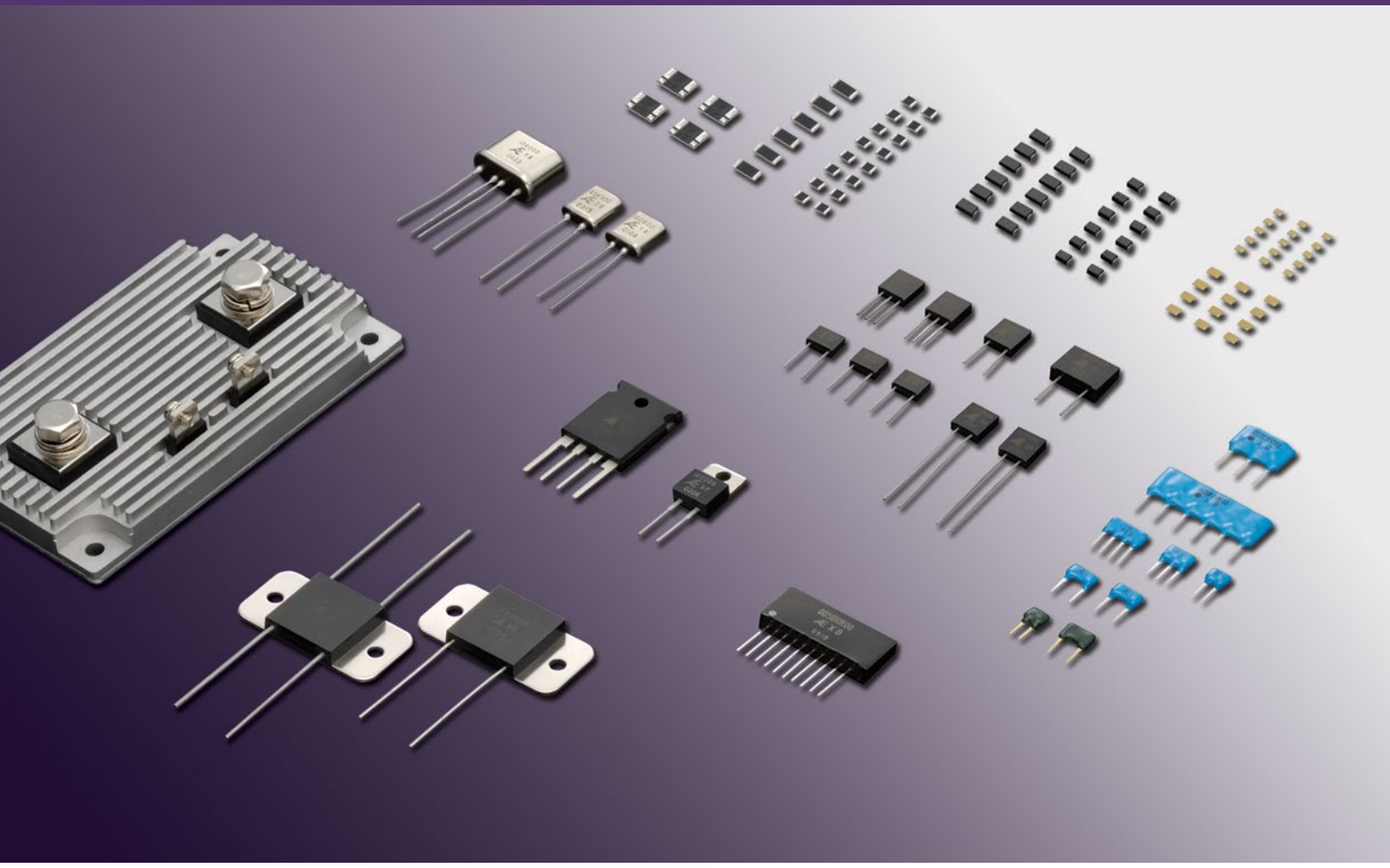
Ultra Precision Resistors

Databook



Bulk Metal® Foil
Thin Film
Thermosensitive

alpha-elec.co.jp

Alpha Electronics | Part of VPG Foil Resistors

Ultra Precision Resistors

www.alpha-elec.co.jp

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Alpha Electronics
A VPG Brand

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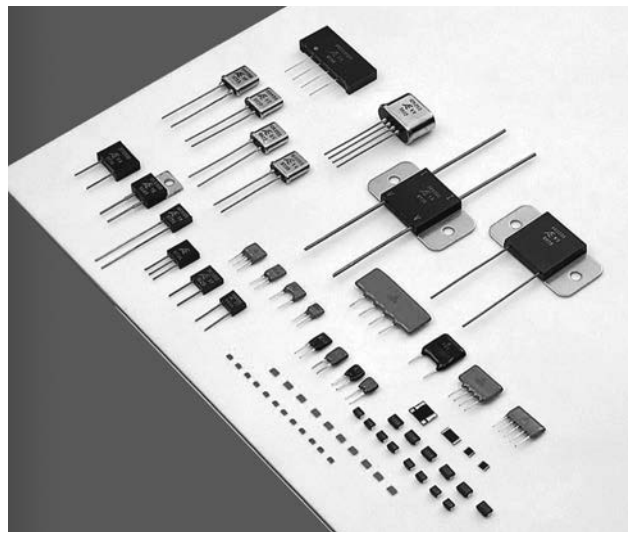
Manufacturing Process, Adjustment of Resistance Value Construction, and Temperature Characteristics of Resistance

A Bulk Metal® foil high precision resistor, unlike a precision-class metal film resistor or wire-wound resistor, is an ultra precision resistor in which the primary resistance element is a special alloy foil several μm thick.

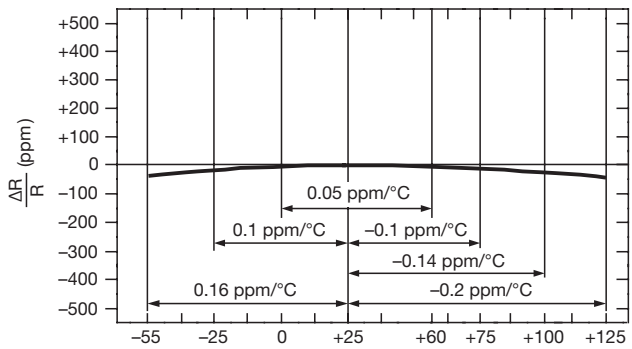
Use of this Bulk Metal® Foil as the resistance element gives superior performance not found in other resistors, satisfying military specification MIL-PRF-55182/9. In particular, the temperature coefficient of resistance has been reduced to an unprecedented, extremely low value by strict quality control of alloy composition and newly developed foil stabilization treatment technology. In addition, from the point of view of long-term stability, which is an important property of a resistor since the foil has a thickness of several μm instead of the extremely thin film of a metal film resistor, the natural stability of metal is preserved, resulting in very little resistance change over several years.

By developing our own original fine photo-etching technology, we have made it possible to form the complicated resistance pattern required for highly accurate resistance values.



MAIN APPLICATIONS

Precise amplifier circuitry and referential power supply in items such, as sophisticated electronic equipment, instrumentation and medical electronic apparatus.



Ambient Temperature (°C) and TCR Chord Slopes for Different Temperature Ranges

CHARACTERISTICS

❶ Temperature Coefficient of Resistance:
0.05 ppm/°C (Typical, 0°C to +60°C)

❷ Resistance Tolerance: ±0.005%

❸ Shelf Life:
25 ppm/year; 50 ppm/3 years
(Hermetically sealed: 5 ppm/year
10 ppm/3 years)

❹ Load Life:
0.005%/2,000 hours at Rated Power (typical)

❺ Thermal EMF: 0.1 μV/°C (between leads)

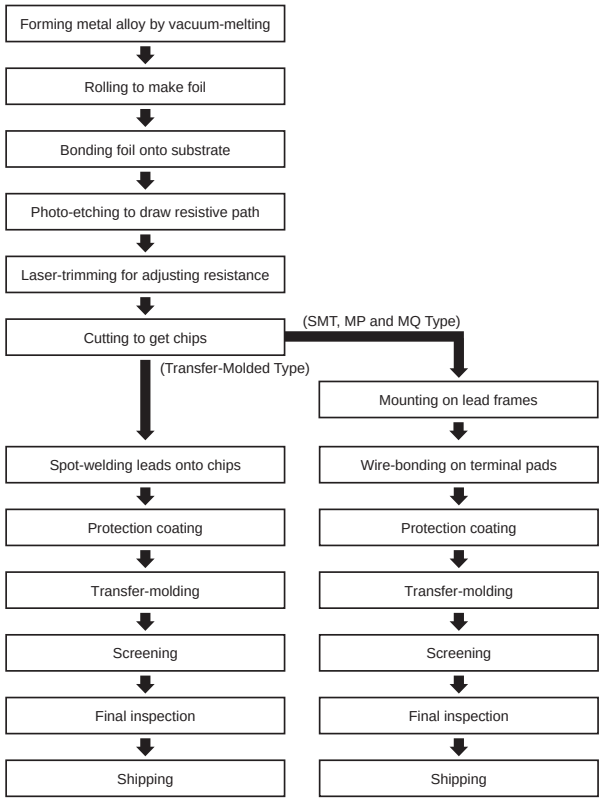
❻ Noise: –42 dB

❼ Voltage Coefficient: 0.3 ppm/V

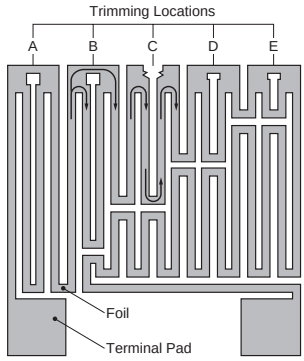
❽ Frequency Characteristics:
Inductance: 0.08 μH
Capacitance: 0.5 pF

Manufacturing Process, Adjustment of Resistance Value Construction, and Temperature Characteristics of Resistance

MANUFACTURING PROCESS



ADJUSTMENT OF RESISTANCE VALUE



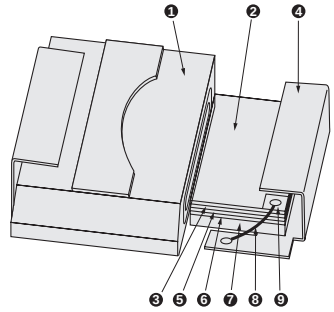
Foil bonded on substrate is photo-etched to make a fine path pattern to provide a desired value. A series of trimming locations are laid out on the pattern, as shown in A through E (fig. above). As shown at C, the trimming method is to increase the resistance by cutting the Bulk Metal® Foil. The resistance value can be made accurate to within ±50 ppm of the desired value by cutting at several of the trimming locations. The locations that are cut for trimming are where the electric current flow (arrows in diagram) will not be affected so that the trimming will not cause electrical noise or changes over the years.

CONSTRUCTION

Construction of SMT (MP, MQ Type)

Outer coating is made of epoxy resin, which provides excellent resistance to moisture, heat and solvents.

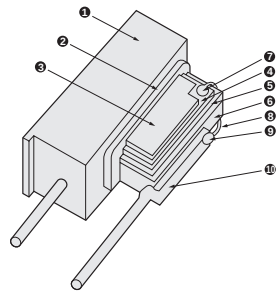
Gold wire-bond connects between lead frames and resistive elements. Also, resistive elements are designed to be mounted on lead frames efficient heat removal.



❶ Transfer-molded resin (heat-resistant epoxy)
❷ Coating for moisture protection and buffering
❸ Protective layer
❹ External lead
❺ Bulk Metal® Foil (etched resistive element)
❻ Bonding layer (polyimede)
❼ Ceramic substrate (high-purity alumina)
❽ Gold wire
❾ Terminal pads

Construction of Transfer-Molded Type

The outer cover is transfer-molded epoxy resin strongly resistant to heat, moisture and solvents. Inside, there are secondary leads which act as a buffer so that stress on the exterior leads is not transmitted to the foil, providing stability against vibrations when the resistor is mounted on a circuit.

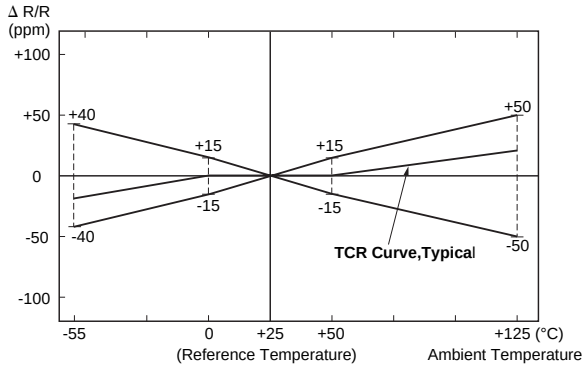


❶ Transfer-molded resin (heat-resistant epoxy)
❷ Coating for moisture protection and buffering
❸ Protective layer
❹ Bulk Metal® Foil (etched resistive element)
❺ Bonding layer (polyimede)
❻ Ceramic substrate (high-purity alumina)
❼ Resin strengthening welded part
❽ Secondary lead (abating mechanical stress from outside)
❾ High-temperature solder
❿ Exterior lead (Dia. 0.65 mm)

Manufacturing Process, Adjustment of Resistance Value Construction, and Temperature Characteristics of Resistance

TEMPERATURE CHARACTERISTICS OF RESISTANCE

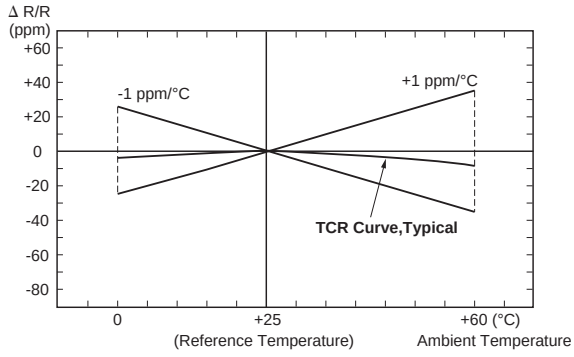
Char.S



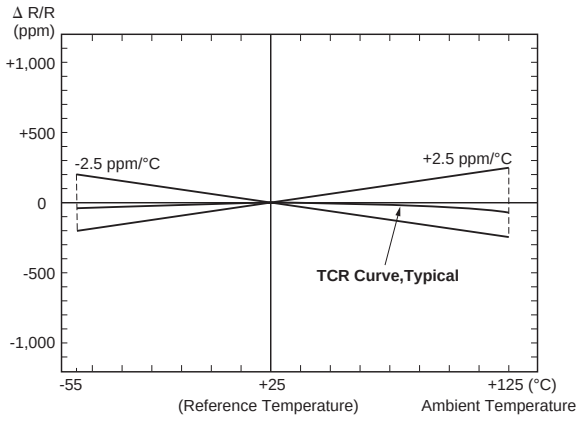
Temperature (°C)	Δ R/R (ppm)
-55	0±40
0	0±15
+50	0±15
+125	0±50

Reference Temperature +25°C

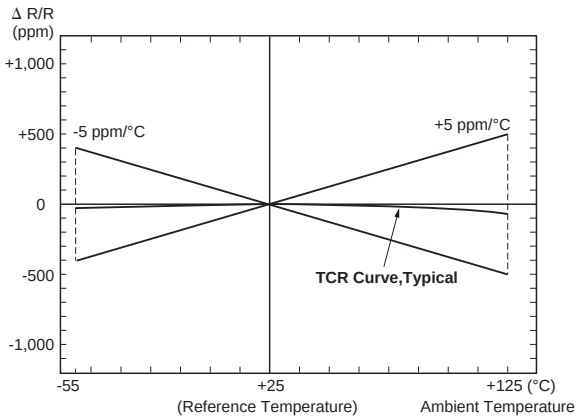
Char.Z (0±1 ppm/°C)



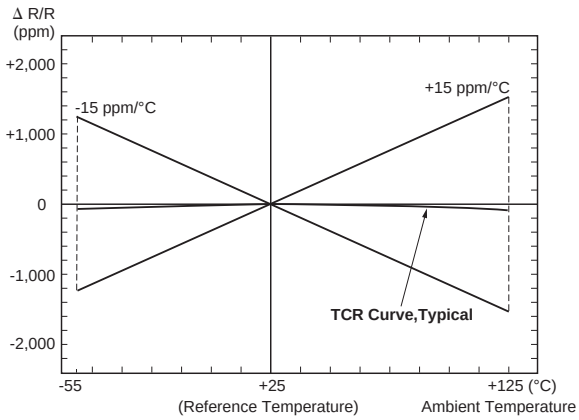
Char.Y (0±2.5 ppm/°C)



Char.X (0±5 ppm/°C)



Char.W (0±15 ppm/°C)



Alpha Electronics
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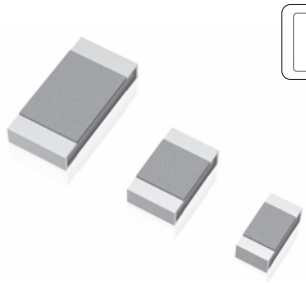
Precision SMD Bulk Metal® Foil Resistor (Wraparound)

Made in Japan



Pb-free Available
RoHS COMPLIANT

FEATURES

- High precision and stable Bulk Metal® Foil resistor with 0603, 0805 and 1206 package
- TCR: 0±1ppm/°C*, 0±2 ppm/°C, 0±5 ppm/°C
- Resistance tolerance: up to ±0.01%
- Load-life stability: ±0.005% (typical, 70°C, 2000 hrs., rated power)
- AEC-Q200 qualified
- No standard resistance value (example: 1K234Ω)
- MOQ: 100 pieces

*Please contact us for availability.

COMPOSITION OF TYPE NUMBER

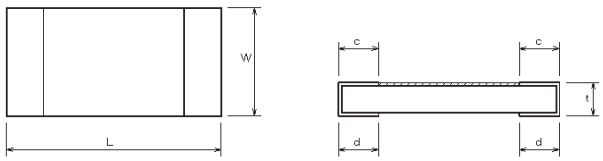
Example:

RWC 10K00 Q L

- L — Tape and Reel Package
- Q — Resistance Tolerance
- 10K00 — Resistance Value
- RWC — Type

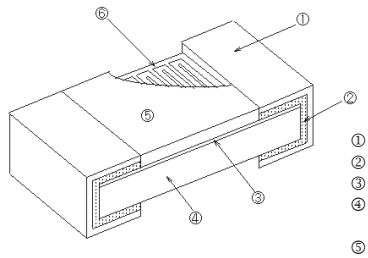
Resistance value is expressed by 4 numbers and 1 alphabet. R or K is a dual-purpose letter that designates both the value range (R for ohmic, K for kiloohm) and the location of decimal point.

CONFIGURATION—DIMENSIONS IN mm



Type	RWA	RWB	RWC
L	1.6±0.2	2.0±0.2	3.2±0.2
W	0.8±0.2	1.25±0.2	1.6±0.2
t	0.5±0.1	0.5±0.1	0.5±0.1
c	0.3±0.25	0.4±0.25	0.5±0.25
d	0.3±0.25	0.4±0.25	0.5±0.25

CONSTRUCTION

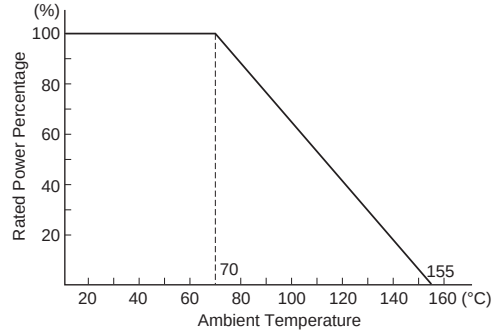


① External terminal (Sn)
② Internal terminal (Cu+Ni)
③ Bonding layer (polyimide)
④ Ceramic substrate (high-purity alumina)
⑤ Solder resist
⑥ Bulk Metal Foil

TCR, RESISTANCE RANGE, TOLERANCE, RATED POWER

Type	TCR –25°C to +125°C (ppm/°C)	Resistance Range (Ω)	Resistance Tolerance (%)	Rated Power at 70°C (W)
RWA	0±5	100 to 1k	±0.1(B)	0.1
		1k to 5k	±0.05(A)	
RWB	0±10	10 to 30	±0.5(D)	0.2
	0±5	30 to 100	±0.1(B)	
	0±2	100 to 1k	±0.05(A), ±0.1(B)	
		1k to 10k	±0.02(Q), ±0.05(A)	
RWC	0±10	5 to 30	±0.5(D)	0.3
	0±5	30 to 100	±0.1(B)	
	0±2	100 to 1k	±0.02(Q), ±0.05(A), ±0.1(B)	
		1k to 30k	±0.01(T), ±0.02(Q), ±0.05(A)	

POWER DERATNG CURVE

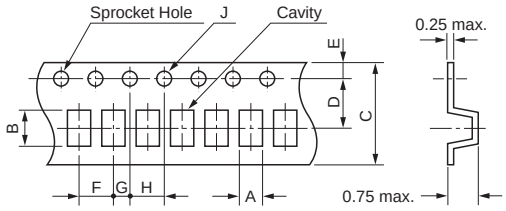


PERFORMANCE

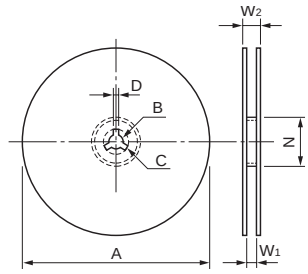
PARAMETERS	TEST CONDITION	SPECIFICATION	
		MIL-PRF-55342	ALPHA Typical
Max. Rated Operating Temperature		70°C	
Working Temperature Range		–65°C to +155°C	
Maximum Working Voltage		RWA=22V, RWB=45V, RWC=95V	
Thermal Shock	–65°C/30 min.⇔+150°C/30 min. 100 cycles	±0.1%	±0.01%
Overloading	Rated Voltage x 2.5, 5 sec.	±0.1%	±0.01%
Low Temperature Storage	–65°C, No Load, 24 hrs.→ Rated Power, 45 min.	±0.1%	±0.01%
Resistance to Soldering Heat	+260°C, 10 sec.	±0.2%	±0.01%
Moisture Resistance	+65°C to –10°C, 90% RH to 98% RH, Rated Voltage, 10 cycles (240 hrs.)	±0.2%	±0.02%
Life	70°C, Rated Power, 1.5 hrs. ON, 0.5 hrs. OFF, 2,000 hrs.	±0.5%	±0.005%
High Temperature Exposure	155°C, No Load, 100 hrs.	±0.1%	±0.02%

TAPE AND REEL PACKAGE (BASED ON EIA-481-1) [DIMENSIONS IN mm]

Tape Dimensions



Reel Dimensions



Type	A	B	C	D	E	F	G	H	J	A	N	B	C	D	W_1	W_2
RWA	1.00 ±0.1	1.80 ±0.1	8.0 ±0.2	3.5 ±0.05	1.75 ±0.1	4.0 ±0.1	2.0 ±0.05	4.0 ±0.1	Dia. 1.55 ±0.55	Dia. 180 0/-1.5	Dia. 60 +1/0	Dia. 13 ±0.2	Dia. 21 ±0.8	2 ±0.5	9.0 +1/-0	13.0 ±1.0
RWB	1.45 ±0.1	2.25 ±0.1	8.0 ±0.2	3.5 ±0.05	1.75 ±0.1	4.0 ±0.1	2.0 ±0.05	4.0 ±0.1	Dia. 1.55 ±0.55							
RWC	1.90 ±0.1	3.50 ±0.1	8.0 ±0.2	3.5 ±0.05	1.75 ±0.1	4.0 ±0.1	2.0 ±0.05	4.0 ±0.1	Dia. 1.55 ±0.55							

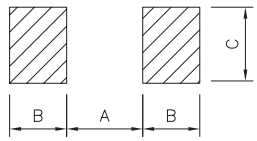
PRECAUTION IN USING FACE-BONDED CHIP RESISTORS

1. Storage
Storage conditions or environment may adversely affect solderability of the exterior terminals. Do not store in high temperature and humidity. The recommended storage environment is lower than 40°C, has less than 70% RH humidity and is free from harmful gases such as sulphur and chlorine.

2. Caution in Soldering
- ❶ IR and vapor phase reflow are recommended.
- ❷ Vacuum pick up is recommended for handling.
- ❸ If the use of a soldering iron becomes necessary, precautionary measures should be taken to avoid any possible damage / overheating.

3. Cleaning
Avoid the use of cleaning agents which could attack epoxy resins, which form part of the resistor construction.

4. Recommended Land Pattern
The dimensions of solder land must be determined in conformity with the size of resistors and with the soldering method. They are also subject to the mounting machine and the material of the substrate.

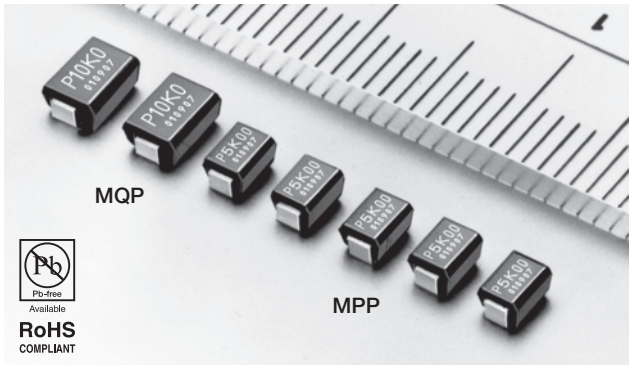


Type	A	B	C
RWA	0.8	0.9	1.0
RWB	0.8	1.2	1.4
RWC	1.6	1.5	1.8

(mm)

Alpha Electronics
A VPG Brand

Z-Foil Ultra High-Precision SMT Resistor (Molded, J-Lead Terminal)



FEATURES

- Temperature coefficient of resistance (TCR): 0.05 ppm/°C typical (0°C to +60°C) by New Generation Z-Foil Technology
- 0.2 ppm/°C typical (–25°C to +125°C, +25°C ref.)
- Resistance tolerance: to ±0.01%
- Power coefficient "ΔR due to self heating": 5 ppm at rated power (typical)
- Power rating: to 200 mW (MPP) and 250 mW (MQP) at +70°C
- Load life stability: to ±0.005% at 70°C, 2000h at rated power (typical)
- Not restricted to standard values, we can supply specific "as required" values at no extra cost or delivery (e.g., 1K2345 vs. 1K)

COMPOSITION OF TYPE NUMBER

Example:

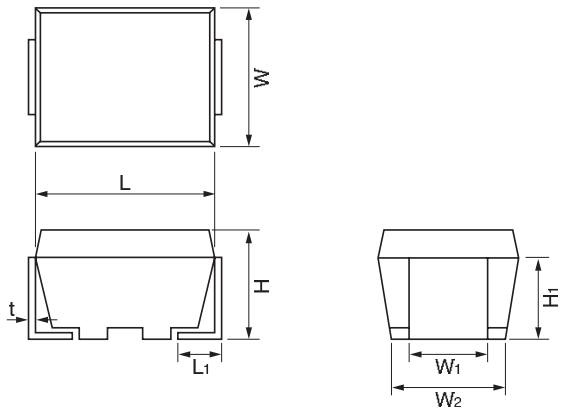
MPP 10K005* T L

- L — Tape & Reel Package Required
- T — Resistance Tolerance
- 10K005* — Resistance Value
- MPP — Type

Resistance value, in ohm, is expressed by a series of six characters, five of which represent significant digits. R or K is a dual-purpose letter that designates both the value range (R for ohmic; K for kilo-ohm) and the location of the decimal point.

* Imprinting indicates up to 3 significant digits but ordered resistance value is traceable by date code

CONFIGURATION (DIMENSIONS IN mm)

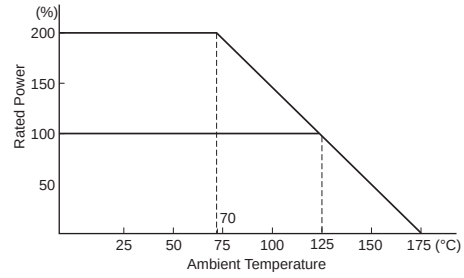


Type	MPP	MQP
L	3.2±0.2	4.5±0.2
W	2.5±0.2	3.2±0.2
H	2.0±0.2	
L_1	0.6±0.2	0.8±0.2
W_1	1.4±0.3	
W_2	2.3±0.2	3.0±0.2
H_1	1.5±0.3	
t	0.15±0.05	

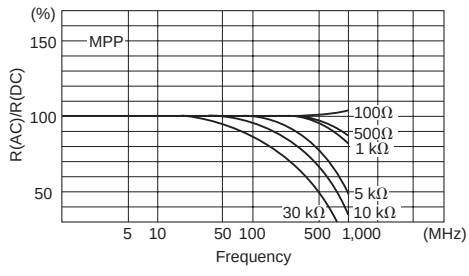
TCR, RESISTANCE RANGE, TOLERANCE, RATED POWER

Type	TCR (ppm/°C) –25°C to +125°C	Resistance Range (Ω)	Resistance Tolerance (%)	Rated Power (W) at 125°C
MPP	±0.2±3.8	30 to <50	±0.1(B)	0.1
	±0.2±2.8	50 to <100	±0.1(B)	
	±0.2±1.8	100 to <1k	±0.02(Q) ±0.05(A) ±0.1(B)	
		1k to ≤30k	±0.01(T) ±0.02(Q) ±0.05(A) ±0.1(B)	
MQP	±0.2±3.8	30 to <50	±0.1(B)	0.125
	±0.2±2.8	50 to <100	±0.1(B)	
	±0.2±1.8	100 to <1k	±0.02(Q) ±0.05(A) ±0.1(B)	
		1k to ≤60k	±0.01(T) ±0.02(Q) ±0.05(A) ±0.1(B)	

POWER DERATING CURVE



FREQUENCY CHARACTERISTICS

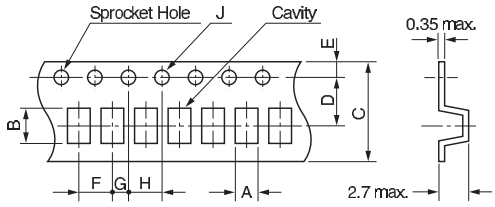


PERFORMANCE

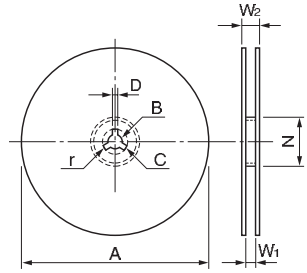
Parameters	Test Condition	Specification		Typical
		MP/MQ	MPP/MQP	MPP/MQP
Maximum Rated Operating Temperature **Working Temperature Range** **Maximum Working Voltage** **Maximum Working Current**		125°C –65°C to +175°C MPP = 50V, MQP = 100V 350 mA		
Thermal Shock **Overload**	–65°C/30 min.↔+150°C/30 min., 5 cycles Rated Voltage x 2.5, 5 sec.	±0.05% ±0.05%	±0.01% ±0.01%	±0.005% ±0.005%
Low Temperature Storage and Life **Outstanding PC Board Bending**	–65°C, No Load, 24 hrs.→Rated Voltage, 45 min. 3 mm Bend, 60 sec.	±0.05% ±0.05%	±0.01% ±0.01%	±0.005% ±0.005%
Dielectric Withstanding Voltage	AC 200V, 1 min.	±0.01%	±0.01%	±0.005%
Insulation Resistance	DC 100V, 1 min.	over 10,000 MΩ		
Resistance to Soldering Heat	260°C, 10 sec.			
Moisture Resistance	+65°C to –10°C, 90% RH to 98% RH, Rated Voltage, 10 cycles (240 hrs.)	±0.05% ±0.05%	±0.03% ±0.03%	±0.01% ±0.01%
Shock	100G, 6 ms, Sawtooth Wave, X, Y, Z, each 10 shocks	±0.02%	±0.02%	±0.01%
Vibration, High Frequency	20G, 10 Hz to 2,000 Hz to 10 Hz, 20 min., X, Y, Z, each 2.5 hrs.	±0.02%	±0.02%	±0.01%
Storage Life	15°C to 35°C, 15% RH to 75% RH, No Load, 10,000 hrs.	±0.005%	±0.005%	±0.0025%
High Temperature Exposure	175°C, No Load, 2,000 hrs.	±0.05%	±0.05%	±0.03%
Life	70°C, Rated Power, 1.5 hr. – on, 0.5 hr. – off, 2,000 hrs.	—	±0.01%	±0.005%
	70°C, Rated Power × 2, 1.5 hr. – on, 0.5 hr. – off, 2,000 hrs.	—	±0.03%	±0.01%

TAPE AND REEL PACKAGE (BASED ON EIA-481-1) (DIMENSIONS IN mm)

Tape Dimensions



Reel Dimensions



Type	A	B	C	D	E	F	G	H	J	A	N	B	C	D	W1	W2	r
MPP	2.8 ±0.2	3.9 ±0.2	12.0 ±0.3	5.5 ±0.05	1.75 ±0.1	4.0 ±0.1	2.0 ±0.05	4.0 ±0.1	Dia. 1.5 ±0.1-0	Dia. 178 ±2	Dia. 60 min.	Dia. 13 ±0.5	Dia. 21 ±0.8	2 ±0.5	12.4 +2.0-0	18.4 max.	1.0 ±0.5
MQP	3.6 ±0.2	5.2 ±0.2	12.0 ±0.3	5.5 ±0.05	1.75 ±0.1	8.0 ±0.1	2.0 ±0.05	4.0 ±0.1	Dia. 1.5 ±0.1-0	Reel Capacity MPP: 1,200 pieces/reel MQP: 800 pieces/reel							

PRECAUTION IN USING FACE-BONDED CHIP RESISTORS

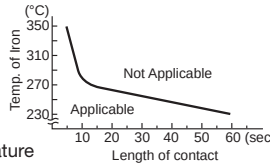
1. Storage

Storage conditions or environment may adversely affect solderability of the exterior terminals. Do not store in high temperature and humidity. The recommended storage environment is lower than 40°C, has less than 70% RH humidity and is free from harmful gases such as sulphur and chlorine.

2. Caution in Soldering

❶ Hand Soldering—Hand soldering is applicable as shown at right.
Recommended
- Temp. of iron tip: 240°C to 270°C
- Power of iron: 20W or less
- Diameter of tip: dia. 3 mm max.

❷ Solder Reflow in Furnace
Recommended
- Peak temperature: 250+0/-5°C
- Holding time: 10 sec. max.
- To cool gradually at room temperature



❸ Dipping in Solder (Wave or Still)
Recommended
- Temp. of solder: 260°C max
- Length of dipping: 10 seconds
- To cool gradually at room temperature

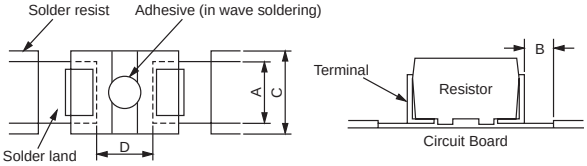
❹ Other
Corrosion-free flux, such as rosin, is recommended. Do not apply pressure to the molded housing immediately after soldering.

3. Cleaning

Use volatile cleaner such as methylalcohol or propyl alcohol.

4. Circuit Board Design

The dimensions of solder land must be determined in conformity with the size of resistors and with the soldering method. They are also subject to the mounting machine and the material of the substrate. See example below.

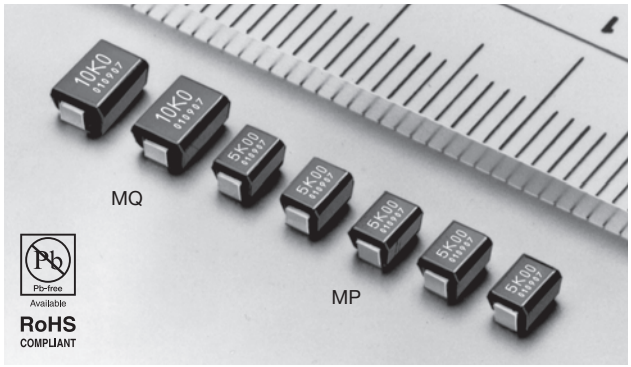


Type	A	B	C	D
MPP	1.6 to 2.0	0.5 to 1.5	2.2 to 2.6	1.8
MQP				2.5

When parts are mounted on a board in high density, solder can possibly attach to the resistors in an excessive amount to affect performance or reliability of the resistors. To prevent this effect, the use of solder resist is recommended to isolate solder lands.

Alpha Electronics
A VPG Brand

Ultra Precision SMT Resistor (Molded, J-Lead Terminal)



TCR, RESISTANCE RANGE, TOLERANCE, RATED POWER

Type	TCR (ppm/°C) –55°C to +125°C*	Resistance Range (Ω)	Resistance Tolerance (%)**	Rated Power (W) at 125°C
MP	0±10	30 to 100	±0.1	0.1
	0±5	100 to 30k	±0.05	
MQ	0±10	30 to 100	±0.1	0.125
	0±5	100 to 60k	±0.05	

* 0±1ppm/°C, 0±2.5ppm/°C are available per request
** Please contact us for tighter tolerances.

COMPOSITION OF TYPE NUMBER

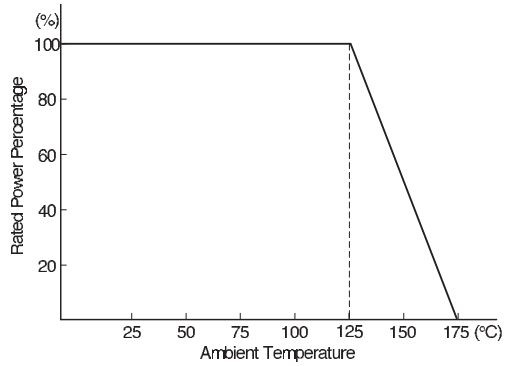
Example:

MQ 10K00 L

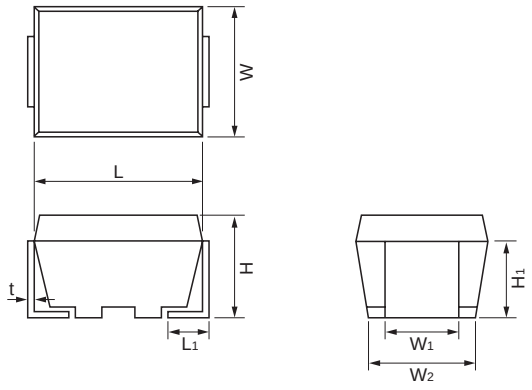
- L — Tape & Reel Package Required
- 10K00 — Resistance Value
- MQ — Type

Resistance value, in ohm, is expressed by a series of five characters, four of which represent significant digits. R or K is a dual-purpose letter that designates both the value range (R for ohmic; K for kilo-ohm) and the location of the decimal point.

POWER DERATING CURVE

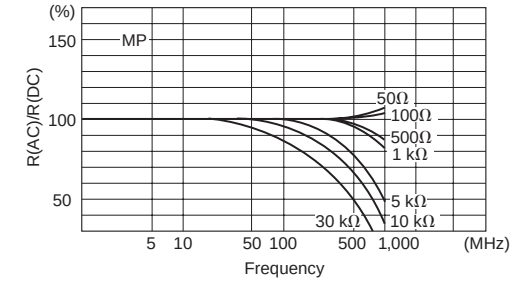


CONFIGURATION (DIMENSIONS IN mm)

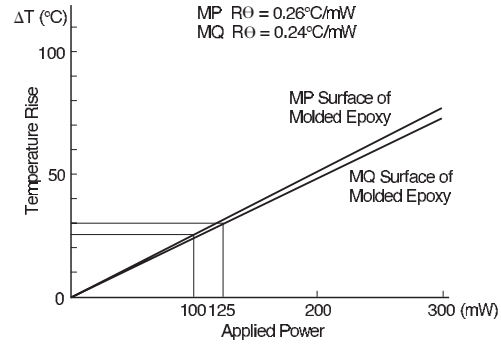


Type	MP	MQ
L	3.2±0.2	4.5±0.2
W	2.5±0.2	3.2±0.2
H	2.0±0.2	
L_1	0.6±0.2	0.8±0.2
W_1	1.4±0.3	
W_2	2.3±0.2	3.0±0.2
H_1	1.5±0.3	
t	0.15±0.05	

FREQUENCY CHARACTERISTICS



TEMPERATURE OF RESISTOR SURFACE

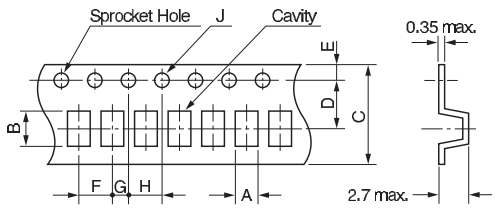


PERFORMANCE

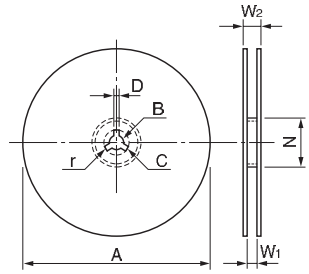
Parameters	Test Condition	ALPHA Specification	ALPHA Typical Test Data
Maximum Rated Operating Temperature		125°C	
Working Temperature Range		-65°C to +175°C	
Maximum Working Voltage		MP=50V, MQ=100V	
Maximum Working Current		350 mA	
Thermal Shock	–65°C/30 min. ↔ +175°C/30 min., 5 cycles	±0.05%	±0.01%
Overload	Rated Voltage x 2.5, 5 sec.	±0.05%	±0.01%
Low Temperature Storage and Operation	–65°C, No Load, 24 hrs.→Rated Voltage, 45 min.	±0.05%	±0.01%
Substrate Bending Test	Substrate Bent 3 mm, 60 sec.	±0.05%	±0.01%
Dielectric Withstanding Voltage	Atmospheric: AC 200V, 1 min.	±0.01%	±0.005%
Insulation Resistance	DC 100V, 1 min.	over 10,000 MΩ	over 10,000 MΩ
Resistance to Soldering Heat	260°C, 10 sec.	±0.05%	±0.01%
Moisture Resistance	+65°C to –10°C, 90% RH to 98% RH, Rated Voltage, 10 cycles (240 hrs.)	±0.05%	±0.03%
Shock	100G, 6 ms, Sawtooth Wave, X, Y, Z, each 10 shocks	±0.02%	±0.01%
Vibration, High Frequency	20G, 10 Hz to 2,000 Hz to 10 Hz, 20 min., X, Y, Z, each 2.5 hrs.	±0.02%	±0.01%
Life	125°C, Rated Power, 1.5 hr. – ON, 0.5 hr. – OFF, 2,000 hrs.	±0.05%	±0.03%
Storage Life	15°C to 35°C, 15% RH to 75% RH, No Load, 10,000 hrs.	±0.005%	±0.0025%
High Temperature Exposure	175°C, No Load, 2,000 hrs.	±0.05%	±0.03%

TAPE AND REEL PACKAGE (BASED ON EIA-481-1) (DIMENSIONS IN mm)

Tape Dimensions



Reel Dimensions



Type	A	B	C	D	E	F	G	H	J	A	N	B	C	D	W1	W2	r
MP	2.8 ±0.2	3.9 ±0.2	12.0 ±0.3	5.5 ±0.05	1.75 ±0.1	4.0 ±0.1	2.0 ±0.05	4.0 ±0.1	Dia. 1.5 ±0.1-0	Dia. 178 ±2	Dia. 60 min.	Dia. 13 ±0.5	Dia. 21 ±0.8	2 ±0.5	12.4 +2.0-0	18.4 max.	1.0 ±0.5
MQ	3.6 ±0.2	5.2 ±0.2	12.0 ±0.3	5.5 ±0.05	1.75 ±0.1	8.0 ±0.1	2.0 ±0.05	4.0 ±0.1	Dia. 1.5 ±0.1-0	Reel Capacity MP: 1,200 pieces/reel MQ: 800 pieces/reel							

PRECAUTION IN USING FACE-BONDED CHIP RESISTORS

1. Storage

Storage conditions or environment may adversely affect solderability of the exterior terminals. Do not store in high temperature and humidity. The recommended storage environment is lower than 40°C, has less than 70% RH humidity and is free from harmful gases such as sulphur and chlorine.

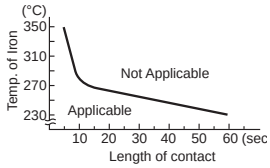
2. Caution in Soldering

❶ Hand Soldering

Hand soldering is applicable as shown at right.

Recommended

- Temp. of iron tip: 240°C to 270°C
- Power of iron: 20W or less
- Diameter of tip: dia. 3 mm max.



❷ Solder Reflow in Furnace

Recommended

- Peak temperature: 250+0/-5°C
- Holding time: 10 sec. max.
- To cool gradually at room temperature

❸ Dipping in Solder (Wave or Still)

Recommended

- Temp. of solder: 260°C max
- Length of dipping: 10 seconds
- To cool gradually at room temperature

❹ Other

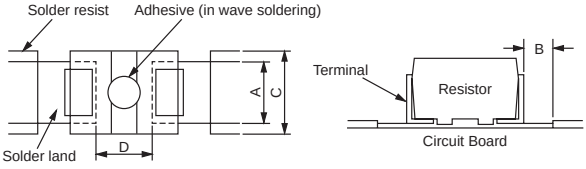
Corrosion-free flux, such as rosin, is recommended. Do not apply pressure to the molded housing immediately after soldering.

3. Cleaning

Use volatile cleaner such as methylalcohol or propyl alcohol.

4. Circuit Board Design

The dimensions of solder land must be determined in conformity with the size of resistors and with the soldering method. They are also subject to the mounting machine and the material of the substrate. See example below.



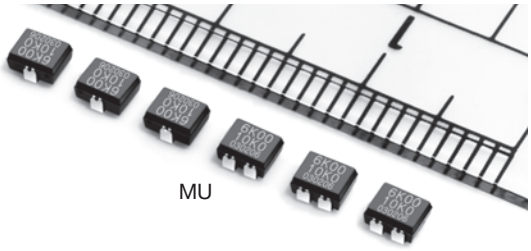
Type	A	B	C	D
MP	1.6 to 2.0	0.5 to 1.5	2.2 to 2.6	1.8
MQ				2.5

Dimensions in mm

When parts are mounted on a board in high density, solder can possibly attach to the resistors in an excessive amount to affect performance or reliability of the resistors. To prevent this effect, the use of solder resist is recommended to isolate solder lands.

Alpha Electronics
A VPG Brand

Ultra Precision SMT Resistor 1-2-3 Network
(Molded, J-Lead Terminal)



Pb-free Available
RoHS COMPLIANT

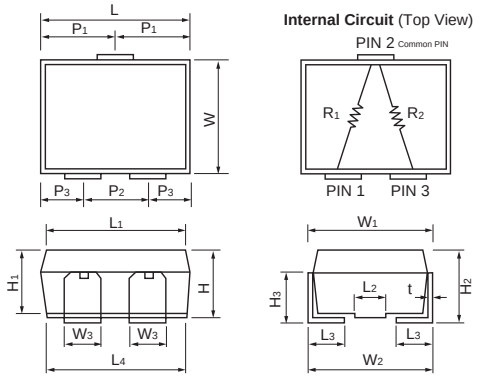
COMPOSITION OF TYPE NUMBER

Example:

MU 1K000/ 10K00 B Q L
① ② ③ ④ ⑤ ⑥

① Type
② Nominal Resistance Values (R1)
③ Nominal Resistance Values (R2)
④ Tolerance (Absolute)
⑤ Tolerance (Matching)
⑥ Tape & Reel Package Being Required

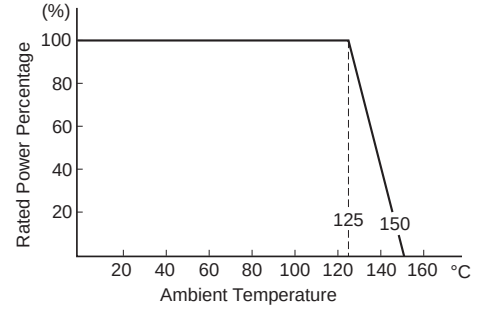
CONFIGURATION (DIMENSIONS IN mm)



L	W	H	H1	H2	H3	P1	P2	P3
3.2 ±0.2	2.5 ±0.2	1.5 ±0.2	1.4 ±0.2	1.6 ±0.2	1.1 ±0.2	1.6 ±0.1	1.4 ±0.1	0.9 ±0.1

W1	W2	W3	L1	L2	L3	L4	t
2.7 ±0.2	2.7 ±0.2	0.8 ±0.1	3.0 ±0.2	0.7 ±0.2	0.8 ±0.1	3.0 ±0.2	0.1 ±0.05

POWER DERATING CURVE



RESISTANCE RANGE, TOLERANCE, RATED POWER

Type	Resistance Range Element**	Resistance Tolerance*		Rated Power/ Element (W) at 125°C
		Absolute*	Matching*	
MU	10Ω ≤R <100Ω	±0.1% (B) ±0.5% (D)	±0.05% (A) ±0.1% (B) ±0.5% (D)	0.05
	100Ω ≤R <1kΩ	±0.05% (A) ±0.1% (B) ±0.5% (D)	±0.02% (Q) ±0.05% (A) ±0.1% (B) ± 0.5% (D)	
	1kΩ ≤R ≤20kΩ	±0.02% (Q) ±0.05% (A) ±0.1% (B) ± 0.5% (D)	±0.01% (T) ±0.02% (Q) ±0.05% (A) ± 0.1% (B) ±0.5% (D)	

* Symbols in parentheses are for type number composition.
** Please contact us for the availability.

ABSOLUTE TCR

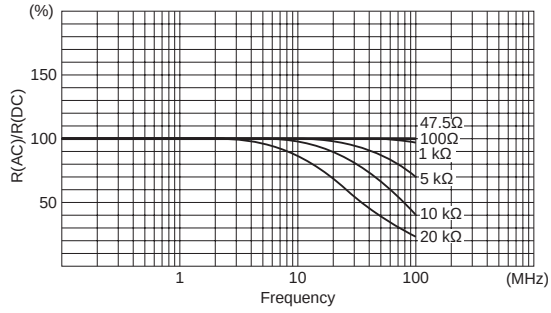
Resistance Range (Ω)	Absolute TCR (ppm/°C) –55C to +125°C
10Ω ≤R <30Ω	±15
30Ω ≤R <100Ω	±10
100Ω ≤R ≤20kΩ	±5

TCR TRACKING

Resistance Ratio	TCR Tracking (ppm/°C) –55°C to +125°C
Ratio = 1	±1
1 <Ratio ≤10	±2
10 <Ratio ≤100	±3
100 <Ratio	±5

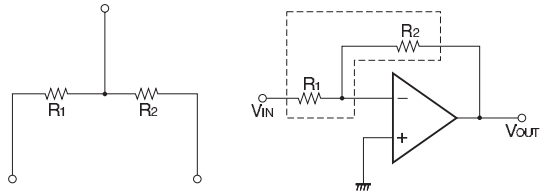
Applicable >50 Ω

FREQUENCY CHARACTERISTICS



EXAMPLE OF APPLICATIONS

An Application of Type MU (input/feedback resistors for amplifiers)
Because the input and the feedback resistors are incorporated into one single element, amplification is not affected by temperature change.

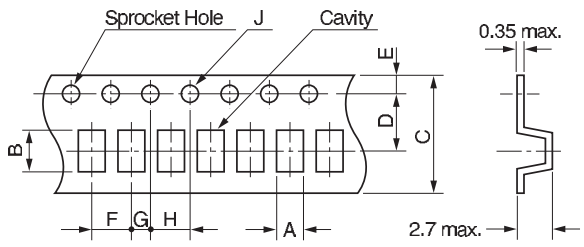


PERFORMANCE

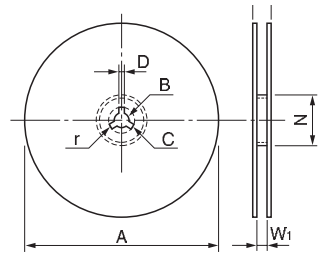
Parameters	Test Condition	ALPHA Specification		ALPHA Typical Test Data	
		Δ R	Δ Ratio	Δ R	Δ Ratio
Maximum Rated Operating Temperature Working Temperature Range		125°C –65°C to +150°C			
Thermal Shock Overload	–65°C/30 min. ↔ +150°C/30 min., 5 cycles Rated Voltage x 2.5, 5 sec.	±0.05% ±0.05%	±0.02% ±0.02%	±0.01% ±0.01%	±0.005% ±0.005%
Low Temperature Storage and Operation Substrate Bending Test	–65°C, No Load, 24 hrs. → Rated Voltage, 45 min. 3 mm Bend 60 sec.	±0.05% ±0.05%	±0.02% ±0.02%	±0.01% ±0.01%	±0.005% ±0.005%
Dielectric Withstanding Voltage Insulation Resistance Resistance to Soldering Heat Moisture Resistance	Atom. Pres.: AC 200V, 1 min. DC 100V, 1 min. 260°C, 10 sec. +65°C to –10°C, 90% to 98% RH, Rated Power, 10 cycles (240 hrs.)	±0.01% over 10,000 MΩ ±0.05% ±0.05%	±0.01% ±0.02% ±0.02%	±0.005% over 10,000 MΩ ±0.01% ±0.03%	±0.0025% ±0.005% ±0.01%
Shock Vibration, High Frequency	100G, 6 ms, Sawtooth Wave, X, Y, Z, each 10 shocks 20G, 10 Hz to 2,000 Hz to 10 Hz, 20 min., X, Y, Z, each 2.5 hrs.	±0.02% ±0.02%	±0.01% ±0.01%	±0.01% ±0.01%	±0.005% ±0.005%
Life	125°C, Rated Power, 1.5 hrs. – ON, 0.5 hrs. – OFF, 2,000 hrs.	±0.05%	±0.02%	±0.03%	±0.015%
Storage Life	15°C to 35°C, 15% RH to 75% RH, No Load, 10,000 hrs.	±0.005%	±0.0025%	±0.0025%	±0.0015%
High Temperature Exposure	150°C, No Load, 2,000 hrs.	±0.05%	±0.02%	±0.02%	±0.01%

TAPE AND REEL PACKAGE (BASED ON EIA-481-1) (DIMENSIONS IN mm)

Tape Dimensions



Reel Dimensions (Reel capacity: 800 pieces/reel)



Type	A	B	C	D	E	F	G	H	J	A	N	B	C	D	W_1	W_2	r
MU	3.6 ±0.2	3.1 ±0.2	12.0 ±0.3	5.5 ±0.05	1.75 ±0.1	8.0 ±0.1	2.0 ±0.05	4.0 ±0.1	Dia. 1.5 +0.1-0	Dia. 178 ±2	Dia. 60 min.	Dia. 13 ±0.5	Dia. 21 ±0.8	2 ±0.5	12.4 +2.0-0	18.4 max.	1.0 ±0.5

PRECAUTION IN USING FACE-BONDED CHIP RESISTOR (DIMENSIONS IN mm)

1. Storage

Storage condition or environment may adversely affect solderability of the exterior terminals. Do not store in high temperature and humidity. The recommended storage environment is lower than 40°C, has less than 70% RH humidity and is free from harmful gases such as sulphur and chlorine.

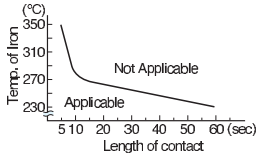
2. Caution in Soldering

❶Hand Soldering

Hand soldering is applicable as shown at right.

Recommended

- Temp. of Iron Tip: 240°C to 270°C
- Power of Iron: 20W or less
- Diameter of Tip: Dia. 3 mm max.



❷Solder Reflow in Furnace

Recommended

- Peak Temperature: 250°C +0°C/-5°C
- Holding time: 10 sec. max.
- To cool gradually at room temperature

❸Dipping in Solder (Wave or Still)

Recommended

- Temp. of Solder: 240°C to 250°C
- Length of Dipping: 3 to 4 seconds
- To cool gradually at room temperature

❹Other

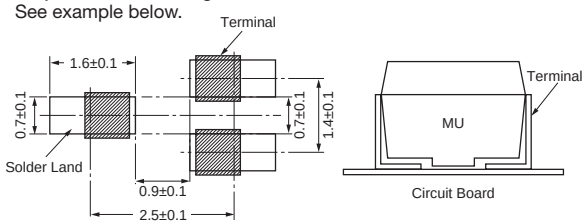
Corrosion-free flux, such as rosin, is recommended. Do not apply pressure to the molded housing immediately after soldering.

3. Cleaning

Use volatile cleaner such as methylalcohol or propylalcohol.

4. Circuit Board Design

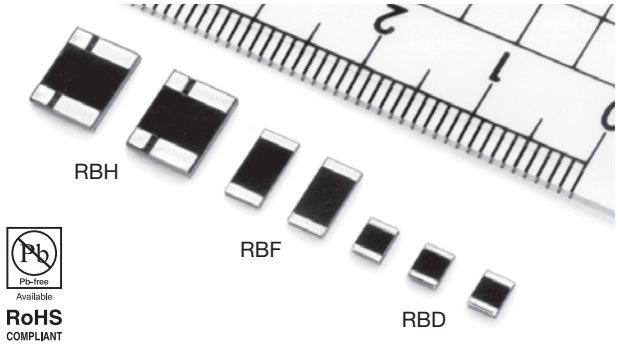
The dimensions of solder land must be determined in conformity with the size of resistors and with the soldering method. They are also subject to the mounting machine and the material of the substrate. See example below.



When parts are mounted on a board in high density, solder can possibly attach to the resistors in an excessive amount to affect performance or reliability of the resistors. To prevent this effect, the use of solder resist is recommended to isolate solder lands.

Alpha Electronics
A VPG Brand

Ultra Precision SMT Current Sense Resistor (Flip-Chip)



Pb-free Available
RoHS COMPLIANT

COMPOSITION OF TYPE NUMBER

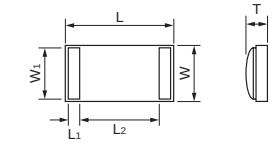
Example:

RBF J R1000 F L

- L — Tape & Reel Package Required
- F — Tolerance
- R1000 — Resistance Value
- J — TCR
- RBF — Type

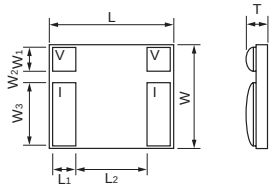
Resistance value in ohm is expressed by a series of four significant digits and an R designates the decimal point.

CONFIGURATION (DIMENSIONS IN mm)



Type	RBD	RBF
L	3.2±0.1	6.3±0.1
W	2.5±0.1	3.2±0.1
L_1	0.5±0.2	0.7±0.2
L_2	2.1±0.2	4.7±0.2
W_1	2.4±0.2	3.0±0.2
T	1.05 max.	

Dimensions in mm

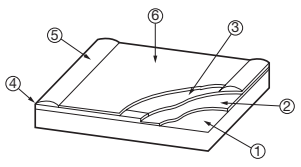


I: Current Sensing Terminal
V: VoltageTerminal

Type	RBH
L	7.5±0.1
W	6.0±0.1
L_1	1.4±0.2
L_2	4.4±0.2
W_1	1.4±0.2
W_2	0.7±0.2
W_3	3.6±0.2
T	1.5 max.

Dimensions in mm

CONSTRUCTION



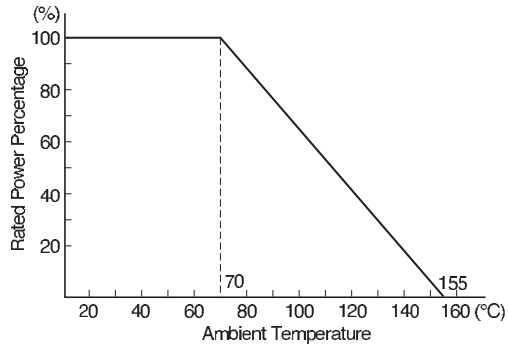
① Ceramic Substrate (High-Purity Alumina)
② Heat-Resistant Bonding Layer
③ Bulk Metal® Foil
④ Metal Plating
⑤ Solder
⑥ Solder-Resist

TCR, RESISTANCE RANGE, TOLERANCE, RATED POWER

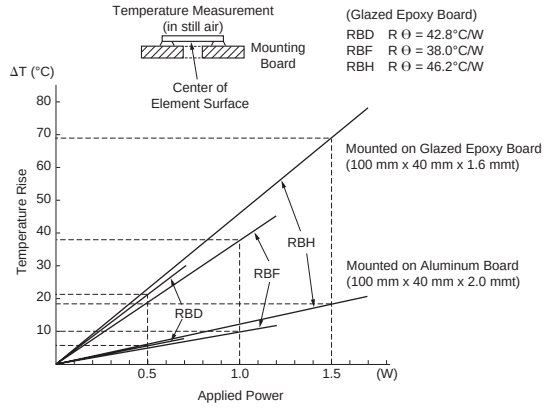
Type	TCR (ppm/°C) –25°C to 125°C*	Resistance Range (Ω)	Resistance Tolerance (%)*	Rated Power (W) at 70°C
RBD	0±25 (J)	0.01 to 0.1	±1 (F) ±2 (G) ±5 (J)	0.5
	0±10 (C) 0±25 (J)	0.1 to 1	±0.5 (D) ±1 (F) ±2 (G) ±5 (J)	
RBF	0±25 (J)	0.01 to 0.1	±1 (F) ±2 (G) ±5 (J)	1
	0±10 (C) 0±25 (J)	0.1 to 1	±0.5 (D) ±1 (F) ±2 (G) ±5 (J)	
RBH	0±10 (C) 0±25 (J)	0.01 to 0.1	±0.5 (D) ±1 (F) ±2 (G) ±5 (J)	1.5

*Symbols parenthesized are for type number composition.

POWER DERATING CURVE



TEMPERATURE OF RESISTOR SURFACE



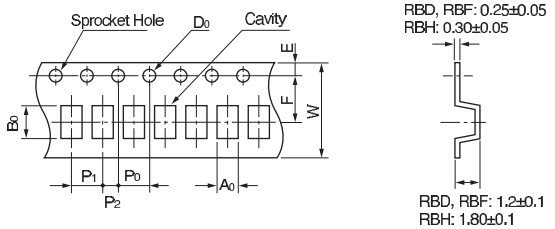
Please use board made of metal for continuous use with 2W at 70°C. Please keep the temperature of board less than 90°C when using the glazed epoxy board.

PERFORMANCE

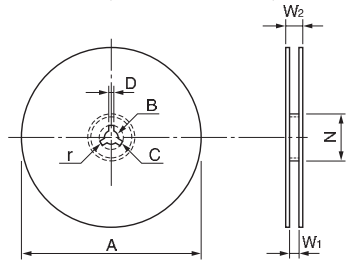
Parameters	Test Condition	ALPHA Specification	ALPHA Typical Test Data
Maximum Rated Operating Temperature **Working Temperature Range**		70°C –65°C to +155°C	
Thermal Shock **Overload**	–65°C/30 min. ↔ +155°C/30 min., 5 cycles Rated Power x 2.5, 5 sec.	±0.1% ±0.1%	±0.03% ±0.03%
Low Temperature Storage and Operation **Substrate Bending Test**	–65°C, No Load, 24 hrs.→ Rated Voltage, 45 min. Substrate Bent 3 mm, 60 sec.	±0.1% ±0.1%	±0.05% ±0.05%
Dielectric Withstanding Voltage **Insulation Resistance** **Resistance to Soldering Heat** **Moisture Resistance**	Atmo. Pres.: AC 200V, 1 min. DC 100V, 1 min. 260°C, 10 sec. +65°C to –10°C, 90% RH to 98% RH, Rated Voltage, 10 cycles (240 hrs.)	±0.05% over 10,000 MΩ ±0.1% ±0.1%	±0.01% over 10,000 MΩ ±0.03% ±0.03%
Shock **Vibration, High Frequency**	100G, 6 ms, Sawtooth Wave, X, Y, Z, each 10 shocks 20G, 10 Hz to 2,000 Hz to 10 Hz, 20 min., X, Y, Z, each 2.5 hrs.	±0.05% ±0.05%	±0.01% ±0.01%
Life	70°C, Rated Power, 1.5 hr. – ON, 0.5 hr. – OFF, 2,000 hrs	±0.1%	±0.05%
Storage Life	15°C to 35°C, 15% RH to 75% RH, No Load, 10,000 hrs.	±0.05%	±0.01%
High Temperature Exposure	155°C, No Load, 2,000 hrs.	±0.1%	±0.05%

TAPE AND REEL PACKAGE (BASED ON EIA-481-1) (DIMENSIONS IN mm)

Tape Dimensions



Reel Dimensions Reel Capacity | RBH: 1,000 pieces/reel | RBD, RBF: 4,000 pieces/reel



Type	A_0	B_0	W	F	E	P_1	P_2	P_0	D_0
RBD	2.85 ±0.1	3.7 ±0.1	8.0 ±0.2	3.5 ±0.05	1.75 ±0.1	4.0 ±0.1	2.0 ±0.05	4.0 ±0.1	Dia.1.5 +0.1-0
RBF	3.4 ±0.1	6.7 ±0.1	12.0 ±0.2	5.5 ±0.05	1.75 ±0.1	4.0 ±0.1	2.0 ±0.05	4.0 ±0.1	Dia.1.5 +0.1-0
RBH	6.3 ±0.1	7.8 ±0.1	16.0 ±0.2	7.5 ±0.1	1.75 ±0.1	8.0 ±0.1	2.0 ±0.1	4.0 ±0.1	Dia.1.5 +0.1-0

Type	A	N	B	C	D	W_1	W_2	r
RBD	Dia.178 ±2	Dia.60 min.	Dia.13 ±0.5	Dia.21 ±0.8	2.0 ±0.5	8.4 +2.0-0	14.4 max.	1.0 ±0.5
RBF	Dia.178 ±2	Dia.60 min.	Dia.13 ±0.5	Dia.21 ±0.8	2.0 ±0.5	12.4 +2.0-0	18.4 max.	1.0 ±0.5
RBH	Dia.178 ±2	Dia.60 min.	Dia.13 ±0.5	Dia.21 ±0.8	2.0 ±0.5	17.0 ±0.3	19.4 ±0.1	1.0 ±0.5

PRECAUTION IN USING SMD CURRENT SENSE RESISTORS

1. Storage
Storage condition or environment may adversely affect solderability of the exterior terminals. Do not store in high temperature and humidity. The recommended storage environment is lower than 40°C, has less than 70% RH humidity and is free from harmful gases such as sulphur and chlorine.

2. Caution in Soldering

❶ Solder Reflow in Furnace
Recommended
- Peak Temperature: 250+0/-5°C
- Holding time: 10 sec. max.
- To cool gradually at room temperature.

❷ Dipping in Solder (Wave or Still)
Recommended
- Temp. of Solder: 260°C max.
- Length of Dipping: 10 sec.

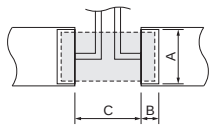
❸ Other
Soldering iron is never recommended. Corrosion-free flux such as rosin is recommended.

3. Cleaning
Use volatile cleaner such as methylalcohol or propylalcohol.

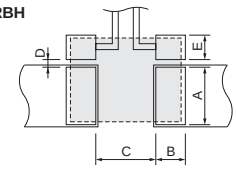
4. Circuit Board Design

❶ Solder Land Dimensions
The dimensions of solder land must be determined in conformity with the size of resistors and with the soldering method. They are also subject to the mounting machine and the material of the substrate. See example at right.

RBD, RBF

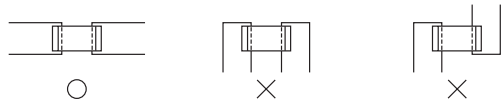


RBH



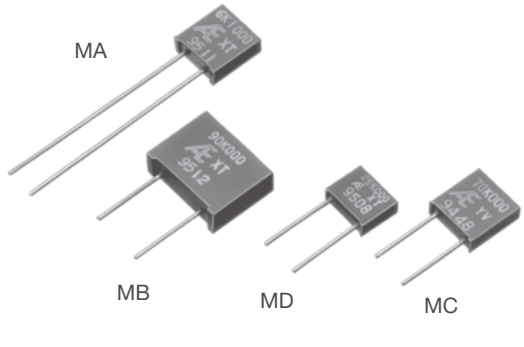
Type	Dimensions in mm				
	A	B	C	D	E
RBD	2.6 to 2.8	0.8	2.0		
RBF	3.4 to 3.6	1.2	4.5		
RBH	3.8 to 4.0	2.0	4.0	0.5	1.7

❷ Circuit Design
It is recommended that the circuit be drawn so that current may approach, cross and go away from the mounted resistor in one direction as illustrated below. Thicker copper foil should be used if possible.



Alpha Electronics
A VPG Brand

Ultra Precision Resistor (Transfer Molded)



Pb-free Available
RoHS COMPLIANT

COMPOSITION OF TYPE NUMBER

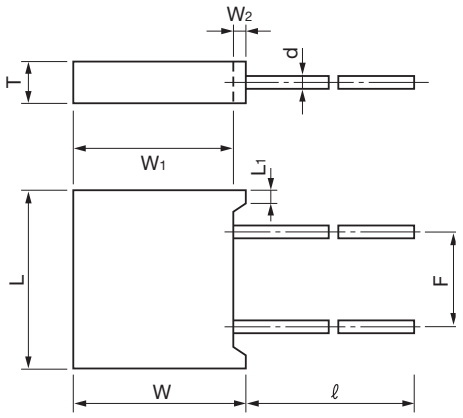
Example:

MA Y 10K000 A

- A — Tolerance
- 10K000 — Resistance Value
- Y — TCR
- MA — Type

Resistance value, in ohm, is expressed by a series of six characters, five of which represent significant digits. R or K is a dual-purpose letter that designates both the value range (R for ohmic; K for kilo-ohm) and the location of decimal point.

CONFIGURATION (DIMENSIONS IN mm)



Type	MA	MC	MB	MD
L	7.9±0.2		13.0±0.3	7.4±0.2
L_1	1.0 max.		1.5 max.	0.8 max.
W	8.3±0.2		10.0±0.3	6.0±0.2
W_1	8.0±0.2		9.5±0.3	5.7±0.2
W_2	0.3 max.		0.5 max.	0.4 max.
T	2.8±0.2	2.3±0.2	4.0±0.3	2.3±0.2
F	3.81±0.25	5.08±0.25	7.5±0.5	5.08±0.25
ℓ	25±10	10±3		
d	Dia. 0.65±0.05			

TCR, RESISTANCE RANGE, TOLERANCE, RATED POWER

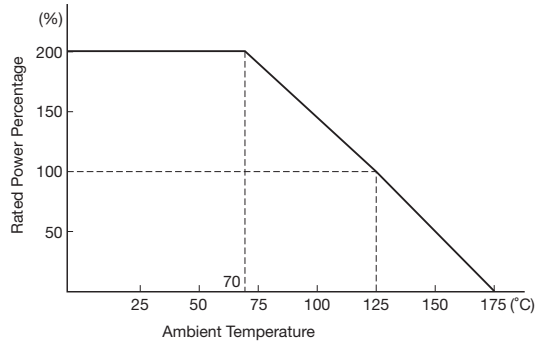
Type	TCR (ppm/°C) –55°C to +125°C*	Resistance Range (Ω)	Resistance Tolerance (%)*†	Rated Power (W) at 125°C
MA MC	0±15 (W)	1 to 5	±0.5 (D) ±1 (F)	0.3 (0.2 at 150 kΩ or above)
	0±5 (X)	5 to 30	±0.1 (B) ±0.5 (D) ±1 (F)	
	0±5 (X) 0±2.5 (Y) 0±1 (Z)**	30 to 200k	±0.005 (V) ±0.01 (T) ±0.02 (Q) ±0.05 (A) ±0.1 (B) ±0.5 (D) ±1 (F)	
MB	0±5 (X)	5 to 30	±0.1 (B) ±0.5 (D) ±1 (F)	0.5 (0.3 at 200 kΩ or above)
	0±5 (X) 0±2.5 (Y) 0±1 (Z)**	30 to 400k	±0.005 (V) ±0.01 (T) ±0.02 (Q) ±0.05 (A) ±0.1 (B) ±0.5 (D) ±1 (F)	
MD	0±5 (X)	5 to 30	±0.1 (B) ±0.5 (D) ±1 (F)	0.125
	0±5 (X) 0±2.5 (Y)	30 to 100	±0.05 (A) ±0.1 (B) ±0.5 (D) ±1 (F)	
	0±5 (X) 0±2.5 (Y) 0±1 (Z)**	100 to 80k	±0.01 (T) ±0.02 (Q) ±0.05 (A) ±0.1 (B) ±0.5 (D) ±1 (F)	

* Symbols in parentheses are for type number composition.

† Resistance figures are the values obtained by measuring the leads at point 12.7±3.2 mm away from the base for Type MA and at point 5.0±1.0 mm for Types MC, MB and MD, but, in case of resistance below 10 ohm, the value at 1.6±0.6 mm away from the base for all types.

**Temperature characteristic Z is applicable for temperature range between 0°C and 60°C.

POWER DERATING CURVE



DSCC SPECIFICATIONS

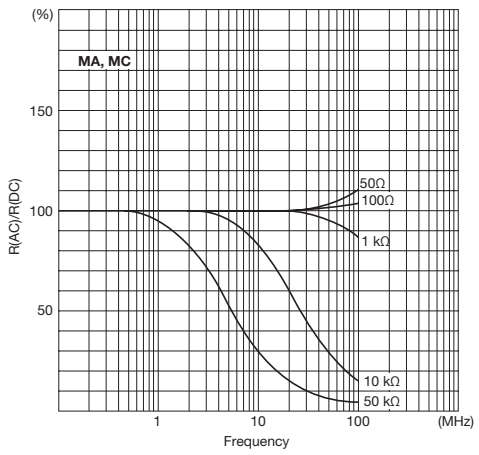
97009
97010
97011

PERFORMANCE

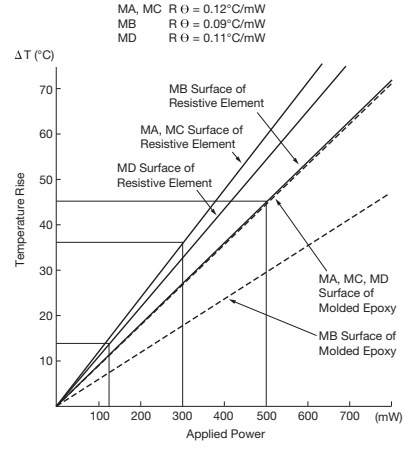
Parameters	Test Condition	MIL-PRF-55182/9 Specification	ALPHA Typical Test Data
Maximum Rated Operating Temperature **Working Temperature Range** **Maximum Working Voltage**		125°C –65°C to +175°C MA, MC=300V, MB=350V, MD=250V	
Power Conditioning **Thermal Shock** **Overload**	125°C, Rated Power, 100 hrs. –65°C/30 min.↔+150°C/30 min., 5 cycles Rated Power x 6.25, 5 sec.	±(0.20%+0.01Ω) ±0.05% ±0.05%	±0.005% ±0.005% ±0.005%
Solderability **Resistance to Solvents**	Steam Aging 8 hrs., 245°C, 5 sec. ❶Isopropyl Alcohol + Mineral Spirits ❷Water + Butyl Cellosolve + Monoethanolamine	over 95% coverage no damage	over 95% coverage no damage
Low Temperature Storage **Low Temperature Operation** **Terminal Strength**	–65°C, 24 hrs. –65°C, Rated Voltage, 45 min. 0.908 kg (2 pounds), 10 sec	±0.05% ±0.05% ±0.02%	±0.0025% ±0.0025% ±0.0025%
Dielectric Withstanding Voltage **Insulation Resistance** **Resistance to Soldering Heat** **Moisture Resistance**	Atmo.Pres.: 300V rms. Baro. Pres. 8 mHg: 200V rms. DC 100V, 2 min. +260°C, 10 sec. +65°C to –10°C, 90% RH to 98% RH, Rated Voltage, 10 cycles (240 hrs.)	±0.02% over 10,000 MΩ ±0.02% ±0.05%	±0.0025% over 10,000 MΩ ±0.0025% ±0.01%
Shock (Specified Pulse) **Vibration, High Frequency**	100G, 6 ms, Sawtooth Wave, X, Y, each 10 shocks 20G, 10 Hz to 2,000 Hz to 10 Hz, 20min., X, Y, each 4 hrs.	±0.01% ±0.02%	±0.0025% ±0.0025%
Life	125°C, Rated Voltage, 1.5 hr. – ON, 0.5 hr. – OFF, 2,000 hrs.	±0.05%	±0.015%
Life 70°C Power Rating	70°C, Rated Voltage x 2, 1.5 hr. – ON, 0.5 hr. – OFF, 2,000 hrs.	±0.05%	±0.015%
Storage Life	15°C to 35°C, 15% RH to 75% RH, No Load, 10,000 hrs.	±0.005%	±0.0025%
High Temperature Exposure	175°C, No Load, 2,000 hrs.	±0.5%	±0.015%
Current Noise **Voltage Coefficient** **Thermal EMF**		-32 dB 0,0005%/V 1.0 µV/°C	-42 dB 0,00003%/V 1.0 µV/°C

Type MA meets requirements of MIL-PRF-55182/9.

FREQUENCY CHARACTERISTICS

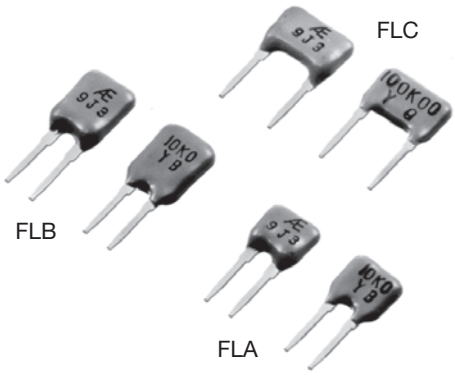


TEMPERATURE OF RESISTOR SURFACE



Alpha Electronics
A VPG Brand

Precision Resistor (Conformally Coated)



Pb-free Available
RoHS COMPLIANT

COMPOSITION OF TYPE NUMBER

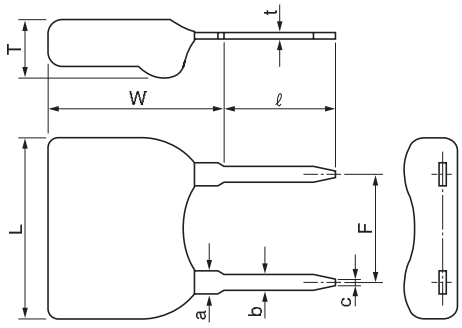
Example:

FLA X 500R00 B

- B — Tolerance
- 500R00 — Resistance Value
- X — TCR
- FLA — Type

Resistance value, in ohm, is expressed by a series of six characters, five of which represent significant digits. R or K is a dual-purpose letter that designates both the value range (R for ohmic; K for kilo-ohm) and the location of decimal point.

CONFIGURATION (DIMENSIONS IN mm)



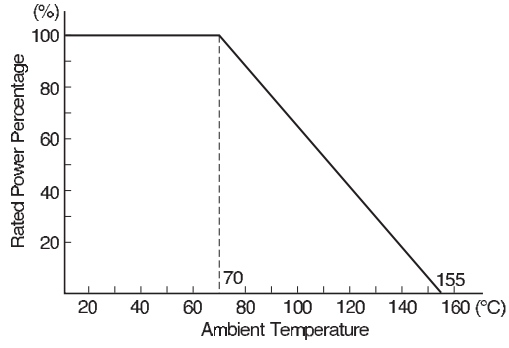
Type	FLA	FLB	FLC
L	5.6±0.5		7.5±0.5
W	6.2±0.5	8.2±0.5	6.2±0.5
T	2.2±0.5		
F	2.54±0.25		5.08±0.25
ℓ	5±1		
t	0.3±0.05		
a	1.0±0.05		
b	0.65±0.05		
c	0.4±0.05		

TCR, RESISTANCE RANGE, TOLERANCE, RATED POWER

Type	TCR (ppm/°C) –25°C to +125°C*	Resistance Range (Ω)	Resistance Tolerance (%)*†	Rated Power (W) at 70°C
FLA	0±5 (X)	5 to 10	±0.1 (B) ±0.5 (D) ±1.0 (F)	0.125
	0±5 (X) 0±2.5 (Y)	10 to 30	±0.1 (B) ±0.5 (D) ±1.0 (F)	
		30 to 100k	±0.05 (A) ±0.1 (B) ±0.5 (D)	
FLB	0±15 (W)	1 to 5	±0.5 (D) ±1.0 (F)	0.25
	0±5 (X)	5 to 10	±0.1 (B) ±0.5 (D) ±1.0 (F)	
	0±5 (X) 0±2.5 (Y)	10 to 100	±0.05 (A) ±0.1 (B) ±0.5 (D) ±1.0 (F)	
		100 to 150k	±0.02 (Q) ±0.05 (A) ±0.1 (B)	
FLC	0±15 (W)	1 to 5	±0.5 (D) ±1.0 (F)	0.25
	0±5 (X)	5 to 10	±0.1 (B) ±0.5 (D) ±1.0 (F)	
	0±5 (X) 0±2.5 (Y)	10 to 30	±0.05 (A) ±0.1 (B) ±0.5(D) ±1.0 (F)	
		30 to 1k	±0.02 (Q) ±0.05 (A) ±0.1 (B) ±0.5 (D)	
		1k to 200k	±0.01 (T) ±0.02 (Q) ±0.05 (A) ±0.1 (B)	

* Symbols parenthesized are for type number composition.
† Resistance figures are the values obtained by measuring at the point 2.5±1.0 mm below the shoulder of leads.

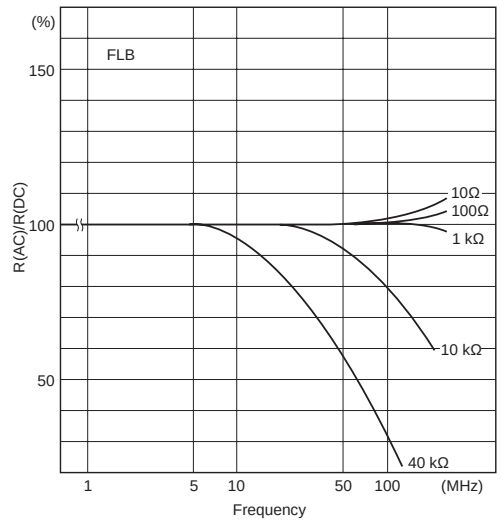
POWER DERATING CURVE



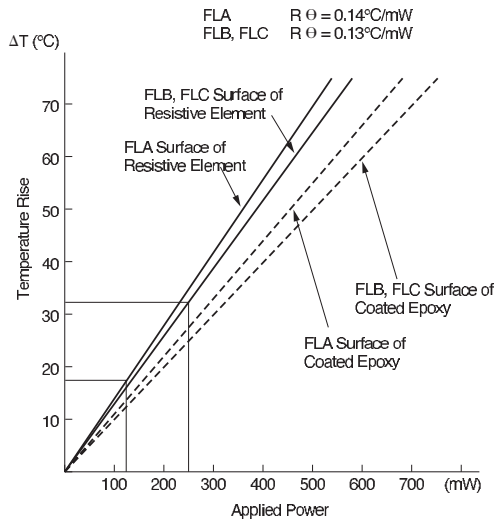
PERFORMANCE

Parameters	Test Condition	ALPHA Specification	ALPHA Typical Test Data
Maximum Rated Operating Temperature **Working Temperature Range** **Maximum Working Voltage**		70°C –25°C to +155°C FLA=250V, FLB/FLC=300V	
Temperature Cycling **Overload**	–25°C/30 min., Room Temperature/5 min., +155°C/30 min., 5 cycles Rated Voltage x 2.5, 5 sec.	±0.05% ±0.05%	±0.01% ±0.0025%
Solderability **Resistance to Solvents**	235°C, 2 sec. ❶ Isopropyl Alcohol ❷ Trichloroethylene	over 75% coverage no damage	over 75% coverage no damage
Low Temperature Storage **Terminal Strength**	–25°C, No Load, 2 hrs. 0.908 kg (2 pounds), 10 sec.	±0.05% ±0.05%	±0.0025% ±0.0025%
Dielectric Withstanding Voltage **Insulation Resistance** **Resistance to Soldering Heat** **Moisture Resistance**	Atmo. Pres.: AC 300V, 1 min. DC 100V, 1 min. 350°C, 3 sec. +65°C to –10°C, 90% RH to 98% RH, Rated Voltage,10 cycles (240 hrs.)	±0.03% over 10,000 MΩ ±0.03% ±0.1%	±0.0025% over 10,000 MΩ ±0.0025% ±0.015%
Shock **Vibration**	50G, 11 ms, Half-Sine Wave, X, Y, Z, each 3 shocks 20G, 10 Hz to 55 Hz to 10 Hz, 1 min., X, Y, Z, each 2 hrs.	±0.03% ±0.03%	±0.005% ±0.005%
Life (Rated Load)	70°C, Rated Power, 1.5 hr. – ON, 0.5 hr. – OFF, 1,000 hrs.	±0.1%	±0.01%
Life (Moisture Load)	40°C, 90% RH to 95% RH, Rated Power, 1.5 hr. – ON, 0.5 hr. – OFF, 1,000 hrs.	±0.05%	±0.01%
Storage Life	15°C to 35°C, 15% RH to 75% RH, No Load, 10,000 hrs.	±0.02%	±0.005%
High Temperature Exposure	155°C, No Load, 1,000 hrs.	±0.05%	±0.01%
Current Noise **Pressure Cooker Test**	 121°C, 100% RH, 2 atmospheric, No Load, 100 hrs.	-25 dB ±0.5%	-42 dB ±0.1%

FREQUENCY CHARACTERISTICS

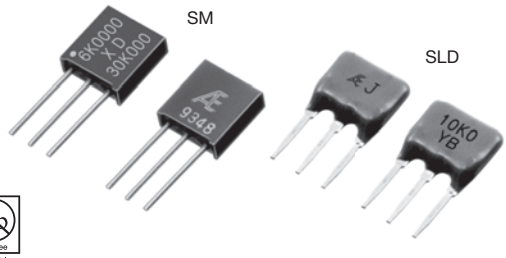


TEMPERATURE OF RESISTOR SURFACE



Alpha Electronics
A VPG Brand

Ultra Precision Resistor 1-2-3 Network



Pb-free Available
RoHS COMPLIANT

DSCC Specification 87026

TCR, RESISTANCE RANGE, TOLERANCE, RATED POWER

Type	TCR (ppm/°C) –55°C to +125°C**		Resistance Range/ Element (Ω)***	Resistance Tolerance (%)		Rated Power/ Package (W)
	Absolute*	Tracking		Absolute*	Matching*	
SM	0±5 (X) 0±2.5 (Y)	See Table 1	50 to 30k	±0.02 (Q) ±0.05 (A) ±0.1 (B)	±0.01 (T) ±0.02 (Q) ±0.05 (A) ±0.1 (B)	0.3 at 125°C
SLD	0±5 (X) 0±2.5 (Y)	See Table 1	50 to 100	±0.1 (B) ±0.5 (D)	±0.05 (A) ±0.1 (B)	0.25 at 70°C
			100 to 30k	±0.05 (A) ±0.1 (B)	±0.02 (Q) ±0.05 (A) ±0.1 (B)	

* Symbols parenthesized are for type number composition.
** -25°C to +125°C for SLD type.
*** Please contact us for the availability.

COMPOSITION OF TYPE NUMBER

Example: $R_1 = R_2$

SM 1X 10K00 B A
① ②③ ④ ⑤ ⑥

Example: $R_1 \neq R_2$

SLD 2 X 1K000/10K00 B Q
① ② ③ ④ ⑤ ⑥

① Type
② Number of Values
③ TCR Absolute
④ Nominal Resistance Values
⑤ Resistance Tolerance (Absolute)
⑥ Resistance Tolerance (Matching)

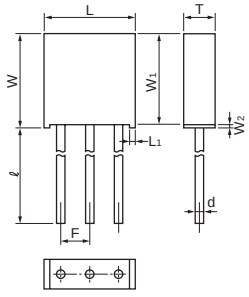
Resistance value, in ohm, is expressed by a series of five characters, four of which represent significant digits. The fifth R or K is a dual-purpose letter that designates both the value range (R for ohmic; K for kilo-ohm) and the location of decimal point.

TABLE 1. TCR TRACKING IS SUBJECT TO RESISTANCE RATIO

Resistance Ratio	TCR Tracking (ppm/°C)
Resistance Ratio = 1	±0.5
1 <Resistance Ratio ≤10	±1
10 <Resistance Ratio ≤100	±2
100 <Resistance Ratio	±3

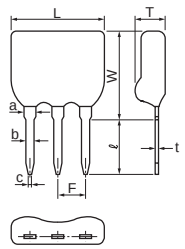
CONFIGURATION (DIMENSIONS IN mm)

SM



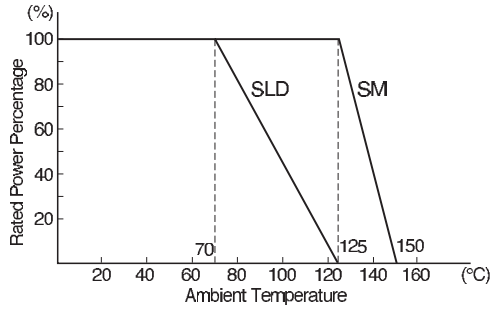
Type	SM
L	7.7±0.2
L_1	1.0 max.
W	8.1±0.2
W_1	7.8±0.2
W_2	0.3 max.
T	2.6±0.2
F	2.54±0.25
ℓ	10±3
d	ϕ0.65±0.05

SLD

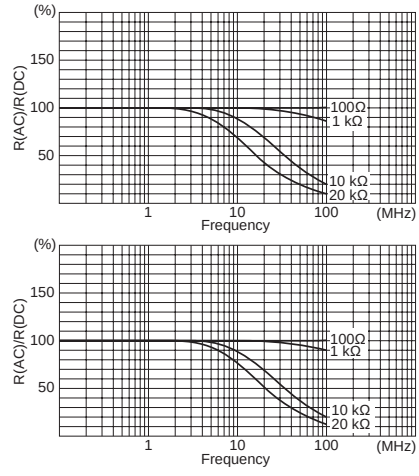


Type	SLD
L	7.5±0.5
W	7.5±0.5
T	2.2±0.5
F	2.54±0.25
ℓ	5±1
t	0.3±0.05
a	1.0±0.05
b	0.65±0.05
c	0.4±0.05

POWER DERATING CURVE



FREQUENCY CHARACTERISTICS



PERFORMANCE—SM

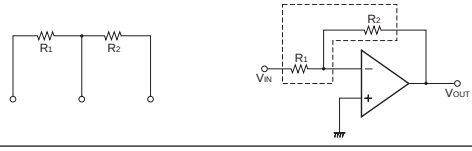
Parameters	Test Condition	ALPHA Specification		ALPHA Typical Test Data	
		ΔR	ΔRatio	ΔR	ΔRatio
Maximum Rated Operating Temperature **Working Temperature Range**		125°C –65°C to +150°C			
Thermal Shock **Overload**	–65°C/30 min.↔ +150°C/30 min., 5 cycles Rated Voltage x 2.5, 5 sec.	±0.02% ±0.02%	±0.01% ±0.01%	±0.005% ±0.0025%	±0.0025% ±0.001%
Solderability	245°C, 5 sec.	over 95% coverage		over 95% coverage	
Resistance to Solvents	❶ Isopropyl Alcohol + Mineral Spirits ❷ Water + Butyl Cellosolve + Monoethanolamine	no damage		no damage	
Low Temperature Storage and Operation **Terminal Strength**	–65°C, No Load, 24 hrs.→Rated Voltage, 45 min. 0.908 kg (2 pounds), 10 sec.	±0.05% ±0.02%	±0.02% ±0.01%	±0.0025% ±0.0025%	±0.001% ±0.001%
Dielectric Withstanding Voltage	Atmo. Pres.: AC 300V, 1 min. Baro. Pres.: 1066 Pa; AC 200V, 1min.	±0.02%	±0.01%	±0.0025%	±0.001%
Insulation Resistance	DC 500V, 2 min.	over 10,000 MΩ		over 10,000 MΩ	
Resistance to Soldering Heat	350°C, 3 sec.	±0.02%	±0.01%	±0.0025%	±0.001%
Moisture Resistance	+65°C to –10°C, 90% RH to 98% RH, Rated Voltage, 10 cycles (240 hrs.)	±0.05%	±0.02%	±0.02%	±0.01%
Shock **Vibration, High Frequency**	100G, 6 ms, Sawtooth Wave, X, Y, Z, each 10 shocks 20G, 10 Hz to 2,000 Hz to 10 Hz, 20 min., X, Y, Z, each 2.5 hrs.	±0.01% ±0.02%	±0.005% ±0.01%	±0.0025% ±0.0025%	±0.001% ±0.001%
Life	125°C, Rated Power, 1.5 hr. – ON, 0.5 hr. – OFF, 2,000 hrs.	±0.05%	±0.02%	±0.015%	±0.005%
Storage Life	15°C to 35°C, 15% RH to 75% RH, No Load, 10,000 hrs.	±0.005%	±0.0025%	±0.0025%	±0.0015%
High Temperature Exposure	150°C, No Load, 2,000 hrs.	±0.05%	±0.02%	±0.015%	±0.005%
Current Noise **Voltage Coefficient** **Thermal EMF**		–32 dB 0.0005%/V 1.0 μV/°C		–42 dB 0.00003%/V 1.0 μV/°C	

PERFORMANCE—SLD

Parameters	Test Condition	ALPHA Specification		ALPHA Typical Test Data	
		ΔR	ΔRatio	ΔR	ΔRatio
Maximum Rated Operating Temperature **Working Temperature Range**		70°C –25°C to +125°C			
Temperature Cycling **Overload**	–25°C/30 min., Room Temperature/5 min., 125°C/30 min., 5 cycles Rated Voltage x 2.5, 5 sec.	±0.05% ±0.05%	±0.01% ±0.01%	±0.01% ±0.0025%	±0.005% ±0.001%
Solderability **Resistance to Solvents**	235°C, 2 sec. Isopropyl Alcohol	over 75% coverage no damage		over 75% coverage no damage	
Low Temperature Operation **Terminal Strength**	–25°C, No Load, 2 hrs. 0.908 kg (2 pounds), 10 sec.	±0.05% ±0.05%	±0.01% ±0.01%	±0.0025% ±0.0025%	±0.001% ±0.001%
Dielectric Withstanding Voltage	Atmo. Pres.: AC 300V, 1 min.	±0.03%	±0.01%	±0.0025%	±0.001%
Insulation Resistance	DC 100V, 1 min.	over 10,000 MΩ		over 10,000 MΩ	
Resistance to Soldering Heat	350°C, 3 sec.	±0.03%	±0.01%	±0.0025%	±0.001%
Moisture Resistance	+65°C to –10°C, 90% RH to 98% RH, Rated Voltage, 10 cycles (240 hrs.)	±0.1%	±0.05%	±0.03%	±0.01%
Shock **Vibration**	50G, 11 ms, Half-Sine Wave, X, Y, Z, each 3 shocks 20G, 10 Hz to 55 Hz to 10 Hz, 1 min., X, Y, Z, each 2 hrs.	±0.03% ±0.03%	±0.01% ±0.01%	±0.005% ±0.005%	±0.001% ±0.001%
Life (Rated Load)	70°C, Rated Power, 1.5 hr. – ON, 0.5 hr. – OFF, 1,000 hrs.	±0.1%	±0.05%	±0.01%	±0.005%
Life (Moisture Load)	40°C 90% RH to 95% RH, Rated Power 1.5 hrs – ON, 0.5 hr. – OFF, 1,000 hrs.	±0.05%	±0.01%	±0.01%	±0.005%
Storage Life	15°C to 35°C, 15% RH to 75% RH, No Load, 10,000 hrs	±0.02%	±0.01%	±0.005%	±0.0025%
High Temperature Exposure	125°C, No Load, 1,000 hrs.	±0.05%	±0.01%	±0.01%	±0.005%

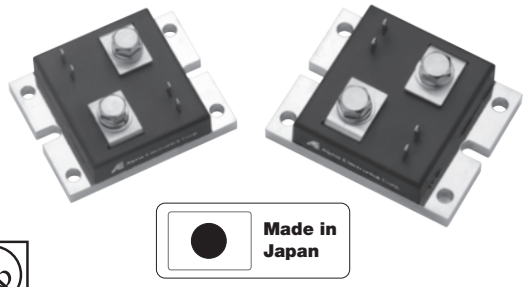
EXAMPLE OF APPLICATION

An application of type SM/SLD (input/feedback resistors for amplifiers) Because the input and the feedback resistors are incorporated into one single element, amplification is not affected by temperature range.



Alpha Electronics
A VPG Brand

High Power Precision Shunt Resistor, Up to 500W



Pb-free Available

RoHS COMPLIANT

CAUTION — tighten screws at
- current terminals: <5.2N · m
- voltage terminals: <0.0195N · m

FEATURES

- **Temperature coefficient of resistance (TCR)**
  +25°C to +60°C, +25°C ref.: 0 ±1 ppm/°C
  –25°C to +125°C, +25°C ref.: 0 ±5 ppm/°C
- Utilizing Ni-Cr Bulk Metal® Foil Technology for realizing low TCR
- Low thermal resistance with Copper plate
  - Improved to 0.1°C/W from 0.3°C/W (conventional model)
  - Maximum rated power up to 500W on heat sink
- Extended max. ambient temperature to 125°C (85°C with conventional model)
- Built-in Pt100 sensor monitor temperature of resistive element
  - Easily define size of suitable heat sink
  - As safety function for continuous operation

CONTRUCTION OF MATERIALS

- Base plate: Nickel-plated Copper
- Current terminal: Nickel-plated Copper (T = 1.0 mm)
- Voltage and Pt terminals: Nickel-plated Copper (T = 0.5 mm)
- Package: PPS Injection-molded case

APPLICATIONS

- Output reference of precision power supply
- Reference of charge-discharge test for high capacity batteries

COMPOSITION OF TYPE NUMBER

Example:

FNP Z R0100 B

- B — Tolerance
- R0100 — Resistance Value*
- Z — TCR
- FNP — Type

* R is a dual-purpose letter that designates both the value range (R for ohmic) and the location of decimal point.

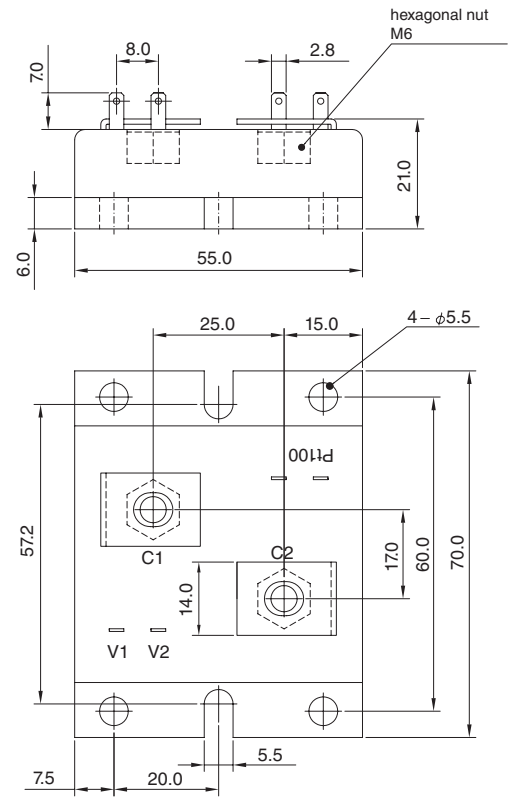
TCR—RESISTANCE VS. TOLERANCE

Tolerance of Built-in Pt100 Sensor:
±[0.8 + 0.008(t)]°C

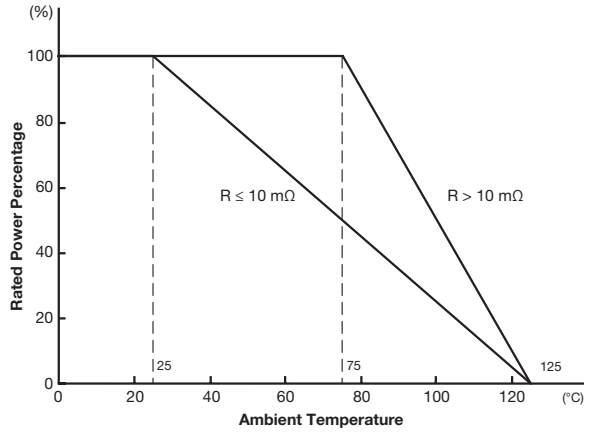
TCR (ppm/°C)	Resistance Range (Ω)	Tolerance (%)	Rated Power (W)
0 ±1 (Z) 0 ±2.5 (Y) (+25°C to +60°C) 0 ±5 (X) (–25°C to +125°C)	0.001 to 10**	±0.05 (A) ±0.1 (B) ±0.5 (D) ±1.0 (F)	500 (on heat sink*)

* Keep temperature of element surface less than 125°C.
** Please contact us for available resistance value

CONFIGURATION—Dimensions in mm



POWER DERATING CURVE



TEMPERATURE CHARACTERISTICS OF RESISTANCE

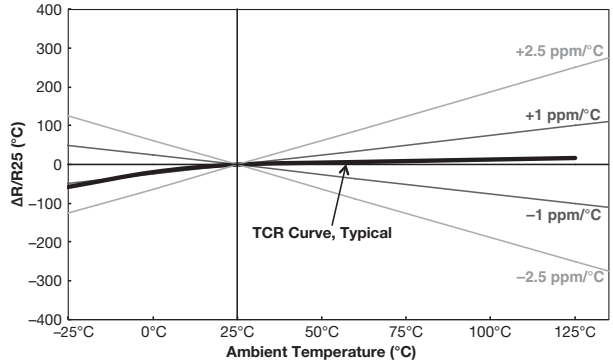
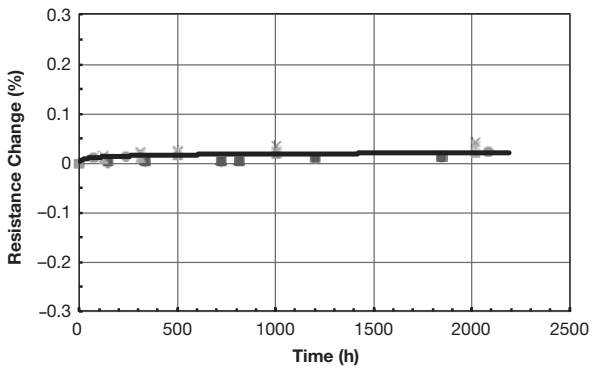


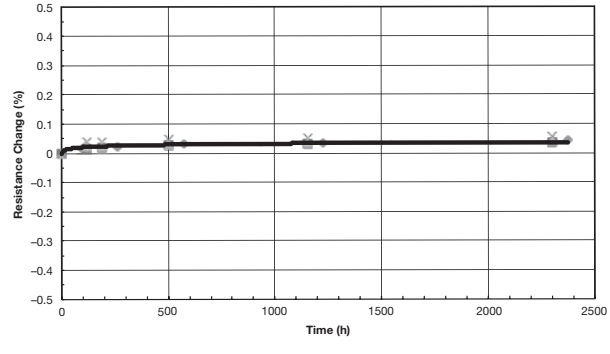
TABLE 2—PERFORMANCE

PARAMETERS	SPECIFICATION	
Maximum Rated Operating Temperature	25°C (R ≤10 mΩ)	75°C (R >10 mΩ)
Working Temperature Range	–55°C to +125°C	
Maximum Working Current	320 A	
Single Pulse Power Load	50 J (tp <10 msec)	
Dielectric Withstanding Voltage	AC 500 V	
Inductance	<10 nH	
Internal Thermal Resistance (element/base plate)	R_θ <0.1°C/W (R >10 mΩ)	
	R_θ <0.2°C/W (R ≤10 mΩ)	
Life (200 W, Element Temperature 100°C)	±0.2% (2000 h)	
High Temperature Exposure (125°C)	±0.2% (2000 h)	

LIFE (200 W, ELEMENT TEMPERATURE +100°C)



HIGH TEMPERATURE EXPOSURE (+125°C)



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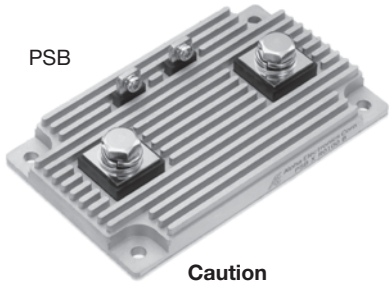
A VPG Brand

Ultra Precision Shunt Resistor (40 Watts)

PSB



Pb-free Available

RoHS COMPLIANT

Caution
Please screw current terminals
>5N · m, voltage terminal >1N · m

FEATURES

- Excellent temperature characteristics created by Bulk Metal® Foil technology
- Accurate value on four-terminal wiring, even in low extremity of resistance
- High heat dissipation due to aluminum-clad construction with fins
- Readiness to mount to heat sink or water-cooled radiator
- Availability of threaded holes to fix cables with screw

APPLICATIONS

- Current-sensing in precise power supply, motor driver, etc.

COMPOSITION OF TYPE NUMBER

Example:

PSB X R0100 B

- B — Tolerance
- R0100 — Resistance Value
- X — TCR
- PSB — Type

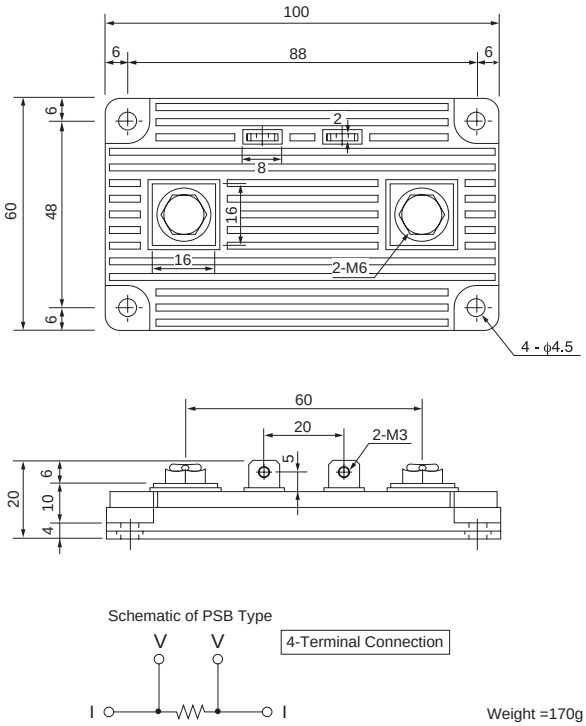
Resistance value in ohm is expressed by a series of four significant digits and an R designating the decimal point.

TCR, RESISTANCE RANGE, TOLERANCE, RATED POWER

TCR (ppm/°C) 0°C to +60°C	Resistance Range (Ω)	Resistance Tolerance (%)	Rated Power (W) at 25°C
0±15 (W)	0.001 to 0.005**	±0.1 (B) ±0.5 (D) ±1 (F)	12 in free air and 40 On heat sink*
0±5 (X) 0±15 (W)	0.005 to 1**		

*Thermal resistance of the heat sink 1°C/W.
Available to use higher rated power with elevation of cooling effect.
Please keep temperature of element surface less than 60°C.
**Please contact us for available resistance value

CONFIGURATION (DIMENSIONS IN mm)

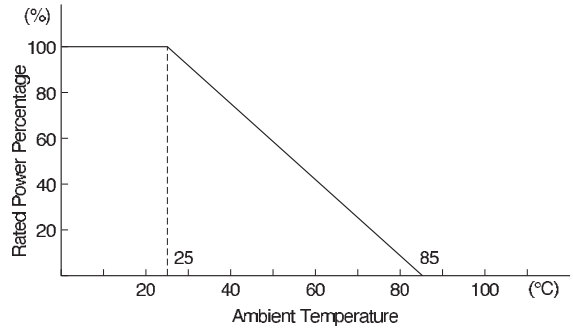


Schematic of PSB Type

4-Terminal Connection

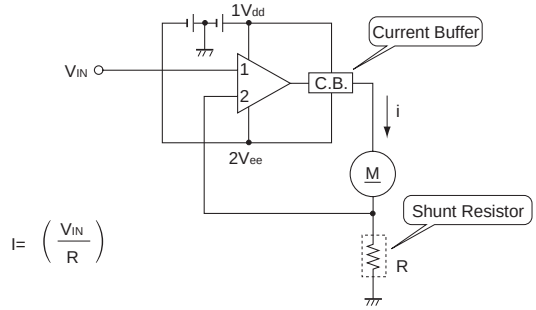
Weight =170g

POWER DERATING CURVE



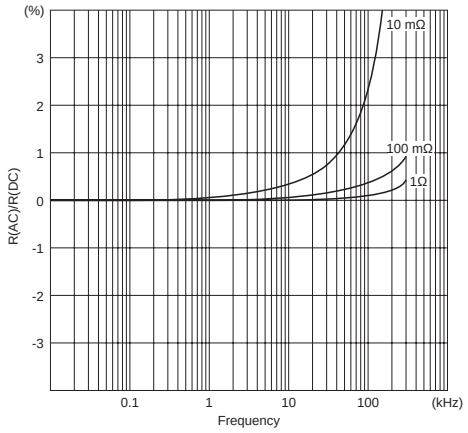
EXAMPLE OF APPLICATIONS

Motor Control Circuit Using Shunt Resistor

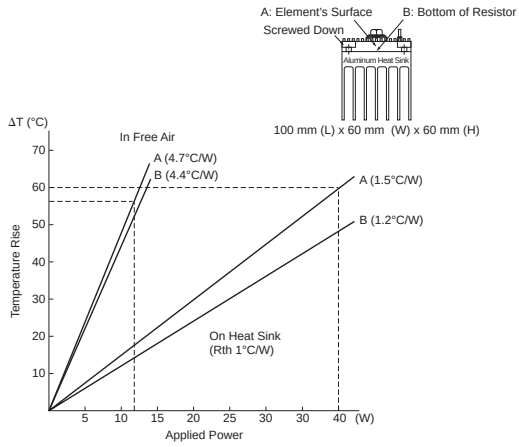


PERFORMANCE			
Parameters	**Test Condition**	**ALPHA Specification**	**ALPHA Typical Test Data**
Maximum Rated Operating Temperature **Working Temperature Range** **Maximum Working Current**		25°C –55°C to +85°C 100A	
Power Conditioning	25°C, Rated Power, 96 hrs.	±0.1%	±0.05%
Low Temperature Storage and Operation	–55°C, No Load, 24 hrs.	±0.1%	±0.05%
Dielectric Withstanding Voltage **Insulation Resistance** **Low Temperature Operation** **Overload**	Atmo. Pres.: AC 750V, 1 min. DC 500V, 2 min. –55°C, Rated Power Rated Power x 2.5, 5 sec.	±0.05% over 10,000 MΩ ±0.1% ±0.1%	±0.01% over 10,000 MΩ ±0.05% ±0.05%
Moisture Resistance	+65°C to –10°C, 90% RH to 98% RH, Rated Voltage, 10 cycles (240 hrs.)	±0.1%	±0.05%
Shock **High Frequency Shock**	30G, 11 ms., Half-Sine Wave, X, Y, Z, 10 shocks each 10 Hz to 50 Hz to 10 Hz, 1 min. X, Y, Z, 2.0 hrs. each	±0.01% ±0.01%	±0.05% ±0.05%
Life	25°C, Rated Power, 1.5 hrs. – ON, 0.5 hrs. – OFF, 2,000 hrs.	±0.2%	±0.05%
High Temperature Exposure	85°C, No Load, 2,000 hrs.	±0.2%	±0.05%
Storage Life	15°C to 35°C, 15% RH to 75% RH, No Load, 10,000 hrs.	±0.05%	±0.01%
Internal Thermal Resistance	Between resistive element and base plate	0.3°C/W	
Thermal Electromotive Force		1 μV/°C	

FREQUENCY CHARACTERISTICS



TEMPERATURE OF RESISTOR SURFACE



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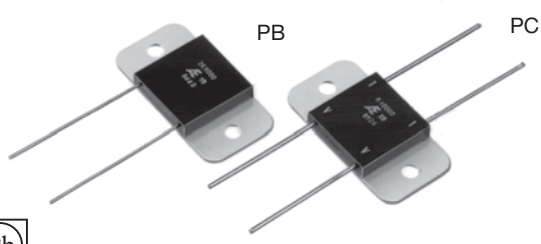
Ultra Precision Power Resistor (10 Watts)



Pb-free Available
RoHS COMPLIANT

COMPOSITION OF TYPE NUMBER

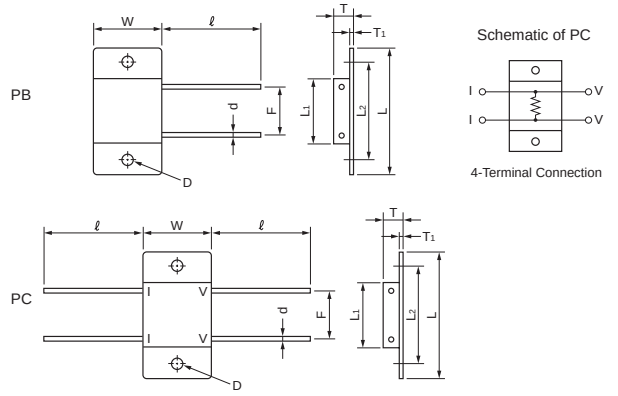
Example:

PB X 50R000 B

- B — Tolerance
- 50R000 — Resistance Value
- X — TCR
- PB — Type

Resistance value, in ohm, is expressed by a series of six characters, five of which represent significant digits. R or K is a dual-purpose letter that designates both the value range (R for ohmic; K for kilo-ohm) and the location of decimal point.

CONFIGURATION (DIMENSIONS IN mm)



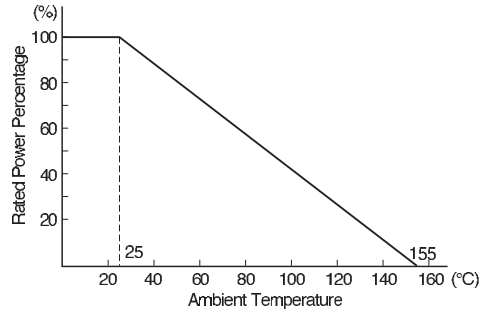
Type	PB	PC
L	40.0±0.2	
L_1	20.0±0.2	
L_2	30.0±0.5	
W	20.0±0.2	
T	5.0±0.2	
T_1	1.0±0.1	
F	15.0±0.5	
ℓ	30±10	
D	Dia. 4.0	
d	Dia. 0.8±0.05	Dia. 1.2±0.05

TCR, RESISTANCE RANGE, TOLERANCE, RATED POWER

Type	TCR (ppm/°C) –25°C to 125°C*	Resistance Range (Ω)	Resistance Tolerance (%)*†	Rated Power (W) at 25°C
PB	0±15 (W)	0.4 to 1	1 to ±5 (F, G, J)	2 in free air and 10 On heat sink **
	0±15 (W) 0±5 (X) 0±2.5 (Y)	1 to 5	±0.5 to ±5 (D, F, G, J)	
		5 to 10	±0.1 to ±5 (B, D, F, G, J)	
		10 to 25	±0.05 to ±5 (A, B, D, F, G, J)	
		25 to 50	±0.02 to ±5 (Q, A, B, D, F, G, J)	
		50 to 50k	±0.01 to ±5 (T, Q, A, B, D, F, G, J)	
PC	0±15 (W)	0.002 to 0.05	±0.5 to ±5 (D, F, G, J)	
	0±15 (W) 0±5 (X)	0.05 to 0.1	±0.5 to ±5 (D, F, G, J)	
	0±15 (W) 0±5 (X) 0±2.5 (Y)	0.1 to 5	±0.1 to ±5 (B, D, F, G, J)	
		5 to 10	±0.05 to ±5 (A, B, D, F, G, J)	
		10 to 25	±0.02 to ±5 (Q, A, B, D, F, G, J)	
		25 to 100	±0.01 to ±5 (T, Q, A, B, D, F, G, J)	

* Symbols in parentheses are for type number composition.
† Resistance figures for type PB are the values obtained by measuring the leads at point 12.7±3.2 mm away from the root, but in case of resistance below 10 ohm, the values at 5.08±0.6 mm away.
** For heat sinking, an aluminum chassis in 152.4 (L) x 101.6 (W) x 50.8 (H) x 1.0 mm (T) shall be used.

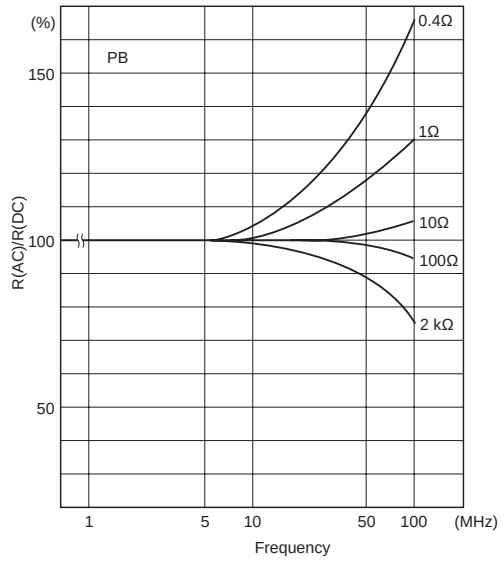
POWER DERATING CURVE



PERFORMANCE

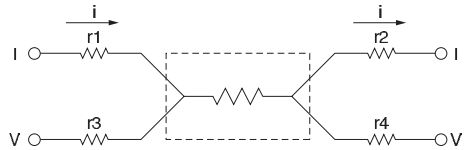
Parameters	Test Condition	MIL-R-39009 Specification	ALPHA Typical Test Data
Maximum Rated Operating Temperature **Working Temperature Range** **Maximum Working Voltage** **Maximum Working Current**		25°C –55°C to +155°C 750V PB=5A, PC=32A	
Power Conditioning	25°C, Rated Voltage, 96 hrs.	±0.2%	±0.2%
Low Temperature Storage **Dielectric Withstanding Voltage** **Insulation Resistance** **Low Temperature Operation** **Overload** **Moisture Resistance** **Terminal Strength**	–55°C, No Load, 24 hrs. Atmo. Pres.: AC 1 KV, 1 min. Baro. Pres. 8 mHg: AC 500V, 1min. DC 500V, 2 min. –55°C, Rated Voltage Rated Voltage x 2.5, 5 sec. +65°C to –10°C, 90% RH to 98% RH, Rated Voltage, 10 cycles (240 hrs.) 2.27 kg (5 pounds),10 sec.	±0.3% ±0.2% over 10,000 MΩ ±0.3% ±0.3% ±0.5% ±0.2%	±0.005% ±0.005% over 10,000 MΩ ±0.005% ±0.01% ±0.05% ±0.005%
Shock **Vibration, High Frequency**	100G, 6 ms., Sawtooth Wave, X, Y, Z, each 3 shocks 20G, 10 Hz to 2,000 Hz to 10 Hz, 20 min., X, Y, Z, each 4 hrs.	±0.2% ±0.2%	±0.005% ±0.005%
Life	25°C, Rated Power, 1.5 hr. – ON, 0.5 hr. – OFF, 2,000 hrs.	±1.0%	±0.01%
High Temperature Exposure	155°C, No Load, 2,000 hrs.	±1.0%	±0.01%
Solderability	245°C, 5 sec.	over 95% coverage	

FREQUENCY CHARACTERISTICS

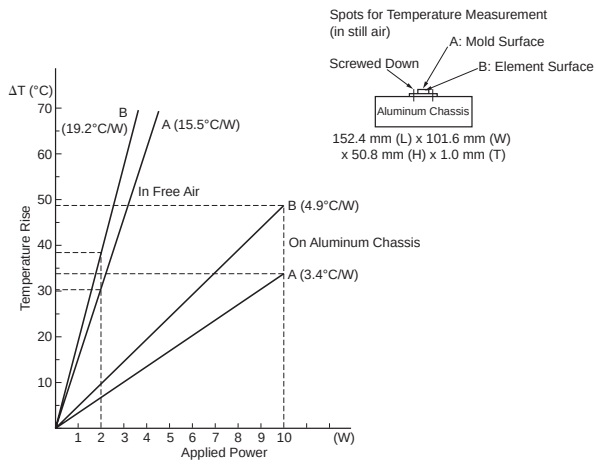


FOUR-TERMINAL RESISTOR

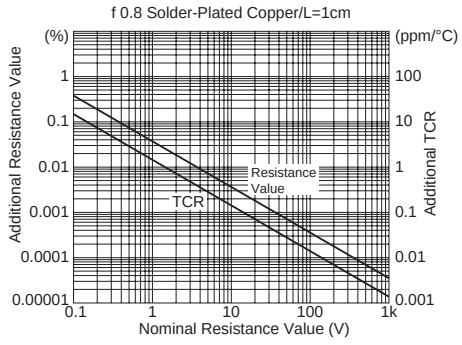
For low ohmic resistor (less than 10 ohm), the resistance value and TCR of the copper lead increases overall resistance value. Four-terminal (Kelvin) connection is recommended per the following figure. Loading current at terminals (V) causes measurement error.



TEMPERATURE OF RESISTOR SURFACE



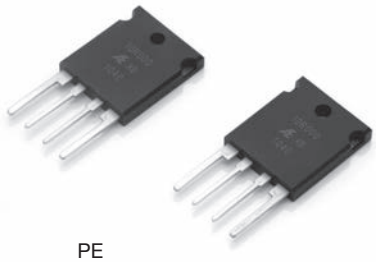
AFFECT OF PB TYPE LEAD FOR RESISTANCE VALUE AND TCR



Resistance Value of Lead: 0.36V/cm
TCR of Lead: 3,900 ppm/°C

Alpha Electronics
A VPG Brand

Ultra Precision Shunt Resistor (10 Watts, TO Package)



PE

Pb-free Available
RoHS COMPLIANT

TCR, RESISTANCE RANGE, TOLERANCE, RATED POWER

TCR (ppm/°C) –25°C to +125°C	Resistance Range (Ω)	Resistance Tolerance (%)	Rated Power (W) at 70°C
0±15 (W) 0±5 (X)	0.5 to 1	±0.05 to ±5 (A, B, D, F, G, J)	1.5 in free air and 10 on heat sink**
	1 to 5	±0.02 to ±5 (Q, A, B, D, F, G, J)	
0±15 (W) 0±5 (X) 0±2.5 (Y)	5 to 25	±0.02 to ±5 (Q, A, B, D, F, G, J)	
	25 to 500	±0.01 (T), ±0.02 (Q) ±0.05 (A), ±0.1 (B) ±0.5 (D), ±1 (F) ±2 (G), ±5 (J)	

** For heat sinking, an aluminum chassis in 152.4 mm (L) ×101.6 mm (W) × 50.8 mm (H) × 1.0 (T) shall be used.

COMPOSITION OF TYPE NUMBER

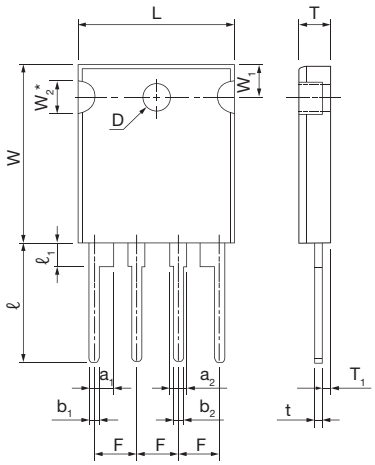
Example:

PE X 1R0000 B

- B — Tolerance
- 1R0000 — Resistance Value
- X — TCR
- PE — Type

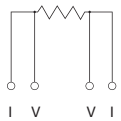
Resistance value, in ohms, is expressed by a series of six characters, five of which represent significant digits. R or K is a dual-purpose letter that designates both the value range (R for ohmic; K for kilo-ohm) and the location of the decimal point.

CONFIGURATION (DIMENSIONS IN mm)



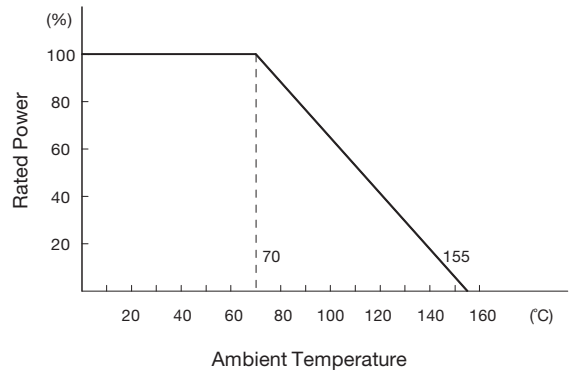
*half circle recess in molding (2)

Schematic of PE

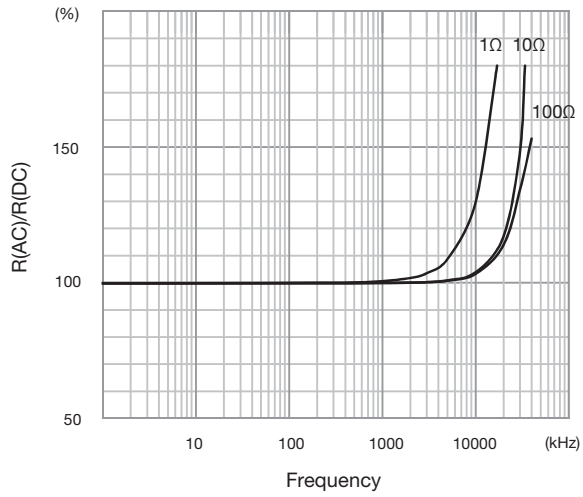


Type	PE
L	19.0±0.5
W	22.0±0.5
W_1	4.0±0.2
W_2*	4.0±0.2
T	4.0±0.2
T_1	1.3±0.2
F	5.08±0.5
ℓ	15.0±1
$ℓ_1$	3.0±0.2
t	0.8±0.1
a_1	3.0±0.2
a_2	2.0±0.2
b_1	1.4±0.1
b_2	1.0±0.1
D	Dia. 3.4±0.2

POWER DERATING CURVE

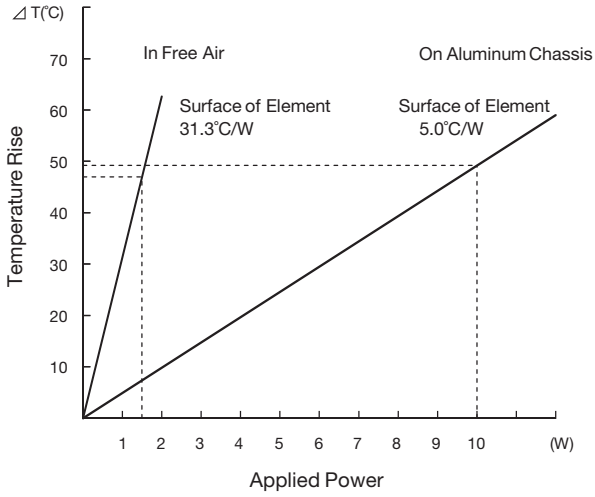


FREQUENCY CHARACTERISTICS



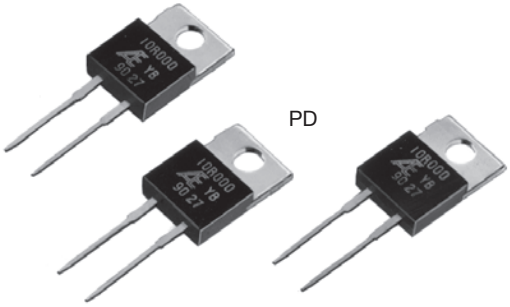
PERFORMANCE			
Parameters	**Test Condition**	**ALPHA Specification**	**ALPHA Typical Test Data**
Maximum Rated Operating Temperature **Working Temperature Range** **Maximum Working Current**		70°C –55°C to +155°C 5A	
Power Conditioning	25°C, Rated Power, 96 hrs.	±0.05%	±0.01%
Low Temperature Storage **Dielectric Withstanding Voltage** **Insulation Resistance** **Low Temperature Operation** **Overload** **Moisture Resistance** **Terminal Strength**	–55°C, No Load, 24 hrs. Atmo. Pres.: AC 1 KV, 1 min. Baro. Pres. 8 mHg: AC 500V, 1 min. DC 500V, 2 min. –55°C, Rated Power Rated Power x 2.5, 5 sec. +65°C to –10°C, 90% RH to 98% RH, Rated Voltage, 10 cycles (240 hrs.) 2.27 kg (5 pounds), 10 sec.	±0.01% ±0.01% over 10,000 MΩ ±0.01% ±0.05% ±0.05% ±0.05%	±0.005% ±0.005% over 10,000 MΩ ±0.005% ±0.01% ±0.02% ±0.005%
Shock **Vibration, High Frequency**	100G, 6 ms., Sawtooth Wave, X, Y, Z, each 3 shocks 20G, 10 Hz to 2,000 Hz to 10 Hz, 20 min., X, Y, Z, each 4 hrs.	±0.01% ±0.01%	±0.005% ±0.005%
Life	70°C, Rated Power, 1.5 hr. – ON, 0.5 hr. – OFF, 2,000 hrs.	±0.05%	±0.02%
High Temperature Exposure	155°C, No Load, 2,000 hrs.	±0.05%	±0.02%
Solderability	245°C, 5 sec.	over 95% coverage	

TEMPERATURE OF RESISTOR SURFACE



Alpha Electronics
A VPG Brand

Ultra Precision Power Resistor (8 Watts, TO-220)



Pb-free Available

RoHS COMPLIANT

COMPOSITION OF TYPE NUMBER

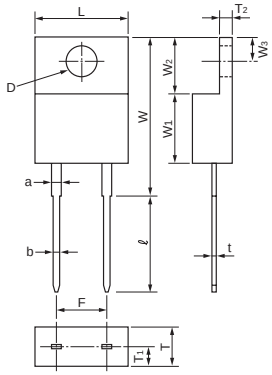
Example:

PD X 50R000 B

- B — Tolerance
- 50R000 — Resistance Value
- X — TCR
- PD — Type

Resistance value, in ohm, is expressed by a series of six characters, five of which represent significant digits. R or K is a dual-purpose letter that designates both the value range (R for ohmic; K for kilo-ohm) and the location of decimal point.

CONFIGURATION (DIMENSIONS IN mm)



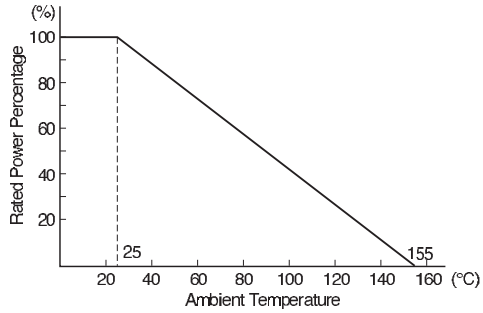
Type	PD
L	10.6 max.
W	19.0±0.5
W_1	8.5±0.2
W_2	6.5±0.2
W_3	2.7±0.5
T	4.5±0.2
T_1	2.0±0.5
T_2	1.5±0.2
F	5.08±0.5
ℓ	11.0±2
t	0.5±0.05
a	1.2±0.1
b	0.75±0.05
D	Dia. 3.6

TCR, RESISTANCE RANGE, TOLERANCE, RATED POWER

Type	TCR (ppm/°C) –25°C to +125°C*	Resistance Range (Ω)	Resistance Tolerance (%)*†	Rated Power (W) at 25°C
PD	0±15 (W)	0.1 to 1	±1 to ±5 (F, G, J)	1.5 In free air and 8 On heat sink**
	0±15 (W) 0±5 (X)	1 to 5	±0.5 to ±5 (D, F, G, J)	
	0±15 (W) 0±5 (X) 0±2.5 (Y)	5 to 10	±0.1 to ±5 (B, D, F, G, J)	
		10 to 25	±0.05 to ±5 (A, B, D, F, G, J)	
		25 to 10k	±0.02 to ±5 (Q, A, B, D, F, G, J)	

* Symbols in parentheses are for type number composition.
† Resistance figures are the values obtained by measuring the leads at point 5.08±0.6 mm away from the root.
** For heat sinking, an aluminum chassis in 152.4 (L) x 101.6 (W) x 50.8 (H) x 1.0 mm (T) should be used.

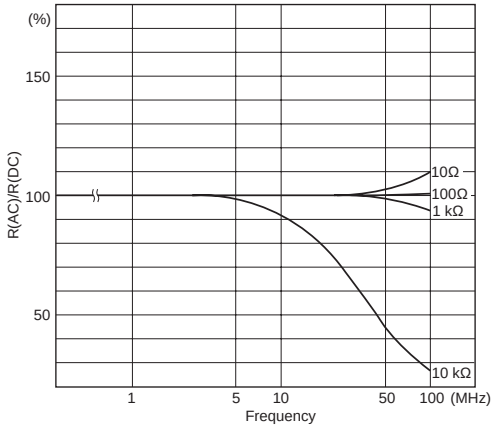
POWER DERATING CURVE



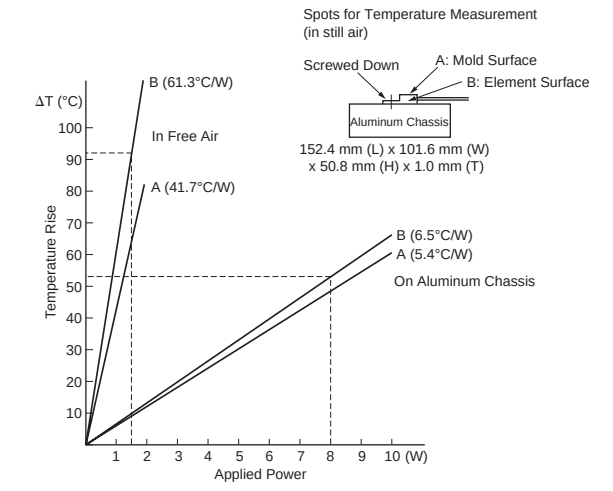
PERFORMANCE

Parameters	Test Condition	MIL-R-39009 Specification	ALPHA Typical Test Data
Maximum Rated Operating Temperature **Working Temperature Range** **Maximum Working Voltage** **Maximum Working Current**		25°C –55°C to +155°C 250V 4A	
Power Conditioning	25°C, Rated Voltage, 96 hrs.	±0.2%	±0.02%
Low Temperature Storage **Dielectric Withstanding Voltage** **Insulation Resistance** **Low Temperature Operation** **Overload** **Moisture Resistance** **Terminal Strength**	–55°C, No Load, 24 hrs. Atmo. Pres.: AC 1 kV, 1 min. Baro. Pres. 8 mHg: AC 500V, 1min. DC 500V, 2 min. –55°C, Rated Voltage Rated Voltage x 2.5, 5 sec. +65°C to –10°C, 90% RH to 98% RH, Rated Voltage, 10 cycles (240 hrs.) 0.908 kg (2 pounds),10 sec.	±0.3% ±0.2% over 10,000 MΩ ±0.3% ±0.3% ±0.5% ±0.2%	±0.005% ±0.005% over 10,000 MΩ ±0.005% ±0.01% ±0.05% ±0.005%
Shock **Vibration, High Frequency**	100G, 6 ms, Sawtooth Wave, X, Y, Z, each 3 shocks 20G, 10 Hz to 2,000 Hz to 10 Hz, 20min., X, Y, Z, each 4 hrs.	±0.2% ±0.2%	±0.005% ±0.005%
Life	25°C, Rated Power, 1.5 hr. – ON, 0.5 hr. – OFF, 2,000 hrs.	±1.0%	±0.01%
High Temperature Exposure	155°C, No Load, 2,000 hrs.	±1.0%	±0.01%
Solderability	245°C, 5 sec.	over 95% coverage	

FREQUENCY CHARACTERISTICS

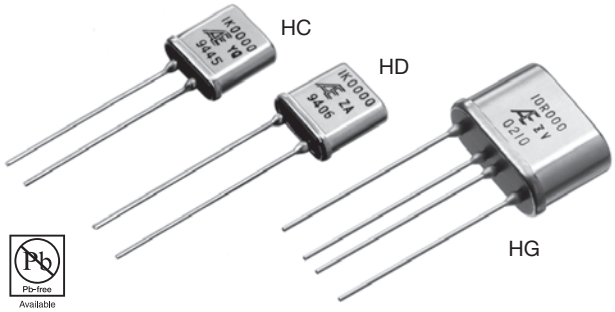


TEMPERATURE OF RESISTOR SURFACE



Alpha Electronics
A VPG Brand

Ultra Precision Resistor (Hermetically Sealed)



Pb-free Available
RoHS COMPLIANT

COMPOSITION OF TYPE NUMBER

Example:

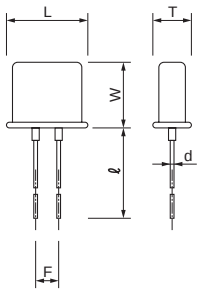
HC Y 30K000 T

- T — Tolerance
- 30K000 — Resistance Value
- Y — TCR
- HC — Type

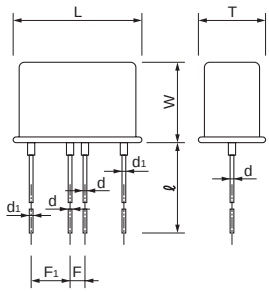
Resistance value, in ohm, is expressed by a series of six characters, five of which represent significant digits. The sixth R or K is a dual-purpose letter that designates both the value range (R for ohmic; K for kilo-ohm) and the location of decimal point.

CONFIGURATION (DIMENSIONS IN mm)

HC, HD Type



HG Type



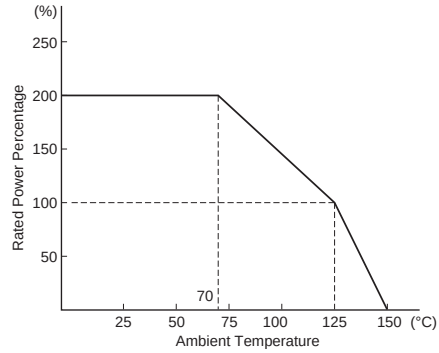
Type	HC	HD	HG
L	10.7±0.3		19.0±0.3
W	10.7±0.3		12.8±0.3
T	4.3±03		8.8±0.3
F	3.81±0.25	5.08±0.25	2.54±0.25
F1	–		5.08±0.25
ℓ	30±10		
d	Dia. 0.65±0.05		
d1	Dia. 0.8±0.05		

TCR, RESISTANCE RANGE, TOLERANCE, RATED POWER

Type	TCR (ppm/°C) –55°C to +125°C*	Resis-tance Range (Ω)	Resistance Tolerance (%)*†	Rated Power (W) at 125°C
HC HD	0±15 (W)	1 to 5	±0.5 (D) ±1 (F)	0.3
	0±5 (X)	5 to 30	±0.1 (B) ±0.5 (D) ±1 (F)	
	0±5 (X) 0±2.5 (Y) 0±1 (Z)**	30 to 120k	±0.005 (V) ±0.01 (T) ±0.02 (Q) ±0.05 (A) ±0.1 (B) ±0.5 (D) ±1 (F)	
HG	0±2.5 (Y) 0±1 (Z)**	1 to 10	±0.01 (T) ±0.02 (Q) ±0.05 (A) ±0.1 (B) ±0.5 (D) ±1 (F)	
		10 to 10k	±0.005 (V) ±0.01 (T) ±0.02 (Q) ±0.05 (A) ±0.1 (B) ±0.5 (D) ±1 (F)	

* Symbols in parentheses are for type number composition.
† Resistance figures are obtained by measuring the leads at point 12.7±3.2 mm away from the base for type HC and HD, but, in case of resistance below 10 ohm, the value at 1.6±0.6 mm away from the base for all types.
**Temperature characteristic Z is applicable for temperature range between 0°C and 60°C.

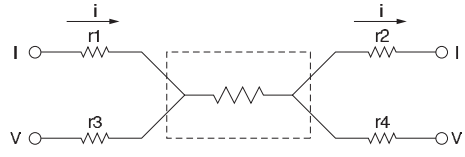
POWER DERATING CURVE



FOUR-TERMINAL (KELVIN) CONNECTION

For low ohmic resistor (less than 10 ohm), the resistance value and TCR of the copper lead increases overall resistance value. Four-terminal (Kelvin) connection is recommended per the following figure. Loading current at voltage and current terminals (V, I) causes measurement error.

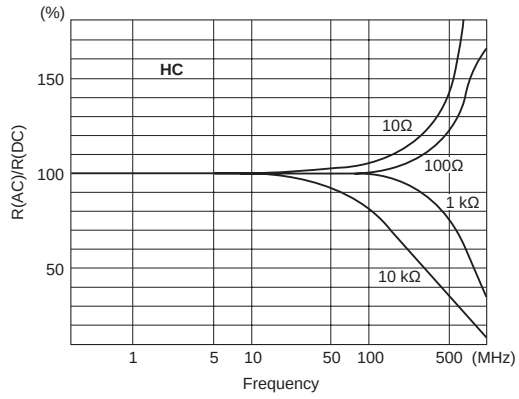
Four-Terminal Resistor



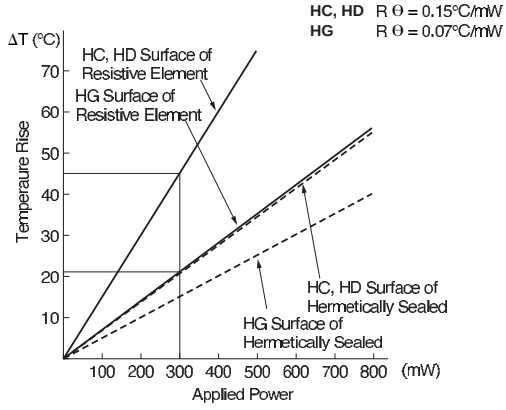
PERFORMANCE

Parameters	Test Condition	MIL-PRF-55182/9 Specification	ALPHA Typical Test Data
Maximum Rated Operating Temperature		125°C	
Working Temperature Range		–65°C to +150°C	
Maximum Working Voltage		300V	
Power Conditioning	125°C, Rated Power, 100 hrs.	±(0.20% +0.01Ω)	±0.0025%
Thermal Shock	–65°C/30 min. ↔ +150°C/30 min., 5 cycles	±0.05%	±0.0025%
Overload	Rated Voltage x 6.25, 5 sec.	±0.05%	±0.0025%
Solderability	Steam Aging 8 hrs., 245°C, 5 sec.	over 95% coverage	
Resistance to Solvents	❶ Isopropyl Alcohol + Mineral Spirits ❷ Water + Butyl Cellosolve + Monoethanolamine	no damage	
Low Temperature Storage	–65°C, 24 hrs.	±0.05%	±0.0025%
Low Temperature Operation	–65°C Rated Voltage, 45 min.	±0.05%	±0.0025%
Terminal Strength	0.908 kg (2 pounds), 10 sec.	±0.02%	±0.001%
Dielectric Withstanding Voltage	Atom. Pres.: 300V rms. Baro. Pres. 8 mHg: 200V rms.	±0.02%	±0.0025%
Insulation Resistance	DC 100V, 2 min.	over 10,000 MΩ	over 10,000 MΩ
Resistance to Soldering Heat	260°C, 10 sec. ±2 sec.	±0.02%	±0.0025%
Moisture Resistance	+65°C to –10°C, 90% RH to 98% RH, Rated Voltage, 10 cycles (240 hrs.)	±0.05%	±0.0025%
Shock (Specified Pulse)	100G, 6 ms, Sawtooth Wave, X, Y, Z, each 10 shocks	±0.01%	±0.0025%
Vibration, High Frequency	20G, 10 Hz to 2,000 Hz to 10 Hz, 20 min., X, Y, each 4 hrs.	±0.02%	±0.0025%
Life	125°C, Rated Power, 1.5 hr. – ON, 0.5 hr. – OFF, 2,000 hrs.	±0.05%	±0.01%
70°C Power Rating	70°C, Rated Voltage x 2, 1.5 hrs. – ON, 0.5 hr. – OFF, 2,000 hrs.	±0.05%	±0.01%
Storage Life	15°C to 35°C, 15% RH to 75% RH, No Load, 10,000 hrs.	±0.005%	±0.0005%
High Temperature Exposure	175°C, No Load, 2,000 hrs.	±0.5%	±0.01%
Current Noise		–32 dB	–42 dB
Voltage Coefficient		0.0001%/V	0.00003%/V
Thermal EMF		1.0 µV/°C	0.1 µV/°C

FREQUENCY CHARACTERISTICS



TEMPERATURE OF RESISTOR SURFACE

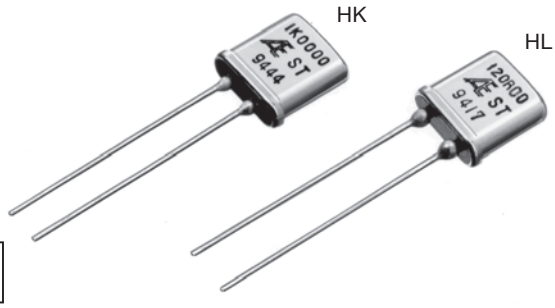


PRECAUTION IN USING HC, HD OR HG RESISTORS

When soldering to mount HC, HD or HG on a board, keep the resistor over 10 mm away from the board surface by using an insulating tube.

Alpha Electronics
A VPG Brand

Zero-TCR Ultra Precision Resistor (Hermetically Sealed)



Pb-free Available

RoHS COMPLIANT

TCR, RESISTANCE RANGE, TOLERANCE, RATED POWER

Type	TCR	Resistance Range (Ω)	Resistance Tolerance (%)*†	Rated Power (W) at 70°C
HK HL	Char. S	100 to 100k	±0.005 (V) ±0.01 (T) ±0.02 (Q) ±0.05 (A) ±0.1 (B) ±0.5 (D) ±1 (F)	0.3

* Symbols parenthesized are for type number composition.
† Resistance figures are obtained by measuring the leads at point 12.7±3.2 mm away from the root.

COMPOSITION OF TYPE NUMBER

Example:

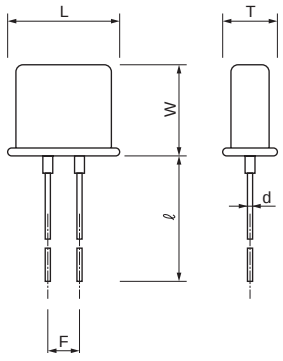
HK S 10K000 T

- T — Tolerance
- 10K000 — Resistance Value
- S — TCR
- HK — Type

Resistance value, in ohm, is expressed by a series of six characters, five of which represent significant digits. R or K is a dual-purpose letter that designates both the value range (R for ohmic; K for kilo-ohm) and the location of decimal point.

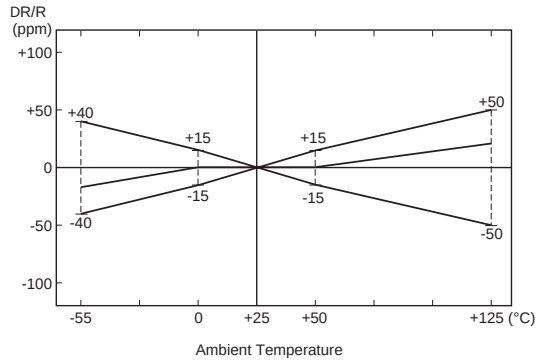
CONFIGURATION (DIMENSIONS IN mm)

HK, HL



Type	HK	HL
L	10.7±0.3	
W	10.7±0.3	
T	4.3±0.3	
F	3.81±0.25	5.08±0.25
ℓ	30±10	
d	ϕ0.65±0.05	

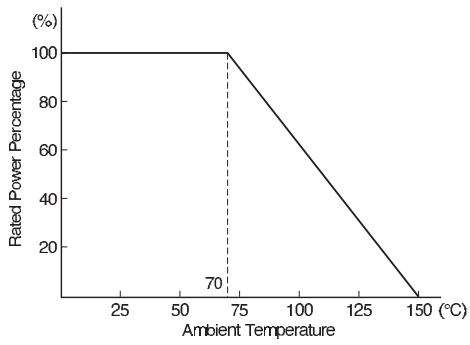
TEMPERATURE CHARACTERISTICS OF RESISTANCE



Temperature (°C)	ΔR/R (ppm)
-55	0±40
0	0±15
+50	0±15
+125	0±50

Reference Temperature +25°C

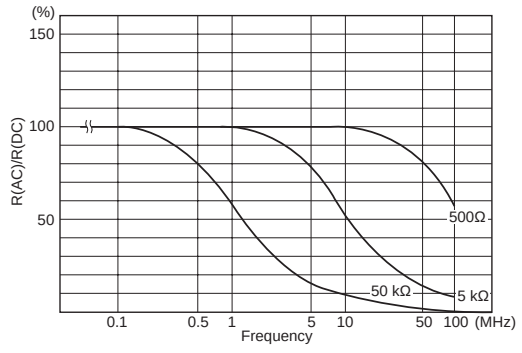
POWER DERATING CURVE



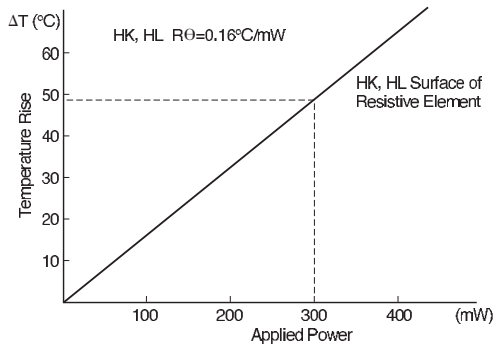
PERFORMANCE

Parameters	Test Condition	ALPHA Specification	ALPHA Typical Test Data
Maximum Rated Operating Temperature **Working Temperature Range** **Maximum Working Voltage**		70°C –65°C to +150°C 300V	
Power Conditioning **Thermal Shock** **Overload**	25°C, Rated Voltage, 96 hrs. –65°C/30 min. ⟷ +150°C/30 min., 5 cycles Rated Voltage x 2.5, 5 sec.	±0.05%	±0.0025%
Solderability	245°C, 5 sec.	over 95% coverage	over 95% coverage
Resistance to Solvents	❶ Isopropyl Alcohol + Mineral Spirits ❷ Water + Butyl Cellosolve + Monoethanolamine	no damage	no damage
Low Temperature Storage **Terminal Strength**	–65°C, No Load, 24 hrs. → Rated Voltage, 45 min. 0.908 kg (2 pounds),10 sec.	±0.05% ±0.02%	±0.0025% ±0.001%
Dielectric Withstanding Voltage **Insulation Resistance** **Resistance to Soldering Heat** **Moisture Resistance**	Atmo. Pres.: AC 300V, 1 min. Baro. Pres. 8 mHg: AC200V, 1min. DC 500V, 2 min. 350°C, 3 sec. +65°C to –10°C, 90% RH to 98% RH, Rated Voltage, 10 cycles (240 hrs.)	±0.02% over 10,000 MΩ ±0.05% ±0.05%	±0.0025% over 10,000 MΩ ±0.0025% ±0.0025%
Shock **Vibration, High Frequency**	100G, 6 ms, Sawtooth Wave, X, Y, Z, each 10 shocks 20G, 10 Hz to 2,000 Hz to 10 Hz, 20 min., X, Y, Z, each 2.5 hrs.	±0.01% ±0.02%	±0.0025% ±0.0025%
Life	70°C, Rated Power, 1.5 hr. – ON, 0.5 hr. – OFF, 2,000 hrs.	±0.05%	±0.01%
Storage Life	15°C to 35°C, 15% RH to 75% RH, No Load, 10,000 hrs.	±0.0025%	±0.0005%
High Temperature Exposure	150°C, No Load, 2,000 hrs.	±0.05%	±0.01%
Current Noise **Voltage Coefficient** **Thermal EMF**		–32 dB 0.0005%/V 1.0 μV/°C	–42 dB 0.00003%/V 0.1 μV/°C

FREQUENCY CHARACTERISTICS



TEMPERATURE OF RESISTOR SURFACE



PRECAUTION IN USING HK OR HL RESISTORS

When soldering to mount HK or HL on a board, keep the resistor over 10 mm away from the board surface by using an insulating tube.

Ultra Precision Resistor Network

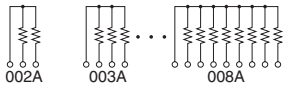
Alpha Electronics
A VPG Brand

Resistor networks from Alpha Electronics, specialists in precision resistors, featuring Bulk Metal® Foil technology, provide excellent performance in TCR tracking, resistance ratio matching and stability.

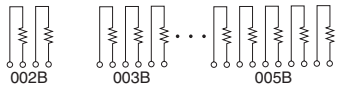
Characteristics
❶ Temperature Characteristics of Resistance: 0±5 ppm/°C
❷ TCR Tracking: ±1 ppm/°C
❸ Resistance Ratio Matching: ±0.01%
❹ Resistance Stability: ±0.005%/year

STANDARD CIRCUIT

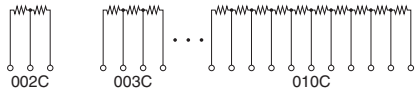
Circuit A (Array)
Circuit Symbol



Circuit B (Independent)
Circuit Symbol



Circuit C (Divider)
Circuit Symbol



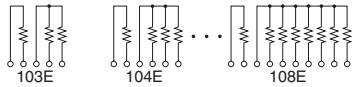
Composition of Circuit Symbol
Example:

0 02 A

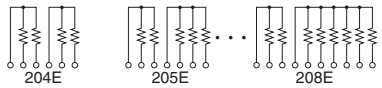
- A — Circuit Symbol
- 02 — Number of Resistance Elements
- 0 — Generic Number

Circuit E (A Circuit Divided into Two)

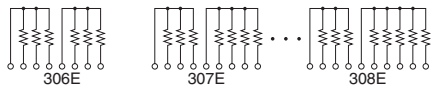
Circuit Symbol



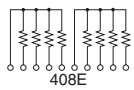
Circuit Symbol



Circuit Symbol



Circuit Symbol



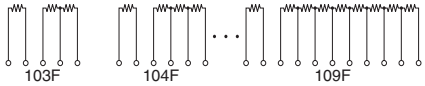
Composition of Circuit Symbol
Example:

1 03 E

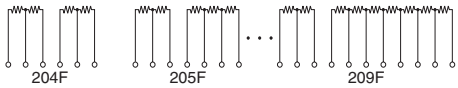
- E — Circuit Symbol
- 03 — Number of Resistance Elements
- 1 — Generic Number

Circuit F (C Circuit Divided into Two)

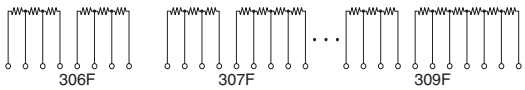
Circuit Symbol



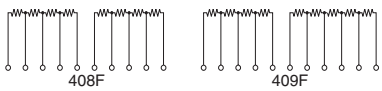
Circuit Symbol



Circuit Symbol



Circuit Symbol



Composition of Circuit Symbol
Example:

1 03 F

- F — Circuit Symbol
- 03 — Number of Resistance Elements
- 1 — Generic Number

Circuits other than listed are available.

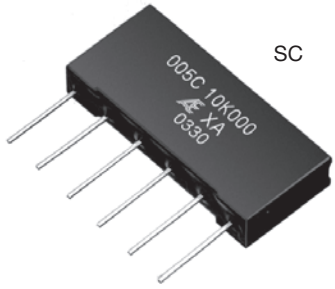
RESISTANCE RANGE AND NUMBER OF ELEMENTS MOUNTABLE

Type		Case Encapsulated Type	Conformally Coated Type		
		SC	SE	SF	SS
Max. Resistance Value/Element (Ω)		120k	120k	120k	20k
Min. Resistance Value/Element (Ω)		30	30	30	30
Max. Resistance Value/Package (Ω)		1,200k	600k	240k	100k
Maximum Number of Network Elements	Circuit A	8	4	—	5
	Circuit B	5	5	2	3
	Circuit C	10	5	2	5
	Circuit E	8	—	—	4
	Circuit F	9	5	—	4

TABLE 1. TEMPERATURE CHARACTERISTICS OF RESISTANCE

TCR (ppm/°C) –25°C to +125°C		
Absolute	Tracking	
	Resistance Ratio (R max./R min.)	TCR Tracking Available
0±5	1 ≤R max./R min. ≤10	±1
	10 <R max./R min. ≤100	±2
	100 <R max./R min.	±3

Ultra Precision Resistor Network (Case-Encapsulated)



SC

Pb-free Available
RoHS COMPLIANT

COMPOSITION OF TYPE NUMBER

Example:

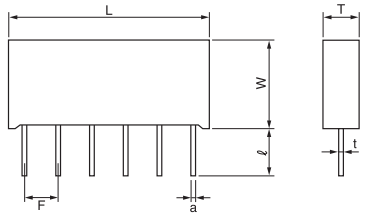
SC 005C 1K000/99K00 B Q
① ② ③ ④ ⑤ ⑥

① Type
② Circuit Symbol
③ Resistance Value (R1)
④ Resistance Value (Rn)
⑤ Resistance Tolerance (Absolute)
⑥ Resistance Tolerance (Matching)

Please specify all values for R1 to Rn when you consult or order us.

Resistance value, in ohm, is expressed by a series of five characters, four of which represent significant digits. R or K is a dual-purpose letter that designates both the value range (R for ohmic; K for kilo-ohm) and the location of decimal point.

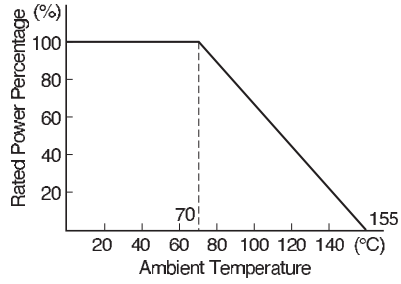
CONFIGURATION (DIMENSIONS IN mm)



Type	SC
L	30.0±0.5
W	13.0±0.5
T	5.0±0.5
ℓ	8±5
a	0.5±0.05
t	0.25±0.05
F	Multiples of 2.54

Lead space will be determined depending on circuit and number of elements.

POWER DERATING CURVE



TCR, RESISTANCE RANGE, TOLERANCE, RATED POWER

Type	TCR (ppm/°C) –25°C to +125°C	Resistance Range Element (Ω)*	Max. Resistance Value Package (Ω)	Resistance Tolerance (%)		Rated Power/ Package (W) at 70°C
				Absolute**	Matching**	
SC	0±5	30 to 120k	1,200k	±0.01 (T) ±0.02 (Q) ±0.05 (A) ±0.1 (B) ±0.5 (D) ±1 (F)	±0.01 (T) ±0.02 (Q) ±0.05 (A) ±0.1 (B) ±0.5 (D) ±1 (F)	1.5

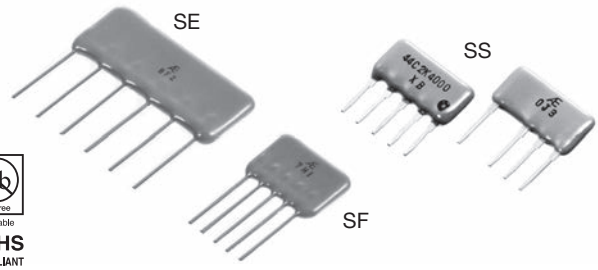
*TCR tracking is dependent on resistance ratio. See Table 1, Ultra Precision Resistor Network datasheet.
**Symbols parenthesized are for type number composition.

PERFORMANCE

Parameters	Test Condition	ALPHA Specification		ALPHA Typical Test Data	
		ΔR	ΔRatio	ΔR	ΔRatio
Maximum Rated Operating Temperature **Working Temperature Range**		70°C –55°C to +155°C			
Thermal Shock	–55°C/30 min.↔+155°C/30 min., 5 cycles	±0.05%	±0.01%	±0.01%	±0.005%
Low Temperature Storage **Overload** **Terminal Strength**	–55°C, No Load, 2 hrs. Rated Voltage x 2.5, 5 sec. 0.51 kg (1.123 pounds),10 sec.	±0.05% ±0.05% ±0.05%	±0.01% ±0.01% ±0.01%	±0.005% ±0.0025% ±0.005%	±0.0025% ±0.001% ±0.0025%
Dielectric Withstanding Voltage	Atmo. Pres.: AC 300V, 1 min.	±0.03%	±0.01%	±0.005%	±0.0025%
Insulation Resistance	DC 100V, 1 min.	over 10,000 MΩ		over 10,000 MΩ	
Resistance to Soldering Heat **Moisture Resistance**	350°C, 3 sec. +65°C to –10°C, 90% RH to 98% RH, Rated Voltage, 10 cycles (240 hrs.)	±0.03% ±0.05%	±0.01% ±0.01%	±0.005% ±0.015%	±0.0025% ±0.005%
Shock **Vibration**	100G, 6 ms., Sawtooth Wave, X, Y, Z, each 6 shocks 20G, 10 Hz to 55 Hz to 10 Hz, 1 min., X, Y, Z, each 2 hrs.	±0.03% ±0.03%	±0.01% ±0.01%	±0.005% ±0.005%	±0.0025% ±0.0025%
Life (Rated Load)	70°C, Rated Power, 1.5 hrs. – ON, 0.5 hr. – OFF, 1,000 hrs.	±0.05%	±0.01%	±0.01%	±0.005%
Life (Moisture Load)	40°C, 90% RH to 95% RH, Rated Power, 1.5 hrs. – ON, 0.5 hr. – OFF, 1,000 hrs.	±0.05%	±0.01%	±0.01%	±0.005%
High Temperature Exposure	155°C, No Load, 1,000 hrs.	±0.03%	±0.01%	±0.01%	±0.005%
Storage Life	15°C to 35°C, 15% RH to 75% RH, No Load, 10,000 hrs.	±0.03%	±0.01%	±0.005%	±0.0025%

Alpha Electronics
A VPG Brand

Precision Resistor Network (Conformally Coated)



Pb-free Available
RoHS COMPLIANT

COMPOSITION OF TYPE NUMBER

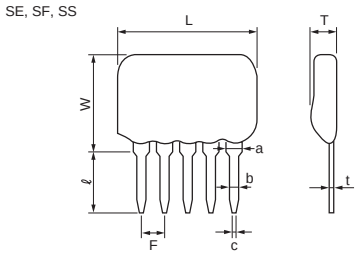
Example:

SE 004A 1K000 / 8K000 B A
① ② ③ ④ ⑤ ⑥

① Type
② Circuit Symbol
③ Resistance Value (R1)
④ Resistance Value (Rn)
⑤ Resistance Tolerance (Absolute)
⑥ Resistance Tolerance (Matching)

Specify all values for R1 to Rn

CONFIGURATION (DIMENSIONS IN mm)



Lead space will be determined depending on circuit and number of elements.

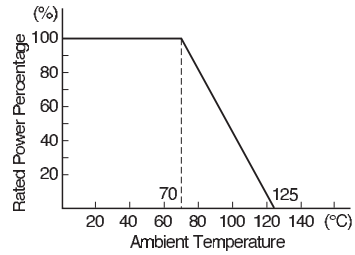
Type	SE	SF	SS
L	29.0±0.5	14.0±0.5	7.5±0.5 to 15.5±0.5
W	12.5±0.5	10.0±0.5	7.3±0.5
T	2.7±0.5		2.2±0.5
ℓ	5±1		
t	0.3±0.05		
a	1.0±0.05		
b	0.65±0.05		
c	0.4±0.05		
F	Multiple of 2.54		

TCR, RESISTANCE RANGE, TOLERANCE, RATED POWER

Type	TCR (ppm/°C)* –25°C to +125°C	Resistance Range Element (Ω)	Maximum Resistance Value Package (Ω)	Resistance Tolerance (%)**		Rated Power/ Package (W) at 70°C
				Absolute	Matching	
SE	0±5	30 to 120k	600k	±0.05 (A) ±0.1 (B) ±0.5 (D) ±1 (F)	±0.01 (T) ±0.02 (Q) ±0.05 (A) ±0.1 (B) ±0.5 (D) ±1 (F)	1
SF		30 to 120k	240k			0.5
SS		30 to 20k	100k			0.5

*TCR tracking is dependent on resistance ratio. See Table 1, Ultra Precision Resistor Network datasheet.
**Symbols parenthesized are for type number composition.

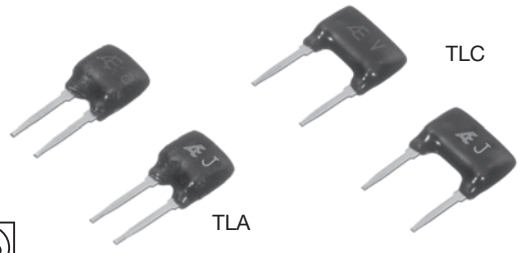
POWER DERATING CURVE



PERFORMANCE

Parameters	Test Condition	ALPHA Specification		ALPHA Typical Test Data	
		ΔR	ΔRatio	ΔR	ΔRatio
Maximum Rated Operating Temperature Working Temperature Range		70°C –25°C to +125°C			
Temperature Cycling	–25°C/30 min., Room Temperature/5 min., +125°C/30 min., 5 cycles	±0.05%	±0.01%	±0.01%	±0.005%
Low Temperature Storage Overload Terminal Strength	–25°C, No Load, 2 hrs. Rated Voltage x 2.5, 5 sec. 0.51 kg (1.123 pounds),10 sec.	±0.05% ±0.05% ±0.05%	±0.01% ±0.01% ±0.01%	±0.005% ±0.0025% ±0.005%	±0.0025% ±0.001% ±0.0025%
Dielectric Withstanding Voltage Insulation Resistance Resistance to Soldering Heat Moisture Resistance	Atmo. Pres.: AC 300V, 1 min. DC 100V, 1 min. 350°C, 3 sec. +65°C to –10°C, 90% RH to 98% RH, Rated Voltage, 10 cycles (240 hrs.)	±0.03% over 10,000 MΩ ±0.03% ±0.1%	±0.01% ±0.01% ±0.05%	±0.005% over 10,000 MΩ ±0.005% ±0.03%	±0.0025% ±0.0025% ±0.005%
Shock Vibration	50G, 11 ms., Half-Sine Wave, X, Y, Z, each 3 shocks 20G, 10 Hz to 55 Hz to 10 Hz, 1 min., X, Y, Z, each 2 hrs.	±0.03% ±0.03%	±0.01% ±0.01%	±0.005% ±0.005%	±0.0025% ±0.0025%
Life (Rated Load)	70°C, Rated Power, 1.5 hrs. – ON, 0.5 hr. – OFF, 1,000 hrs.	±0.1%	±0.05%	±0.01%	±0.005%
Life (Moisture Load)	40°C, 90% RH to 95% RH, Rated Power, 1.5 hrs. – ON, 0.5 hr. – OFF, 1,000 hrs.	±0.1%	±0.05%	±0.01%	±0.005%
High Temperature Exposure	125°C, No Load, 1,000 hrs.	±0.1%	±0.05%	±0.01%	±0.005%
Storage Life	15°C to 35°C, 15% RH to 75% RH, No Load, 10,000 hrs.	±0.05%	±0.03%	±0.005%	±0.0025%

Precision Thin Film Resistor (Conformally Coated)



Pb-free Available
RoHS COMPLIANT

TCR, RESISTANCE RANGE, TOLERANCE, RATED POWER

Type	TCR (ppm/°C) –25°C to +125°C*	Resistance Range (Ω)	Resistance Tolerance (%)*	Rated Power (W) at 70°C
TLA	0±10 (C) 0±5 (X)	100K to 5M	±0.05 (A) ±0.1 (B) ±0.5 (D) ±1 (F)	0.125
TLC		200K to 10M	±0.02 (Q) ±0.05 (A) ±0.1 (B) ±0.5 (D) ±1 (F)	0.25

* Symbols in parentheses are for type number composition.

COMPOSITION OF TYPE NUMBER

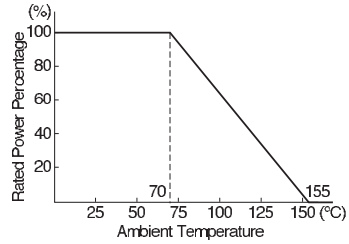
Example:

TLA X 500K00 B

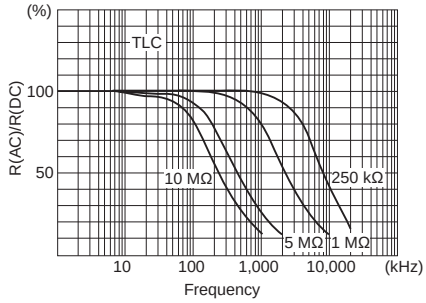
- B — Tolerance
- 500K00 — Resistance Value
- X — TCR
- TLA — Type

Resistance value, in ohm, is expressed by a series of six characters, five of which represent significant digits. K or M is a dual-purpose letter that designates both the value range (K for kilo-ohm; M for mega-ohm) and the location of decimal point.

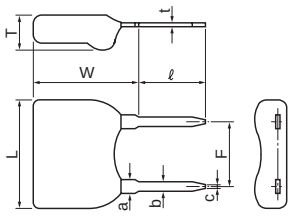
POWER DERATING CURVE



FREQUENCY CHARACTERISTICS



CONFIGURATION (DIMENSIONS IN mm)



Type	TLA	TLC
L	5.3±0.5	7.3±0.5
W	6.2±0.5	
T	2.2±0.5	
F	2.54±0.25	5.08±0.25
ℓ	5±1	
t	0.3±0.05	
a	1.0±0.05	
b	0.65±0.05	
c	0.4±0.05	

PERFORMANCE

Parameters	Test Condition	ALPHA Specification	ALPHA Typical Test Data
Max. Rated Operating Temperature **Working Temperature Range** **Maximum Working Voltage**		70°C –25°C to +155°C TLA = 250V, TLC = 300V	
Temperature Cycling **Overload**	–25°C/30 min., Room Temperature/5 min., +155°C/30 min., 5 cycles Rated Voltage × 2.5, 5 sec.	±0.05% ±0.05%	±0.01% ±0.0025%
Solderability **Resistance to Solvents**	235°C, 2 sec. Isopropyl Alcohol	over 75% coverage no damage	
Low Temperature Storage **Terminal Strength**	–25°C, No Load, 2 hrs. 0.908 kg (2 pounds), 10 sec.	±0.05% ±0.05%	±0.0025% ±0.0025%
Dielectric Withstanding Voltage **Insulation Resistance** **Resistance to Soldering Heat** **Moisture Resistance**	Atmospheric: AC 300V, 1 min. DC 100V, 1 min. 350°C, 3 sec. +65°C to –10°C, 90% RH to 98% RH, Rated Voltage, 10 cycles (240 hrs.)	±0.03% over 10,000 MΩ ±0.03% ±0.1%	±0.0025% over 10,000 MΩ ±0.01% ±0.05%
Life (Rated Load)	70°C, Rated Power, 1.5 hrs. – ON, 0.5 hr. – OFF, 1,000 hrs.	±0.1%	±0.01%
Storage Life	15°C to 35°C,15% RH to 75% RH, No Load, 10,000 hrs.	±0.02%	±0.01%
High Temperature Exposure	155°C, No Load, 1,000 hrs.	±0.05%	±0.02%
Current Noise		–25 dB	–35 dB

CLA, CLB, KLC, NLA, NLB, NMP, NMQ Series

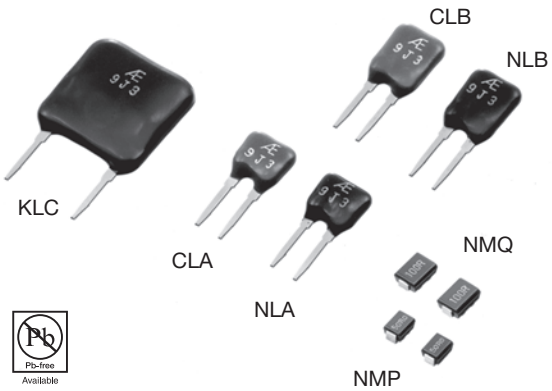
Alpha Electronics
A VPG Brand

Ultra Precision Thermosensitive Resistor

This ultra precision thermosensitive resistor is a new type of resistor produced by the application of Alpha foil resistor technology. It is made of material only a few μm thick and responds rapidly to temperature changes. The metal foil that is used has a resistivity that varies linearly with temperature change. Strict control of foil composition maintains uniform quality without fluctuation of temperature characteristics of resistance. This thermosensitive resistor is produced by the same fine photo-etching technology used in the metal foil precision resistors. The pattern is ideally designed for temperature detection, providing small size and rapid response.

Characterisitics

❶ Since the resistance is provided by metal foil, the resistance is highly stable with little change over time
❷ Temperature characteristics of resistance are almost linear
❸ Response to temperature changes is rapid
❹ This thermosensitive resistor is small and low-priced
❺ Highly accurate with tolerance of resistance values ±0.5%
❻ Temperature characteristics can be freely adjusted (KLC type)



Pb-free Available
RoHS COMPLIANT

Main Applications

- Cold-junction reference for thermocouple
- Temperature-compensation in load cell
- Temperature-compensation device in semiconductor circuit
- Temperature-sensing device

COMPOSITION OF TYPE NUMBER

Example 1:
NLA ① **100R0** ② **F** ③

① Type
② Resistance Value*
③ Tolerance

Example 2:
KLC ① **3000-500R0** ② **F** ③ ④

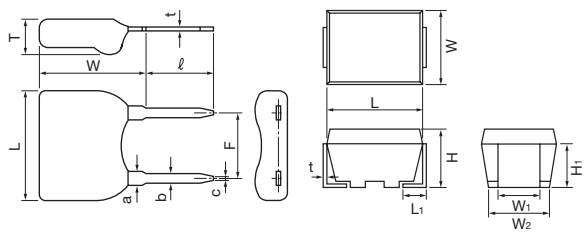
① Type
② TCR**
③ Resistance Value*
④ Tolerance

Example 3:
NMP ① **100R0** ② **F** ③ **L** ④

① Type
② Resistance Value*
③ Tolerance
④ Tape & Reel Package Required

*Resistance value, in ohm, is expressed by a series of five characters, four of which represent significant digits. R or K is a dual-purpose letter that designates both the value range (R for ohmic; K for kilo-ohm) and the location of decimal point.
**Specify a desired TCR, following the type, in four-digit coding. The example “3000” means 3,000 ppm/°C while “0500” means 500 ppm/°C.

CONFIGURATION (DIMENSIONS IN mm)



Type	NLA, CLA	NLB, CLB	KLC
L	5.6±0.5		12.4±0.5
W	6.2±0.5	8.2±0.5	13.3±0.5
T	2.2±0.5		3.3±0.5
F	2.54±0.25		7.62±0.25
ℓ	5.0±1.0		
t	0.3±0.05		
a	1.0±0.05		
b	0.65±0.05		
c	0.4±0.05		

Type	NMP	NMQ
L	3.2±0.2	4.5±0.2
W	2.5±0.2	3.2±0.2
H	2.0±0.2	
L1	0.6±0.2	0.8±0.2
W1	1.4±0.3	
W2	2.3±0.2	3.0±0.2
H1	1.5±0.3	
t	0.15±0.05	

TCR, RESISTANCE RANGE, TOLERANCE, RATED POWER

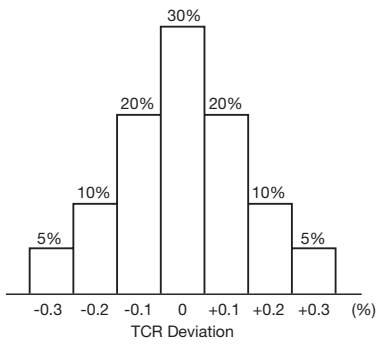
Type	TCR (ppm/°C)	Resistance Range (Ω)	Resistance Tolerance (%) at 0°C	Rated Power (W) at 70°C
NMP	+6,060±2% (0 to 25°C) +6,260±2% (0 to 50°C) +6,660±2% (0 to 100°C)	5 to 250	±0.5 (D) * ±1.0 (F) ±2.0 (G) ±5.0 (J)	0.1
NMQ		5 to 500		0.125
NLA	+6,060±1% (0 to 25°C) +6,260±1% (0 to 50°C) +6,660±1% (0 to 100°C)	5 to 500		0.125
NLB		5 to 1k		0.25
CLA	+4,250±1% (0 to 100°C)	5 to 100		0.125
CLB		5 to 200		0.25
KLC	See Fig.1 on next page			0.25

*Symbols parenthesized are for type number composition.

TAPE AND REEL PACKAGE (BASED ON EIA-481-1)

For details, refer to MP, MQ Series datasheet.

TCR SPREAD FROM NOMINAL AND DISTRIBUTION



TEMPERATURE CHARACTERISTICS OF RESISTANCE

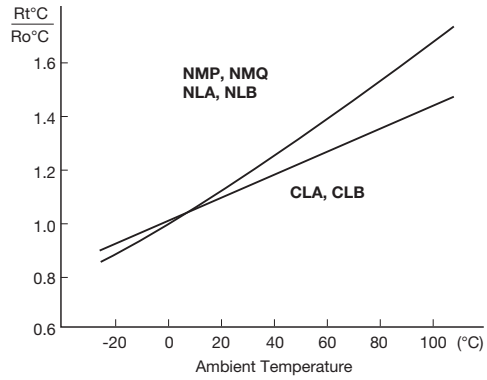
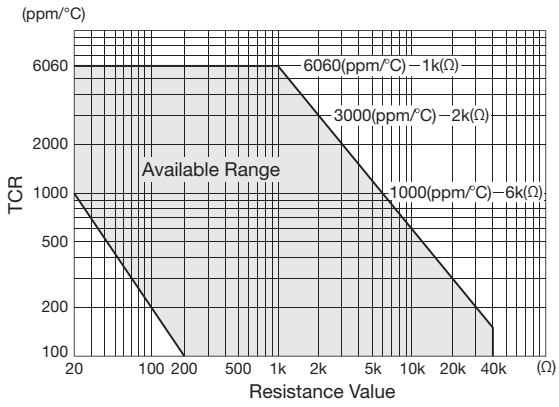
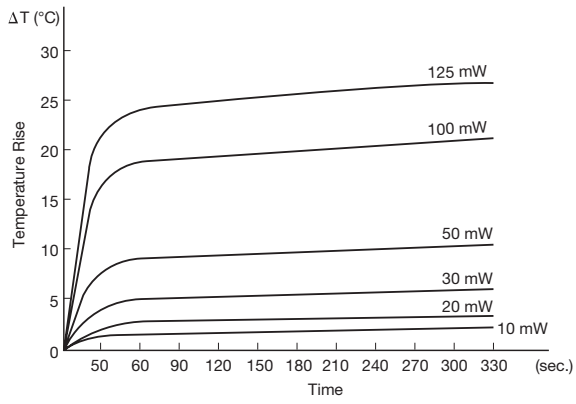


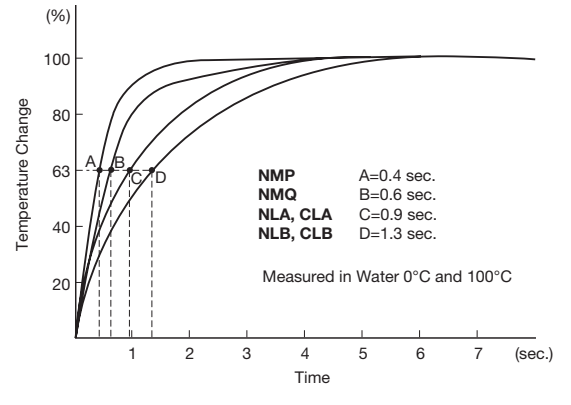
FIG. 1 TCR AND RESISTANCE AVAILABLE IN KLC TYPE



TEMPERATURE OF RESISTOR SURFACE



RESPONSE TIME TO TEMPERATURE CHANGE

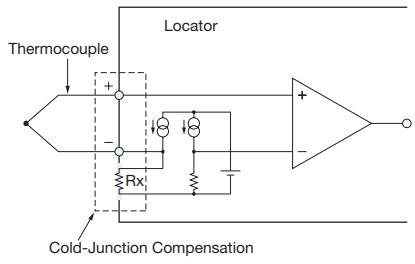


PERFORMANCE

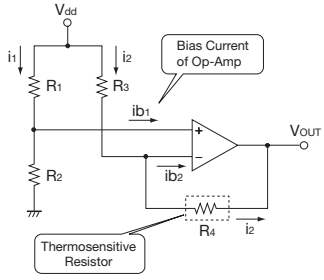
Parameters	Test Condition	ALPHA Specification	ALPHA Typical Test Data
Working Temperature Range **Max. Rated Operating Temp.** **Maximum Working Voltage**		–25°C to +125°C 70°C NMP: 50V; NMQ: 100V NLA, CLA: 250V; NLB, CLB, KLC: 300V	
Temperature Cycling **Overload**	–25°C/30 min., Room Temperature/5 min., +125°C/30 min., 5 cycles Rated Voltage x 2.5, 5 sec.	±0.2% ±0.2%	±0.03% ±0.03%
Solderability **Resistance to Solvents**	235°C, 2 sec. ❶ Isopropyl Alcohol ❷ Trichloroethylene	over 75% coverage no damage	
Low Temperature Storage **Terminal Strength**	–25°C, No Load, 2 hrs. 0.908 kg (2 pounds),10 sec.	±0.2% ±0.2%	±0.03% ±0.03%
Dielectric Withstanding Voltage **Insulation Resistance** **Resistance to Soldering Heat** **Moisture Resistance**	Atmospheric: AC 300V, 1 min. DC 100V, 1 min. 350°C, 3 sec. +65°C to –10°C, 90% RH to 98% RH, Rated Voltage, 10 cycles (240 hrs.)	±0.2% over 10,000 MΩ ±0.2% ±0.5%	±0.03% over 10,000 MΩ ±0.01% ±0.02%
Shock **Vibration**	50G, 11 ms, Half-Sine Wave, X, Y, Z, each 3 shocks 20G, 10 Hz to 55 Hz to 10 Hz, 1 min., X, Y, Z, each 2 hrs.	±0.2% ±0.2%	±0.03% ±0.03%
Life (Rated Load)	70°C, Rated Power, 1.5 hr. – ON, 0.5 hr. – OFF, 1,000 hrs.	±0.5%	±0.03%
Life (Moisture Load)	40°C, 90% RH to 95% RH, Rated Power, 1.5 hr. – ON, 0.5 hr. – OFF, 1,000 hrs.	±0.5%	±0.03%
Storage Life	15°C to 35°C, 15% RH to 75% RH, No Load, 10,000 hrs.	±0.5%	±0.05%
High Temperature Exposure	125°C, No Load, 1,000 hrs.	±1.0 %	±0.1 %

APPLICATIONS OF THERMOSENSITIVE RESISTORS

Example: Cold-junction compensation for temperature measurement using thermocouple



Example: Temperature-sensing circuit



As shown in:

$$V_{OUT} = \left(\frac{R_2}{R_1+R_2} - \frac{R_1}{R_1+R_2} \times \frac{R_4}{R_3}\right) \times V_{dd}$$

Op-Amp output (V_{out}) becomes zero when R_1/R_2 and R_3/R_4 are balanced. So, output voltage ΔV_{out} is $\pm i_2$ x ΔR_4 when R_4 is changed to ΔR_4 from balanced point, $i_1=i_2$ and offset voltage is zero. The formula is as follows:

$$V_{OUT} = -\left(\frac{R_1}{R_1+R_2} \times \frac{1}{R_3}\right) \times \Delta R_4 \times V_{dd}$$

PRECAUTION IN USING NMP AND NMQ RESISTORS

1. Storage

Storage condition or environment may adversely affect solderability of the exterior terminals. Do not store in high temperature and humidity. The recommended storage environment is lower than 40°C, has less than 70% RH humidity and is free from harmful gases such as sulphur and chlorine.

2. Caution in Soldering

❶ Hand Soldering

Hand soldering is applicable as shown at right.

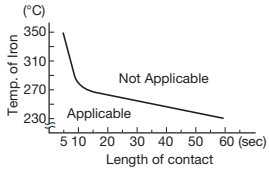
Recommended
- Temperature of Iron Tip: 240°C to 270°C
- Power of Iron: 20W or less
- Diameter of Tip: Dia. 3 mm max.

❷ Solder Reflow in Furnace

Recommended
- Peak Temperature: 250+0/-5°C
- Holding time: 10 sec. max.

❸ Dipping in Solder (Wave or Still)

Recommended
- Temp. of Solder: 260°C max.
- Length of Dipping: 10 sec. max.
- To cool gradually at room temperature



❹ Other

Corrosion-free flux, such as rosin, is recommended.

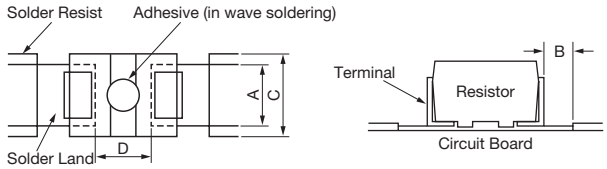
Do not apply pressure to the molded housing immediately after soldering.

3. Cleaning

Use volatile cleaner such as methylalcohol or propylalcohol.

4. Circuit Board Design

The dimensions of solder land must be determined in conformity with the size of resistors and with the soldering method. They are also subject to the mounting machine and the material of the substrate. See example below.



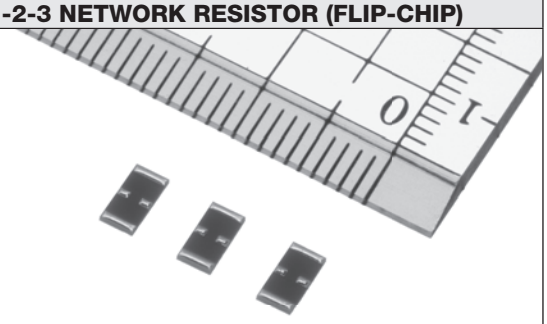
Type	A	B	C	D
NMP	1.6 to 2.0	0.5 to 1.5	2.2 to 2.6	1.8
NMQ				2.5

Dimensions in mm

When parts are mounted on a board in high density, solder can possibly attach to the resistors in an excessive amount to affect performance or reliability of the resistors. To prevent this effect, the use of solder resist is recommended to isolate solder lands.

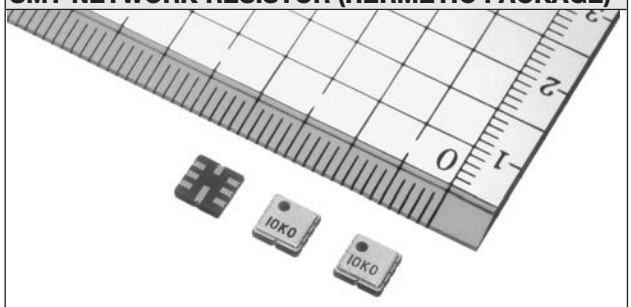
Products for Ultra Precision Resistors and Temperature Sensors

SMT 1-2-3 NETWORK RESISTOR (FLIP-CHIP)



- 5.0 mm x 2.5 mm
- Flip-chip constriction offers saving space
- Excellent cost performance

SMT NETWORK RESISTOR (HERMETIC PACKAGE)



- 5 mm x 5 mm
- Excellent long-term stability
- Excellent moisture resistance
- Excellent TCR

ULTRA PRECISION HIGH POWER SHUNT RESISTOR

- Parallel connected PSB for handling high power current
- Available tight tolerance and lower resistance value than single PSB

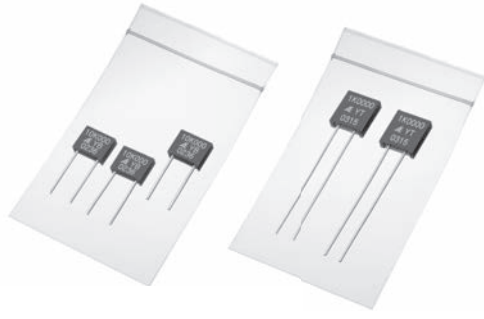
AC COAXIAL SHUNT RESISTOR

- Coaxial construction for AC
- Current terminal designed for excellent heat dissipation

PT TEMPERATURE SENSORS

- Pt temperature sensor utilizing Pt Metal Foil® technology
- Available variety of packages and lead connections

MATCHED RESISTOR SETS



- 0.005% matching tolerance available
- 0.5 ppm/°C tracking TCR available

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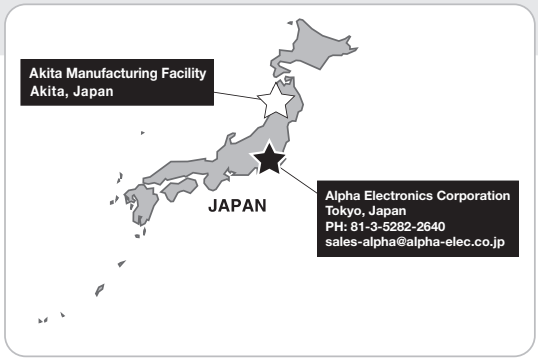
A VPG Brand

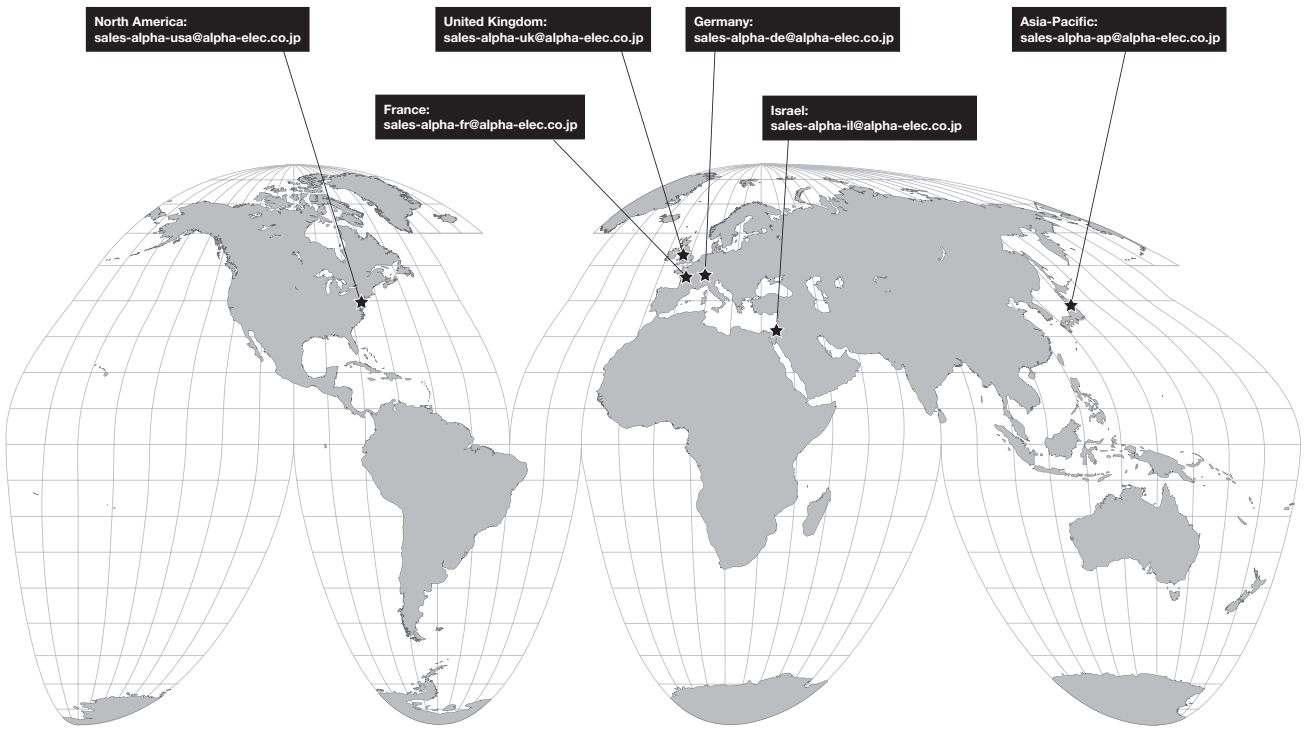
Product and Contact Information

PRODUCT LISTING

Bulk Metal® Foil Ultra Precision Resistors
Precision Thin Film Resistors
Thermosensitive Resistors
Standard Resistors

CONTACT US





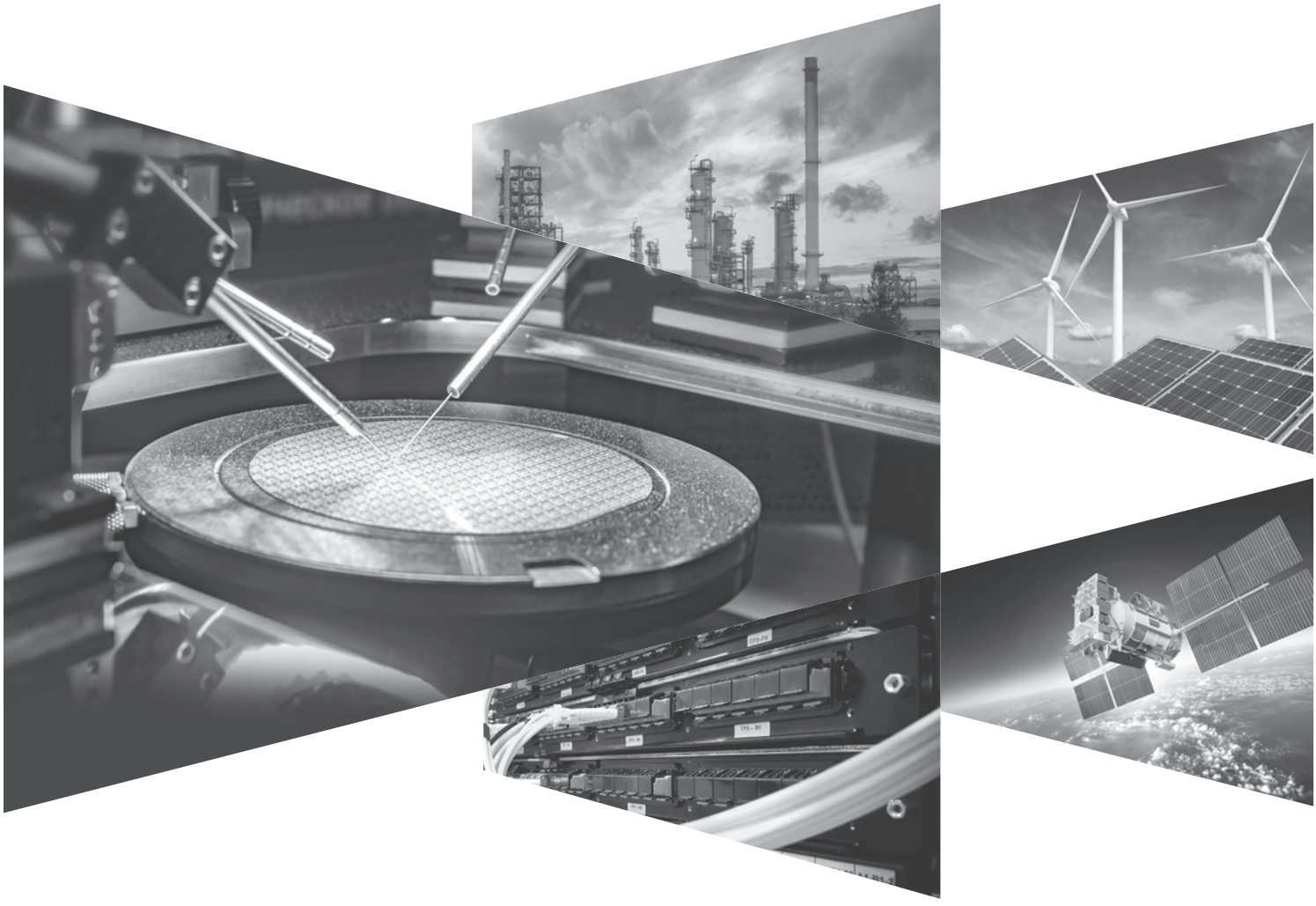
VPG Foil Resistors

VFR · ALPHA ELEC. · POWERTRON · APR

Consistent Precision & Reliability

Precision and reliability are the **heart and soul** of VPG Foil Resistors. For decades we have been known to produce supreme quality products complying with the strictest global standards worldwide. As market demands, we've extended our product line with APR – our new brand for standardized products.

Providing you with the widest selection of highly precise and reliable foil resistors from made-to-order to standardized, that meet any required qualifications.



AAA

VFR RESISTORS
A VPG Brand

AA

Alpha Electronics
A VPG Brand

AA

POWERTRON
A VPG Brand

+A

APR
A VPG Brand

VPG Foil Resistors consists of four brands

VFR – Bulk Metal® Foil

Foil precision resistors produces AAA-class resistors made-to-order, offering high standing reliability and best long-term stability, meeting the EEE /QPL standards.

Key Features

Temperature coefficient of resistance (TCR):
± 0.2 ppm/°C - typical

Resistance Range: 1 mΩ-1.84 MΩ

Resistance tolerance: to ±0.005%

Power Rating: to 10 W

Load Life Stability under Rated Power: to ±0.0025% -typical

EEE / QPL

Alpha Electronics

provides AA class foil resistors, high precision programmable certified resistance decade boxes, primary & secondary standard resistors. Custom designs for thin film resistors and RTD simulators complying with MIL standard.

Key Features

Temperature coefficient of resistance (TCR):
±0.2 ppm/°C - typical

Resistance Range: 1 mΩ-10 MΩ

Resistance tolerance: to ±0.01%

Power Rating: to 500 W

Load Life Stability under Rated Power: to ±0.005% -typical

MIL Standard

Powertron

provides AA class high precision power current sense foil resistors in lower resistance and custom design for thick film power resistors complying with MIL standards.

Key Features

Temperature coefficient of resistance (TCR):
±25 ppm/°C - typical

Resistance Range: 20 mΩ-10 TΩ

Resistance tolerance: to ±0.05%

Power Rating: to 900 W

Load Life Stability under Rated Power: to ±0.5%

MIL Standard

APR

provides off the shelf A+ class standard surface mount resistors packaged in tape & reel and power current-sense resistors with resistance values based on E24 & E96 codes complying with the AEC-Q200 standardization.

Key Features

Temperature coefficient of resistance (TCR):
±2 ppm/°C - typical

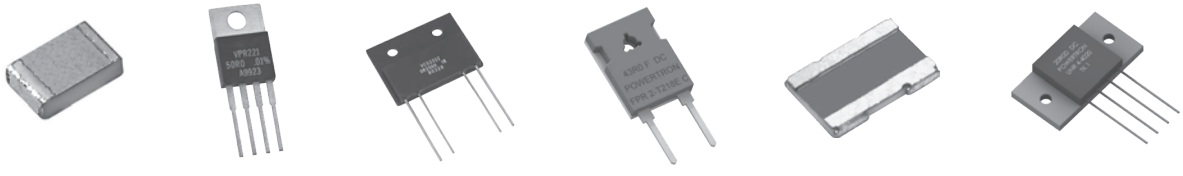
Resistance Range: 0.3 mΩ-1 TΩ

Resistance tolerance: to ±0.005%

Power Rating: to 20 W

Load Life Stability under Rated Power: to ±0.005% -typical

AEC-Q200

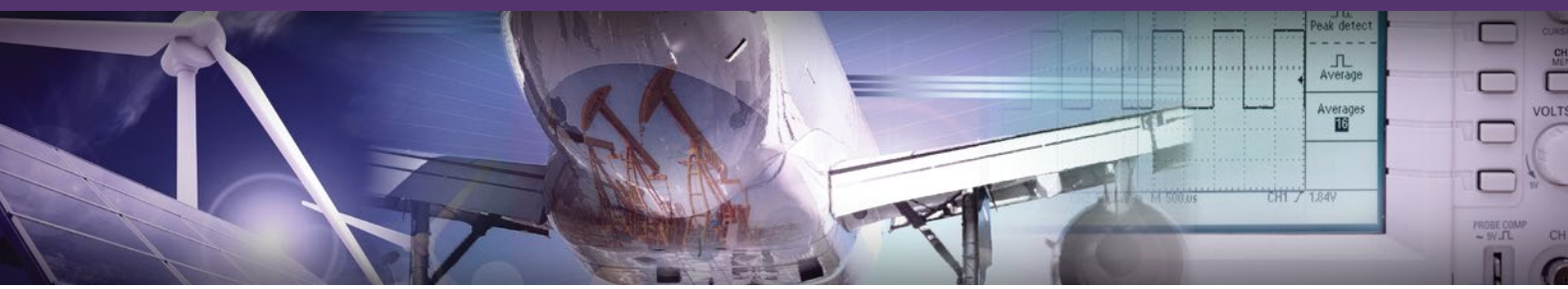


VPG Foil Resistors
VFR • ALPHA ELEC. • POWERTRON • APR

Contact us at foil@vpgsensors.com | vpgfoilresistors.com

9655-EN_Dec23

Alpha Electronics | Part of VPG Foil Resistors



Contact

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