Model 261A02

3-Component ICP® Force Sensor

Installation and Operating Manual

**For assistance with the operation of this product,
contact PCB Piezotronics, Inc.**

Toll-free: 800-828-8840
24-hour SensorLine: 716-684-0001
Fax: 716-684-0987
E-mail: info@pcb.com
Web: www.pcb.com

PCB PIEZOTRONICS INC.
A PCB GROUP COMPANY

Warranty, Service, Repair, and Return Policies and Instructions

The information contained in this document supersedes all similar information that may be found elsewhere in this manual.

Total Customer Satisfaction – PCB Piezotronics guarantees Total Customer Satisfaction. If, at any time, for any reason, you are not completely satisfied with any PCB product, PCB will repair, replace, or exchange it at no charge. You may also choose to have your purchase price refunded in lieu of the repair, replacement, or exchange of the product.

Service – Due to the sophisticated nature of the sensors and associated instrumentation provided by PCB Piezotronics, user servicing or repair is not recommended and, if attempted, may void the factory warranty. Routine maintenance, such as the cleaning of electrical connectors, housings, and mounting surfaces with solutions and techniques that will not harm the physical material of construction, is acceptable. Caution should be observed to insure that liquids are not permitted to migrate into devices that are not hermetically sealed. Such devices should only be wiped with a dampened cloth and never submerged or have liquids poured upon them.

Repair – In the event that equipment becomes damaged or ceases to operate, arrangements should be made to return the equipment to PCB Piezotronics for repair. User servicing or repair is not recommended and, if attempted, may void the factory warranty.

Calibration – Routine calibration of sensors and associated instrumentation is recommended as this helps build confidence in measurement accuracy and acquired data. Equipment calibration cycles are typically established by the users own quality regimen. When in doubt about a calibration cycle, a good "rule of thumb" is to recalibrate on an annual basis. It is also good practice to recalibrate after exposure to any severe temperature extreme, shock, load, or other environmental influence, or prior to any critical test.

PCB Piezotronics maintains an ISO-9001 certified metrology laboratory and offers calibration services, which are accredited by A2LA to ISO/IEC 17025, with full traceablility to N.I.S.T. In addition to the normally supplied calibration, special testing is also available, such as: sensitivity at elevated or cryogenic temperatures, phase response, extended high or low frequency response, extended range, leak testing, hydrostatic pressure testing, and others. For information on standard recalibration services or special testing, contact your local PCB Piezotronics distributor, sales representative, or factory customer service representative.

Returning Equipment – *Following these procedures will insure that your returned materials are handled in the most expedient manner.* Before returning any equipment to PCB Piezotronics, contact your local distributor, sales representative, or factory customer service representative to obtain a Return

Materials Authorization (RMA) Number. This RMA number should be clearly marked on the outside of all package(s) and on the packing list(s) accompanying the shipment. A detailed account of the nature of the problem(s) being experienced with the equipment should also be included inside the package(s) containing any returned materials.

A Purchase Order, included with the returned materials, will expedite the turn-around of serviced equipment. It is recommended to include authorization on the Purchase Order for PCB to proceed with any repairs, as long as they do not exceed 50% of the replacement cost of the returned item(s). PCB will provide a price quotation or replacement recommendation for any item whose repair costs would exceed 50% of replacement cost, or any item that is not economically feasible to repair. For routine calibration services, the Purchase Order should include authorization to proceed and return at current pricing, which can be obtained from a factory customer service representative.

Warranty – All equipment and repair services provided by PCB Piezotronics, Inc. are covered by a limited warranty against defective material and workmanship for a period of one year from date of original purchase. Contact PCB for a complete statement of our warranty. Expendable items, such as batteries and mounting hardware, are not covered by warranty. Mechanical damage to equipment due to improper use is not covered by warranty. Electronic circuitry failure caused by the introduction of unregulated or improper excitation power or electrostatic discharge is not covered by warranty.

Contact Information – International customers should direct all inquiries to their local distributor or sales office. A complete list of distributors and offices can be found at www.pcb.com. Customers within the United States may contact their local sales representative or a factory customer service representative. A complete list of sales representatives can be found at www.pcb.com. Toll-free telephone numbers for a factory customer service representative, in the division responsible for this product, can be found on the title page at the front of this manual. Our ship to address and general contact numbers are:

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3425 Walden Ave.
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DOCUMENT NUMBER: 21354
DOCUMENT REVISION: B
ECN: 17900

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MANUAL NUMBER: 29015
MANUAL REVISION: NR
ECO NUMBER:

1.0 INTRODUCTION

PCB Piezotronics 3-component force link sensors are designed to simultaneously measure dynamic and quasi-static force measurements in three orthogonal directions; F_X, F_Y, and F_Z. (**Figure 1**) The sensors utilize an array of precision aligned, quartz sensing crystals stacked in a preloaded arrangement.

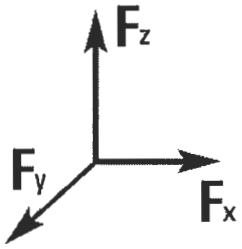


Figure 1 - 3-Component Force Link Axis Definition

2.0 DESCRIPTION

A link consists of a standard PCB 3-component force sensor, preloaded between two precision ground plates. (**Figure 2**) The plates are internally threaded to facilitate fixturing for both tensile and compressive force measurements. External preloads are not required with these sensors, as they are internally preloaded during manufacture.

Figure 2 - ICP® 3-Component Force Link

Caution: Loosening or tightening of the hex nuts will change the internal preload of the sensor. At this point, the sensitivity provided on the calibration certificate will no longer represent that of the sensor. If this should occur, refer to the service and repair document for proper information.

Measurements along the z-axis are proportional to applied compression, tension, and impact forces. Measurements along the x- and y-axis are proportional to shear forces imposed upon the sensor.

ICP® force link sensors contain built-in, microelectronic signal conditioning circuitry to provide clean, low-impedance output signals that can be transmitted over low cost cables and in adverse, industrial environments. Multi-pin connectors facilitate a single point hookup with common, multi-conductor cable.

Power to operate ICP® sensors is generally in the form of a low cost, 24-27 VDC, 2-20 mA constant current supply. PCB offers a number of AC or battery-powered, single or multi-channel power/signal conditioners, with or without gain capabilities for use with force sensors. In addition, many data acquisition systems now incorporate constant current power for directly powering ICP® sensors. Because static calibration or quasi-static short-term response lasting up to a few seconds is often required, PCB manufactures signal conditioners that provide DC coupling.

If questions arise regarding the operation or characteristics of the force sensor products as outlined in this manual, feel free to contact an experienced applications engineer from the Force/Torque Division of PCB toll-free 888-684-0004.

3.0 INSTALLATION

CAUTION!
Please read all instructions before attempting to operate this product.

Damage to built-in amplifier due to incorrect power or misapplication is NOT covered by warranty

Refer to the installation/outline drawing supplied with this manual for specific outline dimensions and installation details for your particular model. The specification is also included to provide details of the sensor's characteristic properties.

The condition of the mating surfaces can adversely affect the sensitivity of the sensor. It is essential that all surfaces be clean, rigid and perfectly flat to avoid erroneous data. A good mating surface may be obtained by lapping, turning, spot-facing, or surface grinding. Surface flatness should be held to within 0.001 (TIR) over the entire mating surface. The protective cap should remain on the connector during installation to prevent contamination or damage.

A light coating of silicon grease (DC-4 or equivalent) on the mating surface enhances the coupling between the mounting base and mounting surface and provides the best high-frequency response.

Connect one end of the interconnect cable to the sensor connector and the other end to the XDCR jack on the signal conditioner. Make sure to tighten the cable connector to the sensor. DO NOT spin the sensor onto the cable, as this fatigues the cable pins, resulting in a shorted signal and a damaged cable.

For installation in dirty, humid, or rugged environments, it is suggested that the connection be shielded against dust or moisture with shrink tubing or other protective material. Strain relieving the cable/sensor connection can also prolong cable life. Mounting cables to a test structure with tape, clamps, or adhesives minimizes cable whip. See **Figure 3**.

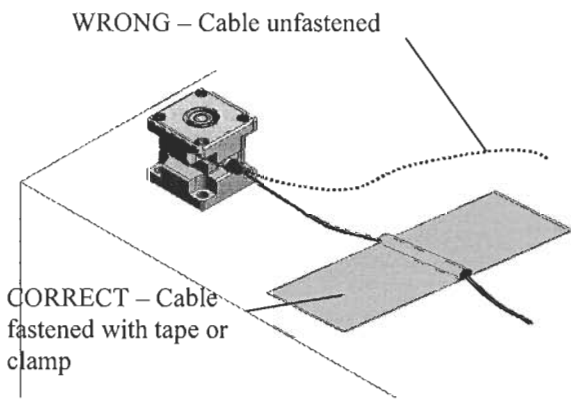


Figure 3 - Cable Strain Relief

4.0 OPERATION

ICP® force link sensors require a constant-current excitation voltage for operation. The enclosed specification sheet provides specific power requirements. Required supply voltage is normally 20 to 30 VDC, while the constant current required ranges from 2 to 20 mA.

PCB standard battery-powered signal conditioners are factory set at 2 mA and may be used to adequately drive a signal for 100 feet. PCB line signal supplies are factory set at 4 mA (and adjustable from 2 to 20 mA), enabling signals to be transmitted over hundreds of feet.

It is necessary to supply the sensor with a 2 to 20 mA constant current at +20 to +30 VDC through a current-regulating diode or equivalent circuit, contained in all PCB signal conditioners. See Guide G-0001E for powering and signal conditioning information pertaining to all ICP® instrumentation.

Most of the signal conditioners manufactured by PCB have an adjustable current feature allowing a choice of input currents from 2 to 20 mA. In general, for lowest noise (best resolution), choose the lower current ranges. When driving long cables (to several thousand feet), use the higher current, up to 20 mA maximum. Consult the factory to determine if higher current settings are required.

Operation requires the connection of the force sensor first to a signal conditioner, then to a readout device (oscilloscope, meter, recorder, or A-to-D board) or to a readout device with built-in ICP® sensor excitation. Tighten the cable to the sensor by hand to ensure good electrical contact.

5.0 POLARITY

Compressive forces upon an ICP® 3-component force link produce a positive-going voltage output. Tensile forces produce a negative-going voltage output. Sensors with reversed polarity are available upon request.

6.0 LOW-FREQUENCY MONITORING

Force link sensors used for applications in short term, steady state monitoring, such as sensor calibration, or short term, quasistatic testing should be powered by signal conditioners that operate in DC-coupled mode. PCB Series 484 Signal Conditioner operates in either AC or DC-coupled mode and may be supplied with gain

features or a zero "clamped" output often necessary in repetitive, positive polarity pulse train applications.

If you wish to learn more about ICP® sensors, consult PCB's General Signal Conditioning Guide (G-0001E), a brochure outlining the technical specifics associated with piezoelectric sensors. This brochure is available from PCB by request, free of charge.

7.0 DISCHARGE TIME CONSTANT

The discharge time constant (DTC) of the entire transduction system from sensor to readout must be considered when attempting to calibrate an ICP® force sensor by static methods. In order to take full advantage of the long DTC built into the force sensor, it is best to DC couple from the sensor to the readout device. Several dual-mode PCB signal conditioners (e.g., Series 484) use direct coupling techniques to decouple the output signal from the sensor bias voltage. With the output of the signal conditioner coupled to a DC readout, such as a digital voltmeter (DVM) or oscilloscope, the time constant of the sensor is not compromised by AC coupling elsewhere in the system.

When DC coupling to a system, it is important to DC couple the entire system and not just from the sensor to the signal conditioner. The system time constant is determined by the shortest time constant in the system. For this reason, the signal conditioner, as well as the readout device, must be DC coupled.

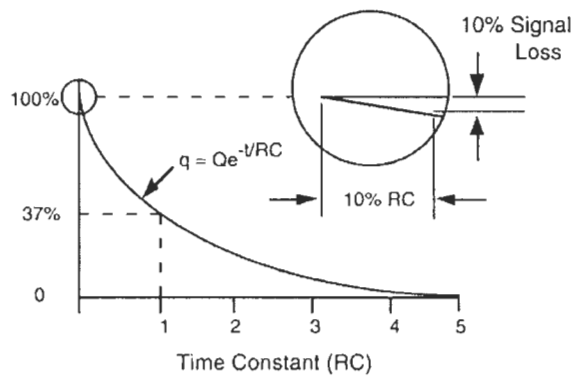


Figure 4 – Discharge Time Constant (DTC) Curve

The discharge time constant represents the decay rate of an input signal. One DTC represents the amount of time taken for the signal to decay to 37% of the initial peak value. As illustrated in **Figure 4**, this is an exponential decay. Approximately five DTC intervals are needed for a peak signal to naturally decay back to zero.

The rule of thumb for signal discharge, as outlined in **Figure 4**, is this: for the first 10% of the DTC, the signal lost is approximately proportional to the time elapsed.

Step Function Response

For example, a sensor with a 500-second DTC loses approximately 1% of its output level the first five seconds (1% of 500) after the application of a steady state force within the measuring range. In this case, the output reading must be taken within five seconds of the force application for 1% accuracy. If it is impossible to avoid AC coupling somewhere in the sensing system, try to keep the coupling DTC at least an order of magnitude longer than the DTC of the force sensor. This avoids compromising the sensor DTC.

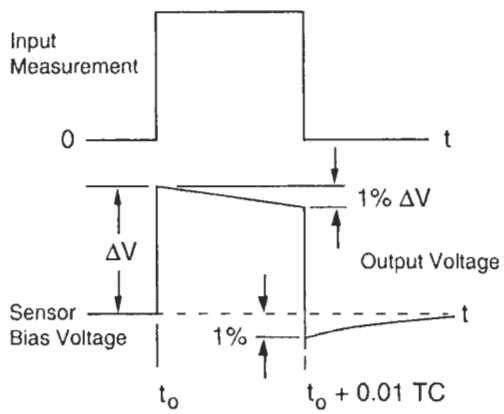


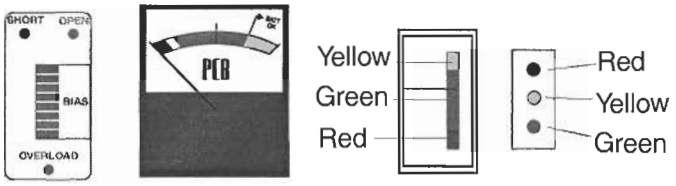
Figure 5 – Step Function Response

8.0 CALIBRATION

A NIST (National Institute of Standards and Technology) traceable calibration graph is supplied with each force sensor certifying its voltage sensitivity (mV/lb). Calibration procedures follow accepted guidelines as recommended by ANSI (American National Standards Institute), ISA (Instrument Society of America), and ISO (International Organization for Standardization). These standards provide the establishment and management of complete calibration systems, thus controlling the accuracy of a sensor's specifications by controlling measuring and test equipment accuracy. PCB is A2LA accredited for technical competence in the field of calibration, meeting the requirements of ISO/IEC 17025-1999 and ANSI/NCSL 2540-1-1994.

9.0 TROUBLESHOOTING

When a PCB signal conditioner with any of the following indicators are used, turn the power on and observe the voltmeter (or LED's) on the front panel.



NORMAL OPERATION

INDICATOR	DVM READING	OPERATION
GREEN (Mid-Scale)	8 to 14 V	Proper range for most ICP® sensors.
GREEN (Low End)	3 to 7 V	Proper range for low bias ICP® sensors.
GREEN (High End)	15 to 17 V	Proper range for high bias ICP® sensors.
RED	0 Volts	Short in the sensor, cable, or connections.
YELLOW	24 to 28 V	Open circuit in the sensor, cable, or connections. (Excitation voltage is being monitored.)

Output voltage moves from YELLOW to GREEN slowly until charging is complete. AC coupled signal conditioners require sufficient time to charge the internal coupling capacitor. Allow signal conditioner to charge for approximately 5 discharge time constants for stable operation.

Note: Most PCB force sensors have an output bias of 8-14 VDC. Refer to the specification sheet with this manual for the bias range of the model you are using. If you are using a low bias sensor, the indicator will be at the bottom end of the green portion of the dial indicator, and may even be in the red portion. This is the expected range and indicates proper operation.

10.0 MAINTENANCE

The sensor connector must be kept clean, especially if it is operating in a dusty and/or wet environment. Because the force sensor is of welded construction, it should be returned to the factory for servicing in the event of serious malfunction.

Observe the following precautions in using the sensor:

- Do not exceed the maximum load levels for the force sensor (see specification sheet).
- Do not subject the sensor to temperatures exceeding that of the specification, normally 250°F (121°C).
- Do not apply voltage to the sensor without current-limiting diodes or other current protection.
- Do not apply more than 20 mA of current to the force sensor.
- When mounting the force sensor, observe installation procedures detailed in Section 3.0 and as outlined on the specific sensor installation/outline drawing to avoid overtorquing when mounting.
- Do not apply more than 30 volts to the sensor.
- Avoid metal-to-metal impacts during applications, which can produce high frequency ringing. Electrical low-pass filtering or a damping material can help reduce such effects.
- Do not spin the sensor onto the cable. This may fatigue the cable pins, causing cable damage. Always insert the cable pin into the sensor and tighten the knurled cable nut to the sensor.

Model Number	3-COMPONENT ICP® FORCE SENSOR	Revision: B
261A02		ECN #: 33704

Performance	ENGLISH	SI	
Sensitivity(± 20 %)(z axis)	2.5 mV/lb	0.56 mV/N	[1]
Sensitivity(± 20 %)(x or y axis)	5 mV/lb	1.12 mV/N	[1]
Measurement Range(z axis)	1000 lb	4.45 kN	
Measurement Range(x or y axis)	1000 lb	4.45 kN	
Maximum Force(z axis)	1320 lb	5.87 kN	
Maximum Force(x or y axis)	1000 lb	4.45 kN	
Maximum Moment(z axis)	40 ft-lb	54.23 N-m	
Maximum Moment(x or y axis)	70 ft-lb	94.91 N-m	
Broadband Resolution(x or y axis)	0.006 lb-rms	0.027 N-rms	[2]
Broadband Resolution(x or y axis)	0.006 lb-rms	0.027 N-rms	[2]
Upper Frequency Limit	10 kHz	10 kHz	
Low Frequency Response(-5 %)(z-axis)	0.01 Hz	0.01 Hz	
Low Frequency Response(-5 %)(x or y axis)	0.001 Hz	0.001 Hz	
Non-Linearity	≤ 1 % FS	≤ 1 % FS	[3]
Cross Talk(between x and y axis)	± 3 %	± 3 %	
Cross Talk(between (x or y axis) and z axis)	± 5 %	± 5 %	
Environmental			
Temperature Range	-65 to +250 °F	-54 to +121 °C	
Electrical			
Full Scale Output(Z Direction)	± 2.5 VDC	± 2.5 VDC	
Full Scale Output(X and Y Direction)	± 5 VDC	± 5 VDC	
Discharge Time Constant(z axis)	≥ 50 sec	≥ 50 sec	
Discharge Time Constant(x or y axis)	≥ 500 sec	≥ 500 sec	
Excitation Voltage(all channels)	20 to 30 VDC	20 to 30 VDC	
Constant Current Excitation(all channels)	2 to 20 mA	2 to 20 mA	
Output Impedance	≤ 100 ohm	≤ 100 ohm	
Output Bias Voltage	8 to 14 VDC	8 to 14 VDC	
Output Polarity	Positive	Positive	
Physical			
Stiffness(z axis)	19 lb/µin	3.3 kN/µm	[2]
Stiffness(x or y axis)	6 lb/µin	1 kN/µm	[2]
Weight	34.40 oz	975 gm	
Housing Material	Stainless Steel	Stainless Steel	
Sealing	Hermetic	Hermetic	
Electrical Connector	4-Pin	4-Pin	
Electrical Connection Position	Side	Side	

CE [4]

All specifications are at room temperature unless otherwise specified.
In the interest of constant product improvement, we reserve the right to change specifications without notice.

ICP® is a registered trademark of PCB Group, Inc.

OPTIONAL VERSIONS

Optional versions have identical specifications and accessories as listed for the standard model except where noted below. More than one option may be used.

M - Metric Mount

W - Water Resistant Cable

Electrical Connection Position	Side	Side

NOTES:

[1] Sensitivites are for listed preload. Sensitivites may vary ±5% depending on preload used.
[2] Typical.
[3] Zero-based, least-squares, straight line method.
[4] See PCB Declaration of Conformance PS023 for details.

Entered: DMW	Engineer: MJK	Sales: KWW	Approved: EB	Spec Number:
Date: 8/17/10	Date: 8/17/10	Date: 8/17/10	Date: 8/17/10	29368

PCB PIEZOTRONICS
FORCE / TORQUE DIVISION
3425 Walden Avenue, Depew, NY 14043

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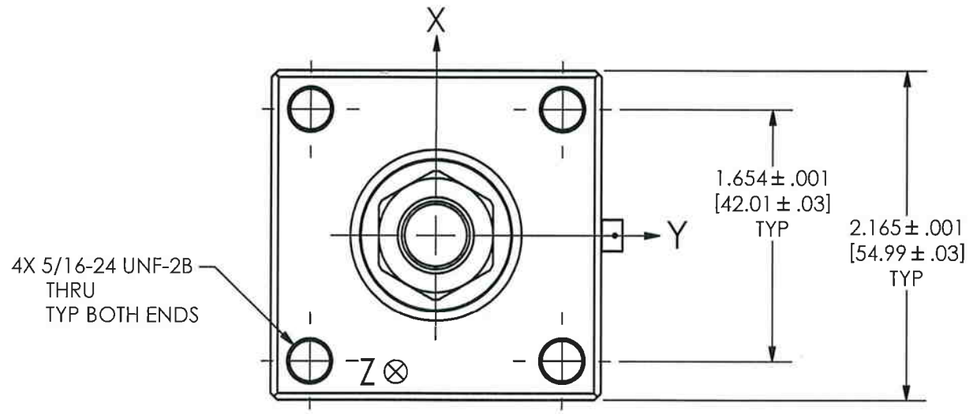
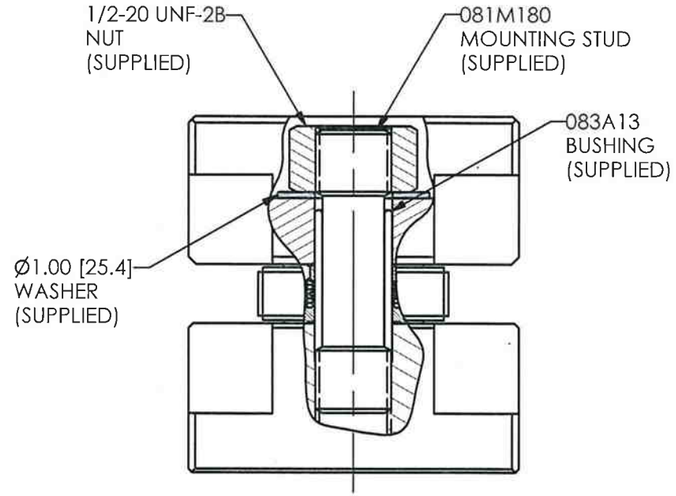
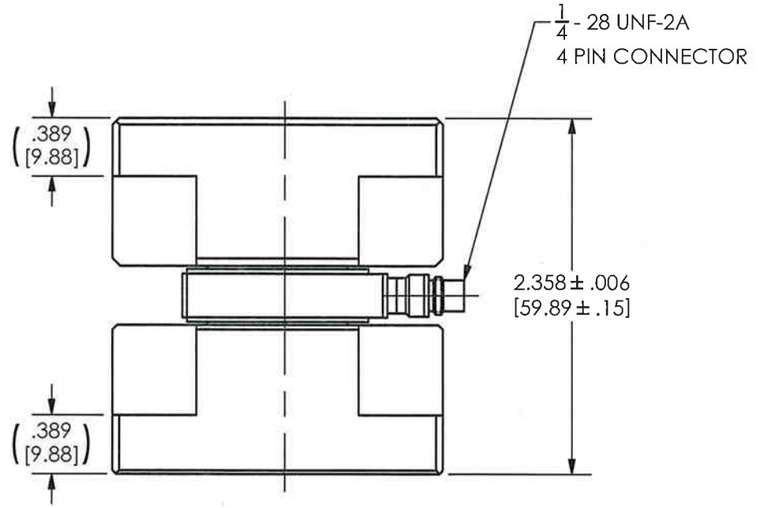
Fax: 716-684-8877
E-Mail: force@pcb.com

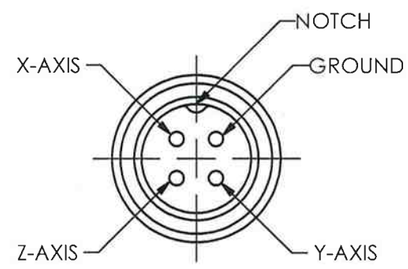
29369

REVISIONS		
REV	DESCRIPTION	ECO
B	UPDATED GRINDING DIMENSION	25375
C	CORRECTED CONNECTOR CALL OUT	30053









PIN OUT
SCALE: 4 X

UNLESS OTHERWISE SPECIFIED TOLERANCES ARE:	
DIMENSIONS IN INCHES	DIMENSIONS IN MILLIMETERS [IN BRACKETS]
DECIMALS XX ±.03, XXX ±.010	DECIMALS X ±0.8, XX ±0.25
ANGLES ± 2 DEGREES	ANGLES ± 2 DEGREES
FILLETS AND RADII .003 - .005	FILLETS AND RADII [0.07 - 0.13]

DRAWN	SMB	2/9/09	MFG	JF	11/21/06
CHK'D	EB	2/9/09	ENGR	NJL	2/4/09
APP'D	EB	2/9/09	SALES	MFG	11/21/06

TITLE
OUTLINE DRAWING
MODEL 261A02
TRIAXIAL FORCE SENSOR

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3425 WALDEN AVE. DEPEW, NY 14043
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CODE IDENT. NO.	DWG. NO.
52681	29369
SCALE: FULL	SHEET 1 OF 1