PIEZOELECTRIC SENSORS FOR DYNAMIC PRESSURE MEASUREMENTS

Model Number Index

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PRESSURE CATALOG

PCB PIEZOTRONICS INC.

PFS DIVISION

PRESSURE AND FORCE SENSORS DIVISION

Helping you make better dynamic measurements ...with quality, innovative instruments!

Pressure and Force Sensors Group

For 30 years, PCB has been manufacturing piezoelectric sensors for dynamic pressure, force, vibration, and shock measurements. This extensive experience in the world of dynamic measurements has made PCB a leader in high quality piezoelectric instrumentation. PCB's commitment to customer satisfaction through the continued investment in research, development, and manufacturing capabilities has enabled us to obtain significant roles in these and other important test situations:

- **General Motors/Harrison** — research on air-conditioning compressor pressure dynamics
- **General Electric** — measure power cogeneration plant pressure
- **Roush Technologies** — analysis of automotive engine combustion pressure
- **Southwest Research Institute** — measure underwater blast
- **Westinghouse** — sense acoustic noise in closed- loop, high-temperature cooling systems
- **U.S. Army** — measure large gun ballistic and free-field blast pressures
- **Rocketdyne** — measure pressures in space shuttle rocket motors
- **Valmet** — monitor paper slurry dynamic pressures
- **NASA (MSFC)** — measure free field space shuttle acoustics

24-hour "SensorLine" ~ Call 716-684-0001

Recognizing that dynamic measurements are seldom routine, PCB has introduced a 24-hour sensor hotline. When you experience an unexpected measurement problem, call the PCB "SensorLine" Saturday, Sunday, or after hours to talk with an application specialist.

Satisfaction Guarantee

We stand behind our products to ensure they operate properly for your application. If for any reason you are not satisfied, contact us immediately to discuss repair, exchange, or credit. Our standard product warranty is one year. If at any time, however, our products do not meet your expectations, feel free to call and talk with a application specialist.

ICP® Sensors

PCB offers the broadest piezoelectric line of charge and ICP sensors for dynamic pressure, force, shock, and vibration measurements. What is ICP? It is a registered trademark that uniquely identifies PCB's sensors incorporating built-in electronics. Many manufacturers of FFT analyzers and data collectors incorporate "ICP-Inputs" for coupling directly to our ICP sensors.

Research and Development

Working along with customers, PCB continually improves and develops new products to meet more demanding dynamic pressure measurement applications. Improved methods of dynamic calibration have been developed to evaluate the performance characteristics of new sensors.

Quality

PCB is an ISO-9001 facility registered by the Underwriters Laboratory, Inc. All quality concerns are addressed by a quality committee consisting of members from each department of PCB. Responsibility is assigned for resolving the concern to the customer's satisfaction, corrective action is initiated, and the customer is notified of concern resolution.

Capabilities

PCB, a self-sufficient, fully-equipped manufacturing facility, strives to provide you with what you want, when you want it, at a reasonable price. Do not hesitate to call to ask one of our applications engineers for product modifications to better suit your application, or to talk to our customer service personnel for expedited delivery or sample hardware needs.

Other Products and Services

In addition to the dynamic pressure sensors featured in this Selection Guide, PCB offers a broad line of piezoelectric sensors and signal conditioners for measuring dynamic force, shock, and vibration. Consult the factory or a field representative for additional information or assistance on the complete line of products offered by PCB.

PCB PRODUCTS AND SERVICES:

FORCE SENSORS-PFS DIVISION

Toll Free: 888-684-0011
E-mail: pfssales@pcb.com
FAX: 716-686-9129
Dynamic quartz force sensors monitor compression, tension, and impact forces involved with the forming, crimping, stressing, welding, machining, or testing of mechanical parts, structures, machines, and tablet presses. A full line of ICP® and charge mode models are available.

ACCELEROMETERS-SVS DIVISION

Toll Free: 888-684-0013
E-mail: svssales@pcb.com
FAX: 716-685-3886
PCB offers the broadest commercial line of piezoelectric vibration and shock accelerometers. Shear structured quartz and ceramic designs incorporating integral electronics include environmental stress screening, high frequency, miniature, shock, pyroshock, ring-shaped, triaxial, flight-tested, low profile, high temperature, seismic, low cost and industrial. PCB also now offers capacitive accelerometers for measurements down to DC for low frequency steady-state applications.

ACTUATORS-AVC DIVISION

Toll Free: 888-684-0013
PCB's Active Vibration Control (AVC) Division provides piezoelectric vibration generators (actuators) for structural research and testing. When implemented in a computer-controlled feedback loop, piezo actuators offer active vibration control for vibration reduction and silencing applications. The new ICP piezoelectric strain sensor is now available for measuring small dynamic strain on top of large static loads.

MACHINERY VIBRATION MONITORING

Industrial Monitoring Instrumentation (IMI), a division of PCB, provides rugged, industrial-grade vibration sensors, electronics, and accessories for predictive maintenance and machinery health-monitoring applications.

SIGNAL CONDITIONERS

A complete line of ICP sensor signal conditioners and charge amplifiers is offered by PCB. Signal conditioners are offered with battery or line power, in single or multichannel configurations, and with or without gain adjust. Additional meters, switches, relays, integrators, and computer-controlled modules are also available.

CALIBRATORS

PCB, and its Modal Shop division, offers a wide variety of calibration systems including low and high pressure dynamic calibrators, shock tube, integrated accelerometer calibration workstation and microphone acoustic array calibrators. See Page 49 for further information on pressure calibrators.

CUSTOM PRODUCTS

PCB offers product modification, special mounting adaptors, special tests and calibration services to make PCB sensors better suited to your application needs. Call, fax, or E-mail your request to one of our applications engineers (see page vi).

THE MODAL SHOP INC (TMS)

Toll Free: 800-860-4867
E-mail: sales@modalshop.com
FAX: 513-458-2172
The Modal Shop, located in Cincinnati to maintain close technical ties with the Structural Dynamic Research Lab of University of Cincinnati, recently became a PCB Group Company. The Modal Shop technology is primarily focused to serve the modal and vibro-acoustics structural test markets with a broad line of modal sensors, structural excitation products, sonic digitizers, precision microphones, low cost acoustic arrays, calibration equipment and rental systems for large channel testing.

TMS STRUCTURAL TESTING PRODUCTS

Lightweight sensors and computer-controlled signal conditioners provide an integrated systems approach at a lower cost per-channel. A complete range of impulse hammers are available for testing very small turbine blades and PC boards to extremely large structures, such as buildings, floors, or bridges. These products, manufactured at the PCB Piezotronics factory in Depew, NY, are engineered and marketed by The Modal Shop, a PCB Group Company.

TMS MICROPHONES AND ACOUSTIC ARRAYS

The Gunnar Rasmussen "Signature Series" precision condenser microphones, preamps and power modules are offered through The Modal Shop. These microphones incorporate four decades of proven design experience in acoustic measurement technology. The Modal Shop also offers the "Acousticel"™, a low cost microphone for large channel vibro acoustic testing.

OCEANA SENSOR TECHNOLOGIES, INC.

Phone: 757-426-3678
Oceana Sensor Technologies (OST), a PCB Group Company, located in Virginia Beach, specializes in the automated assembly of high volume, low cost sensors for automotive, appliance, industrial machinery and OEM instrument markets.

PCB PIEZOTRONICS EUROPE GmbH

Fax: 4-924-627-4099

PCB Piezotronics Europe GmbH located in Germany provides stock in Europe with overnight delivery service.

TESTING SERVICES

Virtually all PCB sensors are supplied with an individual NIST-traceable calibration certificate. PCB's calibration system complies with ISO-9001 and ISO-10012-1.

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Numerical Model Number Page Listing

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TYPICAL DYNAMIC PRESSURE APPLICATIONS

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- Gas and Steam Turbines
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- Flight Dynamics
- Fluid-Borne Noise
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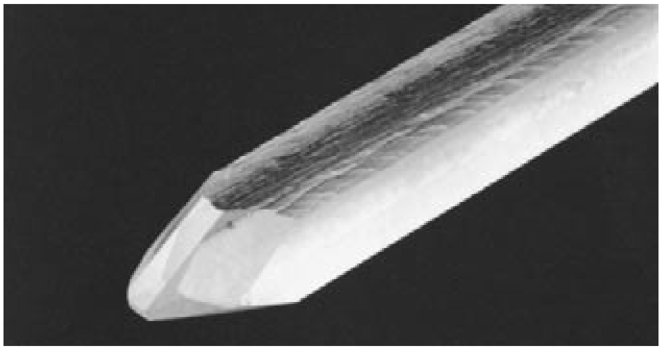
- Hydraulic and Pneumatics
- Pulsations
- Pump/Valve Dynamics
- Waterline Acoustics
- Water Hammer
- Shock Waves
- Turbulence
- Underwater Blast
- Wind Tunnels

Quartz, Tourmaline, and Ceramic Crystal



Cultured Quartz Crystal SiO_2

For dynamic pressure measurements, piezo-type pressure sensors incorporate self-generating quartz, tourmaline, or ceramic sensing elements. Naturally piezoelectric, quartz is the most commonly used crystal; however, certain specialized sensors, such as underwater blast sensors, incorporate volumetrically-sensitive tourmaline. PCB micro-pressure sensors are structured with piezo-ceramic elements.

Our broad commercial line of standard piezoelectric pressure sensors are used for a variety of dynamic pressure measurements, including: compression, pulsations, surges, ballistics, detonation, engine cylinder combustion, shock and blast waves, explosives, high-intensity sound, and other dynamic acoustic and hydraulic processes from <0.001 to >100,000 psi. The capability to measure small pressure fluctuations, such as fluid-borne noise at high static levels, is a unique characteristic of piezo pressure sensors.

PCB sensors are manufactured at our sensor technology center using high-precision CNC machinery. For hermetic sealing, both laser and electron beam welding processes are used. Sensors are also modified and tailored to meet specific customer requirements. Standard and special adaptors can be provided to facilitate sensor installation in existing mounting ports.

Although piezo pressure sensors are primarily recommended for dynamic pressure measurements, some quartz pressure sensors have long discharge time constants that extend low-frequency capability to permit static calibration and measurement of quasi-static pressures over a period of a few seconds. Virtually all sensors are provided with an individual NIST-traceable calibration certificate. Dynamic pressure calibrators are available for our customers who prefer the convenience of on-site recalibration of their sensors.

Piezo pressure sensors may be categorized as either charge mode or ICP® voltage mode output. Charge mode sensors are generally used for higher temperature applications above 275° F. They generate a high-impedance charge signal (pC/psi) that couples to readout instruments through a low-noise cable and charge amplifier. (See Fig. B on page v). The charge amplifier serves to convert the sensor's high-impedance charge output signal to a usable low-impedance voltage signal, normalize the signal, and provide| for gain, ranging, and filtering. High-impedance charge mode systems must be kept very clean. Consequently, they do not operate well in applications requiring long input cables in factory, field, outdoor, or humid environments.

The more popular Integrated Circuit Piezoelectric (ICP®) voltage mode sensors (see Fig. A on page v) incorporate a built-in microelectronic signal conditioner and output a low-impedance voltage signal (mV/psi). ICP sensors operate from a low-cost, constant-current signal conditioner or may connect directly to a readout instrument with a built-in constant-current source.

ICP sensors are well-suited for continuous operation in dirty factory environments, underwater, and through long cables in field test applications. Since special low-noise cable and charge amplifiers are not required, ICP sensor systems are substantially lower in cost per channel.

Because of the ICP sensor's low-impedance output, superior signal to noise, capability to drive long ordinary coaxial cables, and lower cost per channel, they are suitable for virtually all dynamic pressure applications where sensor temperatures do not exceed 275° F.

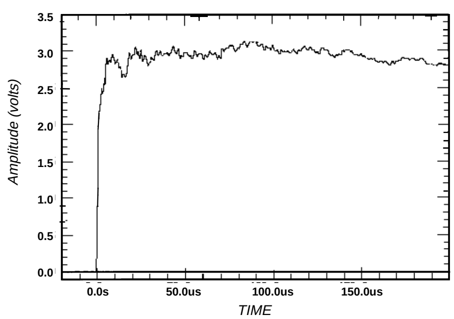
If you would like to discuss your application, or if it is not listed, please call, fax, e-mail or write to PCB for assistance.

Typical Mini Quartz Pressure Sensor

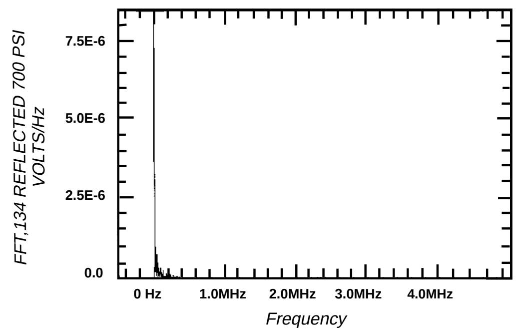
Piezoelectric Pressure Sensors

OUTSTANDING CHARACTERISTICS OF PCB PIEZOELECTRIC PRESSURE SENSORS

- Flush diaphragms accurately measure high-frequency, non-resonant response of shock and blast waves.
- ICP® pressure sensors operate in dirty field, factory, or underwater environments through long, ordinary coaxial cable without loss of signal strength or noise increase.
- A single quartz pressure sensor has a very wide linear dynamic operating range. Several strain or piezoresistive type sensors with narrow measuring ranges would be required to make the range of measurements that can be made by one quartz piezoelectric sensor.
- Wide operating temperature ranges from -400 to > 600° F.
- Rugged, durable solid state construction withstands shock and vibration to tens of thousands of g's.
- PCB mini pressure sensor Series 111, 112, and 113 install in a variety of standard or custom-made adaptors for simplified installation in pre-existing mounting ports.
- Two linear calibration graphs are furnished with most PCB quartz pressure sensors, one for the full-scale range and one for 10% of full scale.
- English or metric installation configurations available.



Shockwave Measurement With Microsecond Rise Time and Non-Resonant Response



FFT Microsecond Shockwave Non-Resonant Response

Figure A

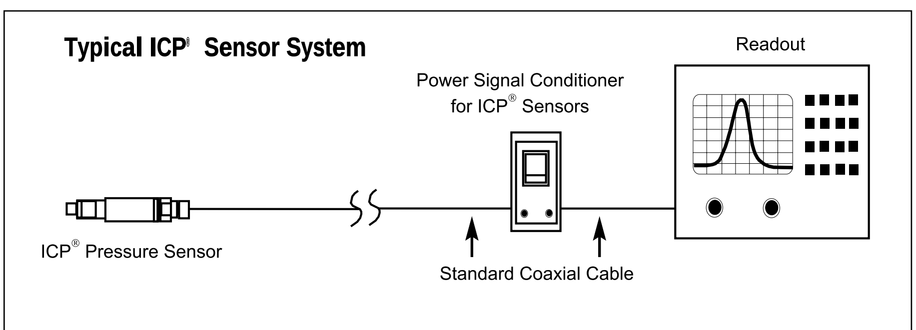
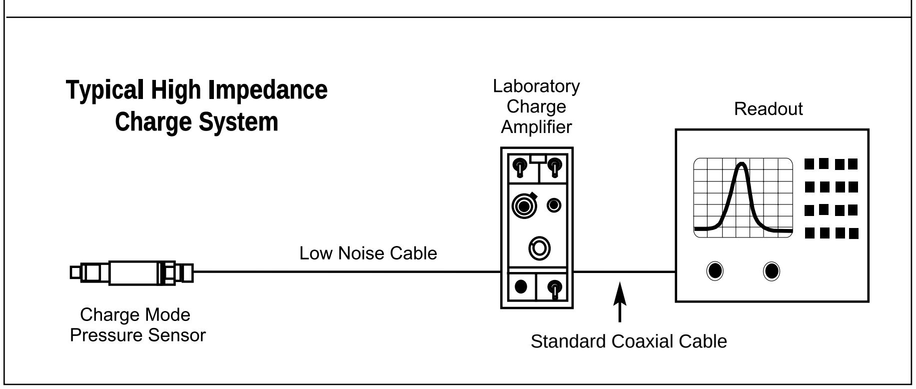


Figure B



Pressure Application Inquiry Form

TO: PCB Piezotronics
Pressure and Force Sensors Division
Fax: (716) 686-9129

The pressure sensors listed in this catalog represent our most popular sensors, which are only a fraction of the sensors we offer. In addition to our standard sensors, PCB can customize sensors to meet your specific needs. Please fill out this inquiry form with any information available to you, so that we may help you with your dynamic measurement application. If you would like to discuss your application, or if it is not listed, please call, fax, Email or write to PCB for suggestions.

Name: ______________________ Date: ______________________
Company: ______________________ Phone: ____________ Ext: ________
Dept.: ______________________ Fax: ______________________
Address: ______________________ City/State ____________ Zip ________

1. NATURE OF REQUEST

❏ Inquiry ❏ Order ❏ Quotation ❏ Delivery Information ❏ Complaint
❏ Service or Repair ❏ Trouble with Equipment ❏ Equipment Operation
❏ Visit required from PCB or Sales Representative in your area

2. DESCRIBE YOUR APPLICATION ______________________

Note: Please indicate priority from 10 (highest) to 1 (lowest)

3. DYNAMIC

____ What is the approximate *DYNAMIC* range? ______________________
____ What is the maximum *STATIC* + *DYNAMIC* range? ______________________
____ Is the event ❏ oscillatory or ❏ a pulse event? Will you be continuously monitoring? ❏ yes ❏ no
____ What is the event pulse duration? ______________________
____ How quickly will the event occur? (rise time or time to peak) ______________________
____ What is the high and low frequency range you want to measure? ______________________
____ Will the sensor be exposed to high shock or vibration? ______________________

4. ENVIRONMENTAL

____ What is the environment temperature range? ____________ °F Will the temperature be cycling? ❏ yes ❏ no
____ What is the maximum operating temperature the sensor will be exposed to? ________ For how long? ________
What type of environment will the sensor be used in?
❏ Air ❏ Underwater ❏ Salt Water ❏ Field ❏ Lab ❏ Humid ❏ Corrosive ❏ Vacuum
❏ Other (please specify): ______________________ For how long? ____________

5. ELECTRICAL

____ What length of cable will you need from the test structure to the readout instrument? ____________
____ What is the desired noise floor or resolution? ______________________
____ What is the desired output? ❏ 5V ❏ 10V ❏ Other (specify) ____________
____ What is the readout device? ❏ A to D ❏ Scope ❏ Other (specify) ____________
____ What is the input impedance of the readout device (if applicable)? ____________
____ Does the readout instrument have a constant current signal conditioner for ICP® sensors? ❏ yes ❏ no
____ What kind of signal conditioner would you like? ❏ Single ❏ Multiple channel How many? ____________
____ Does your readout instrument have gain adjust? ❏ yes ❏ no
____ Would you like to have ❏ AC and/or ❏ DC coupling?
(Note: DC coupling, as provided by the 484B06 or B11 Signal conditioners, is recommended for pressure sensors with long time constants to provide for quasi static calibration.)

6. SPECIAL PHYSICAL CONSIDERATIONS

____ Are there any physical sensor dimension requirements? ______________________
____ Is electrical ground isolation needed? ______________________

General Purpose Quartz Pressure Sensors

- Dynamic phenomena
- Industrial pump pressure monitoring
- Hydraulic and pneumatic pressure line monitoring
- Fluid borne noise
- Pulsations, surges, water hammer, switching transients, cavitation

General purpose quartz pressure sensors are designed for dynamic measurements of compression, combustion, explosion, pulsation, cavitation, blast, pneumatic, hydraulic, fluid and other such pressures.

ICP® pressure sensors, structured with naturally piezoelectric, stable quartz sensing elements and integral electronics, are well suited to measure rapidly changing pressure fluctuations over a wide amplitude and frequency range. Solid-state construction, hermetically-sealed housings, and laser-welded flush diaphragms provide undistorted high frequency response, ruggedness and durability, even in adverse environmental conditions. The result is a quality sensor that offers a repeatable, linear, low impedance voltage output making the sensor suitable for measurements in a variety of gaseous, fluid, and oil environments.

Operating from a low-cost constant-current signal conditioner, ICP sensors provide a clean, high-voltage, low-impedance linear output over a very wide operating range. They drive long, inexpensive, ordinary coaxial cables in field or factory environments without signal degradation. ICP sensors are supplied with hardware and seals for mounting. For convenience in mounting pressure probes, standard and special thread adaptors can be supplied to match specific nonstandard mounting ports (see Mounting Adaptors, page 58).

To allow the user to take advantage of the wide dynamic range capability, many ICP sensors are supplied with two linear calibrations, one at full scale and one 10% of full scale. This means, for example, model 111A24, 5 mV/psi sensor may be used for accurate measurements ranging from 0 to 1000 psi or 0 to 100 psi, or anywhere in between. In fact, a user can measure 1 psi fluctuations at any static level up to 10 000 psi. Large overange capabilities are possible because a pressure sensor's diaphragm is backed by a rigid column of quartz.

PCB PIEZOTRONICS INC. PFS DIVISION

PCB 716-684-0001 **PFS Toll Free** 888-684-0011 **Fax** 716-686-9129 **Email** pfssales@pcb.com **Web Site** www.pcb.com

General Purpose Quartz
ICP® and Charge mode

MINIGAGE ICP® PROBE DESIGNS
Series 111A20 AND 112

Minigages are a popular choice for applications requiring a minimum case diameter (0.218 inch dia) and a flush diaphragm. They install in a threaded stepped hole (5/16-24 or optional 7 mm thread) via the supplied floating clamp nut. See pages 58, 59 and 61 for mounting options. Also see higher frequency (500 kHz) series 113A20 on page 14.

111A20 Series is a general purpose economy ICP sensor that contains a rigid, multiplate, compression design quartz element, with an internal compensating accelerometer (in most models) to minimize vibration sensitivity. ICP sensors with integral microelectronics produce a high quality signal that is virtually independent of cable length and motion. When connected to a PCB signal conditioner, these sensors generate a low-noise, low-impedance analog output signal proportional to the measurand and compatible with most readout instruments. This series contains models 111A21, A22, A23, A24 and A26 that measures dynamic pressures from full vacuum to 10 000 psi. See specifications on pages 4 and 5.

Series 111A20 and 112

2

Models 112A, A02, and A03 acceleration compensated, 1pC/psi minigages are charge mode sensors that measure dynamic pressures from full vacuum to 10 000 psi. The charge signal from these acceleration compensated quartz sensors is converted into a voltage signal by a PCB or other similar charge amplifier. Charge mode sensors may be used at higher temperatures, since the temperature is limited only by the quartz sensing element. System sensitivities depend upon the charge or in-line amplifier used. See specifications on page 6.

Models 101A, 102A02 and 102A07

THREADED GROUND ISOLATED ICP® DESIGNS

Models 101A, 102A02 and 102A07 ground isolated designs incorporate a continuous 3/8-24 mounting thread to accommodate different wall thicknesses. Once the sensor is mounted with the diaghram flush, the combined floating clamp nut/seal locks it in place. See specifications on page 4.

THREADED GENERAL PURPOSE ICP® DESIGNS

Acceleration compensated ICP pressure sensors, Models 101A02, A03, A04, A05, A06 and 102A05 are ground isolated designs with a 3/8-24 fixed mounting thread length for a positive pressure seal at higher pressures. Five ranges are available from 100 to 10 000 psi, with sensitives from 50 to 0.5 mV/psi, for routine hydraulic and pneumatic fluctuating pressure applications. See specifications on pages 4 and 5.

Model 101A02, A03, A04, A05, A06 and 102A05

REPETITIVE HYDRAULIC
Models 108A02 and 118A02

Models 108A02 and 118A02

One of the toughest applications for sensors of any kind is measuring high pressure, repetitive pulses, such as those encountered in fuel injection systems or hydraulic tube endurance testing. These two models are designed to continuously measure repetitive pressures such as those involved in diesel fuel injection or hydraulic tube "torture" testing. Ordinary diaphragm-type sensors usually fatigue quickly in such applications.

For this tough service, PCB pioneered the integral machined diaphragm, devoid of thin diaphragm or flexures susceptible to fatigue failure. The expected life of this sensor is millions of cycles and they are capable of continuously monitoring the processes mentioned above.

Model 108A02 is an ICP quartz sensor containing integral electronics with a sensitivity of 0.5 mV/psi. It can measure repetitive dynamic pressures up to 10 000 psi. See specifications on page 5.

Model 118A02 is a charge mode version of the 108A02 above. It has a sensitivity of 0.1 pC/psi and is ideal for higher temperature applications to 400°F. See specifications on page 6.

INDUSTRIAL, RUGGED
Series 121

Series 121

Designed specifically for industrial applications, this ICP sensor is a more rugged industrial version of the miniature quartz sensor. Standard features of the series 121 include a leak proof, long life integral machined diaphragm, welded construction and a large rugged industrial type connector. This sensor is available in a number of standard ranges and can be readily adapted to meet a variety of special requirements. Type 012 cable with a TNC connector is recommended for use with this sensor. See "Custom Cable Ordering Guide" on page 63. See specifications on page 4.

MINIATURE HIGH SENSITIVITY ICP® PROBES
Series 112A20


Series 112A20

Used to measure small dynamic hydraulic and pneumatic pressures such as turbulence, noise, sound, cavitation and pulsations, especially in adverse environments. Capable of measuring high intensity sound pressures from 0.001 psi (111 dB {air}) to 100 psi (210 dB {air}) at any static level from full vacuum to 2 000 psi. Internal acceleration compensation minimizes vibration sensitivity and an internal discharging resistor automatically eliminates static (DC) signal components. See specifications on page 4.

Model 112A21 is a 50mV/psi general purpose sensor suitable for most low pressure applications.

Model 112A22 has 100mV/psi sensitivity for greater signal strength.

Model 112A23 incorporates special low noise microelectronics for improved resolution.

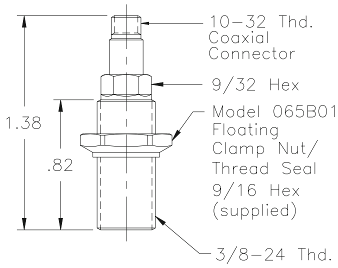
ICP® General Purpose Quartz

With integral electronics

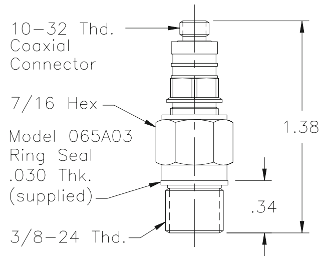
Operate with ICP® power/signal conditioners

Dimensions shown in inches except where noted.

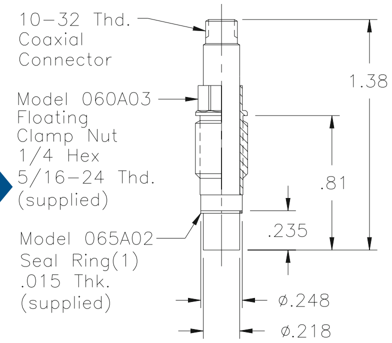
Mounting Adaptors on Page 58



Models 101A, 102A02 and 102A07
Thread Mount with Floating Clamp Nut



Models 101A02, A03, A04, A05, A06, 102A05
Thread Mount Design



Models 111A21, A22, A23, A24, A26, 112A21, A22, A23
Probe Designs

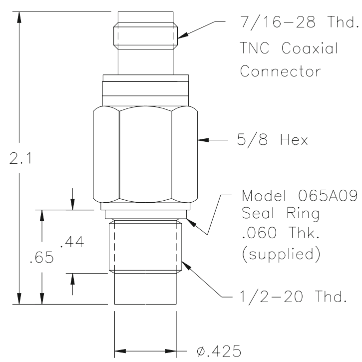
	Dynamic Range (2)	psi	0.01 to 50		0.02 to 100		125	0.1 to 500
	MODEL NUMBERS		102A07 112A22	112A23	102A02, 102A05 112A21	101A, 101A05 111A21	121A	101A06 111A26
AMPLITUDE	Sensitivity (10)	mV/psi	100	50 ± 10			40 ± 20	10 ± 1
	Resolution	psi	0.001		0.002		0.003	0.01
	Range (for 5V output) (3)	psi	50	50 (±2.5v)	100		125	500
	Range (for 10V output) (4)	psi	100	200			250	1000
	Maximum Pressure	psi	500	1000				5000
	Linearity (5)	%FS	≤ 1				≤ 2	
FREQ RESP	Resonant Frequency	kHz	≥ 250				≥ 200	≥ 400
	Rise Time	µs	≤ 2				≤ 2	≤ 1
	Discharge Time Constant (6)	s	≥ 1					≥ 50
	Low Frequency (-5%) (6)	Hz	0.5					0.01
ENVIRONMENT	Shock (max)	g pk	20 000					
	Acceleration Sensitivity	psi/g	≤ 0.002			≤ 0.01	≤ 0.04	≤ 0.002
	Temperature Range	°F	-100 to +275					
	Temperature Coefficient	%/°F	≤ 0.03				≤ 0.04	≤ 0.03
	Flash Temperature	°F	3000					
ELECTRICAL	Polarity (positive pressure)		positive					
	Output Impedance	ohm	≤ 100					
	Output Bias	+volt	8 to 14	3 to 8	8 to 14			
	Power Required: Voltage	+ VDC	20 to 30	11 to 30	20 to 30			
	Constant Current	mA	2 to 20					
	Ground Isolation	model	102A07	n/a	102A02, A05	101A, 101A05	n/a	101A06
PHYSICAL	Sensing Element	material	quartz					
	Case (7)	material	17-4 PH					
	Diaphragm (7) (8)	material	Invar®				17-4 PH (9)	Invar
	Connector (8)	type	10-32 coax				TNC	10-32 coax
	Sealing (8)	type	epoxy					
OPTIONS	Hermetic Seal (8)	prefix	H				n/a	H
	Stainless Steel Diaphragm	prefix	S				n/a	S
	Emralon Gnd. Isolation Coating	prefix	E (111A20 & 112A20 probe series)				n/a	E (111A26)
	Negative Polarity	prefix	N					
	Water-resistant Cable	prefix	W (specify length)					

Notes:
1. For recess mount, Model 065A05 sleeve is available.
2. Measures dynamic pressures from full vacuum to rated maximum.
3. Supplied with two calibrations: 0 to 100% and 0 to 10% of full dynamic range.
4. ≥24 VDC supply required for 10V output. If optional calibration to 10V range is required, linearity spec may change. If negative pressure is applied, the output may be limited by the output bias.
5. % FS any calibration range; zero-based best straight line.

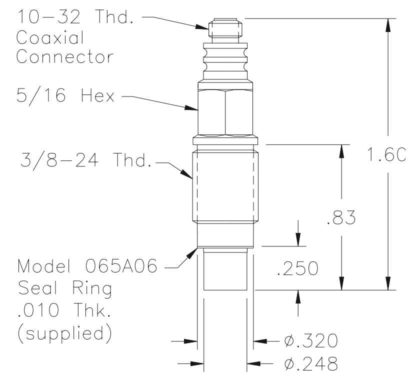
ICP® General Purpose Quartz

With integral electronics

Dimensions shown in inches except where noted.



Models 121A, 121A02, A03, A04
Industrial Design



Model 108A02
Hydraulic Pump Design

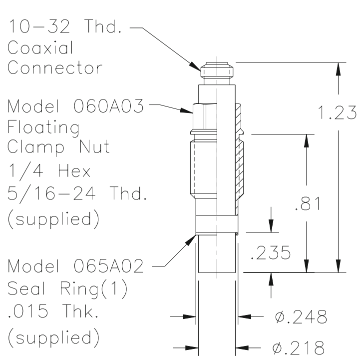
	Dynamic Range (2)	psi	0 .2 to 1000		1 to 5000		2 to 10 000		
	MODEL NUMBERS		101A04 111A24	121A02	101A02 111A22	121A03	101A03 111A23	121A04	108A02
AMPLITUDE	Sensitivity (10)	mV/psi	5 ± 0.5	5 ± 2	1 ± 0.1	1 ± 0.5	0.5 ± 0.05	0.5 ± 0.2	0.5
	Resolution	psi	0.02		0.1		0.2		
	Range (for 5V output) (3)	psi	1000		5000		10 000		
	Range (for 10V output) (4)	psi	2000		10 000		20 000		
	Maximum Pressure	psi	10 000		15 000	10 000		20 000	50 000
	Linearity (5)	%FS	≤ 2						
FREQ RESP	Resonant Frequency	kHz	≥ 400	≥ 200	≥ 400	≥ 200	≥ 400	≥ 200	≥ 250
	Rise Time	µs	≤ 1	≤ 2	≤ 1	≤ 2	≤ 1	≤ 2	
	Discharge Time Constant (6)	s	≥ 100		≥ 500	≥ 100	≥ 1 000	≥ 100	≥ 500
	Low Frequency (-5%) (6)	Hz	0.005		0.001	0.005	0.0005	0.005	0.001
ENVIRONMENTAL	Shock (max)	g pk	20 000						
	Acceleration Sensitivity	psi/g	≤ 0.002	≤ 0.04	≤ 0.002	≤ 0.04	≤ 0.002	≤ 0.04	≤ 0.01
	Temperature Range	°F	-100 to +275						
	Temperature Coefficient	%/°F	≤ 0.03	≤ 0.04	≤ 0.03	≤ 0.04	≤ 0.03	≤ 0.04	≤ 0.03
	Flash Temperature	°F	3000						
ELECTRICAL	Polarity (positive pressure)		positive						
	Output Impedance	ohm	≤ 100						
	Output Bias	+volt	8 to 14						
	Power Required: Voltage	+VDC	20 to 30						
	Constant Current	mA	2 to 20						
	Ground Isolation	model	101A04	n/a	101A02	n/a	101A03	n/a	
PHYSICAL	Sensing Element	material	quartz						
	Case (7)	material	17-4 PH						C-300
	Diaphragm (7) (8)	material	Invar	17-4 PH (9)	Invar	17-4 PH (9)	Invar	17-4 PH (9)	C-300 (9)
	Connector (8)	type	10-32 coax	TNC	10-32 coax	TNC	10-32 coax	TNC	10-32 coax
	Sealing (8)	type	epoxy						hermetic
OPTIONS	Hermetic Seal (8)	prefix	H	n/a	H	n/a	H	n/a	
	Stainless Steel Diaphragm	prefix	S	n/a	S	n/a	S	n/a	
	Emralon Gnd. Isolation Coating	prefix	E (111 only)	n/a	E (111 only)	n/a	E (111 only)	n/a	
	Negative Polarity	prefix	N						
	Water-resistant Cable	prefix	W (specify length)						

6. Discharge Time Constant (DTC) relates low-frequency to signal lost during transient events at room temperature. See technical section on page 78.
7. Special diaphragm or case material available.
8. Diaphragms of all sensors are welded or integral. Hermetic option specifies a fused-glass electrical connector and welded joints.
9. Diaphragms are integral.
10. Unless otherwise designated, sensitivities are ±15%

General Purpose
Quartz Pressure Sensors

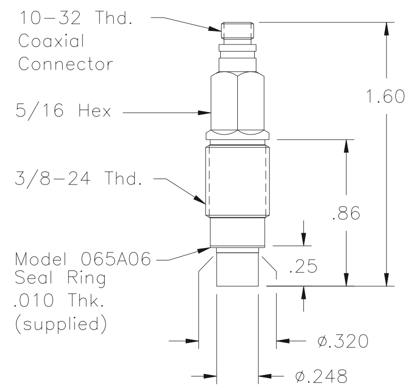
Operate with charge amplifiers and low-noise input cables

Dimensions shown in inches except where noted.



Models 112A, A02, A03

Mounting Adaptors on Page 58



Model 118A02

6

	Dynamic Range (1)	psi	0.02 to 100	0.02 to 3 000	0.02 to 10 000	2 to 20 000
	MODEL NUMBERS		**112A02**	**112A**	**112A03**	**118A02**
AMPLITUDE	Sensitivity (8)	-pC/psi	1			0.1
	Resolution (2)	psi	0.002			0.2
	Maximum Pressure	psi	1000	10 000	15 000	50 000 (5)
	Linearity (3)	%FS	≤ 1			≤ 2
FREQ RESP	Resonant Frequency	kHz	≥ 250			
	Rise Time	µs	≤ 2			
ENVIRONMENTAL	Shock (max)	g pk	20 000			
	Acceleration Sensitivity	psi/g	≤ 0.002			≤ 0.01
	Temperature Range	°F	- 400 to + 400			
	Temperature Coefficient	%/°F	≤ 0.03			≤ 0.04
	Flash Temperature	°F	3000			
ELECTRICAL	Polarity (positive pressure) (7)		negative			
	Capacitance	pF	18			10
	Insulation Resistance at 70° F	ohm	$\geq 10^{12}$			
PHYSICAL	Sensing Element	material	quartz			
	Case (4) (6)	material	17-4 PH			C-300
	Welded Diaphragm (4) (6)	material	Invar			C-300 (9)
	Connector	type	10-32 coaxial			
	Sealing (6)	type	epoxy			
OPTIONS	Hermetic Seal (6)	prefix	H			n/a
	Stainless Steel Diaphragm	prefix	S			n/a
	Emralon Gnd. Isolation Coating	prefix	E			n/a
	Positive Polarity	prefix	P			
	Water-resistant Cable	prefix	W (specify length)			

Notes:
1. Measures dynamic pressures from full vacuum to rated maximum.
2. Resolution determined by system noise and cable length.
3. % FS any calibrated range; zero-based best straight line.
4. Special case and diaphragm material available.
5. Not for continuous, repetitive use at maximum pressure.
6. Diaphragms of all sensors are hermetic welded or integral. Hermetic option specifies a fused-glass electrical connector and welded joints..
7. Charge amplifier inverts the signal.
8. Unless otherwise designated, sesitivities are ±15%.
9. Diaphragm is integral.

High Sensitivity Pressure Sensors

- Acoustic
- Turbulence
- High-intensity sound
- Aircraft flight tests
- Paper slurry pressure measurement
- Valve dynamics

PCB and The Modal Shop, a PCB Group Company, offer a wide range of microphones and pressure sensors for acoustic, turbulence and high intensity sound measurements in a wide variety of laboratory, field and flight applications.

All sensors in this section are structured with acceleration-compensated sensing elements to minimize vibration sensitivity. They incorporate built-in microelectronic circuitry and operate with standard ICP® sensor signal conditioners. Output is a high voltage low impedance signal compatible with standard readout instruments.

ICP quartz pressure sensors are structured with a diaphragm that is supported by a rigid column of quartz. They have the unique capability to measure low acoustic pressure changes under high static loading as might be involved with fluid borne noise measurements in hydraulic systems. The static component of the signal is eliminated from the sensor output due to the discharge time constant of the sensor.

Options for the high sensitivity acoustic sensors include special filtering, biasing, powering and physical configurations.

Also offered by The Modal Shop, are precision Gunner Rasmussen "Signature Series" condenser microphones. The Modal Shop also supplies low cost ICP microphones for large channel vibro-acoustic array sensing applications. For more information, see page i of this catalog.

See pages 37 to 39 for information on high-temperature charge mode acoustic pressure sensors Models 112A04, 112A05, 116B and 116B02.

PCB PIEZOTRONICS INC. PFS DIVISION

PCB 716-684-0001 **PFS Toll Free** 888-684-0011 **Fax** 716-686-9129 **Email** pfssales@pcb.com **Web Site** www.pcb.com

ICP® High Sensitivity
With integral electronics

MINIATURE HIGH SENSITIVITY ICP® QUARTZ PROBES
Series 112A20

Used to measure small dynamic pressures such as turbulence, noise, sound, cavitation, and pulsations in fluids that commonly occur in aerodynamic, hydraulic and blast applications. Capable of measuring high intensity sound pressures from 0.01 psi (130 dB [air]) to 100 psi (210 dB [air]) fluctuating on high static pressures especially in adverse environments. Internal acceleration compensation minimizes vibration sensitivity. A discharging resistor automatically eliminates static (DC) signal components. This sophisticated instrument contains a high-sensitivity multi-plate quartz element and a selected unity gain amplifier to impart a high signal-to-noise ratio.

Operating from a PCB signal conditioner, this sensor generates a high-level, low-impedance analog output signal proportional to the measurand. The analog output is compatible with most readout instruments.

A 5/16-24 floating clamp nut or optional Metric (M7 x .75) thread isolates the sensor against strain and facilitates installation/removal of the sealed sensor assembly. The assembly mounts directly in the test object or in a variety of threaded mounting adaptors. See specifications on page 10.

Models 112A21, 112A22, and 112A23

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Model 112A21 is a general purpose 50 mV/psi sensor with a wide dynamic range suitable for most applications.

Model 112A22 is a higher sensitivity model with 100 mV/psi output.

Model 112A23 is a 50 mV/psi sensor with special low noise, low bias electronics for improved resolution.

Model 102A02, 102A07 and 102A09

GROUND-ISOLATED HIGH SENSITIVITY ICP®
Series 102

These sensors are used for monitoring low-level dynamic pressures such as turbulence, noise, cavitation, pulsations, sonic boom, and aerodynamic phenomenon. The 3/8-24 threaded housing isolates the sensor from electrical noise in the mounting structure. They incorporate high-resolution electronics, offering fast response, excellent signal-to-noise ratio, and low-impedance output. See specifications on page 10.

Models 102A02, A07, and A09 have a 3/8-24 threaded housing and a floating clamp nut to allow the sensor to be mounted at various depths.

Model 102A05 offers a 3/8-24 threaded housing for ease of mounting in closed vessels or chambers.

Model 102A05

ICP® SOUND PRESSURE SENSORS
Series 103

Developed by a leading aeronautical research laboratory, this sophisticated sensor has played a major role in the development of rockets, supersonic bombers and modern weapon systems. These tiny instruments measure transient events, turbulence, and other such acoustic phenomena on structures and aerodynamic models. They are structured with a ceramic crystal element, a microelectronic amplifier and an accelerometer to virtually eliminate vibration sensitivity. A thin, recessed Invar diaphragm and a bender mode crystal element make this sensor useful for very low pressure measurements. With a rise time of less than one millisecond, series 103 will faithfully follow transient events up to several hundred milliseconds duration, such as a step function calibration pressure. See specifications on page 12.

Models 103A, 103A11

Models 103A02, 103A12

Model 103A has a 2 psi range, 1500 mV/psi sensitivity, a flat surface for adhesive mounting, and 12 inch pigtail wire solder connection.

Model 103A02 has the same range and sensitivity of the 103A, with a 10-32 threaded electrical connection.

Model 103A11 has a 6 psi range and a 500 mV/psi sensitivity with the same external configuration as the 103A.

Model 103A12 has a high 6 psi range, 500 mV/psi sensitivity, with a 10-32 threaded electrical connection.

Model 106B

ICP® HIGH-INTENSITY SOUND QUARTZ PRESSURE SENSORS
Series 106

Model 106B and 106B50 are high sensitivity, acceleration compensated ICP quartz pressure sensors suitable for measuring low pressure acoustic phenomena in hydraulic and pneumatic systems. They have the unique capability to measure small pressure changes of less than 0.001 psi under high static conditions. They install in a stepped hole, seal at a shoulder and are retained by a hollow clamp nut. Optional ground-isolated installations are available with nylon-type plastic hardware or Emralon® coating (refer to page 58 and 60 for additional information on mounting adaptors). See specifications on page 11.

Model 106B50

Model 106B, the smaller unit, has a 300 mV/psi sensitivity and a resolution of 91dB (0.0001 psi).
Model 106B50 has 500 mV/psi sensitivity with a resolution to 86 dB (0.00007 psi).

PAPER MACHINE HEADBOX, ICP® QUARTZ SENSOR
Model 106B10

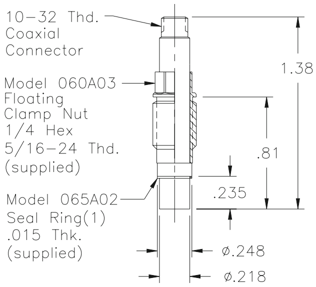
Measures dynamic slurry pressure in the headbox of a paper machine. Model 106B10 features high sensitivity (300 mV/psi) and is capable of measuring minute dynamic pressure fluctuations down to 0.0001 psi. Critical to the application, it features a stainless steel corrosion-resistant diaphragm and a low frequency response down to 0.05 Hz. A floating clamp nut/seal and etched length markings on the housing enable the user to insert the sensor at repeatable depths into the headbox where the measurement is made. See specifications on page 11.

Model 106B10
(Photo 1/3 Actual Size)

ICP® Acoustic/Turbulence-Low Pressure

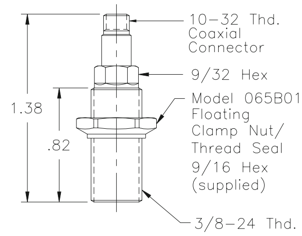
With integral electronics

Dimensions shown in inches except where noted.

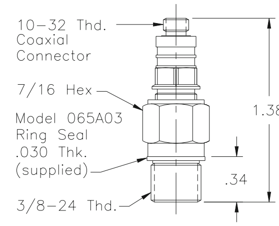


Models 112A21, A22 and A23
Mini Probes

Mounting Adaptors on Page 58



Models 102A02, A07 and A09
Thread Mount with Floating Clamp



Model 102A05
Thread Mount

	Dynamic Range (2)	psi	0.1 to 100	0.01 to 50	
	MODEL NUMBERS		102A02, A05 112A21	102A07, 112A22	102A09, 112A23
AMPLITUDE	Sensitivity (8)	mV/psi	50 ± 10	100	50 ± 10
	Resolution	psi	0.002	0.001	
	Range (output Voltage)	psi	100 (5V)	50 (5V)	50 (2.5V)
	Maximum Pressure	psi	1000	500	1000
	Linearity (3)	%FS	≤ 1		
FREQ RESP	Resonant Frequency	kHz	≥ 250		
	Rise Time	µs	≤ 2		
	Discharge Time Constant (4)	s	≥ 1		
	Low Frequency (-5%) (4)	Hz	0.5		
ENVIRONMENTAL	Shock (max)	g	20 000		
	Acceleration Sensitivity	psi/g	≤ 0.002		
	Temperature Range	°F	-100 to +275		
	Temperature Coefficient	%/°F	≤ 0.03		
	Flash Temperature (max) (7)	°F	3000		
ELECTRICAL	Polarity (positive pressure)		positive		
	Output Impedance	ohm	< 100		
	Output Bias	+ volt	8 to 14		3 to 8
	Power Required: Voltage	+VDC	20 to 30		11 to 30
	Constant Current	mA	2 to 20		
	Ground Isolation	models	102A02, A05	102A07	102A09
PHYSICAL	Sensing Element	material	quartz		
	Case (5)	material	17-4-PH		
	Diaphragm (5) (6)	material	Invar		
	Connector (6)	type	10-32 coax		
	Sealing (6)	type	epoxy (conn)		
OPTIONS	Hermetic Seal (6)	prefix	H		
	Stainless Steel Diaphragm	prefix	S		
	Emralon Gnd. Isolation Coating	prefix	E (112 only)		
	Water-resistant Cable	prefix	W (specify length)		

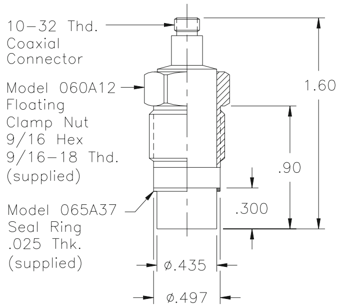
Notes:

1. For recess mount, Model 065A05 seal sleeve is available.
2. Measures dynamic pressures from full vacuum to rated maximum.
3. % FS of any calibration range; zero-based best straight line.
4. Discharge Time Constant (DTC) relates low-frequency to signal lost during transient events at room temperature. See technical section on page 78.
5. Special diaphragm or case material available.
6. Diaphragms of all sensors are welded or integral. Hermetic option specifies a fused-glass electrical connector and welded joints.
7. Flash temperatures associated with shock waves or combustion.
8. Unless otherwise designated, sensitivities are ±15%.

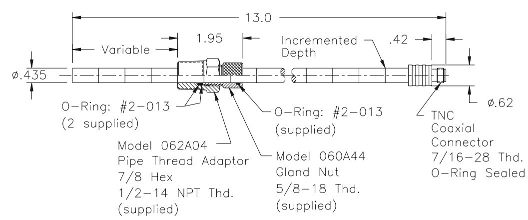
ICP® Acoustic/Turbulence-Low Pressure

With integral electronics

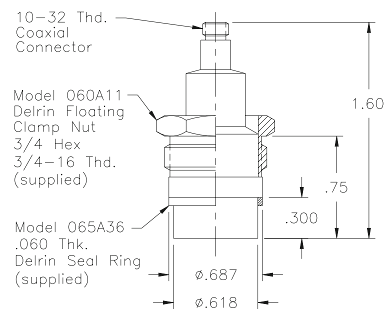
Mounting Adaptors on Page 58



Model 106B



Model 106B10



Model 106B50

	Dynamic Range (2)	psi	0.001 to 8.3	0.0001 to 5	0.001 to 8.3
	MODEL NUMBERS		106B	106B50	106B10
AMPLITUDE	Sensitivity (6)	mV/psi (mV/Pa)	300 (0.04)	500 (0.07)	300 (0.04)
	Resolution	psi (dB)	0.0001 (91)	0.00007 (86)	0.0001 (91)
	Range (± 2.5V output)	psi (dB)	8.3 (186)	5 (182)	8.3 (186)
	Maximum Pressure (step)	psi	200	100	100
	Maximum Pressure (static)	psi	2 000	500	200
	Linearity (2)	%FS	≤ 1		
FREQ RESP	Resonant Frequency	kHz	≥ 60	≥ 40	≥ 60
	Rise Time	µs	≤ 9	≤ 12	≤ 9
	Discharge Time Constant (3)	s	≥ 1		≥ 10
	Low Frequency (-5%) (3)	Hz	0.5		0.05
ENVIRONMENTAL	Shock (max)	g	2000	1000	2000
	Acceleration Sensitivity	psi/g	≤ 0.002		≤ 0.05
	Temperature Range	°F	-65 to +250		
	Temperature Coefficient	%/°F	≤ 0.03		
ELECTRICAL	Polarity (positive pressure)		positive		
	Output Impedance	ohm	≤ 100		
	Output Bias	+ volt	3 to 8		
	Power Required: Voltage	+VDC	11 to 30		
	Constant Current	mA	2 to 20		
	Ground Isolation	models	see options		
PHYSICAL	Sensing Element	material	quartz		
	Case	material	17-4-PH		316L
	Diaphragm (4)	material	316L		
	Connector (4)	type	10-32 coax		TNC coax
	Sealing (4)	type	welded hermetic		environmental
OPTIONS	Hermetic Seal (4)	prefix	standard		n/a
	Stainless Steel Diaphragm	prefix	standard		
	Emralon Gnd. Isolation Coating	prefix	E		n/a
	Water-resistant Cable	prefix	W (specify length)		

Notes:
1. Measures dynamic pressures from full vacuum to rated maximum.
2. % FS of any calibration range; zero-based best straight line.
3. Discharge Time Constant (DTC) relates low-frequency to signal lost during transient events at room temperature. See technical section on page 78.
4. Diaphragms of all sensors are welded or integral. Hermetic option specifies a fused-glass electrical connector and welded joints.
5. Flash temperatures associated with shock waves.
6. Unless otherwise designated, sensitivities are ±15%.

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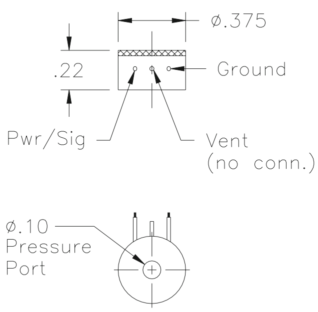
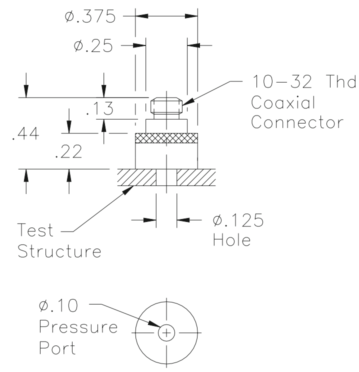
ICP® Acoustic/Turbulence-Low Pressure

With integral electronics

Dimensions shown in inches except where noted.



Models 103A and 103A11



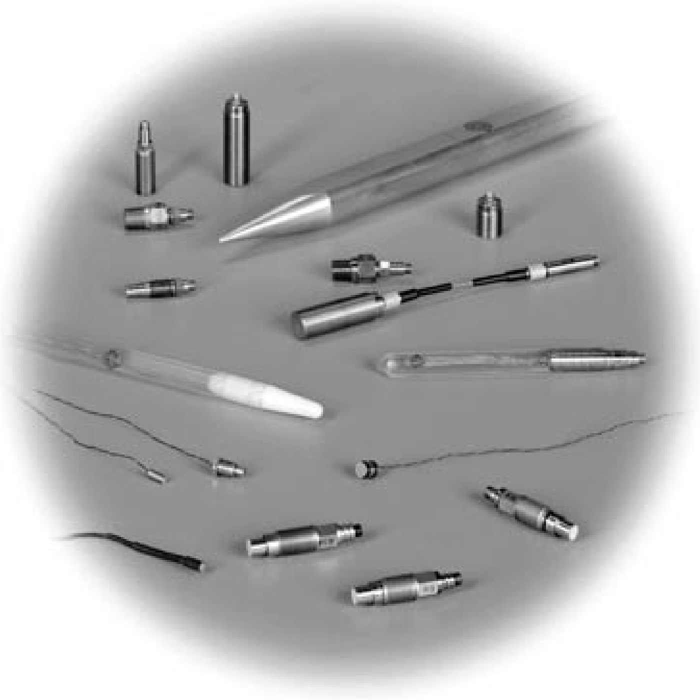
Models 103A02 and 103A12

	Dynamic Range (1)	**psi**	**0.0001 to 2**		**0.007 to 6**	
	MODEL NUMBERS		**103A**	**103A02**	**103A11**	**103A12**
AMPLITUDE	Sensitivity (5)	mV/psi (mv/Pa)	1 500 (0.22)		500 (0.07)	
	Resolution	psi (dB)	0.00002 (78)		0.0007 (88)	
	Range (for 3V output)	psi(dB)	2 (177)		6 (186)	
	Maximum Pressure (step)	psi	25			
	Maximum Pressure (static)	psi	25			
	Linearity (2)	%FS	≤ 2			
FREQ RESP	Resonant Frequency	kHz	≥ 13			
	Rise Time	µs	≤ 25			
	Discharge Time Constant (3)	s	≥ 0.1			
	Low Frequency (-5%) (3)	Hz	5			
ENVIRONMENTAL	Shock (max)	g	1000			
	Acceleration Sensitivity	psi/g	≤ 0.0005			
	Temperature Range	°F	-100 to +175			
	Temperature Coefficient	%/°F	≤ 0.03			
	Flash Temperature (4)	°F	1000			
ELECTRICAL	Polarity (positive pressure)		positive			
	Output Impedance	0hm	≤ 100			
	Output Bias	+ volt	3 to 8			
	Power Required: Voltage	+VDC	11 to 30			
	Constant Current	mA	2 to 20			
PHYSICAL	Sensing Element	material	ceramic			
	Case	material	Invar			
	Diaphragm	material	Invar			
	Connector	type	pigtail	10-32 coax	pigtail	10-32 coax
	Sealing	type	epoxy			

Notes:
1. Measures dynamic pressures from full vacuum to rated maximum.
2. % FS of any calibration range; zero-based best straight line.
3. Discharge Time Constant (DTC) relates low-frequency to signal lost during transient events at room temperature. See technical section on page 78.
4. Flash temperatures associated with shock waves or combustion.
5. Unless otherwise specified, sensitivities are ±15%.

High Frequency Shock Wave/Blast/Explosion Pressure Sensors

- Shock tube
- Free-field blast
- Projectile and time of arrival
- Underwater blast



PCB offers a complete line of ultra-high frequency pressure sensors with quartz, ceramic and tourmaline sensing elements for a wide array of shock wave, blast and explosive testing. Typical applications include measurement of shock and blast waves; combustion, detonation and explosions in closed bombs; projectile velocity; free field and underwater explosive testing; and squib lot acceptance testing. All of these applications require high frequency response and durability; ability to drive long cables and operate in adverse environments may also be important.

For those involved in explosive blast applications, "Soroka's Air Blast Tables" compile free-air incident and reflected blast data from Bare Spherical Pentotlite; this information is available from PCB.

In applications involving long input cables, care must be exercised to assure the measurement system has adequate frequency response. Capacitance associated with the long cables can act as a low pass filter. Sensor output voltage, cable capacitance and constant current are factors to be considered. More current is required to drive higher voltages over longer cables. Selecting a sensor to provide about 1 V full scale for the expected pressure to be measured, rather than 5V, will provide 5 times greater frequency response for a given current and cable length. PCB signal conditioners can be adjusted up to 20 mA to drive long cables.

Most of the sensors listed in this section incorporate acceleration-compensating sensing elements with integral electronics, which provide a frequency-tailored, non-resonant response. Frequency tailored sensors have microsecond rise time and suppressed resonance to faithfully follow shock wave events without the characteristic "ringing" common in other sensors. See typical test results on page v, "Microsecond Shockwave Non-Resonant Response."

The cable driving nomograph listed on pages 82 and 83 will help determine the Voltage/Cable Length/Constant Current requirements and provide information on testing long cables.

High Frequency Shock Wave/Blast/Explosion

GENERAL PURPOSE SENSORS
Series 102

500 kHz ICP® sensors are designed to provide frequency-tailored, non-resonant output when subjected to instantaneous, reflected (face-on) shock wave inputs. They are structured with acceleration-compensated quartz elements and integral microelectronics. Because of their clean, non-resonant output, Series 102A ICP sensors are well suited for high-frequency measurements in shock tubes, closed bombs, and squib (explosive bolt actuators) lot acceptance testing. Their high-voltage, low-impedance output is electrically isolated from ground. Solid-state construction provides ruggedness and durability. See specifications on page 17.

Models 102A, A03, A04, A06 and A15 are available in 5 standard ranges from 100 to 10 000 psi, with sensitivities from 25 to 0.5 mV/psi. Two linear NIST-traceable calibration certificates, Full Scale (FS) and 10% of FS, are supplied with each sensor.

Model 102A12 has an adjustable floating clamp nut, to vary the depth of the sensor in the mounting port.

Models 102A, A03, A04, A06, A15

MINI-PRESSURE PROBES CHARGE AND ICP®
Series 113

500 kHz mini-gauges are designed to excel in shock tube and other high-frequency applications where minimum sensor diameter is required. With frequency-tailored microsecond rise time, these acceleration-compensated sensors follow incident and reflected shock waves without the “ringing” characteristic of most other sensors. Five ranges are available to 10 000 psi. Utilizing a floating clamp nut, they can install in a 5/16-24 or M7 x 0.75 port.

If miniature size is not required, the Series 113 High Frequency Sensors are incorporated in off-ground 3/8-24 threaded housings.
(See 102A description above).

Series 113 are acceleration-compensated 0.35 pC/psi charge mode sensors for use in adverse environmental conditions. The charge signal from this conventional piezoelectric sensor is converted into a voltage signal using a PCB or similar charge amplifier. See specifications on page 18.

Series 113A20 sensors are ICP voltage mode sensors that convert pressure input to a clean, high resolution output which is virtually insensitive to cable length. Five ranges and sensitivities are available. See specifications on page 17.

New Series 113A30 ICP mini-gauges with Invar housing and diaphragm for reduced thermal transient sensitivity are recommended for most shock and blast wave measurements. See specifications on page 17.

Model 102A12

Series 113

High Frequency Shock Wave/Blast/Explosion

HIGH FREQUENCY, ACCELERATION-COMPENSATED QUARTZ PRESSURE PROBES
Series 109B, 119A and 119A10

Designed for high-pressure, high-frequency response applications, such as shock wave, blast, explosion, detonation, and ballistics. The sensors feature an acceleration-compensated quartz element, high resonant frequency, and a rugged ceramic-coated integral diaphragm.

New!
Models 119A11 and 119A12

New Models 119A11 and 119A12 are charge mode sensors designed for pressure measurements up to 80 000 and 120 000 psi. They feature a floating clamp nut that reduces strain sensitivity on the sensor body due to mounting torque. See specifications on page 20.

New Models 109B11 and 109B12 have integral electronics and are designed for 80 000 and 100 000 psi measurements, respectively. They feature a floating clamp nut mount which creates less strain on the body if the sensor is not installed in a precision mounting port. These sensors contain shock protected electronics for applications where the sensor may see high shock. See specifications on page 19.

New!
Models 109B11 and B12

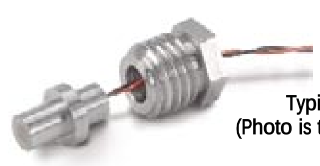
Models 119A and 119A02 are charge mode sensors for use in harsh or high temperature environments, with integral mounting threads. They have dynamic ranges of 80 000 and 120 000 psi, respectively. See specifications on page 20.

Models 119A and 119A02

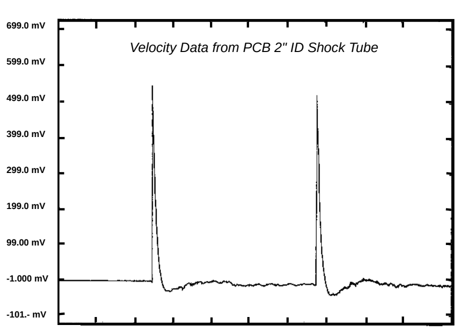
TIME OF ARRIVAL, ICP® MICRO-PRESSURE SENSORS
Series 132A30

High-Sensitivity Micro-Pressure Sensors are well suited for short wavelength acoustic and shock wave measurements associated with high-frequency projectile detection systems. Incorporating a 1mm diameter sensing element and integral microelectronics in a 3mm housing, these sensors have very high sensitivity and microsecond response capable of measuring the bow and stern wave from a passing projectile. An internal 8 kHz high-pass filter eliminates low-frequency inputs. Series 132 Microsensors are available in five different physical configurations to accommodate a wide range of application requirements. See page 21 for specifications.

Series 132A30 Microsensors all have a sensitivity of 100 mV/psi and come in a variety of external configurations to suit your specific application.



Typical 132 Microsensor
(Photo is two times actual size)



Typical Microsensor Incident Pressure Record from 2" I.D. Shock Tube

High Frequency Shock Wave/Blast/Explosion

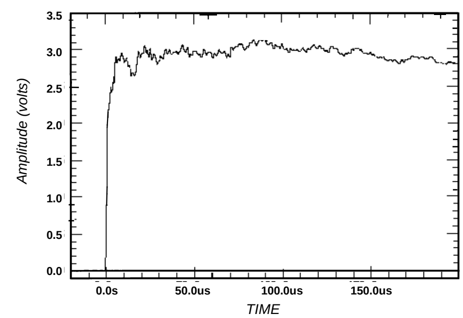
TOURMALINE PRESSURE BAR
Series 134 and 134A20

This unique non-resonant sensor is designed for instantaneous, reflected (face-on) shock wave pressure measurements. A shock wave pressure impacting the tourmaline crystal element dissipates in the special silver bar to which it is bonded without reflecting or “ringing” back through the crystal structure. The sensor has a 0.2-microsecond rise time. Since the sensor diaphragm end is coated with a conductive silver epoxy, the sensor should not be used in water or chemical environments. See specifications on page 22.

Series 134 sensors are charge output versions of the tourmaline pressure bar and are available in 10k and 20k psi ranges. These sensors can be ordered with in-line amplifiers (see below) or used with a conventional laboratory type charge amplifier.

The **134A20 Series** consists of a 134 style sensor in series with a 402 style in-line amplifier to provide a convenient voltage output.

Series 134



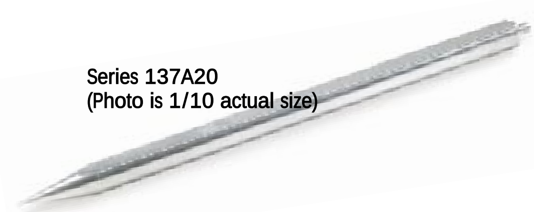
Shockwave Measurement with Microsecond Rise Time and Non-Resonant Response

ICP® FREE-FIELD BLAST PRESSURE “PENCIL” PROBE
Series 137

“Pencil” Probes were originally developed at Aberdeen Proving Ground for measuring blast effects on structures and humans. Although early Models 137A, 137A11 and 137A12 were structured with ceramic elements, the new Series 137A20 incorporates acceleration-compensated quartz elements and integral microelectronics for long cable driving, improved stability and low thermal sensitivity. See page 23 for a typical long-cable, field-blast measurement system.

Series 137A20 ICP pencil probes are available in three models with ranges of 50, 500, and 1000 psi. See specifications on page 23.

Series 137A20
(Photo is 1/10 actual size)



New!
Quartz structured

ICP® TOURMALINE UNDERWATER BLAST SENSOR
Series 138

Series 138 Sensors measure shock wave pressures associated with underwater explosion testing. The sensors are structured with a volumetrically sensitive tourmaline crystal, suspended and sealed in an insulating, oil-filled vinyl tube. They have integral microelectronics. These underwater shock wave sensors provide a clean, non-resonant high-voltage output through long cables in adverse underwater environments. They can be supplied with a sealed cable of appropriate length, ready to operate. Two physical configurations are available. See specifications on page 24.

Models 138A01, A05, A10, A25 and A50 are 7.6 inches in length and contain a weight attachment hole to suspend the sensor in water at a given depth.

Models 138A02, A06, A11, A26 and A51 are 4.2 inches long. They can be taped to a structure or used in restricted locations.

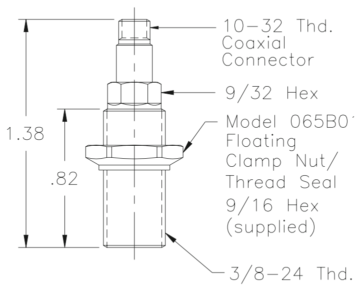
Series 138
(Photo is 1/2 actual size)

ICP® High Frequency-General Purpose

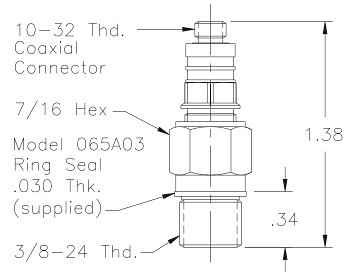
With integral electronics

Optional o-ring isolation mounting adaptor is available for blast applications; see page 59.

Dimensions shown in inches except where noted.

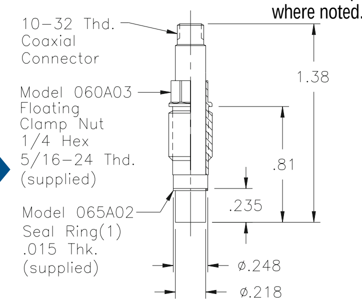


Model 102A12
Ground Isolated



Models 102A, A03, A04, A06, A15
Ground Isolated

Mounting Adaptors on Page 58



Models 113A21, A22, A23, A24, A26
NEW all Invar Models 113A31, A32, A33, A34, A36

	Dynamic Range (2)	psi	0.05 to 200	0.1 to 500	0.2 to 1000	1 to 5000	2 to 10 000
	MODEL NUMBERS		102A12, A15 113A21 113A31	102A06 113A26 113A36	102A04 113A24 113A34	102A 113A22 113A32	102A03 113A23 113A33
AMPLITUDE	Sensitivity (9)	mV/psi	25	10 ± .5	5 ± .25	1 ± .05	0.5 ± .03
	Resolution	psi	0.003	0.01	0.02	0.1	0.2
	Range (for 5V output)	psi	200	500	1000	5000	10 000
	Range (for 10V output) (3)	psi	400	1000	2000	10 000	20 000
	Maximum Pressure	psi	1000	10 000		15 000	20 000
	Linearity (4)	%FS	≤ 1				
FREQ RESP	Resonant Frequency (5)	kHz	≥ 500				
	Rise Time	µs	≤ 1				
	Discharge Time Constant (6)	sec	≥ 1	≥ 50	≥ 100	≥ 500	≥ 1 000
	Low Frequency (-5%) (6)	Hz	0.5	0.01	0.005	0.001	0.0005
ENVIRONMENTAL	Shock (max)	g pk	20 000				
	Acceleration Sensitivity	psi/g	0.002				
	Temperature Range	°F	-100 to +275				
	Temperature Coefficient	%/°F	≤ 0.03				
	Flash Temperature	°F	3000				
ELECTRICAL	Polarity (positive pressure)		positive				
	Output Impedance	ohm	≤ 100				
	Output Bias	+volts	8 to 14				
	Power Required: Voltage	+VDC	20 to 30				
	Constant Current	mA	2 to 20				
	Ground Isolation	model	102A12, A15	102A06	102A04	102A	102A03
PHYSICAL	Sensing Element	material	quartz				
	Case (7)	material	17-4PH (113A30 series : Invar)				
	Diaphragm (8)	material	Invar				
	Connector (8)	type	10-32 coaxial				
	Sealing (8)	type	epoxy				
OPTIONS	Hermetic Seal (8)	prefix	H				
	Stainless Steel Diaphragm	prefix	S (for series 113A20 only)				
	Emralon Gnd. Isolation Coating	prefix	E (for series 113 only)				
	Negative Polarity	prefix	N				
	Momentum Trap	prefix	T				
	Water-resistant Cable	prefix	W (specify length)				

NOTES:

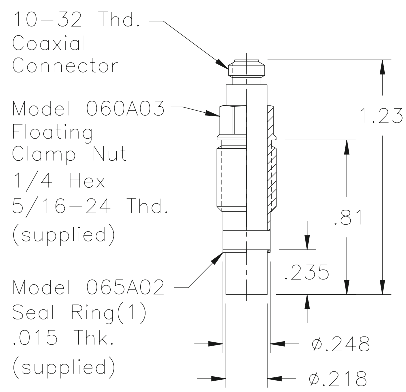
1. For recess mount, Model 065A05 seal sleeve is available.
2. Measures dynamic pressures from full vacuum to rated maximum.
3. ≥+24 VDC supply required for 10V output. If optional calibration to 10V range is required, linearity specs may change.
4. % FS any calibrated range; zero-based best straight line.
5. Suppressed resonance.
6. Discharge Time Constant (DTC) relates low-frequency to signal lost during transient events at room temperature. See technical section on page 78.
7. Special diaphragm or case material available.
8. Diaphragms of all sensors are welded or integral. Hermetic option specifies a fused-glass electrical connector and welded joints.
9. Unless otherwise designated, sensitivities are ± 15%.

High Frequency-General Purpose

Charge mode

Dimensions shown in inches except where noted.

Mounting Adaptors on Page 58



Models 113A, A02 and A03

	Dynamic Range (8)	**psi**	**0.01 to 100**	**0.1 to 3000**	**1 to 15 000**
	MODEL NUMBERS		**113A02**	**113A**	**113A03**
AMPLITUDE	Sensitivity (7)	-pC/psi		0.35	
	Resolution (2)	psi		0.01	
	Maximum Pressure	psi	1000	10 000	20 000
	Linearity (3)	%FS	≤ 1		≤ 2
FREQ RESP	Resonant Frequency (5)	kHz		≥ 500	
	Rise Time	µs		≤ 1	
ENVIRONMENTAL	Shock (max)	g pk		20 000	
	Acceleration Sensitivity	psi/g		0.002	
	Temperature Range	°F		-400 to +400	
	Temprature Coefficient	%/°F		≤ 0.03	
	Flash Temperature	°F		3000	
ELECTRICAL	Polarity (positive pressure) (6)			negative	
	Capacitance	pF		12	
	Insulation Resistance at 70°F	ohm		≥ 10^{12}	
PHYSICAL	Sensing Element	material		quartz	
	Case (4)	material		17-4PH	
	Diaphragm (4)	material		Invar	
	Connector	type		10-32 coaxial	
	Sealing	type		epoxy	
OPTIONS	Hermetic Seal	prefix		H	
	Stainless Steel Diaphragm	prefix		S	
	Emralon Gnd Isolation Coating	prefix		E	
	Positive Polarity	prefix		P	

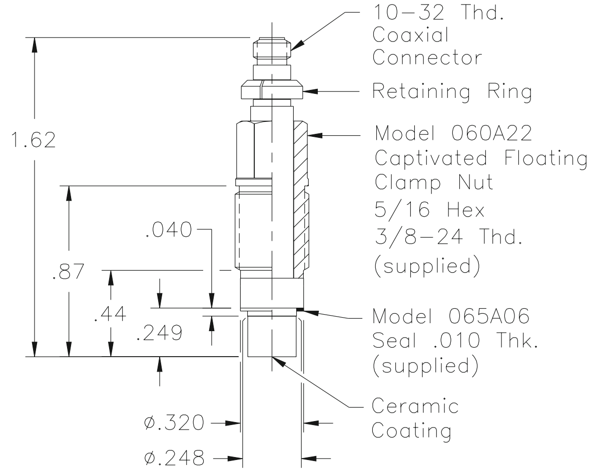
NOTES:

1. For recess mount, Model 065A05 seal sleeve is available.
2. Resolution determined by system noise and cable length.
3. % FS of any calibration range; zero-based best straight line.
4. Special case and diaphragm material available.
5. Suppressed resonance.
6. Charge amplifier inverts the signal.
7. Unless otherwise designated, sensitivities are ±15%.
8. Measures dynamic pressures from full vacuum to rated maximum.

ICP®High Frequency-High Pressure

With integral electronics

Dimensions shown in inches except where noted.



Models 109B11 and 109B12

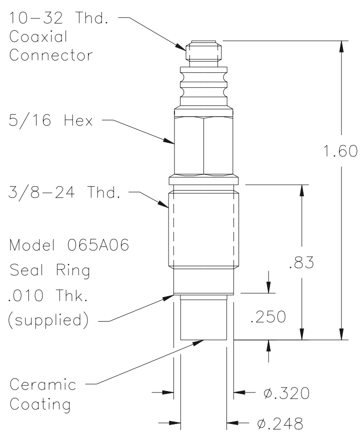
	Dynamic Range (1)	psi	20 to 80 000	20 to 100 000
	MODEL NUMBERS		**109B11**	**109B12**
AMPLITUDE	Sensitivity (3)	mV/psi	0.07	
	Resolution	psi	2	
	Range	psi	80 000 (6V)	100 000 (7V)
	Maximum Pressure	psi	125 000	
	Linearity (2)	%FS	≤ 2	
	Suppressed Resonant	kHz	≥ 400	
FREQ RESP	Rise Time	µs	≤ 1	
	Discharge Time Constant (4)	sec	≥ 2000	
	Low Frequency (-5%) (5)	Hz	0.0003	
ENVIRONMENTAL	Shock (max)	g pk	80 000	
	Acceleration Sensitivity	psi/g	0.004	
	Temperature Range	°F	-100 to +275	
	Temperature Coefficient	%/°F	≤ 0.03	
	Flash Temperature	°F	3000	
ELECTRICAL	Polarity (positive pressure)		positive	
	Output Impedance	ohm	≤ 100	
	Output Bias	+volts	8 to 14	
	Power Required: Voltage	+VDC	20 to 30	
	Constant Current	mA	2 to 20	
PHYSICAL	Sensing Element	material	quartz	
	Case	material	st stl	
	Diaphragm (integral)	material	stainless steel ceramic coated	
	Connector	type	10-32 coaxial	
	Sealing	type	epoxy	
OPT	Water-resistant Cable	prefix	W (specify length)	

NOTES:

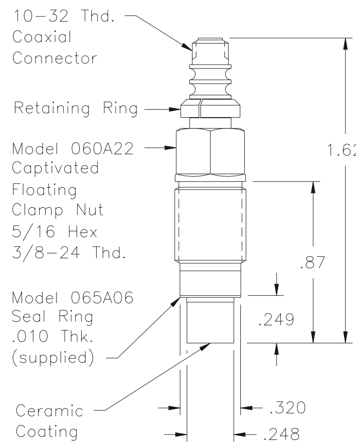
1. Measures dynamic pressures from full vacuum to rated maximum.
2. % FS of any calibration range; zero-based best straight line.
3. Unless otherwise designated, sensitivities are ±15%.
4. Discharge Time Constant (DTC) relates low-frequency to signal lost during transient events at room temperature. See technical section on page 78.
5. For special system requirements to achieve low-frequency response, contact factory.

High Frequency-High Pressure
Charge mode

Dimensions shown in inches except where noted.



Models 119A and 119A02



Models 119A11 and 119A12
NEW High Shock Models

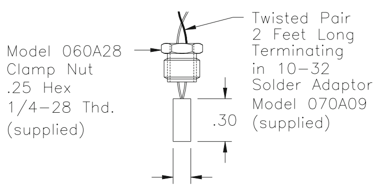
	Dynamic Range (1)	**psi**	**10 to 80 000**		**20 to 120 000**	
	MODEL NUMBERS		**119A**	**119A11**	**119A02**	**119A12**
AMPLITUDE	Sensitivity (5)	-pC/psi	0.25			
	Resolution (2)	psi	1		2	
	Range	psi	80 000		120 000	
	Maximum Pressure	psi	100 000		125 000	
	Linearity (3)	%FS	≤ 2			
FREQ RESP	Resonant Frequency	kHz	≥ 400			
	Rise Time	µs	≤ 1			
ENVIRONMENTAL	Shock (max)	g pk	80 000			
	Acceleration Sensitivity	psi/g	0.004			
	Temperature Range	°F	-400 to +400			
	Temperature Coefficient	%/°F	≤ 0.03			
	Flash Temperature	°F	4000			
ELECTRICAL	Polarity (positive pressure)		negative			
	Capacitance	pF	20			
	Insulation Resistance at 70°F	ohm	$\geq 10^{12}$			
PHYSICAL	Sensing Element	material	quartz			
	Case	material	stainless steel			
	Diaphragm (integral) (4)	material	stainless steel ceramic coated			
	Connector	type	10-32 coaxial			
	Sealing	type	epoxy			
OPT'L	Positive Polarity	prefix	P			
	Water-resistant Cable	prefix	W (specify length)			

NOTES:
1. Measures dynamic pressures from full vacuum to rated maximum.
2. Resolution determined by system noise and cable length.
3. % FS of any calibration range; zero-based best straight line.
4. Diaphragm integral with housing and is ceramic coated.
5. Unless otherwise designated, sensitivities are ±15%.

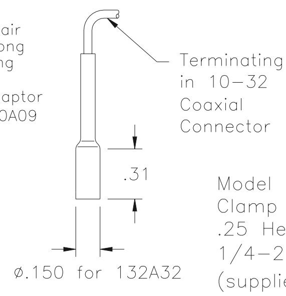
ICP® Time of Arrival Microsensor

With integral electronics

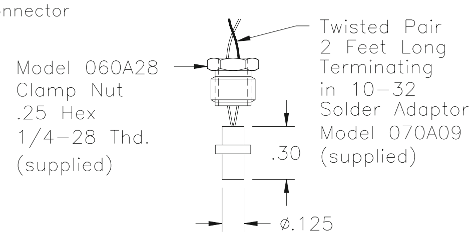
Dimensions shown in inches except where noted.



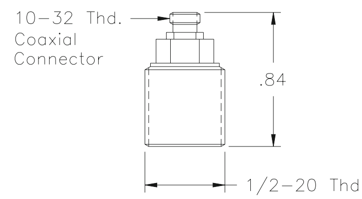
Models 132A31



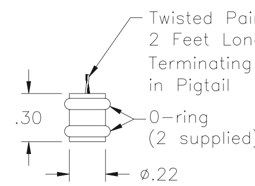
Models 132A32



Models 132A35



Models 132A36



Models 132A37

NOTE:
Diameter of the ceramic sensing element in all models is 0.03 inches.

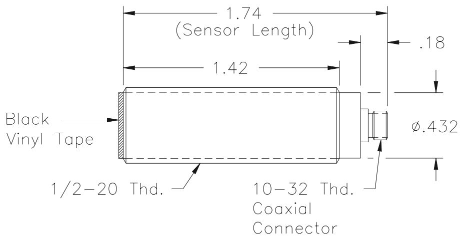
	Dynamic Range (1)	psi	0.05 to 50				
	MODEL NUMBERS		132A31	132A32	132A35	132A36	132A37 (5)
AMPLITUDE	Sensitivity (4)	mV/psi	130 to 180				
	Resolution	psi	0.001				
	Range (for 5V output)	psi	50				
	Maximum Pressure (6)	psi	800				
FREQ RESP	Resonant Frequency	MHz	≥ 1				
	Rise Time (reflected)	µs	≤ 0.5				
	Rise Time (incident, in air) (7)	µs	≤ 3				
	Discharge Time Constant (8)	µs	≥ 45				
	Low Frequency (-5%) (8)	kHz	11				
ELECTRICAL	Temperature Range	°F	0 to +175				
	Polarity (positive pressure)		positive				
	Output Impedance	ohm	≤ 100				
	Output Bias	+volts	8 to 14				
	Power Required: Voltage	+VDC	20 to 30				
PHYSICAL	Constant Current	mA	2 to 20				
	Sensing Element	material	ceramic				
	Case	material	stainless steel				
	Sensing Surface (coating)	material	conductive epoxy				
	Connector	type	pigtail (2)	10-32 plug (3)	pigtail (2)	10-32 jack	pigtail (2)
	Sealing	type	epoxy				

NOTES:

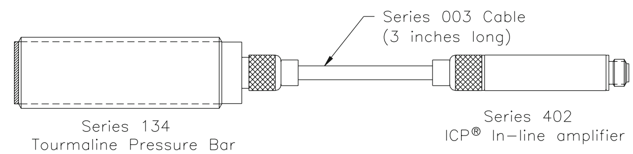
1. Measures dynamic pressures from full vacuum to rated maximum.
2. 10-32 solder connector supplied.
3. On end of attached cable.
4. Unless otherwise designated, sensitivities are ±15%.
5. Adaptor installs with press fit and should not be used at pressures greater than 20 psi unless properly supported from back side to prevent sensor from being blown out at higher pressures.
6. Maximum pressure applies to listed models only with clamp nut.
7. Mach I
8. Discharge Time Constant (DTC) relates low-frequency to signal lost during transient events at room temperature. See technical section on page 78.

Tourmaline Pressure Bar

Dimensions shown in inches except where noted.



Models 134A and 134A02



Series 134A20

NOTE:
Refer to test data plots on page v.

	Dynamic Range (1)	psi	to 10 000	to 20 000
	MODEL NUMBERS		**134A**	**134A02**
AMPLITUDE	Sensitivity (3)	pC/psi	0.125	
	Resolution (2)	psi	1	
	Maximum Pressure	psi	15 000	40 000
	Linearity (2) (4)	%FS	≤ 2	
FREQ RESP	Resonant Frequency	kHz	1500	
	Rise Time (reflected)	µs	≤ 0.2	
ENV'L	Temperature Range	°F	+32 to +120	
	Flash Temperature	°F	5 000	
ELECTRICAL	Polarity (positive pressure)		positive	
	Insulation Resistance at 70°F	> ohm	≥ 10^{10}	
	Capacitance	pF	10	
PHYSICAL	Sensing Surface	material	tourmaline	
	Case	material	303 stainless steel	
	Sensing Surface	material	conductive epoxy with ablative tape	
	Connector	type	10-32	

Specifications for 134A20 Series Tourmaline Pressure Bar Coupled to 402 Style ICP® In-Line Voltage Amplifier (Illustrated Above)

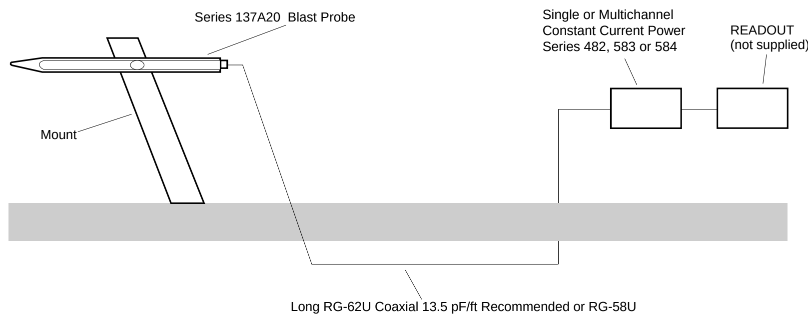
Dynamic Range (1)	psi	1000	5000	10 000	20 000
MODEL NUMBERS		**134A24 (5)**	**134A22 (5)**	**134A23 (5)**	**134A27 (5)**
Tourmaline Pressure Bar	Model Number	134A			
In-Line Voltage Amplifier	Model Number	402A	402A02	402A16	402A17
Sensitivity (3)	mV/psi	5	1	0.5	0.25
Range (for 5V output)	psi	1000	5000	10 000	20 000
Maximum Pressure	psi	15 000			20 000
Discharge Time Constant (4)	sec	≥ 2	≥ 0.2	≥ 1	≥ 0.5
Output Impedance	ohm	≤ 100			
Output Bias	+volts	8 to 14			
Power Required: Voltage	+VDC	20 to 30			
Constant Current	mA	2 to 20			

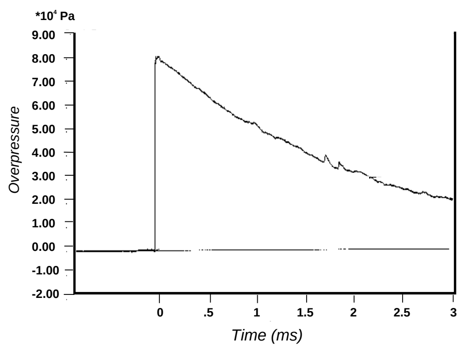
NOTES:
1. Calibrated as a system for voltage sensitivity.
2. % FS of any calibration range; zero-based best straight line.
3. Unless otherwise designated, sensitivities are ±15%.
4. Discharge Time Constant (DTC) relates low-frequency to signal lost during transient events at room temperature. See technical section on page 78.
5. All specifications not listed in this table can be found in the table above for the 134A and 134A02.

ICP® Free Field Blast Pencil Probe-
With integral electronics

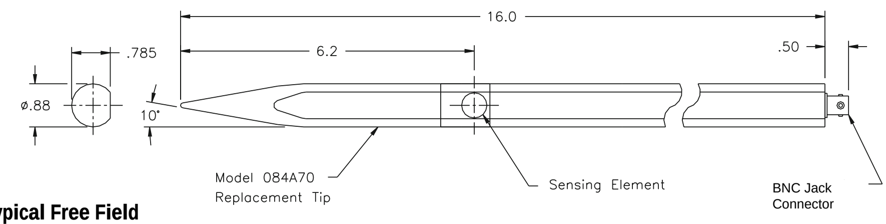
Dimensions shown in inches except where noted.

Typical Field Blast Installation





Typical Free Field Blast Record from 137 Series Blast Probe.



Models 137A21, A22 and A23

	Dynamic Range (1)	psi	0.05 to 50	0.1 to 500	1 to 1000
	MODEL NUMBERS		137A23	137A22	137A21
AMPLITUDE	Sensitivity (5)	mV/psi	100	10	1
	Resolution	psi	0.005	0.01	0.1
	Range (for 5V output)	psi	50	500	1000 (1V)
	Range (for 10V output) (2)	psi	100	1000	5000 (5V)
	Maximum Pressure	psi	1000		5000
	Linearity (3)	%FS	≤ 1		
FREQ RESP	Resonant Frequency	kHz	≥ 500		
	Rise Time (incident)	µs	≤ 4		
	Discharge Time Constant (4)	sec	≥ 0.2		
ENV'L	Temperature Range	°F	-100 to +275		
	Temperature Coefficient	%/°F	≤ 0.03		
ELECTRICAL	Polarity (positive pressure)		positive		
	Output Impedance	ohm	≤ 100		
	Output Bias	+volts	8 to 18	8 to 14	
	Power Required: Voltage	+VDC	20 to 30		
	Constant Current	mA	2 to 20		
PHYSICAL	Sensing Element	material	quartz		
	Probe Case	material	aluminum alloy		
	Diaphragm (sensing element)	material	Invar		
	Connector	type	BNC jack		
	Sealing	type	epoxy		
OPT	Water-resistant Cable	prefix	W (specify length)		

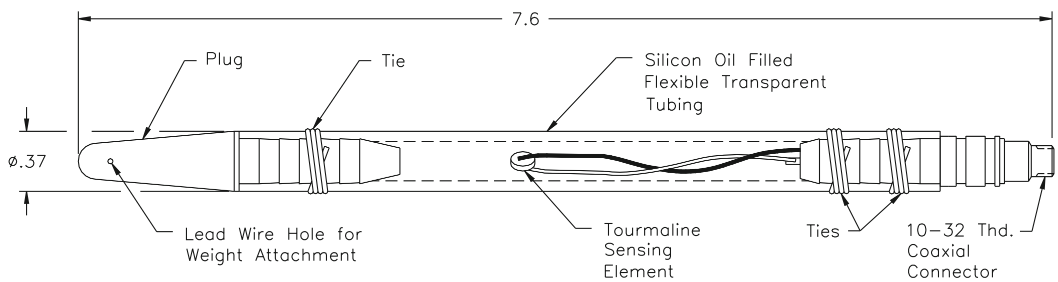
NOTES:

1. Measures dynamic pressures from full vacuum to rated maximum.
2. ≥+24 VDC supply required for 10V output. If optional calibration to 10V range is required, linearity spec may change.
3. % FS any calibrated range; zero-based best straight line.
4. Discharge Time Constant (DTC) relates low-frequency to signal lost during transient events at room temperature. See technical section on page 78.
5. Unless otherwise designated, sensitivities are ±15%.

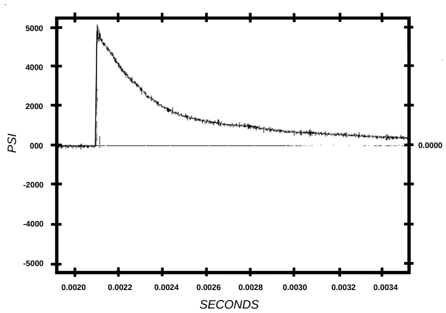
ICP® Tourmaline Underwater Blast Sensor

With integral electronics

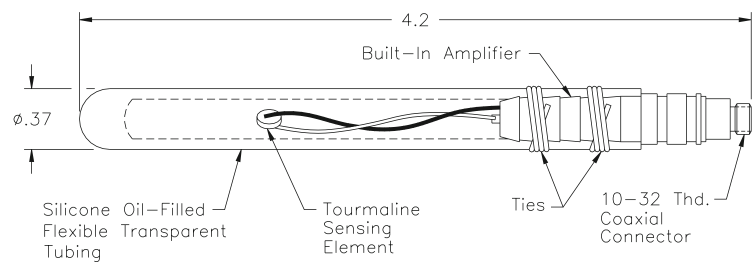
Dimensions shown in inches except where noted.



Models 138A01, A05, A10, A25, A50
Standard Length



Typical Underwater Blast Record from a 138 Type Sensor



Models 138A02, A06, A11, A26, A51
Short Length

	Dynamic Range (1)	**psi**	**1 000**	**5 000**	**10 000**	**25 000**	**50 000**
	MODEL NUMBERS	**long**	**138A01**	**138A05**	**138A10**	**138A25**	**138A50**
		short	**138A02**	**138A06**	**138A11**	**138A26**	**138A51**
AMPLITUDE	Sensitivity (5)	mV/psi	5	1	0.5	0.2	0.1
	Resolution	psi	0.02	0.1	0.2	0.5	1
	Range (for 5V output)	psi	1000	5000	10 000	25 000	50 000
	Range (for 10V output) (2)	psi	2000	10 000	20 000	50 000	n/a
	Maximum Pressure	psi	50 000				
	Linearity (3)	%FS	≤ 2				
FREQ RESP	Resonant Frequency	MHz	≥ 1				
	Rise Time (in water)	µs	≤ 1.5				
	Discharge Time Constant (4)	s	≥ 0.2				
	Low Frequency (-5%) (4)	Hz	2.5				
ENVIRONMENTAL	Shock (max)	g pk	20 000				
	Temperature Range	°F	0 to 100				
	Polarity (positive pressure)		positive				
	Output Impedance	ohm	≤ 100				
	Output Bias	+volts	8 to 14				
	Power Required: Voltage	+VDC	20 to 30				
	Constant Current	mA	2 to 4				
PHYSICAL	Sensing Element	material	tourmaline				
	Connector/Amplifier Housing	material	stainless steel				
	Body Housing	material	Tygon tube, nylon tie, Delrin® plug (where applicable)				
	Connector	type	10-32 coaxial				
	Sealing (connector/amplifier)	type	welded/hermetic				
OPT	Water-resistant Cable	prefix	W (specify length)				

NOTES:
1. Measures dynamic pressures from full vacuum to rated maximum.
2. ≥+24 VDC supply required for 10V output. If optional calibration to 10V range is reqiured, linearity spec may change.
3. % FS of any calibrated range; zero-based best straight line.
4. Discharge Time Constant (DTC) relates low-frequency to signal lost during transient events at room temperature. See technical section on page 78.
5. Unless otherwise designated, sensitivities are ±15%.

Ballistic Pressure Sensors

- Ammunition and gun testing
- Explosives testing
- Closed bombs
- Recoil mechanisms
- Ultra high-frequency detonation

Over 20 years ago, PCB worked with members of the Sporting Arms and Ammunition Manufacturers' Institute (SAAMI) to develop a durable ballistic pressure sensor suitable for implementation into a standardized test method for rapid-fire production testing of ammunition. Out of this cooperative effort, the highly successful PCB series patented 117B Conformal Ballistic Sensor was developed. In this tradition, PCB offers a complete line of sensors for conformal and case mouth measurements.

The 117 Series conformal sensor measures true gun chamber pressure directly through an unmodified shell case. Since the sensor diaphragm is machined to conform flush with the specific chamber diameter, the measurement process is not altered or changed in any way. There are no cartridges to be drilled or troublesome gas passages to be cleaned when using the conformal method. Conformal sensors have proven to be rugged, stable instruments, lasting hundreds of thousands of rounds. Since the same sensor may outlast the life of many barrels, it is possible to start and finish ammunition batch qualification testing without experiencing sensor failure during the test.

Our 118 Series with a ceramic coated integral diaphragm has been upgraded with an even more stable, linear sensing element. This series features a floating clamp nut that reduces strain sensitivity on the sensor body due to mounting torque. The 119 Series is an acceleration compensated version of the 118 Series. The 108 and 109 Series are upgraded ICP® versions of the 118 and 119's. The integral electronics in the 109 Series are shock protected, for use in high shock applications.

PCB introduces the new high performance 165 Series which features an improved design for more stable, reliable measurements. Our new 165 Series was designed to retrofit popular existing mounting port styles. The new series contains a variety of models for different pressure ranges, mounting and sealing requirements.

PCB also offers a high pressure static calibrator Model 905C and a high pressure dynamic calibrator Model 913A10. Side-by-side dynamic/static comparison calibration services are offered for PCB's and competitors' ballistic sensors.

PCB PIEZOTRONICS INC. PFS DIVISION

PRESSURE AND FORCE SENSORS DIVISION

PCB 716-684-0001 **PFS Toll Free** 888-684-0011 **Fax** 716-686-9129 **Email** pfssales@pcb.com **Web Site** www.pcb.com

Interchangeable Quartz Ballistic Sensors

Charge mode

NEW! Interchangeable NATO M10 x 1.0 Mount Series 165

Retrofits common mounting ports for drilled cartridge and case mouth installations in small and large-caliber weapons. The improved design incorporates a more stable structure with diaphragm end seal for better accuracy, reliability, and lower thermal response. The captivated floating clamp nut reduces strain sensitivity and simplifies sensor installation. Detailed installation drawings are available for all of these models. See specifications on page 30.

Model M165A01

The M165A01 Ballistic Sensor has been extensively tested and evaluated by both static and dynamic methods. M10 mounting thread and end seal design retrofits common ports. It has been test-fired for hundreds of rounds to 60 000 and 90 000 psi in a .308 caliber proof barrel. Before shipment, each sensor goes through a factory stabilization process involving static and dynamic cycling to 100K psi and is fired 20 rounds (minimum) in our .308 caliber test barrel.

Model 165A02

Model 165A02 Ballistic Pressure Sensor is designed for case mouth shot shell applications to 20 000 psi. It supersedes the earlier PCB Model 167A. This model has an improved structure for better stability and dynamic-to-static response correlation. Sensitivity is stabilized by pressure cycling to 70 000 psi.

Model M165A03

Model M165A03 Ballistic Pressure Sensor has a shoulder or end-seal mount and is designed for ballistic pressures of up to 80 000 psi. It features a thermal shield for extremely low thermal shock sensitivity. Two mounting methods are available: shoulder seal for flush mount, or end sealing, using the thermal shield. Both seals are supplied with each sensor.

Model 165A05

The 165A05 Ballistic Sensor is manufactured to retrofit weapons which have the conical end seal mounting port. The 165A05 incorporates a specially designed integral diaphragm that reduces thermal output due to transient temperature effects. Because mounting forces are concentrated near the diaphragm, conical end seal sensors require closely controlled mounting torque.

CHARGE MODE QUARTZ BALLISTIC SENSORS
Series 118/119

Charge Mode Pressure Sensors are well suited for high-pressure ballistics, detonation, and explosive research and test applications.

These sensors incorporate stable quartz-sensing elements, a durable-machined ceramic-coated integral diaphragm and floating clamp nut. They retrofit previous Model 118A (3/8-24 and M10) shoulder-seal designs for drilled cartridge and case mouth installations in small and large-caliber weapons. The new design incorporates a more stable structure for improved accuracy, reliability, and lower thermal transient response. See specifications on page 31.

Add prefix "M" to the sensor model number to specify M10 x 1.0 metric mounting (e.g., M109B11).

Models 118B11 and 118B13 sensors have been redesigned for improved stability, accuracy, reliability, and lower thermal transient response. Each sensor is factory stabilized by static and dynamic high-pressure cycling and actual test firing in a .223 caliber test barrel. They are available in ranges of 80 000 and 125 000 psi, respectively.

Models 119A11 and 119A12 are unique, acceleration-compensated, high resolution ballistic sensors designed for high-pressure, high-energy ballistics, detonation, and explosive applications under high-shock conditions, such as those that might be encountered in howitzer and liquid-propellant weapons. Two dynamic ranges of 80 000 and 125 000 psi are available.

Improved!
Models 118B11, B13 and 119A11, A12

New!
Models 108B11 and 108B13

ICP® BALLISTIC SENSORS
Series 108/109

PCB offers a complete line of high pressure ballistic sensors with integral electronics. They operate from a PCB constant-current signal conditioner and provide a high-voltage, low-impedance output. ICP sensors are well suited for applications involving long cables and operation in dirty factory or field environments.

These new sensors incorporate a captivated floating clamp nut and a more stable structure for improved accuracy, reliability, and lower thermal transient sensitivity. They are structured with quartz sensing elements, built-in microelectronics, and an integral machined ceramic-coated diaphragm for greater durability, overrange capability, higher-frequency response, and improved linearity. See specifications on page 32.

Add prefix "M" to the sensor model number to specify M10 x 1.0 metric mounting (e.g., M109B11).

Models 108B11 and 108B13 are ICP integral electronic versions of the charge Models 118B11 and 118B13. They are suitable for routine ammunition, explosive, and reactive measurements.

Models 109B11 and 109B12 are acceleration-compensated ICP sensors for high-energy, high-frequency applications, such as detonation, closed bomb combustion, and explosive blast measurements under extreme shock conditions.

New!
Models 109B11 and 109B12

U.S. and Foreign Patents

CONFORMAL BALLISTIC SENSORS

Series 117B

Conformal ballistic sensors measure true gun chamber pressure directly through the cartridge case. The diaphragm of the conformal sensor is contoured to match a specific chamber diameter. An alignment guide and spacers help the user to install the sensor flush with the gun chamber walls.

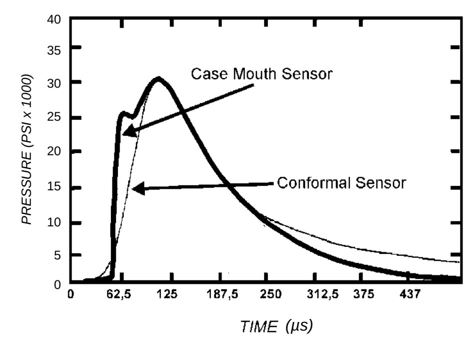
The conformal ballistic sensor, when correctly installed, has a proven life expectancy of hundreds of thousands of rounds, outlasting many test barrels. Rapid-fire testing is possible since there are no cartridges to drill and align, no diaphragm ablatives to apply, and no gas passages to clean. The conformal sensor does not affect operation of the test barrel, nor change the measurement process.

Developed in cooperation with members of SAAMI to provide an accurate rapid-fire electronic production test method to replace the mechanical "copper crusher," the conformal sensor has experienced 20 years of proven performance.

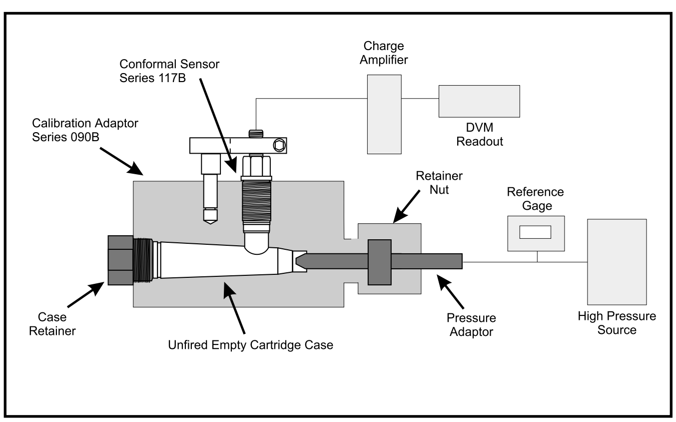
Conformal calibration through an unfired, unmodified empty cartridge shell case with PCB Series 090B Calibration Adaptor accounts for the effects of the cartridge case. Output from the conformal sensor is compatible with any charge amplifier. The PCB Model 400A20 Digital Peak Holding System with simplified single-range charge amplifier and auto-reset peak meter facilitates rapid-fire testing of production ammunition. See page 72 for more information on PCB Model 400A20 Digital Peak Holding System.

The two machined flats near the connector end, an alignment guide, and a captive retaining nut facilitate installation. The nut automatically extracts the sensor when it is unscrewed. Series 090B Calibration Adaptor permits static calibration of the Model 117B Sensor, with pressures to be applied to the empty cartridge case. Spacer set is supplied to facilitate flush installation of the sensor. See specifications on page 29.

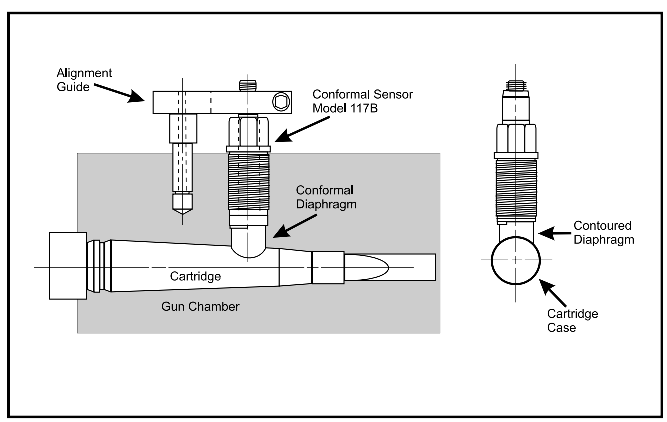
- Proven long life
- Outlasts life of many barrels
- SAAMI-approved test method
- Allows rapid-fire testing
- No drilled cases or recessed passages
- Cost effective



Conformal vs. Standard Case Mouth Installation



Typical Conformal Calibration Adaptor System



Typical Conformal Sensor Installation

SHOTSHELL PRESSURE SENSOR

Model 167A11

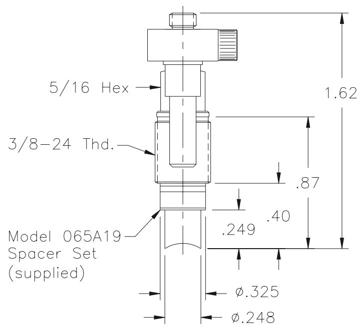
For production testing of shotshell ammunition per SAAMI recommendations, this upgraded sensor measures chamber pressure through the case wall of an unmodified cartridge. The floating clamp nut design reduces torque sensitivity. The thermal sensitivity is minimized due to welded diaphragm design.
See specifications on page 29.

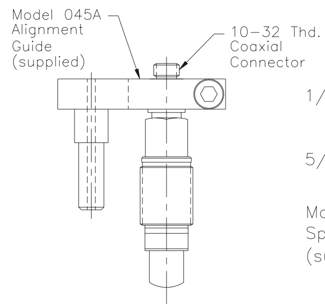
167A11 Shotshell Sensor

Conformal Ballistics

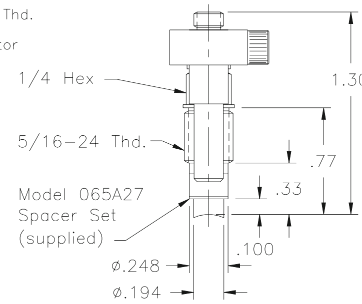
Charge mode

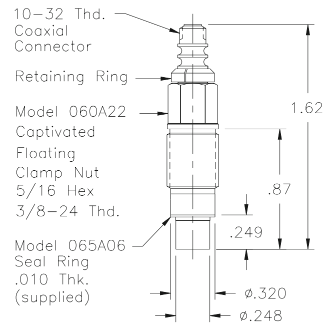
Dimensions shown in inches except where noted.





Side View for 117's





Drawing A:
Models 117B01 to B65 and 117B101 and up (>.350 dia. diaphragm curvature)

Drawing B:
Models 117B66 to 117B100 (<.350 dia. diaphragm curvature)

Drawing C:
Model 167A11 Shot Shell Sensor

Notes:
Series 117 Conformal Sensor diaphragms are machine-contoured to match specific gun chamber calibers. Each caliber has its own specific model number. ***Contact PCB.***
DO NOT machine mounting ports without a detailed Installation Drawing for the specific caliber location.

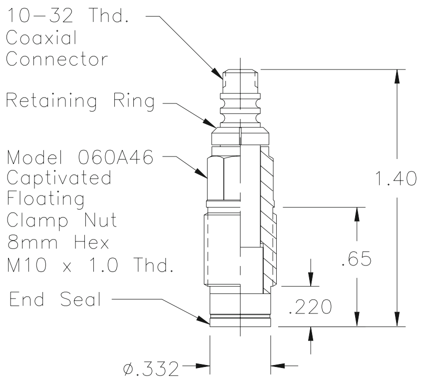
	Dynamic Range	psi	60 000 (3)	35 000 (3)	15 000
	MODEL NUMBERS		Model 117B (4)		Model 167A11
			Riffle and Handgun Calibers		Shotshell
			Drawing A [.248 dia]	Drawing B [.194 dia]	Drawing C
AMPLITUDE	Sensitivity (2)	- pC/psi	0.1		0.2
	Resolution	psi	0.04		0.02
	Maximum Pressure	psi	80 000	40 000	70 000
	Linearity (1)	%FS	≤ 2		≤ 1
FREQ RESP	Resonant Frequency	kHz	≥ 300		≥ 250
	Rise Time	µs	≤ 2		
ELEC	Capacitance	pF	5		
	Insulation Resistance at 70°F	ohm	≥ 10^{12}		
ENVIRONMENTAL	Shock (max)	g pk	20 000	5000	20 000
	Acceleration Sensitivity	psi/g	≤ 0.02		≤ 0.01
	Temperature Range	°F	-100 to +400		-50 to +325
	Temperature Coefficient	%/°F	≤ 0.03		
	Flash Temperature	°F	3000		
PHYSICAL	Sensing Element	material	quartz		
	Case/Diaphragm (integral)	material	17-4		C-300/17-7
	Connector	type	10-32 coaxial		
	Sealing (connector insulators)	type	epoxy		
	Mounting Thread	inch	3/8-24	5/16-24	3/8-24
	Diaphragm Diameter	inch	0.248	0.194	0.248

NOTES:
1. % FS of any calibration range; zero-based best straight line.
2. Unless otherwise designated, sensitivities are ±15%.
3. Calibration data supplied starting at 10 000 psi.
4. Contact PCB for model number to match specific caliber.

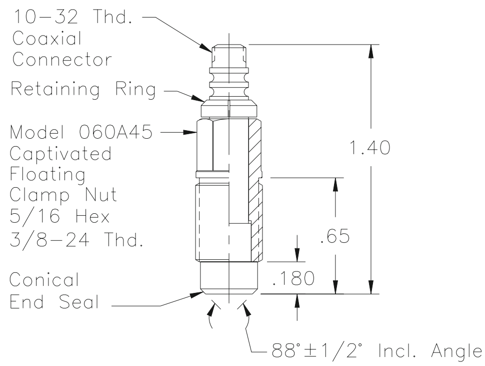
Interchangeable Ballistic Quartz Sensors

Charge mode

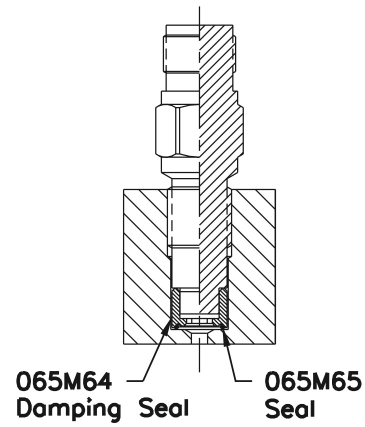
Dimensions shown in inches except where noted.



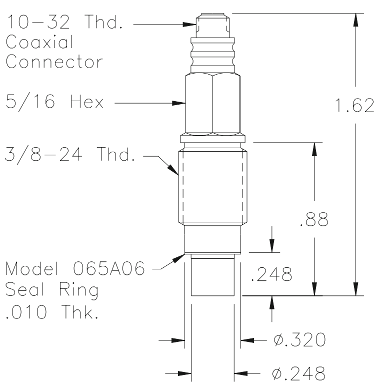
Model M165A01



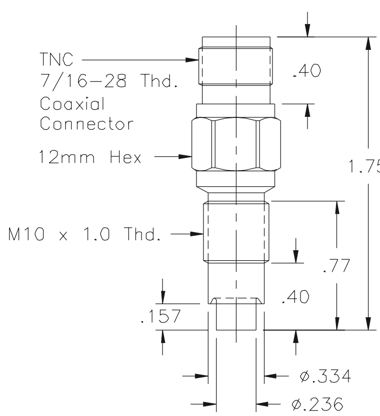
Model 165A05



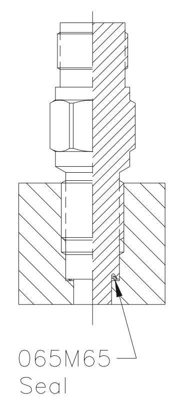
M165A03 End Seal Mount



Model 165A02



Model M165A03



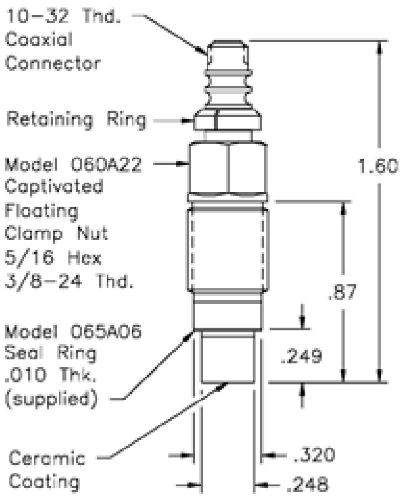
M165A03 Flush Mount

	Dynamic Range (1)	psi (MPa)	70 000 (483)		15 000 (103)	70 000 (483)
	MODEL NUMBERS		M165A01	165A05	165A02	M165A03
AMPLITUDE	Sensitivity (3) (4)	-pC/psi (-pC/MPa)	0.135 (19.6)		0.2 (29)	
AMPLITUDE	Resolution	psi	0.01		0.02	
AMPLITUDE	Maximum Pressure	psi (MPa)	80 000 (552)		70 000 (483)	80 000 (552)
AMPLITUDE	Linearity (2)	% FS	≤ 2.0		≤ 1.0	≤ 2.0
FREQ RESP	Resonant Frequency	kHz	≥ 250			
FREQ RESP	Rise Time	µs	≤ 2.0			
ELEC	Capacitance	pF	5			
ELEC	Insulation Resistance at 70°F	ohm	≥ 10^{12}			
ENVIRONMENTAL	Acceleration Sensitivity	psi/g	≤ 0.02		≤ 0.01	
ENVIRONMENTAL	Operating Temperature Range	°F (°C)	-100 to +400 (-73 to +204)		-50 to +325 (-46 to +163)	
ENVIRONMENTAL	Temp Coefficient of Sensitivity	%/°F (%/°C)	≤ 0.03 (0.054)			
ENVIRONMENTAL	Maximum Shock	g pk (m/s² pk)	20 000 (196 200)			
PHYSICAL	Weight	oz (grams)	0.4 (11)		0.52 (15)	0.7 (19)
PHYSICAL	Mounting Thread	size	M10 x 1.0	3/8 - 24		M10 x 1.0
PHYSICAL	Connector	type	10-32 Coaxial			TNC
OPT	Metric Mounting	prefix	n/a	M		n/a
OPT	English Mounting	model	165A01	n/a		

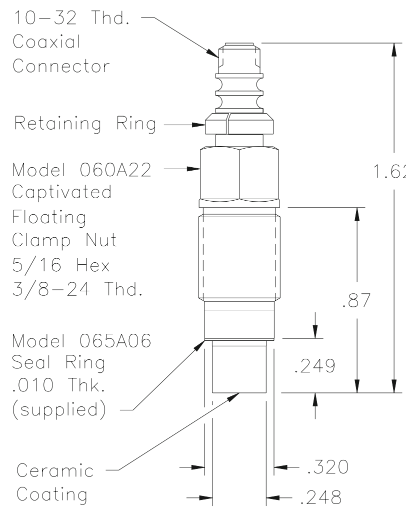
NOTES

1. Measures dynamic pressures from full vacuum to rated maximum.
2. % FS of any calibration range; zero-based best straight line.
3. Charge amplifier inverts the signal.
4. Unless otherwise designated, sensitivities are ±15%.

Dimensions shown in inches except where noted.



Models 118B11 and 118B13
General Purpose Ballistics

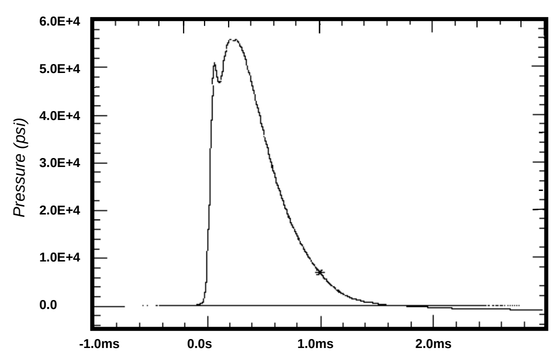


Models 119A11 and 119A12
Acceleration-Compensated

	Dynamic Range	psi	20 to 80 000	20 to 120 000	20 to 80 000	20 to 120 000
	MODEL NUMBERS		**118B11**	**118B13**	**119A11**	**119A12**
AMPLITUDE	Sensitivy	-pC/psi	0.1 (4)		0.25 (3)	
	Resolution	psi	0.02		1	2
	Maximum Pressure	psi	100 000	125 000	100 000	125 000
	Linearity (2)	%FS	≤ 2			
FREQ RESP	Resonant Frequency	kHz	≥ 250		≥ 400 (1)	
	Rise Time	µs	≤ 2		≤ 1	
ELEC	Capacitance	pF	5		20	
	Insulation Resistance at 70°F	ohm	≥ 10^{12}			
ENVIRONMENTAL	Shock (max)	g pk	20 000		80 000	
	Acceleration Sensitivity	psi/g	0.01		0.004	
	Temperature Range	°F	-400 to +400			
	Temperature Coefficient	%/°F	≤ 0.03			
	Flash Temperature	°F	4000			
PHYSICAL	Sensing Element	material	quartz			
	Case/Diaphragm (integral)	material	C-300			
	Connector	type	10-32 coaxial			
	Sealing (connector insulators)	type	epoxy			

Notes:
1. Suppressed resonance.
2.% FS of any calibration range; zero-based straight line.
3. Unless otherwise designated, sensitivities are ±15%.
4. Sensitivity is +25% / -15%

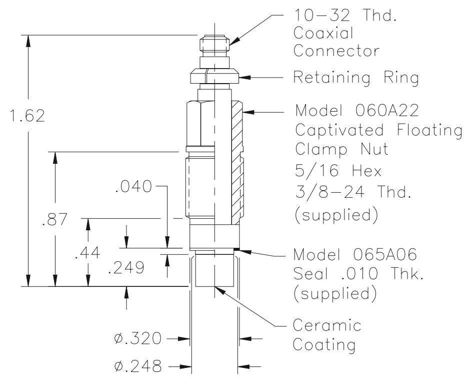
Case Mouth Location
Test Results
.308 Caliber



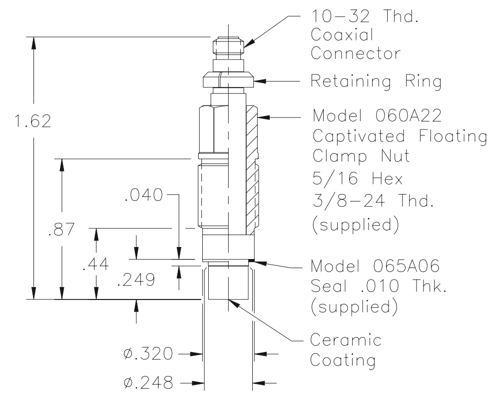
ICP® Ballistics

With integral electronics

Dimensions shown in inches except where noted.



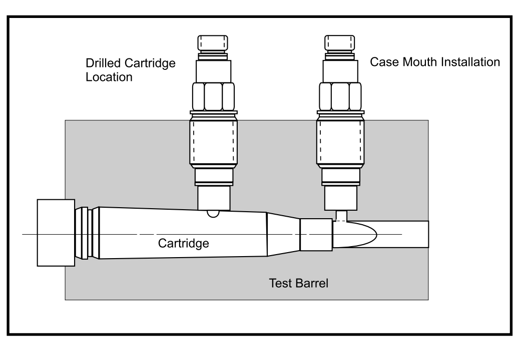
Models 108B11 and 108B13
General Purpose Ballistics



Models 109B11 and 109B12
High Shock Acceleration-Compensated

	Dynamic Range	psi	20 to 80 000	20 to 100 000	20 to 80 000	20 to 100 000
	MODEL NUMBERS		**108B11**	**108B13**	**109B11**	**109B12**
AMPLITUDE	Sensitivity (4)	mV/psi	0.07			
	Resolution	psi	2			
	Maximum Pressure	psi	125 000			
	Linearity (3)	%FS	≤ 2			
FREQ RESP	Resonant Frequency	kHz	≥ 250		≥ 400 (1)	
	Rise Time	µs	≤ 2		≤ 1	
	Discharge Time Constant (2)	sec	≥ 2000			
	Low Frequency (-5%) (2)	Hz	0.0003			
ENVIRONMENTAL	Shock (max)	g pk	20 000		80 000	
	Acceleration Sensitivity	psi/g	≤ 0.01		≤ 0.004	
	Temperature Range	°F	-100 to +275			
	Temperature Coefficient	%/°F	≤ 0.03			
	Flash Temperature	°F	3000			
ELECTRICAL	Output Impedance	ohm	≤ 100			
	Output Bias	+volts	8 to 14			
	Power Required: Voltage	+VDC	20 to 30			
	Constant Current	mA	2 to 20			
PHYSICAL	Sensing Element	material	quartz			
	Case/Diaphragm (integral)	material	stainless steel			
	Connector	type	10-32 type			
	Sealing (connector insulators)	type	epoxy			

Notes:
1. Suppressed resonance.
2. Discharge Time Constant (DTC) relates low-frequency to signal lost during transient events at room temperature. See technical section on page 78.
3. % FS of ant calibration range; zero-based best straight line.
4. Unless otherwise designated, sensitivities are ±15%.



Typical Case Mouth and Drilled Cartridge Locations

Engine Combustion Pressure Sensors

- Combustion
- Compression
- Knock
- Thermodynamic analysis
- Peak pressures

PCB manufactures a wide variety of engine combustion sensors for research applications requiring high precision and accuracy to general purpose peak pressure and spark plug measurements.

The new 145 Series engine combustion sensors have a specially designed quartz sensing element to provide high sensitivity and low measurement error due to temperature transients. They are rugged, accurate and designed to fit into previously machined popular mounting ports.

The 112 Series of engine combustion sensors are designed for routine combustion measurements at an economical price. Many models are offered, to provide a variety of measurement and installation options. PCB can modify standard spark plugs to accommodate 112 type sensors for routine combustion measurements, which eliminates the need to machine the cylinder head. Other models are available for "In-head" installations including 5/16-24 and 3/8-24 mounting threads.

All models in this section feature an uncooled operating range of 600°F or higher.

PCB PIEZOTRONICS INC. PFS DIVISION

PCB 716-684-0001 **PFS Toll Free** 888-684-0011 **Fax** 716-686-9129 **Email** pfssales@pcb.com **Web Site** www.pcb.com

QUARTZ ENGINE COMBUSTION SENSORS
Series 145 and 112B10

Used for engine testing under laboratory and test-track conditions, these sensors feature an acceleration-compensated quartz element that provides clean, noise-free measurement data. Special crystals are used to accommodate operation up to 660°F. The 1 pC/psi output is compatible with standard commercial charge amplifiers.

Model 145A01

Try our new **Model 145A01** for engine research applications where precision measurements are required. This sensor is designed specifically to provide stability under the extreme thermodynamic conditions encountered during the combustion process. This high performance precision-engineered sensor utilizes an advanced design quartz sensing element for thermal stability and operation to 660°F. It fits conveniently into existing popular mounting port styles. Ground isolation is standard.

Model 145A05

Model 145A05 is a high performance sensor for applications where high knock and harsher environments are present. Designed without the groove between the heat shield and quartz element to prevent clogging in applications where richer fuels produce carbon build-up between the heat shield and element. This version of the Series 145 also fits interchangeably with the Model 112B13 and other popular mounting port styles.

Models 112B10 and 112B11

Model 112B10 is designed to be used in conjunction with the Series 65A Spark Plug Adaptor to monitor cylinder pressure in spark ignition engines, without engine modifications (see page 36). These sensors incorporate a special flame-resistant baffle for low-thermal transient sensitivity and minimum base-line distortion. They offer small size, low vibration noise pickup, high sensitivity and resonant frequency, all at an economical price.

Model 112B11 measures pressure in both gasoline and diesel engines. It has all the features of the 112B10 above, but can be mounted in the base of the head, which is especially useful for multivalve engines. A variety of spacer sleeves are supplied with this sensor allowing for installation at varying depths.

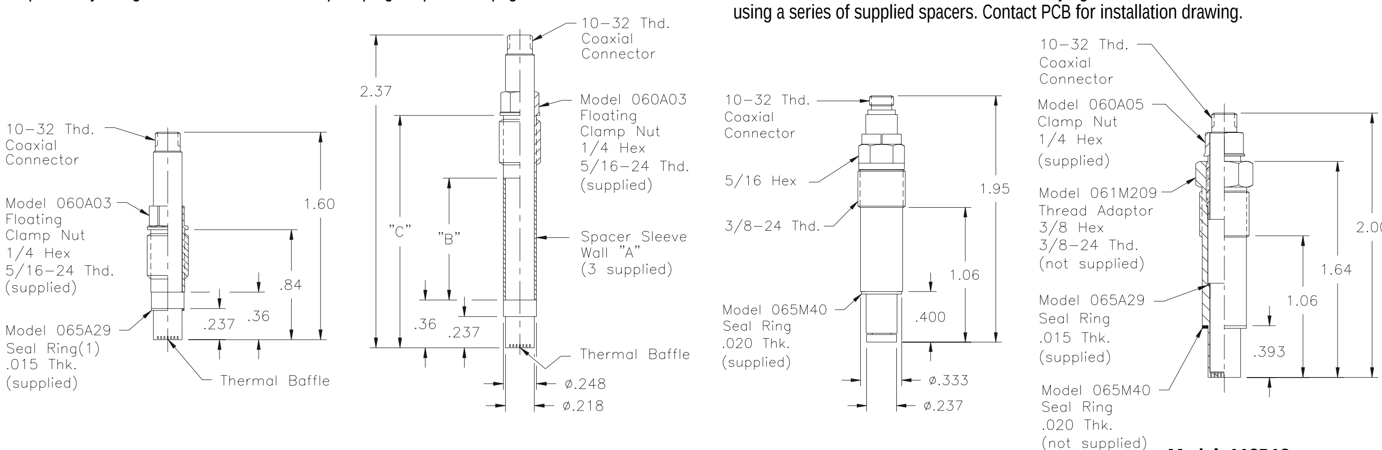
Model 112B13

Model 112B13 retrofits existing ports with a more economical, general purpose combustion sensor. This model offers the performance, durability, and economy of the Model112B11, conveniently packaged in a 3/8-24 (145 series type) threaded housing.

Dimensions shown in inches except where noted.

*Specifically designed for use with the 65A spark plug adaptor. See page 36.

** Model 112B11 can be mounted in walls of varying thickness from .620 to 1.700 using a series of supplied spacers. Contact PCB for installation drawing.



Model 112B10* **Model 112B11**** **Model 145A01 and145A05(6)** **Model 112B13**

	Dynamic Range (1)	**psi**	**3000**			**4000**	
	MODEL NUMBERS		**112B10**	**112B11**	**112B13**	**145A01**	**145A05**
						For Reaseach Applications	
AMPLITUDE	Sensitivity (5)	-pC/psi	1			0.9	
	Resolution (2)	psi	0.01				
	Maximum Pressure	psi	5000		10 000	5000	
	Linearity (3)	%FS	≤ 2			≤ 1	
FREQ RESP	Resonant Frequency	kHz	≥ 200			≥ 60	≥ 90
	Rise Time	µs	≤ 3			≤ 8	≤ 6
ENVIRONMENTAL	Shock (max)	g pk	10 000			5000	
	Acceleration Sensitivity	psi/g	0.002			0.05	
	Temperature Range	°F	-100 to +600			-65 to +660	
	Temperature Coefficient	%/°F	≤ 0.03				
	Flash Temperature	°F	4500			3000	
ELECTRICAL	Polarity (positive pressure)		negative				
	Capacitance	pF	20			8	
	Insulation Resistance at 70°F	ohms	≥ 10^{12}				
PHYSICAL	Sensing Element	material	quartz				
	Case	material	Invar (4)			17-4	
	Diaphragm	material	Invar (with flame baffle) (4)			17-4	
	Connector	type	10-32 coaxial				
	Sealing	type	welded/hermetic				
OPTIONS	Ground Isolation	prefix	n/a			standard	
	Positive Polarity	prefix	P				
	Removal Tool	model	n/a			039A05	

NOTES:
1. For recess mount, Model 065A05 seal sleeve is available.
2. Measures dynamic pressures from full vacuum to rated maximum.
3. % FS of any calibration range; zero-based best straight line.
4. Invar minimizes thermal shock error for general purpose use.
5. Unless otherwise designated, sensitivities are ±15%.
6. The external configuration of the 145A05 is the same as the 145A01 (shown) except it does not have a groove between the heat shield and the quartz element.

140 KNOCK SENSOR-CHARGE MODE

Series 140 Knock Detection Sensors offer a unique approach to analyzing engine combustion severity of knock. The sensor is designed to fit securely in place of a spark plug washer or engine headbolt washer. In this position, it yields an output voltage that corresponds to cylinder combustion pressure.

The stable quartz piezoelectric element, packaged in a welded, stainless steel housing, is mounted in a pre-loaded condition. In applications where the sensor is mounted in place of a spark plug washer, the pre-load on the quartz element is released, in proportion to the combustion pressure, as cylinder combustion occurs. The charge generated by releasing the pre-load can be converted to a voltage through the use of an in-line or lab style charge amplifier. The Knock detection sensors are available for 14mm and 18mm spark plug mount.

Models 140A14 and 140A18 Knock Sensor

ICP® HEADBOLT SENSOR

PCB's low impedance headbolt sensors are designed to mount in place of the large headbolt washer without any rework to the engine head. These thin load washers are an economical way to help measure compression and peak pressure as well as pressure rise.

The integration of a quartz piezoelectric sensing element and a customized housing to replace specific washer sizes, provides a rugged, reliable tool for engine diagnostic and control applications.

Headbolt Sensor (Photo is 2/3 actual size)

SPARK PLUG ADAPTOR Series 65A

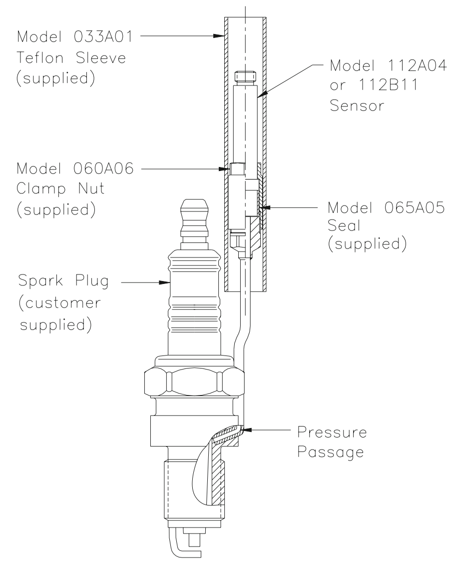
A convenient and low-cost method of monitoring or measuring normal and abnormal combustion and compression pressures in an unmodified internal combustion engine. The spark plug adaptor features:

- external hollow retaining nut
- accessible passage and port for cleaning ease
- easy installation and removal of sensor
- most standard spark plugs can be modified to accept a 112 style sensor
- acceleration-compensated sensor that reduces vibration sensitivity
- compressed air directed to sensor housing via the supplied Teflon® sleeve to keep sensor within the specified operating range

The spark plug adaptor coupled with a 112 type sensor is sensitive to pressure but insensitive to vibratory motion and strain. The results are exceptionally sharp, clean and free of spurious signals which often times mask or obscure the actual pressure signal. The passage diameter and diaphragm clearance are proportioned to impart near critical damping, which means nearly nonresonant acoustic behavior in the tube or probe.

Almost any standard commercial or experimental spark plug can be modified to accommodate most standard quartz mini-probe style sensor.

Series 65A Spark Plug Adaptor



High Temperature and Cryogenic Pressure Sensor

High Temperature

- Gas turbines
- Exhaust manifolds
- Combustion
- Reactor heat exchangers

Cryogenic

- Gas or fluid dynamics
- Flow instabilities
- Pulsations
- Fluid-borne noise

PCB high-temperature quartz sensors measure dynamic pressures in reactors, compressors, engines, turbines, heat exchangers, steam pipes, and combustion chambers. They excel in measuring low-pressure acoustic fluctuations at high static pressure levels.

Series 112 and 116 type sensors are specifically designed for operation at the highest temperature which quartz elements will functionally tolerate. They provide a high impedance charge output and connect to charge or voltage signal amplifiers through low noise cables. When driving long cables, use a short distance of low noise cable between the in-line charge or voltage converters for optimum performance.

Although high-temperature sensors can be installed with the floating clamp nut and seals supplied, PCB can supply the sensors in threaded adaptors custom-made to fit your specific mounting ports.

Series 102A10 Cryogenic Sensors incorporate acceleration-compensated quartz elements and special low-temperature microelectronics to measure dynamic pressures in cryogenic environments. They feature solid-state construction, have flush-welded diaphragms, and withstand high shock and overload pressure.

ICP® cryogenic sensors use an internal high-pass filter to eliminate the static component of the signal, allowing measurement of low-pressure fluid-borne noise, oscillations, and surges under high static load conditions. These sensors were the first to successfully detect and measure uneven fuel flow in rocket engines that caused a “pogo” effect, a vibratory motion in multistage rockets caused by uneven fuel burning.

PCB PIEZOTRONICS INC. PFS DIVISION

PCB 716-684-0001 **PFS Toll Free** 888-684-0011 **Fax** 716-686-9129 **Email** pfssales@pcb.com **Web Site** www.pcb.com

High Temperature - Cryogenic

ICP® and charge mode

HIGH TEMPERATURE PRESSURE SENSORS

Designed for operation at the highest temperatures, these laser welded, hermetically sealed sensors are constructed with quartz sensing elements and fused ceramic insulation connectors. They contain an integral accelerometer to reduce vibration sensitivity. These features insure reliable operation in high temperature environments. The temperature coefficient is supplied with each sensor.

Models 112A04 and 112A05

Hard-line cables (PCB model numbers 008 and 028) are recommended for operating temperatures above 500°F. The cable can be welded to the sensor for operation in pressurized environments.

Models 112A04 and 112A05 high temperature sensors are suited for applications where small size and high frequency are important. They operate to 600°F, have a 1 pC/psi sensitivity and dynamic ranges of 100 and 5000 psi, respectively. The floating clamp nut design isolates against strain and facilitates installation and removal of the sensor. These sensors install either flush of slightly recessed directly in the test object or in a variety of threaded or cooled mounting adaptors. Typical applications include dynamic pressures in gas and steam turbines, heat exchangers and high-intensity acoustics from exhausts. See specifications on page 39.

Models 116B and 116B02

Models 116B and 116B02 are structured with delta compression quartz crystals and operate without cooling to 600°F on engines, compressors, pumps, manifolds, pipes and steam or gas turbines. For use with charge or in-line amplifiers, these high sensitivity, hermetically-sealed sensors have welded joints and a fused ceramic insulated connector. Options include integral hard-line cables to 40 ft for demanding applications such as in nuclear power plants. Special mounting adaptors can be supplied to fit existing mounting holes.

Calibration supplied is at room temperature with coefficients given at 600°F. Optional linear calibration can be furnished at any pressure level to 3000 psi, e. g. 6 pts to 3000 psi or ±50 psi at 1200 psi static. See specifications on page 39.

CRYOGENIC ICP® SENSORS
Series 102A10

These sensors are a special version of PCB's high-resolution, low-impedance, quartz sensors designed for cryogenic environments. Model 102A10 measures dynamic pressures from 0.01 to 100 psi at any static level from full vacuum to 2000 psi. They consistently follow transient events lasting a few percent of the discharge time constant. Since the special cryogenic microelectronics used in the Series 102A10 sensor are current-sensitive (sensitivity changes about 1% per mA), they should be used and calibrated w/4mA constant current. The four models in the series (102A10, 102A11, 102A13 and 102A14) offer a variety of ranges and sensitivities.

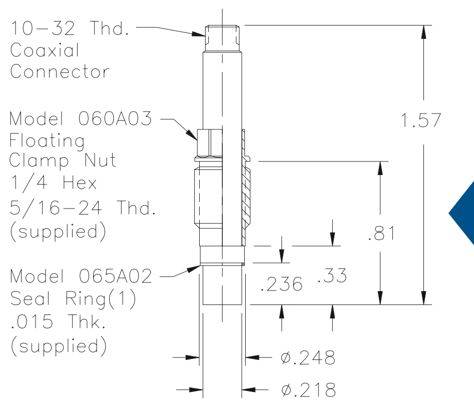
Series 102A10

A **Series 102A10** Sensor operates best in a thermally stabilized environment. If measurements are to be made under thermal shock (ambient or cryogenic) conditions, some type of ablative coating must be used on the sensor diaphragm to prevent or delay the thermal shock. See specifications on page 40.

High Temperature

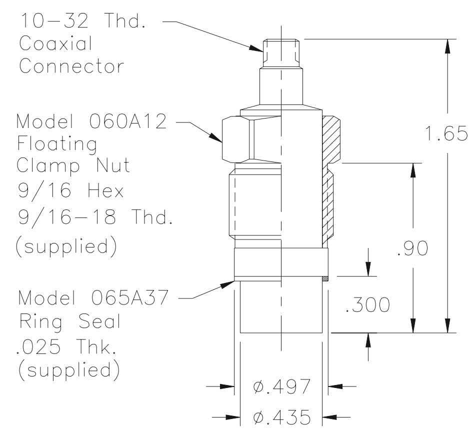
Charge mode

Dimensions shown in inches except where noted.



Models 112A04 and 112A05(1)

Mounting Adaptors on Page 58



Models 116B and 116B02

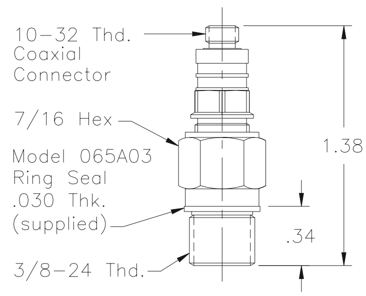
	Dynamic Range (2)	psi	100		5000
	MODEL NUMBERS		**116B02 (5)**	**112A04**	**112A05**
AMPLITUDE	Sensitivity (6)	-pC/psi	7	1	
	Resolution (3)	psi	0.0003	0.004	
	Range	psi	100		5000
	Maximum Pressure	psi	3000	5000	10 000
	Linearity (4)	%FS	≤ 1		
FREQ RESP	Resonant Frequency	kHz	≥ 60	≥ 250	
	Rise Time	µs	≤ 5	≤ 2	
ENVIRONMENTAL	Shock (max)	g pk	2000	10 000	
	Acceleration Sensitivity	psi/g	0.002		
	Temperature Range	°F	-400 to +600		
	Temperature Coefficient	%/°F	≤ 0.04	≤ 0.03	
	Flash Temperature	°F	3000		
ELECTRICAL	Polarity (positive pressure)		negative		
	Capacitance	pF	30	18	
	Insulation Resistance at 70°F	ohm	$\geq 10^{11}$		
	Insulation Resistance at 600°F	ohm	$\geq 10^{9}$		
PHYSICAL	Sensing Element	material	quartz		
	Case	material	316L	17-4 PH	
	Diaphragm	material	stainless steel		
	Connector	type	10-32 coaxial		
	Sealing	type	laser welded hermetic		
	Optional Model	model	116B (5)	n/a	

NOTES:
1. Installs interchangeably with 0.218 diameter quartz mini gages. A 5/16-24 clamp nut is standard; M7 x .75 installation is available.
2. Measures dynamic pressures from full vacuum to rated maximum.
3. Resolution determined by system noise and cable length.
4. % FS of any calibration range; zero-based best straight line.
5. Model 116B has an extended temperature range to 650°F.
6. Unless otherwise designated, sensitivities are ±15%.

ICP® Cryogenic

With integral electronics

Dimensions shown in inches except where noted.



Models 102A10, A11, A13, A14

	Dynamic Range (1)	**psi**	**0.02 to 100**	**0.2 to 1000**	**1 to 5000**	**2 to 10 000**
	MODEL NUMBERS		**102A10**	**102A11**	**102A14**	**102A13**
AMPLITUDE	Sensitivity (5) (6)	mV/psi	50	5	1	0.5
	Resolution	psi	0.002	0.02	0.1	0.2
	Range (for 5V output) (2)	psi	100	1000	5000	10 000
	Range (for 10V output) (2)	psi	200	2000	10 000	15 000 (7.5V)
	Maximum Pressure	psi	2000	15 000		
	Linearity (3)	%FS	≤ 1			≤ 2
FREQ RESP	Resonant Frequency	kHz	≥ 250			
	Rise Time	µs	≤ 2			
	Discharge Time Constant (4)	s	≥ 1	≥ 2		≥ 5
	Low Frequency (-5%) (4)	Hz	0.5	0.25		0.1
ENVIRONMENTAL	Shock (max)	g pk	20 000			
	Acceleration Sensitivity	psi/g	0.002			
	Temperature Range	°F	-423 to +212			
	Temperature Coefficient	%/°F	≤ 0.06			
	Flash Temperature	°F	3000			
ELECTRICAL	Polarity (positive pressure)		positive			
	Output Impedance	ohm	≤ 500			
	Power Required: Voltage	+VDC	11 to 30			
	Constant Current	mA	2 to 20			
	Output Bias (2)	+VDC	3 to 8			
PHYSICAL	Sensing Element	material	quartz			
	Case	material	stainless steel			
	Diaphragm	material	stainless steel			
	Connector	type	10-32 coaxial			
	Sealing	type	welded hermetic			

NOTES:
1. Measures dynamic pressures from full vacuum to rated maximum.
2. Negative dynamic output limited to -2.5 volts.
3. % FS of any calibration range; zero-based best straight line.
4. Discharge Time Constant (DTC) relates low-frequency to signal lost during transient events at room temperature. See technical section on page 78.
5. Calibrated using 4 mA constant current.
6. Unless otherwise designated, sensitivities are ±15%.

Miniature Pressure Sensors

- Space-constrained locations
- Gas or fluid dynamics
- Flow instabilities
- Pulsations, spikes

This sub-miniature sensor series is recommended in applications with very restricted mounting space or where diaphragm diameter is critical. The sensor is designed for compression, actuation, pulsation, cavitation, ultrasonic, hydraulic, fluidic, turbulence and other such *thermally stable* pressure measurements. High-frequency response and low-impedance output, similar to standard-size sensors, is typical.

These quartz ICP® pressure sensors are available in three mounting styles and various dynamic ranges from 100 psi to 30 000 psi. Care must be taken to follow the user manual mounting instructions closely.

Series 105 sensors operate using the same signal-conditioning requirements standard for ICP sensors. Signal conditioners are available from PCB in single- and multiple-channel versions with various options.

PCB PIEZOTRONICS INC. PFS DIVISION

ICP® Miniature

With integral electronics

ICP® MINIATURE PRESSURE SENSORS
Series 105

The Series 105 Quartz Sensors measure slow and fast dynamic pressure from full vacuum to 30 000 psi (relative to the initial or average pressure level). The structure of this tiny instrument contains two quartz disks operating in a thickness-compression mode. An internal, microelectronic, unity-gain amplifier generates a high-level, low-impedance analog output signal. This signal is proportional to the pressure change when the sensor is connected, using a coaxial or two-wire cable, to a PCB signal conditioner. Three external configurations and a variety of sensitivities and ranges offer many mounting and application possibilities.

Miniature sensors operate best in thermally stable environments. When used in any application involving flash or transient thermal inputs, a diaphragm ablative coating (RTV, silicone grease, etc) should be used.

Model 105A
(Photo is one and a half times actual size)

Model 105A is designed for applications where mounting room is strictly limited. This sensor without integral threads for minimum body size is mounted via a clamp nut on the shoulder of the back of the sensor for minimum mounting space requirements. A lightweight ribbon cable can be easily soldered directly to the sensor (signal to center pin and ground to a flat on the sensor body). It is recommended that a 070A09 or a 070B09 solder connector adaptor be used with the ribbon cable. See page 69 for details.

Models 105B02, B12 and B22
Photo is one and a half time actual size)

Models 105B02, B12 and B22 are the most popular design for applications where a 10-32 threaded mounting port is preferred. This mounting configuration comes in a variety of ranges, including 100, 1000 and 5000 psi versions.

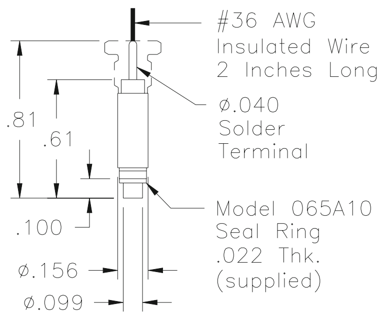
Models 105B03, B13, B23, B33 and B43

Models 105B03, B13, B23, B33 and B43 are available for applications where a 5/16-24 threaded clamp nut is preferred. This mounting configuration comes in a variety of pressure ranges, including 100, 1000, 5000, 10 000 and 30 000 psi versions.

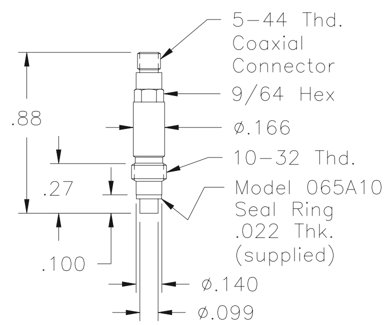
ICP® Miniature

With integral electronics

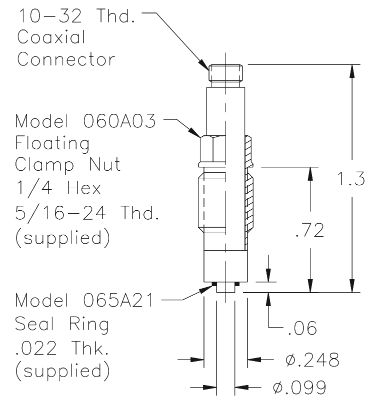
Dimensions shown in inches except where noted.



Model 105A



Model 105B02, 105B12, and 105B22



Model 105B03, B13, B23, B33, B43

	Dynamic Range (1)	**psi**	**100**			**1000**		**5000**		**10 000**	**30 000**
	MODEL NUMBERS		**105A**	**105B02**	**105B03**	**105B12**	**105B13**	**105B22**	**105B23**	**105B33**	**105B43**
AMPLITUDE	Sensitivity (6)	mV/psi	50 (+10/-20)		10	5		1		0.5	0.2
	Resolution	psi	0.005		0.01	0.02		0.1		0.2	0.5
	Range	psi	100			1000		5000		10 000	30 000
	Maximum Pressure	psi	250		500	2000		7500		15 000	40 000
	Linearity (2)	%FS	≤ 2								
FREQ RESP	Resonant Frequency	kHz	≥ 250								
	Rise Time	µs	≤ 2								
	Discharge Time Constant (3)	s	≥ 1							≥ 10	≥ 100
	Low Frequency (-5%) (3)	Hz	0.5							0.05	0.005
ENVIRONMENTAL	Shock (max)	g pk	5000								
	Acceleration Sensitivity	psi/g	0.005								
	Temperature Range	°F	-100 to +250								
	Temperature Coefficient	%/°F	≤ 0.09								
	Flash Temperature	°F	3000								
ELECTRICAL	Polarity (positive pressure)		positive								
	Output Impedance	ohm	< 100								
	Power Required: Voltage	+VDC	20 to 30								
	Constant Current	mA	2 to 20								
PHYSICAL	Sensing Element	material	quartz								
	Case	material	17-4PH								
	Diaphragm (4)	material	17-4PH								
	Connector (5)	type	solder pin	5-44 coax	10-32 coax	5-44 coax	10-32 coax	5-44 coax	10-32 coax		
	Sealing (5)	type	welded	epoxy							
OPTIONS	Hermetic Seal (5)	prefix	n/a		H	n/a	H	n/a	H		
	Negative Polarity	prefix	N								
	Water-resistant Cable	prefix	n/a		W	n/a	W	n/a	W		

NOTES:

1. Measures dynamic pressures from full vacuum to rated maximum.
2. % FS of any calibration range; zero-based best straight line.
3. Discharge Time Constant (DTC) relates low-frequency to signal lost during transient events. See technical section on page 78.
4. Diaphragms are integral.
5. Diaphragms of all sensors are hermetic and integral. Hermetic option specifies a fused-glass electrical connector and welded joints.
6. Unless otherwise designated, sensitivities are ±15%.

PCB's Commitment To You:

LASER WELDER: PCB utilizes both laser and electron beam welding techniques to hermetically seal sensors from outside contamination . . . helping to ensure reliability and longevity.

SKILLED TECHNICIANS: Under a microscope technicians meticulously assemble sensor elements and microelectronic circuitry. . . assuring sensor quality and performance.

CNC DUAL SPINDLE LATHE: A machinist prepares a completely automatic lathe to perform both primary and secondary machining operations, increasing productivity of precision parts . . . to meet customer delivery schedules.

Our machine shop produces over 70 000 precision machine parts each month.

PRODUCTION MACHINE SHOP: Precision Hardinge, computer-controlled automatic lathes and multiple wire EDM machines produce close tolerance parts essential to dynamic sensing instrumentation. PCB's precision machine shop is fully equipped to perform all metal-working operations . . . allowing PCB to fully control the manufacturing process.

Rocket Motor Pressure Sensors

- Combustion dynamics
- Instabilities
- Pulsations

Series 120 Helium Bleed Sensors are designed for measuring dynamic pressures in intense heat flow associated with high-temperature rocket motor environments. Outstanding features of this series include:

- ability to withstand intense heat at sensor tip
- sensor enveloped in cool, helium gas
- reduced vibration sensitivity and integral acceleration compensation
- helium flow increases frequency response of the short connecting passage.

"Helium Bleed" design, an idea originated at the Forrestal Lab of Princeton University during the 1960's, involves enveloping the case and diaphragm of a miniature quartz sensor with a cool flow of helium gas. The gas cools the sensor and insulates the unit from hot combustion gases, while cleaning and improving the response of the connecting passage.

PCB PIEZOTRONICS INC. PFS DIVISION

Rocket Motor

ROCKET MOTOR SENSORS
Series 120

PCB's quartz rocket motor sensors measure combustion instability in rocket engines. These sensors are structured with acceleration-compensated quartz sensing elements and are available in both charge and ICP® voltage mode output versions. Three physical configurations are available with helium bleed, helium bleed and water-cooling, and water-cooling only.

Helium bleed serves to protect the quartz sensor from the intense heat. Helium being less dense than air also increases the frequency response of the recess gas passage. See specifications on pages 47 and 48.

Series 122

Series 122 helium-bleed sensor is well suited for short-duration combustion instability measurements in solid rocket motors. This sensor features a 10-micron helium filter to control the helium flow rate to the sensor body and connecting passage. The element is acceleration compensated and has a two-microsecond rise time, enabling it to capture fast pressure fluctuations. Series 122 is available in both ICP and charge mode models. Special long designs have been supplied to accommodate mounting wall depth up to 18 inches.

Series 123

Series 123 rocket motor sensor is designed to measure combustion instability on some of the highest-energy rocket engines. The unit is suited for long duration measurements, or environments where severe temperature increase in the sensor mounting wall (or high soak temperature after shut down) exists. The unit incorporates helium-bleed, water cooling and two piece construction. Available in ICP and charge designs, a ceramic-coated end piece protects the sensor from the intense flow and environment.

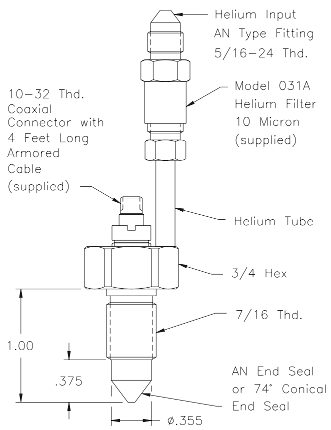
Series124

Series 124 ICP and charge mode watercooled sensors are designed for operation in high-heat transfer, high-vibration environments. They incorporate durable water cooling tubes with AN fittings and a special ceramic-coated end piece.

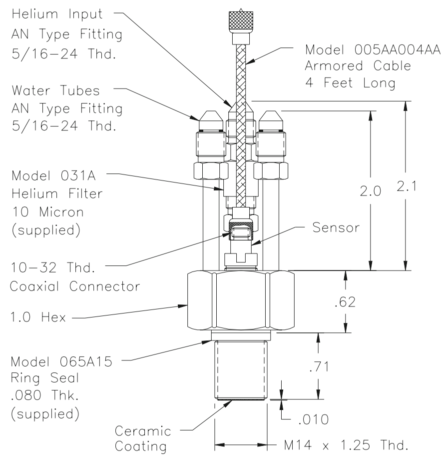
ICP® Rocket Motor

With integral electronics

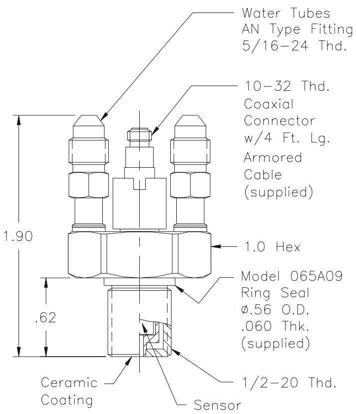
Dimensions shown in inches except where noted.



Series 122A20
Helium Bleed



Series 123A20
Water Cooled & Helium Bleed



Series 124A20
Water Cooled

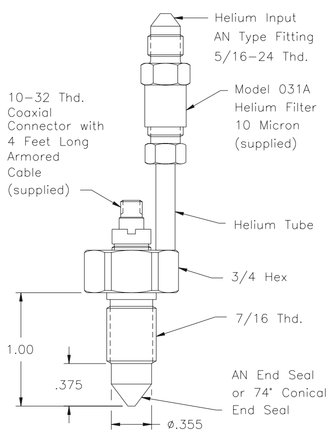
	Dynamic Range (1)	**psi**	**250**	**1 000**	**3 000**	**5 000**
	MODEL NUMBERS		**122A21** **123A21** **124A21**	**122A24** **123A24** **124A24**	**122A22** **123A22**	**124A22**
AMPLITUDE	Sensitivity (6)	mV/psi	20	5	1	
	Resolution	psi	0.005	0.02	0.1	
	Range	psi	250 (5V)	1 000 (5V)	3 000 (3V)	5 000 (5V)
	Maximum Pressure	psi	5 000			7 000
	Linearity (2)	%FS	≤ 1			
FREQ RESP	Resonant Frequency	kHz	≥ 25 (for 122 and 123), ≥ 15 (for 124)			
	Rise Time	µs	≤ 20 (for 122 and 123), ≤ 30 (for 124)			
	Discharge Time Constant (3)	s	≥ 1	≥ 100	≥ 500	
	Low Frequency (-5%) (3)	Hz	0.5	0.005	0.001	
ENVIRONMENTAL	Shock (max)	g pk	10 000			
	Acceleration Sensitivity	psi/g	0.002			
	Temperature Range (4)	°F	-100 to +250			
	Temperature Coefficient	%/°F	≤ 0.03			
	Flash Temperature (5)	°F	4 000 (for 122), 10 000 (for 123), 5 000 (for 124)			
ELECTRICAL	Polarity (positive pressure)		positive			
	Output Impedance	ohm	< 100			
	Power Required : Voltage	+VDC	20 to 30			
	Constant Current	mA	2 to 20			
PHYSICAL	Sensing Element	material	quartz			
	Case	material	17-4PH			
	Diaphragm	material	Invar			
	Connector	type	10-32 coaxial			
	Sealing	type	epoxy (for 122 and 123), welded (for 124)			
	Supplied Accessories		4 ft Cable Model 005AA004AA			
			Model 031A Filter for Models 122A 123A			

NOTES:

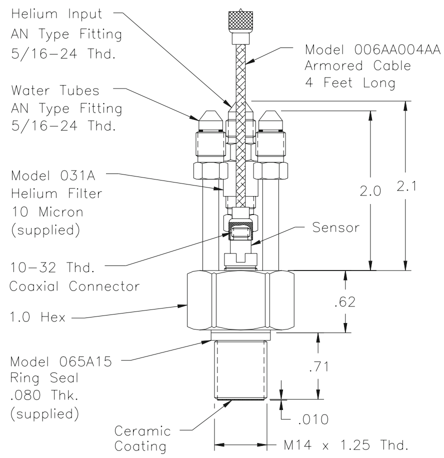
1. Measures dynamic pressures from full vacuum to rated maximum.
2. % FS of any calibration range; zero-based best straight line.
3. Discharge Time Constant (DTC) relates low-frequency to signal lost during transient events at room temperature. See technical section on page 78.
4. Temperature range refers to operating range of sensing element without extra cooling and helium flow. Environment temperature range may be higher, depending on application conditions, water cooling, or helium flow.
5. Flash temperature is defined as having a duration <10 milliseconds.
6. Unless otherwise designated, sensitivities are ±15%.

Rocket Motor
Charge mode

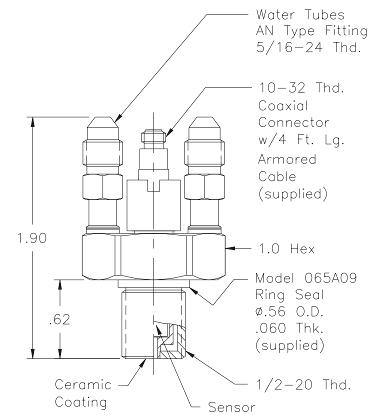
Dimensions shown in inches except where noted.



Model 122A
Helium Bleed



Model 123A
Water Cooled & Helium Bleed



Model 124A
Water Cooled

	Parameter	Unit	122A	123A	124A
	Dynamic Range (1)	**psi**	**3000**		
	MODEL NUMBERS		**122A**	**123A**	**124A**
AMPLITUDE	Sensitivity (6)	pC/psi	1		
AMPLITUDE	Resolution (2)	psi	0.02		0.01
AMPLITUDE	Maximum Pressure	psi	5000		
AMPLITUDE	Linearity (3)	%FS	≤ 1		
FREQ RESP	Resonant Frequency	kHz	≥ 25		≥ 15
FREQ RESP	Rise Time	µs	≤ 20		≤ 30
ENVIRONMENTAL	Shock (max)	g pk	10 000		
ENVIRONMENTAL	Acceleration Sensitivity	psi/g	0.002		
ENVIRONMENTAL	Temperature Range (4)	°F	-450 to +500		
ENVIRONMENTAL	Temperature Coefficient	%/°F	≤ 0.01		
ENVIRONMENTAL	Flash Temperature (5)	°F	4 000	10 000	5 000
ELECTRICAL	Polarity (positive pressure)		negative		
ELECTRICAL	Capacitance	pF	18		
ELECTRICAL	Insulation Resistance at 70°F	ohm	≥ 10^{12}		
PHYSICAL	Sensing Element	material	quartz		
PHYSICAL	Case	material	17-4		
PHYSICAL	Diaphragm	material	Invar		
PHYSICAL	Connector	type	10-32 coaxial		
PHYSICAL	Sealing	type	epoxy		
	Optional with Positive Polarity	prefix	P		
	Supplied Accessories		Model 031A filter		n/a
			4 ft Model 006AA004AA		
			BNC Accessories		

NOTES:
1. Measures dynamic pressures from full vacuum to rated maximum.
2. Resolution determined by system noise and cable length.
3. % FS of any calibration range; zero-based best straight line.
4. Temperature range refers to operating range of sensing element without extra cooling and helium flow. Environment temperature range may be higher, depending on application conditions, water cooling, or helium flow.
5. Flash temperature is defined as having a duration >10 milliseconds.
6. Unless otherwise designated, sensitivities are ±15%.

Pressure Calibrators and Services

PRESSURE CALIBRATORS & SERVICE

Each PCB pressure sensor is provided with an individual calibration certificate traceable to the N.I.S.T. (National Institute of Standards & Technology). All instrumentation and reference standards used in the calibration process are traceable to NIST.

Both static and dynamic methods are used in the calibration process. Special hydraulic and pneumatic impulse and step pressure generators, developed for in-house calibration of PCB sensors, are offered as standard commercial products.

PCB also offers NIST traceable calibration services for other commercial piezoelectric sensors from acoustic levels to greater than 100 000 psi. Calibration services include shock tube amplitude/frequency response testing with microsecond step function pressures. Our new high pressure impulse calibrator, Model 913A10, allows for dynamic versus static response comparison of pressures to 100 000 psi.

Calibration data supplied by various sensor manufacturers may differ considerably. Some manufacturers may provide sensor sensitivity only at specific data points which makes non-linearity less obvious. PCB provides linearity graphs with sensitivity at specific data points. It is a recommended practice to request a copy of the calibration certificate before you purchase so you will be aware of the data being supplied. See page 56 for a copy of a typical calibration certificate. Call, fax, or email a PCB application engineer if you have any questions or need more information relating to pressure sensor calibration.

Test engineer calibrates sensor using 913B02 Hydraulic Impulse Calibrator with tourmaline reference standard.

Calibrator Selection Chart:

PCB CALIBRATOR SELECTION CHART					
Calibrator	**Model #**	**Type**	**Rise Time**	**Pressure Range (psi)**	**Page #**
Shock Tube	901A10	Dynamic-step	1 ns	7 to 1400	50
Low Pressure Pulse Calibrator	903B02	Dynamic-step	5 ms	0 to 150	51
High Pressure Static Calibrator	905C	Static	n/a	10 000 to 100 000	52
Aronson Step Pressure Generator	907 Series	Dynamic	30-50 µs	0 to 1000	53
High Pressure Impulse Calibrator	913A10	Dynamic	3.5 ms	10 000 to 125 000	54
Hydraulic Impulse Calibrator	913B02	Dynamic	3 ms	200 to 20 000	55

Shock Tube - Model 901A10
7-1400 PSI

For shock and blast wave sensor testing and calibration

SHOCK TUBE

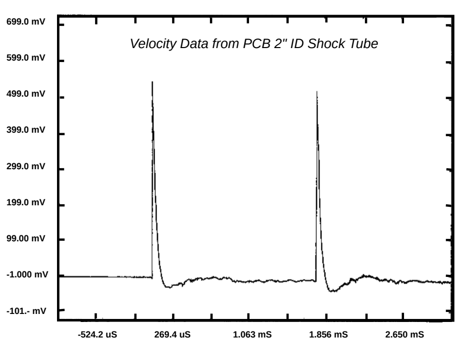
Model 901A10 is a gas-driven shock tube designed for the testing and calibration of high frequency pressure sensors, such as piezoelectric shock/blast wave sensors. The unit features:

- nanosecond rise time
- generates step pressures to 1400 psi
- 7 feet long x 2 inch I.D.
- gas driven: helium, air, nitrogen

Preselected aluminum diaphragms are inserted in the flanges between the driver section and the expansion chamber. Compressed gas pressurizes the driver section, bursting the diaphragm, and sending a well-formed shock wave to the test sensor mounted in the reflection end plate.

By knowing the atmospheric pressure, temperature, and relative humidity, and by measuring the shock wave velocity via the supplied incident sensor, the precise shock wave amplitude is calculated.

SUPPLIED ACCESSORIES
134A Tourmaline Reference Sensor
Series 132A Incident
Pressure Sensor
Power Supply for ICP Sensors
Diaphragms - (24) Aluminum
- (12) Mylar
Wooden Stand (3 pieces)
Brass Valve
Anti-Rotation Plate
Compression Plate
Reflection Plate
Misc: Bolts, Nuts, Gaskets, O-Rings

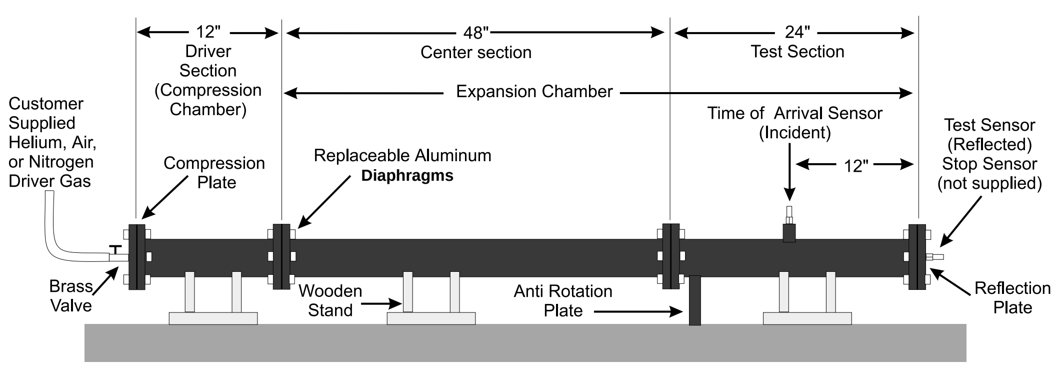


Velocity Record from a PCB Shock Tube

Approximate Shock Pressures as a Function of Diaphragm Material and Burst Pressure

Shock Over Pressure psi	Reflected Over Pressure psi	Diaphragm Material Thickness (inch)	Driver Gas*	Diaphragm Burst Pressure psig
		1100-0 Aluminum		
180	1050	0.064	Helium	1400
144	790	0.04	Helium	880
130	690	0.032	Helium	760
90	435	0.02	Helium	423
		Mylar		
32	110	0.01	Nitrogen	225
3	6.6	0.0005	Air	7

* Customer supplied; Bottled gas recommended (≈ 2 500 psi).



Low Pressure Pulse Calibrator - Model 903B02
0-150 PSI

DYNAMIC PRESSURE, STEP FUNCTION PULSE CALIBRATOR WITH QUICK-OPENING VALVE

Model 903B02 is an aperiodic dynamic pressure source that applies known step changes to pressure sensors within the range of 0 to 150 psi. It determines sensitivity and transient response characteristics.

This unit generates known step-function increase or decrease in pressure for the dynamic calibration of miniature pressure sensors, according to American National Standard ANSI B88.1. This unit features the following characteristics:

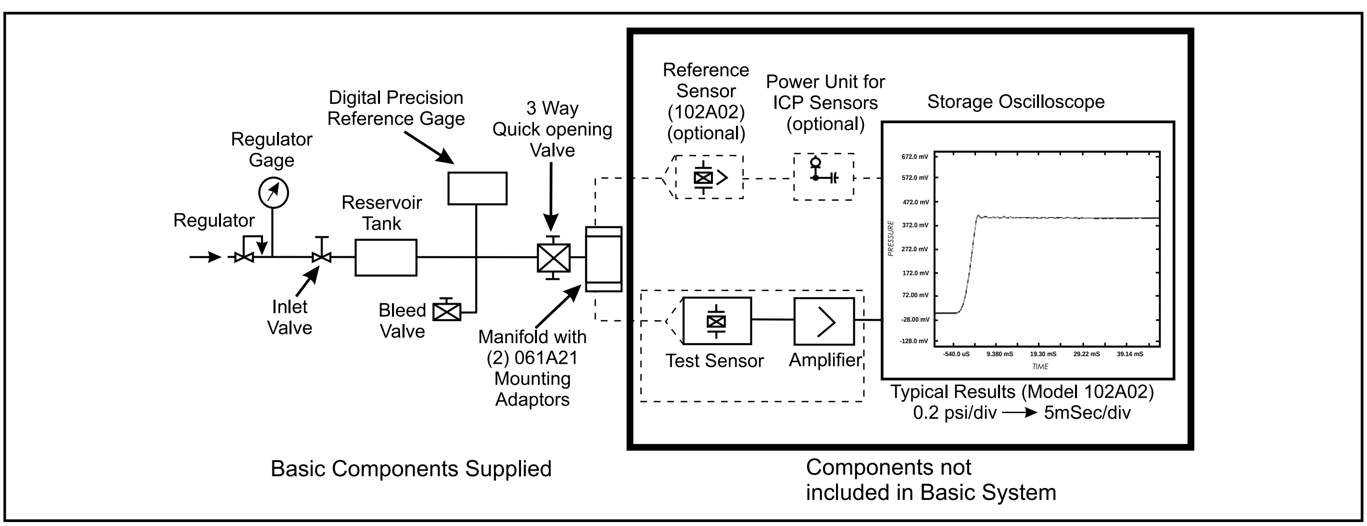
- Measures step pressures to 150 psi
- Offers 5 millisecond rise time
- Exhibits little or no gas resonance
- Provides NIST-traceable calibration
- Operates from shop air supply
- Accomodates two sensors

A manually operated, quick-opening, 3-way valve switches the manifold (sensor) pressure from atmospheric to a precisely known (reservoir) pressure in about 5 milliseconds. The reservoir tank air pressure, displayed on a precision digital reference gauge, is controlled by inlet and bleed valves. The sensor output signal is recorded and measured on an oscilloscope, as illustrated.

Pressure sensors install directly in 3/8-24 threaded ports in the manifold or in appropriate mounting adaptors. A second port in the manifold (normally plugged) accommodates an optional reference pressure sensor for comparison calibration.

Model 903B02		
Calibration Pressure Range	psi	0 to 150
Pressure Step Rise Time (nominal)	m s	5
Reference Gage Range*	psi FS	0 to 150
Reference Gage Accuracy	% FS	0.2
Size (l x w x h)	inch	22 x 24 x 24
Weight	lb	50
Reservoir Maximum Pressure	psi	200
Manifold Sensor Ports	(qty) size	(2) 3/8-24 thd.

* Digital Precision Reference Gage
** Accessories supplied: Model 061A21Thread Adaptor (2), Blank Thread Adaptor (4), Seal (4)



High Pressure Static Calibrator - Model 905C
10 000-100 000 PSI

HIGH PRESSURE CALIBRATION SYSTEM

Model 905C statically calibrates high-pressure piezolectric sensors to 100 000 psi. It consists of a hand-operated hydraulic pressure pump, precision reference standard and auxiliary gages, an ICP® sensor signal conditioner, and a digital voltmeter.

This system features:

- static pressure range to 100 000 psi
- self-contained hydraulic system
- precision digital readout reference gage
- calibration traceable to NIST through reference gage
- excitation for low-impedance sensors
- point-by-point static calibration of high-pressure sensors

The manually operated pump quickly generates a static pressure that is applied to the sensor being calibrated and is measured by the precision reference standard and auxiliary gages. The output signal from the ICP sensor being calibrated and the signal conditioner (or charge mode sensor and associated charge amplifier) are displayed and measured on the digital voltmeter. The digital voltmeter features a (BNC) scope output and a GPIB (General Purpose Interface Bus) output.

The sensor being calibrated is installed into a mounting adaptor that threads into the manifold. A furnished adaptor accommodates PCB Series 108, 109, 117, 118, 119, and some 165 ballistic sensors. Special plugs or adaptors can be supplied for other sensors.

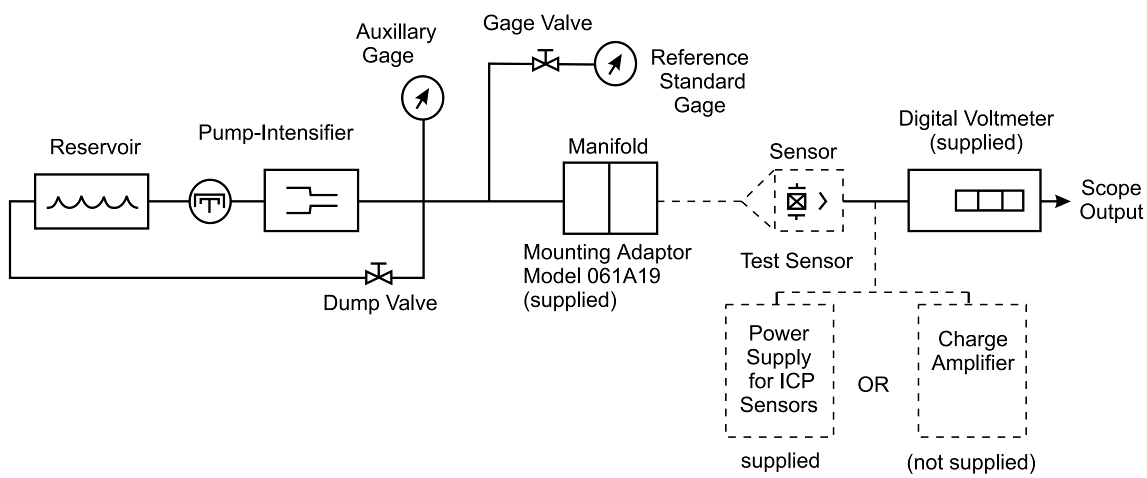
To increase longevity, the precision reference standard gage may be shut off with a valve while the auxiliary gage is used as a reference for pressure cycling.

Model 905C		
Reference Standard Gage Range	psi	10 000 to 100 000*
Measurement Step Increments	psi	5000
Reference Standard Gage Accuracy	% FS	≤ 0.10
Auxiliary Gage Range	psi	0-150 000
Maximum Pump Pressure	psi	150 000
Power (60 Hz)	volt	110 (optional 220)
Approximate Shipping Weight	lb	200

***For calibration below 10 000 psi, an optional model 100M32 calibration adaptor is available.**

Supplied Accessories:

Model 061A19 Adaptor (for PCB Series 108, 109, 117, 118, 119, and 167)
Model 061M47 Blank Thread Adaptor
Model 012A05 Coaxial Cable
Monoplex® -DOS (1 gallon)



Aronson Step Pressure Generator - Model 907A02

0-1 000 PSI

Developed by P. Aronson for U.S. Naval Ordinance Laboratory

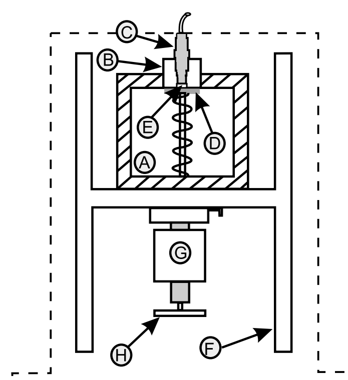
DYNAMIC STEP PRESSURE GENERATOR

Model 907A02 Pressure Step Generator is a simplified precision-calibration device which produces positive going step pressures to 1000 psi, with rise times 30 to 50 microseconds. It may also be used to compare static vs. dynamic calibration, to determine sensor and system discharge time constants and rise times of some lower frequency-type pressure sensors.

Model 907A is available to calibrate small pressure changes at higher static levels. It features additional valves and plumbing to allow control of the initial pressure against the sensor diaphragm, under the poppet valve, including a vacuum. Model 907A incorporates six 22-turn fine-adjusting metering valves for precise pressure control. External gas supplies are required to operate Models 907A02 or 907A. An accurate external pressure reference gage is required to measure the initial and final reservoir static pressures. A second external reference gage is required for Model 907A.

Model 907A07 is a version of Model 907A02 supplied complete with the external reference gage and plumbing ready to connect to the user's pressure source. Model 907A05 is a version of Model 907A supplied with two external pressure reference gages and plumbing.

2 Channel Reference Gage
Supplied with Model 907A05



A - pressure reservoir
B - gage adaptor plug
C - pressure sensor
D - poppet value
E - poppet volume
F - housing - support system
G- impact weight
H - impact plate

Model 907A02		
Pressure Step Amplitude	psi	0 to 1000 (1)
Step Rise Time	µs	≤ 50
Maximum Reservoir Pressure	psi	≤ 2000
Working Medium		Non-corrosive gas (i.e. helium)
Maximum Sensor Size	inch dia.	1
Operating Mode		Manual
Calibration Modes		Dynamic and static (in place)
Locking Mechanism		Keeps poppet valve open or closed
Trigger Signal Generator		Impacts sensor to trigger recording device
Material		Stainless steel and aluminum
Gas Pressure Controls		(3) each type 316L manual valves
Gas Access Ports		2 Swagelok® -type AN connectors; 1 for gas pressure/vacuum sources; 1 for external static reference gages
Size	dia. x h	12 x 21 inch
Weight	lb	75

SUPPLIED ACCESSORIES
Three poppet valves
- one blank for sensors to 1 inch dia.
- one for sensors under 0.5 inch dia.
- one for sensors under 0.25 inch dia.

Three sensor mounting adaptors
- one with 3/8-24 thread
- one for PCB standard 5/16-24 thd.
- one blank plug to accommodate up to 1-inch diameter sensors.

NOTES:
1. Negative Pressure ≤ 14 psi.

High Pressure Impulse Calibrators - Model 913A10

10 000-125 000 PSI

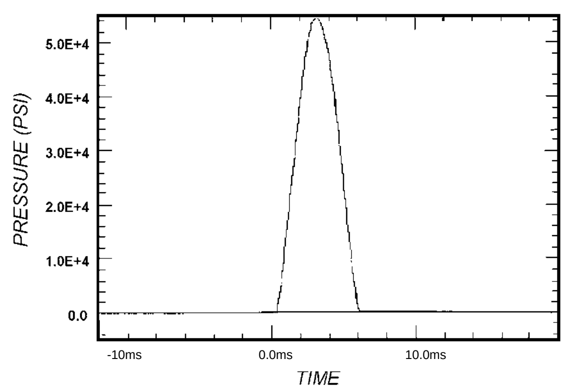
HIGH PRESSURE DYNAMIC IMPULSE CALIBRATOR

Model 913A10 is a reliable, easy-to-use, pneumatically-operated high pressure dynamic calibrator. The Model 913A10 utilizes a rugged, stable, and repeatable PCB quartz shear ICP® accelerometer to accurately determine pressure. This unit features a 42-inch high drop-test fixture with a 53-pound tungsten mass. The mass is lifted and released by a pneumatically controlled carriage and piston. The pneumatic control panel features two safety palm buttons for releasing the drop weight.

A free-falling known mass is dropped onto a piston, creating a hydraulic pressure pulse in the pressure calibration cell. The accelerometer measures the deceleration of the free-falling mass after it strikes the piston. The deceleration of the mass/piston, coupled with the geometries of the piston and cylinder, determine the pressure. This method eliminates the need for complicated drop-mass velocity measurements or uncertainties from referencing another pressure sensor.

The supplied pressure calibration cell, consisting of a precision-machined piston/manifold, is ported for two PCB Series 118/119 Ballistic Pressure Sensors. Various models of high-pressure sensors may be calibrated by interchanging the available drop-in pressure calibration cells.

Model 913A10		
SYSTEM PERFORMANCE DESCRIPTION		
Range (maximum)	psi	125 000
Rise Time	ms	3.5
Pulse Duration	ms	7
Estimated Accuracy	%	±0.3
PHYSICAL DESCRIPTION		
Drop Mass		
Material		Tungsten
Weight	lb	53
Required Air Pressure to lift mass	psi	70 to 110
Drop Test Fixture		
Size (h x dia)	inch	42 x 12
Weight	lb	220
Pneumatics Control Enclosure		
Size (h x w x d)	inch	42 x 25 x 9
Weight	lb	45



Sample Pressure Pulse Generated by Model 913A10 Drop Calibrator ^{2} 8 ms rise time.

SUPPLIED COMPONENTS
- Pressure Calibration Cell
- Reference (ICP) Shear Accelerometer (with NIST-traceable calibration certificate)
- Accelerometer Cable (2)
- Accelerometer Signal Conditioner
- Space Pistons with Caps (4)
- Space Air Filter
- Glycerine (1 pint)
- Rubber Floor Pad
- Spare 5/32-inch OD Nylon Tubing-10 ft
- Spare 1/4-inch OD Polyethylene Tubing-10 ft
- Instruction Manual

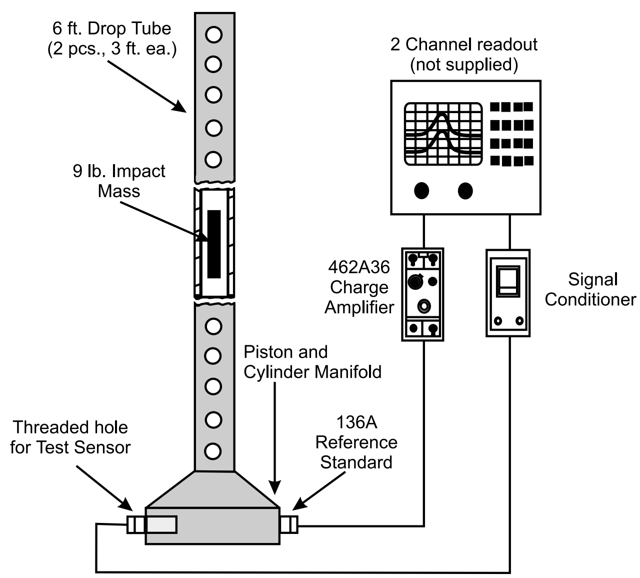
OPTIONAL ACCESSORIES
- Steel Drop Mass-22 lb (Shortens pulse duration to 5 msec.) (Max. Pressure 85 000 psi)
- Eye Hook/Rope (for changing mass)
- Pressure Calibration Cells with Optional Mounting Ports

Hydraulic Impulse Calibrator - Model 913B02

200-20 000 PSI

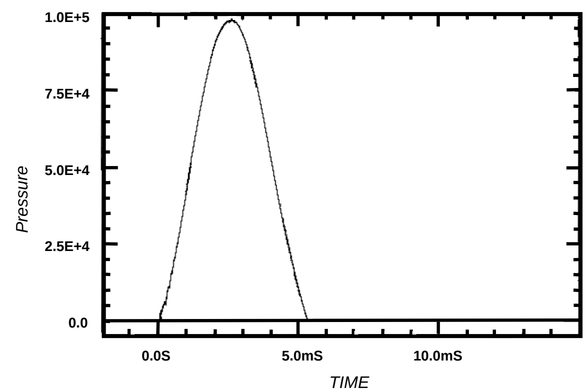
PCB Model 913B02
HYDRAULIC IMPULSE CALIBRATOR
(instrumentaion optional)

- Range to 20 000 psi
- Typical rise time 3 MS
- Pulse duration 6-8 MS



HYDRAULIC IMPULSE CALIBRATOR

Model 913B02 is a hydraulic impulse calibrator utilizing a mass dropped onto a piston in a fluid filled cylinder for comparison calibration of dynamic pressure sensors against a PCB Model 136A tourmaline transfer standard. The pressure cylinder is fitted with the tourmaline reference standard and an installation port for the sensor to be calibrated. Typical performance specifications are 2-3 millisecond rise time with a pulse duration of about 5-6 milliseconds.

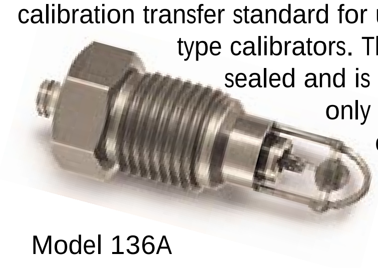


Typical Pressure Pulse Generated by Model 913B02

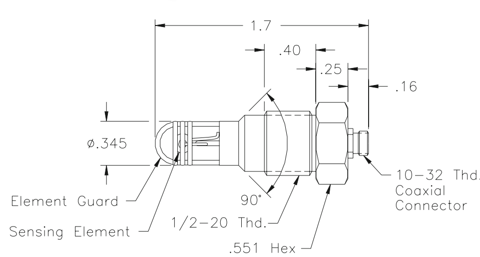
TRANSFER STANDARD

Model 136A is a linear volumetric tourmaline pressure sensor designed to accurately measure rapidly changing hydraulic pressures to 20 000 psi. It is used as the reference transfer standard in the PCB 913B02 Hydraulic Impulse Calibrator.

The Model 136A is structured with a single tourmaline crystal, suspended between two steel posts. Since there is no diaphragm or housing to affect the inherent linearity of the tourmaline crystal, this sensor makes an excellent calibration transfer standard for use in hydraulic impulse-type calibrators. The crystal is epoxy-sealed and is recommended for use only in electrically non-conductive oil environments.



Model 136A



SUPPLIED COMPONENTS
Calibration Stand
Drop Tube and Mass
Model 136A Reference Transfer Sensor
Model 462A37 Charge Amplifier
3 FS0 Calibrations (0 to 1 000, 10 000, and 20 000 psi) traceable to NIST
NOTE:
Because of seal design considerations, Model 136A should not be statically pressurized above 5 000 psi.

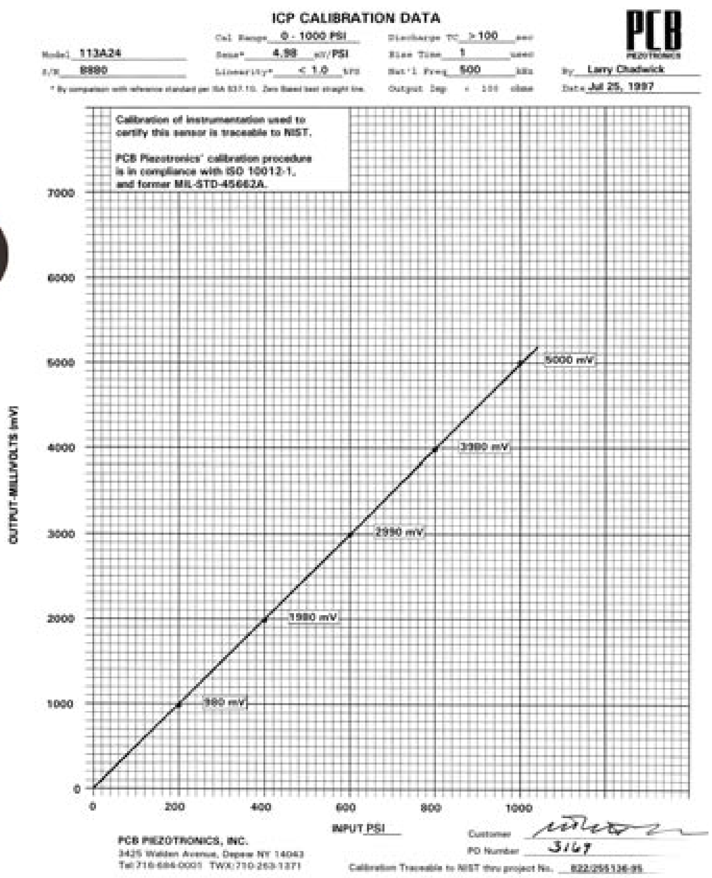
Model 136A Tourmaline Transfer Standard		
Dynamic Range, full scale*	psi	20 000
Maximum Dynamic Pressure	psi	20 000
Resolution	psi	0.5
Sensitivity	pC/psi	0.2
Resonant Frequency	MHz	≥ 1
Rise Time	µs	≤ 1
Linearity (all ranges)	%	≤ 0.5
Capacitance (nominal)	pF	10
Insulation Resistance	ohm	$\geq 10^{12}$
Polarity		negative
Temperature Range	°F	0 to 100
Sealing		epoxy
Case	material	stainless steel
Sensing Element	material	tourmaline
Size (hex x lg)	inch	0.56 x 1.7
Mounting Connector (micro)	thread	1/2 - 20 NF
Connector (micro) (signal)	coaxial	10-32

Typical Calibration Certificate

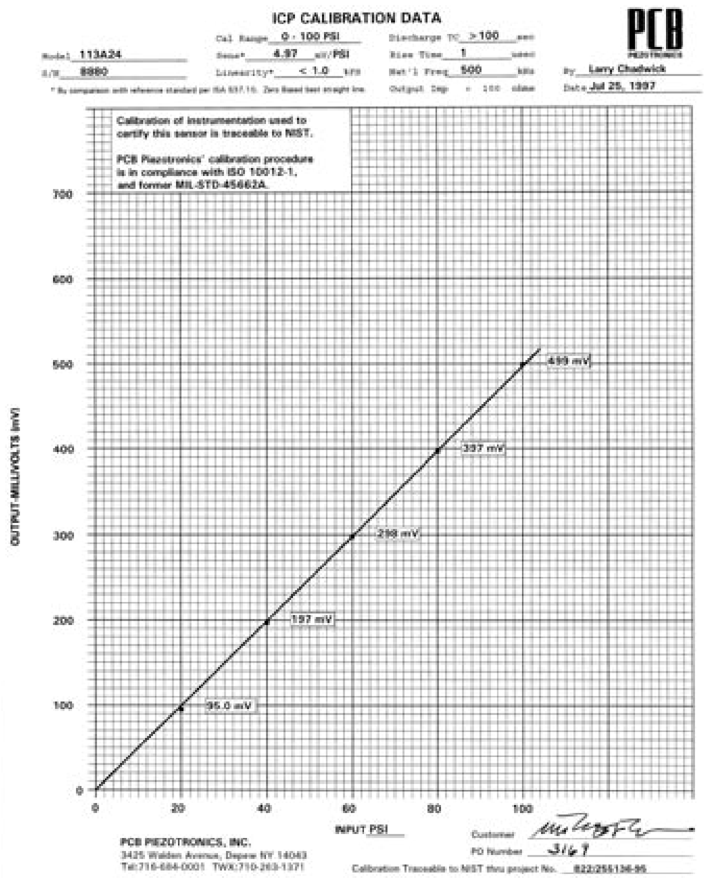
A single quartz pressure sensor has a very wide linear dynamic operating range. Several strain or piezoresistive type sensors with narrow measuring ranges would be required to make the range of measurements that can be made by one piezoelectric sensor.

To make use of their exceptional linear dynamic range, most PCB pressure sensors are furnished with two calibrations. The first calibration is performed over the entire operating range of the sensor, while the second calibration is performed over the first 10% of the operating range.

Illustrated below are two typical NIST traceable calibration certificates furnished with model 113A24 pressure sensor (1000 psi range). The two linear calibrations provided with this sensor are 0 to 1000 psi, full scale and 0 to 100 psi, 10% of full scale. Because of its exceptional linearity and high (5 mV/psi) output, the same sensor can be used for measurements 0 to 5 psi, 0 to 1000 psi, or anywhere in between. There is no need to buy a new sensor each time it is desired to measure a different range.



Sample Calibration Certificate
0 to 1000 PSI
Full Scale



Sample Calibration Certificate
0 to 100 PSI
10% Full Scale

Related Products

- Mounting adaptors
- Standard cables
- Custom cable ordering guide
- Cable description
- Connectors
- Signal conditioners

Typical 4 Channel Model 442A04
Line Powered ICP® Sensor Power/Signal Conditioner
with gain x1, x10, x100. CE marked

PCB PIEZOTRONICS INC. PFS DIVISION

PRESSURE AND FORCE SENSORS DIVISION

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Mounting Adaptors

What are mounting adaptors?

Most quartz pressure probes are designed for precision installation in restricted locations. When minimum dimensions are not required, thread adaptors provide convenient sensor mounting. It is less complicated to drill and tap a 3/8-24 hole for a thread adaptor than it is to machine a precision sensor mounting port. Standard and special adaptors can be supplied to fit specific mounting ports.

Why use mounting adaptors?

When space permits, mounting adaptors offer several advantages. First, the use of an adaptor reduces the need for precision machining in "sensor only" installations. In locations where necessary machining steps are impossible, impractical, or simply inconvenient, the adaptor can be mounted with a few simple steps.

The sensor can be electrically insulated in some adaptors to minimize interference from ground loop noise involved with operation on electrical machinery. Special adaptor materials, sensor coatings and insulating seals can be factory installed to isolate the sensor from ground induced noise.

Watercooled adaptors provide for sensor installation in high temperature applications for dynamic measurements on exhaust manifolds and jet engines.

Watercooled adaptors allow ICP® and charge mode pressure sensors to operate well above their maximum rated temperature range. For example, an ICP sensor, rated to 250°F maximum temperature, will not generally reach 150°F when operating in a Model 64 watercooled adaptor on a 1200°F engine exhaust manifold.

Most mounting adaptors are made of high-strength 17-4 PH stainless steel. Care should be exercised to observe maximum pressured thermal environment, when using adaptors made of lesser-strength materials. For example, Delrin, a type of plastic used to provide sensor ground isolation, should not be used above 500 psi. Low-carbon, 316L stainless is often used for brine and other corrosive environments, LOX (liquid oxygen), and GOX (gaseous oxygen) environments.

In sensor applications involving exposure to flash temperatures, an ablative protective diaphragm coating is beneficial. To captivate the ablative, the sensor may be slightly recessed in an adaptor approximately 0.01 inches with the recess filled with an ablative.

Series 061 Adaptors have straight English or metric threads, of specific length, and a shoulder seal. Thicker walls can be counterbored for flush installations. Sensors may be installed flush with end of adaptor or slightly recessed to contain an ablative coating.

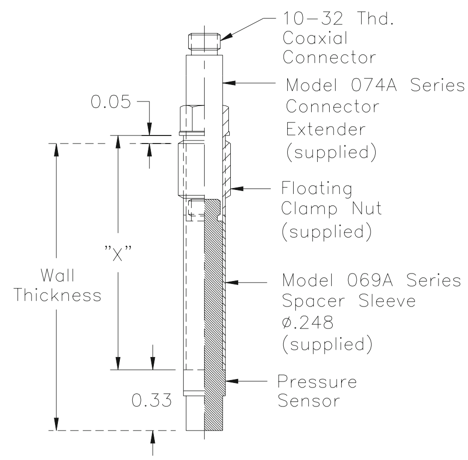
Series 062 Pipe Thread Adaptors provide for convenient sensor installation in pumps and hydraulic systems. Since pipe thread adaptors seal on the threads, it is difficult to achieve a flush mount. For both safety and measurement reasons, "ganging" pipe thread adaptors to adapt up or down is not recommended, especially at high pressures.

Series 064 Water-Cooled Adaptors facilitate sensor installation of sensor in high-temperature applications, such as turbines, jet, internal combustion and engine exhaust. For example, normal water line pressure to WC adaptor keeps an ICP sensor mounted on a 1000°F exhaust manifold well below its 250°F maximum rated temperature. Water cooling should be maintained during the engine shutdown phase to avoid over-heating from heat soak.

CAUTION: Observe maximum pressure limits for adaptors; these limits may be less than the sensors maximum pressure rating.

Connector Extender for Series 111, 112, and 113

Model 074A "X" Connector Extender
(Specify dimension "X". Example 074A1.75 is an extender whose "X" dimension = 1.75 inches)*

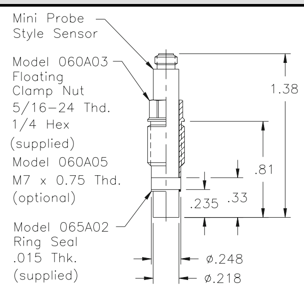


***Dimension "X" = Mounting wall thickness minus 0.28 (flush mtg). Available "X" dims: 0.75 to 4.50 inches in 0.05 inch increments.**

ADAPTORS FOR 111, 112, 113 PRESSURE SENSORS

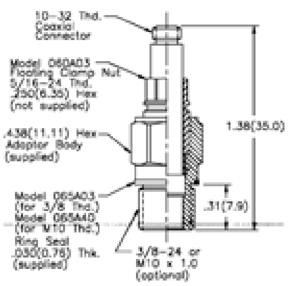
1. Sensor diaphragms are flush mounted unless otherwise noted. 2. Always contact the factory for a detailed installation drawing before preparing mounting ports.

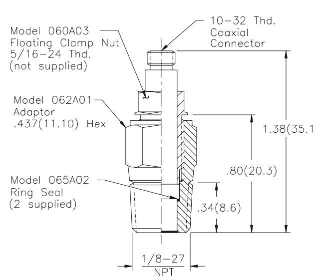
PROBE STYLE SENSOR

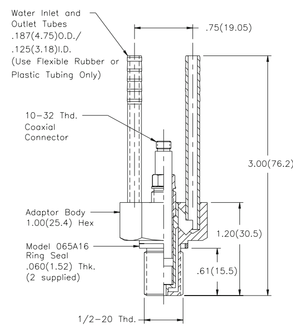


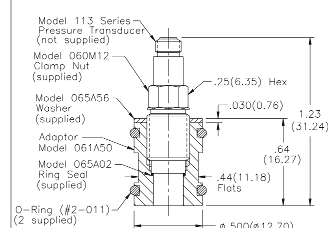
	BENEFITS	LIMITATIONS
	Models 111, 112, 113 Mini Probe Style Sensor (17-4 Ph SS) 5/16-24 thd: Direct mount using floating clamp nut. Use when there is limited space available to install sensor or a flush diaphragm mount is desired. Sensor can be installed using 5/16-24 or optional M7 x 0.75 clamp nut.	Requires precision machining steps. Needs a minimum 0.75 wall thickness or counterbore thicker walls to install. Use 074A connector extender for thicker walls (see page 58).

ADAPTOR TYPE









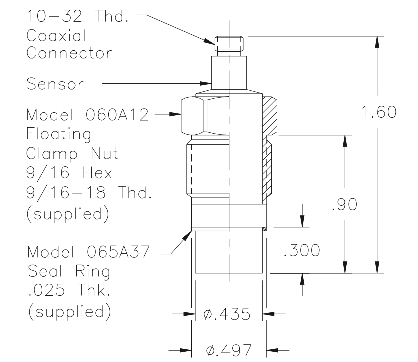
	061A Series Thread Adaptor	062A Series NPT PipeThread Adaptor	064 Series Watercooled Adaptor	O-ring Style Adaptor
BENEFITS	Simplified installation by drilling and tapping 3/8-24 mounting hole. Eliminates precision machining mounting ports. Adapts mini probe style sensor to thin walled applications. **061A01:** (17-4 PH SS) 3/8-24 thd: installs in common 3/8-24 mounting port. **061A09:** (316L) 3/8-24 thd: corrosive resistance (use with 316L sensor). **061A59:** (Delrin) 3/8-24 thd: Delrin material electrically isolates sensor from ground*. **061A57:** (17-4 PH SS) 1/2-20 thd **061A58:** (17-4 PH SS) 3/8-24 thd: dummy plug - plugs port when not testing - (other size plugs are also available).	Conveniently adapts mini probe style sensors to hydraulic 1/8" NPT mounting ports. **062A01:** (17-4 PH SS) 1/8-27 NPT: fits standard 1/8-27 NPT mounting port. **062A05:** (316L) 1/8-27 NPT: corrosive resistance (use with 316L sensor).	Adapts mini probe style sensor to high temp combustion and exhaust manifold environments. **064B01:** (17-4 PH SS) 1/2-20 thd: sensor recessed - isolates sensor from environment. **064B02:** (17-4 PH SS) 1/2-20 thd: sensor flush - better high frequency response.	**061A50:** (303 SS) Adaptor provides acceleration, strain and ground isolation in field blast applications.
LIMITATIONS	Limited to thinner wall or counterbore thicker walls to install. Requires more area to prepare mounting port than mini probe style sensor alone. *Lower strength of Delrin limits use to lower pressure applications (<500 psi).	Since the tapered pipe thread seals on the thread itself, it is more difficult to achieve flush diaphragm mount. Requires more area to prepare mounting port than probe style sensor alone.	Requires greater mounting area. Recessed sensor: reduced frequency capabilities. Flush sensor: diaphragm is susceptible to flash thermal effects.	Adaptor installs with press fit and should not be used at pressures greater than 20 psi unless properly supported from back side to prevent sensors from being blown out at higher pressures.

Mounting Adaptors

ADAPTORS FOR 106B, 116B02, 116B PRESSURE SENSORS

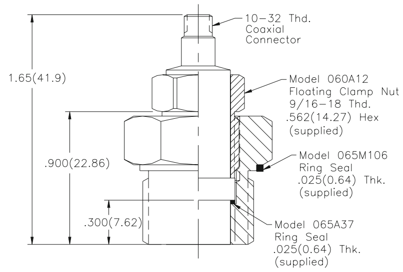
1. Sensor diaphragms are flush mounted unless otherwise noted. 2. Always contact the factory for a detailed installation drawing before preparing mounting ports.

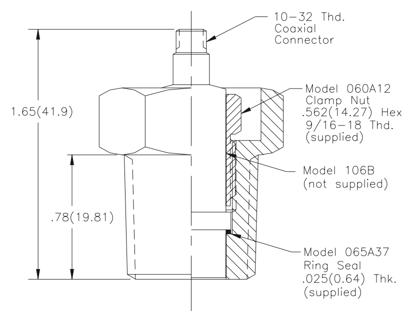
PROBE STYLE SENSOR

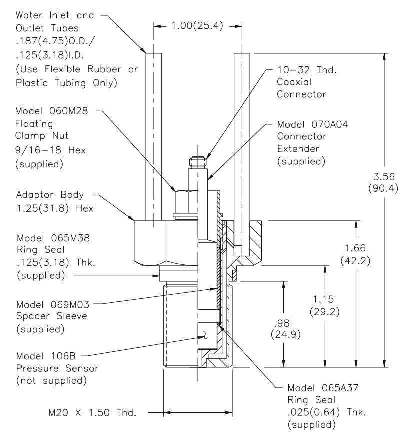


BENEFITS	LIMITATIONS
Models 106B, 116B02, 116B Probe Style Sensor (17-4 PH SS) 3/4-16 thd: Direct mount sensor using floating clamp nut. Use when there is limited space available to install sensor or a flush diaphragm mount is desired. Sensor can be installed using a 3/4-16 clamp nut.	Requires precision machining steps. Needs a minimum 0.75 wall thickness or counterbore thicker walls to install.

ADAPTOR TYPE







	061A Series Thread Adaptor	062A Series NPT Pipe Thread Adaptor	064 Series Watercooled Adaptor
BENEFITS	Simplified installation by drilling and tapping 3/4-16 mounting hole. Eliminates precision machining mounting ports. Adapts probe style sensor to thin walled application. **061A60:** (316L) 3/4-16 thd: corrosive resistance (use with 316L sensor). **061A61:** (Delrin) 3/4-16 thd: Delrin® material electrically isolates sensor from ground.	**062A06:** (17-4 PH SS) 1/2-24 NPT: Conveniently adapts probe style sensors to hydraulic 1/2-14 NPT mounting ports.	Adapts sensor probe to exhaust manifold and other high temperature environments. **064B06** (17-4 PH SS) M20 x 1.50g thd: sensor recessed - isolates sensor from environment. **064B05** (17-4 PH SS) 7/18-14 thd: sensor flush - better high frequency response. Requires greater mounting area.
LIMITATION	Limited to thinner wall or counterbore thicker walls to install. Requires more area to prepare mounting port than probe style sensor alone. Lower strength of Delrin limits use to lower pressure applications (<500 psi).	Since the tapered pipe thread seals on the thread itself, it is more difficult to achieve flush diaphragm mount. Requires more area to prepare mounting port than probe style sensor alone.	Recessed sensor: reduced frequency capabilities. Flush sensor: diaphragm is susceptible to flash thermal effects.

Installation Preparation & Accessories

THIS SECTION IS FOR REFERENCE ONLY. BEFORE PREPARING A MOUNTING HOLE, CONTACT PCB FOR A CURRENT INSTALLATION DRAWING.

Models 040A10 and 040A20 Installation Tooling Kits are available to assist in machining mounting ports for standard design and high-pressure ballistics sensors for applications where PCB mounting adaptors are not used. The kits provide the tooling necessary for precision-machining mounting ports for applicable sensors. Refer to the "Technical Information" section of this catalog for a detailed description of flush versus recess sensor installation.

Installation Kit Model 040A10 (for Series 111, 112, 113 pressure probes). Kit includes all tooling listed below.

Flush Mounting Installation

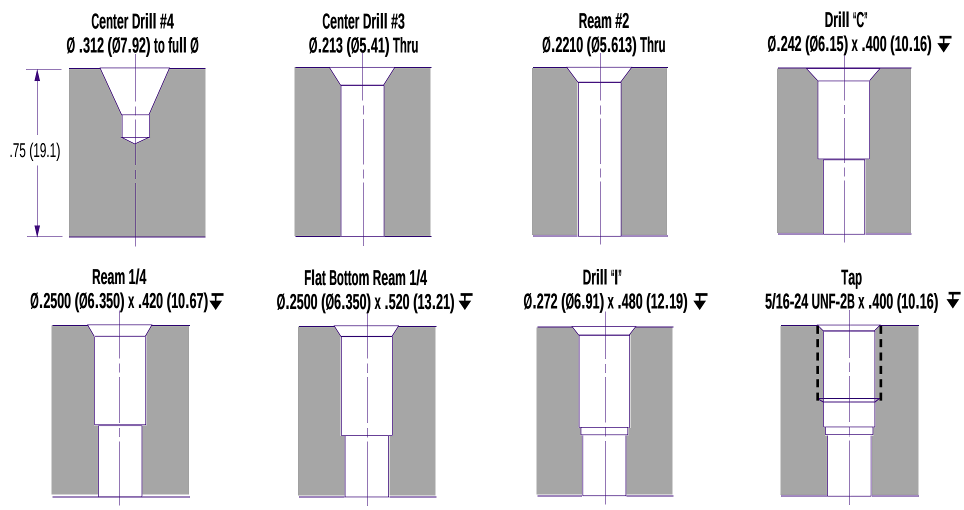
Tool Required:		
Center Drill	#4	(0.312 dia)
Drill	#3	(0.213 dia)
Ream	#2	(0.221 dia)
Drill	“C”	(0.242 dia)
Ream	“1/4”	(0.250 dia)
Flat Bottom Ream	“1/4”	(0.250 dia)
Drill	“1”	(0.272 dia)
Tap	5/16-24 UNF-2B	

Recess Mounting Installation

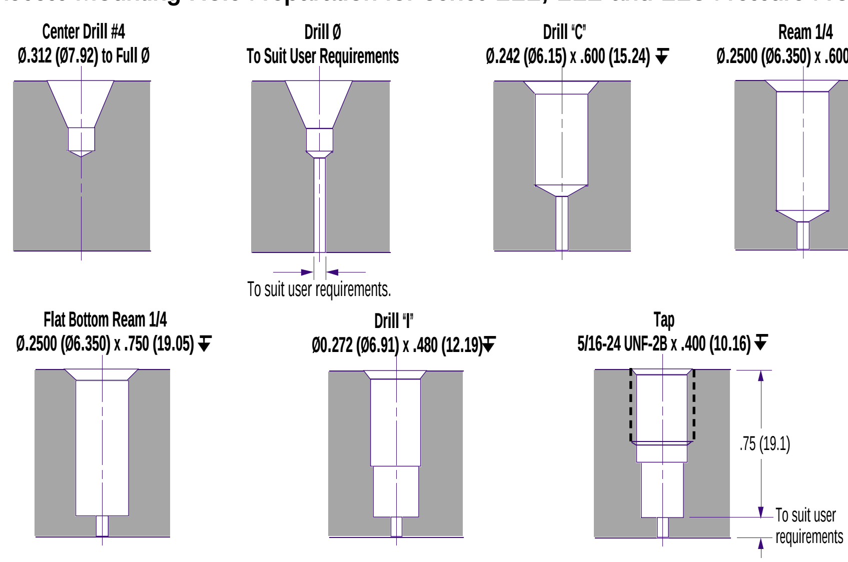
Tool Required:		
Center Drill	#4	(0.312 dia)
Drill	“C”	(0.242 dia)
Ream	“1/4”	(0.250 dia)
Flat Bottom Ream	“1/4”	(0.250 dia)
Drill	“1”	(0.272 dia)
Tap	5/16-24 UNF-2B	

Kit items may be ordered separately. Contact factory for installation drawing for specific model.

Flush Mounting Hole Preparation for Series 111, 112 and 113 Pressure Probes



Recess Mounting Hole Preparation for Series 111, 112 and 113 Pressure Probes



Installation Preparation & Accessories

THIS SECTION IS FOR REFERENCE ONLY. BEFORE PREPARING A MOUNTING HOLE, CONTACT PCB FOR A CURRENT INSTALLATION DRAWING.

Installation Kit Model 040A20 (for Series 108, 118, 109 and 119 Ballistic Pressure Sensors) Kit includes all tooling listed below.

Flush Mounting Installation
Tools Required:

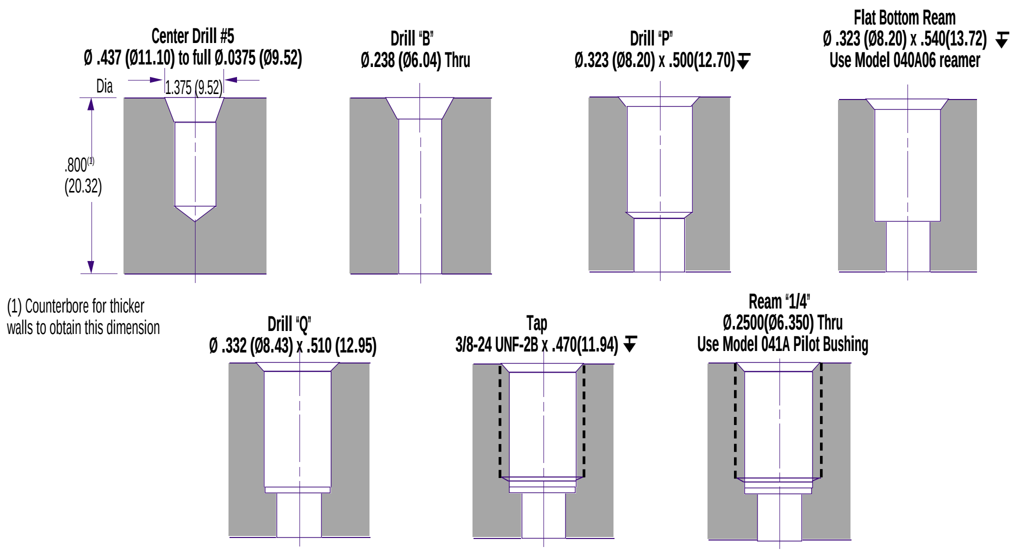
Center Drill	#5	(0.437 dia)
Drill	"B"	(0.238 dia)
Drill	"P"	(0.323 dia)
Flat Bottom Ream		(0.323 dia)(2)
Drill	"Q"	(0.332 dia)
Tap	3/8-24 UNF-2B	
Ream	"1/4"	(0.250 dia) (1)

Recess Mounting Installation
Tools Required:

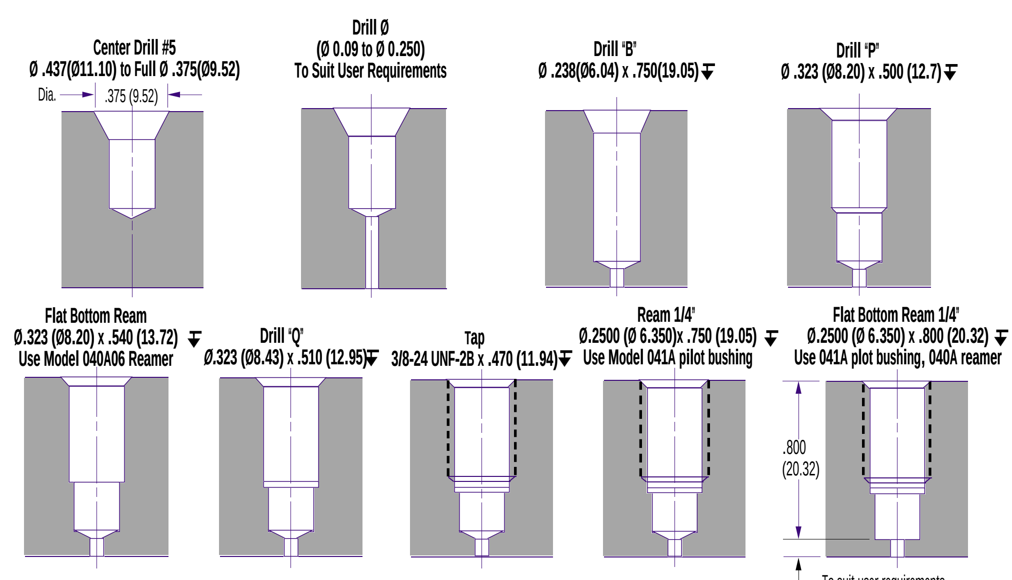
Center Drill	#5	(0.437 dia)
Drill	"B"	(0.238 dia)
Drill	"P"	(0.323 dia)
Flat Bottom Ream(1)		(0.323 dia)(3)
Drill	"Q"	(0.332 dia)
Ream	"1/4"	(0.250 dia)
Tap	3/8-24 UNF-2B	
Flat Bottom Ream (2)		(0.323 dia)

(1) Model 041A Pilot Bushing, (2) Model 040A06, (3) Model 040A
Kit items may be ordered separately. Contact factory for installation drawing for specific model.

Flush Mounting Hole Preparation for Series 108, 118, 109 and 119 Ballistic Sensors



Recess Mounting Hole Preparation for Series 108, 118, 109 and 119 Ballistic Sensors

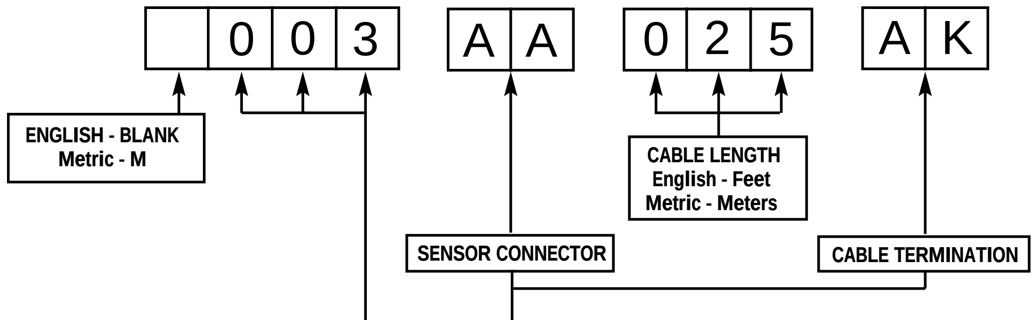


Custom Cable Ordering Guide

TO ORDER CUSTOM CABLES:

1. First designate whether the cable shall be ordered in English or Metric units.
2. Choose the desired cable. (See pages 66 and 67 for cable specifications.)
3. Find the connector that mates to the sensor. (See page 68 for connector outline drawings.)
4. Determine the length of cable required.
5. Choose the cable termination connector. (See page 68.)
6. Fill the squares with appropriate letter or number designation:

EXAMPLE BELOW: 25 ft low-noise cable with 10-32 plug connection to the sensor. The cable terminates in a right angle 10-32 plug.



STANDARD CABLE TYPES

NO.	COAXIAL
002	General purpose white (392°F/200°C)
003	Blue low noise/high temp. (550°F/288°C)
004	Industrial Teflon, high temp. (392°F/200°C)
005	Ruggedized 002 type (275°F/135°C)
006	Ruggedized 003 type (275°F/135°C)
012	General purpose RG-58/U (140°F/60°C)
015	Neoprene jacketed (225°F/107°C)
018	Lightweight black (221°F/105°C)
025	Ruggedized Tefzel jacketed (390°F/199°C)
030	Blue miniature, low noise (400°F/204°C)
033	Underwater, polyurethane (250°F/121°C)
	TWISTED/SHIELDED PAIR
024	Industrial, polyurethane (250°F/121°C)
020	High temperature Teflon (392°F/200°C)
032	General use, lightweight (400°F/204°C)
	MISCELLANEOUS
007	2-conductor red/black ribbon (176°F/80°C)
014	Coiled 2-conductor, 8 ft only (176°F/80°C)
031	Twisted pair, red/white Teflon (400°F/204°C)
035	Mini, red/black twisted pair (400°F/204°C)
	HARDLINE
008	SiO_2Dielectric (1 500°F/816°C) 26 pF/ft
027	MgO Dielectric (1 500°F/816°C) 66 pF/ft
028	SiO_2 Dielectric (1 500°F/816°C) 15 pF/ft
029	SiO_2 Dielectric(1 500°F/816°C) 27 pF/ft

The combination of cables and connectors listed are only recommended configurations; other configurations may be available.
Consult PCB before ordering. See cable and connector descriptions on page 66 thru 68.

STANDARD CONNECTOR TYPES

LETTER	CONNECTOR	RECOMMENDED CABLES
	10-32 Coaxial	
AA	10-32 coaxial plug (standard)	030,033,Groups 1, 3
AW	10-32 coaxial solder adaptor plug (repairable)	007, 031, 035
AH	10-32 coaxial plug (wire lock hex)	Groups 1 & 3
AK	10-32 coaxial plug (right angle)	Groups 1 & 3
AL	10-32 coaxial jack (standard)	Groups 1 & 3
	5-44 COAXIAL	
AG	5-44 coaxial plug (standard)	030, Groups 1 & 3
AF	5-44 coaxial plug (right angle)	Groups 1 & 3
CX	5-44 coaxial jack (standard)	Groups 1 & 3
	"LOCKING"	
AB	BNC jack	Groups 1, 2 & 3
AC	BNC plug	Groups 1, 2, 3 & 5
AQ	TBNC plug (2-pin)	020, 024, 032
AR	TBNC jack (2-pin)	020, 024, 032
AT	TNC plug (threaded)	012, 015, 033
AU	TNC jack (threaded)	012, 015, 033
	INDUSTRIAL	
AE	Environmentally Sealed 2-pin MS3106	004, 012, 024
AM	2-pin military style (MS3106)	Groups 1, 2 & 5
AP	2-pin military style (MS3106) w/strain relief	Group 2
	MISCELLANEOUS	
AD	Pigtail (no connector)	All
AS	Spade lug (specify size)	All (except Group 4)
AO	Integral hardline weld to sensor (consult PCB)	Group 4
AZ	Conhex plug	004

Group 1: 002, 003, 005, 006, 018, 025
Group 2: 004, 012, 020,024,033
Group 3: 010, 034,059 (Terminates in three 6 inch (15cm) 002 cables with specified connector).
Group 4: 008, 027, 028, 029
Group 5: 014, 015

Standard Cables

STOCK CABLES ARE AVAILABLE FOR QUICKEST DELIVERY!

The following pages list stock cables that are generally available for overnight delivery. Should your application require a cable not shown, consult the Custom Cable Ordering Guide on page 63 for ordering information.

Series 002- General Purpose White Coaxial

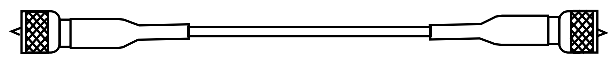
General purpose coaxial cable with an extruded waterproof Teflon insulation jacket: 29 pF/ft cable capacitance, 400°F (204°C) maximum temperature, 0.071 inch (1,8 mm) cable diameter. Suitable for most ICP® sensor applications.

Series 003- Low-noise Blue Coaxial

High-temperature, low-noise cable with Teflon-wrapped insulation. Internal lubricant reduces noise induced by cable motion: 29 pF/ft , 550°F (288°C) maximum temperature, 0.079 inch (2,0 mm) diameter. For use with charge or ICP sensors.

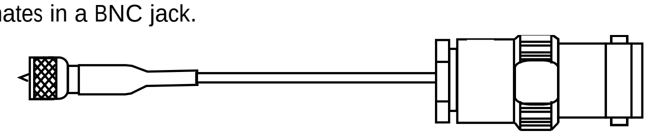
Standard 10-32 coaxial plug for connection to the sensor and terminates in a standard 10-32 coaxial plug.

Length	Coaxial Model No.	Low-Noise Model No.
1 ft (0,3m)	— —	003A01
3 ft (0,9m)	002A03	003A03
5 ft (1,5m)	002A05	003A05
10 ft (3,0m)	002A10	003A10
20 ft (6,1m)	002A20	003A20
30 ft (9,1m)	002A30	003A30
50 ft (15,2m)	002A50	— —



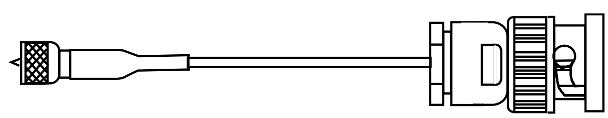
Standard 10-32 coaxial plug for connection to the sensor and terminates in a BNC jack.

Length	Model No.	Model No.
1 ft (0,3m)	002B01	003B01
3 ft (0,9m)	002B03	003B03



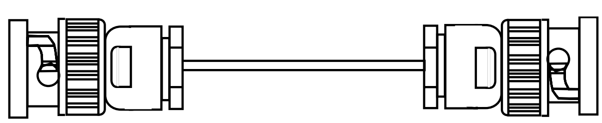
Standard 10-32 coaxial plug for connection to the sensor and terminates in a BNC plug.

Length	Model No.	Model No.
3 ft (0,9m)	002C03	003C03
5 ft (1,5m)	002C05	003C05
10 ft (3,0m)	002C10	003C10
20 ft (6,1m)	002C20	003C20
30 ft (9,1m)	002C30	003C30



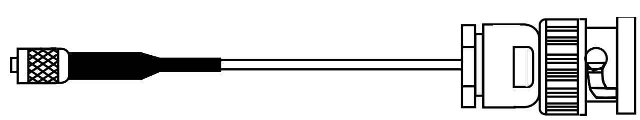
BNC plug to BNC plug extension cable.

Length	Model No.	Model No.
3 ft (0,9m)	002T03	003D03
10 ft (3,0m)	002T10	003D10
20 ft (6,1m)	002T20	003D20



Standard 5-44 coaxial plug for connection to the sensor and terminates in a BNC plug.

Length	Model No.	Model No.
3 ft (0.9m)	002P03	003P03
5 ft (1,5m)	002P05	003P05
10 ft (3,0m)	002P10	003P10
20 ft (6,1m)	002P20	003P20
30 ft (9,1m)	002P30	003P30



Other cables should be ordered according to the Custom Cable Ordering Guide on page 63.

Series 007- 2-CONDUCTOR RIBBON

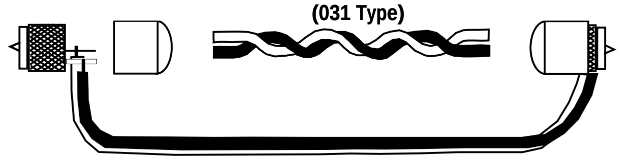
Flexible, 2-conductor ribbon cable (AWG 30) with red/black PVC insulation: 10 pF/ft, 176°F (80°C) maximum temperature. Single strand diameter 0.028 inch (0,71 mm). Excellent for high-shock applications with ICP® sensors. User-repairable.

Series 031 - 2-CONDUCTOR TWISTED PAIR

Flexible, 2-conductor twisted pair (AWG 30) with red/white Teflon insulation: 7 pF/ft, 400°F (204°C) maximum temperature. Single strand diameter 0.03 inch (0,8 mm). Excellent for high-shock applications with ICP sensors. User-repairable.

10-32 coaxial solder adaptor for connection to sensor and terminates in 10-32 coaxial solder adaptor.

Length	Model No.	Model No.
5 ft (1,5 m)	007A05	031A05
10ft (3,0 m)	007A10	031A10
20ft (6,1 m)	007A20	031A20



Series 018- LIGHTWEIGHT COAXIAL

Lightweight coaxial cable with black vinyl insulation jacket: 48 pF/ft cable capacitance, 221°F (105°C) maximum temperature, 0.051 inch (1,3 mm) cable diameter. For use with miniature ICP sensors to reduce cable strain.

Standard 5-44 coaxial plug for connection to the sensor and terminates in a BNC plug.

Length	Model No.
3 ft (0,9m)	018C03
5 ft (1,5m)	018C05
10 ft (3,0m)	018C10
20 ft (6,1m)	018C20
30 ft (9,1m)	018C30

Standard 5-44 coaxial plug for connection to the sensor and terminate a standard 10-32 coaxial plug.

Length	Model No.
3 ft (0,9m)	018G03
5 ft (1,5m)	018G05
10 ft (3,0m)	018G10
20 ft (6,1m)	018G20
30 ft (9,1m)	018G30

Series 012- STANDARD BLACK COAXIAL

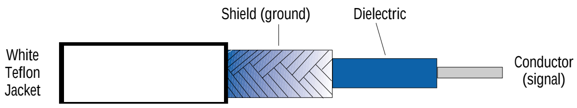
Low-cost, black coaxial cable (RG-58/U) similar to standard television cable: 29 pF/ft capacitance, 140°F (60°C) maximum temperature, 0.195 inch (4,95 mm) cable diameter. Ideal for transmitting low-impedance signals over long cables.

BNC plug to BNC plug extension cable.

Length	Model No.
3 ft (0,9m)	012A03
10 ft (3,0m)	012A10
20 ft (6,1m)	012A20
50 ft (15,2m)	012A50

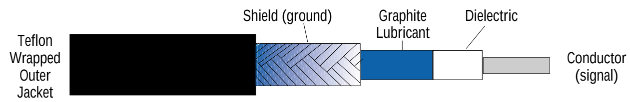
Cable Descriptions

002 - GENERAL PURPOSE WHITE COAXIAL



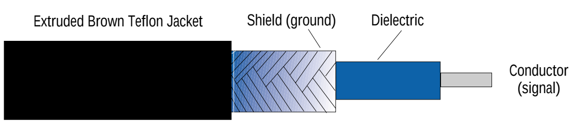
002 CABLE: General purpose, white coaxial cable with waterproof, extruded Teflon jacket: 29 pF/ft, 400°F (204°C) max. temperature, 0.071 inch (1,8mm) diameter. Suitable for ICP sensor applications.

003 - BLUE LOW-NOISE/HIGH-TEMPERATURE COAXIAL



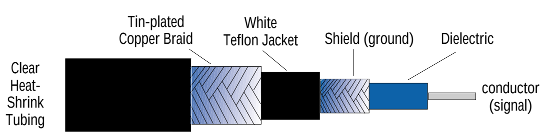
003 CABLE: Blue low-noise, high-temperature coaxial cable with Teflon-wrapped insulation jacket: 29 pF/ft, 550°F (288°C) maximum temperature, 0.079 inch (2,0mm) cable diameter. Recommended for use with either ICP or charge mode piezoelectric sensors.

004 - INDUSTRIAL HIGH-TEMPERATURE COAXIAL



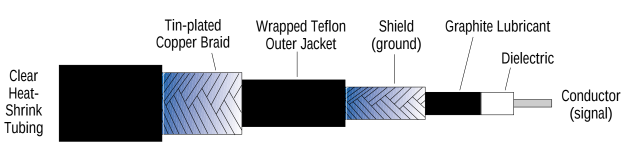
004 CABLE: Industrial coaxial cable with extruded waterproof, brownTeflon insulation jacket: 15 pF/ft, 392°F (200°C) maximum temperature, 0.140 inch (3,6mm) cable diameter. For use with ICP sensors in high temperature or corrosive industrial environment.

005 - RUGGEDIZED 002-TYPE COAXIAL CABLE



005 CABLE: Ruggedized, 002 cable with tin-plated copper braid and heat-shrink tubing: 29 pF/ft, maximum temperature 275°F (135°C), 0.089 inch (2,3mm) diameter. For use with ICP sensors.

006 - RUGGEDIZED 003-TYPE COAXIAL CABLE



006 - CABLE: Ruggedized 003 low-noise cable with tin-plated copper braid and heat-shrink tubing: 29 pF/ft, maximum temperature 275°F (135°C), 0.103 inch (2,62mm) diameter. Recommended for charge mode or ICP sensors requiring a durable cable.

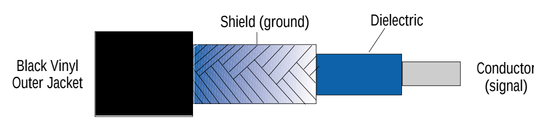
007 - LIGHTWEIGHT 2-CONDUCTOR RIBBON CABLE

007 - CABLE: Lightweight, flexible, 2-conductor ribbon cable (AWG 30) with red/black PVC insulation: 10 pF/ft, max. temp. 176°F (80°C), 0.028 inch (0.71 mm) single strand diameter. Use with 10-32 solder adaptor plug, “W” Suitable for use with ICP sensors. User-repairable.

008 - SILICON DIOXIDE HARDLINE CABLE

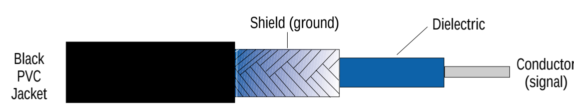
008 - CABLE: Hardline coaxial cable with Inconel 600 outer jacket and SiO_2 Dielectric: 26 pF/ft, max. temp. 1500°F (816°C), 0.125 inch (3,18mm) diameter. Low-cost cable for use with charge mode or ICP sensors when running cable through high-temperature environments.

012 - STANDARD RG-58/U COAXIAL CABLE



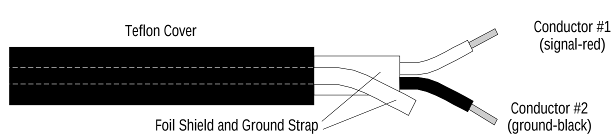
012 - CABLE: Standard RG-58/U coaxial cable with a polyethylene dielectric and black vinyl insulation jacket: 29 pF/ft, max. temperature 140°F (60°C), 0.195 inch (4,95mm) cable diameter. For use as standard extension cable with low-impedance signals.

018 - MINIATURE, LIGHTWEIGHT COAXIAL



018 CABLE: Lightweight, flexible coaxial cable with PVC insulation jacket: 48 pF/ft, 221°F (105°C) max temperature, 0.051 inch (1,3 mm) diameter. Generally for use with 5-44 coaxial connectors on miniature ICP sensors.

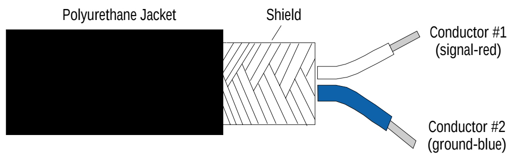
020-HIGH-TEMPERATURE, TWISTED SHIELDED PAIR



020 - CABLE: Twisted shielded pair covered with Teflon insulation jacket: 78 pF/ft, max temperature 392°F (22°C), 0.16 inch (4,06mm) diameter. For use with ICP sensors in high RFI and EMI environments. 100% foil shield.

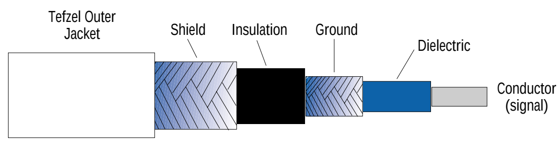
Cable Descriptions

024 - STANDARD INDUSTRIAL, TWISTED SHIELDED PAIR



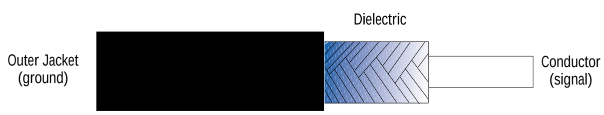
024-CABLE: Polyurethane-jacketed, twisted shielded pair: 31 pF/ft, 250°F (121°C), maximum temperature, 0.25 inch (6,35mm) cable diameter. For use with industrial, ruggedized ICP® sensors in factory environments where RFI and EMI are present.

025 - SHIELED TEFZEL-JACKETED COAXIAL



025-CABLE: White RG178 coaxial with rugged Tefzel® outer insulating jacket: 37 pF/ft, 390°F (199°C), maximum temperature, 0.116 inch (2,95mm) diameter. For use with ICP sensors in industrial or Teflon-prohibitive environments.

027, 028 AND 029 - HARDLINE CABLES

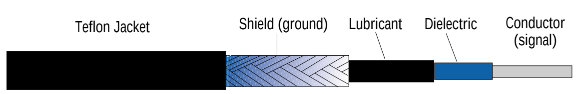


027-CABLE: ARI Hardline coaxial cable with Inconel 600 outer MgO dielectric: 17pF/ft, maximum temperature 1500°F (816°C), 0.125 inch (3,18mm) diameter. Use with standard ICP sensors when running cables through extremely high-temperature environment.

028 - CABLE: Hardline coaxial cable with an Inconel 600 outer conducting jacket, SiO_2 dielectric: 15 pF/ft, maximum temperature 1 500 °F (816°C), 0.125 inch (3,18mm) diameter. For running high-quality, low-or high-impedance signals through high-temperature environments.

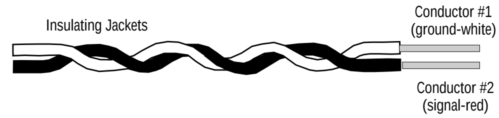
029 - CABLE: Hardline coaxial cable, 304 stainless steel outer jacket, SiO_2 dielectric: 27 pF/ft nominal, maximum temperature 1 500°F (816°C), 0.125 inch (3,18mm) diameter. For running high-quality, low-or high-impedance signals through high-temperature environments.

030- MINIATURE, LOW-NOISE COAXIAL



030-CABLE: Blue low-noise, miniature coaxial cable: 30 pF/ft, maximum temperature 400°F (204°C), 0.031 diameter (0,79mm). Use with either charge of ICP sensors requiring a miniature, lightweight cable.

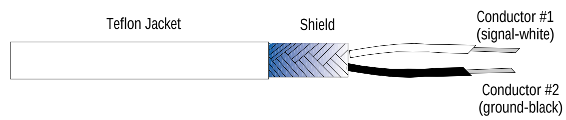
031- RED/WHITE TWISTED PAIR



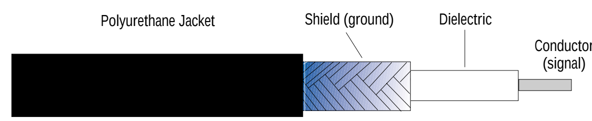
031-CABLE: Red/white two-conductor, twisted pair (AWG 30) with Teflon insulation: 7 pF/ft, maximum temperature 400°F (204°C), 0.03 inch (0,8mm) single diameter. Use with the repairable 10-32 solder connector adaptor “AW”. Suitable for use with ICP sensors.

032 - TWISTED SHIELDED, GENERAL USE 2-CONNECTOR

032 - CABLE: General purpose, twisted, shielded, 2-conductor cable with Teflon jacket: 20pF/ft, 400°F (204°C) maximum temperature, 0.075 inch, (1,9mm) diameter. Use with case-isolated sensors.

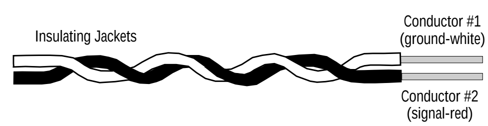


033- POLYURETHANE-JACKETED COAXIAL



033-CABLE: Polyurethane-jacketed coaxial cable: 26 pF/ft, 250°F (121°C) maximum temperature, 0.115 inch (2,9mm) diameter. Suitable for long term underwater testing applications with ICP sensors.

035- MINIATURE RED/BLACK TWISTED PAIR

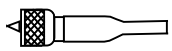


035-CABLE: Miniature red/black twisted pair (AWG 36) with Teflon insulation: 10pF/ft, maximum temperature 400°F (204°C), 0.012 inch (0,3mm) single strand diameter. Use with the user-repairable 10-32 solder connector adaptor “AW”. Suitable for use with ICP sensors.

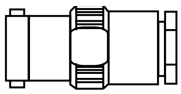
Connector Descriptions

See the catalog cable ordering guide on page 63 to determine cable connector compatibility.
Standard connectors are listed below:

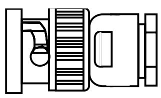
AA.
10-32 Coaxial Plug
(standard)



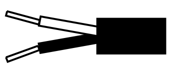
AB. BNC Jack
(standard)



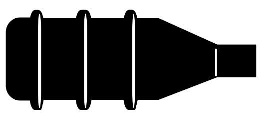
AC. BNC Plug
(standard)



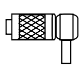
AD. Pigtail
(leads stripped
and tinned)



AE. Environmentally Sealed
Connector
(2-pin MS3106)

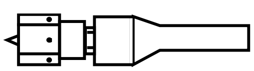


AF. 5-44 Coaxial Plug
(right angle)



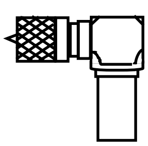
AG. 5-44 Coaxial Plug
(standard)

AH. 10-32 Coaxial Plug
(wire-locking hex)



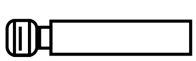
CX. 5-44 Coaxial Jack
(standard)

AK. 10-32 Coaxial Plug
(right angle)

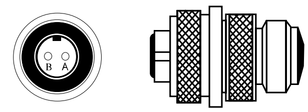


AL. 10-32 Coaxial Jack
(standard)

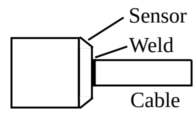
CC. 10-32 Coaxial Jack
Hardline for 008, 027,
028, 029 cable



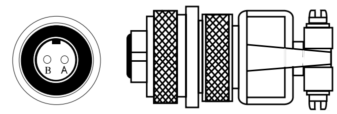
AM. 2-pin Military Style
(MS3106)



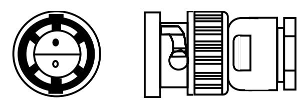
AO. Integral Hardline Weld
to Sensor
(consult PCB)



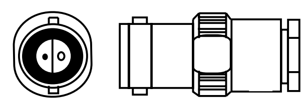
AP. 2-pin Military Style
(MS3106) with
strain relief



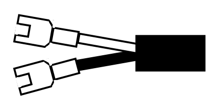
AQ. TBNC Plug
(2-pin)



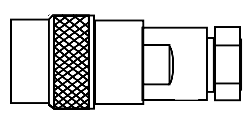
AR. TBNC Jack
(2-pin)



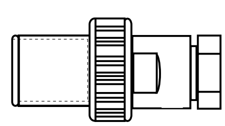
AS. Spade Lug
(specify lug size)



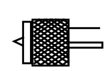
AT. TNC Plug
(threaded)



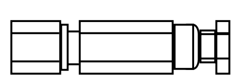
AU. TNC Jack
(threaded)



AW. 10-32 Solder Adaptor
(user-repairable)



AZ. Conhex Plug



Connector Adaptors

070A01

SCOPE INPUT T CONNECTOR: BNC plug to two 10-32 coaxial jacks. Used for splitting low-impedance signals.

070A05

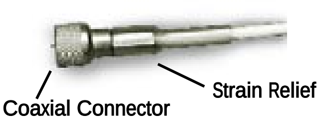
10-32 COAXIAL FEED-THRU CONNECTOR: 10-32 coaxial jack to 10-32 coaxial jack. Joins two cables terminating in 10-32 coaxial plugs.

070A11

BNC T CONNECTOR: BNC plug to two BNC jacks. Used as a cable splitter.

070A14

10-32 HERMETIC FEED-THRU: 10-32 coaxial jack to 10-32 coaxial jack. Tapped 5/16-32.



076B06 and 076B07

076B06 10-32 COAXIAL CONNECTOR: Microdot connector crimp-on type. Requires tool contained in 076B31 kit.

076B07 CABLE STRAIN RELIEF: For 076B06 microdot connectors.

MODEL 076B31 MICRODOT CRIMP-ON CONNECTOR KIT: Includes 1 pin crimping tool, 1 sleeve-crimping tool, and 20 Model 076B06/B07 connectors/cable strain relief's. (Tools not shown) (Wire stripper and soldering iron not included).

070A02

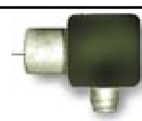
SCOPE INPUT ADAPTOR: 10-32 coaxial jack to BNC plug. For adapting BNC connectors for use with 10-32 coaxial plugs.

070A08

CABLE ADAPTOR: 10-32 coaxial jack to BNC jack. Joins cables terminating in a BNC plug and a 10-32 coaxial plug.

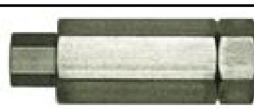
070A12

BNC COUPLER: BNC jack to BNC jack. Joins two cables terminating in BNC plugs.

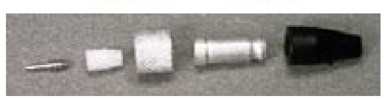


070A20

10-32 COAXIAL RIGHT ANGLE CONNECTOR ADAPTOR: 10-32 Coaxial jack to 10-32 coaxial plug. For use in confined locations.



076A25



076A05

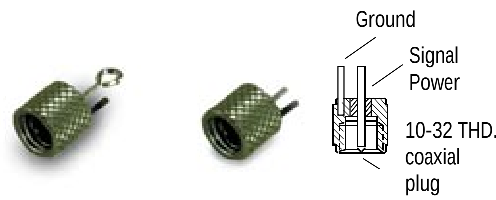
076A05 10-32 COAXIAL PLUG: Microdot connector screw-on type.

076A25 CONNECTOR TOOL: Used to install 076A05 screw-on type microdot connector.

MODEL 076A30 MICRODOT SCREW-ON CONNECTOR KIT: One Model 076A25 Tool and 20 Model 076A05 10-32 coaxial connectors for emergency repair of 002 or 003 type cables.

070A03

CONNECTOR ADAPTOR: 10-32 coaxial plug to BNC jack. Converts 10-32 connectors for use with BNC plugs.

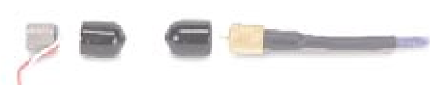


070A09 070B09

SOLDER CONNECTOR ADAPTORS: 10-32 coaxial plug to solder terminals. Excellent for high-shock applications. User-repairable.

070A13

FEED-THRU ADAPTOR: 10-32 coaxial jack to BNC jack. Bulkhead connects BNC plug to 10-32 coaxial plug.



085A18

PLASTIC PROTECTIVE CAP: Provides strain relief for solder connector adaptors, as well as protects cable ends.

085A40

10-32 COAXIAL GROUNDING CAP: Used to short charge mode sensors during storage and transportation.

Signal Conditioners

ICP® sensor signal conditioners provide the necessary constant current excitation voltage to ICP sensors and decouple the sensor bias voltage from the output. A wide selection of signal conditioners are available with battery or line power, with or without gain, in single or multi-channel configurations, and with manual or computer controlled operation.

BATTERY-POWERED SIGNAL CONDITIONER

Battery signal conditioners provide 27 volt, 2 mA constant-current power to ICP sensors. Features include the color-coded circuit check-out meter, a battery test button, and inputs for both an external battery source and a rechargeable battery option. Unity gain and selectable gain units are available.

480C02 Unity gain
480E09 Selectable gain of x1, x10 or x100

To specify recharge option, add prefix “R” to the model number (e.g., R480C02 indicates a Model 480C02 Signal Conditioner supplied with model 488A02 battery charger and three 9-volt NICAD batteries.

Power units have either a color-coded circuit check-out meter or LEDs for monitoring bias voltage on the signal lead. On the check-out meter, green indicates normal operation, red indicates a short, and yellow indicates an open circuit. Single-channel power units are available in sensor kits, complete with the pressure sensor of your choice, ready to connect and operate. These kits are provided ready to connect and operate. See page 74 for detailed information on sensor kits.

480C02

480E09

LINE-TYPE ICP® SENSOR SIGNAL CONDITIONER

AC-type conditioners power ICP low-impedance sensors and couple them to readout instruments. Output current is adjustable from 2 to 20 mA. The higher current is an advantage when driving high-frequency sensor signals over long cables (more than 100 ft.). Line-power units are factory set at 4 mA, which is adequate for most applications.

482A21 Single channel, unity gain, low noise, CE marked
482A22 Four channel, unity gain, low noise, CE marked
442A02 Single channel, gain x1, x10 or x100, low noise, CE marked
482B11 Single channel, gain x1, x10 or x100
442A04 Four channel, gain x1, x10 or x100, low noise, CE marked
482A16 Four channel, gain x1, x10 or x100, overload and fault lights
482A17 Four channel, gain x1, x10 or x100, 4-1 switchable output to one BNC jack
442A06 Single channel, gain x1, x10 or x100, AC/DC selectable, low noise, CE marked
482A18 Eight channel, gain x1, x10 or x100, 8-1 switchable output to one BNC jack, overload and fault lights

To specify operation from 220-volts, add prefix “F” to the model number (e. g., F482A16 indicates a Model 482A16 Signal Conditioner with 220-volt power operation).

482A21 482A22

482A16

442A06

MULTICHANNEL SIGNAL CONDITIONER MODEL 481A02

For powering piezoelectric ICP® sensors, this signal conditioner provides an effective method for managing large numbers of sensor channels. Standard features include gain of x1, x10 and x100 with autoranging and RS232 and RS485 computer-control interface. Additionally, LED indicators monitor normal and faulty operation as well as overload conditions. Power to the sensors is in the form of a 24 VDC, 4mA (adj. from 2 to 20 mA) constant current excitation. Sixteen BNC output jacks are also located on the front panel and 16 BNC input jacks/multipin input/output connectors on the rear panel.

481A02

LABORATORY-STYLE CHARGE AMPLIFIERS

The basic function of a laboratory charge amplifier is to convert the high-impedance charge from a piezoelectric sensor into a low-impedance voltage signal compatible with readout instruments. Signal normalization and gain adjust features allow the user to take advantage of the very wide dynamic range of a piezoelectric sensor.

BASIC "DIAL SENSITIVITY" CHARGE AMPLIFIER

Model 462A is an economically priced multi-range charge amplifier designed for use with quartz and ceramic piezoelectric sensors.

This unit has 11 selectable ranges from 5 to 1000 000 pC, accommodating very large inputs from high-range quartz pressure sensors. The sensitivity dial is adjustable for sensors in 0.1 to 1.1 pC range, which matches most quartz pressure sensors. Sensor sensitivities greater than 1.1 pC/psi can be accomodated. A rear panel CAL INPUT provides for checking range and sensitivity settings. Other features include a switch-type ground to prevent ESD damage when connecting long cables. A three-position time constant switch can be set on "Long" for static calibration and quasi-static measurements, "Medium" for drift-free dynamic operation, and "Short" for use with ceramic sensors.

Options include plug-in filters, a remote ground relay, and rack mounting.

DUAL MODE CHARGE AMPLIFIERS

Models 463A and 464A operate with charge mode piezoelectric sensors and provide a current source for coupling to ICP® voltage mode sensors.

Model 463A is a multi-range "Dial-Cal" charge amplifier similar to the Model 464A with many of the same features. The significant operational differences of model 463A are the built-in calibration features and ranges expressed in psi, g, or lb *Full Scale,* instead of *units per volt.*

Model 464A is multi-range "Dial-Sensitivity" model similar to the Model 462A described above. Operation simply involves switching to the "Charge" or "ICP" mode, dialing in the sensor sensitivity, and switching to the desired range, which reads in units per volt. Plug-in filters, calibration input, and remote ground are standard features.

PCB charge amplifiers have a three-position selectable input time constant (TC) switch. The long TC position allows for static calibration of quartz sensors as well as quasi-static measurements in thermally stable environments; the medium TC provides for drift-free dynamic operation; and the short TC position is used for operation with ceramic-type sensors.

See the *PCB Electronics for Piezoelectric Sensors* catalog for complete information on these products.

462A

463A

MODEL 462B52 LABORATORY-STYLE BALLISTICS CHARGE AMPLIFIER

Designed for use with quartz ballistic sensors, this laboratory-style charge amplifier features a digital dial switch for inputting sensor sensitivity and standardizing the signal sensitivity at 10 000 psi/volt. Other features include: manual or remote grounding, a built-in calibration capacitor, and a three-position discharge time constant switch.

Model 462B52

SYSTEMS 400A20 AND 400A21 AMMUNITION TESTING MONITOR

This Ammunitions Testing Monitor combines a Ballistics Charge Amplifier and a Model 451A07 Digital Peak Meter conveniently packaged together for conducting automated testing of ammunition. **System 400A20** utilizes a Model 462B52 Charge Amplifier standardized at 10 000 psi/volt, while **System 400A21** utilizes a Model 462B53 Charge Amplifier standardized at 1000 MPa/volt.

The charge amplifier portion converts the high-impedance signal from a quartz, charge mode ballistic pressure sensor into a low-impedance voltage signal compatible with readout instruments. The digital ballistics charge amplifier standardizes the measuring system sensitivity by setting the sensor sensitivity on the easy-to-read digital switch. Resetting or zeroing can be accomplished manually or remotely. Other features of this charge amplifier include an external calibration jack and a three-position discharge time constant switch for static-pressure sensor calibration.

Model 451A07 Digital Peak Meter prominently displays the peak voltage or operates in standard digital voltmeter mode. As implemented in the Model 400A20 or 400A21 Testing Monitor System, these values directly correlate to the peak pressure. Additional features of the meter include a DC offset adjustment, range switching, and manual, remote, or automatic resetting. An output jack is provided for connection to an oscilloscope or analyzer.

Specify Models F400A20 or F400A21 (the system model number with an “F” prefix) for optional operation with 210 to 250 VAC power.

Each of the units, Models 462B52, 462B53, and 451A07 may be purchased separately. They operate from 100 to 130 VAC power.

Model 400A20

IN-LINE CHARGE AND VOLTAGE AMPLIFIERS

Operate with charge output sensors and constant-current signal conditioners over standard coaxial cable. Compared to expensive laboratory-style charge amplifiers, in-line models increase signal-to-noise ratio, improve resolution, simplify operation, and substantially lower cost per channel.

422D11 In-line, low-noise charge converter, 100 mV/pC

422D12 In-line, low-noise charge converter, 10 mV/pC

422D13 In-line, low-noise charge converter, 1 mV/pC

High resolution 422E Series is also available.

Series 422D

CONNECTOR AND IN-LINE VOLTAGE FOLLOWERS

The **Series 401 and 402** act as a voltage amplifier to convert the high-impedance output from charge mode sensors to a low-impedance non-inverting voltage signal compatible with readout instruments when coupled with an ICP® signal conditioner. Series 401 Impedance Converters attach directly to the 10-32 coaxial jack on most sensors. Series 402 Voltage Followers connect to the sensor in line, over a short, low-noise input cable.

401A	Impedance Converter connects to 10-32 Jack
402A	Source follower connects in line through a short length of low-noise cable, converts to low-impedance signal, 5pF
402A02	In-line Voltage Follower, 100 pF
402A03	In-line Voltage Follower, 1000 pF

Series 402
(Photo is two times actual size)

To determine the sensitivity (and consequently, the range) of the system, use the law of:

V = Q/C, where V=Voltage Sensitivity (volts/unit)
Q = Charge Sensitivity (pC/unit)
C = Total capacitance of input cable, sensor, and amplifier unit.

Sensor ranging can be accomplished by adding or subtracting capacitance.

ICP® SENSOR SIMULATOR

Model 401A04 consists of a unity gain, non-inverting, impedance-converting voltage amplifier similar to those found in many ICP sensors. When used in conjunction with a signal generator, the electrical characteristics of long cables may be easily determined. Testing long cables is especially important when attempting to measure microsecond response during shock and blast testing.

output

input 401A04

CHARGE CALIBRATION REFERENCE SOURCE

Model 492B03 provides a known charge (pC) or voltage (V) square pulse for calibrating entire measurement systems. This device incorporates a three-position voltage selector switch (0.1, 1.0, 10 volt) and precison attenuator to provide an adjustable voltage pulse from 0 to 10 volts for calibrating low-impedance systems and checking long cables. Engaging high-precision capacitors (100, 1000, and 10 000pF) converts the known voltage level to a charge signal according to: Q = VC. This charge signal provides a means for calibrating charge amplifiers, as well as for determining range and trigger settings. The unit operates from one standard 9V battery and one standard "AA" (1.5V) battery.

492B03

ICP® SENSOR SIMULATOR

Installed in place of an ICP sensor, **Model 492B** provides a total system calibration prior to actual testing. The unit transforms an adjustable internal or external test signal into a simulated sensor signal for calibrating recording systems or tuning long cable lines. It is structured with a square wave oscillator, a precision attenuator, and a line-drive amplifier like those found in ICP sensors.

492B

SUMMATION/DIFFERENTIATION AMPLIFIER

Working in conjunction with a PCB multi Channel Signal Conditioner and PCB pressure sensors, the **Model 490M02** allows exact timing of measurements of a shock wave traveling through a shock tube. The Model 490M02 takes the output from a multichannel ICP Signal Conditioner and differentiates each sensor signal into a sharp peak. The channels are then summed and sent through a single output jack. The resulting consecutive sharp peaks of the pulse may then be fed into a single channel storage scope and accurately measured for time. The Model 490M02 also features a timing pulse output jack to trigger the scope. (Item not shown)

Sensor Kits
For voltage-mode sensors with built-in amplifiers

SENSOR KITS:

Especially for test evaluation, any voltage-mode sensor with built-in amplifier can be supplied in convenient kit form, as illustrated. Packed in a handsome vinyl case, these kits are supplied complete with sensor, signal conditioner, cables, adaptors and accessories ready to connect to your read-out instrument and operate.

Sensor kits are available in a variety of choices with battery or line power, with and without built-in gain. New battery power units feature gain, higher voltage source, 27 volt (extends battery life and dynamic range of many ICP® sensors to full +10V), and an input jack for connecting the Model 073A05 long life (1 year) external battery pack. Options include built-in NICAD batteries and recharger 488A02.

Typical Kit with Sensor, Signal Conditioner, Cables, and Accessories

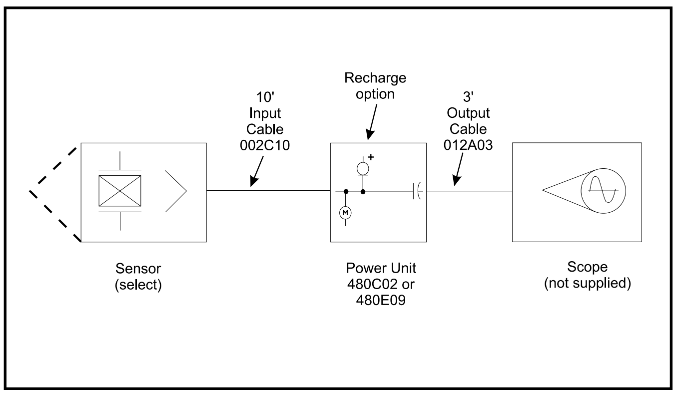
- contains cables, power unit & accessories as shown with specified sensor
- expedites ordering
- simplifies set-up time
- ready to operate
- assures correct power & connections

TO ORDER A BATTERY-POWERED SENSOR KIT:

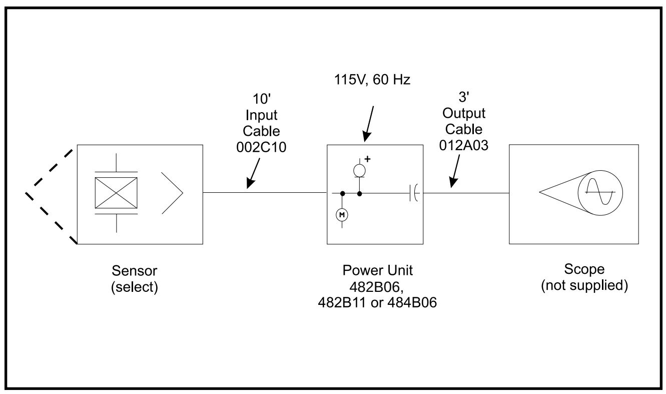
Select the ICP voltage-model sensor of your choice. Add prefix K, KR, GK or GKR in front of sensor model number (eg. K102A) and add kit cost to the sensor price. Specify input cable length if other than 10 feet, up to 50 feet supplied at no additional charge.

TO ORDER A LINE-POWERED SENSOR KIT:

Select the ICP voltage-model sensor of your choice. Add prefix KL, GKL or DKL in front of sensor model number (eg. KL102A) and add kit cost to the sensor price. Specify input cable length if other than 10 feet, up to 50 feet supplied at no additional charge.



Battery-Powered Kit



Line-Powered Kit (105-125 V; 50-60 Hz)
for 220 V option, use prefix F

BATTERY-POWER KITS
Models:

- **K** 480C02 battery power kit, unity gain, BNC input/output
- **KR** 480C02 rechargeable kit with NICAD batteries and 488A02 charger
- **GK** 480E09 battery power kit with gain X1, X10, X100, BNC/BNC
- **GKR** 480E09 rechargeable kit with NICAD batteries and 488A02 recharger

LINE-POWER KITS
Models:

- **KL** 482B06 line power kit, unity gain, BNC input/output
- **GKL** 482B11 line power kit with gain X1, X10, X100, BNC/BNC
- **DKL** 484B06 Line power kit with DC coupling, unity gain, BNC/BNC
- **GDKL** 484B11 line power kit with DC coupling and gain X1, X10, X100, BNC/BNC

SIGNAL CONDITIONER KITS:

When a signal conditioner kit is ordered, add kit prefix to signal conditioner model number (eg. K480C02 is a signal conditioner, input cable and output cable).

CABLE ORDERING INFORMATION:

Model 002C10 Input Cable, 10 foot (10-32 to BNC Plug) and 012A03 output cable, 3 foot (BNC plug to BNC plug) are supplied unless otherwise indicated.

For applications involving sensor cable lengths greater than 100 feet, the line powered "KL" Kits are recommended because of their higher adjustable excitation current supply capacity (2 to 20mA).
Refer to page 82 for information on driving long cables.

Technical Information

INTRODUCTION TO DYNAMIC PRESSURE SENSORS

Piezoelectric Pressure Sensors measure dynamic pressures. They are generally not suited for static pressure measurements. Dynamic pressure measurements including turbulence, blast, ballistics and engine combustion under varying conditions may require sensors with special capabilities. Fast response, ruggedness, high stiffness, extended ranges, and the ability to also measure quasi-static pressures are standard features associated with PCB quartz pressure sensors.

The following information presents some of the design and operating characteristics of PCB pressure sensors to help you better understand how they function, which, in turn, helps you make better dynamic measurements.

TYPES OF PRESSURE SENSORS

This catalog describes two modes of operation for pressure sensors manufactured by PCB. Charge mode pressure sensors generate a high-impedance charge output. ICP® (Integrated Circuit Piezoelectic) voltage mode-type sensors feature built-in microelectronic amplifiers, which convert the high-impedance charge into a low-impedance voltage output. (ICP is a registered trademark of PCB Piezotronics.)

SENSOR CONSTRUCTION

Piezoelectric pressure sensors are available in various shapes and thread configurations to allow suitable mounting for various types of pressure measurements. Quartz crystals are used in most sensors to ensure stable, repeatable operation. The quartz crystals are usually preloaded in the housings to ensure good linearity. Tourmaline, another stable naturally piezoelectric crystal, is used in some PCB sensors where volumetric sensitivity is required.

Figure 1 illustrates the cross-section of a typical quartz pressure sensor. This particular sensor is a General Purpose Series with built-in electronics.

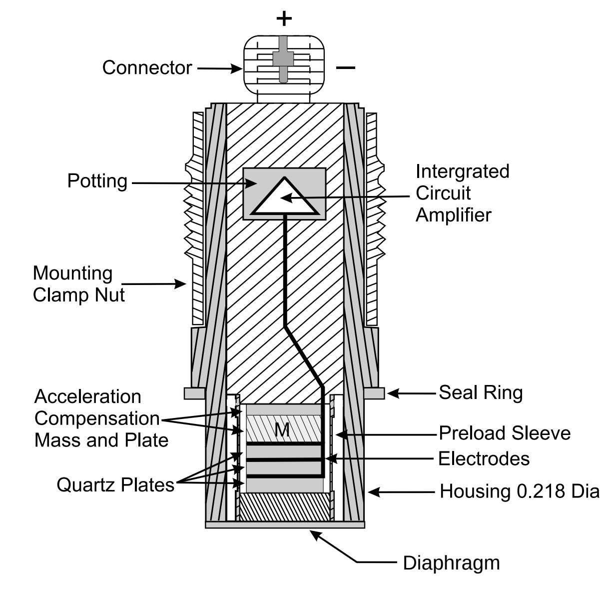


Figure 1. Typical ICP Quartz Pressure Sensor

CHARGE MODE SENSORS

When the crystal is stressed, a charge is generated. This high-impedance output must be routed through a special low-noise cable to an impedance-converting amplifier, such as a laboratory charge amplifier or source follower. High insulation resistances must be maintained in the cables and connections.

The primary function of the charge or voltage amplifier is to convert the high-impedance output to a usable low-impedance voltage signal for recording purposes. Laboratory charge amplifiers provide added versatility for signal normalization, ranging, and filtering. PCB's charge amplifiers have additional input adjustments for quasi-static measurements, static calibration, and drift-free dynamic operation. Miniature in-line amplifiers are generally of fixed range and frequency.

Charge mode quartz pressure sensors may be used at higher temperatures than ICP® sensors, since the temperature limitation is determined by the temperature limit of the crystals (for charge mode sensors) rather than built-in electronics (for ICP sensors).

When considering the use of charge mode systems, remember that the output from the crystals is a high impedance charge. The internal components of the pressure sensor and the external electrical connector maintain a very high (typically 10 e^{13} ohm) insulation resistance. Consequently, any connectors, cables, or amplifiers used must also have a very high insulation resistance to maintain signal integrity.

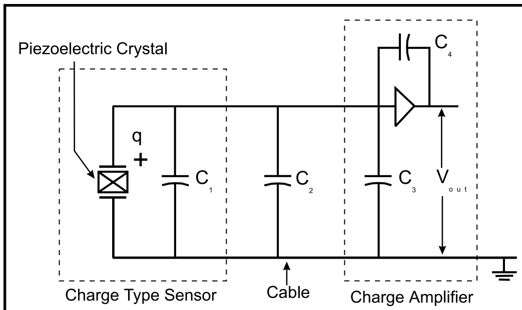


Figure 2. Charge Mode System Schematic

q = charge
C_1 = crystal capacitance
C_2 = cable capacitance
C_3 = amplifier input capacitance
C_4 = feedback capacitor

Figures 2 and 3 show a typical charge amplifier system schematic, including sensor, low-noise cable, and charge amplifier.

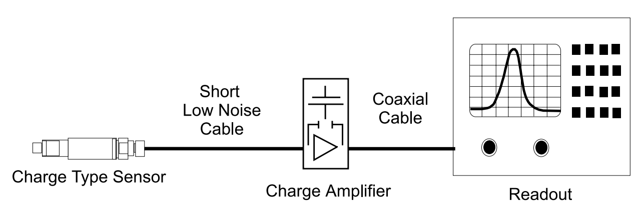


Figure 3. Charge Mode System

Environmental contaminants on the connector, such as moisture, dirt, oil, or grease contribute to reduced insulation, resulting in signal drift and inconsistent results.

Use of special low-noise cable is required with charge mode pressure sensors. Standard, two-wire, or coaxial cable, when flexed, generates a charge between the conductors. This is referred to as triboelectric noise and cannot be distinguished from the sensor's charge output. Low-noise cables have a special graphite lubricant between the dielectric and the braided shield, which minimizes the triboelectric effect and improves the quality of the sensor's charge output signal.

ICP® LOW-IMPEDANCE QUARTZ PRESSURE SENSORS

ICP pressure sensors incorporate a built-in MOSFET microelectronic amplifier to convert the high-impedance charge output into a low-impedance voltage signal. An ICP sensor is powered from a constant-current source and can operate over long coaxial or ribbon cable without signal degradation. The low-impedance voltage signal is not affected by triboelectric cable noise or insulation resistance-degrading contaminants.

Power to operate ICP sensors generally takes the form of a low-cost, 24 to 27 VDC, 2 to 20 mA constant-current supply. ***Figure 4*** schematically illustrates a typical ICP sensor system. PCB offers a number of AC or battery-powered, single or multi-channel signal conditioners, with or without gain capabilities for use with pressure sensors. (See the Related Products Section of this catalog for available models). Some data acquisition systems incorporate constant-current power for directly powering ICP sensors. PCB manufactures DC coupled signal conditioners for use during static calibration or quasi-static measurement applications.

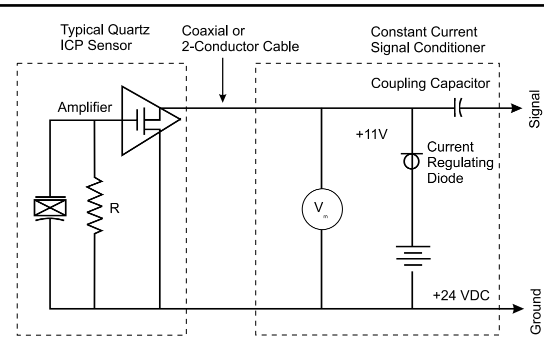


Figure 4. ICP Sensor System Schematic

In addition to ease of operation, ICP® pressure sensors offer advantages over charge mode types in terms of cost per channel, since multi-channel ICP signal conditioners are often available for the cost of a single channel laboratory charge amplifier.

For some severe environments, use of a “hybrid” system, using a charge mode pressure sensor in conjunction with an in-line miniature charge or voltage amplifier and an ICP signal conditioner, can still offer cost savings. ***Figure 5*** shows various complete two-wire system configuration.

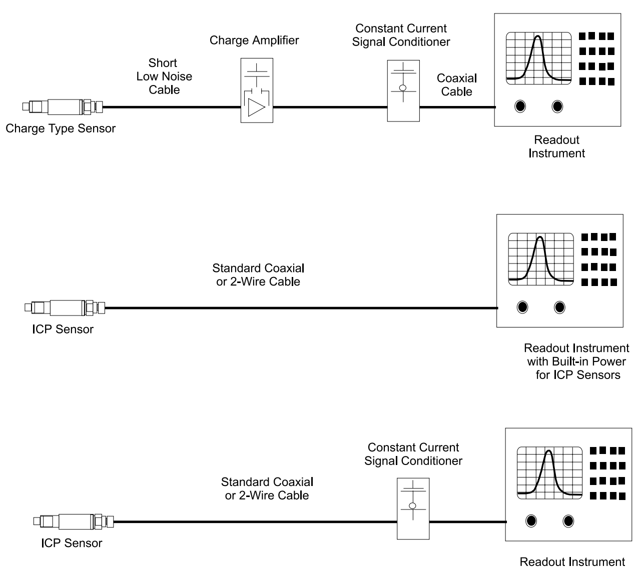


Figure 5. Typical Sensor Systems

POLARITY

When a positive pressure is applied to an ICP pressure sensor, the sensor yields a positive voltage. The polarity of PCB charge mode pressure sensors is just the opposite: when a positive pressure is applied, the sensor yields a negative output. Charge output sensors are usually used with external charge amplifiers that invert the signal. Therefore, the resulting system output polarity of a charge output sensor used with a charge amplifier will produce an output that is the same as an ICP sensor. (Reverse polarity sensors are also available.)

HIGH FREQUENCY RESPONSE

Most PCB piezoelectric pressure sensors are constructed with either compression mode quartz crystals preloaded in a rigid housing, or unconstrained tourmaline crystals. These designs give the sensors microsecond response times and resonant frequencies in the hundreds of kHz, with minimal overshoot or ringing. Small diaphragm diameters ensure spatial resolution of narrow shockwaves.

High-frequency response and rise time can be affected by mounting port geometry and associated electronics. (Limitations of driving long cables at high frequencies are discussed on page 82).

Check all system component specifications before making measurements, or contact PCB for application assistance.

WHY ONLY DYNAMIC PRESSURE CAN BE MEASURED WITH PIEZOELECTRIC PRESSURE SENSORS

The quartz crystals of a piezoelectric pressure sensor generate a charge when pressure is applied. However, even though the electrical insulation resistance is quite large, the charge eventually leaks to zero. The rate at which the charge leaks back to zero is dependent on the electrical insulation resistance.

In a charge mode pressure sensor used with a voltage amplifier, the leakage rate is fixed by values of capacitance and resistance in the sensor, by low-noise cable, and by the external source follower voltage amplifier used. In the case of a charge mode pressure sensor used with a charge amplifier, the leakage rate is fixed by the electrical feedback resistor and capacitor in the charge amplifier.

In a pressure sensor with built-in ICP electronics, the resistance and capacitance of the crystal and the built-in ICP electronics normally determine the leakage rate.

DISCHARGE TIME CONSTANT (DTC)

When leakage of a charge (or voltage) occurs in a resistive-capacitive circuit, the leakage follows an exponential decay. A piezoelectric pressure sensor system behaves similarly. The value of the electrical capacitance of the system (in farads) multiplied by the value of the electrical resistance (in ohms) is called the Discharge Time Constant (in seconds).

DTC is defined as the time required for a sensor or measuring system to discharge its signal to 37% of the original value from a step change of measure. The DTC of a system relates to the low-frequency monitoring capabilities of a system. A long discharge time constant is useful because it allows quasi-static operation during calibration or measurement of certain long-duration pressure pulses.

DTC CHARGE MODE SYSTEM

In a charge mode system, the DTC is usually determined by the settings on an external charge amplifier. PCB Series 460 Charge Amplifiers feature a short, medium, and long time constant switch from which DTC is selected. It is assumed that the electrical insulation resistance is large; otherwise, drift occurs. Therefore, to minimize this drift, the pressure sensor connection point and cable must be kept clean and dry.

LOW-FREQUENCY RESPONSE OF ICP® SYSTEMS

With ICP® sensors, there are three factors that must be considered when making low-frequency measurements.

These are:

1. The discharge time constant characteristic of the pressure sensor.
2. The discharge time constant of the AC coupling circuit used in the signal conditioner with the readout instrument. (If DC coupling is used, only the above [1] needs to be considered.)
3. ICP signal conditioner.

It is important that all factors be readily understood by the user to assure accurate low-frequency measurements.

DTC IN ICP® PRESSURE SENSORS

In PCB pressure sensors featuring built-in ICP electronics, the discharge time constant of the sensor is set at a fixed value by the built-in circuit. Specifications for the ICP pressure sensors shown in this catalog list the DTC for each pressure sensor.

When an ICP sensor is subjected to a step function input, a quantity of charge, Δq, is produced proportional to the mechanical input. Output voltage is $\Delta V = \Delta q/C$ where C is the total capacitance of the sensing element, amplifier, and ranging capacitor. This voltage is then amplified by the MOSFET amplifier to determine final sensor sensitivity. After the initial step input, the charge signal decays according to the equation $\mathbf{q = Qe^{(-t/RC)}}$ where:

- q = instantaneous charge (pC)
- Q = initial quantity of charge (pC)
- R = bias resistor value (ohms)
- C = total capacitance (pF)
- t = time after t_0
- e = base of natural log (2.718)

The equation used to determine signal decay is graphically represented in ***Figure 6***:

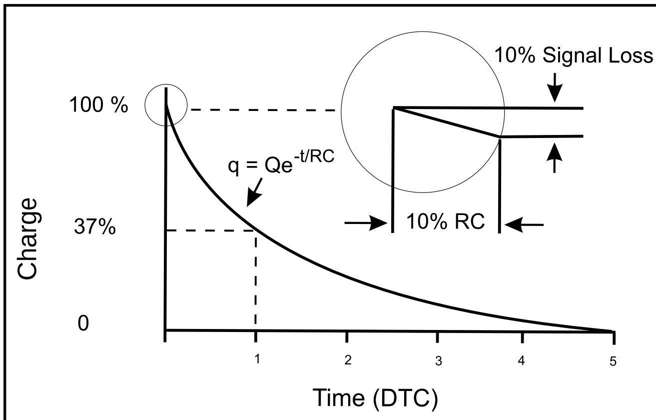


Figure 6. Piezoelectric Signal Exponential Decay

The product of R and C represents the DTC (in seconds) of the sensor. Sensor time constants vary from just a few seconds to >2000 seconds for standard sensors. Special time constants can be supplied by altering the resistor value, R, in the sensor's built-in microelectronic amplifier.

SENSOR/SYSTEM TIME CONSTANT

It is important to determine the discharge time constant (DTC) of an ICP sensor system, as the DTC determines the system's low-frequency response. The DTC of a sensor system is usually dominated by the shortest DTC of either the sensor or signal conditioner.

The sensor DTC is fixed and is specified in this catalog for each sensor. In ICP signal conditioners featuring internal buffer amplifiers, the DTC is fixed by various internal components and is not affected by the input impedance of the readout instrument. PCB signal conditioners with capacitively coupled outputs have a DTC fixed by a shunting resistor across the capacitor. This fixes the DTC in the signal conditioner (usually at 10 seconds), unless the input impedance of the readout instrument is less than 1 megaohm. If the input impedance of the readout is less than 1 megaohm, the DTC is shortened.

After determining the shortest DTC in the system, the value can be used to determine the low frequency cutoff of the sensor system. The system time constant is analogous to a first order high pass RC filter. The theoretical lower-corner cutoff frequency (fc) is illustrated in ***Figure 7*** and is calculated from the following relationships:

3 dB down: fc = 0.16/DTC

10% down: fc = 0.34/DTC

5% down: fc = 0.5/DTC

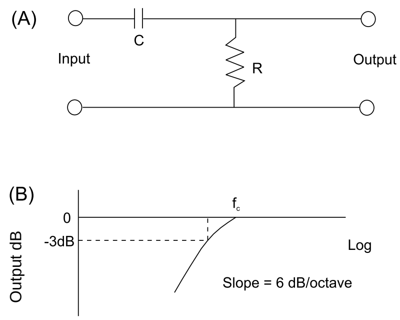


Figure 7. Transfer Characteristics of an ICP Sensor

LONG DURATION EVENTS AND DTC

It is sometimes desirable to measure a pressure lasting a few seconds in duration. This is especially true with high pressure sensor applications where static calibration takes place. (Before performing tests of this nature, it is important to DC-couple the entire monitoring system to prevent rapid signal loss. PCB Series 484 Signal Conditioners have AC and DC coupling modes of operation and are designed for such applications).

The general rule of thumb for such measurements is that the output signal loss and time elapsed over the first 10% of a DTC have a one-to-one relationship. If a sensor has a 500 second DTC, over the first 50 seconds, 10% of the original input signal decays. For 1% accuracy, data should be taken in the first 1% of the DTC. If 8% accuracy is acceptable, the measurement should be taken within 8% of the DTC, and so forth. ***Figure 8*** graphically demonstrates this event.

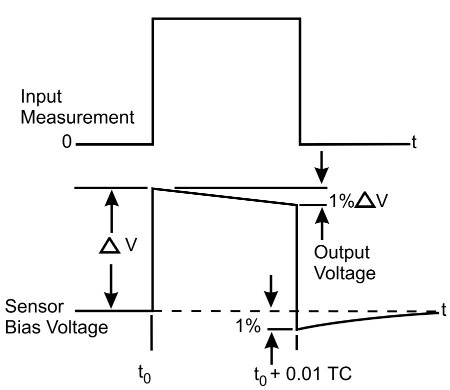


Figure 8. Step Function Response

Left unchanged, the signal naturally decays toward zero. Decay back to zero (or baseline) takes approximately 5 DTC. Notice that after the original step impulse signal is removed, the output signal dips below the base line reference point (t_o + .01 TC). This negative value is the same value as that which has decayed from the original impulse. Further observation reveals that the signal, left untouched, decays upwards toward zero until equilibrium in the system is achieved.

TYPICAL PIEZOELECTRIC SYSTEM OUTPUT

The output characteristic of piezoelectric pressure sensor systems is that of an AC-coupled system, where repetitive signals decay until there is an equal area above and below the original base line. As magnitude levels of the monitored event fluctuate, the output remains stabilized around the base line with the positive and negative areas of the curve remaining equal. ***Figure 9*** represents an AC signal following this curve. (Output from sensors operating in DC mode follow this same pattern but over an extended time frame associated with system discharge time constant values.)

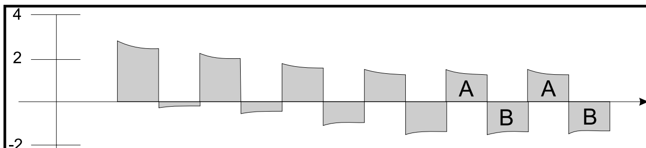


Figure 9. Repetitive Pulse, AC Signal

For example, assume that a 0 to 2 volt output signal is generated from an AC-coupled pressure application with a one-second steady-state pulse rate and one second between pulses. The frequency remains constant, but the signal quickly decays negatively until the signal centers around the original base line (where area A = area B). Peak to peak output remains the same.

INSTALLATION

Precision mounting of pressure sensors is essential for good pressure measurements. Although some mounting information is shown in this catalog, always check the installation drawings supplied in the manual with the sensor, or contact PCB to request detailed mounting instructions. Use good machining practices for the drilling and threading of mounting ports, and torque the sensors to the noted values. Mounting hardware is supplied with PCB sensors. Various standard thread adaptors are available to simplify some sensor installations.

For free field blast applications, try to use “aerodynamically clean” mounts, minimizing unwanted reflections from mounting brackets or tripods.

The sensing crystals of many pressure sensors described in this catalog are located in the diaphragm end of the sensor. Side loading of this part of the sensor during a pressure measurement creates distortions in the signal output. See ***Figure 10.***

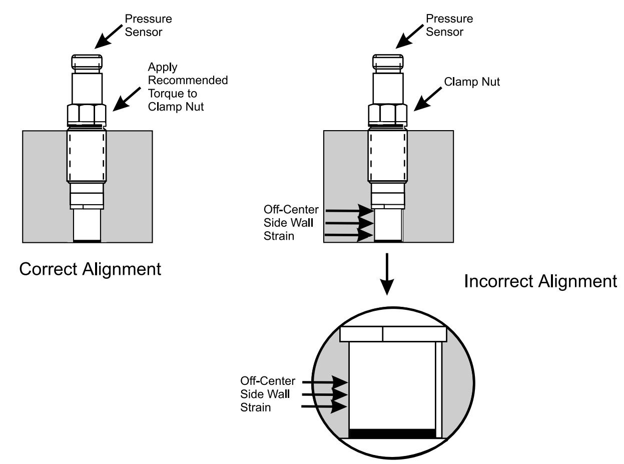


Figure 10. Flush Mount Pressure Alignment

Also important is the avoidance of unusual side loading stresses and strains on the upper body of the sensor. Proper installation minimizes distortions in the output signal. A taut cable pulling at right angles to the electrical connector is an example of putting a side strain into the body. Another is the use of a heavy adaptor with cable attached to the small electrical connector in an environment with high transverse vibration.

In some types of applications, such as free-field blast measurements, a pressure sensor mounted in a thin plate can be subjected to side loading stresses when the pressure causes the plate to flex. Use of an O-ring mount minimizes this effect.

FLUSH VS. RECESS MOUNTING

Flush mounting of pressure sensors in a plate or wall is sometimes desirable for minimizing turbulence, avoiding a cavity effect, or avoiding an increase in a chamber volume. Recess mounting is more desirable in applications where the diaphragm end of the pressure sensor is likely to be subjected to excessive flash temperatures or particle impingement.

Most PCB pressure sensors are supplied with seal rings for flush mounting. Certain models, such as Series 111, 112, and 113 can be provided with seal sleeves for recess mounting ports. Request seal sleeves when ordering.

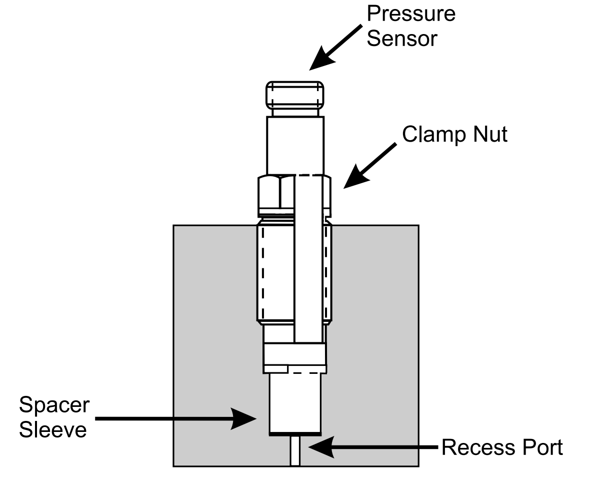


Figure 11. Typical Recess Mount

Consider ordering enough spare seal rings or sleeves, particularly in applications that require frequent removal and reinstallation of the pressure sensor. Before reinstalling a pressure sensor, be sure to check the mounting port to be sure that an old, distorted seal ring is not still in the mounting hole. If you are using PCB pressure sensors and find that you have lost or misplaced the seals, call PCB and request that the needed items be sent out as no-charge samples.

In this catalog, various mounting adaptors are described that often facilitate mounting of the pressure sensors. See pages 58 to 60 for details. Note that pressure sensors and adaptors with straight machined threads use a seal ring as a pressure seal. Pipe thread adaptors have a tapered thread, which results in the threads themselves creating the pressure seal.

Control of the location of the pressure sensor diaphragm is achieved with a straight thread/seal ring mount. Pipe thread mounts do not allow a precision positioning of the depth of the sensor since the seal is provided by progressive tightening of threads in the tapered hole until the required thread engagement is reached. However, pipe threads do offer a convenience of an easier machined port than straight threads. Pipe thread mounts are well suited for some general applications.

THERMAL SHOCK

Automotive in-cylinder pressures, ballistic pressures, and free-field blasts are a few examples of applications that have a thermal shock accompanying the pressure pulse. The thermal shock can be in the form of a radiant heat, such as the flash from an explosion, heat from convection of hot gasses passing over a pressure sensor's diaphragm, or conductive heat from a hot liquid.

Virtually all pressure sensors are sensitive to thermal shock. When heat strikes the diaphragm of a piezoelectric pressure sensor that has crystals contained in an outer housing, the heat can cause an expansion of the case surrounding the internal crystals. Although quartz crystals are not significantly sensitive to thermal shock, the case expansion causes a lessening of the preload force on the crystals, usually causing a negative-signal output. To minimize this effect, various methods are used.

Certain PCB quartz pressure sensors feature internal thermal isolation designs to minimize the effects of thermal shock. Some feature baffled diaphragms. Other models designed for maximizing the frequency response may require thermal protection coating, recess mounting, or a combination to lessen the effects of thermal shock. Examples of coatings include silicone grease, which may also be used to fill a recess mounting hole, RTV silicone rubber, vinyl electrical tape, and ceramic coatings. The RTV and tape are used as ablatives, while the ceramic coating is also used to protect some diaphragms from corrosive gasses and particle impingements.

Crystals other than quartz are used in some PCB sensors. Though sensitive to thermal shock, tourmaline is used for shock tube and underwater blast sensors. In shock tube measurements, the duration of the pressure measurement is usually so short that a layer of vinyl tape is sufficient to delay the thermal effects for the duration of the measurement. In underwater blast applications, heat transfer through the water is not significant.

Note that thermal shock effects do not relate to the pressure sensor specification called “temperature coefficient” used in this catalog. The temperature coefficient specification refers to the change in sensitivity of the sensor relative to the static temperature of the sensor. Unfortunately, since the thermal shock effects cannot be easily quantified, they must be anticipated and minimized by one of the above mentioned techniques in order to ensure better measurement data.

CABLE CONSIDERATIONS AND CONSTANT CURRENT LEVEL

Operation over long cables may affect frequency response and introduce noise and distortion when an insufficient current is available to drive cable capacitance.

Unlike charge mode systems, where the system noise is a function of cable length, ICP® sensors provide a high voltage, low impedance output well-suited for driving long cables through harsh environments. While there is virtually no increase in noise with ICP sensors, the capacitive loading of the cable may distort or filter higher frequency signals depending on the supply current and the output impedance of the sensor.

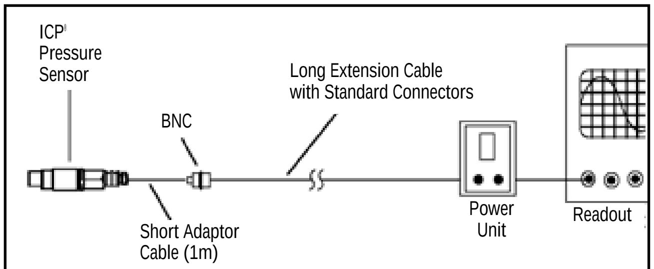


Figure 12 Long Extension Cable Schematic

Generally, this signal distortion is not a problem with lower frequency testing within a range up to 10 000 Hz. However, for higher frequency vibration, shock or transient testing over cables longer than 100 ft. (30 m.), the possibility of signal distortion exists.

The maximum frequency that can be transmitted over a given cable length is a function of both the cable capacitance and the ratio of the peak signal voltage to the current available from the signal conditioner according to:

$$f_{max} = \frac{10^9}{2\pi CV / (I_c - 1)}$$

where, f_{max} = maximum frequency (hertz)
C = cable capacitance (picofarads)
V = maximum peak output from sensor (volts)
I_c = constant current from signal conditioner (mA)
10^9 = scaling factor to equate units

Note that in this equation, 1 mA is subtracted from the total current supplied to sensor (I_c). This is done to compensate for powering the internal electronics. Some specialty sensor electronics may consume more or less current. Contact the manufacturer to determine the correct supply current.

When driving long cables, the equation above shows that as the length of cable, peak voltage output or maximum frequency of interest increases, a greater constant current will be required to drive the signal.

The nomograph on the facing page provides a simple, graphical method for obtaining the expected maximum frequency capability of an ICP measurement system. The maximum peak signal voltage amplitude, cable capacitance and supplied constant current must be known or presumed.

For example, when running a 100 ft. cable with a capacitance of 30 pF/ft, the total capacitance is 3000 pF. This value can be found along the diagonal cable capacitance lines. Assuming the sensor operates at a maximum output range of 5 volts and the constant current signal conditioner is set at 2 mA, the ratio on the vertical axis can be calculated to equal 5. The intersection of the total cable capacitance and this ratio result in a maximum frequency of approximately 10.2 kHz.

The nomograph does not indicate whether the frequency amplitude response at a point is flat, rising or falling. For precautionary reasons, it is good general practice to increase the constant current (if possible) to the sensor (within its maximum limit) so that the frequency determined from the nomograph is approximatley 1.5 to 2 times greater than the maximum frequency of interest.

Note that higher current levels will deplete battery-powered signal conditioners at a faster rate. Also, any current not used by the cable goes directly to power the internal electronics and will create heat. This may cause the sensor to exceed its maximum temperature specification. For this reason, do not supply excessive current over short cable runs or when testing at elevated temperatures.

EXPERIMENTALLY TESTING LONG CABLES

To more accurately determine the effect of long cables, it is recommended to experimentally determine the high frequency electrical characteristics.

The method illustrated in ***Figure 13*** involves connecting the output from a standard signal generator into a unity gain, low-output impedance (<5 ohm) instrumentation amplifier in series with the ICP sensor. The extremely low output impedance is required to minimize the resistance change when the signal generator/amplifier is removed from the system.

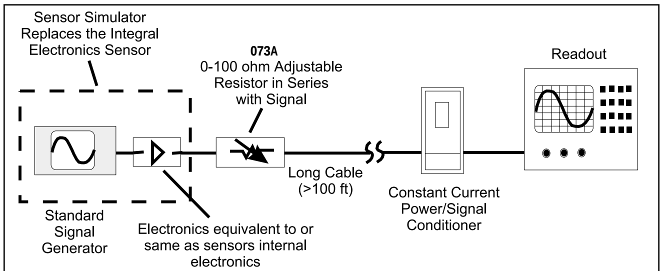
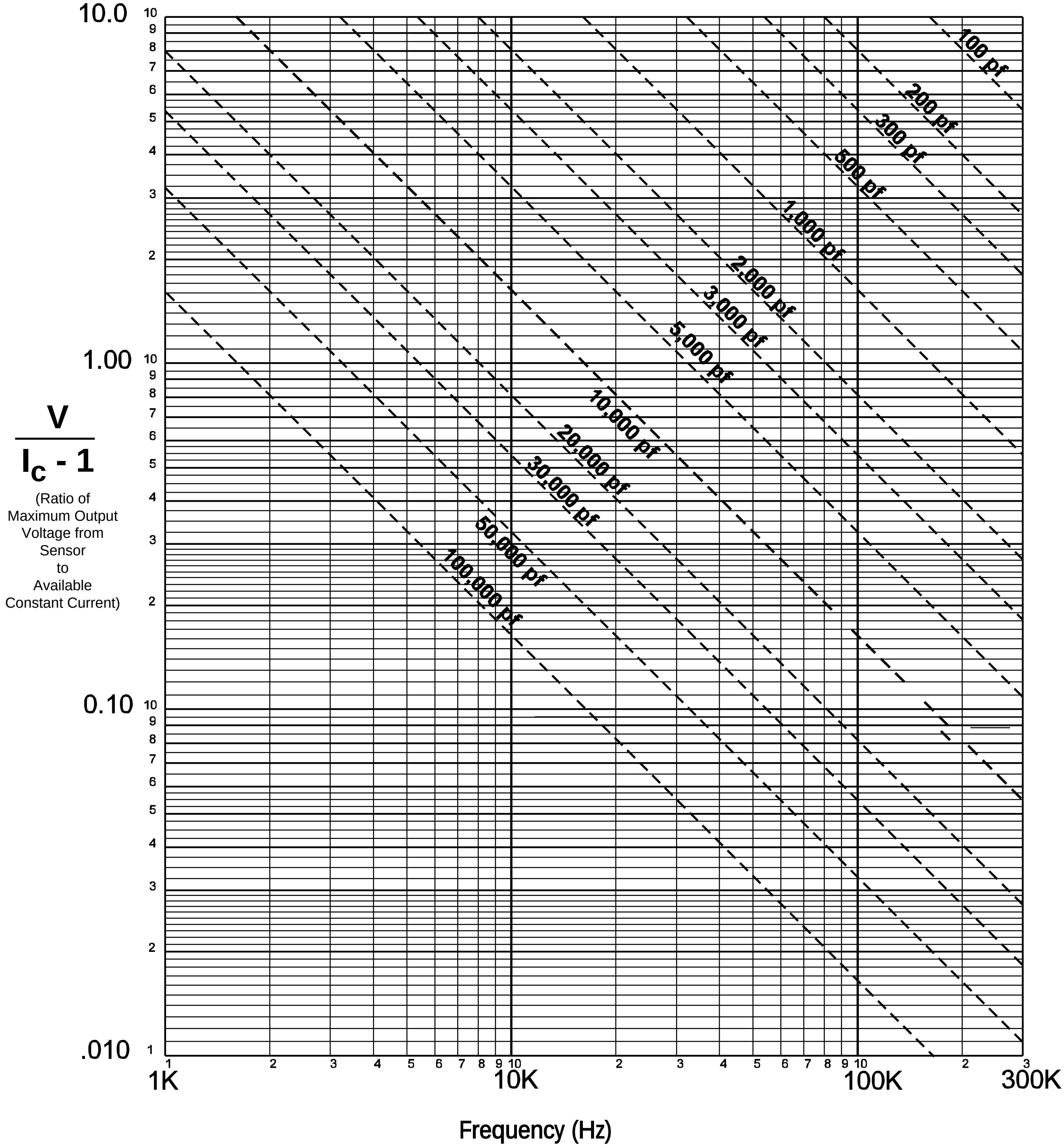


Figure 13 Long Cable Testing

In order to check the frequency/amplitude response of this system, set the signal generator to supply the maximum amplitude of the expected measurement signal. Observe the ratio of the amplitude from the generator to that shown on the scope. If this ratio is 1:1, the system is adequate for your test. (If necessary, be certain to factor in any gain in the signal conditioner or scope.) If the output signal is rising (1:1.3 for example), add series resistance to attenuate the signal. Use of a variable 100 ohm resistor will help set the correct resistance more conveniently. Note that this is the only condition that requires the addition of resistance. If the signal is falling (1:0.75 for example), the constant current level must be increased or the cable capacitance reduced.

It may be necessary to physically install the cable during cable testing to reflect the actual conditions encountered during data acquisition. This will compensate for potential inductive cable effects that are partially a function of the geometry of the cable route.



f_{max} = Maximum frequency given the following characteristics

C = Cable capacitance (pF)
V = Maximum output voltage from sensor (volts)

I_c = Constant current level from power unit (mA)
10^9 = Scale factor to equate units

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Calibration systems for dynamic pressure sensors, force sensors and accelerometers with typical calibration results, Jim Lally, 1985.

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AR-43 **Trouble with Cables**
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AR-51 **Dynamic Step-Pressure Calibration**
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AR-59 **Recommended Practices: Accelerometer, Wiring and Connections**
Reliability of ICP, charge mode systems based upon selection of cables and connectors/long cable use with cable drive nomograph.

AR-60 **Dynamic Pressure Calibration instruments and Sensor Transient Response**
Surveys commercially available dynamic calibration instruments. Proceedings: 17th Sensor Workshop, San Diego CA, Jim Lally, 1993.

Glossary of Terms

As relates to PCB Piezo Pressure Sensors

Absolute Pressure - Pressure measured relative to absolute vacuum.

Acceleration Compensation - An added internal crystal element technique that reduces the sensitivity of a pressure sensor to vibration and shock.

Acceleration Sensitivity - The output of a pressure sensor due to vibration or shock. Typically measured in psi/g.

Ambient Noise - The total background noise level in a specified environment.

Analog Output - The continuous real time output of a piezoelectric sensor or instrument within its specified dynamic range.

Ambient Pressure - The total pressure level in a specified environment.

Attenuation - The effect of reducing signal sensitivity.

Bias Voltage - A DC voltage at the output of an ICP®-type sensor on which an AC measurement signal is superimposed.

Calibration - The process of measuring and documenting a sensor's sensitivity relative to a known input. Data is usually taken at several points to plot linearity.

Cavitation - The sudden formation and collapse of small pressure bubbles in liquids.

Charge Amplifier - A capacitive feedback amplifier that converts the high-impedance output from a charge mode sensor to a low-impedance voltage signal.

Charge Converter - A charge converter is a small, in-line amplifier that is used in close proximity to the sensor to convert the high-impedance output of a charge mode sensor into a low-impedance voltage signal (mV/pC), usually at fixed gain.

Charge Mode - A piezoelectric sensor that outputs a high-impedance charge signal (pC).

Charge Sensitivity - The amount of charge produced by a charge mode sensor per unit of pressure; expressed in pC/psi (pico coulomb per psi).

Clamped Output - Output automatically re-zeroed between repetitive events; keeps signal ground-based, positive-going.

Clipping - Output limitation preventing a signal amplitude from exceeding the limits imposed by the amplifier, supply voltage, or system.

Conformal Ballistic Sensor - A pressure sensor with a curved diaphragm machined to conform to the chamber diameter of the gun. It measures pressure directly, through an unmodified shell case.

Constant Current - Electric current independent of either voltage or resistances and fixed at a specific value. Also called excitation current for ICP sensors. Constant current is provided by all PCB power and amplifying power units, as well as vibration and digital peak meters (required for proper ICP sensor operation). Some commercial FFT analyzers and data collectors also provide constant current for ICP sensors.

Decibel (dB)- A logarithmic representation of a ratio, expressed as 10 times the log of a power ratio or 20 times the log of a voltage, current or units (pressure, force, acceleration) ratio.

Differential Pressure - The difference in pressure between two measurements.

Diaphragm - The sensing membrane of a sensor that transmits pressure to the sensing element.

Digital Output - Providing a readout in numerical digits.

Discharge Time Constant (DTC) - Time required for a sensor or measuring system to discharge its signal to 37% of the original value following a step change of measurand. The discharge time constant directly relates to the low-frequency measuring capability for both transient and sinusoidal events (should not be confused with rise time or time constant).

Dual Mode Charge Amplifier - An amplifier that can be used with either high-impedance charge mode sensors or low-impedance ICP voltage mode sensors.

Dynamic Calibration - Applying a known step input to a pressure sensor, usually in milliseconds or microseconds.

Electro-Magnetic Interference (EMI) - A condition in which an electromagnetic field produces an unwanted noise.

FFT Analyzer - Frequency Spectrum Analyzer computes discrete frequency components as a function of frequency from sampled time data.

Filter - A mechanical or electrical device designed to pass or reject a specific frequency band.

Flash Temperature - Refers to the fast (usually lasting no longer than a few milliseconds) temperature change associated with explosive combustion, detonation, blast, or shock wave measurements. Sensors usually require ablative coating on the diaphragm to reduce flash temperature sensitivity.

Flush Mount - A sensor mounting technique where the diaphragm of the sensor is installed flush with the inside surface of the test chamber.

Free Field Blast - Measurement of a shock wave in an open area.

Frequency Response - The amplitude ratios of output-to-input signals and the phase relationships at different frequencies.

Frequency-Tailored Response - A combination of mechanical and electrical damping in Series 113A20 and certain Series 102 (500kHz) pressure sensors to produce a non-resonant response.

Gauge Pressure - A pressure measurement that is referenced relative to atmospheric pressure. Most piezo sensors measure gauge pressure.

Ground Isolation - Refers to a condition where a sensor's signal ground is electrically isolated from the test structure.

Ground Loop - A condition where sensor and signal conditioner/readout grounds are of different electrical potential. Such conditions cause ground loop "noise" at frequencies typically between 50 and 60 Hz, as well as multiples thereof.

Hertz (Hz) - One cycle or oscillation per second.

ICP® (Integrated Circuit Piezoelectric) - A trademark identifying PCB voltage mode sensors combining an integrated circuit and a piezoelectric sensing element in a single housing to provide a voltage output. Also referred to as "voltage mode sensor." ICP is a registered trademark of PCB Piezotronics, Inc.

Impedance Converter - See Charge Amplifier, Charge Converter, and Source Follower.

Glossary of Terms

As relates to PCB Piezo Pressure Sensors

In-line Charge Converter - See Charge Converter.

Incident Shock Wave Measurement - A shock wave traveling across the sensor's diaphragm, 90° to the sensitive axis.

Insulation Resistance - The resistance in ohms between signal and ground of a sensor or cable.

Measurand - Physical quantity being measured, such as pressure psi or kPa.

NIST (National Institute of Standards and Technology) - Formerly NBS (National Bureau of Standards), a U.S. national standards lab that provides certification for calibration reference standards.

Noise - Any signal in a measurement system other than the signal generated by the measurand. Noise sources include EMI, RFI, triboelectric, and geophysical phenomena.

Non-Resonant Response - See Frequency-Tailored Response.

Output Bias Voltage - A DC voltage at the output of an ICP® sensor on which the signal is superimposed.

PCB - Taken from the word Pico Coulomb, a quantity of electrical charge. (one Pico Coulomb is equal to 1 x 10^{-12} coulomb).

Peak Meter - An instrument that records a peak pulse or highest peak in a pulse train.

Phase - Time relationship of an event to some reference.

Phase Shift - The difference in phase angle between the output and input; typically, a function of frequency.

Pico Coulomb - A measure of charge; equal to 1 x 10^{-12} coulombs.

Piezotronics - Combining the piezoelectric properties of a crystal with the science of electronics.

Polarity - The positive or negative output from a sensor compared to that of the measurand: i.e., positive-going output for increasing pressure. Charge mode sensors usually have negative output which is inverted to positive output by a charge amplifier.

Pyroelectric Output - Unwanted thermally generated output from a piezoelectric crystal due to a varying thermal input.

Quartz - An intrinsically piezoelectric silicon dioxide monocrystal. Generally recognized as the most stable of all piezoelectric materials.

Recessed Mount - A type of mounting technique where the diaphragm of the sensor is not flush with the surface of the test chamber. Although it affects frequency response, this technique protects the sensor diaphragm from the effects of high flash temperatures or particle impingement due to blast effects, thereby prolonging sensor life.

Reflective Shock Wave Measurement - A shock wave instantaneously impacting the diaphragm of a pressure sensor, face on.

RFI - Abbreviation for Radio Frequency Interference.

Repeatability - The ability of a sensor to provide the same output signal corresponding to the same measurand input under the same environmental conditions.

Resolution - The smallest discernible signal from a measurement system; also referred to as threshold.

Resonant Frequency - Frequency where a structure readily vibrates at its natural frequency.

Rise Time - Time required for output of a pressure sensor to rise from 10% to 90% of its final value when subjected to a step input.

Shock Wave - Pressure wave exceeding the speed of sound in gas, solid, or liquid medium.

Signal Conditioning/Power Unit - A power source that supplies constant current to ICP® sensors and removes the bias voltage (may also amplify, attenuate, filter, or normalize.)

Signal-to-Noise Ratio - A sensor's output signal relative to its output noise.

Source Follower - Converts a high-impedance input signal to a low-impedance voltage output. Also referred to as Impedance Converter, generally a voltage gain of one.

Standardized Sensitivity - Refers to standardization (or normalization) of sensor output to a specified value and tolerance (e.g., 10 mV/psi ± 2%).

Static Calibration - Calibration using dead weights as a pressure reference source.

Static Pressure - Steady state or slowly changing pressure, normally measured with strain gauge or other DC-measuring instruments.

Temperature Coefficient - The percent change in the sensitivity of a sensor as a result of a unit change in the operating temperature of the sensor; expressed as percent per degree (i.e., %/°F or %/°C).

Triboelectric Noise - A charge-generated noise caused by friction in a cable. A common source of this noise is the separation and motion between the dielectric and shield of a cable.

Turbulence - The motion of a fluid having local velocities and pressures that fluctuate randomly.

Useful Overrange - The maximum operating range of a pressure sensor determined by either maximum electrical output or maximum mechanical input; in some cases, useful overrange is equal to range.

Voltage Mode - A sensor that incorporates impedance conversion within the sensor package, powered by a constant-current sensor supply, and providing a low impedance output signal.

Zero Shift - The change in the base line level of the output voltage of a sensor after a measurement due to mechanical, electrical, or thermal effects.

Notes

Notes

Conversions/Equivalencies Table

PRESSURE

atmospheres	1.01325	bars
	33.90	feet of H_2O
	29.92	inches of Hg
	760.0	mm of Hg (torr)
	101.325	kN/m^2 (k Pa)
	14.696	pounds/sq. inch
bar	75.01	cm of Hg
	10^5	N/m^2 (Pa)
	14.50	pounds/sq. inch
inches of H_2O	248.84	N/m^2 (Pa)
	0.07355	inches of Hg
mm of Hg (torr)	133.32	N/m^2 (Pa)
	0.01933	pounds/sq. inch
	13.595	mm of H_2O
newtons/sq. centimeter	1.450	pounds/sq. inch
pounds/sq. foot	0.19242	inches of H_2O
	47.880	N/m^2 (Pa)
psi	0.06805	atmospheres
	0.06895	bars
	2.036	inches of Hg
	27.708	inches of H_2O
	703.77	mm of H_2O
	51.72	mm of Hg
	0.68948	N/cm^2
	6 894.8	N/m^2 (Pa)
	7.031 x 10-4	kg (f) mm^2
dB (sound pressure-air)	20 log P/P_o	$P_o = .0029 \times 10^{-6}$ psi

ACCELERATION

accel of gravity (g)	9.80665	meters/second^2
	32.174	feet/second^2
	386.088	inches/second^2
feet/second^2	0.3048	meters/second^2
inches/second^2	0.02540	meters/second^2

FORCE

kilogram (force)	9.80665	newtons
	1.00	kilopound
newton	10^5	dynes
	0.1020	kilogram (force)
	3.597	ounce (force)
	0.2248	pound (force)
	7.2330	poundal
pound (force)	16.00	ounce (force)
	0.45359	kilogram (force)
	4.448	newtons

TEMPERATURE

Celsius to Fahrenheit	°F = 9/5 °C +32
Fahrenheit to Celsius	°C = (°F -32) 5/9
Fahrenheit to Kelvin	°K = 5/9(°F + 459.67)
Fahrenheit to Rankin	°R = °F + 459.67°
Celsius to Kelvin	°K = °C + 273.15°

Commonly Used Prefixes

G	giga	10^9	µ	micro	10^{-6}
M	mega	10^6	n	nano	10^{-9}
k	kilo	10^3	p	pico	10^{-12}
c	centi	10^{-2}			
m	milli	10^{-3}			

WARRANTY

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Catalog specifications are subject to change; before machining installation ports request a copy of the current installation drawing.

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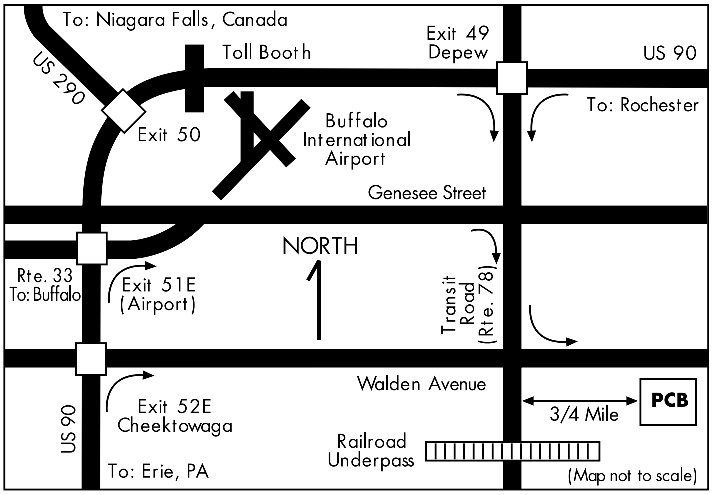

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