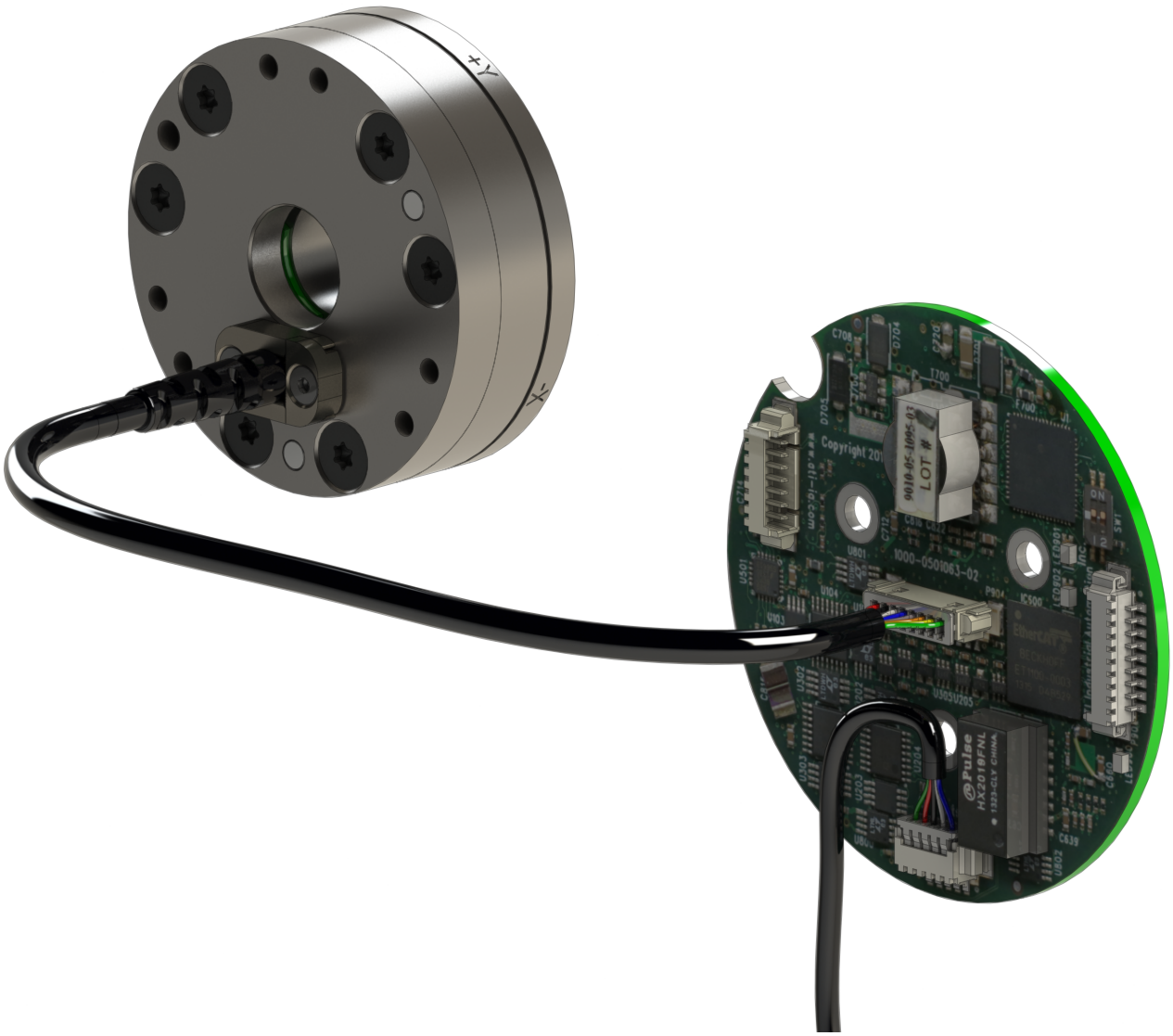
Manual

EtherCAT F/T Interface for OEM



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

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Table of Contents

Glossary

Term	Definition
CoE	CANopen over EtherCAT, the preferred embedded protocol for configuring EtherCAT devices. Used within SDO to encode the configuration data.
DINT	A data type representing a signed integer with 32 bits.
E-Exit	ATI's E-Exit transducers have a cable with an over-molded strain relief.
EtherCAT	An industrial automation fieldbus.
FoE	File access over EtherCAT, the preferred embedded protocol for uploading new firmware to EtherCAT devices.
F/T	Force/Torque.
F/T Transducer	Converts force and torque into an electrical signal.
MAP	The Mounting Adapter Plate (MAP) is the transducer plate that attaches to the fixed surface or robot arm.
MOLEX® PicoBlade®	Product series from the connector manufacturer Molex.
PDO	Process Data Object, a protocol for reading and writing real-time process information cyclically.
P/N	Part Number
PoE	Power-over-Ethernet, is a method of delivering electrical power to a PoE-compatible Ethernet device through the Ethernet cable. This simplifies installation of the Ethernet device since a separate power supply is not needed. The EtherCAT OEM F/T system is Mode A PoE compatible.
SDO	Service Data Object, a protocol for reading and writing configuration information acyclically.
STG	Strain Gage
TAP	Tool Adapter Plate (TAP) is the transducer surface that attaches to the load to be measured.
Transducer	Transducer is the component that converts the sensed load into electrical signals.
UDINT	A data type representing an unsigned integer with 32 bits.
UINT	A data type representing an unsigned integer with 16 bits.
USINT	A data type representing an unsigned integer with 8 bits.

1. Safety

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

1.1 Explanation of Notifications

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

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

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

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

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

1.2 General Safety Guidelines

The customer should verify that the transducer selected is rated for maximum loads and moments expected during operation. Refer to F/T Transducer Manual (9620-05-Transducer Section—Installation and Operation Manual) found in Net F/T Installation and Operation Manual (9610-05-1022) or contact ATI Industrial Automation for assistance. Particular attention should be paid to dynamic loads caused by robot acceleration and deceleration. These forces can be many times the value of static forces in high acceleration or deceleration situations.

1.3 Safety Precautions

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

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

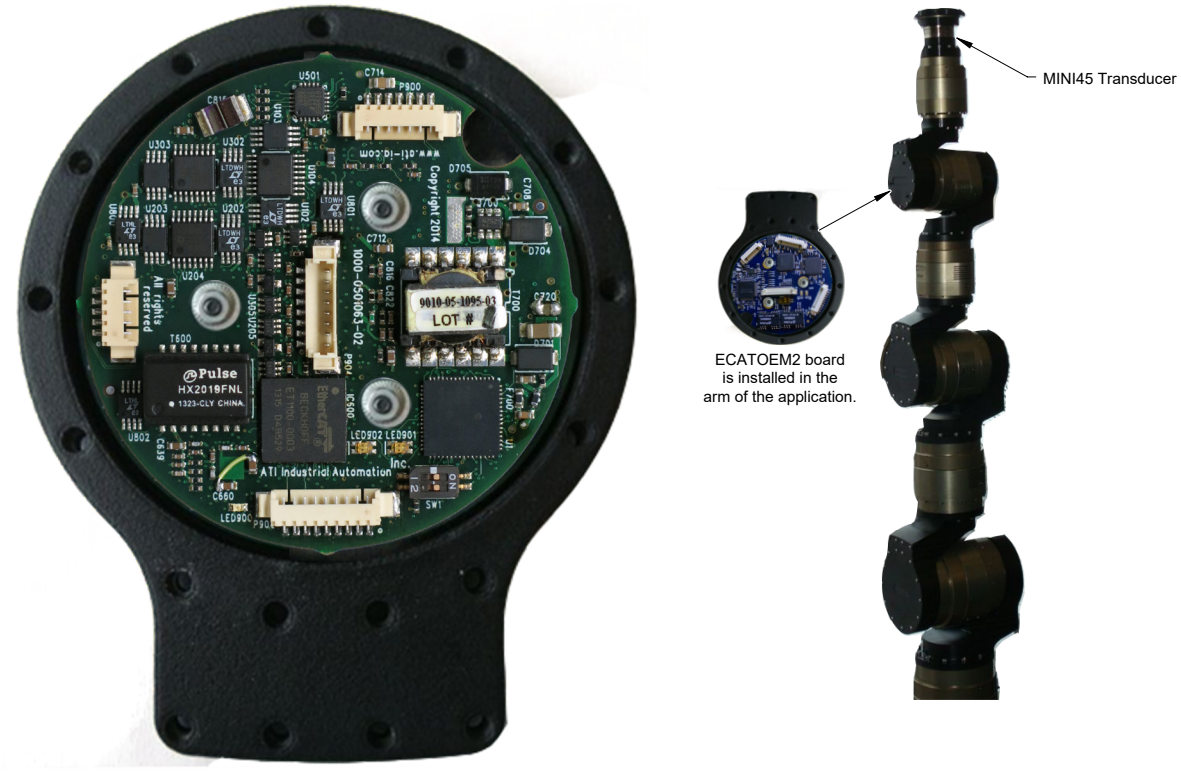
CAUTION: Do not exert excessive force on the transducer. The transducer is a sensitive instrument and can be damaged by applying force exceeding the single-axis overload values of the transducer and cause irreparable damage. Small Nano and Mini transducers can easily be overloaded during installation.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

2. Product Overview

The EtherCAT F/T Interface for OEM System consists of an ATI transducer and a F/T-to-EtherCAT interface board (ECATOEM). The transducer selected includes a Molex PicoBlade connector. The interface board mounts within a customer's enclosure. The customer provides DC power supply (20 to 48 V) or Mode A PoE power supply.

Figure 2.1 shows a sample application that uses the ECATOEM mounted in a segment of a light weight arm and a Mini45 transducer mounted on the arm.

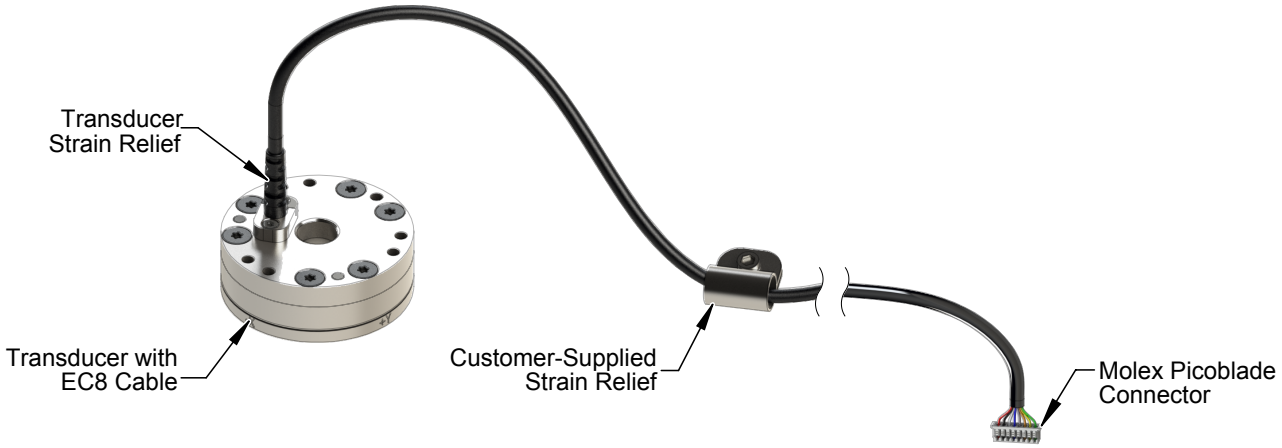
Figure 2.1—Sample Application



3. Compatible Transducer

Transducers with part numbers ending in EC8 are custom designed for use with ECATOEM. It differs from a standard Nano or Mini transducers in that the MOLEX PicoBlade connector contacts are crimped to the eight wires of the transducer cable. Note that unlike the cable represented in the following figures, the actual cable has a longer length of unjacketed wire (and drain wire) that leads up to the Molex connector.

Figure 3.1—Transducer with Strain Relieved EC8 Cable

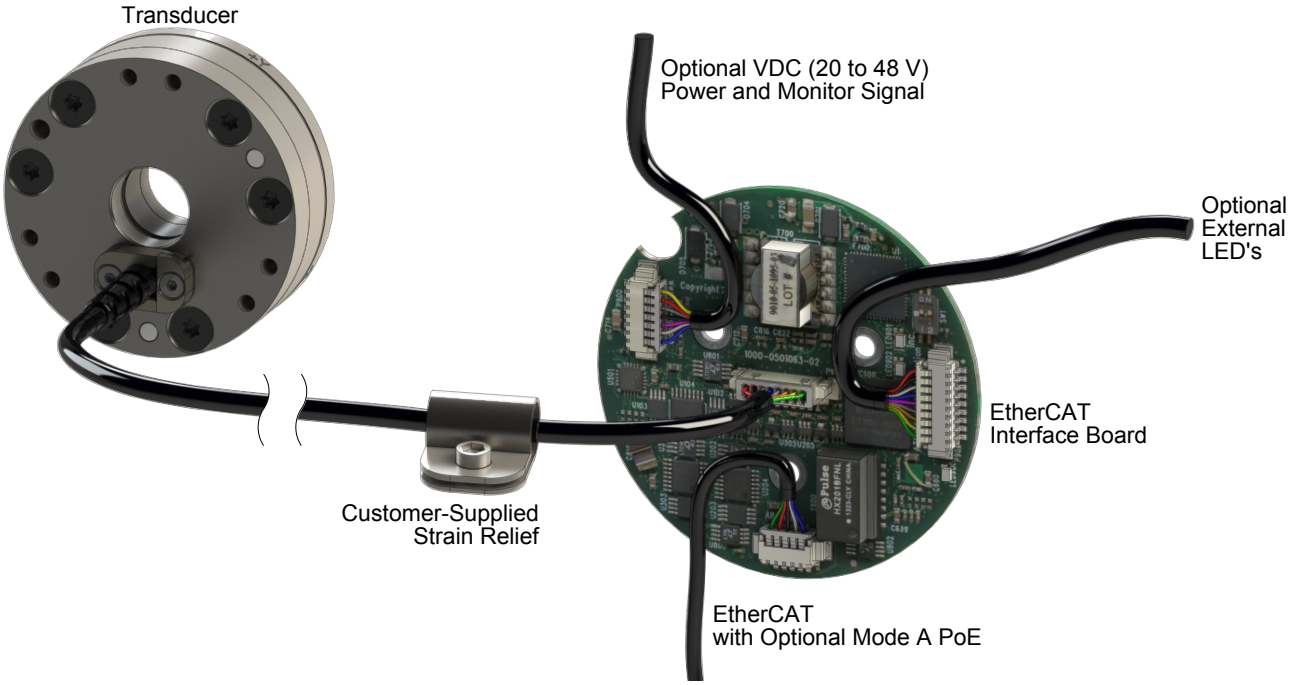


4. ECATOEM Interface Board

The ECATOEM provides an EtherCAT bus interface for ATI's TW transducers. Equipped with an 8-pin MOLEX PicoBlade connector (like the 9105-TW-MINI45-AE-0.3-EC8), they can be plugged directly into the ECATOEM interface board.

NOTICE: The transducer has no strain relief. Suitable strain relief must be provided in the final product to protect the crimp contacts

Figure 4.1—ECATOEM System



The 9105-ECATOEM interfaces with the transducer's strain gages via connector P903 and P904. The strain gage signals get digitized with a 16bit A/D converter, multiplied with the selected calibration matrix and the resulting force/torque data are then transmitted over an EtherCAT bus interface.

Up to 16 transducer calibrations can be stored in the on-board EEPROM.

The ECATOEM can be supplied with a DC power between 20 V and 48 V or with Mode A PoE.

Figure 4.2—ECATOEM Block Diagram

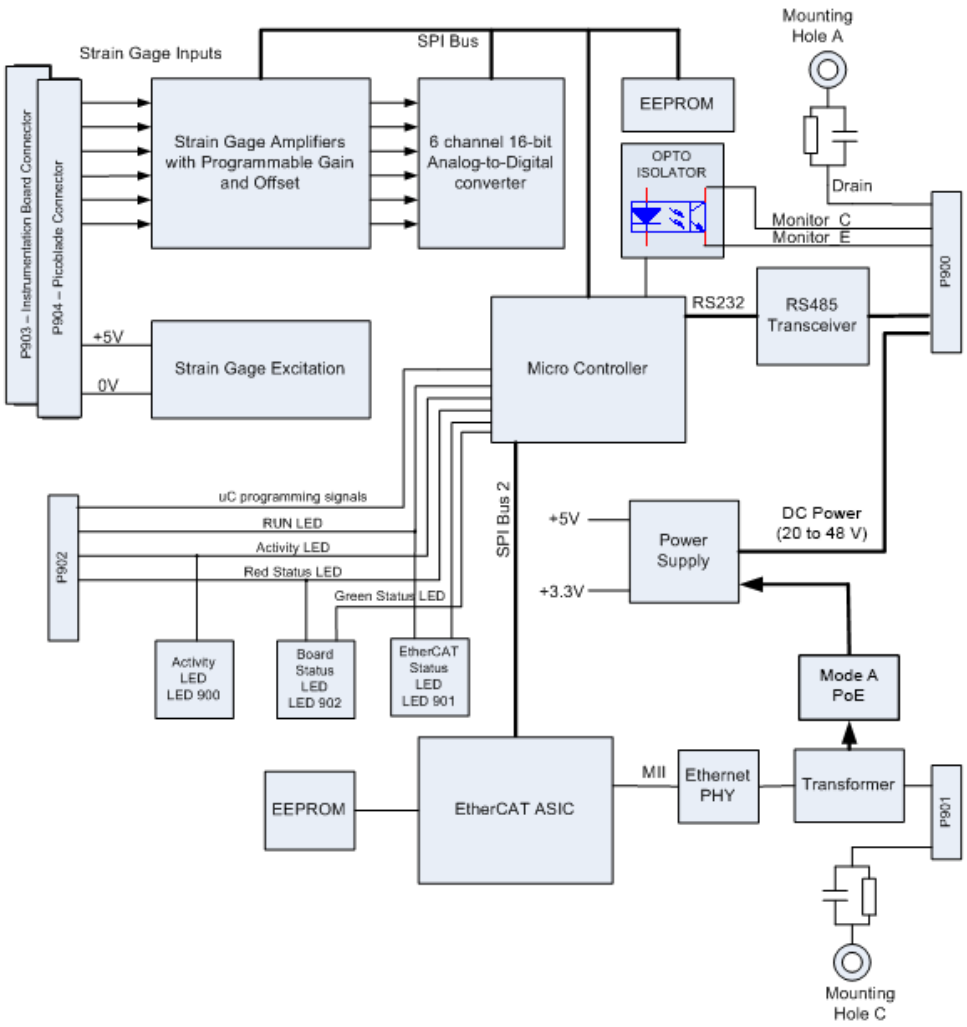
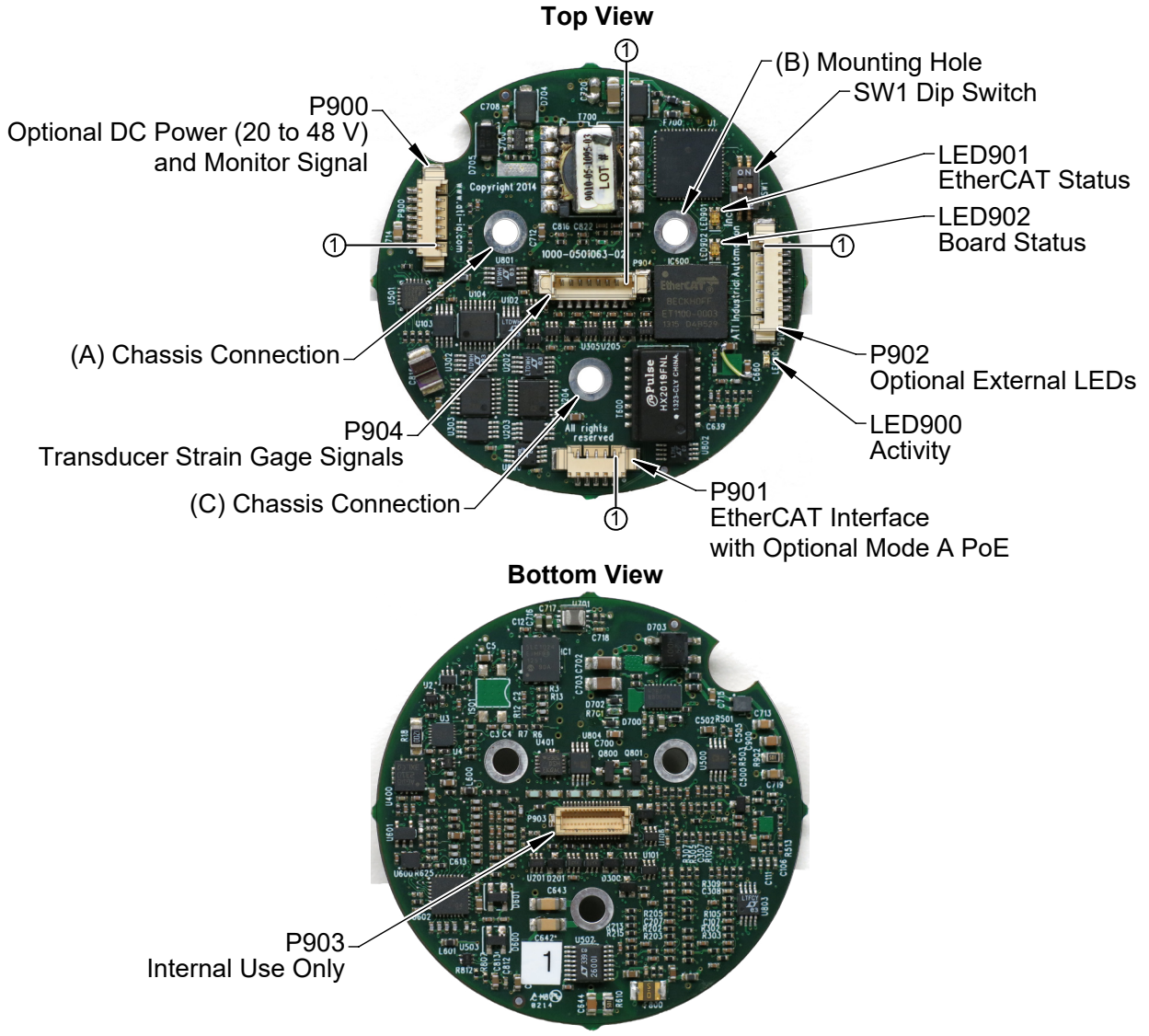


Figure 4.3—ECATOEM – Components



4.1 Connectors

The ECATOEM PCB Assembly has the following connections:

4.1.1 P900 Connector for Optional DC Power and Monitor Signal Interface

Mating connector housing: Molex 51021-0700

Mating connector contact: Molex 50058-8000 (28-32 AWG) or Molex 50079-8000 (26-28 AWG)

Pin No.	Signal Name	Description
1	SL_GND	20 to 48 VDC Power Supply Ground
2	RS485-	- Serial Interface to NetBox
3	DRAIN	Serial Interface Shield
4	RS485+	+ Serial Interface to NetBox
5	SL_VP	20 to 48 VDC Power Supply Positive
6	MONITOR_E	Monitor signal: emitter contact of opto isolator
7	MONITOR_C	Monitor signal: collector contact of opto isolator

4.1.2 P901 Connector for EtherCAT Interfaces

Mating connector housing: Molex 51021-0500
Mating connector contact: Molex 50058-8000 (28-32 AWG) or Molex 50079-8000 (26-28 AWG)

Pin No.	Signal Name	Description
1	TX+	Ethernet Transmit +
2	TX-	Ethernet Transmit -
3	RX+	Ethernet Receive +
4	RX-	Ethernet Receive -
5	Shield	Ethernet cable shield

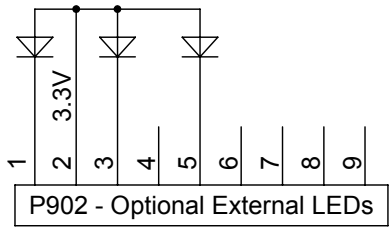
ATI provides a mating wire harness to the RJ45 part: ATI P/N 9105-C-EC5-RJ45-0.2

4.1.3 P902 Connector for optional external LEDs

Mating connector housing: Molex 51021-0900
Mating connector contact: Molex 50058-8000 (28-32 AWG) or Molex 50079-8000 (26-28 AWG)

Pin No.	Signal Name	Description
1	RUN_LED	Connect to cathode of optional external EtherCAT RUN LED
2	+3.3V	Connect to anode of optional external LEDs
3	ACTIVITY_LED	Connect to cathode of optional external ACTIVITY LED
4	+3.3V	Connect to anode of optional external LEDs
5	RED_STATUS_ LED	Connect to cathode of optional external Board Status LED
6	Reserved	For uC programming
7	Reserved	For uC programming
8	Reserved	For uC programming
9	DGND	Ground for +3.3V; used for uC programming

Figure 4.4—P902 LED Wiring Diagram



4.1.4 P904 Connector for Transducer Strain Gage Signals

Mating connector housing: Molex 51021-0800
Mating connector contact: Molex 50058-8000 (28-32 AWG) or Molex 50079-8000 (26-28 AWG)

Pin No.	Signal Name	Description
1	+VSG	5V, Positive strain gage bridge supply voltage
2	-VSG	0V, Negative strain gage bridge supply voltage
3	G0	Strain gage 0 voltage
4	G1	Strain gage 1 voltage
5	G2	Strain gage 2 voltage
6	G3	Strain gage 3 voltage
7	G4	Strain gage 4 voltage
8	G5	Strain gage 5 voltage

4.2 Switch

The following switch is available on the ECATOEM PCB Assembly:

4.2.1 SW1

The two-position DIP switch is currently unused.

Position	ON/OFF	Description
1	ON	**Do Not Use**
	OFF	Default settings OFF
2	ON	**Do Not Use**
	OFF	Default settings OFF

NOTICE: Leave Dip switch in Default state. Changing Dip Switch settings may adversely affect the EtherCAT board functionality.

4.3 LEDs

The following LEDs are available on the ECATOEM PCB Assembly:

4.3.1 LED900 Link/Activity

One green LED signals activity on the EtherCAT port.

LED State	Link	Activity	Condition
Off	No	No	Port closed
Green	Yes	No	Port open
Flashing Green	Yes	Yes	Port open

4.3.2 LED901 EtherCAT Status

One dual-color LED signals the status of the EtherCAT Network in the following way.

LED State	RUN State	ERROR State	Description
OFF	INIT	No	Device is in state INIT
GREEN Blinking	PRE-OP	No	Device is in state PRE-OPERATIONAL
GREEN Single Flash	SAFE-OP	No	Device is in state SAFE-OPERATIONAL
GREEN	OP	No	Device is in state OPERATIONAL
RED Double Flash		Process Data Watchdog Timeout	An application watchdog timeout has occurred. E.g. Sync Manager Watchdog timeout
RED Single Flash		Local Error	Slave device application has changed the EtherCAT state autonomously, due to local error. E.g. device changes its EtherCAT state from OP to SAFE-OP due to a synchronization error
RED Blinking		Invalid Configuration Error	General configuration error. E.g State change commanded by master is impossible due to register or object settings, or invalid hardware configuration (pin sharing violation detected by ESC)

4.3.3 LED902 Board status

One dual-color LED signals the status of the EtherCAT Board in the following way.

LED State	Status	Description
OFF	No Power	The board doesn't have sufficient power
Green	All OK	Fully Operational, No errors
Orange (Amber)	Saturation	Transducer input is saturated; one of the strain gage input voltages is too high; all force and torque data are invalid; use less sensitive calibration if available;
Red	Diagnostic voltage error	One of the internal diagnostic voltages is outside the acceptable range.
Red Blinking (1 Hz)	No calibration loaded	Active calibration slot is empty or has checksum error;
Red Blinking (10 Hz)	Communication error with ECAT ASIC	No or faulty communication between uC and EtherCAT ASIC
Red Blinking (20 Hz)	Gage Saturation	One or more of the transducer gages is saturated. Stop applying force and wait for the error to clear. If the error does not clear, this status signals potential mechanical damage or a loss of power.

5. Operation

5.1 F/T Raw Data Output

F/T data output from the sensor and into the EtherCAT interface is in counts. The user must convert the value from counts to units (refer to *Section 6.2.6.1—Converting Force/Torque Counts to Units*).

5.2 Sample Rate

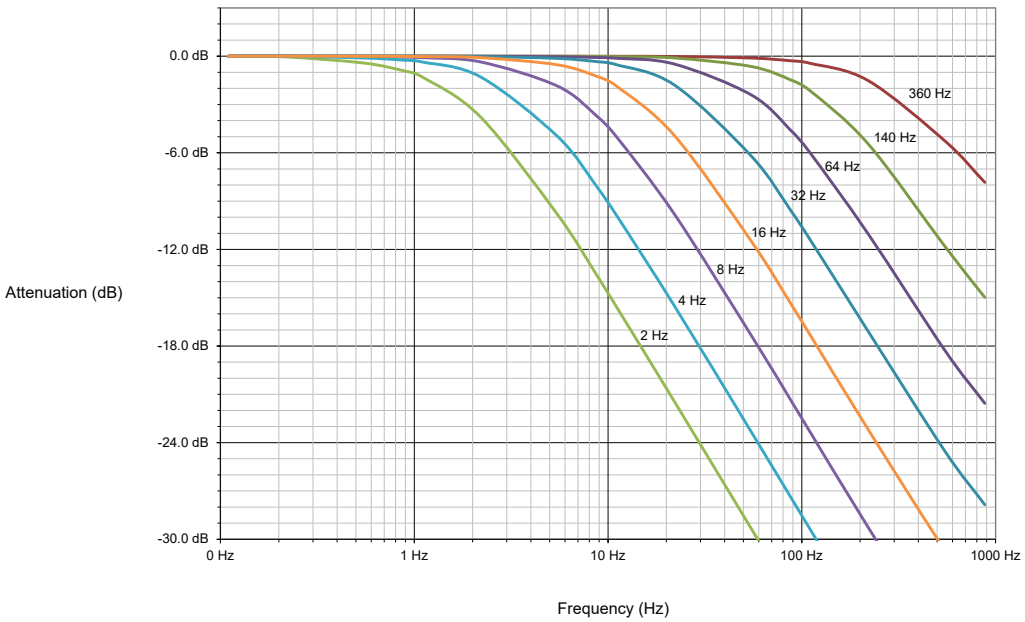
The firmware samples internally at 3000 Hz.

5.3 Filtering

The "Filter Selection" field in *Section 6.2.9—Object 0x7010: Control Codes* controls the coefficient used in the internal IIR filter. The cutoff frequency is dependent on the internal sample rate, which is defined in *Section 5.2—Sample Rate*. The relative cutoff frequencies for different values of this coefficient are:

Coefficient	Cutoff Frequency (Percent of Internal Sample Rate)	Frequency
0	No filter	N/A
1	11.97%	360 Hz
2	4.66%	140 Hz
3	2.17%	64 Hz
4	1.04%	32 Hz
5	0.51%	16 Hz
6	0.26%	8 Hz
7	0.12%	4 Hz
8	0.07%	2 Hz

Figure 5.1—Filter Attenuation at 3 kHz Sample Rate



5.4 Threshold Monitoring

The EtherCAT OEM FT system will allow the user to configure thresholds. To activate a threshold, write the appropriate values in *Section 6.2.3—Object 0x2060: Monitor Condition* then set the bit corresponding to the threshold in the "Monitor Condition Enable Bitmap" in *Section 6.2.9—Object 0x7010: Control Codes*.

The software currently supports one monitor condition.

5.5 Discrete output

The discrete output will turn on when any active monitor condition becomes true.

5.6 Tool Transformation

To activate a tool transformation, write the appropriate transform coefficients to *Section 6.2.1—Object 0x2020: Tool Transformation*, then set the "Tool Transform Index Selection" bits in *Section 6.2.9—Object 0x7010: Control Codes* to activate that condition. The software currently only supports one tool transformation.

6. EtherCAT Bus Interface

The EtherCAT bus interface allows a user to:

- Determine which calibration is active
- Select a calibration to be active
- Read the active calibration information matrix, serial number, etc.
- Read the firmware revision of the ECATOEM
- Read force/torque data
- Read strain gage data and status information.
- Configure tool transformation.
- Set monitor conditions
- Set low pass filter cutoff frequency.
- Bias transducer.

6.1 PDO Interface

The PDO interface is used to exchange data in real-time with the F/T sensor.

a. TxPDO Map / Output Data
The TxPDO combines *Object 0x6000: Reading Data*, *Object 0x6010: Status Code*, and *Object 0x6020: Sample Counter*.

b. RxPDO Map / Input Data
The RxPDO map consists of *Object 0x7010: Control Codes*.

6.2 EtherCAT Dictionary Objects (SDO Data)

The SDO data is used to configure the sensor and read manufacturing and calibration information. This section documents dictionary objects that are specific to the EtherCAT F/T sensor application; it does not list objects which are a required part of the EtherCAT standard.

6.2.1 Object 0x2020: Tool Transformation

This writable object contains the following 32-bit signed integer fields:

Subindex	Name	Description
0x01	Rx	The rotation about the X axis, in units of 0.1 degrees, e.g. an Rx value of 900 = 90 degrees.
0x02	Ry	The rotation about the Y axis, in units of 0.1 degrees.
0x03	Rz	The rotation about the Z axis, in units of 0.1 degrees.
0x04	Dx	The displacement along the x axis, in units of 0.01 calibration length units. E.g. if the distance component of the torque is meters, a Dx value of 100 = 1 meter.
0x05	Dy	The displacement along the y axis, in units of 0.01 calibration length units.
0x06	Dz	The displacement along the z axis, in units of 0.01 calibration length units.

6.2.2 Object 0x2040: Calibration

This read-only object contains information about the currently active calibration selected by the "Calibration Selection" field in *Section 6.2.9—Object 0x7010: Control Codes*. It contains the following fields:

Subindex	Name	Type	Description
0x01	FT Serial	STRING(8)	The FT Serial Number, e.g. "FT01234."
0x02	Calibration Part Number	STRING(30)	The calibration part number e.g. "SI-120-95."
0x03	Calibration Family	STRING(8)	Always reads "ECAT"
0x04	Calibration Time	STRING(30)	The date the sensor was calibrated
0x05	Matrix FxG0	DINT	These 36 elements contain the scaled "working" matrix used for this calibration. This will not necessarily match the calibration matrix in the calibration file, because the calibration matrix has to be scaled to suitably large integers before it can be used by the sensor.
0x06	Matrix FxG1		
0x07	Matrix FxG2		
0x08	Matrix FxG3		
0x09	Matrix FxG4		
0x0a	Matrix FxG5		
0x0b	Matrix FyG0		
0x0c	Matrix FyG1		
0x0d	Matrix FyG2		
0x0e	Matrix FyG3		
0x0f	Matrix FyG4		
0x10	Matrix FyG5		
0x11	Matrix FzG0		
0x12	Matrix FzG1		
0x13	Matrix FzG2		
0x14	Matrix FzG3		
0x15	Matrix FzG4		
0x16	Matrix FzG5		
0x17	Matrix TxG0		
0x18	Matrix TxG1		
0x19	Matrix TxG2		
0x1a	Matrix TxG3		
0x1b	Matrix TxG4		
0x1c	Matrix TxG5		
0x1d	Matrix TyG0		
0x1e	Matrix TyG1		
0x1f	Matrix TyG2		
0x20	Matrix TyG3		
0x21	Matrix TyG4		
0x22	Matrix TyG5		
0x23	Matrix TzG0		
0x24	Matrix TzG1		
0x25	Matrix TzG2		
0x26	Matrix TzG3		
0x27	Matrix TzG4		
0x28	Matrix TzG5		

Subindex	Name	Type	Description	
0x29	Force Units	USINT	Value	Unit
			1	Lbf
			2	N
			3	Klbf
			4	kN
			5	Kg
0x2a	Torque Units	USINT	Value	Unit
			1	Lbf-in
			2	Lbf-ft
			3	N-m
			4	N-mm
			5	Kg-cm
			6	kN-m
0x2b	Max Fx Counts	DINT	The maximum rated value for this axis, in counts.[1]	
0x2c	Max Fy Counts			
0x2d	Max Fz Counts			
0x2e	Max Tx Counts			
0x2f	Max Ty Counts			
0x30	Max Tz Counts			
0x31	Counts Per Force	DINT	The calibration counts per force unit.	
0x32	Counts Per Torque	DINT	The calibration counts per torque unit.	
0x33	Gain G0	UINT16	The code used to program the gain potentiometer	
0x34	Gain G1			
0x35	Gain G2			
0x36	Gain G3			
0x37	Gain G4			
0x38	Gain G5			
0x39	Offset G0	UINT16	The code used to program the offset DAC.	
0x3a	Offset G1			
0x3b	Offset G2			
0x3c	Offset G3			
0x3d	Offset G4			
0x3e	Offset G5			

6.2.3 Object 0x2060: Monitor Condition

This user-writable object allows the user to configure an axis, a threshold value, and direction to continuously evaluate against the current F/T data. When an enabled condition becomes true, the monitor output becomes active and stays active until reset via setting the "Reset Monitor Condition" bit in *Section 6.2.9—Object 0x7010: Control Codes*, which is also mapped into the TxPDO data.

The following fields are available in the monitor condition:

Subindex	Name	Type	Description	
0x01	Threshold Value	DINT	The threshold value to compare against, in counts.	
0x02	Axis	USINT	**Value**	**Axis**
			0x03	Fx
			1	Fy
			2	Fz
			3	Tx
			4	Ty
			5	Tz
0x03	CompareGreaterThan	BOOL	If TRUE, the monitor condition is true when the selected axis is greater than the selected threshold value. If FALSE, the monitor condition is true when the selected axis is less than the selected threshold value.	

6.2.4 Object 0x2080: Diagnostic readings

This read-only object provides access to diagnostic values. These values may be useful when troubleshooting the system. All diagnostic voltages are filtered with the filter coefficient set to "8" – see *Section 5.3—Filtering* for details.

The following fields are available in the Diagnostic Readings object:

Subindex	Name	Type	Description	Limits	Sampling Rate
0x01	6V Supply Sense	UINT16	The 6V supply ADC reading.	2568 to 3970 counts	½ strain gage sampling rate.[1]
0x02	Thermistor	UINT16	The thermistor ADC reading.	None, information only.	½ strain gage sample rate. [1]
0x03	VBridge Volts	INT16	The excitation voltage ADC reading.	17050 to 17750 counts.	Strain gage sampling rate.[1]
0x04	VBridge Current	INT16	The excitation current ADC reading.	500 to 6554 counts.	Strain gage sampling rate.[1]

Note:

1. See *Section —F/T data output from the sensor and into the EtherCAT interface is in counts. The user must convert the value from counts to units (refer to Section 6.2.6.1—Converting Force/Torque Counts to Units).* for strain gage sampling rate.

6.2.5 Object 0x2090: Version

This read-only object provides firmware version information.

The following fields are available in the version object:

Subindex	Name	Type	Description
0x01	Major	UINT16	Major Version
0x02	Minor	UINT16	Minor Version
0x03	Revision	UINT16	Revision

6.2.6 Object 0x6000: Reading Data

This read-only object represents the current force/torque or gage data. It is mapped into the TxPDO input data.

The following fields are present in the reading data:

Subindex	Name	Type	Description
0x01	Fx/Gage0	DINT	If the "Gage Data" bit in *Section 6.2.9—Object 0x7010: Control Codes* is set, these fields contain the 16-bit gage data. If the "Gage Data" bit is cleared, these fields contain the 32-bit F/T result data, in counts.
0x02	Fy/Gage1		
0x03	Fz/Gage2		
0x04	Tx/Gage3		
0x05	Ty/Gage4		
0x06	Tz/Gage5		

6.2.6.1 Converting Force/Torque Counts to Units

The data in the register for this object is in counts. Therefore, the F/T counts must be converted to a value in units.

To convert the SDO counts into units, complete the following steps:

1. Read the Counts per Force SDO register (refer to *Section 6.2.2—Object 0x2040: Calibration* subindex 0x31).
2. Read the Counts per Torque SDO register (refer to *Section 6.2.2—Object 0x2040: Calibration* subindex 0x32).
3. Verify the units of force (refer to *Section 6.2.2—Object 0x2040: Calibration* subindex 0x29).
4. Verify the units of torque (refer to *Section 6.2.2—Object 0x2040: Calibration* subindex 0x2a).
5. Read the F/T counts for force (refer to *Section 6.2.6—Object 0x6000: Reading Data*).
6. Read the F/T counts for torque (refer to *Section 6.2.6—Object 0x6000: Reading Data*).
7. Convert the counts to units.
   a. For force, divide the register from step *5* by the register from step *1*.
   b. For torque, divide the register from step *6* by the register from step *2*.

For example, a user wants the counts for Fx and Tx in units. First, the user reads the registers for the applicable SDO subindexes and finds the following:

Table 6.1—Example of Registers for SDO Subindexes

SDO	Subindex	Register	Description[1]
0x2040	0x31	1, 000, 000	Counts Per Force
0x2040	0x32	1, 000, 000	Counts Per Torque
0x2040	0x29	2	The force units are N.
0x2040	0x2a	3	The torque units are Nm.
0x6000	0x01	5, 214, 777	Fx data in raw counts
0x6000	0x04	4, 214, 777	Tx data in raw counts

Note:

1. The description is not provided in the user's EtherCAT interface but is provided in this table for reference.

Then the user converts counts to units for Fx and Tx.

For Fx: 5, 214, 777 counts ÷ 1, 000, 000 N/counts = 5.21 N

For Tx: 4, 214, 777 counts ÷ 1, 000, 000 Nm/counts = 4.21 Nm

6.2.7 Object 0x6010: Status Code

This object contains a single DINT value (at subindex 0), with the following bitmap:

Bit Number	Description	Indicates Error?
0	Monitor Condition Tripped: This bit becomes active when an active monitor condition becomes true, and remains set until cleared with the "Reset Monitor Conditions" bit in *Section 6.2.9—Object 0x7010: Control Codes*.	No
1	Supply Out of Range: This bit becomes active if the supply sense reading in *Section 6.2.4—Object 0x2080: Diagnostic readings* is out of the expected range. This bit remains set until power cycle. It may indicate a system fault.	Yes
2	Reserved	
3	VBridge Volts Out of Range: This bit is set if the excitation voltage in *Section 6.2.4—Object 0x2080: Diagnostic readings* is out of the expected range. This bit remains set until power cycle. It may indicate a system fault.	Yes
4	VBridge Current Out of Range: This bit is set if the excitation current in *Section 6.2.4—Object 0x2080: Diagnostic readings* is out of the expected range. This bit remains set until power cycle. It may indicate a system fault.	Yes.
5	DPOT Fault. This bit is set if there is an error reading back the value written to a DPOT. It remains set until power cycle.	Yes.
6	EEPROM Fault. This bit is set if there is an error reading back the value written to EEPROM. It remains set until power cycle.	Yes.
7	DAC Fault. This bit is set if there is an error detected communicating with the DAC. The DAC used (LTC2600) does not support a read-back operation, but it does support daisy-chaining, so the firmware detects a failure by prepending a known value to any commands, and looking for an echo of that known value on the SPI input after sending the command. It remains set until power cycle.	Yes.
6-27	Reserved	
28	Simulated Error. This bit mirrors the "Simulated Error Control" bit in *Section 6.2.9—Object 0x7010: Control Codes*.	No, but can be used to test user error handling if treated as such.
29	Calibration checksum error. This bit is set if the active calibration did not have a valid checksum when read from EEPROM.	Yes.
30	Saturation. This bit is set whenever a strain gage sample is saturated, and stays high for 32 samples after the last saturated sample, to allow time for the saturated sample's effect on the filtered data to abate.	Yes.
31	Error: This bit is set whenever any status code bit that indicates an error is set.	Yes

6.2.8 Object 0x6020: Sample Counter

This object contains a single 32-bit unsigned integer at subindex 0 that increments each time an F/T sample (one complete set of gage data) is read.

6.2.9 Object 0x7010: Control Codes

This object is mapped into the RxPDO for real-time control of the F/T system. It contains the following fields:

Subindex	Name	Type	Description	
			Bit	**Function**
0x01	Control 1	DINT	0	1 = Set bias against current load. 0 = Use last set bias.
			1	1 = Select gage output 0 = Select F/T output in counts
			2	1 = Set test error 0 = clear test error
			3	1 = Clear monitor condition status. 0 = Leave monitor condition status as-is.
			4-7	Filter selection
			8-11	Calibration Selection
			12-31	Reserved
			Bit	**Function**
0x02	Control 2	DINT	0-15	Monitor condition enable bitmap
			16-19	Tool transform index selection.[1]
			20-30	Reserved
			31	Simulated Error Control

Note:

1. After changing the tool transform index, it is recommended you do not update the control codes for a period of 500 milliseconds to allow the sensor to fully apply the transformation.

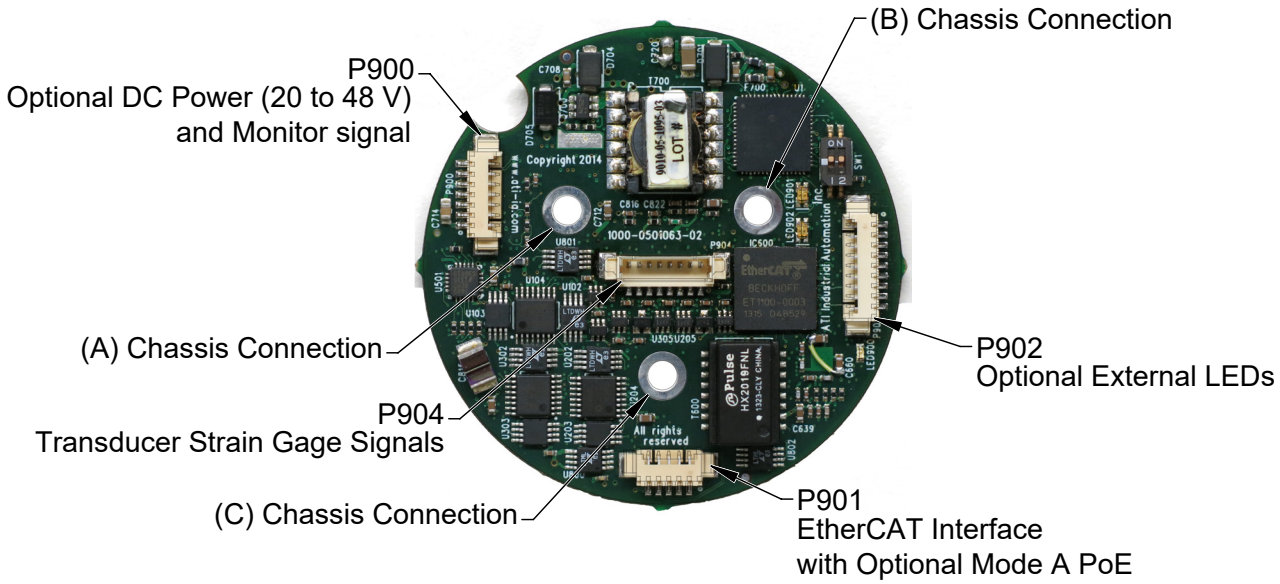
7. Hardware Installation

The following section provides information for installing the ECATOEM PCB into an application.

7.1 Chassis Grounding

The ECATOEM interface board provides three mounting holes. One of these (marked “C” in *Figure 7.1*) provides a path to the shield connection of the EtherCAT bus cable. The mounting hole (marked “A” in the picture below) provides a path to the shield connection of the DC power (20 to 48 V) and monitor signal cable. For best EMI performance both, “A” and “C” should get connected to chassis ground.

Figure 7.1—ECATOEM Interface Board Mounting



NOTICE: To minimize PCB vibration, all three mounting holes should be used.

7.2 Transducer Handling

In addition to the standard transducer handling instructions (see Manual 9620-05-Transducer Section for details), the following should be observed:

- The transducer calibration label FTxxxx must not be removed or painted over. If a transducer gets returned to ATI for calibration or repair, it is important that this number is present.
- The transducer connector has no strain relief. To protect the fragile crimp contacts it is important to provide a suitable strain relief in the final product.

7.3 Ground and cable shield considerations

There are several options for connecting the transducer cable shield:

1. If the transducer is connected to chassis ground, then don’t connect the cable shield (since the shield is connected to the transducer body and such to chassis ground).
2. If the transducer is isolated, then:
   a. Connect the cable shield to chassis ground or
   b. Connect the cable shield to system Ground P900 Pin 9

You may have to experiment to find the best solution for EMC compliance and best noise performance.

7.4 Power Supply Considerations

The ECATOEM interface board can be supplied with a DC voltage between 20 and 48 V (24 V is most commonly used) on P900 or with Mode A PoE through the EtherCAT interface (P901).

The EtherCAT F/T's PoE input is compatible with the IEEE 802.3af (Power-over-Ethernet) specification and uses Mode A to receive power. Mode B requires eight Ethernet conductors and is not supported.

7.5 Installation

The transducer can be used in a variety of applications that will affect how best to route the cable and determine the proper bending radius to use. Some applications will allow the transducer and the cable to remain in a static condition, other applications require the transducer to be in a dynamic condition that requires the cable to be subjected to repetitive motion. It is important not to expose the transducer cable connectors to this repetitive motion, and properly restrain the cable close to the transducer connection. Refer to the Transducer Section Manual (*http://www.ati-ia.com/app_content/documents/9620-05-Transducer%20Section.pdf*) for proper cable bending radius and cable restraint methods.

1. Attach the ECATOEM interface board to the mounting using customer supplied M3 fasteners, use all three mounting holes to secure the board. Refer to *Figure 7.2*.

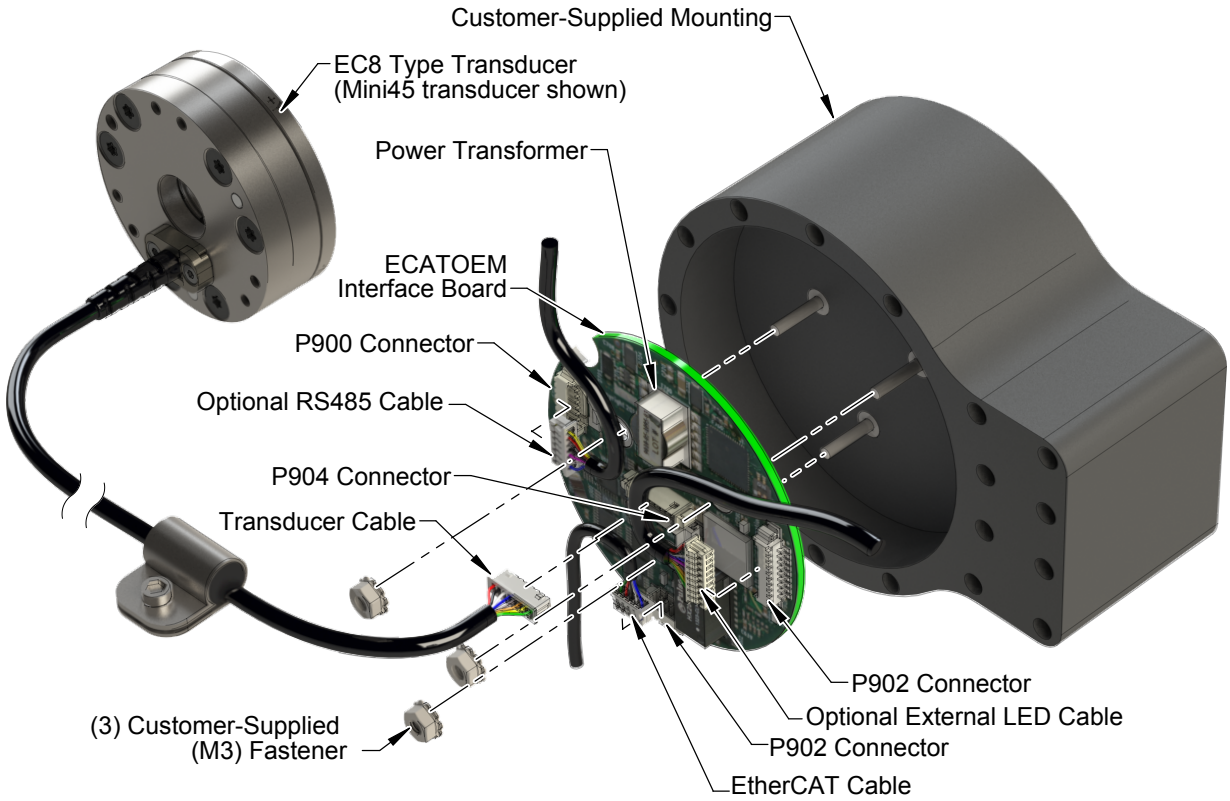
CAUTION: Do not plug in and power the interface board until after it has been mounted and all conductive tools are away from the interface board.

NOTICE: Make sure mounting holes "A" and "C" are connected to chassis ground. Not connecting the "A" and "C" mounting holes to chassis ground may cause unpredictable behavior. Refer to *Figure 7.1*

2. Route and connect the EtherCAT cable to the P901 connector on the ECATOEM interface board.
3. Route and connect the Transducer cable to the P904 connector on the ECATOEM interface board.

NOTICE: Make sure to route the Transducer cable away from the Power Transformer on the ECATOEM interface board. Routing the Transducer cable close to the power transformer can cause noise problems.

Figure 7.2—ECATOEM Interface Board Installation



4. If using an external DC power supply (between 20 and 48 V) instead of Mode A PoE then connect the DC power (Pin 1(-) and Pin 5 (+)) to P900 connector on the ECATOEM interface board (refer to *Section 4.1.1—P900 Connector for Optional DC Power and Monitor Signal Interface* for P900 connector signals).
5. If using the Optional External LED cable route the cable and connect to the P902 connector on the ECATOEM interface board. Refer to *Section 4.1.3—P902 Connector for optional external LEDs* for P902 connector signals.

8. Troubleshooting

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

> Note
>
> Please read the manual before calling customer service. Before calling, have the following information available:
>
> 1. Serial number; for example, FT01234)
> 2. Sensor model; for example, Nano17, Gamma, Theta.
> 3. Calibration; for example, US-15-50, SI-65-6.
> 4. Accurate and complete description of the question or problem
> 5. Description of the third party hardware and software used to connect and supply power to the ECATOEM F/T system.
>
> If possible, be near the F/T system when calling.

Please contact an ATI representative for assistance, if needed:

ATI Industrial Automation
1041 Goodworth Drive
Apex, NC 27539 USA
www.ati-ia.com

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

8.1 Questions and Answers

8.1.1 Errors with Force and Torque Readings

Bad data from the transducer's strain gages can cause errors in force/torque readings. These errors can result in problems with transducer biasing and accuracy. Listed below are the basic conditions of bad data. Use this to troubleshoot your problem.

Table 8.1—Troubleshooting

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

9. Specifications

9.1 Storage and Operating Conditions

Table 9.1—Temperature		
Component	**Storage Temperature, °C**	**Operating Temperature, °C**
ECATOEM	-40 to +85	-30 to +85
9105-MINI45TH12-AE-0.40-EC8	See Transducer Section Manual *http://www.ati-ia.com/app_content/documents/9620-05-Transducer%20Section.pdf*	See Transducer Section Manual *http://www.ati-ia.com/app_content/documents/9620-05-Transducer%20Section.pdf*

9.2 Electrical Specifications

Table 9.2—Power Supply		
Power Source†	**Voltage**	**Maximum Power Consumption[1]**
DCIN through P900	(20V min. to 48V max.)	3.0W

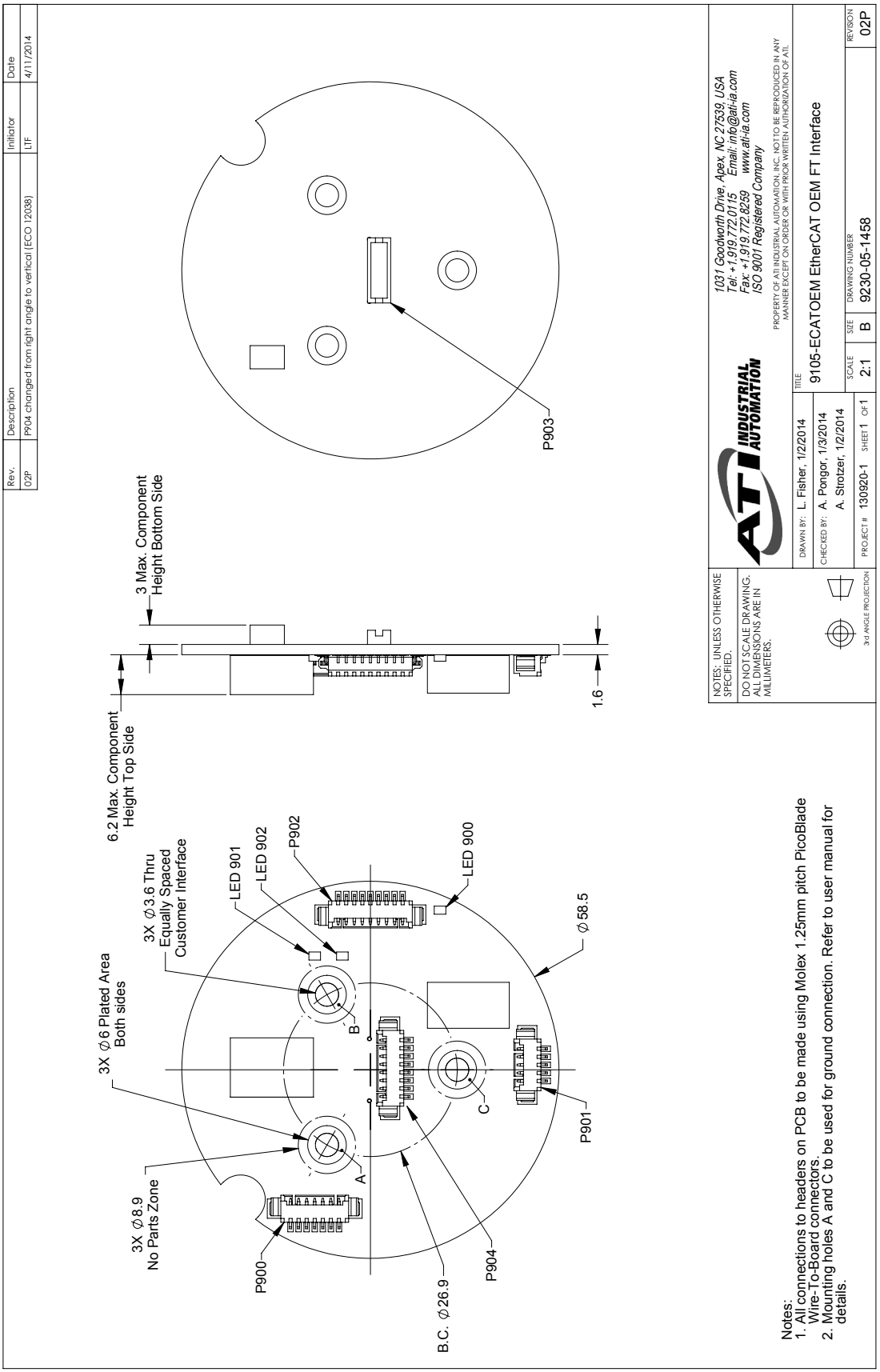
Notes:
1. With Mini45 transducer connected to the ECATOEM interface board Assembly.

The ECATOEM power supply input is protected against wrong polarity.

9.3 Weights and Dimensions

Table 9.3—Weights and Dimensions		
Component	**Weight (approx.)**	**Dimensions**
ECATOEM PCB Assembly	17g (0.6oz)	See drawing in Section 11.1
9105-TW-MINI45-AE-0.3-EC8	See Transducer Section Manual *http://www.ati-ia.com/app_content/documents/9620-05-Transducer%20Section.pdf*	See Transducer Section Manual *http://www.ati-ia.com/app_content/documents/9620-05-Transducer%20Section.pdf*

10. Drawings


Rev.
Description
Initiator
Date
02P
P904 changed from right angle to vertical (ECO 12038)
LTF
4/11/2014
P903
3 Max. Component Height Bottom Side
1.6
6.2 Max. Component Height Top Side
3X ⌀3.6 Thru Equally Spaced Customer Interface
3X ⌀6 Plated Area Both sides
3X ⌀8.9 No Parts Zone
LED 901
LED 902
P902
LED 900
⌀58.5
P901
P900
P904
B.C. ⌀26.9
A
B
C
NOTES: UNLESS OTHERWISE SPECIFIED.
DO NOT SCALE DRAWING. ALL DIMENSIONS ARE IN MILLIMETERS.
3rd ANGLE PROJECTION
DRAWN BY: L. Fisher, 1/2/2014
CHECKED BY: A. Pongor, 1/3/2014
A. Strotzer, 1/2/2014
PROJECT # 130920-1
SHEET 1 OF 1
TITLE
9105-ECATOEM EtherCAT OEM FT Interface
SCALE 2:1
SIZE B
DRAWING NUMBER 9230-05-1458
REVISION 02P
1031 Goodworth Drive, Apex, NC 27539, USA
Tel: +1.919.772.0115 Email: info@ati-ia.com
Fax: +1.919.772.8259 www.ati-ia.com
ISO 9001 Registered Company
PROPERTY OF ATI INDUSTRIAL AUTOMATION, INC. NOT TO BE REPRODUCED IN ANY MANNER EXCEPT ON ORDER OR WITH PRIOR WRITTEN AUTHORIZATION OF ATI.
Notes:
1. All connections to headers on PCB to be made using Molex 1.25mm pitch PicoBlade Wire-To-Board connectors.
2. Mounting holes A and C to be used for ground connection. Refer to user manual for details.

11. Terms and Conditions of Sale

The following Terms and Conditions are a supplement to and include a portion of ATI's Standard Terms and Conditions, which are on file at ATI and available upon request.

ATI warrants to Purchaser that force torque sensor products purchased hereunder will be free from defects in material and workmanship under normal use for a period of one year from the date of shipment. This warranty does not cover components subject to wear and tear under normal usage or those requiring periodic replacement. ATI will have no liability under this warranty unless: (a) ATI is given written notice of the claimed defect and a description thereof with thirty (30) days after Purchaser discovers the defect and in any event, not later than the last day of the warranty period and (b) the defective item is received by ATI not later than (10) days after the last day of the warranty period. ATI's entire liability and Purchaser's sole remedy under this warranty is limited to repair or replacement, at ATI's election, of the defective part or item or, at ATI's election, refund of the price paid for the item. The foregoing warranty does not apply to any defect or failure resulting from improper installation, operation, maintenance, or repair by anyone other than ATI.

ATI will in no event be liable for incidental, consequential, or special damages of any kind, even if TI has been advised of the possibility of such damages. ATI's aggregate liability will in no event exceed the amount paid by the purchaser for the item which is the subject of claim or dispute. ATI will have no liability of any kind for failure of any equipment or other items not supplied by ATI.

No action against ATI, regardless of form, arising out of or in any way connected with products or services supplied hereunder, may be brought more than one year after the cause of action accrued.

No representation or agreement varying or extending the warranty and limitation of remedy provisions contained herein is authorized by ATI, and may not be relied upon as having been authorized by ATI, unless in writing and signed by an executive officer of ATI.

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

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

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