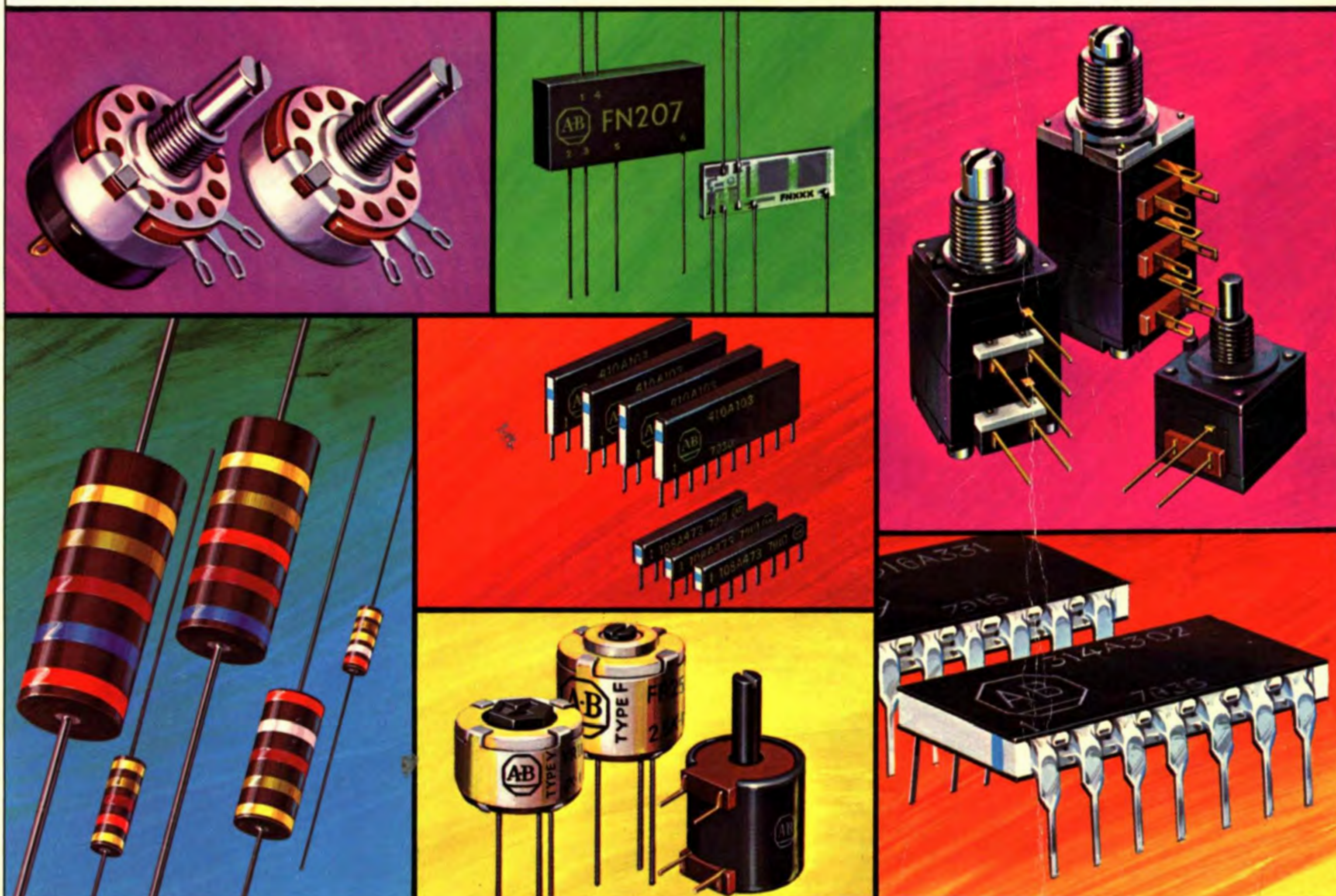
electronic components



electronic components

comprehensive product index

(continued on next page)

■ Suited for adjustable attenuator applications. Details in adjustable attenuator section.

PRODUCT INDEX:

by product category and type identification

FIXED RESISTORS

Type	Product Description	Publication Reference [1] Number	Page No.
BB	Hot-Molded (RCR05)	EC5021-2.1	10
CB	Hot-Molded (RCR07)	EC5021-2.1	10
EB	Hot-Molded (RCR20)	EC5021-2.1	10
GB	Hot-Molded (RCR32)	EC5021-2.1	10
GM	Metal Clad Hot-Molded	EC5021-2.1	16
HB	Hot-Molded (RCR42)	EC5021-2.1	10
HM	Metal Clad Hot-Molded	EC5021-2.1	16

RESISTOR NETWORKS

Type	Product Description	Publication Reference [1] Number	Page No.
Series FN	Custom Precision (Thin Film)	EC5510-2.1	41
Series FN207 FNPC207	Standard Voltage Divider (Precision Thin Film)	EC5515-2.1	51
Series 100-400	Cermet (Thick Film)	EC5420-2.1	59
Series 314-316	Cermet (Thick Film)	EC5410-2.1	63

PANEL POTENTIOMETERS

Type	Product Description	Publication Reference [1] Number	Page No.
G	Hot-Molded (0.5 watt)	EC5605-2.1	83
[2] J	Hot-Molded (2.25 watts)	EC5607-2.1	91
K	Hot-Molded (3 watts)	EC5608-2.1	100
L	Hot-Molded (0.8 watt)	EC5609-2.1	108
M	Conductive Plastic (0.1 watt)	EC5610-2.1	114
W	Hot-Molded (0.5 watt)	EC5612-2.1	118
EJ	Hot-Molded (Extra Life)	EC5620-2.1	124
[2] GD	Hot-Molded (0.5 watt)	EC5630-2.1	128
SP	Cermet (1 watt)	EC5640-2.1	132
WR	Hot-Molded (0.5 watt)	EC5650-2.1	136
Series 70 MOD POT®	Hot-Molded, Cermet Conductive Plastic, Metal Shaft and Bushing	EC5670-2.1	142
Series 72 MOD POT®	Hot-Molded, Cermet Conductive Plastic, Plastic Shaft and Bushing	EC5670-2.1	142
Series 73 MOD POT®	Hot-Molded, Cermet Conductive Plastic, Metal Shaft and Metal Bushing Molded into Plastic Face Plate	EC5670-2.1	142

TRIMMING POTENTIOMETERS

Type	Product Description	Publication Reference [1] Number	Page No.
F	Hot-Molded, Single Turn	EC5806-2.1	166
N	Hot-Molded, Multi-Turn	EC5815-2.1	170
R	Hot-Molded, Multi-Turn	EC5820-2.1	173
S	Cermet, Single Turn	EC5720-2.1	160
Y	Hot-Molded, Single Turn	EC5828-2.1	177
[2] BT	Hot-Molded, Single Turn	EC5920-2.1	192
[2] FD	Hot-Molded, Single Turn, Dual	EC5838-2.1	181
90	Cermet, Single Turn	EC5770-2.1	163

ADJUSTABLE ATTENUATORS

Type	Product Description	Publication Reference [1] Number	Page No.
J	Hot-Molded Bridged-T-Pads (5 watts) Bridged-H-Pads (5 watts) L-Pads (2.25 watts) Straight-T-Pads (2.25 watts)	EC5910-2.1	188
BT	Hot-Molded Bridged-T-Pads (0.25 watt)	EC5920-2.1	192
FD	Hot-Molded Bridged-T-Pads (0.5 watt) L-Pads (0.25 watt)	EC5930-2.1	196
GD	Hot-Molded Bridged-T-Pads (1 watt) L-Pads (0.5 watt)	EC5930-2.1	196
MOD POT®	Hot-Molded Bridged-T-Pads (1 watt) Bridged-H-Pads (1 watt) L-Pads (0.5 watt) Straight-T-Pads (0.5 watt)	EC5670-2.1	142

[1] Separate copies of individual product Technical Publications are available. Please order by noted Publication number(s) from Catalog Service Department.

[2] Suited for adjustable attenuator applications. Details in adjustable attenuator section.

PRODUCT INDEX:

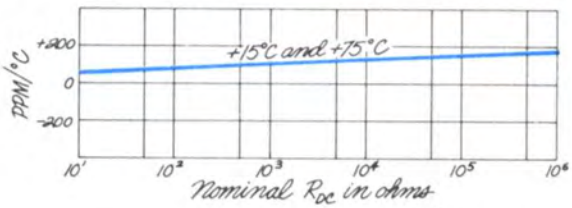
by type identification and product category

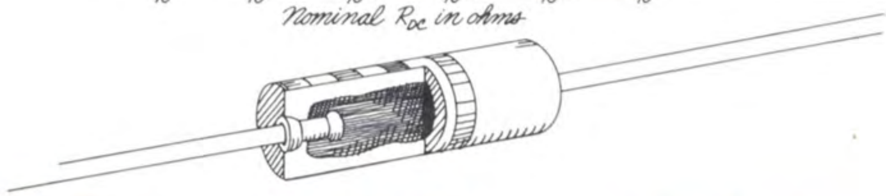
publication reference to product type and category

Publication Reference Number	Type/Product Category	Publication Reference Number	Type/Product Category
EC5021-2.1	Type BB, CB, EB, GB, HB, GM, HM, Fixed Resistors (Hot-Molded)	EC5640-2.1	Type SP, Panel Potentiometer
EC5410-2.1	Series 314-316, Thick Film Networks	EC5650-2.1	Type WR, Panel Potentiometer
EC5420-2.1	Series 100-400, Thick Film Networks	EC5670-2.1	Series 70, 72, 73 Panel Potentiometers/ Adjustable Attenuators
EC5510-2.1	Series FN, Thin Film Network	EC5720-2.1	Type S, Trimming Potentiometer
EC5515-2.1	Series FN207, FNPC207, Thin Film Networks (Standard Voltage Divider)	EC5770-2.1	Type 90, Trimming Potentiometer
EC5605-2.1	Type G, Panel Potentiometer	EC5806-2.1	Type F, Trimming Potentiometer
EC5607-2.1	Type J, Panel Potentiometer	EC5815-2.1	Type N, Trimming Potentiometer
EC5607-2.2	Type J, Panel Potentiometer/Vernier	EC5820-2.1	Type R, Trimming Potentiometer
EC5608-2.1	Type K, Panel Potentiometer	EC5828-2.1	Type Y, Trimming Potentiometer
EC5609-2.1	Type L, Panel Potentiometer	EC5838-2.1	Type FD, Trimming Potentiometer/ Adjustable Attenuator
EC5610-2.1	Type M, Panel Potentiometer	EC5910-2.1	Type J, Adjustable Attenuator
EC5612-2.1	Type W, Panel Potentiometer	EC5920-2.1	Type BT, Adjustable Attenuator/Trimming Potentiometer
EC5620-2.1	Type EJ, Panel Potentiometer	EC5930-2.1	Type FD, GD, Adjustable Attenuators
EC5630-2.1	Type GD, Panel Potentiometer/ Adjustable Attenuator		

Hot-molded resistors provide low temperature coefficient and unmatched reliability.

The Resistance Temperature Coefficient of Allen-Bradley hot-molded fixed resistors is typically less than 200 PPM over the entire resistor range shown in the normal equipment operating temperature of +15°C to +75°C. Excellent RTC ratings have always been an Allen-Bradley benefit. And consistency of Allen-Bradley resistors means repeatable results and tight performance patterns. Allen-Bradley resistors offer the **lowest cost—on the board**—where it counts!

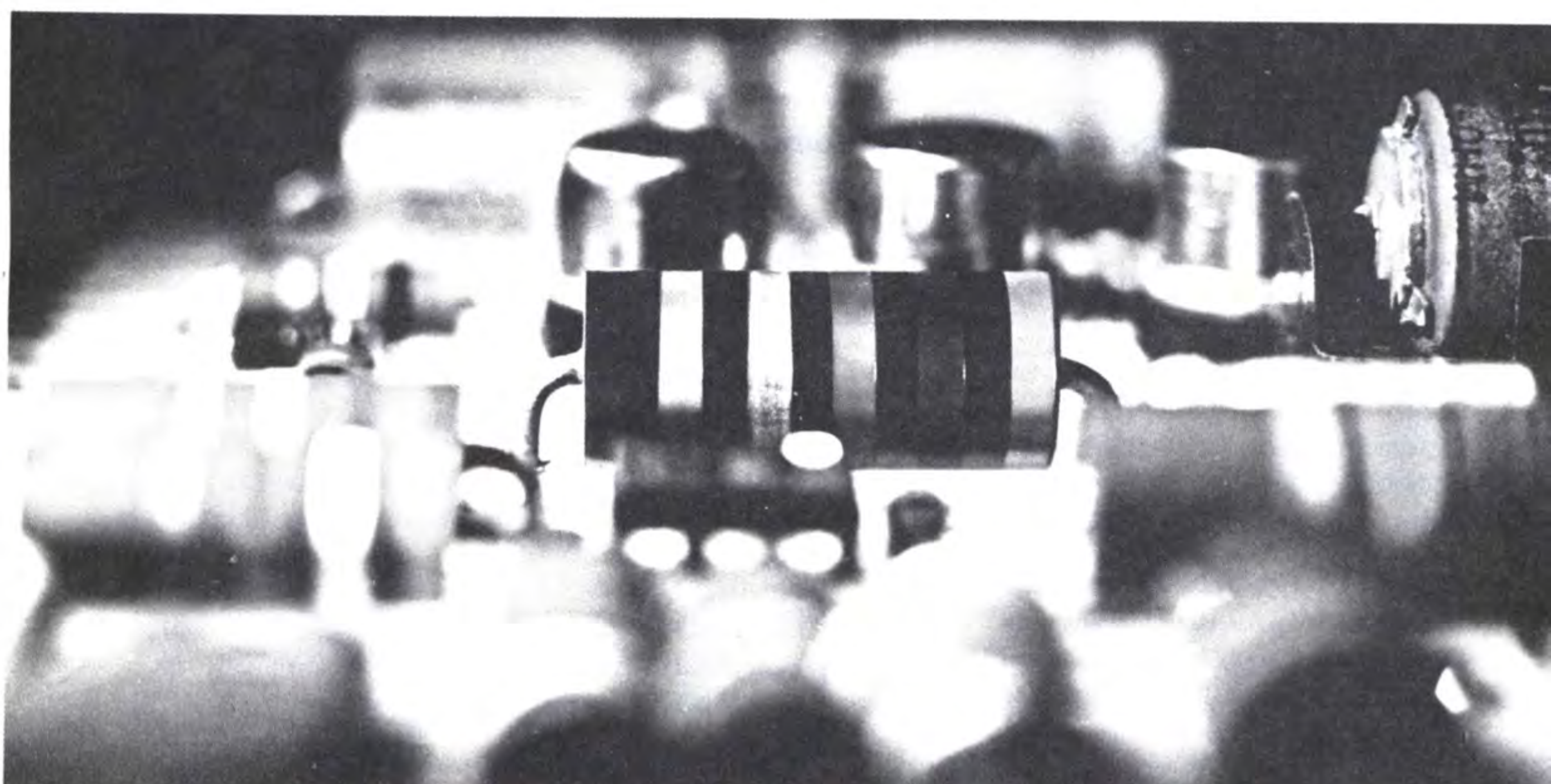




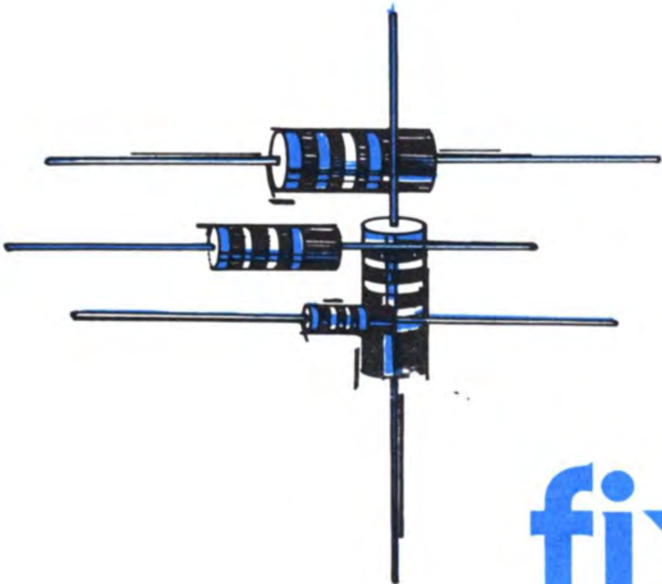
Reliability is unsurpassed. Over 950 million unit test hours without a single failure.

No coatings Insulation and resistance element integrally molded into one solid structure.

Pulse handling characteristics offer outstanding protection against surges and transients.



Quality in the best tradition.



fixed resistors

HOT-MOLDED COMPOSITION

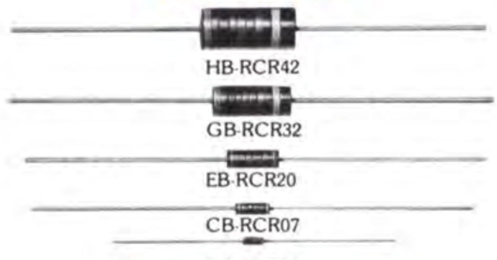
comprehensive product index

1 HOT-MOLDED COMPOSITION RESISTORS, IN STANDARD RESISTANCE VALUES, ARE AVAILABLE FROM STOCK AT ELECTRONIC DISTRIBUTORS.

2 NOT AVAILABLE FROM ELECTRONIC DISTRIBUTORS.

3 REEL PACKAGING CAN BE ORDERED THROUGH ELECTRONIC DISTRIBUTORS.

HOT-MOLDED



NOT TO SCALE

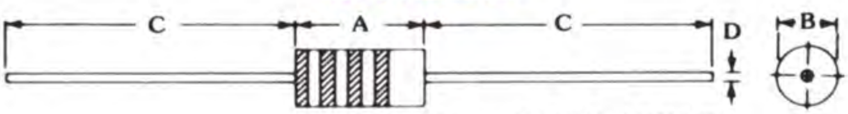
Approved: Allen-Bradley Style RCR resistors not only meet all requirements of MIL-R-39008 but also exceed the S level (best level) of Established Reliability of 0.001% failure rate per 1000 hours. And only Allen-Bradley resistors are available in S level reliabiity in all five wattage sizes over the entire resistance range. The S reliability level is indicated by a yellow 5th color band on the resistor body.

SELECTOR GUIDE

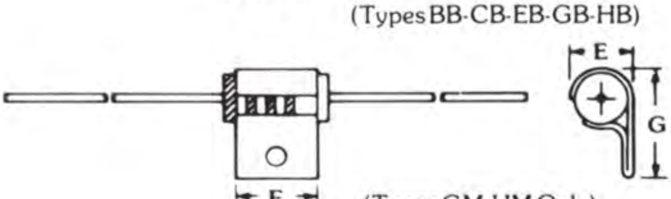
Type	Power at 70° C	Resistance Range	Tolerance	Voltage Rating (RMS)	Maximum Ambient Temperature	Dimensions In Inches (millimeters)							Page No.
						A	B	C	D	E	F	G	
Hot-Molded													
BB	⅛ Watt	2.7 Ohms to 100 Megohms	±5, 10, 20%	150V	+130° C	0.145 (3,68)	0.062 (1,59)	1.000 (25,40)	0.015 (0,38)				10
RCR05		2.7 Ohms to 22 Megohms	±5, 10%										
CB	¼ Watt	2.7 Ohms to 100 Megohms	±5, 10, 20%	250V	+150° C	0.250 (6,35)	0.090 (2,29)	1.500 (38,10)	0.025 (0,64)				10
RCR07		2.7 Ohms to 22 Megohms	±5, 10%										
EB	½ Watt	1.0 Ohm to 100 Megohms	±5, 10, 20%	350V		0.375 (9,52)	0.140 (3,56)	1.500 (38,10)	0.033 (0,84)				10
RCR20		1.0 Ohm to 22 Megohms	±5, 10%										
GB	1 Watt	1.0 Ohm to 100 Megohms	±5, 10, 20%	500V		0.562 (14,29)	0.225 (5,72)	1.500 (38,10)	0.041 (1,04)				10
RCR32		2.7 Ohms to 22 Megohms	±5, 10%										
HB	2 Watts	10 Ohms to 100 Megohms	±5, 10, 20%	750V		0.688 (17,46)	0.312 (7,94)	1.500 (38,10)	0.045 (1,14)				10
RCR42		10 Ohms to 22 Megohms	±5, 10%	500V									
GM	3 Watts	2.7 Ohms to 22 Megohms	±5, 10%	500V		0.562 (14,29)	0.225 (5,72)	1.500 (38,10)	0.041 (1,04)	0.305 (7,75)	0.438 (11,11)	0.656 (16,67)	16
HM	4 Watts	10 Ohms to 22 Megohms		750V		0.688 (17,46)	0.312 (7,94)	1.500 (38,10)	0.045 (1,14)	0.391 (9,92)	0.562 (14,29)	0.766 (19,45)	16

DIMENSIONS

HOT-MOLDED



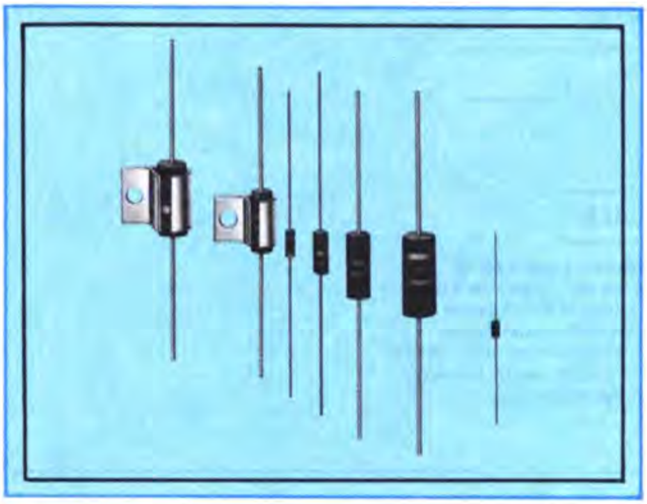
(Types BB-CB-EB-GB-HB)



(Types GM-HM Only)

Types BB, CB, EB, GB, HB, GM, HM Hot-Molded Fixed Resistors

1/8, 1/4, 1/2, 1, and 2 Watts (70° C)
1 Ohm to 1 Teraohm
± 5%, ± 10%, and ± 20% Tolerance



FEATURES

- Reliable
- Uniform Quality
- Predictable Performance
- Conservative Ratings
- Rugged Construction

Outstanding characteristics

Uniform quality — Consistent performance for over 35 years, no difference in quality regardless of value, rating or tolerance purchased: One grade — the finest.

Reliable — Recognized as the **most** reliable of all electronic components, Allen-Bradley hot-molded resistors provide freedom from catastrophic failure when used within ratings.

Predictable performance — Because of their outstanding uniformity, Allen-Bradley hot-molded resistors exhibit consistent responses to environment and loading.

Conservative ratings — All performance specifications are based on extensive testing and massive field experience.

Rugged construction — The solid, integral structure, combining leads, insulation, and resistance material in the exclusive Allen-Bradley hot-molding process provides exceptional strength and resistance to damage in automatic handling machinery.

Wide range of values — Available in standard preferred number values from 1 ohm to 100 megohms. Special values available on request.

High resistance values — Resistance values from 100 megohms to 1 million megohms (1 teraohm) are available on special order, in Types BB, CB, and EB.

Solderable/weldable leads — Hot solder coated leads remain easy to solder even after long periods in stock. The oxygen-free copper leads are readily weldable and allow considerable weld-schedule latitude. Stocking of resistors with two different lead materials is unnecessary.

Tracking — Allen-Bradley resistors exhibit extremely uniform tracking characteristics. For example, in flip-flop circuits, resistors used in pairs which are drawn from the same package or reel (a normal mass production practice) will track with each other throughout changes of temperature, humidity, and load. This assures reliable circuit performance throughout the design life of the equipment.

Durable color coding — Baked-on color code paints are resistant to solvents, and also resist the abrasion and chipping associated with automatic handling. They remain bright and easily readable even after long periods of use.

Temperature stable — Between 0° C and 85° C, Allen-Bradley hot-molded resistors exhibit a very low temperature characteristic, typically less than two percent deviation from room temperature values, less in low resistance values.

Outstanding features

All measurements made at room temperature except during Temperature Characteristics Test and Load Life Test.

For specific conditions such as mounting, test procedures, sequence of tests, etc., refer to Allen-Bradley Publication EC5021-2.2. Applicable test procedure numbers are listed in brackets [ ] below.

Characteristics		Hot-Molded Fixed Resistors 1/8 Watt Type BB	1/4 Watt Type CB	1/2 Watt Type EB	1 Watt Type GB	2 Watt Type HB
Standard Resistance Range [1] Nominal EIA and MIL Values (See Page 20)		2.7 ohms to 100 megohms	2.7 ohms to 100 megohms	1.0 ohm to 100 megohms	1.0 ohm to 100 megohms	10 ohms to 100 megohms
Standard Tolerances		± 5%, ±10%, ± 20%	±5%, ±10%, ± 20%	±5%, ±10%, ± 20%	± 5%, ±10%, ± 20%	±5%, ±10%, ± 20%
Power Rating Maximum continuous rated watts at 70° C ambient based on Load Life Test **[6.12]**		0.125 watt	0.25 watt	0.5 watt	1.0 watt	2.0 watts
Rated Continuous Working Voltage (RCWV) Based on nominal resistance (R) in ohms		$\sqrt{0.125 \times R}$ or 150 volts, whichever is less.	$\sqrt{0.25 \times R}$ or 250 volts, whichever is less.	$\sqrt{0.5 \times R}$ or 350 volts, whichever is less.	$\sqrt{1.0 \times R}$ or 500 volts, whichever is less.	$\sqrt{2.0 \times R}$ or 750 volts, whichever is less.
Maximum Ambient Temperature Power rating derated linearly to zero at this temperature		+ 130° C	+ 150° C	+ 150° C	+ 150° C	+ 150° C
Weight (Approximate)	Resistor with nominal length leads	0.077 gm	0.28 gm	0.61 gm	1.45 gm	2.80 gm
	Leads (per millimeter)	1,2 mg/mm	2,9 mg/mm	5,0 mg/mm	8,0 mg/mm	9,4 mg/mm

[1] MIL-R-39008B Resistance Range
2.7 ohms to 22 megohms for 1/8, 1/4, and 1 watt
1 ohm to 22 megohms for 1/2 watt
10 ohms to 22 megohms for 2 watts

Performance characteristics

Characteristics		Hot-Molded Fixed Resistors 1/8 Watt Type BB	1/4 Watt Type CB	1/2 Watt Type EB	1 Watt Type GB	2 Watt Type HB
Insulation Resistance [6.6] Minimum		10,000 megohms	10,000 megohms	10,000 megohms	10,000 megohms	10,000 megohms
Dielectric Withstanding Voltage [6.5]	At Sea Level Atmospheric Press.	300 volts	500 volts	700 volts	1000 volts	1500 volts
	At 3.4" (86,36 mm) Hg (Simulated 50,000 ft. [15240 meters])	200 volts	325 volts	450 volts	625 volts	625 volts
Resistance-Voltage Coefficient [6.4] Maximum instantaneous change in resistance per volt based on ΔR for ΔV of (1.0−0.1) RCWV. **Nominal Resistance** (ohms)	10K	− 0.020%/volt	− 0.015%/volt	− 0.010%/volt	− 0.007%/volt	− 0.010%/volt
	100K	− 0.030	− 0.020	− 0.015	− 0.012	− 0.015
	1 Meg	− 0.045	− 0.025	− 0.020	− 0.015	− 0.020
	10 Meg	− 0.050	− 0.030	− 0.030	− 0.020	− 0.020
	22 Meg	− 0.050	− 0.035	− 0.035	− 0.020	− 0.020
	100 Meg	− 0.055	− 0.035	− 0.035	− 0.025	− 0.025
Load Life [6.12] 1000 hours operating at RCWV at 70° C ambient for duty cycle of 1½ hour "on", ½ hour "off". Permanent resistance change.	Maximum	+ 4% − 6	+ 4% − 6	+ 4% − 6	+ 4% − 6	+ 4% − 6
	Typical	− 3%	− 3%	− 3%	− 3%	− 3%
Load Life (temperature-derated) 1000 hours (1½ hour "on", ½ hour "off") at RCWV derated per temperature according to chart on Page 13. Tested at temperatures between 70° C and maximum ambient temperature. Permanent resistance change. [**6.12** modified with respect to voltage applied, as described above.]	Maximum	+ 4% − 6	+ 4% − 6	+ 4% − 6	+ 4% − 6	+ 4% − 6
	Typical	− 4%	− 4%	− 4%	− 4%	− 4%

Performance characteristics

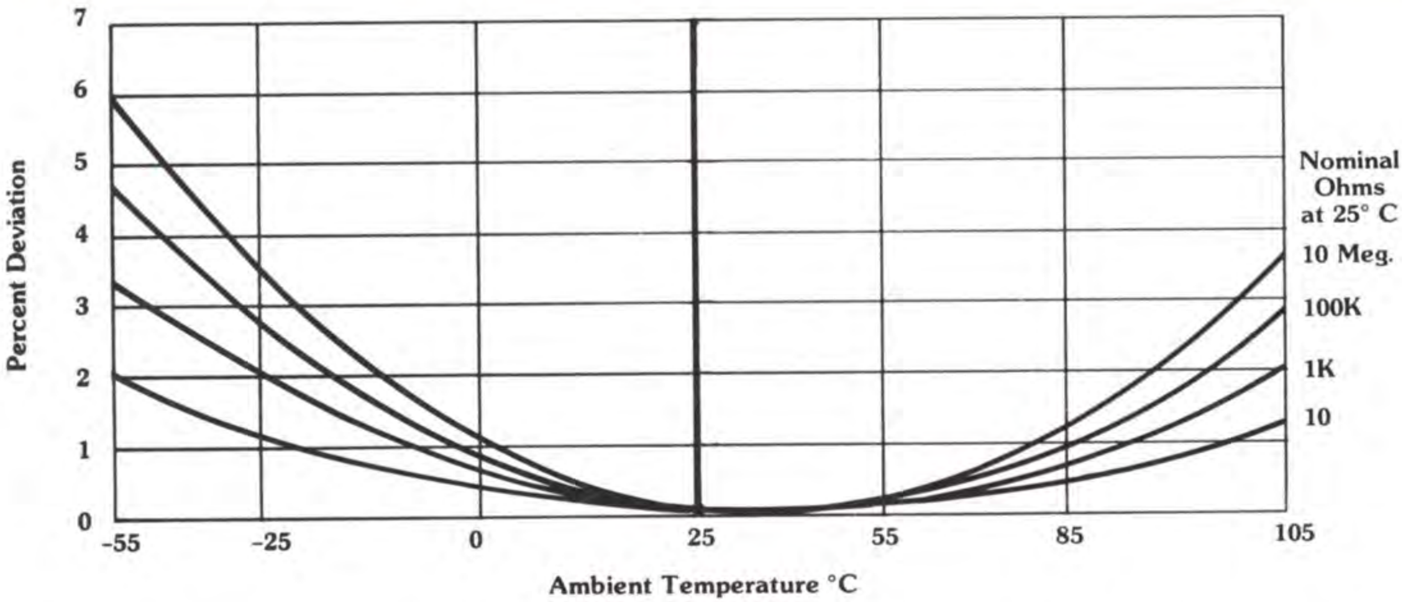
Characteristics			Hot-Molded Fixed Resistors ⅛ Watt Type BB	¼ Watt Type CB	½ Watt Type EB	1 Watt Type GB	2 Watt Type HB
Short-Time Overload [6.11] 5 seconds at 2½ times RCWV; voltage limit as stated. Maximum permanent resistance change.	Voltage Limits		200 volts	400 volts	700 volts	1000 volts	1000 volts
	Maximum		±(2.5% + 0.05 ohm)	±(2% + 0.05 ohm)	±(1% + 0.05 ohm)	±(1% + 0.05 ohm)	±(1% + 0.05 ohm)
	Typical		+ 0.5%	+ 0.5%	+ 0.5%	+ 0.5%	+ 0.5%
Terminal Strength [6.13] 5 lb. (2,27 Kgm) Pull Test. Three turn Twist Test. Maximum permanent resistance change.			±(1% + 0.05 ohm) (2 lb. Pull Test) (0.91 Kgm)	±(1% + 0.05 ohm)	±(1% + 0.05 ohm)	±(1% + 0.05 ohm)	±(1% + 0.05 ohm)
Effect of Solder Heat [6.14] Leads immersed to .125 in. (3,18 mm) of body in 350°C solder for 3 seconds. Maximum permanent resistance change.			±(2% + 0.05 ohm) (250°C Solder)	±(2% + 0.05 ohm)	±(3% + 0.05 ohm)	±(3% + 0.05 ohm)	±(3% + 0.05 ohm)
Vibration [6.17] 10-2000 Hz, 0.06 inch (1,52 mm) peak-to-peak or 20G, whichever is less.	Mechanical or Electrical Damage		No Damage	No Damage	No Damage	No Damage	No Damage
	Maximum Permanent Resistance Change		±(1% + 0.05 ohm)	±(1% + 0.05 ohm)	±(1% + 0.05 ohm)	±(1% + 0.05 ohm)	±(1% + 0.05 ohm)
Shock [6.16] 100g, 6 ms, sawtooth, 10 shocks, 2 planes.	Mechanical or Electrical Damage		No Damage	No Damage	No Damage	No Damage	No Damage
	Maximum Permanent Resistance Change		±(2% + 0.05 ohm)	±(2% + 0.05 ohm)	±(2% + 0.05 ohm)	±(2% + 0.05 ohm)	±(2% + 0.05 ohm)
Moisture Resistance [6.9] Temporary resistance change. See comment on Page 14.	Maximum		+15 −0 %	+12 −0 %	+14 −0 %	+8 −0 %	+7 −0 %
	Typical		+ 9%	+ 6%	+ 7%	+ 5%	+ 4%
Humidity Characteristic (steady state) [6.10] 240 hours at +40° C and 95% relative humidity. Temporary resistance change. **Nominal Resistance** (ohms)	10	Maximum	+8 −0 %	+5 −0 %	+4 −0 %	+3 −0 %	+3 −0 %
		Typical	+ 4%	+ 3%	+ 2%	+ 2%	+ 1%
	1000	Maximum	+9 −0 %	+6 −0 %	+6 −0 %	+4 −0 %	+4 −0 %
		Typical	+ 5%	+ 4%	+ 4%	+ 2%	+ 2%
	100K	Maximum	+11 −0 %	+9 −0 %	+8 −0 %	+5 −0 %	+5 −0 %
		Typical	+ 8%	+ 6%	+ 6%	+ 3%	+ 2.5%
	10 Meg. and 100 Meg.	Maximum	+13 −0 %	+10 −0 %	+9 −0 %	+5 −0 %	+5 −0 %
		Typical	+ 9%	+ 8%	+ 7%	+ 3%	+ 2.5%
Low Temperature Operation [6.7] After 1 hour at −65, +0 −5° C, apply RCWV for 45 minutes. Remove RCWV, return to room temperature. Resistance change measured 24 hours after test.	Maximum		±(2% + 0.05 ohm)	±(2% + 0.05 ohm)	±(2% + 0.05 ohm)	±(2% + 0.05 ohm)	±(2% + 0.05 ohm)
	Typical		+ 0.5%	+ 0.5%	+ 0.5%	+ 0.5%	+ 0.5%
Temperature Cycling [6.8] Limits: −55° C and +85° C. Resistance change after five cycles.	Maximum		±(2% + 0.05 ohm)	±(2% + 0.05 ohm)	±(2% + 0.05 ohm)	±(2% + 0.05 ohm)	±(2% + 0.05 ohm)
	Typical		+ 0.5%	+ 0.5%	+ 0.5%	+ 0.5%	+ 0.5%

Temperature characteristics

In addition to the maximum values given in this table, typical curves of temporary resistance change due to temperature are illustrated at the top of the next page.

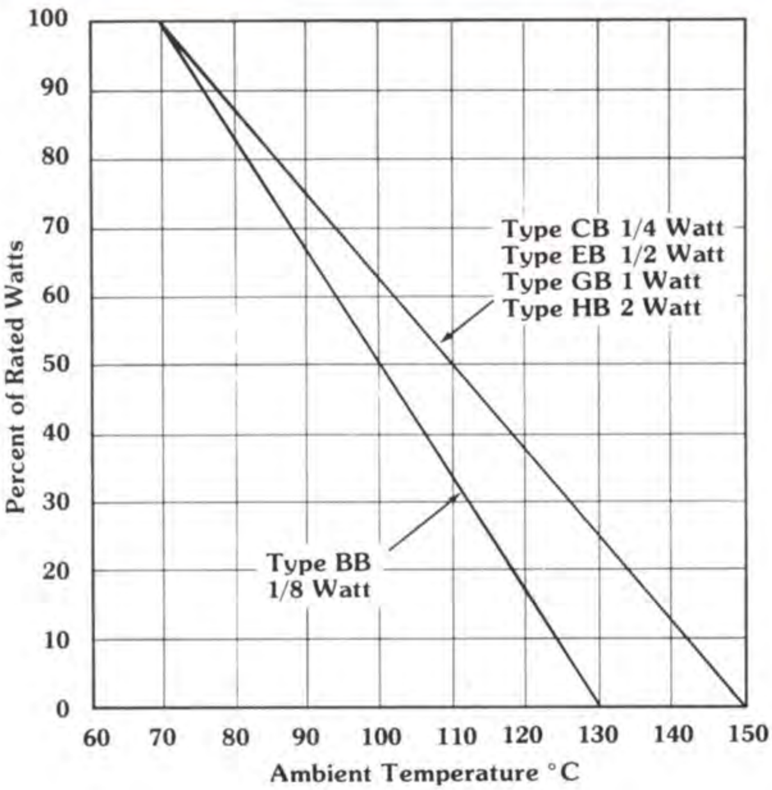
	−55° C	−25° C	−15° C	0° C	+25° C	+55° C	+65° C	+85° C	+105° C
Resistance — Temperature Characteristic [6.3]	**Range** (%)	**Range** (%)	**Range** (%)	**Range** (%)	**Nominal Ohms**	**Range** (%)	**Range** (%)	**Range** (%)	**Range** (%)
Maximum temporary resistance change from the +25° C initial resistance value.	+0.2 to + 2.6	− 0.2 to + 1.3	− 0.2 to + 1.0	− 0.2 to + 0.6	1	− 0.4 to + 0.5	− 0.5 to + 0.7	− 0.5 to + 1.3	− 0.4 to + 2.0
Note — Linear interpolation approximates intermediate values.	+0.2 to + 3.8	− 0.3 to + 2.0	− 0.3 to + 1.5	− 0.3 to + 0.9	10	− 0.6 to + 0.8	− 0.7 to + 1.1	− 0.8 to + 2.0	− 0.6 to + 3.0
	+0.3 to + 5.1	− 0.3 to + 2.7	− 0.4 to + 2.0	− 0.4 to + 1.1	100	− 0.8 to + 1.0	− 0.9 to + 1.5	− 1.0 to + 2.6	− 0.8 to + 4.0
	+0.3 to + 6.4	− 0.4 to + 3.4	− 0.5 to + 2.5	− 0.5 to + 1.4	1000	− 1.0 to + 1.3	− 1.2 to + 1.8	− 1.3 to + 3.3	− 1.0 to + 5.0
	+0.4 to + 7.7	− 0.5 to + 4.0	− 0.6 to + 3.0	− 0.6 to + 1.7	10K	− 1.2 to + 1.5	− 1.4 to + 2.2	− 1.5 to + 3.9	− 1.2 to + 6.0
	+0.5 to + 8.9	− 0.6 to + 4.7	− 0.7 to + 3.5	− 0.7 to + 2.0	100K	− 1.4 to + 1.8	− 1.6 to + 2.6	− 1.8 to + 4.6	− 1.4 to + 7.1
	+0.5 to + 10.2	− 0.7 to + 5.4	− 0.9 to + 4.0	− 0.8 to + 2.3	1 Meg	− 1.6 to + 2.0	− 1.9 to + 3.0	− 2.0 to + 5.2	− 1.6 to + 8.1
	+0.6 to + 11.5	− 0.8 to + 6.0	− 0.9 to + 4.5	− 0.9 to + 2.6	10 Meg	− 1.8 to + 2.3	− 2.1 to + 3.3	− 2.3 to + 5.9	− 1.8 to + 9.1
	+0.6 to + 11.9	− 0.8 to + 6.3	− 0.9 to + 4.7	− 0.9 to + 2.6	22 Meg	− 1.9 to + 2.4	− 2.2 to + 3.5	− 2.4 to + 6.1	− 1.9 to + 9.4
	+0.7 to + 12.8	− 0.8 to + 6.7	− 1.0 to + 5.0	− 0.9 to + 2.8	100 Meg	− 2.0 to + 2.5	− 2.4 to + 3.7	− 2.5 to + 6.6	− 2.0 to + 10.1

Typical resistance — temperature characteristics



Percent Resistance Deviation From 25° C Value for Various Nominal Resistance Values and Temperatures.

Derating with respect to ambient temperature



Derating — For resistors operated in ambient temperatures above 70° C, the change in resistance after 1000 hours under conditions similar to the Load Life Test will be less than + 4% to − 6% when the load wattage is derated in accordance with the curve shown. The most significant factor in proper derating to achieve minimal permanent resistance change over long periods of operation is the resultant surface temperature of the resistor. (See note 7 under Application Information.)

Resistor test voltages — In measuring resistance, it is important to take into account the effects of heating due to voltage application and the "offset" of resistance due to its voltage coefficient. Maximum voltage coefficients are listed on Page 11 of this publication. The voltage used should be applied for as short a time as possible, to minimize the effect of heating. For reference purposes, the voltages listed below should be used.

Nominal Resistance Range	Recommended Test Voltage (DC Volts)
1.0 to 9.1 ohms	0.3 volt
10 to 91 ohms	1.0 volt
100 to 910 ohms	3.0 volts
1000 to 9100 ohms	10 volts
10K to 91K ohms	30 volts
100K ohms and higher	100 volts

Moisture resistance testing — The results obtained from this test, defined in Publication EC5021-2.2 paragraph 6.9 which parallels MIL-STD-202 Method 106 have been found to vary because of the involved equipment required, the inclusion of several destructive-type procedures, and the poor reproduceability of the test. Isolation of the effects of moisture on resistors can be better achieved using the Steady State Humidity Test, paragraph 6.10 in Publication EC5021-2.2, paralleled by MIL-STD-202, Method 103. Maximum and typical values of resistance change for both tests are shown in the table on Page 12 of this publication.

Solderability — Allen-Bradley hot-molded fixed resistors meet the solderability requirements of MIL-R-39008 and MIL-STD-202, Method 208.

Resistance to solvents — The color code remains legible after resistors are subjected to the Resistance To Solvents test of MIL-STD-202, Method 215. Also, the resistors will withstand the Color Code Solvent Resistance test described in Paragraph 6.20 of Publication EC5021-2.2, which includes ultrasonically agitated liquids at elevated temperature.

Military qualification — The Allen-Bradley hot-molded fixed resistors meet or exceed all applicable military specifications including MIL-R-39008, Resistors, Fixed, Composition (Insulated), Established Reliability, and are fully qualified in all wattage sizes and all resistance values to the best reliability level, the "S" level, with a failure rate lower than 0.001% per 1000 hours.

Resistance measuring techniques — Measured resistance value is dependent upon the resistor temperature, the test voltage, and the degree of resistor dryness. Accurate correlation between repeated measurements, especially at different times, and different locations, requires that these three conditions be essentially the same.

Slight variations in resistor body temperature are not significant in room temperature measurements. However, the temperature of the resistor body may increase appreciably when tested at too high a voltage or when the voltage is applied for too long a time causing excessive heating.

The test voltage is very important and sometimes misunderstood or overlooked. This is because a tester is often unaware of the actual voltage that the instrument used is applying to the resistor under test. Commonly used instruments such as highly accurate resistance bridges or digital voltmeters employ relatively low voltages to make measurements, usually around 1 volt and seldom higher than 10 volts. This does not cause significant differences for low resistance values where the use of low test voltages is specified. However, for higher resistance values such as 100K ohms or higher, a test voltage of 90 or 100 volts is specified and use of a low voltage test instrument will result in a substantial difference in readings.

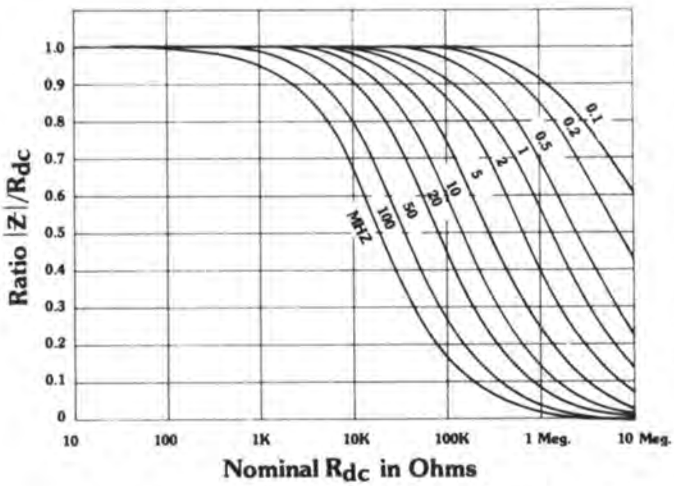
It is important to recognize that apparent out-of-tolerance on the + side can be caused by excessive moisture, and when such a condition is observed the test sample should then be conditioned in a dry oven as described in Publication EC5021-2.2.

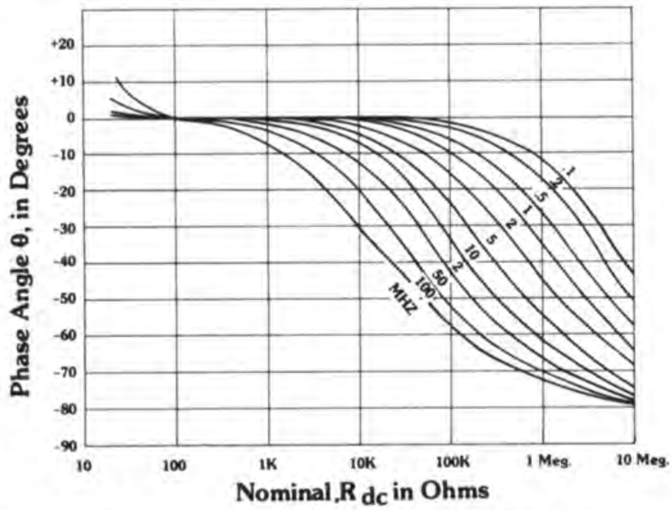
Since both moisture and too low test voltages make the resistance value appear higher than when tested under standard conditions, it can be easily seen how these two effects when combined together may produce a significant measurement difference.

Other A-B hot-molded resistor publications — Resistor Test Procedures - Publication EC5021-2.2 covers resistor test procedures and contains a cross index of Allen-Bradley resistor test methods and the equivalent or near-equivalent methods specified in MIL-R-11, MIL-R-39008, MIL-STD-202 and EIA Specification RS-186.

Typical high frequency characteristics

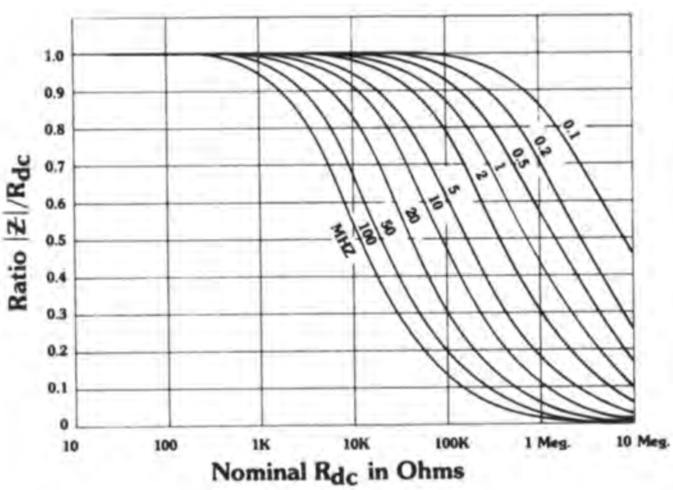
Measurement conditions — The curves below give typical values of impedance to DC resistance ratio and phase angle from 100 KHz to 100 MHz. Care was taken in test fixture design to prevent distributed capacitance to ground along the length of the resistor from contributing to measured values. Lead length was held at one quarter inch to standardize the lead inductance contribution. User's circuit variations from test conditions in mounting position and lead length can have a significant effect on the high frequency characteristics.



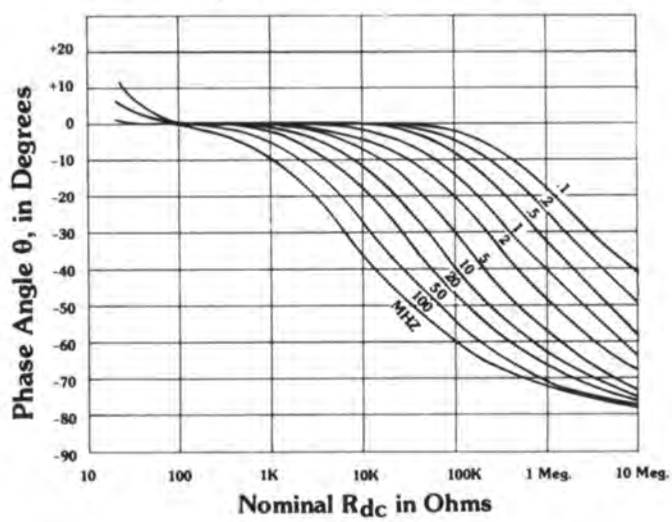


1/8 Watt Type BB **1/4 Watt Type CB**

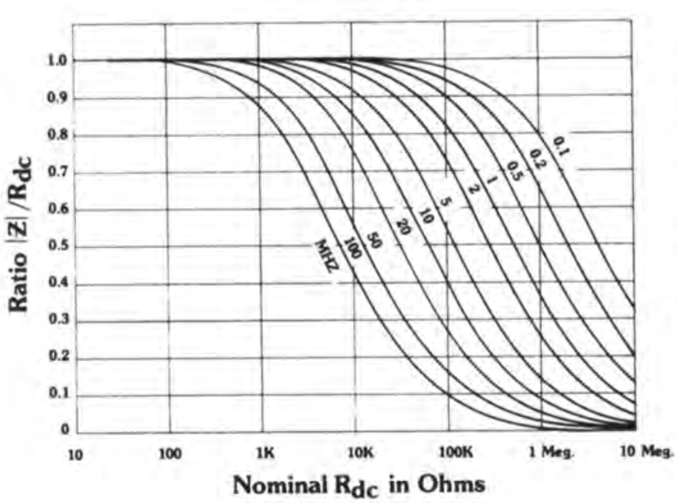
1/8 Watt Type BB **1/4 Watt Type CB**



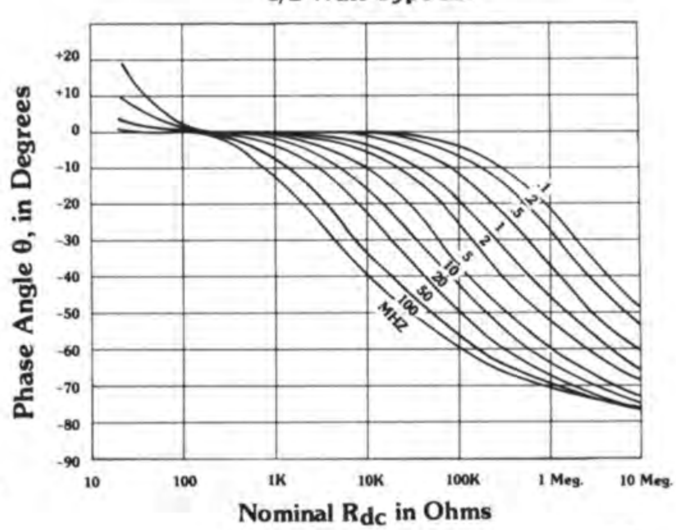
1/2 Watt Type EB



1/2 Watt Type EB

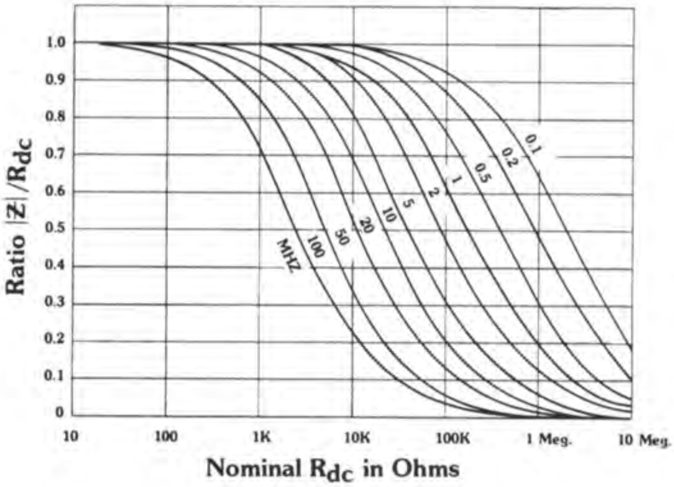


1 Watt Type GB

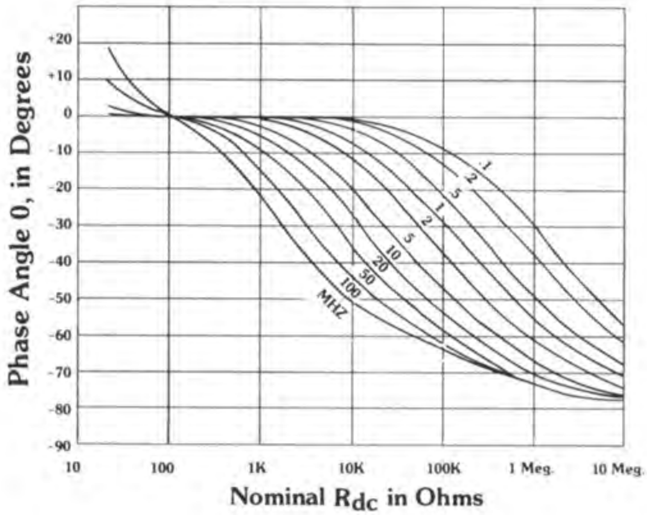


1 Watt Type GB

Typical high frequency characteristics



2 Watt Type HB



2 Watt Type HB

Metal clad fixed resistors

The Allen-Bradley Type GM and HM resistors are insulated Type GB and HB fixed composition resistors fitted with metal clamps which surround the major portion of the resistor. The metal clamps provide rigid mounting and efficient heat transfer from the resistors to the metal chassis or panels on which they are mounted.

It has been well established that Allen-Bradley fixed composition resistors exhibit superior reliability. When used according to published ratings and recommendations they do not open circuit nor exhibit large erratic changes of resistance value. The standard units are available up to and including 2 watt ratings.

Type GM and HM resistors make this same reliable performance AVAILABLE UP TO AND INCLUDING 5 WATTS.

Performance characteristics — The performance characteristics for Types GM and HM are the same as for Types GB and HB respectively, as shown in the tables on pages 11 and 12, with the following exceptions.

Nominal resistance range —
Type GM — 2.7 ohms to 22 megohms
Type HM — 10 ohms to 22 megohms

Standard tolerances — ±5%, ±10%

Power rating — When mounted on the equivalent of a steel panel 4 inches (101,60 mm) square and 0.05 inch (1,27 mm) thick

Type	70°C Ambient	40°C Ambient
GM	3 watts	4 watts
HM	4 watts	5 watts

Rated continuous working voltage (RCWV) —
Type GM $\sqrt{3.0 \times R}$ or 500 volts, whichever is less
Type HM $\sqrt{4.0 \times R}$ or 750 volts, whichever is less

Weight — Approximate, with nominal length leads
Type GM 4.7 gm
Type HM 8.0 gm

Insulation resistance — 100,000 megohms minimum between resistor leads and metal clamp

Dielectric withstanding voltage — At sea level, 1500 volts

Short time overload — ± (2.5% + 0.05 ohm), maximum

Capacitance — Between resistor leads and metal clamp
Type GM 5.6 pF, approximately
Type HM 9.0 pF, approximately

Reel packaged resistors

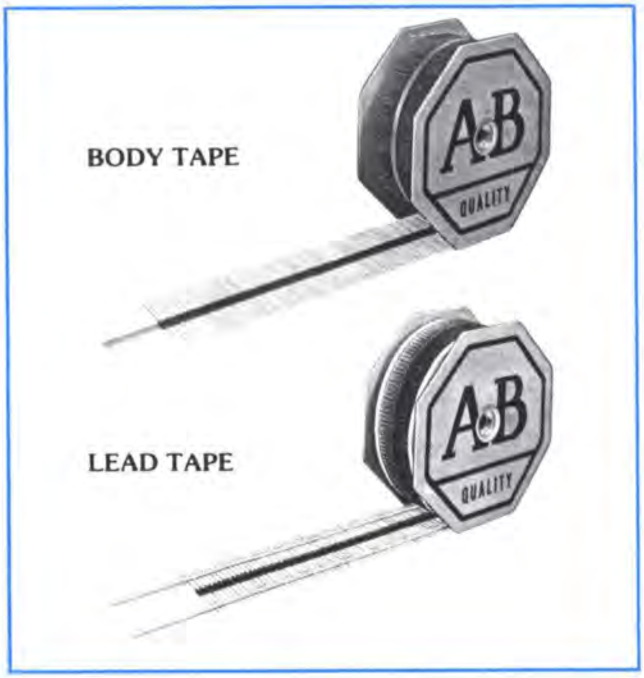
Reel packaged — Allen-Bradley hot-molded fixed resistors may be obtained reel packaged for use directly on automatic assembly equipment.

36-inch leader — A minimum of 36 inches (914,40 mm) of free tape are provided at each end of the reel for splicing purposes on lead tape reels. For body tape, a 12-inch (304,8 mm) leader at the core and a 36-inch (914,40 mm) leader on the outside end.

Heavy duty reel construction — The octagonal reels are made from corrugated fiberboard sides glued to a heavy fiberwound core. The reel is provided with metal bearings having a .562 inch (14,27 mm) hole.

Expendable — Since these reels are intended to be used as one-time dispensers of resistors, there are no storage problems, no returns.

Note: Long term storage of adhesive taped reel-packaged resistors is not recommended due to normal adhesive aging.



General requirements

1. Exposed adhesive of tape shall be less than 0.031 (0,79) in any area where it comes in contact with components or leads.
2. Standard reel packaging is with standard full length component leads. Lead trimming is available upon request for Types CB and EB, such that extension of lead ends beyond outside edges of lead tape is less than 0.031 (0,79).
3. A maximum of 0.25% of the components per reel quantity may be missing without consecutive missing components.
4. Cumulative pitch tolerance on "C" dimension shall not exceed 0.059 (1,5) over six consecutive components.

Tape spacing

A-B Type	Inside Tape Spacing D ± 0.062 (1,57)					
		Class I	Class II	Class III		
BB	1.812 (46,04)					
CB		2.062 ■ (52,39)	2.500 (63,5)	2.875 (73,03)	2.438 (61,93)	
EB		2.062 ■ (52,39)	2.500 (63,5)	2.875 (73,03)	2.438 (61,93)	
GB				2.875 ■ (73,03)	2.438 (61,93)	3.062 (77,27)
HB				2.875 ■ (73,03)	2.438 (61,93)	3.062 (77,77)

■ Standard

Note: Dimensions shown in parentheses are in millimeters.

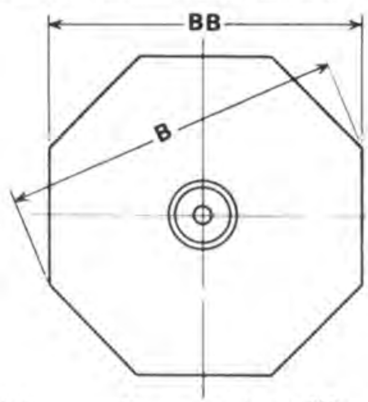
Reel packaging dimensions

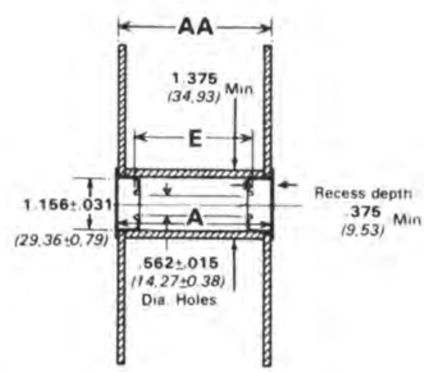
	A-B Type	MIL-R-11 Style	MIL-R-39008 Style	Rating (Watts)	Standard Quantity (per reel)	Across Hubs A Max. Inches	Across Flanges AA Approx. Inches	Across Points B Max. Inches	Across Flats BB Max. Inches	Resistor Spacing C Inches	Between Hub Holes E Approx. Inches	Tape Width F Inches
Body Tape	BB	RC05	RCR05	1/8	1000 [1]	2.468 (62,69)	2.406 (61,11)	4.062 (103,17)	3.750 (95,25)	.076 max. (1,93)	1.593 (40,46)	.125 (3,18)
	BB	RC05	RCR05	1/8	4000 [1]	2.468 (62,69)	2.406 (61,11)	6.500 (165,10)	6.000 (152,40)	.076 max. (1,93)	1.593 (40,46)	.125 (3,18)
	CB	RC07	RCR07	1/4	2500 [1]	3.625 (92,08)	3.562 (90,47)	6.500 (165,10)	6.000 (152,40)	.120 max. (3,05)	2.750 (69,85)	.188 (4,78)
	EB	RC20	RCR20	1/2	2500	3.812 (96,82)	3.750 (95,25)	9.750 (247,65)	9.000 (228,60)	.170 max. (4,32)	2.938 (74,63)	2.50 (6,35)
	EB	RC20	RCR20	1/2	5000	3.812 (96,82)	3.750 (95,25)	13.188 (334,98)	12.188 (309.58)	.170 max. (4,32)	2.938 (74,63)	.250 (6,35)
	GB	RC32	RCR32	1	2000	4.062 (103,17)	4.000 (101,60)	13.188 (334,98)	12.188 (309,58)	.270 max. (6,86)	3.188 (80,98)	.375 (9,53)
	HB	RC42	RCR42	2	1000	4.062 (103,17)	4.000 (101,60)	13.188 (334,98)	12.188 (309,58)	.385 max. (9,78)	3.188 (80,98)	.375 (9,53)
Double Lead Tape	BB [2]	RC05	RCR05	1/8	500 [1]	2.688 (68,28)	2.625 (66,68)	4.062 (103,17)	3.750 (95,25)	.200 ± .015 (5,08 ± 0,38)	1.812 (46,02)	.250 (6,35)
	BB [2]	RC05	RCR05	1/8	2000 [1]	2.688 (68,28)	2.625 (66,68)	6.500 (165,10)	6.000 (152,40)	.200 ± 0.15 (5,08 ± 0,38)	1.812 (46,02)	.250 (6,35)
	CB	RC07	RCR07	1/4	2500 [1]	3.625 (92,08)	3.562 (90,47)	9.750 (247,65)	9.000 (228,60)	.200 ± .015 (5,08 ± 0,38)	2.750 (69,85)	.250 (6,35)
	CB	RC07	RCR07	1/4	5000 [1] [2]	3.625 (92,08)	3.562 (90,47)	13.188 (334,98)	12.188 (309,58)	.200 ± .015 (5,08 ± 0,38)	2.750 (69,85)	.250 (6,35)
	EB	RC20	RCR20	1/2	2500	3.812 (96,82)	3.750 (95,25)	9.750 (247,65)	9.000 (228,60)	.200 ± .015 (5,08 ± 0.38)	2.938 (74,63)	.250 (6,35)
	EB	RC20	RCR20	1/2	5000 [2]	3.812 (96,82)	3.750 (95,25)	13.188 (334,98)	12.188 (309,58)	.200 ± .015 (5,08 ± 0,38)	2.938 (74,63)	.250 (6,35)
	GB	RC32	RCR32	1	2000	4.062 (103,17)	4.000 (101,60)	13.188 (334,98)	12.188 (309,58)	.375 ± .015 (9,53 ± 0,38)	3.188 (80,98)	.250 (6,35)
	HB	RC42	RCR42	2	1000	4.062 (103,17)	4.000 (101,60)	13.188 (334,98)	12.188 (309,58)	.375 ± .015 (9,53 ± 0,38)	3.188 (80,98)	.250 (6,35)

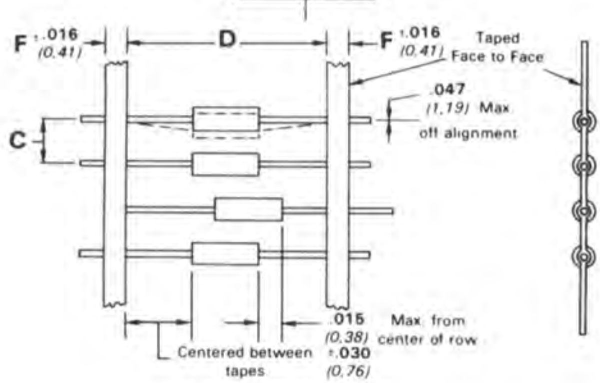
[1] Kraft paper is wound between layers of Types BB and CB for full length of reel. For Types EB, GB, and HB it is wound only as far as necessary for adequate protection.

[2] Available upon request.

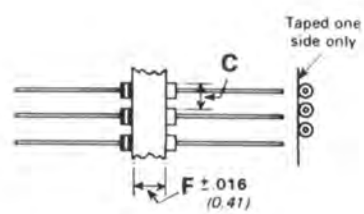
Note: Dimensions shown in parentheses are in millimeters.







LEAD TAPE



BODY TAPE

Application information

The following information has been compiled to aid in the everyday selection and application of Allen-Bradley hot-molded resistors. The statements on this page should be helpful in evaluating the use of all types of A-B hot-molded resistors in broad general terms, and are not to be interpreted as precise. A comprehensive list is made of the standard nominal resistance values in their available tolerance categories, the rated continuous working voltages for all hot-molded types, the part numbers, and color codes — all information provided for all values from 1 ohm to 100 megohms, taking into account the available range of values for each type as of the date of this publication.

1. Low-value resistors exhibit less change due to humidity, temperature and voltage than high-value resistors.
2. Resistance changes due to increase in moisture content are always positive.
3. Resistance changes due to humidity are temporary, and, in the case of Allen-Bradley resistors, are reversible.
4. Change of resistance which has occurred due to humidity may be essentially eliminated by conditioning the resistor at 100°C or by dry storage.
5. The effects of humidity may be minimized by operating the resistor with as little as 1/10 rated wattage load.
6. Resistance change due to load life is permanent and usually ultimately negative.
7. Resistance change due to load life can be minimized — 1% to 2% in many thousands of hours by 50% derating. This same result can be attained by limiting the maximum operating surface temperature of the resistor under load to 100°C. Permanent resistance changes as the result of storage at temperatures below 100°C are negligible, even for extended time periods.
8. Resistance change due to soldering is positive and may be permanent if the resistor has excessive moisture present in its body. It can be greatly minimized if resistors are dry at the time of soldering.
9. The temperature characteristic of Allen-Bradley resistors is positive above +80° and below −10°C.
10. The temperature characteristic of the Allen-Bradley resistor is negligible from −10°C to +80°C.
11. The voltage characteristic (negative) and the temperature characteristic (positive) tend to cancel one another in an Allen-Bradley resistor under average operating conditions, where both significant voltage and elevated temperature are present.
12. The heat sink to which a resistor is connected affects its rating. Resistors operated in multiple should be derated unless adequate heat sinks are provided.
13. The quality and reliability of Allen-Bradley resistors is the same for, and independent of, any resistance tolerances shown on the resistor.
14. Years of accumulated experience have shown that Allen-Bradley hot-molded resistors are unequalled for uniformity, predictable performance, appearance, and freedom from catastrophic failure. Allen-Bradley resistors are made by an exclusive hot-molding process on automatic machines — developed, built, and used only by Allen-Bradley. There is such complete uniformity from one resistor to the next — million after million — that long term in-circuit performance can be predicted with usable accuracy. When used according to published ratings and recommendations, Allen-Bradley hot-molded fixed resistors will not open circuit nor exhibit erratic changes of resistance value. They are probably the most reliable of all electronic components.

Standard resistance values

Nominal Resistance in Ohms — TOLERANCE COLOR CODE — 4th BAND: Gold ± 5%	Silver ± 10%	None ± 20%	Rated Continuous Working Voltage (RCWV) DC or RMS Volts — WATTAGE and TYPE: ⅛ [1] BB	¼ [2] CB	½ [2] EB	1 [2] GB	2 [2] HB	3 [2] GM	4 [3] GM	4 [2] HM	5 [3] HM	Resistor Part Number — Type (BB, CB, EB etc.) XX	Value Code 000	Tolerance (5 = 5%, 1 = 10%, 2 = 20%) X	Resistance Color Code — 1st BAND (1st digit)	2nd BAND (2nd digit)	3rd BAND (Number of zeros after 1st and 2nd digit)
1.0	1.0	1.0	—	—	0.707	1.00	—	—	—	—	—		10G		Brown	Black	Gold
1.1	—	—	—	—	0.742	1.05	—	—	—	—	—		11G		Brown	Brown	Gold
1.2	1.2	—	—	—	0.775	1.10	—	—	—	—	—		12G		Brown	Red	Gold
1.3	—	—	—	—	0.806	1.14	—	—	—	—	—		13G		Brown	Orange	Gold
1.5	1.5	1.5	—	—	0.866	1.22	—	—	—	—	—		15G		Brown	Green	Gold
1.6	—	—	—	—	0.894	1.26	—	—	—	—	—		16G		Brown	Blue	Gold
1.8	1.8	—	—	—	0.949	1.34	—	—	—	—	—		18G		Brown	Gray	Gold
2.0	—	—	—	—	1.00	1.41	—	—	—	—	—		20G		Red	Black	Gold
2.2	2.2	2.2	—	—	1.05	1.48	—	—	—	—	—		22G		Red	Red	Gold
2.4	—	—	—	—	1.10	1.55	—	—	—	—	—		24G		Red	Yellow	Gold
2.7	2.7	—	0.581	0.822	1.16	1.64	—	2.85	3.29	—	—		27G		Red	Violet	Gold
3.0	—	—	0.612	0.866	1.22	1.73	—	3.00	3.46	—	—		30G		Orange	Black	Gold
3.3	3.3	3.3	0.642	0.908	1.28	1.82	—	3.15	3.63	—	—		33G		Orange	Orange	Gold
3.6	—	—	0.671	0.949	1.34	1.90	—	3.29	3.79	—	—		36G		Orange	Blue	Gold
3.9	3.9	—	0.698	0.987	1.40	1.97	—	3.42	3.95	—	—		39G		Orange	White	Gold
4.3	—	—	0.733	1.04	1.47	2.07	—	3.59	4.15	—	—		43G		Yellow	Orange	Gold
4.7	4.7	4.7	0.766	1.08	1.53	2.17	—	3.76	4.34	—	—		47G		Yellow	Violet	Gold
5.1	—	—	0.798	1.13	1.60	2.26	—	3.91	4.52	—	—		51G		Green	Brown	Gold
5.6	5.6	—	0.837	1.18	1.67	2.37	—	4.10	4.73	—	—		56G		Green	Blue	Gold
6.2	—	—	0.880	1.24	1.76	2.49	—	4.31	4.98	—	—		62G		Blue	Red	Gold
6.8	6.8	6.8	0.922	1.30	1.84	2.61	—	4.52	5.22	—	—		68G		Blue	Gray	Gold
7.5	—	—	0.968	1.37	1.94	2.74	—	4.74	5.48	—	—		75G		Violet	Green	Gold
8.2	8.2	—	1.01	1.43	2.02	2.86	—	4.96	5.73	—	—		82G		Gray	Red	Gold
9.1	—	—	1.07	1.51	2.13	3.02	—	5.22	6.03	—	—		91G		White	Brown	Gold
10	10	10	1.12	1.58	2.24	3.16	4.47	5.48	6.32	6.32	7.07		100		Brown	Black	Black
11	—	—	1.17	1.66	2.34	3.32	4.69	5.74	6.63	6.63	7.42		110		Brown	Brown	Black
12	12	—	1.22	1.73	2.45	3.46	4.90	6.00	6.93	6.93	7.75		120		Brown	Red	Black
13	—	—	1.28	1.80	2.55	3.61	5.10	6.24	7.21	7.21	8.06		130		Brown	Orange	Black
15	15	15	1.37	1.94	2.74	3.87	5.48	6.71	7.75	7.75	8.66		150		Brown	Green	Black
16	—	—	1.41	2.00	2.83	4.00	5.66	6.93	8.00	8.00	8.94		160		Brown	Blue	Black
18	18	—	1.50	2.12	3.00	4.24	6.00	7.35	8.48	8.48	9.49		180		Brown	Gray	Black
20	—	—	1.58	2.24	3.16	4.47	6.32	7.75	8.94	8.94	10.0		200		Red	Black	Black
22	22	22	1.66	2.34	3.32	4.69	6.63	8.12	9.38	9.38	10.5		220		Red	Red	Black
24	—	—	1.73	2.45	3.46	4.90	6.93	8.48	9.80	9.80	11.0		240		Red	Yellow	Black
27	27	—	1.84	2.60	3.67	5.20	7.35	9.00	10.4	10.4	11.6		270		Red	Violet	Black
30	—	—	1.94	2.74	3.87	5.48	7.75	9.49	11.0	11.0	12.2		300		Orange	Black	Black
33	33	33	2.03	2.87	4.06	5.74	8.12	9.95	11.5	11.5	12.8		330		Orange	Orange	Black
36	—	—	2.12	3.00	4.24	6.00	8.48	10.4	12.0	12.0	13.4		360		Orange	Blue	Black
39	39	—	2.21	3.12	4.42	6.24	8.83	10.8	12.5	12.5	14.0		390		Orange	White	Black
43	—	—	2.32	3.28	4.64	6.56	9.27	11.4	13.1	13.1	14.7		430		Yellow	Orange	Black
47	47	47	2.42	3.43	4.85	6.86	9.70	11.9	13.7	13.7	15.3		470		Yellow	Violet	Black
51	—	—	2.52	3.57	5.05	7.14	10.1	12.4	14.3	14.3	16.0		510		Green	Brown	Black
56	56	—	2.65	3.74	5.29	7.48	10.6	13.0	15.0	15.0	16.7		560		Green	Blue	Black
62	—	—	2.78	3.94	5.57	7.87	11.1	13.6	15.7	15.7	17.6		620		Blue	Red	Black
68	68	68	2.92	4.12	5.83	8.25	11.7	14.3	16.5	16.5	18.4		680		Blue	Gray	Black
75	—	—	3.06	4.33	6.12	8.66	12.2	15.0	17.3	17.3	19.4		750		Violet	Green	Black
82	82	—	3.20	4.53	6.40	9.06	12.8	15.7	18.1	18.1	20.2		820		Gray	Red	Black
91	—	—	3.37	4.77	6.74	9.54	13.5	16.5	19.1	19.1	21.3		910		White	Brown	Black
100	100	100	3.54	5.00	7.07	10.0	14.1	17.3	20.0	20.0	22.4		101		Brown	Black	Brown
110	—	—	3.71	5.24	7.42	10.5	14.8	18.2	21.0	21.0	23.5		111		Brown	Brown	Brown
120	120	—	3.87	5.48	7.75	11.0	15.5	19.0	21.9	21.9	24.5		121		Brown	Red	Brown
130	—	—	4.03	5.70	8.06	11.4	16.1	19.7	22.8	22.8	25.5		131		Brown	Orange	Brown
150	150	150	4.33	6.12	8.66	12.2	17.3	21.2	24.5	24.5	27.4		151		Brown	Green	Brown
160	—	—	4.47	6.32	8.94	12.6	17.9	21.9	25.3	25.3	28.3		161		Brown	Blue	Brown
180	180	—	4.74	6.71	9.49	13.4	19.0	23.2	26.8	26.8	30.0		181		Brown	Gray	Brown
200	—	—	5.00	7.07	10.0	14.1	20.0	24.5	28.3	28.3	31.6		201		Red	Black	Brown
220	220	220	5.24	7.42	10.5	14.8	21.0	25.7	29.7	29.7	33.2		221		Red	Red	Brown
240	—	—	5.48	7.75	11.0	15.5	21.9	26.8	31.0	31.0	34.6		241		Red	Yellow	Brown
270	270	—	5.81	8.22	11.6	16.4	23.2	28.5	32.9	32.9	36.7		271		Red	Violet	Brown
300	—	—	6.12	8.66	12.2	17.3	24.5	30.0	34.6	34.6	38.7		301		Orange	Black	Brown
330	330	330	6.42	9.08	12.8	18.2	25.7	31.5	36.3	36.3	40.6		331		Orange	Orange	Brown
360	—	—	6.71	9.49	13.4	19.0	26.8	32.9	37.9	37.9	42.4		361		Orange	Blue	Brown
390	390	—	6.98	9.87	14.0	19.7	27.9	34.2	39.5	39.5	44.2		391		Orange	White	Brown
430	—	—	7.33	10.4	14.7	20.7	29.3	35.9	41.5	41.5	46.4		431		Yellow	Orange	Brown
470	470	470	7.66	10.8	15.3	21.7	30.7	37.6	43.4	43.4	48.5		471		Yellow	Violet	Brown

[1] Rating at 70° C, derated to zero at 130° C.

[2] Rating at 70° C, derated to zero at 150° C.

[3] Rating at 40° C, derated to zero at 150° C.

Standard resistance values


Nominal Resistance in Ohms — Tolerance Color Code (4th Band): Gold ± 5%	Silver ± 10%	None ± 20%	Rated Continuous Working Voltage (RCWV) DC or RMS Volts — Wattage and Type: ⅛ [1] BB	¼ [2] CB	½ [2] EB	1 [2] GB	2 [2] HB	3 [2] GM	4 [3] GM	4 [2] HM	5 [3] HM	Resistor Part Number: Type (BB CB EB etc.) XX	Value Code 000	Tolerance (5 = 5% 1 = 10% 2 = 20%) X	Resistance Color Code: 1st BAND 1st digit	2nd BAND 2nd digit	3rd BAND Number of zeros after 1st and 2nd digit
510	—	—	7.98	11.3	16.0	22.6	31.9	39.1	45.2	45.2	50.5		511		Green	Brown	Brown
560	560	—	8.37	11.8	16.7	23.7	33.5	41.0	47.3	47.3	52.9		561		Green	Blue	Brown
620	—	—	8.80	12.4	17.6	24.9	35.2	43.1	49.8	49.8	55.7		621		Blue	Red	Brown
680	680	680	9.22	13.0	18.4	26.1	36.9	45.2	52.2	52.2	58.3		681		Blue	Gray	Brown
750	—	—	9.68	13.7	19.4	27.4	38.7	47.4	54.8	54.8	61.2		751		Violet	Green	Brown
820	820	—	10.1	14.3	20.2	28.6	40.5	49.6	57.3	57.3	64.0		821		Gray	Red	Brown
910	—	—	10.7	15.1	21.3	30.2	42.7	52.2	60.3	60.3	67.5		911		White	Brown	Brown
1000	1000	1000	11.2	15.8	22.4	31.6	44.7	54.8	63.2	63.2	70.7		102		Brown	Black	Red
1100	—	—	11.7	16.6	23.4	33.2	46.9	57.4	66.3	66.3	74.2		112		Brown	Brown	Red
1200	1200	—	12.2	17.3	24.5	34.6	49.0	60.0	69.3	69.3	77.5		122		Brown	Red	Red
1300	—	—	12.8	18.0	25.5	36.1	51.0	62.4	72.1	72.1	80.6		132		Brown	Orange	Red
1500	1500	1500	13.7	19.4	27.4	38.7	54.8	67.1	77.5	77.5	86.6		152		Brown	Green	Red
1600	—	—	14.1	20.0	28.3	40.0	56.6	69.3	80.0	80.0	89.4		162		Brown	Blue	Red
1800	1800	—	15.0	21.2	30.0	42.4	60.0	73.5	84.8	84.8	94.9		182		Brown	Gray	Red
2000	—	—	15.8	22.4	31.6	44.7	63.2	77.5	89.4	89.4	100		202		Red	Black	Red
2200	2200	2200	16.6	23.4	33.2	46.9	66.3	81.2	93.8	93.8	105		222		Red	Red	Red
2400	—	—	17.4	24.5	34.6	49.0	69.3	84.8	98.0	98.0	110		242		Red	Yellow	Red
2700	2700	—	18.4	26.0	36.7	52.0	73.5	90.0	104	104	116		272		Red	Violet	Red
3000	—	—	19.4	27.4	38.7	54.8	77.5	94.9	110	110	122		302		Orange	Black	Red
3300	3300	3300	20.3	28.7	40.6	57.4	81.2	99.5	115	115	128		332		Orange	Orange	Red
3600	—	—	21.2	30.0	42.4	60.0	84.8	104	120	120	134		362		Orange	Blue	Red
3900	3900	—	21.1	31.2	44.2	62.4	88.3	108	125	125	140		392		Orange	White	Red
4300	—	—	23.2	32.8	46.4	65.6	92.7	114	131	131	147		432		Yellow	Orange	Red
4700	4700	4700	24.2	34.3	48.5	68.6	97.0	119	137	137	153		472		Yellow	Violet	Red
5100	—	—	25.2	35.7	50.5	71.4	101.0	124	143	143	160		512		Green	Brown	Red
5600	5600	—	26.5	37.4	52.9	74.8	106	130	150	150	167		562		Green	Blue	Red
6200	—	—	27.8	39.4	55.7	78.7	111	136	157	157	176		622		Blue	Red	Red
6800	6800	6800	29.2	41.2	58.3	82.5	117	143	165	165	184		682		Blue	Gray	Red
7500	—	—	30.6	43.3	61.2	86.6	122	150	173	173	194		752		Violet	Green	Red
8200	8200	—	32.0	45.3	64.0	90.6	128	157	181	181	202		822		Gray	Red	Red
9100	—	—	33.7	47.7	67.4	95.4	135	165	191	191	213		912		White	Brown	Red
10000	10000	10000	35.4	50.0	70.7	100.0	141	173	200	200	224		103		Brown	Black	Orange
11000	—	—	37.1	52.4	74.2	105	148	182	210	210	235		113		Brown	Brown	Orange
12000	12000	—	38.7	54.8	77.5	110	155	190	219	219	245		123		Brown	Red	Orange
13000	—	—	40.3	57.0	80.6	114	161	197	228	228	255		133		Brown	Orange	Orange
15000	15000	15000	43.3	61.2	86.6	122	173	212	245	245	274		153		Brown	Green	Orange
16000	—	—	44.7	63.2	89.4	126	179	219	253	253	283		163		Brown	Blue	Orange
18000	18000	—	47.4	67.1	94.9	134	190	232	268	268	300		183		Brown	Gray	Orange
20000	—	—	50.0	70.7	100.0	141	200	245	283	283	316		203		Red	Black	Orange
22000	22000	22000	52.4	74.2	105	148	210	257	297	297	332		223		Red	Red	Orange
24000	—	—	54.8	77.5	110	155	219	268	310	310	346		243		Red	Yellow	Orange
27000	27000	—	58.1	82.2	116	164	232	285	329	329	367		273		Red	Violet	Orange
30000	—	—	61.2	86.6	122	173	245	300	346	346	387		303		Orange	Black	Orange
33000	33000	33000	64.2	90.8	128	182	257	315	363	363	406		333		Orange	Orange	Orange
36000	—	—	67.1	94.9	134	190	268	329	379	379	424		363		Orange	Blue	Orange
39000	39000	—	69.8	98.7	140	197	279	342	395	395	442		393		Orange	White	Orange
43000	—	—	73.3	104	147	207	293	359	415	415	464		433		Yellow	Orange	Orange
47000	47000	47000	76.6	108	153	217	307	376	434	434	485		473		Yellow	Violet	Orange
51000	—	—	79.8	113	160	226	319	391	452	452	505		513		Green	Brown	Orange
56000	56000	—	83.7	118	167	237	335	410	473	473	529		563		Green	Blue	Orange
62000	—	—	88.0	124	176	249	352	431	498	498	557		623		Blue	Red	Orange
68000	68000	68000	92.2	130	184	261	369	452	500	522	583		683		Blue	Gray	Orange
75000	—	—	96.8	137	194	274	387	474	500	548	612		753		Violet	Green	Orange
82000	82000	—	101	143	202	286	405	496	500	573	640		823		Gray	Red	Orange
91000	—	—	107	151	213	302	427	500	500	603	675		913		White	Brown	Orange
Nominal Resistance in Megohms																	
0.1	0.1	0.1	112	158	224	316	447	500	500	632	707		104		Brown	Black	Yellow
0.11	—	—	117	166	234	332	469	500	500	663	742		114		Brown	Brown	Yellow
0.12	0.12	—	122	173	245	346	490	500	500	693	750		124		Brown	Red	Yellow
0.13	—	—	128	180	255	361	510	500	500	721	750		134		Brown	Orange	Yellow
0.15	0.15	0.15	137	194	274	387	548	500	500	750	750		154		Brown	Green	Yellow
0.16	—	—	141	200	283	400	566	500	500	750	750		164		Brown	Blue	Yellow
0.18	0.18	—	150	212	300	424	600	500	500	750	750		184		Brown	Gray	Yellow
0.20	—	—	150	224	316	447	632	500	500	750	750		204		Red	Black	Yellow
0.22	0.22	0.22	150	234	332	469	663	500	500	750	750		224		Red	Red	Yellow
0.24	—	—	150	245	346	490	693	500	500	750	750		244		Red	Yellow	Yellow

[1] Rating at 70° C, derated to zero at 130° C.

[2] Rating at 70° C, derated to zero at 150° C.

[3] Rating at 40° C, derated to zero at 150° C.

Standard resistance values

Nominal Resistance in Ohms — Tolerance Color Code, 4th Band: Gold ± 5%	Silver ± 10%	None ± 20%	RCWV DC or RMS Volts — 1/8 W [1] BB	1/4 W [2] CB	1/2 W [2] EB	1 W [2] GB	2 W [2] HB	3 W [2] GM	4 W [3] GM	4 W [2] HM	5 W [3] HM	Resistor Part Number (Type BB, CB, EB etc. XX; Value Code 000; Tolerance X: 5 = 5%, 1 = 10%, 2 = 20%) Value Code	Resistance Color Code: 1st BAND (1st digit)	2nd BAND (2nd digit)	3rd BAND (Number of zeros after 1st and 2nd digit)
0.27	0.27	—	150	250	350	500	735	500	500	750	750	274	Red	Violet	Yellow
0.30	—	—	150	250	350	500	750	500	500	750	750	304	Orange	Black	Yellow
0.33	0.33	0.33	150	250	350	500	750	500	500	750	750	334	Orange	Orange	Yellow
0.36	—	—	150	250	350	500	750	500	500	750	750	364	Orange	Blue	Yellow
0.39	0.39	—	150	250	350	500	750	500	500	750	750	394	Orange	White	Yellow
0.43	—	—	150	250	350	500	750	500	500	750	750	434	Yellow	Orange	Yellow
0.47	0.47	0.47	150	250	350	500	750	500	500	750	750	474	Yellow	Violet	Yellow
0.51	—	—	150	250	350	500	750	500	500	750	750	514	Green	Brown	Yellow
0.56	0.56	—	150	250	350	500	750	500	500	750	750	564	Green	Blue	Yellow
0.62	—	—	150	250	350	500	750	500	500	750	750	624	Blue	Red	Yellow
0.68	0.68	0.68	150	250	350	500	750	500	500	750	750	684	Blue	Gray	Yellow
0.75	—	—	150	250	350	500	750	500	500	750	750	754	Violet	Green	Yellow
0.82	0.82	—	150	250	350	500	750	500	500	750	750	824	Gray	Red	Yellow
0.91	—	—	150	250	350	500	750	500	500	750	750	914	White	Brown	Yellow
1.0	1.0	1.0	150	250	350	500	750	500	500	750	750	105	Brown	Black	Green
1.1	—	—	150	250	350	500	750	500	500	750	750	115	Brown	Brown	Green
1.2	1.2	—	150	250	350	500	750	500	500	750	750	125	Brown	Red	Green
1.3	—	—	150	250	350	500	750	500	500	750	750	135	Brown	Orange	Green
1.5	1.5	1.5	150	250	350	500	750	500	500	750	750	155	Brown	Green	Green
1.6	—	—	150	250	350	500	750	500	500	750	750	165	Brown	Blue	Green
1.8	1.8	—	150	250	350	500	750	500	500	750	750	185	Brown	Gray	Green
2.0	—	—	150	250	350	500	750	500	500	750	750	205	Red	Black	Green
2.2	2.2	2.2	150	250	350	500	750	500	500	750	750	225	Red	Red	Green
2.4	—	—	150	250	350	500	750	500	500	750	750	245	Red	Yellow	Green
2.7	2.7	—	150	250	350	500	750	500	500	750	750	275	Red	Violet	Green
3.0	—	—	150	250	350	500	750	500	500	750	750	305	Orange	Black	Green
3.3	3.3	3.3	150	250	350	500	750	500	500	750	750	335	Orange	Orange	Green
3.6	—	—	150	250	350	500	750	500	500	750	750	365	Orange	Blue	Green
3.9	3.9	—	150	250	350	500	750	500	500	750	750	395	Orange	White	Green
4.3	—	—	150	250	350	500	750	500	500	750	750	435	Yellow	Orange	Green
4.7	4.7	4.7	150	250	350	500	750	500	500	750	750	475	Yellow	Violet	Green
5.1	—	—	150	250	350	500	750	500	500	750	750	515	Green	Brown	Green
5.6	5.6	—	150	250	350	500	750	500	500	750	750	565	Green	Blue	Green
6.2	—	—	150	250	350	500	750	500	500	750	750	625	Blue	Red	Green
6.8	6.8	6.8	150	250	350	500	750	500	500	750	750	685	Blue	Gray	Green
7.5	—	—	150	250	350	500	750	500	500	750	750	755	Violet	Green	Green
8.2	8.2	—	150	250	350	500	750	500	500	750	750	825	Gray	Red	Green
9.1	—	—	150	250	350	500	750	500	500	750	750	915	White	Brown	Green
10	10	10	150	250	350	500	750	500	500	750	750	106	Brown	Black	Blue
11	—	—	150	250	350	500	750	500	500	750	750	116	Brown	Brown	Blue
12	12	—	150	250	350	500	750	500	500	750	750	126	Brown	Red	Blue
13	—	—	150	250	350	500	750	500	500	750	750	136	Brown	Orange	Blue
15	15	15	150	250	350	500	750	500	500	750	750	156	Brown	Green	Blue
16	—	—	150	250	350	500	750	500	500	750	750	166	Brown	Blue	Blue
18	18	—	150	250	350	500	750	500	500	750	750	186	Brown	Gray	Blue
20	—	—	150	250	350	500	750	500	500	750	750	206	Red	Black	Blue
22	22	22	150	250	350	500	750	500	500	750	750	226	Red	Red	Blue
24	—	—	150	250	350	500	750	500	500	750	750	246	Red	Yellow	Blue
27	27	—	150	250	350	500	750	500	500	750	750	276	Red	Violet	Blue
30	—	—	150	250	350	500	750	500	500	750	750	306	Orange	Black	Blue
33	33	33	150	250	350	500	750	500	500	750	750	336	Orange	Orange	Blue
36	—	—	150	250	350	500	750	500	500	750	750	366	Orange	Blue	Blue
39	39	—	150	250	350	500	750	500	500	750	750	396	Orange	White	Blue
43	—	—	150	250	350	500	750	500	500	750	750	436	Yellow	Orange	Blue
47	47	47	150	250	350	500	750	500	500	750	750	476	Yellow	Violet	Blue
51	—	—	150	250	350	500	750	500	500	750	750	516	Green	Brown	Blue
56	56	—	150	250	350	500	750	500	500	750	750	566	Green	Blue	Blue
62	—	—	150	250	350	500	750	500	500	750	750	626	Blue	Red	Blue
68	68	68	150	250	350	500	750	500	500	750	750	686	Blue	Gray	Blue
75	—	—	150	250	350	500	750	500	500	750	750	756	Violet	Green	Blue
82	82	—	150	250	350	500	750	500	500	750	750	826	Gray	Red	Blue
91	—	—	150	250	350	500	750	500	500	750	750	916	White	Brown	Blue
100	100	100	150	250	350	500	750	500	500	750	750	107	Brown	Black	Violet

[1] Rating at 70° C, derated to zero at 130° C.

[2] Rating at 70° C, derated to zero at 150° C.

[3] Rating at 40° C, derated to zero at 150° C.

EXPLANATION OF PART NUMBERS

All Allen-Bradley fixed composition resistors are identified by a Part Number which will provide information as to the type of resistor, resistance value, and tolerance. The Part Number is merely for identification on drawings, specifications, ordering, and other areas where it is convenient to use a Part Number to describe a particular resistor. The only markings that appear on the resistor are the Color Code bands.

INDUSTRIAL TYPE DESIGNATION → EB5145

Type or Style

Allen-Bradley	Rating (Watts) (at 70° C)	MIL-R-11 Style	MIL-R-39008 Style
BB	1/8	RC05	RCR05
CB	1/4	RC07	RCR07
EB	1/2	RC20	RCR20
GB	1	RC32	RCR32
HB	2	RC42	RCR42
GM	3	—	—
HM	4	—	—

Resistance

Expressed in ohms and identified by a three-digit number. First two digits represent significant figures. Last digit specifies the number of zeros to follow, except below 10 ohms (see below).

FOR VALUES BELOW 10 OHMS:

ALLEN-BRADLEY DESIGNATION	MIL DESIGNATION
The letter "G" is substituted in place of the third digit. The desired resistance value is then the first two digits multiplied by 0.1.	The letter "R" is substituted in place of a significant digit to represent the decimal point. The following digits represent significant figures.

EXAMPLE

Allen-Bradley	Resistance	MIL Designation
27G	2.7 Ohm	2R7

RESISTANCE TOLERANCE

Allen-Bradley	Tolerance	MIL Designation
5	± 5%	J
1	± 10%	K
2	± 20%	—

Type

Fixed Composition Resistors, Insulated, Established Reliability

FAILURE RATE LEVEL

At 50% rated wattage expressed in %/1000 hrs.

M = 1.0%
P = 0.1%
R = 0.01%
S = 0.001%

MIL-R-39008 TYPE DESIGNATION → RCR 20 G514 JS

MIL-R-11 TYPE DESIGNATION → RC20 GF514J

MAXIMUM AMBIENT TEMPERATURE AND RESISTANCE TEMPERATURE CHARACTERISTIC
(Refer to MIL-R-11 or MIL-R-39008 Specifications as Applicable)

Standard color code and preferred number series

First Band — 1st Digit
Second Band — 2nd Digit

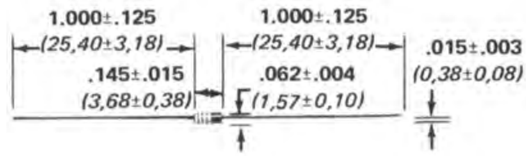
Color	Digit	Multiplier	Tolerance	Reliability Level (Percent Per 1000 Hours) (When Applicable)
Black	0	1	—	—
Brown	1	10	—	M = 1.0%
Red	2	100	—	P = 0.1%
Orange	3	1000	—	R = 0.01%
Yellow	4	10,000	—	S = 0.001%
Green	5	100,000	—	—
Blue	6	1,000,000	—	—
Violet	7	10,000,000	—	—
Gray	8	—	—	—
White	9	—	—	—
Gold	—	0.1	± 5%	—
Silver	—	—	± 10%	—
No color	—	—	± 20%	—

Perferred Number Series

± 5% Tolerance (E24)	10 11 12 13	15 16 18 20	22 24 27 30	33 36 39 43	47 51 56 62	68 75 82 91
± 10% Tolerance (E12)	10 12	15 18	22 27	33 39	47 56	68 82
± 20% Tolerance (E6)	10	15	22	33	47	68

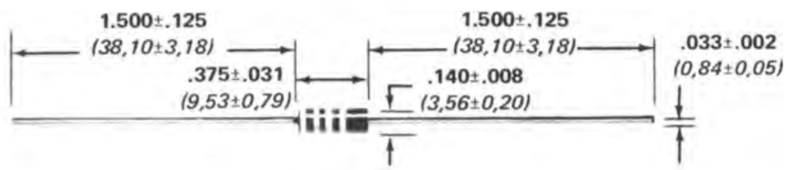
DIMENSIONS

1/8 Watt Type BB

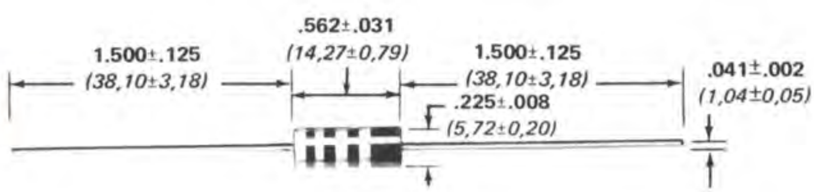


1/4 Watt Type CB

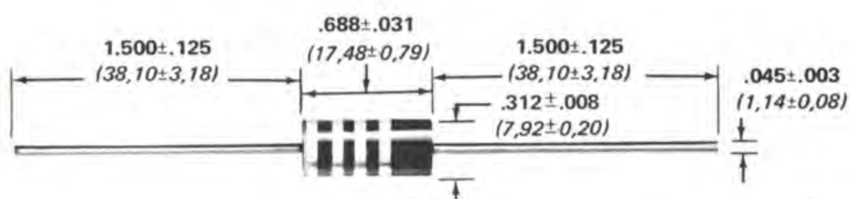
1/2 Watt Type EB



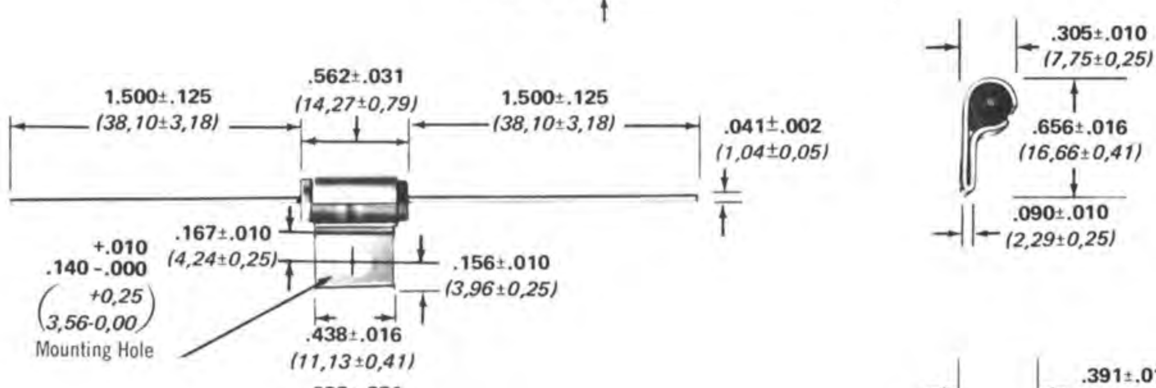
1 Watt Type GB



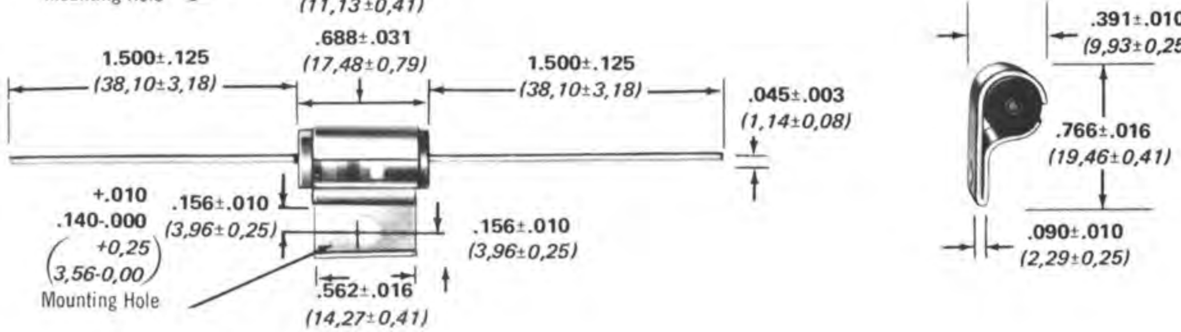
2 Watt Type HB



3 Watt Type GM



4 Watt Type HM



Dimensions shown in parentheses are in millimeters.

Types BB, CB, EB, GB HB, GM, HM Hot-Molded Fixed Resistors

EVALUATION TESTS

- Measurement Methods
- Test Procedures
- Test Sequence

General — This publication defines standardized methods for testing discrete fixed resistors, including basic environmental tests to determine the ability of the resistor to withstand climatic stresses, as well as physical and electrical tests to determine production assembly durability and operational life. The laboratory conditions specified are designed to give results which are indicative of what may be observed under similar stresses which may be encountered in field use. However, they are not intended to be exact or conclusive representations of any specific actual service operation. They are intended to be standardized such that reproducible results can be obtained in repetitive tests or comparison evaluations.

Standard test conditions — Unless otherwise specified herein, or in applicable referenced specifications, all measurements and tests shall be made at temperatures of +15°C to +35°C, at air pressure of 650 to 800 millimeters of mercury, and relative humidity of 45 percent to 75 percent. Whenever these conditions must be closely controlled in order to obtain reproducible results, for referee purposes the ambient temperature shall be 23°C ± 1°C, and the humidity 50 percent ± 2 percent.

Cross reference — At the end of this publication is a cross index table comparing these test methods to similar procedures specified in applicable military or industrial specifications. Wherever the tests are not identical, notations are given regarding the differences.

Resistance measuring techniques — Measured resistance value is dependent upon the resistor temperature, the test voltage, and the degree of resistor dryness. Accurate correlation between repeated measurements, especially at different times, and different locations, requires that these three conditions be essentially the same.

Slight variations in resistor body temperature are not significant in room temperature measurements. However, the temperature of the resistor body may increase appreciably when tested at too high a voltage or when the voltage is applied for too long a time causing excessive heating.

For accurate measurements to determine the resistance value tolerance, the test voltage is very important and sometimes misunderstood or overlooked. This is because a tester is often unaware of the actual voltage that an instrument may be applying to the resistor under test. Commonly used instruments such as highly accurate resistance bridges or digital voltmeters employ relatively low voltages to make measurements, usually around 1 volt and seldom higher than 10 volts. This does not cause significant differences for low resistance values where the use of low test voltages is specified. However, for higher resistance values such as 100K ohms or higher, a test voltage of 100 volts is specified and use of a low voltage test instrument will result in substantial difference in readings. For comparison measurements to determine the resistance change which may occur due to some electrical or environmental stress, either the standard test voltage or a low voltage may be used, since only the resistance change is being examined, independent of the absolute resistance value. The principal requirement is that the same meter be used for both initial and final measurements.

It is important to recognize that apparent out-of-tolerance on the + side can be caused by excessive exposure to high humidity. To eliminate this potential humidity offset, all test samples are to be conditioned in accordance with Paragraph 3.2 prior to commencement of testing. In this manner, the effects of any electrical or environmental stress can be examined separately, without any confusion with possible moisture resistance offset.

1. SCOPE

1.1 Scope — The tests described in this publication are considered appropriate for the evaluation of molded and film type composition resistors.

2. DEFINITIONS

2.1 Power ratings — The maximum continuous power ratings of Allen-Bradley resistors are as indicated in Table 1 on Page 31, and are dependent on the ability of resistors to meet the load life test requirements. See Allen-Bradley Technical Publication EC5021-2.1 for rating details.

2.2 Voltage rating — The maximum rated continuous working voltage (RCWV max.), DC or sine wave RMS at commercial line frequency, which must not exceed the maximum listed in Table 1, is equal to $\sqrt{PR}$, where P is the power rating in watts and R is the nominal resistance in ohms.

3. SAMPLE SELECTION

3.1 Sample selection — Resistors with the narrowest standard commercial tolerance shall be used. Resistance values selected for test shall include the lowest and highest standard values listed by the manufacturer, also the critical values. The critical resistance value is defined as the lowest standard value to which maximum rated continuous working voltage can be applied without exceeding rated continuous wattage at + 70° C ambient temperature. See Table 1. Ten resistors of each type and resistance value should be used for each test group.

3.2 Conditioning — Resistors which are NOT truly hermetically sealed by means of enclosures made of metal, glass or ceramic material with appropriate seals, must first be treated in accordance with Paragraph 7, Conditioning. After conditioning, such resistors should be kept in a desiccator except when under another specified test environment in accordance with the test requirements of Table 2 on Page 31.

4. TESTING SEQUENCE

4.1 Testing sequence — All resistor test specimens shall be subjected to Group 1 tests. Separate samples selected from those tested under Group 1 shall be used for each additional test group. Within a group, tests shall be conducted in the order specified.

5. RESISTANCE MEASUREMENTS

5.1 Resistance measurements — Resistance measurement error shall not exceed one-tenth the allowable resistance change due to testing or 0.5 percent, whichever is less. Unless otherwise specified, the same instrument, temperature (within ±2°C), and DC test voltage listed in the table below (because of instantaneous voltage characteristic) applied for as short a time as *practicable (to avoid heating during the measurement)*, shall be used throughout any one of the performance characteristic tests. Wheatstone Bridge test equipment is preferred.

5.2 Reference test voltages — In the event of a difference in resistance readings attributable to the test voltage used, the specified test voltage listed below shall be used.

Nominal Resistance Range	Recommended Test Voltages (DC Volts)
1.0 to 9.1 ohms	0.3
10 to 91 ohms	1.0
100 to 910 ohms	3.0
1K to 9.1K ohms	10
10K to 91K ohms	30
0.1 Meg. and Higher	100

6. PERFORMANCE CHARACTERISTICS

6.1 Visual and Mechanical Inspection — Conformance with manufacturer's catalog specifications shall be verified.

6.2 Resistance tolerance — Resistance shall not exceed the specified limits when measured at + 25°C ± 2°C using the test voltages listed above.

6.3 Resistance-temperature characteristic

6.3.1 Procedure — Resistors shall be maintained within ± 1°C at each of the ambient temperatures listed in Table 3 on Page 31, and in the order shown. The use of forced circulating air is recommended to assure temperature stability and uniformity. Resistance measurements shall be made at each temperature 15 minutes after air temperature has stabilized at the specified temperature. The percent difference in resistance referred to the resistance at + 25°C shall be computed with the following formula:

$$\text{Percent Resistance Difference} = \frac{(R - r) \times 100}{r}$$

Where: R is the resistance at test temperature
r is the resistance at + 25°C

6.4 Resistance-voltage coefficient

6.4.1 Significance — The instantaneous voltage coefficient is normally important only with respect to incoming inspection testing and in the comparison of results obtained in evaluation testing.

6.4.2 Procedure — The resistance shall be measured at one-tenth the RCWV and at full RCWV. Application of voltages shall be momentary to minimize heating effects. The resistance-voltage coefficient shall be calculated with the following formula:

$$\text{Voltage Coefficient Percent Per Volt} = \frac{(R - r) \times 100}{r \times 0.9\,(\text{RCWV})}$$

Where: R is the resistance at full RCWV
r is the resistance at one-tenth RCWV

6.5 Dielectric withstanding voltage

6.5.1 Mounting — The resistors shall be clamped in the trough of a 90° metallic V-block of such size that the resistor body does not extend beyond the ends of the trough. The resistor leads shall be positioned such that they are no closer to the V-block than if they were parallel to the sides of the V-block. This prevents unnecessary proximity of the leads to the block, while permitting complete seating of the resistor body in the block.

6.5.2 Procedure — Sine wave RMS voltages from an alternating current supply at commercial line frequency not more than 100 Hertz as specified in Table 1 shall be applied at the rate of approximately 100 volts per second between resistor terminals connected together and the V-block, and held for 5 seconds.

6.5.2.1 Sea level atmospheric pressure — The procedure in 6.5.2 shall be carried out at a normal sea level atmospheric pressure of approximately 30 inches (1016 mbars) mercury using the appropriate voltage specified in Table 1.

6.5.2.2 High altitude atmospheric pressure — The procedure in 6.5.2 shall be carried out at a pressure of approximately 3.4 inches (115 mbars) mercury using the appropriate voltage specified in Table 1. This pressure is approximately equivalent to an altitude of 50,000 feet (15240 meters).

6.6 Insulation resistance

6.6.1 Mounting — Resistors shall be clamped between a round non-conducting rod at right angles to the resistor body and a conducting resilient material approximately

0.075 inch (1,90 mm) thick conductively attached or bonded to a rigid metal strap. See Figure 1. The clamping pressure shall be such as to embed the resistor color bands in the resilient material and provide intimate electrical contact over the entire length of the resistor body along a surface line parallel to the longitudinal axis of the resistor. The metal strap and resilient conductive coating shall be at least as wide as the length of the resistor body, and the resistor body shall be approximately centered on the strap. See Figure 1. For types GM and HM, connection may be made to the attached metal clamp in lieu of the coated metal strap described above. The resistivity of the resilient conducting material shall be less than 1000 ohm-centimeters.

6.6.2 Procedure — Avoiding excessive handling to minimize the effects of perspiration or other contaminants, connect the lead wires of the resistor together and measure the resistance between them and the metal strap using a DC test voltage as specified in Table 1.

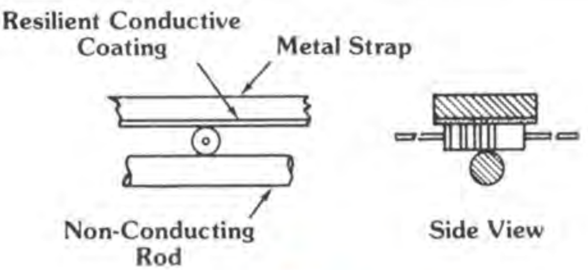


Figure 1

6.7 Low temperature operation

6.7.1 Mounting — Resistors shall be mounted by their leads so that there is at least 1 inch (25,40 mm) of free air space around each resistor and the mounting is in such a position with respect to the air stream that it offers no appreciable obstruction to the flow of air across and around the resistors.

6.7.2 Procedure — Initial resistance shall be measured. The resistors shall then be exposed to the air stream at −65°C (+ 0°C, − 5°C) for 1 hour with no voltage applied, and then 45 minutes with the RCWV applied, after which the resistors shall be placed at room temperature. Approximately 24 hours after return to room temperature, final resistance shall be measured.

6.8 Thermal shock

6.8.1 Procedure — Initial resistance shall be measured. Mounted as specified in 6.7.1, the resistors shall be subjected to the temperature cycle specified in Table 4 on Page 31 for a total of five cycles, performed continuously. Temperatures in Steps 1 and 3 shall be maintained by forced air circulation. The hot and cold chambers shall be of such capacity that the air temperature will reach the temperatures specified in Table 4 within 2 minutes after the resistors have been placed in the appropriate chamber. Final resistance shall be measured approximately 1 hour after completion of the fifth cycle.

6.9 Moisture resistance

6.9.1 Mounting — The resistors shall be fastened by their leads to suitable supports (to insure no mechanical resonances between 10 and 55 Hertz) so that the length of each lead between the resistor body and the support is 3/8 inch (9, 52 mm).

6.9.2 Procedure

6.9.2.1 Cycles — Ten cycles shall be performed as specified in Figure 2.

6.9.2.2 Load — During the first 2 hours of Steps 1 and 4, DC RCWV shall be applied to half the resistors of each type and resistance value on test.

6.9.2.3 Vibration — The mounted resistors shall be subjected to a simple harmonic motion having a maximum amplitude of 0.06 inch (0,15 mm) peak-to-peak, the frequency being varied uniformly from 10 to 55 and back to 10 Hertz in one minute. This motion shall be applied in a direction perpendicular to the longitudinal axis of the resistors.

6.9.2.4 Measurements — Initial resistance shall be measured before the test. After Step 6 in the final cycle, the resistors shall be exposed to a temperature of + 25°C ± 2°C and a relative humidity of 90 to 98 percent, for 1-1/2 to 3-1/2 hours. Upon removal from the test chamber, resistors shall be permitted to dry for a maximum of 4 hours at + 25°C ± 5°C at no less than 50 percent relative humidity. Such drying atmosphere shall not be forced, circulating air. At the end of the drying period, final resistance and insulation resistance (per 6.6) shall be measured.

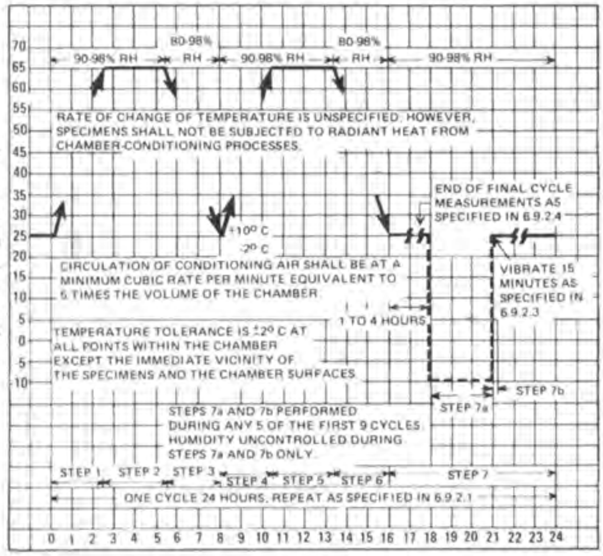


Figure 2

6.10 Humidity characteristic (steady state)

6.10.1 Significance — Results from the moisture resistance testing specified in 6.9 have been found to vary because of the equipment required, and because the results obtained are largely a function of the particular apparatus used, size of chamber, etc. Results obtained with one apparatus cannot be directly compared with results obtained with other apparatus. The following steady state humidity test is recommended in place of the moisture resistance test in order to obtain better isolation of the effects of moisture.

6.10.2 Procedure — Initial resistance values shall be measured. Excessive handling and surface contamination shall be avoided. Resistors shall then be placed in a chamber at a relative humidity of 90 to 95 percent at an ambient temperature of + 40°C ± 2°C for a period of 240 hours. After removal from the chamber, the resistors shall be allowed to dry at room ambient for 4 hours to remove surface moisture following which final resistance measurements shall be made. The resistors may then be subjected to the conditioning described in Paragraph 7 to determine whether the resistance changes due to moisture are permanent.

6.11 Short time overload

6.11.1 Procedure — A well regulated DC or sine wave RMS voltage 2.5 times (2 times for Types GM and HM) the RCWV, but not exceeding the limit values listed in Table 1, shall be applied for 5 seconds. Resistance shall be measured before and approximately 30 minutes after the application of the test voltage.

6.12 Load life

6.12.1 Test conditions — This test shall be conducted at an ambient temperature of +70°C ±2°C. Resistors shall be mounted by their leads soldered to lightweight terminals, and, in addition, for Types GM and HM, their metal clamps should be bolted to a 4 inch (101,60 mm) square steel plate 0.050 inch (1,27 mm) thick, one plate per resistor. The effective length of each lead shall be 1±3/16 inch (25,40 ± 4,76 mm). Resistors shall be so arranged that the heat from any one resistor will not appreciably influence the temperature of any other resistor. There shall be no circulation of air directly over any resistor other than that caused by the heat of that resistor itself. RCWV shall be used.

6.12.2 Procedure — After exposure of the resistors to the +70°C ambient test temperature without load for 2 hours, initial resistances shall be measured at the test ambient temperature. Then DC RCWV shall be applied intermittently 1-1/2 hour "ON", 1/2 hour "OFF" for a total of 1000 hours. Resistance measurements shall be made near the end of the 1/2 hour "OFF" periods at the test ambient temperature after 50 ± 8, 100 ± 8, 250 ± 8, 500 ± 12, 750 ± 12, and 1000 ± 12 hours have elapsed from the time the RCWV was first applied.

6.13 Terminal strength

6.13.1 Procedure

6.13.1.1 Pull — Initial resistance shall be measured. Resistor shall then be held by one lead, and a tensile force of 5 pounds (2,27 kgm) (2 pounds [0,91 kgm] for Type BB) shall be gradually applied to the other lead in the direction of the longitudinal axis of the resistor. The specified force shall be maintained for 5 seconds.

6.13.1.2 Twist — Following the test in 6.13.1.1, the leads shall be bent 90° at a point 1/4 ± 1/64 inch (6,35 ± 0,40 mm) from the resistor body with the radius of curvature at the bend approximately 1/32 inch (0,80 mm). The free end of the lead shall be clamped at a point 3/64 ± 1/64 inch (1,19 ± 0,40 mm) away from the bend. See Figure 3. The resistor body shall then be rotated about the original axis of the terminal through 360° in alternating directions for three such rotations, at the rate of approximately 5 seconds per rotation. After the final rotation, final resistance shall be measured.

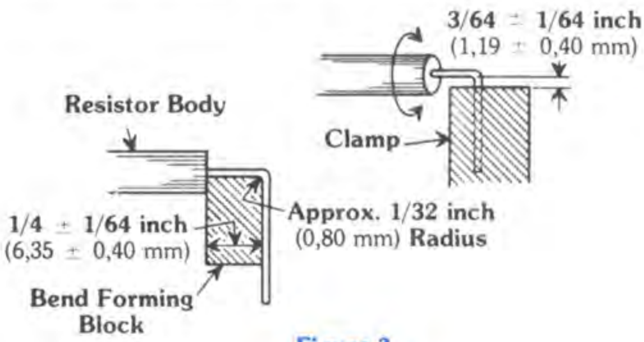


Figure 3

6.14 Resistance to solder heat

6.14.1 Procedure — Initial resistance shall be measured. Resistor leads shall then be immersed, one at a time for 3 ± 1/2 seconds each, in molten solder at +350°C ± 5°C (+250°C ± 5°C for Type BB) to a distance of 1/8 to 3/16 inch (3,18 to 4,76 mm) from the resistor body. Final resistance shall be measured 24 ± 4 hours after the immersions.

6.15 Solderability

6.15.1 Apparatus — A heated still pot or a recirculating flow type soldering machine capable of maintaining the solder at a uniform temperature of +232°C ± 5°C shall be used. If a still pot is used, the stirring paddle and skimmer shall be made of stainless steel or other material which will not contaminate the solder. A dipping device capable of controlling the rate of immersion of resistor leads at 1 ± 1/4 inch (25,40 ± 6,35 mm) per second, and providing a dwell time of 5 ± 1/2 seconds in the solder bath shall be used. For examination, an optical system capable of 10 power magnification shall be used.

6.15.2 Materials — The flux shall consist of a minimum of 35 percent by weight waterwhite rosin dissolved in 99 percent isopropyl alcohol. Solder shall be nominally 60 percent tin, 40 percent lead solder, conforming to Type S, composition Sn60 of Specification QQ-S-571D. ■

6.15.3 Procedure — Both leads of each resistor shall be tested in "as received" condition, with care taken to prevent handling or other contamination which may influence the results of this test. The leads shall be immersed in flux, sufficiently to cover the surfaces to be tested, for 5 to 10 seconds at room temperature. If a scum or dross has accumulated on the solder surface, it shall be skimmed off. If the solder is not circulating, it shall be stirred with the paddle to mix the solder and make the temperature uniform throughout. After stirring, the surface shall be skimmed again. The fluxed leads should then be dipped into the solder once, to the same depth they were immersed in flux, using the dipping apparatus. After dipping, the leads shall be allowed to cool in air. Residual flux may be removed from the leads by dipping in clean isopropyl alcohol and, if necessary, wiping with soft cloth. The surface of each lead shall be examined with the optical system.

6.16 Shock

6.16.1 Mounting — Resistors shall be mounted on appropriate fixtures with their leads supported at a distance of 1/4 inch (6,35 mm) from the resistor body. These fixtures shall be constructed so as to ensure that the points of the resistor mounting supports will have the same motion as the shock table. Test leads shall be 22 AWG or smaller, and of minimum length.

6.16.2 Apparatus — Apparatus shall be provided of such design as to impart a terminal-peak sawtooth shock pulse with a peak value of 100g and normal duration of 6 milliseconds. The actual velocity change must be within 10 percent of the ideal pulse velocity change of 9.7 ft/sec.

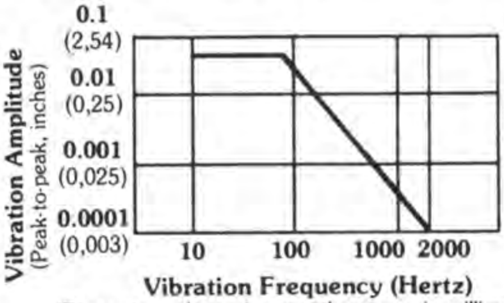
6.16.3 Procedure — Initial resistance shall be measured. The mounted resistors shall then be subjected to 10 impacts in each of two directions: parallel and perpendicular to the longitudinal axis of the resistor. Electrical monitoring shall be provided during the test to detect resistor discontinuities of 0.1 millisecond or greater duration. Final measurements and examination for mechanical failures shall be made after the test.

■ QQ-S-571D — Available from Commanding Officer, Naval Supply Depot, 5801 Tabor Ave., Philadelphia, Pennsylvania 19120, provided a military contract is involved.

6.17 Vibration

6.17.1 Mounting — The mounting fixtures, with resistors mounted as in 6.16.1, shall be so constructed as to be free of mechanical resonances over the frequency range of 10 to 2000 Hertz.

6.17.2 Procedure — Initial resistance shall be measured. The mounted resistors shall then be subjected to the vibration amplitude and frequency range shown in Figure 4. The vibration waveform shall be a simple harmonic motion having an amplitude sufficient to provide 20g constant peak acceleration, but not to exceed 0.06 inch (1,52 mm) peak-to-peak amplitude. The frequency shall be varied approximately logarithmically between the nominal limits of 10 and 2000 Hertz with a return sweep to 10 Hertz. The entire sweep from 10 to 2000 to 10 Hertz shall be traversed in approximately 20 minutes. This sweep cycle shall be performed repeatedly for 6 hours in each of two directions: parallel and perpendicular to the longitudinal axis of the resistor. Interruptions are permitted provided requirements for rate of change and test duration are met. Electrical monitoring shall be provided during this test to detect resistor discontinuities of 0.1 millisecond or greater duration. Final measurements and examination for mechanical failures shall be made after the test.



(Dimensions shown in parentheses are in millimeters.)

Figure 4

6.18 Pulse applications

6.18.1 Significance — For circuit applications where pulses or transients whose peak values exceed steady state ratings are experienced, tests should be made to determine the suitabilty of the resistors being considered for use.

6.18.2 Procedure — In general, such tests should include life tests for at least 1000 hours under conditions which accurately represent the peak value, pulse waveform and repetition rate, under the environmental conditions which must be met. Tests under more severe conditions are recommended to establish the safety factors involved, bearing in mind that every type of resistor can be seriously damaged or completely destroyed if the stress levels are raised sufficiently. Such tests may be made by use of a noninductive capacitor of suitable capacitance value and voltage rating, charged at successively higher voltages and discharged each time through the resistor under test, arranging the circuitry for a minimum and consistent inductance value. Resistance measurements should be made, initially and after each capacitor discharge, by uniform method.

6.19 Color code solvent resistance

6.19.1 Procedure — The purpose of this test is to verify that the color code will not become eligible or discolored on the resistors when subjected to solvents normally used to clean printed wiring assemblies. The following solvents shall not cause mechanical or electrical damage and markings shall remain legible.

1. A 3 to 1 Mixture of mineral spirits and isopropyl alcohol.
2. 1-1-1 trichloroethane.
3. Freon TMC.

The test sample shall be divided into three equal groups, with one group subjected to solvent (1.), the second group to solvent (2.) and the third group to solvent (3.). The solutions shall be maintained at room temperature and samples immersed for one minute. Immediately following emersion, the resistor shall be brushed with a hard bristle toothbrush with normal hand pressure for ten strokes in a forward direction across the body surface. Immediately after brushing, this procedure shall be repeated two additional times. After five minutes after completion the resistor shall be examined.

6.20 Low temperature storage

6.20.1 Mounting — Resistor mounting shall be the same as described in 6.7.1.

6.20.2 Procedure — Initial resistance shall be measured. The resistors shall then be exposed to the air stream at −65°C ± 2°C for a period of 24 ± 4 hours, after which the resistors shall be placed at room temperature. After approximately 2 to 8 hours, final resistance shall be measured.

7. CONDITIONING

7.1 Significance — All resistors except those which are truly hermitically sealed by means of enclosures made of metal, glass or ceramic materials with appropriate seals such as metal to glass, or metal to ceramic, may absorb moisture which can affect resistance values to a varying degree, dependent upon their materials, construction, dimensions and the duration of exposure to atmospheres having a high relative humidity. To eliminate this variable from test results, moisture removal by conditioning with warm DRY air is mandatory if a meaningful comparison of results is desired. Use of a ventilated oven in an air conditioned space is recommended.

7.2 Procedure — Allen-Bradley resistors, as well as competitive makes of similar physical size, should be conditioned in DRY + 100°C (+5°C, −0°C) air for the approximate time listed in Table 1. This is normally sufficient to remove absorbed moisture. Longer drying may be required where resistors have been stored for long periods of time under unusually high relative humidity.

TEST LIMITS AND PROCEDURES FOR HOT-MOLDED FIXED RESISTORS

TABLE 1

Resistor Type	Maximum Continuous Power Rating at +70°C Ambient (Except as Noted) Watts	Maximum Rated Continuous Working Voltage (RCWV) DC or RMS Volts	Dielectric Withstanding Voltage Volts At 30 in. Hg (1016 mbars) Sea Level	Dielectric Withstanding Voltage Volts At 3.4 in. Hg (115 mbars) 50,000 ft. (15240 meters)	Insulation Resistance Test Voltage Volts ± 10%	Short-Time Overload Voltage Limit Volts	Recommended Conditioning Time at +100°C $^{+5°}_{-0°}$C Hours	Critical Resistance Value (See 3.1) Megohms
BB	1/8	150	300	200	100	200	25	0.18
CB	1/4	250	500	325	100	400	50	0.27
EB	1/2	350	700	450	500	700	75	0.27
GB	1	500	1000	625	500	1000	120	0.27
HB	2	750	1500	625	500	1000	130	0.30
GM	3	500	1000	625	500	1000	120	0.091
GM	4 at 40°C	500	1000	625	500	1000	120	0.068
HM	4	750	1500	625	500	1000	130	0.15
HM	5 at 40°C	750	1500	625	500	1000	130	0.12

TABLE 2

	Group 1
6.1	Visual and Mechanical Inspection
6.2	Resistance Tolerance
	Group 2
6.3	Resistance-Temperature Characteristic
6.4	Resistance-Voltage Coefficient
6.5	Dielectric Withstanding Voltage
6.6	Insulation Resistance
	Group 3
6.7	Low Temperature Operation
6.8	Thermal Shock
6.20	Low Temperature Storage
6.9	Moisture Resistance
6.10	Humidity (Steady State) — Alternate test for 6.9
6.11	Short Time Overload
	Group 4
6.12	Load Life
	Group 5
6.13	Terminal Strength
6.14	Resistance to Solder Heat
	Group 6
6.15	Solderability
	Group 7
6.16	Shock
6.17	Vibration
	Group 8
6.18	Pulse Applications
	Group 9
6.19	Color Code Solvent Resistance

TABLE 3

Temperature Characteristic Test Sequence (See 6.3)

Sequence	Ambient Temperature °C
A	+105
B	+85
C	+55
D	+25
E	0
F	−25
G	−55

TABLE 4

Thermal Shock Test Sequence (See 6.8)

Step	Temperature °C	Time Minutes
1	$-55\ ^{+0}_{-3}$	30
2	+25 ±5	5
3	$+85\ ^{+3}_{-0}$	30
4	+25 ±5	5

CROSS INDEX OF RESISTOR TEST METHODS FOR HOT-MOLDED FIXED RESISTORS

The table below lists the Allen-Bradley test methods used and equivalent or similar methods specified in military and industrial specifications with information to make the tests equivalent.

Test Description	Technical Publication EC5021-2.2 Paragraph Number	MIL-R-39008B Paragraph Number and Details	MIL-STD-202E Method and Details	EIA-RS-172-B Paragraph Number and Details
Resistance Measurements	5	**4.7.2** 1. Voltages per Paragraph 5.2	303	**3.2.2** 1. Voltages per Paragraph 5.2
Resistance — Temperature Characteristic	6.3	**4.7.3** 1. Temperatures per Table 3, Page 31 2. Omits recommendation for forced circulating air	**304** 1. Compute percent resistance difference per Paragraph 6.3.1	**3.2.3** 1. Temperatures per Table 3, Page 31 2. Omits recommendation for forced circulating air
Resistance — Voltage Coefficient	6.4	4.7.4	309	**3.2.4** 1. Voltage application should be momentary to minimize heating effects
Dielectric Withstanding Voltage	6.5	**4.7.5** 1. Test voltage to be 1500 volts for 2 watt per Table 1	**301** 1. Test duration 5 seconds. **105C** 1. Test Condition B. Test duration 5 seconds.	**3.2.5** 1. Test voltage to be 1500 volts for 2 watt per Table 1
Insulation Resistance	6.6	4.7.6	**302** 1. Test condition A (⅛ and ¼ watt) 2. Test condition B (½, 1 and 2 watt)	No Equivalent Test
Low Temperature Operation	6.7	4.7.7	No Equivalent Test	3.2.7
Low Temperature Storage	6.20	4.7.17	No Equivalent Test	No Equivalent Test
Thermal Shock	6.8	4.7.8	**107D** 1. Test Condition A	**3.2.8** 1. Test sequence per Table 4
Moisture Resistance	6.9	4.7.9	106D	No Equivalent Test
Humidity (Steady State)	6.10	No Equivalent Test	**103B** 1. Test Condition A 2. Paragraph 3.1 not applicable	**3.2.9** 1. Post Conditioning per Paragraph 6.10.2
Short Time Overload	6.11	4.7.10	No Equivalent Test	3.2.6
Load Life	6.12	4.7.15	**108A** 1. Test Condition D, +70°C	3.2.10
Terminal Strength	6.13	4.7.11	**211A** 1. Test Condition A (⅛ watt) — 2 lbs. (0,91 kg); others 5 lbs. (2,27 kg). 2. Test Condition D	3.2.11
Resistance to Solder Heat	6.14	4.7.12	**210A** 1. Test Condition A for all styles except ⅛ watt shall be +250°C ±5°C.	3.2.12
Solderability	6.15	4.7.16	208C	**EIA-RS-178-B** 1. Test Condition 1
Shock	6.16	4.7.13	**213B** 1. Test Condition 1	No Equivalent Test
Vibration	6.17	4.7.14	**204C** 1. Test Condition D 2. Vibrate 6 hours in each of two planes per Paragraph 6.17.2	No Equivalent Test
Pulse Applications	6.18	6.5	No Equivalent Test	No Equivalent Test
Color Code Solvent Resistance	6.19	No Equivalent Test	**215** 1. Ultrasonic agitation in various solvents at +40°C.	No Equivalent Test
Conditioning	7	**4.4.2** 1. Time and temperature per Page 30	No Equivalent Procedure	**3.1.3** 1. Time and Temperature per Page 30

Military Numbering System Fixed Resistors

MIL-R-11 (RC) RC07GF153K

RC07 Style/Power	GF Characteristic	153 Resistance Value	K Tolerance
(See Tables 1 and 2)	"G" = 70°C max. ambient temperature for full load operation. "F" = temperature coefficient which varies (with resistance) from ±625 ppm/°C to ±3100 ppm/°C.	First two digits are significant, 3rd digit "number of zeros." 153 = 15,000 Ohms	(See Table 4) K = ±10%

■ MIL-R-39008 (RCR) RCR07G153JS

RCR07 Style/Power	G Characteristic	153 Resistance Value	J Tolerance	S Failure Rate
(See Tables 1 and 2)	"G" indicates a max. ambient temperature of 70°C for full load operation, and a TC which varies (with resistance) from ±625 ppm/°C to ±1900 ppm/°C.	First two digits are significant, 3rd digit "number of zeros." 153 = 15,000 Ohms	(See Table 4) J = ± 5%	(See Table 5) S = .001% /1000 hours

MIL-R-10509 (RN) RN55D1003F

RN55 Style/Power	D Characteristic	1003 Resistance Value	F Tolerance
(See Tables 1 and 2)	(See Table 3) D = ±100 ppm/°C	First three digits are significant, 4th digit "number of zeros." 1003 = 100,000 Ohms	(See Table 4) F = ± 1%

■ MIL-R-55182 (RNR) RNR55H1003FS

RNR55 Style, Terminal and Power	H Characteristic	1003 Resistance Value	F Tolerance	S Failure Rate
(See Tables 1 and 2) RNR = Solderable Leads RNC = Solderable/Weldable Leads RNN = Nickel Leads	(See Table 3) H = ±50 ppm/°C	First three digits are significant, 4th digit "number of zeros." 1003 = 100,000 Ohms	(See Table 4) F = ±1%	(See Table 5) S = .001% /1000 hours

MIL-R-22684 (RL) RL07S153J

RL07 Style/Power	S Terminal (Lead)	153 Resistance Value	J Tolerance
(See Tables 1 and 2)	"S" = Solderable	First two digits are significant, 3rd digit "number of zeros." 153 = 15,000 Ohms	(See Table 4) J = ± 5%

■ MIL-R-39017 (RLR) RLR07C1502GR

RLR07 Style/Power	C Terminal (Lead)	1502 Resistance Value	G Tolerance	R Failure Rate
(See Tables 1 and 2)	"C" = Solderable/Weldable	First three digits are significant, 4th digit "number of zeros." 1502 = 15,000 Ohms	(See Table 4) G = ± 2%	(See Table 5) R = .01% /1000 hours

■ **NOTE:** The Established Reliability specification (i.e., MIL-R-39008, MIL-R-39017, and MIL-R-55182) supersede MIL-R-11, MIL-R-22684, and MIL-R-10509 respectively, for all *new* design. Resistors qualified to the three Established Reliability specifications may be substituted, without limitation, wherever the older MIL devices are specified.

TABLE 1 — Resistor Style

- **RC** Fixed Composition Resistor (MIL-R-11)
- **RCR** Fixed Composition Resistor, Established Reliability (MIL-R-39008)
- **RL** Fixed Film Resistor (MIL-R-22684)
- **RLR** Fixed Film Resistor, Established Reliability (MIL-R-39017)
- **RN** Fixed Resistor, High Stability (MIL-R-10509)
- **RNR** Fixed Film Resistor, Established Reliability (MIL-R-55182)

TABLE 2 — Resistor Power

Nominal Body Length x Dia. (in.)	Size	Power (at 70°C Unless Otherwise Stated)
RC - RCR - RL - RLR		
.145 x .062	05	1/8
.250 x .090	07	1/4
.375 x .138	20	1/2
.562 x .225	32	1
.688 x .138	42	2
RN (Characteristic C) - **RNR**		
.150 x .065	50	1/20 at 125°C
.250 x .109	55	1/10 at 125°C
.375 x .125	60	1/8 at 125°C
.625 x .188	65	1/4 at 125°C
.750 x .250	70	1/2 at 125°C
1.062 x .375	75	1 at 125°C
RN (Characteristic D)		
.250 x .109	55	1/8
.375 x .125	60	1/4
.625 x .188	65	1/2
.750 x .250	70	3/4

TABLE 3 — Characteristics

RN	
B	±500 ppm/°C
C	± 50 ppm/°C (T2)
D	±100 ppm/°C (T0, T1)
E	± 25 ppm/°C (T9)
F	± 50 ppm/°C
RNR/ RNC	
H	± 50 ppm/°C (T2)
J	± 25 ppm/°C (T9)
K	±100 ppm/°C (T0, T1)

NOTE: There is no temperature coefficient designation for the RL numbering system, all units are ±100 ppm/°C.

TABLE 4 — Tolerance

- **K** = ±10%
- **J** = ±5%
- **G** = ±2%
- **F** = ±1%
- **D** = ±0.5%
- **C** = ±0.25%
- **B** = ±0.10%

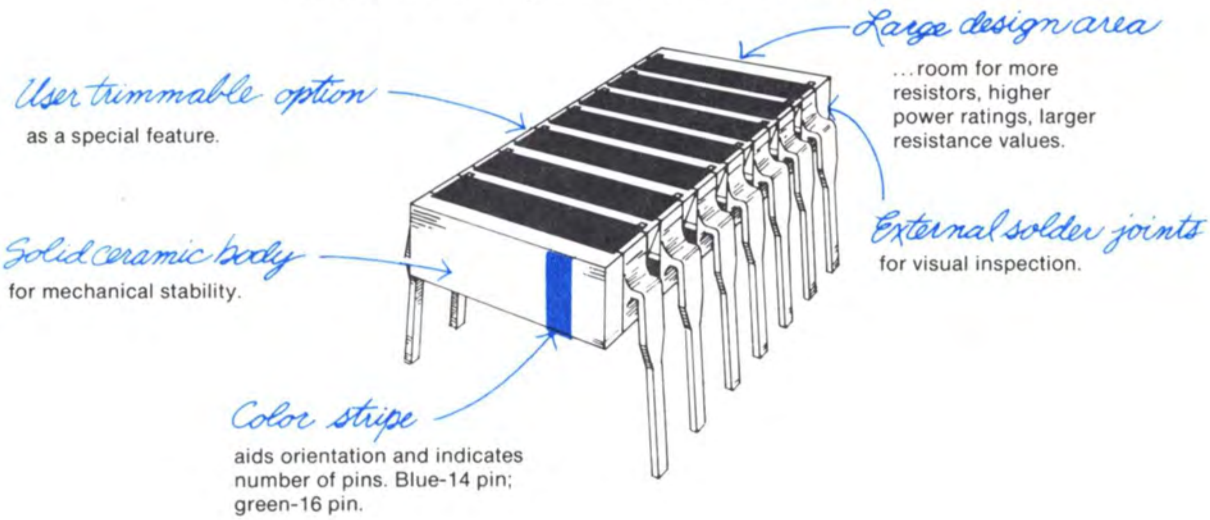
TABLE 5 — Failure Rate

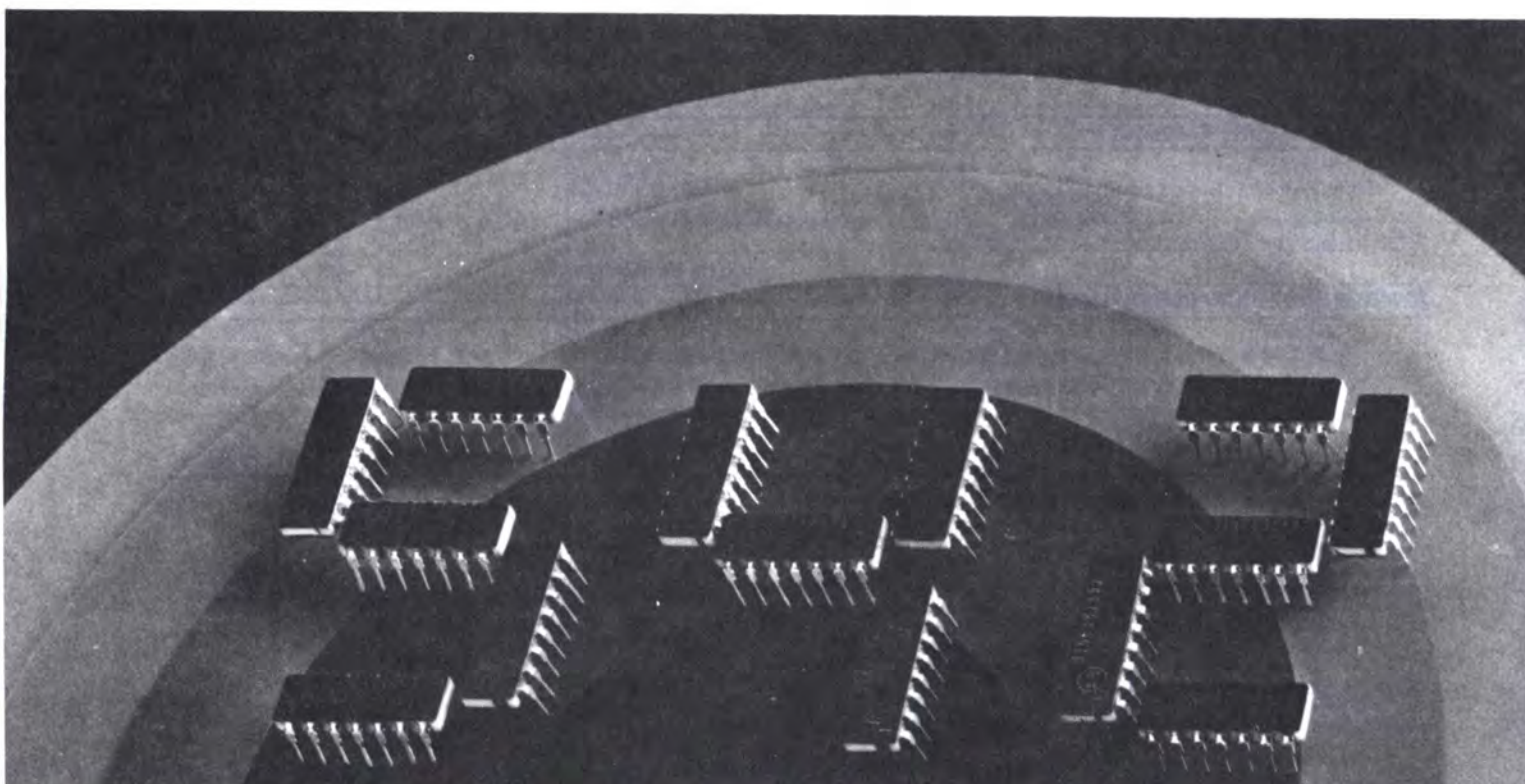
1000 Hours (60 % Confidence)

- **M** = 1.0%
- **P** = 0.1%
- **R** = .01%
- **S** = .001%

Interested in network variety? Select from a spectrum of 542 standards.

Allen-Bradley has the popular configurations you need. Pull-ups. Pull-downs. Line Terminators. Networks to complement Core Memory Sense Amplifiers. TTL to ECL Translators. O-Pad Attenuators. R/2R Ladders. Interconnect Networks. All styles available from your Allen- Bradley *Electronic Distributor*. Call for specs or check your EEM Catalog. If you need specials, contact your local Allen-Bradley district office for fast turnaround. Ask for Publication EC5410-2.1. A-B is an experienced twin-film manufacturer, i.e. precision thin film and thick film.





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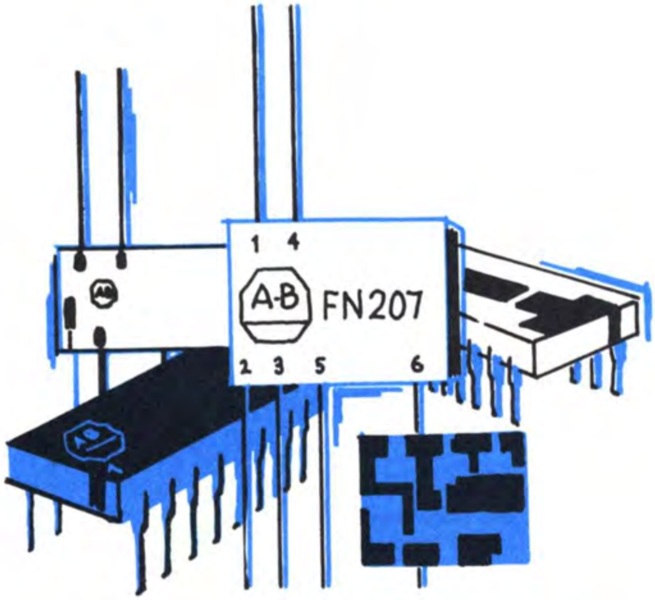


resistor networks

THIN FILM (PRECISION)
THICK FILM (CERMET)

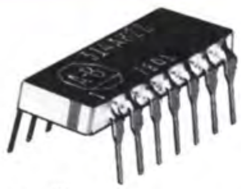
resistor networks

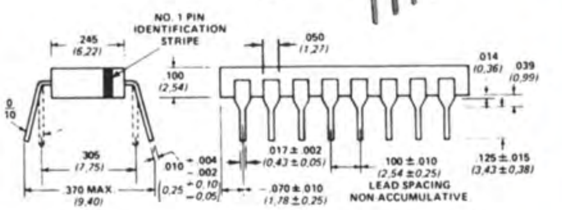
comprehensive product index

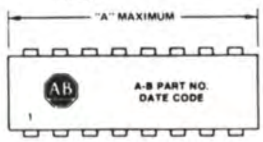
[1] NOT AVAILABLE FROM STOCK AT ELECTRONIC DISTRIBUTORS.

[2] STANDARD VALUES OF I-DIP NETWORKS IN 2% TOLERANCE ARE AVAILABLE FROM STOCK AT ELECTRONIC DISTRIBUTORS.

NEW CERAMIC I-DIP PACKAGE







"A" Maximum		Number of Leads
Decimal	Metric	
.745	18,92	14
.845	21,46	16
.945	24,00	18

SELECTOR GUIDE: STANDARD THICK FILM (CERMET) DIP RESISTOR NETWORKS

314A 316A	314B 316B	314E 316E	316L08	314M110 314M120 314M125	314M130	316T110	314X101 316X101	314Z
APPLICATIONS								
Pull-Up Resistor Arrays for Unused TTL Gates Parallel High Speed Circuitry Wired OR Configurations Pull-Down Applications TTL-MOS Interfacing Digital Pulse Squaring	Transmission Line Termination Power Gate Pull-Up Current Limiting Logic Level Translation	Digital Line Termination ECL and TTL Applications	8 BIT R/2R Ladder Network for D/A and A/D Converter with Bi Polar or CMOS Switches	Complement the 7520 Series of Core Memory Sense Amps	Core-Memory Sense Line Applications with Two 711 Dual Voltage Comparators	TTL to ECL Translator Network	Interconnect Networks Shorting Applications Matrix Interconnections Test Plugs	Fixed Voltage Attenuation with Impedance Matching

Page Number 63

resistor networks

FEATURES
I-SIP CERMET NETWORKS

- Solid Cermic Body
- Triple-Strength Leads
- 0.100 Inch (2,54 mm) Lead Spacing
- 2 Package Heights (.200 Inch, .350 Inch)
- 6, 8 and 10 Pins

SELECTOR GUIDE: STANDARD THICK FILM (CERMET) SIP RESISTOR NETWORKS

106A 108A 110A 406A 408A 410A	106B 108B 110B 406B 408B 410B	106E 108E 110E 406E 408E 410E
	APPLICATIONS	
Pull-Up Resistor Arrays for Unused TTL Gates Parallel High Speed Circuitry Wired OR Configurations Pull-Down Applications TTL-MOS Interfacing Digital Pulse Squaring	Transmission Line Termination Power Gate Pull-Up Current Limiting Logic Level Translation	Digital Line Termination ECL and TTL Applications

Page Number 59

THIN FILM (PRECISION) CUSTOM RESISTOR NETWORKS AND CHIP AND HYBRID NETWORK SUBSTRATES

APPLICATIONS:

These precision networks are ideally suited for use on any electronic equipment requiring close tolerances and/or low temperature coefficient resistors. Some of these applications are listed below.

- — Ladder networks
- — Digital multimeters
- — Current summing applications
- — Precision attenuators
- — A/D and D/A converters
- — Communication equipment
- — Precision voltage dividers
- — Telemetry equipment
- — Coding and decoding circuitry
- — Measurement bridges
- — Paging systems

SELECTOR GUIDE: VOLTAGE DIVIDER NETWORK (Decade Attenuator) — FNPC207, FN207

Page Number

Resistance Tolerance on Total Resistance (R_T) at 25° C
$R_T = R_1 + R_2 + R_3 + R_4 + R_5 + 10$ Megohms ± 0.05%
Ratio Tolerance at +25° C and from 0 to 1000 volts:

$$\frac{R_1+R_2+R_3+R_4}{R_T} = \frac{1 \text{ Megohm}}{10 \text{ Megohms}} = 0.1 \pm 0.03\%$$

$$\frac{R_1+R_2+R_3}{R_T} = \frac{100 \text{ K ohms}}{10 \text{ Megohms}} = 0.01 \pm 0.03\%$$

$$\frac{R_1+R_2}{R_T} = \frac{1 \text{ K ohm}}{10 \text{ Megohms}} = 0.001 \pm 0.03\%$$

$$\frac{R_1}{R_T} = \frac{1 \text{ K ohm}}{10 \text{ Megohms}} = 0.0001 \pm 0.03\%$$

Temperature Coefficient of Resistance .... ±25 ppm/° C
TCR Tracking .... ±5 ppm/° C
Operating Voltage (between pins 1 & 6) .. 1000 volts max.
Operating Temperature .... 0° C to +70° C
Storage Temperature ....—65° C to +175° C

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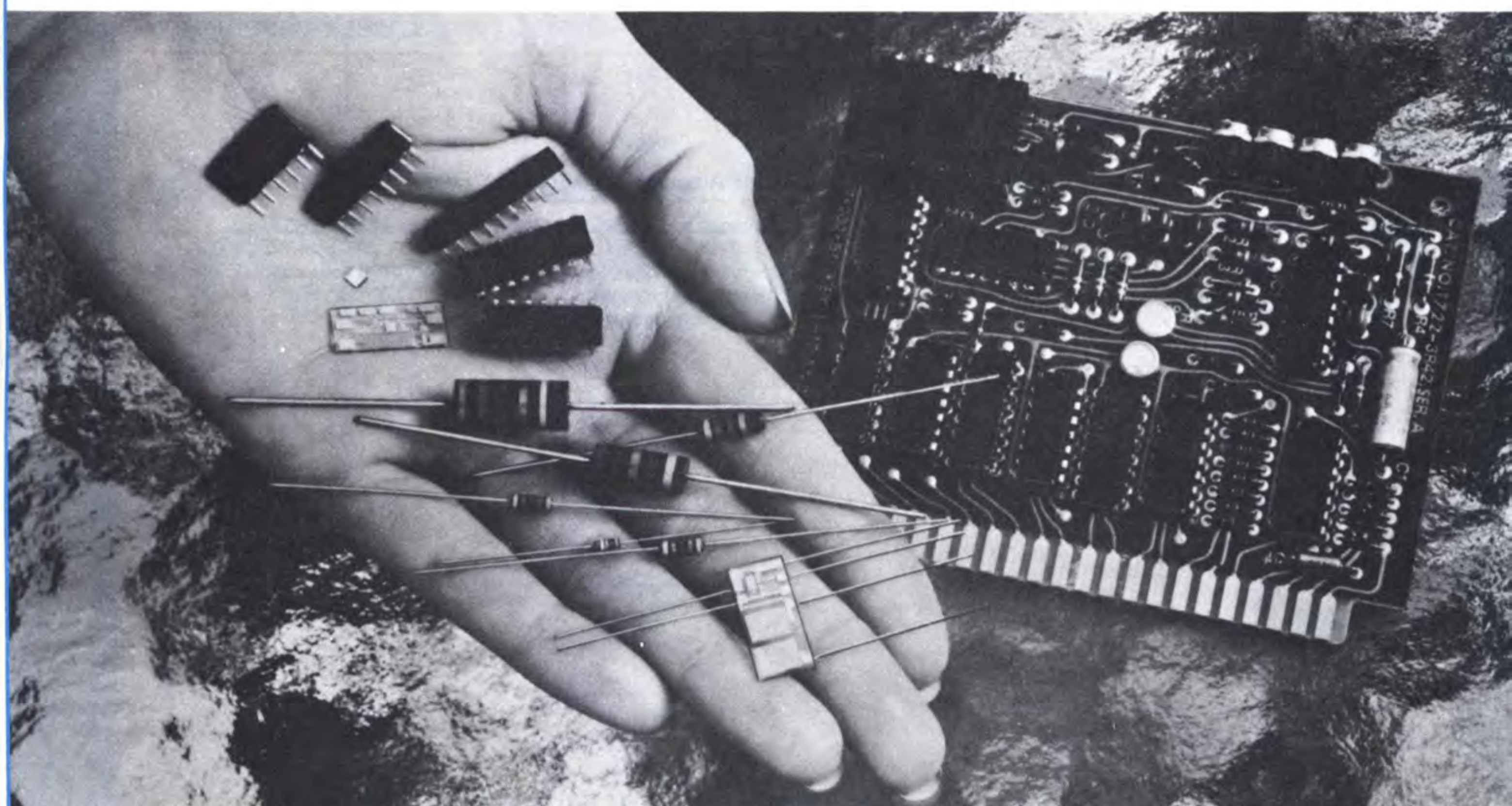
resistor networks

DIP, SIP and chip networks and discretes for virtually any resistor needs.

Allen-Bradley can satisfy most—if not all—of your fixed resistor needs. Networks and discretes. Thin film, thick film and carbon composition. Standards where you expect customs. Examples: Our I-DIP cermet networks are available in 542 stock configurations. Our discrete carbon composition resistors are available in custom high ohmic values at a million megohms in standard small body sizes. Write for technical information today.

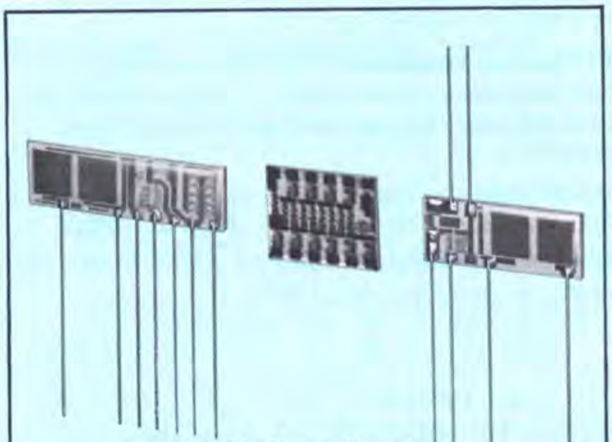
RESISTOR TYPE	RESISTANCE RANGE	POWER RATING	TOLERANCE	TCR
Carbon Comp	1 ohm to 100 megs (custom to 1 million megs.)	⅛W to 4W @ +70°C	±5% to ±20%	Typically less than 250 PPM/°C from +15°C to +75°C
I-DIPs	22 ohms to 1 meg (customs for other values)	100 to 500 mW per resistor @ +70°C	±1%, ±2%	±100 and ±200 PPM/°C
I-SIPs	22 ohms to 1 meg (customs for other values)	125 to 500 mW per resistor at +70°C	±2% or ±1 ohm whichever is greater	±100 PPM/°C
Chips	50 ohms to 10 megs	10 to 250 mW per resistor at +125°C	as low as ±.015%	±25 PPM/°C



Quality in the best tradition.

Series **FN**

Precision Thin Film Custom Resistor Networks



Thin Film Resistor Networks
Conformally Coated and Chip Styles

FEATURES

- 1K Ohms to 10 Megohms
- ± 0.015% Tolerance
- ± 0.015% Ratio
- ± 25 ppm/°C TCR
- ± 5 ppm/°C TCR Tracking
- Conformally Coated Package Styles
- Chip Resistor Networks

SPECIFICATIONS

Introduction

Allen-Bradley thin film resistor networks consist of integrated films of chromium cobalt vacuum deposited on specially selected glass substrates resulting in networks having precision tolerance and stability. They can be calibrated to tolerance at Allen-Bradley or they can be designed for functional (active) trimming by customer.

For additional information on chromium/cobalt technology refer to Allen-Bradley Publication EC90.

General capabilities

Film stability — Unique chromium cobalt thin film provides consistent long term stability.

Interconnection reliability — Metal film interconnections and bonding pads are reliable; no soldered or welded joints.

Electrical uniformity — Resistance change due to temperature (TCR) is low and uniform across substrate (TCRT).

Performance repeatability — Network-to-network, circuit performance is reliable and repeatable.

Consistent quality — From prototype to high volume production, quality is a major factor.

Applications

These precision networks are ideally suited for use on any electronic equipment requiring close tolerances and/or low temperature coefficient resistors. Some of these applications are listed below.

- Ladder networks
- Digital multimeters
- Current summing applications
- Precision attenuators
- A/D and D/A converters
- Communication equipment
- Precision voltage dividers
- Telemetry equipment
- Coding and decoding circuitry
- Measurement bridges
- Paging systems

For application information refer to the following Allen-Bradley Application Notes:

- R/2R Ladder Networks: EC5510-4.2
- Voltage Divider Networks: EC5515-4.2

For handling and soldering procedures refer to Allen-Bradley Product Data EC5570-5.1.

NOT AVAILABLE FROM STOCK AT ELECTRONIC DISTRIBUTORS.

Electrical capabilities

Resistance range — 1K ohms to 10 megohms standard. Single substrate range; 10,000 to 1.

Tolerance (absolute) — As low as ± 0.015 percent at +25°C.

Resistance matching or ratio — As low as ± 0.015 percent at +25°C.

Temperature coefficient of resistance (TCR) — ± 25 ppm/°C standard.

TCR tracking — Between resistors in the same network is ± 5 ppm/°C standard.

Temperature ranges of operation — −55°C to +125°C military; 0°C to + 70°C industrial. Other ranges available.

Temperature range of storage — −65°C to +175°C.

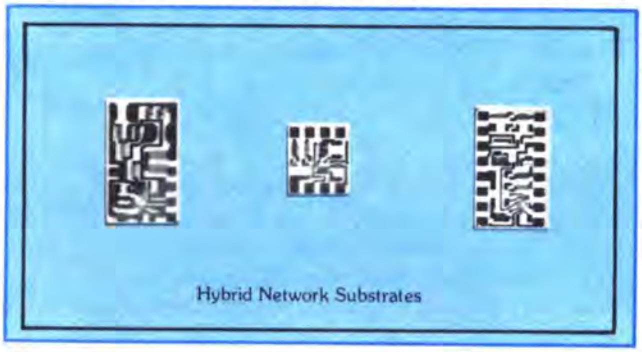
Power rating — 50 milliwatts per resistor standard. Up to 250 milliwatts per resistor special. Power ratings specified at +125°C derated linearly to 0 milliwatt per resistor at +175°C.

Frequency response — Excellent non-inductive high frequency characteristics. Fast rise time. Less than 100 nsec. for packaged precision thin film resistors.

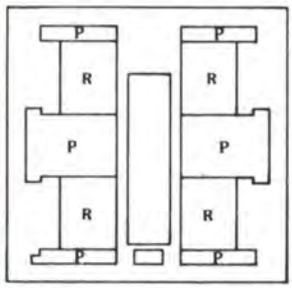
Noise index — Measured on Quantech Model 315 MIL-STD-202D, Method 308, − 60db to − 25db.

Shelf life stability (no load) — $\Delta R < 0.005\%$ per year.

CHIP AND HYBRID NETWORK SUBSTRATE SPECIFICATIONS



Hybrid Network Substrates



Chip Resistor Network
R = Resistor P = Bonding Pad

Hybrid Network Substrate

Hybrid network substrates — Allen-Bradley hybrid network substrates contain resistors, bonding pads and interconnections used in producing hybrid networks. Allen-Bradley does not manufacture complete hybrid circuits, but does manufacture the basic hybrid network substrates.

Termination and bonding pad material — Gold, with a minimum thickness of 5000A, is used for all termination pads, bonding pads and interconnections. This material is compatible with ultrasonic and thermocompression bonding methods for attaching gold or aluminum wire, integrated circuit dice, LID's or beam leaded IC's. Chip capacitors can be attached by reflow solder methods.

Substrate material — Corning 7059 glass (Barium Alumino Silicate - electrically inert [Alkali-free]) .032 ± .005 inch (0,81 0,13mm) thick.

User trimmable option — Chip and hybrid network resistors can be trimmed to tolerance by Allen-Bradley or, if needed, resistors can be designed for active trimming by the user during final hybrid assembly operations to meet predetermined functional requirements. The amount of adjustment available is dependent on the initial resistance value, resolution, final value and available substrate area. The active trimming results in a positive resistance change only and can be done by mechanical methods or a laser. These networks are designated as UTRN's (user trimmable resistor networks).

Standard substrate sizes (in inches) —

.150 x .150	.350 x .150	.200 x .200	.600 x .200
.250 x .150	.450 x .150	.400 x .200	.250 x .250

Bonding pad sizes — 10 mils x 10 mils (down to 5 mils x 5 mils minimum).

Resistance range — 1K ohms to 10 megohms.

Tolerances — Absolute: as low as ± 0.015% at + 25°C. Ratio: as low as ± 0.015% at + 25°C.

TCR — ± 25 ppm/°C
TCRT — ± 5 ppm/°C

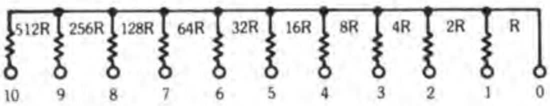
Temperature ranges of operation — − 55°C to +125°C or 0°C to +70°C. Other ranges available.

Power rating — Up to 50mw per resistor.

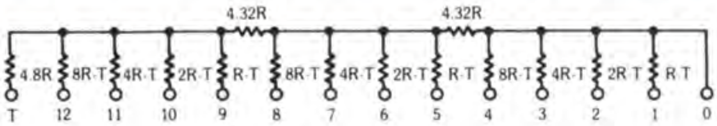
DIAGRAMS

Thin film custom resistor network suggestions

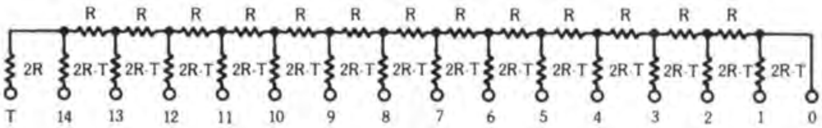
A/D — D/A Converter Networks



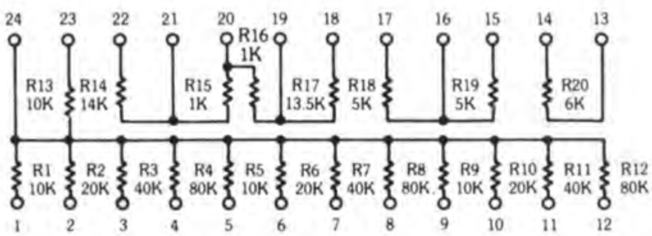
Binary Code — Summing Ladder Network



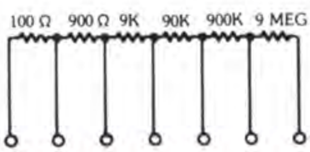
1-2-4-8 BCD Code Ladder Network

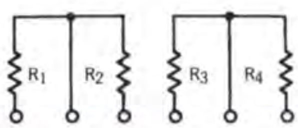


Binary Code — R/2R Voltage Ladder Network

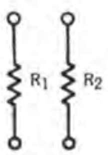


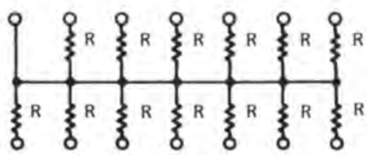
Voltage Dividers

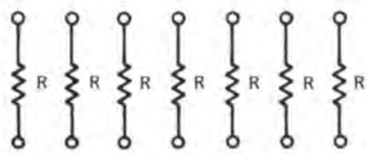




Matched Resistor Arrays







Typical performance test capabilities

Test Group	Order Of Test	Examination or Test	Test Method	Post Test Requirements
I	1	**Visual and Mechanical Examination**	MIL-STD-883, Method 2008, Test Condition A.	In accordance with applicable requirements.
	2	**DC Resistance**	MIL-STD-202, Method 303.	
II	1	**Temperature Cycling**	MIL-STD-883, Method 1010, Test Condition B.	Resistance change ± 0.05 percent maximum
	2	**Low Temperature Operation**	MIL-R-10509F, Paragraph 4.6.5.	Resistance change ± 0.1 percent maximum
	3	**Short Time Overload**	MIL-R-10509F, Paragraph 4.6.6.	Resistance change ± 0.2 percent maximum
	4	**Terminal Strength**	MIL-STD-883, Method 2004, Test Condition A, 3 lb.	Resistance change ± 0.1 percent maximum.
	5	**Resistance to Solvents**	MIL-STD-202, Method 215.	Resistance change ± 0.05 percent maximum. Markings shall remain legible.
III	1	**Dielectric Withstanding Voltage**	MIL-STD-202, Method 301, 500V RMS. Method 105C, Test Condition B with 300V RMS applied for 60 ± 5 sec.	Resistance change ± 0.1 percent maximum.
	2	**Insulation Resistance**	MIL-STD-883, Method 1003, Test Condition D.	10^{12} Ohms minimum.
	3	**Temperature Cycling**	MIL-STD-883, Method 1010, Test Condition B.	Resistance change ± 0.05 percent maximum.
	4	**Resistance to Soldering Heat**	MIL-STD-202, Method 210, Test Condition B.	Resistance change ± 0.05 percent maximum.
	5	**Moisture Resistance**	MIL-STD-883, Method 1004, Figure 1004-1. Omit Paragraphs 3.1 and 3.6.1.	Resistance change ± 0.1 percent maximum.
IV	1	**Resistance Temperature Characteristic**	MIL-STD-202, Method 304, (Over Specified Operating Temperature Range)	Within specified limits.
	2	**Life**	MIL-STD-883, Method 1006, 125°C, 1000 hrs. 1 1/2 hours on, 1/2 hour off.	Resistance change ± 0.1 percent maximum.
V	1	**Solderability**	MIL-STD-883, Method 2003.	Resistance change ± 0.1 percent maximum.
	2	**Vibration, Fatigue**	MIL-STD-883, Method 2005, Condition A.	Resistance change ± 0.05 percent maximum.
	3	**Shock**	MIL-STD-202, Method 213A, Test Condition I.	Resistance change ± 0.05 percent maximum.

INSPECTION CONDITIONS: Unless otherwise specified, all measurements are understood to be made at the following initial inspection conditions:

Normal atmospheric pressure.
Relative humidity of 40 ± 10 percent.
Ambient temperature of 24° ± 2°C.

NOTE: During an inspection or qualification, all the networks shall be subjected to the inspections of Test Group I. The total samples are then divided into Groups II to V inclusive, and subjected to the tests and inspections of the particular group.

R/2R Ladder Network

by John Blanchard
Electronics Application Engineer

Synopsis — This application note discusses the terminology, operation, usage and design considerations of the R/2R ladder network (Figure 1), one of the most commonly used precision resistor networks used for digital to analog (D/A) and analog to digital (A/D) conversion. For further information see Allen-Bradley Technical Publication EC5510-2.1.

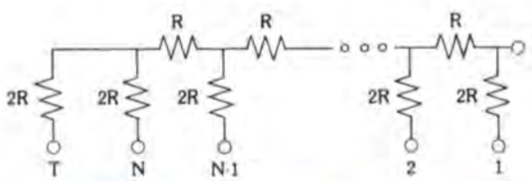


Figure 1. N Bit R/2R Ladder Network

The basic R/2R ladder network — The term ladder network is derived from the ladder-like configuration of this class of circuits. The R/2R ladder receives its name because it is composed of R-valued resistors in the series legs and 2R-valued resistors in the shunt legs. In Figure 1, each of the positions numbered 1, 2, . . . , N-1, N is referred to as a bit. The bits of the ladder are the points at which input signals are presented to the ladder. The inputs may be either serial or parallel with the aid of various solid state registers. Position T, the terminating resistor, is always connected to ground. The function of the terminating resistor is to terminate the ladder such that the output impedance of the ladder is R as measured from the terminal labeled OUT to ground with all bits grounded and to provide the proper output voltages. The position labeled OUT is the point at which the output is taken from the R/2R ladder. The output terminal is commonly used to drive an operational amplifier.

Ideal D/A conversion — The relative simplicity of D/A conversion in comparison to A/D conversion makes it convenient to use D/A conversion for this discussion. In D/A conversion, digital information is presented to the bits of the ladder in the form of zeros and ones. Common convention is that of positive logic in which ground represents a zero and a positive precision reference voltage represents a one. In order to change the input of a bit from a zero to a one or vice-versa, some form of switch is required. For the ideal case of perfect switches, i.e., one being a short circuit when closed and an open circuit when open, a bit is either tied to ground or to a voltage source depending upon the absence or presence of digital information at a bit respectively. To assist in this discussion, a four-bit ladder will be studied. To simplify matters, all resistors, switches, and the reference voltage will be considered as ideal elements.

The first case to be analyzed is the condition of a 1 applied to Bit 1 and 0's applied to all other bits (Figure 2). Bit 1, as will be seen, contributes the most voltage to the output and is called the most significant bit (MSB). When the output voltage is measured for this input condition (the binary word is 1000), it will be $V_{ref}/2$. Thus, the voltage ratio of the output voltage to the input voltage for the MSB energized is nominally .5000000. If the input condition is changed to 0100 (Bit 2 "ON" and all other bits "OFF"), the output voltage becomes $V_{ref}/4$ and the output voltage ratio becomes .2500000. Energizing Bit 3 with all other bits grounded provides a voltage ratio that again is half of the preceding voltage ratio or .1250000. This

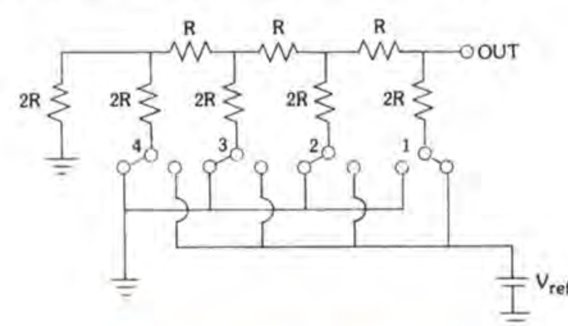


Figure 2. Four Bit R/2R Ladder

R/2R Ladder Network

progression continues in that the voltage ratio for a given bit ideally is half that of the previous bit, thus making the circuit a binary R/2R ladder.

Bit 4 in the example produces the smallest output voltage ratio (.0625000) and is called the least significant bit (LSB). The LSB voltage also represents the smallest voltage change that occurs at the output. For example, when V_{ref} equals one volt, the change in the output voltage that results by applying V_{ref} to Bit 4 is 62.5mV.

The principle of superposition applies to the R/2R ladder because it is a linear circuit. For example, when both Bits 1 and 2 are energized to V_{ref}, the output voltage is a summation of the individual output voltages for each of the energized bits, i.e., $V_{ref}/2 + V_{ref}/4 = 3/4\ V_{ref}$. The superposition principle applies to any combination of energized bits.

The voltage ratio concept can be extended to any number of bits as shown in Table 1.

Bit No.	Voltage Ratio $\frac{V_o}{V_{ref}}$
1 (MSB)	.5
2	.25
3	.125
4	.0625
5	.03125
6	.015625
7	.0078125
8	.00390625
9	.001953125
10	.0009765625
11	.00048828125
12	.000244140625
13	.0001220703125
14	.00006103515625
15	.000030517578125
16	.0000152587890625

Table 1. Table of Output Voltage Ratios

It is obvious that as the number of bits increases, the LSB voltage decreases, i.e., the percent contribution that the LSB voltage makes to the output voltage becomes less and less. This results from the fact that the summation of the voltage ratios approaches unity, or alternately, with $V_{ref} = 1$ volt and all bits in the 1 state, the output voltage approaches 1 volt. The condition in which all bits are energized is referred to as full scale operation of the ladder. The result is the full scale output voltage which can be expressed mathematically as in Equation 1:

$$\text{Full Scale Output Voltage} = V_{ref} \times \sum_{i=1}^{n} \frac{1}{2^i}$$

where n = number of bits.

$$\lim_{n \to \infty} V_{ref} \times \sum_{i=1}^{n} \frac{1}{2^i} = V_{ref}$$

Equation 1

As an example, the LSB of a 16-bit ladder is only $15\mu V$ for $V_{ref} = 1$ and it contributes only .0015 percent to the full scale output voltage.

Full scale accuracy — To this point the discussion has involved only ideal components. To relate to the real world, resistor inaccuracies and stray reactances must be taken into consideration. It now becomes important to determine how the accuracy of an R/2R ladder is specified. A normal accuracy specification for any R/2R ladder is ± 1/2 LSB. For example, this means that when an n bit ladder has all of its bits energized to the 1 state with V_{ref} equal to 1 volt, the output voltage is:

$$\sum_{i=1}^{n} \frac{1}{2^i} \pm \frac{1}{2}\text{LSB} = \sum_{i=1}^{n} \frac{1}{2^i} \pm \frac{1}{2}\frac{1}{2^n} = \sum_{i=1}^{n} \frac{1}{2^i} \pm \frac{1}{2^{n+1}}$$

Using the example of the 4-bit ladder operating at full scale with $V_{ref} = 1$ volt, the output voltage for a ± 1/2 LSB specification is .93750 ± .03125 volts. The ± 1/2 LSB accuracy specification is sufficient to insure that when the LSB is energized to the 1 state, the output it causes is indeed due to a voltage on the LSB and not due to resistor errors in the ladder. A tighter, but necessarily more costly, specification is ± 1/4 LSB which requires that resistor errors be at least a factor of two less than those allowed for the ± 1/2 LSB specification.

In the real world, resistor inaccuracies affect the nominal voltage ratios of Table 1. In practice, the differences between the measured or actual voltage ratio and the nominal voltage ratio for a given bit become the concern. To determine the accuracy of a ladder, the voltage ratio errors are measured for all bits as illustrated for the 15-bit R/2R ladder in Table 2. The bit error column, labeled percent bit error, shows the voltage ratio errors for each bit as a percent of full scale.

Some bit errors have positive signs; others have negative signs. A worst case condition exists when all bits of like (positive or negative) accuracy are energized at the same time. Therefore, the summation of all negative bit voltage ratio errors is compared with the sum of all positive bit voltage ratio errors. The larger of the two summations is chosen as the worst case combination of errors. In Table 2,the worst case error is –.00066 percent as related to full scale.

When the larger summation is less than 1/2 LSB of the ladder, the resistor errors are small enough for the ladder to function properly. In other words, the maximum error that the ladder output can have while operating at full scale is ± 1/2 LSB. When it is recalled that an LSB represents a percent of full scale, ladder accuracies may be conveniently expressed in percent of full scale, or what is referred to as Full Scale Accuracy (FSA). For example, a ± 1/2 LSB specification on a 12-bit ladder is identical to ± .0122 percent FSA. In the example of Table 2, the ladder accuracy specification is ± .00066 percent FSA.

15 Bit Ladder Network
Design Objective = ± .0015% FSA

Pin	BIT	Nominal Volt Ratio	+25°C Measured Ratio	Percent Bit Error
R 3	1	0.5000000	0.5000035	0.00035
R 5	2	0.2500000	0.2499970	-0.00030
R 7	3	0.1250000	0.1249995	-0.00005
R 9	4	0.0625000	0.0624990	-0.00010
R11	5	0.0312500	0.0312488	-0.00012
R13	6	0.0156250	0.0156245	-0.00005
R15	7	0.0078125	0.0078123	-0.00002
R17	8	0.0039062	0.0039060	-0.00002
R19	9	0.0019531	0.0019538	0.00007
R21	10	0.0009766	0.0009766	0.0
R23	11	0.0004883	0.0004883	0.0
R25	12	0.0002441	0.0002441	0.0
R27	13	0.0001221	0.0001221	0.0
R29	14	0.0000610	0.0000610	0.0
R31	15	0.0000305	0.0000305	0.0
	SUM+			**0.00042**
	SUM-			**-0.00066**

PERCENT FSA =
Worst Combination of Percent Bit Errors.

Table 2. 15 Bit R/2R Ladder Actual Test Data

TCR and TCR tracking — Ladders are seldom used at only one temperature. More realistically a customer will specify a required accuracy for a particular temperature range, such as the industrial range of 0°C to + 70°C, or the military range of –55°C to + 125°C. Hence, for an R/2R ladder to have an accuracy of ± 1/2 LSB over a given temperature range, the ladder resistors must have similar temperature coefficients of resistance (TCR). This means that the ladder resistors must track each other with temperature accurately enough so that the ± 1/2 LSB accuracy holds anywhere in the specified temperature range. When temperature fluctuations are of concern, the FSA should be specified over a temperature range. For example, a 12-bit ladder that must have ± 1/2 LSB accuracy from 0°C to –70°C would be specified as ± .0122 percent FSA over that range (see Table 1). Thus, it is not as important to specify TCR as it is to specify FSA over a temperature range.

TCR tracking is an important consideration, particularly when application resistors are fabricated on the same substrate to work in conjunction with the ladder. Common examples of application resistors are resistors that provide gain or offsets for operational amplifiers. They are usually matched to the output impedance of the ladder. In order to maintain tight matching over a temperature range, the TCR tracking between the resistors of the ladder and the application resistors is important.

A typical TCR tracking specification for Allen-Bradley thin film resistor networks is ± 5 ppm/°C. This insures that no two resistors at + 125°C are matched any worse than .05 percent more than their room temperature matching. An increasingly more common yet necessarily more costly tracking specification is ± 2 ppm/°C over a –55°C to + 125°C temperature range. For example, the resistors associated with the operational amplifier of Figure 3 have been specified so as to have a room temperature gain of 2 ± 0.1 percent and a gain at + 125°C of 2 ± 0.12 percent. When the resistors are adjusted to a ± 0.1 percent match at + 25°C, the match may change only an additional .02 percent

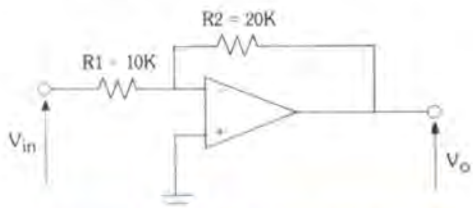


Figure 3. TCR Tracking Example

over the + 100°C temperature rise, which is a change that would result from 2 ppm/°C tracking. A more satisfactory and less costly way of specifying the resistors is to have a room temperature gain equal to 2 ± 0.05 percent and the gain at + 125°C equal to 2 ± 0.12 percent. This effectively loosens the tracking specification to 7 ppm/°C, while, at the same time, does not tax adjustment capabilities. Trade-offs such as this are significant from both design and cost considerations.

Ladder resistance and switch resistances — The choice of the value for R in an R/2R ladder is dependent on both the desired rise time of the output voltage and the type of switch chosen for connecting each of the bits to either ground or the reference voltage.

In general, the higher the value of R, the longer the rise time. This is due to stray capacitance associated with each resistor and its lead wires. The equation that expresses the 10 percent to 90 percent rise time or fall time for a resistor having stray capacitance is:

$$10\% - 90\% \text{ rise time} = RC \ln 9 = 2.2RC$$

The capacitance associated with an Allen-Bradley thin film resistive element is in the 1.0 to 1.5 pF range. Thus, for a constant capacitance, the rise time becomes proportional to the value chosen for R.

Both the "ON" resistance and the current capabilities of the switches govern the choice of R. MOSFET switches, for example, are low power devices. Hence, the ladder resistance should be chosen so that the switch can safely conduct the current when a bit is energized.

Transistor switches generally can handle more current than MOS devices; and as a result, the value chosen for the ladder resistance is less than that when MOS switches are chosen. Regardless of the type of switch used, compensation for the "ON" resistance of the device must be made. To compensate for switch resistances, the "ON" value of the switch resistance (T) is subtracted from each 2R resistor of the ladder as shown in Figure 4. For example, given switches with an "ON" resistance of 10 ohms, an ideal 10K/20K ladder becomes 10K/19.990K. These values then become the values specified for manufacture of the ladder. The "T" value need not necessarily be the same for each bit. When, for example, the switches for the first bits

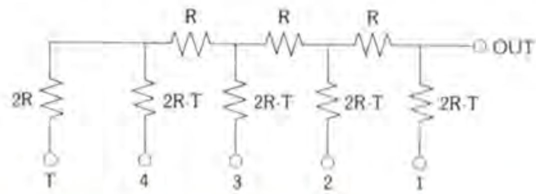


Figure 4. 4-Bit R/2R Ladder With Compensation For Semiconductor Switch Resistances

differ from those for the last bits of the ladder, the "T" values differ. Resistor adjustment techniques make it posible to compensate for different switch resistances.

The magnitude of the "ON" resistance of the switch is important in determining the ladder resistance value. The "ON" resistance of typical switching transistors is 5-10 ohms, where a typical value for MOS devices is 250 ohms. These are nominal values only. Any deviations from nominal introduce unexpected errors in bit outputs for those bits that have been adjusted for the nominal value of the switch resistance. Thus, it becomes important to know not just the nominal switch resistance, but also the range of switch resistances to be encountered, so that any deviation from nominal contributes only a small error to each bit.

The result of this criterion is that for switches having high "ON" resistances, the ladder resistance value is considerably higher than that required for switches having low "ON" resistances. A good rule of thumb is to have switch resistances less than .1 percent of the 2R value. Further, since the TCR of semiconductor switches is considerably higher than that of the ladder resistors, the TCR tracking of the R and 2R branches is adversely affected when the "ON" resistance is too large a percentage of the 2R branches.

Once the ladder resistance value has been chosen, a tolerance must be assigned to the ladder. The tolerance of concern is that of the output impedance, R_{out}. In general, a ladder output impedance tolerance of ±10 percent or ±20 percent is adequate, simply because the performance of a ladder depends on resistor matching and not absolute tolerance. Since application resistors are customarily specified with relationship to the ladder output impedance, a loose tolerance R_{out} will not interfere with the proper performance of the application resistors. Further, by specifying a loose output impedance tolerance, overall ladder costs can be reduced.

Application resistors — Up to now, several points have been made with respect to application resistors. The first was that a room temperature matching or ratio specification must be made in addition to the TCR tracking specification. With the proper care, an application resistor can be specified such that it will perform as desired and take advantage of manufacturing techniques. Resistance ratio matching, however, is not the only method used for specifying application resistors. A second and less commonly used method involves a difference or voltage ratio error, instead of an actual percent match of the application resistor to the output impedance of the ladder. An example might illustrate a comparison of these two methods.

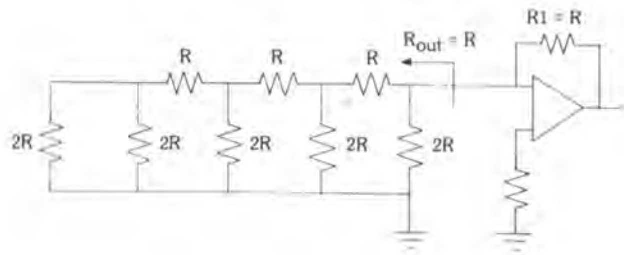


Figure 5. Ratio Matching R1 to R_{out} of Ladder

The measurement technique that is used to match R1 to R_{out} in Figure 5 provides one of the following ratios, depending on how the test equipment is connected:

$$\text{Actual Output Voltage Ratio} = \frac{R1}{R1 + R_{out}} \text{ or } \frac{R_{out}}{R1 + R_{out}}$$

When R1 matches R_{out} perfectly, both the above voltage ratios are .5000000 (R1 = R_{out}). The hypothetical example below shows that the matching is not perfect:

Nominal Output Voltage Ratio	Actual Output Voltage Ratio	Difference or Voltage Ratio Error	Percent Match of R1 to R_{out}
.500000	.499878	.000122	.0488%

The nominal output voltage ratio represents the ideal situation where R1 has been trimmed to match R_{out} perfectly. The actual voltage ratio represents the behavior of application resistor R1 in relationship to the output impedance of the ladder. In the example, the actual output voltage ratio differs from the nominal by 122 ppm, which represents the voltage ratio error method of specifying the application resistor. However, the 122 ppm difference does not mean that there is a 122 ppm (.0122 percent) resistance match to the ladder. To calculate the percent resistance match of R1 to R_{out}, the following equation is used:

$$\text{Actual Voltage Ratio} = \frac{R1}{R1 + R_{out}}$$

Solving for $\frac{R_{out}}{R1}$ the following is obtained:

Equation 2

$$\frac{R_{out}}{R1} = \frac{1 - \text{Actual Voltage Ratio}}{\text{Actual Voltage Ratio}}$$

Equation 3

When the numbers from the example are substituted in Equation 3, the resistance ratio match of R1 to R_{out} is .0488 percent and not .0122 percent! Thus, the method of specifying application resistor accuracy can be deceiving, particularly when a voltage ratio error is used as the specification. This is because the voltage ratio error can appear to be a much tighter specification than that of actual resistance ratio matching expressed in percent.

Power — Power is usually not a major concern when specifying ladders. This is because the voltages applied to the bits are in the range of a few volts to 12 or 15 volts. As a result, power dissipation is kept low and resistance change of the ladder resistors caused by self-heating is minimized. However, power considerations can be of concern for application resistors used as feedback elements for providing operational amplifier gain. With the operational amplifier summing point effectively at ground and connected for unity gain, for example, the full reference voltage can appear across the feedback resistor. To avoid detrimental self-heating effects, care should be taken to keep the maximum resistor dissipation below the rated power. Needless to say, the lower the dissipation, the less likely ladder performance will be degraded. Further, the lower the power levels, the easier it becomes to reduce the overall size of the ladder.

The number of bits — The selection of the number of bits a ladder is to have is effectively a specification for the resolution of the converter. For example, a specification of 0.1 percent resolution on the analog output of a converter requires a 10-bit ladder ($1/2^{10} \times 100\% = 0.0976\%$). The greater the number of bits, the better the resolution. For example, 12-bits provide .0244 percent while 14-bits provide .0061 percent. However, the more bits there are, the more difficult it becomes to manufacture ladders with ±1/2 LSB accuracies, with the practical limit at present being 15 to 16 bits for an R/2R ladder. It becomes extremely difficult to manufacture ladders to less than ± .001 percent FSA at + 25°C, regardless of the numbers of bits.

Advantages of R/2R ladders — The R/2R ladder configuration has several advantages that distinguish it from other types of ladders. Only two resistor values are required. From a manufacturing standpoint, this means that thin film deposition techniques can be utilized to their fullest advantages. The two values of resistors are in a 2 to 1 ratio, and hence, allow excellent TCR tracking and aging characteristics. The second major advantage is that the impedance seen at any bit looking toward the operational amplifier is fairly constant. The R/2R ladder also possesses a certain versatility that other ladders do not. Figure 6 shows the dual of the circuit in Figure 1. It displays the same binary R/2R ladder network that has been discussed, only here it is being driven by digital inputs derived from high impedance sources, i.e., current generators. Instead of an output voltage being of concern, an output current is fed to operational amplifier to generate the analog output. If it is desired to use an R/2R ladder as a current ladder, the manufacturer must be informed so that the resistor nodes are brought out of the package.

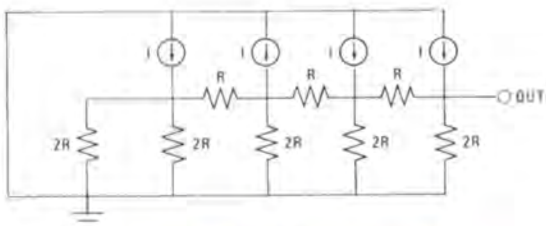


Figure 6. R/2R Current Ladder

A comparison of R/2R ladder fabrication techniques —

- Thin film —
  Thin film networks are made by vapor depositing a metal film on a substrate. By having all resistors on the same substrate, their characteristics closely match one another. The main advantages of thin film networks are that, in general, they have low TCR, tight TCR tracking, uniform aging, and the ability to be trimmed to very tight tolerances.
- Thick film —
  Thick film networks are made by screen printing a cermet material on a substrate. Thick film ladders generally have a slightly higher TCR and TCR tracking and cannot be adjusted as tightly as thin

film ladders. Thick films still have a TCR that is far better than discrete carbon film or carbon composition resistors. The range for thick film TCR is ± 100 ppm/°C to ± 250 ppm/°C and TCR tracking in the range of ± 25 ppm/°C to ± 50 ppm/°C.

- Discrete resistor R/2R ladder networks — Discrete resistors may be used to make R/2R ladder networks, and initially the cost of discretes versus networks may be attractive. However, the ladder assembly cost disadvantages presented by discretes outweigh the parts cost advantage. To manufacture a ladder using discretes, tedious sorting must be performed to obtain the required resistor matching. After sorting, the individual resistors must be assembled. The TCR tracking of the resistors may be so poor that the resistors would have to be sorted for TCR matching. Discretes may also be very inductive, which may result in problems with rise and settling time. Last, discretes age differently, and hence, cause overall ladder accuracy to change.

GLOSSARY OF TERMS —

Application Resistor — Any resistor on the same substrate with a ladder that is not directly a part of the ladder, but that is matched or ratioed to the ladder output impedance.

Bit — Designation for the input leads of ladder networks.

Current Ladder — An R/2R ladder whose bits are all tied to ground and whose inputs are derived from current sources that drive the nodes of the ladder. See Figure 6.

Full Scale — The condition of ladder operation in which all bits are energized.

Full Scale Accuracy (FSA) — The maximum error encountered in a ladder as compared to the full scale of the ladder.

Ladder Network — A repetitive arrangement of precision resistors in a ladder-like configuration that assists in D/A and A/D conversion.

Least Significant Bit (LSB) — That bit in a ladder that produces the smallest output voltage ratio.

Most Significant Bit (MSB) — That bit in a ladder that produces the largest output voltage ratio. In an R/2R ladder, the MSB is always designated bit 1 and produces an ideal output voltage ratio of .5000000.

Resistor Matching or Ratio Matching — Maximum deviation permissible from the ratio of nominal resistance values of two resistors measured at a given temperature. It is usually specified in percent or ppm with one resistor selected as the reference resistor.

"T" Resistance or Switch Resistance — That value of resistance that is removed from the 2R branches of a ladder to compensate for the "ON" resistance of the switches used with each bit.

Temperature Coefficient of Resistance (TCR) — TCR is the change in resistance due to a change in temperature. It has units of %/°C or ppm/°C.

Temperature Coefficient of Resistance Tracking — TCR tracking is the difference in TCR of two or more resistors. As an example, when one resistor has a TCR of + 10 ppm/°C and another has a TCR of + 8 ppm/°C, the two resistors track to + 2 ppm/°C.

Terminating Resistor — Resistor located after the LSB connected to ground to give the ladder proper output impedance and provide the proper output voltage levels.

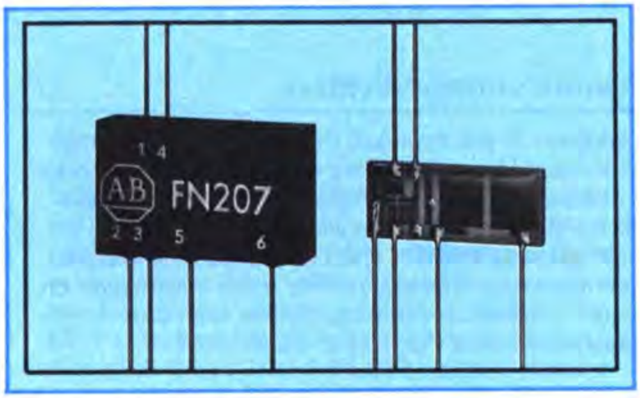
Thick Film — A manufacturing technique in which microelectronic circuits are fabricated by screen printing and firing cermet pastes onto a substrate.

Thin Film — A manufacturing technique in which microelectronic circuits are fabricated by vapor depositing the resistive materials onto a substrate.

Voltage Ratio — The ratio of the output voltage to the input voltage that is produced by energizing any bit or combination of bits of an R/2R ladder.

Series FNPC207 FN207

Precision Voltage Divider



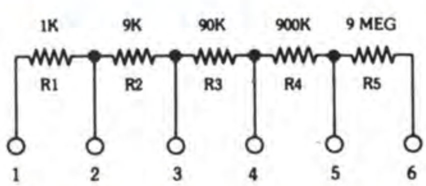
Standard Thin Film Resistor Networks

FEATURES

- 10 Megohms Range
- 5 Decades Attenuation
- .03% Ratios
- 0 to 1000 Volts
- ± 5 ppm/°C Tracking

SPECIFICATIONS

Resistor connections



Electrical capabilities

- Resistance Tolerance on Total Resistance (R_T) at +25°C:

  $R_T = R_1 + R_2 + R_3 + R_4 + R_5 = 10$ Megohms $\pm 0.05\%$

- Ratio Tolerance at +25°C and from 0 to 1000 volts:

$$\frac{R_1 + R_2 + R_3 + R_4}{R_T} = \frac{1\text{ Megohm}}{10\text{ Megohms}} = 0.1 \pm 0.03\%$$

$$\frac{R_1 + R_2 + R_3}{R_T} = \frac{100\text{ K ohms}}{10\text{ Megohms}} = 0.01 \pm 0.03\%$$

$$\frac{R_1 + R_2}{R_T} = \frac{10\text{ K ohms}}{10\text{ Megohms}} = 0.001 \pm 0.03\%$$

$$\frac{R_1}{R_T} = \frac{1\text{ K ohm}}{10\text{ Megohms}} = 0.0001 \pm 0.03\%$$

- Temperature Coefficient of Resistance — ±25 ppm/°C
- TCR Tracking — ± 5 ppm/°C
- Operating Voltage (between pins 1 and 6) 1000 volts maximum
- Operating Temperature — 0°C to +70°C
- Storage Temperature — −65°C to +175°C
- Operating Power at 1000 Volts:

  9 Megohms — 90 mw
  900K ohms — 9 mw
  90K ohms — .9 mw
  9K ohms — .09 mw
  1K ohms — .01 mw

- Voltage Coefficient — 0.01 ppm/volt or less.

Applications

— Input attenuation
— Range selection
— Digital instrumentation
— Digital voltmeters
— Digital multimeters

Refer to Application Note EC5515-4.2 for additional information on Voltage Divider Networks.

NOT AVAILABLE FROM STOCK AT ELECTRONIC DISTRIBUTORS.

Advantages

The conventional method of satisfying precision attenuator requirements in digital instrumentation has been with voltage dividers assembled from discrete wirewound or film resistors. The FN207/FNPC207 precision thin film voltage divider networks offer the following advantages over conventional voltage dividers:

Uniform characteristics — All resistors are deposited onto the substrate simultaneously to provide similar electrical and environmental behavior.

Reliability — All interconnections are metal film — no soldered or welded joints.

Size reduction — The FN207/FNPC207 combine resistance values from 9 megohms to 1 K ohm in a single package. This size reduction offers an inherent savings in instrument space, resulting in reduced instrument size and cost.

Elimination of multimeter calibration adjustments — Precision resistance matching tolerances combined with low temperature characteristics provide attenuator accuracies which eliminate most of the normal calibration requirements in digital multimeters.

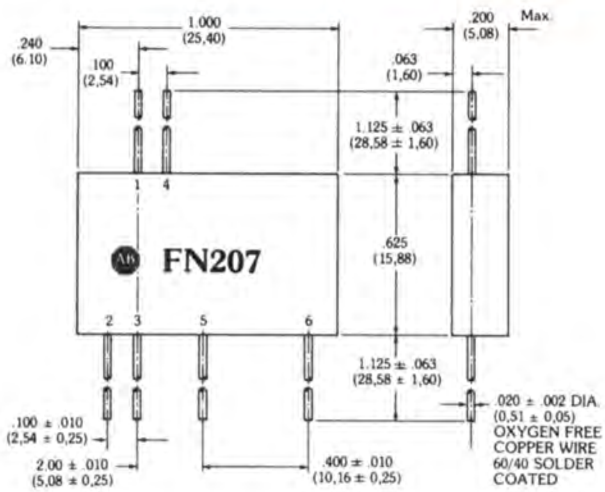
Cost savings — All resistors are deposited simultaneously on a single substrate, eliminating the cost of handling and ratio matching individual discrete resistors. In addition, there is only one part to stock, inspect, and assemble into a printed circuit board.

Custom voltage dividers

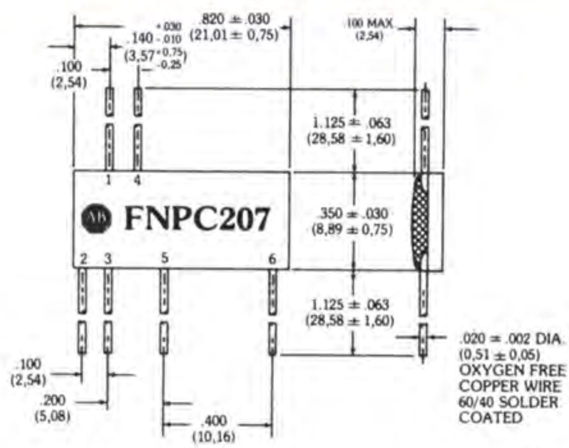
In addition to the standard FN207/FNPC207 voltage divider listed herein, custom voltage divider networks can be manufactured with a large range of resistors and resistance values. They can be designed into a single package to meet specific applications in digital multimeter instrumentation. For more information on custom resistor network capabilities see Allen-Bradley Technical Publication EC5510-2.1

DIMENSIONS

Packaged (Diallylphthalate Case) FN207



Conformally coated (RTV Silicone) FNPC207



Basic dimensions in inches.
Dimensions shown in parentheses are in millimeters.

TOLERANCES
Dimensional Tolerance ±.015 (0,38)
Except as Specified.

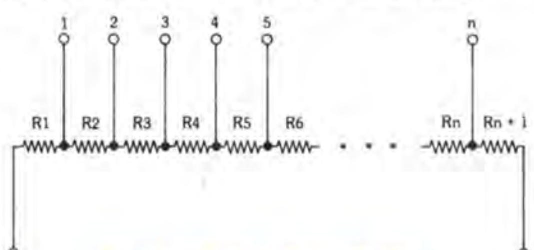
NOT TO SCALE

Voltage Divider Networks

by John Blanchard
Electronics Application Engineer

Synopsis — This application note discusses resistive voltage divider networks and their use in digital instrumentation, particularly digital multimeters. An explanation of voltage divider operation and design guidelines is also given. (For supplementary information on the standard line of A-B FN207/FNPC207 voltage divider networks, see Allen-Bradley Technical Publication EC5515-2.1.)

The basic voltage divider — Two or more individual resistors connected in series comprise a voltage divider (see Figure 1). The purpose of this connection of resistors is to scale down or attenuate a voltage applied across the entire series combination. Thus, instead of working with the applied voltage directly, only a fraction of that voltage is utilized. Such attenuation is necessary when the magnitude of the applied voltage is greater than system components can handle directly.



+V Figure 1. Basic Voltage Divider G

Ideal voltage division — When voltage V_{in} is applied between ground (G) and +V (see Figure 1), the voltage (V_i) that appears at any of the taps can be expressed as:

$$V_i = \frac{\sum_{j=i+1}^{n+1} R_j}{\sum_{j=1}^{n+1} R_j} \times V_{in} \qquad (1)$$

Where n is the highest numbered tap.

A commonly used voltage divider is the 1K, 9K, 90K, 900K, 9M string shown in Figure 2 which performs decade voltage division.

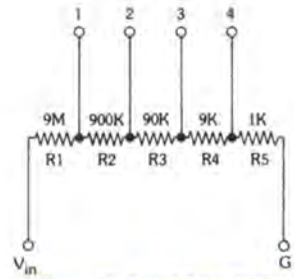


Figure 2. FN207/FNPC207 Decade Voltage Divider

Using equation 1, the tap voltages can be determined. For example, at pin 1,

$$V_1 = \frac{\sum_{j=2}^{5} R_j}{\sum_{j=1}^{5} R_j} \times V_{in} = \frac{900K + 90K + 9K + 1K}{9M + 900K + 90K + 9K + 1K} \times V_{in} \qquad (1)$$

$$= .1 \times V_{in} \text{ Volts}$$

Similarly, it can be shown that $V_2 = .01V_{in}$, $V_3 = .001V_{in}$ and $V_4 = .0001V_{in}$. This can be simplified to $10^{-i}V_{in}$ where i = 1,2,3 or 4.

Applications of thin film voltage dividers — The most common application of thin film voltage dividers is in digital multimeters (DMM). Voltage dividers in these instruments provide a precision attenuator at the input terminals of the meter. Most voltage dividers used in this application have total resistances in the range of 10 megohms and, hence, provide the meter with a high input impedance. This is necessary for voltage measurements to avoid loading the source which is tied to the input terminals.

The most frequently occurring divider configuration is the decade voltage divider shown in Figure 2. Although decade dividers may differ in resistance value from meter to meter, they are similar in that they are high impedance devices that provide the decade division required for the decade range selection of the meter.

Voltage Divider Networks

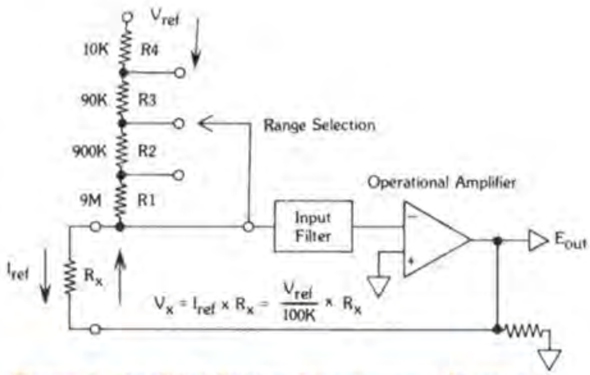


Figure 3. Simplified Kilohm Measurement Diagram in a Digital Multimeter

In larger rack-mounted DMM's the voltage divider is used for DC voltage and ohms measurements only. In the case of DC voltages, the voltage to be measured is applied directly to the divider. The proper divider tap voltage is utilized as a function of the meter range selected by the internal electronics of the meter. Digital multimeters that can measure voltages from fractions of a volt to 1500 volts DC must contain an input divider that can perform the division accurately at all voltage levels.

For ohms measurements, the input divider together with V_{ref} define an accurate reference current (I_{ref}) as shown in Figure 3. The operational amplifier becomes a constant current generator for its feedback resistor, R_x, which is the resistor under test. In Figure 3 the range selection switch is set such that $I_{ref} = \frac{V_{ref}}{100K}$. The voltage V_x measured by the high input impedance DMM is proportional to the resistance R_x ($V_x = \frac{V_{ref}}{100K} R_x$), thus providing for the determination of R_x.

For other measurements, such as AC volts and millivolts, special functional boards are required and hence do not involve the input divider. In some smaller, portable DMM's, the voltage divider is used not only for DC voltage and ohms measurements, but AC voltage measurements as well.

Often thin film resistors constitute only a portion of the input voltage divider. For example, the DMM manufacturer may find that his requirements are such that thin film resistors need be used for only two decades of his four of five decade divider. Allen-Bradley has the capability and will fabricate thin film resistor networks for such portions of a divider.

Design considerations for voltage dividers — Resistor tolerance is the first concern once the number of ranges has been selected for the meter.

There are three common ways of specifying resistor tolerance. The first is to specify one of the divider resistors as a reference that has an absolute tolerance and then to specify a ratio for the remaining resistors to the reference. A second method is to give all resistors of the divider absolute tolerances. The last and most preferable method of specification can be formulated by considering equation 1 which describes how a voltage divider performs functionally. In this instance an absolute tolerance is specified for the summation of all the resistors of the divider string with a ratio of the remaining resistors to the total. An example will illustrate this best.

R1 R2 R3 R4 (in series) $R1 < R2 < R3 < R4$

$$R1 + R2 + R3 + R4 = R_T \pm \text{Absolute Tol.} \quad (2)$$

$$\frac{R1 + R2 + R3}{R_T} = X \pm A\% \quad (3)$$

$$\frac{R1 + R2}{R_T} = Y \pm B\% \quad (4)$$

$$\frac{R1}{R_T} = Z \pm C\% \quad (5)$$

Customarily, the matching percentages in equations 3,4 and 5 represented by A,B and C respectively, are equal. Both the absolute and matching tolerances are usually in the range of 0.01 to 0.1 percent, depending on the overall accuracy of the instrument. A realistic lower limit for the absolute and matching tolerances is 0.01 percent.

Another design consideration for voltage dividers is power coefficient. To explain power coefficient, it must be realized that most dividers operate at voltages to 1000 volts DC. For the purpose of discussion, it is assumed that 1000V are applied to the dividers shown in Figure 2. The following powers are dissipated in the divider resistors:

9M — 90mw
900K — 9mw
90K — .9mw
9K — .09mw
1K — .01mw

Given this power dissipation condition, the power dissipated per unit area that each resistor occupies is highest for the 9M and lowest for the 1K. As a result, the degree to which each resistor self-heats differs. The 9M resistor heats the most and the 1K heats the least. It is this differential heating that is the source of power coefficient. The only circumstance in which power coefficient can be neglected is the condition where the TCR (temperature coefficient of resistance) of the network is zero ppm/°C. For a zero TCR network, no resistance changes result due to self-heating. Such a condition, however, is unrealistic. Most resistors in discrete or network form have non-zero TCR's. Therefore a resistor changes a certain percentage equal to its TCR times the temperature above ambient that it has risen (ΔT) due to self-heating, i.e., $\Delta R(\%) = TCR \times \Delta T$. Considering the differential heating that occurs in the network at 1000V, differential changes in the five resistors of the divider will occur. Fortunately, the only resistor with a significant change is the 9M resistor. The other resistors change negligibly in comparison. The fact that the 9M resistor changes does affect the voltage ratios that the divider produces at 1000V. It is precisely this change in ratio that is referred to as power coefficient and is expressed as the change in voltage ratio, from low voltage (up to 100V) to high voltage (usually 1000V). Power coefficients are typically 0.03 percent over 100 to 1000V in thin film networks. As in the case of matching and absolute tolerances, the power coefficient required is a function of the division accuracy that must be held over the voltage range of the meter.

Voltage coefficient is not significant in a thin film voltage divider. Typical voltage coefficients are in the range of −.005 ppm/Volt to −.01 ppm/Volt. Hence, for a 1000 volt change, voltage coefficient contributes roughly 10 ppm change to the division accuracy.

One last parameter that is of concern is TCR tracking, i.e, the degree to which resistors exhibit similar behavior as the temperature is varied. Typical TCR tracking for thin film resistor networks is 5 ppm/°C. An example demonstrates how TCR tracking affects division accuracy over the temperature range. Given two resistors in a network, 1K and 9K, as shown in Figure 4, the effect of 5 ppm/°C tracking will be examined.

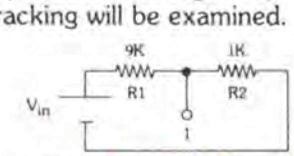


Figure 4. Example Network

Arbitrarily, the 9K resistor is assigned a 0 ppm/°C TCR and the 1K a 5 ppm/°C TCR, which provides the 5 ppm/°C tracking criterion. When the network resistors are adjusted to 0 percent off nominal at room temperature (+25°C), the voltage at pin 1 is $0.1V_{in}$, which is also 0 percent off nominal. When the network is heated to +75°C, for example, the 9K resistor does not change due to its 0 ppm/°C TCR. The 1K resistor, however, now becomes 1000.25 ohm [1000 ohm x (1 + 50°C x 5 ppm/°C)]. At +75°C, the voltage at pin 1 becomes .1000225 V_{in} or .0225 percent off nominal due to TCR tracking.

To see why this takes place, a generalized equation for a two resistor divider where R1 has TCR1 and R2 has TCR2 is shown in Figure 5.

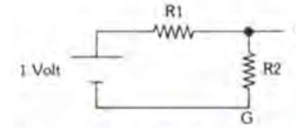


Figure 5. Two Resistor Divider

At +25°C, the voltage at pin 1 is $\frac{R2}{R1 + R2}$ volts, and at T degrees centigrade above room temperature the voltage is

$$\frac{R2\,(1 + T \times TCR2)}{R1\,(1 + T \times TCR1) + R2\,(1 + T \times TCR2)}$$

in volts. It can easily be shown that the percent change in the voltage at pin 1 caused by raising the temperature T degrees centigrade is

$$\left\{ \frac{1}{\frac{R2}{R1 + R2}\left[\frac{R1\,(1 + T \times TCR1)}{R2\,(1 + T \times TCR2)}\right]} - 1 \right\} \times 100\% \qquad (6)$$

which can be simplified to:

$$\left\{ \frac{R1 + R2}{R2 + R1\,[1 + T\,(TCR1 - TCR2)]} - 1 \right\} \times 100\% \qquad (7)$$

The important parameter in the equation is the factor TCR1-TCR2, which is the tracking between R1 and R2. This equation is shown more for academic than practical reasons because it shows directly how TCR tracking affects voltage division accuracy. Equations similar to equation 7 can be derived for dividers involving more than two resistors, although they become complex quickly and are of little value as design tools. The best guideline for TCR tracking is experience which indicates that 5 ppm/°C tracking is adequate for all but the most highly specialized dividers.

Voltage divider guideline summary—

- Number of resistors in divider — This is a function of the application.
- Values of resistors in divider — This is a function of the voltage division ratios required at the taps and the meter input impedance.
- Resistor tolerances — absolute and ratio at +25°C: The customary method is to place an absolute tolerance on the summation of all of the resistors of the divider string with a ratio of the remaining resistors to the total. See equations 2 through 5 on preceding page. The usual range for both absolute and matching tolerances is 0.01 to 0.1 percent at +25°C.
- Maximum applied voltage across the divider: Although the divider can handle higher voltages, 1000 volts is the maximum practical voltage to which Allen-Bradley will test and guarantee specification.
- Power Coefficient — 0.03 percent is typical over 100 to 1000V.
- Voltage Coefficient — Allen-Bradley thin film resistor networks exhibit voltage coefficients from −.005 ppm/Volt to −.01 ppm/Volt.
- TCR: Standard = ±25ppm/°C.
- TCR tracking: Standard = ±5 ppm/°C.

Thin
Film
Networks

HANDLING AND SOLDERING PROCEDURES

The following recommended procedures have been established to minimize damage to thin film networks during handling and soldering. The procedures apply to packaged, conformally coated and chip networks. The packaged and conformally coated networks are available in either a modified flat pack, single in-line or dual in-line styles. The chip networks are available with or without leads.

A. CHIP (BARE SUBSTRATE) NETWORKS WITH OR WITHOUT LEADS

Handling

1. The networks must be handled with utmost care using lint-free gloves and teflon-coated or plastic-tipped tweezers.
2. Care should be taken not to scratch the CrCo metal film because scratches on the resistive film may change the resistance and have an adverse effect on the load life stability and integrity of the film.
3. Dirt, grease or fingerprints may change the resistance and cause the resistors to fail due to electrolysis of the film under electrical load.

Suggested Cleaning Methods

1. Dust can be removed from the networks by brushing the dust off with a soft camel hair brush.
2. Removal of dirt and grease
   a. Bath of heated Alpha 563 (or equivalent) for five minutes (ultrasonic action preferred). Bath temperature should be ± 130° F.
   b. Two baths with ultrasonic action of heated Freon TMC for four minutes each. (Preferably in vapor dryer-degreaser.) Bath temperature should be ± 97° F.

Recommended Protection For Resistive Film

1. It is recommended that the thin film metal surfaces be coated with an RTV silicone adhesive-sealant (Dow Corning RTV3140) to protect the film from moisture and contamination from handling.

Lead Bending

1. The network leads being bent should be held firmly between the bending point and the network body, so that minimum force is applied at the junction of the lead and the network body. The leads must be held very firmly by a clamping fixture, preferably lined with a material which is flexible but firm, such as leather.
2. The minimum distance between the bend point and the body of the network is 1/16 inch.

Lead Cutting

1. The network leads being cut should be held firmly between the cutting point and the network body, so that minimum force is applied at the junction of the lead and the network body. The leads must be held very firmly by a clamping fixture, preferably lined with a material which is flexible but firm, such as leather.

Attachment Of Substrates Without Leads

1. It is recommended that the substrates be attached with nonconductive epoxy die attachment material. A thin coat is recommended so that the substrate will not wobble during bonding. After bonding, the circuit can be coated with an RTV silicone adhesive-sealant (Dow Corning RTV3140).

Bonding Of Substrates Without Leads

1. Ultrasonic or thermal-compression bonding with 1 mil gold wire is recommended. The networks are calibrated assuming the bonds are placed in the center of the bonding pads. It is necessary to bond as close to these centers as possible because the resistance changes as the position of the bonds change.

Soldering Of Substrates With Leads

See Section D

Thin Film Networks

B. CONFORMALLY COATED NETWORKS WITH OR WITHOUT LEADS

Handling

1. The networks must be handled with utmost care to avoid cracking of the substrate.

Protection Of Resistive Film

1. The substrate is coated with an RTV silicone adhesive-sealant (Dow Corning 3140) to protect the resistive film from moisture and contamination from handling. If the resistive film becomes exposed, the same RTV silicone coating should be applied to the substrate.

Lead Bending

1. The network leads being bent should be held firmly between the bending point and the network body, so that minimum force is applied at the junction of the lead and the network body. The leads must be held very firmly by a clamping fixture, preferably lined with a material which is flexible but firm, such as leather.
2. The minimum distance between the bend point and the body of the network is 1/16 inch.

Lead Cutting

1. The network leads being cut should be held firmly between the cutting point and the network body, so that minimum force is applied at the junction of the lead and the network body. The leads must be held very firmly by a clamping fixture, preferably lined with a material which is flexible but firm, such as leather.

Attachment Of Substrates Without Leads

1. It is recommended that the substrates be attached with nonconductive epoxy die attachment material. A thin coat is recommended so that the substrate will not wobble during bonding. After bonding, the circuit can be coated with an RTV silicone adhesive-sealant (Dow Corning RTV3140).

Bonding Of Substrates Without Leads

1. Ultrasonic or thermal-compression bonding of 1 mil gold wire is recommended. The networks are calibrated assuming the bonds are placed in the center of the bonding pads. It is necessary to bond as close to these centers as possible because the resistance changes as the position of the bonds change.

Soldering Of Networks With Leads

See Section D

C. PACKAGED NETWORKS

Lead Bending

1. The network leads being bent should be held firmly between the bending point and the network body, so that minimum force is applied at the junction of the lead and the network body. The leads must be held very firmly by a clamping fixture, preferably lined with a material which is flexible but firm, such as leather.
2. The minimum distance between the bend point and the body of the network is 1/16 inch.

Lead Cutting

1. The network leads being cut should be held firmly between the cutting point and the network body, so that minimum force is applied at the junction of the lead and the network body. The leads must be held very firmly by a clamping fixture, preferably lined with a material which is flexible but firm, such as leather.

Soldering Of Packaged Networks

See Section D

Additional Potting

1. Packaged networks are encased in diallyl phthalate boxes. The network inside the box has a protective layer of Dow Corning RTV3140 as a conformal coat. The network is then placed in the box and the air space is

filled with General Electric's 616 black RTV silicone rubber. If, however, it is desired to pot the packaged network, only those silicone rubbers of the General Electric 616 family or equivalent are recommended.

D. SOLDERING OF CHIP NETWORKS WITH LEADS, CONFORMALLY COATED NETWORKS AND PACKAGED NETWORKS

Particular caution must be exercised when soldering chip and conformally coated thin film networks to printed circuit boards and other similar mounting bases. The following procedures are designed to minimize the effects of soldering on both the mechanical and electrical peformance of the network.

Handling And Lead Bending

1. Refer to Sections A and B that detail the proper procedures for handling and bending the leads of Allen-Bradley thin film chip networks and conformally coated thin film networks respectively. Also, refer to Section C that details the proper procedure for bending the leads of packaged networks.

Heat Sinking

1. Following insertion into the printed circuit board, all leads should be heat sinked at a point as close to solder fillet as possible. This is done to minimize the effect of the solder heat on the tightly trimmed thin film resistors. Further, in the event of an accidental over-temperature setting on a wave solderer or soldering iron, heat sinking will reduce the likelihood of reflowing the solder at the fillet. The maximum temperature that the lead and solder fillet should see during soldering is + 525° F.

Heat Application

1. The duration of heat application should be held to a minimum, with the maximum duration being 10 seconds.

Solder

1. A recommended solder for use with Allen-Bradley thin film networks is 60/40 solder which has a melting temperature of + 374° F. This is the same solder that is used to coat the leads of Allen-Bradley thin film networks.

Temperature Regulation

1. It is recommended that prior to soldering the thin film network, the temperature of the wave solderer or soldering iron be known and be capable of regulation. This is particularly true of soldering irons whose tip temperatures can be considerably higher than the + 525° F maximum for the network. So that the + 525° F maximum is not exceeded, it is suggested that if an iron is to be used, it have some form of tip temperature regulation.

Fluxes

1. Non-activated water white rosin fluxes or very mildly active fluxes should be sufficient to use during the lead attachment operation. Activated fluxes should be avoided because of the conductivity of their residues.

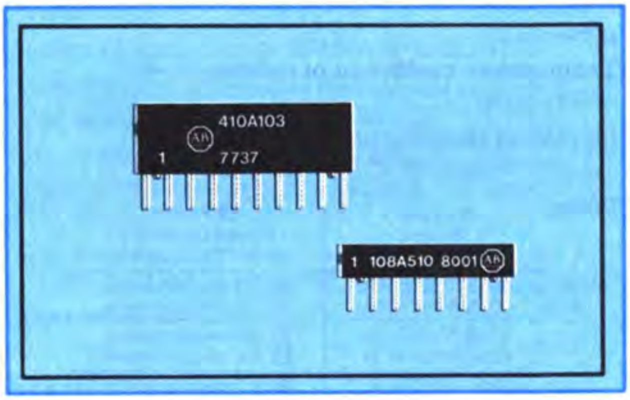
Solvents

1. Following soldering, cleaning of the network may be accomplished by using perchlorethylene as a flux remover and Freon TF as a degreaser. Dwell time in either solvent should be in accordance with usual and recommended practices which generally does not exceed three minutes. Ultrasonic agitation can be used with proper procedures.

NOTE — IMPORTANT NOTICE — READ BEFORE HANDLING PRODUCT — **"Because Allen-Bradley Company cannot foresee or control the varied conditions under which this information or the company products may be used, the company does not guarantee, nor will be responsible for, the applicability or accuracy of the information contained in this publication, any modifications and results of such modifications of company products by the user or other parties, to include additional coating, potting or the like, or the suitability of the products in any specific situation or application. Users of the products should make their own tests to determine and satisfy themselves as to the compatibility of coating and/or potting components with the product as supplied by Allen-Bradley Company as well as the suitability of the product, including any modifications such as coating or potting, for the user's specific purpose of applications. Nothing herein shall be construed as a recommendation for uses which infringe valid patents or as extending a license under valid patents."**

Series 100 400

Cermet Resistor Networks



I-SIP

Single In-Line Package

FEATURES

- Solid Ceramic Body
- Triple-Strength Leads
- 0.100 Inch (2,54mm) Lead Spacing
- Two Package Heights (0.200 in., 0.350 in.)
- 6, 8 and 10 Pins

SPECIFICATIONS

General capabilities

I-SIP – Single In-Line Package:

- A **unique** new packaging concept for single in-line resistor networks.
- Provides standard cermet resistor networks and custom network designs.
- Standard circuits available in 6, 8 and 10 pin packages and in two package profiles.

Applications

– Pull-up and pull-down arrays

– Transmission line terminators

– Current limiting resistors

– ECL terminating networks

– A wide array of custom designs

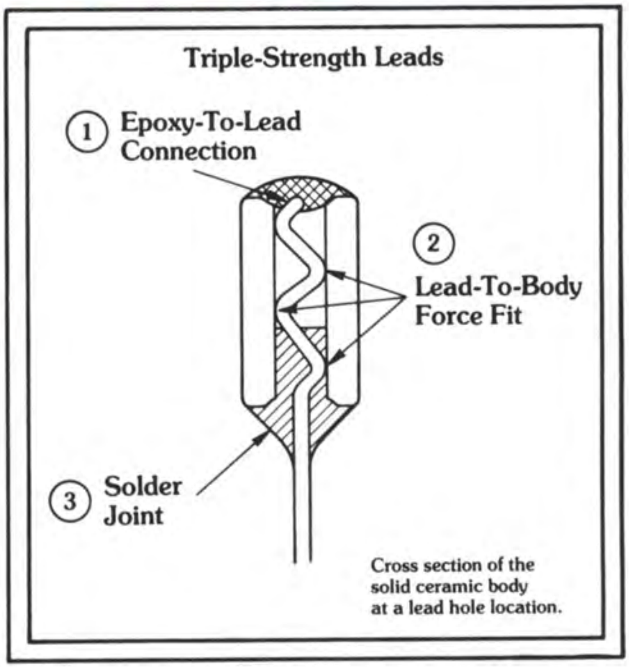
For Applications Information refer to the following Allen-Bradley Application Notes:

– Digital System Resistor Arrays: EC5410-4.1

– ECL Terminator Networks: EC5410-4.2

– Resistive Attenuator Pads: EC5410-4.3

Tough new package



Cermet Resistor Networks

Standard resistance values

Series 406A, 408A, 410A, 406B, 408B and 410B Resistor Networks

R (Ohms)				
22	220	2200	22K	220K
47	470	4700	47K	470K
100	1000	10K	100K	1M

For intermediate values between 22 ohms and 1 megohm not listed above, consult Allen-Bradley Co., Milwaukee, Wisconsin.

Series 406E, 408E and 410E Resistor Networks

R1/R2	Zo (Characteristic Impedance)
220/330	132
3K/6.2K	2.02K

Series 106A, 108A, 110A, 106B, 108B, 110B, 106E, 108E and 110E Resistor Networks:
Consult Allen-Bradley Co., Milwaukee, Wisconsin for available resistor values.

Standard network specifications

Resistor tolerance – ±2% or ±1 ohm whichever is greater.

Temperature coefficient of resistance – ±100 ppm/° C.

Operating temperature range – −55° C to +125° C.

Power –

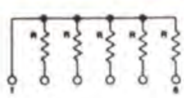
Network Series Designation	[1] Power Dissipation Rating (up to 70° C Ambient)
106A, 108A, 110A	[2] 125 mw/per resistor
406A, 408A, 410A	[2] 250 mw/per resistor
106B, 108B, 110B	[3] 250 mw/per resistor
406B, 408B, 410B	[3] 500 mw/per resistor
106E, 108E, 110E	[2] 125 mw/per resistor
406E, 408E, 410E	[2] 250 mw/per resistor

[1] At +70° C power derates linearly from full rated power to 0 wattage at +150° C.

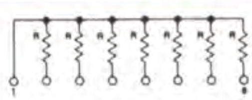
[2] Rated continuous working voltage (RCWV), based on nominal resistance (R) in ohms, is $\sqrt{\text{Individual Resistor Power Rating (see Table)} \times R}$ or 100 volts, whichever is less.

[3] Rated continuous working voltage (RCWV), based on nominal resistance (R) in ohms, is $\sqrt{\text{Individual Resistor Power Rating (see Table)} \times R}$ or 150 volts, whichever is less.

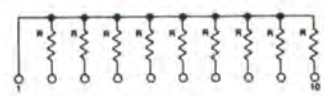
Standard network schematic diagrams



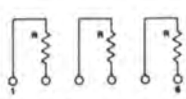
Low Profile 106A
High Profile 406A



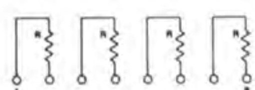
108A
408A



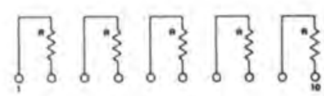
110A
410A



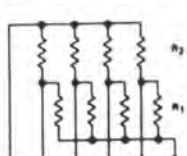
Low Profile 106B
High Profile 406B



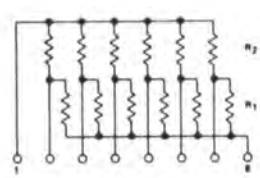
108B
408B



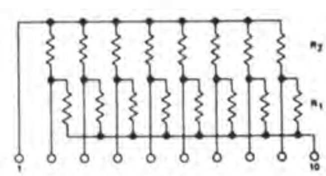
110B
410B



Low Profile 106E
High Profile 406E



108E
408E



110E
410E

Custom resistor networks

When an Allen-Bradley standard resistor network does not fit your exact application, consider our custom resistor networks. The following is a summary of Allen-Bradley custom single-in-line resistor network capabilities:

Resistance range – 10 ohms to 10 megohms. Requests for custom resistor networks can best be met when the total number of different resistor values is limited to a small number.

Tolerance (absolute) – Standard ±2%. Special to ±1.0%.

Resistance matching or ratio – Low as ±1%.

Temperature coefficient of resistance (TCR) – ±250 ppm/° C and ±100 ppm/° C.

TCR tracking – Depends on resistance range and number of resistors. Typical tracking is ±50 ppm/° C or ±100 ppm/° C.

Temperature range of operation – Industrial (0° C to +70° C), Military (−55° C to +125° C) and other ranges available.

User-trimmable option – Resistor networks can be designed to permit the user to actively calibrate the networks in a system. Resistors can be trimmed under actual circuit operating conditions, providing in-circuit settability. Trimming methods include lasers, sand abrasion, and mechanical.

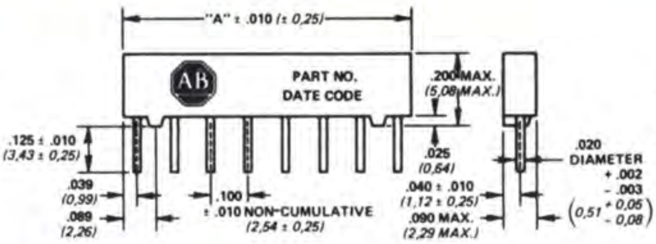
PACKAGE POWER RATINGS (WATTS)
(up to 70° C ambient) ■

Package Height (Profile)	Number of Pins		
	6	8	10
Low Profile (.200" Max.)	.6	.9	1.1
High Profile (.350" Max.)	1.0	1.3	1.8

■ At +70° C power derates linearly from full rated power to 0 wattage at +150° C.

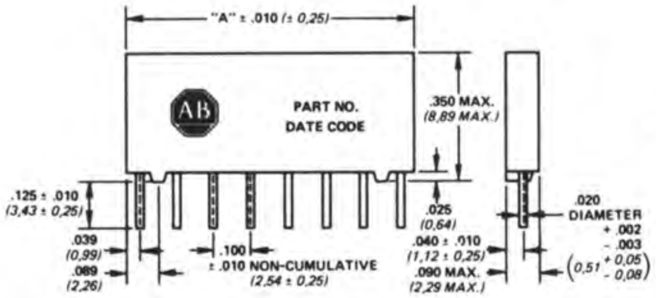
DIMENSIONS

Low profile 100 series



Pkg. Style	No. of Pins	"A" Dimension
106	6	.578 (14,68)
108	8	.778 (19,76)
110	10	.978 (24,84)

High profile 400 series



Pkg. Style	No. of Pins	"A" Dimension
406	6	.578 (14,68)
408	8	.778 (19,76)
410	10	.978 (24,84)

Basic dimensions in inches.
Dimensions shown in parentheses are in millimeters.

TOLERANCES
Dimensional Tolerance ±.005 (0,13)
Angular Tolerance ±5° Except as Specified.

NOT TO SCALE

Cermet Resistor Networks

EXPLANATION OF PART NUMBERS

408A103

Series Designation	Resistance Value
406A 408A 410A 406B 408B 410B	First two digits are significant figures and the third indicates the number of zeros following the first two digits — Examples: 101 = 100 Ohms 102 = 1000 Ohms 122 = 1200 Ohms

408E221331

Series Designation	Resistance Value (R1, R2)
406E 408E 410E	First two digits are significant figures and the third indicates the number of zeros following the first two digits — Examples: 101 = 100 Ohms 102 = 1000 Ohms 122 = 1200 Ohms

Typical performance test capabilities

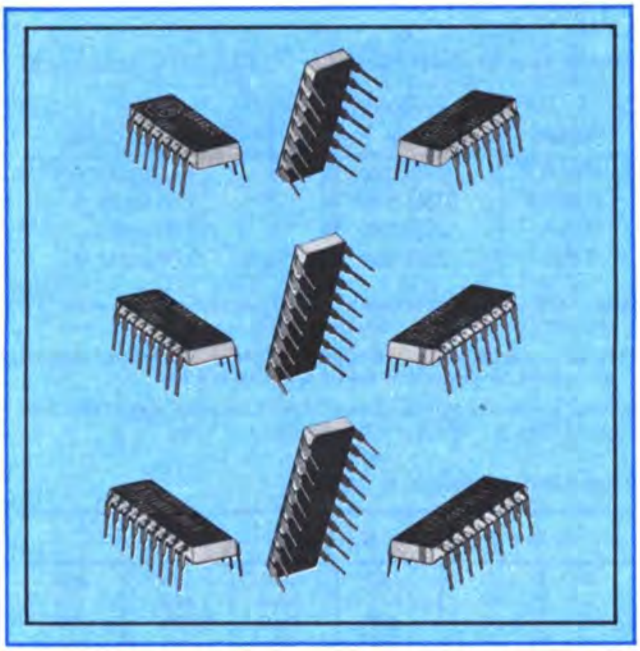
Test Group	Order Of Test	Examination or Test	Test Method Per MIL-R-83401 (Paragraph)	Post Test Requirements
I	1	**Visual and Mechanical Examination**	4.6.2	In accordance with applicable requirements.
	2	**Thermal Shock**	4.6.3	Resistance change ±0.25 percent maximum.
	3	**DC Resistance**	4.6.5	In accordance with applicable requirements.
II	1	**Solderability**	4.6.6	Resistance change ±0.25 percent maximum.
	2	**Resistance to Solvents**	4.6.7	Resistance change ±0.25 percent maximum. Marking shall remain legible.
III	1	**Resistance Temperature Characteristic**	4.6.8	Within specified limits (normally ±100 ppm/° C or ±250 ppm/° C).
	2	**Low Temperature Operation**	4.6.9	Resistance change ±0.25 percent maximum.
	3	**Short Time Overload**	4.6.10	Resistance change ±0.25 percent maximum.
	4	**Terminal Strength**	4.6.11	Resistance change ±0.25 percent maximum.
IV	1	**Dielectric Withstanding Voltage**	4.6.12	Resistance change ±0.25 percent maximum. No mechanical damage, arcing or breakdown.
	2	**Insulation Resistance**	4.6.13	10^{11} Ohms minimum.
	3	**Resistance to Soldering Heat**	4.6.14	Resistance change ±0.25 percent maximum.
	4	**Moisture Resistance**	4.6.15	Resistance change ±0.5 percent maximum.
V	1	**Shock (Specified Pulse)**	4.6.16	Resistance change ±0.25 percent maximum.
	2	**Vibration, High Frequency**	4.6.17	Resistance change ±0.25 percent maximum.
VI	1	**Life**	4.6.18	Resistance change ±0.5 percent maximum.
VII	1	**High Temperature Exposure**	4.6.19	Resistance change ±0.5 percent maximum.
	2	**Low Temperature Storage**	4.6.20	Resistance change ±0.25 percent maximum.

INSPECTION CONDITIONS: Unless otherwise specified, all measurements are understood to be made at the following initial inspection conditions:

Normal atmospheric pressure.
Relative humidity of 40 ± 10 percent.
Ambient temperature of 24° ± 2° C.

NOTE: During an inspection or qualification, all the networks shall be subjected to the inspections of Test Group **I**. The total samples are then divided into Groups **II** to **VII** inclusive, and subjected to the tests and inspections of the particular group.

Series 314, 316
Cermet Resistor Networks



I-DIP
Dual In-Line Package

FEATURES

- Solid Ceramic Body
- Solder Coated Leads
- 0.100 Inch (2,54mm) Lead Spacing
- Low Profile
- 14, 16 and 18 Pin Construction
- Automatically Insertable

SPECIFICATIONS

Standard network applications

NETWORK								
314A 316A	314B 316B	314E 316E	316L08	314M110 314M120 314M125	314M130	316T110	314X101 316X101	314Z
APPLICATIONS								
Pull-Up Resistor Arrays for Unused TTL Gates Parallel High Speed Circuitry Wired OR Configurations Pull-Down Applications TTL-MOS Interfacing Digital Pulse Squaring	Transmission Line Termination Power Gate Pull-Up Current Limiting Logic Level Translation	Digital Line Termination ECL and TTL Applications	8 BIT R/2R Ladder Network for D/A and A/D Converter with Bi Polar or CMOS Switches	Complement the 7520 Series of Core Memory Sense Amps	Core-Memory Sense Line Applications with Two 711 Dual Voltage Comparators	TTL to ECL Translator Network	Interconnect Networks Shorting Applications Matrix Interconnections Test Plugs	Fixed Voltage Attenuation with Impedance Matching

Applications information

For application information refer to the following Allen-Bradley Application Notes:

— Digital System Resistor Arrays: EC5410-4.1
— ECL Terminator Networks: EC5410-4.2
— Resistive Attenuator Pads: EC5410-4.3

Custom resistor networks

When a standard Allen-Bradley network does not meet your requirements, a custom network can be designed to your specifications. See suggestions as shown later in this publication.

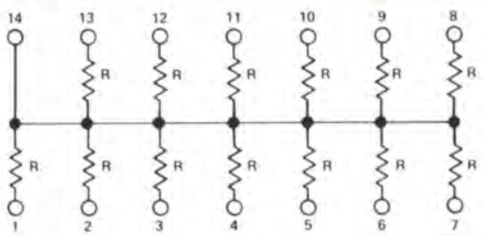
SERIES 314A, 314B, 316A AND 316B

Applications

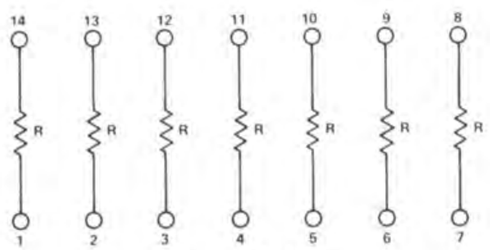
Series 314A and 316A —
Pull-Up resistor arrays for unused TTL gates.
Parallel high speed circuitry.
Wired OR configurations.
Pull-Down applications.
TTL-MOS interfacing.
Digital pulse squaring.

Series 314B and 316B —
Transmission line termination.
Power gate pull-up.
Current limiting.
Logic level translation.

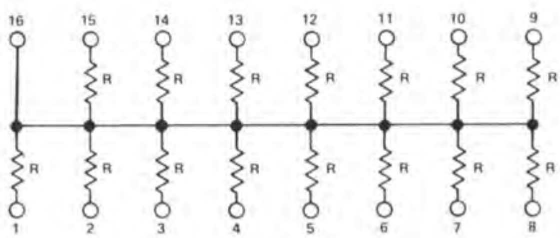
Standard network schematic diagrams



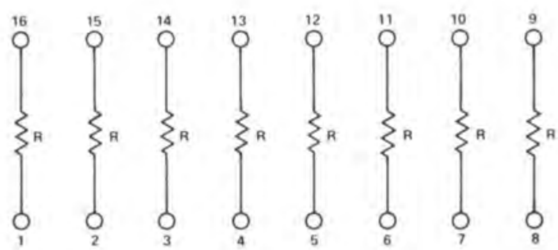
Series 314A



Series 314B



Series 316A



Series 316B

Standard network specifications

Resistor tolerance — ± 2%, also optional tolerance of ± 1% available for certain values.

Temperature coefficient of resistance — ± 100ppm/°C.

Operating temperature range — −55°C to +125°C.

Power dissipation rating — Up to 70° C ambient ■1

Series	Individual Resistor Rating	Total Package Rating
314A	125 mw ■2	1.6 watts
314B	250 mw ■3	1.6 watts
316A	125 mw ■2	1.8 watts
316B	250 mw ■3	1.8 watts

■1 At + 70°C power derates linearly from full rated power to 0 wattage at + 130°C.

■2 Rated continuous working voltage (RCWV), based on nominal resistance (R) in ohms, is $\sqrt{.125 \times R}$ or 150 volts, whichever is less.

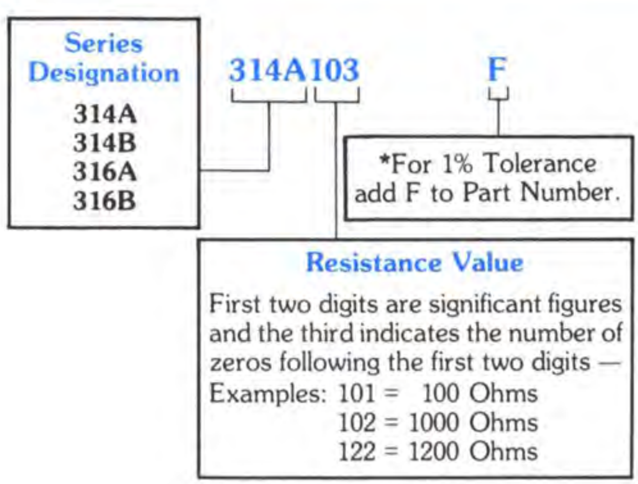
■3 Rated continuous working voltage (RCWV), based on nominal resistance (R) in ohms, is $\sqrt{.25 \times R}$ or 350 volts, whichever is less.

Standard resistance values —

R (Ohms)					
22	110	560	3000	13K	**68K**
24	120	620	**3300**	**15K**	75K
27	130	**680**	3600	16K	82K
30	**150**	750	3900	18K	91K
33	160	820	4300	20K	**100K**
36	180	910	**4700**	**22K**	120K
39	200	**1000**	5100	24K	**150K**
43	**220**	1100	5600	27K	180K
47	240	1200	6000	30K	**220K**
51	270	1300	6200	**33K**	270K
56	300	**1500**	**6800**	36K	**330K**
62	**330**	1600	7500	39K	390K
68	360	1800	8200	43K	**470K**
75	390	2000	9100	**47K**	560K
82	430	**2200**	**10K**	51K	**680K**
91	**470**	2400	11K	56K	**1M**
100	510	2700	12K	62K	

*Bold figures in above Table denote available in ± 1% Tolerance (Add F to Part Number).

Explanation of part numbers

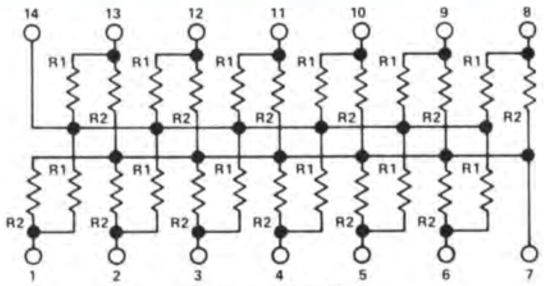


SERIES 314E AND 316E

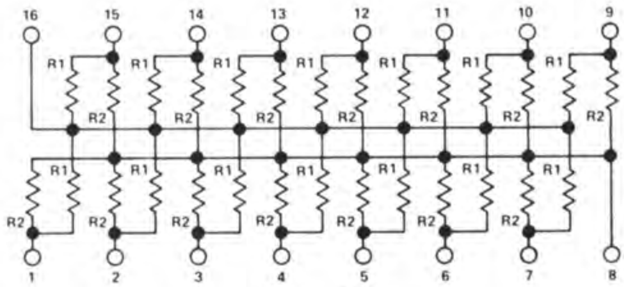
Applications

Series 314E and 316E —
Digital line termination.
ECL and TTL applications.

Standard network schematic diagrams



Series 314E



Series 316E

Standard network specifications

Resistor tolerance — ±2%.

Temperature coefficient of resistance — ±100ppm/°C.

Operating temperature range — −55°C to +125°C.

Power dissipation rating — Up to 70° C ambient [1].

Series	Individual Resistor Rating	Total Package Rating
314E	125 mw	1.6 watts
316E	125 mw	1.8 watts

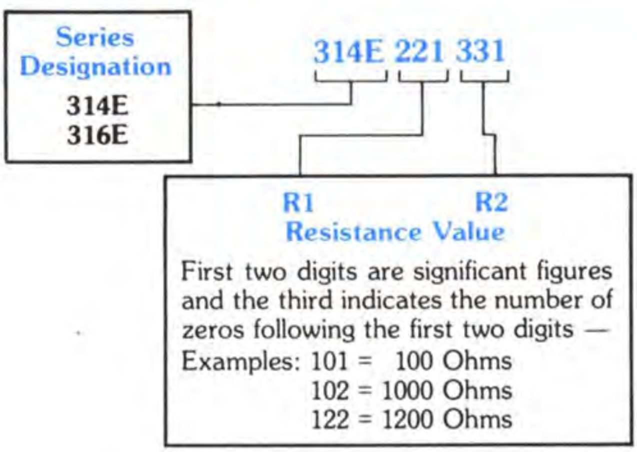
[1] At +70°C power derates linearly from full rated power to 0 wattage at +130°C.

Standard resistance values —

R (Ohms)

R1/R2	Z_o (Characteristic Impedance)	R1/R2	Z_o (Characteristic Impedance)
81/130	50	220/330	132
120/200	75	330/390	179
90/660	80	330/470	194
130/210	80	330/680	222
160/260	100	1.5K/3.3K	1.03K
220/270	121	3K/6.2K	2.02K
180/390	123		

Explanation of part numbers

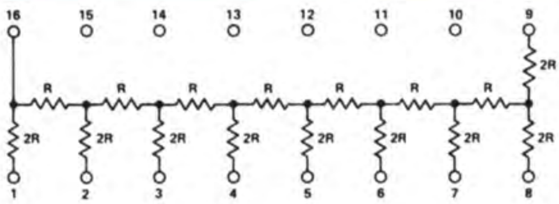


SERIES 316L08

Applications

Series 316L08 —
8 bit R/2R ladder network for D/A and A/D converter with bi-polar or CMOS switches.

Standard network schematic diagram



Series 316L08

Standard network specifications

Ladder network resistance tolerance — ± 2%.

Temperature coefficient of resistance — ± 100ppm/°C.

Operating temperature range — 0°C to +70°C.

Power dissipation rating — Up to 70°C ambient.

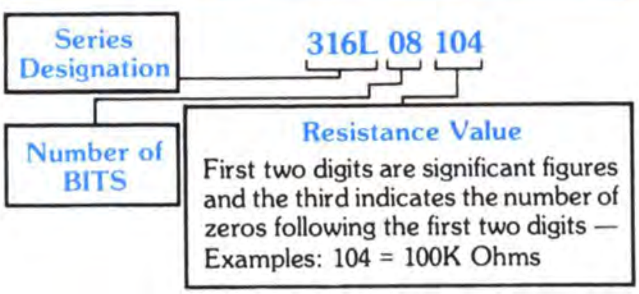
Series	Individual Resistor Rating	Total Package Rating
316L08	50 mw	1.8 watts

Ladder network accuracy — ±1/2 LSB from 0°C to +70°C.

Standard resistance values —

R (Ohms)
25K
50K
100K

Explanation of part numbers

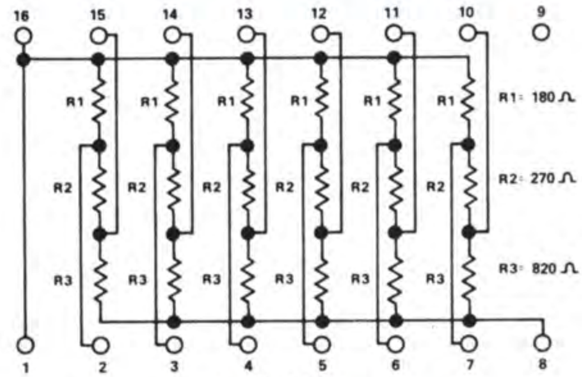


SERIES 316T110

Applications

Series 316T110 —
TTL to ECL translator network.

Standard network schematic diagram



316T110

Standard network specifications

Resistor tolerance — ± 2%.

Temperature coefficient of resistance — ±200 ppm/°C.

Operating temperature range — 0°C to +70°C.

Power dissipation rating — Up to 70°C ambient.

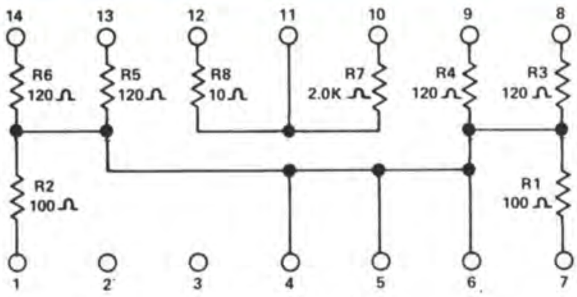
Series	Individual Resistor Rating
316T110	125 mw

SERIES 314M110, 314M120 AND 314M125

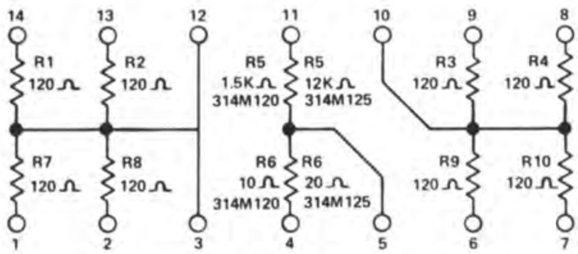
Applications

Series 314M110, 314M120 and 314M125 —
Complement the 7520 series of core-memory sense amps.

Standard network schematic diagrams



314M110



314M120 or 314M125

Standard network specifications

Resistor tolerance —

314M110	± 2%; ± 5% R8 only
314M120 and 314M125	± 2%; ± 5% R6 only

Temperature coefficient of resistance —

314M110	± 200 ppm/°C
314M120 and 314M125	± 100 ppm/°C

Operating temperature range — 0°C to + 70°C.

Power dissipation rating — up to 70°C ambient.

Series	Individual Resistor Rating
314M110	500 mw (R1 and R2) 100 mw (R3 through R8)
314M120 and 314M125	100 mw

Resistance ratios —

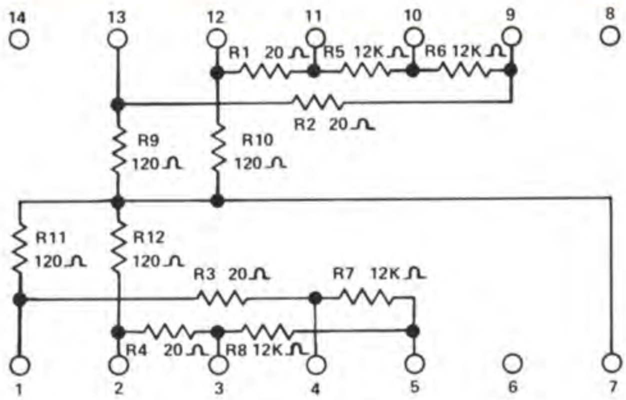
314M110	R3/R4 ± 1.5% R5/R6 ± 1.5% R7/R8 ± 2%
314M120 and 314M125	R1/R2 ± 1.5% R3/R4 ± 1.5% R5/R6 ± 1.5% R7/R8 ± 1.5% R9/R10 ± 1.5%

SERIES 314M130

Applications

Series 314M130 —
Core-memory sense line applications with two 711 dual voltage comparators.

Standard network schematic diagram



314M130

Standard network specifications

Resistor tolerance — ± 2%.

Temperature coefficient of resistance — ± 200 ppm/°C.

Operating temperature range — 0°C to + 70°C.

Power dissipation rating — up to 70°C ambient.

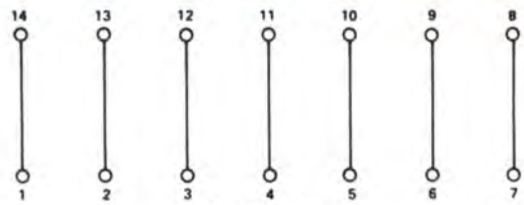
Series	Individual Resistor Rating
314M130	100 mw

SERIES 314X101 AND 316X101

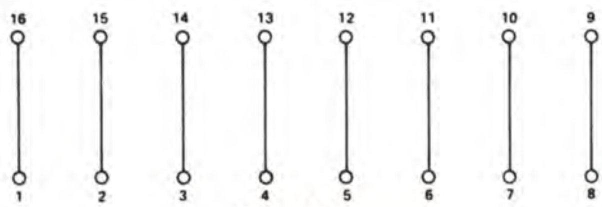
Applications

Series 314X101 and 316X101 —
Interconnect networks.
Shorting applications.
Matrix interconnections.
Test plugs.

Standard network schematic diagrams



314X101



316X101

Standard network specifications

Conductor resistance value = 1 ohm maximum.

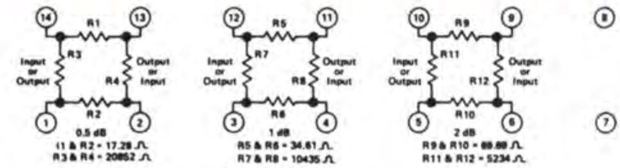
Operating temperature range — −55°C to +125°C.

SERIES 314Z

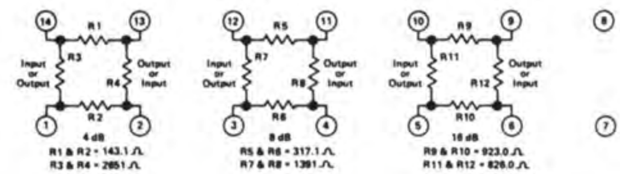
Applications

Series 314Z —
Fixed voltage attenuation with impedance matching.

Standard network schematic diagrams



314Z1001



314Z1002

Standard network specifications

Resistor tolerance — ±1%.

Temperature coefficient of resistance — ±200ppm/°C.

Operating temperature range — 0°C to +70°C.

Characteristic impedance — 600 ohms.

Attenuation tolerance (db) — ±1%.

Attenuation change due to temperature — ±1% additional.

Frequency response — Flat to 1MHz.

Power dissipation rating — Up to 70°C ambient.

Series	Individual Attenuator Rating
314Z	150 mw at 70°C

CUSTOM RESISTOR NETWORKS

When an Allen-Bradley standard resistor network does not fit your exact application, consider our custom resistor networks. The following is a summary of Allen-Bradley custom dual in-line resistor network capabilities:

Resistance range — 10 ohms to 10 megohms. Requests for custom resistor networks can best be met when the total number of different resistor values is limited to a small number.

Tolerance (absolute) — Standard ± 2%. Special to ±1.0%.

Resistance matching or ratio — Low as ± 1%.

Temperature coefficient of resistance (TCR) — ±250 ppm/°C and ±100 ppm/°C.

TCR Tracking — Depends on resistance range and number of resistors. Typical tracking is 50 ppm/°C or 100 ppm/°C.

Temperature range of operation — Industrial (0°C to + 70°C), Military (-55°C to + 125°C) and other ranges available.

Power dissipation rating —

14 pin DIP — 1.6 watts up to 70°C; derated linearly to 0 watts at 130°C.

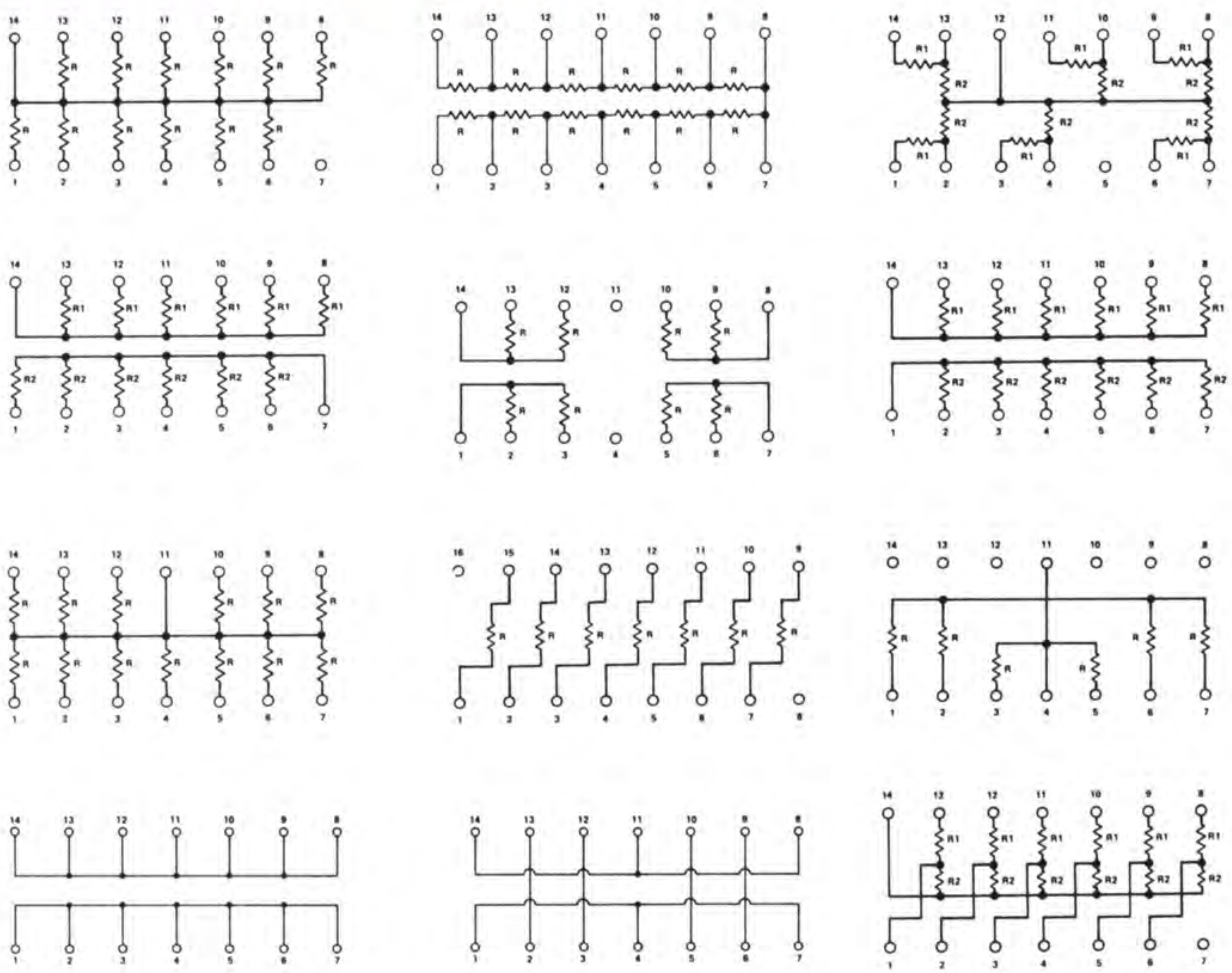
16 pin DIP — 1.8 watts up to 70°C; derated linearly to 0 watts at 130°C.

18 pin DIP — 2.0 watts up to 70°C; derated linearly to 0 watts at 130°C.

User-trimmable option — Resistor networks can be designed to permit the user to actively calibrate the networks in a system. Resistors can be trimmed under actual circuit operating conditions, providing in-circuit settability. Trimming methods include lasers, sand abrasion, and mechanical.

DIAGRAMS

Custom resistor network suggestions



Typical performance test capabilities

Test Group	Order Of Test	Examination or Test	Test Method Per MIL-R-83401 (Paragraph)	Post Test Requirements
I	1	**Visual and Mechanical Examination**	4.6.2	In accordance with applicable requirements.
	2	**Thermal Shock**	4.6.3	Resistance change ± 0.25 percent maximum.
	3	**DC Resistance**	4.6.5	In accordance with applicable requirements.
II	1	**Solderability**	4.6.6	Resistance change ± 0.25 percent maximum.
	2	**Resistance to Solvents**	4.6.7	Resistance change ± 0.25 percent maximum. Marking shall remain legible.
III	1	**Resistance Temperature Characteristic**	4.6.8	Within specified limits (normally ± 100 ppm/°C or ± 250 ppm/°C).
	2	**Low Temperature Operation**	4.6.9	Resistance change ± 0.25 percent maximum.
	3	**Short Time Overload**	4.6.10	Resistance change ± 0.25 percent maximum.
	4	**Terminal Strength**	4.6.11	Resistance change ± 0.25 percent maximum.
IV	1	**Dielectric Withstanding Voltage**	4.6.12	Resistance change ± 0.25 percent maximum. No mechanical damage, arcing or breakdown.
	2	**Insulation Resistance**	4.6.13	10^{11} Ohms minimum.
	3	**Resistance to Soldering Heat**	4.6.14	Resistance change ± 0.25 percent maximum.
	4	**Moisture Resistance**	4.6.15	Resistance change ± 0.5 percent maximum.
V	1	**Shock (Specified Pulse)**	4.6.16	Resistance change ± 0.25 percent maximum.
	2	**Vibration, High Frequency**	4.6.17	Resistance change ± 0.25 percent maximum.
VI	1	**Life**	4.6.18	Resistance change ± 0.5 percent maximum.
VII	1	**High Temperature Exposure**	4.6.19	Resistance change ± 0.5 percent maximum.
	2	**Low Temperature Storage**	4.6.20	Resistance change ± 0.25 percent maximum.

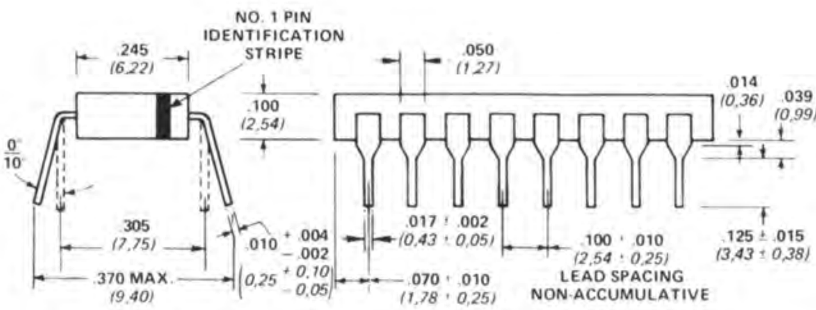
INSPECTION CONDITIONS: Unless otherwise specified, all measurements are understood to be made at the following initial inspection conditions:

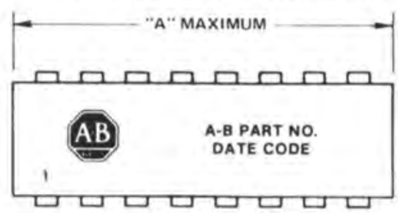
Normal atmospheric pressure.
Relative humidity of 40 ± 10 percent.
Ambient temperature of 24° ± 2°C.

NOTE: During an inspection or qualification, all the networks shall be subjected to the inspections of Test Group **I**. The total samples are then divided into Groups **II** to **VII** inclusive, and subjected to the tests and inspections of the particular group.

DIMENSIONS

"A" Maximum		Number of Leads
Decimal	Metric	
.745	18,92	14
.845	21,46	16
.945	24,00	18





Basic dimensions in inches.
Dimensions shown in parentheses are in millimeters.

TOLERANCES

Dimensional Tolerance ± .005 (0,13)
Angular Tolerance ± 5° Except as Specified.

NOT TO SCALE

Standard Markings

A-B Logo
A-B Part Number
Date Code
Pin #1

Digital System Resistor Arrays

by Allen Salmela
Electronics Application Engineer

Synopsis — This application note discusses prepackaged resistor arrays and their use in digital systems. Functional descriptions, design criteria, and applications for the arrays are provided. For supplementary information on digital system resistor arrays, see "ECL Terminator Networks" (Allen-Bradley Electronics Application Note EC5410-4.2) and Allen-Bradley Technical Publication EC5410-2.1.

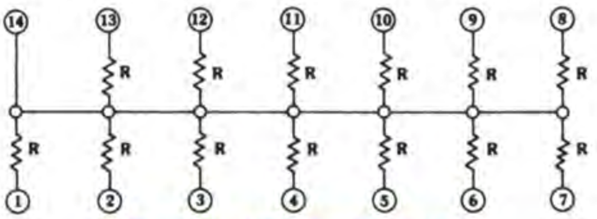


Figure 1. Allen-Bradley 314A

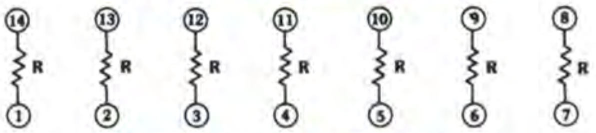


Figure 2. Allen-Bradley 314B

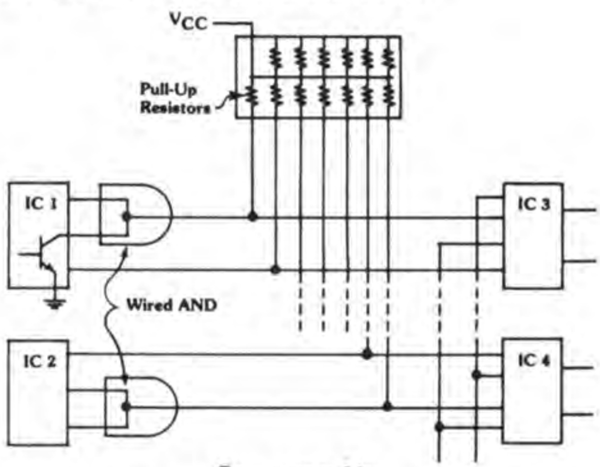
The computer system designer may find the compactness of prepackaged resistor arrays advantageous in certain sections of a system. The applicable areas of use are numerous and the number of resistors required depends upon the design criteria employed. This note discusses the principal areas in a system where resistors are used and the advantages of using them in an array.

Commonly used resistor arrays are shown in Figures 1 and 2. An array of the type shown in Figure 1 is useful where one side of all the resistors is tied to a common voltage level. The array of Figure 2 is useful where resistor isolation is required.

The number of resistors used in a system depends upon the criteria employed by the designer and, in some cases, are dictated by the logic elements themselves. The following are a few examples of where these types of resistor arrays are employed in computer systems.

Pull-up — By common industry usage, a pull-up resistor is one connected to a positive supply voltage to provide a current source. It serves the several functions of providing added noise margin, improving rapid rise times or maintaining proper logic levels. Pull-ups may be placed at such locations as at the receiving end of long cables, at unused gate inputs, at open collector gates, or at a TTL to MOS interface.

Figure 3 demonstrates the use of a pull-up resistor array in conjunction with open collector TTL gates. The resistance must fall within a range that is dictated by the current requirements of the TTL logic levels. Typically, they fall between 300 Ohms and 4000 Ohms, as calculated below.



Component List

IC 1, IC 2 — Triple 3 Input NAND (Series 54, 74)
IC 3, IC 4 — Dual J-K Flip Flop (Series 54, 74)
Pull-Up — 13 Resistor Network (A-B 314A102)

Figure 3. Pull-Up Application

- Logical "1" level — For a proper logical "1" level, the resistance value must be low enough to ensure that sufficient load current and output off current is available. It's value, R_L (max), may be calculated as follows:

$$R_L\,(\text{max}) = \frac{V_{cc} - V_{out}\,(1)}{\Sigma I_{out}\,(1) + \Sigma I_{in}\,(1)}$$

Where:

V_{cc} = the bias voltage

V_{out} (1) = the logical "1" voltage level required.

ΣI_{out} (1) = the summation of the off level reverse currents required.

ΣI_{in} (1) = the summation of the load currents required.

The result of a pull-up resistor of a value greater than that calculated above is an undesirable decrease in the V_{out} (1) logical level.

- Logical "0" level — To maintain the proper logical "0" voltage level, the current through the pull-up resistor must be limited to the maximum sink current capability of one open collector output transistor, less the current being sinked from the TTL loads. This current determines the minimum value, R_L (min), of the pull-up resistor and is calculated as follows:

$$R_L \text{ (min)} = \frac{V_{cc} - V_{out}\text{ (0)}}{I_{sink} - I_{sink}\text{ from loads}}$$

Where:

V_{out} (0) = the required logical "0" voltage level.

I_{sink} = the maximum current sinking capability of one open collector output transistor.

I_{sink} from load = the current sinked from the TTL loads.

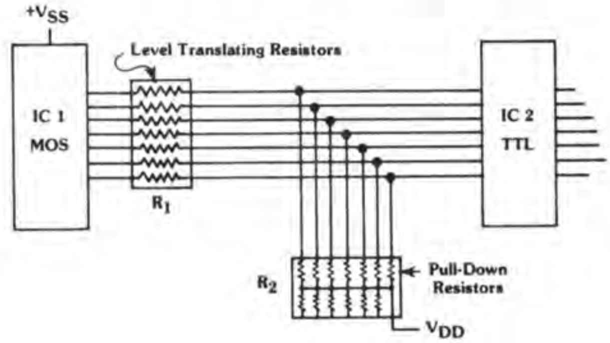
The result of using a pull-up resistor of a value less than the calculated R_L (min) is an undesirable increase in the required logical "0" voltage level.

Note that the pull-up resistor values R_L (min) and R_L (max) depend upon the logic elements used and the configuration in which they are wired. Power dissipation will also be considered when selecting the value. If power dissipation is a significant factor, a value of R_L near R_L (max) rather than R_L (min) would normally be chosen.

Pull-down — By common industry usage, a pull-down resistor is one connected to ground or a negative supply voltage to provide a current sink. It serves the function of allowing negative excursions of the outputs of associated logic elements such that the proper logical "0" level is obtained. Pull-downs are used as a pair with pull-ups for pulse squaring purposes, at the outputs of open collector ECL gates, and at MOS to TTL interfaces.

Figure 4 shows the use of pull-down resistors in conjunction with a MOS to TTL interface along with an associated level translating resistor (see below). This arrangement is one of numerous schemes used in providing the interface match. The purpose of the pull-down resistor is to provide the necessary current sink for the TTL input.

The voltage applied to the TTL input from the resistor network should never exceed +5.5 volts.



Component List

IC 1	— MOS Device (ROM)
IC 2	— TTL Device (Series 54, 74)
Pull-Down	— 13 Resistor Network (A-B 314A681)
Level Translator	— 7 Resistor Network (A-B 314B152)

Figure 4. Pull-Down Application

Therefore:

$$\frac{R_2}{R_1 + R_2 + R_0 \text{ min}} (V_{ss}) \leq 5.5$$

Where,

V_{ss} = bias voltage

R_0 (min) = minimum ON resistance of MOS output transistor

The voltage applied to the TTL input must exceed 2.4 volts to provide the required noise margin.

Therefore:

$$\frac{R_2}{R_1 + R_2 + R_0 \text{ (max)}} (V_{ss}) \geq 2.4$$

Where,

R_0 (max) = maximum ON resistance of MOS output transistor

To preserve the "0" level of 0.4 volts, the low level impedance must sink the required TTL current.

Therefore:

$$R_L \text{ (max)} = R_2 \,//\, [R_1 + R_1 \text{ (max)}]$$

Where,

R_L (max) = known sink impedance

R_1 (max) = sink resistance of MOS transistor

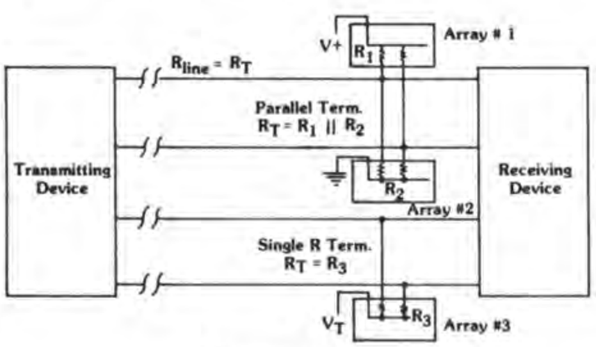
The value of R_1 and R_2 must satisfy the three above conditions for successful operation of this interface scheme.

Level translator — A level translating resistor, in series with a pull-up or pull-down resistor, provides a voltage divider function which is commonly used when interfacing two different types of logic elements. The purpose of this resistor is to establish the proper voltage level at the input of the device being driven. ECL to TTL and MOS to TTL are typical interfaces where a level translating resistor is required.

Figure 4 shows the use of a level translating resistor at a MOS to TTL interface. The resistance must satisfy the three conditions as described in the preceding pull-down resistor section.

Line termination — A termination resistor is one placed at the end of a transmission line for the purpose of matching the impedance of the load to that of the line in high-speed digital systems where pulse reflections from unterminated lines may cause erroneous switching of gates. Line termination techniques are numerous, such as single-ended terminations, parallel terminations, and reverse terminations.

Figure 5 shows the use of resistor arrays for terminating to a current sink (one resistor) and terminating to both a current source and current sink (two resistors). If the termination resistance, R_T, is too high, the line ripples when the level is switched (an inductive-like effect). An R_T lower than the line impedance has a capacitive effect causing a lengthening of the pulse rise time.



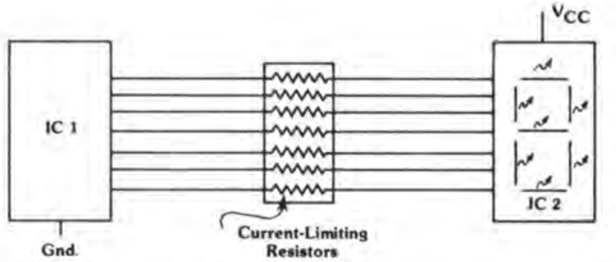
Component List

Array #1 — 13 Resistor Network (Allen-Bradley 314A151)
Array #2 — 13 Resistor Network (Allen-Bradley 314A331)
Array #3 — 13 Resistor Network (Allen-Bradley 314A101)

Figure 5. Line Termination Application

Current limiting — Current-limiting resistors are used in conjunction with such devices as LED's to keep the current at a safe value for the device, or to limit the current flowing through the associated integrated circuit.

The schematic of Figure 6 shows the use of a current-limiting resistor array in conjunction with a decoder/driver and seven segment LED display.



Component List

IC 1 — Decoder/Driver (Series 54, 74)
IC 2 — Seven Segment Display (LED)
Array — Seven Resistor Network (A-B 314B152)

Figure 6. Current Limiting Application

The resistor value is calculated as follows:

$$R = \frac{V_{CC} - V_F - V_{CE}\,(sat)}{I_F}$$

Where:

V_{CC} = bias voltage on the display

V_F = the voltage drop across the segment

$V_{CE}(sat)$ = the low level logic voltage

I_F = the desired segment current

These parameters can be selected from the appropriate device literature.

Resistors are a significant cost element in a typical digital system. Real estate use, handling time and assembly time are the major cost factors. The incorporation of resistors in a prepackaged array can, in many cases, significantly reduce a system cost.

Resistor arrays are presently available for incorporation in digital systems. The characteristics of the arrays are:

- Standard packages: Dual in-line configurations compatible with automatic insertion equipment.
- High density: Up to 13 resistors in a standard 14 pin package.
- Low volume: Component inventories are small. The number of components to be inserted into the printed circuit boards is reduced.

In addition to the characteristics listed on the preceding page, these electrical characteristics are pertinent:

- Resistor arrays are available in many standard values.
- Resistor tolerances are available from a high of ±10% to a more precise ±2% or better.
- Temperature coefficient of resistance (TCR) and TCR tracking can be tailored to satisfy a specified requirement.
- Long term stability is excellent.

For further information on Allen-Bradley's digital system resistor arrays, contact your local Allen-Bradley Sales Office or the Electronics Marketing Department, Allen-Bradley, Milwaukee (414) 671-2000.

ECL Terminator Networks

by John Blanchard
Electronics Application Engineer

Synopsis — This application note discusses resistive termination techniques that are employed with commonly used ECL families. Functional descriptions, design criteria, and applications for ECL terminator networks are provided. For supplementary information on terminator networks, see "Digital System Resistor Arrays," Allen-Bradley Electronics Application Note EC5410-4.1 and Technical Publication EC5410-2.1.

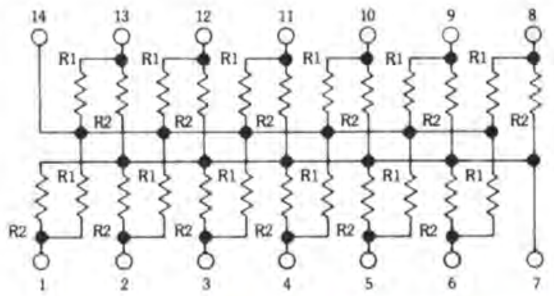


Figure 1. Series 314E — ECL Terminator Network

In high speed logic systems that employ ECL (emitter coupled logic) elements wiring considerations become important. Even several inches of interconnection wire at the high speeds of today's ECL families can behave like a transmission line. Signal reflections and their effect on circuit operation become the main considerations. It is the purpose of this application note to discuss the use of resistive ECL terminator networks to eliminate the effects of unwanted signals and to obtain optimum system performance.

With rise and fall times typically in the 1 to 2 nsec range, overshoot and undershoot become of concern. This ringing results because of capacitance and inductance of the interconnection line and by capacitance presented by the gate being driven. The minimization of undershoot is particularly important because of the nominal 200mV noise margin for most ECL. A general rule is to limit undershoot to less than 10% of the logic swing. This will insure reasonable noise immunity for the gate. The overshoot should be limited to 35% of the logic swing to avoid saturating a gate input. By avoiding saturation, the typical ECL clock rates of 150MHz and higher can be utilized. In order to reduce the effects of ringing and to utilize the speed advantages of ECL, transmission lines or other controlled-impedance systems are used for interconnection.

A resistor array that is designed for use with emitter coupled logic circuitry is shown in Figure 1. The circuit is referred to as an ECL terminator, and it serves a dual purpose. First, R2 is an emitter pull-down resistor and is normally tied to the most negative supply voltage. In its pull-down capacity, R2 supplies the proper line currents. R1 is the terminating resistor, which in parallel with R2, provides the characteristic impedance, Z_o, of the transmission line. R1 normally is tied to ground. By having the line terminated in Z_o, the reflection coefficient of the line is zero and no reflections occur. Thus, the tolerance on the characteristic impedance of the line determines what the tolerance should be on Z_o of the terminator. Most coaxial cables have tolerances in the 2% to 5% range.

The values of R1 and R2 are in part dependent upon the current capabilities of the logic elements, power consumption and the characteristic impedance of the transmission line. The discussion here will be limited to MECL III, MECL 10000, Fairchild 9500, TI's SN10000 and ECL 2500 series, and Signetics 1000 because each of these is capable of driving transmission lines. The design criteria for determining R1 and R2 then becomes simplified to the use of simple equations. For the MECL III, MECL 10000, SN10000, Signetics 10000, and Fairchild 9500 ECL lines of circuits, the values of R1 and R2 may be chosen by knowing the characteristic impedance of the line and by using the criteria:

$$R2 = 2.6Z_o \text{ and } R1 = \frac{R2}{1.6}$$

The following table lists common characteristic impedances and the corresponding values of R1 and R2:

Z_o (Ohms)	R1 (Ohms)	R2 (Ohms)	Allen-Bradley Part Number
50	81	130	314E810131
75	120	200	314E121201
80	130	210	314E131211
100	160	260	314E161261

The recommended terminator resistance values for TI ECL2500 are a 270 Ohm pull-down resistor connected to V'_{EE} (-3.2V) and a 50 Ohm terminating resistor connected to ground.

This type of ECL terminator (Figure 1) network is particularly advantageous when speed is the main concern. Neither the propagation delay nor the rise and fall time of the driving gate signal are affected by loading a long line that has been terminated properly. Another advantage is that there is no distortion of a pulse from a gate. Thus, instead of requiring that gates be lumped at the end of a line, they may be driven with short stubs at various points along the line. This is convenient for a large fanout.

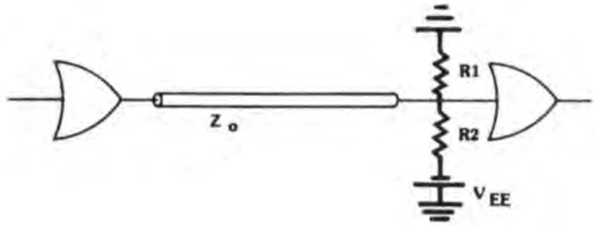


Figure 2. Transmission Line Termination

Figure 2 shows a properly terminated line, where V_{EE} is the ECL vendor's recommended bias supply voltage.

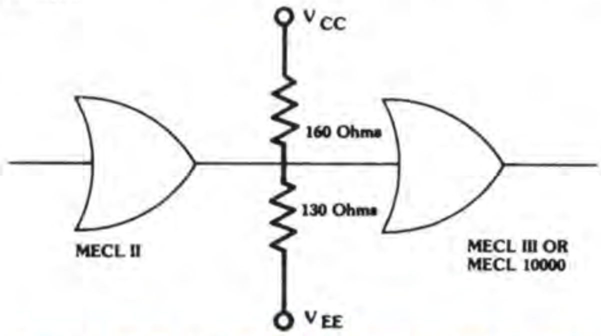


Figure 3. MECL II to MECL III or MECL 10000 Interface

Figure 3 shows Motorola's recommended interface network between MECL II and MECL III or MECL 10000.

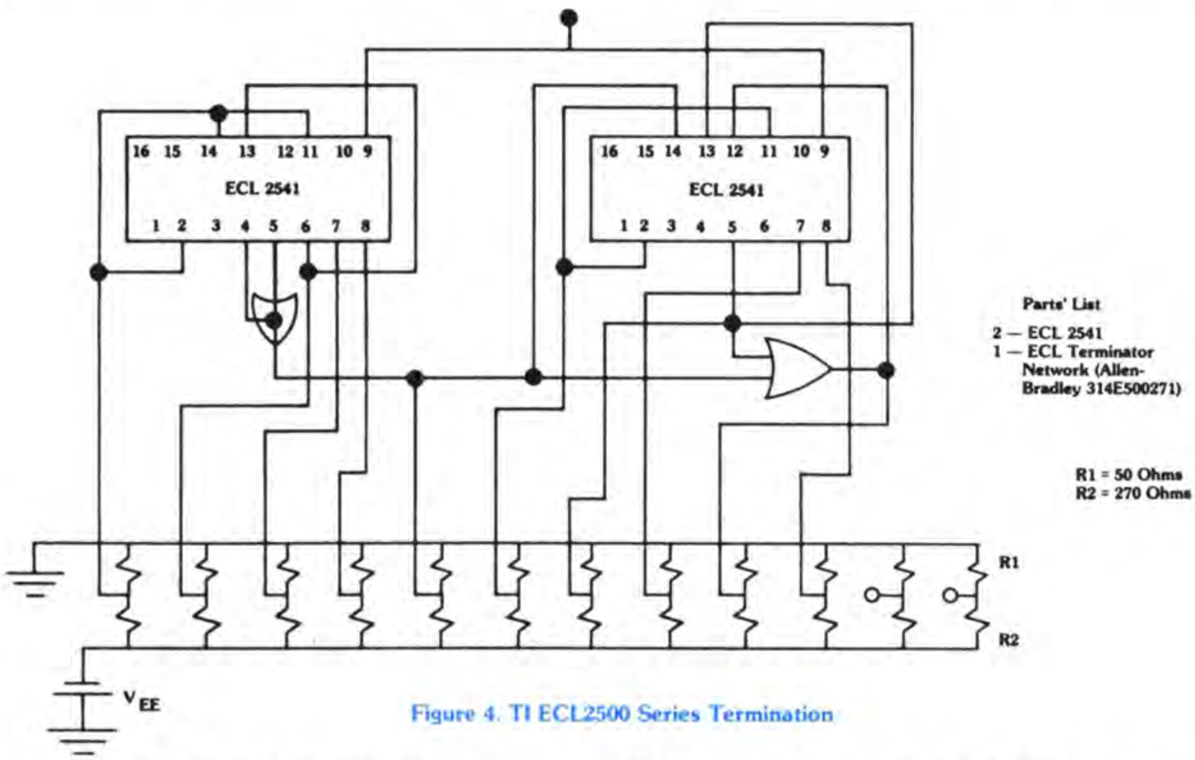


Figure 4. TI ECL2500 Series Termination

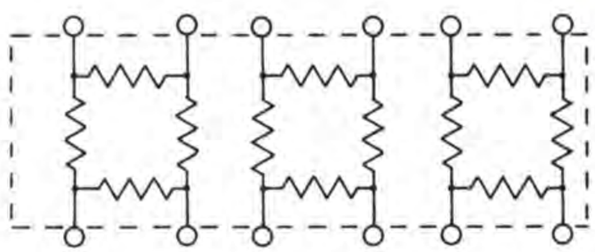
Figure 4 shows a 4-bit binary counter using TI ECL2500 series circuits. Each gate is loaded with a 270 Ohm pull-down resistor and a 50 Ohm terminating resistor.

For further information on Allen-Bradley's ECL terminator networks contact your local Allen-Bradley Sales Office or the Electronics Marketing Department, Allen-Bradley, Milwaukee. (414) 671-2000.

Resistive Attenuator Pads

by Allen Salmela
Electronics Application Engineer

Synopsis — This application note discusses resistive attenuator pads and their use in communication systems. Design criteria and typical applications for attenuator pads are provided. The primary pad discussed is the balanced π "O" version. (For further information see Allen-Bradley Technical Publication EC5410-2.1.)



Modern film technology has made resistive attenuator pads in pre-assembled DIP arrays economical. These arrays are useful in the communication circuits where signal level reductions are required. This application note shows how attenuator pads are used in typical communication circuits.

The most commonly used resistive attenuator pads are shown in Figure 1.

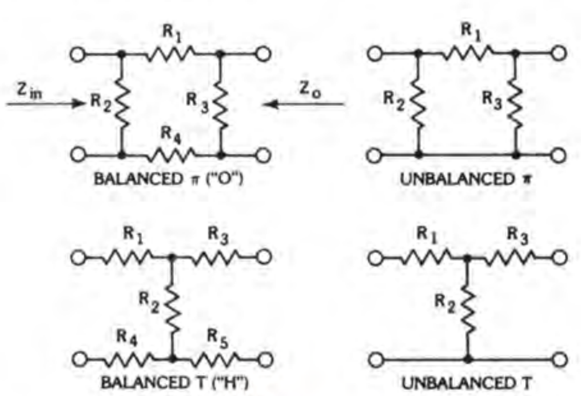


Figure 1

Values of the shunt and series resistors are a function of:

- Attenuator Configuration
- Input Impedance
- Output Impedance
- Attenuation Required

When these four parameters have been selected, formulas for the calculation of the resistive elements can be derived.

Example — A pad is required in a balanced system to match two equal impedances and to provide a given attenuation (dB). Since the system is balanced, a balanced pad is generally required, either the π or T version. The balanced π version shown in Figure 2 will be used in this example.

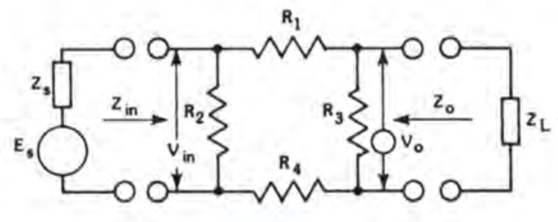


Figure 2

The input and output impedances being equal results in a symmetrical pad; that is the shunt legs are equal ($R_2 = R_3$), the series legs are equal ($R_1 = R_4$), and the source, pad input, pad output and load impedances are equal ($Z_s = Z_{in} = Z_o = Z_L = Z$). The Thevenin equivalent input impedance is:

$$Z_{in} = Z = R_2 // [2R_1 + (R_2//Z_L)] \qquad (1)$$

A voltage divider ratio generates the following equation:

$$V_{in} / V_o = [2R_1 + (R_2//Z_L)]/(R_2//Z_L) \qquad (2)$$

Resistive Attenuator Pads

By solving (1) and (2) for R_1 and R_2, the following relations are obtained.

$$R_2 = Z\,(A + 1)/(A - 1) \qquad R_1 = Z\,(A + 1)\,(A - 1)/4A$$

Where: $A = V_{in}/V_o$

The value of A can be determined from the following pad relationship:

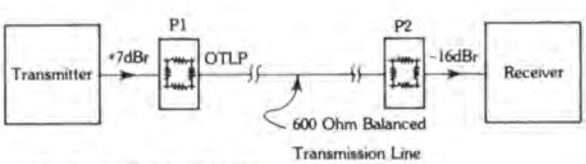
$$|\,dB\,| = 20 \log_{10} \; (V_{in}/V_o)$$

Similar formulas for the calculation of the shunt and series resistors of the remaining three networks, shown in Figure 1, are listed in Table 1. The equations again are true only if the input and output impedances are equal.

Pad Type	Series Resistor (R_1)	Shunt Resistor (R_2)
Unbalanced T	$R_1 = Z(A-1)/(A+1)$	$R_2 = 2AZ/(A^2 -1$
Balanced T (H)	$R_1 = Z(A-1)/[2(A+1)]$	$R_2 = 2AZ/(A^2 -1$
Unbalanced π	$R_1 = Z(A^2 -1)/2A$	$R_2 = Z(A+1)/(A-1)$

Table 1

The derivation becomes more complex in the case of unequal input and output impedances. Detailed calculations are available in the appropriate engineering handbooks.

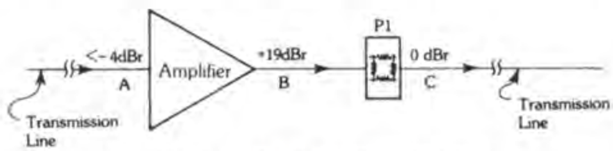


P1 — Allen-Bradley Part No. 314Z1001
P2 — Allen-Bradley Part No. 314Z1002

Figure 3

Resistive pads are commonly used in two-wire switching systems to adjust for a desired signal level, as in Figure 3. Here we are considering the sending end terminals of this network to be the system zero transmission level point (OTLP). All other signal levels in the system are relative to this reference level and are appropriately labeled dBr (decibel relative). Since the signal level out of the transmitter in the above example is +7 dBr, the attenuator pad, P1, is inserted to reduce the sending end level to the desired OTLP. At the receiving end of the line, the summation of the losses in the line plus that inserted by the pad, P2, reduces the signal level to the -16 dBr desired at the receiver. A degree of variability may be required in pads P1 and P2 if the output level varies from transmitter to transmitter and the losses vary from line to line.

Repeaters (amplifiers) and an associated balanced attenuator are commonly used in transmission networks to add gain if signal levels are below a minimum requirement. In the example of Figure 4, the signal level at point A is below the desired -4 dBr minimum. A repeater, with a gain of +23 db (for example), is inserted in the line, thus increasing the signal level to approximately +19 dBr at Point B. A balanced π attenuator pad, P1, is inserted to reduce the signal level to the 0dBr value required at Point C.



P1 — Allen-Bradley Part No. 314Z1001 and 314Z1002

Figure 4

In the above examples, balanced pads with selectable attenuation are required. This is typically provided by DIP pads shown in Figure 5. By cascading attenuator pads, attenuation selectable from 0.5 dB to 31.5 dB in 0.5 dB steps can be obtained. Modern film technology has made these pads available in the prepackaged arrays diagramed in Figure 5.

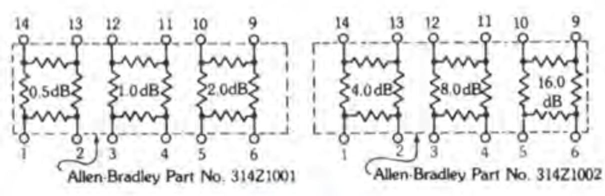
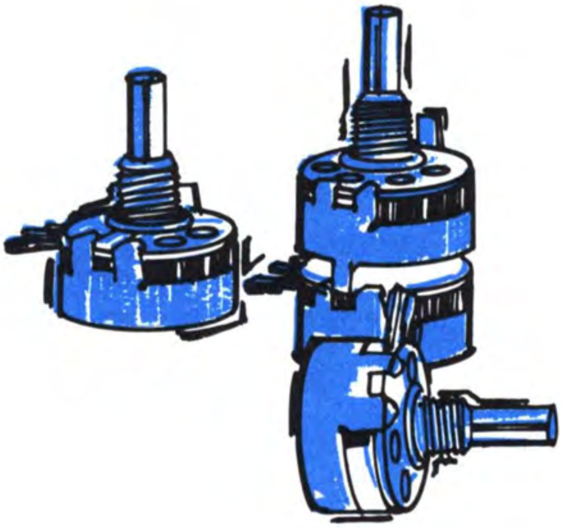


Figure 5

For further information on Allen-Bradley's resistive attenuator pads, contact your local Allen-Bradley Sales Office or the Electronics Marketing Department, Allen-Bradley, Milwaukee, (414) 671-2000.



panel potentiometers

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CONDUCTIVE PLASTIC
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A-B
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Details in adjustable attenuator section.

MOD POT® POTENTIOMETERS ARE AVAILABLE AT ASSEMBLY CENTERS
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AND THEY CAN ASSEMBLE TO YOUR REQUIREMENTS.

SERIES 70 MOD POT®: Modular design innovated by Allen-Bradley offers almost unlimited combinations: single, dual, triple or quadruple sections. Options include PC or solder lug terminals, variety of switches, vernier drives, concentric shafts, hot-molded composition, cermet or conductive plastic resistance elements.

SERIES 72 MOD POT®: Similar to Series 70, except the bushing and shaft are non-metallic. Available in single or dual combination only.

SERIES 73 MOD POT®: Similar to Series 70, except the bushing is of a more economical design. Available in single or dual combination only.

SELECTOR GUIDE:

Type	Page Number	Resistance Element	Resistance Range and Tolerance	Power Rating (Linear Taper)	Voltage Rating (RMS or DC)	Operating Temperature Range	Number of Sections Available	Case Dimensions in Inches (millimeters)	Enclosure
Series 70	142	Cermet	100 Ohms to 5 Megohms ±10%	2.0 Watts at 70° C	350V	−55° C to +150° C	1, 2 3 or 4	0.625 (15,88) Square Lug Terminals 0.594 (15,08) Deep Pin Terminals 0.625 (15,88) Deep (Single Section)	Dust and Splash Resistant
		Composition	50 Ohms to 10 Megohms ±10%, ±20%	1.0 Watt at 70° C		−55° C to +120° C			
		Conductive Plastic	100 Ohms to 1 Megohm ±10%, ±20%	0.5 Watt at 70° C					
Series 72	142	Cermet	100 Ohms to 5 Megohms ±10%	1.0 Watt at 70° C		−55° C to +100° C	1 or 2		
		Composition	50 Ohms to 10 Megohms ±10%, ±20%	0.5 Watt at 70° C					
		Conductive Plastic	100 Ohms to 1 Megohm ±10%, ±20%	0.25 Watt at 70° C					
Series 73	142	Cermet	100 Ohms to 5 Megohms ±10%	2.0 Watts at 70° C		−55° C to +120° C			
		Composition	50 Ohms to 10 Megohms ±10%, ±20%	0.75 Watt at 70° C 1.0 Watt at 40° C					
		Conductive Plastic	100 Ohms to 1 Megohm ±10%, ±20%	0.5 Watt at 70° C					
J(RV4)	91	Composition	50 Ohms to 5 Megohms ±10%, ±20%	2.25 Watts at 70° C	500V	−55° C to +120° C	1, 2 or 3	0.625 (15,88) Deep by 1.156 (29,36) Diameter (Single Section) ■	
EJ	124			2.25 Watts at 70° C			1 or 2		
K	100			3.0 Watts at 70° C		−55° C to +150° C	1, 2 or 3		
G(RV6)	83		100 Ohms to 5 Megohms ±10%, ±20%	0.5 Watt at 70° C	350V	−55° C to +120° C	1	For G, L and W 0.469 (11,91) Deep For GD: 0.547 (13,89) Deep For WR: 0.422 (10,72) Deep by 0.500 (12,70) Diameter Above dimensions for types G and WR do not include the available switch option ■	Immersion Sealed
GD	128						2		
L	108			0.8 Watt at 70° C		−55° C to +150° C	1		
W	118			0.5 Watt at 70° C		−55° C to +120° C			
WR	136			0.5 Watt at 70° C					Dust and Splash Resistant
SP	132	Cermet	50 Ohms to 1 Megohm ±10% (5% available)	1.0 Watt at 70° C	300V	−65° C to +150° C		0.438 (11,11) Deep by 0.375 (9,52) Diameter	Immersion
M	114	Conductive Plastic	100 Ohms to 1 Megohm ±20%	0.1 Watt at 40° C	90V	−25° C to +100° C	1 or 2	0.394 (10,0) Cubed All Versions	Dust and Splash Resistant

■ All depth dimensions are maximum.

panel potentiometers

TYPE J (RV4):
Standard of the industry for quality. Hot-molded composition, 50 ohm to 5 megs. ±10% and ±20% (special values to 1000 megs available). 2.25W at 70° C, single, dual, triple sections available. Switch for single or dual sections.

TYPE EJ:
Extra long life version of the Type J with rotational life exceeding one million rotations, single or dual configurations. Slip clutch available.

TYPE K:
A 3.0W at 70° C version of the popular Type J.

TYPE G (RV6):
Hot-molded composition, 100 ohms to 5 megs, ±10% and ±20%, 0.5W at 70° C, single section available with or without SPST switch.

TYPE GD:
Dual section version of Type G.

TYPE W:
Hot-molded composition, 100 ohms to 5 megs, ±10% and ±20%, 0.5W at 70° C, single section.

TYPE WR:
Radial-lead version of Type W. Available with or without switch. Switch versions offer contacts that close at start of clockwise rotation (TYPE WRS) or with switch with contacts that close at start of counter-clockwise rotation (TYPE WRH).

TYPE L:
Hot-molded composition, 100 ohms to 5 megs, ±10% and ±20%, 0.8W at 70° C, single section.

TYPE M:
Miniature conductive plastic, 100 ohms to 1 meg, ±20% 0.1W at 40° C, single and dual sections available with or without switch. 5 terminal options. Non-metallic case, bushing and shaft.

TYPE SP:
Cermet 50 ohms to 1 meg, ±10%, 1.0W at 70° C, single section. Only ⅜ inch diameter.

Standard options for most types include linear and non-linear tapers, a variety of shafts, bushings, shaft endings, shaft lengths, and hardware

Types GD, J and the multi-section MOD POT® with composition tracks are well suited for attenuator applications.

STANDARD VALUES AND POPULAR SHAFT AND BUSHING COMBINATIONS OF TYPES G, J, W, GD, SP AND WR ARE AVAILABLE FROM STOCK AT ELECTRONIC DISTRIBUTORS. TYPES K, L, M AND EJ ARE AVAILABLE ON A SPECIAL ORDER BASIS.

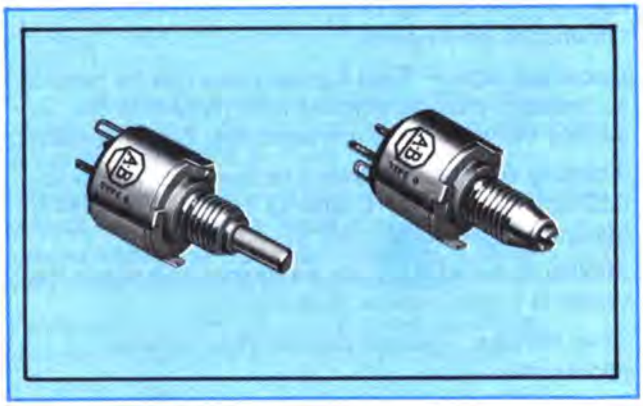
Type **G**

Hot-Molded Panel Potentiometers

1/2 (0.50) Inch (12,70 mm) Diameter

0.5 Watt (70°C)

100 Ohms to 5.0 Megohms



FEATURES

- Linear and Non-Linear Tapers
- Immersion Sealed
- Style RV6
- Switches Available

SPECIFICATIONS

General

Temperature range — −55° C to +120° C.

Total resistance values — Preferred nominal values listed below. Other values available.

OHMS

100	1K	10K	100K	1.0 Meg.
200	2K	20K	200K	2.0 Meg.
220	2.2K	22K	220K	2.2 Meg.
250	2.5K	25K	250K	2.5 Meg.
470	4.7K	47K	470K	4.7 Meg.
500	5K	50K	500K	5.0 Meg.

Total resistance tolerances — ± 20% or ± 10%.

Tapers — Available in the following resistance ranges:

TAPER	TOTAL RESISTANCE RANGE
U	100 Ohms to 5.0 Megohms
A, B, S, & DB	500 Ohms to 2.5 Megohms

See chart on Page 85 for explanation of tapers. Special tapers, where practical, can be supplied.

End resistance — See chart on Page 85.

Switches — Two types of single pole, single throw switches are available. One turns "ON" at start of clockwise shaft rotation, the other at the start of counterclockwise shaft rotation. The switch reduces effective electrical rotation to 248° nominal.

Switch rating for resistive loads are 0.5 ampere 125 volt 60 Hertz and 1.5 amperes 28 volt DC.

Switches can be operated 5000 cycles at full rating.

Applicable military specification — Many of the variable resistors without switches may be ordered as Style RV6 of MIL-R-94.

Electrical

Power — 0.5 watt maximum at +70° C for "U" linear taper provided voltage rating is not exceeded.

Power derating — Derate power linearly from +70° C to zero at +120° C. Derate power 50 percent for non-metallic mounting and for resistors with "A", "B", "S", and "DB" tapers. For rheostat applications, derate power directly with shaft or actuator position.

Voltage — 350 volts maximum working voltage (RMS or DC), or as determined by $E_{max} = \sqrt{PR}$, whichever is less (at sea level).

Dielectric withstanding voltage — Maximum continuous voltage 350 volts (RMS or DC) at sea level. Will withstand a one second test of 750 volts (RMS) at sea level or 350 volts (RMS) at 3.4 inches (86,36 mm) mercury.

Insulation resistance — 1000 megohms minimum for clean and dry conditions at +25° C.

Voltage characteristic — 0.005 percent per volt or 0.5 ohm, whichever is greater.

(Electrical specifications continued on next page.)

Electrical

Capacitance — The capacitance between terminal #1 and #3 with terminal #2 "floating" is approximately 0.5 to 0.75 pF at 1 KHz.

The capacitance between terminal #1 (grounded to bushing) and terminal #3 (shaft in extreme clockwise position) approximately 3.0 to 3.7 pF at 1 KHz.

The capacitance between all terminals shorted together and the bushing is approximately 5.5 to 6.5 pF at 1 KHz.

In all cases capacitance indicated is for resistor only and does not include capacitance of measuring lead wires on test fixtures.

Operational

Load life — 10 percent maximum change in total resistance as a result of a 1000 hour test at rated power across entire element in still air at +70° C (1.5 hour "ON", 0.5 hour "OFF").

Rotational life — 10 percent maximum change in total resistance as a result of a 50,000 cycle life test without load.

Mechanical

Shafts — Diameter of shafts .125 inch (3,18 mm). Minimum length .312 inch (7,94 mm). Maximum length 2.500 inches (63,50 mm) with plain, screwdriver slotted or flatted shaft endings. Preferred shaft lengths and endings are listed in the tables below.

PREFERRED SHAFT LENGTHS

Plain Round

Inches	.500	.625
mm	12,70	15,88

Screwdriver Slotted

Inches	.375	.438	.500	.625	.750	.875
mm	9,52	11,11	12,70	15,88	19,05	22,22

Other lengths available in 1/64 inch (0,40 mm) increments. All shaft lengths are measured from the mounting face of the resistor to the free end of the shaft.

Bushings — All bushings have a 32-NEF-2A thread and are .250 inch (6,35 mm) in diameter. Bushing lengths and types are shown in the table below.

Plain		Locking		Panel Watertight Plain		Panel Watertight Locking	
Inch	mm	Inch	mm	Inch	mm	Inch	mm
.250	6,35	.375	9,52	.250	6,35	.375	9,52
.375	9,52	.500	12,70	.375	9,52	.500	12,70
.500	12,70	.625	15,88	.500	12,70		

After lock nuts on locking bushing are tightened with a torque of 8 inch-pounds (9,22 kgf-cm) shafts will not turn with torques up to 20 inch-ounces (1,44 kgf-cm).

Hardware — Resistors are normally supplied with mounting nut, M-4721, and one internal tooth lock washer, M-4748. Resistors with shaft lock bushings are supplied with one lock nut, M-4761, in addition to the above. Unless otherwise specified, all hardware shipped in bulk.

Mounting bracket B-28868 and printed wiring board F-19942 can also be supplied (separately or mounted on unit) to adapt bushing type resistors for horizontal mounting on printed wiring board. See dimensions on Page 88.

Locating lugs — Four locating lugs can be provided so resistors may be indexed with respect to the surface on which they are mounted. See dimensions.

Turning torque — 0.5 to 3 inch-ounces (0,036 to 0,22 kgf-cm) at +25° C and 13 inch-ounces (0,94 kgf-cm) maximum at −55° C.

Maximum additional torque required to actuate the switch is 5 inch-ounces (0,36 kgf-cm).

Stop torque — 4 inch-pounds (4,61 kgf-cm) minimum.

Rotation — Mechanical rotation for resistors with or without switch is 295° ± 5°.

Electrical rotation is 270° nominal without switch and 248° nominal with switch.

Backlash — 3° maximum.

Construction — Materials are corrosion resistant and essentially non-magnetic; terminals are treated for easy soldering.

The resistor incorporates an internal "O" ring between the shaft and bushing. External surfaces are given special treatment so that the entire resistor is immersion sealed.

A panel "watertight" bushing is available. This bushing is provided with an external "O" ring in addition to the internal "O" ring supplied as standard.

Immersion — No continuous stream of bubbles (4 or more) emanating from the resistor as a result of the immersion test (1 minute in water at +85° C).

Weight — The exact weight of individual resistors depends on the precise mechanical specifications involved. Table below lists approximate net weights of typical Type GA resistors including hardware normally specified.

Bushing	Shaft	Weight	
		Ounces	Grams
.250 in. (6,35 mm) Plain	.750 in. (19,05 mm)	0.24	6.8
.375 in. (9,52 mm) Lock	.438 in. (11,11 mm)	0.24	6.8

Marking — Allen-Bradley part number and nominal total resistance marked in two lines. Other marking possible, limited to maximum of 16 characters in each of two lines for resistors without switch and 9 characters in each of two lines for resistors with switch. A-B monogram plus "Type G" always included.

Environmental

Vibration — 2 percent maximum change in total resistance, 5 percent maximum change in resistance setting. (Tested per method 204, condition "C" of MIL-STD-202.)

Shock — 2 percent maximum change in total resistance. 5 percent maximum change in resistance setting. (Tested per method 213, condition "I" of MIL-STD-202.)

Moisture resistance — 10 percent maximum change in total resistance. (Method 106 of MIL-STD-202.)

Corrosion resistance — Materials show no corrosion after a 200 hour salt spray test. (Method 101 of MIL-STD-202.)

Effect of soldering — 2 percent maximum change in total resistance as a result of immersing the terminals in + 350° C solder to within 0.62 inch (1,57 mm) of the resistor body for 5 seconds.

Temperature cycling — 3 percent maximum change in total resistance as a result of the temperature cycling test (five cycles − 55° C to + 120° C).

Low temperature operation — 2 percent maximum change in total resistance as a result of the low temperature operation test (− 55° C for two hours without load and 45 minutes with rated load.).

Low temperature storage — 2 percent maximum change in total resistance as a result of the storage test (24 hours at − 63° C).

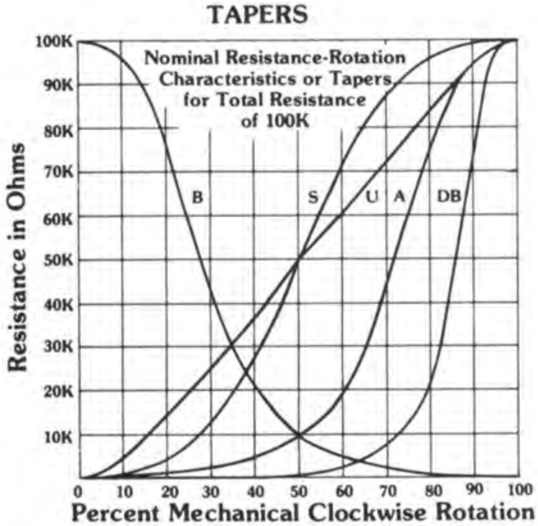
Temperature characteristics — Maximum percent temporary total resistance change from the + 25° C value. See table below.

Nominal Resistance	Degrees Celsius — "U" Linear Taper						
	−55°	−25°	0°	+25°	+55°	+85°	+120°
100 Ohms	+ 4.5	+ 2.5	+ 1.5	0	± 1.0	± 1.5	+ 3.5
1,000 Ohms	+ 5.5	+ 3.0	+ 1.5	0	± 1.0	± 2.0	+ 4.5
10,000 Ohms	+ 7.0	+ 3.5	+ 2.0	0	± 1.0	± 2.5	+ 5.5
100,000 Ohms	+ 8.0	+ 4.0	+ 2.0	0	± 1.5	± 3.0	+ 6.0
1 Megohm	+ 10.0	+ 5.0	+ 2.5	0	± 1.5	± 3.5	+ 7.5

For "S", "A", "B" and "DB" tapers multiply percentage figures shown above by 1.25

Taper data

TAPERS



END RESISTANCE

TAPER	MINIMUM RESISTANCE BETWEEN TERMINALS 1 and 2	MINIMUM RESISTANCE BETWEEN TERMINALS 2 and 3
U & S	1	1
A	1	2
B	2	1
DB	3	2

1 "Less than .004% of total resistance," or "less than 15 ohms" whichever is greater.

2 "Less than 1% of total resistance," or "less than 15 ohms" whichever is greater.

3 Less than 15 ohms.

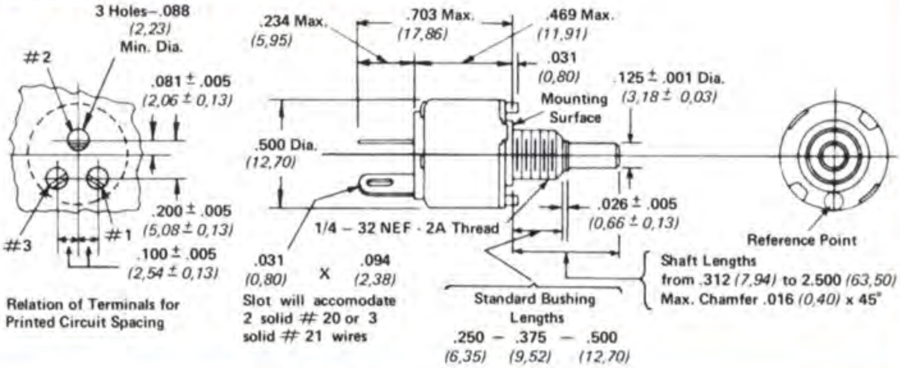
Ordering information

1. Type (GA, GB, GH, GP or GS).
2. Taper.
3. Total resistance.
4. Total resistance tolerance.
5. Bushing type.
6. Bushing length.
7. Shaft ending.
8. Shaft length.
9. Locating lug option.
10. Mounting hardware.
11. Your part number.
12. Marking required.
13. Remarks.

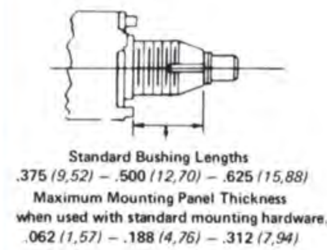
DIMENSIONS

Resistor with lug terminals

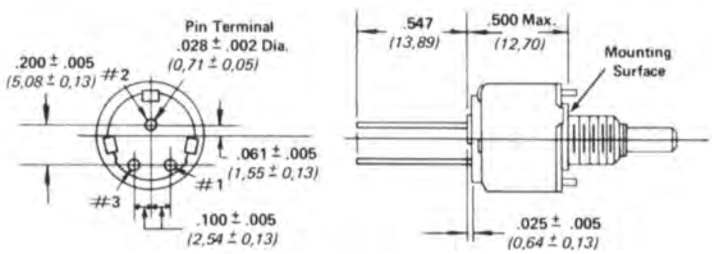
Plain Bushing



Locking Bushing



Resistor with pin terminals



Basic dimensions in inches.

Dimensions shown in parentheses are in millimeters.

TOLERANCES

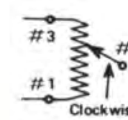
Dimensional tolerance ±.016 (0,40)

Angular tolerance ± 5°

Except as specified.

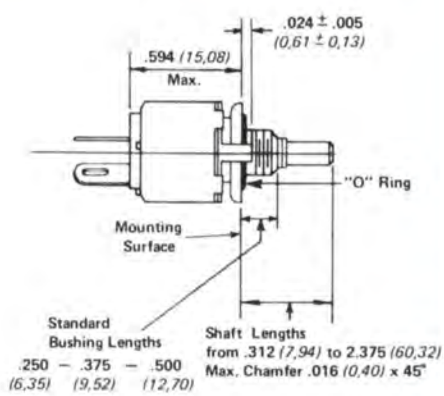
NOT TO SCALE

Resistor Connections

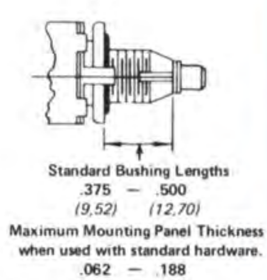


Panel watertight bushing

Plain

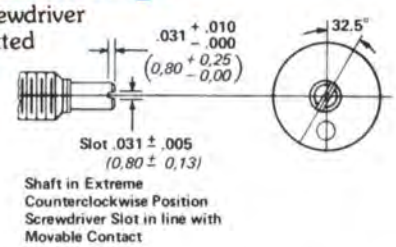


Locking



Shaft endings

Screwdriver Slotted



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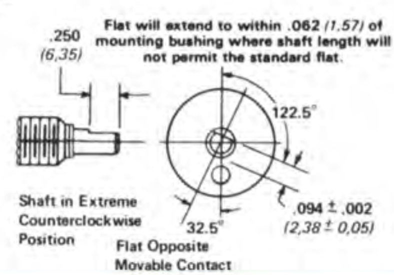
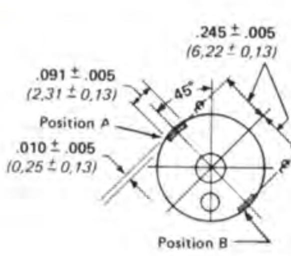


Lug options

Plain and Locking Bushing



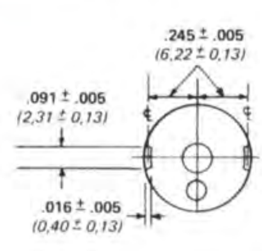
Option No. 2
Standard as Shown
Used Unless
Otherwise Specified

Option No. 1
One Lug in
Position A

Option No. 3
One Lug in
Position B

Option No. 4
No Lugs

Panel Watertight Bushing



Option No. 2
Standard as Shown
Used Unless
Otherwise Specified

Option No. 1
One Lug at 9 o'clock

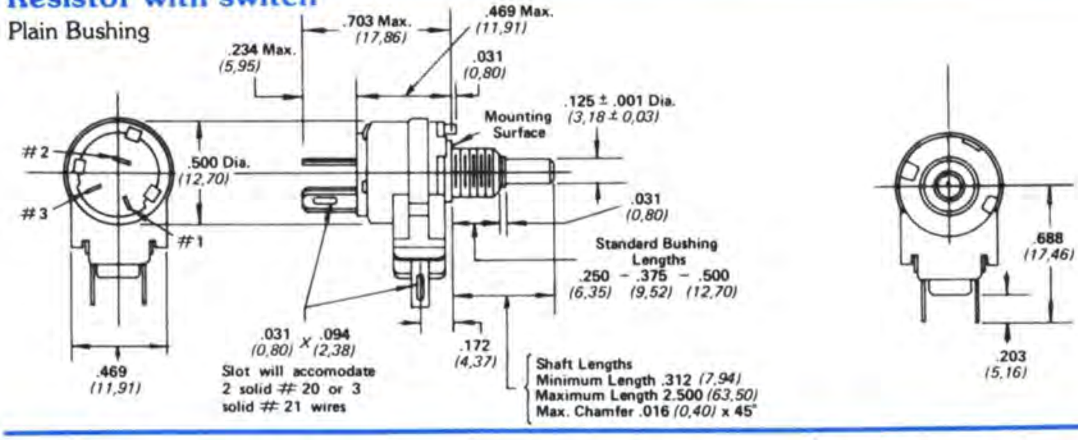
Option No. 3
One Lug at 3 o'clock

Option No. 4
No Lugs

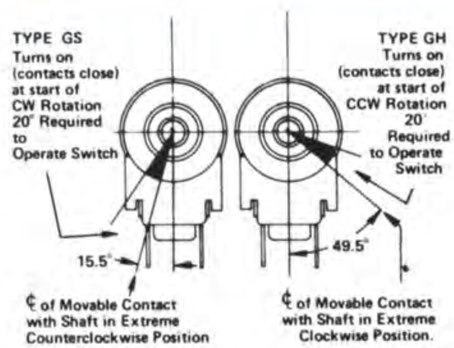
DIMENSIONS

Resistor with switch

Plain Bushing



Switches



Basic dimensions in inches.

Dimensions shown in parentheses are in millimeters.

TOLERANCES

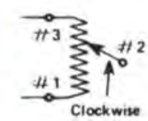
Dimensional tolerance ± .016 (0,40)

Angular tolerance ± 5°

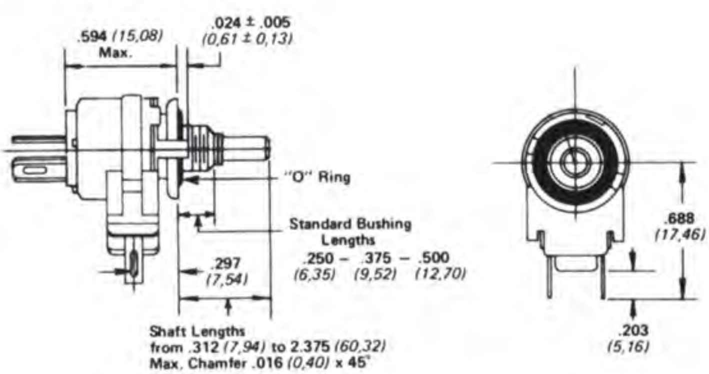
Except as specified.

NOT TO SCALE

Resistor Connections

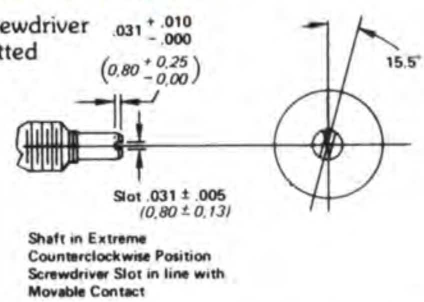


Panel watertight bushing



Shaft endings

Screwdriver Slotted



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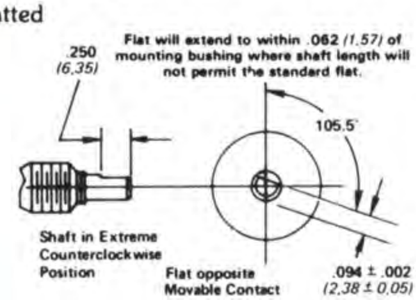
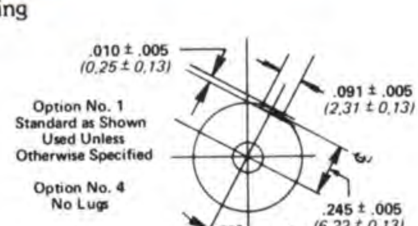
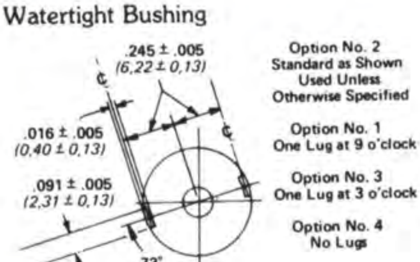


Lug options

Plain Bushing



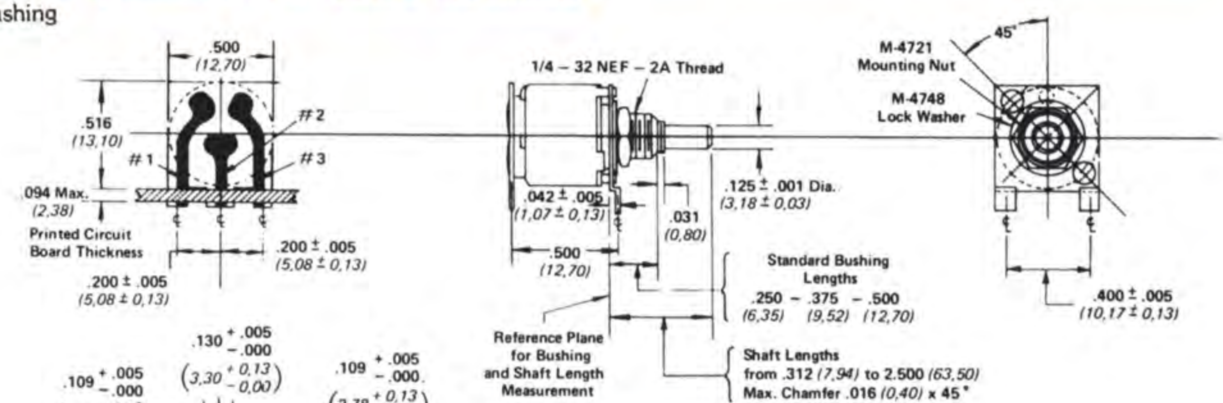
Panel Watertight Bushing

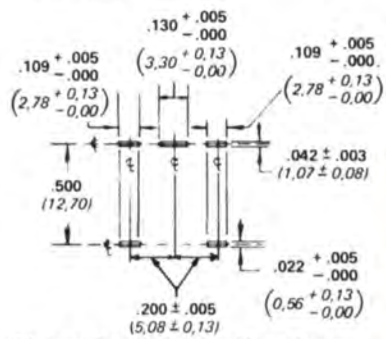


DIMENSIONS

Resistor for printed circuit board mounting

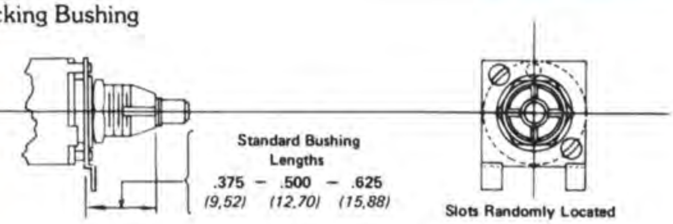
Plain Bushing





Relation of Terminals for Printed Circuit Spacing

Locking Bushing



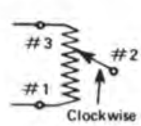
Basic dimensions in inches.

Dimensions shown in parentheses are in millimeters.

TOLERANCES
Dimensional tolerance ± .016 (0,40)
Angular tolerance ± 5°
Except as specified.

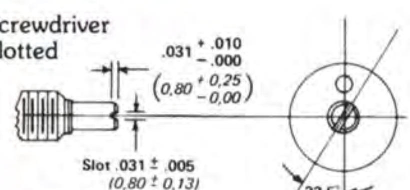
NOT TO SCALE

Resistor Connections



Shaft endings

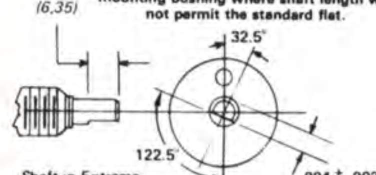
Screwdriver Slotted



Shaft in Extreme Counterclockwise Position Screwdriver Slot in line with Movable Contact

Flatted

Flat will extend to within .062 (1,57) of mounting bushing where shaft length will not permit the standard flat.

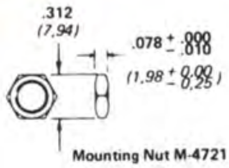


Shaft in Extreme Counterclockwise Position

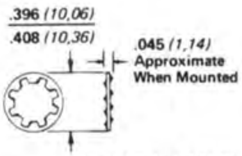
Flat opposite Movable Contact

DIMENSIONS

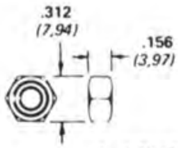
Hardware



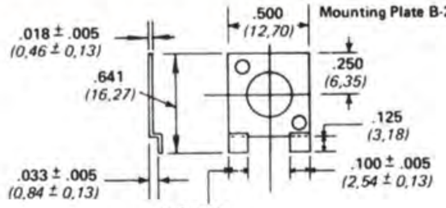
Mounting Nut M-4721



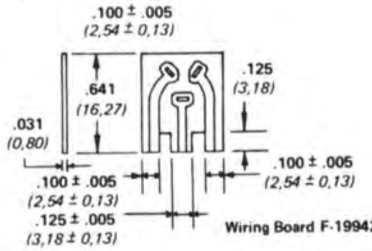
Lock Washer M-4748



Lock Nut M-4761



Mounting Plate B-28868



Wiring Board F-19942

EXPLANATION OF PART NUMBERS

GA2G056S501UA

Basic Type

- **GA** — Basic Type G
- **GS** — Type GA with switch actuated at start of clockwise rotation
- **GH** — Type GA with switch actuated at start of counterclockwise rotation
- **GB** — Type GA with mounting bracket and printed wiring board mounted on resistor
- **GP** — Basic Type G with pin terminals

Locating Lug Option

- **1**
- **2** — Not available with switch unless panel watertight bushing is used
- **3** — Not available with switch unless panel watertight bushing is used
- **4**

Total Resistance Value

First two digits are significant figures and the third indicates the number of zeros following the first two digits —

Examples: 101 = 100 Ohms
501 = 500 Ohms
255 = 2.5 Megohms

Bushing Type and Length

- **G** — Plain .250 inch (6,35 mm) long
- **N** — Plain .375 inch (9,52 mm) long
- **H** — Plain .500 inch (12,70 mm) long
- **M** — Locking .375 inch (9,52 mm) long
- **L** — Locking .500 inch (12,70 mm) long
- **S** — Locking .625 inch (15,88 mm) long
- **T** — Panel Watertight — Plain .250 inch (6,35 mm) long
- **P** — Panel Watertight — Plain .375 inch (9,52 mm) long
- **E** — Panel Watertight — Plain .500 inch (12,70 mm) long
- **Y** — Panel Watertight — Locking .375 inch (9,52 mm) long
- **Z** — Panel Watertight — Locking .500 inch (12,70 mm) long

Shaft Length

Measured from mounting surface in inches and sixty-fourths

Example:
032 = 32/64 or .500 inch (12,70 mm)
200 = 2.000 inches (50,80 mm)
056 = 7/8 or .875 inch (22,22 mm)

Shaft Ending

- **S** — Standard Slot
- **P** — Plain Round
- **F** — Standard Flat

Hardware Combinations

	Mounting Nut	Lock-washer	Locknut
A —	(1)M-4721	(1)M-4748	——
E —	(2)M-4721	(1)M-4748	——
C —	(1)M-4721	(1)M-4748	(1)M-4761
L —	——	——	(1)M-4761
Z —		(no hardware)	

Taper Type and Total Resistance Tolerance

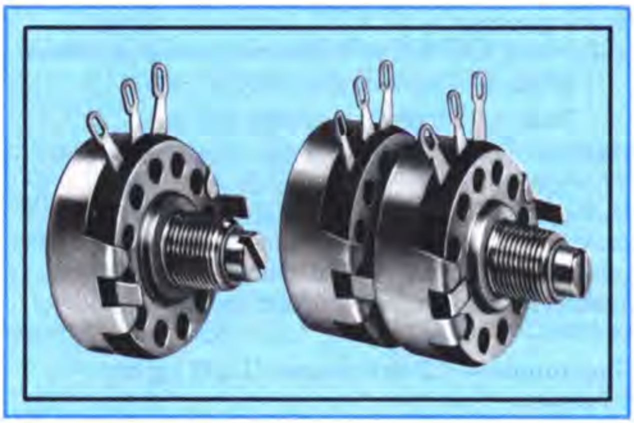
- **U** — Linear (U), ± 10%
- **M** — Linear (U), ± 20%
- **A** — Clockwise Modified Logarithmic (A), ± 10%
- **R** — Clockwise Modified Logarithmic (A), ± 20%
- **B** — Counterclockwise Modified Logarithmic (B), ± 10%
- **T** — Counterclockwise Modified Logarithmic (B), ± 20%
- **D** — Clockwise Exact Logarithmic (DB), ± 10%
- **K** — Clockwise Exact Logarithmic (DB), ± 20%
- **S** — Modified Linear (S), ± 10%
- **Y** — Modified Linear (S), ± 20%

CAUTION: Part number format does not allow for exclusion of invalid mechanical and/or electrical combinations. Check parameter limits in preceding text.

Type J

Hot-Molded Panel Potentiometers

1-5/32 (1.156) Inch (29,36 mm) Diameter
2.25 Watts (70° C)
50 Ohms to 5.0 Megohms



FEATURES

- ±20% or ±10% Tolerance
- Linear and Non-Linear Tapers
- Hot-Molded Composition
- Single, Dual and Triple Sections
- Switches UL Approved
- Style RV4 and 2RV7

SPECIFICATIONS

General

Temperature range — −55° C to +120° C.

Total resistance values — Preferred nominal values listed below. Other values available.

OHMS

50	750	7.5K	75K	750K
100	1K	10K	100K	1 Meg.
200	2K	20K	200K	2 Meg.
250	2.5K	25K	250K	2.5 Meg.
500	5K	50K	500K	5 Meg.

Total resistance tolerances — ±20% or ±10%.

Tapers — Available in the following resistance ranges:

TAPER	TOTAL RESISTANCE RANGE
U	50 Ohms to 5.0 Megohms
A, B, S & DB	250 Ohms to 5.0 Megohms

See chart on Page 93 for explanation of tapers. Special tapers, where practical, can be supplied.

End resistance — See chart on Page 93.

Switches — Single pole, Single throw snap switch that "turns on at start of clockwise rotation". Underwriter rating 2 amperes 125 volts RMS 60 Hertz. Underwriter Laboratories approval file number E-10392. Also rated 10 amperes 10 volts direct current noninductive. Meets 3 ampere 117 volts MIL-R-94 specification. Switches can be operated 5000 cycles at full rating.

Attenuators — See Allen-Bradley Publication EC5910-2.1 for L, Bridged-T, Straight-T and Bridged-H pads.

Applicable military specification — Many of the single variable resistors listed herein may be ordered as Style RV4 of MIL-R-94; and many of the duals may be ordered as Style 2RV7 of MIL-R-94.

Electrical

Power — 2.25 watts maximum at +70° C (single resistors only) provided voltage rating is not exceeded.

Power derating — Derate power linearly from +70° C to zero at +120° C. Derate 50 percent for non-metallic mounting and for resistors with "A", "B", "S", and "DB" tapers. For rheostat applications see Page 94.

For derating of Dual and Triple resistors refer to Page 94.

Voltage — 500 volts maximum working voltage (RMS or DC), or as determined by $E_{max.} = \sqrt{PR}$, whichever is less (at sea level).

Dielectric withstanding voltage — Maximum continuous voltage 500 volts RMS at sea level, 300 volts RMS at 3.4 inches (86,36 mm) mercury. Will withstand a one second test of 1000 volts RMS at sea level or 500 volts RMS at 3.4 inches (86,36 mm) mercury. (Electrical specifications continued on Page 92.)

Electrical

Taps — Single electrical taps are available at 35 percent, 50 percent or 65 percent of rotation. Resistance tolerance ±20 percent. Unless otherwise specified low series tap resistance is provided. See dimensions on Page 97 for tap terminal locations. Consult factory for other available taps.

Capacitance — See Page 94 for explanation.

Operational

Load life — 10 percent maximum change in total resistance as a result of a 1000 hour test at rated power across entire element in still air at +70° C (1.5 hour "ON", 0.5 hour "OFF").

Rotational life — 10 percent maximum change in total resistance as a result of a 100,000 cycle life test without load (single section resistors only).

Mechanical

Shafts — Diameter of shafts .250 inch (6,35 mm). Minimum length .250 inch (6,35 mm). Maximum length 6.000 inches (152,40 mm). Preferred shaft lengths and endings are shown in the table below.

PREFERRED SHAFT LENGTHS

Plain Round

Inches	.500	.625	.750	.875	2.000
mm	12,70	15,88	19,05	22,23	50,80

Screwdriver Slotted

Inches	.500	.625	.750	.875
mm	12,70	15,88	19,05	22,23

Other lengths available in 1/64 inch (0,40 mm) increments. All shaft lengths are measured from the mounting face of the resistor to the free end of the shaft. Special shaft endings can be supplied.

Bushings — All bushings have a 32-NEF-2A thread and are .375 inch (9,52 mm) in diameter. Bushing lengths and types are shown in the table below.

Plain		Standard Locking		Special Locking		Shaft Watertight		Panel and Shaft Watertight	
Inch	mm	Inch	mm	Inch	mm	Inch	mm	Inch	mm
.125	3,18	.500	12,70	.375	9,52	.250	6,35	.281	7,14
.250	6,35			.500	12,70	.375	9,52	.406	10,32
.375	9,52					.500	12,70		
.500	12,70								

All bushing lengths are measured from the mounting face of the resistor and include the bushing washer.

Standard locking bushings will prevent shaft rotation with torques up to 40 inch-ounces (2,88 kgf-cm) after lock nuts have been tightened with a torque of 10 inch-pounds (11,52 kgf-cm).

Hardware — Resistors are normally supplied with one mounting nut, M-2786, and one internal tooth lock washer, M-2898. Resistors with standard locking bushings are normally supplied with one lock nut, B-13750, in addition to the above. Standard locking bushings with MAXIMUM shaft extension of .125 inch (3,18 mm) beyond the bushing can be supplied with acorn lock nut, M-3236, instead of lock nut, B-13750. Unless otherwise specified, all hardware shipped in bulk. For hardware dimensions see Page 97.

Locating lugs — Two locating lugs are provided so resistors may be indexed with respect to the surface on which they are mounted. Lug option 1 standard. See dimensions on Page 97.

Turning torque — At +25° C minimum torque 1 inch-ounce (0,07 kgf-cm). Maximum torque as follows:

Single — 6 inch-ounces (0,43 kgf-cm)

Dual — 12 inch-ounces (0,86 kgf-cm)

Dual concentric types have a maximum torque of 6 inch-ounces (0,43 kgf-cm) on each shaft. Triple concentric types have a maximum torque of 6 inch-ounces (0,43 kgf-cm) on the outer shaft and 12 inch-ounces (0,86 kgf-cm) on the inner shaft. Immersion sealed types require an additional torque of 6 inch-ounces (0,43 kgf-cm).

Stop torque — 12 inch-pounds (13,82 kgf-cm) minimum.

Rotation — Mechanical rotation without switch is 312° ±3°, with switch 333° ±3°. Electrical rotation is 292° nominal.

Backlash — Maximum backlash: single resistors ±1-1/2°, dual resistors ±3°, triple resistors ±6°.

Construction — Materials are corrosion resistant and essentially non-magnetic; terminals are treated for easy soldering.

Immersion sealed types, commonly referred to as "watertight", are optional. These immersion sealed types incorporate an internal "O" ring between the shaft and bushing. External surfaces are given special treatment so that the entire resistor is immersion sealed. This feature is not available when concentric shafts or switches are required.

A panel-shaft "watertight" bushing is also optional. This option is provided with an external "O" ring plus the features of the immersion sealed type. This feature is not available when concentric shafts are required. When furnished with a switch the assembly is not immersion sealed.

Immersion (Immersion sealed types only) — No continuous stream of bubbles (4 or more) emanating from the resistor as a result of the immersion test (1 minute in water at +85° C).

Marking — Allen-Bradley part number and nominal total resistance marked in two lines. Other marking possible, limited to maximum of 13 characters in each of two lines. A-B monogram plus "Type J" always included.

Environmental

Vibration — 2 percent maximum total resistance change and 5 percent maximum resistance setting change. (Single and dual resistors tested per method 204, condition "C" of MIL-STD-202. Triple resistors tested per method 204, condition "A" of MIL-STD-202.)

Shock — 2 percent maximum total resistance change and 5 percent maximum resistance setting change. (Single and dual resistors tested per method 213, condition "I" of MIL-STD-202. Triple resistors tested per method 213, condition "G" of MIL-STD-202.)

Moisture resistance — 10 percent maximum total resistance change. (Tested per method 106 of MIL-STD-202. Resistors with solid shafts only.)

Corrosion resistance — Materials show no corrosion after a 200 hour salt spray test. (Method 101 of MIL-STD-202.)

Effect of soldering — 2 percent maximum change in total resistance as a result of immersing the terminals in 350° C solder to within 0.125 inch (3,18 mm) of the resistor body for 5 seconds.

Temperature cycling — 3 percent maximum change in total resistance as a result of the temperature cycling test (five cycles −55° C to +120° C).

Low temperature operation — 3 percent maximum change in total resistance as a result of the low temperature operation test (−55° C for two hours without load and 45 minutes with rated load).

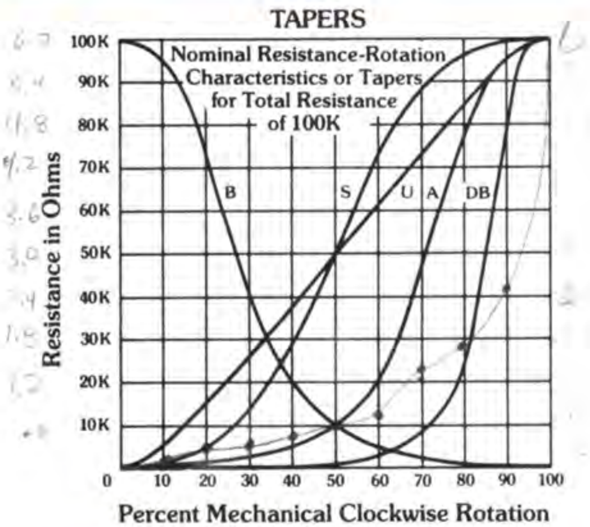
Low temperature storage — 2 percent maximum change in total resistance as a result of the storage test (24 hours at −63° C).

Temperature characteristics — Maximum percent temporary total resistance change from the +25° C value. See table below.

Nominal Resistance	Degrees Celsius — "U" Linear Taper						
	−55°	−25°	0°	+25°	+55°	+85°	+120°
100 Ohms	+ 4.5	+2.5	+1.5	0	±1.0	±1.5	+3.5
1,000 Ohms	+ 5.5	+3.0	+1.5	0	±1.0	±2.0	+4.5
10,000 Ohms	+ 7.0	+3.5	+2.0	0	±1.0	±2.5	+5.5
100,000 Ohms	+ 8.0	+4.0	+2.0	0	±1.5	±3.0	+6.0
1 Megohm	+10.0	+5.0	+2.5	0	±1.5	±3.5	+7.5

For "S", "A", "B" and "DB" tapers multiply percentage figures shown above by 1.25.

Taper data



END RESISTANCE

TAPER	MINIMUM RESISTANCE BETWEEN TERMINALS 1 and 2	MINIMUM RESISTANCE BETWEEN TERMINALS 2 and 3
U & S	1	1
A	1	2
B	2	1
DB	3	2

1 "Less than .004% of total resistance," or "less than 4 ohms" whichever is greater.

2 "Less than 1% of total resistance," or "less than 4 ohms" whichever is greater.

3 Less than 4 ohms.

Ordering information

1. Type (Single, dual or triple).
2. Taper (each element on multi-section controls).
3. Total resistance value (each element on multi-section controls) in ohms.
4. Tolerance (each element on multi-section controls) percent.
5. Bushing type (plain, locking, shaft watertight, or panel and shaft watertight).
6. Bushing length in inches.
7. Shaft ending (plain, slotted or flatted).
8. Shaft length from mounting surface in inches.
9. Switch required?
10. Locating lug option (1, 2, 3 or 4).
11. Mounting hardware (A-B Standard or Other).
12. Part number you have assigned, if any.
13. Marking required on the part.
14. Special features.

Additional ratings

Multiple resistor power derating — The permissible power dissipation in one resistor element is a function of the power dissipation in the other elements. Maximum continuous power rating in watts with entire resistor elements in the circuit are as follows:

$$\left(\frac{W1}{2.25}\right)^2 + \left(\frac{W2}{1.8}\right)^2 + \left(\frac{W3}{1.8}\right)^2 = 1 \text{ (Maximum)}$$

Where W_1 = Watts in entire first or panel resistor element.
W_2 = Watts in entire second or middle resistor element.
W_3 = Watts in entire third or rear resistor element.

Derating with respect to rotation — rheostat application

Percent Rotation	Multiply Wattage Rating By	Percent Rotation	Multiply Wattage Rating By
100	1.00	40	0.81
90	0.99	30	0.68
80	0.98	20	0.49
70	0.96	10	0.23
60	0.93	0	0.11
50	0.89		

Capacitance — The capacitance between terminals #1 and #3 with terminal #2 "floating" is approximately 2 to 3 pF at 1 KHz.

The capacitance between terminal #1 (grounded to bushing) and terminal #3 (shaft in extreme clockwise position) is approximately 10 to 12 pF at 1 KHz.

The capacitance between all terminals shorted together and the bushing is approximately 15 to 20 pF at 1 KHz.

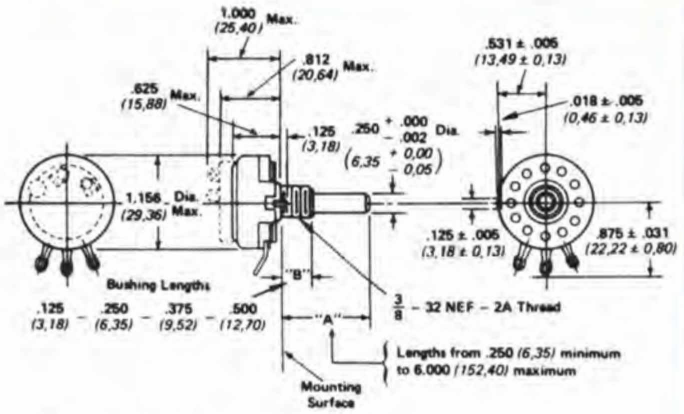
In all cases capacitance indicated is for resistor only and does not include capacitance of measuring lead wires on test fixtures.

	First or Panel Resistor Element W_1	Second or Middle Resistor Element W_2	Third or Rear Resistor Element W_3
DUAL SECTION	2.25 Watts	0 Watt	—
	2.00 Watts	0.83 Watt	—
	1.75 Watts	1.13 Watts	—
	1.50 Watts	1.34 Watts	—
	1.25 Watts	1.49 Watts	—
	1.00 Watts	1.61 Watts	—
	0.75 Watts	1.70 Watts	—
	0.50 Watts	1.76 Watts	—
	0.25 Watts	1.79 Watts	—
	0 Watt	1.80 Watts	—
TRIPLE SECTION	2.0 Watts	0.5 Watt	0.65 Watt
	1.5 Watts	1.0 Watt	0.89 Watt
	1.5 Watts	0.5 Watt	1.24 Watts
	1.0 Watt	1.5 Watts	0.59 Watt
	1.0 Watt	1.0 Watt	1.27 Watts
	1.0 Watt	0.5 Watt	1.53 Watts
	0.5 Watt	1.5 Watts	0.90 Watt
	0.5 Watt	1.0 Watt	1.44 Watts
	0.5 Watt	0.5 Watt	1.68 Watts

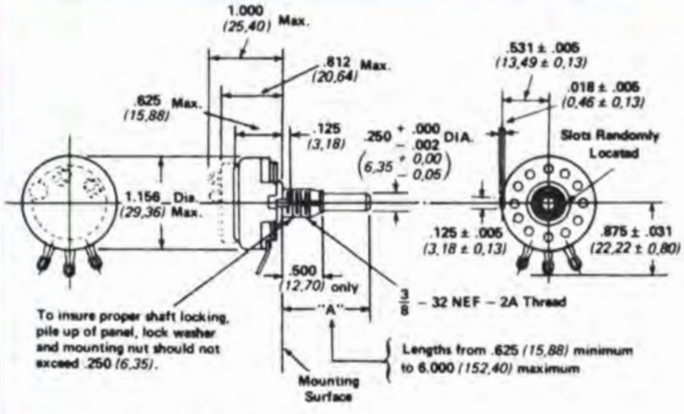
DIMENSIONS

Single section resistors

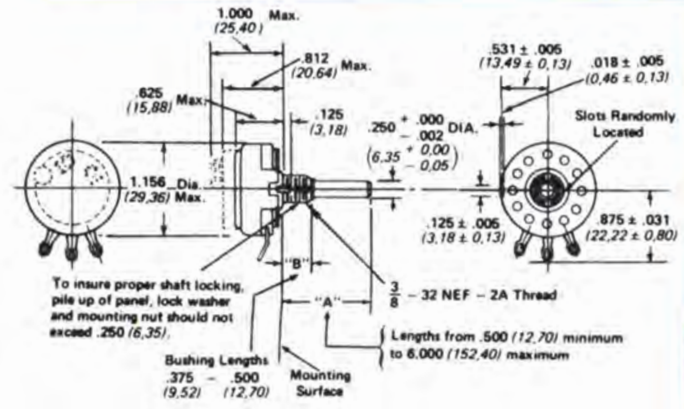
See Page 96 for additional dimensions common to all units.



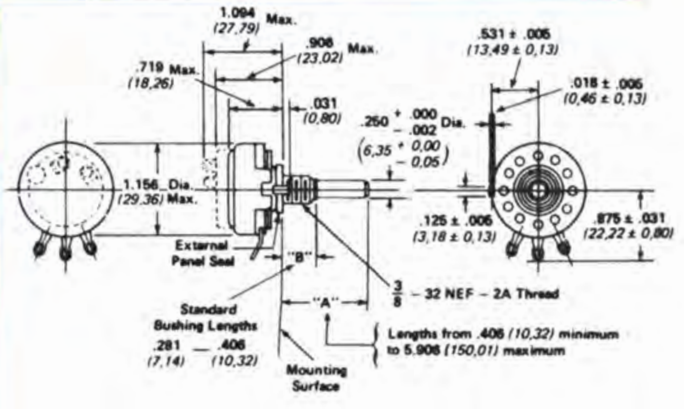
With or Without Switch   Plain Shaft Ending
With Plain Bushing or Shaft Watertight Bushing



With or Without Switch   Plain Shaft Ending
With Standard, Locking Bushing



With or Without Switch   Plain Shaft Ending
With Special Locking Bushing (For Use With Jam Nut M-3638)

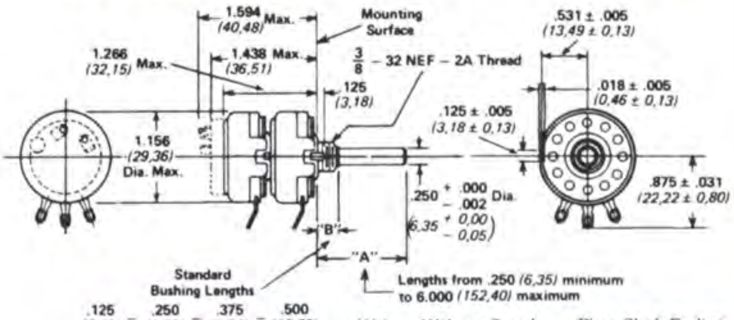


With or Without Switch   Plain Shaft Ending
With Panel Shaft Watertight Bushing

Dual section resistors

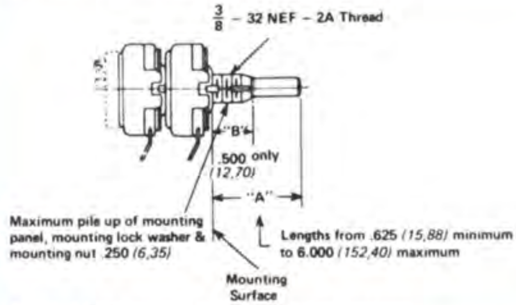
See Page 96 for additional dimensions common to all units.

Plain or Shaft Watertight Bushing



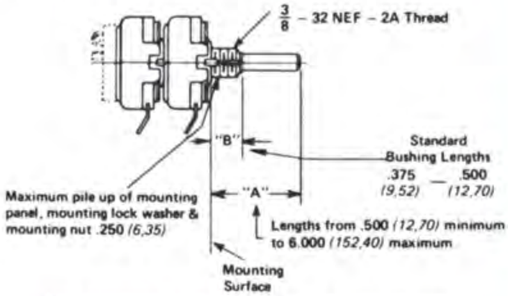
With or Without Switch Plain Shaft Ending

Standard Locking Bushing

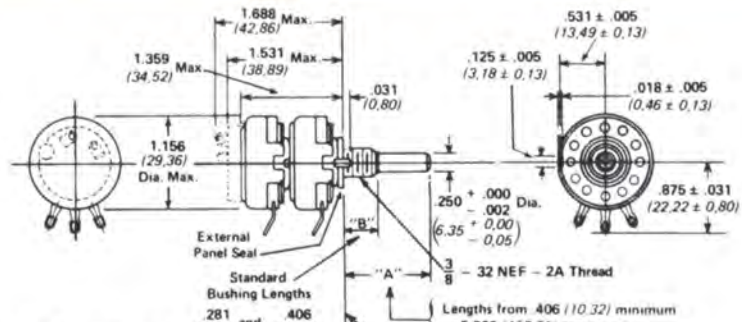


Four randomly located slots on all locking bushings.

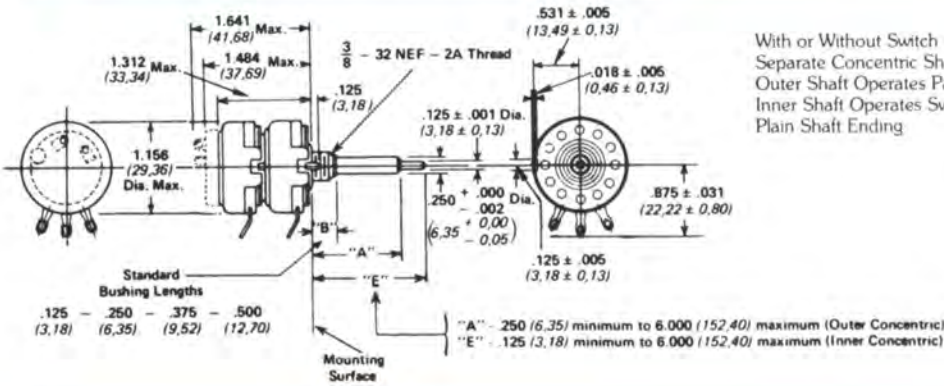
Special Locking Bushing (For Use With Jam Nut M-3638)



Four randomly located slots on all locking bushings.



With or Without Switch
With Panel Shaft Watertight Bushing
Plain Shaft Ending

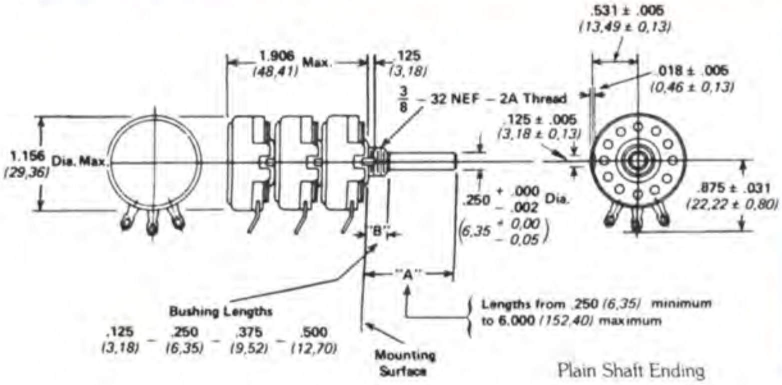


With or Without Switch
Separate Concentric Shafts for Independent Operation of Each Resistor
Outer Shaft Operates Panel Section
Inner Shaft Operates Switch and Rear Section
Plain Shaft Ending

Triple section resistors

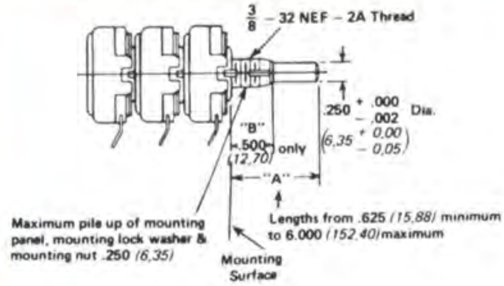
See Page 96 for additional dimensions common to all units.

Plain or Shaft Watertight Bushing



Plain Shaft Ending

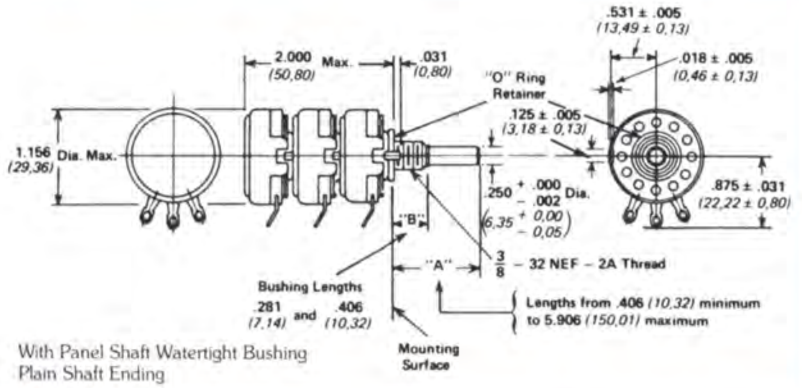
Standard Locking Bushing



Four randomly located slots on all locking bushings.

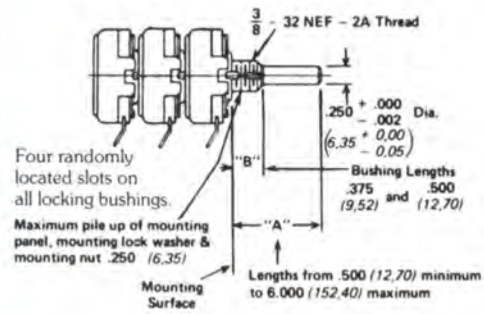
DIMENSIONS

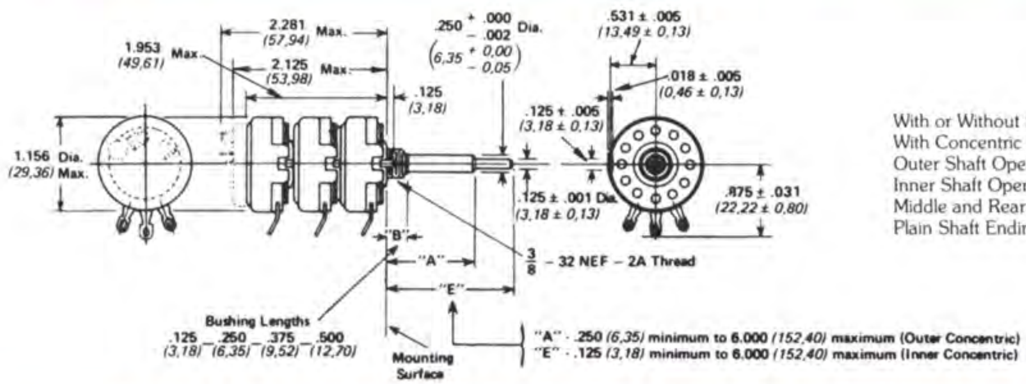
Triple section resistors



With Panel Shaft Watertight Bushing
Plain Shaft Ending

Special Locking Bushing
(For Use With Jam Nut M-3638)





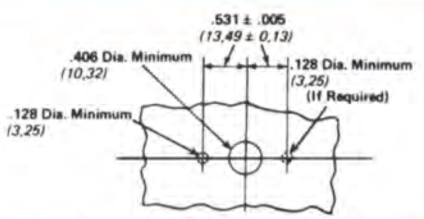
With or Without Switch
With Concentric Shafts
Outer Shaft Operates Panel Section
Inner Shaft Operates Switch.
Middle and Rear Sections
Plain Shaft Ending

DIMENSIONS COMMON TO ALL UNITS

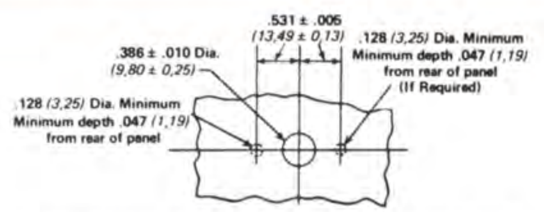
Mounting holes

Basic dimensions in inches. Dimensions shown in PARENTHESES are in millimeters.

TOLERANCE
Dimensional Tolerance ±.016 (0,40).
Except as Specified.
NOT TO SCALE

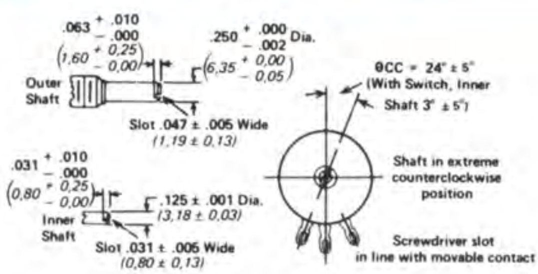


Mounting dimension for resistors with plain bushings, shaft watertight bushings, and locking bushings.

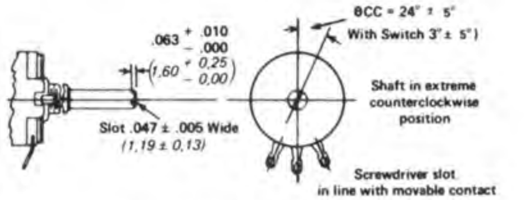


Mounting dimension for resistor with panel shaft watertight bushings.

Standard slotted shaft ending



Dimensions for resistors with concentric shafts.



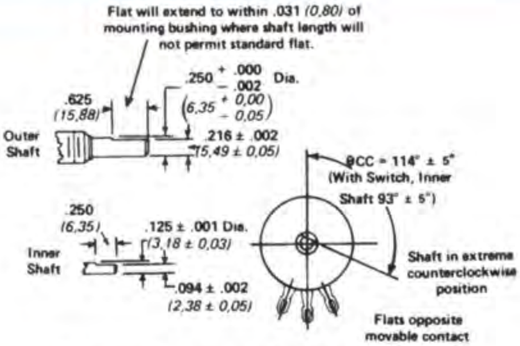
Dimensions for resistors with solid shafts.

All .250 (6,35) diameter shafts supplied with maximum chamfer .031 (0,80) x 45° at the shaft end.

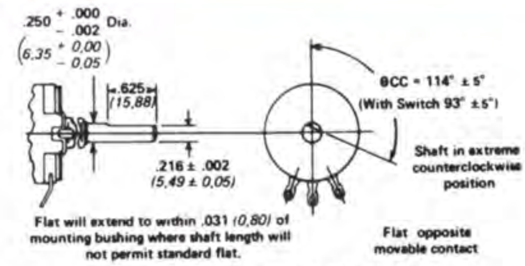
All .125 (3,18) diameter shafts supplied with maximum chamfer .016 (0,40) x 45° at the shaft end.

DIMENSIONS COMMON TO ALL UNITS

Standard flatted shaft ending



Dimensions for resistors with concentric shafts.

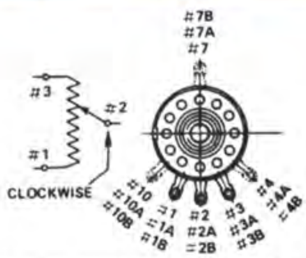


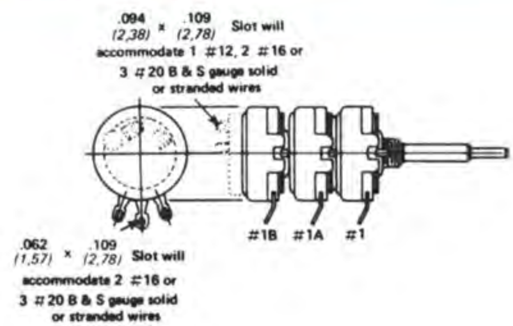
Dimensions for resistors with solid shafts.

All .250 (6,35) diameter shafts supplied with maximum chamfer .031 (0,80) x 45° at the shaft end.

All .125 (3,18) diameter shafts supplied with maximum chamfer .016 (0,40) x 45° at the shaft end.

Terminal connections to resistance element

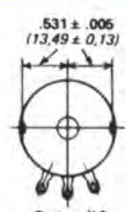




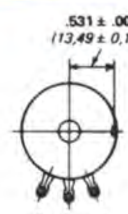
#1 Extreme Counterclockwise End
#2 Movable Contact Brush
#3 Extreme Clockwise End
#4 Tap 65% Effective or Special Between 50% and 100%
#7 Tap 50% Effective Clockwise
#10 Tap 35% Effective Clockwise or Special Between 0 and 50%
Tap Location Tolerances ± 3%

Locating lug options

Option #1
Standard Locating Lug
(Used Unless Otherwise Specified)



Option #2

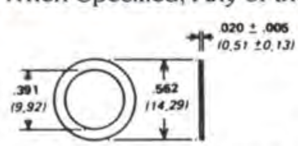


Option #3

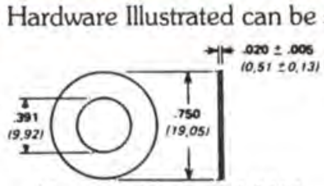
Option #4

Mounting hardware

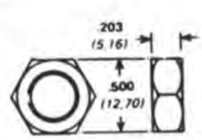
When Specified, Any of the Hardware Illustrated can be supplied (See Page 92)



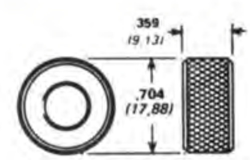
Mounting Washer M-3462



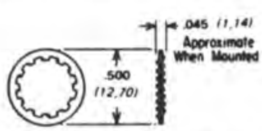
Mounting Washer M-3461



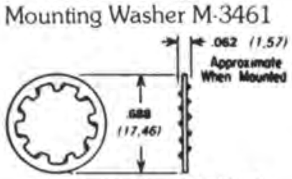
Lock Nut B-13750



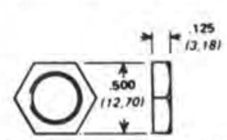
Lock Nut M-3318



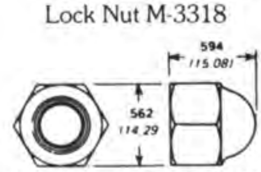
Lock Washer M-2898



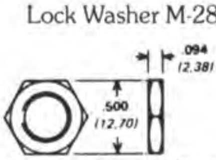
Lock Washer M-3252



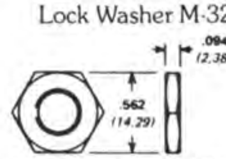
Jam Lock Nut M-3638



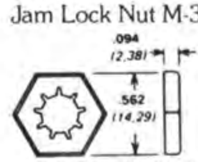
Acorn Lock Nut M-3236



Mounting Nut M-2786



Mounting Nut M-1766



Pal Nut M-2907

Hot-Molded Panel Potentiometers

EXPLANATION OF PART NUMBERS

JA1N056S501UA

Basic Type

JA – Single J
JS – Single J with SPST Switch
JD – Dual J*
JB – Dual J with SPST Switch*
JE – Triple J*

*If the electrical specifications are not identical for each section, a special number will be required.

Locating Lug Option

1
2
3
4

Total Resistance Value

First two digits are significant figures and the third indicates the number of zeros following the first two digits –

Examples: 101 = 100 Ohms
501 = 500 Ohms
255 = 2.5 Megohms

Hardware Combinations

	Mounting Nut	Lockwasher	Locknut
A	(1)M-2786	(1)M-2898	– – –
E	(2)M-2786	(1)M-2898	– – –
C	(1)M-2786	(1)M-2898	(1)B-13750
J	(1)M-2786	(1)M-2898	(1)M-3318
W	(1)M-2786	(1)M-2898	(1)M-3236
Y	(1)M-2786	(1)M-2898	(1)M-3638
N	(1)M-1766	(1)M-3252	– – –
Q	(2)M-1766	(1)M-3252	– – –
S	(1)M-1766	(1)M-3252	(1)B-13750
U	(1)M-1766	(1)M-3252	(1)M-3638
L	– – –	– – –	(1)B-13750
X	(1)M-2907	– – –	– – –
Z	(no hardware)		

Bushing Type and Length

R – Plain, .125 inch (3.18 mm) long
G – Plain, .250 inch (6.35 mm) long
N – Plain, .375 inch (9.52 mm) long
H – Plain, .500 inch (12.70 mm) long
L – Standard Locking – (slotted & bevelled) .500 inch (12.70 mm) long
M – Special Locking – (slotted only) .375 inch (9.52 mm) long
K – Special Locking – (slotted only) .500 inch (12.70 mm) long
F – Shaft Watertight, .250 inch (6.35 mm) long
D – Shaft Watertight, .375 inch (9.52 mm) long
W – Shaft Watertight, .500 inch (12.70 mm) long
P – Panel Shaft Watertight, .281 inch (7.14 mm) long
E – Panel Shaft Watertight .406 inch (10.32 mm) long

Shaft Length

Measured from mounting surface in inches and sixty-fourths

Example:
032 = 32/64 or .500" (12.70 mm)
056 = 7/8 or .875" (22.22 mm)
200 = 2.000" (50.80 mm)

Shaft Ending

Letter	Type
S	Standard Slotted
P	Plain Round
F	Standard Flatted

Taper Type and Total Resistance Tolerance

U – Linear (U), ±10%
M – Linear (U), ±20%
A – Clockwise Modified Logarithmic (A), ±10%
R – Clockwise Modified Logarithmic (A), ±20%
B – Counterclockwise Modified Logarithmic (B), ±10%
T – Counterclockwise Modified Logarithmic (B), ±20%
D – Clockwise Exact Logarithmic (DB), ±10%
K – Clockwise Exact Logarithmic (DB), ±20%
S – Modified Linear (S), ±10%
Y – Modified Linear (S), ±20%
C – Linear (U), ±10% with 50% (center) Tap
F – Linear (U), ±20% with 50% (center) Tap

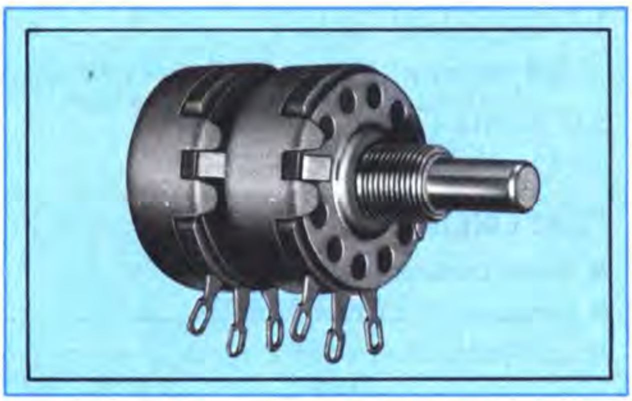
Pad Type and Characteristic Impedance Tolerance

E – Attenuator L-Pad ±15%
L – Attenuator L-Pad ±20%
N – Attenuator Bridged T-Pad ±15%
P – Attenuator Bridged T-Pad ±20%

CAUTION: Part number format does not allow for exclusion of invalid mechanical and/or electrical combinations. Check parameter limits in preceding text.

Type J

Hot-Molded Panel Potentiometers



Vernier Adjustment
1-5/32 (1.156) Inch (29,36 mm) Diameter
2.25 Watts (70°C)
50 Ohms to 5 Megohms

FEATURES

- ±20% or ±10% Tolerance
- Hot-Molded Composition
- Single-Knob, Single-Turn

SPECIFICATIONS

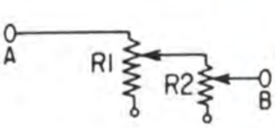
General

Both coarse and fine rheostat or potentiometer adjustments are now possible in a single-knob single-turn control due to the special coupling between front and rear sections of this Type J variable resistor. It's lower in price than concentric construction and needs the panel space of only one control.

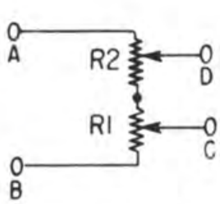
R2 (rear section) is usually the higher value, generally by a factor of about 10 times R1 (greater than 20:1 ratio is not recommended). Built-in backlash will permit R2 to "idle" while a "backing off" adjustment is made in R1. Mechanical independence of R1 covers about 40°.

Typical circuitry

As a rheostat

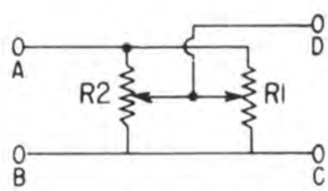


As a potentiometer



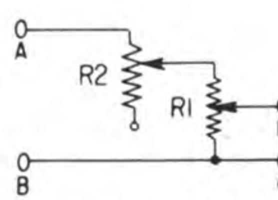
Four-Terminal Circuit

This lifts Terminal C above Terminal B by an amount equal to the voltage in the lower portion of the R1 section.



Three-Terminal Parallel Circuit

In this case, the R2 section is the lower resistance, the R1 is higher. A ratio of 5:1 is probably a good one here due to the loading effect of R2 on R1 adjustments.



Three-Terminal Modified Circuit

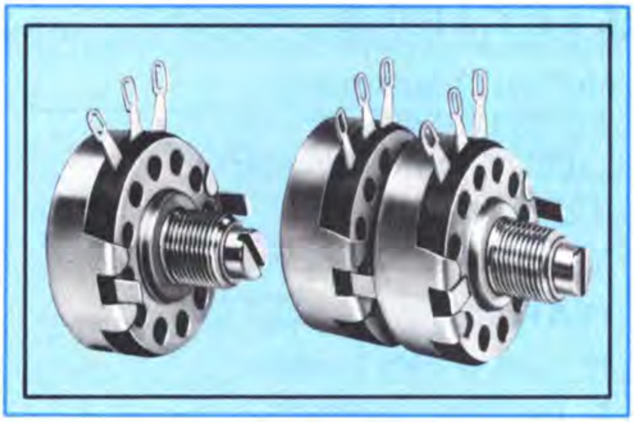
This maintains continuity between B and C but results in a changeable overall resistance between Terminal A and B.

For additional specifications, please refer to Technical Publication EC5607-2.1.

NOT AVAILABLE FROM STOCK AT ELECTRONIC DISTRIBUTORS.

Type K Hot-Molded Panel Potentiometers

1-5/32 (1.156) Inch
(29,36 mm) Diameter
3.0 Watts (70° C)
50 Ohms to 5.0 Megohms



FEATURES

- Single, Dual and Triple Sections
- Linear and Non-Linear Tapers
- ±20% or ±10% Tolerance

SPECIFICATIONS

General

Temperature range — −55° C to +150° C.

Total resistance values — Preferred nominal values listed below. Other values available.

OHMS

50	1K	10K	100K	1 Meg.
100	2.5K	25K	250K	2.5 Meg.
250	5K	50K	500K	5 Meg.
500				

Total resistance tolerances — ±20% or ±10%.

Tapers — Available in the following resistance ranges:

TAPER	TOTAL RESISTANCE RANGE
U	50 Ohms to 5.0 Megohms
A, B, S & DB	250 Ohms to 5.0 Megohms

See chart on following pages for explanation of tapers. Special tapers, where practical, can be supplied.

End resistance — See chart on following pages.

Electrical

Power — 3 watts maximum at +70° C for "U" linear taper only, (single resistors only) provided voltage rating is not exceeded.

Power derating — Derate power linearly from +70° C to zero at +150° C. Derate 50 percent for non-metallic mounting and for resistors with "A", "B", "S", and "DB" tapers. For rheostat applications derate directly with shaft or actuator position.

For derating of Dual and Triple resistors refer to following pages.

Voltage — 500 volts maximum working voltage (RMS or DC), or as determined by $E_{max.} = \sqrt{PR}$, whichever is less (at sea level).

Dielectric withstanding voltage — Maximum continuous voltage 500 volts RMS at sea level. Will withstand a one second test of 1000 volts (RMS or DC) at sea level or 500 volts RMS at 3.4 inches (86,36 mm) mercury.

Capacitance — The capacitance between terminals #1 and #3 with terminal #2 "floating" is approximately 2 to 3 pF at 1 KHz.

The capacitance between terminal #1 (grounded to bushing) and terminal #3 (shaft in extreme clockwise position) is approximately 10 to 12 pF at 1 KHz.

The capacitance between all terminals shorted together and the bushing is approximately 15 to 20 pF at 1 KHz.

In all cases capacitance indicated is for resistor only and does not include capacitance of measuring lead wires on test fixtures.

NOT AVAILABLE FROM STOCK AT ELECTRONIC DISTRIBUTORS.

Operational

Load life — 10 percent maximum change in total resistance as a result of a 1000 hour test at rated power across entire element in still air at +70° C (1.5 hour "ON", 0.5 hour "OFF").

Rotational life — 10 percent maximum change in total resistance as a result of a 100,000 cycle life test without load (single section resistors only).

Mechanical

Shafts — Diameter of shafts .250 inch (6,35 mm). Minimum length .250 inch (6,35 mm). Maximum length 6.000 inches (152,40 mm). Preferred shaft lengths and endings are shown in the table below.

PREFERRED SHAFT LENGTHS

Plain Round

Inches	.500	.625	.750	.875	2.000
mm	12.70	15.88	19.05	22.23	50.80

Screwdriver Slotted

Inches	.500	.625	.750	.875
mm	12.70	15.88	19.05	22.23

Other lengths available in 1/64 inch (0,40 mm) increments. All shaft lengths are measured from the mounting face of the resistor to the free end of the shaft. Concentric shafts available, see DIMENSIONS.

Bushings — All bushings have a 32-NEF-2A thread and are .375 inch (9,52 mm) in diameter. Bushing lengths and types are shown in the table below.

Plain		Standard Locking		Special Locking		Shaft Watertight		Panel and Shaft Watertight	
Inch	mm	Inch	mm	Inch	mm	Inch	mm	Inch	mm
.125	3.18	.500	12.70	.375	9.52	.250	6.35	.281	7.14
.250	6.35			.500	12.70	.375	9.52	.406	10.32
.375	9.52					.500	12.70		
.500	12.70								

All bushing lengths are measured from the mounting face of the resistor and include the bushing washer.

Standard locking bushings will prevent shaft rotation with torques up to 40 inch-ounces (2,88 kgf-cm) after lock nuts have been tightened with a torque of 10 inch-pounds (11,52 kgf-cm).

Hardware — Resistors are normally supplied with one mounting nut, M-2786, and one internal tooth lock washer, M-2898. Resistors with standard locking bushings are normally supplied with one lock nut, B-13750, in addition to the above. Standard locking bushings with MAXIMUM shaft extension of .125 inch (3,18 mm) beyond the bushing can be supplied with acorn lock nut, M-3236, instead of lock nut, B-13750. Unless otherwise specified, all hardware shipped in bulk. For hardware dimensions see Page 106.

Locating lugs — Two locating lugs are provided so resistors may be indexed with respect to the surface on which they are mounted. Four lug options available. Lug option 1 standard. See DIMENSIONS.

Turning torque — At + 25° C minimum torque 1 inch-ounce (0,07 kgf-cm). Maximum torque as follows:

Single — 6 inch-ounces (0,43 kgf-cm)
Dual — 9 inch-ounces (0,65 kgf-cm)
Triple — 12 inch-ounces (0,86 kgf-cm)

Dual concentric types have a maximum torque of 6 inch-ounces (0,43 kgf-cm) on each shaft. Triple concentric types have a maximum torque of 6 inch-ounces (0,43 kgf-cm) on the outer shaft and 9 inch-ounces (0,65 kgf-cm) on the inner shaft. Immersion sealed types require an additional torque of 6 inch-ounces (0,43 kgf-cm).

Stop torque — 12 inch-pounds (13,82 kgf-cm) minimum.

Rotation — Mechanical rotation is 312° ± 3°. Electrical rotation is 292° nominal.

Backlash — Maximum backlash; single resistors ± 1-1/2°, dual resistors ± 3°, triple resistors ± 6°.

Construction — Materials are corrosion resistant and essentially non-magnetic; enclosure is dust and splash resistant; terminals are treated for easy soldering.

Immersion sealed types, commonly referred to as "watertight", are optional. These immersion sealed types incorporate an internal "O" ring between the shaft and bushing. External surfaces are given special treatment so that the entire resistor is immersion sealed. This feature is not available when concentric shafts are required.

A panel-shaft "watertight" bushing is also optional. This option is provided with an external "O" ring plus the features of the immersion sealed type. This feature is not available when concentric shafts are required.

Immersion (Immersion sealed types only) — No continuous stream of bubbles (4 or more) emanating from the resistor as a result of the immersion test (1 minute in water at +85° C).

Marking — Allen-Bradley part number and nominal total resistance marked in two lines. Other marking possible, limited to maximum of 13 characters in each of two lines. A-B monogram plus "Type K" always included.

Environmental

Vibration — 2 percent maximum total resistance change and 5 percent maximum resistance setting change. (Single and dual resistors tested per method 204, condition "C" of MIL-STD-202. Triple resistors tested per method 204, condition "A" of MIL-STD-202.)

Shock — 2 percent maximum total resistance change and 5 percent maximum resistance setting change. (Single and dual resistors tested per method 213, condition "I" of MIL-STD-202. Triple resistors tested per method 213, condition "G" of MIL-STD-202.)

Moisture resistance — 10 percent maximum total resistance change. (Tested per method 106 of MIL-STD-202. Resistors with solid shafts only.)

Corrosion resistance — Materials show no corrosion after a 200 hour salt spray test. (Method 101 of MIL-STD-202.)

Effect of soldering — 2 percent maximum change in total resistance as a result of immersing the terminals in + 350° C solder to within 0.125 inch (3,18 mm) of the resistor body for 5 seconds.

Temperature cycling — 3 percent maximum change in total resistance as a result of the temperature cycling test (five cycles − 55° C to + 150° C).

Low temperature operation — 3 percent maximum change in total resistance as a result of the low temperature operation test (−55° C for two hours without load and 45 minutes with rated load).

Low temperature storage — 2 percent maximum change in total resistance as a result of the storage test (24 hours at −63° C).

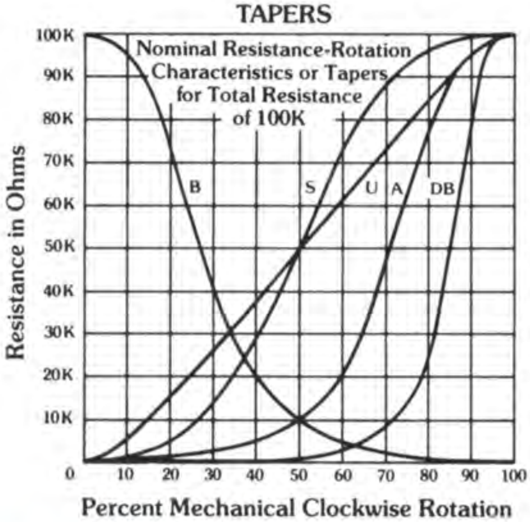
Temperature characteristics — Maximum percent temporary total resistance change from the +25° C value. See table below.

Nominal Resistance	Degrees Celsius — "U" Linear Taper							
	−55°	−25°	0°	+25°	+55°	+85°	+120°	+150°
100 Ohms	+ 4.5	+ 2.5	+ 1.5	0	± 1.0	± 1.5	+ 3.5	+ 5.5
1,000 Ohms	+ 5.5	+ 3.0	+ 1.5	0	± 1.0	± 2.0	+ 4.5	+ 6.5
10,000 Ohms	+ 7.0	+ 3.5	+ 2.0	0	± 1.0	± 2.5	+ 5.5	+ 8.5
100,000 Ohms	+ 8.0	+ 4.0	+ 2.0	0	± 1.5	± 3.0	+ 6.0	+10.5
1 Megohm	+10.0	+ 5.0	+ 2.5	0	± 1.5	± 3.5	+ 7.5	+12.5

For "S", "A", "B" and "DB" tapers multiply percentage figures shown above by 1.25.

Taper data

TAPERS



END RESISTANCE

TAPER	MINIMUM RESISTANCE BETWEEN TERMINALS 1 and 2	MINIMUM RESISTANCE BETWEEN TERMINALS 2 and 3
U & S	1	1
A	1	2
B	2	1
DB	3	2

1 "Less than .004% of total resistance," or "less than 4 ohms" whichever is greater.

2 "Less than 1% of total resistance," or "less than 4 ohms" whichever is greater.

3 Less than 4 ohms.

Ordering information

1. Type (single, dual or triple).
2. Total resistance value (each element on multi-section controls) in ohms.
3. Tolerance (each element on multi-section controls) percent.
4. Taper (each element on multi-section controls).
5. Bushing type (plain, locking, shaft watertight, or panel and shaft watertight).
6. Bushing length in inches or millimeters.
7. Shaft ending (plain, slotted or flatted).
8. Shaft length from mounting surface in inches or millimeters.
9. Locating lug option (1, 2, 3 or 4).
10. Mounting hardware (A-B standard or other).
11. Part number you have assigned, if any.
12. Marking required on the part.
13. Special features.
14. Remarks.

Additional ratings

Multiple resistor power derating — The permissible power dissipation in one resistor element is a function of the power dissipation in the other elements. Maximum continuous power rating in watts with entire resistor elements in the circuit are as follows:

$$\left(\frac{W1}{3}\right)^2 + \left(\frac{W2}{2.4}\right)^2 + \left(\frac{W3}{2.4}\right)^2 = 1 \text{ (Maximum)}$$

Where W_1 = Watts in entire first or panel resistor element.
W_2 = Watts in entire second or middle resistor element.
W_3 = Watts in entire third or rear resistor element.

Derating with respect to rotation — rheostat application

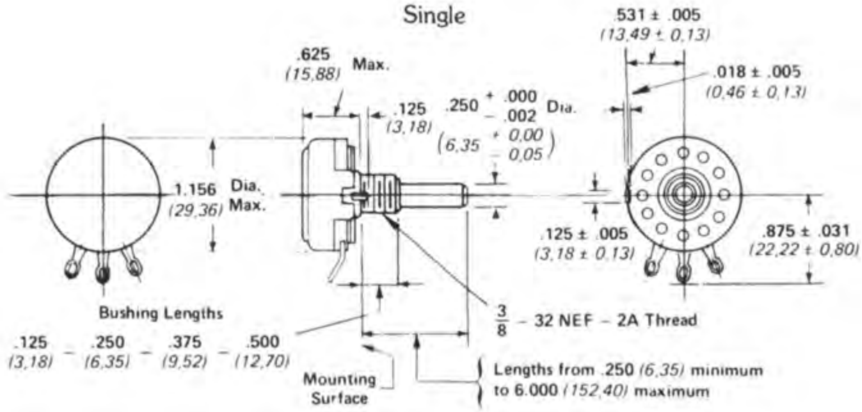
Percent Rotation	Multiply Wattage Rating By	Percent Rotation	Multiply Wattage Rating By
100	1.00	40	0.81
90	0.99	30	0.68
80	0.98	20	0.49
70	0.96	10	0.23
60	0.93	0	0.11
50	0.89		

	First or Panel Resistor Element W_1	Second or Middle Resistor Element W_2	Third or Rear Resistor Element W_3
DUAL	3.0	0	
	2.75	0.96	
	2.50	1.33	
	2.25	1.59	
	2.00	1.79	
	1.75	1.95	
	1.50	2.08	
	1.25	2.18	
	1.00	2.27	
	0.75	2.32	
	0.50	2.37	
	0.25	2.39	
	0	2.40	
	R_1	R_2	R_3
TRIPLE	2.5 Watts	1.0 Watt	0.87 Watt
	2.5 Watts	0.5 Watt	1.23 Watts
	2.0 Watts	1.5 Watts	0.97 Watt
	2.0 Watts	1.0 Watt	1.48 Watts
	2.0 Watts	0.5 Watt	1.72 Watts
	1.5 Watts	2.0 Watts	0.56 Watt
	1.5 Watts	1.5 Watts	1.44 Watts
	1.5 Watts	1.0 Watt	1.82 Watts
	1.5 Watts	0.5 Watt	2.02 Watts
	1.0 Watt	2.0 Watts	1.06 Watts
	1.0 Watt	1.5 Watts	1.70 Watts
	1.0 Watt	1.0 Watt	2.03 Watts
	1.0 Watt	0.5 Watt	2.20 Watts
	0.5 Watt	2.0 Watts	1.26 Watts
	0.5 Watt	1.5 Watts	1.83 Watts
	0.5 Watt	1.0 Watt	2.14 Watts
	0.5 Watt	0.5 Watt	2.31 Watts

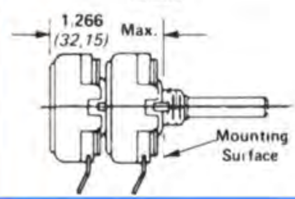
DIMENSIONS

Plain or shaft watertight bushing

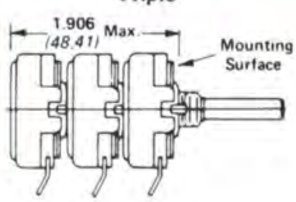
Single



Dual

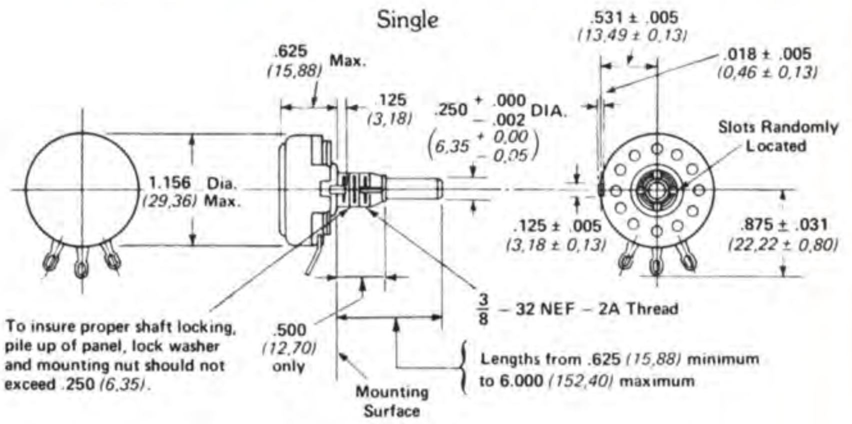


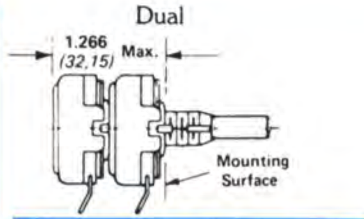
Triple

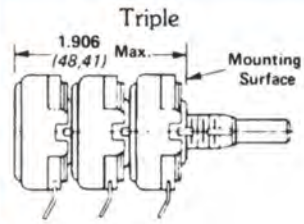


DIMENSIONS

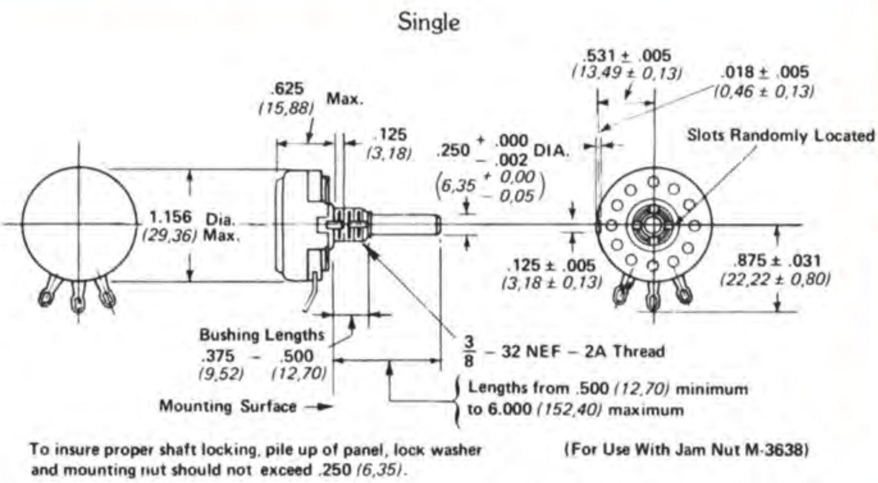
Standard locking bushing

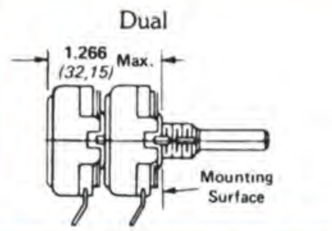


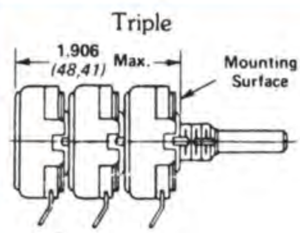




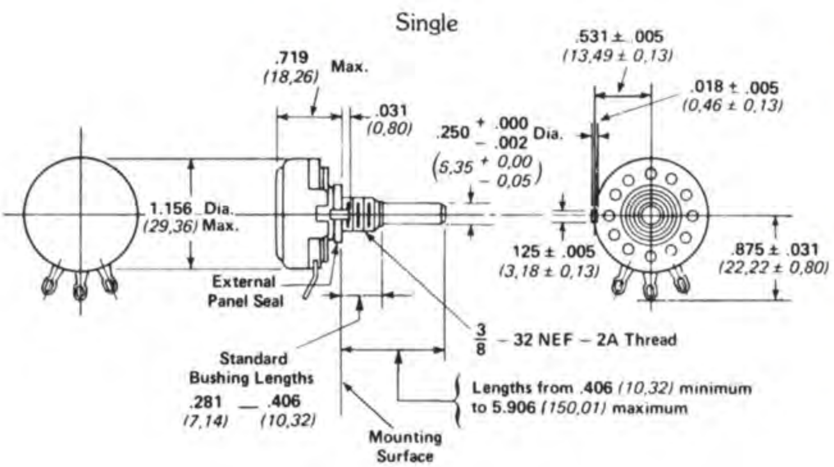
Special locking bushing

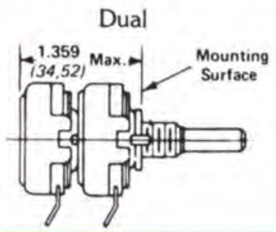


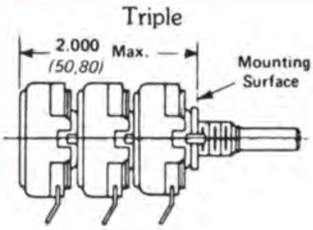




Panel-shaft watertight bushing



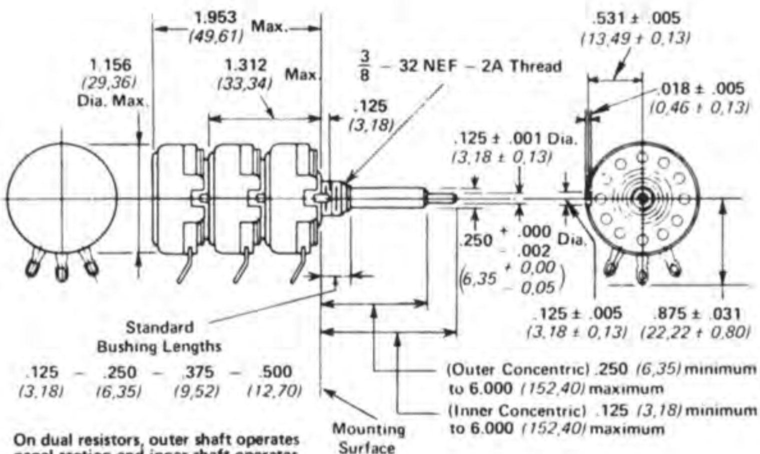




DIMENSIONS

Concentric shaft

Dual - Triple



On dual resistors, outer shaft operates panel section and inner shaft operates rear section.

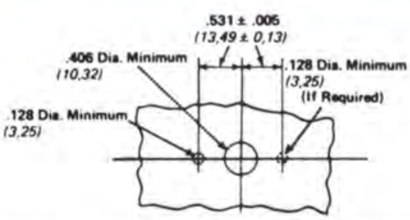
On triple resistors, outer shaft operates panel section and inner shaft operates middle and rear section.

DIMENSIONS COMMON TO ALL UNITS

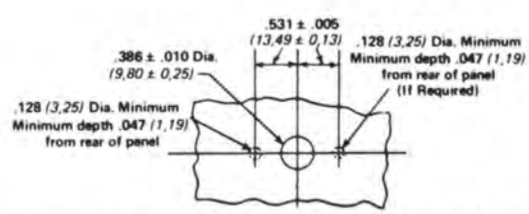
Mounting holes

Basic dimensions in inches. Dimensions shown in PARENTHESES are in millimeters.

TOLERANCE
Dimensional Tolerance ±.016 (0.40).
Except as Specified.
NOT TO SCALE

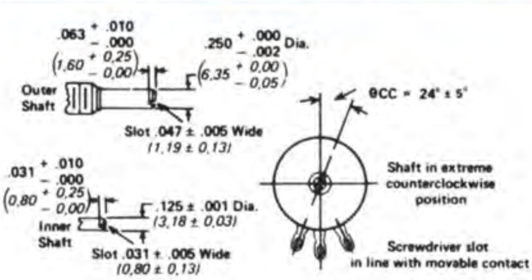


Mounting dimension for resistors with plain bushings, shaft watertight bushings, and locking bushings.

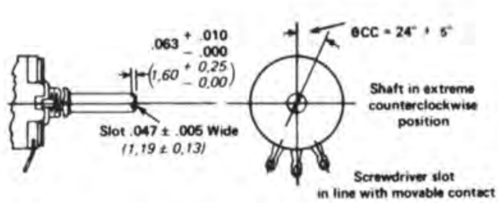


Mounting dimension for resistor with panel and shaft watertight bushings.

Standard slotted shaft ending



Dimensions for resistors with concentric shafts.



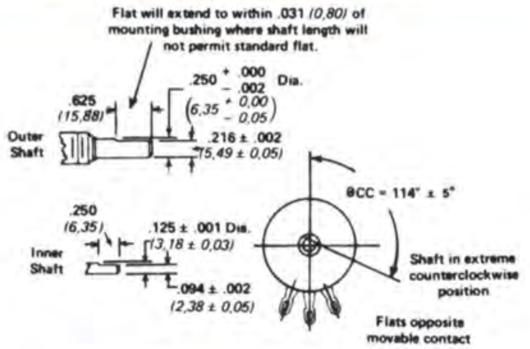
Dimensions for resistors with solid shafts.

All .250 (6.35) diameter shafts supplied with maximum chamfer .031 (0.80) x 45° at the shaft end.

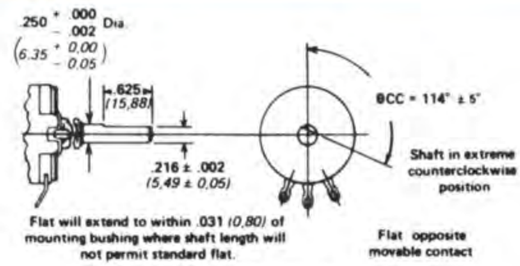
All .125 (3.18) diameter shafts supplied with maximum chamfer .016 (0.40) x 45° at the shaft end.

DIMENSIONS COMMON TO ALL UNITS

Standard flatted shaft ending



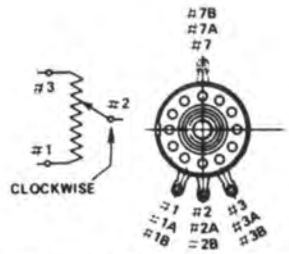
Dimensions for resistors with concentric shafts



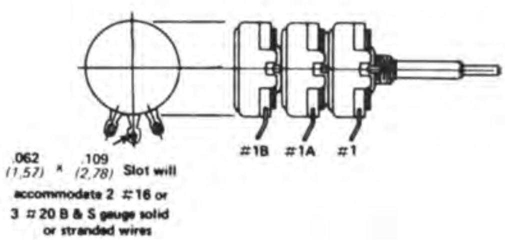
Dimensions for resistors with solid shafts.

> All .250 (6.35) diameter shafts supplied with maximum chamfer .031 (0.80) x 45° at the shaft end.
>
> All .125 (3.18) diameter shafts supplied with maximum chamfer .016 (0.40) x 45° at the shaft end.

Terminal connections to resistance element

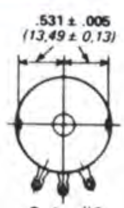


#1 Extreme Counterclockwise End
#2 Movable Contact Brush
#3 Extreme Clockwise End
#7 Tap 50% Effective Clockwise



Locating lug options

Option #1
Standard Locating Lug
(Used Unless Otherwise Specified)



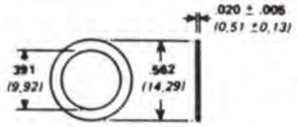
Option #2

Option #3

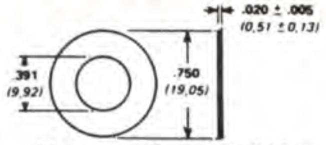
Option #4
(No Locating Lug)

Mounting hardware

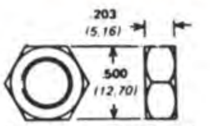
When Specified, Any of the Hardware Illustrated can be supplied (See Page 101)



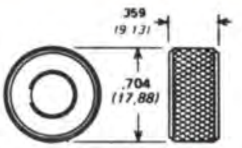
Mounting Washer M-3462



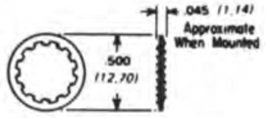
Mounting Washer M-3461



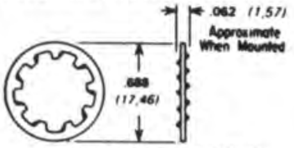
Lock Nut B-13750



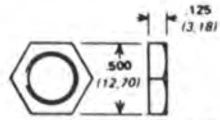
Lock Nut M-3318



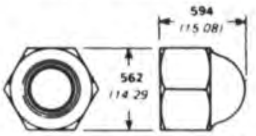
Lock Washer M-2898



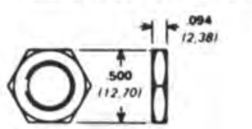
Lock Washer M-3252



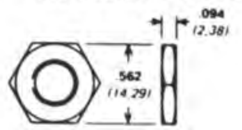
Jam Lock Nut M-3638



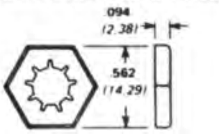
Acorn Lock Nut M-3236



Mounting Nut M-2786



Mounting Nut M-1766



Pal Nut M-2907

EXPLANATION OF PART NUMBERS

KA1N056S501UA

Basic Type

KA - Single K
KD - Dual K*
KE - Triple K*

*If the electrical specifications are not identical for each section, a special number will be required.

Locating Lug Option

1
2
3
4

Total Resistance Value

First two digits are significant figures and the third indicates the number of zeros following the first two digits —

Examples: 101 = 100 Ohms
501 = 500 Ohms
255 = 2.5 Megohms

Bushing Type and Length

- **R** - Plain, .125 inch (3,18 mm) long
- **G** - Plain, .250 inch (6,35 mm) long
- **N** - Plain, .375 inch (9,52 mm) long
- **H** - Plain, .500 inch (12,70 mm) long
- **L** - Standard Locking — (slotted and bevelled) .500 inch (12,70 mm) long
- **M** - Special Locking — (slotted only) .375 inch (9,52 mm) long
- **K** - Special Locking — (slotted only) .500 inch (12,70 mm) long
- **F** - Shaft Watertight, .250 inch (6,35 mm) long
- **D** - Shaft Watertight, .375 inch (9,52 mm) long
- **W** - Shaft Watertight, .500 inch (12,70 mm) long
- **P** - Panel Shaft Watertight, .281 inch (7,14 mm) long
- **E** - Panel Shaft Watertight .406 inch (10,32 mm) long

Shaft Length

Measured from mounting surface in inches and sixty-fourths

Example:
032 = 32/64 or .500 in. (12,70 mm)
056 = 7/8 or .875 in. (22,22 mm)
200 = 2.000 in. (50,80 mm)

Preferred Shaft Lengths and Endings

Plain Round

Inches	.500	.625	.750	.875	2.000
mm	12,70	15,88	19,05	22,23	50,80

Screwdriver Slotted

Inches	.500	.625	.750	.875
mm	12,70	15,88	19,05	22,23

Hardware Combinations

Mounting Nut	Lockwasher	Locknut
A - (1)M-2786	(1)M-2898	- - -
E - (2)M-2786	(1)M-2898	- - -
C - (1)M-2786	(1)M-2898	(1)B-13750
J - (1)M-2786	(1)M-2898	(1)M-3318
W - (1)M-2786	(1)M-2898	(1)M-3236
Y - (1)M-2786	(1)M-2898	(1)M-3638
N - (1)M-1766	(1)M-3252	- - -
Q - (2)M-1766	(1)M-3252	- - -
S - (1)M-1766	(1)M-3252	(1)B-13750
U - (1)M-1766	(1)M-3252	(1)M-3638
L - - - -	- - -	(1)B-13750
X - (1)M-2907	- - -	- - -
Z - (no hardware)		

Taper Type and Total Resistance Tolerance

- **U** - Linear (U), ± 10%
- **M** - Linear (U), ± 20%
- **A** - Clockwise Modified Logarithmic (A), ± 10%
- **R** - Clockwise Modified Logarithmic (A), ± 20%
- **B** - Counterclockwise Modified Logarithmic (B), ± 10%
- **T** - Counterclockwise Modified Logarithmic (B), ± 20%
- **D** - Clockwise Exact Logarithmic (DB), ± 10%
- **K** - Clockwise Exact Logarithmic (DB), ± 20%
- **S** - Modified Linear (S), ± 10%
- **Y** - Modified Linear (S), ± 20%
- **C** - Linear (U), ± 10% with 50% (center) Tap
- **F** - Linear (U), ± 20% with 50% (center) Tap

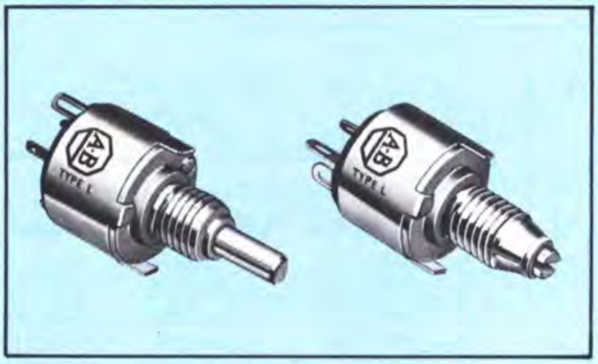
Shaft Ending

Letter	Type
S	Standard Slotted
P	Plain Round
F	Standard Flatted

CAUTION: Part number format does not allow for exclusion of invalid mechanical and/or electrical combinations. Check parameter limits in preceding text.

Type L Hot-Molded Panel Potentiometers

1/2 (0.50) Inch (12,70 mm) Diameter
0.8 Watt (70° C)
100 Ohms to 5.0 Megohms



FEATURES

- Linear and Non-Linear Tapers
- Immersion Sealed
- Lug or Pin Terminals

SPECIFICATIONS

General

Temperature range — −55° C to +150° C.

Total resistance values — Preferred nominal values listed below. Other values available.

OHMS

100	1K	10K	100K	1 Meg.
250	2.5K	25K	250K	2.5 Meg.
500	5K	50K	500K	5 Meg.

Total resistance tolerances — ± 20% or ± 10%.

Tapers — Available in following resistance ranges:

TAPER	TOTAL RESISTANCE RANGE
U	100 Ohms to 5.0 Megohms
A, B, S, & DB	500 Ohms to 2.5 Megohms

See chart on following pages for explanation of tapers. Special tapers, where practical, can be supplied.

End resistance — See chart on following pages.

Electrical

Power — 0.8 watt maximum at +70° C, for "U" linear taper, provided voltage is not exceeded.

Power derating — Derate power linearly from +70° C to zero at +150° C. Derate power 50 percent for non-metallic mounting and for resistors with "A", "B", "S", and "DB" tapers. For rheostat applications, derate power directly with shaft or actuator position.

Voltage — 350 volts maximum working voltage (RMS or DC), or as determined by $E_{max.} = \sqrt{PR}$, whichever is less (at sea level).

Dielectric withstanding voltage — Will withstand a one second test of 750 volts (RMS or DC) at sea level or 350 volts (RMS or DC) at 3.4 inches (86,36 mm) mercury.

Insulation resistance — 1000 megohms minimum for clean and dry conditions at +25° C.

Voltage characteristic — 0.005 percent per volt or 0.5 ohm, whichever is greater.

Capacitance — The capacitance between terminal #1 and #3 with terminal #2 "floating" is approximately 0.5 to 0.75 pF at 1 KHz.

The capacitance between terminal #1 (grounded to bushing) and terminal #3 (shaft in extreme clockwise position) is approximately 3.0 to 3.7 pF at 1 KHz.

The capacitance between all terminals shorted together and the bushing is approximately 5.5 to 6.5 pF at 1 KHz.

In all cases capacitance indicated is for resistor only and does not include capacitance of measuring lead wires on test fixtures.

Operational

Load life — 10 percent maximum change in total resistance as a result of a 1000 hour test at rated power across entire element in still air at +70° C (1.5 hour "ON," 0.5 hour "OFF").

Rotational life — 10 percent maximum change in total resistance as a result of a 50,000 cycle life test without load.

Mechanical

Shafts — Diameter of shafts .125 inch (3,18 mm). Minimum length .312 inch (7,94 mm). Maximum length 2.500 inches (63,50 mm) with plain,

(Mechanical specifications continued on next page.)

NOT AVAILABLE FROM STOCK AT ELECTRONIC DISTRIBUTORS.

screwdriver slotted or flatted shaft endings. Preferred shaft lengths and endings are listed in the table below.

PREFERRED SHAFT LENGTHS

	Plain Round		Screwdriver Slotted					
Inches	.500	.625	.375	.438	.500	.625	.750	.875
mm	12,70	15,88	9,52	11,11	12,70	15,88	19,05	22,22

Other lengths available in 1/64 inch (0,40 mm) increments. All shaft lengths are measured from the mounting face of the resistor to the free end of the shaft.

Bushings — All bushings have a 32-NEF-2A thread and are .250 inch (6,35 mm) in diameter. Bushing lengths and types are shown in the table below.

Plain		Locking		Panel Watertight Plain		Panel Watertight Locking	
Inch	mm	Inch	mm	Inch	mm	Inch	mm
.250	6,35	.375	9,52	.250	6,35	.375	9,52
.375	9,52	.500	12,70	.375	9,52	.500	12,70
.500	12,70	.625	15,88	.500	12,70		

After lock nuts on locking bushing are tightened with a torque of 8 inch-pounds (9,22 kgf-cm) shafts will not turn with torques up to 20 inch-ounces (1,44 kgf-cm).

Hardware — Resistors are normally supplied with one mounting nut, M-4721, and one internal tooth lock washer, M-4748. Resistors with shaft lock bushings are supplied with one lock nut, M-4761, in addition to the above. Unless otherwise specified, all hardware shipped in bulk.

Mounting plate B-28868 and printed wiring board F-19942 can also be supplied (separately or mounted on unit) to adapt bushing type resistors for horizontal mounting on printed wiring boards. See DIMENSIONS.

Locating lugs — Four locating lug options can be provided so the resistor may be indexed with respect to the surface on which it is mounted. Unless otherwise specified, resistors are supplied in accordance with Option No. 2. See DIMENSIONS.

Turning torque — 0.5 to 3 inch-ounces (0,036 to 0,22 kgf-cm) at +25° C and 13 inch-ounces (0,94 kgf-cm) maximum at −55° C.

Stop torque — 4 inch-pounds (4,61 kgf-cm) minimum.

Rotation — Mechanical rotation is 295° ± 5°. Electrical rotation is 270° nominal.

Backlash — 3° maximum.

Construction — Materials are corrosion resistant and essentially non-magnetic; terminals are treated for easy soldering.

The resistor incorporates an internal "O" ring between the shaft and bushing. External surfaces are given special treatment so that the entire resistor is immersion sealed or "watertight."

A "panel watertight" bushing is available. This bushing is provided with an external "O" ring in addition to the internal "O" ring supplied as standard.

Immersion — No continuous stream of bubbles (4 or more) emanating from the resistor as a result of the immersion test (1 minute in water at +85° C).

Weight — The exact weight of individual resistors depends on the precise mechanical specifications involved. An approximate net weight of typical resistor including hardware normally specified would be 0.24 ounce (6,8 gms).

Marking — Allen-Bradley part number and nominal total resistance marked in two lines. Other marking possible, limited to maximum of 16 characters in each of two lines. A-B monogram plus "Type L" always included.

Environmental

Vibration — 2 percent maximum change in total resistance, 5 percent maximum change in resistance setting. (Tested per method 204, condition "C" of MIL-STD-202.)

Shock — 2 percent maximum change in total resistance. 5 percent maximum change in resistance setting. (Tested per method 213, condition "I" of MIL-STD-202.)

Moisture resistance — 10 percent maximum change in total resistance. (Method 106 of MIL-STD-202.)

Corrosion resistance — Materials show no corrosion after a 200 hour salt spray test. (Method 101 of MIL-STD-202.)

Effect of soldering — 2 percent maximum change in total resistance as a result of immersing the terminals in +350° C solder to within 0.125 inch (3,18 mm) of the resistor body for 5 seconds.

Temperature cycling — 3 percent maximum change in total resistance as a result of the temperature cycling test (five cycles −55° C to +150° C).

Low temperature operation — 2 percent maximum change in total resistance as a result of the low temperature operation test (−55° C for two hours without load and 45 minutes with rated load).

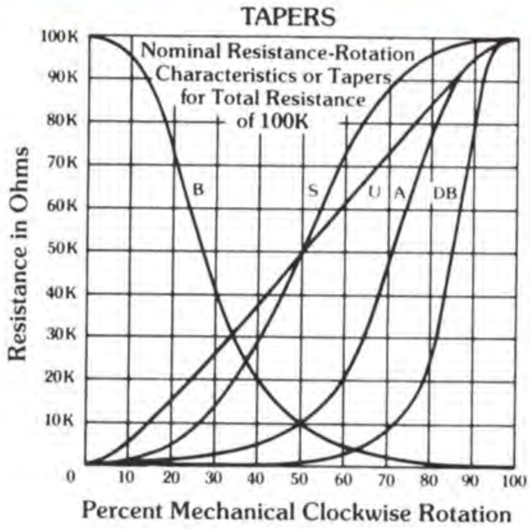
Low temperature storage — 2 percent maximum change in total resistance as a result of the storage test (24 hours at −63° C).

Temperature characteristics — Maximum percent temporary total resistance change from the +25° C value. See table below.

Nominal Resistance	Degrees Celsius — "U" Linear Taper							
	−55°	−25°	0°	25°	+55°	+85°	+120°	+150°
100 Ohms	+4.5	+2.5	+1.5	0	±1.0	±1.5	+3.5	+5.5
1,000 Ohms	+5.5	+3.0	+1.5	0	±1.0	±2.0	+4.5	+6.5
10,000 Ohms	+7.0	+3.5	+2.0	0	±1.0	±2.5	+5.5	+8.5
100,000 Ohms	+8.0	+4.0	+2.0	0	±1.5	±3.0	+6.0	+10.5
1 Megohm	+10.0	+5.0	+2.5	0	±1.5	±3.5	+7.5	+12.5

For "S", "A", "B" and "DB" tapers multiply percentage figures shown above by 1.25.

Taper data



TAPER	END RESISTANCE MINIMUM RESISTANCE BETWEEN TERMINALS 1 and 2	MINIMUM RESISTANCE BETWEEN TERMINALS 2 and 3
U & S	1	1
A	1	2
B	2	1
DB	3	2

1 "Less than .004% of total resistance," or "less than 15 ohms" whichever is greater.

2 "Less than 1% of total resistance," or "less than 15 ohms" whichever is greater.

3 Less than 15 ohms.

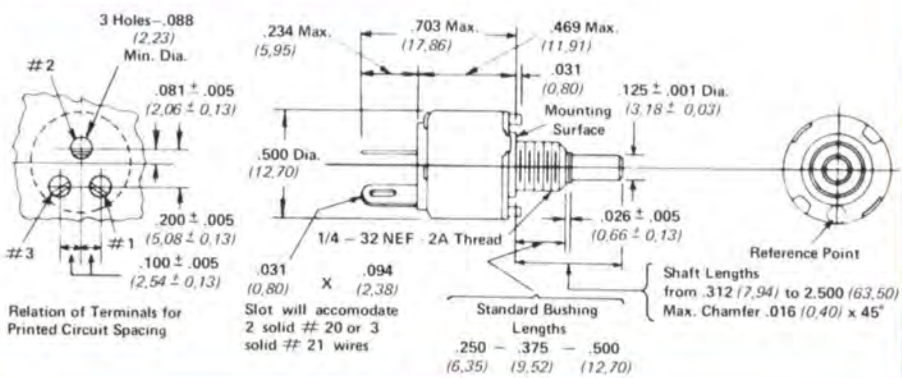
Ordering information

1. Type (LA, LB or LP).
2. Taper.
3. Total resistance.
4. Total resistance tolerance.
5. Bushing type.
6. Bushing length.
7. Shaft ending.
8. Shaft length.
9. Locating lug option.
10. Mounting hardware.
11. Your part number.
12. Marking required.
13. Remarks.

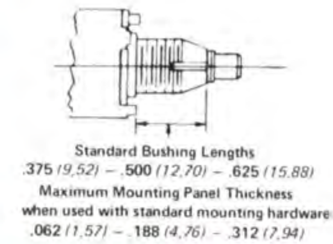
DIMENSIONS

Resistor with lug terminals

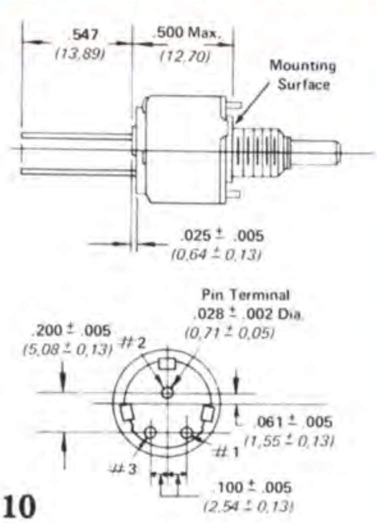
Plain Bushing



Locking Bushing

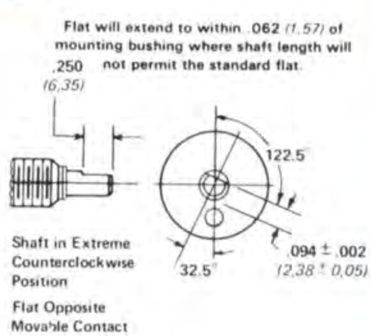


Resistor with pin terminals

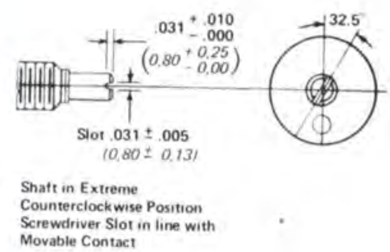


Shafts

Flatted



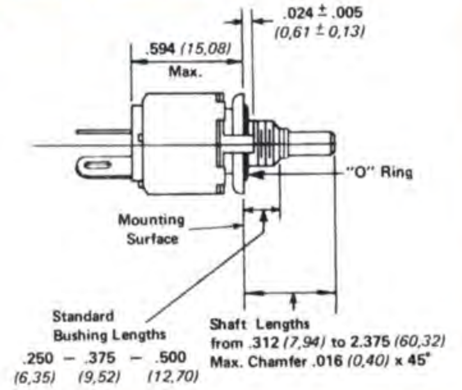
Screwdriver Slotted



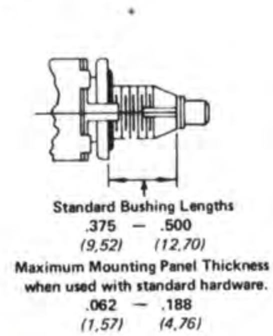
DIMENSIONS

Panel watertight bushing

Plain Bushing

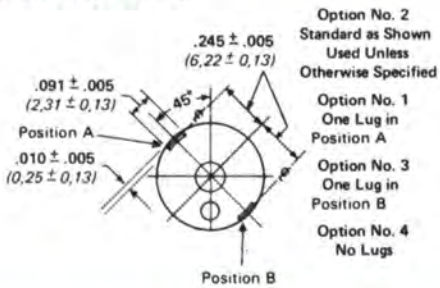


Locking Bushing

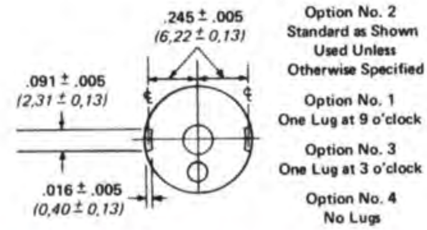


Lug options

Plain and Locking Bushing

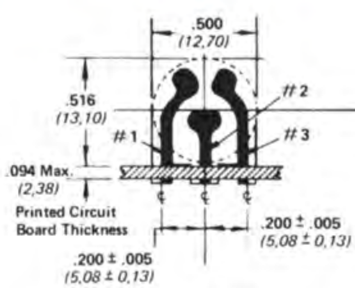


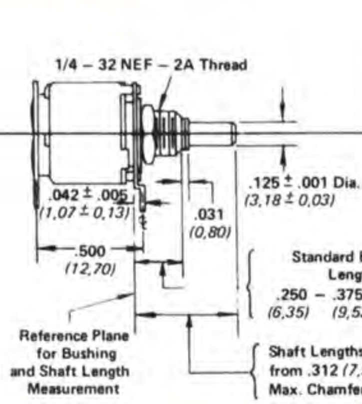
Panel Watertight Bushing

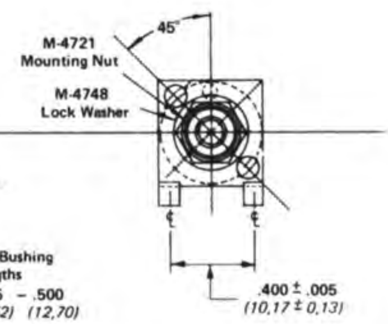


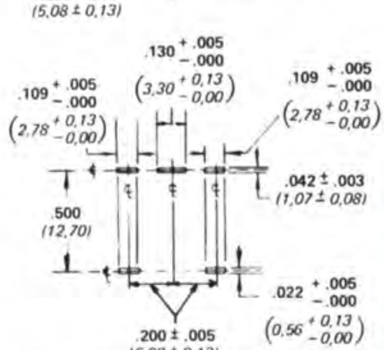
Resistor for printed circuit board mounting

Plain Bushing



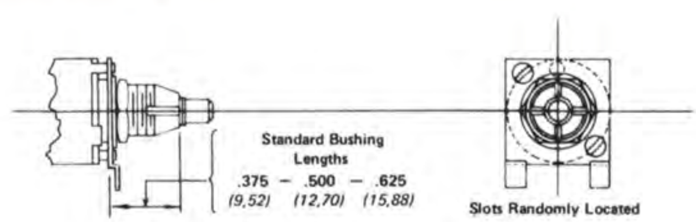






Relation of Terminals for Printed Circuit Spacing

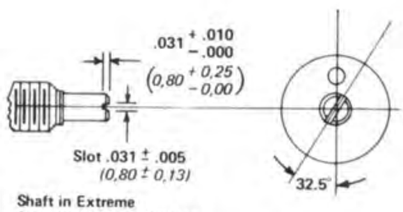
Locking Bushing



DIMENSIONS

Shafts for resistor for printed circuit board mounting

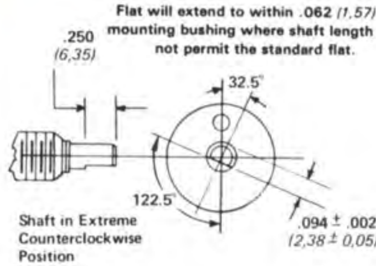
Screwdriver Slotted



Shaft in Extreme Counterclockwise Position Screwdriver Slot in line with Movable Contact

Flatted

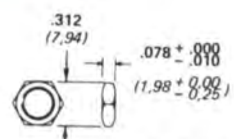
Flat will extend to within .062 *(1,57)* of mounting bushing where shaft length will not permit the standard flat.



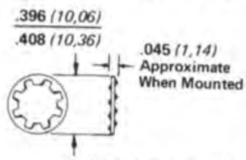
Shaft in Extreme Counterclockwise Position

Flat opposite Movable Contact

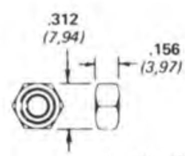
Hardware



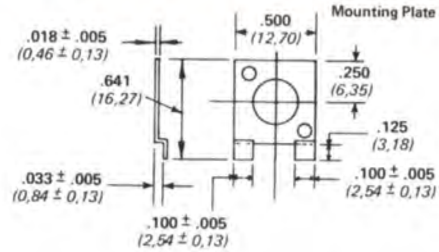
Mounting Nut M-4721



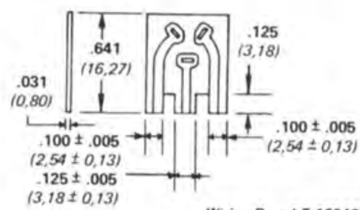
Lock Washer M-4748



Lock Nut M-4761



Mounting Plate B-28868



Wiring Board F-19942

Basic dimensions in inches.

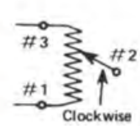
Dimensions shown in PARENTHESES are in millimeters.

TOLERANCES

Dimensional Tolerance ± .016 (0,40)
Angular Tolerance ± 5°
Except as specified.

NOT TO SCALE

Resistor Connections



EXPLANATION OF PART NUMBERS

NOTE: Part number format allows development of some part numbers which cannot be manufactured. (Example: LA2N400P101AA which has an invalid shaft length and invalid resistance value for an "A" taper.) Check parameter limits in preceding text, when developing a part number.

Combinations which are valid and do not fit into a part number, (Examples: Special tapers, special shafts, etc.) will be assigned a special part number by the factory. Refer to "Ordering Information", in the preceding text, for the required data for the assignment of a special part number by the factory.

LA2G056S501UA

Basic Type

LA — Basic Type L

LB — Type LA with mounting plate and printed wiring board mounted on resistor

LP — Basic Type LA with pin terminals

Locating Lug Option

1
2
3
4

Total Resistance Value

First two digits are significant figures and the third indicates the number of zeros following the first two digits —

Examples: 101 = 100 Ohms
501 = 500 Ohms
255 = 2.5 Megohms

Bushing Type and Length

G — Plain .250 inch (6,35 mm) long

N — Plain .375 inch (9,52 mm) long

H — Plain .500 inch (12,70 mm) long

M — Locking .375 inch (9,52 mm) long

L — Locking .500 inch (12,70 mm) long

S — Locking .625 inch (15,88 mm) long

T — Panel Watertight — Plain .250 inch (6,35 mm) long

P — Panel Watertight — Plain .375 inch (9,52 mm) long

E — Panel Watertight — Plain .500 inch (12,70 mm) long

Y — Panel Watertight — Locking .375 inch (9,52 mm) long

Z — Panel Watertight — Locking .500 inch (12,70 mm) long

Shaft Length

Measured from mounting surface in inches and sixty-fourths

Example:
032 = 32/64 or .500 inch (12,70 mm)
056 = 7/8 or .875 inch (22,22 mm)
200 = 2.000 inches (50,80 mm)

Shaft Ending

S — Standard Slot

P — Plain Round

F — Standard Flat

Hardware Combinations

	Mounting Nut	Lock-washer	Locknut
A —	(1)M-4721	(1)M-4748	——
E —	(2)M-4721	(1)M-4748	——
C —	(1)M-4721	(1)M-4748	(1)M-4761
L —	——	——	(1)M-4761
Z —	(no hardware)		

Taper Type and Total Resistance Tolerance

U — Linear (U), ± 10%

M — Linear (U), ± 20%

A — Clockwise Modified Logarithmic (A), ± 10%

R — Clockwise Modified Logarithmic (A), ± 20%

B — Counterclockwise Modified Logarithmic (B), ± 10%

T — Counterclockwise Modified Logarithmic (B), ± 20%

D — Clockwise Exact Logarithmic (DB), ± 10%

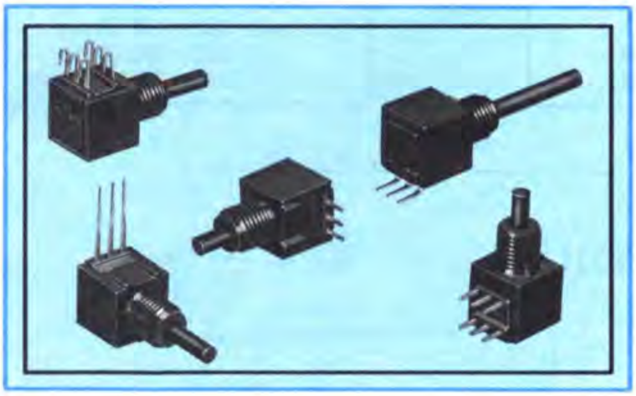
K — Clockwise Exact Logarithmic (DB), ± 20%

S — Modified Linear (S), ± 10%

Y — Modified Linear (S), ± 20%

Type M Conductive Plastic Panel Potentiometers

The MINI-METRIC®
0.1 Watt (40° C)
10,0 MM Cube
100 Ohms to 1.0 Megohm



FEATURES

- ±20% Tolerance
- Linear and Non-Linear Tapers
- Plastic Shaft, Bushing and Case
- Single (Type MA) and Dual (Type MD) Resistors
- Switches (Type MS)

SPECIFICATIONS

General

Temperature range — −25° C to +100° C.

Total resistance values — Preferred values.

OHMS				
100 220 470	1K 2.2K 4.7K	10K 22K 47K	100K 220K 470K	1.0 Meg.

Total resistance tolerances — ±20%.

Tapers — Tapers available in the following resistance ranges:

TAPER	TOTAL RESISTANCE RANGE
U	100 Ohms to 1.0 Megohms
A & B	470 Ohms to 470 Kilohms

See chart on page 115 for explanation of tapers.

Independent linearity — 5 percent (linear taper). 100 ohms through 100K.

End resistance — 3 ohms maximum.

Detent — Types "MA" and "MD" may be supplied with a detent at the clockwise or counterclockwise end of rotation. Detent travel is 33 degrees.

Rotary switch — Two switches are available, see page 115 for drawings and explanation.

Electrical

Power — 0.1 watt on the panel section; 0.05 watt on the rear section at +40° C, for "U" linear taper, provided voltage is not exceeded.

Power derating — Derate power linearly from +40° C to zero at +100° C. Derate power 50 percent for resistors with "A" and "B" tapers. For rheostat applications, derate power directly with shaft or actuator position.

Voltage — 90 volts maximum working voltage (RMS or DC), or as determined by $E_{max.} = \sqrt{PR}$, whichever is less (at sea level).

Dielectric withstanding voltage — Maximum continuous voltage 90 volts (RMS or DC) at sea level. Will withstand a one second test of 1000 volts (RMS) at sea level.

Insulation resistance — 1000 megohms minimum for clean and dry conditions at +25° C.

Operational

Contact resistance variation — Linear taper: less than 2 percent or 3 ohms, whichever is greater. 'A' or 'B' tapers: less than 4 percent or 6 ohms, whichever is greater. (Operational specifications continued on Page 115.)

NOT AVAILABLE FROM STOCK AT ELECTRONIC DISTRIBUTORS.

Operational

Load life – 10 percent maximum change in total resistance as a result of a 1000 hour test at rated power across entire element in still air at +40° C (1.5 hour "ON", 0.5 hour "OFF").

Rotational life – 10 percent maximum change in total resistance as a result of a 10,000 cycle life test.

Mechanical

Shafts – Diameter of shafts 3,0 mm plain shaft ending. Standard shaft lengths in mm (±0,51): 10,0, 12,5, 16,0, 20,0, 25,0. All shaft lengths are measured from the mounting face of the resistor to the free end of the shaft.

Bushings – 7 mm long, 7 mm diameter, plain bushing with M7 x 0,75 thread.

Turning torque – 1,7 to 21 mN-m (0.24 to 3.0 inch-ounces) at +25° C.

Mounting torque – Torque applied to mounting nuts should not exceed 900 mN-m (8 inch-pounds).

Stop torque – 225 mN-m (2 inch-pounds) minimum.

Rotation – Mechanical travel 300°, electrical travel 220°.

Terminals – As shown on Page 116. Mounting bracket 60136-035-01 may be used with terminal option C.

Construction – Materials are corrosion resistant and essentially non-magnetic; enclosure is dust and splash resistant. Shaft and bushing are plastic.

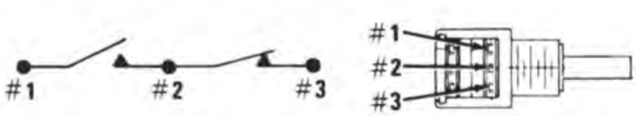
Marking – Allen-Bradley part number and nominal total resistance marked in two lines. Other marking possible; 8 characters in each of three lines. A-B monogram plus "Type M" always included.

Rotary switches

Type 1001 or 2001 as shown. Each switch consists of sliding contacts bearing on a metal plate or substrate to achieve the "ON" and "OFF" positions. Switch actuation travel is 33 degrees.

The switches will be electrically and mechanically operative after a 10,000 cycle life test; make and break 0.4 amps, 17 volts, DC at +25° C with resistive load.

Switch Number 1001 Shown in Detent at CCW End of Rotation. Available on Rear Section Only.



Switch Number 2001 Shown in Detent at CW End of Rotation. Available on Panel Section Only.

Environmental

Vibration – 2 percent maximum change in total resistance, 5 percent maximum change in resistance setting. (Tested per method 204, condition "C" of MIL-STD-202.)

Shock – 2 percent maximum change in total resistance. 5 percent maximum change in resistance setting. (Tested per method 213, condition "I" of MIL-STD-202.)

Humidity – 6.5 percent maximum change in total resistance. (Method 103B, condition "B" of MIL-STD-202.)

Corrosion resistance – Materials show no corrosion after the 96 hour test. (Method 101 of MIL-STD-202.)

Effect of soldering – 1 percent maximum change in total resistance. (Method 210A, condition "E" of MIL-STD-202). **Temperatures over 280° C may permanently damage the variable resistors.**

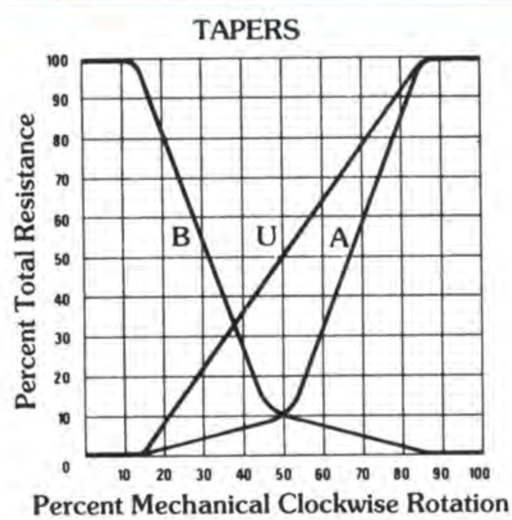
Temperature cycling – 3 percent maximum change in total resistance as a result of the temperature cycling test. (Five cycles at −25° C to +100° C.)

Low temperature operation – 3 percent maximum change in total resistance as a result of the low temperature operation test. (−25° C for two hours without load and 45 minutes with rated load.)

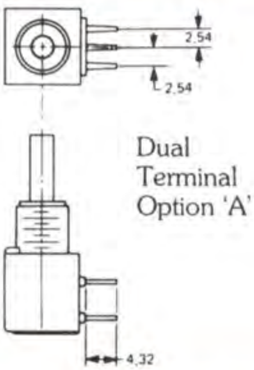
Ordering information

1. Taper (each section on dual controls).
2. Total resistance (each section on dual controls).
3. Total resistance tolerance (each section on dual controls).
4. Switch type.
5. Shaft length.
6. Detent (CW or CCW).
7. Your part number.
8. Marking required.

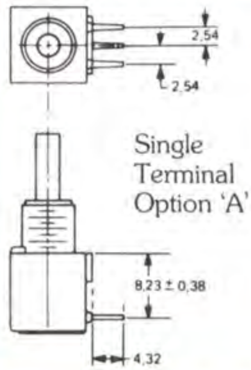
Taper data



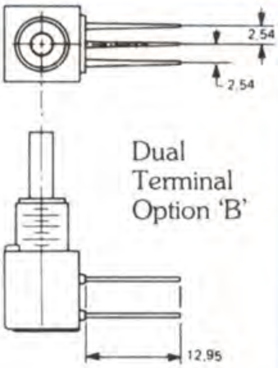
Terminal options



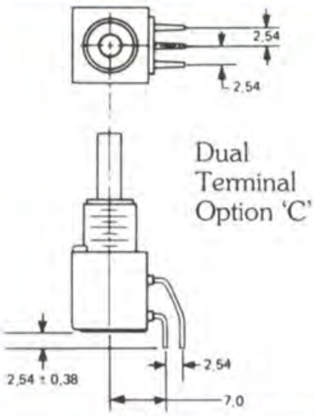
Dual Terminal Option 'A'



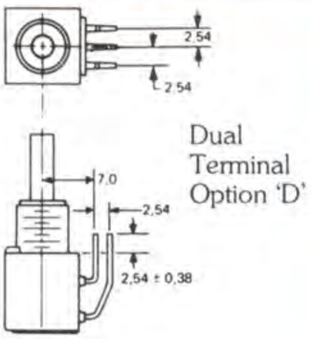
Single Terminal Option 'A'



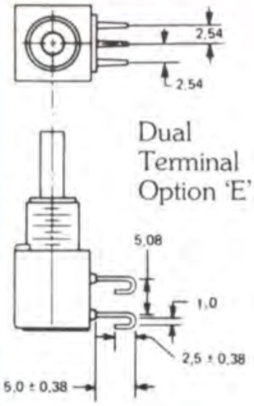
Dual Terminal Option 'B'



Dual Terminal Option 'C'

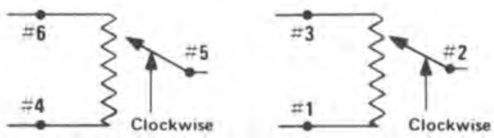


Dual Terminal Option 'D'



Dual Terminal Option 'E'

Resistor Connections



Rear Section Panel Section

DIMENSIONS

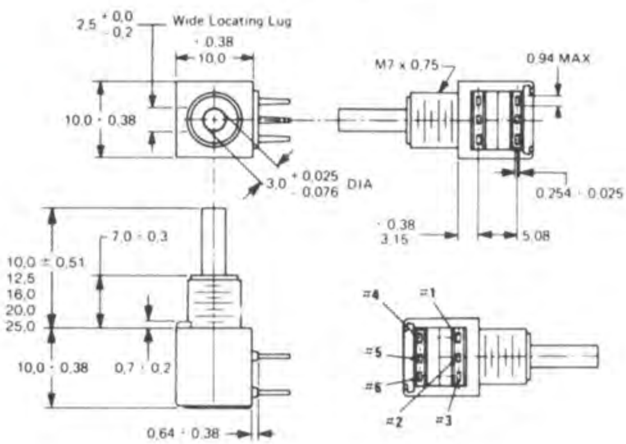
Dimensions apply to types MA, MD and MS except terminals 1, 2 and 3 are omitted from type MA.

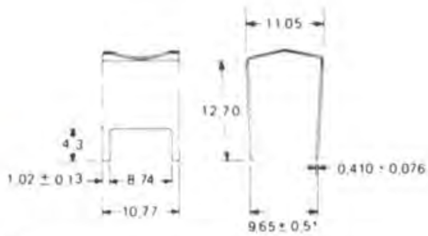
Basic dimensions in millimeters.

Terminal spacing determined at the mounting surface.

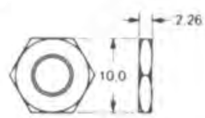
TOLERANCE
Dimensional tolerance ±0,25 Except as Specified.

NOT TO SCALE

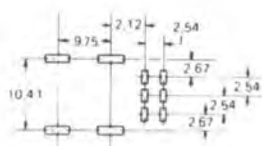




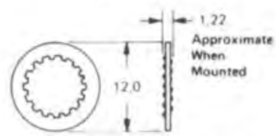
Mounting Bracket 60136-035-01 for Terminal Option C



Mounting Nut 29340-901-23



Layout Dimensions for Mounting Bracket



Lock Washer 29309-901-23

Conversion table

MM	INCH	MM	INCH	MM	INCH
0,025	.001	2,12	.084	9,75	.384
0,076	.003	2,50	.098	10,00	.394
0,13	.005	2,54	.100	10,41	.410
0,20	.008	2,67	.105	10,77	.424
0,25	.010	3,00	.118	11,05	.435
0,30	.012	3,15	.124	12,00	.472
0,38	.015	4,30	.169	12,50	.492
0,41	.016	4,32	.170	12,70	.500
0,64	.025	5,00	.197	12,95	.510
0,70	.028	5,08	.200	16,00	.630
0,94	.037	7,00	.276	20,00	.787
1,00	.039	8,23	.324	25,00	.984
1,02	.040	8,74	.344		
1,22	.048	9,65	.380		

Conductive Plastic Panel Potentiometers

EXPLANATION OF PART NUMBERS

MD2BA2E3A

Type

- **MA** – Single Variable Resistor
- **MD** – Dual Variable Resistor
- **MS** – Variable Resistor with a Switch

Bushing

- **2** – Plain 7 mm, M7 x 0.75

Shaft Length

- **A** – 10,0 mm
- **B** – 12,5 mm
- **C** – 16,0 mm
- **D** – 20,0 mm
- **E** – 25,0 mm

PANEL SECTION

REAR SECTION

Taper Type and Total Resistance Tolerance or Switch

- **2** – Linear (U) ±20%
- **3** – CW Modified Log (A) ±20%
- **4** – CCW Modified Log (B) ±20%
- **5** – Switch
- **6** – Type MA–Panel Section

PANEL SECTION

REAR SECTION

Total Resistance Value or Switch Type

- **A** – 100 Ohm
- **B** – 220 Ohm
- **C** – 470 Ohm
- **D** – 1K
- **E** – 2.2K
- **F** – 4.7K
- **G** – 10K
- **H** – 22K
- **J** – 47K
- **K** – 100K
- **L** – 220K
- **M** – 470K
- **N** – 1 Meg
- **1** – 1001 Switch (CCW detent) (Rear Section Only)
- **2** – 2001 Switch (CW detent) (Panel Section Only)
- **6** – Type MA–Panel Section

TERMINAL OPTION

Terminal Options
(as shown on Page 116)

- **A** – 4,32 mm P/C Pin
- **B** – 12,95 mm P/C Pin
- **C** – 2,54 mm Rear Form
- **D** – 2,54 mm Front Form
- **E** – 5,00 mm J Hook

Example: **MA2B66G2B**

Denotes: **MA** – Single Variable Resistor
2 – Plain 7 mm Bushing
B – Shaft Length Of 12,5 mm
6 – MA–Panel Section } No Element in
6 – MA–Panel Section } First Section
G – 10KΩ Resistance Value
2 – Linear Taper ±20%
B – 12,95 mm Long Straight Terminals

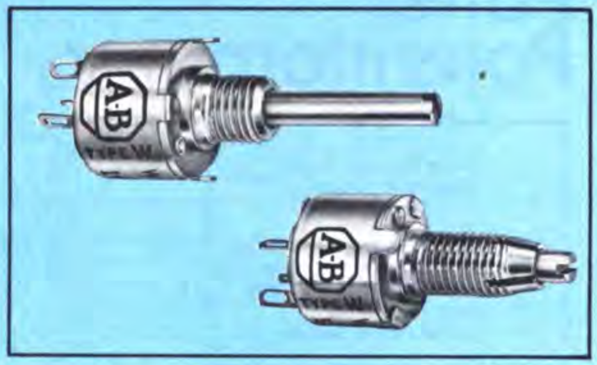
MS2E25K4D

Denotes: **MS** – Variable Resistor with a Switch
2 – Plain 7 mm Bushing
E – Shaft Length Of 25,0 mm
2 – 2001 Switch (CW Detent)
5 – Switch
K – 100KΩ Resistance Value
4 – CCW Modified Log (B) Taper ±20%
D – 2,54 mm Front Form Terminals

CAUTION: Part number format does not exclude invalid mechanical and/or electrical combinations. Check parameter limits in preceding text.

Type W

Hot-Molded Panel Potentiometers



1/2 (0.50) Inch (12,70 mm) Diameter
0.5 Watt (70°C)
100 Ohms to 5.0 Megohms

FEATURES

- Linear and Non-Linear Tapers
- Immersion Sealed
- Style RV6

SPECIFICATIONS

General

Temperature range — −55° C to +120° C.

Total resistance values — Preferred nominal values listed below. Other values available.

OHMS

100	1K	10K	100K	1.0 Meg.
200	2K	20K	200K	2.0 Meg.
220	2.2K	22K	220K	2.2 Meg.
250	2.5K	25K	250K	2.5 Meg.
470	4.7K	47K	470K	4.7 Meg.
500	5K	50K	500K	5.0 Meg.

Total resistance tolerances — ± 20% or ± 10%.

Tapers — Available in the following resistance ranges:

TAPER	TOTAL RESISTANCE RANGE
U	100 Ohms to 5.0 Megohms
A, B, S & DB	500 Ohms to 2.5 Megohms

See chart on following pages for explanation of tapers. Special tapers, where practical, can be supplied.

End resistance — See chart on following pages.

Applicable military specification — Many of the variable resistors may be ordered as Style RV6 of MIL-R-94.

Electrical

Power — 0.5 watt maximum at +70° C for "U" linear taper provided voltage rating is not exceeded.

Power derating — Derate power linearly from +70° C to zero at +120° C. Derate power 50 percent for non-metallic mounting and for resistors with "A", "B", "S", and "DB" tapers. For rheostat applications, derate power directly with shaft or actuator position.

Voltage — 350 volts maximum working voltage (RMS or DC), or as determined by $E_{max.} = \sqrt{PR}$, whichever is less (at sea level).

Dielectric withstanding voltage — Maximum continuous voltage 350 volts (RMS or DC) at sea level. Will withstand a one second test of 750 volts (RMS or DC) at sea level or 350 volts (RMS or DC) at 3.4 inches (86,36 mm) mercury.

Insulation resistance — 1000 megohms minimum for clean and dry conditions at +25° C.

Voltage characteristic — 0.005 percent per volt or 0.5 ohm, whichever is greater.

Capacitance — The capacitance between terminal #1 and #3 with terminal #2 "floating" is approximately 0.5 to 0.75 pF at 1 KHZ.

The capacitance between terminal #1 (grounded to bushing) and terminal #3 (shaft in extreme clockwise position) is approximately 3.0 to 3.7 pF at 1 KHz.

The capacitance between all terminals shorted together and the bushing is approximately 5.5 to 6.5 pF at 1 KHz.

In all cases capacitance indicated is for resistor only and does not include capacitance of measuring lead wires on test fixtures.

Operational

Load life — 10 percent maximum change in total resistance as a result of a 1000 hour test at rated power across entire element in still air at +70° C (1.5 hour "ON", 0.5 hour "OFF").

(Operational specifications continued on next page.)

Operational

Rotational life —10 percent maximum change in total resistance as a result of a 50,000 cycle life test without load.

Mechanical

Shafts —Diameter of shafts .125 inch (3,18 mm). Minimum length .125 inch (3,18 mm). Maximum length 2.500 inches (63,50 mm) with plain, screwdriver slotted or flatted shaft endings. Preferred shaft lengths and endings are listed in the tables below.

PREFERRED SHAFT LENGTHS

Plain Round

Inches	.500	.625
mm	12,70	15,88

Screwdriver Slotted

Inches	.375	.438	.500	.625	.750	.875
mm	9,52	11,11	12,70	15,88	19,05	22,22

Other lengths available in 1/64 inch (0,40 mm) increments. All shaft lengths are measured from the mounting face of the resistor to the free end of the shaft. The shaft can be flush with the bushing end or recessed on resistors with plain bushings.

Bushings —All bushings have a 32-NEF-2A thread and are .250 inch (6,35 mm) in diameter. Bushing lengths and types are shown in the table below.

Plain		Locking		Panel Watertight Plain		Panel Watertight Locking	
Inch	mm	Inch	mm	Inch	mm	Inch	mm
.250	6,35	.375	9,52	.250	6,35	.375	9,52
.375	9,52	.500	12,70	.375	9,52	.500	12,70
.500	12,70	.625	15,88	.500	12,70		

After lock nuts on locking bushing are tightened with a torque of 8 inch-pounds (9,22 kgf-cm) shafts will not turn with torques up to 20 inch-ounces (1,44 kgf-cm).

Hardware —Resistors are normally supplied with mounting nut, M-4721, and one internal tooth lock washer, M-4748. Resistors with shaft lock bushings are supplied with one lock nut, M-4761, in addition to the above. Unless otherwise specified, all hardware shipped in bulk.

Locating lugs —Four locating lug options can be provided so resistors may be indexed with respect to the surface on which they are mounted. Unless otherwise specified, resistors are supplied in accordance with Option No. 2. See DIMENSIONS.

Turning torque —0.5 to 3 inch-ounces (0,036 to 0,22 kgf-cm) at + 25° C and 13 inch-ounces (0,94 kgf-cm) maximum at − 55° C.

Stop torque —4 inch-pounds (4,61 kgf-cm) minimum.

Rotation —Mechanical rotation is 295° ± 5°. Electrical rotation is 270° nominal.

Backlash —3° maximum.

Construction —Materials are corrosion resistant and essentially non-magnetic; terminals are treated for easy soldering.

The resistor incorporates an internal "O" ring between the shaft and bushing. External surfaces are given special treatment so that the entire resistor is immersion sealed.

A panel "watertight" bushing is available. This bushing is provided with an external "O" ring in addition to the internal "O" ring supplied as standard.

Terminals —These resistors are supplied with solder lug terminals (Type WA) or printed circuit pin terminals (Type WP). Terminals are treated for easy soldering.

Immersion —No continuous stream of bubbles (4 or more) emanating from the resistor as a result of the immersion test (1 minute in water at + 85° C).

Weight —The exact weight of individual resistors depends on the precise mechanical specifications involved. An approximate net weight of a typical resistor including hardware normally specified would be 0.24 ounce (6,8 gms).

Marking —Allen-Bradley part number and nominal total resistance marked in two lines. Other marking possible, limited to maximum of 16 characters in each of two lines. A-B monogram plus "Type W" always included.

Environmental

Vibration —2 percent maximum change in total resistance, 5 percent maximum change in resistance setting. (Tested per method 204, condition "C" of MIL-STD-202.)

Shock —2 percent maximum change in total resistance, 5 percent maximum change in resistance setting. (Tested per method 213, condition "I" of MIL-STD-202.)

Moisture resistance —10 percent maximum change in total resistance. (Method 106 of MIL-STD-202.)

Corrosion resistance —Materials show no corrosion after a 200 hour salt spray test. (Method 101 of MIL-STD-202.)

Effect of soldering —2 percent maximum change in total resistance as a result of immersing the terminals in + 350° C solder to within .125 inch (3,18 mm) of the resistor body for 5 seconds.

Temperature cycling —3 percent maximum change in total resistance as a result of the temperature cycling test (five cycles − 55° C to + 120° C).

Low temperature operation —2 percent maximum change in total resistance as a result of the low temperature operation test (− 55° C for two hours without load and 45 minutes with rated load).

Low temperature storage —2 percent maximu[illegible] change in total resistance as a result of the sto[illegible] test (24 hours at − 63° C).

Environmental

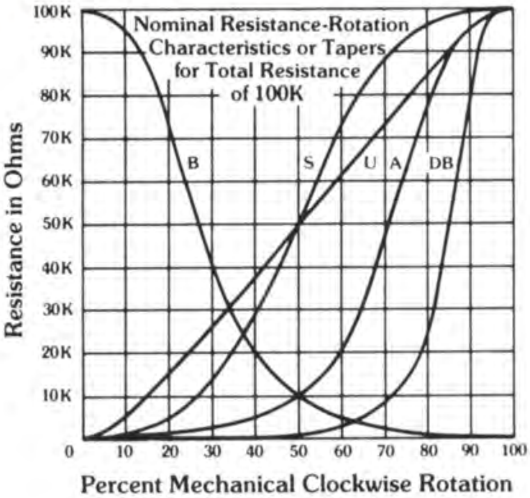
Temperature characteristics — Maximum percent temporary total resistance change from the + 25° C value. See table to right.

For "S", "A", "B" and "DB" tapers multiply percentage figures shown by 1.25.

Nominal Resistance	Degrees Celsius — "U" Linear Taper						
	−55°	−25°	0°	+25°	+55°	+85°	+120°
100 Ohms	+ 4.5	+ 2.5	+ 1.5	0	± 1.0	± 1.5	+ 3.5
1,000 Ohms	+ 5.5	+ 3.0	+ 1.5	0	± 1.0	± 2.0	+ 4.5
10,000 Ohms	+ 7.0	+ 3.5	+ 2.0	0	± 1.0	± 2.5	+ 5.5
100,000 Ohms	+ 8.0	+ 4.0	+ 2.0	0	± 1.5	± 3.0	+ 6.0
1 Megohm	+10.0	+ 5.0	+ 2.5	0	± 1.5	± 3.5	+ 7.5

Taper data

TAPERS



END RESISTANCE

TAPER	MINIMUM RESISTANCE BETWEEN TERMINALS 1 and 2	MINIMUM RESISTANCE BETWEEN TERMINALS 2 and 3
U & S	1	1
A	1	2
B	2	1
DB	3	2

1 "Less than .004% of total resistance," or "less than 15 ohms" whichever is greater.

2 "Less than 1% of total resistance," or "less than 15 ohms" whichever is greater.

3 Less than 15 ohms.

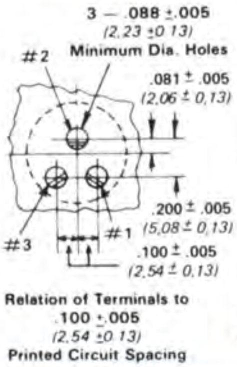
Ordering information

1. Type (WA or WP).
2. Taper.
3. Total resistance.
4. Total resistance tolerance.
5. Bushing type.
6. Bushing length.
7. Shaft ending.
8. Shaft length.
9. Locating lug option.
10. Mounting hardware.
11. Your part number.
12. Marking required.
13. Remarks.

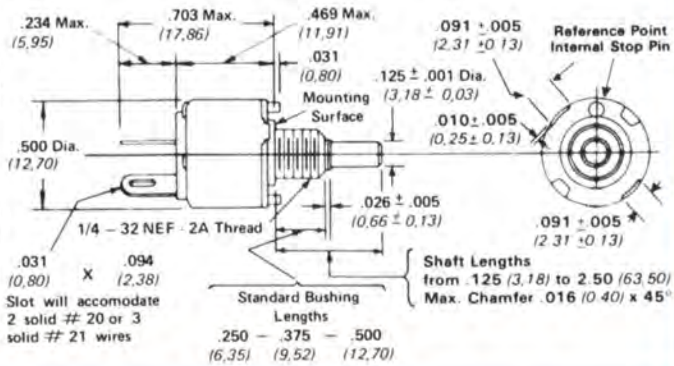
DIMENSIONS

Type WA

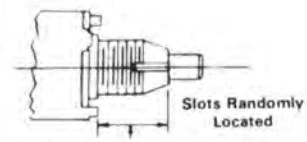
Location of Terminals



Plain Bushing



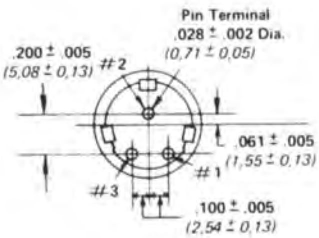
Shaft Locking Bushing



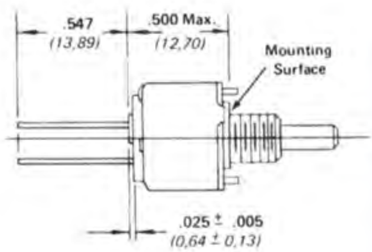
Standard Bushing Lengths
.375 *(9,52)* **— .500** *(12,70)* **— .625** *(15,88)*
Maximum Mounting Panel Thickness
.062 *(1,57)* **— .188** *(4,76)* **— .312** *(7,94)*
when used with one M-4748 Lock Washer and one M-4721 Mounting Nut. Shaft must extend .016 *(0,40)* **beyond bushing.**

Type WP

Location of Terminals



Plain Bushing



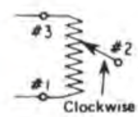
Basic dimensions in inches.

Dimensions shown in parentheses are in millimeters.

TOLERANCES
Dimensional tolerance ±.016 (0,40)
Angular tolerance ± 5°
Except as specified.

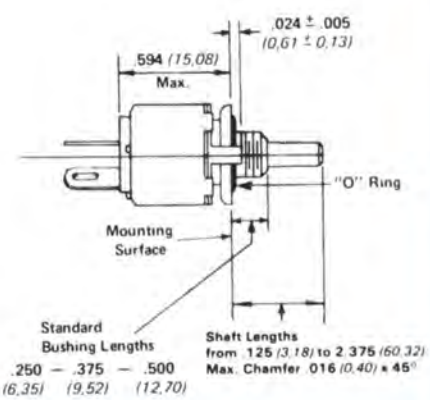
NOT TO SCALE

Resistor Connections

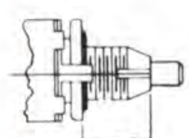


Panel watertight bushing

Plain



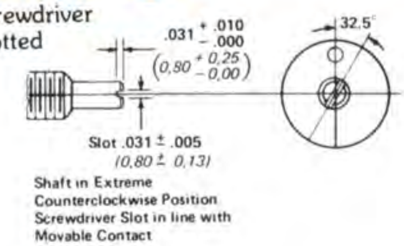
Locking



Standard Bushing Lengths
.375 — .500
(9,52) (12,70)
Maximum Mounting Panel Thickness when used with standard hardware.
.062 — .188
(1,57) (4,76)

Shaft endings

Screwdriver Slotted



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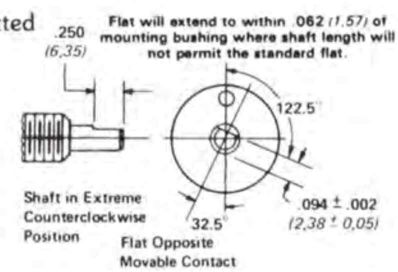
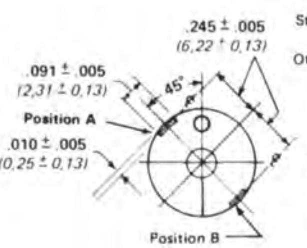


Lug options

Plain and Locking Bushing



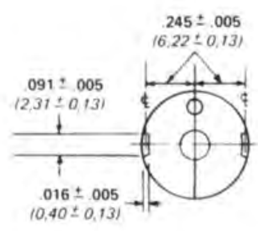
Option No. 2
Standard as Shown
Used Unless
Otherwise Specified

Option No. 1
One Lug in
Position A

Option No. 3
One Lug in
Position B

Option No. 4
No Lugs

Panel Watertight Bushing



Option No. 2
Standard as Shown
Used Unless
Otherwise Specified

Option No. 1
One Lug at 9 o'clock

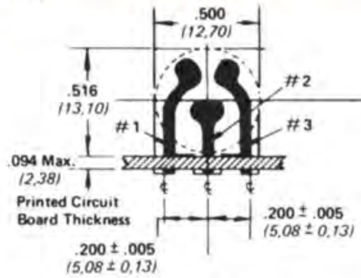
Option No. 3
One Lug at 3 o'clock

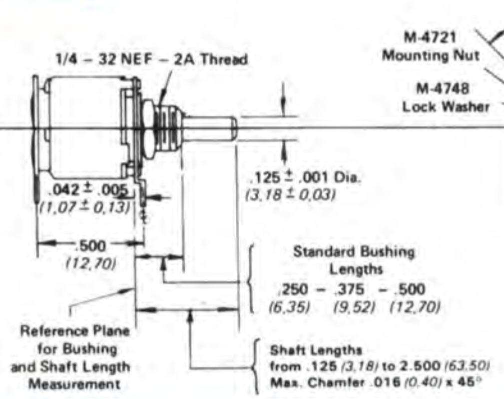
Option No. 4
No Lugs

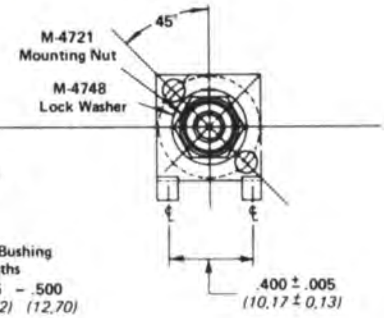
DIMENSIONS

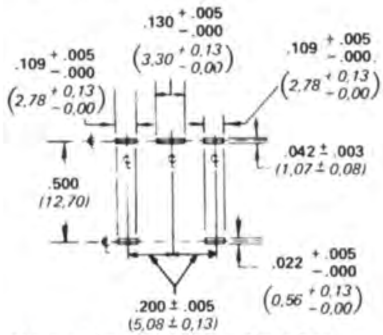
Resistor for printed circuit board mounting

Plain Bushing



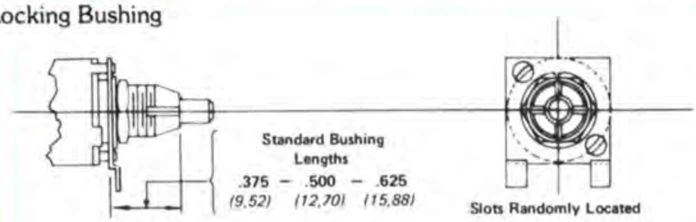






Relation of Terminals for Printed Circuit Spacing

Locking Bushing



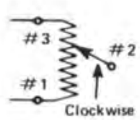
Basic dimensions in inches.

Dimensions shown in parentheses are in millimeters.

TOLERANCES
Dimensional tolerance ± .016 (0,40)
Angular tolerance ± 5°
Except as specified.

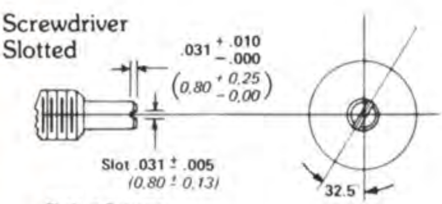
NOT TO SCALE

Resistor Connections



Shaft endings

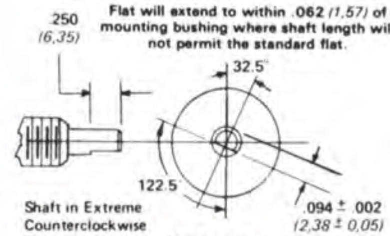
Screwdriver Slotted



Shaft in Extreme Counterclockwise Position Screwdriver Slot in line with Movable Contact

Flatted

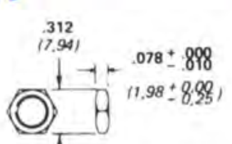
Flat will extend to within .062 (1,57) of mounting bushing where shaft length will not permit the standard flat.



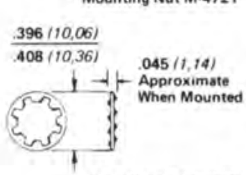
Shaft in Extreme Counterclockwise Position

Flat opposite Movable Contact

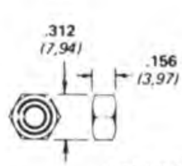
Hardware



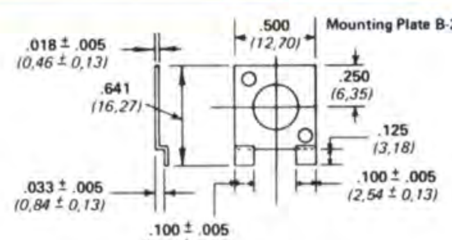
Mounting Nut M-4721



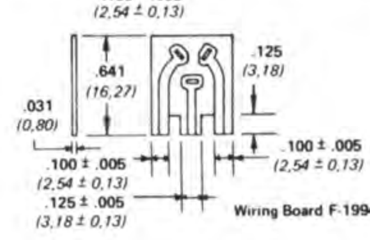
Lock Washer M-4748



Lock Nut M-4761



Mounting Plate B-28868



Wiring Board F-19942

EXPLANATION OF PART NUMBERS

NOTE: Part number format allows development of some part numbers which cannot be manufactured. (Example: WA2N400P101AA which has an invalid shaft length and invalid resistance value for an "A" taper.) Check parameter limits in preceding text, when developing a part number.

Combinations which are valid and do not fit into a part number, (Examples: Special tapers, special shafts, etc.) will be assigned a special part number by the factory. Refer to "Ordering Information" in preceding text, for the required data for the assignment of a special part number by the factory.

WA2G056S501UA

Basic Type

- **WA** — Basic Type W
- **WP** — Type W with Pin Terminals
- **WB** — Type W for PC Board Mtg.

Locating Lug Option

1
2
3
4

Total Resistance Value

First two digits are significant figures and the third indicates the number of zeros following the first two digits —

Examples: 101 = 100 Ohms
501 = 500 Ohms
255 = 2.5 Megohms

Hardware Combinations

	Mounting Nut	Lock-washer	Locknut
A —	(1)M-4721	(1)M-4748	——
E —	(2)M-4721	(1)M-4748	——
C —	(1)M-4721	(1)M-4748	(1)M-4761
L —	——	——	(1)M-4761
Z —	(No hardware)		

Bushing Type and Length

- **G** — Plain .250 inch (6,35 mm) long
- **N** — Plain .375 inch (9,52 mm) long
- **H** — Plain .500 inch (12,70 mm) long
- **M** — Locking .375 inch (9,52 mm) long
- **L** — Locking .500 inch (12,70 mm) long
- **S** — Locking .625 inch (15,88 mm) long
- **T** — Panel Watertight — Plain, .250 inch (6,35 mm) long
- **P** — Panel Watertight — Plain, .375 inch (9,52 mm) long
- **E** — Panel Watertight — Plain, .500 inch (12,70 mm) long
- **Y** — Panel Watertight — Locking, .375 inch (9,52 mm) long
- **Z** — Panel Watertight — Locking, .500 inch (12,70 mm) long

Shaft Length

Measured from mounting surface in inches and sixty-fourths

Example:
032 = 32/64 or .500 inch (12,70 mm)
056 = 7/8 or .875 inch (22,22 mm)
200 = 2.000 inches (50,80 mm)

Shaft Ending

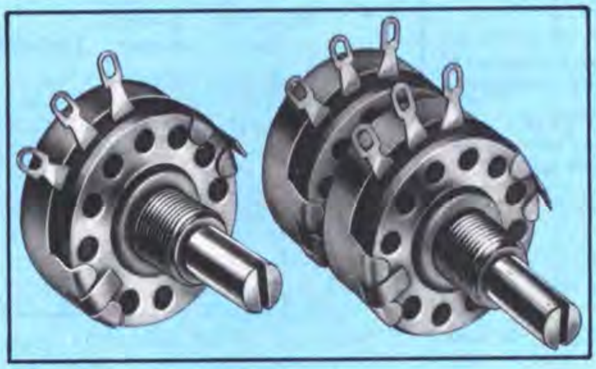
- **S** — Standard Slot
- **P** — Plain Round
- **F** — Standard Flat

Taper Type and Total Resistance Tolerance

- **U** — Linear (U), ± 10%
- **M** — Linear (U), ± 20%
- **A** — Clockwise Modified Logarithmic (A), ± 10%
- **R** — Clockwise Modified Logarithmic (A), ± 20%
- **B** — Counterclockwise Modified Logarithmic (B), ± 10%
- **T** — Counterclockwise Modified Logarithmic (B), ± 20%
- **D** — Clockwise Exact Logarithmic (DB), ± 10%
- **K** — Clockwise Exact Logarithmic (DB), ± 20%
- **S** — Modified Linear (S), ± 10%
- **Y** — Modified Linear (S), ± 20%

Type **EJ**

Hot-Molded Panel Potentiometers



1 MILLION ROTATIONS

1-5/32 (1.156) Inch (29,36 mm) Diameter

2.25 Watts (70° C)

50 Ohms to 5.0 Megohms

FEATURES

- Linear and Non-Linear Tapers
- Single and Dual Sections
- Slip Clutch Available

SPECIFICATIONS

General

Temperature range — − 55° C to + 120° C.

Total resistance values — Preferred nominal values listed below. Other values available.

OHMS

50	1K	10K	100K	1.0 Meg.
100	2.5K	25K	250K	2.0 Meg.
250	5K	50K	500K	2.5 Meg.
500				5.0 Meg.

Total resistance tolerances — ± 20% or ± 10%.

Tapers — Available in the following resistance ranges:

TAPER	TOTAL RESISTANCE RANGE
U	50 Ohms to 5.0 Megohms
A, B, S, & DB	250 Ohms to 5.0 Megohms

See chart on following pages for explanation of tapers. Special tapers, where practical, can be supplied.

End resistance — See chart on following pages.

Electrical

Power — 2.25 watt maximum at + 70° C (single resistors only) provided voltage rating is not exceeded.

Power derating — Derate power linearly from + 70° C to zero at + 120° C. Derate power 50 percent for non-metallic mounting and for resistors with "A", "B", "S", and "DB" tapers. See following pages for additional power derating information.

Voltage — 500 volts maximum working voltage (RMS or DC), or as determined by Emax $= \sqrt{PR}$, whichever is less (at sea level).

Dielectric withstanding voltage — Maximum continuous voltage 500 volts (RMS or DC) at sea level. Will withstand a one second test of 1000 volts (RMS or DC) at sea level or 500 volts (RMS or DC) at 3.4 inches (86,36 mm) mercury.

Voltage characteristic — 0.005 percent per volt or 0.5 ohm, whichever is greater.

Capacitance — The capacitance between terminal #1 and #3 with terminal #2 "floating" is approximately 2 to 3 pF at 1 KHz.

The capacitance between terminal #1 (grounded to bushing) and terminal #3 (shaft in extreme clockwise position) is approximately 10 to 12 pF at 1 KHz.

The capacitance between all terminals shorted together and the bushing is approximately 15 to 20 pF at 1 KHz.

In all cases capacitance indicated is for resistor only and does not include capacitance of measuring lead wires on test fixtures.

Operational

Load life — 10 percent maximum change in total resistance as a result of a 1000 hour test at rated power across entire element in still air at + 70° C (1.5 hour "ON", 0.5 hour "OFF").

Rotational life — 10 percent maximum change in total resistance as a result of a 1,000,000 cycle life test without load.

NOT AVAILABLE FROM STOCK AT ELECTRONIC DISTRIBUTORS.

Mechanical

Slip clutch — The single section Type EJ is available with a slip clutch as Type EJC that prevents damage to the variable resistor when the shaft is rotated past the end stops. Slip torque is 2±1 inch-pounds (2,31±1,15 kgf-cm).

Shafts — Diameter of shafts .250 inch (6,35 mm). Minimum length .375 inch (9,52 mm). Maximum length 6.000 inches (152,40 mm). Preferred shaft lengths and endings are shown in the table below.

PREFERRED SHAFT LENGTHS
For Types EJ, EJD and EJC

Plain Round —

Inches	.500	.625	.750	.875 ■	2.000 ■
mm	12,70	15,88	19,05	22,23	50,80

Screwdriver Slotted —

Inches	.500	.625	.750	.875 ■
mm	12,70	15,88	19,05	22,23

■ **Only** these lengths and endings are available for Type EJC.

Other lengths available in 1/64 inch (0,40 mm) increments. All shaft lengths are measured from the mounting face of the resistor to the free end of the shaft.

Bushings — Plain bushings only. All bushings have a 32-NEF-2A thread and are .375 inch (9,52 mm) in diameter. Length .250 inch (6,35 mm), .375 inch (9,52 mm) or .500 inch (12,70 mm), measured from the mounting surface of the bushing.

Hardware — Resistors are normally supplied with one mounting nut M-2786 and one internal tooth lock washer M-2898. Unless otherwise specified, all hardware shipped in bulk.

Locating lugs — Two locating lugs are provided so resistors may be indexed with respect to the surface on which they are mounted. Four lug options available. Lug option 1 standard. See dimensions on following pages.

Turning torque — At + 25° C minimum torque 1 inch-ounce (0,07 kgf-cm). Maximum torque as follows:

Single — 6 inch-ounces (0,43 kgf-cm)
Dual — 9 inch-ounces (0,65 kgf-cm)

Stop torque — 12 inch-pounds (13,82 kgf-cm) minimum.

Rotation — Mechanical 312° ±3°. Electrical 292° nominal.

Backlash — Maximum backlash: single resistors ± 1-1/2°, dual resistors ± 3°.

Construction — Materials are corrosion resistant and essentially non-magnetic; enclosure is dust and splash resistant; terminals are treated for easy soldering.

Marking — Allen-Bradley part number and nominal total resistance are marked in two lines. Other marking possible, limited to maximum of 13 characters in each of two lines. A-B monogram plus "Type EJ" always included.

Environmental

Vibration — 2 percent maximum change in total resistance, 5 percent maximum change in resistance setting. (Tested per method 204, condition "C" of MIL-STD-202.)

Shock — 2 percent maximum change in total resistance. 5 percent maximum change in resistance setting. (Tested per method 213, condition "I" of MIL-STD-202.)

Moisture resistance — 10 percent maximum change in total resistance. (Method 106 of MIL-STD-202.)

Corrosion resistance — Materials show no corrosion after a 200 hour salt spray test. (Method 101 of MIL-STD-202.)

Effect of soldering — 2 percent maximum change in total resistance as a result of immersing the terminals in + 350° C solder to within 0.125 inch (3,18 mm) of the resistor body for 5 seconds.

Temperature cycling — 3 percent maximum change in total resistance as a result of the temperature cycling test (five cycles − 55° C to + 120° C).

Low temperature operation — 3 percent maximum change in total resistance as a result of the low temperature operation test (− 55° C for two hours without load and 45 minutes with rated load).

Low temperature storage — 2 percent maximum change in total resistance as a result of the storage test (24 hours at − 55° C).

Temperature characteristics — Maximum percent temporary total resistance change from the + 25° C value. See table below.

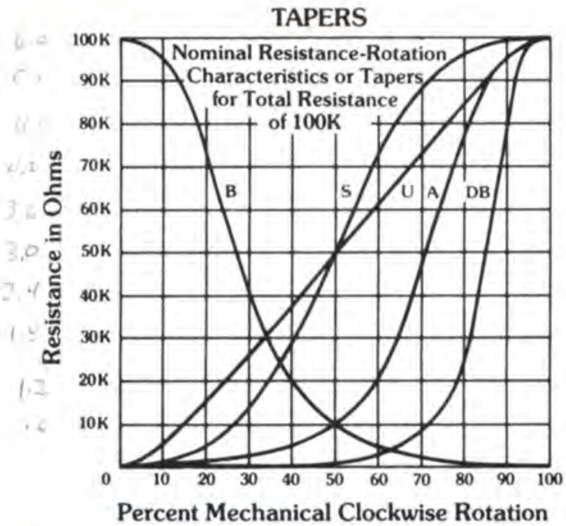
Nominal Resistance	Degrees Celsius — "U" Linear Taper						
	−55°	−25°	0°	+25°	+55°	+85°	+120°
100 Ohms	+ 4.5	+ 2.5	+ 1.5	0	± 1.0	± 1.5	+ 3.5
1,000 Ohms	+ 5.5	+ 3.0	+ 1.5	0	± 1.0	± 2.0	+ 4.5
10,000 Ohms	+ 7.0	+ 3.5	+ 2.0	0	± 1.0	± 2.5	+ 5.5
100,000 Ohms	+ 8.0	+ 4.0	+ 2.0	0	± 1.5	± 3.0	+ 6.0
1 Megohm	+10.0	+ 5.0	+ 2.5	0	± 1.5	± 3.5	+ 7.5

For "S", "A", "B" and "DB" tapers multiply percentage figures shown above by 1.25.

Ordering information

1. Type (EJA, EJD or EJC).
2. Taper (each section).
3. Total resistance (each section).
4. Total resistance tolerance (each section).
5. Bushing length.
6. Shaft ending.
7. Shaft length.
8. Locating lug option.
9. Mounting hardware.
10. Your part number.
11. Marking required.
12. Remarks.

Taper data



END RESISTANCE

TAPER	MINIMUM RESISTANCE BETWEEN TERMINALS 1 and 2	MINIMUM RESISTANCE BETWEEN TERMINALS 2 and 3
U & S	1	1
A	1	2
B	2	1
DB	3	2

1 "Less than .004% of total resistance," or "less than 4 ohms" whichever is greater.

2 "Less than 1% of total resistance," or "less than 4 ohms" whichever is greater.

3 Less than 4 ohms.

Additional ratings

Multiple resistor power derating — The permissible power dissipation in one resistor element is a function of the power dissipation in the other resistor element. Maximum continuous power rating in watts with entire resistor element in the circuit are as follows:

$$\left(\frac{W_1}{2.25}\right)^2 + \left(\frac{W_2}{1.8}\right)^2 = 1 \text{ (Maximum)}$$

Where W_1 = Watts in entire first or panel resistor element.
W_2 = Watts in entire second or rear resistor element.

WATTS

W_1	2.25	2.00	1.75	1.50	1.25	1.00	0.75	0.50	0.25	0
W_2	0	0.83	1.13	1.34	1.49	1.61	1.70	1.76	1.79	1.80

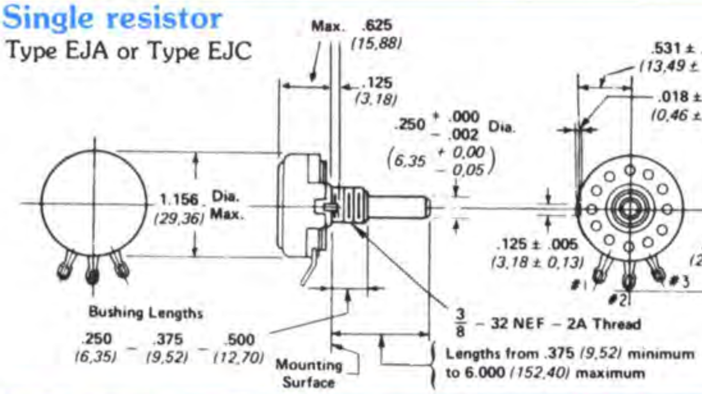
Derating with respect to rotation — rheostat application

Percent Rotation	Multiply Wattage Rating By	Percent Rotation	Multiply Wattage Rating By
100	1.00	40	0.81
90	0.99	30	0.68
80	0.98	20	0.49
70	0.96	10	0.23
60	0.93	0	0.11
50	0.89		

DIMENSIONS

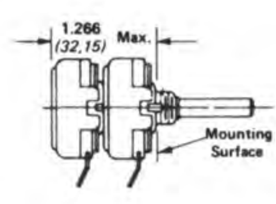
Single resistor

Type EJA or Type EJC



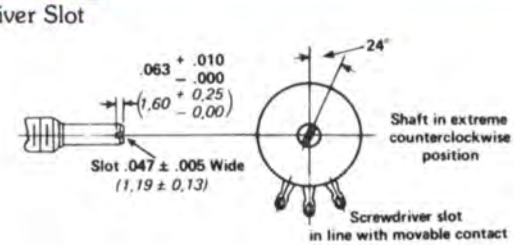
Dual resistor

Type EJD



Shaft endings

Screwdriver Slot



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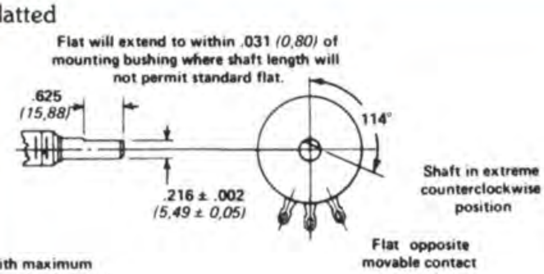
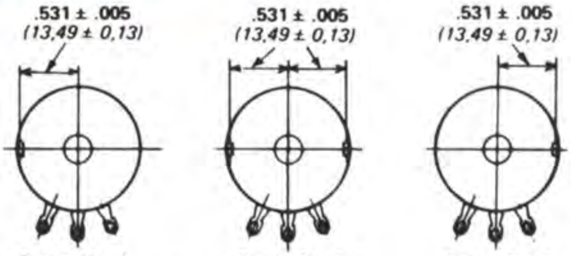


All shafts supplied with maximum chamfer .031 (0,80) x 45° at the shaft end

DIMENSIONS

Locating lug options



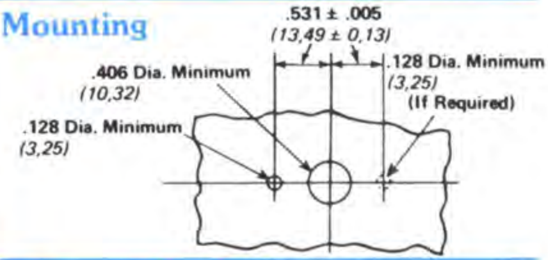
Option No. 1
Standard Locating Lug
(Used Unless Otherwise Specified)

Option No. 2

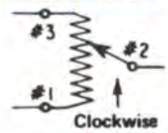
Option No. 3

Option No. 4 — No Locating Lugs

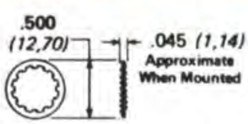
Mounting



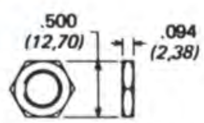
Resistor connections



Mounting hardware



Lock Washer M-2898



Mounting Nut M-2786

Basic dimensions in inches.

Dimensions shown in PARENTHESES are in millimeters.

TOLERANCES
Dimensional Tolerance ±.016 (0,40)
Angular Tolerance ± 5°
Except as specified.

NOT TO SCALE

EXPLANATION OF PART NUMBERS

EJA2N056S501U

Basic Type

EJA — Single EJ

EJD — Dual EJ*

EJC — Single EJ with Slip Clutch

* If the electrical specifications are not identical for each section, a special part number will be required.

Locating Lug Option

1
2
3
4

Total Resistance Value

First two digits are significant figures and the third indicates the number of zeros following the first two digits —

Examples: 101 = 100 Ohms
501 = 500 Ohms
255 = 2.5 Megohms

Bushing Type and Length

G — Plain .250 inch (6,35 mm) long
N — Plain .375 inch (9,52 mm) long
H — Plain .500 inch (12,70 mm) long

Shaft Length

Measured from mounting surface in inches and sixty-fourths

Example:
032 = 32/64 or .500 inch (12,70 mm)
056 = 7/8 or .875 inch (22,22 mm)
200 = 2.000 inches (50,80 mm)

Preferred Shaft Length and Endings

Type EJ and Type EJD	
Plain Round	**Screwdriver Slotted**
.500 (12,70 mm) .625 (15,88 mm) .750 (19,05 mm) .875 (22,22 mm) 2.000 (50,80 mm)	.500 (12,70 mm) .625 (15,88 mm) .750 (19,05 mm) .875 (22,22 mm) —
Type EJC	
.875 (22,22 mm) 2.000 (50,80 mm)	.875 (22,22 mm)

Shaft Ending

S — Screwdriver Slotted
P — Plain Round
F — Standard Flat

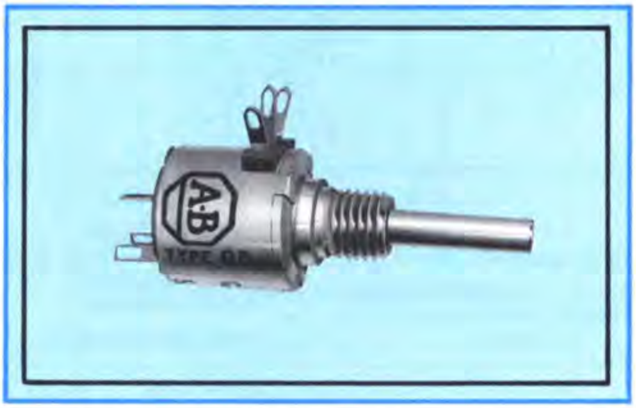
Taper Type and Total Resistance Tolerance

U — Linear (U), ± 10%
M — Linear (U), ± 20%
A — Clockwise Modified Logarithmic (A), ± 10%
R — Clockwise Modified Logarithmic (A), ± 20%
B — Counterclockwise Modified Logarithmic (B), ± 10%
T — Counterclockwise Modified Logarithmic (B), ± 20%
D — Clockwise Exact Logarithmic (DB), ± 10%
K — Clockwise Exact Logarithmic (DB), ± 20%
S — Modified Linear (S), ± 10%
Y — Modified Linear (S), ± 20%

CAUTION: Part number format does not allow for exclusion of invalid mechanical and/or electrical combinations. Check parameter limits in preceding text.

Type GD
Hot-Molded Panel Potentiometers

1/2 (0.50) Inch (12,70 mm) Diameter
0.5 Watt (70° C)
100 Ohms to 5.0 Megohms



FEATURES

- Linear and Non-Linear Tapers
- Attenuators
- Immersion Sealed
- Dual Section

SPECIFICATIONS

General

Temperature range — −55° C to +120° C.

Total resistance values — Preferred nominal values listed below. Other values available.

OHMS

100	1K	10K	100K	1 Meg.
200	2K	20K	200K	2 Meg.
250	2.5K	25K	250K	2.5 Meg.
500	5K	50K	500K	5 Meg.

Total resistance tolerances — ± 20% or ± 10%.

Tapers — Available in following resistance ranges:

TAPER	TOTAL RESISTANCE RANGE
U	100 Ohms to 5.0 Megohms
A, B, S, & DB	500 Ohms to 2.5 Megohms

See chart on following pages for explanation of tapers. Special tapers, where practical, can be supplied.

End resistance — See chart on following pages.

Attenuators — See Allen-Bradley Publication EC5930-2.1

Electrical

Power — Maximum power rating for "U" linear tapers at + 70° C with both elements in the circuit are as follows:

	WATTS						
Front Resistor	0.5	0.46	0.4	0.35	0.3	0.2	0
Rear Resistor	0	0.2	0.3	0.35	0.4	0.46	0.5

Front resistor is adjacent to the actuator. Voltage rating must not be exceeded.

Power derating — Derate power linearly from +70° C to zero at +120° C. Derate power 50 percent for non-metallic mounting and for resistors with "A", "B", "S", and "DB" tapers. For rheostat applications, derate power directly with shaft or actuator position.

Voltage — 350 volts maximum working voltage (RMS or DC), or as determined by $E_{max.} = \sqrt{PR}$, whichever is less (at sea level).

Dielectric withstanding voltage — Will withstand a one second test of 750 volts (RMS or DC) at sea level or 350 volts (RMS or DC) at 3.4 inches (86,36 mm) mercury.

Insulation resistance — 1000 megohms minimum for clean and dry conditions at + 25° C.

Voltage characteristic — 0.005 percent per volt or 0.5 ohm, whichever is greater.

Operational

Load life — 10 percent maximum change in total resistance as a result of a 1000 hour test at rated power across entire element in still air at +70° C (1.5 hour "ON," 0.5 hour "OFF").

Rotational life — 10 percent maximum change in total resistance as a result of a 50,000 cycle life test without load.

Mechanical

Shafts — Diameter of shafts .125 inch (3,18 mm). Minimum length .125 inch (3,18 mm). Maximum length 2.500 inches (63,50 mm) with plain,

(Mechanical specifications continued on next page.)

screwdriver slotted or flatted shaft endings. Preferred shaft lengths and endings are listed in the table below.

PREFERRED SHAFT LENGTHS

	Plain Round		Screwdriver Slotted					
Inches	.500	.625	.375	.438	.500	.625	.750	.875
mm	12,70	15,88	9,52	11,11	12,70	15,88	19,05	22,22

Other lengths available in 1/64 inch (0,40 mm) increments. All shaft lengths are measured from the mounting face of the resistor to the free end of the shaft. The shaft can be flush with the bushing end or recessed on resistors with plain bushings.

Bushings — All bushings have a 32-NEF-2A thread and are .250 inch (6,35 mm) in diameter. Bushing lengths and types are shown in the table below.

Plain		Locking		Panel Watertight Plain		Panel Watertight Locking	
Inch	mm	Inch	mm	Inch	mm	Inch	mm
.250	6,35	.375	9,52	.250	6,35	.375	9,52
.375	9,52	.500	12,70	.375	9,52	.500	12,70
.500	12,70	.625	15,88	.500	12,70		

After lock nuts on locking bushing are tightened with a torque of 8 inch-pounds (9,22 kgf-cm) shafts will not turn with torques up to 20 inch-ounces (1,44 kgf-cm).

Hardware — Resistors are normally supplied with one mounting nut, M-4721, and one internal tooth lock washer, M-4748. Resistors with shaft lock bushings are supplied with one lock nut, M-4761, in addition to the above. Unless otherwise specified, all hardware shipped in bulk.

Locating lugs — Locating lug options can be provided so resistors may be indexed with respect to the surface on which they are mounted. See dimensions.

Turning torque — 0.5 to 4.5 inch-ounces (0,036 to 0,32 kgf-cm) at + 25° C and 13 inch-ounces (0,94 kgf-cm) maximum at − 55° C.

Stop torque — 2 inch-pounds (2,31 kgf-cm) minimum.

Rotation — Mechanical rotation is 295° ± 5°. Electrical rotation is 270° nominal.

Backlash — 3° maximum.

Construction — Materials are corrosion resistant and essentially non-magnetic; terminals are treated for easy soldering.

The resistor incorporates an internal "O" ring between the shaft and bushing. External surfaces are given special treatment so that the entire resistor is immersion sealed or "watertight."

A "panel watertight" bushing is available. This bushing is provided with an external "O" ring in addition to the internal "O" ring supplied as standard.

Immersion — No continuous stream of bubbles (4 or more) emanating from the resistor as a result of the immersion test (1 minute in water at + 85° C).

Weight — The exact weight of individual resistors depends on the precise mechanical specifications involved. An approximate net weight of typical resistor including hardware normally specified would be 0.24 ounce (6,8 gms).

Marking — Allen-Bradley part number and nominal total resistance marked in two lines. Other marking possible, limited to maximum of 13 characters in each of two lines. A-B monogram plus "Type GD" always included.

Environmental

Vibration — 2 percent maximum change in total resistance, 5 percent maximum change in resistance setting. (Tested per method 204, condition "C" of MIL-STD-202.)

Shock — 2 percent maximum change in total resistance. 5 percent maximum change in resistance setting. (Tested per method 213, condition "I" of MIL-STD-202.)

Moisture resistance — 10 percent maximum change in total resistance. (Method 106 of MIL-STD-202.)

Corrosion resistance — Materials show no corrosion after a 200 hour salt spray test. (Method 101 of MIL-STD-202.)

Effect of soldering — 2 percent maximum change in total resistance as a result of immersing the terminals in + 350° C solder to within .062 inch (1,57 mm) of the resistor body for 5 seconds.

Temperature cycling — 3 percent maximum change in total resistance as a result of the temperature cycling test (five cycles − 55° C to + 120° C).

Low temperature operation — 2 percent maximum change in total resistance as a result of the low temperature operation test (− 55° C for two hours without load and 45 minutes with rated load).

Low temperature storage — 2 percent maximum change in total resistance as a result of the storage test (24 hours at − 63° C).

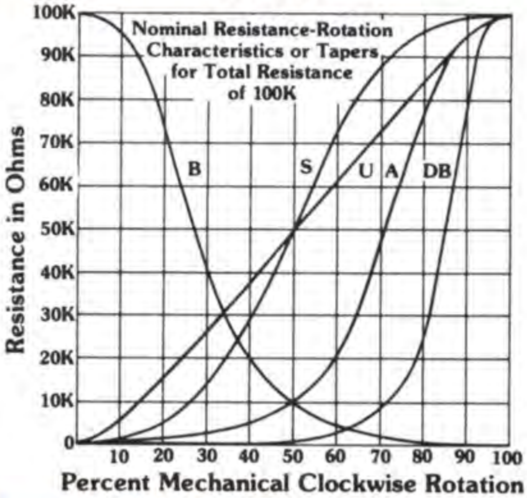
Temperature characteristics — Maximum percent temporary total resistance change from the + 25° C value. See table below.

Nominal Resistance	Degrees Celsius — "U" Linear Taper						
	−55°	−25°	0°	+25°	+55°	+85°	+120°
100 Ohms	+ 4.5	+ 2.5	+1.5	0	±1.0	±1.5	+ 3.5
1,000 Ohms	+ 5.5	+ 3.0	+1.5	0	±1.0	±2.0	+ 4.5
10,000 Ohms	+ 7.0	+ 3.5	+2.0	0	±1.0	±2.5	+ 5.5
100,000 Ohms	+ 8.0	+ 4.0	+ 2.0	0	±1.5	±3.0	+ 6.0
1 Megohm	+10.0	+ 5.0	+ 2.5	0	±1.5	±3.5	+ 7.5

For "S", "A", "B" and "DB" tapers multiply percentage figures shown above by 1.25.

Taper data

TAPERS



END RESISTANCE

TAPER	MINIMUM RESISTANCE BETWEEN TERMINALS 1 and 2	MINIMUM RESISTANCE BETWEEN TERMINALS 2 and 3
U & S	[1]	[1]
A	[1]	[2]
B	[2]	[1]
DB	[3]	[2]

[1] "Less than .004% of total resistance," or "less than 10 ohms" whichever is greater.

[2] "Less than 1% of total resistance," or "less than 10 ohms" whichever is greater.

[3] Less than 10 ohms.

Ordering information

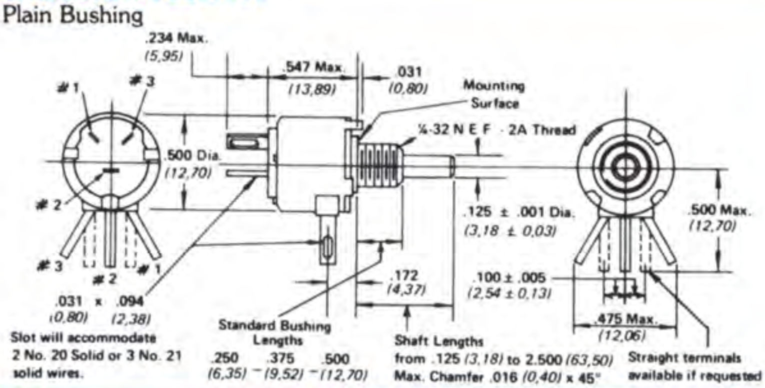
1. Type (GD).
2. Taper. [4]
3. Total resistance. [4]
4. Total resistance tolerance. [4]
5. Bushing type.
6. Bushing length.
7. Shaft ending.
8. Shaft length.
9. Locating lug option.
10. Mounting hardware.
11. Your part number.
12. Marking required.
13. Remarks. [4]

[4] When specifying attenuators specify attenuator type, characteristic impedance, tolerance on characteristic impedance and under remarks specify standard or limited attenuation.

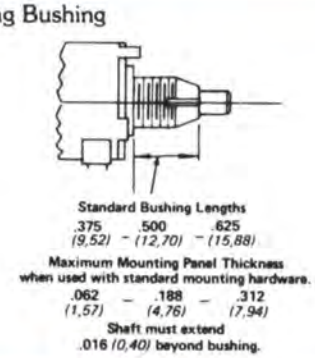
DIMENSIONS

Standard resistor

Plain Bushing

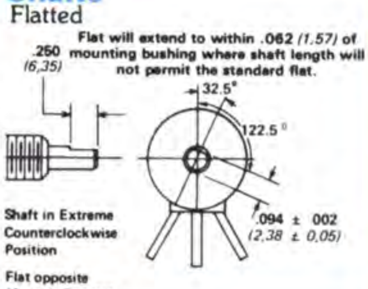


Locking Bushing

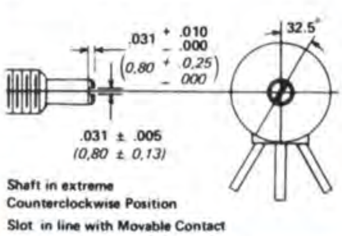


Shafts

Flatted

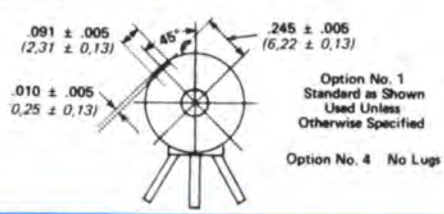


Screwdriver Slotted



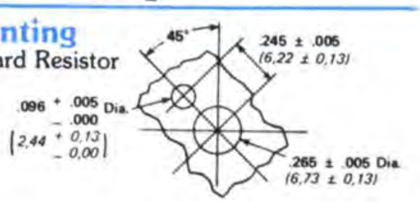
Locating lugs

Standard Resistor



Mounting

Standard Resistor



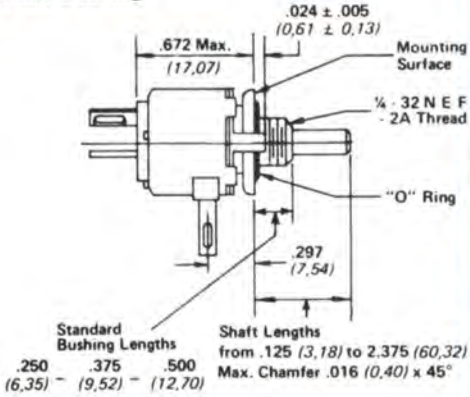
Basic dimensions in inches.
Dimensions shown in PARENTHESES are in millimeters.

TOLERANCES
Dimensional Tolerance ± .016 (0,40).
Angular Tolerance ± 5°.
Except as specified.
NOT TO SCALE

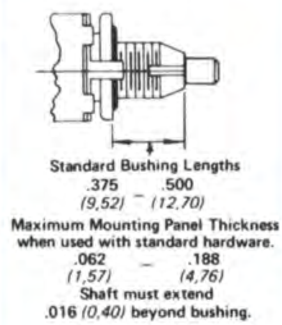
DIMENSIONS

Panel watertight resistor

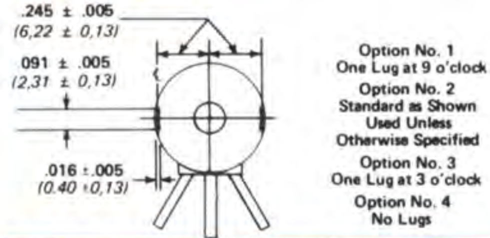
Plain Bushing



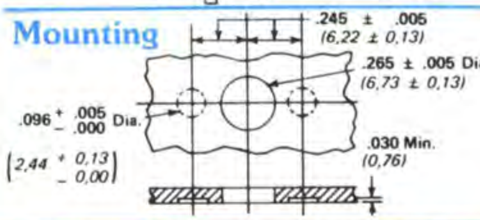
Locking Bushing



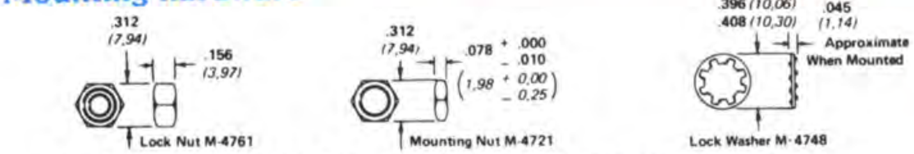
Locating lugs



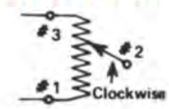
Mounting



Mounting hardware



Resistor connections



EXPLANATION OF PART NUMBERS

GD1G056S501UA

Basic Type

GD — Dual variable resistor —

If the electrical specifications are not identical for each section, a special number will be required.

Locating Lug Option

1
2 ■
3 ■
4

■ Available only with panel watertight resistor.

Total Resistance Value

First two digits are significant figures and the third indicates the number of zeros following the first two digits —

Examples: 101 = 100 Ohms
501 = 500 Ohms
255 = 2.5 Megohms

Hardware Combinations

	Mounting Nut	Lock-washer	Locknut
A —	(1)M-4721	(1)M-4748	— —
E —	(2)M-4721	(1)M-4748	— —
C —	(1)M-4721	(1)M-4748	(1)M-4761
L —	— —	— —	(1)M-4761
Z —	(no hardware)		

Bushing Type and Length

- G — Plain .250 inch (6,35 mm) long
- N — Plain .375 inch (9,52 mm) long
- H — Plain .500 inch (12,70 mm) long
- M — Locking .375 inch (9,52 mm) long
- L — Locking .500 inch (12,70 mm) long
- S — Locking .625 inch (15,88 mm) long
- T — Panel Watertight — Plain, .250 inch (6,35 mm) long
- P — Panel Watertight — Plain, .375 inch (9,52 mm) long
- E — Panel Watertight — Plain, .500 inch (12,70 mm) long
- Y — Panel Watertight — Locking, .375 inch (9,52 mm) long
- Z — Panel Watertight — Locking, .500 inch (12,70 mm) long

Shaft Length

Measured from mounting surface in inches and sixty-fourths

Example:
032 = 32/64 or .500 in. (12,70 mm)
056 = 7/8 or .875 in. (22,22 mm)
200 = 2.000 in. (50,80 mm)

Shaft Ending

- S — Standard Slot
- P — Plain Round
- F — Standard Flat

Electrical Specification — Taper Type and Total Resistance Tolerance

- U — Linear (U), ± 10%
- M — Linear (U), ± 20%
- A — Clockwise Modified Logarithmic (A), ± 10%
- R — Clockwise Modified Logarithmic (A), ± 20%
- B — Counterclockwise Modified Logarithmic (B), ± 10%
- T — Counterclockwise Modified Logarithmic (B), ± 20%
- D — Clockwise Exact Logarithmic (DB), ± 10%
- K — Clockwise Exact Logarithmic (DB), ± 20%
- S — Modified Linear (S), ± 10%
- Y — Modified Linear (S), ± 20%

Pad Type and Characteristic Impedance Tolerance

- E — L-Pad Attenuator, ± 15%
- L — L-Pad Attenuator, ± 20%
- N — Bridged T-Pad Attenuator, ± 15%
- P — Bridged T-Pad Attenuator, ± 20%

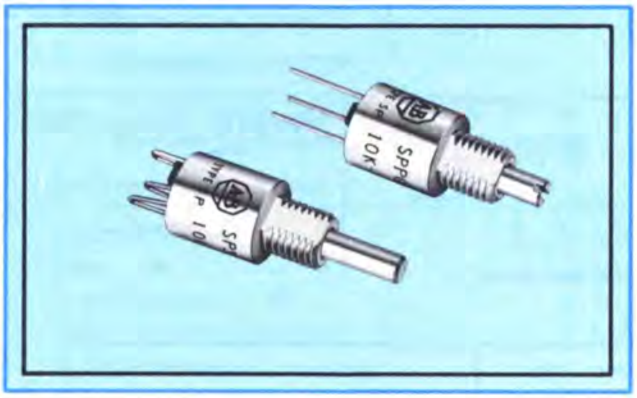
CAUTION: Part number format does not allow for exclusion of invalid mechanical and/or electrical combinations. Check parameter limits in preceding text.

Type SP Cermet Panel Potentiometers

1.0 Watt (70°C)

3/8 (0.375) Inch (9,52 mm) Diameter

50 Ohms to 1.0 Megohm



FEATURES

- TCR ±100 ppm/°C Maximum
- Cermet
- 2 Types
  Solder Terminals or Pin Terminals
- 7 Locating Lug Options
- Immersion Sealed
- ±10% Tolerance

SPECIFICATIONS

General

Temperature range — −65°C to +150°C.

Total resistance values — Preferred nominal values listed below.

OHMS

50	500	5K	50K	500K
75	750	7.5K	75K	750K
100	1K	10K	100K	1 Meg.
200	2K	20K	200K	
250	2.5K	25K	250K	

Total resistance tolerances — ±10 percent standard, ±5 percent available on request.

Taper — **(Resistance—rotation characteristics)** — "U" linear taper.

End resistance — Less than 5 ohms at both ends.

Electrical

Power — 1 watt maximum at +70°C provided voltage rating is not exceeded.

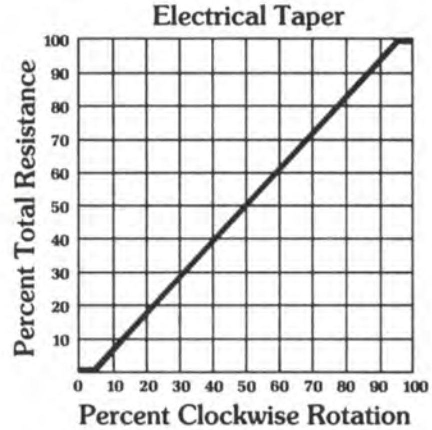
Power derating — Derate power linearly from +70°C to zero at +150°C. Derate power 50 percent for non-metallic mounting. For rheostat applications, derate power directly with shaft or actuator position.

Voltage — 300 volts maximum working voltage (RMS or DC), or as determined by $E_{max.} = \sqrt{PR}$, whichever is less (at sea level).

Dielectric withstanding voltage — Will withstand a one second test of 750 volts RMS at sea level, or 350 volts RMS at 3.4 inches (86,36 mm) mercury.

Insulation resistance — 100 megohms minimum for clean and dry conditions at +25°C.

Electrical Taper



Operational

Contact resistance variation — Less than 3 percent of nominal resistance value.

Load life — 5 percent maximum change in total resistance as a result of a 1000 hour test at rated power across entire element in still air at +70°C (1.5 hour "ON," 0.5 hour "OFF").

Rotational life — 10 percent maximum change in total resistance as a result of 25,000 cycles under load.

Mechanical

Construction — Materials are essentially non-magnetic. Terminals are treated for easy soldering. The resistor incorporates an internal "O" ring between the shaft and bushing. External surfaces are given special treatment so that the entire unit is immersion sealed.

Shafts — Diameter of shafts .125 inch (3,18 mm). Minimum length .188 inch (4,76 mm). Maximum length 2.500 inches (63,50 mm) with plain, slotted or flatted shaft endings described on page 134. Preferred shaft lengths are listed in the table below.

PREFERRED SHAFT LENGTHS
With Plain Round or Slotted Endings

Inch	.312	.375	.438	.500	.625	.750	.875
mm	7,94	9,52	11,11	12,70	15,88	19,05	22,22

Other shaft lengths available in 1/64 inch (0,40 mm) increments. All shaft lengths are measured from the mounting face of the resistor to the free end of the shaft.

Bushings — All bushings have a 32-NEF-2A thread and are .250 inch (6,35 mm) in diameter. Preferred bushing type and lengths are shown in the table below.

BUSHING TYPE	BUSHING LENGTH	
	Inch	mm
Plain	.250 .375	6,35 9,52

All bushing lengths are measured from the mounting face to the end of the bushing.

Turning torque — 0.5 to 6 inch-ounces (0,036 to 0,44 kgf-cm) at +25°C.

Stop torque — 3 inch-pounds (3,46 kgf-cm) minimum.

Rotation — 280° ± 5°.

Backlash — Maximum of 3 degrees.

Weight — Approximately 5 grams.

Locating lugs — Locating lugs can be provided so the resistor may be indexed with respect to the surface on which it is mounted. Seven different locating lug options are available. Double flatted bushings and lug adapters accomplish this function. All lug adapters shipped in bulk. Unless otherwise specified, resistors are supplied in accordance with Option No. 2. See dimensions on page 134.

Hardware — Standard hardware is one mounting nut M-4721 and one internal tooth lock washer M-4748. Unless otherwise specified, all hardware shipped in bulk.

Marking — Allen-Bradley part number and nominal total resistance are marked in two lines. Other marking possible, limited to a maximum of 13 characters in each of two lines. A-B monogram plus "Type SP" always included.

Environmental

Vibration — 2 percent maximum change in total resistance, 5 percent maximum change in resistance setting. (Tested per method 204, condition "C" of MIL-STD-202).

Shock — 2 percent maximum change in total resistance. 5 percent maximum change in resistance setting. (Tested per method 213, condition "I" of MIL-STD-202.)

Moisture resistance — 2 percent maximum change in total resistance. (Method 106 of MIL-STD-202.)

Effect of soldering — 1 percent maximum change in total resistance as a result of immersing the terminals in 350°C solder to within 0.062 inch (1,59 mm) of the resistor for 5 ± ½ seconds.

Temperature cycling — 3 percent maximum change in total resistance as a result of the temperature cycling test. (Five cycles at —65°C to +150°C).

High temperature exposure — 4 percent maximum change in total resistance as a result of the high temperature exposure test. (+150°C for 1000 hours without load.)

Low temperature operation — 2 percent maximum change in total resistance as a result of the low temperature operation test. (—65°C for two hours without load and 45 minutes with rated load.)

Temperature coefficient — Total resistance change less than ± 100 ppm/°C. (Tested per method 304 of MIL-STD-202.)

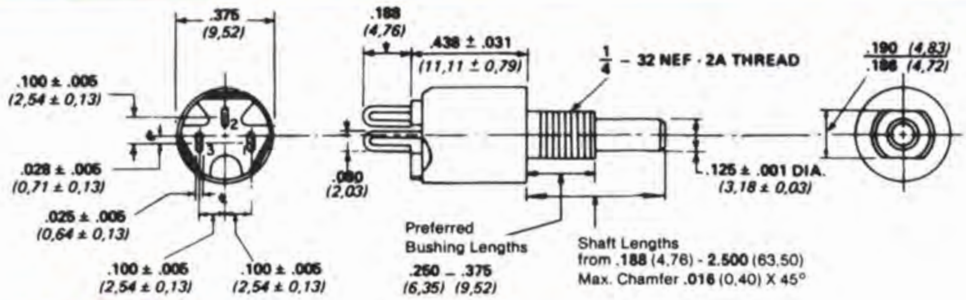
Immersion — No continuous stream of bubbles (4 or more) emanating from the resistor as a result of the immersion test (1 minute in water at +85°C).

Ordering information

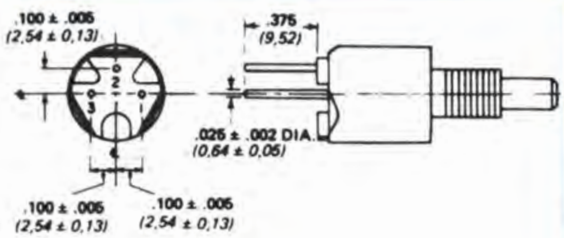
1. Type (SPS or SPP).
2. Total resistance value.
3. Tolerance on total resistance.
4. Bushing length in inches or millimeters.
5. Shaft ending (Plain, Slotted or Flatted).
6. Shaft length from mounting surface in inches or millimeters.
7. Locating lug option (1, 2, 3, 4, 5, 6 or 7).
8. Mounting hardware (A-B standard or other).
9. Part number you have assigned.
10. Marking required on the part.
11. Remarks.

DIMENSIONS

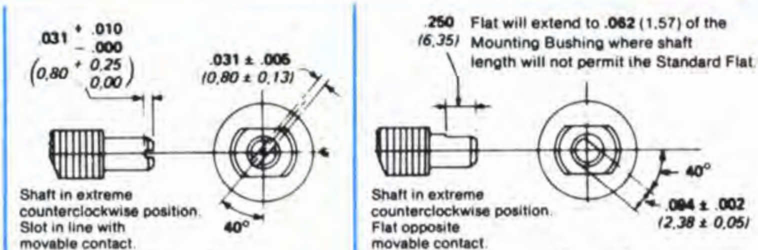
Type SPS plain bushing — solder terminals



Type SPP plain bushing — pin terminals



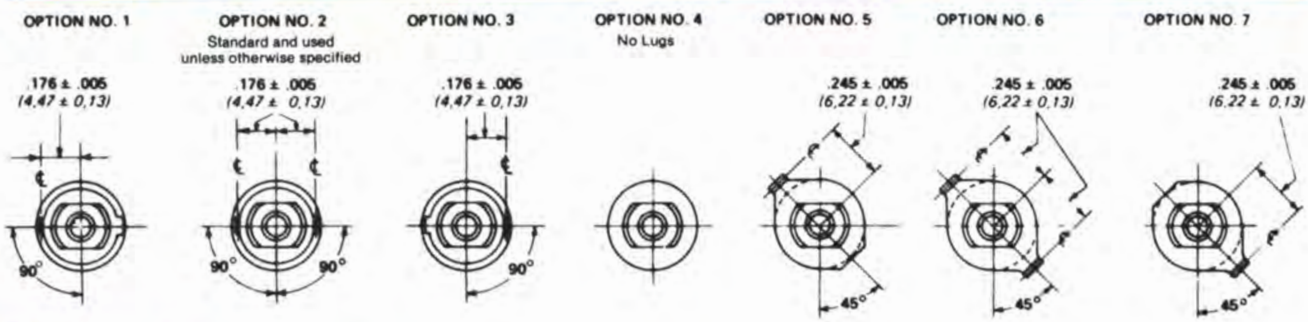
Shaft endings



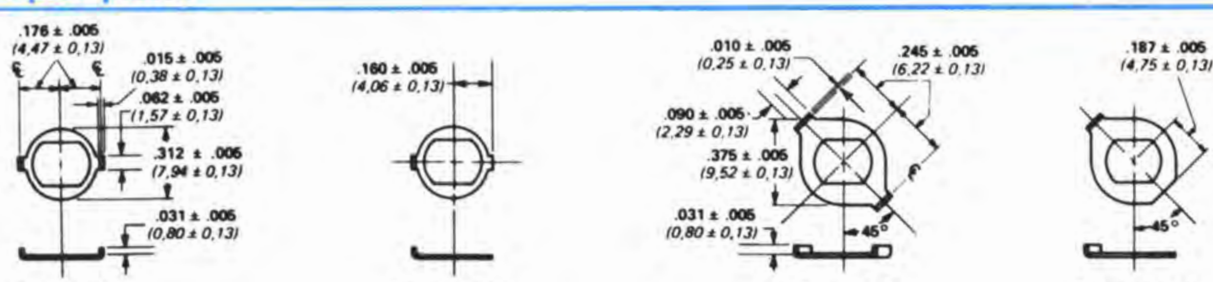
Slotted

Flatted

Locating lug options



Adapter plates



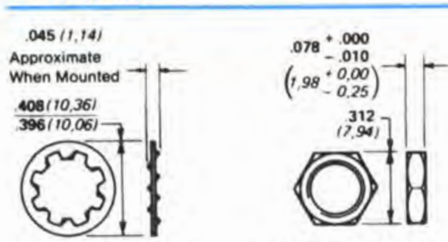
Option No. 2
B-39339

Option No. 1 & 3
B-39340

Option No. 6
B-39341

Option No. 5 & 7
B-39342

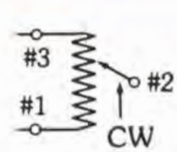
Hardware



Lock Washer M-4748

Mounting Nut M-4721

Resistor connections



Basic dimensions in inches.

Dimensions shown in parentheses are in millimeters.

TOLERANCES

Dimensional tolerance ±.016 (0,40)
Angular tolerance ±5°
Except as specified.

NOT TO SCALE

Cermet Panel Potentiometers

EXPLANATION OF PART NUMBERS

SPSG056S501U

Basic Type
SPS — Lug Terminals

SPP — Pin Terminals

Bushing Type and Length
G — Plain .250 inch (6,35 mm) long

N — Plain .375 inch (9,52 mm) long

Shaft Length
Measured from mounting surface in inches and sixty-fourths.

Examples:

056 = 7/8 or .875 inch (22,22 mm)

200 = 2.000 inches (50,80 mm)

Shaft Ending
S — Slotted

P — Plain Round

F — Flatted

Total Resistance Value
First two digits are significant figures and the third indicates the number of zeros following the first two digits —

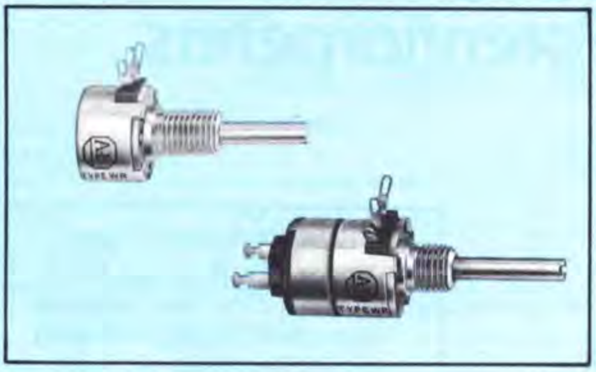
Examples: 101 = 100 Ohms
501 = 500 Ohms
254 = 250K

Taper Type and Total Resistance Tolerance
U — Linear (U), ± 10%

X — Linear (U), ± 5%

CAUTION: Part number format does not allow for exclusion of invalid mechanical and/or electrical combinations. Check parameter limits in preceding text.

Type WR Hot-Molded Panel Potentiometers



1/2 (0.50) Inch (12,70 mm) Diameter
0.5 Watt (70° C)
100 Ohms to 5.0 Megohms

FEATURES

- Linear and Non-Linear Tapers
- Radial Terminals
- Switches Available

SPECIFICATIONS

General

Temperature range — Variable resistor −55° C to +120° C. Switch −55° C to +100° C.

Total resistance values — Preferred nominal values listed below. Other values available.

OHMS

100	1K	10K	100K	1.0 Meg.
200	2K	20K	200K	2.0 Meg.
220	2.2K	22K	220K	2.2 Meg.
250	2.5K	25K	250K	2.5 Meg.
470	4.7K	47K	470K	4.7 Meg.
500	5K	50K	500K	5.0 Meg.

Total resistance tolerances — ± 20% or ± 10%.

Tapers — Available in following resistance ranges:

TAPER	TOTAL RESISTANCE RANGE
U	100 Ohms to 5.0 Megohms
A, B, S, & DB	500 Ohms to 2.5 Megohms

See chart on following pages for explanation of tapers. Special tapers, where practical, can be supplied.

End resistance — See chart on following pages.

Switches — Two types of single pole, single throw switches are available. One turns "ON" at start of clockwise shaft rotation, the other at the start of counterclockwise shaft rotation. The switch reduces effective electrical rotation to 248° nominal.

Switch rating for resistive loads is 1.0 ampere 125 volt 60 Hertz.

Switches can be operated 10,000 cycles at full rating.

Electrical

Power — 0.5 watt maximum at +70° C for "U" linear taper provided voltage rating is not exceeded.

Power derating — Derate power linearly from +70° C to zero at +120° C. Derate power 50 percent for non-metallic mounting and for resistors with "A", "B", "S", and "DB" tapers. For rheostat applications, derate power directly with shaft or actuator position.

Voltage — 350 volts maximum working voltage (RMS or DC), or as determined by $E_{max.} = \sqrt{PR}$, whichever is less (at sea level).

Dielectric withstanding voltage — Maximum continuous voltage 350 volts (RMS or DC) at sea level. Will withstand a one second test of 750 volts (RMS) at sea level or 350 volts (RMS) at 3.4 inches (86,36 mm) mercury.

Insulation resistance — 1000 megohms minimum for clean and dry conditions at +25° C.

Operational

Load life — 10 percent maximum change in total resistance as a result of a 1000 hour test at rated power across entire element in still air at +70° C (1.5 hour "ON," 0.5 hour "OFF").

Rotational life — 10 percent maximum change in total resistance as a result of a 50,000 cycle life test without load (variable resistor only).

Mechanical

Shafts — Diameter of shafts .125 inch (3,18 mm). Minimum length .125 inch (3,18 mm). Maximum length 2.500 inches (63,50 mm) with plain, screw-driver slotted or flatted shaft endings. Preferred shaft lengths and endings are listed in the following table.

PREFERRED SHAFT LENGTHS

	Plain Round		Screwdriver Slotted					
Inches	.500	.625	.375	.438	.500	.625	.750	.875
mm	12,70	15,88	9,52	11,11	12,70	15,88	19,05	22,22

Other lengths available in 1/64 inch (0,40 mm) increments. All shaft lengths are measured from the mounting face of the resistor to the free end of the shaft. The shaft can be flush with the bushing end or recessed on resistors with plain bushings.

Bushings — All bushings have a 32-NEF-2A thread and are .250 inch (6,35 mm) in diameter. Bushing lengths and types are shown in the table below.

Plain		Locking		Panel Watertight Plain	
Inch	mm	Inch	mm	Inch	mm
.250	6,35	.375	9,52	.250	6,35
.375	9,52	.500	12,70		

After lock nuts on locking bushing are tightened with a torque of 8 inch-pounds (9,22 kgf-cm) shafts will not turn with torques up to 20 inch-ounces (1,44 kgf-cm).

Hardware — Resistors are normally supplied with one mounting nut, M-4721, and one internal tooth lock washer, M-4748. Resistors with shaft lock bushings are supplied with one lock nut, M-4761, in addition to the above. Unless otherwise specified, all hardware shipped in bulk.

Locating lugs — Locating lugs can be supplied to prevent turning or movement with respect to the surface upon which the resistor is mounted. Four different locating lug options are available. See DIMENSIONS.

Turning torque — The torque required to rotate the shaft is 0.5 inch-ounce (0,036 kgf-cm) minimum, 3 inch-ounces (0,22 kgf-cm) maximum at +25° C ambient temperature, and 13 inch-ounces (0,94 kgf-cm) maximum at −55° C ambient.

Maximum additional torque required to operate the switch is 1 to 6 inch-ounces (0,072 to 0,432 kgf-cm).

Stop torque — 2 inch-pounds (2,31 kgf-cm) minimum.

Rotation — Mechanical rotation for resistors with or without switch is 295° ± 5°.

Electrical rotation is 270° nominal without switch and 248° nominal with switch.

Backlash — 3° maximum.

Construction — Materials are corrosion resistant and essentially non-magnetic, terminals are treated for easy soldering; enclosure is dust and splash resistant.

Immersion-sealed types, commonly referred to as "watertight" are optional. These immersion-sealed types incorporate an internal "O" ring seal between the shaft and bushing. External surfaces are given special treatment so that the entire resistor is immersion-sealed so that no continuous stream of bubbles (4 or more) emanates from the resistor as a result of the immersion test (1 minute in water at +85° C).

A panel-shaft "watertight" bushing is also optional. This bushing is provided with an external "O" ring in addition to the features of the immersion-sealed type.

Weight — The exact weight of individual resistors depends on the precise mechanical specifications involved. For example a Type WR resistor with 0.250 inch (6,35 mm) bushing and 0.875 inch (22,22 mm) shaft will weigh approximately 0.27 ounces (7,57 grams).

Marking — Allen-Bradley part number and nominal total resistance marked in two lines. Other marking possible, limited to maximum of 13 characters in each of two lines. A-B monogram plus "Type WR" always included.

Environmental

Vibration — 2 percent maximum change in total resistance, 5 percent maximum change in resistance setting. (Tested per method 204, condition "C" of MIL-STD-202.)

Shock — 2 percent maximum change in total resistance. 5 percent maximum change in resistance setting. (Tested per method 213, condition "I" of MIL-STD-202.)

Humidity/moisture resistance — All resistors exhibit less than 10 percent total resistance change when tested per MIL-STD-202, Method 103, Condition "B". Sealed resistors exhibit less than 10 percent total resistance change when tested per MIL-STD-202, Method 106.

Corrosion resistance — Materials show no corrosion after a 200 hour salt spray test. (Method 101 of MIL-STD-202.)

Effect of soldering — 2 percent maximum change in total resistance as a result of immersing the terminals in +350° C solder to within 0.125 inch (3,18 mm) of the resistor body for 5 seconds.

Temperature cycling — 3 percent maximum change in total resistance as a result of the temperature cycling test (five cycles −55° C to +120° C for resistor and five cycles at −55° C to +100° C for resistor with switch).

Environmental

Low temperature operation — 2 percent maximum change in total resistance as a result of the low temperature operation test (− 55° C for two hours without load and 45 minutes with rated load).

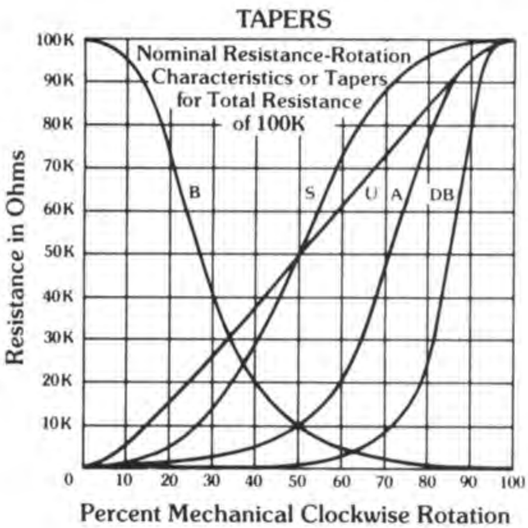
Low temperature storage — 2 percent maximum change in total resistance as a result of the storage test (24 hours at − 63° C).

Temperature characteristics — Maximum percent temporary total resistance change from the + 25° C value. See table to right.

For "S", "A", "B" and "DB" tapers multiply percentage figures shown by 1.25.

Nominal Resistance	Degrees Celsius — "U" Linear Taper						
	−55°	−25°	0°	+25°	+55°	+85°	+120°
100 Ohms	+ 4.5	+ 2.5	+ 1.5	0	± 1.0	± 1.5	+ 3.5
1,000 Ohms	+ 5.5	+ 3.0	+ 1.5	0	± 1.0	± 2.0	+ 4.5
10,000 Ohms	+ 7.0	+ 3.5	+ 2.0	0	± 1.0	± 2.5	+ 5.5
100,000 Ohms	+ 8.0	+ 4.0	+ 2.0	0	± 1.5	± 3.0	+ 6.0
1 Megohm	+10.0	+ 5.0	+ 2.5	0	± 1.5	± 3.5	+ 7.5

Taper data



END RESISTANCE

TAPER	MINIMUM RESISTANCE BETWEEN TERMINALS 1 and 2	MINIMUM RESISTANCE BETWEEN TERMINALS 2 and 3
U & S	1	1
A	1	2
B	2	1
DB	3	2

1 "Less than .004% of total resistance," or "less than 10 ohms" whichever is greater.

2 "Less than 1% of total resistance," or "less than 10 ohms" whichever is greater.

3 Less than 10 ohms.

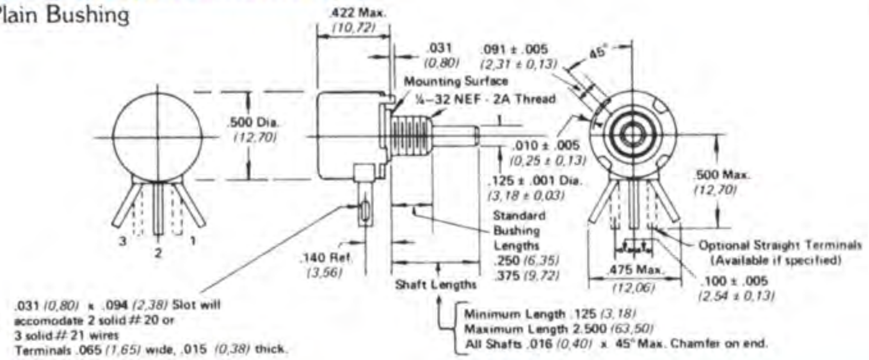
Ordering information

1. Type (WRA, WRH or WRS).
2. Taper.
3. Total resistance.
4. Tolerance.
5. Bushing type.
6. Bushing length.
7. Shaft ending.
8. Shaft length.
9. Locating lug option.
10. Mounting hardware.
11. Your part number.
12. Marking required.
13. Remarks.

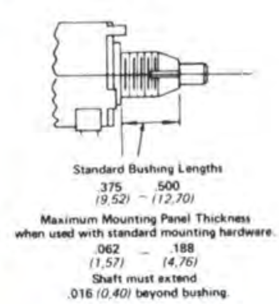
DIMENSIONS

Standard potentiometer

Plain Bushing

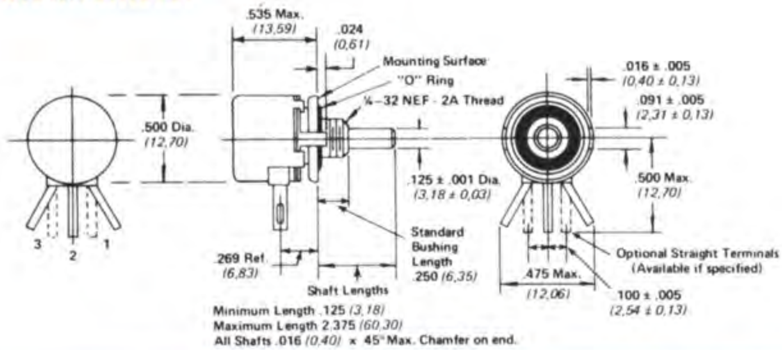


Locking Bushing



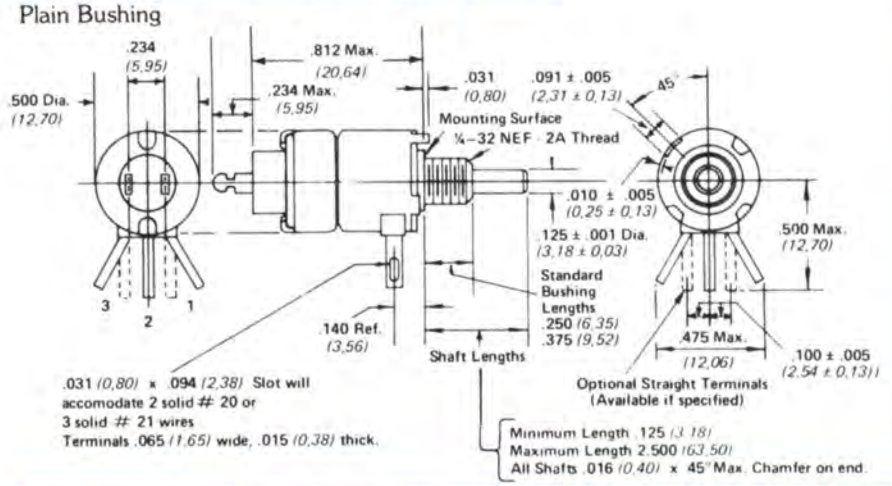
Panel watertight potentiometer

Plain Bushing

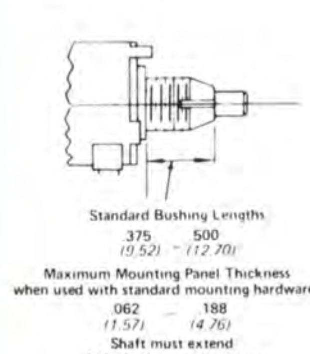


Standard potentiometer with switch

Plain Bushing

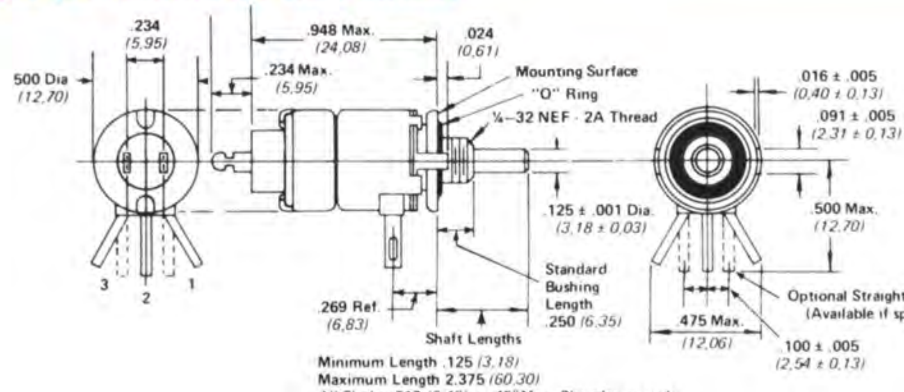


Locking Bushing



Panel watertight potentiometer with switch

Plain Bushing

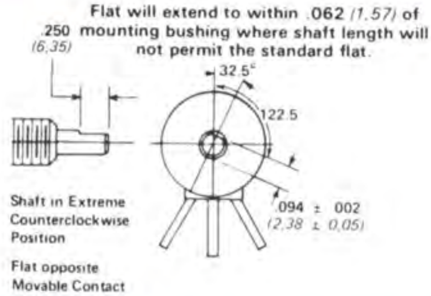


Type **WR**

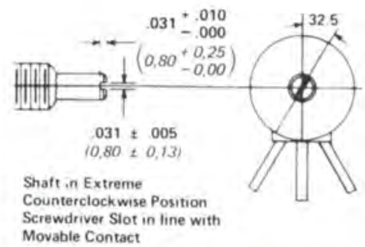
DIMENSIONS

Shaft endings

Flatted

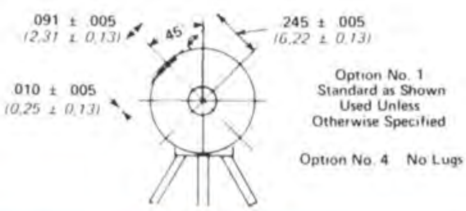


Screwdriver Slotted

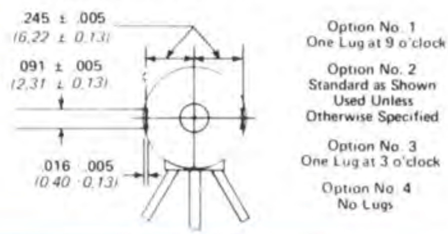


Lug options

Standard Potentiometer

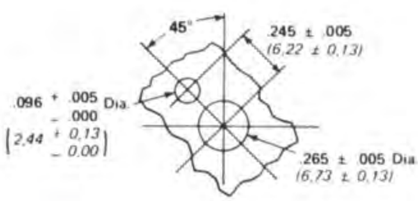


Panel Watertight Potentiometer

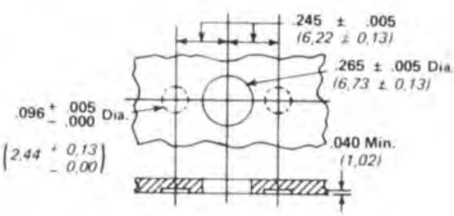


Mounting

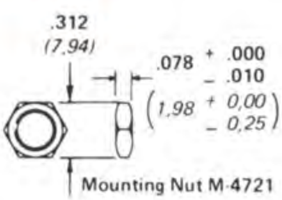
Standard Potentiometer

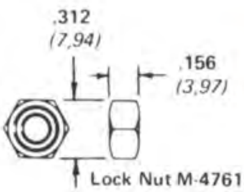


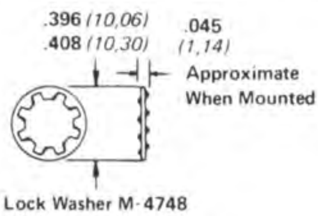
Panel Watertight Potentiometer



Hardware







Basic dimensions in inches.

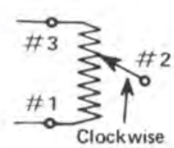
Dimensions shown in parentheses are in millimeters.

TOLERANCES

Dimensional tolerance ± .016 (0,40)
Angular tolerance ± 5°
Except as specified.

NOT TO SCALE

Potentiometer Connections



EXPLANATION OF PART NUMBERS

NOTE: Part number format allows development of some part numbers which cannot be manufactured. (Example: WRA2N400P101AA which has an invalid shaft length and invalid resistance value for an "A" taper.) Check parameter limits in preceding text, when developing a part number.

Combinations which are valid and do not fit into a part number, (Examples: Special tapers, special shafts, etc.) will be assigned a special part number by the factory. Refer to "Ordering Information", in the preceding text, for the required data for the assignment of a special part number by the factory.

WRA1G056S501U

Basic Type

WRA — Basic Type WR.

WRS — With switch actuated at start of clockwise rotation.

WRH — With switch actuated at start of counterclockwise rotation.

Locating Lug Option

1
2
3
4

2, 3: Not available unless panel watertight bushing is used

Total Resistance Value

First two digits are significant figures and the third indicates the number of zeros following the first two digits —

Examples: 101 = 100 Ohms
501 = 500 Ohms
255 = 2.5 Megohms

Bushing Type and Length

- **G** — Plain — Dust and Splash Resistant .250 inch (6,35 mm) long
- **N** — Plain — Dust and Splash Resistant .375 inch (9,52 mm) long
- **M** — Locking — Dust and Splash Resistant .375 inch (9,52 mm) long
- **L** — Locking — Dust and Splash Resistant .500 inch (12,70 mm) long
- **A** — Plain — Immersion-sealed .250 inch (6,35 mm) long
- **B** — Plain — Immersion-sealed .375 inch (9,52 mm) long
- **C** — Locking — Immersion-sealed .375 inch (9,52 mm) long
- **D** — Locking — Immersion-sealed .500 inch (12,70 mm) long
- **T** — Panel Watertight — Plain — Immersion-sealed .250 inch (6,35 mm) long

Shaft Length

Measured from mounting surface in inches and sixty-fourths

Example:
032 = 32/64 or .500 inch (12,70 mm)
200 = 2.000 inches (50,80 mm)
056 = 7/8 or .875 inch (22,22 mm)

Preferred Shaft Lengths and Endings

Plain Round

Inches	.500	.625
mm	12,70	15,88

Screwdriver Slotted

Inches	.375	.438	.500	.625	.750	.875
mm	9,52	11,11	12,70	15,88	19,05	22,22

Shaft Ending

- **S** — Standard Slot
- **P** — Plain Round
- **F** — Standard Flat

Taper Type and Total Resistance Tolerance

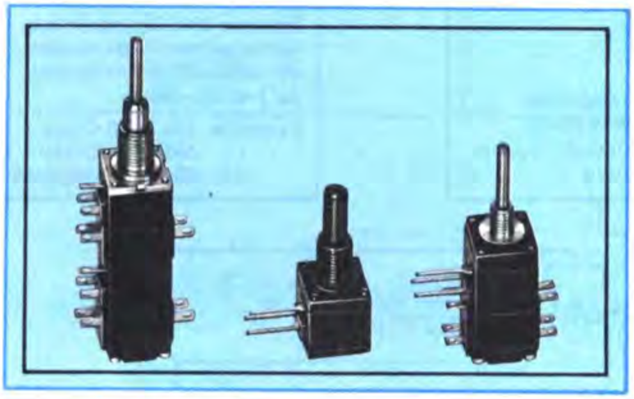
- **U** — Linear (U), ± 10%
- **M** — Linear (U), ± 20%
- **A** — Clockwise Modified Logarithmic (A), ± 10%
- **R** — Clockwise Modified Logarithmic (A), ± 20%
- **B** — Counterclockwise Modified Logarithmic (B), ± 10%
- **T** — Counterclockwise Modified Logarithmic (B), ± 20%
- **D** — Clockwise Exact Logarithmic (DB), ± 10%
- **K** — Clockwise Exact Logarithmic (DB), ± 20%
- **S** — Modified Linear (S), ± 10%
- **Y** — Modified Linear (S), ± 20%

MOD POT®

Series 70, 72, 73

Conductive Plastic (CP), Cermet and Hot-Molded Carbon Panel Potentiometers

5/8 (0.625) Inch (15,88 mm) Square
50 Ohms to 10.0 Megohms



FEATURES

- Versatility
- Quadruple Controls
- Many Switch Options
- Linear and Non-Linear Tapers
- Attenuators

SPECIFICATIONS

General

Versatile Panel Potentiometer

The MOD POT® concept consists of standardized potentiometer modules that can be mixed and matched in over a billion combinations. Now, you can be far more imaginative with potentiometers because you can get special combinations with the ease of standards.

Allen-Bradley originated the modular potentiometer concept in response to requests from design engineers who wanted virtually unlimited variety in variable resistors for greatly increased design freedom.

MOD POT® modules are 5/8 inch square by about 1/2 inch deep. This provides minimum center-to-center distance for compact panel mounting. You can gang resistance and switch modules in combinations of up to four modules. Select from a whole family of resistive elements, resistive values and tolerances, tapers, shafts, bushings, lug options and more. You get a virtually unlimited number of design options.

The MOD POT® Family includes:

Series 70 – Metal Shaft – Metal Bushing.

Series 72 – Plastic Shaft – Plastic Bushing.

Series 73 – Metal Shaft – Metal Bushing molded into a Plastic Face Plate.

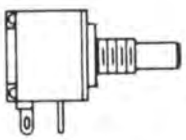
See Page 143 for possible basic combinations.

Unmatched Flexibility

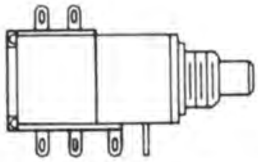
MOD POT® POTENTIOMETERS ARE AVAILABLE AT ASSEMBLY CENTERS MAINTAINED BY ELECTRONIC DISTRIBUTORS.

Basic combinations

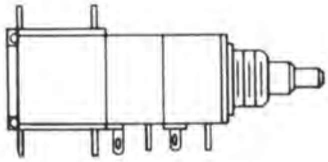
The MOD POT® Potentiometer is available in single, dual, triple, and quadruple construction. This includes potentiometer, switch and vernier drive modules. The table below lists some of the options available for single and multi-section controls. Because of the versatility of the MOD POT® Potentiometer, many other options are available. Momentary push switches may be used in place of push-pull switches in the listed combinations.



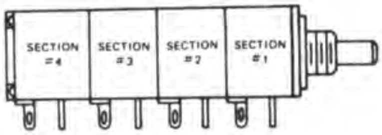
Single Unit



Dual Unit



Triple Unit



Quad Unit

	Section #1	Section #2	Section #3	Section #4	Combination 5	Series 70	Series 72	Series 73	See Note
Single Unit	Potentiometer				1A	A	A	A	
	Rotary Switch				2A	A	A	A	4
	Push-Pull Switch				3A	A	NA	A	
Dual Unit Single Shaft	Potentiometer	Potentiometer			4A	A	A	A	
		Rotary Switch			5A	A	A	A	4
		Push-Pull Switch			5B	A	NA	A	
	Vernier Drive	Potentiometer			6A	A	A	A	
Dual Unit Concentric Shaft	Potentiometer	Potentiometer			7A	A	NA	A	
		Push-Pull Switch			8A	A	NA	A	
		Rotary Switch			9A	A	NA	A	
	Vernier Drive	Potentiometer			10A	A	NA	A	3
	Rotary Switch	Push-Pull Switch			11A	A	NA	A	
Triple Unit Single Shaft	Potentiometer	Potentiometer	Potentiometer		12A	A	NA	NA	
			Push-Pull Switch		12B	A	NA	NA	
		Rotary Switch	Push-Pull Switch		12C	A	NA	NA	
		Potentiometer	Rotary Switch		13A	A	NA	NA	
		Rotary Switch			13B	A	NA	NA	
	Vernier Drive	Potentiometer	Potentiometer		14A	A	NA	NA	
Triple Unit Concentric Shaft	Potentiometer	Potentiometer	Potentiometer		15A	A	NA	NA	
			Rotary Switch		16A	A	NA	NA	
			Push-Pull Switch		17A	A	NA	NA	
		Rotary Switch			18A	A	NA	NA	
	Vernier Drive	Potentiometer	Potentiometer		19A	A	NA	NA	1 or 3
			Rotary Switch		20A	A	NA	NA	1
Quad Unit Single Shaft	Potentiometer	Potentiometer	Potentiometer	Potentiometer	23A	A	NA	NA	
				Push-Pull Switch	23B	A	NA	NA	
			Rotary Switch		23C	A	NA	NA	
	Vernier Drive	Potentiometer	Potentiometer	Potentiometer	25A	A	NA	NA	
Quad Unit Concentric Shaft	Potentiometer	Potentiometer	Potentiometer	Potentiometer	26A	A	NA	NA	
				Rotary Switch	27A	A	NA	NA	
		Rotary Switch			28A	A	NA	NA	1
		Potentiometer	Rotary Switch	Rotary Switch	29A	A	NA	NA	
				Push-Pull Switch	30A	A	NA	NA	
			Potentiometer		31A	A	NA	NA	
	Vernier Drive	Potentiometer		Potentiometer	32A	A	NA	NA	1, 2 or 3
				Rotary Switch	33A	A	NA	NA	1 or 2

A — Available
NA — Not Available

NOTES:
1. The outer shaft operates Sections #1 and #2.
2. The outer shaft operates Sections #1, #2 and #3.
3. The inner shaft (.078 inch [1.98mm] diameter) is for the coarse adjustment, the outer shaft for the fine adjustment.
4. Series 72 must have .250 inch (6.35 mm) diameter shaft.
5. Combination code used for reference to a type of buildup only. Refer to Dimension Section for Code Number Identification. This is not a part number.

SPECIFICATIONS

General

TEMPERATURE RANGE

Series	Unit	Maximum Temp. °C	Minimum Temp. °C
70	Hot-Molded or Conductive Plastic	+120°	−55°
	Cermet	+150°	−55°
72	Hot-Molded, Conductive Plastic or Cermet	+100°	−55°
73	Hot-Molded, Conductive Plastic or Cermet	+120°	−55°
70, 72, 73	Vernier	+100°	−55°
70, 72, 73	Switches	+100°	−55°

POWER

Series	Power in Watts per Section			
	Hot-Molded at 70° C	Hot-Molded at 40° C	Cermet at 70° C	CP at 70° C
70 (single)	1.0	—	2.0	.5
70 (multi-section)	.5	—	1.0	.25
72 (single)	.5	—	1.0	.25
72 (dual)	.5	—	.5	.25
73 (single)	.75	1.0	2.0	.5
73 (dual)	.5	—	1.0	.25

Power derating — Derate power linearly from rated temperature to zero at maximum temperature. Derate power 50 percent for non-metallic mounting. Derate 60 percent for CP elements with "A" and "B" tapers. Derate 50 percent for hot-molded elements with "A", "B", "S", and "DB" tapers. For rheostat applications, derate power directly with shaft or actuator position.

Hardware — Hardware is: .250 inch (6,35 mm) diameter bushing: (1) M-4748, (1) M-4721, (1) M-4761 (M-4761 is supplied only with locking bushings).

.375 inch (9,52 mm) diameter bushing: (1) M-2898, (1) M-2786, (1) M-3638 (M-3638 is supplied only with locking bushings).

All hardware shipped in bulk — not assembled unless otherwise specified.

Mounting torque (Series 72) — Torque applied to the mounting nuts should not exceed 7 inch-pounds (790 mN-m) for the .250 inch (6,35 mm) diameter bushing or 14 inch-pounds (1580 mN-m) for the .375 inch (9,52 mm) diameter bushing.

Turning torque — Initially, at 25° C, the potentiometer torque will be 0.5 inch-ounce (3,5 mN-m) minimum while the maximum is:

Style	TORQUE INCH-OUNCES (mN-m)	
	Cermet and Hot-Molded Elements	CP Elements
Single	3 (21)	1.5 (11)
Dual	6 (42)	2.5 (18)
Triple	8 (56)	3.5 (25)
Quad	10 (71)	4.5 (32)

The maximum additional torque required for the vernier drive is 10 inch-ounces (71 mN-m) on inner, coarse adjustment shaft. See Page 147 for switch torques.

Stop torque — Minimum of 4 inch-pounds (451 mN-m) except for the Series 72 with a .125 inch (3,18 mm) diameter shaft which is 2 inch-pounds (225 mN-m) minimum. Vernier drives have slip clutches.

Rotation —

Shaft Operates	Rotation In Degrees	
	Total Mechanical	Electrical
Potentiometers	300	260
Potentiometers and Rotary Switch	300	260
Potentiometers and Push-Pull Switches	305	260
Rotary Switches	25	—
Rotary Switches and Push-Pull Switches	30	—

Vernier drive — Two vernier drive modules are available with hot-molded and cermet modules. Through a gearing arrangement, the total rotation will be changed to 16 turns or 4 turns. A ratchet clutch is provided in place of fixed stops for the fine adjustment shaft. Series 70 and 73 variable resistors may have concentric shafts. The inner concentric shaft (.078 inch [1,98 mm] diameter) may be used as a coarse adjustment shaft.

Enclosure — Dust and splash resistant. They are not immersion sealed.

Materials — Corrosion-resistant and essentially nonmagnetic. The shafts and bushings of the Series 72 are plastic.

Standard marking — Allen-Bradley part number and nominal total resistance are marked in two lines. Other marking possible. A-B monogram plus "MOD POT"® always included.

Mechanical

PREFERRED SHAFT LENGTHS AND ENDINGS

Shaft Type	Preferred Shaft Lengths in Inches								
	Plain End			Slotted End			Flatted End		
	Series	70 73	72	Series	70 73	72	Series	70 73	72
	—			See Note 1	NA	A	—		
Solid .250 Inch Diameter (6.35 mm)	.375 (9.52 mm)	A	NA	.375 (9.52 mm)	A	NA	.750 (19.05 mm)	A	NA
	.500 (12.70 mm)	A	NA	.500 (12.70 mm)	A	NA	—		
	.625 (15.88 mm)	A	NA	.625 (15.88 mm)	A	NA	—		
	.750 (19.05 mm)	A	NA	.750 (19.05 mm)	A	A	—		
	.875 (22.22 mm)	A	NA	.875 (22.22 mm)	A	A	—		
Solid .125 Inch Diameter (3.18 mm)	.375 (9.52 mm)	A	NA	.375 (9.52 mm)	A	NA	.750 (19.05 mm)	A	NA
	.500 (12.70 mm)	A	A	.500 (12.70 mm)	A	NA	—		
	.625 (15.88 mm)	A	A	.625 (15.88 mm)	A	NA	—		
	.750 (19.05 mm)	A	A	.750 (19.05 mm)	A	NA	—		
	.875 (22.22 mm)	A	NA	.875 (22.22 mm)	A	NA	—		
Outer Concentric	.500 (12.70 mm)	A	NA						
	.625 (15.88 mm)	A	NA						
	.750 (19.05 mm)	A	NA						
Inner Concentric	1.000 (25.40 mm)	A	NA						
	1.125 (28.58 mm)	A	NA						
	1.250 (31.75 mm)	A	NA						

Maximum shaft length 2.500 inches (63.50mm) for Series 70 and 73.

All shaft lengths are measured from the mounting face of the bushing to the free end of the shaft. Shafts on push-pull switches are measured in the extended position. .078 inch (1.98mm) diameter solid and .125 inch (3.18mm) diameter hollow shafts are only available with plain endings. See dimension drawings. Special shaft lengths in 1/64 inch increments and special shaft endings can be supplied of the Series 70 and 73.

A = Available NA = Not Available

BUSHINGS

Diameter	Type	Length		Series		
		Inches	Millimeters	70	72	73
See Note 1				NA	A	NA
.250 Inch (6.35 mm)	Plain	.250	6.35	A	A	A
		.375	9.52	A	NA	A
	Locking	.375	9.52	A	NA	A
		.500	12.70	A	NA	A
.375 Inch (9.52 mm)	Plain	.250	6.35	A	NA	A
		.375	9.52	A	A	A
		.500	12.70	A	NA	NA
	Locking	.375	9.52	A	NA	A
		.500	12.70	A	NA	A

Mounting bushings are supplied with 32-NEF-2A thread. All bushing lengths are measured from the mounting face to the end of the bushing.

SHAFT AND BUSHING COMBINATIONS

Shaft Type	Shaft Diameter in Inches	
	.375 (9.52 mm) Dia. Bushing	.250 (6.35 mm) Dia. Bushing
Solid or Outer Concentric	.250 (6.35 mm)	.125 (3.18 mm)
Inner Concentric	.125 (3.18 mm) Verniers (.078 (1.98 mm)	.078 (1.98 mm)

Series 72 shafts and bushings are plastic.

1 No mounting bushing. Shaft is cross slotted for screwdriver actuation and is flush with the face plate. See dimensions on Page 150.

Environmental

Vibration – 2 percent maximum change in total resistance. 5 percent maximum change in resistance setting. (Tested per method 204, condition "C" of MIL-STD-202.)

Shock – 2 percent maximum change in total resistance. 5 percent maximum change in resistance setting. (Tested per method 213, condition "I" of MIL-STD-202.)

Humidity – Maximum change in total resistance as a result of 95 percent relative humidity at 40° C for 100 hours: 5 percent for cermet element, 10 percent for hot-molded and CP elements.

Temperature cycling – 3 percent maximum change in total resistance as a result of the temperature cycling test. (Five cycles at −55° C to the maximum temperature.)

Effect of soldering – Maximum change in total resistance as a result of immersing the terminals in 350° C solder to within 0.125 inch (3.18 mm) of the resistor body for 5 seconds: 1 percent for cermet element, 2 percent for hot-molded and CP elements.

Low temperature operation – Maximum change in total resistance as a result of the low temperature operation test (−55° C for two hours without load and 45 minutes with rated load) 2 percent for cermet element, 3 percent for hot-molded and CP elements.

High temperature exposure – Maximum change in total resistance as a result of the high temperature exposure test (maximum rated temperature for 1000 hours without load) 4 percent cermet element, 10 percent hot-molded and CP elements.

Operational

Contact resistance variation – linear taper – Maximum value is: Hot-Molded & Cermet - 1.5 percent of nominal resistance value or 1.5 ohms, whichever is greater. CP - 1.0 percent of nominal resistance value.

Load life – Maximum change in total resistance as a result of a 1000 hour test at rated power across entire element at +70° C (1.5 hour "ON", 0.5 hour "OFF") 5 percent for cermet element, 10 percent for hot-molded and CP elements.

Rotational life – 10 percent maximum change in total resistance as a result of a 100,000 cycle life test without load.

Electrical

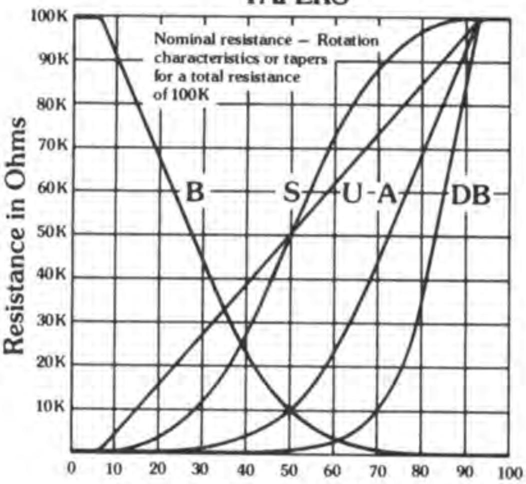
Total resistance values — Preferred nominal values — see below for Resistance Ranges.

OHMS

50	750	10K	200K	1.0 Meg.
75	1K	20K	250K	2.5 Meg.
100	2K	25K	500K	5.0 Meg.
200	2.5K	50K	750K	10.0 Meg.
250	5K	75K		
500	7.5K	100K		

Total resistance tolerances — Hot-Molded, CP — ±10% or ±20%; Cermet — ±10%

TAPERS



Percent Clockwise Rotation

Tapers — Available in the following resistance ranges:

UNIT	TAPER	TOTAL RESISTANCE RANGE
Hot-Molded	U	50 Ohms to 10.0 Megohms
	A, B, S & DB	250 Ohms to 10.0 Megohms
Cermet	U	100 Ohms to 5.0 Megohms
CP	U	100 Ohms to 1.0 Megohm
	A & B	250 Ohms to 1.0 Megohm

Independent linearity — ±5 percent for linear tapers with a total resistance up to 1.0 megohm.

Dielectric withstanding voltage - Maximum continuous voltage, 350 volts (RMS) at sea level. Will withstand a one second test of 1000 volts (RMS) at sea level or 500 volts (RMS) at 3.4 inches (86,36) mercury.

Insulation resistance - 1000 megohms minimum for clean and dry conditions at +25° C.

Temperature coefficient — Total resistance change less than ±100 ppm/° C, cermet linear taper.

Temperature characteristics — Maximum percent temporary total resistance change from the +25° C value. See chart below.

Nominal Resistance in Ohms	CP — "U" Linear Taper, ° C							
	−55°	−25°	0°	+25°	+55°	+85°	+100°	+120°
100	−9.0	−6.0	−3.0	0	+3.5	+6.5	+8.0	+10
1K	±5.5	±3.0	±1.5	0	±1.5	±3.0	±4.0	±5.0
10K	+5.0	+3.0	±1.5	0	±2.0	±2.0	±2.5	±3.0
100K	+5.0	+3.0	±1.5	0	±2.0	±2.0	±2.5	±3.0
1.0 Meg.	+6.0	+3.0	±2.0	0	±2.5	±3.0	±4.0	+5.0
Nominal Resistance in Ohms	**HOT MOLDED — "U" Linear Taper, ° C**							
	−55°	−25°	0°	+25°	+55°	+85°	+100°	+120°
100	+ 4.5	+2.5	+1.5	0	±1.0	±1.5	+2.0	+3.5
1K	+ 5.5	+3.0	+1.5	0	±1.0	±2.0	+2.5	+4.5
10K	+ 7.0	+3.5	+2.0	0	±1.0	±2.5	+3.0	+5.5
100K	+ 8.0	+4.0	+2.0	0	±1.5	±3.0	+3.5	+6.0
1.0 Meg.	+10.0	+5.0	+2.5	0	±1.5	±3.5	+5.0	+7.5

For "S", "A", "B" and "DB" tapers multiply percentage figures shown above by 1.25 on Hot-Molded elements.

End resistance —

TAPER	Minimum Resistance Between Terminals: Hot-Molded		CP and Cermet	
	1 & 2	2 & 3	1 & 2	2 & 3
U	1	1	4	4
S	1	1	—	—
A	1	2	4	4
B	2	1	4	4
DB	3	2	—	—

1 Less than 0.004 percent of total resistance or less than 4 ohms, whichever is greater.

2 Less than 1 percent of total resistance or less than 4 ohms, whichever is greater.

3 Less than 4 ohms.

4 Less than 2 ohms.

Taps — A tap is available on hot-molded modules with lug terminals at 50 percent of mechanical rotation. Resistance tolerance ±20 percent. Unless otherwise specified low series tap resistance is provided. See dimensions on Page 149.

Voltage — 350 volts maximum working voltage (RMS or DC), or as determined by Emax. = $\sqrt{PR}$, whichever is less (at sea level).

ATTENUATORS — HOT MOLDED

Series	Bridged-T	L	Bridged-H	Straight-T
70	A	A	A	A
72	A	A	NA	NA
73	A	A	NA	NA

Consult factory for further details

A = Available NA = Not Available

Switches

Rotary Switch – The rotary switch consists of two sets of contacts. See Part Number Explanation for available options. When supplied on the Series 72, the rotary switch must be used with a .250 inch (6,35 mm) diameter shaft.

Push-pull switch – A four pole switch that is operated by a .125 inch (3,18 mm) diameter solid shaft. An inner concentric shaft that operated the push-pull switch only may have a diameter of .125 inch (3,18 mm) or .078 inch (1,98 mm). Shaft lengths are measured from the bushing mounting surface to the free end of the shaft with the shaft in the extended position. Available only on Series 70 and 73.

Momentary push switch – A push-pull switch equipped with a return spring such that the switch will return to the extended position when the actuating force is removed. Available only on Series 70 and 73.

Ambient temperature – −55° C to +100° C.

Life – The switches will be electrically and mechanically operative after operational life test at rated current and voltage with a resistive load, as per switch characteristics below.

Terminals – Switches are available with lug terminals only. They are not available with square terminals. On request, switches will be rotated 90° such that the switch terminals come out the sides of the control instead of the top and bottom.

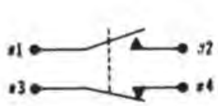
SWITCH PART NUMBER EXPLANATION

Switch Number	Switch Type	Detent At	In Detent	
			Terminals 1 & 2	Terminals 3 & 4
3001	Push-Pull	–	–	–
3002	Momentary Push	–	–	–
1BT1	Rotary	CCW end	Open	Closed
1001				
2BT1	Rotary	CW end	Open	Closed
2001				
1BT3	Rotary	CCW end	Open	Open
1003				
2BT3	Rotary	CW end	Open	Open
2003				

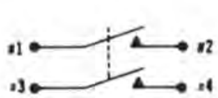
SWITCH CHARACTERISTICS

Switch Type	Voltage In Volts at 60 Hz RMS	Current In Amps	Actuating Force (Initially, 25° C)		Length of Throw		Operational Life In Cycles
			Minimum	Maximum	Shaft Operates Switch & Pot	Shaft Operates Switch Only	
Push-Pull 3001	125	2	7 ounces (1,9 N)	19 ounces (5,3 N)	.125 In. (3,18 mm)	.125 In. (3,18 mm)	25,000
Momentary Push 3002	125	2	20 ounces (5,6 N)	30 ounces (8,3 N)	.125 In. (3,18 mm)	.125 In. (3,18 mm)	25,000
Rotary 1001 1003, 2001, 2003	125	2	–	20 inch-ounces (141 mN-m)	15°	25°	25,000
Rotary 1BT1, 1BT3 2BT1, 2BT3	125	.1	3.5 inch-ounces (24,7 mN-m)	7.5 inch-ounces (53 mN-m)	15°	25°	5,000
	1	.01	3.5 inch-ounces (24,7 mN-m)	7.5 inch-ounces (53 mN-m)	15°	25°	5,000

Rotary Switches

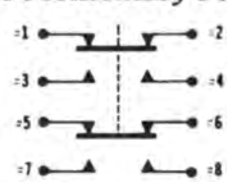


Switch Number
1BT1, 1001, 2BT1 or 2001
Shown in Detent



Switch Number
1BT3, 1003, 2BT3 or 2003
Shown in Detent

Push-Pull or Momentary Push Switch

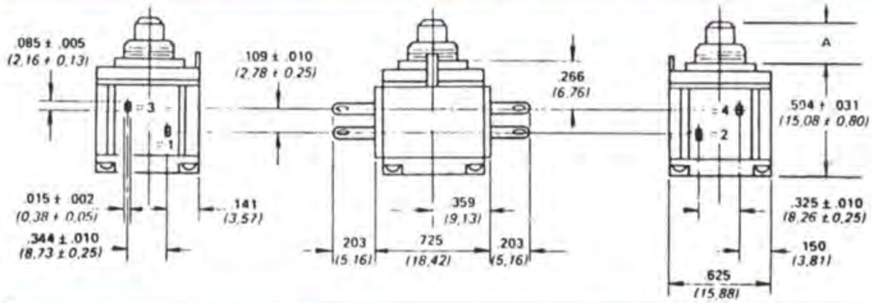


Switch Number
3001 or 3002
With Shaft Extended

DIMENSIONS

Switches and potentiometers — lug terminals

2A



Rotary Switch

Basic dimensions in inches.

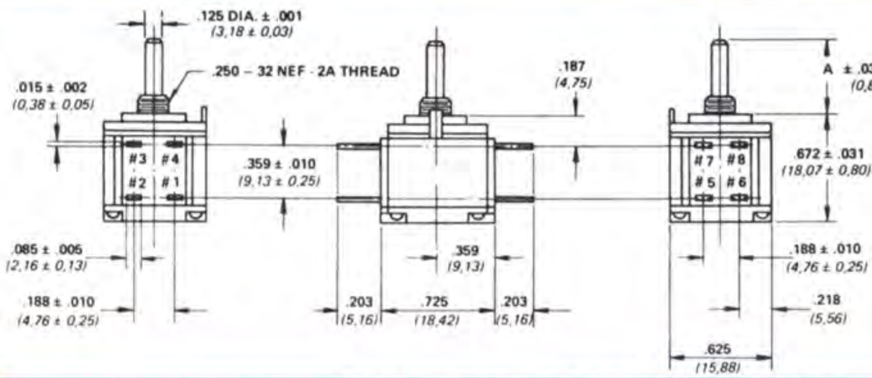
Dimensions in parentheses are in millimeters.

TOLERANCE
Dimensional Tolerance
±.016 (0,40)
Except as Specified

Terminal numbers for reference ONLY.
Module letters for reference ONLY.

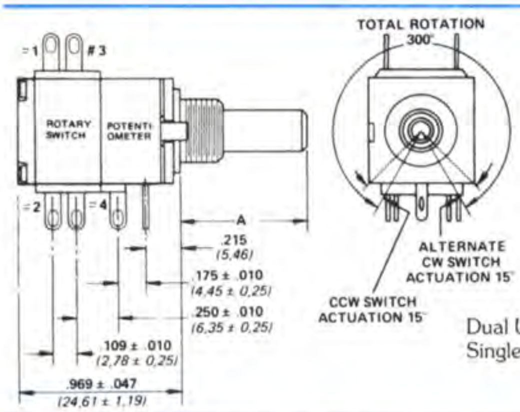
NOT TO SCALE

3A



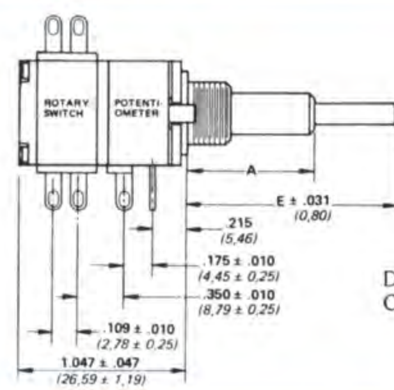
Push-Pull or Momentary Push Switch

5A



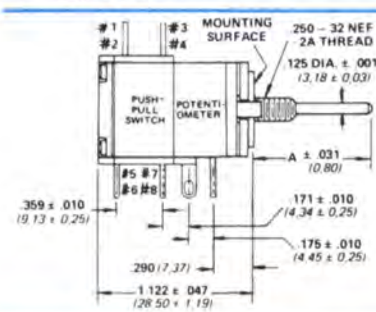
Dual Unit With Single Shaft

9A



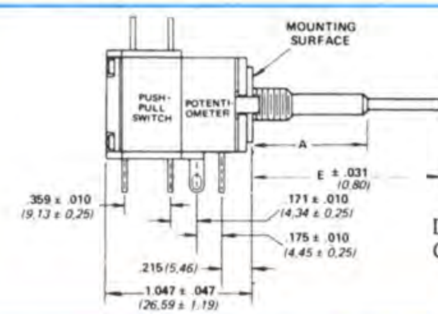
Dual Unit With Concentric Shaft

5B



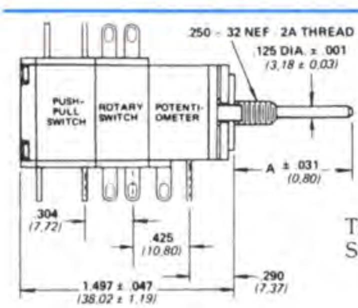
Dual Unit With Single Shaft

8A

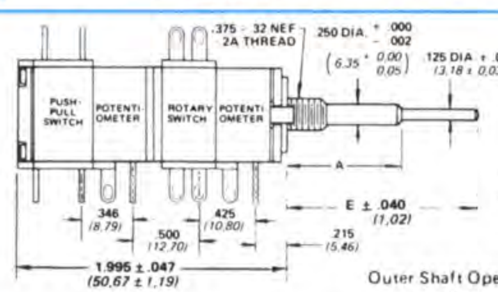


Dual Unit With Concentric Shaft

12C



Triple Unit With Single Shaft



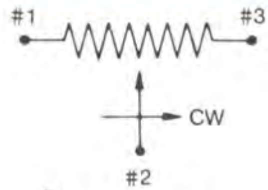
Quad Unit With Concentric Shaft

Outer Shaft Operates Sections #1 and #2

Combination code used for reference to a type of buildup only. This is not a part number.

DIMENSIONS

Potentiometers — lug terminals



Basic dimensions in inches.

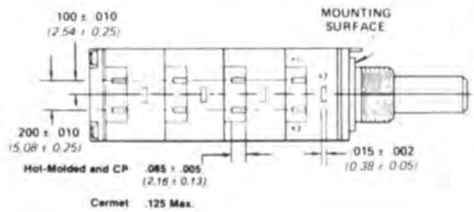
Dimensions shown in ITALICS are in millimeters.

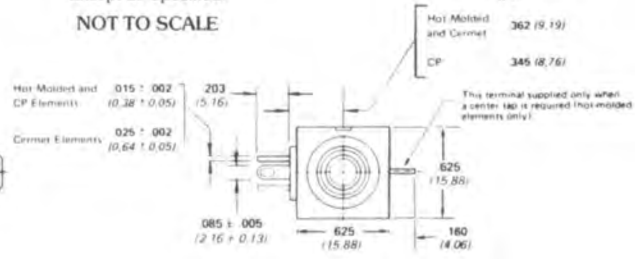
TOLERANCE

Dimensional Tolerance ±.016 (0,40)
Except as Specified.

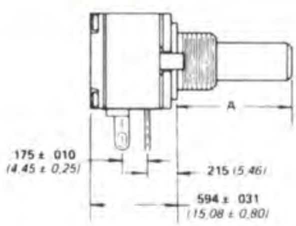
NOT TO SCALE

Terminal numbers for reference only.
Terminal hole size .047 ± .005 x .078 ± .005
(1,19 ± 0,13 x 1,98 ± 0,13)



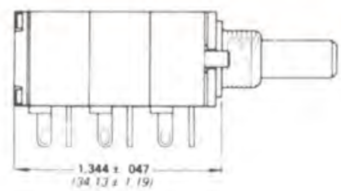


1A



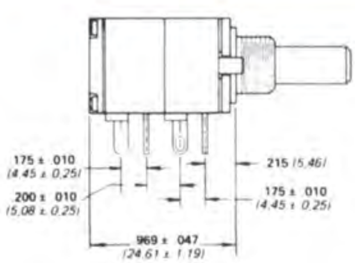
Single Unit
Single Shaft

12A



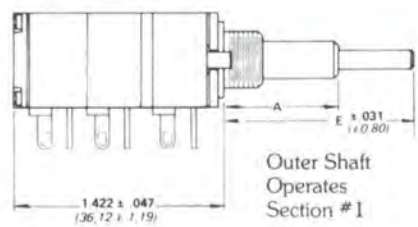
Triple Unit
Single Shaft

4A



Dual Unit
Single Shaft

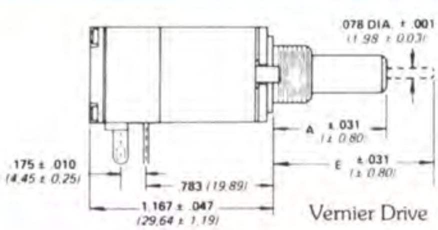
15A



Outer Shaft
Operates
Section #1

Triple Unit
Concentric Shaft

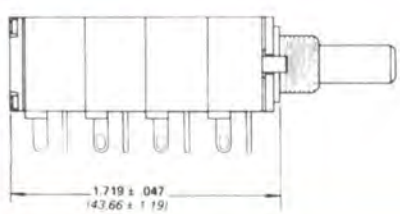
6A
10A



Vernier Drive

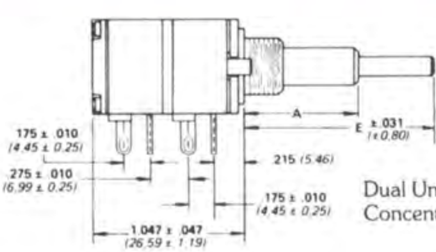
Dual Unit
Concentric or
Single Shaft

23A



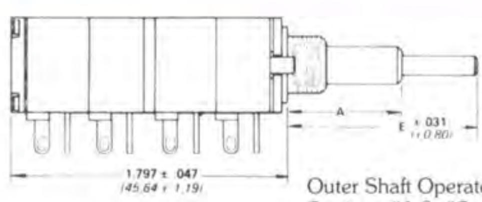
Quad Unit
Single Shaft

7A



Dual Unit
Concentric Shaft

26A



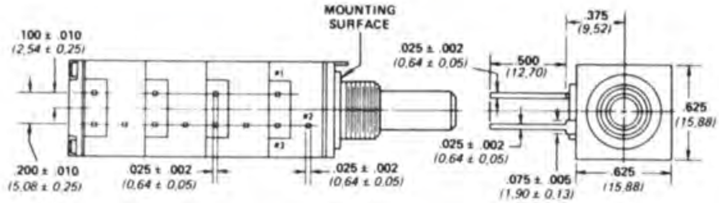
Outer Shaft Operates
Sections #1 & #2

Quad Unit
Concentric Shaft

Combination code used for reference to a type of buildup only. This is not a part number.

DIMENSIONS

Potentiometers — square terminals



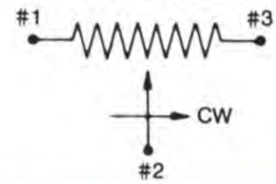
Basic dimensions in inches.

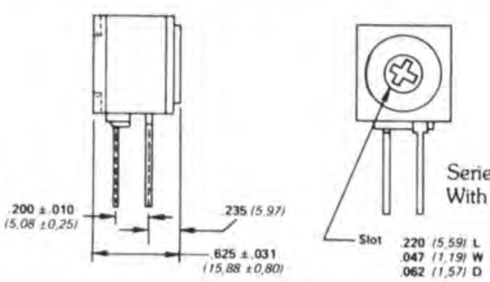
Dimensions shown in ITALICS are in millimeters.

TOLERANCE

Dimensional Tolerance ±.016 (0,40)
Except as Specified.

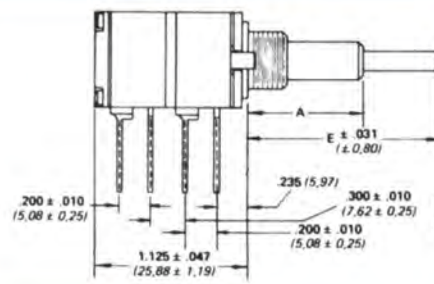
NOT TO SCALE





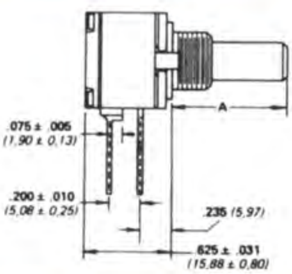
Series 72 Faceplate With Flush Shaft

7A



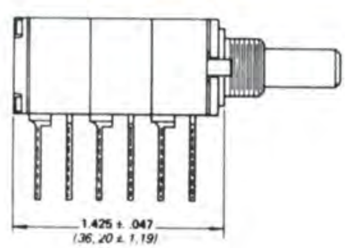
Dual Unit
Concentric Shaft

1A



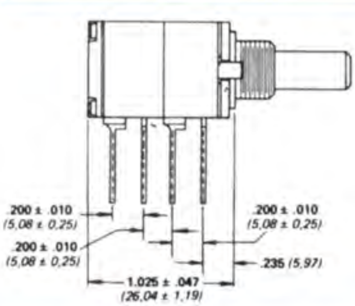
Single Unit
Single Shaft

12A



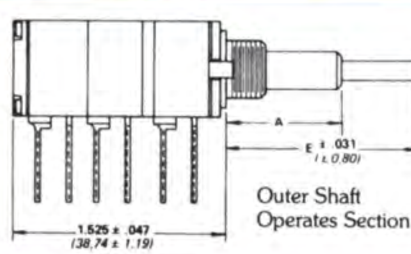
Triple Unit
Single Shaft

4A



Dual Unit
Single Shaft

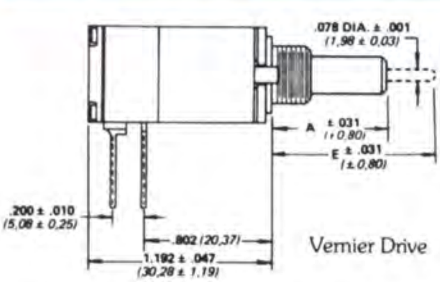
15A



Triple Unit
Concentric Shaft

Outer Shaft
Operates Section #1

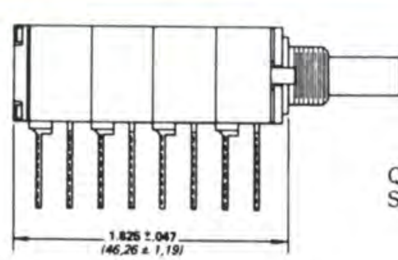
6A 10A



Dual Unit
Concentric or
Single Shaft

Vernier Drive

23A



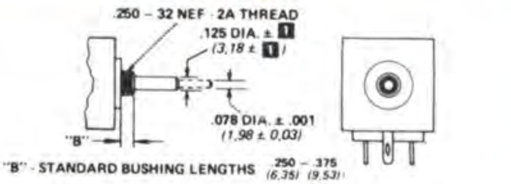
Quad Unit
Single Shaft

Combination code used for reference to a type of buildup only. This is not a part number.

DIMENSIONS

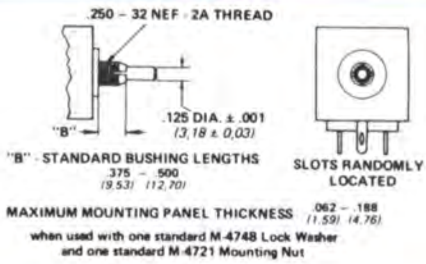
Bushing, shaft and hardware dimensions

.250 (6,35) Diameter Bushings

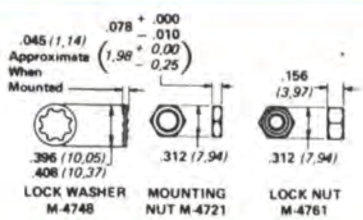


1 Tolerance – Series 70 & 73 ± .001 (± 0,03) – Series 72 + .001 – .003 (+ 0,03 – 0,08)

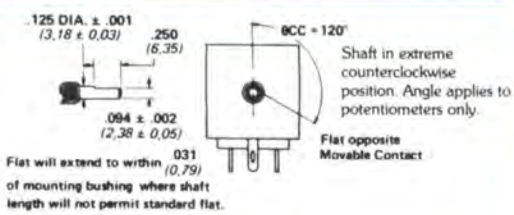
Plain Bushing



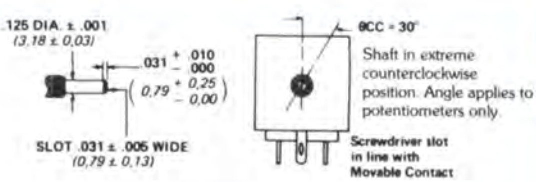
Locking Bushing



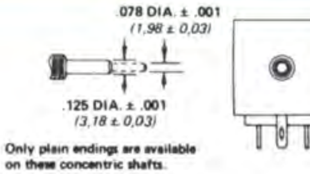
Hardware



Standard Flatted Shaft

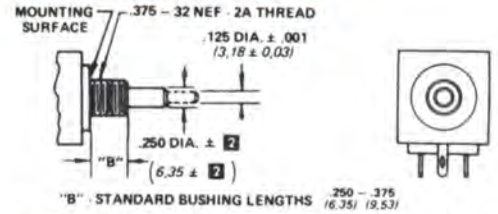


Standard Slotted Shaft



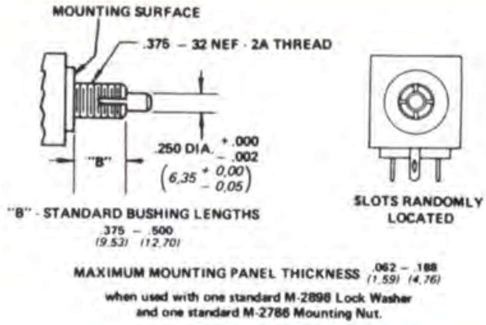
Concentric Shafts - Plain Ending

.375 (9,53) Diameter Bushings

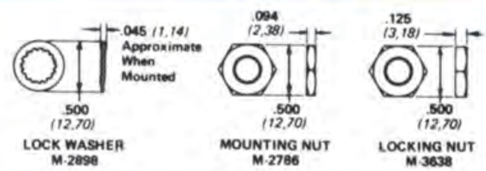


2 Tolerance – Series 70 & 73 + .000 – .002 (+ 0,00 – 0,05) – Series 72 + .001 – .006 (+ 0,03 – 0,15)

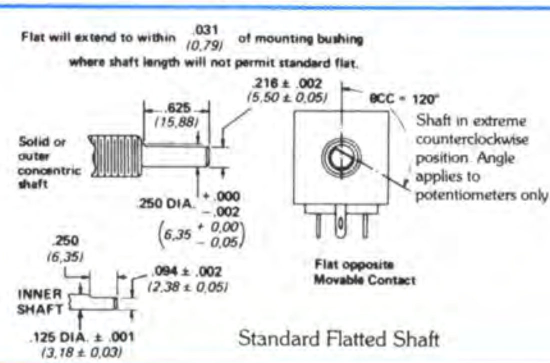
Plain Bushing



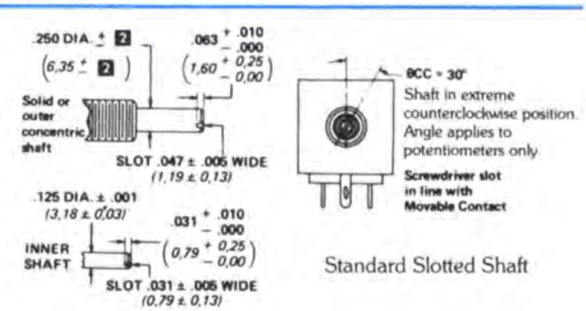
Locking Bushing



Hardware



Standard Flatted Shaft



Standard Slotted Shaft

Basic dimensions in inches.

Dimensions shown in ITALICS are in millimeters.

TOLERANCE

Dimensional Tolerance ±.016 (0,40)
Angular Tolerance ±5°
Except as Specified.

NOT TO SCALE

DIMENSIONS

Locating lug options — Series 70 ■

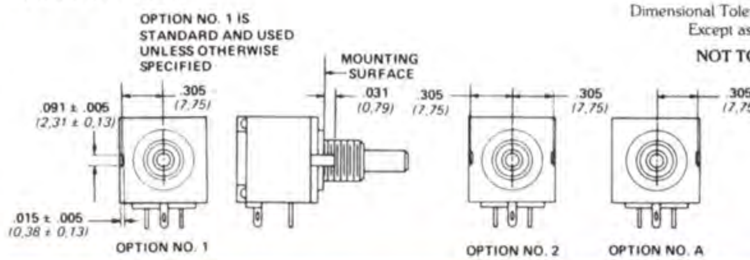
Basic dimensions in inches.
Dimensions shown in ITALICS are in millimeters.

TOLERANCE

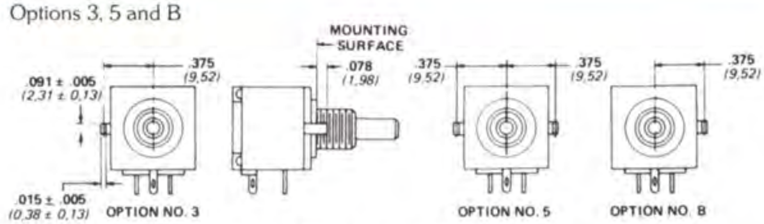
Dimensional Tolerance ± .016 (0.40)
Except as Specified.

NOT TO SCALE

Options 1, 2 and A

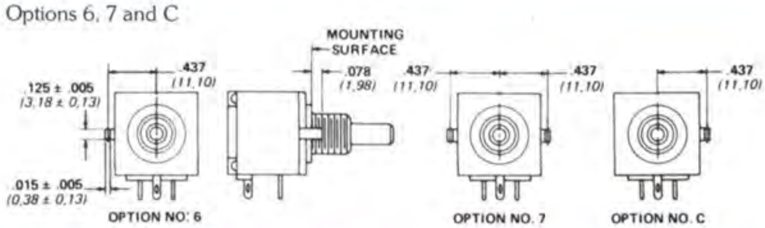


Options 3, 5 and B



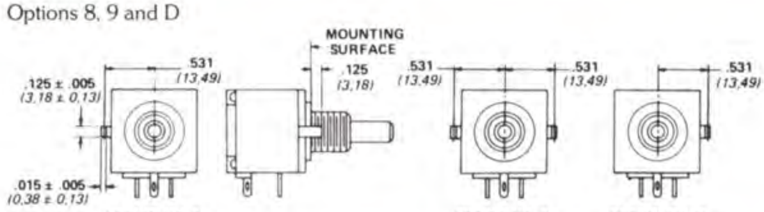
Locating Lugs Compatible With RV5

Options 6, 7 and C



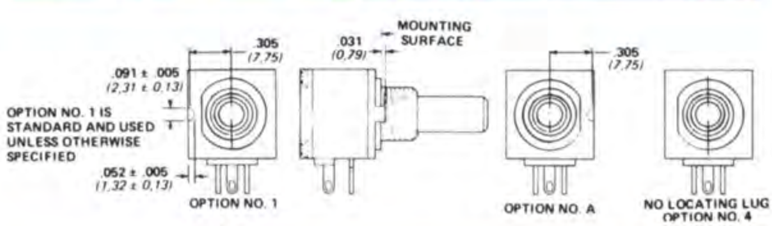
Locating Lugs Compatible With RV2

Options 8, 9 and D



Locating Lugs Compatible With RV4

Locating lug options — Series 72 and 73



Series	Available Lug Options
70 ■	1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D
72	1, 4, A
73	1, 4, A

■ Series 70 Option No. 4: No Locating Lug.

EXPLANATION OF PART NUMBERS

7c A 4 H 032 P253 A

NOTE: Part number format allows for development of some part numbers which cannot be manufactured. (Example: 70A1G400L101A, which has an invalid shaft length and invalid resistance value for an "A" taper.) Check parameter limits in preceding text, when developing a part number.

Combinations which are valid and do not fit into a part number. (Examples: Concentric shafts, push-pull switches, special tapers, etc.) will be assigned a special part number by the factory. Refer to "Ordering Information", below, for the required data for the assignment of a special part number.

70A1G056L501U

Locating Lug Option

1	6	A
2	7	B
3	8	C
4	9	D
5		

Shaft Type and Bushing Diameter

Code Letter	Shaft Type Diameter Inch	Shaft Type Diameter Millimeters	Shaft Type Ending	Bushing Diameter Inch	Bushing Diameter Millimeters
S	.250	(6.35)	Standard Slot	.375	(9.52)
P	.250	(6.35)	Plain Round	.375	(9.52)
F	.250	(6.35)	Standard Flat	.375	(9.52)
L	.125	(3.18)	Standard Slot	.250	(6.35)
R	.125	(3.18)	Plain Round	.250	(6.35)
K	.125	(3.18)	Standard Flat	.250	(6.35)
X	.250	(6.35)	Cross Slot	—	—

Total Resistance Value

First two digits are significant figures and the third indicates the number of zeros following the first two digits —

Examples: 500 = 50 Ohms
501 = 500 Ohms
255 = 2.5 Megohms

25 000

Basic Type

MOD POT®

Series 70
Series 72
Series 73

Configuration Lug Terminals

A – Single (Hot-Molded)
B – Single (Cermet)
J – Single (Conductive Plastic)
C – Dual (Hot-Molded) [1]
D – Dual (Cermet) [1]
T – Dual (Conductive Plastic) [1]
E – Triple (Hot-Molded) [1]
F – Triple (Cermet) [1]
G – Quad (Hot-Molded) [1]
H – Quad (Cermet) [1]
K – Single (Hot-Molded) with Switch 1001
L – Single (Cermet) with Switch 1001

Square Terminals

M – Single (Hot-Molded)
N – Single (Cermet)
U – Single (Conductive Plastic)
P – Dual (Hot-Molded) [1]
R – Dual (Cermet) [1]
W – Dual (Conductive Plastic) [1]

[1] If the electrical specifications are not identical for each section, a special number will be assigned.

Bushing Type and Length

F – Face Plate
G – Plain .250 Inch (6.35 mm) long
N – Plain .375 Inch (9.52 mm) long
H – Plain .500 inch (12.70 mm) long
M – Locking .375 inch (9.52 mm) long
L – Locking .500 inch (12.70 mm) long

Shaft Length

Measured from mounting surface of the potentiometer in inches and sixty-fourths.

Use a three digit code

Examples:

7/8" shaft length: 056 — inches 0, sixty-fourths 56/64 = 7/8"

1-1/4 shaft length: 116 — one inch, 16/64 or 1/4 inch

Some Common Shaft Lengths

Inches Fraction	Inches Decimal	Three Digit Part Number Code
1/4	.250	016
3/8	.375	024
7/16	.437	028
1/2	.500	032
5/8	.625	040
3/4	.750	048
7/8	.875	056
1	1.000	100
1-1/8	1.125	108
1-1/4	1.250	116
1-1/2	1.500	132
2	2.000	200

Taper Type and Total Resistance Tolerance

CERMET

W – Linear (U), ±10%

HOT-MOLDED OR CONDUCTIVE PLASTIC

U – Linear (U), ±10%
M – Linear (U), ±20%
A – Clockwise Modified Logarithmic (A), ±10%
R – Clockwise Modified Logarithmic (A), ±20%
B – Counterclockwise Modified Logarithmic (B), ±10%
T – Counterclockwise Modified Logarithmic (B), ±20%

HOT-MOLDED

D – Clockwise Exact Logarithmic (DB), ±10%
K – Clockwise Exact Logarithmic (DB), ±20%
S – Modified Linear (S), ±10%
Y – Modified Linear (S), ±20%
C – Linear (U), ±10% with 50% (center) Tap
F – Linear (U), ±20% with 50% (center) Tap

Attenuator Type and Characteristic Impedance Tolerance

HOT-MOLDED

E – Attenuator L-Pad ±15%
L – Attenuator L-Pad ±20%
N – Attenuator Bridged T-Pad ±15%
P – Attenuator Bridged T-Pad ±20%

Ordering information

1. Basic type (Series 70, Series 72 or Series 73).
2. Type of element (cermet, hot-molded or conductive plastic [CP]).
3. Type of terminals (resistor element only).
4. Number of sections.
5. Taper (each element on multi-section controls).
6. Total resistance value (each element on multi-section controls) in ohms.
7. Tolerance (each element on multi-section controls) percent.
8. Bushing type (plain or locking).
9. Bushing length in inches or millimeters.
10. Bushing diameter .375 inch (9.52 mm) or .250 inch (6.35 mm).
11. Shaft ending (plain, slotted or flatted).
12. Shaft length from mounting surface in inches or millimeters.
13. Switch type.
14. Vernier drive.
15. Locating lug option.
16. Mounting hardware (A-B standard or other).
17. Your part number, if any.
18. Marking required on the part.
19. Special features.

1/4

Types **G, J, W**

Hot-Molded Panel Potentiometers

SPECIFICATION MIL-R-94 PART NUMBER EXPLANATION

The following is an explanation of the part numbers used to identify Specification MIL-R-94 Variable Resistors. Part number format does not allow for exclusion of invalid mechanical and/or electrical combinations.

Example of Complete Designation:

Style *(Table 1)*	**Bushing Type and Length** *(Table 2)*	**Switch** *(Table 3)*	**Temperature and Moisture Resistance Characteristic** *(Table 4)*	**Shaft Ending** *(Table 5)*	**Shaft Length** *(Table 6)*	**Resistance Value** *(Table 7)*	**Taper Type and Total Resistance Tolerance** *(Table 8)*
RV4	N	A	Y	S	D	102	A
RV6	N	A	Y	S	D	102	A
2RV7	N	■1	Y	S	D	■2	A

Table 1 — Style

MIL-R-94 Style	Allen-Bradley Type
RV4	J
RV6	G or W
2RV7	J (Dual)

Table 2 — Bushing Type and Length

Bushing Type	RV4 Length	RV6 Length	2RV7 Length
N	Plain $\frac{3}{8}$ in.	Plain $\frac{1}{4}$ in.	Plain $\frac{3}{8}$ in.
L	Locking $\frac{1}{2}$ in.	Locking $\frac{1}{2}$ in.	Locking $\frac{1}{2}$ in.
S	Shaft and Panel — Sealed (non-locking) $\frac{3}{8}$ in.	Shaft and Panel — Sealed (non-locking) $\frac{1}{4}$ in.	Shaft and Panel — Sealed (non-locking) $\frac{3}{8}$ in.
T	N/A	Shaft and Panel — Sealed (locking) $\frac{1}{2}$ in.	N/A

Table 3 — Switch

Switch	RV4	RV6	2RV7
'A'	No Switch	No Switch	■1
'B'	SPST Switch	N/A	■1

Table 4 — Temperature and Moisture Resistance Characteristics

Temperature and Moisture Resistance Characteristics	RV4	RV6	2RV7
Symbol	Y	Y	Y

Table 5 — Shaft Ending

Shaft Ending	RV4	RV6	2RV7
S	Slotted	Slotted	Slotted

■1 Not shown in part number for 2RV7.

■2 Dual units — two resistance values shown in this space for 2RV7. (Example: 102 102).

Table 6 — Shaft Length

Shaft Length Symbol	RV4 ■ Bushings N and S	RV4 ■ Bushing L	RV6 ■ Bushings N and S	RV6 ■ Bushings L and T	2RV7 ■ Bushings N and S	2RV7 ■ Bushing L
A----	N/A	⅝ in.	⅝ in.	⅝ in.	N/A	⅝ in.
B----	½ in.	N/A	N/A	N/A	½ in.	N/A
D----	⅞ in.	⅞ in.	⅞ in.	⅞ in.	⅞ in.	⅞ in.
G----	1¼ in.	N/A	N/A	N/A	1¼ in.	N/A
J ----	2 in.	N/A	N/A	N/A	2 in.	N/A
K----	2½ in.	N/A	N/A	N/A	2½ in.	N/A
L ----	N/A	N/A	⅜ in.	N/A	N/A	N/A
N----	1½ in.	N/A	N/A	N/A	1½ in.	N/A

■ Shafts are measured from mounting surface to end of shaft.

Table 8 — Taper Type and Total Resistance Tolerance

Symbol	Total Resistance Tolerance %	RV4 Taper	Allen-Bradley Taper	RV6 Taper	Allen-Bradley Taper	2RV7 Taper	Allen-Bradley Taper
A	± 10	A	U	A	U	A	U
B	± 20	A	U	A	U	N/A	N/A
C	± 10	C	A	C	A	N/A	N/A
D	± 20	C	A	C	A	N/A	N/A
E	± 10	F	B	F	B	N/A	N/A
F	± 20	F	B	F	B	N/A	N/A

INCHES ⟷ METRIC CONVERSION TABLE

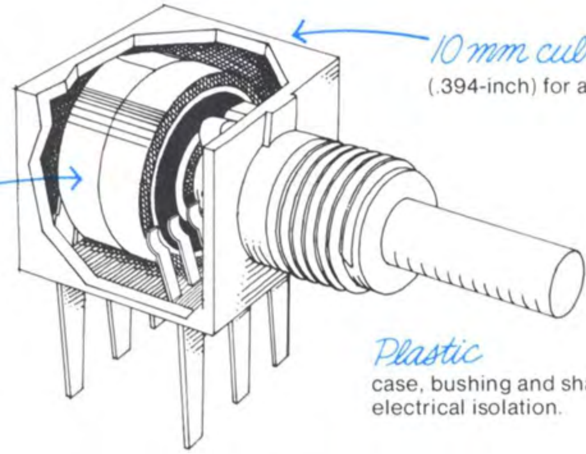
INCHES		MM	INCHES		MM
¼	.250	6,35	1	1.000	25,40
⅜	.375	9,52	1¼	1.250	31,75
½	.500	12,70	1½	1.500	38,10
⅝	.625	15,88	2	2.000	50,80
¾	.750	19,05	2½	2.500	63,50
⅞	.875	22,22			

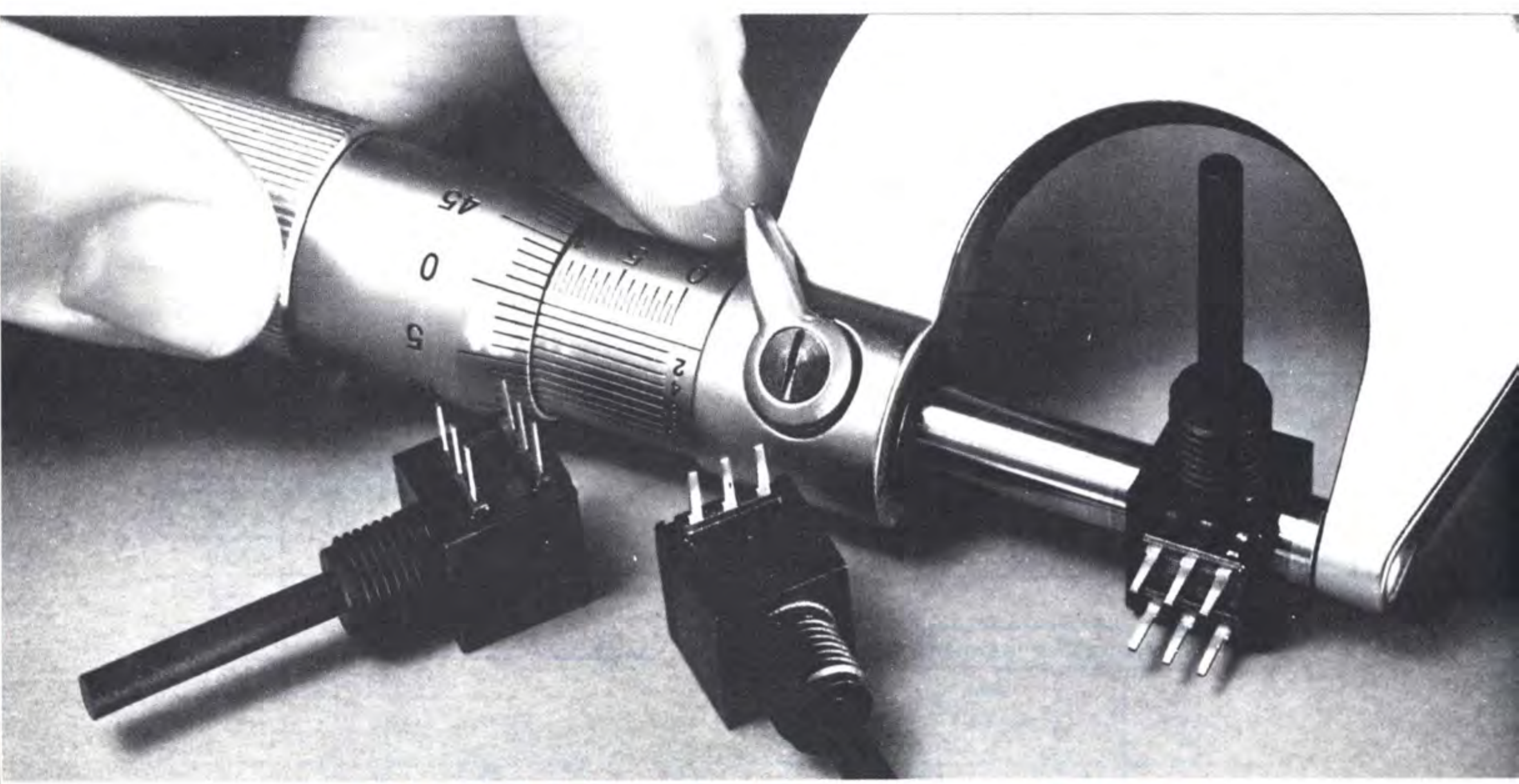
Table 7 — Resistance Values

Resistance Symbol	RV4 Resistance Value (Ohms)	RV6 Resistance Value (Ohms)	2RV7 Resistance Value (Ohms)
500	50	—	50
101	100	100	100
151	150	—	150
201	200	200	200
251	250	250	250
351	350	—	350
501	500	500	500
751	750	—	750
102	1K	1K	1K
152	1.5K	—	1.5K
202	2K	2K	2K
252	2.5K	2.5K	2.5K
352	3.5K	—	3.5K
502	5K	5K	5K
752	7.5K	—	7.5K
103	10K	10K	10K
153	15K	—	15K
203	20K	20K	20K
253	25K	25K	25K
353	35K	—	35K
503	50K	50K	50K
753	75K	—	75K
104	100K	100K	100K
154	150K	—	150K
204	200K	200K	200K
254	250K	250K	250K
354	350K	—	350K
504	500K	500K	500K
754	750K	—	750K
	Megohms	Megohms	Megohms
105	1.0	1.0	1.0
155	1.5	—	1.5
205	2.0	2.0	2.0
255	2.5	2.5	2.5
355	3.5	—	3.5
505	5.0	5.0	5.0

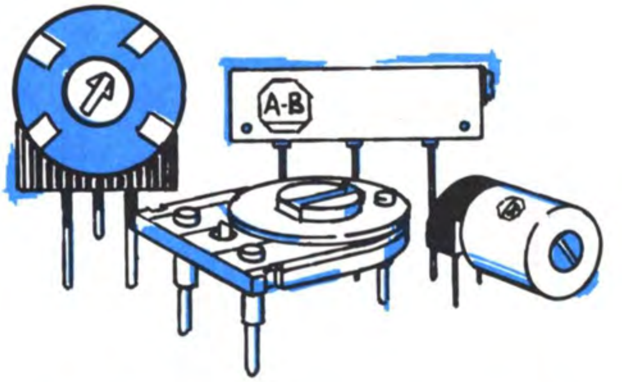
The one variable the world can standardize on.

Our new Type M conductive plastic variable resistor is hard metric. A 10 mm cube that's tiny, flexible and rugged. The MINI-METRIC is the smallest dual pot available today. Manufactured in the United States, it's dimensioned the way the rest of the world thinks. Allen-Bradley has what you need; or, it can be ordered through our distributors. Ask for Publication EC5610-2.1.





Quality in the best tradition.



trimming potentiometers

CERMET

HOT-MOLDED COMPOSITION

A-B QUALITY

trimming potentiometers

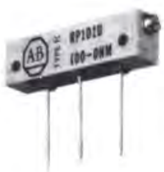
trimming potentiometers

comprehensive product index

■ Suited for adjustable attenuator applications. Details in adjustable attenuator section.

trimming potentiometers

TYPE 90:
Cermet, single turn, 0.5W at 70° C, 1.0W at 40° C, 100 ohms to 2 megs, ±20%, pin terminals, top and side adjustment, linear taper.



TYPE R:
Hot-molded composition, 25 turns, 0.25W at 70° C, 100 ohms to 2.5 megs, ±10% and ±20%, pin or solder lug terminals, linear taper.

TYPE FD:
Dual version of Type F; front section: solder lug only, rear section: pin or lug. Well suited for Bridged-T or L-pad attenuator applications.

TYPE S:
Cermet, single turn, 0.5W at 85° C, 50 ohms to 1 meg. ±10%, pin terminals, top and side adjustment, linear taper.

TYPE N:
Hot-molded composition 25 turns, 0.33W at 50° C, 100 ohms to 2.5 megs, ±10% and ±20%, pin terminals, linear taper.

TYPE BT:
An all plastic version of the Type FD for excellent performance at high frequencies. Two terminal configurations avaialble. Also well suited for Bridged-T or L-pad attenuator applications.

TYPE F:
Hot-molded composition, single turn, 0.25W at 70° C, 100 ohms to 5 megs, ±10% and ±20%, pin or solder lug terminals, top and side adjustment, 5 standard tapers.

TYPE Y:
Hot-molded composition, single turn, 0.25W at 50° C, 100 ohms to 5 megs, ±10% and ±20%, pin or solder lug terminals, 5 types, top and side adjustment, 5 standard tapers.

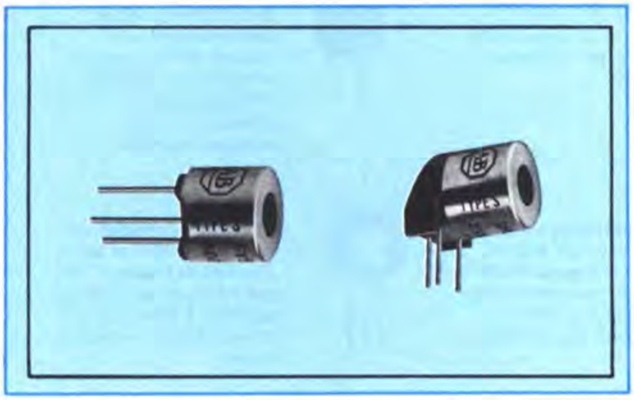
SELECTOR GUIDE

Type	Publication Number	Resistance Element and Adjustment Turns	Resistance Range and Tolerance	Power	Voltage Rating (RMS or DC)	Operating Temperature Range	Terminal Types	Case Dimensions in Inches (millimeters)	Enclosure	Page Number
90	EC5770-2.1	Cermet Single Turn	100 Ohms to 2 Megohms ±20%	0.5 Watt at 70° C 1.0 Watt at 40° C	200V	−55° C to +125° C	Pin	L 0.466 (11,9) W 0.393 (10,0) D 0.228 (5,8)	Open Frame	163
S	EC5720-2.1		50 Ohms to 1 Megohm ±10%	0.5 Watt at 85° C	300V	−65° C to +150° C		0.375 (9,52) Diameter by 0.375 (9,52)	Immersion Sealed	160
N	EC5815-2.1	Composition Multi-Turn	100 Ohms to 2.5 Megohms ±10%, ±20%	0.33 Watt at 50° C		−55° C to +100° C		L 1.250 (31,75) H 0.359 (9,13) W 0.250 (6,35)		170
R	EC5820-2.1			0.25 Watt at 70° C		−55° C to +125° C	Pin or Solder Lug			173
F	EC5806-2.1	Composition Single Turn	100 Ohms to 5 Megohms ±10%, ±20%	0.25 Watt at 70° C	350V	−55° C to +120° C	Pin or Solder Lug	0.500 (12,70) Diameter by 0.531 (13,49)		166
FD	EC5838-2.1						Front: Lug Rear: Lug or Pin	0.500 (12,70) Diameter by 0.688 (17,46)		181
BT	EC5920-2.1			Consult Factory		−40° C to +120° C	Front: 3 Lugs Rear: 3 Pins or Front: 2 Pins Rear: 2 Pins	0.500 (12,70) Diameter by 0.535 (13,59)	Dust and Splash Resistant	192
Y	EC5828-2.1			0.25 Watt at 50° C	350V	−55° C to +100° C	Pin or Solder Lug	0.500 (12,70) Diameter by 0.359 (9,13)	Dust and Splash Resistant	177

Type S

Cermet Trimming Potentiometers

0.5 Watt (85°C)
3/8 (0.375) Inch (9,52 mm) Diameter
50 Ohms to 1.0 Megohm



FEATURES

- TCR<±100ppm/°C
- Cermet Single Turn
- Horizontal or Vertical Mounting
- Multi-Fingered Wiper
- Immersion Sealed
- ±10% or ±5% Tolerance

SPECIFICATIONS

General

Temperature range — −65°C to +150°C.

Total resistance values — 50 ohms to 1.0 megohm. EIA and IEC resistance values available as shown on the following pages.

Total resistance tolerances — ±10 percent standard. ±5% available on request.

Taper — Standard linear. Other tapers, consult factory.

End resistance — Less than 5 ohms at both ends.

Electrical

Power — 0.5 watt at +85°C, derate to zero at +150°C.

Power derating — Linearly with actuator position for rheostat usage.

Voltage — 300 volts RMS maximum within power rating limits.

Dielectric withstanding voltage — 750 volts at sea level for one second.

Insulation resistance — 1000 meghoms minimum.

Operational

Contact resistance variation — Typically less than 3 percent of total resistance or 3 ohms, whichever is greater.

Load life — 1000 hours at +85°C, 3 percent maximum change in total resistance.

Rotational life — 1000 cycles, 5 percent maximum change in total resistance.

Mechanical

Rotation — 280° ±10° stop to stop.

Turning torque — 0.5 to 6.0 inch-ounces (0,036 to 0,44 kgf-cm).

Stop torque — 25 inch-ounces (1,8 kgf-cm) minimum.

Construction — Immersion sealed per MIL-R-22097.

Terminals — Solderable per method 208, MIL-STD-202.

Weight — Approximately 0.05 ounce (1,3 gm).

Marking — Allen-Bradley part number and nominal total resistance are marked in two lines. Other marking possible, limited to a maximum of 13 characters in each of two lines. A-B monogram plus "Type S" always included.

AVAILABLE FROM STOCK AT ELECTRONIC DISTRIBUTORS.

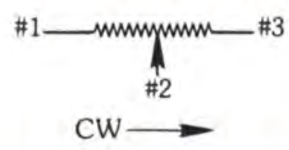
Cermet Trimming Potentiometers

Environmental

PARAMETER	MAXIMUM CHANGE	TEST METHOD
Vibration	2% Total Resistance 2% Setting Stability	Method 204, Cond. D, MIL-STD-202
Shock	2% Total Resistance 2% Setting Stability	Method 213, Cond. I, MIL-STD-202
Moisture Resistance	2% Total Resistance	Method 106, MIL-STD-202
Corrosion Resistance	96 Hour Test	Method 101, MIL-STD-202 (200 Hrs.)
Effect of Soldering	1% Total Resistance	MIL-R-22097 (5 Sec., 0.062 Inch)
High Temperature Exposure	3% Total Resistance	MIL-R-22097 (1000 Hrs. at 150°C)
Low Temperature Operation	2% Total Resistance	MIL-R-22097 (−65°C)
Thermal Shock	3% Total Resistance	Method 107, MIL-STD-202
Temperature Coefficient	±100 ppm/°C Max.	Method 304, MIL-STD-202

Note: Unless otherwise specified, Terms, Definitions, and Test Procedures are in accordance with Variable Resistive Components Institute Standards vrci-t-110 and vrci-t-215.

Resistor Connections



DIMENSIONS

Vertical adjustment

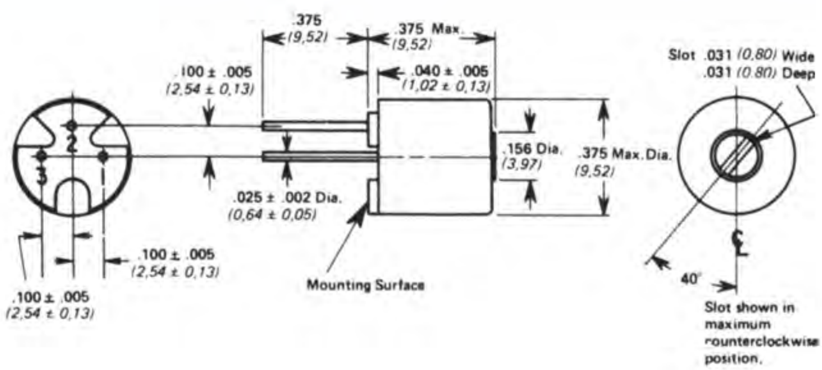
TYPE SV

Basic dimensions in inches.

Dimensions shown in parentheses are in millimeters.

TOLERANCES
Dimensional tolerance ±.016 (0,40)
Angular tolerance ±5°
Except as specified.

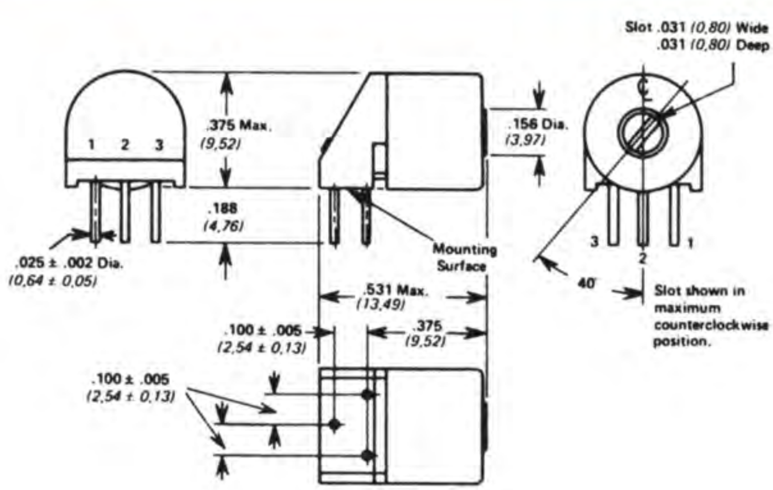
NOT TO SCALE



DIMENSIONS

Horizontal adjustment

TYPE SH



EXPLANATION OF PART NUMBERS

SH 1031

Basic Types

SV — Vertical Adjustment
SH — Horizontal Adjustment

Total Resistance Value

First two digits are significant figures and the third indicates the number of zeros following the first two digits —

Example: 101 = 100 Ohms
501 = 500 Ohms
105 = 1 Megohm

Tolerances

5 = ± 5%
1 = ± 10%

TOTAL RESISTANCE VALUES AND TOLERANCE

OHMS ±10%							
50	200	750	2.5K	10K	50K	200K	750K
75	250	1K	5K	20K	75K	250K	1 Meg.
100	500	2K	7.5K	25K	100K	500K	

IEC STANDARD RESISTANCE VALUES AVAILABLE BY SPECIAL ORDER

	220	2.2K	22K	220K
47	470	4.7K	47K	470K

For other values consult factory.

Type 90 Cermet Trimming Potentiometers

1.0 Watt (40°C) 0.5 Watt (70°C)

0.467 Inch (11,9 mm) by
0.393 Inch (10,0 mm)

100 Ohms to 2.0 Megohms

FEATURES

- TCR ±100 ppm/°C
- Cermet Single Turn
- Horizontal or Vertical Mounting
- Open Frame
- ±20% Tolerance

SPECIFICATIONS

General

Temperature range — −55°C to +125°C.

Total resistance values — 100 ohms to 2.0 megohms. EIA and IEC resistance values available as shown on page 165.

Total resistance tolerances — ±20 percent standard. Other tolerances available. Consult factory.

Taper — Standard linear taper.

End resistance — Less than 2 ohms at both ends.

Electrical

Power — 1.0 watt maximum at +40°C or 0.5 watt maximum at +70°C provided voltage rating is not exceeded.

Power derating — Derate power linearly from +70°C to zero at +125°C. For rheostat applications derate directly with shaft or actuator position.

Voltage — 200 volts maximum working voltage (RMS or DC), or as determined by $E_{max.} = \sqrt{PR}$, whichever is less (at sea level).

Slider current — 100 mA (RMS or DC) maximum provided power rating is not exceeded.

Operational

Contact resistance variation — Less than 3 percent of nominal resistance value, or 5 ohms, whichever is greater (MIL-R-22097 Pg. 4.6.4).

Load life — 2 percent maximum change in total resistance as a result of a 1000 hour test at rated power across entire element in still air at +70°C (1.5 hours "ON," 0.5 hour "OFF").

Rotational life — 3 percent maximum change in total resistance as a result of 200 cycles.

Mechanical

Rotation — 270° mechanical; 220° electrical.

Turning torque — 4 inch-ounces (28,2 mNm) maximum at +25°C.

Stop torque — 8 inch-ounces (56,0 mNm) minimum.

Terminals — Pin type on 0.100 inch (2,54 mm) grid system for printed boards. Adequate strength for mounting without additional support.

Construction — Cermet element in an open type construction. The actuator is electrically connected to the number 2 terminal.

Weight — Less than 0.042 ounce (1,2 gm).

Marking — A-B monogram plus resistance value.

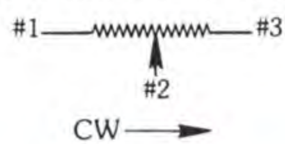
AVAILABLE FROM STOCK AT ELECTRONIC DISTRIBUTORS.

Cermet Trimming Potentiometers

Environmental

PARAMETER	MAXIMUM CHANGE	TEST METHOD
Vibration	1% Total Resistance 2% Setting Stability	IEC 68-2-6 (Procedure B4, 10 to 500 Hz, 10G)
Bump	1% Total Resistance 2% Setting Stability	IEC 68-2-29 (4000 bumps, 40G)
Damp Heat	3% Total Resistance	IEC 68-2-3
Solderability	1% Total Resistance	IEC 68-2-20, Test T
Effect of Soldering	1% Total Resistance	IEC 68-2-20, Test T
High Temperature Exposure	3% Total Resistance	(+125°C for 1000 hours without load)
Thermal Shock	1% Total Resistance	(5 cycles at −55°C to +125°C)
Temperature Coefficient	±100 ppm/°C	

Resistor Connections



DIMENSIONS

Top adjustment

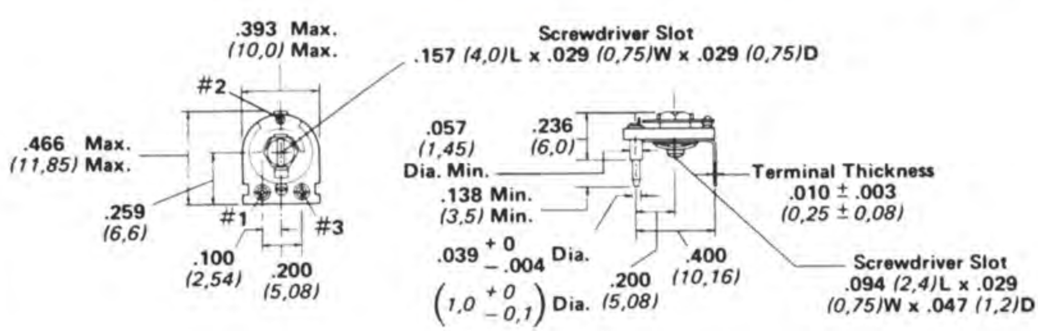
Basic dimensions in inches.

Dimensions shown in parentheses are in millimeters.

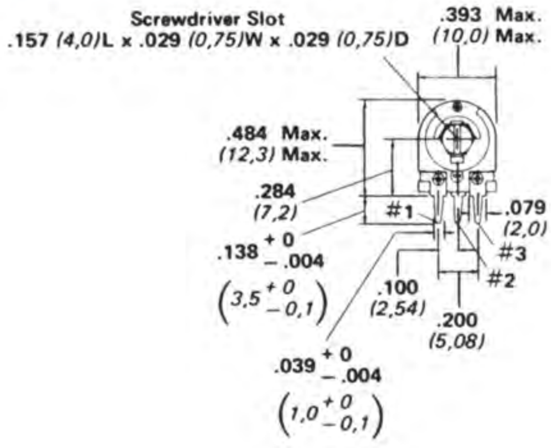
TOLERANCE
Dimensional tolerance ±.010 (0,25)
Except as specified.

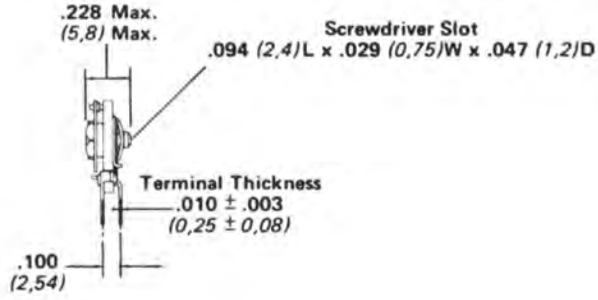
NOT TO SCALE

TYPE 90H



TYPE 90V





EXPLANATION OF PART NUMBERS

Resistance Value (Ohms)	Top Adjustment	Side Adjustment
100	90H1012	90V1012
200	90H2012	90V2012
500	90H5012	90V5012
1000	90H1022	90V1022
2000	90H2022	90V2022
5000	90H5022	90V5022
10K	90H1032	90V1032
20K	90H2032	90V2032
50K	90H5032	90V5032
100K	90H1042	90V1042
200K	90H2042	90V2042
500K	90H5042	90V5042
1 Meg.	90H1052	90V1052
2 Meg.	90H2052	90V2052

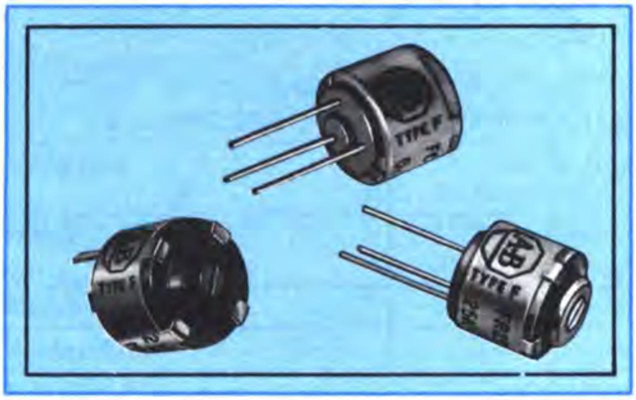
IEC RESISTANCE VALUES AVAILABLE BY SPECIAL ORDER

OHMS ±20%			
220	2.2K	22K	220K
470	4.7K	47K	470K

For other values consult factory.

Type F

Hot-Molded Trimming Potentiometers



0.25 Watt (70°C)
1/2 (0.50) Inch (12,70 mm) Diameter
100 Ohms to 5.0 Megohms

FEATURES

- Hot-Molded Single Turn
- Pin or Solder Lug Terminals
- Horizontal or Vertical Mounting
- Immersion Sealed
- ±20% or ±10% Tolerance

SPECIFICATIONS

General

Temperature range — −55°C to +120°C.

Total resistance values — 100 ohms to 5.0 megohms. EIA and IEC standard resistance values available as shown on Page 168. Other than preferred values are also available.

Total resistance tolerances — ±20% or ±10%.

Tapers — Available in the following resistance ranges:

TAPER	TOTAL RESISTANCE RANGE
U	100 Ohms to 5.0 Megohms
A, B, S, & DB	500 Ohms to 2.5 Megohms

See chart on Page 168 for explanation of tapers.

End resistance — At both ends less than one percent of total resistance or "less than 15 ohms," whichever is greater.

Electrical

Power — 0.25 watt maximum at +70°C for "U" linear taper, provided voltage rating is not exceeded.

Power derating — Derate power linearly from +70°C wattage to zero at +120°C. Derate 50 percent for "A" "B", "S", or "DB" tapers. For rheostat applications derate directly with shaft or actuator position.

Voltage — 350 volts maximum working voltage within power rating limits.

Dielectric withstanding voltage — 750 volts at sea level for one second.

Insulation resistance — 1000 megohms minimum.

Voltage characteristic — 0.005 percent per volt or 0.5 ohm, whichever is greater.

Operational

Contact resistance variation — Less than 3 percent of nominal total resistance value.

Load life — 10 percent maximum change in total resistance as a result of 1000 hour test at rated power across entire element in still air at +70°C. (1.5 hour "ON" — 0.5 hour "OFF.")

Rotational life — 10 percent maximum change in total resistance as a result of 5000 cycles under load.

Mechanical

Rotation — 295° ±5°.

Turning torque — 0.25 to 3.0 inch-ounces (0,018 to 0,216 kgf-cm) at +25°C.

Stop torque — Will withstand greater than 10 inch-ounces (0,72 kgf-cm) shaft torque. (Mechanical specifications continued on Page 167.)

Hot-Molded Trimming Potentiometers

Mechanical

Backlash — Maximum of 3°.

Construction — Materials essentially non-magnetic. Enclosure is immersion sealed. Terminals are treated for easy soldering.

Weight — Approximately 7 grams.

Marking — Allen-Bradley part number and nominal total resistance are marked in two lines. Other marking possible limited to two lines. On types FR, FC, FP and FM space permits 16 characters per line. On types FH and FS space permits 8 characters per line. A-B monogram plus "Type F" always included.

Environmental

PARAMETER	MAXIMUM CHANGE	TEST METHOD
Vibration	2% Total Resistance 5% Setting Stability	Method 204, Cond. C, MIL-STD-202
Shock	2% Total Resistance 5% Setting Stability	Method 213, Cond. I, MIL-STD-202
Moisture Resistance	10% Total Resistance	Method 106, MIL-STD-202
Effect of Soldering	2% Total Resistance	MIL-R-94, Par. 4.6.6
Low Temperature Storage	2% Total Resistance	MIL-R-94, Par. 4.6.11
Low Temperature Operation	2% Total Resistance	MIL-R-94, Par. 4.6.12
Temperature Cycling	3% Total Resistance	MIL-R-94, Par. 4.6.13

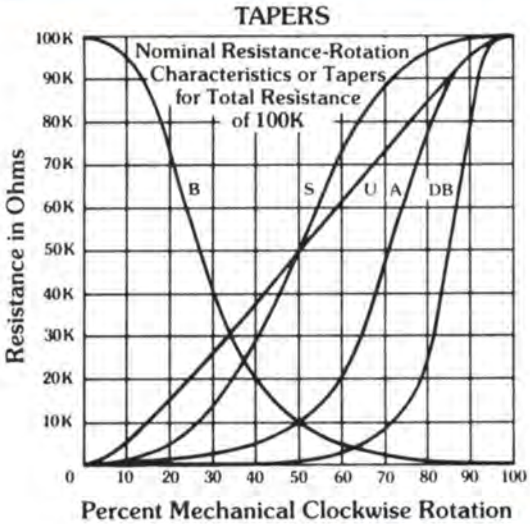
NOTE: Unless otherwise specified, Terms, Definitions and Test Procedures are in accordance with Variable Resistive Components Institute Standards vrci-t-110 and vrci-215. Maximum environmental change is specified as 2 ohms on resistive values where 2 ohms exceeds the specified percentage change.

Temperature characteristics — Maximum percent temporary total resistance change from the +25°C value.

Nominal Resistance	Degrees Celsius						
	−55°	−25°	0°	+25°	+55°	+85°	+120°
100 Ohms	+ 4.5	+2.5	+1.5	0	± 1.0	± 1.5	+ 3.5
1000 Ohms	+ 5.5	+3.0	+1.5	0	± 1.0	± 2.0	+ 4.5
10,000 Ohms	+ 7.0	+3.5	+2.0	0	± 1.0	± 2.5	+ 5.5
100,000 Ohms	+ 8.0	+4.0	+2.0	0	± 1.5	± 3.0	+ 6.0
1 Megohm	+10.0	+5.0	+2.5	0	± 1.5	± 3.5	+ 7.5

For "S", "B" and "DB" tapers multiply percentage figures shown above by 1.25.

Taper data

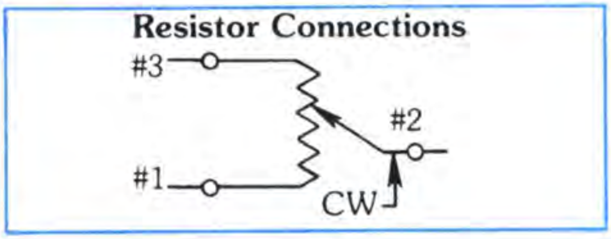


IEC RESISTANCE VALUES AVAILABLE BY SPECIAL ORDER

OHMS ±10% — ±20%				
220 470	2.2K 4.7K	22K 47K	220K 470K	2.2M

PREFERRED NOMINAL VALUES IN OHMS

100	1K	10K	100K	1.0 Meg.
200	2K	20K	200K	2.0 Meg.
250	2.5K	25K	250K	2.5 Meg.
500	5K	50K	500K	5.0 Meg.

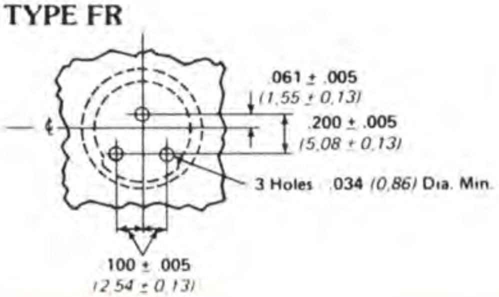


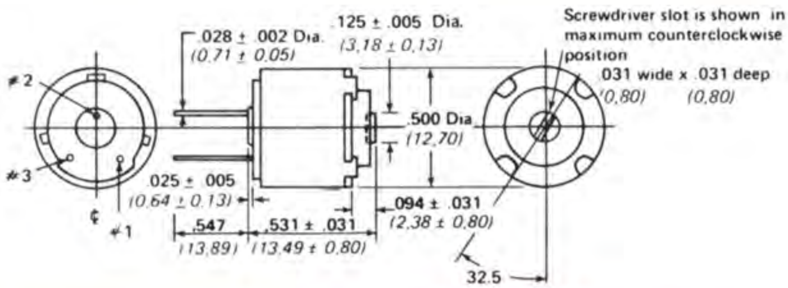
DIMENSIONS

Basic dimensions in inches.
Dimensions shown in parentheses are in millimeters.
Terminal spacing determined at mounting surface.

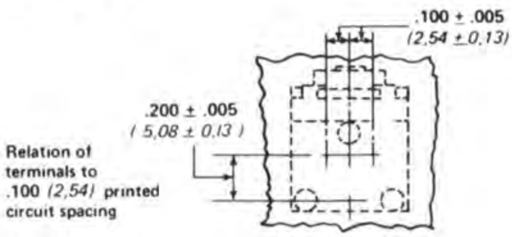
TOLERANCES
Dimensional tolerance ±.016 (0,40).
Angular tolerance ±5°.
Except as specified.
NOT TO SCALE

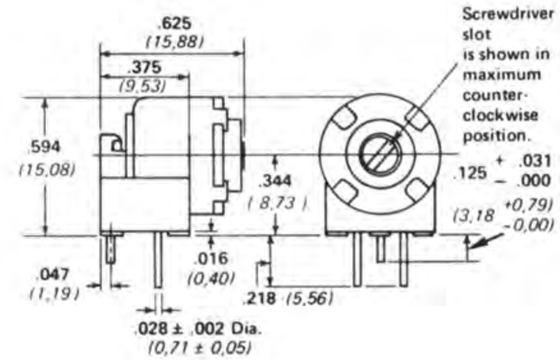
TYPE FC
TYPE FR





TYPE FH
TYPE FS

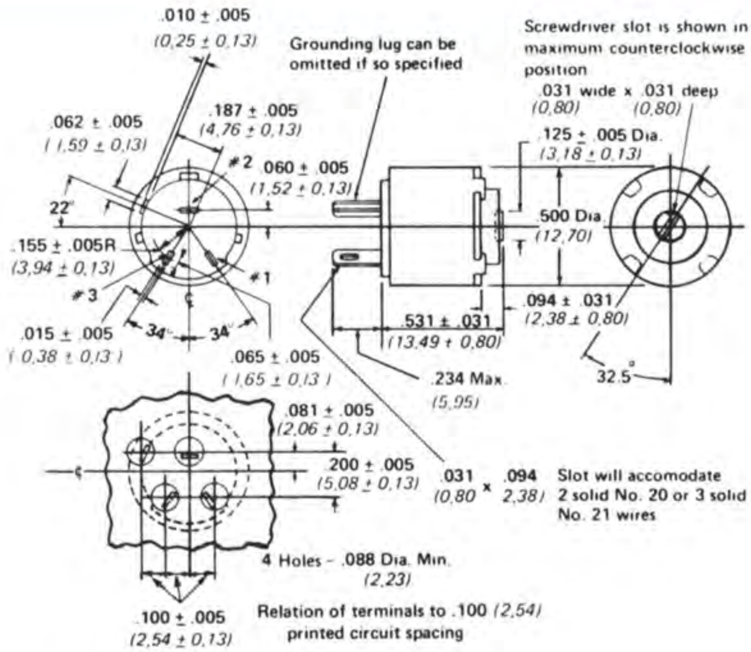




Hot-Molded Trimming Potentiometers

DIMENSIONS

TYPE FM
TYPE FP



EXPLANATION OF PART NUMBERS

FR102U

Basic Type

- ■ **FR** — Pin terminals — plastic shaft.
- **FH** — Pin terminals — plastic shaft, — horizontal mounting.
- **FC** — Pin terminals — metal shaft.
- **FS** — Pin terminals — metal shaft, — horizontal mounting.
- **FP** — Lug terminals — plastic shaft.
- **FM** — Lug terminals — metal shaft.

Total Resistance Value

First two digits are significant figures and the third indicates the number of zeros following the first two digits —

Examples: 101 = 100 Ohms
501 = 500 Ohms
255 = 2.5 Megohms

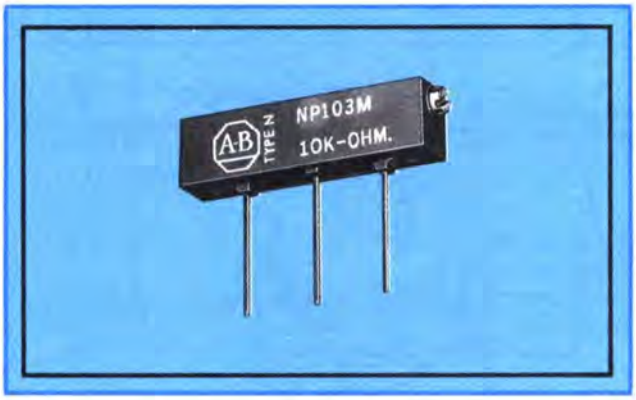
Taper Type and Total Resistance Tolerance

- **U** — Linear (U), ±10%
- **M** — Linear (U), ±20%
- **A** — Clockwise Modified Logarithmic (A), ±10%
- **R** — Clockwise Modified Logarithmic (A), ±20%
- **B** — Counterclockwise Modified Logarithmic (B), ±10%
- **T** — Counterclockwise Modified Logarithmic (B), ±20%
- **D** — Clockwise Exact Logarithmic (DB), ±10%
- **K** — Clockwise Exact Logarithmic (DB), ±20%
- **S** — Modified Linear (S), ±10%
- **Y** — Modified Linear (S), ±20%

■ AVAILABLE, IN STANDARD VALUES, FROM STOCK AT ELECTRONIC DISTRIBUTORS.

Type N Hot-Molded Trimming Potentiometers

0.33 Watt (50°C)
1-1/4 (1.25) Inch (31,75 mm) Long Rectangular
100 Ohms to 2.5 Megohms



FEATURES

- Hot-Molded Multi-Turn
- Pin Terminals
- 25 Turns
- Immersion Sealed
- ±10% or ±20% Tolerance

SPECIFICATIONS

General

Temperature range — −55°C to +100°C.

Total resistance values — 100 ohms to 2.5 megohms. EIA and IEC resistance values available as shown on page 172.

Total resistance tolerances — ±10 percent or ±20 percent.

End resistance — At both ends less than .004 percent of total resistance or "less than 20 ohms," whichever is greater.

Taper — Standard "U" linear taper.

Electrical

Power — 0.33 watt maximum at +50°C provided voltage rating is not exceeded.

Power derating — Linearly with actuator position for rheostat usage.

Voltage — 300 volts RMS maximum within power rating limits.

Dielectric withstanding voltage — 700 volts at sea level for one second.

Insulation resistance — 1000 megohms minimum.

Operational

Contact resistance variation — Less than 2 percent of total resistance or 2 ohms, whichever is greater.

Load life — 10 percent maximum change in total resistance and 2 percent maximum change in setting stability as a result of a 1000 hour test at rated power across entire element in still air at +70°C. (1.5 hour "ON" — 0.5 hour "OFF.")

Rotational life — 5 percent maximum change in total resistance as a result of 500 cycles (25,000 turns of actuator) under load.

Mechanical

Number of turns — 25±3 turns. Mechanical release at end positions. Resistance between terminals 1 and 2 increases with clockwise rotation.

Turning torque — 0.10 to 8 inch-ounces (0,007 to 0,58 kgf-cm) at +25°C.

Construction — Materials are corrosion resistant and essentially non-magnetic. Enclosure is immersion sealed. Terminals are treated for easy soldering.

Weight — Approximately 3 grams.

Marking — Allen-Bradley part number and nominal total resistance are marked in two lines. Other marking possible, limited to maximum of 10 characters in each of two lines. A-B monogram plus "Type N" always included.

AVAILABLE, IN STANDARD VALUES, FROM STOCK AT ELECTRONIC DISTRIBUTORS.

Hot-Molded Trimming Potentiometers

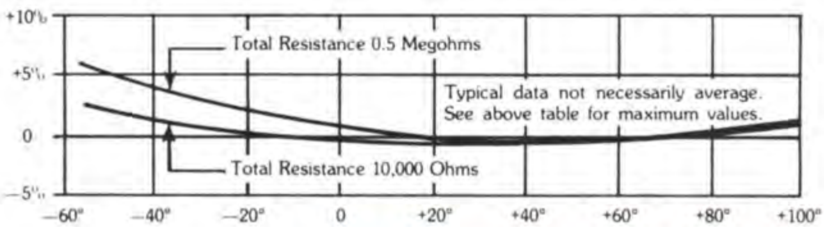
Environmental

PARAMETER	MAXIMUM CHANGE	TEST METHOD
Vibration	3% Total Resistance 3% Setting Stability	EIA Standard RS-186B, Method 7, Type 1 and Method 8, Type 1
Shock	2% Total Resistance 2% Setting Stability	Method 213, Cond. I, MIL-STD-202
Humidity	10% Total Resistance	Method 1, EIA Standard RS-186B
Corrosion Resistance	96 Hour Test	Method 5, EIA Standard RS-186B
Effect of Soldering	2% Total Resistance	MIL-R-22097
High Temperature Exposure	12% Total Resistance 2% Setting Stability	1,000 Hrs. at +100°C
Low Temperature Operation	2% Total Resistance 2% Setting Stability	MIL-R-22097
Temperature Cycling	3% Total Resistance 2% Setting Stability	Method 107, Cond. B, MIL-STD-202

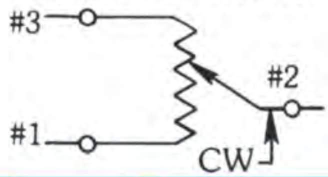
NOTE: Unless otherwise specified, Terms, Definitions and Test Procedures are in accordance with Variable Resistive Components Institute Standards vrci-t-110 and vrci-215. Maximum environmental change is specified as 2 ohms on resistive values where 2 ohms exceeds the specified percentage change.

Temperature characteristics — Maximum percent temporary total resistance change from the +25°C value.

Nominal Resistance	Degrees Celsius						
	−55°	−25°	0°	+25°	+55°	+85°	+100°
100 Ohms	+ 4.5	+2.5	+1.5	0	± 1.0	± 1.5	+ 2.0
1000 Ohms	+ 5.5	+3.0	+1.5	0	± 1.0	± 2.0	+ 2.5
10,000 Ohms	+ 7.0	+3.5	+2.0	0	± 1.0	± 2.5	+ 2.7
100,000 Ohms	+ 8.0	+4.0	+2.0	0	± 1.5	± 3.0	+ 3.2
1 Megohm	+10.0	+5.0	+2.5	0	± 1.5	± 3.5	+ 4.0



Resistor Connections

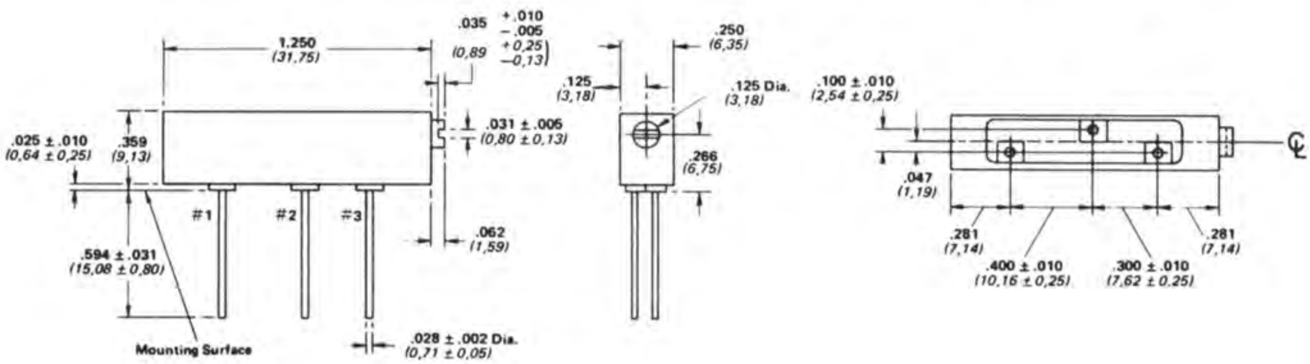


DIMENSIONS

Basic dimensions in inches.
Dimensions shown in parentheses are in millimeters.
Terminal spacing determined at mounting surface.

TOLERANCE
Dimensional tolerance ±.016 (0,40).
Except as specified.

NOT TO SCALE



EXPLANATION OF PART NUMBERS

Resistance Value (Ohms)	Pin Terminals Tolerance ±10%	Pin Terminals Tolerance ±20%
100	NP101U	NP101M
200	NP201U	NP201M
250	NP251U	NP251M
500	NP501U	NP501M
1K	NP102U	NP102M
2K	NP202U	NP202M
2.5K	NP252U	NP252M
5K	NP502U	NP502M
10K	NP103U	NP103M
20K	NP203U	NP203M
25K	NP253U	NP253M
50K	NP503U	NP503M
100K	NP104U	NP104M
200K	NP204U	NP204M
250K	NP254U	NP254M
500K	NP504U	NP504M
1.0 Meg.	NP105U	NP105M
2.0 Meg.	NP205U	NP205M
2.5 Meg.	NP255U	NP255M

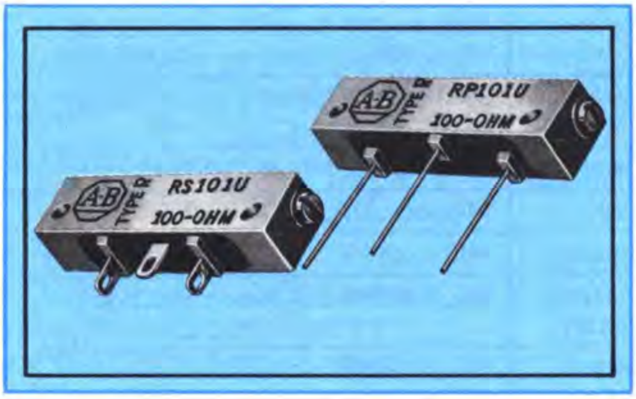
IEC RESISTANCE VALUES AVAILABLE BY SPECIAL ORDER

OHMS ±10% — ±20%				
220 470	2.2K 4.7K	22K 47K	220K 470K	2.2M

For other values consult factory.

Type R

Hot-Molded Trimming Potentiometers



0.25 Watt (70°C)

1-1/4 (1.25) Inch (31,75 mm) Long Rectangular

100 Ohms to 2.5 Megohms

FEATURES

- Hot-Molded Multi-Turn
- Pin or Lug Terminals
- 25 Turns
- Immersion Sealed
- ±10% or ±20% Tolerance

SPECIFICATIONS

General

Temperature range — −55°C to +125°C.

Total resistance values — 100 ohms to 2.5 megohms. EIA and IEC resistance values available as shown on page 176.

Total resistance tolerances — ±10 percent or ±20 percent.

End resistance — At both ends less than .004 percent of total resistance or "less than 20 ohms," whichever is greater.

Applicable military specification — Many of the Type RS trimming potentiometers can be ordered as Style RJ11 of MIL-R-22097.

Electrical

Power — 0.25 watt maximum at +70°C, derate to zero at +125°C.

Power derating — Linearly with actuator position for rheostat usage.

Voltage — 300 volts RMS maximum within power rating limits.

Dielectric withstanding voltage — 900 volts at sea level for one second.

Insulation resistance — 1000 megohms minimum.

Operational

Contact resistance variation — Less than 2 percent of nominal total resistance value.

Load life — 10 percent maximum change in total resistance and 2 percent maximum change in setting stability as a result of a 1000 hour test at rated power across entire element in still air at +70°C. (1.5 hour "ON" — 0.5 hour "OFF.")

Rotational life — 5 percent maximum change in total resistance as a result of 500 cycles (25,000 turns of actuator) under load.

Mechanical

Number of turns — 25±3 turns. Mechanical release at end positions. Resistance between terminals 1 and 2 increases with clockwise rotation.

Turning torque — 0.10 to 8 inch-ounces (0,007 to 0,58 kgf-cm) at +25°C.

Construction — Materials are corrosion resistant and essentially non-magnetic. Enclosure is immersion sealed. Terminals are treated for easy soldering.

Weight — Approximately 3 grams.

Marking — Allen-Bradley part number and nominal total resistance are marked in two lines. Other marking possible, limited to maximum of 9 characters in the first line and 8 characters in the second line. A-B monogram plus "Type R" always included.

Hot-Molded Trimming Potentiometers

Environmental

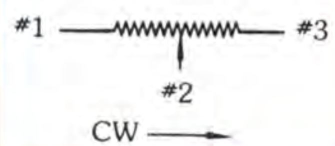
PARAMETER	MAXIMUM CHANGE	TEST METHOD
Vibration	2% Total Resistance 2% Setting Stability	Method 204, Cond. D, MIL-STD-202 (Type RK is Tested per Method 201)
Shock	2% Total Resistance 2% Setting Stability	Method 213, Cond. I, MIL-STD-202
Moisture Resistance	10% Total Resistance	Method 106, MIL-STD-202
Corrosion Resistance	96 Hour Test	Method 101A, MIL-STD-202
Effect of Soldering	2% Total Resistance	MIL-R-22097
High Temperature Exposure	12% Total Resistance 2% Setting Stability	MIL-R-22097 (250 Hrs. at +125°C)
Low Temperature Operation	2% Total Resistance 2% Setting Stability	MIL-R-22097
Temperature Cycling	3% Total Resistance 2% Setting Stability	Method 107, Cond. B, MIL-STD-202

NOTE: Unless otherwise specified, Terms, Definitions and Test Procedures are in accordance with Variable Resistive Components Institute Standards vrci-110 and vrci-215. Maximum environmental change is specified as 2 ohms on resistive values where 2 ohms exceeds the specified percentage change.

Temperature characteristics — Maximum percent temporary total resistance change from the +25°C value.

Nominal Resistance	Degrees Celsius						
	−55°	−25°	0°	+25°	+55°	+85°	+125°
100 Ohms	+ 4.5	+2.5	+1.5	0	±1.0	±1.5	+4.0
1000 Ohms	+ 5.5	+3.0	+1.5	0	±1.0	±2.0	+4.5
10,000 Ohms	+ 7.0	+3.5	+2.0	0	±1.0	±2.5	+5.5
100,000 Ohms	+ 8.0	+4.0	+2.0	0	±1.5	±3.0	+6.5
1 Megohm	+10.0	+5.0	+2.5	0	±1.5	±3.5	+8.0

Resistor Connections

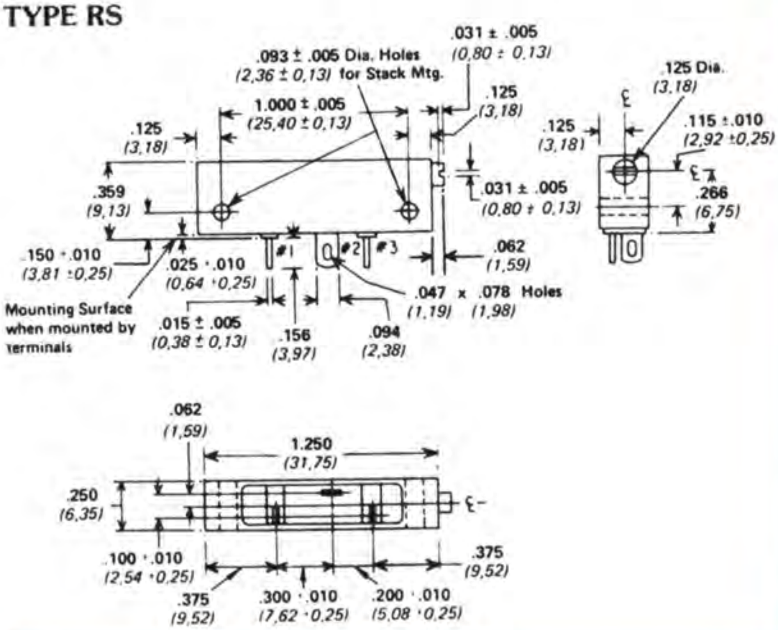


DIMENSIONS

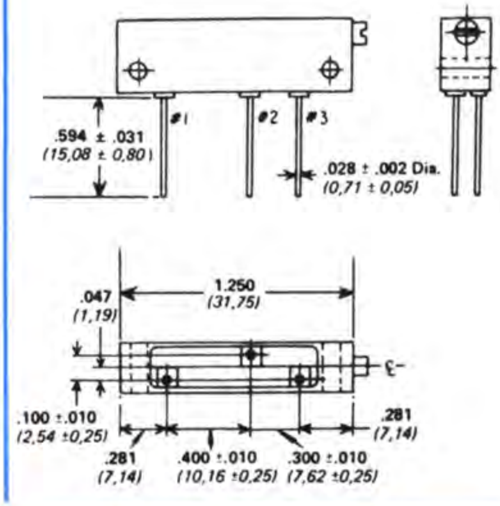
Basic dimensions in inches.
Dimensions shown in parentheses are in millimeters.
Terminal spacing determined at mounting surface.

TOLERANCE
Dimensional tolerance ±.016 (0,40).
Except as specified.
NOT TO SCALE

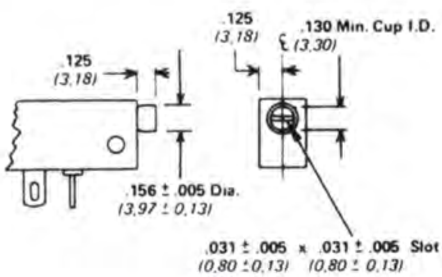
TYPE RS



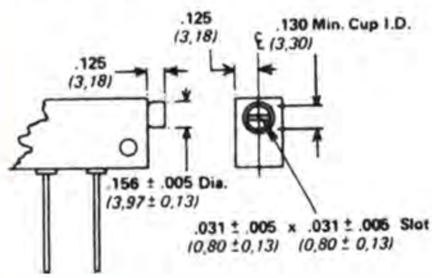
TYPE RP



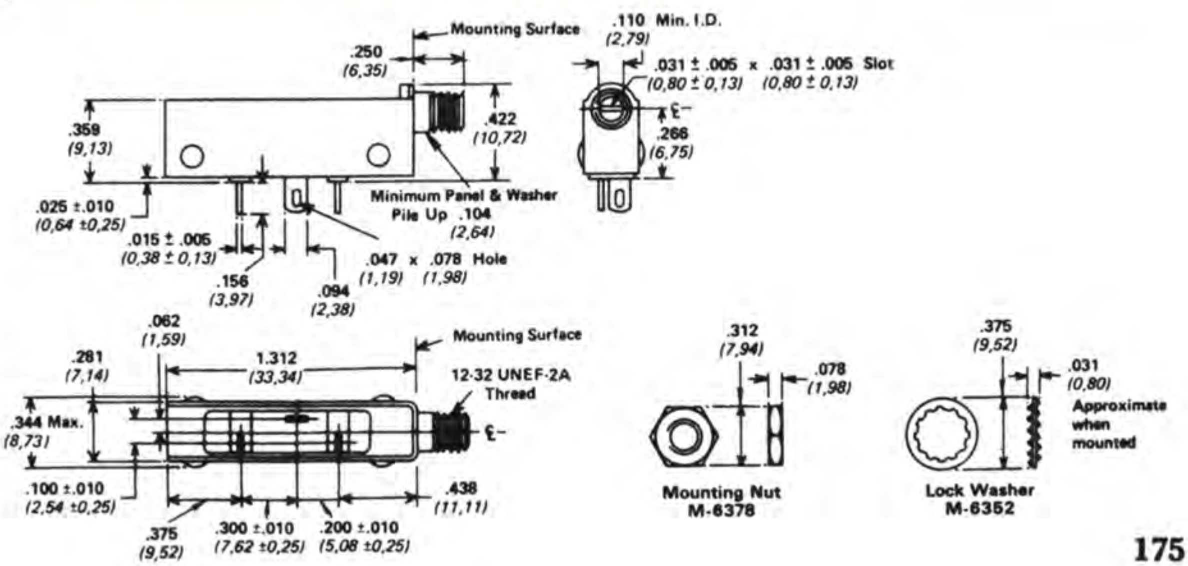
TYPE RC



TYPE RH



TYPE RK



Mounting Nut
M-6378

Lock Washer
M-6352

Hot-Molded Trimming Potentiometers

EXPLANATION OF PART NUMBERS

RS501M

Basic Type

- ■ **RS** — Lug Terminals
- ■ **RP** — Pin Terminals
- **RC** — Lug Terminals and cup-washer housing actuator
- **RH** — Pin Terminals and cup-washer housing actuator
- **RK** — Lug Terminals — panel mounting with 0.250 inch (6,35mm) long bushing

Total Resistance Tolerance

U — 10%
M — 20%

Resistance Value

First two digits are significant figures and the third indicates the number of zeros following the first two digits —

Examples: 501 = 500 Ohms
255 = 2.5 Megohms

TOTAL RESISTANCE VALUES AND TOLERANCE

OHMS ±10% - ±20%				
100 200 250 500	1K 2K 2.5K 5K	10K 20K 25K 50K	100K 200K 250K 500K	1.0 Meg. 2.0 Meg. 2.5 Meg.

IEC RESISTANCE VALUES AVAILABLE BY SPECIAL ORDER

OHMS ±10% - ±20%				
220 470	2.2K 4.7K	22K 47K	220K 470K	2.2M

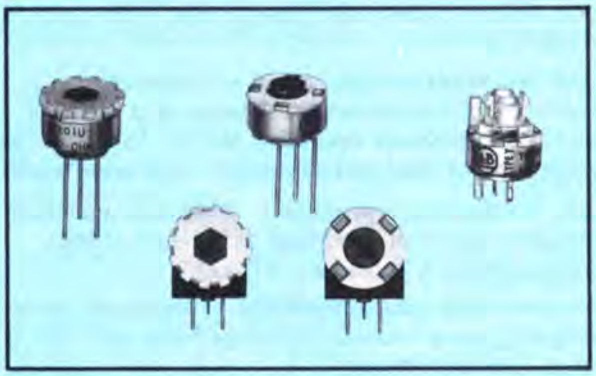
For other values consult factory.

■ AVAILABLE, IN 10% TOLERANCE AND STANDARD VALUES, FROM STOCK AT ELECTRONIC DISTRIBUTORS.

Type Y

Hot-Molded Trimming Potentiometers

0.25 Watt (50° C)
1/2 (0.50) Inch (12,70 mm) Diameter
100 Ohms to 5.0 Megohms



FEATURES

- Single Turn
- Pin or Solder Lug Terminals
- Thumbwheel or Screwdriver Adjustment
- Horizontal or Vertical Mounting
- ± 20% or ± 10% Tolerance

SPECIFICATIONS

General

Temperature range — −55° C to +100° C.

Total resistance values — Preferred nominal values listed below. Other values available.

OHMS

100	1K	10K	100K	1 Meg.
200	2K	20K	200K	2 Meg.
250	2.5K	25K	250K	2.5 Meg.
500	5K	50K	500K	5 Meg.

Total resistance tolerances — ± 20% or ± 10%.

Tapers — **(Resistance — rotation characteristics)** — Available in the following resistance ranges:

TAPER	TOTAL RESISTANCE RANGE
U	100 Ohms to 5.0 Megohms
A, B, S, & DB	500 Ohms to 2.5 Megohms

See chart on following pages for explanation of tapers. Special tapers, where practical, can be supplied.

End resistance — See chart on following pages.

Electrical

Power — 0.25 watt maximum for "U" linear taper at +50° C provided voltage rating is not exceeded.

Power derating — Derate power linearly from +50° C to zero at +100° C. Derate power 50 percent for resistors with "A", "B", "S", and "DB" tapers. For rheostat applications, derate power directly with shaft or actuator position.

Voltage — 350 volts maximum working voltage (RMS or DC), or as determined by $E_{max.} = \sqrt{PR}$, whichever is less (at sea level).

Dielectric withstanding voltage — Will withstand a one second test of 750 volts (RMS or DC) at sea level or 350 volts (RMS or DC) at 3.4 inches (86,36 mm) mercury.

Insulation resistance — 1000 megohms minimum for clean and dry conditions at +25° C.

Voltage characteristic — 0.005 percent per volt or 0.5 ohm, whichever is greater.

Operational

Load life — 10 percent maximum change in total resistance as a result of a 1000 hour test at rated power across entire element in still air at +50° C (1.5 hour "ON", 0.5 hour "OFF").

Rotational life — Maximum change in total resistance as a result of 5000 cycles under load is 10 percent for values above 500K ohms and less than 5 percent for values below 500K ohms.

Mechanical

Shafts — Thumbwheel or screwdriver adjustment, refer to DIMENSIONS on following pages.

Rotation — 295° + 5°.

Turning torque — 0.25 to 3 inch-ounces (0,018 to 0,22 kgf-cm) at + 25° C.

Backlash — Maximum of 3 degrees.

Stop torque — 2 inch-pounds (2,31 kgf-cm) minimum.

Construction — Materials are corrosion resistant and essentially non-magnetic. Enclosure is dust and splash resistant. Terminals are treated for easy soldering.

Standard marking — Allen-Bradley part number and nominal resistance value. Other marking possible, limited to maximum of 16 characters in each of two lines for Types YR, YC and YN. 8 characters in each of two lines for Types YH and YS. A-B monogram plus "Type Y" always included.

Environmental

Vibration — 3 percent maximum change in total resistance or setting. (Tested per EIA Standard RS-186B, Method 7, Type I and Method 8, Type I.)

Shock, medium impact — 3 percent maximum change in total resistance or setting after a 50G, 11 millisecond test.

Effect of soldering — 2 percent maximum change in total resistance as a result of immersing the terminals in + 350° C solder to within 0.125 inch (3,18 mm) of the resistor for a maximum of 3 seconds. (Tested per EIA Standard RS-186B, Method 10.)

Steady state humidity — Maximum temporary resistance change 10 percent. (Tested for 96 hours per EIA Standard RS-186B, Method 1.)

Salt spray — No evidence of corrosion damage. (Tested for 96 hours per EIA Standard RS-186B, Method 5, using Type I [20%] salt solution.)

Temperature cycling — 3 percent maximum change in total resistance as a result of the temperature cycling test. (Five cycles − 55° C to + 100° C.)

Low temperature operation — 2 percent maximum change in total resistance as a result of the low temperature operation test. (− 55° C for two hours without load and 45 minutes with rated load.)

Low temperature storage — 2 percent maximum change in the total resistance as a result of the storage test. (24 hours at − 63° C.)

Temperature characteristics — Maximum percent temporary total resistance change from the + 25° C value. See table below.

Nominal Resistance	Degrees Celsius — "U" Linear Taper						
	−55°	25°	0°	+25°	+55°	+85°	+100°
100 Ohms	+ 4.5	+ 2.5	+1.5	0	±1.0	±1.5	+ 2.0
1,000 Ohms	+ 5.5	+ 3.0	+1.5	0	±1.0	±2.0	+ 2.5
10,000 Ohms	+ 7.0	+ 3.5	+2.0	0	±1.0	±2.5	+ 2.7
100,000 Ohms	+ 8.0	+ 4.0	+2.0	0	±1.5	±3.0	+ 3.2
1 Megohm	+10.0	+ 5.0	+2.5	0	±1.5	±3.5	+ 4.0

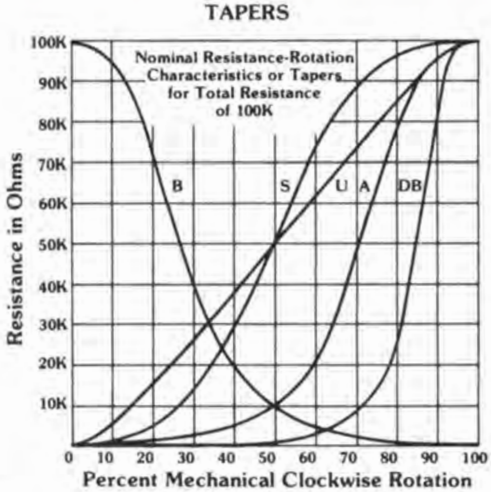
For "S", "A", "B" and "DB" tapers multiply percentage figures shown above by 1.25.

Ordering information

1. Type (YR, YC, YH, YS or YN).
2. Taper.
3. Total resistance vlaue in ohms.
4. Total resistance tolerance.
5. Your part number.
6. Marking.
7. YN — unless otherwise specified the 3 spacers will be provided (see YN back page).

Taper data

TAPERS



END RESISTANCE

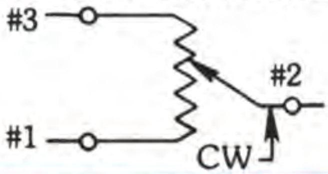
TAPER	MINIMUM RESISTANCE BETWEEN TERMINALS 1 and 2	MINIMUM RESISTANCE BETWEEN TERMINALS 2 and 3
U & S	[1]	[1]
A	[1]	[2]
B	[2]	[1]
DB	[3]	[2]

[1] "Less than .004% of total resistance," or "less than 15 ohms" whichever is greater.

[2] "Less than 1% of total resistance," or "less than 15 ohms" whichever is greater.

[3] Less than 15 ohms.

Resistor Connections



DIMENSIONS

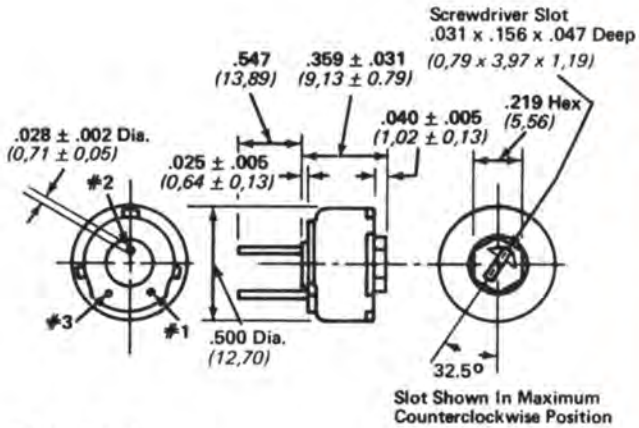
Basic dimensions in inches.

Dimensions shown in parentheses are in millimeters.
Terminal spacing determined at mounting surface.

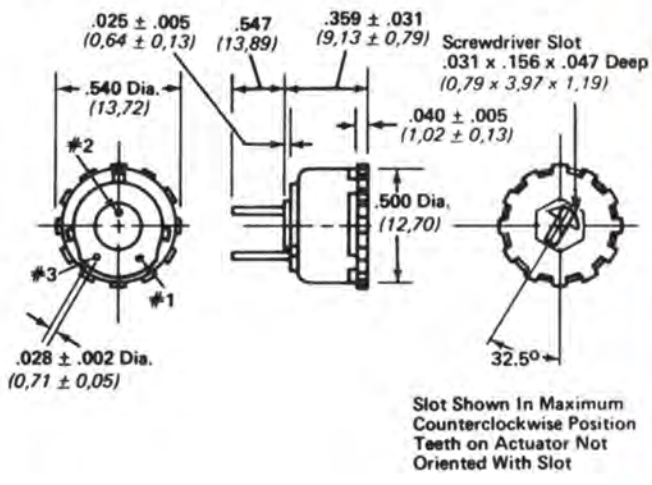
TOLERANCES
Dimensional tolerance ±.016 (0,40)
Angular tolerance ±5°
Except as specified.

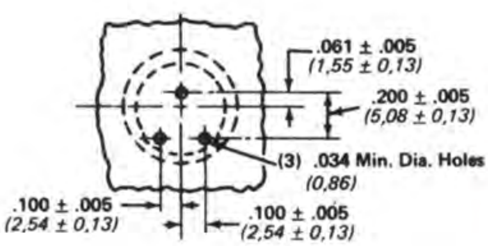
NOT TO SCALE

TYPE YR

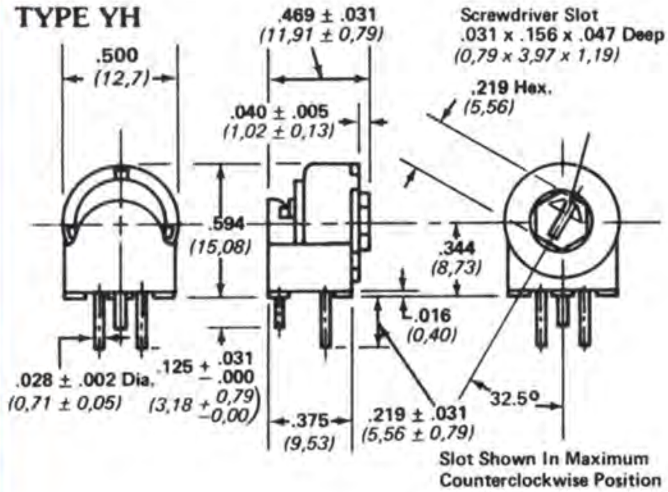


TYPE YC

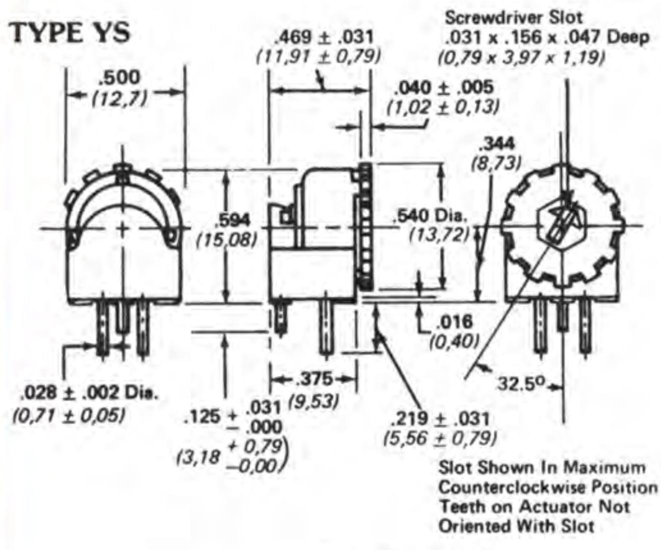


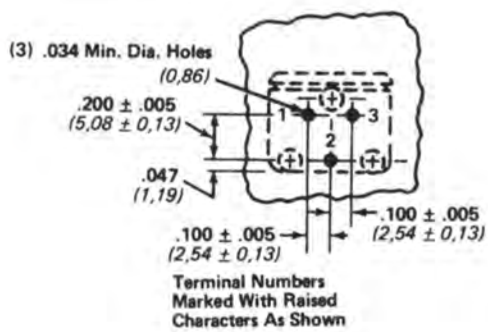


TYPE YH



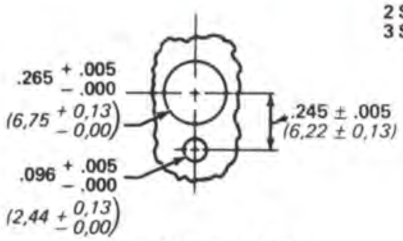
TYPE YS



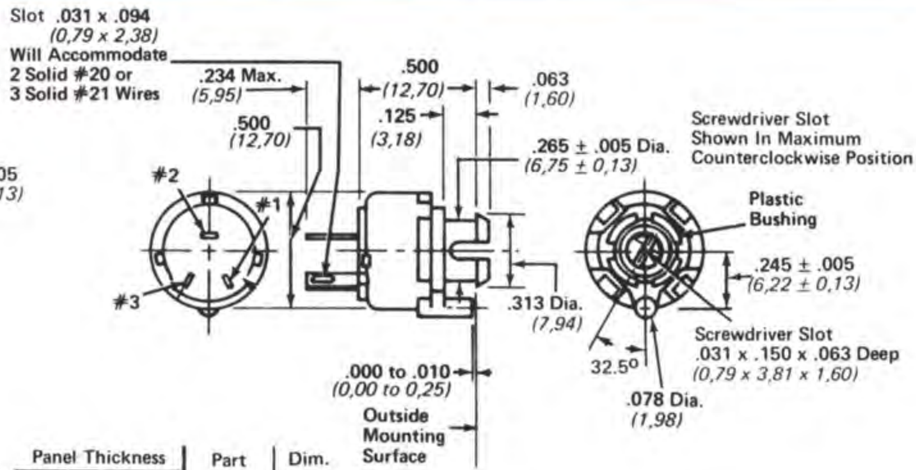


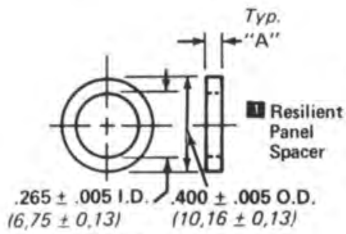
DIMENSIONS

TYPE YN



NOTE: Panel Mounting Holes.
(Holes Must Be Burr Free
On Device Side Of Panel)





Panel Thickness Min.	Panel Thickness Max.	Part No.	Dim. "A"
.000 (.000)	.037 (0,89)	F25262	.125 (3,18)
.032 (0,80)	.060 (1,52)	F25263	.094 (2,38)
.062 (1,57)	.082 (2,03)	F25264	.063 (1,60)

[1] Refer to Ordering information.

EXPLANATION OF PART NUMBERS

YR102M

Basic Type

- [1] **YR** — Pin terminals
- [1] **YC** — Pin terminals, slotted and notched actuator
- **YH** — Pin terminals and horizontal mounting base
- **YS** — Pin terminals, slotted and notched actuator, and horizontal mounting base
- **YN** — Lug terminals and snap-in panel mounting bushing

Resistance Value

First two digits are significant figures and the third indicates the number of zeros following the first two digits —

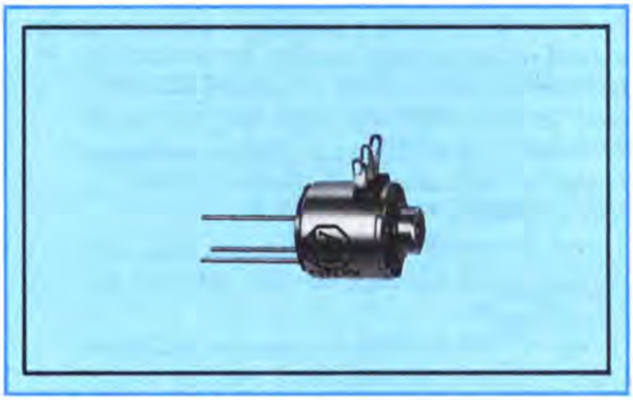
Examples: 101 = 100 Ohms
501 = 500 Ohms
255 = 2.5 Megohms

Taper Type and Total Resistance Tolerance

- **U** — Linear (U), ± 10%
- **M** — Linear (U), ± 20%
- **A** — Clockwise Modified Logarithmic (A), ± 10%
- **R** — Clockwise Modified Logarithmic (A), ± 20%
- **B** — Counterclockwise Modified Logarithmic (B), ± 10%
- **T** — Counterclockwise Modified Logarithmic (B), ± 20%
- **D** — Clockwise Exact Logarithmic (DB), ± 10%
- **K** — Clockwise Exact Logarithmic (DB), ± 20%
- **S** — Modified Linear (S), ± 10%
- **Y** — Modified Linear (S), ± 20%

[1] AVAILABLE, IN STANDARD VALUES, FROM STOCK AT ELECTRONIC DISTRIBUTORS.

Type FD Hot-Molded Trimming Potentiometers



0.25 Watt (70°C)
1/2 (0.50) Inch (12,70 mm) Diameter
100 Ohms to 5.0 Megohms

FEATURES

- Hot-Molded Single Turn
- Dual Trimmer
- Attenuator Applications Bridged-T or L Pads
- Immersion Sealed
- ±20% or ±10% Tolerance

SPECIFICATIONS

General

Temperature range — −55°C to +120°C.

Total resistance values — Preferred nominal values listed below. Other values available.

OHMS				
100	1K	10K	100K	1 Meg.
200	2K	20K	200K	2 Meg.
250	2.5K	25K	250K	2.5 Meg.
500	5K	50K	500K	5 Meg.

Total resistance tolerances — ±20% or ±10%.

Tapers — **(Resistance — rotation characteristics)** — Available in the following resistance ranges:

TAPER	TOTAL RESISTANCE RANGE
U	100 Ohms to 5.0 Megohms
A, B, S & DB	500 Ohms to 2.5 Megohms

See chart on following pages for explanation of tapers. Special tapers, where practical, can be supplied.

End resistance — See chart on following pages.

Attenuators — See Allen-Bradley Publication EC5930-2.1

Electrical

Power — Maximum power ratings for "U" linear tapers at +70°C with both elements in the circuit are as follows:

	WATTS						
Front Resistor	0.25	0.23	0.2	0.18	0.15	0.1	0
Rear Resistor	0	0.1	0.15	0.18	0.2	0.23	0.25

(Front resistor is adjacent to the actuator. Voltage rating must not be exceeded.)

Power derating — Derate power linearly from +70°C to zero at +120°C. Derate power 50 percent for non-metallic mounting or for resistors with "A", "B", "S", and "DB" tapers. For rheostat applications, derate power directly with shaft or actuator position.

Voltage — 350 volts maximum working voltage (RMS or DC), or as determined by $E_{max.} = \sqrt{PR}$, whichever is less (at sea level).

Dielectric withstanding voltage — Will withstand a one second test of 750 volts (RMS or DC) at sea level or 350 volts (RMS or DC) at 3.4 inches (86,36 mm) mercury.

Insulation resistance — 1000 megohms minimum for clean and dry conditions at +25°C.

Voltage characteristic — 0.005 percent per volt or 0.5 ohm, whichever is greater.

Operational

Load life — 10 percent maximum change in total resistance as a result of a 1000 hour test at rated power across entire element in still air at +70°C (1.5 hour "ON," 0.5 hour "OFF"). (Operational specifications continued on next page.)

NOT AVAILABLE FROM STOCK AT ELECTRONIC DISTRIBUTORS.

Hot-Molded Trimming Potentiometers

Rotational life — 10 percent maximum change in total resistance as a result of 50,000 cycles under load.

Mechanical

Shafts — Flush or extended 0.125 inch (3,18 mm) above face plate (see dimensions on following page).

Rotation — 295° ±5°.

Turning torque — 0.5 to 4.5 inch-ounces (0,036 to 0,32 kgf-cm) at +25°C and 13 inch-ounces (0,94 kgf-cm) maximum at —55°C.

Backlash — Maximum of 3 degrees.

Stop torque — 1 inch-pound (1,15 kgf-cm) minimum.

Construction — Materials are corrosion resistant and essentially non-magnetic. Enclosure is immersion sealed. Terminals are treated for easy soldering.

Weight — Approximately 7 grams.

Standard marking — Allen-Bradley part number and nominal total resistance are marked in two lines. Other marking possible, limited to a maximum of 16 characters in each of two lines. A-B monogram plus "Type FD" always included.

Environmental

Vibration — 2 percent maximum change in total resistance, 5 percent maximum change in resistance setting. (Tested per method 204, condition "C" of MIL-STD-202.)

Shock — 2 percent maximum change in total resistance. 5 percent maximum change in resistance settings. (Tested per method 213, condition "I" of MIL-STD-202.)

Effect of soldering — 2 percent maximum change in total resistance as a result of immersing the terminals in 350°C solder to within 0.125 inch (3,18 mm) of the resistor for 5 seconds.

Moisture resistance — 10 percent maximum change in total resistance. (Method 106 of MIL-STD-202.)

Corrosion resistance — Materials show no corrosion after the 200 hour test. (Method 101 of MIL-STD-202.)

Temperature cycling — 3 percent maximum change in total resistance as a result of the temperature cycling test. (Five cycles at —55°C to +120°C.)

Low temperature operation — 2 percent maximum change in total resistance as a result of the low temperature operation test. (—55°C for two hours without load and 45 minutes with rated load.)

Temperature characteristics — Maximum percent temporary total resistance change from the +25°C value. See table below.

Nominal Resistance	Degrees Celsius — "U" Linear Taper						
	—55°	—25°	0°	+25°	+55°	+85°	+120°
100 Ohms	+ 4.5	+2.5	+1.5	0	±1.0	±1.5	+3.5
1,000 Ohms	+ 5.5	+3.0	+1.5	0	±1.0	±2.0	+4.5
10,000 Ohms	+ 7.0	+3.5	+2.0	0	±1.0	±2.5	+5.5
100,000 Ohms	+ 8.0	+4.0	+2.0	0	±1.5	±3.0	+6.0
1 Megohm	+10.0	+5.0	+2.5	0	±1.5	±3.5	+7.5

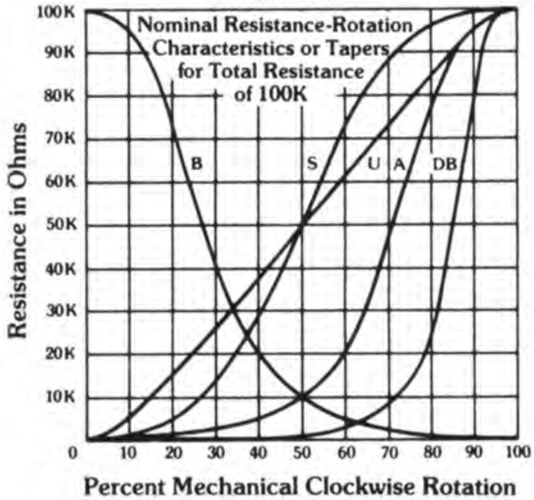
For "S", "A", "B" and "DB" tapers multiply percentage figures shown above by 1.25.

Ordering information

1. Type (FDE, FDL, FDP or FDT).
2. Taper.
3. Total resistance value in ohms.
4. Total resistance tolerance.
5. Your part number.
6. Marking
7. Remarks

Taper data

TAPERS



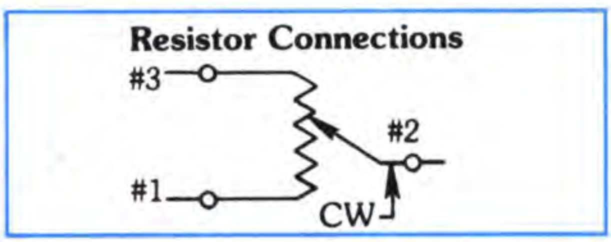
END RESISTANCE

TAPER	MINIMUM RESISTANCE BETWEEN TERMINALS 1 and 2	MINIMUM RESISTANCE BETWEEN TERMINALS 2 and 3
U & S	1	1
A	1	2
B	2	1
DB	3	2

1 "Less than .004% of total resistance," or "less than 15 ohms" whichever is greater.

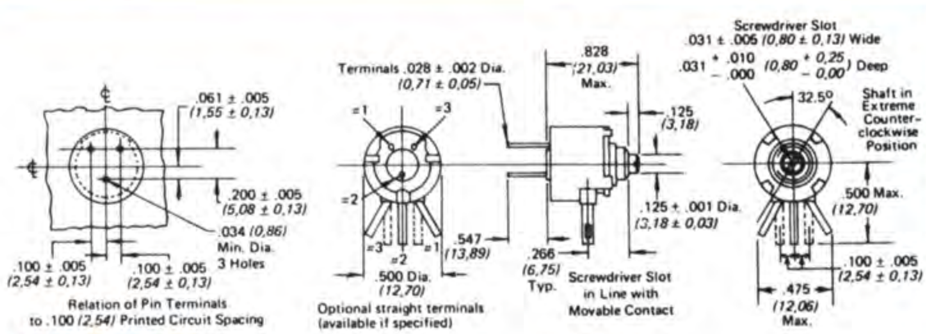
2 "Less than 1% of total resistance," or "less than 15 ohms" whichever is greater.

3 Less than 15 ohms.

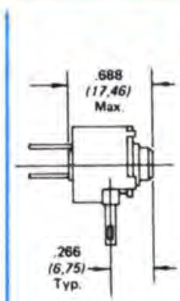


DIMENSIONS

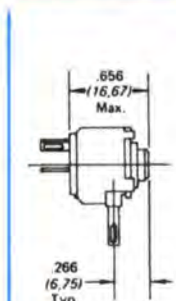
TYPE FDE



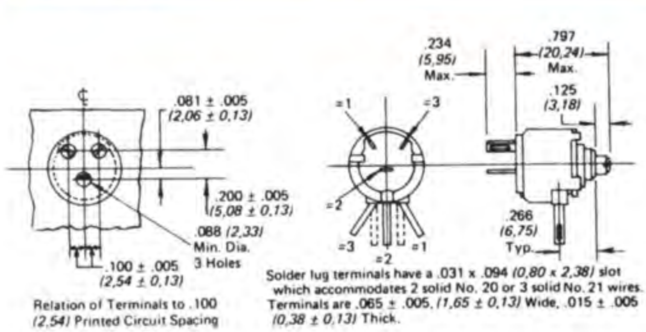
TYPE FDP



TYPE FDL



TYPE FDT



Basic dimensions in inches.

Dimensions shown in parentheses are in millimeters.

TOLERANCES
Dimensional tolerance ±.016 (0,40)
Angular tolerance ±5°
Except as specified.

NOT TO SCALE

Hot-Molded Trimming Potentiometers

EXPLANATION OF PART NUMBERS

FDP102U

Basic Type

FDE — Pin terminals on rear resistor and 0.125 inch (3,18 mm) extended metal shaft

FDL — Lug terminals on rear resistor flush metal shaft

FDP — Pin terminals on rear resistor and flush metal shaft

FDT — Lug terminals on rear resistor and 0.125 inch (3,18 mm) extended metal shaft

Total Resistance Value

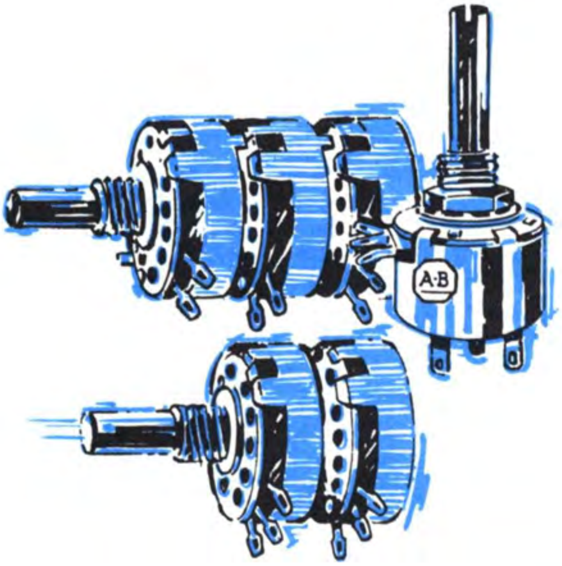
First two digits are significant figures and the third indicates the number of zeros following the first two digits —

Examples: 101 = 100 Ohms
501 = 500 Ohms
255 = 2.5 Megohms

Electrical Specifications Taper Type and Total Resistance Tolerance

U — Linear (U), ±10%
M — Linear (U), ±20%
A — Clockwise Modified Logarithmic (A), ±10%
R — Clockwise Modified Logarithmic (A), ±20%
B — Counterclockwise Modified Logarithmic (B), ±10%
T — Counterclockwise Modified Logarithmic (B), ±20%
D — Clockwise Exact Logarithmic (DB), ±10%
K — Clockwise Exact Logarithmic (DB), ±20%
S — Modified Linear (S), ±10%
Y — Modified Linear (S), ±20%
E — L-Pad Attenuator, ±15%
L — L-Pad Attenuator, ±20%
N — Bridged T-Pad Attenuator ±15%
P — Bridged T-Pad Attenuator, ±20%

CAUTION: Part number format does not allow for exclusion of invalid mechanical and/or electrical combinations. Check parameter limits in preceding text.



adjustable attenuators

HOT-MOLDED COMPOSITION

comprehensive product index

SELECTOR GUIDE

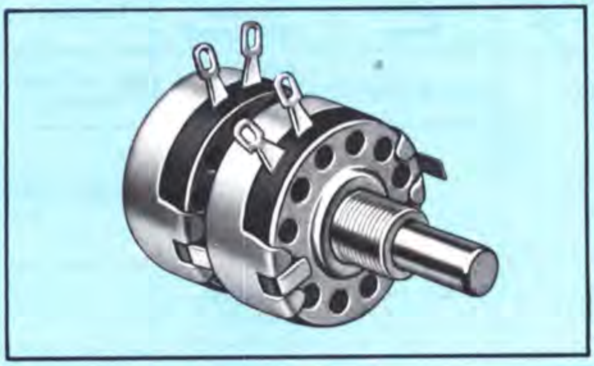
Type	Page Number	Resistance Element	Characteristic Impedance and Tolerance	Number of Sections Available	Voltage Rating (RMS or DC)	Operating Temperature Range	Case Dimensions In Inches (Millimeters)	Enclosure
BT	192	Hot-Molded Carbon Composition	75 Ohms ± 20%	2	4.33V	-40° C to +120° C	0.500 (12,70) Diameter by 0.535 (13,59)	Dust and Splash Resistant
FD	196		[1] [1] 50, 75, 100 150, 300 and 600 Ohms ±20% and ±15%	2	350V	-55° C to +120° C	0.500 (12,70) Diameter by 0.688 (17,46)	Immersion Sealed
GD	196			2			0.500 (12,70) Diameter by 0.547 (13,89)	
J	188			2 or 3	500V		1.156 (29,36) Diameter by 1.266 (32,15) (Dual Section)	Dust and Splash Resistant
MOD POT®	142				350V		.625 (15,88) Square by .969 (24,61) Dual Section Lug Terminal	

[1] Available as Bridged-T Pads only.

Type	POWER RATING			
	Bridged-T	Bridged-H	L	Straight-T
BT	0.25 Watt at 50° C	—	—	—
FD	0.5 Watt at 70° C	—	0.25 Watt at 70° C	—
GD	1.0 Watt at 70° C	—	0.5 Watt at 70° C	—
J	5 Watts at 70° C		2.25 Watts at 70° C	
MOD POT®	1.0 Watt at 70° C		0.5 Watt at 70° C	

Type J

Hot-Molded Adjustable Attenuators



4 Attenuator Types

50 Ohms to 2500 Ohms

1-5/32 (1.156) Inch (29,36 mm) Diameter

FEATURES

- 100,000 Cycle Rotational Life
- SPST Switch Available — UL Approved

SPECIFICATIONS

General

Characteristic impedance values — Preferred impedance values are listed below. Other values are available on special order.

50 Ohms	100 Ohms	300 Ohms
75 Ohms	150 Ohms	600 Ohms

Tolerances on characteristic impedance — Standard tolerances ±20 percent and ±15 percent. A tolerance of ±10 percent is available on special basis, depending on type, impedance value and the required attenuation. Consult factory for analysis in individual cases. When tested for overall tolerance at the factory, the fixed resistors used in the test circuit are all ±0.25 percent resistors.

Recommended characteristic impedance test — The characteristic impedance is measured by connecting the variable resistors in the circuit, shown on next page including a load resistor that is equal to the characteristic impedance. The characteristic impedance is measured between points "A" and "B". For controls with a limited attenuation, a specified series fixed resistor must be placed between points "C" and "D". When tested at the factory, the fixed resistors have a tolerance of ± 0.25 percent.

Attenuation and insertion loss — The graphs on the following pages show the characteristics of standard attenuators.

Special attenuation characteristics — Special attenuators can be supplied where the total attenuation is less than the standard value. A series fixed resistor will be required in the shunt section.

Switches — SPST switch is available only with L and Bridged-T attenuator types. Switch is UL approved.

Electrical

Power handling capacity — The maximum power handling capacities given below are based on any shaft position with the attenuators mounted on a 4-inch square 16 gauge steel panel or equivalent. Derate 50 percent for mounting on non-metallic panel. Derate linearly to zero at +120°C.

Attenuator Type	Maximum Load at +70°C
Bridged-T	5 Watts
Bridged-H	5 Watts
L	2.25 Watts
Straight-T	2.25 Watts

Operational

Load life — Operated at rated power for 1,000 hours, the characteristic impedance will be within 10 percent of its initial value.

Rotational life — Characteristic impedance is within 10 percent of its initial value after 100,000 rotational cycles.

Mechanical

Mechanical configurations — Allen-Bradley panel potentiometers for attenuators are available in all the same mechanical configurations as the Type J. Refer to Publication EC5607-2.1.

Fixed resistors — Attenuators are furnished without fixed resistors.

Wiring — No interconnections are made at the factory. Refer to following page for wiring.

NOT AVAILABLE FROM STOCK AT ELECTRONIC DISTRIBUTORS.

Hot-Molded Adjustable Attenuators

Ordering information

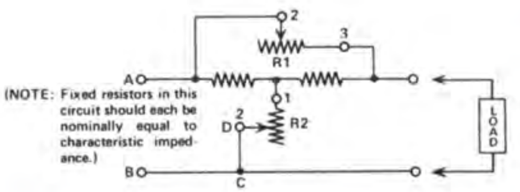
Below is a checklist of data needed to fill an order for Type J panel potentiometers intended for attenuator use. Please refer to Publication EC5607-2.1 for details.

1. Type of attenuator.
2. Attenuation characteristic (A-B Standard or Other).
3. Characteristic impedance in ohms.
4. Tolerance on characteristic impedance — ±20%, ±15% or ±10%.
5. Bushing type (Plain, Locking, Shaft Watertight or Shaft and Panel Watertight).
6. Bushing length in inches.
7. Shaft ending (Plain, Slotted or Flatted).
8. Shaft length from mounting surface in inches.
9. Is switch required?
10. Locating lug option (1, 2, 3, or 4).
11. Mounting hardware (A-B Standard or Other).
12. Part number you have assigned, if any.
13. Marking required on the part.
14. Special features.
15. Remarks.

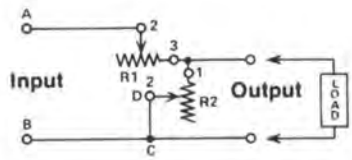
RECOMMENDED WIRING

Standard attenuators

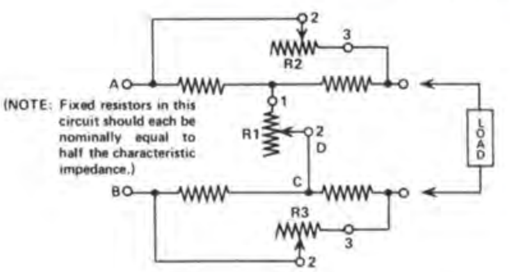
BRIDGED-T



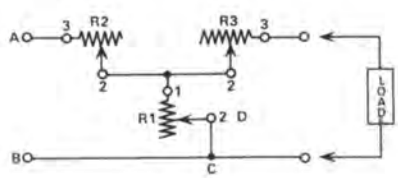
L



BRIDGED-H

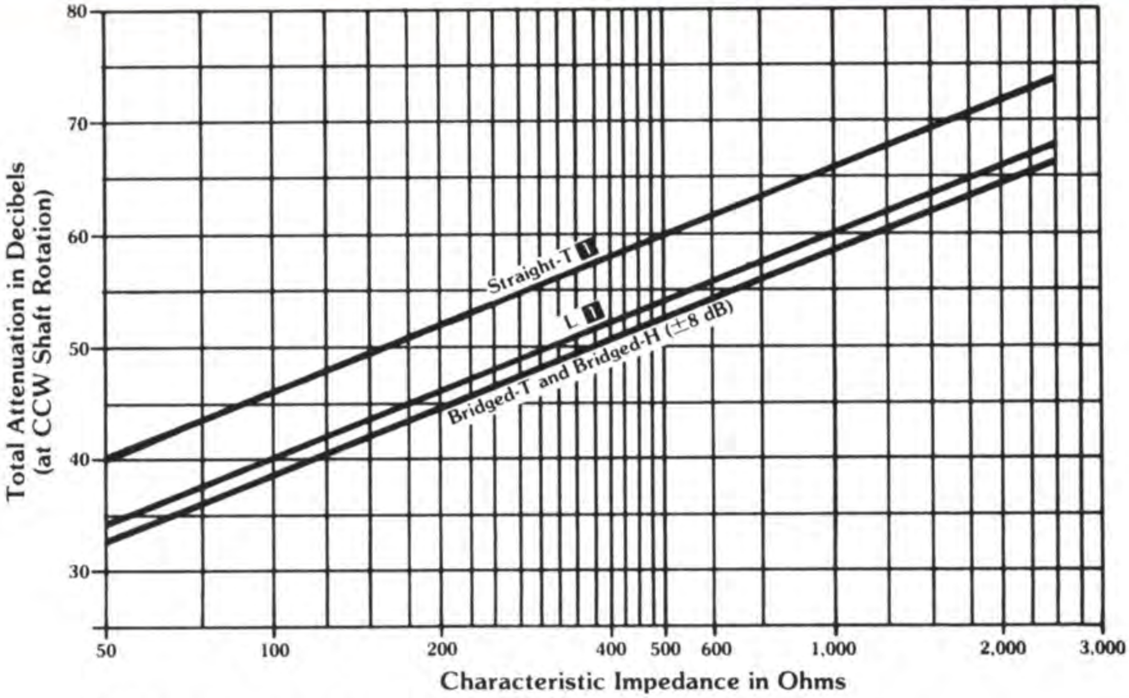


STRAIGHT-T



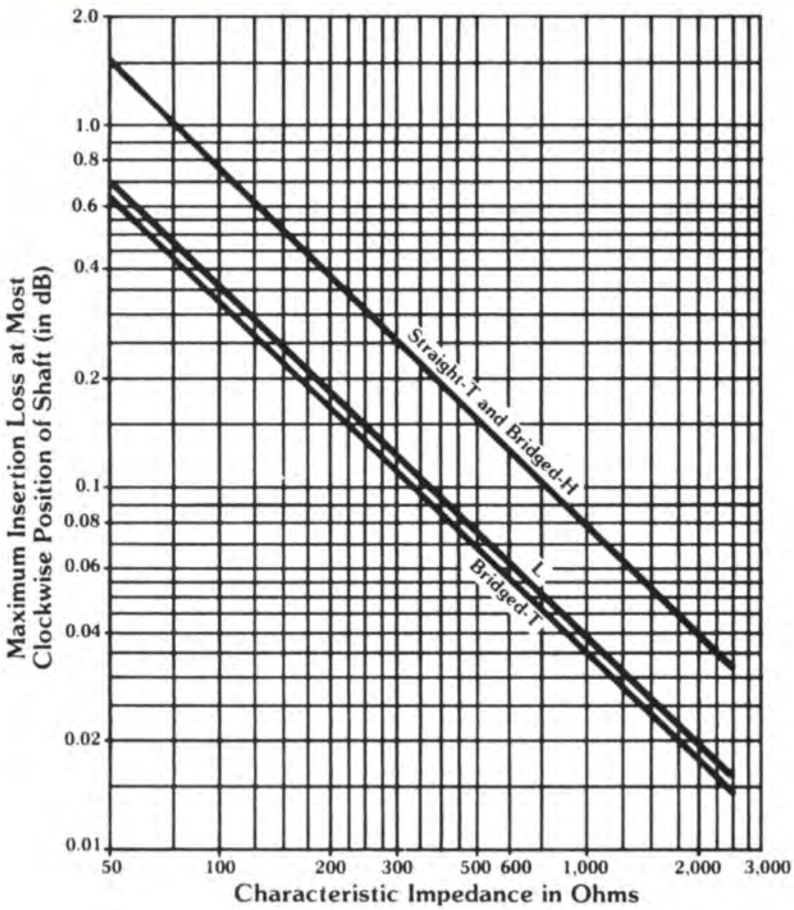
GRAPHS

Standard total attenuation for attenuators



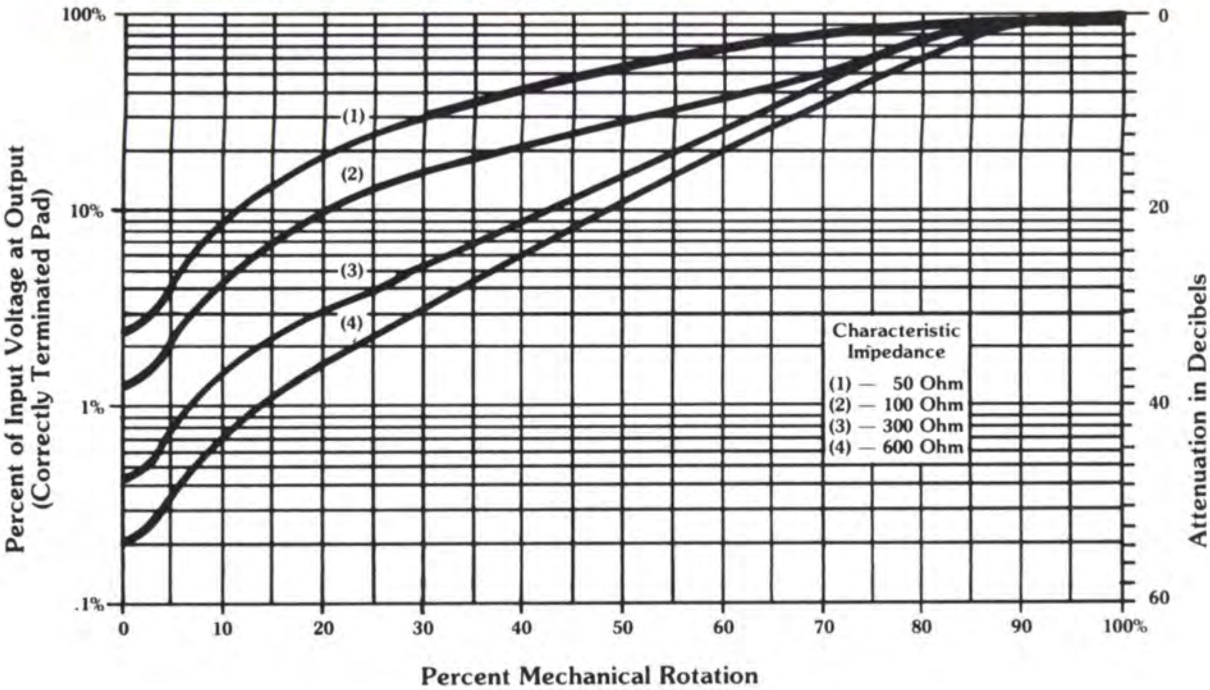
1 Minimum attenuation on the L pad and the Straight-T pad is the nominal value minus 13 dB. The maximum attenuation is not specified.

Standard maximum insertion loss for attenuators

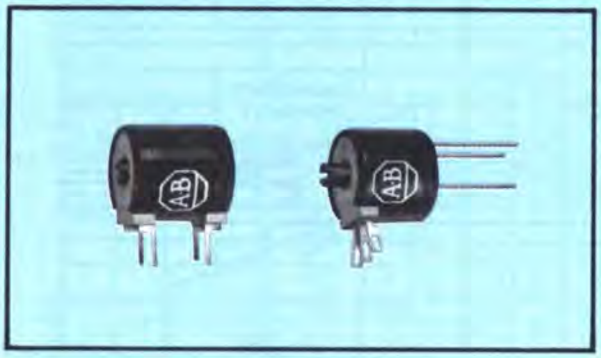


GRAPHS

Standard nominal attenuation characteristics



Type BT Hot-Molded Adjustable Attenuators



0.25 Watt (50°C)
1/2 (0.50) Inch (12,70 mm) Diameter
75 Ohms

FEATURES

- Hot-Molded Single Turn
- 2 Attenuator Types
- −40° C to +120° C
- Dust and Splash Resistant
- ±20% or ±15% Tolerance

SPECIFICATIONS

General

Temperature range — −40° C to +120° C.

Application — For use as 75-ohm Bridged-T attenuator.

Standard characteristic impedance value — Standard impedance value 75 ohms.

Tolerance on characteristic impedance — Standard tolerances ±20 or ±15 percent over entire rotation; from end to end. When tested for overall tolerance at the factory, the fixed resistors used in the test circuit are all ±0.25 percent resistors. All measurements are made at DC.

Recommended characteristic impedance test — The characteristic impedance is measured by connecting the variable resistors into the circuit as shown on the following pages, including a load resistor that is equal to the characteristic impedance. The characteristic impedance is then measured between points A and B with an ohmmeter. When tested at the factory, the fixed resistors have a tolerance of ±0.25 percent.

Attenuation and insertion loss — When measured in the recommended circuit, the attenuation at the CCW end of rotation shall be 20 dB minimum. The insertion loss at the CW end of rotation shall be 1.0 dB maximum. All measurements are made at DC.

Wiring — To provide complete attenuator networks, the variable resistors described in this publication require some form of interconnection. To permit additional wiring at the time of installation, no interconnections are made at the factory.

Fixed resistors — Bridged-T attenuators require fixed resistances to complete the attenuator circuit. Attenuators are furnished without resistors to keep the solder lugs free to accommodate additional wiring that may be made at the time of installation. Also, the choice of tolerance, wattage rating, and type of fixed resistor is fully within the user's control.

Electrical

Power handling capacity — The maximum power handling capacity is 0.25 watt at +50° C and is based on any shaft position. Derate linearly to zero at +120° C.

Voltage — 4.33 volts maximum working voltage (RMS or DC).

Dielectric withstanding voltage — Will withstand a one second test of 500 volts (RMS or DC) at sea level, +25° C.

Insulation resistance — 100 megohms minimum for clean and dry conditions at +25° C.

Operational

Rotational life — Less than 10 percent change of characteristic impedance as a result of a 5000 cycle life test. No load.

Load life — Less than 10 percent change of characteristic impedance as a result of the load life test. Tested per EIA Standard RS-186D, Method 12; 1000 hours, +50° ± 2° C ambient temperature with rated load applied 1.5 hours "ON", 0.5 hour "OFF".

NOT AVAILABLE FROM STOCK AT ELECTRONIC DISTRIBUTORS.

Hot-Molded Adjustable Attenuators

Mechanical

Shafts — Shaft length .031 inch (0,80 mm) minimum to .500 inch (12,70 mm) maximum (see dimensions on next page).

Rotation — 295° ± 5° mechanical.

Turning torque — 0.5 to 5.0 inch-ounces (0,036 to 0,36 kgf-cm) at +25° C and 13 inch-ounces (0,94 kgf-cm) maximum at −40° C.

Stop torque — 10 inch-ounces (0,72 kgf-cm) minimum.

Construction — Materials are essentially non-magnetic. Enclosure is dust and splash resistant. Terminals are treated for easy soldering.

Marking — Allen-Bradley part number and nominal characteristic impedance value are marked in two lines. Other marking possible, limited to a maximum of 13 characters in each of two lines including spacings, placed 13 to a line on the side of the enclosure. A-B monogram plus "TYPE BT" always included.

Environmental

Vibration — Less than 10 percent change of characteristic impedance. (Tested per EIA Standard RS-186D, Method 7, Type III.)

Steady state humidity — Less than 10 percent temporary change of characteristic impedance. (Tested for 96 hours per EIA Standard RS-186D, Method 1.)

Temperature cycling — Less than 10 percent change of characteristic impedance. (Tested per EIA Standard RS-186D, Method 11, except low temperature −40° C and high temperature +120° C).

High temperature exposure — Less than 10 percent change of characteristic impedance. (Tested for 1000 hours at +120° C per EIA Standard RS-186D, Method 12.) No load.

Low temperature operation — Less than 10 percent change of characteristic impedance as a result of the low temperature operation test (−40° C for 2 hours without load and 45 minutes with rated load).

Low temperature storage — Less than 10 percent change of characteristic impedance as a result of the low temperature storage test (24 hours at −40° C).

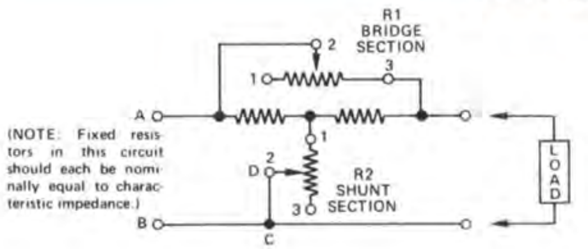
Ordering information

1. Type (BT2 or BT4).
2. Shaft length and material — (plastic or metal).
3. Part number you have assigned, if any.
4. Marking required on the part.
5. Remarks.

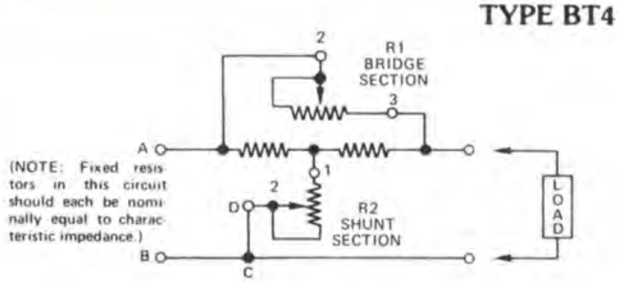
RECOMMENDED WIRING

Bridged-T attenuators

TYPE BT2



TYPE BT4



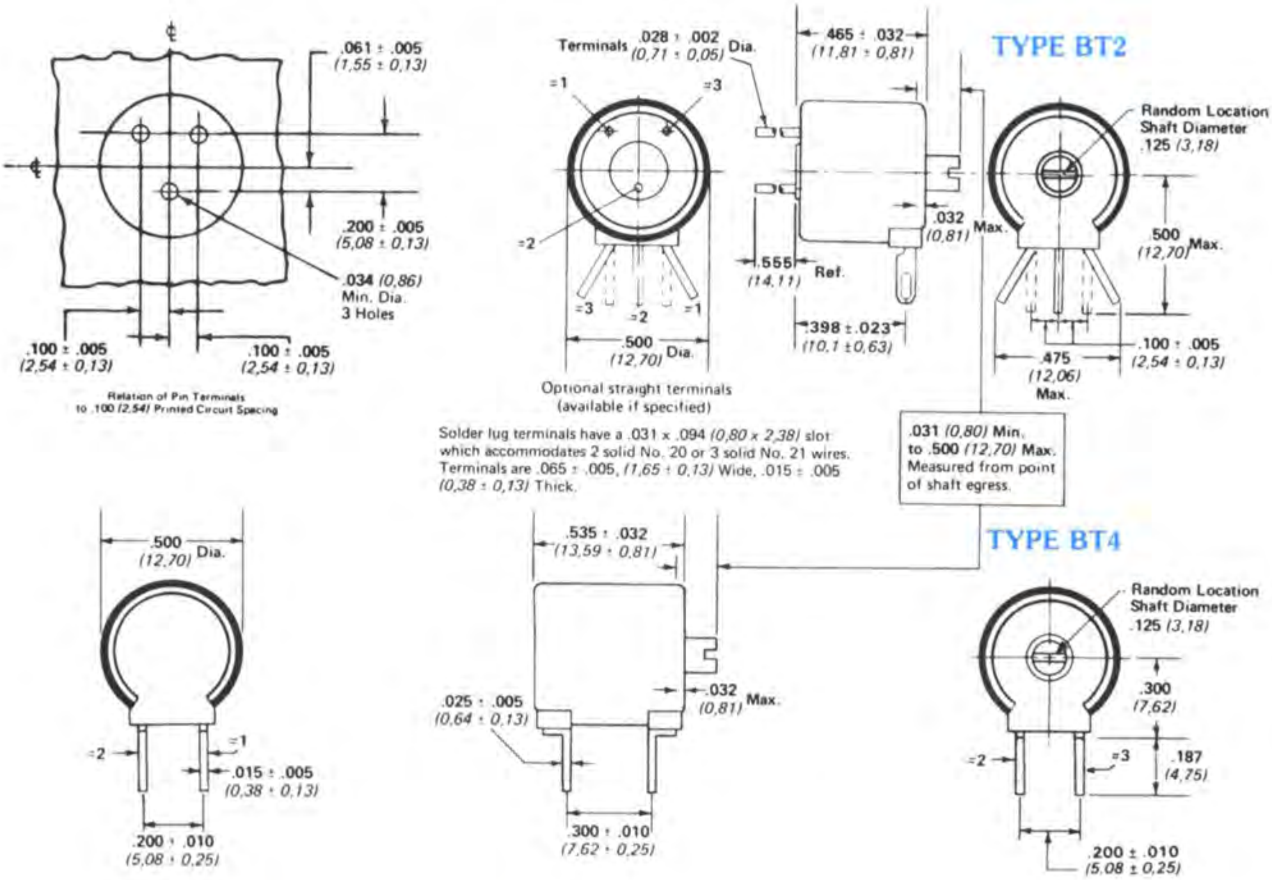
Note: Unless otherwise specified, all parameters are based on the above circuits. The R1 section is adjacent to the shaft.

DIMENSIONS

Basic dimensions in inches.
Dimensions shown in parentheses are in millimeters.
Terminal spacing determined at mounting surface.

TOLERANCE
Dimensional tolerance ±.016 (0,40).
Except as specified.

NOT TO SCALE



SHAFT LENGTHS AND MATERIAL

Plastic		Metal	
Inch	Millimeters	Inch	Millimeters
.031	0,80	—	—
.125	3,18	.125	3,18
.250	6,35	.250	6,35
.375	9,52	.375	9,52
.500	12,70	.500	12,70

SCREWDRIVER SLOTS

Plastic		Metal	
.031 ± .005 (0,80 ± 0,13)	Wide	.031 ± .005 (0,80 ± 0,13)	Wide
.040 ± .005 (1,02 ± 0,13)	Deep	$.031^{+.010}_{-.000}$ $\left(0{,}80^{+0{,}25}_{-0{,}00}\right)$	Deep

Hot-Molded Adjustable Attenuators

EXPLANATION OF PART NUMBERS

BT2B750P

Basic Type

BT2 — 3 solder lug terminals on front section; 3 round pin terminals on rear section.

BT4 — 2 printed circuit pin terminals on both sections.

Shaft Length and Material

Plastic	Inch	Millimeters	Metal
A	.031	(0,80)	—
B	.125	(3,18)	M
C	.250	(6,35)	N
D	.375	(9,52)	P
E	.500	(12,70)	R

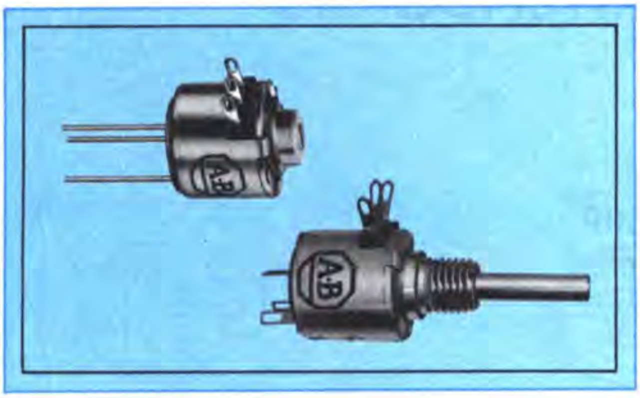
Impedance Value and Tolerance

750P — 75 Ohm ± 20% Bridged-T Attenuator

750N — 75 Ohm ± 15% Bridged-T Attenuator

Types FD, GD

Hot-Molded Adjustable Attenuators



2 Attenuator Types
50 Ohms to 2500 Ohms
1/2 (0.50) Inch (12,70 mm) Diameter

FEATURES

- ±20% or ±10% Tolerance
- Hot-Molded Composition
- −55° C to + 120° C

SPECIFICATIONS

General

Characteristic impedance values — Preferred impedance values are listed below. Other values are available.

50 Ohms ■	100 Ohms	300 Ohms
75 Ohms ■	150 Ohms	600 Ohms

■ Available in Bridged-T Pads only.

Tolerances on characteristic impedance — Standard tolerance ± 20 and ± 15 percent. When tested for overall tolerance at the factory, the fixed resistors used in the test circuit are all ± 0.25 percent resistors.

Recommended characteristic impedance test — The characteristic impedance is measured by connecting the variable resistors into the circuit as shown on the next page, including a load resistor that is equal to the characteristic impedance. The characteristic impedance is then measured between points 'A' and 'B' with an ohmmeter. For controls with a limited attenuation, a specified series fixed resistor must be placed between points 'C' and 'D'. When tested at the factory, the fixed resistors have a tolerance of ± 0.25 percent.

Attenuation and insertion loss — The graphs on the following pages show the characteristics of standard attenuators.

Special attenuation characteristics — Special attenuators can be supplied where the total attenuation is less than the standard value. A series fixed resistor will be required in the shunt section.

Electrical

Power handling capacity — The maximum power handling capacities given below are based on any shaft position. Derate linearly to zero at +120° C. Type GD power rating is based on being mounted on a 4-inch (101,60 mm) square, .062 inch (1,57 mm) thick steel panel or equivalent; derate 50 percent for mounting on non-metallic panel.

Power Rating at + 70°C

Circuit	Type FD	Type GD
Bridged-T	0.5 watt	1 watt
L	0.25 watt	0.5 watt

Operational

Load life — Less than 10 percent change of characteristic impedance as a result of the load life test. 1000 hours (1.5 hours "ON", 0.5 hour "OFF") at rated load.

Rotational life — Less than 10 percent change of characteristic impedance as a result of a 5000 cycle life test for the Type FD and 50,000 cycle life test for the Type GD.

TYPE GD, IN SELECTED VALUES, IS AVAILABLE FROM STOCK AT ELECTRONIC DISTRIBUTORS.

Hot-Molded Adjustable Attenuators

Mechanical

Mechanical configurations — All the same mechanical configurations as the Type GD and Type FD shown in Technical Publications EC5630-2.1 and EC5838-2.1 are available.

Fixed resistors — Attenuators are furnished without fixed resistors.

Wiring — No interconnections are made at the factory. Refer below for wiring.

Moisture resistance — Changes in impedance are less than 10 percent as a result of the moisture resistance test.

Standard marking — Standard marking is the Allen-Bradley octagon trademark plus "Type FD" or "Type GD" and Allen-Bradley part number with nominal characteristic impedance value.

If marking other than our standard is required, space permits a maximum of 32 characters, including spacings, placed 16 to a line on the side of the enclosure.

Ordering information

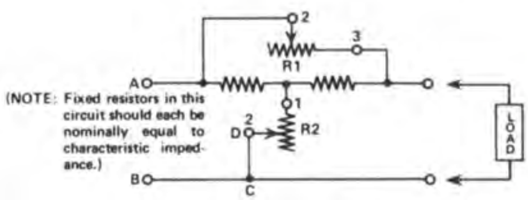
Below is a checklist of data needed to fill an order for variable attenuators. Refer to Technical Publications EC5630-2.1 and EC5838-2.1

1. Type of control (Type GD, FDP, FDL, FDE, or FDT).
2. Type of attenuator (Bridged-T Pad or L-Pad).
3. Attenuation characteristic (A-B Standard or Other).
4. Characteristic impedance in ohms.
5. Tolerance on characteristic impedance — ±20%, or ±15%.
6. Bushing type (Type GD only). (Plain, Locking, Plain Panel Watertight, or Locking Panel Watertight).
7. Bushing length in inches or millimeters (Type GD only).
8. Shaft ending (Type GD only) (Plain, Slotted or Flatted).
9. Shaft length from mounting surface in inches or millimeters (Type GD only).
10. Locating lug option (Type GD only) (Option 1 or 4).
11. Mounting hardware (Type GD only) (A-B Standard or Other).
12. Part number you have assigned, if any.
13. Marking required on the part.
14. Special features.
15. Remarks.

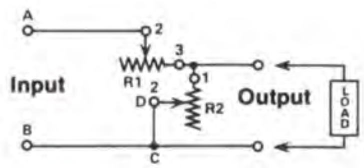
RECOMMENDED WIRING

Standard attenuators

BRIDGED-T

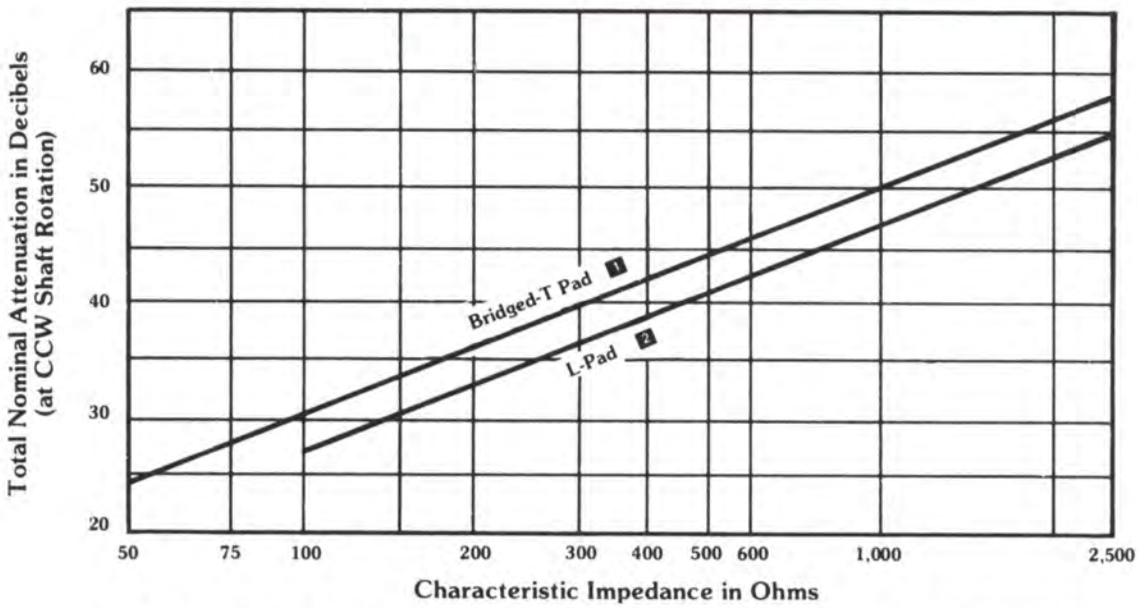


L



GRAPHS

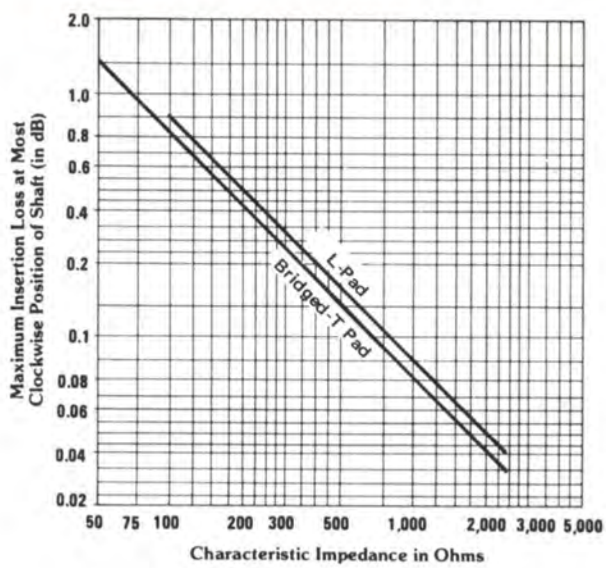
Standard total attenuation for attenuators



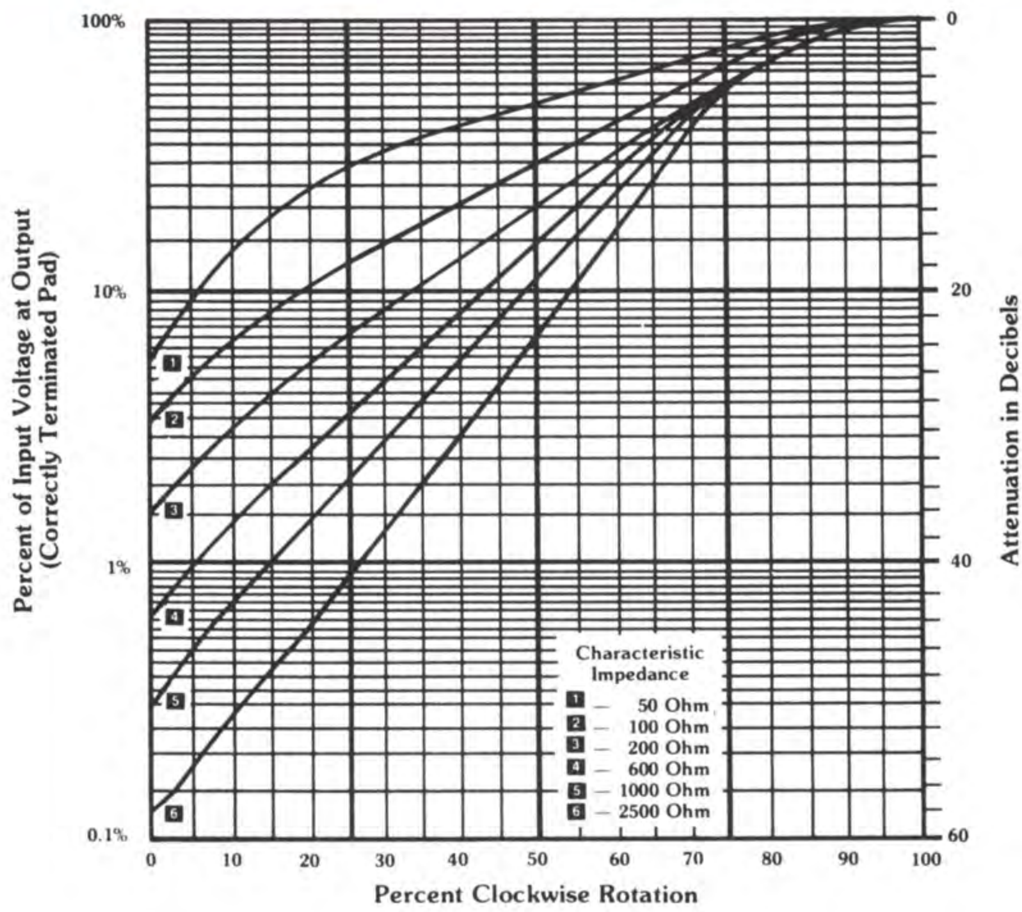
1 The minimum value of the total attenuation on the Bridged-T Pad is the nominal value minus 5 dB, while the maximum value is the nominal value plus 15 dB.

2 The minimum value of the total attenuation on the L-Pad is the nominal value minus 7 dB. The maximum attenuation value is not specified.

Standard maximum insertion loss for attenuators



Standard nominal attenuation characteristics



terms of sale

General — No addition to or modification of any of the Terms and Conditions of Sale as they appear herein for product sales of Allen-Bradley Company (Allen-Bradley) shall be binding upon Allen-Bradley unless signed in writing by a duly authorized representative at Allen-Bradley Headquarters.

Terms — Terms to customers of satisfactory credit are 1%, 10th and 25th, 30 days net from date of invoice. To avoid delay in filling orders, purchasers without previous experience with the Allen-Bradley Company should include credit references with their first order, or remit cash.

Minimum Billing Charge — Minimum order billing **$100.00**. Minimum item billing **$35.00** per shipment.

Shipping Terms — F.O.B. Factory. Buyer to pay all transportation.

Over/Under Shipments — The contract quantity for each line item will be satisfied when the quantity shipped is within plus or minus five percent (5%) of the actual quantity order. The quantity billed will be the actual quantity shipped.

Shipment — Shipment shall be F.O.B. Allen-Bradley's factory, warehouse or other point of shipment by Allen-Bradley. Scheduled or stipulated shipping dates are approximate and based upon prompt receipt of all necessary information from Buyer.

Allen-Bradley shall not be liable for any loss, damage or delay in delivery due to causes beyond its reasonable control, or acts of God, acts of the buyer, acts of civil or military authority, fires, strikes, floods, epidemics, quarantine restrictions, war, riots, delays in transportation, transportation embargoes, or inability due to causes beyond its reasonable control to obtain necessary engineering talent, labor, materials or manufacturing facilities. In the event of such delay, the delivery date shall be extended for that length of time as may be reasonably necessary to compensate for the delay.

Responsibility and Title — Title in the equipment shall remain with Allen-Bradley as security only and until full payment therefor. Risk of loss for the equipment shall pass to Buyer upon shipment from F.O.B. point.

Export Packing — Allen-Bradley will supply equipment for under-deck overseas shipment packed in accordance with its regular export standard, at no additional charge to Buyer. Where such packing for export must conform to definite specifications that differ from the Allen-Bradley standard, the Buyer will be charged for the extra cost thus incurred.

Damage Claims — All claims for breakage and damage whether concealed or obvious must be made to the carrier by the Buyer as soon as possible after receipt of the shipment. Allen-Bradley will be glad to render the Buyer reasonable assistance in the securing of adjustment for such damage claims.

Quotations — All written quotations automatically expire unless accepted within 60 days from the date quoted.

Verbal quotations expire the same day they are used.

Quotations to be binding must specifically identify each product and list the actual quantities involved.

All stenographic and clerical errors are subject to correction.

Price Change — Unless otherwise agreed in writing between Allen-Bradley and Buyer, Allen-Bradley reserves the right to increase or decrease any price with any such increase or decrease to apply to any portion(s) of the sale which is unshipped as of the effective date of such change. Such price change will not apply to any portion(s) of the sale shipped and billed prior to the effective date of the price change.

Taxes — The Buyer shall pay or reimburse Seller for all sales, use, excise or similar taxes.

Access — Unless approved in writing by an officer of Allen-Bradley any access to Allen-Bradley facilities, records or data by Buyer or customer(s) of Buyer, as well as respective agents or representatives, for whatever purpose shall exclude access to proprietary processes and information.

Catalog Prices — Prices shown in any Allen-Bradley publication are subject to change without notice and are not to be construed as a definite quotation or offer to sell by the Company. Such literature is maintained only as a source of general information, and any prices shown therein are subject to confirmation with a specific quotation.

Warranty — Allen-Bradley Company warrants for a period of one (1) year from date of the Allen-Bradley invoice that equipment furnished under the order will be of merchantable quality free from defects in material, workmanship and design each as determined, at the date of shipment by Allen-Bradley, by generally recognized, applicable and accepted practices and procedures in the industry — to include any specifications specifically agreed to in writing by Allen-Bradley prior to the date of shipment. Allen-Bradley will not be liable for any design furnished by Buyer and incorporated into equipment.

Satisfaction of this warranty, consistent with other provisions herein, will be limited to the replacement or repair or modification of, or issuance of a credit for, the equipment involved, at Allen-Bradley's option, with Allen-Bradley to determine the availability of service personnel and any absorbtion of associated service expenses; such warranty satisfaction available only if (a) Allen-Bradley is promptly notified in writing upon discovery of an alleged defect and (b) Allen-Bradley's examination of the subject equipment discloses to its satisfaction that any defect has not been caused by misuse; neglect; improper installation; improper operation; improper maintenance, repair or alteration; accident; or unusual deterioration or degradation of the equipment or parts thereof due to physical environment or due to electrical or electromagnetic noise environment. THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, WHETHER EXPRESSED, IMPLIED OR STATUTORY INCLUDING IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS and hereby excludes certifications or the like for equipment performance, use or design with respect to any standard, regulation or the like (unless and to the extent independently approved in writing at Allen-Bradley Headquarters) AND EXTENDS ONLY TO BUYER OR CUSTOMER PURCHASING FROM ALLEN-BRADLEY OR AN AUTHORIZED ALLEN-BRADLEY DISTRIBUTOR.

Return of Equipment — Authority for return of equipment, whether under the Warranty Clause or otherwise must be obtained from Allen-Bradley. Such authority shall be granted for each reasonable request. Unless such authority has been granted, shipment will be refused. All equipment returned should include reference to all pertinent order information for that equipment to include order, part numbers as well as details of the system from which the equipment was removed when appropriate. Cost for placing equipment returned for credit in a salable condition will be charged to Buyer, except for, and Allen-Bradley will pay return transportation only for, those returns based upon conditions or circumstances for which Allen-Bradley is responsible by the terms and conditions herein.

Cancellation and Termination — Any order placed with Allen-Bradley can be cancelled by the Buyer only upon payment of reasonable cancellation charges, which shall take into account expenses already incurred and commitments made by Allen-Bradley.

No termination by Buyer for default shall be effective unless and until Allen-Bradley shall have failed to correct such alleged default within 45 days after receipt by Allen-Bradley of the written notice specifying such default.

Patents — Allen-Bradley shall defend any suit or proceeding brought against Buyer or customer of Buyer, so far as based upon a claim that the design or construction of equipment sold by Allen-Bradley infringes a United States Patent (excepting a claim based upon a design or modification incorporated in such equipment at the request of Buyer); provided that Buyer promptly notifies Allen-Bradley of any such suit or proceeding in writing and provided that at Allen-Bradley's expense (a) Buyer gives Allen-Bradley the right to defend or control the defense of any such suit or proceeding to include settlement, and (b) Buyer provides all necessary information and assistance for such defense. This obligation to defend shall extend, in the case of non-standard equipment sold by Allen-Bradley to Buyer to a claim based upon the use of the equipment but only when such use is not in combination with any other apparatus and only to the extent that Allen-Bradley was informed by Buyer of such use in writing prior to the date of shipment.

Allen-Bradley will pay all costs and damages finally awarded or agreed upon by Allen-Bradley which are directly related to any such claim. In the event said equipment, or any part thereof, is in such suit held to constitute infringement and the use of said equipment or part is enjoined, Allen-Bradley will, at its own expense and obligation, either procure for the Buyer the right to continue using said equipment or part, or replace same with non-infringing equipment, or modify it so it becomes non-infringing or remove said apparatus and refund the purchase price and the transportation and installation costs thereof. THIS PARAGRAPH SETS FORTH ALLEN-BRADLEY'S ENTIRE LIABILITY WITH RESPECT TO PATENTS.

All right, title and interest in any inventions, developments, improvements or modifications of or for equipment subject to the order will remain with Allen-Bradley unless otherwise agreed to in a separate written agreement signed by both Allen-Bradley and Buyer.

Government Clauses and Contracts — Government Contract clauses and any clauses essentially based upon Government Contract Regulations shall only apply to sales subject to a Government Contract. In the event this sale is subject to a Government Contract, the terms and conditions of this sale shall include, if any, only those Government Contract clauses — not inconsistent with terms and conditions herein — which applicable Regulations (and the Prime and/or Subcontract to which this sale is subject) require to be included in a Contract or Subcontract such as this sale and only for the minimum necessary purposes of the clause.

terms of sale

Equipment sold by Allen-Bradley is not intended to be used, nor shall it be used, as a "Basic Component" under 10 CFR 21 (NRC).

Assignment — This agreement may not be assigned by either party without the written consent of the other party except (1) to a successor corporation by merger or consolidation of either party, or (2) to any corporation acquiring by sale, lease or otherwise substantially all of the property, assets and business of either party, or any division or segment thereof having control of the activities or business to which this agreement relates, or (3) to any corporation controlling, controlled by, or under common control with, either party.

Governing Law — The sale and purchase of the equipment, including all terms and conditions thereof, shall be governed by the Uniform Commercial Code of the State of Wisconsin.

Limit of Liability — IN NO EVENT WILL ALLEN-BRADLEY ASSUME RESPONSIBILITY FOR OR BE LIABLE (a) FOR PENALTIES OR PENALTY CLAUSES OF ANY DESCRIPTION, OR (b) FOR CERTIFICATION NOT OTHERWISE SPECIFICALLY PROVIDED HEREIN AND/OR FOR INDEMNIFICATION OF BUYER OR OTHERS FOR COSTS, DAMAGES, OR EXPENSES, EACH ARISING OUT OF OR RELATED TO THE EQUIPMENT OR SERVICES OF THIS ORDER, OR (c) FOR INDIRECT OR CONSEQUENTIAL DAMAGES UNDER ANY CIRCUMSTANCES.

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