



## F/T Sensor Data Acquisition (DAQ) Systems

Manual



Document #: 9620-05-DAQ

## Foreword

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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)

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## Table of Contents

<b>Foreword .....</b>	<b>2</b>
<b>Glossary .....</b>	<b>6</b>
<b>1. Safety.....</b>	<b>7</b>
1.1 <b>Explanation of Notifications.....</b>	<b>7</b>
1.2 <b>General Safety Guidelines.....</b>	<b>7</b>
1.3 <b>Safety Precautions .....</b>	<b>7</b>
<b>2. Product Overview .....</b>	<b>8</b>
2.1 <b>System with a TW Transducer, IFPS Box, and USB DAQ Device .....</b>	<b>8</b>
2.2 <b>System with a TIF Transducer, PS Box, and DAQ Card.....</b>	<b>10</b>
2.3 <b>System with Multiple Transducers, IFPSMC Box, and a USB DAQ Device .....</b>	<b>11</b>
2.4 <b>System with Multiple Transducers, IFPSMC Box, and a DAQ Card .....</b>	<b>12</b>
2.5 <b>System with Multiple Transducers, IFPSMC Box, Wired I/O Connections for User Devices, and USB DAQ Device.....</b>	<b>13</b>
2.6 <b>System with BNC Interface Box.....</b>	<b>14</b>
2.7 <b>Transducer .....</b>	<b>15</b>
2.8 <b>Transducer Cable .....</b>	<b>15</b>
2.9 <b>Interface Power Supply Box.....</b>	<b>16</b>
2.10 <b>Power Supply Box.....</b>	<b>17</b>
2.11 <b>Power Supply Cable .....</b>	<b>17</b>
2.12 <b>Multiple IFPSMC Boxes .....</b>	<b>18</b>
2.13 <b>DAQ Shielded Cables from Multiple IFPSMC Box to DAQ Device.....</b>	<b>18</b>
2.14 <b>Data Acquisition System .....</b>	<b>19</b>
2.15 <b>BNC Interface Box.....</b>	<b>19</b>
2.16 <b>DAQ System Software Overview .....</b>	<b>20</b>
2.17 <b>Interface Plates.....</b>	<b>20</b>
<b>3. System Functionality .....</b>	<b>21</b>
3.1 <b>Mechanical Description .....</b>	<b>21</b>
3.2 <b>Electronic Hardware.....</b>	<b>22</b>
3.3 <b>Load Calculation .....</b>	<b>23</b>
3.3.1 <b>Strain Gage Data.....</b>	<b>24</b>
3.3.2 <b>Offset Correction .....</b>	<b>24</b>
3.3.3 <b>Calibration Matrix .....</b>	<b>24</b>
3.3.4 <b>Gain Correction Factor .....</b>	<b>25</b>

<b>3.4 ATI DAQ Software.....</b>	<b>26</b>
3.4.1 Reusable Software Components.....	26
3.4.1.1 ATI DAQ FT Automation Server.....	26
3.4.1.2 C Library .....	26
3.4.2 Sample Applications .....	26
3.4.2.1 Windows Demo (Visual Basic 6.0).....	26
3.4.2.2 LabVIEW Sample .....	26
3.4.3 Designing a Customized DAQ F/T Application.....	27
3.4.3.1 Device Drivers for a DAQ Device and Target Operating System.....	27
3.4.3.2 ATI DAQ F/T Components or C Library .....	27
<b>4. Installation .....</b>	<b>28</b>
4.1 Installing a DAQ System with a Transducer, IFPS or PS Box, and DAQ Device .....	28
4.2 Installing a DAQ System with Multiple Transducers, IFPSMC Box, and DAQ Device .....	33
4.3 Installing a DAQ System with Multiple Transducers, IFPSMC Box, Wired I/O Connections, and USB DAQ Device.....	36
4.4 Install the F/T Demo Software.....	38
4.5 Electrical Connection Information.....	40
4.5.1 Signals and Power .....	40
4.5.2 Electrical Specifications.....	41
4.5.2.1 Transducer Output Signals .....	41
4.5.3 Transducer Signals.....	42
4.5.4 PS and IFPS Signals.....	43
4.5.4.1 PS 20-pin Circular Connector .....	43
4.5.4.2 PS and IFPS 26-pin High Density D-Subminiature Connector .....	43
4.5.5 DAQ Card Connections.....	44
4.5.5.1 Standard DAQ Card Connections.....	44
4.5.5.3 Using Unused DAQ Card Resources .....	47
4.5.6 Transducer Connections on a Multi-Sensor IFPSMC Box .....	47
<b>5. Operation .....</b>	<b>60</b>
5.1 Writing DAQ F/T Application .....	60
5.2 Data Collection Rates .....	60
5.3 Multiple Calibrations .....	60
5.4 Resolution.....	60
5.5 Environmental .....	61
<b>6. Maintenance.....</b>	<b>62</b>
6.1 Periodic Inspection .....	62
6.2 Periodic Calibration .....	62
6.3 Multiple IFPSMC Box Recalibration.....	62
6.3.1 Removing and Replacing the IFPS Card for Recalibration .....	63

<b>7. Troubleshooting .....</b>	<b>66</b>
<b>7.1 Errors with Force and Torque Readings .....</b>	<b>67</b>
<b>7.2 Detecting Failures (Diagnostics) .....</b>	<b>68</b>
7.2.1 Detecting Connection Issues.....	68
7.2.2 Detecting Cable Problems.....	68
7.2.3 Detecting Sensitivity Changes.....	68
<b>8. Terms and Conditions of Sale .....</b>	<b>69</b>
<b>Appendix A – Tool Transformation .....</b>	<b>70</b>

## 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. ( <a href="http://www.ni.com">www.ni.com</a> )
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. There is no personnel safety risk associated with the intended design of the products described within this manual. 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  $\pm 10$  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.

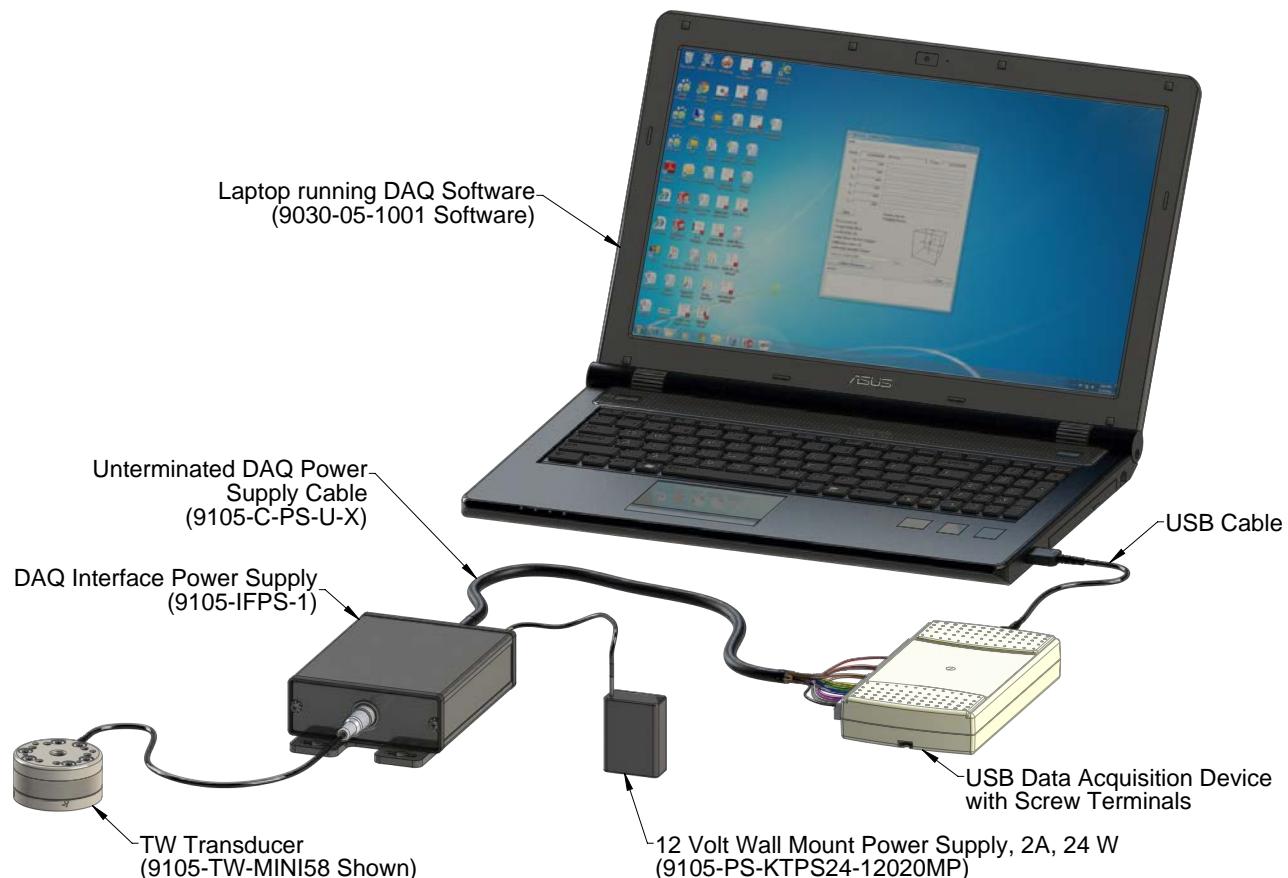
### 2.1 System with a TW Transducer, IFPS Box, and USB DAQ Device

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**

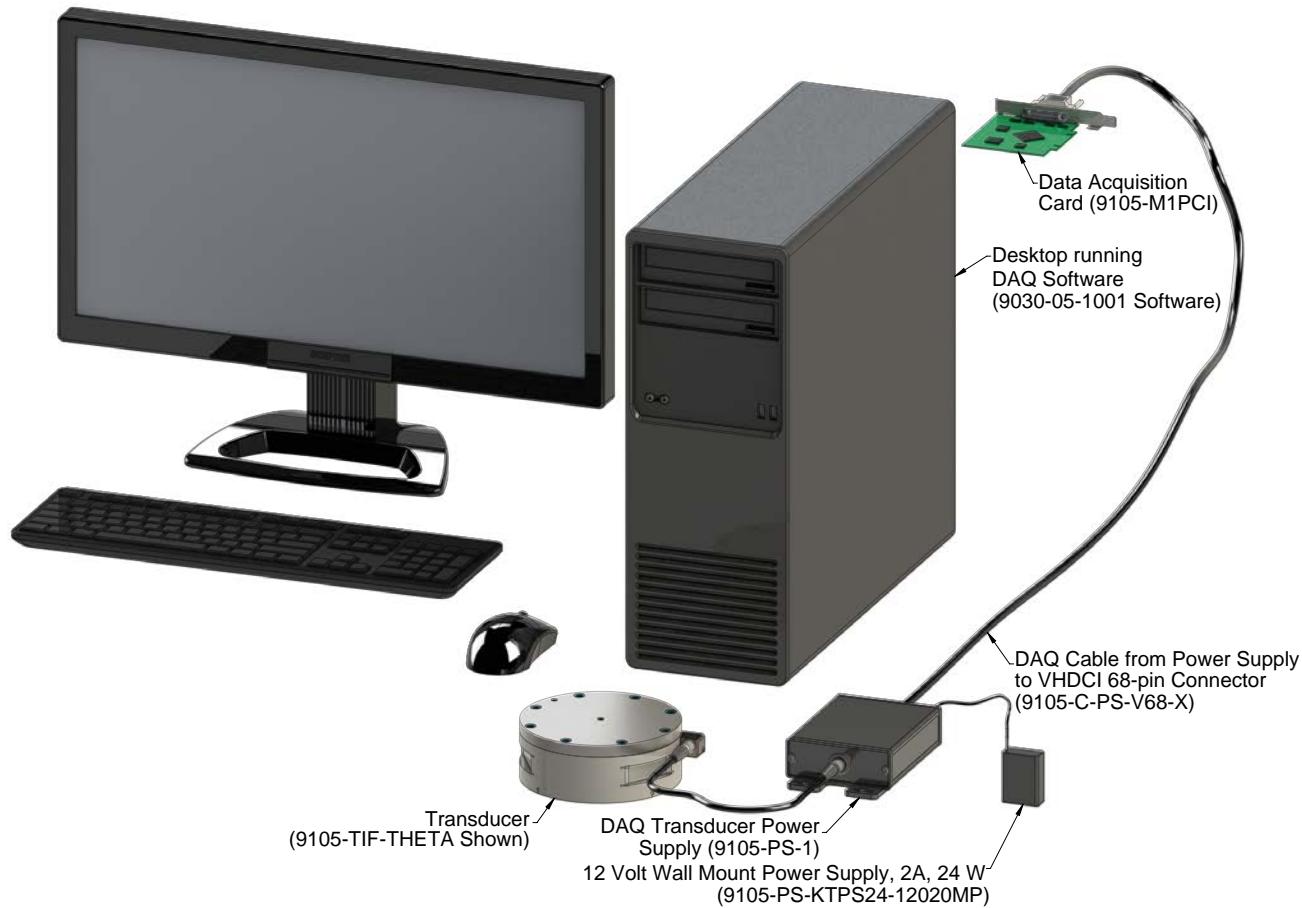


## 2.2 System with a TIF Transducer, PS Box, and DAQ Card

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**

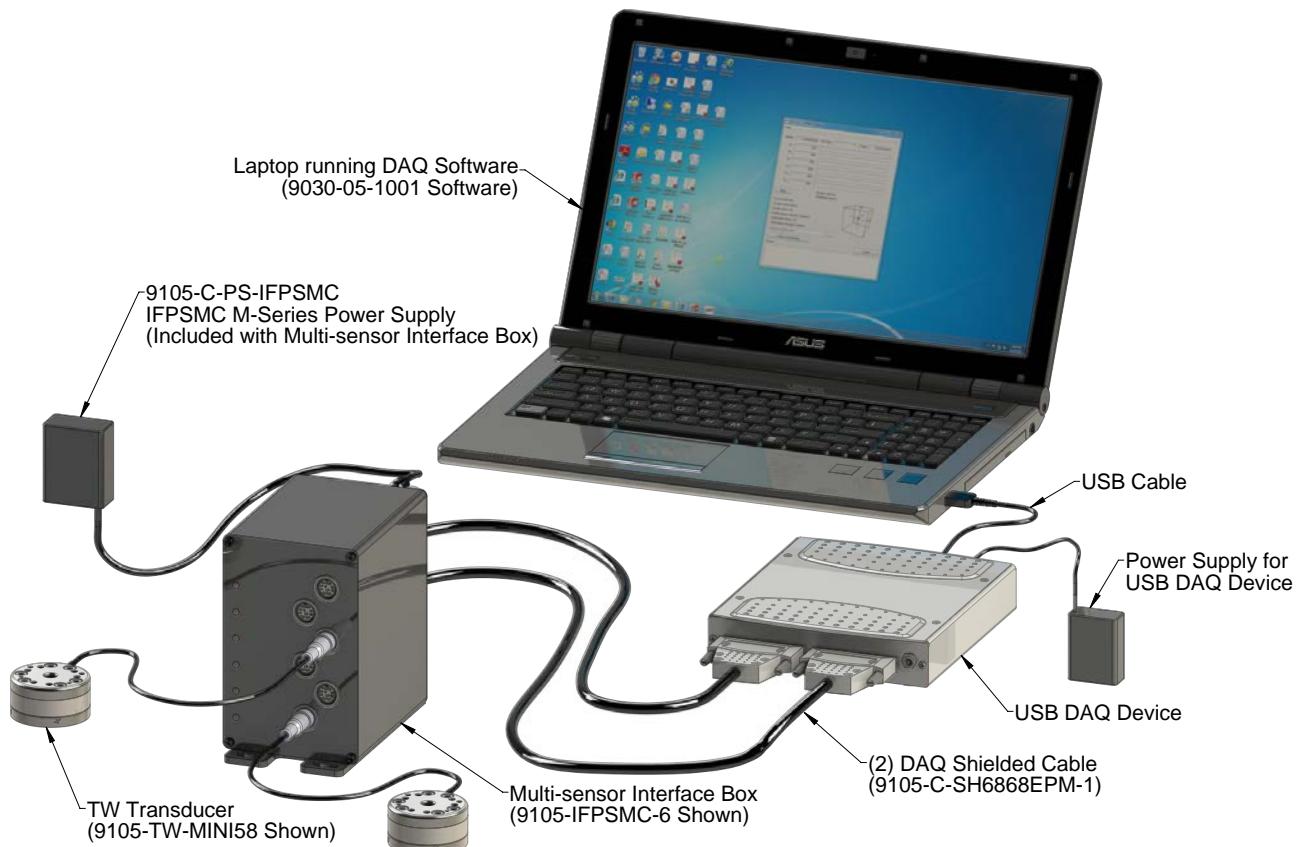


## 2.3 System with Multiple Transducers, IFPSMC Box, and a USB DAQ Device

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**

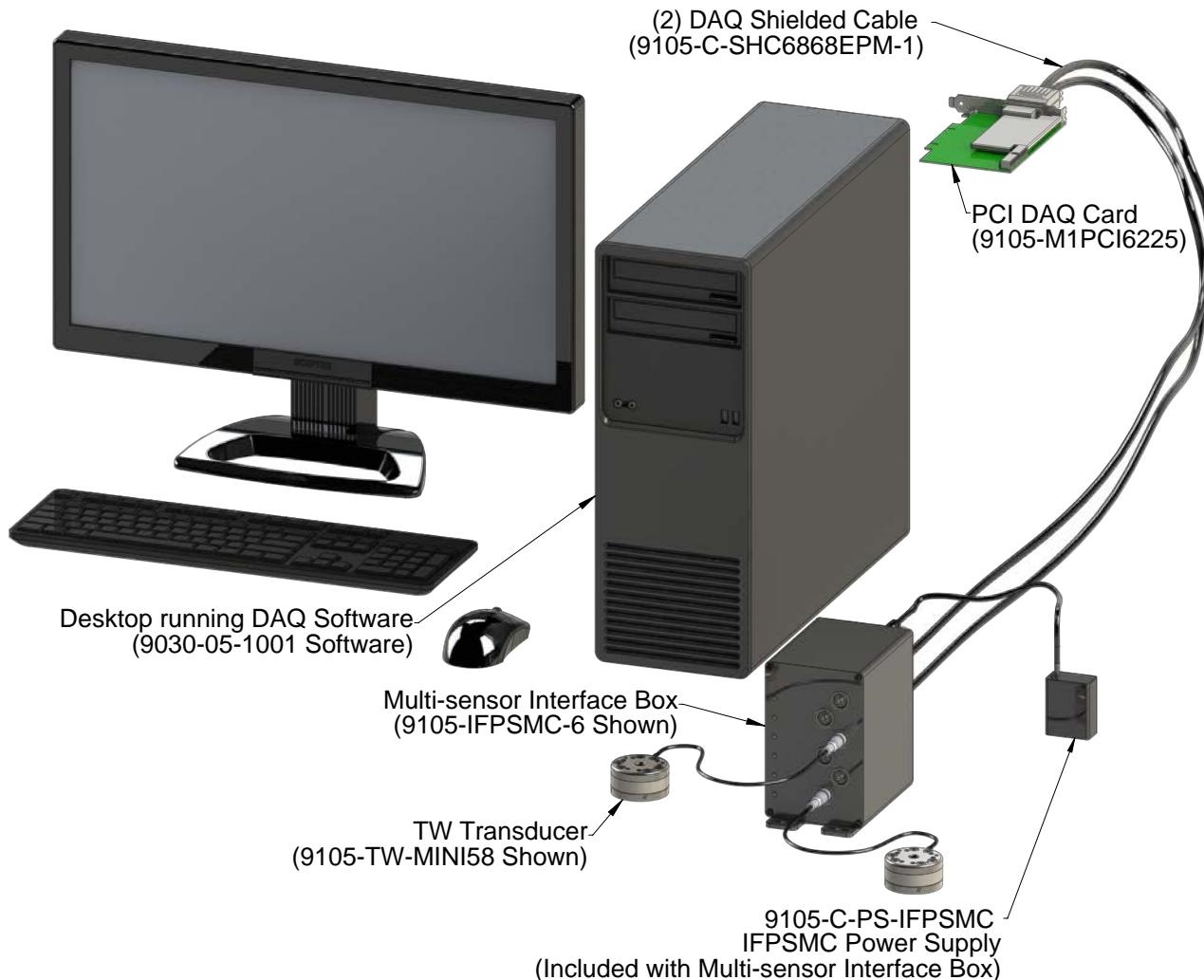


## 2.4 System with Multiple Transducers, IFPSMC Box, and a DAQ Card

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**

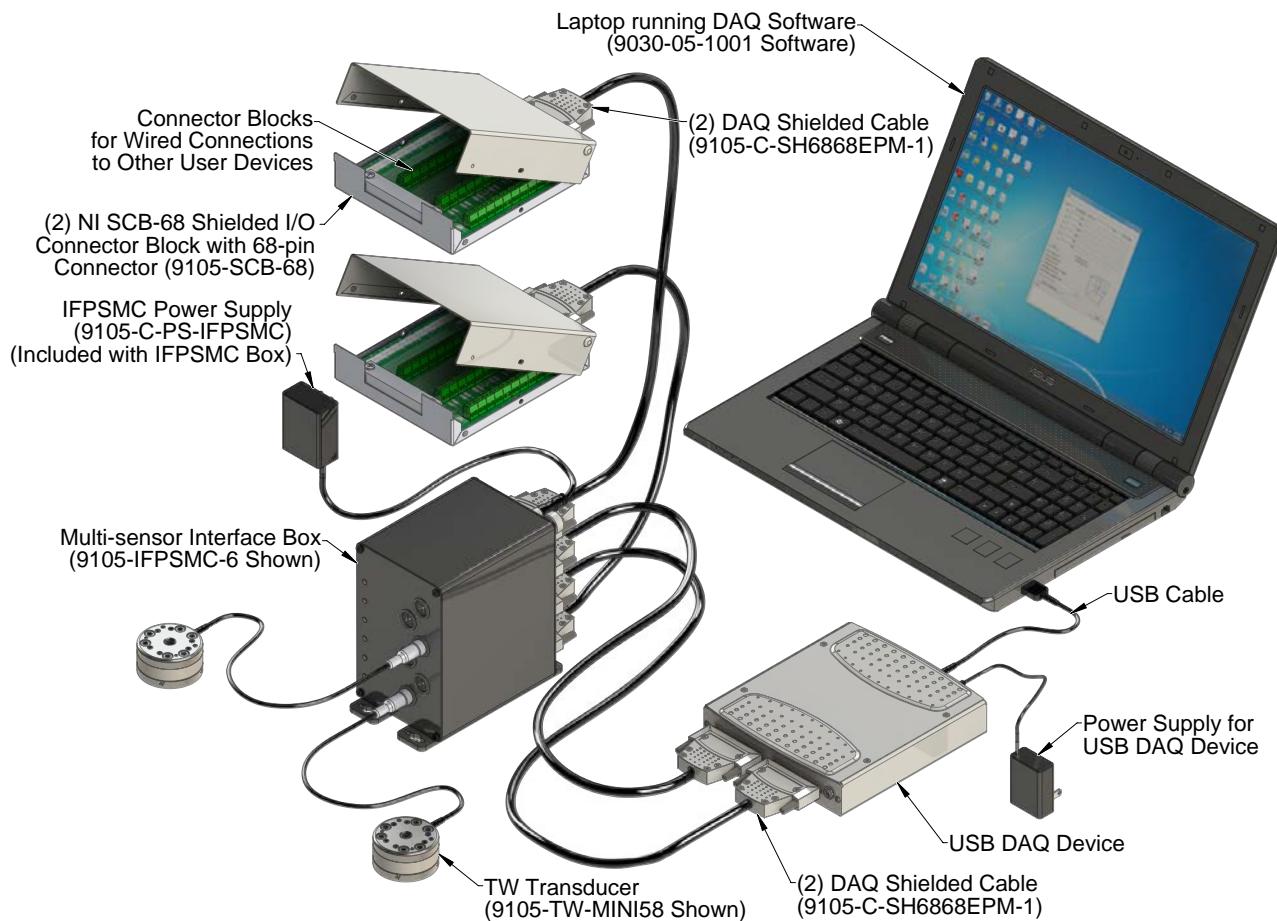


## 2.5 System with Multiple Transducers, IFPSMC Box, Wired I/O Connections for User Devices, and USB DAQ Device

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**



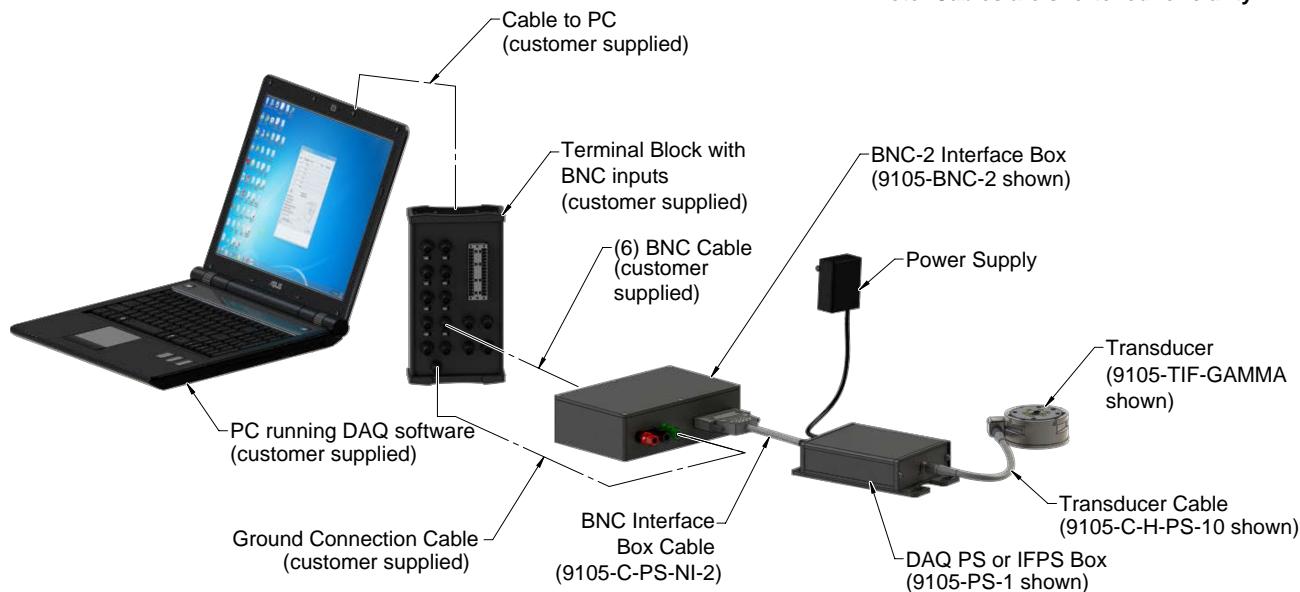
## 2.6 System with BNC Interface Box

A system may consist of the following components:

- Transducer
- Power supply
- BNC interface box (refer to *Figure 2.15*)
- DAQ device with multiple BNC inputs (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**

Note: Cables are shortened for clarity.



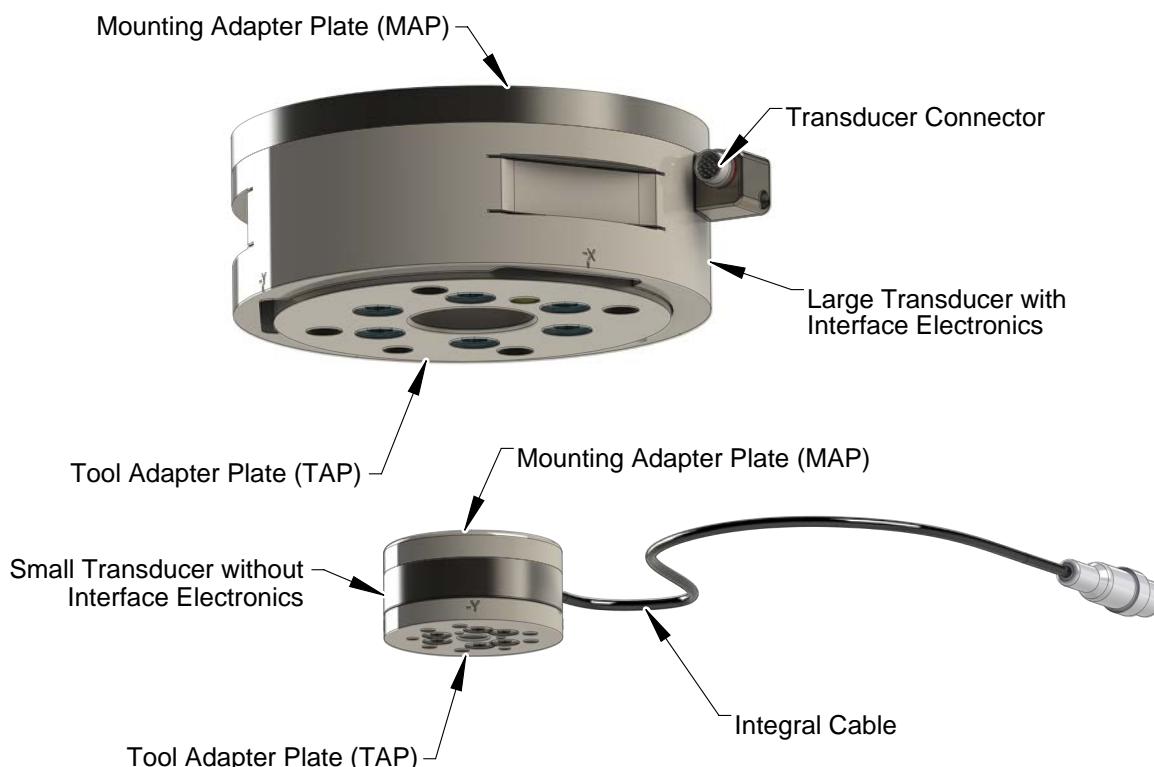
## 2.7 Transducer

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](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**

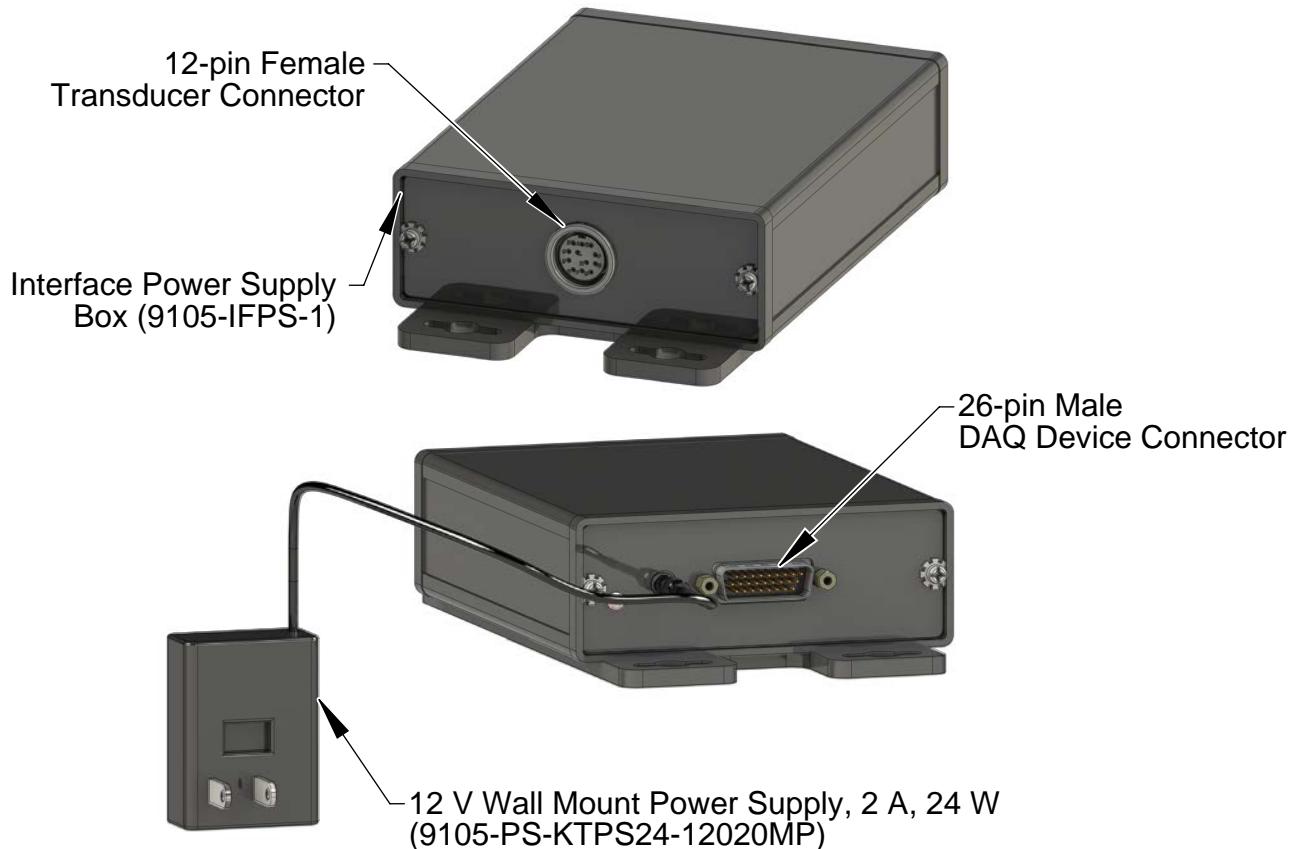


## 2.9 Interface Power Supply Box

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](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**

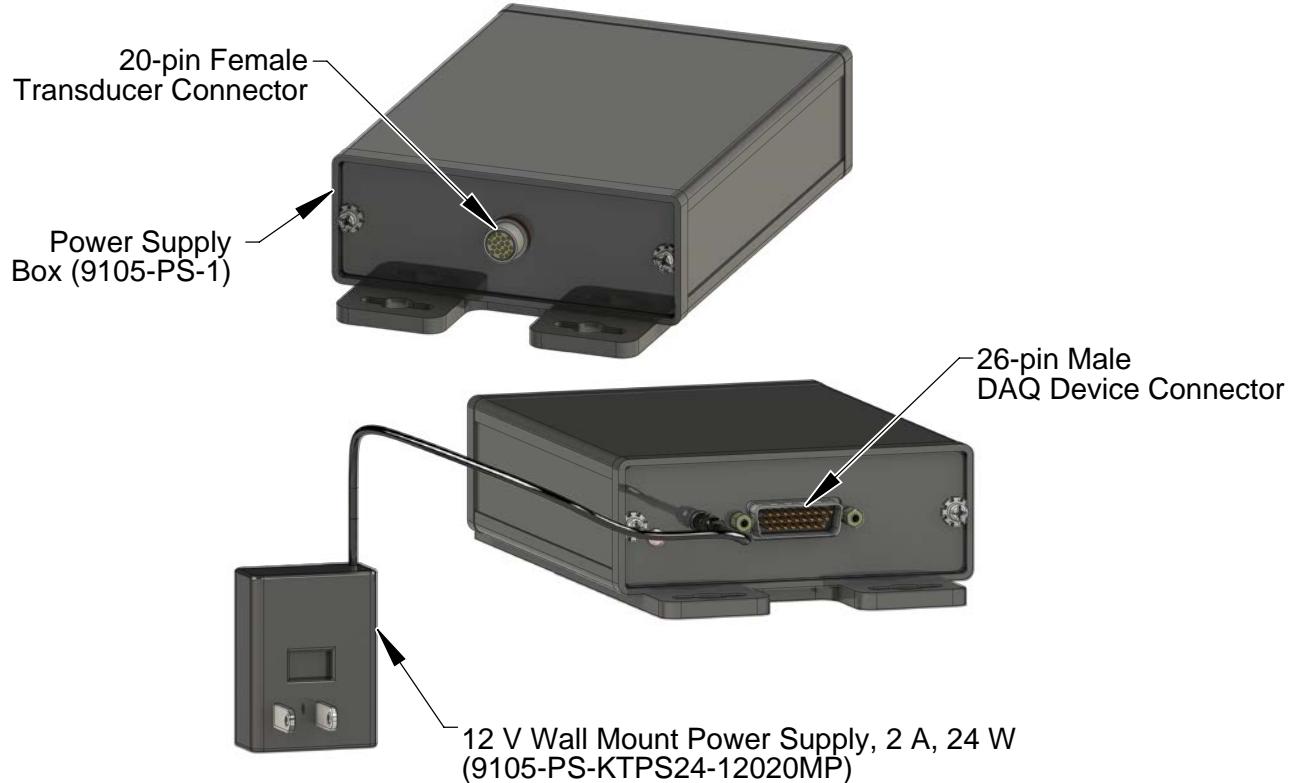


## 2.10 Power Supply Box

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\\_literature.aspx](https://www.ati-ia.com/products/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.

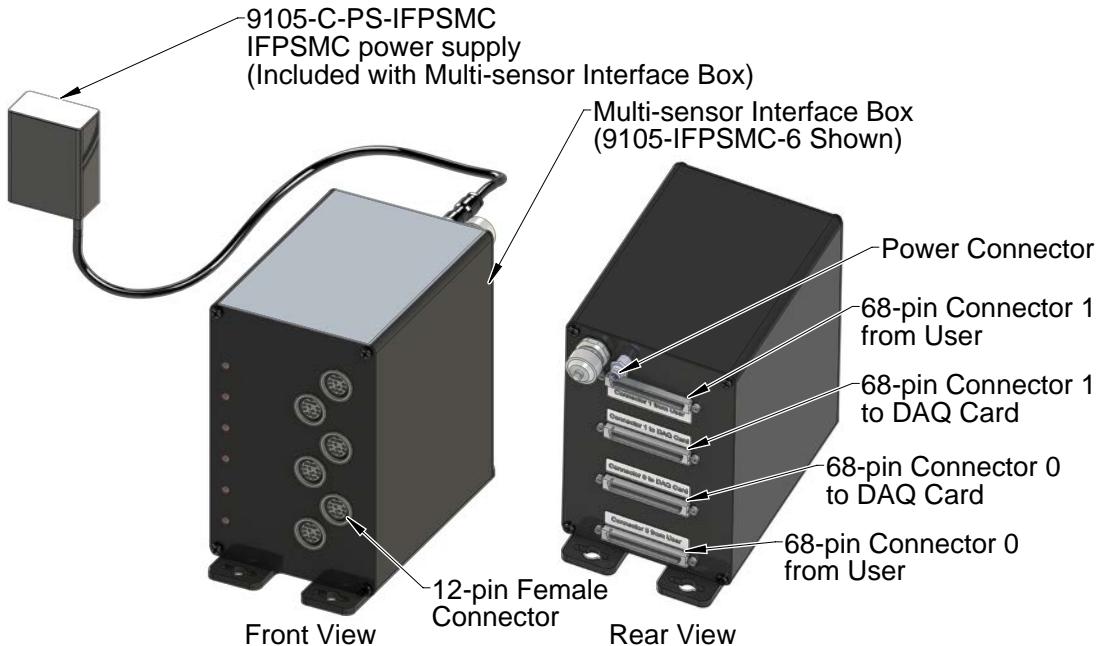
**Figure 2.11—Power Supply Cables**



## 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](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.

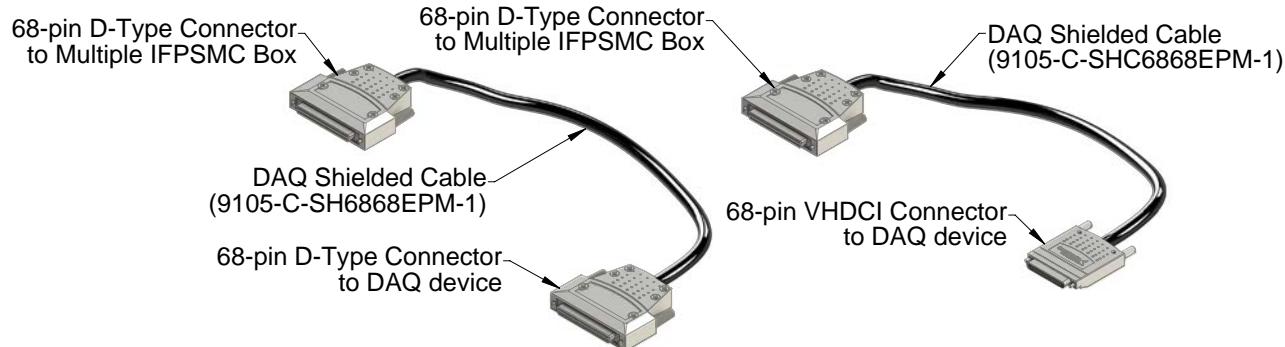
**NOTICE:** Like the standard DAQ F/T systems, the transducer signals from the multiple-IFPS box are configured for differential input channels.

**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.

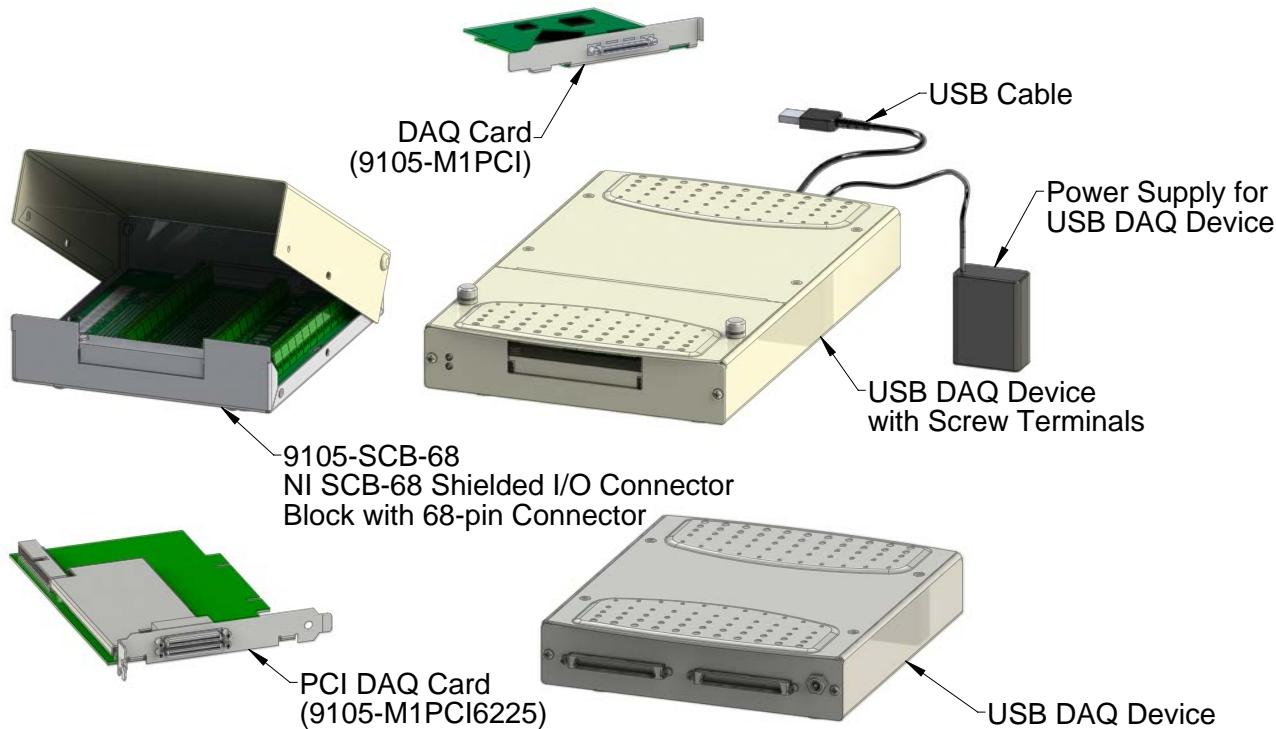
Figure 2.13—DAQ Shielded Cables



## 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.

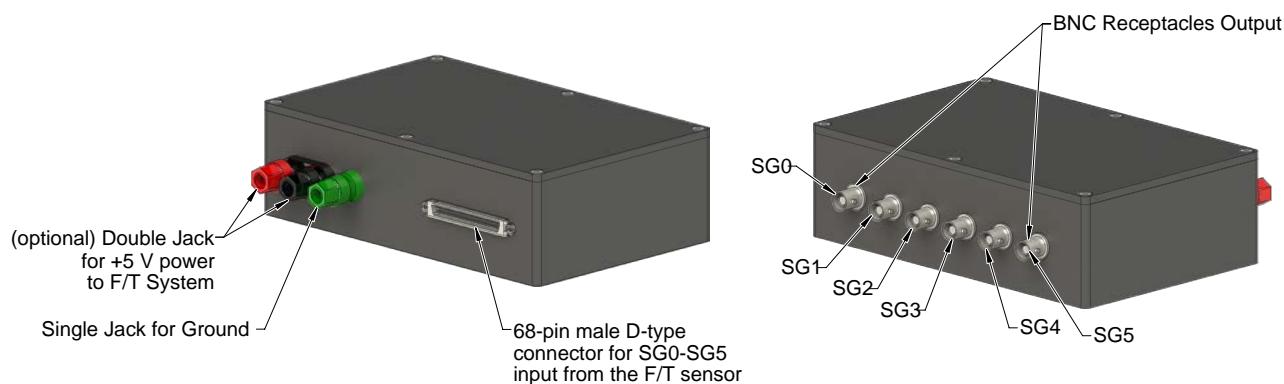
Figure 2.14—Data Acquisition System



## 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 [http://www.ati-ia.com/download/DAQ\\_FT/DAQ%20FT%20Software.htm](http://www.ati-ia.com/download/DAQ_FT/DAQ%20FT%20Software.htm).

**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](https://www.ati-ia.com/products/ft/ft_ModelListing.aspx).

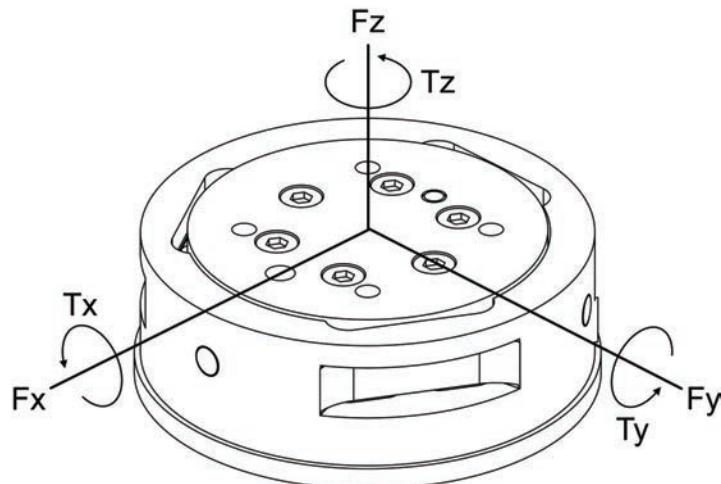
### 3. System Functionality

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:

$$\Delta R = S_a \cdot R_0 \cdot e$$

$\Delta R$  = Change in resistance of strain gage

$S_a$  = Gage factor of strain gage

$R_0$  = Resistance of strain gage unstrained

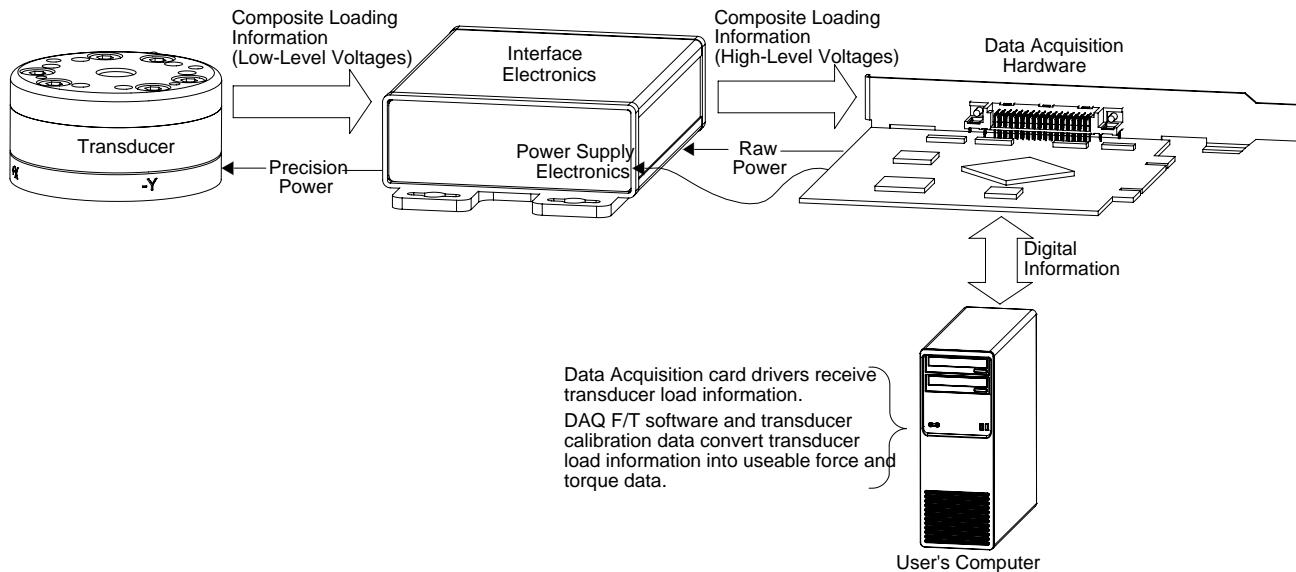
$e$  = Strain applied to strain gage

### 3.2 Electronic Hardware

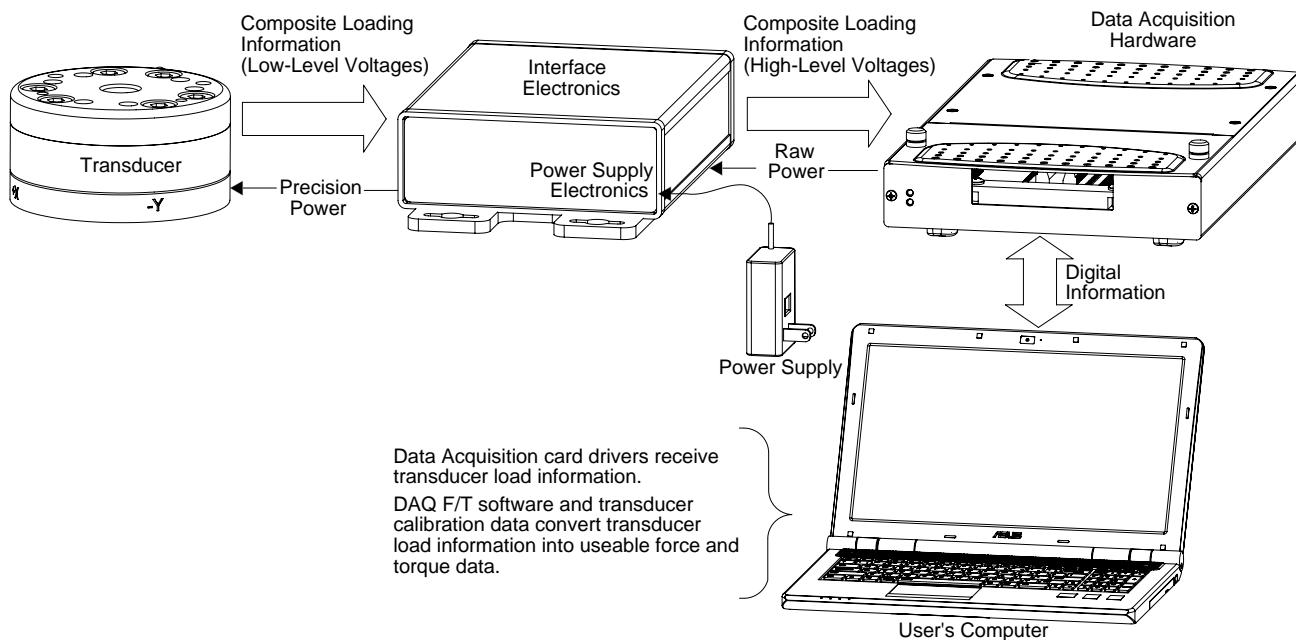
The electronic hardware measures changes in resistance; the software described in [Section 3.4—ATI DAQ Software](#), converts the changes to force and torque components.

[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**

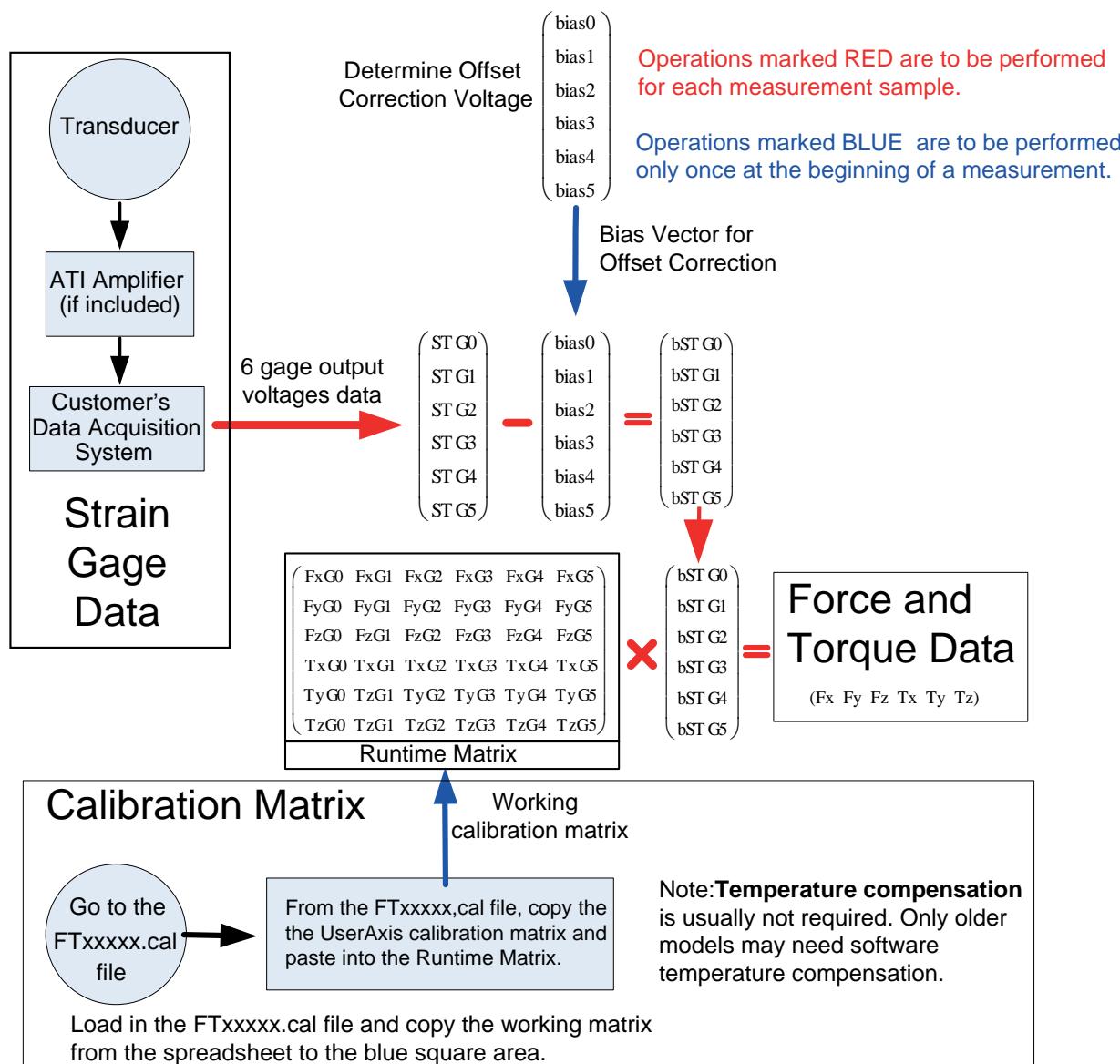


### 3.3 Load Calculation

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**



### **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**

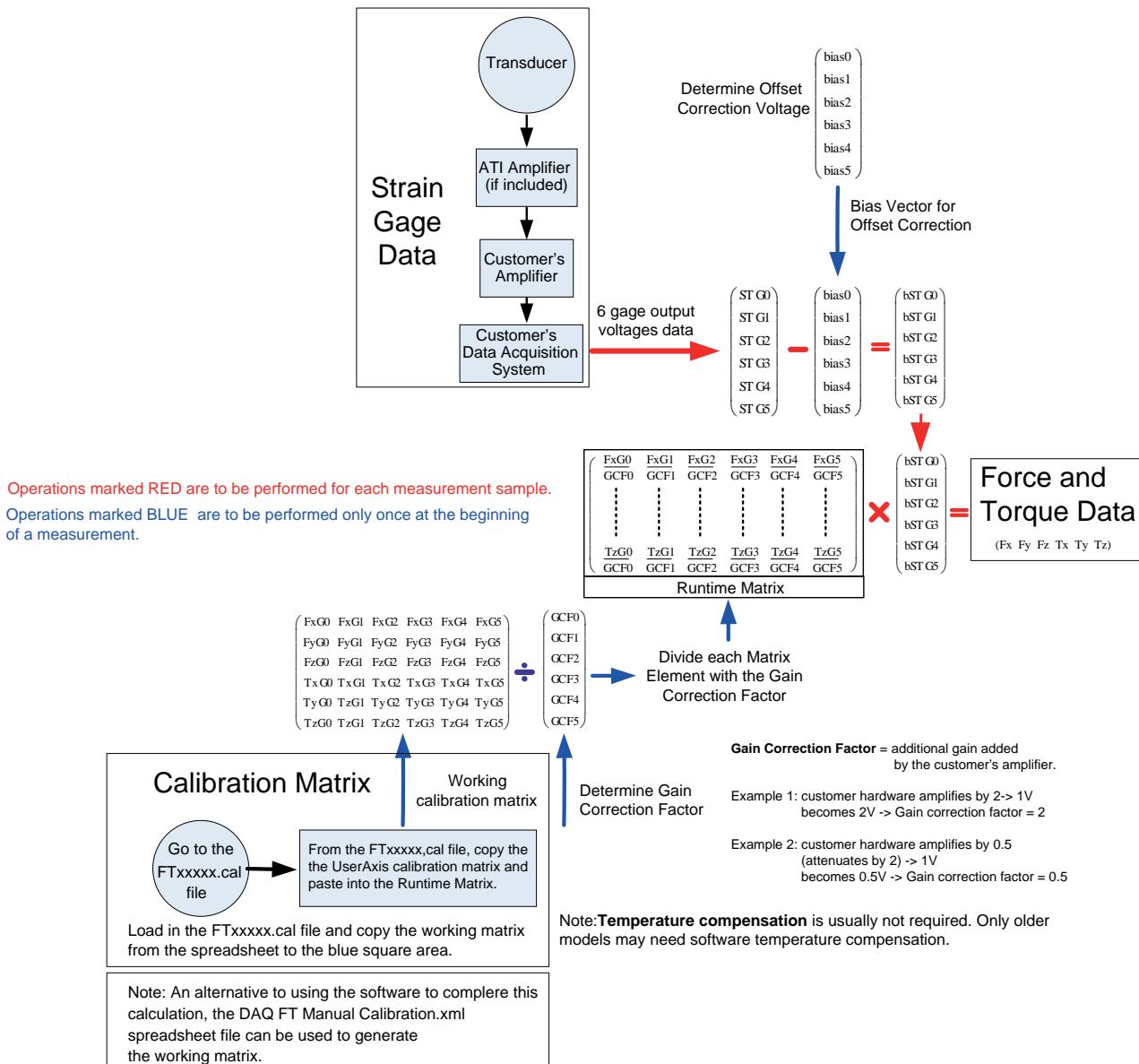
The calibration matrix is the transducer calibration matrix provided on the software zip folder from ATI. The ATI supplied six-by-six calibration matrix matches the sensor's FTxxxx serial number in either the ATI software or the customer software. This standard matrix when multiplied by the biased strain 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: [http://www.ati-ia.com/download/DAQ\\_FT/DAQ%20FT%20Software.htm](http://www.ati-ia.com/download/DAQ_FT/DAQ%20FT%20Software.htm).

#### **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*

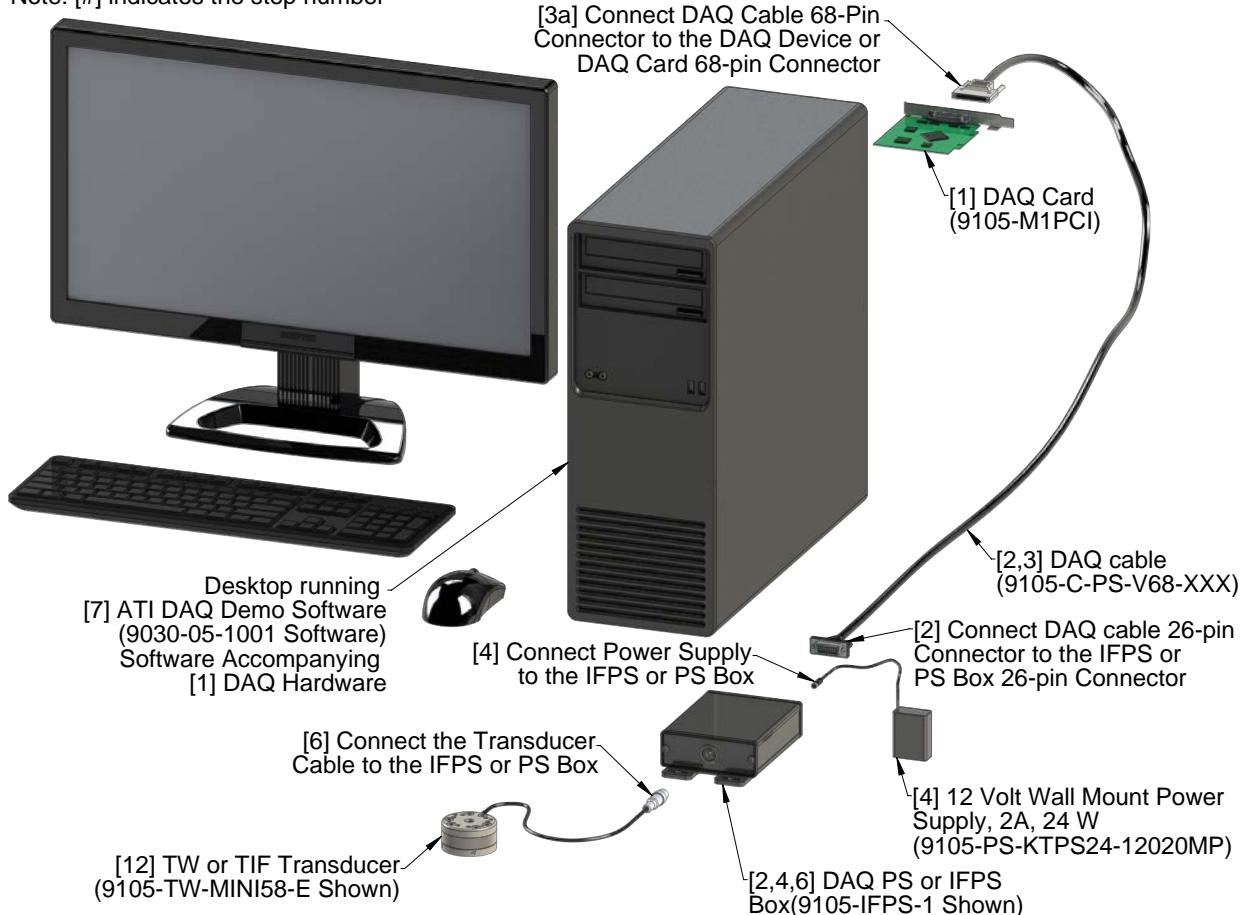
### 4.1 Installing a DAQ System with a Transducer, IFPS or PS Box, and DAQ Device

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.

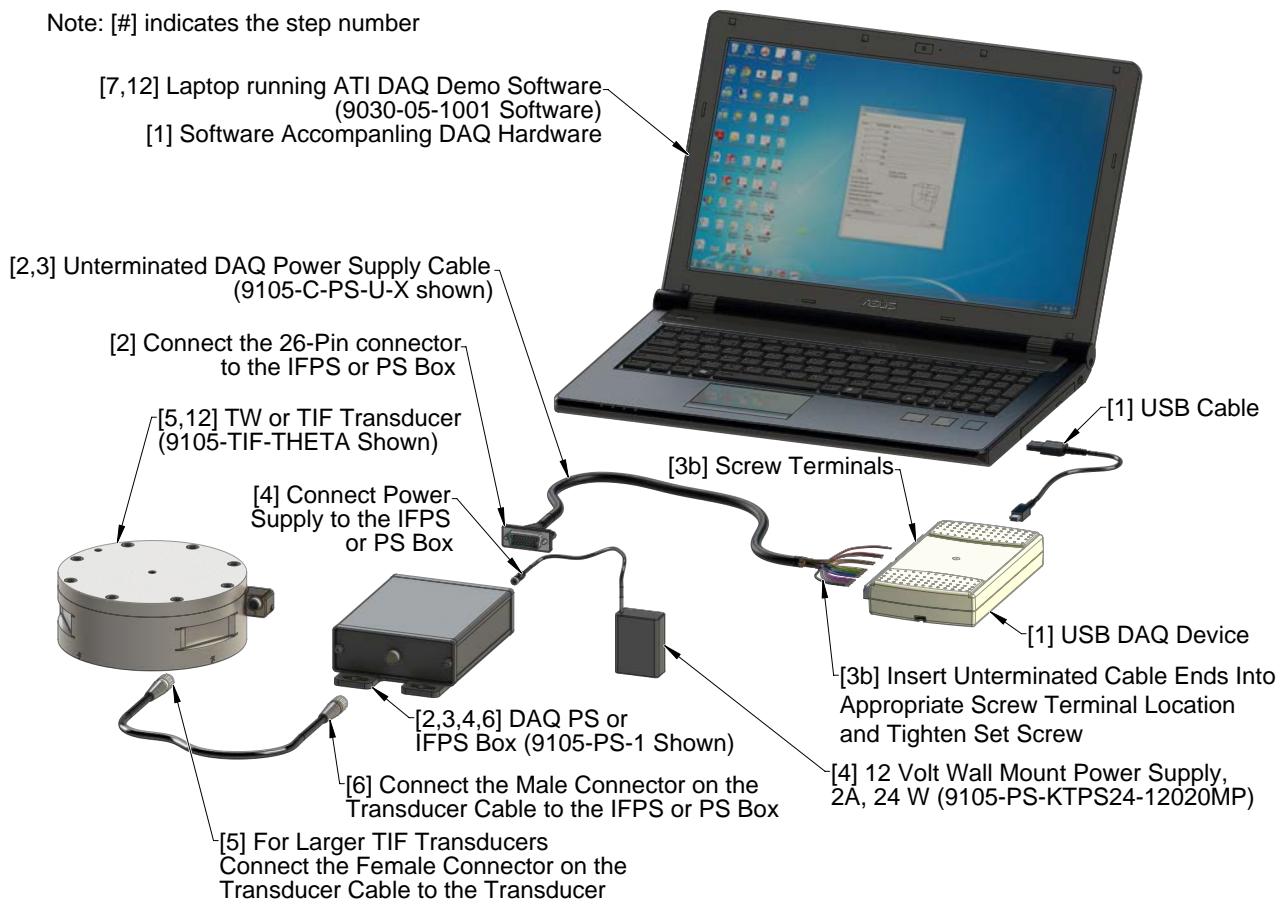
**Figure 4.1—Single TW Transducer, IFPS, and DAQ Card System Installation**

Note: [#] indicates the step number



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

Note: [#] indicates the step number

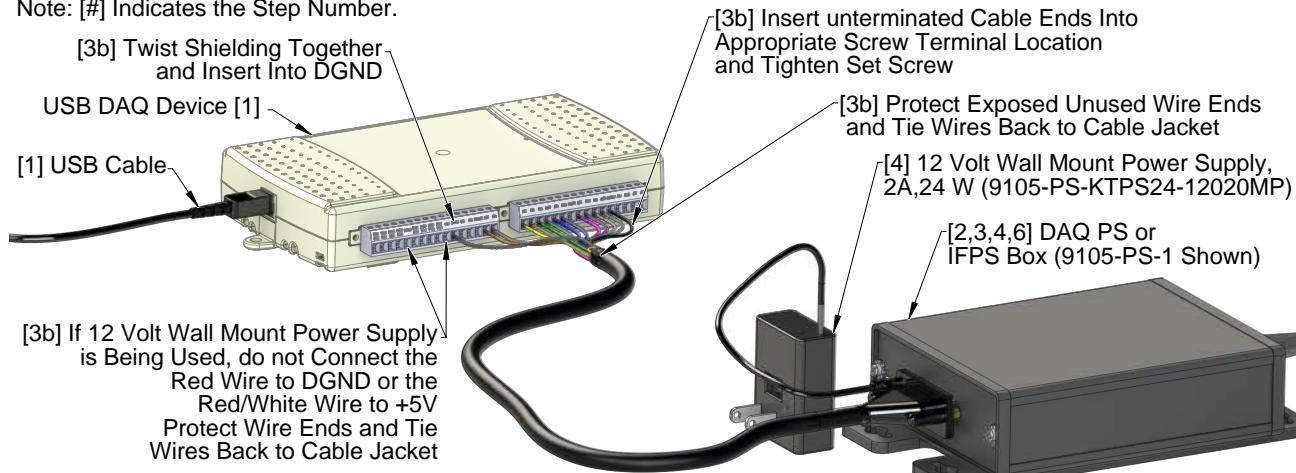


3. Depending on the DAQ Device and power cable being installed, one of the following connection methods may be applied:
  - If the Power Supply cable is equipped with a 68-pin connector, attach the connector to the NI DAQ Card or DAQ device and tighten the jackscrews on the connector to ensure a good 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.

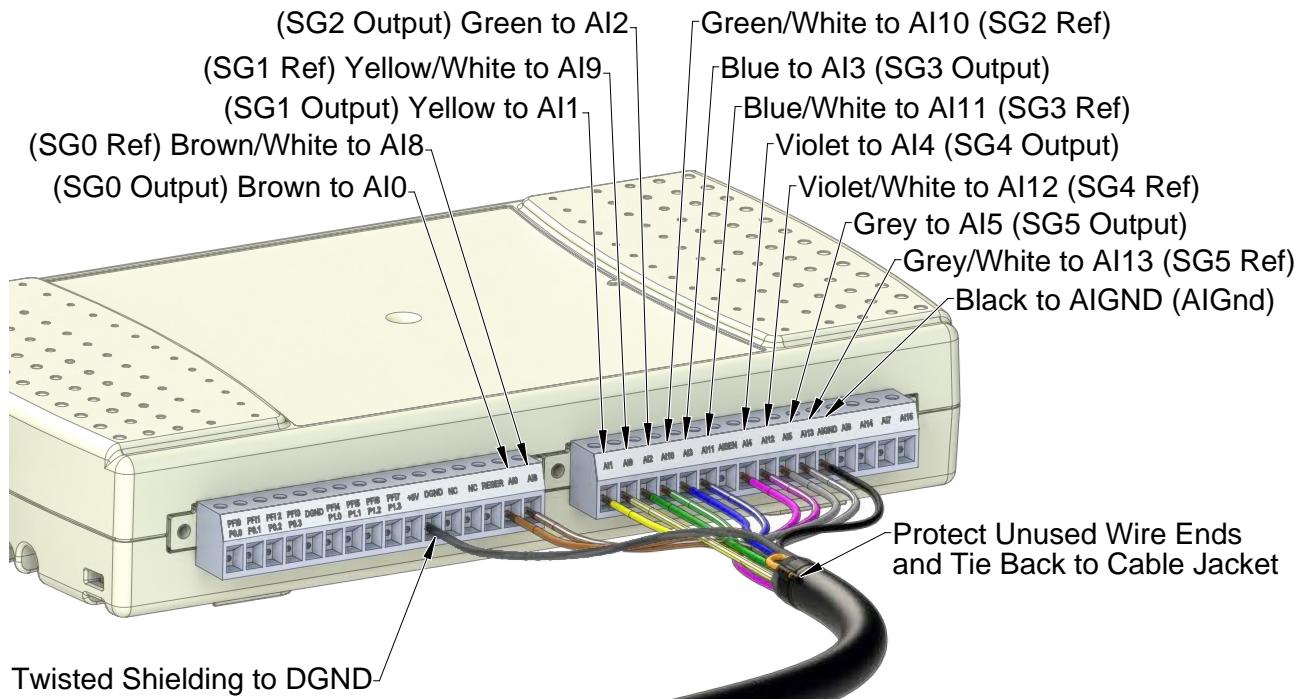
**Figure 4.3—Unterminated Cable Wiring (9105-C-PS-U-x) and USB DAQ Device System Installation**

Note: [#] Indicates the Step Number.



**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 <sup>1</sup>	N/A <sup>1</sup>	37	D GND	No ATI Connection <sup>1</sup>	N/A <sup>1</sup>
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 <sup>1</sup>	N/A <sup>1</sup>	42	+5V	No ATI Connection <sup>1</sup>	N/A <sup>1</sup>
11	D GND	Shielding	Twisted shielding	43	D GND	Shielding <sup>2</sup>	Twisted shielding <sup>2</sup>
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 <sup>2</sup>	Brown <sup>2</sup>
16	AI 8	SG0 reference	Brown/White	48	AI 24	SG0 reference <sup>2</sup>	Brown/White <sup>2</sup>
17	AI 1	SG1 output	Yellow	49	AI 17	SG1 output <sup>2</sup>	Yellow <sup>2</sup>
18	AI 9	SG1 reference	Yellow/White	50	AI 25	SG1 reference <sup>2</sup>	Yellow/White <sup>2</sup>
19	AI 2	SG2 output	Green	51	AI 18	SG2 output <sup>2</sup>	Green <sup>2</sup>
20	AI 10	SG2 reference	Green/White	52	AI 26	SG2 reference <sup>2</sup>	Green/White <sup>2</sup>
21	AI 3	SG3 output	Blue	53	AI 19	SG3 output <sup>2</sup>	Blue <sup>2</sup>
22	AI 11	SG3 reference	Blue/White	54	AI 27	SG3 reference <sup>2</sup>	Blue/White <sup>2</sup>
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 <sup>2</sup>	Violet <sup>2</sup>
25	AI 12	SG4 reference	Violet/White	57	AI 28	SG4 reference <sup>2</sup>	Violet/White <sup>2</sup>
26	AI 5	SG5 output	Grey	58	AI 21	SG5 output <sup>2</sup>	Grey <sup>2</sup>
27	AI 13	SG5 reference	Grey/White	59	AI 29	SG5 reference <sup>2</sup>	Grey/White <sup>2</sup>
28	AI GND	AGnd power input	Black	60	AI GND	AI GND <sup>2</sup>	Black <sup>2</sup>
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)

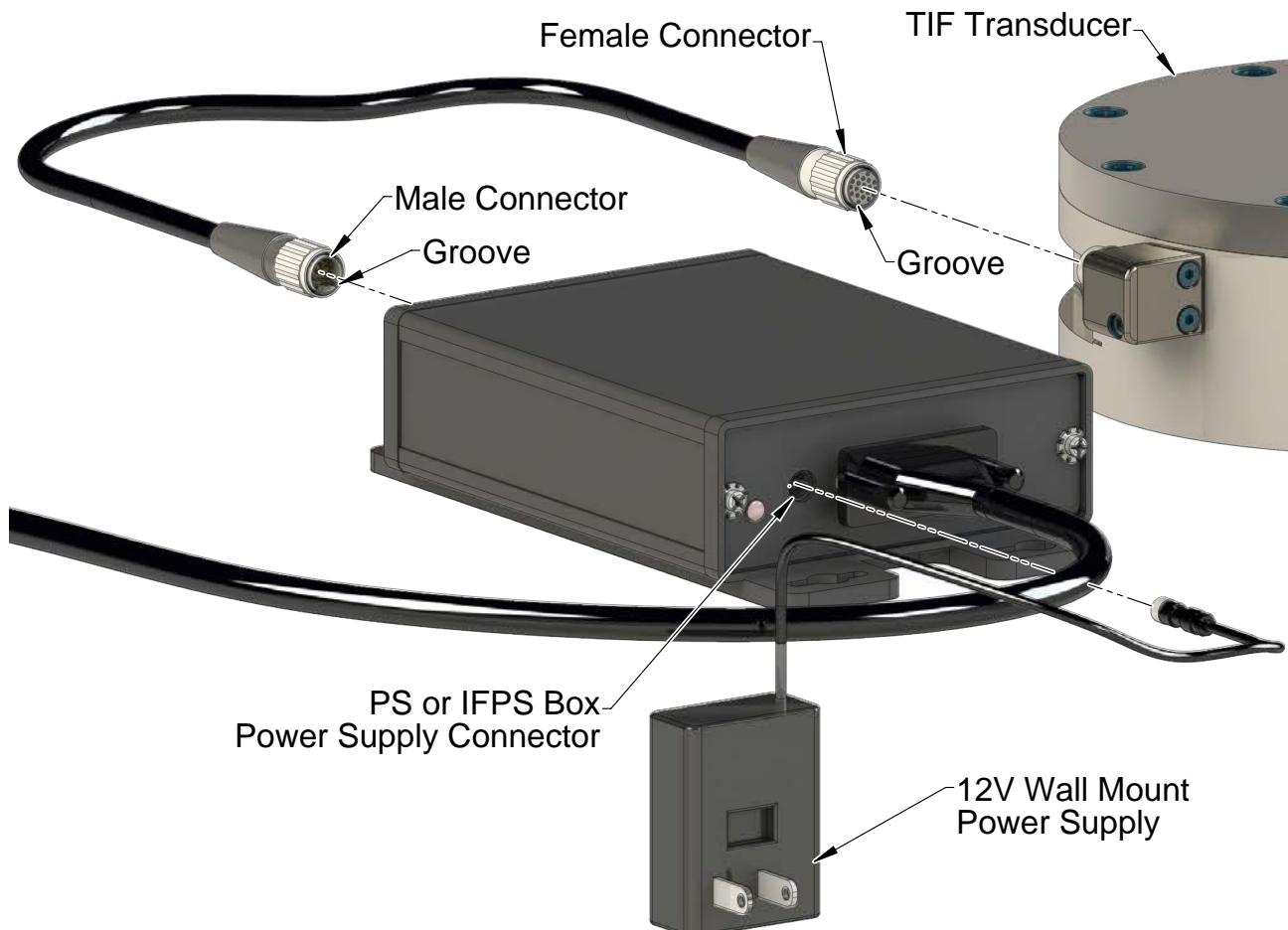
- Do not connect the (+5 V) red wire and the power ground (DGND) red/white wire on systems that have PS or IFPS boxes with a 12 V wall mounted power supply. The (+5V) red wire and the power ground (DGND) red/white wire are only required for systems that do not have a separate wall mounted power supply. Connect to external power source, not the +5 V through the USB.
- 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**

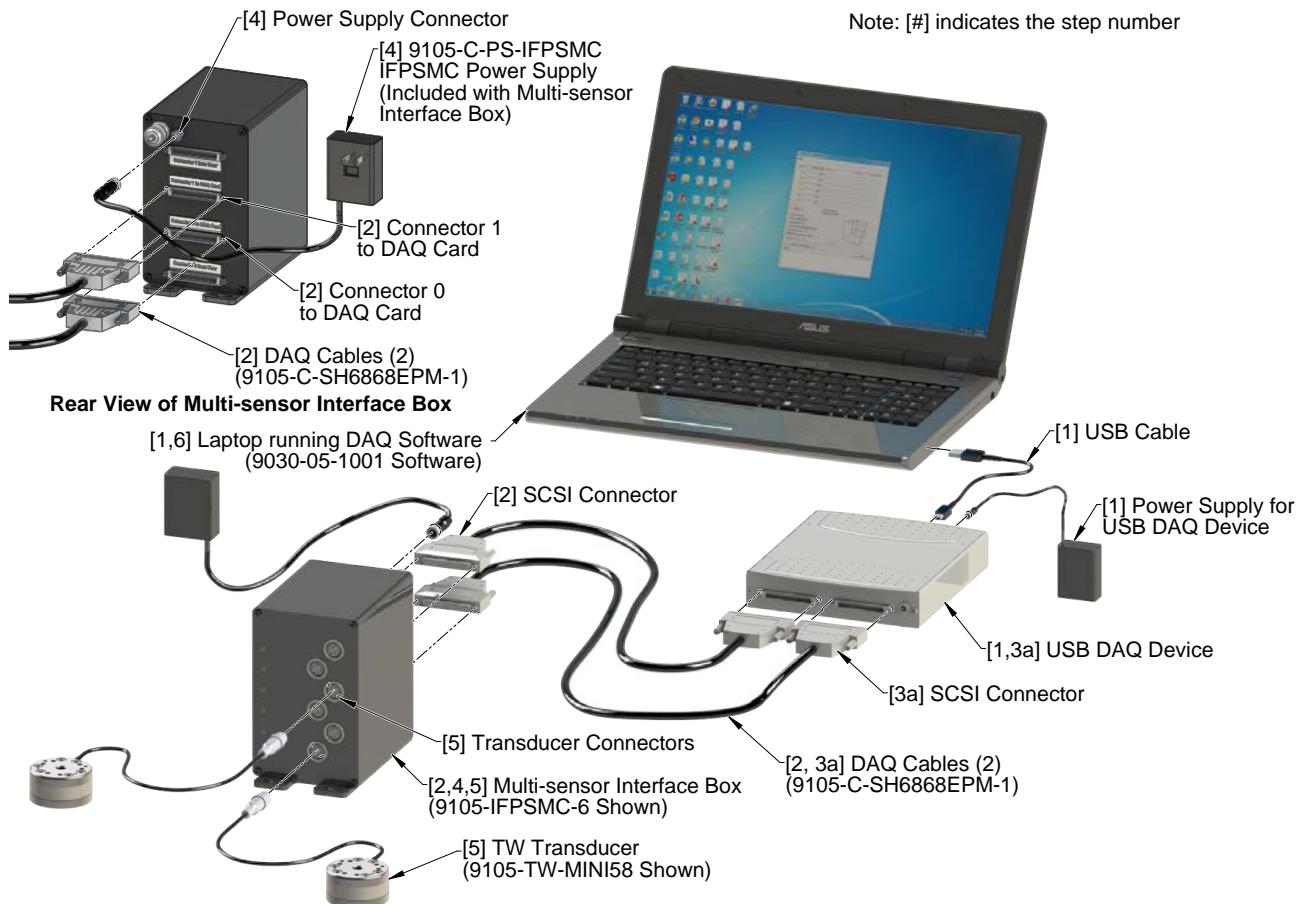


5. Connect the male connector on the transducer cable to the connector on the PS or IFPS box.
6. Refer to [Section 4.4—Install the F/T Demo Software](#) to complete the installation.

## 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](#)).

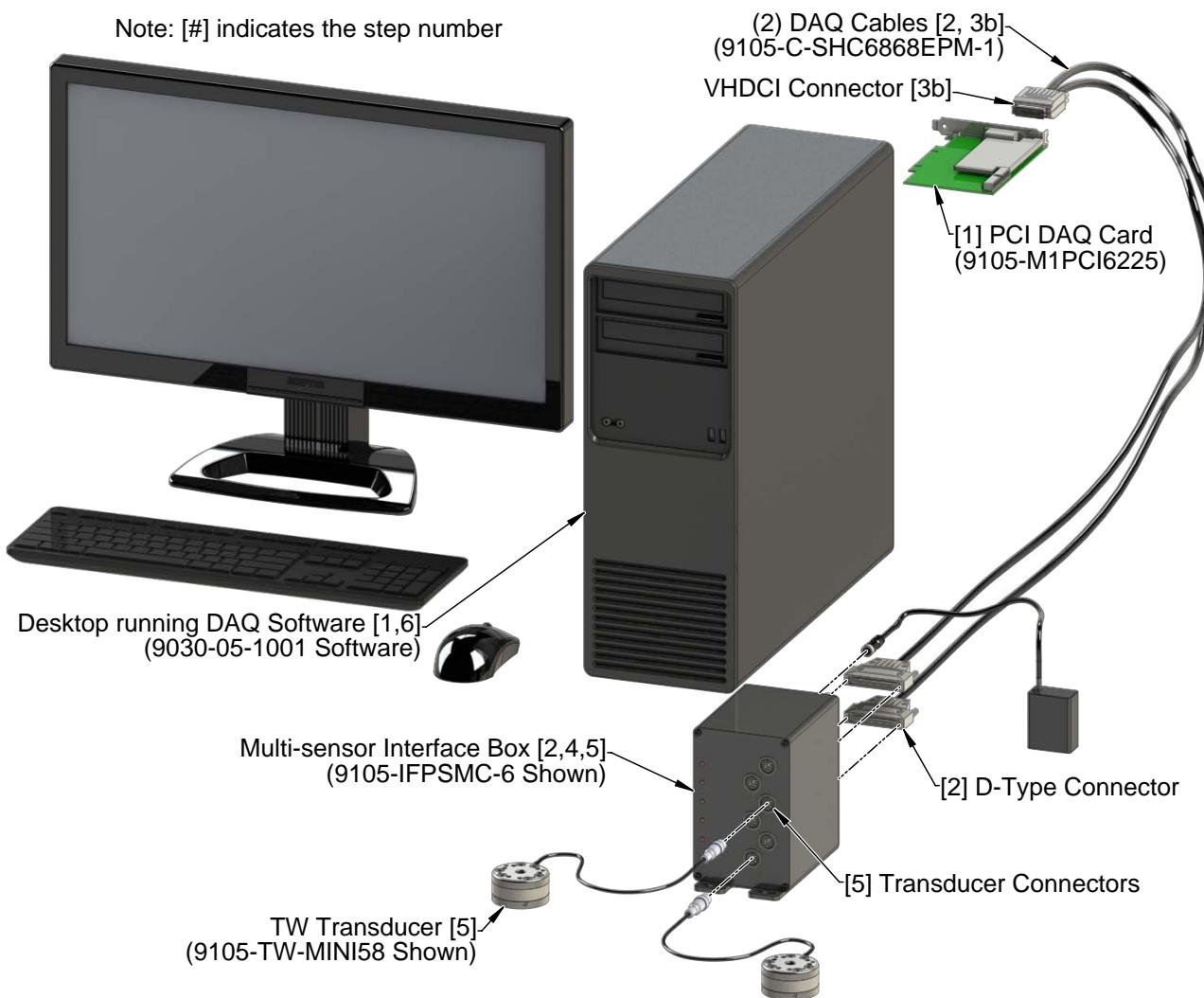
**Figure 4.6—Multiple TW Transducers, IFPSMC, and USB DAQ Device System Installation**



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.

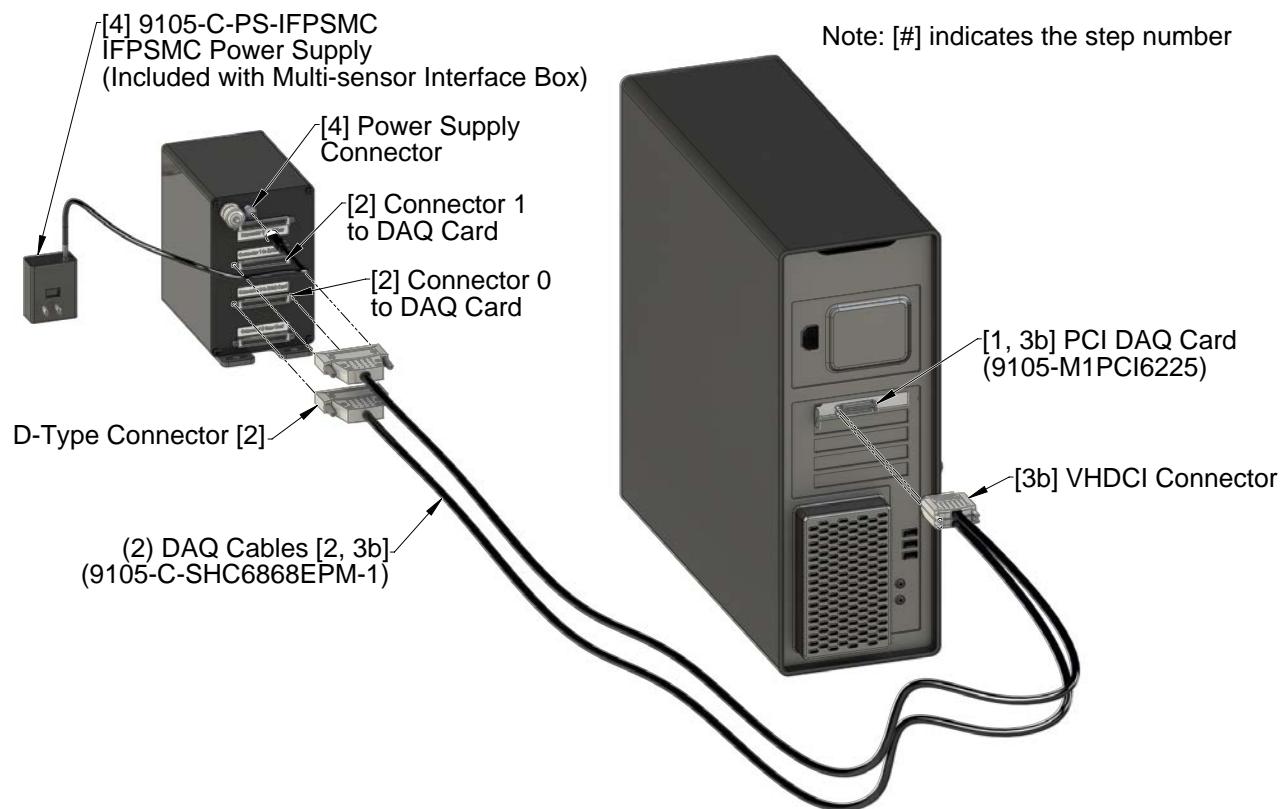
**Figure 4.7—Multiple TW Transducers, IFPSMC, and DAQ Card System Installation**



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.

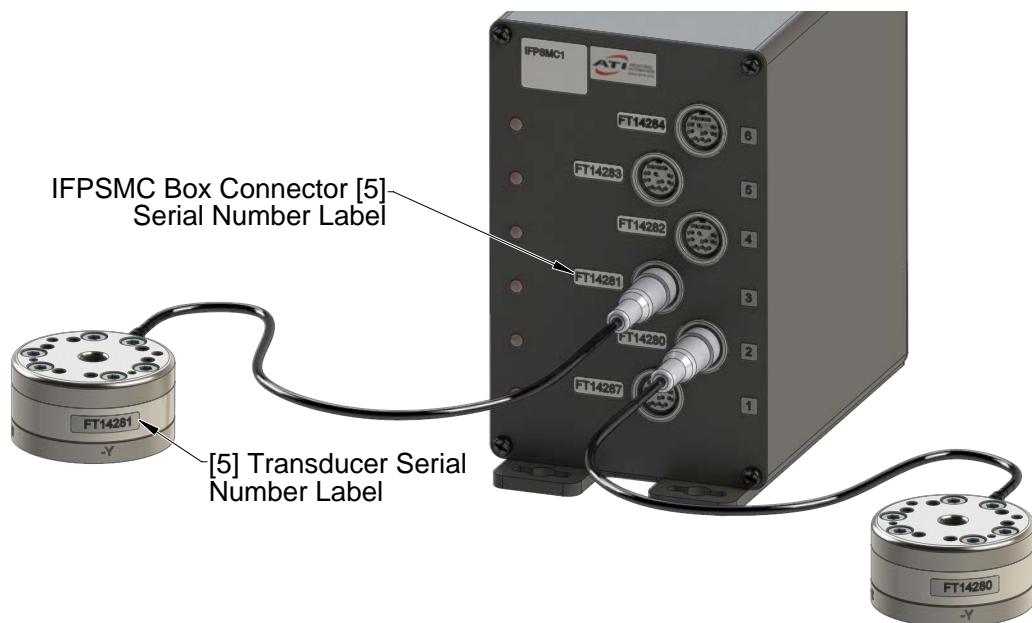
**NOTICE:** If not using a National Instruments DAQ board with mass termination, the user must provide a connector at that end of the cable (refer to [Section 4.5—Electrical Connection Information](#) for connection information).

**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

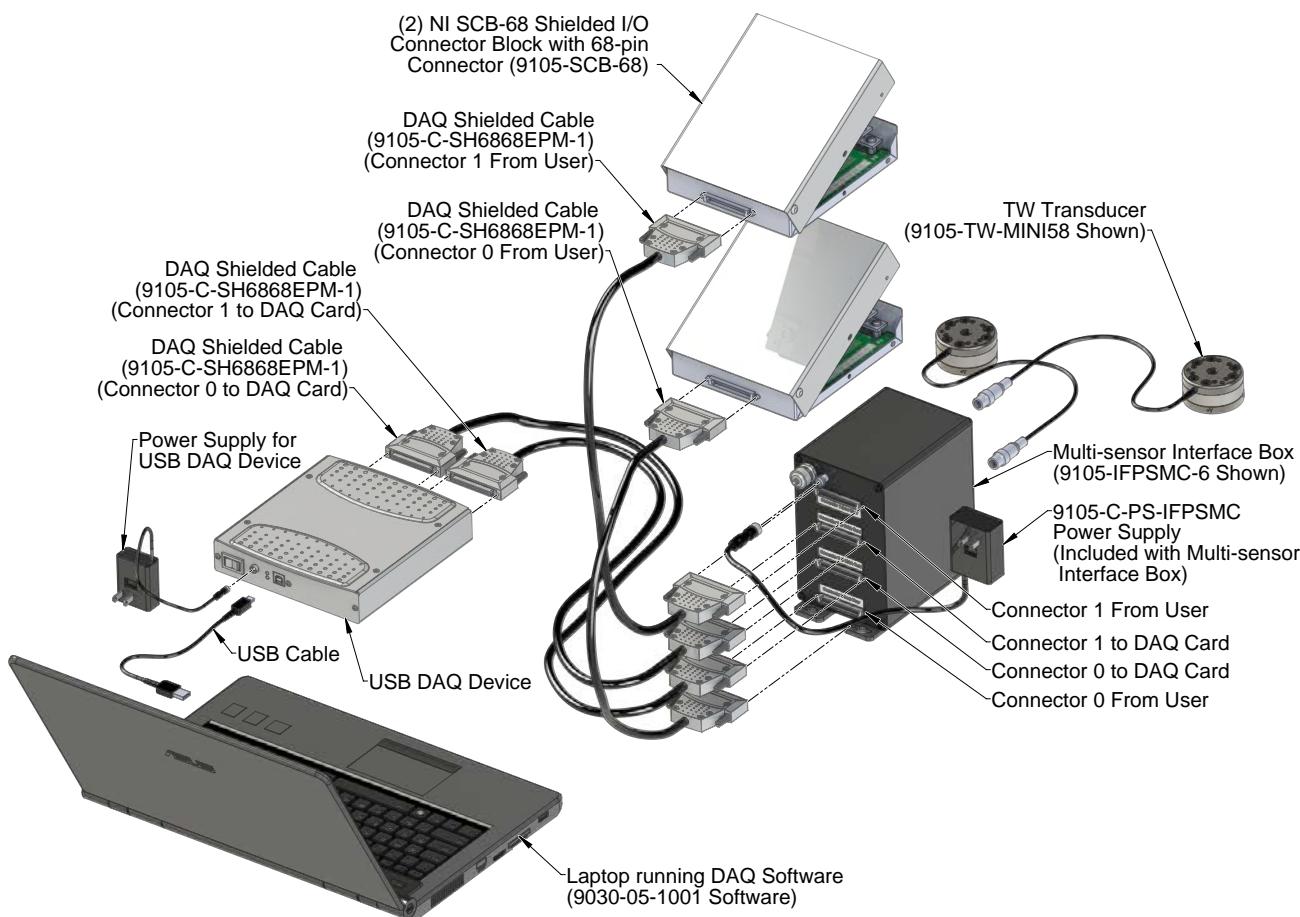
To ensure a seamless connection between the 9105-IFPSMC-X box and a DAQ Device with screw-terminals, the following connections need to be made to connect the transducer strain gage voltage outputs to the DAQ Device screw-terminals.

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.

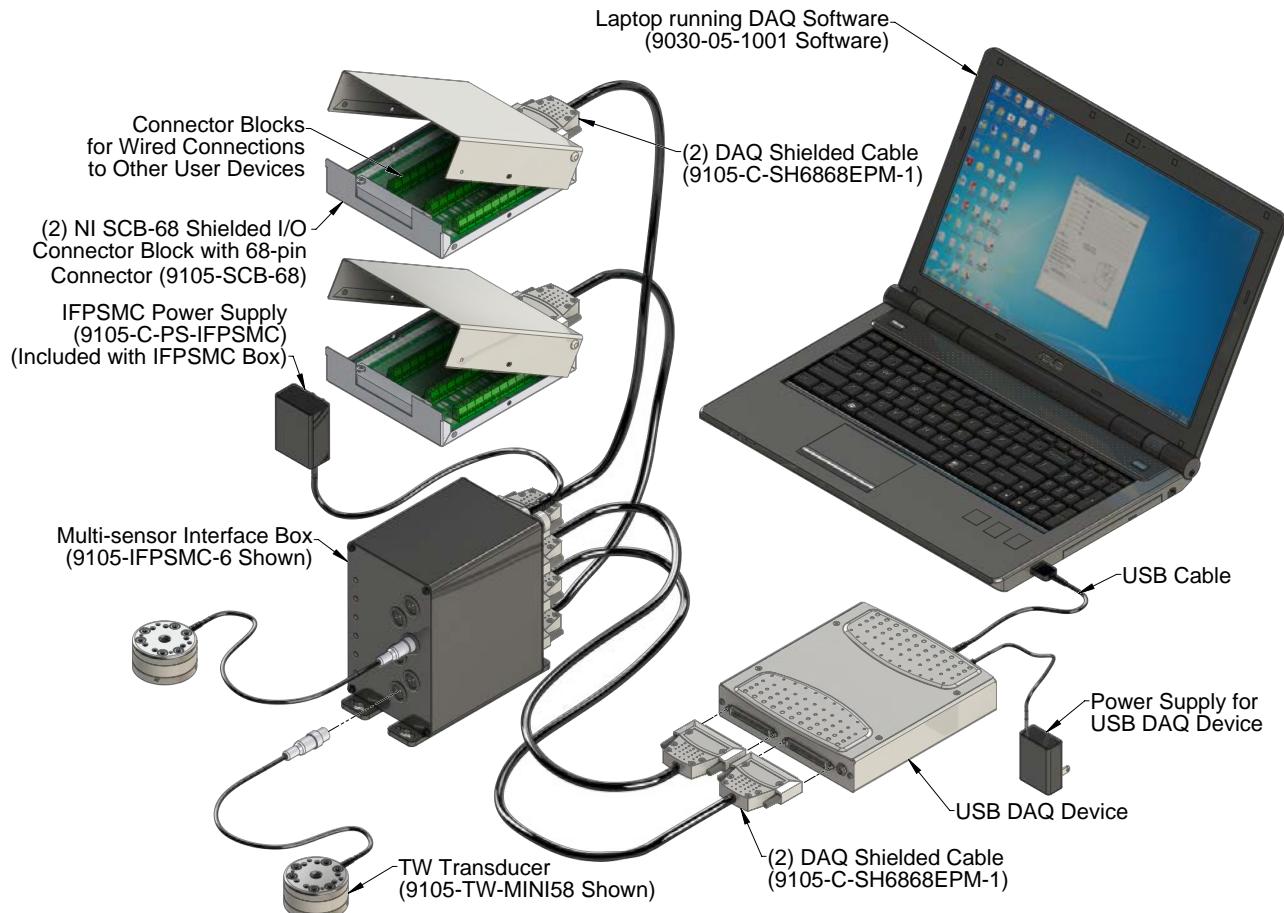
**NOTICE:** The NI SCB-68 I/O connector block's switches MUST be set to direct feed through mode. See NI SCB-68 manufacturer's manual for direction.

**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.

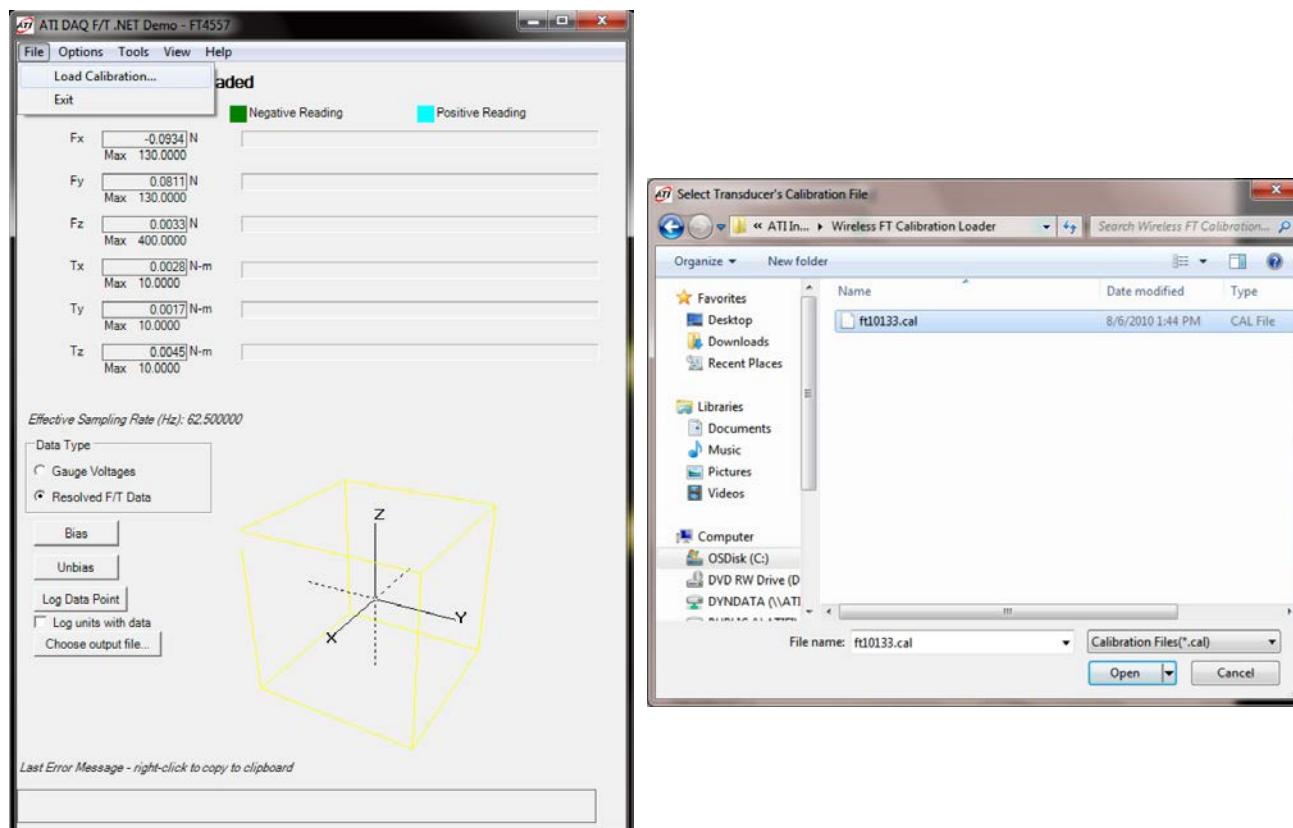
Install the F/T software. The installation program starts automatically. The software can be downloaded from the ATI website at: <http://www.ati-ia.com/Products/ft/Software/SysSoftwareTemplates.aspx>. On the webpage, select DAQ F/T to download the files.

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).

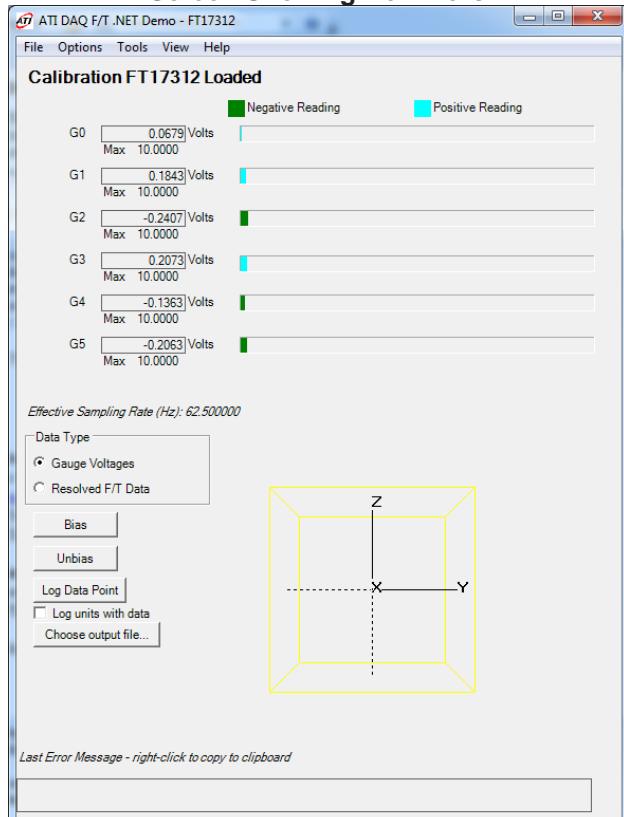
**NOTICE:** The ATI DAQ demo only works in conjunction with National Instruments DAQ boards.

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.

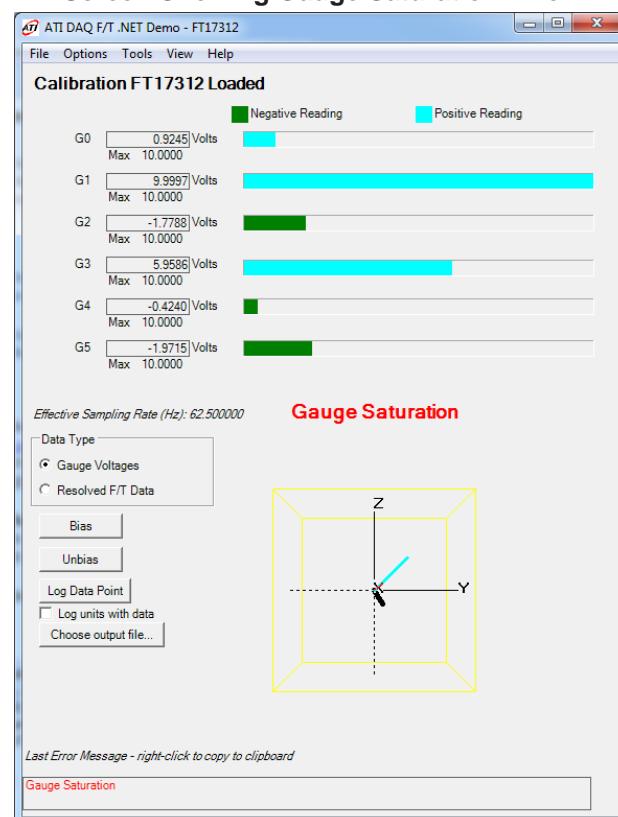
**NOTICE:** A saturation error will be generated when the transducer or data acquisition hardware has a load or signal outside of its sensing range. The screen on the right in *Figure 4.13* shows a Gauge Saturation error.

**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 <sup>1</sup>	Positive power used by PS or IFPS box
0V <sup>1</sup>	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 <sub>ANA</sub> Power Input Voltage	13.00	15.00	17.00	V DC
-V <sub>ANA</sub> Power Input Voltage	-17.00	-15.00	-13.00	V DC
+V <sub>ANA</sub> Power Input Current			50	mA
-V <sub>ANA</sub> Power Input Current			-45	mA
V <sub>ANA</sub> Power Input Noise			75	mV p-p
V <sub>ANA</sub> 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 <sup>1</sup>	-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	AI Gnd	Black
Shell	Shielding	Shield

Note: The AI Gnd 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 <sup>1</sup>	Red <sup>1</sup>	(+5V) <sup>1</sup>	(+5V) <sup>1</sup>
		11	13	0V power <sup>1</sup>	Red/White <sup>1</sup>	(D Gnd) <sup>1</sup>	(D Gnd) <sup>1</sup>
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)

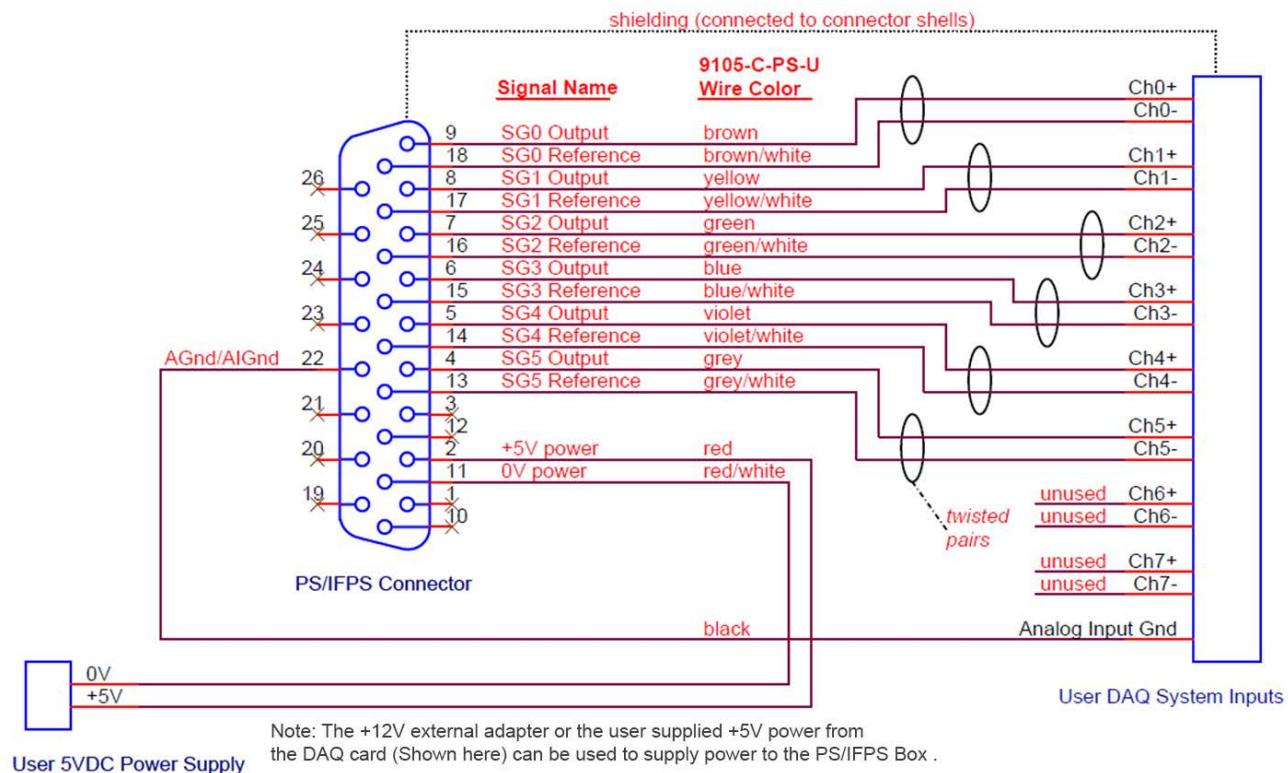
1. This connection is for an external power supply, not a USB device.
2. When using NI Compact DAQ system or any NI DAQ card with isolated analog inputs (AGND is not connected to Chassis Ground). Cable shield and AGND must be connected at the end of the cable in DAQ system side. If using ATI cable 9105-C-PS-d37-xx,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

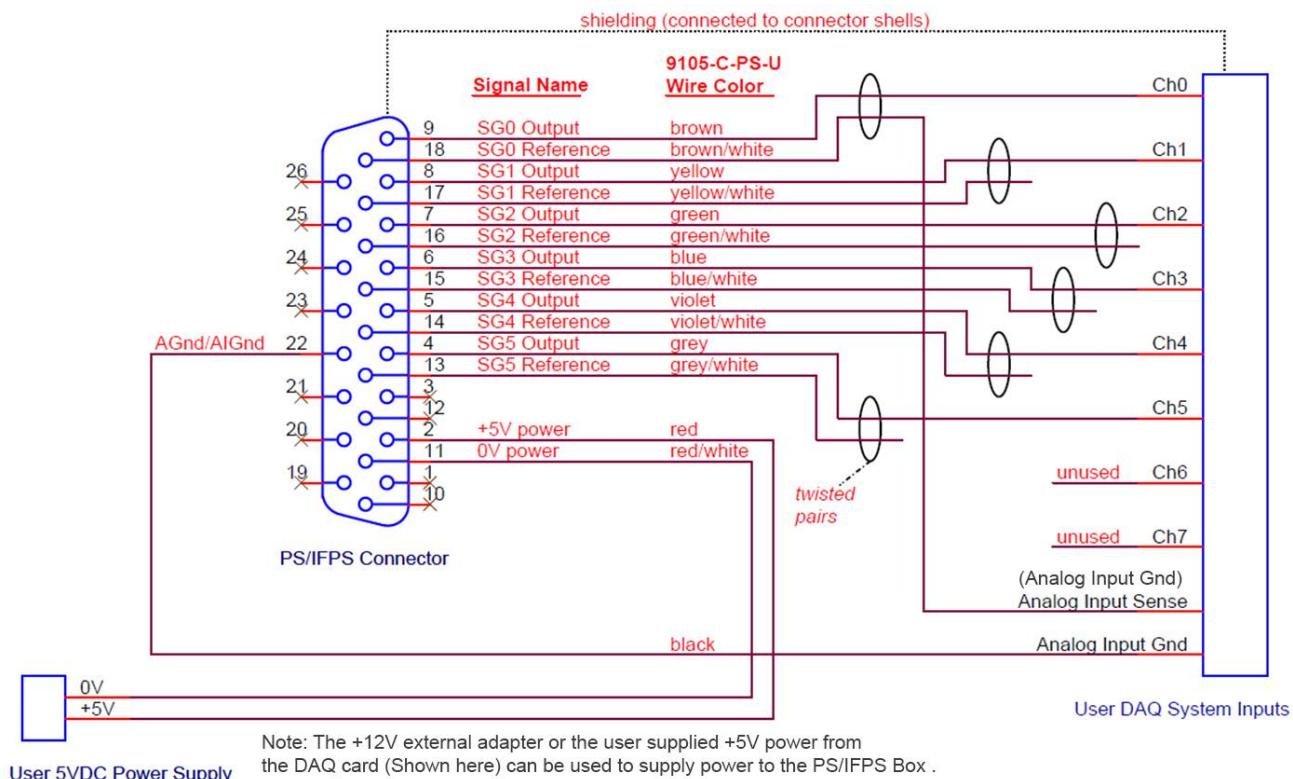
Advanced users may have purchased systems that use an unterminated power supply cable. The NI signal names listed in *Table 4.8* may be used as a guide when connecting the unterminated cable to other National Instruments data acquisition equipment.

*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/IFPS 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.

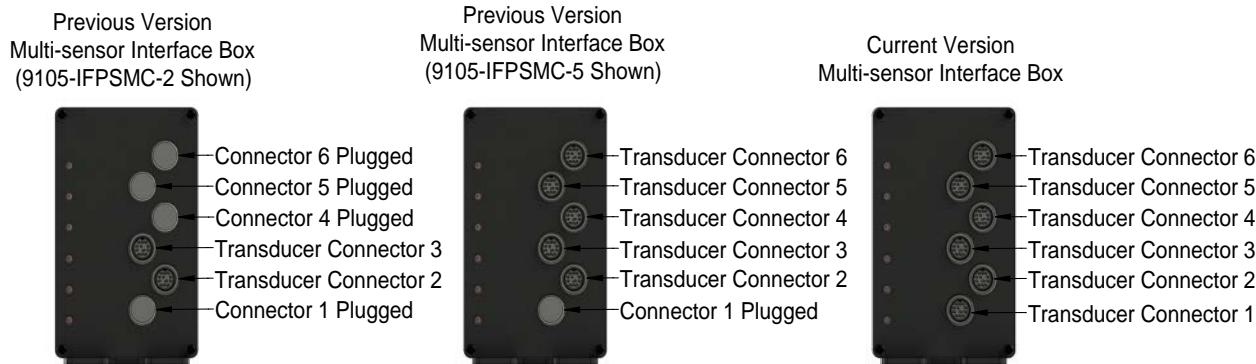
**Table 4.9—9105-IFPSMC Scan List for Each Transducer**

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 IPFSMC, 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 IPFSMC 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 IPFSMC 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 IPFSMC 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

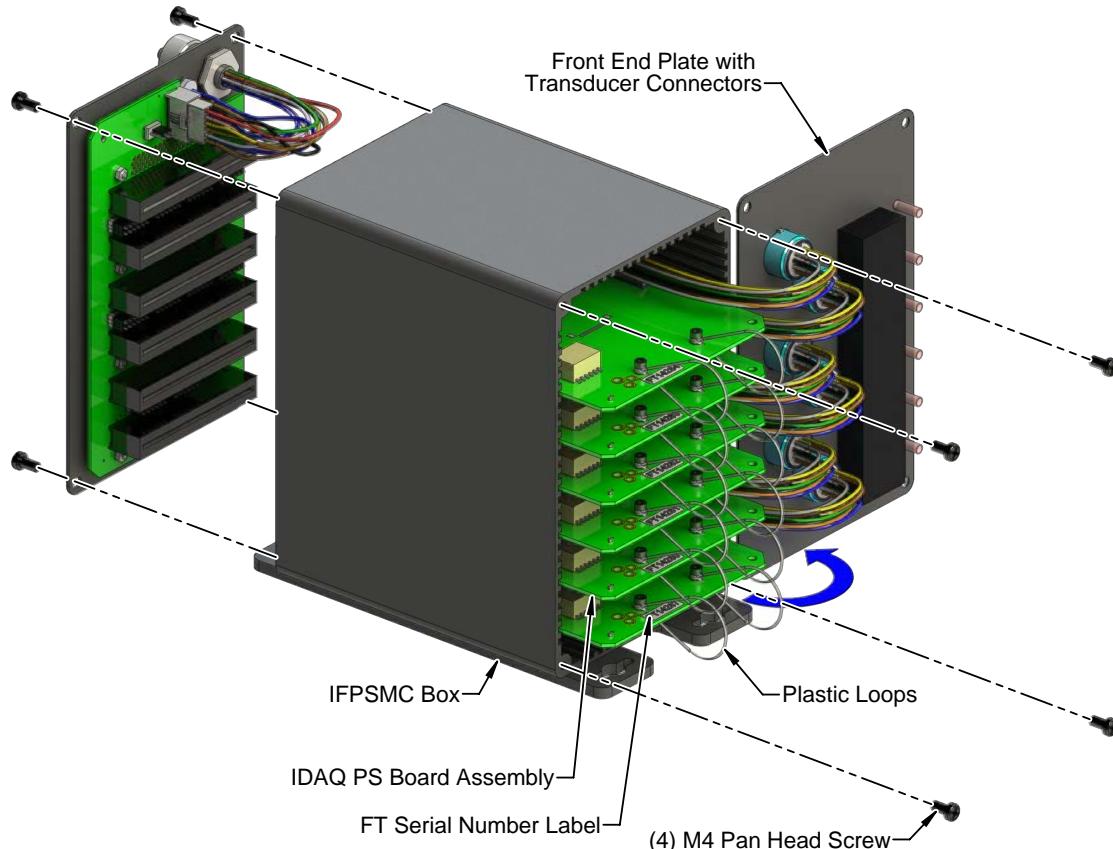
*Parts required:* 12 pin jumpers supplied with the IFPSMC Box (ATI part number 1590-2225000-12) (Amphenol FCI part number 69145-212LF)

**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](#).

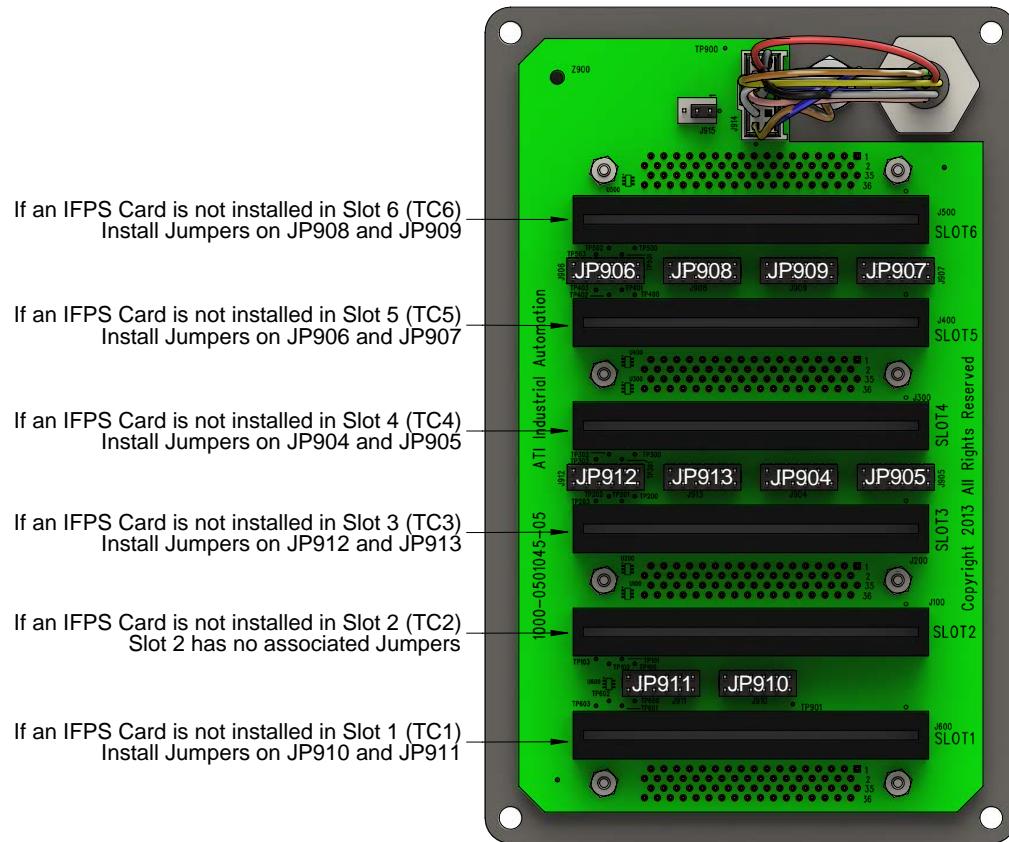
**Figure 4.17—IFPSMC Box Disassembly**



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](#).

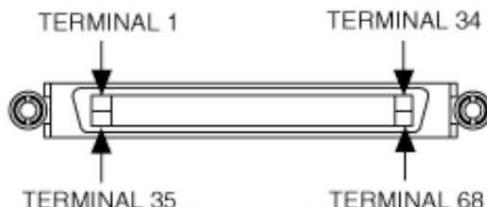
**NOTICE:** Do not install jumpers for DAQ boards that are installed in the IFPSMC box. Only install the associated jumpers for slots without a DAQ board installed. The jumpers make available the signals not used for the Transducer signals, this will override the signals from the transducer connectors.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

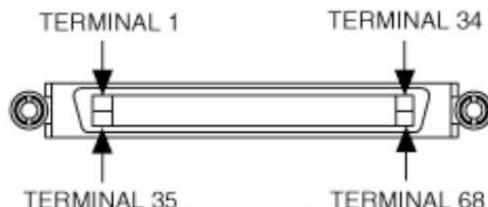


Table 4.12—IFPSMC Box Connector 1 User Signals Available

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

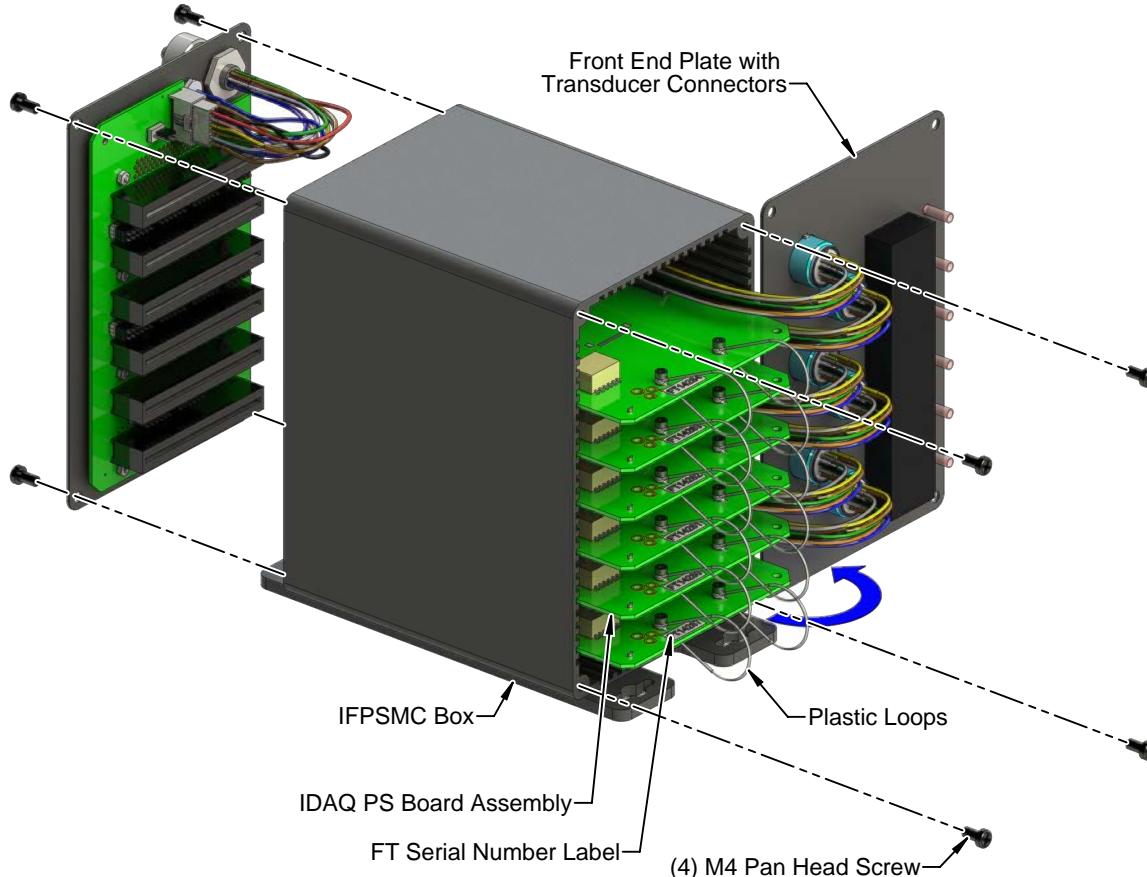
**Parts required:** 9105-IFPSMC-PCB

**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.

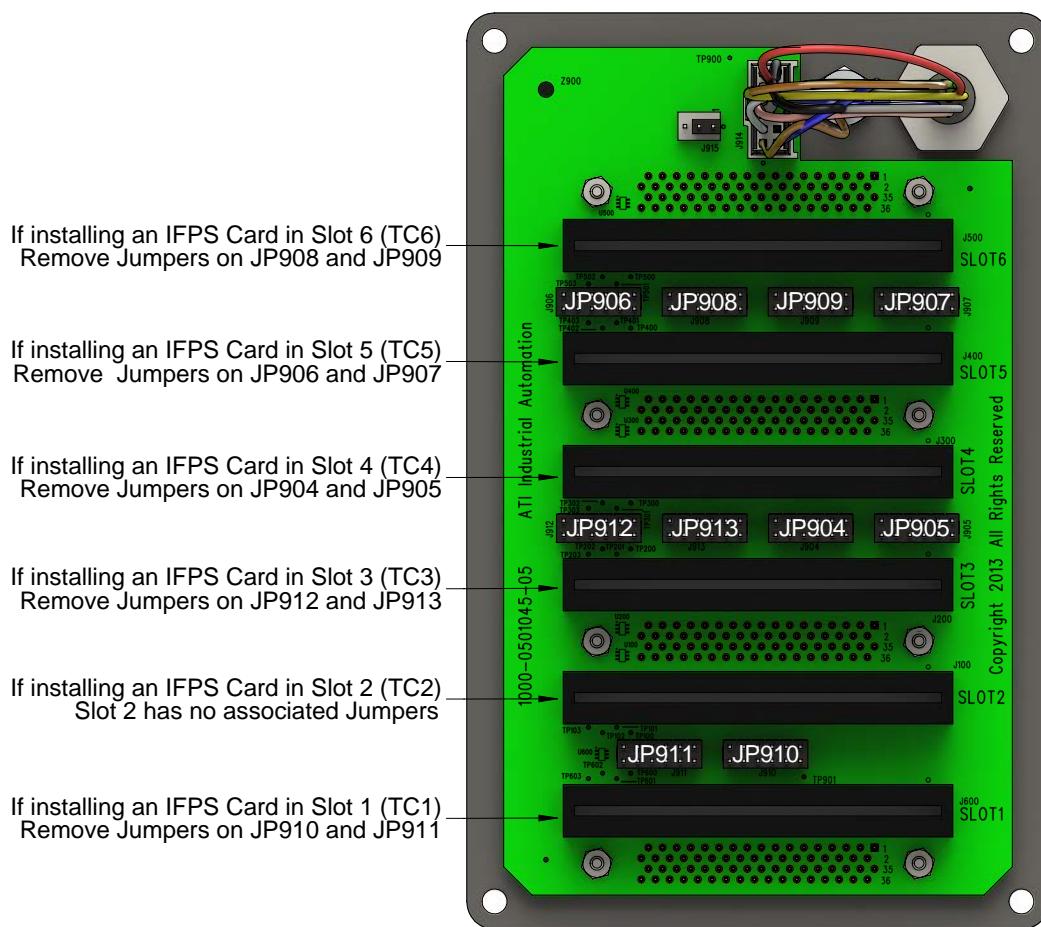
1. Disconnect all cables, transducers and the power supply from the IFPSMC box.
2. Remove the (4) M4 pan head screws from the front panel using a Phillips head screw driver.
3. Carefully rotate the front panel open to the right side of the box, as shown in [Figure 4.21](#).

**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](#).

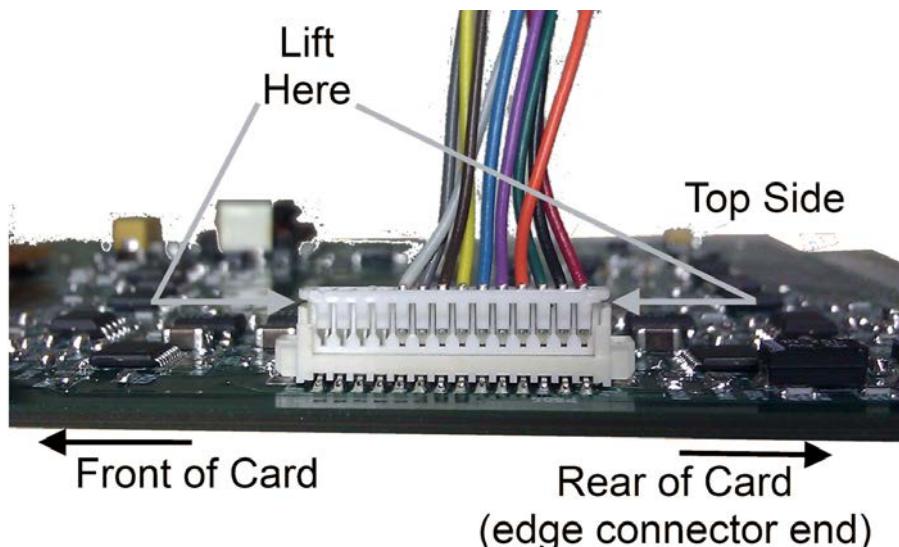
**NOTICE:** The jumpers allow access to channels not used by unpopulated IFPS cards through the connector 0 and 1 from user connectors on the back of the IFPSMC box. Refer to [Table 4.11](#) and [Table 4.12](#) for more information. Remove the jumpers associated with the slot for the IFPS card being 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**



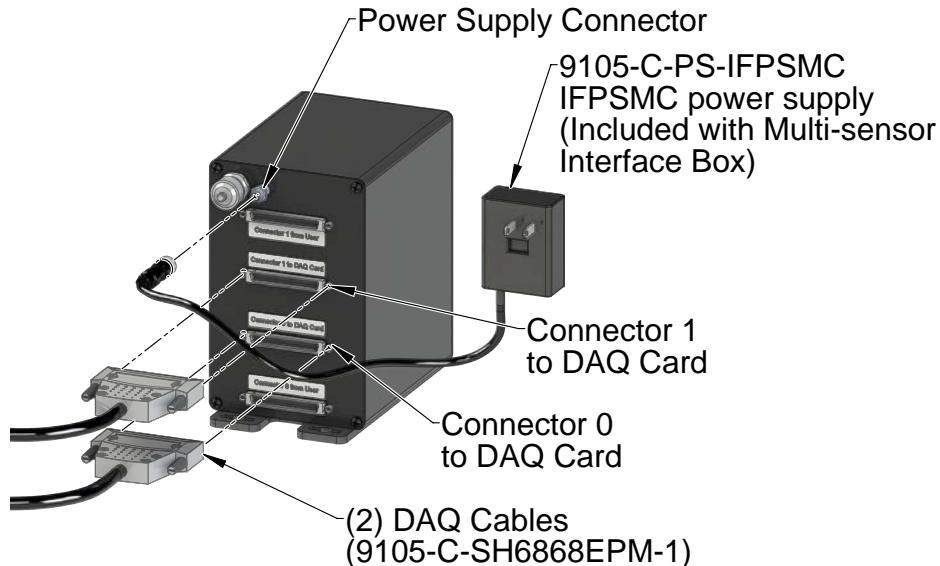
14. Install the IFPS card into the next available slot of the IFPSMC box. Seat the new IFPS card into the backplane by pushing the board in until it seats into the backplane connector.
15. Carefully rotate the front panel back into place on the IFPSMC box. Note: Do not pinch any wire between the front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

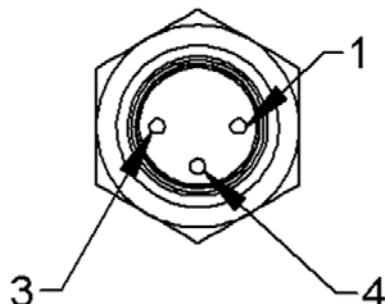
**Figure 4.25—Power Supply and DAQ Cable Connections**



#### 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<sup>†</sup>, 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.

<sup>†</sup> 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

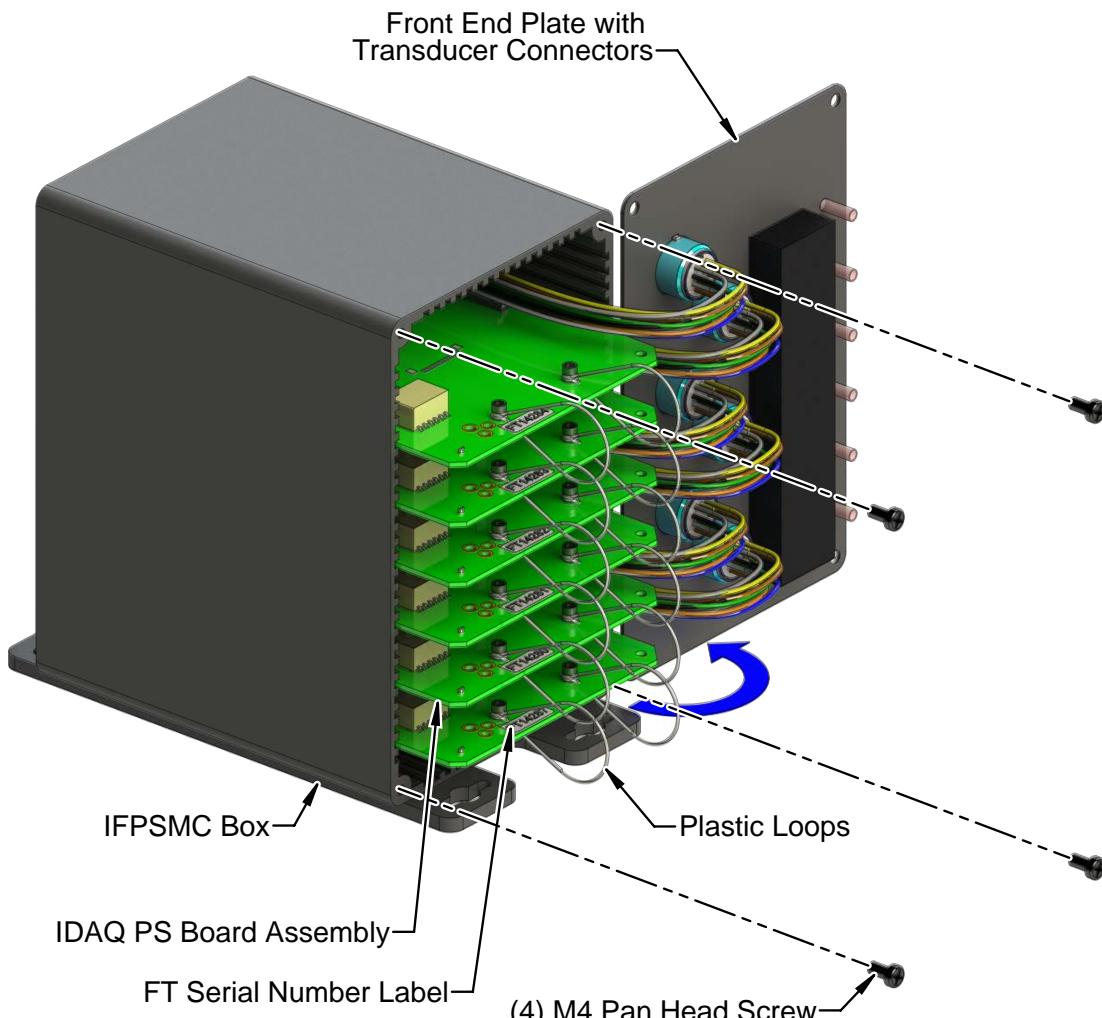
*Parts required:* 9105-IFPSMC-PCB

**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*.

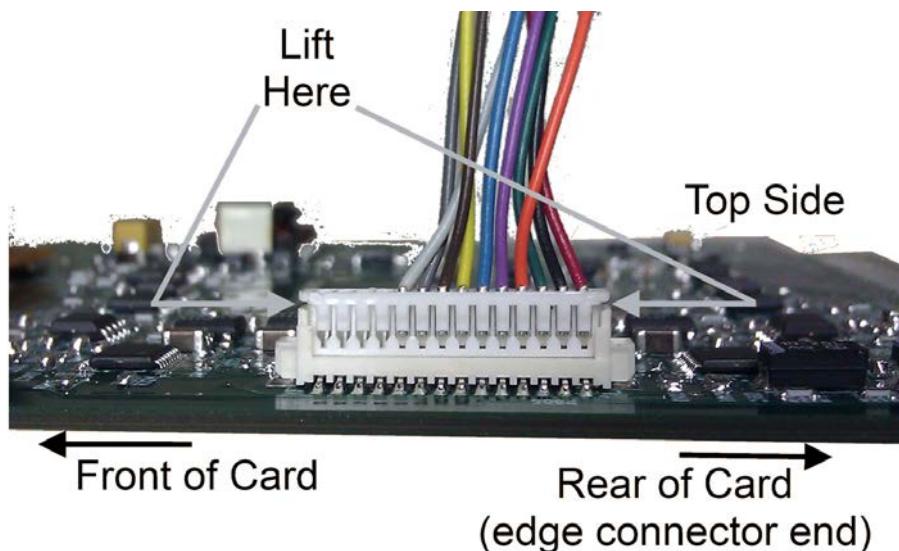
**Figure 6.1—IFPSMC Box Disassembly**



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			

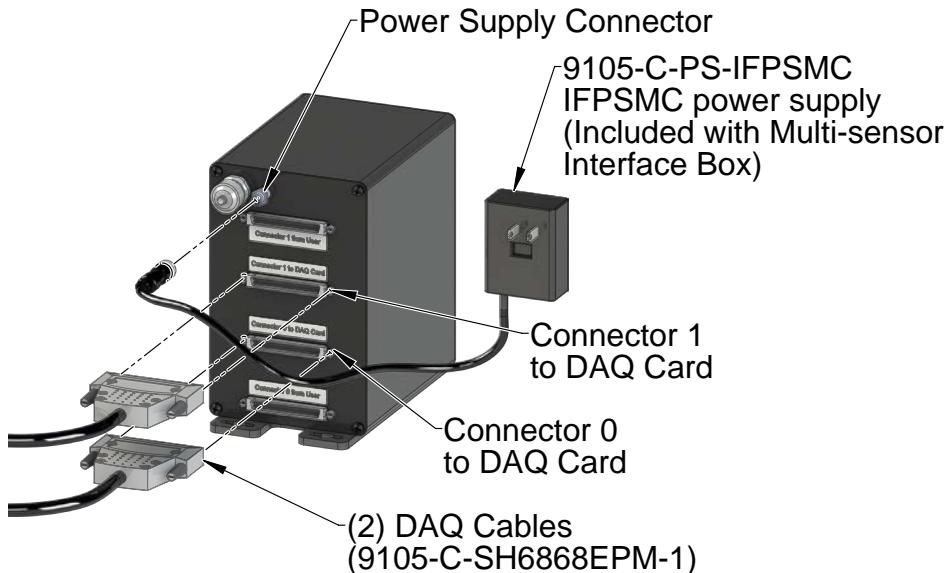
9. Connect the transducer connector harness from the connector on the front panel to the IFPS card, as shown in [Figure 6.2](#).
10. Install the IFPS card into the slot in the IFPSMC box. Seat the new IFPS card into the backplane by pushing the board in until it seats into the backplane connector.
11. 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](mailto: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 ( $\pm 5V$  or  $\pm 10V$ ) 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  $-10^{\circ}C$ .

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.

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 expressed 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.

In the course of supplying products and services hereunder, ATI may provide or disclose to Purchaser confidential and proprietary information of ATI relating to the design, operation, or other aspects of ATI's products. As between ATI and Purchaser, ownership of such information, including without limitation any computer software provided to Purchaser by ATI, shall remain in ATI and such information is licensed to Purchaser only for Purchaser's use in operating the products supplied by ATI hereunder in Purchaser's internal business operations.

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.

Purchaser will not be liable hereunder with respect to disclosure or use of information which: (a) is in the public domain when received from ATI, (b) is thereafter published or otherwise enters the public domain through no fault of Purchaser, (c) is in Purchaser's possession prior to receipt from ATI, (d) is lawfully obtained by Purchaser from a third party entitled to disclose it, or (f) is required to be disclosed by judicial order or other governmental authority, provided that, with respect to such to maintain the confidentiality of such information.

## 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.

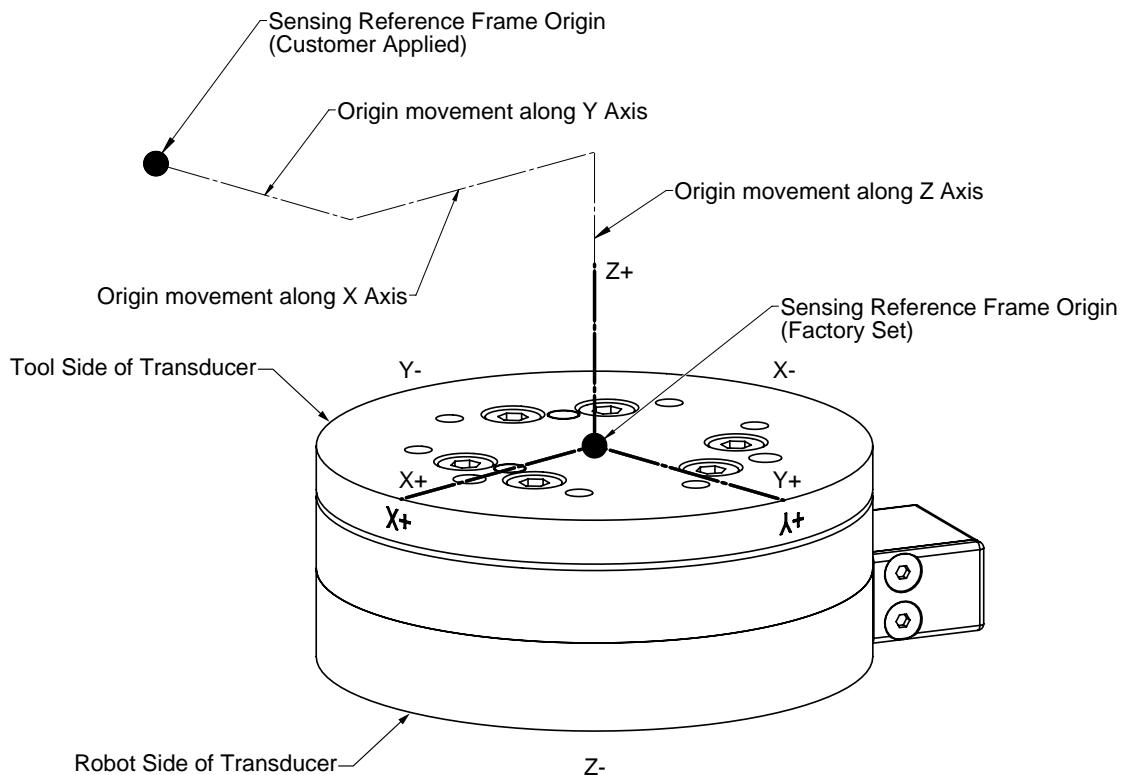
Tool Transformations Screen Controls:

- 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**

