Application Notes
Trimming Potentiometers

TRIMMING POTENTIOMETERS

The material in this section is intended to provide you with guidelines and thoughts to consider during the selection and application of BI Technologies line of trimming potentiometers. Proper component usage is important in achieving good overall performance, long life, and the lowest cost for your system. We have included in these notes additional information that may be helpful in preventing damage to trimmers that may occur from in-house or outside contract assembly and soldering processes. If you have questions that are not covered here, please don't hesitate to call and discuss your requirements with our application engineers.

TRIMMER STYLES, CONSTRUCTION, AND COMPONENT PARTS

There are three basic trimmer styles and their variations in this catalog. They are:

- Round single turn
- Square multiturn
- Rectangular multiturn

The basic components of each are the cermet resistance element, the wiper, and the rotor or slider and its drive mechanism that moves the wiper on the element. All must be designed and manufactured to operate together with high precision over a broad temperature range.

THE CERMET RESISTANCE ELEMENT

The cermet element is fundamentally responsible for the electrical performance of the trimmer. Key performance parameters such as the basic resistance value, temperature coefficient, voltage coefficient, resolution, and contact resistance variation (CRV) are directly related to the element construction.

THE WIPER OR MOVING CONTACT

The wiper is also a major contributor to good electrical performance. It must make reliable electrical contact with the surface of the cermet element. The contact resistance must be low and must not vary substantially as it is moved over the element surface. It must be accurately settable without backlash. Lastly, it must remain at its established set point without substantial dimensional shifting or corrosion under all trimmer operating conditions.

BI TECHNOLOGIES MATERIALS AND CONSTRUCTION

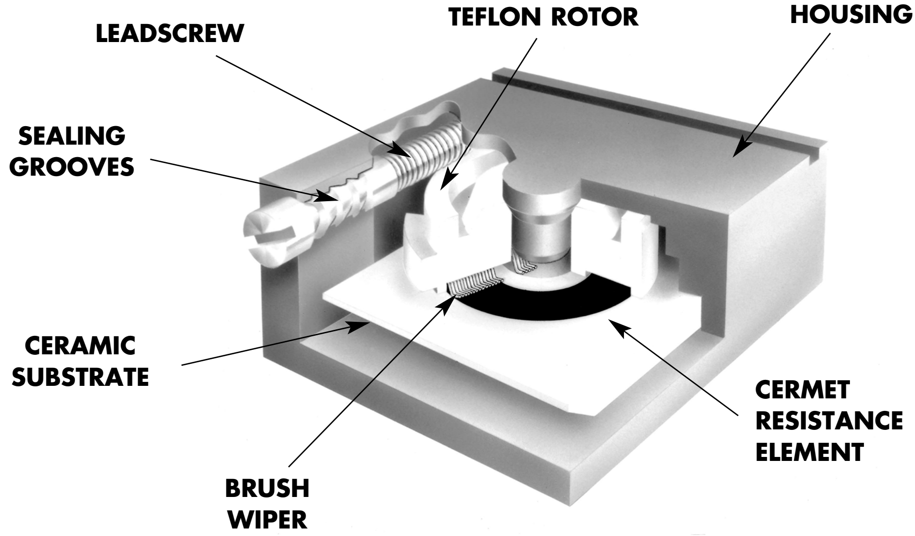
The combination of proprietary cermet element technology, precious metal brush contacts and swaged pin element connections used in BI trimmers permits the manufacture of precision, high quality trimmers that span the resistance range from 10 ohms to over 5 megohms. The small size and planar construction of these trimmers minimize stray circuit reactances and permit the trimmers to perform well in many high frequency applications.

Leadscrew
Precision brass leadscrew cuts its own grooves in the teflon rotor so that the operation of the rotor is free of backlash. Setability is excellent.

Sealing Grooves
Leadscrew has specially cut grooves to ensure a watertight seal.

Ceramic Substrate
High density substrate provides an excellent base for the element and is a good conductor of heat.

Cermet Element
BI's proprietary cermet element matches the materials in the wirebrush so that CRV is minimized and the high temperature setability is excellent.



Swaged Pins
BI's pin connections, which are swaged to the substrate, are free of solder and maintain high conductivity with time and temperature cycling.

1 TERMS AND DEFINITIONS

The terms and definitions used in this catalog have been edited from the Variable Resistive Components Institute (VRCI) data for trimming potentiometers.

VRCI publishes generally accepted terms, definitions, and test standards for trimming potentiometers, and for other variable resistive devices. If you would like additional information or definition on industry standards, please contact one of our application engineers.

1.1 LIST OF SYMBOLS

1.1.1 ELECTRICAL

- E - Total applied voltage
- e - Output voltage
- e/E - Output ratio
- ENR - Equivalent noise resistance
- V_m - Minimum voltage
- R_t - Total resistance
- R_e - End resistance
- R_m - Absolute minimum resistance
- R_L - Load resistance
- TC - Temperature coefficient of resistance
- RTC - Resistance temperature characteristic
- CRV - Contact resistance variation
- CT - Center tap
- SL - Wiper (slider)
- P - Power handling capability in watts

1.1.2 MECHANICAL

- CW - Clockwise rotation
- CCW - Counterclockwise rotation
- ST - Single turn trimming potentiometer

- MT - Multiturn, screw actuated trimming potentiometer
- SS - Stops, solid
- C - Continuous rotation
- SC - Stops, clutch action
- L - Insulated wire lead terminals
- P - Pin terminals, flat base mount normally for printed circuit application
- W - Edge mounted terminals, adjustment shaft 180° from terminals
- X - Edge mounted terminals, adjustment shaft 90° from terminals
- S - Solder lug

1.2 GENERAL TERMS

1.2.1 TRIMMING POTENTIOMETER:

An electrical mechanical device with three terminals. Two terminals are connected to the ends of a resistive element and one terminal is connected to a movable conductive contact which slides over the element, thus allowing the input voltage to be divided as a function of the mechanical input. It can function as either a voltage divider or rheostat.

1.2.1.1 WIREWOUND TRIMMING POTENTIOMETER:

A trimming potentiometer characterized by a resistance element made up of turns of wire on which the wiper contacts only a small portion of each turn.

1.2.1.2 NON-WIREWOUND TRIMMING POTENTIOMETER:

A trimming potentiometer characterized by the continuous nature of the surface area of the resistance element to be contacted. Contact is maintained over a continuous, unbroken path. The resistance is achieved by using material compositions other than wire such as carbon, conductive plastic, metal film and cermet.

1.2.2 RESISTANCE ELEMENT:

A continuous, unbroken length of resistive material without joints, bonds or welds except at the junction of the element and the electrical terminals connected to each end of the element or at an intermediate point such as a center tap.

1.2.3 ADJUSTMENT SHAFT:

The mechanical input member of a trimming potentiometer which when actuated causes the wiper to traverse the resistance element resulting in a change in output voltage or resistance.

1.2.3.1 SINGLE TURN ADJUSTMENT:

Requires 360° or less mechanical input to cause the wiper to traverse the total resistance element.

1.2.3.2 MULTITURN ADJUSTMENT:

Requires more than 360° mechanical adjustment to cause the wiper to traverse the total resistance element.

1.2.4 TERMINAL:

An external member that provides electrical access to the resistance element and wiper.

1.2.4.1 LEADWIRE TYPE: (L)

Flexible insulated conductor.

1.2.4.2 PRINTED CIRCUIT TERMINAL:(P, W&X)

Rigid uninsulated electrical conductor so arranged, suitable for printed circuit board plug-in.

1.2.4.3 SOLDER LUG TERMINAL: (S)

Rigid uninsulated electrical conductor so arranged, suitable for external lead attachment.

1.2.5 WIPER: (SL)

The wiper is the member in contact with the resistive element that allows the output to be varied with the mechanical member adjustment.

1.2.6 STOP-CLUTCH: (SC)

A device which allows the wiper to idle at the ends of the resistive element without damage as the adjustment shaft continues to be actuated in the same direction.

1.2.7 STOP-SOLID: (SS)
A positive limit to mechanical and/or electrical adjustment.

1.2.8 STACKING:
The mounting of one trimming potentiometer adjacent to or on top of another utilizing the same mounting hardware.

1.2.9 THEORETICAL RESOLUTION:
(Wirewound only) The theoretical measurement of sensitivity to which the output ratio may be adjusted and is the reciprocal of the number of turns of wire in resistance winding expressed as a percentage.

N = Total number of resistance wire turns.

1/N X 100 = Theoretical resolution percent.

2 INPUT AND OUTPUT TERMS

2.1 INPUT TERMS

2.1.1 TOTAL APPLIED VOLTAGE: (e)
The total voltage applied between the designated input terminals.

2.2 OUTPUT TERMS

2.2.1 OUTPUT VOLTAGE: (e)
The voltage between the wiper terminal and the designated reference point. Unless otherwise specified, the designated reference point is the CCW terminal (See 3.1).

2.2.2 OUTPUT RATIO (OUTPUT VOLTAGE RATIO): (e/E)
The ratio of the output voltage to the designated input reference voltage. Unless otherwise specified, the reference voltage is the total applied voltage.

2.3 LOAD TERMS

2.3.1 LOAD RESISTANCE: (R_L)
An external resistance as seen by the Output Voltage (connected between the wiper terminal and the designated reference point).

3 ROTATION AND TRANSLATION

3.1 DIRECTION OF TRAVEL:
Clockwise (CW) or counterclockwise (CCW) rotation when viewing the adjustment shaft end of the potentiometer. The designation of terminals in the figure corresponds to the direction of wiper travel.

3.2 MECHANICAL TRAVEL

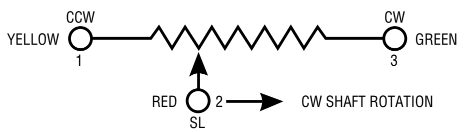


Figure 3.1 Circuit and Travel Diagram

3.2.1 MECHANICAL TRAVEL - SOLID STOPS: (SS)
The total travel of the adjustment shaft between integral stops. Continuity must be maintained throughout the travel.

3.2.2 MECHANICAL TRAVEL - CLUTCHING ACTION: (SC)
The total travel of the adjustment shaft between the points where clutch actuation begins. Continuity must be maintained throughout the travel and during clutch actuation.

3.2.3 MECHANICAL TRAVEL - CONTINUOUS ROTATION: (C)
The total travel of the adjustment shaft when the wiper movement is unrestricted at either end of the resistive element as the adjustment shaft continues to be actuated.

3.3 ADJUSTMENT TRAVEL (ELECTRICAL):

The total travel of the adjustment shaft between minimum and maximum output voltages.

3.4 CONTINUITY TRAVEL:

The total travel of the shaft over which electrical continuity is maintained between the wiper and the resistance element.

4 GENERAL ELECTRICAL CHARACTERISTICS

4.1 TOTAL RESISTANCE: (R_t)

The dc resistance between the input terminals with the wiper positioned to either end stop, or in dead band for continuous rotation potentiometers.

4.2 ABSOLUTE MINIMUM RESISTANCE: (R_m)

The resistance measured between the wiper terminal and each end terminal with the wiper positioned to give a minimum value.

4.3 END RESISTANCE: (R_e)

The resistance measured between the wiper terminal and an end terminal when the wiper is positioned at the corresponding end of mechanical travel. Absolute minimum resistance and end resistance are synonymous for continuous rotation trimmers.

4.4 TEMPERATURE COEFFICIENT OF RESISTANCE: (TC)

The unit change in resistance per degree celsius change from a reference temperature, expressed in parts per million per degree celsius as follows:

$$TC = \frac{R_2 - R_1}{R_1(T_2 - T_1)} \times 10^6$$

Where:

R_1 = Resistance at reference temperature in ohms

R_2 = Resistance at test temperature in ohms

T_1 = Reference temperature in degrees celsius

T_2 = Test temperature in degrees celsius

4.5 RESISTANCE-TEMPERATURE CHARACTERISTIC: (RTC)

The difference between the total resistance values measured at a reference temperature of 25°C and the specified test temperature expressed as a percent of

$$RTC = \frac{R_2 - R_1}{R_1} \times 100$$

the Total Resistance.

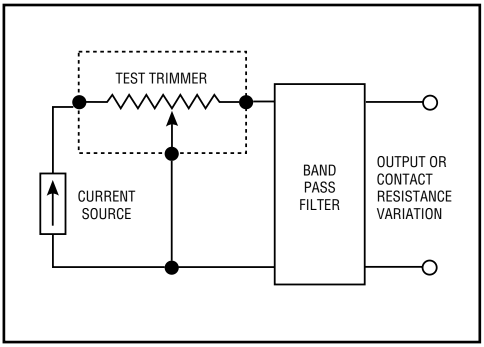
Where:

R_1 = Resistance at reference temperature (25°C) in ohms

R_2 = Resistance at the test temperature in ohms

4.6 CONTACT RESISTANCE VARIATION: (CRV)

The apparent resistance seen between the wiper and the resistance element when the wiper is energized with a specified current and moved over the adjustment travel in either direction at a constant speed. The output variations are measured over a specified frequency bandwidth, exclusive of the effects due to roll-on or roll-off of the terminations and is expressed in ohms or % of Rt.



4.7 EQUIVALENT NOISE RESISTANCE: (ENR)
(Wirewound only) Any spurious variation in the electrical output not present in the input, defined quantitatively in terms of an equivalent parasitic, transient resistance in ohms, appearing between the contact and the resistive element when the shaft is rotated or translated. The Equivalent Noise Resistance is defined independently of the resolution, functional characteristics and the total travel. The magnitude of the Equivalent Noise Resistance is the maximum departure from a specific reference line. The wiper of the potentiometer is required to be excited by a specific current and moved at a specific speed.

4.8 CONTINUITY:
Continuity is the maintenance of continuous electrical contact between the wiper and both end terminals of the resistive element.

4.9 SETTING STABILITY:
The amount of change in the output voltage, without readjustment, expressed as a percentage of the total applied voltage.

4.10 DIELECTRIC STRENGTH:
The ability to withstand the application of a specified potential of a given characteristic, between the terminals and all other external conducting member such as shaft, housing and mounting hardware without exceeding a specified leakage current value.

4.11 INSULATION RESISTANCE:
The resistance to a specified dc voltage impressed between the terminals and all other external conducting members such as shaft, housing and mounting hardware.

4.12 POWER RATING:
The maximum power that a trimming potentiometer can dissipate across the total resistive element under specified conditions while meeting specified performance requirements.

4.13 LIFE

4.13.1 ROTATIONAL LIFE:
The number of cycles obtainable under specific operating conditions while remaining within specified allowable degradation. A cycle is defined as one complete traversal of the wiper over the resistive element in both directions.

4.13.2 LOAD LIFE:
The number of hours at which a device may dissipate rated power under specified operating conditions while remaining within specified allowable degradations.

4.14 ADJUSTABILITY:
Defines the precision with which the output of a device can be set to the desired value.

4.14.1 ADJUSTABILITY (OUTPUT RESISTANCE):
The precision with which the output resistance of a device can be set to the desired value.

4.14.2 ADJUSTABILITY (OUTPUT VOLTAGE RATIO):
The precision with which the output voltage ratio of a device can be set to the desired value.

5 GENERAL MECHANICAL CHARACTERISTICS

5.1 TORQUE

5.1.1 STARTING (OPERATING) TORQUE:
The maximum moment in the clockwise and counterclockwise directions required to initiate shaft adjustment anywhere in the mechanical travel.

5.1.2 STOP TORQUE:
The maximum static moment that can be applied to adjustment shaft at each mechanical stop for a specified period of time without loss of continuity or mechanical damage affecting operational characteristics.

5.2 SOLDERABILITY:
The ability of the terminals to accept a uniform coating of solder under specified conditions.

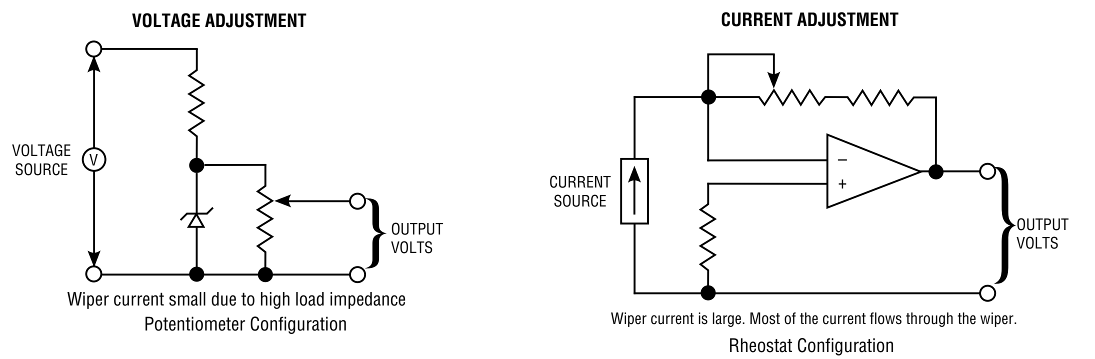
5.3 WELDABILITY:
The ability of materials to be welded together under specified conditions.

5.4 TERMINAL STRENGTH:
The ability of the terminals to withstand specified mechanical stresses without sustaining damage that would affect utility of the terminals or operation of the trimming potentiometer.

5.5 IMMERSION SEALED:
The ability of the unit to withstand submersion in acceptable cleaning solutions used in normal soldering processes without performance degradation under specific environmental conditions.

APPLICATION BASICS

A trimmer is generally used in an electrical or electronic circuit for the purpose of providing minor adjustments or calibrations. This implies that the trimmer is not used in the regular operation of the circuit, but would be required to make initial and periodic adjustments to compensate for circuit variables. This implies that the trimmer must be able to remain at its setting for long periods of time without variation in setting or contact resistance.



A trimmer can be used as potentiometer or rheostat. A potentiometer is a three terminal device typically used to vary voltage. In potentiometric configurations, the wiper terminal is lightly loaded so that wiper current is generally small.

A rheostat is a two terminal device typically used to control current. Wiper current is generally larger in rheostat circuits.

I. Types of Applications

The majority of applications for trimmers occur in electronic circuits.

Typical uses are in the following devices:

A. Amplifiers
B. Timing circuits
C. Voltage and current regulators
D. Voltage and frequency converters

II. Selection Criteria

The initial considerations for trimmer type selection are:

A. Resolution of adjustment
B. Setability and time to set
C. Physical and environmental conditions
D. Stability of setting required
E. Circuit packaging requirements

A. Resolution of Adjustment

1. Multiturns

- Multiturns provide better resolution than single turns. Models with a longer element exhibit better resolution than those with a short element. Typical multiturn shaft revolutions range from 15 to 20 turns for end to end travel.
- The contact design and stability are important considerations in achieving high resolution. The contact area must be small and the contact must move smoothly in order to provide high resolution. A noisy contact will make accurate setting very difficult.
- All BI trimmers utilize smooth cermet materials, precious metal wire brush contacts and backlash-free wiper designs that ensure high resolution setability.
- Reference BI multiturn models:
  Square multiturns - 44, 64, 66, 67, 68
  Rectangular multiturns 78, 89

2. Single Turns

- Single turn resolution for models with a longer cermet element (larger diameter) is quite respectable. This is especially true with BI wire brush contacts and smooth cermet films.
- Reference BI single turn models:
  Small diameter - 24, 25, 62, 82
  Larger diameter - 72, 91, 93

3. Surface Mount Models

- Single turn - 21, 23, 83
- Multiturn - 44, 84

Call for application assistance if high resolution is critical in your application.

B. Setability and Time to Set

The enemies of setability are poor resolution, mechanical backlash and high CRV. BI has addressed these problems in the design of trimmer models. BI's smooth cermet materials, precious metal split brush contacts and teflon rotors work together to provide outstanding setability.

"Time to set" tests show the following:

Setting Attributes	Single Turn	Multiturn
High accuracy		Best
Fastest to high accuracy		Best
Fastest to approximate setting	Best	

C. Physical and Environmental Issues

1. Physical considerations in trimmer selection

- Case style desired
- Top or side adjust
- Pin style required
- Mechanical support required
- Board height requirements

2. Assembly process considerations
   BI offers a variety of trimmer models that are sealed to help protect against moisture and board washing processes.
   - Open vs. Sealed
   - Max time/temperature exposure
3. Environmental operating considerations
   - Operating temperature range
   - Resistance temperature coefficient
   - Vibration and shock tolerance
4. Human operating conditions
   When you complete your design, be careful to consider the tortures that clever human beings with a screwdriver in hand can impose on trimmers. For example, while a trimmer configuration mounted on edge might be a board space saver, a trimmer that mounts flat on the board may be more resistant to abuse by a heavy handed technician making adjustments through a hole in the chassis.

If you have questions about your options, call BI application engineers. We will help.

D. Stability of Setting

It is highly desirable that once the trimmer has been set, it should remain at that setting independent of time, operating temperature changes, vibration, shock and humidity. This property of stability is largely a factor of the compatibility of the materials at the moving contact interface and the thermal matching of the elements of the trimmer structure.

BI uses noble metals in both the wire brush contact and the cermet element. These materials are relatively soft, highly compatible and provide an excellent, low resistance, non-corroding interface. The contact drive structure and materials are chosen for their stability and compatibility. The high contact forces utilized at the brush/element interface reduce susceptibility to shock and vibration. The circuit designer can contribute significantly to short term operating and long term stability by mounting the trimmer away from high thermal gradients, hot spots and sources of excessive vibration.

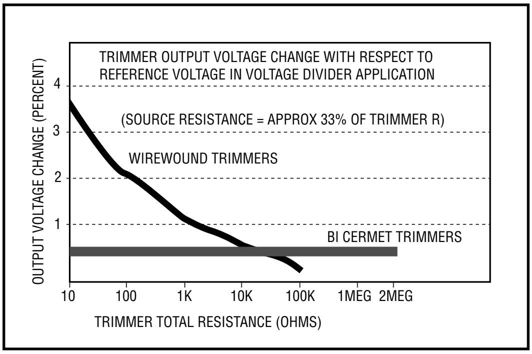
E. Circuit Packaging

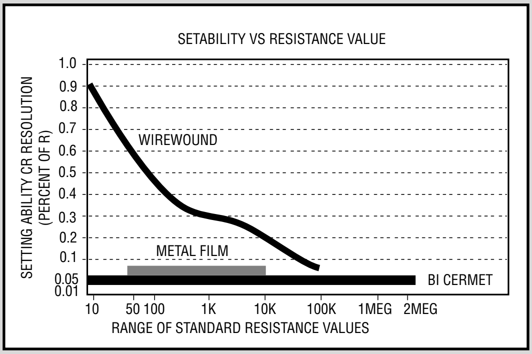
BI manufactures trimmers in a variety of package styles and sizes. The chances are excellent that stock models are locally available that will fit your requirements. Models include both pin style and surface mount single and multiturn configurations. Special electrical and mechanical features are available for specific customer applications. Call your local representative or the factory direct for information on special packaging.

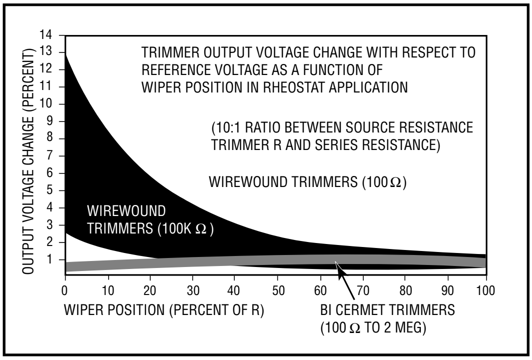
CHARACTERISTICS	WIREWOUND	NON WIREWOUND TRIMMERS			
		Cermet	Hot-Mold Carbon	Carbon Film	Thin-Metal Film
Setting Ability	Poor to Good	Excellent	Excellent	Excellent	Excellent
Resistance Range	Low to Medium	Low thru High	Medium to High	Medium to High	Low to Medium
Power Rating	Medium	High	Low	Low	Medium
Temp Coefficient	Lowest	Low to Med	High	High	Low
Environmental Stability					
High Temperature	Good to Exc.	Excellent	Poor	Fair	Excellent
Load Life	Good to Exc.	Excellent	Fair	Fair	Excellent
Humidity	Good to Exc.	Excellent	Poor	Poor	Excellent
Rotational Life	Good	Excellent	Good	Good	Fair
Rheostat Usage	Good	Fair to Good	Poor	Poor	Fair
AC Usage	Fair	Excellent	Excellent	Excellent	Excellent

DESIGN CONSIDERATIONS AND THE CERMET ADVANTAGE

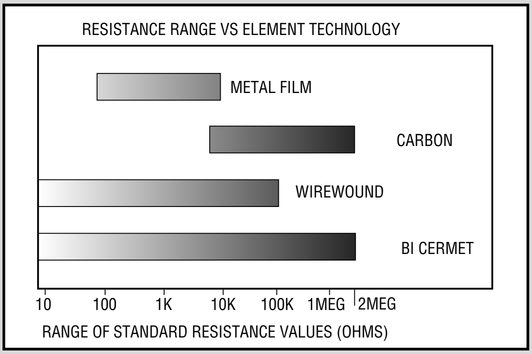
1. **Essentially infinite resolution.** Proprietary cermet BI film materials and wire brush technology produce a cermet trimmer that provides essentially infinite resolution. Wirewound trimmers are limited in resolution because each wire turn appears as a definite "step" during adjustment. As a result, a wirewound's best setting ability is in the order of 0.17%, and this is possible only at resistance values of 50K and 100K ohms where very fine fragile wire is used. The cermet element provides a setting ability as precise as ±0.01%.



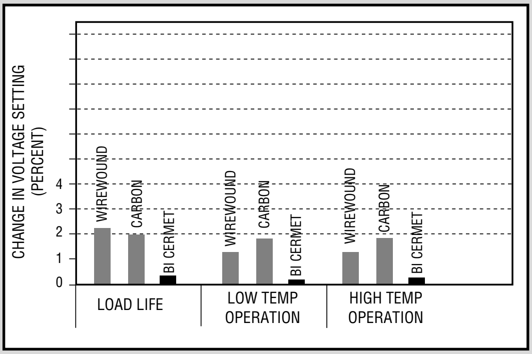


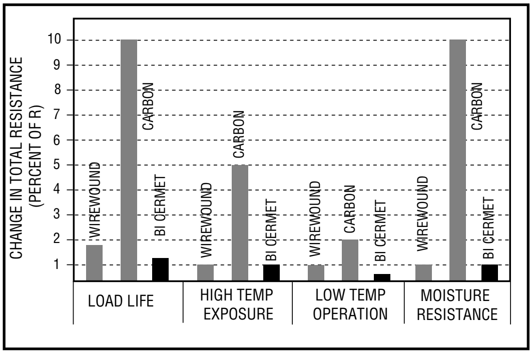


2. Wide resistance range. BI cermet trimmer technology covers applications from 10 ohms thru 2 megohms. This can simplify and reduce design, testing and stocking costs.



3. Environmental stability. It is important in most applications that both the total resistance and voltage setting remain relatively unchanged during temperature extremes, long-term load life, humidity cycling, shock and vibration. BI cermet trimming potentiometers show superior resistance stability and excellent voltage setting stability. Certified test reports covering the resistance range of 100 ohms to 500K show that the average change in total resistance after 1,000 hour load life tests is 0.3% with a maximum observed change of 1.25%.

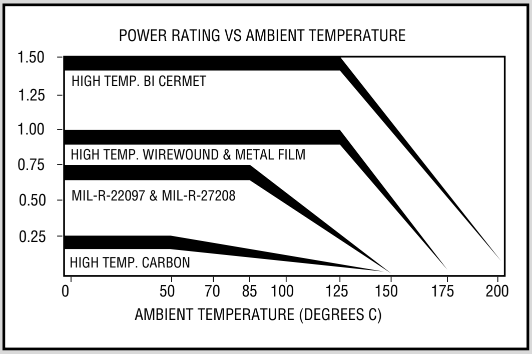




4. Lower costs. Cermet potentiometers not only perform well, but typically cost less. BI cermet trimmers, for example, are generally priced lower than wirewound and metal film competitors. Cermet prices are also generally uniform across the resistance range, whereas other trimmer prices may vary as much as 100 percent, depending upon the resistance value desired.

5. Longer, trouble-free life. The useful operational life of a cermet trimmer far exceeds that of wirewounds, metal film and carbon units. The cermet element has substantial thickness, and its hard surface is resistant to abrasion. Moisture has little or no effect upon the tough cermet element. Unlike wirewounds, the cermet element is fired at high temperature and is free from sudden mechanical failure.

6. Power rating and high temperature. In applications requiring high power and reliable operation at extremely high temperatures, cermet is superior to wirewound technology. Wattage ratings on cermet pots are consistently higher than comparable wirewounds, and the cermet units can withstand power surges several times their rated wattage. Wirewounds and thin metal film potentiometers are extremely susceptible to failure when operated at temperatures or power levels above their ratings. Power overloads can burn out wire, whereas cermet units operate satisfactorily above rated power limits for



substantial periods of time.

7. A.C. performance. Cermet potentiometers perform at frequencies up to 200 megahertz with minimal phase shift. In wirewounds, there is high phase shift in frequencies over 400 Hz, due to capacitance from resistance wire to the core and inductive effects of the coil.

8. Reliability. In BI's reliability and quality control program, every step and process during manufacture is closely controlled to assure conformance to stringent BI standards. These standards are designed to assure maximum reliability in the product's end use.

9. Tempco. The temperature performance of a trimmer is based upon more than the tempco of the resistance element. In evaluating comparable wirewound and cermet trimmers, the effect of tempco is found to be considerably less in cermet when other effects such as resolution and setting stability are included. To consider wire tempco alone is like measuring an automobile's performance strictly on the basis of the engine's horsepower rating. In circuit applications, there is more to consider, since the amount of voltage or resistance shift is the product of resolution and wiper stability as well as tempco. In practical applications, cermet stability is superior to wirewounds. If you add in environmental effects of vibration and shock, cermet wins by an even wider margin. The charts illustrate cermet vs wirewound stability in both voltage divider and rheostat applications.

SOME THOUGHTS FOR THE CIRCUIT DESIGNER

Rotation Conventions

In general, it is preferable to connect the trimmer so that clockwise rotation:

1. Increases the attribute quantity
2. Moves the position "up"
3. Moves the position "right"

There are exceptions. The important thought is to make the adjustment as intuitive as possible.

Maximum Ratings

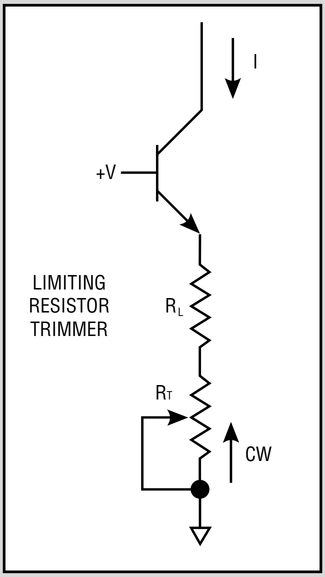
Pay attention to maximum voltage, current and power ratings in both normal and non-operating conditions. Non-operating conditions, such as warm up, device failure and misadjustment, may be easily overlooked in the product design and testing cycles. Take appropriate steps to establish adjustment limits through hardware.

Linear Circuit Applications

A. Establishing Limits

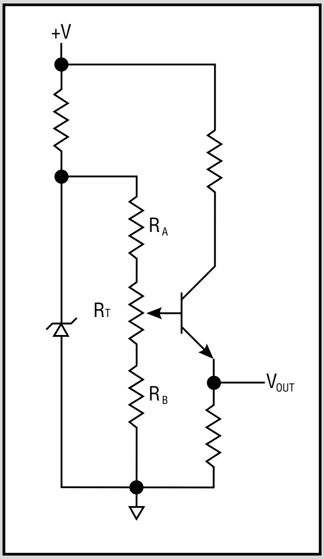
When a trimmer is properly utilized in a circuit, the maximum rotation end to end will provide the adjustment range required but will not operate inappropriate or unsafe circuit conditions.

The rheostat R_T in the circuit shown below will become a short circuit when rotated fully counterclockwise. Limiting resistor R_L is required to limit both trimmer and transistor



currents to safe levels.

The potentiometer in the circuit shown below adjusts the output voltage over a specific range as



Define adjustment limits carefully and establish them with appropriate circuitry.

B. Dealing With Amplifier Offset Voltage

Amplifier voltage offset adjustments represent a high percentage of trimmer applications.

Offset voltages can occur due to the following:

1. Amplifier internal imbalances
2. Amplifier supply voltage imbalances
3. Unbalanced input circuitry
4. Externally-caused thermal EMFs generated on the circuit card

All of the above can change with time, ambient temperature and varying input circuit conditions.

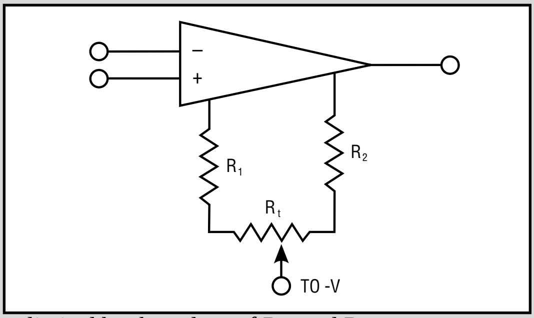
There are two general types of voltage offset solutions:

1. Take steps to avoid thermally generated offset problems by minimizing board hot spots and by locating sensitive circuits away from thermal gradients.

   Balance voltages and impedances where possible.

2. Provide a means of zeroing the offset voltages. Two methods are shown below:

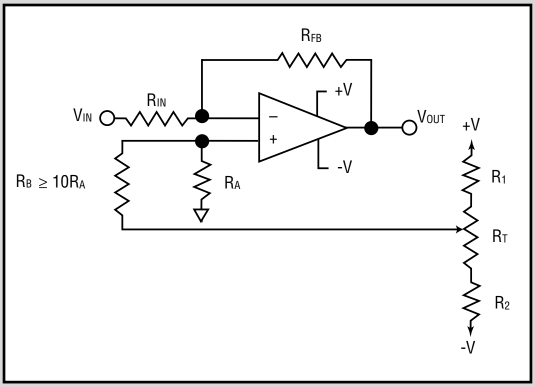
   a. For amplifiers with offset trim terminals, the circuit in figure 1 can provide compensation that can be appropriately scaled by the size of R_1 and R_2. This method becomes inappropriate when the trimmer wiper current becomes small enough to risk dry circuit conditions.



limited by the values of R_A and R_B.

FIGURE 1.

b. When the circuit in Figure 1 becomes inappropriate, the circuit shown in Figure 2 can be used. Scale R_1, R_2, R_T, R_A, and R_B as required. This circuit can also be adapted for use in a potentiometric amplifier circuit



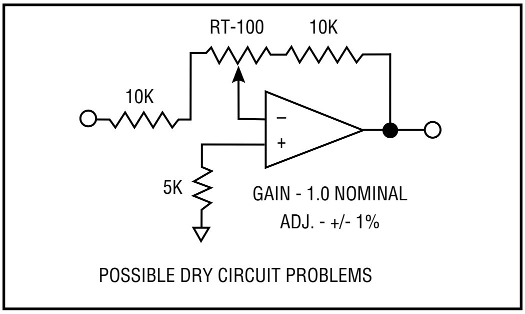
configuration if required.

FIGURE 2.

C. Correctly Using the Trimmer to Avoid Dry Circuit Risk

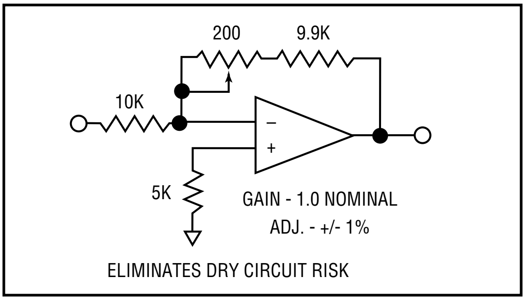
The end connections to BI cermet elements are made with a swaging process so that the resistance of the end connections remains small and constant for the life of the device. The connection between the moving contact and the element surface, however, is not gas tight and requires special consideration.

BI's precious metal brush contact provides a surface-conforming, non-oxidizing, high force connection that is highly superior to trimmers using non-precious metal wipers and films. In a few circuit applications such as the op amp gain control circuit below, the current through the wiper would be very low (nano or pico amps). This is not enough current to absolutely ensure a low resistance contact in the absence of



contact motion.

The circuit designer would be wise to consider an alternate circuit configuration to avoid the dry circuit problems that might arise. This is especially important in circuits that are adjusted and then forgotten for long periods. In the example shown below, the amplifier current will flow through the wiper contact to minimize the possibility of a high resistance connection. This circuit is also superior to the one above in that an open wiper will only cause a small shift in gain versus amplifier



lockup in the circuit above.

D. Digital Circuits Also Need Trimmers

The same general analog circuit considerations apply to digital circuits, although you may not have to worry as much about dry circuit conditions in digital applications.

1. Think about rotation conventions
2. Pay attention to maximum ratings
3. Limit unnecessary adjustment range with additional resistors
4. Tie the unused end of the trimmer to the wiper in rheostat configurations

Digital circuits such as oscillators and timers frequently require very precise adjustment and long term stability. In these cases, wisdom suggests that the selection of the trimmer range be limited to just the tolerance compensation required and that a multiturn trimmer be used to achieve the best resolution and stability possible.

E. Surviving the Circuit Board Manufacturing Process

The printed circuit board assembly and cleaning processes are likely to subject your trimmers to the most severe ambient conditions that the trimmer will see in its lifetime. For example:

Parameter	Typical	Some Processes
Positive Temperature Shock (°C)	70	125
Negative Temperature Shock (°C)	25	70
Max Temperature (°C)	150	180
Time above 125°C (sec.)	20	75
Number of Temperature Cycles	5	10-12

Choose an appropriately designed trimmer for your board processes. Then take the steps that you can to minimize damage to your trimmers and other components.

1. Orient shaft or rotor seal away from the high pressure water stream.
2. Preheat stuffed boards to the max allowable temperature.
3. Heat the top and bottom of the board.
4. Reduce the time in the solder.
5. Lengthen the time between solder and wash cycles.
6. Cool the boards prior to entering the wash cycle.
7. Minimize the temperature difference between wash and rinse cycles.
8. Use heated air for air knives.

Further application assistance is always available by contacting your local representative, a factory office, or BI's product application group.