Axia130 F/T Sensor Manual

Document #: 9620-05-B-Axia130

Engineered Products for Robotic Productivity

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Foreword

ATI F/T Sensing Systems are considered components/ semi-finished goods intended for use in larger system/ device/ finished good.

In consideration that ATI Industrial Automation, Inc. (ATI) products are intended for use with robotic and/or automated machines, ATI does not recommend the use of its products for applications wherein failure or malfunction of an ATI component or system threatens life or makes injury probable. Anyone who uses or incorporates ATI components within any potentially life-threatening system must obtain ATI's prior consent based upon assurance to ATI that a malfunction of ATI's component does not pose direct or indirect threat of injury or death, and (even if such consent is given) shall indemnify ATI from any claim, loss, liability, and related expenses arising from any injury or death resulting from use of ATI components.

Note:

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

1. Serial number, for example: FT01234
2. Model, for example: Axia130-M125
3. Calibration, for example: SI-2000-125 or SI-4000-300
4. Accurate and complete description of the question or concern
5. Computer and software information, for example: operating system, PC type, drivers, and application software

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

Please contact an ATI representative for assistance, if needed:

Sale, Service and Information about ATI products:

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Glossary

Term	Definition
Bias	Bias may also be referred to as “zero out” or “tare” the sensor. Biasing is useful for eliminating the effects of gravity (tool weight) or other acting forces, as well as the effects of drift. 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.
Calibration	Defines a specific measurement or sensing range for a given sensor. Calibration is also the process of measuring a transducer’s raw response to loads and creating data used in converting the response to forces and torques.
Complex Loading	Any load that is not purely in one axis.
Communication Interface Versions	The software standard that the customer device uses to apply features to the sensor and for the sensor to report data, for example: EtherCAT, RS422, and Ethernet.
Coordinate Frame	See Point of Origin.
Data Rate	How fast data can be output over a network.
Force	A force is a push or pull action on an object caused by an interaction with another object. Force = mass X acceleration
FS	Full-Scale, refers to the limits of a given calibration or sensing range.
F/T	Force/Torque.
F_{xy}	The resultant force vector comprised of components F_x and F_y.
Hysteresis	A source of measurement error 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 sensor doesn’t match the bolt pattern on the robot arm or customer tooling. The interface plate has two bolt patterns, one on either side of the plate. One side is for the sensor. The other side is for the robot arm or customer tooling.
IP67	Ingress protection rating “67” designates protection against dust and submersion under 1 m of fresh water.
Master Device	A customer supplied device such as a personal computer, robot, or programmable logic controller (PLC) that is compatible a specific communication interface.
Measurement Uncertainty	Commonly referred to as “accuracy”, “measurement uncertainty” is the worst-case error between the measured value and the true load. The measurement uncertainty is specified as a percentage of the full-scale measurement range for a given sensor model and calibration size. This value takes into account multiple sources of error. The sensor’s calibration certificate lists the measurement uncertainty percentage. For more information, refer to *Section 2.2: Measurement Uncertainty* in the Frequently Asked Questions (FAQ) document located at: *https://www.ati-ia.com/library/documents/FT_FAQ.pdf*.
Mechanical Coupling	When an external object such as customer tooling or utilities contacts a sensor’s surface between the sensor’s mounting side and tool side.
Mounting Interface Plate	An interface plate that attaches the sensor to a fixed surface like a robot arm.

Term	Definition
N/A	Not Applicable
Overload	The condition where more load is applied to the transducer than it can measure. This will result in saturation.
P/N	Part Number
Point of Origin	The point on the sensor from which all forces and torques are measured.
Power Cycle	When a user removes and then restores power to a device.
Resolution	The smallest change in load that can be measured. Resolution is usually much smaller than accuracy.
Sample Rate	How fast the ADCs are sampling inside the unit.
Saturation	The condition where the transducer or data acquisition hardware has a load or signal outside of its sensing range.
Sensor	The component that converts a detected load into electrical signals.
Sensor System (or configuration)	The entire assembly consisting of a sensor body and a system interface to translate force and torque signals into a specific communication interface/protocol.
Tool Interface Plate	An interface plate that attaches the customer’s tooling to the tooling side (sensing side) of the sensor.
Torque	The application of a force through a lever or moment arm that causes something to want to turn. For example, a user applies torque to a screw to make it turn. Torque = force x moment arm length
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 selected is rated for maximum loads and torques expected during operation. Because static forces are less than the dynamic forces from the acceleration or declaration 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.

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

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

CAUTION: The sensor should be protected from impact and shock loads that exceed rated ranges during transport as the impacts can damage the sensor's performance. Refer to *Section 7—Specifications* for more information about rated ranges.

2. Product Overview

The Axia130 Force/Torque (F/T) sensor measures six components of force and torque ($F_x \backslash F_y \backslash F_z \backslash T_x \backslash T_y \backslash T_z$) that are applied to the tool side of the sensor. The sensor communicates this data to a device such as a personal computer, robot, or PLC). The ATI Axia-series product line differs from the other ATI F/T sensor models. Thus, the Axia sensors have different options and available features. The Axia-series force/torque sensors are available in several different payload and communication interface versions. For more information about the communication interface, refer to the applicable ATI Axia F/T sensor manual (*Table 2.1*).

The Axia130 sensor is available in different model types (Axia130-M*XXX*) that are identifiable by the grooves on the outer housing; refer to *Section 2.1—Groove Identification for Axia130 Models*. The M*XXX* suffix signifies the full-scale torque measurement range. For the calibration range of each model type, refer to *Section 7.3—Calibration Ranges*.

The sensor's mounting side attaches to a rigid fixture or robot. The tool side attaches to the customer tooling. Users may need interface plates to install the sensor; refer to *Section 3.1—Interface Plates*. The robot mounting side of the sensor has a 112 mm diameter bolt circle (BC) with (6) M8 counterbored holes and (2) slip fit dowel holes. The tooling side of the sensor has a 64 mm diameter BC with (12) M6 tapped holes and (2) slip fit dowel holes (refer to the *ATI Axia sensor customer drawing*). The sensor is IP67 rated.

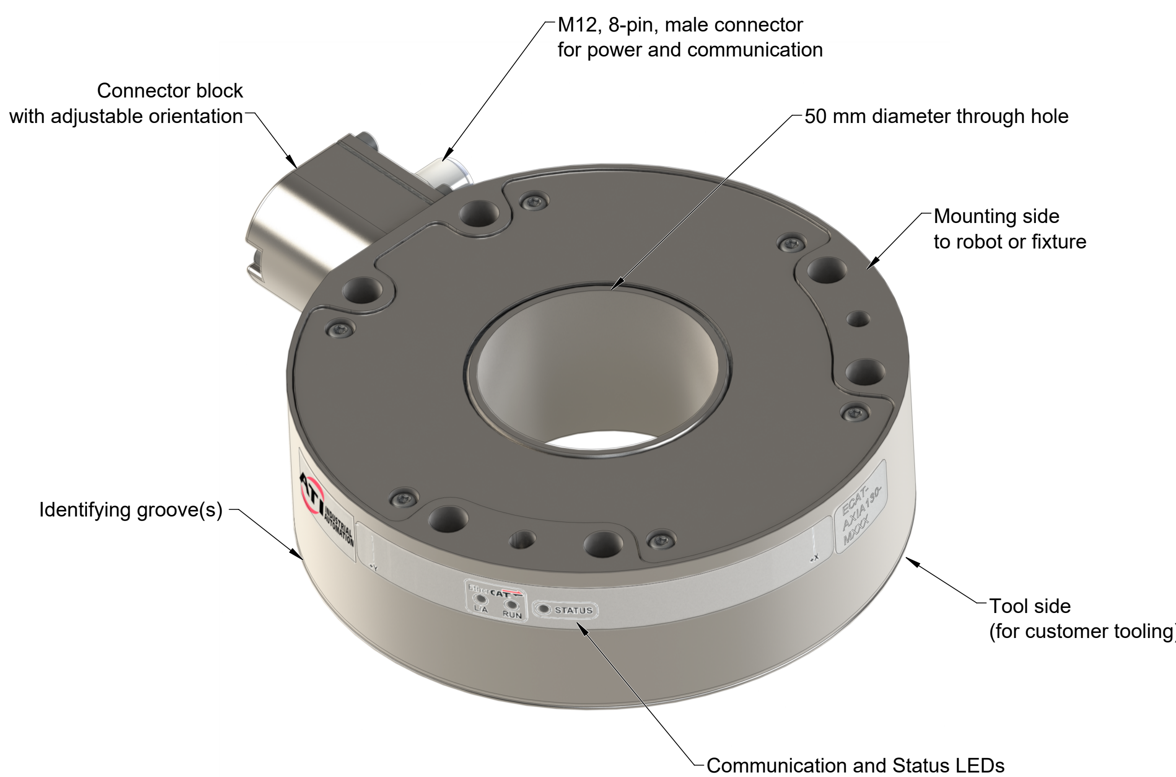
An M12 8-pin male connector is for power and communication. On the side of the sensor, LEDs indicate the sensor's operation state. For the connector pin assignments on the sensor and cables, sensor cable part numbers, and more information about the LEDs, refer to the applicable ATI communication interface manual in *Table 2.1*.

The ATI Axia130 sensor customer drawing is available here: *http://www.ati-ia.com/app_content/Documents/9630-05-0006.auto.pdf*.

The Axia130 sensor has the following additional features:

- 50 mm diameter through hole.
- Electrical connector with adjustable orientation (refer to *Section 3.3.1—Adjust the Connector Block Orientation*).

Figure 2.1—Axia130 F/T Sensor



For more information on the electrical and software features of a specific communication interface version and the applicable cable, refer to the ATI manual in the following table:

Table 2.1—Communication/Software ATI Manual Reference

Sensor Model ATI P/N	Communication Type	ATI Cable P/N	Refer to the ATI Manual
9105-NET-Axia130-M125	Ethernet	9105-C-ZC28-ZC28-X[1]-Z2[2] 9105-C-ZC28-U-RJ45S-X[1]	ATI F/T Ethernet Axia manual (ATI document #*9620-05-C-Ethernet Axia*)
9105-NET-Axia130-M300			
9105-ECAT-Axia130-M125	EtherCAT	9105-C-ZC28-ZC28-X[1]-Z2[2] 9105-C-ZC28-U-RJ45S-X[1]	ATI F/T EtherCAT Axia manual (ATI document #*9620-05-C-EtherCAT Axia*)
9105-ECAT-Axia130-M300			
9105-RS422-Axia130-M125	RS422	9105-C-ZC28-ZC28-X[1]-Z2[2,3] 9105-C-ZC28-MS-ZC35-X[1,3]	ATI F/T RS422 Axia manual (ATI document #*9620-05-C-RS422 Axia*)
9105-RS422-Axia130-M300			

Note:

1. The X in the part number signifies the cable length. For more information, contact ATI.
2. Included in 9105-CKIT-ZC28-ZC28-5; refer to *Table 3.3*.
3. Customers must use either the 9105-C-ZC28-MS-ZC35-X DB9 serial cable or their own RS422 serial cable with a DB9 or USB connector to the ATI sensor cable.

2.1 Groove Identification for Axia130 Models

The Axia130 sensor is available in different model types (Axia130-M*XXX*) that are identifiable by the number of grooves on the outer housing. The M*XXX* suffix signifies the full-scale torque measurement range. For the calibration range of each model type, refer to *Section 7.3—Calibration Ranges*.

Table 2.2—Axia Models

Model	Part Number	Number of Identifying Grooves[1]	Material
Axia130-M125	9105-X[2]-Axia130-M125	1	Aluminum
Axia130-M300	9105-X[2]-Axia130-M300	2	Stainless Steel

Notes:

1. Identifying grooves are physical indentations in the sensor body (refer to *Figure 2.1*). These grooves provide users a quick visual method to differentiate the sensor models.
2. X signifies the communication interface version option.

3. Installation

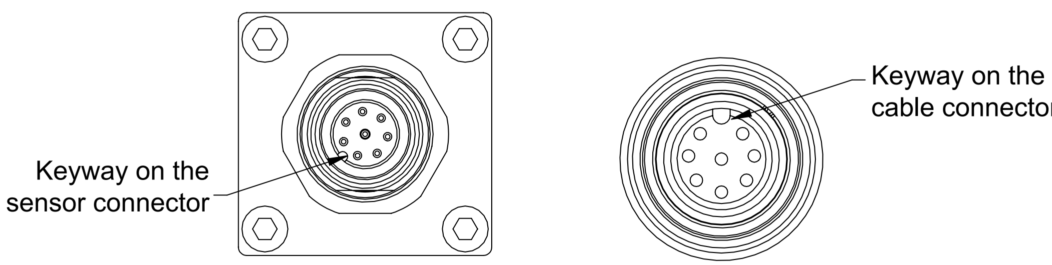
WARNING: Performing maintenance or repair on the sensor when circuits (e.g. power, water, and air) are energized could result in death or serious injury. Discharge and verify all energized circuits are de-energized in accordance with the customer's safety practices and policies.

CAUTION: Modification or disassembly of the sensor could cause damage and void the warranty. Use the supplied mounting bolt pattern and the provided tool side mounting bolt pattern to mount the sensor to the robot and customer tooling to the sensor (refer to the customer drawing).

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

CAUTION: Avoid damage to the sensor from Electro-Static 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.



NOTICE: Depending on the maintenance or repair being performed, utilities to the sensor may not need to be disconnected.

3.1 Interface Plates

The sensor's mounting side attaches to a surface like the robot arm, and the sensor's tool side attaches to the customer tooling. ATI can supply mounting kits that include a mounting interface plate and fasteners; for more information, contact ATI (refer to page B-2). If the customer chooses to supply their own interface plates, refer to the following design guidelines and the *ATI Axia sensor customer drawing*.

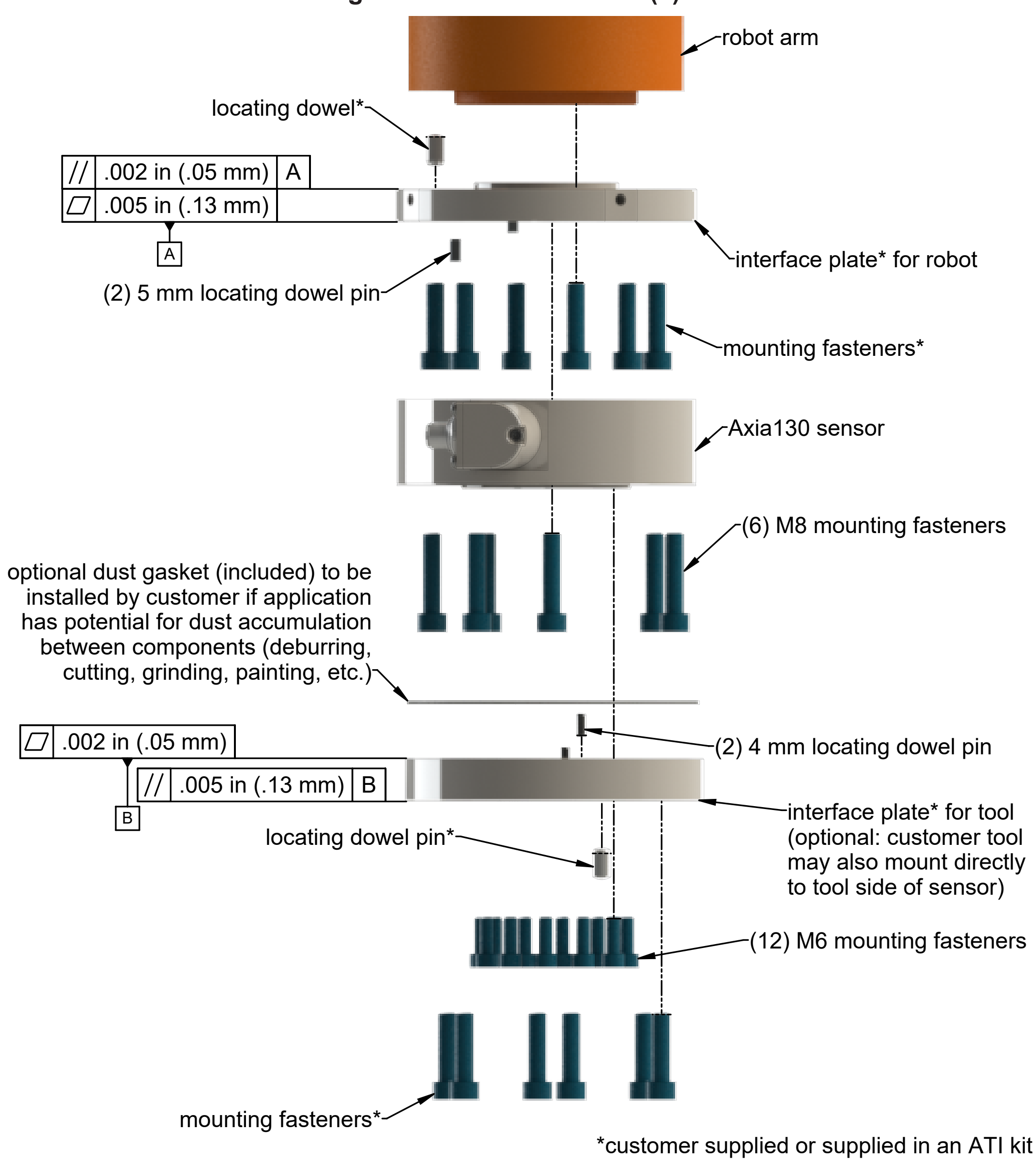
CAUTION: Incorrect installation of robot mounting and tool interface plates will result in the failure of the F/T sensor to function properly.

CAUTION: The customer tool should only touch the tool side of the sensor or a tool interface plate. If the customer tool touches any other part of the sensor, the sensor will not properly detect 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 dowel pin and a 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 interfere with the internal electronics of the sensor. For thread depth, mounting patterns, and other details refer to the *ATI sensor drawing*.
- 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 be as strong or stronger than the sensor so that maximum force and torque values applied to the sensor do not distort the interface plate. For these force and torque values, refer to *Section 7—Specifications*.
- The interface plate must provide a flat and parallel mounting surface for the sensor.

Figure 3.1—Interface Plate(s)



3.1.1 ATI Interface Plate Kits

ATI offers the following ISO 9409-1 compliant interface plate kit options. These options are for mounting the sensor to common robot flange bolt patterns and replicating those common patterns on the sensor's tool side. For assistance selecting an interface plate or for more information, contact an ATI representative.

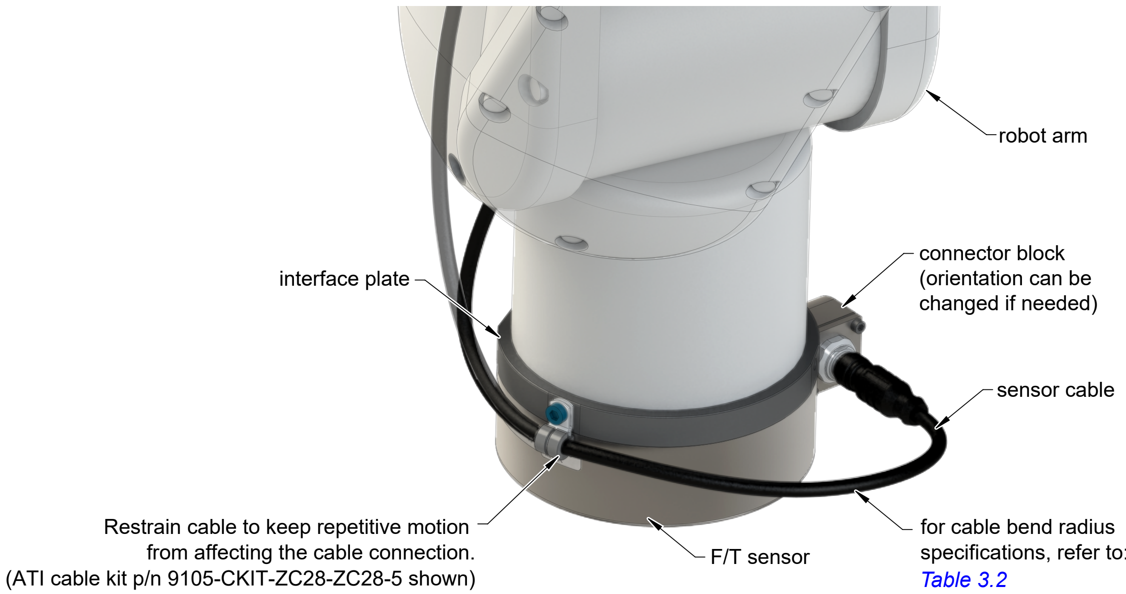
Table 3.1—ATI ISO 9409-1 Interface Plate Kits

ISO Standard Robot Flange Pattern	Bolt Circle Diameter	Interface Plate ATI P/N	Side of Sensor: Mounting or Tool	Description
ISO 9409-1-100-6-M8	100 mm	9105-IP-2274	Mounting	Through holes for (6) M8 socket head cap screws, 63 mm diameter boss, (1) 8 mm dowel pin
		9105-IP-2273	Tool	Tapped holes for (6) M8 socket head cap screws, 63 mm diameter recess, (1) 8 mm dowel pin
ISO 9409-1-125-6-M10	125 mm	9105-IP-2281	Mounting	Through holes for (6) M10 socket head cap screws, 80 mm diameter boss, (1) 10 mm dowel pin
		9105-IP-2280	Tool	Tapped holes for (6) M10 socket head cap screws, 80 mm diameter recess, (1) 10 mm dowel pin
ISO 9409-1-160-6-M10	160 mm	9105-IP-2283	Mounting	Through holes for (6) M10 socket head cap screws, 100 mm diameter boss, (1) 10 mm dowel pin
		9105-IP-2282	Tool	Tapped holes for (6) M10 socket head cap screws, 100 mm diameter recess, (1) 10 mm dowel pin

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.

Figure 3.2—Routing of the Sensor Cable

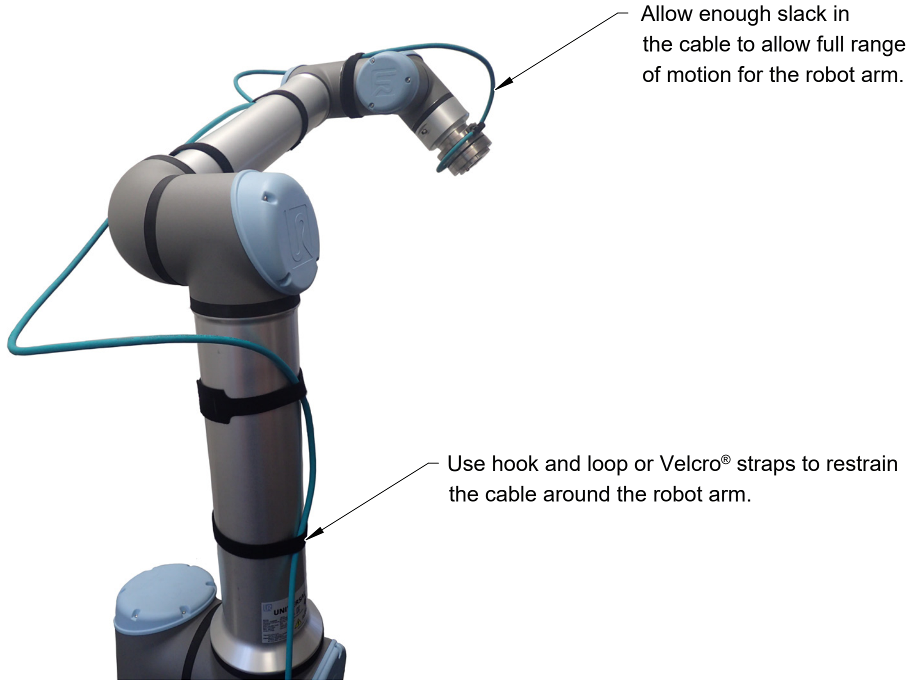


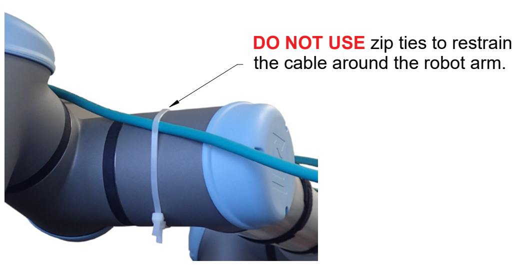
⚠	**CAUTION:** Subjecting the connector to the repetitive motion will cause damage to the connector. Restrain the cable close to the connector so that the repetitive motion of the robot does not interfere with the cable connector.

⚠	**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. Use a robot dresspack solution, if possible. An example of how to route the cable, if a dresspack is not available, are shown in the following figures and descriptions. Affix the cable by using hook and loop straps or Velcro® straps; do not use cable ties or zip ties.

Figure 3.3—Example of Cable Routing Without a Dresspack Solution (sensor shown for reference only)



> **CAUTION:** Do not use 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 damage the cable. 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**
>
> 
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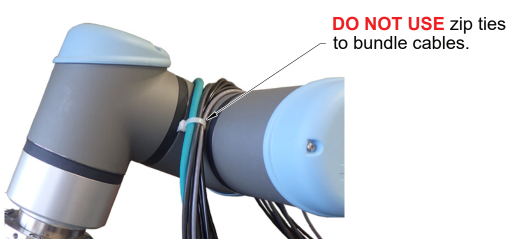
> 
>
>
> **CORRECT**
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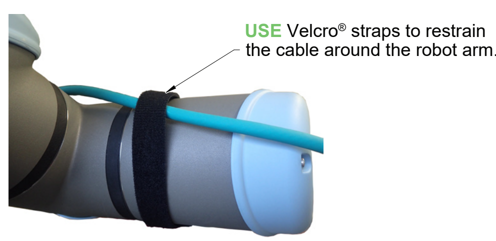
> 
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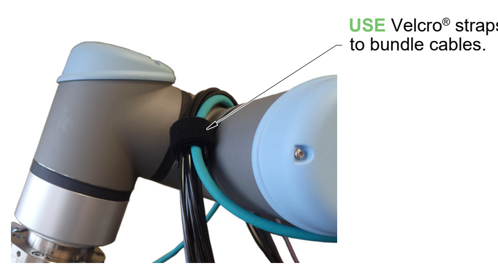
> 
>

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

CAUTION: When routing cables do not bend less than the minimum bending radius specified in *Table 3.2*. A bend radius too small causes the cable to fail from fatigue of the robot's repetitive motion.

Table 3.2—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-ZC28-ZC28-X[2]-Z2[3]	7.65 (0.30)	31	1.2	80	3.15	180°/m or 55°/ft
9105-C-ZC28-U-RJ45S-X[2]	6 (0.24)	25	1	50	2	

Notes:

1. Temperature affects cable flexibility. ATI recommends increasing the minimum dynamic bending radius for lower temperatures.
2. The X in the part number represents the cable length. For more information, contact ATI.
3. Available in an ATI kit; refer to *Table 3.3*.
4. For information specific to the cable part number, refer to the appropriate manual in *Table 2.1*.

3.3 Cable Kits

For an image of the P-clip, refer to *Figure 3.2*.

Table 3.3—Cable Kit 9105-CKIT-ZC28-ZC28-5

Part Number	Description	Quantity
9105-C-ZC28-ZC28-5-Z2	8-pin M12 connector to 8-pin M12 connector, with a 5 m cable	1
9005-05-1083	(1) P-clamp and (1) M5 x 8 socket head cap screw	1

3.3.1 Adjust the Connector Block Orientation

WARNING: Do not adjust the connector block orientation if the sensor is not completely dry or is powered on.

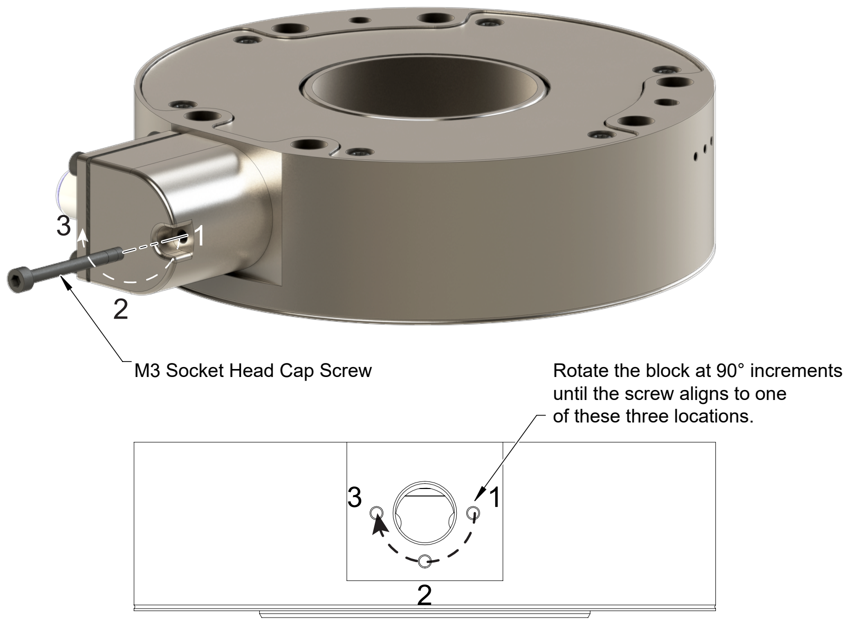
NOTICE: Position 1 is the default orientation of the connector block. When ATI ships Axia130 sensors to the customer, the connector block is in the default position.

Tools required: *2.5 mm hex key*

Supplies required: *Loctite® 222*

1. Use a 2.5 mm hex key to remove the M3 socket head cap screw.
2. Rotate the connector block to one of the 90° increments shown in the following figure.
3. Apply Loctite 222 to the threads of the M3 socket head cap screw.
4. Use a 2.5 mm hex key to install the screw. Tighten to 8 in-lbs (0.9 Nm).

Figure 3.4—Adjust the Connector Block Orientation



3.4 Install the Sensor

Parts required: *Refer to Figure 3.5 and the ATI sensor drawing*

Tools required: *4 mm, 5 mm, and 6 mm hex key*

Supplies required: *Clean cloth, Loctite® 242*

1. Clean the mounting surfaces.
2. Use the mounting fasteners to attach the interface plate to the mounting surface.

> **NOTICE:** When installing an interface plate:
>
> - Screws must have a minimum thread engagement length of 8 mm for the mounting side and 6 mm for the tool side. Maximum screw thread engagement shall not exceed the threaded depth listed on the *ATI sensor drawing*.
> - Unless otherwise specified, apply Loctite 242 to the (6) M8 and (12) M6 socket head cap screws (class 12.9) so that the fasteners secure the sensor to the interface plate.

3. Attach the mounting side of the sensor to the interface plate.
   a. Secure the mounting side of the sensor to the interface plate with the (6) M8 socket head cap screws, class 12.9. Use a 6 mm hex key to tighten the fasteners to 190 in-lb (21.5 Nm).
4. Optional: Install the supplied dust gasket.

> **NOTICE:** ATI-supplied dust gasket should be used if application has the potential for dust accumulation between components (deburring, cutting, grinding, painting, etc.).

   a. Place the dust gasket on the tool-side of the Axia130 sensor, centering the gasket around the center hub of the sensor.

6. Install the customer tooling or interface plate to the tool side of the sensor.

> **NOTICE:** The tool must not touch any other part of the sensor except the tool side or the tool interface plate; otherwise, the sensor does not properly detect loads.

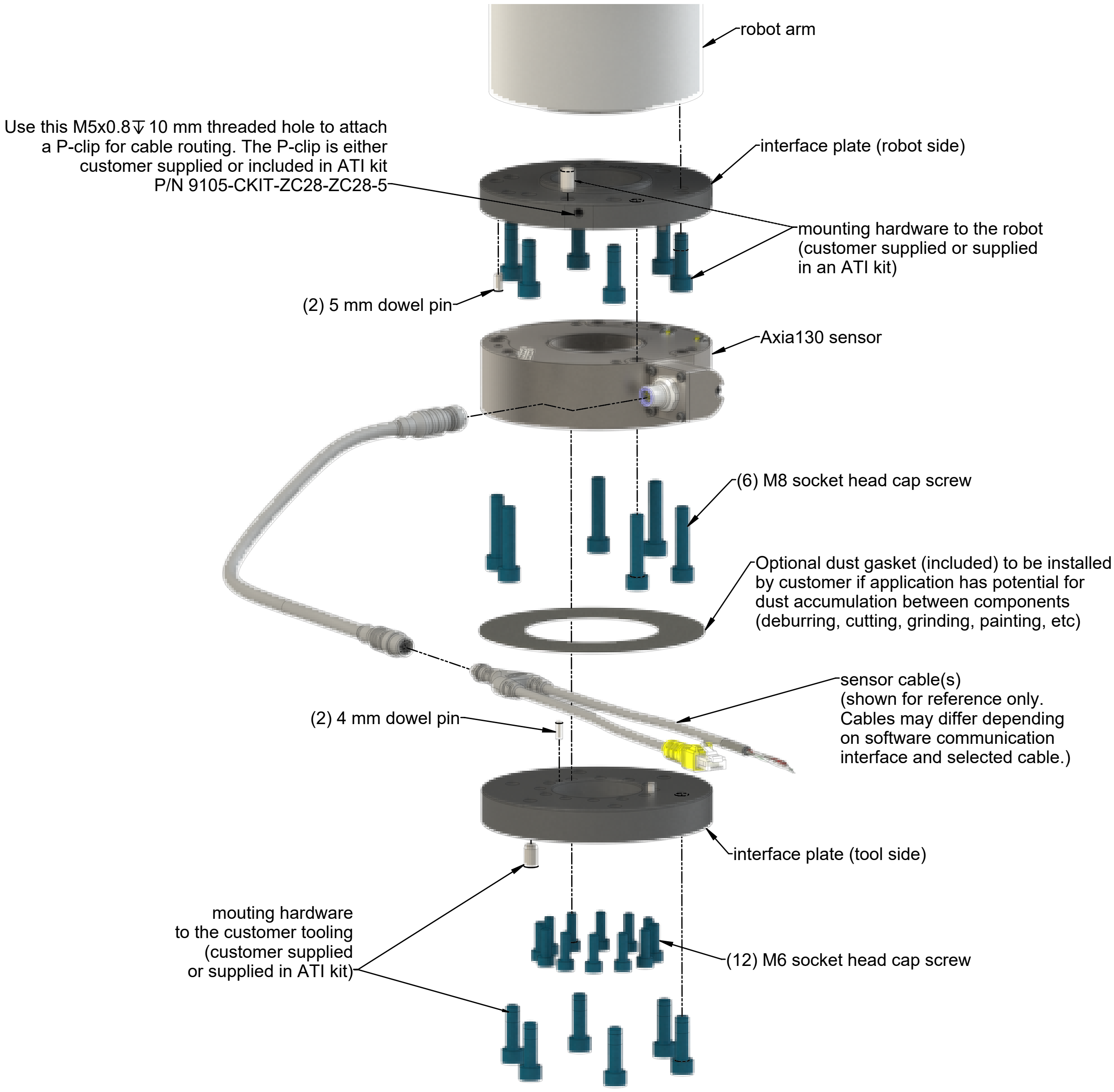
   a. Secure an interface plate or the customer tooling to the tool side sensor with the (12) M6 socket head cap screws, class 12.9. Use a 5 mm hex key to tighten the fasteners to 89 in-lb (10.1 Nm) for the Axia130-M125, and to 110 in-lb for the Axia130-M300.

7. Connect the cable(s) from the sensor to the customer interface. For the sensor and cable connector pinout information, refer to the applicable manual in *Table 2.1*.
8. After connecting the cable to the customer interface, set-up the sensor communication interface software; for additional information about the software communication interface, refer to the applicable manual in *Table 2.1*.

> **NOTICE:** For the LED outputs that indicate the sensor's operational condition, refer to the applicable manual listed in *Table 2.1.*

9. Properly restrain and route the cable; refer to *Section 3.2—Routing the Cable*. If using an ATI cable kit:
   a. Secure the P-clip to the interface plate (refer to *Figure 3.2*). Use a 4 mm hex key to tighten the M5 socket head cap screw.
   b. 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—Accuracy Check Procedure*).
11. Safely start normal operation.

Figure 3.5—Installation of the Axia130 Sensor to the Robot



NOTE: Cable lengths are shortened in the figure for reference only.

3.5 Remove the Sensor

Tools required: *5 mm and 6 mm hex key*

1. Turn off all energized circuits, for example: electrical.
2. Remove the cable from the sensor's connection.
3. Remove customer tooling from the sensor.
    a. Supporting the customer tooling and/or interface plate, use a 5 mm hex key to remove the (12) M6 socket head cap screws.
4. Remove the sensor from the robot or interface plate.
    a. Supporting the sensor, use a 6 mm hex key to remove the (6) M8 socket head cap screws.
5. Remove the sensor.

3.6 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.

NOTICE: For optimal results, write a robot program to move the sensor and mass to each of the following positions sequentially. At each position, the robot should pause to record the sensor's output. Avoid jogging the robot and waiting several minutes between each position.

3. Move the robot so that the sensor is in the following positions:
   a. Record the sensor's output, $F_{x,\ point\ n}$ \ $F_{y,\ point\ n}$ \ $F_{z,\ point\ n}$ 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 $F_{x,\ average}$ \ $F_{y,\ average}$ \ $F_{z,\ average}$:
   a. Use the following equations, to complete the calculations:

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

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

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

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

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

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

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

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

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 Axia130-M125 sensor's rated accuracy is 2% the range on all axes. For a 2000 N F_{xy} range and a 4000 N F_z range, the allowable errors of any single data point would be ± 40 N F_xy and ± 80 N F_z respectively. Since F_z has the larger tolerance, then one data point could be + 80 N and another data point could be –80 N, for a total range (max-min) of 160 N error.
- In addition, the tooling mass should be within 160 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

3.7 Detecting Sensitivity Changes

Sensitivity checking of the sensor can also be used to measure the 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).

4. Operation

Information that applies generally to all Axia130 sensors is in the following section. For more information specific to the communication protocol of the sensor, such as sampling rate, LEDs, operation commands, refer to the applicable manual in *Table 2.1*.

4.1 Sensor Environment

CAUTION: Damage to the outer jacket of the sensor cable could enable moisture or water to enter an otherwise sealed sensor. Ensure the cable jacket is in good condition to prevent sensor damage.

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

The user must ensure that the water in the environment does not exceed the IP67 rating of the sensor. With an IP67 rating, the sensor is dustproof and water resistant up to 1 m of submersion in fresh water for up to 30 minutes as well as when exposed to high pressure spray. While the Axia130 sensor is IP67 rated, keep debris and dust from accumulating on or in the sensor.

4.2 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. For the sensor's point of origin, refer to the *ATI sensor drawing*. The tool transformation function allows measurement of the forces and torques at a reference point other than the sensor's point of origin. For more information about tool transformation commands and settings, refer to the applicable manual in *Table 2.1*.

> **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 4.2.1—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 \ D_y \ D_z) and (3) rotations (R_x \ R_y \ R_z), for example:

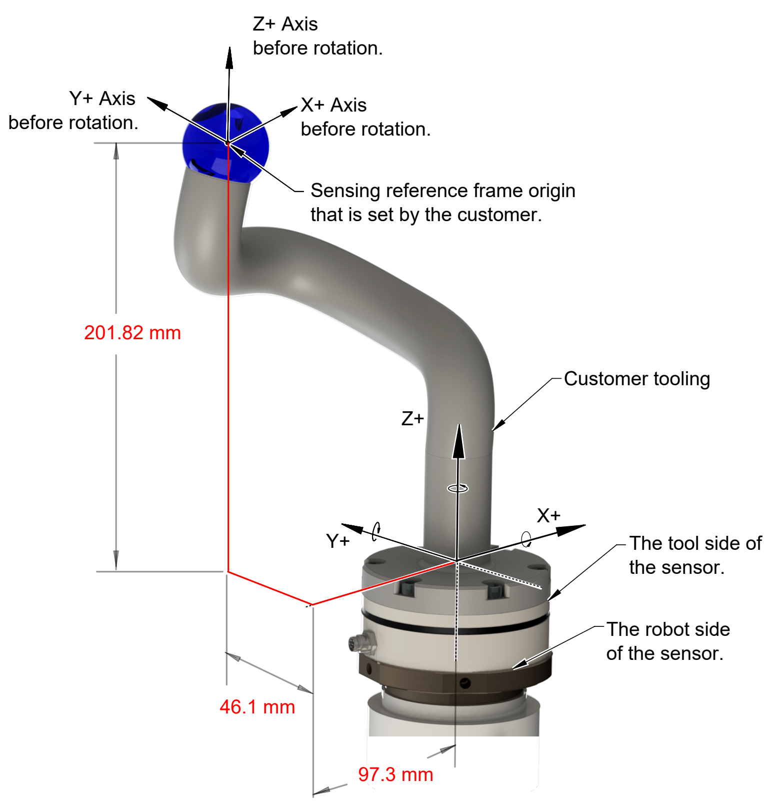
D_x = -97.3 mm D_y = 46.1 mm D_z = 201.82 mm R_x = +90° rotation R_y = +180° rotation R_z = 0° rotation

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.

> **NOTICE:** In the following figures, the sensor model is shown for reference only. The connector and sensor axes may align differently between sensor models. To determine the location of the default sensor axes, refer to the ATI sensor drawing or the axes labels on the sensor.

Figure 4.1—Tool Transformation : Distances (sensor shown for reference only)

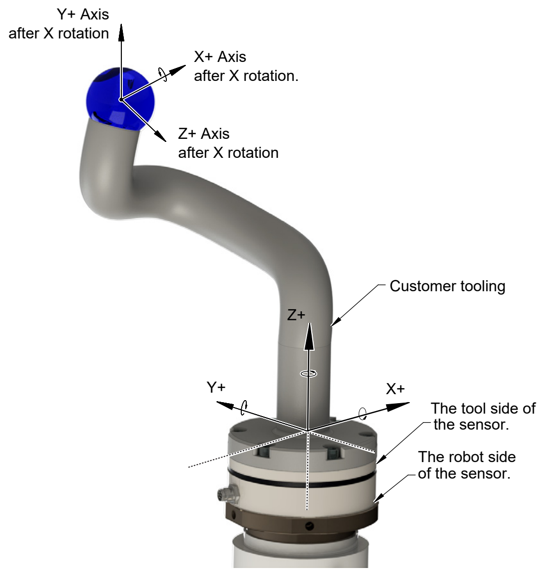


After the displacements, the user point of origin rotates in the following order:

1. The first rotation is about the X-axis.

- Recall in this example R_x = +90° rotation. The user point of origin rotates +90° about the X-axis, in the following figure.

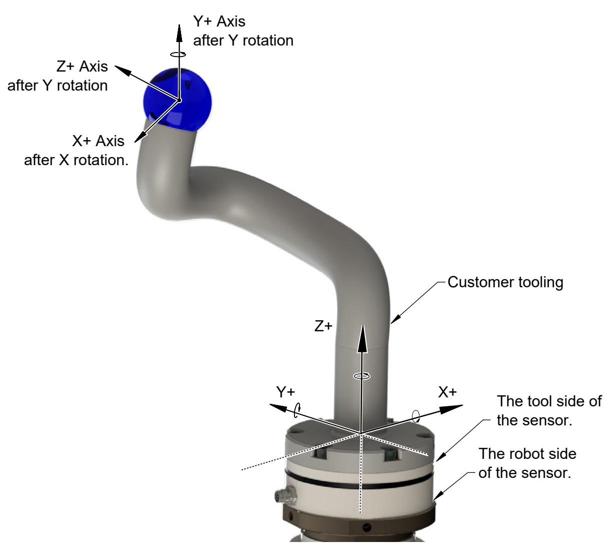
Figure 4.2—Tool Transformation : Rotation About the X-Axis (sensor shown for reference only)



2. The second rotation is about the Y-axis of the new user output reference frame.

- In this example R_y = +180° rotation. The user point of origin rotates +180° about the Y-axis of the new user output reference frame, in the following figure.

Figure 4.3—Tool Transformation: Rotation About the Y-Axis(sensor shown for reference only)



3. The third and final rotation is about the Z-axis of the new user output reference frame.

- In this example R_Z = 0° 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.

4.2.1 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.

5. Maintenance

5.1 Periodic Inspection

With industrial-type applications that frequently move the system's cabling, inspect the cable jacket for signs of wear. While the Axia sensor is IP67 rated, keep debris and dust from accumulating on or in the sensor. Clean the surface of the sensor with isopropyl alcohol.

5.2 Periodic Calibrating

Periodic calibration of the sensor and its electronics is required to maintain traceability to national standards. The sensor cannot be calibrated in the field; return the sensor to ATI for recalibration. Contact an ATI account manager or *rma-admin@ati-ia.com* to request a Returned Materials Authorization (RMA) for recalibration. ATI recommends annual accuracy checks (refer to *Section 3.6—Accuracy Check Procedure*). If the sensor does not meet the performance requirements of the user application and fails the accuracy check, return the sensor to ATI for re-calibration.

6. Troubleshooting

This section includes solutions to some issues that might arise when setting-up and using the sensor. For questions and troubleshooting assistance with software, refer to the appropriate manual in *Table 2.1*. Answers to frequently asked questions are available from the ATI website: *https://www.ati-ia.com/library/documents/FT_FAQ.pdf*.

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

> Note:
>
> Please read the manual before calling customer service. Before calling, have the following information available:
>
> 1. Serial number, for example: FT01234
> 2. Sensor model, for example: Axia130-M125
> 3. Calibration, for example: SI-2000-125 or SI-4000-300
> 4. Accurate and complete description of the question or concern
> 5. Computer and software information. for example: operating system, PC type, drivers, and application software.
>
> Be near the F/T system when calling (if possible).

Please contact an ATI representative for assistance, if needed:

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@novanta.com*

24/7 Support: +1 855 ATI-IA 00 (+1 855-284-4200)

6.1 Basic Guidance for Troubleshooting

Basic symptoms of inaccurate data and errors are listed in the following section. For each symptom, causes and appropriate solutions are suggested.

Symptom: Noise — jumps in force torque readings greater than 0.05% of full-scale counts.	**Cause:** Noise can be caused by mechanical vibrations and electrical disturbances that are possibly from a poor ground. Electrical interference can also come from a high noise output device such as a motor. **Solution:** Make sure that the DC supply voltage for the Axia sensor has little to no noise superimposed. Ground the sensor by connecting the cable's shield to ground. In most setups, 0 V is also connected to ground. Connect the robot or other fixture to the same ground. Verify that sensor cables do not cross over other cables or are within close proximity to other equipment that could generate electrical noise. Avoid sources of mechanical noise. If not possible, apply a filter to the data as described in the applicable communication interface ATI manual in *Table 2.1*.
	Cause: Noise can also indicate component failure within the system. **Solution:** Check the status code of the sensor; refer to the applicable communication interface ATI manual in *Table 2.1*. Perform an accuracy check; refer to *Section 3.6—Accuracy Check Procedure* or refer to *Section 4.5: How do I evaluate the accuracy of health of the sensor?* in the Frequently Asked Questions (FAQ) ATI document located at: *https://www.ati-ia.com/library/documents/FT_FAQ.pdf*. To return the sensor to ATI for inspection, contact ATI for a Returned Materials Authorization (RMA); refer to *Section 5.2—Periodic Calibrating*.
Symptom: Drift — when the force torque data continues to increase or decrease after a load is removed.	**Cause:** Some drift from a change in temperature is normal. Drift is observed more easily in the Z axis, compared to the X and Y axes. **Solution:** For approximately thirty minutes, allow the sensor to warm up until it is at a steady state with the air and other objects touching the sensor. Use the bias command to shift the readings back to zero. Bias regularly. Use an insulator between the sensor and any tooling or fixtures which are at a different temperature. Avoid creating a temperature gradient across the sensor. Shield the sensor from excessive air flow. For more information about how to avoid drift from temperature change, refer to the following ATI document: *https://www.ati-ia.com/Library/Documents/DriftExplanation.pdf*.

Symptom: Hysteresis — when the sensor is loaded from a zeroed or biased state and then the load is removed, sensor output does not immediately return to zero.	**Cause:** Mechanical coupling or internal failure can cause Hysteresis which is outside of the sensor's specified and acceptable measurement uncertainty (error) range. **Solution:** Verify the sensor is properly installed, fasteners are tightened, and the customer tooling is securely installed per *Section 3—Installation*. Use the bias command to shift the readings back to zero.
Symptom: The initial F/T values are non-zero and no load is applied.	Normal. Bias the sensor to bring all the F/T values back to zero.
Symptom: The sensor does not report accurate F/T data.	**Cause:** The sensor may be in an error state. **Solution:** Check the sensor status code. For how to read and interpret the status code, refer to the appropriate manual in *Table 2.1*). If there are no error bits ON, continue troubleshooting. **Cause:** The sensor is not properly installed or not mounted to a flat, stiff surface. **Solution:** Verify the sensor is correctly installed per *Section 3—Installation*. **Cause:** The mounting fasteners are not properly secured. **Solution:** Verify the fasteners are secured per the installation procedures in *Section 3.4—Install the Sensor*. If fasteners are customer supplied, do not use fasteners that are too long. For maximum fastener penetration depth into the sensor, refer to the *ATI sensor drawing*. When selecting fasteners: use a high quality, high strength screw or bolt and ensure the fastener's material type, fastener head, and fastener grade are proper for the application. **Cause:** Mechanical coupling — an external object such as customer tooling or utilities contacts a sensor's surface between the mounting side and tool side. **Solution:** Remove any debris between the tool side and interface plate. Use proper cable management for cables and hoses; do not connect them tightly between the mounting and tool side of the sensor. Anything that contacts surfaces such as the through hole in the sensor or cover plates on either side of the sensor induces loading or movement that could result in inaccurate F/T data.

Symptom: The F/T values do not match expected values, for example: the F/T values are fluctuating but are higher than a known applied load.	**Cause:** The sensor may be in a mode that reports gage data instead of F/T data. **Solution:** Gage data is not a 1:1 correlation to F/T axis data. View F/T data instead of gage data; refer to the applicable communication interface ATI manual in *Table 2.1*. **Cause:** The sensor outputs data in counts. The user must convert the counts to calibration units. **Solution:** Counts must be divided by the Counts per Force (CpF) or Counts per Torque (CpT) in order to convert them to calibration units such as N and Nm. In addition to CpF and CpT, depending on the communication protocol, the values may be further scaled by a 16-bit scale factor. 16-bit counts must be divided by (CpF or CpT ÷ 16-bit scale factor) in order to convert to calibration units. **Cause:** If once the F/T readings are converted to calibration units and exceed the sensor's calibration range per *Section 7.3—Calibration Ranges*, the reported values are inaccurate and the sensor may be overloaded. **Solution:** Check the status code. For information on how to read and interpret the sensor's status code, refer to the applicable communication interface ATI manual in *Table 2.1*. Unmount the sensor. Improper mounting methods can induce high loads in the sensor. After reinstalling the sensor and without applying a load, if errors such as "Sensing Range Exceeded", "Gage Out of Range", or "Gage Broken" persist, the sensor is likely permanently damaged due to overload.

7. Specifications

Some requirements and specifications for the Axia130 sensor interface are covered in the following sections. For more information, refer to the *ATI sensor drawing*.

7.1 Storage and Operating Conditions

Table 7.1—Environmental Conditions	
Parameter	**Value**
Storage Temperature, °C	-45 to +85
Operating Temperature, °C	-20 to +70
Relative Humidity	<95%, non-condensing

7.2 Electrical Specifications

Table 7.2—Power Supply[1]				
Power Source	**Voltage**			**Power Consumption**
	Minimum	**Nominal**	**Maximum**	**Maximum**
DC Power	12 V	24 V	30 V	1.5 W

Notes:

1. 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.

7.3 Calibration Ranges

Table 7.3—Calibration Ranges			
Model	**Axia130-M125**		
Parameter	Fxy	Fz	Txyz
Calibration Range 0 (SI-2000-125)	2000 N	4000 N	125 Nm
Model	**Axia130-M300**		
Parameter	Fxy	Fz	Txyz
Calibration Range 0 (SI-4000-300)	4000 N	6000 N	300 Nm

7.4 Default Peak Values

When powered on, the sensor records the peak values seen on any single axis. The following values are the default values programmed at the factory during calibration. If the sensor shows peak values higher than these defaults, the sensor has been loaded past the intended calibrated sensing range.

Table 7.4—Default Peak Values in Counts

Sensor Model	Axia130-M125					
Parameter	Fx	Fy	Fz	Tx	Ty	Tz
Positive Default Value	7.5×10^8		1.5×10^9	4.6875×10^7		
Negative Default Value	-7.5×10^8		-1.5×10^9	-4.6875×10^7		
Sensor Model	**Axia130-M300**					
Parameter	Fx	Fy	Fz	Tx	Ty	Tz
Positive Default Value	8.4×10^8		1.26×10^9	6.3×10^7		
Negative Default Value	-8.4×10^8		-1.26×10^9	-6.3×10^7		

8. 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.

No representation or agreement varying or extending the warranty and limitation of remedy provisions contained herein is authorized by ATI, and may not be relied upon as having been authorized by ATI, unless in writing and signed by an executive officer of ATI.

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