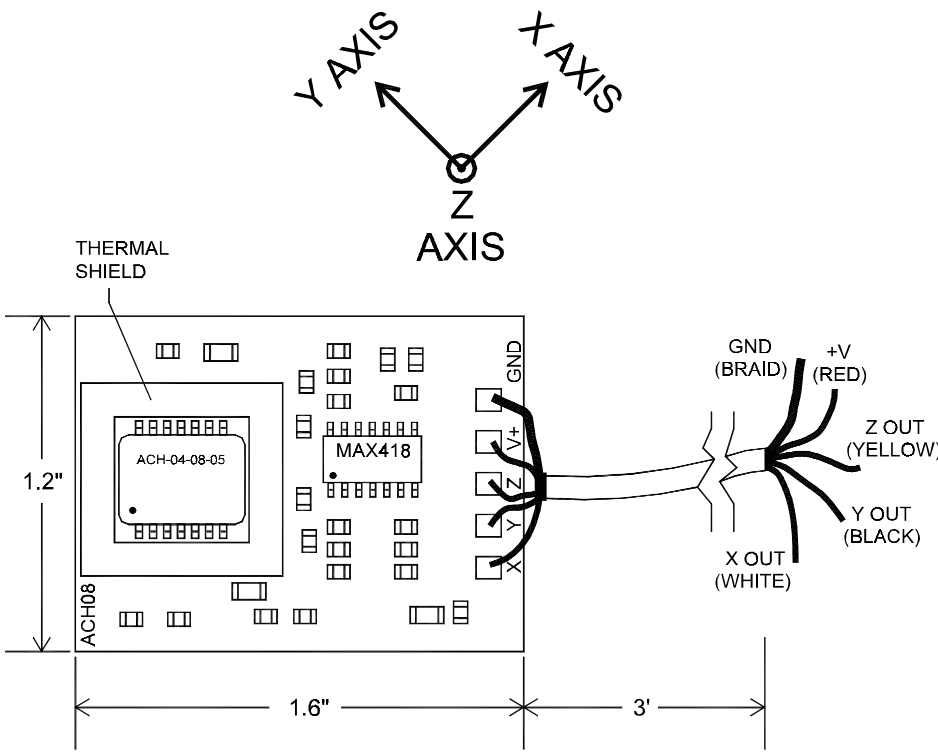
ACH-04-08-05 Analog Test PCB

1.0 INTRODUCTION

The ACH-04-08-05 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.

Features of the accelerometer test kit include:

- 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)



2.0 REFERENCE MATERIALS

2.1 Revision Summary

This paragraph is reserved for a revision summary of changes and additions made to this specification. No summary is required on this initial release (Rev O).

2.2 Customer Assistance

Reference MSI Part Number 1005685-1 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 with respect to GND)	+12	V

2.5 Cable Descriptions

COLOR	NAME	DESCRIPTION
Red	+V	Device Power - Positive voltage with respect to GND
Braid	GND	Device Power - Negative voltage with respect to +V
White	XOUT	X Axis analog output
Black	YOUT	Y Axis analog output
Yellow	ZOUT	Z Axis analog output

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	-	+105	°C

† Nominal sensitivity will typically change less than ±2dB over temperature range.

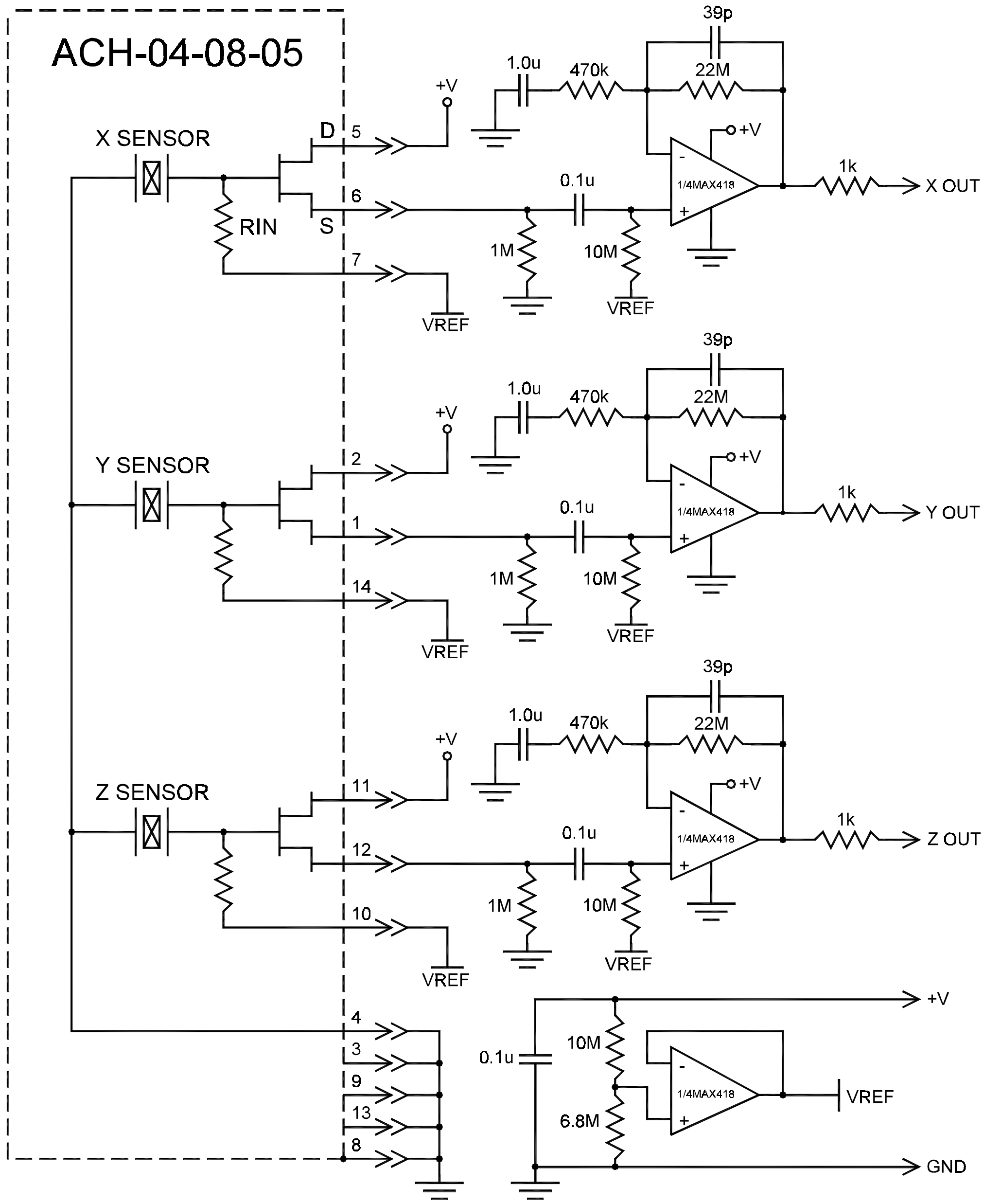
2.7 Specification

CHARACTERISTICS (T=25°C)	SYMBOL	MIN	TYP	MAX	UNITS
X Axis Sensitivity	M_X	-	70	-	mV / g
Y Axis Sensitivity	M_Y	-	70	-	mV / g
Z Axis Sensitivity	M_Z	-	50	-	mV / g
Lower Frequency Limit (-3dB Point)	f_{L3dB}	-	0.55	-	Hz
Upper Frequency Limit (-3dB Point)	f_{U3dB}	-	185	-	Hz
Transverse Sensitivity	M_T	-	10	-	%
Base Strain Sensitivity	-	-	0.05	-	g / με
Temperature Transient Sensitivity	-	-	0.2	-	g / °C / min
Dynamic Range	-	-	±35	-	g's
Equivalent Noise (100Hz Reference)	e_{100}	-	0.2	-	mg / √Hz

2.8 Electrical Specifications

CHARACTERISTICS (T=25°C)	SYMBOL	MIN	TYP	MAX	UNITS
Recommended Supply Voltage	+V	4.5	-	9.0	VDC
Supply Current	Isupply	-	13	-	µA

2.9 Electrical Schematic



3.0 REQUIREMENTS

3.1 Circuit Description

Referring to the preceding electrical schematic, the ACH-04-08-05 is modeled as a group of three JFET's, resistors, and capacitors, inside the dotted line (which represents the EMI/RFI metal shield). Each of the three channels, for the X, Y and Z axes, is identical. The following discussion applies to each channel although only the X-axis is referenced.

The Drain (D) of the JFET (Pin 5) is connected to +V. Note that the Drain and Source (S) of these particular JFET's (similar to the industry standard 2N4117 series) are symmetric, so they can be interchanged without affecting performance. Therefore, pins 5 & 6 could be interchanged, if required. The impedance matching resistor, R_{IN}, which (along with the JFET) is inside the ACH-04-08-05, is connected to VREF. In this circuit, VREF is approximately 2.0VDC with a +5V supply, so a DC voltage of approximately 2.6V appears at the JFET's Gate (Pin 6). This comes from 2.0VDC for VREF with about 0.6VDC from the JFET's V_{GS} threshold. VREF is generated by the buffered voltage divider shown on the lower right hand side of the schematic, where the 10M and 6.8M divide the +V supply voltage. The 0.1µF capacitor, from +V to GND, helps filter any noise on the power supply.

To properly function, all JFET's must be biased. Biasing sets the JFET's operating point and therefore its gain. There are fundamentally three biasing schemes (see, for example, Siliconix's® Application Note LPD-3, FET BIASING) including constant-voltage, constant current, and self bias, with many different ways to implement each scheme. For this circuit, a simple "source-resistor bias" in a source-follower configuration is used. A source-follower is a form of constant-current biasing with a gain slightly below one (1). Here we are using the 1MΩ resistor connected from the JFET Source to GND to bias the JFET. Recall that we have approximately 2.6V across the 1MΩ resistor. From Ohm's Law (V=I*R), that equates to 2.6µA per channel for a total of 7.8µA out of the total system current of 13µA (60%). Smaller bias currents (less than 1µA) are possible if required.

The signal is next passed through a High-Pass-Filter (HPF) formed by the 0.1µF capacitor and the 10MΩ resistor (connected between the positive input of the operational amplifier, op-amp, and VREF). The HPF pole is set at 0.16Hz which is calculated from $f_{-3dB} = 1/(2\pi RC)$. The system gain of 47.8 is set by the 22MΩ and 470kΩ resistors in the op-amp's feedback loop according to: Gain = 1 + (22MΩ / 470kΩ). Another HPF is formed by the 470kΩ resistor and the 1.0µF connected to GND, with a corner frequency of 0.34Hz. This HPF sets the op-amp's DC gain at one (1) minimizing the DC offset at the output. The combination of the accelerometer's inherent HPF at 0.35Hz and the Analog Test PCB's 0.34Hz corner results in a system -3dB corner frequency of 0.55Hz.

The 39pF capacitor in parallel with the 22MΩ resistor in the feedback loop forms a Low-Pass-Filter (LPF) with a corner frequency of 185Hz calculated from f-3dB = 1/(2πRC). The ACH-04-08-05 is capable of operating to much higher frequencies (above 3kHz) but would require a higher bandwidth, and therefore, a higher current draw op-amp. Alternatively, the system gain could be reduced to increase the circuit's bandwidth. The 1kΩ resistor in series with the output prevents the op-amp from oscillating when driving large, capacitive loads.

3.2 Temperature Transient Sensitivity

Because of the its very low operating frequency, the ACH-04-08-05 exhibits high Temperature Transient Sensitivity (TTS). TTS is defined as the accelerometer's output response to <u>RAPID</u> temperature changes and is expressed in equivalent g's per degree C. This effect should not be confused with the ACH-04-08-05's sensitivity shift versus temperature which is defined at static (unchanging) temperatures and is unrelated to TTS (see the ACH-04-08-05's Application Specification #114-27002). The TTS effect will show as a low frequency ("DC") drift when the device is subjected to temperature gradients. Even small temperature changes can produce significant DC 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, which are at various temperatures, from circulating around the ACH-04-08-05. These "wind currents" can be minimized by encasing the accelerometer in a shell. The shell can be made of almost anything. In the ACH-04-08-05 Analog Test PCB Kit, the wind-shell is made from die-cut foam, with double-sided tape on either surface, and a clear mylar top. While not completely air-tight, the foam/mylar wind shield minimizes TTS sufficiently for most applications. If TTS effects need to be reduced further, the shell may be coated with an epoxy or like material as shown the ACH-04-08-05 Application Specification No. 114-27002.

3.3 Frequency Response

The ACH-04-08-05 Accelerometer and ACH-04-08-05 Analog Test PCB frequency response plots are compared below reflecting the influence of the filters on the system response. The circuit gain and corner frequencies can be easily adjusted per the discussion in Section 3.1, Circuit Description. Note that, for clarity, the Y axis is "Normalized Amplitude". Therefore, the graph does not reflect the x47.8 (33.6dB) gain in the Analog Test PCB circuit.