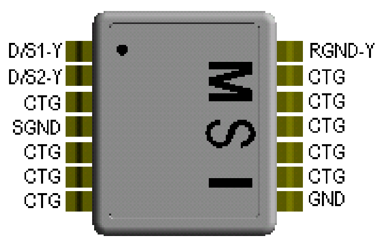
## 1.0 INTRODUCTION

This specification covers the application requirements of Measurement Specialties Accelerometer ACH-04-08-09. The accelerometer contains one 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.

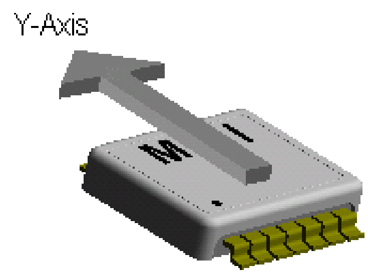
The ACH-04-08-09 accelerometer can be used in a wide range of applications including motion measurement and control systems, speaker feedback systems, vibration switches, shipment monitor and material handling systems, security systems, computer input/output devices, and data loggers.

Pinout




CTG = Connect To Ground

Sensitivity Axis




Features of the accelerometer include

- 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 4µA)**
- **Low Cost**

## 2.0 REFERENCE MATERIALS

### 2.1 Revision Summary
This paragraph is reserved for a revision summary of changes and additions made to this specification.

### 2.2 Customer Assistance
Reference MSI Part Number 1005755-1 and call (610) 650-1500 in the USA or +49 6074 862 822 in Europe to obtain additional product information.

### 2.3 Drawings
MSI Customer Drawings are available for specific products. The information contained in Customer Drawings takes priority if there is a conflict with this specification or with any other technical document supplied by MSI.

### 2.4 Absolute Maximum Ratings

| CHARACTERISTICS | VALUE | UNITS |
|---|---|---|
| Applied Voltage ($V_{DD}$ with respect to GND) | +28 | V |
| Package Power Dissipation | 35 | MW |
| ESD (Mil-Std-883, Method 3015.6) (qualification performed on ACH04-08-05) | 2000 | V |

## 2.5 Pin Descriptions

| PIN NUMBER | NAME | DESCRIPTION |
|---|---|---|
| 1 | D/S1-Y ❖ | Y-Axis JFET Drain or Source |
| 2 | D/S2-Y ❖ | Y-Axis JFET Source or Drain |
| 4 | SGND | Sensor Common |
| 8 | GND | Connect to GND - Device Shield |
| 14 | RGND-Y | Resistor GND for the Y-Axis |
| 3, 5, 6, 7, 9, 10, 11, 12, 13 | CTG | Connect to GND |

❖ JFET is symmetrical. The DRAIN and SOURCE are interchangeable.

## 2.6 Environmental Characteristics

| CHARACTERISTICS (T=25°C) | SYMBOL | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|
| Operating Temperature ❖ | $T_{OP}$ | -40 | - | +85 | °C |
| Storage Temperature | $T_S$ | -40 | - | +90 | °C |
| Relative Humidity γ | RH | 0 | - | 95 | %R.H. |
| Maximum Shock (Any Axis) | $S_{MAX}$ | 1,000 | - | - | g |

❖ Nominal sensitivity will typically change less than ±2dB over temperature range. γ Humidity must be non-condensing.

## 2.7 Specification

| CHARACTERISTIC (T=25°C) ✦ | SYMBOL | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|
| Y Axis Sensitivity ✪ ❖ | $M_X$ | 5.00 | 6.00 | 10.00 | mV/g |
| Lower Frequency Limit (3dB Point) | $f_{L3dB}$ | 0.07 | 0.18 | 0.40 | Hz |
| Upper Frequency Limit (3dB Point) | $f_{U3dB}$ | 1,000 | 1,500 | - | Hz |
| Resonant Frequency | $f_o$ | - | 3,450 | - | Hz |
| Resonant Q | $Q_R$ | - | 10 | - | Hz/Hz |
| Transverse Sensitivity | $M_T$ | - | < 20 | - | % |
| Base Strain Sensitivity | - | - | 0.03 | - | g/με |
| Temperature Transient Sensitivity | - | - | 0.3 | - | g/°C |
| Dynamic Range | - | - | ±40 | - | g's |
| Linearity (FS) | - | - | < 0.1 | < 2.0 | % |
| Equivalent Noise (100Hz) | $e_{100}$ | - | 1.0 | - | mg/√Hz |
| Weight | - | - | 0.33 | - | Grams |

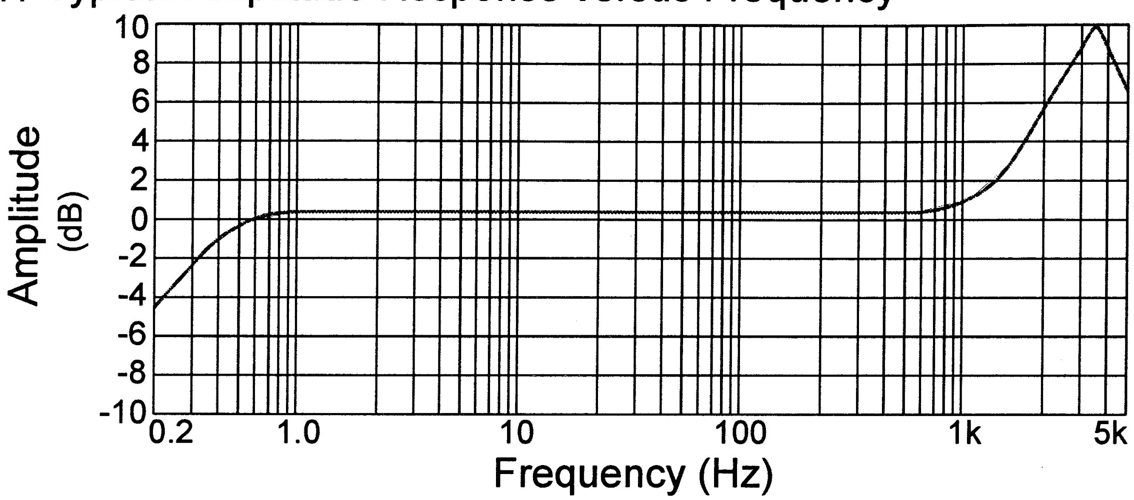
✦ Reference Frequency is 100 Hz. ✪ Assumes constant current bias, guarded Drain & Source
❖ Tighter sensitivity tolerances available. Consult factory for options.

## 2.8 Electrical Specifications

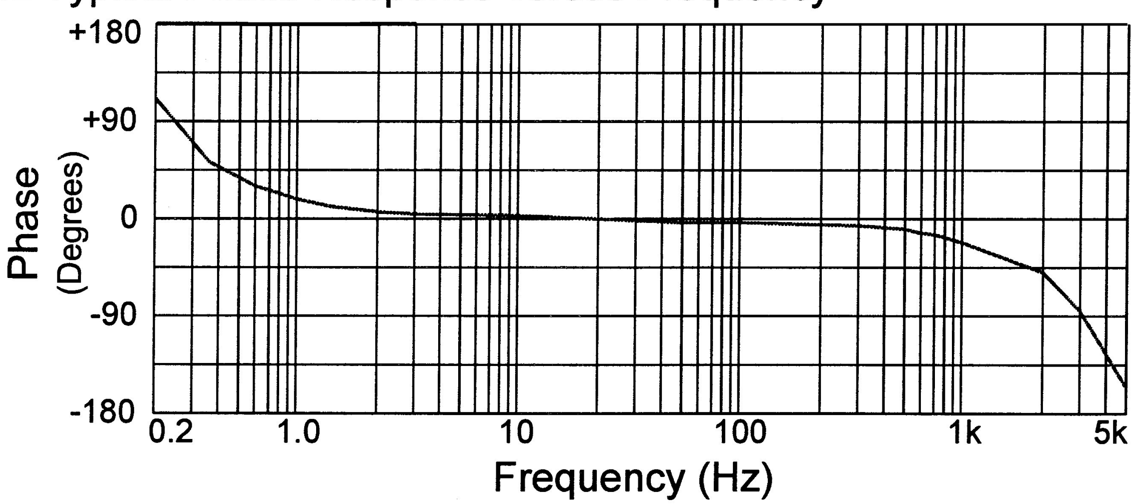
| CHARACTERISTICS (T=25°C) ✦ | SYMBOL | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|
| Quiescent Current | $I_Q$ | 1 | 2 | 9 | µA |
| Gate-Drain Voltage | - | -30 | - | - | V |
| Gate-Source Voltage | - | -30 | - | - | V |
| Gate-Source Cut-Off Voltage | $V_{GS(OFF)}$ | -0.45 | - | 3.2 | V |
| Saturation Drain Current ❖ | $I_{DSS}$ | 10 | - | 150 | µA |
| CS Forward Transconductance ❖ | $g_{FS}$ | 50 | - | 210 | µS |

✦ JFET's similar to 2N4117. ❖ Specifications modified from standard 2N4117 JFET's.

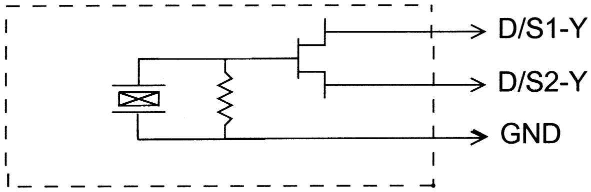
## 2.9.1 Typical Amplitude Response versus Frequency




## 2.9.2 Typical Phase Response versus Frequency



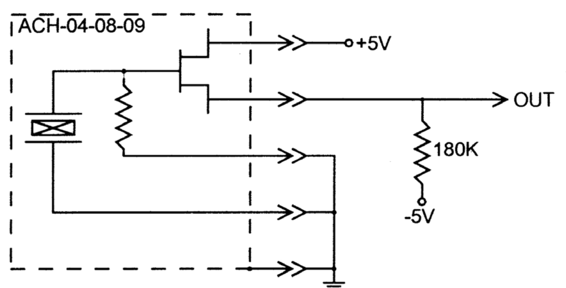
### 2.9.1 Equivalent Electrical Schematic




Notes: 1. JFET similar to 2N4117
2. Conductive case connected to GND

### 2.9.2 Interface Test Circuit

Resistor Bias with Split Supply

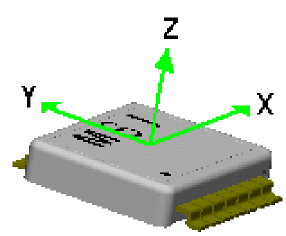



Notes: 1. Resistor value can be adjusted for individual applications.
2. +/- supply voltage can be scaled

## 3.0 REQUIREMENTS

### 3.1 Detailed Description

The sensing element is a small cantilever beam consisting of a metal substrate with a piezoelectric ceramic element affixed to one side. The beam is supported at one end while the opposite end is allowed to flex in response to acceleration. A small metallic mass is bonded to the free end of the beam. The beam flex strains the piezoelectric material, which in turn generates a charge proportional to the applied acceleration. The beam is oriented to sense acceleration in the defined Y-axis.





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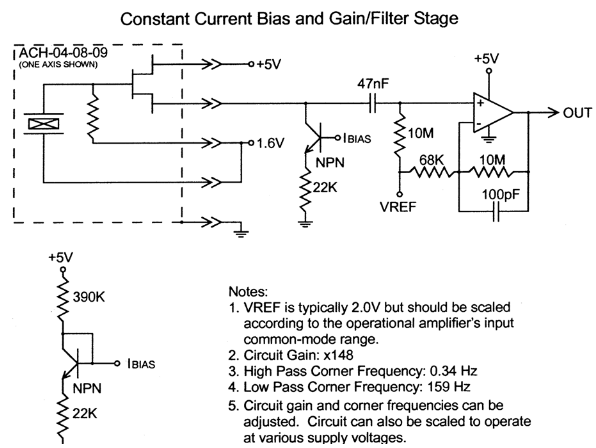
### 3.2 Electrical Interface

The ACH-04-08-09 contains one JFET which functions as an impedance converter easing electrical interface requirements. The JFET is similar to the industry standard part number 2N4117. The user MUST bias the JFET properly in order for the unit to meet the specifications contained in this document. There are many possible interface circuits. The JFET biasing circuit, equivalent to the circuit used in MSI's final production test, is shown on page 4. As a simple single sided source follower, the $V_{DD}$ can be between 3 and 28 Volts. Another example circuit is shown below.

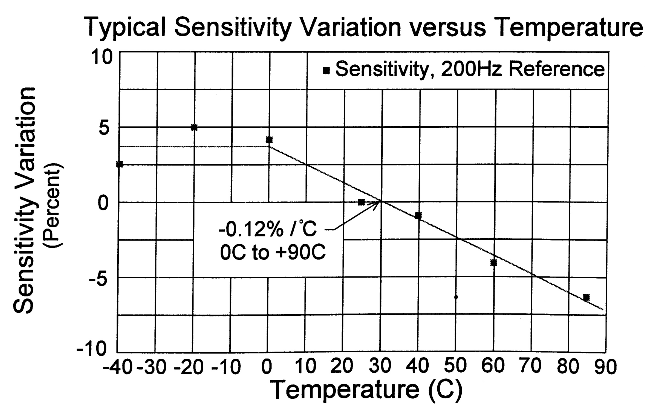
The constant-current bias circuit minimizes device-to-device and temperature related JFET transconductance variations while keeping the JFET gain near one . With the additional operational amplifier, the circuit has a gain of x148, a one-pole low-pass filter at 159Hz, and a one-pole high-pass filter at 0.34Hz. The circuit component values and DC reference/supply voltages can be scaled to fit many applications.

The resistor bias circuit positions the operating point in the middle of the transconductance curve again minimizing transconductance variations. This circuit can also be powered from a single-supply voltage by creating an artificial ground, VREF.




### 3.3 Sensitivity Variation versus Temperature

The ACH-04-08-09's typical sensitivity variation versus temperature is shown below. As shown, the sensor typical output varies +5% / -7.5% from -40°C to +90°C, respectively, relative to 25°C. For many applications, this variation is acceptable (less than ±2dB from -40°C to +90°C). If a tighter tolerance is required, the ACH-04-08-09 can be temperature compensated. A simple method is to use linear temperature coefficient resistors in the feedback network of an operational amplifier used to condition the accelerometer's signal. KOA Speer Electronics, Inc. (Bradford, PA) manufactures a variety of these resistors (LT73 and MLT product family). Note that since the resistors have a negative temperature coefficient, they need to be placed in the circuit such that the gain increases with increasing temperature.

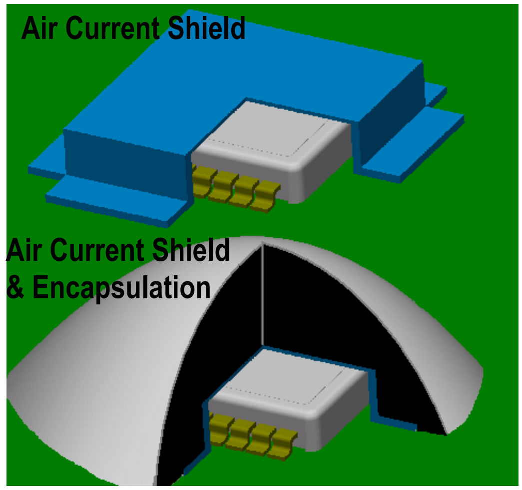



### 3.4 Temperature Transient Sensitivity (TTS)

Because of the its very low operating frequency, the ACH-04-08-09 exhibits high Temperature Transient Sensitivity (TTS). TTS is defined as the accelerometer's output response to RAPID temperature changes and is expressed in equivalent g's per degree C. This effect should not be confused with the ACH-04-08-09's sensitivity shift versus temperature which is defined at static (unchanging) temperatures and is unrelated to TTS (see above). The ACH-04-08-09's TTS will manifest itself as a low frequency drift when the device is subjected to temperature gradients. Even small temperature changes can produce significant drift.

TTS results primarily from differences in the thermal coefficients of expansion (TCE) of the various materials in the accelerometer. During product development, every effort is made to match TCE's. However, many mismatches are unavoidable. Even small TCE mismatches can lead to high TTS when combined with low frequency measurement capability since TTS is primarily a low frequency phenomena.

Fortunately, it is easy to minimize TTS effects. The key is to prevent air currents from circulating around the ACH-04-08-09. Encasing the accelerometer in an air current shield can minimize these air currents. The shield can be made of almost anything. Successful TTS minimization shells have been made from plastic, paper, metal, etc. While the shield does not have to be airtight, tighter seals provide better performance. Encapsulating the ACH-04-08-09 can also provide an effective air current shield. To ensure that the ACH-04-08-09's housing is not compressed under the weight of the encapsulant, MSI recommends that a spacer be placed above the unit. Note that the best performance is obtained by combining an air current shield with encapsulation.

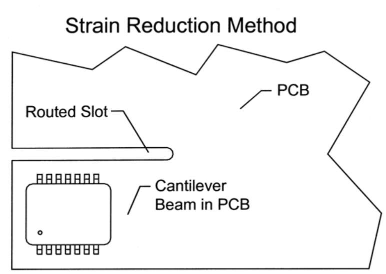



### 3.5 Base Strain Sensitivity (BSS)

The ACH-04-08-09 displays Base Strain Sensitivity (BSS) for many of the same reasons that it displays TTS; namely, low frequency operation and low modulus/high TCE materials. BSS is defined as the amount of output signal generated as a result of strain in the accelerometer's mounting surface and is expressed in terms of equivalent g's per base micro-strain, $g/\mu\varepsilon$.

The best way to minimize BSS effects is to stiffen the mounting structure. Stiffer mounting structures are typically less susceptible to bending. However, since the ACH-04-08-09 is designed to be attached to a circuit board, it may be impractical to stiffen the mounting surface.

In this situation, the accelerometer can be mounted at the end of a cantilever beam routed into the circuit board, where minimal strain is coupled into the accelerometer. Mounting arrangements such as this are very effective for low frequency applications. However, they are unacceptable for high frequency measurements where the signal to be measured is near or above the resonant frequency of the circuit board's cantilever beam. Implementation of a cantilever beam, strain minimization design requires careful analysis to accurately position the cantilever resonance well above the frequency range of interest.

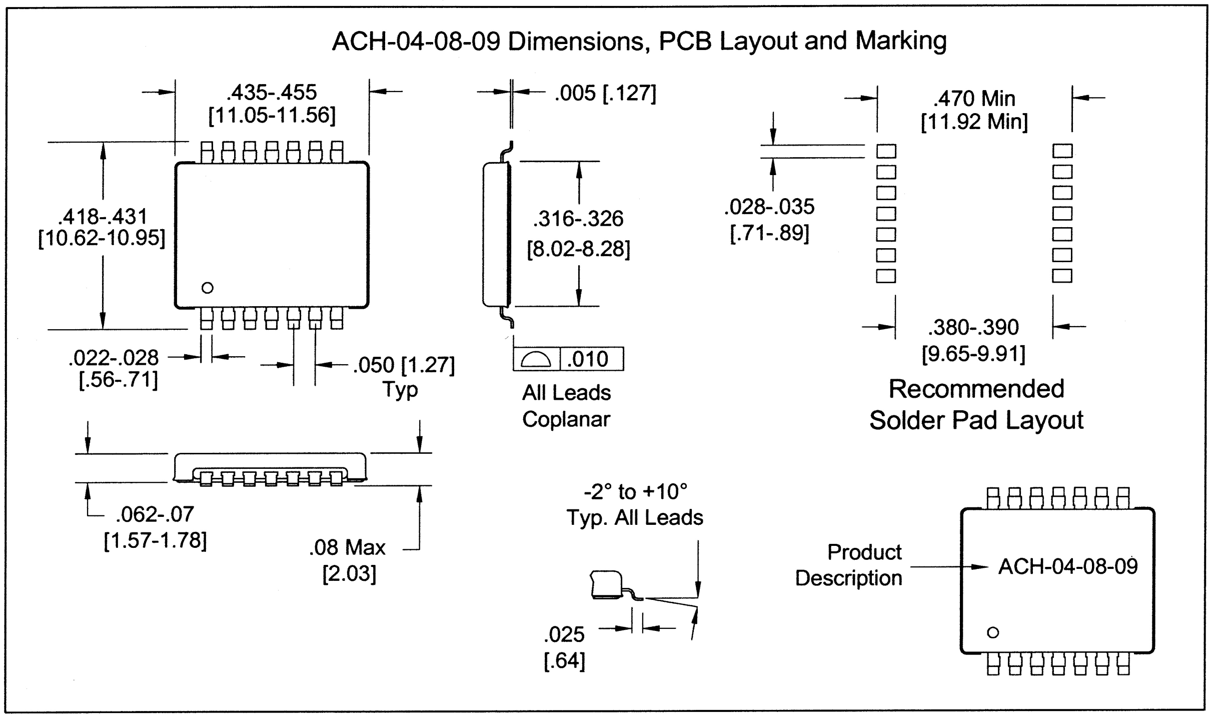



### 3.6 IC Package

To insure proper protection against RF and EM interference, the outer surface of the package is conductive and electrically connected to the GND pin. Exercise caution when laying out PC boards to ensure that no uninsulated traces are located under the package. They could contact the package surface and be shorted to GND. It is recommended that all 14 pins of the package be soldered to the PC board to insure good mechanical coupling of acceleration, motion, and shock. Complete soldering will also eliminate undesirable mechanical resonances of the IC package.

The package is sealed to eliminate the effects of normal exposure to the environment and typical cleaning processes found in an electronic manufacturing facility. However, the package seal is not hermetic and exposure to acidic, basic, corrosive, or aqueous environments is not recommended. Because of process variations, the ACH-04-08-09 should be qualified through the intended production assembly processes (soldering, wash, etc.) before releasing to production. Recommended alternative soldering processes include laser, hand and hot bar soldering. Contact MSI for more detailed information.

### 3.7 ACH-04-08-09 Mechanical Dimensions





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