Piezo Film Sensors

Product Guide and Price List

Measurement Specialties, Inc.
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15 MAY 01

P/N: 1005602-1 REV K

TYPICAL APPLICATIONS FOR PIEZO FILM SENSORS

Accelerometer

ACH-01 (General Purpose)
- Car Alarm
- Shipping Damage
- Machinery Monitoring
- Motional Feedback for Speakers
- Security Sensing
- Appliance Monitoring

ACH04-08 (Multi-Axis)
- Disc Drive Shock Sensing
- Impact Switching
- Biomedical Monitoring

Shockwriter 3000
- Shipping Damage
- Materials Handling
- Machinery Monitoring

Vibration/Motion Film Sensor

DT Series (Unlaminated, Unshielded)
- Dynamic Strain Gages
- Acoustic Pickups
- Musical Instrument Triggers
- Tamper Detection

LDT Series (Laminated, Unshielded)
- Antitheft Alarm
- Vending
  . Dispensing Verification
  . Coin Drop Counters
  . Antitamper
  . Penetration Panels
- Fan Failure
- Appliance Monitoring
  - Washer Imbalance
  . Microwave - Sound Pickup
  . Dishwasher Spray Arm
  - Water Flow Sensor
  . Vacuum Soil Sensing

SDT Series (Unlaminated, Shielded)
- Musical Instrument Triggers
- Contact Microphones

Custom Sensors
- Textile Sensors
  . Thread Break/Tension
- Medical Monitoring
  . Patient Bed Monitor
  . Pulse Counter
  . Fetal Heart Monitor
  . Apnea Monitoring
  . Anesthesia Monitor (Sleep Disorder)
  . Respiratory Air Flow
  . Sleep Disorder (REM)
  . Pacemaker Activity Monitor
- Earthquake Alarm

Switch

SW100 Series
- Pinball Impact Switches
- Gaming Machine Switches
- Utility Meter Counters

Custom Switches
- Vector Switch/Joystick
- CMOS Circuit Wake-up Switch
- Pacinko Game
- Electronic Piano Keys
- Impact Printer Timing Switch
- Sports Scoring
  . Karate Boxing Force
  . Dartboard Scoring
- Snap Action Switches
- Beam Switch

Ultrasound

- Air-Ranging Proximity
- Medical Imaging Catheters
- Phased Array
- Non Destructive Testing
- Acoustic Emission
- Shockwave Sensors
- Level Sensors (Inkjet, toner)
- Robotic Tactile Sensors
- Variable Force Sensors

Audio/Acoustic

- Microphones
  . Dive Helmets
  . Gas Mask
  . Contact
- Acoustic Pickups
- Flow Sensors
- Speakers
  . Novelty Consumer
  . Tweeters
  . Pagers
- Hydrophones
  . Navy SONAR
  . Geophysical SONAR
- Active Vibration Damping/Noise

Traffic Sensors

Series BL
- Vehicle Classification
- Weight-in-Motion
- Speed/Red Light Enforcement
- Airport Taxiway
- Security/Safety

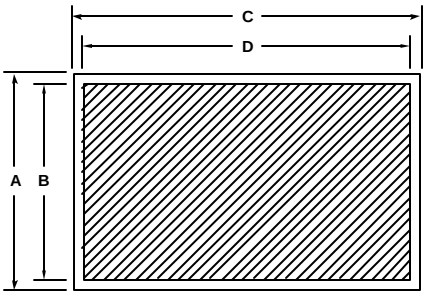
Piezo Cable

- Step Switches
- Pedestrian Mats
- Perimeter Security
- Antitamper

Power Supply

- Alternate Energy

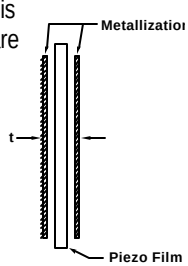
Metallized Piezo Film Sheets



Piezo film is available in a variety of different film sizes and thicknesses. These can be fabricated into simple transducers, or for use as full size sheets for applications such as speakers.

Metallization options include a compliant silver ink as well as sputtered metallization. The silver ink is best for applications where mechanical stress is being applied to the film. Thin sputtered metallization is brittle, and used where signal to noise requirements dictate very low mass loading by the electrodes. These are only general rules, and a discussion with our applications engineers will help you to make the best choice for your specific application.

Silver ink lends itself to custom metallization patterns for easy lead attachment. Our standard sputtered metallization is a nickel copper alloy, which has good conductivity and is resistant to oxidation. Other metallizations such as gold are available on a custom basis with a set up fee.



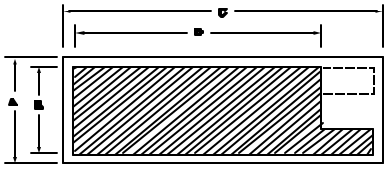
Piezo Film is available in different thicknesses. Thinner films (28 and 52 µm) are the most common, due to their higher capacitance and good mechanical qualities. Thicker film (110 µm) is used where maximum robustness is needed, or if the sensor is being used in a thickness mode (d_{33}) application.

DIMENSIONS in INCHES [mm]								Low Volume Price (US $)
Description	A Film	B Electrode	C Film	D Electrode	t (µm)	Metallization	Part #	
28 µm piezo film	8.00 [203]	7.50 [190]	5.50 [140]	5.00 [127]	28	NiCu Alloy	1-1003703-4	$55.00
28 µm piezo film	8.00 [203]	7.50 [190]	11.00 [280]	10.50 [267]	28	NiCu Alloy	1-1003702-4	$110.00
28 µm piezo film	8.00 [203]	7.50 [190]	5.50 [140]	5.00 [127]	40	Silver Ink	1-1004347-0	$55.00
28 µm piezo film	8.00 [203]	7.50 [190]	11.00 [280]	10.50 [267]	40	Silver Ink	1-1004346-0	$110.00
52 µm piezo film	8.00 [203]	7.50 [190]	5.50 [140]	5.00 [127]	52	NiCu Alloy	2-1003703-4	$65.00
52 µm piezo film	8.00 [203]	7.50 [190]	11.00 [280]	10.50 [267]	52	NiCu Alloy	2-1003702-4	$130.00
52 µm piezo film	8.00 [203]	7.50 [190]	5.50 [140]	5.00 [127]	64	Silver Ink	2-1004347-0	$65.00
52 µm piezo film	8.00 [203]	7.50 [190]	11.00 [280]	10.50 [267]	64	Silver Ink	2-1004346-0	$130.00
110 µm piezo film	8.00 [203]	7.50 [190]	5.50 [140]	5.00 [127]	110	NiCu Alloy	3-1003703-4	$75.00
110 µm piezo film	8.00 [203]	7.50 [190]	11.00 [280]	10.50 [267]	110	NiCu Alloy	3-1003702-4	$150.00
110 µm piezo film	8.00 [203]	7.50 [190]	5.50 [140]	5.00 [127]	122	Silver Ink	3-1004347-0	$75.00
110 µm piezo film	8.00 [203]	7.50 [190]	11.00 [280]	10.50 [267]	122	Silver Ink	3-1004346-0	$150.00

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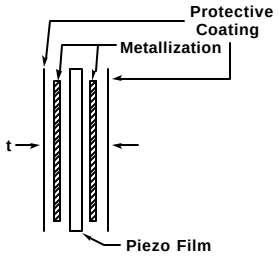
DT Series Elements



The DT series of piezo film sensors elements are rectangular elements of piezo film with silver ink screen printed electrodes. They are available in a variety of different sizes and thicknesses.

The DT film element produces more than 10 millivolts per microstrain, about 60 dB higher than the voltage output of a foil strain gage. The capacitance is proportional to the area and inversely proportional to the thickness of the element.

The DT series sensors are the simplest form of piezo film sensors, used primarily as dynamic strain gages and contact microphones for vibration or impact detection. These are available without any leads for those applications where the customer wants to make his own lead attachment. They can be readily adhered to a surface with double-sided tape or epoxy. Lead attachment can be achieved by compressive clamping, crimps, eyelets, conductive epoxy or low temperature solders.



DT elements are supplied with a thin urethane coating over the active sensor area; the lead attachment legs are free of the insulating urethane coating.

Dimensions in INCHES [mm]								Low Volume Price (US $)
Description (No Leads)	A Film	B Electrode	C Film	D Electrode	t (µm)	Cap (nF)	Part #	
DT1-028K	.64 [16]	.484 [12]	1.63 [41]	1.19 [30]	40	1.38	1-1002608-0	$1.00
DT1-052K	.64 [16]	.484 [12]	1.63 [41]	1.19 [30]	70	.740	2-1002608-0	$1.25
DT2-028K	.64 [16]	.484 [12]	2.86 [73]	2.42 [62]	40	2.78	1-1002145-0	$2.00
DT2-052K	.64 [16]	.484 [12]	2.86 [73]	2.42 [62]	70	1.44	2-1002145-0	$2.50
DT4-028K	.86 [22]	.740 [19]	6.72 [171]	6.13 [156]	40	11.00	1-1002149-0	$4.00
DT4-052K	.86 [22]	.740 [19]	6.72 [171]	6.13 [156]	70	5.70	2-1002149-0	$4.80

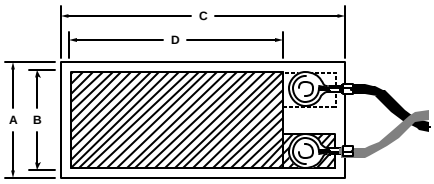
Please contact factory for custom part quotations and volume pricing.

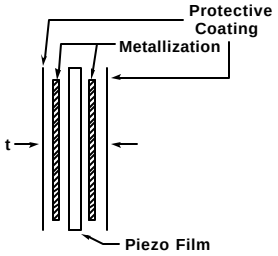
DT Series Elements with Lead Attachment

The DT series of piezo film sensors elements are rectangular elements of piezo film with silver ink screen printed electrodes. They are available in a variety of different sizes and thicknesses.

Piezo film sensor elements are available with two lead attachment options. These include wires riveted to the film or wires attached to the film with eyelets. The eyelets offer holes at the lead attachment location to facilitate mounting.

The capacitance is proportional to the area and inversely proportional to the thickness of the element.





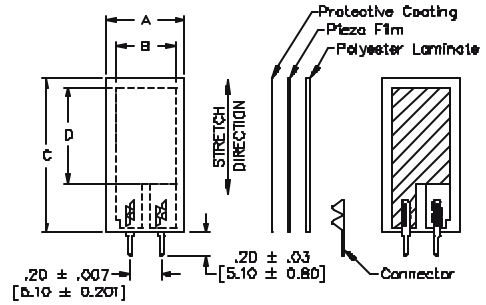
Dimensions in INCHES [mm]								Low Volume Price (US $)
Description	A Film	B Electrode	C Film	D Electrode	t (µm)	Cap (nF)	Part #	
DT1-028K/L w/rivets	.64 [16]	.484 [12]	1.63 [41]	1.19 [30]	40	1.38	1-1002908-0	$3.00
DT1-052K/L w/rivets	.64 [16]	.484 [12]	1.63 [41]	1.19 [30]	70	.740	2-1002908-0	$3.25
DT2-028K/L w/rivets	.64 [16]	.484 [12]	2.86 [73]	2.42 [62]	40	2.78	1-1003744-0	$4.00
DT2-052K/L w/rivets	.64 [16]	.484 [12]	2.86 [73]	2.42 [62]	70	1.44	2-1003744-0	$4.50
DT4-028K/L w/rivets	.86 [22]	.740 [19]	6.72 [171]	6.13 [156]	40	11.00	1-1002150-0	$6.00
DT4-052K/L w/rivets	.86 [22]	.740 [19]	6.72 [171]	6.13 [156]	70	5.70	2-1002150-0	$6.80

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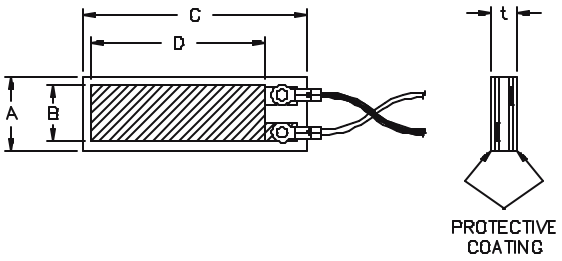
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LDT Series Elements with Lead Attachment and Lamination

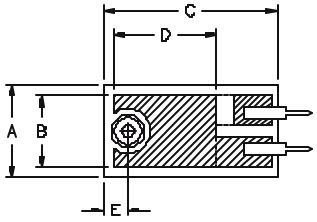
The 'L' in LDT stands for 'laminated' sensor. Typically, a 0.005" (125 µm) polyester layer is laminated to a 28 µm or 52 µm piezo film element. When used in a 'bending' mode, laminated film elements develop much higher voltage output when flexed than non-laminated (i.e., DT series) elements. The piezo film is off the neutral axis in the laminate, and is strained more when flexed. Applications for this include beam-type vibration sensors for vehicle alarms and solid state switches for counters and momentary contact closure type switches. Piezo film sensor LDT elements are available in a variety of lead attachment options. The LDT0-028K has crimped-on pins, 0.200" on center, suitable for soldering. For significantly increased sensitivity, the LDTM-028K (M-Mass) combines an LDT0-028K form factor with the addition of a .72 gram round mass (located E (.14") from the edge on the opposite side of the crimps in the center of the A (.26") dimension.) The LDT1, 2 and 4 have 12" of 26 gauge twisted pair wire. The capacitance is proportional to the area and inversely proportional to the thickness of the element.



LDT0-028K (with crimped-on solder tabs)



LDT Series with rivets and wire leads



LDTM

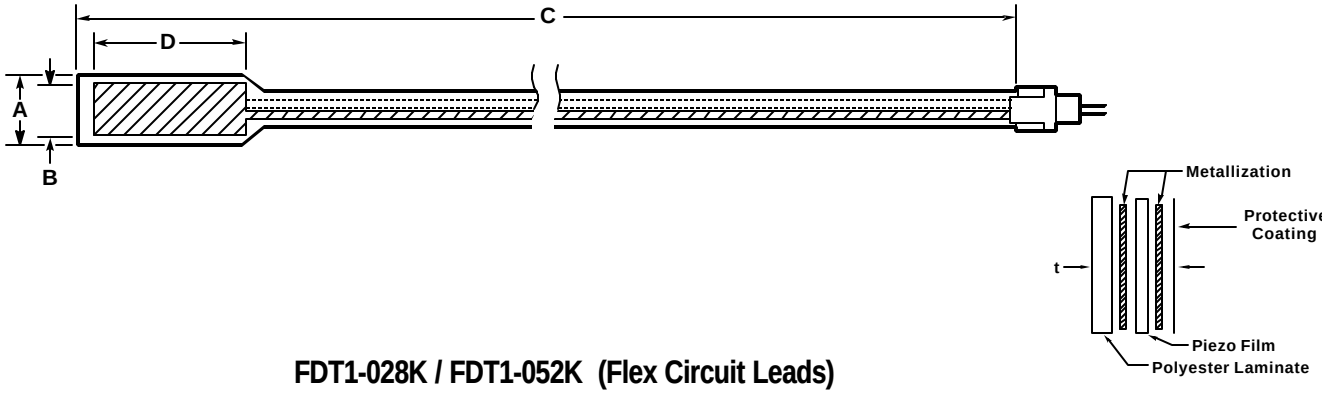
The LDT0-028K and LDTM-028K with solder tabs can be soldered directly to a PCB with a reasonable level of care. Piezo film cannot withstand high temperatures (> 80?C), and therefore soldering of the pins to a PCB must be done quickly. A heatsink clamped to the interface area between the film and the crimps will take the heat away from the film. Pre-tin the PCB and then quickly solder the sensor to the board. Do not allow the soldering iron to touch the film, and do not use a dwell time of over 5 seconds on the pins. Low temperature solders can also be used. For tightly toleranced sensitivity requirements, please consult MSI Sensors for techniques used to control variations of boundary conditions in production. Detailed specification sheets are available from our website.

Dimensions in INCHES [mm]								Low Volume Price (US $)
Description	A Film	B Electrode	C Film	D Electrode	t (µm)	Cap (nF)	Part #	
LDT0-028K/L w/crimps	.520 [13]	.400 [10]	.980 [25]	.580 [15]	205	.500	0-1002794-0	$.75
LDT1-028K/L w/rivets	.640 [16]	.484 [12]	1.63 [41]	1.19 [30]	205	1.38	1-1002910-0	$2.50
LDT2-028K/L w/rivets	.640 [16]	.484 [12]	2.86 [73]	2.42 [62]	205	2.78	1-1003745-0	$4.50
LDT4-028K/L w/rivets	.860 [22]	.740 [19]	6.72 [171]	6.13 [156]	205	11.0	1-1002405-0	$7.50
LDTM-028K w/crimps	.520 [13]	.400 [10]	.980 [25]	.580 [15]	205	.420	0-1005447-1	$1.00

FDT Series Elements with Lead Attachment

The 'F' in FDT Series stands for 'Flexible Leads'. These are rectangular elements of piezo film with silver ink screen printed electrodes. Rather than making the lead attachment near the sensor, the piezo polymer tail extends from the active sensor area as flex circuit material with offset traces. This gives a very flat, flexible lead, with a connector at the end.

The FDT elements are available in a variety of different sizes and thicknesses. They are available without a laminate (FDT), with a laminate (0.005" mylar) on one side (FLDT) or with tape release layer adhesive (FDT with adh) in the sensor area.



FDT1-028K / FDT1-052K (Flex Circuit Leads)

The connector pins on the FDT sensors can be directly soldered to a PCB with a reasonable level of care. This component cannot withstand high temperatures (>80?C), and therefore soldering of the pins to a PCB must be done quickly. A heatsink clamped to the interface area between the film and the crimps will take the heat away from the film. Pre-tin the pins and then quickly solder them to the board. Do not allow the soldering iron to touch the film, and do not use a dwell time of over 5 seconds on the pins. Low temperature solder can also be used. The FDT is also available with a connector for insertion onto standard .025" square pins.

Dimensions in INCHES [mm]								Low Volume Price (US $)
Description	A Film	B Electrode	C Film	D Electrode	t (µm)	Cap (nF)	Part #	
FDT1-028K	.620 [16]	.485 [12]	9.25 [235]	1.16 [30]	55	1.37	1-1002785-1	$4.50
FDT1-052K	.620 [16]	.485 [12]	9.25 [235]	1.16 [30]	85	.740	2-1002785-1	$5.00
FLDT1-028K	.620 [16]	.485 [12]	9.25 [235]	1.16 [30]	205	1.37	1-1002786-1	$4.50
FLDT1-052K	.620 [16]	.485 [12]	9.25 [235]	1.16 [30]	230	.740	2-1002786-1	$5.00
FDT1-028K w/adh-F	.650 [17]	.485 [12]	5.51 [140]	1.18 [30]	125	1.37	0-1001777-0	$4.50

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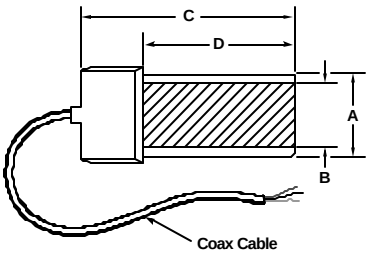
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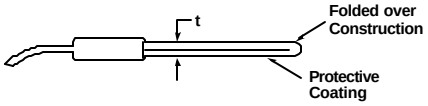
SDT Shielded Piezo Film Sensors Element with Shielded Cable

The 'S' in SDT Series stands for 'Shielded Sensor'. SDT1 piezo film sensors consist of rectangular elements of piezo film together with a molded plastic housing and 18" of coaxial cable. The sensor area, screen printed with silver ink, is folded over on itself, giving a self-shielding of the transducer area. This is important in applications where 60 Hz EMI cannot be properly filtered, or in applications in a high EMI environment.

The SDT1 can be adhered to other surfaces using double sided adhesives, epoxy or cyanoacrylate (super-glue). Care should be taken if the sensor is to be removed, as the double-side adhesive can peel the metallization from the film.

When adhered to a surface in this manner, the SDT1 is an excellent contact microphone or dynamic strain gage. The output from the SDT1 can input directly to an oscilloscope or a signal analyzer. The low frequency roll off for the sensor is determined by the input impedance of the electronics. Typical impedances to be used would be at least 1 M O for most applications, and may need to be as high as 100 M O if 1-10 Hz frequencies are being monitored. Detailed specification sheets are available from our website.





Dimensions in INCHES (mm)								Low Volume Price (US $)
Description	A Film	B Electrode	C Film	D Electrode	t (µm)	Cap (nF)	Part #	
SDT1-028K	.644 (16)	.520 (13)	1.641 (41)	1.18 (30)	75	2.78	1-1000288-0	$25.00

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Piezo Polymer Thick Film Elements

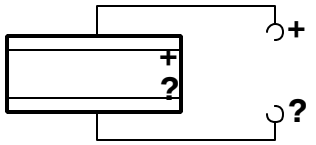
Piezo film has typically been available in thin film (9 – 110 µm) formats. These are useful thicknesses for most applications. Over the past few years, extensive research has been done to produce thicker films and non-standard shapes for those specialized applications where very high sensitivity is needed in the thickness mode (d_{33})or for hydrostatic (d_h) measurements, like sonar.

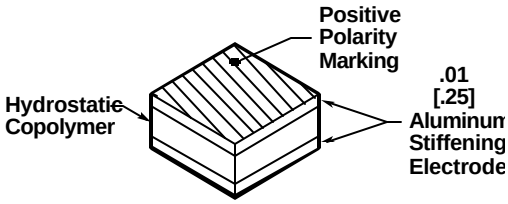
MSI has developed thick film elements of piezo polymer. The standard building block for this is 500 µm material, which can be multi-layer stacked for increased sensitivity. As the thickness of the series stacked sensor increases, the sensitivity increases, but the capacitance decreases proportionately.

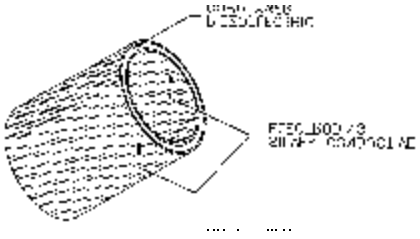
Additional stacking options are available on a custom basis for parallel wired configurations, where elements of film are laminated and wired to give a higher capacitance per unit of surface area. This option can also be used in order to create a shielded transducer, or an acceleration canceling device. The piezo polymer thick film elements can be provided with aluminum electrodes which clamp the in-plane piezo coefficients and therefore increase the hydrostatic sensitivity. These elements can be fabricated to customer specification, and can be made in sizes up to 12" x 18".

Thick piezo polymer can also be supplied in a cylinder format, with a wall thickness of 1.07 mm. The inner and outer walls are metallized with silver ink for electrodes. Wires can be affixed to these electrodes with conductive epoxy. Please specify the length dimension of the cylinder sensor when ordering.

Schematic:







Description	Dimensions		Capacitance pF/in$_2$ [pF/cm$_2$]	Sensitivity (dB, re1 V/µPa)	Part No.	Low Volume Price (US $)
	Polymer Thickness	Overall Thickness				
500S Tile	.020 [.51]	.040 [1]	88.90 [14]	-198.0	0-1001160-0	$25.00/in ^{2}
1000S Tile	.040 [1]	.059 [2]	44.40 [7]	-192.0	0-1001155-0	$50.00/in ^{2}
1500S Tile	.060 [2]	.079 [2]	29.60 [5]	-188.5	0-1001172-0	$75.00/in ^{2}
Cylinder	.047 [1]	Diameter .440 [11]	41 pF/in [16 pF/cm]	-195.0	0-1001911-1 (+) 0-1001911-2 (-)	$25.00 each

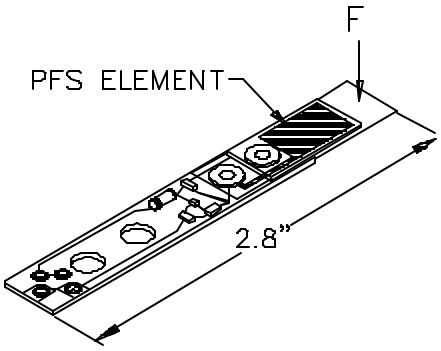
NOTE: The (+) and (-) refer to the polarity

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Piezo Film Solid State Switches

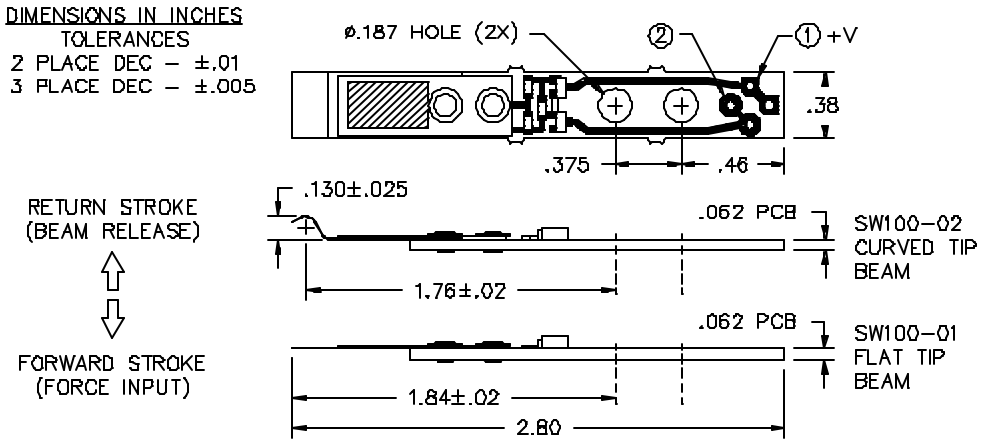
Piezo film's capability to generate a high voltage output under bending strain, combined with its rugged form factor, make it an ideal candidate for solid state impact switches. Rather than using a switch contact closure, the piezo film generates a pulse which is detected by electronics. Although many of the DT's, LDT's and FLDT's supplied by MSI are used for switch applications, it is sometimes convenient to have a switch with integrated electronics.



Smart Switch SW100

The SW100 is an ideal configuration for impact detection and momentary switch applications. A direct contact force on the tip of the stainless steel cantilever beam of the SW100 induces strain on the laminated Piezo Film Sensor (PFS) element. With dynamic strain, the PFS element generates an output that activates a built-in, normally-open circuit. Once activated, the circuit resembles the closure of a contact switch, but without the inherent discontinuity that contact points exhibit because of corrosion, pitting and bouncing. Thus the SW100 provides a single digital pulse that is ideal for triggering digital circuits and signal processing. The imperviousness, elasticity and reliability of the PFS element, along with the noise rejection characteristics of the circuit, combine to provide the SW100 with features that suit applications demanding consistent, reliable performance throughout tens of millions of switching cycles.

Custom options are available to fit specific customer applications. For more information on the SW100, please call one of our applications engineers .Detailed specification sheets are available from our website.



Description	Beam Tip	Stroke Direction to Trigger Switch	Part #	Low Volume Price (US $)
SW100-01-R	Flat	Reversed	0-1002393-1	$5.00
SW100-01-F	Flat	Forward	0-1002393-2	$5.00
SW100-02-R	Curved	Reversed	0-1002132-1	$5.00
SW100-02-F	Curved	Forward	0-1002132-2	$5.00

***Please contact factory for custom part quotations and volume pricing.**

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Internet: www.msiusa.com
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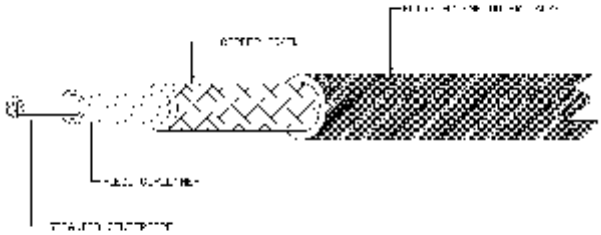
Piezo Polymer Coaxial Cable

Piezo cable is an alternative form of piezo polymer sensor. Designed as a coax cable, the piezo polymer is the"dielectric" between the center core and the outer braid. When the cable is compressed or stretched, a charge or voltage is generated proportional to the stress.

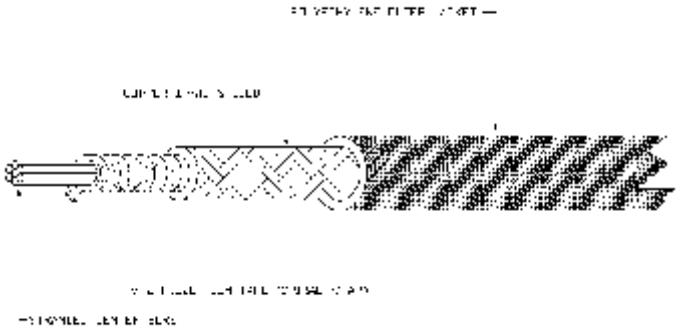
Piezo cable has a number of advantages in certain applications. Due to its coaxial design, the cable is self-shielded, allowing its use in a high EMI environment. The piezo cable can be spliced to passive coax, using standard coax splice techniques. It is extremely rugged, and will withstand repeated impacts. Its linear format makes it ideal for monitoring large areas which would be difficult and more expensive to do with piezo film.

Continuous lengths of piezo cable is available in a variety of different gages and construction formats. As a standard product, it is offered as a 20 AWG center core with a polyethylene outer jacket

We offer two versions of the piezo cable: copolymer and spiral wrap. Detailed specification sheets are available from our website.



20 AWG CABLE - COPOLYMER



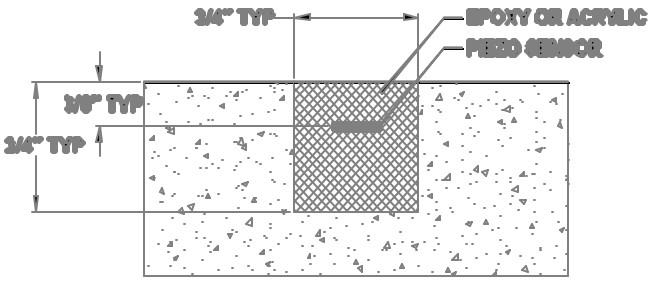
20 AWG CABLE - SPIRAL WRAP

Description	Dimensions (Nom)		Capacitance pF/Foot (Nom) [pF/Meter]	Part No.	Price per meter (US $)
	Center Core	Outside Dia.			
20 AWG Piezo Cable	**.040** [1]	**.107** [3]	**200** [655]	0-1005646-1	$16.50 (**1-500 meters)***
20 AWG Piezo Cable - spiral wrap construction	**.040** [1]	.**105** [3]	**279** [980]	0-1005801-1	$12.50 (**1-500 meters)***

***Please contact factory for custom part quotations and volume pricing.**

Traffic Sensors

The **Roadtrax** BL Traffic Sensor is designed for Permanent or Temporary installation into or onto the road surface for the collection of traffic data. The unique construction of the sensor allows it to be installed directly into the road in a flexible format so that it can conform to the profile of the road. The flat construction of the sensor gives an inherent rejection of road noise due to road bending, adjacent lanes, and bow waves for approaching vehicles. The small cut in the road minimizes the damage that is done to the road, speeds up the installation and reduces the amount of epoxy that is used for the installation. The Roadtrax BL sensor is available both as a Class I sensor for the highest level of uniformity needed for Weigh in Motion applications and as a Class II sensor which is more cost effective for Counting, Classifying, High speed Toll Booths, Speed Detection, and Red Light Cameras.



Permanent In-The-Road Installation

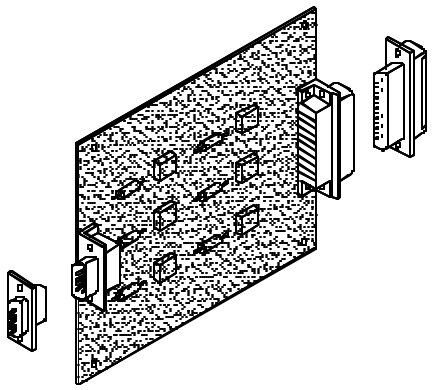
- Uniform, **high amplitude** piezoelectric output **compatible with existing** counters and classifiers on the market.
- Excellent Signal to Noise Ratio which has an inherent **10:1 rejection** of road noise due to road bending, adjacent lanes and bow waves of approaching vehicles.
- Easy installation in a 3/4" x 3/4" slot, which minimizes the disturbance of the road, decreases the depth of the road cut, and minimizes the amount of epoxy needed.
- Flexible sensor - conforms to any road profile while maintaining a uniform distance to the road surface.
- The **final installation is flush** with the road surface - snowplows will not do damage to the sensor.
- Durable enough to withstand normal installation handling and **hundreds of millions ESAL's.**
- All sensors are **100% tested and certified** for performance as a complete sensor prior to shipment.
- Custom Passive Signal Cable with **High Density Polyethylene Jacket** which is rated for direct burial and resists nicks and cuts.
- Class II sensors are tested to ±20% uniformity; Class I (WIM) are tested to ±7% uniformity.

Description	Part #	Price (US $) (Qty 1-49)
6' BL Class II w/100'	0-1005333-1	$299.00
8' BL Class II w/100'	1-1005333-1	$359.00
10' BL Class II w/100'	3-1005333-1	$419.00
11' BL Class II w/100'	4-1005333-1	$449.00
12' BL Class II w/100'	5-1005333-1	$479.00
6' BL WIM	1-1005438-1	$568.00
8' BL WIM	2-1005438-1	$682.00
10' BL WIM	4-1005438-1	$796.00
11' BL WIM	5-1005438-1	$853.00
12' BL WIM	6-1005438-1	$910.00
Extra Cable (50' increments only)	0-1004552-0	$.50/ft

For additional information, request the BL Sensor Package, also available on our website.

Interface Circuit Board
for Piezoelectric Traffic Sensor

The Traffic Sensor Interface Board is designed to condition signals from MSI's piezoelectric traffic sensors to interface with a wide variety of industry standard traffic data collection modules. The Traffic Sensor Interface Board contains six channel sensor signal conditioning circuitry, user adjustable comparator, digital pulse output, and internal power regulation. The Interface Board can be powered from a single supply voltage between +8VDC and +28 VDC.



SPECIFICATIONS

Number of input/output channels	6
Input (Analog)	9 Pin D type Male Connector
Output (Digital)	25 Pin D type Male Connector
Circuit Board Size	220mm x 128mm
Front Panel	50mm x 128mm
Storage Temperature	-40?C ~ +85?C
Operating Temperature	-40?C ~ +70?C

Output Connector Pin Assignment	
Pin #	**Assignment**
1	GND
2	Power Supply
3	Not Used
4	Digital Output (CH1)
5	Digital Output (CH2)
6	Digital Output (CH3)
7	Digital Output (CH4)
8	Digital Output (CH5)
9	Digital Output (CH6)
10-25	Not Used

Input Connector Pin Assignment	
Pin #	**Assignment**
1	CH6
2	CH5
3	CH4
4	CH3
5	CH2
6	CH1
7	GND
8-9	Not Used

Description	**Part #**	**Low Volume Price (US $)**
Interface Circuit Board for Piezoelectric Traffic Sensor	0-1005766-0	$300.00

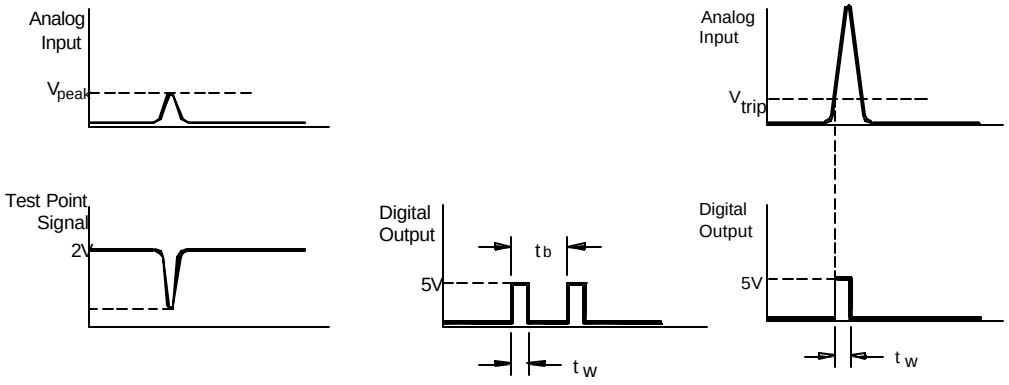
Interface Circuit Board for Piezoelectric Traffic Sensor (cont'd)

SPECIFICATIONS (cont'd)

Analog Circuit				
	Min	**Typ**	**Max**	**Unit**
Dynamic range	25		3V	mV
Gain		2		
Lower cutoff frequency (-3dB)		0.5		Hz
Upper cutoff frequency (-3dB)		1,200		Hz
Power Supply	+8		+28	VDC

Digital Output				
	Min	**Typ**	**Max**	**Unit**
Output Impedance			10k	ohms
Pulse output	4.5	5	5.5	V
Pulse width, t_w	2.8	3.3	3.8	ms
Black-out time, t_b	8.5	10.0	11.5	ms

Trip Level		
Dip Switch Position	**V_{triup}**	**Unit**
All Off	0.05	V
1 On	0.1	V
2 On	0.2	V
3 On	0.4	V
4 On	0.8	V



NOTE: V_{trip} indicates the sensor voltage output to trigger digital output.

NOTE: Test point signal has -2X gain and +2V DC offset.

Accelerometers

The MSI family of accelerometers addresses a wide range of application needs. The ACH-01 is a general purpose, low cost, linear single axis accelerometer for a variety of monitoring applications. The ACH-04-08-05 is a multi-axis accelerometer, and the ACH-04-08-09 is a single-axis accelerometer, both with integrated buffer electronics designed for PCB mounting applications.

The MSI family of accelerometers have opened new doors to the design engineer who needs to continuously monitor vibration, shock and acceleration. Detailed specification sheets are available from our website.

MSI Accelerometers			
	Applications	**Features**	**Benefits**
ACH-01-XX	? Car alarms ? Motional feedback for speakers ? Integrated motor vibration monitor ? Appliance vibration monitoring ? Shipping damage recorder ? Musical instrument pickups	? Low cost ? Very low power ? Single axis ? Wide frequency response ? Large dynamic range ? Small, lightweight ? Buffered electronic output	? High performance/price ratio ? Low impedance output for simplified user interface ? Very rugged to reduce failures ? Ability to easily measure high frequency events ? Low noise - High output
ACH-04-08-05	? Disk drive shock sensor ? Appliance vibration monitoring ? Automotive applications ? Security sensors	? Very low cost ? Very low power ? Multiple axis response, each as an independent channel ? Small size - PCB mountable ? Integrated buffer electronics ? Low corner frequency	? Exceptional performance at a very low cost ? Buffered output lowers noise, reduces user interface electronics ? Measures acceleration in multiple axes with only one sensor
ACH-04-08-09	? Car alarms ? Appliance vibration monitoring ? Security sensors ? Low cost embedded applications	? Very low cost ? Very low power ? Single axis ? Integrated buffer electronics ? Small size - PCB mountable ? Low frequency response	? Excellent performance at very low cost ? Buffered output lowers noise, reduces user interface electronics ? High sensitivity with very low power

Accelerometers

Production Qualified Accelerometers				
		ACH-01-XX	**ACH-04-08-05**	**ACH-04-08-09**
Key Features		-Wide Frequency Range -Wide Dynamic Range -High Sensitivity -Low Noise -JFET Buffer	-Low Frequency Operation -3 Simultaneous Analog Outputs -Low current generation - JFET Buffer	-Low Frequency Operation -Low Current Operation - JFET Buffer
Sensitive Axes	X-Axis	---	X	--
	Y-Axis	---	X	X
	Z-Axis	X	X	--
Sensitivity (Nominal)		10 mV/g	1.8 mV/g	6mV/g
Frequency Range (±3 dB)		1.0 Hz-20 kHz	0.5 Hz to 4 kHz	0.2 to 1500 Hz
Dynamic Range		±250 g	±250 g	±40 g
Resolution (@ 100 Hz)		40µg/√Hz	200 µg/√Hz	40 µg/√Hz
Resonant Frequency		>35 kHz	9.2 kHz	3.4 kHz
Resonant Q (Hz/Hz)		30	10	10
Transverse Sensitivity		5%	15%	<20%
Linearity		0.1%	0.1%	0.1%
Operating Temperature		-40 °C to +85 °C	-40 °C to +85 °C	-40 °C to +85 °C
Storage Temperature		-40 °C to +85 °C	-40 °C to +85 °C	-40 °C to +85 °C
Maximum Shock		1000 g	1000 g	1000 g
Supply Voltage		3 V to 40 V	3 V to 40 V	3 V to 28 V
Supply Current		2 µA Typical	6 µA Typical	2 µA Typical
Weight		3 grams	0.35 grams	0.35 grams
Size (mm)		13 x 19 x 6	11 x 10 x 1.8	11 x 10 x 1.8
Mounting Method		Adhesive	Hand Solder to PCB	Hand Solder to PCB

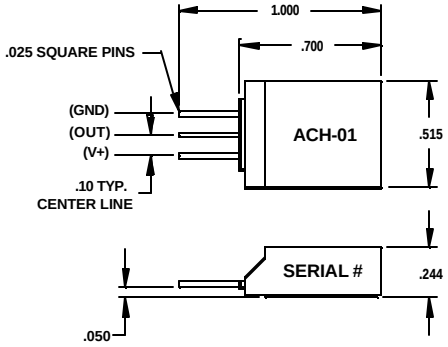
ACH-01 (General Purpose)

The ACH-01 is an inexpensive, very robust, general purpose accelerometer with outstanding performance characteristics. The use of KYNAR Piezo Film in the ACH-01 provides many cost/performance advantages that allow it to be used in a wide range of applications where the use of traditional accelerometer technology is impractical. It is specifically designed for high volume applications which require the permanent installation of an accelerometer, such as machine health monitoring, modal analysis, automotive sensors, appliances, and feedback control systems.

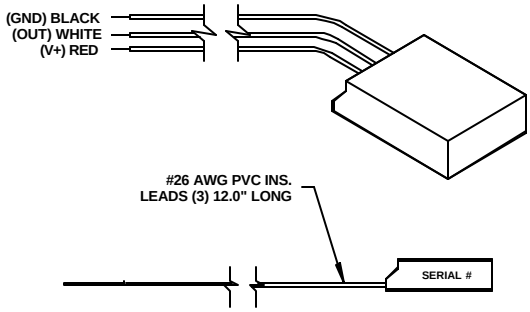
FEATURES

? Wide Frequency Response
? Excellent Phase Response
? Wide Temperature Range
? Wide Dynamic Range
? Small Temperature Dependence
? Low Cost
? Large Supply Voltage Range
? Excellent Linearity
? Low Impedance Output
? Very High Resonance
? Electrically Isolated Base
? Low Mechanical Q
• Low transverse sensitivity

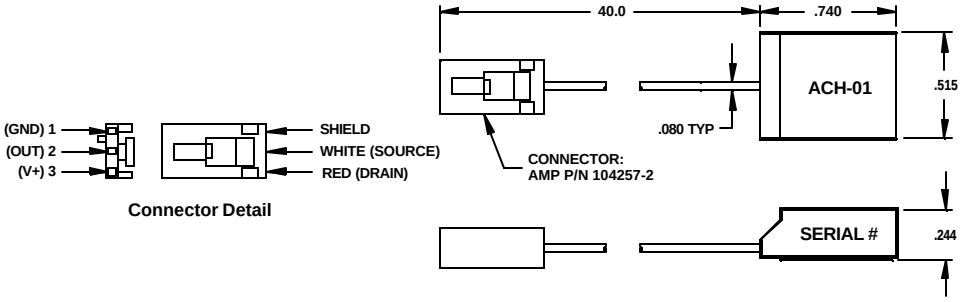
Note: All dimensions in inches and are reference.



ACH-01-02 with Pins



ACH-01-04 with Wires



Connector Detail

ACH-01-03 with Shielded Cable

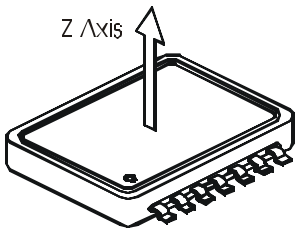
Please contact factory for custom part quotations and volume pricing.

Description	Cable Configuration	Part #	Low Volume Price (US $)
ACH01-02/10	3 Pins, .25" square	0-1000985-0	$19.95
ACH-01-03/10	40" coax cable with female connector	1-1001220-0	$19.95
ACH-01-04/10	Wires	1-1001497-0	$19.95

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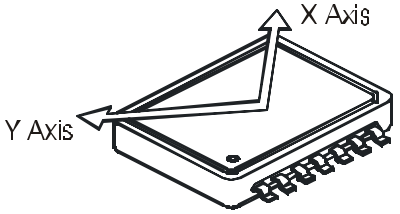
ACH-04-08-05 (Multi-Axis)

Sensitivity Axes



The ACH-04-08-05 accelerometer contains three piezoelectric sensing elements oriented to simultaneously measure acceleration in three orthogonal, linear axes. Internal JFET's provide for a low impedance, buffered output with a wide variety of possible, application specific, signal conditioning circuitry. The sensor responds over a broad frequency range, from below 0.5Hz to above 5kHz, as a result of the integrated electronics and the damped sensing elements.

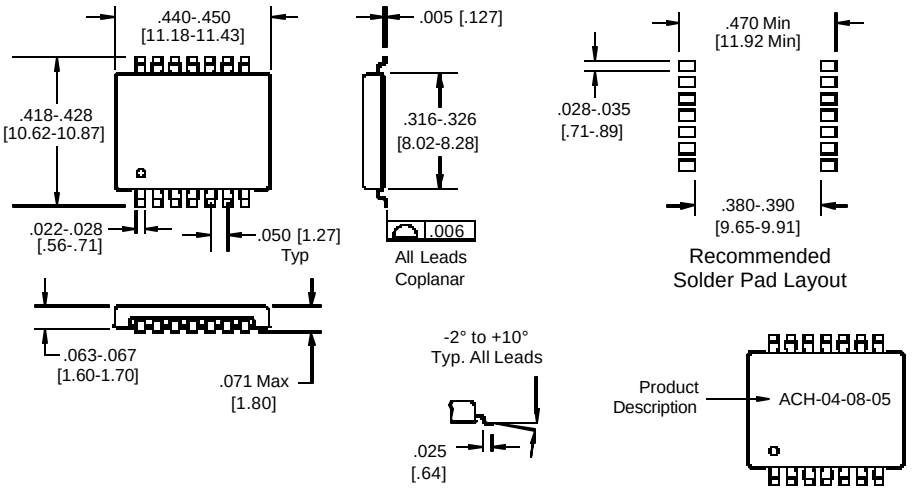
The ACH-04-08-05 accelerometer can be used in a wide range of applications including motional measurement and control systems, speaker feedback systems, vibration switches, shipment monitor and material handling systems, security systems, computer input/output devices, and data loggers. The device is not IR reflow solderable.



FEATURES:

? Fully Contained 3-Axis Accelerometer
? Low Frequency Response
? High Resonant Frequency & Low Q
? Excellent Linearity
? Three Simultaneous Analog Outputs
? Low-Impedance Output
? Ultra-Low Power
? Low Cost

ACH-04-08-05 Dimensions, PCB Layout and Marking



Description	Part #	Low Volume price (US $)
ACH-04-08-05	0-1003800-5	$25.00

Please contact factory for custom part quotations and volume pricing.

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ACH-04-08-09 (Single Axis)

The ACH-04-08-09 accelerometer contains a single mass loaded piezoelectric sensing element oriented to measure acceleration in the plane of the device. An internal JFET provides for a low impedance, buffered output allowing a wide variety of off chip application specific signal conditioning circuitry. The sensor responds over a broad frequency range, from below 0.5Hz to above 2kHz, as a result of the integrated electronics and the damped sensing elements.

The ACH-04-08-09 accelerometer can be used in a wide range of applications including motion measurement and control systems, speaker feedback systems, vibration switches, shipment monitor and material handling systems, security systems, computer input/output devices, and data loggers.

Pinout

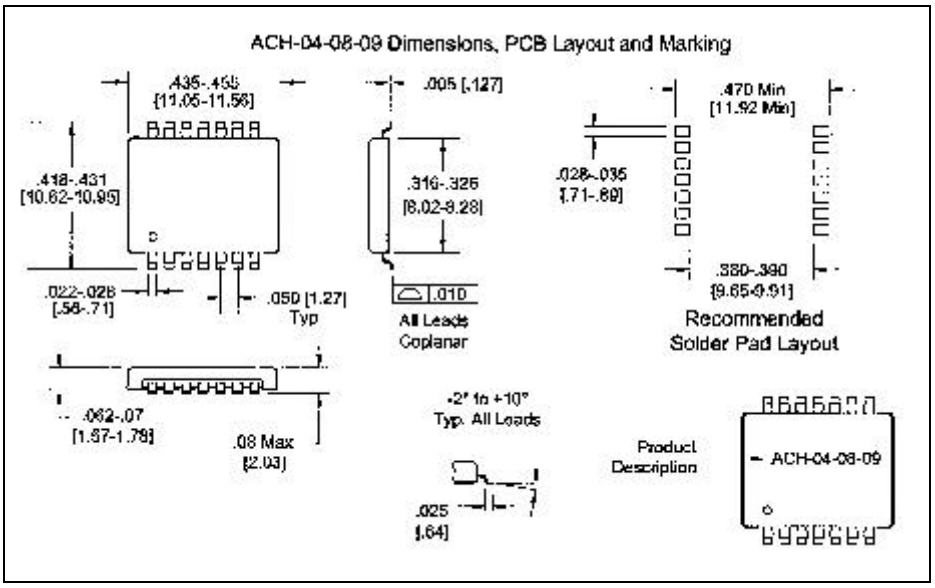


Sensitivity Axis



FEATURES:

- Fully Contained Single Axis Accelerometer
- Low Frequency Response
- Single Buffered Analog Output
- Low-Impedance Output
- Low Q at Resonance
- Excellent Linearity
- Ultra-Low Power (Typical I_Q of 4mA)
- Low Cost



Description	Part #	Low Volume price (US $)
ACH-04-08-09	0-1005755-1	$25.00

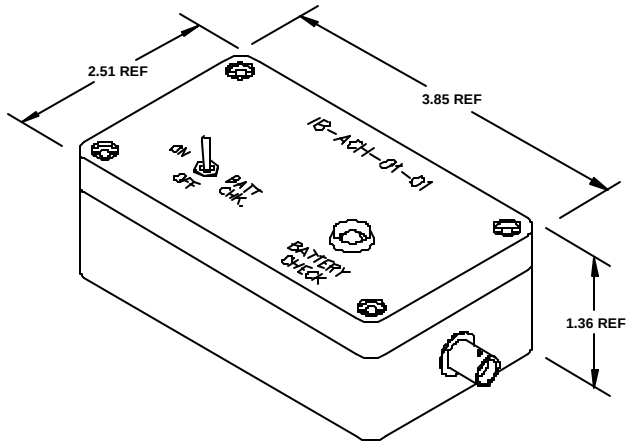
Please contact factory for custom part quotations and volume pricing.

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e-mail: sensors@msiusa.com

IB-ACH01 (Amplifier Box)

MSI has developed this low cost interface amplifier specifically for use with the ACH-01. It is designed to mate directly to the connector supplied with the ACH-01-03 assembly. For use with either the ACH-01-02 or ACH-01-04, an adapter is required to interface the two components.

Characteristics	IB-ACH-01
Gain	10 X
Low Frequency Filter	-3dB @ 2 Hz, fixed
High Frequency Filter	-3dB @ 30 kHz, fixed
Power Supply	One 9 Volt Battery
Input Interface	FET for ACH-01
Supply Current	4.0 mA
Battery Life	80 Hours
Low Battery Cutoff	7.2 V
Output Impedance	100 O
Output Connector	BNC



Description	Part #	Low Volume Price (US $)
IB-ACH-01	0-1003058-0	$100.00

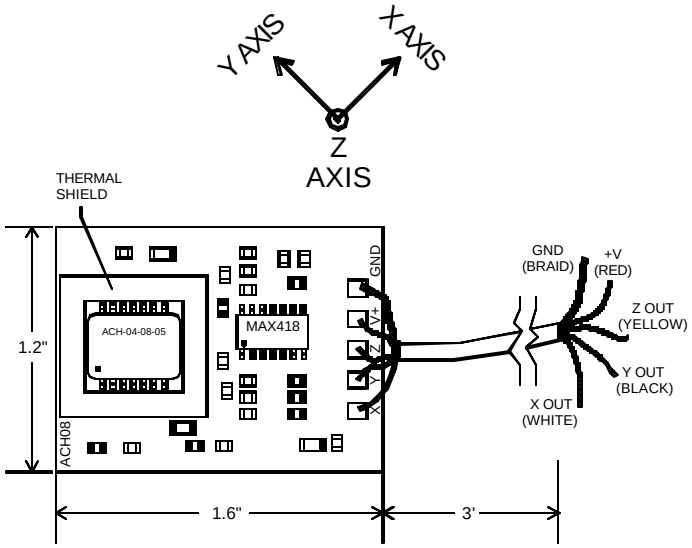
Please contact factory for custom part quotations and volume pricing.

ACH-04-08-05 Analog Test PCB

The ACH04-08-05 Accelerometer Analog Test PCB provides a simple way to evaluate the ACH-04-08-05 three-axis accelerometer. The unit consists of the ACH-04-08-05 accelerometer, a low-power operational amplifier, along with passive resistors and capacitors to provide signal conditioning. The sensor and circuit are preassembled on a double-sided, printed circuit board with three feet of flexible cable for easy user interface. The system demonstrates the basic capabilities of the ACH-04-08-05 accelerometer. Detailed specification sheets are available from our website.

FEATURES:

? Signal Conditioned 3-Axis Accelerometer
? High-Pass Filter @ 0.34Hz
? Low-Pass Filter @ 185Hz
? Requires Only Single +5V Power Supply
? Three Simultaneous Analog Outputs
? Low-Impedance Output
? Integrated Thermal Shield
? Ultra-Low Power (13µA @ 5V)

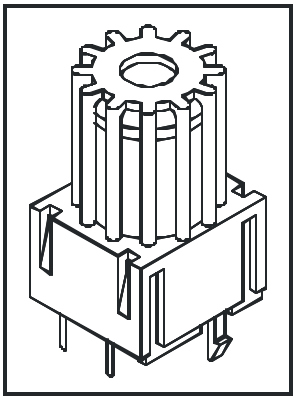


Description	Part #	Low Volume price (US $)
ACH-04-08-05 Analog Test PCB	0-1005685-1	$50.00

Please contact factory for custom part quotations and volume pricing.

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e-mail: sensors@msiusa.com

40kHz Omni Directional Ultrasound Transmitters
40kHz Wide Angle Ultrasound Receivers



Piezoelectric film (PVDF) ultrasound transmitters and receivers offer unique advantages for air ranging applications. Cylindrical 40kHz PVDF transmitters exhibit omni-directional horizontal beam directivity and broad band characteristics.

Cylindrical 40kHz PVDF receivers exhibit very wide horizontal beam directivity and broad band characteristics. These characteristics lend unique solutions in many applications such as two-dimensional positioning, digitizer, object detection, and distance measurement.

Depending on the applications, resonance frequency and vertical beam directivity of the transmitter and receiver can easily be customized by changing the diameter and length of the PVDF cylinder. The receiver has a very wide horizontal beam angle and it can be reduced by changing the housing design if necessary.

PVDF transmitters and receivers also have very low resonance Q value. Typically, PVDF transmitters have a Q value of 5 and PVDF receivers have a Q value of 4 This means that the rising time and the signal decay time are much faster than the conventional ceramic transmitters. This characteristic is suitable for high speed data acquisition or high speed digitizer applications.

A test board, consisting of snap-in mounting holes and test pins, is available for easy evaluation of the 40kHz transmitters. A preamplifier is available for easy evaluation of the 40kHz receivers.

FEATURES:

- Omni-directional horizontal beam directivity
- Broad band
- Low resonance Q
- Excellent impact resistance
- Low cost
- Light weight

Description	Part #	Low Volume Price (1 - 9) (US $)
40 kHz Transmitter	1005853-1	$10.00
Test Board (for Transmitter)	1005854-1	$10.00
Drive Electronics (for Transmitter)	1005855-1	$100.00
40kHz Receiver	1005856-1	$10.00
Preamplifier Board (for Receiver)	1005857-1	$25.00

Please contact factory for custom part quotations and volume pricing.

Shockwriter 3000®



The Shockwriter 3000 is a portable event recorder which monitors the environmental conditions during transportation and records specific events which exceed user defined standards. The combination of a triaxial accelerometer and thermistor provide the capability to accurately record vibration (shock) in any axes simultaneously as well as temperature. All recorded information is stored with the commensurate date including hour and minutes for easy possession tracking.

The unit is designed with a great deal of flexibility such that the end user can program the specific operating conditions based upon their specific application. The unit is easily programmed by a simple menu driven setup screen through an RS-232 serial interface port and a host computer (portable PC). In addition, the unit can be reprogrammed at any time in the future if the application or environmental conditions merit different monitoring thresholds.

Some of the specific operating parameters programmed by the end user include: temperature monitoring thresholds and intervals; acceleration thresholds and duration of event; sleep mode power conservation; data storage priority sorting and arming method. The most significant vibration events will contain additional information that will allow the user to graph the information (all three axes) or save it for further processing including signature analysis or statistical process control.

FEATURES

? Measures shock in three axes simultaneously, as well as temperature extremes, with commensurate date and time
? Password protected memory and setup configuration
? Permanent memory of data (even with loss or interruption of power)
? User friendly menu driven software programmed via RS232 port, DOS compatible or Windows95
? Lightweight (2.5lbs); slim profile
? Battery powered with long life power saving options
? Over 700 separate total events can be recorded
? Significant events can be easily graphed or transferred to more familiar software packages
? Fast software prevents Shockwriter from missing events
? Reusable for many different applications
? Affordable

For additional information, request the Shockwriter Catalog.

APPLICATIONS

? Continuation of ISO 9000 practices throughout transit
? Detection of events that may cause hidden damage (before installation begins)
? In-house materials handling / production monitoring
? Military hardware - certificate of transportation
? Aerospace hardware - certificate of transportation
? Insurance claim assistance
? Machinery monitoring
? Packaging optimization
? Air cargo quality
? International ocean transportation
? Railroad car coupling events

Description	Part #	Low Volume Price (US $)
Shockwriter Kit (contains Shockwriter, software, power pack, data cable)	0-1005204-1	$1,350.00
Data Cable (additional)	0-1005118-1	$80.00
Power Pack (additional)	0-1005117-1	$70.00

Measurement Specialties, Inc.
P.O. Box 799, Valley Forge, PA 19482
Tel: 610.650.1500 FAX 610.650.1509
Internet: www.msiusa.com
e-mail: sensors@msiusa.com

KITS:

A good way to learn more about piezo film sensors is to purchase one of our design kits. These kits illustrate the use of piezo film in different configurations, and are a good starting point to learn more about piezo film sensors and their applications.

Basic Design Kit: This kit demonstrates the use of MSI piezo film sensors as microphones, speakers, switches and acoustic pickups. All the components and film samples in the kit can be used for experimentation.

Contents of the Basic Design Kit:

- Technical Manual
- Speaker Element
- Piezo Cable
- Flicker
- SW100-01-F
- ACH04-08-05
- SDT1-028K
- DT0-028K
- LDT1-028K
- DT1-028K
- Test PCB ACH-04-08 (w/o Analog circuit)
- Application Notes
- Application Specs
- Instruction Sheets

Piezo Cable Kit: This kit features MSI piezo polymer in coaxial cable format. Piezo cable is especially useful for large area sensing applications such as physical security and safety mat sensors, proximity sensors, traffic sensors and security fence transducers.

Contents of the Piezo Cable Kit:

- Technical Manual
- Application Specs
- 20 AWG Piezo Cable spliced to RG-174/U with BNC Connector

Vibration and Acceleration Kit: This kit demonstrates the capabilities of piezo film as a vibration sensor and accelerometer component. The kit includes shielded and unshielded thin film sensors and an ACH-01 accelerometer component with an interface amplifier.

Contents of the Vibration and Acceleration Kit:

- Technical Manual
- SDT1-028K
- ACH-01 MSI Box
- ACH01-03/10
- LDT1-028K
- LDT0-028K
- DT1-028K
- 9 Volt Battery
- Application Specs
- Instruction Sheets

Ultrasound Design Kit (40KHz): This kit demonstrates the basic design concept of ultrasonic digitizers and distance measurements. Since piezo film ultrasound transducers have low Q values and very wide beam directivities, it is perfect for high resolution position detection applications. The kit includes transmitters, receivers, and interface electronics.

Contents of the Ultrasound Design Kit:

- Four 40KHz transmitters
- Four 40KHz receivers
- One drive electronic circuit board
- Two preamplifiers
- Two test boards
- Cable assemblies
- Product data sheets and an instruction sheet

Description	Part #	Price (US $)
Basic Design Kit	0-1004308-0	$135.00
Piezo Cable Kit	0-1003726-0	$75.00
Vibration/Acceleration Kit	0-1003460-0	$189.00
Ultrasound Design Kit	0-1005870-1	$200.00

What You Should Know Before You Buy

ORDERING:

PHONE - Where and When to call

Call us direct at 610-650-1500 weekdays between 8 a.m. and 5 p.m. Eastern time zone. On the West Coast, please call 916-983-8644.

Have your purchase order number or VISA® /Master Card® number and expiration date handy.

FAX - Where and When to FAX

Fax us direct at 610-650-1509 anytime.

MAIL

Send your Company Purchase Order to:

Measurement Specialties, Inc.
Customer Service Department
P.O. Box 799
Valley Forge, PA 19482

MINIMUM ORDER $100 (US Dollars)

SHIPPING:

Carriers

Products ordered through MSI are shipped from point of manufacture via ground carrier. Selection of carrier is based on weight and delivery location. Air freight is available at your request.

Shipping Charge

Shipping charges are prepaid and added to your invoice. You may request carrier charges be charged to your account.

PAYMENT:

Terms

Subject to credit approval, payment terms are net 30 days from invoice date. VISA and MasterCard are also accepted for payment.

PRICING:

Pricing

Prices in this catalog are in **U.S. DOLLARS**. These prices are valid through December 31, 2001.

Catalog Errors

Measurement Specialties reserves the right to correct printing errors and change prices without notice.

Taxes

We are required to collect all state and local sales/use taxes unless we have a tax exempt certificate on file.

RETURNS:

Before returning any item, please call to obtain a Return Material Authorization (RMA) from our Customer Service Department at 610-650-1503. This number will help us adjust your account as quickly as possible. We will ask for: the reason for the return, your purchase order number, date of purchase, and the MSI Order Number. Instructions for shipment will be given at that time.

MSI's QA department will analyze the returned goods and determine the cause of failure. If MSI confirms responsibility and the parts are in warranty, then appropriate credit or replacements will be sent.

TERMS & CONDITIONS OF SALE:

All orders are sold under the MSI Terms and Conditions of Sale.

ORDER FORM

Order by FAX: (610) 650-1509 (Copy of Company P.O. MUST accompany your order)

Order by Phone: (610) 650-1503 Monday - Friday, 8:00 am - 5:00 pm EST

BILL TO: (Please print) _____

Name _____

Company _____

Address _____

_____

_____

Phone ( ) _____

[ ] Is a confirming telephone order of (date) _____

[ ] Bill Company P.O. (Copy must be attached)

[ ] Check Enclosed [ ] VISA [ ] MasterCard

Exp Date _____

SHIP TO: (Please print) (DELIVERY TO STREET ADDRESS ONLY)

Name _____

Company _____

Address _____

_____

_____

Phone ( ) _____

Card No. _____

Signature _____

Part #	Description	Quantity	Unit Price (US $)	TOTAL (US $)

Ordering Information: Delivery: From Stock

Terms: 30 days net with approved credit

SHIPPING: FOB Valley Forge, PA USA

By UPS Ground or as specified by customer.

Shipping and handling charges will be added to your invoice

Sales Tax	
GRAND TOTAL (US DOLLARS)	

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Terms and Conditions of Sale

Measurement Specialties Incorporated, Sensors Division

1. **Quotations and Acceptance:**
   (a) Quotations are valid for a period of sixty (60) days from date of quotation, and represent no obligation until Measurement Specialties, Sensors Division (hereafter MSI SENSORS) accepts the written Purchase order.
   (b) In the event of inconsistency between MSI SENSORS' and the Purchaser's conditions, MSI SENSORS' shall prevail. No variation of MSI SENSORS' conditions shall be binding upon MSI SENSORS unless and until the variation has been accepted in writing by a duly authorized person on behalf of MSI SENSORS.
2. **Price and Delivery:**
   (a) Unless otherwise agreed, Delivery will be F.O.B. MSI SENSORS' facility, Valley Forge, PA., and goods will be packed to MSI SENSORS' normal specification in nonreturnable packaging. Transportation will be arranged at the request and at the expense of the Purchaser. Where applicable, COD charges will be added to the price of the goods.
   (b) Any delivery period quoted is an estimate only and commences from MSI SENSORS' acknowledgment of the Purchaser's order. The sole remedy of Purchaser for failure of MSI SENSORS to deliver in a timely manner shall be for Purchaser to acquire the goods from another source, in which case said quantity shall be eliminated from this contract, and Purchaser shall have no claim against MSI SENSORS for damages.
   (c) MSI SENSORS reserves the right to deliver in more than one lot and to invoice each lot separately.
   (d) Shortages, defective or damaged goods must be reported to MSI SENSORS within thirty (30) days of Delivery. All goods are shipped at Purchaser's risk and claims for goods damaged or lost in transit should be filed by the consignee direct with the transportation company.
   (e) All returned materials must have a Returned Materials Authorization (RMA) number issued by MSI SENSORS. This authorization is valid for a period of 30 days. Returns at the customer convenience are limited to standard, catalog items, and are subject to a $100 or 15% restocking fee, whichever is greater, excluding freight charges. Returned materials for Quality Complaints will be evaluated by the quality department and a credit issued when the complaint is approved. Customer specific products may not be returned except for Quality Complaints or MSI SENSORS
   (f) For all Customer Specific Products, MSI SENSORS reserves the right for a shipping tolerance of ± 5% for each shipment and for the total order. Cancellation charges and/or inventory carrying costs may be imposed for products when orders are canceled or modified within eight weeks of the scheduled ship date.
3. **Title and Risk of Loss:**
   (a) Title will pass to the Purchaser only on receipt by MSI SENSORS of payment for the full invoice price of the goods.
   (b) Risk of loss shall pass to the Purchaser on leaving MSI SENSORS' premises.
4. **Payment:**
   (a) Payment shall be due 30 days from date of invoice, subject to credit approval, except where MSI SENSORS stipulates CWO or COD terms. Payment shall not be withheld on account of any claim by the Purchaser against MSI SENSORS. MSI SENSORS reserves the right to charge interest at 1.5% per month on any sum outstanding after the due date.
   (b) MSI SENSORS reserves the right, among other remedies, either to cancel this contract or to suspend further deliveries under it in the event Buyer fails to pay for any one shipment when payment becomes due. Should Buyer' financial responsibility become unsatisfactory to MSI SENSORS, cash payments or satisfactory security may be required by MSI SENSORS.
   (c) Any tax, duty, custom, or other fee of any nature imposed upon this transaction by any federal, state, or local government authority shall be paid by the Purchaser, in addition to the price quoted or invoiced. In the event MSI SENSORS is required to prepay any such tax, Purchaser will reimburse MSI SENSORS.
   (d) Unless specifically otherwise stated, all payments are to be made in United States Dollars ($), with the payment check drawn on a US Bank. All banking charges, if any, are to be pre-paid by the Purchaser.
5. **Technical Assistance and Data:** MSI SENSORS may, at Purchaser's request, furnish technical assistance, advice and information with respect to the goods supplied under this Contract, if and to the extent that such assistance, advice and information is readily available, except for proprietary techniques or procedures. It is expressly agreed that there is no obligation to provide such information, and that the information is subject to the limitation of liability in paragraph 10 below. MSI SENSORS accepts no liability in contract, tort or otherwise for any damages or injury arising directly or indirectly from any error or omission in such technical data or literature.
6. **Warranty:**
   (a) MSI SENSORS warrants title to the product sold hereunder and that for a period of 90 days from Delivery it conforms to MSI SENSORS' specifications and is free from defects in material and workmanship. If the product fails to meet said warranties, MSI SENSORS shall replace or issue credit for the non-conforming product at no cost to Buyer. The foregoing is Buyer' sole and exclusive remedy for failure of MSI SENSORS to deliver or supply product that meets the foregoing warranties. **MSI SENSORS MAKES NO OTHER WARRANTY OF ANY KIND EXPRESS OR IMPLIED INCLUDING ANY WARRANTY OF MERCHANTABILITY, FITNESS OF THE PRODUCT FOR ANY PARTICULAR PURPOSE EVEN IF THAT PURPOSE IS KNOWN TO MSI SENSORS, OR ANY WARRANTY RELATING TO PATENTS, TRADEMARKS, COPYRIGHTS OR OTHER INTELLECTUAL PROPERTY.**
   (b) Purchaser warrants that the designs and specifications furnished by it to MSI SENSORS will not infringe any patent, trademark or copyright with respect to the manufacture and sale of the resulting products.
7. **Tools:** Tools made for the manufacture of goods to be supplied under the contract and the copyright therein remain MSI SENSORS' property notwithstanding that the Purchaser may have been debited with any sum in respect of their cost.
8. **Excusable Delays:** No liability shall result from delay in performance or non-performance in whole or in part if performance as agreed has been made impracticable by compliance in good faith with any applicable foreign or domestic governmental regulation or order whether or not it later proves to be invalid, or by the occurrence of a contingency the non-occurrence of which was a basic assumption on which this contract was made, including, but not limited to, acts of God, fire, flood, accident, riot, war, sabotage, strike, labor trouble or shortage, or embargo. MSI SENSORS' inability to obtain at prices and on terms deemed by it to be practicable any required raw material, energy source, equipment, labor, or transportation, or any increased costs due to capital improvements for environmental protection shall also be sufficient to relieve MSI SENSORS of its obligation to perform hereunder. If any of such circumstances affect only a part of MSI SENSORS' capacity to perform, MSI SENSORS shall have the right to allocate production and deliveries among all of its customers and its own requirements in a manner and at such times as MSI SENSORS may determine. Quantities affected by this paragraph may, at the option of either party, be eliminated from the contract without liability, but the contract shall remain otherwise unaffected.
9. **Indemnification**: Buyer agrees to indemnify, defend and hold MSI SENSORS harmless from and against that portion of any liability, cost, expense (including reasonable attorneys' fees), claim, judgment, settlement or damage that MSI SENSORS may be required to pay to any third party (including, but not limited to, any employee of Buyer who alleges or proves that he or she has been injured in the course of his or her employment while working with the products supplied by the MSI SENSORS under this agreement), which I) is caused or contributed to by the negligence or fault of Buyer; or ii) results from the infringement of any patent, trademark or copyright related to the products (or designs and specifications therefor) supplied to Buyer hereunder. In case the Buyer resells the products supplied by the MSI SENSORS under this agreement, Buyer will request and if possible obtain from its purchaser an indemnification similar to the foregoing for the benefit of Buyer and MSI SENSORS.
10. **Limitation of Liability:** MSI SENSORS shall not be liable on contract, tort or otherwise for any loss or damage suffered by the Purchaser whatsoever or howsoever arising out of or in connection with the supply of goods or services by MSI SENSORS other than to supply goods conforming to the original agreed specifications or at MSI SENSORS' option to refund to the Purchaser any moneys already paid in respect of the goods. MSI SENSORS' liability with respect to this contract and the products purchased under it shall not exceed the purchase price of the portion of such product as to which liability arises and MSI SENSORS shall not be liable for any injury, loss or damage, resulting from the handling or use of the product shipped hereunder whether in manufacturing process or otherwise. **In no event shall MSI SENSORS be liable for special, incidental or consequential damages, including, but not limited to, loss of profits, capital or business opportunity; downtime costs; or claims of customers of Buyer**. Failure to give MSI SENSORS notice of any claim within 30 days of Delivery of the product concerned shall constitute a waiver of such claim by Buyer. Notwithstanding any applicable statute of limitations to the contrary, any action by Buyer relating to a claim hereunder must be instituted no later than two (2) years after the occurrence of the event upon which the claim is based. All of the foregoing limitations shall apply irrespective of whether Buyer' claim is based upon breach of contract, breach of warranty, negligence, strict liability, or any other legal theory.
11. **Termination:** If the Purchaser commits any breach of the terms and conditions of the contract or suffers distress or execution or becomes insolvent or commits an act of bankruptcy or enters into any arrangement or composition with his creditors or goes or is put into liquidation (other than solely for amalgamation or reconstruction while solvent) or if a receiver is appointed over any part of the Purchaser's business, MSI SENSORS may without prejudice to any rights which may have accrued or which may accrue to it terminate the contract summarily by notice in writing.
12. **Entire Agreement** This agreement constitutes the entire contract of sale and purchase of the product herein named. It is not assignable by Buyer without the written consent of MSI SENSORS. No modification of this contract shall be of any force or effect unless in writing signed by the parties and no modification shall be effected by the acknowledgment or acceptance of purchase order forms containing different terms or conditions.
13. **Governing Law**: This contract shall be governed by and construed in accordance with the laws of the Commonwealth of Pennsylvania. Any lawsuit brought by Buyer arising out of the transactions covered hereunder shall be instituted in the appropriate state or federal court located in Philadelphia County, Pennsylvania, and Buyer further submits itself to the jurisdiction of said courts in the event MSI SENSORS elects to institute any action in said courts.

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