Model 160MK Bridgesensor

Features

- Compact, complete and convenient to use
- Easy access to all trim adjustments
- Half Bridge applications made easy by Internal Completion Resistors
- On card Bridge Balance Trimpot eliminates additional wiring for Three Wire applications
- Changing Bridge supply voltage is easy using on board trimpot with adjustment range from +4 to +10 VDC
- Bridge supply lead resistance effects can be ignored with built-in remote sensing
- Filter frequency can be changed with the flick of a DIP switch
- Worst Case design is simplified with fully specified engineering specifications. No phone calls, no letters, it's all right here

Description

The CALEX 160MK Bridgesensor is a complete signal conditioning system on a card designed expressly for either half or full bridge transducers. The 160MK consists of a high performance instrumentation amplifier, a user adjustable active filter, high stability bridge supply and reference regulator in a state-of-the-art hybrid circuit, which is mounted on a PC board mounting kit containing all of the required external circuitry, trimpots, etc., so that only point to point wiring need be made to the inputs, outputs and power to have a complete signal conditioning system up and running.

The mounting kit provides coarse and fine gain adjustment trimpots along with input and output offset adjustments, DIP switches for setting the bridge supply output and active low pass filter cutoff frequency.

Application of the 160MK is easy by following the detailed applications information that is included with this data sheet and full engineering specifications allow easy and complete worst case analysis.

160MK Schematic

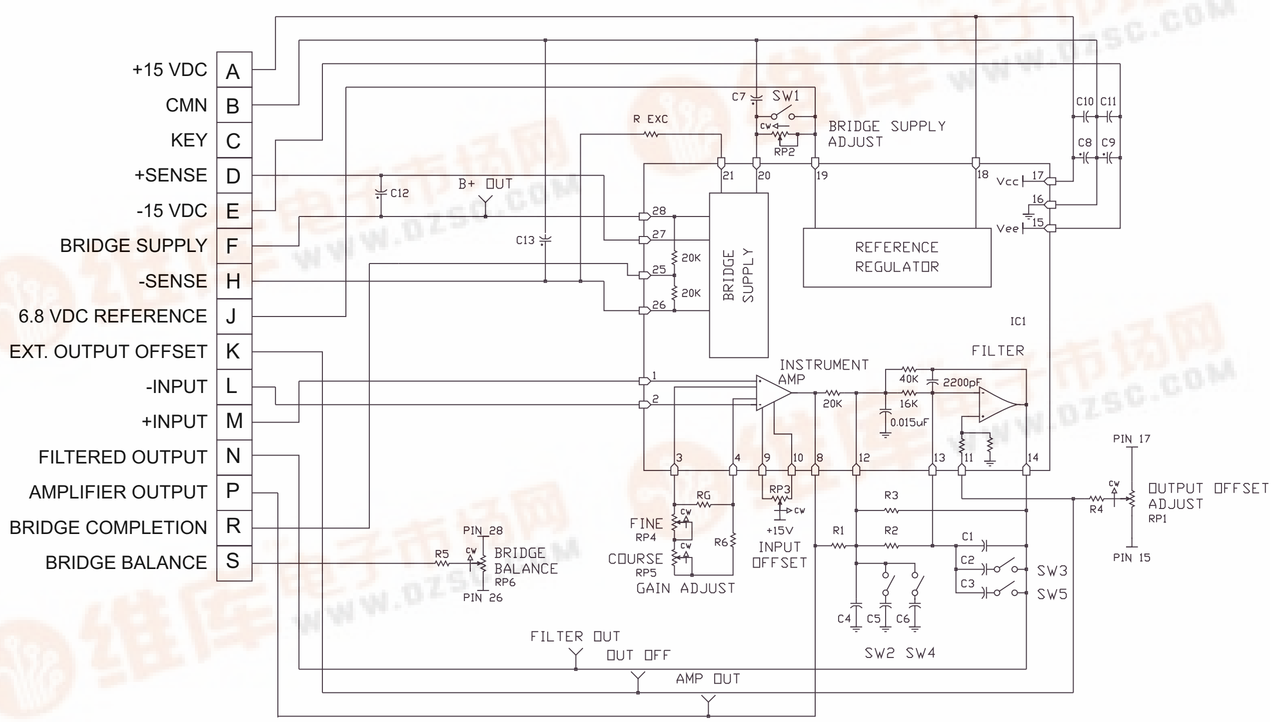


FIGURE 1. Complete schematic of the 160MK Bridgesensor

Specifications

Conditions (Unless Noted): Ta = 25°C, Vs = ±15 VDC, G = 500 V/V

Parameter		Minimum	Typical	Maximum	Units
Amplifier (1)					
Gain Range	Adjustable (2) w/External Set Resistor	100 2		500 5000	V/V
Gain Equation		Rg = 80,000/(G-2)			ohms
Gain Equation Accuracy 2 < G < 1000 V/V			3		%
Gain Range w/Temperature:	w/Trimpots Amplifier alone		75 15	150	ppm/°C
Nonlinearity, ±10V Output Swing			0.002	0.005	%
Offset Voltage, Input and Output		Adjustable to Zero			
Warmup Drift (3)			1		µV
Vs. Temperature:	G = 2V/V G = 1000V/V At Other Gains, Max.		30 1 ±4 ±(100/G)	75 4	µV/°C
Vs. Power Supply Pin K tied to Pin B			1		µV/V
Output Offset Adjust Range		±10			V
Input Bias Current (4) Vs. Temperature			10 25	50	nA pA/°C
Input Offset Current Vs. Temperature			5 10	20	nA pA/°C
Input Impedance (5)		4G ohms || 15 pF			
Common Mode Input Voltage:	Range, Linear Response Maximum		±9.5 ±15		VDC
CMR (6):	1 kHz bw, DC-60 Hz (7) 10 Hz bw, DC-60 Hz (7)	110 110	140 140		dB
Input Noise Voltage:	0.1 Hz - 10 Hz 10 Hz - 100 Hz		0.3 1		µv P-P
Current:	0.1 Hz - 10 Hz 10 Hz - 100 Hz		60 100		pA P-P
Rated Output:	Voltage, 2 kohm Load Current Load Capacitance Short Circuit	±10 ±5	Indefinite	1000	VDC mA pF
Dynamic Response (8):	Small Signal Bandwidth Amp Out Gain Bandwidth (9)		Adjustable 25		kHz MHz
Low Pass Filter (10):	Number of Poles DC Gain (Pin P to N) Roll Off		2 -2 40		V/V dB/Dec
Bridge Excitation Supply (11)					
Output Adjustment Range:	w/Trimpot w/Ext Resistor	4 4		10 12	VDC
Output Current (12)		0		100	mA
Load Regulation I_L = 0 - 100 mA			0.1	0.2	%
Line Regulation Vin = 14.5 - 18 VDC			0.05	0.5	%/V
Stability (13):	Short Term Long Term Vs. Temperature Warm-up Drift		0.05 0.2 40 0.1	80	%/24 Hrs %/kHrs ppm/°C %
Short Circuit Protection		8 Hours Minimum			
Output Noise, 10 Hz - 1 kHz			200		µV P-P
Internal Reference Voltage (15)		6.46	6.80	7.14	VDC
Half Bridge Completion					
Nominal Resistance Value			20		kohms
Initial Accuracy				1	%
Temperature Tracking				5	ppm/°C
Balance Adjustment Range		5			%
Power Requirements					
Voltage:	Rated Performance Operating	±12	±15	±18	VDC
Current (14)			±12		mA
Environmental					
Ambient:	Operating Storage	-25 -40		70 100	°C

Notes:

(1) Specifications referred to the filter output (Pin N).
(2) Using on board coarse and fine gain adjust trimpots.
(3) Warm-up drift is specified as the input offset drift for the first 5 minutes after the application of power with G = 1000 V/V, Bridge supply = 10V driving a 350 ohm bridge.
(4) Measured at 25°C Ambient with unit fully warmed up.
(5) Measured from -Input to +Input or input with respect to ground.
(6) Specified with 1 kohm source impedance imbalance, 100 < Gain < 1000 V/V.
(7) Filter frequency set with DIP switches.
(8) Small signal response, switch or resistor/capacitor selectable, see applications section.
(9) This is the instrumentation amplifier basic gain bandwidth product, the filtered output will provide for a constant cutoff frequency regardless of gain.
(10) The low pass filter cutoff frequency is adjustable to 10, 100 and 1000 Hz using the onboard DIP switches and from 1 Hz to 10 KHz using external resistors and capacitors.
(11) Bridge supply must be operated with +Sense connected to the Bridge Supply Pin and with -Sense connected to Common.
(12) The bridge supply maximum output current is a function of input to output voltage differential and temperature. See graphs and applications section for more information.
(13) Stability is defined after a 5 minute warm-up period and with constant line, load and ambient temperature unless otherwise specified.
(14) Quiescent current for amplifiers only, the current drawn from the bridge supply must be added to the +15 VDC current drain for total current draw.
(15) Referred to Pin J, this is a high impedance output and should not be loaded greater than 50 MicroAmps. Buffer this reference with an OP-AMP for greatest accuracy.

Functional Description

The CALEX Model 160MK is a completely self contained single channel signal conditioning system on a card. This device offers the high performance and reliability of hybrid circuitry with the completeness of a mounting kit containing all trimpots and components needed for operation, all that needs to be added is power and transducer inputs to get a conditioned output suitable for driving A/D converters, panel meters, indicators, or PC based controllers. A full schematic of the 160MK is shown in Figure 1.

Instrumentation Amplifier

The heart of the 160MK is the high performance instrumentation amplifier. This amplifier features low noise, low drift and high accuracy along with trimpot adjustments for coarse/fine gain and input offset voltage. The direct instrumentation amplifier output is brought out to Pin P on the 160MK, this signal is inverted (Vo = Gain x (- (+Input - -Input)) with respect to the input pin labeling but can be used where the full 25 MHz gain bandwidth product is required such as for mechanical vibration analysis. This output is also brought out to the test point AMP OUT at the trimpot edge of the mounting kit. The trimpots allow a gain adjustment range of 100 to 500 V/V with a coarse and fine gain adjuster (clockwise rotation increases gain). A user supplied resistor can be used in place of the trimpots (see equations below) to get any gain from 2 to 5000V/V (referred to filtered output). To use an external resistor remove R6 from the mounting kit to disable the trimpots, then calculate the required value for RG and solder it on the mounting kit in the spot provided.

The gain equation accuracy is ±3 percent for gains from 2 to 1000 V/V.

$$RG = \frac{80{,}000}{G - 2} \text{ ohms}$$

Equation 1: User supplied resistor value required to set gain with respect to Pin N, filtered output.

$$RG = \frac{40{,}000}{G - 1} \text{ ohms}$$

Equation 2: User supplied resistor value required to set gain with respect to Pin P, amplifier direct output (this is an inverted output). NOTE: If a fixed resistor is used for RG, then resistor R6 should be removed from the 160MK to disable the gain trimpots.

Example Resistor Values for Common Gains (to Filtered Output):

Required Gain, Filtered Output	**RG Value**
10	10,000 ohms
100	816 ohms
333.33	241 ohms (Use for 3mV/V Transducers)
500	160 ohms (Use for 2mV/V Transducers)
1000	80.2 ohms

Note: A high stability, 5 ppm/°C metal film resistor should be selected for RG for maximum performance.

The instrumentation amplifier also has a trimpot adjustment for input offset voltage, this trimpot should be used to null the instrumentation amplifier offset only. System offsets should be adjusted out using the Bridge Balance or the Output Offset feature (see applications section for more information) to retain minimum offset drift of the instrumentation amplifier.

The 160MK inputs should be placed as close to the transducer as possible. This will minimize any possible pickup of electrostatic or electromagnetic noise into the very high impedance inputs. See the applications section for more information on shielding methods.

Active Filter

The output of the instrumentation amplifier is internally connected to the input of a 2 pole, inverting gain (-2V/V)active filter. This filter has an adjustable filter cutoff frequency of 10, 100 and 1kHz by the use of on board DIP switches and can be set to any frequency from 10 Hz to 10 kHz by the use of user supplied resistors and capacitors. The filtered output is brought out to Pin N and to test point FIL OUT at the trimpot end of the board on the 160MK. Pin N is the standard output for most strain gage and instrumentation applications, by using the filtered output extraneous noise above the useful signal frequency is removed at a rate of 40dB/decade above the filter cutoff frequency allowing very precise and low noise measurements to be made. Figure 2 details the DIP switch settings and the equations required to set the filter cutoff to any other frequency.

The filter stage is also the input for the output offset voltage adjustment. The output offset may be adjusted with the on board trimpot or by driving the output offset input (Pin K) with a low impedance source or the wiper of a trimpot (see application section for more information on using this feature). If an external trimpot is to be used R4 should be removed from the 160MK, this will disconnect the internal trimpot from any loading or interaction with the external trim. If the output offset feature is not desired then connect the External Output Offset (Pin K) to Common (Pin B) directly at the mounting kit. The gain from the External Output Offset pin (Pin K) to the filtered output (Pin N) is approximately 0.7 V/V (i.e. if Pin K is changed by 1 Volt in a positive direction then Pin N will also change by 0.7 Volts in a positive direction).

Filter Cutoff Frequency Adjustment

Cutoff Frequency	SW2	SW3	SW4	SW5
10 Hz	ON	ON		
100 Hz			ON	ON
1000 Hz or User Select	ALL OFF			

$$C1 = 0.0022\ \mu F \left[\frac{1000}{Fc} - 1 \right]$$

$$C4 = 0.015\ \mu F \left[\frac{1000}{Fc} - 1 \right]$$

CUTOFF FREQUENCY > 1000 Hz

$$R1 = 20{,}000 / \left[\frac{Fc}{1000} - 1 \right]$$

$$R2 = 16{,}000 / \left[\frac{Fc}{1000} - 1 \right]$$

$$R3 = 40{,}000 / \left[\frac{Fc}{1000} - 1 \right]$$

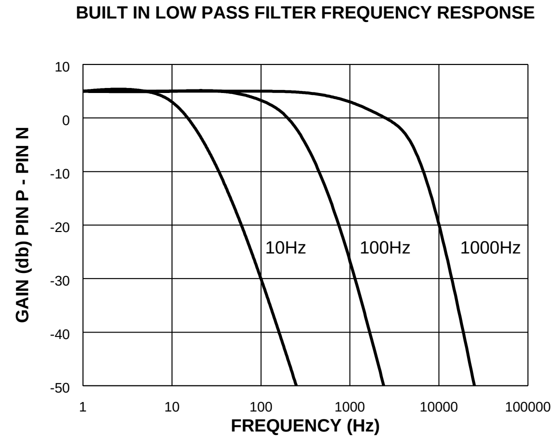


FIGURE 2. Dip switch settings and equations required to set the filter cutoff frequency.

Bridge Supply

The bridge excitation supply is a very well regulated low noise output designed to drive either full or half bridge transducers from 0 to 100mA output current. The output can be set to a fixed +10V by setting DIP switch SW1 ON. By setting SW1 OFF the output can be adjusted from +4 to +10Volts by adjusting the bridge supply adjust trimpot. If a bridge supply output in the range of +10 to +12 Volts is desired a user supplied resistor can be installed for R EXC (SW1 should be set ON), see Figure 3 for proper values of R EXC to use.

The bridge supply uses + and - sense connections to compensate for any line drops that might be present when using remote transducers, see the applications examples for more information on properly using the + and - sense pins. If remote sensing is not required connect +Sense (Pin D) to Bridge Supply (Pin F) and -Sense (Pin H) to Common (Pin B) directly at the mounting kit socket. The maximum voltage difference between the Bridge Supply, Pin F and the +Sense, Pin D, is 0.4V.

A location is provided for damping capacitors C12 and C13 on the 160MK to provide AC coupling and compensate for

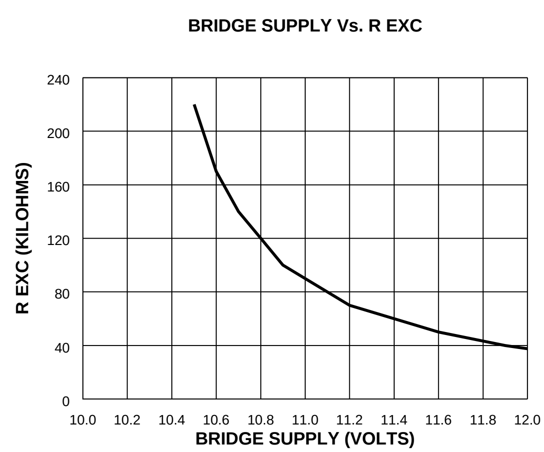


FIGURE 3. Graph of R EXC vs. Bridge Supply voltage for excitation voltage from 10 to 12 VDC

parasitics in especially long cable runs to the transducer, it is suggested that if the transducer load is more than 3 feet away from the 160MK that a 1 to 10 µF, 35 Volt Tantalum capacitor be used for C12 and C13 to ensure stability.

The maximum safe bridge supply current is affected by the regulator input to output voltage differential and ambient temperature. The maximum input-output Vs. current is shown in Figure 4. This graph is for ambient temperatures of 25°C or below.

DERATING CURVE

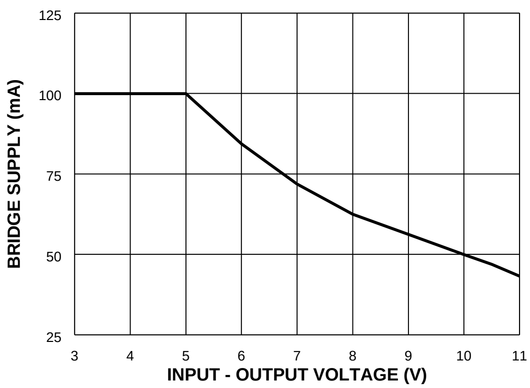


FIGURE 4. Graph of Bridge Supply maximum output current Vs. input to output voltage differential

The ambient temperature derating lowers the maximum safe output current above 50°C ambient by 2 mA/°C. That is if the maximum ambient of the 160MK is 65°C the output current must be lowered by 30 mA ((65 - 50) x 2 = 30) over what Figure 4 shows as a safe maximum.

Figure 5 combines the above information into a single graph of maximum internal power dissipation Vs. ambient temperature.

A method of extending the maximum safe Bridge Supply current is to use an external pass transistor. As shown in Figure 6 this method is the ultimate for lowering internal dissipation, the 160MK must supply only the op-amp bias current. With the TIP31 transistor specified the maximum bridge supply current is increased to 1 Amp or more (with proper heat sinking) for any load voltage from 4 to 12 Volts. This circuit is also useful for running multiple bridges from one 160MK allowing ratiometric measurements to be made with one 160MK Bridge Supply and Reference driving a common A/D converter.

SAFE OPERATING AREA CURVE

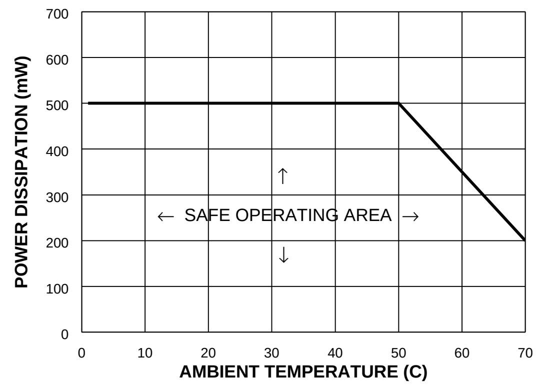


FIGURE 5. Graph of maximum internal power dissipation Vs. ambient temperature.

This method is useful in lowering the internal temperature rise of the hybrid circuit. A lower temperature rise will lower warmup drift and make the circuit less sensitive to air currents that might pass along the 160MK. If very high accuracy, and repeatable measurements are being attempted one of these methods should be used to lower the power (and hence temperature rise) in the hybrid circuit.

The 6.8 VDC reference (Pin J) can be used as reference for any other circuitry or an A/D converter, comparator trip level reference or panel meter reference. The output current of this pin is limited to 50 µA maximum.

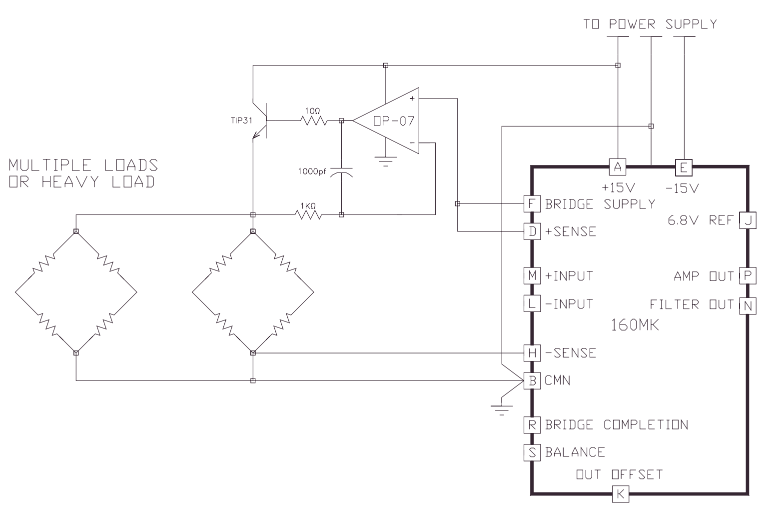


FIGURE 6. Drive very low impedance loads or multiple load cells with an external pass transistor wired on the 160MK's mating socket.

Half Bridge Completion/Bridge Balance

Two 20k ohm thin film resistors are located in the hybrid circuit from the Bridge Output (Pin 28) to the -Sense (Pin 26). These resistors form a precision low drift voltage divider for the Bridge Supply. This circuit can be used as the other half of a Half Bridge (i.e. one leg or 3 wire) transducer to provide a common mode voltage to the instrumentation amplifier that matches the transducer zero offset voltage. This allows increased gain to be used in the instrumentation amplifier resulting in higher achievable sensitivity. This voltage divider is brought out to Pin R on the 160MK and can be directly connected to either the + or - Input pins.

A companion circuit on the 160MK controls the Bridge Balance. This circuit is a trimpot connected across the bridge balance resistors that along with a series resistor (R5) adds or subtracts a small correction or balancing voltage to the half bridge completion circuit (about ±5% adjustment range). Normally Pin S would be connected to Pin R if half bridge completion is being used. The bridge balance can also be connected directly to a full bridge transducer to allow nulling and R5 can be changed on the 160MK to get different zero adjustment sensitivity.

General Calibration Procedures

The 160MK comes from the factory adjusted to the following specifications:

GAIN .... 333 V/V

INPUT OFFSET .... Adjusted to 0

OUTPUT OFFSET .... Adjusted to 0

BRIDGE SUPPLY .... SW1 CLOSED, Bridge Output at +10 Volts

FILTER .... SW2 - SW5 OFF, Filter at 1 kHz

BRIDGE BALANCE .... Pin S at 0 Volts

When adjusting the 160MK to other values the following methodology should be used,

1) Ground the inputs and the output offset pins, set the input offset trimpot to get 0 Volts on the output you will be using (Pins N or P). Input offset is for amplifier nulling only. Do not use the input offset for zeroing systems offsets, use the bridge balance or the output offset adjustments for system offset correction.

2) Using a millivolt calibrator or the transducer output itself, set the gain so that the proper full scale output voltage is realized (the mV calibrator or transducer should be set to simulate full scale output).

3) If system offsets must be accounted for repeat step 1 again with the inputs disconnected from the source and connected to ground, then reconnect the inputs and re-zero the output with the bridge balance (if used) or the output offset adjustment.

4) Steps 1 - 4 above may need to be repeated several times to achieve the desired accuracy of gain and offset.

160MK Application Examples

Linear NTC Thermistor Oven Controller

A linear NTC (Negative Temperature Coefficient) thermistor can be interfaced to the 160MK with the following circuit. The circuit as shown can be used in a precision temperature controller that can be used to keep various electronic circuits at a constant temperature for improved performance to study growth with constant environment variables.

The transducer used is an ALPHA THERMISTOR INC. ALN630-1. This thermistor actually consists of 2 thermistors and a shunt resistor. This arrangement of thermistors produces a linear output, accurate to within ±0.3°C over a -30 to +50°C range. The Bridge excitation is set to 4 Volts for minimum self heating of the thermistor, Rb is chosen to be 22,300 ohms as per ALPHA's data sheet.

To calibrate the system place the thermistor in an ice bath and set the input offset to zero output on the DVM, the place the thermistor in a +50°C hot oil bath and set the gain trimpots for a +5 Volt reading on the DVM. This procedure may need to be repeated several times to achieve the desired accuracy. The DVM will now read directly in °C (be sure to set the DVM's decimal place one digit to the right).

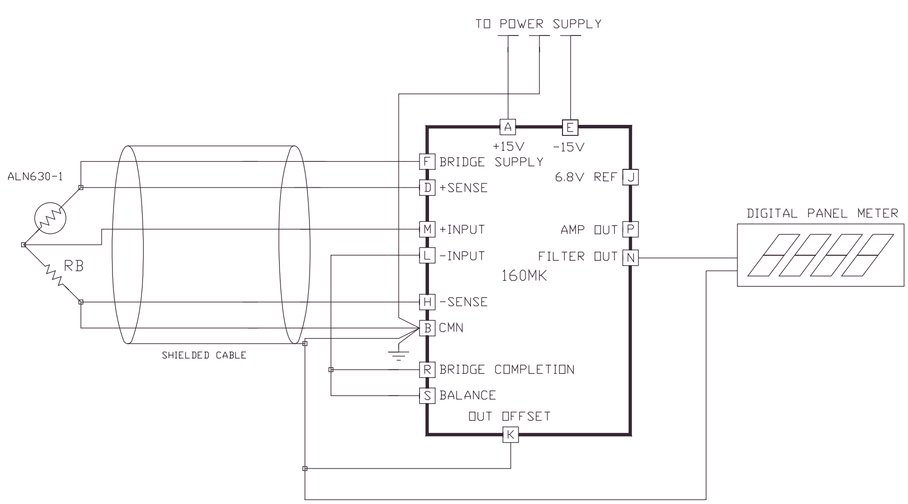


FIGURE 7. NTC Thermistor Interfacing Circuit

Digital Scales with Remote Tare Adjustment

The 160MK can be used as the heart of a very effective digital scale system as shown below. The 160MK is interfaced to a standard 3mV/V full bridge transducer. With the bridge excitation set to 10 Volts a gain of 333 V/V is required to get a 10 Volt full scale output. The output offset pin (K) is used here to interface to a front panel pot by the display, this pot allows a tare or dead weight adjustment to be made by the operator as required to set the system offset to zero reading for zero weight on the scale (resistor R4 should be removed from the 160MK to disable any interaction of the internal output offset adjustment). The system is calibrated by applying zero weight with the output offset pin and the inputs connected to ground and adjusting the input offset to get a zero reading, then remove the inputs from ground and apply a full scale load to the scale (or simulate one with a mV calibrator) and adjust the gain trimpots for a full scale reading on the readout. This procedure may have to be repeated several times to get the desired accuracy of gain and offset.

Thermocouple Interfacing

The 160MK, while designed for bridge transducer applications can be used for a variety of other signal conditioning applications as well. The thermocouple amplifier shown here can be built for all common thermocouple types by using the proper resistor values as shown in the table. The amplifier functions as a differential gain stage with one input sensing the thermocouple input and the other input sensing the ambient temperature as derived by the temperature dependant current of IC1 (AD590). The AD590 functions as an electronic ice point so that all thermocouple connections can be made at room temperature.

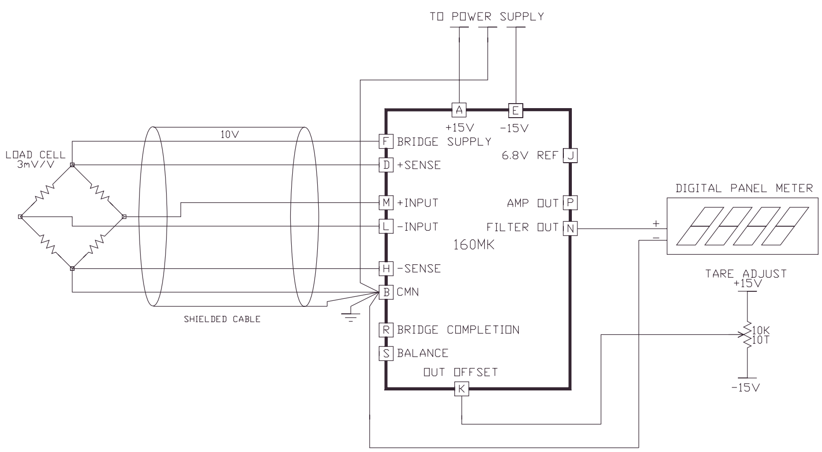


FIGURE 8. A digital scale application of the 160MK with a remote tare adjustment.

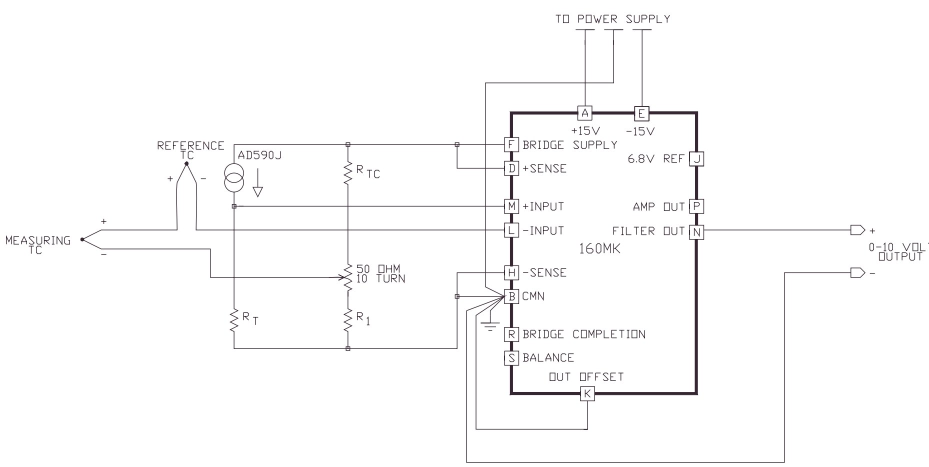


FIGURE 9. The 160MK used as a thermocouple amplifier.

Thermocouple Type	R1	RTC	RT	Temperature Range	Gain	RG
J	348 ohms	154K	51.1 ohms	700°C	255	316 ohms
K	267 ohms	154K	40.2 ohms	1200°C	205	392 ohms
R	75 ohms	348K	6.04 ohms	1400°C	624	130 ohms
S	75 ohms	348K	6.04 ohms	1400°C	696	115 ohms
T	275 ohms	154K	41.2 ohms	400°C	479	169 ohms

Note: Use stable RN55C 1% metal film resistors for best performance

Retrofitting MK165 Applications

Converting MK165 Designs to the 160MK

CALEX has designed the 160MK. to be an attractive upgrade path for existing MK165 applications offering enhanced specifications and features, while minimizing the changes required to already designed MK165 systems. Below in Table I is a list of the differences in the pin connections of the 160MK and MK165 and suggested changes.

Table I

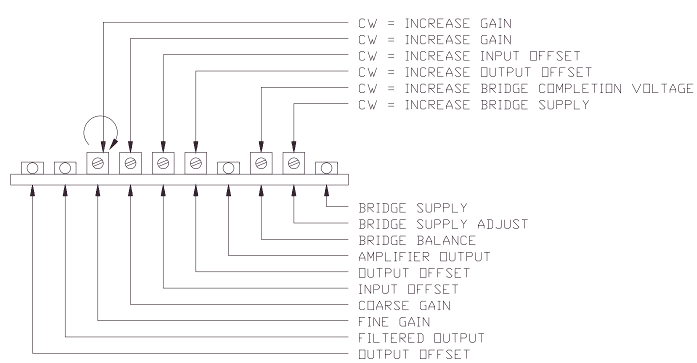
Comparison of the 160MK and MK165 mounting kit and pin assignments.

Mounting Kit	160MK Function	MK165 Function	Suggested Change from MK165 to 160MK
A	+15 VDC	+15 VDC	No Change Required
B	COMMON	COMMON	No Change Required
C	KEY	COMPARATOR OUT	The 160MK does not implement a level comparator, disconnect this pin. The key on MK165 applications must be moved to this pin from pin R in order for the 160MK to seat in the socket properly.
D	+SENSE	+SENSE	No Change Required
E	-15 VDC	-15 VDC	No Change Required
F	BRIDGE SUPPLY	BRIDGE SUPPLY	No Change Required
H	-SENSE	-SENSE	No Change Required
J	6.8V REFERENCE	10.3V REFERENCE	If this pin is used in the MK165 design please note that the 160MK is a 6.8V reference.
K	OUT OFFSET	OUT OFFSET	The 160MK output offset is similar in function, but different in voltage level requirements, please see application information.
L	-INPUT	-INPUT	No Change Required
M	+INPUT	+INPUT	No Change Required
N	FILTER OUT	AMPLIFIER OUT	No change required to use filter output feature of 160MK, to use full bandwidth output connect MK165 pin N to 160MK pin P, but the inversion in signal may require a reversal in pins L and M.
P	AMPLIFIER OUT	COMPARATOR INPUT	If the MK 165 has pins N and P connected be sure to disconnect, use pin P on the 160MK for full bandwidth applications, see also note on pin N above.
R	BRIDGE COMPLETION	KEY	This pin was not used on the MK165
S	BRIDGE BALANCE	COMPARATOR SET	If this pin was connected to external circuitry on the MK165 disconnect it. On the 160MK this pin is the bridge balance output.

160MK Trimpot Adjustments

The 160MK uses the same location on all trimpots and test points as the MK165 to further reduce the effort required to upgrade to the 160MK. For most applications no pins need be changed and the 160MK is a pin for pin enhanced replacement for the MK165. Be sure to disconnect Pins P and N (if they are connected on the MK165) as these pins connect the filtered output an amplifier output together on the 160MK (which will cause a shorted output condition).

160MK Trimpot Adjustments Detail



Help!
What To Do If You Can't Get It Working.

Q1) It just won't work!

A) If the 160MK is wired into a larger system try and isolate the 160MK by disconnecting the input and outputs from the system. Larger systems are best debugged by disconnecting all of the functional blocks and starting at the input side then progressing through the system a functional block at a time. I also find it helpful to redraw the schematic diagram a block at a time being sure that I understand where ALL of the current paths are flowing, usually I can spot the problem when I find a current path that defies the laws of physics or I spot an open path. Remember: Divide and Conquer!

Q2) OK, it still won't work!

A) Check the power supply currents with the inputs connected to Pin B (common). The supply currents should be reasonable (see the data sheet). Check all the pin connections again, try and draw the schematic from the wiring that you are looking at. See if turning any of the trimpots produces any kind of changes on the output pins (Pins N and P).

Q3) The output appears unstable or is oscillating.

A) The standard practice of running input lines in shielded cable should be avoided on the amplifier outputs. These outputs are low impedance and are not susceptible to noise pickup, but are susceptible to oscillation due to capacitive loading as is the case when shielded cable is used. The filtered output is able to drive up to 1000pF without stability problems, so be sure to keep the output loading below this value.

Q4) The output is at a supply rail or has severe 60Hz noise on it.

A) The most misunderstood application of instrumentation amplifiers concerns the return path for the input bias currents. There must be a path for the input bias currents (small as they are) to return to system common. If no path is provided then the inputs will float to an undetermined voltage, usually driving the amplifier input stage nonlinear and providing a meaningless and often times noisy appearing output. If the transducer is a half or full bridge then the path is provided through the bridge itself, but if the transducer is a thermocouple then the potential for floating inputs is real. A large resistor (> 1 Meg) must be connected from each input to system common to provide for a ground return.

If the system doesn't work properly then examine the input current paths and be sure that there is a return path for the input bias currents, if this is not readily apparent then connect a large resistor to each input to common and see if the system functions properly.

Q5) The completed system has more noise than I thought it would .

A) Try and adjust the cutoff frequency of the filter down to 10 Hz, also be sure that any shielded cables that are used for the inputs are only grounded at one end. Check that the power supply is stable and noise free. In general use the lowest possible filter frequency that you can, this will always minimize the system noise bandwidth.

Q6) I can't get the gain and offset adjusted properly.

A) First be sure that the gain you need is within the internal trimpots adjustment range of 100 to 500 V/V, if it is not then you will need to calculate and use a fixed resistor for RG. Be sure to use the input offset adjustment only when the inputs are grounded, this will insure that the input offset is in fact only correcting for the internal offsets of the 160MK. Use the output offset and bridge balance for any required system offsets.

Q7) I've tried my best but I still need help!

A) By all means feel free to give CALEX applications engineering a call toll free at 800-542-3355. We spend a lot of time debugging our own system and can sometimes spot trouble immediately. Also, we learn a lot about how our customers use our products so we can make them even more useful in the future.

Mechanical Specifications