



Serial Axia F/T Sensor Manual



Document #: 9610-05-Serial Axia

Engineered Products for Robotic Productivity

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This product conforms to EU Directive CE 2011/65/EU (RoHS).

Note:

Please read the manual before calling customer service, and have the following information available:

1. Serial number (e.g., FT01234)
2. Sensor model (e.g., Axia80, etc.)
3. Calibration (e.g., US-15-50, SI-65-6, etc.)
4. Accurate and complete description of the question or problem
 - For the status code; refer to *Section 4.8—Status Code*.
 - For the system's response to the status command; refer to *Section 5.13—Status Command: "status"*.
5. Computer and software information (operating system, PC type, drivers, application software, and other relevant information about the application's configuration)

Be near the F/T system when calling (if possible).

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Glossary

Term	Definitions
Active Configuration	The configuration that the system is currently using.
ADC	Analog-to-digital converter.
Baud Rate	A number that is related to the speed of data transmission in a system. The data indicates the number of electrical oscillations per second that occurs within a data transmission.
Calibration	The factory-supplied data used by Serial Axia sensor so it can report accurate sensor readings. Calibrations apply to a specific loading range.
Complex Loading	Any force or torque load that is not purely in one axis.
Configuration	User-defined settings that include which force and torque units are reported and which calibration is to be used.
Control Panel	A feature on a personal computer operating system where the user can adjust system settings.
Coordinate Frame	See Point of Origin.
CRC	Cyclic Redundancy Check is an error-detecting code commonly used in digital networks and storage devices to detect accidental changes to raw data. Blocks of data entering these systems get a short check value attached, based on the remainder of a polynomial division of their contents.
Data Rate	How fast data is output over the serial interface.
Delimiter	A character such as a comma that separates a sequence of values.
Force	The push or pull exerted on an object. Mathematically, force is expressed as: Force = mass x acceleration
FS	Full-Scale.
FT or F/T	Force and Torque.
F_{xy}	The resultant force vector comprised of components F_x and F_y .
Hysteresis	A source of measurement error that is caused by the residual effects of previously applied loads.
Interface Plate	A separate plate that attaches the sensor to another surface. Interface plates are often used if the bolt pattern on the MAP or TAP doesn't match the bolt pattern on the robot arm or customer tooling. The interface plate has two bolt patterns on either side of the plate. One side is for the MAP or TAP. The other side is for the robot arm or customer tooling.
IP64	Ingress protection rating "64" designates protection against dust and splashing of water. An IP64 rating does not guarantee protection when a user submerges a device in water or any type of fluid.
Mounting Adapter Plate MAP	The surface of the sensor that attaches to a fixed surface like an interface plate or robot arm.
MCU	Microcontroller unit. A part of the software and electronics of the sensor. The MCU contains a computer processing unit that includes memory.
N/A	Not applicable.
NVM	Non-Volatile Memory. Storage of information or device memory that can be retrieved even after the device goes through a power cycle (turned off and then back on).
Overload	The condition where more load is applied to the sensor than the rated measurement range that can be applied to the sensor. Overloads result in reduced accuracy and potentially reduced sensor life.
PCB	Printed circuit board.
P/N	Part Number
Point of Origin	The location on the sensor from which all forces and torques are measured. Also known as the Coordinate Frame.
Power Cycle	When a user removes and then restores power to a device.

Term	Definitions
Resolution	The smallest change in load that can be measured.
Sample Rate	How fast the ADCs are sampling inside the unit.
Sense loads	The ATI F/T sensor detects sense loads that are a cumulation of forces and torques acted upon the customer tooling.
Sensor	The component that converts a detected load into electrical signals.
Status Bit	A unit of computer data sent from the ATI F/T sensor.
Status Word	The status code
Tool Adapter Plate TAP	The surface of the sensor that attaches to a fixed surface like an interface plate or the customer tooling.
Torque	The measurement of force exerted on an object causing it to rotate. Mathematically, torque
Transducer	Every transducer is also (or has) a sensor but every sensor isn't a transducer. A transducer is more than a sensor. It consists of a sensor/actuator along with signal conditioning units.
T_{xy}	The resultant torque vector comprised of components T_x and T_y .

1. Safety

The safety section describes general safety guidelines to be followed with this product, explanations of the notifications found in this manual, and safety precautions that apply to the product. Product specific notifications are imbedded within the sections of this manual (where they apply).

1.1 Explanation of Notifications

These notifications are used in all of ATI manuals and are not specific to this product. The user should heed all notifications from the robot manufacturer and/or the manufacturers of other components used in the installation.



DANGER: Notification of information or instructions that if not followed will result in death or serious injury. The notification provides information about the nature of the hazardous situation, the consequences of not avoiding the hazard, and the method for avoiding the situation.



WARNING: Notification of information or instructions that if not followed could result in death or serious injury. The notification provides information about the nature of the hazardous situation, the consequences of not avoiding the hazard, and the method for avoiding the situation.



CAUTION: Notification of information or instructions that if not followed could result in moderate injury or will cause damage to equipment. The notification provides information about the nature of the hazardous situation, the consequences of not avoiding the hazard, and the method for avoiding the situation.

NOTICE: Notification of specific information or instructions about maintaining, operating, installing, or setting up the product that if not followed could result in damage to equipment. The notification can emphasize, but is not limited to: specific grease types, best operating practices, and maintenance tips.

1.2 General Safety Guidelines

The customer should verify that the sensor is rated for the maximum load and torque expected during operation. Because static forces are less than the dynamic forces from the acceleration or deceleration of the robot, be aware of the dynamic loads caused by the robot.

1.3 Safety Precautions



CAUTION: Modifying or disassembly of the sensor could cause damage and void the warranty. Use the supplied mounting interface plate and the provided tool side mounting bolt pattern to mount the sensor to the robot and customer tooling to the sensor. Refer to [Section 10—Drawings](#) for more information.



CAUTION: Probing openings in the sensor causes damage to the instrumentation. Avoid prying into the openings of the sensor.



CAUTION: Do not overload the sensor. Exceeding the single-axis overload values of the sensor causes irreparable damage.



CAUTION: Do not contact the IP64 seal. Contacting the seal can cause the sensor to malfunction.



CAUTION: The sensor should be protected from impact and shock loads that exceed rated ranges during transportation as the impacts can damage the sensor's performance. Refer to [Section 9—Specifications](#) for more information about rated ranges.

2. Product Overview

The Serial Axia Force/Torque (F/T) sensor measures six components of force and torque ($F_x \setminus F_y \setminus F_z \setminus T_x \setminus T_y \setminus T_z$) and communicates this data to a personal computer. The sensor communicates data by using RS485 protocol.

The mounting side attaches to a mounting interface plate, which mounts to the customer robot. The tool side attaches to the customer tooling. Both the mounting and tool sides have a 71.12 mm bolt circle pattern with (6) M5 tapped holes and (2) slip fit dowel holes (refer to [Section 10—Drawings](#) for more information). The sensor is IP64 rated. A M8 6-pin male connector is for power and signals. For the pin assignments, refer to [Section 3.5—Pin and Wire Assignments for Serial and Power Connection](#). For available cable configurations, refer to [Table 2.1](#).

The Serial Axia sensor offers the following features:

- Provides calibrated force/torque data
- Bias functionality
- Programmable low-pass filtering with cut-off frequency
- LED indicator for Link/Activity (L/A), Diagnostic (DIAG), and Status. (refer to [Section 4.2—LED Outputs on the Serial Axia Sensor](#) for more information)

Figure 2.1—Serial Axia F/T Sensor

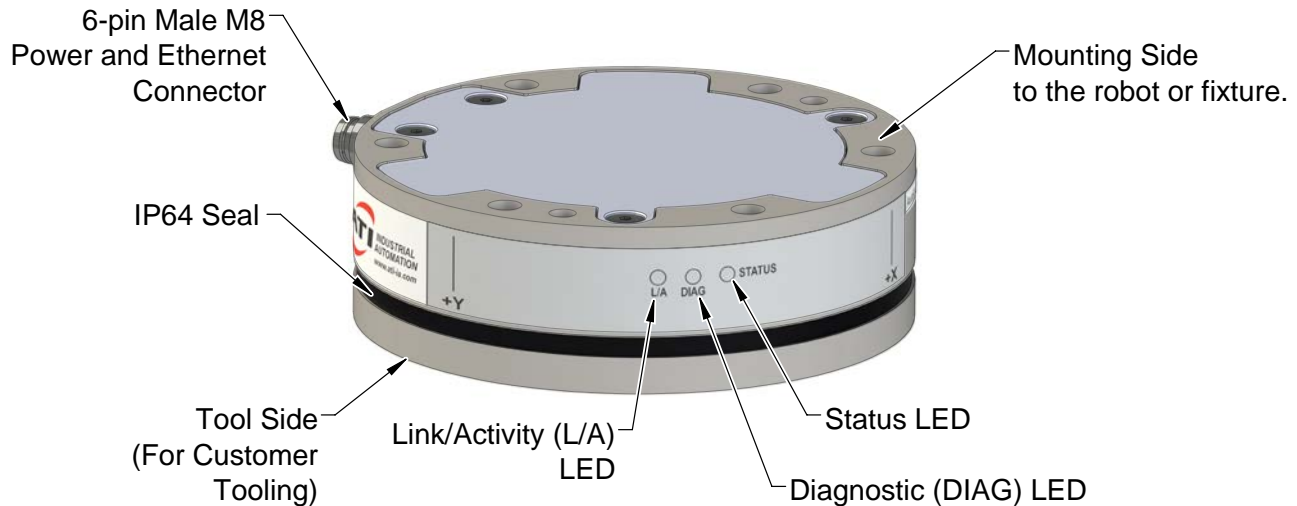


Table 2.1—Serial Axia Cable Configurations		
Configuration	Cable Part Number	Cable Description
(1) Cable that routes from the sensor to a USB connection on the customer application.	9105-C-ZC33-ZC34-XXX	6-pin female M8 Connector to a USB type A plug.
(1) Optional sensor cable for clock synchronization. The cable routes from the audio jack in the USB type A plug on the USB cable, 9105-C-ZC33-ZC34-XXX, to the customer's application.	9105-CP-ZC38-U-1.8 ¹	A 3.5 mm stereo audio jack plug to an unterminated end for grounding a signal wire and connecting a signal wire.
Notes:		
1. The 9105-CP-ZC38-U-1.8 sensor cable can be used as hardwired, clock synchronization method of interfacing with the sensor for transmitting and receiving data on demand. (refer to Section 2.2—Sync Functionality Overview for more information)		
2. The "X" in the part number represents cable length.		
3. For cable specifications, refer to Section 9.4—Cable Specifications and Section 10—Drawings .		

2.1 Overview of Axia Models

The Axia sensor is available in three different models. An overview of each model is summarized in the following table:

Table 2.2—Axia Models			
Model	Part Number	Number of Identifying Grooves ¹	Material
Axia80-M8	9105-RS485-Axia80-M8	3	Aluminum
Axia80-M20	9105-RS485-Axia80-M20 ²	0	
Axia80-M50	9105-RS485-Axia80-M50	2	Stainless Steel

Notes:

1. Identifying grooves are physical indentations in the sensor body (refer to [Figure 2.2](#)). These grooves provide users a quick visual method to differentiate the sensor models.
2. Formally 9105-RS485-Axia80
3. For calibration ranges, refer to [Section 9.3—Calibration Ranges](#).

Figure 2.2—Identifying Grooves (Axia80-M8 shown as a reference)

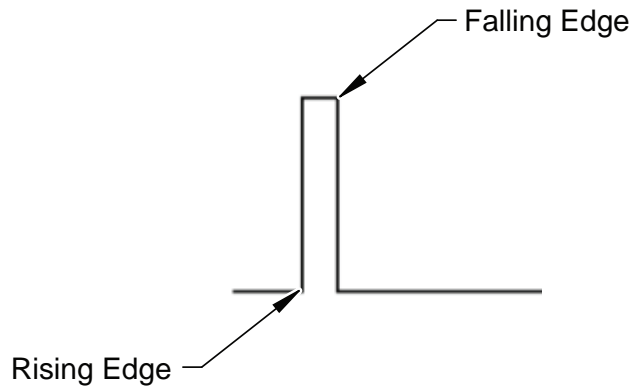


2.2 Sync Functionality Overview

Sync functionality is possible if the 9105-CP-ZC38-U-1.8 cable is used from (refer to [Table 2.1](#)). When the user applies a rising edge of at least 5 V to the red and black conductors ([Table 3.5](#)), the sync functionality of the sensor is activated. Upon activation of the sync function, the sensor outputs the most recently collected data point which is equivalent to the output from the “s” command ([Section 5.3—Query Commands: “s” or “c”](#)) sent over a RS-485 cable interface.

An electrical pulse is shown in the following figure. The rising edge of the pulse starts at 5 V. The falling edge of the pulse, is when the voltage is no longer within 5-12 V. 12 V is the maximum voltage that the cable allows (refer to [Section 9.4.2—9105-CP-ZC38-U-1.8](#) in the specification section). The sync functionality is no longer activated when the voltage is outside the 5-12 V range.

Figure 2.3—Electrical Pulse



3. Installation



WARNING: Performing maintenance or repair on the sensor when circuits (for example: power, water, and air) are energized could result in death or serious injury. Discharge and verify all energized circuits are de-energized in accordance with the customer's safety practices and policies.



CAUTION: Using fasteners that exceed the customer interface depth penetrates the body of the sensor, damages the electronics, and voids the warranty. Refer to [Section 10—Drawings](#) for more information.



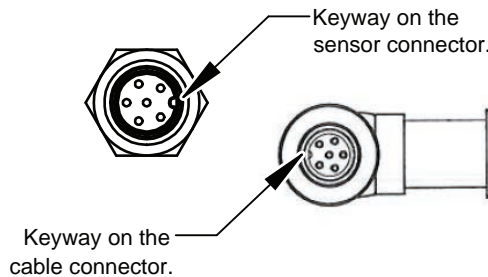
CAUTION: Thread locker applied to fasteners must not be used more than once. Fasteners might become loose and cause equipment damage. Always apply new thread locker when reusing fasteners.



CAUTION: Avoid damage to the sensor from electrostatic discharge. Ensure proper grounding procedures are followed when handling the sensor or cables connected to the sensor. Failure to follow proper grounding procedures could damage the sensor.



CAUTION: Do not apply excessive force to the sensor and cable connector during installation, or damage will occur to the connectors. Align the keyway on the sensor and cable connector during installation to avoid applying excessive force to the connectors.



3.1 Interface Plates

The sensor's mounting side attaches to the robot arm, and the sensor's tool side attaches to the customer tooling. If interface plates are required to adapt the sensor to the robot arm and customer tooling, ATI can supply custom robot mounting and tool interface plates. For technical information on the sensor's mounting features, refer to [Section 10—Drawings](#) of this manual.



CAUTION: Incorrect installation of robot mounting and tool interface plates results in the failure of the F/T sensor to function properly. Because the mounting and tool sides of the sensor have identical bolt patterns, verify the robot mounting and tool interface plates are installed correctly.

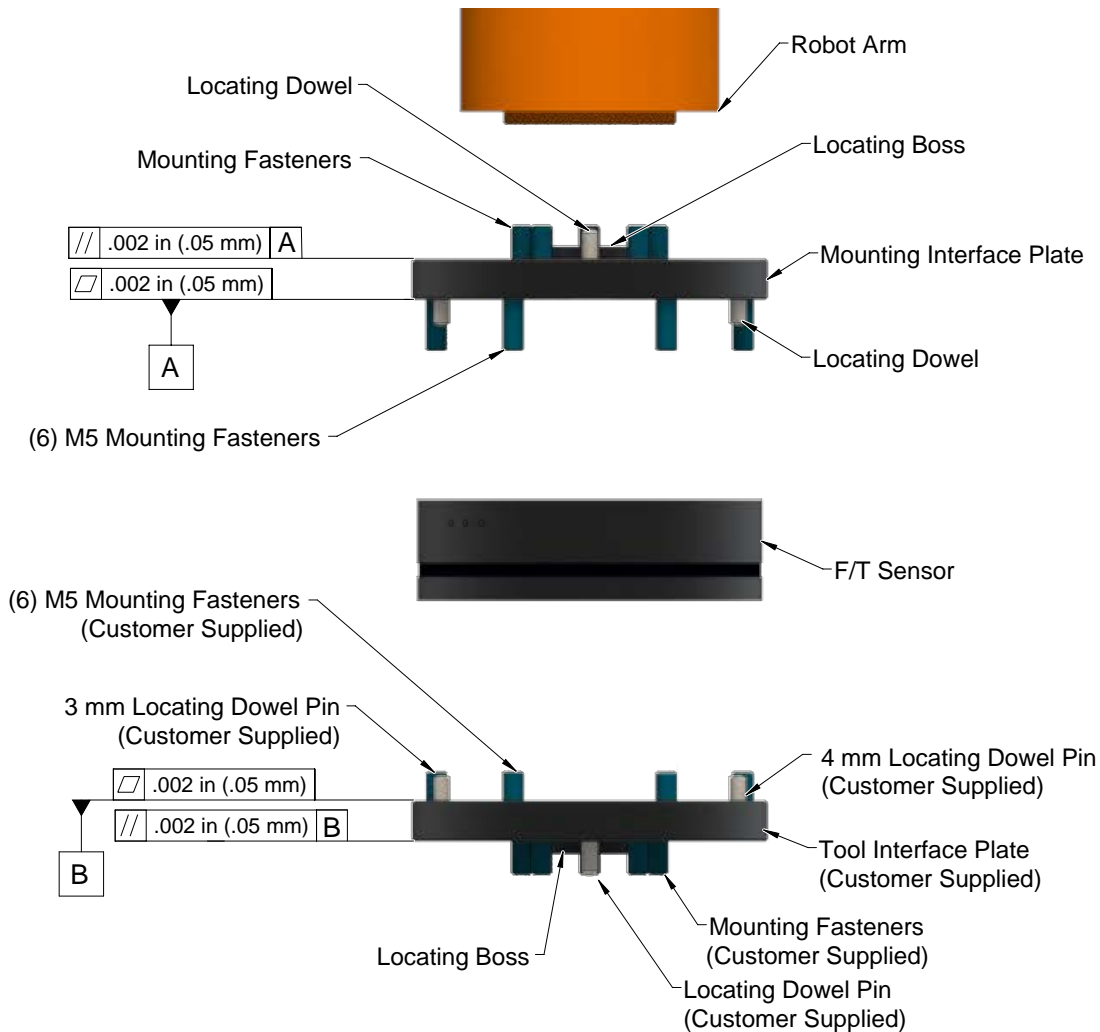


CAUTION: The customer tool should only touch the tool interface plate. If the customer tool touches any other part of the sensor, it will not properly sense loads.

If the customer chooses to design and build an interface plate, consider the following points:

- The interface plate should include bolt holes for mounting fasteners as well as a dowel pin and boss for accurate positioning to the robot or customer’s device.
- The thickness of the interface plate must provide sufficient thread engagement for the mounting fasteners.
- The mounting fasteners should not extend through the sensor’s housing or interfere with the internal electronics. For thread depth, mounting patterns, and other details, refer to [Section 10—Drawings](#).
- Do not use dowel pins that exceed length requirements and prevent the interface plate from mating flush with the robot and customer tooling. Fasteners that exceed length requirements create a gap between the interfacing surfaces and cause damage.
- The interface plate must not distort from the maximum force and torque values that can be applied to the sensor. For these values, refer to [Section 9—Specifications](#).
- The interface plate must provide a flat and parallel mounting surface for the sensor.

Figure 3.1 —Interface Plate(s)

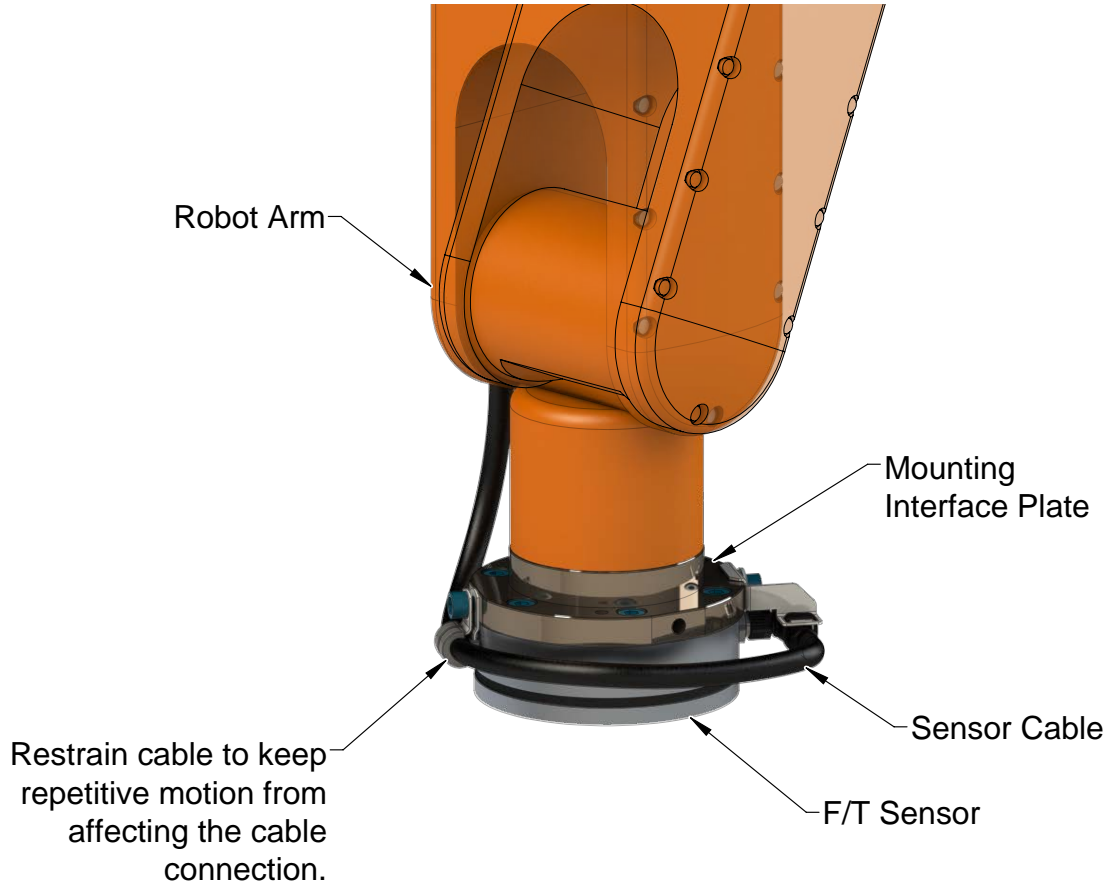


3.2 Routing the Cable

The routing and bending radius of the cable depends upon the customer application. Unlike motionless applications, where the cable is in a static condition, dynamic applications subject the cable to a repetitive motion. For dynamic applications, restrain the cable at a distance that does not expose and damage the sensor's cable connection from the robot's repetitive motion.

NOTICE: The maximum supported cable length is 25 m.

Figure 3.2—Routing of the Sensor Cable

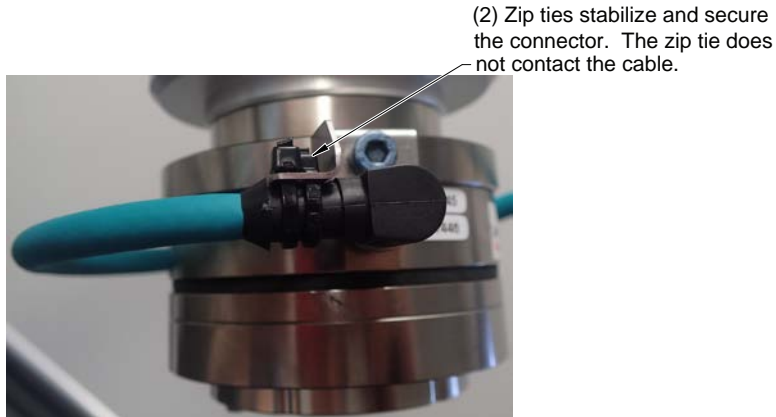




CAUTION: Subjecting the connector to the repetitive motion will cause damage to the connector. Restrain the cable close to the connector so that the repetitive motion of the robot does not interfere with the cable connector.

For added stability, zip ties can be used to secure the cable to a mounting bracket (refer to the following figure). The zip ties should never contact the cable jacket.

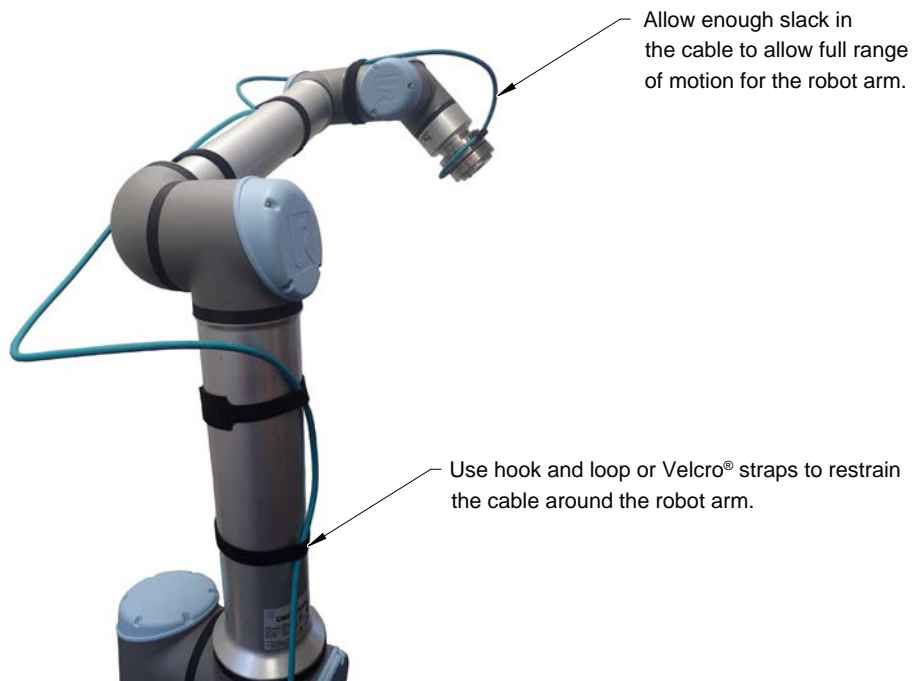
Figure 3.3—Use Zip Ties on the Connector



CAUTION: Improper cable routing may cause injury to personnel, poor functionality of critical electrical lines, or damage to the equipment. The electrical line, especially where attached to the sensor's connector, must be routed to avoid stress failure, sharp bends, or a disconnection from the equipment. Damage to the sensor or cable from improper routing will void the warranty.

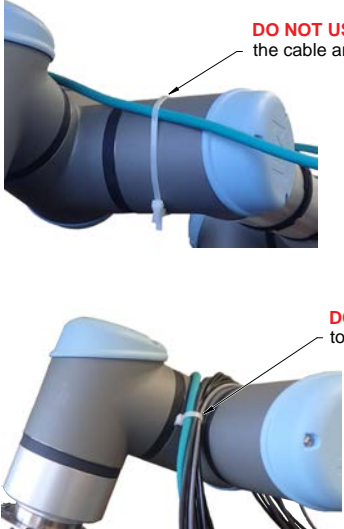
Route the sensor cable so that it is not stressed, pulled, kinked, cut, or otherwise damaged throughout the full range of motion. Affix the cable by using hook and loop straps or Velcro® straps; do not use cable ties or zip ties.

Figure 3.4—Use Hook and Loop or Velcro® Straps on the Cable

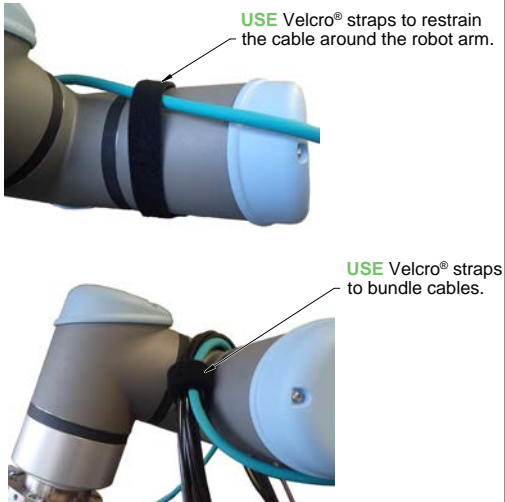


CAUTION: Do not cable ties or zip ties to bundle cables or restrain the cable to the robot arm. Directly affixing cable ties or zip ties to the cable jacket will prevent power and signal communication between the F/T sensor and robot controller. Use hook and loop or Velcro straps on the cable jacket surfaces. Examples of the incorrect and correct methods to restrain or bundle cables are in the following pictures:

INCORRECT



CORRECT



CAUTION: Do not damage or crush the cable by over tightening the straps on the cable.

CAUTION: When routing the cables, do not bend less than the minimum bending radius specified in [Table 3.1](#). A bend radius too small causes the cable to fail from fatigue of the robot’s repetitive motion.

Table 3.1—Sensor Cable Bending Radius and Dynamic Twist Angle

Cable Part Number	Cable Diameter mm (in)	Static Bending Radius (at room temperature)		Dynamic Bending Radius (at room temperature)		Dynamic Cable Twist Angle per Unit Length
		mm	in	mm	in	
		9105-C-ZC33-ZC34-XXX	6.2 (.24)	31	1.3	

Notes:

- Temperature affects cable flexibility. ATI recommends increasing the minimum dynamic bending radius for lower temperatures.

3.3 Installing the Sensor to the Robot

Parts required: Refer to [Figure 3.9](#) and [Section 10—Drawings](#).

Tools required: 4 mm hex key or 4 mm low profile hex key (part of ATI Kit P/N 9105-IP-2126)

Supplies required: Clean rag, Loctite® 242 (if applicable, refer to [step 3](#) and [4](#))

1. Clean the mounting surfaces.
2. Attach the mounting interface plate to the robot arm with the mounting fasteners.

NOTICE: When mounting the sensor to the mounting interface plate, mounting the customer tooling or interface plate to the sensor, consider the following points:

- Screws must have a minimum thread engagement length of 4.5 mm and a maximum thread engagement less than the threaded depth that is listed in the customer drawing [Section 10—Drawings](#).
- Unless otherwise specified, apply Loctite 242 to the (6) M5 socket head cap screws (class 12.9) so that the fasteners secure the sensor to the mounting plate.

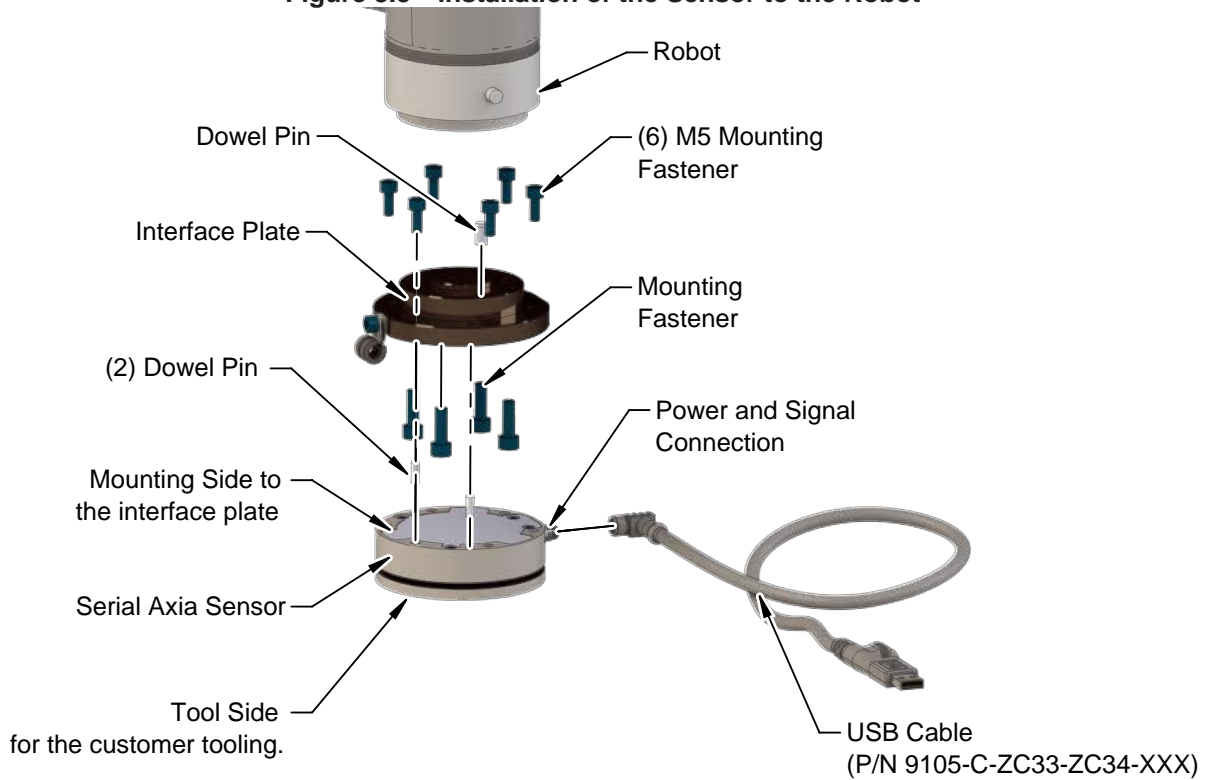
3. Attach the sensor to the mounting interface plate.
 - a. Using a 4 mm hex key, secure the sensor to the mounting interface plate with (6) M5 socket head cap screws (class 12.9). Tighten the fasteners per the specifications in the following table.

Model	Torque
Axia80-M8	52 in-lbs (5.88 Nm)
Axia80-M20	
Axia80-M50	75 in-lbs (8.47 Nm)

4. Once the sensor is installed on the robot, the customer tooling or tool interface plate can be installed.

NOTICE: The tool must not touch any other part of the sensor except the tool side; otherwise, the sensor will not properly detect loads.

Figure 3.5—Installation of the Sensor to the Robot

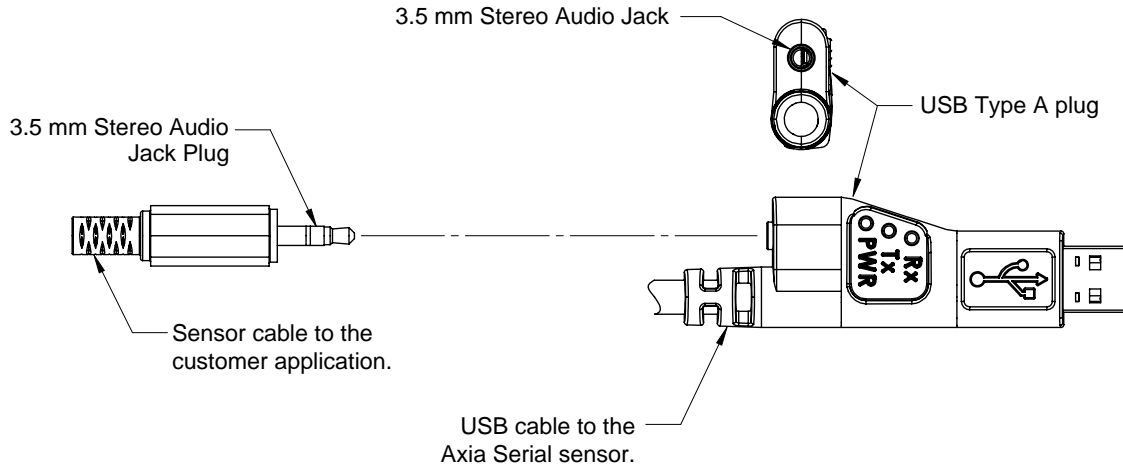


NOTICE: After connecting the cable to the sensor and applying power, the customer can refer to the following sections for monitoring the status of the sensor:

- For the Serial Axia Sensor LED outputs, refer to [Section 4.2—LED Outputs on the Serial Axia Sensor](#).
- For the USB cable LED outputs, refer to [Section 4.3—LED Outputs on the USB Cable, P/N 9105-C-ZC33-ZC34-XXX](#).

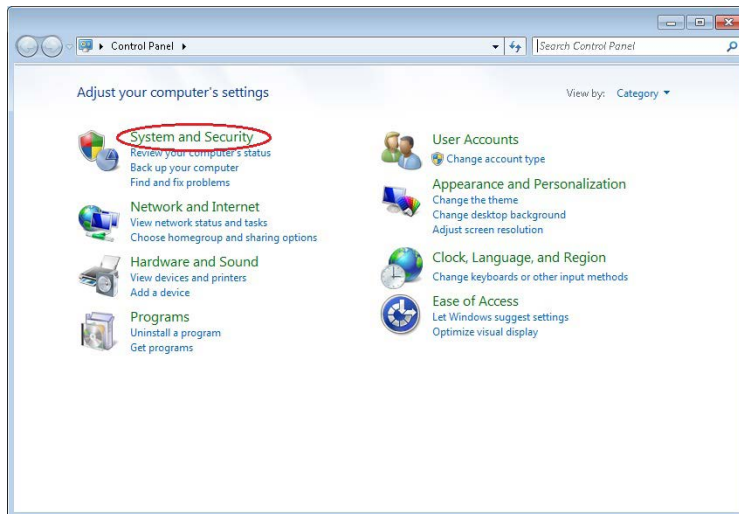
5. Connect the cable(s) to the sensor and customer application. Refer to [Section 3.5—Pin and Wire Assignments for Serial and Power Connection](#).
 - a. Connect the 6-pin female M8 connector on the cable to the sensor's M8 connector. Tighten to 4.43 in-lbs (0.5 Nm).
 - b. Connect the USB type A plug to the customer application.
 - c. If applicable, the user can connect the stereo audio jack plug of a signal cable P/N 9105-CP-ZC38-U-1.8 ([Table 2.1](#)) to the jack in the USB type A plug. (refer to [Figure 3.6](#))
 - d. Then route the cable to the customer connection.

Figure 3.6—Connecting a Stereo Audio Jack Plug on a Signal Cable to the USB type A plug



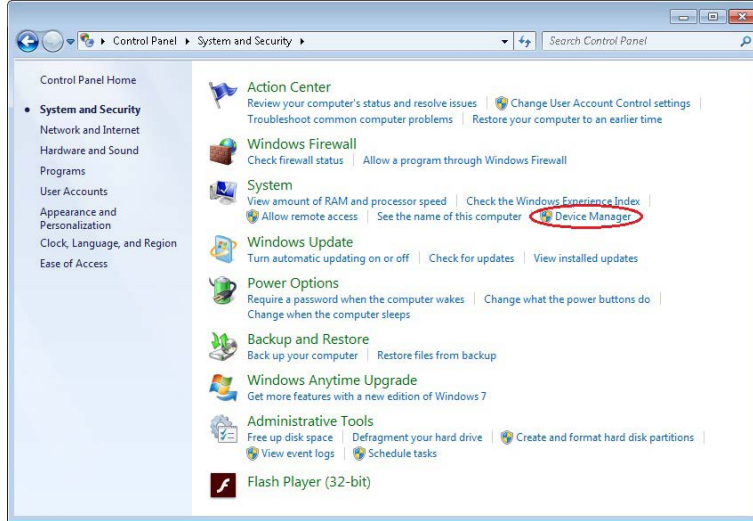
6. After connecting the USB plug to the customer application or computer, the operating system obtains the proper COM port drivers. Wait a few minutes. If the COM port drivers do not install on their own, visit this website for more information: <http://www.ftdichip.com/Support/Documents/InstallGuides.htm>.
7. Verify the installation is complete.
 - a. Select **System Security** on the Control Panel.

Figure 3.7—Control Panel



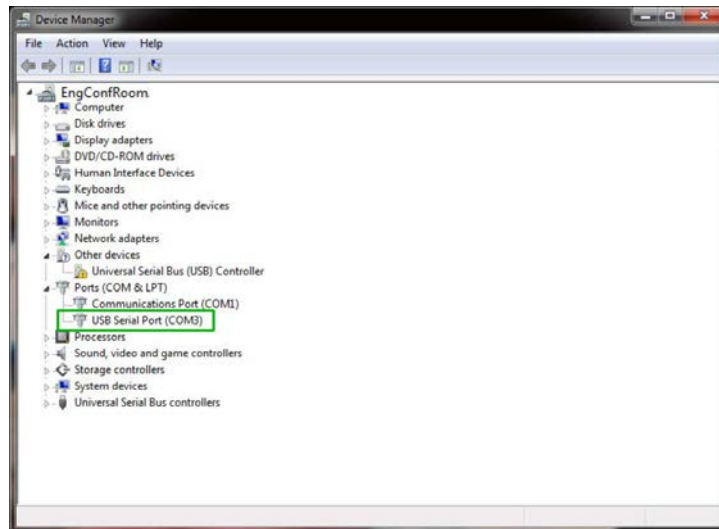
- b. Select **Device Manager** on the System and Security Panel.

Figure 3.8—System and Security Panel



- c. In the Device Manager, under **Ports (COM & LPT)** the Serial Axia sensor is assigned a COM port.

Figure 3.9—Device Manager



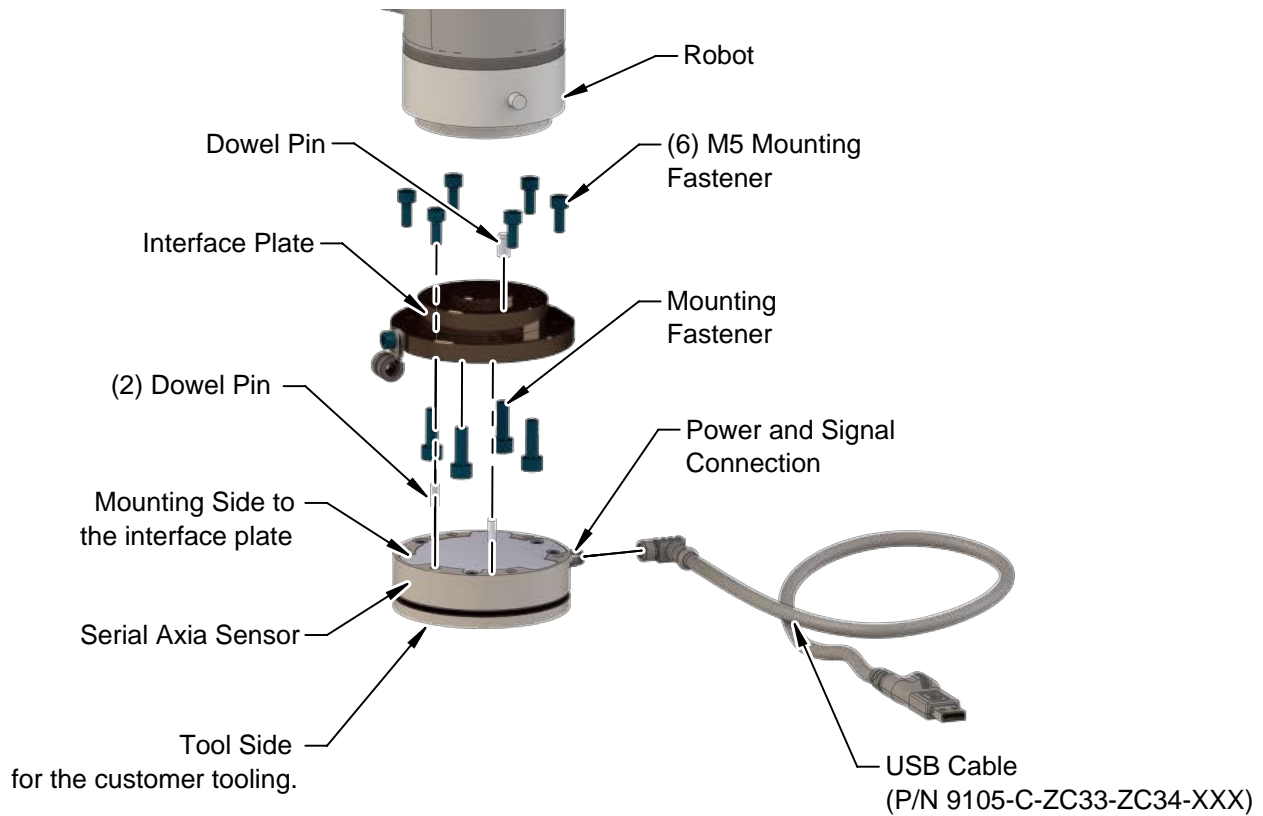
8. To send commands through the USB cable, set up a serial console (refer to [Section 3.6—Setting-Up Communications with the Serial Axia Sensor](#)).
9. Properly restrain and route the cable (refer to [Section 3.2—Routing the Cable](#)).
10. After installation is complete, the sensor is ready for an accuracy check (refer to [Section 3.6—Setting-Up Communications with the Serial Axia Sensor](#)).
11. Safely start normal operation.

3.4 Removing the Sensor from the Robot


Tools required: 4 mm hex key

1. Turn off all energized circuits, for example: electrical.
2. Remove the 6-pin female M8 cable from the sensor's connection.
3. Supporting the customer tooling and/or interface plate, remove the customer supplied screws that attach to the customer tooling to the sensor.
4. Supporting the sensor, use a 4 mm hex key to remove the (6) M5 socket head cap screws that secure to the sensor to the mounting interface plate or robot.
5. Remove the sensor.

Figure 3.10—Remove the Sensor from the Robot



3.5 Pin and Wire Assignments for Serial and Power Connection

	CAUTION: Ensure the cable shield is properly grounded. Improper shielding on the cables can cause communication errors and an inoperative Serial Axia sensor.
---	--

The following section provides the pin assignment for the connector on the Serial Axia sensor and applicable connectors on the cables from [Table 2.1](#). Refer to the following table or [Section 9.2—Electrical Specifications](#) for supply voltage ratings. Refer to [Section 9.4—Cable Specifications](#) for additional cable technical specifications.

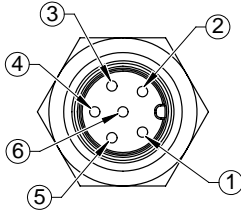
Power Source	Voltage			Power Consumption
	Minimum	Nominal	Maximum	Maximum
DC Power	12 V	24 V	30 V	1.5 W

Notes:

- The power supply input is reverse polarity protected. If the power and ground to the power supply inputs are plugged in reverse, then the reverse polarity protection stops the incorrectly wired supply input from damaging or powering on the sensor.

3.5.1 Pin Assignment for the 6-pin M8 Male Connector on the Sensor

The following table details the signals and corresponding pin numbers on the M8 connector (ZC28) on the Serial Axia sensor.

Connector Schematic	Pin Number	Signal
	1	RS485+
	2	RS485-
	3	CLK_SYNC
	4	Ground (for CLK_SYNC)
	5	V +
	6	V -

3.5.2 Pin Assignment for Cable P/N 9105-CP-ZC38-U-1.8

The following table details the signals and corresponding pin numbers for unterminated wires on cable P/N 9105-CP-ZC38-U-1.8 that connects from the USB cable P/N 9105-C-ZC33-ZC34-XXX to the customer's device.

Wire Jacket Color	Signal
-	Shield
Black	Ground
Red	CLK_SYNC

3.6 Setting-Up Communications with the Serial Axia Sensor

The Serial Axia sensor is a serial device that is used programmatically with the user's application. When the sensor is attached via cable to the customer's personal computer or robot, the computer assigns the sensor a COM port. Then by using a serial console on the computer, the user can communicate with the sensor. Free serial console software, such as PuTTY, is available online. Serial commands are covered in [Section 5—Serial Commands](#) and [Section 6—Serial Axia Sensor “Robot Mode”](#).

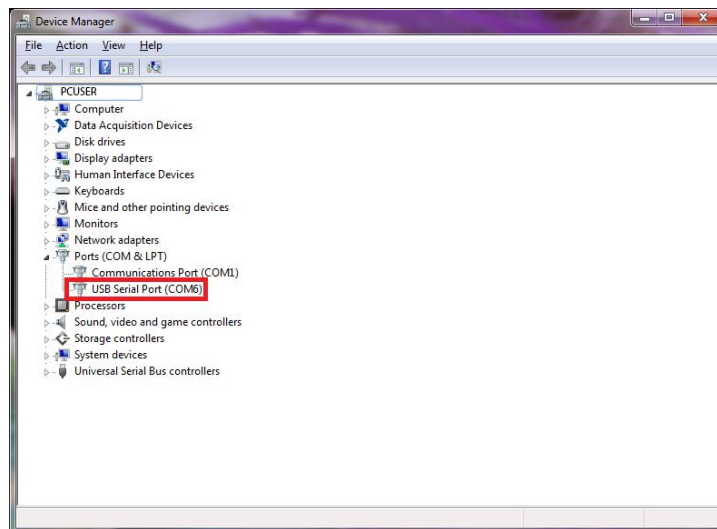
For additional instructions on setting up a serial console like PuTTY, refer to the following procedure:

1. Install the Axia sensor's USB driver.

NOTICE: Depending on the computer and firewall settings, the USB driver may be automatically installed when the sensor cable is installed into the computer's USB port. If not, to access the driver that is used by the Serial Axia USB cable, refer to the following website: <http://www.ftdichip.com/Drivers/VCP.htm>.

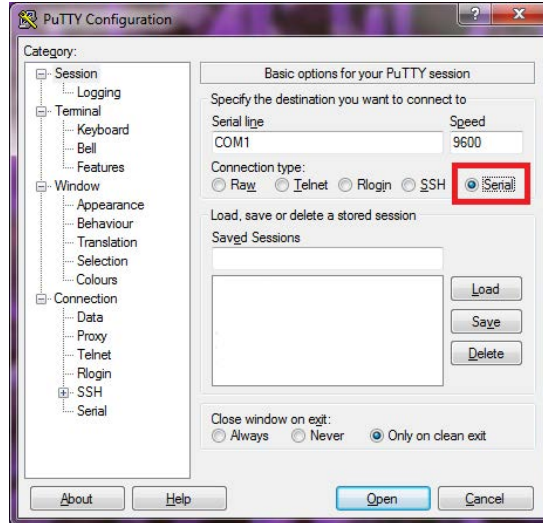
2. Find the COM port that is assigned to the Serial Axia sensor device.
 - In Windows®, from the Control Panel go to the Device Manager > **ports** > **USB Serial Port**. The sensor is assigned **COM6** in the following figure.

Figure 3.11—Device Manager, Port Assignment



3. Open the serial console, for example: PuTTY. A window opens that allows the user to set the configuration for the session.
4. Set the configuration:
 - a. Under **Connection type**: select the radio button for **Serial**.

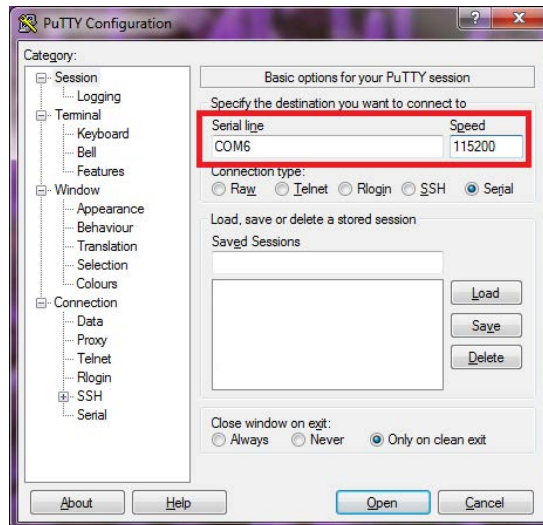
Figure 3.12—Set the Connection Type to Serial



- b. In the **Serial Line** field, enter the assigned COM port from step 2.
- c. In the **Speed** field, enter the default baud rate of 115200 or the baud rate to which the user has set the Serial Axia sensor. Refer to [Section 5.9.11—Baud Rate Command: “set baud”](#) for more information on how to set the baud rate.

NOTICE: If the baud rate that is set on serial console configuration does not match the baud rate set on the Serial Axia sensor, then the console terminal window will open but commands cannot be sent.

Figure 3.13—Set the COM port and the Baud Rate



- d. Select **Open**.

- e. After a terminal window opens, the user can then start entering commands.
- f. After a command is entered from [Section 5—Serial Commands](#) or [Section 6—Serial Axia Sensor “Robot Mode”](#), press the (enter) key to send the command.

NOTICE: Commands which are entered are not case sensitive.

Figure 3.14—PuTTY Terminal Window



3.7 Accuracy Check Procedure

Complete the following procedures after the initial installation of the sensor to the robot and once annually for maintenance.

NOTICE: The mass on the tool side can be the weight of the tooling used in the application.

1. Attach a fixed mass to the tool side of the F/T sensor:
 - a. Remove cables that form bridges between the sensor's mounting and tool sides.
2. Power on the sensor. Allow a 30 minute warm-up time. Minimize external sources of temperature change.
3. Move the robot so that the sensor is in the following positions:
 - a. Record the sensor's output, $F_{x, \text{point } n}$, $F_{y, \text{point } n}$, $F_{z, \text{point } n}$, at each point without biasing.
 - Point 1: +Z up
 - Point 2: +X up
 - Point 3: +Y up
 - Point 4: -X up
 - Point 5: -Y up
 - Point 6: -Z up
4. Calculate $F_{x, \text{average}}$, $F_{y, \text{average}}$, and $F_{z, \text{average}}$:
 - a. Use the following equations, to complete the calculations:

$$F_{x, \text{average}} = \frac{F_{x, \text{point } 1} + F_{x, \text{point } 2} + \dots + F_{x, \text{point } 6}}{6}$$

$$F_{y, \text{average}} = \frac{F_{y, \text{point } 1} + F_{y, \text{point } 2} + \dots + F_{y, \text{point } 6}}{6}$$

$$F_{z, \text{average}} = \frac{F_{z, \text{point } 1} + F_{z, \text{point } 2} + \dots + F_{z, \text{point } 6}}{6}$$

5. For each of the 6 points, complete the following calculation:

$$F_x = F_{x, \text{point } n} - F_{x, \text{average}}$$

$$F_y = F_{y, \text{point } n} - F_{y, \text{average}}$$

$$F_z = F_{z, \text{point } n} - F_{z, \text{average}}$$

$$\text{Tooling Mass} = \sqrt{F_x^2 + F_y^2 + F_z^2}$$

6. The calculated tooling masses for all (6) points should deviate from each other by less than twice the worst accuracy rating of the sensor.
 - For example: the Axia80-M20 sensor's rated accuracy is 2% the range on all axes. For a 500 N F_{xy} range and a 900 N F_z range, the allowable errors of any single data point would be ± 10 N F_{xy} and ± 18 N F_z respectively. Since F_z has the larger tolerance, then one data point could be + 18 N and another data point could be - 18 N, for a total range (max-min) of 36 N error.
 - In addition, the tooling mass should be within 36 N of the results of this test when it was performed with a new sensor.
7. If this test fails, then the sensor should be returned to ATI for diagnosis or recalibration.

4. Operation

The following section provides information required when using the software to operate the Serial Axia sensor.

4.1 Sensor Environment



CAUTION: Damage to the outer jacketing of the sensor cable could enable moisture or water to enter an otherwise sealed sensor. Ensure the cable jacketing has not deteriorated to prevent sensor damage.

NOTICE: Sensors may react to exceptionally strong and changing electromagnetic fields, such as those fields created by magnetic resonance imaging (MRI) machines.

The user must ensure that the dust and water in the environment does not exceed the IP64 rating of the sensor.

4.2 LED Outputs on the Serial Axia Sensor

The sensor provides (3) LED units for Link/Activity (L/A), Diagnostic (DIAG), and Status. Each of these units can be off, red, green, or both red and green (orange).

4.2.1 LED Self-Test Sequence

When the user applies power to the sensor, the sensor completes a self-test, during which the LEDs individually turn on in the following sequence:

Sequence Order	LED	State	Duration
1	All	Off	Approximately one second for each LED.
2	Status	Red	
3	DIAG	Red	
4	L/A	Red	
5	Status	Green	
6	DIAG	Green	
7	L/A	Green	

4.2.2 L/A LED

One LED signals link/activity on the communications port as follows:

LED State	Link	Activity	Condition
Off	No	No	Serial link/activity is not detected.
Green	Yes	Yes	Serial link/activity is detected. The light stays green for 5 seconds after any link activity.

4.2.3 DIAG LED

One LED signals the diagnostic communication status of the Serial Axia sensor interface as follows:

Table 4.3—DIAG LED	
LED State	Description
Red	Indicates an error in the STATUS word (refer to Table 4.8) except the following: 1. The gage temperature is out of range (bit 0). 2. A gage is disconnected (bit 2).
Off	Serial interface is in the state "Operational". No errors are found.

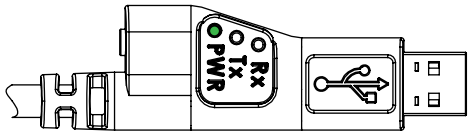
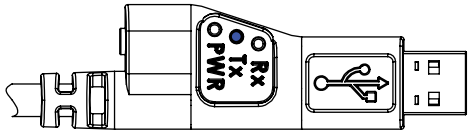
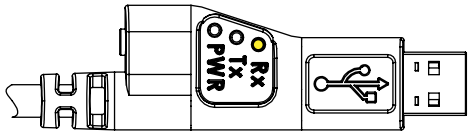
4.2.4 Sensor Status LED

One LED signals the health status of the sensor as follows:

Table 4.4—Sensor Status LED	
LED State	Description
Off	The sensor is powering up and checking STATUS.
Red	Indicates an error in the STATUS word (refer to Table 4.8).
Green	Normal operation. Indicates no error in the STATUS word.
Red/Green (Orange)	Indicates that a F/T axis is out of range.

4.3 LED Outputs on the USB Cable, P/N 9105-C-ZC33-ZC34-XXX

The USB type A plug has (3) LED units for power (PWR), transmitting (Tx), and receiving (Rx). Refer to the following table for the LED status.

Table 4.5—USB Cable Status LED		
Diagram	LED State	Description
	Off	No power is supplied.
	Green	Power is supplied.
	Off	Data is not transmitting to the sensor.
	Blue	Data is transmitting to the sensor.
	Off	The USB port is not receiving data.
	Yellow	The USB port is receiving data.

4.4 Sample Rate

The power-on default sample rate is the rate the user set before removing power. The sample rate is stored to nonvolatile memory. The ADC rate controls the current sample rate. The following table lists the rounded and exact sample rates.

Table 4.6—Sample Rate					
Rounded Sample Rate	0.5 kHz	1 kHz	2 kHz	4 kHz	8 kHz
Exact Sample Rate	488 Hz	976 Hz	1953 Hz	3906 Hz	7912 Hz

4.4.1 Sample Rate Versus Data Rate

The data rate is how fast data can be output over the serial interface.

If the data rate is faster than the sample rate, the customer sees duplicate samples output over the network until the next sample is read internally. A faster data rate could be useful so that the sensor sends data at the same rate that other devices in a customer's system are outputting. For example: if a device on the same application as the Axia is outputting data at 7,000 Hz, the customer may want the Axia to be outputting data to the network at 7,000 Hz as well, even though the sensor is not sampling that quickly internally.

If the sample rate is faster than the data rate, the customer does not receive the data from every internal sample over the network. However, any filters that are enabled work based on the faster internal sample rate, and so the sensor filters out higher frequency noise sources than if the filter is operating at a slower data rate.

4.5 Low-Pass Filter

The power-on default selection is no filtering. The field in controls the current filter selection. The cutoff frequency (for example: -3 dB frequency) is dependent on the sample rate selection, which is defined in [Section 4.4—Sample Rate](#). The cutoff frequencies for the different sampling rates are listed in the following table.

Table 4.7—Low-Pass Filtering					
Selected Filter	-3dB Cutoff Frequency (in Hz)				
	at 488 Hz Sample Rate	at 976 Hz Sample Rate	at 1953 Hz Sample Rate	at 3906 kHz Sample Rate	at 7912 Hz Sample Rate
0	200	350	500	1000	2000
1	58	115	235	460	935.10
2	22	45	90	180	364.04
3	10	21	43	84	169.52
4	5	10	20	40	81.24
5	2.5	5	10	20	39.84
6	1.3	3	5	10	20.31
7	0.6	1.2	2.4	4.7	9.37
8	0.3	0.7	1.4	2.7	5.47

Figure 4.1—Filter Attenuation at 0.5 kHz Sample Rate

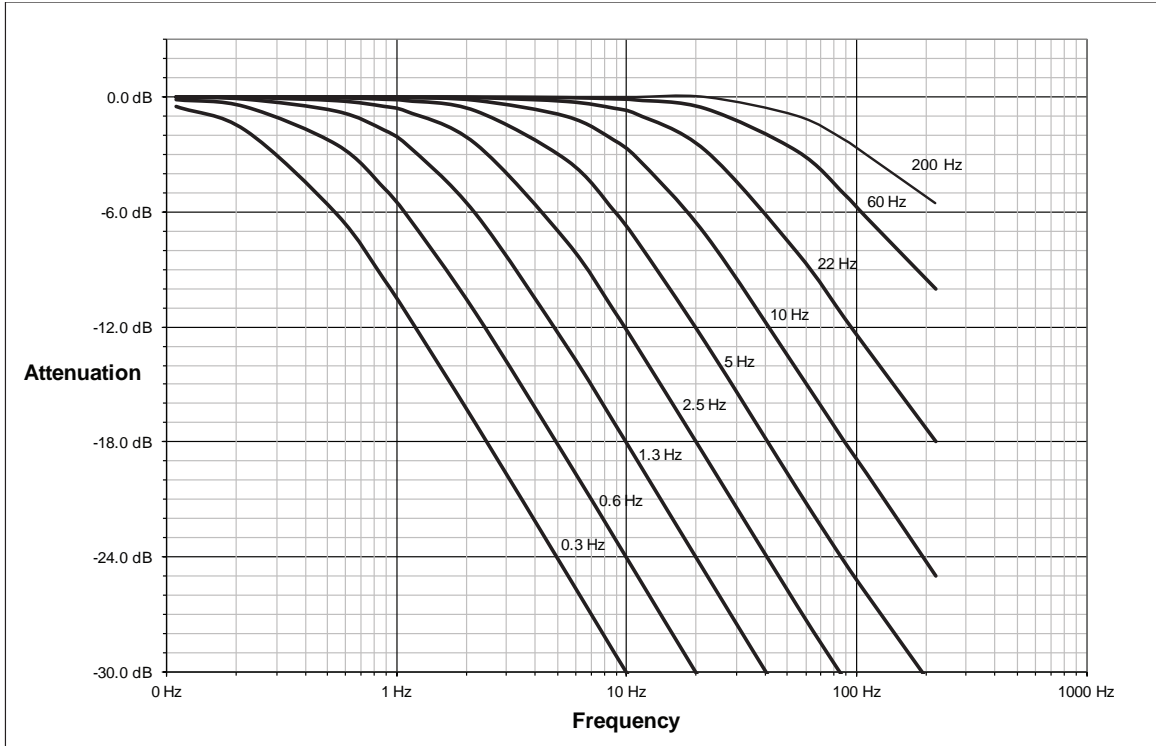


Figure 4.2—Filter Attenuation at 1 kHz Sample Rate

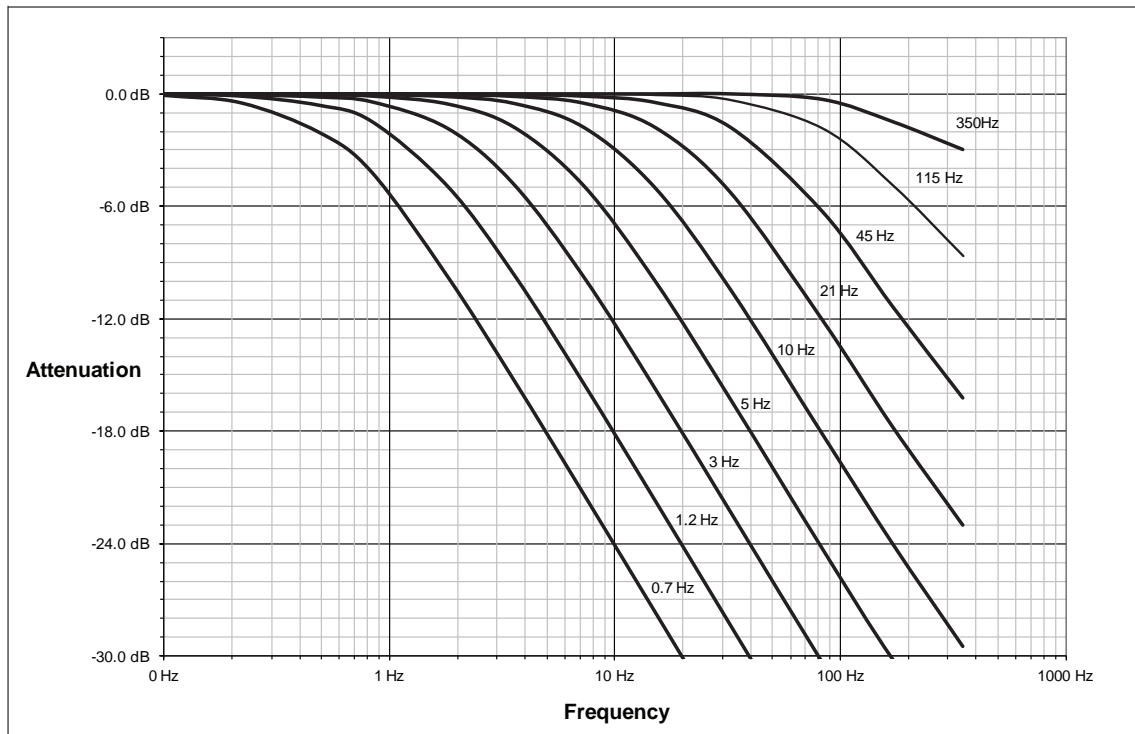


Figure 4.3—Filter Attenuation at 2 kHz Sample Rate

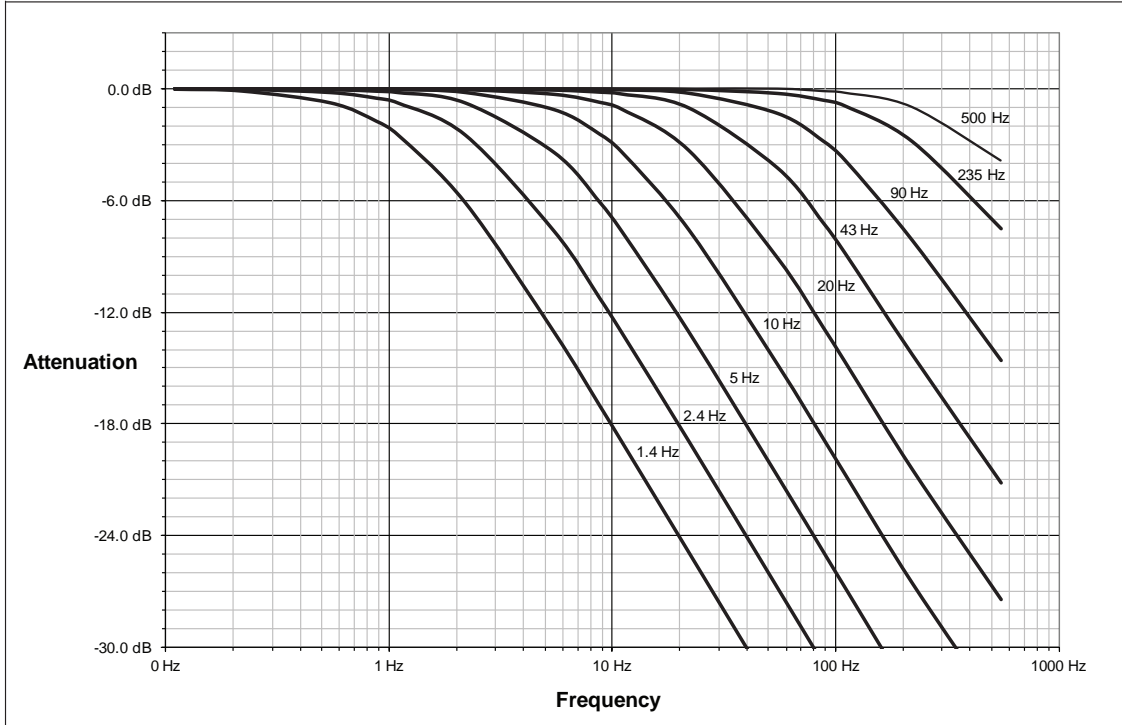


Figure 4.4—Filter Attenuation at 4 kHz Sample Rate

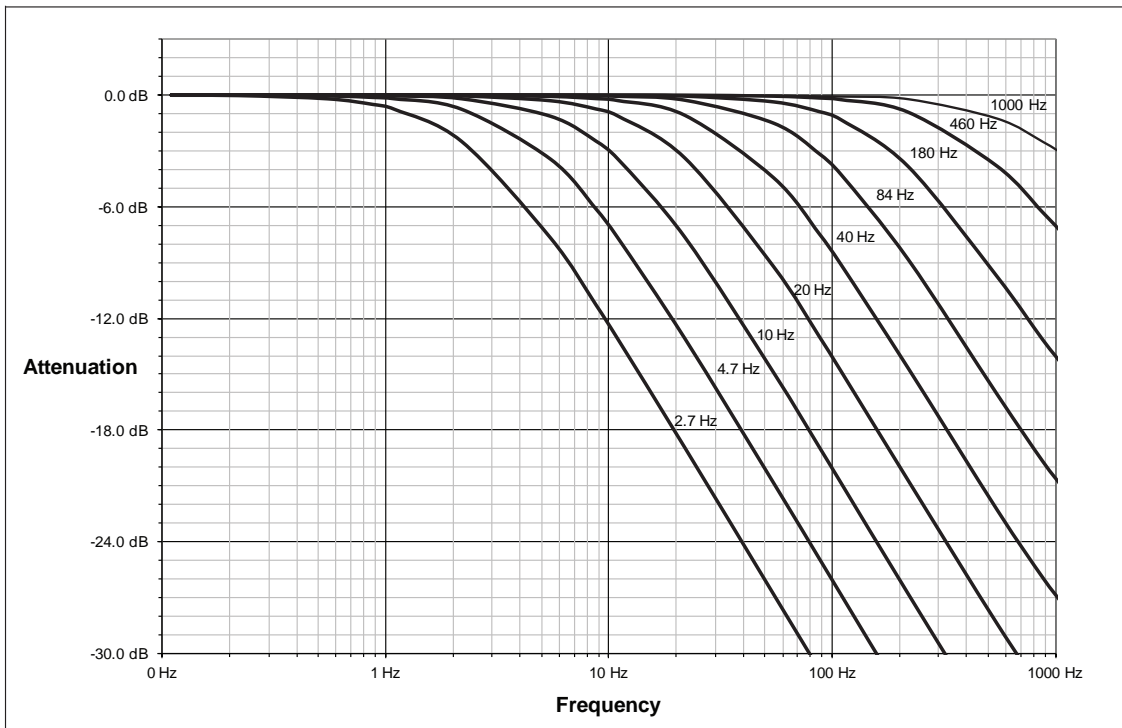
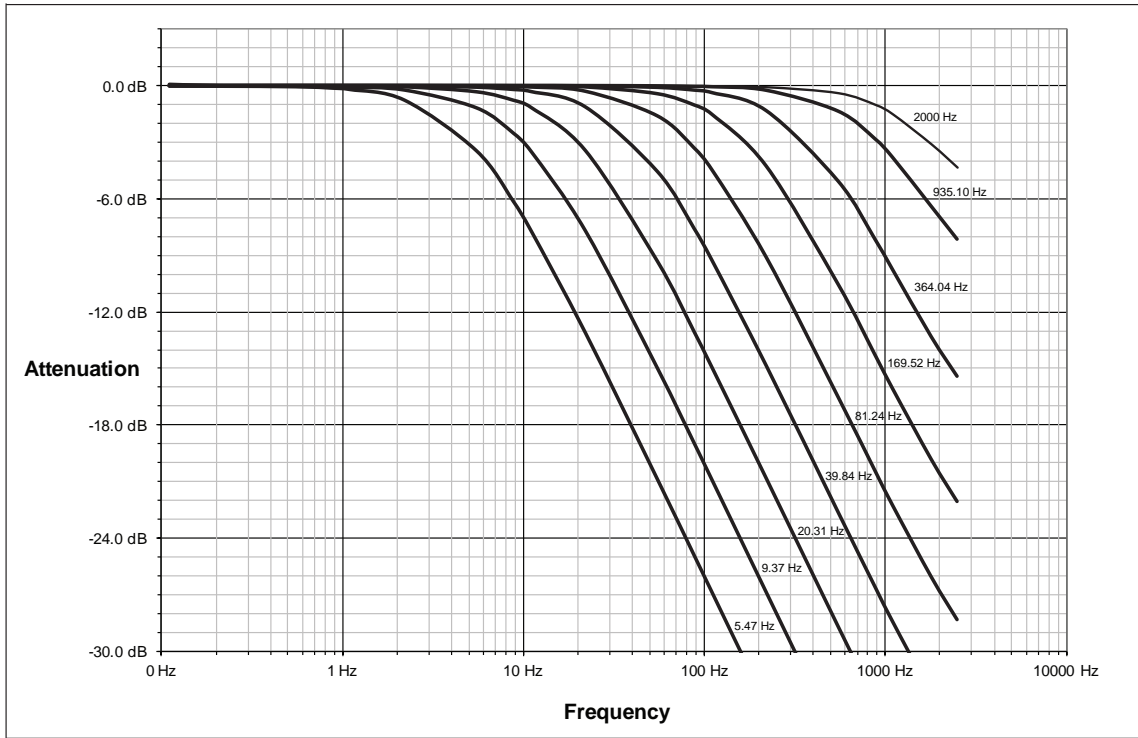


Figure 4.5—Filter Attenuation at 8 kHz Sample Rate



4.6 Bias

Biasing is useful for eliminating the effects of gravity (tool weight) or other acting forces. When the bias function is used, the software collects data for the forces and torques that are currently acting on the sensor and use these readings as a reference for future readings. Future readings will have this reference subtracted from them before they are transmitted.

4.7 Tool Transformation

By default, the forces and torques are reported with respect to a point of origin on the sensor that is set by ATI. Refer to the drawing in for the sensor's point of origin. The tool transformation function allows measurement of the forces and torques at a reference point other than the sensor's point of origin.



CAUTION: If the customer sets a reference point that is at the same location to which a force is applied, there will be no report of a torque applied to the sensor. As a result, the sensor could be overloaded (refer to [Section 4.7.1—Avoid Overloading the Sensor During Tool Transformation](#)). Therefore, when evaluating overloading conditions, use the sensor's point of origin as the reference point.

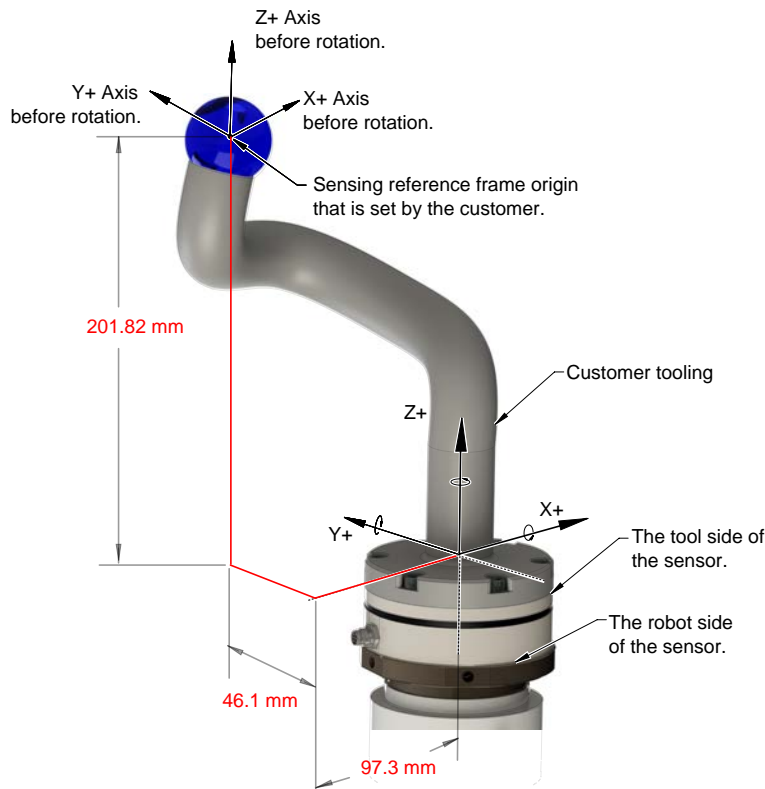
The user defines a reference point by inputting a parameter set that is a series of (3) displacements ($D_x \setminus D_y \setminus D_z$) and (3) rotations ($R_x \setminus R_y \setminus R_z$), for example:

$D_x = -97.3 \text{ mm}$ $D_y = 46.1 \text{ mm}$ $D_z = 201.82 \text{ mm}$ $R_x = +90^\circ \text{ rotation}$ $R_y = +180^\circ \text{ rotation}$ $R_z = 0^\circ \text{ rotation}$

If zeros are entered for any of the parameter set values, the tool transformation is not performed for that particular parameter. Entering zero for all of the parameters, turns the tool transformation feature off. Once a new parameter set is entered and saved, previously entered parameter sets are no longer in effect.

Once a user enters a parameter set, the displacements are performed first. The displacements of the user reference frame of origin from the sensor point of origin is shown in the following figure. In this figure, the user reference frame of origin has not yet rotated relative to the sensor point of origin.

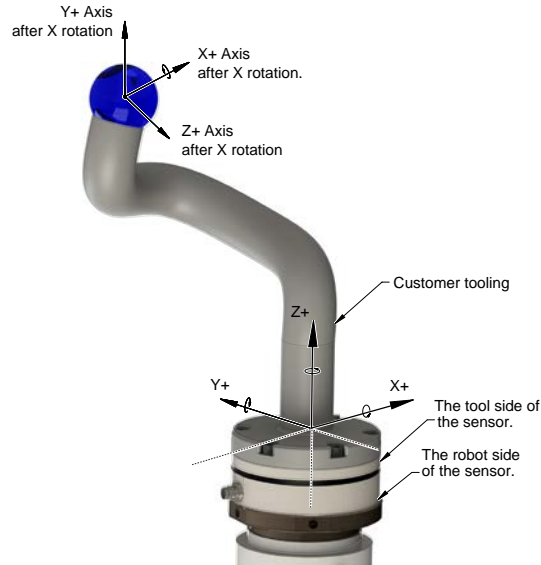
Figure 4.6—Tool Transformation : Distances



After the displacements, the user point of origin rotates in the following order:

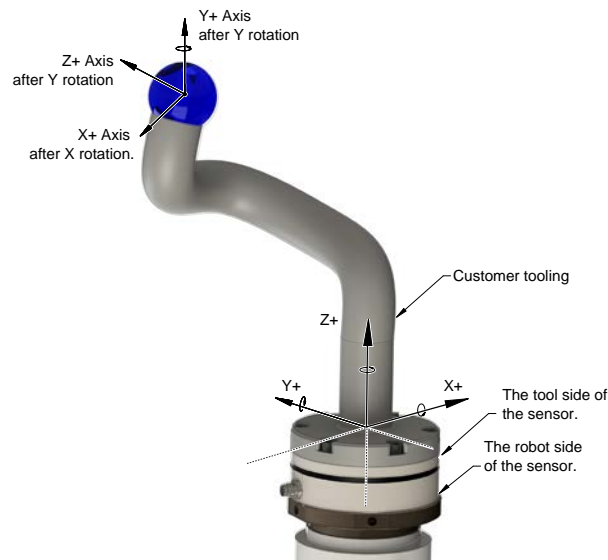
1. The first rotation is about the X-axis.
 - Recall in this example $R_x = +90^\circ$ rotation. The user point of origin rotates $+90^\circ$ about the X-axis, in the following figure.

Figure 4.7—Tool Transformation : Rotation About the X-Axis



2. The second rotation is about the Y-axis of the new user output reference frame.
 - In this example $R_y = +180^\circ$ rotation. The user point of origin rotates $+180^\circ$ about the Y-axis of the new user output reference frame, in the following figure.

Figure 4.8—Tool Transformation: Rotation About the Y-Axis



3. The third and final rotation is about the Z-axis of the new user output reference frame.
 - In this example $R_z = 0^\circ$ rotation. Therefore, the user point of origin does not rotate any more.
- After, the rotations are complete, the final user reference frame of origin is set.

4.7.1 Avoid Overloading the Sensor During Tool Transformation

It is possible for the user to set a reference point of origin that does not detect that a torque is applied to the customer tooling, and by extension, the sensor. Torque is the force multiplied by the distance of that force from a reference point of origin. If the customer reference point of origin is at the same point at which a force is applied, the distance from that force to the customer reference point of origin is zero. Any force that is multiplied by a distance of zero yields zero torque. The software tool transformation reports that no torque is applied to the sensor. However, the sensor's point of origin has not changed, and the force is still applied at a distance from the sensor's point of origin. Therefore, if the customer is evaluating overloading conditions, the customer should use the sensor's point of origin as the reference point.

4.7.2 Tool Transformation Functionality Through a Serial Interface

The user defines a reference point by inputting a parameter set that is a series of (3) displacements ($D_x \setminus D_y \setminus D_z$) and (3) rotations ($R_x \setminus R_y \setminus R_z$). A user can issue tool transformation commands through a serial console interface. For commands that write a parameter set and units in a serial console, refer to [Section 5.9—Write “set” Commands](#).

4.8 Status Code

A bitmap from bit number 0 to 31 for the current condition of the sensor is in the following table. The user can retrieve the status code using the serial commands (refer to [Section 5.3.4—How to Interpret the Output from “!” Specifier](#)).

Table 4.8—Status Code		
Bit Number	Description	Indicates an Error?
0	Internal Temperature Out of Range: This bit is active (high) if the temperature is outside the range -5° to 70°C.	Yes
1	Supply Voltage Out of Range: This bit is active (high) if the input voltage is outside the range of 12 V to 32 V.	Yes
2	Broken Gage: This bit is active (high) whenever the gage reads positive full scale. It self resets 32 sample periods after the condition clears.	Yes
3	Busy Bit. The sensor is performing (1) or more of the following activities that may temporarily affect the F/T data: <ul style="list-style-type: none"> • Committing a change to NVM. • Changing the filter time constant. • Changing the calibration in use. • Changing the ADC sampling rate. • Any ADC ISR overrun. 	No
4	Reserved.	Yes
5	Other error bit. This bit is set whenever an error other than those specified in this table exists.	Yes
6 to 15	Reserved.	Yes
16 to 26	Reserved.	No
27	Gage Out of Range: The bit is set whenever a gage sample is outside of the range gageMinRange to gageMaxRange. This bit stays high for 32 samples after the last such sample so that time abates for the sample’s effect on the data.	Yes
28	Simulated Error. This bit is used to test user error handling.	No
29	Calibration checksum error: This bit is set if the active calibration has an invalid checksum.	Yes
30	Force/Torque Out of Range: This bit is active whenever the force/torque sample is out of range or saturated. This bit stays high for 32 samples after the last such sample so that time abates for the sample’s effect on the data.	Yes
31	Error: This bit is set whenever any status code bit that indicates an error is set.	Yes

4.8.1 Status Code: Sensing Range Exceeded

Bit 30 in [Table 4.8](#) is set when an F/T load is outside the sensor’s detection capability. Bit 30 is set when either of the following conditions are TRUE:

- The total percentage of the calibrated range used by F_{xy} and T_z axes is greater than 105%. Refer to the following F_{xy} T_z equation:

$$\frac{\sqrt{F_X^2 + F_Y^2}}{F_{XY} \text{CalibratedRange}} + \frac{|T_Z|}{T_Z \text{CalibratedRange}} > 105\%$$

- The total percentage of the calibrated range used by F_z and T_{xy} axes is greater than 105%. Refer to the following $F_z T_{xy}$ equation:

$$\frac{|F_z|}{F_z \text{CalibratedRange}} + \frac{\sqrt{T_x^2 + T_y^2}}{T_{XY} \text{CalibratedRange}} > 105\%$$

Refer to [Section 9.3—Calibration Ranges](#) for the calibrated ranges that are used in the preceding equations.

- For Example:

An Axia80-M20 sensor that uses calibration range 0 is subjected to the following loads and has the following calibration ranges:

Table 4.9—Example of Force/Torque Out of Range		
Axis	Applied Load	Calibration Range 0 <i>Table 8.3 Value</i>
F_x	87.5 N	500 N
F_y	-151.6 N	500 N
F_z	-500.0 N	900 N
T_x	1.0 Nm	20 Nm
T_y	2.0 Nm	20 Nm
T_z	-17.5 Nm	20 Nm

The $F_{xy} T_z$ equation simplifies as follows:

$$\frac{\sqrt{(87.5 \text{ N})^2 + (-151.6 \text{ N})^2}}{500 \text{ N}} + \frac{|-17.5 \text{ Nm}|}{20 \text{ Nm}} > 105\%$$

$$\frac{175 \text{ N}}{500 \text{ N}} + \frac{17.5 \text{ Nm}}{20 \text{ Nm}} > 105\%$$

$$35\% + 87.5\% > 105\%$$

$$122.5\% > 105\%$$

The $F_z T_{xy}$ equation simplifies as follows:

$$\frac{|-500 \text{ N}|}{900 \text{ N}} + \frac{\sqrt{(1.0 \text{ Nm})^2 + (2.0 \text{ Nm})^2}}{20 \text{ Nm}} > 105\%$$

$$\frac{500 \text{ N}}{900 \text{ N}} + \frac{1.73 \text{ Nm}}{20 \text{ Nm}} > 105\%$$

$$55.6\% + 8.7\% > 105\%$$

$$64.3\% > 105\%$$

Because the $F_{xy} T_z$ equation simplified to TRUE, bit 30 in [Table 4.8](#) is set.

5. Serial Commands

These serial commands can be used to view the status, parameters, and adjust settings of the sensor. Refer to [Section 3.6—Setting-Up Communications with the Serial Axia Sensor](#) for setting up a serial console.

5.1 Help Command: “h” or “?”

The help command reports a list of the main commands and software version.

“h” command format:

user: h

response:

```
=====
ATI Ethernet Axia F/T Version: 1.0.17 => Feb 21 2018 14:03:20 BL=3
=> Enter most commands without operands to display current status.
=====
BIAS [ON | OFF | <values>] => Control user bias
PEAK => View/set/clear peak values
SET => Print all fields
SET [field-name] => Print matching field(s)
SET [field-name] [value] => Write field with value
VIEW [0 | 1 | A] => View calibrations: 0, 1, or Active
DIAG => Diagnostic status report
SIMERR [ON | OFF] => Control simulated error
RESET => Reset the MCU
STATUS => Print Status Report
SAVEALL => Save all parameters to NVM
C [HD01234567FTXYZMS in any order] => Continuous mode
C 0->7=gages XYZ=Forces/Torques M=Magnitude C=Counts U=Units
C H=Hex D=Decimal F=Force T=Torque '>'=condensed '<'=formatted
C S=checksum #=LineCounter @=ADC_SampleCounter !=StatusWord
C Press multiple keys to exit
S => Single Sample, same format as Continuous mode
=====
```

5.2 Reset Sensor Command: “reset”

The “reset” command resets the MCU.

“reset” command format:

user: reset

response:

BL3I0+I1+C=

=====

RESET due to SoftwareReset

SPI EEPROM 24-bit address => M95M01

SPI EEPROM POST = Good

SPI EEPROM Parameter status: copy 0 Good, copy 1 Good

Entering main loop

ADC reset

=====

ATI Ethernet Axia F/T Version: 1.0.17 => Feb 21 2018 14:03:20 BL=3

=> Enter most commands without operands to display current status.

=====

BIAS [ON | OFF | <values>] => Control user bias

PEAK => View/set/clear peak values

SET => Print all fields

SET [field-name] => Print matching field(s)

SET [field-name] [value] => Write field with value

VIEW [0 | 1 | A] => View calibrations: 0, 1, or Active

DIAG => Diagnostic status report

SIMERR [ON | OFF] => Control simulated error

RESET => Reset the MCU

STATUS => Print Status Report

SAVEALL => Save all parameters to NVM

C [HD01234567FTXYZMS in any order] => Continuous mode

C 0->7=gages XYZ=Forces/Torques M=Magnitude C=Counts U=Units

C H=Hex D=Decimal F=Force T=Torque '>'=condensed '<'=formatted

C S=checksum #=LineCounter @=ADC_SampleCounter !=StatusWord

C Press multiple keys to exit

S => Single Sample, same format as Continuous mode

=====

5.3 Query Commands: “s” or “c”

The query command starts the high-speed data transmission of FT data. The “s” command reports a single line of FT data that is scaled by the counts per force or counts per torque. The “c” command reports continuous lines of FT data that stop when the user holds another key, for example: “enter”, until the output of data ceases. The “c” command reports data at the rate specified in the rdtRate. The data reported by issuing a query command can be adjusted as detailed in the following section.

Query “s” command format:

```
user:      s
response:  > 34.928 N 10.234 N -0.370 N -0.1196 Nm -0.0787 Nm -0.9156 Nm
```

Query “c” command format:

```
user:      c
response:  > 34.946 N 10.277 N -0.398 N -0.1179 Nm -0.0791 Nm -0.9163 Nm
           34.915 N 10.290 N -0.419 N -0.1179 Nm -0.0793 Nm -0.9154 Nm
           34.922 N 10.253 N -0.397 N -0.1185 Nm -0.0783 Nm -0.9159 Nm
           ...
           ...
           ...
```

user: <holds another key such as ‘Enter’ and waits for the data transmission to stop>

No return data.

5.3.1 Converting Counts Per Force/Torque to FT Values

To obtain the real force and torque values, each force value must be divided by the counts per force (cpf) factor, and each torque value must be divided by the counts per torque (cpt) factor. The cpf and cpt factors can be obtained using the “set” command; refer to [Section 5.8—Set Command: “set”](#).

For example: if a calibration reports 1,000,000 counts per N and the F_z reports 4,500,000 counts, then the force applied in the Z axis is 4.5 N.

5.3.2 Secondary Commands for the Query “c” or “s” Command

The type of data reported from the query “c” or “s” command can be adjusted using secondary commands or specifiers. This feature is useful for users who want to develop their own program for storing the data to an external file or view the data in figures such as charts. A list of secondary commands is in [Table 5.1](#).

If a “s” or “c” command is issued without a specifier(s), the specifier(s) from the previous “c” or “s” command is used in the data print out. The power-on default specifier is the following: “FXYZTXYZ”.

Table 5.1—Secondary “c” or “s” Commands		
Category	Secondary Command or Specifier	Notes
Gage number(s).	0	Gage values are printed in counts only. As many as all gage numbers can be reported or as few as a single gage number.
	1	
	2	
	3	
	4	
	5	
	6	
Axis.	x	The user can choose to view force and torque data in the x, y, z axis. The output value can be displayed in F/T counts or engineering units. Counts are converted to units by scaling or dividing the count value by the cpf or cpt. Refer to Section 5.3.1—Converting Counts Per Force/Torque to FT Values .
	y	
	z	
	m	
Force and/or Torque.	f	The XYZM force data is displayed.
	t	The XYZM torque data is displayed.
Magnitude	m	Force or torque data is displayed as the magnitude of the vector components in the x, y, and z axis. The output value can be displayed in F/T counts or engineering units. Counts are converted to units by scaling or dividing the count value by the cpf or cpt. Refer to Section 5.3.1—Converting Counts Per Force/Torque to FT Values .
Counts or Units.	c	The XYZM data is displayed in counts.
	u	The XYZM data is displayed with the selected user units, for example: N or Nm. Units are the default setting.
Numeric System.	h	The data is displayed as a hexadecimal number. Except any data printed in units is always displayed as a decimal number by default.
	d	The data is displayed as a decimal number.
Format.	>	The data is displayed in a formatted human-readable output, for example: lined-up columns. “>” is the default setting.
	<	The data is displayed in a compressed output that has no leading zeros, trailing zeros, or unnecessary blanks. This output is intended for high-speed applications that are used in an automated setting.
Additional inputs to aid in the development of a software program.	s	This command specifies a CRC.
	#	This command specifies a sample counter that is incremented each time that a “c” or “s” line is printed.
	@	This command specifies an ADC read counter that is incremented each time that the ADC is read.
Troubleshooting	!	This command specifies the 32-bit status code. Refer to Section 5.3.4—How to Interpret the Output from “!” Specifier .

5.3.3 Examples of Secondary Commands (Specifiers)

The following are examples of a “c” or “s” command with specifiers:

1. C XTY is interpreted as:

```
user:          s xty
response:      0.001 N      0.0009 Nm
```

- a. The C is a command for reporting continuous lines of data.
 - b. The X specifies printing F_x , because force is the default.
 - c. The T specifies printing torques whenever an x, y, z, or m is seen from now on (on this line).
 - d. The Y specifies printing T_y .
2. C TXY is interpreted as:

```
user:          s txy
response:      0.0009 Nm   0.0009 Nm
```

- a. The C is a command for reporting continuous lines of data.
- b. The T specifies printing torques whenever an x, y, z, or m is seen from now on (on this line).
- c. The X specifies printing T_x .
- d. The Y specifies printing T_y .

3. S D0123 is interpreted as:

```
user:          s d01234567
response:      246123      245592      246707      246029
```

- a. The S is a command for reporting a single line of data.
- b. The D specifies printing raw ADC values in counts decimal.
- c. A number 0 through 7 specifies to print the data for the corresponding gage number. For example, the 0 specifies to print data for gage 0, and the 3 specifies to print data for gage 3.

4. S CDFXYZTXYZ is interpreted as:

```
user:          s cdfxyztxyz
response:      961      959      963      960      966      965
```

- a. The S is a command for reporting a single line of data.
- b. The C and D specifies printing x, y, z, or m FT data in counts decimal.
- c. The F specifies printing torques whenever an X, Y, Z, or M is seen from now on (on this line).
- d. The T specifies printing the torques whenever an X, Y, Z, or M is seen from now on (on this line).

5.3.4 How to Interpret the Output from “!” Specifier

The output from “!” specifier reports an output in hexadecimal that must be converted to a 32-bit binary number that correlates to a status code from [Table 4.8](#). Refer to the following table for an example of bit patterns:

Table 5.2—Bit Pattern Examples		
Bit Number	Simple Description Refer to Table 4.8 .	Bit Pattern
0	Temperature	0x80000001
1	Supply voltage	0x80000002
2	Broken gage	0x80000004
3	Busy bit	0x80000008
4	Reserved	N/A
5	Other	0x80000020
6 to 15	Reserved	N/A
16 to 26		
27	Gage out of range	0x88000000
28	Simulated error	0x10000000
29	Calibration checksum error	0xA0000000
30	F/T out of range	0xC0000000
31	Any error	0x80000000
--	Healthy	0x00000000

The bit pattern can be different, if there is more than one error present.

For example:

user: s !

response: 80000005

Using a free online calculator, the user can convert the hexadecimal number to a binary number:

Hex	8	0	0	0	0	0	0	5
Binary	1000	0000	0000	0000	0000	0000	0000	0101

The binary number has 32-bits total. The least significant bit is on the right end of the following table. “1” means the bit is on. “0” means the bit is off.

Binary Number	1	0	0	0	0	000	0000	0000	0000	0000	00	0	0	0	1	0	1
Bit Position	31	30	29	28	27	26 to 6						5	4	3	2	1	0

So in this example, bit number 0, 2 and 31 are on. According to the preceding table, the sensor has a “temperature”, “broken gage error”, and “any error” status codes. Refer to [Table 4.8](#) for more information.

5.4 Bias Command: “bias”

The “bias” command reports the current bias status of the sensor.

“bias” command format:

user: bias

response: BIAS OFF

In this case, the command reports the status that the bias feature is off.

5.4.1 Secondary Bias Commands: “on”, “off”, “[values]”

The secondary commands allow the user to turn the bias feature on and off. Turning the feature on, sets the FT output to 0. Turning the feature off, clears the bias bit. Also, the user can bias the sensor with user determined values.

“bias” command format for turning the feature “on” or “off”:

user: bias on

response: BIAS ON

“bias” command format for turning the feature on with values that are determined by the user:

user: bias [values]

response: BIAS

5.5 Peak Command: “peak”

The “peak” command reports the highest and lowest values of $F_x \setminus F_y \setminus F_z \setminus T_x \setminus T_y \setminus T_z$ that occurred for a run-time and for all-time, since the last “reset” or “peak reset” command was issued.

“peak” command format:

user: peak

response:	F/T	Units	RunPeak-	RunPeak+	AllPeak-	AllPeak+
	---	-----	-----	-----	-----	-----
	Fx	N	34.205	35.264	-750.000	750.000
	Fy	N	7.573	10.596	-750.000	750.000
	Fz	N	-4.591	3.248	-1350.000	1350.000
	Tx	Nm	-0.157	0.071	-30.000	30.000
	Ty	Nm	-0.138	-0.042	-30.000	30.000
	Tz	Nm	-0.952	-0.890	-30.000	30.000

5.6 Peak Reset Command: “peak reset”

The highest and lowest values of $F_x \setminus F_y \setminus F_z \setminus T_x \setminus T_y \setminus T_z$ that occurred for a run-time and all-time can be set to the following values by using the “peak reset” command.

“peak reset” command format:

```

user:      peak reset
response:  F/T    Units  RunPeak-  RunPeak+  AllPeak-  AllPeak+
          ---    -
          Fx     N      2147.484 -2147.484  -750.000   750.000
          Fy     N      2147.484 -2147.484  -750.000   750.000
          Fz     N      2147.484 -2147.484 -1350.000  1350.000
          Tx     Nm     2147.484 -2147.484  -30.000    30.000
          Ty     Nm     2147.484 -2147.484  -30.000    30.000
          Tz     Nm     2147.484 -2147.484  -30.000    30.000
  
```

5.7 Save All Command: “saveall”

The “saveall” command records all values that remain through a power cycle to NVM.

“saveall” command format:

```

user:      saveall
response:  Parameters saved to NVM bank 0
           Parameters saved to NVM bank 1
  
```

5.8 Set Command: “set”

The “set” command reports all parameters. In some cases, the user can also write these parameters. These parameters are listed in [Table 5.3](#).

“set” command format:

```

user:      set
response:  Field                               Value
          -----
          serialNum                           FT22835
          partNum                             SI-500-20
          calFamily                           NET
          ...
  
```

To read a stored parameter in NVM for a field from [Table 5.3](#), enter “set [field]”.

For example:

```

user:      set cpf
response:  Field                               Value
          -----
          cpf                                  100000
  
```


Table 5.3—"set" Fields					
Field	Long Name	User Read/Write	Description	Example Contents	Type
serialNum	FT Serial	Read	The FT serial number	FT001234	STRING(8)
partNum	Calibration Part Number		The calibration part number	Num-4	STRING(30)
calFamily	Calibration Family		The field always reads "NET".	NET	STRING(8)
calTime	Calibration Time		The date and time the sensor was calibrated.	1970-01-01 00:00	STRING(30)
max0	Max F _x Counts	Read	The maximum rated value for this axis, in F/T counts.	214748647	32-bit unsigned integer
max1	Max F _y Counts				
max2	Max F _z Counts				
max3	Max T _x Counts				
max4	Max T _y Counts				
max5	Max T _z Counts				
forceUnits	Force Units	Read	Force units: 0 = Lbf 1 = N 2 = Klbf 3 = kN 4 = Kg	1	8-bit unsigned integer
torqueUnits	Torque Units		Torque units: 0 = Lbf-in 1 = Lbf-ft 2 = Nm 3 = Nmm 4 = Kg-cm 5 = kN-m	2	
cpf	Counts per Force	Read	Calibration counts per force unit.	1000000	32-bit unsigned integer
cpt	Counts per Torque		Calibration counts per torque unit.		
peakPos0	PeakLoadsPosF _x		All-time peak positive force/torque loads that are in F/T counts.	2395927	
peakPos1	PeakLoadsPosF _y			624574	
peakPos2	PeakLoadsPosF _z			0	
peakPos3	PeakLoadsPosT _z			0	
peakPos4	PeakLoadsPosT _y			159210	
peakPos5	PeakLoadsPosT _x	74910			

Table 5.3—"set" Fields					
Field	Long Name	User Read/Write	Description	Example Contents	Type
peakNeg0	PeakLoadsNegF _x	Read	All-time peak negative force/ torque loads that are in F/T counts.	-988570	32-bit unsigned integer
peakNeg1	PeakLoadsNegF _y			-2099525	
peakNeg2	PeakLoadsNegF _z			-91487584	
peakNeg3	PeakLoadsNegT _x			-48751	
peakNeg4	PeakLoadsNegT _y			-12854	
peakNeg5	PeakLoadsNegT _z			0	
sensorHwVer	N/A	Read	The version of the sensor hardware	0	16-bit integer
adcRate	N/A	Read and Write	The ADC update rate in Hz. The ADC rate must be one of the following in units of Hz: 488 976 1953 3906 7812	976	16-bit integer
rdtRate			The RDT transmission rate in units of Hz. The RDT transmission rate must be 1 to the adcRate.	40	
rdtSize			The number of RDT records to include in each UDP packet that is transmitted.		
filTc	N/A	Read and Write	The IIR filter shift value.	0	8-bit integer
calib			The calibration to use: 0 or 1 This bit controls which of the two sets of calibrations are displayed in the preceding fields.	0	

Table 5.3—"set" Fields						
Field	Long Name	User Read/Write	Description	Example Contents	Type	
location	N/A	Read and Write	Display the physical location of the sensor.	Alex's Bench	String(40)	
serNum	N/A	Read	The serial number	Serial number	String(100)	
hwProdCode			The hardware product code	HW Product Code	String(20)	
hwRev			The hardware revision number	0	16-bit integer	
ttdu	N/A	Read and Write	Tool transformation distance units: 0 = in 1 = ft 2 = mm 3 = cm 4 = m	0	8-bit integer	
ttau			Tool transformation angle units: 0 = degrees 1 = radians			
ttdx			D_x		Tool transform distances	float
ttdy			D_y			
ttdz			D_z			
ttrx			R_x		Tool transform rotation angles	
ttry			R_y			
ttrz			R_z			
baud	N/A	Read and Write	UART baud rate. Must be in range from 300 baud to 3M baud. Any baud rate change is temporary until a SAVEALL command is issued.	115200	32-bit integer	
msg			Unprompted error messages: 1 = print unprompted messages 0 = do not print unprompted messages	0	8-bit integer	

5.9 Write “set” Commands

A secondary “set” command allows the user to write or edit the stored parameter in a certain field in [Table 5.3](#). All write commands are temporary until a “saveall” command is issued. When a “saveall” command is given, the parameter is stored in NVM.

5.9.1 Message Command: “set msg”

The user can change the unprompted error messages that are reported, where:

- [1] prints unprompted messages.
- [0] does not print unprompted messages.

“set msg” read and write command format, for example:

```
user:      set msg
response:  Field      Value
          -----
          msg        1
user:      set msg 0
response:  msg was 1 now 0
```

5.9.2 RDT Sample Rate Command: “set rdtRate”

The user can set the RDT sampling rate by entering a value in the range of 1 to the ADC rate value.

“set rdtrate” sample rate read and write command format, for example:

```
user:      set rdtRate
response:  Field      Value
          -----
          rdtRate     976
user:      set rdtRate 800
response:  rdtRate was 976 now 800
```

5.9.3 ADC Sample Rate Command: “set adcRate”

The user can set the ADC sampling rate with a value that is listed in [Table 4.6](#).

“set adcRate” read and write command format, for example:

```
user:      set adcrate
response:  Field      Value
          -----
          adcRate     976
user:      set adcrate 7812
response:  adcRate was 976 now 7812
```

5.9.4 Filtering Level Command: “set filTc”

The user can set the filtering level with a value that is listed in [Table 4.7](#).

“set filTc” read and write command format, for example:

```
user:      set filTc
response:  Field          Value
           -----
                   filTc          0

user:      set filTc 1
response:  filTc was 0 now 1
```

5.9.5 Calibration Range Command: “set calib”

The user can set the calibration range, where:

0 = Calibration Range 0.

1 = Calibration Range 1.

The values within the ranges are listed in [Table 8.3](#).

“set calib” read and write command format, for example:

```
user:      set calib
response:  Field          Value
           -----
                   CALIB          0

user:      set calib 1
response:  calib was 0 now 1
```

5.9.6 Sensor Location Command: “set location”

The user can write the physical location of the sensor. If the location contains whitespace, then the parameter must be in quotes.

“set location” read and write command format, for example:

```
user:      set location
response:  Field          Value
           -----
                   Location      robot 1

user:      set location “robot in lab”
response:  location was robot 1 now robot in lab
```

5.9.7 Tool Transform Distance Units Command: “set ttdu”

The user can set the units for the tool transformation distance, where:

- 0 = in.
- 1 = ft.
- 2 = mm.
- 3 = cm.
- 4 = m.

“set ttdu” read and write command format, for example:

```
user:      set ttdu
response:  Field      Value
          -----
          ttdu      1
user:      set ttdu 0
response:  ttdu was 1 now 0
```

5.9.8 Tool Transform Angle Units Command: “set ttau”

The user can set the units for the tool transformation angle, where:

- 0 = degrees.
- 1 = radians.

“set ttau” read and write command format, for example:

```
user:      set ttau
response:  Field      Value
          -----
          ttau      0
user:      set ttau 1
response:  ttau was 0 now 1
```

5.9.9 Tool Transform Distances Command: “set ttdx”, “set ttdy”, “set ttdz”

The user can write or edit the tool transform distances.

The following is an example of the read and write command format:

```
user:      set ttdx
response:  Field      Value
          -----
          ttdx      0
user:      set ttdx 100
response:  ttdx was 0 now 100
```

5.9.10 Tool Transform Rotation Angles Command: “set ttrx”, “set ttry”, “set ttrz”

The user can write or edit the tool transform rotation angles.

The following is an example of the read and write command format:

```
user:      set ttrx
response:  Field      Value
           -----
           ttrx      0

user:      set ttrx 30
response:  ttrx was 0 now 30
```

5.9.11 Baud Rate Command: “set baud”

The user can set the baud rate of the sensor. The baud rate must be a value from 300 to 3000000.

“set baud” read and write command format:

```
user:      set baud
response:  Field      Value
           -----
           baud      115200

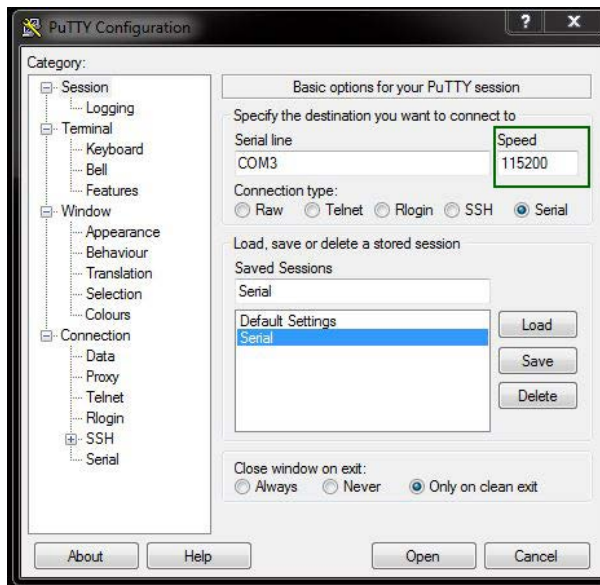
user:      set baud 300
response:  baud was 115200 now 300
```

Changing the RS-485 baud rate to 300 now!

Make sure you change your console baud rate to match.

The response to change your console baud rate to match refers to the “speed” field in [Figure 5.1](#), which shows PuTTY but may be different if another serial console is used.

Figure 5.1—Changing the Speed to Match the “set baud” Rate



5.10 Simulated Error Command: “simerr”

The “simerr” command refers to bit 28 from [Table 4.8](#). The command can be issued to view status of bit 28 or turn bit 28 on or off. The simulated error command is useful for customers, who need to test their error-handling routines. When a simulated error occurs, the “red” status LED turns on; refer to [Section 4.2.4—Sensor Status LED](#).

“simerr” read command format, for example:

```
user:      simerr
response:  SIMERR ON
```

“simerr” write command format, for example:

```
user:      simerr off
response:  SIMERR OFF
```

5.11 View Calibration Command: “view”

The view calibration command reports properties such as F/T part number, units, calibration date, calibration family of a certain calibration or multiple calibrations. The view command can be used in conjunction with a second operand, where:

- 0 = Calibration 0
- 1 = Calibration 1
- A = Active Calibration
- (No Operand) = All Calibrations

“view” command format, for example:

```
user:      view 0
response:  Field                Contents
          -----
          CalSlot                0
          serialNum              FT22835
          partNum                SI-500-20
          calFamily              NET
          calTime                 2/6/2018
          forceUnits              N
          torqueUnits             Nm
```


5.12 Diagnostic Status Command: “diag”

The diagnostic status command provides a report for each of the gages within the sensor. The information can be compared to the values in [Section 9.3—Calibration Ranges](#). Use the [Section 5.13—Status Command: “status”](#), for troubleshooting.

“diag” command format:

```

user:      diag
response:  Gage  Counts Axis Units      F/T  AllPeak-  AllPeak+  ToolTransform
          -----
          0    -254360 Fx   N    34.972  -750.000  750.000  Dx  0.000 in
          1      89944 Fy   N    10.240  -750.000  750.000  Dy  0.000 in
          2    360233 Fz   N     2.530 -1350.000 1350.000  Dz  0.000 in
          3    398749 Tx   Nm   -0.118  -30.000   30.000  Rx  0.000 deg
          4    176726 Ty   Nm   -0.081  -30.000   30.000  Ry  0.000 deg
          5    156030 Tz   Nm   -0.909  -30.000   30.000  Rz  0.000 deg
          6    -1386148 24.5 *C
          7    6293685 39.1 *C
    
```

5.13 Status Command: “status”

If there could be an underlying problem within the sensor hardware, the “status” command can be used to retrieve detailed information or for the user to send the information to ATI for troubleshooting.

“status” command format (the content may vary among sensors):

```
user:      status
response:  NVM-Image-0 Good 529 K bytes ==
NVM-Image-1 Good 529 K bytes ==
SPI-Param-0 Good 1164 bytes
SPI-Param-1 Good 1164 bytes
RAM-Param Good 1164 bytes
UART ---- 115.4 KHz RX faults: 1
SPI-ADC ---- 14.0 MHz
SPI-EEPROM ---- 14.0 MHz
MCU-Clock Good 168.0 MHz
MCU-Part Good PIC32MZ2048EFH064 A1 S/N: 7fedd880 39c4fb9a
MCU-FPU ---- ID=a7 REV=32 UFRP=1 FC=1 HAS08=1 F64=1 L=1 W=1 3D=0 PS=0 D=1 S=1
FS=1 FO=0 FN=0 MAC=0 ABS=1 NAN=1 RM=0
MCU-WatchDg Good Timeout = 62.500 ms Windowed = Off
MCU-RCON Good BrownOutReset PowerOnReset
MCU-Supply Good 15.3 V
MCU-Regs Good
MCU-PC Good
MCU-RAM ---- 512 K bytes Errors: 0
MCU-GPIO Good
PCB-Temp Good 39.7 *C
Gage-Temp Good 25.2 *C
ADC-Gages Good Spikes: 0
ADC-RegWr Good Rate= 976 Hz Resets=1
ADC-Intrpt Good ISR overruns: 0 CRC errors: 0
PHY-State Good ISR overruns: 0
EEPROM Good Retries: 0
MonTime Good Max: 694 uS
Stack Good 393868 bytes available of 395632 bytes allocated
Host Good Name: AXIAETHERNET IP: 0.0.0.0 Gateway: 0.0.0.0 MAC:
00:16:bd:00:22:1e
```

6. Serial Axia Sensor “Robot Mode”

When in “robot mode” the Serial Axia sensor is able to complete these following actions:

- enter and exit “robot mode”
- print a single reading or continuous reading of FT values
- print the counts per force and counts per torque

In addition to the preceding basic commands, the Serial Axia sensor is able to complete the following, more advanced actions:

- set either 16-bit or 32-bit output values
- set the ADC sample rate
- set the IIR filter shift value
- set the calibration value
- view the current output bit or calibration value
- bias FT data

Refer to the following sections for an explanation of each command for entering and exiting “robot mode” and commands for obtaining and manipulating FT data. For instructions on setting up a serial console, refer to [Section 3.6—Setting-Up Communications with the Serial Axia Sensor](#).

NOTICE: After the user has entered “robot mode”, do not press the (enter) key after issuing a command. As soon as the user types the character, for example “r”, the software recognizes the input command and outputs data. The console does not echo or show the command the user has entered.

6.1 Enter and Exit “Robot Mode”: “m” command

To enter or leave “robot mode”, the sensor must first be attached via a USB cable to a serial port on a personal computer. After opening up the serial console, enter “robot mode” by typing the character “m”. Then the sensor can be installed on the robot. Refer to [Section 3.3—Installing the Sensor to the Robot](#). For example:

<the user enters “m”>

response: Parameters saved to NVM bank 0
Parameters saved to NVM bank 1

To exit “robot mode”, remove the sensor from the robot. Refer to [Section 3.4—Removing the Sensor from the Robot](#). Attach the sensor to a personal computer and open a serial console. Type the character “m”. For example:

<the user enters “m”>

response: Parameters saved to NVM bank 0

6.2 Print a Single Reading of FT Values: “r” command

To receive a single FT reading of each axis, type the character “r”. The output is in hexadecimal. There is not a delimiter between FT values.

The out put has the following format: N (record number 0-9), $F_x \setminus F_y \setminus F_z \setminus T_x \setminus T_y \setminus T_z$

To understand how to read these outputs, refer to [Section 6.5—Interpreting Robot Mode Readings](#).

The “r” command format, for example:

<the user enters “r”>

response: 20000000FFFFFFFFFFFF0000

6.3 Print and Stop a Continuous Output or High Speed Streaming of FT Values: “s” and “e” command

To receive a continuous output or start high speed streaming of FT values in each axis, type the character “s”. The output is in hexadecimal. There is not a delimiter between FT values. The out put has the following format: N (record number 0-9), $F_x \setminus F_y \setminus F_z \setminus T_x \setminus T_y \setminus T_z$. There is not a delimiter between FT values. To understand how to read these outputs, refer to [Section 6.5—Interpreting Robot Mode Readings](#).

The “s” command format, for example:

<the user enters “s”>

```
response:  0FFFF0000000000000FFFFFFFFFF
          1FFFF0000000000000FFFFFFFFFF
          2FFFF0000000000000FFFFFFFFFF
          3FFFF0000000000000FFFFFFFFFF
          4FFFF0000000000000FFFFFFFFFF
          5FFFF0000000000000FFFFFFFFFF
          6FFFF0000000000000FFFFFFFFFF
          7FFFF0000000000000FFFFFFFFFF
          8FFFF0000000000000FFFFFFFFFF
          9FFFF0000000000000FFFFFFFFFF
          0FFFF0000000000000FFFFFFFFFF
```

To stop receiving a continuous output or stop streaming FT values, press any keyboard character (or e) until the streaming stops.

6.4 Print the Counts Per Force and Counts Per Torque for Each Axis: “p” command

To output the counts per force and counts per torque values in each axis, type the character “p”. The “p” command has this format: counts per F_x (in Newtons or N), counts per F_y (N), counts per F_z (N), counts per T_x (in Newtons per meter), counts per T_y (Nm), counts per T_z (Nm). For example:

<the user enters “p”>

```
response:  10000.00, 10000.00, 10000.00, 10000.00, 10000.00, 10000.00
```

6.5 Interpreting Robot Mode Readings

The following is an example of how to interpret “robot mode” FT readings into decimal values.

The “p” counts per force and counts per torque command and “r” single FT reading command have the following outputs:

P = 15.2588, 15.2588, 15.2588, 15.2588, 15.2588, 15.2588

R = 1FFFF00000023000000000000

The “p” command has this format:

Table 6.1—The “p” Command Format					
Counts per F_x	Counts per F_y	Counts per F_z	Counts per T_x	Counts per T_y	Counts per T_z
15.2588	15.2588	15.2588	15.2588	15.2588	15.2588

The “r” command has this format in hexadecimal:

Table 6.2—The “r” and “s” Command Format						
Counter	F_x Counts	F_y Counts	F_z Counts	T_x Counts	T_y Counts	T_z Counts
1	FFFF	0000	0023	0000	0000	0000

Free calculators are available on the internet to convert hexadecimal values to decimal values.

After converting the hexadecimal to decimal, divide the output from the “r” command by the output from the “p” command to obtain human readable FT values. For example:

$$F_x = \text{FFFF} \div 15.2588 = -1 \div 15.2588 = -0.06554 \text{ N}$$

$$F_y = 0000 \div 15.2588 = 0 \div 15.2588 = 0 \text{ N}$$

$$F_z = 0023 \div 15.2588 = 35 \div 15.2588 = 2.2938 \text{ N}$$

$$T_x = 0000 \div 15.2588 = 0 \div 15.2588 = 0 \text{ N}$$

$$T_y = 0000 \div 15.2588 = 0 \div 15.2588 = 0 \text{ N}$$

$$T_z = 0000 \div 15.2588 = 0 \div 15.2588 = 0 \text{ N}$$

6.6 Other Commands

The following sections list and describe more advanced commands in “robot mode”. All of the commands must be issued while the sensor is connected via a USB cable to a serial port on a personal computer. After issuing commands to adjust the settings, the sensor can then be installed on a robot. Refer to [Section 3.3—Installing the Sensor to the Robot](#). To adjust the settings on the sensor again, the sensor must be removed from the robot. Refer to [Section 3.4—Removing the Sensor from the Robot](#).

6.6.1 Set 16 or 32-Bit Output Values for Each Axis: “w” command

Type the character “w” followed by a “2” to select 2 byte or 16-bit output values (4 hexadecimal characters). 16-bit output values are the default setting. Type the character “w” followed by a “4” to select 4 bytes or 32-bit output values (8 hexadecimal characters). For example:

<the user enters “w2”>

response: Parameters saved to NVM bank 0

Parameters saved to NVM bank 1

The 32-bit output mode provides the user with more resolution or precision of FT data than the 16-bit output mode because the 16-bit reading shows the upper 16-bits of the 32-bit reading.

6.6.2 Set the ADC Sample Rate: “a” command

The ADC sample rate that is set for the sensor must match the same sample rate set on the serial console. Refer to [Figure 5.1](#).

Type the character “a” and one of the following values 0 to 4 for ADC sample rate:

- 0 for 488
- 1 for 976
- 2 for 1953
- 3 for 3906
- 4 for 7912

The selected ADC sample rate is saved to NVM. Refer to [Section 4.4—Sample Rate](#) for more information about ADC sample rate. For example:

<the user enters “a0”>

```
response: Parameters saved to NVM bank 0
          Parameters saved to NVM bank 1
```

6.6.3 Set the IIR Filter Shift Value: “f” command

Type the character “f” and an index value from 0 to 8. The value is saved to NVM. Refer to [Section 4.5—Low-Pass Filter](#) for more information about filtering. For example:

<the user enters “f0”>

```
response: Parameters saved to NVM bank 0
          Parameters saved to NVM bank 1
```

6.6.4 Set the Calibration Value: “c” command

Type the character “c” and a value of “0” or “1”. The value is saved to NVM. Refer to [Section 9.3—Calibration Ranges](#) for technical specifications. For example:

<the user enters “c0”>

```
response: Parameters saved to NVM bank 0
          Parameters saved to NVM bank 1
```

6.6.5 View the Current Output Bit or Calibration Value in NVM: “r” command

Type the character “w” or “c” followed by “r”, to see the current value that is stored to NVM. For example:

<the user enters “cr”>

```
response: 0
          Parameters saved to NVM bank 0
          Parameters saved to NVM bank 1
```

6.6.6 Bias Command: “O” command

Type the character “o” command, and the FT output is reset to zero. There is not a response, when the command is entered.

7. Maintenance

7.1 Periodic Inspection

With industrial-type applications that frequently move the system's cabling, check the cable jacket for signs of wear. The Axia sensor is IP64 rated. Debris and dust should be kept from accumulating in or on the sensor. The surface of the sensor can be cleaned with isopropyl alcohol, if contaminated by its environment. The sensor itself should experience no wear, if used within the operating ranges and fastened to the proper torque specification. Refer to [Section 9—Specifications](#) and [Section 3.3—Installing the Sensor to the Robot](#).

7.2 Periodic Calibrating

Periodic calibration of the sensor and its electronics is required to maintain traceability to national standards. Follow the applicable ISO-9000-type standards for calibration. ATI Industrial Automation recommends annual accuracy checks. Refer to [Section 3.6—Setting-Up Communications with the Serial Axia Sensor](#).

8. Troubleshooting

This section includes answers to some issues that might arise when setting up and using the Serial Axia. The question or problem is listed followed by its probable answer or solution. They are categorized for easy reference.

The information in this section should answer many questions that might arise in the field. Customer service is available to users who have problems or questions addressed in the manuals.

Note

Please read the manual before calling customer service. Before calling, have the following information available:

1. Serial number (e.g., FT01234)
2. Sensor model (e.g., Axia80, etc.)
3. Calibration (e.g., US-15-50, SI-65-6, etc.)
4. Accurate and complete description of the question or problem
 - For the status code; refer to [Section 4.8—Status Code](#).
 - For the system's response to the status command; refer to [Section 5.13—Status Command: "status"](#).
5. Computer and software information (operating system, PC type, drivers, application software, and other relevant information about the application's configuration)

If possible, be near the F/T system when calling.

For additional troubleshooting information or to speak with a customer service representative, please contact ATI at:

ATI Industrial Automation

1031 Goodworth Drive
Apex, NC 27539 USA
www.ati-ia.com

Application Engineering

Tel: +1.919.772.0115, Extension 511
Fax: +1.919.772.8259
E-mail: ft_support@ati-ia.com

8.1 Errors Powering Up

Table 7.1—Powering Up	
Symptom	Resolution
Status LED stays red after the (20) second power up phase.	Check the sensor cable connections. Verify the sensor cable is not damaged. There may be an internal error in the sensor
Status LED is red for the first (20) seconds, after power up, and then turns green.	Normal operation.
The L/A LED is not green or flashing green.	Check the serial cable connection.

8.2 Errors with Force and Torque Readings

Incorrect data from the sensor’s strain gages can cause errors in force/torque readings. The basic conditions of incorrect data are in the following table. Use this table to troubleshoot a problem. In most cases, problems are better observed while looking at the raw strain gage data. Refer to [Section 5.3—Query Commands: “s” or “c”](#) for more details.

Table 7.2—Errors with Force and Torque Readings		
Symptom	Cause	Resolution
The sensor is not streaming measurement data to the customer devices.	The sensor is not properly installed.	Verify the sensor is correctly installed. Ensure the robot mounting and tool adapter plates are installed on the proper side of the sensor. Refer to Section 3—Installation for more information.
Either the “Force/Torque Out of Range” or the “Gage Out Range” bit is set. Refer to Section 4.8—Status Code .	The sensor is reporting that it is no longer within the calibrated range and may experience inaccuracy and reduced life. If the “Force/Torque Out of Range” bit is set, refer to Section 4.8.1—Status Code: Sensing Range Exceeded for more information.	Perform an accuracy check. Refer to Section 3.6—Setting-Up Communications with the Serial Axia Sensor . If the sensor fails the accuracy check, return the sensor to ATI for diagnosis.
The “Broken Gage Bit” is set. Refer to Section 4.8—Status Code .	An electrical failure has potentially occurred inside the sensor.	The sensor must be returned to ATI for diagnosis.
Noise: jumps in force torque data readings (with the sensor unloaded) greater than 0.05% of full scale counts is abnormal.	Noise can be caused by mechanical vibrations and electrical disturbances, possibly from a poor ground. Noise can also indicate component failure within the system.	Make sure that the DC supply voltage for the Axia sensor has little to no noise superimposed. The sensor should be grounded through installation construction. See Section 8.3—Reducing Noise .

Table 7.2—Errors with Force and Torque Readings		
Symptom	Cause	Resolution
Drift: after a load is removed or applied, the raw gage reading does not stabilize but continues to increase or decrease.	Some drift from a change in temperature or mechanical coupling is normal. Mechanical coupling occurs when a tool plate contacts the sensor body, for example: debris between the tool adapter plate and the sensor body or in applications such as hoses and wires attached to a tool.	A shift in the raw gage reading is observed more easily in the resolved data mode using the bias command.
Hysteresis: when the sensor is loaded and then unloaded, gage readings do not return quickly and completely to their original readings.	Hysteresis is caused by mechanical coupling (explained in “cause” for drift) or internal failure.	Use the bias command to shift the readings back to zero.

8.3 Reducing Noise

8.3.1 Mechanical Vibration

In many cases, perceived noise is actually a real fluctuation of force and/or torque, caused by vibrations in the tooling or the robot arm. The Serial Axia sensor offers digital low-pass filters that can dampen frequencies above a certain threshold. If digital low-pass filters are insufficient, a digital filter may be added to the application software.

8.3.2 Electrical Interference

To reduce the effects of electrical noise on the sensor, do the following:

- If interference by motors or other noise-generating equipment is observed, check the sensor’s ground connections.
- If sufficient grounding is not possible or does not reduce noise, consider using the sensor’s digital low-pass filters.
- Verify the power supply is Class 1, which has an earth ground connection.

8.4 Detecting Sensitivity Changes

Sensitivity checking of the sensor can also be used to measure the Sensor Axia sensor's health. Apply known loads to the sensor and verifying the system output matches the known loads. For example, a sensor mounted to a robot arm may have an end-effector attached to it. Use the following process to set a sensitivity value:

1. If the end-effector has moving parts, they must be moved in a known position.
 - a. Place the robot arm in an orientation that allows the gravity load from the end-effector to exert load on many sensor output axes.
2. Record the output readings.
3. Position the robot arm to apply another load, this time causing the outputs to move far from the earlier readings.
4. Record the second set of output readings.
5. Find the differences from the first and second set of readings.
6. Use the differences as a sensitivity value.

Even if the sensitivity values vary from sample set to sample set, these values can be used to detect gross errors. Either the resolved outputs or the raw sensor voltages may be used (the same must be used for all steps of this process).

9. Specifications

The requirements for the Sensor Axia sensor are covered in the following sections.

9.1 Environmental Conditions

Table 8.1—Environmental Conditions	
Parameter	Value
Storage Temperature, °C	-20 to +85
Operating Temperature, °C	0 to +65
Relative Humidity	<95%, non-condensing

9.2 Electrical Specifications

Table 8.2—Power Supply ¹				
Power Source	Voltage			Power Consumption
	Minimum	Nominal	Maximum	Maximum
DC Power	12 V	24 V	30 V	1.5 W

Notes:

- The power supply input is reverse polarity protected. If the power and ground to the power supply inputs are plugged in reverse, then the reverse polarity protection stops the incorrectly wired supply input from damaging or powering on the sensor.

9.3 Calibration Ranges

Table 8.3—Calibration Range 0 and Calibration Range 1									
Model	Axia80-M8			Axia80-M20			Axia80-M50		
Parameter	Fxy	Fz	Txyz	Fxy	Fz	Txyz	Fxy	Fz	Txyz
Calibration Range 0	150 N	470 N	8 Nm	500 N	900 N	20 Nm	1200 N	2000 N	50 Nm
Calibration Range 1	75 N	235 N	4 Nm	200 N	360 N	8 Nm	480 N	800 N	20 Nm

Notes:

- Each Axia80 sensor is calibrated with both of these calibration ranges.

9.4 Cable Specifications

9.4.1 9105-C-ZC33-ZC34-XXX

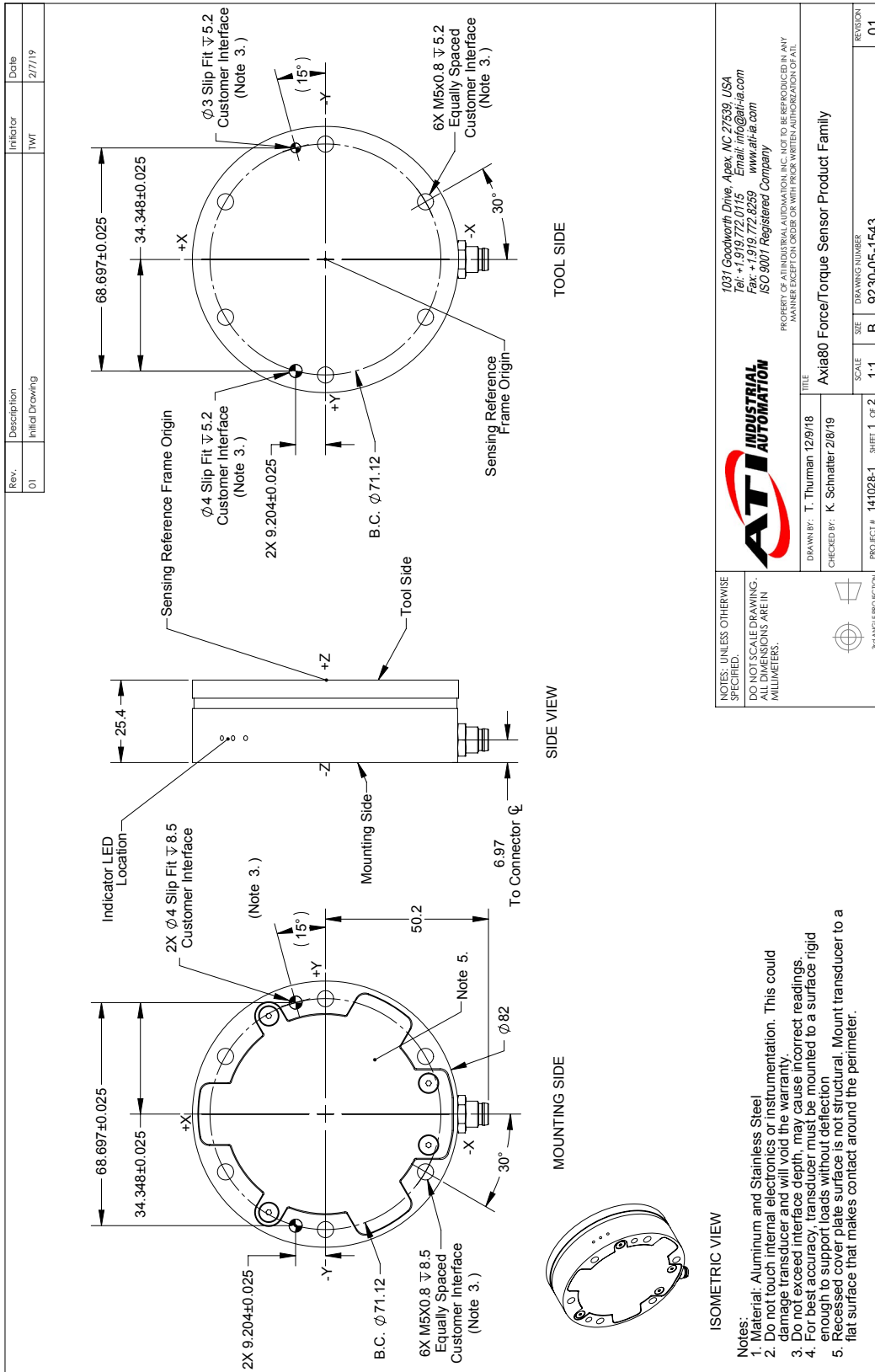
Table 8.4—9105-C-ZC33-ZC34-XXX 6-pin Female A-Coded M8 Connector and USB Type A Plug	
Parameter	Value
Voltage Rating	12-30 V
IP Rating	IP67: When the M8 connector is attached. IP50: USB connector.
Operating Temperature Range (Min-Max)	-5°C to 70°C
Torsion Rating	1 million torsion cycles of $\pm 180^\circ/\text{m}$
Flex Rating	1 million bending cycles at a bending radius per Table 3.1

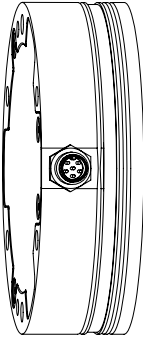
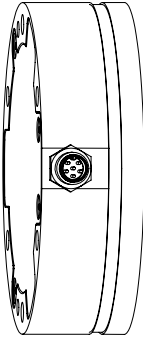
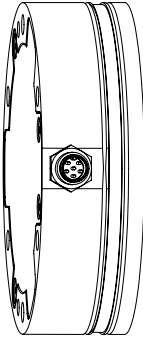
9.4.2 9105-CP-ZC38-U-1.8

Table 8.5—9105-CP-ZC38-U-1.8, Sensor Cable for Clock Synchronization	
Parameter	Value
Voltage Rating	12 VDC Max.

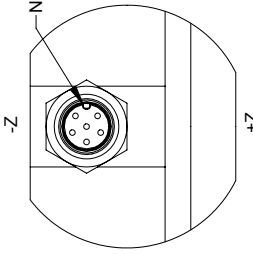
10. Drawings

10.1 Axia80 Force/Torque Sensor 9230-05-1543

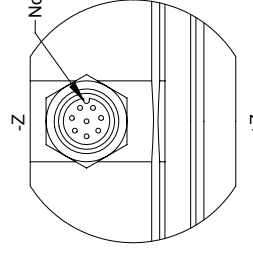


			
Model	Axia80-M8	Axia80-M20*	Axia80-M50
Body Material	Aluminum	Aluminum	Stainless Steel
Mass	280g	280g	680g
Identifying Marks	Three Grooves	No Grooves	Two Grooves

* Formerly Axia80




Connector View
 9105-ECAT-Axia80-MXX
 9105-RS485-Axia80-MXX
 9105-NET-Axia80-MXX-ZC22



Connector View
 9105-NET-Axia80-MXX

NOTES: UNLESS OTHERWISE SPECIFIED:
 DO NOT SCALE DRAWING.
 ALL DIMENSIONS ARE IN MILLIMETERS.

3/4 ANGLE PROJECTION



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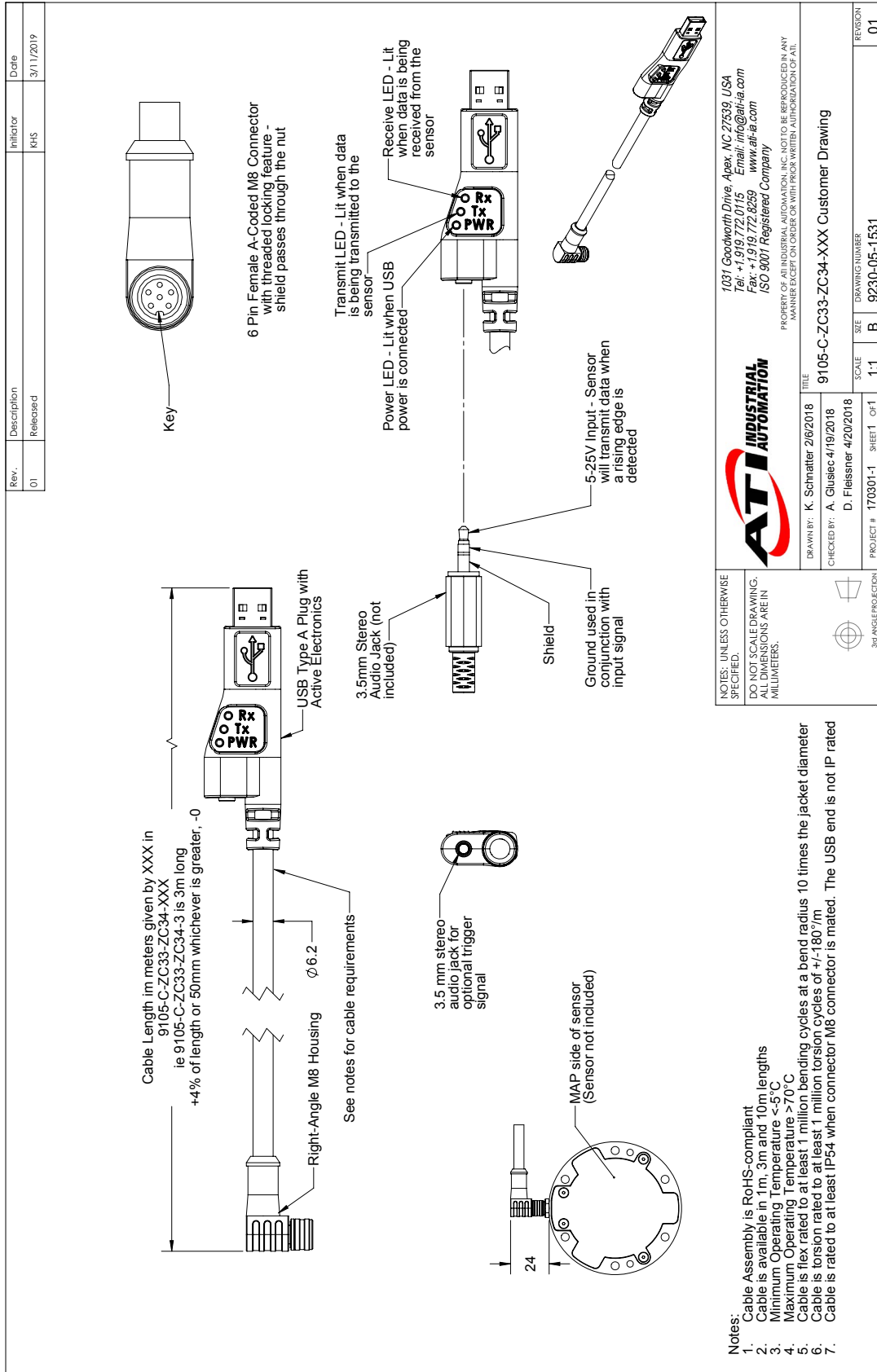
DRAWN BY: T. Thurman 12/9/18
 CHECKED BY: K. Schmatter 2/8/19

TITLE: Axia80 Force/Torque Sensor Product Family

SCALE: 1:2
 SIZE: B
 DRAWING NUMBER: 9230-05-1543
 PROJECT #: 141028-1 SHEET 2 OF 2

REVISION: 01

10.2 Cable, Net Axia to USB Type A Plug



11. Terms and Conditions of Sale

The following Terms and Conditions are a supplement to and include a portion of ATI's Standard Terms and Conditions, which are on file at ATI and available upon request.

ATI warrants to Purchaser that force torque sensor products purchased hereunder will be free from defects in material and workmanship under normal use for a period of one (1) year from the date of shipment. The warranty period for repairs made under a RMA shall be for the duration of the original warranty, or ninety (90) days from the date of repaired product shipment, whichever is longer. ATI will have no liability under this warranty unless: (a) ATI is given written notice of the claimed defect and a description thereof with thirty (30) days after Purchaser discovers the defect and in any event, not later than the last day of the warranty period and (b) the defective item is received by ATI not later than (10) days after the last day of the warranty period. ATI's entire liability and Purchaser's sole remedy under this warranty is limited to repair or replacement, at ATI's election, of the defective part or item or, at ATI's election, refund of the price paid for the item. The foregoing warranty does not apply to any defect or failure resulting from improper installation, operation, maintenance, or repair by anyone other than ATI.

ATI will in no event be liable for incidental, consequential, or special damages of any kind, even if ATI has been advised of the possibility of such damages. ATI's aggregate liability will in no event exceed the amount paid by the purchaser for the item which is the subject of claim or dispute. ATI will have no liability of any kind for failure of any equipment or other items not supplied by ATI.

No action against ATI, regardless of form, arising out of or in any way connected with products or services supplied hereunder, may be brought more than one year after the cause of action accrued.

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