Commissioning instructions

FTN

Force/torque sensor system

Translation of original commissioning instructions

Hand in hand for tomorrow

Imprint

Technical changes:
We reserve the right to make alterations for the purpose of technical improvement.

Document number: 389242

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Dear Customer,

Thank you for trusting our products and our family-owned company, the leading technology supplier of robots and production machines.

Our team is always available to answer any questions on this product and other solutions. Ask us questions and challenge us. We will find a solution!

Best regards,

Your SCHUNK team

Customer Management
Tel. +49-7133-103-2503
Fax +49-7133-103-2189
cmg@de.schunk.com

Please read the operating manual in full and keep it close to the product.

Table of Contents

1 General

1.1 About this manual

This manual contains important information for a safe and appropriate use of the product.

This manual is an integral part of the product and must be kept accessible for the personnel at all times.

Before starting work, the personnel must have read and understood this operating manual. Prerequisite for safe working is the observance of all safety instructions in this manual.

In addition to these instructions, the documents listed under ▸ 1.1.2 [🗋 6] are applicable.

NOTE: The illustrations in this manual are intended to provide a basic understanding and may deviate from the actual version.

1.1.1 Presentation of Warning Labels

To make risks clear, the following signal words and symbols are used for safety notes.

⚠ DANGER

Dangers for persons!

Non-observance will inevitably cause irreversible injury or death.

⚠ WARNING

Dangers for persons!

Non-observance can lead to irreversible injury and even death.

⚠ CAUTION

Dangers for persons!

Non-observance can cause minor injuries.

CAUTION

Material damage!

Information about avoiding material damage.

1.1.2 Applicable documents

- General terms of business *
- Catalog data sheet of the purchased product *
- Assembly and operating manual of the sensor *

The documents labeled with an asterisk (*) can be downloaded from **schunk.com**.

1.1.3 Variants

This operating manual applies to the following variations:

- Force/torque sensor system FTN EtherNet/IP interface (CAN bus and DeviceNet)
- Force/torque sensor system FTN PROFINET interface

1.2 Warranty

If the product is used as intended, the warranty is valid for 12 months from the ex-works delivery date under the following conditions:

- Observe the ambient conditions and operating conditions

Parts touching the workpiece and wear parts are not included in the warranty.

1.3 Scope of delivery

The scope of delivery includes

- Force/torque sensor system FTN in the ordered model
- Force/torque sensor with sensor cable
- NetBox
- Commissioning instructions
- Commissioning CD with calibration certificates
- Accessory pack

Depending on the variant, the scope of delivery includes:

- External power supply unit for NetBox
- Adapter cable M12 to RJ45
- Mini to Micro (M12) DeviceNet adapter
- Cable for DeviceNet

2 Basic safety notes

2.1 Intended use

The product is used to record, convert and evaluate analog output signals into electrical signals using a NetBox and a web browser interface.

- Appropriate use of the product includes compliance with all instructions in this manual.

2.2 Inappropriate use

The product is not a safety component in accordance with the EC Machine Directive 2006/42/EC and must not be used in safety-relevant parts of machine control units.

2.3 Constructional changes

Implementation of structural changes

By conversions, changes, and reworking, e.g. additional threads, holes, or safety devices can impair the functioning or safety of the product or damage it.

- Structural changes should only be made with the written approval of SCHUNK.

2.4 Spare parts

Use of unauthorized spare parts

Using unauthorized spare parts can endanger personnel and damage the product or cause it to malfunction.

- Use only original spare parts or spares authorized by SCHUNK.

2.5 Personnel qualification

Inadequate qualifications of the personnel

If the personnel working with the product is not sufficiently qualified, the result may be serious injuries and significant property damage.

- All work may only be performed by qualified personnel.
- Before working with the product, the personnel must have read and understood the complete assembly and operating manual.
- Observe the national safety regulations and rules and general safety instructions.

2.6 Disposal

Handling of disposal

The incorrect handling of disposal may impair the product's safety and cause serious injuries as well as considerable material and environmental harm.

- Follow local regulations on dispatching product components for recycling or proper disposal.

2.7 Notes on particular risks

⚠ DANGER

Danger from electric voltage!

Touching live parts may result in death.

- Switch off the power supply before any assembly, adjustment or maintenance work and secure against being switched on again.
- Only qualified electricians may perform electrical installations.
- Check if de-energized, ground it and hot-wire.
- Cover live parts.

3 Technical data

3.1 Basic Data

Designation	NetBox
Weight [kg]	
without retaining plate	0.8
with retaining plate	1.1

More technical data is included in the catalog data sheet. Whichever is the latest version.

3.2 Ambient conditions and operating conditions

Designation	NetBox
Ambient temperature [°C]	
during storage	
min.	-40
max.	100
during operation	
min.	-20
max.	70
Protection class IP	65

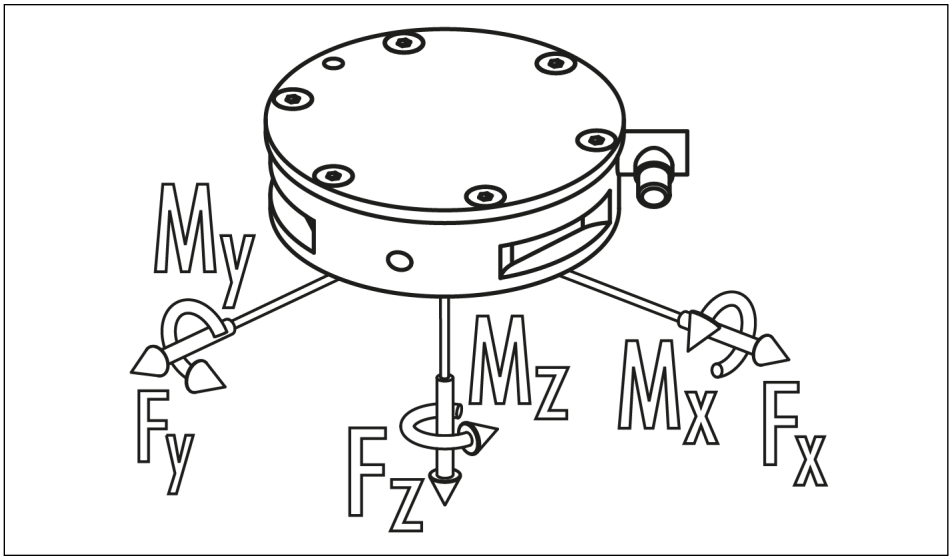
Tab.: Ambient conditions and operating conditions for NetBox

3.3 Force-torque sensor

NOTE

All forces and torques acting on the sensor must be within the specified range of measurement. Exceeding the range of measurement will reduce the maximum number of load cycles and may lead to damage of the sensor.

Information on the range of measurement of each individual force-torque sensor is provided in the catalog data sheet. The latest version is always applicable.



Dimensions and max. loads on the force-torque sensor

Detailed information on the mounting, installation and maintenance of the sensor is provided in the Assembly and Operating Manual for the sensor, ▸ 1.1.2 [🗋 6].

4 Design and description

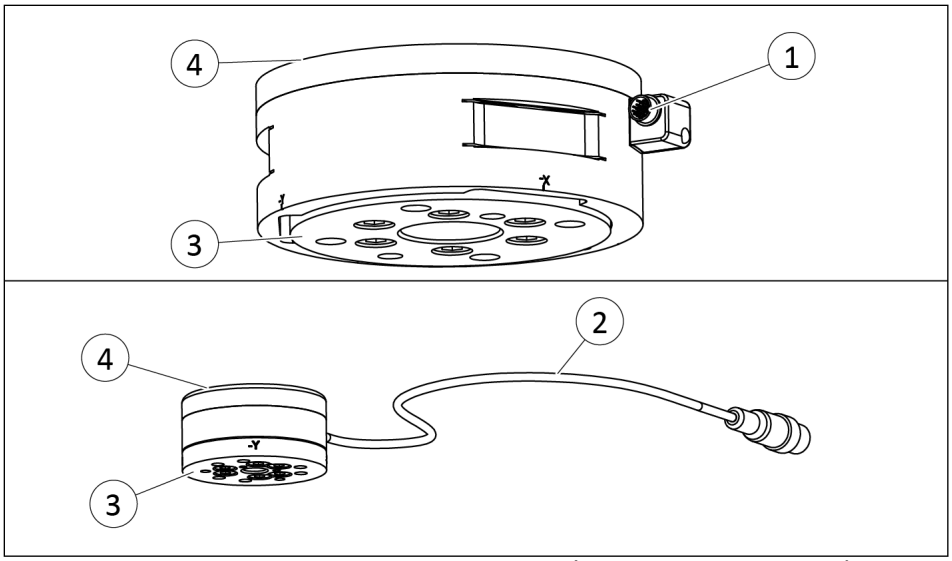
4.1 Design

NOTE

For the sake of clarity, the sizes of the force-torque sensors have been combined into two size groups in some places in this manual:

- FT Nano and FT Mini
- FT Gamma, FT Delta, FT Theta and FT Omega

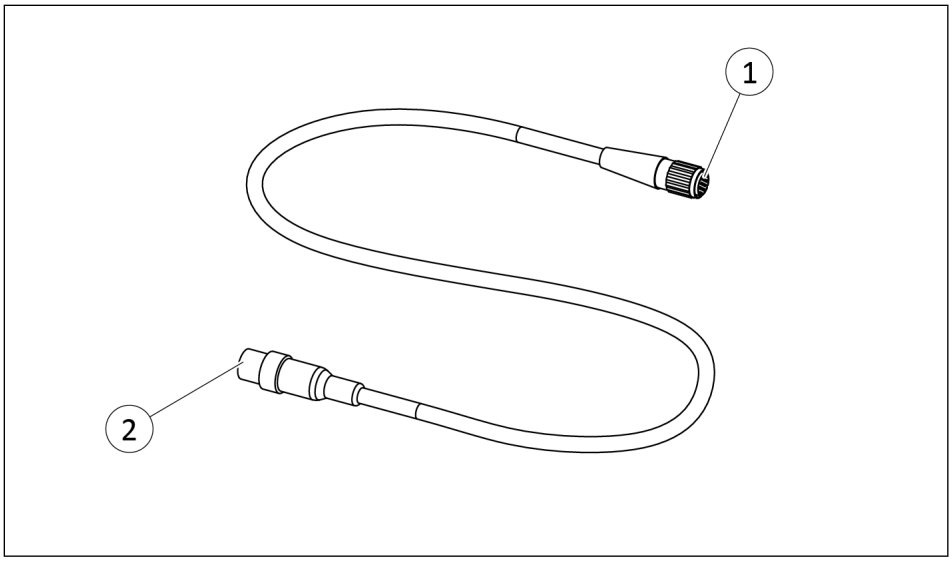
Force-torque sensor



***Top**: Force-torque sensor with interface electronics (from gamma and larger) /*
***Bottom**: Force-torque sensor with sensor cable (Nano and Mini)*

1	Sensor cable connection
2	Integrated sensor cable
3	Tool side adapter plate
4	Robot side adapter plate

Sensor cables

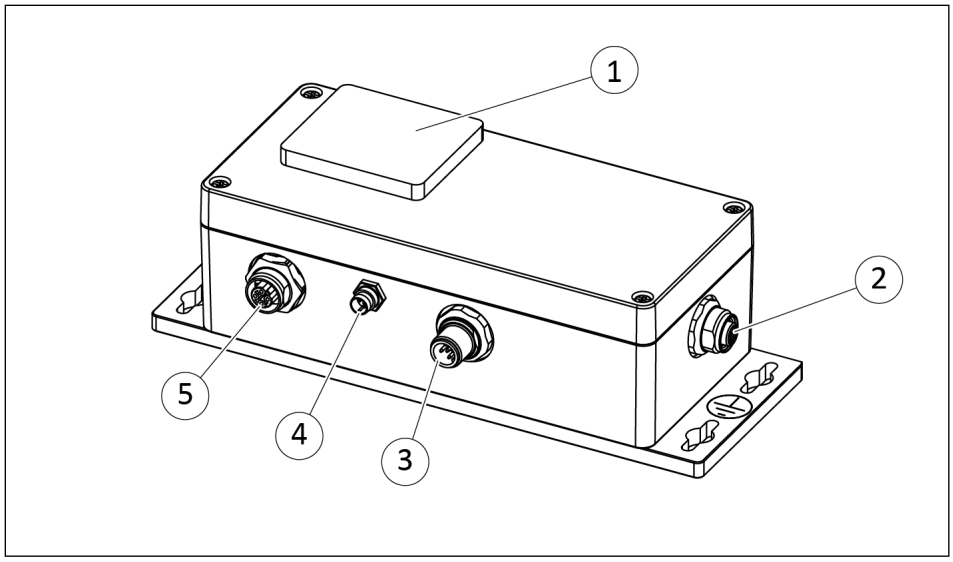


Sensor cables

1	Force/torque sensor connection
2	NetBox connection

NetBox (NETB)

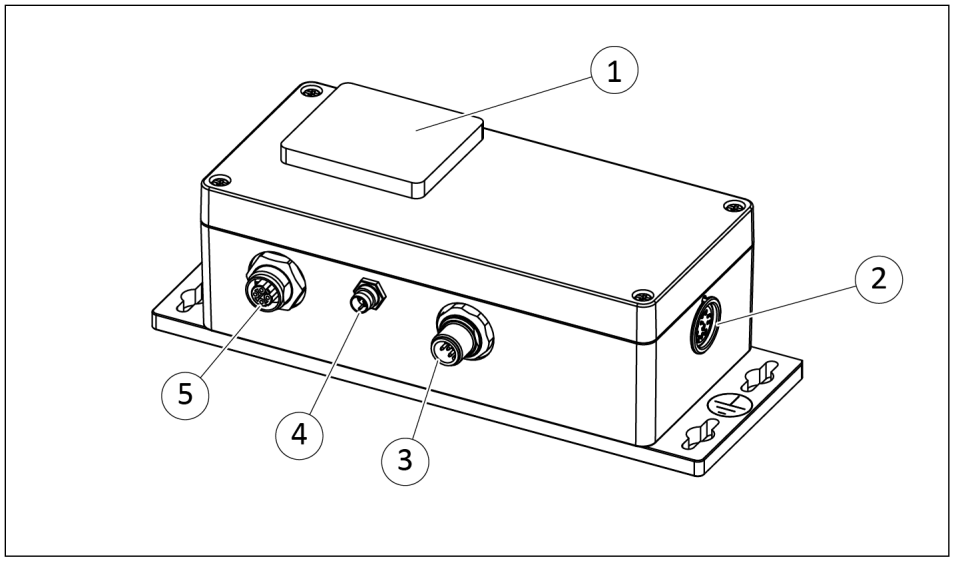
for Gamma and higher (sensors with integrated electronics)



1	DIP switch and status display
2	Sensor cable connection
3	CAN bus connection/external power supply unit
4	Relay output for threshold monitoring
5	EtherNet/IP connection

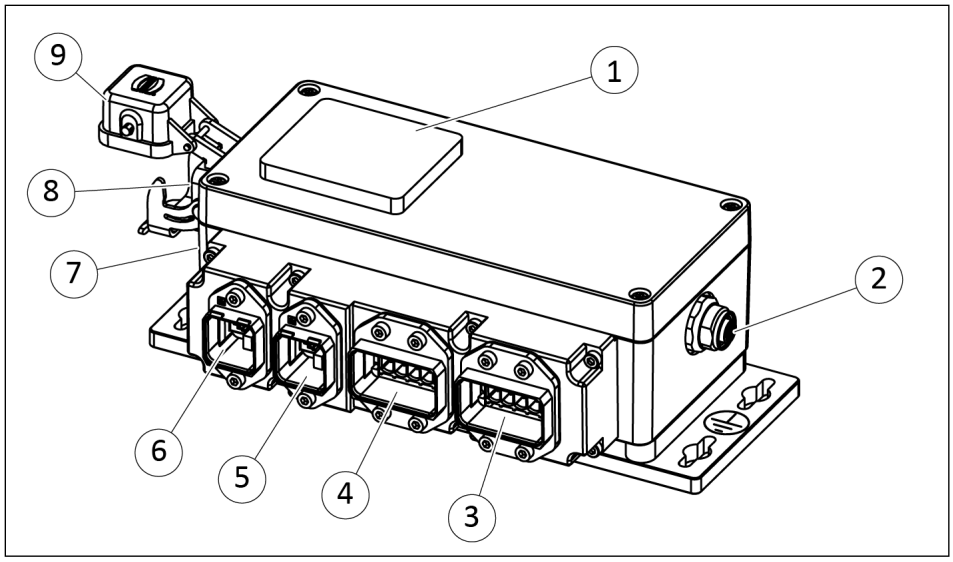
NetBox (NETBA)

for Nano and Mini (sensors without integrated electronics)



1	DIP switch and status display
2	Sensor cable connection
3	CAN bus connection/external power supply unit
4	Relay output for threshold monitoring
5	EtherNet/IP connection

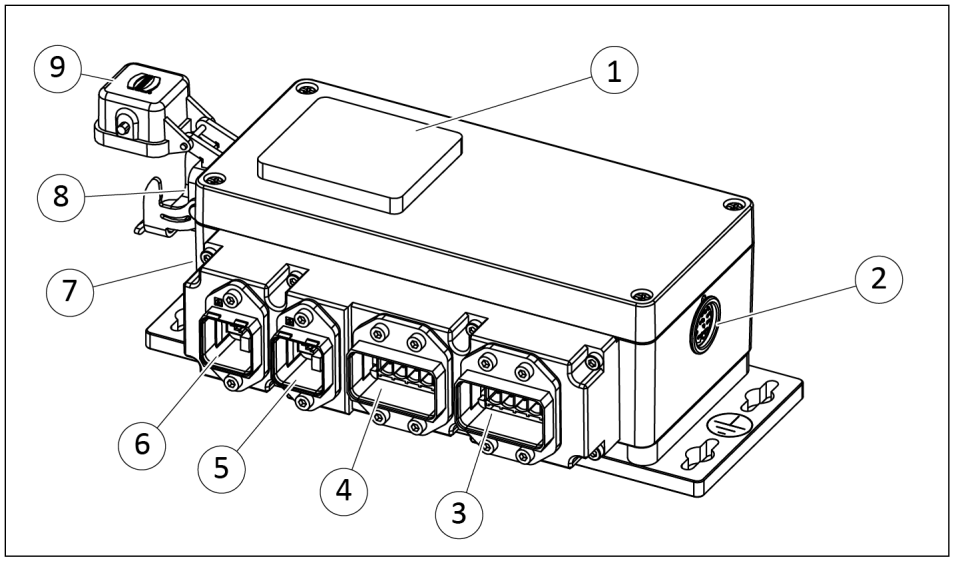
NetBox (NETB-PN2) for Gamma and higher (sensors with integrated electronics)



1	DIP switch and status display
2	Sensor cable connection
3	Voltage supply OUT connection
4	Voltage supply IN connection
5	EtherNet OUT connection
6	EtherNet IN connection
7	Relay output for threshold monitoring
8	Service port RJ45 connection
9	Self-closing cap (IP67 protected)

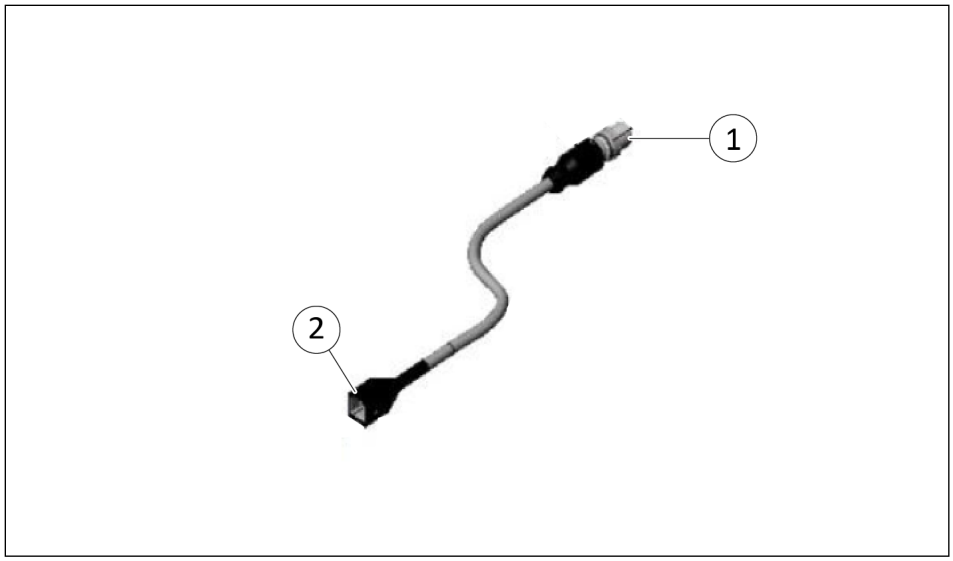
NetBox (NETBA-PN2)

for Nano and Mini (sensors without integrated electronics)



1	DIP switch and status display
2	Sensor cable connection
3	Voltage supply OUT connection
4	Voltage supply IN connection
5	EtherNet OUT connection
6	EtherNet IN connection
7	Relay output for threshold monitoring
8	Service port RJ45 connection
9	Self-closing cap (IP67 protected)

Adapter cable from M12 socket on NetBox to RJ45 socket



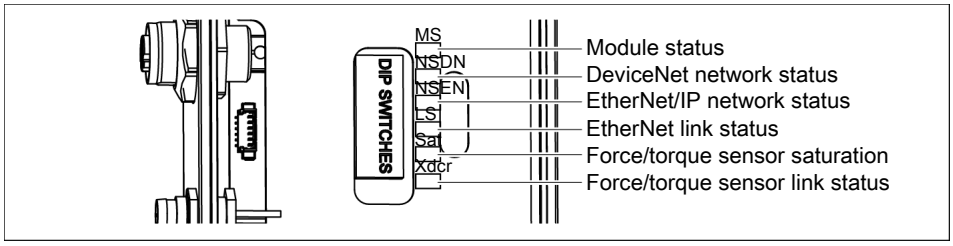
1	M12 connector (type D), connection to EtherNet/IP switch
2	RJ45 connector, connection to adapter cable

4.2 Description

The force/torque sensor is connected to the system via EtherNet/IP or DeviceNet (optional PROFINET). The web browser interface makes it easy to configure and set the force/torque sensor.

4.3 Status LEDs

Standard NetBox

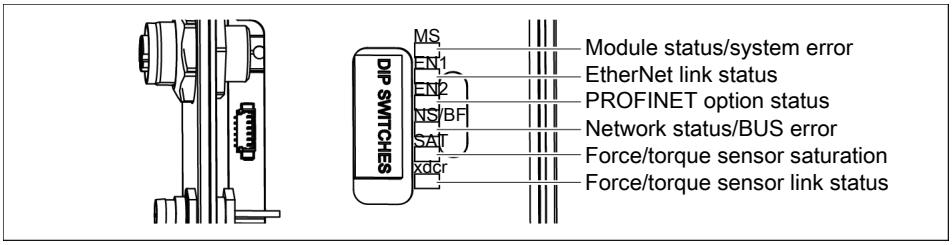


Status LEDs on the standard NetBox

Function	Designation	Status	Description
Module status	MS	Off	No voltage supply connected.
		Green	Normal operation.
		Flashes red	The NetBox was configured incorrectly or inconsistently.
DeviceNet network status	NS DN	Off	MAC ID used twice, DeviceNET protocol not selected or no voltage supply connected.
		Flashes green	No DeviceNet connection available.
		Green	DeviceNet connected.
		Flashes red	Timeout on DeviceNet I/O connection
EtherNet/IP network status	NS EN	Off	No voltage supply connected. EtherNet/IP is disabled or no IP address is assigned.
		Flashes green	The IP address is assigned but there is no connection to the EtherNet/IP.
		Green	The EtherNet/IP connection has been established.
		Flashes red	Timeout on EtherNet/IP connection.
EtherNet link status	LS EN	Off	No voltage supply connected or no link.
		Green	Link available.
		Yellow	Connection disabled.

Function	Designation	Status	Description
		Flashes green	Connection available.
		Flashes yellow	EtherNet data collision
		Red	N/A
Force/torque sensor saturation	Sat	Off	No voltage supply connected or the force applied is appropriate.
		Red	Force/torque sensor is subject to a load or signal that is outside the range of measurement. The output values are invalid.
Force/torque sensor link status	Xdcr	Green	The data acquisition system works perfectly.
		Red	There is an error in the data acquisition system or a restart is being performed.

NetBox with PROFINET



Status LEDs on the NetBox with PROFINET option

Function	Designation	Status	Description
Module status	MS	Off	No voltage supply connected.
		Green	Normal operation.
		Flashes red	The NetBox was configured incorrectly or inconsistently.
EtherNet link status	EN 1	Off	No voltage supply connected or no link.
		Green	Link available.
		Flashes green	Connection available.
PROFINET option status	EN 2	Off	PROFINET disabled or no voltage supply connected.
		Green	PROFINET connection available.
		Flashes yellow	PROFINET is working.
		Yellow	
Network status/BUS error	NS/BF Yellow	The NS/BF LED always only indicates the status of the bus connection with the highest priority. The prioritization is as follows: • PROFINET • EtherNet/IP • DeviceNet	
		Off	• **PROFINET**: Network connected or no voltage supply connected. • **EtherNet/IP**: No IP address assigned, network disabled or no voltage supply connected.

Function	Designation	Status	Description
			• **DeviceNet**: MAC ID used twice, DeviceNET protocol not selected or no voltage supply connected.
		Green	• **PROFINET**: N/A • **EtherNet/IP**: Connected to network • **DeviceNet**: DeviceNet Master connected
		Flashes green	• **PROFINET**: N/A • **EtherNet/IP**: IP address assigned, but no network connection available • **DeviceNet**: No network connection
		Red	• **PROFINET**: Duplicate IP address found • **EtherNet/IP**: Duplicate IP address found or EtherNet/IP network • **DeviceNet**: Network error
		Flashes red	Timeout on connections
Force/torque sensor saturation	Sat	Off	No voltage supply connected or the force applied is appropriate.
		Red	Force/torque sensor is subject to a load or signal that is outside the range of measurement. The output values are invalid.
Force/torque sensor link status	Xdcr	Green	The data acquisition system works perfectly.
		Red	There is an error in the data acquisition system or a restart is being performed.

5 Assembly and settings

5.1 Installing and connecting

⚠ DANGER

Danger from electric voltage!

Touching live parts may result in death.

- Switch off the power supply before any assembly, adjustment or maintenance work and secure against being switched on again.
- Only qualified electricians may perform electrical installations.
- Check if de-energized, ground it and hot-wire.
- Cover live parts.

CAUTION

Risk of damage to the electronics!

A faulty connection can cause damage to the internal electronics.

- The supply network must be a network of type "PELV" for power and logic.
- Observe the PIN assignment of the connecting terminals.
- Make sure that all components are grounded correctly.

1. Connect components of the force-torque sensor system with each other, ▸ 5.2 [🗋 20].
2. Optional: Install the software, ▸ 5.3 [🗋 31].
3. Check for functionality.
4. Mount the force-torque sensor on the robot, see the installation and operating instructions for the sensor.

5.2 Electrical connection

Type of voltage supply **	Min. voltage [V]	Min. voltage [V]	Max. energy consumption
Power over EtherNet ***	36	57	6
Pwr/CAN	11	25	6

*Tab.: Power supply requirements **

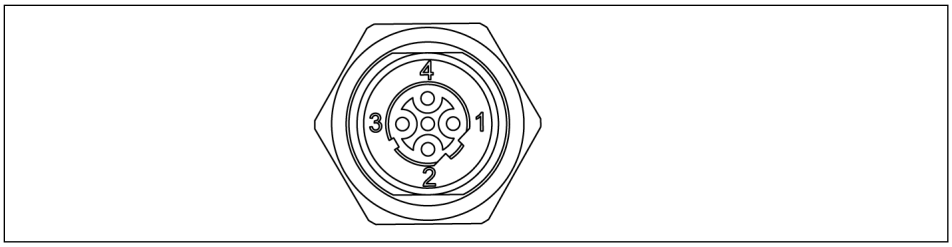
* The FT Gamma and its integrated electronics consumes 2.4 W of system power. Other FT sensors consume less power.

** Power is drawn from only one power source at a time.

*** Complies with IEEE 802.3af, Class 0, supplied with power via data lines. Uses Mode A to receive power. Mode B is not supported.

EtherNet/IP

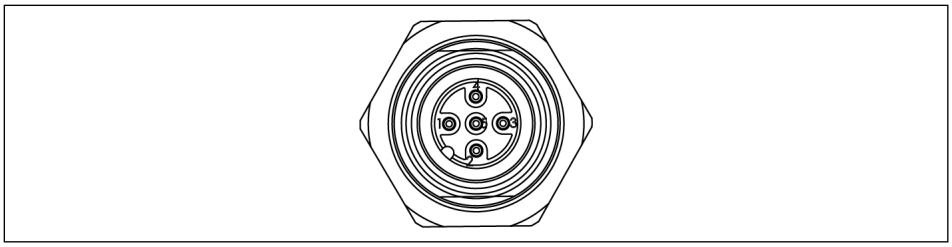
EtherNet/IP cable connections to NetBox



EtherNet/IP M12 D-Coded, 4-pin socket on the NetBox

Pin	Signal
1	TX+
2	RX+
3	TX-
4	RX-

Pwr/CAN voltage supply connection on NetBox



Pwr/CAN M12 5-pin socket on the NetBox for voltage supply connection

Pin	Signal
1	Drain
2	V+ *
3	V- *
4	CAN_H
5	CAN_L

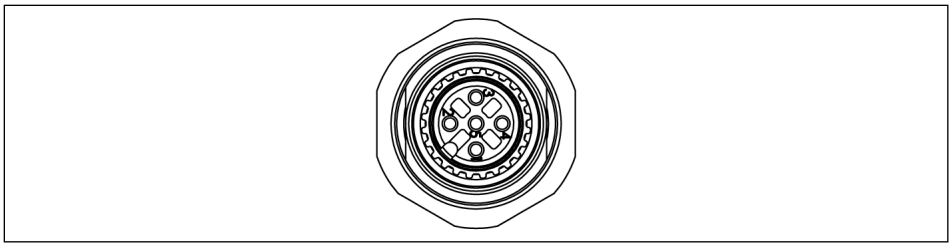
* VDC, 11 V to 25 V, 6 W

Sensor cable connection on NetBox

Normally the NetBox is connected to the FT sensor via a DeviceNet standard cable set. In cases where this type of cable set cannot be used, observe the following:

- The cable specifications for DeviceNet thick wiring are ideal.
- The RS485+ and RS485- cables must form a twisted pair.
- Cable capacities should be low enough to operate with 1.25 Mbps.
- The total resistance of the individual conductors should not exceed 0.5 Ω.

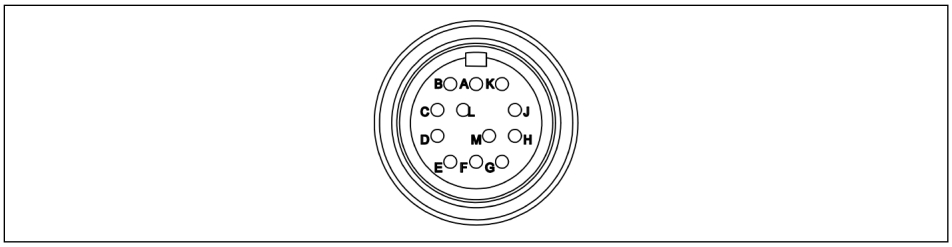
NetBox (NETB)



Socket on the NetBox for sensor cable connection, M12 5-pin

Pin	Signal
1	Drain
2	V+
3	V-
4	RS485+
5	RS485-

NetBox (NETBA)



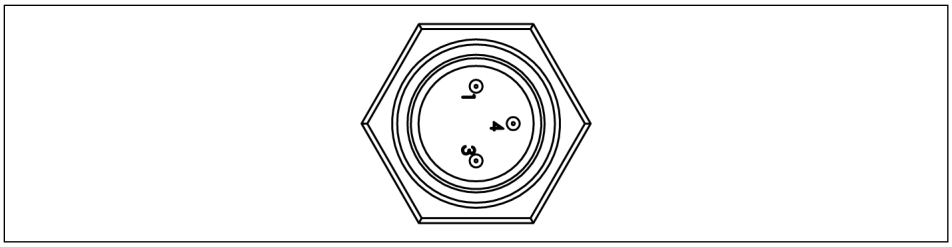
Socket on the NetBox (BA) for sensor cable connection, circular

Pin	Signal
A	-
B	G4
C	G5
D	G2
E	G3
F	G0
G	G1
H	-
J	-VSG
K	+VSG
L	-
M	-

Relay output for threshold monitoring

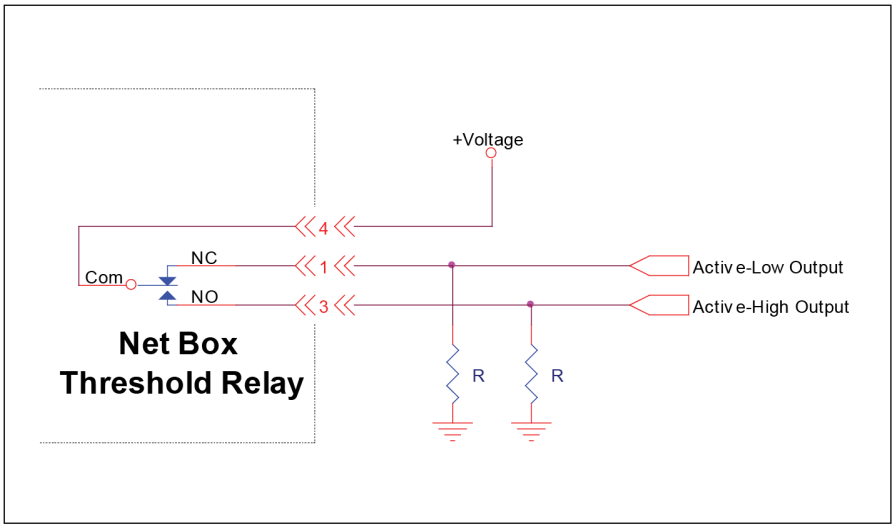
The standard threshold relay contacts (NC, NO or COM) are protected against overload by a resettable fuse. The relay switches on within 6 ms.

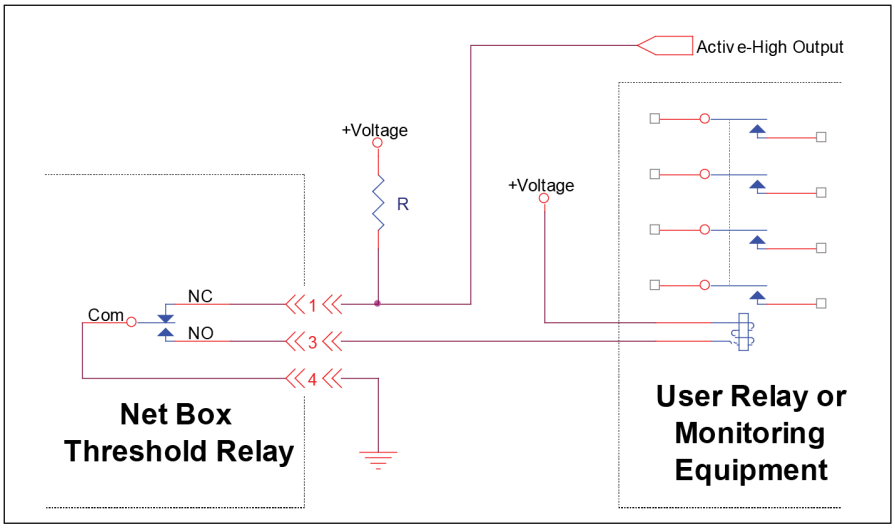
	Max. nominal power	Max. load
Current strength	50 mA	10 µA
Voltage	42 VDC, 30 VAC	10 mVDC



Connector on NetBox for relay output, M8 3-pin

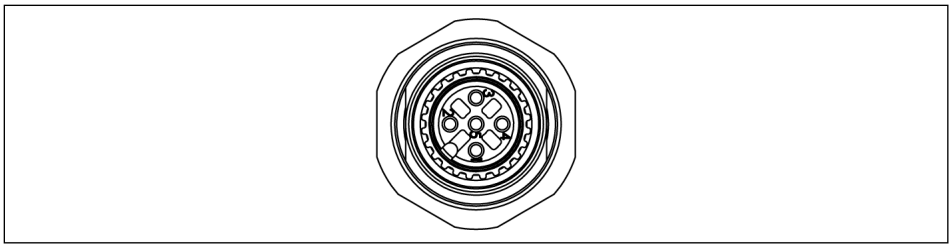
Pin	EtherNet/IP™	
	Name	Description
1	NO	Normally open contact
3	NC	Normally closed contact
4	Com	Common





PROFINET

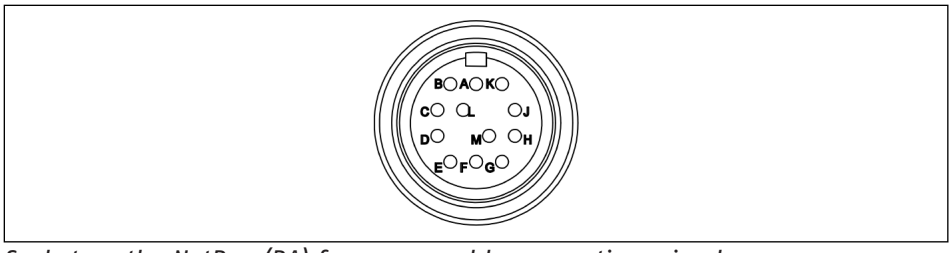
NetBox (NETB-PN2)



Socket on the NetBox for sensor cable connection, M12 5-pin

Pin	Signal
1	Drain
2	V+
3	V-
4	CAN_H
5	CAN_L

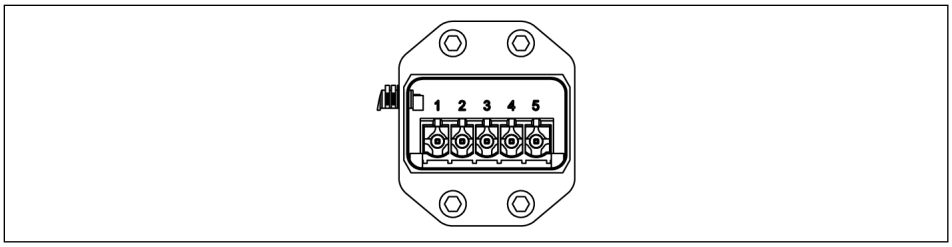
NetBox (NETBA)



Socket on the NetBox (BA) for sensor cable connection, circular

Pin	Signal
A	-
B	G4
C	G5
D	G2
E	G3
F	G0
G	G1
H	-
J	-VSG
K	+VSG
L	-
M	-

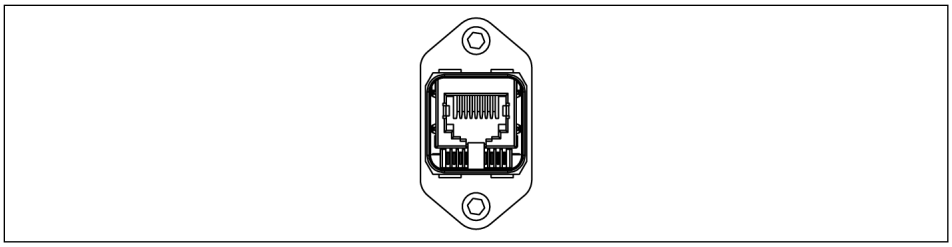
Voltage supply IN/OUT connection



Phoenix Contact 5-pin socket

Pin	Signal
1	US1+ (L1)
2	US1- (N1)
3	US2+ (L2)
4	US2- (N2)
5	FE

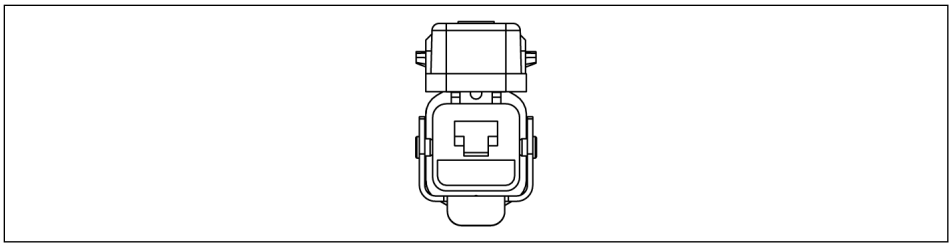
EtherNet IN/OUT connection



Phoenix Contact RJ45 socket

Pin	Signal
1	RX1+
2	RX1-
3	TX+
4	RJ45_4
5	RJ45_5
6	TX1-
7	RJ45_7
8	RJ45_8

Service port RJ45 connection



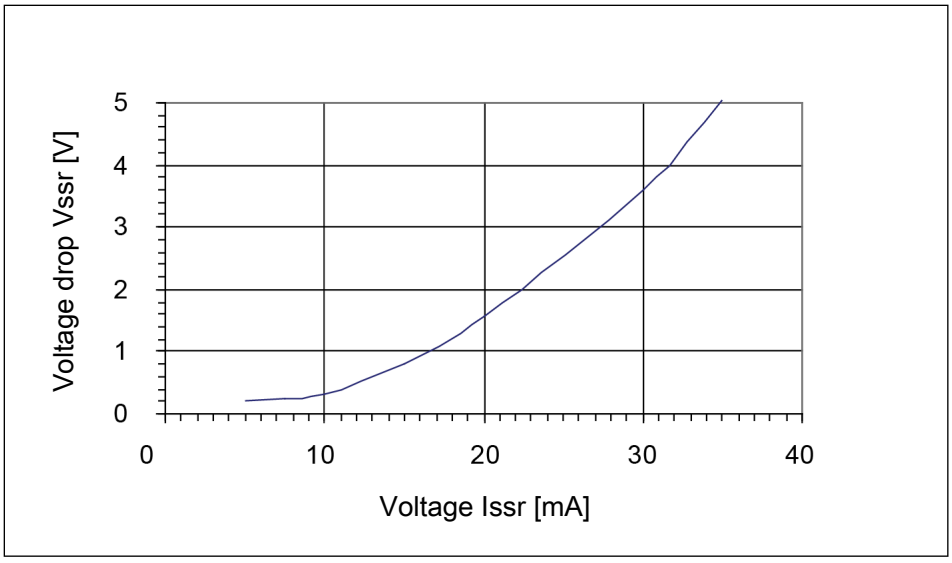
Harting service port RJ45 connection

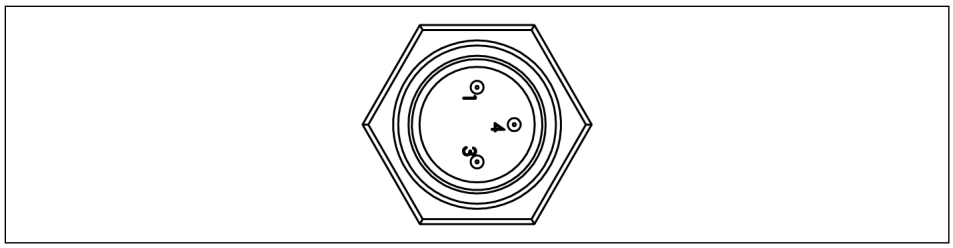
Pin	Signal
1	RX1+
2	RX1–
3	TX+
4	RJ45_4
5	RJ45_5
6	TX1–
7	RJ45_7
8	RJ45_8

Relay output for threshold monitoring

The optional semiconductor threshold relay contacts (SSR+ and SSR–) are protected against reverse voltage by a Zener diode. The relay switches on within 500 µs.

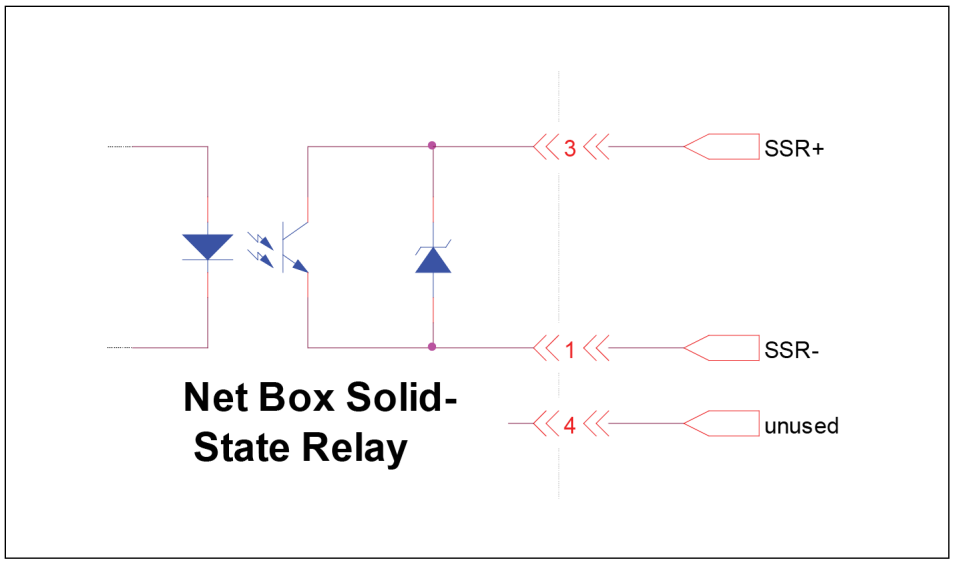
	Max. load
Current strength [mA]	35
Voltage [VDC]	30

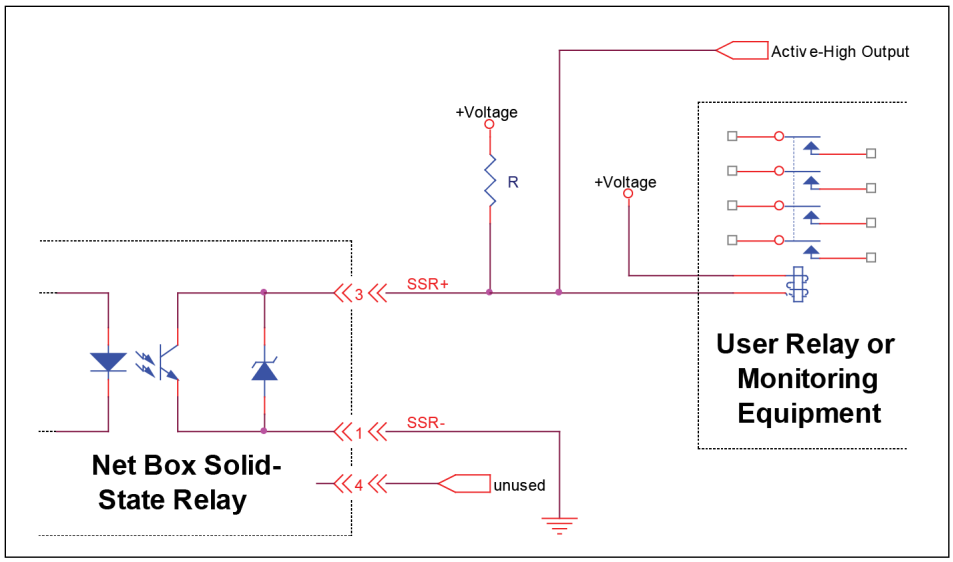




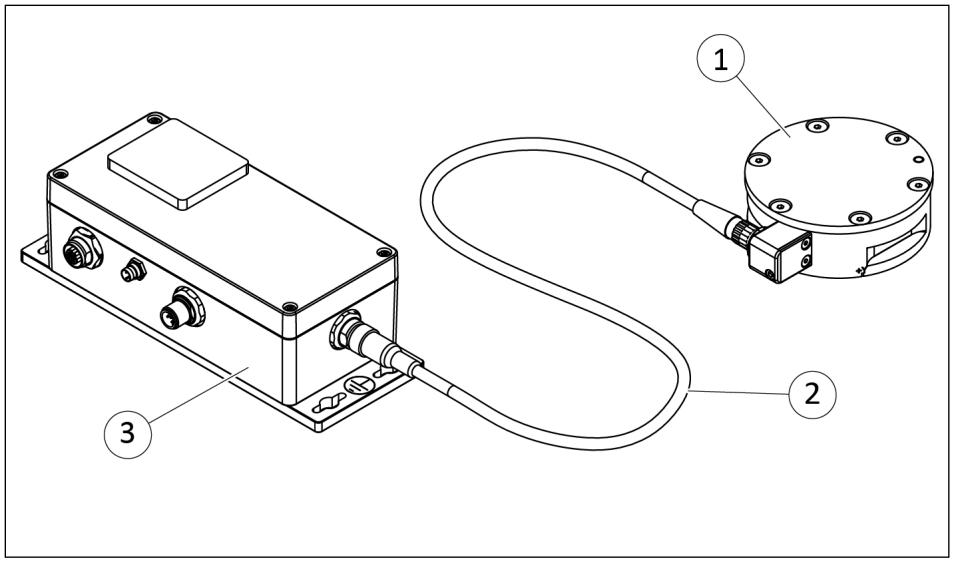
Socket on NetBox for relay output, M8 3-pin

Pin	PROFINET	
	Name	Description
1	SSR-	Solid-state relay, negative connection
3	SSR+	Solid-state relay, positive connection
4	-	not occupied





5.2.1 Connecting the force/torque sensor



Connecting the force/torque sensor (FT from Gamma and higher shown as an example) with NetBox (NETB)

1. Connect the supplied sensor cable (2) with the M12 connector to the force/torque sensor (1).
2. Connect the supplied sensor cable (2) to the M12 socket on the NetBox (3) and screw on tight.
   - ⇨ Max. tightening torque for NetBox (NETB): 3 Nm
   - ⇨ Max. tightening torque for NetBox (NETBA): 0.7 Nm

5.2.2 Voltage supply

The voltage supply for the NetBox can be established via PoE or with an external power supply unit.

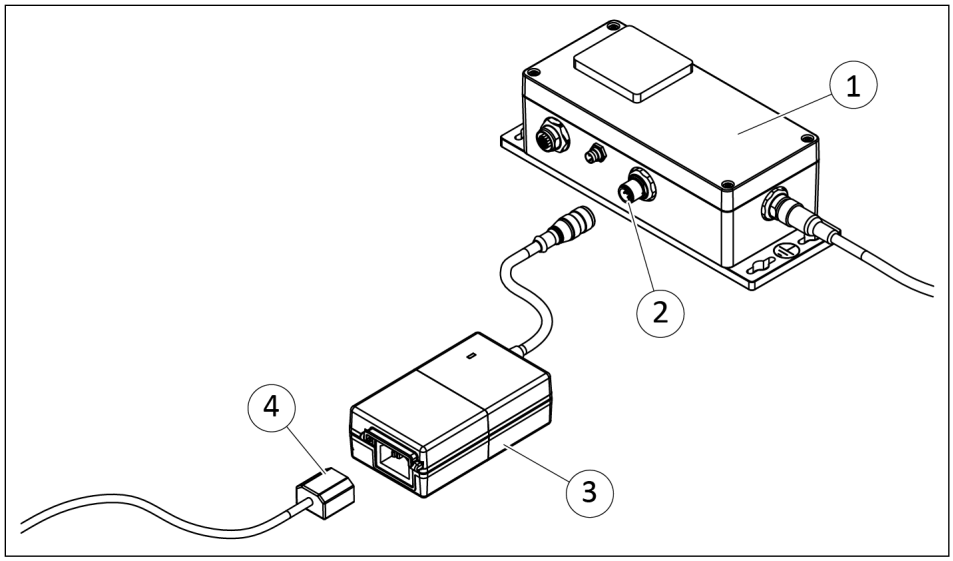
Power over EtherNet (PoE)

NOTE

The PoE interface is compatible with the IEEE 802.3af PoE specification and uses Mode A for the voltage supply. 8 EtherNet cables are required for Mode B. It is for this reason that Mode B is not supported. The Power over EtherNet voltage supply cannot be used for the PROFINET variant.

Establish Power over EtherNet (PoE) voltage supply for EtherNet connection, ▸ 5.2.3 [🗋 29].

Pwr/CAN socket with external power supply unit



Voltage supply with external power supply unit

- The force/torque sensor was connected to the NetBox.

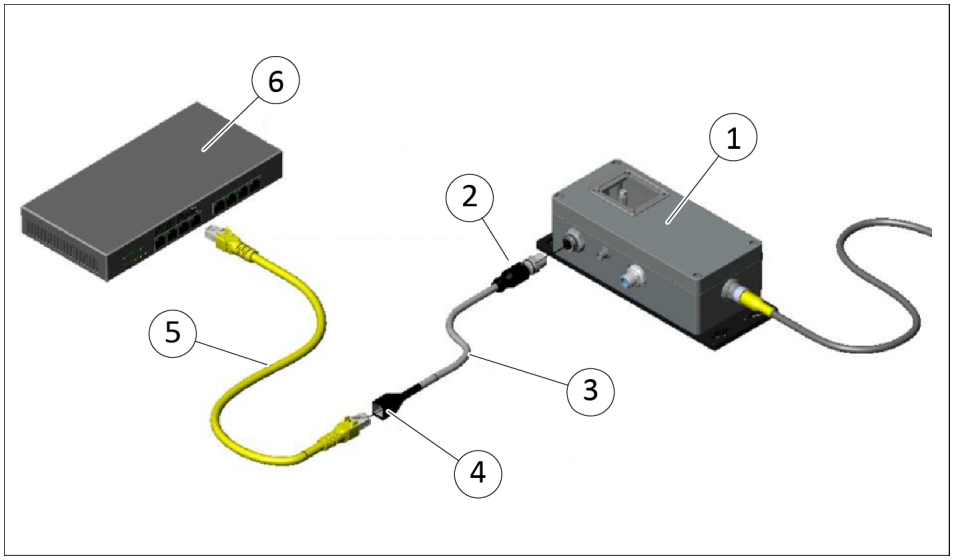
1. Connect the external power supply unit (3) to the M12 socket (2) on the NetBox (1) and screw it tight.
   ⇨ Max. tightening torque: 3 Nm
2. Connect the power cable (4) to the power supply unit (3).

5.2.3 Establishing an EtherNet/IP connection

NOTE

For the best possible performance, SCHUNK recommends a point-to-point EtherNet connection.

EtherNet connection with EtherNet switch

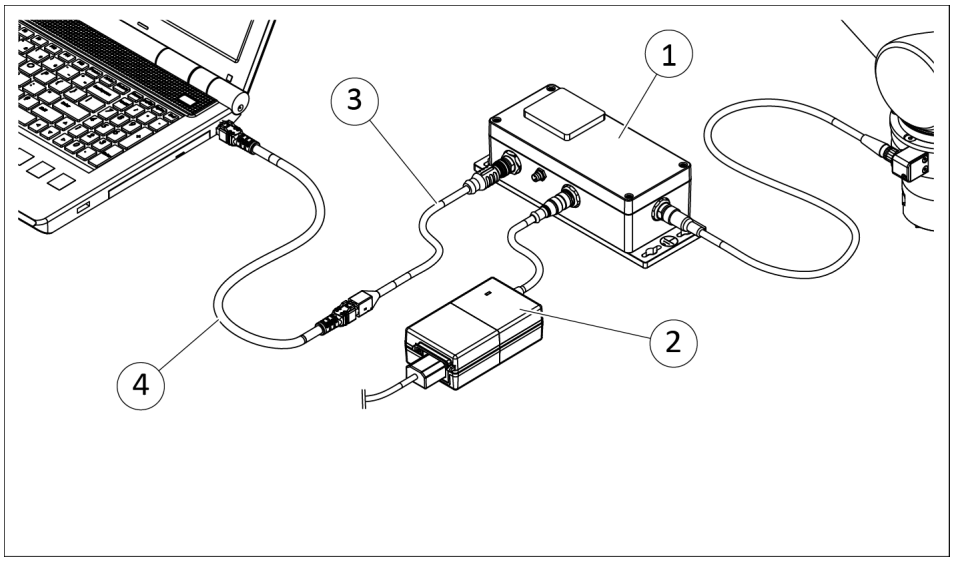


Voltage supply via PoE

- The force/torque sensor was connected to the NetBox.

1. Connect the EtherNet switch (6) to the AC voltage supply. Any EtherNet switch that supports PoE can be used.
   ⇨ The Power LED on the EtherNet switch (6) lights up green.
2. Connect the EtherNet switch (6) to the EtherNet network.
3. Connect the adapter cable (3) with the M12 connector (2) to the NetBox (1).
4. Connect the RJ45 EtherNet cable (5) with RJ45 connector (4) to the adapter cable.
5. Connect the RJ45 EtherNet cable (5) to a PoE port on the EtherNet switch (6).
   ⇨ The LEDs on the NetBox flash red and green for approx. 20 seconds, then all LEDs light up green.

Point-to-point EtherNet connection



- The force/torque sensor was connected to the NetBox.
- The voltage supply of the NetBox via the external power supply unit (2) has been established.
- The computer must be connected to the EtherNet network.

1. Connect the adapter cable (3) with the M12 connector to the NetBox (1).
2. Connect the RJ45 EtherNet cable (4) with RJ45 connector to the adapter cable (3).
3. Connect the RJ45 EtherNet cable (5) to the LAN port on the computer.
   - ⇨ **Standard NetBox only**: All status LEDs flash green once and red once in the following order: MS, NS DN, NS EN, LS EN, Sat, Xdcr.
   - ⇨ **PROFINET NetBox only**: All status LEDs flash green once and red once in the following order: MS, EN1, NS/BF, Sat, Xdcr. The LED EN2 does not flash.
   - ⇨ The Xdcr LED lights up red, the MS LED flashes red. The LS EN LED flashes green as soon as the NetBox is connected to the EtherNet network.
   - ⇨ Approximately 20 seconds later, the MS and Xdcr LEDs will light up green. The force/torque sensor system is now ready for operation. Check the system in the event of deviating behavior, ▸ 6 [🗋 90].

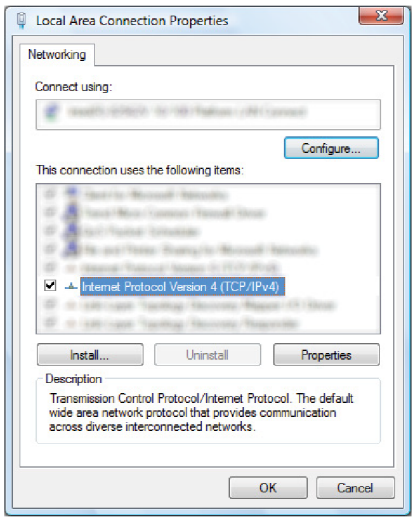
5.3 Start-up

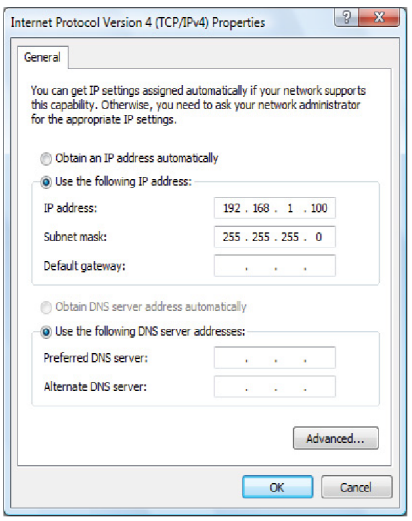
5.3.1 Initial setup of PC network settings

NOTE

Before performing EtherNet configuration via the web browser interface, configure the initial network settings on the PC once only. SCHUNK recommends the use of a dedicated computer for the connected NetBox so that the network settings can remain set permanently.

1. Disconnect the EtherNet cable from the LAN port on the computer.
2. In the computer settings under "Network & Internet" open the "Local Area Connection Properties".



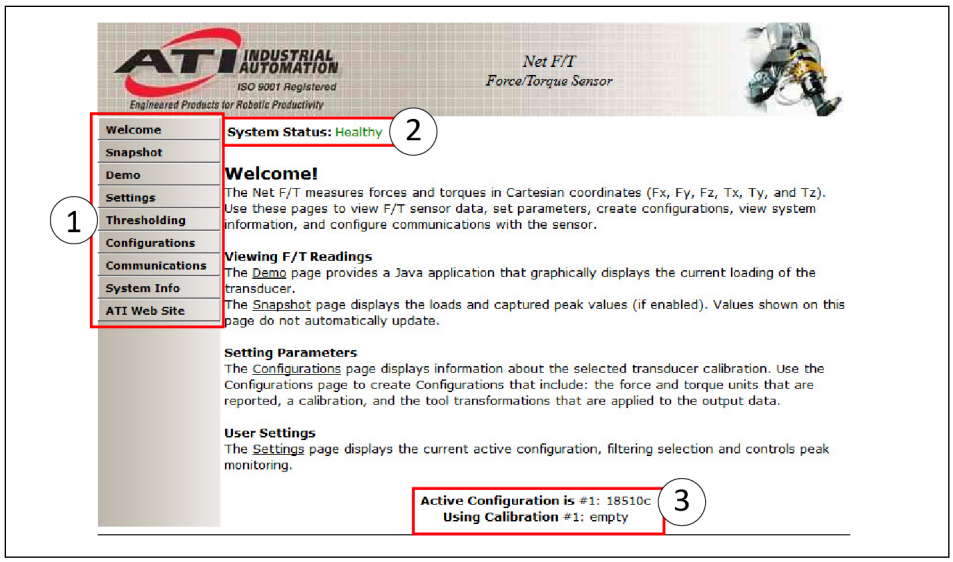


3. Click "Internet Protocol Version 4 (TCP/IPv4)" and click "Properties".
4. Select the "Use the following IP address" option.
5. Enter 192.168.1.100 in the "IP address" field. Enter 255.255.255.0 in the "Subnet mask" field.
6. Click "OK" and close the computer settings.
7. Connect the EtherNet cable to the LAN port on the computer.
   ⇨ The computer recognizes the connection.

5.3.2 Web browser interface

The web browser interface provides all configuration options for the FTN force/torque sensor system. Enter the IP address of the sensor system in the web browser. The Welcome Page (index.htm) opens.

Welcome Page

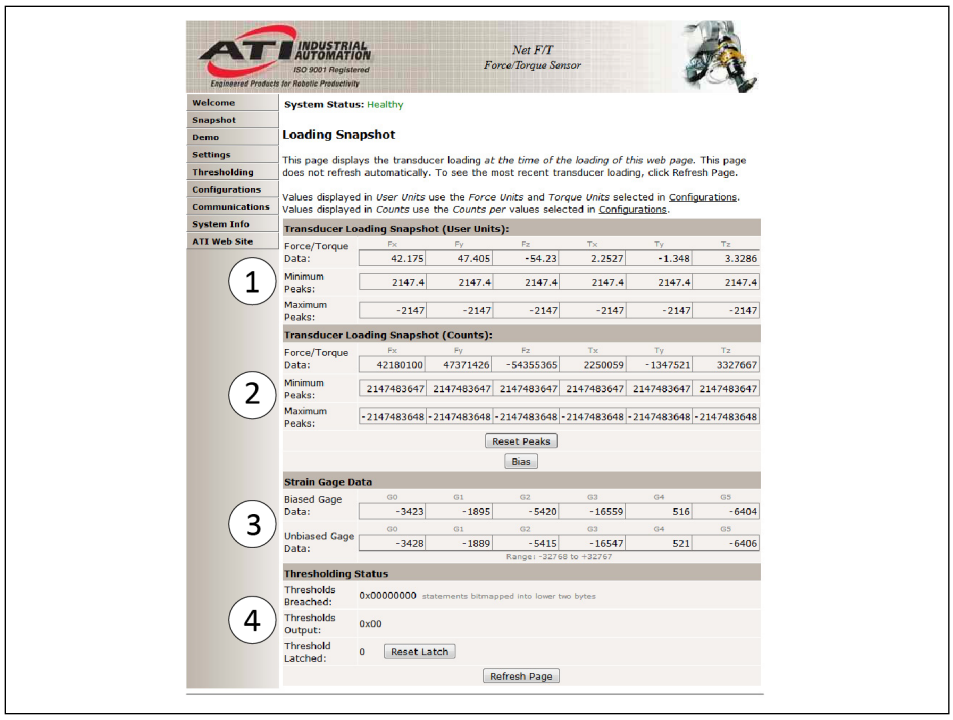


Welcome Page of the web browser interface

1. Open various subtopics via the navigation bar on the left (1).
   ⇨ The status (2) of the FTN force/torque sensor system is shown at the top of the page. It always shows the status at the time the page was opened.
2. Refresh the page to display the current status.
   ⇨ The current configuration and the calibration (3) used are displayed at the bottom of the page.

Snapshot

1. Enable "Peak monitoring" on the setting page to see the current load on the force/torque sensor and the maximum and minimum peaks on the Snapshot page.
   ⇨ The threshold monitoring is displayed in the lower area.
2. The values are static. Refresh the page to display the current values.

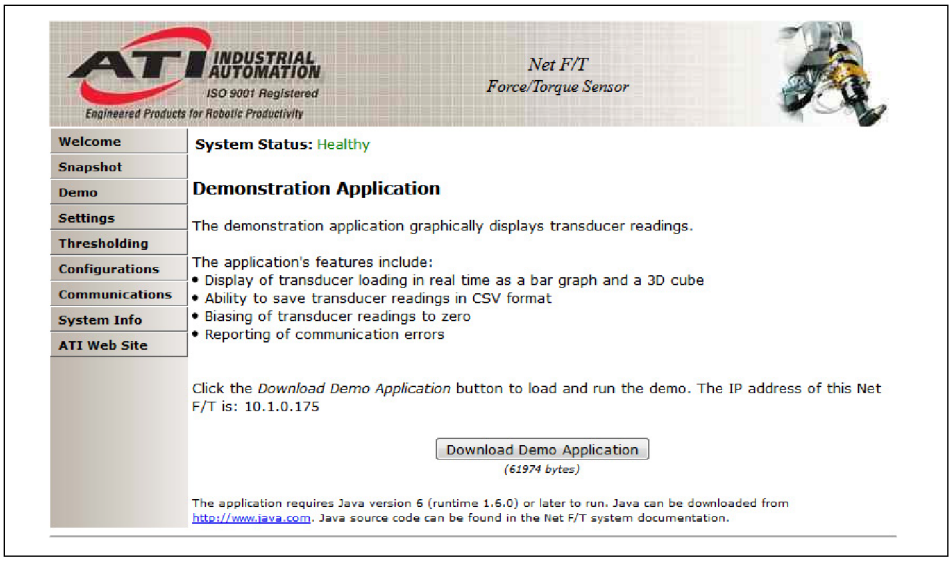


Item	Field	Description
1	Force/Torque Data	Displays the force and torque data in the units selected on the Configuration page. When strain gages are saturated, these values are invalid and are displayed in red and crossed out.
	Minimum Peaks	Displays the minimum peaks in the units selected on the Configuration page.
	Maximum Peaks	Displays the maximum peaks in the units selected on the Configuration page.
2	Force/Torque Data	Displays the force and torque data scaled with the "Counts per force" and "Counts per torque" values displayed on the configuration page. When strain gages are saturated, these values are invalid and are displayed in red and crossed out.
	Minimum Peaks	Displays the minimum peaks scaled with the "Counts per force" and "Counts per torque" values displayed on the configuration page.

Item	Field	Description
	Maximum Peaks	Displays the maximum peaks scaled with the "Counts per force" and "Counts per torque" values displayed on the configuration page.
	Reset Peaks	This button resets the captured peaks and refreshes the Snapshot page.
	Bias button	This button resets the captured force and torque values and refreshes the Snapshot page. The current load is set as the new zero point. The bias can be reversed by setting all values for "Software Bias Vector" on the settings page to zero.
3	Biased Gage Data	Displays the strain gages minus the "Software Bias Vector".
	Unbiased Gage Data	Displays strain gage raw data for easy troubleshooting. Saturated values are displayed in red.**IMPORTANT! The measured values of the FT sensor on this page are captured when the page requests them. It is possible that the measured values at the bottom of the page are from later FT datasets than the values at the top. The displayed values are invalid in the event of saturation errors. The individual strain gage values do not correspond to the individual force and torque axes.**
4	Thresholds Breached	Indicates which threshold conditions are or were true since the last execution of the "Reset Latch" function. Each bit in the lower two bytes of this hexadecimal number represents a threshold statement. The list shows the bit pattern that each threshold statement number represents. • 0: 0x00000001 • 1: 0x00000002 • 2: 0x00000004 • 3: 0x00000008 • 4: 0x00000010 • 5: 0x00000020 • 6: 0x00000040 • 7: 0x00000080 • 8: 0x00000100 • 9: 0x00000200

Item	Field	Description
		• 10: 0x00000400 • 11: 0x00000800 • 12: 0x00001000 • 13: 0x00002000 • 14: 0x00004000 • 15: 0x00008000 The value "Thresholds Breached" is the result of linking the bit patterns for all true statements together. The "Threshold Breached" value is reset to zero by the Reset Latch function.
4	Thresholds Output	Displays the output value of the thresholds determined by bitwise OR-ing of the output codes of all true threshold statements.
	Thresholds Latched	Indicates "1" when threshold conditions are or were met. The "Thresholds Latched" value is set to zero by clicking the "Reset Latch" button.
	Reset latch	The button resets the value for "Thresholds Latched" and refreshes the Snapshot page. If no threshold conditions are met, the "Thresholds Breached", "Thresholds Output", and "Thresholds Latched" values are set to zero and the system status "Threshold Level Latched condition is cleared" is displayed.
	Refresh Page	The button refreshes the Snapshot page and the values are updated. This button is equivalent to using the "Reload" or "Refresh" command in the browser.

Demonstration application

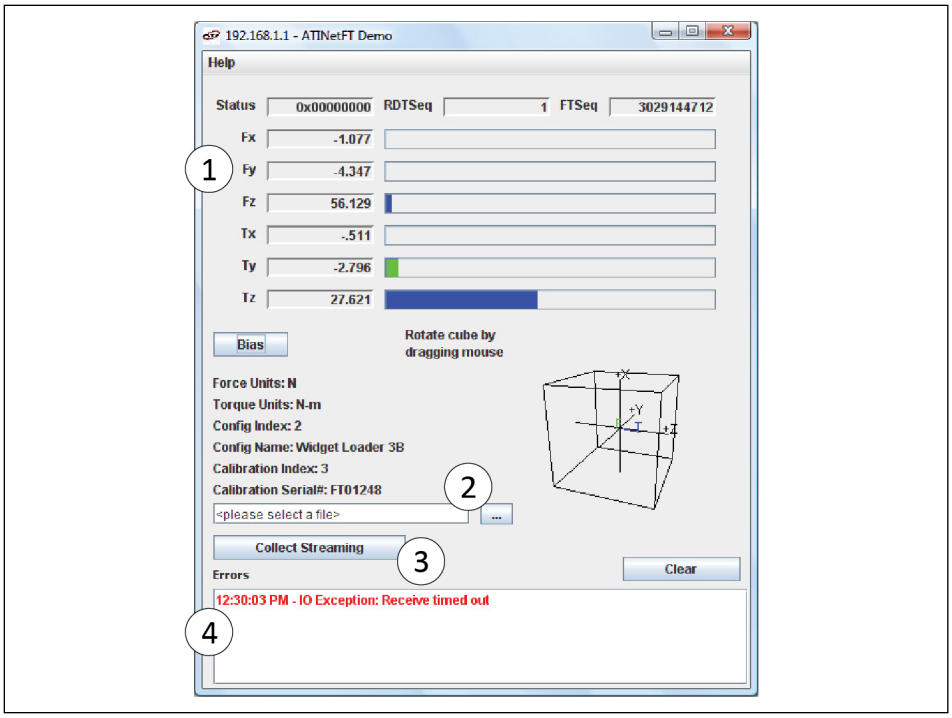


NOTE

Instead of the demo application, you can also write your own Java application. All necessary files and source codes can be downloaded from a**ti-ia.com/Products/ft/software/net_ft_software.aspx**.

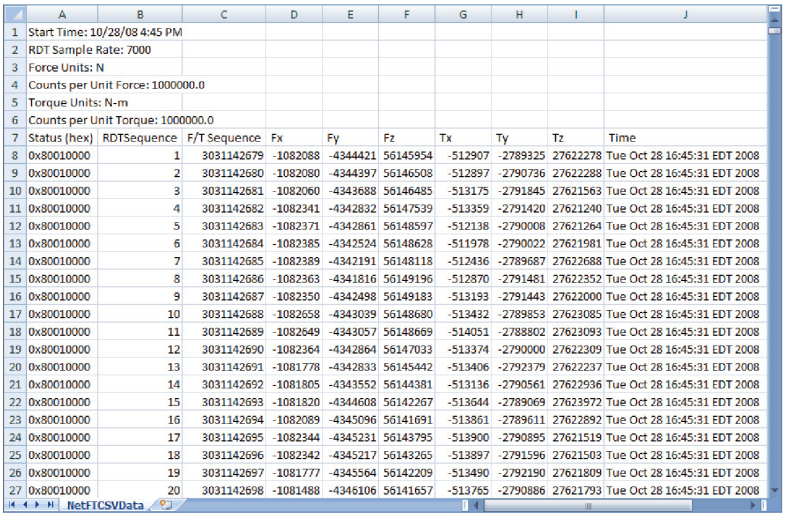
- A Java version 6.0 or higher is installed on the connected computer.

1. Click on the "Download Demo Application" button to download the Java demo application.
   ⇨ A window opens.
2. Enter the IP address of the NetBox and confirm with "OK". The IP address is located above the "Download Demo Application" button on the demo page and can be looked up there "Download Demo Application".
   ⇨ The Java Demo Application opens.



⇨ The currently collected data are displayed in the upper area (1).

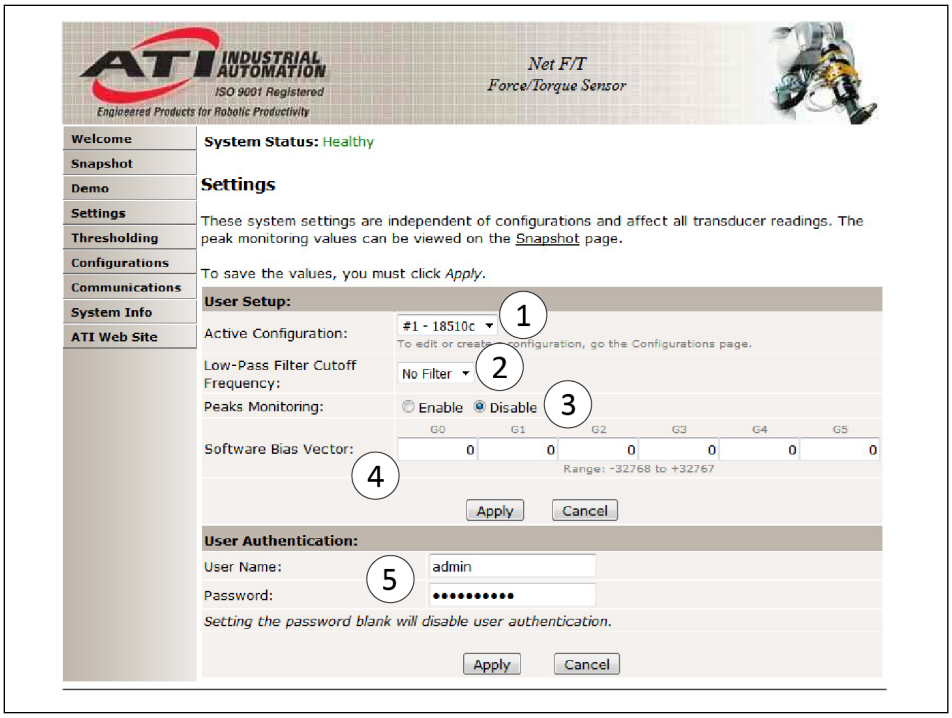
3. Click the "..." (2) button and select the path for saving the CSV evaluation file.
4. Click the "Start Collecting" (3) button.
   ⇨ The application collects the force/torque sensor system data and stores them in the CSV file separated with commas.
   ⇨ If an error occurs, it is listed in the error list (4).
5. Click the "Stop Collecting" (3) button to stop the data transfer.
6. Open CSV file.



	A	B	C	D	E	F	G	H	I	J
1	Start Time: 10/28/08 4:45 PM									
2	RDT Sample Rate: 7000									
3	Force Units: N									
4	Counts per Unit Force: 1000000.0									
5	Torque Units: N-m									
6	Counts per Unit Torque: 1000000.0									
7	Status (hex)	RDTSequence	F/T Sequence	Fx	Fy	Fz	Tx	Ty	Tz	Time
8	0x80010000	1	3031142679	-1082088	-4344421	56145954	-512907	-2789325	27622278	Tue Oct 28 16:45:31 EDT 2008
9	0x80010000	2	3031142680	-1082080	-4344397	56146508	-512897	-2790736	27622288	Tue Oct 28 16:45:31 EDT 2008
10	0x80010000	3	3031142681	-1082060	-4343688	56146485	-513175	-2791845	27621563	Tue Oct 28 16:45:31 EDT 2008
11	0x80010000	4	3031142682	-1082341	-4342832	56147539	-513359	-2791420	27621240	Tue Oct 28 16:45:31 EDT 2008
12	0x80010000	5	3031142683	-1082371	-4342861	56148597	-512138	-2790008	27621264	Tue Oct 28 16:45:31 EDT 2008
13	0x80010000	6	3031142684	-1082385	-4342524	56148628	-511978	-2790022	27621981	Tue Oct 28 16:45:31 EDT 2008
14	0x80010000	7	3031142685	-1082389	-4342191	56148118	-512436	-2789687	27622688	Tue Oct 28 16:45:31 EDT 2008
15	0x80010000	8	3031142686	-1082363	-4341816	56149196	-512870	-2791481	27622352	Tue Oct 28 16:45:31 EDT 2008
16	0x80010000	9	3031142687	-1082350	-4342498	56149183	-513193	-2791443	27622000	Tue Oct 28 16:45:31 EDT 2008
17	0x80010000	10	3031142688	-1082658	-4343039	56148680	-513432	-2789853	27623085	Tue Oct 28 16:45:31 EDT 2008
18	0x80010000	11	3031142689	-1082649	-4343057	56148669	-514051	-2788802	27623093	Tue Oct 28 16:45:31 EDT 2008
19	0x80010000	12	3031142690	-1082364	-4342864	56147033	-513374	-2790000	27622309	Tue Oct 28 16:45:31 EDT 2008
20	0x80010000	13	3031142691	-1081778	-4342833	56145442	-513406	-2792379	27622237	Tue Oct 28 16:45:31 EDT 2008
21	0x80010000	14	3031142692	-1081805	-4343552	56144381	-513136	-2790561	27622936	Tue Oct 28 16:45:31 EDT 2008
22	0x80010000	15	3031142693	-1081820	-4344608	56142267	-513644	-2789069	27623972	Tue Oct 28 16:45:31 EDT 2008
23	0x80010000	16	3031142694	-1082089	-4345096	56141691	-513861	-2789611	27622892	Tue Oct 28 16:45:31 EDT 2008
24	0x80010000	17	3031142695	-1082344	-4345231	56143795	-513900	-2790895	27621519	Tue Oct 28 16:45:31 EDT 2008
25	0x80010000	18	3031142696	-1082342	-4345217	56143265	-513897	-2791596	27621503	Tue Oct 28 16:45:31 EDT 2008
26	0x80010000	19	3031142697	-1081777	-4345564	56142209	-513490	-2792190	27621809	Tue Oct 28 16:45:31 EDT 2008
27	0x80010000	20	3031142698	-1081488	-4346106	56141657	-513765	-2790886	27621793	Tue Oct 28 16:45:31 EDT 2008

NetFTCSVData

Settings



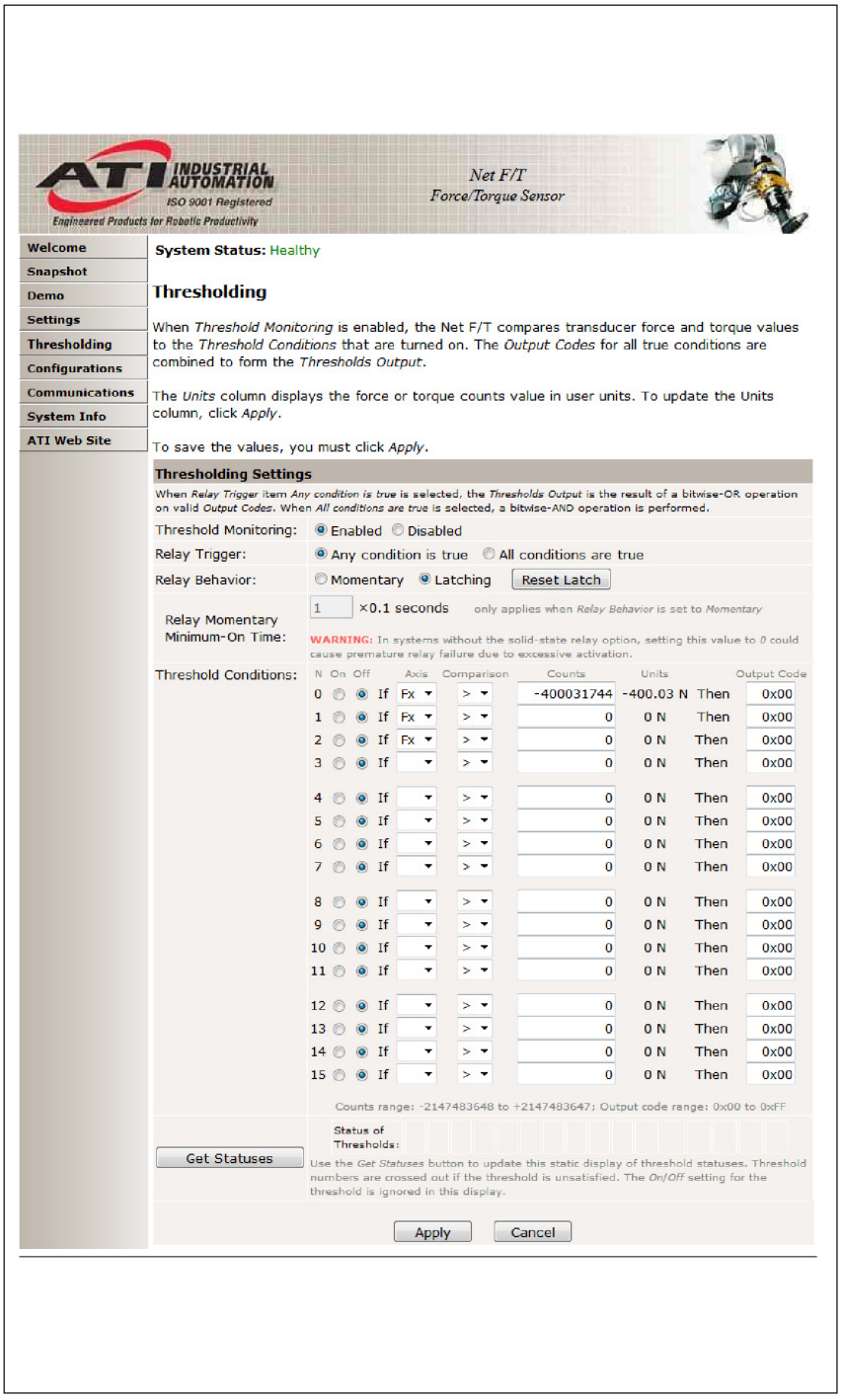
1	Selection of one of the 16 configurations defined on the Configuration page
2	Selects the low-pass filter cutoff frequency. Selecting "No Filter" disables the low-pass filter function
3	When enabled, the lowest and highest forces and torques are stored as minimum and maximum peaks. Useful during teach-in or to track crashes.
4	The bias vector is stored here and can be used on the Snapshot page. It sets the force and torque data to zero in order to avoid falsifications due to external influences.
5	User authentication that restricts access to all pages except the Welcome page. The password can be reset by switching DIP switch 9 on and off five times. No more than 2 seconds may elapse between one "on" and the next "on".

Thresholding

The threshold monitoring compares the currently measured forces and torques with user-defined thresholds and issues a message when the thresholds are reached. The output of the threshold monitoring is displayed on the Snapshot page.

If one of the set thresholds is reached, the following happens:

- The output of the threshold monitoring is updated.
- Bit 16 of the status code becomes "true".
- The relay for threshold monitoring interrupts the connection at PIN 3.



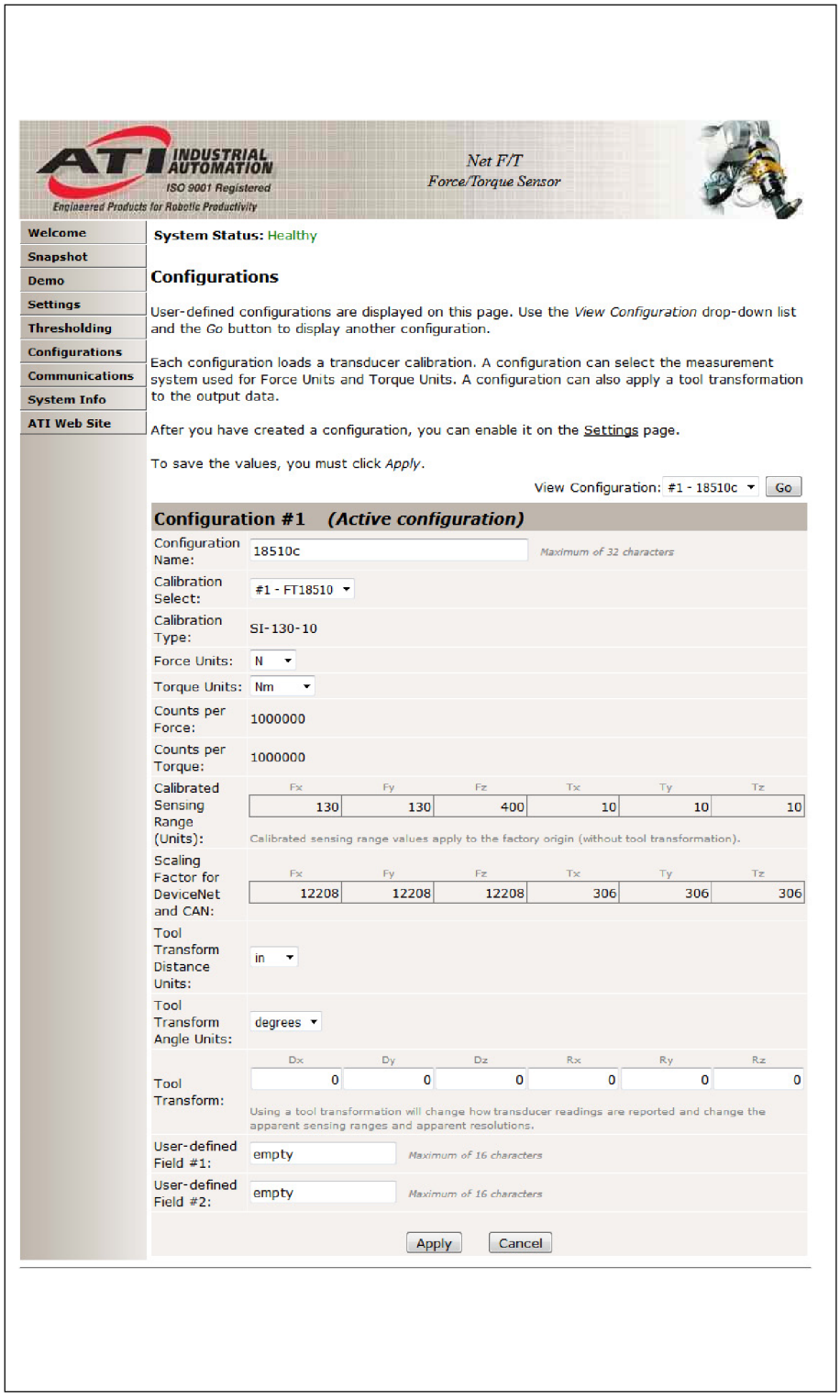
Tab.: Threshold conditions

Table column	Description	Comment
N	Statement number	
On/Off	Selects which statements are included when processing threshold conditions.	
Axis	Selects the axis to be used in the comparison statement.	empty = statement disabled Fx = Fx-axis Fy = Fy-axis Fz = Fz-axis Tx = Tx-axis Ty = Ty-axis Tz = Tz axis
Comparison	Selects the type of comparison to be performed.	> Greater than < Less than
Counts	Displays the load value to be compared with the measured value of the FT sensor. This value is displayed in the units of the active configuration after the "Apply" button has been clicked. To determine the Counts value to use from a value in user units, the value in user units must be multiplied by Counts per force (or Counts per torque, if applicable). **IMPORTANT! Comparison levels are stored as count values and only change when the user enters new count values. Changing the configuration or the force units or the torque units does not change or adjust the count values.**	Example: Desired load: 6.25 N Unit: N (from Configuration page) Counts per force value: 1000000 (from Configuration page) Counts = Desired load × Counts per force = 6.25 N × 1000000 counts/N = 6250000 counts
Units	Displays the count value in the units of the active configuration. This value is only updated after the "Apply" button has been clicked.	
Output Code	If the comparison of this statement is true, this 8-bit value is ORed bitwise with the output code values of all other true statements to form the threshold output. All set bits remain temporarily stored until "Reset Latch" is pressed. If no statements were true, the threshold output is zero.	The value is displayed in hexadecimal in the format 0x00. Output codes can be in hexadecimal or decimal format.
Reset Latch button	This button clears threshold latching and refreshes the thresholding page. When threshold conditions no longer apply, "Thresholds Breached", "Thresholds Output", and "Thresholds Latched" are set to zero, and the System Status: 'Threshold Level Latched' is cleared.	

Table column	Description	Comment
	The button resets the value for "Thresholds Latched" and refreshes the Snapshot page. If no threshold conditions are met, the "Thresholds Breached", "Thresholds Output", and "Thresholds Latched" values are set to zero and the system status "Threshold Level Latched condition is cleared" is displayed.	

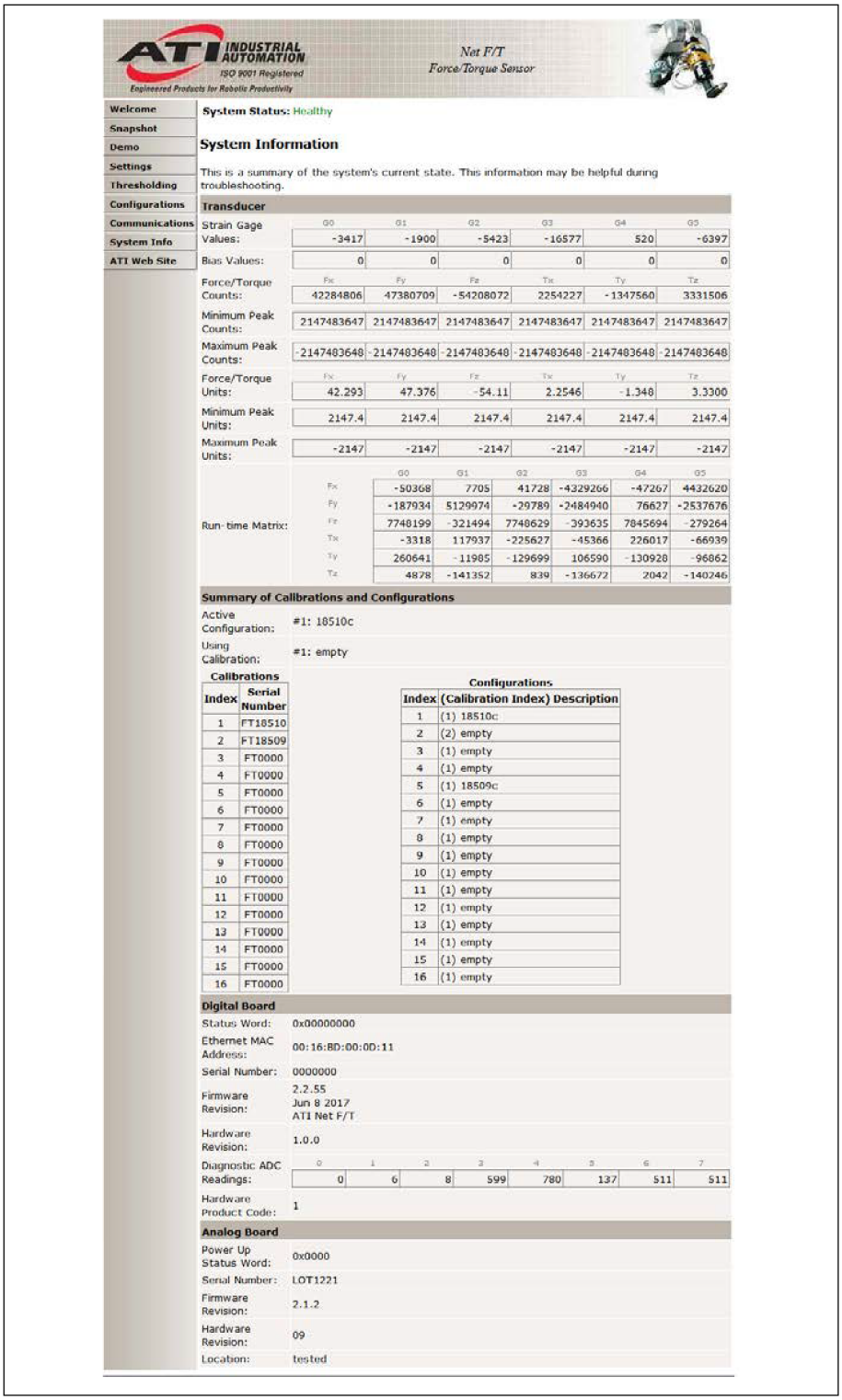
Configurations

On the Configuration page, the force/torque sensor calibrations can be configured and saved.



System information

The page shows a summary of the current status of the force/ torque sensor system and is used for troubleshooting.



ATI INDUSTRIAL AUTOMATION
ISO 9001 Registered
Engineered Products for Robotic Productivity

Net F/T
Force/Torque Sensor

Welcome | Snapshot | Demo | Settings | Thresholding | Configurations | Communications | System Info | ATI Web Site

System Status: Healthy

System Information

This is a summary of the system's current state. This information may be helpful during troubleshooting.

Transducer

	G0	G1	G2	G3	G4	G5
Strain Gage Values:	-3417	-1900	-5423	-16577	520	-6397
Bias Values:	0	0	0	0	0	0

	Fx	Fy	Fz	Tx	Ty	Tz
Force/Torque Counts:	42284806	47380709	-54208072	2254227	-1347560	3331506
Minimum Peak Counts:	2147483647	2147483647	2147483647	2147483647	2147483647	2147483647
Maximum Peak Counts:	-2147483648	-2147483648	-2147483648	-2147483648	-2147483648	-2147483648
Force/Torque Units:	42.293	47.376	-54.11	2.2546	-1.348	3.3300
Minimum Peak Units:	2147.4	2147.4	2147.4	2147.4	2147.4	2147.4
Maximum Peak Units:	-2147	-2147	-2147	-2147	-2147	-2147

Run-time Matrix:

	G0	G1	G2	G3	G4	G5
Fx	-50368	7705	41728	-4329266	-47267	4432620
Fy	-187934	5129974	-29789	-2484940	76627	-2537676
Fz	7748199	-321494	7748629	-393635	7845694	-279264
Tx	-3318	117937	-225627	-45366	226017	-66939
Ty	260641	-11905	-129699	106590	-130928	-96862
Tz	4878	-141352	839	-136672	2042	-140246

Summary of Calibrations and Configurations

Active Configuration: #1: 18510c

Using Calibration: #1: empty

Calibrations

Index	Serial Number
1	FT18510
2	FT18509
3	FT0000
4	FT0000
5	FT0000
6	FT0000
7	FT0000
8	FT0000
9	FT0000
10	FT0000
11	FT0000
12	FT0000
13	FT0000
14	FT0000
15	FT0000
16	FT0000

Configurations

Index	(Calibration Index) Description
1	(1) 18510c
2	(2) empty
3	(1) empty
4	(1) empty
5	(1) 18509c
6	(1) empty
7	(1) empty
8	(1) empty
9	(1) empty
10	(1) empty
11	(1) empty
12	(1) empty
13	(1) empty
14	(1) empty
15	(1) empty
16	(1) empty

Digital Board

Status Word: 0x00000000

Ethernet MAC Address: 00:16:BD:00:0D:11

Serial Number: 0000000

Firmware Revision: 2.2.55 Jun 8 2017 ATI Net F/T

Hardware Revision: 1.0.0

Diagnostic ADC Readings:	0	1	2	3	4	5	6	7
	0	6	8	599	780	137	511	511

Hardware Product Code: 1

Analog Board

Power Up Status Word: 0x0000

Serial Number: LOT1221

Firmware Revision: 2.1.2

Hardware Revision: 09

Location: tested

5.3.3 EtherNet/IP

NOTE

Information about the CIP model and required parameters for the connection with EtherNet/IP or DeviceNet at ▶ 5.3.11 [🗋 81].

IP address configuration for EtherNet

NOTE

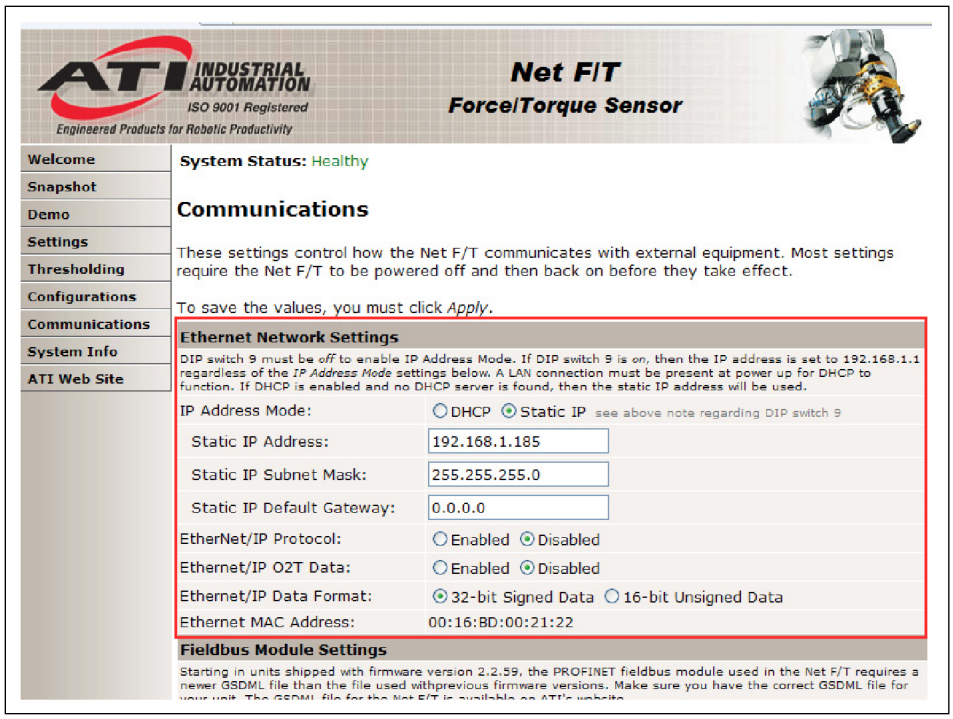
The Force/torque sensor system FTN is shipped with DHCP enabled and the static IP address set to 192.168.1.1. The static IP address is automatically used if the customer network does not support DHCP.

- **Variant 1**: Set DIP switch 9 to "ON". The IP address is set to 192.168.1.1.
- **Variant 2**: Set a static IP address in the FTNsettings via the web browser interface. DIP switch 9 must then be set to "OFF".
- **Variant 3**: Use DHCP server to perform IP address assignment. DIP switch 9 must then be set to "OFF". The option can be enabled in the web browser interface.

Select/set variant 2 or 3 for EtherNet connection

■ The initial setup of the network settings has been performed, ▶ 5.3.1 [🗋 31].

1. Open the Internet browser and enter "192.168.1.1" in the address line.
   ⇨ The Welcome page opens.
2. Click on the "Communications" button via the navigation bar on the left.
   ⇨ The Communications page opens.



3. Select an option under "IP Address Mode". Which option is to be selected depends on the customer's network.
   ⇨ Select the "DHCP" option and click the "Apply" button.
   ⇨ Select the "Static IP" option and fill in the three fields "Static IP Address", "Static IP Subnet Mask" and "Static IP Default Gateway" as shown in the graphic and click on the "Apply" button.
4. Enable option "EtherNet/IP O2T" if the force/torque sensor system is to accept a 4-byte output bitmap. When disabled, no data can be read from the system via EtherNet/IP.
5. The 'EtherNet/IP Data Format' option changes the EtherNet/IP output data between default 32 bit and unsigned 16 bit. *
6. **Only if PoE is used**: Disconnect NetBox from the EtherNet switch.
7. Restart NetBox.

* Unsigned 16-bit values use the same 16-bit scaling factor that is used for DeviceNet, CAN and TCP interface data. Since these are unsigned, a "no load" value is counted as +32768, a negative full-scale value is given as approximately 0 counts, and a positive load is given as approximately 65536 counts.

EtherNet/IP operation

NOTE

The sensor system, FTN , operates as a server on the EtherNet/IP network and supports Class 3 'Connected Explicit Messaging': UCMM Explicit Messaging and Class 1 Connected Cyclic I/O Messaging. The EtherNet/IP network supports an input-only connection and not a list-only connection. The sensor system does not support client functionality.

Case	Instance	Size [bytes]	RT transfer format	Connection type
Configuration	128	0	n/a	n/a
Input (Target to Originator)	100	28	Modeless	Point-to-Point
Output (Originator to Target) EtherNet/IP 02T Data Disabled	102	0	Modeless	Point-to-Point
Output (Originator to Target) EtherNet/IP 02T Data Enabled	102	4	Run/Idle	Point-to-Point

Tab.: Class 1 connection information parameters

Status LED

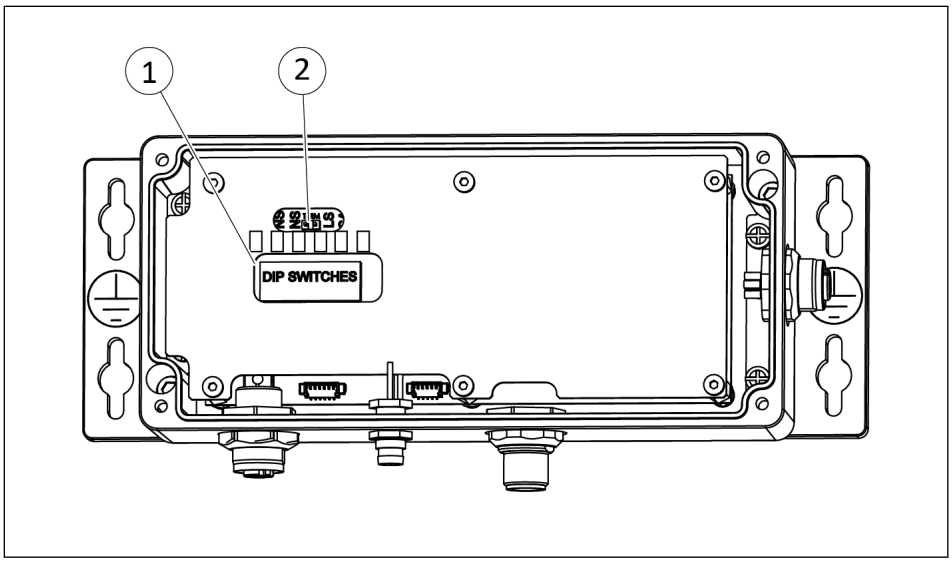
The module status LED is marked as "MS" on the NetBox. It indicates the device status for power supply and proper operation. The EtherNet/IP network status LED is marked "NS EN" on the NetBox, ▶ 4.3 [🗋 15].

5.3.4 CAN bus

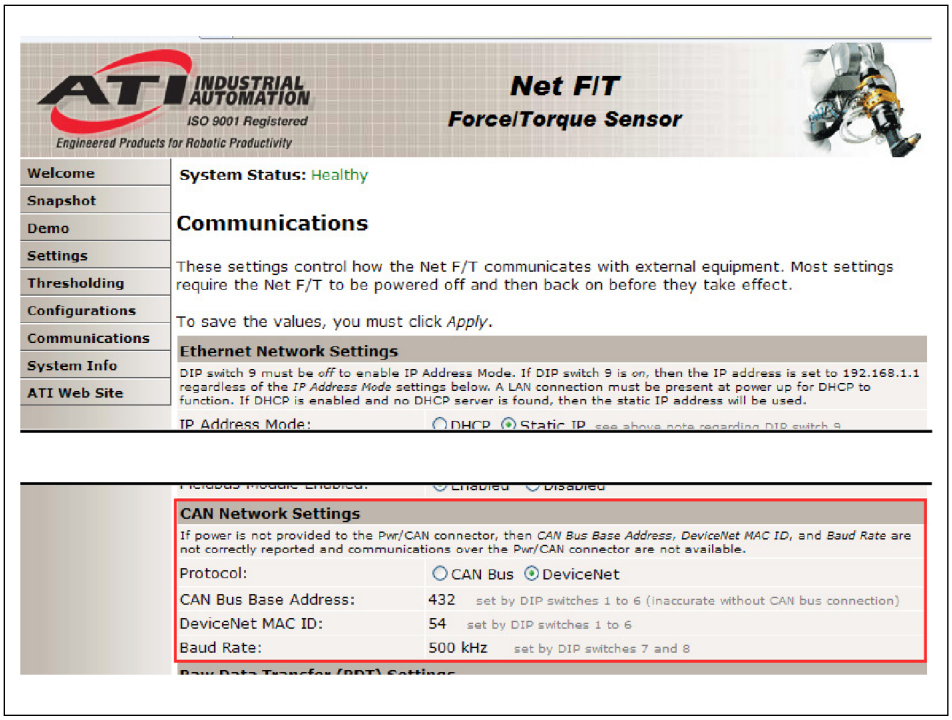
NOTE

The sensor system, FTN , supports a basic CAN protocol to allow reading of force/torque data and the system status word over CAN without the need for a DeviceNet scanner. The settings for the CAN bus base address and the baud rate are configured via the DIP switches.

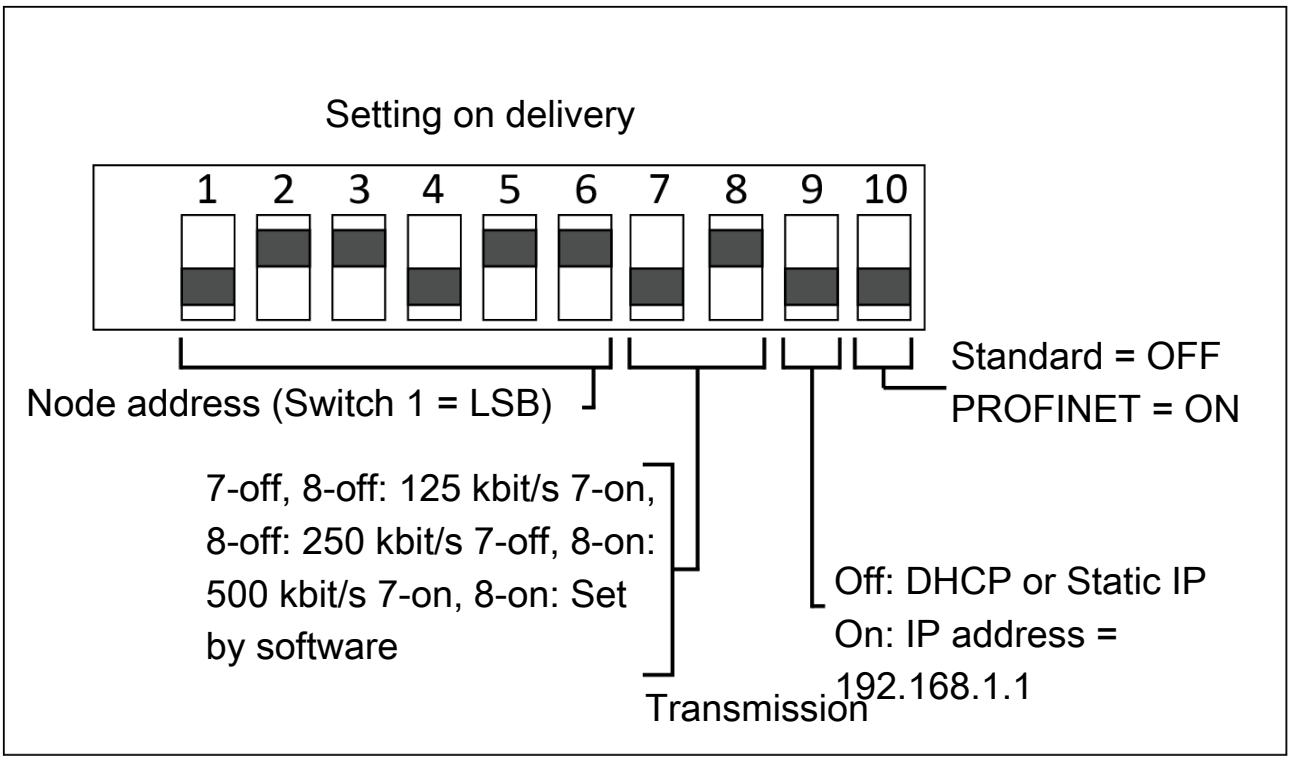
1. Loosen the fastening screws on the four corners on the top of the NetBox and remove the cover.
2. Open NetBox. **IMPORTANT! Risk of damage to the internal electronics! Protect the inside of the NetBox from contamination.**



3. Make settings on DIP switches (1) as required.
4. Remove the termination resistor (2) if it is not to be used.
5. Place the cover on the NetBox and tighten the fastening screws.



1. Select "CAN Bus" on the Communications page under CAN Network Settings.
2. Set the "CAN Bus Base Address" and the "Baud Rate" via DIP switches. The set values are displayed here.



Tab.: DIP switch settings for CAN bus base address

Base address	DIP switches 123456	Base address	DIP switches 123456	Base address	DIP switches 123456	Base address	DIP switches 123456
0	000000	128	000010	256	000001	384	000011
8	100000	136	100010	264	100001	392	100011
16	010000	144	010010	272	010001	400	010011
24	110000	152	110010	280	110001	408	110011
32	001000	160	001010	288	001001	416	001011
40	101000	168	101010	296	101001	424	101011
48	011000	176	011010	304	011001	432	011011
56	111000	184	111010	312	111001	440	111011
64	000100	192	000110	320	000101	448	000111
72	100100	200	100110	328	100101	456	100111
80	010100	208	010110	336	010101	464	010111
88	110100	216	110110	344	110101	472	110111
96	001100	224	001110	352	001101	480	001111
104	101100	232	101110	360	101101	488	101111
112	011100	240	011110	368	011101	496	011111
120	111100	248	111110	376	111101	504	111111

Baud rate

The baud rate is set to either 125 kbps, 250 kbps or 500 kbps via hardware or software configuration. The baud rate is set by software when DIP switch positions 7 and 8 are ON.

Calculating FT values for CAN

The sensor system, FTN , multiplies each F/T value by a factor before it is sent via the CAN interface. This calculation allows the F/T values to be sent with full resolution. The application program must divide each F/T value by a certain factor to obtain the actual data.

Protocol description

A data request message sent to the FTN sensor system, initiates the copying of the current set of F/T data to an output buffer and the subsequent transmission of the output buffer.

Depending on the request message identifier (REQUEST LONG or REQUEST SHORT), the sensor system either sends 32-bit values packed into four messages or 16-bit values packed into two messages.

The values are in little endian format (least significant byte first). For example, 16-bit value 0x56 0x02 stands for 0x0256. Signed numbers use the 2's complement format. The 32-bit value received as 0x0F 0xCF 0xDA 0xDA 0xFD represents 0xFDDACF0F, which is a negative number (because the highest bit is set). Its decimal value is -35991793.

If a data request telegram is received during an ongoing transmission, the ongoing transmission is terminated and the new request is processed.

Base address and communication format

The CAN bus base address is set via DIP switches 1 to 6. The factory default base address is 432.

Tab.: Request long data

Request to sensor system	Response from sensor system	CAN identifier	Data length in bytes	1st to 4th data bytes	5th to 8th data bytes	Description
Request long data	–	Base address	1	0x01 (BYTE)	N/A	Sends a copy of the force and torque data in long format (an ongoing transmission is terminated)
–	Fx and Tx data	Base address +1	8	Fx value (DINT)	Tx value (DINT)	Force and torque values of the X-axis in long format
–	Fy and Ty data	Base address +2	8	Fy value (DINT)	Ty value (DINT)	Force and torque values of the Y-axis in long format
–	Fz and Tz data	Base address +3	8	Fz value (DINT)	Tz value (DINT)	Force and torque values of the Z-axis in long format
–	Status and sample number	Base address +4	8	System status (DINT)	Sample number (DINT)	System status word and sample number in long format

Tab.: Request short data

Request to sensor system	Response from sensor system	CAN identifier	Data length in bytes	1st to 4th data bytes	5th to 8th data bytes	Description
Request short data	–	Base address	1	0x02 (BYTE)	N/A	Sends a copy of the force and torque data in short format (an ongoing transmission is terminated)
–	Fx, Tx, Fy and Tx data	Base address +5	8	Fx value (INT) Tx value (INT)	Fy value (INT) Ty value (INT)	Force and torque values of the X-axis and force and torque of the Y-axis in short format
–	Fz and Tz data, status and sample number	Base address +6	8	Fz value (INT) Tz value (INT)	System status (INT)	

Request to sensor system	Response from sensor system	CAN identifier	Data length in bytes	1st to 4th data bytes	5th to 8th data bytes	Description
					Sample number (INT)	Z-axis force and torque values, system status word and sample in short format.

Tab.: Bias command

Request to sensor system	Response from sensor system	CAN identifier	Data length in bytes	1st to 4th data bytes	5th to 8th data bytes	Description
Bias	–	Base address	1	0x04 (BYTE)	N/A	Sets the force and torque readings to zero at the current load level.

Tab.: Clear threshold latch command

Request to sensor system	Response from sensor system	CAN identifier	Data length in bytes	1st to 4th data bytes	5th to 8th data bytes	Description
Clear threshold latch	–	Base address	1	0x08 (BYTE)	N/A	Clears the threshold latch so it can respond to subsequent conditions.

5.3.5 DeviceNet

NOTE

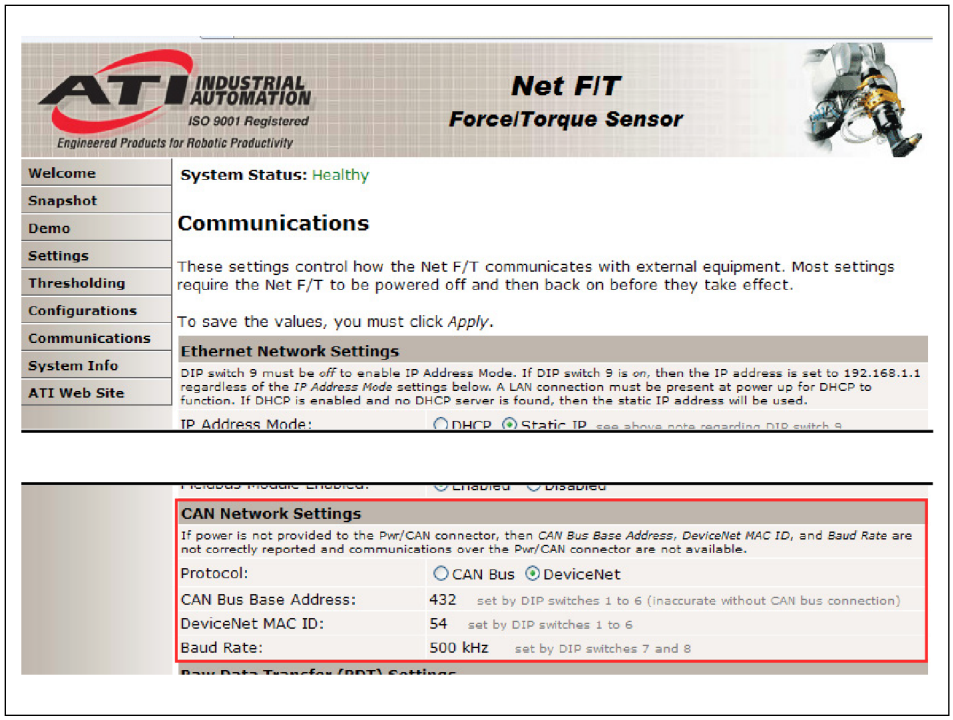
Information about the CIP model and required parameters for the connection with EtherNet/IP or DeviceNet at ▸ 5.3.11 [🗋 81].

NOTE

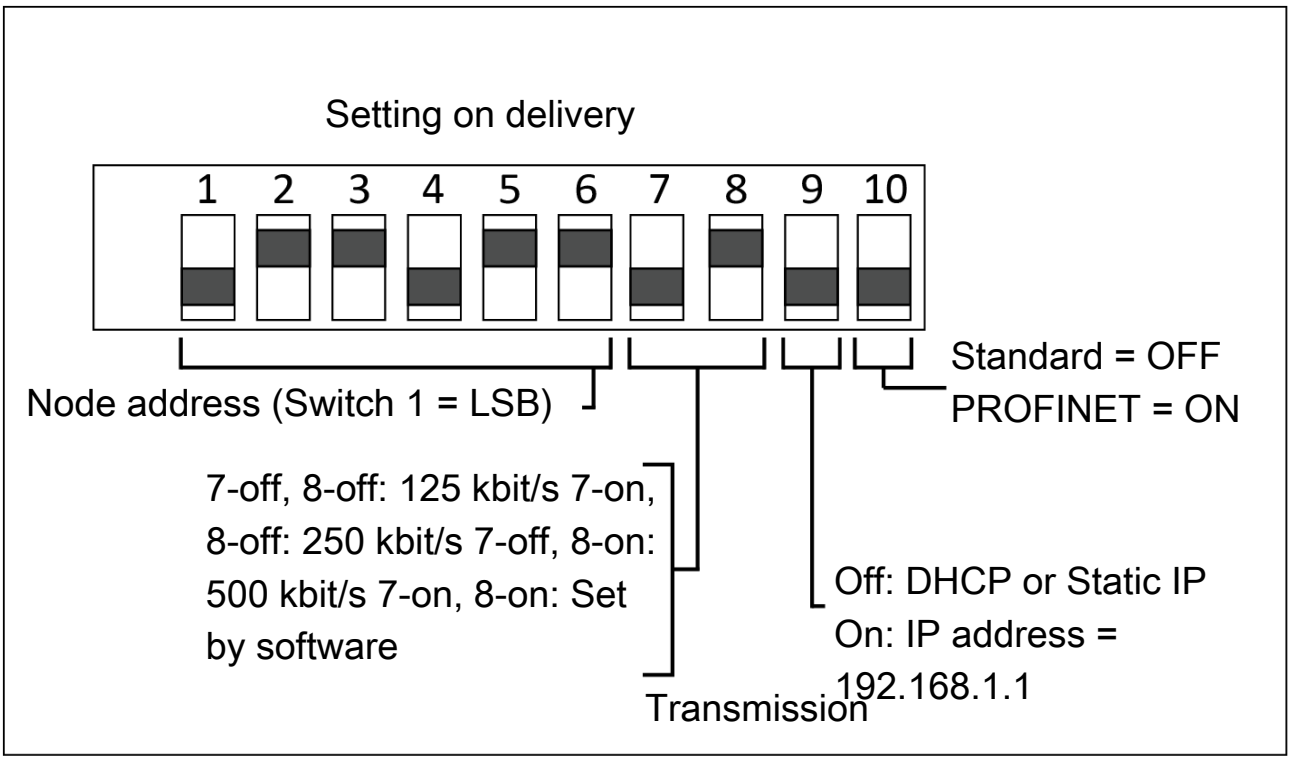
The sensor system, FTN , operates as a Group 2–only server in the EtherNet/IP network and supports "Explicit Messaging" and "Polled I/O Messaging' for the predefined master/slave connection set. The FTN DeviceNet node supports the Unconnected Message Manager (UCMM).

The Pwr/CAN connector on the NetBox can be used for a DeviceNet connection.

1. Loosen the fastening screws on the four corners on the top of the NetBox and remove the cover.
2. Open NetBox. **IMPORTANT! Risk of damage to the internal electronics! Protect the inside of the NetBox from contamination.**
3. Make settings on DIP switches as required.
4. Place the cover on the NetBox and tighten the fastening screws.



1. Select "DeviceNet" on the Communications page under CAN Network Settings.
2. Set the "DeviceNet MAC ID" and the "Baud Rate" via DIP switches. The set values are displayed here.



MAC ID

The MAC ID is set to a value from 0 to 63 either by hardware or software configuration. For the MAC ID to be set by software, DIP switch positions 1 to 8 must be ON. If the MAC ID is set by software, the baud rate must also be set by software. The factory set MAC ID is 54.

Tab.: DeviceNet MAC ID DIP Switch Settings

MAC ID	DIP switches 123456	MAC ID	DIP switches 123456	MAC ID	DIP switches 123456	MAC ID	DIP switches 123456
0	000000	16	000010	32	000001	48	000011
1	100000	17	100010	33	100001	49	100011
2	010000	18	010010	34	010001	50	010011
3	110000	19	110010	35	110001	51	110011
4	001000	20	001010	36	001001	52	001011
5	101000	21	101010	37	101001	53	101011
6	011000	22	011010	38	011001	54	011011
7	111000	23	111010	39	111001	55	111011
8	000100	24	000110	40	000101	56	000111
9	100100	25	100110	41	100101	57	100111
10	010100	26	010110	42	010101	58	010111
11	110100	27	110110	43	110101	59	110111
12	001100	28	001110	44	001101	60	001111
13	101100	29	101110	45	101101	61	101111
14	011100	30	011110	46	011101	62	011111
15	111100	31	111110	47	111101	63	111111

Baud rate

The baud rate is set to either 125 kbps, 250 kbps or 500 kbps via hardware or software configuration. The baud rate is set by software when DIP switch positions 7 and 8 are ON.

Status LED

The module status LED is marked as "MS" on the NetBox. It indicates the device status for power supply and proper operation. The DeviceNet network status LED is marked "NS DN" on the NetBox, ▸ 4.3 [🗋 15].

EDS file

The DeviceNet Electronic Data Sheet (EDS) file for the system is located in the \EDS directory and can be downloaded from https://www.ati-ia.com/Products/ft/software/net_ft_software.aspx.

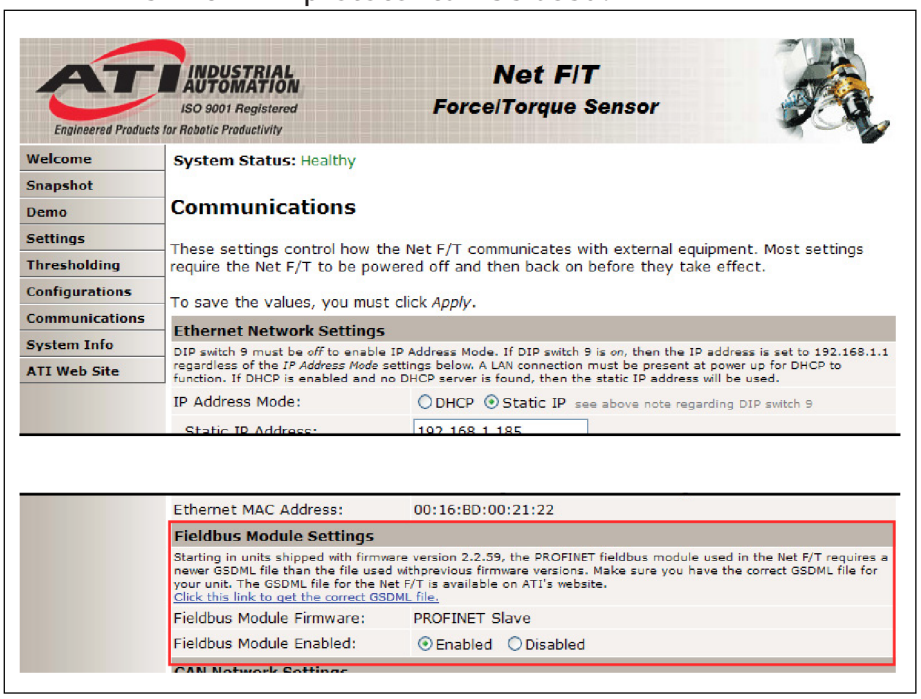
5.3.6 PROFINET

NOTE

If "Fieldbus Module Enabled" is set to "Enabled", the selection of the active configuration and the selection of the threshold statements are controlled by the PROFINET output data. When enabled, these values are not controlled by NetBox web pages or the CGI interface.

The NetBox (NETB-PN2) or (NETBA-PN2) is required for the PROFINET interface.

- Enable the option "Fieldbus Module Enabled" on the Communications page under Fieldbus Module Settings.
  ⇨ The PROFINET protocol can be used.



A GSDML file can be downloaded from **ati-ia.com/Products/ft/software/net_ft_software**.

Parameter	Description
DCP	is supported
Protocols used	UDP, IP, ARP, ICMP (Ping)
Topology recognition	LLDP, SNMP, MIB2, physical device
VLAN and priority tagging	yes
Context management	by CL-RPC
Min. cycle time [ms]	2
Min. FT data update rate [Hz]	20
Transmission speed [MBit/s]	100
Data transport layer	EtherNet II, IEEE 802.3

Tab.: PROFINET interface parameters

16-bit word	Data type	Name	Description/Function
0	INT	Status	Status word, bit 16 to 31
1	INT	Fx	Force in X-direction, 16-bit format
2	INT	Fy	Force in Y-direction, 16-bit format
3	INT	Fz	Force in Z-direction, 16-bit format
4	INT	Tx	Torque about the X-axis, 16-bit format
5	INT	Ty	Torque about the Y-axis, 16-bit format
6	INT	Tz	Torque about the Z-axis, 16-bit format
7	UINT	Sequence	Incremented each time a dataset is sent

Tab.: PROFINET interface parameters

- Input word 0, status, contains bits 16 to 31 of the system status code of the force/torque sensor system FTN, ▸ 6 [🗋 90].
- Input words 1–6 contain values representing the F/T vectors Fx, Fy, Fz, Tx, Ty and Tz. To reduce the amount of data transmitted via PROFINET, they are reduced to 16 bits before transmission using the scaling factor for DeviceNet and CAN values.
- To obtain the F/T values in user units, each force value received must be divided by (Counts per force ÷ Scaling factor for DeviceNet and CAN) for the axis and each torque value received must be divided by (Counts per torque ÷ Scaling factor for DeviceNet and CAN) for the axis. *

* The Counts per force, Counts per torque and Scaling factor for DeviceNet and CAN can be found on the Configuration page web browser interface.

Output mapping

Byte	Bit number	Name	Description/Function
0	0	Bias	Execute tare function to set any load measurement values to zero
	1	Reset latch	Reset threshold latch
	2	reserved	reserved
	3	reserved	reserved
	4	reserved	reserved
	5	reserved	reserved
	6	reserved	reserved
	7	reserved	reserved
1	0	Config select bit 0	selects a FTN configuration, between 0 and 15
	1	Config select bit 1	
	2	Config select bit 2	
	3	Config select bit 3	
	4	reserved	reserved
	5	reserved	reserved
	6	reserved	reserved
	7	reserved	reserved
2	0–7	Threshold high	Threshold enable mask, high byte
3	0–7	Threshold low	Threshold enable mask, low byte

- Output byte 0, bit 0 performs a BIAS/zeroing function when the byte is set to one. Details about this function can be found in the Snapshot page web browser interface under the "Bias" button. Bit 0 should be set to one for at least 100 ms to ensure that BIAS/zeroing is executed. Bit 0 is then set to zero again.
- Output byte 0, bit 1 performs a reset threshold latch function when the byte is set to one. Details about this function can be found in the Thresholding page web browser interface under the "Reset Latch" button. Bit 1 should be set to one for at least 100 ms to ensure that reset latch is executed. Bit 1 is then set to zero again.
- Output byte 0, bits 2–7 are reserved and should not be used.

- Output byte 1, bits 0–3 select the active configuration (0 to 15) to be used. After a delay of up to one second, the newly selected configuration is usable. During the configuration change, the force/torque system does not provide valid F/T data. Details of the active configuration can be found in the Settings page web browser interface.
- Output byte 1, bits 4–7 are reserved and should not be used.
- Output bytes 2 and 3 form a 16-bit threshold enable mask that enables and disables threshold conditions. Each bit 0–15 (of the threshold enable mask) corresponds directly to the corresponding threshold condition number N. A value of one enables the corresponding condition and a value of zero disables the condition. Further information on thresholding can be found in the Thresholding page web browser interface.

Communications CGI (comm.cgi) options

The NetBox for PROFINET can switch the PROFINET function on and off via CGI. The following function is additionally available in the comm.cgi:

Variable name	Allowed values	Description
fieldbusenabled	Integers: 0 or 1	Enable (value = 1) or disable (value = 0) the PROFINET fieldbus interface.

Further functions in the section "CGI Communications", ▶ 5.3.9 [🗋 70].

XML page elements

The NetBox for PROFINET has two additional XML elements, which are included in the output of the netftapi2.xml page. The following elements are additionally available in the netftapi2.xml page:

XML element	Data type	Description	Reference
fieldbusenabled	ENABL	Setting for PROFINET interface	comm
fieldbusfirmware	STRING64	Firmware version of the PROFINET interface	comm

Resetting to default settings

The PROFINET station name and the PROFINET IP address can be reset to the default settings. This is useful if already configured devices in the PROFINET network are to be moved or replaced. Resetting has no effect on the default EtherNet and EtherNet/IP settings.

- Fieldbus module is enabled.
- Power supply is connected.

1. Disconnect PROFINET network connection.
2. Remove NetBox cover.
3. Set DIP switch 10 to "ON".
4. As soon as the MS LED flashes red, set DIP switch 10 back to the "OFF" position.
5. Replace NetBox cover.
6. Disconnect power supply.

⇨ The PROFINET station name and the PROFINET IP address will be reset the next time the power supply is connected.

Replacing and installing the NetBox for PROFINET

- Replacement can be done if the topology of the PROFINET network has been correctly defined with the PROFINET engineering tool and if the PROFINET controller supports automatic device replacement.

1. Disconnect the voltage supply and network connection of the box to be replaced.
2. If necessary, remove the NetBox from the system.
3. Mount the new NetBox.
4. Connect voltage supply and network connection.

⇨ The new NetBox is automatically assigned the name and IP address of the old NetBox.

⇨ After a few seconds the NS/BF LED is permanently green and the NetBox is working correctly in the network.

Replacing and installing a previously commissioned NetBox

- Replacement can be done if the topology of the PROFINET network has been correctly defined with the PROFINET engineering tool and if the PROFINET controller supports automatic device replacement.

1. Disconnect the voltage supply and network connection of the box to be replaced.
2. If necessary, remove the NetBox from the system.
3. Mount the new NetBox.
4. Connect voltage supply.
5. Reset default settings, see previous section "Resetting to default settings".
6. Connect network connection.

⇨ The new NetBox is automatically assigned the name and IP address of the old NetBox.

⇨ After a few seconds the NS/BF LED is permanently green and the NetBox is working correctly in the network.

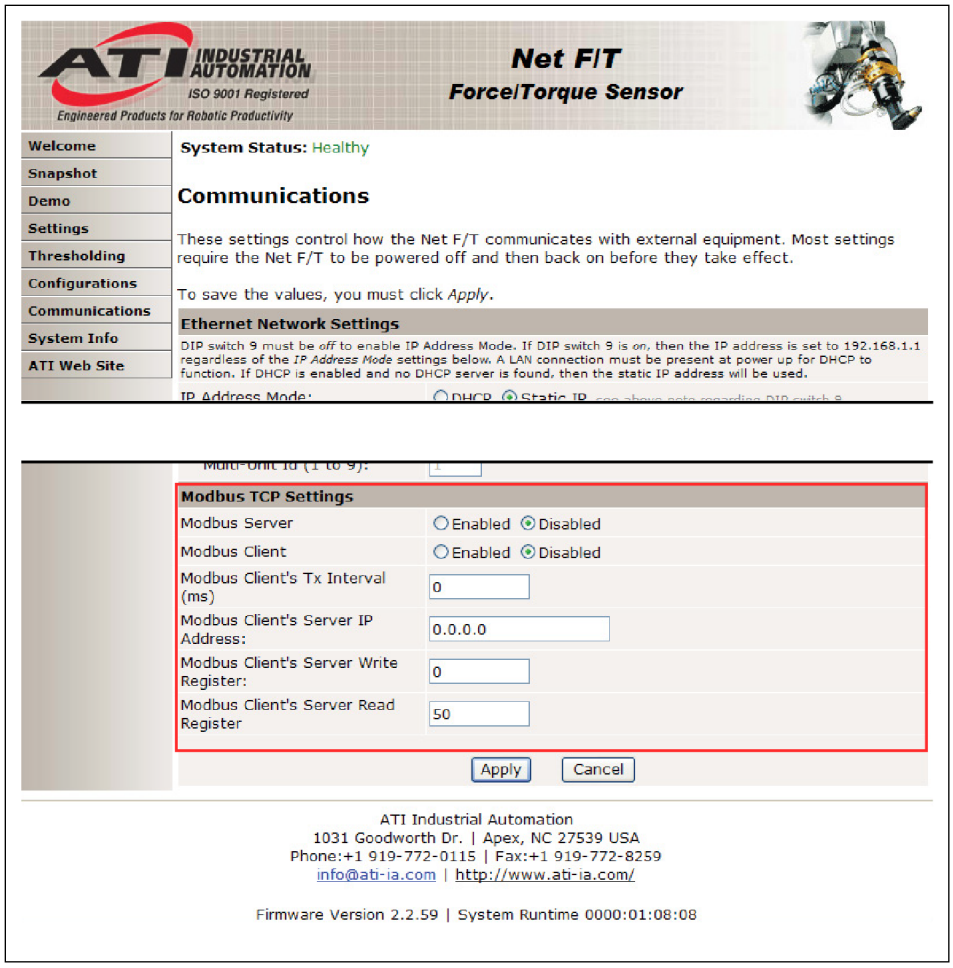
5.3.7 TCP Interface

NOTE

If the remote Modbus server reports that the "Modbus Read/Write Multiple Registers" command is not supported, the register transfer is completed via the "Read Holding Registers" and "Write Multiple Registers" commands.

1. Enable the option "Modbus Server" on the Communications page under Modbus TCP Settings.
   ⇨ The Modbus commands "Read Input Registers", "Read Holding Registers", "Write Single Registers", "Write Multiple Registers" and "Read/Write Multiple Registers" are supported.
2. Enable the option "Modbus Client".
3. In the "Modbus Client's Tx Interval" field, define every how many milliseconds the Modbus client should use the "Modbus Read/Write Multiple Registers" command to transfer/write internal registers 0 to 26 to the remote Modbus server and simultaneously read registers 27 to 42.
4. Enter the IP address of the remote Modbus server in the "Modbus Client's Server IP Address" field.
5. In the "Modbus Client's Server Write Register" field, specify at which register number the Modbus client should start to write to the remote server.

6. In the "Modbus Client's Server Write Register" field, specify at which register number the Modbus client should start reading from the remote server.



NetBox register	Corresponding robot register	Direction (from NetBox)	Function
0	128	Out	Force X
1	129	Out	Force Y
2	130	Out	Force Z
3	131	Out	Torque X
4	132	Out	Torque Y
5	133	Out	Torque Z
6	134	Out	Status MSB
7	135	Out	Status LSB
8	136	Out	Gage 0
9	137	Out	Gage 1
10	138	Out	Gage 2
11	139	Out	Gage 3
12	140	Out	Gage 4

NetBox register	Corresponding robot register	Direction (from NetBox)	Function
13	141	Out	Gage 5
14	142	Out	Force units
15	143	Out	Torque units
16	144	Out	Scale factor 0
17	145	Out	Scale factor 1
18	146	Out	Scale factor 2
19	147	Out	Scale factor 3
20	148	Out	Scale factor 4
21	149	Out	Scale factor 5
22	150	Out	Counts per force MSW
23	151	Out	Counts per force LSW
24	152	Out	Counts per torque MSW
25	153	Out	Counts per torque LSW
26	154	Out	Sequence number
27	155	In	System commands
28	156	In	Transform distance units
29	157	In	Transform angle units
30	158	In	Dx * 100
31	159	In	Dy * 100
32	160	In	Dz * 100
33	161	In	Rx * 100
34	162	In	Ry * 100
35	163	In	Rz * 100
36	164	In	MCEnable LSW
37	165	In	MCEnable MSW
38	166	In	WMC index
39	167	In	WMC axis
40	168	In	WMC output code
41	169	In	WMC comparison
42	170	In	WMC compare value

Tab.: TCP register map

Information about the TCP Interface

The TCP interface runs on TCP port 49151. All commands are 20 bytes long. All outputs start with the two-byte header 0x12, 0x34.

Command codes

READFT = 0, // Read out FT values
READCALINFO = 1, // Read out calibration
WRITETRANSFORM = 2, Write tool transformation
WRITETHRESHOLD = 3, Write conditions for monitoring

Read out FT Commands

{
uint8 command; // Must always be READFT (0)
uint8 reserved[15]; // Should always be at value=0
*uint16 MCEnable; // Bitmap of MCs to be enabled **
*uint16 sysCommands; // Bitmap of system commands ***
}

* Each bit position 0–15 in MCEnable corresponds to the monitoring state at this index. If the bit is a '1', this monitoring condition is enabled. If the bit is a '0', this monitoring condition is disabled.

* Bit 0 of sysCommands controls the action BIAS/zeroing. If bit 0 is a
* "1", the system is pre-loaded. If bit 0 is a '0', no action is performed.
Bit 1 of sysCommands controls the latching of the monitoring condition. If bit 1 is a '1', the monitoring state memory is cleared and the evaluation of the monitoring condition starts again. If bit 1 is a '0', no action is performed.

Read out the FT output

{
uint16 header; // Always 0x1234
uint16 status; // Upper 16 bits of the 32-bit status codes.
int16 ForceX; // 16-bit force Fx output
int16 ForceY; // 16-bit force Fy output
int16 ForceZ; // 16-bit force Fz output
int16 TorqueX; // 16-bit torque Tx
int16 TorqueY; // 16-bit torque Ty
int16 TorqueZ; // 16-bit torque Tz
}

The force and torque values in the response are equal = current FT value × calibration counts per unit ÷ 16-bit scaling factor.
The counts per unit and the scaling factor are read out with the command "Read calibration information".

Reading calibration info command

{
uint8 command; // Must always be READCALINFO (1)
uint16 reserved[19]; // Should always be 0

}

Read calibration info output

{
uint16 header; // Always 0x1234
uint8 forceUnits; // Force unit
uint8 torqueUnits; // Torque unit
int32 countsPerForce; // Calibration counter per force unit
int32 countsPerTorque; // Calibration counter per torque unit
int16 scaleFactors[6]; // Further scaling for 16-bit counter

}

Force unit	Code for unit	Torque unit
Pound	1	Pound-inch
Newton	2	Pound-foot
Kilo-pound	3	Newton meter
Kilonewton	4	Newton millimeter
Kilogram	5	Kilogram-force centimeter
Gram	6	Kilonewton meter

Convert units command

{
uint8 command; // Must always be WRITETRANSFORM (2)
uint8 transformDistUnits; // Units for dx, dy, dz
uint8 transformAngleUnits; // Units for rx, ry, rz
int16 transform[6]; // dx, dy, dz, rx, ry, rz
uint8 reserved[5]; // Should always be 0
}

* The "transform" elements are multiplied by 100 to achieve good granularity with integer values.

Force unit	Code for unit	Torque unit
Inch	1	Degrees
Foot	2	Radian
Millimeter	3	
Centimeter	4	
Meter	5	

Monitor conditions command

{
uint8 command; // Must always be WRITETRESHOLD
uint8 index; // Index for condition monitoring: 0-31
uint8 axis; // 0=fx, 1=fy, 2=fz, 3=tx, 4=ty, 5=tz
iunt8 outputCode; // Output code of condition monitoring
int8 comparison; // Code for comparison, 1 for "greater than" (>), -1 for "less than" (<)
int8 compareValue; // Value for comparison, divided by 16 bits, scaling factor
}

Output

{
uint16 header; // Must always be 0x1234
uint8 commandEcho; // Echo command
uint8 status; // 0 = successful, not 0= not successful

}

5.3.8 UDP interface (Raw Data Transfer)

CAUTION

Network disturbances possible!

The RDT streaming modes send very large data packets. This may interfere with other connections on the network.

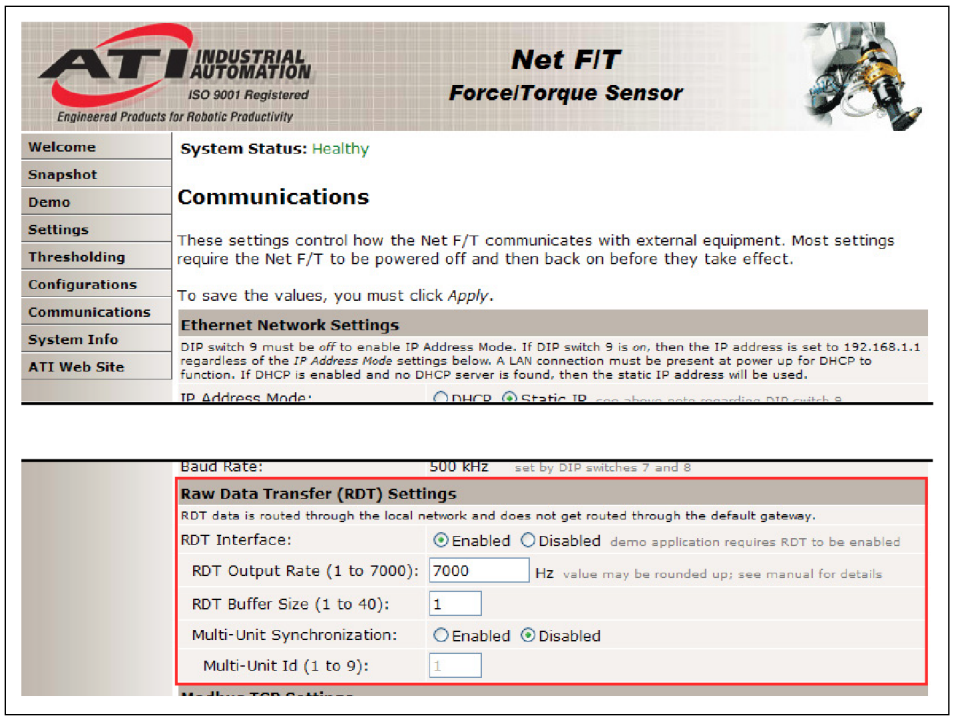
- Use a permanently assigned EtherNet network for reading out FTN data.
- Use the high output speed only when necessary.
- Always end the readout with the command 0x0000. If the client that requested the data is disconnected from the network without sending the 0x0000 command, the force/moment sensor system continues to stream.

NOTE

The RDT protocol is designed to respond to only one client. When a second client sends a command, the Net F/T responds to the new client. Multiple clients could repeatedly request individual packets, minimizing problems (the Java demo works this way).

The force/torque sensor system can output data at up to 7000 Hz over EtherNet/IP using UDP. This method of fast data acquisition is called Raw Data Transfer (RDT). It is useful when the computational complexity of DeviceNet or EtherNet/IP is too great for an application, or when additional speed is required for data acquisition.

1. On the Communications page under Raw Data Transfer (RDT) Settings, enable the "RDT Interface" option.
   ⇨ The NetBox establishes a point-to-point UDP connection to a host computer.
2. In the field "RDT Output Rate" enter the data rate per second at which the NetBox should send the RDT data to a host. Use integer fractions of 7000 (e.g. 7000/2=3500 or 7000/3=2333). If a different sample rate is entered, the force/torque sensor system automatically switches to the next higher sample rate.
3. In the "RDT Buffer Size" field, enter the number of data packets that are to be bundled into a block and then sent per sample.



NOTE

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.

Mode	Command	Speed	Situation best suited to
0x0002	Start high-speed real-time streaming	Fast (up to 7000 Hz)	Application that responds in real-time
0x0003	Start high-speed buffered streaming	Fast (up to 7000 Hz), but comes in bursts (buffers)	Collecting data at high speed, but not respond to it in real-time. Buffer size is set on the Communication Settings web page.

Tab.: Streaming modes

RDT requests

The force/moment sensor system monitors UDP port 49152 for requests. It also sends the output RDT messages from this port.

All RDT requests use the following structure:

{
Uint16 command_header = 0x1234; // Required
Uint16 command; // RDT command to execute
Uint32 sample_count; // Number of samples to output (0 = infinite)
}

Select RDT command:

Command	Name	Output
0x0000	Stop streaming	-
0x0002	Start high-speed real-time streaming	RDT record(s)
0x0003	Start high-speed buffered streaming	RDT record(s)
0x0041	Reset threshold latch	-
0x0042	Set software bias	-

Tab.: RDT commands

Set value for "Sample_count". If "sample_count" is set to zero, the NetBox reads data until an RDT request is sent with the command "Set to zero".

RDT datasets sent in response to an RDT request have the following structure:

```
{
Uint32 rdt_sequence; // RDT sequence number of the packet
Uint32 ft_sequence; // Internal sequence number of the dataset
Uint32 status; // System status code
// Force and torque measurement values use count 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
}
```

Command	Description
rdt_sequence	The "rdt_sequence" describes the position of the RDT record within a single output stream. This information is useful to determine if datasets were lost during transmission. For example, for a request of 1000 records, the rdt_sequence starts at 1 and runs to 1000. The RDT sequence counter is set to zero for the increment following 4294967295 (2^{32}–1).
ft_sequence	The "ft_sequence" describes the internal number of the sample taken from the FT dataset contained in the RDT dataset. The FT sequence number starts at 0 when the system is switched on and increases with the internal sample rate (7000 per second). The value for "ft_sequence" is not set to 0 when the RDT request is completed. This counter switches to 0 at the increment following 4294967295 (2^{32}–1).
status	Contains the system status code at the time of the dataset.
Fx, Fy, Fz, Tx, Ty, Tz	F/T data as count values

NOTE

In buffered mode, the number of RDT datasets received in a UDP packet is equal to the RDT buffer size displayed on the "Communications" page.

Extended RDT requests

The extended RDT request is used if the sensor system is to send the UDP FT data to a different IP address than the one from which the request originates. This is useful, for example, if the FTN stream data is sent to a multicast address so that several clients can receive the stream simultaneously. The commands sent are the same as for the standard RDT request. The only difference is that the high bit must be set to '1'. Command code 2 for high-speed streaming is therefore set to 0x8002 for extended RDT requests, for example.

Example: To request high-speed streaming to multicast address 224.0.5.128, port 28250, a UDP packet must be sent 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. How to subscribe to a multicast IP address in the client-side client system can be found in the documentation of the client system.

Extended RDT requests have the following structure:

```
{
Uint16 hdr ; // Always has the value 0x1234
Uint16 cmd; // Command code with high bit, value = 1
Uint32 count; // Number of samples to be output
uint32 ipaddr_dest; // IP address to which the evaluation should be sent
uint16 port_dest; // Port to which the evaluation should be sent
}
```

Calculating FT values for RDT requests

To obtain the real force and torque values, each force output value must be divided by the "Counts per force" factor and each torque output value must be divided by the "Counts per torque" factor. The factors "cfgcpf" and "cfgcpt" can be taken from the *netftapi2.xml* page, ▸ 5.3.10 [🗋 81].

Examples of C code at http://www.ati-ia.com/Products/ft/software/net_ ft_software.aspx.

5.3.9 Common Gateway Interface (CGI)

NOTE
The maximum length of these URLs can be determined by a number of factors outside the force/torque sensor system. Exceeding the maximum length may result in an error or variables being incorrectly set.

The force/torque sensor system can also be configured via EtherNet/IP using the standard HTTP get method. It sends configuration variables and their associated values in the requested URL. URLs are constructed using the following syntax:

- *http://<netFTAddress>/<CGIPage.cgi>?<firstVariableAssignment><&nextVariable Assignment>*

http:/	indicates an HTTP request
<netFTAddress>	the EtherNet/IP address of the force/torque sensor system
/	a separator
<CGIPage.cgi>	name of the CGI page that contains the variables to be accessed
?	a separator that marks the beginning of variable assignments
<firstVariableAssignment>	a variable assignment using the format described below
<&nextVariableAssignment>	a variable assignment with the format described below, but the variable name is proceeded with an ampersand. This variable assignment is optional and can be repeated for multiple variables.

Each variable can only be set from the CGI page that is responsible for that variable. Each CGI page and its associated adjustable variables are listed in the following tables.

- *variableName=newValue*

variableName	name of the variable to be assigned
=	indicates assignment
newValue	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*

  instructs the force/torque sensor system to set the CGI variables setcfgsel to 2, setuserfilter to 0, and setpke to 1 using the IP address 192.168.1.1.

CGI settings

<table>
<tr><th>Variable name</th><th>Value range (integer)</th><th>Description</th></tr>
<tr><td>setcfgsel</td><td>0 to 15</td><td>Sets the active configuration. Note that the value used by setcfgsel is one less than the configuration numbers on the web page.</td></tr>
<tr><td>setuserfilter</td><td>0 to 12</td><td>Sets the cutoff frequency of the low-pass filtering as follows:
<table>
<tr><th>Value</th><th>Limit frequency [Hz]</th><th>Value</th><th>Limit frequency [Hz]</th></tr>
<tr><td>0</td><td>no filter</td><td>7</td><td>8</td></tr>
<tr><td>1</td><td>838</td><td>8</td><td>5</td></tr>
<tr><td>2</td><td>326</td><td>9</td><td>1500</td></tr>
<tr><td>3</td><td>152</td><td>10</td><td>2000</td></tr>
<tr><td>4</td><td>73</td><td>11</td><td>2500</td></tr>
<tr><td>5</td><td>35</td><td>12</td><td>3000</td></tr>
<tr><td>6</td><td>18</td><td></td><td></td></tr>
</table></td></tr>
<tr><td>setpke</td><td>0 or 1</td><td>Enables (value = 1) or disables (value = 0) peak logging</td></tr>
<tr><td>setbiasn</td><td>−32768 to 32767</td><td>Sets the offset value for strain gage n. For example, Setbias3=0 would set BIAS/zeroing of the fourth strain gage to zero (strain gages are enumerated starting at zero)</td></tr>
</table>

CGI threshold monitoring

Threshold monitoring can be switched off or on and must have an axis, comparison type, comparison count value, and output code defined.

Variable name	Value range	Description
setmce	0 or 1 (integer)	Enables (value=1) or disables (value=0) the threshold monitoring.
mcen	0 or 1 (integer)	Enables (value=1) or disables (value=0) en threshold n.
mcxn	–1 to 5 (integer)	Selects the axis evaluated by threshold statement n.
mcvn	–2147483648 to +2147483647 (integer)	Sets the count value to compare the current axis value with the threshold statement n.
mcon	0x00 to 0xFF (hexadecimal)	Sets the output code for threshold statement n.
n is an integer ranging from 0 to 15 that monitors the threshold statement index.		

Value	Description	Menu value
–1	disabled	blank
0	F_x–axis	F_x
1	F_y–axis	F_y
2	F_z–axis	F_z
3	M_x–axis	M_x
4	M_y–axis	M_Y
5	M_z–axis	M_z

CGI configuration

Analogous to the configuration page from the web browser interface, the output parameters of the force/torque sensor system can be specified here. When using config.cgi, the cfgid value indicates 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.

Variable name	Value range	Description
cfgid	0 to 15 (integer)	Zero-based index of the configuration to be set during this CGI call. This variable is required for all calls to config.cgi.
cfgnam	Text string of up to 16 characters	Name for configuration
cfgcalsel	0 to 15 (integer)	Sets the calibration used by the configuration.
cfgfu	1 to 6 (integer)	Sets the force units used by the configuration. This value determines the Counts per force and Max ratings values on the config.htm user web page.

Value	Description	Menu value
1	Pound-force	lbf
2	Newton	N
3	Kilopound-force	klbf
4	Kilonewton	kN
5	Kilogram-force	kgf
6	Gram-force	gf

cfgtu	1 to 6 (integer)	The torque units used by the configuration. This value determines the Counts per torque and Max ratings values on the config.htm user web page.

Value	Description	Menu value
1	Pound-force inch	lbf in
2	Pound-force feet	lbf ft
3	Newton meter	Nm
4	Newton millimeter	Nmm
5	Kilogram-force centimeter	kgf cm
6	Kilonewton meter	kNm

cfgtdu	1 to 5 (integer)	The distance measurement units used by the configuration's tool transformation.

Value	Description	Menu value

Variable name	Value range	Description		
		1	Inch	in
		2	Foot	ft
		3	Millimeter	mm
		4	Centimeter	cm
		5	Meter	m
cfgtau	1 or 2 (integer)	The rotation units used by the configuration's tool transformation.		
		Value	**Description**	**Menu value**
		1	Degrees [°]	Degrees
		2	Radius	Radian
cfgtfx0	Floating point number	Sets the tool transformation distance Dx. Distance must be in cfgtdu distance units.		
cfgtfx1	Floating point number	Sets the tool transformation distance Dy. Distance must be in cfgtdu distance units.		
cfgtfx2	Floating point number	Sets the tool transformation distance Dz. Distance must be in cfgtdu distance units.		
cfgtfx3	Floating point number	Sets the tool transformation rotation Rx. Rotation must be in cfgtau angular units.		
cfgtfx4	Floating point number	Sets the tool transformation rotation Ry. Rotation must be in cfgtau angular units.		
cfgtfx5	Floating point number	Sets the tool transformation rotation Rz. Rotation must be in cfgtau angular units.		
cfgusra	Text string of up to 16 characters	Stores text in user-defined field #1.		
cfgusrb	Text string of up to 16 characters	Stores text in user-defined field #2.		

CGI communications

Analogous to the Communications page from the web browser interface, the network settings for the NetBox are defined here.

Variable name	Value range	Description
comnetdhcp	0 or 1 (integer)	Sets DHCP behavior. **Value** **Description** 0 Use DHCP if available on the network 1 Use static IP address.
comnetip	Each IPV4 address in dot-decimal notation	Sets the static IP address when DHCP is disabled.
comnetmsk	Any IPV4 subnet mask in dot-decimal notation	Sets the static subnet mask when DHCP is disabled.
comnetgw	Each IPV4 address in dot-decimal notation	Sets the gateway to be used when DHCP is disabled.
comeipe	0 or 1 (integer)	Enables (value=1) or disables (value=0) the EtherNet/IP protocol. CAN bus must be selected if EtherNet/IP is enabled.
mcxn	-1 to 5 (integer)	Selects the CAN bus protocol. **Value** **Description** 0 CAN bus 1 DeviceNet compatibility mode protocol EtherNet/IP must be disabled if DeviceNet is enabled.
comrdte	0 or 1 (integer)	Enables (value=1) or disables (value=0) the RDT interface.
comrdtrate	1 to 7000 (integer)	Sets the RDT output rate in Hertz. The actual value used may be rounded up.
comrdtbsiz	1 to 40 (integer)	RDT buffer mode, buffer size

5.3.10 System settings XML pages

The current settings of the force/torque sensor system can be retrieved in XML format via standard EtherNet HTTP requests and allow programs to read out values, e.g. the Counts per force value. The Java demo application uses data provided in these XML pages to correctly scale the displayed data.

Data type	Description
DINT	Signed double integer (32 bit)
ENABL	Boolean using Enabled to represent 1 and Disabled to represent 0
HEXn	Hexadecimal number of n bits, prefixed with 0x.
INT	Signed integer (16 bit)
REAL	Floating-point number (32 bit)
SINT	Signed short integer (8 bit)
STRINGn	String of n characters
UDINT	Unsigned double integer (32 bit)
UINT	Unsigned integer (16 bit)
USINT	Unsigned short integer (8 bit)

The values of all data types are represented as ASCII strings. Arrays are represented when the suffix [i] is appended to the data type, where i represents the number of values in the array. Array values in an XML element can be separated by a semicolon, comma, or space.

System and configuration information (netftapi2.xml)

The XML page *netftapi2.xml* retrieves the system setup and the active configuration. To retrieve information of other configurations, these configurations must be made active before the request.

To do this, append "?index=n" to the request, where n is the index of the desired configuration. If no configuration index is specified, the active configuration is assumed. For example, to retrieve configuration information for the second configuration, the requested page would be *netftapi2.xml?index=1*.

The reference column in the following table indicates which .htm page and which .cgi function accesses this element.

XML element	Data type	Description	Reference
runstat	HEX32	System status code	–
runft	DINT[6]	Force and torque values in counts	rundata
runpkmx	DINT[6]	Maximum peak values in counts	rundata
runpkmn	DINT[6]	Minimum peak values in counts	rundata
runsg	INT[6]	Strain gage values	rundata
runmcb	HEX32	Thresholds breached	rundata
runmco	HEX8	Thresholds output	rundata
runmcl	USINT	Threshold latched	rundata
setcfgsel	USINT	Active configuration	setting
setuserfilter	USINT	Low-pass filter cutoff frequency menu selection	setting
setpke	USINT	Peak monitoring processing status	setting
setbias	DINT[6]	Software bias vector	setting
setmce	USINT	Threshold processing status	moncon
mce	USINT[16]	Threshold statements' individual enabling	moncon
mcx	USINT[16]	Threshold statements' selected axes	moncon
mcc	USINT[16]	Threshold statements' comparisons	moncon
mcv	DINT[16]	Threshold statements' counts values for comparison	moncon
mco	HEX8[16]	Threshold statements' output codes	moncon

XML element	Data type	Description	Reference
cfgnam	STRING32	Name of active configuration	config
cfgcalsel	USINT	Calibration used by active configuration	config
cfgcalsn	STRING8	Serial number of active configuration's calibration	config
cfgfu	USINT	Force units used by active configuration	config
scfgfu	STRING8	Name of force units used by active configuration	config
cfgtu	USINT	Torque units used by active configuration	config
scfgtu	STRING8	Name of torque units used by active configuration	config
cfgcpf	DINT	Counts per force as determined by the active configuration settings	config
cfgcpt	DINT	Counts per torque as determined by the active configuration settings	config
cfgmr	REAL[6]	Calibrated sensing ranges in units as determined by the active configuration settings	config
cfgtdu	USINT	Tool transformation distance units used by active configuration	config
scfgtdu	STRING16	Name of tool transformation distance units used by active configuration	config
cfgtau	USINT	Tool transformation rotation units used by active configuration	config
scfgtau	STRING8	Name of tool transformation rotation units used by active configuration	config
cfgtfx	REAL[6]	Tool transformation distances and rotations applied by active configuration	config

XML element	Data type	Description	Reference
cfgusra	STRING16	User-defined field #1 for the active configuration	config
cfgusrb	STRING16	User-defined field #2 for the active configuration	config
comnetdhcp	ENABL	DHCP behavior setting	comm
comnetip	STRING15	Static IP address	comm
comnetmsk	STRING15	Static IP subnet mask	comm
comnetgw	STRING15	Static IP gateway	comm
comeipe	ENABL	EtherNet/IP protocol setting	comm
nethwaddr	STRING17	EtherNet MAC address	comm
comdnte	ENABL	CAN bus protocol setting	comm
comdntmac	USINT	DeviceNet MAC ID	comm
comdntbaud	USINT	CAN network baud rate: 0 = 125 kHz 1 = 250 kHz 2 = 500 kHz 3 = SoftSet	comm
comrdte	ENABL	RDT interface setting	comm
comrdtrate	UDINT	RDT output rate	comm
comrdtbsiz	USINT	RDT buffer mode, buffer size	comm
mfgdighwa	STRING17	EtherNet MAC address	manuf
mfgdigsn	STRING8	Digital board serial number	manuf
mfgdigver	STRING8	Digital board firmware revision	manuf
mfgdigrev	STRING8	Digital board hardware revision	manuf
mfganasn	STRING8	Analog board serial number	manuf
mfganarev	STRING8	Analog board hardware revision	manuf
mfgtxdmdl	STRING16	Analog board location	manuf
netip	STRING15	IP address in use	–
runrate	UDINT	Internal sample rate for strain gage collection	–

Calibration information (netftcalapi.xml)

The netftcalapi.xml XML page retrieves information about a specific calibration. The calibration information retrieved was not changed by any of the force/torque system configuration settings.

A calibration index can be specified during the request. To do this, append "?index=n" to the request, where n is the index of the desired configuration. If no configuration index is specified, the active configuration is assumed.

For example, to retrieve calibration information for the third calibration, the requested page would be *netftcalapi.xml?index=2*.

XML element	Data type	Calibration information
calsn	STRING8	Serial number
calpn	STRING32	Calibration type
caldt	*STRING20*	Calibration date
calfu	USINT	Force units (refer to config.cgi variable cfgfu for values)
scalfu	STRING8	Name of force units
caltu	USINT	Torque units used (refer to config.cgi variable cfgtu for values)
scaltu	*STRING8*	Name of torque units
calmr	REAL[6]	Calibrated sensing ranges in calfu and caltu units
calcpf	DINT	Counts per force unit
calcpt	DINT	Counts per torque unit
calsf	DINT[6]	Scaling factor for DeviceNet and CAN
calusra	STRING16	Calibration note field #1
calusrb	STRING16	Calibration note field #2

5.3.11 CIP model EtherNet/IP and DeviceNet

NOTE

EtherNet/IP and DeviceNet protocols cannot be enabled simultaneously.

Further information on the two connection options, ▸ 5.3.5 [🗋 52] and ▸ 5.3.3 [🗋 43].

Name	Value
Supplier number	555
Device type	0
Product code number	1
Product name	ATI Industrial Automation F/T

Tab.: Name and data value

WORD (16-bit)	Name
0	Status word, bits 16 to 31
1	Fx (16 bit)
2	Fy (16 bit)
3	Fz (16 bit)
4	Tx (16 bit)
5	Ty (16 bit)
6	Tz (16 bit)

Tab.: DeviceNet input bitmap

DWORD (32 bit)	Name
0	Status word (32 bit)
1	Fx (32 bit)
2	Fy (32 bit)
3	Fz (32 bit)
4	Tx (32 bit)
5	Ty (32 bit)
6	Tz (32 bit)

Tab.: EtherNet/IP input bitmap

NOTE

There is no output data if the EtherNet/IP 02T Data option is disabled on the "Communications" page.

Byte	Bit number	Name	Description/Function
0	0	BIAS/zeroing	Execute tare function to set any load measurement values to zero
	1	Reset latch	Reset threshold latch
	2	reserved	reserved
	3	reserved	reserved
	4	reserved	reserved
	5	reserved	reserved
	6	reserved	reserved
	7	reserved	reserved
1	0	Config Select Bit 0	Selects a Net F/T configuration, from 0 to 15
	1	Config Select Bit 1	
	2	Config Select Bit 2	
	3	Config Select Bit 3	
	4	reserved	reserved
	5	reserved	reserved
	6	reserved	reserved
	7	reserved	reserved
2	0–7	Threshold high	Threshold enable mask, high byte
3	0–7	Threshold low	Threshold enable mask, low byte

Tab.: EtherNet/IP output mapping

5.3.11.1 Calculating FT values for CIP

EtherNet/IP

For the 16-bit format: To obtain the actual force and torque values, an "idle" value is reported as +32768 counts, a negative full load is reported as approximately 0 counts, and a positive full load is reported as approximately 65536 counts. Each force value received must be divided by *(Counts per force ÷ Scaling factor for DeviceNet and CAN)* for the axis and each torque value received must be divided by *(Counts per torque ÷ Scaling factor for DeviceNet and CAN)* for the axis.

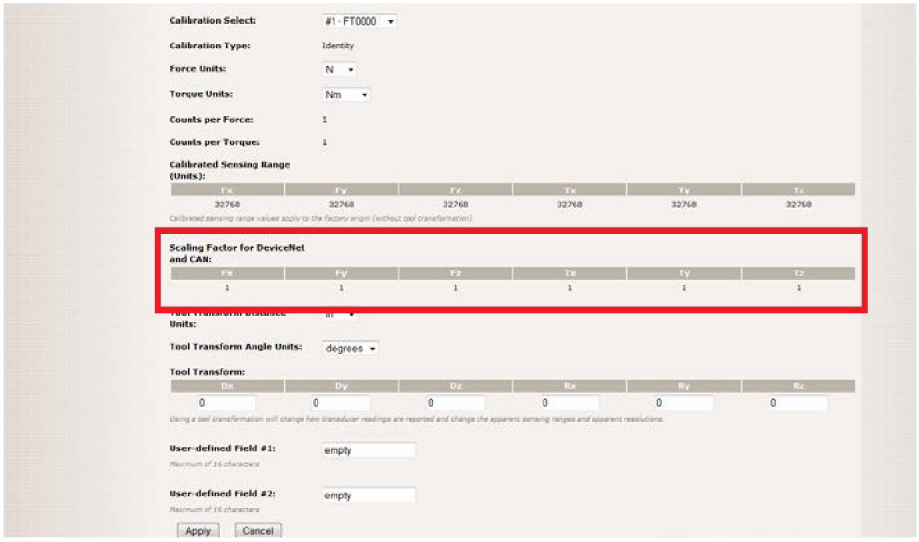
For the calculation, use the scaling factors from the corresponding configuration, which is usually the active configuration.

For the 32-bit format: To obtain the real force and torque values, each force output value must be divided by the "Counts per force" factor and each torque output value must be divided by the "Counts per torque" factor.

The "Counts per force" and "Counts per torque" factors can be called up via the "Configurations" web browser interface.

DeviceNet

To reduce the amount of data transmitted via DeviceNet, the force and torque values are reduced to 16 bits before transmission using the scaling factor for DeviceNet and CAN values.



Scaling factors for DeviceNet and CAN (from the website)

For the calculation, use the scaling factors from the corresponding configuration, which is usually the active configuration.

To obtain the force and torque values in user units, each force value received must be divided by *(Counts per force ÷ Scaling factor for DeviceNet and CAN)* for the axis and each torque value received must be divided by *(Counts per torque ÷ Scaling factor for DeviceNet and CAN)* for the axis.

The counts per force, counts per torque and the scaling factor for DeviceNet and CAN factors can be accessed in the "Configurations" web browser interface.

5.3.11.2 Object model

Data types

Data type	Description
BOOL	Boolean
BYTE	Bit string (8 bit)
DINT	Signed double integer (32 bit)
DWORD	Bit string (32 bit)
INT	Signed integer (16 bit)
REAL	Floating point
SHORT_STRING	Character string (1 byte per character, 1 byte length indicator)
SINT	Signed short integer (8 bit)
STRING	Character string (1 byte per character)
UDINT	Unsigned double integer (32 bit)
UINT	Unsigned integer (16 bit)
USINT	Unsigned short integer (8 bit)
WORD	Bit string (16 bit)

Tab.: Description of all data types used in the object model

EtherNet/IP

To obtain the actual force and torque values, each force output value must be divided by the "Counts per force" factor and each torque output value must be divided by the "Counts per torque" factor.

Attribute ID	Name	Data type	Default data value	Access rule
1	Revision	UINT	N/A	Get
2	Max. instance	UINT	6	Get
3	Number of instances	UINT	6	Get
100	BIAS/Zeroing *	USINT	N/A	Set

Tab.: Name and data value

* A value other than zero causes BIAS/zeroing, a value of zero cancels BIAS/zeroing of the transducer readings.

Attribute ID	Name	Data type	Default data value	Access rule
1	Raw measured value	INT	N/A	Get
2	Gage bias	INT	N/A	Get/Set

*Tab.: Instance attributes (instance 1-6) **

* The 1st instances 1-6 correspond to gages 0-5 respectively.

Service codes	Class level	Instance level	Service name
0x0E	Yes	Yes	Get_Attribute_Single
0x10	No	Yes	Set_Attribute_Single

*Tab.: Instance attributes (instance 1-6) **

* The 1st instances 1–6 correspond to gages 0–5 respectively.

FT sensor (0x65-6 instances)

Attribute ID	Name	Data type	Default data value	Access rule
1	Revision	UINT	1	Get
2	Max. instance	UINT	6	Get
3	Number of instances	UINT	6	Get

Tab.: Class attributes (instance 0)

Attribute ID	Name	Data type	Default data value	Access rule
1 **	Resolved axis data (32 bit)	DINT	N/A	Get
2	Resolved axis data (16 bit) (for DeviceNet)	INT	N/A	Get
3	Minimum peak value	DINT	N/A	Get/Set ***
4	Maximum peak value	DINT	N/A	Get/Set ***

*Tab.: Instance attributes (instance 1-6) **

* Instances 1, 2, 3, 4, 5, 6 correspond to axes Fx, Fy, Fz, Tx, Ty, Tz, respectively.

** When 16-bit unsigned data is enabled, the upper 16 bits always remain 0 and the lower 16 bits are the unsigned 16-bit F/T data.

*** Each attribute value set resets the specified peak value.

Service code	Implementation on		Service name
	Class level	Instance level	
0x0E	Yes	Yes	Get_Attribute_Single
0x10	No	Yes	Set_Attribute_Single

Tab.: Common services

FT sensor (0x65-6 instances)

Attribute ID	Name	Data type	Default data value	Access rule
1	Revision	UINT	1	Get

Tab.: Class attributes (instance 0)

Attribute ID	Name	Data type	Default data value	Access rule
1	Thresholds breached	DWORD	N/A	Get
2	Thresholds output result	BYTE	N/A	Get
3	Threshold latched	BOOL	N/A	Get/Set *

Tab.: Instance attributes (instance 1-6)

* Each attribute value set sets the value to *FALSE*.

Service code	Implementation on		Service name
	Class level	Instance level	
0x0E	Yes	Yes	Get_Attribute_Single
0x10	No	Yes	Set_Attribute_Single

Tab.: Common services

System status object (0x67-1 instances)

Attribute ID	Name	Data type	Default data value	Access rule
1	Revision	UINT	1	Get

Tab.: Class attributes (instance 0)

Attribute ID	Name	Data type	Default data value	Access rule
1	Status code (32 bit)	DWORD	N/A	Get
2	Status code (16 bit) *	BYTE	N/A	Get

Tab.: Instance attributes (instance 1-6)

* This attribute is dimensioned for DeviceNet.

Service code	Implementation on		Service name
	Class level	Instance level	
0x0E	Yes	Yes	Get_Attribute_Single

Tab.: Common services

Object configurations (0x71-16 instances)

Attribute ID	Name	Data type	Default data value	Access rule
1	Name configuration	SHORT_STRING[32]	N/A	Get/Set
2	Calibration selection (0 to 15)	USINT	N/A	Get/Set
3	Type of calibration selection	SHORT_STRING[32]	N/A	Get
4	User-force units *	BYTE	N/A	Get/Set
5	User torque units **	BYTE	N/A	Get/Set
6	User transformation - Dx	REAL	N/A	Get/Set
7	User transformation - Dy	REAL	N/A	Get/Set
8	User transformation - Dz	REAL	N/A	Get/Set
9	User transformation - Rx	REAL	N/A	Get/Set
10	User transformation - Ry	REAL	N/A	Get/Set
11	User transformation - Rz	REAL	N/A	Get/Set
12	User transformation distance units ***	BYTE	N/A	Get/Set
13	User transformation angle units ****	BYTE	N/A	Get/Set
14	User counts per force unit	UINT	N/A	Get
15	User counts per torque unit	UINT	N/A	Get
16	User max. rating - Fx	REAL	N/A	Get
17	User max. rating - Fy	REAL	N/A	Get
18	User max. rating - Fz	REAL	N/A	Get
19	User max. rating - Tx	REAL	N/A	Get
20	User max. rating - Ty	REAL	N/A	Get

Attribute ID	Name	Data type	Default data value	Access rule
21	User max. rating - Tz	REAL	N/A	Get
100	User-defined field #1	SHORT_STRING[16]	N/A	Get/Set
101	User-defined field #2	SHORT_STRING[16]	N/A	Get/Set

* Variable cfgfu, ▶ 5.3.9 [🗋 70]

** Variable cfgtu, ▶ 5.3.9 [🗋 70]

*** Variable cfgtdu, ▶ 5.3.9 [🗋 70]

**** Variable cfgtau, ▶ 5.3.9 [🗋 70]

Service code	Implementation on		Service name
	Class level	Instance level	
0x0E	Yes	Yes	Get_Attribute_Single
0x10	No	Yes	Set_Attribute_Single

Tab.: Common services

Thresholding settings object (0x73-32 instances)

Attribute ID	Name	Data type	Default data value	Access rule
1	Revision	UINT	1	Get
2	Max. instance	UINT	32	Get
3	Number of instances	UINT	32	Get

Tab.: Class attributes (instance 0)

Attribute ID	Name	Data type	Default data value	Access rule
1 **	Enable/Disable	BOOL	N/A	Get/Set
2	Axis number *	SINT	N/A	Get/Set
3	Comparison **	SINT	N/A	Get/Set
4	Counts value	DINT	N/A	Get/Set
5	Output code	BYTE	N/A	Get/Set

*Tab.: Instance attributes (instance 1-32) **

* Variable mcxn, ▶ 5.3.9 [🗋 70]

** Variable mccn, ▶ 5.3.9 [🗋 70]

Service code	Implementation on		Service name
	Class level	Instance level	
0x0E	Yes	Yes	Get_Attribute_Single
0x10	No	Yes	Set_Attribute_Single

Tab.: Common services

6 Troubleshooting

6.1 System status code

During each measurement, a system status code is stored and output in addition to numerous diagnostic checks.

The bit patterns for all present error conditions together form the system status code. If an error is present, bit 31 of the system status code is set. Bit 16 is set if a threshold is latched. This bit does not indicate a system error.

Bit	Bit pattern	Description
31	0x80000000	Error bit (set if any error condition exists)
30	0x40000000	CPU or RAM error
29	0x20000000	Digital board error
28	0x10000000	Analog board error
27	0x08000000	Serial link communication error
26	0x04000000	Program memory verification error
25	0x02000000	Halted due to configuration errors
24	0x01000000	Settings validation error
23	0x00800000	Configuration settings incompatible with transducer calibration
22	0x00400000	Network communication failure
21	0x00200000	CAN communication error
20	0x00100000	RDT communication error
19	0x00080000	EtherNet/IP protocol failure
18	0x00040000	DeviceNet-compatibility mode protocol failure
17	0x00020000	Transducer saturation or A/D operation error
16	0x00020000	Threshold latched
15	0x00008000	reserved
14	0x00004000	Watchdog timeout error
13	0x00002000	Stack check error
12	0x00001000	Serial EEPROM I2C communications failure
11	0x00000800	Serial flash SPI communications failure
10	0x00000400	Analog board watchdog timeout error
9	0x00000200	Excessive strain gage excitation current
8	0x00000100	Insufficient strain gage excitation current
7	0x00000080	Artificial analog ground out of range
6	0x00000040	Analog board power supply too high
5	0x00000020	Analog board power supply too low

Bit	Bit pattern	Description
4	0x00000010	Serial link data unavailable
3	0x00000008	Reference voltage or power monitoring error
2	0x00000004	Internal temperature error
1	0x00000002	HTTP protocol failure
0	0x00000001	reserved
–	0x00000000	Healthy

6.2 Status word

The status word is a bitmap that contains information about the errors that occur in various subsystems of the FT sensor.

Bit	Description
0	Watchdog reset – the analog board was reset by the watchdog timer.
1	Excitation voltage too high
2	Excitation voltage too low
3	Artificial analog ground out of range (above 0.007 V).
4	Power supply too high (> 25 V).
5	Power supply too low (< 10 V).
6	Not used.
7	Error accessing stored settings in EEPROM – EEPROM hardware did not respond.
8	Invalid configuration data (baud rate).
9	Strain gage bridge supply current too high (> 3 V on current sense).
10	Not used (strain gage bridge supply current was too low)
11	Thermistor too high (> 100°C (1.5 V on thermistor)).
12	Thermistor too low. (< -40°C (0.1 V on thermistor).
13	Not used (DAC reading was out of range)
14	Not used.
15	Any error sets this bit.

6.3 Voltage supply

Error	Possible solution
The Xdcr LED lights up red 20 seconds after the NetBox is rebooted.	Check force/torque sensor cable for damage and correct connection. There is an internal error in the NetBox.
The LS EN LED does not light up green.	Check EtherNet cable for damage and correct connection.

6.4 Communication error

Error	Possible solution
The IP address is assigned incorrectly.	Check IP address, ▸ 5.3.3 [🗋 43].
No IP address assigned by DHCP.	Connect EtherNet cable at reboot. DHCP was not selected correctly, ▸ 5.3.3 [🗋 43].
The NetBox is not found in the Internet browser although an IP address was assigned.	Clear the ARP table on the computer to remove possible devices previously used with the same IP address. Restart the computer. Open Windows Start, select "Run" and enter "arp -d*".
An incorrect CAN bus base address, DeviceNet Mac ID and/or transmission rate is specified.	The Pwr/CAN connector must be connected correctly.
The system status indicates a DeviceNet protocol error.	Check the connection at the Pwr/CAN connector.

6.5 Demo program (Java)

Error	Possible solution
The demo program displays "0" for the forces and torques and "?" for the configuration data.	Check the IP address and restart the demo program.
Error message "Could not find the main class" and is closed.	A newer Java version is required.
Error message "Excessive IO exception" and timeout.	The EtherNet connection has been interrupted. Check that the EtherNet cable and voltage supply are connected correctly.
Error message "IO exception". The demo program cannot find the stored file because the path is no longer correct or it has been renamed.	Name file correctly or create new file.

6.6 Force/torque sensor

Error	Possible solution
Sat-LED lights up red.	Force/torque sensor is subject to a load or signal that is outside the range of measurement. Stop applying force and wait until the LED is no longer red and the error disappears.
Signal noise is caused by mechanical vibration or electrical interference, or because a component in the force/torque sensor system has failed.	Ensure that the system is properly grounded and isolated from external electrical interference.
Measured values are not completely reset after loading and unloading or there is an internal error in the overall system.	Drift is caused, for example, by rapid temperature changes. Have the force/torque sensor adjusted to the ambient temperature before measuring again. Operate all components separately. Thoroughly clean the sensor body and adapter plate of contamination.

6.7 Web browser interface

Error	Possible solution
The "Invalid Request page" is displayed.	One or more entries on the page are invalid. Find errors and correct information.
The page "HTTP 1.0 401 Error- Unauthorized page" is displayed.	ATI is performing server maintenance. Try accessing again later.

7 Maintenance

CAUTION

Material damage due to improper disassembly!

Incorrect works can cause damage to the mechanics and internal electronics.

- Disassembly or opening of the product is not permitted.
- Only allow SCHUNK to repair the product.

This product must not be disassembled for maintenance.

Maintenance intervals

Maintenance interval	Maintenance work
weekly	Check all parts for damage and wear.
as required	Send damaged products to SCHUNK for repair.

8 EU Declaration of Conformity

Manufacturer/ Distributor	SCHUNK SE & Co. KG Spanntechnik | Greiftechnik | Automatisierungstechnik Bahnhofstr. 106 – 134 D–74348 Lauffen/Neckar

We hereby declare on our sole authority that the product meets the requirements of the following directives at the time of the declaration.
The declaration is rendered invalid if modifications are made to the product.

Product designation:	Force/torque sensor system FTN This declaration of conformity is valid for all variants mentioned in the appendix.

- **Electromagnetic compatibility (EMC directive) 2014/30/EU**

Applied harmonized standards, especially:

IEC 61326–2:2022	Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 2–3: Particular requirements – Test configuration, operational conditions and performance criteria for transducers with integrated or remote signal conditioning (IEC 61326–2–3:2020)

All related technical documentation has been prepared in electronic form according to Directive 2014/30/EU and will be made available to national authorities on demand. The signatory is resident at the manufacturer's address and is authorized to compile this documentation.

Signed for and on behalf of: SCHUNK SE & Co. KG

Lauffen/Neckar, November 2022

Signature: see original declaration

Dr.-Ing. Manuel Baumeister, Technology & Innovation

9 UKCA Declaration of Conformity

Manufacturer/ Distributor	SCHUNK Intec Limited Clamping and gripping technology 3 Drakes Mews, Crownhill MK8 0ER Milton Keynes

We hereby declare on our sole authority that the product meets the requirements of the following directives at the time of the declaration.
The declaration is rendered invalid if modifications are made to the product.

Product designation:	Force/torque sensor system FTN
ID number	

- **Electromagnetic Compatibility Regulations 2016**

Applied harmonized standards, especially:

IEC 61326-2:2022	Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 2-3: Particular requirements – Test configuration, operational conditions and performance criteria for transducers with integrated or remote signal conditioning (IEC 61326-2-3:2020)

Person authorized to compile the technical documentation:
Marcel Machado, address: refer to manufacturer's address

Signed for and on behalf of: SCHUNK SE & Co. KG

Lauffen/Neckar, November 2022

Dr.-Ing. Manuel Baumeister, Head of Systems Engineering, Technology & Innovation

10 Appendix to the declaration of conformity

This declaration of conformity is valid for all variants of the force/torque sensor mentioned in this appendix.

FTD-interface

FTD-Nano-17 SI-12-0.12
FTD-Nano-17 SI-25-0.25
FTD-Nano-17 SI-50-0.5
FTD-Nano-17-T SI-8-0.05
FTD-Nano-17-T SI-16-0.1
FTD-Nano-17-T SI-32-0.2
FTD-Nano-25 SI-125-3
FTD-Nano-25 SI-250-6
FTD-Nano-43 SI-9-0.125
FTD-Nano-43 SI-18-0.25
FTD-Nano-43 SI-36-0.5
FTD-Mini-40 SI-20-1
FTD-Mini-40 SI-40-2
FTD-Mini-40 SI-80-4
FTD-Mini 43 SI-62-0.75
FTD-Mini 43 SI-125-1.5
FTD-Mini 43 SI-250-3
FTD-Mini-45 SI-145-5
FTD-Mini-45 SI-290-10
FTD-Mini-45 SI-580-20
FTD-Mini-58 SI-700-30
FTD-Mini-58 SI-1400-60
FTD-Mini-58 SI-2800-120
FTD-Mini-85 SI-475-20
FTD-Mini-85 SI-950-40
FTD-Mini-85 SI-1900-80
FTD-Gamma SI-32-2.5
FTD-Gamma SI-65-5
FTD-Gamma SI-130-10
FTD-Delta SI-165-15
FTD-Delta SI-330-30
FTD-Delta SI-660-60
FTD-Theta SI-1000-120
FTD-Theta SI-1500-240
FTD-Theta SI-2500-400

FTD-Omega85 SI-475-20
FTD-Omega85 SI-950-40
FTD-Omega85 SI-1900-80
FTD-Omega-160 SI-1000-120
FTD-Omega-160 SI-1500-240
FTD-Omega-160 SI-2500-400
FTD-Omega-191 SI-1800-350
FTD-Omega-191 SI-3600-700
FTD-Omega-191 SI-7200-1400
FTD-Omega-250 SI 4000 500
FTD-Omega-250 SI 8000 1000
FTD-Omega-250 SI-16000-2000
FTD-Omega-331 SI-10000-1500
FTD-Omega-331 SI-20000-3000
FTD-Omega-331 SI-40000-6000

FTN-interface

FTN-Nano-17 SI-12-0.12
FTN-Nano-17 SI-25-0.25
FTN-Nano-17 SI-50-0.5
FTN-Nano-17-T SI-8-0.05
FTN-Nano-17-T SI-16-0.1
FTN-Nano-17-T SI-32-0.2
FTN-Nano-25 SI-125-3
FTN-Nano-25 SI-250-6
FTN-Nano-43 SI-9-0.125
FTN-Nano-43 SI-18-0.25
FTN-Nano-43 SI-36-0.5
FTN-Mini-40 SI-20-1
FTN-Mini-40 SI-40-2
FTN-Mini-40 SI-80-4
FTN-Mini 43 SI-62-0.75
FTN-Mini 43 SI-125-1.5
FTN-Mini 43 SI-250-3
FTN-Mini-45 SI-145-5
FTN-Mini-45 SI-290-10
FTN-Mini-45 SI-580-20
FTN-Mini-58 SI-700-30
FTN-Mini-58 SI-1400-60
FTN-Mini-58 SI-2800-120

FTN-Mini-85 SI-475-20
FTN-Mini-85 SI-950-40
FTN-Mini-85 SI-1900-80
FTN-Gamma SI-32-2.5
FTN-Gamma SI-65-5
FTN-Gamma SI-130-10
FTN-Delta SI-165-15
FTN-Delta SI-330-30
FTN-Delta SI-660-60
FTN-Theta SI-1000-120
FTN-Theta SI-1500-240
FTN-Theta SI-2500-400
FTN-Omega85 SI-475-20
FTN-Omega85 SI-950-40
FTN-Omega85 SI-1900-80
FTN-Omega 160 SI 1000 120
FTN-Omega-160 SI-1500-240
FTN-Omega 160 SI 2500 400
FTN-Omega-191 SI-1800-350
FTN-Omega-191 SI-3600-700
FTN-Omega-191 SI-7200-1400
FTN-Omega-250 SI-4000-500
FTN-Omega 250 SI-8000-1000
FTN-Omega 250 SI 16000 2000
FTN-Omega-331 SI-10000-1500
FTN-Omega-331 SI-20000-3000
FTN-Omega 331 SI-40000-6000

FTE-interface

FTE-Nano-17 SI-12-0.12
FTE-Nano-17 SI-25-0.25
FTE-Nano-17 SI-50-0.5
FTE-Nano-17-T SI-8-0.05
FTE-Nano-17-T SI-16-0.1
FTE-Nano-17-T SI-32-0.2
FTE-Nano-25 SI-125-3
FTE-Nano-25 SI-250-6
FTE-Nano-43 SI-9-0.125
FTE-Nano-43 SI-18-0.25
FTE-Nano-43 SI-36-0.5

FTE-Mini-40 SI-20-1
FTE-Mini-40 SI-40-2
FTE-Mini-40 SI-80-4
FTE-Mini 43 SI-62-0.75
FTE-Mini 43 SI-125-1.5
FTE-Mini 43 SI-250-3
FTE-Mini-45 SI-145-5
FTE-Mini-45 SI-290-10
FTE-Mini-45 SI-580-20
FTE-Mini-58 SI-700-30
FTE-Mini-58 SI-1400-60
FTE-Mini-58 SI-2800-120
FTE-Mini-85 SI-475-20
FTE-Mini-85 SI-950-40
FTE-Mini-85 SI-1900-80
FTE-Gamma IP65 SI-32-2.5
FTE-Gamma IP65 SI-65-5
FTE-Gamma-IP65 SI-130-10
FTE-Delta-IP60 SI-165-15
FTE-Delta-IP65 SI-165-15
FTE-Delta-IP60 SI-330-30
FTE-Delta-IP65 SI-330-30
FTE-Delta-IP60 SI-660-60
FTE-Delta IP65 SI-660-60
FTE-Omega 160-IP60 SI 1000-120
FTE-Omega 160-IP65 SI 1000-120
FTE-Omega 160-IP60 SI 1500-240
FTE-Omega 160-IP65 SI 1500-240
FTE-Omega 160-IP60 SI 2500-400
FTE-Omega 160-IP65 SI 2500-400
FTE-Omega 250 IP60 SI 4000 500
FTE-Omega 250-IP60 SI-8000-1000
FTE-Omega 250-IP60 SI-16000-2000

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