F/T Data Acquisition (DAQ)

Six-Axis Force/Torque Sensor System

Compilation of Manuals

F/T Sensor
Data Acquisition (DAQ) Systems

Manual

Document #: 9620-05-DAQ

Engineered Products for Robotic Productivity
Pinnacle Park • 1041 Goodworth Drive • Apex, NC 27539 • Tel: +1-919.772.0115 • Fax: +1-919.772.8259 • www.ati-ia.com

F/T Transducer

Six-Axis
Force/Torque Sensor System

Installation and Operation Manual

Document #: 9620-05-Transducer Section

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Foreword

ATI Force/Torque Sensing Systems are considered components / semi-finished goods intended for use in a 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 a 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.

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

1. Serial number (e.g., FT01234)
2. Transducer model (e.g., Nano17, Gamma, Theta, etc.)
3. Calibration (e.g., US-15-50, SI-65-6, etc.)
4. Accurate and complete description of the question or problem
5. Computer and software information (Operating system, PC type, drivers, application software, and other relevant information about the configuration)

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

Please contact an ATI representative for assistance, if needed:

Sale, Service and Information about ATI products:

ATI Industrial Automation
1031 Goodworth Drive
Apex, NC 27539 USA
www.ati-ia.com
Tel: +1.919.772.0115
Fax: +1.919.772.8259

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

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Glossary

Term	Definition
Accuracy	See Measurement Uncertainty.
ActiveX Component	A reusable software component for the Windows applications.
BNC	Bayonet Neill-Concelman (BNC) is a type of quick-connect/disconnect frequency connector.
Calibration File	A computer file containing transducer calibration information. This file must match the transducer serial number and is required for operation.
Compound Loading	Any load that is not purely in one axis.
DAQ	Data Acquisition device.
FS	Full-Scale.
F/T	Force and Torque.
Fxy	The resultant force vector comprised of components Fx and Fy.
Hysteresis	A source of measurement caused by the residual effects of previously applied loads.
IFPS	InterFace Power Supply box.
IFPSMC	Multiple InterFace Power Supply box.
IP	Ingress Protection Rating
LabVIEW	A graphical programming environment created for data acquisition tasks by National Instruments.
Manual Calculations	Programmatically calculating force and torque values without using the ATI DAQ F/T component.
MAP	Mounting Adapter Plate. The MAP part of the transducer is attached to the fixed surface or robot arm.
Maximum Single-Axis Overload	The largest amount of pure load (not compound loading) that the transducer can withstand without damage.
Measurement Uncertainty	The maximum expected error in measurements, as specified on the calibration certificate.
NI	National Instruments™ Corporation, the owner of the National Instruments™ and “LabVIEW” trademarks. (*www.ni.com*)
OEM	Original Equipment Manufacturer (OEM) is a entity that makes equipment with parts made by another entity.
Overload	The condition where a load greater than the transducer can measure is applied, resulting in saturation of the transducer, and cause irreparable damage.
PC Card	A small personal computer (PC) card for use in most laptop computers.
PCMCIA Card	See PC Card. (PCMCIA has been renamed PC Card by its standards organization.)
Point of Origin	The point on the transducer from which all forces and torques are measured.
PS	Power Supply box.
Quantization	The process of the continuously varying transducer signal being converted into discrete digital values. Usually used when describing the change from one digital value to the next.
Resolution	The smallest change in load that can be measured. The resolution is usually much smaller than accuracy.
Saturation	The condition where the transducer or data acquisition hardware has a load or signal outside of its sensing range.
Sensor System	The entire assembly consisting of parts from transducer to data acquisition card.
TAP	Tool Adapter Plate. The TAP part of the transducer is attached to the load that is to be measured.
TIF	A larger transducer that has integrated electronics to condition the transducer signal.
Tool Transformation	Mathematically changing the measurement coordinate system by translating the origin and/or rotating the axes.
Transducer	The component that converts the sensed load into electrical signals.
TW	Small transducers that do not have integrated electronics for conditioning the transducer signal require the use of a interface power supply box, which houses the electronics.
Txy	The resultant torque vector comprised of components Tx and Ty.
Visual Basic	A Microsoft programming environment for developing Windows-based applications.

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. More specific notifications are imbedded within the sections of the manual where they apply.

1.1 Explanation of Notifications

The following notifications are specific to the product(s) covered by this manual. It is expected that the user 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 transducer selected is rated for maximum loads and moments expected during operation. Refer to F/T Transducer Manual (*9620-05-Transducer Section* manual) or contact ATI Industrial Automation for assistance. Particular attention should be paid to dynamic loads caused by robot acceleration and deceleration. In high acceleration or deceleration situations, these forces can greatly exceed the value of static forces.

1.3 Safety Precautions

CAUTION: Do not remove any fasteners, or disassemble transducers, without a removable mounting adapter plate. Doing so can cause irreparable damage to the transducer and void the warranty. Leave all fasteners in place and the transducer in its assembled state. This applies to Nano, Mini, IP-rated, and some Omega transducers.

CAUTION: Do not probe any openings in the transducer. This will damage the instrumentation.

CAUTION: Do not exert excessive force on the transducer. The transducer is a sensitive instrument and can be damaged by applying a force that exceeds any of the single-axis overload values of the transducer, causing irreparable damage. Small Nano and Mini transducers can easily be overloaded during installation. Refer to the F/T Transducer manual (*9620-05-Transducer Section* manual) for specific transducer overload values.

2. Product Overview

The DAQ system is a multi-axis force and torque (F/T) transducer system that simultaneously measures forces (Fx, Fy, and Fz) and torques (Tx, Ty, and Tz). The DAQ F/T system outputs six amplified strain gage voltages (SG0 to SG5) to the DAQ device; then these gage voltages are processed through the ATI supplied six-by-six calibration matrix (refer to *Section 3.3—Load Calculation*) to obtain the F/T measurements (Fx, Fy, Fz, Tx, Ty, and Tz).

NOTICE: To avoid invalid F/T measurements, always keep the applied loads within the sensor's calibration range and monitor the gage voltages for saturation. Default gage output voltage is ± 10 V. for the sensor's calibration range, refer to the *9620-05-Transducer Section* manual.

Components are available for single TW Transducer DAQ Systems, TIF Transducer DAQ Systems, and multiple TW Transducer DAQ Systems. Other equipment is available such as rack mounted equipment, BNC interface boxes, IP rated transducers, IP rated cables, OEM interface boards, cable extensions, and many DAQ device and card options.

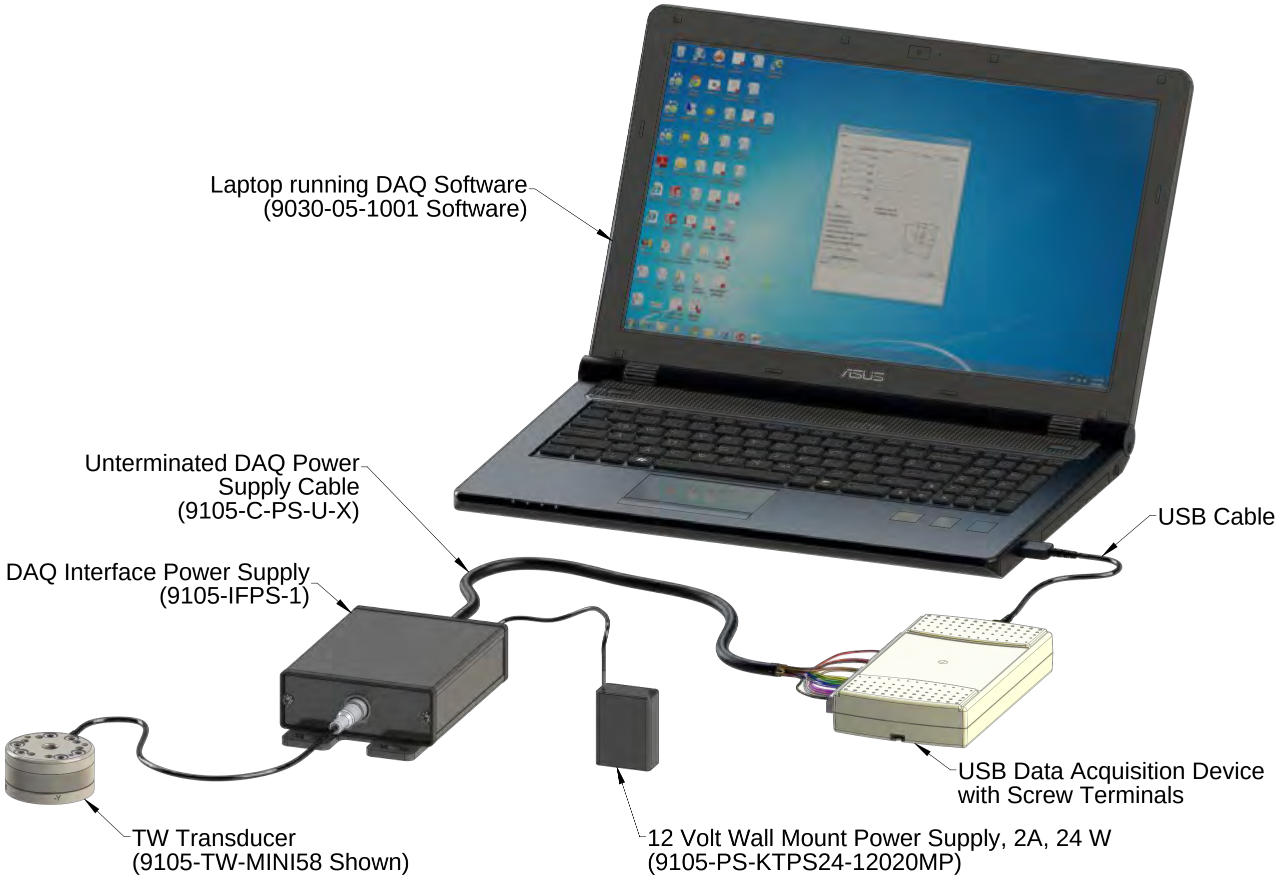
2.1 System with a TW Transducer, IFPS Box, and USB DAQ Device

Typically DAQ systems are limited to a single transducer, PS or IFPS box. DAQ devices with 64 pin screw terminals can be used to support two transducers and two PS or IFPS boxes. For additional required screw terminal connections, refer to *Table 4.1*.

A TW Transducer system may consist of the following components (refer to *Figure 2.1*):

- TW Transducer
- Interface power supply (IFPS)
- Data Acquisition (DAQ) Device or Data Acquisition (DAQ) card
- DAQ Software, running on a laptop or desktop (refer to *Section 3.4—ATI DAQ Software*)
- Supporting power supplies for IFPS or DAQ device
- Cable from IFPS to DAQ Device or DAQ card
- USB cable from USB DAQ device to PC

Figure 2.1—System with a Single TW Transducer, IFPS Box, and USB DAQ Device

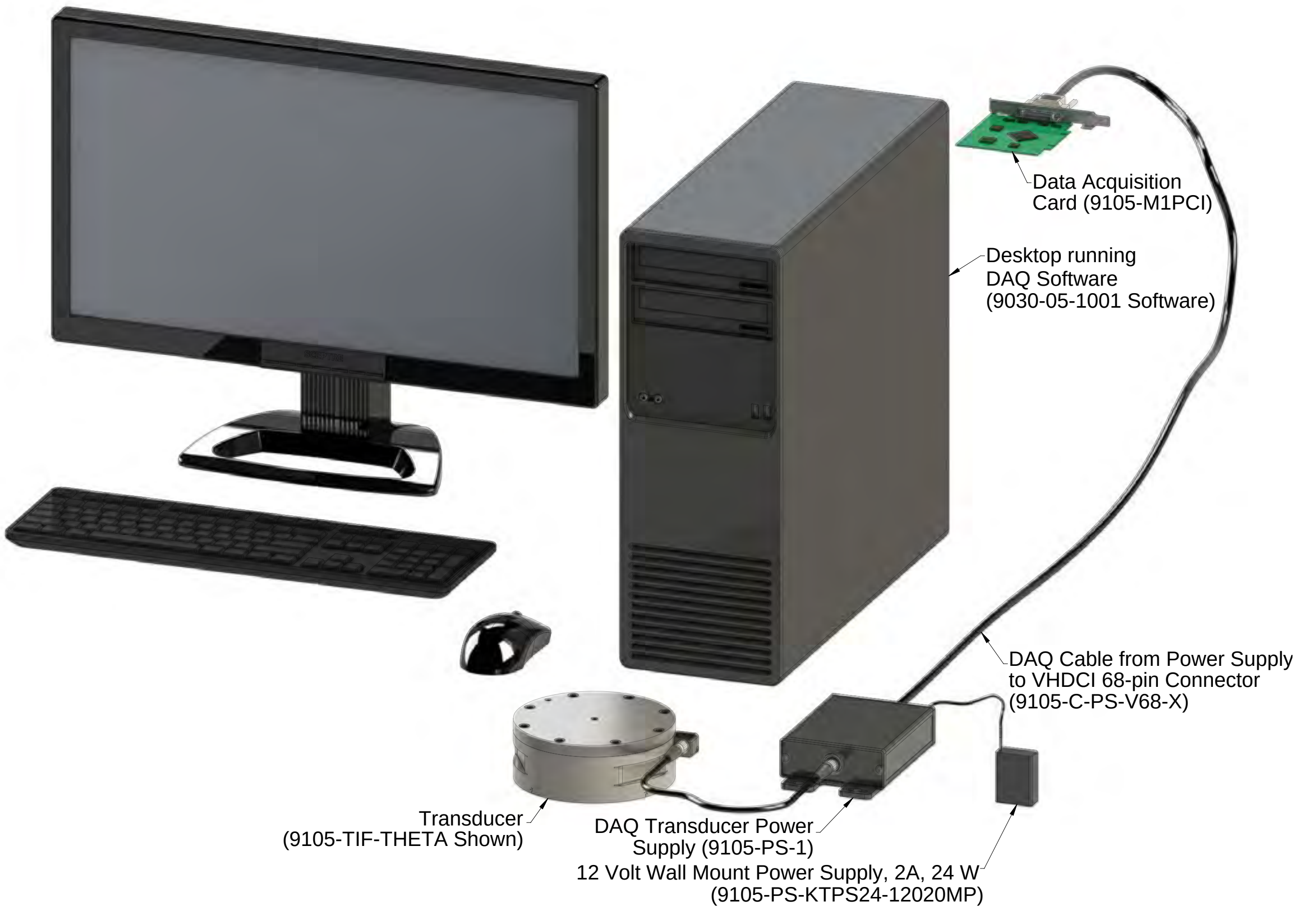


2.2 System with a TIF Transducer, PS Box, and DAQ Card

A TIF Transducer system may consist of the following components:

- TIF Transducer
- Power supply (PS)
- Data Acquisition (DAQ) Device or Data Acquisition (DAQ) card
- DAQ Software, running on a laptop or desktop
- Supporting power supplies for PS or DAQ device
- Transducer cable
- DAQ Cable from PS to DAQ Device or DAQ card

Figure 2.2—System with a Single TIF Transducer, PS Box, and DAQ Card

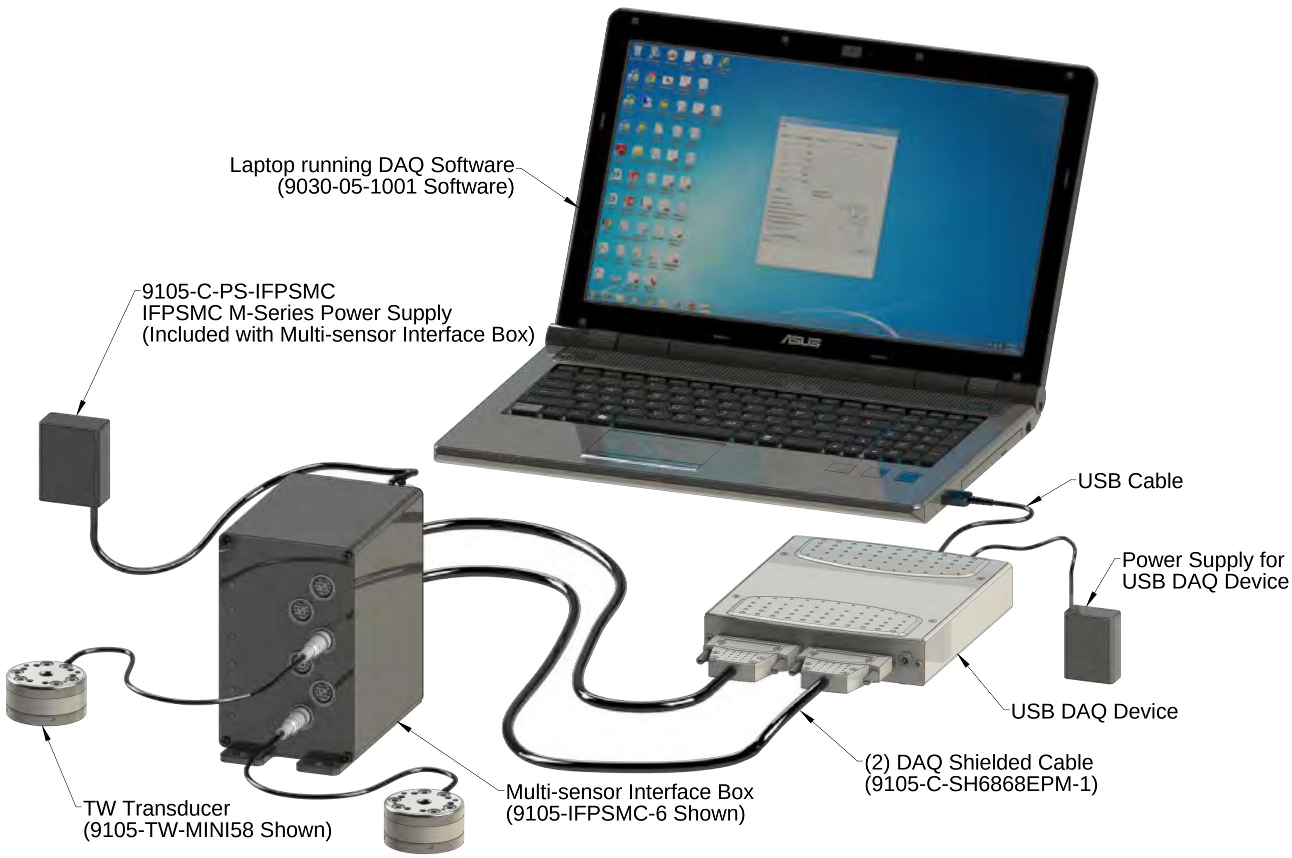


2.3 System with Multiple Transducers, IFPSMC Box, and a USB DAQ Device

A Multiple Transducer system may consist of the following components:

- Up to six TW Transducers
- Multi-sensor Interface Box (Multiple IFPS)
- Data Acquisition (DAQ) Device
- DAQ Software, running on a laptop or desktop
- Supporting power supplies for DAQ device or Multiple IFPS (Power supply included with Multiple IFPS)
- USB cable from USB DAQ device to PC
- DAQ Cables from Multi-sensor Interface box (IFPSMC) to a DAQ Device or Card

Figure 2.3—System with Multiple Transducers, IFPSMC Box, and a USB DAQ Device

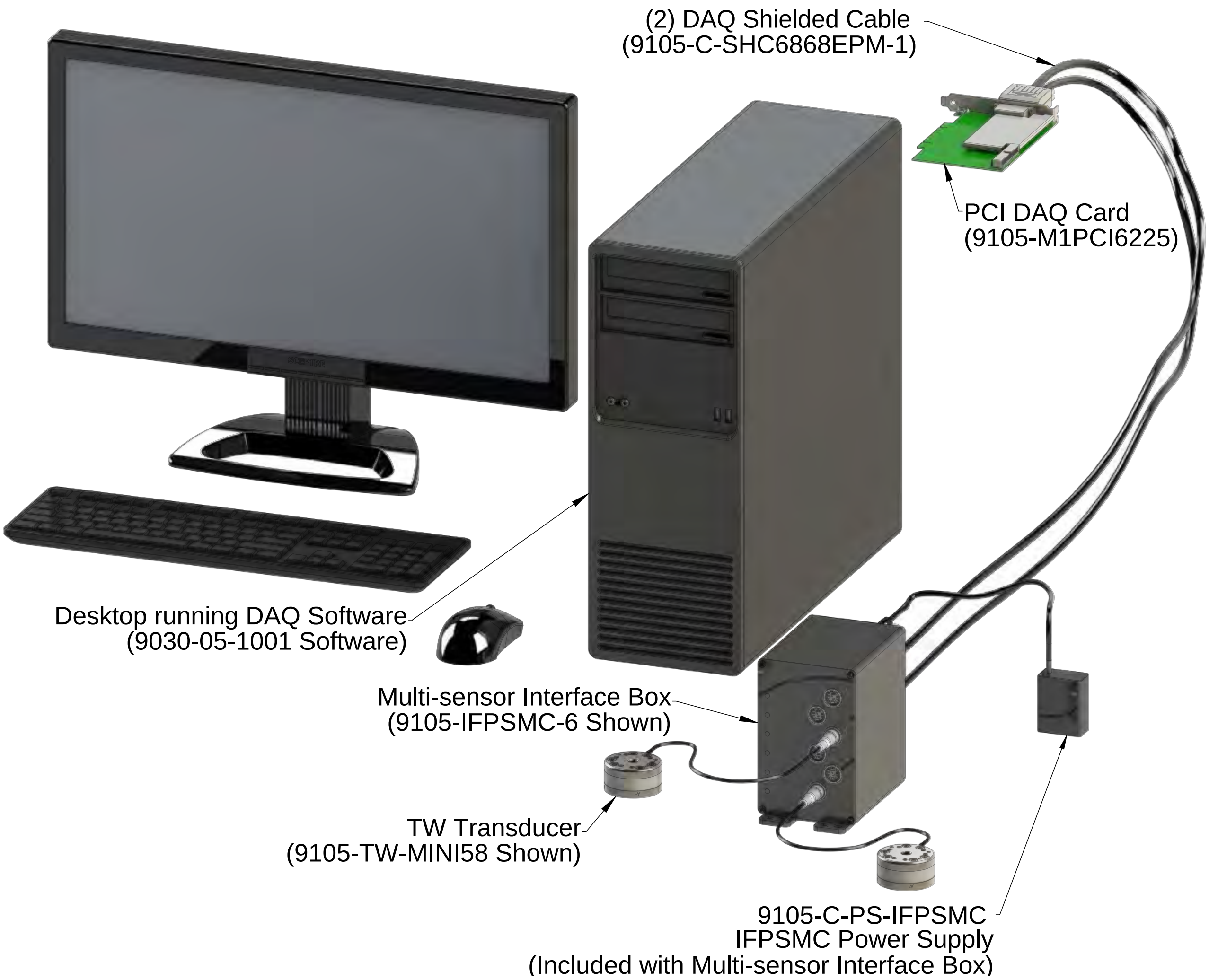


2.4 System with Multiple Transducers, IFPSMC Box, and a DAQ Card

A Multiple Transducer system may consist of the following components:

- Up to six TW Transducers
- Multi-sensor Interface Box (Multiple IFPS)
- Data Acquisition (DAQ) Card
- DAQ Software, running on a laptop or desktop
- Supporting power supplies for DAQ device or Multiple IFPS
  (Power supply included with Multiple IFPS)
- DAQ Cables from Multi-sensor Interface box (IFPSMC) to a DAQ Device or Card

Figure 2.4—System with Multiple Transducers, IFPSMC Box, and a DAQ Card

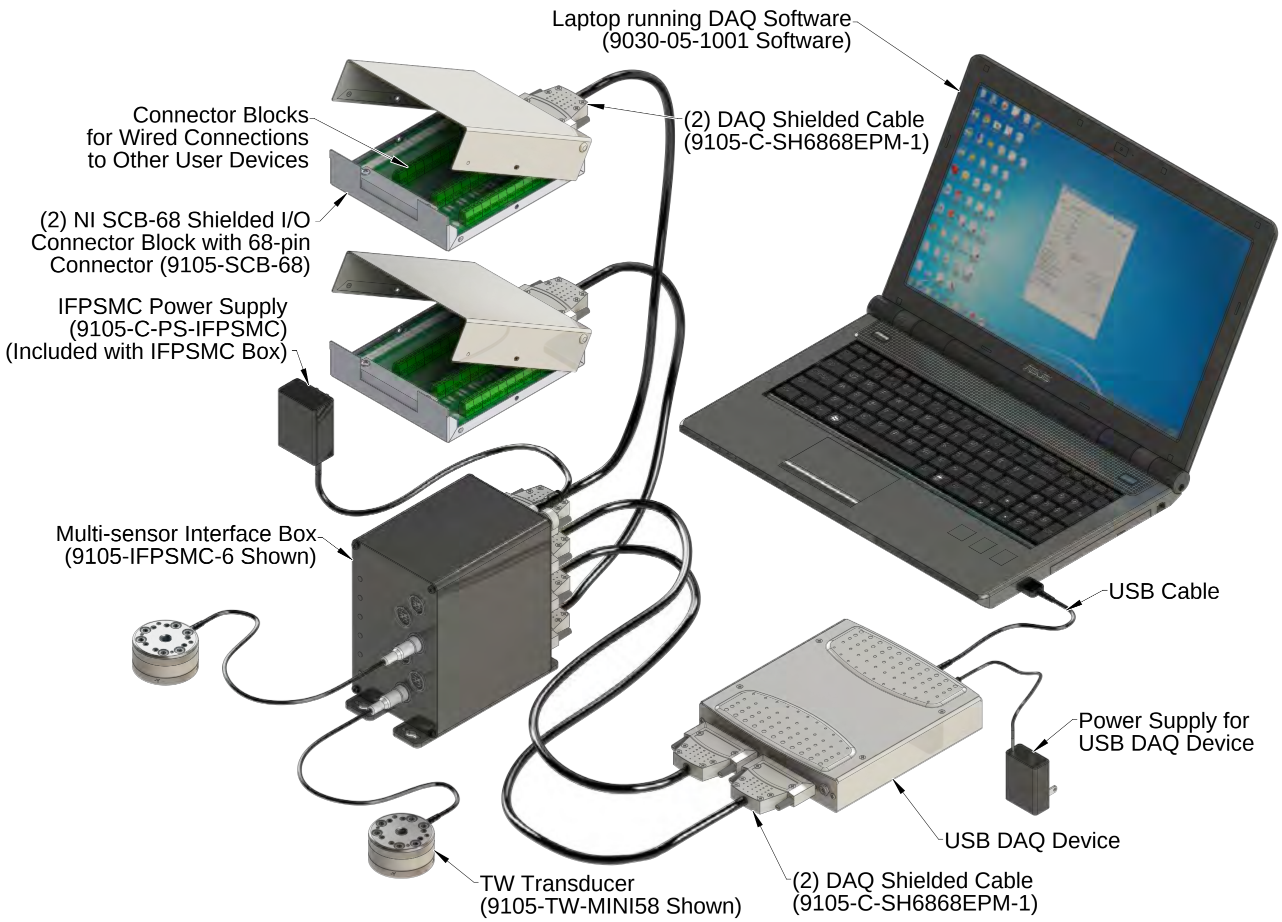


2.5 System with Multiple Transducers, IFPSMC Box, Wired I/O Connections for User Devices, and USB DAQ Device

A Multiple Transducer system may consist of the following components:

- Up to six TW Transducers
- Multi-sensor Interface Box (Multiple IFPS)
- Data Acquisition (DAQ) Device
- DAQ Software, running on a laptop or desktop
- Supporting power supplies for DAQ device or Multiple IFPS
  (Power supply included with Multiple IFPS)
- USB cable from USB DAQ device to PC
- DAQ Cables from Multi-sensor Interface box (IFPSMC) to I/O connector Blocks and DAQ device

Figure 2.5—System with Multiple Transducers, IFPSMC Box, Wired I/O Connections and DAQ Device

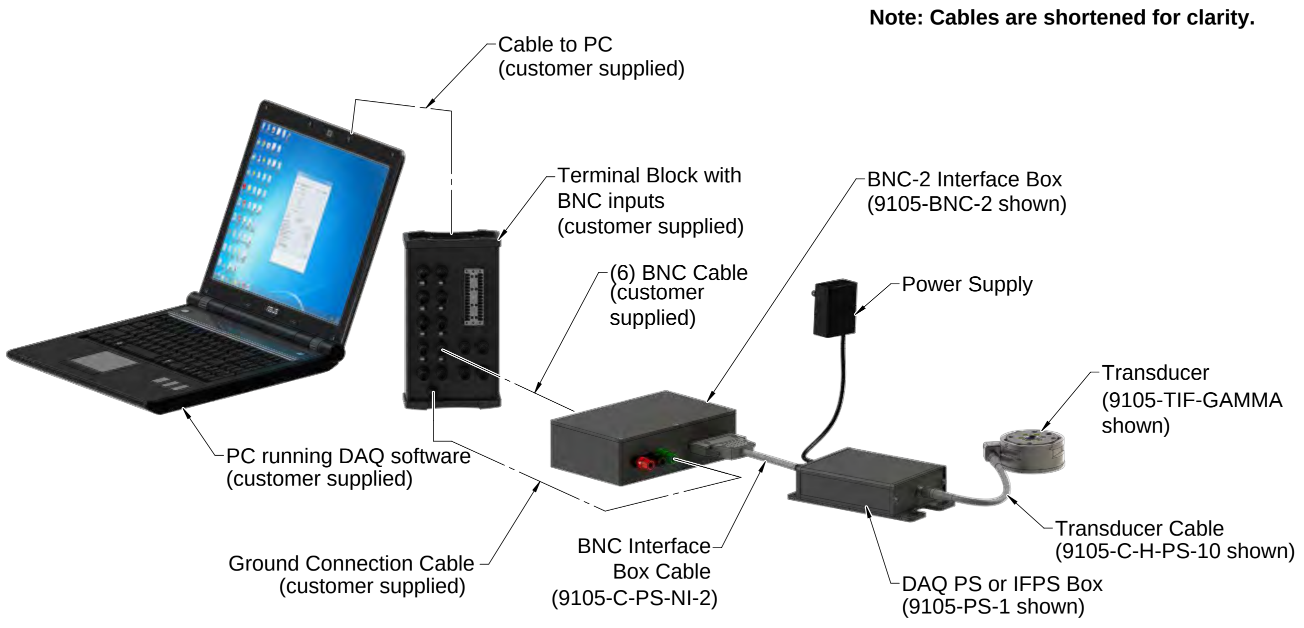


2.6 System with BNC Interface Box

A system may consist of the following components:

- Transducer
- Power supply
- BNC interface box (refer to *Figure 2.15*)
- DAQ device with multiple BNC imputs (customer supplied)
- PC (customer supplied)
- DAQ software, running on a laptop or desktop
- Transducer cable
- BNC interface box cable
- Cables from the BNC interface box to BNC input connectors on customer supplied DAQ device (customer supplied)
- Cables from the DAQ device to the PC (customer supplied)

Figure 2.6—System with BNC Interface Box



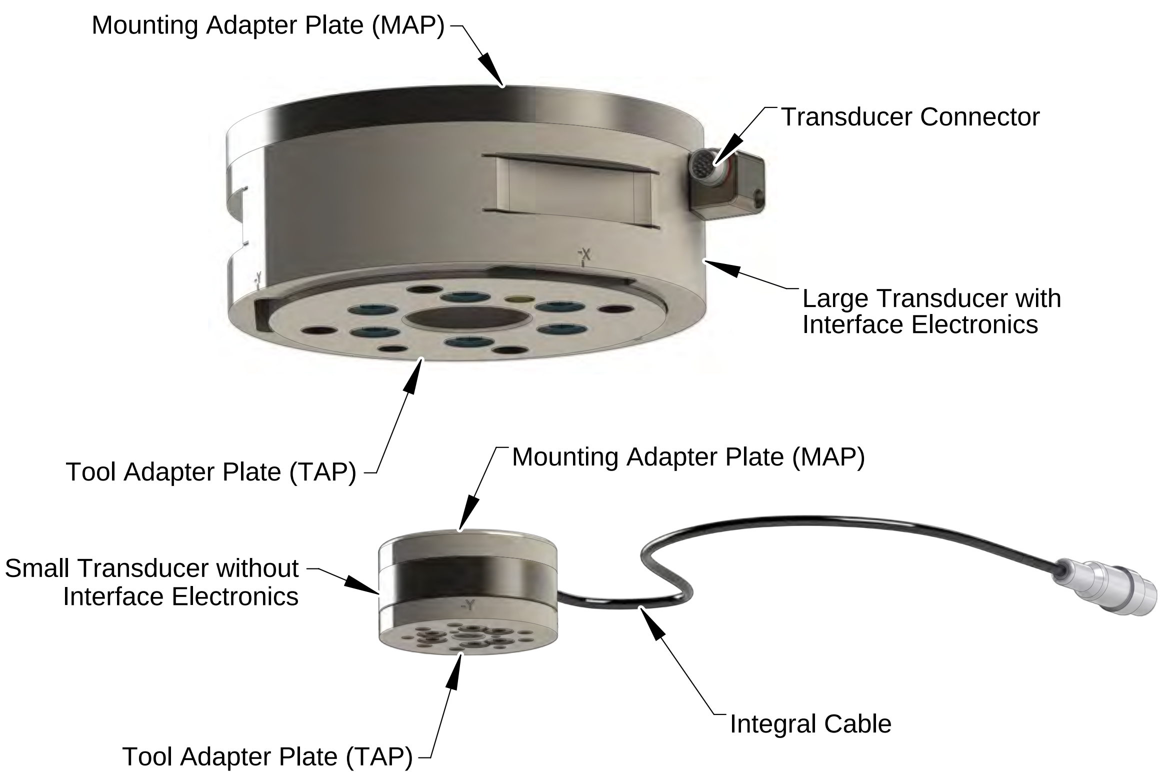
2.7 Transducer

The transducer is a compact, durable, monolithic structure that converts force and torque into analog strain gage signals. The transducer is commonly used as a wrist sensor mounted between a robot and a robot end-effector. Transducers with a standard tool adapter are shown in *Figure 2.7*.

Large Gamma, Delta, Theta, and Omega transducers have integrated interface electronics and require a separate cable to connect to a power supply box. Small Nano and Mini transducers do not have integrated interface electronics but have an integrated cable to connect to an interface power supply box

For information on mounting, cable routing, and specifications (for example: resolution and weight), refer to the *9620-05-Transducer Section* manual. Drawings are available on the ATI website. For a full list of transducer models and links to their web pages, refer to *https://www.ati-ia.com/products/ft/ft_ModelListing.aspx*

Figure 2.7—Transducer



2.8 Transducer Cable

The high-flex life transducer cable is electrically shielded to protect transmission from the transducer Power Supply or Interface Power Supply boxes. Small transducers have the cable integrally attached. Larger transducers have a separate transducer cable, see *Figure 2.8*.

For cable routing and minimum bend radius, refer to the *9620-05-Transducer Section* manual.

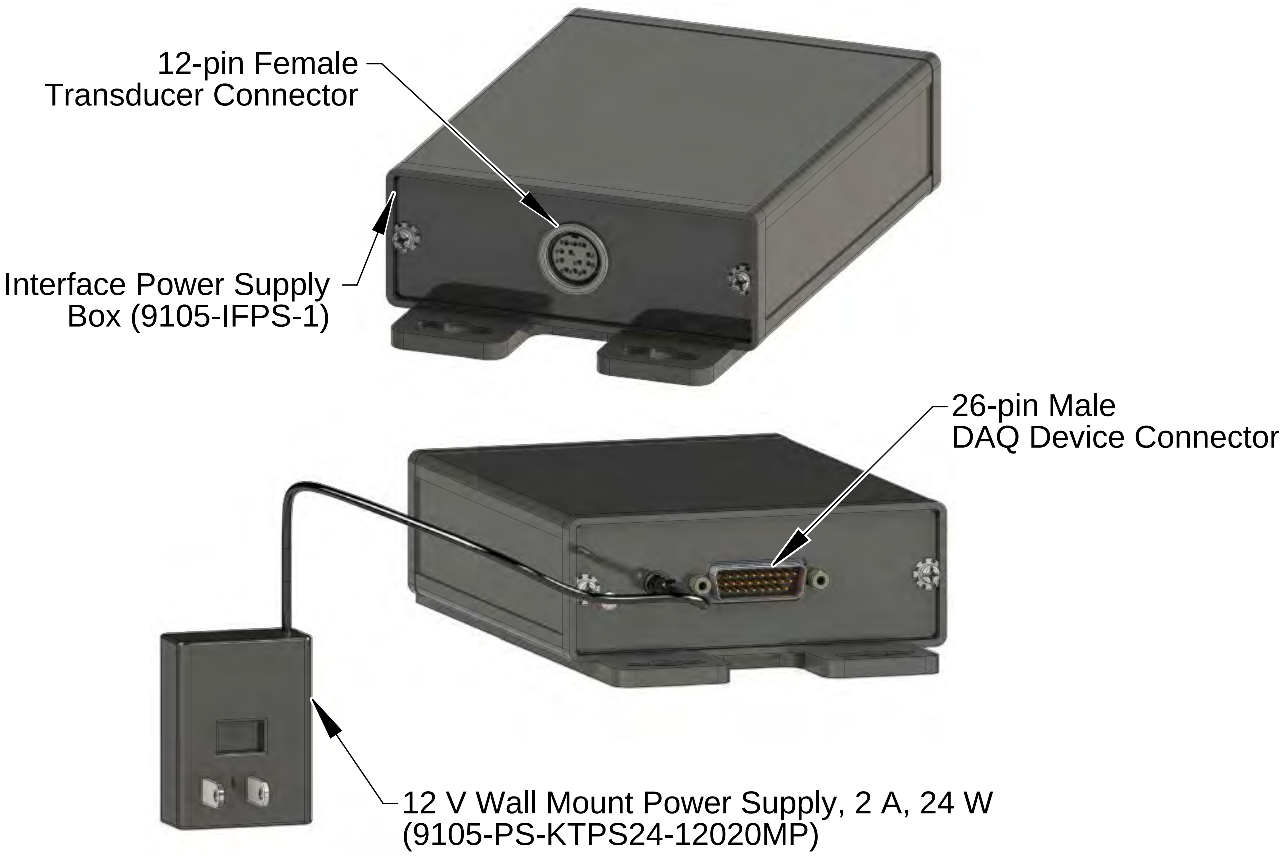
Figure 2.8—Transducer Cable for 9105-TIF Transducers

2.9 Interface Power Supply Box

The Interface Power Supply (IFPS) box is used with the small Nano and Mini transducers. The IFPS Box supplies power to the transducer and supplementary electronics; it also conditions the transducer signals utilized by the data acquisition system. For the drawing, refer to the ATI website: *https://www.ati-ia.com/products/ft/ft_literature.aspx*.

Power to the IFPS box can be provided through either the 12 V wall-mounted power supply included with the IFPS box; or a 5 V source from the DAQ device through the 26-Pin male connector located on the box. The IFPS box only requires one source; if both sources are connected, the IFPS box will use the 12 V source and the 5 V source will be ignored.

Figure 2.9—Interface Power Supply

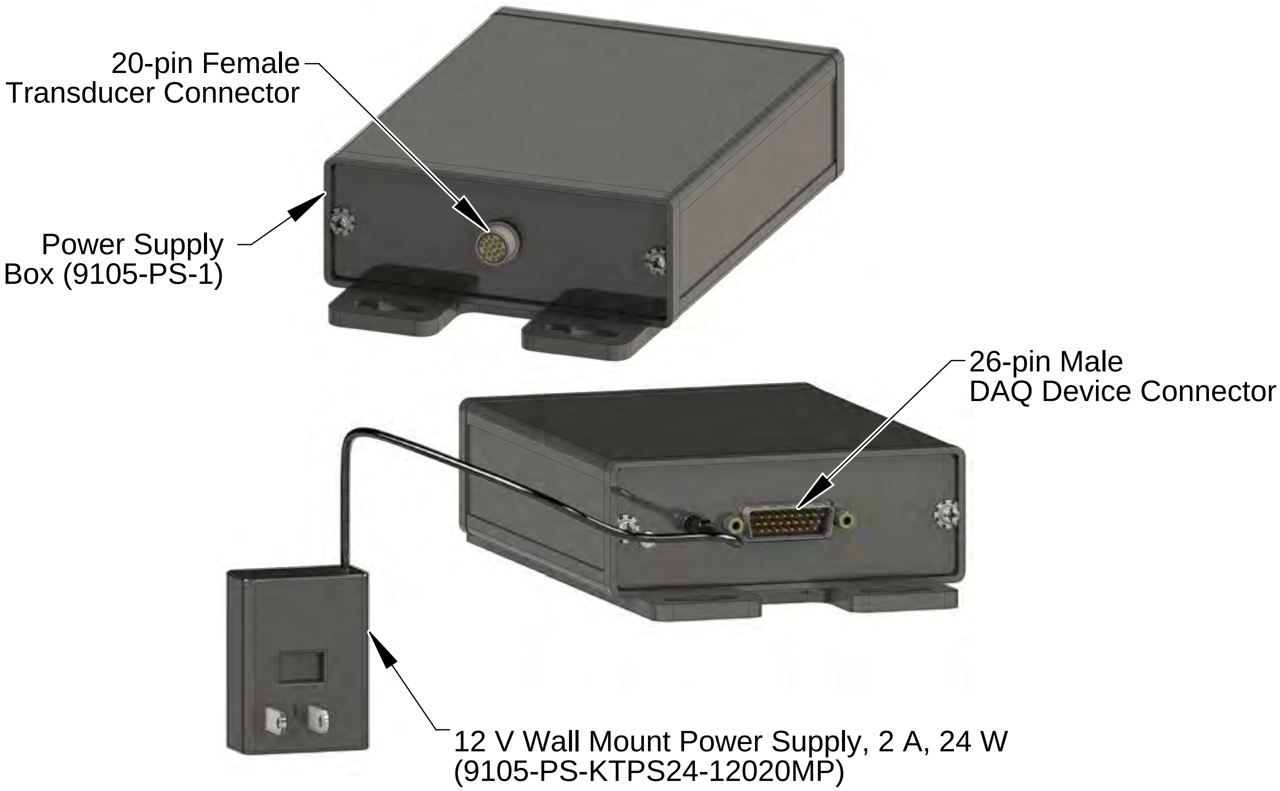


2.10 Power Supply Box

The Power Supply (PS) box is used with larger transducers that have on-board interface electronics. For the drawing, refer to the ATI website: *https://www.ati-ia.com/products/ft/ft_literature.aspx*. To connect to the transducer, the PS is equipped with a 20-Pin female connector for the transducer cable connection. A 12 V wall-mounted power supply is included with the PS box. The PS box can be powered using the power supply cable from the DAQ device. A 26-pin male connector provides the interface to the DAQ Device.

Power to the PS box can be provided through either the 12 V wall-mounted power supply included with the PS box; or a 5 V source to the 26-Pin male connector located on the box. The PS box only requires one source; if both sources are connected, the PS box will use the 12 V source and the 5 V source will be ignored.

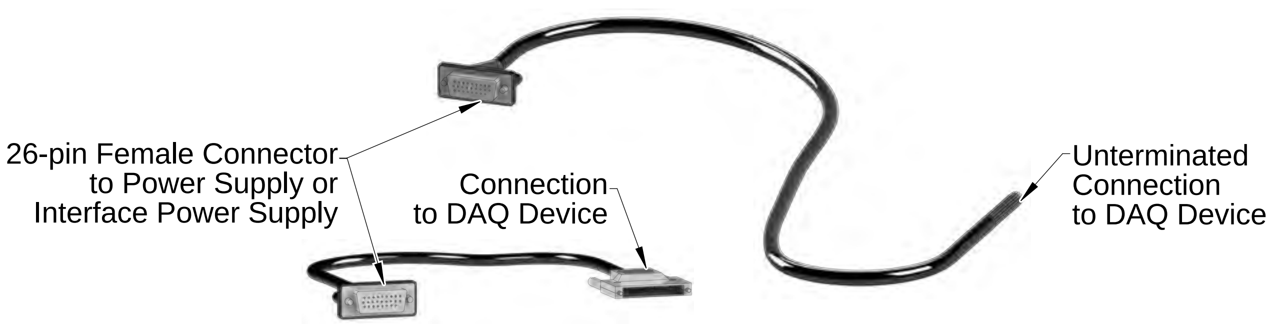
Figure 2.10—Power Supply



2.11 Power Supply Cable

The power supply cable connects the Power Supply box or Interface Power Supply box to the DAQ Device or DAQ card. This cable usually has a connector on the data acquisition end but is also available unterminated.

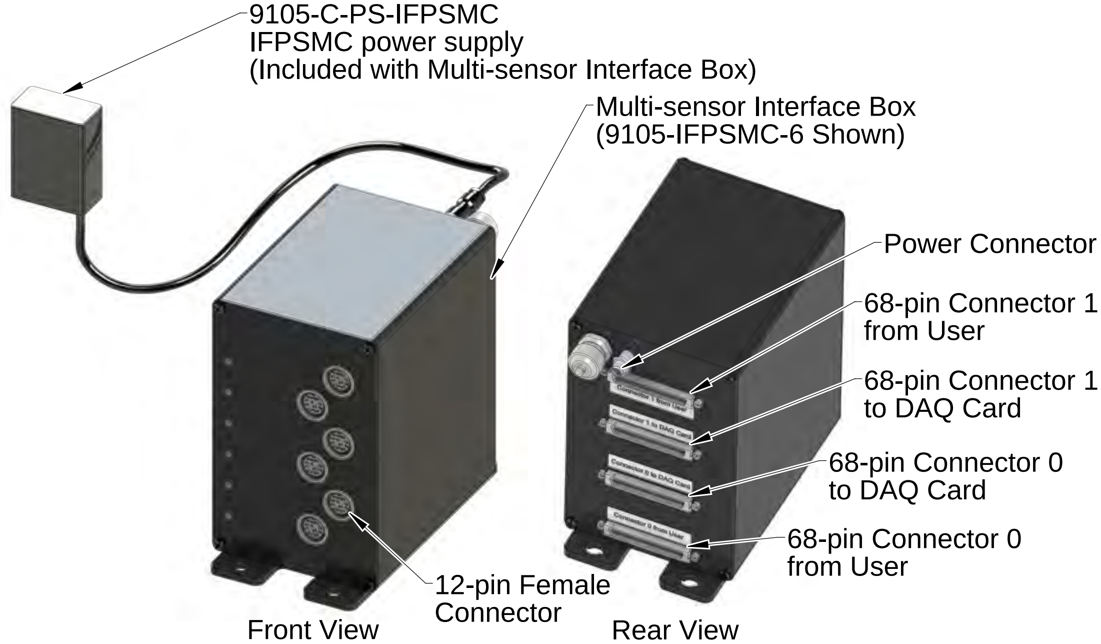
Figure 2.11—Power Supply Cables



2.12 Multiple IFPSMC Boxes

Multiple-IFPSMC boxes allow for multiple transducers to be connected to one or two data acquisition cards. For the drawing, refer to the ATI website: *https://www.ati-ia.com/products/ft/ft_literature.aspx*. In cases where numerous transducers are utilized, a pair of data acquisition cards may be necessary.

Figure 2.12—A Multiple 9105-IFPSMC Box



The Multiple-IFPS box connects to the supplied data acquisition card using standard cabling. The power connection and all data acquisition cabling are located on the back of the box. Connections to the 9105-TW-type transducers are located at the front of the box. The box also features slotted mounting feet for ease in mounting it to a surface. An external wall-mounted power supply is included with the box.

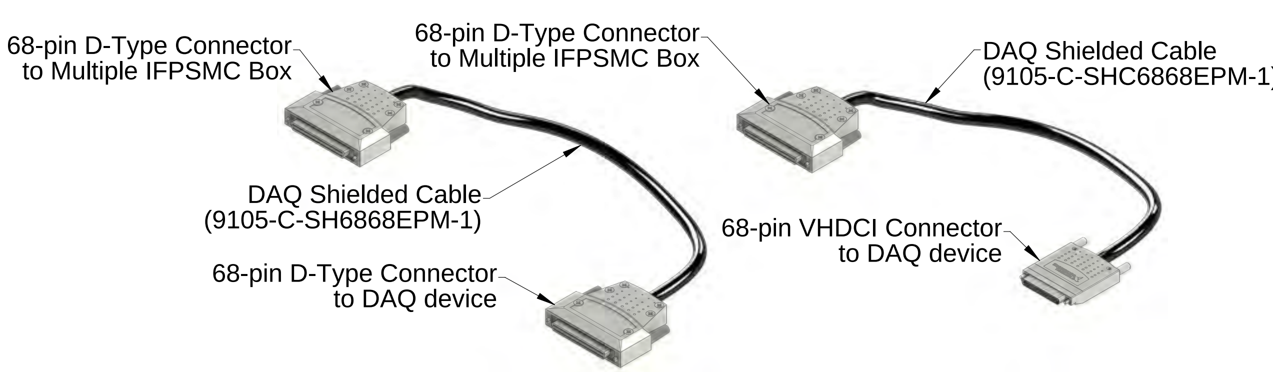
NOTICE: Like the standard DAQ F/T systems, the transducer signals from the multiple-IFPS box are configured for differential input channels.

NOTICE: The ATI demo software and National Instruments driver require a scan list that indicates which channels are used for a transducer. For example, a 9105-IFPSMC-3 connected to the DAQ card dev1 would require the scan list dev1/ai18:23 to read transducer 2. The same system would use the scan list dev1/38:39,dev1/ai48:51 to read transducer 4.

2.13 DAQ Shielded Cables from Multiple IFPSMC Box to DAQ Device

The DAQ shielded cable connects the Multiple Interface Power Supply box to a DAQ Device or DAQ card.

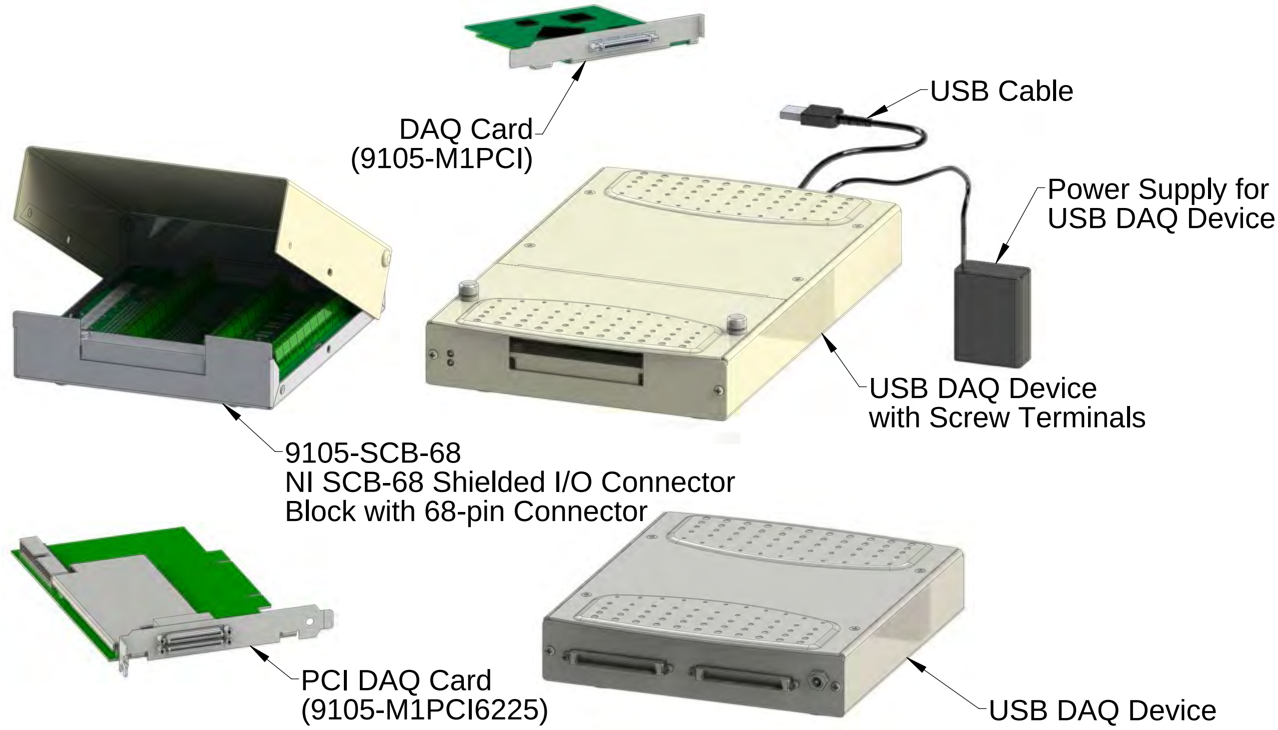
Figure 2.13—DAQ Shielded Cables



2.14 Data Acquisition System

The Data Acquisition System converts transducer signals from analog voltages into data a computer can process. Using ATI software, transducer data is converted to force and torque values. The Data Acquisition System also supplies raw power to the transducer system. A variety of Data Acquisition components are available to meet the needs of numerous applications. Contact ATI for more information.

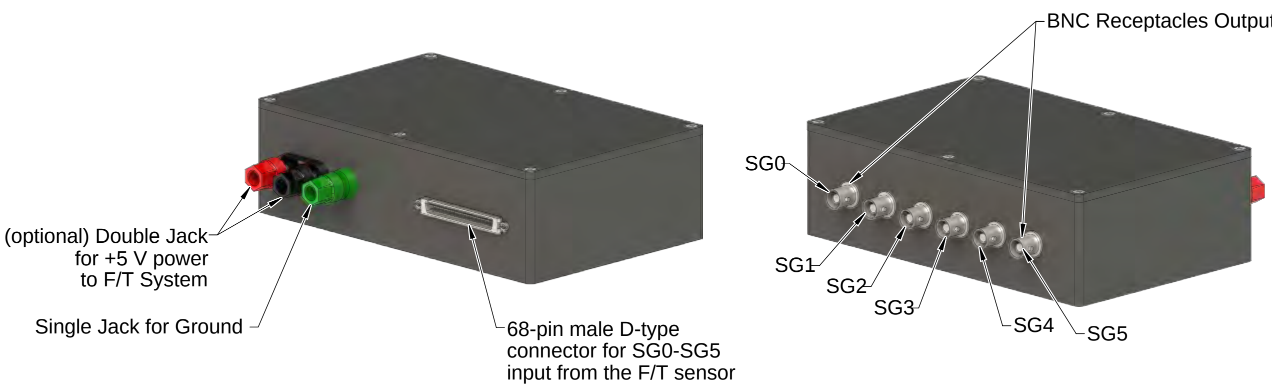
Figure 2.14—Data Acquisition System



2.15 BNC Interface Box

A BNC interface box transfers the sensor signals to a customer-supplied BNC block (refer to *Figure 2.6*). Connections on the box are described in the following figure:

Figure 2.15—BNC Interface Box



2.16 DAQ System Software Overview

Upon shipment of the product, ATI sends the customer a zip file that contains the software and calibration data needed to convert transducer data into F/T measurements or output. Included in the file are Microsoft Windows drivers, sample programs, C source code, and detailed help files. Download the most recent release of the DAQ software at *https://www.ati-ia.com/Products/ft/software/daq_software.aspx*.

> **NOTICE:** The DAQ system file sent via email to the customer included with the DAQ system contains extensive help files on the software that benefits both the beginner and the advanced user. The file includes a spreadsheet to help advanced users with calculations. For more information, refer to the *Advanced Techniques* section in the help file.

For more information about the DAQ system software, refer to *Section 3.4—ATI DAQ Software*.

2.17 Interface Plates

Larger transducers come with a standard mounting adapter to mechanically attach the transducer to the robot arm or apparatus that will be applying the force. The transducer also has a standard tool adapter with an ISO 9409-1 interface for Gamma, Delta, and Theta models..

The mounting adapter consists of:

- Mounting adapter plate
- Mounting screws

For further information, refer to the *9620-05-Transducer Section* manual for specifications (i.e., resolution, weight). Drawings are available on the ATI website. For a list of transducer models and links to their web pages, refer to: *https://www.ati-ia.com/products/ft/ft_ModelListing.aspx*

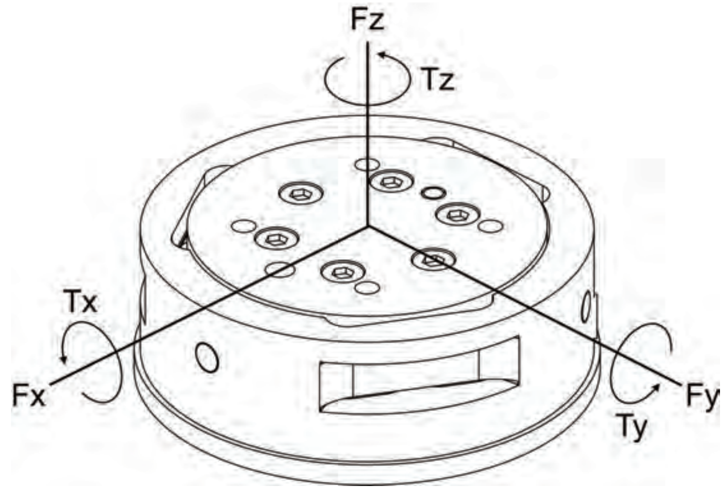
3. System Functionality

This section provides a functional outline of the F/T system. The F/T system is broken into four areas: Mechanical, Electrical, Load Calculations, and ATI DAQ Software.

3.1 Mechanical Description

The transducer responds to applied forces and torque in accordance with Newton's third law which states: For every action there is always an opposed or equal reaction; or, the mutual action of two bodies upon each other are always equal, and directed to contrary parts.

Figure 3.1—Applied Force and Torque Vector on Transducer



The force applied to the transducer flexes three symmetrically placed beams using Hooke's law:

$s = E \cdot e$

s = Stress applied to the beam (s is proportional to force)

E = Elasticity modulus of the beam

e = Strain applied to the beam

NOTICE: The transducer is a monolithic structure. The beams are machined from a solid piece of metal. This decreases hysteresis and increases the strength and repeatability of the structure.

Semiconductor strain gages are attached to the beams and act as strain-sensitive resistors. The resistance of the strain gage changes as a function of the applied strain as follows:

$\Delta R = S_a \cdot R_o \cdot e$

ΔR = Change in resistance of strain gage

S_a = Gage factor of strain gage

R_o = Resistance of strain gage unstrained

e = Strain applied to strain gage

3.2 Electronic Hardware

The electronic hardware measures changes in resistance; the software described in *Section 3.4—ATI DAQ Software*, converts the changes to force and torque components.

Figure 3.2 and *Figure 3.3* depict an example of the electronic hardware used in a DAQ system. The figures also illustrate how the transducer's voltage signal, created as a response to applied forces and torques are processed and routed to the DAQ card for conversion to usable force and torque data.

Figure 3.2—Electronic Hardware Outline Power supplied Through Data Acquisition Hardware

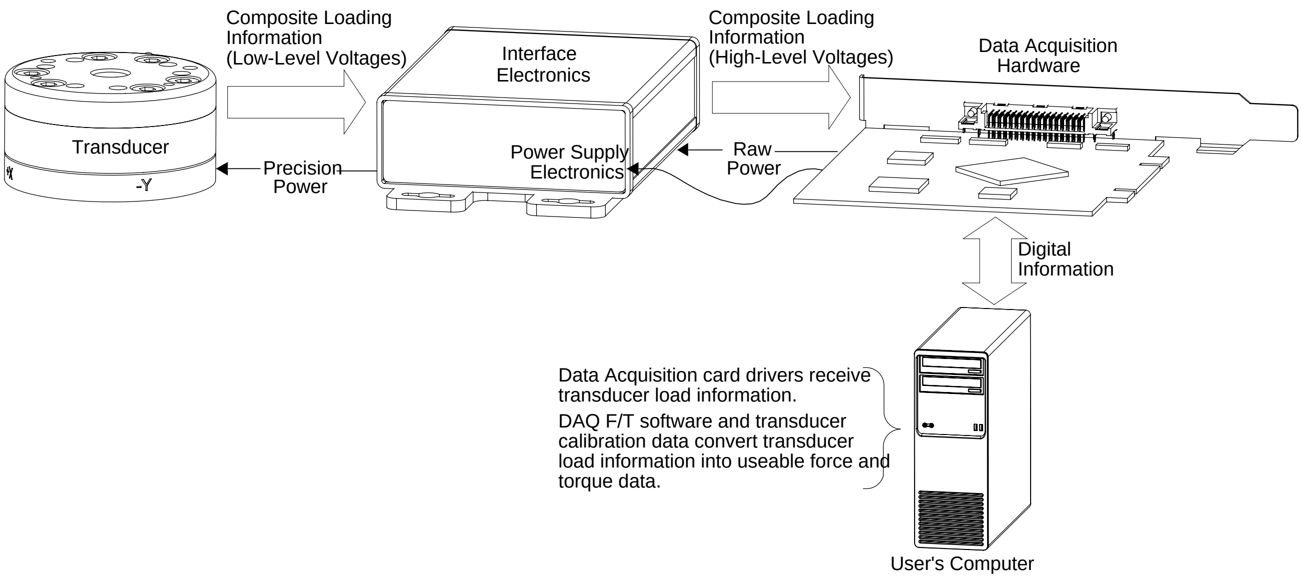
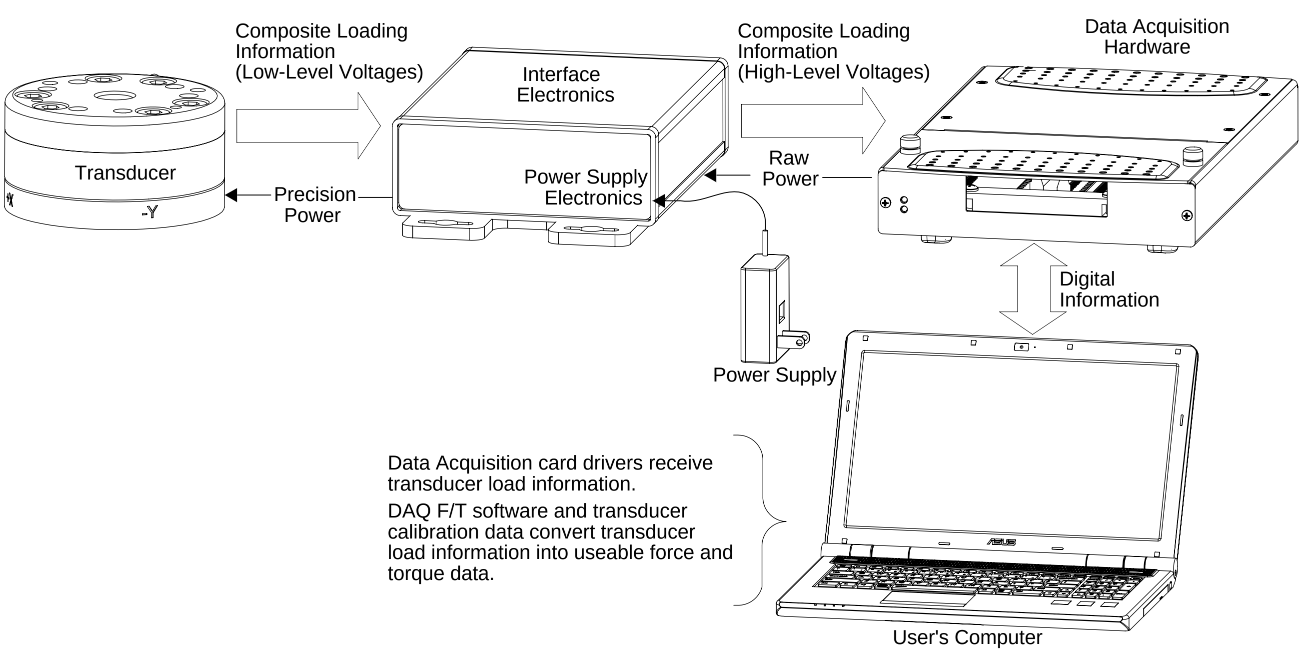


Figure 3.3—Electronic Hardware Outline Power supplied by Separate Power Supply

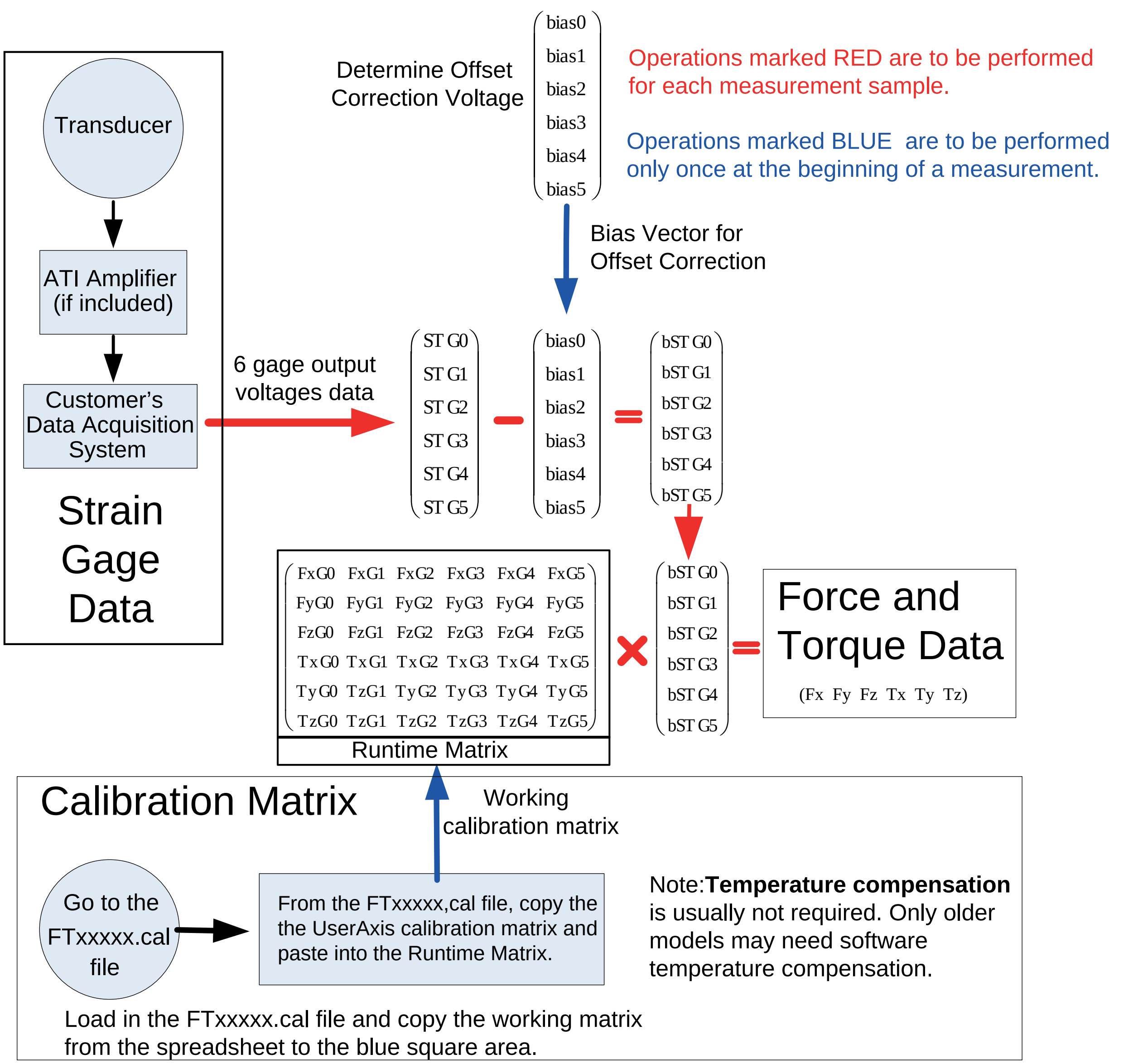


3.3 Load Calculation

Calculations must be performed to derive the loads sensed at the transducer. The transducer reports the loads as composite values that require conversion to values corresponding to the six Cartesian axes. ATI supplies software to perform these calculations. Both the software and the transducer's calibration values can be accessed from the media that accompanies the transducer. *Figure 3.4* shows the calculation required to convert strain gage data into force and torque data. This method can be used in Matlab, or through other software that enables manual matrix calculations.

NOTICE: The software zip folder included with the DAQ system contains extensive help files on its software that will benefit both the beginner and advanced user. The folder also includes a spreadsheet to help advanced users with calculations, see the Advanced Techniques section of the help file for more information.

Figure 3.4—FT Matrix Calculations



Note: An alternative to using the software to complere this calculation, the DAQ FT Manual Calibration.xml spreadsheet file can be used to generate the working matrix.

3.3.1 Strain Gage Data

Strain gage data represents amplified voltages from the transducers that are converted to digital data by the Data Acquisition system. Use the demo program to monitor the strain gage data during installation. Monitoring can be used to avoid saturation errors which can damage the transducer.

3.3.2 Offset Correction

Offset correction is a bias vector that zeros out the force and torque data compensating for the weight of tooling or variation in room temperature. For an example without offset correction the tooling weight is seen as a force data on the transducer, using offset correction the force from the weight of the tool will be zeroed out.

3.3.3 Calibration Matrix

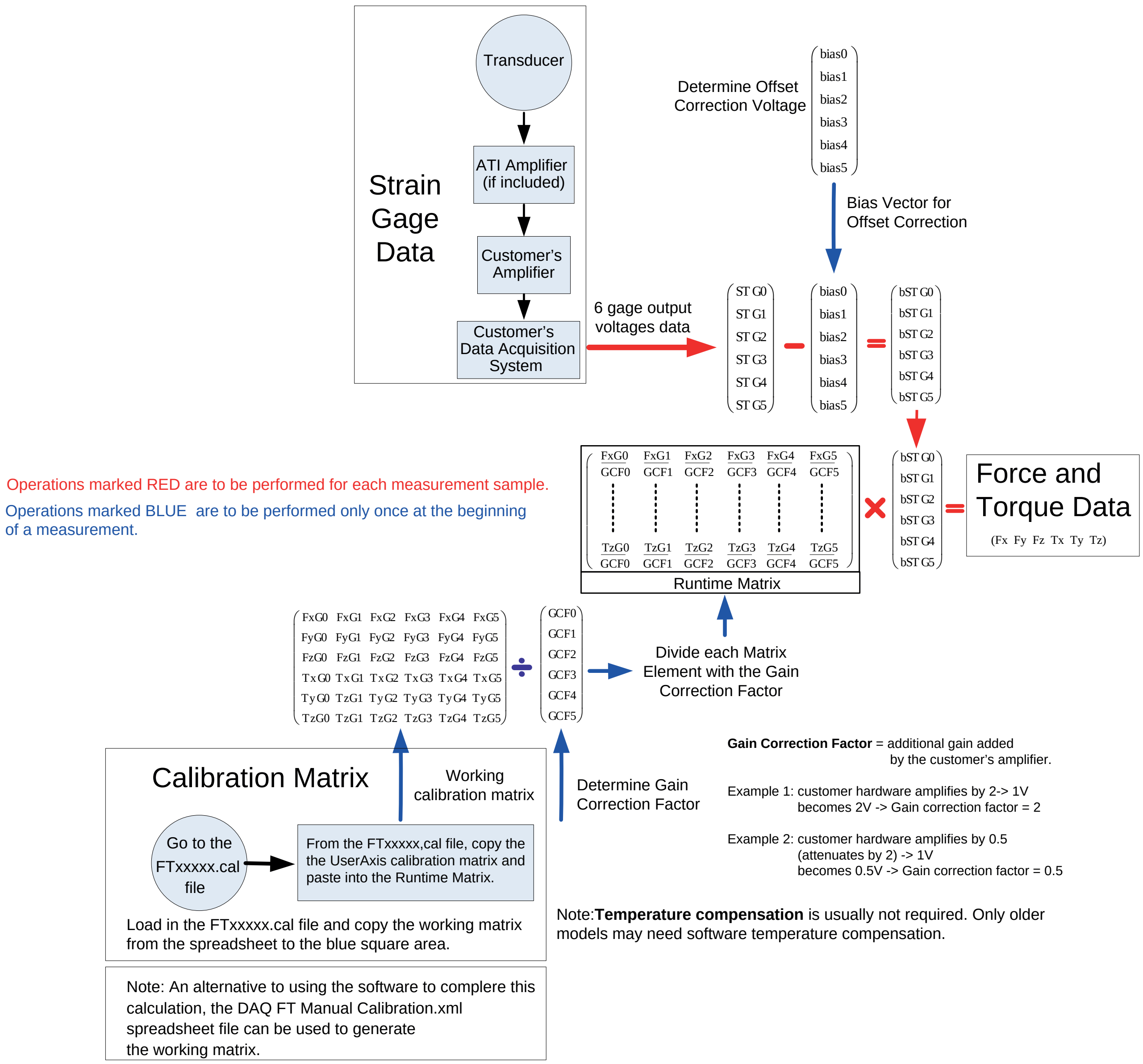
The calibration matrix is the transducer calibration matrix provided on the software zip folder from ATI. The ATI supplied six-by-six calibration matrix matches the sensor's FTxxxxx serial number in either the ATI software or the customer software. This standard matrix when multiplied by the biased strain gage data being generated from the transducer provides the force and torque data that can be used for the application.

NOTICE: There is not a 1:1 correlation between the six gage outputs (SG0 to SG5) and the six F/T measurements (Fx, Fy, Fz, Tx, Ty, and Tz), for example: SG0 does not equal Fx.

3.3.4 Gain Correction Factor

Gain correction factor is only required when a customer amplifier is being used. The gain correction factor is used to correct for the customer amplification. Each matrix element is divided by the gain correction factor to determine the runtime matrix. The calculations required to convert the strain gage data with customer amplifier gain correction into force and torque data is shown in *Figure 3.5*.

Figure 3.5—FT Matrix Calculations with Customer Amplifier Gain Correction Factor



3.4 ATI DAQ Software

The computer with the F/T system's data acquisition card installed or data acquisition device attached, converts the strain gage data into useful force and torque values. The ATI DAQ software provides a user interface for viewing and editing (or providing controls) the data values.

The ATI DAQ F/T Software files contain reusable software components to build an application and sample applications to get started. (Unless otherwise noted, all Windows components and applications support Windows XP, Vista, 2007, 2008, and 2010).

NOTICE: The ATI DAQ F/T software files contain extensive documentation about the software. File updates can be found at: *https://www.ati-ia.com/Products/ft/software/daq_software.aspx*.

3.4.1 Reusable Software Components

3.4.1.1 ATI DAQ FT Automation Server

This Windows ActiveX component reads calibration files, configures the transducer system, and converts raw voltages from any data acquisition system into forces and torques. ATI DAQ FT can be used in development platforms that support ActiveX or Automation containment, for example: Microsoft Visual Basic 6.0, Microsoft Visual C++, Microsoft.NET Platform, and National Instruments LabVIEW. Its programming API is documented in the ATI DAQ FT help files.

3.4.1.2 C Library

This code library uses standard ANSI C to read calibration files, configure the transducer system, and convert voltage data from any data acquisition system into forces and torques.

3.4.2 Sample Applications

3.4.2.1 Windows Demo (Visual Basic 6.0)

This executable program is a good place to try out a new transducer system in Windows. It uses National Instruments software and ATIDAQFT to give a real-time display of F/T data from National Instruments devices. It provides complete options for configuration of the F/T system. Microsoft Visual Basic 6.0 source is included. With the IFPSMC system, only one transducer can be viewed at a time with the correct scan list used.

3.4.2.2 LabVIEW Sample

This is a demo application in LabVIEW using the ATIDAQFT Automation server and the Analog Input VIs provided by NI-DAQ. This sample application provides a real-time display of F/T data.

3.4.3 Designing a Customized DAQ F/T Application

A DAQ F/T application must include at least two components:

3.4.3.1 Device Drivers for a DAQ Device and Target Operating System

National Instruments includes several sets of Windows device drivers with their data acquisition devices, including 32-bit DLLs, LabVIEW VIs, and ActiveX controls. Non-Windows device drivers for National Instruments systems may be available from third-party sources. For other brands of data acquisition devices, device drivers must be obtained from the device manufacturer or a third-party source.

3.4.3.2 ATI DAQ F/T Components or C Library

This part of an application is used to load a calibration file, apply settings such as tool transformations, and convert raw voltages into forces and torques. For Windows applications, the ATI DAQ FT Automation server is recommended. The conversion to forces and torques can occur in real time, or can be applied as a batch operation at the end of the acquisition operation.

In some applications, using the ATI DAQ FT component to process data is impractical. This could be due to client applications or operating systems that do not support ActiveX, or very high-speed real-time performance requirements. In these cases, ATI DAQ FT can be used during configuration stages but need not be present in the final application. For more information, see the ATI DAQ FT Component Reference/Designing Your Application/ Advanced Techniques section of the ATI DAQ FT help file.

4. Installation

Before installing the transducer on the robot, install the DAQ system components, and install the software on the computer connected to the DAQ system. After testing the transducer and DAQ system to check its functionality, the transducer can be installed on the robot. The ATI DAQ Demo Software can be used to monitor forces, torques and strain gages on the transducer during installation to the robot.

The following sections provide instruction for installing some typical DAQ Systems:

Section 4.1—Installing a DAQ System with a Transducer, IFPS or PS Box, and DAQ Device

Section 4.2—Installing a DAQ System with Multiple Transducers, IFPSMC Box, and DAQ Device

Section 4.3—Installing a DAQ System with Multiple Transducers, IFPSMC Box, Wired I/O Connections, and USB DAQ Device

4.1 Installing a DAQ System with a Transducer, IFPS or PS Box, and DAQ Device

Typically DAQ systems are limited to a single transducer, PS or IFPS box. DAQ devices with 64-pin screw terminals can support two transducers and two PS or IFPS boxes. For additional screw terminal connections required, refer to *Table 4.1*.

1. Install the data acquisition system hardware (DAQ card, DAQ Device, power supply, and/or cabling) and its accompanying software following the instructions included with the hardware.
2. Connect the 26-pin connector of the power supply cable to the DAQ Power Supply (PS) or Interface Power Supply (IFPS) box. Tighten the jackscrews on the connector to ensure a strong electrical connection.

CAUTION: When connected to power, do not touch the 26-pin connector or any unterminated cables. Contact with the connector or cables creates high risk for an ESD event. Always use ESD control methods when performing assembly/configuration.

Figure 4.1—Single TW Transducer, IFPS, and DAQ Card System Installation

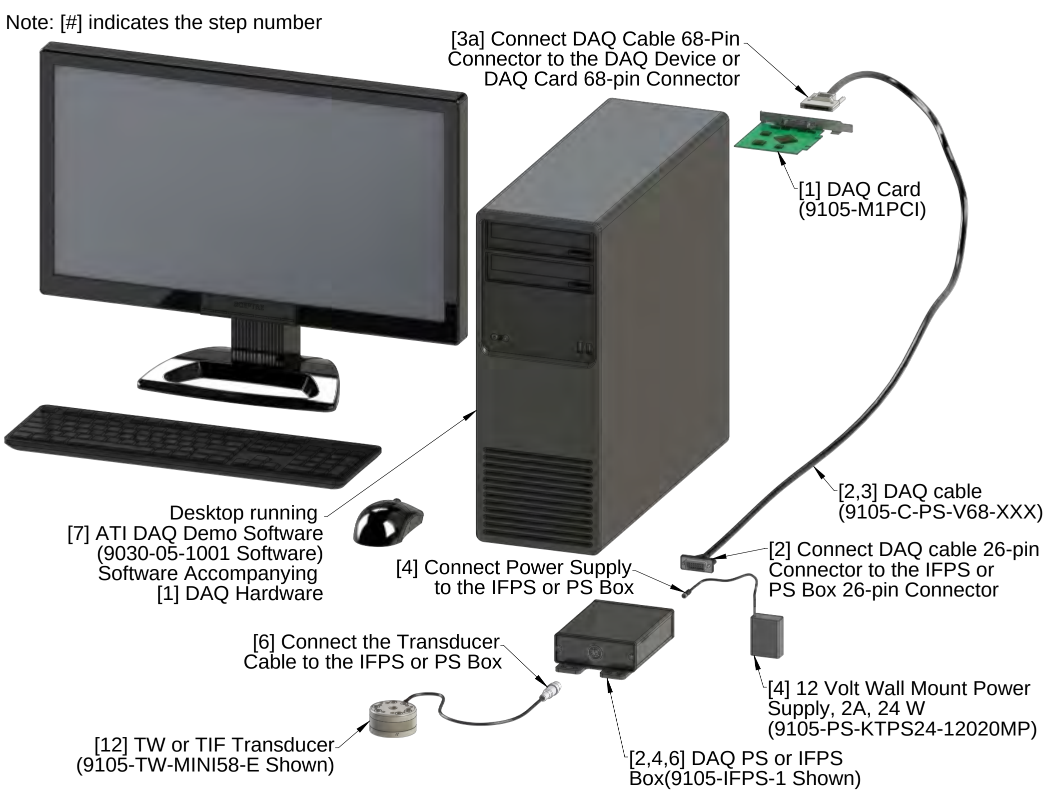
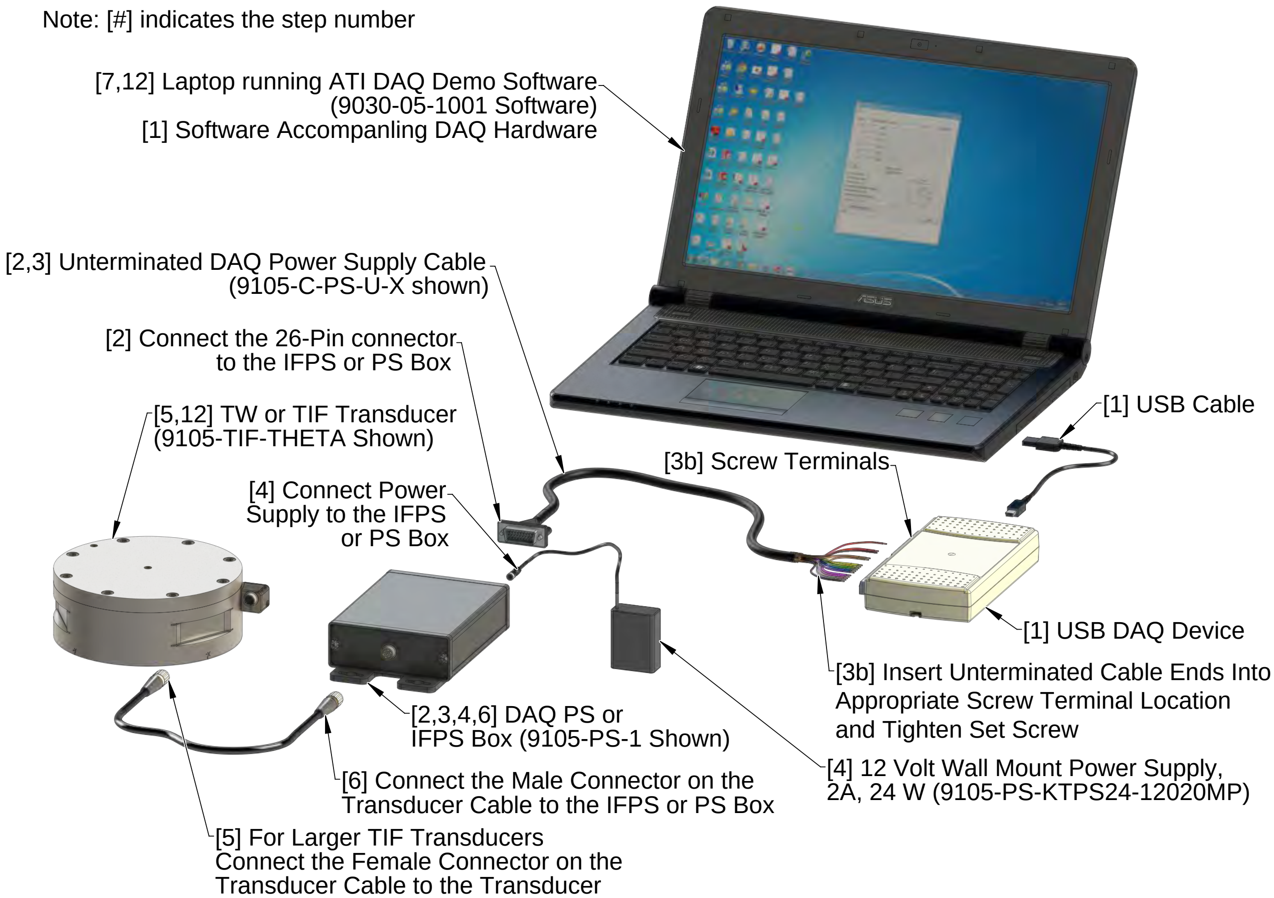


Figure 4.2—Single TIF Transducer, PS, and USB DAQ Device System Installation

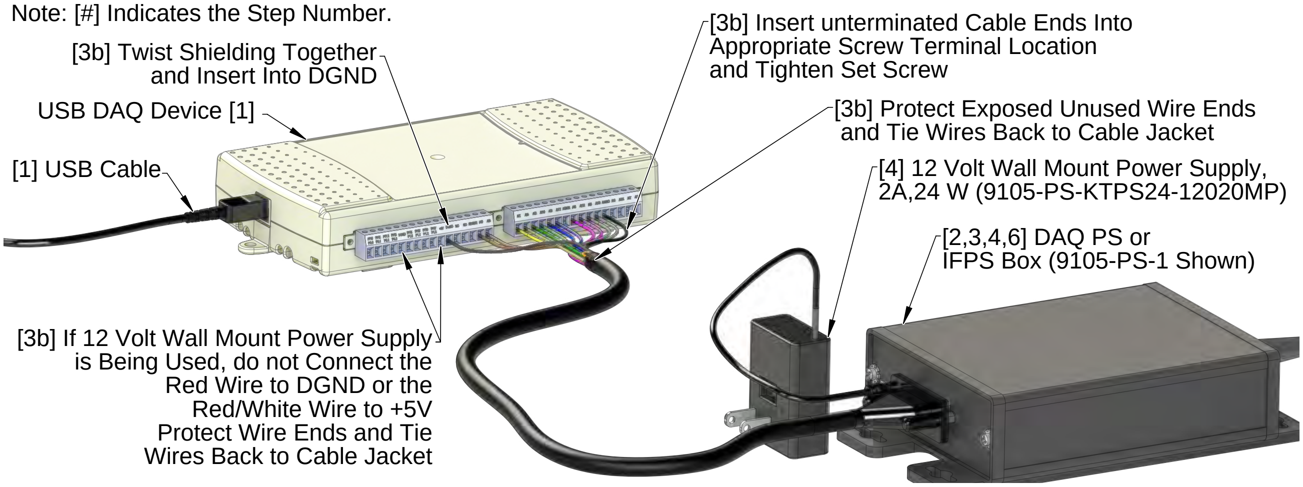


3. Depending on the DAQ Device and power cable being installed, one of the following connection methods may be applied:

- If the Power Supply cable is equipped with a 68-pin connector, attach the connector to the NI DAQ Card or DAQ device and tighten the jackscrews on the connector to ensure a good electrical connection.
- If the Power Supply cable has an unterminated end, insert the unterminated wires into the desired screw terminals on the DAQ device and tighten the set screw to ensure good connection. Protect exposed unused wire ends by tying them back to cable jacket. Refer to *Figure 4.3, Figure 4.4,* and *Table 4.1.*

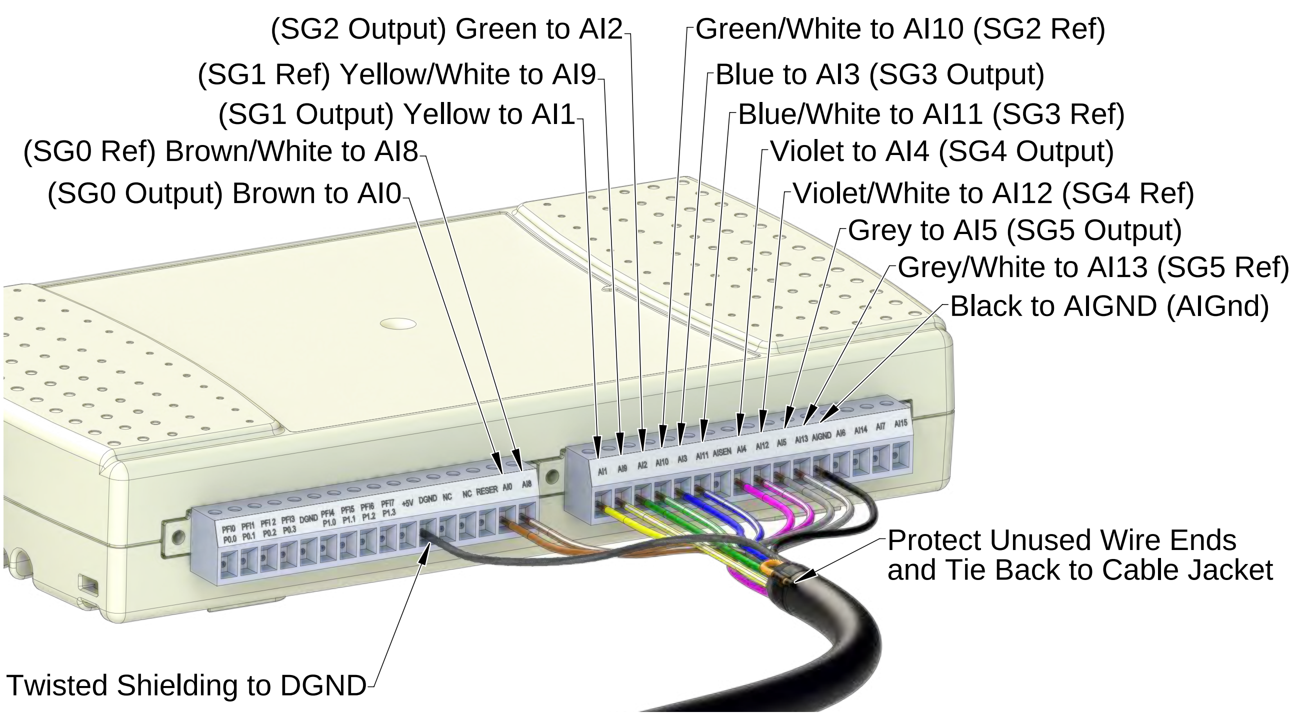
NOTICE: A National Instruments DAQ Device with 64-pin screw terminals such as a USB-6218 can support system with two transducers and two PS or IFPS boxes. Refer to *Table 4.1* for wiring connections.

Figure 4.3—Unterminated Cable Wiring (9105-C-PS-U-x) and USB DAQ Device System Installation



NOTICE: If a National Instruments DAQ board with mass termination is not used, users must provide a connector at that end of the cable. See *Section 4.5—Electrical Connection Information* for connection information.

Figure 4.4—Unterminated Cable Wiring (9105-C-PS-U-x) for a NI 32 Screw Terminal USB DAQ Device



NOTICE: When installing the BNC interface box to the customer supplied DAQ BNC (refer to *Figure 2.6* and *Figure 2.15*), verify that the BNC interface box outputs to the DAQ BNC inputs are in order (SG0 to SG5).

Table 4.1—Unterminated Cable (9105-C-PS-U-x) for a NI 32 and 64 Pin Screw Terminal DAQ Device

NI 32 or 64 Pin # and Screw Terminal Labels		Description	Wire Colors	NI 64 Pin # and Screw Terminal Labels		Description	Wire Colors
1	PFI 0/P0.0 (In)	No ATI Connection	N/A	33	PFI 8/P0.4 (In)	No ATI Connection	N/A
2	PFI 1/P0.1 (In)	No ATI Connection	N/A	34	PFI 9/P0.5 (In)	No ATI Connection	N/A
3	PFI 2/P0.2 (In)	No ATI Connection	N/A	35	PFI 10/P0.6 (In)	No ATI Connection	N/A
4	PFI 3/P0.3 (In)	No ATI Connection	N/A	36	PFI 11/P0.7 (In)	No ATI Connection	N/A
5	D GND	No ATI Connection[1]	N/A[1]	37	D GND	No ATI Connection[1]	N/A[1]
6	PFI 4/P1.0 (Out)	No ATI Connection	N/A	38	PFI 12/P1.4 (Out)	No ATI Connection	N/A
7	PFI 5/P1.1 (Out)	No ATI Connection	N/A	39	PFI 13/P1.5 (Out)	No ATI Connection	N/A
8	PFI 6/P1.2 (Out)	No ATI Connection	N/A	40	PFI 14/P1.6 (Out)	No ATI Connection	N/A
9	PFI 7/P1.3 (Out)	No ATI Connection	N/A	41	PFI 15/P1.7 (Out)	No ATI Connection	N/A
10	+5V	No ATI Connection[1]	N/A[1]	42	+5V	No ATI Connection[1]	N/A[1]
11	D GND	Shielding	Twisted shielding	43	D GND	Shielding[2]	Twisted shielding[2]
12	NC or AO 0	No ATI Connection	N/A	44	NC	No ATI Connection	N/A
13	NC or AO 1	No ATI Connection	N/A	45	NC	No ATI Connection	N/A
14	Reser or AO GND	No ATI Connection	N/A	46	AI GND	No ATI Connection	N/A
15	AI 0	SG0 output	Brown	47	AI 16	SG0 output[2]	Brown[2]
16	AI 8	SG0 reference	Brown/White	48	AI 24	SG0 reference[2]	Brown/White[2]
17	AI 1	SG1 output	Yellow	49	AI 17	SG1 output[2]	Yellow[2]
18	AI 9	SG1 reference	Yellow/White	50	AI 25	SG1 reference[2]	Yellow/White[2]
19	AI 2	SG2 output	Green	51	AI 18	SG2 output[2]	Green[2]
20	AI 10	SG2 reference	Green/White	52	AI 26	SG2 reference[2]	Green/White[2]
21	AI 3	SG3 output	Blue	53	AI 19	SG3 output[2]	Blue[2]
22	AI 11	SG3 reference	Blue/White	54	AI 27	SG3 reference[2]	Blue/White[2]
23	AI SENSE	No ATI Connection	N/A	55	AI GND	No ATI Connection	N/A
24	AI 4	SG4 output	Violet	56	AI 20	SG4 output[2]	Violet[2]
25	AI 12	SG4 reference	Violet/White	57	AI 28	SG4 reference[2]	Violet/White[2]
26	AI 5	SG5 output	Grey	58	AI 21	SG5 output[2]	Grey[2]
27	AI 13	SG5 reference	Grey/White	59	AI 29	SG5 reference[2]	Grey/White[2]
28	AI GND	AGnd power input	Black	60	AI GND	AI GND[2]	Black[2]
29	AI 6	No ATI Connection	N/A	61	AI 22	No ATI Connection	N/A
30	AI 14	No ATI Connection	N/A	62	AI 30	No ATI Connection	N/A
31	AI 7	No ATI Connection	N/A	63	AI 23	No ATI Connection	N/A
32	AI 15	No ATI Connection	N/A	64	AI 31	No ATI Connection	N/A

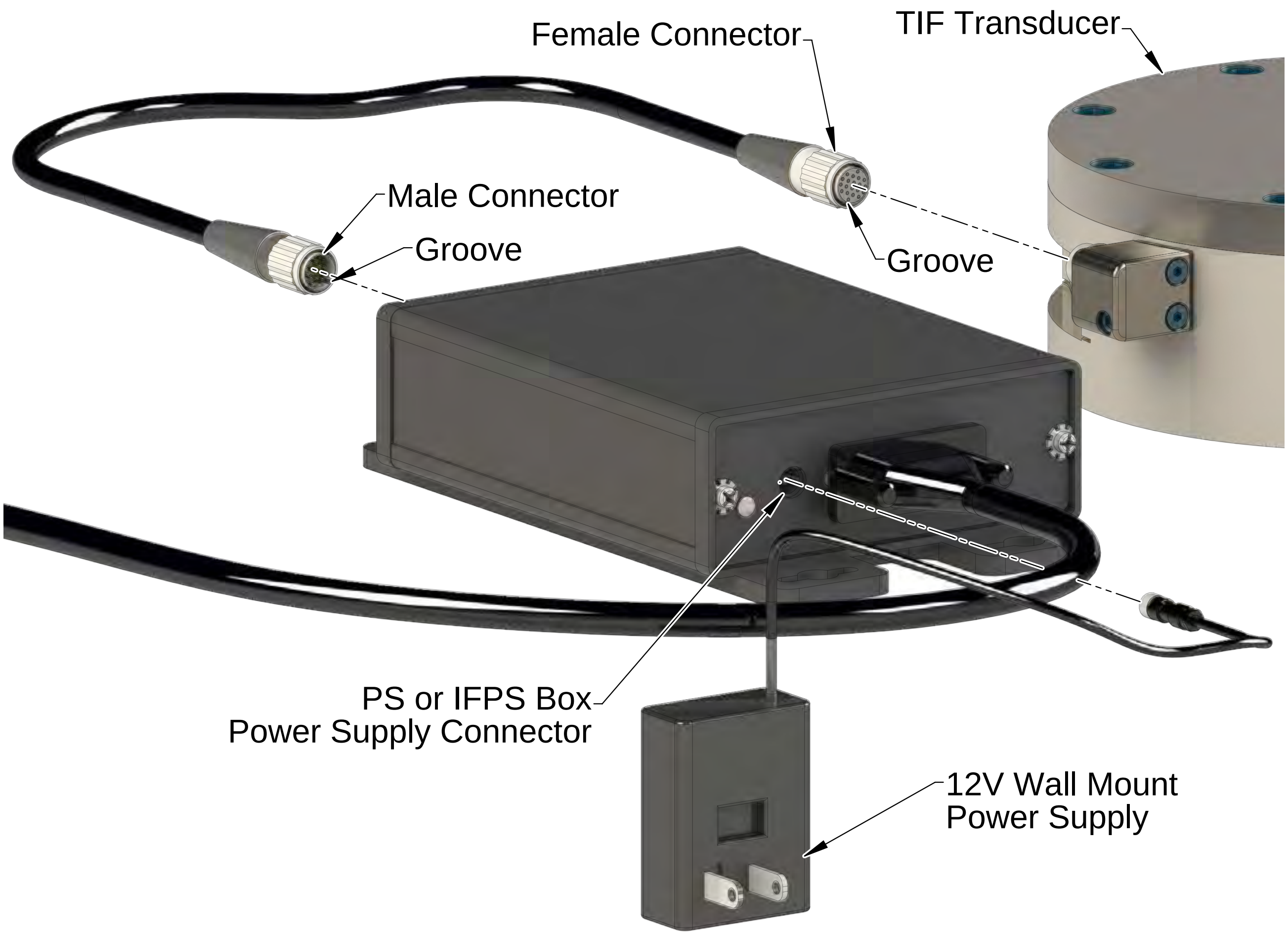
Notes: (Note # shown in table as superscript)

1. Do not connect the (+5 V) red wire and the power ground (DGND) red/white wire on systems that have PS or IFPS boxes with a 12 V wall mounted power supply. The (+5V) red wire and the power ground (DGND) red/white wire are only required for systems that do not have a separate wall mounted power supply. Connect to external power source, not the +5 V through the USB.
2. Indicates the wired connection for the 2nd transducer and PS or IFPS box for NI 64-pin screw terminal connections only.

3. If equipped, plug 12 volt wall mount power supply into outlet and connect the power supply cable to the PS or IFPS box.
4. For larger TIF transducers, connect the female connector on the transducer cable to the transducer.
   a. Line up the groove on the connector to the key in the port by rotating the connector while lightly forcing the connector into the port. When the groove lines up, the connector will noticeably go deeper into the port.
   b. Screw the connector shell into the transducer until it seats firmly.

CAUTION: Cables on the Nano and Mini transducers are permanently attached to the transducer and cannot be disconnected. Do not attempt to disassemble these transducers as damage will occur.

Figure 4.5—Transducer Connector

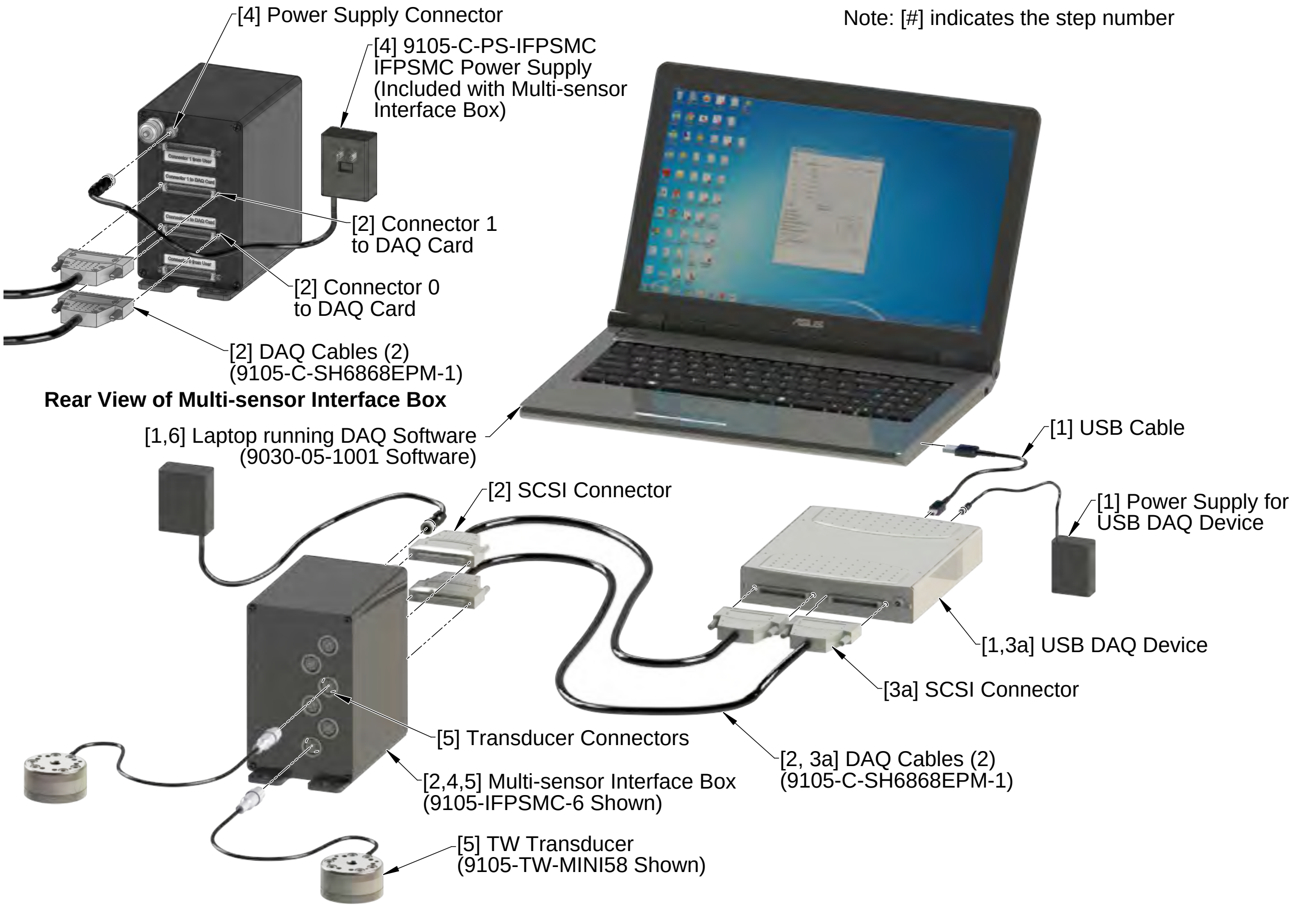


5. Connect the male connector on the transducer cable to the connector on the PS or IFPS box.
6. Refer to *Section 4.4—Install the F/T Demo Software* to complete the installation.

4.2 Installing a DAQ System with Multiple Transducers, IFPSMC Box, and DAQ Device

1. Install the data acquisition system hardware (DAQ card, DAQ Device, power supply, and/or cabling) and its accompanying software following the instructions included with the hardware (refer to *Figure 4.6* and *Figure 4.7*).

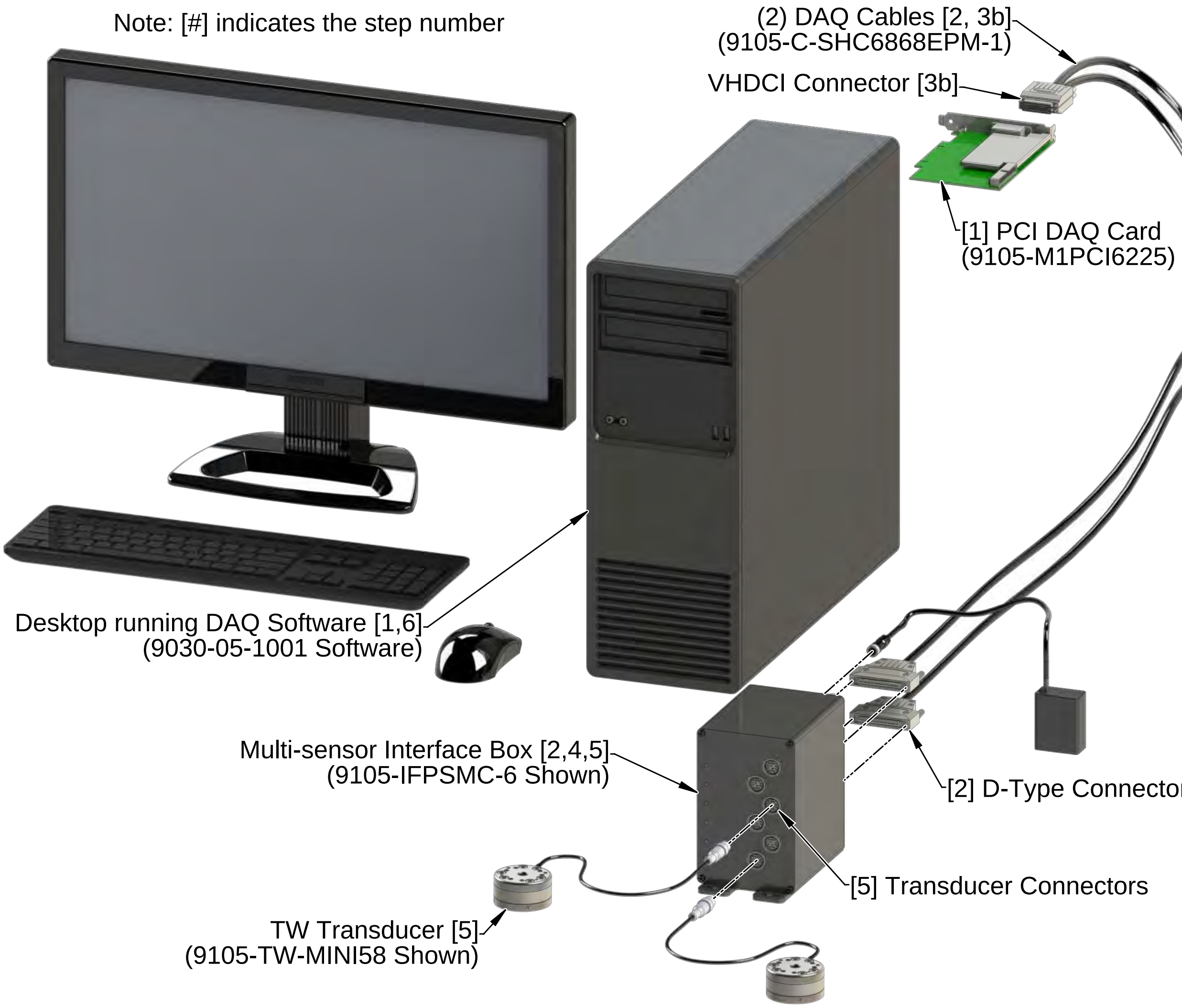
Figure 4.6—Multiple TW Transducers, IFPSMC, and USB DAQ Device System Installation



2. Connect the 68-pin, D-Type connector on the DAQ cables to the connectors on the back of the IFPSMC-X box labeled “Connector 0 to DAQ Card” and “Connector 1 to DAQ Card”.Tighten the jackscrews on the connector to insure a good electrical connection.

NOTICE: The connections from the SCB-68s to the user’s DAQ device should be made over shielded twisted pair wiring for noise immunity and to ensure that the shield connections are properly made. Use a differential mode for better noise performance. Use the appropriate screw terminals and wires gages to correctly pass the sensor signals through.

Figure 4.7—Multiple TW Transducers, IFPSMC, and DAQ Card System Installation

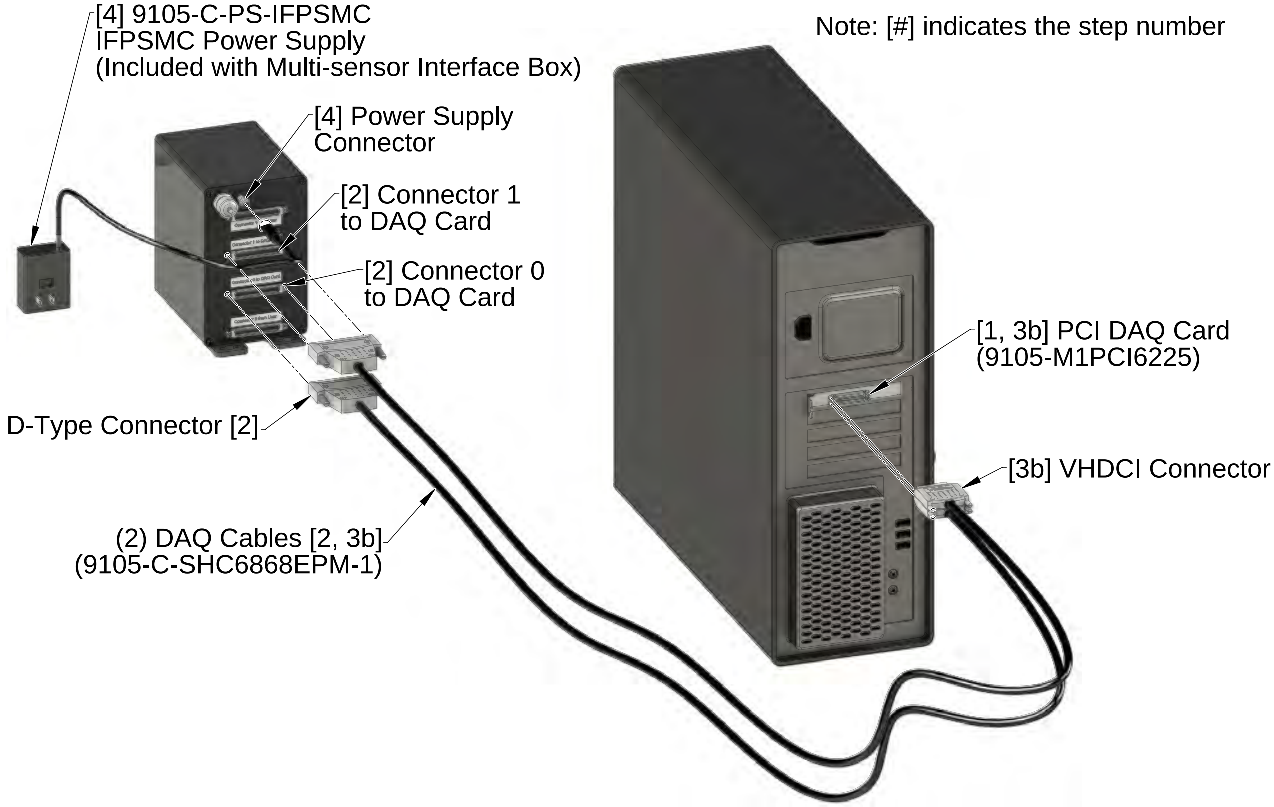


3. Depending on the DAQ Device and DAQ cables being installed, one of the following connection methods may be applied:

- If DAQ cables are equipped with a 68-pin D-Type connector, attach the connectors to the DAQ device and tighten the jackscrews on the connector to insure a good electrical connection.
- If DAQ cables are equipped with a 68-pin VHDCI connector, attach the connectors to the DAQ Card and tighten the jackscrews on the connector to insure a good electrical connection.
- If the DAQ cables have an unterminated ends, insert the unterminated wires into the desired screw terminals on the DAQ device and tighten the set screw to ensure good connection.

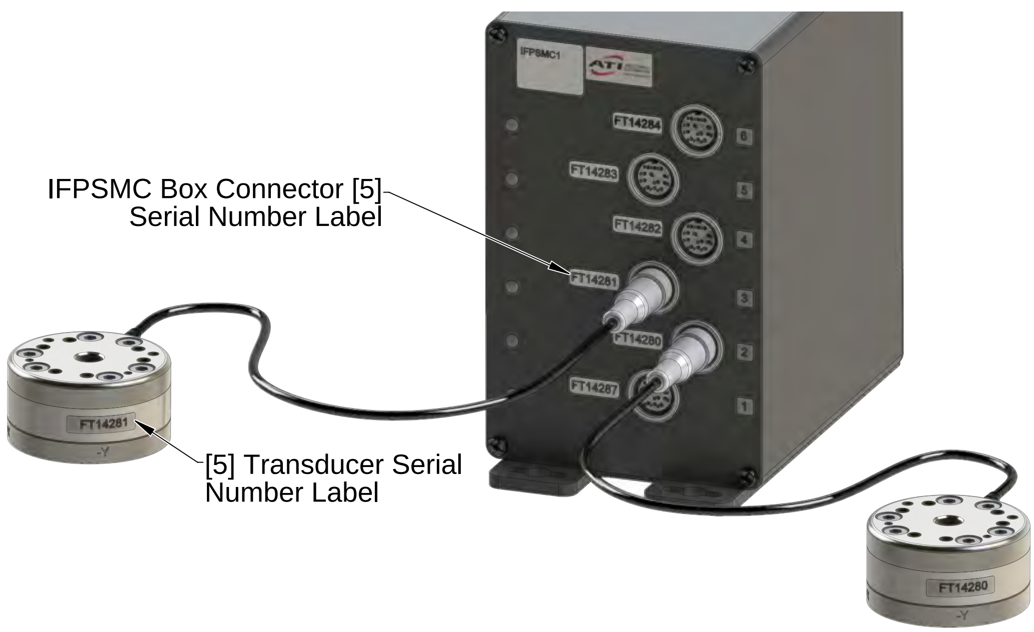
NOTICE: If not using a National Instruments DAQ board with mass termination, the user must provide a connector at that end of the cable (refer to *Section 4.5—Electrical Connection Information* for connection information).

Figure 4.8—Rear view of Multiple TW Transducers, IFPSMC, and DAQ Card System Installation



4. Plug 12 V wall mount power supply into outlet and connect the power supply cable to the power supply connector on the back of the IFPSMC box.
5. Connect the male connector on the transducer cable to the appropriate connector on the front of the IFPSMC box. Note: The serial number label on the transducer must match the serial number label on the IFPSMC Box connector it is plugged into. Refer to *Figure 4.9.*
6. To complete the installation, refer to *Section 4.4—Install the F/T Demo Software*.

Figure 4.9—Match the Serial Number Labels from the Transducer and the IFPSMC Box Connectors



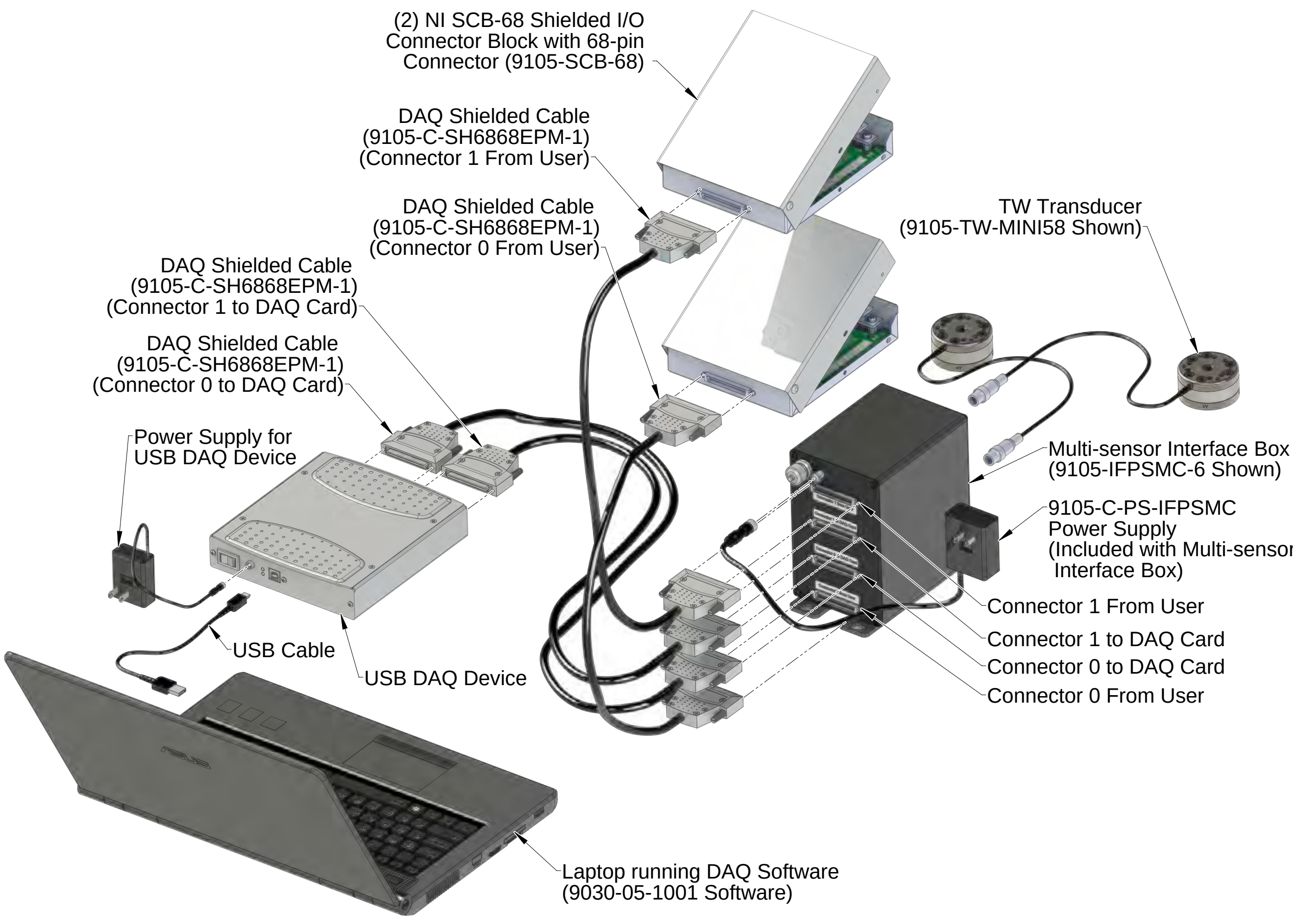
4.3 Installing a DAQ System with Multiple Transducers, IFPSMC Box, Wired I/O Connections, and USB DAQ Device

To ensure a seamless connection between the 9105-IFPSMC-X box and a DAQ Device with screw-terminals, the following connections need to be made to connect the transducer strain gage voltage outputs to the DAQ Device screw-terminals.

The 9105-IFPSMC Box is supplied with a 9105-C-PS-IFPSMC M-Series power supply.
(2) NI-SH68-68-EPM (ATI p/n 9105-SH6868EPM-1) 68-pin cables and (2) NI SCB-68 break-out boxes (ATI p/n 9105-SCB-68) will be needed.

1. Install the data acquisition system hardware (DAQ card, DAQ Device, power supply, and/or cabling) and its accompanying software following the instructions included with the hardware. Refer to *Figure 4.10* and *Figure 4.11*.
2. Connect the (2) 68-pin, D-Type connector on the DAQ shielded cables to the connectors on the back of the IFPSMC-X box labeled *Connector 0 to DAQ Card* and *Connector 1 to DAQ Card*. Tighten the jackscrews on the connector to insure a good electrical connection.

Figure 4.10—Multiple Transducer, IFPSMC Box, I/O Connector Block, and USB DAQ Device Installation



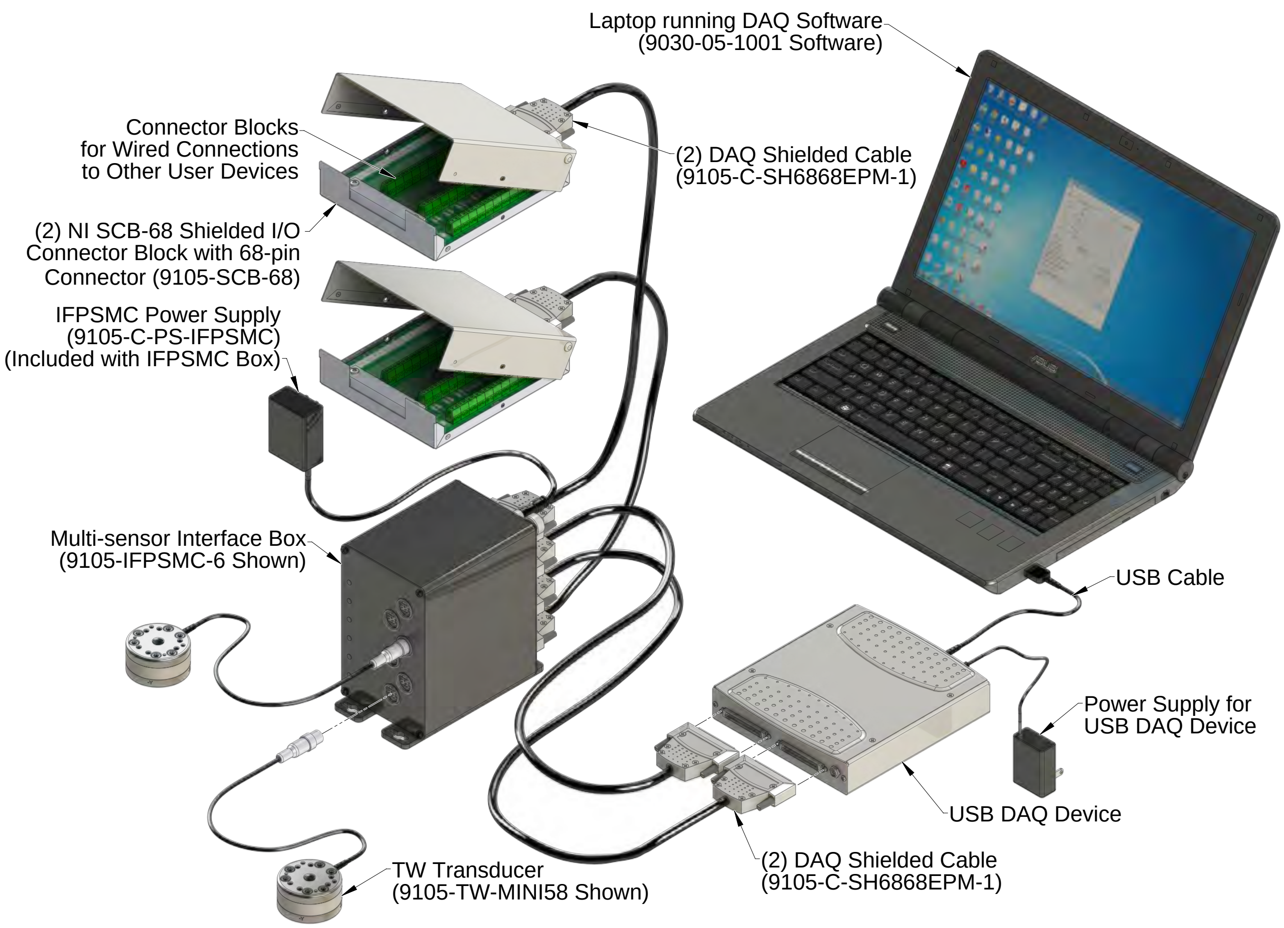
3. Connect the other ends of the DAQ shielded cables to a USB DAQ Device or DAQ Card. Tighten the jackscrews on the connector to ensure a good electrical connection.

NOTICE: The NI SCB-68 I/O connector block's switches MUST be set to direct feed through mode. See NI SCB-68 manufacturer's manual for direction.

NOTICE: The connections from the SCB-68s to the user's DAQ device should be made over shielded twisted pair wiring for noise immunity and to ensure that the shield connections are properly made. We recommend using differential mode for better noise performance. Use the appropriate screw terminals and wires gages to pass the sensor signals correctly through.

4. Connect the 9105-C-PS-IFPSMC power supply to the back of the IFPSMC-X box as shown in *Figure 4.10* and plug the power supply into a wall outlet.
5. Connect the male connectors on the transducer cables to the appropriate connector on the front of the IFPSMC box. Note: The serial number label on the Transducer must match the serial number label of the IFPSMC Box connector it is plugged into. Refer to *Figure 4.9.*
6. Connect the (2) 68-pin, D-Type connectors on the DAQ shielded cables to the connectors on the back of the IFPSMC-X box labeled *Connector 0 from User* and *Connector 1 from User*. Tighten the jackscrews on the connectors to ensure a strong electrical connection.
7. Connect the other ends of the DAQ shielded cables to a NI SCB-68 (ATI p/n 9105-SCB-68) I/O connector block. Tighten the jackscrews on the connector to insure a good electrical connection.
8. Wire connections between the NI SCB-68 I/O connector blocks and other user devices can be made to the available connection on the screw terminals. Refer to *Section 4.5.6—Transducer Connections on a Multi-Sensor IFPSMC Box* for available connections.
9. Refer to *Section 4.4—Install the F/T Demo Software* to complete the installation.

Figure 4.11—Multiple Transducer, IFPSMC Box, I/O Connector Block, and USB DAQ Device Installation



4.4 Install the F/T Demo Software

NOTICE: The calibration file(s) are sent in an e-mail as a zip file attachment. The zip file is required to install the calibration files.

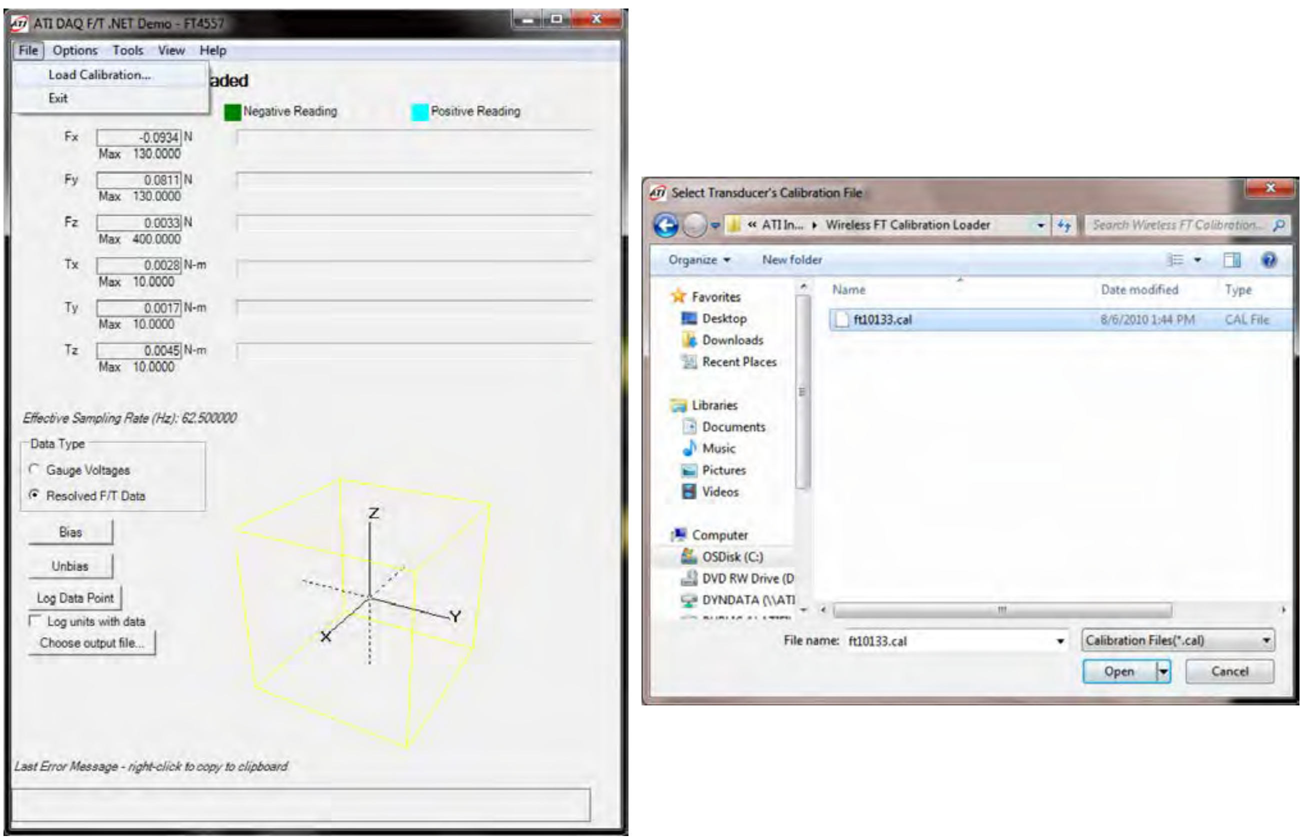
Install the F/T software. The installation program starts automatically. The software can be downloaded from the ATI website at: *https://www.ati-ia.com/Products/ft/software/daq_software.aspx*. On the webpage, select **DAQ F/T** to download the files.

1. Click the **Setup.Exe** file found in the root directory. Follow the installation instructions given by the program.

NOTICE: Calibration files in the unpacked directory are labelled based on the transducer's serial number; the files are in the format of FTxxxx.CAL.

2. Unpack the **FTxxxx.zip** file. Select the file with name based on transducer's serial number, and copy the file from the unpacked directory to the program directory **ATI DAQ FT**. If the system was ordered with more than one calibration, multiple calibration files will be available to copy.
3. From the Start menu and under programs, run the demo program: Programs\ATI DAQ FT\ATI DAQ FT Demo. Click on **File**, and then **Load Calibration**. Find the calibration data file saved earlier and click the **Open** button.

Figure 4.12—Load the Calibration Data File



4. The program displays two sets of bar graphs: one labeled **Force** and the other labeled **Torque**.
5. Gently apply load to the transducer without over-ranging the transducer. (As load is applied, the bar graphs show corresponding movement).

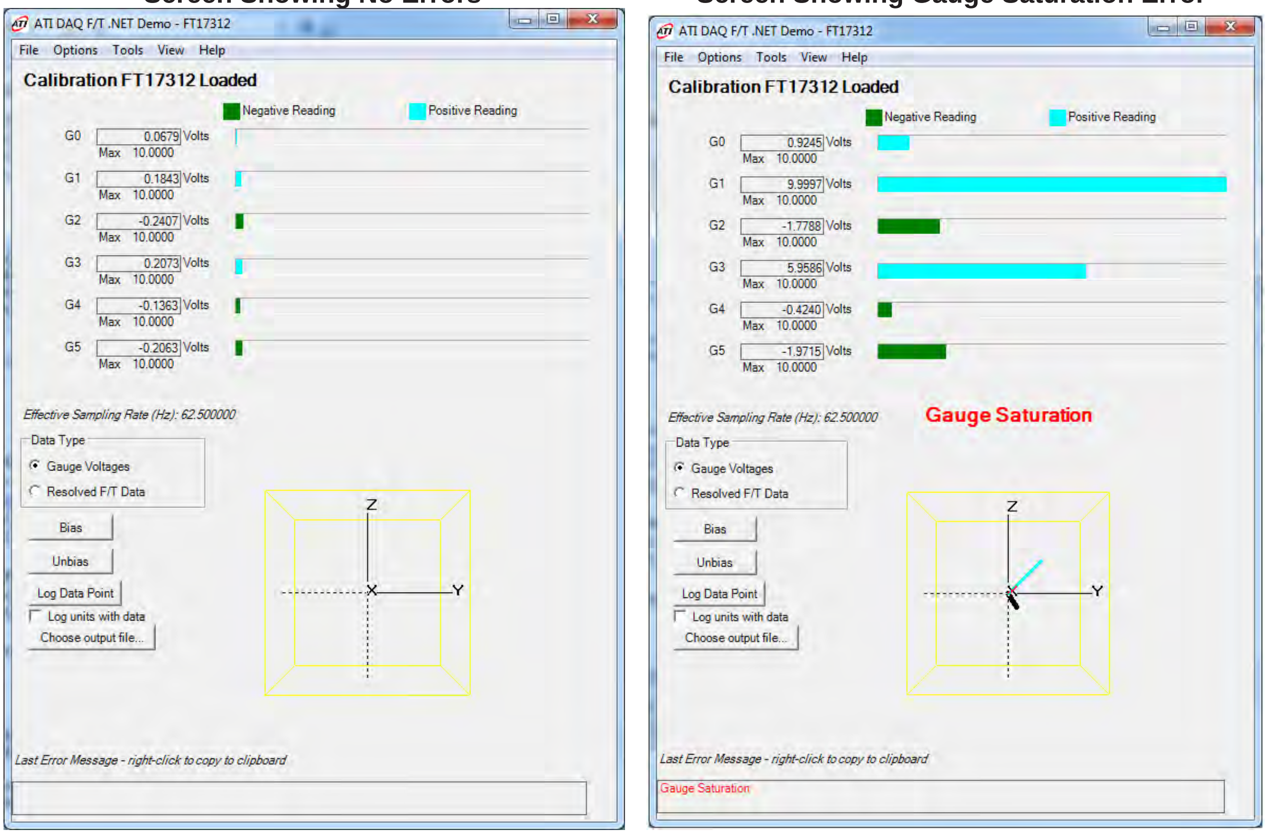
NOTICE: The ATI DAQ demo only works in conjunction with National Instruments DAQ boards.

6. Once the DAQ system is set up and functioning properly, install the transducer on the configuration. As the transducer is installed on the robot or device, use the ATI demo software to monitor strain gage voltages and to prevent the strain gage voltages from exceeding the transducer's overload rating. In the **Data Type** field select **Gauge Voltages** to monitor the gage voltages during installation. If a gage saturation error is reported, stop applying force immediately and wait until error clears.

> **NOTICE:** A saturation error will be generated when the transducer or data acquisition hardware has a load or signal outside of its sensing range. The screen on the right in *Figure 4.13* shows a Gauge Saturation error.

Figure 4.13—Set Gauge Voltages Data Type and Monitor for Gauge Saturation Errors

Screen Showing No Errors — **Screen Showing Gauge Saturation Error**



> **NOTICE:** Do not exceed the transducer's overload ratings. Smaller transducers can be irreparably damaged in the application of small loads when using tools (moment arm increases applied loads), in the process of mounting the transducer. Be sure to use the demo application to monitor the transducer for gage saturation errors during installation. If an error is indicated, stop from applying force to the transducer and wait until the error clears before continuing installation. If error does not clear, it may indicate loss of power or that the overload value has been exceeded.

7. For the proper installation of the transducer to the robot or other device, refer to the *9620-05-Transducer Section* manual.
8. After installation of the transducer is complete, select **Resolved F/T Data** in the **Data Type** box. The system is ready for operation.

4.5 Electrical Connection Information

Detailed information about the electrical connections of the various F/T system components is in the following section.

NOTICE: Information in this section is intended for advanced users. Users whose systems include an ATI-supplied DAQ card may skip this section.

The ATI DAQ F/T software features a modular design allowing for use with any data acquisition system capable of electrically interfacing to the F/T System.

4.5.1 Signals and Power

CAUTION: The analog signals output by the transducer do not map directly into force and torque vectors. ATI DAQ F/T software with the calibration matrix must be used to convert these values into force and torque data.

Table 4.2—Signal Descriptions

Signal Name	Description
SGx Output	The non-inverting (positive) half of output of SGx
SGx Reference	The inverting (negative) half of output of SGx
+VANA	Positive power supply used by transducer
AGnd	Power supply return used by transducer
-VANA	Negative power supply used by transducer
+5V [1]	Positive power used by PS or IFPS box
0V [1]	Power supply return used by PS or IFPS box
AIGnd	Analog Input Ground used for input current return from data acquisition card
Reserved	This connection has an internal or future use. Do not use.

Note:

1. Power to the PS / IFPS box can be provided from either a 5 V source through the 26-Pin connector or through the 12 V wall mounted power supply.

The PS and IFPS boxes include a 12 V wall mounted power supply. Power to the PS or IFPS box can be provided through either the 12 V wall-mounted power supply or a 5 V source to the 26-Pin connector. The PS box only requires one source; if both sources are connected, the PS box will use the 12 V source and the 5 V source will be ignored.

Systems with an ATI-supplied DAQ card derive power from either the DAQ card or the 12 V wall mounted power supply. If using a customer supplied DAQ card, a 12 V wall-mounted power supply can be used, or a +5V and 0V power to the PS / IFPS box will need to be supplied. Without a PS box, the user will need to supply +VANA, AGnd , and -VANA power to the transducer. (Applicable to 9105-TIF transducers only; 9105-TW transducers require an IFPS box.)

4.5.2 Electrical Specifications

Table 4.3—PS and IFPS box with transducer attached				
Signal	**Minimum**	**Typical**	**Maximum**	**Units**
+12V External Power Input Supply Voltage	8	12	15	VDC
+5V Power Input Voltage	4.65	5	9	VDC
+5V Power Input Power		1.6		W
+5V Power Input Current @ 4VDC		324		mA
+5V Power Input Current @ 5VDC		275		mA
+5V Power Input Current @ 12VDC		140		mA
+5V Power Input Current @ 15VDC		120		mA
+5V Power Input Noise			75	mV p-p
+5V Power Input Regulation			0.5	%

Table 4.4—Transducer with On-board Interface Board				
Signal	**Minimum**	**Typical**	**Maximum**	**Units**
$+V_{ANA}$ Power Input Voltage	13.00	15.00	17.00	V DC
$-V_{ANA}$ Power Input Voltage	-17.00	-15.00	-13.00	V DC
$+V_{ANA}$ Power Input Current			50	mA
$-V_{ANA}$ Power Input Current			-45	mA
V_{ANA} Power Input Noise			75	mV p-p
V_{ANA} Power Input Regulation			0.5%	

4.5.2.1 Transducer Output Signals

Transducer Output Signals are emitted by the transducer and passed through the PS or IFPS box.

Table 4.5—Transducer Output Signals			
Signal	**Minimum**	**Maximum**	**Units**
SGx output [1]	-VANA +0.6	+VANA –0.8	V
SGx reference	AGnd	AGnd	V
SGx output, over 10V calibrated range	-10	+10	V
SGx output, over 5V calibrated range	-5	+5	V
Note: 1. These output levels only occur if the transducer is loaded significantly past its calibration range.			

The transducer outputs are designed to work with a differential input to the DAQ system for best performance. Transducer outputs are ground-referenced differential signals. The output impedance of each DAQ signal is 100Ω.

The calibrated output voltage range is indicated as a suffix to the calibration. For example, a Gamma transducer with SI-65-5 calibration and a +10V output voltage range would be expressed as a GAMMA/SI-65-5:10V. The output voltage range can also be read using the OutputRange property of the ATIDAQFT software component.

4.5.3 Transducer Signals

Details on the connections for transducers with on-board electronics (9105-TIF part numbers). These transducers have a 20-pin connector. User connections to transducers without on-board electronics (9105-TWx part numbers) are not supported and therefore not covered in this document.

A 9105-TIF transducer connector mates to a Hirose HR25-9TP-20S connector. A 9105-TIF-x-IPx Transducer connector mates to a Lemo FGG.3K.320 connector. Refer to *Table 4.6* for wire colors use with 9105-C-x-U cable assemblies.

NOTICE: Multi-colored wires are identified as follows:

- the first color listed is the predominant color of the wire.
- the second color listed is the stripe on the wire.

Table 4.6—Transducer connector connections and 9105-C-x-U cable wire colors

Pin Number		Description	Wire Colors
9105-TIF Transducer	9105-TIF-x-IPx Transducer		
1	7	SG0 output	Brown
2	5	Reserved	Orange
3	8	SG0 reference	Brown/White
4	14	SG3 reference	Blue/White
5	18	SG5 reference	Grey/White
6	1	+VANA power input	Red
7	9	SG1 output	Yellow
8	13	SG3 output	Blue
9	17	SG5 output	Grey
10	4	AGnd power input	Black
11	2	-VANA power input	Red/White
12	10	SG1 reference	Yellow/White
13	15	SG4 output	Violet
14	19	T out	White
15	3	Reserved	Black/White
16	6	Reserved	Orange/White
17	11	SG2 output	Green
18	16	SG4 reference	Violet/White
19	20	T ref	White/Black
20	12	SG2 reference	Green/White
Shell	Shell	Shielding	Shield

4.5.4 PS and IFPS Signals

4.5.4.1 PS 20-pin Circular Connector

The PS 20-pin circular connector signals and pin numbering are the same as the 9105-TIF transducer signals listed in *Section 4.5.3—Transducer Signals*. See *Table 4.6*.

4.5.4.2 PS and IFPS 26-pin High Density D-Subminiature Connector

This connector mates to an industry standard female 26-pin high-density D-subminiature connector with screw locks. For wire colors use with 9105-C-PS-U cable assemblies, refer to *Table 4.7*.

Table 4.7—PS box and IFPS box connector connections and 9105-C-PS-U cable wire colors

Pin Number	Description	Wire Colors
1	Reserved	Orange
2	+5V power input	Red
3	T out	White
4	SG5 output	Grey
5	SG4 output	Violet
6	SG3 output	Blue
7	SG2 output	Green
8	SG1 output	Yellow
9	SG0 output	Brown
10	Reserved	Orange/White
11	0V power input	Red/White
12	T ref	White/Black
13	SG5 reference	Grey/White
14	SG4 reference	Violet/White
15	SG3 reference	Blue/White
16	SG2 reference	Green/White
17	SG1 reference	Yellow/White
18	SG0 reference	Brown/White
19	Reserved	Black/White
22	AIGnd	Black
Shell	Shielding	Shield

Note: The AIGnd is an Analog Input Ground used for input current return from data acquisition card. The black wire is from the Black / Black/White pair.

4.5.5 DAQ Card Connections

4.5.5.1 Standard DAQ Card Connections

The standard DAQ card configuration uses National Instruments 68-pin M series connectors. Advanced users can use the following table to better understand the system connections. Unlisted connector pins are not used.

Table 4.8—System Connections

Pin Number				**ATI Signal**	**9105-C-PS-U-x Wire Color**	**NI name**	
9105-TIF-x Transducer connector	**9105-TIF-x-IPx Transducer connector**	**DAQ-side connector on PS or IFPS box**	**68-pin connector on National Instruments board**			**32 and 64 Pin**	**64 Pin**
		2	8	+5V power[1]	Red[1]	(+5V)[1]	(+5V)[1]
		11	13	0V power[1]	Red/White[1]	(D Gnd)[1]	(D Gnd)[1]
6	1	21		+VANA power			
10	4	22	56	AGnd/AIGnd	Black	(AIGnd)	(AIGnd)
11	2	23		-VANA power			
1	7	9	68	SG0 output	Brown	(AI 0)	(AI 16)
3	8	18	34	SG0 reference	Brown/White	(AI 8)	(AI 24)
7	9	8	33	SG1 output	Yellow	(AI 1)	(AI 17)
12	10	17	66	SG1 reference	Yellow/White	(AI 9)	(AI 25)
17	11	7	65	SG2 output	Green	(AI 2)	(AI 18)
20	12	16	31	SG2 reference	Green/White	(AI 10)	(AI 26)
8	13	6	30	SG3 output	Blue	(AI 3)	(AI 19)
4	14	15	63	SG3 reference	Blue/White	(AI 11)	(AI 27)
13	15	5	28	SG4 output	Violet	(AI 4)	(AI 20)
18	16	14	61	SG4 reference	Violet/White	(AI 12)	(AI 28)
9	17	4	60	SG5 output	Grey	(AI 5)	(AI 21)
5	`8	13	26	SG5 reference	Grey/White	(AI 13)	(AI 29)
14	19	3	25	T out			
19	20	12	58	T ref			
2	5	1	57	reserved			
16	6	10	23	reserved			
15	3	19	52	9105-C-PS-V68 cables reserved			
			11	9105-C-PS-NI cables reserved			
Shell	Shell	Shell	Shell	Shielding	Twisted Shielding	(D Gnd)	(D Gnd)

Notes: (Note # shown in table as superscript)

1. This connection is for an external power supply, not a USB device.
2. When using NI Compact DAQ system or any NI DAQ card with isolated analog inputs (AGND is not connected to Chassis Ground). Cable shield and AGND must be connected at the end of the cable in DAQ system side. If using ATI cable 9105-C-PS-d37-xx, AGND and DB26 Connector Shell/cable shield are connected inside the cable. Refer to *Section 4.5.5.2—Custom DAQ Card Connections*.

4.5.5.2 Custom DAQ Card Connections

Advanced users may have purchased systems that use an unterminated power supply cable. The NI signal names listed in *Table 4.8* may be used as a guide when connecting the unterminated cable to other National Instruments data acquisition equipment.

Figure 4.14 and *Figure 4.15* show example connection schemes for connecting an IFPS or PS box to a data acquisition system. In this case, the signal names on the examples must be matched to equivalent names on the data acquisition system. The optional Ch6 connections are not shown here but can be found in *Table 4.8*. Differential signal connections are preferred as they will give the best results (see *Figure 4.14*).

Figure 4.14—Differential Connections to a Data Acquisition System

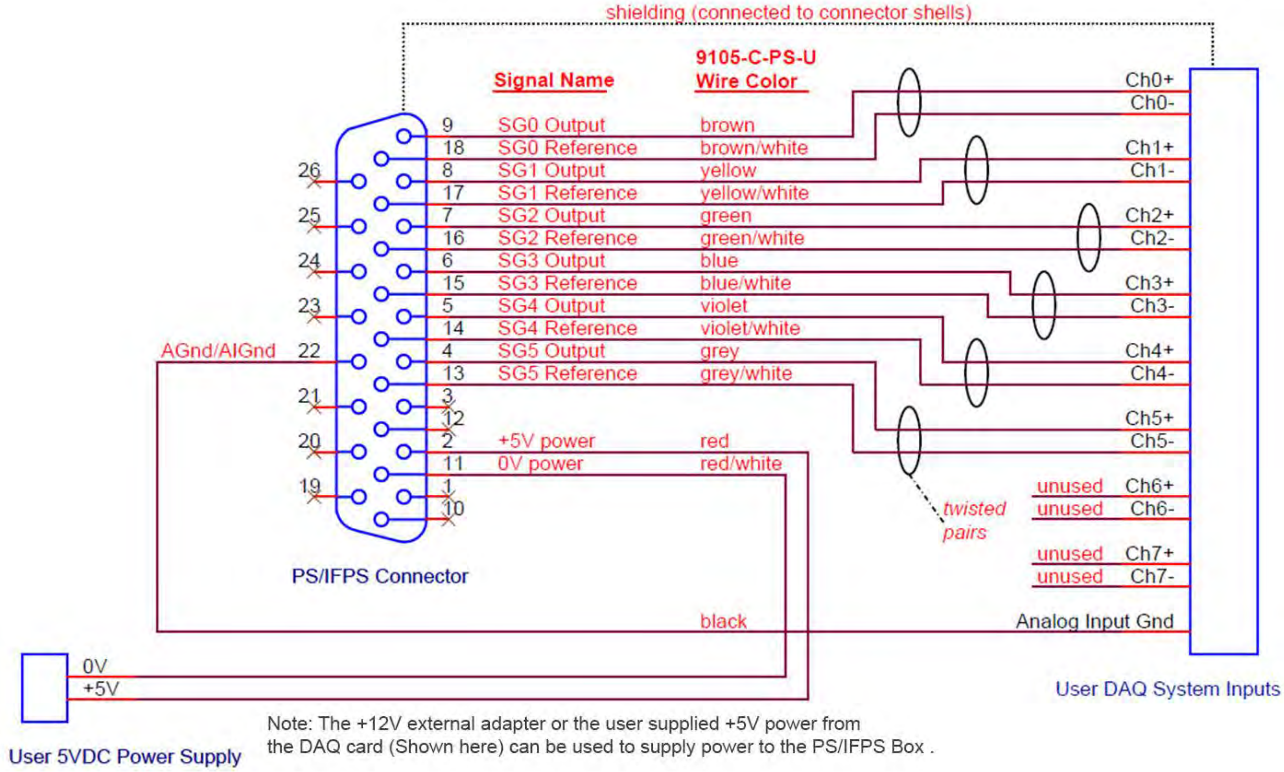
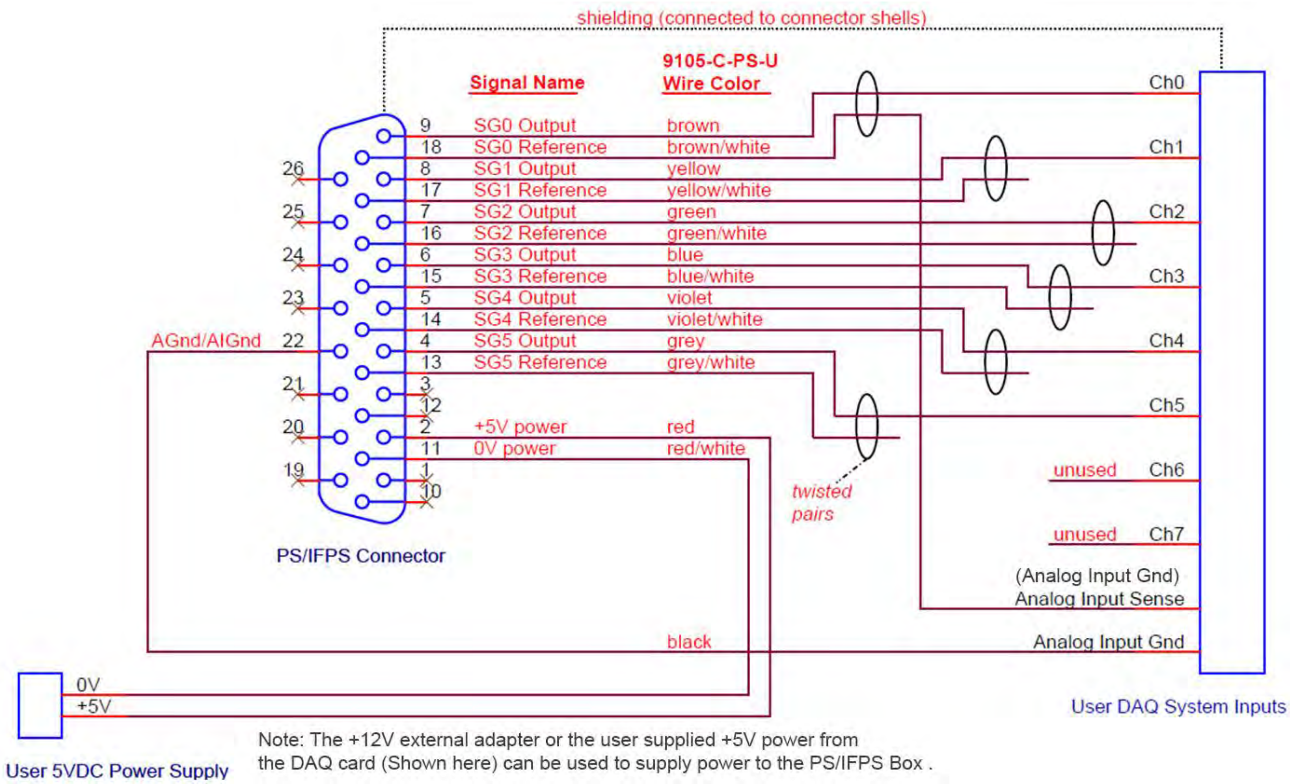


Figure 4.15—Single-Ended Connections to a Data Acquisition System



A connection from the DAQ F/T's AGnd/AIGnd line to the data acquisition system's analog input ground or analog ground is required in most cases. This line allows the return of the small amount of current used by the data acquisition system. Noise can result if this current isn't returned via the AGnd/AIGnd path.

For best noise performance, the cabling from the PS/IFPS connector should be shielded and each strain gage's signals in a twisted pair. The shielding should be connected to the PS/IFPS connector shell and to the shell of the data acquisition system's connector. If the data acquisition system has no connector or its connector shell is electrically floating, then the shield at the PS/IPFS connector should be connected to the AGnd/AIGnd signal.

It may be important to consider the voltage drop of the +5V and 0V power lines to certify a sufficient voltage is delivered to the PS/IFPS box. Note: that as the delivered voltage drops, the current consumption will increase.

4.5.5.3 Using Unused DAQ Card Resources

Additional functions not used in the standard configuration are available on the ATI-supplied DAQ card; however, information on using these resources is outside the scope of this manual. Users who wish to use the ATI-supplied DAQ card need to consult the DAQ card documentation for connections and functionality. *Table 4.11* and *Table 4.12* show which signals are used by the F/T system and cannot be used for other purposes. If designed improperly, additional connections to the DAQ card may introduce ground loops and noise.

Table 4.9—9105-IFPSMC Scan List for Each Transducer

Transducer	National Instruments Scan List
1	devx/ai4:7, devx/ai16:17
2	devx/ai18:23
3	devx/ai32:37
4	devx/ai38:39, devx/ai48:51
5	devx/ai52:55, devx/ai64:65
6	devx/ai66:71

4.5.6 Transducer Connections on a Multi-Sensor IFPSMC Box

The IFPSMC transducer connectors are numbered 1 through 6, with the first transducer located at the bottom of the box. Current IFPSMC models have all transducer connectors populated in the front plate; depending on the model, however, certain models may not have the associated IFPS cards installed. Previous versions were not supplied with all transducer connectors or associated IFPS cards installed, refer to *Figure 4.16*.

Figure 4.16—IFPSMC Box Transducer Connections

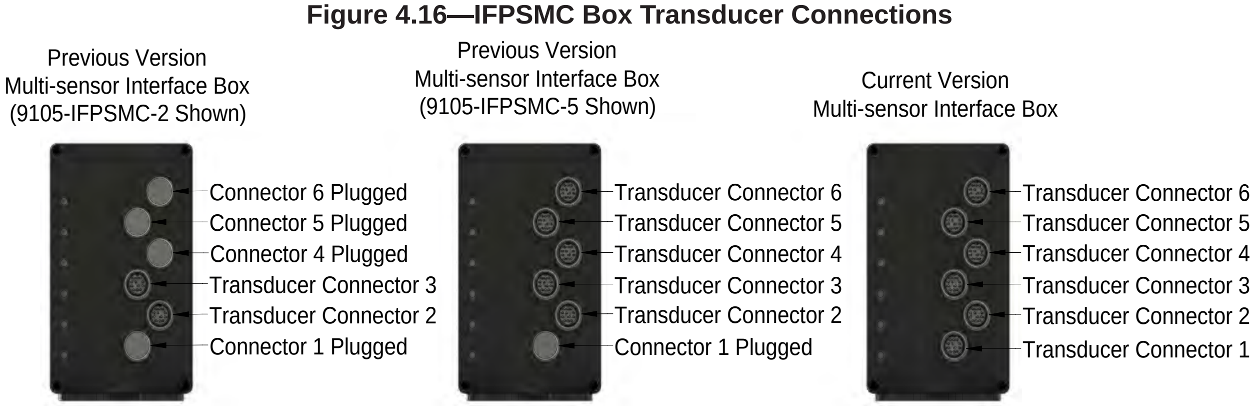


Table 4.10 shows the channel assignments for the 9105-IPFSMC and National Instruments card, using National Instruments' nomenclature. Note: that with the IFPSMC, transducers are generally assigned such that unused channels are grouped together. Channels that do not have a transducer assigned to them by ATI may be used for other purposes through the (connector 0 from user) and (connector 1 from user) connectors, only if the 12 pin jumpers are installed on the backplane inside the IFPSMC box. Refer to *Section 4.5.6.1—Installing 12 Pin Jumpers on the Backplane to Make Unused Transducer Signals Available to the User*

DAQ card signals unused by the IFPSMC electronics are made available to the user via the connectors labeled (connector 0 from user) and (connector 1 from user). The signal names and pin assignments of these connectors match those of connectors connector 0 to DAQ card and connector 1 to DAQ Card, respectively. DAQ card signals used by the IFPSMC electronics are not connected on either user connector. For signal names and pin assignments of DAQ card connectors 0 and 1, refer to the NI DAQ card pinout section of National Instruments M-Series documentation or *Table 4.11* and *Table 4.12*.

Table 4.10—Signal Allocation for Transducer Connectors

Transducer Connector	Signal	NI Differential Channel	NI +Input Channel	NI -Input Channel	DAQ Card Connector # / NI +Input Pin	DAQ Card Connector # / NI -Input Pin
1	SG0	AI 4	AI 4	AI 12	0 / 28	0 / 61
	SG1	AI 5	AI 5	AI 13	0 / 60	0 / 26
	SG2	AI 6	AI 6	AI 14	0 / 25	0 / 58
	SG3	AI 7	AI 7	AI 15	0 / 57	0 / 23
	SG4	AI 16	AI 16	AI 24	1 / 68	1 / 34
	SG5	AI 17	AI 17	AI 25	1 / 33	1 / 67
2	SG0	AI 18	AI 18	AI 26	1 / 32	1 / 66
	SG1	AI 19	AI 19	AI 27	1 / 65	1 / 31
	SG2	AI 20	AI 20	AI 28	1 / 30	1 / 64
	SG3	AI 21	AI 21	AI 29	1 / 29	1 / 63
	SG4	AI 22	AI 22	AI 30	1 / 62	1 / 28
	SG5	AI 23	AI 23	AI 31	1 / 27	1 / 61
3	SG0	AI 32	AI 32	AI 40	1 / 26	1 / 60
	SG1	AI 33	AI 33	AI 41	1 / 59	1 / 25
	SG2	AI 34	AI 34	ai42	1 / 24	1 / 58
	SG3	AI 35	AI 35	AI 43	1 / 23	1 / 57
	SG4	AI 36	AI 36	AI 44	1 / 55	1 / 21
	SG5	AI 37	AI 37	AI 45	1 / 20	1 / 54
4	SG0	AI 38	AI 38	AI 46	1 / 19	1 / 53
	SG1	AI 39	AI 39	AI 47	1 / 52	1 / 18
	SG2	AI 48	AI 48	AI 56	1 / 17	1 / 51
	SG3	AI 49	AI 49	AI 57	1 / 16	1 / 50
	SG4	AI 50	AI 50	AI 58	1 / 49	1 / 15
	SG5	AI 51	AI 51	AI 59	1 / 14	1 / 48
5	SG0	AI 52	AI 52	AI 60	1 / 13	1 / 47
	SG1	AI 53	AI 53	AI 61	1 / 46	1 / 12
	SG2	AI 54	AI 54	AI 62	1 / 11	1 / 45
	SG3	AI 55	AI 55	AI 63	1 / 10	1 / 44
	SG4	AI 64	AI 64	AI 72	1 / 42	1 / 8
	SG5	AI 65	AI 65	AI 73	1 / 7	1 / 41
6	SG0	AI 66	AI 66	AI 74	1 / 6	1 / 40
	SG1	AI 67	AI 67	AI 75	1 / 39	1 / 5
	SG2	AI 68	AI 68	AI 76	1 / 4	1 / 38
	SG3	AI 69	AI 69	AI 77	1 / 3	1 / 37
	SG4	AI 70	AI 70	AI 78	1 / 36	1 / 2
	SG5	AI 71	AI 71	AI 79	1 / 1	1 / 35

4.5.6.1 Installing 12 Pin Jumpers on the Backplane to Make Unused Transducer Signals Available to the User

Tools required: *#2 Phillips head screw driver*

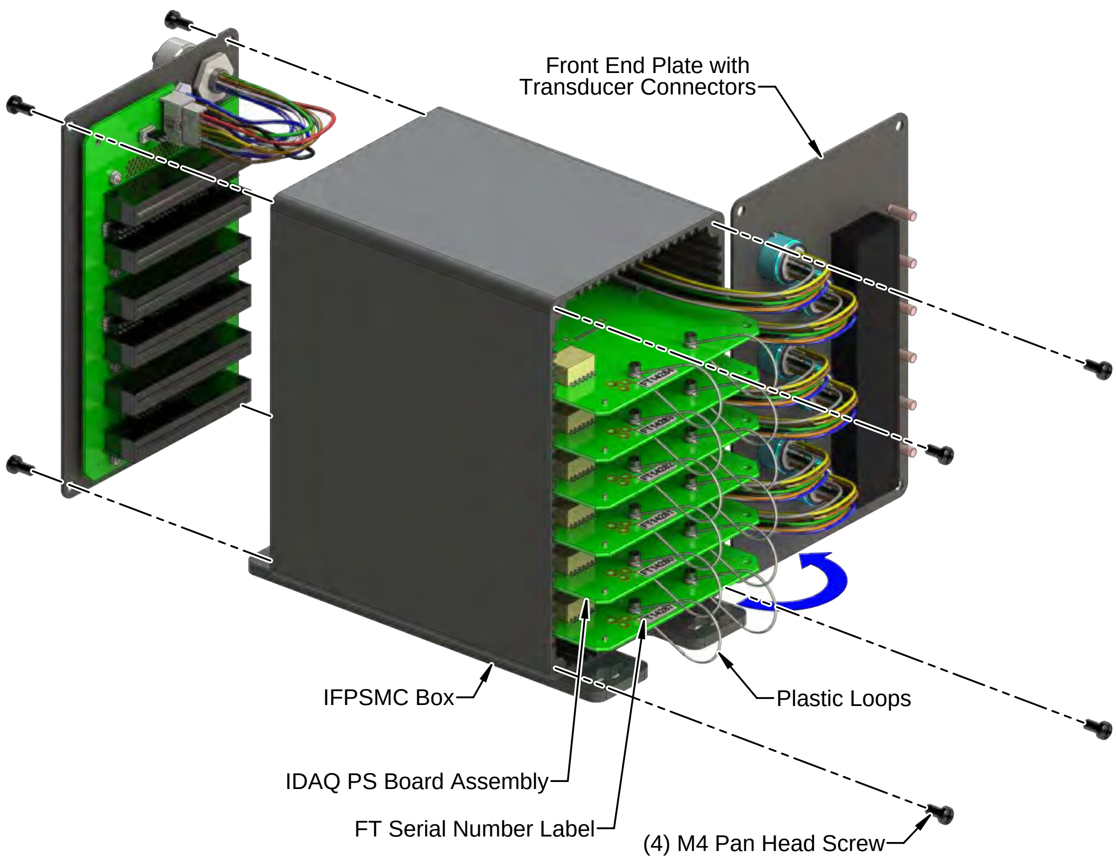
Parts required: *12 pin jumpers supplied with the IFPSMC Box (ATI part number1590-2225000-12) (Amphenol FCI part number 69145-212LF)*

NOTICE: The following steps must be performed at an anti-static workstation.

NOTICE: Make sure the transducers are re-connected to the same connector on the front panel when re-assembling the IFPSMC box. Also ensure the transducers and the connector on the front panel are clearly marked with the serial number label.

1. Disconnect all cables, transducers and the power supply from the IFPSMC box.
2. Remove the (4) M4 pan head screws from the front panel using a Phillips head screw driver.
3. Carefully rotate the front panel open to the right side of the box, as shown in *Figure 4.17*.

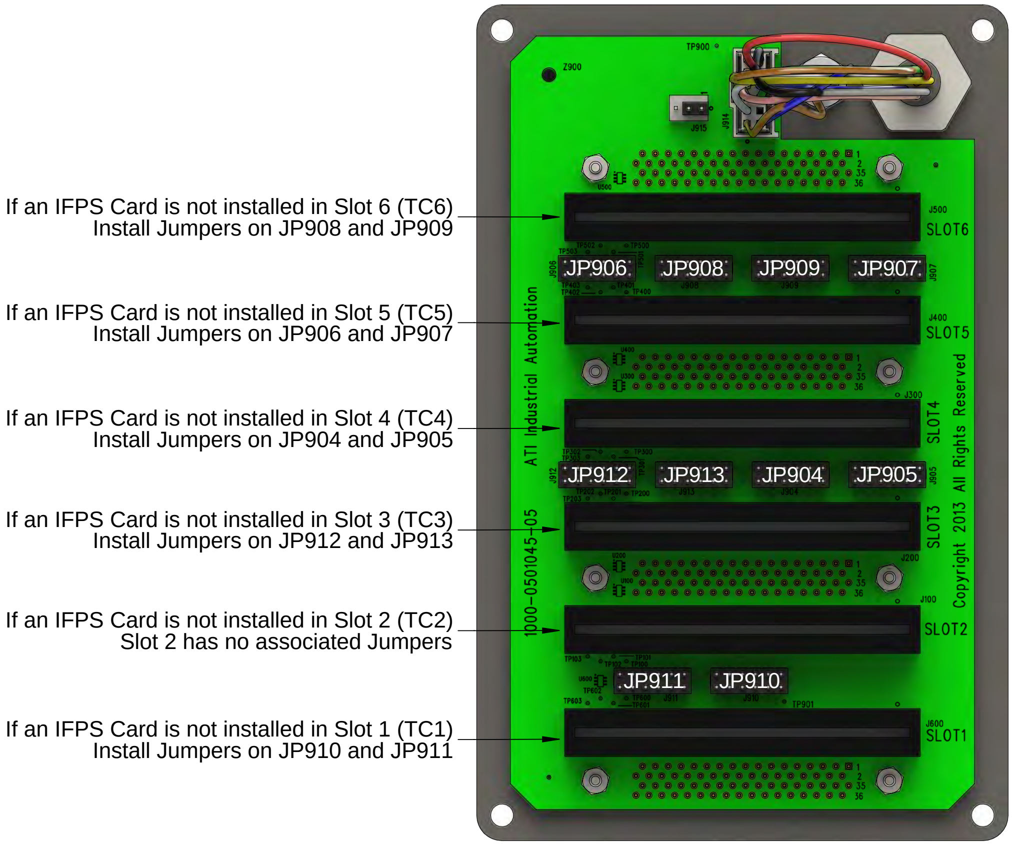
Figure 4.17—IFPSMC Box Disassembly



4. Disconnect all the DAQ boards from the backplane by firmly holding the top of the IFPSMC box and simultaneously pulling the two plastic loops attached to each board. Pull each board out about 1/2” to disconnect it from the backplane.
5. Remove the (4) M4 pan head screws from the back panel using a phillips head screw driver.
6. Remove the back panel with the backplane board attached.
7. Remove the jumpers from the bag supplied with the IFPSMC box. Jumpers can be installed for all the DAQ boards that are not installed in the IFPSMC box. Refer to *Figure 4.18*.

NOTICE: Do not install jumpers for DAQ boards that are installed in the IFPSMC box. Only install the associated jumpers for slots without a DAQ board installed. The jumpers make available the signals not used for the Transducer signals, this will override the signals from the transducer connectors. Refer to *Table 4.11* and *Table 4.12* for signal available.

Figure 4.18—Install 12 Pin Jumpers on the IFPSMC Backplane



8. Attach the back panel to the IFPSMC box, secure with the (4) M4 pan head screws.
9. Connect the DAQ boards to the backplane by pushing them in until they seat into the backplane connector. Connect all the DAQ boards disconnected in step *4*.
10. Carefully rotate the front panel back into place on the IFPSMC box and secure using the (4) M4 pan head screws,
11. Connect the male connector on the transducer cable to the appropriate connector on the front of the IFPSMC box. Note: The serial number label on the transducer must match the serial number label on the IFPSMC Box connector the transducer is plugged into. Refer to *Figure 4.9.*
12. Reconnect the power supply and DAQ cables to the back of the IFPSMC box. Refer to *Figure 4.25.*
13. After the procedure is complete, resume normal operation.

Figure 4.19—Multiple IFPS Box Connector 0 and Connector 1

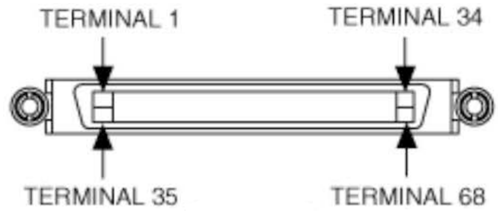


Table 4.11—IFPSMC Box Connector 0 User Signals Available

Pin Number	Signal	IFPS Model					
		IFPSMC-1	IFPSMC-2	IFPSMC-3	IFPSMC-4	IFPSMC-5	IFPSMC-6
1	P2.6	Available	Available	Available	Available	Available	Available
2	P2.4	Available	Available	Available	Available	Available	Available
3	P2.1	Available	Available	Available	Available	Available	Available
4	D GND	Available	Available	Available	Available	Available	Available
5	P1.6	Available	Available	Available	Available	Available	Available
6	P1.5	Available	Available	Available	Available	Available	Available
7	D GND	Available	Available	Available	Available	Available	Available
8	+5V	Available	Available	Available	Available	Available	Available
9	D GND	Available	Available	Available	Available	Available	Available
10	P1.1	Available	Available	Available	Available	Available	Available
11	P1.0	Available	Available	Available	Available	Available	Available
12	D GND	Available	Available	Available	Available	Available	Available
13	D GND	Available	Available	Available	Available	Available	Available
14	+5V	Available	Available	Available	Available	Available	Available
15	D GND	Available	Available	Available	Available	Available	Available
16	P0.6	Available	Available	Available	Available	Available	Available
17	P0.1	Available	Available	Available	Available	Available	Available
18	D GND	Available	Available	Available	Available	Available	Available
19	P0.4	Available	Available	Available	Available	Available	Available
20	NC	Available	Available	Available	Available	Available	Available
21	AO 1	Available	Available	Available	Available	Available	Available
22	AO 0	Available	Available	Available	Available	Available	Available
23	AI 15	Available	Available	Available	Available	Available	TC1-SG3(-)
24	AI GND						
25	AI 6	Available	Available	Available	Available	Available	TC1-SG2(+)
26	AI 13	Available	Available	Available	Available	Available	TC1-SG1(-)
27	AI GND						
28	AI 4	Available	Available	Available	Available	Available	TC1-SG0(+)
29	AI GND						
30	AI 3	Available(+)	Available(+)	Available(+)	Available(+)	Available(+)	Available(+)
31	AI 10	Available(-)	Available(-)	Available(-)	Available(-)	Available(-)	Available(-)
32	AI GND						
33	AI 1	Available(+)	Available(+)	Available(+)	Available(+)	Available(+)	Available(+)
34	AI 8	Available(-)	Available(-)	Available(-)	Available(-)	Available(-)	Available(-)

Notes:

1. TC-SGx(x) = Transducer Connection number - Signal (SGx) - positive (+) or negative (-) input
2. Available (x) = User signal available - positive (+) or negative (-) input

Table 4.11—IFPSMC Box Connector 0 User Signals Available							
Pin Number	Signal	IFPS Model					
		IFPSMC-1	IFPSMC-2	IFPSMC-3	IFPSMC-4	IFPSMC-5	IFPSMC-6
35	D GND	Available	Available	Available	Available	Available	Available
36	D GND	Available	Available	Available	Available	Available	Available
37	P2.0	Available	Available	Available	Available	Available	Available
38	P1.7	Available	Available	Available	Available	Available	Available
39	P2.7	Available	Available	Available	Available	Available	Available
40	P2.5	Available	Available	Available	Available	Available	Available
41	P1.4	Available	Available	Available	Available	Available	Available
42	P1.3	Available	Available	Available	Available	Available	Available
43	P1.2	Available	Available	Available	Available	Available	Available
44	D GND	Available	Available	Available	Available	Available	Available
45	P2.2	Available	Available	Available	Available	Available	Available
46	P2.3	Available	Available	Available	Available	Available	Available
47	P0.3	Available	Available	Available	Available	Available	Available
48	P0.7	Available	Available	Available	Available	Available	Available
49	P0.2	Available	Available	Available	Available	Available	Available
50	D GND	Available	Available	Available	Available	Available	Available
51	P0.5	Available	Available	Available	Available	Available	Available
52	P0.0	Available	Available	Available	Available	Available	Available
53	D GND	Available	Available	Available	Available	Available	Available
54	AO GND	Available	Available	Available	Available	Available	Available
55	AO GND	Available	Available	Available	Available	Available	Available
56	AI GND						
57	AI 7	Available(+)	Available(+)	Available(+)	Available(+)	Available(+)	TC1-SG3(+)
58	AI 14	Available(-)	Available(-)	Available(-)	Available(-)	Available(-)	TC1-SG2(-)
59	AI GND						
60	AI 5	Available(+)	Available(+)	Available(+)	Available(+)	Available(+)	TC1-SG1(+)
61	AI 12	Available(-)	Available(-)	Available(-)	Available(-)	Available(-)	TC1-SG0(-)
62	AI SENSE1						
63	AI 11	Available(-)	Available(-)	Available(-)	Available(-)	Available(-)	Available(-)
64	AI GND						
65	AI 2	Available(+)	Available(+)	Available(+)	Available(+)	Available(+)	Available(+)
66	AI 9	Available(-)	Available(-)	Available(-)	Available(-)	Available(-)	Available(-)
67	AI GND						
68	AI 0	Available(+)	Available(+)	Available(+)	Available(+)	Available(+)	Available(+)

Notes:

1. TC-SGx(x) = Transducer Connection number - Signal (SGx) - positive (+) or negative (-) input
2. Available (x) = User signal available - positive (+) or negative (-) input

Figure 4.20—Multiple IFPS Box Connector 0 and Connector 1

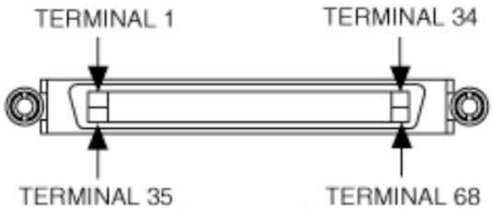


Table 4.12—IFPSMC Box Connector 1 User Signals Available							
Pin Number	Signal	IFPS Model					
		IFPSMC-1	IFPSMC-2	IFPSMC-3	IFPSMC-4	IFPSMC-5	IFPSMC-6
1	AI 71	Available(+)	Available(+)	Available(+)	Available(+)	TC6-SG5(+)	TC6-SG5(+)
2	AI 78	Available(-)	Available(-)	Available(-)	Available(-)	TC6-SG4(-)	TC6-SG4(-)
3	AI 69	Available(+)	Available(+)	Available(+)	Available(+)	TC6-SG3(+)	TC6-SG3(+)
4	AI 68	Available(+)	Available(+)	Available(+)	Available(+)	TC6-SG2(+)	TC6-SG2(+)
5	AI 75	Available(-)	Available(-)	Available(-)	Available(-)	TC6-SG1(-)	TC6-SG1(-)
6	AI 66	Available(+)	Available(+)	Available(+)	Available(+)	TC6-SG0(+)	TC6-SG0(+)
7	AI 65	Available(+)	Available(+)	Available(+)	TC5-SG5(+)	TC5-SG5(+)	TC5-SG5(+)
8	AI 72	Available(-)	Available(-)	Available(-)	TC5-SG4(-)	TC5-SG4(-)	TC5-SG4(-)
9	AI GND						
10	AI 55	Available(+)	Available(+)	Available(+)	TC5-SG3(+)	TC5-SG3(+)	TC5-SG3(+)
11	AI 54	Available(+)	Available(+)	Available(+)	TC5-SG2(+)	TC5-SG2(+)	TC5-SG2(+)
12	AI 61	Available(-)	Available(-)	Available(-)	TC5-SG1(-)	TC5-SG1(-)	TC5-SG1(-)
13	AI 52	Available(+)	Available(+)	Available(+)	TC5-SG0(+)	TC5-SG0(+)	TC5-SG0(+)
14	AI 51	Available(+)	Available(+)	TC4-SG5(+)	TC4-SG5(+)	TC4-SG5(+)	TC4-SG5(+)
15	AI 58	Available(-)	Available(-)	TC4-SG4(-)	TC4-SG4(-)	TC4-SG4(-)	TC4-SG4(-)
16	AI 49	Available(+)	Available(+)	TC4-SG3(+)	TC4-SG3(+)	TC4-SG3(+)	TC4-SG3(+)
17	AI 48	Available(+)	Available(+)	TC4-SG2(+)	TC4-SG2(+)	TC4-SG2(+)	TC4-SG2(+)
18	AI 47	Available(-)	Available(-)	TC4-SG1(-)	TC4-SG1(-)	TC4-SG1(-)	TC4-SG1(-)
19	AI 38	Available(+)	Available(+)	TC4-SG0(+)	TC4-SG0(+)	TC4-SG0(+)	TC4-SG0(+)
20	AI 37	Available(+)	TC3-SG5(+)	TC3-SG5(+)	TC3-SG5(+)	TC3-SG5(+)	TC3-SG5(+)
21	AI 44	Available(-)	TC3-SG4(-)	TC3-SG4(-)	TC3-SG4(-)	TC3-SG4(-)	TC3-SG4(-)
22	AI GND						
23	AI 35	Available(+)	TC3-SG3(+)	TC3-SG3(+)	TC3-SG3(+)	TC3-SG3(+)	TC3-SG3(+)
24	AI 34	Available(+)	TC3-SG2(+)	TC3-SG2(+)	TC3-SG2(+)	TC3-SG2(+)	TC3-SG2(+)
25	AI 41	Available(-)	TC3-SG1(-)	TC3-SG1(-)	TC3-SG1(-)	TC3-SG1(-)	TC3-SG1(-)
26	AI 32	Available(+)	TC3-SG0(+)	TC3-SG0(+)	TC3-SG0(+)	TC3-SG0(+)	TC3-SG0(+)
27	AI 23	TC2-SG5(+)	TC2-SG5(+)	TC2-SG5(+)	TC2-SG5(+)	TC2-SG5(+)	TC2-SG5(+)
28	AI 30	TC2-SG4(-)	TC2-SG4(-)	TC2-SG4(-)	TC2-SG4(-)	TC2-SG4(-)	TC2-SG4(-)
29	AI 21	TC2-SG3(+)	TC2-SG3(+)	TC2-SG3(+)	TC2-SG3(+)	TC2-SG3(+)	TC2-SG3(+)
30	AI 20	TC2-SG2(+)	TC2-SG2(+)	TC2-SG2(+)	TC2-SG2(+)	TC2-SG2(+)	TC2-SG2(+)
31	AI 27	TC2-SG1(-)	TC2-SG1(-)	TC2-SG1(-)	TC2-SG1(-)	TC2-SG1(-)	TC2-SG1(-)
32	AI 18	TC2-SG0(+)	TC2-SG0(+)	TC2-SG0(+)	TC2-SG0(+)	TC2-SG0(+)	TC2-SG0(+)
33	AI 17	Available(+)	Available(+)	Available(+)	Available(+)	Available(+)	TC1-SG5(+)
34	AI 24	Available(-)	Available(-)	Available(-)	Available(-)	Available(-)	TC1-SG4(-)

Notes:

1. TC-SGx(x) = Transducer Connection number - Signal (SGx) - positive (+) or negative (-) input
2. Available (x) = User signal available - positive (+) or negative (-) input

Table 4.12—IFPSMC Box Connector 1 User Signals Available							
Pin Number	Signal	IFPS Model					
		IFPSMC-1	IFPSMC-2	IFPSMC-3	IFPSMC-4	IFPSMC-5	IFPSMC-6
35	AI 79	Available(-)	Available(-)	Available(-)	Available(-)	TC6-SG5(-)	TC6-SG5(-)
36	AI 70	Available(+)	Available(+)	Available(+)	Available(+)	TC6-SG4(+)	TC6-SG4(+)
37	AI 77	Available(-)	Available(-)	Available(-)	Available(-)	TC6-SG3(-)	TC6-SG3(-)
38	AI 76	Available(-)	Available(-)	Available(-)	Available(-)	TC6-SG2(-)	TC6-SG2(-)
39	AI 67	Available(+)	Available(+)	Available(+)	Available(+)	TC6-SG1(+)	TC6-SG1(+)
40	AI 74	Available(-)	Available(-)	Available(-)	Available(-)	TC6-SG0(-)	TC6-SG0(-)
41	AI 73	Available(-)	Available(-)	Available(-)	TC5-SG5(-)	TC5-SG5(-)	TC5-SG5(-)
42	AI 64	Available(+)	Available(+)	Available(+)	TC5-SG4(+)	TC5-SG4(+)	TC5-SG4(+)
43	AI GND						
44	AI 63	Available(-)	Available(-)	Available(-)	TC5-SG3(-)	TC5-SG3(-)	TC5-SG3(-)
45	AI 62	Available(-)	Available(-)	Available(-)	TC5-SG2(-)	TC5-SG2(-)	TC5-SG2(-)
46	AI 53	Available(+)	Available(+)	Available(+)	TC5-SG1(+)	TC5-SG1(+)	TC5-SG1(+)
47	AI 60	Available(-)	Available(-)	Available(-)	TC5-SG0(-)	TC5-SG0(-)	TC5-SG0(-)
48	AI 59	Available(-)	Available(-)	TC4-SG5(-)	TC4-SG5(-)	TC4-SG5(-)	TC4-SG5(-)
49	AI 50	Available(+)	Available(+)	TC4-SG4(+)	TC4-SG4(+)	TC4-SG4(+)	TC4-SG4(+)
50	AI 57	Available(-)	Available(-)	TC4-SG3(-)	TC4-SG3(-)	TC4-SG3(-)	TC4-SG3(-)
51	AI 56	Available(-)	Available(-)	TC4-SG2(-)	TC4-SG2(-)	TC4-SG2(-)	TC4-SG2(-)
52	AI 39	Available(+)	Available(+)	TC4-SG1(+)	TC4-SG1(+)	TC4-SG1(+)	TC4-SG1(+)
53	AI 46	Available(-)	Available(-)	TC4-SG0(-)	TC4-SG0(-)	TC4-SG0(-)	TC4-SG0(-)
54	AI 45	Available(-)	TC3-SG5(-)	TC3-SG5(-)	TC3-SG5(-)	TC3-SG5(-)	TC3-SG5(-)
55	AI 36	Available(+)	TC3-SG4(+)	TC3-SG4(+)	TC3-SG4(+)	TC3-SG4(+)	TC3-SG4(+)
56	AI SENSE 2						
57	AI 43	Available(-)	TC3-SG3(-)	TC3-SG3(-)	TC3-SG3(-)	TC3-SG3(-)	TC3-SG3(-)
58	AI 42	Available(-)	TC3-SG2(-)	TC3-SG2(-)	TC3-SG2(-)	TC3-SG2(-)	TC3-SG2(-)
59	AI 33	Available(+)	TC3-SG1(+)	TC3-SG1(+)	TC3-SG1(+)	TC3-SG1(+)	TC3-SG1(+)
60	AI 40	Available(-)	TC3-SG0(-)	TC3-SG0(-)	TC3-SG0(-)	TC3-SG0(-)	TC3-SG0(-)
61	AI 31	TC2-SG5(-)	TC2-SG5(-)	TC2-SG5(-)	TC2-SG5(-)	TC2-SG5(-)	TC2-SG5(-)
62	AI 22	TC2-SG4(+)	TC2-SG4(+)	TC2-SG4(+)	TC2-SG4(+)	TC2-SG4(+)	TC2-SG4(+)
63	AI 29	TC2-SG3(-)	TC2-SG3(-)	TC2-SG3(-)	TC2-SG3(-)	TC2-SG3(-)	TC2-SG3(-)
64	AI 28	TC2-SG2(-)	TC2-SG2(-)	TC2-SG2(-)	TC2-SG2(-)	TC2-SG2(-)	TC2-SG2(-)
65	AI 19	TC2-SG1(+)	TC2-SG1(+)	TC2-SG1(+)	TC2-SG1(+)	TC2-SG1(+)	TC2-SG1(+)
66	AI 26	TC2-SG0(-)	TC2-SG0(-)	TC2-SG0(-)	TC2-SG0(-)	TC2-SG0(-)	TC2-SG0(-)
67	AI 25	Available(-)	Available(-)	Available(-)	Available(-)	Available(-)	TC1-SG5(-)
68	AI 16	Available(+)	Available(+)	Available(+)	Available(+)	Available(+)	TC1-SG4(+)

Notes:

1. TC-SGx(x) = Transducer Connection number - Signal (SGx) - positive (+) or negative (-) input
2. Available (x) = User signal available - positive (+) or negative (-) input

4.5.6.2 Installing Additional IFPS Cards in an IFPSMC Box

Current IFPSMC box models have all transducer connectors installed on the front panel; additional IFPS cards can be added to use with additional transducers.

Tools required: *#2 Phillips head screw driver*

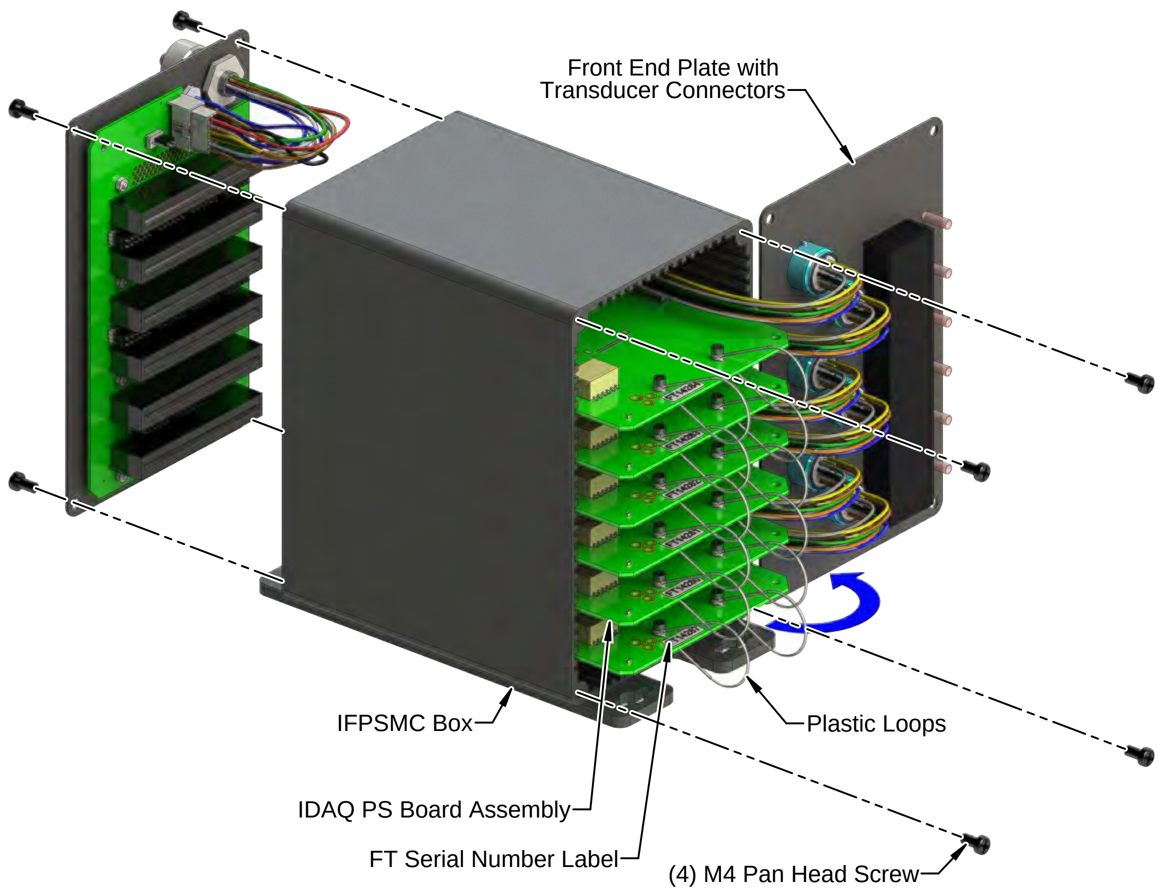
Parts required: *9105-IFPSMC-PCB*

NOTICE: The following steps must be done at an anti-static workstation.

NOTICE: Make sure the transducers are re-connected to the same connector on the front panel when re-assembling the IFPSMC box. Also ensure the transducers and the connector on the front panel are clearly marked with the serial number label.

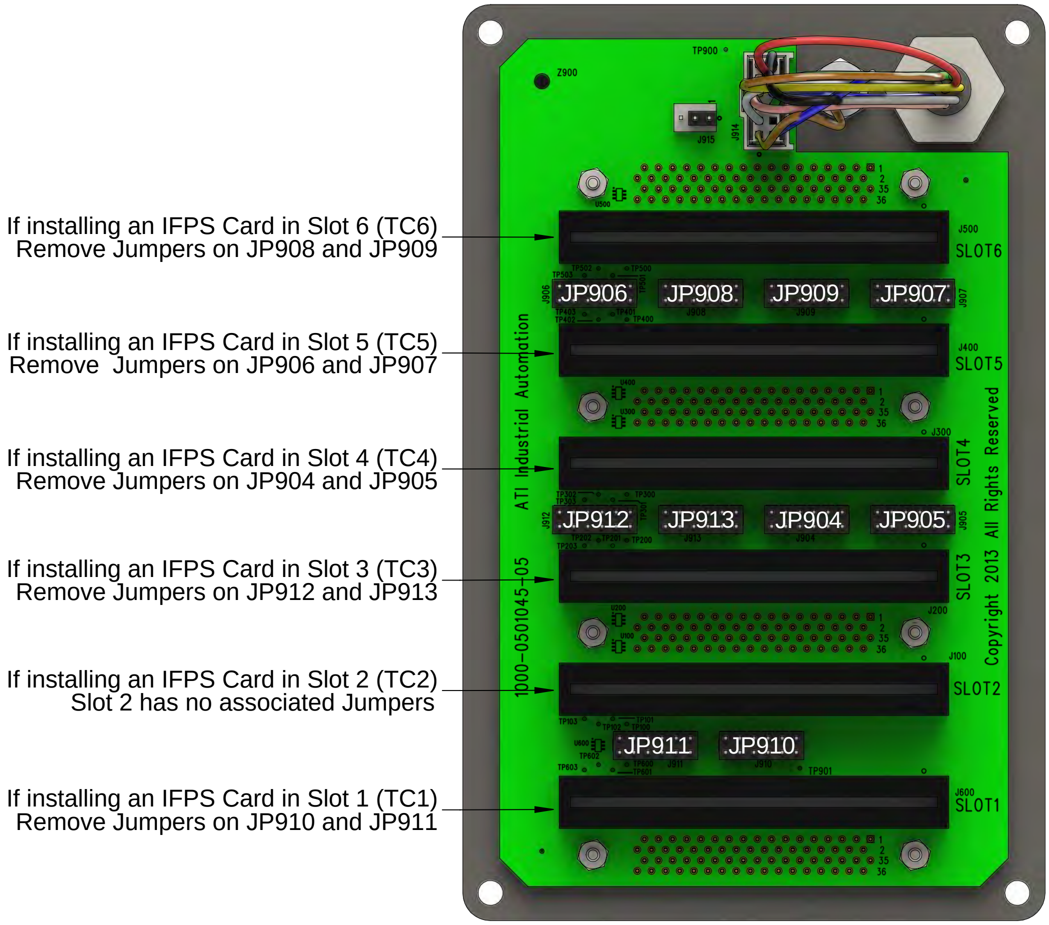
1. Disconnect all cables, transducers and the power supply from the IFPSMC box.
2. Remove the (4) M4 pan head screws from the front panel using a Phillips head screw driver.
3. Carefully rotate the front panel open to the right side of the box, as shown in *Figure 4.21*.

Figure 4.21—IFPSMC Box Disassembly



4. Determine the next available slot in the IFPSMC box. Note: The slots should be populated starting with slot 2 then 3, 4, 5, 6, and 1. Slot 1 should be the last slot populated.
5. Look into the front of the IFPSMC box to verify there are no jumpers installed for the IFPS card to be installed (refer to *Figure 4.22).*
   a. If the corresponding 12 pin jumper is installed for the slot to be populated, it must be removed. Proceed to step *6*.
   b. If the 12 pin jumpers are not installed proceed to step *12*.

Figure 4.22—Removing 12 Pin Jumpers on the IFPSMC Backplane



6. Disconnect all the IFPS cards from the backplane by firmly holding the top of the IFPSMC box and simultaneously pulling the two plastic loops attached to each board. Pull each board out about 1/2” to disconnect from the backplane. Refer to *Figure 4.21*.
7. Remove the (4) M4 pan head screws from the back panel using a Phillips head screw driver.
8. Carefully remove the back panel with the backplane board attached.
9. Remove the 12 pin jumpers from the backplane for the IFPS card being installed. Refer to *Figure 4.22*.

NOTICE: The jumpers allow access to channels not used by unpopulated IFPS cards through the connector 0 and 1 from user connectors on the back of the IFPSMC box. Refer to *Table 4.11* and *Table 4.12* for more information. Remove the jumpers associated with the slot for the IFPS card being installed, refer to *Figure 4.22*. If access to extra signals is not desired, safely remove all 10 of the 12 pin jumpers to simplify future IFPS card installation.

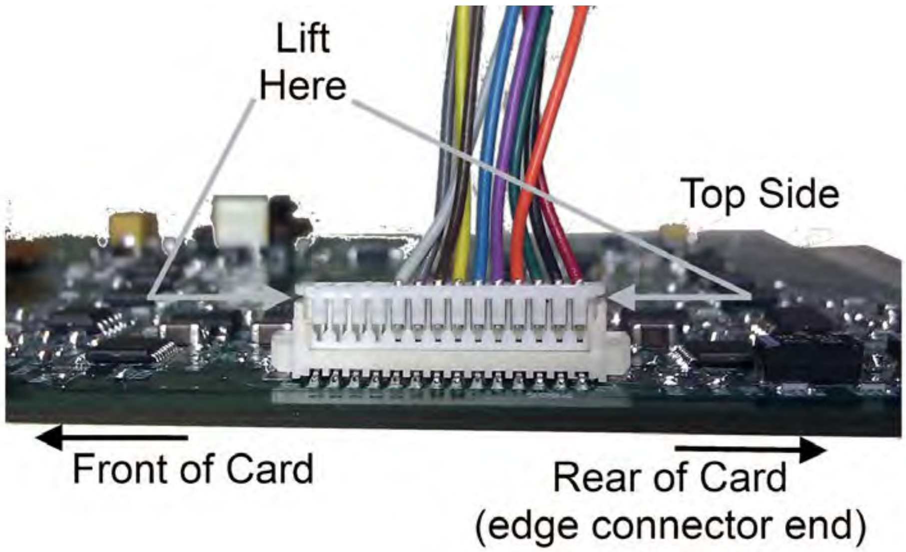
10. Carefully attach the back panel to the IFPSMC box. Note: be sure not to pinch any wire between the back panel and the box. Secure the back panel with the (4) M4 pan head screws. Refer to *Figure 4.21*.
11. Connect the IFPS card to the backplane by pushing the board in until it seats into the backplane connector. Connect all the IFPS cards disconnected in step *6*.
12. Remove the new IFPS card from the anti-static bag. Note: the serial number on the IFPS card, which slot number it will be installed in, and the serial number of the transducer the card will be connected to. Record this information in *Table 4.13*. The serial number on the card should match the serial number on the transducer.

Table 4.13—IFPSMC IFPS Cards and Transducers

Slot	IFPS Card SN	Transducer FT SN	Notes
Transducer 6			
Transducer 5			
Transducer 4			
Transducer 3			
Transducer 2			
Transducer 1			

13. Connect the transducer connector harness from the connector on the front panel to the IFPS card, as shown in *Figure 4.23*.

Figure 4.23—Transducer Connector Harness Connection

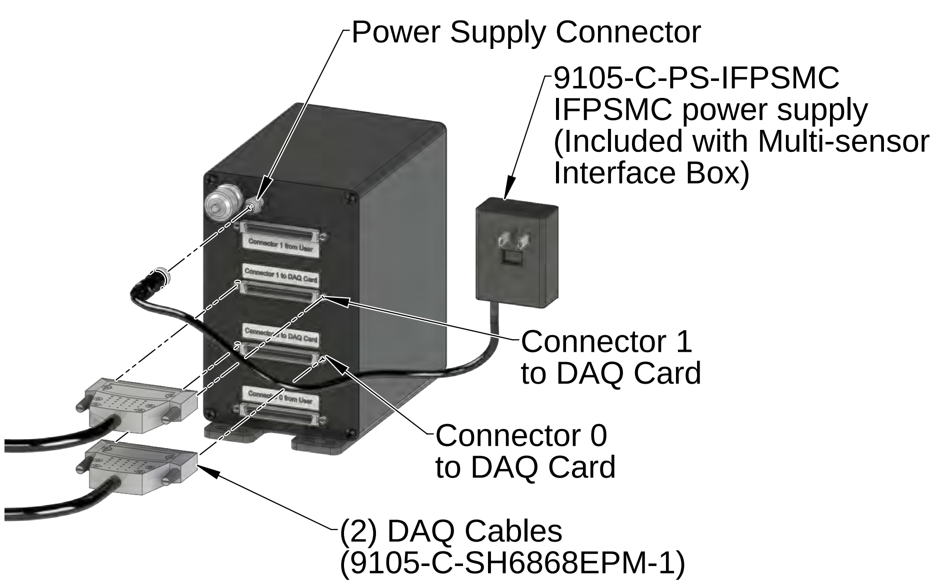


14. Install the IFPS card into the next available slot of the IFPSMC box. Seat the new IFPS card into the backplane by pushing the board in until it seats into the backplane connector.
15. Carefully rotate the front panel back into place on the IFPSMC box. Note: Do not pinch any wire between the front panel and the box. Secure the front panel using the (4) M4 pan head screws.

Figure 4.24—IFPSMC Box FT Connector Labels

16. Locate the FT serial number label supplied with the kit and fix the label to the front panel, next to the connector of the recently installed IFPS card. The FT serial number label should match both the IFPS card and transducer serial numbers associated with the connector. Refer to *Figure 4.24.*
17. Connect the male connector on the transducer cable to the connector on the front of the IFPSMC box corresponding to the recently installed IFPS card.
18. Reconnect the power supply and DAQ cables to the back of the IFPSMC box. Refer to *Figure 4.25.*
19. After the procedure is complete, resume normal operation.

Figure 4.25—Power Supply and DAQ Cable Connections



4.5.6.3 Power

The small connector on the rear of the box is for power input. A Murr 7000-08481-0000000 connector (female) may be used to mate with the power input connector.

Figure 4.26—Power Input Connector

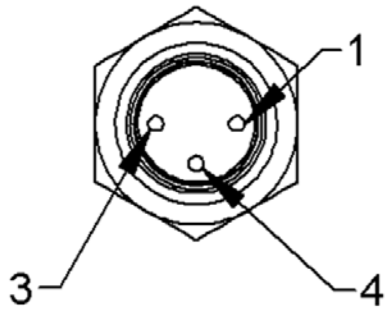


Table 4.14—IFPSMC Power Input Connector Pin Assignments	
Pin	**Description**
1	+V input
3	0V input
4	No connection

The IFPSMC accepts from +4.65VDC to +15VDC.

Table 4.15—Typical Input Current at Various Voltages at Room Temperature			
Model	**Current Draw**		
	@ 5VDC	**@12VDC**	**@15VDC**
9105-IFPSMC-2	0.36A	0.19A	0.16A
9105-IFPSMC-3	0.54A	0.28A	0.24A
9105-IFPSMC-4	0.72A	0.37A	0.32A
9105-IFPSMC-5	0.90A	0.46A	0.40A
9105-IFPSMC-6	1.08A	0.56A	0.48A

5. Operation

5.1 Writing DAQ F/T Application

See the ATI DAQ FT help file for information on developing an application.

5.2 Data Collection Rates

Our DAQ F/T sensor systems are designed to be electrically compatible with most commercially-available, general-purpose and high-accuracy data acquisition hardware. For best performance in all applications, the transducer electronics have bandwidth of 5kHz to 10kHz (depending on gain settings). This allows collection of all transducer frequency content. Note: that to satisfy the Nyquist Theorem†, the data needs to be coupled at a rate greater than twice the highest frequency present, even if data at that frequency is not preferred.

Note: that significant error can be introduced in the transducer data if a National Instruments E-Series card is sampling each data set at over 40 kHz (240 kHz per channel). Users with fast NI-DAQ devices should not use the single-scan functions of NI-DAQ, such as AI_Read_Scan and AI-VRead_Scan. A buffered operation (such as Scan_Op) should be used instead. In the ATI DAQ FT Demo, the Buffer Mode option should be enabled.

† The Nyquist Theorem applies to data collection and states that data acquired must be collected at a data rate greater than twice the highest frequency present in the data, otherwise the data will be erroneous.

5.3 Multiple Calibrations

Some transducers have multiple calibrations, to allow the transducer to have greater range or finer resolution, depending on the circumstance. Changing to another calibration is done by loading the new calibration in the demo software; select the File/Open Calibration menu or update the CalFilePath property in an application.

5.4 Resolution

ATI's transducers have a three sensing beam configurations where the three beams are equally spaced around a central hub and attached to the outside wall of the transducer. This design transfers applied loads to multiple sensing beams allowing the transducer to increase its sensing range in a given axis provided a counterpart axis has reduced loading (see *9620-05-Transducer Section* manual for compound loading information).

The resolution of each transducer axis depends on how the applied load is spread among the sensing beams. The best resolution occurs when quantization of the gages is evenly distributed as load is applied. In the worst case scenario, the discrete value of all involved gages increases at the same time. The typical scenario will be somewhere in between these two.

F/T resolutions are specified as typical resolution, defined as the average of the worst and best case scenarios. Because both multi-gage effects can be modeled as a normal distribution, this value represents the most commonly perceived average resolution. The DAQ F/T resolutions are based on real-number calculations and do not result in clean fractions. To express the values as clean fractions, the values that a 16-bit DAQ card can achieve will have to be used. The yielded values are a conservative estimation of the transducer's actual performance.

5.5 Environmental

The standard F/T system is designed to be used in standard laboratory or light-manufacturing conditions. Transducers with an IP60 designation are able to withstand dusty environments. Transducers with an IP65 designation are able to withstand dusty environments and wash down, and those with an IP68 designation are able to withstand dusty environments and freshwater immersion to a specified depth. For transducer environmental information, refer to the *9620-05-Transducer Section* manual.

IP60 and non-IP rated transducers, the PS box, and the IFPS box can be used in environments with up to 95% relative humidity, non-condensing.

Table 5.1—Interface Box Temperature Ranges

Model	Storage	Operation	Units
PS box	-30 to 75	0 to 60	°C
IFPS box	-30 to 75	0 to 60	°C

Note: These temperature ranges specify the storage and operation ranges in which the electronics can survive without damage. They do not take accuracy into account.

6. Maintenance

6.1 Periodic Inspection

For most applications, part replacement during normal operation is unnecessary. With industrial-type applications that frequently move the system's cabling, the cable jacket should be periodically checked for signs of wear. These applications should implement the procedures discussed in *Section 7.2—Detecting Failures (Diagnostics)* to detect any failures.

The transducer must be kept free of excessive dust, debris, or moisture. Applications with metallic debris (i.e., electrically-conductive) must protect the transducer from this debris. Transducers without specific factory-installed protection should be considered unprotected. Should the internal structure of the transducers become clogged with particles, the calibration may be affected or the transducer may be damaged

6.2 Periodic Calibration

Periodic calibration of the transducer and DAQ card is required to maintain traceability to national standards. Follow any applicable ISO-9000-type standards for calibration. ATI Industrial Automation recommends annual recalibrations, particularly for applications that frequently cycle the loads applied to the transducer.

6.3 Multiple IFPSMC Box Recalibration

The electronics (IFPS card) in the IFPSMC are needed along with the transducers when the transducers are being recalibrated. Sending the entire IFPSMC box for recalibration along with the transducers is recommended. Occasionally, circumstances require the recalibration of a single transducer, while other transducers remain in use. In this case, remove the transducer's IFPS card from the IFPSMC box to accompany the transducer for recalibration. For instructions, refer to *Section 6.3.1—Removing and Replacing the IFPS Card for Recalibration*.

6.3.1 Removing and Replacing the IFPS Card for Recalibration

Tools required: *#2 Phillips head screw driver*

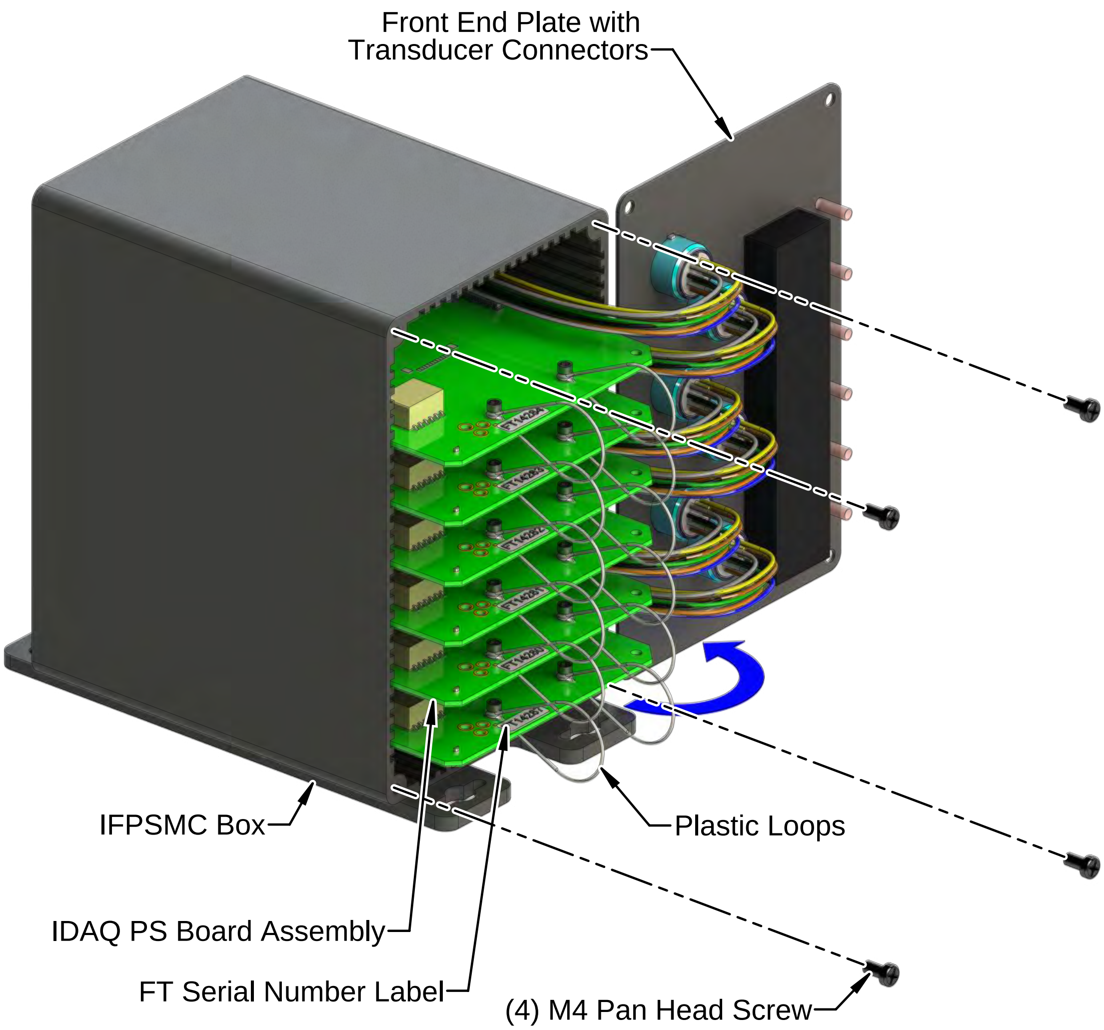
Parts required: *9105-IFPSMC-PCB*

NOTICE: The following steps need to be done at an anti-static workstation.

NOTICE: Make sure the transducers are re-connected to the same connector on the front panel when re-assembling the IFPSMC box. Also ensure the transducers and the connector on the front panel are clearly marked with the serial number label.

1. Disconnect all cables, transducers and the power supply from the IFPSMC box.
2. Remove the (4) M4 pan head screws from the front panel using a phillips head screw driver.
3. Carefully rotate the front panel open to the right side of the box, as shown in *Figure 6.1*.

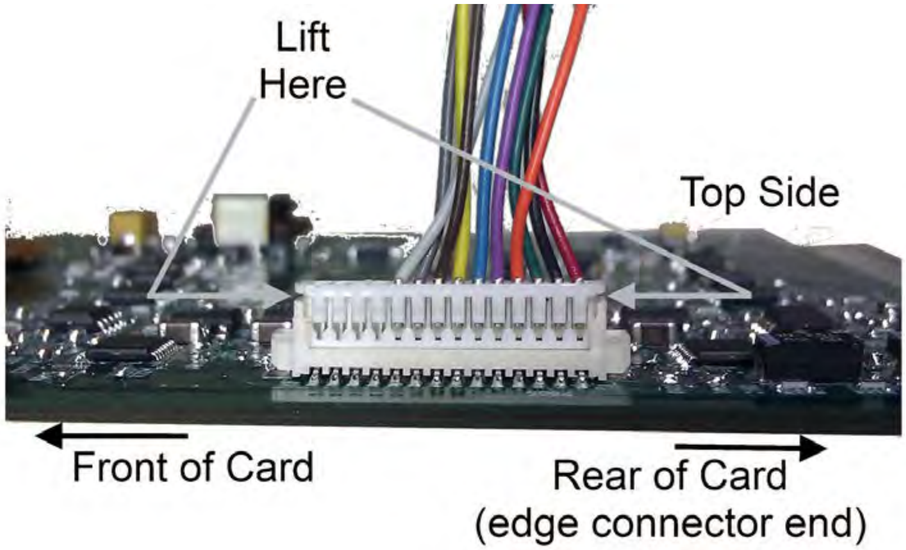
Figure 6.1—IFPSMC Box Disassembly



4. Identify the IFPS card to be removed by following the wires from the associated transducer connector.
5. Disconnect the IFPS card from the backplane by firmly holding the top of the IFPSMC box and simultaneously pulling the two plastic loops attached to each board. Slide the board out.

6. (Using fingernails) carefully remove the transducer connector harness from the IFPS card by simultaneously prying up both ends of the connector. See the "Lift Here" call out in *Figure 6.2*.

Figure 6.2—Transducer Connector Harness Connection



7. Place the IFPS card into an anti-static bag and send with the transducer to be recalibrated to ATI.
8. Remove the recalibrated IFPS card from the anti-static bag and note the serial number on the IFPS card, which slot number it will be installed in, and the serial number of the transducer it will be connected too. Record this information in *Table 6.1*.

Table 6.1—IFPSMC IFPS Cards and Transducers			
Slot	**IFPS Card SN**	**Transducer FT SN**	**Notes**
Transducer 6			
Transducer 5			
Transducer 4			
Transducer 3			
Transducer 2			
Transducer 1			

9. Connect the transducer connector harness from the connector on the front panel to the IFPS card, as shown in *Figure 6.2.*
10. Install the IFPS card into the slot in the IFPSMC box. Seat the new IFPS card into the backplane by pushing the board in until it seats into the backplane connector.
11. Carefully rotate the front panel back into place on the IFPSMC box. Note: be sure not to pinch any wire between the front panel and the box. Secure the front panel using the (4) M4 pan head screws,

Figure 6.3—IFPSMC Box FT Connector Labels

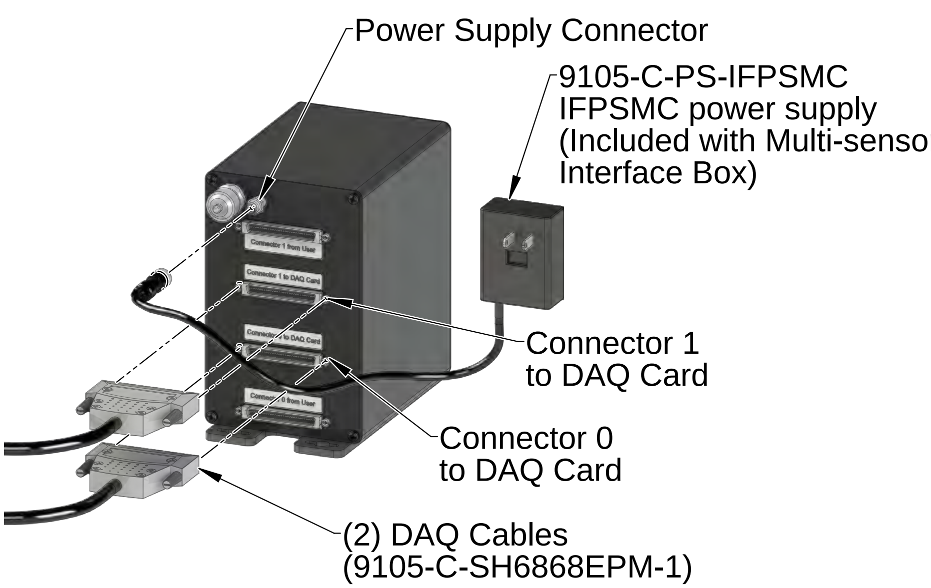
12. Remove the old FT serial number label from the front panel and fix the FT serial number label supplied with the kit to the front panel for the IFPS card just installed. Refer to *Figure 6.3.*

13. Connect the male connector on the transducer cable to the appropriate connector on the front of the IFPSMC box. Note: The Serial number label on the Transducer must match the serial number label on the IFPSMC Box connector it is plugged into. Refer to *Figure 4.9.*

14. Reconnect the power supply and DAQ cables to the back of the IFPSMC box. Refer to *Figure 6.4.*

15. After the procedure is complete, resume normal operation.

Figure 6.4—Power Supply and DAQ Cable Connections



7. Troubleshooting

Information to assist troubleshooting the DAQ system is included in this section. Each potential question or problem is listed and followed by its probable answer or solution; all are categorized for easy reference.

If needed, customer service is available to users:

ATI Industrial Automation
Attn: F/T Customer Service
Pinnacle Park
1031 Goodworth Drive
Apex, NC 27539 USA

Phone: +1.919.772.0115
Fax:+1.919.772.8259
Email: *ft_support@ati-ia.com*

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

1. Serial number (e.g., FT01234)
2. Transducer model (e.g., Nano17, Gamma, Theta, etc.)
3. Calibration (e.g., US-15-50, SI-65-6, etc.)
4. Accurate and complete description of the question or problem
5. Computer and software information (Operating system, PC type, drivers, application software, and other relevant information about the configuration)

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

7.1 Errors with Force and Torque Readings

Inaccurate data from the transducer's strain gages can cause errors in force/torque readings. These errors can result in problems with threshold monitoring, sensor biasing and accuracy. Basic conditions of such data is included in the following table. Use this table to troubleshoot problems. In most cases, problems are easier to detect while viewing raw strain gage data.

Table 7.1—Troubleshooting Table

Symptom	Cause	Resolution
Saturation	When the data from a raw decimal strain gage reads the positive or negative maximums, that gage is saturated. Saturation occurs if the sensor is loaded beyond its rated maximum or in the event of an electrical failure within the system.	Stop applying force to the transducer and wait until the error clears to continue. If error does not clear, it may indicate the overload value has been exceeded or a loss of power.
Noise	Excessive noise can be caused by mechanical vibrations and electrical disturbances, possibly from a poor ground. It can also indicate component failure within the system.	Make sure the unit is grounded properly and the area is isolated from electrical disturbances.
Drift	After a load is removed or applied, the raw gage reading does not stabilize but continues to increase or decrease. This may be observed more easily while viewing resolved F/T data. Drift is caused by temperature change, mechanical coupling, or internal failure. Mechanical coupling is caused when a physical connection is made between the tool plate and the sensor body (i.e., plastic filings between the tool adapter plate and the transducer body). Some mechanical coupling is common, such as hoses and wires attached to a tool.	Make sure the tool, tool adapter plate and the transducer body are isolated from each other and no debris lies between the transducer body and tool plate.
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 drift section) or internal failure.	Make sure the tool, tool adapter plate and the transducer body are isolated from each other and no debris lies between the transducer body and tool plate.

7.2 Detecting Failures (Diagnostics)

7.2.1 Detecting Connection Issues

The F/T system is designed to output voltages that are within the specified output voltage range (±5V or ±10V) as long as the transducer is not being overloaded and is connected to the PS or IFPS box. If the transducer cable is disconnected or has been damaged, the output of the system will be outside the specified output voltage range. By performing periodic checks of the voltages, a failure can be detected. If any of the voltages are at or outside this range, a problem with the transducer or its cabling may exist.

CAUTION: When any strain gage output is saturated or otherwise inoperable, all transducer F/T readings are invalid. Therefore, it is vitally important to monitor for these conditions.

7.2.2 Detecting Cable Problems

A properly functioning DAQ system will deliver voltages representative of transducer loading from the transducer to the DAQ card inputs. The DAQ system provides two safety features to aid in detection of cabling problems that could disrupt the reading of transducer voltages.

1. If the cable is disconnected between the transducer and its IFPS or PS box, voltages sent to the DAQ card from the box will be forced to a saturation level.
2. The T out signal outputs a voltage that is either -1.54V if no temperature reader circuit is installed, or a voltage greater than +0.5V if the temperature reader is installed and the temperature is above -10^{o}C.

If the acquired transducer voltages are A/D saturated or T out is not between -1.6V to -1.5V, or not between +0.5V and saturation, there may be a cable issue.

7.2.3 Detecting Sensitivity Changes

Sensitivity checking of the transducer can be used to measure the transducer system's health. This is done by applying known loads to the transducer and verifying the system output matches the known loads.

For example, a transducer mounted to a robot arm may have an end-effector attached to it:

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

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

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 year from the date of shipment. This warranty does not cover components subject to wear and tear under normal usage or those requiring periodic replacement. 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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Without ATI's prior written permission, Purchaser will not use such information for any other purpose of provide or otherwise make such information available to any third party. Purchaser agrees to take all reasonable precautions to prevent any unauthorized use or disclosure of such information.

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Appendix A – Tool Transformation

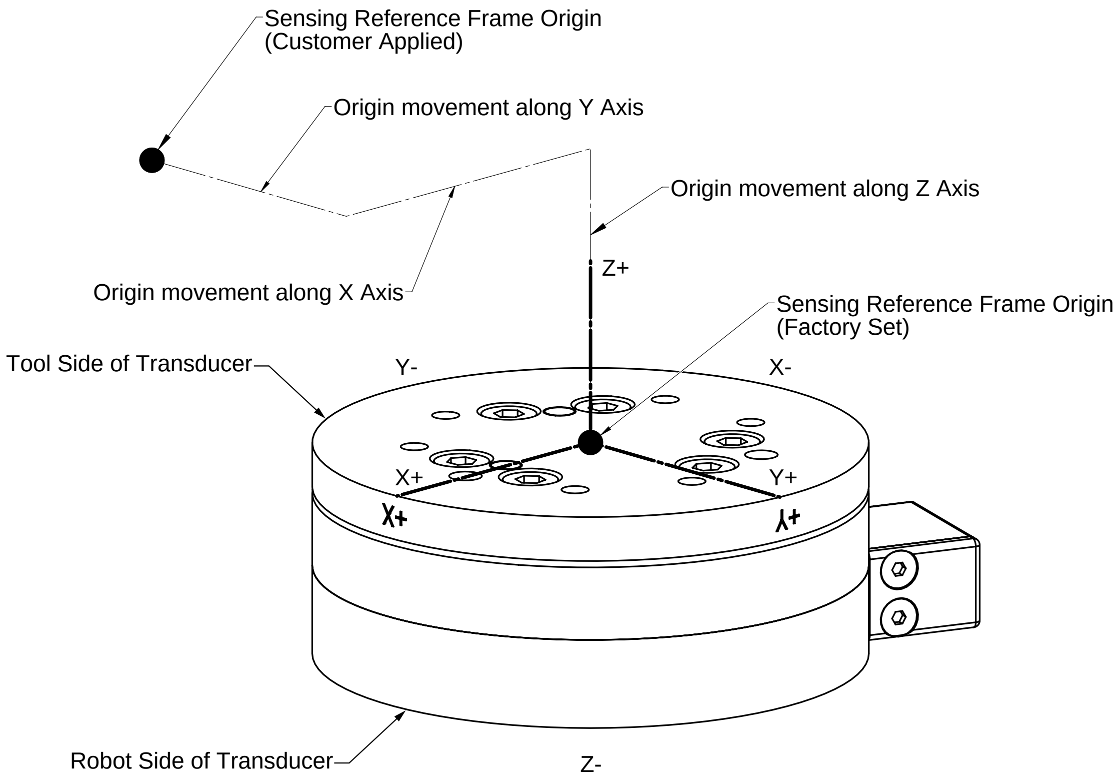
The tool transformation feature allows a series of tool transformations to be used to measure the forces and torques acting at a point other than the origin of the sensor. If both rotations and displacements are specified within a particular tool transformation, displacements are performed first, in the order DX, DY, DZ, then rotations are performed, in the order RX, RY, RZ. If it is critical that rotations occur before displacements, entering a tool transformation with only rotations before entering a second tool transformation with displacements.

Tool Transformations Screen Controls:

- Displacement DX, DY, and DZ: The displacement along each axis is measured in the distance component of the calibration's torque units, so if the sensor was calibrated to use Newton-meters as the torque unit, the displacement is measured in meters.
- Rotations RX, RY, and RZ: The rotation about each axis, in radians.
- Add: Adds the current tool transformation to the transformation queue.
- Remove: Removes the highlighted transformation from the queue, also fills the displacement and rotation controls with the values of the removed transformation.
- Cancel: Returns to the main form without applying any changes made to the transformation queue.
- Apply Transformation: Applies transformations in the queue and returns to the main form.

Displacement allows the customer to move the sensing reference frame origin along the X, Y, and Z axes. Displacement should be calculated and values should be entered before rotation. Displacement is measured in units which are set as either Nm or in-lbs. on the Calibration Screen.

Figure A.1—Displacement of Sensing Reference Frame Origin



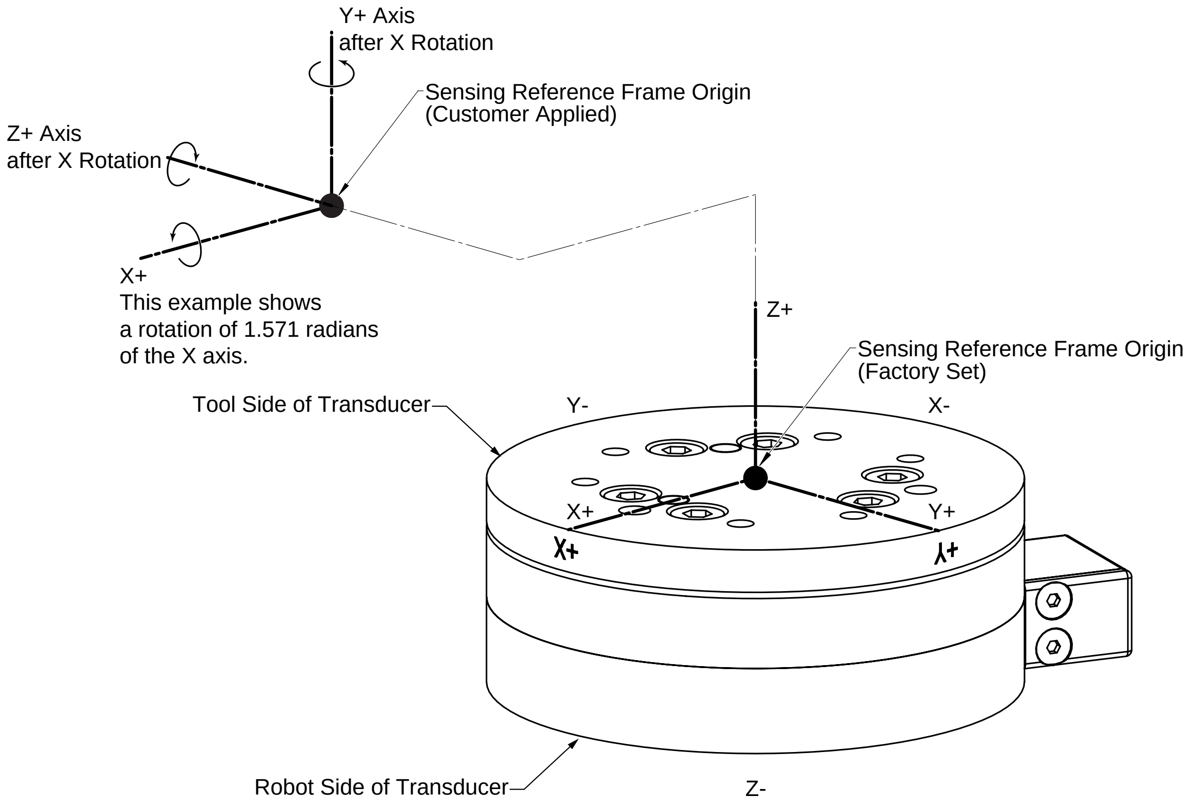
Rotation allows the customer to rotate the axes while maintaining the frame origin. *Figure A.2* shows the direction of rotation about the axis. Rotation is measured in radians.

When a value is entered for RX, RY, or RZ the following will result:

- RX value will rotate Y and Z about X in the direction shown (see *Figure A.2*).
- RY value will rotate X and Z about Y in the direction shown.
- RZ value will rotate X and Y about Z in the direction shown.

In a tool transformation, the order of the rotations is critical. The X-rotation occurs first, followed by rotation about Y (in its new orientation), then Z. Therefore, rotations MUST be expressed in this order

Figure A.2—Rotating Reference Frame



F/T Transducer

Six-Axis
Force/Torque Sensor System

Installation and Operation Manual

Document #: 9620-05-Transducer Section

Engineered Products for Robotic Productivity

Pinnacle Park • 1041 Goodworth Drive • Apex, NC 27539 • Tel: +1-919.772.0115 • Fax: +1-919.772.8259 • www.ati-ia.com

Foreword

ATI Force/Torque Sensing Systems are considered components / semi-finished goods intended for use in a 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. Before calling, have the following information available:

1. Serial number (e.g., FT01234)
2. Transducer model (e.g., Nano17, Gamma, Theta, etc.)
3. Calibration (e.g., US-15-50, SI-65-6, etc.)
4. Accurate and complete description of the question or problem
5. Computer and software information. Operating system, PC type, drivers, application software, and other relevant information about the configuration.

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

For additional information or assistance, please refer to the following contacts:

Sale, Service and Information about ATI products:

ATI Industrial Automation
1041 Goodworth Drive
Apex, NC 27539 USA
www.ati-ia.com
Tel: +1.919.772.0115
Fax: +1.919.772.8259

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

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Glossary

Term	Definition
Accuracy	See Measurement Uncertainty.
Calibration Certificate	A statement that says the equipment measures correctly. These statements usually mean the equipment has been tested against national standards. The statements are produced as a result of calibration or re-calibration.
Calibration	The act of measuring a transducer's raw response to loads and creating data used in converting the response to forces and torques.
Compound Loading	Any load that is not purely in one axis.
Coordinate Frame	See Point of Origin
DAQ F/T	An F/T Sensor System that uses industry standard data acquisition fasteners (usually computer cards) to convert the transducer signals into digital data.
DAQ	Data Acquisition device.
DoF	Degrees of Freedom. See Six Degrees of Freedom.
F/T Controller	The electronics that connect to mux transducers.
F/T	Force and Torque.
Force	The push or pull exerted on an object.
FS	Full-Scale
Full-Scale Error	A measurement of sensing error. For example, if the calibrated measurement range of a sensor is 100 Newtons and the sensor is accurate to within 1 Newton, that sensor will have a Full-Scale Error of 1% (1% = 0.01 = 1 N / 100 N).
Fxy	The resultant force vector comprised of components Fx and Fy.
Hysteresis	A source of measurement error caused by the residual effects of previously applied loads.
IP60	Ingress Protection Rating "60" designates protection against dust
IP65	Ingress Protection Rating "65" designates protection against water spray
IP68	Ingress Protection Rating "68" designates submergibility in fresh water, in this case, to a depth of 10 meters
MAP	Mounting Adapter Plate. The transducer's MAP attaches to the fixed surface or robot arm.
Max. Single-Axis Overload	The largest amount of load in a single axis (all other axes are unloaded) that the transducer can withstand without damage.
Measurement Uncertainty	The maximum expected error in measurements, as specified on the calibration certificate.
Moment	When something receives a torque, we say a moment is applied to it.
Mux Box	A box that holds mux electronics for transducers that are too small for on-board electronics.
Mux	Short for multiplexer. F/T Controller Sensor Systems use mux electronics to interface to the transducer signals.
Net F/T	An F/T Sensor System that connects to the customer's monitoring equipment via Ethernet or CAN bus or DeviceNet.
Offset Compensation	Correction of errors that change the zero point of a transducer's readings.
Overload	The condition where more load is applied to the transducer than it can measure. This will result in saturation.
Point of Origin	The point on the transducer from which all forces and torques are measured.

Term	Definition
Quantization	The way the continuously variable transducer signal is converted into discreet digital values. Usually used when describing the change from one digital value to the next.
Re-calibration	The periodic verification of measurement equipment, like transducers, calipers and voltmeters, to prove it still measures correctly. The equipment may be adjusted if it doesn’t measure correctly.
Reaction Torque	Torque applied that does not result in movement. Think of the twisting you attempt to put on a screw or bolt when it does not move. ATI transducers sense reaction torque.
Resolution	The smallest change in load that can be measured. This is usually much smaller than accuracy.
Rotary Torque	Torque resulting in something moving. Generally this refers to the torque on things like drive shafts. ATI transducers cannot sense rotational torque.
Saturation	The condition where the transducer or data acquisition fasteners has a load or signal outside of its sensing range.
Sensor System	The entire assembly consisting of parts from transducer to data acquisition card.
Six Degrees of Freedom	Fx, Fy, Fz, Tx, Ty and Tz.
Six-axis Force/Torque Sensor	A device that measures the outputting forces and torques from all three Cartesian coordinates (x, y and z). A six-axis force/torque transducer is also known as a multi-axis force/torque transducer, multi-axis load cell, F/T sensor, or six-axis load cell.
Span Compensation	Correction of errors that affect the sensitivity of a transducer.
TAP	Tool Adapter Plate. The TAP part of the transducer is attached to the load that is to be measured.
Tool Transformation	Mathematically changing the measurement coordinate system by translating the origin and/or rotating the axes.
Torque	The measurement of force exerted on an object causing it to rotate.
Transducer	The component that converts the sensed load into electrical signals.
Txy	The resultant torque vector comprised of components Tx and Ty.

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. There is no personnel safety risk associated with the intended design of the products described within this manual. 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 transducer selected is rated for maximum loads and moments expected during operation. For this information, refer to *Section 5—Transducer Specifications* or contact an ATI representative for assistance. Particular attention should be paid to dynamic loads caused by robot acceleration and deceleration. These forces can be many times the value of static forces in high acceleration or deceleration situations.

1.3 Safety Precautions

CAUTION: Do not remove any fasteners or disassemble transducers without a removable mounting adapter plate. These include Nano, Mini, IP-rated, and some Omega transducers. This will cause irreparable damage to the transducer and void the warranty. Leave all fasteners in place and do not disassemble the transducer.

CAUTION: Do not probe any openings in the transducer. This will damage the instrumentation.

CAUTION: Do not exert excessive force on the transducer. The transducer is a sensitive instrument and can be damaged by applying force exceeding the single-axis overload values of the transducer and cause irreparable damage. Small Nano and Mini transducers can easily be overloaded during installation. For specific transducer overload values, refer to *Section 5—Transducer Specifications*.

2. Product Overview

A transducer is a device that measures the outputting forces and torques from all three Cartesian coordinates (x, y, and z). A six-axis force/torque transducer is also known as a multi-axis force/torque transducer, multi-axis load cell, F/T sensor, or six-axis load cell.

The ATI Multi-Axis Force/Torque (F/T) sensor system measures all six components of force and torque. The system consists of a transducer, shielded high-flex cable, and intelligent data acquisition system (Ethernet/ DeviceNet interface or F/T controller). F/T sensors are used throughout industry for product testing, robotic assembly, grinding, and polishing. In research, ATI sensors are used in robotic surgery, haptics, rehabilitation, neurology, and many others applications.

3. Installing the Transducer

Information on the transducer environment, IP rating, mounting, and routing of the transducer cable are included in the following sections.

3.1 Transducer Environment

To ensure proper operation, the IP rating of the transducer must match or exceed the transducer's environment. Unless otherwise specified, a transducer has no special IP protection. In this case, the transducer may be used only in benign environments with no dust, debris, liquids, or sprays. For information on the transducer's temperature performance, refer to *Section 4.1—Accuracy over Temperature*.

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

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

NOTICE: Transducers without an IP protection may exhibit a small offset in readings when exposed to strong light.

3.2 Mounting the Transducer

There are two different mounting methods for transducers. The first method has a fixed bolt pattern on the tool side of the transducer and a removable adapter plate on the mounting (robot or other device) side. The adapter plate needs to be removed from the transducer and machined with the mounting bolt pattern to match the robot or other device. If the device covers the mounting fasteners used to connect the transducer, the removable adapter plate can't be used alone. If this is the case a user designed interface plate is needed between the transducer and the robot or other device. For more details, refer to *Section 3.2.1—Interface Plate Design* and *Section 3.2.2—Mounting the Transducer with a Removable Mounting Adapter Plate.*

The second method is for transducers with non-removable adapter plates with fixed bolt patterns on both the tool and mounting sides of the transducer (Nano, Mini, IP-rated and some Omega transducers). This type may require a user designed interface plate to attach the transducer to the robot or other device. For more information, refer to *Section 3.2.1—Interface Plate Design* and *Section 3.2.3—Mounting the Transducer with a Non-removable Adapter Plate*.

CAUTION: Do not remove any fasteners or disassemble transducers without a removable adapter plate, these include Nano, Mini, IP-rated, and some Omega transducers. Disassembly causes irreparable damage to the transducer and voids the warranty. Leave all fasteners in place and do not disassemble the transducer.

To determine if the adapter plate is removable for a transducer, refer to the product drawings in *Section 5—Transducer Specifications*. Mount the transducer to a structure with sufficient mechanical strength. Not doing so can lead to sub-optimum performance.

3.2.1 Interface Plate Design

Interface plates may be required between the robot or other device and the transducer and between the transducer and the tooling. If the robot, other device, or tooling covers the mounting fasteners for the transducer, an interface plate is required. Custom interface plates are available from ATI upon request.

There are two types of mounting adapter plate (robot side). For small transducers such as Nano, Mini, IP-rated, and some Omega, the mounting adapter plate is factory installed and should not be removed or machined. The mounting interface plate must be machined with the corresponding bolt pattern and dowel locations, refer to the transducer drawings. Links to drawings are included in *Section 5—Transducer Specifications*.

Larger transducers have removable mounting adapter plates (refer to *Section 3.2.2—Mounting the Transducer with a Removable Mounting Adapter Plate*). Machine the mounting interface plate to match the bolt pattern and dowel hole in the removable mounting adapter plate.

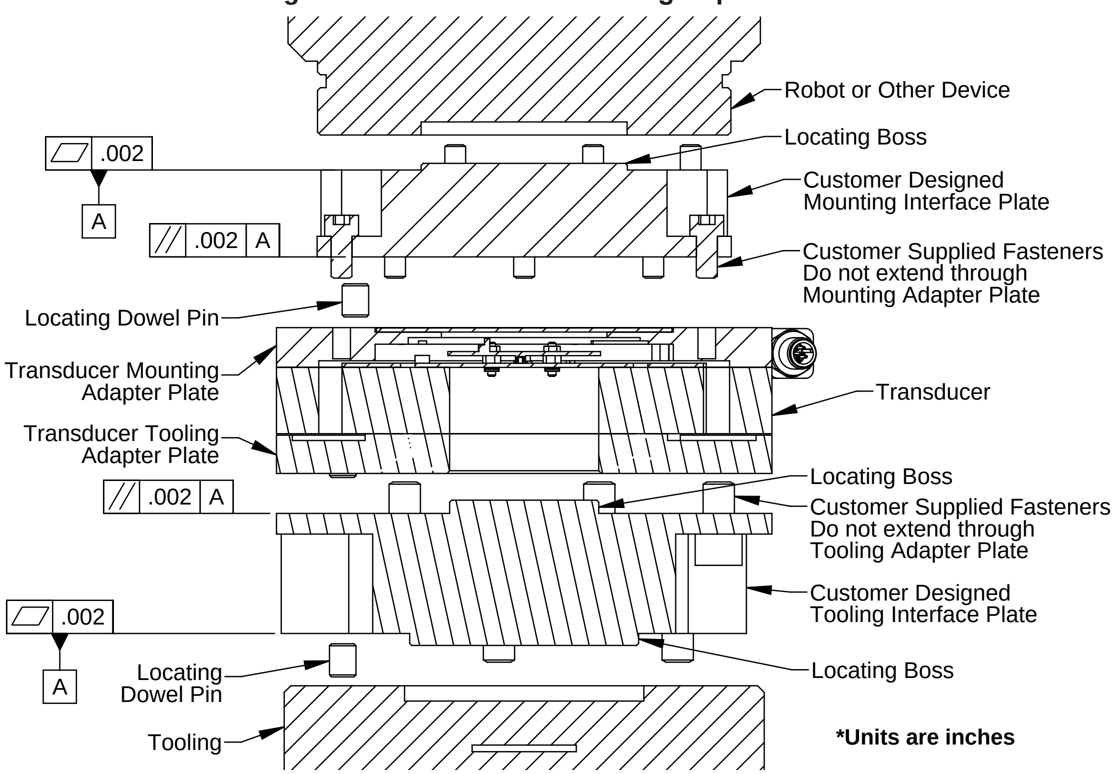
The transducer tooling adapter plate is factory installed and the bolt circle is shown with the transducer in drawings; for links to the drawings, refer to *Section 5—Transducer Specifications*. Most large F/T tool adapters follow the ISO 9409-1 mounting pattern. Machine the tooling interface plate to attach to this bolt circle.

NOTICE: The tool may not contact any other part of the transducer except the tool mounting surface. If the tool contacts any other part of the transducer, the transducer will not properly sense loads. Make sure the tool mounts to the tool mounting surface and does not contact any other part of the transducer.

If the customer chooses to design and build a mounting or tooling interface plate, consider the following points. Links to the product drawings are in *Section 5—Transducer Specifications*.

- The interface plate should be designed to include bolt holes for mounting, dowel pins, and a boss for accurate positioning on the robot or other devices and to the adapter plate. These locating features should orient the X and Y axis of the Transducer to the X and Y axis of the robot.
- The thickness of the interface plate must be great enough to provide the necessary thread engagement for the mounting fasteners.
- Mounting fasteners must not be too long. They should not extend through the adapter plate to avoid interference with the electronics inside the transducer. For thread depth, mounting patterns, and other details, refer to the drawings.
- The interface plate must be properly designed to provide rigid mounting for the transducer. The interface plate should not distort under maximum sensor range of the transducer .
- The interface plate design must provide a flat and parallel mounting surface for the transducer.

Figure 3.1—Interface Plate Design Specification



3.2.2 Mounting the Transducer with a Removable Mounting Adapter Plate

First, determine if the transducer can attach directly to the robot/device arm or if an interface plate is needed. If an interface plate is need for the robot side and/or tool side, refer to *Section 3.2.1—Interface Plate Design* for details to design an interface plate before continuing with this procedure.

1. Remove power to the transducer.
2. Remove all mounting fasteners from the mounting adapter plate and set aside.

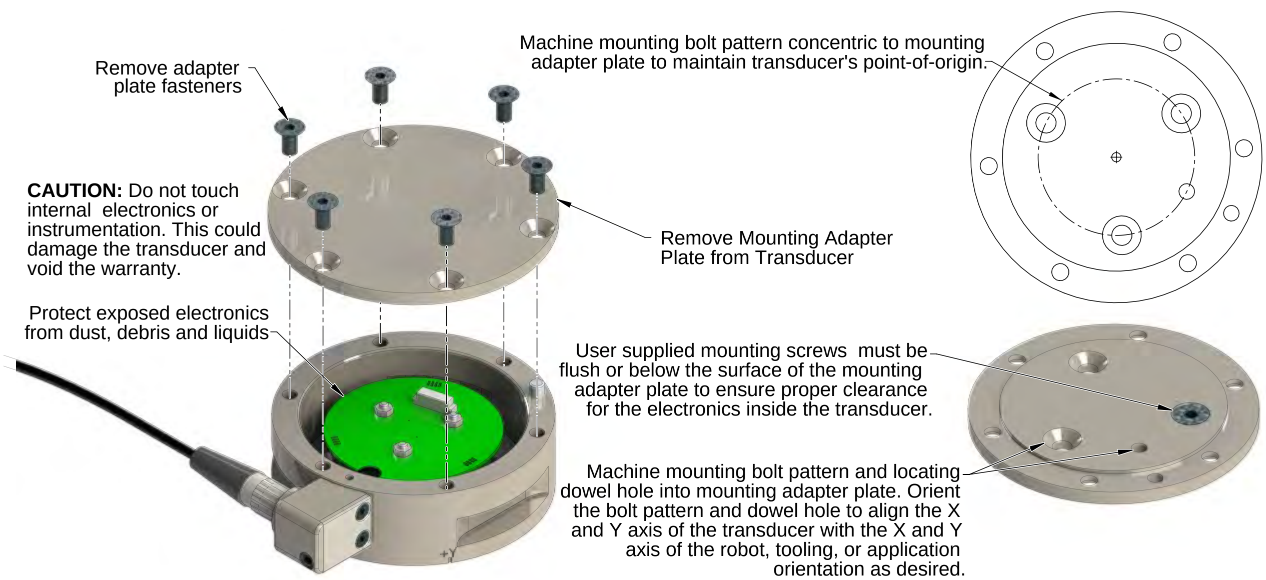
> **CAUTION:** Do not touch internal electronics or instrumentation. This could damage the transducer and void the warranty. When the adapter plate is removed protect the exposed electronics from dust, debris, liquids, and other foreign objects.

3. Remove the adapter plate from the transducer. Machine the mounting bolt pattern from the robot, interface plate, or other device into the removable adapter plate. Make sure the bolt pattern and dowel hole orient the X and Y axis of the transducer with the X and Y axis of the robot.

> **NOTICE:** Customers who machine their own interface patterns should avoid placing all mounting features in the center of the adapter plate. A larger bolt circle provides the most accurate readings because it induces less bending in the plate.

> **CAUTION:** Mounting fasteners should not extend into the transducer beyond the adapter plate surface. This could cause damage to the internal electronics. When machining the removable adapter plate, make sure the heads of the fasteners are flush or below the surface of the adapter plate.

Figure 3.2—Removable Adapter Plate



4. Mount removable adapter plate to the robot, other device, or interface plate using customer supplied fasteners. If fasteners do not have pre-applied adhesive, apply Loctite 222® to the fasteners.

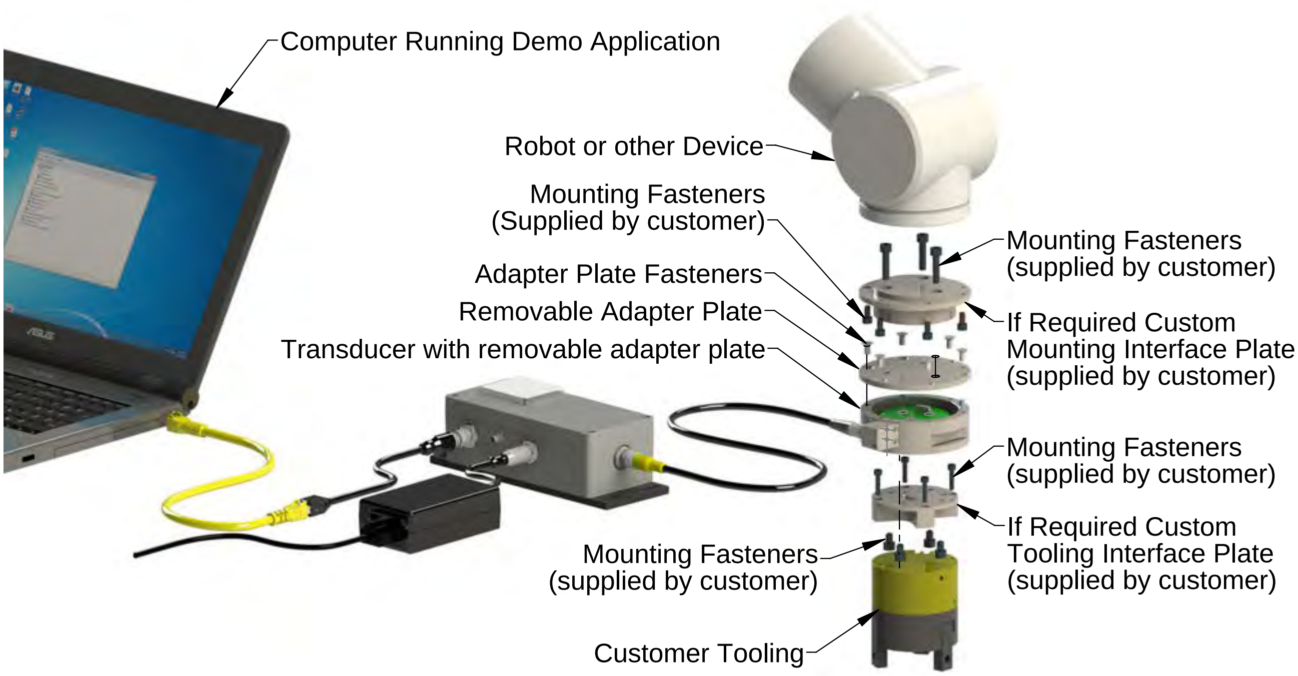
> **NOTICE:** Make sure the adapter plate orients the transducer so that the connector is at the appropriate location to route the cabling properly (refer to *Section 3.3—Routing the Transducer Cable*).

5. Attach the transducer to the removable adapter plate, hand tighten fasteners.
6. Connect power to the transducer, and wait until demo application displays **load data** when applying force on the transducer.

CAUTION: Do not exceed the transducer's overload ratings. If smaller transducers are not carefully installed, irreparable damage can occur by applying small loads using tools (moment arm increases applied loads). When installing, use the demo application to monitor for gage saturation errors. If an error occurs, stop applying force to the transducer and wait until the error clears to continue installation. If error does not clear, it may indicate loss of power or the overload value has been exceeded.

7. Monitor the demo application for gage saturation errors during installation. If an error is displayed, stop applying the force to the transducer and wait until the error clears. Then continue installation.
8. Tighten the fasteners mounting the transducer to the removable adapter plate.

Figure 3.3—Installing Transducers with Removable Mounting Adapter Plates



CAUTION: Do not use fasteners that will exceed the customer interface depth specified for the transducer. Using longer fasteners will penetrate the body of the transducer and damage the electronics, voiding the warranty. Use fasteners that provide the customer interface depth specified for the transducer. Refer to the transducer drawing.

NOTICE: The tool may not contact any other part of the transducer except the tool mounting surface. If the tool contacts any other part of the transducer it will not properly sense loads. Make sure the tool mounts to the tool mounting surface and does not contact any other part of the transducer.

9. Monitor the demo application for gage saturation errors during installation. If an error is displayed stop applying the force to the transducer and wait until the error clears before continuing installation.
10. With customer supplied fasteners, attach the customer tooling or tooling interface plate to the transducer. The transducer has a mounting pattern on the tool side of the transducer. If fasteners do not have pre-applied adhesive, apply Loctite 222.

3.2.3 Mounting the Transducer with a Non-removable Adapter Plate

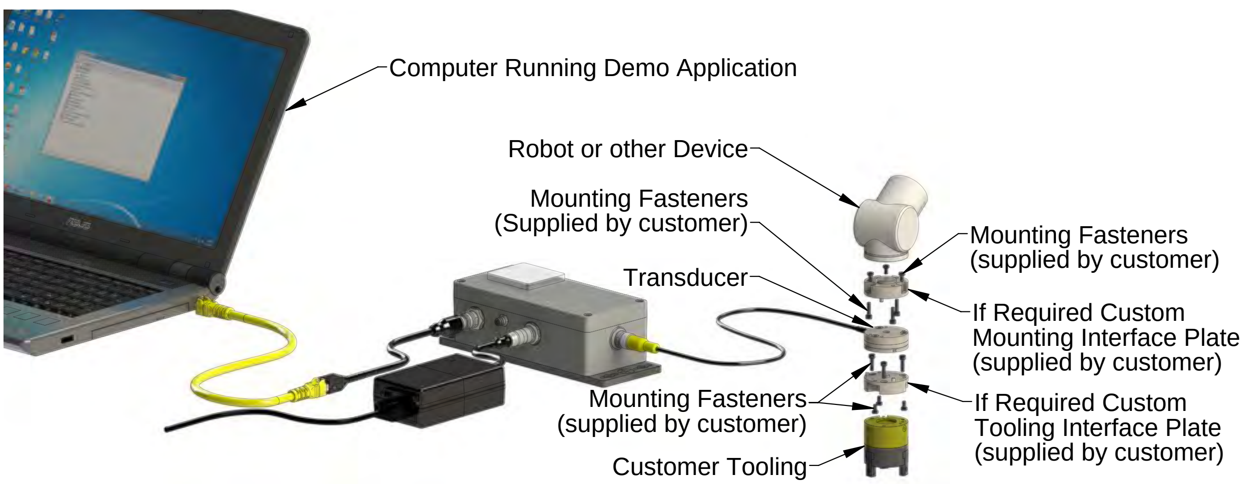
CAUTION: Do not attempt to drill, tap, machine, or otherwise modify or disassemble the transducer. Such work could damage the transducer and will void the warranty. Use the mounting bolt pattern provided to attach the transducer to the robot or other device and to mount the tool to the transducer. See the transducer drawings for details.

CAUTION: Do not use fasteners that will exceed the customer interface depth specified on for the transducer. Using longer fasteners will penetrate the body of the transducer, damage the electronics, and void the warranty. Use fasteners that provide the customer interface depth specified for the transducer. Refer to the transducer drawing.

CAUTION: Do not exceed the transducer's overload ratings. If smaller transducers are not carefully installed, irreparable damage can occur by applying small loads using tools (moment arm increases applied loads). When installing, use the demo application to monitor for gage saturation errors. If an error occurs, stop applying force to the transducer and wait until the error clears to continue installation. If error does not clear, it may indicate loss of power or the overload value has been exceeded.

1. During installation, monitor the demo application for gage saturation errors. If an error is displayed, stop applying the force to the transducer, and wait until the error clears before continuing installation.
2. Mount the transducer to the user-designed interface plate, directly to the robot, or other device with customer supplied fasteners. If fasteners do not have pre-applied adhesive, apply Loctite 222 to the fasteners.

Figure 3.4—Installing Transducers with Non-removable Adapter Plates (Net F/T System Shown)



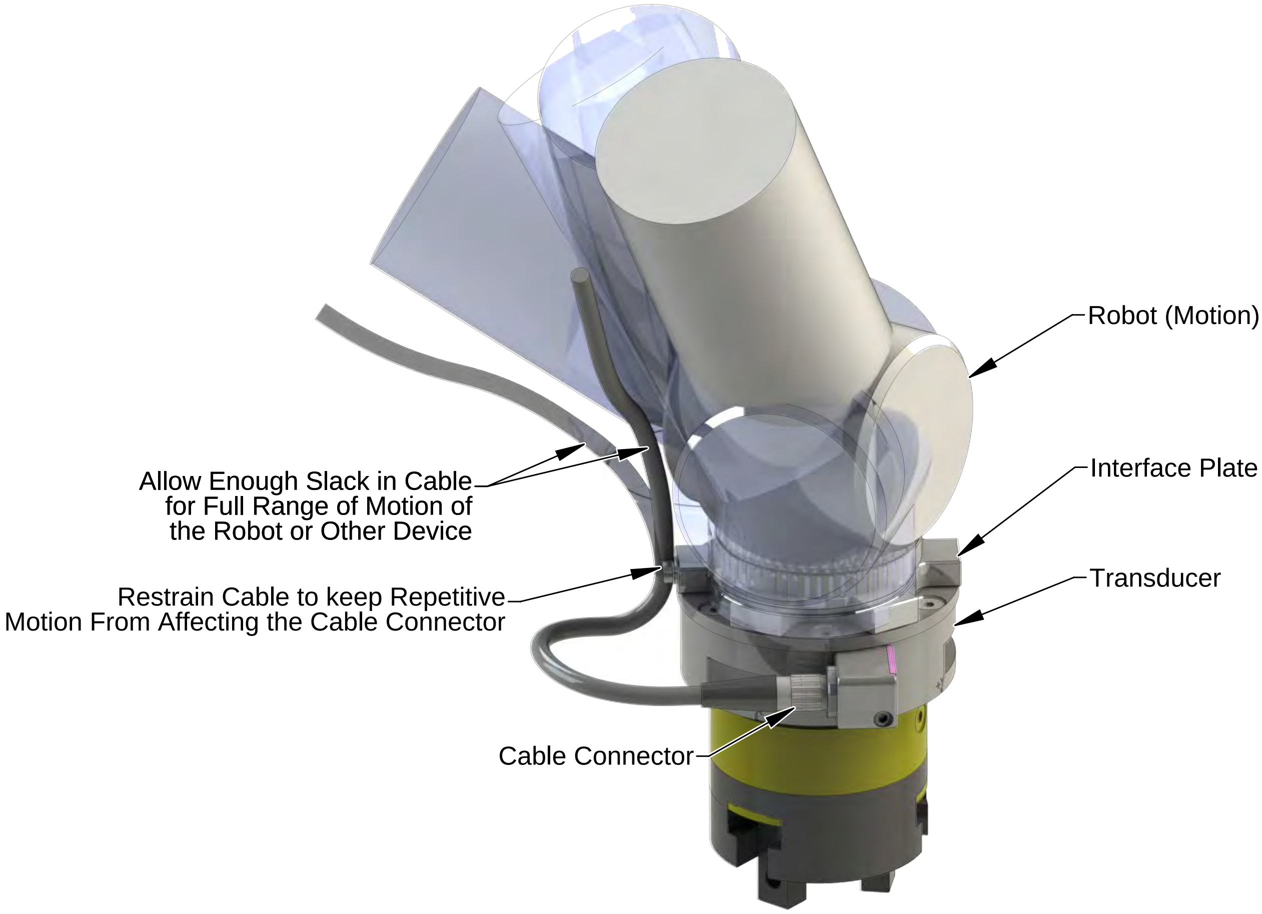
NOTICE: The tool may not touch any other part of the transducer except the tool mounting surface. If the tool touches any other part of the transducer it will not properly sense loads. Make sure the tool mounts to the tool mounting surface and does not touch any other part of the transducer.

3. Monitor the demo application for gage saturation errors during installation. If an error is displayed stop applying the force to the transducer and wait until the error clears before continuing installation.
4. Attach the customer tooling or tooling interface plate to the transducer with customer supplied fasteners, the transducer provides a mounting pattern on the tool side of the transducer. If fasteners do not have pre-applied adhesive, apply Loctite 222 to the fasteners.

3.3 Routing the Transducer Cable

The application for the transducer determines the best cable routing method and the proper cable bending radius. Some applications keep the transducer and cable static. Other applications are dynamic and can put the transducer and cable through repetitive motions. It is important not to expose the transducer cable connectors to this repetitive motion and properly restrain the cable close to the transducer connection

Figure 3.5—Restrain Transducer Cable Close to Cable Connector



CAUTION: Do not subject the transducer cable connector to the repetitive motion of the robot or other device. Subjecting the connector to the repetitive motion will cause damage to the connector. Restrain the cable close to the connector to keep the repetitive motion of the robot from affecting the cable connector.

CAUTION: When routing cables do not bend the cable to a smaller radius than the minimum bending radius specified in *Table 3.1*. The cable will fail due to fatigue from the repetitive motion. When routing the cable make sure the cable bends are larger then the minimum dynamic bending radius specified for the cable type.

CAUTION: Do not stress or over bend the transducer cable, especially where it is attached to the transducer. This is particularly important on the Nano and Mini series of transducers. For these transducers, do not bend the cable any closer than 25 mm (1 inch) to the transducer. Sharp bends must be avoided as they can damage the cable and transducer and will void the warranty.

Figure 3.6—Transducer Bending Radius

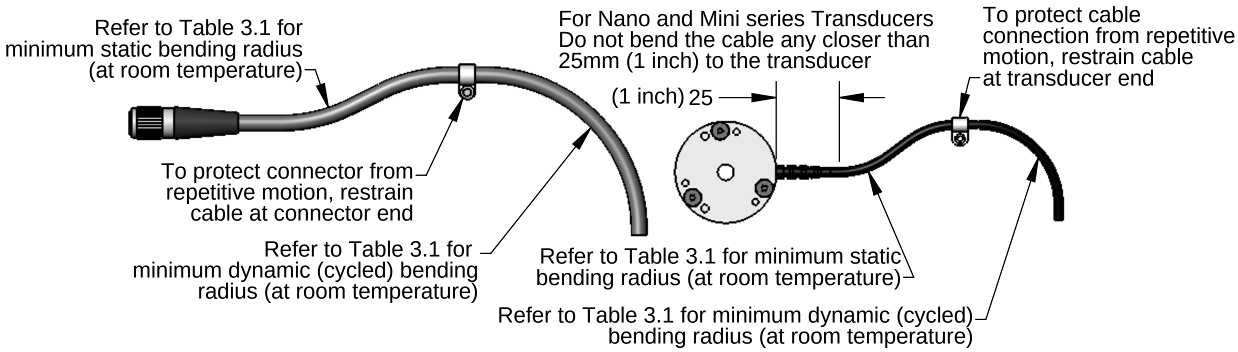


Table 3.1—Transducer Cable Bending Radius

Cable Type	Cable Dia. (mm)	Static Bending Radius (at room temperature)		Dynamic Bending Radius (at room temperature)	
		mm	inch	mm	inch
9105-TW	3.2	16	0.63	32	1.26
9105-C3	4.4	22	0.87	44	1.73
9105-CM	4.4	22	0.87	44	1.73
9105-CW	4.4	22	0.87	44	1.73
9105-CT	6.1	30.5	1.20	61	2.40
9105-C	3.2	16	0.63	32	1.26
	4.4	22	0.87	44	1.73
	6.1	30.5	1.20	61	2.40
	10.0	50	1.97	100	3.94
9105-C-MTR	8.4	42	1.65	84	3.31
9105-C-MTS	8.4	42	1.65	84	3.31
9105-CF-MTR 9105-CF-MTS	8.5	42.5	1.67	85	3.35

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

Route the transducer cable so that it is not stressed, pulled, kinked, cut, or otherwise damaged throughout the full range of motion. See the accompanying system manual for the transducer cable interfacing. If the desired application results in the cable rubbing, then use a loose plastic spiral wrap for protection.

CAUTION: Be careful not to crush the cable by over tightening tie wraps or walking on the cable, since this may damage the cable.

CAUTION: Cables on the Nano and Mini transducers are permanently attached to the transducer and cannot be disconnected. Do not attempt to disassemble these transducers, this will damage the transducer and void the warranty. Do not attempt to replace the cable. Contact ATI service for assistance.

CAUTION: Nano and Mini integral cables and cables of the 9105-C-H type must not subject the transducer end connection to more than 10 lbf (45 N) of side-to-side or pull force or permanent damage will result.

CAUTION: Larger transducers have removable cables. Do not attempt to disconnect these transducer cables by pulling on the cable itself or the connector boot; this can damage the system.

4. Operation Topics

4.1 Accuracy over Temperature

Typical gain errors introduced over temperature for F/T transducers with fasteners temperature compensation are listed in the following table. Changes in sensitivity are independent of the transducer's rated accuracy at room temperature; add the two accuracy ratings to find an overall estimated accuracy at a certain temperature. This overall accuracy assumes that the unloaded and loaded measurements were taken at the same temperature. Drift error over temperature is not compensated and varies with each transducer. For best results, take a reference reading or execute the bias function at the current temperature before applying the load of interest.

Table 4.1—Error Introduced Over Temperature for Non-Gamma Transducers

Deviation from 22°C	Typical Gain Error
± 5°C	0.1%
± 15°C	0.5%
± 25°C[1]	1%
± 50°C[1]	5%

Note:
1. Deviation is bounded by transducer operational limits in *Section 4.3—Environmental*.

Table 4.2—Error Introduced Over Temperature for Gamma Transducers

Deviation from 22°C	Typical Gain Error
± 5°C	0.1%
± 15°C	0.5%
± 25°C[1]	1.5%
± 50°C[1]	7%

Note:
1. Deviation is bounded by transducer operational limits in *Section 4.3—Environmental*

4.2 Tool Transformation Effects

All transducer working specifications pertain to the factory point-of-origin only. This includes the transducer's range, resolution, and accuracy. The transducer working specifications at a customer-applied point-of-origin differ from those at the factory point-of-origin.

4.3 Environmental

The F/T system is designed to be used in standard laboratory or light-manufacturing conditions. Transducers with an IP60 designation are able to withstand dusty environments, those with an IP65 designation are able to withstand dusty environments and wash down, and those with an IP68 designation are able to withstand dusty environments and fresh-water immersion to a specified depth. Transducers without IP65 or IP68 designation may be used in environments with up to 95% relative humidity, non-condensing.

Table 4.3—Transducer Temperature Ranges

Transducer Model Series	Storage	Operation	Unit
9105-TIF Transducer	-25 to +80	0 to +60	°C
9105-TW Transducer	-25 to +80	0 to +80	
9105-TW-MINI/NANO Transducer	-40 to +100	0 to +100	
9105-T Transducer	-20 to 80	0 to +70	
9105-TWE Transducer	-25 to 85	0 to +85	
9105-NET Transducer	0 to +85	0 to +85	
9105-ECAT Transducer	0 to +70	0 to +70	

Note:

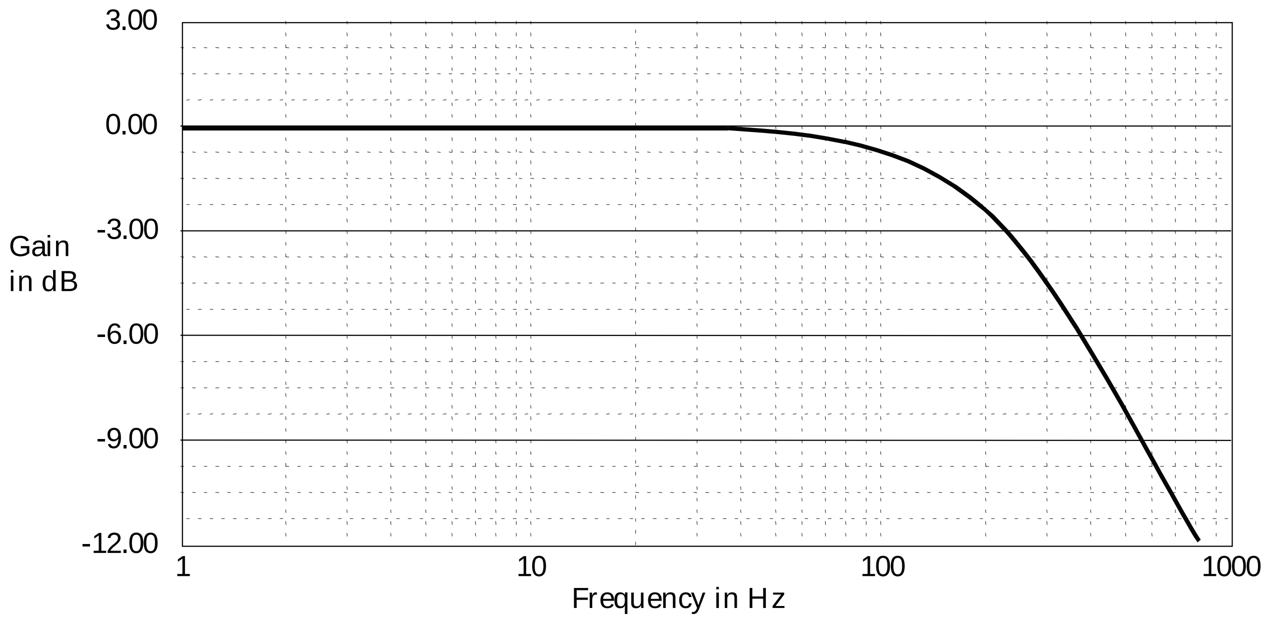
1. These temperature ranges specify the storage and operation ranges in which the transducer can survive without damage. They do not take accuracy into account.

4.4 Mux Transducer Input Filter Frequency Response

NOTICE: Mux transducers are only used in 9105-CTL, 9105-CON, and 9105-CTE systems.

The input filter used in 9105-T transducers and in the Mux box is used to prevent aliasing. This filtering is not used in 9105-TIF (DAQ) or a TWE transducers.

Figure 4.1—Mux input filter frequency response (-3dB @ 235Hz)



4.5 Transducer Strain Gage Saturation

The F/T sensor's strain gages are optimally placed to share information between the forces and torques applied to the sensor. Because of this sharing, it is possible to saturate the transducer with a complex load that has components below the rated load of the sensor. However, this arrangement allows a greater sensing range and resolution.

CAUTION: When any strain gage is saturated or otherwise inoperable, **all transducer F/T readings are invalid**. It is vitally important to monitor for these conditions.

5. Transducer Specifications

5.1 Notes on the Specification Section

5.1.1 ATI Website

All transducer specifications and additional information are also available on the ATI website: *https://www.ati-ia.com/products/ft/ft_ModelListing.aspx*.

5.1.2 About CTL Calibration Specifications

CTL refers to F/T systems that use the F/T Controller. Transducers used in these systems either have a 9105-T-x model transducer or include a Mux Box. The output resolution of CTL systems is different from other systems. CTL systems also provide analog voltage outputs that represent each of the six axes. CTL transducers have their own calibration specification listings because of these differences.

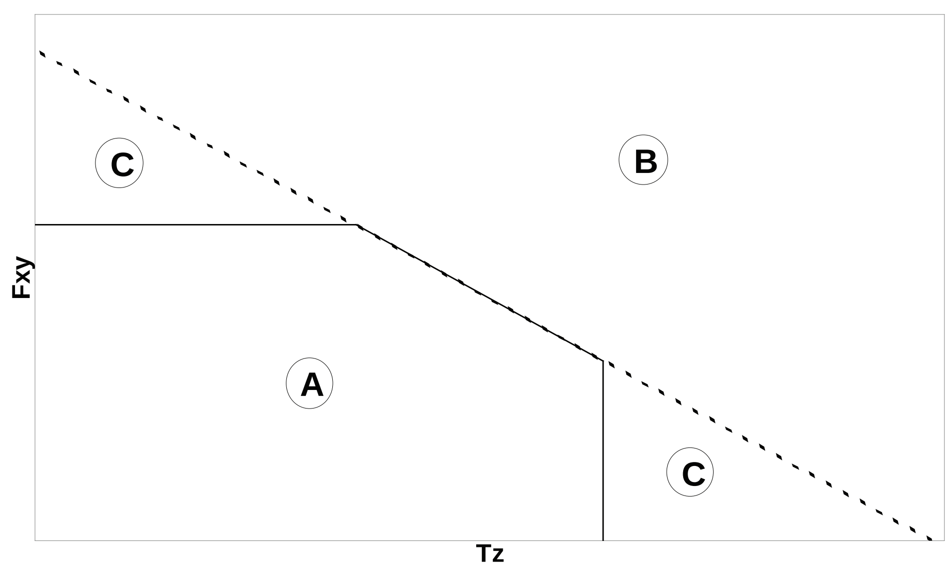
5.1.3 Complex Loading Graph Description

The graphs in the sections for each transducer may be used to estimate a sensor's range under complex loading. Each page represents one sensor body with either English or Metric units. The top graph represents combinations of forces in the X and/or Y directions with torques about the Z-axis. The bottom graph represents combinations of Z-axis forces with X- and/or Y-axis torques. The graphs contain several different calibrations, distinguished by line weight.

The sample graph shown in *Figure 5.1* shows how operating ranges can change with complex loading. The regions are indicated by the following labels:

A. Normal operating region. You can expect to achieve rated accuracy in this region.
B. Saturation region. Any load in this region will report a gage saturation condition.
C. Extended operating region. In this region, the sensor will operate correctly but the full-scale accuracy is not guaranteed.

Figure 5.1—Complex Loading Sample Graph



5.2 Nano17 Titanium

In addition to the information in the following sections, refer to the ATI website:

Table 5.1—Nano17 Titanium Drawing and Web Links		
Model	**Drawing Part Number**	**ATI Website Address**
Nano17 Titanium	*9230-05-1336*	*https://www.ati-ia.com/products/ft/ft_models.aspx?id=Nano17+Titanium*

5.2.1 Nano17 Titanium Physical Properties

Table 5.2—Nano17 Titanium Physical Properties		
Single-Axis Overload	**(US) Standard Units**	**(SI) Metric Units**
Fxy	±35 lbf	±160 N
Fz	±70 lbf	±310 N
Txy	±8.9 inf-lb	±1 Nm
Tz	±10 inf-lb	±1.2 Nm
Stiffness (Calculated)		
X-axis & Y-axis forces (Kx, Ky)	2.7×10^{4} lb/in	4.8×10^{6} N/m
Z-axis force (Kz)	3.8×10^{4} lb/in	6.6×10^{6} N/m
X-axis & Y-axis torque (Ktx, Kty)	1.2×10^{3} lbf-in/rad	1.4×10^{2} Nm/rad
Z-axis torque (Ktz)	2.0×10^{3} lbf-in/rad	2.2×10^{2} Nm/rad
Resonant Frequency		
Fx, Fy, Tz	3000 Hz	3000 Hz
Fz, Tx, Ty	3000 Hz	3000 Hz
Physical Specifications		
Weight[1]	0.0223 lb	0.0101 kg
Diameter[1]	0.669 in	17 mm
Height[1]	0.571 in	14.5 mm
Note: 1. Specifications include standard interface plates.		

5.2.2 Calibration Specifications (excludes CTL calibrations)

Table 5.3— Nano17 Titanium Calibrations (excludes CTL calibrations)1, 2									
Sensor	**(US) Standard Calibration**	**Fx,Fy (lbf)**	**Fz (lbf)**	**Tx,Ty (lbf-in)**	**Tz (lbf-in)**	**Fx,Fy (lbf)**	**Fz (lbf)**	**Tx,Ty (lbf-in)**	**Tz (lbf-in)**
Nano17 Titanium	US-1.8-0.4	1.8	3.15	0.4	0.4	1/3400	1/2720	7/92800	1/18560
Nano17 Titanium	US-3.6-0.8	3.6	6.3	0.8	0.8	1/1700	1/1360	7/46400	1/9280
Nano17 Titanium	US-7.2-1.6	7.2	12.6	1.6	1.6	1/850	1/680	7/23200	1/4640
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz (N)**	**Tx,Ty (Nmm)**	**Tz (Nmm)**	**Fx,Fy (N)**	**Fz (N)**	**Tx,Ty (Nmm)**	**Tz (Nmm)**
Nano17 Titanium	SI-8-0.05	8	14.1	50	50	1/682	1/682	3/364	5/728
Nano17 Titanium	SI-16-0.1	16	28.2	100	100	1/341	1/341	3/182	5/364
Nano17 Titanium	SI-32-0.2	32	56.4	200	200	1/171	1/171	3/92	5/184
		Sensing Ranges				**Resolution (DAQ, Net F/T)[3]**			

Notes:
1. These system resolutions quoted are the effective resolution after dropping eight counts of noise. The effective resolution can be improved with filtering.
2. Applied loads must be within range in each of the six axes for the F/T sensor to measure correctly.
3. DAQ resolutions are typical for a 16-bit data acquisition system.

5.2.3 CTL Calibration Specifications

Table 5.4— Nano17 Titanium CTL Calibrations1, 2									
Sensor	**(US) Standard Calibration**	**Fx,Fy (lbf)**	**Fz (lbf)**	**Tx,Ty (lbf-in)**	**Tz (lbf-in)**	**Fx,Fy (lbf)**	**Fz (lbf)**	**Tx,Ty (lbf-in)**	**Tz (lbf-in)**
Nano17 Titanium	US-1.8-0.4	1.8	3.15	0.4	0.4	1/1700	1/1360	7/46400	1/9280
Nano17 Titanium	US-3.6-0.8	3.6	6.3	0.8	0.8	1/850	1/680	7/23200	1/4640
Nano17 Titanium	US-7.2-1.6	7.2	12.6	1.6	1.6	1/425	1/340	7/11600	1/2320
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz (N)**	**Tx,Ty (Nmm)**	**Tz (Nmm)**	**Fx,Fy (N)**	**Fz (N)**	**Tx,Ty (Nmm)**	**Tz (Nmm)**
Nano17 Titanium	SI-8-0.05	8	14.1	50	50	1/341	1/341	3/182	5/364
Nano17 Titanium	SI-16-0.1	16	28.2	100	100	2/341	2/341	3/91	5/182
Nano17 Titanium	SI-32-0.2	32	56.4	200	200	2/171	2/171	3/46	5/92
		Sensing Ranges				**Resolution (Controller)**			

Notes:
1. CTL resolutions are typical. System resolutions quoted are the effective resolution after dropping eight counts of noise. The effective resolution can be improved with filtering.
2. Applied loads must be within range in each of the six axes for the F/T sensor to measure correctly.

5.2.4 CTL Analog Output

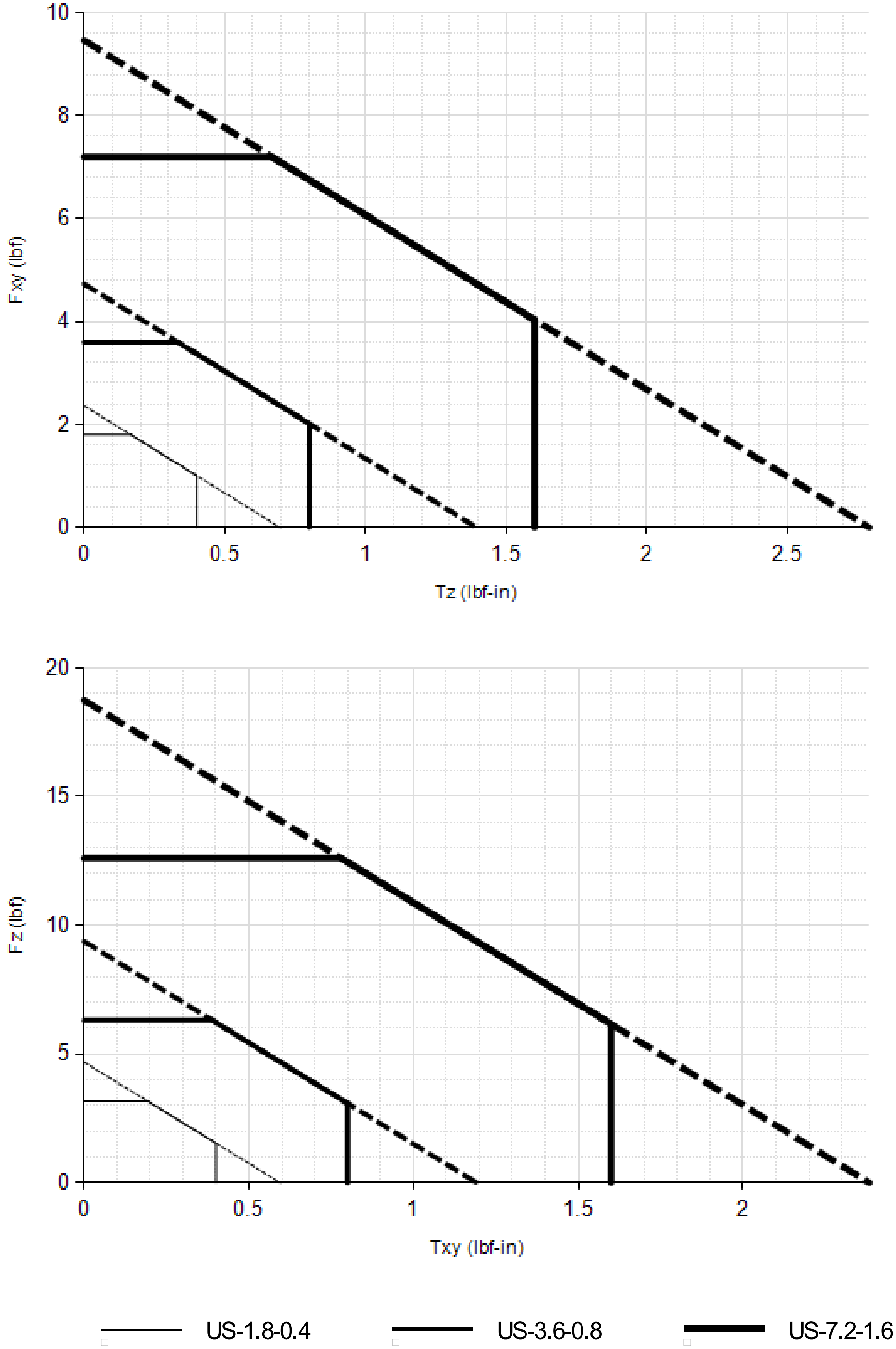
Table 5.5— Nano17 Titanium Analog Output							
Sensor	**(US) Standard Calibration**	**Fx,Fy (lbf)**	**Fz (lbf)**	**Tx,Ty,Tz (lbf-in)**	**Fx,Fy (lbf/V)**	**Fz (lbf/V)**	**Tx,Ty,Tz (lbf-in/V)**
Nano17 Titanium	US-1.8-0.4	±1.8	±3.15	±0.4	0.18	0.315	0.04
Nano17 Titanium	US-3.6-0.8	±3.6	±6.3	±0.8	0.36	0.63	0.08
Nano17 Titanium	US-7.2-1.6	±7.2	±12.6	±1.6	0.72	1.26	0.16
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz (N)**	**Tx,Ty,Tz (Nmm)**	**Fx,Fy (N/V)**	**Fz (N/V)**	**Tx,Ty,Tz (Nmm/V)**
Nano17 Titanium	SI-8-0.05	±8	±14.1	±50	0.8	1.41	5
Nano17 Titanium	SI-16-0.1	±16	±28.2	±100	1.6	2.82	10
Nano17 Titanium	SI-32-0.2	±32	±56.4	±200	3.2	5.64	20
		Analog Output Range			**Analog ±10V Sensitivity[1]**		

Notes:
1. ±5V Sensitivity values are double the listed ±10V Sensitivity values.

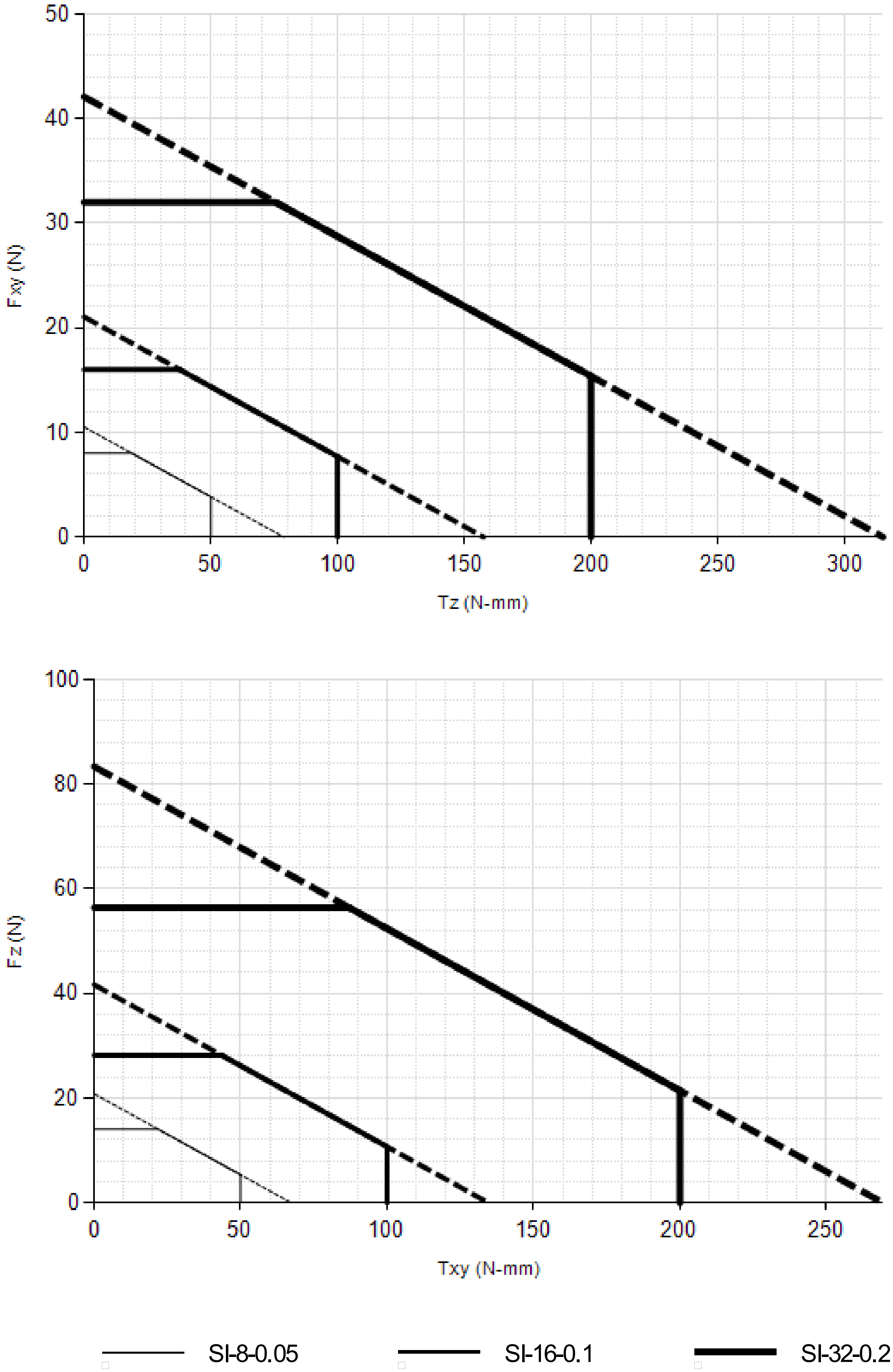
5.2.5 CTL Counts Value

Table 5.6—Counts Value					
Sensor	**Calibration**	**Fx, Fy, Fz (/ lbf)**	**Tx, Ty, Tz (/ lbf-in)**	**Fx, Fy, Fz (/ N)**	**Tx, Ty, Tz (/ Nmm)**
Nano17 Titanium	US-1.8–0.4 / SI-8–0.05	54400	371200	1280	256
Nano17 Titanium	US-3.6–0.8 / SI-16–0.1	27200	185600	640	128
Nano17 Titanium	US-7.2–1.6 / SI-32–0.2	13600	82800	320	64
Nano17 Titanium	Tool Transform Factor	0.0022 in/lbf		0.0375 mm/N	
		Counts Value – Standard (US)		**Counts Value – Metric (SI)**	

5.2.6 Nano17 Titanium (US Calibration Complex Loading)



5.2.7 Nano17 Titanium (SI Calibration Complex Loading)



5.3 Nano17 Specifications (Includes IP65/IP68 Versions)

In addition to the information in the following sections, refer to the ATI website:

Table 5.7—Nano17 Drawing and Web Links		
Model	**Drawing Part Number**	**ATI Website Address**
Nano17	9230-05-1073	https://www.ati-ia.com/products/ft/ft_models.aspx?id=Nano17
Nano17-E	9230-05-1311	
Nano17 IP65/IP68	9230-05-1364	https://www.ati-ia.com/products/ft/ft_models.aspx?id=Nano17+IP65%2fIP68

5.3.1 Nano17 Physical Properties

Table 5.8—Nano17 Physical Properties		
Single-Axis Overload	**(US) Standard Units**	**(SI) Metric Units**
Fxy	±56 lbf	±250 N
Fz	±110 lbf	±480 N
Txy	±14 inf-lb	±1.6 Nm
Tz	±16 inf-lb	±1.8 Nm
Stiffness (Calculated)		
X-axis & Y-axis forces (Kx, Ky)	4.7×10^{4} lb/in	8.2×10^{6} N/m
Z-axis force (Kz)	6.5×10^{4} lb/in	1.1×10^{7} N/m
X-axis & Y-axis torque (Ktx, Kty)	2.1×10^{3} lbf-in/rad	2.4×10^{2} Nm/rad
Z-axis torque (Ktz)	3.4×10^{3} lbf-in/rad	3.8×10^{2} Nm/rad
Resonant Frequency		
Fx, Fy, Tz	7200 Hz	7200 Hz
Fz, Tx, Ty	7200 Hz	7200 Hz
Physical Specifications		
Weight[1]	0.02 lb	0.00907 kg
Diameter[1]	0.669 in	17 mm
Height[1]	0.571 in	14.5 mm
Note: 1. Specifications include standard interface plates.		

5.3.2 Nano17 IP65/IP68 Physical Properties

Table 5.9—Nano17 IP65/IP68 Physical Properties		
Single-Axis Overload	**(US) Standard Units**	**(SI) Metric Units**
Fxy	±56 lbf	±250 N
Fz	±110 lbf	±480 N
Txy	±14 inf-lb	±1.6 Nm
Tz	±16 inf-lb	±1.8 Nm
Stiffness (Calculated)		
X-axis & Y-axis forces (Kx, Ky)	4.7×10^4 lb/in	8.2×10^6 N/m
Z-axis force (Kz)	6.5×10^4 lb/in	1.1×10^7 N/m
X-axis & Y-axis torque (Ktx, Kty)	2.1×10^3 lbf-in/rad	2.4×10^2 Nm/rad
Z-axis torque (Ktz)	3.4×10^3 lbf-in/rad	3.8×10^2 Nm/rad
Resonant Frequency		
Fx, Fy, Tz	2200 Hz	2200 Hz
Fz, Tx, Ty	2200 Hz	2200 Hz
Physical Specifications		
Weight[1]	0.09 lb	0.0408 kg
Diameter[1]	0.79 in	20.1 mm
Height[1]	0.873 in	22.2 mm
Note: 1. Specifications include standard interface plates.		

CAUTION: When submerged, IP68 transducers exhibit a decrease in Fz range related to the submersion depth. This loss is the result of pressure-induced preloading on the transducer. The preload can be masked by biasing the transducer at the depth prior to applying the load to be measured. The following estimates are for room temperature fresh water at sea level.

	Submersion Depth	
IP68 Nano17	**US**	**Metric**
Fz preload at 4 m depth	2.01 lb	8.93 N
Fz preload at other depths	-0.15 lb/ft × depth In Feet	-2.23 N/m × depth In Meters

5.3.3 Calibration Specifications (excludes CTL calibrations)

Table 5.10— Nano17 Calibrations (excludes CTL calibrations)1, 2

Sensor	(US) Standard Calibration	Fx,Fy (lbf)	Fz[3] (lbf)	Tx,Ty (lbf-in)	Tz (lbf-in)	Fx,Fy (lbf)	Fz[3] (lbf)	Tx,Ty (lbf-in)	Tz (lbf-in)
Nano17	US-3-1	3	4.25	1	1	1/1280	1/1280	1/8000	1/8000
Nano17	US-6-2	6	8.5	2	2	1/640	1/640	1/4000	1/4000
Nano17	US-12-4	12	17	4	4	1/320	1/320	1/2000	1/2000
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz[3] (N)**	**Tx,Ty (Nmm)**	**Tz (Nmm)**	**Fx,Fy (N)**	**Fz[3] (N)**	**Tx,Ty (Nmm)**	**Tz (Nmm)**
Nano17	SI-12-0.12	12	17	120	120	1/320	1/320	1/64	1/64
Nano17	SI-25-0.25	25	35	250	250	1/160	1/160	1/32	1/32
Nano17	SI-50-0.5	50	70	500	500	1/80	1/80	1/16	1/16
		Sensing Ranges				**Resolution (DAQ, Net F/T)[4]**			

Notes:
1. These system resolutions quoted are the effective resolution after dropping eight counts of noise. The effective resolution can be improved with filtering.
2. Applied loads must be within range in each of the six axes for the F/T sensor to measure correctly.
3. For IP68 version see caution on physical properties page.
4. DAQ resolutions are typical for a 16-bit data acquisition system.

5.3.4 CTL Calibration Specifications

Table 5.11— Nano17 CTL Calibrations1, 2

Sensor	(US) Standard Calibration	Fx,Fy (lbf)	Fz[3] (lbf)	Tx,Ty (lbf-in)	Tz (lbf-in)	Fx,Fy (lbf)	Fz[3] (lbf)	Tx,Ty (lbf-in)	Tz (lbf-in)
Nano17	US-3-1	3	4.25	1	1	1/640	1/640	1/4000	1/4000
Nano17	US-6-2	6	8.5	2	2	1/320	1/320	1/2000	1/2000
Nano17	US-12-4	12	17	4	4	1/160	1/160	1/1000	1/1000
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz[3] (N)**	**Tx,Ty (Nmm)**	**Tz (Nmm)**	**Fx,Fy (N)**	**Fz[3] (N)**	**Tx,Ty (Nmm)**	**Tz (Nmm)**
Nano17	SI-12-0.12	12	17	120	120	1/160	1/160	1/32	1/32
Nano17	SI-25-0.25	25	35	250	250	1/80	1/80	1/16	1/16
Nano17	SI-50-0.5	50	70	500	500	1/40	1/40	1/8	1/8
		Sensing Ranges				**Resolution (Controller)**			

Notes:
1. CTL resolutions are typical. System resolutions quoted are the effective resolution after dropping eight counts of noise. The effective resolution can be improved with filtering.
2. Applied loads must be within range in each of the six axes for the F/T sensor to measure correctly.
3. For IP68 version see caution on physical properties page.

5.3.5 CTL Analog Output

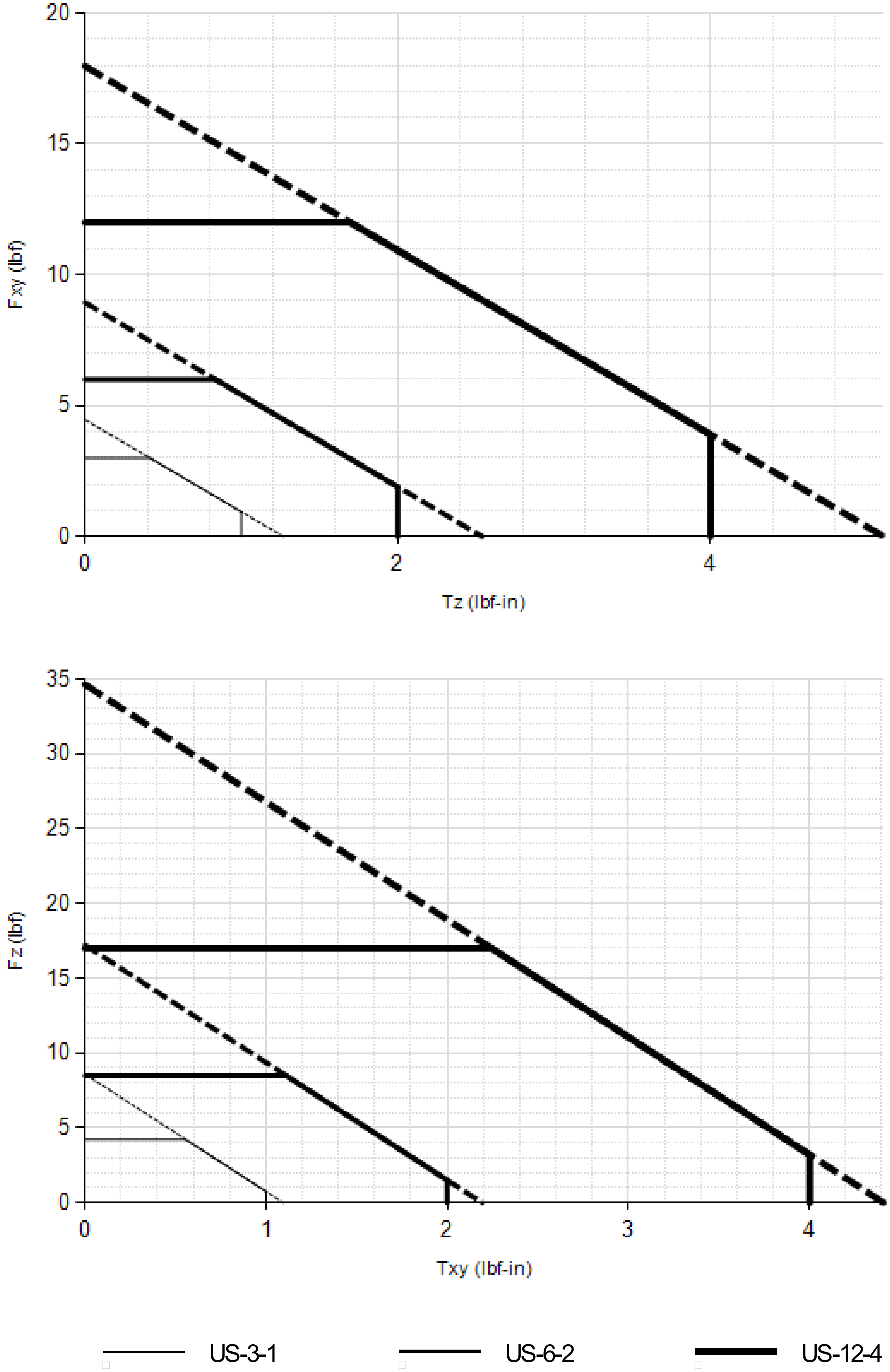
Table 5.12— Nano17 Analog Output							
Sensor	**(US) Standard Calibration**	**Fx,Fy (lbf)**	**Fz[2] (lbf)**	**Tx,Ty,Tz (lbf-in)**	**Fx,Fy (lbf/V)**	**Fz[2] (lbf/V)**	**Tx,Ty,Tz (lbf-in/V)**
Nano17	US-3-1	±3	±4.25	±1	0.3	0.425	0.1
Nano17	US-6-2	±6	±8.5	±2	0.6	0.85	0.2
Nano17	US-12-4	±12	±17	±4	1.2	1.7	0.4
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz[2] (N)**	**Tx,Ty,Tz (Nmm)**	**Fx,Fy (N/V)**	**Fz[2] (N/V)**	**Tx,Ty,Tz (Nmm/V)**
Nano17	SI-12-0.12	±12	±17	±120	1.2	1.7	12
Nano17	SI-25-0.25	±25	±35	±250	2.5	3.5	25
Nano17	SI-50-0.5	±50	±70	±500	5	7	50
		Analog Output Range			**Analog ±10V Sensitivity[1]**		

Notes:
1. ±5V Sensitivity values are double the listed ±10V Sensitivity values.
2. For IP68 version see caution on physical properties page.

5.3.6 CTL Counts Value

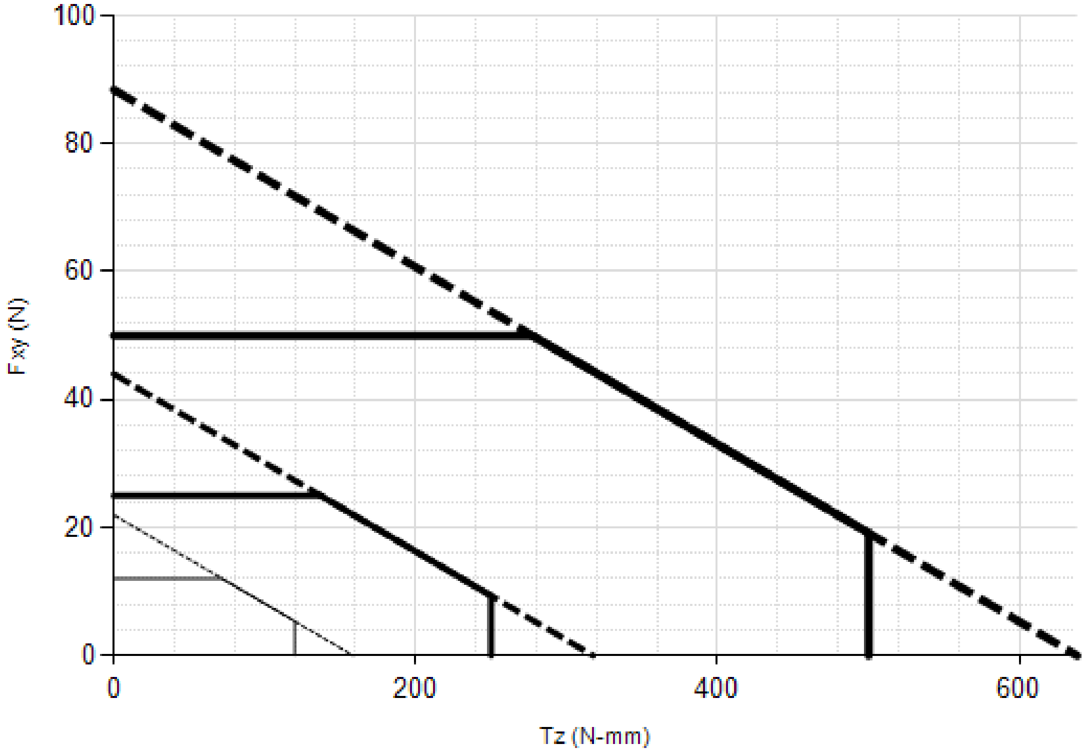
Table 5.13—Counts Value					
Sensor	**Calibration**	**Fx, Fy, Fz (/ lbf)**	**Tx, Ty, Tz (/ lbf-in)**	**Fx, Fy, Fz (/ N)**	**Tx, Ty, Tz (/ Nmm)**
Nano17	US-3–1 / SI-12–0.25	5120	32000	1280	256
Nano17	US-6–2 / SI-25–0.25	2560	16000	640	128
Nano17	US-12–4 / SI-50–0.5	1280	8000	320	64
Nano17	Tool Transform Factor	0.0016 in/lbf		0.05 mm/N	
		Counts Value – Standard (US)		**Counts Value – Metric (SI)**	

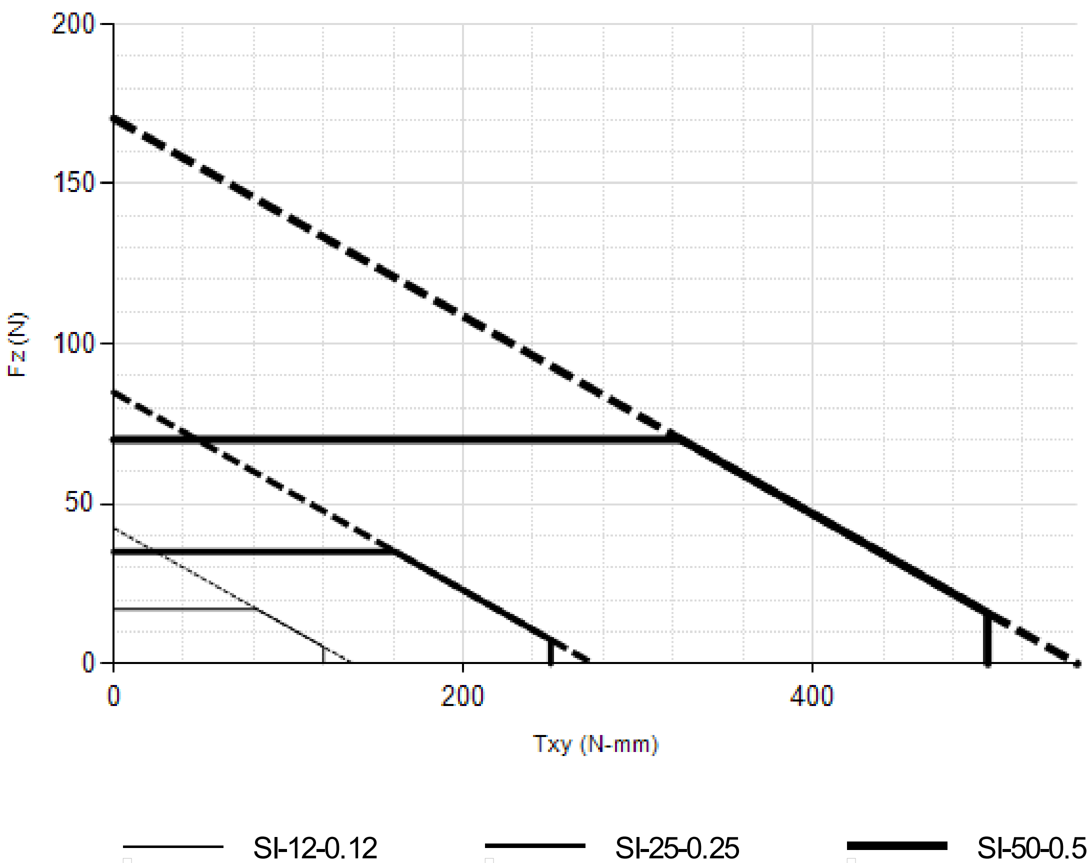
5.3.7 Nano17 (US Calibration Complex Loading)(Includes IP65/IP68)[1]



Note: 1. For IP68 version see caution on physical properties page.

5.3.8 Nano17 (SI Calibration Complex Loading)(Includes IP65/IP68)[1]





Note: 1. For IP68 version see caution on physical properties page.

5.4 Nano25 Specifications (Includes IP65/IP68 Versions)

In addition to the information in the following sections, refer to the ATI website:

Table 5.14—Nano25 Drawing and Web Links		
Model	**Drawing Part Number**	**ATI Website Address**
Nano25	*9230-05-1083*	*https://www.ati-ia.com/products/ft/ft_models.aspx?id=Nano25*
Nano25-E	*9230-05-1312*	
Nano25 IP65/ IP68 (Axial Cable Exit)	*9230-05-1259*	*https://www.ati-ia.com/products/ft/ft_models.aspx?id=Nano25+IP65%2fIP68*
Nano25 IP65/ IP68 (Radial Cable Exit)	*9230-05-1337*	

5.4.1 Nano25 Physical Properties

Table 5.15—Nano25 Physical Properties		
Single-Axis Overload	**(US) Standard Units**	**(SI) Metric Units**
Fxy	±520 lbf	±2300 N
Fz	±1600 lbf	±7300 N
Txy	±380 inf-lb	±43 Nm
Tz	±560 inf-lb	±63 Nm
Stiffness (Calculated)		
X-axis & Y-axis forces (Kx, Ky)	$3.0x10^5$ lb/in	$5.3x10^7$ N/m
Z-axis force (Kz)	$6.3x10^5$ lb/in	$1.1x10^8$ N/m
X-axis & Y-axis torque (Ktx, Kty)	$5.7x10^4$ lbf-in/rad	$6.5x10^3$ Nm/rad
Z-axis torque (Ktz)	$8.1x10^4$ lbf-in/rad	$9.2x10^3$ Nm/rad
Resonant Frequency		
Fx, Fy, Tz	3600 Hz	3600 Hz
Fz, Tx, Ty	3800 Hz	3800 Hz
Physical Specifications		
Weight[1]	0.14 lb	0.0634 kg
Diameter[1]	0.984 in	25 mm
Height[1]	0.85 in	21.6 mm
Note: 1. Specifications include standard interface plates.		

5.4.2 Nano25 IP65/IP68 Physical Properties

Table 5.16—Nano25 IP65/IP68 Physical Properties		
Single-Axis Overload	**(US) Standard Units**	**(SI) Metric Units**
Fxy	±520 lbf	±2300 N
Fz	±1600 lbf	±7300 N
Txy	±380 inf-lb	±43 Nm
Tz	±560 inf-lb	±63 Nm
Stiffness (Calculated)		
X-axis & Y-axis forces (Kx, Ky)	$3.0x10^{5}$ lb/in	$5.3x10^{7}$ N/m
Z-axis force (Kz)	$6.3x10^{5}$ lb/in	$1.1x10^{8}$ N/m
X-axis & Y-axis torque (Ktx, Kty)	$5.7x10^{4}$ lbf-in/rad	$6.5x10^{3}$ Nm/rad
Z-axis torque (Ktz)	$8.1x10^{4}$ lbf-in/rad	$9.2x10^{3}$ Nm/rad
Resonant Frequency		
Fx, Fy, Tz	3400 Hz	3400 Hz
Fz, Tx, Ty	3500 Hz	3500 Hz
Physical Specifications		
Weight[1]	0.3 lb	0.136 kg
Diameter[1]	1.1 in	28 mm
Height[1]	1.08 in	27.5 mm
Note: 1. Specifications include standard interface plates.		

CAUTION: When submerged, IP68 transducers exhibit a decrease in Fz range related to the submersion depth. This loss is the result of pressure-induced preloading on the transducer. The preload can be masked by biasing the transducer at the depth prior to applying the load to be measured. The following estimates are for room temperature fresh water at sea level.

Submersion Depth		
IP68 Nano17	**US**	**Metric**
Fz preload at 4 m depth	4.33 lb	19.3 N
Fz preload at other depths	-0.33 lb/ft × depthInFeet	-4.81 N/m × depthInMeters

NOTICE: The outer body of the IP65 and the IP68 versions of the Nano25 are electrically floating from the rest of the system. If the transducer signal has additional noise, it may be necessary to electrically connect the transducer body to the case of the F/T system.

5.4.3 Calibration Specifications (excludes CTL calibrations)

Table 5.17— Nano25 Calibrations (excludes CTL calibrations)[1, 2, 4]

Sensor	(US) Standard Calibration	Fx,Fy (lbf)	Fz[3] (lbf)	Tx,Ty (lbf-in)	Tz (lbf-in)	Fx,Fy (lbf)	Fz[3] (lbf)	Tx,Ty (lbf-in)	Tz (lbf-in)
Nano25	US-25-25	25	100	25	25	1/224	3/224	1/160	1/320
Nano25	US-50-50	50	200	50	30	1/112	3/112	1/80	1/160
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz[3] (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**	**Fx,Fy (N)**	**Fz[3] (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**
Nano25	SI-125-3	125	500	3	3	1/48	1/16	1/1320	1/2640
Nano25	SI-250-6	250	1000	6	3.4	1/24	1/8	1/660	1/1320
		Sensing Ranges				**Resolution (DAQ, Net F/T)[5]**			

Notes:
1. These system resolutions quoted are the effective resolution after dropping four counts of noise. The effective resolution can be improved with filtering.
2. Applied loads must be within range in each of the six axes for the F/T sensor to measure correctly.
3. For IP68 version see caution on physical properties page.
4. Applying moments beyond ±30 lbf-in (±3.4Nm) in Tz can cause hysteresis and permanent zero-point change in the Nano25 (applies to all versions of the Nano25).
5. DAQ resolutions are typical for a 16-bit data acquisition system.

5.4.4 CTL Calibration Specifications

Table 5.18— Nano25 CTL Calibrations[1, 2, 4]

Sensor	(US) Standard Calibration	Fx,Fy (lbf)	Fz[3] (lbf)	Tx,Ty (lbf-in)	Tz (lbf-in)	Fx,Fy (lbf)	Fz[3] (lbf)	Tx,Ty (lbf-in)	Tz (lbf-in)
Nano25	US-25-25	25	100	25	25	1/112	3/112	1/80	1/160
Nano25	US-50-50	50	200	50	30	1/56	3/56	1/40	1/80
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz[3] (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**	**Fx,Fy (N)**	**Fz[3] (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**
Nano25	SI-125-3	125	500	3	3	1/24	1/8	1/660	1/1320
Nano25	SI-250-6	250	1000	6	3.4	1/12	1/4	1/330	1/660
		Sensing Ranges				**Resolution (Controller)**			

Notes:
1. CTL resolutions are typical. System resolutions quoted are the effective resolution after dropping eight counts of noise. The effective resolution can be improved with filtering.
2. Applied loads must be within range in each of the six axes for the F/T sensor to measure correctly.
3. For IP68 version see caution on physical properties page.
4. Applying moments beyond ±30 lbf-in (±3.4Nm) in Tz can cause hysteresis and permanent zero-point change in the Nano25 (applies to all versions of the Nano25).

5.4.5 CTL Analog Output

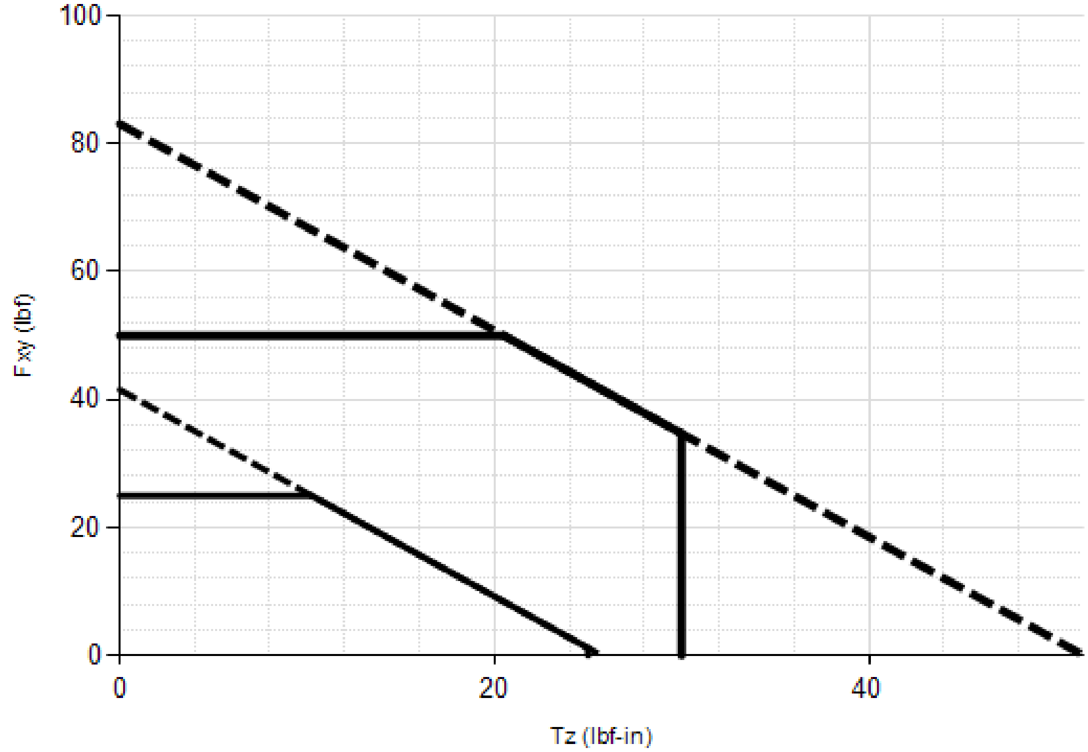
Table 5.19— Nano25 Analog Output							
Sensor	**(US) Standard Calibration**	**Fx,Fy (lbf)**	**Fz[2] (lbf)**	**Tx,Ty,Tz (lbf-in)**	**Fx,Fy (lbf/V)**	**Fz[2] (lbf/V)**	**Tx,Ty,Tz (lbf-in/V)**
Nano25	US-25-25	±25	±100	±25	2.5	10	2.5
Nano25	US-50-50	±50	±200	±50	5	20	5
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz[2] (N)**	**Tx,Ty,Tz (Nmm)**	**Fx,Fy (N/V)**	**Fz[2] (N/V)**	**Tx,Ty,Tz (Nm/V)**
Nano25	SI-125-3	±125	±500	±3	12.5	50	0.3
Nano25	SI-250-6	±250	±1000	±6	25	100	0.6
		Analog Output Range			**Analog ±10V Sensitivity[1]**		

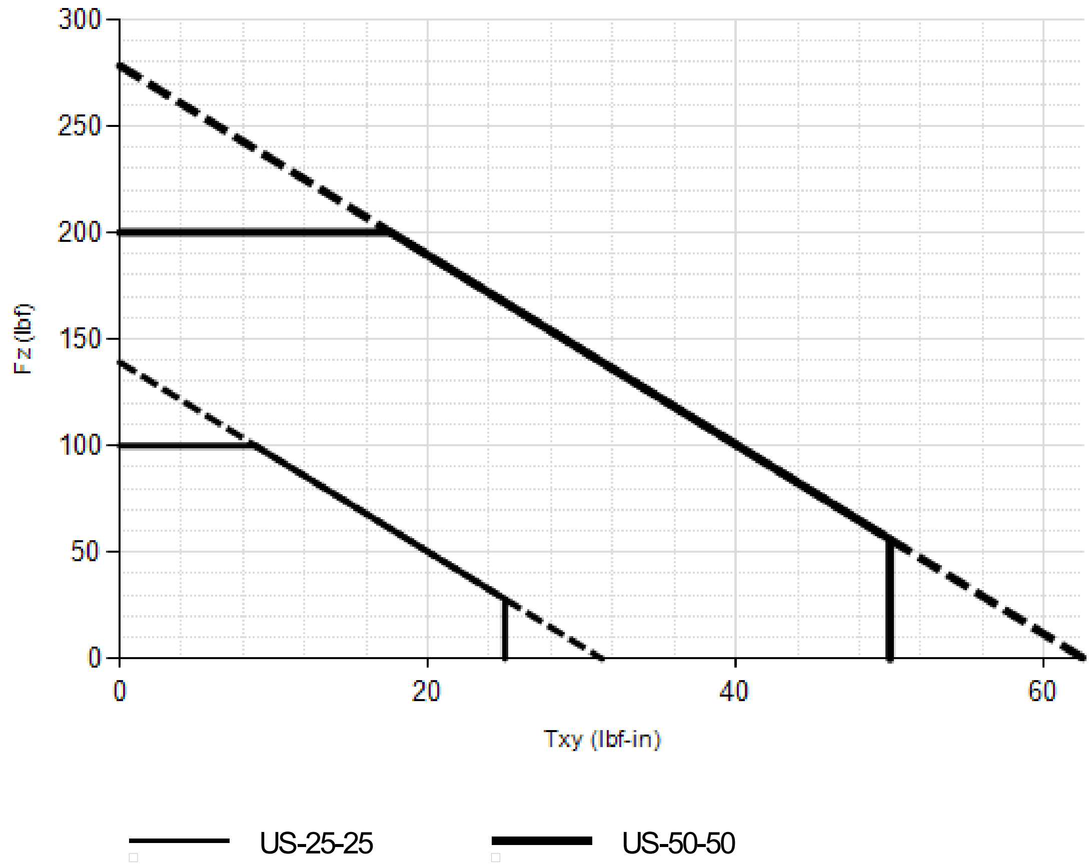
Notes:
1. ±5V Sensitivity values are double the listed ±10V Sensitivity values.
2. For IP68 version see caution on physical properties page.

5.4.6 CTL Counts Value

Table 5.20—Counts Value					
Sensor	**Calibration**	**Fx, Fy, Fz (/ lbf)**	**Tx, Ty, Tz (/ lbf-in)**	**Fx, Fy, Fz**	**Tx, Ty, Tz**
Nano25	US-25–25 / SI-125–3	896	1280	192 / N	10560 / N
Nano25	US-50–50 / SI-250–6	448	640	96 / Nm	5280 / Nm
Nano25	Tool Transform Factor	0.007 in/lbf		0.18182 mm/N	
		Counts Value – Standard (US)		**Counts Value – Metric (SI)**	

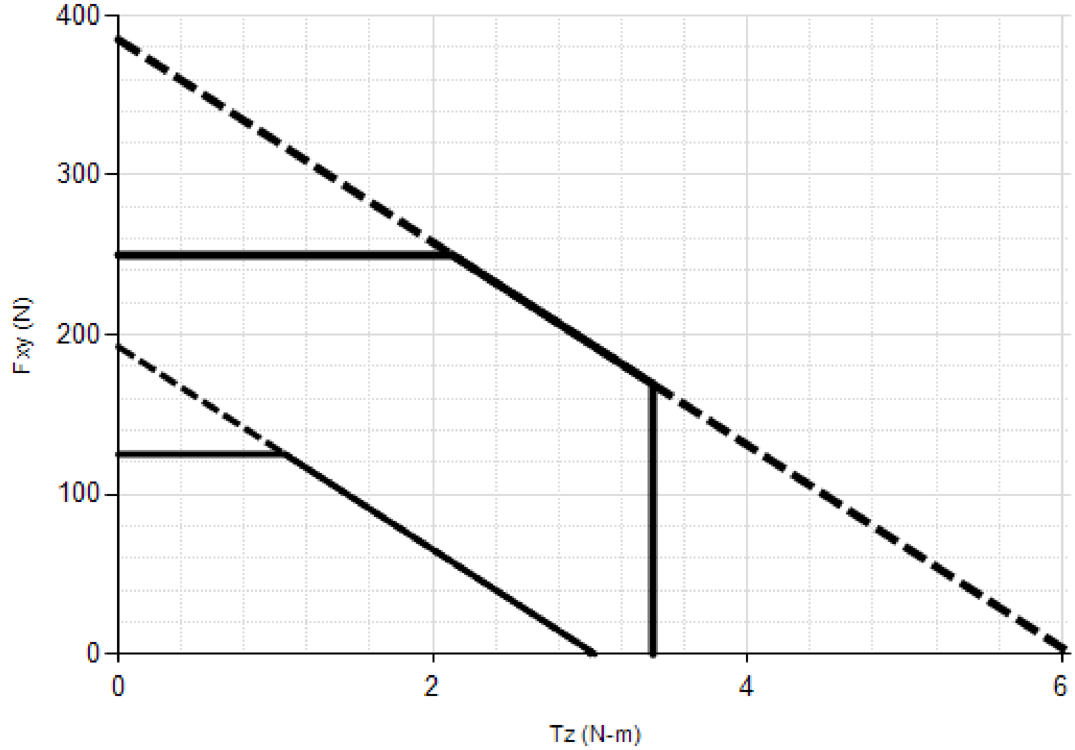
5.4.7 Nano25 (US Calibration Complex Loading)(Includes IP65/IP68)[1]

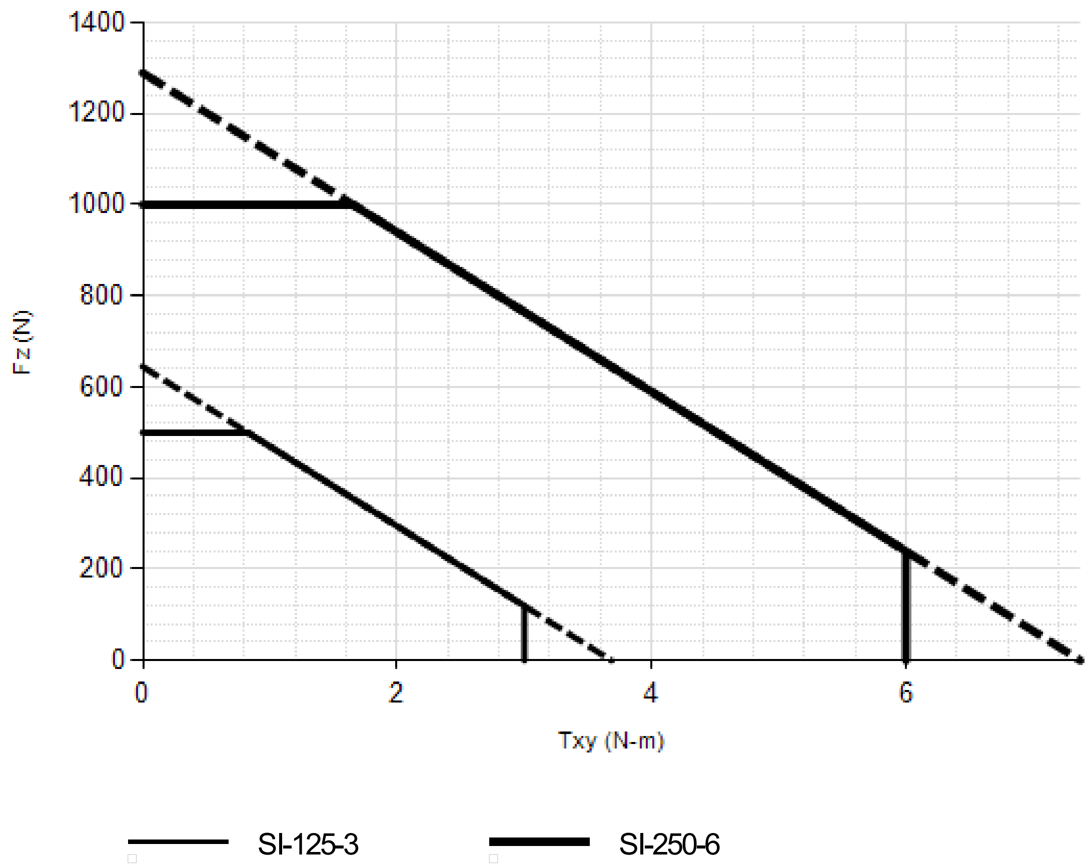




Note: 1. For IP68 version see caution on physical properties page.

5.4.8 Nano25 (SI Calibration Complex Loading)(Includes IP65/IP68)[1]





Note: 1. For IP68 version see caution on physical properties page.

5.5 Nano43 Specifications

In addition to the information in the following sections, refer to the ATI website:

Table 5.21—Nano43 Drawing and Web Links		
Model	**Drawing Part Number**	**ATI Website Address**
Nano25	*9230-05-1110*	*https://www.ati-ia.com/products/ft/ft_models.aspx?id=Nano43*

5.5.1 Nano43 Physical Properties

Table 5.22—Nano43 Physical Properties		
Single-Axis Overload	**(US) Standard Units**	**(SI) Metric Units**
Fxy	±68 lbf	±300 N
Fz	±86 lbf	±380 N
Txy	±29 inf-lb	±3.2 Nm
Tz	±41 inf-lb	±4.6 Nm
Stiffness (Calculated)		
X-axis & Y-axis forces (Kx, Ky)	2.9×10^4 lb/in	5.2×10^6 N/m
Z-axis force (Kz)	2.9×10^4 lb/in	5.2×10^6 N/m
X-axis & Y-axis torque (Ktx, Kty)	6.8×10^3 lbf-in/rad	7.7×10^2 Nm/rad
Z-axis torque (Ktz)	1.0×10^4 lbf-in/rad	1.1×10^3 Nm/rad
Resonant Frequency		
Fx, Fy, Tz	2800 Hz	2800 Hz
Fz, Tx, Ty	2300 Hz	2300 Hz
Physical Specifications		
Weight[1]	0.0854 lb	0.0387 kg
Diameter[1]	1.69 in	43 mm
Height[1]	0.454 in	11.5 mm
Note: 1. Specifications include standard interface plates.		

NOTICE: The outer body of the Nano43 is electrically floating from the rest of the system. If the transducer signal has additional noise, it may be necessary to electrically connect the transducer body to the case of the F/T system.

5.5.2 Calibration Specifications (excludes CTL calibrations)

Table 5.23— Nano43 Calibrations (excludes CTL calibrations)[1, 2]

Sensor	(US) Standard Calibration	Fx,Fy (lbf)	Fz (lbf)	Tx,Ty (lbf-in)	Tz (lbf-in)	Fx,Fy (lbf)	Fz (lbf)	Tx,Ty (lbf-in)	Tz (lbf-in)
Nano43	US-2-1	2	2	1	1	1/2320	1/2320	1/4640	1/4640
Nano43	US-4-2	4	4	2	2	1/1160	1/1160	1/2320	1/2320
Nano43	US-8-4	8	8	4	4	1/580	1/580	1/1160	1/1160
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz (N)**	**Tx,Ty (Nmm)**	**Tz (Nmm)**	**Fx,Fy (N)**	**Fz (N)**	**Tx,Ty (Nmm)**	**Tz (Nmm)**
Nano43	SI-9-0.125	9	9	125	125	1/512	1/512	1/40	1/40
Nano43	SI-18-0.25	18	18	250	250	1/256	1/256	1/20	1/20
Nano43	SI-36-0.5	36	36	500	500	1/128	1/128	1/10	1/10
		Sensing Ranges				**Resolution (DAQ, Net F/T)[3]**			

Notes:
1. These system resolutions quoted are the effective resolution after dropping eight counts of noise. The effective resolution can be improved with filtering.
2. Applied loads must be within range in each of the six axes for the F/T sensor to measure correctly.
3. DAQ resolutions are typical for a 16-bit data acquisition system.

5.5.3 CTL Calibration Specifications

Table 5.24— Nano43 CTL Calibrations[1, 2]

Sensor	(US) Standard Calibration	Fx,Fy (lbf)	Fz (lbf)	Tx,Ty (lbf-in)	Tz (lbf-in)	Fx,Fy (lbf)	Fz (lbf)	Tx,Ty (lbf-in)	Tz (lbf-in)
Nano43	US-2-1	2	2	1	1	1/1160	1/1160	1/2320	1/2320
Nano43	US-4-2	4	4	2	2	1/580	1/580	1/1160	1/1160
Nano43	US-8-4	8	8	4	4	1/290	1/290	1/580	1/580
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz (N)**	**Tx,Ty (Nmm)**	**Tz (Nmm)**	**Fx,Fy (N)**	**Fz (N)**	**Tx,Ty (Nmm)**	**Tz (Nmm)**
Nano43	SI-9-0.125	9	9	125	125	1/256	1/256	1/20	1/20
Nano43	SI-18-0.25	18	18	250	250	1/128	1/128	1/10	1/10
Nano43	SI-36-0.5	36	36	500	500	1/64	1/64	1/5	1/5
		Sensing Ranges				**Resolution (Controller)**			

Notes:
1. CTL resolutions are typical. System resolutions quoted are the effective resolution after dropping eight counts of noise. The effective resolution can be improved with filtering.
2. Applied loads must be within range in each of the six axes for the F/T sensor to measure correctly.

5.5.4 CTL Analog Output

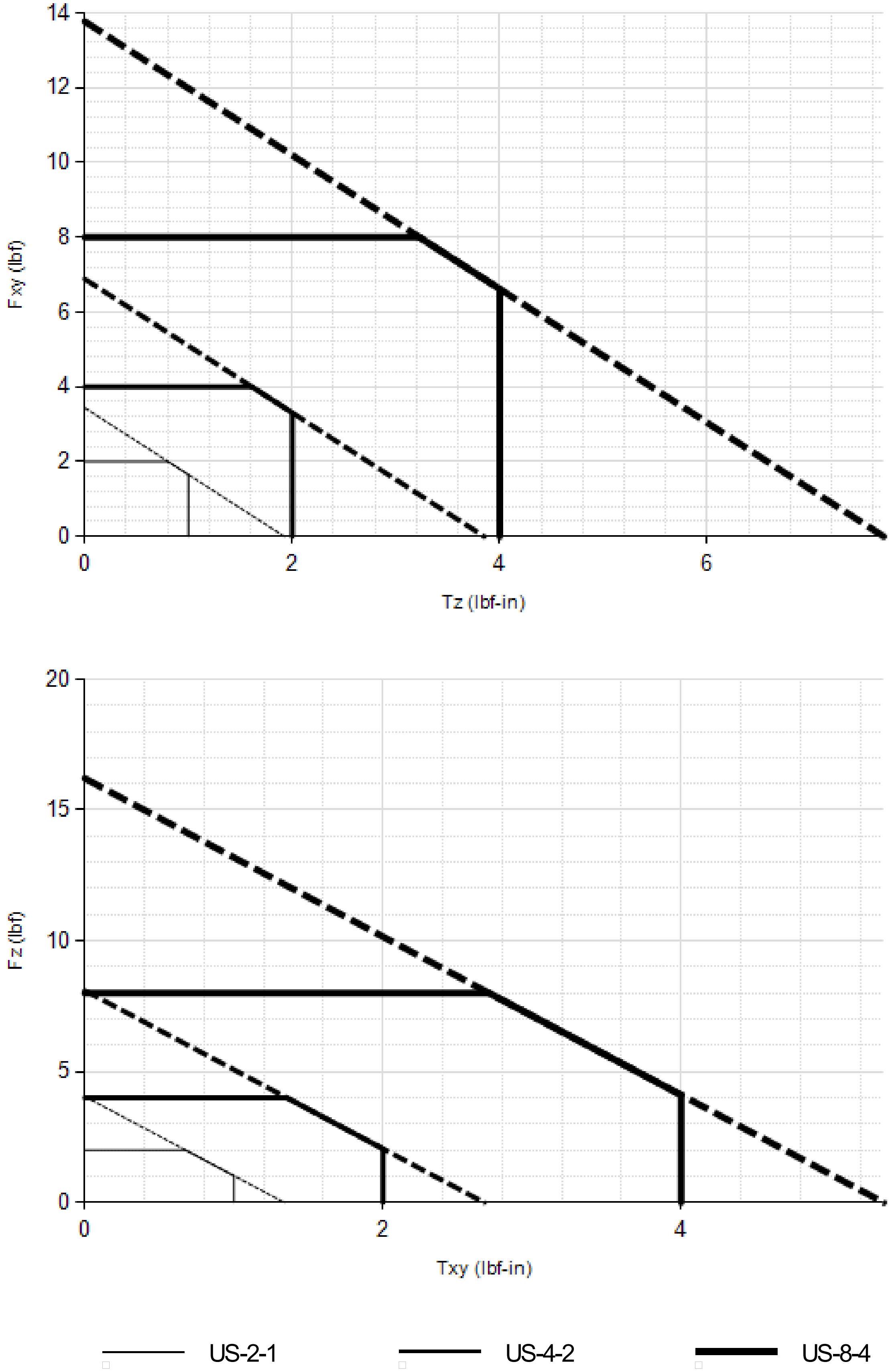
Table 5.25— Nano43 Analog Output							
Sensor	**(US) Standard Calibration**	**Fx,Fy (lbf)**	**Fz (lbf)**	**Tx,Ty,Tz (lbf-in)**	**Fx,Fy (lbf/V)**	**Fz (lbf/V)**	**Tx,Ty,Tz (lbf-in/V)**
Nano43	US-2-1	N/A	N/A	N/A	N/A	N/A	N/A
Nano43	US-4-2	±4	±4	±2	0.4	0.4	0.2
Nano43	US-8-4	±8	±8	±4	0.8	0.8	0.4
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz (N)**	**Tx,Ty,Tz (Nmm)**	**Fx,Fy (N/V)**	**Fz (N/V)**	**Tx,Ty,Tz (Nm/V)**
Nano43	SI-9-0.125	N/A	N/A	N/A	N/A	N/A	N/A
Nano43	SI-18-0.25	±18	±18	±250	1.8	1.8	25
Nano43	SI-36-0.5	±36	±36	±500	3.6	3.6	50
		Analog Output Range			**Analog ±10V Sensitivity[1]**		

Notes:
1. ±5V Sensitivity values are double the listed ±10V Sensitivity values.

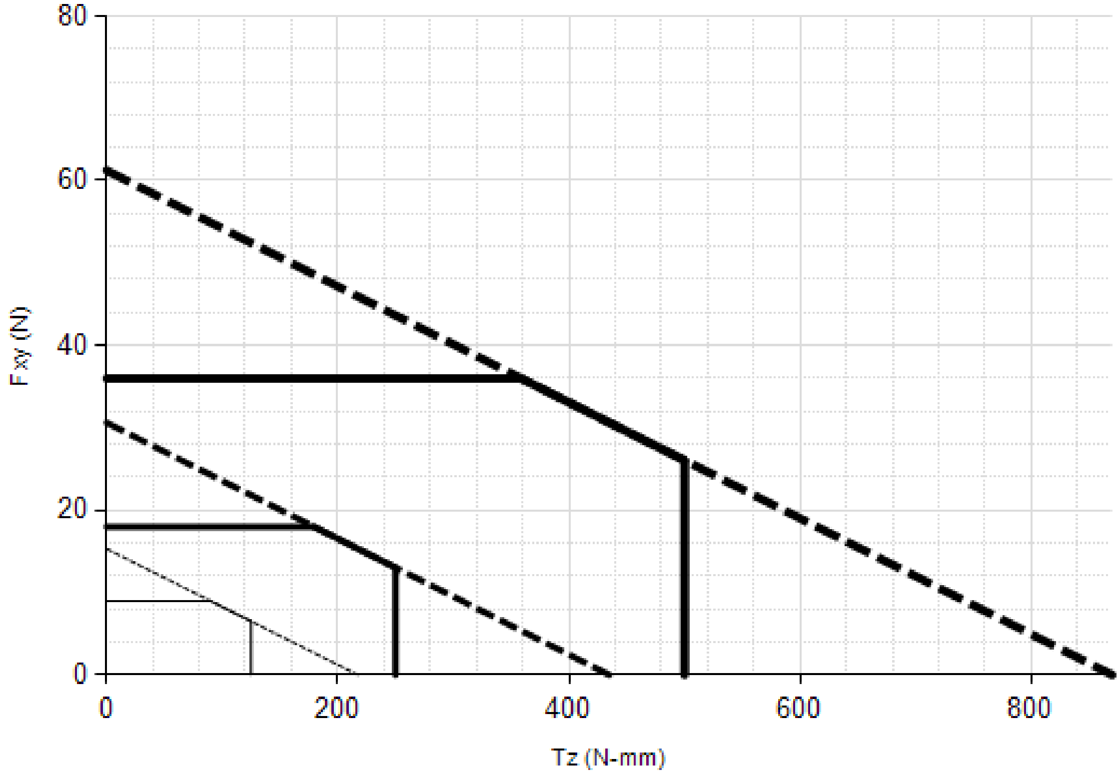
5.5.5 CTL Counts Value

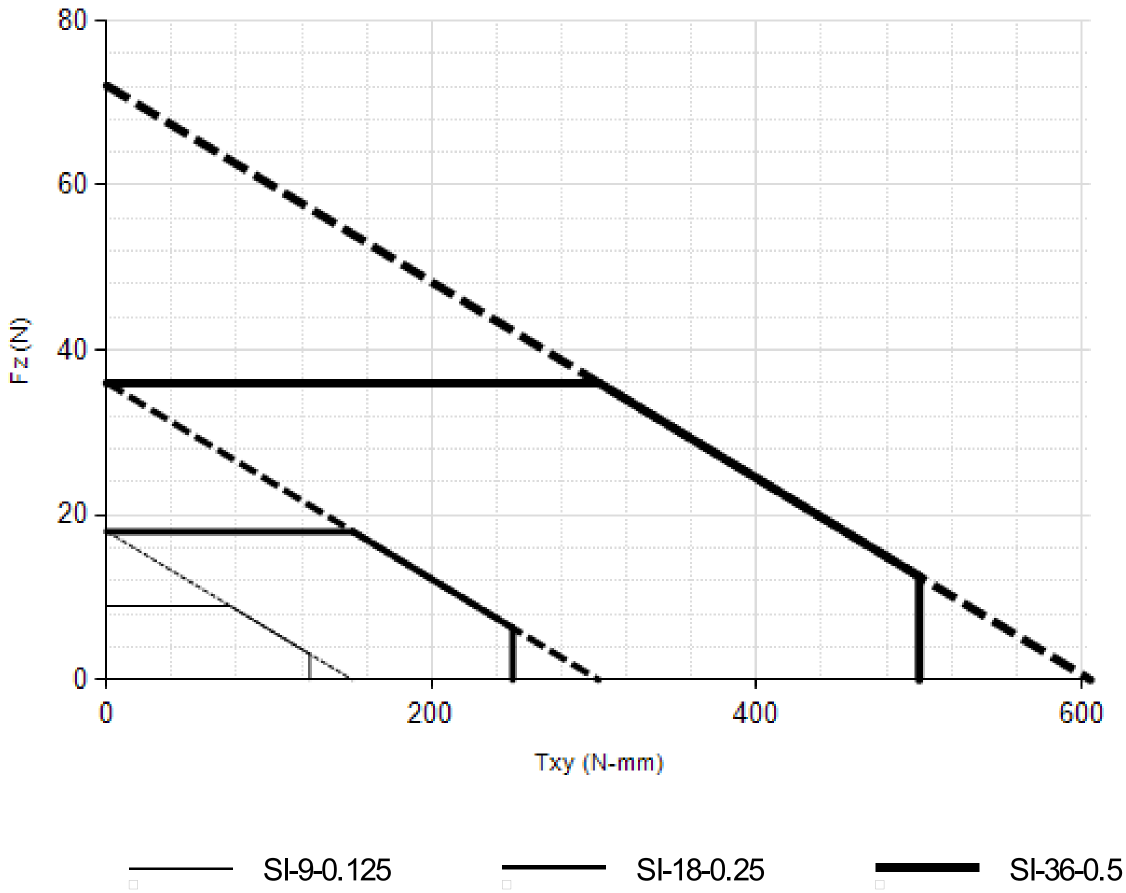
Table 5.26—Counts Value					
Sensor	**Calibration**	**Fx, Fy, Fz (/ lbf)**	**Tx, Ty, Tz (/ lbf-in)**	**Fx, Fy, Fz (/ N)**	**Tx, Ty, Tz (/ Nmm)**
Nano43	US-2-1 / SI-9-0.125	N/A	N/A	N/A	N/A
Nano43	US-4–2 / SI-18–0.25	4640	9280	1024	80
Nano43	US-8–4 / SI-36–0.5	2320	4640	512	40
Nano43	Tool Transform Factor	0.005 in/lbf		0.128 mm/N	
		Counts Value – Standard (US)		**Counts Value – Metric (SI)**	

5.5.6 Nano43 (US Calibration Complex Loading)



5.5.7 Nano43 (SI Calibration Complex Loading)





5.6 Mini27 Titanium Specifications

In addition to the information in the following sections, refer to the ATI website:

Table 5.27—Mini27 Drawing and Web Links		
Model	**Drawing Part Number**	**ATI Website Address**
Mini27	*9230-05-1420*	*https://www.ati-ia.com/products/ft/ft_models.aspx?id=Mini27+Titanium*
Mini27-E	*9230-05-1553*	

5.6.1 Mini27 Titanium Physical Properties

Table 5.28—Mini27 Titanium Physical Properties		
Single-Axis Overload	**(US) Standard Units**	**(SI) Metric Units**
Fxy	±330 lbf	±1500 N
Fz	±1000 lbf	±4600 N
Txy	±270 inf-lb	±30 Nm
Tz	±360 inf-lb	±40 Nm
Stiffness (Calculated)		
X-axis & Y-axis forces (Kx, Ky)	$1.8x10^5$ lb/in	$3.1x10^7$ N/m
Z-axis force (Kz)	$3.6x10^5$ lb/in	$6.4x10^7$ N/m
X-axis & Y-axis torque (Ktx, Kty)	$4.0x10^4$ lbf-in/rad	$4.5x10^3$ Nm/rad
Z-axis torque (Ktz)	$5.8x10^4$ lbf-in/rad	$6.5x10^3$ Nm/rad
Resonant Frequency		
Fx, Fy, Tz	N/A	N/A
Fz, Tx, Ty	N/A	N/A
Physical Specifications		
Weight[1]	0.0736 lb	0.0334 kg
Diameter[1]	1.06 in	27 mm
Height[1]	0.715 in	18.2 mm
Note: 1. Specifications include standard interface plates.		

5.6.2 Calibration Specifications (excludes CTL calibrations)

Table 5.29—Mini27 Titanium Calibrations (excludes CTL calibrations)[1, 2]

Sensor	(US) Standard Calibration	Fx,Fy (lbf)	Fz (lbf)	Tx,Ty (lbf-in)	Tz (lbf-in)	Fx,Fy (lbf)	Fz (lbf)	Tx,Ty (lbf-in)	Tz (lbf-in)
Mini27 Titanium	US-10-18	10	20	18	10	1/400	3/400	1/400	1/800
Mini27 Titanium	US-20-36	20	40	36	20	1/200	3/200	1/200	1/400
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**	**Fx,Fy (N)**	**Fz (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**
Mini27 Titanium	SI-40-2	40	80	2	1	3/200	3/100	3/8000	1/4000
Mini27 Titanium	SI-80-4	80	160	4	2	3/100	3/50	3/4000	1/2000
		Sensing Ranges				**Resolution (DAQ, Net F/T)[3]**			

Notes:
1. These system resolutions quoted are the effective resolution after dropping four counts of noise. The effective resolution can be improved with filtering.
2. Applied loads must be within range in each of the six axes for the F/T sensor to measure correctly.
3. DAQ resolutions are typical for a 16-bit data acquisition system.

5.6.3 CTL Calibration Specifications

Table 5.30— Mini27 Titanium CTL Calibrations[1, 2]

Sensor	(US) Standard Calibration	Fx,Fy (lbf)	Fz (lbf)	Tx,Ty (lbf-in)	Tz (lbf-in)	Fx,Fy (lbf)	Fz (lbf)	Tx,Ty (lbf-in)	Tz (lbf-in)
Mini27 Titanium	US-10-18	10	20	18	10	1/200	3/200	1/200	1/400
Mini27 Titanium	US-20-36	20	40	36	20	1/100	3/100	1/100	1/200
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**	**Fx,Fy (N)**	**Fz (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**
Mini27 Titanium	SI-40-2	40	80	2	1	3/100	3/50	3/4000	1/2000
Mini27 Titanium	SI-80-4	80	160	4	2	3/50	3/25	3/2000	1/1000
		Sensing Ranges				**Resolution (Controller)**			

Notes:
1. CTL resolutions are typical. System resolutions quoted are the effective resolution after dropping eight counts of noise. The effective resolution can be improved with filtering.
2. Applied loads must be within range in each of the six axes for the F/T sensor to measure correctly.

5.6.4 CTL Analog Output

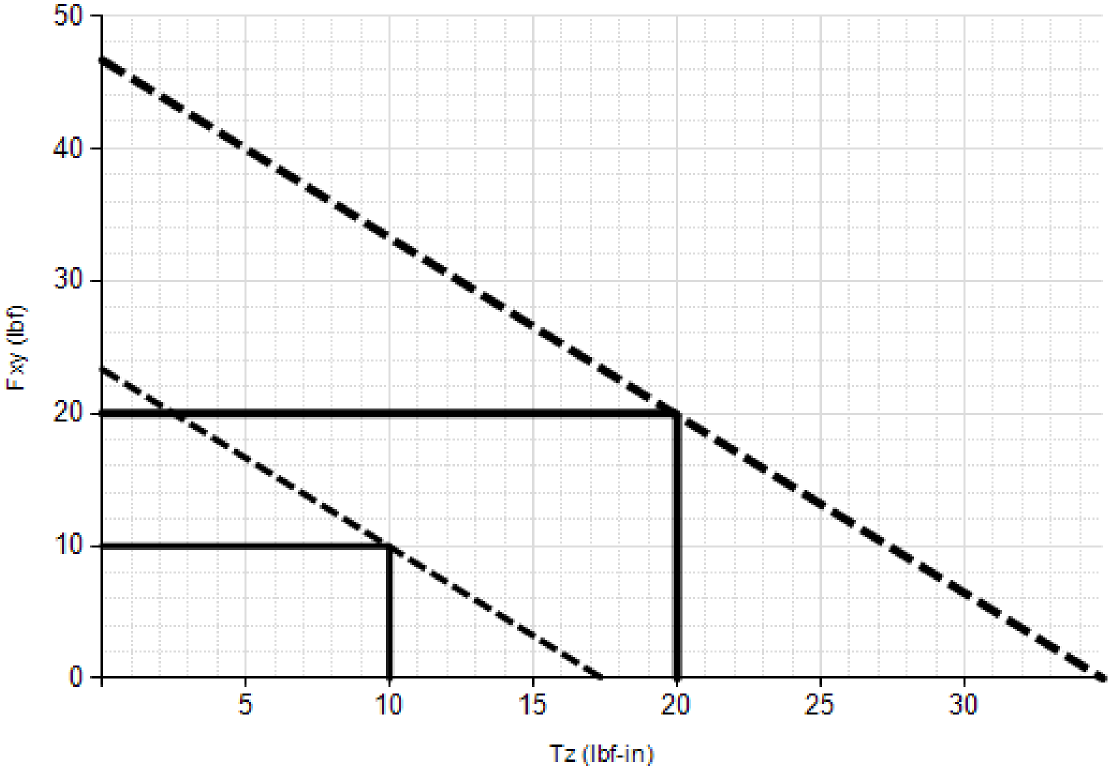
Table 5.31— Mini27 Titanium Analog Output							
Sensor	**(US) Standard Calibration**	**Fx,Fy (lbf)**	**Fz (lbf)**	**Tx,Ty,Tz (lbf-in)**	**Fx,Fy (lbf/V)**	**Fz (lbf/V)**	**Tx,Ty,Tz (lbf-in/V)**
Mini27 Titanium	US-10-18	±10	±20	±18	1	2	1.8
Mini27 Titanium	US-20-36	±20	±40	±36	2	4	3.6
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz (N)**	**Tx,Ty,Tz (Nmm)**	**Fx,Fy (N/V)**	**Fz (N/V)**	**Tx,Ty,Tz (Nm/V)**
Mini27 Titanium	SI-40-2	±40	±80	±2	4	8	0.2
Mini27 Titanium	SI-80-4	±80	±160	±4	8	16	0.4
		Analog Output Range			**Analog ±10V Sensitivity[1]**		

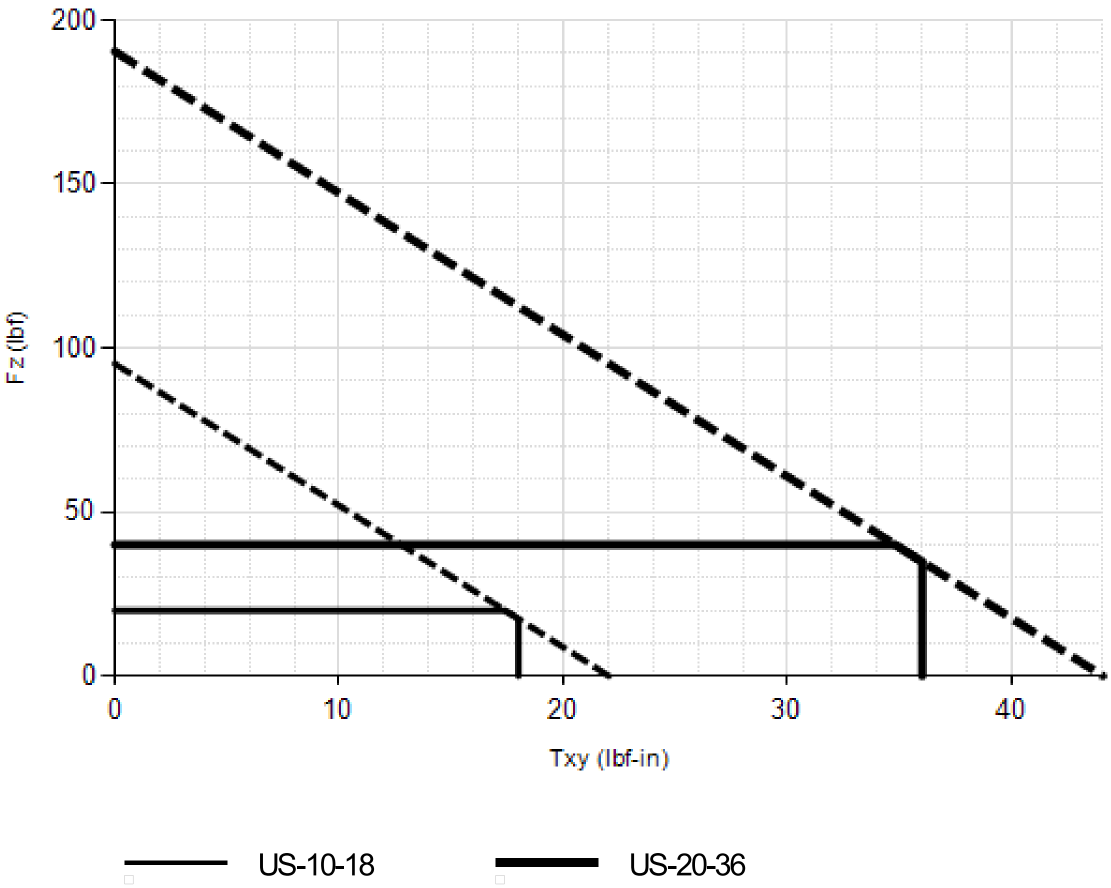
Notes:
1. ±5V Sensitivity values are double the listed ±10V Sensitivity values.

5.6.5 CTL Counts Value

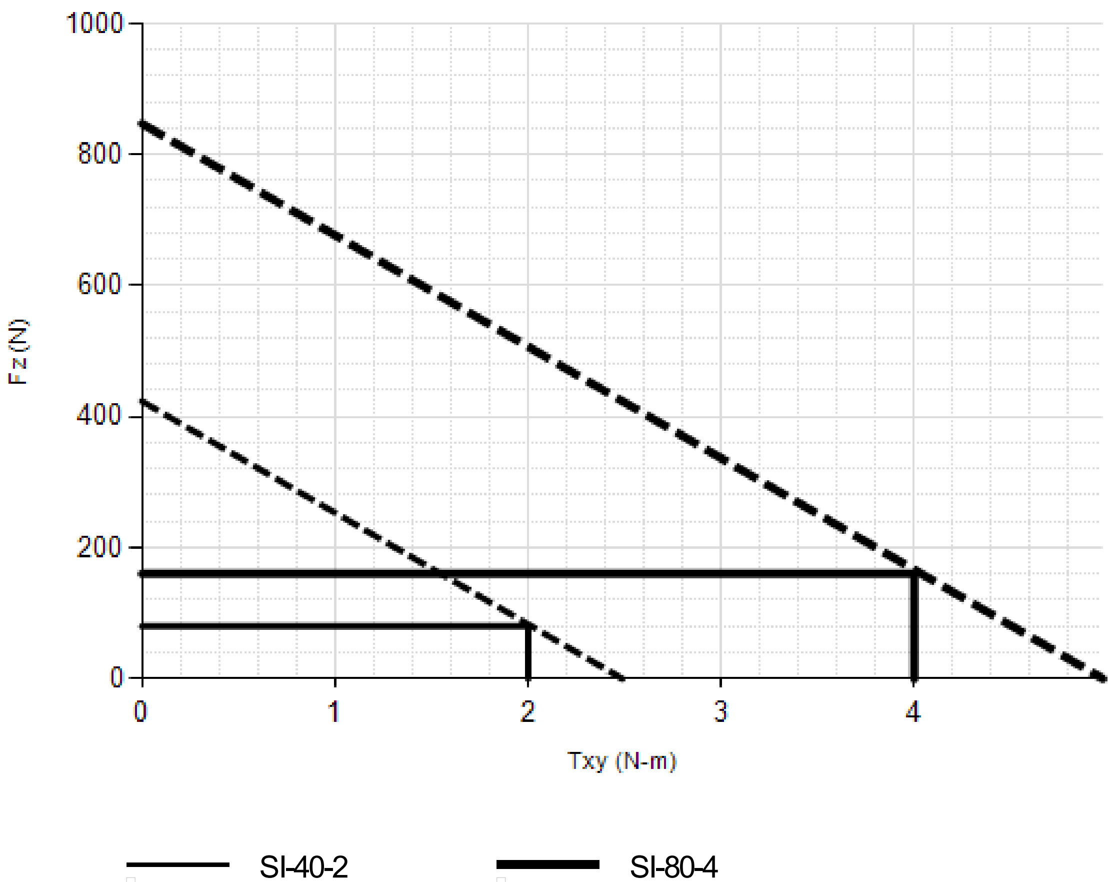
Table 5.32—Counts Value					
Sensor	**Calibration**	**Fx, Fy, Fz (/ lbf)**	**Tx, Ty, Tz (/ lbf-in)**	**Fx, Fy, Fz (/ N)**	**Tx, Ty, Tz (/ Nm)**
Mini27 Titanium	US-1–18 / SI-40–2	3200	3200	800	32000
Mini27 Titanium	US-20–36 / SI-80–4	1600	1600	400	16000
Mini27 Titanium	Tool Transform Factor	0.01 in/lbf		0.25 mm/N	
		Counts Value – Standard (US)		**Counts Value – Metric (SI)**	

5.6.6 Mini27 Titanium (US Calibration Complex Loading)





5.6.7 Mini27 Titanium (SI Calibration Complex Loading)



5.7 Mini40 Specifications (Includes IP65/IP68 Versions)

In addition to the information in the following sections, refer to the ATI website:

Table 5.33—Mini40 Drawing and Web Links		
Model	**Drawing Part Number**	**ATI Website Address**
Mini40-A (axial exit)and Mini40-R (radial exit)	*9230-05-1278*	*https://www.ati-ia.com/products/ft/ft_models.aspx?id=Mini40*
Mini40-E	*9230-05-1314*	
Mini40 IP65/IP68	*9230-05-1421*	*https://www.ati-ia.com/products/ft/ft_models.aspx?id=Mini40+IP65%2fIP68*

5.7.1 Mini40 Physical Properties

Table 5.34—Mini40 Physical Properties		
Single-Axis Overload	**(US) Standard Units**	**(SI) Metric Units**
Fxy	±180 lbf	±810 N
Fz	±530 lbf	±2400 N
Txy	±170 inf-lb	±19 Nm
Tz	±180 inf-lb	±20 Nm
Stiffness (Calculated)		
X-axis & Y-axis forces (Kx, Ky)	6.1×10^4 lb/in	1.1×10^7 N/m
Z-axis force (Kz)	1.2×10^5 lb/in	2.0×10^7 N/m
X-axis & Y-axis torque (Ktx, Kty)	2.5×10^4 lbf-in/rad	2.8×10^3 Nm/rad
Z-axis torque (Ktz)	3.6×10^4 lbf-in/rad	4.0×10^3 Nm/rad
Resonant Frequency		
Fx, Fy, Tz	3200 Hz	3200 Hz
Fz, Tx, Ty	4900 Hz	4900 Hz
Physical Specifications		
Weight[1]	0.11 lb	0.0499 kg
Diameter[1]	1.57 in	40 mm
Height[1]	0.482 in	12.2 mm
Note: 1. Specifications include standard interface plates.		

5.7.2 Mini40 IP65/IP68 Physical Properties

Table 5.35—Mini40 IP65/IP68 Physical Properties		
Single-Axis Overload	**(US) Standard Units**	**(SI) Metric Units**
Fxy	±180 lbf	±810 N
Fz	±530 lbf	±2400 N
Txy	±170 inf-lb	±19 Nm
Tz	±180 inf-lb	±20 Nm
Stiffness (Calculated)		
X-axis & Y-axis forces (Kx, Ky)	6.1×10^4 lb/in	1.1×10^7 N/m
Z-axis force (Kz)	1.2×10^5 lb/in	2.0×10^7 N/m
X-axis & Y-axis torque (Ktx, Kty)	2.5×10^4 lbf-in/rad	2.8×10^3 Nm/rad
Z-axis torque (Ktz)	3.6×10^4 lbf-in/rad	4.0×10^3 Nm/rad
Resonant Frequency		
Fx, Fy, Tz	1400 Hz	1400 Hz
Fz, Tx, Ty	1300 Hz	1300 Hz
Physical Specifications		
Weight[1]	0.6 lb	0.272 kg
Diameter[1]	2.1 in	53.3 mm
Height[1]	0.83 in	21.1 mm
Note: 1. Specifications include standard interface plates.		

CAUTION: When submerged, IP68 transducers exhibit a decrease in Fz range related to the submersion depth. This loss is the result of pressure-induced preloading on the transducer. The preload can be masked by biasing the transducer at the depth prior to applying the load to be measured. The following estimates are for room temperature fresh water at sea level.

Submersion Depth		
IP68 Mini40	**US**	**Metric**
Fz preload at 4 m depth	17.0 lb	75.5 N
Fz preload at other depths	-1.29 lb/ft × depthInFeet	-18.9 N/m × depthInMeters

5.7.3 Calibration Specifications (excludes CTL calibrations)

Table 5.36— Mini40 Calibrations (excludes CTL calibrations)[1, 2]

Sensor	(US) Standard Calibration	Fx,Fy (lbf)	Fz[3] (lbf)	Tx,Ty (lbf-in)	Tz (lbf-in)	Fx,Fy (lbf)	Fz[3] (lbf)	Tx,Ty (lbf-in)	Tz (lbf-in)
Mini40	US-5-10	5	15	10	10	1/800	1/400	1/800	1/800
Mini40	US-10-20	10	30	20	20	1/400	1/200	1/400	1/400
Mini40	US-20-40	20	60	40	40	1/200	1/100	1/200	1/200
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz[3] (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**	**Fx,Fy (N)**	**Fz[3] (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**
Mini40	SI-20-1	20	60	1	1	1/200	1/100	1/8000	1/8000
Mini40	SI-40-2	40	120	2	2	1/100	1/50	1/4000	1/4000
Mini40	SI-80-4	80	240	4	4	1/50	1/25	1/2000	1/2000
		Sensing Ranges				**Resolution (DAQ, Net F/T)[4]**			

Notes:
1. These system resolutions quoted are the effective resolution after dropping four counts of noise. The effective resolution can be improved with filtering.
2. Applied loads must be within range in each of the six axes for the F/T sensor to measure correctly.
3. For IP68 version see caution on physical properties page.
4. DAQ resolutions are typical for a 16-bit data acquisition system.

5.7.4 CTL Calibration Specifications

Table 5.37— Mini40 CTL Calibrations[1, 2]									
Sensor	**(US) Standard Calibration**	**Fx,Fy (lbf)**	**Fz[3] (lbf)**	**Tx,Ty (lbf-in)**	**Tz (lbf-in)**	**Fx,Fy (lbf)**	**Fz[3] (lbf)**	**Tx,Ty (lbf-in)**	**Tz (lbf-in)**
Mini40	US-5-10	5	15	10	10	1/400	1/200	1/400	1/400
Mini40	US-10-20	10	30	20	20	1/200	1/100	1/200	1/200
Mini40	US-20-40	20	60	40	40	1/100	1/50	1/100	1/100
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz[3] (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**	**Fx,Fy (N)**	**Fz[3] (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**
Mini40	SI-20-1	20	60	1	1	1/100	1/50	1/4000	1/4000
Mini40	SI-40-2	40	120	2	2	1/50	1/25	1/2000	1/2000
Mini40	SI-80-4	80	240	4	4	1/25	2/25	1/1000	1/1000
		Sensing Ranges				**Resolution (Controller)**			

Notes:
1. CTL resolutions are typical. System resolutions quoted are the effective resolution after dropping eight counts of noise. The effective resolution can be improved with filtering.
2. Applied loads must be within range in each of the six axes for the F/T sensor to measure correctly.
3. For IP68 version see caution on physical properties page.

5.7.5 CTL Analog Output

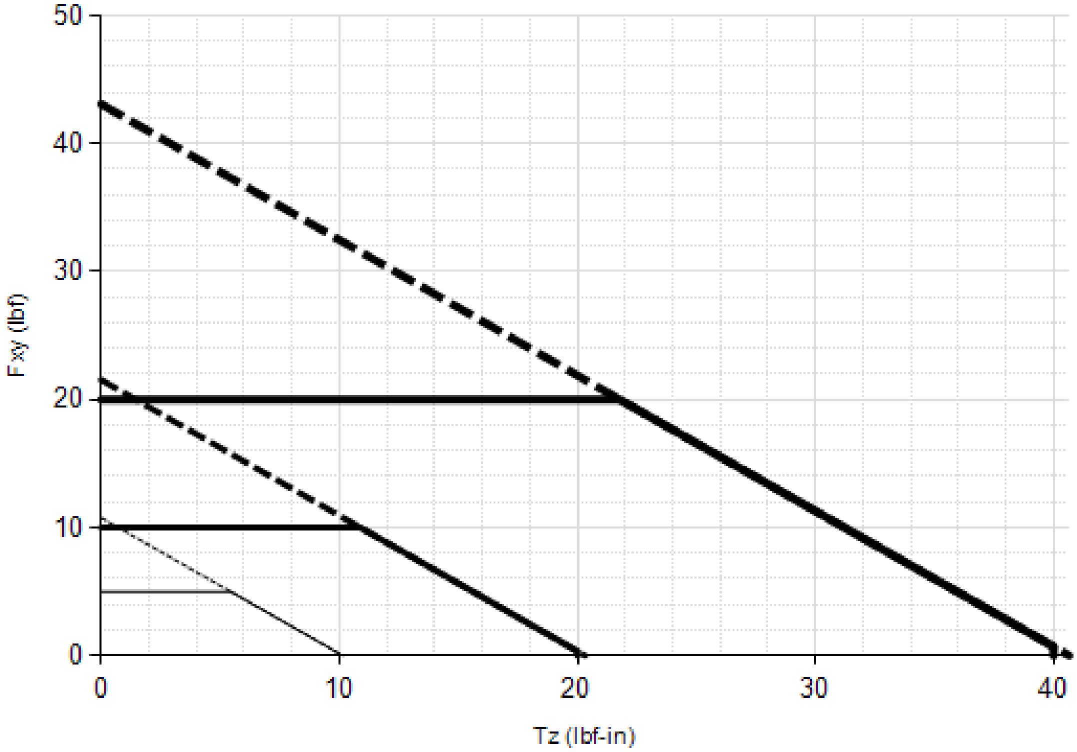
Table 5.38— Mini40 Analog Output							
Sensor	**(US) Standard Calibration**	**Fx,Fy (lbf)**	**Fz[2] (lbf)**	**Tx,Ty,Tz (lbf-in)**	**Fx,Fy (lbf/V)**	**Fz[2] (lbf/V)**	**Tx,Ty,Tz (lbf-in/V)**
Mini40	US-5-10	±5	±15	±10	0.5	1.5	1
Mini40	US-10-20	±10	±30	±20	1	3	2
Mini40	US-20-40	±20	±60	±40	2	6	4
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz[2] (N)**	**Tx,Ty,Tz (Nm)**	**Fx,Fy (N/V)**	**Fz[2] (N/V)**	**Tx,Ty,Tz (Nm/V)**
Mini40	SI-20-1	±20	±60	±1	2	6	0.1
Mini40	SI-40-2	±40	±120	±2	4	12	0.2
Mini40	SI-80-4	±80	±240	±4	8	24	0.4
		Analog Output Range			**Analog ±10V Sensitivity[1]**		

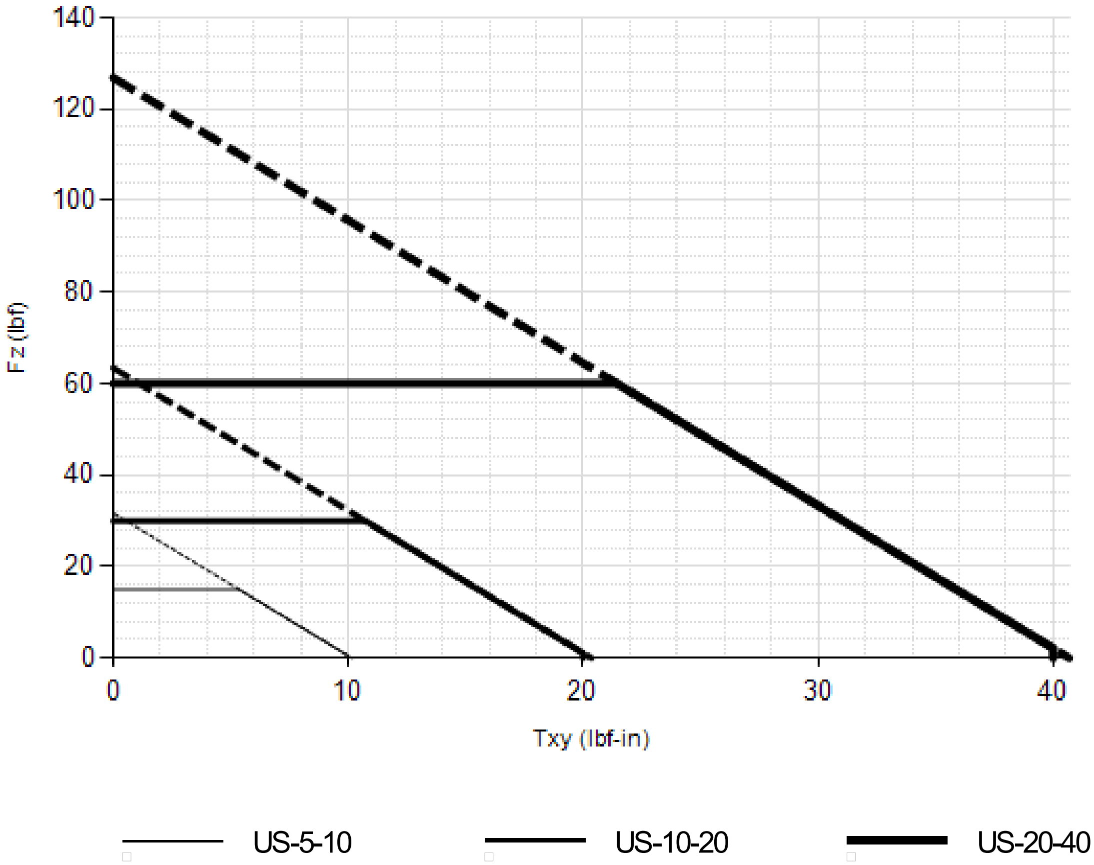
Notes:
1. ±5V Sensitivity values are double the listed ±10V Sensitivity values.
2. For IP68 version see caution on physical properties page.

5.7.6 CTL Counts Value

Table 5.39—Counts Value					
Sensor	**Calibration**	**Fx, Fy, Fz (/ lbf)**	**Tx, Ty, Tz (/ lbf-in)**	**Fx, Fy, Fz (/ N)**	**Tx, Ty, Tz (/ Nm)**
Mini40	US-5–10 / SI-20–1	3200	3200	800	32000
Mini40	US-10–20 / SI-40–2	1600	1600	400	16000
Mini40	US-20–40 / SI-80-4	800	800	200	8000
Mini40	Tool Transform Factor	0.01 in/lbf		0.25 mm/N	
		Counts Value – Standard (US)		**Counts Value – Metric (SI)**	

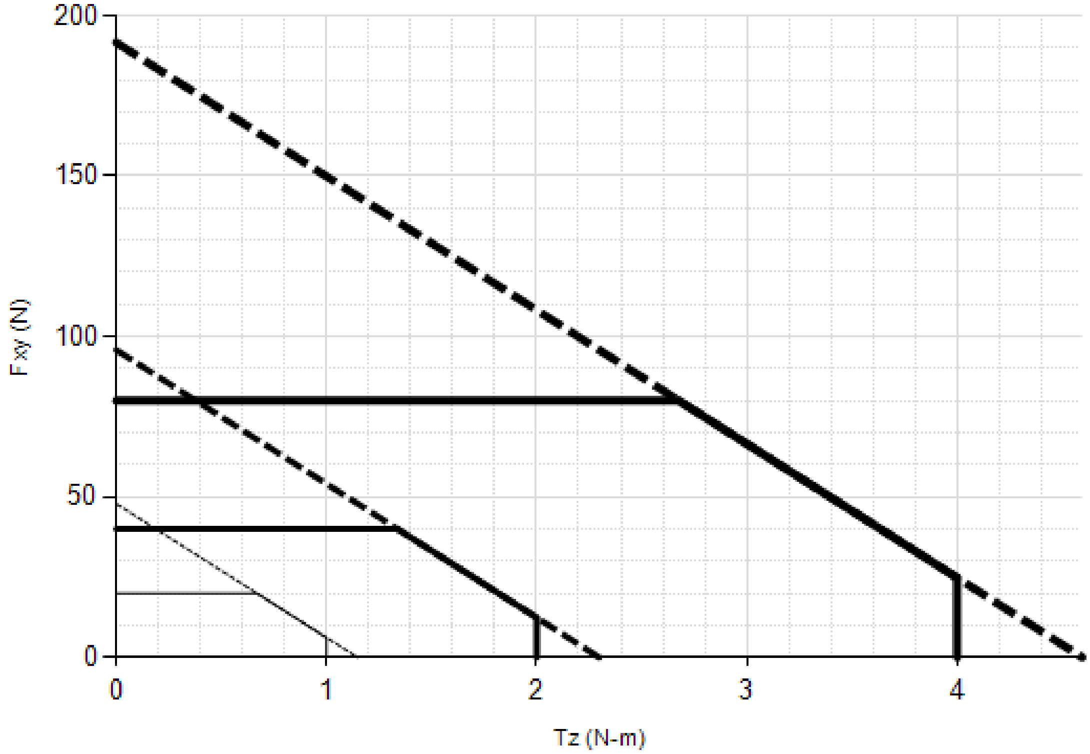
5.7.7 Mini40 (US Calibration Complex Loading)(Includes IP65/IP68)[1]

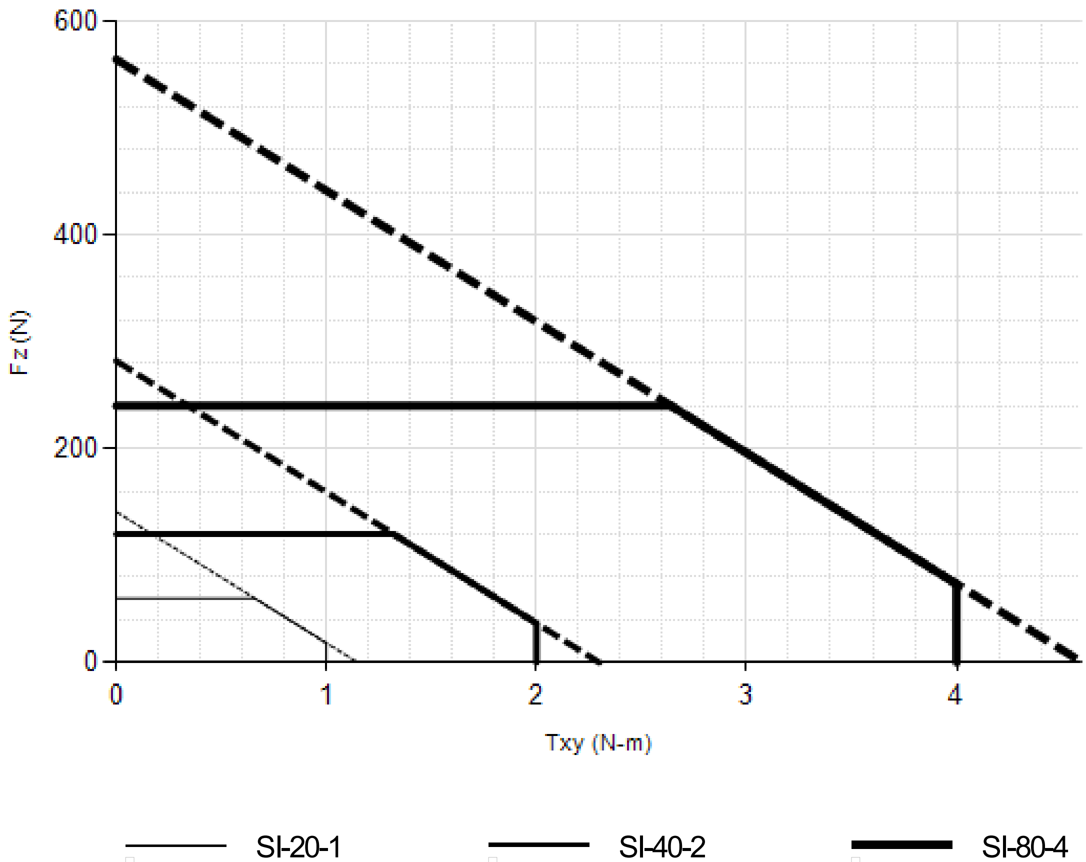




Note: 1. For IP68 version see caution on physical properties page.

5.7.8 Mini40 (SI Calibration Complex Loading)(Includes IP65/IP68)[1]





Note: 1. For IP68 version see caution on physical properties page.

5.8 Mini43LP Specifications

In addition to the information in the following sections, refer to the ATI website:

Table 5.40—Mini43LP Drawing and Web Links		
Model	Drawing Part Number	ATI Website Address
Mini43LP	9630-05-0005	http://www.ati-ia.com/app_content/Documents/9630-05-0005.auto.pdf

5.8.1 Mini43LP Physical Properties

Table 5.41—Mini43LP Physical Properties		
Single-Axis Overload	**(US) Standard Units**	**(SI) Metric Units**
Fxy	280 lb	1200 N
Fz	280 lb	1200 N
Txy	130 lb-in	15 Nm
Tz	220 lb-in	25 Nm
Stiffness (Calculated)		
X-axis & Y-axis forces (Kx, Ky)	1.9×10^5 lb/in	3.3×10^7 N/m
Z-axis force (Kz)	1.2×10^5 lb/in	2.1×10^7 N/m
X-axis & Y-axis torque (Ktx, Kty)	3.0×10^4 lbf-in/rad	3.4×10^3 Nm/rad
Z-axis torque (Ktz)	1.0×10^5 lbf-in/rad	1.1×10^4 Nm/rad
Resonant Frequency		
Fx, Fy, Tz	5200 Hz	
Fz, Tx, Ty	7300 Hz	
Physical Specifications		
Weight[1]	0.11 lb	0.05 kg
Diameter[1]	1.69 in	43 mm
Height[1]	0.31 in	7.9 mm

5.8.2 Calibration Specifications

Table 5.42—Mini43LP Calibrations[1, 2]									
Sensor	**(US) Standard Calibration**	**Fx,Fy (lb)**	**Fz (lb)**	**Tx,Ty (lb-in)**	**Tz (lb-in)**	**Fx,Fy (lb)**	**Fz (lb)**	**Tx,Ty (lb-in)**	**Tz (lb-in)**
Mini43LP	US-12.5-6	12.5	12.5	6	11	1/320	1/320	1/648	1/368
Mini43LP	US-25-12.5	25	25	12.5	22	1/160	1/160	1/324	1/184
Mini43LP	US-50-25	50	50	25	44	1/80	1/80	1/162	1/92
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**	**Fx,Fy (N)**	**Fz (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**
Mini43LP	SI-62-0.75	62	62	0.75	1.25	1/64	1/64	1/5120	1/3280
Mini43LP	SI-125-1.5	125	125	1.5	2.5	1/32	1/32	1/2560	1/1640
Mini43LP	SI-250-3	250	250	3	5	1/16	1/16	1/1360	1/820
		Sensing Ranges				**Resolution[3]**			

Notes:
1. These system resolutions quoted are the effective resolution after dropping four counts of noise. The effective resolution can be improved with filtering.
2. Applied loads must be within range in each of the six axes for the F/T sensor to measure correctly.
3. Resolutions are typical for a 16-bit data.

5.8.3 CTL Analog Output

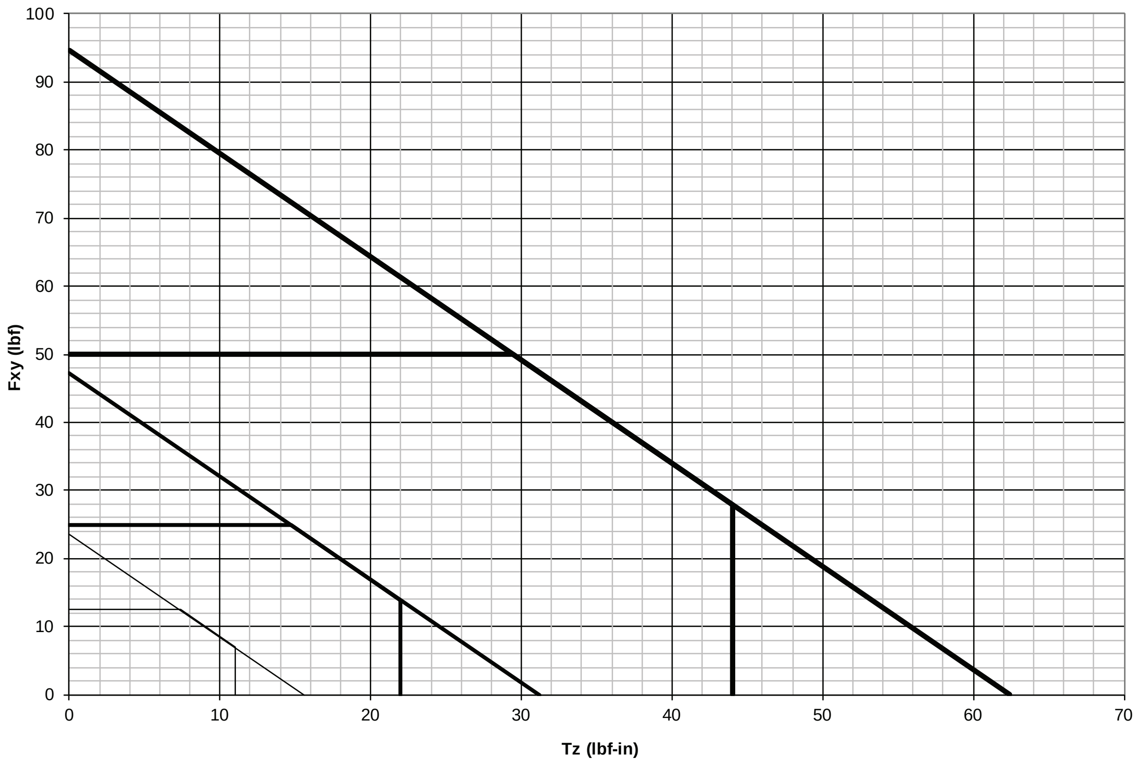
Table 5.43—Mini43LP Analog Output							
Sensor	**(US) Standard Calibration**	**Fx,Fy (lbf)**	**Fz[2] (lbf)**	**Tx,Ty,Tz (lbf-in)**	**Fx,Fy (lbf/V)**	**Fz[2] (lbf/V)**	**Tx,Ty,Tz (lbf-in/V)**
Mini43LP	US-12.5-6	±12.5	±6	±11	1.25	0.6	1.1
Mini43LP	US-25-12.5	±25	±12.5	±22	2.5	1.25	2.2
Mini43LP	US-50-25	±50	±25	±44	5	2.5	4.4
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz[2] (N)**	**Tx,Ty,Tz (Nm)**	**Fx,Fy (N/V)**	**Fz[2] (N/V)**	**Tx,Ty,Tz (Nm/V)**
Mini43LP	SI-62-0.75	±62	±0.75	±1.25	6.2	0.075	0.125
Mini43LP	SI-125-1.5	±125	±1.5	±2.5	12.5	0.15	0.25
Mini43LP	SI-250-3	±250	±3	±5	25	0.3	0.5
		Analog Output Range			**Analog ±10V Sensitivity[1]**		

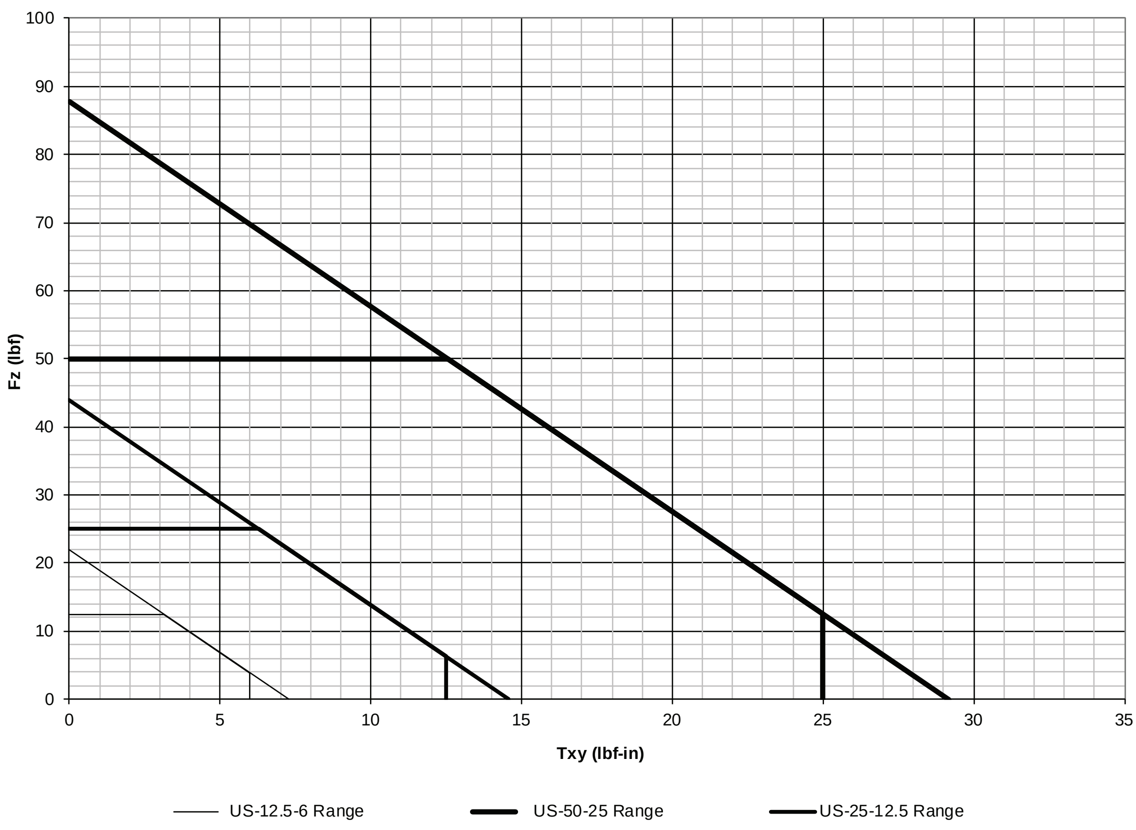
Notes:
1. ±5V Sensitivity values are double the listed ±10V Sensitivity values.

5.8.4 CTL Counts Value

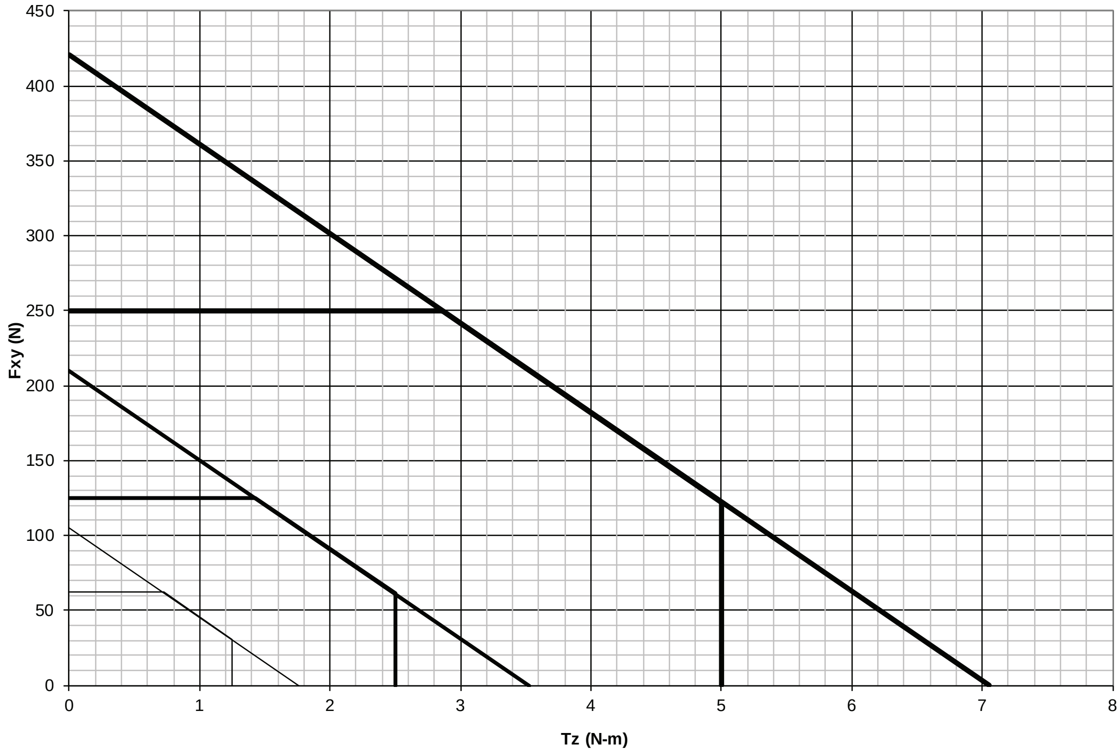
Table 5.44—Counts Value					
Sensor	**Calibration**	**Fx, Fy, Fz (/ lbf)**	**Tx, Ty, Tz (/ lbf-in)**	**Fx, Fy, Fz (/ N)**	**Tx, Ty, Tz (/ Nm)**
Mini43LP	US-12.5-6 / SI-62-0.75	3200	3680	640	32800
Mini43LP	US-25-12.5 / SI-125-1.5	1600	1840	320	16400
Mini43LP	US-50-25 / SI-250-3	800	920	160	8200
		Counts Value – Standard (US)		**Counts Value – Metric (SI)**	

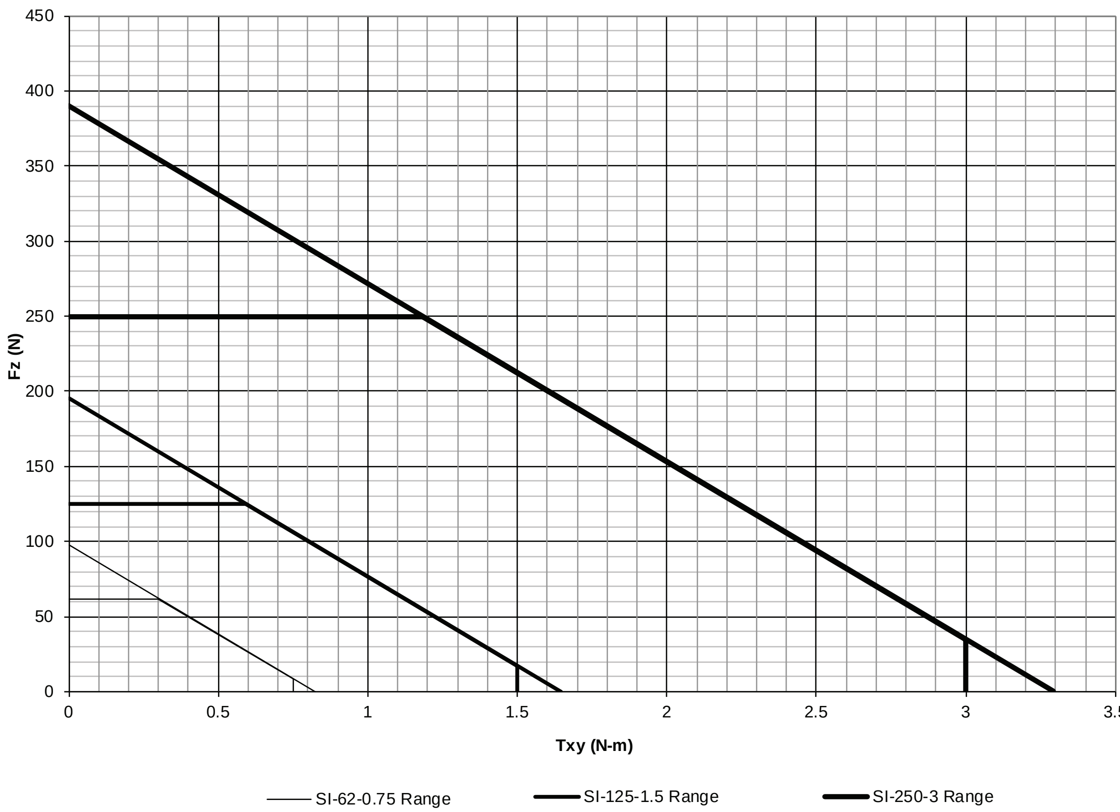
5.8.5 Mini43LP (US Calibration Complex Loading)





5.8.6 Mini43LP (SI Calibration Complex Loading)





5.9 Mini45 Titanium Specifications

In addition to the information in the following sections, refer to the ATI website:

Table 5.45—Mini45 Drawing and Web Links		
Model	**Drawing Part Number**	**ATI Website Address**
Mini45 Titanium Axial Exit	*9230-05-1440*	*https://www.ati-ia.com/products/ft/ft_models.aspx?id=Mini45+Titanium*
Mini45 Titanium Right Angle E-Exit	*9230-05-1441*	

5.9.1 Mini45 Titanium Physical Properties

Table 5.46—Mini45 Titanium Physical Properties		
Single-Axis Overload	**(US) Standard Units**	**(SI) Metric Units**
Fxy	±670 lbf	±3000 N
Fz	±1400 lbf	±6400 N
Txy	±590 inf-lb	±67 Nm
Tz	±720 inf-lb	±81 Nm
Stiffness (Calculated)		
X-axis & Y-axis forces (Kx, Ky)	$2.5x10^5$ lb/in	$4.3x10^7$ N/m
Z-axis force (Kz)	$3.3x10^5$ lb/in	$5.7x10^7$ N/m
X-axis & Y-axis torque (Ktx, Kty)	$8.6x10^4$ lbf-in/rad	$9.7x10^3$ Nm/rad
Z-axis torque (Ktz)	$1.8x10^5$ lbf-in/rad	$2.0x10^4$ Nm/rad
Resonant Frequency		
Fx, Fy, Tz	5800 Hz	5800 Hz
Fz, Tx, Ty	4600 Hz	4600 Hz
Physical Specifications		
Weight[1]	0.22 lb	0.0998 kg
Diameter[1]	1.77 in	45 mm
Height[1]	0.69 in	17.5 mm
Note: 1. Specifications include standard interface plates.		

5.9.2 Calibration Specifications (excludes CTL calibrations)

Table 5.47— Mini45 Titanium Calibrations (excludes CTL calibrations)[1, 2]

Sensor	(US) Standard Calibration	Fx,Fy (lbf)	Fz (lbf)	Tx,Ty (lbf-in)	Tz (lbf-in)	Fx,Fy (lbf)	Fz (lbf)	Tx,Ty (lbf-in)	Tz (lbf-in)
Mini45 Titanium	US-15-25	15	30	25	25	3/800	1/160	1/300	1/400
Mini45 Titanium	US-30-50	30	60	50	50	3/400	1/80	1/150	1/200
Mini45 Titanium	US-60-100	60	120	100	100	3/200	1/40	1/75	1/100
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**	**Fx,Fy (N)**	**Fz (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**
Mini45 Titanium	SI-60-3	60	120	3	3	1/60	7/240	3/8000	1/3200
Mini45 Titanium	SI-120-6	120	240	6	6	1/30	7/120	3/4000	1/1600
Mini45 Titanium	SI-240-12	240	480	12	12	1/15	7/60	3/2000	1/800
		Sensing Ranges				**Resolution (DAQ, Net F/T)[3]**			

Notes:
1. These system resolutions quoted are the effective resolution after dropping four counts of noise. The effective resolution can be improved with filtering.
2. Applied loads must be within range in each of the six axes for the F/T sensor to measure correctly.
3. DAQ resolutions are typical for a 16-bit data acquisition system.

5.9.3 CTL Calibration Specifications

Table 5.48— Mini45 Titanium CTL Calibrations[1, 2]

Sensor	(US) Standard Calibration	Fx,Fy (lbf)	Fz (lbf)	Tx,Ty (lbf-in)	Tz (lbf-in)	Fx,Fy (lbf)	Fz (lbf)	Tx,Ty (lbf-in)	Tz (lbf-in)
Mini45 Titanium	US-15-25	15	30	25	25	3/400	1/80	1/150	1/200
Mini45 Titanium	US-30-50	30	60	50	50	3/200	1/40	1/75	1/100
Mini45 Titanium	US-60-100	60	120	100	100	3/100	1/20	2/75	1/50
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**	**Fx,Fy (N)**	**Fz (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**
Mini45 Titanium	SI-60-3	60	120	3	3	1/30	7/120	3/4000	1/1600
Mini45 Titanium	SI-120-6	120	240	6	6	1/15	7/60	3/2000	1/800
Mini45 Titanium	SI-240-12	240	480	12	12	2/15	7/30	3/1000	1/400
		Sensing Ranges				**Resolution (Controller)**			

Notes:
1. CTL resolutions are typical. System resolutions quoted are the effective resolution after dropping eight counts of noise. The effective resolution can be improved with filtering.
2. Applied loads must be within range in each of the six axes for the F/T sensor to measure correctly.

5.9.4 CTL Analog Output

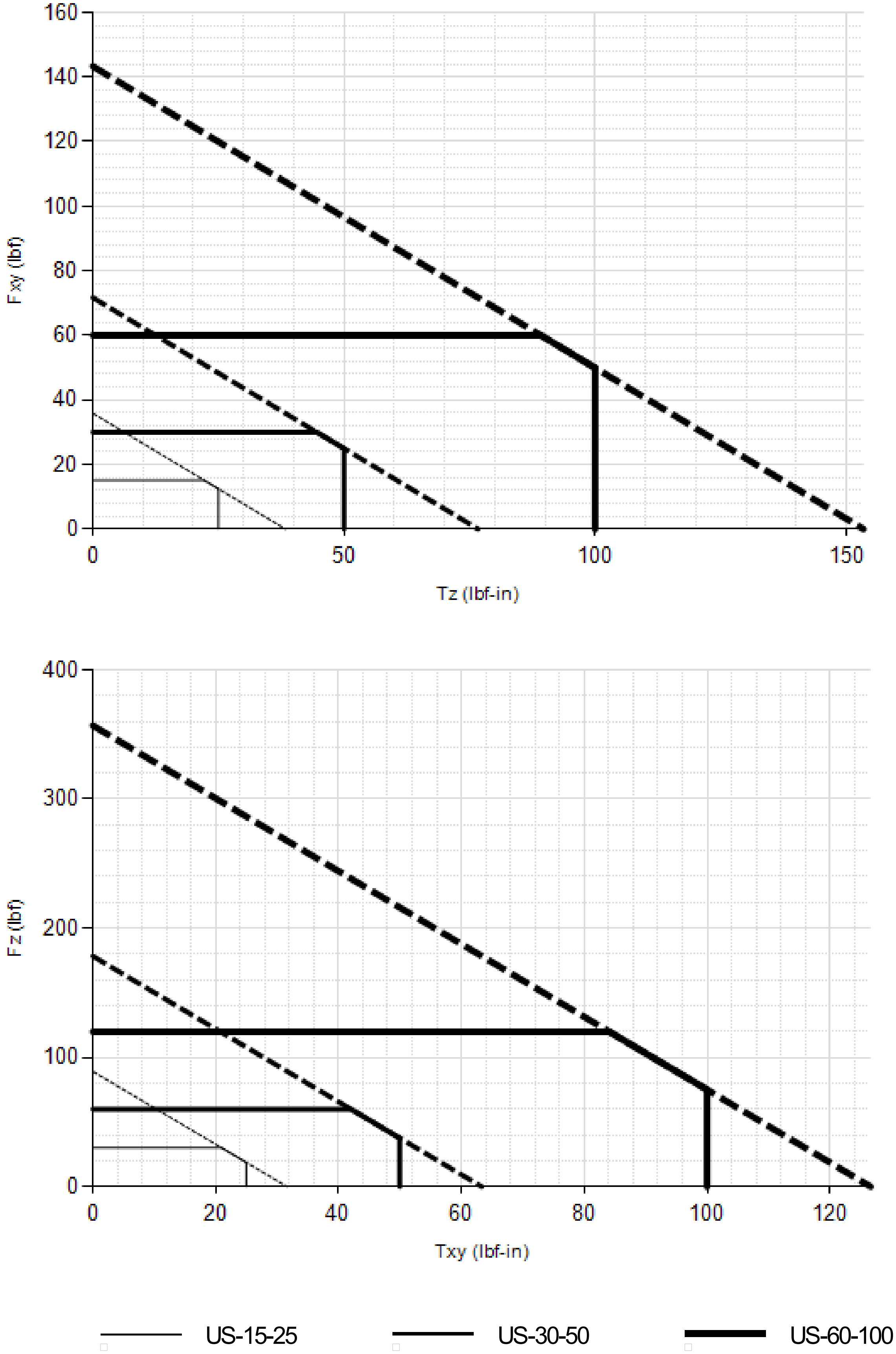
Table 5.49— Mini45 Titanium Analog Output							
Sensor	**(US) Standard Calibration**	**Fx,Fy (lbf)**	**Fz (lbf)**	**Tx,Ty,Tz (lbf-in)**	**Fx,Fy (lbf/V)**	**Fz (lbf/V)**	**Tx,Ty,Tz (lbf-in/V)**
Mini45 Titanium	US-15-25	±15	±30	±25	1.5	3	2.5
Mini45 Titanium	US-30-50	±30	±60	±50	3	6	5
Mini45 Titanium	US-60-100	±60	±120	±100	6	12	10
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz (N)**	**Tx,Ty,Tz (Nmm)**	**Fx,Fy (N/V)**	**Fz (N/V)**	**Tx,Ty,Tz (Nm/V)**
Mini45 Titanium	SI-60-3	±60	±120	±3	6	12	0.3
Mini45 Titanium	SI-120-6	±120	±240	±6	12	24	0.6
Mini45 Titanium	SI-240-12	±240	±480	±12	24	48	1.2
		Analog Output Range			**Analog ±10V Sensitivity[1]**		

Notes:
1. ±5V Sensitivity values are double the listed ±10V Sensitivity values.

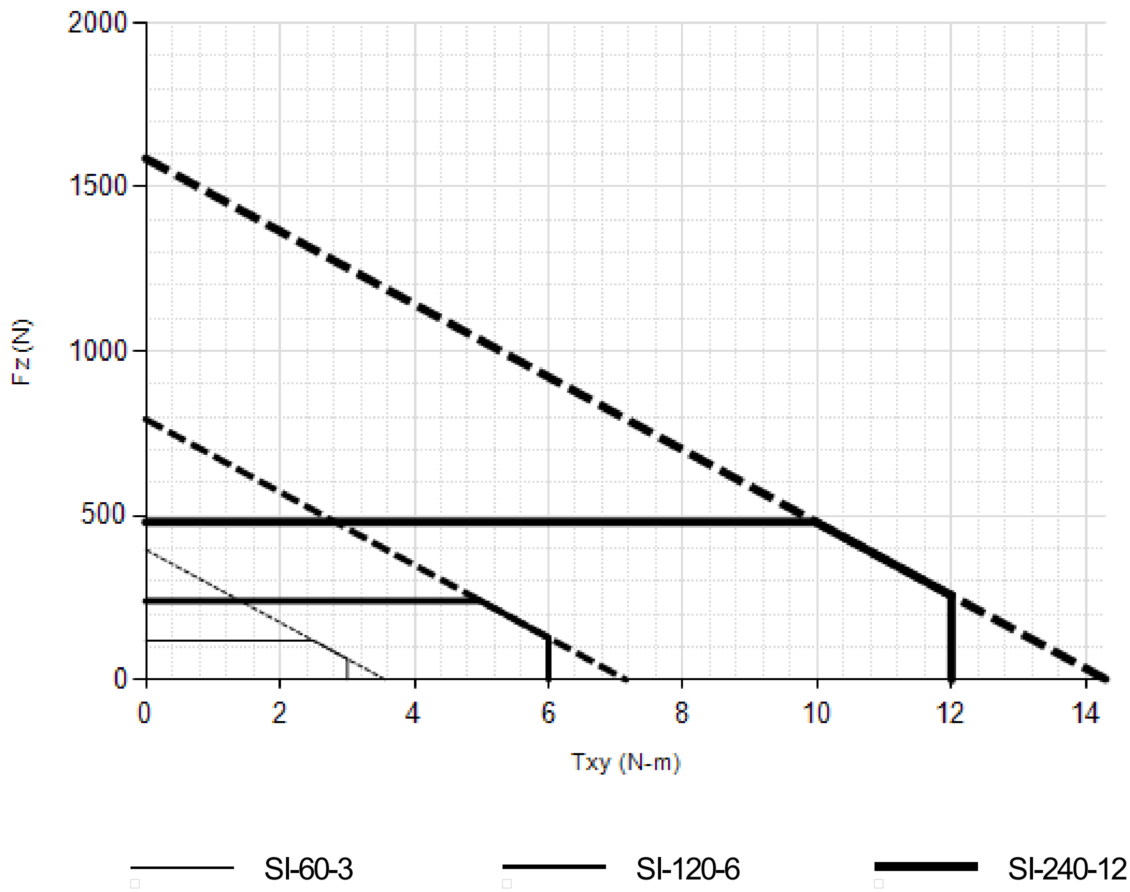
5.9.5 CTL Counts Value

Table 5.50—Counts Value					
Sensor	**Calibration**	**Fx, Fy, Fz (/ lbf)**	**Tx, Ty, Tz (/ lbf-in)**	**Fx, Fy, Fz (/ N)**	**Tx, Ty, Tz (/ Nm)**
Mini45 Titanium	US-15-25 / SI-60-3	640	704	128	6016
Mini45 Titanium	US-30-50 / SI-120-6	320	352	64	3008
Mini45 Titanium	US-60-100 / SI-240-12	160	176	32	1504
Mini45 Titanium	Tool Transform Factor	0.009091 in/lbf		0.21277 mm/N	
		Counts Value – Standard (US)		**Counts Value – Metric (SI)**	

5.9.6 Mini45 Titanium (US Calibration Complex Loading)



5.9.7 Mini45 Titanium (SI Calibration Complex Loading)



5.10 Mini45 Specifications (Includes IP65/IP68 Versions)

In addition to the information in the following sections, refer to the ATI website:

Table 5.51—Mini45 Drawing and Web Links

Model	Drawing Part Number	ATI Website Address
Mini45-A (axial exit)and Mini45-R (radial exit)	*9230-05-1094*	*https://www.ati-ia.com/products/ft/ft_models.aspx?id=Mini45*
Mini45-E	*9230-05-1315*	
Mini45-ERA	*9230-05-1338*	
Mini45-AE	*9230-05-1431*	
Mini45 IP65/IP68	*9230-05-1443*	*https://www.ati-ia.com/products/ft/ft_models.aspx?id=Mini45+IP65%2fIP68*

5.10.1 Mini45 Physical Properties

Table 5.52—Mini45 Physical Properties

Single-Axis Overload	(US) Standard Units	(SI) Metric Units
Fxy	±1100 lbf	±5100 N
Fz	±2300 lbf	±10000 N
Txy	±1000 inf-lb	±110 Nm
Tz	±1200 inf-lb	±140 Nm
Stiffness (Calculated)		
X-axis & Y-axis forces (Kx, Ky)	4.2×10^{5} lb/in	7.4×10^{7} N/m
Z-axis force (Kz)	5.6×10^{5} lb/in	9.8×10^{7} N/m
X-axis & Y-axis torque (Ktx, Kty)	1.5×10^{5} lbf-in/rad	1.7×10^{4} Nm/rad
Z-axis torque (Ktz)	3.1×10^{5} lbf-in/rad	3.5×10^{4} Nm/rad
Resonant Frequency		
Fx, Fy, Tz	5600 Hz	5600 Hz
Fz, Tx, Ty	5400 Hz	5400 Hz
Physical Specifications		
Weight[1]	0.202 lb	0.0917 kg
Diameter[1]	1.77 in	45 mm
Height[1]	0.618 in	15.7 mm
Note: 1. Specifications include standard interface plates.		

5.10.2 Mini45 IP65/IP68 Physical Properties

Table 5.53—Mini45 IP65/IP68 Physical Properties

Single-Axis Overload	**(US) Standard Units**	**(SI) Metric Units**
Fxy	±1100 lbf	±5100 N
Fz	±2300 lbf	±10000 N
Txy	±1000 inf-lb	±110 Nm
Tz	±1200 inf-lb	±140 Nm
Stiffness (Calculated)		
X-axis & Y-axis forces (Kx, Ky)	4.2x10^5 lb/in	7.4x10^7 N/m
Z-axis force (Kz)	5.6x10^5 lb/in	9.8x10^7 N/m
X-axis & Y-axis torque (Ktx, Kty)	1.5x10^5 lbf-in/rad	1.7x10^4 Nm/rad
Z-axis torque (Ktz)	3.1x10^5 lbf-in/rad	3.5x10^4 Nm/rad
Resonant Frequency		
Fx, Fy, Tz	5200 Hz	5200 Hz
Fz, Tx, Ty	4200 Hz	4200 Hz
Physical Specifications		
Weight[1]	0.861 lb	0.391 kg
Diameter[1]	2.28 in	57.9 mm
Height[1]	0.988 in	25.1 mm

Note:
1. Specifications include standard interface plates.

CAUTION: When submerged, IP68 transducers exhibit a decrease in Fz range related to the submersion depth. This loss is the result of pressure-induced preloading on the transducer. The preload can be masked by biasing the transducer at the depth prior to applying the load to be measured. The following estimates are for room temperature fresh water at sea level.

Submersion Depth

IP68 Mini45	**US**	**Metric**
Fz preload at 4 m depth	17.0 lb	75.5 N
Fz preload at other depths	-1.29 lb/ft × depthInFeet	-18.9 N/m × depthInMeters

5.10.3 Calibration Specifications (excludes CTL calibrations)

Table 5.54— Mini45 Calibrations (excludes CTL calibrations)[1, 2]

Sensor	(US) Standard Calibration	Fx,Fy (lbf)	Fz[3] (lbf)	Tx,Ty (lbf-in)	Tz (lbf-in)	Fx,Fy (lbf)	Fz[3] (lbf)	Tx,Ty (lbf-in)	Tz (lbf-in)
Mini45	US-30-40	30	60	40	40	1/80	1/80	1/88	1/176
Mini45	US-60-80	60	120	80	80	1/40	1/40	1/44	1/88
Mini45	US-120-160	120	240	160	160	1/20	1/20	1/22	1/44
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz[3] (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**	**Fx,Fy (N)**	**Fz[3] (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**
Mini45	SI-145-5	145	290	5	5	1/16	1/16	1/752	1/1504
Mini45	SI-290-10	290	580	10	10	1/8	1/8	1/376	1/752
Mini45	SI-580-20	580	1160	20	20	1/4	1/4	1/188	1/376
		Sensing Ranges				**Resolution (DAQ, Net F/T)[4]**			

Notes:
1. These system resolutions quoted are the effective resolution after dropping four counts of noise. The effective resolution can be improved with filtering.
2. Applied loads must be within range in each of the six axes for the F/T sensor to measure correctly.
3. For IP68 version see caution on physical properties page.
4. DAQ resolutions are typical for a 16-bit data acquisition system.

5.10.4 CTL Calibration Specifications

Table 5.55— Mini45 CTL Calibrations[1, 2]

Sensor	(US) Standard Calibration	Fx,Fy (lbf)	Fz[3] (lbf)	Tx,Ty (lbf-in)	Tz (lbf-in)	Fx,Fy (lbf)	Fz[3] (lbf)	Tx,Ty (lbf-in)	Tz (lbf-in)
Mini45	US-30-40	30	60	40	40	1/40	1/40	1/44	1/88
Mini45	US-60-80	60	120	80	80	1/20	1/20	1/22	1/44
Mini45	US-120-160	120	240	160	160	1/10	1/10	1/11	1/22
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz[3] (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**	**Fx,Fy (N)**	**Fz[3] (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**
Mini45	SI-145-5	145	290	5	5	1/8	1/8	1/376	1/752
Mini45	SI-290-10	290	580	10	10	1/4	1/4	1/188	1/376
Mini45	SI-580-20	580	1160	20	20	1/2	1/2	1/94	1/188
		Sensing Ranges				**Resolution (Controller)**			

Notes:
1. CTL resolutions are typical. System resolutions quoted are the effective resolution after dropping eight counts of noise. The effective resolution can be improved with filtering.
2. Applied loads must be within range in each of the six axes for the F/T sensor to measure correctly.
3. For IP68 version see caution on physical properties page.

5.10.5 CTL Analog Output

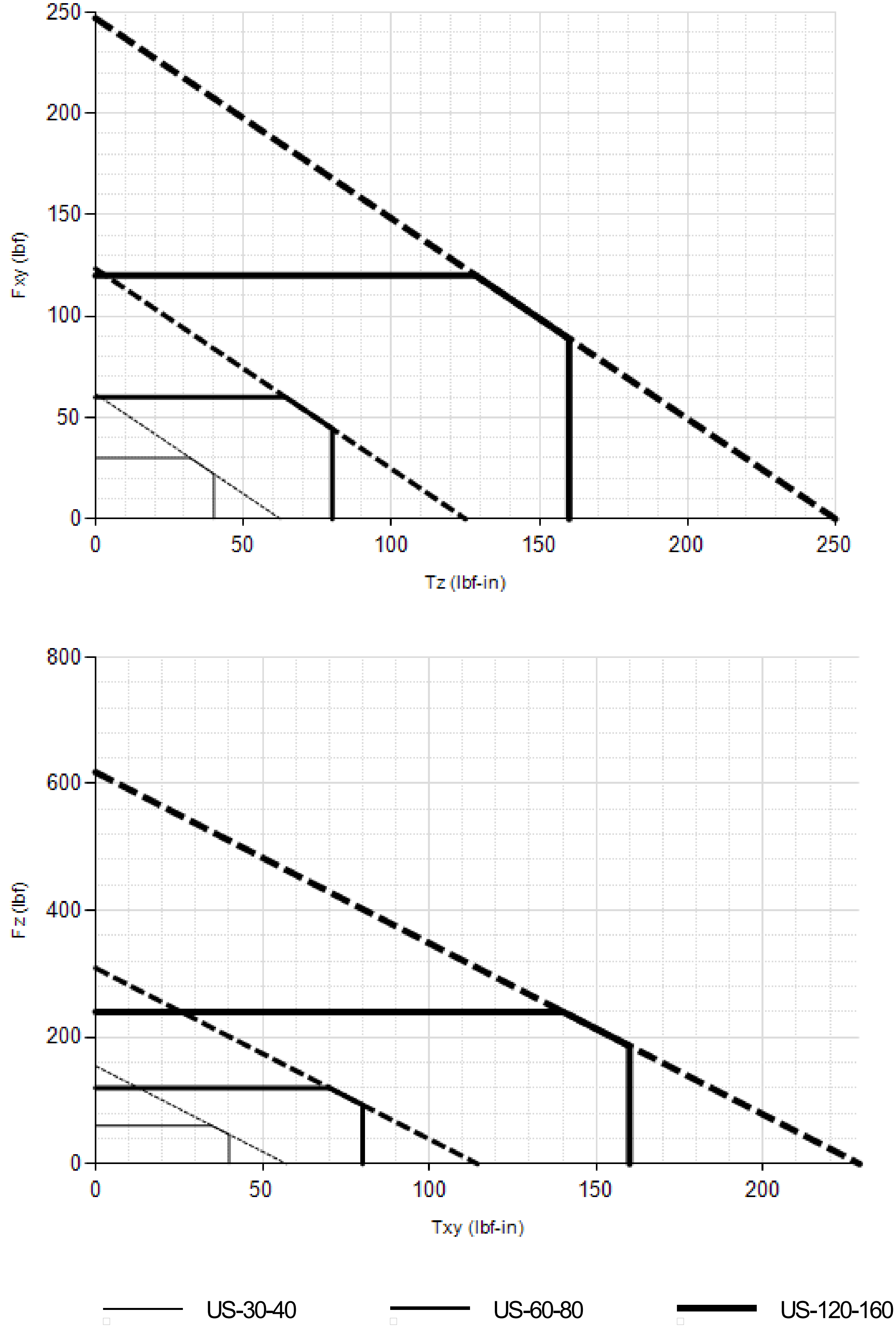
Table 5.56— Mini45 Analog Output							
Sensor	**(US) Standard Calibration**	**Fx,Fy (lbf)**	**Fz[2] (lbf)**	**Tx,Ty,Tz (lbf-in)**	**Fx,Fy (lbf/V)**	**Fz[2] (lbf/V)**	**Tx,Ty,Tz (lbf-in/V)**
Mini45	US-30-40	±30	±60	±40	3	6	4
Mini45	US-60-80	±60	±120	±80	6	12	8
Mini45	US-120-160	±120	±240	±160	12	24	16
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz[2] (N)**	**Tx,Ty,Tz (Nm)**	**Fx,Fy (N/V)**	**Fz[2] (N/V)**	**Tx,Ty,Tz (Nm/V)**
Mini45	SI-145-5	±145	±290	±5	14.5	29	0.5
Mini45	SI-290-10	±290	±580	±10	29	58	1
Mini45	SI-580-20	±580	±1160	±20	58	116	2
		Analog Output Range			**Analog ±10V Sensitivity[1]**		

Notes:
1. ±5V Sensitivity values are double the listed ±10V Sensitivity values.
2. For IP68 version see caution on physical properties page.

5.10.6 CTL Counts Value

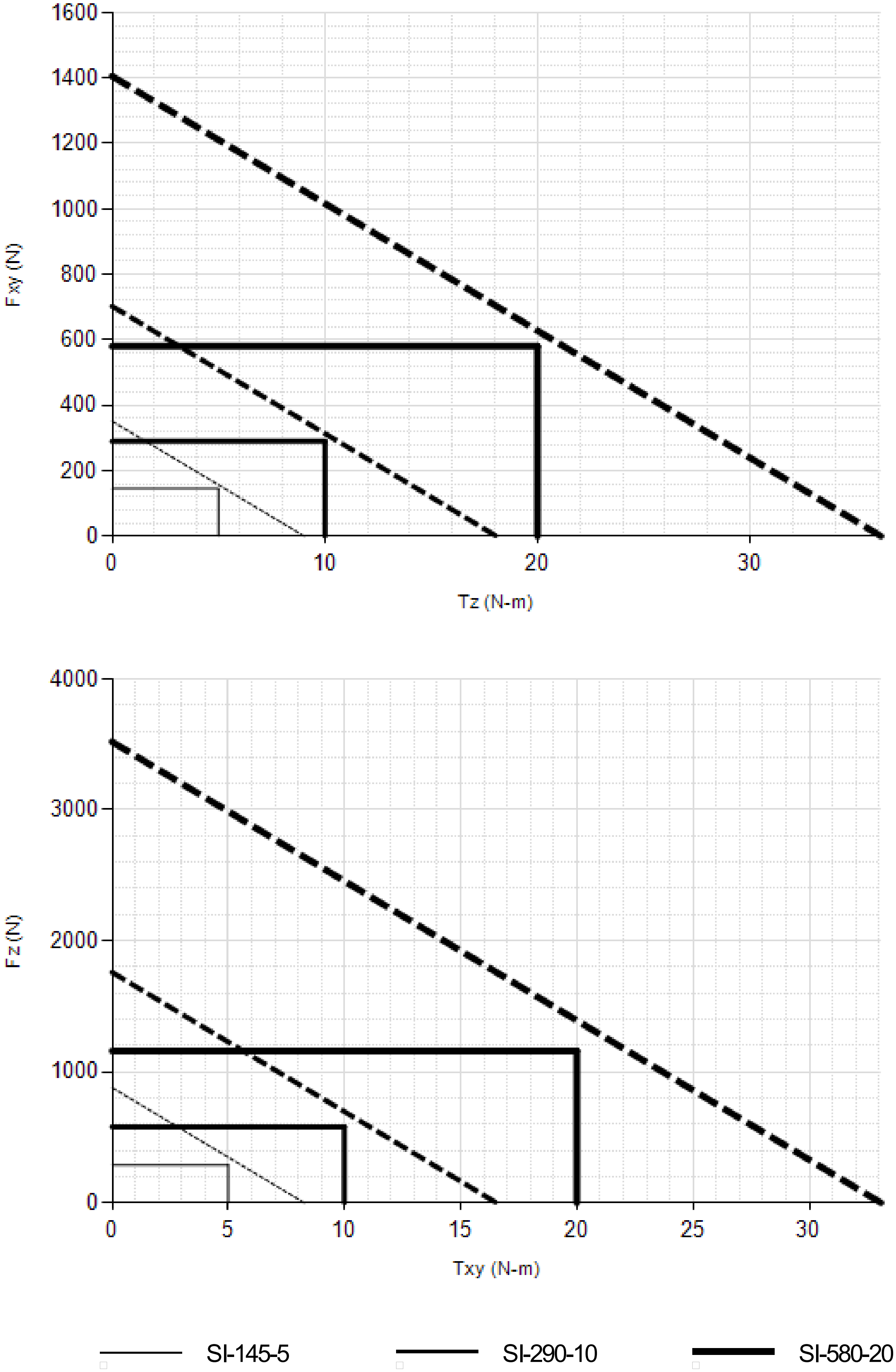
Table 5.57—Counts Value					
Sensor	**Calibration**	**Fx, Fy, Fz (/ lbf)**	**Tx, Ty, Tz (/ lbf-in)**	**Fx, Fy, Fz (/ N)**	**Tx, Ty, Tz (/ Nm)**
Mini45	US-30–40 / SI-145–5	640	704	128	6016
Mini45	US-60–80 / SI-290–10	320	352	64	3008
Mini45	US-120–160 / SI-580–20	160	176	32	1504
Mini45	Tool Transform Factor	0.009091 in/lbf		0.21277 mm/N	
		Counts Value – Standard (US)		**Counts Value – Metric (SI)**	

5.10.7 Mini45 (US Calibration Complex Loading)(Includes IP65/IP68)[1]



Note: 1. For IP68 version see caution on physical properties page.

5.10.8 Mini45 (SI Calibration Complex Loading)(Includes IP65/IP68)[1]



Note: 1. For IP68 version see caution on physical properties page.

5.11 Mini58 Specifications (Includes IP60/IP65/IP68 Versions)

In addition to the information in the following sections, refer to the ATI website:

Table 5.58—Mini58 Drawing and Web Links		
Model	**Drawing Part Number**	**ATI Website Address**
Mini58	*9230-05-1383*	*https://www.ati-ia.com/products/ft/ft_models.aspx?id=Mini58*
Mini58-ERA	*9230-05-1522*	
Mini58 IP60	*9230-05-1437*	*https://www.ati-ia.com/products/ft/ft_models.aspx?id=Mini58+IP60*
Mini58 IP65/IP68	*9230-05-1454*	*https://www.ati-ia.com/products/ft/ft_models.aspx?id=Mini58+IP65%2fIP68*

5.11.1 Mini58 Physical Properties

Table 5.59—Mini58 Physical Properties		
Single-Axis Overload	**(US) Standard Units**	**(SI) Metric Units**
Fxy	±4800 lbf	±21000 N
Fz	±11000 lbf	±48000 N
Txy	±5300 inf-lb	±590 Nm
Tz	±7100 inf-lb	±800 Nm
Stiffness (Calculated)		
X-axis & Y-axis forces (Kx, Ky)	1.4×10^6 lb/in	2.5×10^8 N/m
Z-axis force (Kz)	2.1×10^6 lb/in	3.7×10^8 N/m
X-axis & Y-axis torque (Ktx, Kty)	9.3×10^5 lbf-in/rad	1.1×10^5 Nm/rad
Z-axis torque (Ktz)	1.8×10^6 lbf-in/rad	2.0×10^5 Nm/rad
Resonant Frequency		
Fx, Fy, Tz	3000 Hz	3000 Hz
Fz, Tx, Ty	5700 Hz	5700 Hz
Physical Specifications		
Weight[1]	0.76 lb	0.345 kg
Diameter[1]	2.28 in	58 mm
Height[1]	1.18 in	30 mm
Note: 1. Specifications include standard interface plates.		

5.11.2 Mini58 IP60 Physical Properties

Table 5.60—Mini58 IP60 Physical Properties		
Single-Axis Overload	**(US) Standard Units**	**(SI) Metric Units**
Fxy	±4800 lbf	±21000 N
Fz	±11000 lbf	±48000 N
Txy	±5300 inf-lb	±590 Nm
Tz	±7100 inf-lb	±800 Nm
Stiffness (Calculated)		
X-axis & Y-axis forces (Kx, Ky)	1.4×10^6 lb/in	2.5×10^8 N/m
Z-axis force (Kz)	2.1×10^6 lb/in	3.7×10^8 N/m
X-axis & Y-axis torque (Ktx, Kty)	9.3×10^5 lbf-in/rad	1.1×10^5 Nm/rad
Z-axis torque (Ktz)	1.8×10^6 lbf-in/rad	2.0×10^5 Nm/rad
Resonant Frequency		
Fx, Fy, Tz	N/A	N/A
Fz, Tx, Ty	N/A	N/A
Physical Specifications		
Weight[1]	1.15 lb	0.522 kg
Diameter[1]	3.23 in	82 mm
Height[1]	1.42 in	36.2 mm
Note: 1. Specifications include standard interface plates.		

5.11.3 Mini58 IP65/IP68 Physical Properties

Table 5.61—Mini58 IP65/IP68 Physical Properties		
Single-Axis Overload	**(US) Standard Units**	**(SI) Metric Units**
Fxy	±4800 lbf	±21000 N
Fz	±11000 lbf	±48000 N
Txy	±5300 inf-lb	±590 Nm
Tz	±7100 inf-lb	±800 Nm
Stiffness (Calculated)		
X-axis & Y-axis forces (Kx, Ky)	1.4×10^6 lb/in	2.5×10^8 N/m
Z-axis force (Kz)	2.1×10^6 lb/in	3.7×10^8 N/m
X-axis & Y-axis torque (Ktx, Kty)	9.3×10^5 lbf-in/rad	1.1×10^5 Nm/rad
Z-axis torque (Ktz)	1.8×10^6 lbf-in/rad	2.0×10^5 Nm/rad
Resonant Frequency		
Fx, Fy, Tz	N/A	N/A
Fz, Tx, Ty	N/A	N/A
Physical Specifications		
Weight[1]	1.77 lb	0.804 kg
Diameter[1]	2.58 in	65.4 mm
Height[1]	1.48 in	37.6 mm
Note: 1. Specifications include standard interface plates.		

CAUTION: When submerged, IP68 transducers exhibit a decrease in Fz range related to the submersion depth. This loss is the result of pressure-induced preloading on the transducer. The preload can be masked by biasing the transducer at the depth prior to applying the load to be measured. The following estimates are for room temperature fresh water at sea level.

Submersion Depth		
IP68 Mini58	**US**	**Metric**
Fz preload at 4 m depth	24.3 lb	108 N
Fz preload at other depths	-1.86 lb/ft × depthInFeet	-27.1 N/m × depthInMeters

5.11.4 Calibration Specifications (excludes CTL calibrations)

Table 5.62— Mini58 Calibrations (excludes CTL calibrations)[1, 2]

Sensor	(US) Standard Calibration	Fx,Fy (lbf)	Fz[3] (lbf)	Tx,Ty (lbf-in)	Tz (lbf-in)	Fx,Fy (lbf)	Fz[3] (lbf)	Tx,Ty (lbf-in)	Tz (lbf-in)
Mini58	US-150-250	150	375	250	250	5/112	1/16	1/20	7/240
Mini58	US-300-500	300	750	500	500	5/56	1/8	1/10	7/120
Mini58	US-600-1000	600	1500	1000	1000	5/28	1/4	1/5	7/60
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz[3] (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**	**Fx,Fy (N)**	**Fz[3] (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**
Mini58	SI-700-30	700	1700	30	30	1/6	7/24	9/1600	1/320
Mini58	SI-1400-60	1400	3400	60	60	1/3	7/12	9/800	1/160
Mini58	SI-2800-120	2800	6800	120	120	3/4	1 1/4	9/400	1/80
		Sensing Ranges				**Resolution (DAQ, Net F/T)[4]**			

Notes:
1. These system resolutions quoted are the effective resolution after dropping four counts of noise. The effective resolution can be improved with filtering.
2. Applied loads must be within range in each of the six axes for the F/T sensor to measure correctly.
3. For IP68 version see caution on physical properties page.
4. DAQ resolutions are typical for a 16-bit data acquisition system.

5.11.5 CTL Calibration Specifications

Table 5.63— Mini58 CTL Calibrations[1, 2]									
Sensor	**(US) Standard Calibration**	**Fx,Fy (lbf)**	**Fz[3] (lbf)**	**Tx,Ty (lbf-in)**	**Tz (lbf-in)**	**Fx,Fy (lbf)**	**Fz[3] (lbf)**	**Tx,Ty (lbf-in)**	**Tz (lbf-in)**
Mini58	US-150-250	150	375	250	250	5/56	1/8	1/10	7/120
Mini58	US-300-500	300	750	500	500	5/28	1/4	1/5	7/60
Mini58	US-600-1000	600	1500	1000	1000	5/14	1/2	2/5	7/30
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz[3] (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**	**Fx,Fy (N)**	**Fz[3] (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**
Mini58	SI-700-30	700	1700	30	30	1/3	7/12	9/800	1/160
Mini58	SI-1400-60	1400	3400	60	60	2/3	1 1/6	9/400	1/80
Mini58	SI-2800-120	2800	6800	120	120	1 1/2	2 1/2	9/200	1/40
		Sensing Ranges				**Resolution (Controller)**			

Notes:
1. CTL resolutions are typical. System resolutions quoted are the effective resolution after dropping eight counts of noise. The effective resolution can be improved with filtering.
2. Applied loads must be within range in each of the six axes for the F/T sensor to measure correctly.
3. For IP68 version see caution on physical properties page.

5.11.6 CTL Analog Output

Table 5.64— Mini58 Analog Output							
Sensor	**(US) Standard Calibration**	**Fx,Fy (lbf)**	**Fz[2] (lbf)**	**Tx,Ty,Tz (lbf-in)**	**Fx,Fy (lbf/V)**	**Fz[2] (lbf/V)**	**Tx,Ty,Tz (lbf-in/V)**
Mini58	US-150-250	±150	±375	±250	15	37.5	25
Mini58	US-300-500	±300	±750	±500	30	75	50
Mini58	US-600-1000	±600	±1500	±1000	60	150	100
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz[2] (N)**	**Tx,Ty,Tz (Nm)**	**Fx,Fy (N/V)**	**Fz[2] (N/V)**	**Tx,Ty,Tz (Nm/V)**
Mini58	SI-700-30	±700	±1700	±30	70	170	3
Mini58	SI-1400-60	±1400	±3400	±60	140	340	6
Mini58	SI-2800-120	±2800	±6800	±120	280	680	12
		Analog Output Range			**Analog ±10V Sensitivity[1]**		

Notes:
1. ±5V Sensitivity values are double the listed ±10V Sensitivity values.
2. For IP68 version see caution on physical properties page.

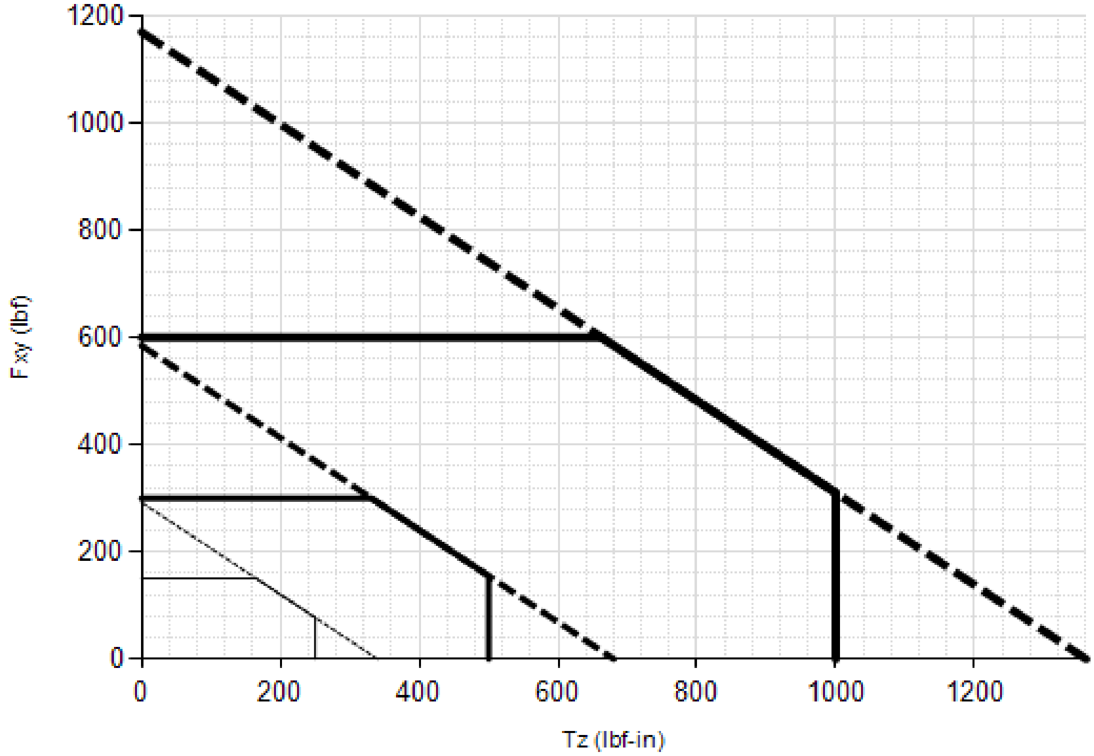
5.11.7 CTL Counts Value

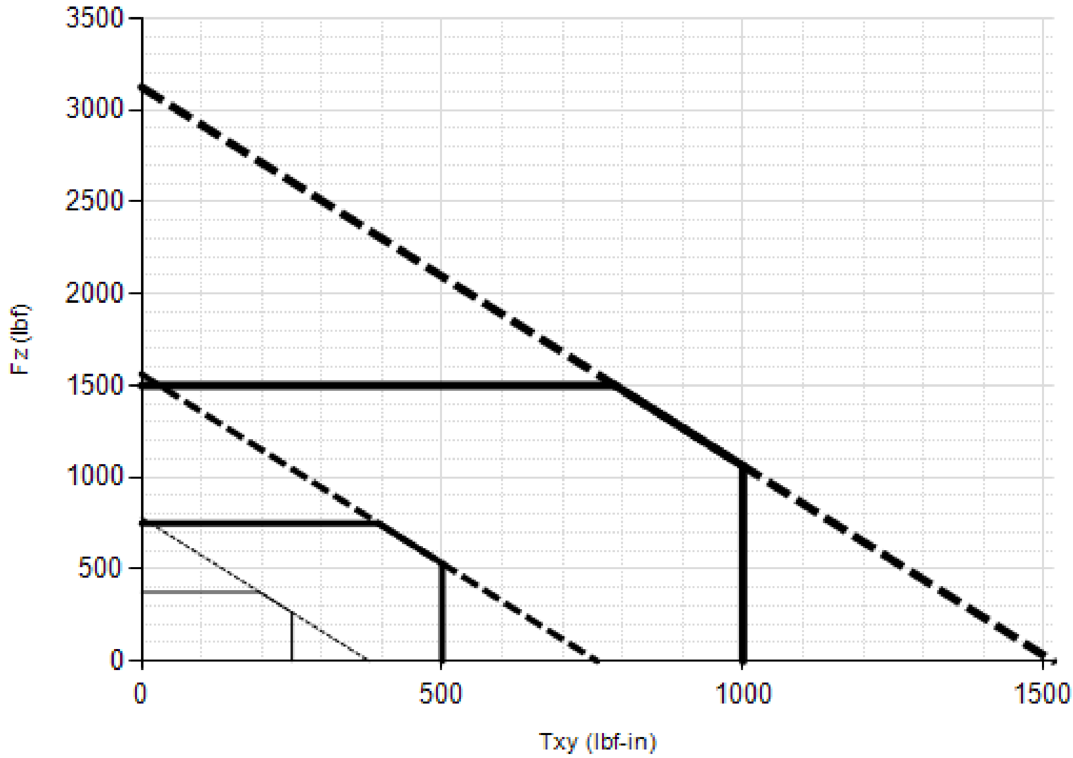
Table 5.65—Counts Value					
Sensor	**Calibration**	**Fx, Fy, Fz (/ lbf)**	**Tx, Ty, Tz (/ lbf-in)**	**Fx, Fy, Fz (/ N)**	**Tx, Ty, Tz (/ Nm)**
Mini58	US-150-250 / SI-700-30	448	960	96	6400
Mini58	US-300-500 / SI-1400-60	224	480	48	3200
Mini58	US-600-1000 / SI-2800-120	112	240	16	1600
Mini58	Tool Transform Factor	See Tool Transform Factor table			
		Counts Value – Standard (US)		**Counts Value – Metric (SI)**	

5.11.8 Tool Transform Factor

Table 5.66—Tool Transform Factor			
Sensor	**Calibration**	**US (English)**	SI (Metric)
Mini58	US-150-250 / SI-700-30	0.00467 in/lbf	0.150 mm/N
Mini58	US-300-500 / SI-1400-60	0.00467 in/lbf	0.150 mm/N
Mini58	US-600-1000 / SI-2800-120	0.00467 in/lbf	0.150 mm/N

5.11.9 Mini58 (US Calibration Complex Loading)(Includes IP60/IP65/IP68)[1]

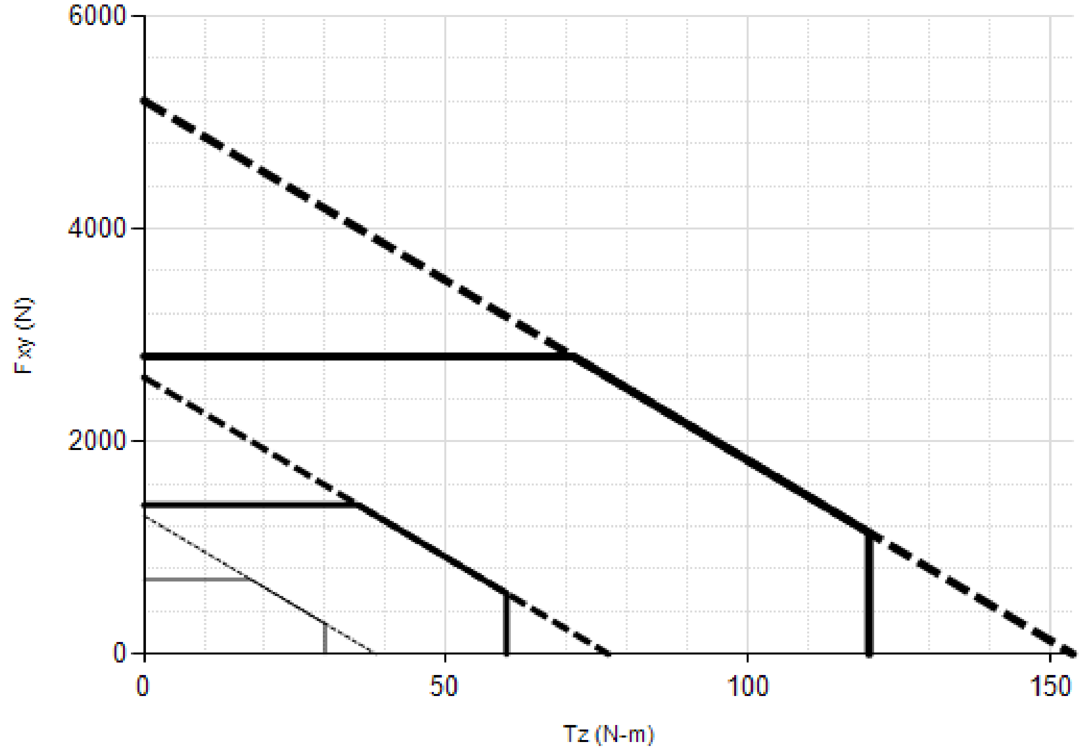


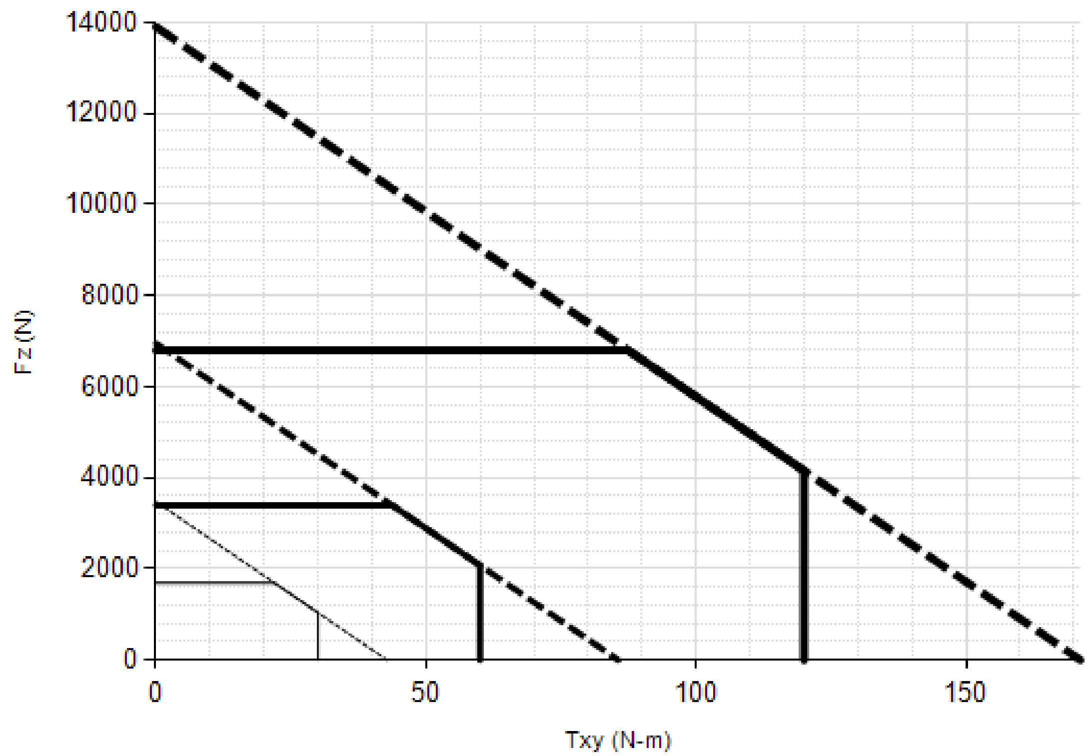


US-150-250 US-300-500 US-600-1000

Note: 1. For IP68 version see caution on physical properties page.

5.11.10 Mini58 (SI Calibration Complex Loading)(Includes IP60/IP65/IP68)[1]





SI-700-30 SI-1400-60 SI-2800-120

Note: 1. For IP68 version see caution on physical properties page.

5.12 Mini85 Specifications

In addition to the information in the following sections, refer to the ATI website:

Table 5.67—Mini85 Drawing and Web Links		
Model	**Drawing Part Number**	**ATI Website Address**
Mini85	*9230-05-1383*	*https://www.ati-ia.com/products/ft/ft_models.aspx?id=Mini85*
Mini85 with 20 mm through hole	*9230-05-1323*	

5.12.1 Mini85 Physical Properties

Table 5.68—Mini85 Physical Properties		
Single-Axis Overload	**(US) Standard Units**	**(SI) Metric Units**
Fxy	±2800 lbf	±13000 N
Fz	±6100 lbf	±27000 N
Txy	±4400 inf-lb	±500 Nm
Tz	±5400 inf-lb	±610 Nm
Stiffness (Calculated)		
X-axis & Y-axis forces (Kx, Ky)	$4.4x10^5$ lb/in	$7.7x10^7$ N/m
Z-axis force (Kz)	$6.8x10^5$ lb/in	$1.2x10^8$ N/m
X-axis & Y-axis torque (Ktx, Kty)	$7.2x10^5$ lbf-in/rad	$8.1x10^4$ Nm/rad
Z-axis torque (Ktz)	$1.2x10^6$ lbf-in/rad	$1.3x10^5$ Nm/rad
Resonant Frequency		
Fx, Fy, Tz	2400 Hz	2400 Hz
Fz, Tx, Ty	3100 Hz	3100 Hz
Physical Specifications		
Weight[1]	1.4 lb	0.635 kg
Diameter[1]	3.35 in	85.1 mm
Height[1]	1.17 in	29.8 mm
Note: 1. Specifications include standard interface plates.		

5.12.2 Calibration Specifications (excludes CTL calibrations)

Table 5.69— Mini85 Calibrations (excludes CTL calibrations)[1, 2]									
Sensor	**(US) Standard Calibration**	**Fx,Fy (lbf)**	**Fz (lbf)**	**Tx,Ty (lbf-in)**	**Tz (lbf-in)**	**Fx,Fy (lbf)**	**Fz (lbf)**	**Tx,Ty (lbf-in)**	**Tz (lbf-in)**
Mini85	US-105-185	105	210	185	185	1/52	7/260	5/168	1/48
Mini85	US-210-370	210	420	370	370	5/128	3/64	5/84	1/24
Mini85	US-420-740	420	840	740	740	5/64	3/32	5/42	1/12
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**	**Fx,Fy (N)**	**Fz (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**
Mini85	SI-475-20	475	950	20	20	9/112	3/28	5/1496	7/2992
Mini85	SI-950-40	950	1900	40	40	9/56	3/14	5/748	7/1496
Mini85	SI-1900-80	1900	3800	80	80	9/28	3/7	5/374	7/748
		Sensing Ranges				**Resolution (DAQ, Net F/T)[3]**			

Notes:
1. These system resolutions quoted are the effective resolution after dropping four counts of noise. The effective resolution can be improved with filtering.
2. Applied loads must be within range in each of the six axes for the F/T sensor to measure correctly.
3. DAQ resolutions are typical for a 16-bit data acquisition system.

5.12.3 CTL Calibration Specifications

Table 5.70— Mini85 CTL Calibrations[1, 2]									
Sensor	**(US) Standard Calibration**	**Fx,Fy (lbf)**	**Fz (lbf)**	**Tx,Ty (lbf-in)**	**Tz (lbf-in)**	**Fx,Fy (lbf)**	**Fz (lbf)**	**Tx,Ty (lbf-in)**	**Tz (lbf-in)**
Mini85	US-105-185	105	210	185	185	1/26	7/130	5/84	1/24
Mini85	US-210-370	210	420	370	370	5/64	3/32	5/42	1/12
Mini85	US-420-740	420	840	740	740	5/32	3/16	5/21	1/6
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**	**Fx,Fy (N)**	**Fz (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**
Mini85	SI-475-20	475	950	20	20	9/56	3/14	5/748	7/1496
Mini85	SI-950-40	950	1900	40	40	9/28	3/7	5/374	7/748
Mini85	SI-1900-80	1900	3800	80	80	9/14	6/7	5/187	7/374
		Sensing Ranges				**Resolution (Controller)**			

Notes:
1. CTL resolutions are typical. System resolutions quoted are the effective resolution after dropping eight counts of noise. The effective resolution can be improved with filtering.
2. Applied loads must be within range in each of the six axes for the F/T sensor to measure correctly.

5.12.4 CTL Analog Output

Table 5.71— Mini85 Analog Output							
Sensor	**(US) Standard Calibration**	**Fx,Fy (lbf)**	**Fz (lbf)**	**Tx,Ty,Tz (lbf-in)**	**Fx,Fy (lbf/V)**	**Fz (lbf/V)**	**Tx,Ty,Tz (lbf-in/V)**
Mini85	US-105-185	±105	±210	±185	10.5	21	18.5
Mini85	US-210-370	±210	±420	±370	21	42	37
Mini85	US-420-740	±420	±840	±740	42	84	74
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz (N)**	**Tx,Ty,Tz (Nm)**	**Fx,Fy (N/V)**	**Fz (N/V)**	**Tx,Ty,Tz (Nm/V)**
Mini85	SI-475-20	±475	±950	±20	47.5	95	2
Mini85	SI-950-40	±950	±1900	±40	95	190	4
Mini85	SI-1900-80	±1900	±3800	±80	190	380	8
		Analog Output Range			**Analog ±10V Sensitivity**[1]		

Notes:
1. ±5V Sensitivity values are double the listed ±10V Sensitivity values.

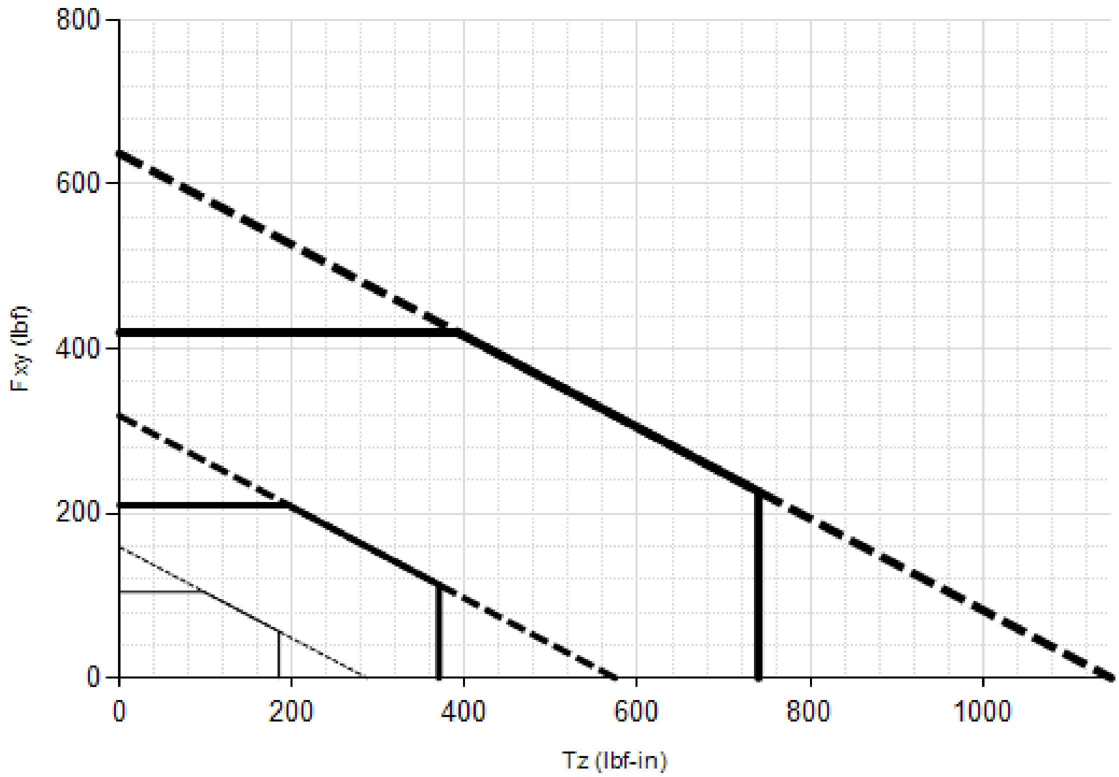
5.12.5 CTL Counts Value

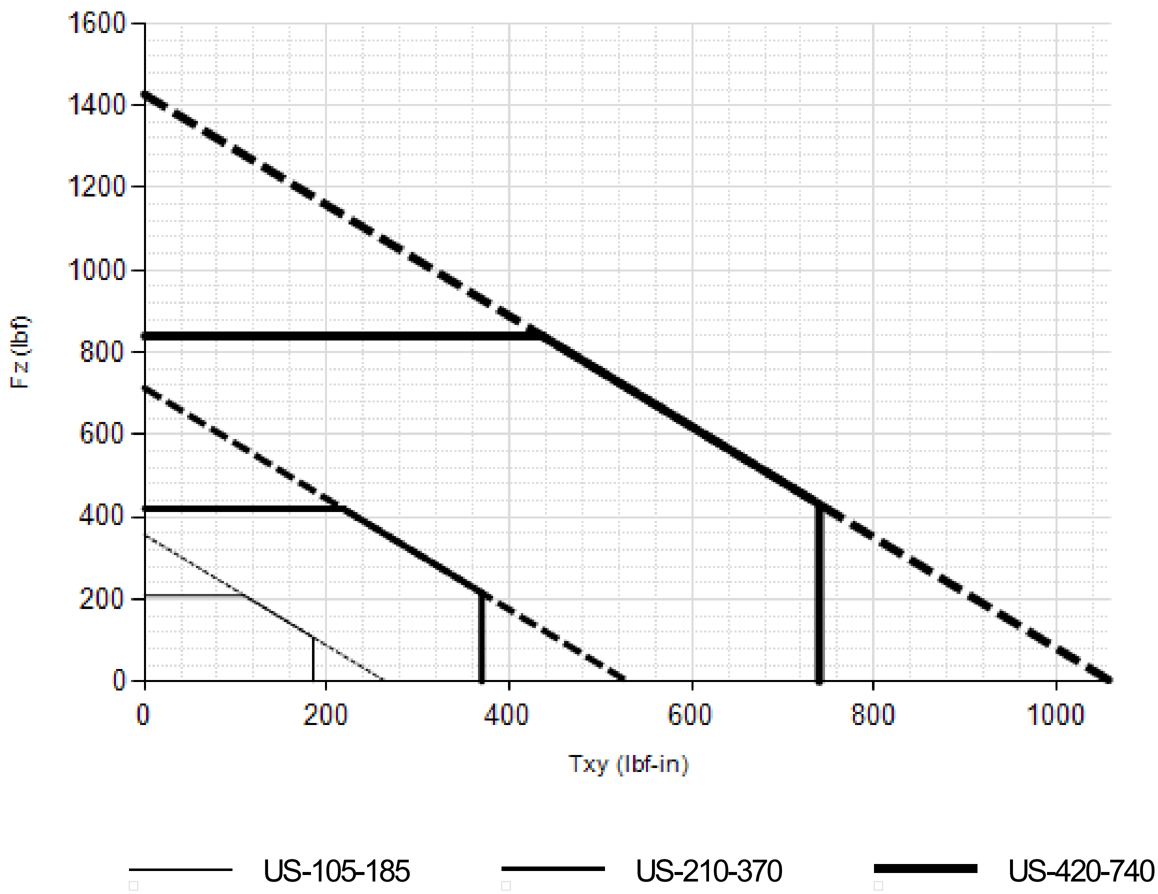
Table 5.72—Counts Value					
Sensor	**Calibration**	**Fx, Fy, Fz (/ lbf)**	**Tx, Ty, Tz (/ lbf-in)**	**Fx, Fy, Fz (/ N)**	**Tx, Ty, Tz (/ Nm)**
Mini85	US-105-185 / SI-475-20	1040	1344	448	11968
Mini85	US-210-370 / SI-950-40	512	672	224	5984
Mini85	US-420-740 / SI-1900-80	256	336	112	2992
Mini85	Tool Transform Factor	See Tool Transform Factor table			
		Counts Value – Standard (US)		**Counts Value – Metric (SI)**	

5.12.6 Tool Transform Factor

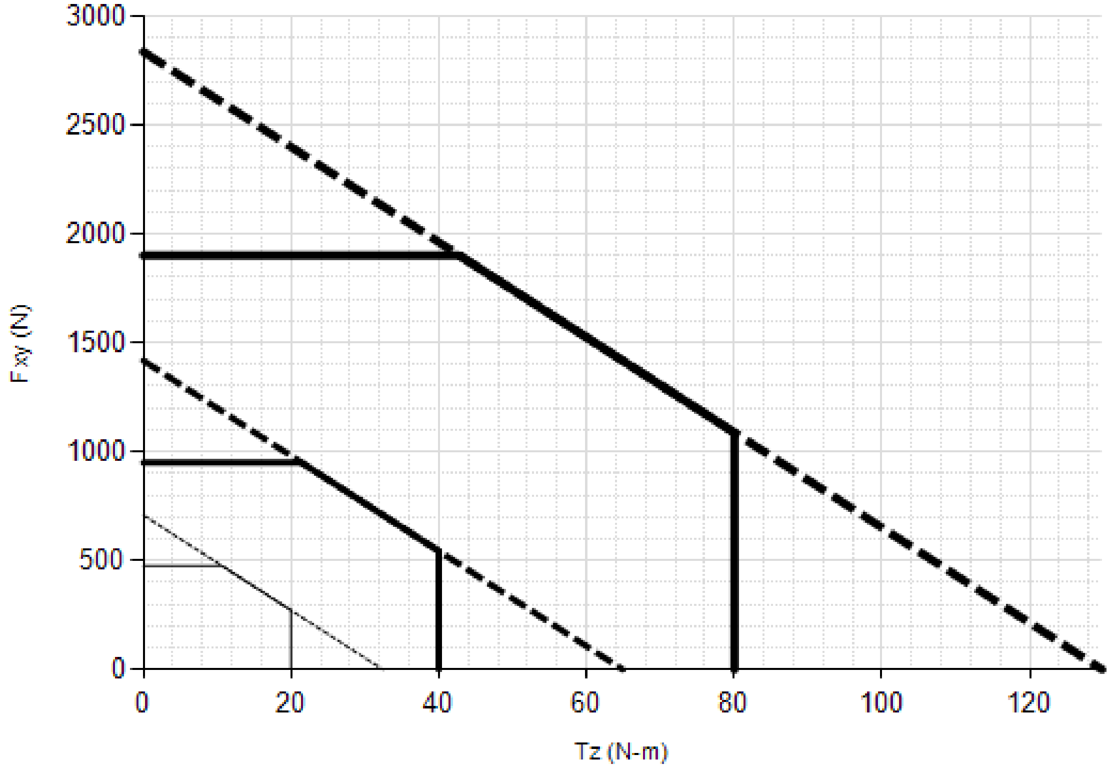
Table 5.73—Tool Transform Factor			
Sensor	**Calibration**	**US (English)**	SI (Metric)
Mini85	US-105-185 / SI-475-20	0.00774 in/lbf	0.374 mm/N
Mini85	US-210-370 / SI-950-40	0.00762 in/lbf	0.374 mm/N
Mini85	US-420-740 / SI-1900-80	0.00762 in/lbf	0.374 mm/N

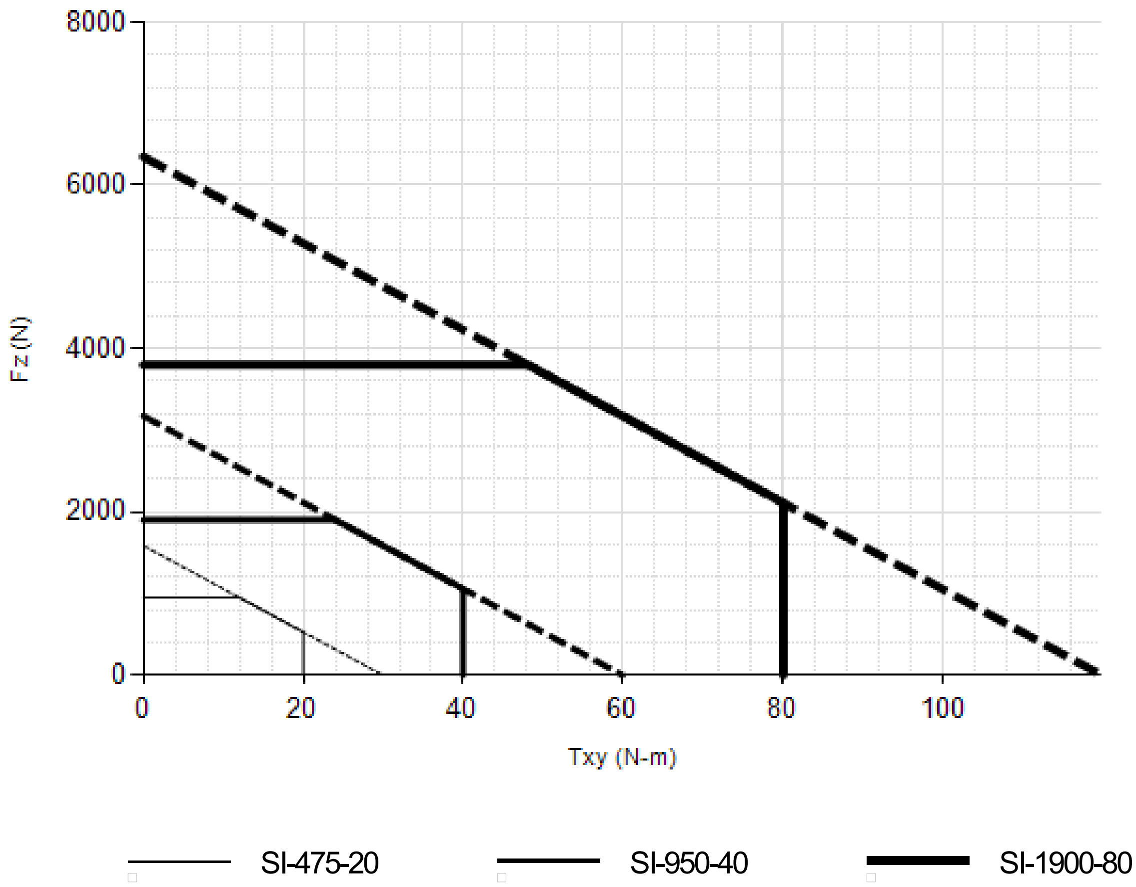
5.12.7 Mini85 (US Calibration Complex Loading)(Includes IP60)





5.12.8 Mini85 (SI Calibration Complex Loading)(Includes IP60)





5.13 Gamma Specifications (Includes IP60/IP65/IP68 Versions)

In addition to the information in the following sections, refer to the ATI website:

Table 5.74—Gamma Drawing and Web Links		
Model	**Drawing Part Number**	**ATI Website Address**
Gamma Mux[1] transducer without standard mounting adapter	*9230-05-1103*	*https://www.ati-ia.com/products/ft/ft_models.aspx?id=Gamma*
Gamma DAQ/NET transducer with mounting adapter plate	*9230-05-1329*	
Gamma adapter mounting plate (non-IP rated)	*9230-05-1057*	
Gamma IP60	*9230-05-1335*	*https://www.ati-ia.com/products/ft/ft_models.aspx?id=Gamma+IP60*
Gamma IP65	*9230-05-1307*	*https://www.ati-ia.com/products/ft/ft_models.aspx?id=Gamma+IP65*
Gamma IP65 ECAT	*9230-05-1508*	
Gamma IP68	*9230-05-1386*	*https://www.ati-ia.com/products/ft/ft_models.aspx?id=Gamma+IP68*
Note: 1. Mux transducers are used in F/T Controller systems.		

5.13.1 Gamma Physical Properties

Table 5.75—Gamma Physical Properties		
Single-Axis Overload	**(US) Standard Units**	**(SI) Metric Units**
Fxy	±280 lbf	±1200 N
Fz	±930 lbf	±4100 N
Txy	±700 inf-lb	±79 Nm
Tz	±730 inf-lb	±82 Nm
Stiffness (Calculated)		
X-axis & Y-axis forces (Kx, Ky)	5.2×10^4 lb/in	9.1×10^6 N/m
Z-axis force (Kz)	1.0×10^5 lb/in	1.8×10^7 N/m
X-axis & Y-axis torque (Ktx, Kty)	9.3×10^4 lbf-in/rad	1.1×10^4 Nm/rad
Z-axis torque (Ktz)	1.4×10^5 lbf-in/rad	1.6×10^4 Nm/rad
Resonant Frequency		
Fx, Fy, Tz	1400 Hz	1400 Hz
Fz, Tx, Ty	2000 Hz	2000 Hz
Physical Specifications		
Weight[1]	0.562 lb	0.255 kg
Diameter[1]	2.97 in	75.4 mm
Height[1]	1.31 in	33.3 mm
Note: 1. Specifications include standard interface plates.		

5.13.2 Gamma IP60 Physical Properties

Table 5.76—Gamma IP60 Physical Properties		
Single-Axis Overload	**(US) Standard Units**	**(SI) Metric Units**
Fxy	±280 lbf	±1200 N
Fz	±930 lbf	±4100 N
Txy	±700 inf-lb	±79 Nm
Tz	±730 inf-lb	±82 Nm
Stiffness (Calculated)		
X-axis & Y-axis forces (Kx, Ky)	$5.2x10^{4}$ lb/in	$9.1x10^{6}$ N/m
Z-axis force (Kz)	$1.0x10^{5}$ lb/in	$1.8x10^{7}$ N/m
X-axis & Y-axis torque (Ktx, Kty)	$9.3x10^{4}$ lbf-in/rad	$1.1x10^{4}$ Nm/rad
Z-axis torque (Ktz)	$1.4x10^{5}$ lbf-in/rad	$1.6x10^{4}$ Nm/rad
Resonant Frequency		
Fx, Fy, Tz	1200 Hz	1200 Hz
Fz, Tx, Ty	1200 Hz	1200 Hz
Physical Specifications		
Weight[1]	1.03 lb	0.467 kg
Diameter[1]	3.9 in	99.1 mm
Height[1]	1.56 in	39.6 mm
Note: 1. Specifications include standard interface plates.		

5.13.3 Gamma IP65 Physical Properties

Table 5.77—Gamma IP65 Physical Properties		
Single-Axis Overload	**(US) Standard Units**	**(SI) Metric Units**
Fxy	±280 lbf	±1200 N
Fz	±930 lbf	±4100 N
Txy	±700 inf-lb	±79 Nm
Tz	±730 inf-lb	±82 Nm
Stiffness (Calculated)		
X-axis & Y-axis forces (Kx, Ky)	$5.2x10^{4}$ lb/in	$9.1x10^{6}$ N/m
Z-axis force (Kz)	$1.0x10^{5}$ lb/in	$1.8x10^{7}$ N/m
X-axis & Y-axis torque (Ktx, Kty)	$9.3x10^{4}$ lbf-in/rad	$1.1x10^{4}$ Nm/rad
Z-axis torque (Ktz)	$1.4x10^{5}$ lbf-in/rad	$1.6x10^{4}$ Nm/rad
Resonant Frequency		
Fx, Fy, Tz	1000 Hz	1000 Hz
Fz, Tx, Ty	970 Hz	970 Hz
Physical Specifications		
Weight[1]	2.4 lb	1.09 kg
Diameter[1]	4.37 in	111 mm
Height[1]	2.06 in	52.3 mm
Note: 1. Specifications include standard interface plates.		

5.13.4 Gamma IP68 Physical Properties

Table 5.78—Gamma IP68 Physical Properties		
Single-Axis Overload	**(US) Standard Units**	**(SI) Metric Units**
Fxy	±280 lbf	±1200 N
Fz	±930 lbf	±4100 N
Txy	±700 inf-lb	±79 Nm
Tz	±730 inf-lb	±82 Nm
Stiffness (Calculated)		
X-axis & Y-axis forces (Kx, Ky)	$5.2x10^{4}$ lb/in	$9.1x10^{6}$ N/m
Z-axis force (Kz)	$1.0x10^{5}$ lb/in	$1.8x10^{7}$ N/m
X-axis & Y-axis torque (Ktx, Kty)	$9.3x10^{4}$ lbf-in/rad	$1.1x10^{4}$ Nm/rad
Z-axis torque (Ktz)	$1.4x10^{5}$ lbf-in/rad	$1.6x10^{4}$ Nm/rad
Resonant Frequency		
Fx, Fy, Tz	1250 Hz	1250 Hz
Fz, Tx, Ty	940 Hz	940 Hz
Physical Specifications		
Weight[1]	4.37 lb	1.98 kg
Diameter[1]	4.37 in	111 mm
Height[1]	2.06 in	52.3 mm
Note: 1. Specifications include standard interface plates.		

CAUTION: When submerged, IP68 transducers exhibit a decrease in Fz range related to the submersion depth. This loss is the result of pressure-induced preloading on the transducer. The preload can be masked by biasing the transducer at the depth prior to applying the load to be measured. The following estimates are for room temperature fresh water at sea level.

Submersion Depth		
IP68 Gamma	**US**	**Metric**
Fz preload at 4 m depth	-42.9 lb	-191 N
Fz preload at other depths	-3.27 lb/ft × depthInFeet	-47.4 N/m × depthInMeters

5.13.5 Calibration Specifications (excludes CTL calibrations)

Table 5.79— Gamma Calibrations (excludes CTL calibrations)[1, 2]									
Sensor	**(US) Standard Calibration**	**Fx,Fy (lbf)**	**Fz[3] (lbf)**	**Tx,Ty (lbf-in)**	**Tz (lbf-in)**	**Fx,Fy (lbf)**	**Fz[3] (lbf)**	**Tx,Ty (lbf-in)**	**Tz (lbf-in)**
Gamma	US-7.5-25	7.5	25	25	25	1/640	1/320	1/320	1/320
Gamma	US-15-50	15	50	50	50	1/320	1/160	1/160	1/160
Gamma	US-30-100	30	100	100	100	1/160	1/80	1/80	1/80
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz[3] (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**	**Fx,Fy (N)**	**Fz[3] (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**
Gamma	SI-32-2.5	32	100	2.5	2.5	1/160	1/80	1/2000	1/2000
Gamma	SI-65-5	65	200	5	5	1/80	1/40	10/13333	10/13333
Gamma	SI-130-10	130	400	10	10	1/40	1/20	1/800	1/800
		Sensing Ranges				**Resolution (DAQ, Net F/T)[4]**			

Notes:
1. These system resolutions quoted are the effective resolution after dropping four counts of noise. The effective resolution can be improved with filtering.
2. Applied loads must be within range in each of the six axes for the F/T sensor to measure correctly.
3. For IP68 version see caution on physical properties page.
4. DAQ resolutions are typical for a 16-bit data acquisition system.

5.13.6 CTL Calibration Specifications

Table 5.80— Gamma CTL Calibrations[1, 2]									
Sensor	**(US) Standard Calibration**	**Fx,Fy (lbf)**	**Fz[3] (lbf)**	**Tx,Ty (lbf-in)**	**Tz (lbf-in)**	**Fx,Fy (lbf)**	**Fz[3] (lbf)**	**Tx,Ty (lbf-in)**	**Tz (lbf-in)**
Gamma	US-7.5-25	7.5	25	25	25	1/320	1/160	1/160	1/160
Gamma	US-15-50	15	50	50	50	1/160	1/80	1/80	1/80
Gamma	US-30-100	30	100	100	100	1/80	1/40	1/40	1/40
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz[3] (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**	**Fx,Fy (N)**	**Fz[3] (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**
Gamma	SI-32-2.5	32	100	2.5	2.5	1/80	1/40	1/1000	1/1000
Gamma	SI-65-5	65	200	5	5	1/40	1/20	5/3333	5/3333
Gamma	SI-130-10	130	400	10	10	1/20	1/10	1/400	1/400
		Sensing Ranges				**Resolution (Controller)**			

Notes:
1. CTL resolutions are typical. System resolutions quoted are the effective resolution after dropping eight counts of noise. The effective resolution can be improved with filtering.
2. Applied loads must be within range in each of the six axes for the F/T sensor to measure correctly.
3. For IP68 version see caution on physical properties page.

5.13.7 CTL Analog Output

Table 5.81— Gamma Analog Output							
Sensor	**(US) Standard Calibration**	**Fx,Fy (lbf)**	**Fz[2] (lbf)**	**Tx,Ty,Tz (lbf-in)**	**Fx,Fy (lbf/V)**	**Fz[2] (lbf/V)**	**Tx,Ty,Tz (lbf-in/V)**
Gamma	US-7.5-25	±7.5	±25	±25	0.75	2.5	2.5
Gamma	US-15-50	±15	±50	±50	1.5	5	5
Gamma	US-30-100	±30	±100	±100	3	10	10
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz[2] (N)**	**Tx,Ty,Tz (Nm)**	**Fx,Fy (N/V)**	**Fz[2] (N/V)**	**Tx,Ty,Tz (Nm/V)**
Gamma	SI-32-2.5	±32	±100	±2.5	3.2	10	0.25
Gamma	SI-65-5	±65	±200	±5	6.5	20	0.5
Gamma	SI-130-10	±130	±400	±10	13	40	1
		Analog Output Range			**Analog ±10V Sensitivity[1]**		

Notes:
1. ±5V Sensitivity values are double the listed ±10V Sensitivity values.
2. For IP68 version see caution on physical properties page.

5.13.8 CTL Counts Value

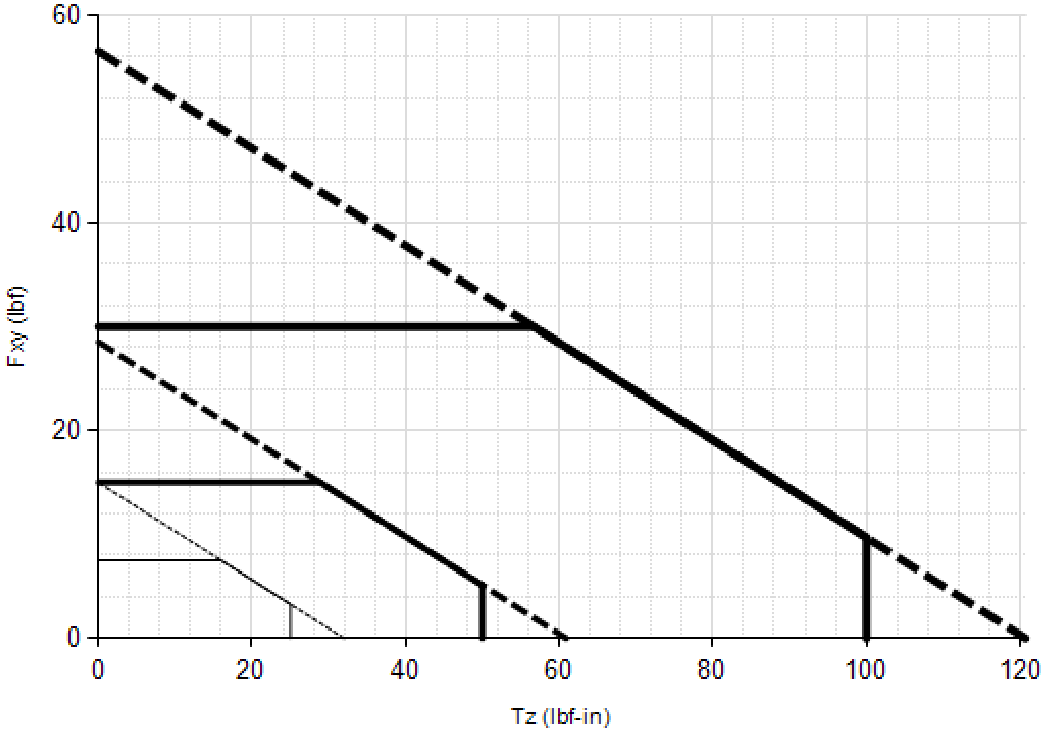
Table 5.82—Counts Value					
Sensor	**Calibration**	**Fx, Fy, Fz (/ lbf)**	**Tx, Ty, Tz (/ lbf-in)**	**Fx, Fy, Fz (/ N)**	**Tx, Ty, Tz (/ Nm)**
Gamma	US-7.5–25 / SI-32–2.5	2560	2560	640	8000
Gamma	US-15–50 / SI-65–5	1280	1280	320	5333.33
Gamma	US-30–100 / SI-130–10	640	640	160	3200
Gamma	Tool Transform Factor	See Tool Transform Factor table			
		Counts Value – Standard (US)		**Counts Value – Metric (SI)**	

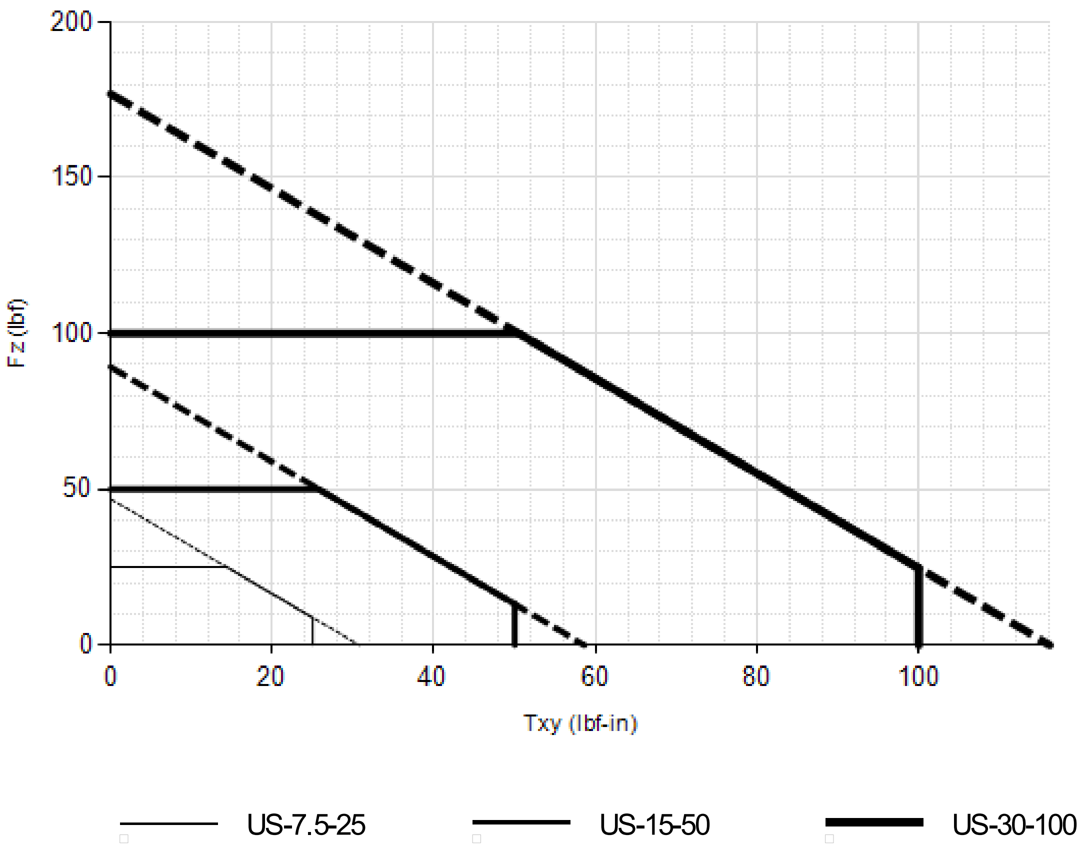
5.13.9 Tool Transform Factor

Table 5.83—Tool Transform Factor			
Sensor	**Calibration**	**US (English)**	SI (Metric)
Gamma	US-7.5–25 / SI-32–2.5	0.01 in/lbf	0.8 mm/N
Gamma	US-15–50 / SI-65–5	0.01 in/lbf	0.6 mm/N
Gamma	US-30–100 / SI-130–10	0.01 in/lbf	0.y h5 mm/N

.

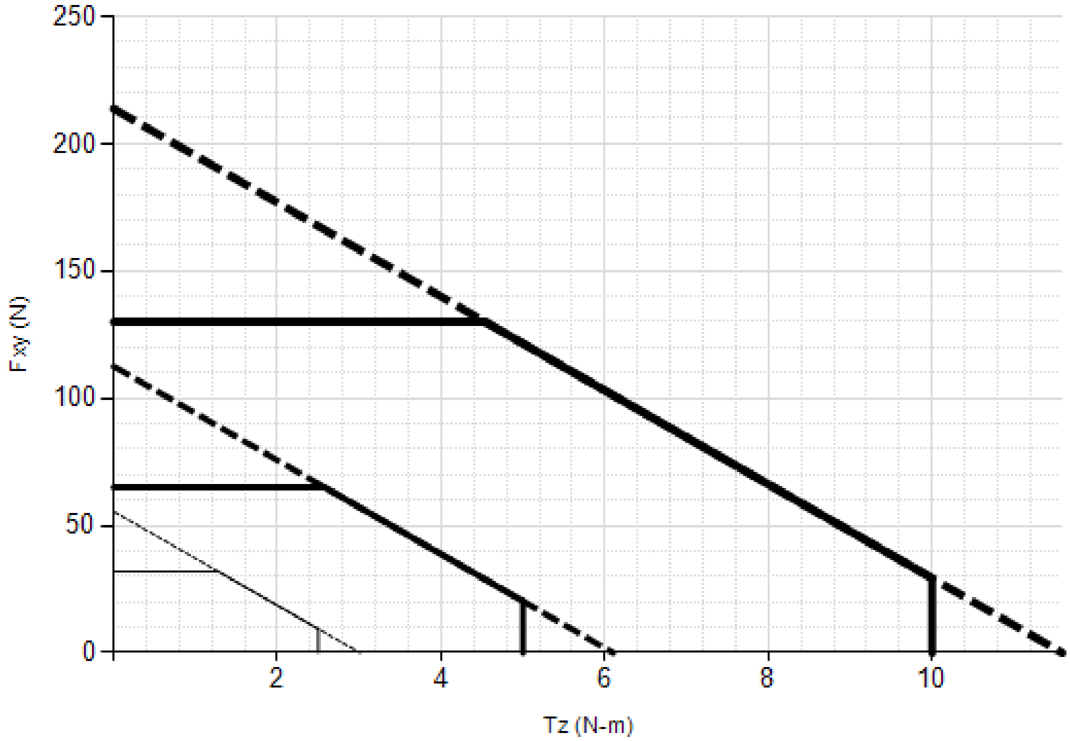
5.13.10 Gamma (US Calibration Complex Loading) (Includes IP60/IP65/IP68)[1]

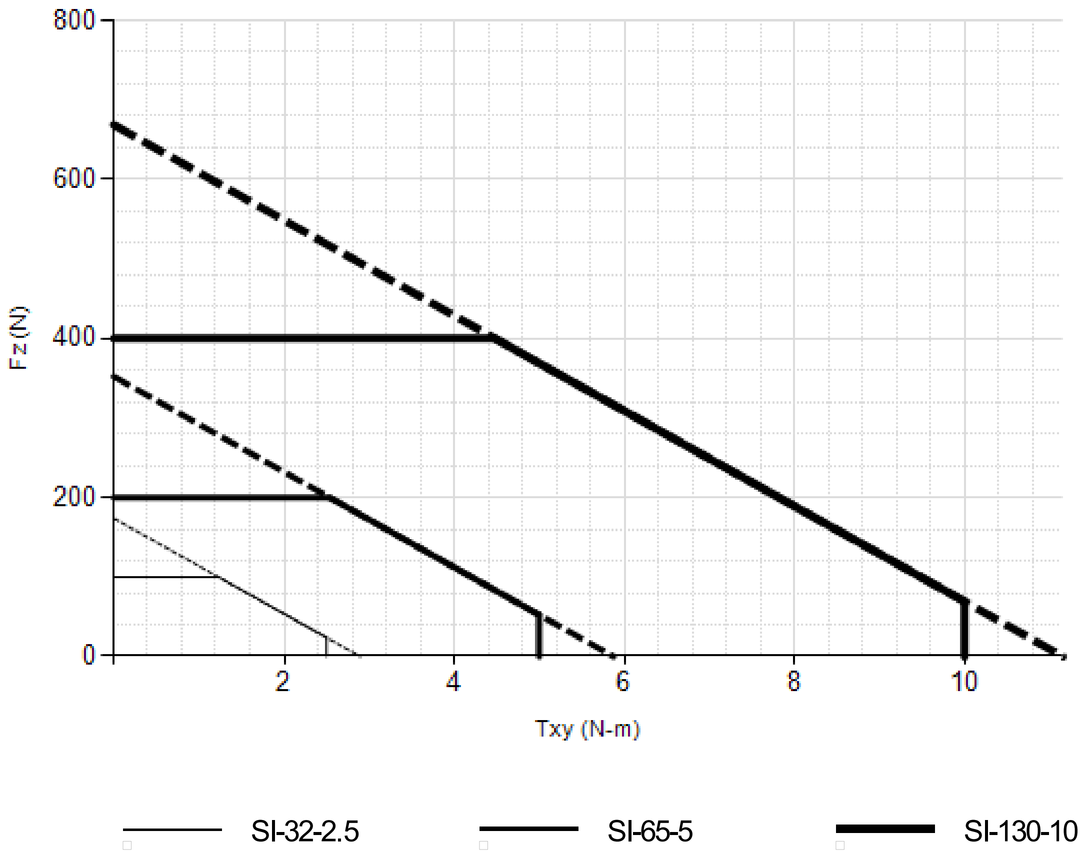




Note: 1. For IP68 version see caution on physical properties page.

5.13.11 Gamma (SI Calibration Complex Loading) (Includes IP60/IP65/IP68)[1]





Note: 1. For IP68 version see caution on physical properties page.

5.14 Delta Specifications (Includes IP60/IP65/IP68 Versions)

In addition to the information in the following sections, refer to the ATI website:

Table 5.84—Delta Drawing and Web Links		
Model	**Drawing Part Number**	**ATI Website Address**
Delta Mux[1] transducer without standard mounting adapter	*9230-05-1102*	*https://www.ati-ia.com/products/ft/ft_models.aspx?id=Delta*
Delta DAQ/NET transducer with mounting adapter plate	*9230-05-1330*	
Delta adapter mounting plate (non-IP rated)	*9230-05-1063*	
Delta IP60	*9230-05-1262*	*https://www.ati-ia.com/products/ft/ft_models.aspx?id=Delta+IP60*
Delta IP60 ECAT	*9230-05-1510*	
Delta IP65	*9230-05-1267*	*https://www.ati-ia.com/products/ft/ft_models.aspx?id=Delta+IP65*
Delta IP65 ECAT	*9230-05-1469*	
Delta IP68	*9230-05-1272*	*https://www.ati-ia.com/products/ft/ft_models.aspx?id=Delta+IP68*

Note:
1. Mux transducers are used in F/T Controller systems.

5.14.1 Delta Physical Properties

Table 5.85—Delta Physical Properties		
Single-Axis Overload	**(US) Standard Units**	**(SI) Metric Units**
Fxy	±840 lbf	±3700 N
Fz	±2300 lbf	±10000 N
Txy	±2500 inf-lb	±280 Nm
Tz	±3600 inf-lb	±400 Nm
Stiffness (Calculated)		
X-axis & Y-axis forces (Kx, Ky)	2.0×10^5 lb/in	3.6×10^7 N/m
Z-axis force (Kz)	3.4×10^5 lb/in	5.9×10^7 N/m
X-axis & Y-axis torque (Ktx, Kty)	4.6×10^5 lbf-in/rad	5.2×10^4 Nm/rad
Z-axis torque (Ktz)	8.1×10^5 lbf-in/rad	9.1×10^4 Nm/rad
Resonant Frequency		
Fx, Fy, Tz	1500 Hz	1500 Hz
Fz, Tx, Ty	1700 Hz	1700 Hz
Physical Specifications		
Weight[1]	2.01 lb	0.913 kg
Diameter[1]	3.72 in	94.5 mm
Height[1]	1.31 in	33.3 mm

Note:
1. Specifications include standard interface plates.

5.14.2 Delta IP60 Physical Properties

Table 5.86—Delta IP60 Physical Properties		
Single-Axis Overload	**(US) Standard Units**	**(SI) Metric Units**
Fxy	±840 lbf	±3700 N
Fz	±2300 lbf	±10000 N
Txy	±2500 inf-lb	±280 Nm
Tz	±3600 inf-lb	±400 Nm
Stiffness (Calculated)		
X-axis & Y-axis forces (Kx, Ky)	2.0×10^5 lb/in	3.6×10^7 N/m
Z-axis force (Kz)	3.4×10^5 lb/in	5.9×10^7 N/m
X-axis & Y-axis torque (Ktx, Kty)	4.6×10^5 lbf-in/rad	5.2×10^4 Nm/rad
Z-axis torque (Ktz)	8.1×10^5 lbf-in/rad	9.1×10^4 Nm/rad
Resonant Frequency		
Fx, Fy, Tz	1100 Hz	1100 Hz
Fz, Tx, Ty	1100 Hz	1100 Hz
Physical Specifications		
Weight[1]	4 lb	1.81 kg
Diameter[1]	4.6 in	117 mm
Height[1]	1.85 in	47.1 mm
Note: 1. Specifications include standard interface plates.		

5.14.3 Delta IP65 Physical Properties

Table 5.87—Delta IP65 Physical Properties		
Single-Axis Overload	**(US) Standard Units**	**(SI) Metric Units**
Fxy	±840 lbf	±3700 N
Fz	±2300 lbf	±10000 N
Txy	±2500 inf-lb	±280 Nm
Tz	±3600 inf-lb	±400 Nm
Stiffness (Calculated)		
X-axis & Y-axis forces (Kx, Ky)	2.0×10^5 lb/in	3.6×10^7 N/m
Z-axis force (Kz)	3.4×10^5 lb/in	5.9×10^7 N/m
X-axis & Y-axis torque (Ktx, Kty)	4.6×10^5 lbf-in/rad	5.2×10^4 Nm/rad
Z-axis torque (Ktz)	8.1×10^5 lbf-in/rad	9.1×10^4 Nm/rad
Resonant Frequency		
Fx, Fy, Tz	880 Hz	880 Hz
Fz, Tx, Ty	920 Hz	920 Hz
Physical Specifications		
Weight[1]	3.91 lb	1.77 kg
Diameter[1]	4.96 in	126 mm
Height[1]	2.06 in	52.2 mm
Note: 1. Specifications include standard interface plates.		

5.14.4 Delta IP68 Physical Properties

Table 5.88—Delta IP68 Physical Properties		
Single-Axis Overload	**(US) Standard Units**	**(SI) Metric Units**
Fxy	±840 lbf	±3700 N
Fz	±2300 lbf	±10000 N
Txy	±2500 inf-lb	±280 Nm
Tz	±3600 inf-lb	±400 Nm
Stiffness (Calculated)		
X-axis & Y-axis forces (Kx, Ky)	2.0×10^{5} lb/in	3.6×10^{7} N/m
Z-axis force (Kz)	3.4×10^{5} lb/in	5.9×10^{7} N/m
X-axis & Y-axis torque (Ktx, Kty)	4.6×10^{5} lbf-in/rad	5.2×10^{4} Nm/rad
Z-axis torque (Ktz)	8.1×10^{5} lbf-in/rad	9.1×10^{4} Nm/rad
Resonant Frequency		
Fx, Fy, Tz	950 Hz	950 Hz
Fz, Tx, Ty	960 Hz	960 Hz
Physical Specifications		
Weight[1]	5.8 lb	2.63 kg
Diameter[1]	4 in	102 mm
Height[1]	2.06 in	52.2 mm
Note: 1. Specifications include standard interface plates.		

CAUTION: When submerged, IP68 transducers exhibit a decrease in Fz range related to the submersion depth. This loss is the result of pressure-induced preloading on the transducer. The preload can be masked by biasing the transducer at the depth prior to applying the load to be measured. The following estimates are for room temperature fresh water at sea level.

Submersion Depth		
IP68 Delta	**US**	**Metric**
Fz preload at 10 m depth	161 lb	716 N
Fz preload at other depths	-4.9 lb/ft × depthInFeet	-72 N/m × depthInMeters

5.14.5 Calibration Specifications (excludes CTL calibrations)

Table 5.89— Delta Calibrations (excludes CTL calibrations)[1, 2]

Sensor	(US) Standard Calibration	Fx,Fy (lbf)	Fz[3] (lbf)	Tx,Ty (lbf-in)	Tz (lbf-in)	Fx,Fy (lbf)	Fz[3] (lbf)	Tx,Ty (lbf-in)	Tz (lbf-in)
Delta	US-50-150	50	150	150	150	1/128	1/64	3/128	1/64
Delta	US-75-300	75	225	300	300	1/64	1/32	3/64	1/32
Delta	US-150-600	150	450	600	600	1/32	1/16	3/32	1/16
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz[3] (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**	**Fx,Fy (N)**	**Fz[3] (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**
Delta	SI-165-15	165	495	15	15	1/32	1/16	1/528	1/528
Delta	SI-330-30	330	990	30	30	1/16	1/8	5/1333	5/1333
Delta	SI-660-60	660	1980	60	60	1/8	1/4	10/1333	10/1333
		Sensing Ranges				**Resolution (DAQ, Net F/T)[4]**			

Notes:
1. These system resolutions quoted are the effective resolution after dropping four counts of noise. The effective resolution can be improved with filtering.
2. Applied loads must be within range in each of the six axes for the F/T sensor to measure correctly.
3. For IP68 version see caution on physical properties page.
4. DAQ resolutions are typical for a 16-bit data acquisition system.

5.14.6 CTL Calibration Specifications

Table 5.90— Delta CTL Calibrations[1, 2]

Sensor	(US) Standard Calibration	Fx,Fy (lbf)	Fz[3] (lbf)	Tx,Ty (lbf-in)	Tz (lbf-in)	Fx,Fy (lbf)	Fz[3] (lbf)	Tx,Ty (lbf-in)	Tz (lbf-in)
Delta	US-50-150	50	150	150	150	1/64	1/32	3/64	1/32
Delta	US-75-300	75	225	300	300	1/32	1/16	3/32	1/16
Delta	US-150-600	150	450	600	600	1/16	1/8	3/16	1/8
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz[3] (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**	**Fx,Fy (N)**	**Fz[3] (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**
Delta	SI-165-15	165	495	15	15	1/16	1/8	1/264	1/264
Delta	SI-330-30	330	990	30	30	1/8	1/4	10/1333	10/1333
Delta	SI-660-60	660	1980	60	60	1/4	1/2	5/333	5/333
		Sensing Ranges				**Resolution (Controller)**			

Notes:
1. CTL resolutions are typical. System resolutions quoted are the effective resolution after dropping eight counts of noise. The effective resolution can be improved with filtering.
2. Applied loads must be within range in each of the six axes for the F/T sensor to measure correctly.
3. For IP68 version see caution on physical properties page.

5.14.7 CTL Analog Output

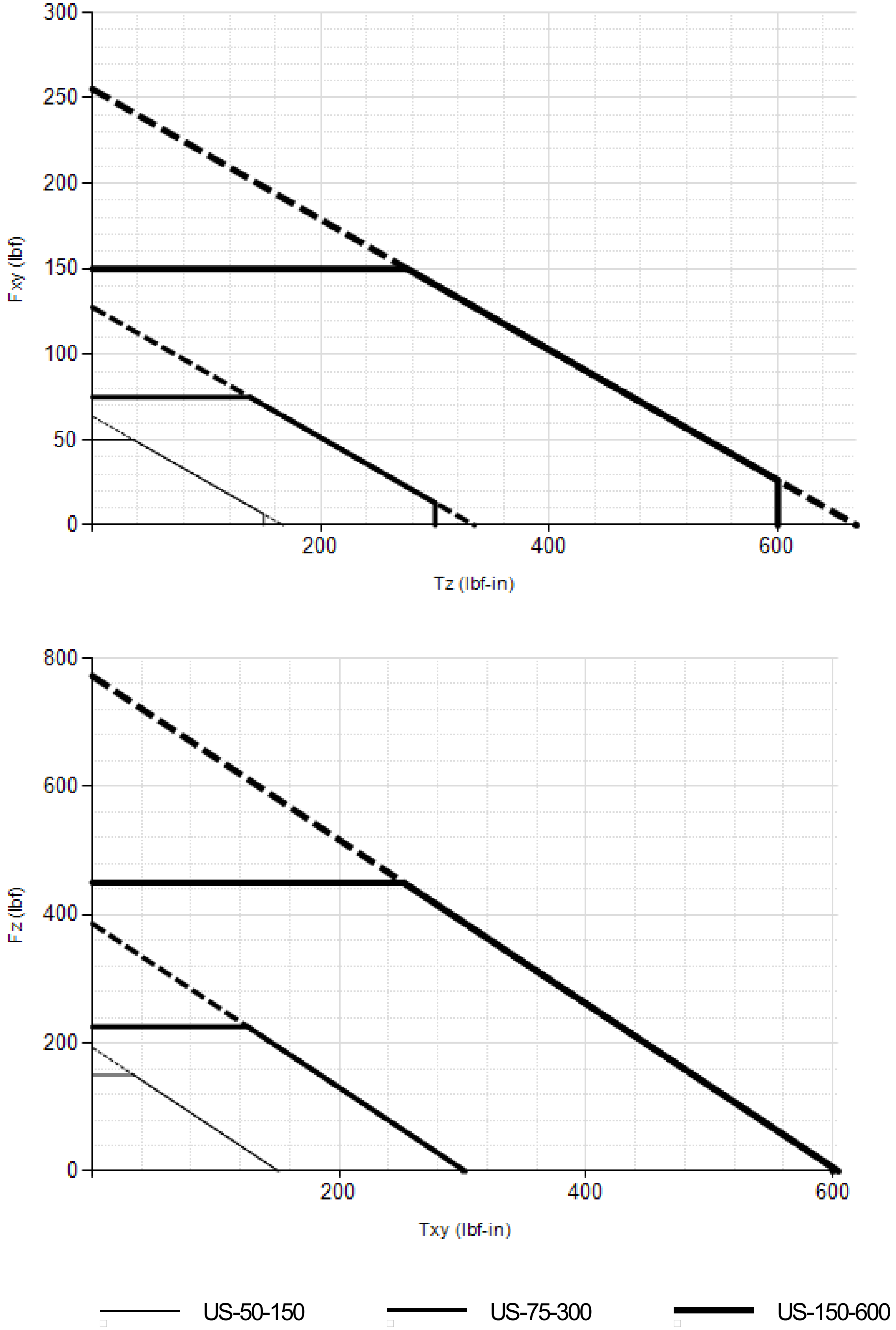
Table 5.91— Delta Analog Output							
Sensor	**(US) Standard Calibration**	**Fx,Fy (lbf)**	**Fz[2] (lbf)**	**Tx,Ty,Tz (lbf-in)**	**Fx,Fy (lbf/V)**	**Fz[2] (lbf/V)**	**Tx,Ty,Tz (lbf-in/V)**
Delta	US-50-150	±50	±150	±150	5	15	15
Delta	US-75-300	±75	±225	±300	7.5	22.5	30
Delta	US-150-600	±150	±450	±600	15	45	60
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz[2] (N)**	**Tx,Ty,Tz (Nm)**	**Fx,Fy (N/V)**	**Fz[2] (N/V)**	**Tx,Ty,Tz (Nm/V)**
Delta	SI-165-15	±165	±495	±15	16.5	49.5	1.5
Delta	SI-330-30	±330	±990	±30	33	99	3
Delta	SI-660-60	±660	±1980	±60	66	198	6
		Analog Output Range			**Analog ±10V Sensitivity[1]**		

Notes:
1. ±5V Sensitivity values are double the listed ±10V Sensitivity values.
2. For IP68 version see caution on physical properties page.

5.14.8 CTL Counts Value

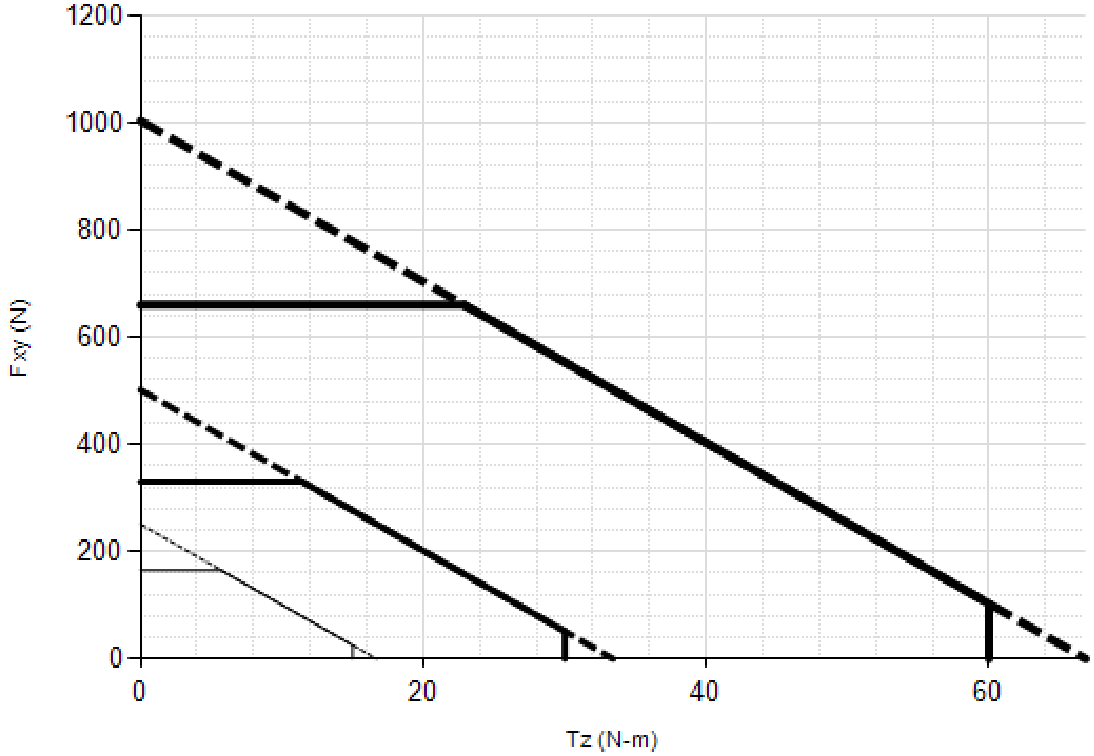
Table 5.92—Counts Value					
Sensor	**Calibration**	**Fx, Fy, Fz (/ lbf)**	**Tx, Ty, Tz (/ lbf-in)**	**Fx, Fy, Fz (/ N)**	**Tx, Ty, Tz (/ Nm)**
Delta	US-7.5–25 / SI-32–2.5	512	512	128	2112
Delta	US-15–50 / SI-65–5	256	256	64	1066.67
Delta	US-30–100 / SI-130–10	128	128	32	533.333
Delta	Tool Transform Factor	0.01 in/lbf		0.6 mm/N	
		Counts Value – Standard (US)		**Counts Value – Metric (SI)**	

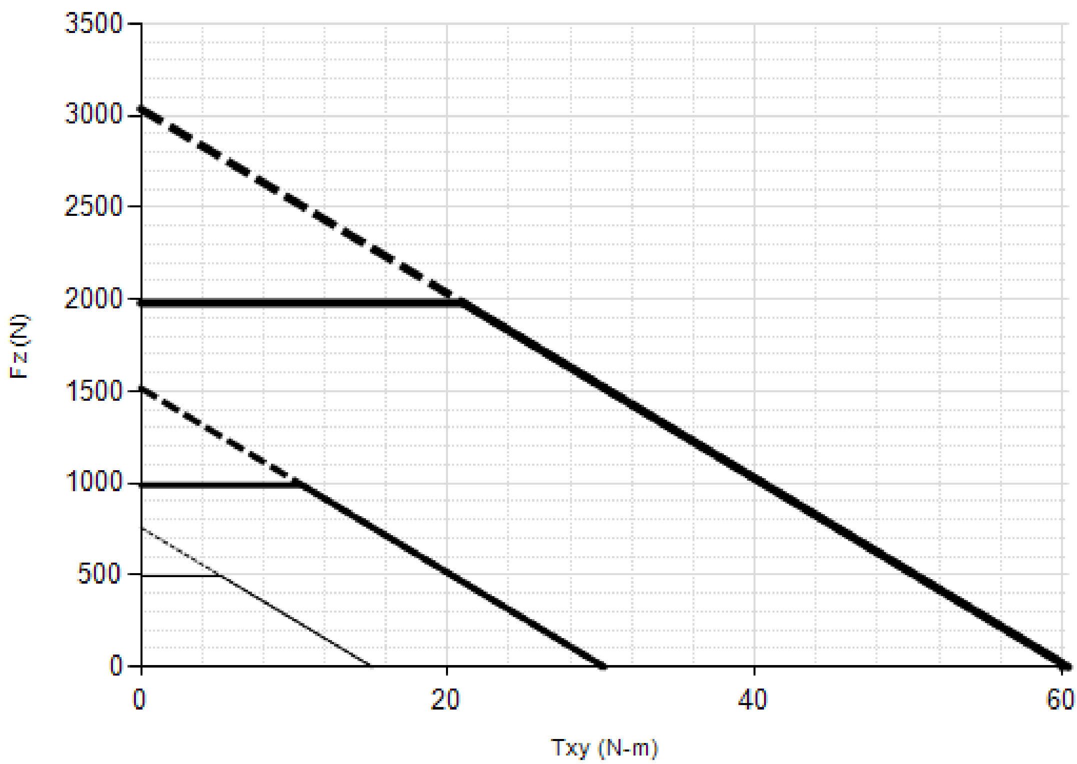
5.14.9 Delta (US Calibration Complex Loading)(Includes IP60/IP65/IP68)[1]



Note: 1. For IP68 version see caution on physical properties page.

5.14.10 Delta (SI Calibration Complex Loading)(Includes IP60/IP65/IP68)[1]





SI-165-15 SI-330-30 SI-660-60

Note: 1. For IP68 version see caution on physical properties page.

5.15 Theta Specifications (Includes IP60/IP65/IP68 Versions)

In addition to the information in the following sections, refer to the ATI website:

Table 5.93—Theta Drawing and Web Links		
Model	**Drawing Part Number**	**ATI Website Address**
Theta Mux[1] transducer without standard mounting adapter	9230-05-1104	https://www.ati-ia.com/products/ft/ft_models.aspx?id=Theta
Theta DAQ/NET transducer with mounting adapter plate	9230-05-1331	
Theta adapter mounting plate (non-IP rated)	9230-05-1076	
Theta IP60	9230-05-1263	https://www.ati-ia.com/products/ft/ft_models.aspx?id=Theta+IP60
Theta IP65	9230-05-1268	https://www.ati-ia.com/products/ft/ft_models.aspx?id=Theta+IP65%2fIP68
Theta IP68-10m	9230-05-1273	
Note: 1. Mux transducers are used in F/T Controller systems.		

5.15.1 Theta Physical Properties

Table 5.94—Theta Physical Properties		
Single-Axis Overload	**(US) Standard Units**	**(SI) Metric Units**
Fxy	±4500 lbf	±20000 N
Fz	±11000 lbf	±51000 N
Txy	±18000 inf-lb	±2000 Nm
Tz	±18000 inf-lb	±2000 Nm
Stiffness (Calculated)		
X-axis & Y-axis forces (Kx, Ky)	4.0×10^{5} lb/in	7.1×10^{7} N/m
Z-axis force (Kz)	6.9×10^{5} lb/in	1.2×10^{8} N/m
X-axis & Y-axis torque (Ktx, Kty)	3.0×10^{6} lbf-in/rad	3.4×10^{5} Nm/rad
Z-axis torque (Ktz)	4.7×10^{6} lbf-in/rad	5.3×10^{5} Nm/rad
Resonant Frequency		
Fx, Fy, Tz	680 Hz	680 Hz
Fz, Tx, Ty	820 Hz	820 Hz
Physical Specifications		
Weight[1]	11 lb	4.99 kg
Diameter[1]	6.1 in	155 mm
Height[1]	2.41 in	61.1 mm
Note: 1. Specifications include standard interface plates.		

5.15.2 Theta IP60 Physical Properties

Table 5.95—Theta IP60 Physical Properties		
Single-Axis Overload	**(US) Standard Units**	**(SI) Metric Units**
Fxy	±4500 lbf	±20000 N
Fz	±11000 lbf	±51000 N
Txy	±18000 inf-lb	±2000 Nm
Tz	±18000 inf-lb	±2000 Nm
Stiffness (Calculated)		
X-axis & Y-axis forces (Kx, Ky)	4.0×10^5 lb/in	7.1×10^7 N/m
Z-axis force (Kz)	6.9×10^5 lb/in	1.2×10^8 N/m
X-axis & Y-axis torque (Ktx, Kty)	3.0×10^6 lbf-in/rad	3.4×10^5 Nm/rad
Z-axis torque (Ktz)	4.7×10^6 lbf-in/rad	5.3×10^5 Nm/rad
Resonant Frequency		
Fx, Fy, Tz	N/A	N/A
Fz, Tx, Ty	N/A	N/A
Physical Specifications		
Weight[1]	19 lb	8.62 kg
Diameter[1]	7.63 in	194 mm
Height[1]	2.91 in	74 mm
Note: 1. Specifications include standard interface plates.		

5.15.3 Theta IP65/IP68 Physical Properties

Table 5.96—Theta IP65/IP68 Physical Properties		
Single-Axis Overload	**(US) Standard Units**	**(SI) Metric Units**
Fxy	±4500 lbf	±20000 N
Fz	±11000 lbf	±51000 N
Txy	±18000 inf-lb	±2000 Nm
Tz	±18000 inf-lb	±2000 Nm
Stiffness (Calculated)		
X-axis & Y-axis forces (Kx, Ky)	4.0×10^5 lb/in	7.1×10^7 N/m
Z-axis force (Kz)	6.9×10^5 lb/in	1.2×10^8 N/m
X-axis & Y-axis torque (Ktx, Kty)	3.0×10^6 lbf-in/rad	3.4×10^5 Nm/rad
Z-axis torque (Ktz)	4.7×10^6 lbf-in/rad	5.3×10^5 Nm/rad
Resonant Frequency		
Fx, Fy, Tz	N/A	N/A
Fz, Tx, Ty	N/A	N/A
Physical Specifications		
Weight[1]	19.8 lb	9 kg
Diameter[1]	6.41 in	163 mm
Height[1]	2.95 in	74.8 mm
Note: 1. Specifications include standard interface plates.		

CAUTION: When submerged, IP68 transducers exhibit a decrease in Fz range related to the submersion depth. This loss is the result of pressure-induced preloading on the transducer. The preload can be masked by biasing the transducer at the depth prior to applying the load to be measured. The following estimates are for room temperature fresh water at sea level.

Submersion Depth		
IP68 Theta	**US**	**Metric**
Fz preload at 10 m depth	429 lb	1907 N
Fz preload at other depths	-13 lb/ft × depthInFeet	-191 N/m × depthInMeters

5.15.4 Calibration Specifications (excludes CTL calibrations)

Table 5.97— Theta Calibrations (excludes CTL calibrations)1, 2

Sensor	(US) Standard Calibration	Fx,Fy (lbf)	Fz³ (lbf)	Tx,Ty (lbf-in)	Tz (lbf-in)	Fx,Fy (lbf)	Fz³ (lbf)	Tx,Ty (lbf-in)	Tz (lbf-in)
Theta	US-200-1000	200	500	1000	1000	1/32	1/16	1/8	1/8
Theta	US-300-1800	300	875	1800	1800	5/68	5/34	5/16	5/16
Theta	US-600-3600	600	1500	3600	3600	1/8	1/4	1/2	1/2
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz³ (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**	**Fx,Fy (N)**	**Fz³ (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**
Theta	SI-1000-120	1000	2500	120	120	1/4	1/4	1/40	1/80
Theta	SI-1500-240	1500	3750	240	240	1/2	1/2	1/20	1/40
Theta	SI-2500-400	2500	6250	400	400	1/2	1	1/20	1/20
		Sensing Ranges				**Resolution (DAQ, Net F/T)⁴**			

Notes:
1. These system resolutions quoted are the effective resolution after dropping four counts of noise. The effective resolution can be improved with filtering.
2. Applied loads must be within range in each of the six axes for the F/T sensor to measure correctly.
3. For IP68 version see caution on physical properties page.
4. DAQ resolutions are typical for a 16-bit data acquisition system.

5.15.5 CTL Calibration Specifications

Table 5.98— Theta CTL Calibrations1, 2

Sensor	(US) Standard Calibration	Fx,Fy (lbf)	Fz³ (lbf)	Tx,Ty (lbf-in)	Tz (lbf-in)	Fx,Fy (lbf)	Fz³ (lbf)	Tx,Ty (lbf-in)	Tz (lbf-in)
Theta	US-200-1000	200	500	1000	1000	1/16	1/8	1/4	1/4
Theta	US-300-1800	300	875	1800	1800	5/34	5/17	5/8	5/8
Theta	US-600-3600	600	1500	3600	3600	1/4	1/2	1	1
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz³ (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**	**Fx,Fy (N)**	**Fz³ (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**
Theta	SI-1000-120	1000	2500	120	120	1/2	1/2	1/20	1/40
Theta	SI-1500-240	1500	3750	240	240	1	1	1/10	1/20
Theta	SI-2500-400	2500	6250	400	400	1	2	1/10	1/10
		Sensing Ranges				**Resolution (Controller)**			

Notes:
1. CTL resolutions are typical. System resolutions quoted are the effective resolution after dropping eight counts of noise. The effective resolution can be improved with filtering.
2. Applied loads must be within range in each of the six axes for the F/T sensor to measure correctly.
3. For IP68 version see caution on physical properties page.

5.15.6 CTL Analog Output

Table 5.99— Theta Analog Output							
Sensor	**(US) Standard Calibration**	**Fx,Fy (lbf)**	**Fz[2] (lbf)**	**Tx,Ty,Tz (lbf-in)**	**Fx,Fy (lbf/V)**	**Fz[2] (lbf/V)**	**Tx,Ty,Tz (lbf-in/V)**
Theta	US-200-1000	±200	±500	±1000	20	50	100
Theta	US-300-1800	±300	±875	±1800	30	87.5	180
Theta	US-600-3600	±600	±1500	±3600	60	150	360
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz[2] (N)**	**Tx,Ty,Tz (Nm)**	**Fx,Fy (N/V)**	**Fz[2] (N/V)**	**Tx,Ty,Tz (Nm/V)**
Theta	SI-1000-120	±1000	±2500	±120	100	250	12
Theta	SI-1500-240	±1500	±3750	±240	150	375	24
Theta	SI-2500-400	±2500	±6250	±400	250	625	40
		Analog Output Range			**Analog ±10V Sensitivity[1]**		

Notes:
1. ±5V Sensitivity values are double the listed ±10V Sensitivity values.
2. For IP68 version see caution on physical properties page.

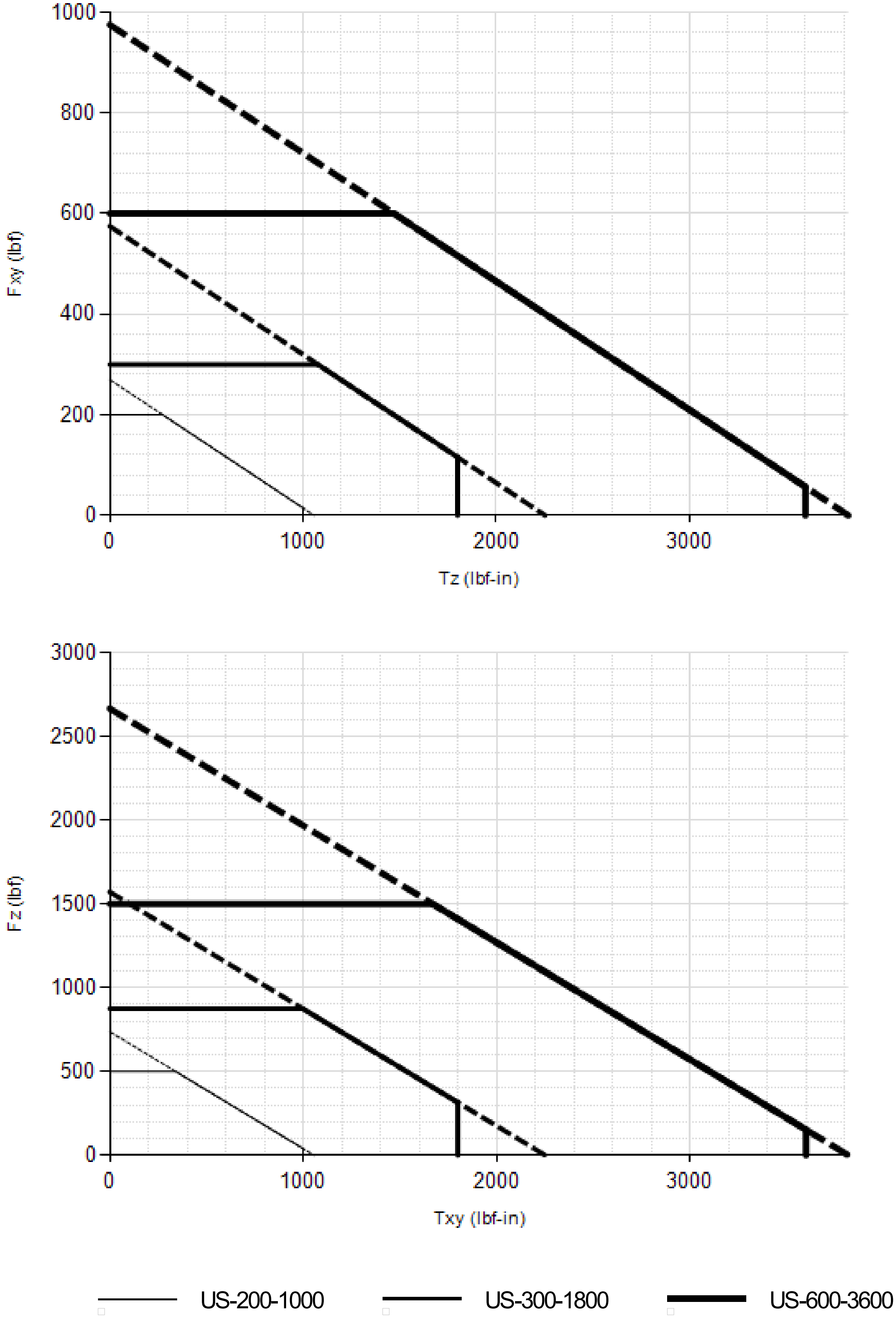
5.15.7 CTL Counts Value

Table 5.100—Counts Value					
Sensor	**Calibration**	**Fx, Fy, Fz (/ lbf)**	**Tx, Ty, Tz (/ lbf-in)**	**Fx, Fy, Fz (/ N)**	**Tx, Ty, Tz (/ Nm)**
Theta	US-200–1000 / SI-1000–120	128	64	32	320
Theta	US-300–1800 / SI-1500–240	54.4	12.8	16	160
Theta	US-600–3600 / SI-2500–400	32	16	16	80
Theta	Tool Transform Factor	See Tool Transform Factor table			
		Counts Value – Standard (US)		**Counts Value – Metric (SI)**	

5.15.8 Tool Transform Factor

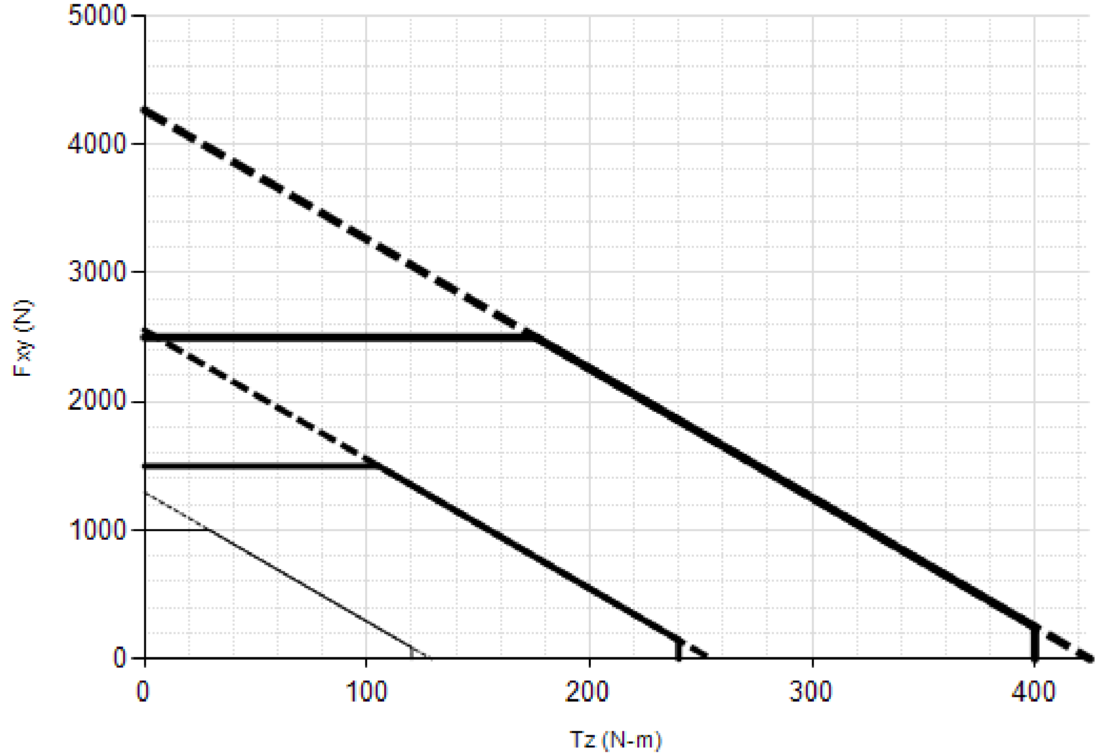
Table 5.101—Tool Transform Factor			
Sensor	**Calibration**	**US (English)**	SI (Metric)
Theta	US-200–1000 / SI-1000–120	0.02 in/lbf	1 mm/N
Theta	US-300–1800 / SI-1500–240	0.0425 in/lbf	1 mm/N
Theta	US-600–3600 / SI-2500–400	0.02 in/lbf	2 mm/N

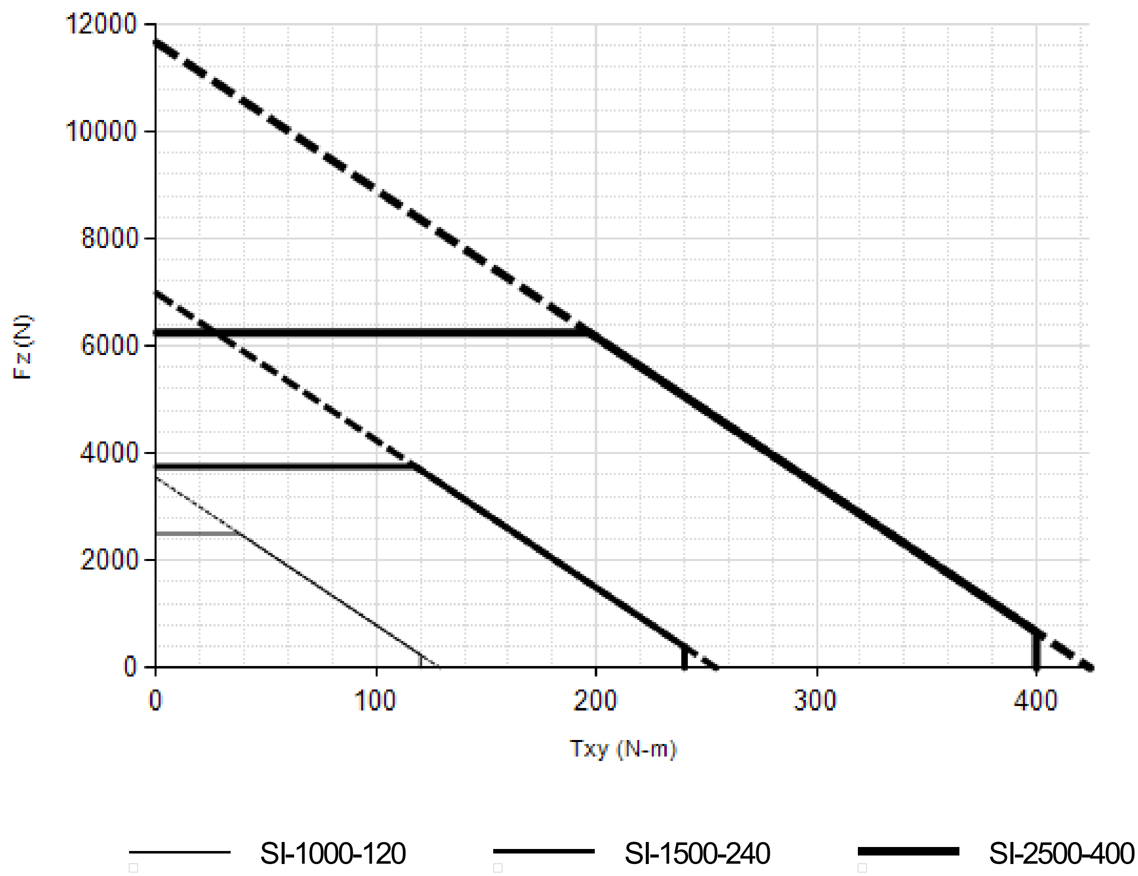
5.15.9 Theta (US Calibration Complex Loading)(Includes IP60/IP65/IP68)[1]



Note: 1. For IP68 version see caution on physical properties page.

5.15.10 Theta (SI Calibration Complex Loading)(Includes IP60/IP65/IP68)[1]





5.16 Omega85 Specifications (Includes IP60/IP65/IP68 Versions)

In addition to the information in the following sections, refer to the ATI website:

Table 5.102—Omega85 Drawing and Web Links		
Model	**Drawing Part Number**	**ATI Website Address**
Omega85	*9230-05-1341*	*https://www.ati-ia.com/products/ft/ft_models.aspx?id=Omega85*
Omega85 IP65	*9230-05-1382*	*https://www.ati-ia.com/products/ft/ft_models.aspx?id=Omega85+IP65%2fIP68*
Omega85 IP68	*9230-05-1396*	

5.16.1 Omega85 Physical Properties

Table 5.103—Omega85 Physical Properties		
Single-Axis Overload	**(US) Standard Units**	**(SI) Metric Units**
Fxy	±2800 lbf	±13000 N
Fz	±6100 lbf	±27000 N
Txy	±4400 inf-lb	±500 Nm
Tz	±5400 inf-lb	±610 Nm
Stiffness (Calculated)		
X-axis & Y-axis forces (Kx, Ky)	$4.4x10^{5}$ lb/in	$7.7x10^{7}$ N/m
Z-axis force (Kz)	$6.8x10^{5}$ lb/in	$1.2x10^{8}$ N/m
X-axis & Y-axis torque (Ktx, Kty)	$7.2x10^{5}$ lbf-in/rad	$8.1x10^{4}$ Nm/rad
Z-axis torque (Ktz)	$1.2x10^{6}$ lbf-in/rad	$1.3x10^{5}$ Nm/rad
Resonant Frequency		
Fx, Fy, Tz	2100 Hz	2100 Hz
Fz, Tx, Ty	3000 Hz	3000 Hz
Physical Specifications		
Weight[1]	1.45 lb	0.658 kg
Diameter[1]	3.35 in	85.1 mm
Height[1]	1.32 in	33.4 mm
Note: 1. Specifications include standard interface plates.		

5.16.2 Omega85 IP65/IP68 Physical Properties

Table 5.104—Omega85 IP65/IP68 Physical Properties

Single-Axis Overload	**(US) Standard Units**	**(SI) Metric Units**
Fxy	±2800 lbf	±13000 N
Fz	±6100 lbf	±27000 N
Txy	±4400 inf-lb	±500 Nm
Tz	±5400 inf-lb	±610 Nm
Stiffness (Calculated)		
X-axis & Y-axis forces (Kx, Ky)	$4.4x10^{5}$ lb/in	$7.7x10^{7}$ N/m
Z-axis force (Kz)	$6.8x10^{5}$ lb/in	$1.2x10^{8}$ N/m
X-axis & Y-axis torque (Ktx, Kty)	$7.2x10^{5}$ lbf-in/rad	$8.1x10^{4}$ Nm/rad
Z-axis torque (Ktz)	$1.2x10^{6}$ lbf-in/rad	$1.3x10^{5}$ Nm/rad
Resonant Frequency		
Fx, Fy, Tz	N/A	N/A
Fz, Tx, Ty	N/A	N/A
Physical Specifications		
Weight[1]	4.2 lb	1.91 kg
Diameter[1]	3.65 in	92.7 mm
Height[1]	1.52 in	38.7 mm

Note:
1. Specifications include standard interface plates.

CAUTION: When submerged, IP68 transducers exhibit a decrease in Fz range related to the submersion depth. This loss is the result of pressure-induced preloading on the transducer. The preload can be masked by biasing the transducer at the depth prior to applying the load to be measured. The following estimates are for room temperature fresh water at sea level.

Submersion Depth

IP68 Omega85	**US**	**Metric**
Fz preload at 10 m depth	128 lb	570 N
Fz preload at other depths	-3.9 lb/ft × depthInFeet	-57 N/m × depthInMeters

5.16.3 Calibration Specifications (excludes CTL calibrations)

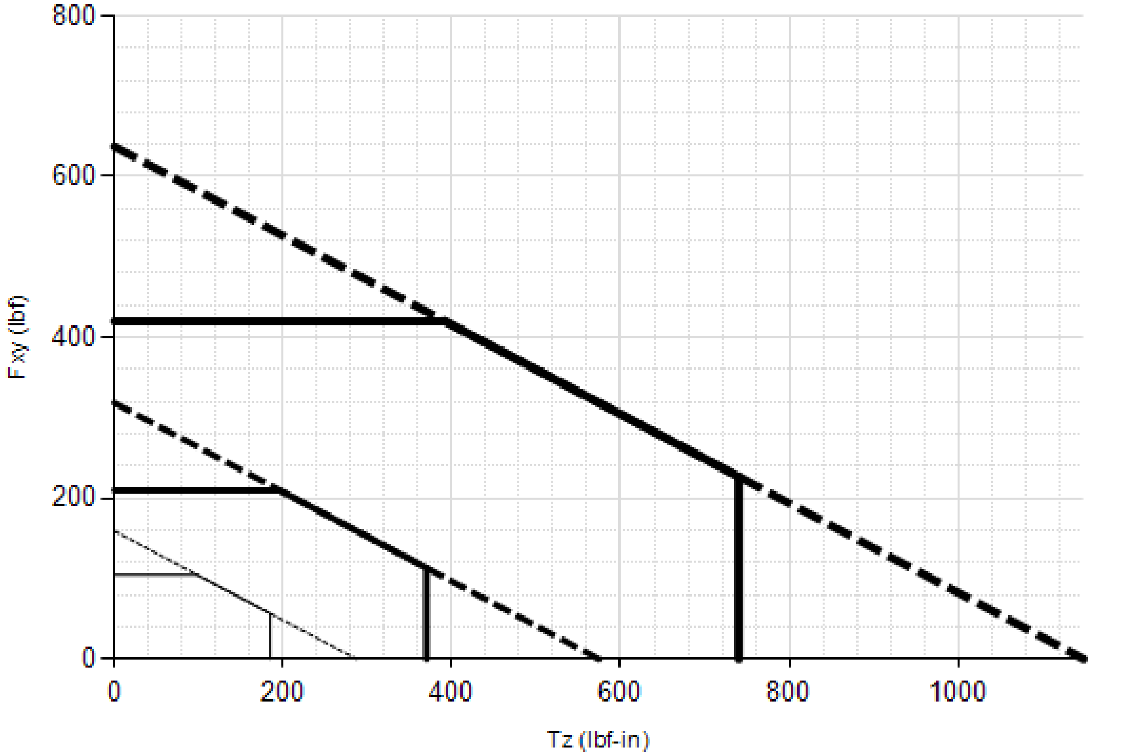
Table 5.105— Omega85 Calibrations (excludes CTL calibrations)1, 2									
Sensor	**(US) Standard Calibration**	**Fx,Fy (lbf)**	**Fz[3] (lbf)**	**Tx,Ty (lbf-in)**	**Tz (lbf-in)**	**Fx,Fy (lbf)**	**Fz[3] (lbf)**	**Tx,Ty (lbf-in)**	**Tz (lbf-in)**
Omega85	US-105-185	105	210	185	185	1/52	3/130	3/112	1/48
Omega85	US-210-370	210	420	370	370	5/128	3/64	3/56	1/24
Omega85	US-420-740	420	840	740	740	5/64	3/32	3/28	1/12
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz[3] (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**	**Fx,Fy (N)**	**Fz[3] (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**
Omega85	SI-475-20	475	950	20	20	1/14	3/28	5/1496	7/2992
Omega85	SI-950-40	950	1900	40	40	1/7	3/14	5/748	7/1496
Omega85	SI-1900-80	1900	3800	80	80	2/7	3/7	5/374	7/748
		Sensing Ranges				**Resolution (DAQ, Net F/T)[4]**			

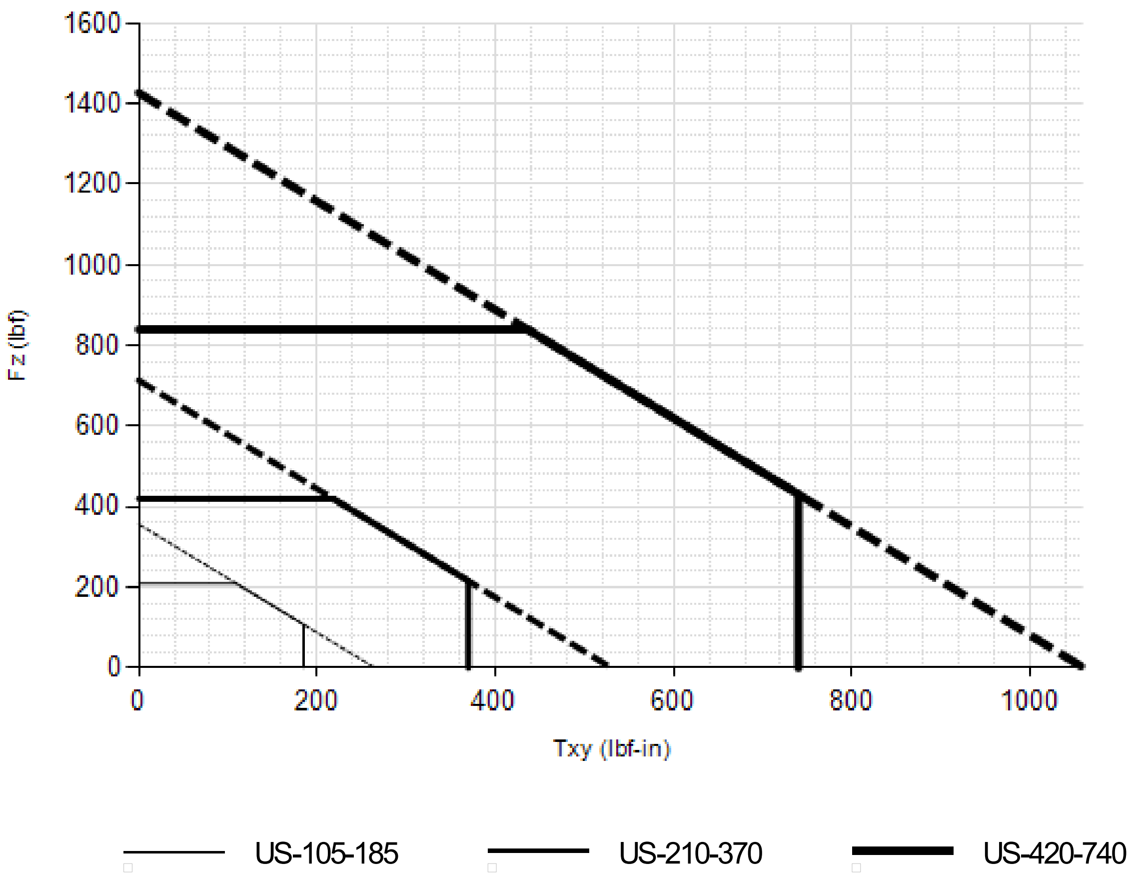
Notes:

1. These system resolutions quoted are the effective resolution after dropping four counts of noise. The effective resolution can be improved with filtering.
2. Applied loads must be within range in each of the six axes for the F/T sensor to measure correctly.
3. For IP68 version see caution on physical properties page.
4. DAQ resolutions are typical for a 16-bit data acquisition system.

NOTICE: The Omega85 does not support an on-board mux board, therefore it cannot be used with the F/T Controller. For Controller F/T systems we recommend the Mini85.

5.16.4 Omega85 (US Calibration Complex Loading)(Includes IP65/IP68)[1]





Note: 1. For IP68 version see caution on physical properties page.

5.17 Omega160 Specifications (Includes IP60/IP65/IP68 Versions)

NOTICE: For transducer versions without a through hole and without an IP rating, use a metallic adapter plate that covers the center hole.

In addition to the information in the following sections, refer to the ATI website:

Table 5.106—Omega160 Drawing and Web Links		
Model	**Drawing Part Number**	**ATI Website Address**
Omega160 Mux[1] without mounting adapter plate	*9230-05-1093*	*https://www.ati-ia.com/products/ft/ft_models.aspx?id=Omega160*
Omega160 DAQ/NET with mounting adapter plate	*9230-05-1131*	
TIF Omega160 with 53 mm hole	*9230-05-1412*	
Omega160 IP60	*9230-05-1264*	*https://www.ati-ia.com/products/ft/ft_models.aspx?id=Omega160+IP60*
Omega160 IP60 ECAT	*9230-05-1487*	
Omaga160 IP65	*9230-05-1269*	*https://www.ati-ia.com/products/ft/ft_models.aspx?id=Omega160+IP65%2fIP68*
Omega160 IP68-10 m	*9230-05-1274*	
Omega160 IP65 ECAT	*9230-05-1499*	

Note:

1. Mux transducers are used in F/T Controller systems.

5.17.1 Omega160 Physical Properties

Table 5.107—Omega160 Physical Properties		
Single-Axis Overload	**(US) Standard Units**	**(SI) Metric Units**
Fxy	±3900 lbf	±18000 N
Fz	±11000 lbf	±48000 N
Txy	±15000 inf-lb	±1700 Nm
Tz	±17000 inf-lb	±1900 Nm
Stiffness (Calculated)		
X-axis & Y-axis forces (Kx, Ky)	4.0×10^{5} lb/in	7.0×10^{7} N/m
Z-axis force (Kz)	6.8×10^{5} lb/in	1.2×10^{8} N/m
X-axis & Y-axis torque (Ktx, Kty)	2.9×10^{6} lbf-in/rad	3.3×10^{5} Nm/rad
Z-axis torque (Ktz)	4.6×10^{6} lbf-in/rad	5.2×10^{5} Nm/rad
Resonant Frequency		
Fx, Fy, Tz	1300 Hz	1300 Hz
Fz, Tx, Ty	1000 Hz	1000 Hz
Physical Specifications		
Weight[1]	6 lb	2.72 kg
Diameter[1]	6.16 in	157 mm
Height[1]	2.2 in	55.9 mm

Note:
1. Specifications include standard interface plates.

5.17.2 Omega160 IP160 Physical Properties (Includes ECAT)

Table 5.108—Omega160 IP160 Physical Properties		
Single-Axis Overload	**(US) Standard Units**	**(SI) Metric Units**
Fxy	±3900 lbf	±18000 N
Fz	±11000 lbf	±48000 N
Txy	±15000 inf-lb	±1700 Nm
Tz	±17000 inf-lb	±1900 Nm
Stiffness (Calculated)		
X-axis & Y-axis forces (Kx, Ky)	4.0×10^{5} lb/in	7.0×10^{7} N/m
Z-axis force (Kz)	6.8×10^{5} lb/in	1.2×10^{8} N/m
X-axis & Y-axis torque (Ktx, Kty)	2.9×10^{6} lbf-in/rad	3.3×10^{5} Nm/rad
Z-axis torque (Ktz)	4.6×10^{6} lbf-in/rad	5.2×10^{5} Nm/rad
Resonant Frequency		
Fx, Fy, Tz	1100 Hz	1100 Hz
Fz, Tx, Ty	1000 Hz	1000 Hz
Physical Specifications		
Weight[1]	16.9 lb	7.67 kg
Diameter[1]	7.63 in	194 mm
Height[1]	2.27 in	57.7 mm
Note: 1. Specifications include standard interface plates.		

5.17.3 Omega160 IP65/IP68 Physical Properties

Table 5.109—Omega160 IP65/IP68 Physical Properties		
Single-Axis Overload	**(US) Standard Units**	**(SI) Metric Units**
Fxy	±3900 lbf	±18000 N
Fz	±11000 lbf	±48000 N
Txy	±15000 inf-lb	±1700 Nm
Tz	±17000 inf-lb	±1900 Nm
Stiffness (Calculated)		
X-axis & Y-axis forces (Kx, Ky)	4.0×10^{5} lb/in	7.0×10^{7} N/m
Z-axis force (Kz)	6.8×10^{5} lb/in	1.2×10^{8} N/m
X-axis & Y-axis torque (Ktx, Kty)	2.9×10^{6} lbf-in/rad	3.3×10^{5} Nm/rad
Z-axis torque (Ktz)	4.6×10^{6} lbf-in/rad	5.2×10^{5} Nm/rad
Resonant Frequency		
Fx, Fy, Tz	1200 Hz	1200 Hz
Fz, Tx, Ty	900 Hz	900 Hz
Physical Specifications		
Weight[1]	16 lb	7.26 kg
Diameter[1]	6.5 in	165 mm
Height[1]	2.59 in	65.9 mm
Note: 1. Specifications include standard interface plates.		

CAUTION: When submerged, IP68 transducers exhibit a decrease in Fz range related to the submersion depth. This loss is the result of pressure-induced preloading on the transducer. The preload can be masked by biasing the transducer at the depth prior to applying the load to be measured. The following estimates are for room temperature fresh water at sea level.

Submersion Depth		
IP68 Omega160	**US**	**Metric**
Fz preload at 10 m depth	429 lb	1907 N
Fz preload at other depths	-13 lb/ft × depthInFeet	-191 N/m × depthInMeters

5.17.4 Calibration Specifications (excludes CTL calibrations)

Table 5.110— Omega160 Calibrations (excludes CTL calibrations)1, 2									
Sensor	**(US) Standard Calibration**	**Fx,Fy (lbf)**	**Fz³ (lbf)**	**Tx,Ty (lbf-in)**	**Tz (lbf-in)**	**Fx,Fy (lbf)**	**Fz³ (lbf)**	**Tx,Ty (lbf-in)**	**Tz (lbf-in)**
Omega160	US-200-1000	200	500	1000	1000	1/32	1/16	1/8	1/8
Omega160	US-300-1800	300	875	1800	1800	5/68	5/34	5/16	5/16
Omega160	US-600-3600	600	1500	3600	3600	1/8	1/4	1/2	1/4
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz³ (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**	**Fx,Fy (N)**	**Fz³ (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**
Omega160	SI-1000-120	1000	2500	120	120	1/4	1/4	1/40	1/80
Omega160	SI-1500-240	1500	3750	240	240	1/4	1/2	1/20	1/40
Omega160	SI-2500-400	2500	6250	400	400	1/2	3/4	1/20	1/20
		Sensing Ranges				**Resolution (DAQ, Net F/T)⁴**			

Notes:
1. These system resolutions quoted are the effective resolution after dropping four counts of noise. The effective resolution can be improved with filtering.
2. Applied loads must be within range in each of the six axes for the F/T sensor to measure correctly.
3. For IP68 version see caution on physical properties page.
4. DAQ resolutions are typical for a 16-bit data acquisition system.

5.17.5 CTL Calibration Specifications

Table 5.111— Omega160 CTL Calibrations1, 2									
Sensor	**(US) Standard Calibration**	**Fx,Fy (lbf)**	**Fz³ (lbf)**	**Tx,Ty (lbf-in)**	**Tz (lbf-in)**	**Fx,Fy (lbf)**	**Fz³ (lbf)**	**Tx,Ty (lbf-in)**	**Tz (lbf-in)**
Omega160	US-200-1000	200	500	1000	1000	1/16	1/8	1/4	1/4
Omega160	US-300-1800	300	875	1800	1800	5/34	5/17	5/8	5/8
Omega160	US-600-3600	600	1500	3600	3600	1/4	1/2	1	1/2
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz³ (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**	**Fx,Fy (N)**	**Fz³ (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**
Omega160	SI-1000-120	1000	2500	120	120	1/2	1/2	1/20	1/40
Omega160	SI-1500-240	1500	3750	240	240	1/2	1	1/10	1/20
Omega160	SI-2500-400	2500	6250	400	400	1	1 1/2	1/10	1/10
		Sensing Ranges				**Resolution (Controller)**			

Notes:
1. CTL resolutions are typical. System resolutions quoted are the effective resolution after dropping eight counts of noise. The effective resolution can be improved with filtering.
2. Applied loads must be within range in each of the six axes for the F/T sensor to measure correctly.
3. For IP68 version see caution on physical properties page.

5.17.6 CTL Analog Output

Table 5.112— Omega160 Analog Output							
Sensor	**(US) Standard Calibration**	**Fx,Fy (lbf)**	**Fz[2] (lbf)**	**Tx,Ty,Tz (lbf-in)**	**Fx,Fy (lbf/V)**	**Fz[2] (lbf/V)**	**Tx,Ty,Tz (lbf-in/V)**
Omega160	US-200-1000	±200	±500	±1000	20	50	100
Omega160	US-300-1800	±300	±875	±1800	30	87.5	180
Omega160	US-600-3600	±600	±1500	±3600	60	150	360
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz (N)**	**Tx,Ty,Tz (Nm)**	**Fx,Fy (N/V)**	**Fz[2] (N/V)**	**Tx,Ty,Tz (Nm/V)**
Omega160	SI-1000-120	±1000	±2500	±120	100	250	12
Omega160	SI-1500-240	±1500	±3750	±240	150	375	24
Omega160	SI-2500-400	±2500	±6250	±400	250	625	40
		Analog Output Range			**Analog ±10V Sensitivity[1]**		

Notes:
1. ±5V Sensitivity values are double the listed ±10V Sensitivity values.
2. For IP68 version see caution on physical properties page.

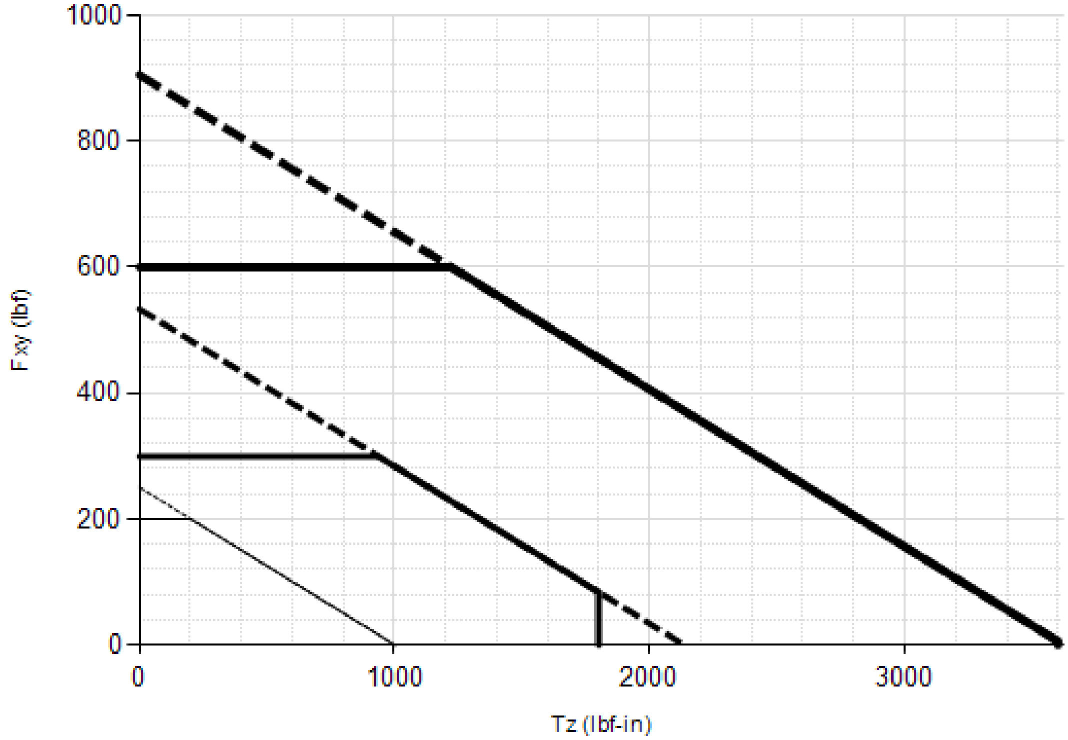
5.17.7 CTL Counts Value

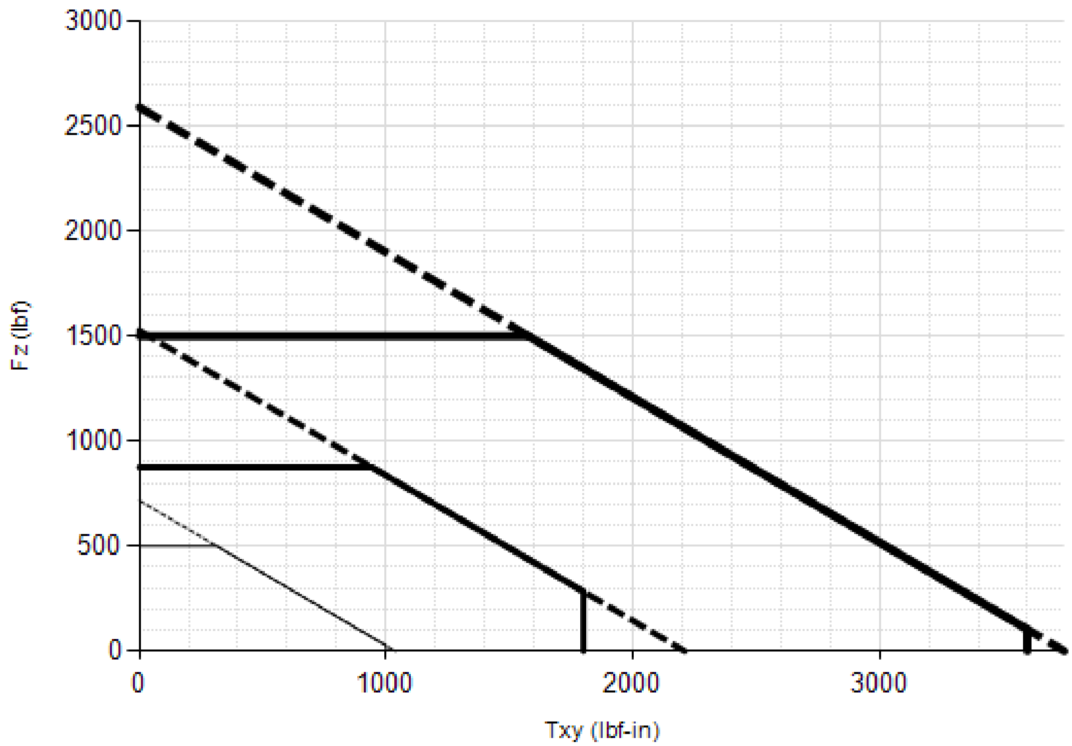
Table 5.113—Counts Value					
Sensor	**Calibration**	**Fx, Fy, Fz (/ lbf)**	**Tx, Ty, Tz (/ lbf-in)**	**Fx, Fy, Fz (/ N)**	**Tx, Ty, Tz (/ Nm)**
Omega160	US-200–1000 / SI-1000–120	128	64	32	320
Omega160	US-300–1800 / SI-1500–240	54.4	12.8	16	160
Omega160	US-600–3600 / SI-2500–400	32	16	16	80
Omega160	Tool Transform Factor	See Tool Transform Factor table			
		Counts Value – Standard (US)		**Counts Value – Metric (SI)**	

5.17.8 Tool Transform Factor

Table 5.114—Tool Transform Factor			
Sensor	**Calibration**	**US (English)**	SI (Metric)
Omega160	US-200–1000 / SI-1000–120	0.02 in/lbf	1 mm/N
Omega160	US-300–1800 / SI-1500–240	0.0425 in/lbf	1 mm/N
Omega160	US-600–3600 / SI-2500–400	0.02 in/lbf	2 mm/N

5.17.9 Omega160 (US Calibration Complex Loading) (Includes IP60/IP65/IP68)[1]

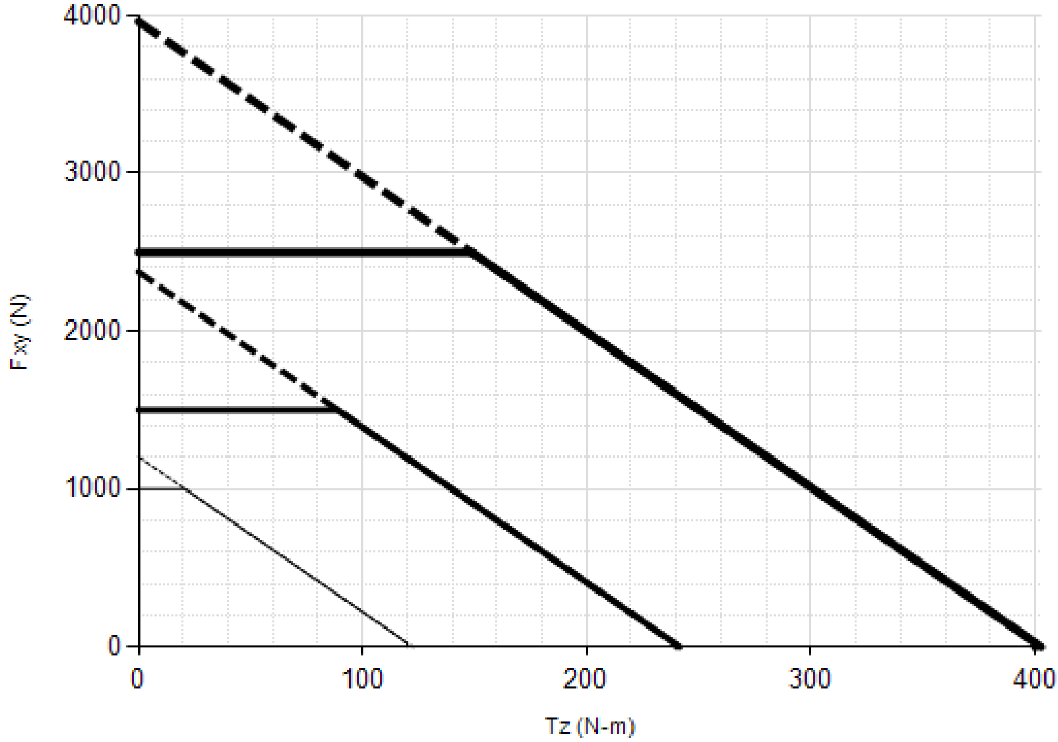


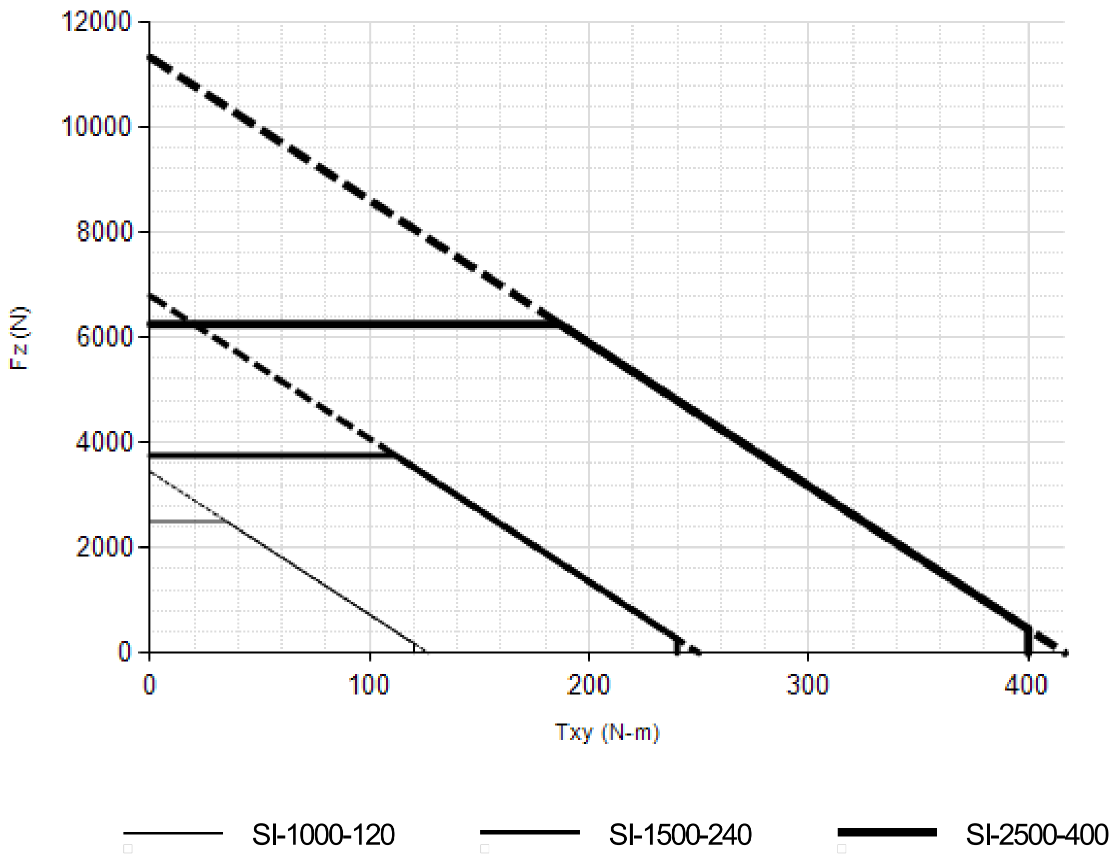


US-200-1000 US-300-1800 US-600-3600

Note: 1. For IP68 version see caution on physical properties page.

5.17.10 Omega160 (SI Calibration Complex Loading) (Includes IP60/IP65/IP68)[1]





Note: 1. For IP68 version see caution on physical properties page.

5.18 Omega190 Specifications

In addition to the information in the following sections, refer to the ATI website:

Table 5.115—Omega190 Drawing and Web Links		
Model	**Drawing Part Number**	**ATI Website Address**
Omega190 DAQ/Net	*9230-05-1095*	*https://www.ati-ia.com/products/ft/ft_models.aspx?ID=Omega190*

5.18.1 Omega190 Physical Properties

Table 5.116—Omega190 Physical Properties		
Single-Axis Overload	**(US) Standard Units**	**(SI) Metric Units**
Fxy	±8000 lbf	±36000 N
Fz	±25000 lbf	±110000 N
Txy	±60000 lbf-in	±6800 Nm
Tz	±60000 lbf-in	±6800 Nm
Stiffness (Calculated)		
X-axis & Y-axis forces (Kx, Ky)	1.4×10^{6} lb/in	2.4×10^{8} N/m
Z-axis force (Kz)	2.1×10^{6} lb/in	3.6×10^{8} N/m
X-axis & Y-axis torque (Ktx, Kty)	1.4×10^{7} lbf-in/rad	1.5×10^{6} Nm/rad
Z-axis torque (Ktz)	2.8×10^{7} lbf-in/rad	3.2×10^{6} Nm/rad
Resonant Frequency		
Fx, Fy, Tz	N/A	N/A
Fz, Tx, Ty	N/A	N/A
Physical Specifications		
Weight[1]	14 lb	6.35 kg
Diameter[1]	7.48 in	190 mm
Height[1]	2.2 in	55.9 mm
Note: 1. Specifications include standard interface plates.		

5.18.2 Calibration Specifications (excludes CTL calibrations)

Table 5.117— Omega190 Calibrations (excludes CTL calibrations)1, 2									
Sensor	**(US) Standard Calibration**	**Fx,Fy (lbf)**	**Fz[3] (lbf)**	**Tx,Ty (lbf-in)**	**Tz (lbf-in)**	**Fx,Fy (lbf)**	**Fz[3] (lbf)**	**Tx,Ty (lbf-in)**	**Tz (lbf-in)**
Omega190	US-400-3000	400	1000	3000	3000	5/64	5/32	15/32	5/16
Omega190	US-800-6000	800	2000	6000	6000	5/32	5/16	15/16	5/8
Omega190	US-1600-12000	1600	4000	12000	12000	5/16	5/8	1 7/8	1 1/4
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz[3] (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**	**Fx,Fy (N)**	**Fz[3] (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**
Omega190	SI-1800-350	1800	4500	350	350	3/8	3/4	5/96	5/144
Omega190	SI-3600-700	3600	9000	700	700	3/4	1 1/2	5/48	5/72
Omega190	SI-7200-1400	7200	18000	1400	1400	1 1/2	3	5/24	5/36
		Sensing Ranges				**Resolution (DAQ, Net F/T)[4]**			

Notes:
1. These system resolutions quoted are the effective resolution after dropping four counts of noise. The effective resolution can be improved with filtering.
2. Applied loads must be within range in each of the six axes for the F/T sensor to measure correctly.
3. For IP68 version see caution on physical properties page.
4. DAQ resolutions are typical for a 16-bit data acquisition system.

5.18.3 CTL Calibration Specifications

Table 5.118— Omega190 CTL Calibrations1, 2									
Sensor	**(US) Standard Calibration**	**Fx,Fy (lbf)**	**Fz[3] (lbf)**	**Tx,Ty (lbf-in)**	**Tz (lbf-in)**	**Fx,Fy (lbf)**	**Fz[3] (lbf)**	**Tx,Ty (lbf-in)**	**Tz (lbf-in)**
Omega190	US-400-3000	400	1000	3000	3000	5/32	5/16	15/16	5/8
Omega190	US-800-6000	800	2000	6000	6000	5/16	5/8	1 7/8	1 1/4
Omega190	US-1600-12000	1600	4000	12000	12000	5/8	1 1/4	3 3/4	2 1/2
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz[3] (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**	**Fx,Fy (N)**	**Fz[3] (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**
Omega190	SI-1800-350	1800	4500	350	350	3/4	1 1/2	5/48	5/72
Omega190	SI-3600-700	3600	9000	700	700	1 1/2	3	5/24	5/36
Omega190	SI-7200-1400	7200	18000	1400	1400	3	6	5/12	5/18
		Sensing Ranges				**Resolution (Controller)**			

Notes:
1. CTL resolutions are typical. System resolutions quoted are the effective resolution after dropping eight counts of noise. The effective resolution can be improved with filtering.
2. Applied loads must be within range in each of the six axes for the F/T sensor to measure correctly.
3. For IP68 version see caution on physical properties page.

5.18.4 CTL Analog Output

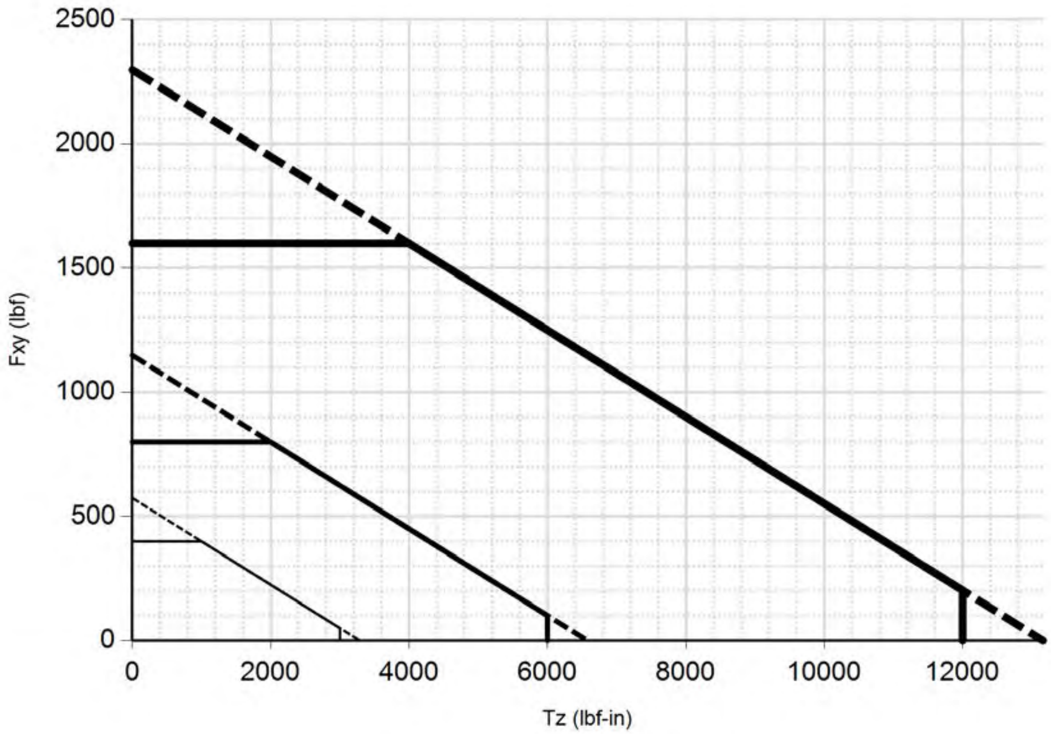
Table 5.119— Omega190 Analog Output							
Sensor	**(US) Standard Calibration**	**Fx,Fy (lbf)**	**Fz[2] (lbf)**	**Tx,Ty,Tz (lbf-in)**	**Fx,Fy (lbf/V)**	**Fz[2] (lbf/V)**	**Tx,Ty,Tz (lbf-in/V)**
Omega190	US-400-3000	±400	±1000	±3000	40	100	300
Omega190	US-800-6000	±800	±2000	±6000	80	200	600
Omega190	US-1600-12000	±1600	±4000	±12000	160	400	1200
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz[2] (N)**	**Tx,Ty,Tz (Nm)**	**Fx,Fy (N/V)**	**Fz[2] (N/V)**	**Tx,Ty,Tz (Nm/V)**
Omega190	SI-1800-350	±1800	±4500	±350	180	450	35
Omega190	SI-3600-700	±3600	±9000	±700	360	900	70
Omega190	SI-7200-1400	±7200	±18000	±1400	720	1800	140
		Analog Output Range			**Analog ±10V Sensitivity[1]**		

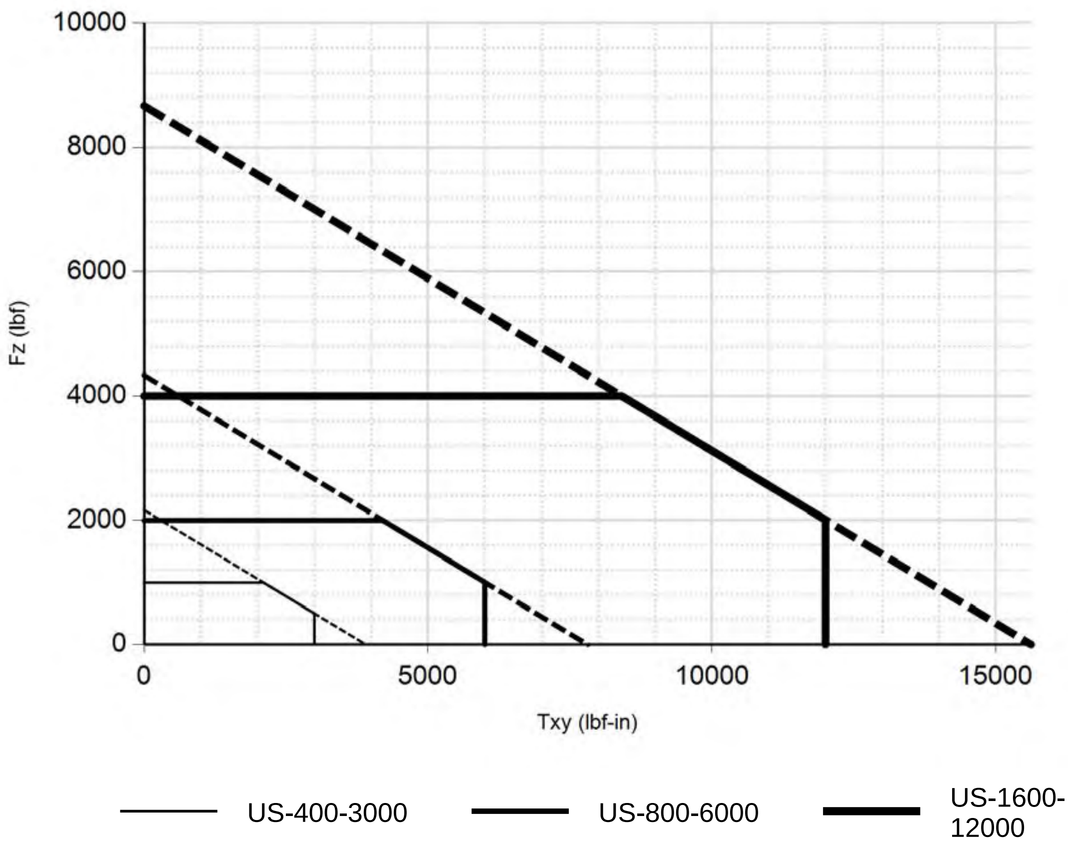
Notes:
1. ±5V Sensitivity values are double the listed ±10V Sensitivity values.
2. For IP68 version see caution on physical properties page.

5.18.5 CTL Counts Value

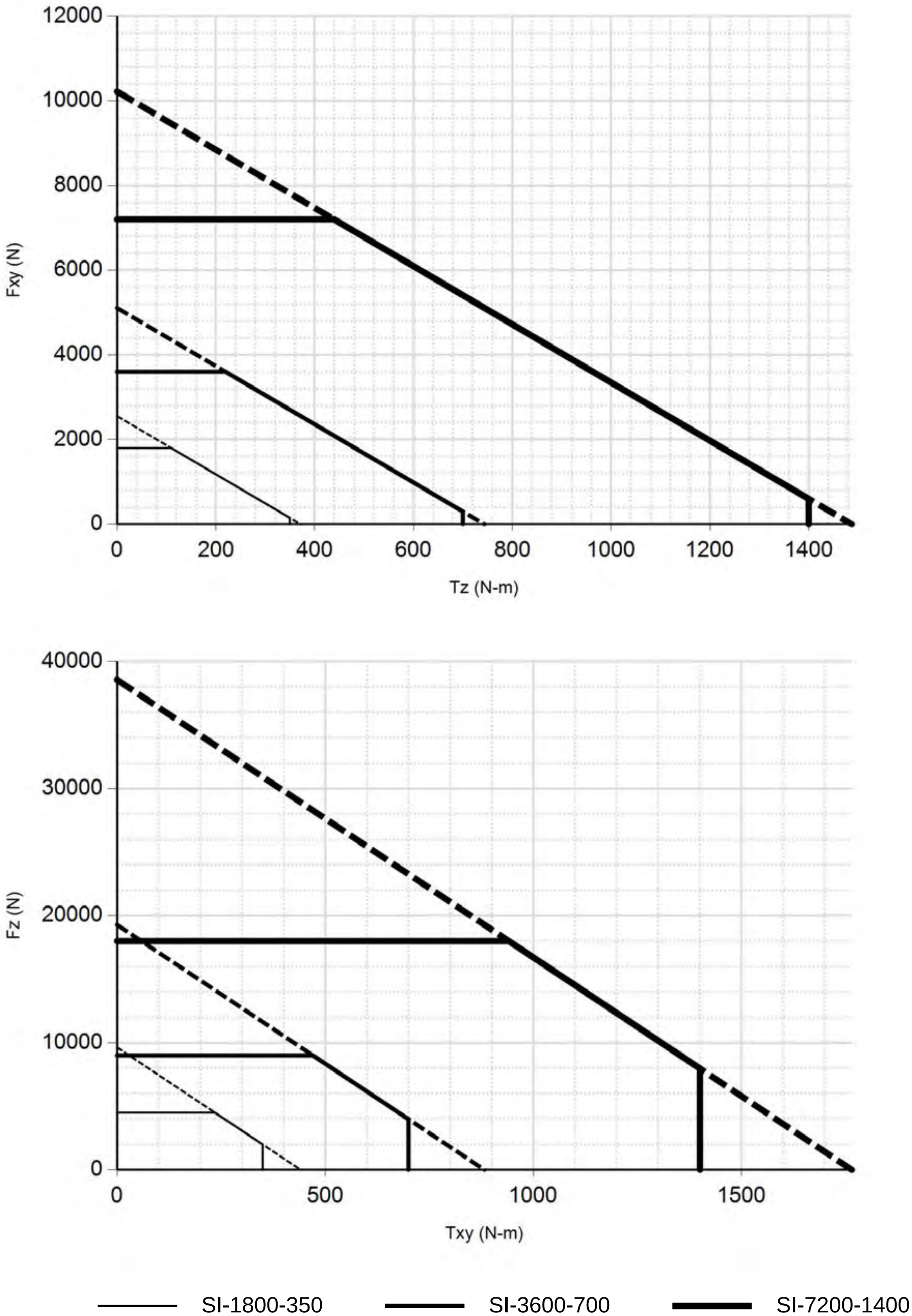
Table 5.120—Counts Value					
Sensor	**Calibration**	**Fx, Fy, Fz (/ lbf)**	**Tx, Ty, Tz (/ lbf-in)**	**Fx, Fy, Fz (/ N)**	**Tx, Ty, Tz (/ Nm)**
Omega190	US-400-3000 / SI-1800-350	153.6	307.2	32	230.4
Omega190	US-800-6000 / SI-3600-700	76.8	153.6	16	115.2
Omega190	US-1600-12000 / SI-7200-1400	38.4	76.8	8	57.6
Omega190	Tool Transform Factor	0.005 in/lbf		1.3889 mm/N	
		Counts Value – Standard (US)		**Counts Value – Metric (SI)**	

5.18.6 Omega190 (US Calibration Complex Loading)





5.18.7 Omega190 (SI Calibration Complex Loading)



5.19 Omega191 Specifications (Includes IP60/IP65/IP68 Versions)

NOTICE: For transducer versions without a through hole and without an IP rating, use a metallic adapter plate that covers the center hole.

In addition to the information in the following sections, refer to the ATI website:

Table 5.121—Omega191 Drawing and Web Links		
Model	**Drawing Part Number**	**ATI Website Address**
Omega191 DAQ/Net	*9230-05-1464*	*https://www.ati-ia.com/products/ft/ft_models.aspx?id=Omega191*
Omega191 IP60	*9230-05-1470*	*https://www.ati-ia.com/products/ft/ft_models.aspx?id=Omega191+IP60*
Omega191 IP65 Mux[1]/DAQ/Net	*9230-05-1471*	*https://www.ati-ia.com/products/ft/ft_models.aspx?id=Omega191+IP65%2fIP68*
Omega191 IP68 Mux[1]/DAQ/Net	*9230-05-1472*	

Note:
1. Mux transducers are used in F/T Controller systems.

5.19.1 Omega191 Physical Properties

Table 5.122—Omega191 Physical Properties		
Single-Axis Overload	**(US) Standard Units**	**(SI) Metric Units**
Fxy	±8000 lbf	±36000 N
Fz	±25000 lbf	±110000 N
Txy	±60000 inf-lb	±6800 Nm
Tz	±60000 inf-lb	±6800 Nm
Stiffness (Calculated)		
X-axis & Y-axis forces (Kx, Ky)	1.4×10^{6} lb/in	2.4×10^{8} N/m
Z-axis force (Kz)	2.1×10^{6} lb/in	3.6×10^{8} N/m
X-axis & Y-axis torque (Ktx, Kty)	1.4×10^{7} lbf-in/rad	1.5×10^{6} Nm/rad
Z-axis torque (Ktz)	2.8×10^{7} lbf-in/rad	3.2×10^{6} Nm/rad
Resonant Frequency		
Fx, Fy, Tz	N/A	N/A
Fz, Tx, Ty	N/A	N/A
Physical Specifications		
Weight[1]	20.8 lb	9.41 kg
Diameter[1]	7.48 in	190 mm
Height[1]	2.52 in	64 mm

Note:
1. Specifications include standard interface plates.

5.19.2 Omega191 IP60 Physical Properties

Table 5.123—Omega191 IP60 Physical Properties		
Single-Axis Overload	**(US) Standard Units**	**(SI) Metric Units**
Fxy	±8000 lbf	±36000 N
Fz	±25000 lbf	±110000 N
Txy	±60000 inf-lb	±6800 Nm
Tz	±60000 inf-lb	±6800 Nm
Stiffness (Calculated)		
X-axis & Y-axis forces (Kx, Ky)	$1.4x10^{6}$ lb/in	$2.4x10^{8}$ N/m
Z-axis force (Kz)	$2.1x10^{6}$ lb/in	$3.6x10^{8}$ N/m
X-axis & Y-axis torque (Ktx, Kty)	$1.4x10^{7}$ lbf-in/rad	$1.5x10^{6}$ Nm/rad
Z-axis torque (Ktz)	$2.8x10^{7}$ lbf-in/rad	$3.2x10^{6}$ Nm/rad
Resonant Frequency		
Fx, Fy, Tz	1200 Hz	1200 Hz
Fz, Tx, Ty	1200 Hz	1200 Hz
Physical Specifications		
Weight[1]	31 lb	14.1 kg
Diameter[1]	9.37 in	238 mm
Height[1]	2.9 in	73.7 mm
Note: 1. Specifications include standard interface plates.		

5.19.3 Omega191 IP65/IP68 Physical Properties

Table 5.124—Omega191 IP65/IP68 Physical Properties		
Single-Axis Overload	**(US) Standard Units**	**(SI) Metric Units**
Fxy	±8000 lbf	±36000 N
Fz	±25000 lbf	±110000 N
Txy	±60000 inf-lb	±6800 Nm
Tz	±60000 inf-lb	±6800 Nm
Stiffness (Calculated)		
X-axis & Y-axis forces (Kx, Ky)	$1.4x10^{6}$ lb/in	$2.4x10^{8}$ N/m
Z-axis force (Kz)	$2.1x10^{6}$ lb/in	$3.6x10^{8}$ N/m
X-axis & Y-axis torque (Ktx, Kty)	$1.4x10^{7}$ lbf-in/rad	$1.5x10^{6}$ Nm/rad
Z-axis torque (Ktz)	$2.8x10^{7}$ lbf-in/rad	$3.2x10^{6}$ Nm/rad
Resonant Frequency		
Fx, Fy, Tz	1400 Hz	1400 Hz
Fz, Tx, Ty	980 Hz	980 Hz
Physical Specifications		
Weight[1]	29 lb	13.2 kg
Diameter[1]	8.03 in	204 mm
Height[1]	2.94 in	74.8 mm
Note: 1. Specifications include standard interface plates.		

CAUTION: When submerged, IP68 transducers exhibit a decrease in Fz range related to the submersion depth. This loss is the result of pressure-induced preloading on the transducer. The preload can be masked by biasing the transducer at the depth prior to applying the load to be measured. The following estimates are for room temperature fresh water at sea level.

Submersion Depth		
IP68 Omega191	**US**	**Metric**
Fz preload at 10 m depth	661 lb	2941 N
Fz preload at other depths	-20 lb/ft × depthInFeet	-294 N/m × depthInMeters

5.19.4 Calibration Specifications (excludes CTL calibrations)

Table 5.125— Omega191 Calibrations (excludes CTL calibrations)1, 2									
Sensor	**(US) Standard Calibration**	**Fx,Fy (lbf)**	**Fz[3] (lbf)**	**Tx,Ty (lbf-in)**	**Tz (lbf-in)**	**Fx,Fy (lbf)**	**Fz[3] (lbf)**	**Tx,Ty (lbf-in)**	**Tz (lbf-in)**
Omega191	US-400-3000	400	1000	3000	3000	5/64	5/32	15/32	5/16
Omega191	US-800-6000	800	2000	6000	6000	5/32	5/16	15/16	5/8
Omega191	US-1600-12000	1600	4000	12000	12000	5/16	5/8	1 7/8	1 1/4
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz[3] (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**	**Fx,Fy (N)**	**Fz[3] (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**
Omega191	SI-1800-350	1800	4500	350	350	3/8	3/4	5/96	5/144
Omega191	SI-3600-700	3600	9000	700	700	3/4	1 1/2	5/48	5/72
Omega191	SI-7200-1400	7200	18000	1400	1400	1 1/2	3	5/24	5/36
		Sensing Ranges				**Resolution (DAQ, Net F/T)[4]**			

Notes:
1. These system resolutions quoted are the effective resolution after dropping four counts of noise. The effective resolution can be improved with filtering.
2. Applied loads must be within range in each of the six axes for the F/T sensor to measure correctly.
3. For IP68 version see caution on physical properties page.
4. DAQ resolutions are typical for a 16-bit data acquisition system.

5.19.5 CTL Calibration Specifications

Table 5.126— Omega191 CTL Calibrations1, 2									
Sensor	**(US) Standard Calibration**	**Fx,Fy (lbf)**	**Fz[3] (lbf)**	**Tx,Ty (lbf-in)**	**Tz (lbf-in)**	**Fx,Fy (lbf)**	**Fz[3] (lbf)**	**Tx,Ty (lbf-in)**	**Tz (lbf-in)**
Omega191	US-400-3000	400	1000	3000	3000	5/32	5/16	15/16	5/8
Omega191	US-800-6000	800	2000	6000	6000	5/16	5/8	1 7/8	1 1/4
Omega191	US-1600-12000	1600	4000	12000	12000	5/8	1 1/4	3 3/4	2 1/2
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz[3] (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**	**Fx,Fy (N)**	**Fz[3] (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**
Omega191	SI-1800-350	1800	4500	350	350	3/4	1 1/2	5/48	5/72
Omega191	SI-3600-700	3600	9000	700	700	1 1/2	3	5/24	5/36
Omega191	SI-7200-1400	7200	18000	1400	1400	3	6	5/12	5/18
		Sensing Ranges				**Resolution (Controller)**			

Notes:
1. CTL resolutions are typical. System resolutions quoted are the effective resolution after dropping eight counts of noise. The effective resolution can be improved with filtering.
2. Applied loads must be within range in each of the six axes for the F/T sensor to measure correctly.
3. For IP68 version see caution on physical properties page.

5.19.6 CTL Analog Output

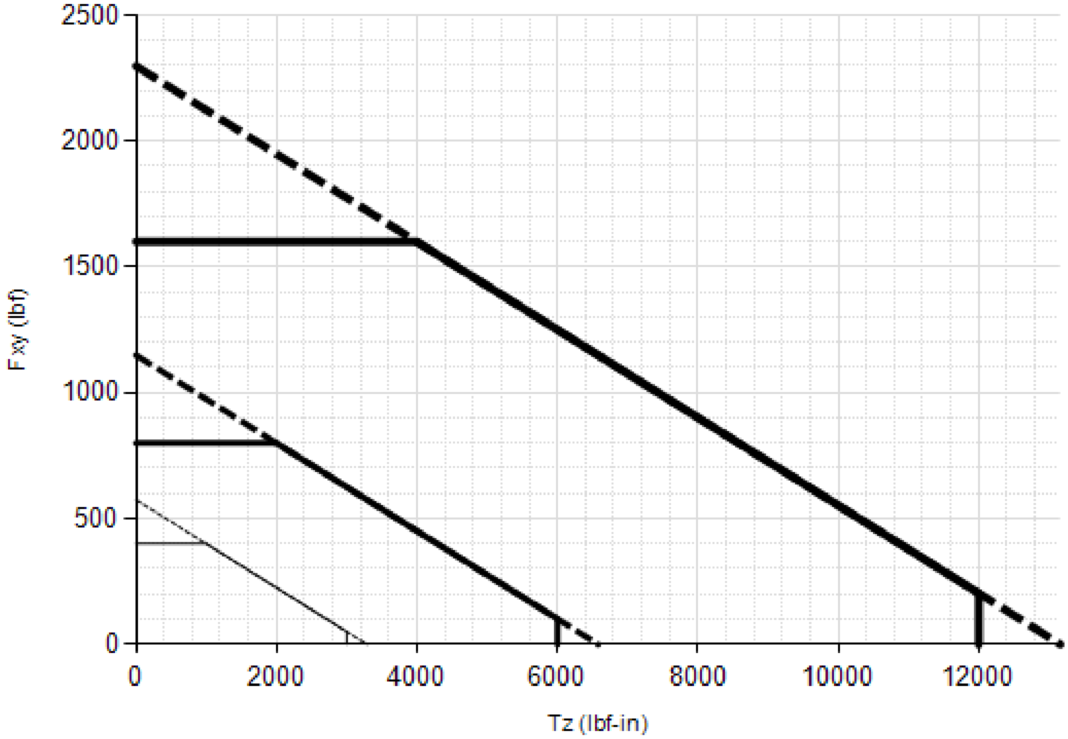
Table 5.127— Omega191 Analog Output							
Sensor	**(US) Standard Calibration**	**Fx,Fy (lbf)**	**Fz[2] (lbf)**	**Tx,Ty,Tz (lbf-in)**	**Fx,Fy (lbf/V)**	**Fz[2] (lbf/V)**	**Tx,Ty,Tz (lbf-in/V)**
Omega191	US-400-3000	±400	±1000	±3000	40	100	300
Omega191	US-800-6000	±800	±2000	±6000	80	200	600
Omega191	US-1600-12000	±1600	±4000	±12000	160	400	1200
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz[2] (N)**	**Tx,Ty,Tz (Nm)**	**Fx,Fy (N/V)**	**Fz[2] (N/V)**	**Tx,Ty,Tz (Nm/V)**
Omega191	SI-1800-350	±1800	±4500	±350	180	450	35
Omega191	SI-3600-700	±3600	±9000	±700	360	900	70
Omega191	SI-7200-1400	±7200	±18000	±1400	720	1800	140
		Analog Output Range			**Analog ±10V Sensitivity[1]**		

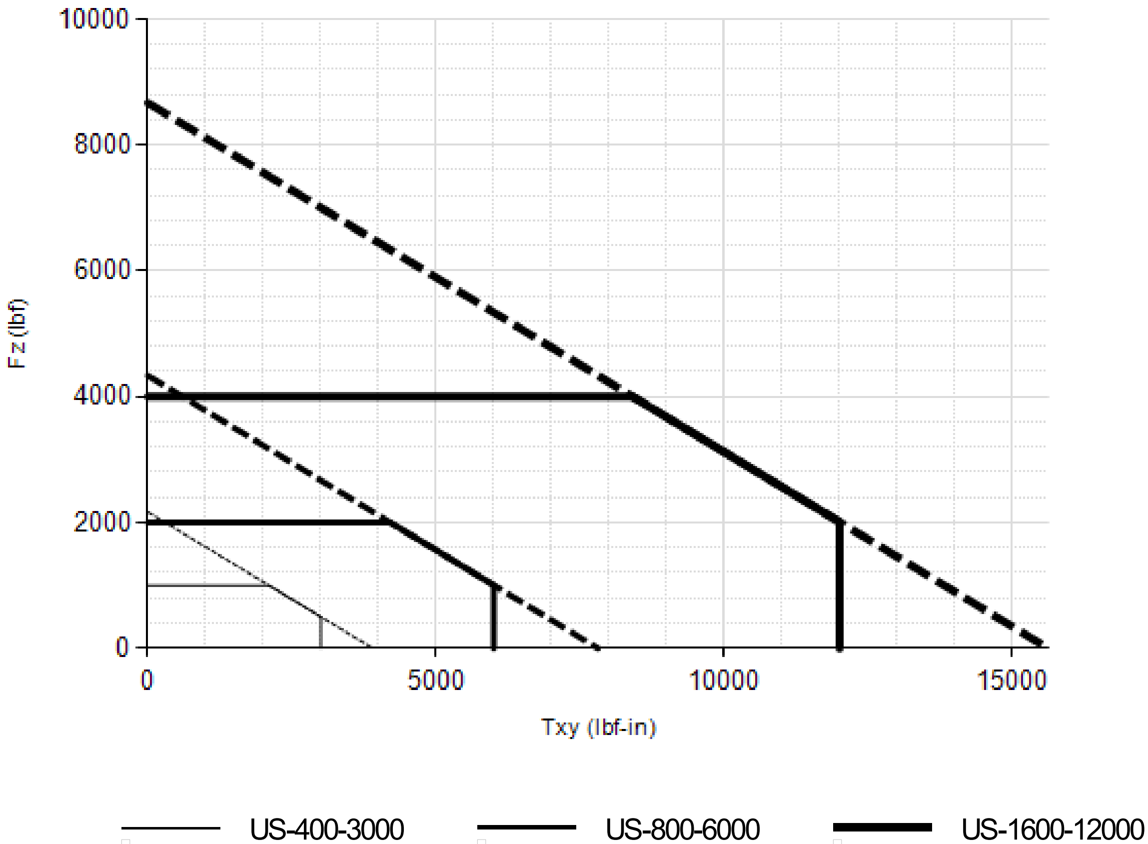
Notes:
1. ±5V Sensitivity values are double the listed ±10V Sensitivity values.
2. For IP68 version see caution on physical properties page.

5.19.7 CTL Counts Value

Table 5.128—Counts Value					
Sensor	**Calibration**	**Fx, Fy, Fz (/ lbf)**	**Tx, Ty, Tz (/ lbf-in)**	**Fx, Fy, Fz (/ N)**	**Tx, Ty, Tz (/ Nm)**
Omega191	US-400-3000 / SI-1800-350	153.6	307.2	32	230.4
Omega191	US-800-6000 / SI-3600-700	76.8	153.6	16	115.2
Omega191	US-1600-12000 / SI-7200-1400	38.4	76.8	8	57.6
Omega191	Tool Transform Factor	0.005 in/lbf		1.3889 mm/N	
		Counts Value – Standard (US)		**Counts Value – Metric (SI)**	

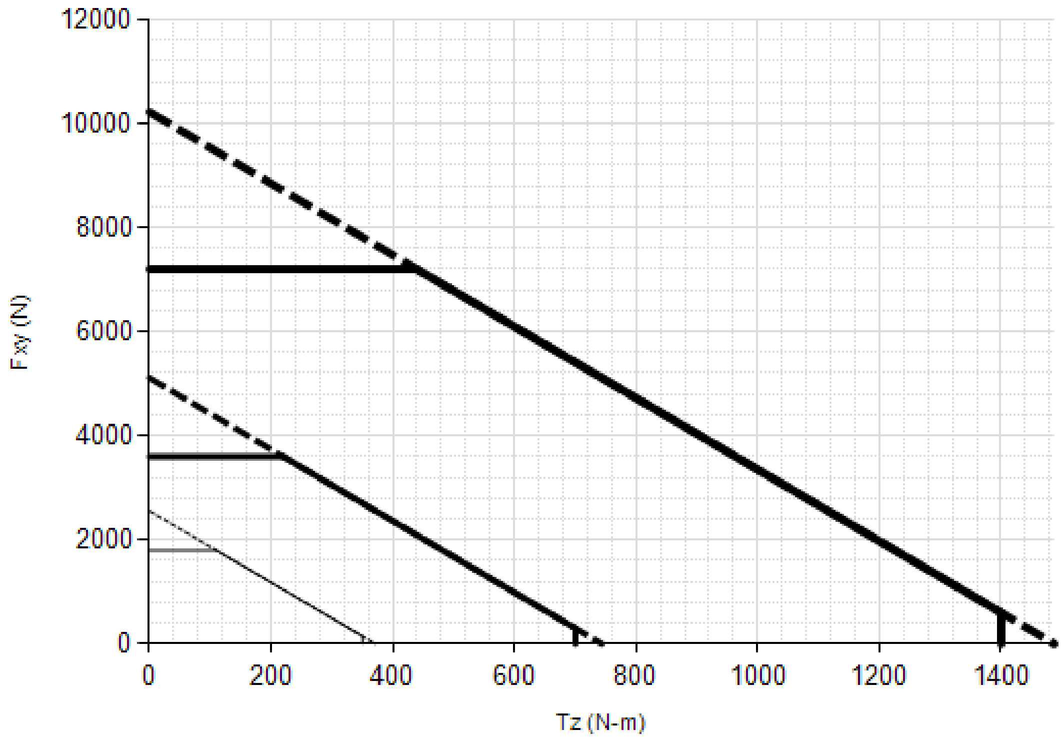
5.19.8 Omega191 (US Calibration Complex Loading) (Includes IP60/IP65/IP68)[1]

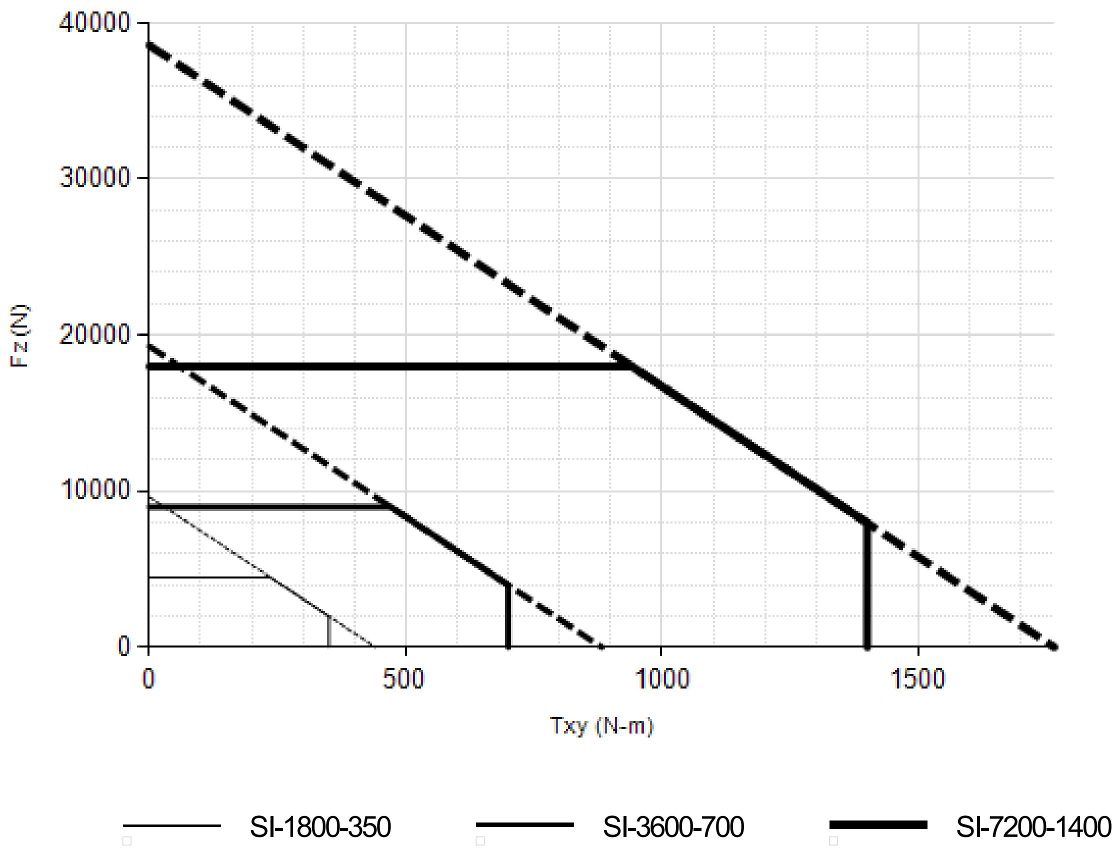




Note: 1. For IP68 version see caution on physical properties page.

5.19.9 Omega191 (SI Calibration Complex Loading) (Includes IP60/IP65/IP68)[1]





Note: 1. For IP68 version see caution on physical properties page.

5.20 Omega250 Specifications (Includes IP60/IP65/IP68)

In addition to the information in the following sections, refer to the ATI website:

Table 5.129—Omega250 Drawing and Web Links		
Model	**Drawing Part Number**	**ATI Website Address**
Omega250 DAQ/Net	*9230-05-1468*	*https://www.ati-ia.com/products/ft/ft_models.aspx?id=Omega250+IP60*
Omega250 IP60	*9230-05-1266*	
Omega250 IP65	*9230-05-1271*	*https://www.ati-ia.com/products/ft/ft_models.aspx?id=Omega250+IP65%2fIP68*
Omega250 IP68-10 m	*9230-05-1276*	

5.20.1 Omega250 Physical Properties (Includes IP60/IP65/IP68)

Table 5.130—Omega250 Physical Properties (Includes IP60/IP65/IP68)		
Single-Axis Overload	**(US) Standard Units**	**(SI) Metric Units**
Fxy	±37000 lbf	±160000 N
Fz	±74000 lbf	±330000 N
Txy	±180000 inf-lb	±21000 Nm
Tz	±220000 inf-lb	±25000 Nm
Stiffness (Calculated)		
X-axis & Y-axis forces (Kx, Ky)	$2.4x10^{6}$ lb/in	$4.2x10^{8}$ N/m
Z-axis force (Kz)	$3.2x10^{6}$ lb/in	$5.6x10^{8}$ N/m
X-axis & Y-axis torque (Ktx, Kty)	$2.7x10^{7}$ lbf-in/rad	$3.0x10^{6}$ Nm/rad
Z-axis torque (Ktz)	$5.5x10^{7}$ lbf-in/rad	$6.2x10^{6}$ Nm/rad
Resonant Frequency		
Fx, Fy, Tz	780 Hz	780 Hz
Fz, Tx, Ty	770 Hz	770 Hz
Physical Specifications		
Weight[1]	70 lb	31.8 kg
Diameter[1]	11.6 in	295 mm
Height[1]	3.74 in	94.9 mm
Note: 1. Specifications include standard interface plates.		

CAUTION: When submerged, IP68 transducers exhibit a decrease in Fz range related to the submersion depth. This loss is the result of pressure-induced preloading on the transducer. The preload can be masked by biasing the transducer at the depth prior to applying the load to be measured. The following estimates are for room temperature fresh water at sea level.

Submersion Depth		
IP68 Omega250	**US**	**Metric**
Fz preload at 10 m depth	-1138 lb	-5061 N
Fz preload at other depths	-35 lb/ft × depthInFeet	-506 N/m × depthInMeters

5.20.2 Calibration Specifications (excludes CTL calibrations)

Table 5.131— Omega250 Calibrations (excludes CTL calibrations)1, 2									
Sensor	**(US) Standard Calibration**	**Fx,Fy (lbf)**	**Fz³ (lbf)**	**Tx,Ty (lbf-in)**	**Tz (lbf-in)**	**Fx,Fy (lbf)**	**Fz³ (lbf)**	**Tx,Ty (lbf-in)**	**Tz (lbf-in)**
Omega250	US-900-4500	900	1800	4500	4500	1/2	1/2	1	1
Omega250	US-1800-9000	1800	3600	9000	9000	1	1	2	2
Omega250	US-3600-18000	3600	7200	18000	18000	2	2	5	5
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz³ (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**	**Fx,Fy (N)**	**Fz³ (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**
Omega250	SI-4000-500	4000	8000	500	500	1	2	1/8	1/8
Omega250	SI-8000-1000	8000	16000	1000	1000	2	4	1/4	1/4
Omega250	SI-16000-2000	16000	32000	2000	2000	4	8	1/2	1/2
		Sensing Ranges				**Resolution (DAQ, Net F/T)⁴**			

Notes:
1. These system resolutions quoted are the effective resolution after dropping four counts of noise. The effective resolution can be improved with filtering.
2. Applied loads must be within range in each of the six axes for the F/T sensor to measure correctly.
3. For IP68 version see caution on physical properties page.
4. DAQ resolutions are typical for a 16-bit data acquisition system.

5.20.3 CTL Calibration Specifications

Table 5.132— Omega250 CTL Calibrations1, 2									
Sensor	**(US) Standard Calibration**	**Fx,Fy (lbf)**	**Fz³ (lbf)**	**Tx,Ty (lbf-in)**	**Tz (lbf-in)**	**Fx,Fy (lbf)**	**Fz³ (lbf)**	**Tx,Ty (lbf-in)**	**Tz (lbf-in)**
Omega250	US-900-4500	900	1800	4500	4500	1	1	2	2
Omega250	US-1800-9000	1800	3600	9000	9000	2	2	5	5
Omega250	US-3600-18000	3600	7200	18000	18000	5	5	10	10
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz³ (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**	**Fx,Fy (N)**	**Fz³ (N)**	**Tx,Ty (Nm)**	**Tz (Nm)**
Omega250	SI-4000-500	4000	8000	500	500	2	4	1/4	1/4
Omega250	SI-8000-1000	8000	16000	1000	1000	4	8	1/2	1/2
Omega250	SI-16000-2000	16000	32000	2000	2000	8	16	1	1
		Sensing Ranges				**Resolution (Controller)**			

Notes:
1. CTL resolutions are typical. System resolutions quoted are the effective resolution after dropping eight counts of noise. The effective resolution can be improved with filtering.
2. Applied loads must be within range in each of the six axes for the F/T sensor to measure correctly.
3. For IP68 version see caution on physical properties page.

5.20.4 CTL Analog Output

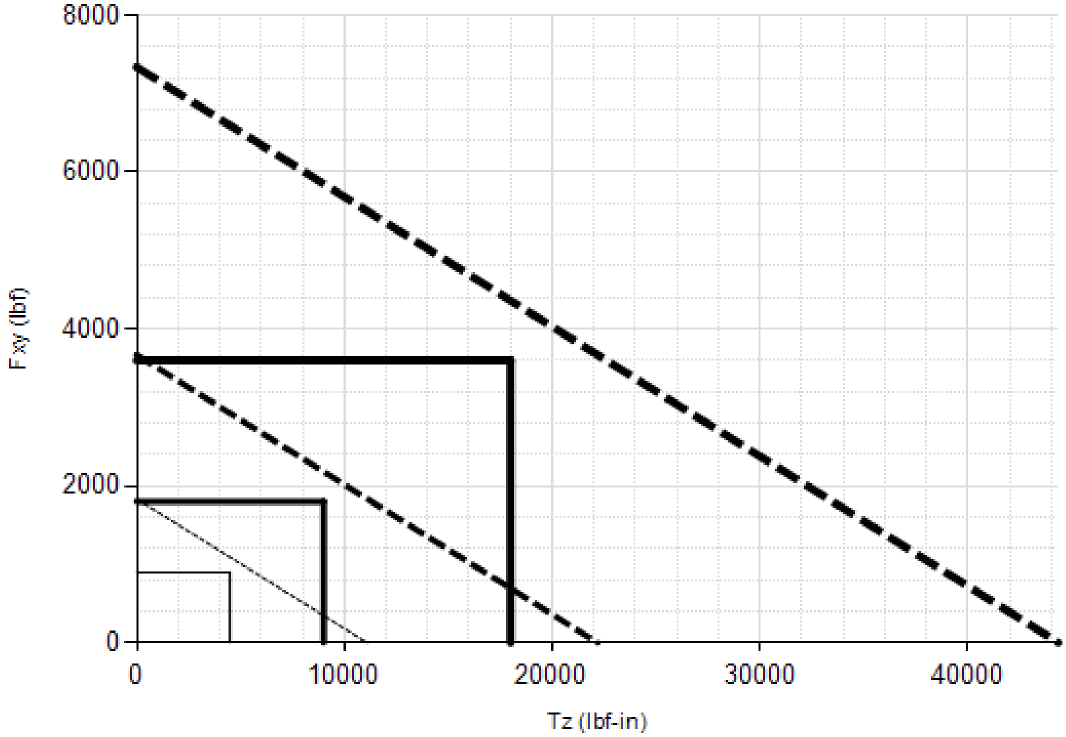
Table 5.133— Omega250 Analog Output							
Sensor	**(US) Standard Calibration**	**Fx,Fy (lbf)**	**Fz[2] (lbf)**	**Tx,Ty,Tz (lbf-in)**	**Fx,Fy (lbf/V)**	**Fz[2] (lbf/V)**	**Tx,Ty,Tz (lbf-in/V)**
Omega250	US-900-4500	±900	±1800	±4500	90	180	450
Omega250	US-1800-9000	±1800	±3600	±9000	180	360	900
Omega250	US-3600-18000	±3600	±7200	±18000	360	720	1800
Sensor	**(SI) Metric Calibration**	**Fx,Fy (N)**	**Fz[2] (N)**	**Tx,Ty,Tz (Nm)**	**Fx,Fy (N/V)**	**Fz[2] (N/V)**	**Tx,Ty,Tz (Nm/V)**
Omega250	SI-4000-500	±4000	±8000	±500	400	800	50
Omega250	SI-8000-1000	±8000	±16000	±1000	800	1600	100
Omega250	SI-16000-2000	±16000	±32000	±2000	1600	3200	200
		Analog Output Range			**Analog ±10V Sensitivity[1]**		

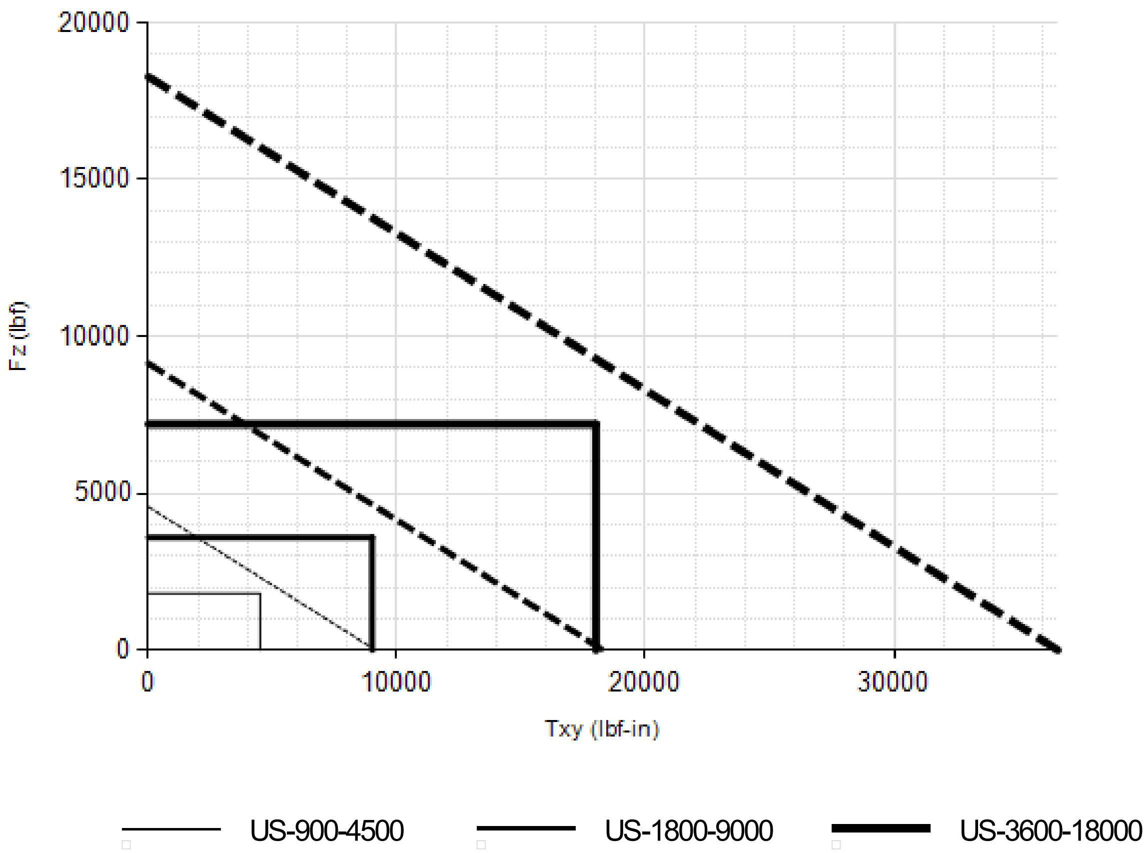
Notes:
1. ±5V Sensitivity values are double the listed ±10V Sensitivity values.
2. For IP68 version see caution on physical properties page.

5.20.5 CTL Counts Value

Table 5.134—Counts Value					
Sensor	**Calibration**	**Fx, Fy, Fz (/ lbf)**	**Tx, Ty, Tz (/ lbf-in)**	**Fx, Fy, Fz (/ N)**	**Tx, Ty, Tz (/ Nm)**
Omega250	US-900–4500 / SI-4000–500	8	4	4000	32000
Omega250	US-1800–9000 / SI-8000–1000	4	2	2000	16000
Omega250	US-3600–18000 / SI-16000-2000	2	1	1000	8000
Omega250	Tool Transform Factor	0.02 in/lbf		1.25 mm/N	
		Counts Value – Standard (US)		**Counts Value – Metric (SI)**	

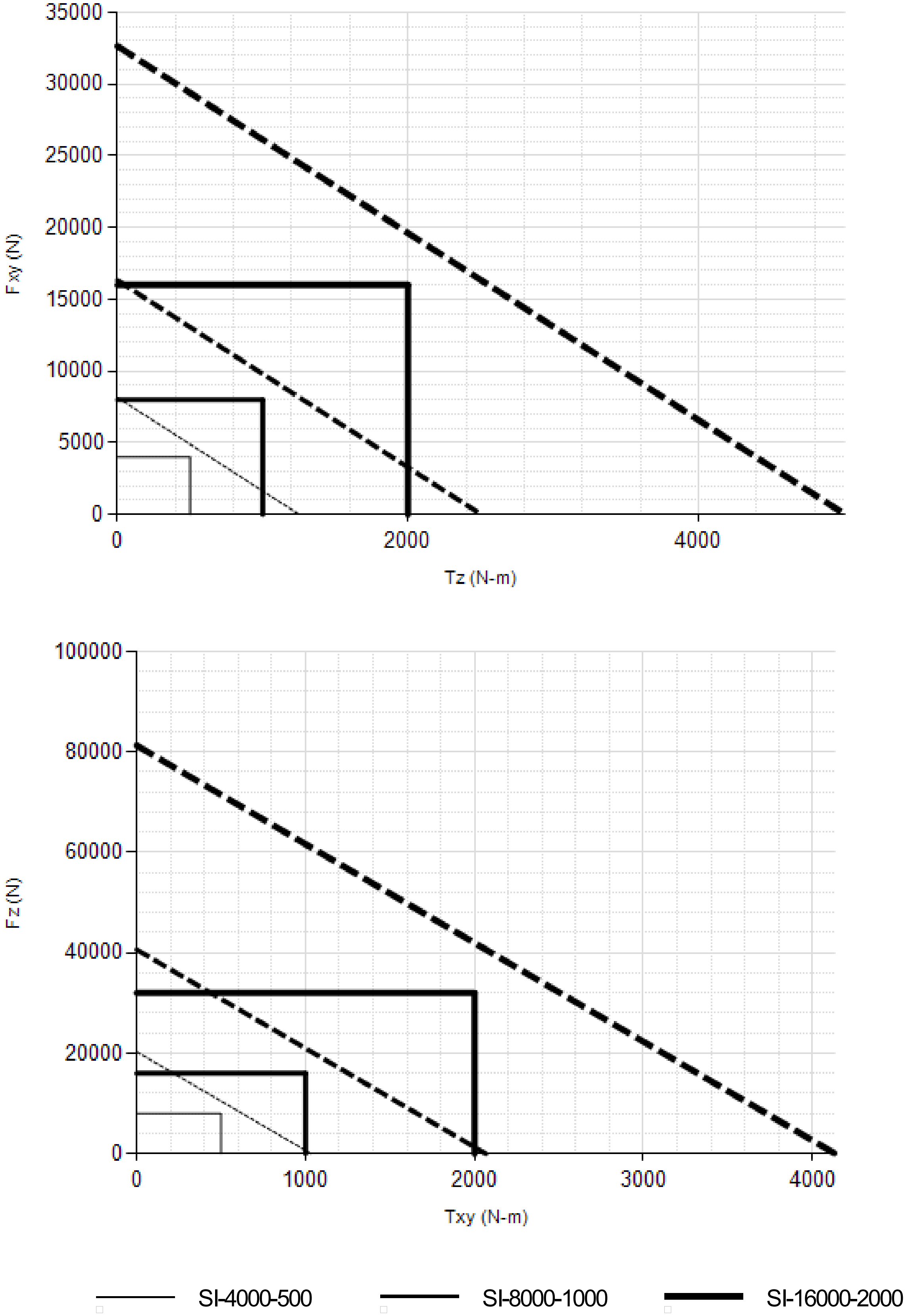
5.20.6 Omega250 (US Calibration Complex Loading) (Includes IP60/IP65/IP68)[1]





Note: 1. For IP68 version see caution on physical properties page.

5.20.7 Omega250 (SI Calibration Complex Loading) (Includes IP60/IP65/IP68)[1]



Note: 1. For IP68 version see caution on physical properties page.

5.21 Omega331 Specifications (Includes IP65)

In addition to the information in the following sections, refer to the ATI website:

Table 5.135—Omega331 Drawing and Web Links		
Model	**Drawing Part Number**	**ATI Website Address**
Omega331	*9230-05-1158*	*https://www.ati-ia.com/products/ft/ft_models.aspx?id=Omega331*
Omega331 IP65	*9230-05-1360*	

5.21.1 Omega331 Physical Properties (Includes IP65)

Table 5.136—Omega331 Physical Properties (Includes IP60/IP65)		
Single-Axis Overload	**(US) Standard Units**	**(SI) Metric Units**
Fxy	±53000 lbf	±240000 N
Fz	±120000 lbf	±520000 N
Txy	±280000 inf-lb	±32000 Nm
Tz	±320000 inf-lb	±36000 Nm
Stiffness (Calculated)		
X-axis & Y-axis forces (Kx, Ky)	$6.9x10^{6}$ lb/in	$1.2x10^{9}$ N/m
Z-axis force (Kz)	$7.3x10^{6}$ lb/in	$1.3x10^{9}$ N/m
X-axis & Y-axis torque (Ktx, Kty)	$8.1x10^{7}$ lbf-in/rad	$9.2x10^{6}$ Nm/rad
Z-axis torque (Ktz)	$2.1x10^{8}$ lbf-in/rad	$2.4x10^{7}$ Nm/rad
Resonant Frequency		
Fx, Fy, Tz	N/A	N/A
Fz, Tx, Ty	N/A	N/A
Physical Specifications		
Weight[1]	104 lb	47 kg
Diameter[1]	13 in	330 mm
Height[1]	4.22 in	107 mm
Note: 1. Specifications include standard interface plates.		

5.21.2 Calibration Specifications (excludes CTL calibrations)

Table 5.137— Omega331 Calibrations (excludes CTL calibrations)1, 2									
Sensor	**(US) Standard Calibration**	**Fx,Fy (lbf)**	**Fz (lbf)**	**Tx,Ty (lbf-in)**	**Tz (lbf-in)**	**Fx,Fy (lbf)**	**Fz (lbf)**	**Tx,Ty (lbf-in)**	**Tz (lbf-in)**
Omega331	US-2250-13000	2250	5250	13000	13000	3/8	1	3 3/4	1 7/8
Omega331	US-4500-26000	4500	10500	26000	26000	3/4	2	7 1/2	3 3/4
Omega331	US-9000-52000	9000	21000	52000	52000	1 1/2	4	15	7 1/2
Sensor	**(SI) Metric Calibration**	**Fx,Fy (kN)**	**Fz (kN)**	**Tx,Ty (kNm)**	**Tz (kNm)**	**Fx,Fy (kN)**	**Fz (kN)**	**Tx,Ty (kNm)**	**Tz (kNm)**
Omega331	SI-10000-1500	10	22	1.5	1.5	1/640	1/240	3/8000	3/16000
Omega331	SI-20000-3000	20	44	3	3	1/320	1/120	3/4000	3/8000
Omega331	SI-40000-6000	40	88	6	6	1/160	1/60	3/2000	3/4000
		Sensing Ranges				**Resolution (DAQ, Net F/T)[3]**			

Notes:
1. These system resolutions quoted are the effective resolution after dropping four counts of noise. The effective resolution can be improved with filtering.
2. Applied loads must be within range in each of the six axes for the F/T sensor to measure correctly.
3. DAQ resolutions are typical for a 16-bit data acquisition system.

5.21.3 CTL Calibration Specifications

Table 5.138— Omega331 CTL Calibrations1, 2									
Sensor	**(US) Standard Calibration**	**Fx,Fy (lbf)**	**Fz (lbf)**	**Tx,Ty (lbf-in)**	**Tz (lbf-in)**	**Fx,Fy (lbf)**	**Fz (lbf)**	**Tx,Ty (lbf-in)**	**Tz (lbf-in)**
Omega331	US-2250-13000	2250	5250	13000	13000	3/4	2	7 1/2	3 3/4
Omega331	US-4500-26000	4500	10500	26000	26000	1 1/2	4	15	7 1/2
Omega331	US-9000-52000	9000	21000	52000	52000	3	8	30	15
Sensor	**(SI) Metric Calibration**	**Fx,Fy (kN)**	**Fz (kN)**	**Tx,Ty (kNm)**	**Tz (kNm)**	**Fx,Fy (kN)**	**Fz (kN)**	**Tx,Ty (kNm)**	**Tz (kNm)**
Omega331	SI-10000-1500	10	22	1.5	1.5	1/320	1/120	3/4000	3/8000
Omega331	SI-20000-3000	20	44	3	3	1/160	1/60	3/2000	3/4000
Omega331	SI-40000-6000	40	88	6	6	1/80	1/30	3/1000	3/2000
		Sensing Ranges				**Resolution (Controller)**			

Notes:
1. CTL resolutions are typical. System resolutions quoted are the effective resolution after dropping eight counts of noise. The effective resolution can be improved with filtering.
2. Applied loads must be within range in each of the six axes for the F/T sensor to measure correctly.

5.21.4 CTL Analog Output

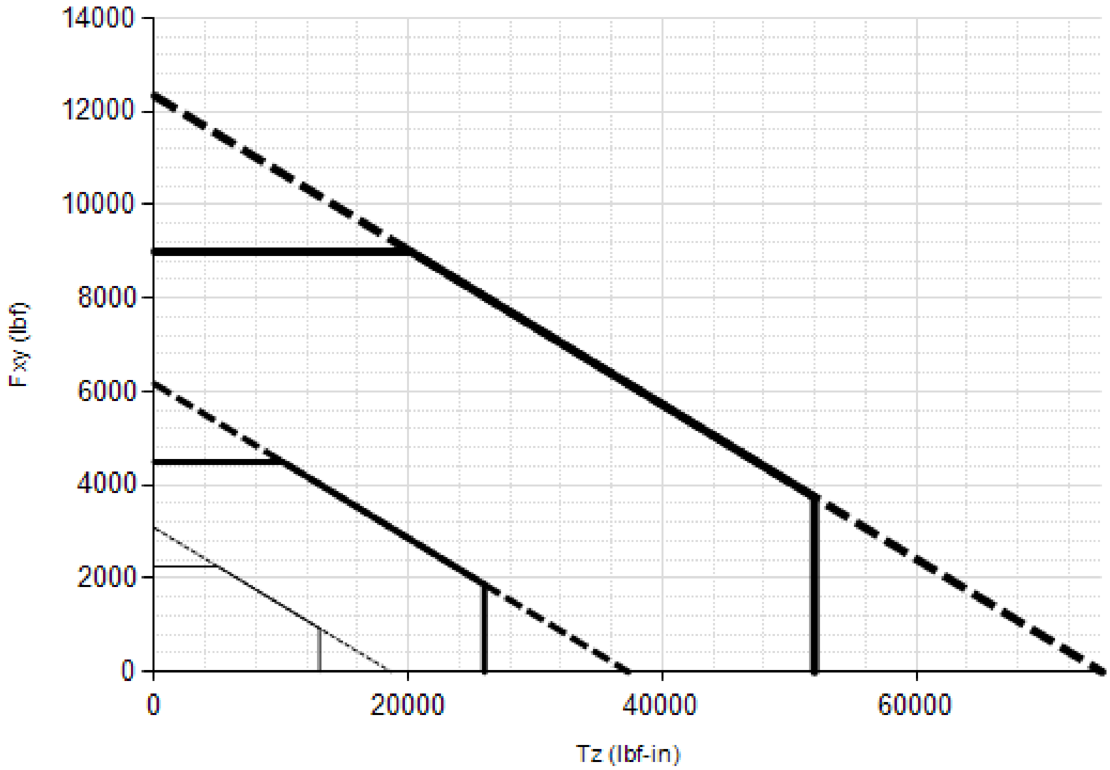
Table 5.139— Omega331 Analog Output							
Sensor	**(US) Standard Calibration**	**Fx,Fy (lbf)**	**Fz (lbf)**	**Tx,Ty,Tz (lbf-in)**	**Fx,Fy (lbf/V)**	**Fz (lbf/V)**	**Tx,Ty,Tz (lbf-in/V)**
Omega331	US-2250-13000	±2250	±5250	±13000	225	525	1300
Omega331	US-4500-26000	±4500	±10500	±26000	450	1050	2600
Omega331	US-9000-52000	±9000	±21000	±52000	900	2100	5200
Sensor	**(SI) Metric Calibration**	**Fx,Fy (kN)**	**Fz (kN)**	**Tx,Ty,Tz (kNm)**	**Fx,Fy (kN/V)**	**Fz (kN/V)**	**Tx,Ty,Tz (kNm/V)**
Omega331	SI-10000-1500	±10	±22	±1.5	1	2.2	0.15
Omega331	SI-20000-3000	±20	±44	±3	2	4.4	0.3
Omega331	SI-40000-6000	±40	±88	±6	4	8.8	0.6
		Analog Output Range			**Analog ±10V Sensitivity[1]**		

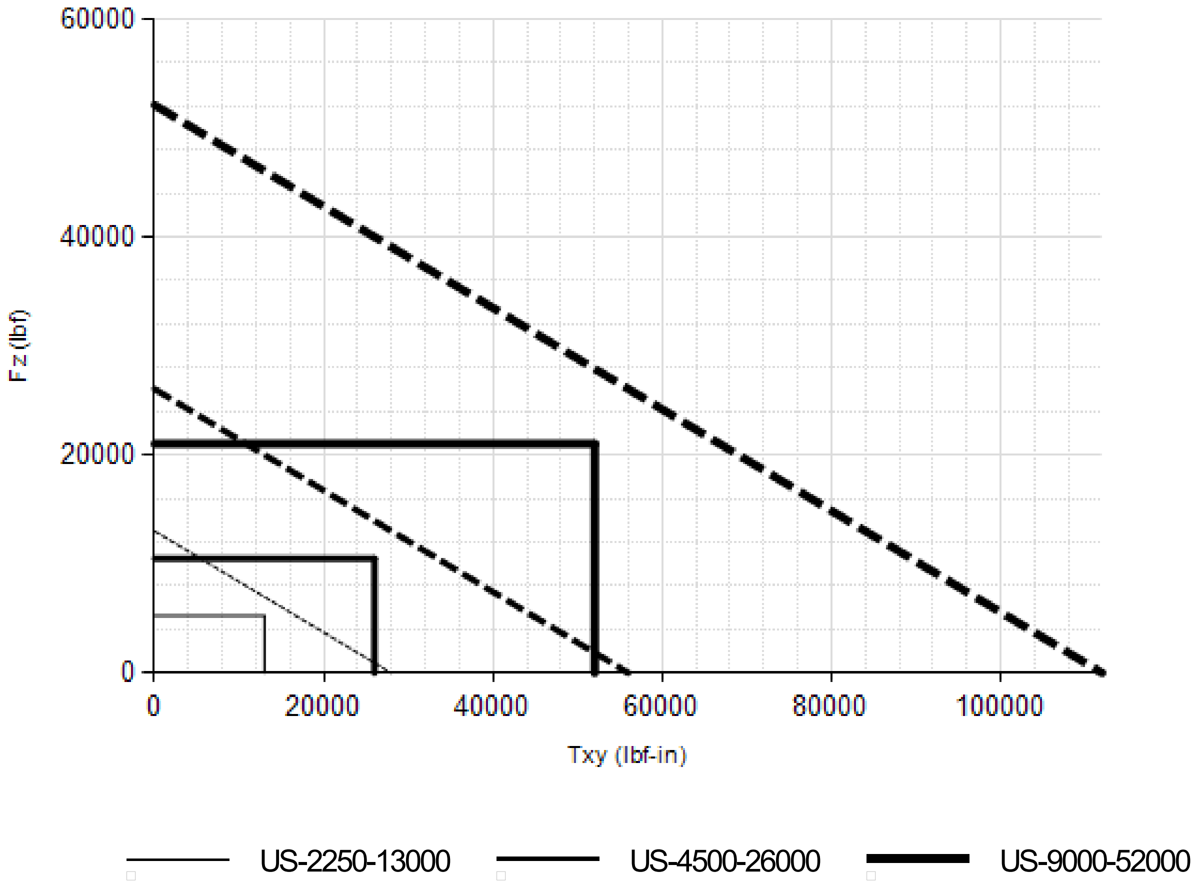
Notes:
1. ±5V Sensitivity values are double the listed ±10V Sensitivity values.

5.21.5 CTL Counts Value

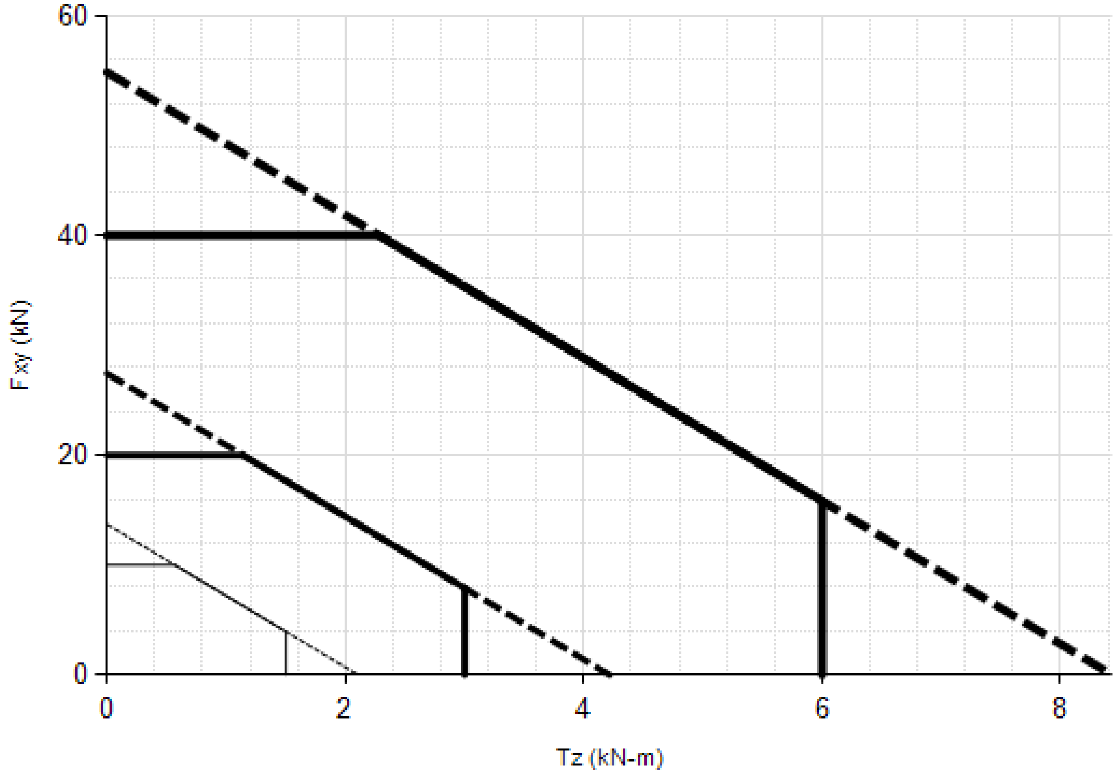
Table 5.140—Counts Value					
Sensor	**Calibration**	**Fx, Fy, Fz (/ lbf)**	**Tx, Ty, Tz (/ lbf-in)**	**Fx, Fy, Fz (/ kN)**	**Tx, Ty, Tz (/ kNm)**
Omega331	US-2250–13000 / SI-10000–1500	32	6.4	7680	64000
Omega331	US-4500–26000 / SI-20000–3000	16	3.2	3840	32000
Omega331	US-9000–52000 / SI-40000–6000	8	1.6	1920	16000
Omega331	Tool Transform Factor	0.05 in/lbf		1.2 mm/N	
		Counts Value – Standard (US)		**Counts Value – Metric (SI)**	

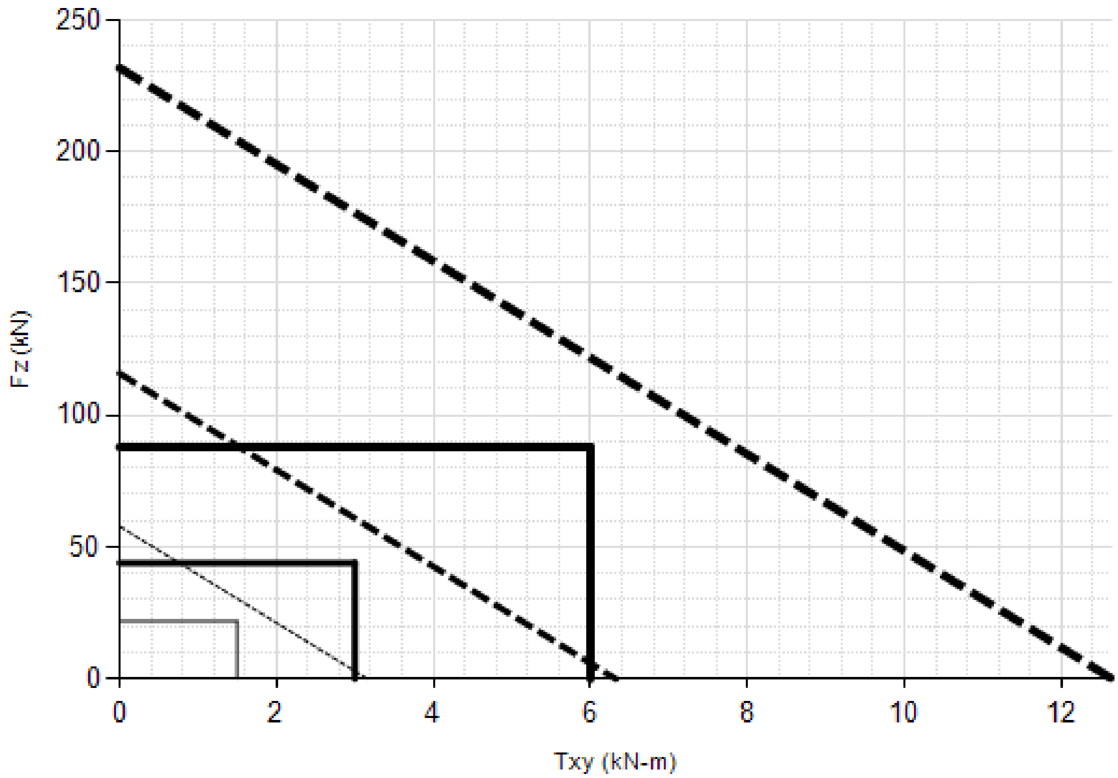
5.21.6 Omega331 (US Calibration Complex Loading) (Includes IP65)





5.21.7 Omega331 (SI Calibration Complex Loading) (Includes IP65)





SI-10000-1500 SI-20000-3000 SI-40000-6000

6. Diagnostics and Maintenance

6.1 Reducing Noise

6.1.1 Mechanical Vibration

In many cases, perceived noise is actually a real fluctuation of force and/or torque. This fluctuation is caused by vibrations in the tooling or the robot arm. Many F/T systems offer filtering or averaging that can smooth out noise. If this is not sufficient, consider adding a digital filter to the application software.

6.1.2 Electrical Interference

If interference by motors or other noise-generating equipment is observed, check the F/T's ground connections.

If sufficient grounding is not possible or does not reduce the noise, consider using averaging or filtering.

6.2 Detecting Failures (Diagnostics)

6.2.1 Detecting Sensitivity Changes

Sensitivity checking of the transducer can also be used to measure the transducer system's health. Apply known loads to the transducer and verifying the system output matches the known loads, for example: a transducer mounted to a robot arm may have an end-effector attached to it. If the end-effector has moving parts, they must be moved in a known position.

This check is done by completing the following steps:

1. Place the robot arm in an orientation that allows the gravity load from the end-effector to exert load on many transducer 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, and use it as the sensitivity value.

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

CAUTION: When any strain gage is saturated or otherwise inoperable, **all transducer F/T readings are invalid**. It is vitally important to monitor for these conditions.

6.3 Scheduled Maintenance

6.3.1 Periodic Inspection

For most applications, there are no parts that need to be replaced during normal operation. With industrial-type applications that continuously or frequently move the system's cabling, you should periodically check the cable jacket for signs of wear. These applications should implement the procedures discussed in *Section 6.2—Detecting Failures (Diagnostics)* to detect any failures.

Transducers that are not IP60, IP65, or IP68 rated must be kept free of excessive dust, debris, or moisture. IP60-rated transducers must be kept free of excessive moisture. Debris and dust should be kept from accumulating on or in a transducer.

6.3.2 Periodic Calibration

Periodic calibration of the transducer and its electronics is required to maintain traceability to national standards. Follow any applicable ISO-9000-type standards for calibration. ATI Industrial Automation recommends annual recalibrations, especially for applications that frequently cycle the loads applied to the transducer.

6.4 A Note on Servicing Transducer Cabling

6.4.1 Calibrations

In many cases the transducer cable comprises part of the calibrated transducer. In these cases, changing the length or type of the cable can affect the calibration. When making cabling changes, check with ATI Industrial Automation to ensure the system's calibration is not be affected.

6.4.2 Cabling and Connectors

The transducer cables and connectors are not designed to be serviced by users, for example: the high flex life stranding in the cables is difficult to service and if improperly assembled, the stranding fails.

However, in some cases, users many need to temporarily remove the connector on a cable that is permanently attached to a transducer such as Nano and Mini models. When reattaching the wires to the connector, encase each conductor in heat shrink tubing at the connection to prevent premature fatiguing of the mechanical connection. Also, exactly reconnect any components contained in the connector; otherwise, improper service impacts system performance and accuracy.

To prevent transducer damage, ensure the cable jacketing is in proper condition. Damage to the outer jacketing of the transducer cable enables moisture or water to enter an otherwise sealed transducer.

6.5 Resolution

ATI's transducers have a three sensing beam configuration where the three beams are equally spaced around a central hub and attached to the outside wall of the transducer. This three beam configuration transfers applied loads to multiple sensing beams. Also if a counterpart axis has reduced, this configuration allows the transducer to increase its sensing range in a given axis.

The resolution of each transducer axis depends on how the applied load is spread among the sensing beams. The best resolution occurs when the quantization of the gages is evenly distributed as load is applied. In the worst case scenario, the discrete value of all involved gages increases at the same time.

F/T resolutions are specified as typical resolution which is the average of the worst and best case scenarios. Because both multi-gage effects can be modeled as a normal distribution, this value represents the most commonly perceived, average resolution. Although this misrepresents the actual performance of the transducers, it results in a close (and always conservative) estimate.

7. 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 year from the date of shipment. This warranty does not cover components subject to wear and tear under normal usage or those requiring periodic replacement. ATI will have no liability under this warranty unless: (a) ATI is given written notice of the claimed defect and a description thereof within 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 ten (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 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.

Unless otherwise agreed in writing by ATI, all designs, drawings, data, inventions, software and other technology made or developed by ATI in the course of providing products and services hereunder, and all rights therein under any patent, copyright or other law protecting intellectual property, shall be and remain ATI's property. The sale of products or services hereunder does not convey any express or implied license under any patent, copyright or other intellectual property right owned or controlled by ATI, whether relating to the products sold or any other matter, except for the license expressly granted below.

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Without ATI's prior written permission, Purchaser will not use such information for any other purpose or provide or otherwise make such information available to any third party. Purchaser agrees to take all reasonable precautions to prevent any unauthorized use or disclosure of such information.

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