Integrating ATI EtherCAT Force/Torque Sensors with KUKA® FTCtrl

Manual

Document #: 9620-05-D-ATI KUKA FTCtrl

Engineered Products for Robotic Productivity

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Foreword

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For terms and conditions of sale, refer to the *website* or contact an ATI representative.

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Note:

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

1. Serial number (e.g., FT01234)
2. Sensor model (e.g., Axia90-M50)
3. Calibration (e.g., US-15-50, SI-65-6, etc.)
4. Accurate and complete description of the question or problem.
5. Robot model, controller model, controller software version, and installed KUKA FTCtrl options.

Be near the F/T system when calling (if possible). For questions specific to KUKA-provided software or hardware, please contact KUKA's technical support.

Please contact an ATI representative for assistance, if needed:

Sale, Service and Information about ATI products:

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Glossary

Term	Definitions
Control Code	An output command signal that corresponds to a feature of the ATI sensor, for example: Bias, Filter selection, set Sample Rate, and select Calibration. Bit maps of control codes are available in the ATI manual for the sensor.
Counts	Data type that the ATI sensor reports Force/Torque values. To convert to user units, the Counts must be divided by a scaling factor like Counts per Force (CpF) or Counts per Torque (CpT).
Data Rate	How fast data is output over the network.
DINT	A (32) bit data type that represents a signed double integer.
ESI	EtherCAT Slave Information (ESI) is an ATI-provided EtherCAT (*.XML) file type that defines the ATI EtherCAT sensor product in the installation of WorkVisual.
EtherCAT	An industrial automation fieldbus.
Ethernet	A family of computer networking technologies commonly used in local area networks.
Force	A force is a push or pull action on an object caused by an interaction with another object. Force = mass x acceleration
FTCtrl	KUKA's Integrated ForceTorqueOption (FTCtrl) is an add-on package that allows the robot to react in real-time to its surrounding and to deviate from its programed path or speed, based on feedback from the force sensor.
FT or F/T	Force and Torque.
IO or I/O	Input and Output.
Interface Plate	A separate plate that attaches the sensor to another surface. Interface plates are often used if the bolt pattern on the sensor doesn't match the bolt pattern on the robot arm or customer tooling. The interface plate has two bolt patterns, one on either side of the plate. One side is for the sensor. The other side is for the robot arm or customer tooling.
N/A	Not applicable.
P/N	Part Number
Power Cycle	When a user removes and then restores power to a device.
Real-type Variable	An advanced programming feature where the end user can convert binary IO to REAL numbers (32 bit floating point number) that are stored in variables.
Sensor	The component that converts a detected load into electrical signals.
Sensor System (or configuration)	The entire assembly consisting of a sensor body and a system interface to translate force and torque signals into a specific communication interface/protocol.
Torque	The application of a force through a lever or moment arm that causes something to want to turn. For example, a user applies torque to a screw to make it turn. Torque = force x moment arm
UDINT	A (32) bit type that represents an unsigned double integer.
User Units	The end user's units of measurement such as Newtons (N) and Newton meter (Nm).
WorkVisual (or KUKA. WorkVisual)	A KUKA software package that is a development environment for configuring, programming, and troubleshooting a KUKA industrial robot or customer-specific kinematic system. The end user must install this software on a laptop or PC.

1. Safety

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

1.1 Explanation of Notifications

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

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

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

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

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

1.2 General Safety Guidelines

The customer should verify that the sensor is rated for the maximum load and torque expected during operation. Because static forces are less than the dynamic forces from the acceleration or deceleration of the robot, be aware of the dynamic loads caused by the robot.

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

2. Product Overview

ATI 6-axis Force Torque (F/T) sensors are a high performance option for use with KUKA®'s ForceTorqueControl software. KUKA's Integrated ForceTorqueControl option (FTCtrl) allows the robot to react in real-time to its surroundings and to deviate from its programmed path or speed, based on feedback from the force sensor.

While the ATI Ethernet (NET) F/T sensor with Net Box is the preferred product for use with KUKA. ForceTorqueControl, ATI's EtherCAT Axia and other EtherCAT F/T sensors are also compatible. Specifically for ATI's low-cost Axia line, only the EtherCAT version Axia is compatible. For more information about ATI sensor models, refer to the *ATI website*.

For more information about KUKA products, refer to *https://www.kuka.com/*. To access KUKA manuals, log-in to their *customer portal* or contact a representative at KUKA.

This manual includes these main how-to topics:

- Step-by-step instructions of how to integrate ATI F/T sensors into KUKA Digital IO and then into KUKA FTCtrl software in *Section 4—Software Setup*.
- A brief overview of how to convert I/O signals into KRL variables in *Section 6.3—Use F/T Data as REAL-type Variables*.

2.1 System Components

To use ATI EtherCAT F/T sensors within a KUKA system, verify the following hardware and software requirements are met:

2.1.1 ATI

For a general image of Axia and standard F/T sensor configurations, refer to *Figure 2.1*, *Figure 2.2*, and *Figure 2.3*.

Sensor

- Standard EtherCAT F/T: contact an *ATI applications engineer* for more information
- Axia EtherCAT F/T: refer to the Axia *webpage*

NOTICE: Examples in this manual use an ATI EtherCAT Axia80 sensor: ATI P/N 9105-ECAT-AXIA80.

NOTICE: ATI Ethernet (NET) F/T with Net Box (a different product from the EtherCAT sensors described in this manual) is the preferred, easily integrated sensor interface for use with KUKA FTCtrl. Instructions for the integration of NET F/T sensors with KUKA FTCtrl is included in the KUKA FTCtrl documentation. For ATI's low-cost Axia line, only the EtherCAT Axia version is compatible.

Interface Plate

- Mounting Adapter Plate (MAP), customer or ATI supplied, from sensor to the robot
- Tool Adapter Plate (TAP), customer or ATI supplied, from sensor to the tool

NOTICE: If using a large, non-IP rated sensor with removable MAP, it may be possible to machine the mounting patterns directly into the MAP. For mounting information, refer to the *ATI Transducer Section F/T manual*.

Cable

- CAT5 or higher EtherCAT cable from sensor to KUKA's RJ45 EtherCAT Extension Bus port
- For the ATI EtherCAT Axia, ATI provides two cables for power and EtherCAT connection (refer to the *ATI F/T EtherCAT Axia manual*).
- For other ATI EtherCAT F/T sensors, contact ATI F/T applications support (*ft.support@novanta.com*) for the correct cable.

Software

- EtherCAT ESI (*.XML) file, which is available to download from the ATI website
- For EtherCAT Axia, refer to *https://www.ati-ia.com/Products/ft/software/axia_software.aspx*.
- For other EtherCAT F/T, refer to *https://www.ati-ia.com/Products/ft/software/SysSoftwareTemplates.aspx?family=8*.

Reference Materials

- *ATI EtherCAT Axia Manual*
- *ATI EtherCAT F/T Manual*

Figure 2.1—ATI F/T Axia Components (parts may vary)

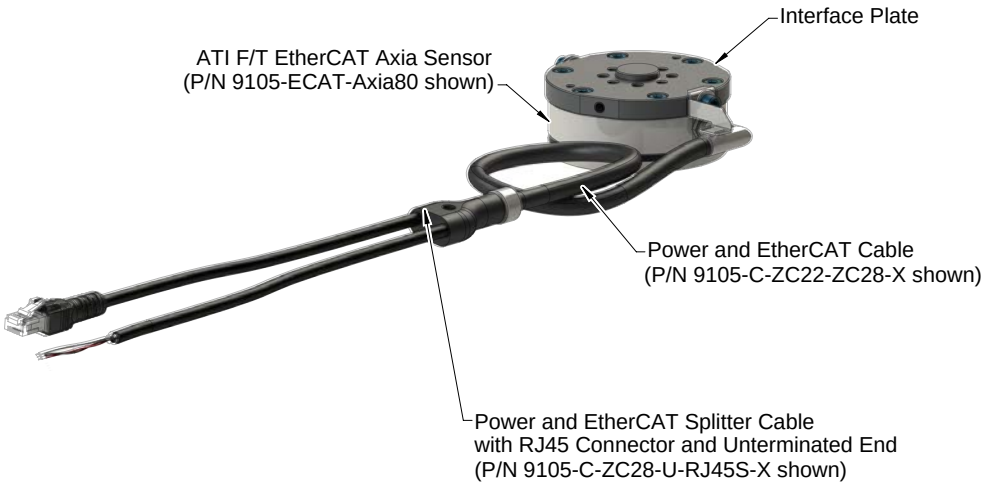


Figure 2.2—ATI F/T Standard Components with Power Supply (parts may vary)

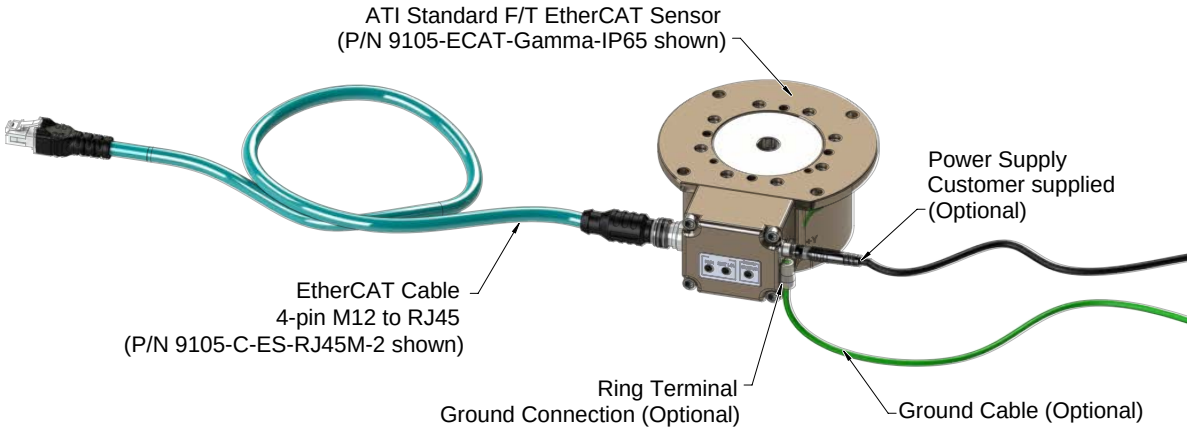
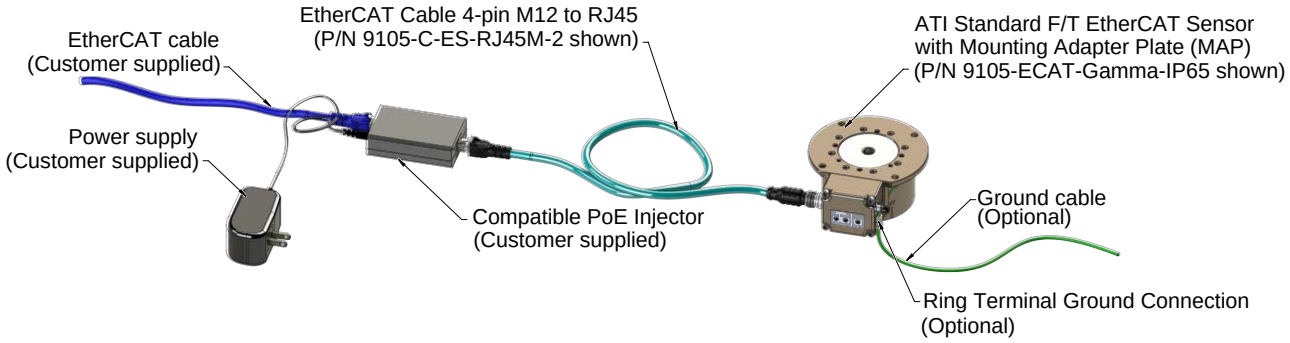


Figure 2.3—ATI F/T Standard Components with PoE (parts may vary)



2.1.2 KUKA

Contact a KUKA sales or applications representative to ensure the correct components for the robot and controller. Be sure to specify a preference for an ATI sensor system.

Hardware

- KRC4 or newer robot controller if using KUKA FTCtrl
- Access to KRC's X44 EtherCAT Extension bus (or KEI Interface for KRC5 controllers)
- PC on Robot Controller's network, with WorkVisual installed

Software

- WorkVisual
- FTCtrl option, if using KUKA.ForceTorqueControl

NOTICE: This manual includes instructions for FTCtrl V3.x, 4.x, and 5.x. Some steps differ among these versions.

Reference Materials

NOTICE: To access KUKA manuals, log-in to their *customer portal* or contact a representative at KUKA.

- *KUKA KRL Programming Manual*
- *KUKA WorkVisual Manual*
- *KUKA FTCtrl Manual*
- *KUKA CREAD/CWRITE Manual*

3. Hardware Set-Up

1. Mount the sensor to the robot using interface plate(s).
    - For mounting guidelines, refer to the ATI's *Transducer Section F/T manual*, or for Axia sensors, refer to the ATI Axia sensor manual, such as: #*9620-05-B-Axia80*. Manuals are available on the *ATI webpage*.
2. Install the rest of the tooling.
3. Connect the sensor's power supply cable to an appropriate power supply.
    - For details, refer to the appropriate ATI sensor manual.
    - The sensor's LEDs light up through the startup sequence.
4. Connect the Ethernet cable from the sensor to the KUKA X44 EtherCAT Extension Bus port (or KEI interface on KRC5 controllers).

4. Software Setup

For the software setup, complete these three tasks:

Section 4.1—Integrate the ATI Sensor's Data into KRC Digital IO

Section 4.2—Confirm ATI Sensor EtherCAT Slave on Teach Pendant

Section 4.3—Set Up FTCtrl to Use EtherCAT Axia/FT Data

4.1 Integrate the ATI Sensor's Data into KRC Digital IO

Complete this task through KUKA's WorkVisual Development Environment.

This task has three parts:

1. Add the ATI sensor to the DTM Catalog (refer to *Section 4.1.1*).
2. Add the ATI sensor to KUKA Extension Bus in the WorkVisual Project (refer to *Section 4.1.2*).
3. Map the ATI sensor's data into the Project's I/O (refer to *Section 4.1.3*).

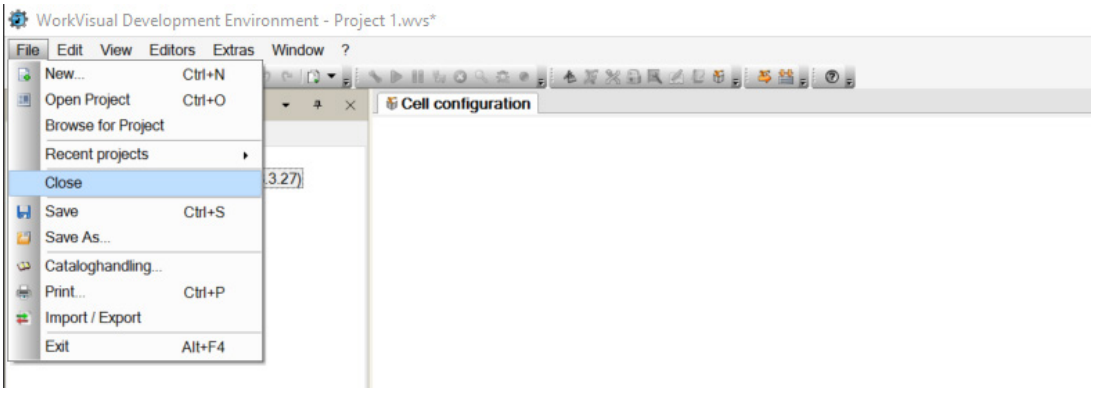
4.1.1 Add the ATI Sensor to the DTM Catalog

The ATI EtherCAT Axia product is defined with an ATI-provided EtherCAT ESI (*.XML) file in this installation of WorkVisual. This part should be completed once per EtherCAT Axia *.XML version, per WorkVisual environment. If another EtherCAT Axia with newer firmware and ESI *.XML file is used later, the new ESI *.XML file must be added to the DTM catalog.

1. Download the appropriate ATI ESI file to the laptop or PC.
   - For EtherCAT Axia, refer to *https://www.ati-ia.com/Products/ft/software/axia_software.aspx*.
   - For other EtherCAT F/T, refer to *https://www.ati-ia.com/Products/ft/software/SysSoftwareTemplates.aspx?family=8*.
2. Close the current Project in WorkVisual.

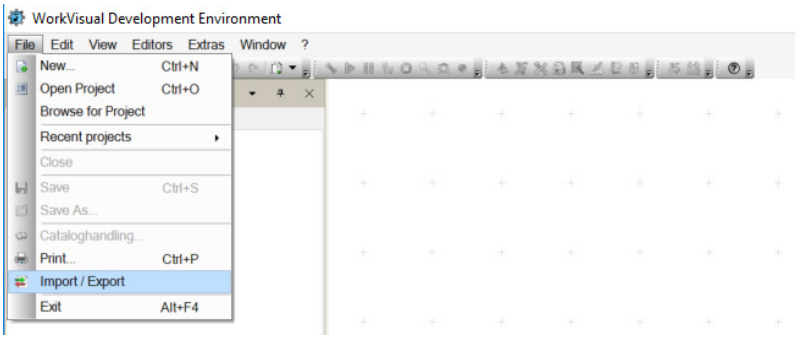
NOTICE: The DTM Catalog cannot be changed if any Projects are open.

Figure 4.1—Close All Projects



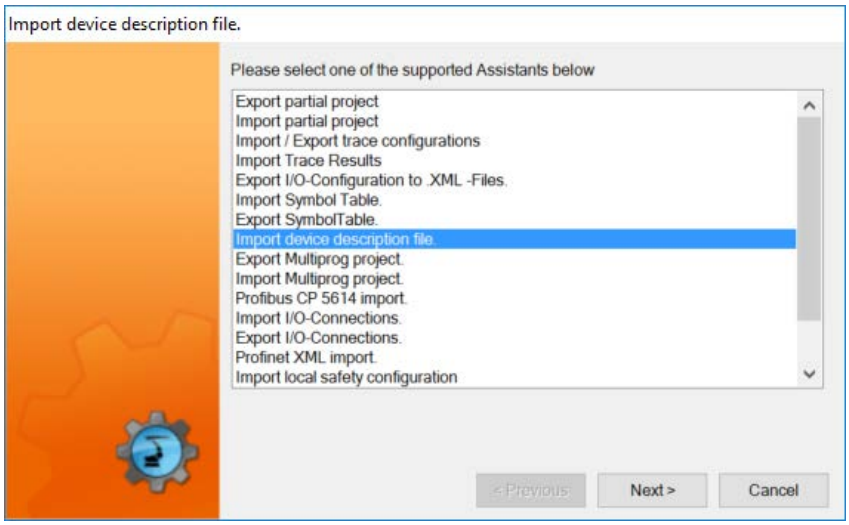
3. From the **File** dropdown menu, select **Import/Export**.

Figure 4.2—Import a New File



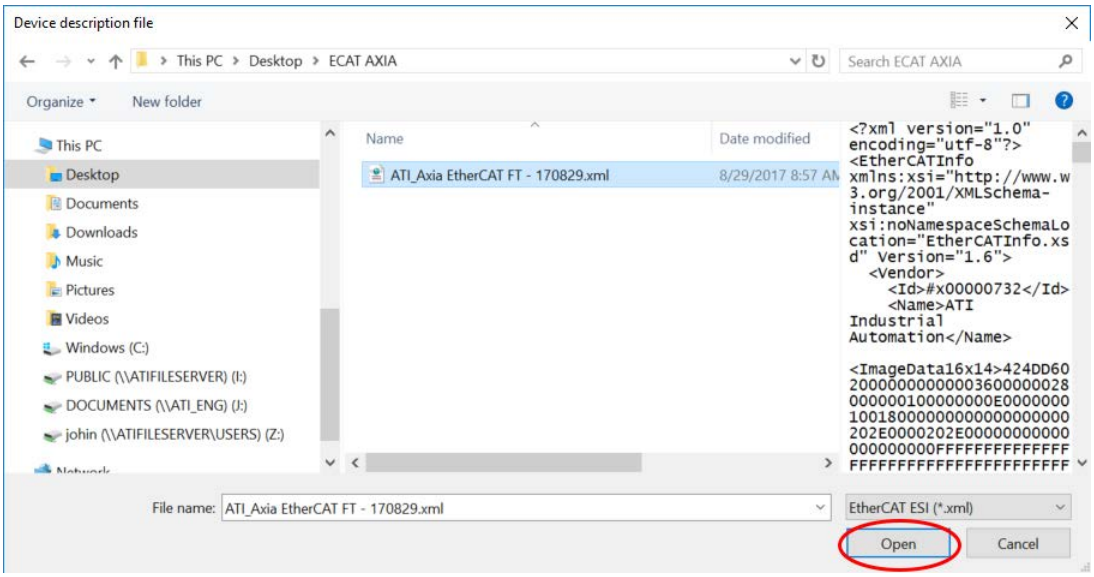
4. Select **Import device description file** and click **Next>**.

Figure 4.3—Import Device Description File



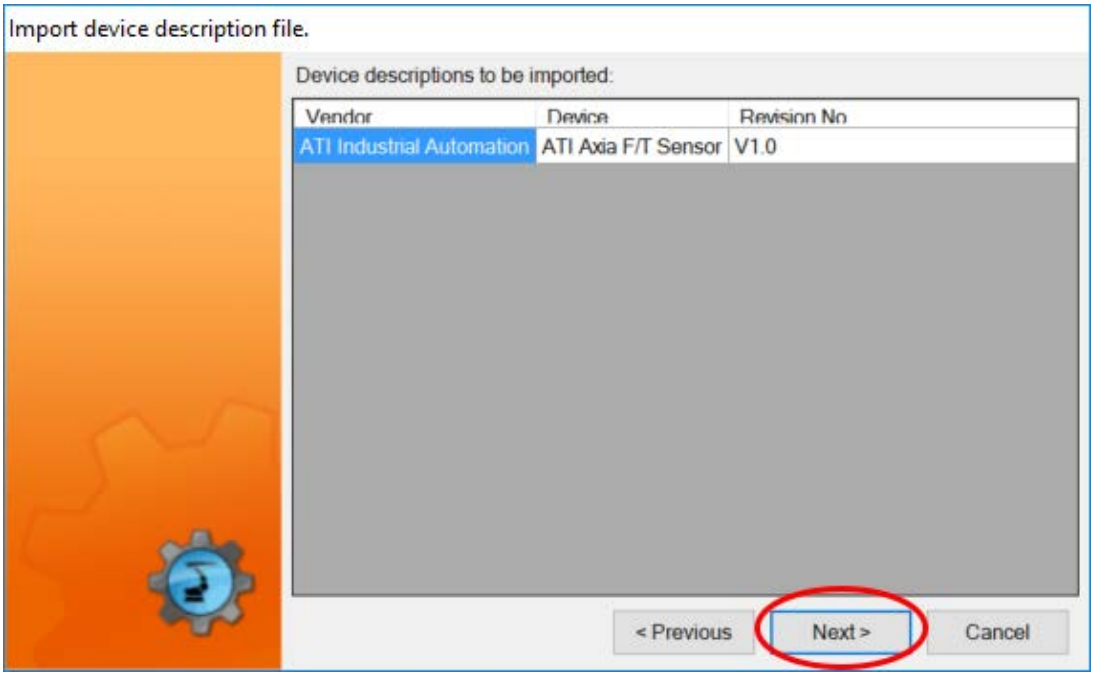
5. In the directory, navigate to the location of the ATI EtherCAT Axia *.XML ESI file. Select **Open**.

Figure 4.4—Open the ATI EtherCAT Axia *.XML File



6. Click **Next>**.

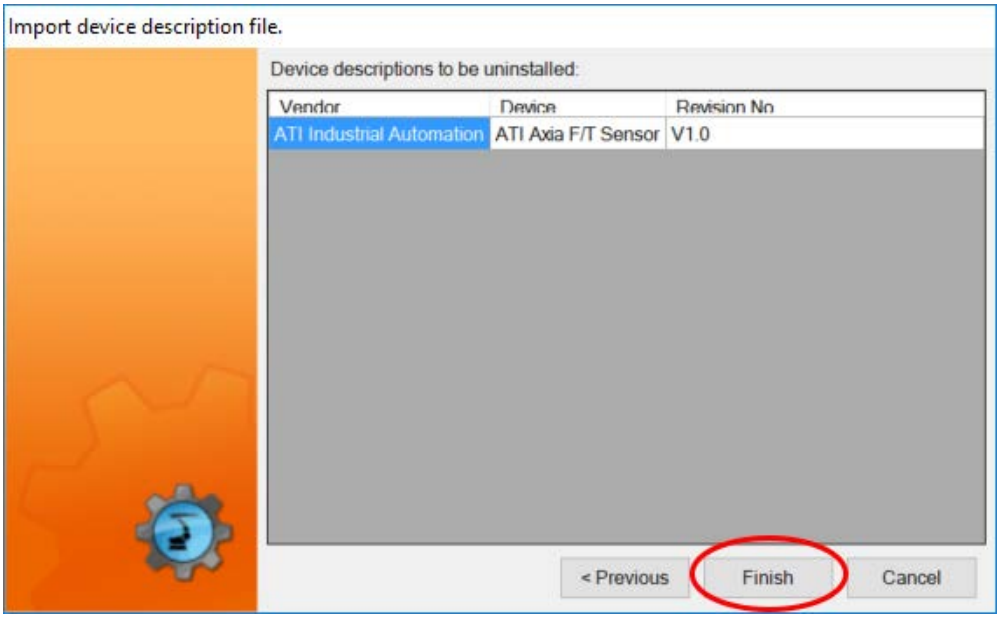
Figure 4.5—Import the ATI EtherCAT Axia *.XML File



NOTICE: Any existing ATI EtherCAT ESI file versions that are installed will show up in the following window. To ensure the most current version is installed, remove older versions.

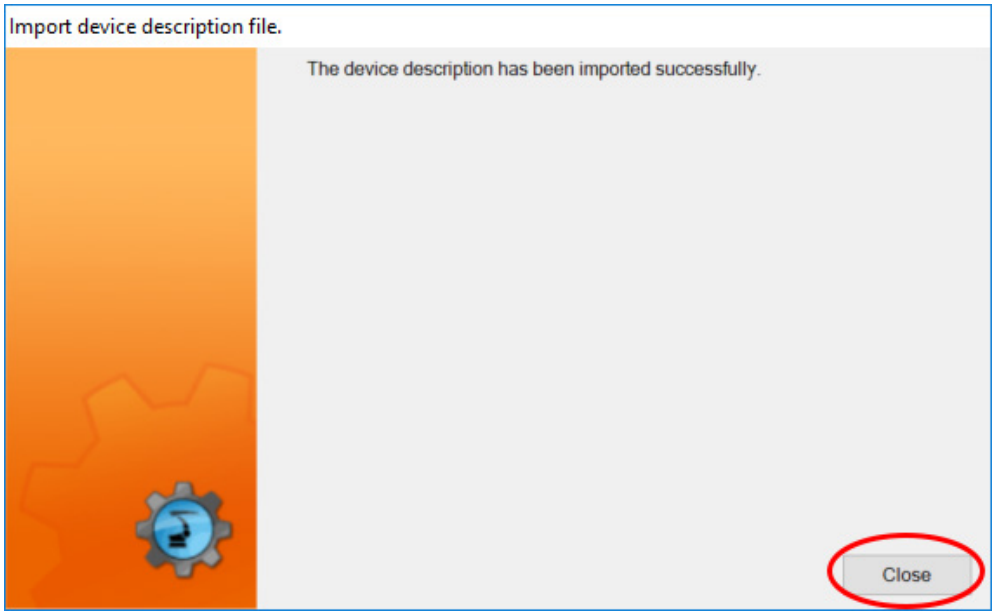
7. Click **Finish**.

Figure 4.6—Finish Importing the File



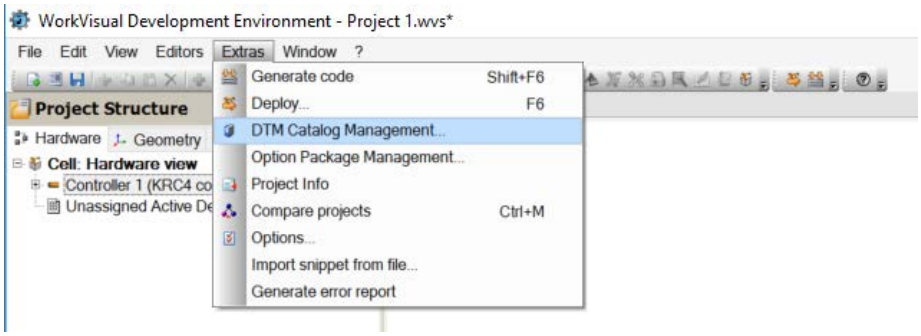
8. After WorkVisual finishes importing the file, click **Close**.

Figure 4.7—Close Window



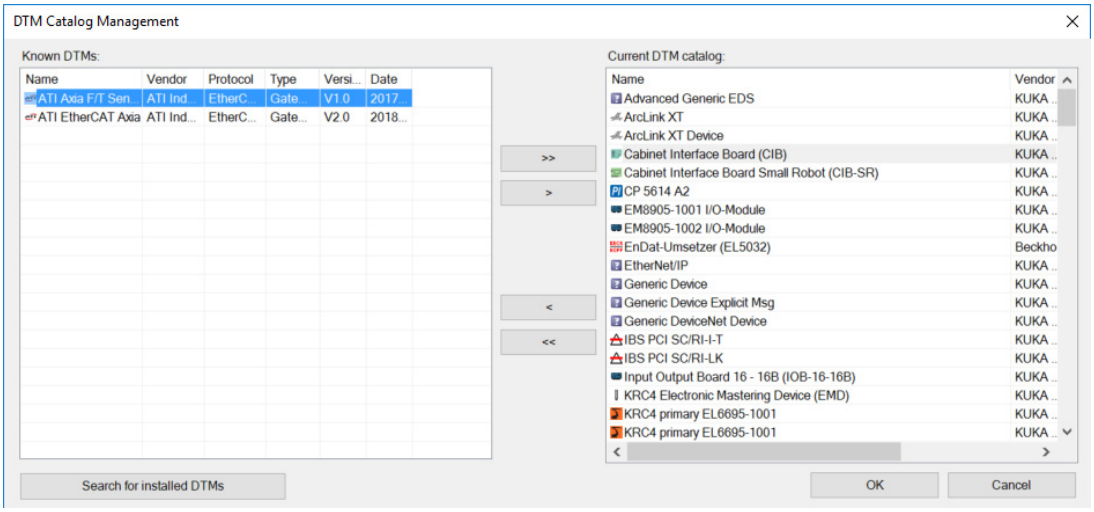
9. From the **Extras** dropdown menu in WorkVisual, select **DTM Catalog Management**.

Figure 4.8—Extra Menu



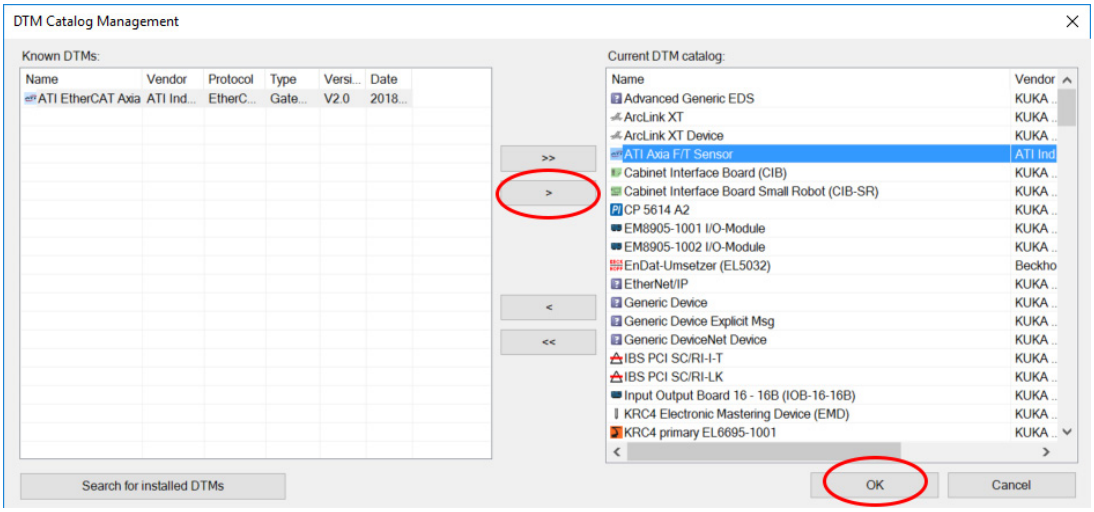
10. At the bottom of the window, click **Search for installed DTMs**.
11. In the **Known DTMs:** pane, select the ATI EtherCAT sensor with the name of the ESI Device Description file imported in Step *5*.

Figure 4.9—Select the ATI File from Known DTMs



12. Click the > button to move the desired DTM into the **Current DTM catalog**.
13. Click **OK**.

Figure 4.10—Move the ATI Sensor to the DTM Catalog

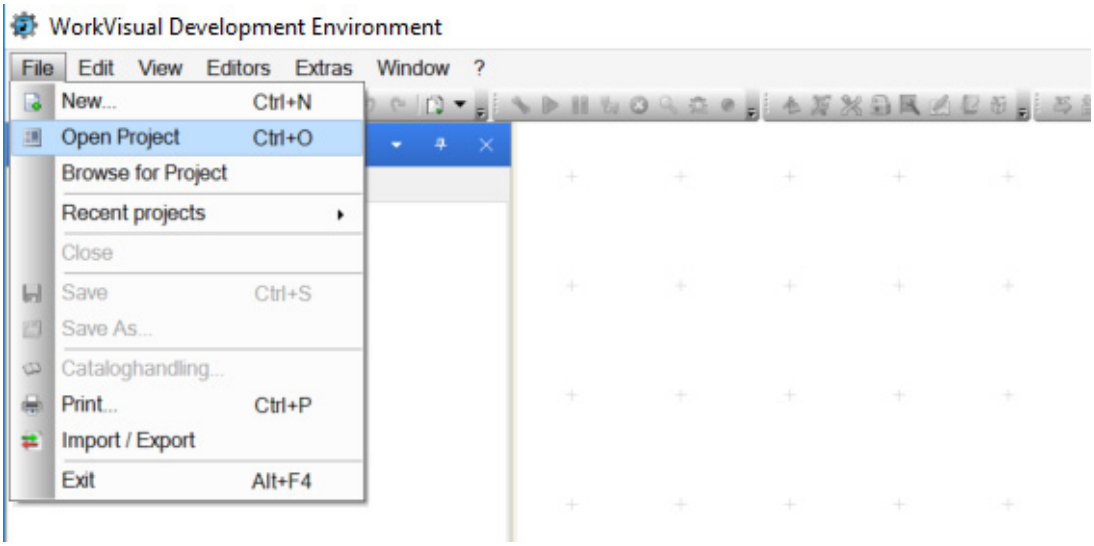


4.1.2 Add the Sensor to KUKA Extension Bus

For this part, the ATI device is added to the DTM catalog of each WorkVisual Project that uses the ATI sensor. If multiple sensors are used in a project, this part must be repeated for each sensor.

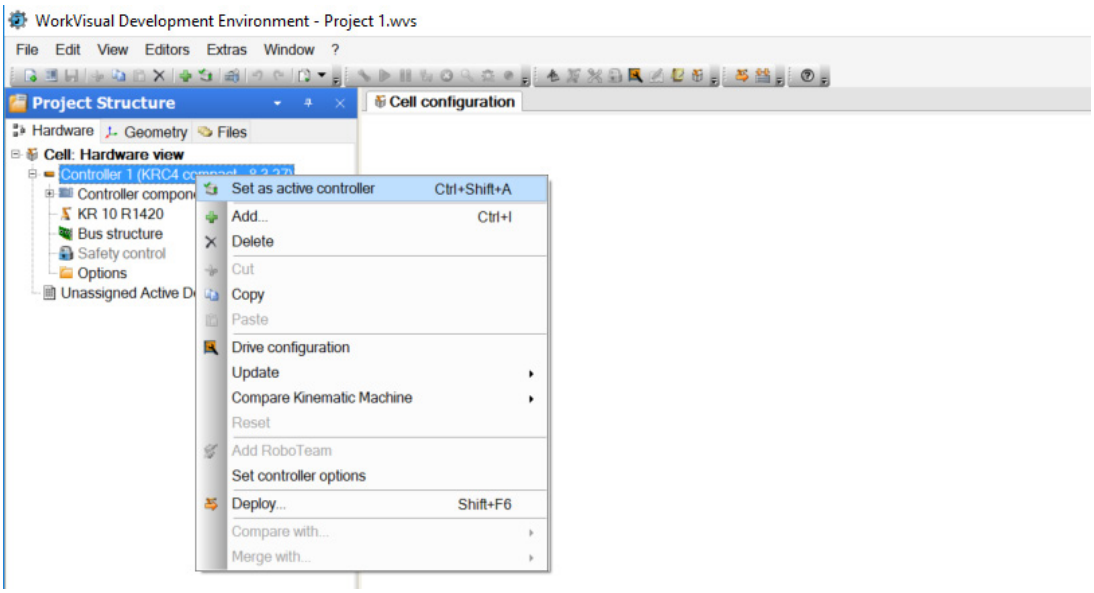
1. From the **File** dropdown menu, select **Open Project**.

Figure 4.11—Open Project



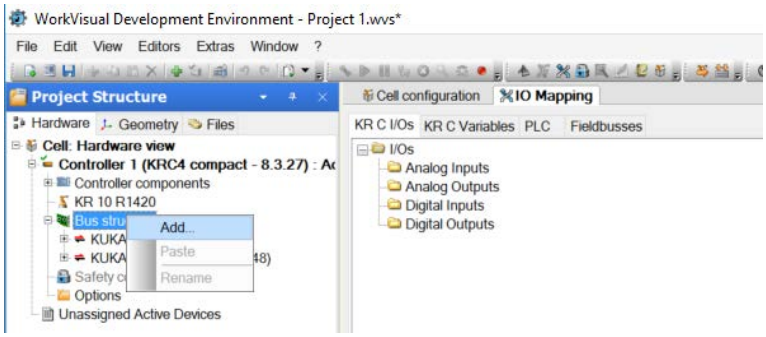
2. On the **Project Structure**, right-click the controller, and select **Set as active controller**.

Figure 4.12—Activate the Controller



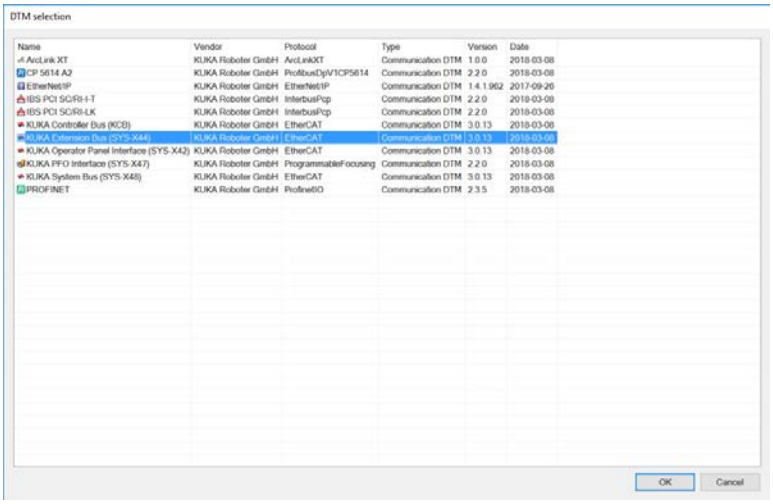
NOTICE: If **KUKA Extension Bus (SYS-X44)** is not already in the controller's bus structure, then complete these steps:

1. Right-click **Bus Structure** and select **Add**.



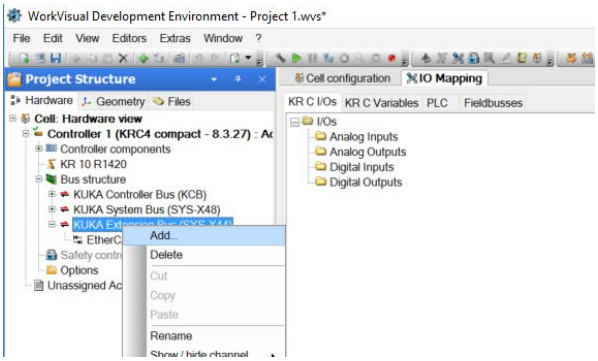
2. Select **KUKA Extension Bus**.

3. Click **OK**.



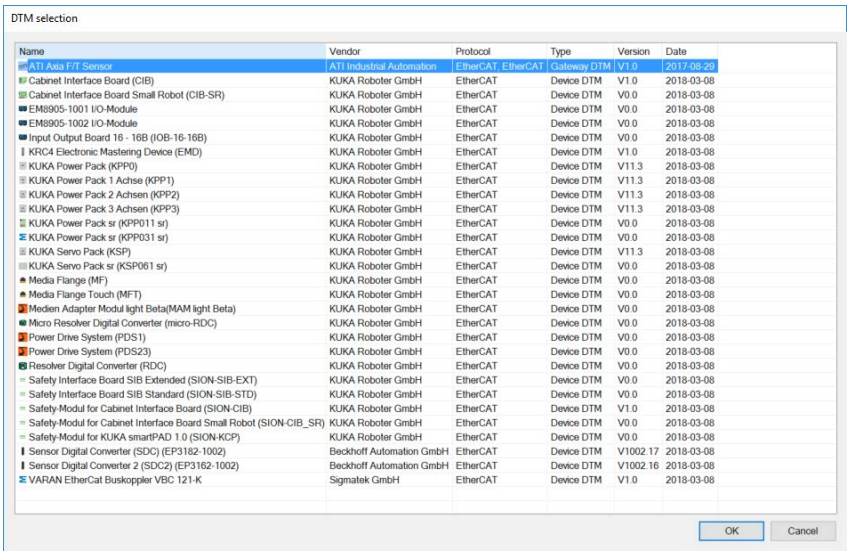
3. Add the ATI sensor:
   a. Right-click the **KUKA Extension Bus**, and select **Add**.

Figure 4.13—Add the ATI Sensor to the KUKA Extension Bus



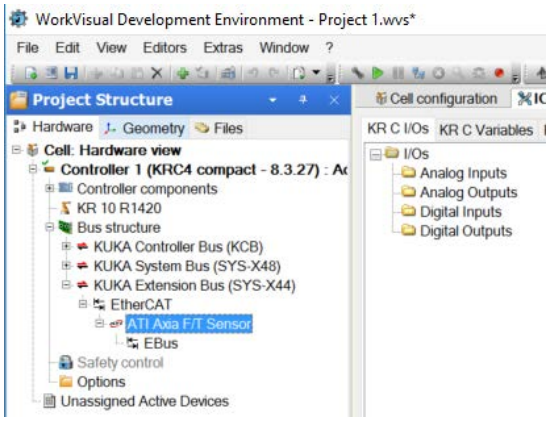
   b. In the DTM Selection window, select the appropriate ATI sensor, and click **OK**.

Figure 4.14—Select the ATI Sensor



4. Confirm that the ATI sensor is in the KUKA Extension Bus EtherCAT structure.

Figure 4.15—ATI Sensor Added to the Extension Bus



4.1.3 Map the Sensor's Data into the Project's I/O

Inputs of the WorkVisual Project are the signals from the ATI sensor to the robot controller. In ATI documentation, these signals are referred to as outputs. Mapping the input signals varies for different versions of the KUKA FTCtrl software. For V3.x, refer to *Section 4.1.3.1*. For V4.x and V5.x, refer to *Section 4.1.3.2*.

Outputs of the WorkVisual Project are signals from the robot controller to the ATI sensor. In the ATI documentation, these signals are referred to as inputs. Mapping the outputs is the same for all software versions of KUKA FTCtrl: refer to *Section 4.1.3.3*. These Outputs are the Control Codes.

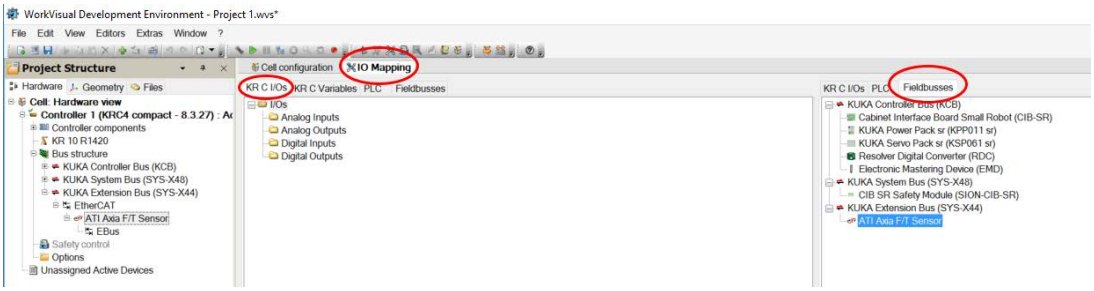
The Control Codes are used for commands to the sensor such as Bias, Filter selection, set Sample Rate, and selecting which Calibration to use. For a bit map of these control codes, see the *Control Codes* section in the ATI sensor's manual.

For example, with ATI EtherCAT Axia, a Control Code 1, Bit 0, refers to Set Bias. The Set Bias can have a value 1 or 0, where 1 = set bias and 0 = use last set bias. So, this Control Code must be pulsed/flashed to 1 in order to bias the sensor, and then returned to 0 to continue reading measurements.

4.1.3.1 Map the Sensor's Digital Inputs (for V3.x)

1. In the WorkVisual **IO Mapping** editor tab, open **KRC I/Os** in the left pane and **Fieldbusses** in the right pane.

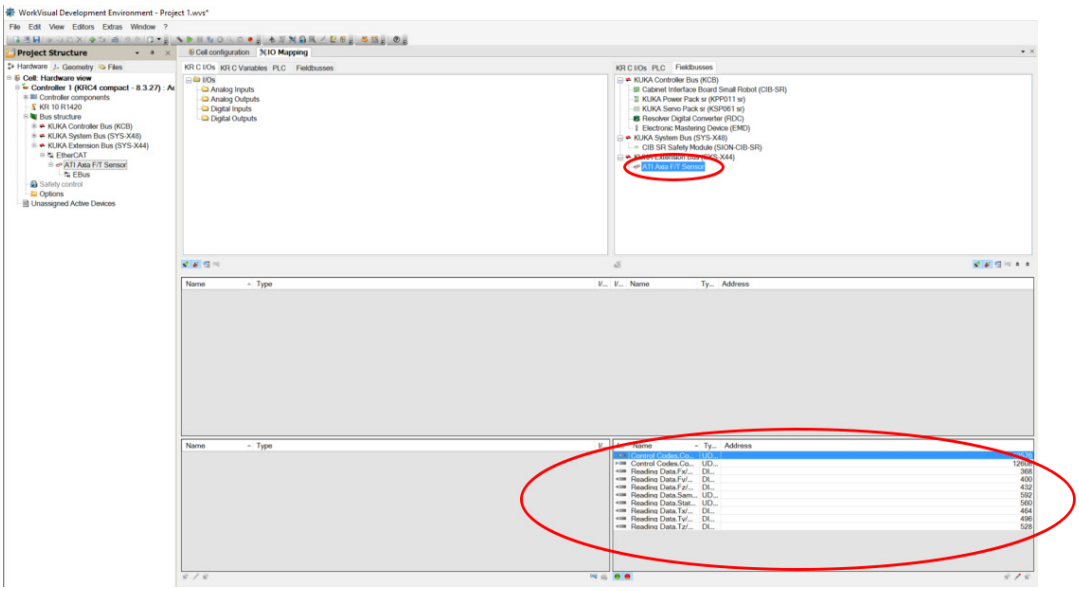
Figure 4.16—IO Mapping Editor



2. In the **Fieldbusses** pane, select the ATI Axia (or other ATI ECAT F/T sensor).

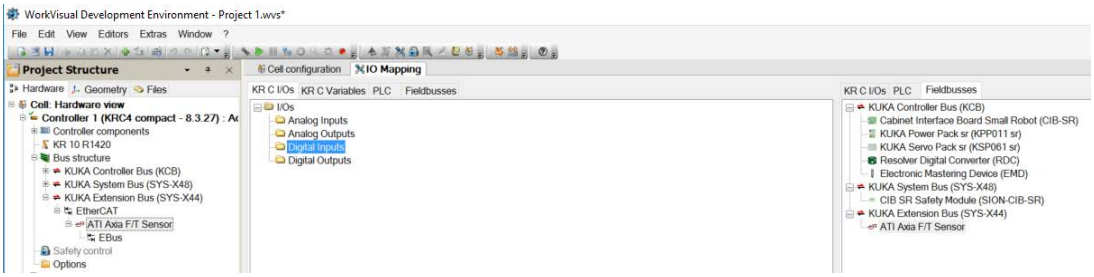
- The Axia's signals display in the lower pane (refer to *Figure 4.17*).
- Note that the sensor's Force and Torque data are of type DINT (double integer). A DINT is 32 bits. The inputs *Status Code* and *Sample Counter*, and the output control codes are UDINT (unsigned double integer). A UDINT is also 32 bits. The exact signals may appear different for different ATI sensors.

Figure 4.17—Select the ATI Sensor in the Fieldbusses



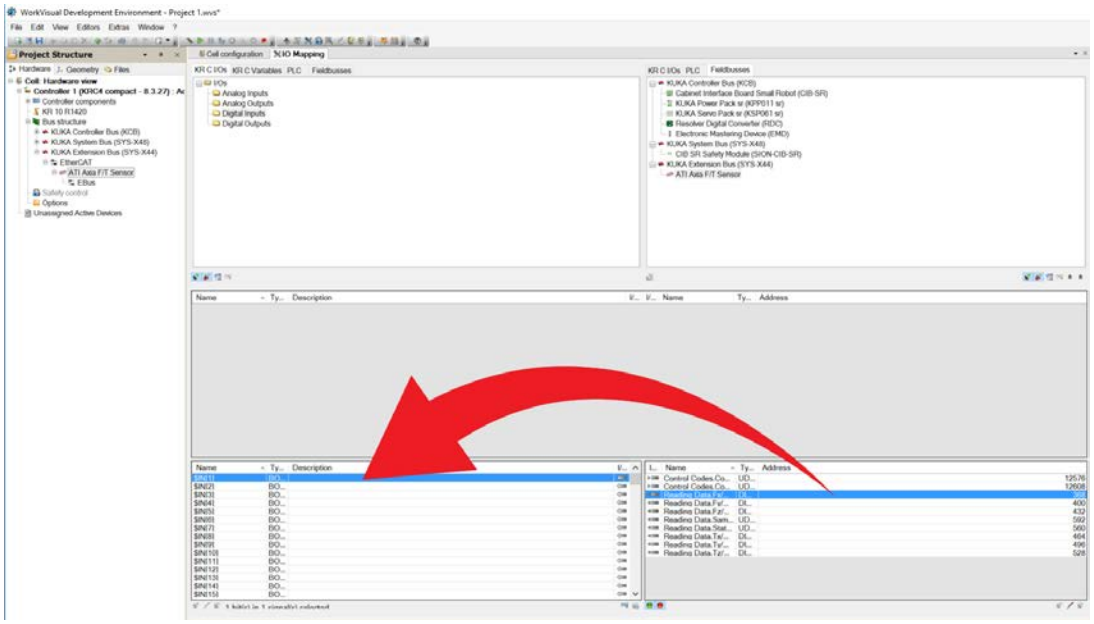
3. In the **KRC I/Os** pane, select **Digital Inputs**.
   - The KRC Input signals display in the lower pane (refer to *Figure 4.19*).

Figure 4.18—KRC I/O's Digital Inputs



4. Select the sensor's *Reading Data.Fx* signal and move it to the desired KRC input.
   - In this example, *Fx* is mapped to input bits starting at input bit 1 (*$IN[1]*).

Figure 4.19—Select and Move Signal Input

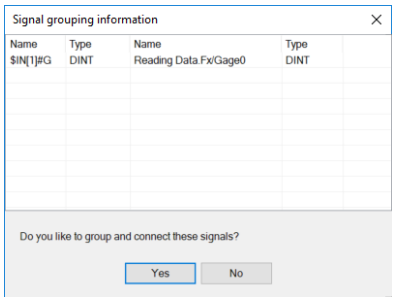


NOTICE: These KRC I/O input signals are being sent out of the ATI sensor and into the robot controller. In ATI's documentation for the sensor, these inputs are referred to as outputs.

5. WorkVisual automatically groups the KRC input bits to fit the sensor signal's data size.

- In this example, the *Fx DINT* will use *$IN[1]* through *$IN[32]*.
- If prompted to group and connect these signals, click **Yes**.

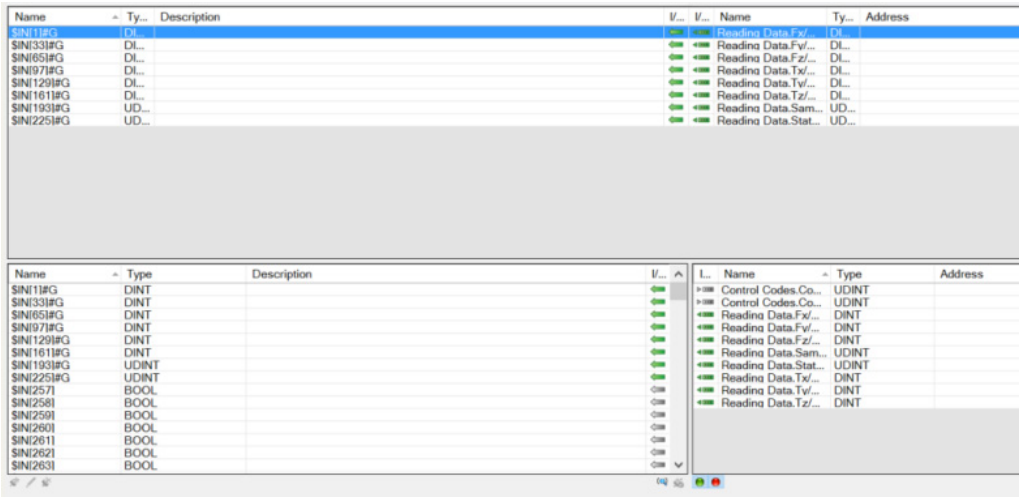
Figure 4.20—Confirm Automated Grouping and Connecting of Signal



6. Repeat for all inputs (NOT the Control Code Outputs).

- When inputs are mapped, the input icon next to the signal will show green, and the mapped signals will appear in the upper pane.
- Note that all force and torque values are DINTs, while the status and sample numbers are UDINT. The input data is a total of 256 bits.
- In this example (*Figure 4.21*), all sensor inputs are mapped to **KRC IO** groups, which uses *$IN[1]* through *$IN[256]*.
- Signals do not have to be mapped exactly as shown, but end users should take note of the mapping in their controller for *Section 4.3—Set Up FTCtrl to Use EtherCAT Axia/FT Data*.

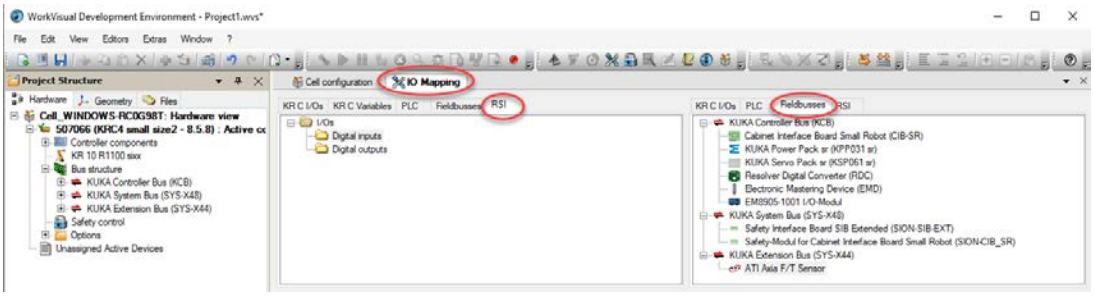
Figure 4.21—Sensor Inputs Mapped to KRC IO Groups



4.1.3.2 Map the Sensor's Digital Inputs (for V4.x and V5.x)

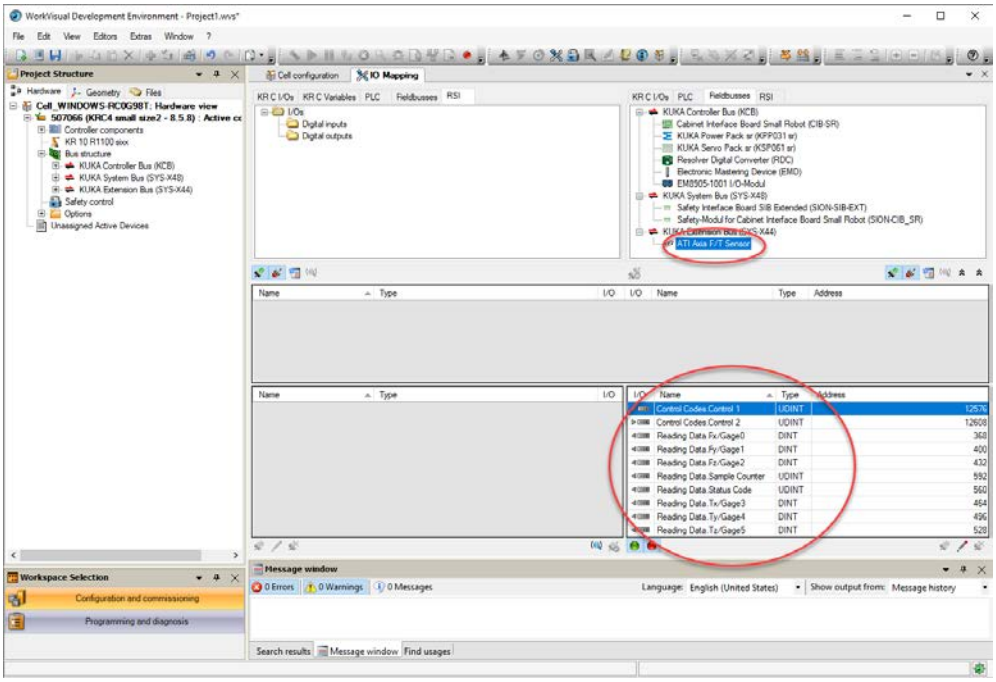
1. In the WorkVisual **IO Mapping** editor tab, open **RSI** in the left pane and **Fieldbusses** in the right pane.

Figure 4.22—IO Mapping Editor



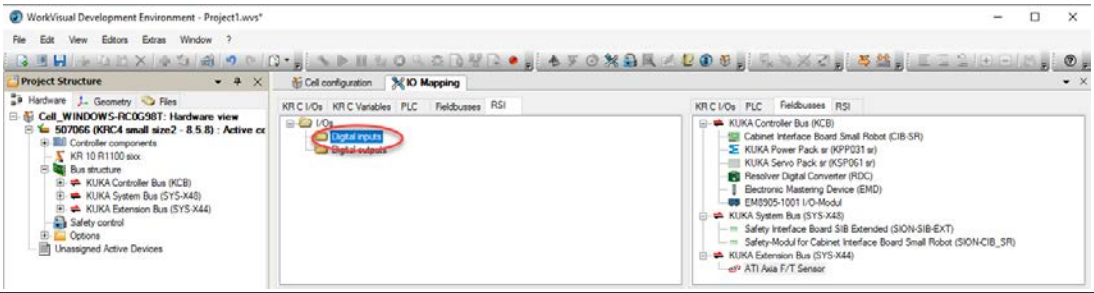
2. In the **Fieldbusses** pane, select the ATI sensor.
   - The Axia's signals display in the lower pane (refer to *Figure 4.23*).
   - Note that the sensor's force and torque data are of type DINT (double integer). A DINT is 32 bits. The inputs *Status Code* and *Sample Counter*, and the output *Control Codes* are UDINT (unsigned double integer). A UDINT is also 32 bits. The exact signals may appear different for different ATI sensors.

Figure 4.23—Select the ATI Sensor in the Fieldbusses



3. In the **RSI** pane, select **Digital inputs**.
   - The RSI input signals should display in the lower pane (refer to *Figure 4.25*).

Figure 4.24—RSI's Digital Inputs

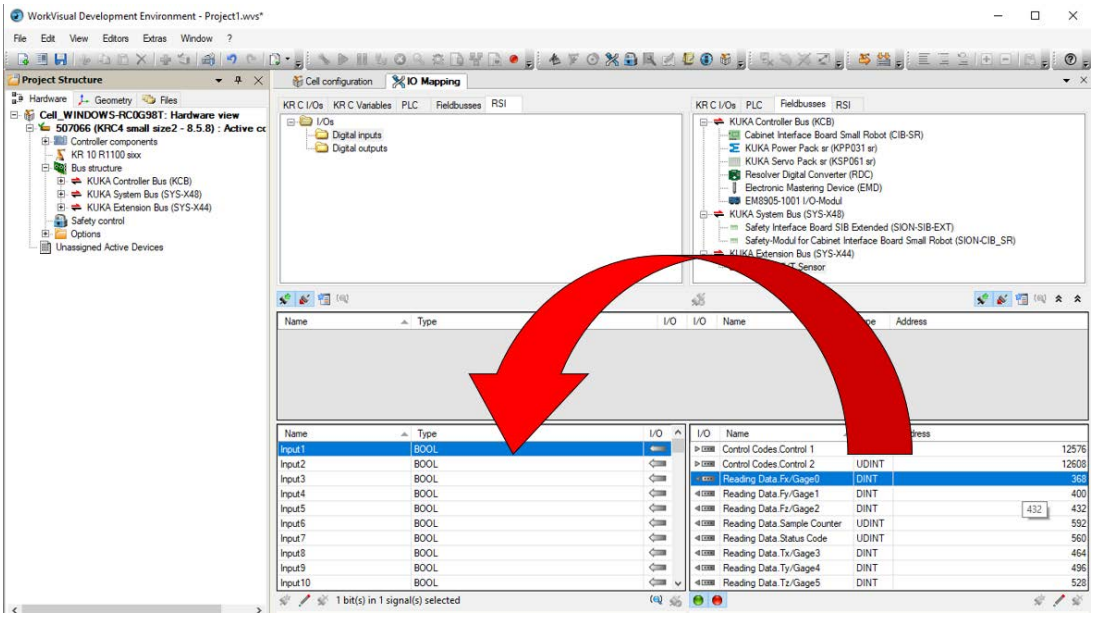


4. Select the sensor's *Reading Data.Fx* signal and move to the desired **RSI** input.

- In this example, *Fx* mapped to input bits starting at input bit 1 (*$IN[1]*).

NOTICE: These KRC I/O input signals are being sent out of the ATI sensor and into the robot controller. In ATI's documentation for the sensor, these inputs are referred to as outputs.

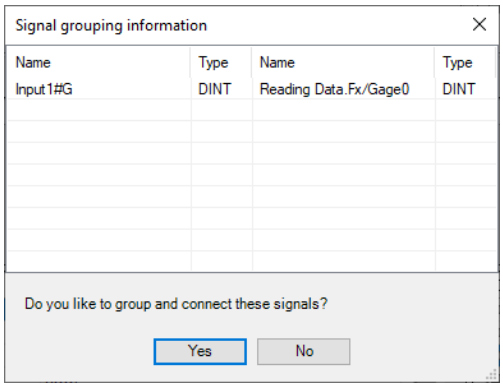
Figure 4.25—Select and Move Signal Input



5. WorkVisual automatically groups the KRC input bits to fit the sensor signal's data size.

- In this example, the *Fx DINT* will use *$IN[1]* through *$IN[32]*.
- If prompted to group and connect these signals, click **Yes**.

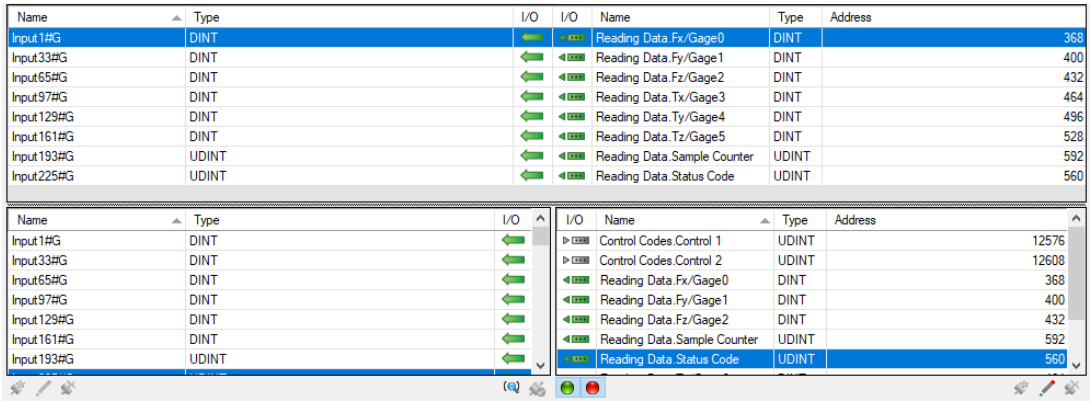
Figure 4.26—Confirm Automated Grouping and Connecting of Signal



6. Repeat for all inputs (NOT the Control Code Outputs).

- When inputs are mapped, the input icon next to the signal will show green, and the mapped signals will appear in the upper pane.
- Note that all force and torque values are DINTs, while the status and sample numbers are UDINT. The input data is a total of 256 bits.
- In this example (*Figure 4.27*), all sensor inputs are mapped to **RSI IO** groups, which uses *$IN[1]* through *$IN[256]*.
- Signals do not have to be mapped exactly as shown, but end users should take note of the mapping in their controller for *Section 4.3—Set Up FTCtrl to Use EtherCAT Axia/FT Data*.

Figure 4.27—Sensor Inputs Mapped to RSI IO Groups

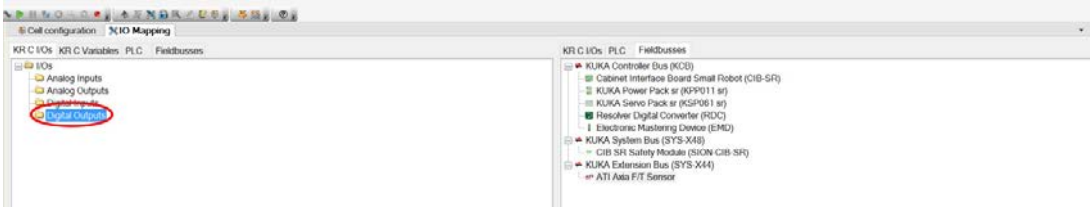


4.1.3.3 Map the Sensor's Digital Outputs (for V3.x, V4.x, and V5.x)

1. In the **KRC IOs** pane (not in the RSI pane), select **Digital Outputs**.

- The KRC Output signals should display in the lower pane (refer to *Figure 4.29*).

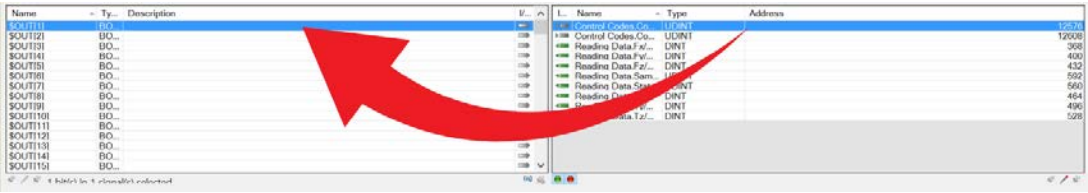
Figure 4.28—KRC IO's Digital Outputs



2. Repeat the mapping process for the two *Control Code* signals.

NOTICE: These KRC I/O output signals are being sent out of the robot controller and into the sensor. In ATI's documentation for the sensor, these outputs are referred to as inputs.

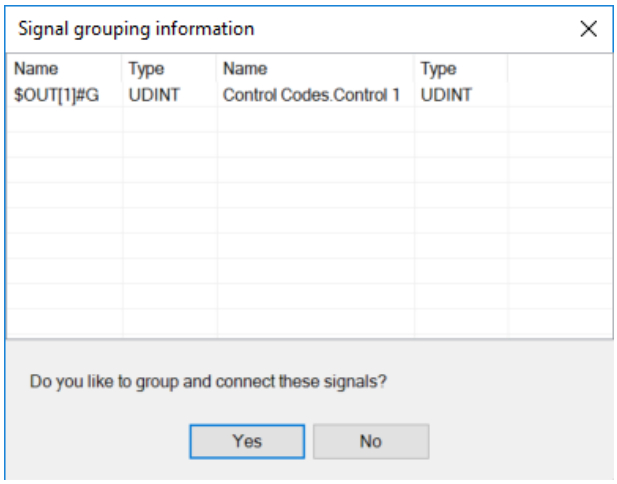
Figure 4.29—Map the Control Code Signals



3. WorkVisual automatically groups the **KRC** output bits to fit the sensor signal's data size.

- In this example, the first *Control Code* UDINT will use *$OUT[1]* through *$OUT[32]*.
- If prompted to group and connect these signals, click **Yes**.

Figure 4.30—Confirm Automated Grouping and Connecting of Signal



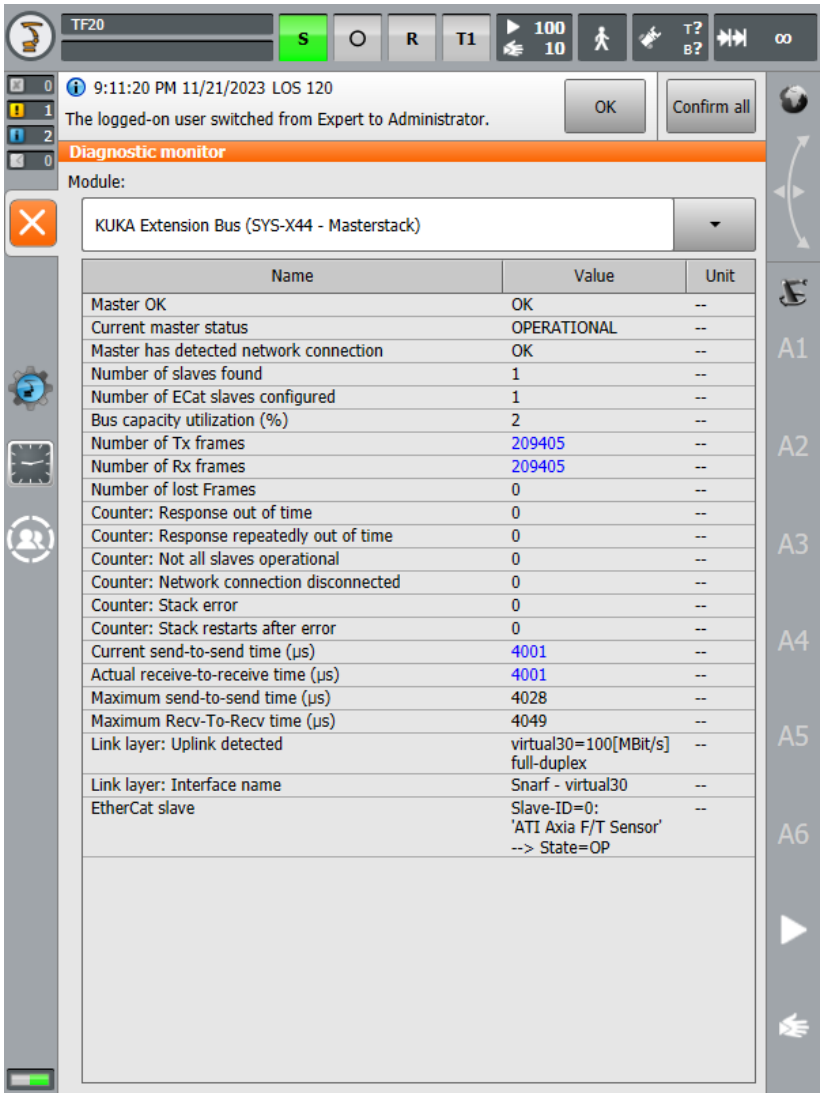
4. Repeat for the second *Control Code*.

- When all input and output signals are mapped, all IO icons in the sensor signal list should be green.

4.2 Confirm ATI Sensor EtherCAT Slave on Teach Pendant

1. Deploy the WorkVisual Project to the controller.
2. Confirm that the ATI EtherCAT Axia or ATI EtherCAT F/T sensor is a slave on the controller's EtherCAT bus.
   a. From the KUKA **Main Menu** (robot icon) select **Diagnosis** and then **Diagnostic Monitor**.
   b. Change the selected **Module:** in the dropdown menu to **KUKA Extension Bus (SYS-X44 – Masterstack)**.
   c. In the **Name** column, confirm that **EtherCAT slave** is listed with the **Value** as the appropriate ATI sensor name, such as *ATI Axia F/T Sensor*.

Figure 4.31—Diagnostic Monitor for KUKA Extension Bus (SYS-X44 – Masterstack)



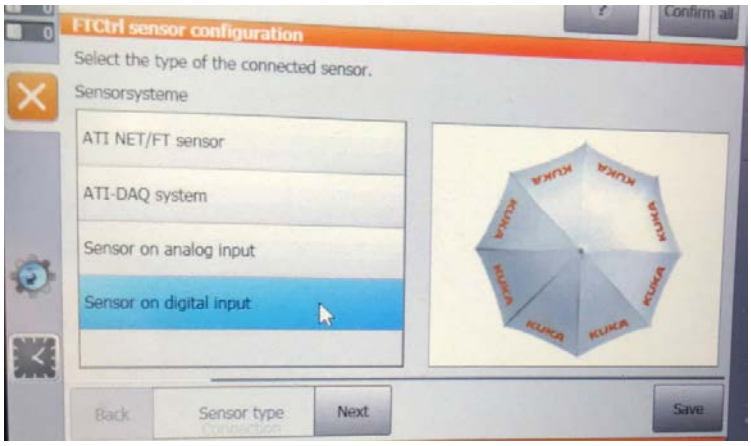
4.3 Set Up FTCtrl to Use EtherCAT Axia/FT Data

To complete the following steps, the end user should be familiar with using the KUKA FTCtrl option software. For guidance on using this software, refer to the *KUKA FTCtrl* manual, or contact a KUKA representative.

4.3.1 KUKA FTCtrl V3.x

1. In the **Sensor Setup** menu, select type **Sensor on digital input**.

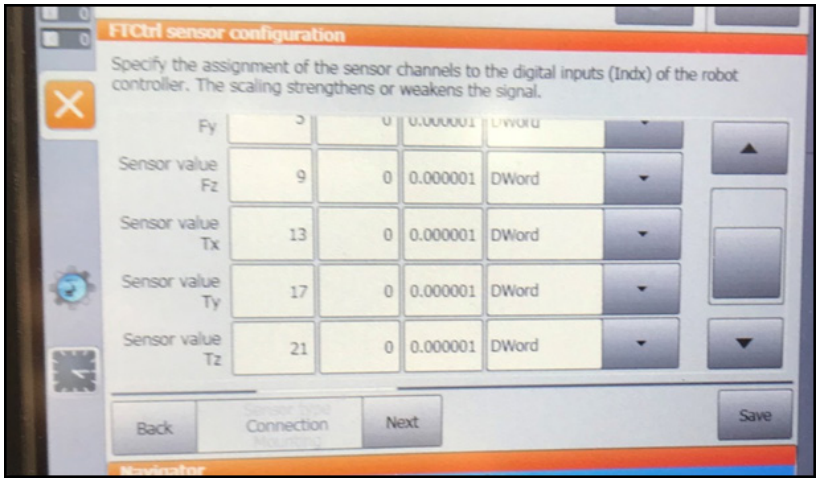
Figure 4.32—Select Sensor System



2. Map the sensor values (Fx,Fy,Fz,Tx,Ty,Tz) in FTCtrl to the correct Digital IO. In this **FTCtrl Sensor Configuration**, **Index** refers to the Digital IO byte.

- Because 1 byte contains 8 bits, the byte index increments 4 bytes for every 32 bits.
- Per the example in *Section 4.1.3.1—Map the Sensor's Digital Inputs (for V3.x)*, *Fx* data was mapped to Bits 1 through 32. Thus, *Fx* starts at BYTE 1. *Fy* was mapped to Bits 33 through 64. Thus, *Fy* starts at BYTE 5. And so the mapping continues for the other sensor values.
- Be sure these byte indices are correctly mapped to the Digital IO in the controller, because they may be different from the example in *Section 4.1.3.1*.

Figure 4.33—FTCtrl Sensor Configuration



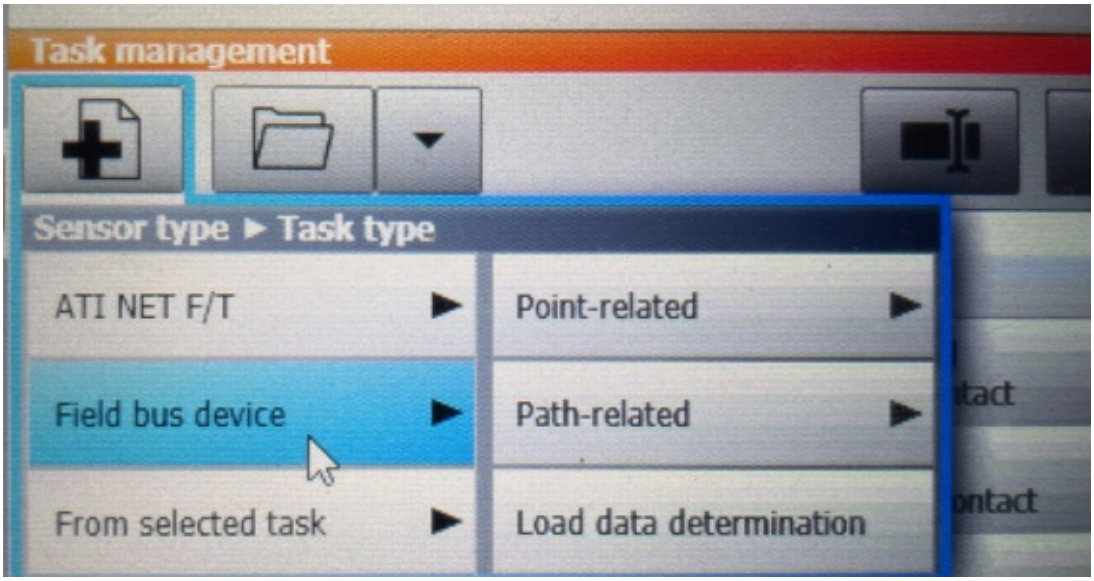
3. In the **Offset** field, enter *0* for all values.
4. Set the **Data width** to *DWord*.
5. Set the **Scaling Factor** (refer to *Section 6.2—Convert ATI F/T Sensor's Data From Counts to User Units*).
6. Press **Save**.
7. Continue with the FTCtrl task set up as described in the *KUKA FTCtrl* manual.

4.3.2 KUKA FTCtrl V4.x and V5.x

1. Link the sensor system selection to each individual FTCtrl task independently:

- When creating a new task in the **Task Management** window, select type **Field bus device,** and then the desired task type.

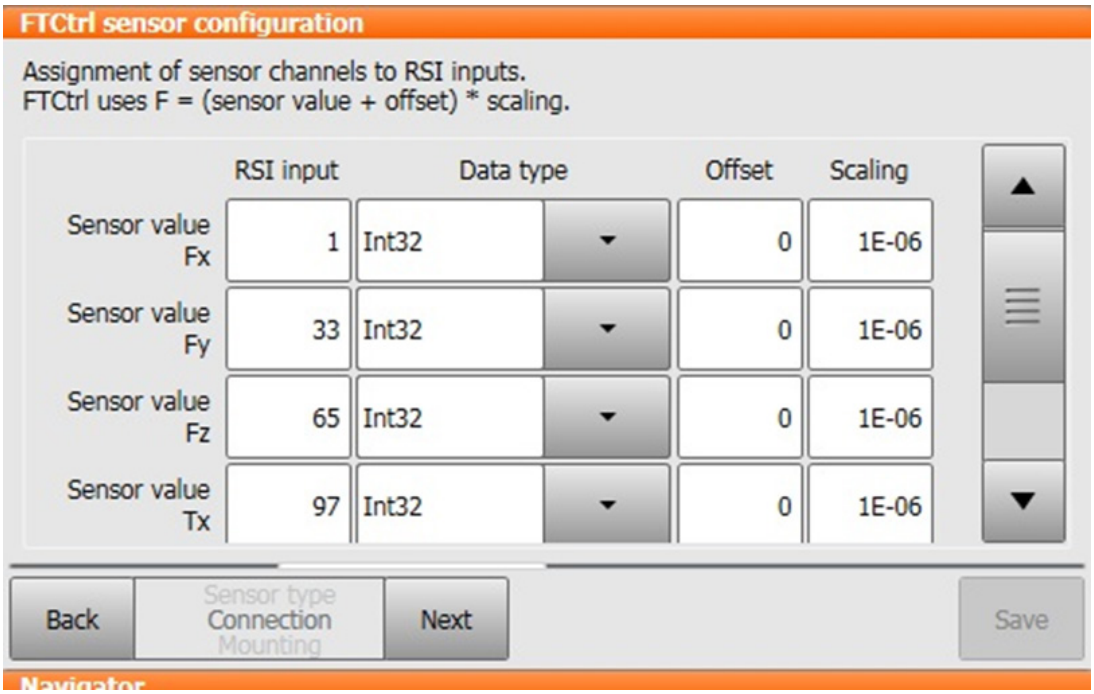
Figure 4.34—Link the Sensor System to the FTCtrl Task



2. Map the sensor values (Fx,Fy,Fz,Tx,Ty,Tz) in FTCtrl to the correct Digital IO. In this **FTCtrl Sensor Configuration**, **RSI input** refers to the RSI Digital IO bit.

- Per the example in *Section 4.1.3.2—Map the Sensor's Digital Inputs (for V4.x and V5.x)*, *Fx* data was mapped to Bits 1 through 32. Thus, *Fx* starts at BIT 1. *Fy* was mapped to Bits 33 through 64. Thus, *Fy* starts at BIT 33. And so the mapping continues for the other sensor values.
- Be sure these bit indices are correctly mapped to the Digital IO in the controller, because they may be different from the example in *Section 4.1.3.2*.

Figure 4.35—FTCtrl Sensor Configuration



3. In the **Offset** field, enter **0** for all values.
4. Set the **Data type** to *Int32*.
5. Set the **Scaling Factor** (refer to *Section 6.2—Convert ATI F/T Sensor's Data From Counts to User Units*).
6. Press **Save**.
   - Once saved, the scaling displays in scientific notation (refer to *Figure 4.35*).
7. Continue with the FTCtrl task set up as described in the *KUKA FTCtrl* manual.

5. FTCtrl Programming

For information on how to program the application, refer to the *KUKA.ForceTorqueManual* and consult with a KUKA applications engineer. FTCtrl training is available through KUKA College.

6. Monitoring F/T Data

6.1 View Sensor Signals on Teach Pendant

If the sensor inputs are mapped into KRC Digital IO (*Section 4.3.1—KUKA FTCtrl V3.x*), navigate to the **Digital Inputs**. The individual bits should flash as the sensor reads values.

Remember, each 32 bits corresponds to an input reading from the sensor. In the example from *Section 4.3.1—KUKA FTCtrl V3.x*, *$IN[1]* to *$IN[32]* were mapped to the *Fx* reading. *$IN[1]* through *$IN[32]* are a 32-bit binary representation of the *Fx* reading, in Counts.

See the applicable *ATI sensor manual* for more information on Counts vs. user units.

6.2 Convert ATI F/T Sensor's Data From Counts to User Units

Upon receipt of each real-time F/T sample in Counts, divide these values by the Counts per Force (CpF) and Counts per Torque (CpT) scaling factor. These scaling factors are in the sensor's Calibration Object.

- To determine the CpF or CpT of an ATI sensor, refer to the ATI manual. For an ATI EtherCAT Axia, ATI provides a *Calibration and Accuracy Report* that lists the CpF and CpT values in the *Output Scaling* section.
- For example, if the sensor's CpF is 1,000,000 Counts per Newton (N), then Force (N) = Counts ÷ 1,000,000.

NOTICE: KUKA FTCtrl Digital IO Sensor Type requires specifying a **Scaling Factor**. A **Scaling Factor** is the same as 1 ÷ CpF or 1 ÷ CpT. So for a CpF of 1,000,000, enter a **Scaling Factor** of 0.000001.

6.3 Use F/T Data as REAL-type Variables

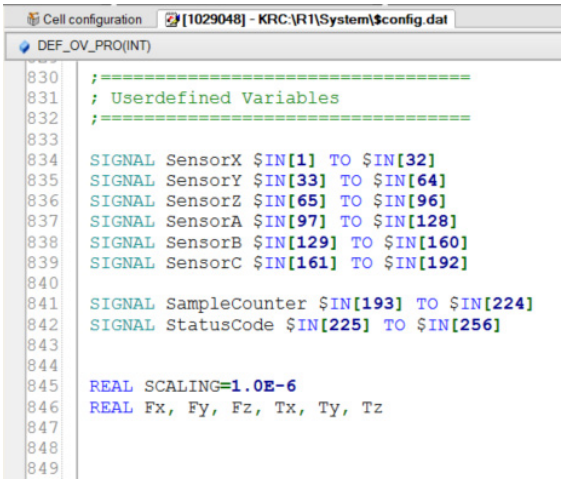
In this section, these steps (namely converting from binary IO to REAL variables) require approximately *KUKA Programming 2* level of KUKA programming experience. ATI is not a robotic integrator and can only provide limited support.

1. Programmatically, group each 32-bit binary number so that they can be converted into REAL numbers and stored in variables:
   - Group the 32 bits with the **KUKA SIGNAL** command.
   - For values to update constantly, write the program in the **KRC**'s **submit program**.
   - Note: If the sensor signals are mapped to the **RSI IO** (V4.x and V5.x), then they also must be mapped to the **KRC IO**.
2. Determine the **Scaling Factor** for the sensor (refer to *Section 6.2—Convert ATI F/T Sensor's Data From Counts to User Units*).

NOTICE: The **Scaling Factor** is used to convert the sensor's F/T data from Counts to user units, such as N and Nm.

3. Create REAL variables for the scaling factor (1/CpF or 1/CpT) and the forces and torques in R1\System\$config.dat. Refer to *Figure 6.1*.

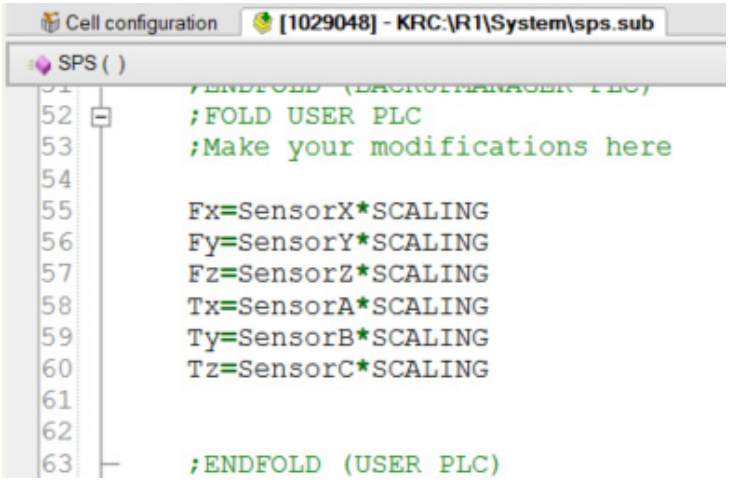
Figure 6.1—Create User Defined Variables



4. Convert the sensor's F/T data readings from Counts to user units, such as N and Nm. Refer to *Section 6.2—Convert ATI F/T Sensor's Data From Counts to User Units*.

- In order to constantly update the values, program the following calculation, as shown in *Figure 6.2*, into the controllers R1\System\sps.sub program.

Figure 6.2—Calculation to Constantly Update Values



7. Troubleshooting Guidance

When troubleshooting the ATI sensor, refer to the appropriate *ATI manual*. Answers to frequently asked questions are available from the ATI website: *https://www.ati-ia.com/library/documents/FT_FAQ.pdf*.

> Note:
>
> Please read the manual before calling customer service, and have the following information available:
>
> 1. Serial number (e.g., FT01234)
> 2. Sensor model (e.g., Axia90-M50)
> 3. Calibration (e.g., US-15-50, SI-65-6, etc.)
> 4. Accurate and complete description of the question or problem
> 5. Robot model, controller model, controller software version, and installed KUKA FTCtrl options.
>
> Be near the F/T system when calling (if possible). For questions specific to KUKA-provided software or hardware, please contact KUKA's technical support.

For additional troubleshooting information or to speak with a customer service representative, please contact ATI at:

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

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

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

8. Specifications

8.1 F/T Sensor

For specifications of the ATI sensor, refer to the *ATI website* or appropriate *ATI F/T sensor manual*.