ULTRA PRECISION WIREWOUND RESISTORS

Resistance Wire

Mills selects the optimal type and size of resistance wire alloy for winding its resistors based upon the physical size of the resistor and the resistance and temperature coefficient required. These typically non-magnetic alloys possess properties that enhance the utility of each resistor manufactured, including high electrical resistivity, low temperature coefficient of resistance (≤10 ppm/ºC) over a wide temperature range (-65ºC to 125ºC), low thermal EMF vs. copper, and high tensile strength. The high resistivity of these alloys allows Mills to place very high resistance values in very small packages. In addition, Mills uses other alloys to achieve temperature coefficients of up to 6,000 ppm/ºC.

Termination

All ultra-precision resistors produced by Mills are welded in the sandwich or layered style to guarantee accuracy and stability. All welding is performed under high-power binocular microscopes. Welding equipment, electrode pressures and heat cycles are monitored regularly. Terminal materials are selected for maximum weldability and low thermal EMF.

Lead Material

On our standard resistors, the solder coated, oxygen free copper lead is molded into the winding bobbin to assure structural integrity. Other lead materials are possible; Nickel, Brass, and Dumet are some of the more popular.

Bobbins

Bobbins are made from molded high temperature epoxy. The thermal expansion properties of this product is similar to the wire used in the resistor and designed to minimize any stress on the resistor due to environmental changes.

Quality Control

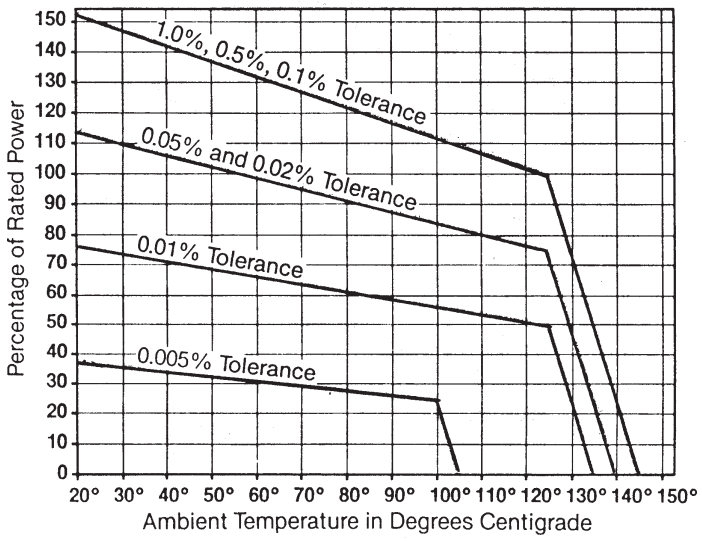
Mills Resistor meets all applicable quality assurance standards. Our quality control manual is available upon request.

Encapsulation

After the resistor has been wound, terminated, and aged, a special coating is applied to the windings to further protect the windings during the encapsulation process. An epoxy resin specially selected because its linear expansion capabilities match that of the wire is used to encapsulate the resistor element.

Wattage Ratings

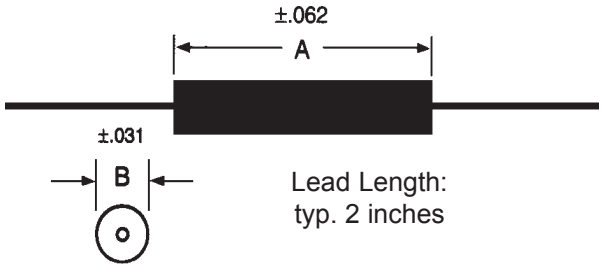
The wattage ratings listed on the following pages for ultra-precision wirewound resistors are maximum wattage ratings. They are based upon an ambient temperature of 125ºC. Ultra-precision wirewound resistors should not be used at a combination of full wattage and maximum ambient temperature where reliability is an important factor. When high reliability is required, a multiplication factor of 0.6 should be applied to the wattage listed. Also as tolerances get tighter, the resistor can only operate at a fraction of its rated power (see derating chart).



MR500 SERIES

This series offers the same reliability and quality as our MR100 series resistor, only in a smaller package. Designed for tight places, the many different sizes shown here should provide the design engineer with enough flexibility. However, we will be happy to design a resistor to meet your exact specifications.

Part No.	A	B	Wattage	Max Voltage	Max Ω	Leads
MR501	0.155	0.080	0.025	10	30 K	.0126
MR502	0.210	0.080	0.030	10	30 K	.0126
MR503	0.200	0.100	0.040	20	70 K	.0126
MR504	0.250	0.100	0.050	30	150 K	.020
MR505	0.312	0.100	0.060	30	75 K	.0126
MR506	0.187	0.125	0.050	30	100 K	.020
MR507	0.200	0.125	0.050	30	100 K	.0126
MR508	0.250	0.125	0.060	50	250 K	.020
MR509	0.312	0.125	0.060	50	250 K	.020
MR510	0.375	0.125	0.100	75	400 K	.020
MR511	0.500	0.125	0.125	80	400 K	.020
MR512	0.312	0.156	0.100	85	600 K	.0126



Leads smaller than 0.020 are Grade A Nickel. Leads of 0.020 diameter and larger are tinned copper. Other lead materials and diameters are available, please call the factory.

Wattage rating is for full power dissipation at 125ºC continuous operation.

How to Order

MILLS P/N	TC (PPM/ºC)	CONFIG	OHMS	TOLERANCE	LEADS
MR106	W – Std	R – Radial	use	T – .01	U – .020TC
MR9355	M – 4500		"R" for ohms	P – .025	S – .025TC
MR506	Q – 3900		"K" for KΩ	A – .05	M – .032TC
(etc)	N – 6000		"M" for MΩ	B – .10	
	G – 5		as the decimal	D – .50	
	J – 2		point		

The Mills Resistor part number is made up of body style, temperature coefficient, ohmic value and tolerance. In calling out the ohmic value, all digits are significant; we use a letter designator as the decimal point for the multiplier. The standard configuration for the MR100, MR300, MR93, and MR500 series resistors is axial leads with diameters as indicated in the above tables. Additional configurations are possible; please see the inside back cover for more options.

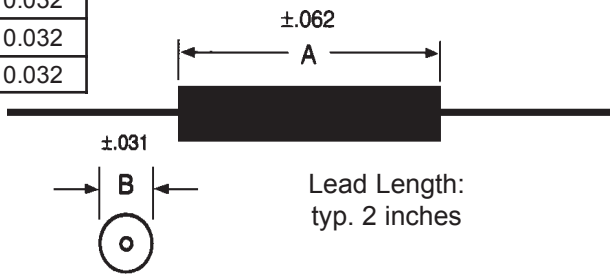
Thus the Mills part number MR506Q1K5B calls out an .05 watt resistor of 1.5KΩ, temperature coefficient of 3,900 ppm/ºC, and a tolerance of 0.1%; the part number MR106W5K0B calls out a .25 watt resistor of 5KΩ with the standard TC and a tolerance of ±0.1%; and the part number MR9355N1K0F calls out a .15w resistor of 1KΩ with a TC of 6,000 ppm/ºC and a tolerance of ±1%.

MR100 SERIES

This is our standard line of ultra precision resistors. The sizes below should handle most of your needs; however we can provide other sizes and custom configurations should they be required. Just call the factory and describe your needs.

Part No.	A	B	Wattage	Max Voltage	Max Ω	Leads
MR101	0.250	0.187	0.120	100	500 K	0.025
MR102	0.375	0.187	0.150	125	1.5 M	0.025
MR103	0.500	0.187	0.200	175	1.8 M	0.025
MR104	0.250	0.250	0.150	125	1.2 M	0.025
MR105	0.344	0.250	0.200	175	20 M	0.025
MR106	0.500	0.250	0.250	250	3.0 M	0.025
MR107	0.750	0.250	0.375	500	3.5 M	0.025
MR108	0.500	0.375	0.375	600	9.0 M	0.032
MR109	0.625	0.375	0.400	600	9.0 M	0.032
MR110	0.750	0.375	0.500	800	14.0 M	0.032
MR111	0.828	0.375	0.500	800	14.0 M	0.032
MR112	1.000	0.375	0.750	800	20.0 M	0.032
MR113	0.500	0.500	0.500	500	18.0 M	0.032
MR114	1.000	0.500	1.000	1000	35.0 M	0.032
MR115	1.500	0.500	1.500	1000	50.0 M	0.032
MR116	2.000	0.500	2.000	1200	75.0 M	0.032

Need Parts Quickly?
Ask about our ***FastLane Program***. Many of our resistors can be made to order in as little as 10 days.



Lead Length:
typ. 2 inches

MR300 SERIES

These resistors, although dimensionally the same as the MR100 series resistors, offer much greater stability over the lifetime of the resistor. Maximum drift of .002% per year is available in most cases.. Order these resistors for applications in which it is important that the resistance repeat every time.

Mills Resistor takes special care in winding these resistors. These resistors undergo tensionless winding and the windings are then specially treated for physical stability. Our proprietary aging process completes the manufacture, insuring great stability and reliability.

Part No.	A	B	Wattage	Max Voltage	Max Ω	Leads
MR301	0.250	0.187	0.120	100	500 K	0.025
MR302	0.375	0.187	0.150	125	1.5 M	0.025
MR303	0.500	0.187	0.200	175	1.8 M	0.025
MR304	0.250	0.250	0.150	125	1.2 M	0.025
MR305	0.344	0.250	0.200	175	20 M	0.025
MR306	0.500	0.250	0.250	250	3.0 M	0.025
MR307	0.750	0.250	0.375	500	3.5 M	0.025
MR308	0.500	0.375	0.375	600	9.0 M	0.032
MR309	0.625	0.375	0.400	600	9.0 M	0.032
MR310	0.750	0.375	0.500	800	14.0 M	0.032
MR311	0.828	0.375	0.500	800	14.0 M	0.032
MR312	1.000	0.375	0.750	800	20.0 M	0.032
MR313	0.500	0.500	0.500	500	18.0 M	0.032
MR314	1.000	0.500	1.000	1000	35.0 M	0.032
MR315	1.500	0.500	1.500	1000	50.0 M	0.032
MR316	2.000	0.500	2.000	1200	75.0 M	0.032

Order Hotline: 916-422-5461
Fax: 916-422-1409
Visit our website @ *www.millsresistor.com*

Reactance or Rise Time

Both inductive and capacitive reactance are intrinsic to the construction of wirewound resistors. In high speed circuits, the rise time of the resistor may be more significant than the actual accuracy of the resistor. These values vary with bobbin size and configuration, winding techniques, and wire diameter. Mills attempts to minimize reactance always.

Critical Resistance Value

This is the resistance value where the resistor dissipates the full rated power at the maximum working voltage. For resistance values below this threshold, voltage must be reduced so as to not exceed maximum rated power. For values above, the power must be derated so that maximum voltage is not exceeded.

$$R_{cv} = \frac{E_m^2}{P_R}$$

Marking

Standard markings are the Mills Resistor logo, part number, tolerance, resistance and date code. On very small resistors the part number may be abbreviated. All markings are made with two part epoxy ink designed to resist most cleaning solvents used during circuit board assembly.

Need Parts Quickly?
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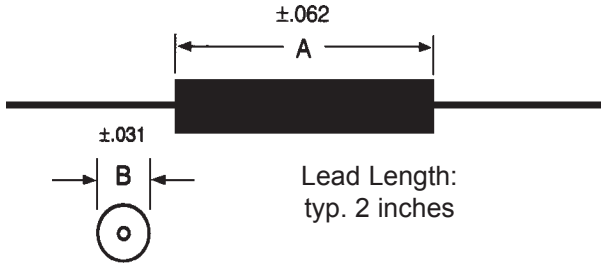

MR93 SERIES

Part No.	A	B	Wattage	Max Voltage	Max Ω	Leads
MR9352	1.000	0.375	0.500	600	1.5 M	0.032
MR9353	0.750	0.375	0.330	300	750 K	0.032
MR9354	0.750	0.250	0.250	300	511 K	0.032
MR9355	0.500	0.250	0.150	300	226 K	0.032
MR9356	0.344	0.250	0.130	300	127 K	0.032
MR9357	1.000	0.500	0.750	600	2.0 M	0.032
MR9358	1.500	0.500	1.000	900	3.0 M	0.032
MR9359	2.000	0.500	1.250	1200	5.0 M	0.032

Equivalent to our MR100 Series, these resistors are included for those customers that require the specific attributes called out in the MIL-R-93 specification. The resistors here are axial leaded. Other configurations specified in Mil-R-93 are available, just call and ask.

Standard Temperature Coefficient of Resistance: 20ppm/ºC from -65 ºC to 125 ºC

Other configurations are possible. Please see the MR100 series resistor or give Mills Resistor a call.

See the inside back cover for ordering information.

Resistor Tolerance

Mills Resistor uses calibration bridges which are annually calibrated to NIST traceable standards to verify the resistance during the manufacturing process. A final resistance check is performed immediately before shipping. Standard available tolerances are 1%, 0.5%, 0.25%, 0.1%, 0.05% and 0.01%. In some cases accuracies of .005% and tighter are available; contact the factory. Please see the chart below for minimum resistance and minimum tolerance ratings.

Resistance Range

Maximum resistance values are shown in the accompanying tables. Minimum values can be manufactured down to 0.5 ohms (and below in some cases). Values in the megohm range can be considered common in all resistor sizes that accommodate a maximum ohmic value greater than 1 megohm. Please see the chart below for minimum resistance and minimum tolerance ratings.

Thermal EMF

This parasitic voltage is generated at the junction of dissimilar metals when the metals are at different temperatures. Thermal EMF is created in a resistor due to external temperature gradients and non-symmetrical power distribution within the resistor. Mills Resistor's construction method virtually eliminates this effect.

TCR Tracking

The use of proprietary manufacturing processes allows Mills to offer TCR tracking of 2ppm/ºC. The tracking of multiple resistors is dependent upon value, style and temperature range. Please check with our engineering department with your specific requirements.

Stability

Stability is usually expressed as a change in resistance per unit of time. Mills' resistors have a typical shelf life (no-load) stability of <30ppm/year. Shelf life stabilities of <10ppm/year are available (MR300 series). Typical load-life stability (10,000 hours at 125ºC) is ±0.01%.

Temperature Coefficient of Resistance (TCR)

TCR is defined as the unit change in resistance per degree change in the temperature of the resistor. This change in wirewound resistors is non-linear and must be stipulated over a specific temperature range. TCR is expressed in parts per million per degree Centigrade (ppm/ºC) and is provided by the following formula.

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

R_1 = Resistance at temperature, T_1
R_2 = Resistance at the test temperature, T_2
T_1 = Reference temperature in ºC
T_2 = Test temperature in ºC

See the chart below for minimum resistance and minimum tolerance ratings.

Tolerance and TCR

Measurements are made on equipment calibrated to NIST standards. Limitations do exist in measuring two-leaded resistors, so there are minimum practical tolerance limits depending upon the resistance required. The following tables shows these.

Tolerance	Min Ω
0 ± .005%	1KΩ and over
0 ± .01%	50Ω to 1KΩ
0 ± .05%	5Ω to 50Ω
0 ± .10%	1Ω to 5Ω
0 ± .25%	.05Ω to 1Ω

ppm/ºC	Resistance Range
0 ± 10	100Ω and over
0 ± 15	10Ω to 100Ω
0 ± 30	1Ω to 10Ω
0 ± 90	less than 1Ω