be discarded, but the sequence number will be reset to zero. Note that the Get Value command will still report the last known good values, but the sequence number will be reset. The first data point calculated after the flush will be sequence number 1.

Command Syntax	;<NodeID>,F,F CRLF :<NodeID>,F,F,<CRC16> CRLF	or
Response Syntax	<NodeID>,F,F,FIFO flushed,<CRC16> CRLF	
Example Command	;000,F,F CRLF	
Example Response	001,F,F,FIFO flushed,8AFD CRLF	

3.2.18 BUS SCAN

This command will cause all devices on an RS-485 bus to respond in turn allowing you to identify which addresses are present on an unknown bus. While this will work with specific addresses, this command is intended to be a broadcast command.

Command Syntax	;<NodeID>,* CRLF :<NodeID>*,<CRC16> CRLF	or
Response Syntax	<NodeID>*,<CRC16> CRLF	
Example Command	;000,* CRLF	
Example Response	249,*,2566 CRLF 250,*,7958 CRLF	
Notes	<p>This command has delayed responses based on the actual addresses present on the bus. Approximate completion times are:</p> <ul style="list-style-type: none"> 500000 baud, 0.205 seconds 115200 baud, 0.460 seconds 9600baud, 4.1 seconds 300 baud, 128.0 seconds 	

3.2.19 SOFT RESET

If for some reason you need to issue a soft reset command to the sensor, this command is available. This will not cycle power to any portion of the sensor, but will reset the microcontroller, reload the non-volatile settings and re-initialize the hardware. The unit should be able to respond to messages again within approximately 3 seconds, under normal conditions.

Command Syntax	;<NodeID>,>shutdown -r now CRLF :<NodeID>,>shutdown -r now ,<CRC16> CRLF	or
Response Syntax	<i>There is no response to this command</i>	
Example Command	;186,>shutdown -r now CRLF	

3.2.20 RELATIVE ZERO

The JDx family of sensors offers you the ability to compensate for any installation offsets you may encounter. This alleviates the majority of tolerance concerns when designing brackets or mounting surfaces for the JDx. When the command is issued to capture a relative zero, the device will capture its next reading as the new zero point. A non-volatile save (see section 0) is required for this value to persist following a power cycle or manual reset. It is important to note that very large physical offset values can reduce the effective range and accuracy of the sensor.

Command Syntax	;<NodeID>,Z,1 CRLF	or	
	:<NodeID>,Z,1,<CRC16> CRLF		
Response Syntax	Varies per number of axes in your product: <NodeID>,Z,1,<1 st axis offset>,...,<CRC16> CRLF		
Example Command	;027,Z,1 CRLF		
Example Response	027,Z,1,-74.4550,Software zero,4756 CRLF		(Single axis inclinometer)
	027,Z,1,-74.1570,-7.2397,Software zero,547E CRLF		(Dual axis inclinometer)

3.3 DATA INTEGRITY, CRC

All responses from the JDx sensor include an ASCII based 16-bit CRC value. The value is provided so that the customer may choose to validate packet content integrity in any environment. The CRC implementation was borrowed from the CRC calculation algorithm used by the Modbus protocol⁹. The CRC16 value is transmitted in plain ASCII character encoding in hexadecimal format. The CRC value is always the last 2 bytes prior to the CR and LF which represents the last four ASCII characters of the transmitted packet.

3.4 SHARED RS-485 BUS

A helpful resource for RS-485 networks and implementation is authored by Texas Instruments¹⁰.

⁹See also <https://www.libcrc.org/> specifically https://www.libcrc.org/crc_modbus/. The JDx implements revision 69 of the "libcrc.org" code.

¹⁰The RS-485 Design Guide, authored by Texas Instruments, <http://www.ti.com/lit/an/slla272c/slla272c.pdf>

APPENDIX A: WARRANTY & LIMITATION OF LIABILITY

Standard goods (those listed in Jewell Instruments' published sales literature, excluding software) manufactured by Jewell Instruments LLC are warranted against defects in materials and workmanship for twelve (12) months from the date of shipment from Jewell's premises with the following exceptions: Series 900 analog or digital clinometers are warranted against defects in materials and workmanship for 90 days from the delivery date. Jewell will repair or replace (at its option) goods that prove to be defective during the warranty period provided that they are returned prepaid to Jewell and:

- (a) that the goods were used at all times for the purpose for which they were designed and in accordance with any instructions given by Jewell in respect of them,
- (b) that notice is received by Jewell within 30 days of the defects becoming apparent, and
- (c) that return authorization is received from Jewell prior to the goods being sent back.

Should goods be damaged in transit to the Purchaser, Jewell will accept no liability unless the Purchaser can show that such damage arose solely from Jewell's failure to pack the goods properly for shipment.

Software products are warranted to perform substantially in accordance with their documentation for 90 days following your receipt of the software. Jewell and its suppliers do not and cannot warrant the performance or results you may obtain by using the software or its documentation.

In respect to goods or parts thereof manufactured by others and resold by Jewell, Jewell will pass on to the customer the benefit of any guarantee or warranty received by Jewell from the original manufacturer insofar as such guarantee or warranty is assignable.

ANY OTHER CONDITIONS OR WARRANTIES WHETHER EXPRESS OR IMPLIED BY STATUTE OR OTHERWISE ARE EXCLUDED. THE REMEDIES PROVIDED HEREIN ARE THE BUYER'S SOLE AND EXCLUSIVE REMEDIES. JEWELL INSTRUMENTS LLC SHALL NOT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES, INCLUDING LOST PROFITS OR LOST SAVINGS, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY. THIS WARRANTY EXTENDS ONLY TO THE ORIGINAL PURCHASER AND IS EXPRESSLY IN LIEU OF ALL OTHER WARRANTIES, WHETHER OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR USE, AND OF ALL OTHER OBLIGATIONS AND LIABILITIES OF ANY KIND AND CHARACTER. THERE ARE NO WARRANTIES WHICH EXTEND BEYOND THE DESCRIPTION ON THE FACE HEREOF.

Jewell's liability arising out of the sale of its goods is expressly limited to the repair and/or replacement of defective parts or the cost of such repair and/or replacement.

If software does not perform substantially in accordance with the documentation, the entire and exclusive liability and remedy shall be limited to either, at Jewell's option, the replacement of the software or the refund of the license fee you paid for the software.

Liability for any other form of loss or damage is hereby expressly excluded.

Customer shall indemnify Jewell against any third party claim arising out of the use of goods and/or services supplied by Jewell, including any claim arising directly or indirectly out of alleged negligence on the part of Jewell, its employees, servants, representatives or agents.