Potentiometers and Trimmers

These application notes are valid unless otherwise specified in the datasheets.

1. GENERAL DEFINITIONS

1.1 - Potentiometer

A potentiometer is a mechanically actuated variable resistor with three terminals. Two of the terminals are linked to the ends of the resistive element and the third is connected to a mobile contact moving over the resistive track. The output voltage becomes a function of the position of this contact. Potentiometer is advised to be used as a voltage divider.

1.2 - Trimming potentiometer (trimmer)

A potentiometer designed for relatively infrequent adjustments.

1.3 - Multi-ganged potentiometer

A potentiometer with two or more sections, each electrically independent, operated by a common spindle.

1.4 - Multi-turn potentiometer

A potentiometer with a shaft rotation of more than 360° from one end of the resistive element to the other. Multi-turn types are usually trimming or precision potentiometers.

1.5 - Sealed potentiometers

Two levels of sealing are usually recognized. The less severe one provides protection only against dust and cleaning processes (solvent splashes and vapors). For definition of sealing, see table IP codes definition Sfernice Application Note: www.vishay.com/doc?52029. Hermetic sealing is more rigorous and protects the product against environmental pressure. (Not applicable for trimmers and potentiometers)

1.6 - Panel seal

This is used to seal the cut-out hole through which the potentiometer is mounted.

1.7 - Spindle seal

One or more O-rings are used to seal the spindle/case joint.

2. MECHANICAL DEFINITIONS

2.1 - Mechanical travel

The full extent of travel between the end stops of the spindle (fig. 1). In potentiometers fitted with a slipping clutch, the position of the end stops is defined as those points where the clutch starts to slip at each end of the travel of the moving contact.

2.2 - Effective electrical travel

The angle of rotation of the spindle throughout which the resistance changes in the manner prescribed by the specified resistance law. (Fig. 1)

Caution: For trimmers, the recommended working area for customer applicataion is between 50 % and 90 % of the electrical travel.

2.3 - End stop torque

The maximum torque that may be applied to the spindle when set against either end stop without causing any damage.

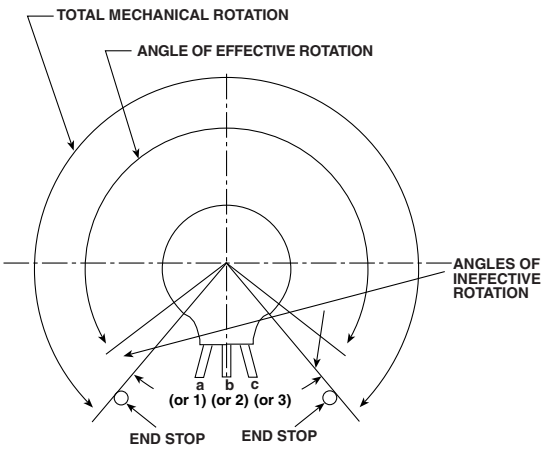


Fig. 1

2.4 - Operating torque

The necessary torque to move the contact in either direction from a random position away from end stops.

2.5 - Locking torque

The torque that may be applied to the shaft of a potentiometer fitted with a locking device without causing shaft rotation.

2.6 - Rotational life

The minimum number of cycles of operations obtainable under specified operating conditions while product remains

functional. A cycle is defined as the travel of the moving contact on the resistance element, and back on 90 % of the effective electrical travel.

2.7 - Direction of rotation

Rotation is defined as clockwise or counter-clockwise when viewing the surface of the potentiometer which includes the means of actuation.

2.8 - Adjustment shaft

The mechanical input member of a potentiometer which, when rotated, causes the wiper to travel the resistance element resulting in a change in output voltage or resistance.

2.8.2 - Single-turn Adjustment

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

2.8.2 - Multi-turn Adjustment

Requires more than 360° mechanical input to cause the wiper to travel the total resistance element.

2.9 - Terminal

An external contact that provides electrical connection to the resistance element and wiper.

2.9.1 -Printed Circuit Terminal

Rigid non-insulated electrical conductor suitable for printed circuit board

2.9.2 -Solder Lug Terminal

Rigid non-insulated electrical conductor suitable for external lead attachment

2.9.3 -Leadwire Type

Flexible insulated conductor

2.10 - Stop clutch on multiterm trimmers

A device that allows the wiper to idle at the ends of the resistance element while the adjustment shaft continues to be actuated in the same direction. We recommend to not exceed 10 screw turns at clutch position to not damage internal mechanism.

2.11 - Stop

A positive limit to mechanical and electrical adjustment.

3. INPUT AND OUTPUT TERMS

3.1 Input terms

3.1.1 -Total Applied Voltage

(V_e) The total voltage applied between the designated input terminals.

Note

When plus (+) and minus (-) voltages are applied to the potentiometer, the total applied voltage (commonly called peak-to-peak applied voltage) is equal to the sum of the two voltages. Each individual voltage is referred to as zero-to-peak applied voltage.

3.2 - Output terms

3.2.1 - Output Voltage

(Vs) The voltage between the wiper terminal and the designated reference points. Unless otherwise specified, the designated reference point is the counter-clockwise (CCW) terminal.

3.2.2 - Output Voltage Adjustment Ratio

(V_s/V_e) The ratio of the output voltage to the designated input reference voltage. Unless otherwise specified the reference voltage is the total applied voltage.

3.2.3 - Output Resistance

The resistance measured between the wiper terminal and the designated reference point. Unless otherwise specified, the designated reference point is the CCW terminal.

3.3 - Load terms

3.3.1 - Load Resistance

The external resistance as seen by the output voltage (connected between the wiper terminal and the designated reference point).

Note

No load means an infinite load resistance.
In case of unspecified conditions of use or test, this load resistance shall be at least 100 times higher than the total potentiometer nominal resistance value.

4. ELECTRICAL DEFINITIONS

4.1 - Power rating

The maximum power that can be dissipated across the total resistance element, i.e., between terminals a (or 1) and c (or 3), at the specified ambient temperature. In practice this dissipation is modified by the following conditions:

4.1.1 - For ambient temperatures higher than that specified, reference should be made to the derating curve.

4.1.2 - For high values of resistance, the limiting element voltage may prevent the maximum power rating from being obtained.

4.1.3 - For situations when the power is dissipated in only part of the resistance element, the maximum current capacity of the element will prohibit maximum total power dissipation.

4.2 - Resistance taper

The relationship between the mechanical position of the moving contact and the resistance value across terminals a and b. (This may also be expressed as the relationship between the position of the moving contact and the ratio V_s/V_e). Typical available taper are indicated in figure 2.

Potentiometers and Trimmers

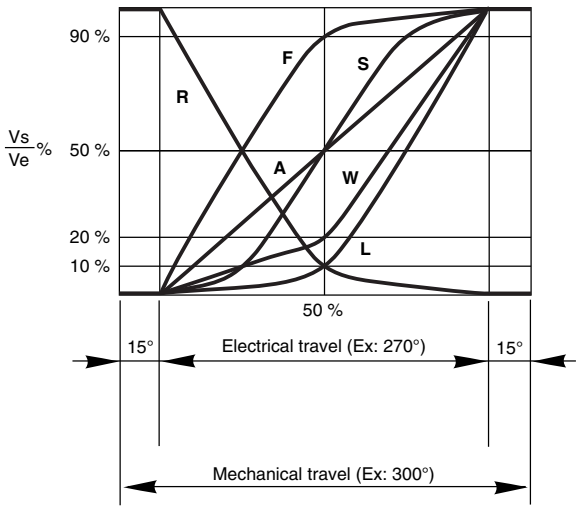


Fig. 2

CODE	TYPE	DEFINITION
A	Linear taper	
L	Clockwise logarithmic (audio taper)	50 % of electrical travel, Vs/Ve = 10 % ± 3 %
F	Inverse, clockwise logarithmic	50 % of electrical travel, Vs/Ve = 90 % ± 3 %
R	Counter-clockwise logarithmic	50 % of electrical travel, Vs/Ve = 10 % ± 3 %
W	Clockwise logarithmic	50 % of electrical travel, Vs/Ve = 20 % ± 3 %
S	S taper	25 % of electrical travel, Vs/Ve = 10 % 75 % of electrical travel, Vs/Ve = 90 %

4.3 - Conformity

This is a measure of the maximum deviation of the actual to the correspondant theoretical voltage expressed as percent of the total applied voltage.

4.4 - Linearity (see fig. 3)

Specific type of conformity when the specified law or output ratio is shown as a straight line

Output ratio $\frac{V_s}{V_e}$

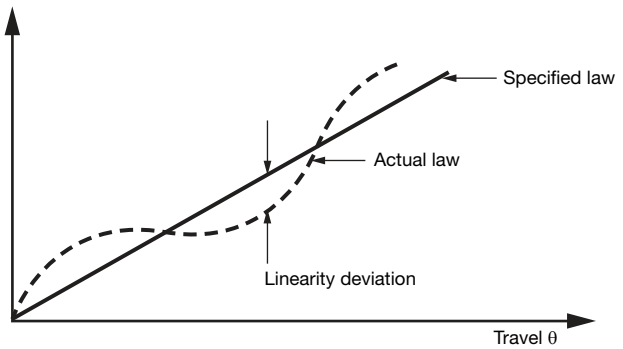


Fig. 3 - Linearity

4.5 - Independent linearity (best straight line) (see fig. 4)

Specific type of conformity when the maximum vertical deviation, expressed as a percentage of the total applied voltage, of the actual law from a straight reference line with its slope and position is chosen to minimize deviations over the effective electrical travel or any specified portion thereof.

Note

- Requirements for minimum and maximum outout ratio, when specified, will limit the slope and position of the reference line

Mathematically:

$$\frac{V_s}{V_e} = P\left(\frac{\theta}{\theta_A}\right) + Q \pm C$$

where

P is the unspecified slope

Q is the unspecified intercept at $\theta = 0$

P and Q are chosen to minimize C but are limited by the output ratio requirement

θ_A is the amount of effective electriacl travel

Output ratio $\frac{V_s}{V_e}$

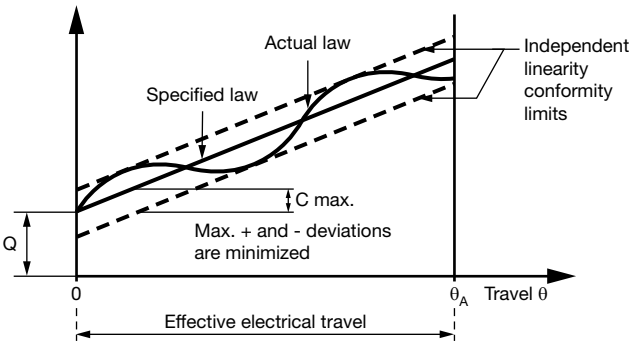


Fig. 4

4.6 - Total resistance

The resistance value of the resistive element measured between connections a and c or 1 and 3 in conditions defined by CECC 41000:
Temperature: + 20 °C ± 1 °C
Relative humidity: 65 % ± 2 %
This value has to be included between limits of resistance nominal value according to tolerance.

4.6.1 - Minimum Effective Resistance

The resistance value at each end of the effective rotation between termination b (or 2) and the nearest end termination, a or c (1 or 3).

4.7 - Effective resistance

The portion of the total resistance over which the resistance changes in accordance with the declared resistance law. It is the total resistance minus the sum of the two minimum effective resistance values.

APPLICATION NOTE

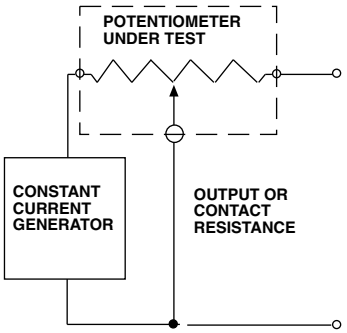
Potentiometers and Trimmers

4.8 - End resistance

The resistance measured between termination a or c and termination b when the moving contact is positioned at the corresponding end of mechanical travel.

4.9 - Contact resistance

The resistance appearing between the contact and the resistive element when the shaft is rotated or translated. The wiper of the potentiometer is excited by a specific current and moved at a specified speed over 10 % to 90 % of the effective electrical travel.



4.10 - Continuity

Continuity is the maintenance of continuous electrical contact between the wiper and the resistive element over the total mechanical travel in both directions.

4.11 - Setting stability

For a fixed setting of the adjustment shaft, the amount of change in the output voltage due to the effects of an environmental condition, (expressed as a percentage of the total applied voltage).

4.12 - Setting ability

A measure of the ability for the user to adjust the wiper to any particular voltage ratio or resistance output.

4.13 - Resolution

This term is used in the description of wirewound potentiometers and is a measure of the sensitivity to which the output ratio of the potentiometer may be set. The theoretical resolution is the reciprocal of the number of turns of the resistance winding in the actual electrical travel multiplied by 100 i.e., (expressed as a percentage).

4.14 - Limiting element voltage

The maximum voltage that may be applied across the element of a potentiometer, provided that the power rating is not exceeded.

4.15 - Insulation voltage

The maximum voltage which may be applied under continuous operating conditions between any potentiometer termination and other external conductive parts connected together. The insulation voltage is not less than 1.4 times the limiting element voltage.

4.16 - Dielectric strength (voltage proof)

The maximum voltage which may be applied under 1 ATM pressure for 60 s between any potentiometer termination and any external conductive part without breakdown occuring. Dielectric strength is not less than 1.4 times the insulation voltage.

4.17 - Insulation resistance

The resistance measured between the terminals and other external conductive parts (e.g., shaft, housing, or mounting), when a specified D.C. voltage is applied.

4.18 - Temperature coefficient of resistance (TCR)

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

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

Where :

R_1 = Resistance in ohms, at reference temperature
R_2 = Resistance in ohms, at test temperature
T_1 = Reference temperature in °C
T_2 = Test temperature in °C

4.19 - Hysteresis

Average of the voltage deviation between clockwise and counter clockwise for specified travel increments over the theoretical electrical travel, expressed as a percentage of the total applied voltage.

5. PANEL MOUNTING RECOMMENDATIONS

5.1 - Tightening torque on mounting nut

Tightening torque shall remain within the limits described on product datasheets.

Caution:

Exceeding advised maximum tightening torque will affect announced operating torque and rotational life causing severe shaft to bushing sizing.

5.2 - Mounting of panel sealing ring

Careful attention must be paid on cleanness when mounting panel sealing ring

Caution:

Any pollution like sand grain, dust or metal shaving particle on the sealing ring will affect panel sealing effectiveness along the time.

5.2 - Radial and axial shaft efforts

Axial efforts on shaft shall remain below 10 N. No radial efforts on shaft.

Caution:

Exceeding authorized values defined here before will affect announced operating torque and rotational life performances.

Potentiometers and Trimmers

6. ENVIRONMENTAL DEFINITIONS

6.1 - Climatic category

The climatic category is defined in terms of the temperature extremes (hot and cold) and number of days exposure to dampness, heat, and steady-state conditions that the component is designed to withstand.

The category is indicated by a series of three sets of digits, separated by oblique strokes, as follows:

- First set: Two digits denoting the minimum ambient temperature of operation (cold test).
- Second set: Three digits denoting the upper category temperature.
- Third set: Two digits denoting the number of days used for the “dampness, heat, and steady-state” test.
  Example: 55/100/56
  Cold: - 55 °C
  Upper category temperature: + 100 °C
  (maximum allowable temperature: + 125 °C)
  Damp heat: 56 days.

6.2 - Classify materials

Plastic materials used are UL 94 class V-O and/or our products are compliant with the flammability test of STD UL746C § 17 and 52.