Model 165 Bridgesensor

Features

- No other Function Modules Needed. Just Add Power
- Under or Over Voltage Alarm Function Built-in
- Power Almost any Transducer with 4 to 10 Volt Excitation
- Affordable Results with High Performance
- Ignore Most AC Noise with High CMRR
- Save Space and Weight in Portable Set-ups
- Ignore Harsh Environments using Encapsulated Module
- Set up in Minimum Time with Convenient Mounting

Applications

- Pressure Monitoring and Alarm
- Data Acquisition Systems
- Temperature Controller
- Strain Gage Testing
- Load Cell Weighing Applications
- Thermocouple Amplifier
- RTD Measurements

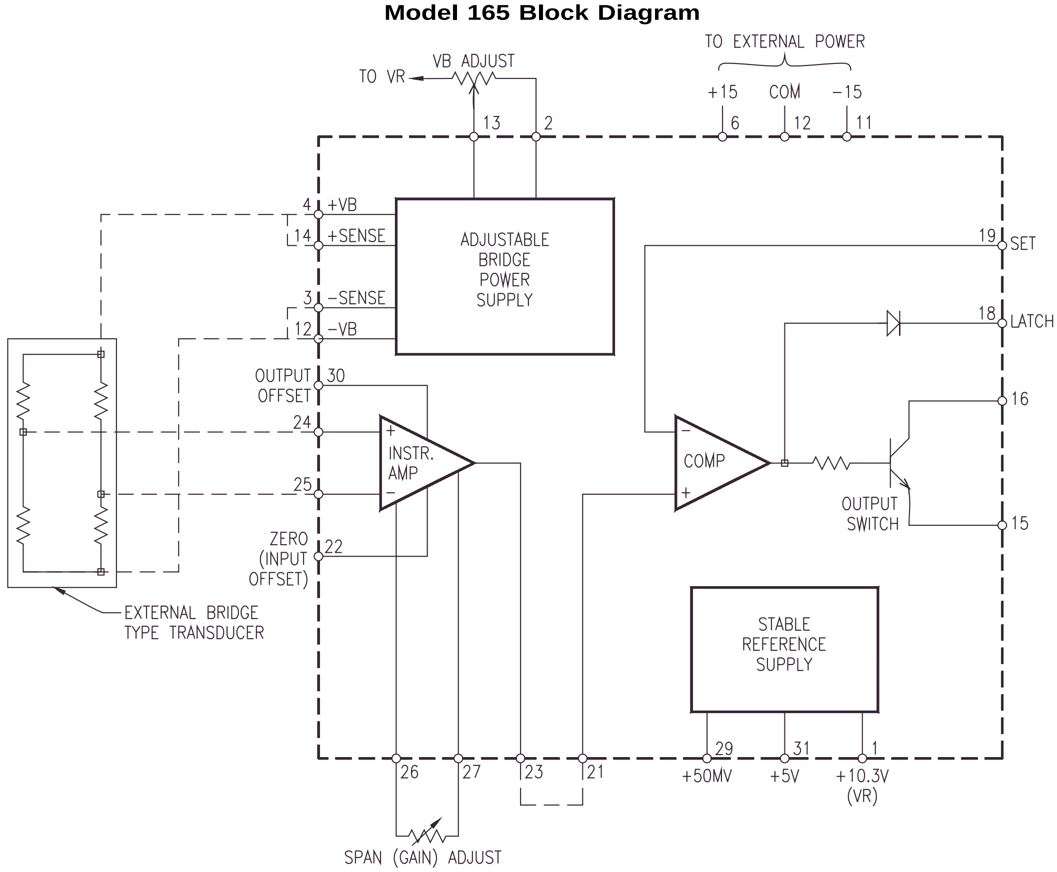
Description

The Model 165 Bridgesensor is a complete signal conditioning system designed for use with RTD's, transducer bridge circuits, thermocouples, and other signal sources. It provides power to excite a strain gage or other type of bridge signal. In addition, a sensitive comparator is included that can be connected to monitor the amplifier output. The comparator drives an output switch that can be used to operate a relay, light or audible alarm.

The Model 165 also includes a stable voltage reference source which is then available as a comparator trip point reference or for use as an output offset voltage for the amplifier. When used in an instrumentation system, external adjustment pots are frequently required. For this reason, a complete printed circuit mounting kit is available which furnishes all the necessary pots as well as test points and jumpers to alter the operational mode. The mounting kit plugs into a 15 pin card edge connector that comes with the mounting kit.

A complete instrumentation or control system can be built using the Model 165, a power source, and a transducer. The power source can be either single or dual polarity.

Model 165 Block Diagram



Specifications

Instrumentation Amplifier	
Gain Range, adjustable Gain Nonlinearity Gain Temperature Coefficient	10 to 1000 ±0.01% ±50 ppm/°C
Input Resistance - Differential Common Mode	10 megohm 500 megohm
Common Mode Voltage: Single Supply Operation Dual Supply Operation	 +2V to +7V -7V to + 7V
CMRR, DC to 100 Hz, G = 100 1 kHz	100 dB, min. 80 dB typ.
Input Offset Voltage (adjustable) Temperature Coefficient Power Supply Sensitivity	±2 mV max. 5 µV/°C max. 50 µV/V max.
Input Bias Current Temperature Coefficient Differential	70 nA max. 1 nA/°C max. ±10 nA max.
Output Single Supply Operation (2k ohm min. load to common) Dual Supply Operation Minimum Load Resistance	 +0.05V to +10V -10V to + 10V 2k ohm
Frequency Response, Gain = 100 Full Power Bandwidth, Gain = 100, with 2k or greater load	10 kHz 2 kHz
Reference Supply	
+VR Temperature Coefficient Output Impedence, at DC at 100 kHz Load Current	+10.3V, ±0.03V ±0.01%/°C max. 0.05 ohm 10 ohms 5 mA max.
+5V Reference Output Impedance, to 100 kHz	5 Volts ±1% 1.3k ohm
+0.05V Reference Output Impedance, to 100 kHz	0.05 Volts ±2% 25 ohms
Bridge Excitation Supply	
Adjustment Range Temperature Coefficient Output Current, at 4 Volts, at 10 Volts (see Figure 2.)	+4 to +10 Volts ±0.01%/°C max. 47 mA max. 100 mA max.
Noise Voltage, DC to 10 kHz Load Regulation, 0 to max. Load, Power Supply Sensitivity Output Impedance, at DC, at 100 kHz	1 mVRMS, max. 0.01%, max. 1 mV/V max. 0.05 ohm typ. 5 ohms typ.
Comparator	
Trip Point Range Dual Supply Single Supply Temperature Coefficient	 -10 to +10 Volts +50 mV to + 10 Volts ±10 µV/ C max.
Hysteresis Dual Supply Single Supply	 8 mV max. at DC 4 mV max. at DC
Output - Pin 16 High State, max. Source Voltage Low State, 100 mA max. Current Leakage Current at +16 Volts	 +16 Volts +0.7 Volts max. 10 µA max
Response Time, 100 mV Overdrive	70 µs max.
Rise and Fall Time, 2k to +15V	2 µs max.
Power Requirements	
Mounted on MK165:	
Single Supply Operation	+14 to +16 Volts
Dual Supply Operation	±14 to ±16 Volts
Current with max. Bridge Load Positive Supply Negative Supply	 130 mA max. 2 mA max.
Note: Add any comparator output current to positive power supply requirement.	
Environment	
Temperature	0°C to +70°C
Size (inches)	2" x 2" x 0.6"

Transducer Excitation-Bridge Supply

The Bridge Supply is variable from +4 to +10 Volts and is short circuit protected for momentary shorts to common. It has two limits. A maximum current of 100 mA and a maximum dissipation of the output transistor. The Bridge Supply Maximum Load curves, figure 2, show the maximum load current and the smallest load resistance as a function of the bridge supply output voltage.

BRIDGE SUPPLY MAXIMUM LOAD

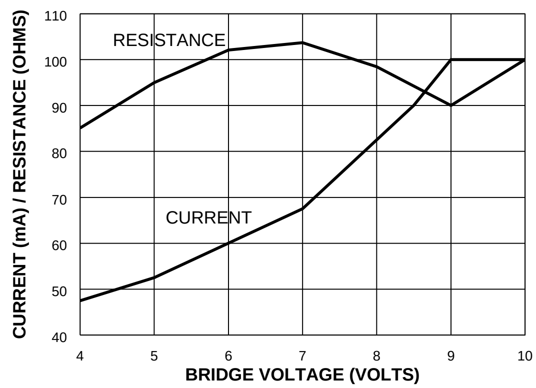


FIGURE 2. Bridge Supply Maximum Load

If a sensor has a lower resistance than allowed by the resistance curve, a series resistor can be added to the bridge supply output, pin 4. The bridge supply +sense, pin 14 is connected directly to the sensor since that is the voltage to regulate. See figure 3. The series resistor, RS can be determined from the following equation:

$$RS = RB (10 - VB) / VB$$

where RB is the sensor resistance and VB is the desired sensor excitation voltage.

An example is illustrated in Figure 3, RTD Application. A standard Platinum RTD with a 0° resistance of 50 ohms and an alpha of 0.00385 is used. It is desired to have an output of + 10 Volts for +100° and to measure temperatures between -20 and + 100°C, with zero Volts out at 0°. The Model 165 is operated with dual 15 Volt supplies. The comparator is connected to monitor the amplifier output and the set point, pin 19, is connected to a potentiometer that is connected between the + and -15 Volt supplies. This allows setting the comparator to any temperature in the measurement range. The comparator output is connected as an emitter follower, driving the load positive when the amplifier output exceeds the set point. The comparator output could be used to drive a DC controlled solid state relay, for example.

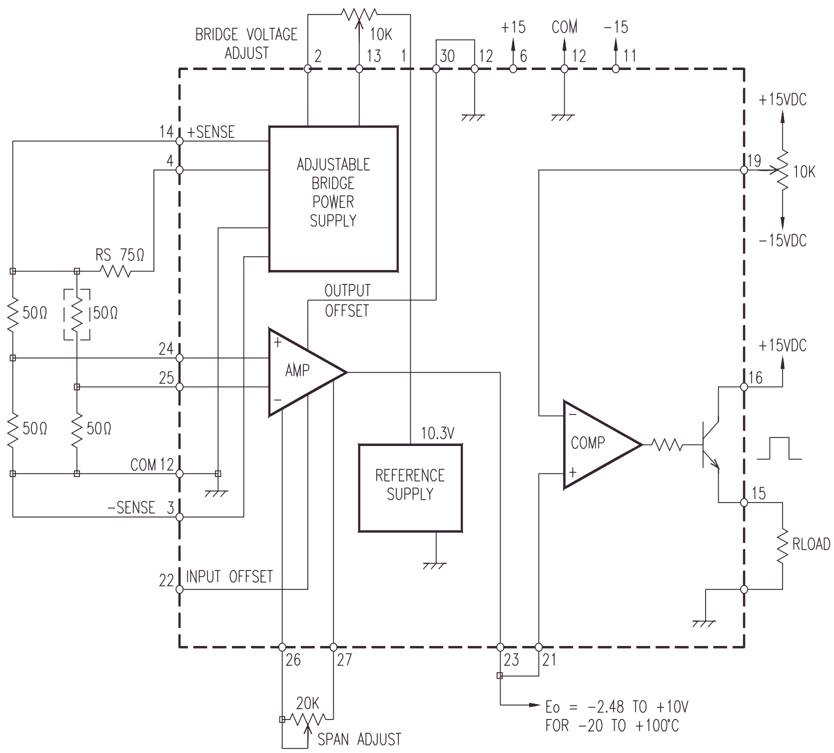


FIGURE 3. RTD Bridge Application

The series resistor, RS is determined as follows:

Sensor Resistance = 50 ohms

Sensor Voltage = 4 Volts at 80 mA

The Bridge Supply Maximum Load curves show a maximum current of 47 mA and a minimum resistance of 85 ohms at 4 Volts.

RS = 50 (10 - 4) / 4 = 75 ohms

The power in RS = I x I x RS = .08 x .08 x 75 = 0.48 Watt
Use a 1 Watt resistor.

Pin 14 will be at 10 Volts when the voltage across the 50 ohm bridge is set to 4 Volts. Do not bypass the sensor with a capacitor.

At 0° the bridge will be balanced and the amplifier output will be zero. At +100° the resistance of the RTD will be 69.25 ohms producing a voltage of +1.677 Volts at the amplifier negative input. The gain required for 10 Volts output is then 10/(2.0 - 1.677) = 30.96, which is set by the potentiometer between pins 26 and 27. At -20° the RTD resistance will be 46.15 ohms, giving a voltage of +2.080 at the amplifier negative input. The output voltage will be 30.96 (-.08) = -2.48 Volts.

The error due to the Model 165 typical 0.5 mV input offset is 30.96 x .5E - 3 = 15.4 mV, or about 0.15°, and the input offset, pin 22, can be left open. Do not connect pin 22 to any voltage when it is desired not to adjust the input offset.

Instrumentation Amplifier

The built-in amplifier is a true differential input, low drift, instrumentation amplifier. It is factory trimmed for a high common mode rejection ratio (CMRR) and has external adjustments for input and output offsets. The minimum gain is 10 and the maximum gain is 1000. Gain is set be one resistor, Rg, connected across pin 26 and 27. RG can be determined to within 2% from the following formula, for gain A:

Rg = [(2.02E5/A) - 200] / [1 - 10 / A]

In most applications it is best to split the gain resistor into two potentiometers to provide a coarse and a fine adjustment. Gain resistors should have low temperature coefficient.

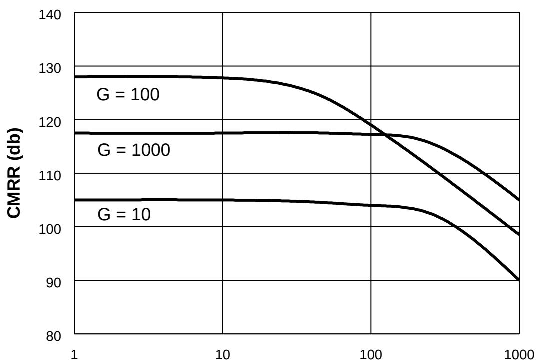
The input offset is the output voltage divided by the amplifier gain. For example, if the gain is 500 and the output voltage is 0.5 Volt, the input offset is 1 mV. The input offset is measured and adjusted by shorting the two inputs together and connecting them to common. The output offset, pin 30, must be connected to pin 3 for no output offset. The input offset is then adjusted for zero output.

If a single +15 Volt supply is used, the input must have a common mode voltage between +2 and +7 Volts. The output offset must be set to +50 mV or greater. The output offset is applied to pin 30 and is not amplified by the gain of the amplifier The output of the amplifier should be loaded by connecting a 2000 ohm resistor from pin 23 to pin 12, amp common. Connect the 50 mV reference, pin 29, to pin 31, for this adjustment. Measure the voltage between pin 30 and the amplifier output, pin 23, and adjust the input offset for zero volts.

The output offset appears at the amplifier output unaltered by the amplifier gain. This useful feature allows the output to be purposely offset when using a single power supply or to add corrective voltages such as thermocouple cold junction compensation or tare weight. The output offset is buffered by a high input impedance amplifier with a typical input current of 15 nanoamps.

The amplifier output swings from + 50 mV to at least +10.05 Volts when operated from a single +15 Volt supply and loaded with a 2k resistor. When operated from dual 15 Volt supplies, the output will swing a minimum of ±10 Volts into a 2k Load. The output is protected against shorts to the power supply common.

MODEL 165
COMMON MODE REJECTION RATIO



Output Comparator

The comparator is designed to monitor the output of the instrumentation amplifier and provide a solid state switch closure when the amplifier voltage reaches a pre-set level. The pre-set level is determined by a potentiometer adjusted voltage which is fed into the set input of the comparator. For a precise and stable set point, the Model 165 provides a very stable 10.3 Volt reference voltage that can be used as a source for the set point.

If the set input is more positive than the comparator input, the output switch will be OFF, and of course the reverse is also true. The output switch is an open collector NPN transistor and will source or sink up to 100 mA. The switch is current limited so that it cannot be damaged by trying to drive too small a load resistance. However, if the collector of the transistor is connected directly to a positive supply such as +15 VDC and the emitter is grounded, the transistor would have to dissipate over 2 Watts if turned on and would fail after a short time. Use caution when connecting load circuits.

An internal diode latch circuit is also included in the comparator. By connecting pin 18 to pin 20, the comparator will latch in the switch ON state when the input becomes more positive than the set point. It will not un-latch after the input signal decreases unless the connection from pin 18 to 20 is opened momentarily or all module power is removed momentarily.

Reference Supply

The reference power supply uses a very stable zener reference diode as the primary reference voltage. This voltage is then converted to three values for use as excitation power supply voltage adjust, comparator set point adjust and amplifier output offset. The three voltages are +10.3V, +5.0V, and +50mV. When the Model 165 is used with a single polarity power supply the amplifier output will not swing to ground potential but it can go to a little below 50mV. By applying 50mV to the output offset input, a zero signal to the amplifier becomes equal to 50mV at the output. The amplifier may then swing to a positive value to represent an increasing input signal. If it is desired to observe both increasing and decreasing signal changes with a single polarity power supply it then becomes necessary to make the zero signal level in between 50mV and 10 Volts such as 5.0 Volts. The 5.0 Volt reference voltage is therefore connected to the output offset. This offsets the amplifier output to +5.0 Volts for zero input signal.

Application Information

Pressure Transducer

Figure 4 shows a typical application using a standard 350 ohm pressure transducer bridge circuit. The bridge voltage has been adjusted for 10 Volts giving a full scale pressure output of 30mV from the bridge for 3000 psi. The gain of the amplifier has been set at 333.33 so that a 0 to 3000 psi pressure change is represented as a 10 Volt output change. The power supply is a single +15VDC so the -15V pin has been jumped to common. The common mode voltage for the amplifier input is +5 Volts and is thus within the range specified. The circuit is to trip at 2000 psi and sound an alarm. The output of the amplifier has been offset to 50mV so that zero psi corresponds to 50mV and 3000 psi is +10.050 Volts. Therefore 2000 psi is (333.333) (0.020) + 50mV = 6.7166 Volts. The comparator set point is adjusted for this value. Latching has been incorporated through a push button switch which allows for reset after the pressure drops below 2000 psi.

This example also serves to illustrate the use of the bridge power supply sensing wires. The transducer is located a significant distance away from the Model 165 so there is a noticeable resistance in the lead wires of 10 ohms. If the sense wires were connected to Vb right at the module, the actual voltage across the bridge would be 28.38mV full scale instead of 30mV. Connecting the sense wires directly across the bridge eliminates the problem entirely. As can be seen, the need for using the separate sense lines depends entirely on the amount of lead resistance between the bridge power supply and the bridge itself.

Load Cell Weighing

Figure 5 shows a similar application except here it is required to observe plus and minus changes about an equilibrium balance point for the bridge. A good example would be a load cell used in a weighing system. It is also necessary to use a single polarity power supply. In this case the bridge power supply and input offset are adjusted as before. The output however is offset to +5.0 VDC by using the reference supply and the output offset pin. Negative loads cause the output voltage to drop below 5.0 Volts and positive load is greater than 5.0 Volts. In the example shown, the comparator is not used but could easily be connected to provide a switch closure at any load in the range.

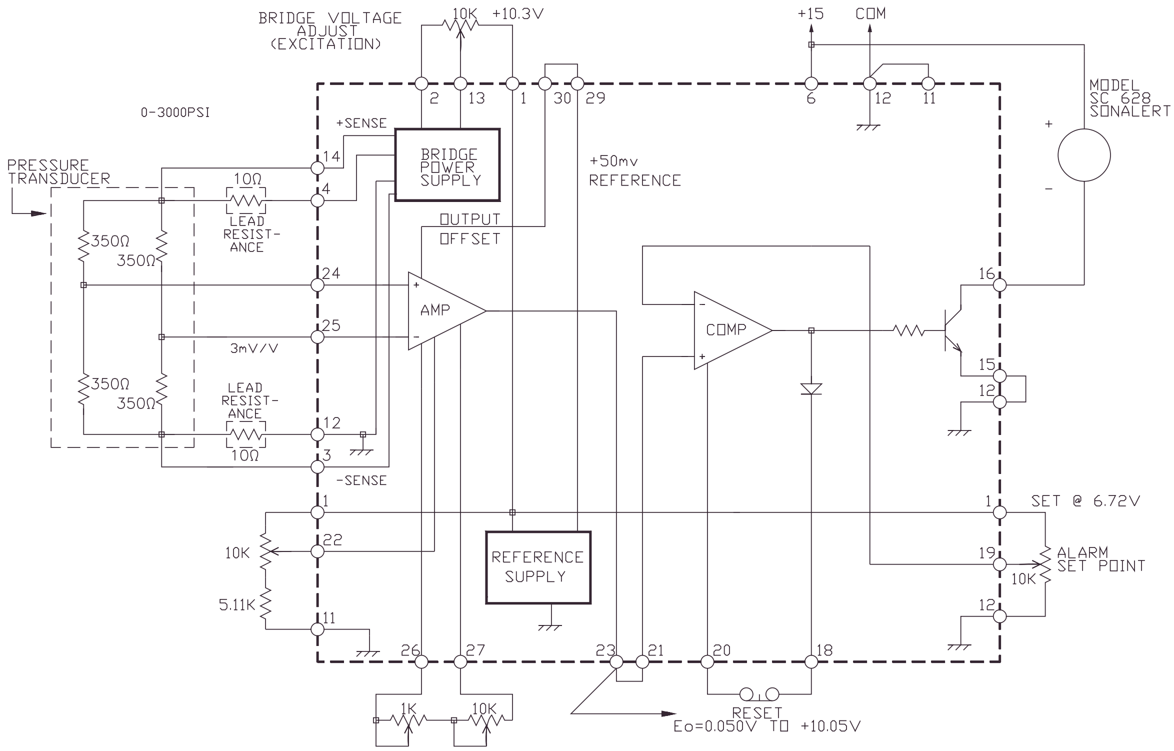


FIGURE 4. Pressure Transducer Application

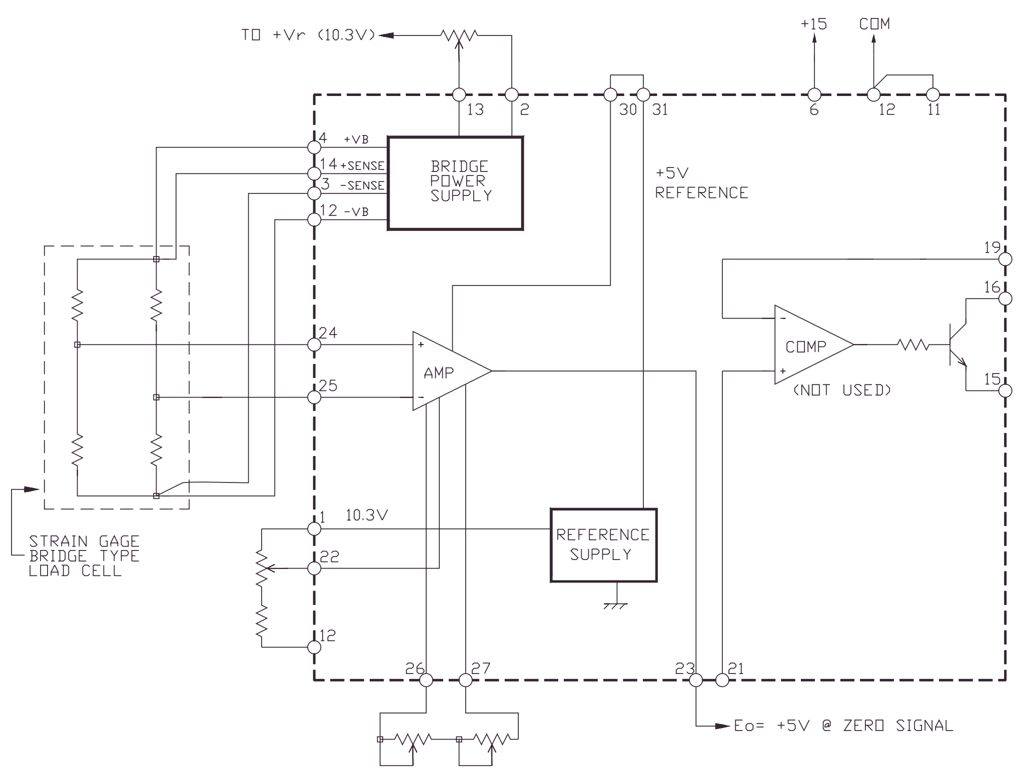


FIGURE 5. Load Cell Example

Thermocouple Control System

The Model 165 is stable enough to use as a thermocouple amplifier. A few additions allow it to become a complete control system.

By using the circuit shown in Figure 6 with 2 type J thermocouples, the reference junction cancels the ambient temperature from the measurement junction and the AD580J, a current source with a temperature coefficient of 1 microamp per degree Kelvin, adds in the ambient temperature voltage across the 54.9 ohm resistor.

A type J has an EMF of 27.388 mV at 500°. An amplifier output of 10 mV/°C requires a gain of

5V / 0.027388 = 182.56.

At 25° the AD590J has an output current of 298.2 microamp. For 10 mV/° output, the series resistor required is

.01 / (1E - 6) (182.56) = 54.77 ohms.

Use a standard 54.9 ohm resistor. The resistance Rt subtracts out the 273.2 microamp 0° current from the AD590J. With a 5 Volt supply, Rt will be about 18.3k. The CALEX Model 152, a FET input high performance amplifier provides a low impedance 5 Volt source for the compensation circuit, using Model 165 +5 Volt reference as its input.

Set the gain of the 165 to 182.56 by making Rg = 959 ohms using low temperature coefficient resistors, and adjust the input offset to zero. Place both thermocouples and the AD590J in a known temperature environment near 25° and adjust Rt for an amplifier output of 10 mV times the known temperature. If the temperature is 22°, adjust Rt for an output of +0.220 Volts.

The output of the amplifier can be read out, recorded, or used in conjunction with the comparator. The comparator switch is shown operating a relay that controls heater power. A diode must be used across the relay coil as shown to protect the comparator output transistor from the relay coil inductive voltage spikes. The circuit of Figure 6 provides a complete low cost temperature control system.

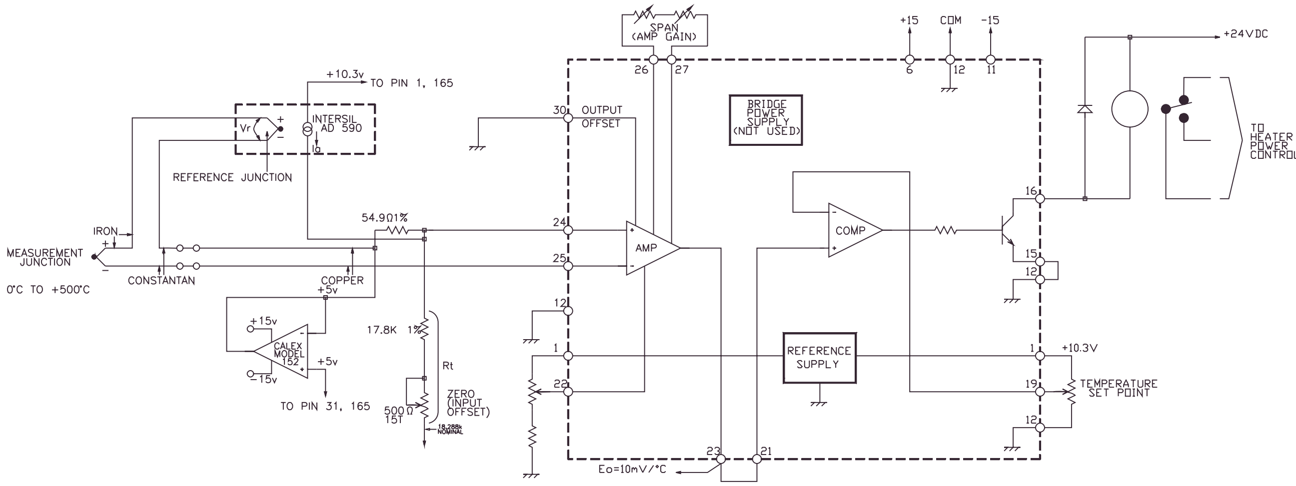
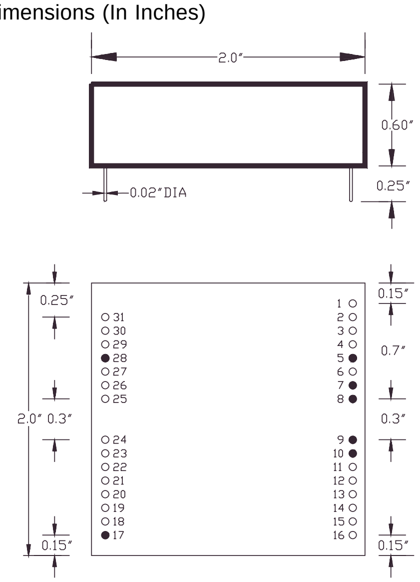


FIGURE 6. Thermocouple Control System using a Model 165

Mechanical Specifications

Outline Dimensions (In Inches)



Bottom View

Shaded pins not installed. Shown for position only.

Pin Assignments			
1	REFERENCE +10.3V	17	*not installed*
2	EX. ADJ. CCW	18	COMPARATOR OUT
3	- SENSE	19	COMPARATOR SET INPUT
4	BRIDGE SUPPLY OUT	20	LATCH INPUT
5	*not installed*	21	COMPARATOR IN
6	+Vs	22	INPUT OFFSET ADJ.
7	*not installed*	23	AMP OUT
8	*not installed*	24	+ IN
9	*not installed*	25	- IN
10	*not installed*	26	GAIN PROGRAMMING
11	AMP CMN	27	GAIN PROGRAMMING
12	COMMON	28	*not installed*
13	EXC. ADJ. WIPER	29	50 mV REFERENCE
14	+ SENSE BRIDGE SUPPLY	30	OUTPUT OFFSETTING
15	SOURCE OUT	31	5V REFERENCE
16	SINK OUT		

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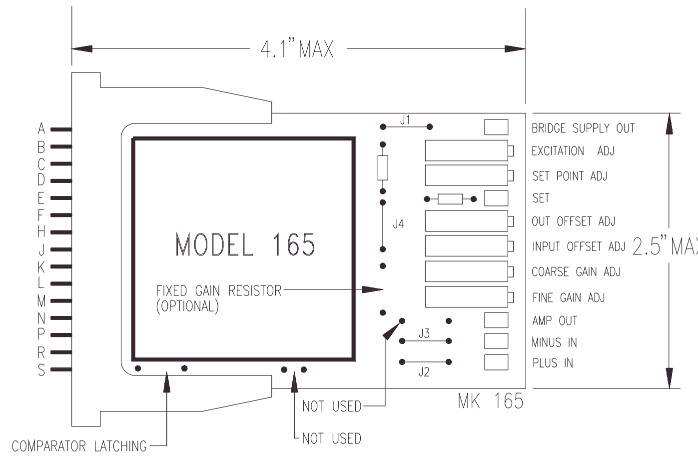
Mounting Kit

Figure 7 shows a complete schematic of the MK165 mounting kit with a 165 module installed. The mounting kit provides six 15 turn adjustment potentiometers for bridge supply voltage, comparator set point, output offset, input offset and coarse and fine gain adjustments. Five jumper positions are included, one to change from dual to single supply operations, one for latching operation, and three for either variable, 50 mV, or 5.0V output offsets. Five test jacks are also mounted and the locations are shown by the Y symbol on the schematic. The Output offset is adjustable from zero to +6.5 V.

The MK165 comes complete with a mating 15 pin connector. It is factory adjusted as follows:

Standard Configuration	
Single Supply Operation	
GAIN	100
OUTPUT OFFSET	+50 mV
BRIDGE SUPPLY	10 V
COMPARATOR SET POINT: J1 & J3 INSTALLED	1V



J4 added when variable output offset is required (Use Out Offset pot).

J3 added when output offset of 50 mV is required (standard).

J2 added when output offset of 5 volts required.

FIGURE 8.
MK165 mounting kit, 15 pin connector and 165 module.

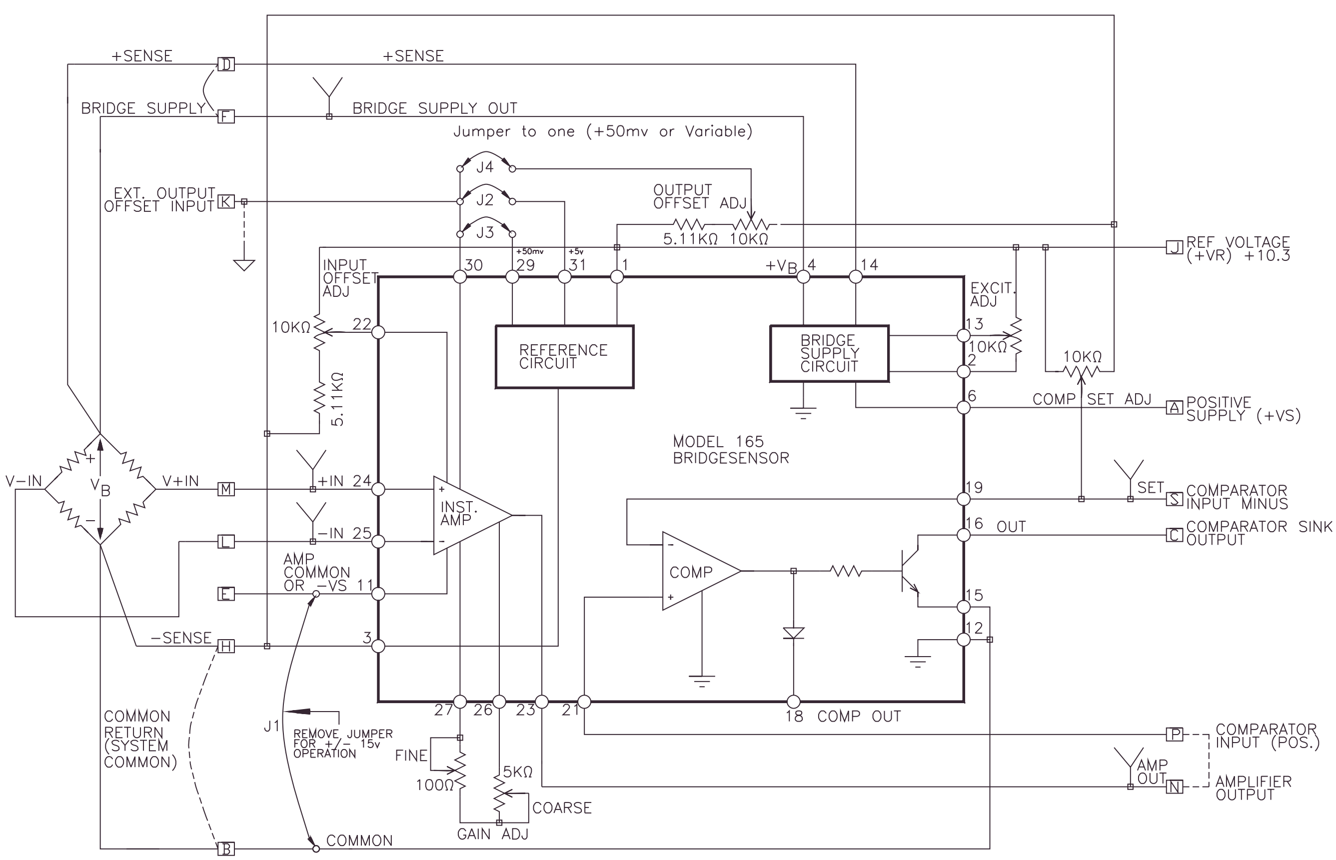


FIGURE 7. Schematic of the MK 165 Mounting Kit with a 165 module installed.