SENSOR
SYSTEMS, L.L.C.

Your Trusted Partner for Customer Precision Solutions

STANDARD AND CUSTOM POTENTIOMETER TUTORIAL

Sensor Systems LLC Division, located in St. Petersburg, Florida, has supplied precision electromechanical components for Industrial, Medical, Military, and Commercial applications for over six decades. This brochure features our capability to provide the system designer precise position, velocity, and direction information with the broadest product line of linear and rotary standard and custom potentiometers in the industry.

Sensor Systems LLC products are designed to operate in the hostile environments of Land, Sea, Air and Space. Our manufacturing and quality systems meet the most rigorous requirements of both Defense and Industrial applications. From standard potentiometers to unique custom potentiometers, Sensor Systems LLC has the capabilities and expertise to find a solution for

Experience

The following cross section of application experience illustrates Sensor Systems LLC broad scope of standard and custom designed potentiometer

Medical
• X-Ray positioning
• Strip charts
• Instrumentation
• Fibrillators

Commercial
• Photo developing
• Strip chart recorders
• Lighting controls

Entertainment
• Audio faders
• Motion picture cameras
• Recording equipment

Robotics
• Machine vision
• Touch sensing

Space
• Antenna positioning
• Camera positioning

Heavy Machinery
• Leveling systems
• Engine control

Aircraft (Mil & Commercial)
• Radar antennae
• Flap control
• Inertial navigation

Missiles
• Stabilization
• Fin controls
• Gyro sensing

Tactical Ground Systems
• Turret control systems
• Missile defense systems

Ground Radar Systems
• Search and track radar

Aircraft (Mil & Commercial)
• Radar antennae
• Flap control
• Inertial navigation

Product Scope

Sensor Systems LLC manufactures the most complete line of standard and custom potentiometers in the industry. Both rotary and rectilinear potentiometers are available in conductive plastic and wirewound designs.

Mechanical Design

A wide selection of case and shaft designs make it easy to select a potentiometer to fit your needs. Rear shaft extensions, flats or slots can usually be provided.

Terminations (CP Only)
Silver deposition in terminal and mounting screw pas sages assure extreme reliability under the most difficult Military and Industrial environments.

Multiturn Capability
Unique construction features of the multiturn units have resulted in the shortest lengths for the number of turns available - to 130 turns. (1 turn = 360°)

Functions
A wide range of non-linear functions can be provided using customized elements: square, sine/cosine, secant, tangent, log, empirical, modified audio taper, etc.

Other Special Characteristics
- Brush-to-case insulation breakdown to 1500V
- Doubling or tripling of wattage
- Minimum brush-to-case capacitance
- Multiple outputs from single cup or element
- Integral wing resistors for matched temperature coefficients
- Integral electrical interconnections between gangs

Before You Start

"Selecting a potentiometer to meet your application seems fairly straightforward at first. You know the resistance or voltage profile you want to meet, and the rest is up to the catalog... Then you start to think about your system needs: environment, tolerance buildups, rate and bandwidth. Do you need to trim for slope?"

Sensor Systems LLC's engineering and technical sales team are prepared to help you through the selection process, assuring the most cost effective potentiometer for your requirement. We have an extensive library of standard products to meet your needs, and stand ready to design for any custom requirements you might specify.

If you are not intimately familiar with specifying these components, we invite you to read through the following short tutorial before you tackle the data pages.

MECHANICAL DESIGN ACTIVITY

Although the mechanical variations available in our standard configurations are numerous, **Sensor Systems LLC** supplies custom designs to fill all needs of the system designer. Special mounts, shaft configurations and non- standard sizes are all available. Your special designs can generally be accommodated without sacrifice of the standard characteristics of the **Sensor Systems LLC** potentiometer.

ELEMENT DESIGN

Varied and unique elements can be supplied to mount in systems or on existing components. **Sensor Systems LLC** will supply preferred mounting arrangements, methods of setting contacts, and operational procedures, so that the element will easily be accommodated in your production flow.

Linear as well as Functional potentiometric elements are available. Consult **Sensor Systems LLC** Applications Engineering Staff with your specific requirements.

DIRECTION OF ACTUATION

Rotary Potentiometers

Sensor Systems LLC potentiometers are truly bi-directional with insignificant errors resulting from CCW to CW shaft actuation.

Unless otherwise specified, all shaft directions in rotary potentiometers are considered to be counterclockwise (CCW), when the unit is viewed from the rear end; i.e. clockwise, when viewed from the mounting face. Voltage is increasing from terminal 3, designated (-) to terminal 1, designated (+).

Rectilinear Potentiometers

Unless otherwise specified, the "Full-In" position is the mini- mum voltage potential and the "Full-Out" position the maxi- mum voltage potential.

LIFE

The life of **Sensor Systems LLC** conductive plastic potentiometers in most applications is exceptionally long. This is due to the thin, smooth, continuous conductive film and its application to a substrate having a shape compatible to the form and travel of the precious metal wipers used throughout. The wiper attack angle is matched to the surface to give minimum wear and friction. Since the conductive film has a very low contact resistance component, wiper pressures in excess of 8 gms are not required, further improving life.

In most applications **Sensor Systems LLC** conductive plastic potentiometers will have a useful life of many mil- lions of cycles, from a minimum of 5 x 106 to 100 x 106 full scale cycles in rotary configurations, and from 1 x 106 to 60 x 106 inches in rectilinear configurations.

Common life degradation tolerances are 1.5x initial specifications. **Sensor Systems LLC** potentiometers meet and often surpass these requirements. **Sensor Systems LLC** conductive plastic potentiometers meet and exceed all life requirements of MIL-R-39023.

Sensor Systems LLC wirewound potentiometers meet and exceed all life requirements of MIL-R-12934.

ACTUATION SPEED

As a general rule, the lower the actuation speed the longer the life. Sensor Systems LLC potentiometers are not particularly speed sensitive unless such speeds are high enough to produce wiper bounce, or other similar effects.

The preferred speed of actuation on rotary potentiometers is 100 R.P.M. or less with capabilities to 500 R.P.M. The preferred speed on linear motion potentiometers is 50"/sec. or less with capabilities to 100"/sec.

RESOLUTION

Resolution is defined as the smallest increment of shaft movement which will produce a corresponding charge of output, or the minimum detectable voltage change with shaft movement.

The resolution of **Sensor Systems LLC** conductive film potentiometers is virtually infinite. Mechanical factors such as backlash, stiction, etc., have a much greater effect on discernible resolution than the film surface itself. As little as 5 x 100-6” wiper motion will produce an output voltage change.

In a feedback servo system virtually infinite resolution permits high amplifier gains and improvement in frequency response. High performance servos are made possible without hunting.

In non-linear potentiometers, resolution is constant regardless of output voltage slope variations.

Wirewound units display a "staircase" output. The amplitude of each step is a function of the winding.

RESISTANCE

In an electrically discontinuous element, resistance, or terminal resistance, is the resistance of the potentiometer, measured in ohms, between the excitation terminals. In an electrically continuous element with excitation terminals 180o apart, (i.e. Sine-Cosine function) the resistance is equal to 1/4 of the entire ring resistance. This type of resistance notation is often referred to as "Resistance per Quadrant".

In Sensor Systems LLC potentiometers, the standard resistance tolerance is ±10% for conductive plastic units, and ±5% for wirewound units unless otherwise specified.

TAPS, DEFINED:

A tap is an electrical connection made to the resistance element at any point between the end terminals.

TAP TYPES & APPLICATION:

Two types of taps are available, as follows:

Zero-Width Tap:
A zero-width tap is one which does not effectively distort the output in the immediate area of the tap. From an output standpoint it is not discernible, and hence of zero-width. The zero-width tap is used to establish voltage reference points. Resistance between the terminal and the tap is approximately 4% of the terminal resistance.

Zero Resistance or Semi-Power Taps:
A zero-resistance tap is one with a minimum resistance value, but one with a finite or discernible width. The net effect on the output of such a tap is a "dead band" or "flat", wherein the voltage across that band or "flat" is virtually constant, and does not change in accordance with the slope characteristics.

These taps are used for points of excitation, current drain, shunting, etc. See Fig. 2B below. The resistance between the tap and the terminal is virtually zero, i.e. 2-5 ohms. See table in "Optional Electrical Characteristics" section for actual value of width and current.

END POINTS:

End points, of themselves, are of no functional use to the user except as references to locate taps, etc. End points constitute the end of the function travel and the beginning of the overtravel.

Top Silver End Terminations: (CP Only)
A type of tap used for excitation, wherein the connection is placed on the conductive film. This is the most common connection which is used, and has an end resistance below 0.5 Ω

For certain applications requiring a smooth transition from end to function, this tap may not be suitable. See Fig. 1A.

Undersilver End Terminations: (CP Only)
Also used for excitation but one where the connection is placed beneath all or part of the conductive film. This type of end yields a smooth transition, but has a resistance between the wiper and the terminal of approximately 0.5% of the terminal resistance. See Fig. 1B.

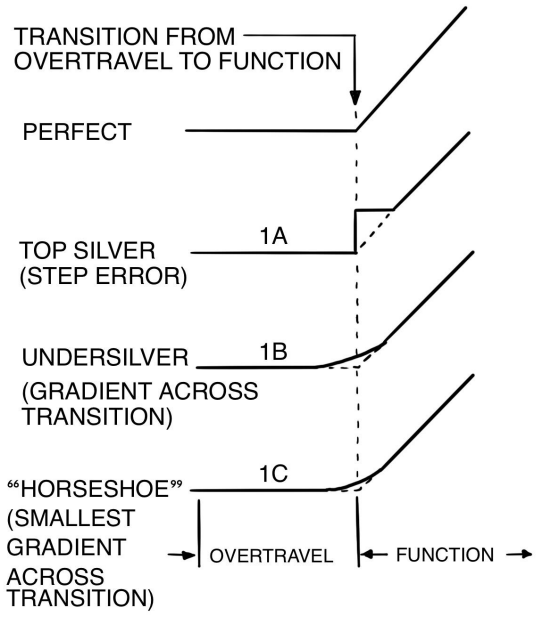


FIGURE 1

Horseshoe End Terminations: (CP Only)
A combination of 1A and 1B above, except the oversilver portion is absent from the wiper path. This sharpens the transition without producing the characteristics of the end resistance. See Fig. 1C.

INTEGRAL WING & SHUNT RESISTORS

The conductive film used in **Sensor Systems LLC** potentiometers can be deposited or otherwise fashioned so as to incorporate, integral to the element, both wing and shunt type resistors. Those areas of the film not traversed by the wiper are used for these functions. This capability is used extensively in producing non-linear functions.

Wing Resistor:

This resistive film is applied in a continuous layer and those portions to be used as wing resistor are physically isolated and connected between the electrical ends of the potentiometer and the excitation terminals. This isolated section acts as a fixed resistor and can be adjusted to obtain the exact value desired. There is, of course, no characteristics mismatch, thereby enhancing the function stability.
Wing resistors serve to drop the applied voltage across the potentiometer. Voltage variation over a portion of the applied voltage is thereby easily attained. See Fig. 2A.

Shunt Resistors:

Shunt resistors are formed in the same manner as wing resistors and are connected through taps (see applicable section) at specific points. Shunts serve to form parallel circuits in specific areas of the function. Shunts both with and without wings serve to generate complex and unique output curves. See Fig. 2B.

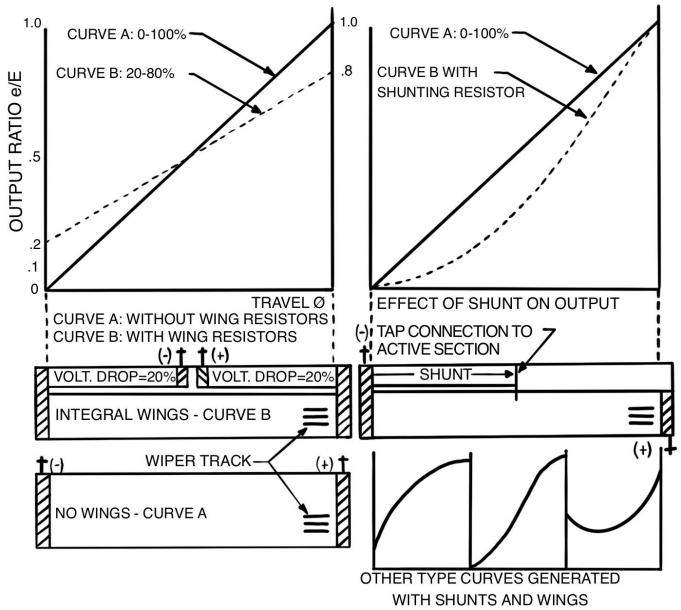


FIGURE 2A FIGURE 2B

ACCURACY, LINEARITY AND CONFORMITY

Types of Data Supplied

Sensor Systems LLC potentiometers are supplied with data, upon request. In one of the following formats:

Check-off Data: Inspector stamped evidence of inspection.

Point by Point Data: Output data every 10° unless other- wise required.

Continuous Recording: Strip chart continuous error recording for Linearity and Output Smoothness.

Special Data: Special data and acceptance test procedures can be generated as required.

Linearity

"Linearity" and "Accuracy" defined:

"Linearity" or "Accuracy" is the degree of proportionality of the output voltage with respect to the position of the shaft. It is expressed as a maximum deviation (in percent or applied voltage) from the desired output. Accuracy capability is de- pendent on size. length of function angle and length of stroke. The longer the active film the better accuracy potential.

A "linear" potentiometer is one where the output voltage is directly proportional to the angular or linear position of the shaft.

There are several ways in which linearity can be specified. They are:

Independent Linearity:

Independent linearity is the maximum deviation of the actual voltage output from a "best" straight line reference whose slope and position minimize the maximum deviations. It is measured over the nominal electrical travel or function angle. The "best" straight line is that which can be obtained by the least-squares method of fitting to the data, or other similar means.

In practice, trimmer resistors are normally supplied in the user's system, one for each excitation terminal. The value of these resistors determine the slope and, hence, the position of the straight line reference. Such resistors are often referred to as pads, padders, or padding resistors.

STANDARD DATA FORM:
*Loaded-Continuous recording, or point-x-point, as applicable.
Unloaded-Continuous recording, or checkoff, as applicable. *See applicable section on loading effects on page 7.

HOW TO SPECIFY:
Independent Linearity ±x.xx%
Function angle xxx± °x°, or x.xx".

Note: If the term "Linearity" only is used, it will be interpreted as *Independent Linearity* unless data or other descriptions indicate otherwise.

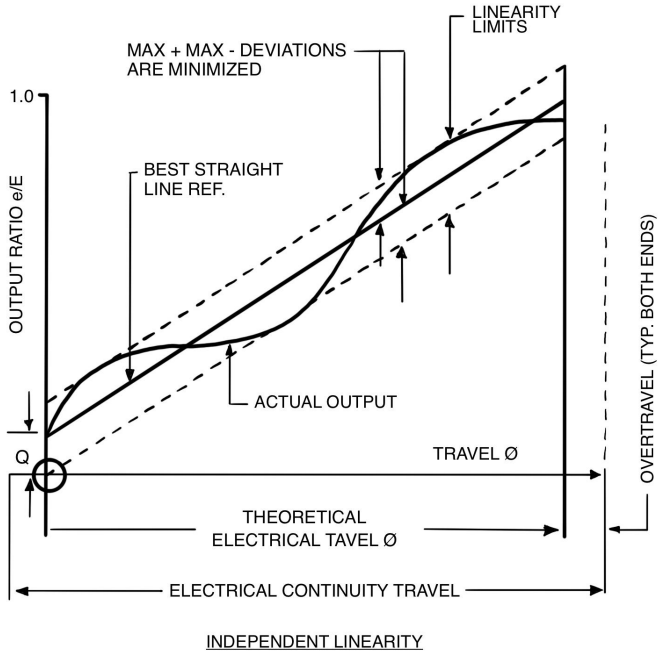


FIGURE 3

Mathematically: e/E=P(Ø ØT)+Q±C

Where: P=unspecified slope
Q=unspecified slope intercept at Ø ° = 0
C=Linearity tolerance
P & Ø chosen to minimize C: See diagram Fig. 3.

Zero-based Linearity

Zero-based linearity is the same as independent linearity except the best straight-line reference is drawn through the zero-voltage output at the start of the function angle. Therefore, the origin of the straight line reference is fixed.

Only one padding resistor, attached to the maximum output terminal is used to adjust the slope of the line reference.

STANDARD DATA FORM:
Loaded-Continuous recording, or point-x-point data, as applicable.
Unloaded-Continuous recording, or check-off, as applicable.

HOW TO SPECIFY:
Zero-based linearity ±x.xx%
Function angle xxx± °x°, or x.xx".

Mathematically: e/E=P (Ø/ ØT)+B±C

Where: P=Unspecified slope.
B=Specified slope intercept at Ø ° =0
See Fig. 4

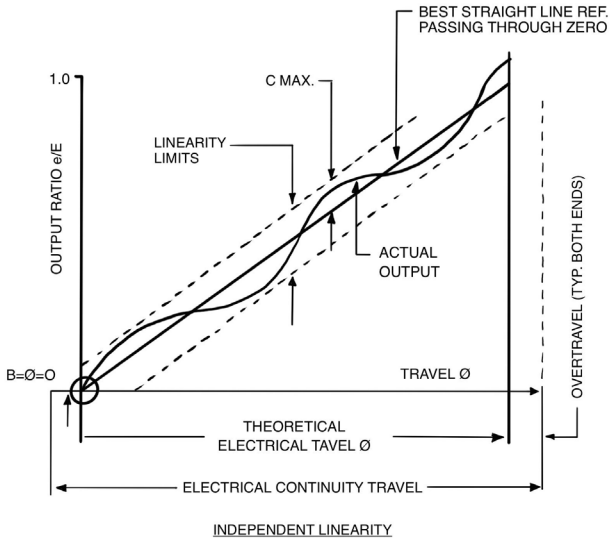


FIGURE 4

Terminal Linearity

Terminal linearity is the same as independent linearity except the straight reference line is fixed on both ends and is drawn through the zero-voltage output at the start of the function angle, and through the maximum output at the end of the function angle. No padding resistors are used. The slope of the straight line is fixed and as such constitutes the theoretical output function.

See Fig. 5

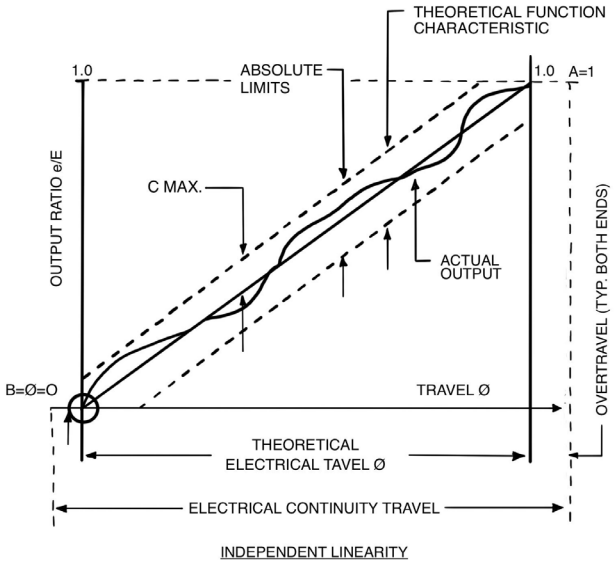


FIGURE 5

STANDARD DATA FORM: Point-x-point data.

HOW TO SPECIFY:
(1) Terminal linearity ±x.xx% over a function angle of xxx± °x°.
(2) Terminal linearity ±x.xx%.
Excitation voltage, slope in volts/ o or volts/inch.

Mathematically: e/E=A(Ø/ ØT)+B±C

Where: A=Specified slope
B=Given intercept at Ø ° =O
C=Linearity tolerance

Absolute Linearity

The term "Absolute Linearity" is merely an extension of terminal linearity in that it is the maximum output deviation from a straight-line reference which is specified and fixed, and constitutes the theoretical output.

Absolute linearity is terminal linearity with no function angle tolerance. It is measured over all or part of the specified theoretical function travel and is expressed as a percentage of the total applied voltage.
The straight line reference may be fully defined by specifying the low and high end theoretical output ratios, and the theoretical function travel. Unless otherwise stated, end points will be interpreted as 0% and 100%. See Fig. 5.

STANDARD DATA FORM: Point-x-point data or strip re- cording.

HOW TO SPECIFY: Absolute Linearity ±x.xx%
Low end ratio x.x%
High end ratio x.x%
Function Travel xxx °
or x.xx" Ref.
Mathematically: e/E=A(Ø/ ØT)+B±C

Where: A=Specified slope
B=Given intercept at Ø° =0
C=Linearity tolerance

CONFORMITY

"Conformity" Defined Conformity is the maximum deviation from a prescribed non-proportional output whose non-proportionality is a function of travel. Whereas linear potentiometers, by definition, have outputs proportional to travel, non-linear or functional potentiometers have outputs that are not proportional to travel. Types of conformity are the same as the linear definitions noted above. Substitute the term "prescribed function line" in place of straight-line reference to permit their application to non-linear potentiometers.

STANDARD DATA FORM: Point-x-point
HOW TO SPECIFY: Non-proportional functions are specified via graphs, specified outputs at travel references, or mathematically.

Conformity Tolerances:
Sine-Cosine and similar functions:
% peak to peak of applied voltage
Empirical Functions: ±x.xx% of applied voltage

Mathematically: Absolute conformity
e/E=f(Ø) ±C=A(Ø)+B±C
Where: A=defined slope
B=intercept at Ø=0

LINEARITY OR CONFORMITY, LIMITS, TOLERANCES

Up to this point all tolerances have been expressed as constant limits, i.e. x.xx%. However, limits may be specified in several ways.

Constant Limit: Permissible conformity deviations specified as a percentage of total applied voltage.

Zero to Peak Constant Limits: Permissible conformity deviations specified as a percentage of zero to peak applied voltage.

Note: The numerical value of zero to peak errors is equal to double that of equal value peak to peak errors. The zero to peak applied voltage is one half the total peak to peak voltage.

Proportional Limits: Permissible deviations in conformity specified as a percentage of the theoretical output ratio at the point of measurement. This is also known as “local linearity”.

Note: Where the theoretical voltage ratio approaches zero, proportional limits may become impossible to obtain. Care must be taken to specify a practical tolerance in that region.
Modified Proportional Limits: Any combination of constant and proportional limits.

See Fig. 6 for examples of Limits.

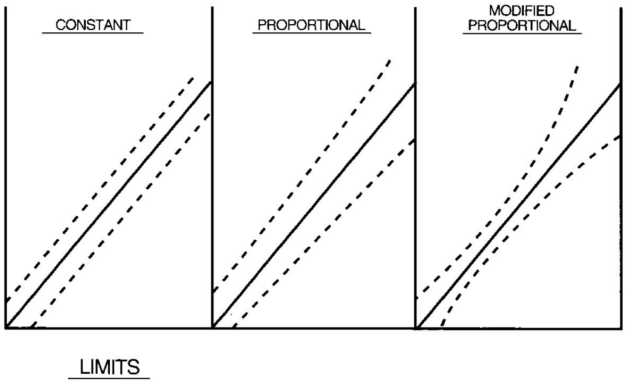
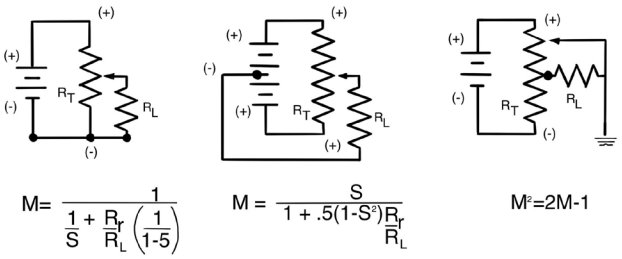


FIGURE 6

LINEARITY OR CONFORMITY CHANGE DUE TO RESISTIVE LOADING

The application of a resistive load to the wiper circuit of a potentiometer produces an error or change in the theoretical output. **Sensor Systems LLC** potentiometers can be loaded in several ways. For example:

a) between wiper and end
b) between wiper and center tap ungrounded
c) between wiper and center tap grounded
d) between wiper and power supply CT grounded
The loading method and magnitude determine the magnitude of the resulting error and at what point in the function it is maximum. See Fig. 7A, 7B & 7C below for typical schematics.



FIGURES 7A,7B & 7C

Mathematically:
Where: S = Open circuit output
M = Loaded Output
RL = Load Resistance
RT = Total potentiometer Resistance

Maximum Error
The maximum error occurs at approximately 67% of the function angle in a potentiometer loaded per Fig. 7A and 67% of each half equidistant about the center tap in a potentiometer loaded per Fig. 7C.

Mathematically:
Δ= S-M = (P) (M) (S) (1-S)
Where: S = Open circuit output
M = Loaded output
$P = \frac{R_L}{R_T}$
Therefore: Where: S = M
Δ = S-M=P(M^2-M^3)
dΔ/dm=P(2M-3M^2)= 0^{dm} M=.667

Sensor Systems LLC potentiometers are easily compensated for most loading configurations. As standard, 100:1 loads are preferred, loads as great as 10:1 are possible in certain configurations.

Note: Capacitive and inductive loading is not well tolerated, especially in discontinuous elements. Such loading is to be avoided in film potentiometric applications.

OUTPUT SMOOTHNESS (CP ONLY)

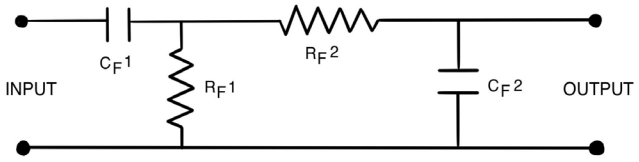
The purpose of the output smoothness specification is to detect, quantitatively, spurious variations in the output, which are not present in the input. Output smoothness is expressed as a percentage of the applied voltage measured over specified portions of the function travel, and includes the effects of contact resistance variations, and other forms of micro non-linearity.
The basis of output smoothness is to simulate actual usage by applying constant speed, and passing the output signal through a filter designed to simulate the response of the system for which the potentiometer is intended. The filtered output will show output anomalies, which occur over short periods with respect to the filter time constant. It will also show slower deviations which occur over periods in

excess of the filter time constant, as variations in output level.

In practice, and unless otherwise specified, the output smoothness test in accordance with MIL-R-39023 is used as the standard. This specification provides for the following:

SPEED: 4RPM
FILTER CIRCUIT: per Figure 8A (8Hz-160Hz)

Load: As required for conformity or linearity tests. If none, then R_L= 100 x R_T
Where:
R_L = Load resistance,
R_L = Potentiometer total resistance.



WHERE: C_F1 = 0.050 uf, C_F2 = 0.10 uf
R_F1 = 400 K , R_F2 = 10 K

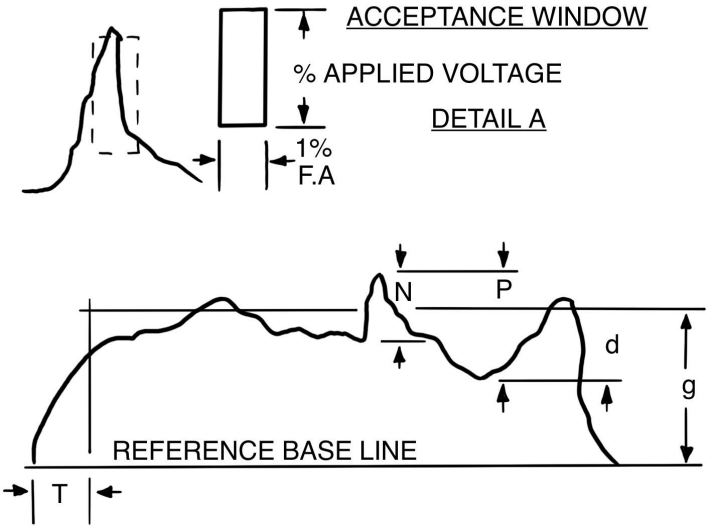
MIL-R-39023: OUTPUT SMOOTHNESS CIRCUIT

FIGURE 8A

TRAVEL INCREMENT:1.0% of function angle.

SAMPLE ANALYSIS: See Fig. 8B

Note: Changes occurring at the normal points of abrupt changes in the output slope, start, end and reversal are not considered output smoothness effects and are not rejectable.



g: FILTER OUTPUT LEVEL FOR NOMINAL GRADIENT
d: LARGEST DEVIATION FROM NOMINAL GRADIENT
I.E SLOPE VARIATION d/g
P: GREATEST PEAK TO PEAK DEVIATION
T: FILTER CHARGING TIME
N: SUDDEN EXCURSION, FILTER NOISE
(SEE DETAIL -A-)

FIGURE 8B

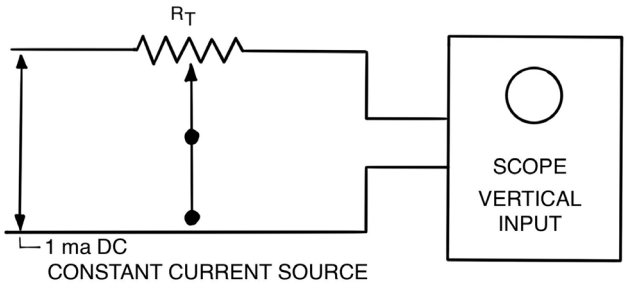
CRITERIA:
Output smoothness characteristics to 0.01% of applied volt- age over 1% of the function angle are available. The following MIL-R-39023 Specifications are commonly specified.

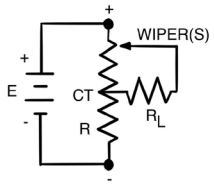
Peak to Peak Voltage (e/E)

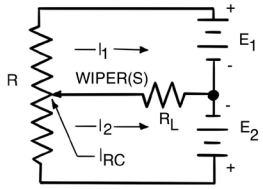
Symbol	Initial (%)	Degraded(%)
A	2.0	2.2
B	0.5	0.7
C	0.1	0.15
D	0.025	0.04
E	0.010	0.02

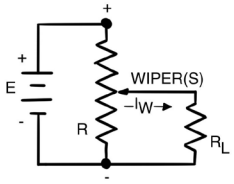
NOISE (WW ONLY)

Mil-R-12934 Equivalent test for spurious variations in wirewound output, due to parasitic transient resistance between the contact and resistive element, is determined by using Fig. 8C circuit.









FIGURES 9A, 9B, 9C

WIPER CURRENT

The normal working wiper current is 1 ma maximum, and such should be the specification of choice for the systems designer. Potentiometers with as much as 10 ma wiper current can be provided where necessary.

Wiper current develops under loaded conditions and affects output smoothness as well as conformity. For example:

Mathematically:

Load to Center Tap of Potentiometer:
(tap not grounded) see Fig. 9A
Iw = E/(1+2R_L/R_T) ((0.5R_T) (R_L) + 0.5R_T)/.5R_T+R_L)

Load to Center Tap of Power Supply:
See Fig. 9B
Iw = (R_L)(I1-I2)-E=0=E/R_L
Current is maximum at each end, zero at the electrical center of the potentiometer.

Load to End
see Fig. 9C

Iw=E/(1+R_L/R_T)((R_T x R_L)/(R_T+R_L)) = E/R_L

Current is maximum at the end farthest from load, decreasing to zero at load end.

QUADRATURE

Quadrature is defined as a phase shift between input and output caused by capacitive and inductive characteristics of potentiometers and loads, as well as circuit components.

The conductive plastic film used in **Sensor Systems LLC** potentiometers does not generate any significant quadrature under resistive loading conditions, and therefore, no special compensating circuitry is required.

POWER DISSIPATION

Power dissipation is the maximum power that can be dissipated safely by the potentiometer at a certain ambient temperature. It is expressed in wattage, and is equal to the square of excitation voltage, divided by the terminal resistance.

The power dissipation varies with size and is stated on the individual specification sheets contained herein.

DERATING: All **Sensor Systems LLC** potentiometers dissipate the maximum specified wattage @ 25°C and the linearly derated to zero wattage @ + 125°C. Deration to higher temperatures is possible in some configurations. See Fig. 10.

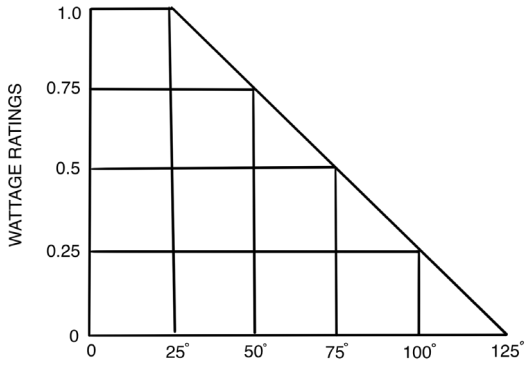


FIGURE 10

Mathematically where:

W_F= 1-S(T_2-T_1)
W_A = (W_F)(W_M) W_F = Multiplier
W_M = Maximum wattage rating for device
W_A = Actual wattage rating @ temperature
S = Slope of derating curve-.01
T_2 = Temperature, operating
T_1 = Reference temperature @ 100% power = +25°C

RELIABILITY CONSIDERATIONS

The reliability of a potentiometer depends on its ability to continue performing its intended function. Since the primary function is to provide continuous and proportional voltage output, the primary reliability considerations are continuity and proportional voltage output. A failure in continuity is always catastrophic as the device is no longer acting as a potentiometer.

The primary constituents of continuity are:

a. Wiper contact to conductive surface.
b. Continuous conductive surface.
c. Wiper (output) and excitation terminal continuity.

Wipers

Sensor Systems LLC uses two types of wiper construction, flat stamping, and circular wire form. Both types exhibit totally separate and independent arms. Each arm is designed to have different resonant frequencies, thereby precluding discontinuity under vibration. The wiper materials are matched to the surfaces being wiped to minimize wear. True redundancy is obtained by first welding all wipers to their respective mounts, followed by soldering over the welded section.

Probability of Failure of Wiper Contacts

1. The probability that an event will happen is the ratio of the number of favorable cases to the entire number of possible cases, provided all cases are equally likely to occur.
2. The probability of simultaneous occurrence of two independent events whose respective probabilities are a and b, is a x b.
3. The probability of occurrence of one or the other of two mutually exclusive events whose respective probabilities are a and b is a + b.

Case1: Will maintain contact
Case 2: Will not maintain contact=Failure case.
Probability of Failure: 1/2
Probability of Simultaneous Failure = $(1/2)^1$, $(1/2)^2$, $(1/2)^3$, $(1/2)^N$, = $(1/2)^N$
Failure Probability Ratio:
(Multiple vs. single wiper arm) =
$\frac{(1/2)^N}{(1/2)}$ = $(1/2)^{N-1}$

Therefore: Multiple arms (N) are (1/2)N-1 times as reliable as a single wiper. The standard four (4) arm wiper utilized in **Sensor Systems LLC** potentiometers is, therefore, eight (8) times less likely to lose continuity as a single wiper.

In summary, the **Sensor Systems LLC** Potentiometer offers an extreme high degree of reliability, and true redundancy throughout.

ENVIRONMENT

Sensor Systems LLC potentiometers meet all the environmental requirements of MIL-R-39023 and MIL-R-12934.

Temperature Coefficient of Resistance (TCR)-(CP Only)
Per MIL-R39023 and to -400PPM/°C

Vibration, Shock, Acceleration

Sensor Systems LLC potentiometers easily withstand high G forces without losing continuity. A momentary dis- continuity equal to or greater than 0.1ms is generally considered a failure. Wipers are so arranged that each separate wiper arm is independent and has a different natural frequency. This coupled with the low wiper mass, results in an extremely stable assembly. No increase in torque is necessary under the "preferred" values listed below:

Environment	Acceleration	Special Design Capability To
Sinusoidal Vibration	50 G's or less	100 G's, 5-2KHz
Random Vibration	0.04PSD, 7.3G RMS	0.4PSD, 23.1G RMS
Sinusoidal Shock (11ms)	50 G's or less 30 G's or	150 G's 100 G's 150 G's
Sawtooth Shock (7ms)	less 50 G's or less	

Note: Some special designs have been tested to 300G Acceleration, 150G Sinusoidal Vibration, 0.6PSD Random Vibration, and 200G Sinusoidal Shock without damage, degradation or loss of continuity. Consult factory with such requirements

Effect of Life on Resistance, Output Smoothness, Conformity and Torque (Conductive Plastic Only)
Under the test conditions per Mil-R-39023, resistance and conformity levels remain well within specification. See Fig. 11 for graphical presentation of data. Typical resistance values were approx. .05% $\Delta R/10^6$ cycles with worst case .075% $\Delta R/10^6$ cycles. Typical output smoothness values were +.008 in/oz/10^6 cycles in the first 5 x 10^6 cycles and +.002 in/oz/10^6 cycles thereafter. Conformity values were $\Delta.00690/10^6$ cycles.

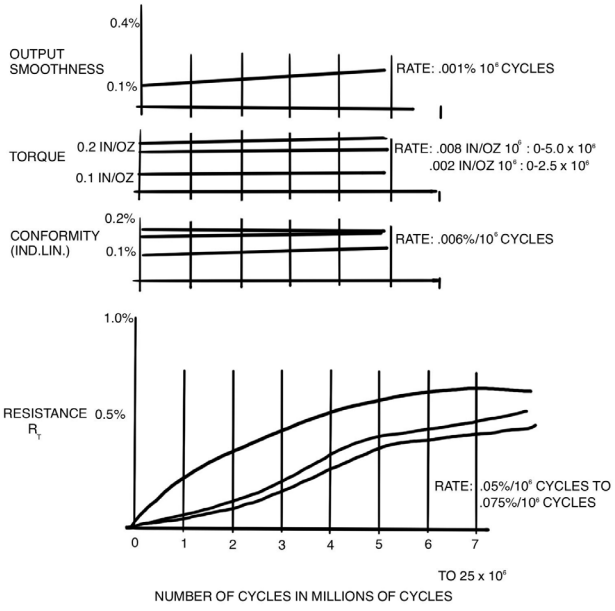


FIGURE 11

Effect of Load Life on Resistance
(Conductive Plastic Only)
900 hrs. of load life per MIL-R-39023 generally results in resistance changes of less than 1%, and worst case less than 1.5%. There is virtually no change in other electrical characteristics.

MECHANICAL CHARACTERISTICS

Rotary Potentiometers

TORQUE:
Sensor Systems LLC potentiometers are designed for low torque actuation, Unless otherwise specified, ball bearings are used for all rotary potentiometers. Since the wiper/film coefficient of friction is low, the net unit torque is well below most system requirements.

Special "low torque" designs are available where necessary. The starting torque levels are enumerated on the individual data sheets.

MOMENT OF INERTIA:
Since the internal rotating masses are small, moment of inertia is generally well below most system requirements. The moment of inertia for each model is listed on the individual data sheets.

Rectilinear Potentiometers

ACTUATING FORCE:
All **Sensor Systems LLC** rectilinear potentiometers incorporate extruded or machined ways, which are matched to sliding blocks carrying film and commutator wipers. The configurations of the ways and block are so designed to minimize misfit under temperature environments. Hence, actuating force under temperature extremes closely matches initial values.

ANTI-ACCELERATION & ANTI-TEMPERATURE DESIGN:
All standard **Sensor Systems LLC** rectilinear potentiometers incorporate a spring load between the shaft and wiper block designed to exceed forces introduced from high shaft accelerations. Under such forces, the spring load will keep the block in intimate contact with the shaft so as to maintain the block/shaft positional integrity throughout the force cycle.

The spring force also compensates for thermal mismatch between the shaft and the block materials, by allowing the block to grow or shrink with respect to the shaft without permanent setting of the block material.

As a result, the block never becomes loose, or changes its relationship with respect to the shaft.

MISALIGNMENT FEATURE
Shaft misalignment is available as a standard configuration on "Tuff-Line" Model 111, and is available on other rectilinear models by special order.

Consult **Sensor Systems LLC** Applications Engineering Staff with your specific requirements.

RUGGEDNESS
The square configured models incorporate single piece "U" or box extrusions which are highly resistant to mechanical distortion. The round configured models incorporate single piece "U" or clamshell extrusions, with single piece tube type covers. A body within a body construction results which is extremely resistant to distortion, providing a most rugged construction.

Stainless steel shafts are used throughout to complement the above.

ROTATING SHAFT FEATURE
Most rectilinear models incorporate or can incorporate rotatable shafts with threaded ends which can be threaded to stationary mounts.

Consult the individual model sheets or **Sensor Systems LLC** Applications Engineering Staff.

Quick Reference Guide

Single-Turn and Multi-Turn Wirewound Precision Potentiometer

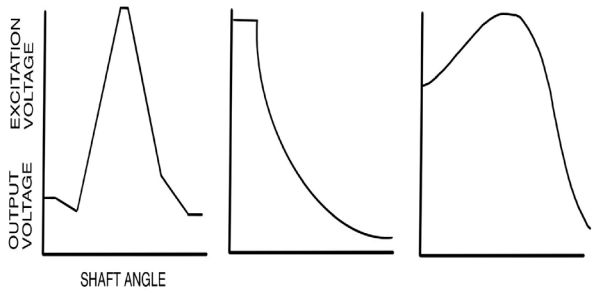
Series	Turns	Resistance Range	Linearity	Power W	Shaft Dia.	Pkg. Dia.	Mount	Page
RC-05	1	50 to 50KΩ	± 0.2% to 0.5%	1.5	⅛”	½”	Servo	40
5001	1	10Ω to 50KΩ	±5%	2.0	⅛”	½”	Bushing	43
RC Series	1	50 to 1MΩ	±0.03% to 0.4%	2.0 to 8.0	⅛”, ¼ ”	⅞” to 3”	Bushing/Servo	41,42
7501	1	50Ω to 50KΩ	±1%	2.25	⅛”	¾”	Bushing	44
0871	1	100Ω to 50KΩ	±0.5%	1.25	⅛”	⅞”	Bushing/Servo	45
1061	1	50Ω to 50KΩ	±0.5%	1.5	⅛”	1-1/16”	Bushing/Servo	46
1441	1	50Ω to 50KΩ	±0.5%	2.0	¼ ”	1-7/16”	Bushing/Servo	47
H-151	1	100Ω to 100KΩ	±0.5%	3.5	¼ ”	1-½”	Bushing	48
5000	10	100Ω to 100KΩ	±0.5%	1.5	¼ ”	½”	Bushing	51
5005	5	50Ω to 50KΩ	±0.5%	1.0	¼ ”	½”	Bushing	51
MD & MS	10/40	60Ω to 3MΩ	±0.006% to .1%	1.0 to 8.0	⅛”, ¼ ”	½” to 3”	Servo	49,50
7400	10	100Ω to 100KΩΩ	±0.25%	3.0	¼ ”	¾”	Bushing	52
7405	5	100Ω to 50KΩ	±0.5%	2.0	¼ ”	¾”	Bushing	52
8400	10	100Ω to 100KΩ	±0.25%	3.0	¼ ”	⅞”	Bushing/Servo	53,54
8403	3	50Ω to 50KΩ	±0.5%	2.0	¼ ”	⅞”	Bushing/Servo	53,54
8405	5	50Ω to 50KΩ	±0.5%	2.0	¼ ”	⅞”	Bushing/Servo	53,54
8500	10	100Ω to 100KΩ	±0.25%	3.0	⅛”	⅞”	Bushing/Servo	53,54
8503	3	50Ω to 50KΩ	±0.5%	2.0	⅛”	⅞”	Bushing/Servo	53,54
8505	5	50Ω to 50KΩ	±0.5%	2.0	⅛”	⅞”	Bushing/Servo	53,54
1000	10	500Ω to 250KΩ	±0.5%	3.0	¼ ”	1”	Bushing	55
1005	5	250Ω to 100KΩ	±0.5%	2.0	¼ ”	1”	Bushing	55
1215	15	500Ω to 450Ω	±0.1%	4.0	¼ ”	1”	Bushing	55
1220	20	1KΩ to 600KΩ	±0.1%	5.0	¼ ”	1”	Bushing	55

Rotary Precision Potentiometers
Optional Rotary Electrical Characteristics

LINEARITY OR CONFORMITY
Unless otherwise indicated the linearity shown on the catalog sheets is Independent Linearity. Terminal, index point, absolute and other linearity or conformity types are available for your order.

Unless otherwise indicated all cups in a ganged unit are phased for the simultaneous output of 50% of excitation voltage to an accuracy equal to the Linearity tolerance. Electrical output matching between cups, the output of one cup as a function of the output of another cup rather than just as a function of shaft rotation, and similar output relationships are available to suit. Tracking tolerances are nominally 2x the linearity tolerances

NON-LINEAR OUTPUTS
Standard potentiometers are available with sinusoidal function outputs (See Pages 6 & 7); two independent outputs are provided, +sine and +cosine. If desired, as many as four independent outputs corresponding to +sine, +cosine, -sine and -cosine can be supplied from a single cup. A wide variety of other non-linear output potentiometers are available to your order. Typical types are shown at right:



MATCHING FUNCTIONS (TRACKING AND/OR PHASING)

LOAD COMPENSATION
Where desired, potentiometers of the linear or non-linear type can be compensated during manufacture for the errors introduced by electrical loading of the wiper, thereby eliminating such errors from the system.

TAPS
Taps can be provided at locations to suit. Unless otherwise indicated, tap location is defined in terms of voltage ratio, e.g., a center tap is defined as existing at 50% of the excitation volt- age. Alternatively, a tap can be specified as being located so many degrees from a given voltage output angle, e.g, from the start of the Electrical Function Angle where the output voltage ratio is zero. Unless otherwise indicated, the tap is located to the same accuracy as the Linearity tolerance

Two types of taps are available, depending upon the application or, more directly, upon the relative amount of current being drawn through it. Zero-width taps are used as voltage reference points, where the current being drawn through the taps is less than 10% of the excitation current or 4 ma., whichever is less. Zero-Width taps have a minimum resistance between wiper and tap equal to approximately 4% of the terminal resistance Zero-resistance taps are used as voltage excitation points, where a relatively large current is being drawn through the tap. Zero-resistance taps have a resistance (approximately 2-5 ohms) and have a maximum width and a current carrying capacity as indicated below:

MAXIMUM TAP WIDTH FOR ZERO-RESISTANCE TAPS

DIAMETER	SINGLE-TURN	MULTI-TURN	MAXIMUM TAP CURRENT
½”	6°	10°	50 ma.
⅞”	3°	5°*	50 ma.
1 3/32”	2.5°		50 ma.
7/16”/11/2”	2.0°		50 ma.
1 ¾”	1.75°	2°	50 ma.
2”	1.5°	2°	50 ma.
3”	0.6°		65 ma.
5”	0.3°		80 ma.

*Except Model 7810 where the maximum tap width is 36°.

WATTAGE

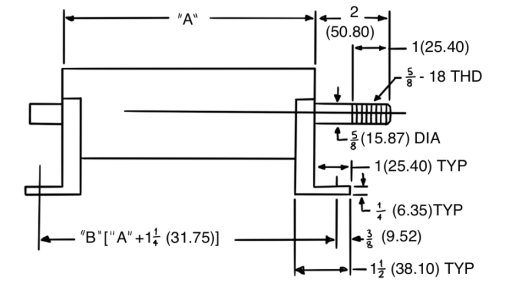
The power dissipation shown on the individual specification page is the units rated power under ambient conditions, (25°C). Al units will dissipate rated power to 85°C, then derate linearity to zero power at 125°C.

OTHER TYPICAL SPECIAL ELECTRICAL CHARACTERISTICS

1 Brush-to-case insulation breakdown to 1500V.
2. Doubling or tripling of wattage ratings.
3. Minimum brush-to-case capacitance
4 .Multiple outputs from single cups.
5. Integral wing resistors of matched temperature coefficients.
6.Integral electrical interconnections between cups in gang

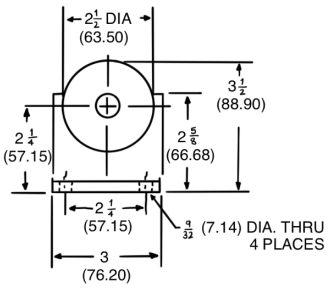
Linear Motion Precision Potentiometers

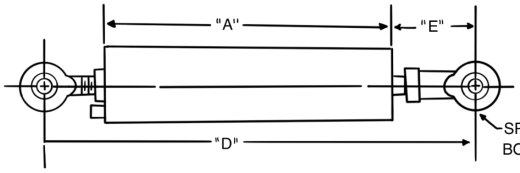
Model 110 TUFF-LINE Infinite Resolution



*Receptacle and mating plug

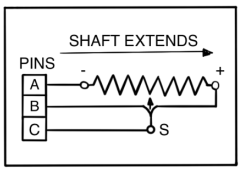
"A" = 6" (152.40) + TOTAL MECH. TRAVEL(IN 1" (25.4) INCREMENTS)





SPHERICAL BEARING BOTH ENDS
BORE 0.625 + 0.0015 - 0.0003
BALL WIDTH: 0.750 +0.000 -0.005

A = 6" + TOTAL MECH. TRAVEL (IN 1" INCREMENTS)
B = A + 1 1/4
C = 2"
D = A + E + 2"
E = 3"



SPECIFICATIONS

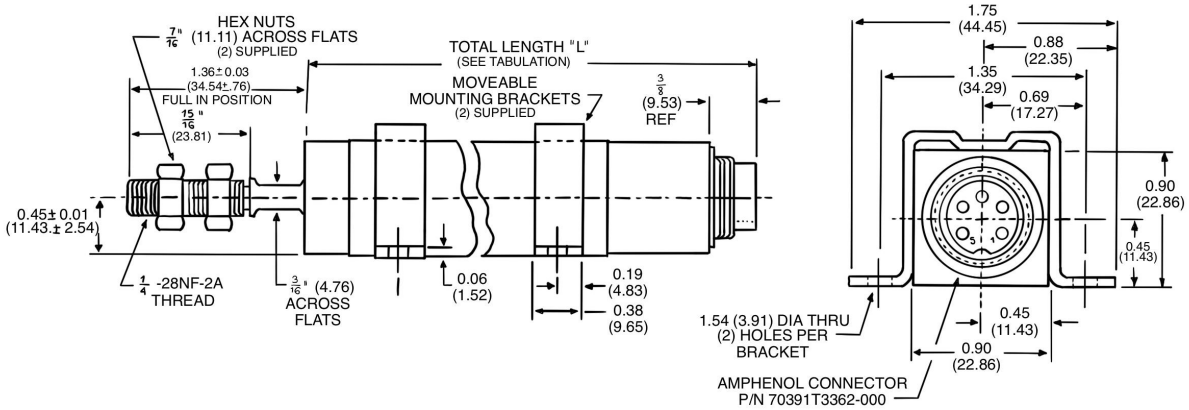
ELECTRICAL	STANDARD
Resistance Range ±10%	500Ω/in. to 100KΩ/in.
Independent Linearity or Conformity	To ±0.01%, Depending on stroke
Electrical Stroke ±0.015	12” to 48”
Maximum No. of Taps	—
Wattage	1 Watt/in.
Temperature Range.	-55°C to 125°C
Dielectric Strength	750V RMS

MECHANICAL	STANDARD
Mechanical Travel Beyond Stroke	+0.250”-0
Starting Force (Max.) (Depending on Stroke)	16 oz-24 oz. @25°C
Stroke Velocity	50”/sec.
Shaft Free to Rotate	Yes
Misalignment	No

For Optional Mechanical Configurations, see page 21

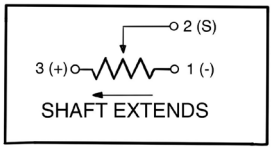
Linear Motion Precision Potentiometers

Model 190 TUFF-LINE Infinite Resolution

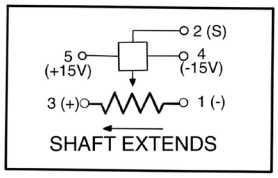


ELECTRICAL FUNCTION - INCH (NOM)	1.00 (25.4)	2.00 (50.8)	3.00 (76.2)	4.00 (101.6)	5.00 (127.0)	6.00 (152.4)
MECHANICAL STROKE - INCH (MIN)	1.20 (30.48)	2.20 (55.88)	3.20 (81.28)	4.20 (106.68)	5.20 (132.08)	6.20 (157.48)
DIMENSION "L" - INCH (NOM)	3.50 (88.9	4.50 (114.3)	6.50 (165.1)	7.50 (190.5)	8.50 (215.9)	9.50 (241.3)

STANDARD VERSION



OP-AMP VERSION



ORDERING INFORMATION

190 — 1 — A — 1K — A

MODEL NUMBER	TRAVEL	OP Amp Option	Resistance Value	Linearity
	1:1 2:2 3:3 4:4 5:5 6:6	A: with OP Amp N: without OP Amp	1K 5K 10K	A: 1.0% B: 2.0% C: 3.0% D: 4.0%

SPECIFICATIONS

ELECTRICAL	STANDARD
Resistance Range ±20%	1KΩ, 5K, 10K ohm
Independent Linearity or Conformity	±1.0%, 0.5%, 0.25% Or 0.1%
Electrical Stroke ±0.005	1" to 6" In 1" increments
Wattage	0.75 Watt/in.
Temperature Range.	-55°C to 105°C
Matting Connector	70391T3361-001/005R.A

MECHANICAL	STANDARD
Mechanical Travel Beyond Stroke	+0.24 -0
Operating Force (Max.)	1 lb. (450 grams)
Life.	10 million cycles.

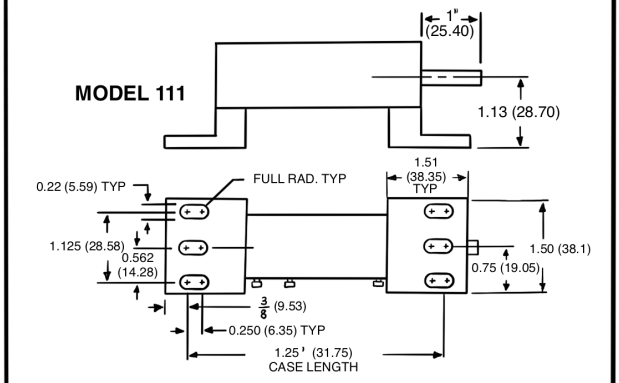
For Optional Mechanical Configurations, see page 21

Linear Motion Precision Potentiometers

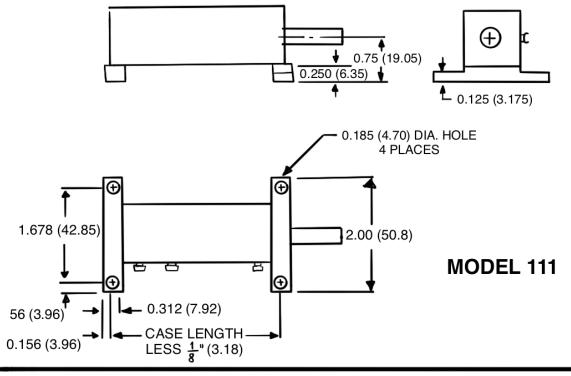
Optional Mechanical Configurations

MOUNTINGS

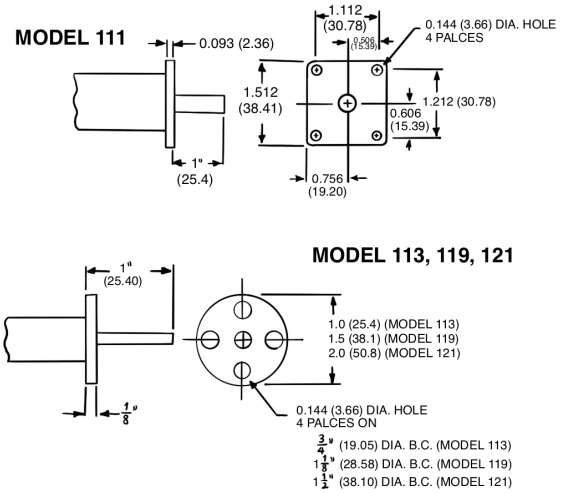
FORE-AFT BRACKETS



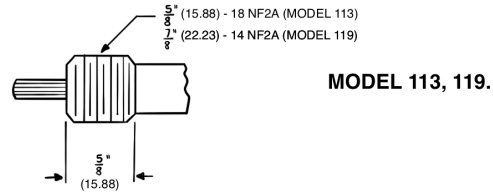
SIDE BRACKETS



FLANGE

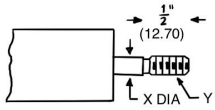


THREADED CASE



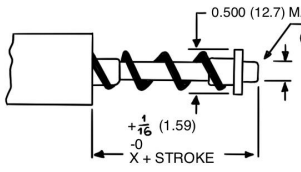
SHAFT ENDINGS

THREADED ENDS



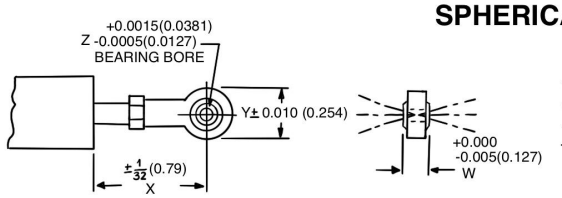
MODEL NO.	"Y" (THD.)
111, 119 121	#10-32
113, 120	#4-40

SPRING RETURN
(For mechanical travels up to 1")



MODEL NO.	X	Y
111, 121	1 5/16 (33.34)	0.250 (6.35)/0.248 (6.30)
113	3/4 (19.05)	0.125 (3.18)/0.124 (3.15)
119	1 5/16 (33.34)	0.1875 (4.76)/0.1845 (4.734)

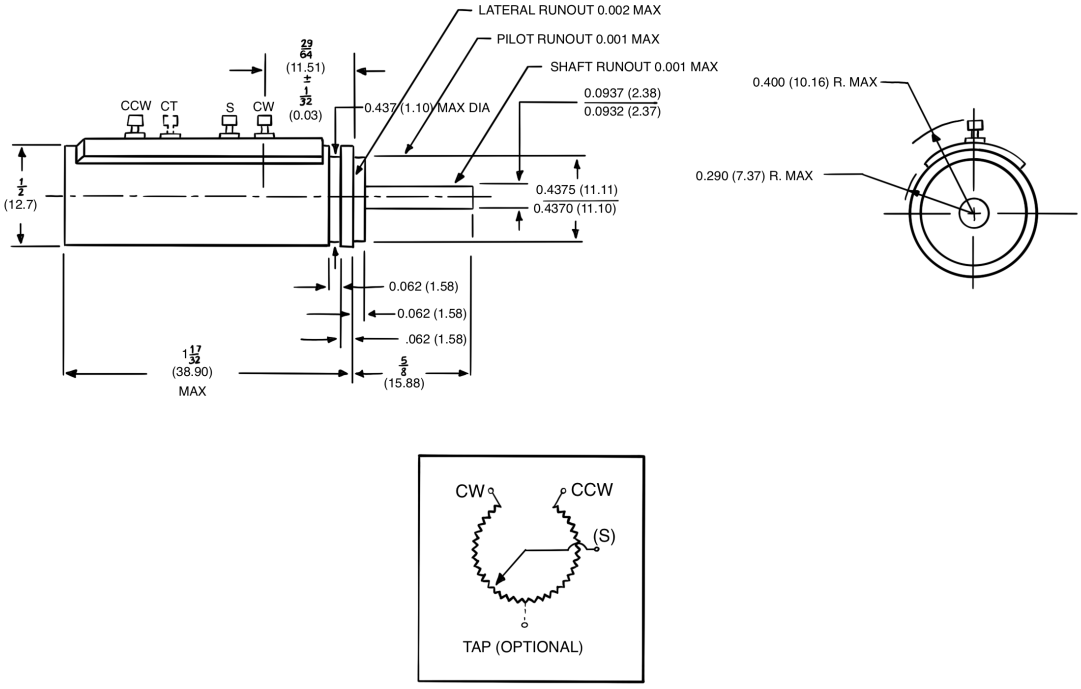
SPHERICAL BEARING



MODEL NO.	W	X	Y	Z
111, 121	0.31 (7.87)	1 1/4 (31.75)	0.63 (16.00)	0.190 (4.83)
119	0.25 (6.35)	1 3/16 (30.84)	0.47 (11.94)	0.125 (3.18)

Rotary Precision Potentiometers

Model 5010- Multi-turn, Infinite Resolution



SPECIFICATIONS

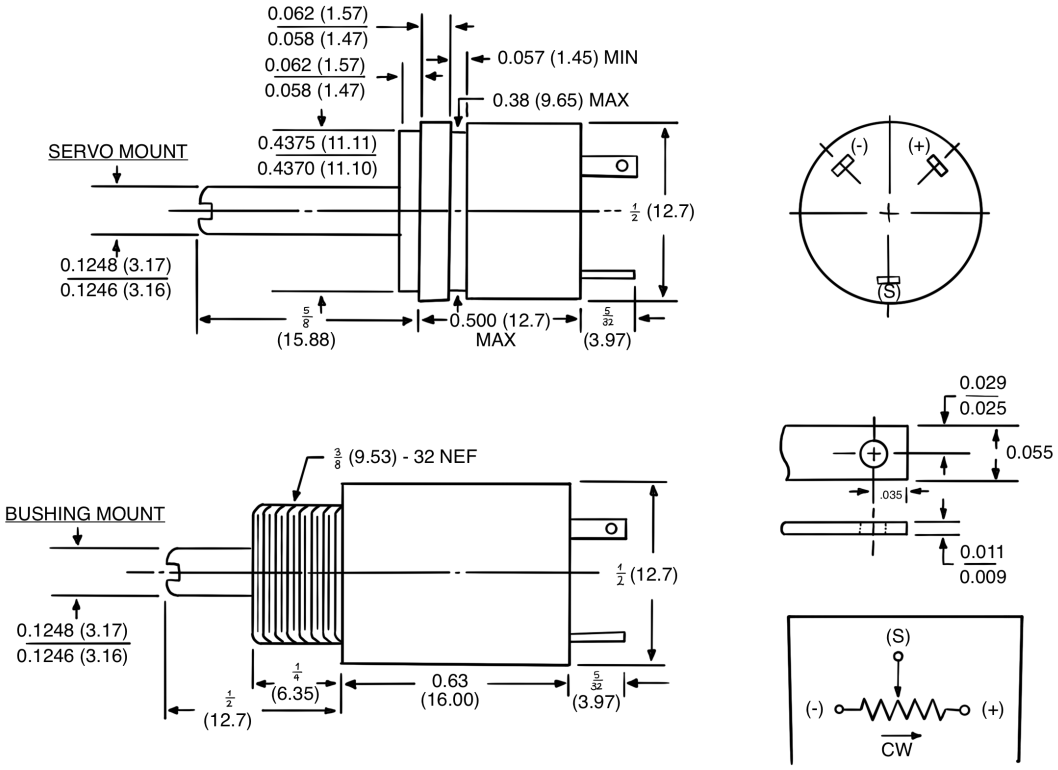
ELECTRICAL	STANDARD
Resistance Range ±10%	10Ω-500Ω
Independent Linearity	To ±0.25%,
Electrical Function Angle ±5°	3600°
Electrical Contact Angle	Same as Mechanical Rotation
Power Dissipation (at 25°C)	2 Watts
Temperature Range.	-55°C to 125°C
Dielectric Strength	500V RMS

MECHANICAL	STANDARD
Mechanical Rotation +40°-0° (Stops Available)	3600°
Starting Torque in-Oz (Max)	0.2
Max. Weight in Oz. (Single Section)	1
Stop Strength in Oz.	10

For Optional Mechanical Configurations, see pages 36 and 37.

Rotary Precision Potentiometers

Model 55 — Single-Turn, Infinite Resolution



SPECIFICATIONS

ELECTRICAL	STANDARD
Resistance Range ±10%	1KΩ-50KΩ
Independent Linearity or Conformity	±2% to 1.0%
Electrical Function Angle ±5°	300°
Electrical Contact Angle ±5° -10	350°
Maximum No. of Taps	—
Wattage	1 Watt
Temperature Range.	-55°C to +125°C
Dielectric Strength	500V RMS

MECHANICAL	STANDARD
Mechanical Rotation +40°-0° (Stops Available)	360° Continuous
Starting Torque in-Oz (Max)	0.15
Max. Weight in Oz. (Single Section)	0.5
End Play	0.005” max.
Moment of Inertia. gcm^2	0.1

Rotary Precision Potentiometers

Optional Rotary Mechanical Configurations

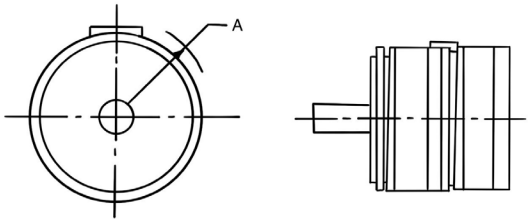
GANGING

Unless otherwise indicated, ganged units are factory phased and locked into position. For Applications requiring phase adjustability between cups in the field the following ganging configurations are available:

CLAMP LUG GANGING

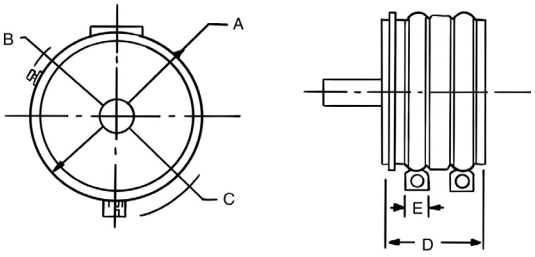
SERIES	70	100	170	200	300
MAX ADDITIONAL LENGTH PER CLIP	0.636	0.635	0.985	0.985	1.360
"A" MAXIMUM RADIUS OVER CLAMPS	0.531	0.656	0.968	1.125	1.625
NO. OF CLAMPS EQUALLY SPACED	3	3	3	3	6

CLAMP LUG GANGING



CLAMP BAND ASSEMBLY

SERIES	70	100	150	170	200	300
"A" MAX. DIA	0.968	1.140	1.525	1.860	2.105	3.090
"B" MAX. RADIUS	0.593	0.703	0.906	1.031	1.156	1.812
"C" MAX. RADIUS	0.612	0.730	0.948	1.155	1.285	1.795
"D" MAX. OVERALL CASE LENGTH (1 CUP)	0.718	0.718	0.875	1.062	1.062	1.350



CLAMP BAND ASSEMBLY

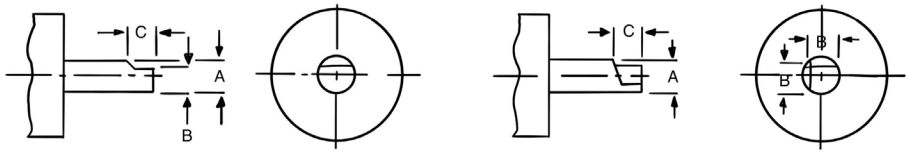
Potentiometer cups can be ganged with other potentiometer cups and/or with VERNITRON Precision Commutators. Ganging is usually done with cups of the same diameter. Ganging between cups of different diameters can be provided on a custom basis.\

SHAFT ENDINGS

Shown below are commonly used special shaft endings. Shafts containing integral gears, splines and other similar custom features can be provided to your order.

SINGLE & DOUBLE FLAT

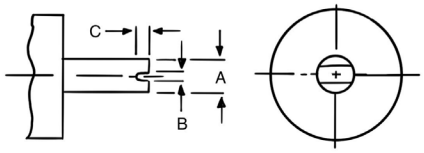
A (DIA)	B	C (LENGTH)
3/32	0.080	1/8
1/8	0.107	1/8
3/16	0.160	3/16
1/4	0.213	3/16



SLOTTED SHAFT

A (DIA)	B	C (LENGTH)
3/32	0.015	0.030
1/8	0.030	0.045
3/16	0.062	0.093
1/4	0.062	0.093

SLOTTED SHAFT



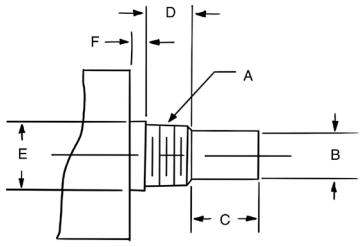
MOUNTING

Shown below are commonly used special mountings. Mountings containing integral gears, ear lugs and other similar custom features can be provided to your order.

BUSHING MOUNT

MODEL	56	70, 150, 100	200, 170, 300	5000	7800	20000
A	⅜-32 NEF	⅜-32 NEF	⅜-32 NEF	¼ -32 NEF	⅜-32 NEF	⅜-32 NEF
B	0.1250 0.1245	0.1250 0.1245	0.2500 0.2495	0.0937 0.0932	0.1250 0.1245	0.2500 0.2495
C	7/16	7/16	1/2	7/16	1/2	3/8
D	1/4	1/4	1/4	1/4	1/4	3/16
E	- -	- -	- -	- -	- -	0.4082 0.4052
F	-	-	-	-	-	1/14

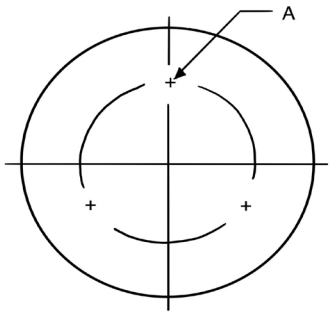
BUSHING MOUNT



TAPPED HOLE MOUNT

MODEL	55	78	105	175	205	305	5010
"A" THREAD SIZE	0-80	0-80 2-56 4-40	0-80 2-56 OR 4-40	2-50 4-40 6-32 8-32	2-50 4-40 6-32 8-32	8-32	0-80
BOLT CIRCLE DIA $\pm$0.005	0.480 0.480	0.670 0.520	0.875 0.625	1.450 1.343	1.700 1.625	1.750 1.750	0.344 0.344
MAX DEPTH OF HOLE	0.125	0.125	0.125	0.187	0.187	0.187	0.55

TAPPED HOLE MOUNT

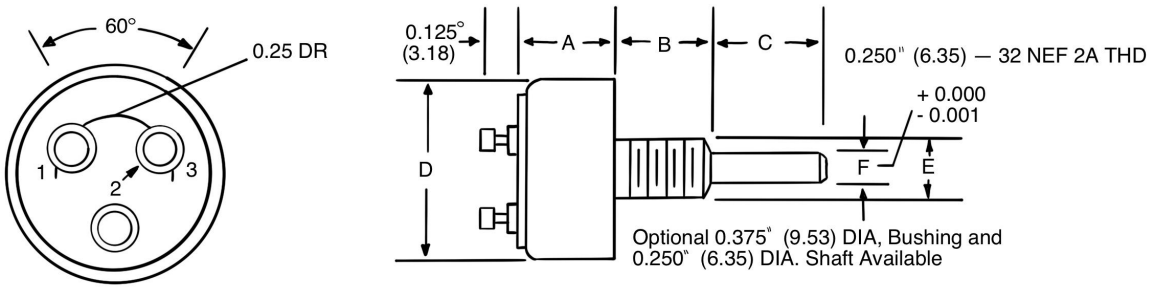


TERMINALS

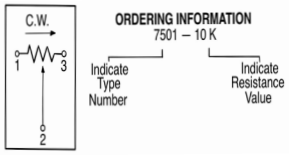
Unless otherwise indicated, terminals are precious-metal plated solder lug type. Their locations can be varied to meet your particular requirements. Wire leads to your required length and location, with or without integral connectors, bolt or screw type terminals, dummy terminals and other custom terminal configurations are available to suit.

Precision Potentiometers

7510 Series — ¾" Diameter Wirewound, Single-Turn



Lock washers and hex-mtg. Nuts supplied with each unit.
Unless otherwise stated, tolerances are ± 0.015" (0.38)



DIMENSIONS							
Length					Diameter		
Model	Turns	A (overall)	B (Bushing)	C(Shaft)	D (Overall)	E (Bushing)	F (Shaft)
7501	1	.400"(10.16)	.375"(9.53)	.500"(12.70)	.750"(19.05)	.250"(6.35)	.125"(3.18)

SPECIFICATIONS

ELECTRICAL	STANDARD
Power Rating	2.25W @ 40°C
Standard Resistance Range	50Ω to 50KΩ
Resistance Tolerance	±5% std
Temperature Coefficient (wire)	±20ppm/°C max
Linearity (independent)	±1%
Wattage	1 Watt
Temperature Range. +125°C	-55°C to
Dielectric Strength	500V RMS

MECHANICAL	STANDARD
Mechanical Rotation +40°-0°	Continuous
Operating Torque	2 oz-in. Max
Max. Weight in Oz. (Single Section)	0.5
End Play	0.005" max.
Moment of Inertia. gcm^2	0.1

ENVIRONMENTAL

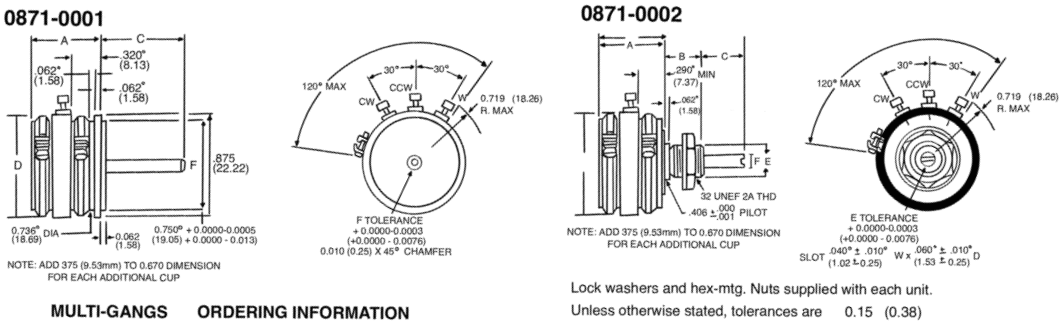
Models 7501 meets, or exceeds, all of the environmental and life requirements of MIL-R-12934.

Standard Resistance Value Available (Ω)	Nominal Resolution (%)
50	0.44
100	0.36
250	0.23
500	0.22
1K	0.22
5K	0.12
10K	0.096
50K	0.062

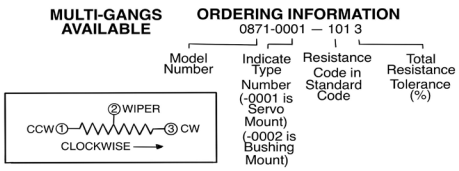
Precision Potentiometers

0871 Series—⅞ ” Diameter Wirewound, Single-Turn Servo/Bushing Mount

(Commercial Equivalent of RR0900/RR3100)



MULTI-GANGS ORDERING INFORMATION



DIMENSIONS						
	Length			Diameter		
Model	A (Body)	B (Bushing)	C(Shaft)	D (Overall)	E (Bushing)	F (Shaft)
0871-0001	.670”(17.02)	—	.500”(12.70)	.875”(22.22)	—	.125”(3.17)
0871-0002	.645”(16.38)	.250”(6.35)	.250”(6.35)	.875”(22.22)	.375”(9.53)	.125”(3.17)

SPECIFICATIONS

ELECTRICAL	STANDARD
Power Rating	1.25W @ 70°C
Standard Resistance Range	100Ω to 50KΩ
Resistance Tolerance	±3% std
Temperature Coefficient (wire)	±20ppm/°C max
Linearity (independent)	±0.5%
Noise During Adjustment	100Ω max.
Dielectric Strength	MIL-R-12934
Insulation Resistance	1000MΩ min @ 500 VDC

MECHANICAL	STANDARD
Operating Temperature Range	-65 to +125 °C
Mechanical Angle	Continuous
Operating Torque	0.30 Oz-in. (.009N*m) max. (Add 75% each cup)
Starting Torque	0.30 Oz-in. (.009N*m) max
Electrical Travel	350 ±2°
Shaft Runout T.I.R	0.001” (.25)
Shaft End Play T.I.R	0.005” (.127)
Shaft Radical Play	0.002” (0.51) T.I.R
Pilot Surface Runout T.I.R	0.002” (0.51)
Lateral Runout	0.002” (0.51) T.I.R
Rotation Life	1,000,000 shaft revolutions
Terminals	Gold Plated Turrets

ENVIRONMENTAL

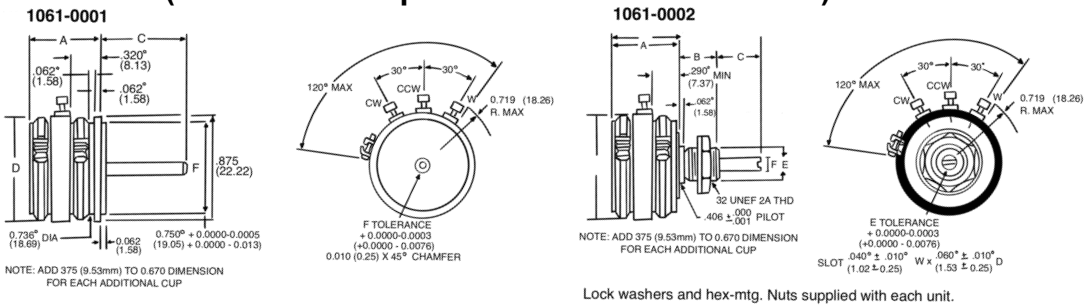
Models 0871-0001 and 0871-002 meet, or exceed all requirements of MIL-R-12934.

Standard Resistance Value Available (Ω)	Nominal Resolution (%)
50	0.292
100	0.233
250	0.173
500	0.152
1K	0.149
5K	0.107
10K	0.090
20K	0.070
50K	0.059

Precision Potentiometers

1061 Series—1 1/16” Diameter Wirewound, Single-Turn Servo/Bushing Mount

(Commercial Equivalent of RR1100/RR3200)



Lock washers and hex-mtg. Nuts supplied with each unit.
Unless otherwise stated, tolerances are 0.15 (0.38)

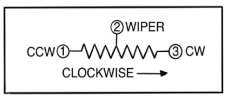
MULTI-GANGS ORDERING INFORMATION

MULTI-GANGS AVAILABLE

ORDERING INFORMATION

1061-0001 — 101 3

Model Number | Indicate Type Number (-0001 is Servo Mount) (-0002 is Bushing Mount) | Resistance Code in Standard Code | Total Resistance Tolerance (%)



DIMENSIONS						
Length				Diameter		
Model	A (Body)	B (Bushing)	C(Shaft)	D (Overall)	E (Bushing)	F (Shaft)
1061-0001	.670”(17.02)	—	.875”(22.23)	1.062”(29.97)	—	.125”(3.17)
1061-0002	.645”(16.38)	.375”(9.53)	.500”(12.70)	1.062”(29.97)	.375”(9.53)	.125”(3.17)

SPECIFICATIONS

ELECTRICAL	STANDARD
Power Rating	1.5W @ 70°C
Standard Resistance Range	50Ω to 50KΩ
Resistance Tolerance	±3% std
Temperature Coefficient (wire)	±20ppm/°C max
Linearity (independent)	±0.5%
Noise During Adjustment	100Ω max.
Dielectric Strength	MIL-R-12934
Insulation Resistance	1000MΩ min @ 500 VDC

MECHANICAL	STANDARD
Operating Temperature Range	-65 to +125 °C
Mechanical Angle	Continuous
Operating Torque	0.30 Oz-in. (.009N*m) max. (Add 75% each cup)
Starting Torque	0.50 Oz-in. (.009N*m) max
Electrical Travel	350 ±2°
Shaft Runout T.I.R	0.001” (.25)
Shaft End Play T.I.R	0.005” (.127)
Shaft Radical Play	0.002” (0.51) T.I.R
Pilot Surface Runout T.I.R	0.0015” (0.038)
Lateral Runout	0.002” (0.51) T.I.R
Rotation Life	1,000,000 shaft revolutions
Terminals	Gold Plated Turrets

ENVIRONMENTAL

Models 1061-0001 and 1061-002 meet, or exceed all requirements of MIL-R-12934.

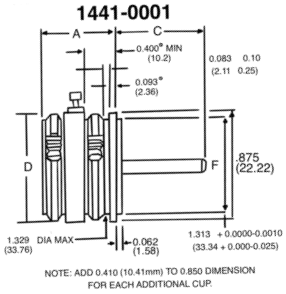
Standard Resistance Value Available (Ω)	Nominal Resolution (%)
50	0.301
100	0.231
200	0.188
500	0.140
1K	0.115
2K	0.131
5K	0.106
10K	0.085
20K	0.062
50K	0.052

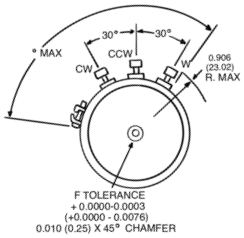
Precision Potentiometers

1441 Series—1 7/16” Diameter Wirewound, Single-Turn Servo/Bushing Mount

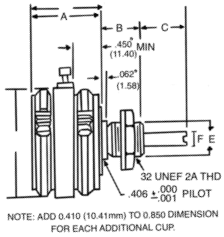
(Commercial Equivalent of RR1300/RR3300)

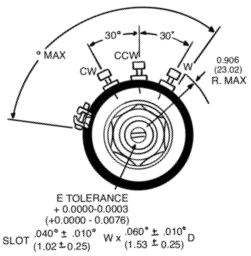
1441-0001





1441-0002



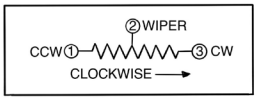


Lock washers and hex-mtg. Nuts supplied with each unit.
Unless otherwise stated, tolerances are 0.15 (0.38)

MULTI-GANGS ORDERING INFORMATION

DIMENSIONS						
Length				Diameter		
Model	A (Body)	B (Bushing)	C(Shaft)	D (Overall)	E (Bushing)	F (Shaft)
1061-0001	.670”(17.02)	—	.875”(22.23)	1.062”(29.97)	—	.125”(3.17)
1061-0002	.645”(16.38)	.375”(9.53)	.500”(12.70)	1.062”(29.97)	.375”(9.53)	.125”(3.17)

MULTI-GANGS AVAILABLE



ORDERING INFORMATION

1441– 0002 — 101 3

- Model Number
- Indicate Type Number (-0001 is Servo Mount) (-0002 is Bushing Mount)
- Resistance Code in Standard Code
- Total Resistance Tolerance (%)

SPECIFICATIONS

ELECTRICAL

	STANDARD
Power Rating	2.0W @ 70°C
Standard Resistance Range	50Ω to 50KΩ
Resistance Tolerance	±3% std
Temperature Coefficient (wire)	±20ppm/°C max
Linearity (independent)	±0.5%
Noise During Adjustment	100Ω max.
Dielectric Strength	MIL-R-12934
Insulation Resistance	1000MΩ min @ 500 VDC

MECHANICAL

	STANDARD
Operating Temperature Range	-65 to +150 °C
Mechanical Angle	Continuous
Operating Torque	0.30 Oz-in. (.009N*m) max. (Add 75% each cup)
Starting Torque	0.50 Oz-in. (.009N*m) max
Electrical Travel	350 ±2°
Shaft Runout T.I.R	0.001” (.25)
Shaft End Play T.I.R	0.005” (.127)
Shaft Radical Play	0.002” (0.51) T.I.R
Pilot Surface Runout T.I.R	0.0015” (0.038)
Lateral Runout	0.002” (0.51) T.I.R
Rotation Life	1,000,000 shaft revolutions
Terminals	Gold Plated Turrets

ENVIRONMENTAL

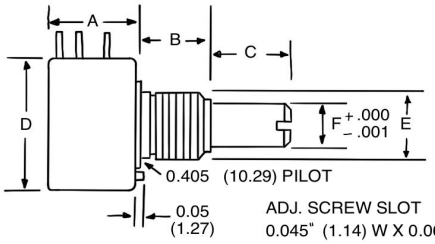
Models 1441-0001 and 1441-002 meet, or exceed all requirements of MIL-R-12934.

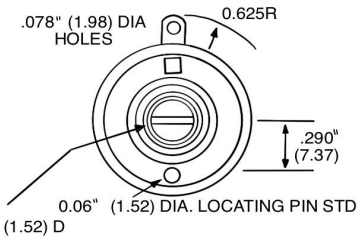
Standard Resistance Value Available (Ω)	Nominal Resolution (%)
50	0.258
100	0.201
200	0.172
500	0.143
1K	0.106
2K	0.087
5K	0.093
10K	0.072
20K	0.058
40K	0.044 (50K available)

Precision Potentiometers

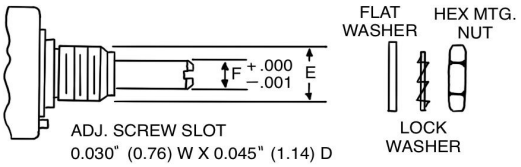
8400/8500 Series— ⅞ ” Diameter Wirewound, Multi-Turn Bushing Mount

8400, 8403, 8405





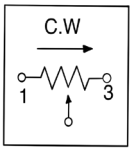
8500, 8503, 8505



DIMENSIONS							
Length					Diameter		
Model	Turns	A (Bosy)	B (Bushing)	C(Shaft)	D (Overall)	E (Bushing)	F (Shaft)
8400	10	1.125”(28.58)	.312”(7.92)	.500”(12.70)	.875”(22.23)	.375”(9.53)	.250”(6.35)
8500	10	1.125”(28.58)	.312”(7.92)	.500”(12.70)	.875”(22.23)	.250”(6.35)	.125”(3.18)
8403	3	.641”(17.28)	.312”(7.92)	.500”(12.70)	.875”(22.23)	.375”(9.53)	.250”(6.35)
8503	3	.641”(17.28)	.312”(7.92)	.500”(12.70)	.875”(22.23)	.250”(6.35)	.125”(3.18)
8405	5	.765”(19.43)	.312”(7.92)	.500”(12.70)	.875”(22.23)	.375”(9.53)	.250”(6.35)
8505	5	.765”(19.43)	.312”(7.92)	.500”(12.70)	.875”(22.23)	.250”(6.35)	.125”(3.18)

MULTI-GANGS AVAILABLE UP TO THREE SECTIONS

Lock washers and heat-mtg. Nuts supplied with each unit. Unless otherwise stated, tolerances are ± 0.015" (0.38)



ORDERING INFORMATION

8500 — 50K

Indicate Type Number — Indicate Resistance Value

SPECIFICATIONS

ELECTRICAL

	STANDARD
Power Rating	8400/85000W- 3W @ 70°C 8403/8503, 8405/8505-2W @ 40°C
Standard Resistance Range	8400/8500 100Ω -100KΩ 8403/8503, 8405/8505- 50Ω to 50KΩ
Resistance Tolerance	±5% std
Temperature Coefficient (wire)	±20ppm/°C max
Linearity (independent)	8400/8500 — ±0.25% 8403/8503 — ±0.5% 8405/8505 — ±0.5%
Noise During Adjustment	100Ω max.
Absolute Minimum Resistance	2Ω or 0.25% (W.I.G)
Insulation Resistance	1000MΩ min @ 500 VDC

MECHANICAL

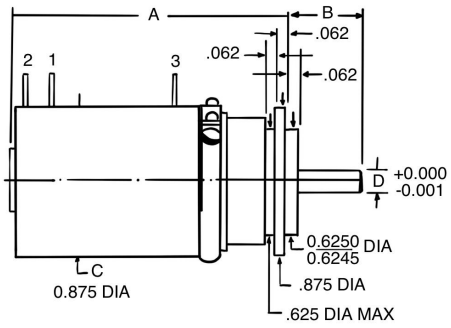
	STANDARD
Operating Temperature Range	-55 to +125 °C
Total Adjustment Torque	8400/8500–10; 8403/8503–3; 8405/8505–5
Mechanical Rotation	Same as electrical rotation
Operating Torque	1.0 Oz-in. Max
Mechanical Stops	48 Oz-in. Min.
Electrical Travel	8400/8500–3600° (10°-0°) 8403/8503–1080° (10°-0°) 8405/8505–1800° (10°-0°)

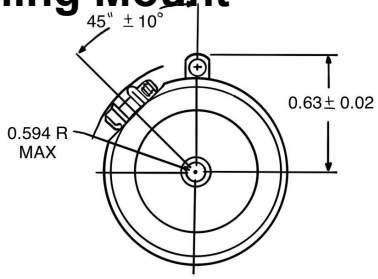
ENVIRONMENTAL

Standard Resistance Value Available (Ω)	Nominal Resolution (%)	
	8400/8500	8403/8503 8405/8505
50	—	0.153
100	0.062	0.119
200	0.046	0.113
500	0.036	0.074
1K	0.030	0.070
2K	0.025	0.047
5K	0.018	0.047
10K	0.015	0.041
20K	0.015	0.030
30K	0.011	0.025
50K	0.010	0.025
100K	0.009	—

Precision Potentiometers

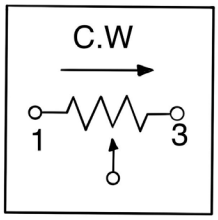
8400/8500 Series— ⅞ ” Diameter Wirewound, Multi-Turn Bushing Mount





DIMENSIONS					
Length				Diameter	
Model	Turns	A (Body)	B (Bushing)	C (Body)	D(Shaft)
8400-001	10	1.583”(40.2)	.500”(12.70)	.875”(22.23)	.250”(6.35)
8500-001	10	1.583”(40.2)	.500”(12.70)	.875”(22.23)	.125”(3.18)
8403-001	3	1.099”(27.91)	.500”(12.70)	.875”(22.23)	.250”(6.35)
8503-001	3	1.099”(27.91)	.500”(12.70)	.875”(22.23)	.125”(3.18)
8405-001	5	1.224”(31.09)	.500”(12.70)	.875”(22.23)	.250”(6.35)
8505-001	5	1.224”(31.09)	.500”(12.70)	.875”(22.23)	.125”(3.18)

MULTI-GANGS AVAILABLE UP TO THREE SECTIONS



ORDERING INFORMATION

8500 — 001 — 50K

Indicate Type Number

Indicate Resistance Value

SPECIFICATIONS

ELECTRICAL

	STANDARD
Power Rating	8400/85000W- 3W @ 70°C 8403/8503, 8405/8505-2W @ 40°C
Standard Resistance Range	8400/8500 100Ω -100KΩ 8403/8503, 8405/8505- 50Ω to 50KΩ
Resistance Tolerance	±5% std
Temperature Coefficient (wire)	±20ppm/°C max
Linearity (independent)	8400/8500 — ±0.25% 8403/8503 — ±0.5% 8405/8505 — ±0.5%
Noise During Adjustment	100Ω max.
Absolute Minimum Resistance	2Ω or 0.25% (W.I.G)
Insulation Resistance	1000MΩ min @ 500 VDC

MECHANICAL

	STANDARD
Operating Temperature Range	-55 to +125 °C
Total Adjustment Torque	8400/8500–10; 8403/8503–3; 8405/8505–5
Mechanical Rotation	Same as electrical rotation
Operating Torque	1.0 Oz-in. Max
Mechanical Stops	48 Oz-in. Min.
Electrical Travel	8400/8500–3600° (10°-0°) 8403/8503–1080° (10°-0°) 8405/8505–1800° (10°-0°)

ENVIRONMENTAL

Models 8400, 8405, 8500, 8503, 8505 meet, or exceed, all of the environmental and life requirements of MIL-R-12934

Standard Resistance Value Available (Ω)	Nominal Resolution (%)	
	8400/8500	8403/8503 8405/8505
50	—	0.153
100	0.062	0.119
200	0.046	0.113
500	0.036	0.074
1K	0.030	0.070
2K	0.025	0.047
5K	0.018	0.047
10K	0.015	0.041
20K	0.015	0.030
30K	0.011	0.025
50K	0.010	0.025
100K	0.009	—