Model 83162

Dual-Channel Signal Conditioning Card

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IMPORTANT NOTICE
Read Section 3.1 “Sensor Connections” before operating your tilt sensors.
Improper connection can cause *permanent sensor damage!*

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1 Introduction

Model 83162 is a precision two-channel signal conditioning circuit for use with all electrolytic tilt sensors. It has switchable gain and filter settings and will produce peak performance from your Applied Geomechanics 755-, 756-, 757- and 758-Series Miniature Tilt Sensors and from the Model 84053 Ceramic Tilt Sensor assembly. In addition to its two tilt channels, Model 83162 has a third channel for temperature measurement.

Model 83162 generates a balanced AC sensor excitation, then amplifies, rectifies and filters the sensor outputs to produce high-level DC signals proportional to the tilt angle. Distances between card and tilt sensors can be up to 100m. The circuit operates a National Semiconductor LM35 temperature sensor which may be in the external tilt sensor module or on the signal conditioner card. Model 83162 will drive its conditioned DC outputs over cable lengths of 1000m.

2 Specifications

General specifications for the Model 83162 Signal Conditioning Card are presented in Table 1. See Appendix B for custom scale factor and filter specifications for your equipment.

Table 1

INPUT CHANNELS	Two electrolytic tilt sensors, one LM35 Temperature Sensor
TILT OUTPUT	Two single-ended *and* two differential analog outputs, proportional to tilt: Output voltage range: ±8 VDC (single-ended), ±16 VDC (differential)
OUTPUT GAINS	Two switchable gains, 10:1 ratio standard, other ratios on request. Toggle switch on board.
SCALE FACTORS†	<u>When used with</u>: / <u>High-Gain</u> / <u>Low-Gain</u> / <u>Range</u> 755-Series Sensors: 0.1 μradian/mV* / 1.0 μradian/mV / ±8000 μradians 756-Series Sensors: 0.1 degree/V / 1.0 degree/V / ±8 degrees 757 & 758-Series: 1.0 degree/V / 10 degrees/V / ±60 & ±80 degrees Model 84053: 1 μradian/mV / 8 μradians/mV / ±3.6 degrees
OUTPUT FILTERS	Two switchable low-pass integrators, roll-off = 6 dB/octave. Time constants = 0.05 and 7.5 seconds, other settings on request. Toggle switch on board.
TEMPERATURE OUTPUT	0.1°C/mV (single-ended), -40° to +100°C, ± 0.75°C accuracy typical, 0°C = 0 mV
OUTPUT IMPEDANCE	270 ohms, short circuit and surge protected
POWER REQUIREMENTS	±11 to ±15 VDC @ +11 and –6 mA typical; 250 mV peak-to-peak ripple max.; reverse polarity protected
CONNECTIONS	Sensor: Gold-plated 100 mil header pins; Power & Signal: 3 ft (0.8 m) pigtail, tinned ends
MOUNTING HOLES	Four holes, each 0.125 inch (3.2 mm) diameter; see Figure 2 for locations
ENVIRONMENTAL	-25° to +85°C operational, -30° to +100°C storage; 0 to 90% humidity, noncondensing
MATERIALS	Fiberglass printed circuit board with thru-hole soldered components
SIZE & WEIGHT	3.85-inch (98 mm) diameter round board, 1.12 inches (28 mm) high at switches; 30 g

* 1 degree = 3600 arc seconds = 17453 μradians (microradians)
† Single-ended outputs; divide by 2 for differential outputs

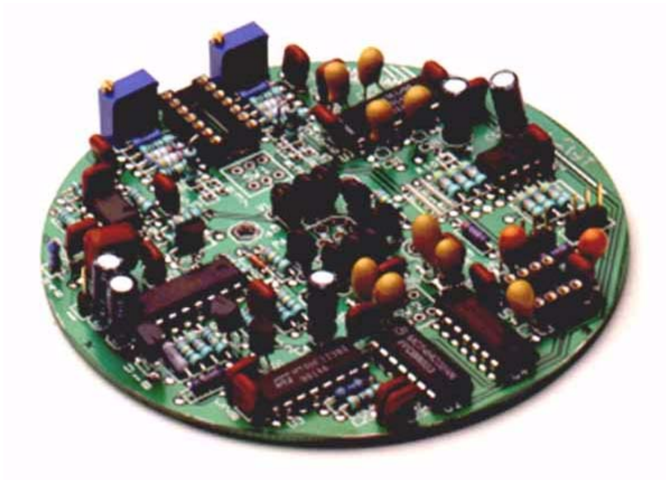

Figure 1. Model 83162 Signal Conditioning Card, Component Side

3 Operation

3.1 Sensor Connections

Tilt sensor connections are made at two 3-pin headers (male connectors). These headers are labeled P1 and P2 on the circuit board and in Figures 2 and 3. P2 is also called the X channel in our documentation, while P1 is called the Y channel. The individual pins are assigned the symbols +, E and – (Figures 2 and 3). The corresponding wires of your Miniature Tilt Sensor are specified in the user's manual for your sensor. In most cases, one side of the female connector on the sensor wires is labeled "+" to indicate the polarity. Reversing the polarity of the tilt sensor connector will not damage the sensor.

Your tilt sensors have been calibrated to specific channels (P1 or P2) of the Model 83162 card. Calibration data are contained in Appendix B.These channels are indicated in Appendix B.

A third 3-pin header, labeled P3 on the circuit card, is for connection of a National Semiconductor LM35 temperature sensor (Figures 2 and 3). Its polarity is indicated by the "+" symbol at P3 in Figures 2 and 3. Table 2 lists pin functions for the temperature sensor. The temperature sensor is included in some, but not all Miniature Tilt Sensors sold by Applied Geomechanics. In some cases the Model 83162 is delivered with the temperature sensor soldered to the card. Whether or not this has been done is indicated in Appendix C.

Table 2. Temperature Sensor Pin Functions at Connector P3

Pin	Wire Color (if external sensor)	Polarity	Function
T1	Red	+	+9 VDC (+V_S)
T2	Orange		Signal (V_{OUT})
T3	Yellow		GND

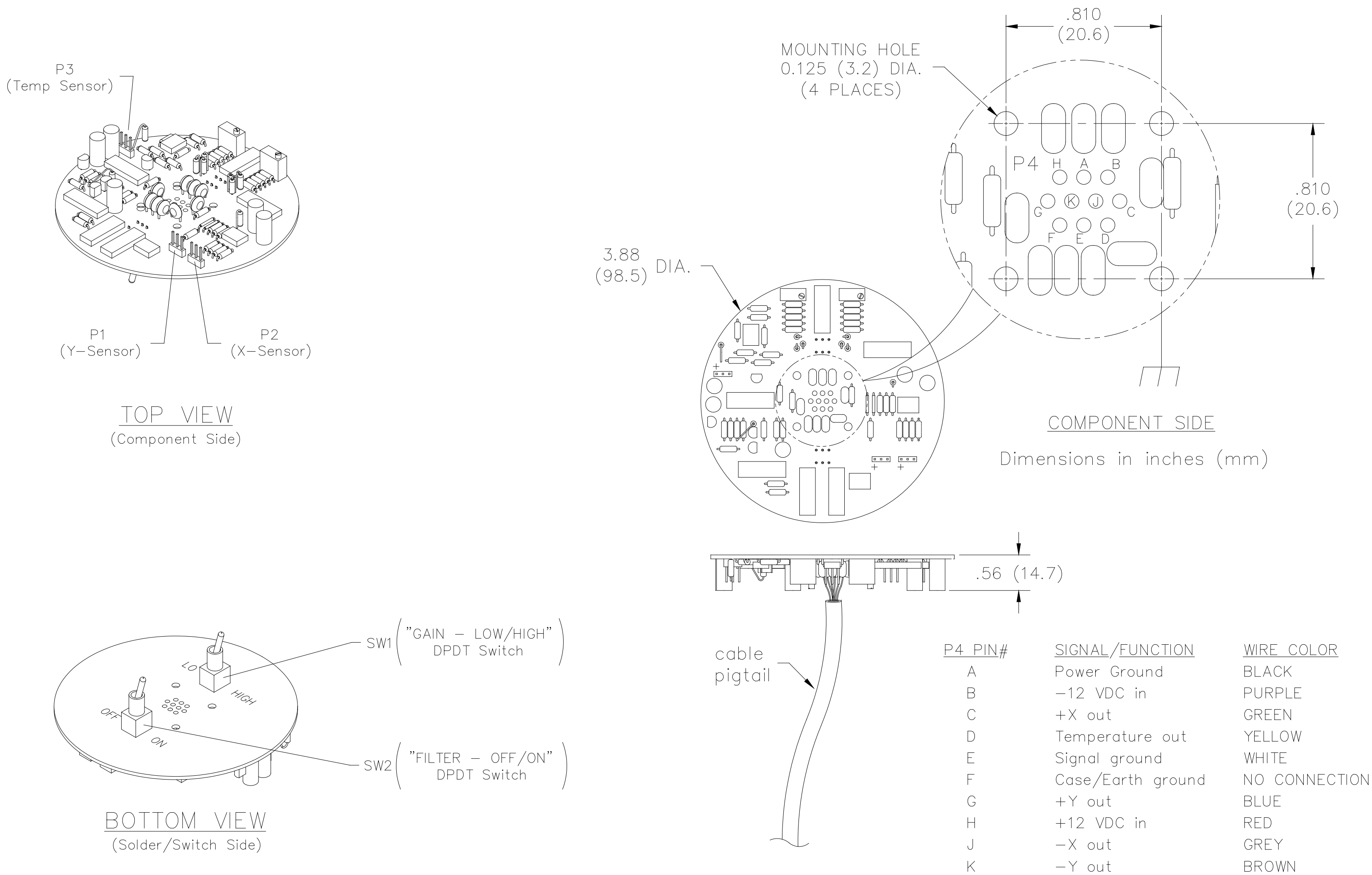

Figure 2. Model 83162 Dimensions and Features; Dimensions in inches (mm)

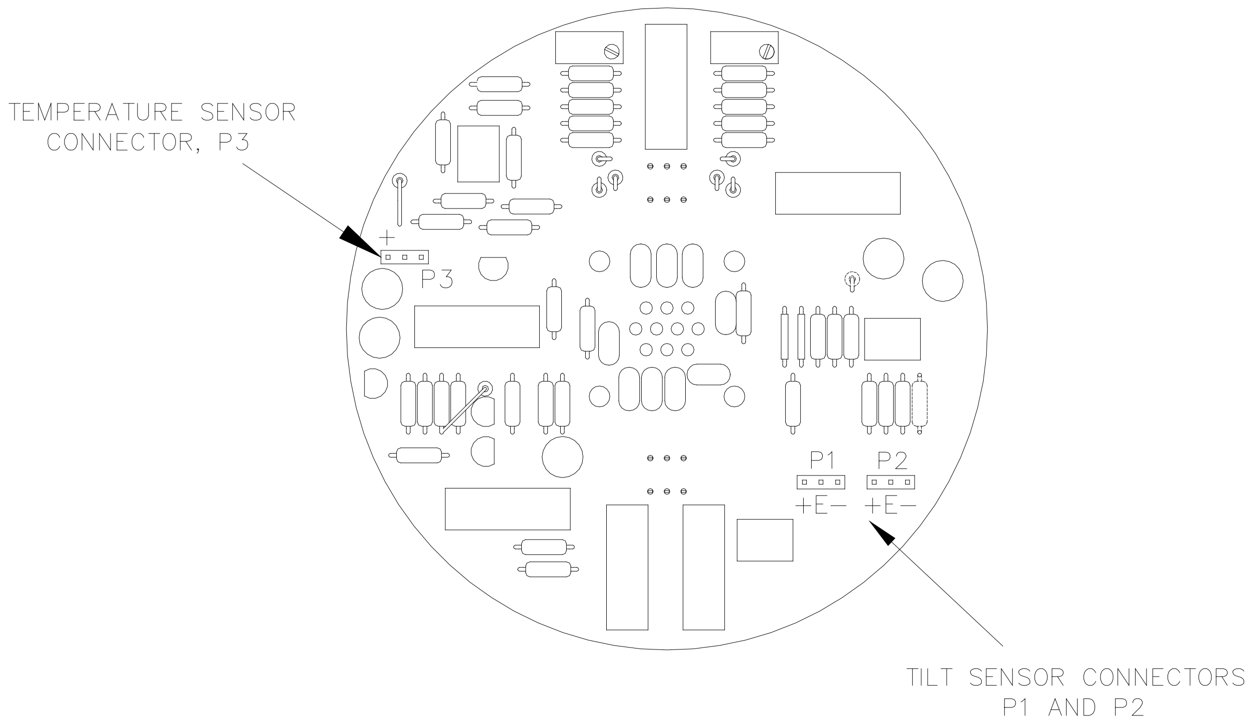

Figure 3. Component Side, Showing Sensor Connections

Note that connector P3 supplies DC power for the temperature sensor. Electrolytic tilt sensors are permanently damaged by direct current (DC). For this reason, *NEVER CONNECT A TILT SENSOR TO **P3**. PERMANENT SENSOR DAMAGE THAT IS NOT COVERED BY THE WARRANTY WILL RESULT!*

3.2 Power Input and Signal Output Connections

Power and signal connections are made at the tinned wire ends of the cable pigtail, which is soldered to the center of the circuit card at position P4. Each solder pad on the card is identified with a letter between A and K (Figure 2). Corresponding wire colors and functions are given in Table 3.

Table 3. Wire Colors and Functions in Cable Pigtail		
P4 Pin (Solder Pad) Number	**Signal/Function**	**Wire Color**
A	Power ground (PWR GND)	Black
B	–12 VDC in	Purple
C	+X out	Green
D	Temperature out	Yellow
E	Signal ground	White
F	Case/Earth ground (ESD)	No Connection
G	+Y out	Blue
H	+12 VDC in	Red
J	–X out	Grey
K	–Y out	Brown
---	Cable shield	Drain wire

Figure 4 below shows how two wire two 12 Volt batteries to provide the dual power supply required by the Model 83162 card.

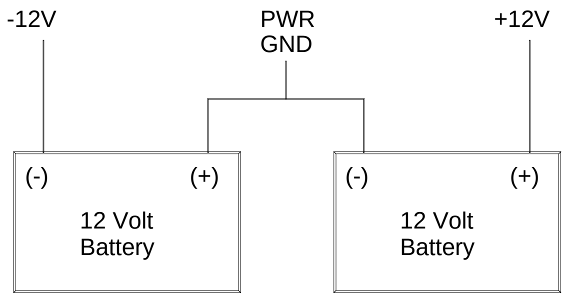

Figure 4. Power Supply Connections for Model 83162

3.3 Single-Ended and Differential Outputs

When a voltage output signal is measured with reference to ground, it is termed a *single-ended* output. This is the most common way that analog voltage signals are measured. Model 83162 has two analog grounds: *signal ground* and *power ground* (Table 3). Both are common on the circuit card. For best results, do *not* connect the signal and power ground wires at your power supply or recorder (voltmeter, datalogger, etc.). Use the power ground wire as the ground for your power supply and the signal ground wire as the ground for your voltage measurement. By keeping the two grounds separate, you avoid the voltage drop, ΔV, that results from current C flowing in the power ground wire. From Ohm's Law we know that $\Delta V = CR$, where R is the resistance of the wire.

To further improve signal quality, *differential* measurement may be used. Differential measurement eliminates the ground wire entirely and thereby prevents noise carried on the ground wire from degrading signal quality. To make a differential measurement, the signal +X (or +Y) is recorded with reference to –X (or –Y). The +X and –X signals are equal and opposite on the Model 83162 card, as are the +Y and –Y signals. Noise induced in the transmission wires between the card and your voltmeter will normally be of equal magnitude and polarity on both wires of a differential pair. Thus, it is cancelled when you make your measurement.

The tilt outputs of the Model 83162 card may be measured as single-ended or differential signals. The temperature output is provided as a single-ended signal only.

If you connect the power ground wire to earth, do so at one end only to prevent ground loops.

3.4 Grounding and Transient Protection

High-voltage transients from lightning or unstable power supplies are one of the most common causes of damage to electronic instrumentation. In a typical occurrence, the high-voltage transient travels down the cable to the electronic circuitry, where the delicate components are overloaded and fail. Model 83162 provides transient voltage protection using *tranzorbs* (surge suppressors) that connect each input and output pad at the center of the circuit card to the four mounting holes and to pad F (see detail of P4 in Figure 2). The tranzorbs have extremely high resistance under normal operating conditions and therefore no effect on the performance of the circuit. However, they short when they encounter a high-voltage transient on one of their leads. The transient is thus shorted to the mounting holes and pad F (ESD ground), where it can be grounded to earth before damaging the electronic components. For this protection method to be effective, pad F or one (or more) of the four mounting must be solidly grounded to earth via a grounding rod or other means.

The use of tranzorbs in the Model 83162 provides a single layer of transient protection. Additional layers of protection are available from commercial sources and may be added in lightning-prone areas.

If you connect the cable shield to earth, we recommend that you do so at one end only to prevent ground loops, which may induce noise in your tilt and temperature signals.

3.5 Using the Switches

Two toggle switches are mounted on the Model 83162 card opposite the component side. One is the GAIN switch with LOW and HIGH settings. The other is the low-pass FILTER switch with ON and OFF settings. Figure 2 shows the location and settings of both switches. Scale factors associated with each gain setting, and time constants associated with each filter setting, are listed in Appendix B.

In some units the filter switches are replaced by “jumper” clips to save space at customer request.

Gain or filter settings may be changed at any time. To do so, simply move the toggle of the switch.

3.6 Converting Voltage Readings to Tilt Angles and Temperatures

The tiltmeter voltage outputs are quickly converted to tilt angles as follows: .Multiply the voltage reading by the scale factor supplied in Appendix B. For example, if the scale factor is 1.012

microrandians/mV and the voltage reading is +2.000 Volts (2000 mV), then the tilt angle is +2,024 microradians from sensor null.

Similarly, the voltage reading from the temperature sensor is converted to temperature by multiplying it by 100°C/Volt (0.1°C/mV). For example, if the reading is 0.289 Volt (289 mV), the temperature is 28.9°C.

4 Initial Checkout Procedure

After receiving your Model 83162 Signal Conditioning Card, verify that it is functioning properly by following the steps below:

1. Connect your tilt sensor to the card according to the instructions in Section 3.1.

2. Connect +12V and –12V power to the pigtail wires according to the information in Section 3.2.

3. Connect a voltmeter to the +X and Signal Ground wires.

4. Perform steps 5 through 10 below first with the filter switch OFF, and then with the filter ON.

5. Identify the (+) and (–) tilt directions for your tilt sensor (they are marked on the sensor). With the sensor in your hand, rotate it to verify the polarity of the outputs. A rotation in the (+) direction should make the voltage reading become more positive. A (–) rotation should make it become more negative.

6. Verify that the output moves through its full single-ended range of approximately +8 volts to –8 Volts. Note that if you are using a 755-Series sensor, the output will move to full range with a rotation of only 0.5 degree or less.

7. If you have a biaxial sensor, connect the voltmeter to the +Y and Signal Ground wires and repeat steps 4 and 5.

8. Connect the voltmeter to the +X and –X output wires for differential output and repeat steps 4 and 5. The full-scale range should now be approximately +16 volts to –16 Volts.

9. If you have a biaxial sensor, connect the voltmeter to the +Y and –Y output wires for differential output and repeat steps 4 and 5. The full-scale range should now be approximately +16 volts to –16 Volts.

10. To check your temperature sensor, connect the voltmeter to the Temperature and Signal Ground wires. Verify that the reading is approximately the same as the ambient temperature (25°C = 250 mV).

If your system does not perform as described above, please contact Applied Geomechanics for assistance.

5 Maintenance and Troubleshooting

5.1 *Routine Maintenance*

Your Model 83162 signal conditioner card should be operated within the environmental limits listed in Table 1. Avoid operating the card in the presence of corrosive liquids or gases. Keep the card clean and free of dust and dirt. If possible, package it in a protective enclosure.

Protect your signal conditioner from water condensation and submergence. *WATER DAMAGE VOIDS THE WARRANTY!*

5.2 *Determining the Cause of Malfunctions*

Apart from the the procedures described below, Model 83162 is not field-serviceable. Should you encounter problems not described here, please contact an Applied Geomechanics service engineer for assistance.

If there is no output when you have connected the signal conditioner to a tilt sensor and to power, first make sure that the connectors are properly applied (Sections 3.1 and 3.2) and are making electrical contact. Check the voltage level and the polarity of the power supply. Failure to obtain an output signal normally is the result of lack of power or a broken wire or connection.

Verify that the tilt and temperature sensors are connected to the correct headers on the card and have the correct polarity (Section 3.1, Figure 2 and 3). The tilt sensors must only be connected to headers P2 and P1 for X and Y, respectively, and the temperature sensor must be connected to P3. *CONNECTING THE TILT SENSOR TO P3 WILL CAUSE PERMANENT TILT SENSOR!*

WARNING !

NEVER USE AN OHMMETER TO MEASURE APPLIED GEOMECHANICS TILT SENSORS. APPLYING DC CURRENT THROUGH THE SENSORS WILL CAUSE PERMANENT DAMAGE THAT IS NOT COVERED BY THE WARRANTY.

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B LM35 Precision Centigrade Temperature Sensor

The following information is summarized from the National Instruments datasheet for the LM35 family of analog temperature sensors. The version used by Applied Geomechanics is the LM35CZ.

The LM35 Series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 family does not require any external calibration or trimming to provide typical accuracies of ± 3 /4 °C. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. As it draws only 60 µA from its supply, it has very low self-heating, less than 0.1°C in still air. The LM35CZ is rated for a –40° to +110°C range.

Key Features

- Calibrated directly in ° Celsius (Centigrade)
- 0.5°C accuracy at +25°C
- Operates from 4 to 30 volts
- Less than 60 µA current drain
- Low self-heating, 0.08°C in still air
- Nonlinearity only ± 1 /4 °C typical

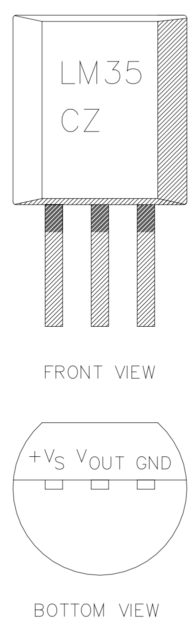

Figure 5. LM35CZ Temperature Sensor