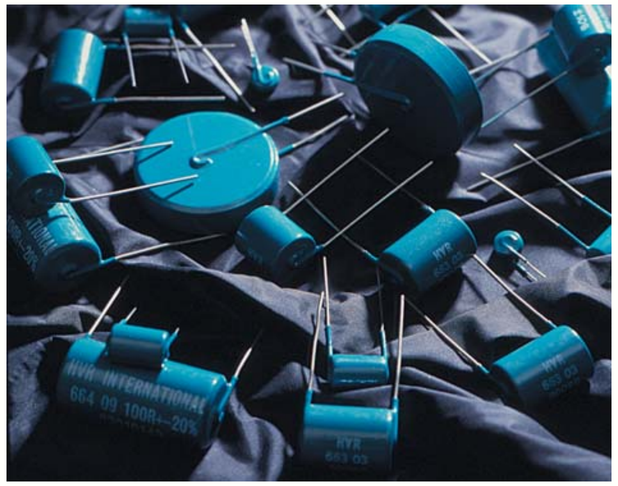
Technical Specifications

THERMAL PARAMETERS

Heat generated by H.V. Resistors for Compact Circuitry is dissipated mainly by radiation and convection from the exposed surface areas. Within restricted domains, mathematical models may be employed to permit heat transfer estimations.

Symbols

ΔT = Temperature Rise (°C)
W_a = Watts / Unit Exposed Surface Area (W.cm^{-2})
v = Volume of Active Material (cm^3)
c_m = Specific Heat Capacity of Active Material = 2J. cm^{-3}.°C^{-1}
Do = Overall Diameter (mm)
τ = Resistor Thermal Time Constant (s)



Radiation and Convection	$W_a = 0.00026(\Delta T)^{1.4}$ (ΔT = 50°C to 175°C, Do = 10 mm to 151 mm, Ambient 25°C)
Thermal Conductivity	0.04 W / cm^2.°C / cm
Maximum Insertion Energy Ratings	For a Resistor initially at 25°C : 350 Joules / cm^3 (Infrequently) For a Resistor initially at 25°C : 250 Joules / cm^3 (Continuously)
Recommended Operating Temperatures	200 °C (Infrequent Operation) 150 °C (Continuous Operation)
Temperature Rise from Energy Injection	ΔT (°C) = Joules (per Resistor) / (v x c_m) (Free Air)
Thermal Time Constant	τ (s) = Max Joules @ 25°C / Max Watts @ 25°C
Full Cooling	$\geq 4\tau$

De-rating for other ambient Temperatures (Ta°C) Multiply Max Joules @ 25°C & Max Watts @ 25°C by the ratio (150 - Ta) / 125

Repetitive Thermal Impulsing:
Assuming that the Heat Transfer Coefficient α (W / cm^2.°C / cm) is constant over the operating temperature range, then the Peak Temperature Rise (ΔTp) associated with repetitive impulsing can be estimated by way of reference to a classical geometric progression ...

$$\Delta Tp\ (°C) = \Delta T \times (1 - (e^{-(t/\tau)})^n) \div (1 - e^{-(t/\tau)}) \quad ....1$$

where:
ΔT is the Temperature Rise associated with each electrical impulse (°C)
τ is the Resistor Thermal Time Constant (s)
t is the Repetition Rate (s)
n is the number of impulses

If the number of impulses (n) $\rightarrow \infty$ (ie continuous duty), then equation 1 can be simplified thus ...

$$\Delta Tp\ (°C) = \Delta T \div (1 - e^{-(t/\tau)}) \quad .... 2$$

Custom Variants

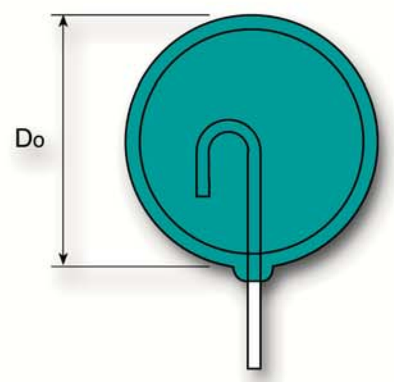
No additonal charges are made for creating specific length versions or specific Resistance Value versions of the above types. Similarly, crimped lead versions (fixed stand off height) and double leaded versions (greater stability) are available as standard.

Similarly, Stud (male) and Ferrule (female) metric (M4 - M8) threaded termination variants (mechanical mounting) are available at extra charge.

H.V. Resistors for Compact Circuitry

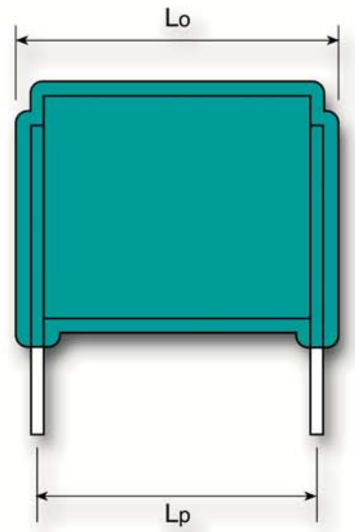
- **100% Active Material**
- **High Surge Energy Rating**
- **High Voltage Withstand**
- **Essentially Non-Inductive**
- **Wide Resistivity Range**
- **Wide Range of Geometries**
- **Custom Solutions Readily Available**
- **Suitable for PCB Assembly**
- **Free Design Service**

HVR's range of High Voltage Resistors for Compact Circuitry are manufactured from a carefully selected mixture of clays, alumina and carbon. After blending, the material is pressed to the required shape and then fired, in a controlled atmosphere, at high temperature.



This sintering process produces a Ceramic Carbon Resistor which is 100% active material and therefore of minimum size. The H.V. Resistors for Compact Circuitry range feature radial lead terminations and a high quality epoxy resin coating to improve both dielectric withstand and mechanical robustness.

Inherently non-inductive and capable of withstanding transient high voltage impulses, this range is ideally suited to charging, discharge, snubber, voltage divider and overvoltage protection applications. These typical applications feature within high voltage power supplies, lasers, radar, medical and military equipment.



Technical Specifications

RESISTOR TYPE	ACTIVE MATERIAL DIMENSION CODE	OVERALL DIMENSIONS Do MAXIMUM	Lo MAXIMUM	Lp PITCH	VOLUME OF ACTIVE MATERIAL (v)	MAXIMUM JOULES @ 25°C	MAXIMUM WATTS @ 25°C	THERMAL TIME CONSTANT (τ)	WEIGHT	A / L	RESISTANCE RANGE MINIMUM	MAXIMUM	MAXIMUM WORKING VOLTAGE ($V_{Working}$) (1/10 μs IMPULSE)	MAXIMUM WORKING VOLTAGE ($V_{Working}$) (1.2/50 μs IMPULSE)	MAXIMUM WORKING VOLTAGE ($V_{Working}$) (10/1000 μs IMPULSE)	MAXIMUM WORKING VOLTAGE ($V_{Working}$) (500/5000 μs IMPULSE)
Units		(mm)	(mm)	(mm)	(cm^3)	(J)	(W)	(Seconds)	(g)	(cm)	(Ohms)	(Ohms)	(kV)	(kV)	(kV)	(kV)
AB 912	1104	13	9	4.5 - 6.0	0.4	100	1.00	100	2.0	2.4	1R2	8K2	1.84R x (-1 + √ (1 + 5.0 / R))	0.37R x (-1 + √ (1 + 25 / R))	0.0184R x (-1+ √ (1+ 501 / R))	0.0037R x (-1+ √ (1+ 2504 / R))
AB 903	1107	13	12	7.5 - 9.0	0.7	175	1.25	140	2.5	1.4	2R2	15K0	1.84R x (-1 + √ (1 + 8.8 / R))	0.37R x (-1 + √ (1 + 44 / R))	0.0184R x (-1+ √ (1+ 877 / R))	0.0037R x (-1+ √ (1+ 4383 / R))
AB 017	1111	13	16	11.5 - 13.0	1.0	250	1.50	165	3.5	0.9	3R3	22K0	1.84R x (-1 + √ (1 + 13.8 / R))	0.37R x (-1 + √ (1 + 69 / R))	0.0184R x (-1+ √ (1+ 1377 / R))	0.0037R x (-1+ √ (1+ 6887 / R))
AB 892	1114	13	19	14.5 - 16.0	1.3	325	1.75	185	4.0	0.7	4R7	27K0	1.84R x (-1 + √ (1 + 17.5 / R))	0.37R x (-1 + √ (1 + 88 / R))	0.0184R x (-1+ √ (1+ 1753 / R))	0.0037R x (-1+ √ (1+ 8765 / R))
AJ 149	1117	13	22	17.5 - 19.0	1.6	400	2.00	200	5.0	0.6	5R6	33K0	1.84R x (-1 + √ (1 + 21.3 / R))	0.37R x (-1 + √ (1 + 106 / R))	0.0184R x (-1+ √ (1+ 2128 / R))	0.0037R x (-1+ √ (1+ 10644 / R))
AB 986	1414	16	19	14.5 - 16.0	2.2	550	2.25	245	6.5	1.1	2R7	18K0	2.99R x (-1 + √ (1 + 10.8 / R))	0.60R x (-1 + √ (1 + 54 / R))	0.0299R x (-1+ √ (1+ 1082 / R))	0.0060R x (-1+ √ (1+ 5411 / R))
AB 993	1417	16	22	17.5 - 19.0	2.6	650	2.50	260	7.0	0.9	3R3	22K0	2.99R x (-1 + √ (1 + 13.1 / R))	0.60R x (-1 + √ (1 + 66 / R))	0.0299R x (-1+ √ (1+ 1314 / R))	0.0060R x (-1+ √ (1+ 6571 / R))
AB 058	1911	21	16	11.5 - 13.0	3.1	775	2.75	280	9.0	2.6	1R2	8K2	5.50R x (-1 + √ (1 + 4.6 / R))	1.10R x (-1 + √ (1 + 23 / R))	0.0550R x (-1+ √ (1+ 462 / R))	0.0110R x (-1+ √ (1+ 2308 / R))
AB 840	1915	21	20	15.5 - 17.0	4.3	1075	3.25	330	11.5	1.9	1R5	10K0	5.50R x (-1 + √ (1 + 6.3 / R))	1.10R x (-1 + √ (1 + 31 / R))	0.0550R x (-1+ √ (1+ 630 / R))	0.0110R x (-1+ √ (1+ 3148 / R))
AB 893	1917	21	22	17.5 - 19.0	4.8	1200	3.50	345	13.0	1.7	1R8	12K0	5.50R x (-1 + √ (1 + 7.1 / R))	1.10R x (-1 + √ (1 + 36 / R))	0.0550R x (-1+ √ (1+ 714 / R))	0.0110R x (-1+ √ (1+ 3568 / R))
AB 620	1920	21	25	20.5 - 22.0	5.7	1425	4.00	355	15.0	1.4	2R2	15K0	5.50R x (-1 + √ (1 + 8.4 / R))	1.10R x (-1 + √ (1 + 42 / R))	0.0550R x (-1+ √ (1+ 839 / R))	0.0110R x (-1+ √ (1+ 4197 / R))
AB 663	1927	21	32	27.5 - 29.0	7.7	1925	4.75	405	20.0	1.1	2R7	18K0	5.39R x (-1 + √ (1 + 11.3 / R))	1.08R x (-1 + √ (1 + 57 / R))	0.0539R x (-1+ √ (1+ 1133 / R))	0.0108R x (-1+ √ (1+ 5666 / R))
AB 880	2410	26	15	10.5 - 12.0	4.5	1125	3.75	300	12.5	4.5	0R68	4K7	8.78R x (-1 + √ (1 + 2.6 / R))	1.76R x (-1 + √ (1 + 13 / R))	0.0878R x (-1+ √ (1+ 263 / R))	0.0176R x (-1+ √ (1+ 1315 / R))
AB 885	2415	26	20	15.5 - 17.0	6.8	1700	4.50	380	17.5	3.0	1R0	6K8	8.78R x (-1 + √ (1 + 3.9 / R))	1.76R x (-1 + √ (1 + 20 / R))	0.0878R x (-1+ √ (1+ 395 / R))	0.0176R x (-1+ √ (1+ 1973 / R))
AB 881	2420	26	25	20.5 - 22.0	9.0	2250	5.25	430	22.5	2.3	1R5	8K2	8.78R x (-1 + √ (1 + 5.3 / R))	1.76R x (-1 + √ (1 + 26 / R))	0.0878R x (-1+ √ (1+ 526 / R))	0.0176R x (-1+ √ (1+ 2630 / R))
AB 662	2425	26	30	25.5 - 27.0	11.3	2825	6.00	470	28.0	1.8	1R8	12K0	8.78R x (-1 + √ (1 + 6.6 / R))	1.76R x (-1 + √ (1 + 33 / R))	0.0878R x (-1+ √ (1+ 658 / R))	0.0176R x (-1+ √ (1+ 3288 / R))
AB 241	2435	26	40	35.5 - 37.0	15.8	3950	7.75	510	38.0	1.3	2R2	15K0	7.90R x (-1 + √ (1 + 9.2 / R))	1.58R x (-1 + √ (1 + 46 / R))	0.0790R x (-1+ √ (1+ 921 / R))	0.0158R x (-1+ √ (1+ 4603 / R))
AB 664	2450	26	55	50.5 - 52.0	22.6	5650	10.00	565	54.0	0.9	3R3	22K0	6.59R x (-1 + √ (1 + 13.2 / R))	1.32R x (-1 + √ (1 + 66 / R))	0.0659R x (-1+ √ (1+ 1315 / R))	0.0132R x (-1+ √ (1+ 6576 / R))
AB 252	3115	33	20	15.5 - 17.0	11.3	2825	6.50	435	28.0	5.0	0R56	3K9	14.65R x (-1 + √ (1 + 2.4 / R))	2.93R x (-1 + √ (1 + 12 / R))	0.1465R x (-1+ √ (1+ 236 / R))	0.0293R x (-1+ √ (1+ 1182 / R))
AB 857	3127	33	32	27.5 - 29.0	20.4	5100	9.00	565	48.5	2.8	1R0	6K8	14.36R x (-1 + √ (1 + 4.3 / R))	2.87R x (-1 + √ (1 + 21 / R))	0.1436R x (-1+ √ (1+ 426 / R))	0.0287R x (-1+ √ (1+ 2128 / R))
AB 185	3135	33	40	35.5 - 37.0	26.4	6600	10.50	630	62.5	2.2	1R5	10K0	13.19R x (-1 + √ (1 + 5.5 / R))	2.64R x (-1 + √ (1 + 28 / R))	0.1319R x (-1+ √ (1+ 552 / R))	0.0264R x (-1+ √ (1+ 2759 / R))
AB 186	3150	33	55	50.5 - 52.0	37.7	9425	13.75	685	88.0	1.5	2R2	15K0	10.99R x (-1 + √ (1 + 7.9 / R))	2.20R x (-1 + √ (1 + 39 / R))	0.1099R x (-1+ √ (1+ 788 / R))	0.0220R x (-1+ √ (1+ 3942 / R))

PHYSICAL / MECHANICAL PARAMETERS

Explanation of Dimension Code

Each Resistor type is assigned a 4 digit code, the first 2 digits give the nominal Active Diameter (D) in mm and the last 2 digits give the nominal Active Length (L) of the Resistor in mm. From this information the Volume of Active Material (v) may be determined.

Construction

The Tinned Copper lead terminations are attached to the Copper metallised contact on the Resistor body opposing flat surfaces, with high melting point solder. This permits reliable short time operation at temperatures up to 200°C.

Coating

The coating consists of a high quality epoxy resin applied by fluidised bed technique. The coating finish is hard, smooth and has good appearance to harmonise with other electronic components.

The Resistor leads may be preformed to fit Printed Circuit Boards (PCB's) provided certain precautions are observed. During preforming, the Resistor ends should be grasped between thumb and forefinger. Examine the wire at the Resistor body junction to ensure the coating is not cracked.

If this range of Resistors experience surface temperatures regularly in excess of 150°C, the coating will tend to degrade slightly, becoming 'coffee coloured'. Though unsightly, performance is not compromised.

Whilst the coating can reduce the rate of moisture ingress, it is not impervious to liquids.

Terminations / Soldering

The Tinned Copper wire lead terminations are 0.9mm in Diameter (AB 912 - AB 993) and 1.1mm in Diameter (AB 058 - AB 186) and require, as a minimum, PCB mounting holes of 1.2 mm and 1.5 mm Diameter respectively.

Soldering is permissible with mildly activated fluxed solders with liquidous properties less than 230°C.

Coefficient of Linear Expansion

In the range $+4 \times 10^{-6}$ to $+10 \times 10^{-6}$ per °C depending on material Resistivity.

ELECTRICAL PARAMETERS

Resistance Values

Whilst E24 values are preferred, other values are readily available at no additional cost.

Resistance Tolerance

+/- 20%, +/- 10% and +/- 5% available as standard.

Resistivity Range - ρ

3 Ohm cm to 20000 Ohm cm $\rho = R \times A/L$ where R = Resistance Value

Temperature Coefficient - TCR

-0.05% to -0.15% per °C Temperature Rise depending on Resistivity Value.

$TCR = 0.16 \times e^{-(\log\rho/1.4)} - 0.135$ (%/°C Temperature Rise)

Voltage Coefficient - VCR

-0.5% to -7.5% / kV / cm

$VCR = -0.62 \times \rho^{0.22}$ (%/kV/cm)   For ρ domain 10 to 7500 Ohm cm

Inductance

This is negligible (nH) and the Resistors may be described as non-inductive. In practice the inductance of connecting leads will be greater than that of the Resistors.

Maximum Working Voltages

The Maximum Working Voltage levels ($V_{working}$) can be derived from the appropriate formulae illustrated in the table above. Waveforms are defined in the usual manner: 1.2/50μs indicates a rise time to peak value in 1.2μs and an exponential decay to half amplitude in a total time of 50μs.

Worked example : Consider an AB 664 Resistor with a Resistance Value of 1K0 and waveform of 10/1000μs.

$V_{working} = 0.0659\ R \times (-1 + \sqrt{(1 + 1315 / R)}) = 34.36$ kV   (Say 34kV)

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