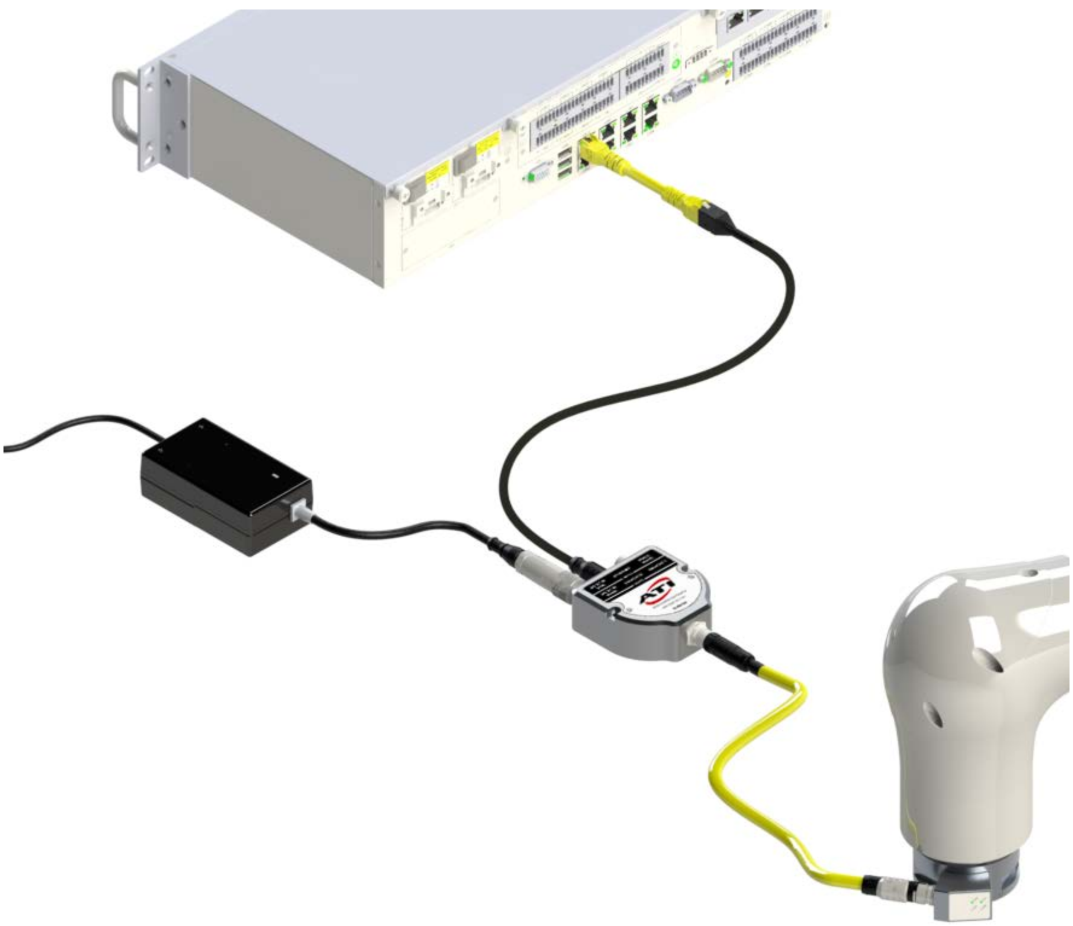
NETrs F/T

Network and Serial (NETrs)
Force/Torque Sensor System

Manual



Document #: 9620-05-NETRS FT

Engineered Products for Robotic Productivity

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Foreword

Note

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

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

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

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

Sale, Service and Information about ATI products:

ATI Industrial Automation (a Novanta Company)
1031 Goodworth Drive
Apex, NC 27539 USA
www.ati-ia.com
Tel: +1 919-772-0115
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Application Engineering
E-mail: *ft.support@novanta.com*

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

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Glossary

Term	Definitions
Accelerometer	A device provided within ATI's Varo sensors that measures acceleration. ATI's Varo sensors use a Micro Electronic Mechanical System (MEMS) accelerometer.
Accuracy	See Measurement Uncertainty.
Active Configuration	The configuration the system is currently using.
Calibration	The factory-supplied data used by NETrs F/T so it can report accurate transducer readings. Calibrations apply to a given loading range.
CAN	Controller Area Network (CAN) is a low level communication protocol used in some networks, including DeviceNet. The Net F/T system has a simple CAN protocol that can be used to read force and torque values.
CEB	Communications Electronics Box is a component of the ATI Network RS422/485 Force/Torque systems that houses additional electronics for power or additional network capability.
CGI	Common Gateway Interface (CGI) is the method of using web URLs to communicate data and parameters back to a web device.
Compound Loading	Any force or torque load that is not purely in one axis.
Configuration	User-defined settings that include which force and torque units are reported, which calibration is to be used, and any tool transformation data.
Coordinate Frame	See Point of Origin.
DeviceNet™	A Fieldbus communication network used mostly by devices in industrial settings, that communicates using CAN. DeviceNet is a trademark of ODVA.
DeviceNet Compatibility Mode	A feature of the Net F/T that allows it to respond like a certified DeviceNet device.
DHCP	Dynamic Host Configuration Protocol (DHCP) is an automatic method for Ethernet equipment to obtain an IP address. The Net F/T system can obtain its IP address using DHCP on networks that support this protocol.
EtherNet/IP™	EtherNet/IP (Ethernet Industrial Protocol) is a Fieldbus communication network, used mostly by devices in industrial settings, that communicates using Ethernet. EtherNet/IP is a trademark of ControlNet International Ltd. used under license by ODVA.
Ethernet Network Switch	Ethernet network switches are electronic devices that connect multiple Ethernet cables to an Ethernet network while directing the flow of traffic.
Fieldbus	A generic term referring to any one of a number of industrial computer networking standards. Examples include: CAN, Modbus, and PROFINET.
FS	Full-Scale.
F/T	Force and Torque.
Fxy	The resultant force vector comprised of components Fx and Fy.
Gyroscope	A device provided within ATI's Varo sensors that measures orientation and angular velocity. ATI's Varo sensors use a Micro Electronic Mechanical System (MEMS) gyroscope.
Hysteresis	A source of measurement caused by the residual effects of previously applied loads.
IMU	Inertial measurement unit (IMU) is a device that detects acceleration and angular velocity (gyroscopic data).
IP Address	An IP Address (Internet Protocol Address) is an electronic address assigned to an Ethernet device so that it may send and receive Ethernet data. IP addresses may be either manually selected by the user or automatically assigned by the DHCP protocol.
IPV4	IPV4 (Internet Protocol Version 4) describes IP addresses using four bytes, usually expressed in the dot-decimal notation, such as, 192.168.1.1 for example.
Java™	Java is a programming language often used for programs on web pages. The Net F/T demo is a Java application. Java is a registered trademark of Sun Microsystems, Inc.
MAC Address	MAC Addresses (Media Access Control Addresses) are the unique addresses given to every Ethernet device when it is manufactured, to be used as an electronic Ethernet serial number.

Term	Definitions
MAC ID	Media Access Code Identifier (MAC ID) is a unique number that is user assigned to each DeviceNet device on a DeviceNet network. Also called Node Address.
Maximum Single-Axis Overload	The largest amount of pure load (not compound loading) that the transducer can withstand without damage.
MAP	The Mounting Adapter Plate (MAP) is the transducer plate that attaches to the fixed surface or robot arm.
Measurement Uncertainty	The maximum expected error in measurements, as specified on the calibration certificate.
Net Box	A component of the Network RS422/485 Force/Torque system that contains the power supply and network interfaces. For NETrs sensors, the Net Box will only be used for customers using a standard transducer with EtherNet/IP™ PROFINET, or CANbus communications.
NETrs	Network RS422/RS485. ATI's Force/Torque system that combines both network and RS422/RS485 communication into a singular system.
NetRS CEB	A component of the Network RS422/485 Force/Torque system that contains the power supply and network interfaces. For NetRS sensors, the NetRS CEB will be used for customers using a Mini or Nano transducer.
Node Address	See MAC ID.
ODVA™	ODVA (Open DeviceNet Vendors Association, Inc.) is an organization that defines DeviceNet, EtherNet/IP, and other industrial networks. ATI Industrial Automation is a member of ODVA. ODVA is a registered trademark of Open DeviceNet Vendors Association, Inc.
Overload	The condition where more load is applied to the transducer than it can measure. This will result in saturation.
P/N	Part Number
Point of Origin	The location on the transducer from which all forces and torques are measured. Also known as the Coordinate Frame.
PROFINET	An Ethernet-based fieldbus used in factory automation.
Quantization	The process of converting a continuously variable transducer signal into discrete digital values. Usually used when describing the change from one digital value to the next increment.
RDT	Raw Data Transfer (RDT) is a fast and simple Net F/T protocol for control and data transfer via UDP.
Resolution	The smallest change in load that can be measured. This is usually much smaller than accuracy.
Saturation	The condition where the transducer has a load outside of its sensing range.
Sensor System	The assembly consisting of all components which includes the transducer, hardware, and Net Box for some systems.
TAP	Tool Adapter Plate (TAP) is the transducer surface that attaches to the load to be measured.
TCP	Transmission Control Protocol (TCP) is a low-level method of transmitting data over Ethernet. TCP provides a slower, more reliable delivery of data than UDP.
Monitor Conditions	A Net F/T function that performs a simple arithmetic comparison of a user-defined Condition to the loading on a transducer axis.
Tool Transformation	A method of mathematically shifting the measurement coordinate system to translate the point of origin and/or rotate its axes.
Transducer	Transducer is the component that converts the sensed load into electrical signals.
Txy	The resultant torque vector comprised of components Tx and Ty.
UDP	UDP (User Datagram Protocol) is a low-level method of transmitting data over Ethernet. While UDP is faster than TCP, unlike TCP lost UDP data is not resent.

1. Safety

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

1.1 Explanation of Notifications

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

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

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

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

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

1.2 General Safety Guidelines

The customer should verify that the transducer selected is rated for maximum loads and moments expected during operation. For assistance, refer to F/T Transducer Manual (*9620-05-Transducer Section*) or contact ATI Industrial Automation. Particular attention should be paid to dynamic loads caused by robot acceleration and deceleration. These forces can be many times the value of static forces in high acceleration or deceleration situations.

1.3 Safety Precautions

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

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

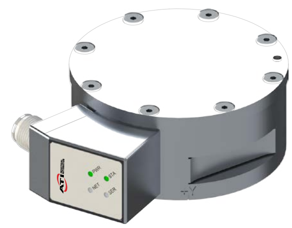
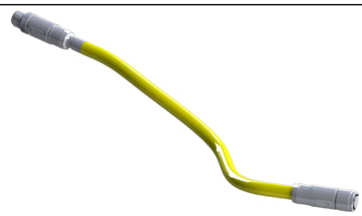
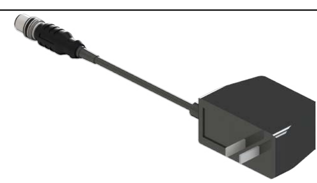
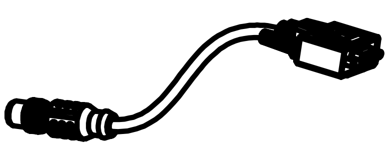
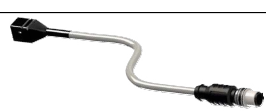
CAUTION: Do not exert excessive force on the transducer. The transducer is a sensitive instrument and can be damaged by applying force exceeding the single-axis overload values of the transducer and cause irreparable damage. Small Nano and Mini transducers can easily be overloaded during installation.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

2. Product Overview

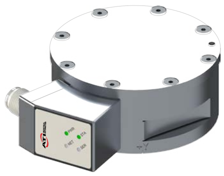
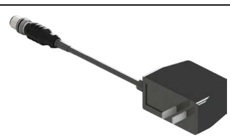
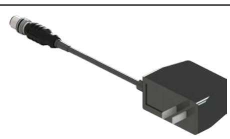
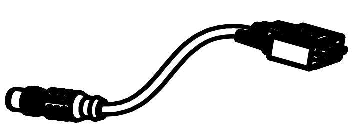
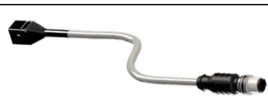
The Network RS422/485 Force/Torque (NETrs F/T) sensor system is a multi-axis force and torque sensor system that simultaneously measures forces Fx, Fy, Fz, and torques Tx, Ty, and Tz. The NETrs system can communicate via User Datagram Protocol (UDP), Transmission Control Protocol (TCP), Raw Data Transfer (RDT), PROFINET, EtherNet/IP™ or DeviceNet®, or via console commands over a serial connection. More functionality can be found in *Section 2.2—NETrs System Functionality.*

2.1 NETrs System Components

The main components of the NETrs F/T system are displayed in *Table 2.1*.

Table 2.1—Network RS422/485 System Components		
Standard Transducer with Splitter Box		
Image	**Description**	**Part Numbers**
	Standard Transducer	9105-NETRS-*SensorModel*
	Transducer Cable	9105-C-MA12F1-MA12M1-01-1.0 9105-C-MA12F1-MA12M1-01-5.0 9105-C-MA12F1-MA12M1-01-10.0
	Splitter Box	9105-GEN3-SPLIT-001
	Power Supply	9105-CBL-S-G1-Q5F-WWPS1-1.5
	M12 to DB9 Serial Adapter	9105-C-D09F1-MD4M1-01-5.0
	M12 to RJ45 Ethernet Adapter	9105-C-R08F1-MD04M1-01-0.2 (Default)[1]

Note:
1. Additional cable lengths available.

Table 2.1—Network RS422/485 System Components		
Standard Transducer with Net Box		
Image	**Description**	**Part Number**
	Standard Transducer	9105-NETRS-*SensorModel*
	Transducer Cable	9105-C-MA12F1-MA12M1-01-1.0 9105-C-MA12F1-MA12M1-01-5.0 9105-C-MA12F1-MA12M1-01-10.0
	NET Box	9105-NETB
	Power Cable	9105-CBL-S-G1-Q5F-WWPS1-1.5
	M12 to RJ45 Ethernet Adapter	9105-C-R08F1-MD04M1-01-0.2 (Default)[1]
Mini/Nano Transducers		
Image	**Description**	**Part Number**
	Transducer with integral cable	9105-TW-*SensorModel*
	NETrs Communications Electronics Box (CEB)	9105-NETRS-CEB-001
	Power Supply	9105-CBL-S-G1-Q5F-WWPS1-1.5
	M12 to DB9 Serial Adapter	9105-C-D09F1-MD4M1-01-5.0
	M12 to RJ45 Ethernet Adapter	9105-C-R08F1-MD04M1-01-0.2 (Default)[1]

Note:

1. Additional cable lengths available.

- **NETrs F/T Transducer:** converts the force and torque loads into electrical signals and transmits them over the transducer cable. Most of ATI's sensors send digital signals. ATI's smallest sensors without on-board electronics (Nano and Mini series), transmit analog signals. For more information, refer to the F/T Transducer Manual (*9620-05-Transducer Section*).
- **Transducer Cable:** delivers power to the transducer and transmits the transducer's strain gage data. Transducers with on-board electronics connect to either a splitter box or the Net Box depending on the user's communication preferences. Any DeviceNet compatible cable with correct gender M12 Micro connectors can be used. ATI Industrial Automation supplies a robotic grade high flex transducer cable with each NETrs F/T system. Transducers without on-board electronics (Mini or Nano series) include an attached transducer cable that connects to a NetRS Communications Electronics Box (CEB). The transducer cable is an integral part of transducer and cannot be removed.
- **Splitter Box:** splits the transducer cable into connections for power, Ethernet, and serial. The splitter box is necessary for any application using a standard transducer without the Net Box.
- **Power Cable:** provides power to the transducer via splitter box, Net Box, or NETrs CEB**.**
- **Communication Cables:** transmits signals over Ethernet or serial connections.
- **Net Box:** processes and communicates the transducer's force and torque readings to the user's equipment. The Net Box (9105-NETB) is specific to customers using a standard transducer that require communication of PROFINET or EtherNet/IP™. The Net Box also responds to DeviceNet® commands sent over the CAN Bus connection. The Net Box is an IP65-rated aluminum housing. A Net Box is not used for any applications using a standard transducer communicating via TCP, UDP, or serial.
- **NetRS CEB:** processes and communicates the transducer's force and torque readers to the user's equipment. The NetRS CEB (9105-NETRS-CEB-001) is specific to customers using a Nano or Mini series transducer
- **ATI Industrial Automation software, calibration documents, and manuals** (including this manual). This information is on the ATI website (*https://www.ati-ia.com/Products/ft/sensors.aspx*) or sent as an e-mail upon purchase of the system.
- Other optional components include:
    - Power supply that plugs into a 100–240 VAC (50–60 Hz) power outlet and provides power to the sensor via splitter box or Net Box.
    - M12 to RJ45 Ethernet cable adapter
    - M12 to DB9 serial cable adapter
    - Mini to Micro (M12) DeviceNet adapter (for the Pwr/CAN connector)
    - DeviceNet cabling (for the Pwr/CAN connector)
    - Ethernet cabling
    - Robot-grade transducer cables of different lengths

2.2 NETrs System Functionality

The NETrs F/T system supports the following features:

- **Multiple Calibrations**

  The NETrs F/T can hold up to four different transducer calibrations, and each can have a different sensing range. The different calibrations are created with different load scenarios during the calibration process at the factory and stored in the NETrs F/T.

  Multiple calibrations allow for a larger calibration for coarse adjustments and smaller calibrations for fine adjustments, or to use the same transducer in two or more very different loading regimes. Contact ATI Industrial Automation for information on obtaining additional transducer calibrations.

- **Multiple Interfaces**

  The NETrs system communicates via User Datagram Protocol (UDP), Transmission Control Protocol (TCP), and Raw Data Transfer (RDT). By adding a Net Box (9105-NETB), ATI's NETrs F/T system can communicate via PROFINET and EtherNet/IP™, and is compatible with DeviceNet®. NETrs sensors can also communicate via console commands over a serial connection.

- **Force and Torque Values**

  The NETrs F/T outputs scaled numbers, or counts, that represent the loading of each force and torque axis. ATI's NETrs sensor also includes functionality to resolve force and torque values into other units of measurement that can be configured by the user via console commands or on the NETrs *FT Configuration* webpage, reference *Section 4.1—ATI Force/Torque Webpages*.

- **System Status Code**

  Each NETrs F/T output data record contains a system status code which indicates the health of the transducer and the Net Box. For details, refer to *Section 7.1—System Status Code*.

- **Onboard Inertial Measurement Unit (IMU)**

  Both triaxial acceleration and angular velocity measurements are available from the on-board accelerometer and gyroscope. For details, refer to *Section 5.1.5—IMU Data: Configurating Accelerometer and Gyroscope*

- **Monitor Conditions**

  The NETrs F/T is capable of monitoring the force and torque levels of each axis and setting an output code if a reading crosses a user-defined condition. The NETrs F/T can monitor up to 16 conditions simultaneously, and each condition can be enabled and disabled individually or as a group. Set up monitor conditions on the NETrs F/T's *Thresholding* web page, reference *Section 4.1—ATI Force/Torque Webpages*.

- **Tool Transformations**

  The NETrs F/T is capable of measuring the forces and torques acting at a point other than the factory-defined point-of-origin (also known as the sensing reference frame origin). This change of reference is called a tool transformation. Specify tool transformations for each configuration on the NETrs F/T's *FT Configurations* web page, reference *Section 4.1—ATI Force/Torque Webpages*.

- **Power Supply**

  The NETrs F/T system accepts power from a DC power source with an output voltage between 12V and 30V.

3. Installation and Set-Up

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

CAUTION: Using fasteners that exceed the customer interface depth penetrates the body of the sensor, damages the electronics, and voids the warranty. For more information, refer to the customer drawings.

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

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

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

This section will overview how to connect and prepare the sensor for operation. Information on mounting the sensor can be found in the *Transducer manual*.

3.1 Connecting Standard Transducer System

ATI's selection of standard transducers include the Gamma series, Delta series, and Omega series. For users interested in communicating with a standard transducer via serial, UDP or TCP, refer to *Section 3.1.1—Option 1: Connecting Transducer Using Splitter Box.*

For users interested in communicating with a standard transducer via PROFINET, EtherNet/IP™ or DeviceNet®, refer to *Section 3.1.2—Option 2: Connecting the Transducer to the Net Box.*

CAUTION: The Splitter Box should be grounded through at least one of the two mounting tabs. Ground the shield pin of the power supply cable to earth and power supply (-) for best noise performance.

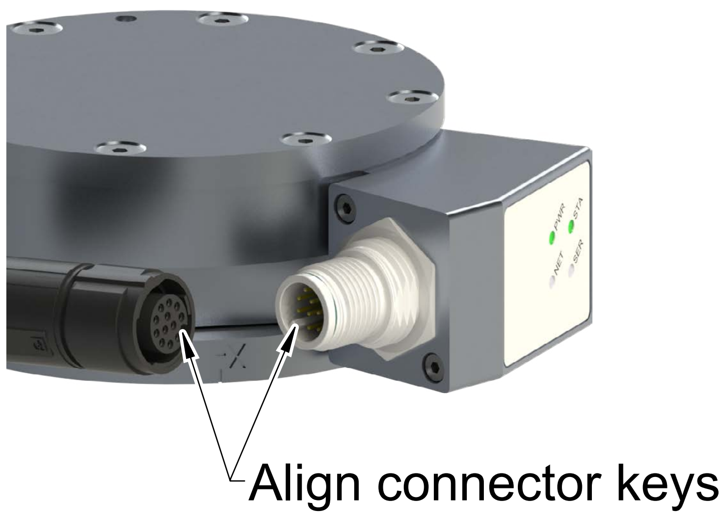
3.1.1 Option 1: Connecting Transducer Using Splitter Box

Supplies required:

- Transducer Cable (9105-C-MA12F1-MA12M1-01-*LENGTH*)
- Splitter Box (9105-GEN3-SPLIT-001)
- Power Supply (9105-CBL-S-G1-Q5F-WWPS1-1.5)
- Communication cables: Ethernet: M12 to RJ45 adapter (9105-C-R08F1-MD04M1-01-0.2), and customer-supplied standard RJ45 cable
  Serial: M12 to D-Sub adapter (9105-C-D09F1-MD4M1-01-5.0)

2. Connect transducer to splitter box using transducer cable.
   a. Align the female M12 connector of the transducer cable into the male M12 connector of the transducer. Use the key to ensure pins are aligned correctly. Refer to *Section 8—Specifications* for detailed pinout information.

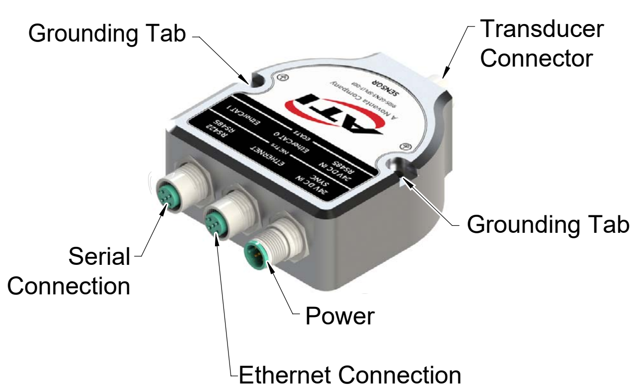
Figure 3.1—Connect Transducer Cable



   b. Tighten cable sleeve clockwise to lock the connector at a recommended torque value of 0.8 Nm to 1.0 Nm. Refer to *Figure 3.1.*

   c. Align the male M12 connector of the transducer cable to the female M12 socket of the splitter box. Splitter box should be clearly labeled “Transducer” to identify correct placement, refer to *Figure 3.2* Refer to *Section 8—Specifications* for detailed splitter box pinout information.

Figure 3.2—Splitter Box Overview



   d. Tighten its sleeve clockwise to lock the connector at a recommended torque value of 0.8 Nm to 1.0 Nm.

3. Connect desired communication: Ethernet, Serial, or both.

- Ethernet:
    a. Locate the Ethernet connector on the splitter box. Refer to *Figure 3.2.*

    b. Connect the M12 to RJ45 adapter to the splitter box. Tighten the sleeve fully to lock the connector at a recommended torque of 0.8 Nm to 1.0 Nm.

    c. Connect a standard RJ45 cable (customer-supplied) to the adapter.

    d. Plug the other end of the RJ45 cable into the port of an Ethernet switch.

    NOTICE: To achieve the best Ethernet performance and to reduce the likelihood of losing data, connect the Ethernet cable directly to the host computer.

- Serial:
    a. Locate the serial connector on the splitter box. Refer to *Figure 3.2.*

    b. Connect the M12 to DB9 adapter to splitter box. Tighten the sleeve fully to lock the connector at a recommended torque of 0.8 Nm to 1.0 Nm..

    c. Plug the other end of the serial cable into customer equipment.

    NOTICE: The serial connector is compatible with both RS422 and RS485 communication. To wire inputs for the desired RS communication appropriately, refer to *Table 8.4.*

4. Connect power to splitter box.
    a. Locate the power input on the splitter box. Refer to *Figure 3.2.*

    b. Connect the power supply cable to the splitter box connector.

    c. Connect the power supply to a power source.

    d. If using the Clock Sync feature, Refer to *Section 8.3* for connector pin-outs..

5. If using Ethernet, continue to *Section 3.2—Connecting to Ethernet.*

3.1.2 Option 2: Connecting the Transducer to the Net Box

CAUTION: The Net Box should be mounted in an area that it is not exposed to temperatures outside of its working range (see *Section 8.1—Electrical Specifications (Power Supply)*). It is designed to be used indoors in a non-dynamic, non-vibratory environment and may be mounted in any orientation. It is designed to meet IP65 ingress protection.

CAUTION: The Net Box should be grounded through at least one of the four mounting tabs. Ground the shield pin of the power supply cable to earth and power supply (-) for best noise performance.

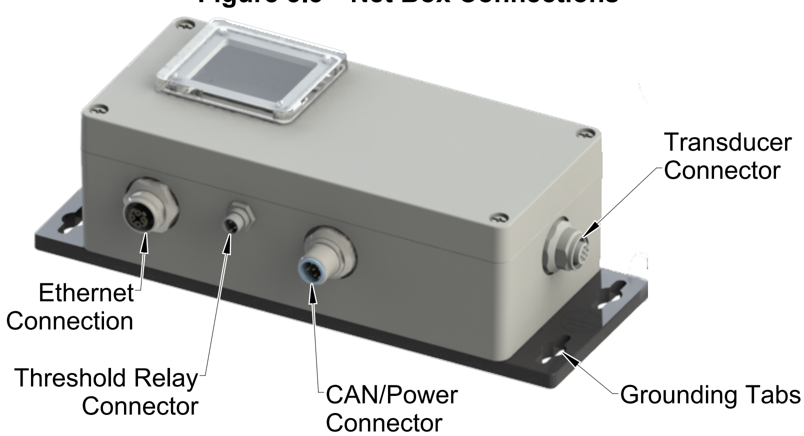
CAUTION: To avoid disturbed transducer signals, especially in a noisy environment and when using long transducer cables, it is highly recommended to provide a low impedance ground connection for the transducer body.

Supplies required:

- Transducer Cable (9105-C-MA12F1-MA05M1-01-*LENGTH*)
- Network Box (9105-NETB)
- Power Supply (9105-CBL-S-G1-Q5F-WWPS1-1.5)
- Ethernet cables: M12 to RJ45 adapter (9105-C-ES-RJ45-0.2), and customer-supplied standard RJ45 cable.

1. Connect transducer to Net Box using transducer cable.
    a. Align the female M12 connector of the transducer cable into the male M12 connector of the transducer. Use the key to ensure pins are aligned correctly. Refer to *Figure 3.1*
    b. Tighten cable sleeve clockwise to lock the connector at a recommended torque value of 0.8 Nm to 1.0 Nm.
    c. Align the male M12 connector of the transducer cable to the female M12 socket of the Net Box. Refer to *Figure 3.3.* Refer to *Section 8—Specifications* for detailed Net Box pinout information.

Figure 3.3—Net Box Connections



    d. Tighten sleeve clockwise to lock the connector at a recommended torque value of 0.8 Nm to 1.0 Nm.

2. Connect Ethernet communication:
    a. Locate the Ethernet connector on the Net Box. Refer to *Figure 3.3.*
    b. Connect an M12 to RJ45 adapter to the Net Box. Tighten the sleeve fully to lock the connector at a recommended torque of 0.8 Nm to 1.0 Nm.
    c. Connect a standard RJ45 cable (customer-supplied) to the adapter.
    d. Plug the other end of the Ethernet cable into the port of an Ethernet switch.

NOTICE: To achieve the best Ethernet performance and to reduce the likelihood of losing data, connect the Net Box directly to the host computer.

3. Connect power to the Net Box
    a. Locate the power input on the Net Box. Refer to *Figure 3.3.*
    b. Connect the power supply cable to the Net Box connector.
    c. Connect power supply to power source.
4. If using Ethernet, continue to *Section 3.2—Connecting to Ethernet.*

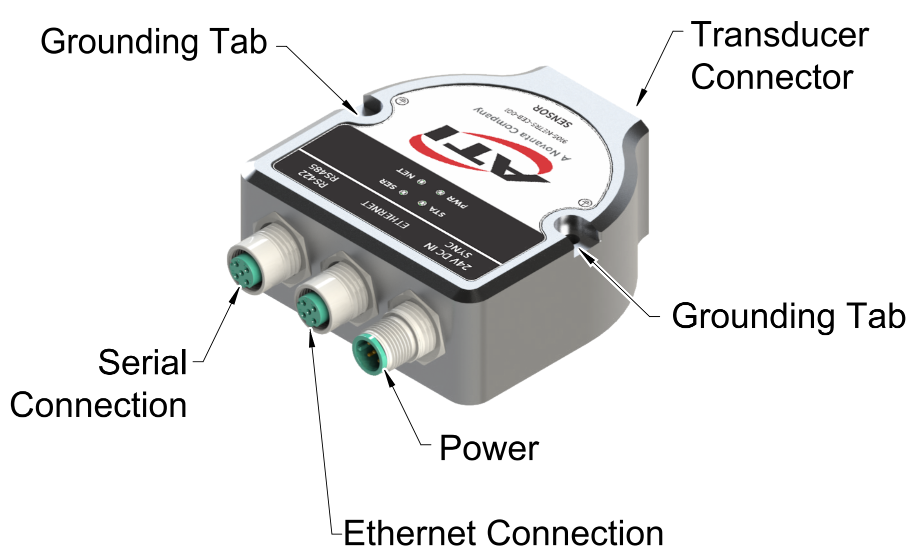
3.2 Connecting a Mini or Nano Transducer

ATI offers a selection of smaller transducers that require the use of a the NetRS Communications Electronics Box (CEB), which houses an additional electronic board. Those sensors include the Nano series and Mini series. These sensors include an attached transducer cable.

Supplies required:

- NETrs CEB (9105-NETRS-CEB-001)
- Power Supply (9105-CBL-S-G1-Q5F-WWPS1-1.5)
- Communication cables: Ethernet: M12 to RJ45 adapter (9105-C-R08F1-MD04M1-01-0.2), and customer-supplied standard RJ45 cable
  Serial: M12 to D-Sub adapter (9105-C-D09F1-MD4M1-01-5.0)

Figure 3.4—NetRS CEB Inputs



1. Connect transducer cable to the NETrs CEB.
    a. Align M12 male transducer cable connector with M12 female transducer socket on NETrs CEB.
    b. Tighten cable sleeve clockwise to lock the connector at a recommended torque value of 0.7 Nm.
2. Connect desired communication: Ethernet, Serial, or both.

- Ethernet:
    a. Locate the Ethernet connector on the NETrs CEB. Refer to *Figure 3.4.*
    b. Connect an M12 to RJ45 adapter to the NETrs CEB. Tighten the sleeve fully to lock the connector at a recommended torque of 0.8 Nm to 1.0 Nm.
    c. Connect a standard RJ45 cable (customer-supplied) to the adapter.

d. Plug the other end of the Ethernet cable into the port of an Ethernet switch.

NOTICE: To achieve the best Ethernet performance and to reduce the likelihood of losing data, connect the NetRS CEB directly to the host computer.

- Serial:
  a. Locate the serial connector on the NETrs CEB. Refer to *Figure 3.4.*
  b. Connect serial cable to the NETrs CEB.
  c. Plug the other end of the serial cable into customer equipment.

3. Connect power
   a. Identify the power input on the NETrs CEB. Refer to *Figure 3.4.*
   b. Connect the power supply cable to the NETrs CEB.
   c. Connect the power supply to a power source.
4. If using Ethernet, continue to *Section 3.3—Set up the RS422/RS485 Communication Interface.*

3.3 Set up the RS422/RS485 Communication Interface

The NETrs sensor is a serial device that is used programmatically with the user's application.

When the sensor is attached via cable to the customer's device such as a personal computer or robot, the computer assigns the sensor a COM port. Then by using a console on the computer, the user can communicate with the sensor. Free console software, such as PuTTY, is available online. Commands are covered in *Section 5—Operation*

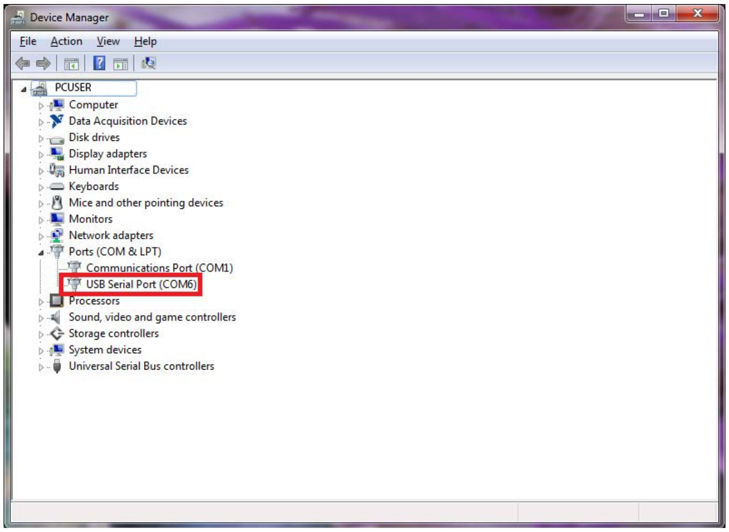
For additional instructions on setting up a console like PuTTY, refer to the following procedure:

1. If an RS422/RS485 serial port is not on the customer device, use a third party serial device to add the port.
2. Connect the RS422/RS485 cable from the NETrs sensor configuration to the RS422/RS485 serial port
3. Find the COM port that is assigned to the NETrs device.

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

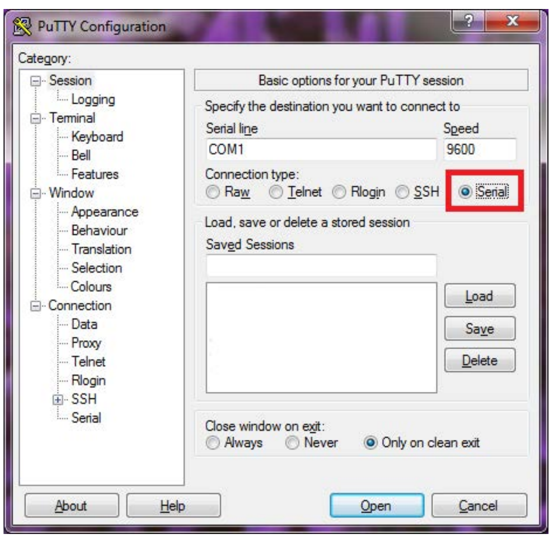
NOTICE: The name of the device may differ based on the name of the PC's RS422/RS485 port or name of the third-party RS422/RS485 device.

Figure 3.3.1-Device Manager, Port Assignment

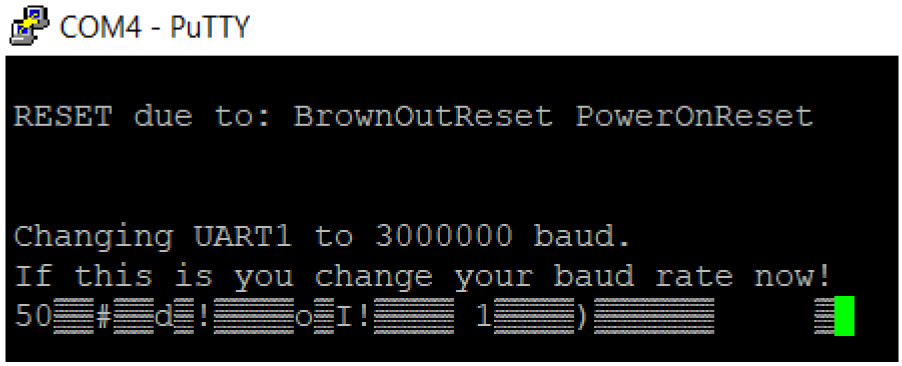


4. Open the console, for example: PuTTY. A window opens that allows the user to set the configuration for the session.
5. Set the configuration:
   a. Under **Connection type:** select the radio button for **Serial**.

Figure 3.3.2-Set the Connection Type to Serial

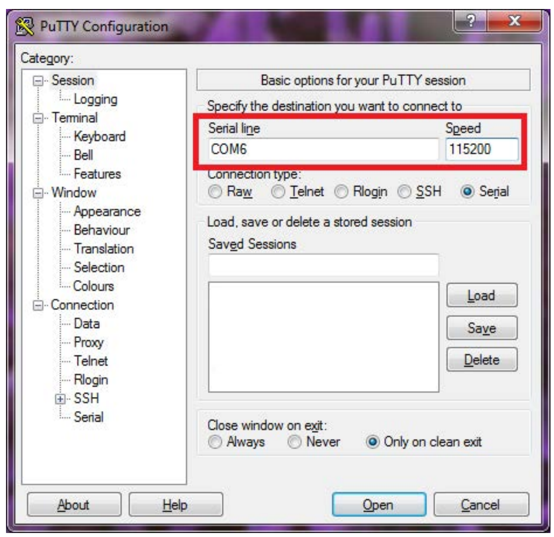


   b. In the **Serial Line** field, enter the assigned COM port from step 3.
   c. In the **Speed** field, enter the default baud rate of 115200 or the baud rate to which the user has set the NETrs Refer to *Section 5.1.2—Set Command* for more information on how to set the baud rate.



NOTICE: If the baud rate that is set on the console configuration does not match the baud rate set on the NETrs, then the console terminal window will open but commands cannot be sent. The factory default baud rate is 115200. In case the user cannot remember what baud rate the sensor is set to, at startup the sensor will print a message at 115,200 baud to list the actual baud rate setting.

Figure 3.3.3—**Set the COM port and the Baud Rate**



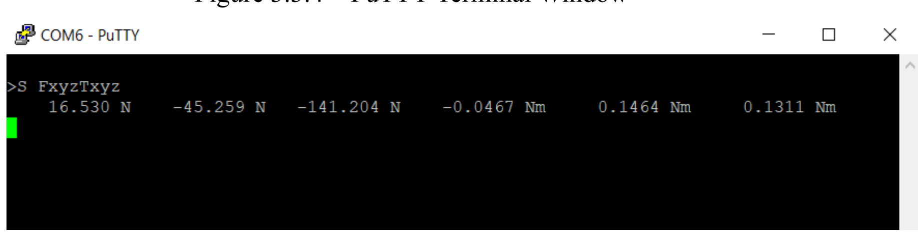
d. Select **Open**.

e. After a terminal window opens, the user can then start entering commands.

f. After a command is entered from *Section 5—Operation.*

NOTICE: Commands which are entered are not case sensitive.

Figure 3.3.4—PuTTY Terminal Window



3.4 Connecting to Ethernet

For information on configuring NETrs F/T Ethernet settings, refer to *Section 3.4.1—IP Address Configuration for Ethernet*, and for information on configuring a Windows XP or Windows Vista or later computer, refer to *Section 3.4.2—Connecting to Ethernet using a Windows Computer*.

NOTICE: Avoid connecting the NETrs F/T to the organization's network. Being connected to a network requires the periodic access to the Ethernet interface by processes other than the measurement application. This type of network connection can lead to loss of NETrs F/T UDP data.

NOTICE: Use a dedicated Ethernet network for the NETrs F/T. Placing the NETrs F/T on a dedicated Ethernet network with no other devices on the network, other than the host computer, removes data collisions and gives the best network performance.

3.4.1 IP Address Configuration for Ethernet

The NETrs F/T system's IP address settings are only loaded upon power up, consequently the NETrs F/T must be power cycled for new IP address setting changes to be used. There are two methods the NETrs F/T system's IP address can be configured.

Method 1: Set IP address to a static value stored on the NETrs F/T's *Communications* web page. This method is described in *3.4.2.*

Method 2: Let a DHCP server take care of the IP address assignment. This option can be enabled in the NETrs F/T's webpages (see *3.4.2* for details). To use this method, a DHCP server must be present in the network. This is usually the case in company networks.

The NETrs F/T is shipped with DHCP enabled and the static IP address set to 192.168.1.1. If the network does not support DHCP, the static IP address is automatically used. If a LAN connection is absent during power up, DHCP is not be used.

3.4.2 Connecting to Ethernet using a Windows Computer

Most of the Ethernet configuration is completed through the ATI NETrs F/T's webpages. To initially access the webpages, set-up the NETrs F/T to work on the network by assigning it an IP address and telling it basic information about the network.

For purposes of this initial connection, a computer is connected directly to the NETrs F/T and disconnected from the LAN. Temporarily provide a computer with a fixed IP address of 192.168.1.100. It is important that the Ethernet cable to the Net F/T is disconnected from the computer during this step.

NOTICE: If a computer has multiple connections to Ethernet, such as a LAN connection and a wireless connection, be sure to select the LAN that will be connected to the NETrs F/T.

1. Unplug the Ethernet cable from the LAN port on the computer.
2. Open the computer's Internet Protocol (TCP/IP) Properties window. Refer to the appropriate set of instructions depending on the computer operating system:

- Windows 10:

  g. From the **Start** menu, select **Control Panel**.

  h. Click on the **Network and Internet** icon.

  i. Click on the **Network and Sharing Center** icon.

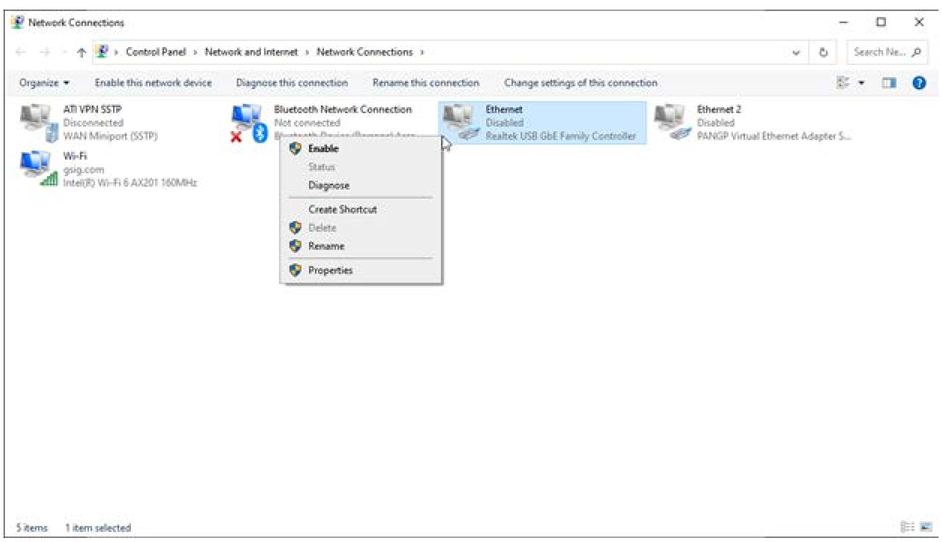
  j. Click on the **Change adapter settings** link on the left side of the window.

  - A new window opens that displays the available network adapters.

  k. Right click the network adapter to which the sensor is connected.

  l. From the dropdown menu, select **Properties**.

Figure 3.5—Windows 10 Networking Information

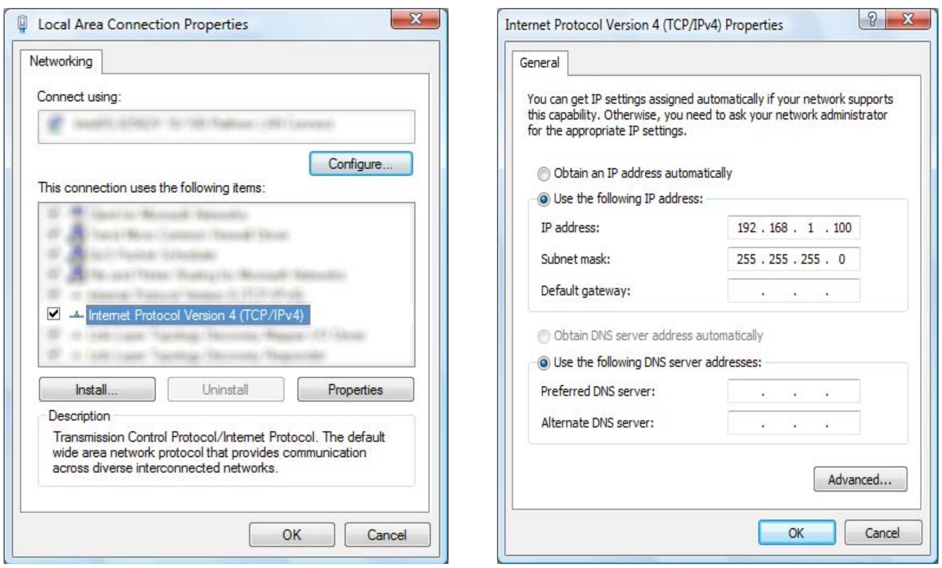


  m. In the Ethernet Properties' Networking tab, select **Internet Protocol Version 4 (TCP/IPv4)** from the list of items (refer to *Figure 3.5*).

  n. Click the **Properties** button.

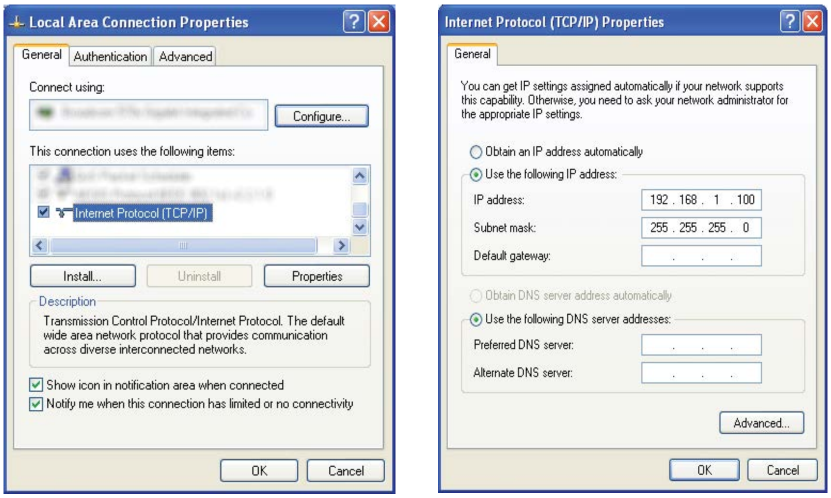
- Windows Vista and Windows 7:
    a. From the **Start** menu, select **Control Panel**.
    b. For Vista, click on **Control Panel Home**.
    c. Click on the **Network and Internet** icon.
    d. Click on the **Network and Sharing Center** icon.
    e. For Vista, click on the **Manage Network Connections** task link. For Windows 7, click on the **Local Area Connection** link.
    f. For Vista, right-click on **Local Area Connection** and click the **Properties** button. For Windows 7, click on the **Properties** button.
    g. Select **Internet Protocol Version 4** *(TCP/IPv4)* connection item and click on the **Properties** button.

Figure 3.6—Connection Properties



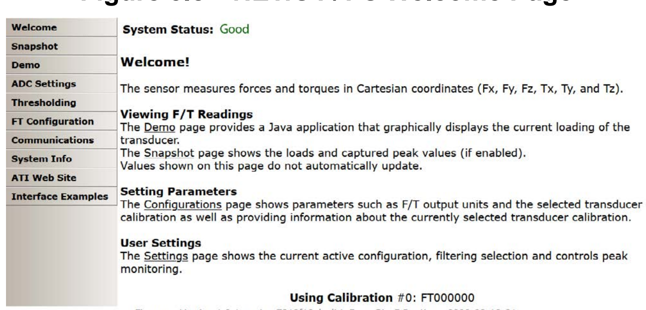
- Windows XP:
  - a. From the **Start** menu, select **Control Panel**.
  - b. Select the **Network Connections** icon from within the Control Panel. If the Control Panel says **Pick a category** at the top, first click on the **Network and Internet Connections** icon.
  - c. Click on the **Network Connections** icon.
  - d. Right-click on **Local Area Connection** and select **Properties**.
  - e. Select **Internet Protocol (TCP/IP)** connection item and click on the **Properties** button.

Figure 3.7—Windows XP Networking Information



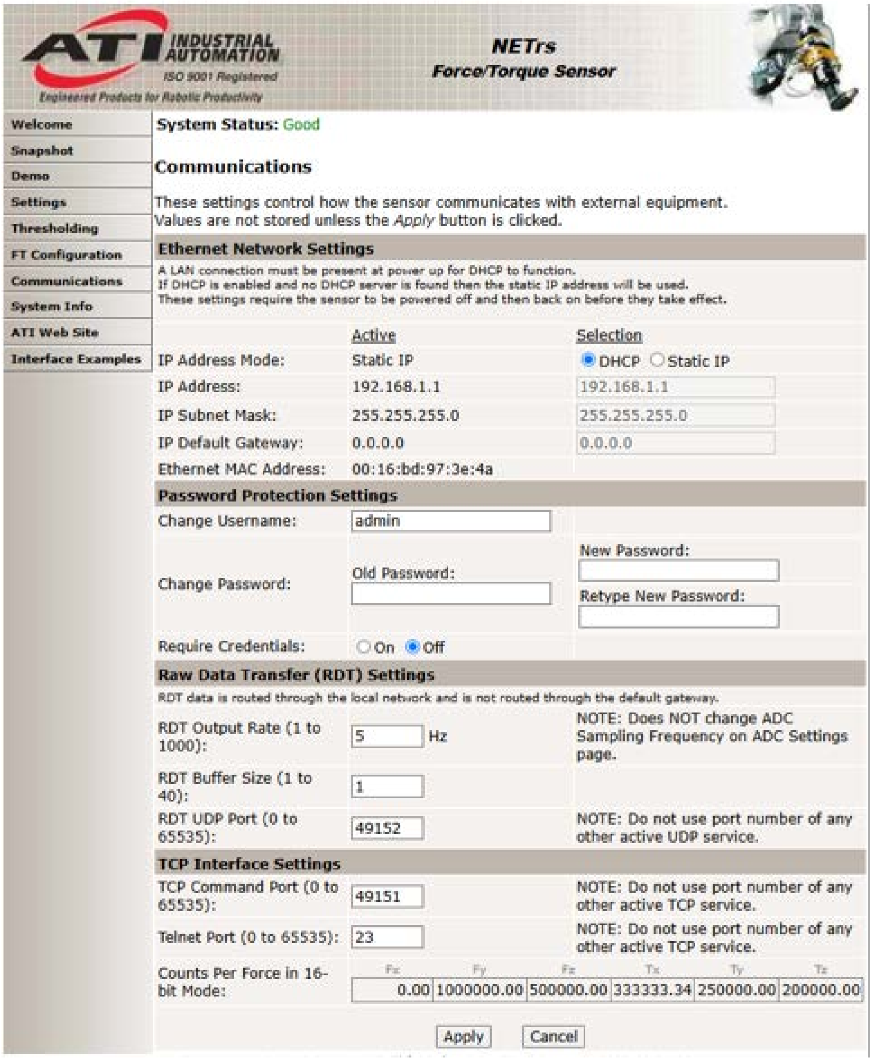
3. Record the values and settings shown in the properties window. Use these recorded values later to return the computer to its original configuration.
4. Select the **Use the following IP address** button.
5. In the **IP address**: field, type 192.168.1.100.
6. In the **Subnet mask**: field, type 255.255.255.0.
7. Click on the **OK** button.
8. Click on the **Local Area Connection Properties** window's **Close** button.
9. Use an Ethernet cable to connect the Net F/T system to the computer's LAN connection. Wait for the computer to recognize the connection.
10. Type the address *192.168.1.1* in the web browser to view the *ATI NETrs F/T's Welcome* page.

Figure 3.8—NETrs F/T's Welcome Page



11. On the left side of the page are menu buttons that link to various NETrs F/T web pages. Click on the **Communications** button.

Figure 3.9—The NETrs F/T's Communications Page



12. Select the IP address mode.

    a. If the user's IT department provided settings for a static IP address, type the provided values for the IP address, subnet mask, and default gateway, then click the **Apply** button. Power-cycle the sensor. Go to step *13.*

    b. If the user's IT department provided settings for DHCP, click the **Enabled** radio button next to DHCP, and then click the **Apply** button at the bottom. Power-cycle the sensor.

13. Open up the TCP/IP properties of the local area connection again. Restore the settings to the values before the settings were reconfigured. These are the values recorded in Step 3.

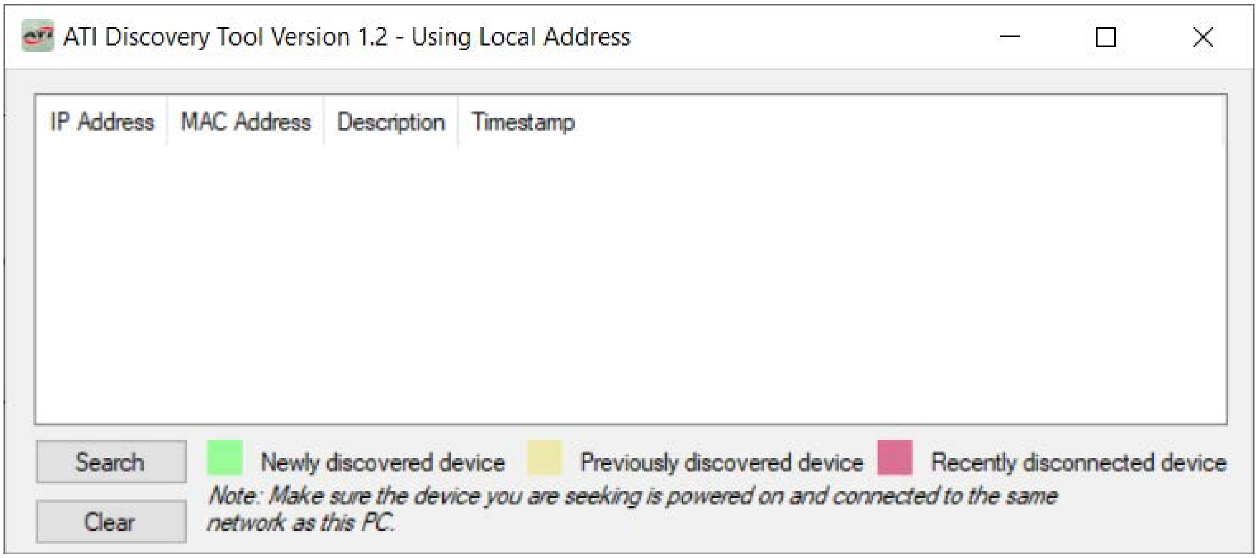
14. Open up a new web browser window, type the IP address given to the NETrs F/T system into the browser's address bar, and press the ENTER key. The ATI NETrs F/T's *Welcome* web page displays again. Now it is possible to communicate with the NETrs F/T without reconfiguring the communication settings.

3.5 Finding the NETrs on a NETwork

To find the IP address assigned by the DHCP server to an Ethernet Sensor, refer to the following procedure;

1. Download the ATI Discovery Tool from the ATI website: *https://www.ati-ia.com/Products/ft/software/net_ft_software.aspx*.
2. The first time this discovery tool is downloaded, the program may trigger a firewall alert. Select the check boxes to give permission for the network to communicate with the sensor, and click the **Allow access** button.

Figure 3.10— Windows 7/8/10 Firewall Alert



3. *The discovery tool opens in a window, and scans the network for available devices. The scan takes a few minutes. Verify the MAC address on the sensor's label matches the MAC address displayed in the window.*
4. *Use this IP address assigned by the DHCP server to the sensor's MAC address to communicate between the senor and network.*

Next, find the IP address assigned to the NETrs F/T

NOTICE: If the network is still not able to communicate, users should contact their IT Department for assistance.

NOTICE: IP addresses assigned by a DHCP server are not permanent and may change if the NETrs F/T is disconnected from the network for a period of time. Users should contact their IT department for more information.

NOTICE: If the *ATI Discovery Tool* found the Net F/T, but the internet browser is unable to open the found IP address, try clearing previous device entries from the computer's ARP table. Do this by either restarting the computer or, using administrative privileges, go to the computer's **Start** menu, select **Run**..., and type "`arp -d *`".

This step is necessary if another device previously occupied the same IP address that the Net F/T is now using.

3.6 Connecting to EtherNet/IP, PROFINET, DeviceNet

Refer to the *NET FT manual* for detailed information

4. Configuring Force/Torque Settings

Prior to operation, users can configure force/torque settings in order to stream and read data appropriate to the application. This can be completed through a variety of methods:

- *ATI Force/Torque Webpages*
- *F/T Data Viewer*
- *Console commands*
- *Common Gateway Interface (CGI)*

4.1 ATI Force/Torque Webpages

The NETrs F/T's webpages provide full configuration options for the NETrs F/T sensor system. There are several pages which can be selected by the menu bar toward the top of the webpage.

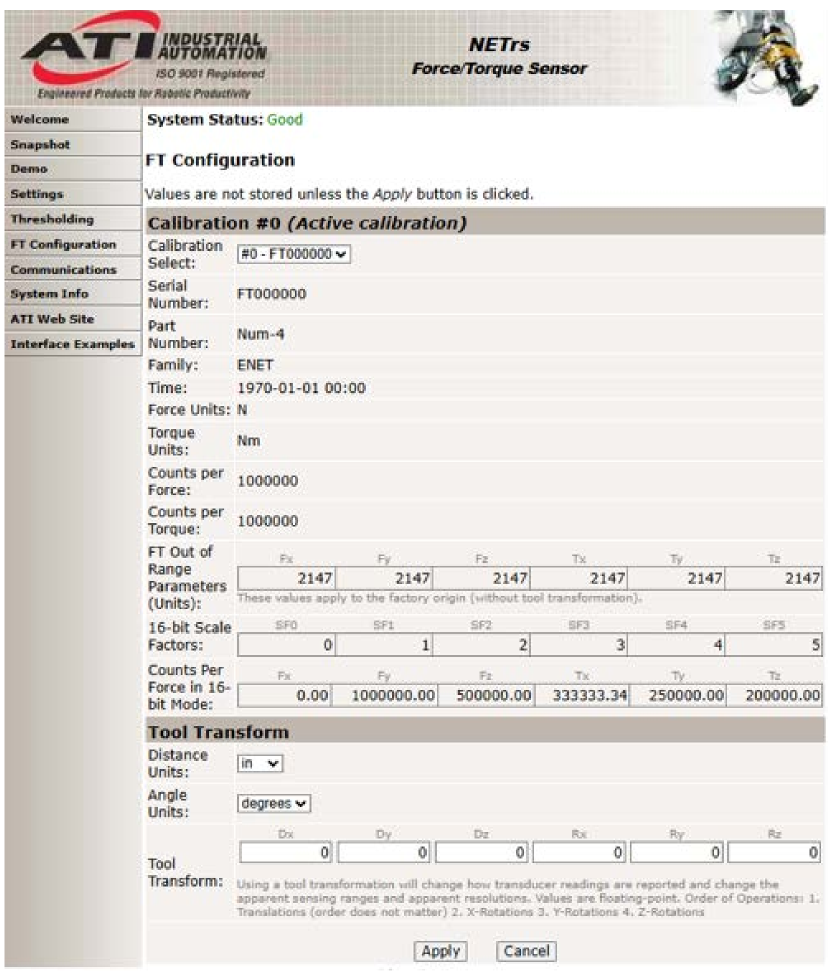
The NETrs F/T's webpages use simple HTML and browser scripting and the pages do not require any plug-ins. If browser scripting is disabled some non-critical user interface features are not available. .

NOTICE: Before configuring settings, ensure Network Settings on **Communications webpage** are accurate.

To configure the force/torque sensor settings:

1. Navigate to the **FT Configuration** webpage.

Figure 4.1—Configuration Webpage

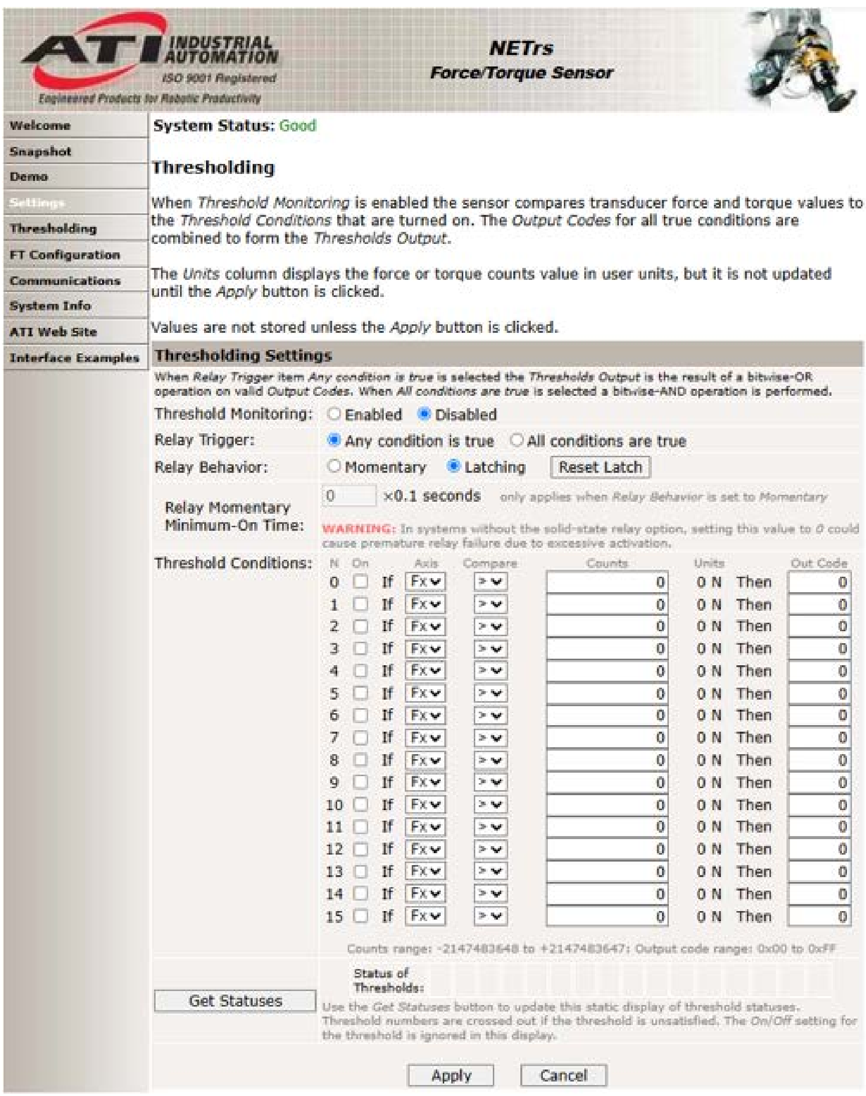


2. Select the desired calibration from the **Calibration Select** dropdown. There may only be one option.
3. Input desired Tool Transform data, using *Table 4.1* as a guide.

Table 4.1—Tool Transformation Overview		
Menu Value	**Description**	**Order**
Distance Units	Unit of measurement. Select one of: inch, foot, milimeter, centimeter, and meter.	N/A
Angle Units	Unit of measurement. Select between degrees and radians.	N/A
Dx	Distance to move X axis	1
Dy	Distance to move Y axis	2
Dz	Distance to move Z axis	3
Rx	Rotation angle about X axis	4
Ry	Rotation angle about Y axis	5
Rz	Rotation angle about Z axis	6

4. Click **Apply** button to implement changes on this page.
5. Navigate to the **Thresholding** webpage.

Figure 4.2—Thresholding Webpage



6. Specify the output parameters using *Table 4.2* as a guide.

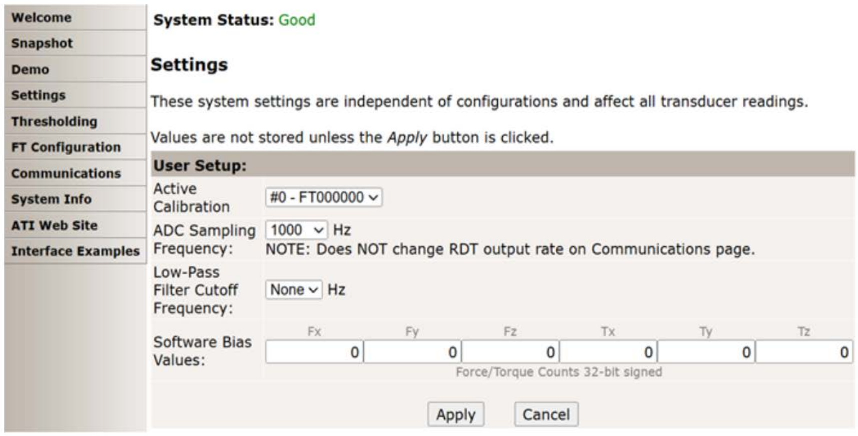
<table>
<tr><th colspan="3">Table 4.2—Thresholding Webpage Overview</th></tr>
<tr><th>Menu Value</th><th colspan="2">Description</th></tr>
<tr><td>Threshold Monitoring</td><td colspan="2">Enabled: Turns on thresholding and below conditions will be monitored.
Disabled: Turns off thresholding functionality.</td></tr>
<tr><td>Relay Trigger</td><td colspan="2">Any condition is true: Valid output code present if any individual conditions are met.
All conditions are true: Valid output code present if all conditions are met.</td></tr>
<tr><td>Relay Behavior</td><td colspan="2">Momentary: Valid output code will only be active while threshold is met. If conditions change and threshold is no longer met, output code will no longer be displayed.
Latching: Valid output code will be active after a threshold is met, even if conditions change and threshold was only met briefly.</td></tr>
<tr><td>Relay Momentary Minimum-On Time</td><td colspan="2">This can only be set if ‘Momentary’ is selected under Relay Behavior. This input signals how long the output code will be present after the condition is met.</td></tr>
<tr><td>Reset Latch</td><td colspan="2">Clears any condition latching and reloads the monitor conditions page.</td></tr>
<tr><td rowspan="7">Threshold Conditions</td><th>Thresholding Subhead</th><th>Description</th></tr>
<tr><td>N</td><td>Statement number</td></tr>
<tr><td>On</td><td>If selected, the following condition will be monitored.</td></tr>
<tr><td>Axis</td><td>Choose between Fx, Fy, Fz, Tx, Ty, and Tz</td></tr>
<tr><td>Compare</td><td>Choose between less than or greater than.</td></tr>
<tr><td>Counts[1]</td><td>The loading level to be compared to the trandsucer reading.Counts = Desired Loading Level × Counts per Force

Example:
$6.25\ N \times 1000000\ counts/N = 6250000\ counts$
Desired Loading Level: 6.25 N
Force Units: N (from **Configurations** web page)
Counts per Force value: 1000000 (from **Configurations** page)</td></tr>
<tr><td>Out Code</td><td>When this statement’s comparison is found true, this 8-bit value is bitwise or’ed with the Output Code values of all other true statements to form the Condition output. Any set bits remain latched until Reset Latch is called. If no statements have been true, the Condition output is zero.
The value is displayed in hexadecimal in the format 0x00. Output Codes may be in the hexadecimal or decimal format.
If this statement is true, Bit 16 of the system status code (see *7.1*) sets to one.</td></tr>
<tr><td>Get Statuses</td><td colspan="2">This will refresh the display of the status of threshold values to current.</td></tr>
<tr><td colspan="3">1. Comparison levels are stored as counts and only change when the user inputs new counts values. Changing the configuration or the force units or the torque units does not change or adjust the counts values.</td></tr>
</table>

7. Click **Apply** button to implement changes on this page.

8. Navitage to the **ADC Settings** webpage.

Figure 4.3—Settings Webpage



9. Select the desired calibration under the **Active Calibration** drop down. There may only be one listed.
10. Select desired sampling and filtering rate.

> **NOTICE:** Software Bias Values display the current bias offset applied to the transducer strain gage readings.

11. Click **Apply** button to implement changes on this page.
12. Complete IMU calibration process, as outlined in the *ATI F/T Transducer Section Manual.*

4.2 F/T Data Viewer

For detailed information on the F/T Data Viewer installation and functionality, refer to the *F/T Data Viewer Manual.*

4.3 Console commands

Refer to *Section 5.1—Serial* for commands used to configure the force/torque sensor via serial.

4.4 Common Gateway Interface (CGI)

The NETrs F/T can be configured over Ethernet using the standard HTTP get method which sends configuration variables and their values in the requested URL.

Each variable is only settable from the *CGI* page which is responsible for that variable. Each *CGI* page and associated settable variables are listed in tables within the following section.

URLs are constructed using the following syntax:

http://<NETrsFTAddress>/<CGIPage.cgi>?<firstVariableAssignment><&nextVariable Assignment>

where:

http://	indicates an HTTP request
<NETrsFTAddress>	is the Ethernet address of the NETrs F/T system
/	a separator
<CGIPage.cgi>	the name of the *CGI* page that holds the variables to be accessed
?	a separator marking the start of variable assignments
<firstVariableAssignment>	a variable assignment using the format described below
<&nextVariableAssignment>	a variable assignment using the format described below, but the variable name is proceeded by an ampersand. This variable assignment is optional

and may be repeated for multiple variables.

Variables are assigned new values using the syntax:

variableName=newValue

where:

variableName — is the name of the variable to be assigned

= — indicates assignment

newValue — is the value to be assigned to the variable. Text for text variables should not be enclosed in quotes. To include the ampersand character in text for a text variable use *%26*. Floating point numbers are limited to twenty characters.

Example:

http://192.168.1.1/setting.cgi?setcfgsel=2&setuserfilter=0&setpke=1

tells the NETrs F/T at IP address 192.168.1.1 to set CGI variables *setcfgsel* to 2, *setuserfilter* to 0, and *setpke* to 1.

The maximum length of these URLs may be determined by a number of factors external to the NETrs F/T. Exceeding the maximum length may result in an error or variables being incorrectly set.

4.4.1 Settings CGI (setting.cgi)

This CGI allows the user to specify certain global settings such as Low-Pass Filter selection, Peak Monitoring Enable, Software Bias Vector, and Active Configuration selection.

<table>
<tr><th colspan="6">Table 4.3—setting.cgi Variables</th></tr>
<tr><th>Variable Name</th><th>Allowed Values</th><th colspan="4">Description</th></tr>
<tr><td>cfgcalsel</td><td>integers: 0 to 3</td><td colspan="4">Sets the active configuration. Note that the value used by cfgcalsel is one less than the configuration numbers displayed on the web pages.</td></tr>
<tr><td rowspan="7">setuserfilter[1]</td><td rowspan="7">integers: 0 to 8</td><td colspan="4">Sets the cutoff frequency of the low-pass filtering as follows:</td></tr>
<tr><th>Value</th><th>Cutoff</th><th>Value</th><th>Cutoff</th></tr>
<tr><td>0</td><td>no filter</td><td>5</td><td>5.1 Hz</td></tr>
<tr><td>1</td><td>120 Hz</td><td>6</td><td>2.6 Hz</td></tr>
<tr><td>2</td><td>46.6 Hz</td><td>7</td><td>1.2 Hz</td></tr>
<tr><td>3</td><td>21.7 Hz</td><td>8</td><td>0.7 Hz</td></tr>
<tr><td>4</td><td>10.4 Hz</td><td></td><td></td></tr>
<tr><td>setadcrate</td><td>integers:
1000
2000
4000
8000
16000</td><td colspan="4">Sets the active sample rate in Hz. 1000 is the ATI NETrs default.</td></tr>
<tr><td>setbiasn</td><td>integers:
-32768 to 32767</td><td colspan="4">Sets the offset value for strain gage n. For example, setbias3=0 would zero the bias of the fourth strain gage (Strain gages are enumerated starting at zero.)</td></tr>
<tr><td colspan="6">Note:
1. Values are displayed based on 1 kHz sampe rate, which is the default for ATI NETrs sensors.</td></tr>
</table>

4.4.2 Monitor Conditions CGI (moncon.cgi)

This CGI defines and controls Monitor Conditions statements. Monitor Conditions statements can be turned off or on and need to have an axis, a comparison type, a comparison counts value, and an output code defined.

<table>
<tr><th colspan="5">Table 4.4—moncon.cgi Variables</th></tr>
<tr><th>Variable Name</th><th>Allowed Values</th><th colspan="3">Description</th></tr>
<tr><td>setmce</td><td>Integers: 0 or 1</td><td colspan="3">Enable (value = 1) or disable (value = 0) all Condition statement processing.</td></tr>
<tr><td>mcen</td><td>Integers: 0 or 1</td><td colspan="3">Enable (value = 1) or disable (value = 0) Condition statement n.</td></tr>
<tr><td rowspan="9">mcxn</td><td rowspan="9">Integers: -1 to 5</td><td colspan="3">Selects the axis evaluated by Condition statement n.</td></tr>
<tr><th>Value</th><th>Description</th><th>Menu Value</th></tr>
<tr><td>-1</td><td>Statement disabled</td><td>blank</td></tr>
<tr><td>0</td><td>Fx axis</td><td>Fx</td></tr>
<tr><td>1</td><td>Fy axis</td><td>Fy</td></tr>
<tr><td>2</td><td>Fz axis</td><td>Fz</td></tr>
<tr><td>3</td><td>Tx axis</td><td>Tx</td></tr>
<tr><td>4</td><td>Ty axis</td><td>Ty</td></tr>
<tr><td>5</td><td>Tz axis</td><td>Tz</td></tr>
</table>

Table 4.4—moncon.cgi Variables		
Variable Name	**Allowed Values**	**Description**
mcv*n*	Integers: -2147483648 to +2147483647	Sets the counts value to compare the current axis value by Condition statement *n*.
mco*n*	Hexadecimal: 0x00 to 0xFF	Sets the output code for Condition statement *n*.
where *n* is an integer ranging from 0 to 15 representing the Condition statement index		

4.4.3 Configurations CGI (config.cgi)

Use this CGI to specify the output parameters of the sensor system. Any of the sixteen configurations can be defined. Changing configurations allows selection of the transducer calibration to use and what tool transformations to apply to that calibration.

When using config.cgi the cfgid value specifies which configuration is targeted. For example, http://<netFTAddress>/config.cgi?cfgid=3&cfgnam=test123 sets the name of the fourth configuration (which is at index 3) to test123.

<table>
<tr><th colspan="5">Table 4.5—config.cgi Variables</th></tr>
<tr><th>Variable Name</th><th>Allowed Values</th><th colspan="3">Description</th></tr>
<tr><td>cfgcalsel</td><td>integers: 0 to 3</td><td colspan="3">Sets the calibration used by the configuration.</td></tr>
<tr><td rowspan="7">cfgtdu</td><td rowspan="7">Integers: 1 to 5</td><td colspan="3">The distance measurement units used by the configuration’s tool transformation.</td></tr>
<tr><th>Value</th><th>Description</th><th>Menu Value</th></tr>
<tr><td>1</td><td>inch</td><td>in</td></tr>
<tr><td>2</td><td>foot</td><td>ft</td></tr>
<tr><td>3</td><td>millimeter</td><td>mm</td></tr>
<tr><td>4</td><td>centimeter</td><td>cm</td></tr>
<tr><td>5</td><td>meter</td><td>m</td></tr>
<tr><td rowspan="4">cfgtau</td><td rowspan="4">Integers: 1 or 2</td><td colspan="3">The rotation units used by the configuration’s tool transformation.</td></tr>
<tr><th>Value</th><th>Description</th><th>Menu Value</th></tr>
<tr><td>1</td><td>degrees (°)</td><td>degrees</td></tr>
<tr><td>2</td><td>radians</td><td>radians</td></tr>
<tr><td>cfgtfx0</td><td>Floating point</td><td colspan="3">Sets the tool transformation distance Dx. Distance must be in cfgtdu distance units.</td></tr>
<tr><td>cfgtfx1</td><td>Floating point</td><td colspan="3">Sets the tool transformation distance Dy. Distance must be in cfgtdu distance units.</td></tr>
<tr><td>cfgtfx2</td><td>Floating point</td><td colspan="3">Sets the tool transformation distance Dz. Distance must be in cfgtdu distance units.</td></tr>
<tr><td>cfgtfx3</td><td>Floating point</td><td colspan="3">Sets the tool transformation rotation Rx. Rotation must be in cfgtau angular units.</td></tr>
<tr><td>cfgtfx4</td><td>Floating point</td><td colspan="3">Sets the tool transformation rotation Ry. Rotation must be in cfgtau angular units.</td></tr>
<tr><td>cfgtfx5</td><td>Floating point</td><td colspan="3">Sets the tool transformation rotation Rz. Rotation must be in cfgtau angular units.</td></tr>
</table>

4.4.4 Communications CGI (comm.cgi)

This CGI sets the networking options of the Net Box. For more information on the parameters, refer to *Section 4.7—Communication Settings Page (comm.htm)*.

<table>
<tr><th colspan="4">Table 4.6—comm.cgi Variables</th></tr>
<tr><th>Variable Name</th><th>Allowed Values</th><th colspan="2">Description</th></tr>
<tr><td rowspan="4">comnetdhcp</td><td rowspan="4">Integers: 0 or 1</td><td colspan="2">Sets DHCP behavior.</td></tr>
<tr><th>Value</th><th>Description</th></tr>
<tr><td>0</td><td>Use DHCP if available on network</td></tr>
<tr><td>1</td><td>Use software-defined static IP values</td></tr>
<tr><td>comnetip</td><td>Any IPV4 address in dot-decimal notation</td><td colspan="2">Sets the static IP address to be used when DHCP is disabled.</td></tr>
<tr><td>comnetmsk</td><td>Any IPV4 subnet mask in dot-decimal notation</td><td colspan="2">Sets the subnet mask to be used when DHCP is disabled.</td></tr>
<tr><td>comnetgw</td><td>Any IPV4 address in dot-decimal notation</td><td colspan="2">Sets the gateway to be used when DHCP is disabled.</td></tr>
<tr><td>comrdtrate</td><td>1 to 7000</td><td colspan="2">Sets the RDT output rate in Hertz. The actual value used may be rounded up; see Section 4.7—Communication Settings Page (comm.htm) for details.</td></tr>
<tr><td>comrdtbsiz</td><td>Integers: 1 to 40</td><td colspan="2">RDT Buffer Mode buffer size.</td></tr>
<tr><td>comrdtport</td><td>0 to 65535</td><td colspan="2">RDT listening port</td></tr>
<tr><td>comtcpport</td><td>0 to 65535</td><td colspan="2">TCP listening port</td></tr>
<tr><td>comtelnetport</td><td>0 to 65535</td><td colspan="2">Telnet listening port</td></tr>
</table>

5. Operation

The NETrs system has the capability of communicating via a number of networks, including:

- *Console Commands via Serial*
- *User Datagram Protocol (UDP Interface Using RDT)*
- *TCP Interface*
- *EtherNet/IP™*
- *PROFINET*
- *DeviceNet®*
- *Controller Area Network (CAN)*

5.1 Console Commands via Serial

When the sensor is attached via cable to the customer's computer or robot, the computer assigns the sensor a COM port. Then by using a console on the computer, the user can communicate with the sensor. A full list of serial commands is outlined in *Table 5.1.*

Table 5.1—Serial Commands

Command	Command with Operands	Description
Help	h	Prints a summary of the available console commands and available operands.
	H	
	?	
Bias	bias	Displays current bias status
	bias on	Turns bias on
	bias off	Turns bias off
	bias [value]	Sets bias to particular value in F/T counts
Peak	peak	Displays the run-time and all-time F/T data peaks in units.
	peak c	Displays the run-time and all-time F/T data peaks in counts.
	peak r	Resets run-time F/T data peaks.
C/S	c	Continuous flow of values. Reference *Section 5.1.1—Query Commands: "s" or "c".*
	s	Single line of values. Reference *Section 5.1.1—Query Commands: "s" or "c"*
Set	set	Prints all setting field values. Reference *Section 4.1.2—Cal Command*
	set [field]	Prints specific setting field value.
	set [field] [value]	Sets specific setting field with value entered.
Simerr	simerr on	Turns the simulated error status bit on. Refer to *Table 7.1*
	simerr off	Turns the simulated error status bit off. Refer to *Table 7.1*
Reset	reset	Resets the processor, returning all parameters and settings to their saved defaults.
Saveall	saveall	Writes all settings to non-volatile memory. This is typically used if any settings have been updated.
Status	status	Prints a status report on the various components of the sensor

Table 5.1—Serial Commands		
Command	**Command with Operands**	**Description**
MC	mc	Prints all global monitor condition status information.
View	view	Prints calibration report properties such as F/T part number, serial number, units, calibration date, and calibration family.
	view 0	Prints calibration properties for Calibration 0.
	view 1	Prints calibration properties for Calibration 1.
	view 2	Prints calibration properties for Calibration 2.
	view a	Prints calibration properties for active calibration.
Diag	diag	Prints a diagnostic report of gage number, gage readings in counts, and a gage status indicator. Indicators include: "w" gage in warning range "!" gage in error range "x" gage disconnected
IMUsave	IMU	Saves IMU calibration data following procedure outlined in Transducer manual. Refer to the *ATI F/T Transducer Section Manual.*
ACCLCAL	ACCLCAL [value]	Changes the gain of the IMU's accelerometer and gyroscope. Refer to *Section 5.1.5—IMU Data: Configurating Accelerometer and Gyroscope*
NETBOX	netbox	Enters Netbox console mode to communicate with legacy Netbox.
Console	console	Temporarily enters normal console mode until next boot. Use this to access the console interface while in NETBOX or YELLOW mode.

5.1.1 Query Commands: "s" or "c"

The query command starts the high-speed data transmission of FT data. The "s" command reports a single line of sensor data that is scaled by the counts per force or counts per torque. The "c" command reports continuous lines of sensor data that stop when the user holds another key, for example: "enter", until the output of data ceases. The "c" command reports data at the rate specified in the rdtRate parameter.

The following are examples of an "S" or "C" command with specifiers:

1. Example: S c0123

user: `S c0123`

response: `fd6b02 ff240d fe2b34 fe273d`

   a. S: prints a single line of data.

   b. c: prints data in counts.

   c. 0123: a number 0 through 7 specifies to print the data for the corresponding gage number. So 0 will print data for gage zero, and 3 will print data for gage four. In this example, the response will print gage data for gages zero, one, two, and three.

   d. Data is displayed in hexidecimal by default.

2. Example: s >012345du67

user: `s >012345du67`

response: `fd6afd ff2407 fe2b2a fe272f fdb571 fec16b -3506688 4194771`

a. S: a command for reporting a single line of data.

b. >: will print the data in a compressed output, intended for highspeed applications.

c. 012345: will print the data for the corresponding gages zero through six.

d. D: any data following prints in decimal format.

e. U: any data following will prints in units.

f. 67: will print the data for the corresponding gages seven and eight.

Table 5.2—S or C command specifiers

Category	Specifier	Description
Gage number(s)	01234567	Specifies active ADC channels 0 to 7. Raw values are printed in counts only.
Axis	XYZ	Specifies z, y, or z force or torque data
	M	Specifies force or torque Magnitude data
Force and/or torque	F	The following XYZM data specifies force (default)
	T	The following XYZM data specifies torque
Counts or units	C	Data is printed in counts
	U	Data is printed in units (default)
Numeric system	D	Data is printed in decimal
	H	Data is printed in hexadecimal, except any data always printed in decimal (default)
Format	<	Data is printed in human-readable form with lined-up columns (default)
	>	Data is printed in compressed format, intended for high-speed automated applications.
Additional inputs to aid in development of customer software program	#	Specifies a sample counter that prints for every new C or S line.
	@	Specifies an ADC read counter that prints for every time the ADC is read.
	;	Uses a comma between fields instead of blanks
	S	Specifies a 16-bit CRC.
Troubleshooting	!	Specifies a 32-bit Status Code. Reference *Table 8.1.*
Long Specifier	$	Long Specifier tag to indicate following characters are related to a long specifier. Refer to *Section 5.1.6—IMU Data: Streaming*

5.1.2 Set Command

The set command allows users to either view or set specific settings, which are outlined in *Table 5.3—Set Commands.* The following are examples of a set command with specifiers:

1. Example: set baud

user: `set baud`

response:`baud rate 115200`

- By entering the set command with the operand “baud”, the sensor will print the current baud rate

user: `set baud 1000000`

response: `baud rate was 115200, now 1000000`

user: `saveall`

response: `Parameters saved to NVM bank 0`

```
Parameters saved to NVM bank 1
```

- By entering a value after the baud rate set command, the user can set a new baud rate.
- Remember to send a saveall command to ensure all changes are saved to non-volatile memory.

2. Example: set ttdx

user: `set ttdx`

response:

```
Field               Value
-----               -----
ttdx                0
```

- By entering the set command with the operand "ttdx", the sensor will print the current tool transformation distance in the X axis.

user: `set ttdx 1`

response:
```
set ttdx 1
ttdx was "0" now "1"
```

user: `saveall`

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

- By default, tool transformation units are millimeters for distance and radians for angle. These units can be changed using the ttdu (distance units) and ttau (angle units) commands. Reference *Table 5.3.*
- Remember to send a saveall command to ensure all changes are saved to non-volatile memory.

Table 5.3—Set Commands

Field	Read/Edit	Example	Data Type	Description
SerialNum	Read	FT00123	STRING(8)	Calibrated F/T serial number
partNum	Read	Num-4	STRING(30)	Calibration part number
calFamily	Read	ENET	STRING(8)	Always reads "ENET"
CalTime	Read	1970-01-01 00:00	STRING(30)	Date and time sensor was calibrated
max0	Read	2147483647	32-bit unsigned integer	Maximum rated force value in counts for the that axis.
max1				
max2				
max3				Maximum rated torque value in counts for that axis.
max4				
max5				
forceUnits	Read	1	8-bit unsigned integer	Force units. 0=Lbf, 1=N, 2=Klbf, 3=kN, 4=Kg
torqueUnits		2		Torque units. 0=Lbf-in, 1=Lbf-ft, 2=Nm, 3=Nmm, 4=Kg-cm, 5=kN-m
cpf	Read	100000	32-bit unsigned integer	Calibration counts per force unit.
cpt		100000		Calibration counts per torque unit.

Table 5.3—Set Commands				
Field	**Read/Edit**	**Example**	**Data Type**	**Description**
peakPos0	Read	2395927	32-bit unsigned integer	Peak Loads Positive. All-time peak positive force and torque loads in F/T counts
peakPos1		624576		
peakPos2		35521		
peakPos3		721632		
peakPos4		159210		
peakPos5		74910		
PeakNeg0	Read	-988570	32-bit unsigned integer	Peak Loads Negative. All-time peak negative force and torque loads in F/T counts
PeakNeg1		-2008525		
PeakNeg2		-9148784		
PeakNeg3		-46851		
PeakNeg4		-12383		
PeakNeg5		0		
sensorHwVer	Read	0	16-bit unsigned integer	Active version of the sensor hardware
sensorInstr		1		Internal Manufacturing Data
paramWrites		4		Number of times the sensor wrote the parameters to NVM
adcRate	Read and Edit	1000 (default)	16-bit unsigned integer	ADC rate in Hz: 1000, 2000, 4000, 8000, 16000.
rdtRate		40		RDT transmission rate in Hz. This number can range from 1 to the ADC Rate.
rdtSize		40		Number of RDT records to include in each UDP packet. This number will range from 1 to 40.
rdtPort		49152 (default)		UDP listening port for RDT commands.
tcpPort		49151 (default)		UDP listening port for TCP commands.
telnetPort		23 (default)		UDP listening port for telnet connections
filTc		0 (default)		(IIR) filter code This setting changes the parameter that determines data filtering.
calib		1	8-bit unsigned integer	Three calibrations to use. Either 0, 1, or 2.
location		Bench	STRING(40)	Shows physical location.

<table>
<tr><th colspan="5">Table 5.3—Set Commands</th></tr>
<tr><th>Field</th><th>Read/Edit</th><th>Example</th><th>Data Type</th><th>Description</th></tr>
<tr><td>serNum</td><td rowspan="3">Read</td><td>FT001234</td><td>STRING(100)</td><td>Physical sensor serial number</td></tr>
<tr><td>hwProdCode</td><td>Num-4</td><td>STRING(20)</td><td>Hardware product code</td></tr>
<tr><td>hwRev</td><td>04</td><td>16-bit unsigned integer</td><td>Hardware revision number</td></tr>
<tr><td>sipmode</td><td>Read and Edit</td><td>1</td><td>8-bit unsigned integer</td><td>0=DHCP
1=Static</td></tr>
<tr><td>sipadr</td><td>Read and Edit</td><td>192.168.137.155 (Default)</td><td rowspan="3">32-bit unsigned integer</td><td>Static IP address</td></tr>
<tr><td>sipmsk</td><td>Read and Edit</td><td>255.255.255.0 (Default)</td><td>Static IP subnet mask</td></tr>
<tr><td>sipgtw</td><td>Read and Edit</td><td>0.0.0.0 (Default)</td><td>Static IP gateway</td></tr>
<tr><td>mac</td><td>Read</td><td>MCU Serial number. d8:80:39:7a:c4:5e (default)</td><td>48-bit unsigned integer</td><td>MAC address</td></tr>
<tr><td>ttdu</td><td rowspan="2">Read and Edit</td><td>2</td><td rowspan="2">8-bit unsigned integer</td><td>Tool Transform distance units 0=in, 1=ft, 2=mm, 3=cm, 4=m</td></tr>
<tr><td>ttau</td><td>1</td><td>Tool Transform angle units. 0=degrees, 1=radians</td></tr>
<tr><td>ttdx</td><td rowspan="6">Read and edit</td><td>0 (default)</td><td rowspan="6">float</td><td rowspan="3">Tool Transform distances</td></tr>
<tr><td>ttdy</td><td>0 (default)</td></tr>
<tr><td>ttdz</td><td>0 (default)</td></tr>
<tr><td>ttrx</td><td>0 (default)</td><td rowspan="3">Tool Transform rotation angles</td></tr>
<tr><td>ttry</td><td>0 (default)</td></tr>
<tr><td>ttrz</td><td>0 (default)</td></tr>
<tr><td>baud</td><td rowspan="2">Read and edit</td><td>115200 (default)</td><td>32-bit unsigned integer</td><td>UART baud rate. Must be between 300 and 3M. All baud rates are temporary until saveall command is sent.</td></tr>
<tr><td>msg</td><td>1</td><td rowspan="2">8-bit unsigned integer</td><td>0=print only prompted messages
1=print all messages</td></tr>
<tr><td>serial</td><td>Read</td><td>0</td><td>0= Ethernet and serial
1=Serial-only mode.</td></tr>
</table>

Table 5.3—Set Commands				
Field	**Read/Edit**	**Example**	**Data Type**	**Description**
Vmid	Read and edit	0	8-bit unsigned integer	0= ADC_MID_VBR 1= SENS_MID_VBR
mcEnabled		1		1 = enabled, 0 = disabled. Global monitor conditions enabled or disabled.
mcOutMomen		1		0: Monitor Conditions Momentary. Valid output code will only be active while threshold is met. If conditions change and threshold is no longer met, output code will no longer be displayed. 1: Latching: Valid output code will be active after a threshold is met, even if conditions change and threshold was only met briefly.
mcOutDelay		20		Global monitor conditions momentary delay. How long monitor condition will remain latched after it trips. This value is displayed in tenths of a second.
mcAndCodes		1		0: Uses the AND bitwise. If all set thresholding conditions are met, monitor condition will trip. 1: Uses OR bitwise. If any set thresholding condition is met, monitor condition will trip.
yellow	Read	on	8-bit unit	Prints status of Yellow Mode: on or off
internalMass		0.5	float	For Yellow Mode users. Internal mass in kilograms.
Framex		0	16-bit unit	For Yellow Mode users Specific sensor frame data.
Framey		0		
Framez		0		
Framew		0		
Framep		0		
Framer		0		
ybaud	Read and edit	0		Prints Yellow Mode baud rate.
yserNum	Read		STRING(20)	Prints Yellow Mode serial number.

5.1.3 Counts Per Force/Torque to FT Values

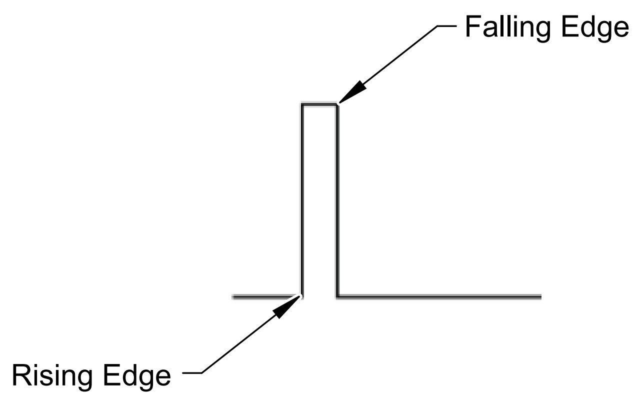
To obtain the real force and torque values, each force value must be divided by the counts per force (cpf) factor, and each torque value must divided by the counts per torque (cpt) factor. The cpf and cpt factors can be obtained using the secondary cal commands. Refer to *Section 5.2—Set Command.*. For example: if a calibration reports 1,000,000 counts per N and the Fz reports 4,500,000 counts, then the force applied in the Z axis is 4.5 N.

5.1.4 Clock Sync Functionality

Clock sync functionality activates when the user applies a rising edge of at least 5 V to the conductors. Upon activation of the sync function, the sensor outputs the most recently collected data point which is equivalent to the output from the "s" command (*Section 5.1.1—Query Commands: "s" or "c"*) sent over an RS422 cable interface. Data outspeeds can be matched up to 2 kHz.

An electrical pulse is shown in the following figure. The rising edge of the pulse starts at 5 V. The falling edge of the pulse is when the voltage is no longer within 5-30 V. 30 V is the maximum voltage that the cable allows. The sync functionality is no longer activated when the voltage is outside the 5-30 V range.

Figure 5.1—Electrical Pulse



5.1.5 IMU Data: Configurating Accelerometer and Gyroscope

NOTICE: Prior to streaming or setting up IMU data, the user needs to complete an IMU calibration as outlined in the *ATI F/T Transducer Section Manual.*

The IMU accelerometer and gyroscope can be configured by using the `acclcal` command (reference *Table 5.1—Console Commands).* The following six combinations are available for the user:

- `acclcal 2g`: sets the accelerometer sensing range to +/- 2g, and the gyroscope to 2000 DPS
- `acclcal 4g`: sets the accelerometer sensing range to +/- 4g, and the gyroscope to 2000 DPS
- `acclcal 8g`: sets the accelerometer sensing range to +/- 8g, and the gyroscope to 2000 DPS
- `acclcal 16g`: sets the accelerometer sensing range to +/- 16g, and the gyroscope to 2000 DPS
- `acclcal 8g250`: sets the accelerometer sensing range to +/- 8g, and the gyroscope to 250 DPS
- `acclcal 8g500`: sets the accelerometer sensing range to +/- 8g, and the gyroscope to 500 DPS

5.1.6 IMU Data: Streaming

Accelerometer and gyroscope IMU data is streamed via C/S commands using long specifiers. The Accelerometer performance is 0.3 m/s and the gyroscope is 3.1 dps. After the specifier tag "**$**" from *Table 5.2*, long specifiers outline IMU steaming data. Additional modifiers may be used to control the type of data. Reference *Table 5.5——IMU Specifiers* for IMU data streaming options.

Table 5.4—IMU Specifiers

Specifier	Name	Modifiers[1]	Units	Type	Axes
$A	Accelerometer	C	counts	16-bit	XYZ
		U	m/s^2		
$G	Gyro	C	counts		
		U	radian/s		
$LA	Linear Acceleration	C	counts		
		U	m/s^2		
$GV	Gravity Vector	C	counts		
		U	m/s^2		
$AV	Angular Velocity	C	counts		
		U	radian/s		
$ACL	Linear Acceleration Accuracy Level[2]	Bits 76	0: Unreliable 1: Low Accuracy 2: Medium Accuracy 3: High Accuracy	8-bit	N/A
	Accelerometer Accuracy Level[2]	Bits 54			
	Gyro Accuracy Level[2]	Bits 32			
$US	MicroSecond (us) counter	None	counts	32-bit	N/A
$HDR	Send 0x1234 for packet synchronization	None	N/A	16-bit	N/A
$TW	Enable two-way Continuous Mode communication	N/A: No data returned			

Notes:
1. Modifiers
   C: Prints the raw IMU data.
   U: Prints the calibrated IMU data. If a field allows modifiers but a modifier is not present, calibrated IMU data prints by default.
2. Refer to *Section 5.1.7—IMU Accuracy Checking Procedure*.

Examples:

1. Accelerometer

user: `s $axyz`

response: `s $axyz`

```
-0.527       0.488       -9.965
```

- By entering the `s` command with the operand `$axyz`, the sensor will print the acceleration data in the X, Y, and Z axis.
- Values will be printed in calibrated IMU data by default.

2. Gyroscope

user: `s $gxyz`

response: `s $gxy`

```
-0.004      -0.111      -0.045
```

- By entering the `s` command with the operand `$gxyz`, the sensor will print the gyroscope data in the X, Y, and Z axis.
- Values will be printed in calibrated IMU data by default.

5.1.7 IMU Accuracy Checking Procedure

The IMU contains a self-accuracy check, which monitors the output of the accelerometer and gyroscope. The accuracy of the IMU data is reported to the end user with the following definitions:

Table 5.5—IMU Accuracy Level Mask

Description	Binary Value	Decimal Value
Unreliable	00	0
Accuracy Low	01	1
Accuracy Medium	10	2
Accuracy High	11	3

While the end user must decide the exact performance accuracy that is needed for an application, the datasheet specifications correspond to operating the sensor at a high accuracy status. If the current, reported accuracy status is below the level that is desired by the end user, a calibration procedure can be performed as described in *Section 3.7—IMU Dynamic Calibration Procedure*

To properly read the accuracy level output, the user will need to convert the hexidecimal output into binary.

1. Example: Accuracy Levels

user: `s $acl`

response: `s $acl`

`24`

- By entering the `s` command with the operand `$acl`, the sensor will print the acceleration and gyromscope accuracy levels.
- Data is printed in hexidecimal. The user will need to convert the hexidecimal output to binary to read the accuracy level. In this example, 24 would convert to 0010 0100 in binary.
- By referencing *Table 6.5* and *Table 6.6,* the user can match the binary output with an accuaracy level. In this example, 0010 0100 would indicate the linear accelerometer (00) is unreliable, the accelerometer (10) is medium accuracy, and the gyroscope (01) is low accuracy.

5.1.8 Yellow Mode

For users who purchased a sensor for usage with FANUC force control, the sensor will be shipped in Yellow Mode. Refer to the *Fanuc-Ready manual* for detailed information on the sensor's serial functionality.

5.2 UDP Interface Using RDT

The NETrs F/T can output data at up to 8000 Hz over Ethernet using UDP. This method of fast data collection is called Raw Data Transfer (RDT). If the overhead of DeviceNet or EtherNet/IP is too much for an application, or if extra speed is required in data acquisition, RDT provides an easy method to obtain the forces, torques, and status codes of the NETrs F/T system.

NOTICE: Multi-byte values must be transferred to the network high byte first and with the correct number of bytes. Some compilers align structures to large field sizes, such as 32- or 64-bit fields, and send an incorrect number of bytes. C compilers usually provide the functions *htons(), htonl(), ntohs(),* and *ntohl()* that can automatically handle these issues.

5.2.1 RDT Protocol

There are four commands in the RDT protocol, which are listed in *Table 5.4*. Any command received by the NETrs F/T takes precedence over any previously received commands.

Table 5.6—RDT Commands

Command	Command Name	Command Response
0x0000	Stop streaming	none
0x0002	Start high-speed real-time streaming	RDT record(s)
0x0003	Start high-speed buffered streaming	RDT record(s)
0x0042	Set Software Bias	none

1. High-speed real-time streaming (up to 7000 Hz) is best for real-time response applications.
2. High-speed buffered streaming (up to 7000 Hz in bursts) is best for collecting data at high speed, but not responding in real time.

To start the NETrs F/T outputting RDT messages, send an RDT request to it. The NETrs F/T listens for RDT requests on UDP port 49152. It also sends the RDT output messages from this port.

CAUTION: A dedicated Ethernet network should be used for the streaming of NETrs F/T data. NETrs F/T RDT streaming modes can send large amounts of data to the Ethernet connection which can disrupt other communications on the network. See *Section 16.1—Improving Ethernet Throughput*.

CAUTION: To reduce the possibility of network problems, especially when on a shared network, NETrs F/T RDT streaming modes should only be used at high output rate when absolutely necessary.

NOTICE: All NETrs F/T RDT streaming modes continue to stream until a Stop Streaming command (0x0000) is received. If the client that requested the data is removed from the network (disconnected, powered down, out of wireless range, etc.) before it sends a Stop Streaming command, the NETrs F/T will continue to stream data to the network even though there is no recipient.

All RDT requests use the following RDT request structure:

```
{
    Uint16 command_header = 0x1234;     // Required
    Uint16 command;                // Command to execute
    Uint32 sample_count;           // Samples to output (0 = infinite)
}
```

Set the command field of the RDT request to the command from *Table 5.4*. Set sample_count to the number of samples to output. If the sample_count is set to zero, the Net Box continuously outputs until the user sends a RDT request with command set to zero.

RDT records sent in request to an RDT request have this structure: {

```
    Uint32 rdt_sequence; // RDT sequence number of this packet.
    Uint32 ft_sequence;  // The record's internal sequence number
    Uint32 status;       // System status code

    // Force and torque readings use counts values
    Int32 Fx;     // X-axis force
    Int32 Fy;     // Y-axis force
    Int32 Fz;     // Z-axis force
    Int32 Tx;     // X-axis torque
    Int32 Ty;     // Y-axis torque
    Int32 Tz;     // Z-axis torque
}
```

rdt_sequence:	The position of the RDT record within a single output stream. The RDT sequence number is useful for determining if any records were lost in transit. For example, in a request for 1000 records, rdt_sequence will start at 1 and run to 1000. The RDT sequence counter will roll over to zero for the increment following 4294967295 (2^{32}-1).
ft_sequence:	The internal sample number of the F/T record contained in this RDT record. The F/T sequence number starts at 0 when the Net F/T is powered up and increments at the internal sample rate (7000 per sec). Unlike the RDT sequence number, ft_sequence does not reset to zero when an RDT request is received. The F/T sequence counter will roll over to zero for the increment following 4294967295 (2^{32}-1)
status:	Contains the system status code at the time of the record.
Fx, Fy, Fz, Tx, Ty, Tz:	The F/T data as counts values.

If using buffered mode, then the number of RDT records received in a UDP packet is equal to the RDT buffer size displayed on the *Communications* web page. For a description of RDT Buffer Size, see *Section 4.7—Communication Settings Page (comm.htm)*.

5.2.2 Extended RDT Requests

The extended RDT request format is used when the NETrs F/T should send the UDP F/T data to a different IP address than the IP address from which the request comes. This is useful, for example, if the NETrs F/T stream data is sent to a multicast address so that multiple clients can receive the stream at once.

Extended RDT requests have the following structure:

```
{
uint16 hdr;              /* Always set to 0x1234 */
uint16 cmd;              /* The command code, with high bit set to '1'. */
uint32 count;            /* The number of samples to send in response. */
uint32 ipaddr_dest;      /* The ip address to send the response to. */
uint16 port_dest;        /* The port to send the response to. */
}
```

The command codes used in the Extended RDT format are the same as the command codes in normal RDT requests, except that the high bit is set to a '1'. For example, the command code 2, for high-speed streaming, is changed to 0x8002 for use with the Extended RDT request packet structure.

For example, to request high speed streaming to the multicast address 224.0.5.128, port 28250, send a UDP packet with the following data:

```
{ 0x12, 0x34, 0x80, 0x02, 0x00, 0x00, 0x00, 0x00, 224, 0, 5, 128, 0x6e, 0x5a };
```

Clients can then subscribe to the UDP multicast IP address 224.0.5.128, and receive the streaming data on port 28250. Users should consult their client system's documentation for information on how to subscribe to a multicast IP address.

5.2.3 Calculating F/T Values for RDT

To obtain the real force and torque values, each force output value has to be divided by the Counts per Force and each torque output value has to be divided by the Counts per Torque factor. The Counts per Force and Counts per Torque factors can be obtained from netftapi2.xml page.

5.2.4 Multiple Clients

The RDT protocol is designed to respond to one client only. If a second client sends a command, the Net F/T will respond to the new client. Multiple clients could repeatedly request single packets, minimizing problems (the Java demo operates in this manner).

5.2.5 Notes on UDP and RDT Mode

RDT communications use UDP, with its minimal overhead, to maximize throughput. Unlike TCP, UDP does not check if a package was actually received.

In some Ethernet network configurations this can lead to the loss of RDT data sets. By checking the RDT

sequence number of each set, it can be determined if a data set was lost. The RDT sequence number of each data set sent is one greater than the last data set sent for that RDT request. If a received data set's RDT sequence number is not one greater than the last received data set, then a loss of data has occurred (the program must also account for rollover of the RDT sequence number).

The likelihood of data loss highly depends on the Ethernet network configuration, and there are ways to reduce the probability of data loss to almost zero.

The maximum data latency, measured from the beginning of data acquisition to when the last data bit is sent to the Ethernet network, is less than 28 µs.

The NETrs F/T only supports one UDP connection at a time.

5.2.6 Example Code

Example C code can be found on the ATI website at *http://www.ati-ia.com/Products/ft/software/net_ft_software.aspx*.

5.3 TCP Interface

The TCP interface listens on TCP port 49151. All commands are 20 bytes in length. All responses begin with the two byte header 0x12, 0x34.

5.3.1 Command Codes

```
READFT          =     0,    /* Read F/T values. */
READCALINFO     =     1,    /* Read calibration info. */
WRITETRANSFORM  =     2,    /* Write tool transformation. */
WRITECondition  =     3,    /* Write monitor condition. */
```

5.3.2 Read F/T Command

```
{
uint8          command;       /* Must be READFT (0) . */
uint8          reserved[15]; /* Should be all 0s. */
uint16    MCEnable;     /* Bitmap of MCs to enable. */
uint16    sysCommands;  /* Bitmap of system commands. */
}
```

Each bit position 0-15 in MCEnable corresponds to the monitor condition at that index. If the bit is a '1', that monitor condition is enabled. If the bit is a '0', that monitor condition is disabled.

Bit 0 of sysCommands controls the Bias. If bit 0 is a '1', the system is biased. If bit 0 is a '0', no action is taken.

Bit 1 of sysCommands controls the monitor condition latch. If bit 1 is a ‘1’, the monitor condition latch is cleared, and monitor condition evaluation begins again. If bit 1 is a ‘0’, no action is taken.

5.3.3 Read F/T Response

```
{
uint16 header;     /* always 0x1234. */
uint16 status;     /* Upper 16 bits of status code. */
int16 ForceX;      /* 16-bit Force X counts. */
int16 ForceY;      /* 16-bit Force Y counts. */
int16 ForceZ;      /* 16-bit Force Z counts. */
int16 TorqueX;     /* 16-bit Torque X counts. */
int16 TorqueY;     /* 16-bit Torque Y counts. */
int16 TorqueZ;     /* 16-bit Torque Z counts. */
}
```

The status code is the upper 16 bits of the 32-bit status code.

The force and torque values in the response are equal to (actual ft value × calibration counts per unit ÷ 16-bit scaling factor). The counts per unit and scaling factor are read using the read calibration information command.

5.3.4 Read Calibration Info Command

```
{
    uint8 command;        /* Must be READCALINFO (1). */
    uint8 reserved[19];          /* Should be all 0s. */
}
```

5.3.5 Read Calibration Info Response

```
{
    uint16 header;               /* always 0x1234. */
    uint8 forceUnits;            /* Force Units. */
    uint8 torqueUnits;           /* Torque Units. */
    uint32 countsPerForce;       /* Calibration Counts per force unit. */
    uint32 countsPerTorque;      /* Calibration Counts per torque unit. */
    uint16 scaleFactors[6];      /* Further scaling for 16-bit counts. */
}
```

The status code is the upper 16 bits of the 32-bit status code.

The force and torque values in the response are equal to (actual ft value × calibration counts per unit ÷16-bit scaling factor). The counts per unit and scaling factor are read using the read calibration information command.

The force unit codes are:

1: Pound
2: Newton
3: Kilopound
4: Kilonewton
5: Kilogram
6: Gram

The torque unit codes are:

1: Pound-inch
2: Pound-foot
3: Newton-meter
4: Newton-millimeter
5: Kilogram-centimeter
6: Kilonewton-meter

5.3.6 Write Tool Transform Command

```
{
    uint8 command; /* Must be WRITETRANSFORM (2). */
uint8 transformDistUnits; /* Units of dx,dy,dz */
uint8 transformAngleUnits; /* Units of rx,ry,rz */
int16 transform[6]; /* dx, dy, dz, rx, ry, rz */
uint8 reserved[5]; /* Should be all zeroes. */
}
```

The 'transform' elements are multiplied by 100 to provide good granularity with integer numbers.

The distance unit codes are:

1: Inch
2: Foot
3: Millimeter
4: Centimeter
5: Meter

The angle unit codes are:

1: Degrees
2: Radians.

The response is a standard Write Response

5.3.7 Write Monitor Condition Command

```
{
    uint8 command;              /* Must be WRITECondition. */
    uint8 index;          /* Index of monitor condition. 0-31. */
    uint8 axis;           /* 0 = fx, 1 = fy, 2 = fz, 3 = tx, 4 = ty, 5 = tz. */
    uint8 outputCode;           /* Output code of monitor condition. */
    int8 comparison;            /* Comparison code. 1 for "greater than" (>), -1
                          for "less than" (<). */
    int16 compareValue;   /* Comparison value, divided by 16 bit
                          Scaling factor. */
}
```

5.3.8 Write Response

```
{
    uint16 header;        /* Always 0x1234. */
    uint8 commandEcho;    /* Echoes command. */
    uint8 status;         /* 0 if successful, nonzero if not. */
```

5.4 EtherNet/IP™

Refer to the *NET FT manual* for detailed information on EtherNet/IP™ communication.

5.5 PROFINET

Refer to the *NET FT manual* for detailed information on PROFINET communication.

5.6 DeviceNet®

Refer to the *NET FT manual* for detailed information on DeviceNet® communication.

5.7 Controller Area Network

Refer to the *NET FT manual* for detailed information on Controller Area Network (CAN) communication.

5.8 LEDs

The sensor includes four LED units: Power, Serial, EtherNET, and Status. Each of these LEDs can be off, red, green, or both red and green, which may appear as orange.

Figure 5.2—NETrs LEDS

At power up, each LED (Power, Serial, EtherNet, Status) go through the following test sequence once: off, flash red, flash green, flash orange (red and green together), off.

Table 5.5 outlines LED behavior during normal operation.

Table 5.7—NETrs Sensor LED Descriptions

LED	Label	LED State	Description
Serial Activity	SER	Solid Red	Not in use
		Green	LED will light green for five seconds following any serial activity
Power	PWR	Off	No power
		Solid Green	Powered on
Ethernet Activity	NET	Solid Red	Not in use
		Green	LED will light green for five seconds following any Ethernet activity
Status	STA	Solid Green	No errors
		Slow Blinking Red	Calibration checksum error
		Fast Blinking Red	Ethernet communication error
		Solid Orange (Red and Green)	Axis out of range error.
		Solid Red	Serious status error. Reference *Section 7.2—Status Word.*

5.9 Filtering

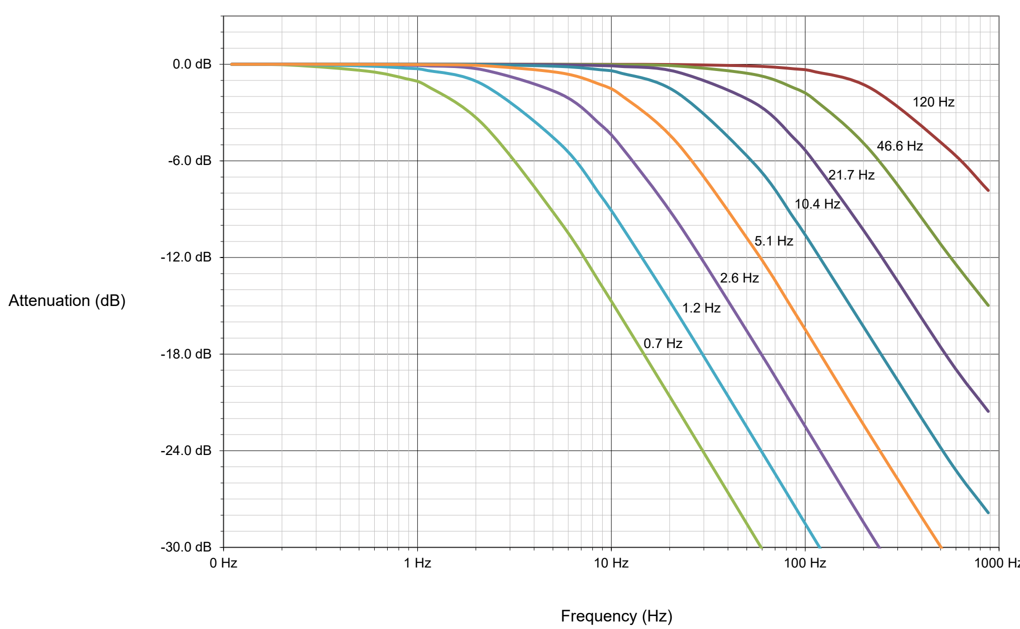
The cutoff frequency is dependent on the internal sample rate, which is 1000 Hz by default. The user can configure the sample rate by sending a set command (reference *Table 5.3)*. The relative cutoff frequencies for different values of this coefficient are:

Table 5.8—Filtering		
Coefficient	**Cutoff Frequency (Percent of Internal Sample Rate)**	**Frequency[1]**
0	No filter	15.9 kHz
1	11.97%	120 Hz
2	4.66%	46.6 Hz
3	2.17%	21.7 Hz
4	1.04%	10.4 Hz
5	0.51%	5.1 Hz
6	0.26%	2.6 Hz
7	0.12%	1.2 Hz
8	0.07%	0.7 Hz

Note:

1. Values are displayed based on a 1 kHz sample rate, which is the default for ATI NETrs sensors.

Figure 5.3—Filter Attenuation at 1 kHz Sample Rate



6. Scheduled Maintenance

For most applications, there are no parts that need to be replaced during normal operation. With industrial-type applications that continuously or frequently move the system's cabling, periodically check the cable jacket for signs of wear.

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 are to be considered unprotected. The internal structure of the transducers can become clogged with particles and will become uncalibrated or even damaged.

7. Troubleshooting

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

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

For information related to ATI's Net FT system, including any Net Box (9105-NETB), refer to the *NET FT manual.*

> Note:
>
> Please read the manual before calling customer service. Before calling, have the following information available:
>
> 1. Serial number (e.g., FT01234)
> 2. Transducer model (e.g., Nano17, Gamma, Theta, etc.)
> 3. Calibration (e.g., US-15-50, SI-65-6, etc.)
> 4. Accurate and complete description of the question or problem
> 5. Computer and software information (operating system, PC type, drivers, application software, and other relevant information about the configuration).
>
> If possible, be near the F/T system when calling.

For assistance, please refer to one of the following contacts:

ATI Industrial Automation (a Novanta Company)
1031 Goodworth Drive
Apex, NC 27539 USA
www.ati-ia.com
Tel: +1 919-772-0115
Fax: +1 919-772-8259

Application Engineering
E-mail: *ft.support@novanta.com*

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

7.1 System Status Code

The NETrs F/T performs many diagnostic checks during operation and reports results in a 32-bit system status code. Each F/T record includes this system status code. The bit patterns for all present error conditions are or'ed together to form the system status code. If any error condition is present then bit 31 of the system status code is set.

Bit 16 is set if a Condition is latched. This bit does not indicate a system error.

The system status code should be:

0x00000000 if no errors and no Condition statements are breached

0x80010000 if no errors and a Condition statement is breached.

Any other code signals means there is a serious error. Possible errors and their bit assignments are in *Table 8.1*.

7.2 Status Word

The Status Word is a bitmap which contains information about the errors that can occur in various subsystems of the NETrs F/T sensor.

<table>
<tr><th colspan="6">Table 7.1—Status Word Bit Assignments</th></tr>
<tr><th>Bit</th><th>Bit Pattern</th><th colspan="4">Description</th></tr>
<tr><td>0</td><td>0x00000001</td><td colspan="4">Gage temperature is outside the expected range of -5 to 70 degrees C</td></tr>
<tr><td>1</td><td>0x00000002</td><td colspan="4">Supply voltage is outside the expected range of 12V to 32 V</td></tr>
<tr><td>2</td><td>0x00000004</td><td colspan="4">Broken Gage</td></tr>
<tr><td>3</td><td>0x00000008</td><td colspan="4">Busy Bit</td></tr>
<tr><td>4</td><td>0x00000010</td><td colspan="4">PCB Temperature out of range</td></tr>
<tr><td>5</td><td>0x00000020</td><td colspan="4">Common error bit</td></tr>
<tr><td>6</td><td>0x00000040</td><td colspan="4">MCU Temperature</td></tr>
<tr><td>7</td><td>0x00000080</td><td colspan="4">Gage Overflowed</td></tr>
<tr><td>8</td><td>0x00000100</td><td colspan="4">Safe Mode</td></tr>
<tr><td>9-10</td><td></td><td colspan="4">Reserved</td></tr>
<tr><td>11</td><td>0x00000800</td><td colspan="4">IMU Accuracy Unreliable</td></tr>
<tr><td>12-15</td><td></td><td colspan="4">Reserved</td></tr>
<tr><td>16</td><td>0x00010000</td><td colspan="4">Monitor Condition 0 Output</td></tr>
<tr><td rowspan="5">17-18</td><td rowspan="5">0x00060000</td><th>Status Bit 18</th><th>Status Bit 17</th><th>Decimal Value</th><th>Description</th></tr>
<tr><td>0</td><td>0</td><td>0</td><td>Unreliable</td></tr>
<tr><td>0</td><td>1</td><td>1</td><td>Accuracy Low</td></tr>
<tr><td>1</td><td>0</td><td>2</td><td>Accuracy Medium</td></tr>
<tr><td>1</td><td>1</td><td>3</td><td>Accuracy High</td></tr>
<tr><td>19</td><td>0x00080000</td><td colspan="4">IMU Error</td></tr>
<tr><td>20-25</td><td></td><td colspan="4">Reserved</td></tr>
<tr><td>26</td><td>0x04000000</td><td colspan="4">Gage Out of Range Warning</td></tr>
<tr><td>27</td><td>0x08000000</td><td colspan="4">Gage Out of Range</td></tr>
<tr><td>28</td><td>0x10000000</td><td colspan="4">Simulated Error</td></tr>
<tr><td>29</td><td>0x20000000</td><td colspan="4">Calibration Checksum Error.</td></tr>
<tr><td>30</td><td>0x40000000</td><td colspan="4">Force/Torque Out of Range</td></tr>
<tr><td>31</td><td>0x80000000</td><td colspan="4">Any Error</td></tr>
</table>

7.3 Questions and Answers

Table 7.2—Communications	
Question/Problem	**Answer/Solution**
What IP address is assigned to the NETrs F/T?	If using console communication, send a "status" command. Refer to the "Network" line for current IP address. User can also download ATI's Discover Tool, found on the ATI software webpage. This software will identify all IP addresses of ATI devices on your local network.
How can the NETrs F/T system be set to the default IP address of 192.168.1.1?	The sensor IP address can be configured on the FT Webpages. Refer to *Section 4.1—ATI Force/Torque Webpages.* Additionally, if using serial communication, use the "cal sipadr" command to set a new IP address. Refer to *Section 5.1—Console Commands via Serial.*
DHCP is not assigning an IP address	Ethernet LAN must be connected during power up. DHCP is not selected as the IP Address Mode on the *Communications* web page (refer to *Section 4.1—ATI Force/Torque Webpages).* The DHCP server waits more than 30 seconds to respond.
Browser cannot find the NETrs F/T on Ethernet network even though the NETrs F/T configuration utility reports an IP address.	Clear the Windows computer's ARP table to remove memory of a previous device that used the same IP address as the NETrs F/T by restarting the computer or, with administrative privileges, by going to the computer's Start menu, selecting Run..., and typing "arp –d *".
Incorrect CAN Bus Base Address, DeviceNet MAC ID, and/or Baud Rate reported	Power must be present on the Pwr/CAN connector to correctly report these values.
System status reports DeviceNet Protocol Failure when using DeviceNet	DeviceNet is not available unless power is present on the Pwr/CAN connector.

Table 7.3—Java Demo	
Question/Problem	**Answer/Solution**
Demo displays zeros for force and torque values and question marks for configuration data	Check IP address and restart demo.
Excessive IO exception: Receive timed out errors	The Ethernet connection was interrupted. Check Ethernet cabling and NETrs F/T power.
Error message: IO exception: <path and file name> (The process cannot access the file because it is being used by another process)	Selected file for data is in use by another program. Close file or change file name and press Collect Streaming again.
The message Could not find the main class. Program will exit appears in a window titled Java Virtual Machine Launcher.	Computer requires a newer version of Java. Java may be downloaded from *www.java.com/getjava*.

Table 7.4—Web Pages	
Question/Problem	**Answer/Solution**
The Invalid Request page appears	One or more entries on the previous web page were invalid or out of range. Go back to the previous page and review the last entry. Make only one change at a time to make debugging easier.

Table 7.4—Web Pages	
Question/Problem	**Answer/Solution**
The HTTP 1.0 401 Error - Unauthorized page appears	An unsuccessful attempt to access a protected page of the web server. These pages are reserved for ATI Industrial Automation maintenance.

Table 7.5—IMU Accuracy	
Question/Problem	**Answer/Solution**
The IMU accuracy level is not high.	The zero offsets of the IMU hardware may be out of adjustment. Complete the IMU Dynamic Calibration Procedure, as outlined in the *Transducer Manual*.

7.3.1 Errors with Force and Torque Readings

Invalid data from the transducer's strain gages can cause errors in force/torque readings. These errors can result in problems with condition monitoring, transducer biasing, and accuracy. Basic conditions of invalid data are listed in the following table. Use this following table to troubleshoot a problem. In most cases, problems can be better identified while looking at the raw strain gage data, displayed on the *Snapshot* web page. See *Section 4.1—ATI Force/Torque Webpages.*

Table 7.6—Errors with Force and Torque Readings	
Question/Problem	**Answer/Solution**
Noise	Jumps in raw strain gage readings (with transducer unloaded) greater than 250 counts is considered abnormal. Noise can be caused by mechanical vibrations and electrical disturbances, possibly from a poor ground. It can also indicate component failure within the system. See *Section 7.4—Reducing Noise.*
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 in resolved data mode using the bias command. 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 transducer body (i.e., filings between the tool adapter plate and the transducer body). Some mechanical coupling is common, such as hoses and wires attached to a tool.
Hysteresis	When the transducer 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.
Sensor is giving unexpected values.	Complete an accuracy check. Refer to *Section 7.6—Accuracy Check* If symptoms continue, contact ATI customer service at *ft.support@novanta.com.*

7.4 Reducing Noise

7.4.1 Mechanical Vibration

In many cases, perceived noise is actually a real fluctuation of force and/or torque, caused by vibrations in the tooling or the robot arm. The NETrs F/T system offers digital low-pass filters that can dampen frequencies above a certain Condition. If this is not sufficient, add a digital filter to the application software.

7.4.2 Electrical Interference

If observing interference by motors or other noise-generating equipment, check the NETrsF/T's ground connections. If sufficient grounding is not possible or does not reduce the noise, consider using the NETrs F/T's digital low pass filters. Verify the use of Class 1 power supply which has an earth ground connection.

Alternatively, use a benchtop supply with a DeviceNet cable, connecting the drain wire to functional earth at the power supply.

Another potential solution is to connect drain and supply (-) together at the supply with a short, solid connection.

7.5 Increase Operating System Performance

For optimal computer performance in response to the NETrs F/T's fast data rates, consider the following:

- **Disable software firewall.** One way to improve the Ethernet performance is not to have any software firewall activated. In some cases, IT personnel may need to assist.
- **Disable file and printer sharing**. The processes associated with file and printer sharing can slow down an operating system's response to Ethernet data and may lead to lost data.
- **Disable unnecessary network services.** Unnecessary network services and protocols can slow down an operating system's response to Ethernet data and may lead to lost data. For the best UDP performance, try to turn off every network service except for TCP/IP.
- **Use an Ethernet traffic snooper.** An Ethernet traffic snooper can be invaluable in detecting unforeseen processes using-up Ethernet bandwidth and potentially slowing down the response of the computer's operating system. A traffic snooper is an advanced technique that a user's IT department may need to set-up. The free software program Wireshark (www.wireshark.org) is commonly used as a traffic snooper.
- **Use a dedicated computer.** A dedicated measurement computer that is isolated from the company network and not burdened by the company network processes.

7.6 Accuracy Check

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

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

1. Attach a fixed mass to the tool side of the F/T sensor:
   a. Remove cables that form bridges between the sensor's mounting and tool sides.
2. Power on the sensor. Allow a 30 minute warm-up time. Minimize external sources of temperature change.

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

3. Move the robot so that the sensor is in the following positions:
   a. Record the sensor's output, $F_{x,\ point\ n}$ $F_{y,\ point\ n}$ $F_{z,\ point\ n}$, at each point without biasing.
      - Point 1: +Z up
      - Point 2: +X up
      - Point 3: +Y up
      - Point 4: -X up
      - Point 5: -Y up
      - Point 6: -Z up
4. Calculate $F_{x,\ average}$, $F_{y,\ average}$, and $F_{z,\ average}$:
   a. Use the following equations, to complete the calculations:

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

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

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

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

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

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

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

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

6. The calculated tooling masses for all (6) points should deviate from each other by less than twice the worst accuracy rating of the sensor.

- For example: the Axia80-M20 sensor's rated accuracy is 2% the range on all axes. For a 500 N F_{xy} range and a 900 N F_z range, the allowable errors of any single data point would be ± 10 N F_xy and ± 18 N F_z respectively. Since F_z has the larger tolerance, then one data point could be + 18 N and another data point could be - 18 N, for a total range (max-min) of 36 N error.
- In addition, the tooling mass should be within 36 N of the results of this test when it was performed with a new sensor.

7. If this test fails, then the sensor should be returned to ATI for diagnosis or recalibration.

8. Specifications

For specifications specific to the transducer, reference the *Transducer Manual*. For any specifications related to Net FT systems, including the Net Box, reference the *Net FT manual*.

For more specifications or other pertinent documentation specific to the NETrs system, visit the *ATI website*.

8.1 Storage and Operating Conditions

Table 8.1—Temperature		
Component	**Storage Temperature, °C**	**Operating Temperature, °C**
NETrs Electronics	-40 to +100	-20 to +70
NETrs CEB	-40 to +100	-20 to +70

8.2 Electrical Specifications (Power Supply)

Table 8.2—Power Supply Requirements			
Power Source[1]	**Minimum Voltage**	**Maximum Voltage**	**Maximum Power Consumption**
Power	12 V	30 V	3 W

Note:

1. Power is drawn from only one power source at a time.
2. Conforms to IEEE 802.3af, class 0, receiving power from data lines. Uses Mode A to receive power. Mode B is not supported.

8.2.1 Mating Connectors

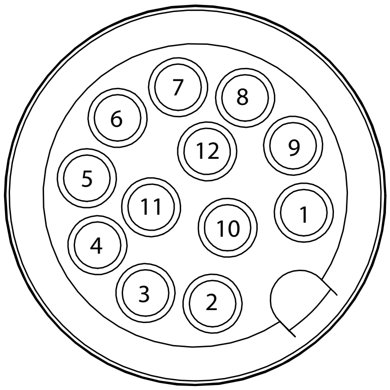
Table 8.3—Mechanical Specifications of Connectors			
Connector	**Mating Type**	**Recommended Torque**	**Maximum Torque**
Standard Transducer	M12 12-Pin, Male	0.8 Nm to 1.0 Nm	3.0 Nm
Mini/Nano Transducer	Circular, Male	0.7 Nm	
Splitter Box Input: Transducer Cable	M12 12-Pin Female	0.8 Nm to 1.0 Nm	3.0 Nm
Splitter Box Output: Ethernet	M12 D-Coded, 4-Pin Female	0.8 Nm to 1.0 Nm	3.0 Nm
Splitter Box Output: Serial	M12 D-Coded, 4-Pin Female	0.8 Nm to 1.0 Nm	3.0 Nm
Splitter Box Power	M12 5-Pin Male	0.8 Nm to 1.0 Nm	3.0 Nm
NETrs CEB Input: Transducer Cable	Circular, Female	0.7 Nm	
NETrs CEB Output: Ethernet	M12 D-Coded, 4-Pin Female	0.8 Nm to 1.0 Nm	3.0 Nm
NETrs CEB Output: Serial	M12 D-Coded 4-Pin Female	0.8 Nm to 1.0 Nm	3.0 Nm
NETrs CEB Power	M12 5-Pin Male	0.8 Nm to 1.0 Nm	3.0 Nm

8.3 Connector Pin-Out Assignments

8.3.1 Splitter Box

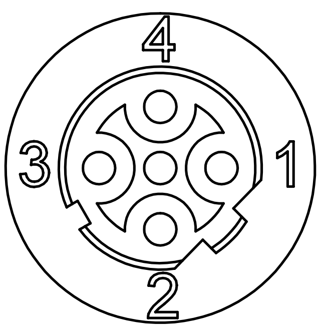
Pinout information for the Splitter Box (9105-GEN3-SPLIT-001) is outlined below.

Table 8.4—Splitter Box Transducer Cable Connector[1]

Connector	Pin	Assignment
	1	RS422_TX+ OR RS485+
	2	RS422_TX- OR RS485-
	3	RS422_ RX+
	4	RS422_ RX-
	5	SYNC_GND
	6	SYNC+
	7	V_0(GND)
	8	V+
	9	Ethernet TX+
	10	Ethernet TX-
	11	Ethernet RX+
	12	Ethernet RX-
	Shell	Drain

Note:
1. RS422 communication uses pins 1, 2, 3, and 4. RS485 communication only uses pins 1 and 2.

Table 8.5—Splitter Box RS422/RS485 Connector[1]

Connector	Pin	Assignment
	1	RS422_TX+ OR RS485+
	2	RS422_ RX+
	3	RS422_TX- OR RS485-
	4	RS422_ RX-

Note:
1. RS422 communication uses all four pins. RS485 communication only uses pins 1 and 3.

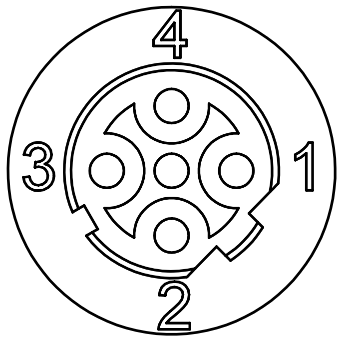
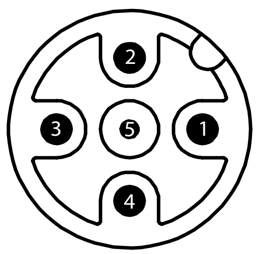
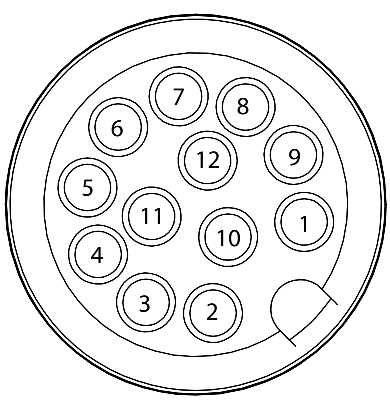
Table 8.6—Splitter Box Ethernet Connector		
Connector	**Pin**	**Assignment**
	1	Ethernet TX+
	2	Ethernet RX+
	3	Ethernet TX-
	4	Ethernet RX-

Table 8.7—Splitter Box Power Connector		
Connector	**Pin**	**Assignment**
	1	Drain
	2	V+
	3	V_0 (GND)
	4	SYNC+
	5	SYNC_GND

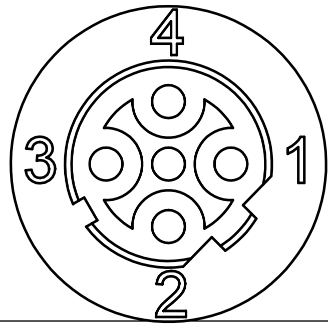
8.3.2 NETrs CEB

Information on the NETRS CEB is outlined below. For detailed pinouts on the Net Box (9105-NETB), refer to the *Net FT manual*.

Table 8.8—NETrs CEB Transducer Connector[1]		
Connector	**Pin**	**Assignment**
	1	RS422_TX+ OR RS485+
	2	RS422_TX- OR RS485-
	3	RS422_ RX+
	4	RS422_ RX-
	5	SYNC_GND
	6	SYNC+
	7	V_0(GND)
	8	V+
	9	Ethernet TX+
	10	Ethernet TX-
	11	Ethernet RX+
	12	Ethernet RX-
	Shell	Drain

Note:

1. RS422 communication uses pins 1, 2, 3, and 4. RS485 communication only uses pins 1 and 2.

Table 8.9—NETrs CEB RS422/RS485 Connector[1]		
Connector	**Pin**	**Assignment**
	1	RS422_TX+ OR RS485+
	2	RS422_ RX+
	3	RS422_TX- OR RS485-
	4	RS422_ RX-

Note:
1. RS422 communication uses all four pins. RS485 communication only uses pins 1 and 3.

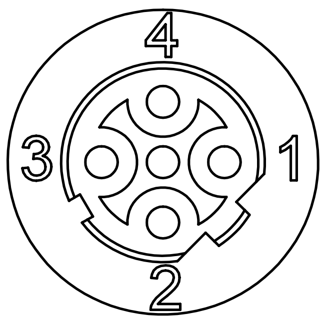
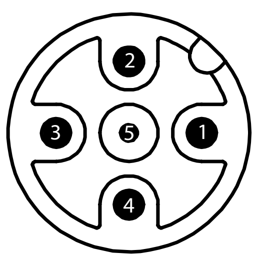
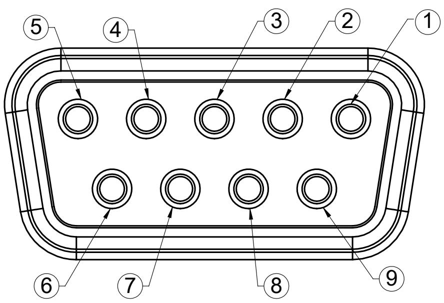
Table 8.10—Splitter Box Ethernet Connector		
Connector	**Pin**	**Assignment**
	1	Ethernet TX+
	2	Ethernet RX+
	3	Ethernet TX-
	4	Ethernet RX-

Table 8.11—Splitter Box Power Connector		
Connector	**Pin**	**Assignment**
	1	Drain
	2	V+
	3	V_0 (GND)
	4	SYNC+
	5	SYNC_GND

8.3.3 Serial Cable

<table>
<tr><th colspan="4">Table 8.12—M12 to DB9 Serial Adapter Cable (9105-C-D09F1-MD4M1-01-5.0)[1]</th></tr>
<tr><th>Connector</th><th>Pin</th><th>Wire Color</th><th>Assignment</th></tr>
<tr><td rowspan="5">
</td><td>1</td><td>Green</td><td>RS422_RX-</td></tr>
<tr><td>2</td><td>White/Green</td><td>RS422_RX+</td></tr>
<tr><td>3</td><td>White/Orange</td><td>RS422_TX+ OR RS485+</td></tr>
<tr><td>4</td><td>Orange</td><td>RS422_TX- OR RS485-</td></tr>
<tr><td>5-9</td><td colspan="2">Not used</td></tr>
<tr><td colspan="4">Note:
1. RS422 communication uses all four pins. RS485 communication only uses pins 3 and 4.</td></tr>
</table>

9. Drawings

Drawings are available on the *ATI website* or by contacting an ATI representative.

10. Terms and Conditions of Sale

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