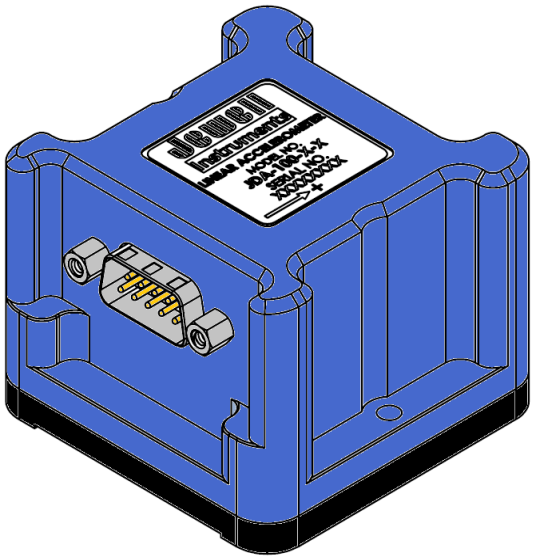
Quick Start Guide

for the

JDx Series of Inclinometers & Accelerometers



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REVISION HISTORY

Revision	Date	Change Description
1	3/30/17	Initial release
2	5/1/17	Corrected typo in Change Baud command, section 3.2.6. Corrected checksum value, pg 7. Corrected command syntax, pg 6. Corrected typo, pg 8. Corrected paragraph in section 3.2.11, pg 9.
3	5/4/17 – 6/20/17	Commentary added to introduction regarding initial setup "A" and "B" notation on pin-out corrected Change Baud augmented to allow parity control "Get Value" and "Streaming": data now reported with 'V' identifier Sensor Node ID (address) now reflects the serial number Data FIFO commands added Bus Scan command added Soft Reset command added Get Value responses detailed per product type Clerical updates (sections 4.2, 3.2.3, 3.2.4, 3.2.5) Cleanup of page breaks, paragraphs, grammar and typos.
A	6/21/17	Production release

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MANUAL ACRONYMS & NOTATIONS

JDI	Jewell Digital Inclinometer
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 DB9 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 however you see fit (programming charges may apply).

2 INSTALLATION

The following sections cover mechanical connections and mechanical installation.

2.1 MECHANICAL CONNECTIONS

The inclinometer comes fitted with 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 pinout for the JDx sensor is provided below.

Table 1: JDx Series DB9 Pinout

9-PIN CONNECTOR	
PIN	**ASSIGNMENT**
1	(-), [RS-485]
2	(+), [RS-485]
3	N/C
4	N/C
5	GND, [RS-485]
6	N/C
7	N/C
8	PWR-
9	PWR+

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.

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.

2.2 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.

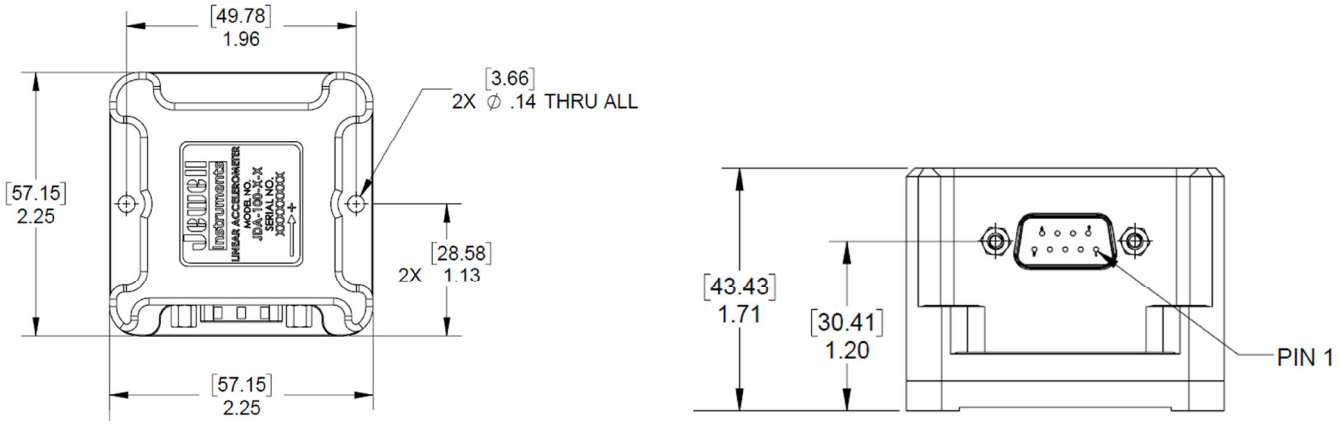

Figure 1: JDx Outline & Dimensions

2.3 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 enabled, though the termination may be disabled at the installer's preference. Enabling and disabling of the termination resistor is accomplished through firmware commands covered in Section 3.

Early versions of the JDx sensor also include biasing resistors on the A and B signals. The RS-485 (A) signal is pulled high and the RS-485 (B) signal is pulled low to the RS-485 ground reference. Standard future revisions will not have the bus biasing resistors installed, though they will be available for custom orders.

2.4 GALVANIC ISOLATION & JDx GROUNDING & TRANSIENT PROTECTION

Both the power connections and RS-485 connections are Galvanically isolated from the internal sensor. The power inputs are rated to 2kVAC whereas the RS-485 connections are rated to 5kVAC. 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 as a Galvanic isolation.

The shell of the DB9 has 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. Further, all inputs and outputs have differential transorbs.

3 JDX COMMUNICATION PROTOCOLS

The JDx sensor data is easy to retrieve from the sensor as a simple and intuitive protocol has been implemented. To obtain this data, a simple terminal emulation program[1] (or equivalent) may be used on the system/computer side. The sections below outline the communication settings, firmware commands, and protocols.

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 2: JDx Series Default Communication Settings

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

3.2 FIRMWARE COMMANDS & PROTOCOLS

The firmware commands and protocols are provided in the sections below.

[1] RealTerm Serial Capture Program, or HyperTerminal are example programs. RealTerm may be downloaded free of charge from https://sourceforge.net/projects/realterm/

3.2.1 General Command Formats

The notation used in this quick start guide is as follows:

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 CRLF[2], 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. 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 implement 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 command.
All commands in the following sections must be issued using ASCII text only.

[2] The JDx implements a 1 second timeout (similar to MODBUS) allowing it to respond (with a delay) to commands that are missing the CRLF line ending.

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 3.2.13)

Command Syntax	;<NodeID>,V<CRLF> or :<NodeID>,V,<CRC16><CRLF>
Response Syntax	Varies per "sample type", reflecting the sensor configuration purchased[3]. <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>
Note	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] Custom configurations including blended accelerometer/inclinometer outputs are available, contact sales@jewellinstruments.com for more information.

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	;<NodeID>,S,<1|0>CRLF or :<NodeID>,S,<1|0>,<CRC16>CRLF
Response Syntax	<NodeID>,S,<0=OFF, 1=ON>,Streaming,<CRC16>CRLF (Subsequent data points will adhere to the "V" command's syntax, see section 3.2.2)
Example Command	;009,S,1CRLF
Example Response	009,S,1,Streaming,F465 CRLF 009,V,7,+2.9175,-0.3806,+17.620,20,ACA9CRLF 009,V,7,+2.9182,-0.3804,+17.618,21,7B87CRLF 009,V,7,+2.9190,-0.3806,+17.618,22,E773CRLF
Note	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.

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,2CRLF
Example Response	002,A,002,Address,<CRC16>CRLF
Note	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 (aka data sample rate) of the JDx sensor. The table below shows the combinations which are allowed vs the baud rate. Care must be taken in selecting the bandwidth of the sensor and the baud of the sensor. For obvious reasons, the user should not select the highest output data rate and lowest baud setting.

Table 3: JDx Bandwidth vs Baud[4]

	Bandwidth (Output Sample Rate)					
Baud	**3.9**	**7.8**	**15.6**	**31.2**	**62.5**	**125**
300	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
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,15.6CRLF
Example Response	001,B,15.6,Data rate,3.9,-3dB,2258CRLF
Note	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. Bandwidth may be reduced by the "Data Averaging" setting, see also section 3.2.7

[4] Combinations with a "*" denote configurations that are possible, but subsequent communications will likely need to be retried as the bus bandwidth is nearly full.

3.2.6 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 of 19200 bps. The baud value must be an integer between 300 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.

Command Syntax	;<NodeID>,C,B,< 300|9600|19200|38400|57600|115200|500000>,E<CRLF> or :<NodeID>,C,B,< 300|9600|19200|38400|57600|115200|500000>,E,<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,115200,8n1,1 sec delayed baud change,DE2D<CRLF> 001,C,B,115200,8n1,New baud,D511<CRLF>
Note	A Non-Volatile Save command is required to save the new New_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. Switching from baud rates below 9600, the first line may not completely print before the 1.0 sec time expires.

3.2.7 DATA AVERAGING

This command changes the number of output samples which are averaged together. Each JDx sensor is shipped from the factory with a default averaging of 1 sample, i.e, no averaging. The JDx sensor will average the specified number 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.

Command Syntax	;<NodeID>,D,<New_Average><CRLF> or :<NodeID>,D,<New_Average>,<CRC16><CRLF>
Response Syntax	<NodeID>,D,<New_Average>,Samples to average,<CRC16><CRLF>
Example Command	;001,D,2000<CRLF>
Example Response	001,D,2000,Samples to average, 2998<CRLF>
Note	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.

3.2.8 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 up.

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

3.2.9 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	;<NodeID>,N,RCRLF	or
	:<NodeID>,N,R,<CRC16>CRLF	
Response Syntax	<NodeID>,N,R,Settings loaded OK,<Calc'ed CRC>,<ROM CRC>,<CRC16>CRLF	
Example Command	;001,N,RCRLF	
Example Response	001,N,R,Settings loaded OK,0xB97C,0xB97C,92C3CRLF	
Note	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. <Calc'ed CRC>, <ROM CRC> & <CRC16> are reported in hexadecimal.	

3.2.10 QUERY

This command queries the settings of the JDx sensor and transmits it out to the RS-485 bus for the user to review how the JDx sensor is configured.

Command Syntax	;<NodeID>,Q,<Q|B|D>CRLF or :<NodeID>,Q,< Q|B|D><CRC16>CRLF where <Q|B|D> is one of the following (select one only): Q is full report, B = bandwidth, D = data samples to average
Response Syntax	Varies with query request.
Example Command	;001,Q,BCRLF
Example Response	001,Q,B,3.9,Data rate,1.0,-3dB,D042CRLF
Note	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 all settings is available via a ";001,Q,QCRLF" command. <CRC16> is reported in hexadecimal.

3.2.11 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 enabled. 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 helpful information regarding RS-485 networks.

Command Syntax	;<NodeID>,X,<1|0>CRLF or :<NodeID>,X,<1|0>,<CRC16>CRLF
Response Syntax	<NodeID>,X,1,RS485 termination ,<CRC16>CRLF
Example Command	;001,X,1CRLF
Example Response	001,X,1,RS485 termination,E8D6CRLF
Note	<CRC16> is reported in hexadecimal.

3.2.12 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,QCRLF	or
	:<NodeID>,F,Q,<CRC16>CRLF	
Response Syntax	<NodeID>,F,Q,<FIFO_size>,<CRC16>CRLF	
Example Command	;000,F,QCRLF	
Example Response	001,F,Q,27,D1C1CRLF	

3.2.13 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,DCRLF	or
	:<NodeID>,F,D,<CRC16>CRLF	
Response Syntax	<NodeID>,F,D,Dumping <N>+ entries,<CRC16>CRLF	
Example Command	;000,F,DCRLF	
Example Response	250,F,D,Dumping 2+ entries,85D0CRLF 250,V,R,-393,-1333,+255300,+1697,1032,2478 CRLF 250,V,R,-383,-1329,+255303,+1697,1033,9105 CRLF	

3.2.14 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.

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

3.2.15 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	or
	:<NodeID>,*,<CRC16>CRLF	
Response Syntax	<NodeID>,*,<CRC16>CRLF	
Example Command	;000,*CRLF	
Example Response	249,*,2566CRLF 250,*,7958CRLF	
Note:	This command has delayed responses based on the actual addresses present on the bus. Approximate completion times are:	

- 500000 baud, 0.205 seconds
- 115200 baud, 0.460 seconds
- 9600baud, 4.1 seconds
- 300 baud, 128.0 seconds

3.2.16 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.

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

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 protocol[5]. 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 Instruments[6].

[5] See http://modbus.org/docs/PI_MBUS_300.pdf (page marked "112"). See also https://www.libcrc.org/ specifically https://www.libcrc.org/crc_modbus/. The JDx implements revision 69 of the "libcrc.org" code.
[6] The RS-485 Design Guide, authored by Texas Instruments, http://www.ti.com/lit/an/slla272c/slla272c.pdf

APPENDIX A: WARRANTY & LIMITATION OF LIABILITY

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(c) that return authorization is received from Jewell prior to the goods being sent back.

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