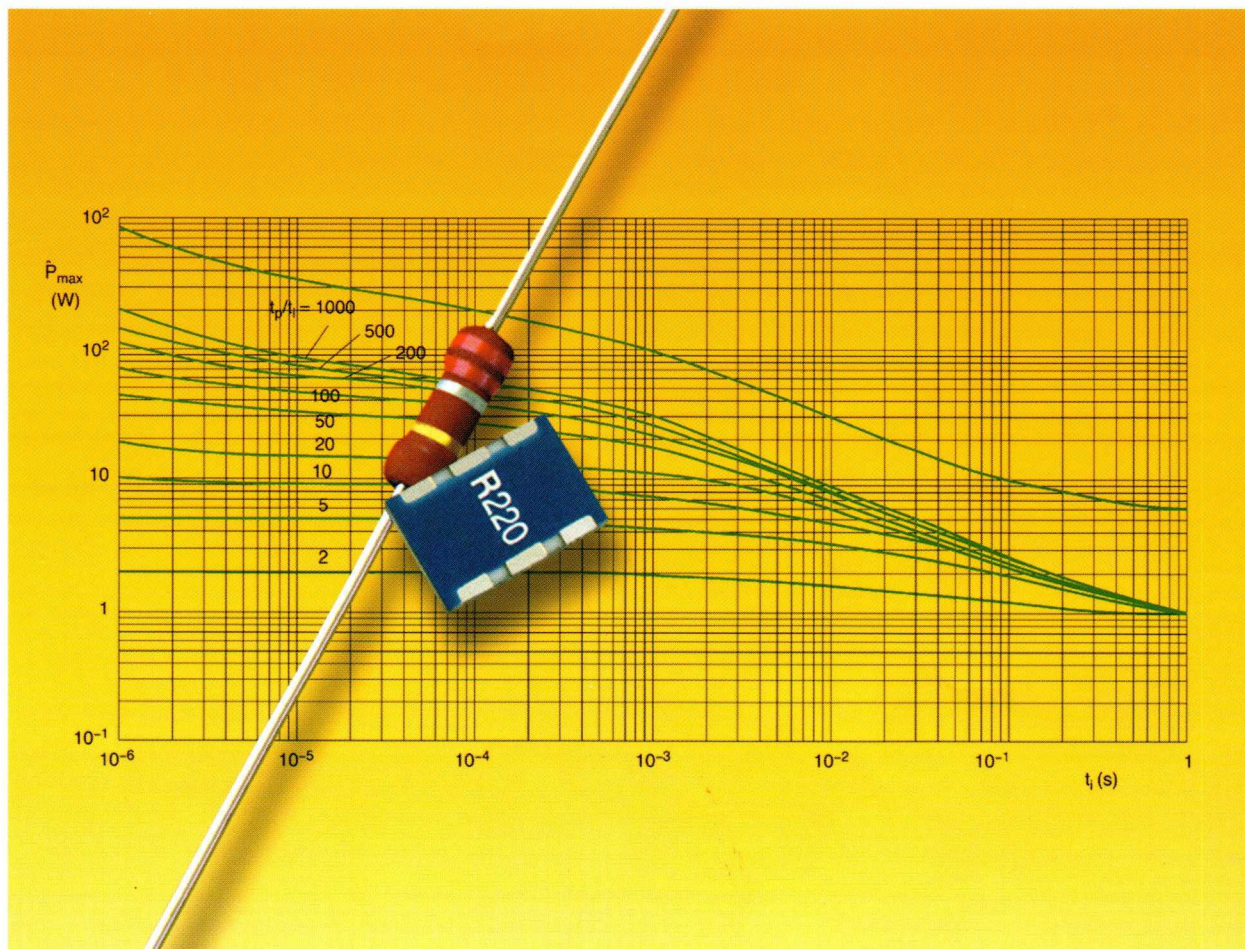




1997

Data Handbook PA08

Welcome to the European edition of Philips Components' Fixed Resistor Data Handbook. The wide range of our fixed resistor programme covers all resistor technologies and reflects our strong commitment to this important area of the passive-component market.

QUALITY ASSURED

Although the initial cost of resistors is generally low, the large numbers used in a typical circuit means that their reliability is of ultimate importance. Component reliability is, therefore, our prime consideration and quality our main commitment. A commitment which extends into all aspects of our business from the design and manufacturing process, to the supply and service we offer to customers. Our resistor facility in Roermond - The Netherlands is an ISO 9001 certified supplier which is supported by means of statistical process control (SPC) procedures at all key points in the production process.

CUSTOMER SERVICE

Philips Components has a network of sales organizations that communicate directly with the regional Business Centre for fixed resistors. Short communication lines mean fast response to all customer enquiries and rapid problem solving.

ADVANCED RESISTOR TECHNOLOGIES

Our fixed resistors are made using thick, thin and metal-film technologies. And, responding to market trends for miniaturization and high-accuracy, we have a strong programme of surface-mount devices and application specific resistors. The range is divided into three categories:

- **Surface-mount resistors.** These are truly miniature devices and are ideal for applications where space and weight are limited. Available in tolerances down to 0.1%, they meet the most demanding industrial standards.
- **Film resistors.** For all general purpose consumer and industrial equipment. They are subdivided into carbon and metal-film resistors, and fusible metal-film resistors. We also have a range of 1% tolerance metal-film resistors for professional equipment.
- **Application specific resistors.** For applications demanding the ultimate in accuracy or operation in extreme environments. These hi-rel types include leaded and surface-mount devices for precision, low-ohmic, high-ohmic, high voltage and power applications.

We hope you'll find this Data Handbook useful and easy to use. If you can't find the resistor you want, need more information or require a special selection, please call your nearest sales office. You'll find their address on the back cover of this book.

Fixed Resistors

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DEFINITIONS

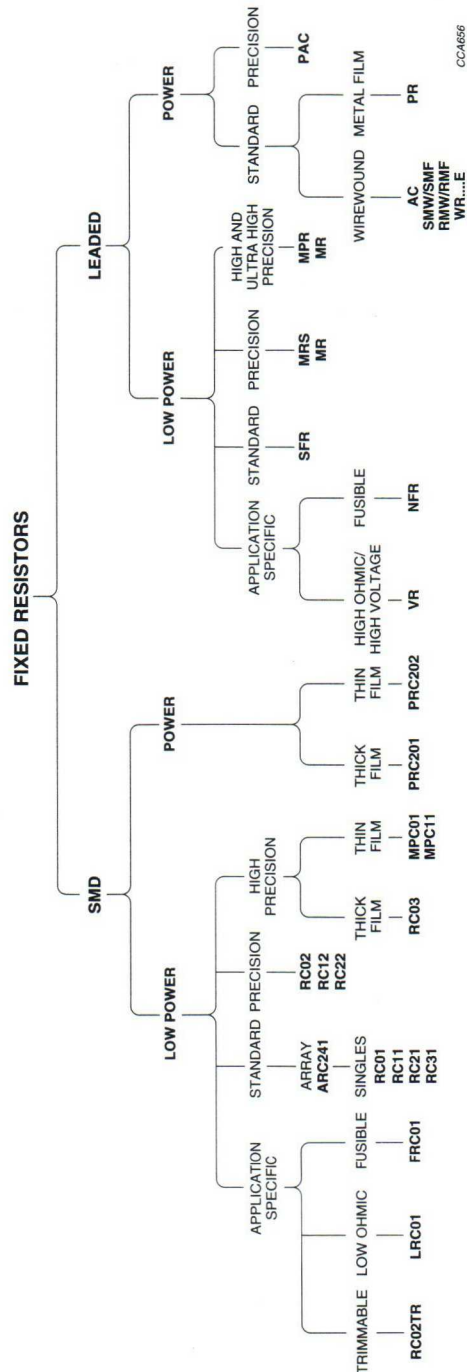
Data sheet status	
Objective specification	This data sheet contains target or goal specifications for product development.
Preliminary specification	This data sheet contains preliminary data; supplementary data may be published later.
Product specification	This data sheet contains final product specifications.
Application information	
Where application information is given, it is advisory and does not form part of the specification.	

LIFE SUPPORT APPLICATIONS

These products are not designed for use in life support appliances, devices, or systems where malfunction of these products can reasonably be expected to result in personal injury. Philips customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify Philips for any damages resulting from such improper use or sale.

Fixed Resistors

Resistor Programme



CCA656

SMD CHIP RESISTORS

Chip resistors

Selection guide

APPLICATION	TYPE	SIZE CODE	TOL. (%)	RESISTANCE RANGE	TEMP. COEFF. ($\times 10^{-6}/K$)	MAX. (V/W)	SERIES	PAGE
Standard	RC01	1206	5 or 2	1 to 4.7 Ω 5.1 Ω to 10 M Ω	$\leq \pm 250$ $\leq \pm 200$	200/0.25	E24	34
	RC11	0805		1 Ω to 4.7 Ω 5.1 Ω to 10 M Ω	$\leq \pm 250$ $\leq \pm 200$	150/0.125		34
	RC21	0603		1 to 10 Ω 11 Ω to 910 k Ω 1 to 6.8 M Ω	$-200/+500$ ± 200 ± 300	50/0.063		34
	RC31	0402		10 Ω to 1 M Ω	$\leq \pm 200$	50/0.063		34
	ARC241	4 $\times$ 0603		10 Ω to 1 M Ω	$\leq \pm 200$	50/0.062		45
Precision TC100	RC02H	1206	1	1 to 4.99 Ω 5.1 to 9.76 Ω 10 Ω to 1 M Ω 1.02 to 10 M Ω	$\leq \pm 250$ $\leq \pm 200$ $\leq \pm 100$ $\leq \pm 200$	200/0.25	E24/96	50
	RC12H	0805		1 to 4.99 Ω 5.1 to 9.76 Ω 10 Ω to 1 M Ω 1 to 10 M Ω	$\leq \pm 250$ $\leq \pm 200$ $\leq \pm 100$ $\leq \pm 200$	150/0.125		50
	RC22H	0603		1 to 4.99 Ω 5.1 to 9.76 Ω 10 Ω to 1 M Ω	$\leq \pm 250$ $\leq \pm 200$ $\leq \pm 100$	50/0.063		50
Precision TC50	RC02G	1206	1	100 Ω to 1 M Ω	$\leq \pm 50$	200/0.25		50
	RC12G	0805		100 Ω to 1 M Ω	$\leq \pm 50$	150/0.125		50
High precision	RC03G	1206	0.5	100 to 249 Ω 255 Ω to 1 M Ω	$\leq \pm 100$ $\leq \pm 50$	200/0.125		61

Chip resistors

Selection guide

APPLICATION	TYPE	SIZE CODE	TOL. (%)	RESISTANCE RANGE	TEMP. COEFF. (× 10 ⁻⁶ /K)	MAX. (V/W)	SERIES	PAGE
Application specific	RC02TR trimmable	1206	+0/-20 or +0/-30	1 to 4.99 Ω 5.1 to 97.6 Ω 100 Ω to 1 MΩ	≤±250 ≤±200 ≤±100	200/0.25	E24	67
	LRC01 low-ohmic		5	0.05 to 0.075 Ω 0.082 to 0.091 Ω 0.1 to 0.147 Ω 0.15 to 0.392 Ω 0.4 to 0.91 Ω	≤±2000 ≤±1500 ≤±1000 ≤±700 ≤±250	0.25		72
	FRC01 fusible			1 to 250 Ω		≤±200		200/0.125
	PRC201 power	1218	5	0.020 to 0.033 Ω 0.033 to 0.060 Ω 0.060 to 0.1 Ω	≤±2000 ≤±1000 ≤±700	200/1		85
			5 or 1	0.1 to 0.2 Ω 0.2 to 1 Ω 1 to 10 Ω 10 Ω to 1 MΩ	≤±700 ≤±250 ≤±200 ≤±100			
Power	PRC202	1218	5 or 1	0.47 to 1 Ω 1 Ω to 100 kΩ	≤±200 ≤±50	200/1	E24	96
High precision	MPC01	1206	0.1	10 Ω to 100 kΩ	≤±25	100/0.125	all values	104
	MPC11	0805		14 Ω to 30 kΩ		100/0.1		104

Chip resistors

General Introduction

INTRODUCTION

Data in data sheets is presented - whenever possible - according to a 'format', in which the following chapters are stated:

- TITLE
- FEATURES
- APPLICATIONS
- DESCRIPTION
- QUICK REFERENCE DATA
- ORDERING INFORMATION
- FUNCTIONAL DESCRIPTION
 - Product characterization
 - Limiting values
- MECHANICAL DATA
 - Mass
 - Marking
 - Outlines
- TESTS AND REQUIREMENTS

The chapters listed above are explained in this section "General Introduction Chip resistors", with detailed information in the relevant data sheet. Chapters "Mounting" and "Packaging" are detailed in separate sections.

DESCRIPTION

All types of chip resistors have a rectangular ceramic body. The resistive element is a metal glaze film. The chips have been trimmed to the required ohmic resistance by cutting one or more grooves in the resistive layer. This process is completely computer controlled and yields a high reliability. The terminations are attached using either a silver dipping method or by applying nickel terminations which are covered with lead/tin.

The resistive layer is coated with a coloured protective layer. This protective layer provides electrical, mechanical and/or environmental protection - also against soldering flux and cleaning solvents, in accordance with "MIL-STD-202E", method 215 and "IEC 68-2-45".

ORDERING INFORMATION

Resistors are ordered by their **ordering code**, a 12-digit number. In general, the packaging method and resistance code are integral parts of this number.

Exceptions to this rule are customer/application specific resistors that are not included in our standard series, such as higher ohmic values and non-standard values.

FUNCTIONAL DESCRIPTION

The functional description includes: nominal resistance range and tolerance, limiting voltage, temperature coefficient, absolute maximum dissipation, climatic category and stability.

The **limiting voltage** (DC or RMS) is the maximum voltage that may be continuously applied to the resistor element, see "IEC publications 115-8".

The temperature rise in a resistor due to power dissipation, is determined by the laws of heat - conduction, convection and radiation. The maximum body temperature usually occurs in the middle of the resistor and is called the **hot-spot** temperature.

In the normal operating temperature range of chip resistors the temperature rise at the hot-spot, ΔT , is proportional to the power dissipated: $\Delta T = A \times P$. The proportionally constant 'A' gives the temperature rise per Watt of dissipated power and can be interpreted as a thermal resistance in K/W. This thermal resistance is dependent on the heat conductivity of the materials used (including the PCB), the way of mounting and the dimensions of the resistor. The sum of the temperature rise and the ambient temperature is:

$$T_m = T_{amb} + \Delta T$$

where:

T_m = hot-spot temperature

T_{amb} = ambient temperature

ΔT = temperature rise at hot-spot.

The stability of a chip resistor during endurance tests is mainly determined by the hot-spot temperature and the resistive materials used.

Summarizing

DESCRIPTION	RELATIONSHIP
Dimensions, conductance of materials and mounting determine	heat resistance
Heat resistance $\times$ dissipation gives	temperature rise
Temperature rise + ambient temperature give	hot-spot temperature

Chip resistors

General Introduction

Performance

When specifying the performance of a resistor, the dissipation is given as a function of the hot-spot temperature, with the ambient temperature as a parameter.

From $\Delta T = A \times P$ and $T_m = T_{amb} + \Delta T$ it follows that:

$$P = \frac{T_m - T_{amb}}{A}$$

If P is plotted against T_m for a constant value of A , parallel straight lines are obtained for different values of the ambient temperature. The slope of these lines,

$$\frac{dP}{dT_m} = \frac{1}{A}$$

is the reciprocal of the heat resistance and is the characteristic for the resistor and its environment.

The temperature coefficient

The temperature coefficient of resistance is a ratio which indicates the rate of increase (decrease) of resistance per Kelvin (K) increase (decrease) of temperature within a specified range, and is expressed in parts per million per K ($\times 10^{-6}/K$).

EXAMPLE

If the temperature coefficient of a resistor of $R_{nom} = 1 \text{ k}\Omega$ between -55°C and $+155^\circ\text{C}$ is $\pm 200 \times 10^{-6}/K$, its resistance will be,

at 25°C :

1000Ω (nominal = rated value)

at $+155^\circ\text{C}$:

$1000 \Omega \pm (130 \times 200 \times 10^{-6}) \times 1000 \Omega$
 $= 1026 \Omega$ or 974Ω

at -55°C :

$1000 \Omega \pm (80 \times 200 \times 10^{-6}) \times 1000 \Omega$
 $= 1016 \Omega$ or 984Ω

If the temperature coefficient is specified as $\leq 200 \times 10^{-6}/K$ the resistance will be within the shaded area as shown in Fig.1.

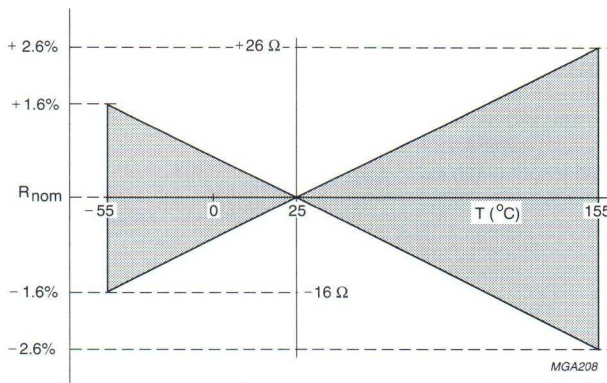


Fig.1 Temperature coefficient.

Chip resistors

General Introduction

Noise

Most resistors generate noise due to the passage of current through the resistor. This noise is dependent on the amount of current, the resistive material and the physical construction of the resistor. The physical construction is partly influenced by the laser trimming process which cuts a groove in the resistive material. Typical current noise levels are shown in Fig.2.

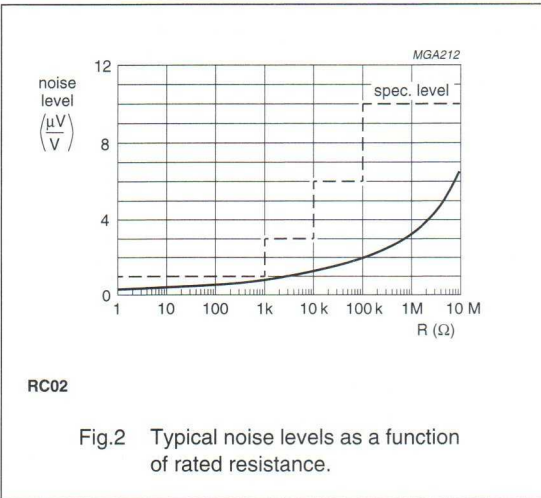


Fig.2 Typical noise levels as a function of rated resistance.

Frequency behaviour

Resistors in general are designed to function according to ohmic laws. This is basically true of rectangular chip resistors for frequencies up to 100 kHz. At higher frequencies, the capacitance of the terminations and the inductance of the resistive path length begin to have an effect.

Basically, chip resistors can be represented by an ideal resistor switched in series with a coil and both switched parallel to a capacitor. The values of the capacitance and inductance are mainly determined by the dimensions of the terminations and the conductive path length. The trimming pattern has a negligible influence on the inductance as the path length is not influenced. Also, its influence on the capacitance is negligible as the total capacitance is largely determined by the terminations.

The environment surrounding chips (e.g. landing paths, nearby tracks and the material of the printed-circuit board) has a large influence on the behaviour of the chip on the printed-circuit board.

Typical values of capacitance and inductance

QUANTITY	CHIP PROPERTIES			
	THIN FILM	THICK FILM		
	1206 R < 1 k Ω	1206	0805	0603
Capacitance	0.05 pF	0.05 pF	0.09 pF	0.05 pF
Inductance	2 nH	2 nH	1 nH	0.4 nH

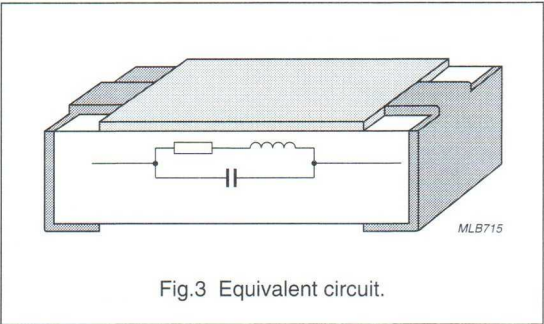
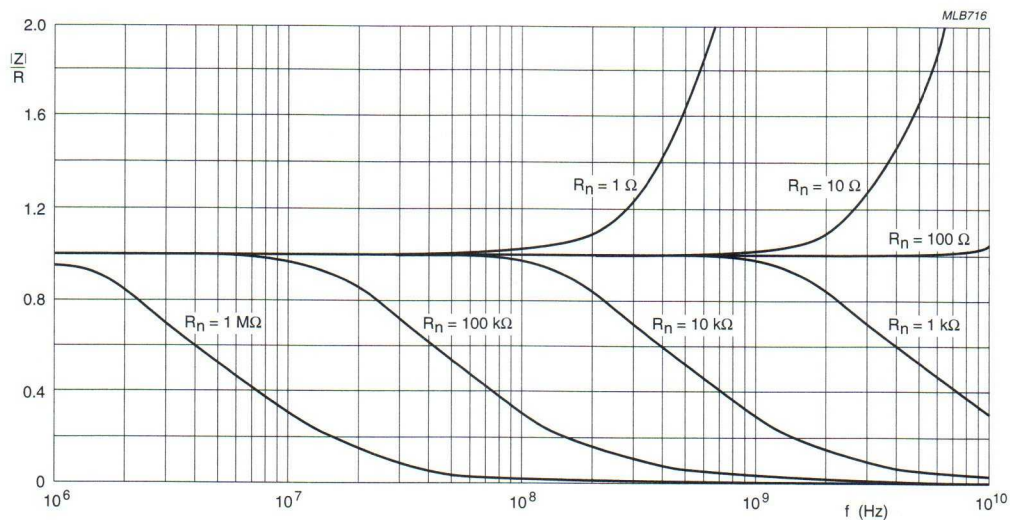


Fig.3 Equivalent circuit.

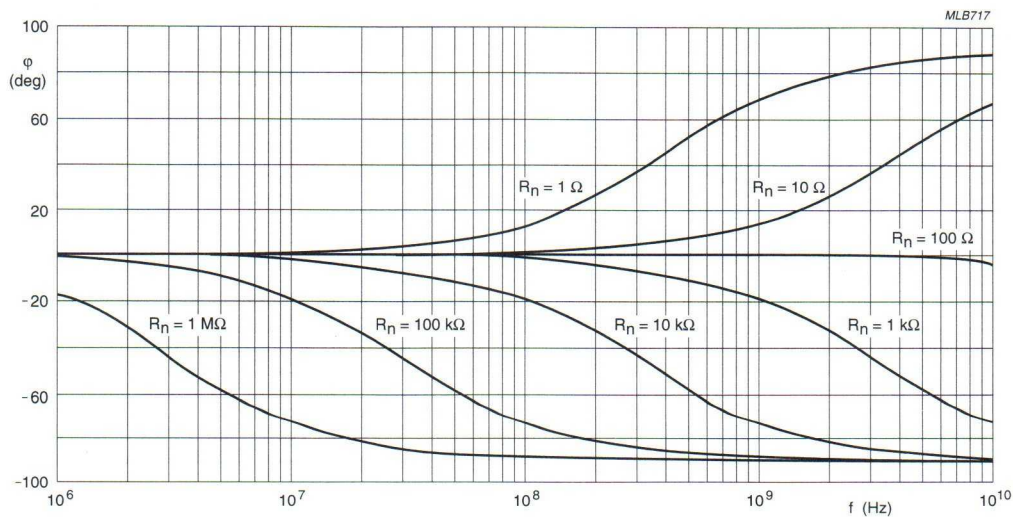
Chip resistors

General Introduction



Size 0603

Fig.4 Impedance as a function of frequency for a chip resistor.



Size 0603

Fig.5 Phase shift as a function of frequency for a chip resistor.

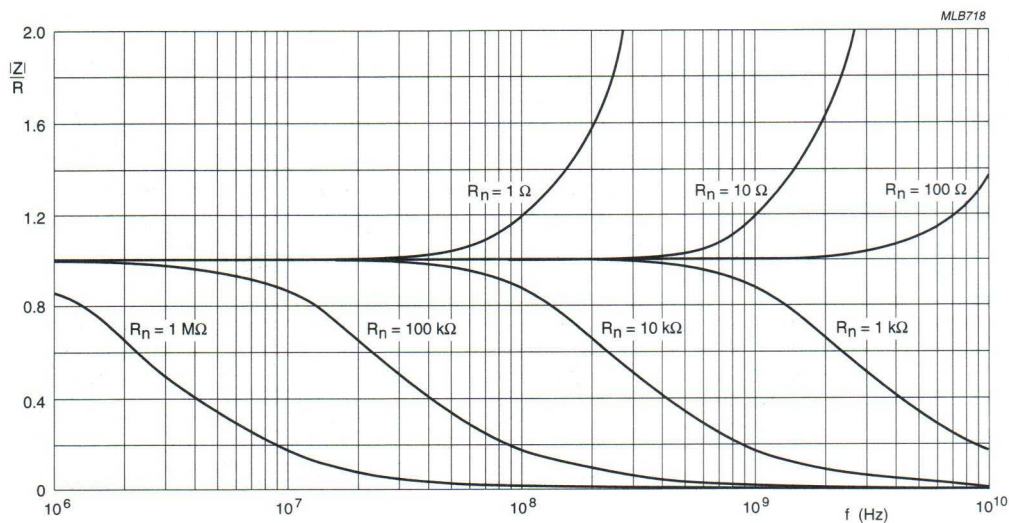


Fig.6 Impedance as a function of frequency for a chip resistor.

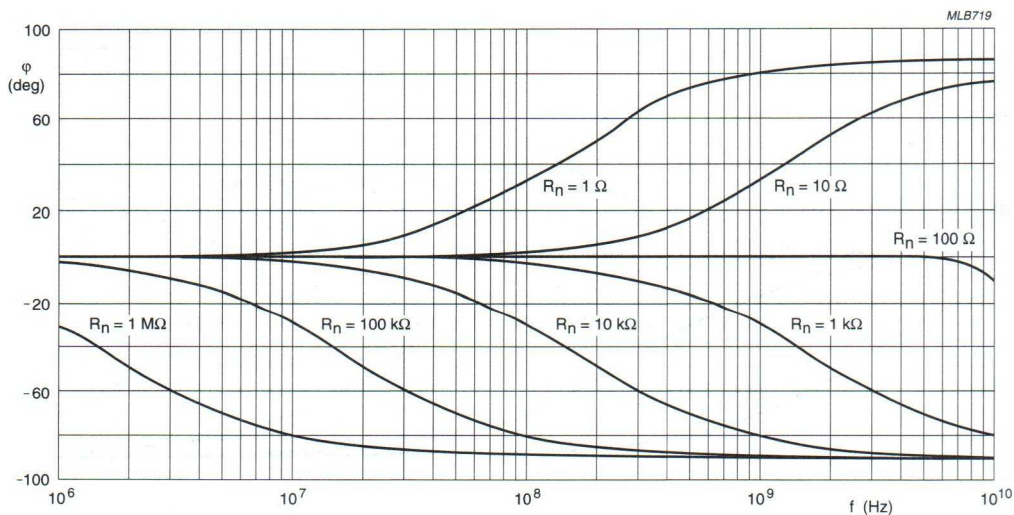
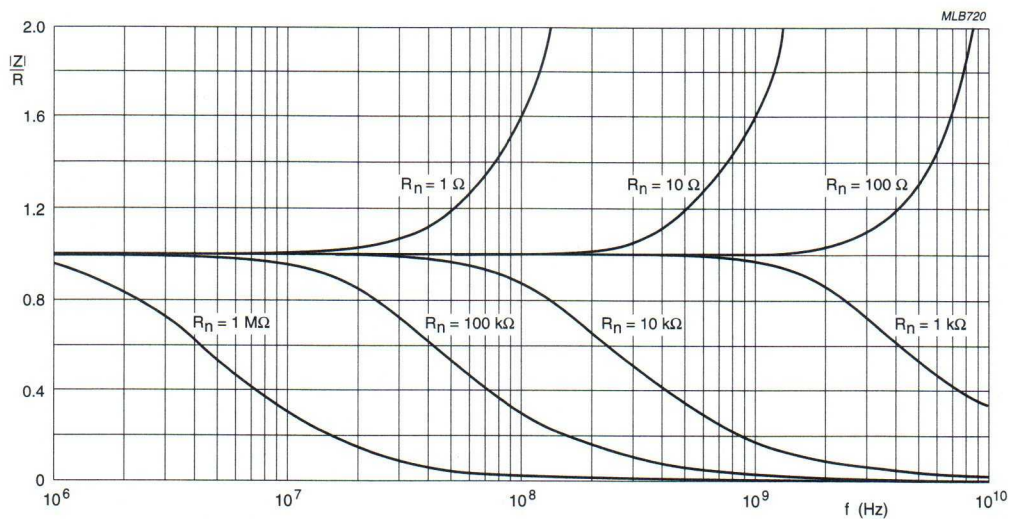


Fig.7 Phase shift as a function of frequency for a chip resistor.

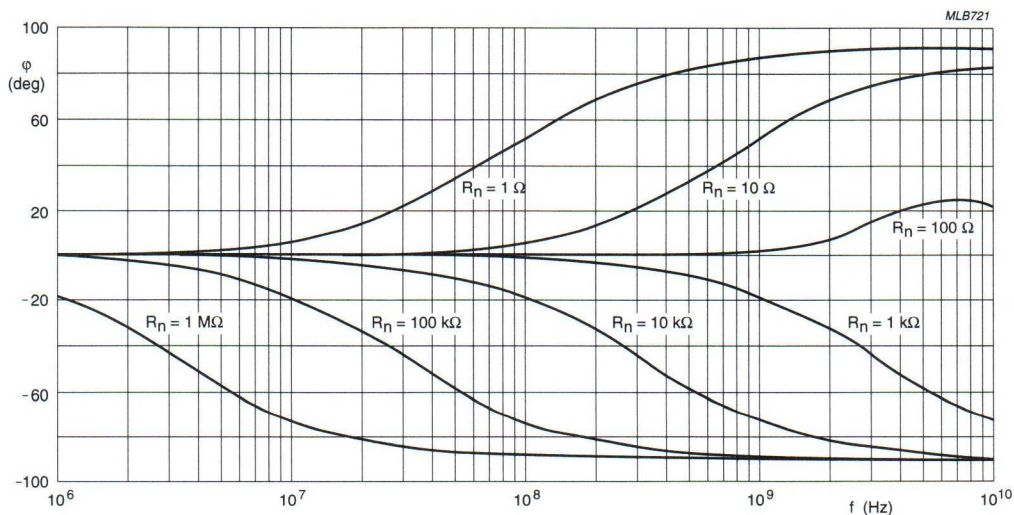
Chip resistors

General Introduction



Size 1206

Fig.8 Impedance as a function of frequency for a chip resistor.



Size 1206

Fig.9 Phase shift as a function of frequency for a chip resistor.

Chip resistors

General Introduction

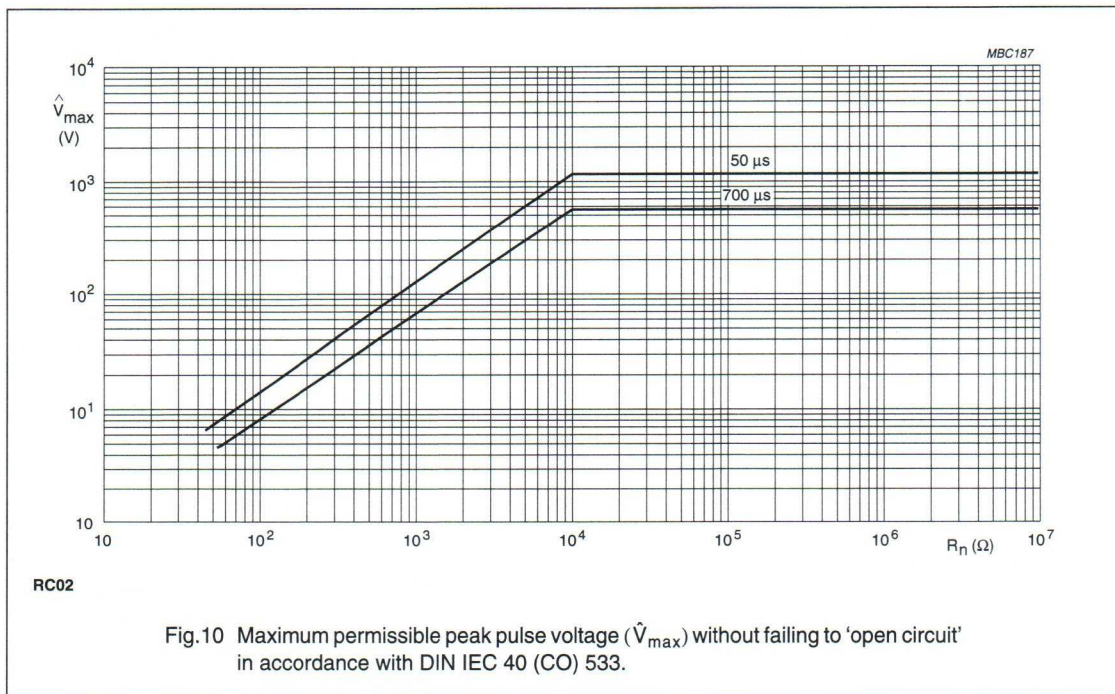
PULSE-LOAD BEHAVIOUR

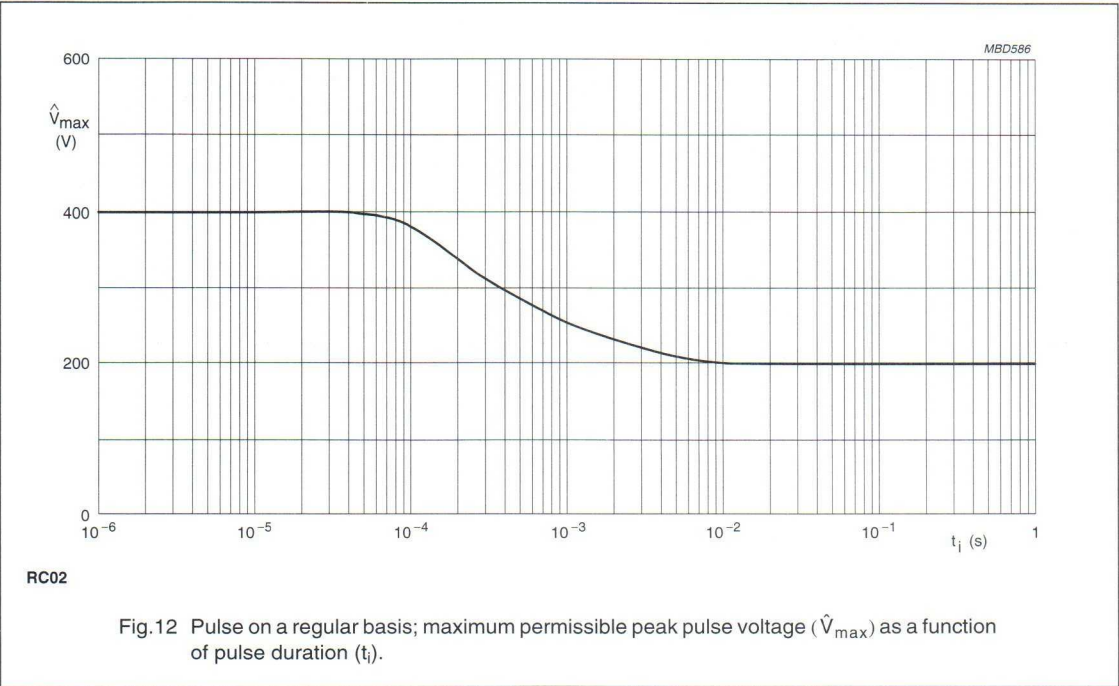
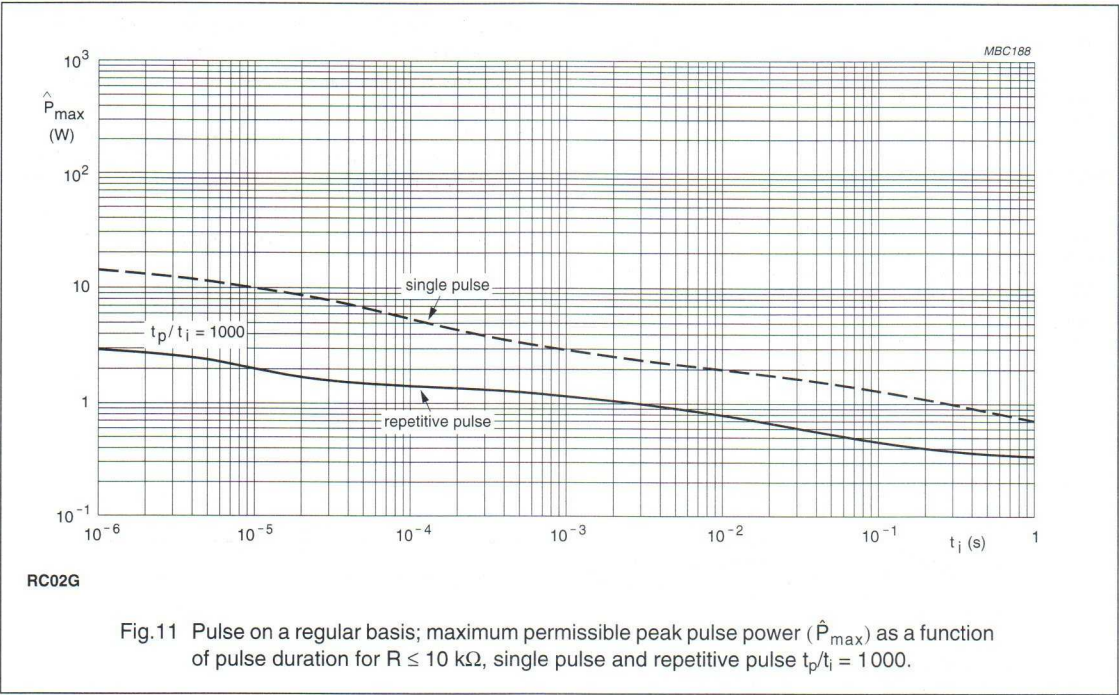
The load, due to a single pulse at which chip resistors fail by going open circuit, is determined by shape and time. A standard way to establish pulse load limits is shown in Table 1.

Table 1 Pulse load limits

PARAMETER	VALUE	UNIT
Exponential time constant	50 to 700	μs
Repetition time	12 to 25	s
Amount of pulses	5 to 10	

With this test, it can be determined at which applied voltage the resistive value changes about 0.5% of its nominal value under the above mentioned pulse conditions. Figure 10 shows test results for the RC02 chip resistors. If applied regularly the load is destructive, therefore the load must not be applied regularly during the load life of the resistors. However, the magnitude of a pulse at which failure occurs is of little practical value. The maximum 'single-pulse' load that may be applied in a regular way can be determined in a similar manner.





Chip resistors

General Introduction

Definitions of pulses

SINGLE PULSE

The resistor is considered to be operating under single pulse conditions if, during its life, it is loaded with a limited number (approximately 1500) of pulses over long time intervals (greater than one hour).

REPETITIVE PULSE

The resistor is operating under repetitive pulse conditions if it is loaded by a continuous train of pulses of similar power.

The dashed line in Fig.11 shows the observed maximum load for the RC02G chip resistors under single-pulse loading.

More usually, the resistor must withstand a continuous train of pulses of repetition time ' t_p ' during which only a small resistance change is acceptable. This resistance change ($\Delta R/R$) is equal to the change permissible under continuous load conditions. The continuous pulse train and small permissible resistance change reduces the maximum handling capability.

The continuous pulse train maximum handling capacity of chip resistors has been determined experimentally. Measurements have shown that the handling capacity varies with the resistive value applied. However, maximum peak pulse voltages as indicated in Fig.12, should not be exceeded.

Determination of pulse-load

The graphs in Figs 11 and 12 may be used to determine the maximum pulse-load for a resistor.

- For repetitive rectangular pulses:

- $\frac{\hat{V}_i^2}{R}$ must be lower than the value of $\hat{P}_{\max}$ given by the solid lines of Fig.11 for the applicable value of t_i and duty cycle t_p/t_i .

- $\hat{V}_i$ must be lower than the value of $\hat{V}_{\max}$ given in Fig.12 for the applicable value of t_i .

- For repetitive exponential pulses:

- As for rectangular pulses, except that $t_i = 0.5 \tau$.

- For single rectangular pulses:

- $\frac{\hat{V}_i^2}{R}$ must be lower than the $\hat{P}_{\max}$ given by the dashed line of Fig.11 for the applicable value of t_i .

- $\hat{V}_i$ must be lower than the value of $\hat{V}_{\max}$ given in Fig.12 for the applicable value of t_i .

Chip resistors

General Introduction

Definition of symbols (see Figs 11, 12, 13 and 14)

SYMBOL	DESCRIPTION
$\hat{P}$	applied peak pulse power
$\hat{P}_{\max}$	maximum permissible peak pulse power (Fig.11)
$\hat{V}_i$	applied peak pulse voltage (Figs 13 and 14)
$\hat{V}_{\max}$	maximum permissible peak pulse voltage (Fig.12)
R_{nom}	nominal resistance value
t_i	pulse duration (rectangular pulses)
t_p	pulse repetition time
τ	time constant (exponential pulses)
T_{amb}	ambient temperature
$T_{m(\max)}$	maximum hot-spot temperature of the resistor

Examples

Determine the stability of a typical resistor for operation under the following pulse-load conditions.

CONTINUOUS PULSE TRAIN

A 100 Ω resistor is required to operate under the following conditions: $V_i = 10$ V; $t_i = 10^{-5}$ s; $t_p = 10^{-2}$ s.

Therefore:

$$\hat{P} = \frac{10^2}{100} = 1 \text{ W and } \frac{t_p}{t_i} = \frac{10^{-2}}{10^{-5}} = 1000$$

For $t_i = 10^{-5}$ s and $\frac{t_p}{t_i} = 1000$, Fig.11 gives $\hat{P}_{\max} = 2$ W and Fig.12 gives $\hat{V}_{\max} = 400$ V. As the operating conditions $\hat{P} = 1$ W and $\hat{V}_i = 10$ V are lower than these limiting values, this resistor may be safely used.

SINGLE PULSE

A 10 k Ω resistor is required to operate under the following conditions: $\hat{V}_i = 250$ V; $t_i = 10^{-5}$ s.

Therefore:

$$\hat{P}_{\max} = \frac{250^2}{10000} = 6.25 \text{ W}$$

The dashed curve of Fig.11 shows that at $t_i = 10^{-5}$ s, the permissible $\hat{P}_{\max} = 10$ W and Fig.12 shows a permissible $\hat{V}_{\max}$ of 400 V, so this resistor may be used.

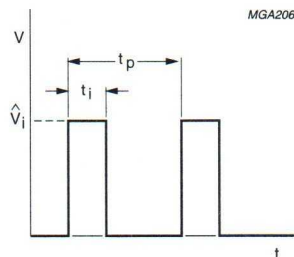


Fig.13 Rectangular pulses.

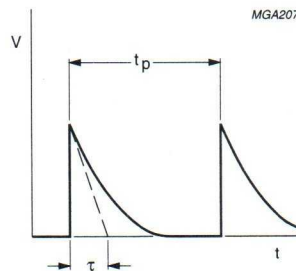


Fig.14 Exponential pulses.

MECHANICAL DATA

Outlines

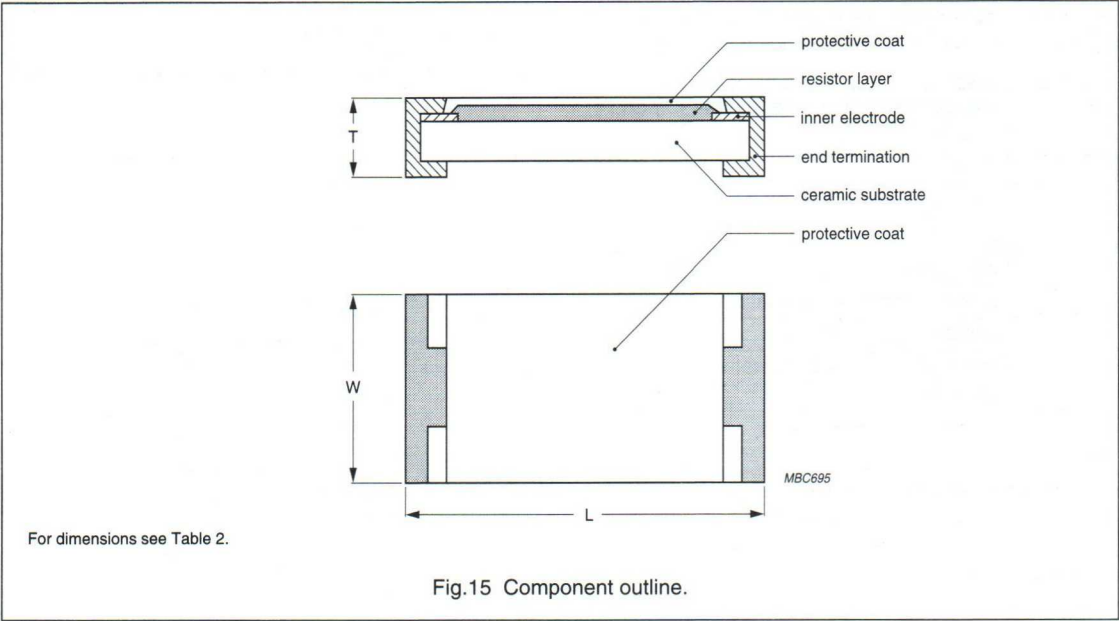


Table 2 Chip resistor type; USA case size code; mass per 100 units and relevant physical dimensions; see Fig.15

TYPE	USA SIZE CODE	L (mm)	W (mm)	T (mm)	MASS (g)
RC0...	1206	3.2	1.6	0.6	1.0
RC1..	0805	2.0	1.25	0.6	0.55
RC2..	0603	1.6	0.8	0.45	0.25
RC3.	0402	1.0	0.5	0.35	0.052

Marking

Wherever possible chip resistors are provided with a **resistance code**; see Table 3. The resistance code includes the first two or three significant digits of the resistance value (in ohms) followed by the number of zeros to follow. Whether two or three significant values are represented depends on the tolerance:

- $\pm 5\%$ requires two digits
- $\pm 2\%$ tolerance may be marked with two or three digits
- $\pm 1\%$ and lower requires three digits.

Table 3 Resistance value indication

INDICATOR	TOL. $\geq \pm 2\%$	TOL. $\leq \pm 1\%$
0	0.0 Ω ; jumper	—
R ⁽¹⁾	1 to 91 Ω	1 to 976 Ω
1	100 to 910 Ω	1 to 9.76 k Ω
2	1 to 9.1 k Ω	10 to 97.6 k Ω
3	10 to 91 k Ω	100 to 976 k Ω
4	100 to 910 k Ω	1 M Ω
5	1 to 9.1 M Ω	—
6	10 M Ω	—

Note

1. R denotes the decimal point.

Chip resistors

General Introduction

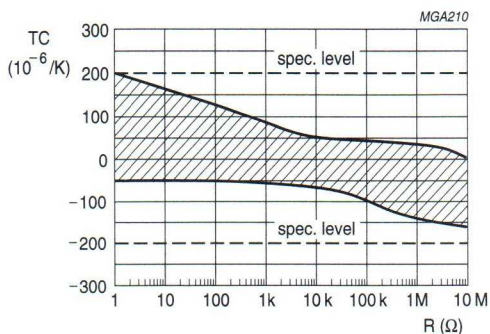
TESTS AND PROCEDURES

To guarantee zero defect production standards, Statistical Process Control is an essential part of our production processes. Furthermore, our production process is operating in accordance with "ISO 9000".

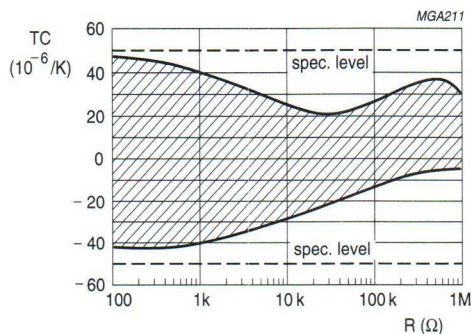
Essentially all tests on resistors are carried out in accordance with the schedule of "IEC publication 115-1"

in the specified climatic category and in accordance with IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components". In some instances deviations from the IEC recommendations are made.

Tests and their requirements are described in detail in the data sheets.



a. RC01.

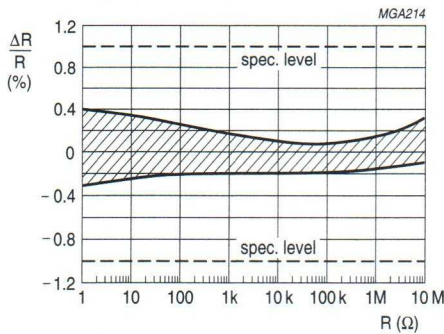


b. RC02G.

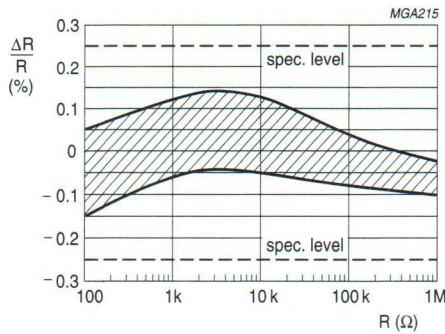
Fig.16 Typical temperature coefficients between the lower and upper category temperatures.

Chip resistors

General Introduction

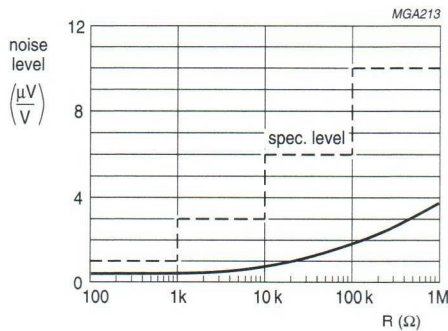


a. RC01.



b. RC02G.

Fig.17 Typical percentage change in resistance after soldering for 10 seconds at 260 °C, completely immersed.

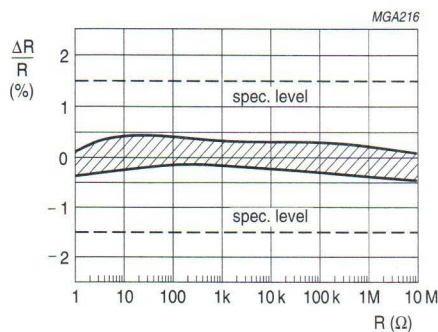


RC02G

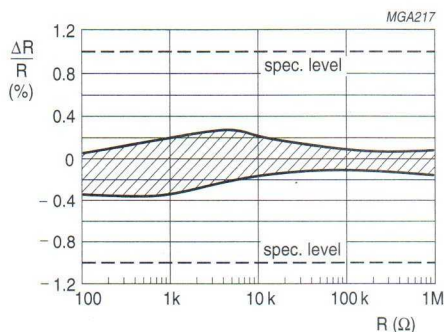
Fig.18 Typical noise level as a function of rated resistance measured using Quantech - equipment.

Chip resistors

General Introduction

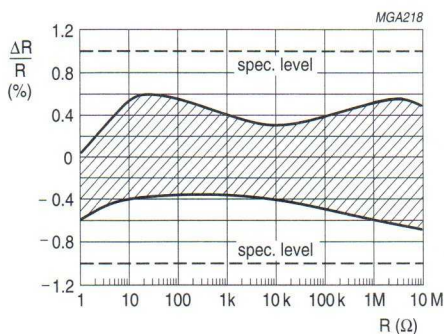


a. RC01.

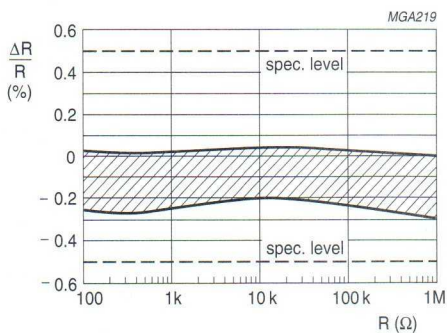


b. RC02G.

Fig.19 Typical percentage change in resistance after 56 days at 40 °C and 90 to 95% relative humidity loaded with P_{nom} .



a. RC01.



b. RC02G.

Fig.20 Typical percentage change in resistance after 1000 hours loaded with P_{nom} at 70 °C ambient temperature.

Chip resistors

Mounting

MOUNTING

Due to their rectangular shape and small dimensional tolerances, Surface Mounted Resistors are suitable for handling by automatic placement systems. Chip placement can be on ceramic substrates and printed-circuit boards (PCBs). Electrical connection to the circuit is by wave, vapour phase or infrared soldering. The end terminations guarantee a reliable contact and the protective coating enables 'face down' mounting.

The temperature rise in a resistor due to power dissipation, is determined by the laws of heat - conduction, convection and radiation. The maximum body temperature usually occurs in the middle of the resistor and is called the **hot-spot** temperature.

The hot-spot temperature depends on the ambient temperature and the dissipated power. This is described in the data sheets under the chapter heading "Functional description".

The hot-spot temperature is important for mounting because the connections to the chip resistors will reach a temperature close to the hot-spot temperature. Heat conducted by the connections must not reach the melting

point of the solder at the joints. Therefore a maximum solder joint temperature of 110 °C is advised.

The ambient temperature on large or very dense printed-circuit boards (PCBs) is influenced by the dissipated power. The ambient temperature will again influence the hot-spot temperature. Therefore, the packing density that is allowed on the PCB is influenced by the dissipated power.

Example of mounting effects

Assume that the maximum temperature of a PCB is 95 °C and the ambient temperature is 50 °C. In this case the maximum temperature rise that may be allowed is 45 °C. In the graph (see Fig.1), this point is found by drawing the line from point A (PCB = 95 °C) to point B ($T_{\text{amb}} = 50$ °C) and from here to the left axis.

To find the maximum packing density, this horizontal line is extended until it intersects with the curve, 0.125 W (point C). The maximum packing density, 19 units/50 × 50 mm² (point D), is found on the horizontal axis.

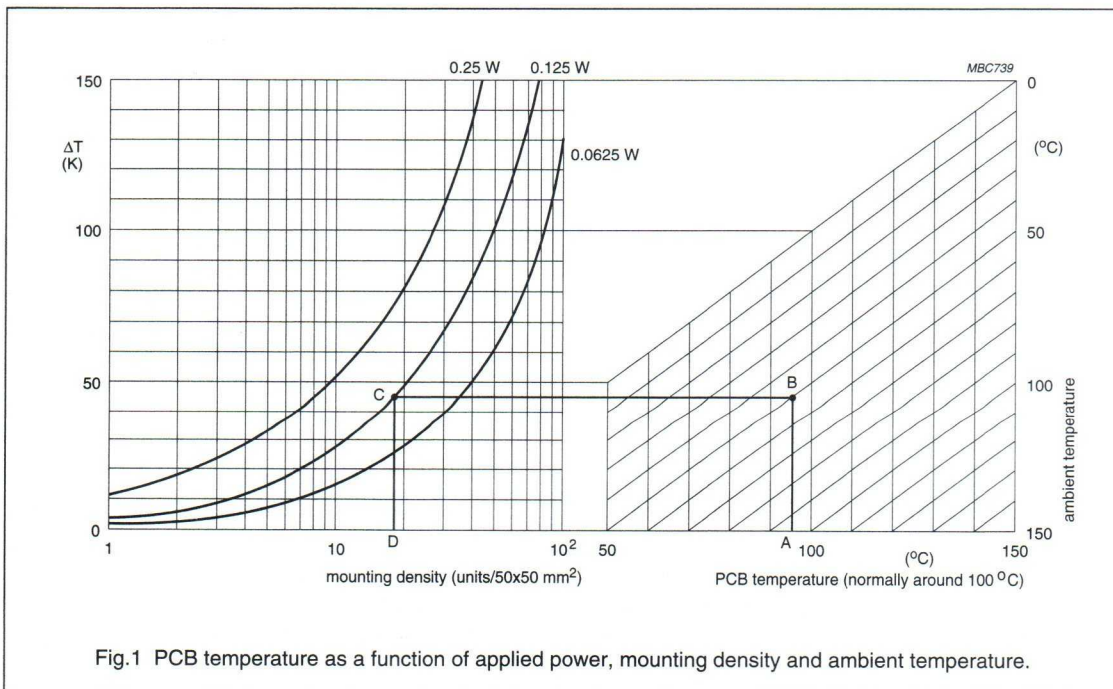


Fig.1 PCB temperature as a function of applied power, mounting density and ambient temperature.

Chip resistors

Mounting

Thermal resistance (R_{th})

Thermal resistance prohibits the release of heat generated within the resistor to the surrounding environment. It is expressed in K/W and defines the surface temperature (T_{HS}) of the resistor in relation to the ambient temperature (T_{amb}) and the load (P) of the resistor, as follows:

$$T_{HS} = T_{amb} + P \times R_{th}$$

Due to their direct contact with the solder spot, chip resistors dissipate over 85% of their heat via conduction to the solder spot and hence to the PCB. Thus the PCB on which the chip resistor is mounted functions as a heat sink. Different PCBs have different heat conductance. Figure 2 shows the different values of heat resistance per material type. Substrates with a higher heat conductance give lower thermal resistance figures; substrates with a lower heat conductance give higher thermal resistance figures.

It should be noted that the temperature of the terminations of the chip resistor is virtually the same as the hot-spot temperature. Therefore the power that may be dissipated by the resistor is dependent on:

- T_{amb} (which is also dependent on the packing density)
- R_{th} of the PCB
- maximum solder spot temperature (generally 110 °C).

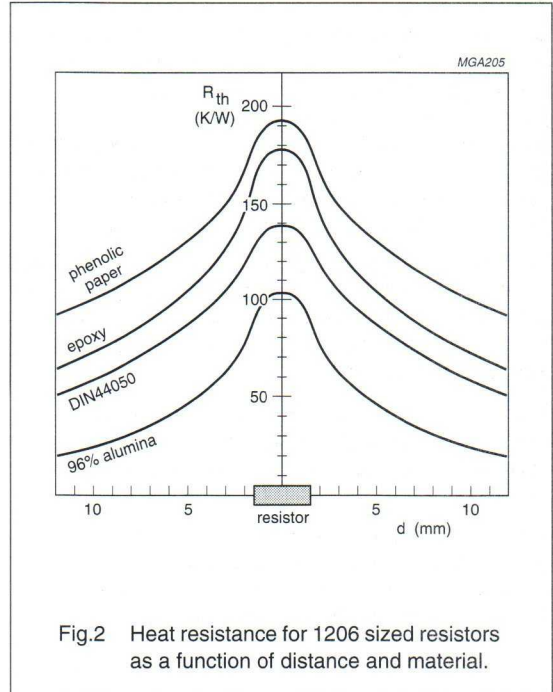
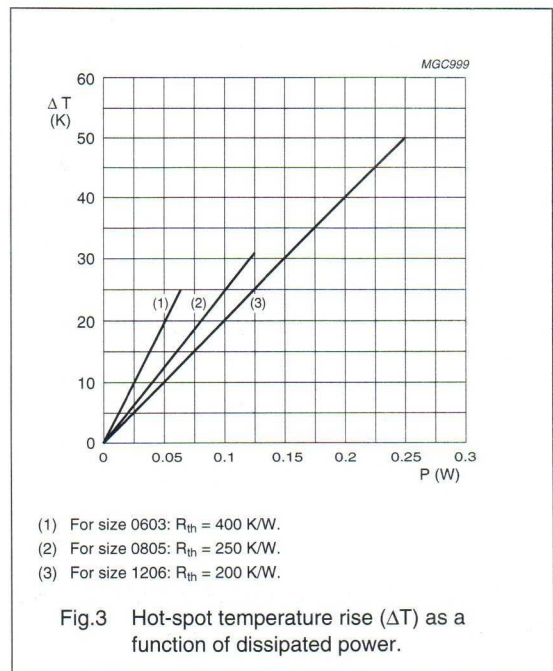


Fig.2 Heat resistance for 1206 sized resistors as a function of distance and material.



- (1) For size 0603: $R_{th} = 400$ K/W.
- (2) For size 0805: $R_{th} = 250$ K/W.
- (3) For size 1206: $R_{th} = 200$ K/W.

Fig.3 Hot-spot temperature rise (ΔT) as a function of dissipated power.

FOOTPRINT DIMENSIONS

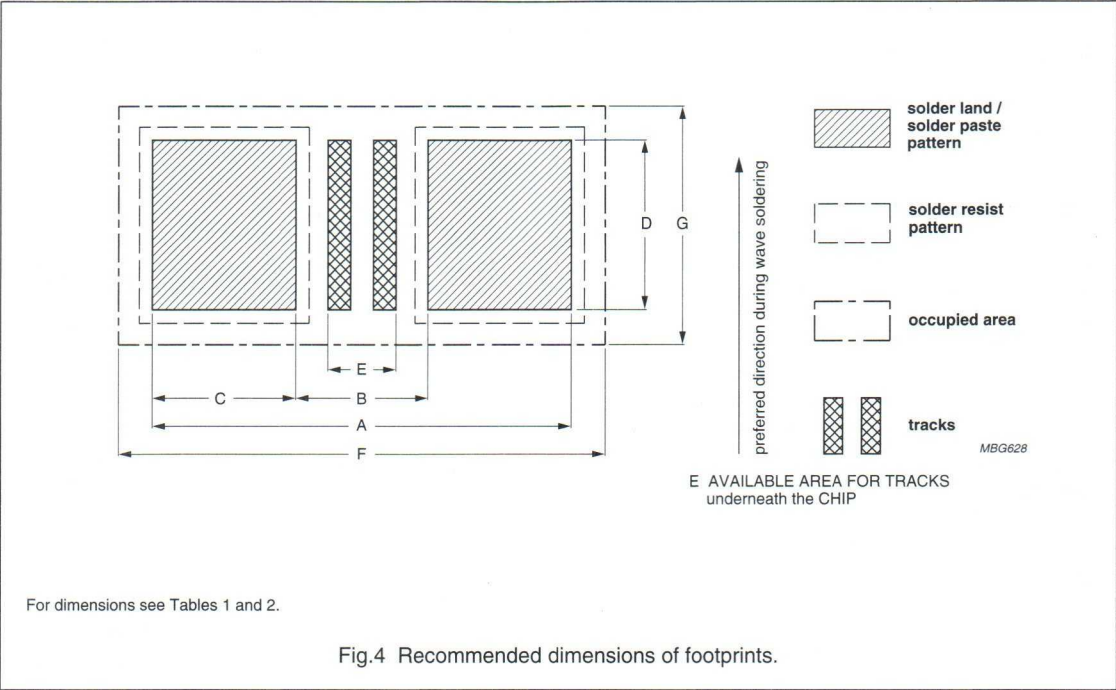


Table 1 Reflow soldering; for dimensions see also Fig.4

SIZE CODE	FOOTPRINT DIMENSIONS (mm)							PROCESSING REMARKS	PLACEMENT ACCURACY (mm)
	A	B	C	D	E	F	G		
0402	1.50	0.50	0.50	0.60	0.10	1.75	0.95	IR or hot plate soldering	±0.15
0603	2.1	0.7	0.7	0.9	0.26	2.5	1.5		±0.15
0603	2.1	0.5	0.8	0.9	0.0	2.5	1.7		±0.25
0805	2.6	0.9	0.85	1.4	0.5	3.0	2.1		±0.25
1206	3.8	2.0	0.9	1.8	1.4	4.2	2.5		±0.25

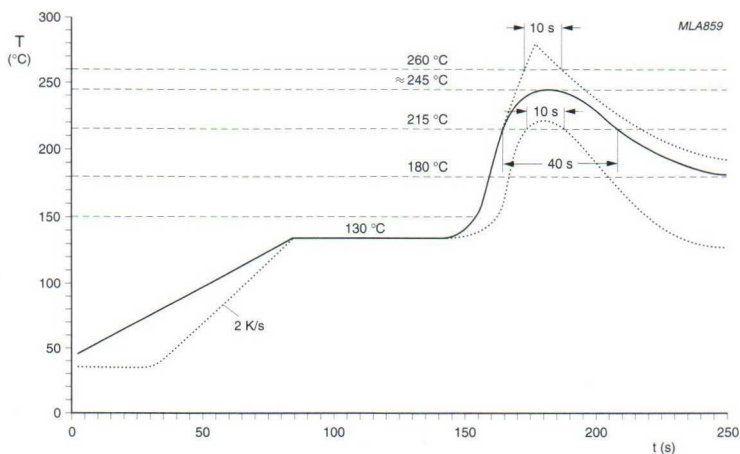
Table 2 Wave soldering (no dummy tracks allowed for the high voltage series); for dimensions see also Fig.4

SIZE CODE	FOOTPRINT DIMENSIONS (mm)							PROPOSED NUMBER AND DIMENSIONS OF DUMMY TRACKS (mm)	PLACEMENT ACCURACY (mm)
	A	B	C	D	E	F	G		
0603	2.5	1.1	0.7	0.8	0.3	3.0	1.7	1 × (0.3 × 0.8)	±0.15
0603	2.7	0.9	0.9	0.8	0.15	3.2	1.9	1 × (0.15 × 0.8)	±0.25
0805	3.3	1.3	1.0	1.3	0.7	3.9	2.4	1 × (0.3 × 1.3)	±0.25
1206	4.5	2.5	1.0	1.7	1.25	5.0	2.8	3 × (0.25 × 1.7)	±0.25
1218	4.4	1.9	1.25	4.8	1.3	4.6	5.6	—	±0.25

SOLDERING CONDITIONS

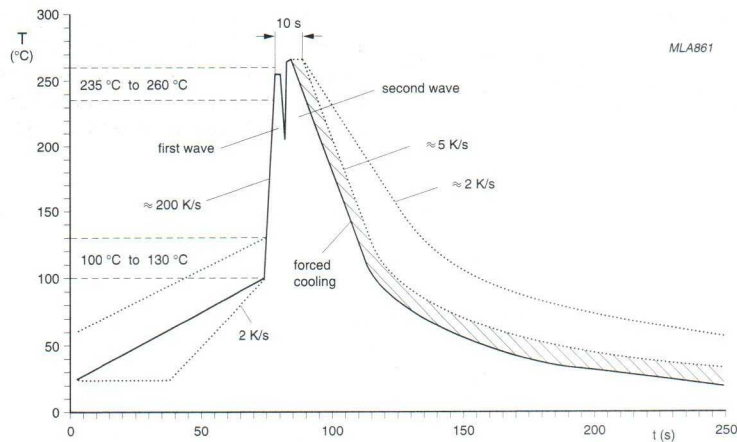
The robust construction of chip resistors allows them to be completely immersed in a solder bath of 260 °C for one minute. Therefore, it is possible to mount Surface Mounted Resistors on one side of a PCB and other discrete components on the reverse (mixed PCBs).

Surface Mounted Resistors are tested for solderability at 235 °C during 2 seconds. The test condition for no leaching is 260 °C for 60 seconds. Typical examples of soldering processes that provide reliable joints without any damage, are given in Figs 5, 6 and 7.



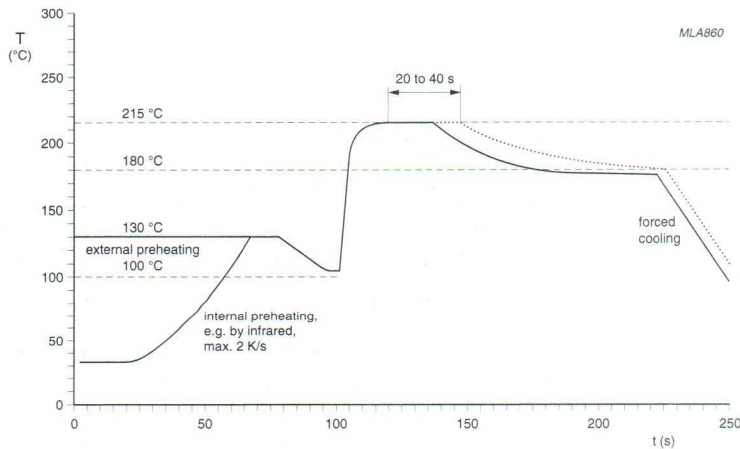
Typical values (solid line).
Process limits (dotted lines).

Fig.5 Infrared soldering.



Typical values (solid line).
Process limits (dotted lines).
The resistors may be soldered twice in accordance with this method if desired.

Fig.6 Double wave soldering.



Typical values (solid line).
Process limits (dotted line).

Fig.7 Vapour phase soldering.

Chip resistors

Packaging

PACKAGING

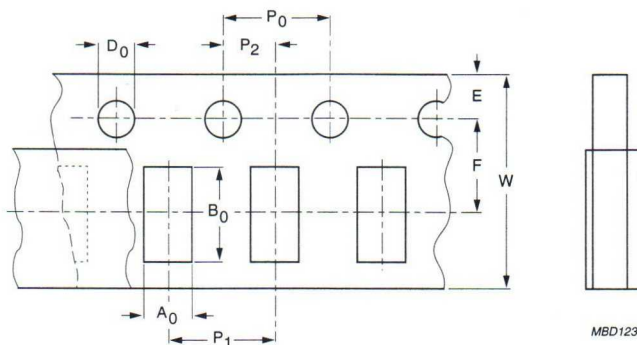
Tape and reel specifications

All tape and reel specifications are in accordance with the second edition of "IEC 286-3". Basic dimensions are given in Figs 1, 2 and 4, and Tables 1, 2 and 4.

Peel-off force

Peel-off forces of both cardboard and blister tapes are in accordance with "IEC 286-3"; that is, 0.1 N to 0.7 N at a peel-off speed of 120 mm/minute and 0.2 N to 1.0 N at a peel-off speed of 300 mm/minute. For both speeds, the peel-off angle should be between 165° and 180°.

Cardboard tape



MBD123

Cumulative tolerance over 10 holes: ± 0.2 mm.

Bottom fixing tape thickness: 50 ± 10 μ m.

Top fixing tape thickness: 50 ± 10 μ m.

For dimensions see Table 1.

Carrier tape thickness:

0.6 ± 0.05 mm (0402, 0603)

0.75 ± 0.05 mm (1206; 0805).

Fig.1 Cardboard tape.

Table 1 Dimensions of cardboard tape for relevant chip size; see Fig.1

SYMBOL	PRODUCT SIZE CODE								UNIT
	0402		0603		0805		1206		
	SIZE	TOL.	SIZE	TOL.	SIZE	TOL.	SIZE	TOL.	
A ₀	0.70	±0.05	1.0	+0.2/−0	1.5	+0.2/−0	1.85	+0.2/−0	mm
B ₀	1.20	±0.05	1.8	+0.2/−0	2.25	+0.2/−0	3.45	+0.2/−0	mm
W	8	±0.2	8	±0.3	8	±0.3	8	±0.3	mm
E	1.75	±0.1	1.75	±0.1	1.75	±0.1	1.75	±0.1	mm
F	3.5	±0.05	3.5	±0.05	3.5	±0.05	3.5	±0.05	mm
D ₀	1.5	+0.1/−0	1.5	+0.1/−0	1.5	+0.1/−0	1.5	+0.1/−0	mm
P ₀	4	±0.1	4	±0.1	4	±0.1	4	±0.1	mm
P ₁	2	±0.1	4	±0.1	4	±0.1	4	±0.1	mm
P ₂	2 or 0	±0.05	2	±0.05	2	±0.05	2	±0.05	mm

Chip resistors

Packaging

Embossed carrier tape

ENVIRONMENTAL CONSIDERATIONS

- Cover tape, carrier tape and reel do not contain environmentally-harmful PVC materials.
- Tape and reel are antistatic.
- Because the carrier tape is made of polycarbonate, a homogeneous material (mono-plastic), it is ideally suited for recycling.
- Compared to other PVC-free materials polycarbonate shows excellent stiffness and very little deformation with temperature.

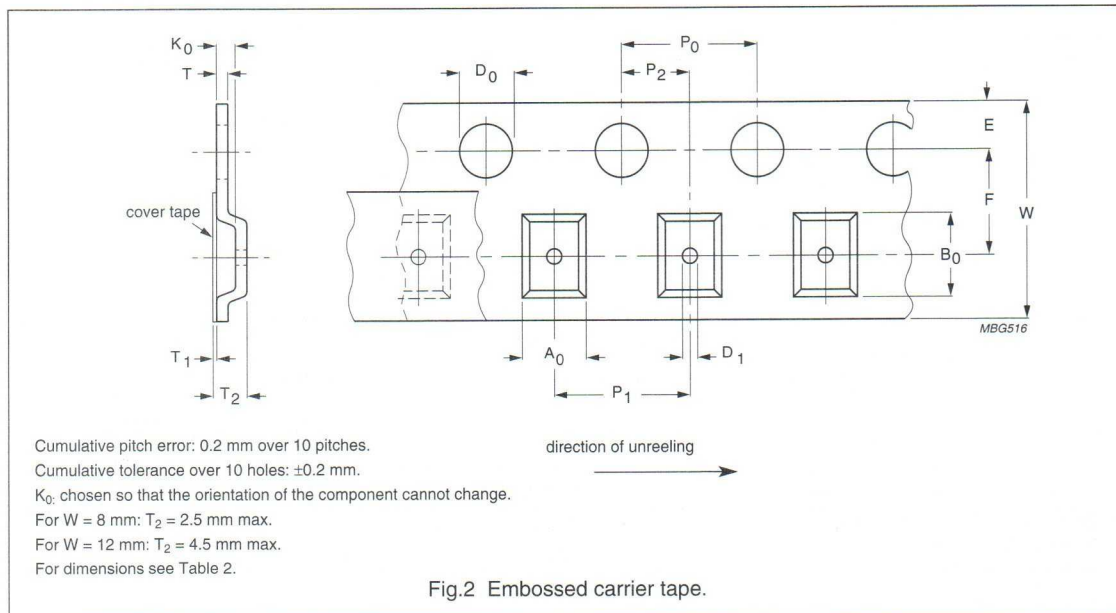


Table 2 Dimensions of embossed carrier tape for relevant chip size; see Fig.2

SYMBOL	PRODUCT SIZE CODE			TOLERANCE	UNIT
	0805	1206	1218		
A ₀ nominal clearance; note 1	0.30			—	mm
B ₀ nominal clearance; note 1	0.20			—	mm
K ₀ minimum clearance; note 1	0.10			—	mm
W	8.1	8.1	12	± 0.2	mm
E	1.75	1.75	1.75	± 0.1	mm
F	3.5	3.5	5.5	± 0.05	mm
D ₀	1.5	1.5	1.5	+0.1/-0.0	mm
D ₁	≥ 1	≥ 1	≥ 1.5	+0.1/-0.0	mm
P ₀ ; note 2	4	4	4	± 0.1	mm
P ₁	4	4	8	± 0.1	mm
P ₂	2	2	2	± 0.05	mm

Notes

1. Possible product displacement in pocket.
2. P₀ pitch tolerance over any 10 pitches is ± 0.2 mm.

Leader/trailer tape specification

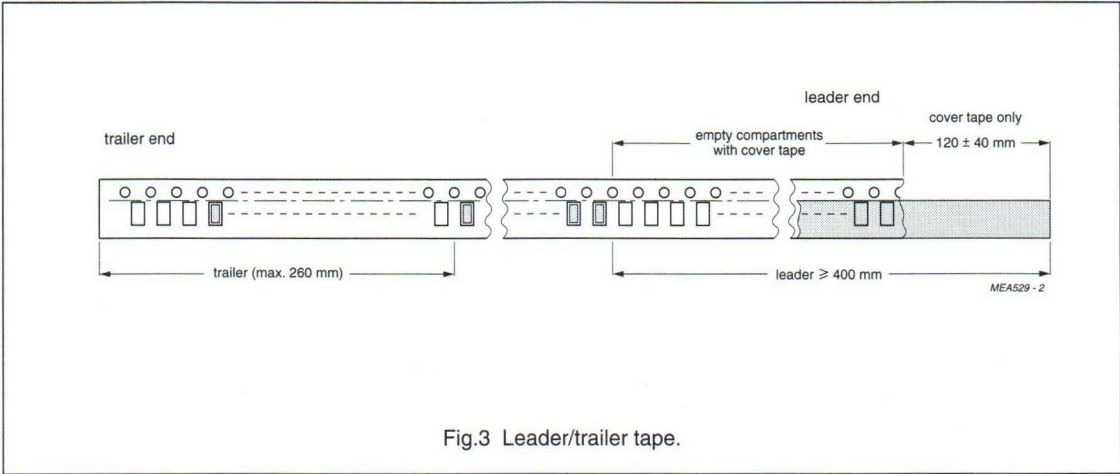


Table 3 Leader/trailer tape data

DESCRIPTION	VALUE
Minimum length of empty compartments at leader end	≥400 mm of which a minimum 240 mm of empty compartments are covered with cover tape and 120 ±40 mm cover tape only.
Minimum length of empty compartments at trailer end	208 mm or 260 mm; if the length is 260 mm an extra product is placed at 208 mm to mark this position

REEL SPECIFICATIONS

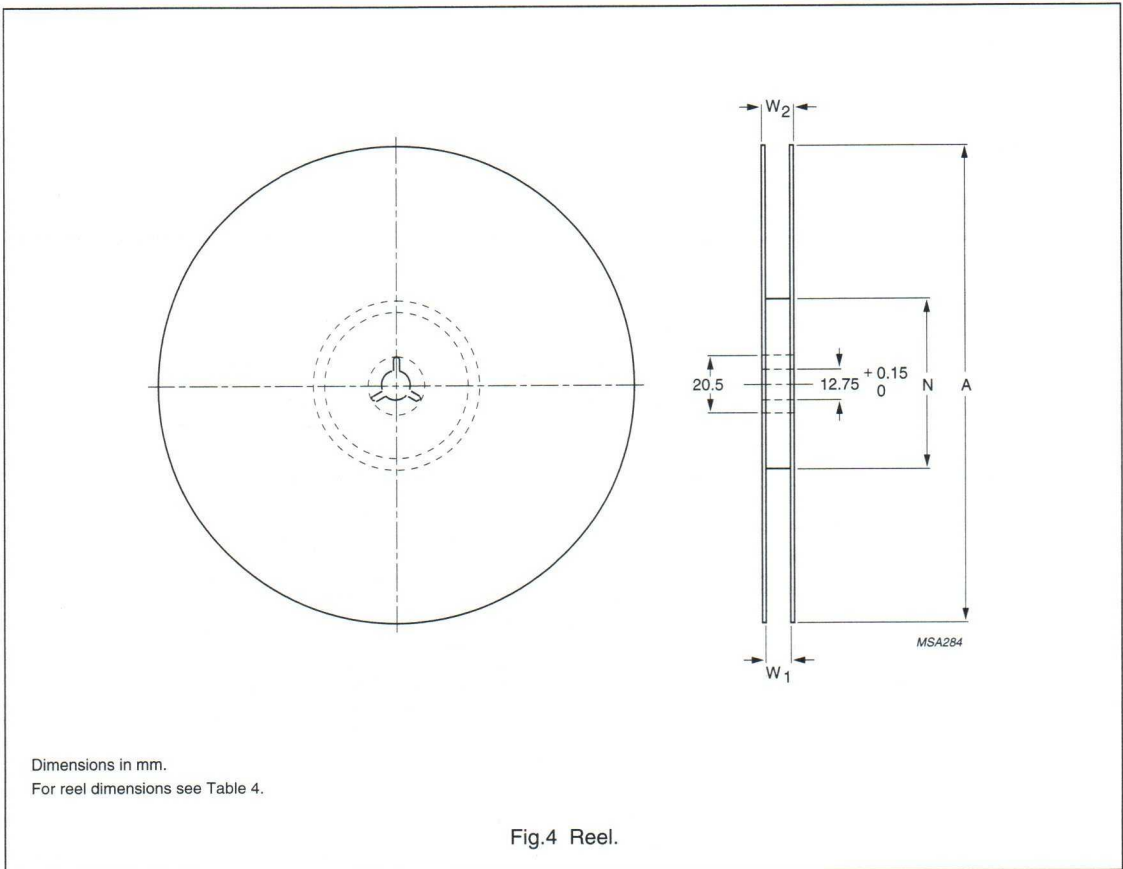


Table 4 Reel dimensions; see Fig.4

PRODUCT SIZE CODE	UNITS PER REEL	TAPE WIDTH (mm)	A (mm)	N (mm)	W ₁ (mm)	W ₂ MAX. (mm)
0402	10000	8	180	62 ±1.5	8.4 +1.5/-0.0	14.4
1206; 0603; 0805	20000		330			
	10000		250			
	5000		180			
1218	1000	12	180		12.4 +2/-0.0	18.4
	5000		260			

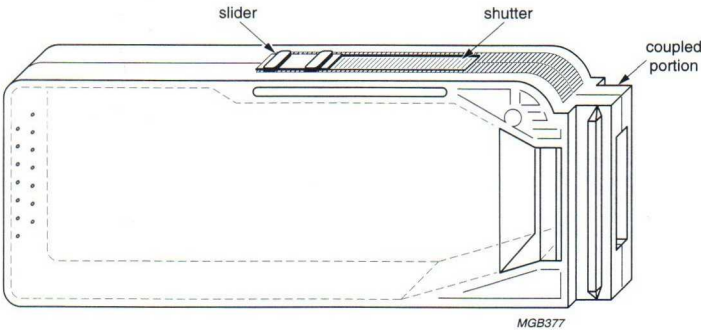
Chip resistors

Packaging

BULK CASE SPECIFICATION

Features and benefits:

- Reduced costs
 - Storage
 - Transport
 - Machine handling
 - Packaging.



For dimensions see Table 5.

Fig.5 Bulk case outline.

Table 5 Bulk case dimensions; see Fig.5

LENGTH (mm)	WIDTH (mm)	THICKNESS (mm)
110	35	12

Table 6 Product size versus packaged quantity

PRODUCT SIZE CODE	UNITS PER CASE
0402	100 000
0603	25 000
0805	10 000

PRODUCT SPECIFICATIONS SMD

Standard chip resistors sizes 1206, 0805, 0603 and 0402

RC01/11/21/31

FEATURES

- Low assembly costs
- High component and equipment reliability
- Excellent performance at high frequency, especially the RC31
- Complete standard SMD family.

APPLICATIONS

- All general purpose applications.

DESCRIPTION

The resistors are constructed on a high grade ceramic body (aluminium oxide). Internal metal electrodes are added at each end and connected by a resistive paste which is applied to the top surface of the substrate. The composition of the paste is adjusted to give the approximate resistance required and the value is trimmed to within tolerance, by laser cutting of this resistive layer.

The resistive layer is covered with a protective coat and printed with the resistance value. Finally, the two external end terminations are added. For ease of soldering the outer layer of these end terminations is a lead/tin alloy.

QUICK REFERENCE DATA

DESCRIPTION	VALUE			
	RC01	RC11	RC21	RC31 ⁽¹⁾
Size code	1206 (3216)	0805 (2012)	0603 (1608)	0402(1005)
Resistance range	1 Ω to 10 M Ω			10 Ω to 1 M Ω
Resistance tolerance and E-series	$\pm 5\%$, $\pm 2\%$; E24 series			
Temperature coefficient: 1 $\Omega \leq R < 5 \Omega$ 5 $\Omega \leq R \leq 10 \text{ M}\Omega$	$\leq \pm 250 \times 10^{-6}/\text{K}$ $\leq \pm 200 \times 10^{-6}/\text{K}$			$\leq \pm 200 \times 10^{-6}/\text{K}$
Maximum dissipation at $T_{\text{amb}} = 70^\circ\text{C}$	0.25 W	0.125 W	0.063 W	0.063 W
Maximum permissible voltage	200 V (DC or RMS)	150 V (DC or RMS)	50 V (DC or RMS)	50 V (DC or RMS)
Climatic category (IEC 68)	55/155/56			55/125/56
Basic specification	IEC 115-8			
Stability after: load, 1000 hours at $T_{\text{amb}} = 70^\circ\text{C}$: 1 $\Omega \leq R \leq 1 \text{ M}\Omega$ R > 1 M Ω climatic tests: 1 $\Omega \leq R \leq 1 \text{ M}\Omega$ R > 1 M Ω resistance to soldering heat short time overload	$\Delta R/R \text{ max.: } \pm 1.5\% + 0.1 \Omega$ $\Delta R/R \text{ max.: } \pm 3.0\% + 0.1 \Omega$ $\Delta R/R \text{ max.: } \pm 1.5\% + 0.1 \Omega$ $\Delta R/R \text{ max.: } \pm 3.0\% + 0.1 \Omega$ $\Delta R/R \text{ max.: } \pm 0.5\% + 0.05 \Omega$ $\Delta R/R \text{ max.: } \pm 1.0\% + 0.05 \Omega$			$\Delta R/R \text{ max.: } \pm 3.0\% + 0.1 \Omega$ $\Delta R/R \text{ max.: } \pm 1.0\% + 0.1 \Omega$ $\Delta R/R \text{ max.: } \pm 1.0\% + 0.1 \Omega$ $\Delta R/R \text{ max.: } \pm 2.0\% + 0.1 \Omega$

Note

1. Data for RC31 is preliminary.

Standard chip resistors sizes 1206, 0805, 0603 and 0402

RC01/11/21/31

ORDERING INFORMATION

Table 1 Ordering code indicating resistor type and packaging

TYPE	TOL. (%)	ORDERING CODE 2322					
		CARDBOARD TAPE ON REEL ⁽¹⁾			BULK CASE		
		5000 units	10000 units	20000 units	10000 units	25000 units	100000 units
RC01	±5	711 61...	711 51...	711 81...	—	—	—
	±2	711 41...	—	711 71...	—	—	—
RC11	±5	730 61...	730 71...	730 81...	731 81...	—	—
	±2	730 31...	—	730 41...	731 51...	—	—
RC21	±5	702 60...	702 70...	702 81...	—	702 80...	—
	±2	702 65...	—	702 75...	—	702 50...	—
RC31	±5	—	705 70...	—	—	—	705 80...
Jumper 0 Ω							
RC01 ⁽²⁾	—	711 91032	711 91005	711 92004	—	—	—
RC11 ⁽²⁾	—	730 91002	730 91003	730 92002	731 91006	—	—
RC21 ⁽³⁾	—	702 96001	702 97001	702 92002	—	702 91002	—
RC31 ⁽³⁾	—	—	705 91001	—	—	—	705 91005

Notes

1. Embossed carrier tape available on request for types RC01 and RC11.
2. The jumper has a maximum resistance $R_{\max} = 50 \text{ m}\Omega$ and a rated current $I_R = 2 \text{ A}$.
3. The jumper has a maximum resistance $R_{\max} = 50 \text{ m}\Omega$ and a rated current $I_R = 1 \text{ A}$.

Ordering code (12NC)

- The resistors have a 12-digit ordering code starting with 2322
- The subsequent 5 digits indicate the resistor type and packaging; see Table 1.
- The remaining 3 digits indicate the resistance value:
 - The first 2 digits indicate the resistance value.
 - The last digit indicates the resistance decade in accordance with Table 2.

Table 2 Last digit of 12NC

RESISTANCE DECADE	LAST DIGIT
1 to 9.76 Ω	8
10 to 97.6 Ω	9
100 to 976 Ω	1
1 to 9.76 kΩ	2
10 to 97.6 kΩ	3
100 to 976 kΩ	4
1 to 9.76 MΩ	5
10 MΩ	6

ORDERING EXAMPLE

The ordering code of a RC11 resistor, value 4700 Ω with ±2% tolerance, supplied on cardboard tape of 5000 units per reel is:
2322 730 31472.

Standard chip resistors

sizes 1206, 0805, 0603 and 0402

RC01/11/21/31

FUNCTIONAL DESCRIPTION

Product characterization

Standard values of nominal resistance are taken from the E24 series for resistors with a tolerance of $\pm 5\%$ or $\pm 2\%$. The values of the E24 series are in accordance with "IEC publication 63".

Limiting values

TYPE	LIMITING VOLTAGE ⁽¹⁾ (V)	LIMITING POWER (W)
RC01	200	0.25
RC11	150	0.125
RC21	50	0.063
RC31		

Note

1. This is the maximum voltage that may be continuously applied to the resistor element, see "IEC publication 115-8".

DERATING

The power that the resistor can dissipate depends on the operating temperature; see Fig.1.

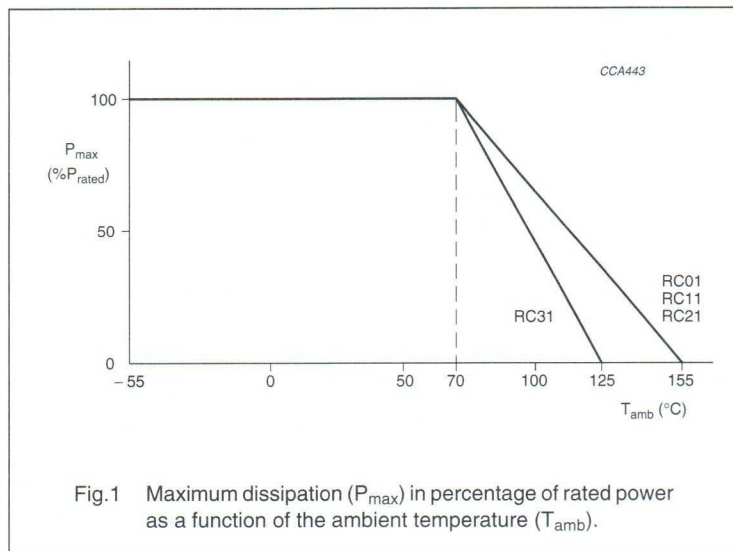


Fig.1 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

PULSE LOADING CAPABILITIES

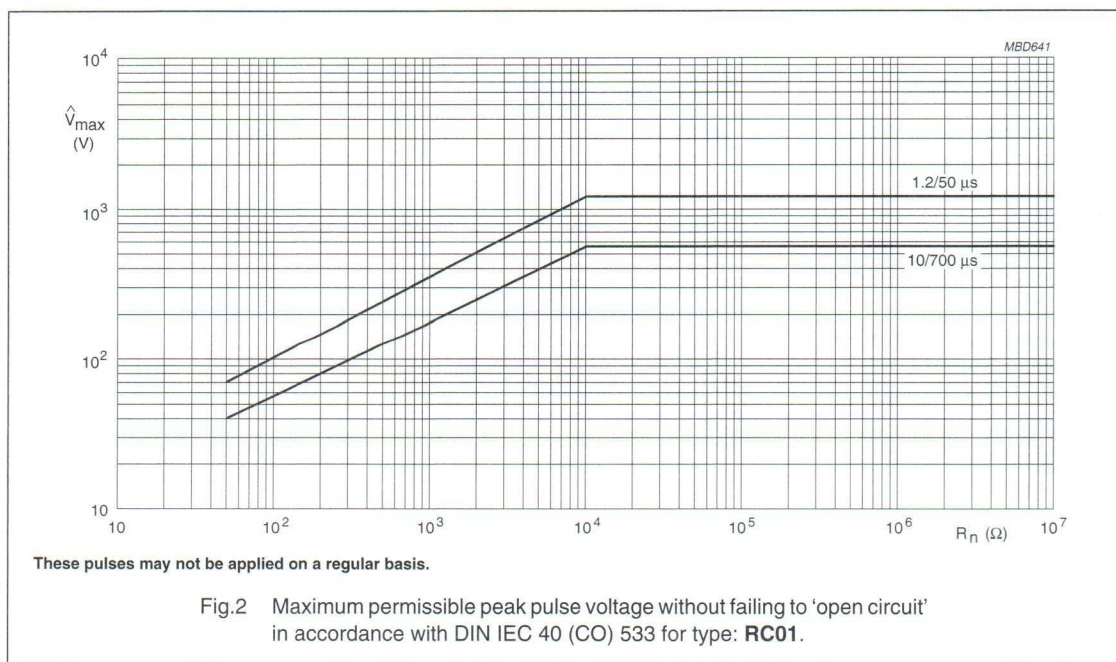
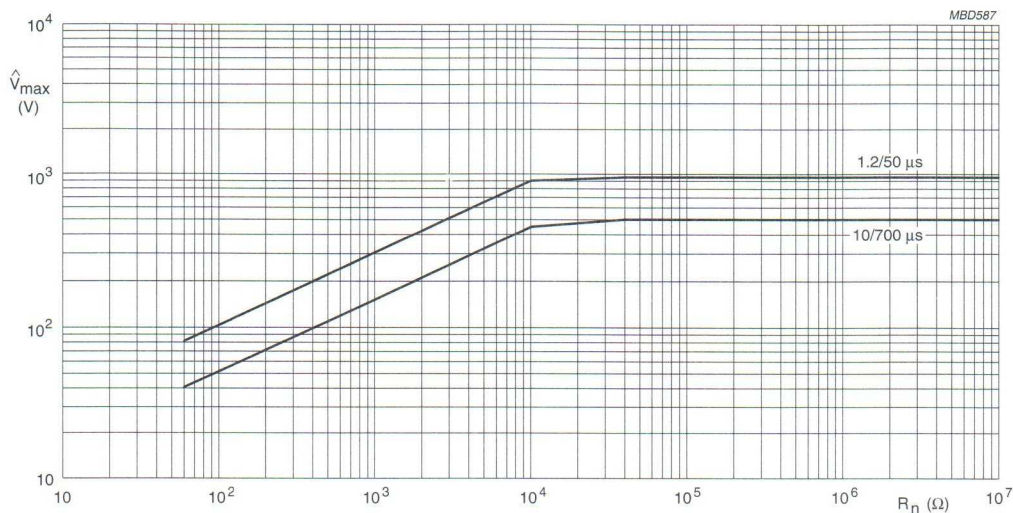


Fig.2 Maximum permissible peak pulse voltage without failing to 'open circuit' in accordance with DIN IEC 40 (CO) 533 for type: **RC01**.

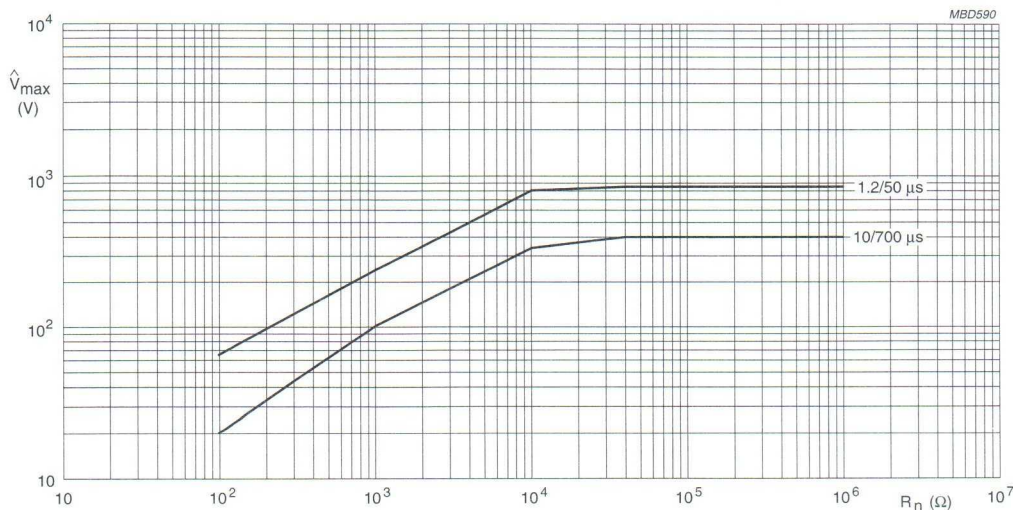
Standard chip resistors sizes 1206, 0805, 0603 and 0402

RC01/11/21/31



These pulses may not be applied on a regular basis.

Fig.3 Maximum permissible peak pulse voltage without failing to 'open circuit' in accordance with DIN IEC 40 (CO) 533 for type: **RC11**.



These pulses may not be applied on a regular basis.

Fig.4 Maximum permissible peak pulse voltage without failing to 'open circuit' in accordance with DIN IEC 40 (CO) 533 for type: **RC21**.

Standard chip resistors

sizes 1206, 0805, 0603 and 0402

RC01/11/21/31

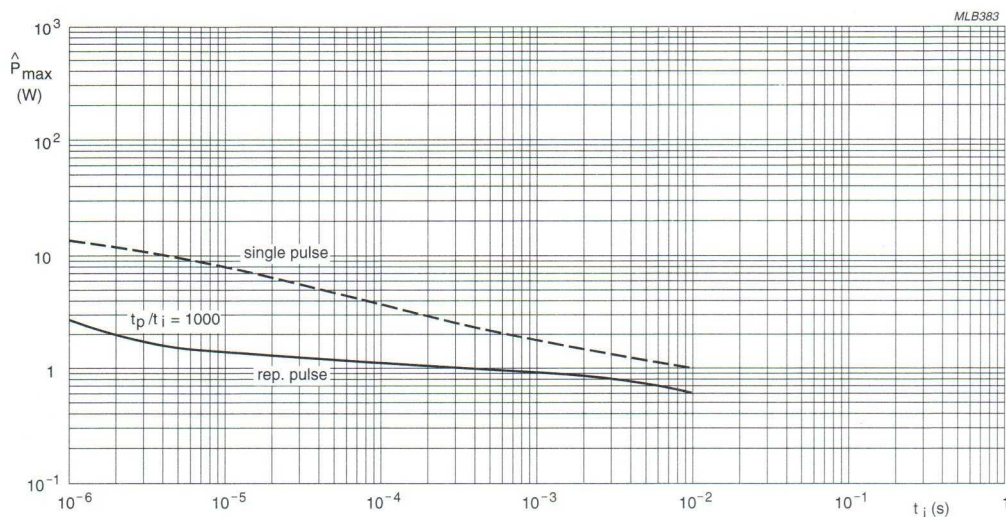


Fig.5 Pulse on a regular basis for type: **RC01**; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration for $R \leq 10 \text{ k}\Omega$, single pulse and repetitive pulse $t_p/t_i = 1000$.

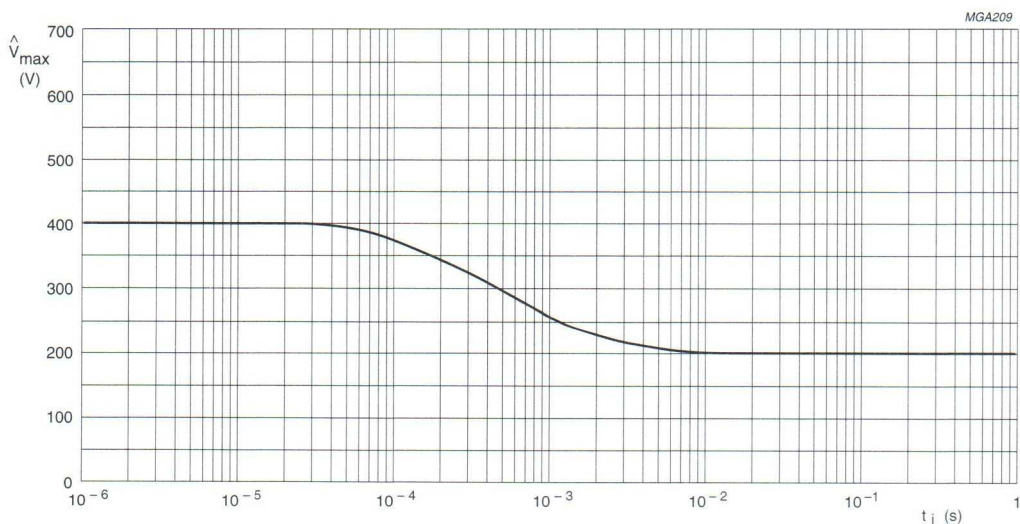


Fig.6 Pulse on a regular basis for type: **RC01**; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration.

Standard chip resistors sizes 1206, 0805, 0603 and 0402

RC01/11/21/31

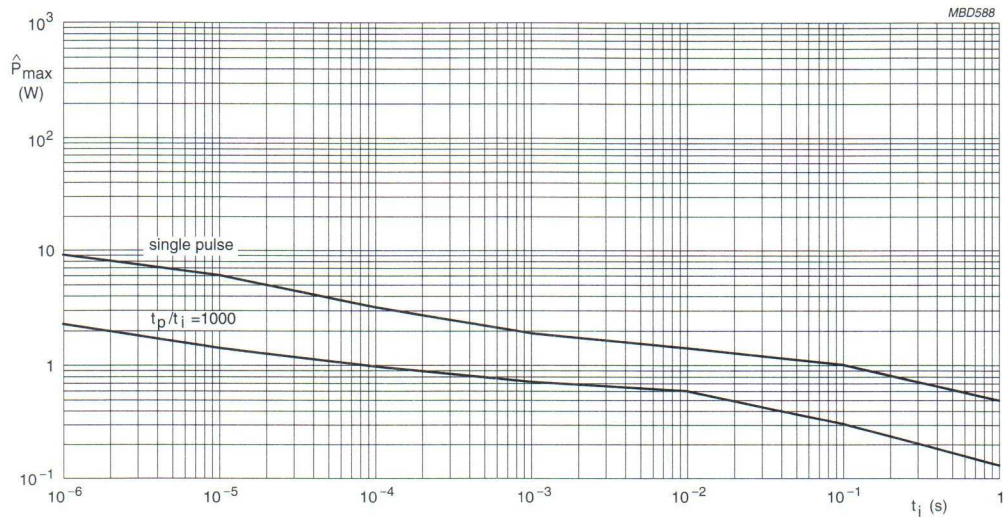


Fig.7 Pulse on a regular basis for type: **RC11**; maximum permissible peak pulse power ($\hat{P}_{\max}$) as a function of pulse duration for $R \leq 10 \text{ k}\Omega$, single pulse and repetitive pulse $t_p/t_i = 1000$.

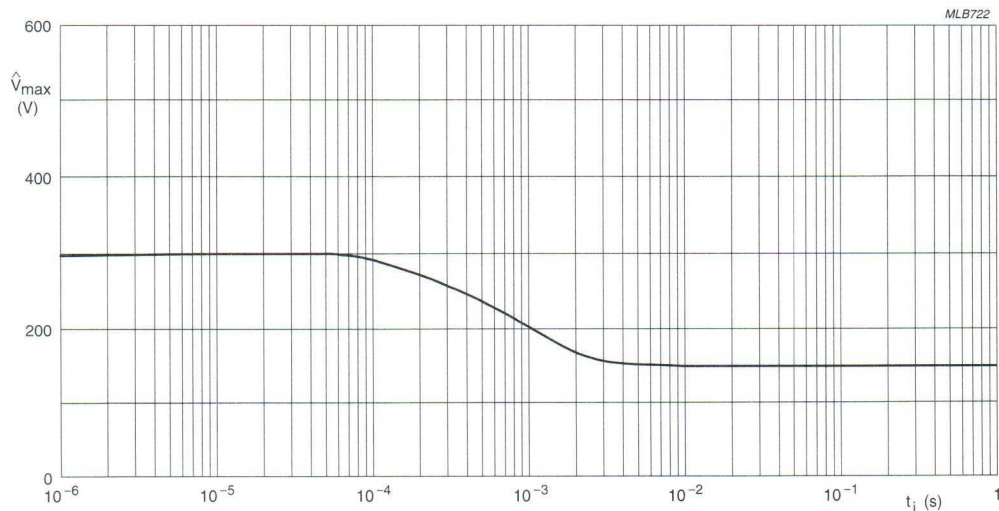


Fig.8 Pulse on a regular basis for type: **RC11**; maximum permissible peak pulse voltage ($\hat{V}_{\max}$) as a function of pulse duration.

Standard chip resistors

sizes 1206, 0805, 0603 and 0402

RC01/11/21/31

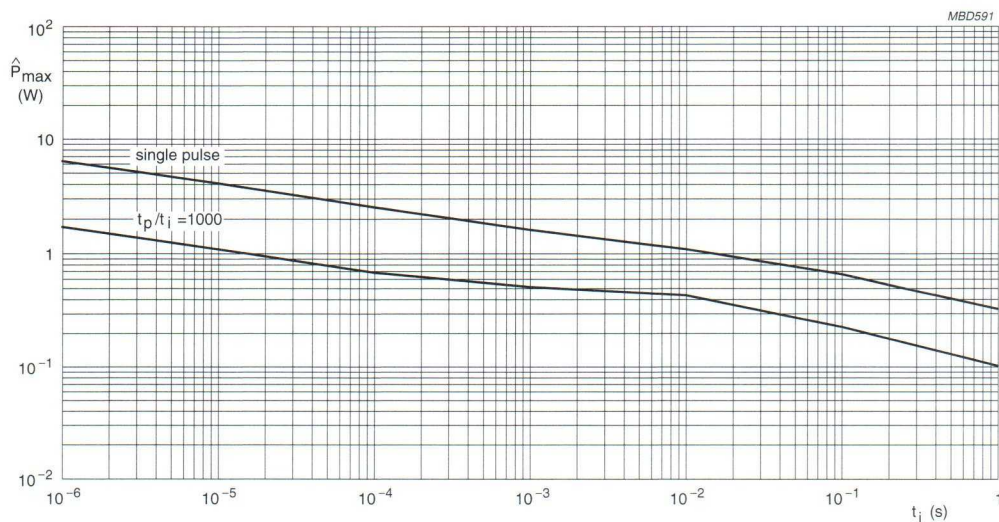


Fig.9 Pulse on a regular basis for type: **RC21**; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration for $R \leq 10 \text{ k}\Omega$, single pulse and repetitive pulse $t_p/t_i = 1000$.

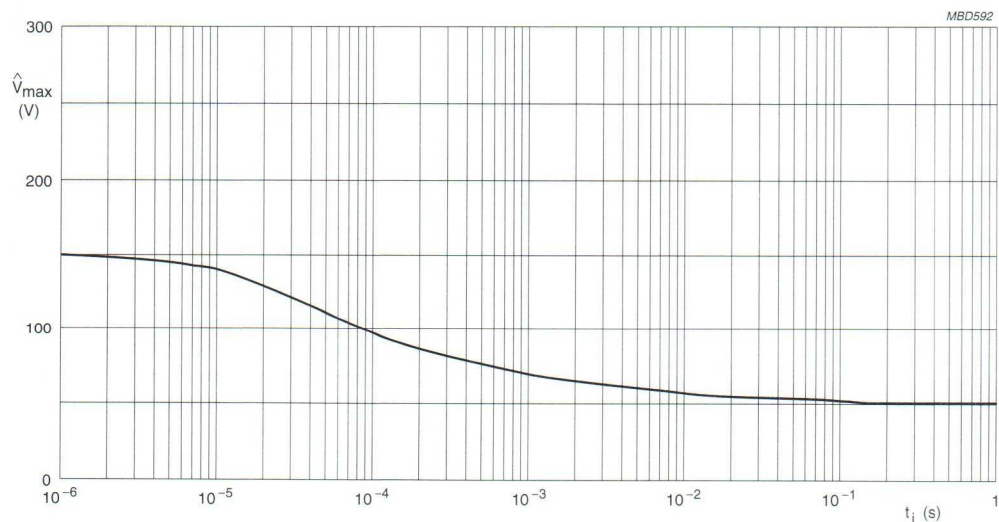


Fig.10 Pulse on a regular basis for type: **RC21**; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration.

Standard chip resistors

sizes 1206, 0805, 0603 and 0402

RC01/11/21/31

MECHANICAL DATA

Mass per 100 units

TYPE	MASS (g)
RC01	1.0
RC11	0.55
RC21	0.25
RC31	0.052

Marking

Each resistor, except RC31, is marked with a three digit code (occasionally four digit) on the protective coating to designate the nominal resistance value.

3-DIGIT MARKING

For values up to 91 Ω the R is used as a decimal point. For values of 100 Ω or greater the first 2 digits are significant, the third indicates the number of zeros to follow.

Example

MARKING	RESISTANCE
12R	12 Ω
823	82 k Ω

4-DIGIT MARKING

For values up to 976 Ω the R is used as a decimal point. For values of 1 k Ω or greater the first 3 digits are significant, the fourth indicates the number of zeros to follow.

Example

MARKING	RESISTANCE
12R0	12 Ω
8202	82 k Ω

The packaging is also marked and includes resistance value, tolerance, TC value, catalogue number, quantity, production period, batch number and source code.

Outlines

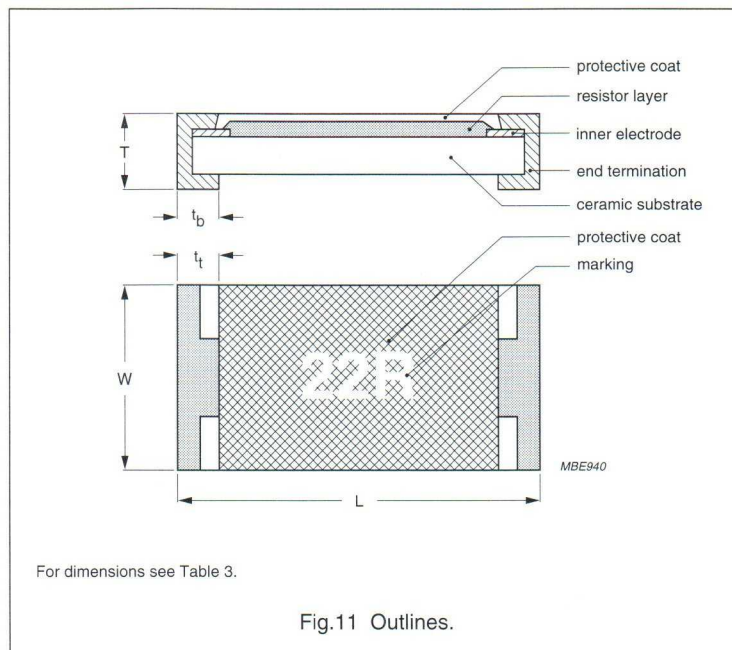


Table 3 Chip resistor types and relevant physical dimensions; see Fig.11

TYPE	L (mm)	W (mm)	T (mm)	t _t (mm)	t _b (mm)
RC01	3.20 +0.10/-0.20	1.60 ±0.15	0.55 ±0.10	0.45 ±0.25	0.50 ±0.25
RC11	2.00 ±0.15	1.25 ±0.15	0.55 ±0.10	0.40 ±0.20	0.40 ±0.20
RC21	1.60 ±0.10	0.80 +0.15/-0.05	0.45 ±0.10	0.30 ±0.20	0.30 ±0.20
RC31	1.00 ±0.05	0.50 ±0.05	0.35 ±0.05	0.20 ±0.10	0.25 ±0.10

Standard chip resistors
sizes 1206, 0805, 0603 and 0402

RC01/11/21/31

Unless otherwise specified the following values apply:

- Temperature: 15 °C to 35 °C
- Relative humidity: 45% to 75%
- Air pressure: 86 kPa to 106 kPa (860 mbar to 1060 mbar).

In Table 4 the tests and requirements are listed with reference to the relevant clauses of "IEC publications 115-8 and 68"; a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

All soldering tests are performed with mildly activated flux.

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of "IEC publication 115-8", category **LCT/UCT/56** (rated temperature range: Lower Category Temperature, Upper Category Temperature; damp heat, long term, 56 days). The testing also covers the requirements specified by EIA and EIAJ.

The tests are carried out in accordance with IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components" and under standard atmospheric conditions according to "IEC 68-1", subclause 5.3.

Table 4 Test procedures and requirements

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	RESISTANCE RANGE	REQUIREMENTS			
					RC01	RC11	RC21	RC31
Tests in accordance with the schedule of IEC publication 115-8								
4.4.1		visual examination			no holes; clean surface; no damage			
4.4.2		dimensions (outline; see Fig.11)	gauge (mm)		$0.45 \leq T \leq 0.65$ $1.45 \leq W \leq 1.75$ $3.0 \leq L \leq 3.3$	$0.45 \leq T \leq 0.65$ $1.10 \leq W \leq 1.40$ $1.85 \leq L \leq 2.15$	$0.35 \leq T \leq 0.55$ $0.75 \leq W \leq 0.95$ $1.50 \leq L \leq 1.70$	$0.30 \leq T \leq 0.40$ $0.45 \leq W \leq 0.55$ $0.95 \leq L \leq 1.05$
4.5		resistance	applied voltage (+0/−10%): R < 10 Ω: 0.1 V 10 Ω ≤ R < 100 Ω: 0.3 V 100 Ω ≤ R < 1 kΩ: 1 V 1 kΩ ≤ R < 10 kΩ: 3 V 10 kΩ ≤ R < 100 kΩ: 10 V 100 kΩ ≤ R < 1 MΩ: 25 V R ≥ 1 MΩ: 50 V		$R - R_{nom}$: max. ±2% or $R - R_{nom}$: max. ±5%			$R - R_{nom}$: max. ±5%

Standard chip resistors

sizes 1206, 0805, 0603 and 0402

RC01/11/21/31

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	RESISTANCE RANGE	REQUIREMENTS			
					RC01	RC11	RC21	RC31
4.18	20 (Ta)	resistance to soldering heat	unmounted chips; 10 s; 260 ±5 °C			no visual damage $\Delta R/R$ max.: ±0.5% +0.05 Ω;	no visual damage $\Delta R/R$ max.: ±1% +0.1 Ω	no visual damage $\Delta R/R$ max.: ±1% +0.1 Ω
4.29	45 (Xa)	component solvent resistance	isopropyl alcohol or H ₂ O followed by brushing in accordance with "MIL 202 F"			no visual damage	no visual damage	
4.17	20 (Ta)	solderability	unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C			good finning (≥95% covered); no visual damage		
4.7		voltage proof on insulation	maximum voltage (RMS) during 1 minute metal block method			no breakdown or flashover		
4.13		short time overload	room temperature; $P = 6.25 \times P_n$; 5 s ($V \leq 2 \times V_{max}$)			$\Delta R/R$ max.: ±1% +0.05 Ω	$\Delta R/R$ max.: ±2% +0.1 Ω	
4.33		bending	resistors mounted on a 90 mm glass epoxy resin PCB (FR4), bending: 3 mm for RC01 and 5 mm for RC11 , RC21 and RC31			no visual damage $\Delta R/R$ max.: ±0.5% +0.05 Ω	no visual damage $\Delta R/R$ max.: ±2% +0.1 Ω	
4.19	14 (Na)	rapid change of temperature	30 minutes at LCT and 30 minutes at UCT; 5 cycles					
4.23		climatic sequence:						
4.23.3	30 (D)	damp heat (accelerated) 1st cycle	6 days; 55 °C; 95 to 98% RH	$R \leq 1 \text{ M}\Omega$		R_{ins} min.: 10 ⁴ MΩ		$\Delta R/R$ max.: ±1% +0.1 Ω
4.23.6	30 (D)	damp heat (accelerated) remaining cycles		$R > 1 \text{ M}\Omega$		$\Delta R/R$ max.: ±3% +0.1 Ω		not applicable

Standard chip resistors

sizes 1206, 0805, 0603 and 0402

RC01/11/21/31

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	RESISTANCE RANGE	REQUIREMENTS			
					RC01	RC11	RC21	RC31
4.24.2	3 (Ca)	damp heat (steady state) (IEC)	56 days; 40 °C; 90 to 95% RH; loaded with 0.01 P _n (IEC steps: 4 to 100 V)	R ≤ 1 MΩ R > 1 MΩ		ΔR/R max.: ±1.5% +0.1 Ω ΔR/R max.: ±3% +0.1 Ω		ΔR/R max.: ±3% +0.1 Ω not applicable
4.25.1		endurance (at 70 °C)	1 000 hours; loaded with P _n or V _{maxi} ; 1.5 hours on and 0.5 hours off	R ≤ 1 MΩ R > 1 MΩ		ΔR/R max.: ±1.5% +0.1 Ω ΔR/R max.: ±3% +0.1 Ω		ΔR/R max.: ±3% +0.1 Ω not applicable
4.23.2	27 (Ba)	endurance at upper category temperature	1 000 hours; no load	R ≤ 1 MΩ		ΔR/R max.: ±1.5% +0.1 Ω		ΔR/R max.: ±3% +0.1 Ω
4.8.4.2		temperature coefficient	at 20/LCT/20 °C and 20/UCT/20 °C (TC × 10 ⁻⁶ /K)	R > 1 MΩ R < 5 Ω R ≤ 10 MΩ		ΔR/R max.: ±3% +0.1 Ω ≤ ±250 ≤ ±200		not applicable not applicable ≤ ±200
Other tests in accordance with IEC 115 clauses and IEC 68 test method								
4.17	20 (Tb)	solderability (after ageing)	8 hours steam or 16 hours 155 °C; unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C			good tinning (≥95% covered); no damage		
4.6.1.1		insulation resistance	voltage (DC) after 1 minute, metal block method: 100 V for RC01 and RC11 , 50 V for RC21 and RC31			R _{ins} min.: 10 ³ MΩ		
4.12		noise	IEC publication 195 (measured with Quantech - equipment)	R ≤ 1 kΩ R ≤ 10 kΩ R ≤ 100 kΩ R ≤ 1 MΩ		max. 1 μV/V max. 3 μV/V max. 6 μV/V max. 10 μV/V		
Other applicable tests								
		humidity load (steady state) (JIS)	1 000 hours; +40 °C; 90 to 95% RH; loaded with P _n or V _{maxi} ; 1.5 hours on and 0.5 hours off	R ≤ 1 MΩ R > 1 MΩ		ΔR/R max.: ±3% +0.1 Ω ΔR/R max.: ±5% +0.1 Ω		not applicable
		leaching	unmounted chips; 60 s; 260 ±5 °C			good tinning; no leaching		
		trio damp heat test	1 000 hours; +85 °C; 85% RH; loaded with 0.1 P _n or V _{max}	R ≤ 1 MΩ R > 1 MΩ		ΔR/R max.: ±3% +0.1 Ω ΔR/R max.: ±5% +0.1 Ω		not applicable

Array chip resistor

ARC241

FEATURES

- Four resistors in one 1206-sized package
- Low assembly costs
- Reduced size of final equipment.

APPLICATIONS

- Computers
- Microcomputer driven applications:
 - Portable radio
 - CD and cassette players
 - Car telephones
 - Camcorders, etc.

DESCRIPTION

The resistors are constructed on a high grade ceramic body (aluminium oxide). Internal metal electrodes are added at each end and connected by a resistive paste which is applied to the top surface of the substrate. The composition of the paste is adjusted to give the approximate resistance required and the value is trimmed to within tolerance, by laser cutting of this resistive layer.

The resistive layer is covered with a protective coating and printed with the resistance value. Finally, external end terminations are added. For ease of soldering the outer layer of these end terminations is a lead/tin alloy.

QUICK REFERENCE DATA

DESCRIPTION	VALUE
Resistance range	10 Ω to 1 M Ω
Resistance tolerance and E-series	$\pm 5\%$; E24 series
Temperature coefficient	$\leq \pm 200 \times 10^{-6}/K$
Absolute maximum dissipation at $T_{amb} = 70^\circ C$	0.062 W
Maximum permissible voltage	50 V (DC or RMS)
Climatic category (IEC 68)	55/125/56
Basic specification	IEC 115-8
Stability after:	
load, 1000 hours at $T_{amb} = 70^\circ C$	$\Delta R/R \text{ max.}: \pm 2.0\% + 0.1 \Omega$
climatic tests	$\Delta R/R \text{ max.}: \pm 3.0\% + 0.1 \Omega$
resistance to soldering heat	$\Delta R/R \text{ max.}: \pm 0.5\% + 0.05 \Omega$
short time overload	$\Delta R/R \text{ max.}: \pm 1.0\% + 0.05 \Omega$

ORDERING INFORMATION

Table 1 Ordering code indicating resistor type and packaging

TYPE	ORDERING CODE 2350 03.
	CARDBOARD TAPE ON REEL
	5000 units
ARC241	4 10...
Jumper 0 Ω	
ARC241; note 1	4 91001

Note

1. The jumper has a maximum resistance $R_{max} = 50 \text{ m}\Omega$ and a rated current $I_R = 1 \text{ A}$.

Ordering code (12NC)

- The resistors have a 12-digit ordering code starting with 2350 03.
- The subsequent three digits indicate the resistor type and packaging; see Table 1.
- The remaining 3 digits indicate the resistance value:
 - The first 2 digits indicate the resistance value
 - The last digit indicates the resistance decade in accordance with Table 2.

Table 2 Last digit of 12NC

RESISTANCE	LAST DIGIT
10 to 91 Ω	9
100 to 910 Ω	1
1 to 9.1 k Ω	2
10 to 91 k Ω	3
100 to 910 k Ω	4
1 M Ω	5

ORDERING EXAMPLE

The ordering code of an ARC241 resistor, value 100 Ω , supplied on cardboard tape of 5000 units per reel is: 2350 034 10101.

Array chip resistor

ARC241

FUNCTIONAL DESCRIPTION

Product characterization

Standard values of nominal resistance are taken from the E24 series for resistors with a tolerance of $\pm 5\%$. The values of the E24 series are in accordance with "IEC publication 63".

Limiting values

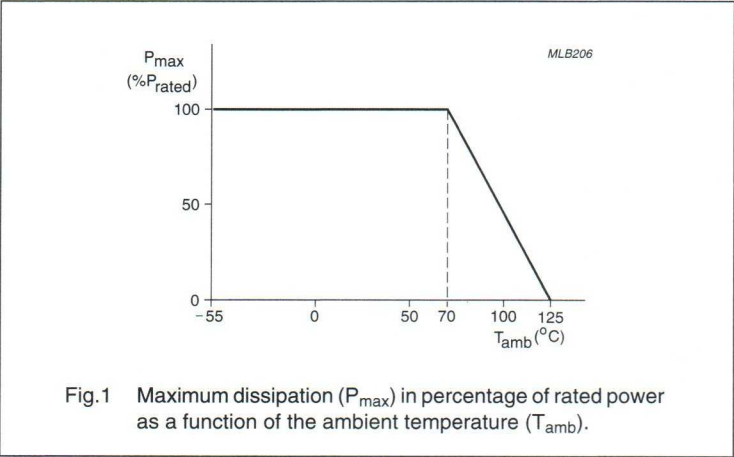
TYPE	LIMITING VOLTAGE ⁽¹⁾ (V)	LIMITING POWER (W)
ARC241	50	0.062

Note

1. This is the maximum voltage that may be continuously applied to the resistor element, see "IEC publication 115-8".

DERATING

The power that the resistor can dissipate depends on the operating temperature; see Fig.1.



Array chip resistor

ARC241

MECHANICAL DATA

Mass per 100 units

TYPE	MASS (g)
ARC241	1.1

Marking

All resistors are marked with a three digit code on the protective coat to designate the nominal resistance value.

3-DIGIT MARKING

For values up to 91 Ω the R is used as a decimal point. For values of 100 Ω or greater the first 2 digits apply to the resistance value and the fourth indicates the number of zeros to follow.

Example

MARKING	RESISTANCE
12R	12 Ω
123	12 k Ω
124	120 k Ω
000	jumper

PACKAGE MARKING

The packaging is also marked and includes resistance value, tolerance, TC value, catalogue number, quantity, production period, batch number and source code.

Outlines

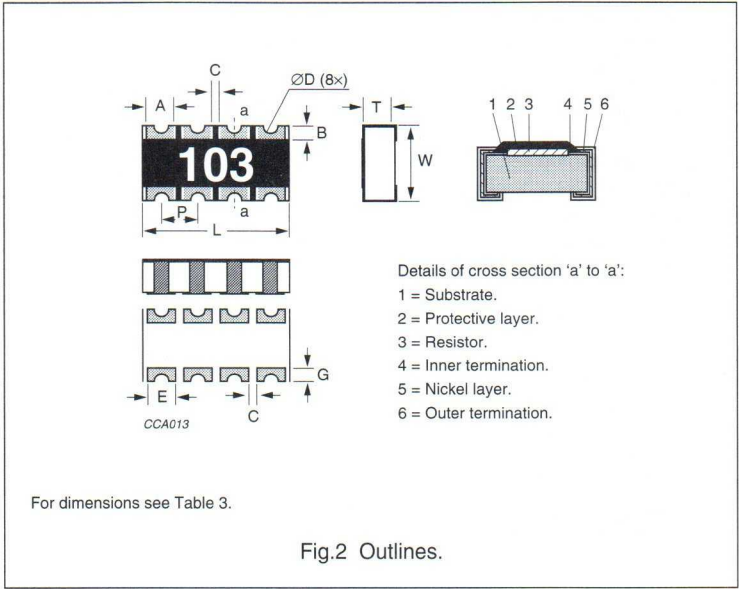


Table 3 Physical dimensions; see Fig.2

SYMBOL	VALUE	TOL.	UNIT
L	3.20	+0.20/-0.10	mm
W	1.60	+0.20/-0.10	mm
T	0.60	± 0.20	mm
A	0.60	± 0.15	mm
D	(0.30)	—	mm
B	0.35	± 0.15	mm
P	0.80	± 0.15	mm
E	0.50	± 0.15	mm
G	0.50	± 0.15	mm
C	0.10	min.	mm

Array chip resistor

ARC241

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of "IEC publication 115-8", category 55/125/56 (rated temperature range -55 to +125 °C; damp heat, long term, 56 days). The testing also covers the requirements specified by EIA, EIAJ and JIS.

The tests are carried out in accordance with IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components" and under standard atmospheric conditions according to "IEC 68-1", subclause 5.3.

Unless otherwise specified the following values apply:

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

Air pressure: 86 kPa to 106 kPa
(860 mbar to 1060 mbar).

In Table 4 the tests and requirements are listed with reference to the relevant clauses of "IEC publications 115-8 and 68"; a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

All soldering tests are performed with mildly activated flux.

Table 4 Test procedures and requirements

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
Tests in accordance with the schedule of IEC publication 115-8				
4.4.1		visual examination		no holes; clean surface; no damage
4.4.2		dimensions (outline; see Fig.2)	gauge (mm)	$0.40 \leq T \leq 0.80$ $1.50 \leq W \leq 1.80$ $3.1 \leq L \leq 3.4$
4.5		resistance	applied voltage (+0/-10%): $10 \Omega \leq R < 100 \Omega$: 0.3 V $100 \Omega \leq R < 1 \text{ k}\Omega$: 1 V $1 \text{ k}\Omega \leq R < 10 \text{ k}\Omega$: 3 V $10 \text{ k}\Omega \leq R < 100 \text{ k}\Omega$: 10 V $100 \text{ k}\Omega \leq R < 1 \text{ M}\Omega$: 25 V $R \geq 1 \text{ M}\Omega$: 50 V	$R - R_{\text{nom}}$: max. $\pm 5\%$
4.18	20 (Ta)	resistance to soldering heat	unmounted chips; 10 s; $260 \pm 5 \text{ }^\circ\text{C}$	no visual damage $\Delta R/R$ max.: $\pm 0.5\% + 0.05 \Omega$
4.29	45 (Xa)	component solvent resistance	isopropyl alcohol or H ₂ O followed by brushing in accordance with "MIL 202 F"	no visual damage
4.17	20 (Ta)	solderability	unmounted chips completely immersed for $2 \pm 0.5 \text{ s}$ in a solder bath at $235 \pm 5 \text{ }^\circ\text{C}$	good tinning ($\geq 95\%$ covered); no visual damage
4.7		voltage proof on insulation	maximum voltage (RMS) during 1 minute metal block method	no breakdown or flashover
4.13		short time overload	room temperature; $P = 6.25 \times P_n$; 5 s ($V \leq 2 \times V_{\text{max}}$)	$\Delta R/R$ max.: $\pm 1\% + 0.05 \Omega$
4.33		bending	resistors mounted on a 90 mm glass epoxy resin PCB (FR4), bending: 5 m	no visual damage $\Delta R/R$ max.: $\pm 1\% + 0.05 \Omega$

Array chip resistor

ARC241

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.19	14 (Na)	rapid change of temperature	30 minutes at LCT and 30 minutes at UCT; 5 cycles	no visual damage $\Delta R/R$ max.: $\pm 0.5\% + 0.05 \Omega$
4.23	30 (D)	climatic sequence:	6 days; 55 °C; 95 to 98% RH	R_{ins} min.: $10^3 M\Omega$ $\Delta R/R$ max.: $\pm 1.5\% + 0.1 \Omega$
4.23.3		damp heat (accelerated) 1st cycle		
4.23.6		damp heat (accelerated) remaining cycles		
4.24.2	3 (Ca)	damp heat (steady state) (IEC)	56 days; 40 °C; 90 to 95% RH; loaded with $0.01 P_n$ (IEC steps: 4 to 100 V)	$\Delta R/R$ max.: $\pm 3\% + 0.1 \Omega$
4.25.1		endurance (at 70 °C)	1000 hours; loaded with P_n or V_{max} ; 1.5 hours on and 0.5 hours off	$\Delta R/R$ max.: $\pm 2\% + 0.1 \Omega$
4.23.2	27 (Ba)	endurance at upper category temperature	1000 hours; no load	$\Delta R/R$ max.: $\pm 2\% + 0.1 \Omega$
4.8.4.2		temperature coefficient	at 20/LCT/20 °C and 20/UCT/20 °C ($TC \times 10^{-6}/K$)	$\leq \pm 200$
Other tests in accordance with IEC 115 clauses and IEC 68 test method				
4.17	20 (Tb)	solderability (after ageing)	8 hours steam or 16 hours 155 °C; unmounted chips completely immersed for 2 ± 0.5 s in a solder bath at 235 ± 5 °C	good tinning ($\geq 95\%$ covered); no damage
4.6.1.1		insulation resistance	voltage (DC) after 1 minute, metal block method: 10 V	R_{ins} min.: $10^4 M\Omega$
4.12		noise	IEC publication 195 (measured with Quantech - equipment)	$R < 1 K$; max. $1 \mu V/V$ $R < 10 K$; max. $3 \mu V/V$ $R < 100 K$; max. $6 \mu V/V$ $R < 1 M$; max. $10 \mu V/V$
Other applicable tests				
	(JIS)	moisture load	1000 hours; +60 °C; 90 to 95% RH; loaded with P_n or V_{max} ; 1.5 hours on and 0.5 hours off	$\Delta R/R$ max.: $\pm 3\% + 0.1 \Omega$
		leaching	unmounted chips; 60 s; 260 ± 5 °C	good tinning; no leaching
	(JIS)	temperature cycling	30 minutes at LCT, 10 minutes 20 °C, 30 minutes at UCT, 10 minutes 20 °C; 5 cycles	no visual damage $\Delta R/R$ max.: $\pm 0.5\% + 0.05 \Omega$
		pull strength	30 s, 500 grams on terminations	no visual damage $\Delta R/R$ max.: $\pm 1\% + 0.05 \Omega$

Precision chip resistors

sizes 1206, 0805 and 0603

RC02/12/22

FEATURES

- Low assembly costs
- High component and equipment reliability
- Excellent performance at high frequency, especially the RC22.
- TC 50 in thick film technology
- Complete precision SMD family.

APPLICATIONS

- All general purpose applications.

DESCRIPTION

The resistors are constructed on a high grade ceramic body (aluminium oxide). Internal metal electrodes are added at each end and connected by a resistive paste which is applied to the top surface of the substrate. The composition of the paste is adjusted to give the approximate resistance required and the value is trimmed to within tolerance, by laser cutting of this resistive layer.

The resistive layer is covered with a protective coat and printed with the resistance value (no printing on RC22). Finally, the two external end terminations are added. For ease of soldering the outerlayer of these end terminations is a lead/tin alloy.

QUICK REFERENCE DATA

DESCRIPTION	VALUE				
	RC02H	RC02G	RC12H	RC12G	RC22H
Size code	1206 (3216)		0805 (2012)		0603 (1608)
Resistance range	1 Ω to 10 M Ω	100 Ω to 1 M Ω	1 Ω to 10 M Ω	100 Ω to 1 M Ω	1 Ω to 10 M Ω
Resistance tolerance and E-series	$\pm 1\%$; E24/E96 series				
Temperature coefficient; note 1: 1 $\Omega \leq R < 5 \Omega$ 5 $\Omega \leq R < 10 \Omega$ 10 $\Omega \leq R < 100 \Omega$ 100 $\Omega \leq R \leq 1 \text{ M}\Omega$ 1 M $\Omega < R \leq 10 \text{ M}\Omega$	$\leq \pm 250$ $\leq \pm 200$ $\leq \pm 100$ $\leq \pm 100$ $\leq \pm 200$	— — — $\leq \pm 50$ —	$\leq \pm 250$ $\leq \pm 200$ $\leq \pm 100$ $\leq \pm 100$ $\leq \pm 200$	— — — $\leq \pm 50$ —	$\leq \pm 250$ $\leq \pm 200$ $\leq \pm 100$ $\leq \pm 100$ $\leq \pm 200$
Maximum dissipation at $T_{\text{amb}} = 70^\circ\text{C}$	0.25 W		0.125 W		0.063 W
Maximum permissible voltage	200 V (DC or RMS)		150 V (DC or RMS)		50 V (DC or RMS)
Climatic category (IEC 68)	55/155/56	55/125/56	55/155/56	55/125/56	55/155/56
Basic specification	IEC 115-8				
Stability after: load, 1000 hours at $T_{\text{amb}} = 70^\circ\text{C}$: 1 $\Omega \leq R \leq 1 \text{ M}\Omega$ R > 1 M Ω climatic tests: 1 $\Omega \leq R \leq 1 \text{ M}\Omega$ R > 1 M Ω resistance to soldering heat short time overload	$\Delta R/R$ max.: $\pm 1.0\% + 0.05 \Omega$ $\Delta R/R$ max.: $\pm 1.5\% + 0.05 \Omega$ $\Delta R/R$ max.: $\pm 1.0\% + 0.05 \Omega$ $\Delta R/R$ max.: $\pm 1.5\% + 0.05 \Omega$ $\Delta R/R$ max.: $\pm 0.5\% + 0.05 \Omega$ $\Delta R/R$ max.: $\pm 1.0\% + 0.05 \Omega$				

Note

1. All TC values should be multiplied by $10^{-6}/\text{K}$.

Precision chip resistors sizes 1206, 0805 and 0603

RC02/12/22

ORDERING INFORMATION

Table 1 Ordering code indicating type and packaging

TYPE	ORDERING CODE 2322				
	CARDBOARD TAPE ON REEL			EMBOSSED CARRIER TAPE ON REEL	
	5000 units	10000 units	20000 units	5000 units	10000 units
RC02H	724 6....	724 7....	724 8....	724 2....	724 4....
RC02G	722 2....	722 3....	—	723 6....	723 7....
RC12H	734 6....	734 7....	734 8....	734 2....	734 4....
RC12G	732 6....	732 7....	—	733 6....	733 7....
RC22H	704 6....	704 7....	704 8....	—	—
Jumper 0 Ω					
RC02H; note 1	724 92006	724 92007	—	724 92002	724 92004
RC12H; note 1	734 92006	734 92007	—	734 92002	734 92004
RC22H; note 2	704 92006	704 92007	—	—	—

Notes

1. The jumper has a maximum resistance $R_{\max} = 50 \text{ m}\Omega$ and a rated current $I_R = 2 \text{ A}$.
2. The jumper has a maximum resistance $R_{\max} = 50 \text{ m}\Omega$ and a rated current $I_R = 1 \text{ A}$.

Ordering code (12NC)

- The resistors have a 12-digit ordering code starting with 2322.
- The subsequent 4 digits indicate the resistor type and packaging; see Table 1.
- The remaining 4 digits indicate the resistance value:
 - The first 3 digits indicate the resistance value.
 - The last digit indicates the resistance decade in accordance with Table 2.

Table 2 Last digit of 12NC

RESISTANCE DECADE	LAST DIGIT
1 to 9.76 Ω	8
10 to 97.6 Ω	9
100 to 976 Ω	1
1 to 9.76 k Ω	2
10 to 97.6 k Ω	3
100 to 976 k Ω	4
1 to 9.76 M Ω	5
10 M Ω	6

Type designation

SIZE	TYPE	TC SERIES
1206	RC02H	100
	RC02G	50
0805	RC12H	100
	RC12G	50
0603	RC22H	100

ORDERING EXAMPLE

The ordering code of a RC02H resistor, value 4750 Ω , supplied on cardboard tape of 5000 units per reel is: 2322 724 64752.

Precision chip resistors sizes 1206, 0805 and 0603

RC02/12/22

FUNCTIONAL DESCRIPTION

Product characterization

Standard values of nominal resistance are taken from the E24/E96 series for resistors with a tolerance of $\pm 1\%$. The values of the E24/96 series are in accordance with "IEC publication 63".

Limiting values

TYPE	LIMITING VOLTAGE ⁽¹⁾ (V)	LIMITING POWER (W)
RC02	200	0.25
RC12	150	0.125
RC22	50	0.063

Note

1. This is the maximum voltage that may be continuously applied to the resistor element, see "IEC publication 115-8".

DERATING

The power that the resistor can dissipate depends on the operating temperature; see Fig.1.

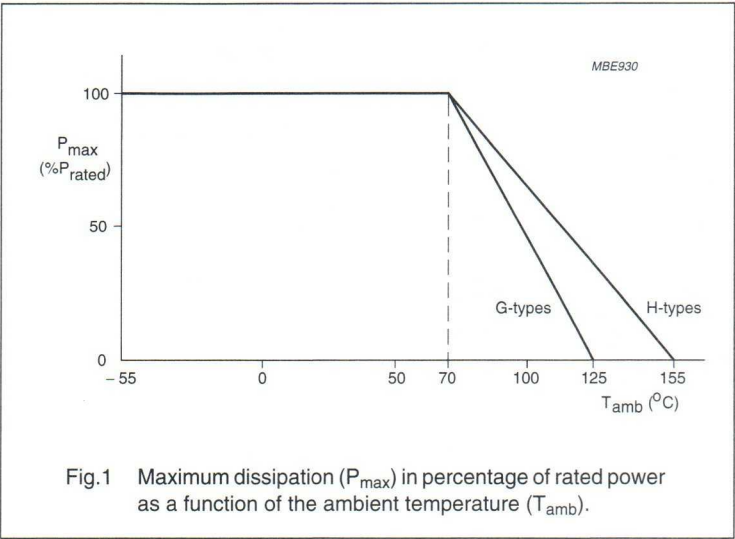
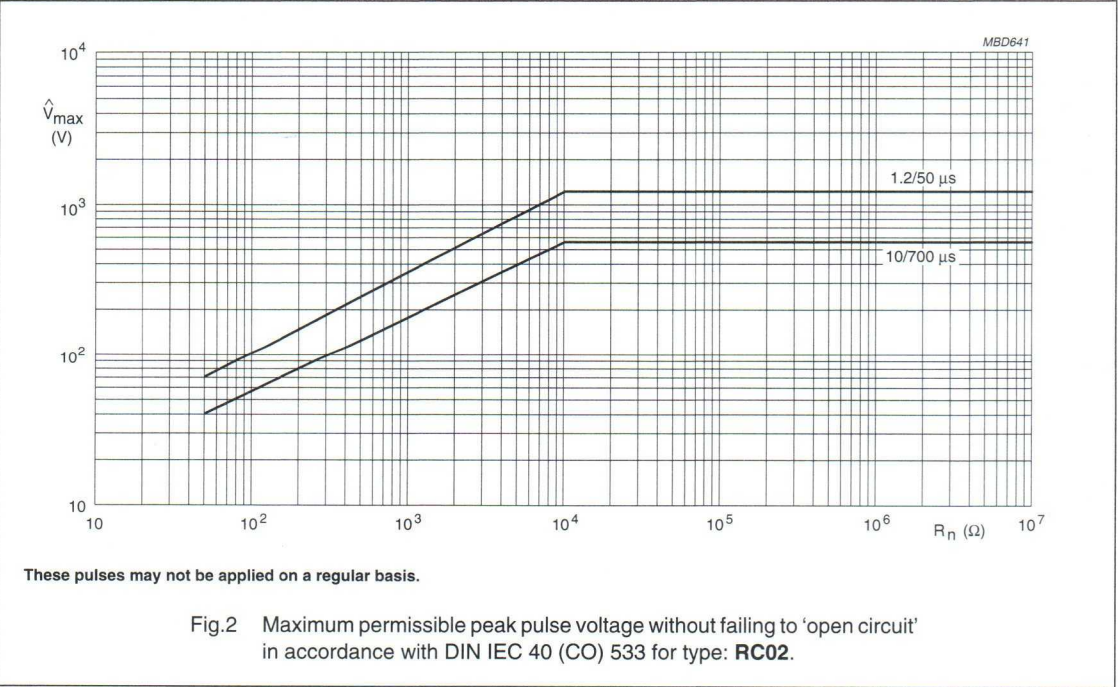


Fig.1 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

PULSE LOADING CAPABILITIES

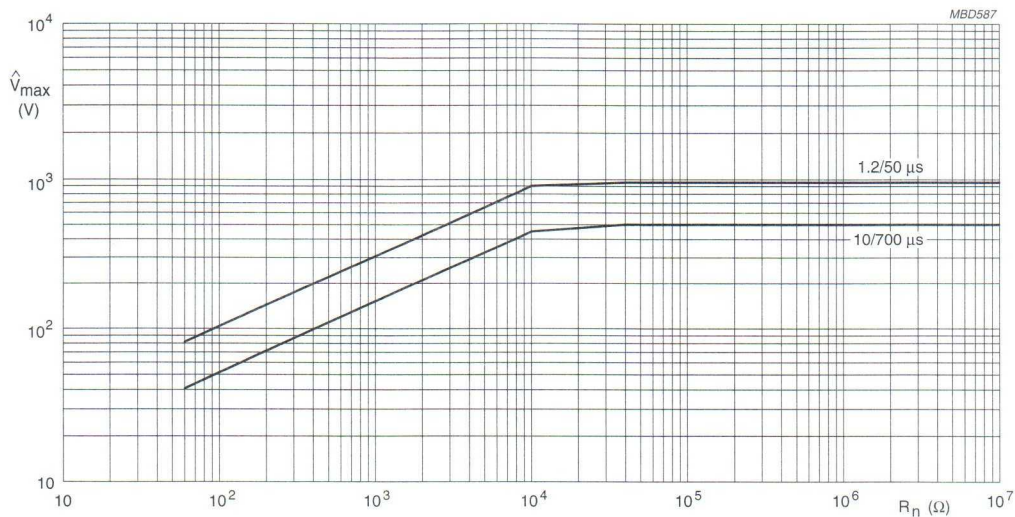


These pulses may not be applied on a regular basis.

Fig.2 Maximum permissible peak pulse voltage without failing to 'open circuit' in accordance with DIN IEC 40 (CO) 533 for type: **RC02**.

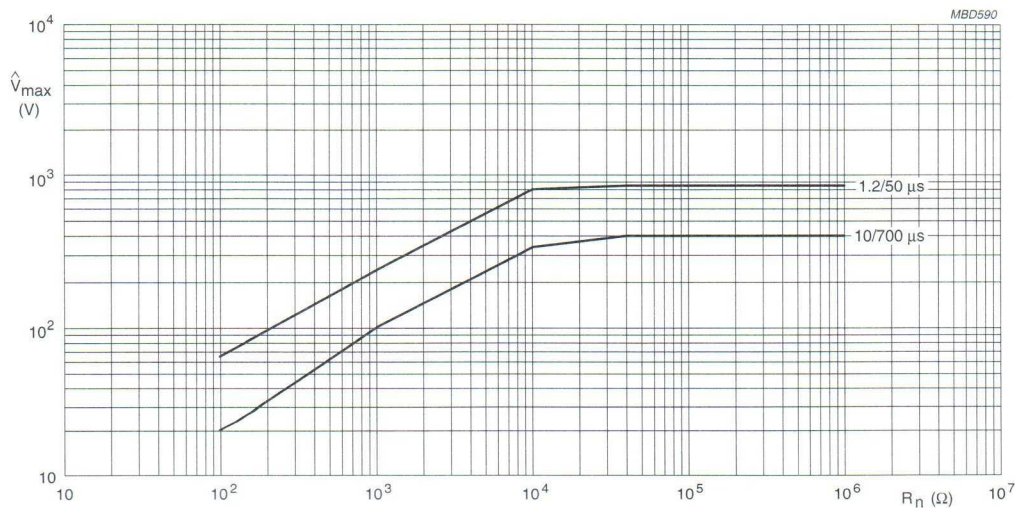
Precision chip resistors sizes 1206, 0805 and 0603

RC02/12/22



These pulses may not be applied on a regular basis.

Fig.3 Maximum permissible peak pulse voltage without failing to 'open circuit' in accordance with DIN IEC 40 (CO) 533 for type: **RC12**.



These pulses may not be applied on a regular basis.

Fig.4 Maximum permissible peak pulse voltage without failing to 'open circuit' in accordance with DIN IEC 40 (CO) 533 for type: **RC22**.

Precision chip resistors sizes 1206, 0805 and 0603

RC02/12/22

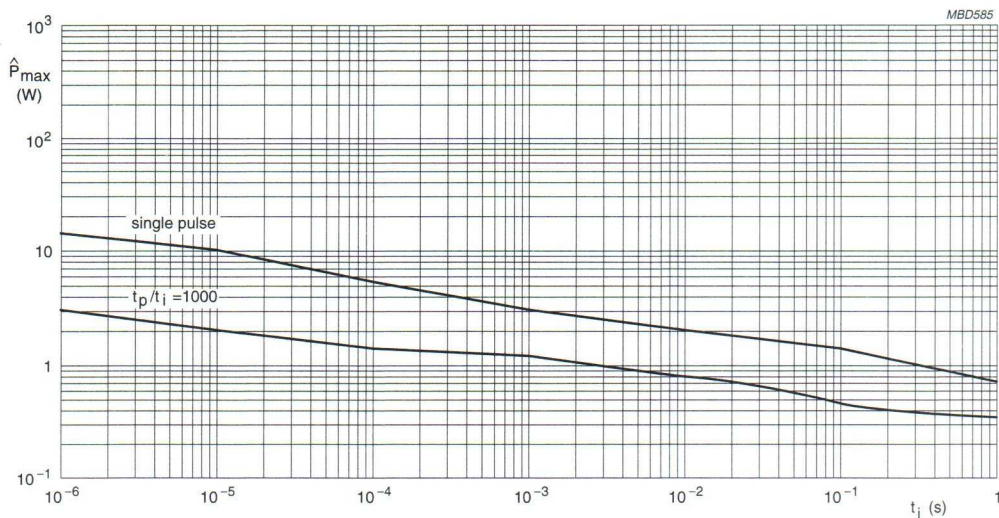


Fig.5 Pulse on a regular basis for type: **RC02**; maximum permissible peak pulse power ($\hat{P}_{\max}$) as a function of pulse duration for $R \leq 10 \text{ k}\Omega$, single pulse and repetitive pulse $t_p/t_i = 1000$.

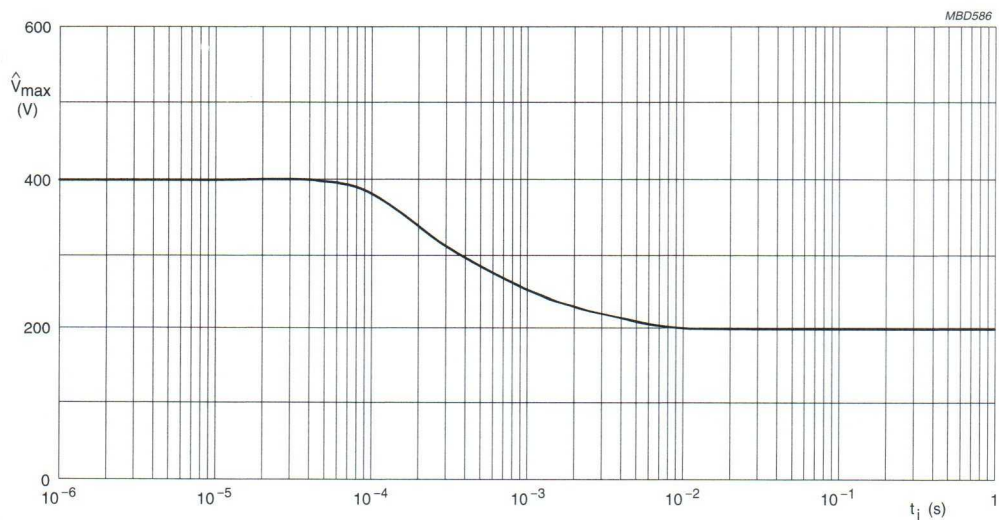


Fig.6 Pulse on a regular basis for type: **RC02**; maximum permissible peak pulse voltage ($\hat{V}_{\max}$) as a function of pulse duration.

Precision chip resistors
sizes 1206, 0805 and 0603

RC02/12/22

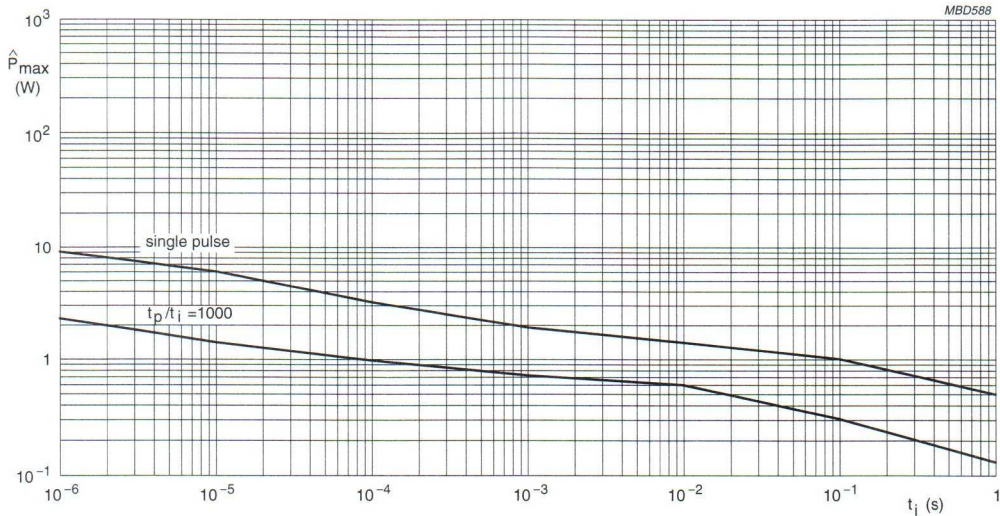


Fig.7 Pulse on a regular basis for type: **RC12**; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration for $R \leq 10 \text{ k}\Omega$, single pulse and repetitive pulse $t_p/t_i = 1000$.

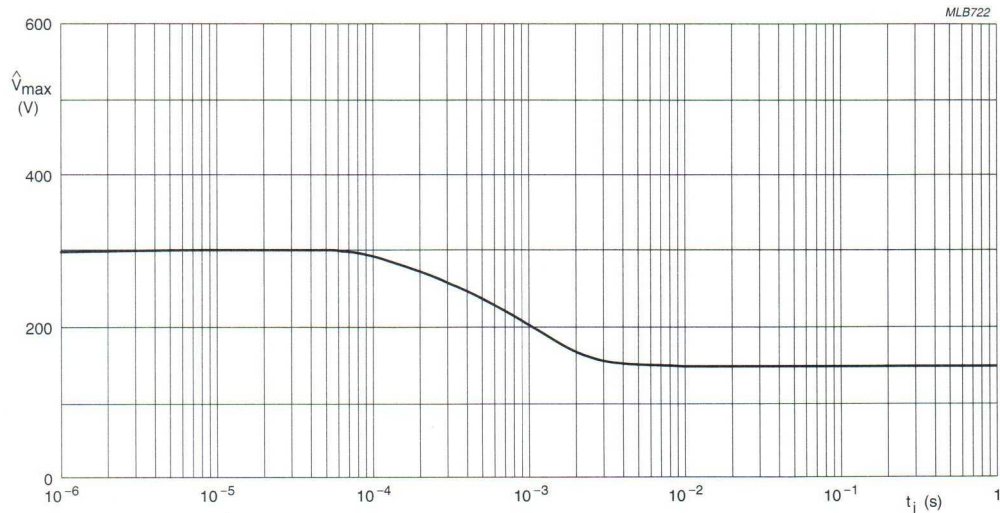


Fig.8 Pulse on a regular basis for type: **RC12**; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration.

Precision chip resistors sizes 1206, 0805 and 0603

RC02/12/22

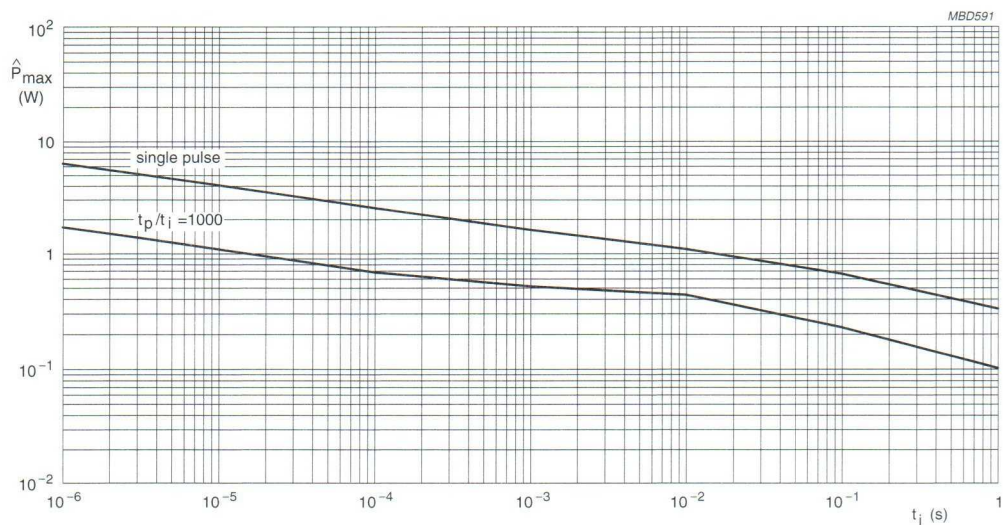


Fig.9 Pulse on a regular basis for type: **RC22**; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration for $R \leq 10 \text{ k}\Omega$, single pulse and repetitive pulse $t_p/t_i = 1000$.

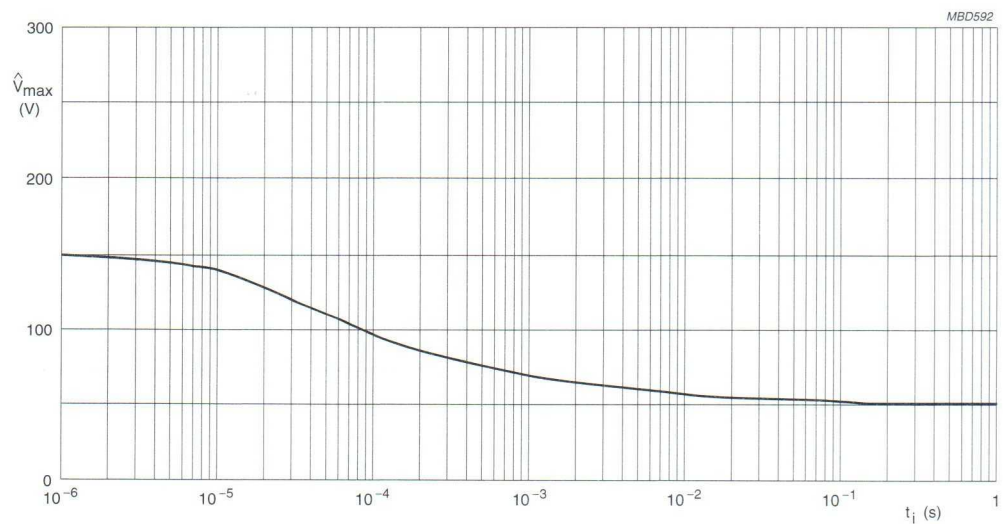


Fig.10 Pulse on a regular basis for type: **RC22**; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration.

Precision chip resistors
sizes 1206, 0805 and 0603

RC02/12/22

MECHANICAL DATA

Mass per 100 units

TYPE	MASS (g)
RC02	1.0
RC12	0.55
RC22	0.25

Marking

All resistors except RC22 are marked with a four digit code on the protective coat to designate the nominal resistance value.

4-DIGIT MARKING

For values up to 976 Ω the R is used as a decimal point. For values of 1 kΩ or greater the first 3 digits apply to the resistance value and the fourth indicates the number of zeros to follow.

Example

MARKING	RESISTANCE
121R	121 Ω
4021	4.02 kΩ
1503	150 kΩ

PACKAGE MARKING

The packaging of all resistors including RC22 is also marked and includes resistance value, tolerance, TC value, catalogue number, quantity, production period, batch number and source code.

Outlines

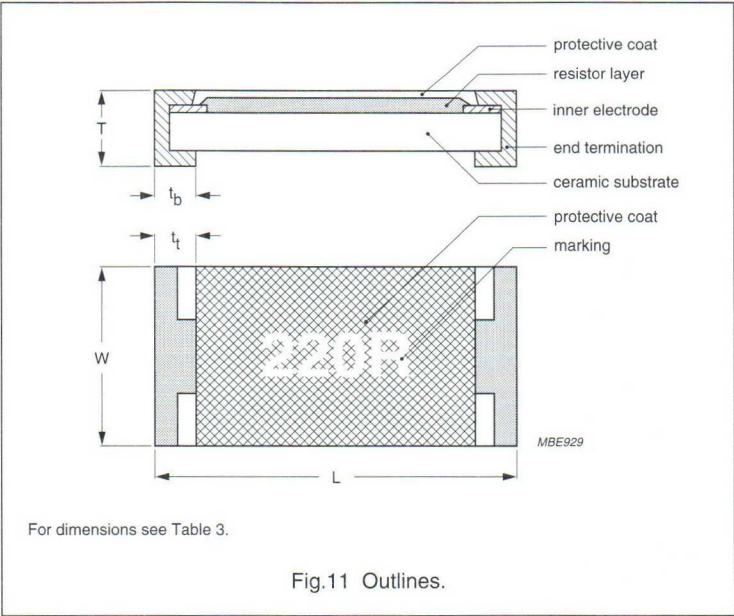


Table 3 Chip resistor types and relevant physical dimensions; see Fig.11

TYPE	L (mm)	W (mm)	T (mm)	t _t (mm)	t _b (mm)
RC02	3.20 +0.10/−0.20	1.60 ±0.15	0.55 ±0.10	0.45 ±0.25	0.50 ±0.25
RC12	2.00 ±0.15	1.25 ±0.15	0.55 ±0.10	0.40 ±0.20	0.40 ±0.20
RC22	1.60 ±0.10	0.80 +0.15/−0.05	0.45 ±0.10	0.30 ±0.20	0.30 ±0.20

Precision chip resistors sizes 1206, 0805 and 0603

RC02/12/22

Unless otherwise specified the following values apply:

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

Air pressure: 86 kPa to 106 kPa (860 mbar to 1060 mbar).

In Table 4 the tests and requirements are listed with reference to the relevant clauses of "IEC publications 115-8 and 68"; a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

All soldering tests are performed with mildly activated flux.

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of "IEC publication 115-8", category **LCT/UCT/56** (rated temperature range: Lower Category Temperature, Upper Category Temperature; damp heat, long term, **56** days). The testing also covers the requirements specified by EIA and EIAJ.

The tests are carried out in accordance with IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components" and under standard atmospheric conditions according to "IEC 68-1", subclause 5.3.

Table 4 Test procedures and requirements

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	RESISTANCE RANGE	REQUIREMENTS			
					RC02H	RC02G	RC12H	RC12G
Tests in accordance with the schedule of IEC publication 115-8								
4.4.1		visual examination			no holes; clean surface; no damage			
4.4.2		dimensions (outline; see Fig.11)	gauge (mm)		$0.45 \leq T \leq 0.65$ $1.45 \leq W \leq 1.75$ $3.0 \leq L \leq 3.3$	$0.45 \leq T \leq 0.65$ $1.10 \leq W \leq 1.40$ $1.85 \leq L \leq 2.15$	$0.35 \leq T \leq 0.55$ $0.75 \leq W \leq 0.95$ $1.50 \leq L \leq 1.70$	
4.5		resistance	applied voltage (+0/−10%): R < 10 Ω: 0.1 V 10 Ω ≤ R < 100 Ω: 0.3 V 100 Ω ≤ R < 1 kΩ: 1 V 1 kΩ ≤ R < 10 kΩ: 3 V 10 kΩ ≤ R < 100 kΩ: 10 V 100 kΩ ≤ R < 1 MΩ: 25 V R ≥ 1 MΩ: 50 V		R − R _{nom} : max. ±1%			
4.18	20 (Ta)	resistance to soldering heat	unmounted chips; 10 s; 260 ±5 °C		no visual damage ΔR/R max.: ±0.5% +0.05 Ω			
4.29	45 (Xa)	component solvent resistance	isopropyl alcohol or H ₂ O followed by brushing in accordance with "MIL 202 F"		no visual damage			

Precision chip resistors

sizes 1206, 0805 and 0603

RC02/12/22

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	RESISTANCE RANGE	REQUIREMENTS				
					RC02H	RC02G	RC12H	RC12G	RC22H
4.17	20 (Ta)	solderability	unmounted chips completely immersed for 2 ± 0.5 s in a solder bath at 235 ± 5 °C		good tinning ($\geq 95\%$ covered); no visual damage				
4.7		voltage proof on insulation	maximum voltage (RMS) during 1 minute, metal block method		no breakdown or flashover				
4.13		short time overload	room temperature; $P = 6.25 \times P_n$; $5 \text{ s } (V \leq 2 \times V_{max})$		$\Delta R/R$ max.: $\pm 1\% + 0.05 \Omega$				
4.33		bending	resistors mounted on a 90 mm glass epoxy resin PCB (FR4), bending: 3 mm for RC02H and RC02G ; 5 mm for RC12H , RC12G and RC22H		no visual damage $\Delta R/R$ max.: $\pm 0.5\% + 0.05 \Omega$				
4.19	14 (Na)	rapid change of temperature	30 minutes at LCT and 30 minutes at UCT; 5 cycles		no visual damage $\Delta R/R$ max.: $\pm 0.5\% + 0.05 \Omega$				
4.23		climatic sequence:							
4.23.3	30 (D)	damp heat (accelerated) 1st cycle	6 days; 55 °C; 95 to 98% RH	$R \leq 1 \text{ M}\Omega$ $R > 1 \text{ M}\Omega$	R_{ins} min.: $10^4 \text{ M}\Omega$ $\Delta R/R$ max.: $\pm 1.0\% + 0.05 \Omega$ $\Delta R/R$ max.: $\pm 1.5\% + 0.05 \Omega$				
4.23.6	30 (D)	damp heat (accelerated) remaining cycles		$R \leq 1 \text{ M}\Omega$ $R > 1 \text{ M}\Omega$	$\Delta R/R$ max.: $\pm 1.0\% + 0.05 \Omega$ $\Delta R/R$ max.: $\pm 1.5\% + 0.05 \Omega$				
4.24.2	3 (Ca)	damp heat (steady state) (IEC)	56 days; 40 °C; 90 to 95% RH; loaded with $0.01 P_n$ (IEC steps: 4 to 100 V)	$R \leq 1 \text{ M}\Omega$ $R > 1 \text{ M}\Omega$	$\Delta R/R$ max.: $\pm 1.0\% + 0.05 \Omega$ $\Delta R/R$ max.: $\pm 1.5\% + 0.05 \Omega$				
4.25.1		endurance (at 70 °C)	1000 hours; loaded with P_n or V_{max} ; 1.5 hours on and 0.5 hours off	$R \leq 1 \text{ M}\Omega$ $R > 1 \text{ M}\Omega$	$\Delta R/R$ max.: $\pm 1.0\% + 0.05 \Omega$ $\Delta R/R$ max.: $\pm 1.5\% + 0.05 \Omega$				
4.23.2	27 (Ba)	endurance at upper category temperature	1000 hours; no load	$R \leq 1 \text{ M}\Omega$ $R > 1 \text{ M}\Omega$	$\Delta R/R$ max.: $\pm 1.0\% + 0.05 \Omega$ $\Delta R/R$ max.: $\pm 1.5\% + 0.05 \Omega$				

Precision chip resistors

sizes 1206, 0805 and 0603

RC02/12/22

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	RESISTANCE RANGE	REQUIREMENTS				
					RC02H	RC02G	RC12H	RC12G	RC22H
4.8.4.2		temperature coefficient	at 25/LCT/25 °C and 25/UCT/25 °C ($TC \times 10^{-6}/K$)	$R < 5 \Omega$ $R < 10 \Omega$ $R < 100 \Omega$ $R \leq 1 M\Omega$ $R \leq 10 M\Omega$	$\leq \pm 250$ $\leq \pm 200$ $\leq \pm 100$ $\leq \pm 100$ $\leq \pm 200$	— — — $\leq \pm 50$ —	$\leq \pm 250$ $\leq \pm 200$ $\leq \pm 100$ $\leq \pm 100$ $\leq \pm 200$	— — — $\leq \pm 50$ —	$\leq \pm 250$ $\leq \pm 200$ $\leq \pm 100$ $\leq \pm 100$ $\leq \pm 200$
Other tests in accordance with IEC 115 clauses and IEC 68 test method									
4.17	20 (Tb)	solderability (after ageing)	8 hours steam or 16 hours 155 °C; unmounted chips completely immersed for 2 ± 0.5 s in a solder bath at 235 ± 5 °C		good tinning ($\geq 95\%$ covered); no damage				
4.6.1.1		insulation resistance	voltage (DC) after 1 minute, metal block method: 100 V for RC02H , RC02G , RC12H and RC12G , 50 V for RC22H		R_{ins} min.: $10^3 M\Omega$				
4.12		noise	IEC publication 195 (measured with Quantech - equipment)	$R \leq 1 k\Omega$ $R \leq 10 k\Omega$ $R \leq 100 k\Omega$ $R \leq 1 M\Omega$	max. 1 $\mu V/V$ max. 3 $\mu V/V$ max. 6 $\mu V/V$ max. 10 $\mu V/V$				
Other applicable tests									
		humidity load (steady state) (JIS)	1000 hours; +40 °C; 90 to 95% RH; loaded with P_n or V_{max} ; 1.5 hours on and 0.5 hours off	$R \leq 1 M\Omega$ $R > 1 M\Omega$	$\Delta R/R$ max.: $\pm 2\% + 0.1 \Omega$ $\Delta R/R$ max.: $\pm 3\% + 0.1 \Omega$				
		leaching	unmounted chips 60 s; 260 ± 5 °C		good tinning; no leaching				
		trio damp heat test	1000 hours; +85 °C; 85% RH; loaded with 0.1 P_n or V_{max}	$R \leq 1 M\Omega$ $R > 1 M\Omega$	$\Delta R/R$ max.: $\pm 2\% + 0.1 \Omega$ $\Delta R/R$ max.: $\pm 3\% + 0.1 \Omega$				

High precision chip resistor size 1206

RC03G

FEATURES

- Reduced size of final equipment
- Low assembly costs
- Higher component and equipment reliability
- Excellent performance at high frequency.

APPLICATIONS

- Power supply in small sized equipment
- Telecommunication
- Medical and Military
- Automotive industry.

DESCRIPTION

The resistors are constructed on a high grade ceramic body (aluminium oxide). Internal metal electrodes are added at each end and connected by a resistive paste which is applied to the top surface of the substrate. The composition of the paste is adjusted to give the approximate resistance required and the value is trimmed to within tolerance, by laser cutting of this resistive layer.

The resistive layer is covered with a protective coating and printed with the resistance value. Finally, the two external end terminations are added. For ease of soldering the outer layer of these end terminations is a lead/tin alloy.

QUICK REFERENCE DATA

DESCRIPTION	VALUE
Resistance range	100 Ω to 1 M Ω
Resistance tolerance and E-series	$\pm 0.5\%$; E24/E96 series
Temperature coefficient 100 $\Omega \leq R < 250 \Omega$ 250 $\Omega \leq R \leq 1 \text{ M}\Omega$	$\leq \pm 100 \times 10^{-6}/\text{K}$ $\leq \pm 50 \times 10^{-6}/\text{K}$
Absolute maximum dissipation at $T_{\text{amb}} = 70^\circ\text{C}$	0.125 W
Maximum permissible voltage	200 V (DC or RMS)
Climatic category (IEC 68)	55/125/56
Basic specification	IEC 115-8
Stability after: load, 1000 hours at $T_{\text{amb}} = 70^\circ\text{C}$ climatic tests resistance to soldering heat short time overload	$\Delta R/R_{\text{max}}: \pm 0.5\% + 0.05 \Omega$ $\Delta R/R_{\text{max}}: \pm 1\% + 0.05 \Omega$ $\Delta R/R_{\text{max}}: \pm 0.25\% + 0.05 \Omega$ $\Delta R/R_{\text{max}}: \pm 0.25\% + 0.05 \Omega$

ORDERING INFORMATION

Table 1 Ordering code indicating resistor type and packaging

TYPE	ORDERING CODE 2322 725
	EMBOSSED CARRIER TAPE ON REEL
	5000 units
RC03G	1

Ordering code (12NC)

- The resistors have a 12-digit ordering code starting with 2322 725.
- The subsequent first digit indicates the resistor type and packaging; see Table 1.
- The remaining 4 digits indicate the resistance value:
 - The first 3 digits indicate the resistance value
 - The last digit indicates the resistance decade in accordance with Table 2.

Table 2 Last digit of 12 NC

RESISTANCE	LAST DIGIT
100 to 976 Ω	1
1 to 9.76 k Ω	2
10 to 97.6 k Ω	3
100 to 976 k Ω	4
1 M Ω	5

ORDERING EXAMPLE

The ordering code of a RC03G resistor, value 4750 Ω , supplied on embossed carrier tape of 5000 units per reel is: 2322 725 14752.

High precision chip resistor size 1206

RC03G

FUNCTIONAL DESCRIPTION

Product characterization

Standard values of nominal resistance are taken from the E24/E96 series for resistors with a tolerance of $\pm 0.5\%$. The values of the E24/96 series are in accordance with "IEC publication 63".

Limiting values

TYPE	LIMITING VOLTAGE ⁽¹⁾ (V)	LIMITING POWER (W)
RC03G	200	0.125

Note

1. This is the maximum voltage that may be continuously applied to the resistor element, see "IEC publication 115-8".

DERATING

The power that the resistor can dissipate depends on the operating temperature; see Fig.1.

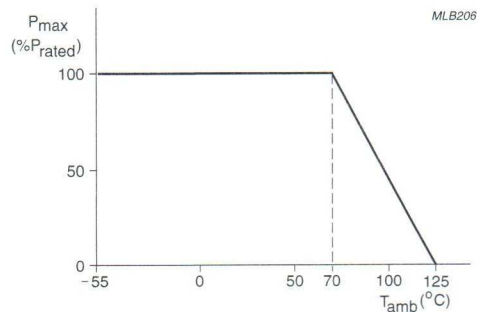
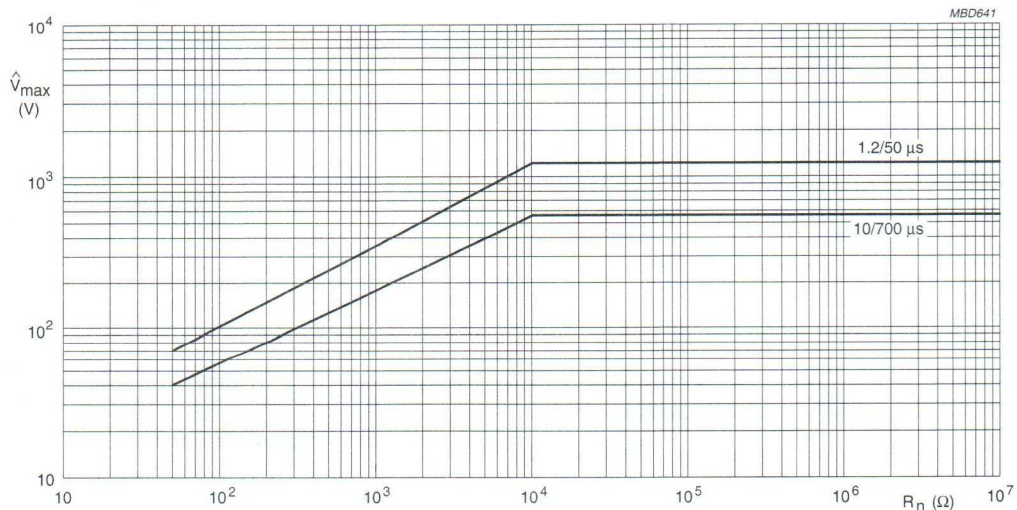


Fig.1 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

PULSE LOADING CAPABILITIES



These pulses may not be applied on a regular basis.

Fig.2 Maximum permissible peak pulse voltage without failing to 'open circuit' in accordance with DIN IEC 40 (CO) 533.

High precision chip resistor size 1206

RC03G

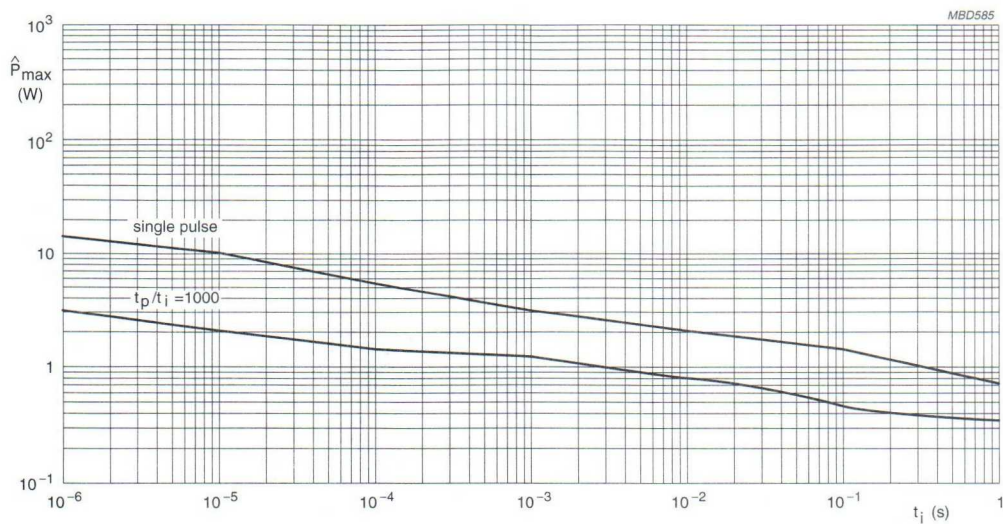


Fig.3 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{\max}$) as a function of pulse duration for $R \leq 10 \text{ k}\Omega$, single pulse and repetitive pulse $t_p/t_i = 1000$.

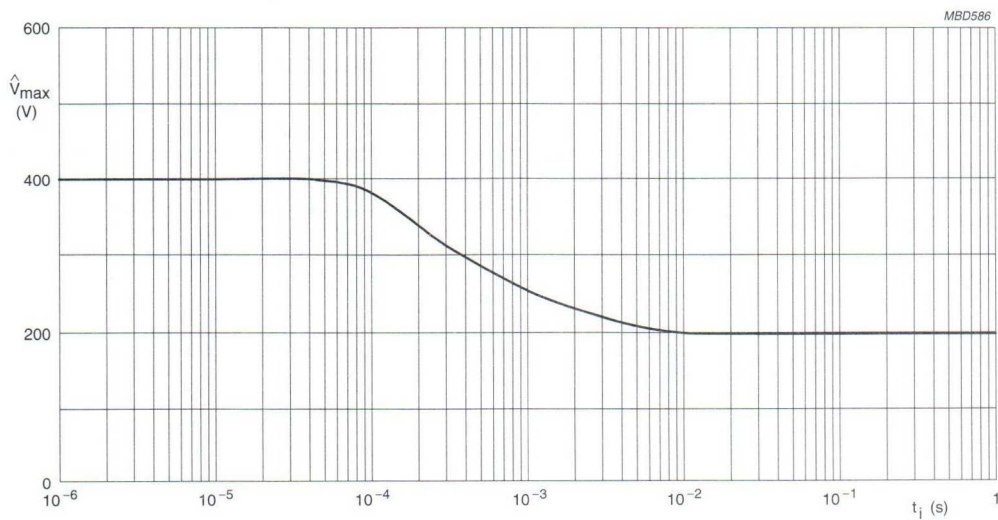


Fig.4 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{\max}$) as a function of pulse duration.

High precision chip resistor size 1206

RC03G

MECHANICAL DATA

Mass per 100 units

TYPE	MASS (g)
RC03G	1

Marking

All resistors are marked with a four digit code on the protective coat to designate the nominal resistance value.

4-DIGIT MARKING

For values up to 976 Ω the R is used as a decimal point. For values of 1 k Ω or greater the first 3 digits apply to the resistance value and the fourth indicates the number of zeros to follow.

Example

MARKING	RESISTANCE
121R	121 Ω
4021	4.02 k Ω
1503	150 k Ω

PACKAGE MARKING

The packaging is also marked and includes resistance value, tolerance, TC value, catalogue number, quantity, production period, batch number and source code.

Outlines

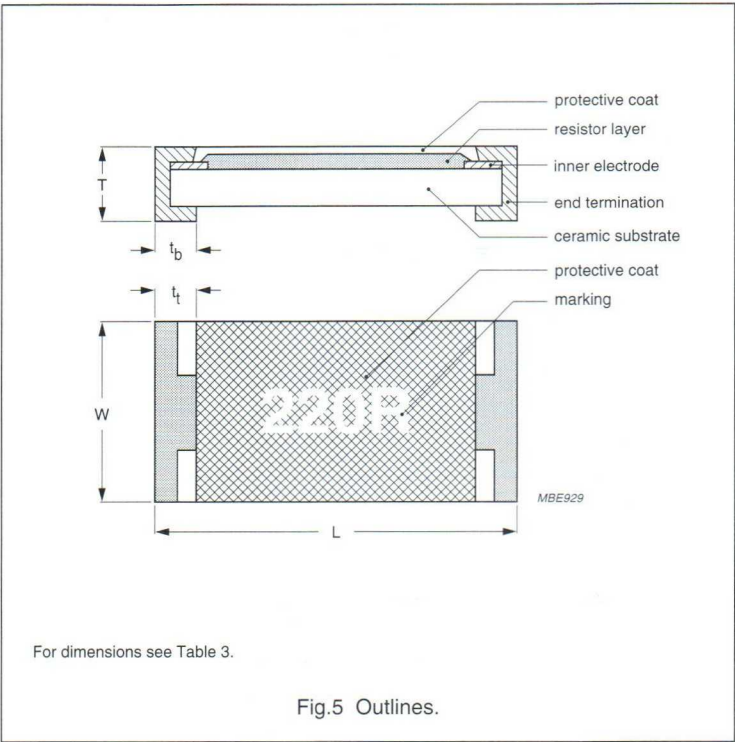


Table 3 Chip resistor type and relevant physical dimensions; see Fig.5

TYPE	L (mm)	W (mm)	T (mm)	t _t (mm)	t _b (mm)
RC03G	3.20 +0.10/-0.20	1.60 ±0.15	0.55 ±0.10	0.45 ±0.25	0.50 ±0.25

High precision chip resistor size 1206

RC03G

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of "IEC publication 115-8", category 55/125/56 (rated temperature range -55 to +125 °C; damp heat, long term, 56 days). The testing also covers the requirements specified by EIA and EIAJ.

The tests are carried out in accordance with IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components" and under standard atmospheric conditions according to "IEC 68-1", subclause 5.3.

Unless otherwise specified the following values apply:

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

Air pressure: 86 kPa to 106 kPa
(860 mbar to 1060 mbar).

In Table 4 the tests and requirements are listed with reference to the relevant clauses of "IEC publications 115-8 and 68"; a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

All soldering tests are performed with mildly activated flux.

Table 4 Test procedures and requirements

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.17	20 (Ta)	soldering	unmounted chips completely immersed for 2 ± 0.5 s in a solder bath at 235 ± 5 °C; flux 600	good tinning ($\geq 95\%$ covered); no damage
4.17	20 (Tb)	solderability	16 hours steam or 16 hours at 155 °C; unmounted chips completely immersed for 2 ± 0.5 s in a solder bath at 235 ± 5 °C; flux 600	good tinning ($\geq 95\%$ covered); no damage
4.18	20 (Tb)	resistance to soldering heat	10 s; 260 ± 5 °C; flux 600	$\Delta R/R$ max.: $\pm 0.25\% + 0.05 \Omega$
		leaching	unmounted chips 60 s; 260 ± 5 °C	good tinning; no leaching
4.19	14 (Na)	rapid change of temperature	30 minutes at -55 °C and 30 minutes at +125 °C; 5 cycles	$\Delta R/R$ max.: $\pm 0.25\% + 0.05 \Omega$
4.22	6 (Fc)	vibration	frequency: 10 to 500 Hz; displacement 1.5 mm or acceleration 10 g; 3 directions; total 6 hours	no damage $\Delta R/R$ max.: $\pm 0.25\% + 0.05 \Omega$
4.20	29 (Eb)	bump	3×1500 bumps in 3 directions; 40 g	no damage $\Delta R/R$ max.: $\pm 0.25\% + 0.05 \Omega$
4.23		climatic sequence:		
4.23.2	2 (Ba)	dry heat	16 hours; 125 °C	
4.23.3	30 (D)	damp heat (accelerated) 1st cycle	24 hours; 55 °C; 95 to 100% RH	
4.23.4	1 (Aa)	cold	2 hours; -55 °C	
4.23.5	13 (M)	low air pressure	1 hour; 8.5 kPa; 15 to 35 °C	
4.23.6	30 (D)	damp heat (accelerated) remaining cycles	5 days; 55 °C; 95 to 100% RH	R_{ins} min.: 1000 M Ω $\Delta R/R$ max.: $\pm 1\% + 0.05 \Omega$

High precision chip resistor size 1206

RC03G

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.24.2	3 (Ca)	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; loaded with 0.01P _n (IEC steps: 0 to 100 V); dissipation ≤1 mW	R _{ins} min.: 1 000 MΩ ΔR/R max.: ±1% +0.05 Ω
4.25.1		endurance	1 000 hours; 70 °C; nominal dissipation; 1.5 hours on and 0.5 hours off	ΔR/R max.: ±0.5% +0.05 Ω
4.6.1.1		insulation resistance	100 V (DC) after 1 minute	R _{ins} min.: 1 000 MΩ
4.13		short time overload	room temperature; dissipation 6.25 × P _n ; 5 s (voltage not more than 2 × V _{max})	ΔR/R max.: ±0.25% +0.05 Ω
4.8.4.2		temperature coefficient	between -55 °C and +125 °C	R < 250 Ω: ≤ ±100 × 10 ⁻⁶ /K 250 Ω ≤ R: ≤ ±50 × 10 ⁻⁶ /K
4.12		noise	IEC publication 195 (measured with Quantech - equipment)	R < 1 kΩ: max. 1 μV/V R < 10 kΩ: max. 3 μV/V R < 100 kΩ: max. 6 μV/V R < 1 MΩ: max. 10 μV/V
4.23.2	27 (Ba)	endurance at upper category temperature	1 000 hours; 125 °C; no load	no visual damage ΔR/R max.: ±0.5% +0.05 Ω
4.7		voltage proof on insulation	200 V (RMS) during 1 minute	no breakdown

Trimmable chip resistor size 1206

RC02TR

FEATURES

- Reduced size of final equipment
- Low assembly costs
- Specific electrical requirements (such as HF characteristics).

APPLICATIONS

This trimmable chip-resistor is suitable for the whole electronic industry and can replace trimmer resistors in several applications.

DESCRIPTION

The resistors are constructed on a high grade ceramic body (aluminium oxide). Internal metal electrodes are added at each end and a connection is made between them using a resistive metal glaze; the approximate resistor values are dependent on the composition of the glaze.

The resistive layer is covered with a translucent protective coat. Finally, two end electrodes are added, the composition of which has been designed to provide ease of soldering.

QUICK REFERENCE DATA

DESCRIPTION	VALUE
Resistance range	1 Ω to 1 M Ω ; E24 series
Resistance tolerance	0/-20% and 0/-30%
Maximum trimming factor	2×
Temperature coefficient:	
1 $\Omega \leq R \leq 4.99 \Omega$	$\leq \pm 250 \times 10^{-6}/K$
5.1 $\Omega \leq R \leq 9.76 \Omega$	$\leq \pm 200 \times 10^{-6}/K$
10 $\Omega \leq R \leq 1 \text{ M}\Omega$	$\leq \pm 100 \times 10^{-6}/K$
Absolute maximum dissipation at $T_{\text{amb}} = 70^\circ\text{C}$	0.25 W
Maximum permissible voltage	200 V (RMS)
Climatic category (IEC 68)	55/155/56
Basic specification	IEC 115-8
Stability ⁽¹⁾ after:	
load, 1000 hours at $T_{\text{amb}} = 70^\circ\text{C}$	$\Delta R/R \text{ max.: } \pm 1\% + 0.05 \Omega$
load, 8000 hours at $T_{\text{amb}} = 70^\circ\text{C}$	$\Delta R/R \text{ max.: } \pm 2\% + 0.10 \Omega$
climatic tests	$\Delta R/R \text{ max.: } \pm 1.5\% + 0.05 \Omega$
soldering	$\Delta R/R \text{ max.: } \pm 1\% + 0.05 \Omega$
short time overload, 400 V max.	$\Delta R/R \text{ max.: } \pm 1\% + 0.10 \Omega$

Note

1. This stability data is valid for non-trimmed resistors. Some properties can change after trimming because of insufficient lacquering.

ORDERING INFORMATION

Ordering code (12NC)

The resistors have a 12-digit catalogue number starting with 2322 724 9. The subsequent 4 digits indicate the packaging and resistance value; see Table 1.

Table 1 Ordering code indicating resistor type and packaging

TYPE	ORDERING CODE 2322 724 9....	
	CARDBOARD TAPE ON REEL	EMBOSSED CARRIER TAPE ON REEL
	5000 units	5000 units
RC02TR	ON REQUEST	

Trimmable chip resistor
size 1206

RC02TR

FUNCTIONAL DESCRIPTION

Product characterization

Standard values of nominal resistance are taken from the E24 series for resistors with a tolerance of 0/-20% and 0/-30%.

Limiting values

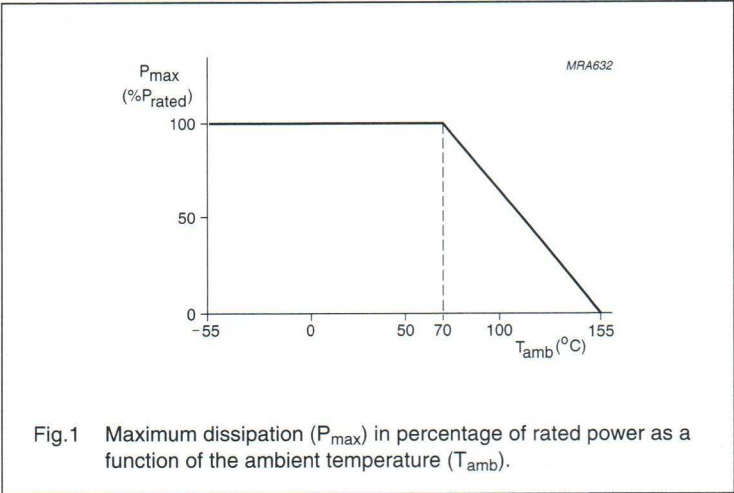
TYPE	LIMITING VOLTAGE ⁽¹⁾ (V)	LIMITING POWER (W)
RC02TR	200	0.25

Note

1. The maximum voltage that may be continuously applied to the resistor element, see "IEC publication 115-8".

DERATING

The power that the resistor can dissipate depends on the operating temperature; see Fig.1.



Application information

TRIMMING INSTRUCTIONS WITH YAG-LASER

Typical values for:

- Cutting speed = 30 to 300 mm/s
- Laser power = 1 to 8 W
- Maximum trimming length = 60% of resistor film width
- Minimum distance between end termination and trimming cut = 0.20 mm
- Minimum distance between cuts (double-cut) = 0.50 mm.

PROTECTION OF LASER CUT

With epoxy-phenol lacquers, epoxy resins or silicon alkyd-resins. This is necessary for humidity tests and stability at load.

Trimable chip resistor
size 1206

RC02TR

MECHANICAL DATA

Mass per 100 units

TYPE	MASS (g)
RC02TR	1

Marking

The resistor is not marked. The packaging is marked and includes resistance value, tolerance, TC value, catalogue number, quantity, production period, batch number and source code.

Outlines

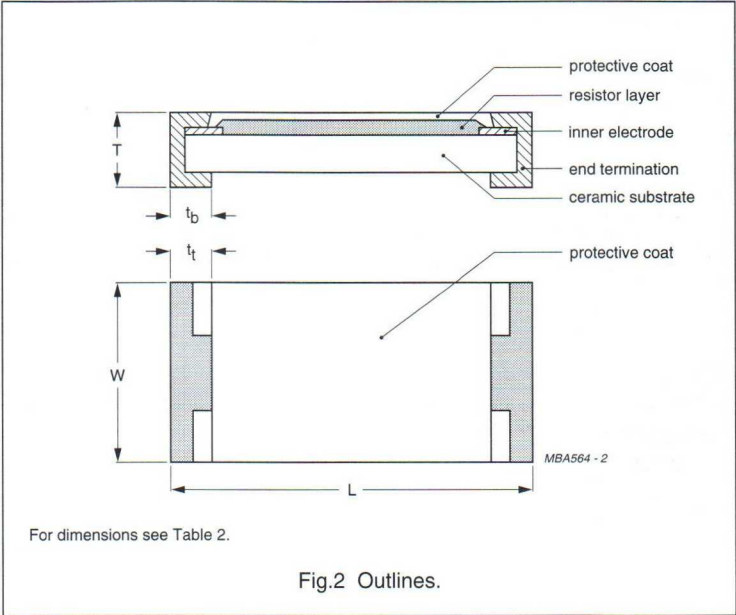


Table 2 Chip resistor type and relevant physical dimensions; see Fig.2

TYPE	L (mm)	W (mm)	T (mm)	t _t (mm)	t _b (mm)
RC02TR	3.20 +0.10/-0.20	1.60 ±0.15	0.55 ±0.10	0.45 ±0.25	0.50 ±0.25

Trimmable chip resistor size 1206

RC02TR

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of "IEC publication 115-8", category 55/155/56 (rated temperature range -55 to $+155$ °C; damp heat, long term, 56 days). The testing also covers the requirements specified by EIA and EIAJ.

The tests are carried out in accordance with IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components" and under standard atmospheric conditions in accordance with "IEC 68-1", subclause 5.3.

Unless otherwise specified the following values apply:

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

Air pressure: 86 kPa to 106 kPa
(860 mbar to 1060 mbar).

In Table 3 the tests and requirements are listed with reference to the relevant clauses of "IEC publications 115-8 and 68"; a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

All soldering tests are performed with mildly activated flux.

Table 3 Test procedures and requirements

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.17	20 (Ta)	soldering	unmounted chips completely immersed for 2 ± 0.5 s in a solder bath at 235 ± 10 °C; flux 600; 0.2% CI activated flux 600	good tinning; no damage
4.18	20 (Tb)	resistance to soldering heat	10 s; 260 ± 5 °C; flux 600	$\Delta R/R$ max.: $\pm 1\% + 0.05 \Omega$
4.19	14 (Na)	rapid change of temperature	30 minutes at -55 °C and 30 minutes at $+155$ °C; 5 cycles	$\Delta R/R$ max.: $\pm 1\% + 0.05 \Omega$
4.22	6 (Fc)	vibration	frequency: 10 to 500 Hz; displacement 1.5 mm or acceleration 10 g; 3 directions; total 6 hours	no damage $\Delta R/R$ max.: $\pm 0.5\% + 0.05 \Omega$
4.20	29 (Eb)	bump	3×1500 bumps in 3 directions; 40 g	no damage $\Delta R/R$ max.: $\pm 0.25\% + 0.05 \Omega$
		bending	resistors mounted on a 90 mm glass epoxy resin printed-circuit board (JIS-c5200); bending: 3 mm	no visual damage $\Delta R/R$ max.: $\pm 1\% + 0.05 \Omega$
4.23 4.23.2 4.23.3 4.23.4 4.23.5 4.23.6	2 (Ba) 30 (D) 1 (Aa) 13 (M) 30 (D)	climatic sequence: dry heat damp heat (accelerated) 1st cycle cold low air pressure damp heat (accelerated) remaining cycles	16 hours; 155 °C 24 hours; 55 °C; 95 to 100% RH 2 hours; -55 °C 1 hour; 8.5 kPa; 15 to 35 °C 5 days; 55 °C; 95 to 100% RH	R_{ins} min.: 1000 M Ω $\Delta R/R$ max.: $\pm 1.5\% + 0.05 \Omega$
4.24.2	3 (Ca)	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; loaded with 0.01 P _N (IEC steps: 1 to 100 V)	R_{ins} min.: 1000 M Ω $\Delta R/R$ max.: $\pm 1.5\% + 0.05 \Omega$

Trimmable chip resistor size 1206

RC02TR

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.25.1		endurance	1 000 hours; 70 °C; nominal dissipation; 1.5 hours on and 0.5 hours off	$\Delta R/R$ max.: $\pm 1\% + 0.05 \Omega$
4.6.1.1		insulation resistance	100 V (DC) after 1 minute	R_{ins} min.: 1 000 M Ω
4.13		short time overload	room temperature; dissipation $6.25 \times P_n$; 5 s (voltage not more than $2 \times V_{max}$)	$\Delta R/R$ max.: $\pm 1\% + 0.05 \Omega$
4.8.4.2		temperature coefficient	between -55 °C and +155 °C	$1 \Omega \leq R \leq 4.99 \Omega$: $\leq \pm 250 \times 10^{-6}/K$ $5.1 \Omega \leq R \leq 9.76 \Omega$: $\leq \pm 200 \times 10^{-6}/K$ $10 \Omega \leq R \leq 1 \text{ M}\Omega$: $\leq \pm 100 \times 10^{-6}/K$
4.12		noise	IEC publication 195 (measured with Quantech - equipment)	$R < 1 \text{ k}\Omega$: max. 1 $\mu V/V$ $R < 10 \text{ k}\Omega$: max. 3 $\mu V/V$ $R < 100 \text{ k}\Omega$: max. 6 $\mu V/V$
4.23.2	27 (Ba)	endurance at upper category temperature	1 000 hours; 155 °C; no load	no visual damage $\Delta R/R$ max.: $\pm 1\% + 0.05 \Omega$
4.7		voltage proof on insulation	200 V (RMS) during 1 minute	no breakdown

Low-ohmic chip resistors size 1206

LRC01

FEATURES

- Reduced size of final equipment
- Low assembly costs
- Higher component and equipment reliability
- Excellent performance at high frequency.

APPLICATIONS

- Battery loaders
- Power supplies in small sized equipment
- Car telephones
- Portable stereo equipment.

DESCRIPTION

The resistors are constructed on a high grade ceramic body (aluminium oxide). Internal metal electrodes are added at each end and connected by a resistive paste which is applied to the top surface of the substrate. The composition of the paste is adjusted to give the approximate resistance required and the value is trimmed to within tolerance, by laser cutting of this resistive layer.

The resistive layer is covered with a protective coating and printed with the resistance value. Finally, the two external end terminations are added. For ease of soldering the outer layer of these end terminations is a lead/tin alloy.

ORDERING INFORMATION

Ordering code (12NC)

The resistors have a 12-digit ordering code starting with 2322. The following 8 digits are indicated in Table 1.

The resistors are packaged in embossed carrier tape, 5000 units per reel.

QUICK REFERENCE DATA

DESCRIPTION	VALUE
	LRC01
Size code	1206 (3216)
Resistance range	50 mΩ to 910 mΩ; E24 series
Resistance tolerance	±5%
Temperature coefficient:	
50 mΩ ≤ R < 75 mΩ	≤ ±2000 × 10 ⁻⁶ /K
75 mΩ ≤ R < 100 mΩ	≤ ±1500 × 10 ⁻⁶ /K
100 mΩ ≤ R < 150 mΩ	≤ ±1000 × 10 ⁻⁶ /K
150 mΩ ≤ R < 400 mΩ	≤ ±700 × 10 ⁻⁶ /K
400 mΩ ≤ R < 1 Ω	≤ ±250 × 10 ⁻⁶ /K
Absolute maximum dissipation at T _{amb} = 70 °C	0.25 W
Operating temperature range	-55 to +125 °C
Climatic category (IEC 68)	55/125/56
Basic specification	IEC 115-8
Stability after:	
load, 1 000 hours at T _{amb} = 70 °C	ΔR/R max.: ±3% (typ. 1%)
climatic tests	ΔR/R max.: ±3% (typ. 1%)
resistance to soldering heat test	ΔR/R max.: ±1% (typ. 0.25%)
short time overload	ΔR/R max.: ±1% (typ. 0.5%)

Table 1 Resistance values and relevant ordering code

VALUE (mΩ)	ORDERING CODE	VALUE (mΩ)	ORDERING CODE
	2322 724		2322 724
51	96032	240	96011
56	96033	270	96012
62	96034	300	96013
68	96035	330	96014
75	96036	360	96015
82	96037	390	96016
91	96038	430	96017
100	96002	470	96018
110	96003	510	96019
120	96004	560	96027
130	96005	620	96021
150	96006	680	96022
160	96007	750	96023
180	96008	820	96024
200	96009	910	96025
220	96026		

Low-ohmic chip resistors size 1206

LRC01

FUNCTIONAL DESCRIPTION

Product characterization

The resistors are available in the E24 series for resistors with a tolerance of $\pm 5\%$. The values of the E24 series are in accordance with "IEC publication 63".

Limiting values

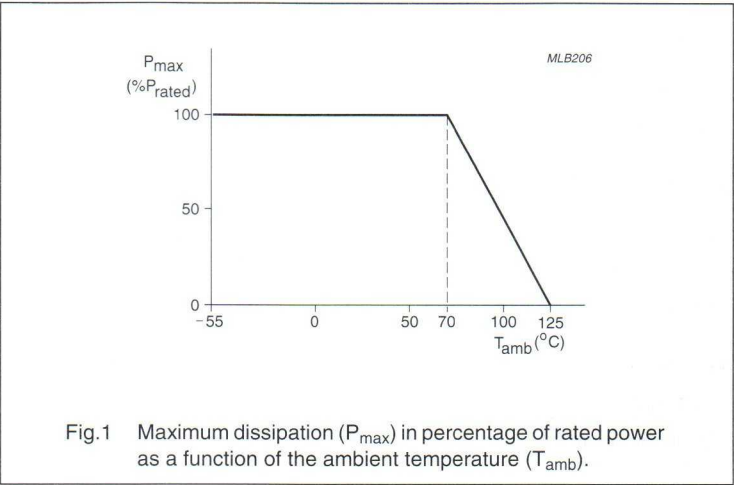
TYPE	LIMITING VOLTAGE ⁽¹⁾ (V)	LIMITING POWER (W)
LRC01	200	0.25

Note

1. The maximum voltage that may be continuously applied to the resistor element, see "IEC publication 115-8".

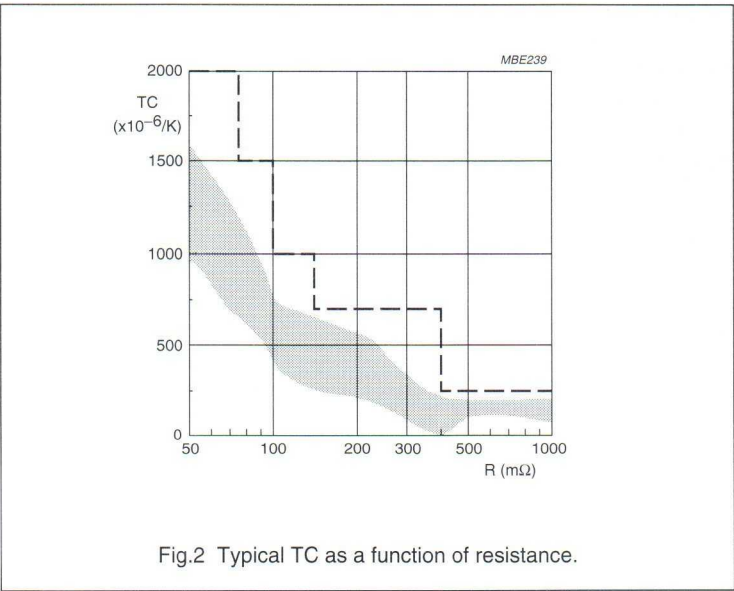
DERATING

The power that the resistor can dissipate depends on the operating temperature; see Fig.1.



Temperature coefficient

Figure 2 shows the typical temperature coefficient of the resistor.



Low-ohmic chip resistors size 1206

LRC01

MECHANICAL DATA

Mass per 100 units

TYPE	MASS (g)
LRC01	1

Marking

Each resistor is marked with a 4-digit code on the protective coating to designate the nominal resistance value.

4-DIGIT MARKING

The R is used as a decimal point.

Magnitude indicators

RESISTANCE	INDICATOR
50 mΩ to 910 mΩ	R

Example

MARKING	RESISTANCE
R210	0.210 Ω
R560	0.560 Ω

The packaging is also marked and includes resistance value, tolerance, TC value, catalogue number, quantity, production period, batch number and source code.

Outlines

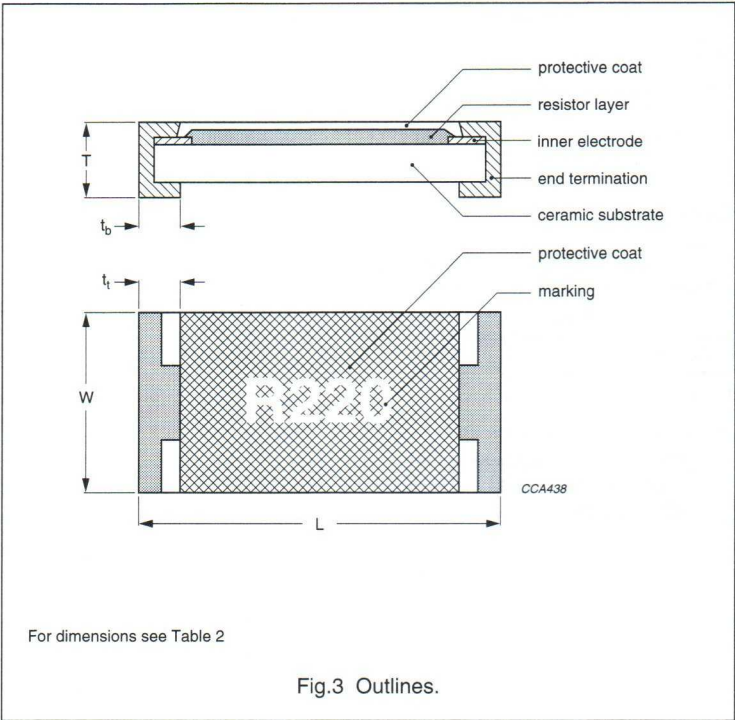


Table 2 Chip resistor type and relevant physical dimensions; see Fig.3

TYPE	L (mm)	W (mm)	T (mm)	t _t (mm)	t _b (mm)
LRC01	3.20 +0.10/-0.20	1.60 ±0.15	0.55 ±0.10	0.45 ±0.25	0.50 ±0.25

Low-ohmic chip resistors

size 1206

LRC01

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of "IEC publication 115-8", category 55/125/56 (rated temperature range -55 to $+125$ °C; damp heat, long term, 56 days). The testing also covers the requirements specified by EIA and EIAJ.

The tests are carried out in accordance with IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components" and under standard atmospheric conditions according to "IEC 68-1", subclause 5.3.

Unless otherwise specified the following values apply:

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

Air pressure: 86 kPa to 106 kPa.

In Table 3 the tests and requirements are listed with reference to the relevant clauses of "IEC publications 115-8 and 68", a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

All soldering tests are performed with mildly activated flux.

Table 3 Test procedures and requirements

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
Tests in accordance with the schedule of IEC publication 115-8				
4.4.1		visual examination		no holes; clean surface; no damage
4.4.2		dimensions (outline)	gauge	$0.45 \text{ mm} \leq T \leq 0.65 \text{ mm}$ $1.45 \text{ mm} \leq W \leq 1.75 \text{ mm}$ $3.0 \text{ mm} \leq L \leq 3.3 \text{ mm}$
4.5		resistance	applied voltage (+0/−10%): 0.1 V	$R - R_{\text{nom}}$: max. $\pm 5\%$
4.18	20 (Tb)	resistance to soldering heat	10 s ; 260 ± 5 °C; flux 600	$\Delta R/R$ max.: $\pm 1\%$
4.29	45 (Xa)	component solvent resistance	isopropyl alcohol; H_2O	no visible damage
4.17	20 (Ta)	solderability	unmounted chips completely immersed for $2 \pm 0.5 \text{ s}$ in a solder bath at 235 ± 5 °C; flux 600	good tinning ($\geq 95\%$ covered); no damage
4.7		voltage proof on insulation	200 V (RMS) during 1 minute	no breakdown or flashover
4.13		short time overload	room temperature; dissipation $6.25 \times P_n$; 5 s (voltage not more than $2 \times V_{\text{max}}$)	$\Delta R/R$ max.: $\pm 1\%$
4.19	14 (Na)	rapid change of temperature	30 minutes at -55 °C and 30 minutes at $+125$ °C; 5 cycles	no visible damage $\Delta R/R$ max.: $\pm 1\%$

Low-ohmic chip resistors size 1206

LRC01

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.23 4.23.2 4.23.3 4.23.4 4.23.5 4.23.6	2 (Ba) 30 (D) 1 (Aa) 13 (M) 30 (D)	climatic sequence: dry heat damp heat (accelerated) 1st cycle cold low air pressure damp heat (accelerated) remaining cycles	16 hours; 125 °C 24 hours; 55 °C; 95 to 100% RH 2 hours; -55 °C 1 hour; 8.5 kPa; 15 to 35 °C 5 days; 55 °C; 95 to 100% RH	$\Delta R/R$ max.: $\pm 3\%$
4.6.1.1		insulation resistance	100 V (DC) after 1 minute	R_{ins} min.: 1000 M Ω
4.24.2	3 (Ca)	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; loaded with 0.01P _n (IEC steps: 4 to 100 V)	no visible damage $\Delta R/R$ max.: $\pm 3\%$
4.25.1		endurance (at 70 °C)	1000 hours; loaded with P _n or V _{max} ; 1.5 hours on and 0.5 hours off	no visible damage $\Delta R/R$ max.: $\pm 3\%$
4.23.2	27 (Ba)	endurance at upper category temperature	1000 hours; 125 °C; no load	no visible damage $\Delta R/R$ max.: $\pm 3\%$
4.8.4.2		temperature coefficient	at 20/-55/20 °C and 20/125/20 °C	50 m Ω $\leq R < 75$ m Ω : $\leq \pm 2000 \times 10^{-6}/K$ 75 m Ω $\leq R < 100$ m Ω : $\leq \pm 1500 \times 10^{-6}/K$ 100 m Ω $\leq R < 150$ m Ω : $\leq \pm 1000 \times 10^{-6}/K$ 150 m Ω $\leq R < 400$ m Ω : $\leq \pm 700 \times 10^{-6}/K$ 400 m Ω $\leq R < 1$ Ω : $\leq \pm 250 \times 10^{-6}/K$

Low-ohmic chip resistors

size 1206

LRC01

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
Other tests in accordance with IEC 115 clauses and IEC 68 test method				
4.17	20 (Tb)	solderability (after ageing)	16 hours steam or 16 hours at 155 °C; unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C; flux 600	good tinning (≥95% covered); no damage
4.22	6 (Fc)	vibration (mounted state)	frequency: 10 to 500 Hz; displacement 1.5 mm or acceleration 10 g; 3 directions; total 6 hours	no damage ΔR/R max.: ±1%
4.20	29 (Eb)	bump (mounted state)	3 × 1500 bumps in 3 directions; 40 g	no damage ΔR/R max.: ±1%
Other applicable tests				
		leaching	unmounted chips 60 s; 250 ±5 °C	good tinning; no leaching
		damp heat (steady state) (JIS)	1 000 hours; +40 °C; 90 to 95% RH; loaded with P _n or V _{max} ; 1.5 hours on and 0.5 hours off	ΔR/R max.: ±3%

Fusible chip resistor size 1206

FRC01

FEATURES

- Overload protection without the risk of fire
- Grey coating for ease of recognition
- Reduced size of final equipment
- Low assembly costs
- Higher component and equipment reliability.

APPLICATIONS

- Power supplies in small sized equipment
- Car telephones
- Portable radio, CD and cassette players.

DESCRIPTION

The resistors are constructed on a high grade ceramic body (aluminium oxide). Internal metal electrodes are added at each end and connected by a resistive paste which is applied to the top surface of the substrate. The composition of the paste is adjusted to give the approximate resistance required and the value is trimmed to within tolerance, by laser cutting of this resistive layer.

The resistive layer is covered with a protective coat and printed with the resistance value. Finally, the two external end terminations are added. For ease of soldering the outer layer of these end terminations is a lead/tin alloy.

To enable recognition of a fused device, the resistor should be mounted face up.

QUICK REFERENCE DATA

DESCRIPTION	VALUE
Resistance range	1 to 240 Ω ; E24 series
Resistance tolerance	$\pm 5\%$
Temperature coefficient: 1 to 4.7 Ω 5.1 to 240 Ω	$\leq \pm 250 \times 10^{-6}/K$ $\leq \pm 200 \times 10^{-6}/K$
Absolute maximum dissipation at $T_{amb} = 70^\circ C$	0.125 W
Maximum permissible voltage	200 V (DC or RMS)
Operating temperature range	$-55^\circ C$ to $+125^\circ C$
Climatic category (IEC 68)	55/125/56
Basic specification	IEC 115-8
Stability after: load, 1000 hours at $T_{amb} = 70^\circ C$ climatic tests resistance to soldering heat test short time overload, 400 V max.	$\Delta R/R$ max.: $\pm 3\% + 0.10 \Omega$ $\Delta R/R$ max.: $\pm 3\% + 0.10 \Omega$ $\Delta R/R$ max.: $\pm 1\% + 0.05 \Omega$ $\Delta R/R$ max.: $\pm 1\% + 0.05 \Omega$

ORDERING INFORMATION

Table 1 Ordering code indicating type and packaging

TYPE	ORDERING CODE 2322 750	
	EMBOSSED CARRIER TAPE ON REEL	
	5000 units	10000 units
FRC01	6....	7....

Ordering code (12NC)

- The resistors have a 12-digit ordering code starting with 2322
- The subsequent 4 digits indicate the resistor type and packaging; see Table 1
- The remaining 4 digits indicate the resistance value
 - The first 3 digits indicate the resistance value
 - The last digit indicates the resistance decade in accordance with Table 2.

Table 2 Last digit of 12NC

RESISTANCE DECADE	LAST DIGIT
1 to 9.76 Ω	8
10 to 97.6 Ω	9
100 to 240 Ω	1

ORDERING EXAMPLE

The ordering code of a FRC01 resistor, value 200 Ω , packed in blister tape and supplied on a reel of 5000 units is: 2322 750 62001.

Fusible chip resistor
size 1206

FRC01

FUNCTIONAL DESCRIPTION

Product characterization

Standard values of nominal resistance are taken from the E24 series for resistors with a tolerance of $\pm 5\%$. The values of the E24 series are

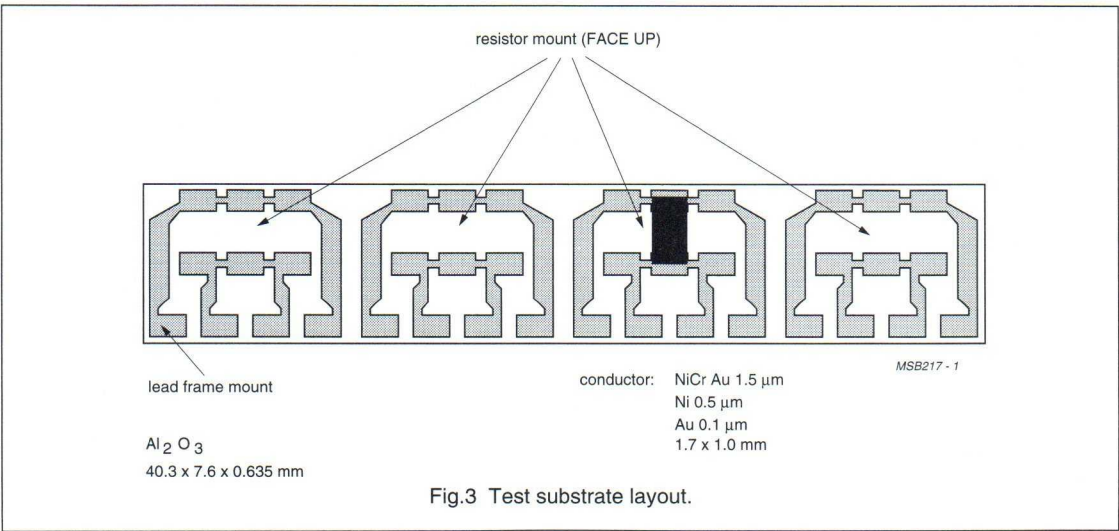
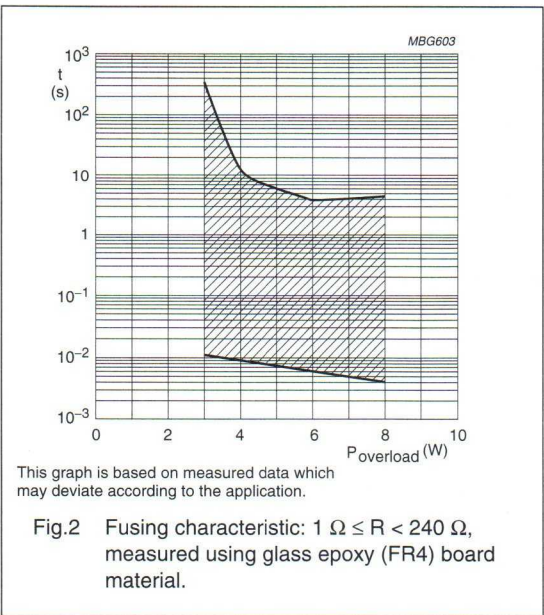
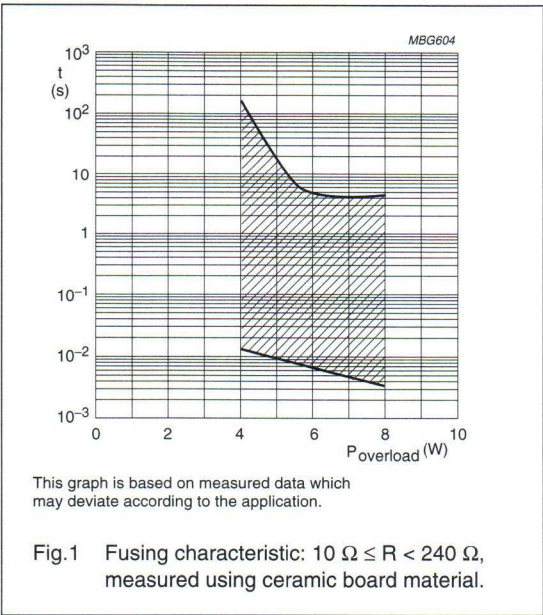
in accordance with
"IEC publication 63".

Fusing characteristics

The resistors will fuse without the risk of fire and within an indicated range of overload. Fusing means that the

resistive value of the resistor increases at least 1000 times; see Figs 1 and 2.

The fusing characteristic is measured under constant voltage with resistors mounted on a ceramic or glass epoxy (FR4) substrate; see Fig.3.



Fusible chip resistor size 1206

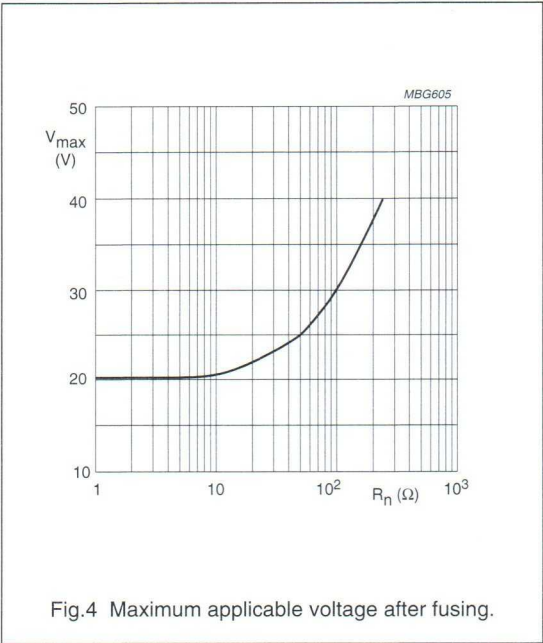
FRC01

Limiting values

TYPE	LIMITING VOLTAGE ⁽¹⁾ (V)	LIMITING POWER (W)
FRC01	200; note 2	0.125

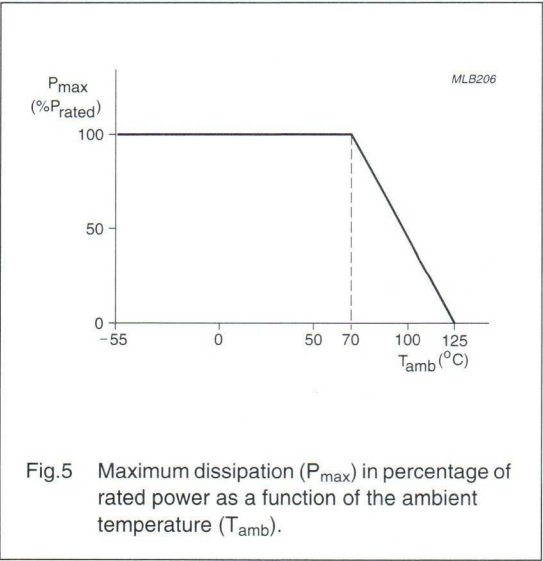
Notes

1. The maximum voltage that may be continuously applied to the resistor element, see "IEC publication 115-8".
2. The maximum voltage that may be applied after fusing is shown in Fig.4.

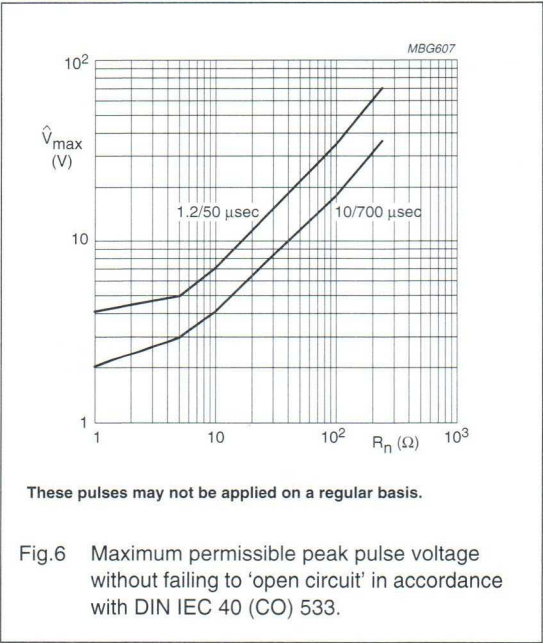


DERATING

The power that the resistor can dissipate depends on the operating temperature; see Fig.5.



PULSE LOADING CAPABILITIES



Fusible chip resistor size 1206

FRC01

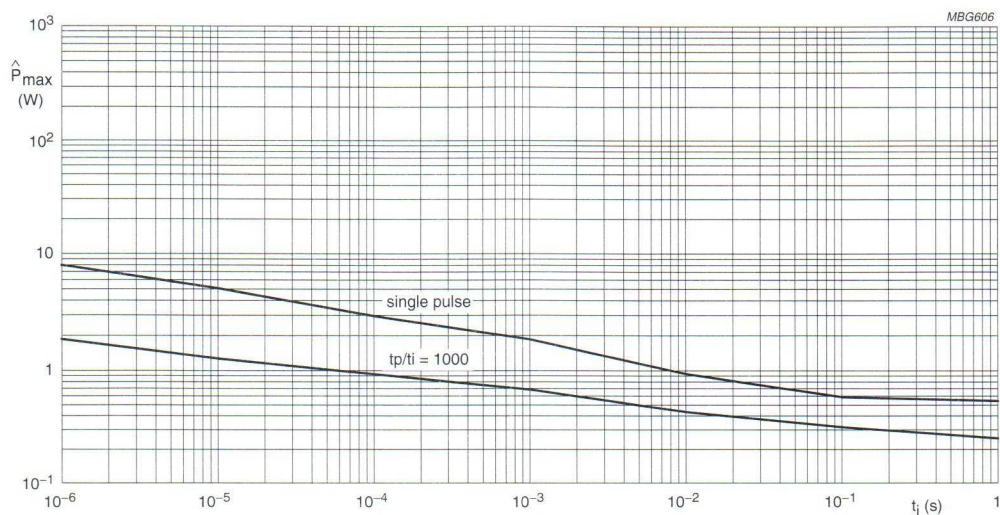


Fig.7 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration, single pulse and repetitive pulse $t_p/t_i = 1000$.

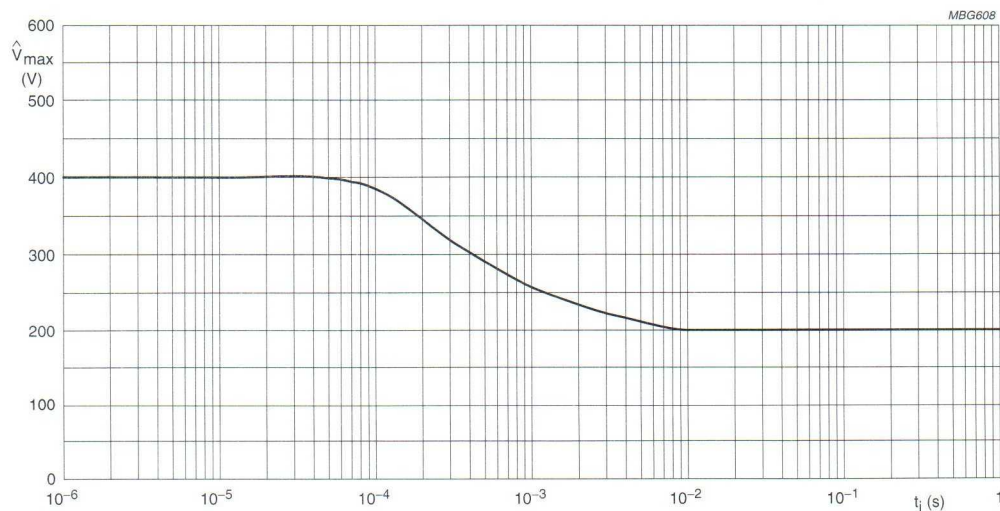


Fig.8 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration.

Fusible chip resistor
size 1206

FRC01

MECHANICAL DATA

Mass per 100 units

TYPE	MASS (g)
FRC01	1.0

Marking

All resistors are marked with a four digit code on the protective coat to designate the nominal resistance value.

4-DIGIT MARKING

For all values, the R is used as a decimal point.

Example

MARKING	RESISTANCE
120R	120 Ω

PACKAGE MARKING

The packaging is also marked and includes resistance value, tolerance, TC value, catalogue number, quantity, production period, batch number and source code.

Outlines

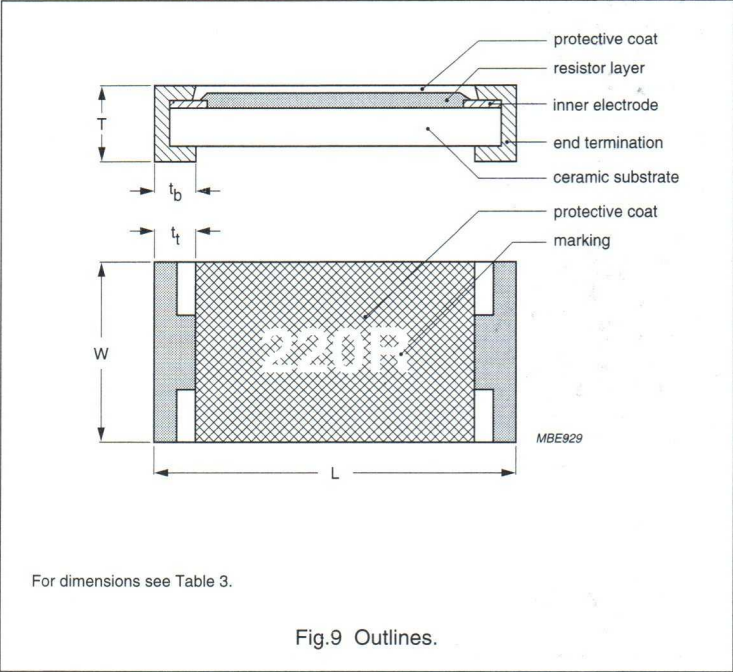


Table 3 Chip resistor type and relevant physical dimensions; see Fig.9

TYPE	L (mm)	W (mm)	T (mm)	t _t (mm)	t _b (mm)
FRC01	3.20 +0.10/-0.20	1.60 ±0.15	0.55 ±0.10	0.45 ±0.25	0.50 ±0.25

Fusible chip resistor size 1206

FRC01

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of "IEC publication 115-8", category **LCT/UCT/56** (rated temperature range: **Lower Category Temperature, Upper Category Temperature**; damp heat, long term, **56** days). The testing also covers the requirements specified by EIA and EIAJ.

The tests are carried out in accordance with IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components" and under standard atmospheric conditions according to "IEC 68-1", subclause 5.3.

Unless otherwise specified the following values apply:

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

Air pressure: 86 kPa to 106 kPa
(860 mbar to 1060 mbar).

In Table 4 the tests and requirements are listed with reference to the relevant clauses of "IEC publications 115-8 and 68"; a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

All soldering tests are performed with mildly activated flux.

Table 4 Test procedures and requirements

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
Tests in accordance with the schedule of IEC publication 115-8				
4.4.1		visual examination		no holes; clean surface; no damage
4.4.2		dimensions (outline)	gauge (mm)	$0.45 \leq T \leq 0.65$ $1.45 \leq W \leq 1.75$ $3.0 \leq L \leq 3.3$
4.5		resistance	applied voltage (+0/-10%): $R < 10 \Omega$: 0.1 V $10 \Omega \leq R < 100 \Omega$: 0.3 V $100 \Omega \leq R < 240 \Omega$: 1 V	$R - R_{nom}$: max. $\pm 5\%$
4.18	20 (Ta)	resistance to soldering heat	unmounted chips; 10 s; 260 ± 5 °C	no visual damage $\Delta R/R$ max.: $\pm 1\% + 0.05 \Omega$
4.29	45 (Xa)	component solvent resistance	isopropyl alcohol or H ₂ O followed by brushing in accordance with "MIL 202 F"	no visual damage
4.17	20 (Ta)	solderability	unmounted chips completely immersed for 2 ± 0.5 s in a solder bath at 235 ± 5 °C	good tinning ($\geq 95\%$ covered); no visual damage
4.7		voltage proof on insulation	maximum voltage (RMS) during 1 minute metal block method	no breakdown or flashover
4.13		short time overload	room temperature; $P = 6.25 \times P_n$; 5 s ($V \leq 2 \times V_{max}$)	$\Delta R/R$ max.: $\pm 1\% + 0.05 \Omega$
4.33		bending	resistors mounted on a 90 mm glass epoxy resin PCB (FR4), bending: 3 mm	no visual damage $\Delta R/R$ max.: $\pm 1\% + 0.05 \Omega$
4.19	14 (Na)	rapid change of temperature	30 minutes at LCT and 30 minutes at UCT; 5 cycles	no visual damage $\Delta R/R$ max.: $\pm 1\% + 0.05 \Omega$

Fusible chip resistor size 1206

FRC01

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.23 4.23.3 4.23.6	30 (D) 30 (D)	climatic sequence: damp heat (accelerated) 1st cycle damp heat (accelerated) remaining cycles	6 days; 55 °C; 95 to 98% RH	R_{ins} min.: 10^4 M Ω $\Delta R/R$ max.: $\pm 3\% + 0.1 \Omega$
4.24.2	3 (Ca)	damp heat (steady state) (IEC)	56 days; 40 °C; 90 to 95% RH; loaded with 0.01 P_n (IEC steps: 4 to 100 V)	$\Delta R/R$ max.: $\pm 3\% + 0.1 \Omega$
4.25.1		endurance (at 70 °C)	1000 hours; loaded with P_n or V_{max} ; 1.5 hours on and 0.5 hours off	$\Delta R/R$ max.: $\pm 3\% + 0.1 \Omega$
4.23.2	27 (Ba)	endurance at upper category temperature	1000 hours; no load	$\Delta R/R$ max.: $\pm 3\% + 0.1 \Omega$
4.8.4.2		temperature coefficient	at 20/LCT/20 °C and 20/UCT/20 °C ($TC \times 10^{-6}/K$): $R < 5 \Omega$ $R \leq 240 \Omega$	 $\leq \pm 250$ $\leq \pm 200$
Other tests in accordance with IEC 115 clauses and IEC 68 test method				
4.17	20 (Tb)	solderability (after ageing)	8 hours steam or 16 hours 155 °C; unmounted chips completely immersed for 2 ± 0.5 s in a solder bath at 235 ± 5 °C	good tinning ($\geq 95\%$ covered); no damage
4.6.1.1		insulation resistance	voltage (DC) after 1 minute, metal block method: 100 V	R_{ins} min.: 10^3 M Ω
4.12		noise	IEC publication 195 (measured with Quantech - equipment)	max. 2 $\mu V/V$
Other applicable tests				
	(JIS)	humidity load (steady state)	1000 hours; +40 °C; 90 to 95% RH loaded with P_n or V_{max} ; 1.5 hours on and 0.5 hours off	$\Delta R/R$ max.: $\pm 5\% + 0.1 \Omega$
		leaching	unmounted chips 60 s ; 260 ± 5 °C	good tinning; no leaching
		trio damp heat test	1000 hours; +85 °C; 85% RH loaded with 0.1 P_n or V_{max}	$\Delta R/R$ max.: $\pm 5\% + 0.1 \Omega$

Power chip resistor size 1218

PRC201

FEATURES

- Reduced size of final equipment
- Low assembly costs
- Higher component and equipment reliability
- Excellent performance at high frequency.

APPLICATIONS

- Power supplies in small sized equipment
- Camcorders
- Portable radio, CD and cassette players
- Automotive.

DESCRIPTION

The resistors are constructed on a high grade ceramic body (aluminium oxide). Internal metal electrodes are added at each end and connected by a resistive paste which is applied to the top surface of the substrate. The composition of the paste is adjusted to give the approximate resistance required and the value is trimmed to within tolerance, by laser cutting of this resistive layer.

The resistive layer is covered with a protective coating and printed with the resistance value. Finally, the two external end terminations are added. To guarantee optimum solderability the outer layer consists of a lead-tin alloy.

QUICK REFERENCE DATA

DESCRIPTION	VALUE
Resistance range	0.02 Ω to 1 MΩ
Resistance tolerance and series: 0.02 Ω ≤ R ≤ 1 MΩ 0.1 Ω ≤ R ≤ 1 MΩ	±5%, E24 series ±1%, E24/E96 series
Temperature coefficient: 0.020 Ω ≤ R < 0.033 Ω 0.033 Ω ≤ R < 0.060 Ω 0.060 Ω ≤ R < 0.2 Ω 0.2 Ω ≤ R < 1 Ω 1 Ω ≤ R < 10 Ω 10 Ω ≤ R ≤ 1 MΩ	≤ ±2000 × 10 ⁻⁶ /K ≤ ±1000 × 10 ⁻⁶ /K ≤ ±700 × 10 ⁻⁶ /K ≤ ±250 × 10 ⁻⁶ /K ≤ ±200 × 10 ⁻⁶ /K ≤ ±100 × 10 ⁻⁶ /K
Absolute maximum dissipation at T _{amb} = 70 °C	1 W
Maximum permissible voltage	200 V (DC or RMS)
Maximum permissible current	6 A (DC or RMS)
Operating temperature range	-55 °C to +155 °C
Basic specification	IEC 115-8
Stability after: load, 1000 hours at T _{amb} = 70 °C: 0.02 Ω ≤ R < 0.1 Ω 0.1 Ω ≤ R ≤ 1 MΩ climatic tests resistance to soldering heat test: 0.02 Ω ≤ R < 0.1 Ω 0.1 Ω ≤ R ≤ 1 MΩ short time overload	ΔR/R max.: ±5% ΔR/R max.: ±3% ΔR/R max.: ±3% ΔR/R max.: ±2% ΔR/R max.: ±1% ΔR/R max.: ±1%

Power chip resistor
size 1218

PRC201

ORDERING INFORMATION

Table 1 Ordering code indicating resistor type and packaging

TYPE	TOL (%)	ORDERING CODE 2322 735	
		EMBOSSED CARRIER TAPE ON REEL	
		1 000 units	5 000 units
PRC201	5%; note 1	30...	60...
	1%	1....	2....
Jumper 0 Ω			
PRC201; note 2	—	90003	90006

Notes

- 1. Code numbers for values less than 0.1 Ω are available on request.
- 2. The jumper has a maximum resistance $R_{max} = 20\text{ m}\Omega$ and a rated current $I_R = 6\text{ A}$.

Ordering code (12NC)

- The resistors have a 12-digit ordering code starting with 2322.
- The subsequent four or five digits indicate the resistor type and packaging; see Table 1.
- The remaining digits indicate the resistance value:
 - The first 2 digits for 5% or 3 digits for 1% tolerance products indicate the resistance value.
 - The last digit indicates the resistance decade in accordance with Table 2.

Table 2 Last digit of 12NC

RESISTANCE DECADE	LAST DIGIT
0.02 to 0.091 Ω	note 1
0.1 to 0.91 Ω	7
1 to 9.1 Ω	8
10 to 91 Ω	9
100 to 910 Ω	1
1 to 9.1 kΩ	2
10 to 91 kΩ	3
100 to 910 kΩ	4
1 MΩ	5

Note

- 1. Code numbers for values less than 0.1 Ω are available on request.

ORDERING EXAMPLE

The ordering code of a PRC201 resistor, value 470 Ω with 5% tolerance, supplied on embossed carrier tape of 5 000 units per reel is: 2322 735 60471.

Power chip resistor size 1218

PRC201

FUNCTIONAL DESCRIPTION

Product characterization

Standard values of nominal resistance are taken from the E24 or E96 series for resistors with a tolerance of $\pm 5\%$ or $\pm 1\%$. The values of the E24 series are in accordance with "IEC publication 63".

DERATING

The power that the resistor can dissipate depends on the operating temperature; see Fig.1.

TEMPERATURE COEFFICIENT

Figure 2 shows the typical TC of the low ohmic part of the resistor.

Limiting values

TYPE	LIMITING VOLTAGE ⁽¹⁾ (V)	LIMITING CURRENT (A)	LIMITING POWER (W)
PRC201	200	6	1

Note

1. The maximum voltage that may be continuously applied to the resistor element, see "IEC publication 115-8".

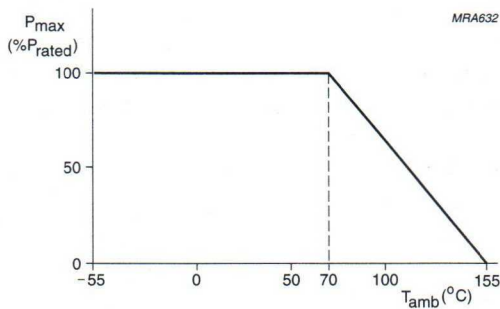


Fig.1 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

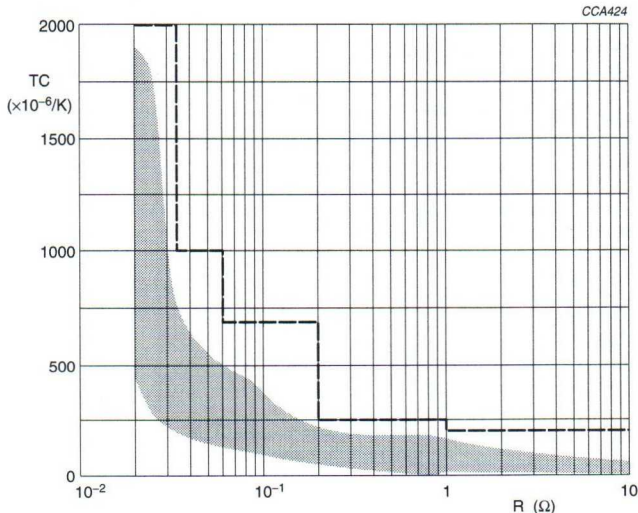


Fig.2 Typical TC as a function of resistance for low ohmic values.

Power chip resistor size 1218

PRC201

PULSE LOADING CAPABILITIES

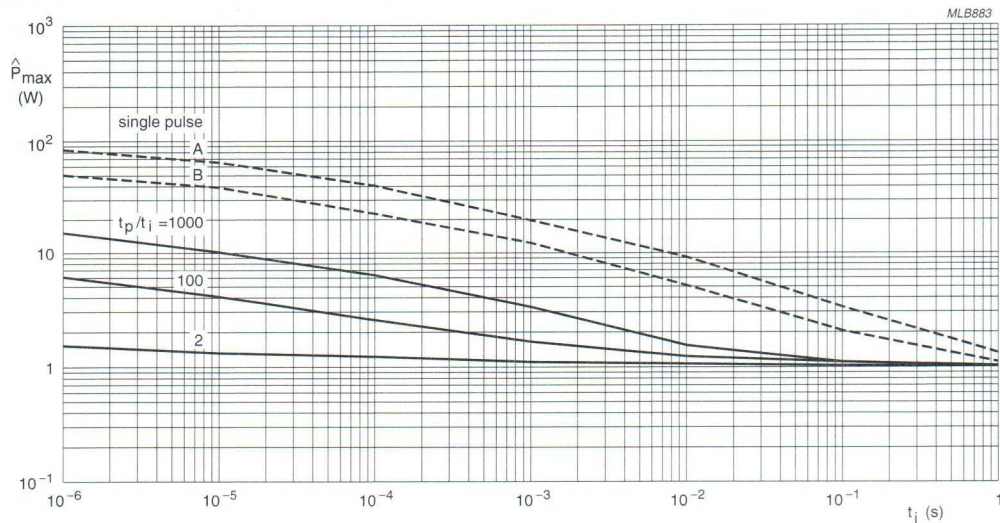
Single pulse A: $R_n \leq 300 \Omega$.Single pulse B: $R_n > 300 \Omega$.

Fig.3 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration for $R \leq 10 \text{ k}\Omega$, single pulse and repetitive pulse t_p/t_i .

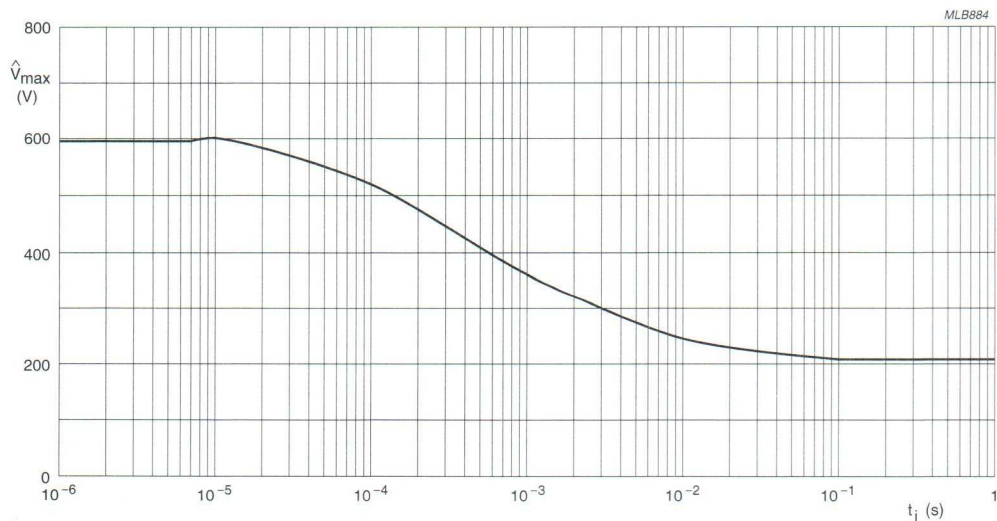
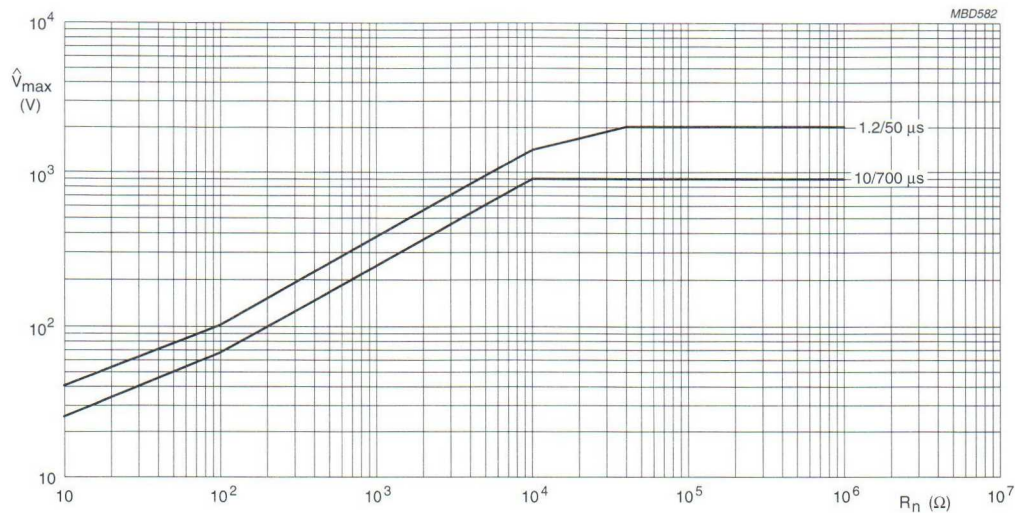


Fig.4 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration.

Power chip resistor size 1218

PRC201



These pulses may not be applied on a regular basis.

Fig.5 Maximum permissible peak pulse voltage without failing to 'open circuit' in accordance with DIN IEC 40 (CO) 533.

Power chip resistor size 1218

PRC201

Application information

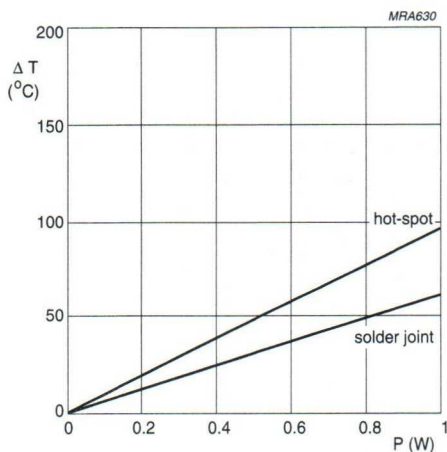


Fig.6 Temperature rise at hot-spot and solder joint as a function of dissipated power, for a resistor mounted horizontally on ceramic PCB.

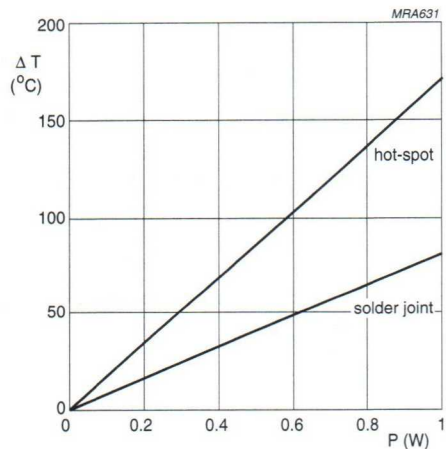


Fig.7 Temperature rise at hot-spot and solder joint as a function of dissipated power, for a resistor mounted horizontally on a FR4 PCB.

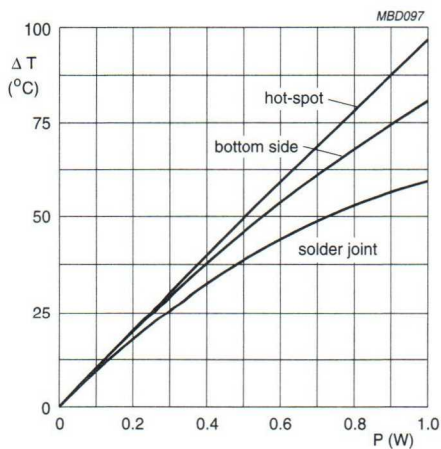
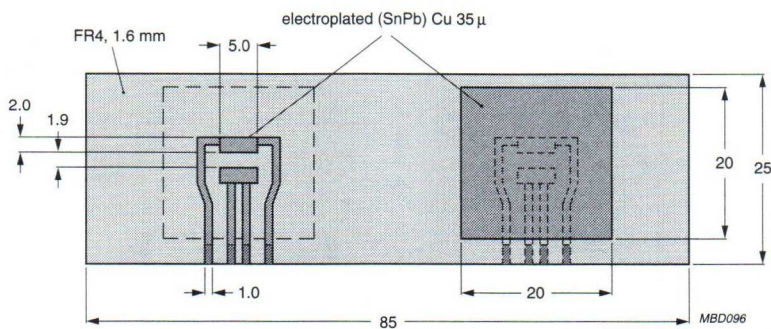


Fig.8 Temperature rise at hot-spot and solder joint as a function of dissipated power, for a resistor horizontally mounted on the test substrate; see Fig.9.

Power chip resistor size 1218

PRC201



Dimensions in mm.

Fig.9 Test substrate layout. The tracks on the substrate for values below 33 mΩ are wider. With this substrate, the resistance of the tracks becomes significant compared to the resistor tested. Due to the current loading required for resistor testing these tracks may be damaged.

Power chip resistor size 1218

PRC201

MECHANICAL DATA

Mass per 100 units

TYPE	MASS (g)
PRC201	3

Marking

Each resistor is marked with the nominal resistance value.

4-DIGIT MARKING

For values up to 910 Ω the R is used as a decimal point. For values of 1 k Ω or greater the letter K or M is used as the decimal point for the k Ω or M Ω indication.

Magnitude indicators

RESISTANCE	INDICATOR
0.02 to 910 Ω	R
1 to 910 k Ω	K
1 M Ω	M

Example

MARKING	RESISTANCE
120R	120 Ω
4K70	4.70 k Ω

The packaging is also marked and includes resistance value, tolerance, TC value, catalogue number, quantity, production period, batch number and source code.

Outlines

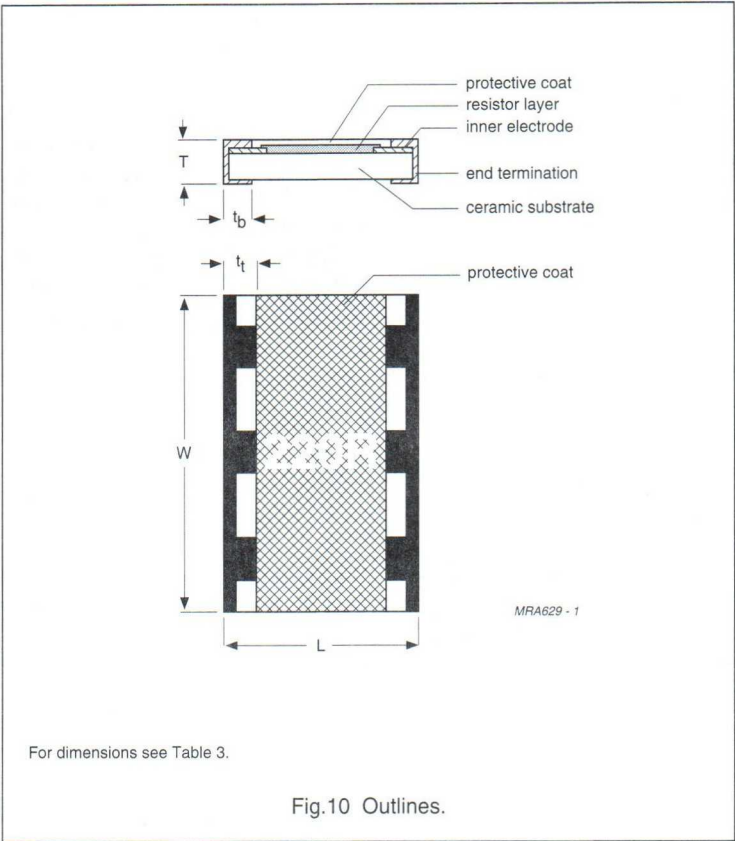


Table 3 Chip resistor type and relevant physical dimensions; see Fig.10

TYPE	L (mm)	W (mm)	T (mm)	t _t (mm)	t _b (mm)
PRC201	3.05 ±0.15	4.60 ±0.20	0.55 ±0.10	0.45 ±0.25	0.50 ±0.25

Power chip resistor size 1218

PRC201

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of "IEC publication 115-8", category 55/155/56 (rated temperature range -55 to +155 °C; damp heat, long term, 56 days). The testing also covers the requirements specified by EIA and EIAJ.

The tests are carried out in accordance with IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components" and under standard atmospheric conditions in accordance with "IEC 68-1", subclause 5.3.

Unless otherwise specified the following values apply:

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

Air pressure: 86 kPa to 106 kPa
(860 mbar to 1060 mbar).

In Table 4 the tests and requirements are listed with reference to the relevant clauses of "IEC publications 115-8 and 68"; a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

All soldering tests are performed with mildly activated flux.

Table 4 Test procedures and requirements

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
Tests in accordance with the schedule of IEC publication 115-8				
4.4.1		visual examination		no holes; clean surface; no damage
4.4.2		dimensions (outline)	gauge	$0.45 \text{ mm} \leq T \leq 0.65 \text{ mm}$ $4.4 \text{ mm} \leq W \leq 4.8 \text{ mm}$ $2.9 \text{ mm} \leq L \leq 3.2 \text{ mm}$
4.5		resistance	applied voltage (+0/-10%): $R < 10 \Omega$: 0.1 V $10 \Omega \leq R < 100 \Omega$: 0.3 V $100 \Omega \leq R < 1 \text{ k}\Omega$: 1 V $1 \text{ k}\Omega \leq R < 10 \text{ k}\Omega$: 3 V $10 \text{ k}\Omega \leq R < 100 \text{ k}\Omega$: 10 V $100 \text{ k}\Omega \leq R < 1 \text{ M}\Omega$: 25 V $1 \text{ M}\Omega$: 50 V	$R - R_{\text{nom}}$: max. $\pm 5\%$ or 1%
4.18	20 (Tb)	resistance to soldering heat	10 s; 260 ± 5 °C; flux 600	$0.020 \Omega \leq R < 0.1 \Omega$: $\Delta R/R$ max.: $\pm 2\%$ $0.1 \Omega \leq R \leq 1 \text{ M}\Omega$: $\Delta R/R$ max.: $\pm 1\%$
4.29	45 (Xa)	component solvent resistance	isopropyl alcohol; H ₂ O	no visible damage
4.17	20 (Ta)	solderability	unmounted chips completely immersed for 2 ± 0.5 s in a solder bath at 235 ± 5 °C; flux 600	good tinning ($\geq 95\%$ covered); no damage
4.7		voltage proof on insulation	200 V (RMS) during 1 minute	no breakdown or flashover

Power chip resistor size 1218

PRC201

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.13		short time overload	room temperature; dissipation $6.25 \times P_n$; 5 s (voltage not more than $2 \times V_{max}$)	$\Delta R/R$ max.: $\pm 1\%$
4.33		bending	resistors mounted on a 90 mm glass epoxy resin PCB (FR4), bending: 2 mm	no damage $\Delta R/R$ max.: $\pm 1\%$
4.19	14 (Na)	rapid change of temperature	30 minutes at $-55\text{ }^\circ\text{C}$ and 30 minutes at $+155\text{ }^\circ\text{C}$; 5 cycles	no visible damage $\Delta R/R$ max.: $\pm 1\%$
4.23		climatic sequence:		
4.23.2	2 (Ba)	dry heat	16 hours; $155\text{ }^\circ\text{C}$	
4.23.3	30 (D)	damp heat (accelerated) 1st cycle	24 hours; $55\text{ }^\circ\text{C}$; 95 to 100% RH	
4.23.4	1 (Aa)	cold	2 hours; $-55\text{ }^\circ\text{C}$	
4.23.5	13 (M)	low air pressure	1 hour; 8.5 kPa; 15 to $35\text{ }^\circ\text{C}$	
4.23.6	30 (D)	damp heat (accelerated) remaining cycles	5 days; $55\text{ }^\circ\text{C}$; 95 to 100% RH	$\Delta R/R$ max.: $\pm 3\%$
4.6.1.1		insulation resistance	100 V (DC) after 1 minute	R_{ins} min.: 1000 M Ω
4.24.2	3 (Ca)	damp heat (steady state)	56 days; $40\text{ }^\circ\text{C}$; 90 to 95% RH; loaded with $0.01P_n$ (IEC steps: 4 to 100 V)	no visible damage $\Delta R/R$ max.: $\pm 3\%$
4.25.1		endurance (at $70\text{ }^\circ\text{C}$)	1000 hours; loaded with P_n or V_{max} ; 1.5 hours on and 0.5 hours off	no visible damage $0.020\text{ }\Omega \leq R < 0.1\text{ }\Omega$: $\Delta R/R$ max.: $\pm 5\%$ $0.1\text{ }\Omega \leq R \leq 1\text{ M}\Omega$: $\Delta R/R$ max.: $\pm 3\%$
4.23.2	27 (Ba)	endurance at upper category temperature	1000 hours; $155\text{ }^\circ\text{C}$; no load	no visible damage $\Delta R/R$ max.: $\pm 3\%$

Power chip resistor size 1218

PRC201

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.8.4.2		temperature coefficient	at 20/-55/20 °C and 20/155/20 °C	$0.020 \Omega \leq R < 0.033 \Omega$: $\Delta R/R \text{ max.: } \pm 2000 \times 10^{-6}/K$ $0.033 \Omega \leq R < 0.060 \Omega$: $\Delta R/R \text{ max.: } \pm 1000 \times 10^{-6}/K$ $0.060 \Omega \leq R < 0.2 \Omega$: $\Delta R/R \text{ max.: } \pm 700 \times 10^{-6}/K$ $0.2 \Omega \leq R < 1 \Omega$: $\Delta R/R \text{ max.: } \pm 250 \times 10^{-6}/K$ $1 \Omega \leq R < 10 \Omega$: $\Delta R/R \text{ max.: } \pm 200 \times 10^{-6}/K$ $10 \Omega \leq R$: $\Delta R/R \text{ max.: } \pm 100 \times 10^{-6}/K$
Other tests in accordance with IEC 115 clauses and IEC 68 test method				
4.17	20 (Tb)	solderability (after ageing)	16 hours steam or 16 hours at 155 °C; unmounted chips completely immersed for 2 ± 0.5 s in a solder bath at 235 ± 5 °C; flux 600	good tinning ($\geq 95\%$ covered); no damage
4.22	6 (Fc)	vibration (mounted state)	frequency: 10 to 500 Hz; displacement 1.5 mm or acceleration 10 g; 3 directions; total 6 hours	no damage $\Delta R/R \text{ max.: } \pm 1\%$
4.20	29 (Eb)	bump (mounted state)	3×1500 bumps in 3 directions; 40 g	no damage $\Delta R/R \text{ max.: } \pm 1\%$
Other applicable tests				
		leaching	unmounted chips 60 s; 260 ± 5 °C	good tinning; no leaching

Power metal film chip resistor size 1218

PRC202

FEATURES

- Excellent pulse load performance
- Reduced size of final equipment
- Low assembly costs
- Higher component and equipment reliability.

APPLICATIONS

- Automotive.

DESCRIPTION

A metal film (resistive) layer is deposited on a high grade ceramic body (aluminium oxide). The layer is trimmed to its nominal value and covered with a protective coat.

On each end a contact is made by applying several layers. To guarantee optimum solderability the outer layer consists of a lead tin alloy.

QUICK REFERENCE DATA

DESCRIPTION	VALUE
Resistance range	0.47 Ω to 100 Ω ; E24 series
Resistance tolerance	$\pm 1\%$, $\pm 5\%$
Temperature coefficient: 470 m $\Omega \leq R < 1 \Omega$ $1 \Omega \leq R \leq 100 \Omega$	$\leq \pm 200 \times 10^{-6}/K$ $\leq \pm 50 \times 10^{-6}/K$
Absolute maximum dissipation at $T_{amb} = 70^\circ C$	1 W
Maximum permissible voltage	200 V
Operating temperature range	$-55^\circ C$ to $+155^\circ C$
Basic specification	IEC 115-8
Stability after: load, 1000 hours at $T_{amb} = 70^\circ C$ climatic tests resistance to soldering heat test short time overload	$\Delta R/R$ max.: $\pm 1\%$ $\Delta R/R$ max.: $\pm 1\%$ $\Delta R/R$ max.: $\pm 0.5\%$ $\Delta R/R$ max.: $\pm 1\%$

ORDERING INFORMATION

Table 1 Ordering code indicating resistor type and packaging

TYPE	TOL.	ORDERING CODE 2322 736	
		EMBOSSSED CARRIER TAPE ON REEL	
		1000 units	5000 units
PRC202	$\pm 5\%$	30...	60...
	$\pm 1\%$	1....	2....

Ordering code (12NC)

- The resistors have a 12-digit ordering code starting with 2322 736.
- The subsequent first digit indicates the resistor type and packaging; see Table 1.
- The remaining digits indicate the resistance value:
 - The first 2 digits for 5% or 3 digits for 1% tolerance products indicate the resistance value.
 - The last digit indicates the resistance decade in accordance with Table 2.

Table 2 Last digit of 12NC

RESISTANCE DECADE	LAST DIGIT
0.47 to 0.91 Ω	7
1 to 9.1 Ω	8
10 to 91 Ω	9
100 Ω	1

ORDERING EXAMPLE

The ordering code of a PRC202 resistor, value 47 Ω with 1% tolerance, supplied on embossed carrier tape of 5 000 units per reel is: 2322 736 24709.

Power metal film chip resistor size 1218

PRC202

FUNCTIONAL DESCRIPTION

Product characterization

The resistors are available in the E24 series for resistors with a tolerance of $\pm 5\%$ and $\pm 1\%$. The values of the E24 series are in accordance with "IEC publication 63".

Limiting values

TYPE	LIMITING VOLTAGE ⁽¹⁾ (V)	LIMITING POWER (W)
PRC202	$\sqrt{P_n \times R}$	1

Note

- The maximum voltage that may be continuously applied to the resistor element, see "IEC publication 115-8".

DERATING

The power that the resistor can dissipate depends on the operating temperature; see Fig.1.

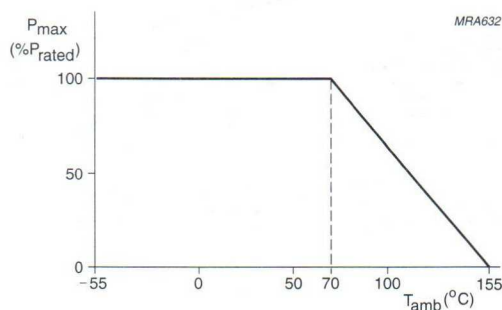


Fig.1 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

PULSE LOADING CAPABILITIES

Detailed design in support with respect to thermal behaviour and pulse loading capability is available on request.



These pulses may not be applied on a regular basis.

Fig.2 Maximum permissible peak pulse voltage without failing to 'open circuit' in accordance with DIN IEC 40 (CO) 533.

Power metal film chip resistor size 1218

PRC202

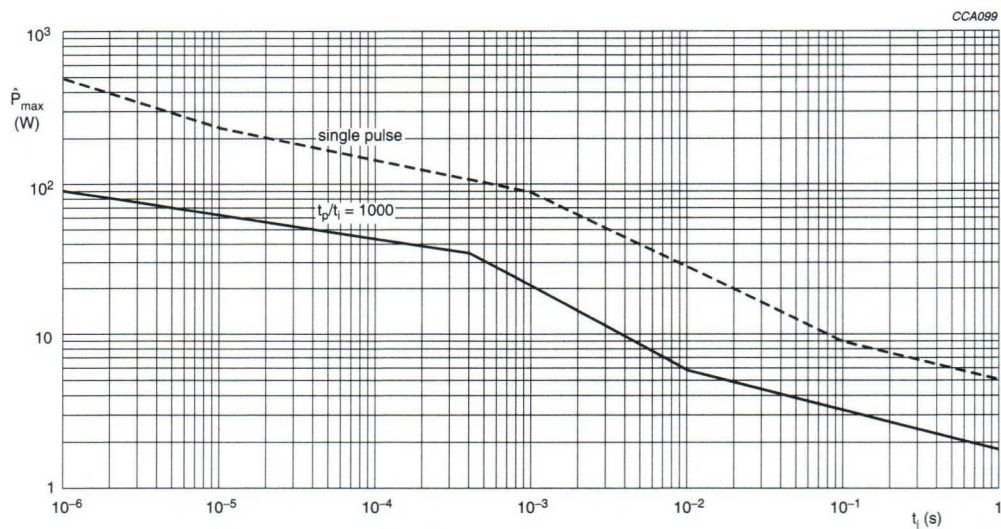


Fig.3 Pulse on a regular basis; maximum permissible peak pulse power ($\dot{P}_{\max}$) as a function of pulse duration, single pulse and repetitive pulse t_p/t_i .

Power metal film chip resistor size 1218

PRC202

Application information

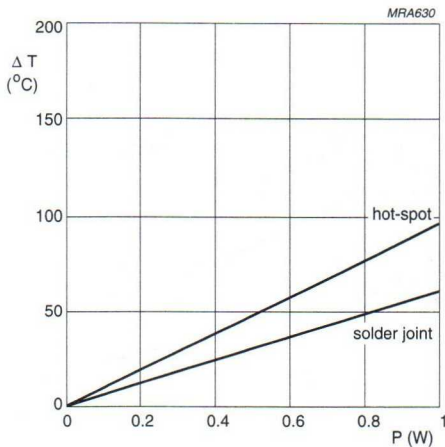


Fig.4 Temperature rise at hot-spot and solder joint as a function of dissipated power, for a PRC202 resistor mounted horizontally on ceramic PCB.

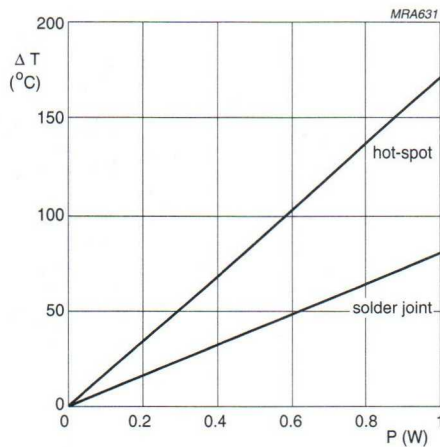


Fig.5 Temperature rise at hot-spot and solder joint as a function of dissipated power, for a PRC202 resistor mounted horizontally on a FR4 PCB.

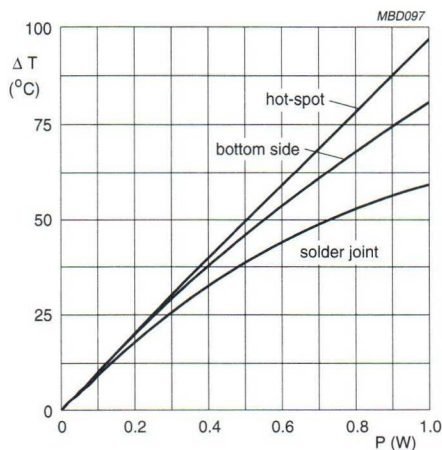


Fig.6 Temperature rise at hot-spot and solder joint as a function of dissipated power, for a PRC202 resistor horizontally mounted on the test substrate; see Fig.7.

Power metal film chip resistor size 1218

PRC202

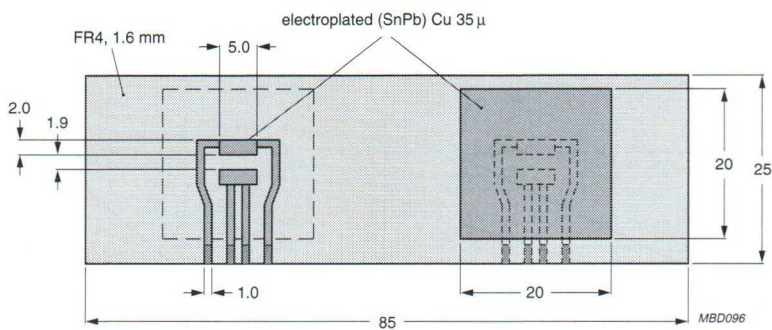


Fig.7 Test substrate layout.

Power metal film chip resistor
size 1218

PRC202

MECHANICAL DATA

Mass per 100 units

TYPE	MASS (g)
PRC202	3

Marking

Each resistor is marked with the nominal resistance value.

4-DIGIT MARKING

The R is used as a decimal point.

Magnitude indicators

RESISTANCE	INDICATOR
0.47 to 100 Ω	R

Example

MARKING	RESISTANCE
80R	80 Ω

The packaging is also marked and includes resistance value, tolerance, TC value, catalogue number, quantity, production period, batch number and source code.

Outlines

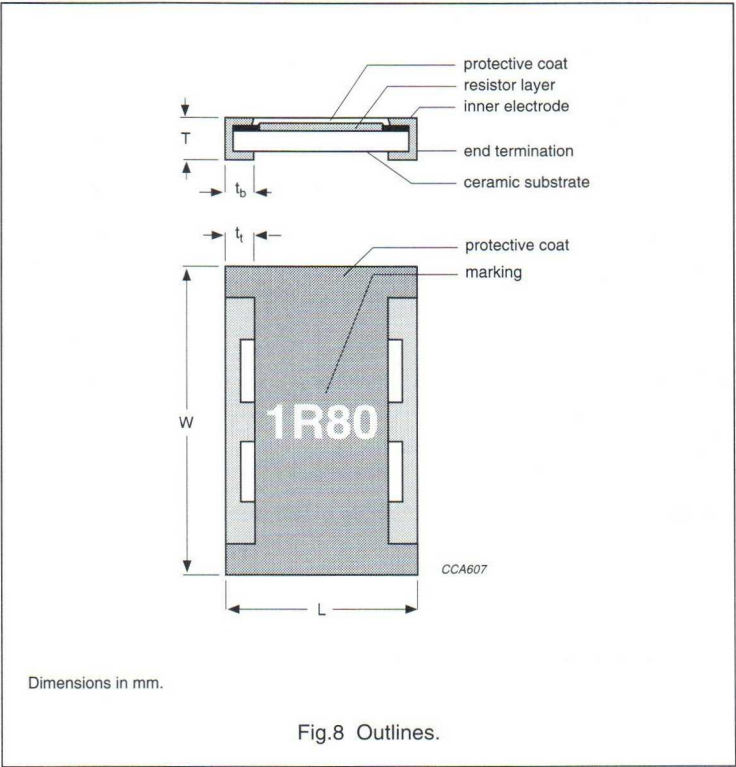


Table 3 Chip resistor type and relevant physical dimensions; see Fig.8

TYPE	L (mm)	W (mm)	T (mm)	t _t (mm)	t _b (mm)
PRC202	3.05 ±0.15	4.60 ±0.2	0.55 ±0.10	0.45 ±0.25	0.50 ±0.25

Power metal film chip resistor size 1218

PRC202

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of "IEC publication 115-8", category 55/155/56 (rated temperature range -55 to +155 °C; damp heat, long term, 56 days). The testing also covers the requirements specified by EIA and EIAJ.

The tests are carried out in accordance with IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components" and under standard atmospheric conditions in accordance with "IEC 68-1", subclause 5.3.

Unless otherwise specified the following values apply:

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

Air pressure: 86 kPa to 106 kPa
(860 mbar to 1060 mbar).

In Table 4 the tests and requirements are listed with reference to the relevant clauses of "IEC publications 115-8 and 68"; a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

All soldering tests are performed with mildly activated flux.

Table 4 Test procedures and requirements

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
Tests in accordance with the schedule of IEC publication 115-8				
4.4.1		visual examination		no holes; clean surface; no damage
4.4.2		dimensions (outline)	gauge	$0.45 \text{ mm} \leq T \leq 0.65 \text{ mm}$ $4.4 \text{ mm} \leq W \leq 4.8 \text{ mm}$ $2.9 \text{ mm} \leq L \leq 3.2 \text{ mm}$
4.5		resistance	applied voltage (+0/-10%): $R < 10 \Omega$: 0.1 V $10 \Omega \leq R < 100 \Omega$: 0.3 V $100 \Omega \leq R$: 1 V	$R - R_{\text{nom}}$: max. $\pm 5\%$ or $R - R_{\text{nom}}$: max. $\pm 1\%$
4.18	20 (Tb)	resistance to soldering heat	10 s; $260 \pm 5 \text{ }^{\circ}\text{C}$	$\Delta R/R$ max.: $\pm 0.5\%$
4.29	45 (Xa)	component solvent resistance	isopropyl alcohol; H ₂ O	no visible damage
4.17	20 (Ta)	solderability	unmounted chips completely immersed for $2 \pm 0.5 \text{ s}$ in a solder bath at $235 \pm 5 \text{ }^{\circ}\text{C}$	good tinning ($\geq 95\%$ covered); no damage
4.7		voltage proof on insulation	200 V (RMS) during 1 minute	no breakdown or flashover
4.13		short time overload	room temperature; dissipation $6.25 \times P_{\text{n}}$; 5 s (voltage not more than $2 \times V_{\text{max}}$)	$\Delta R/R$ max.: $\pm 1\%$
4.33		bending	resistors mounted on a 90 mm glass epoxy resin PCB (FR4), bending: 2 mm	no damage $\Delta R/R$ max.: $\pm 0.5\%$
4.19	14 (Na)	rapid change of temperature	30 minutes at $-55 \text{ }^{\circ}\text{C}$ and 30 minutes at $+125 \text{ }^{\circ}\text{C}$; 5 cycles	no visible damage $\Delta R/R$ max.: $\pm 0.5\%$

Power metal film chip resistor size 1218

PRC202

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.23		climatic sequence:		
4.23.2	2 (Ba)	dry heat	16 hours; 155 °C	
4.23.3	30 (D)	damp heat (accelerated) 1st cycle	24 hours; 55 °C; 95 to 100% RH	
4.23.4	1 (Aa)	cold	2 hours; -55 °C	
4.23.5	13 (M)	low air pressure	1 hour; 8.5 kPa; 15 to 35 °C	
4.23.6	30 (D)	damp heat (accelerated) remaining cycles	5 days; 55 °C; 95 to 100% RH	$\Delta R/R$ max.: $\pm 1\%$ R_{ins} min.: 1000 M Ω
4.6.1.1		insulation resistance	100 V (DC) after 1 minute	R_{ins} min.: 10000 M Ω
4.24.2	3 (Ca)	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; loaded with 0.01 P_n (IEC steps: 4 to 100 V)	no visible damage $\Delta R/R$ max.: $\pm 1\%$
4.25.1		endurance (at 70 °C)	1000 hours; loaded with P_n or V_{max} ; 1.5 hours on and 0.5 hours off	no visible damage $\Delta R/R$ max.: $\pm 1\%$
4.23.2	27 (Ba)	endurance at upper category temperature	1000 hours; 155 °C; no load	no visible damage $\Delta R/R$ max.: $\pm 1\%$
4.8.4.2		temperature coefficient	at 20/-55/20 °C and 20/155/20 °C	$0.47 \Omega \leq R < 1 \Omega$: $\Delta R/R$ max.: $\pm 200 \times 10^{-6}/K$ $1 \Omega \leq R$: $\Delta R/R$ max.: $\pm 50 \times 10^{-6}/K$
Other tests in accordance with IEC 115 clauses and IEC 68 test method				
4.17	20 (Tb)	solderability (after ageing)	16 hours steam or 16 hours at 155 °C; unmounted chips completely immersed for 2 ± 0.5 s in a solder bath at 235 ± 5 °C	good tinning ($\geq 95\%$ covered); no damage
4.22	6 (Fc)	vibration (mounted state)	frequency: 10 to 500 Hz; displacement 1.5 mm or acceleration 10 g; three directions; total 6 hours	no damage $\Delta R/R$ max.: $\pm 1\%$
4.20	29 (Eb)	bump (mounted state)	3×1500 bumps in three directions; 40 g	no damage $\Delta R/R$ max.: $\pm 1\%$
Other applicable tests				
		leaching	unmounted chips 60 s; 260 ± 5 °C	good tinning; no leaching

Metal film precision chip resistors sizes 1206 and 0805

MPC01/11

FEATURES

- Reduced size of final equipment
- Lower assembly costs
- Excellent pulse stability for single pulse conditions
- High stability and low temperature coefficient.

APPLICATIONS

- Computers
- Telecommunication equipment
- Test and measuring equipment.

DESCRIPTION

A metal film layer is deposited on a high grade ceramic body (aluminium oxide). This resistive layer is trimmed to its nominal value and on both ends a contact is made which will guarantee optimum solderability. This is achieved by applying several layers and for ease of soldering the outer layer consists of a lead/tin alloy.

The resistive layer is covered with a protective coat.

ORDERING INFORMATION

Ordering code (12NC)

- The resistors have a 12-digit ordering code starting with 2322 7
- The subsequent first 4 digits indicate the resistor type and packaging; see Table 1.
- The remaining 4 digits indicate the resistance value:
 - The first 3 digits indicate the resistance value.
 - The last digit indicates the resistance decade in accordance with Table 2.

QUICK REFERENCE DATA

DESCRIPTION	VALUE	
	MPC01	MPC11 ⁽¹⁾
Resistance range	10 Ω to 100 k Ω	14 Ω to 30 k Ω
Resistance tolerance	$\pm 0.1\%$; all values; preferred values E24 or E96 series	
Temperature coefficient	$\leq 25 \times 10^{-6}/K$	
Absolute maximum dissipation at $T_{amb} = 70^\circ C$	0.125 W	0.1 W
Maximum permissible voltage	100 V (DC or RMS)	
R_{th} according to DIN 44050	170 K/W on epoxy phenol PCB	–
Climatic category (IEC 68)	55/125/56	
Basic specification	IEC 115-8	
Stability after:		
load, 1 000 hours at $T_{amb} = 70^\circ C$	$\Delta R/R$ max.: $\pm 0.10\%$	
load, 8000 hours at $T_{amb} = 70^\circ C$	$\Delta R/R$ max.: $\pm 0.25\%$	
climatic tests	$\Delta R/R$ max.: $\pm 0.25\%$	
soldering	$\Delta R/R$ max.: $\pm 0.10\%$	
short time overload, 200 V max.	$\Delta R/R$ max.: $\pm 0.10\%$	

Note

1. Data for MPC11 is preliminary.

Table 1 Four digits to indicate type and packaging for resistances as listed

TYPE	ORDERING CODE 2322	
	EMBOSSED CARRIER TAPE ON REEL	
	1 000 units	5000 units
MPC01	741 2....	741 3....
MPC11	744 2....	744 3....

Table 2 Last digit of 12NC

RESISTANCE DECADE	LAST DIGIT
10 $\Omega \leq R < 100 \Omega$	9
100 $\Omega \leq R < 1 \text{ k}\Omega$	1
1 k $\Omega \leq R < 10 \text{ k}\Omega$	2
10 k $\Omega \leq R < 100 \text{ k}\Omega$	3
100 k Ω	4

ORDERING EXAMPLE

The ordering code of a MPC01 resistor, value 50 Ω , supplied on embossed carrier tape of 5 000 units per reel is: 2322 741 35009.

Metal film precision chip resistors sizes 1206 and 0805

MPC01/11

FUNCTIONAL DESCRIPTION

Product characterization

Any value in the range can be supplied, provided that the resistance value may be expressed in three significant digits and an indication of magnitude. Values which cannot be expressed in this way, are available upon request.

Limiting values

TYPE	LIMITING VOLTAGE ⁽¹⁾ (V)	LIMITING POWER (W)
MPC01	100	0.125
MPC11	100	0.1

Note

1. The maximum voltage that may be continuously applied to the resistor element, see "IEC publication 115-8".

DERATING

The power that the resistor can dissipate depends on the operating temperature; see Fig.1.

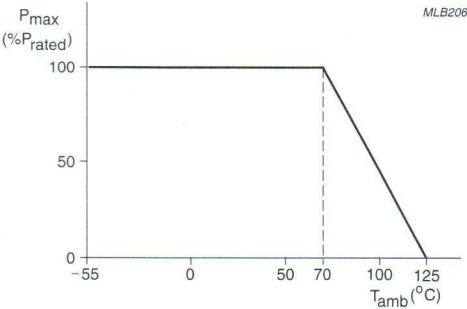
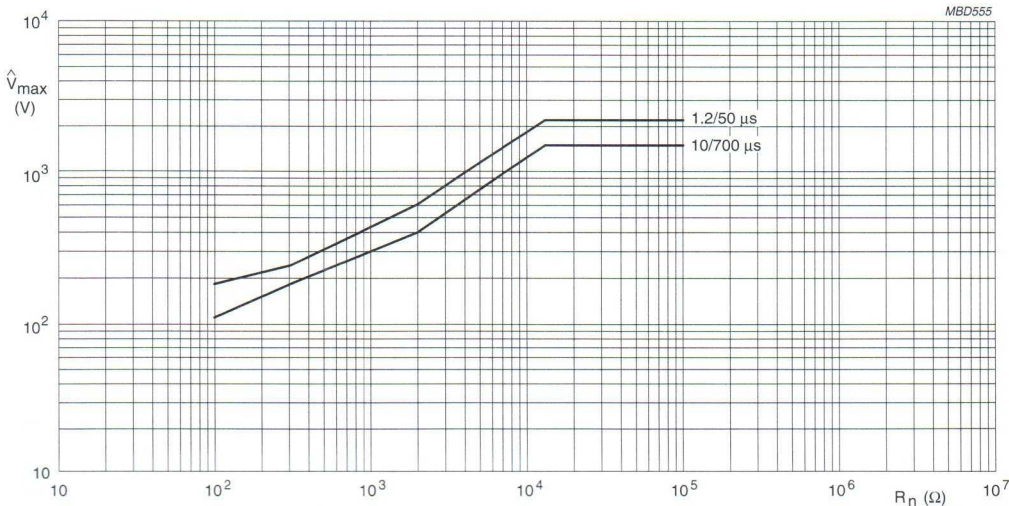


Fig.1 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

PULSE LOADING CAPABILITIES

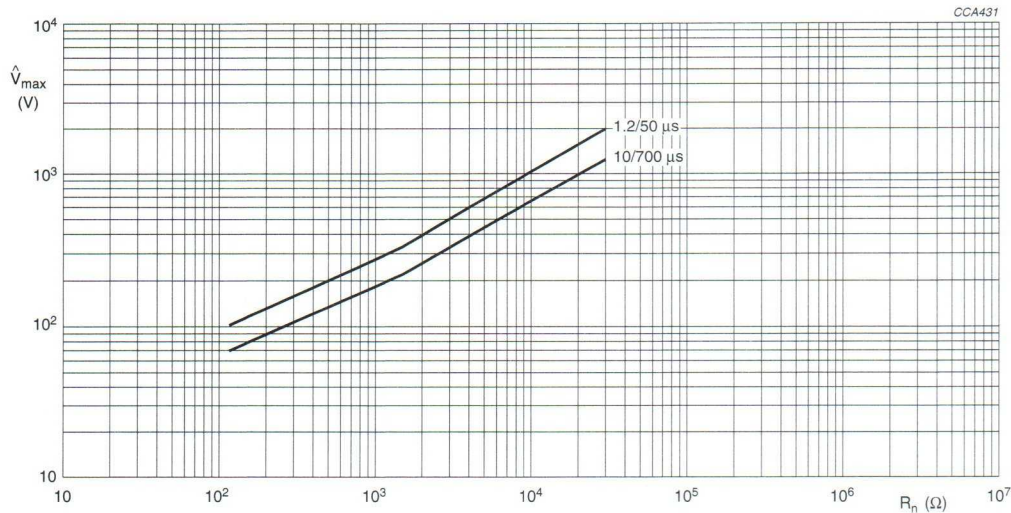


These pulses may not be applied on a regular basis.

Fig.2 Maximum permissible peak pulse voltage for **MPC01** without failing to 'open circuit' in accordance with DIN IEC 40 (CO) 533.

Metal film precision chip resistors
sizes 1206 and 0805

MPC01/11



These pulses may not be applied on a regular basis.

Fig.3 Maximum permissible peak pulse voltage for **MPC11** without failing to 'open circuit' in accordance with DIN IEC 40 (CO) 533.

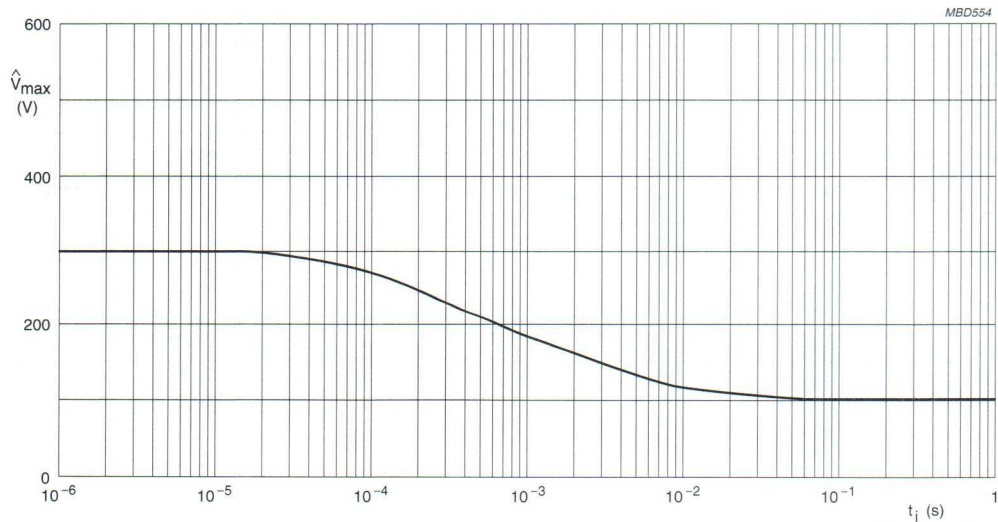


Fig.4 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration.

Metal film precision chip resistors
sizes 1206 and 0805

MPC01/11

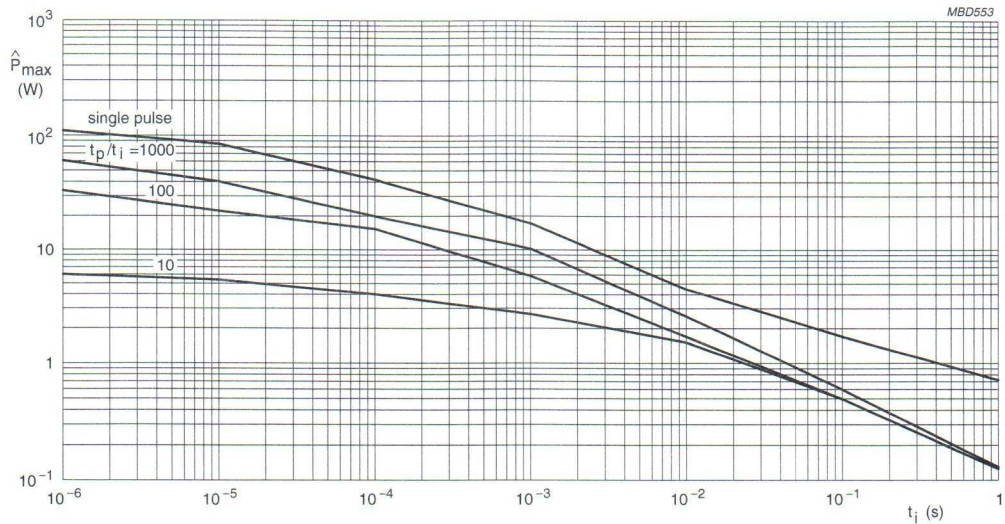


Fig.5 Pulse on a regular basis for **MPC01**; maximum permissible peak pulse power ($\hat{P}_{\max}$) as a function of pulse duration for $R \leq 10 \text{ k}\Omega$, single pulse and repetitive pulse t_p/t_i .

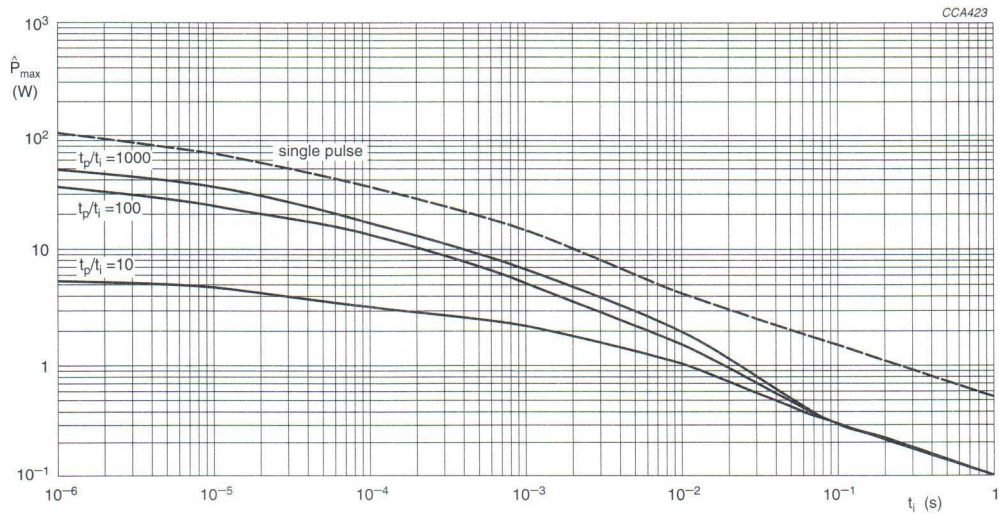


Fig.6 Pulse on a regular basis for **MPC11**; maximum permissible peak pulse power ($\hat{P}_{\max}$) as a function of pulse duration for $R \leq 10 \text{ k}\Omega$, single pulse and repetitive pulse t_p/t_i .

Metal film precision chip resistors
sizes 1206 and 0805

MPC01/11

MECHANICAL DATA

Mass per 100 units

TYPE	MASS (g)
MPC01	1.0
MPC11	0.55

Marking

Resistors from the E24 or E96 series and those with 3 significant numbers are marked with four digits. Resistors of other values are not marked.

4-DIGIT MARKING

For values up to 976 Ω the R is used as a decimal point. For values of 1 kΩ or greater the first 3 digits apply to the resistance value and the fourth indicates the number of zeros to follow.

Example

MARKING	RESISTANCE
50R0	50 Ω
402R	402 Ω
1502	15 kΩ

PACKAGE MARKING

The packaging of all resistors is also marked and includes resistance value, tolerance, TC value, catalogue number, quantity, production period, batch number and source code.

Outlines

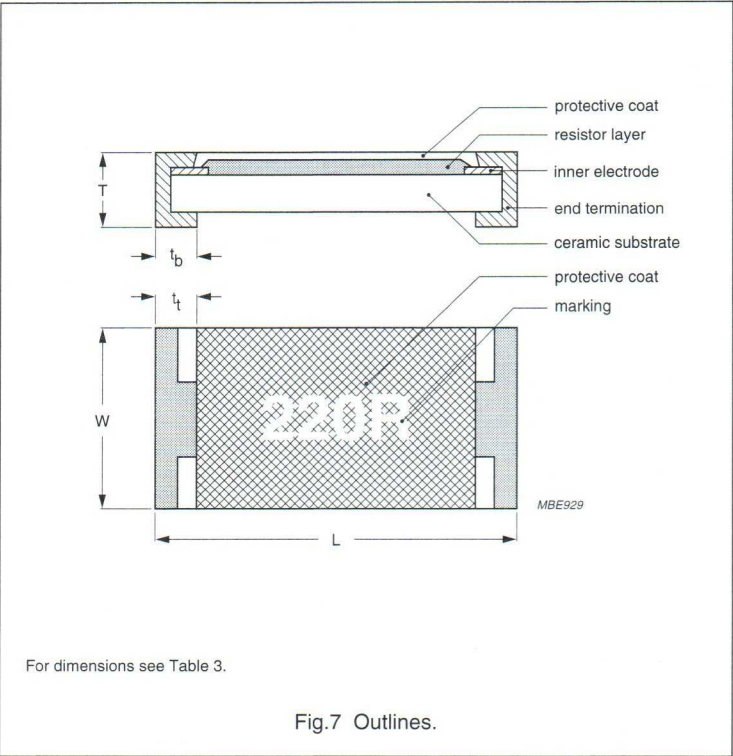


Table 3 Chip resistor type and relevant physical dimensions; see Fig.7

TYPE	L (mm)	W (mm)	T (mm)	t _t (mm)	t _b (mm)
MPC01	3.20 +0.10/-0.20	1.60 ±0.15	0.55 ±0.10	0.35 ±0.25	0.50 ±0.25
MPC11	2.00 ±0.15	1.25 ±0.15	0.55 ±0.10	0.30 ±0.20	0.40 ±0.20

Metal film precision chip resistors sizes 1206 and 0805

MPC01/11

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of "IEC publication 115-8", category **LCT/UCT/56** (rated temperature range: **Lower Category Temperature**, **Upper Category Temperature**; damp heat, long term, **56** days). The testing also covers the requirements specified by EIA and EIAJ.

The tests are carried out in accordance with IEC publication 68,

"Recommended basic climatic and mechanical robustness testing procedure for electronic components" and under standard atmospheric conditions according to "IEC 68-1", subclause 5.3.

Unless otherwise specified the following values apply:

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

Air pressure: 86 kPa to 106 kPa
(860 mbar to 1060 mbar).

In Table 4 the tests and requirements are listed with reference to the relevant clauses of "IEC publications 115-8 and 68", a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

All soldering tests are performed with mildly activated flux.

Table 4 Test procedures and requirements

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS	
				MPC01	MPC11
Tests in accordance with the schedule of IEC publication 115-8					
4.4.1		visual examination		no holes; clean surface; no damage	
4.4.2		dimensions (outline)	gauge (mm)	0.45 ≤ T ≤ 0.65 1.45 ≤ W ≤ 1.7 3.0 ≤ L ≤ 3.3	0.45 ≤ T ≤ 0.65 1.1 ≤ W ≤ 1.4 1.85 ≤ L ≤ 2.15
4.5		resistance	applied voltage (+0/−10%): 10 Ω ≤ R < 100 Ω: 0.3 V 100 Ω ≤ R < 1 kΩ: 1 V 1 kΩ ≤ R < 10 kΩ: 3 V 10 kΩ ≤ R < 100 kΩ: 10 V 100 kΩ: 25 V	R − R _{nom} : max. ±0.1%	
4.18	20 (Ta)	resistance to soldering heat	unmounted chips; 10 s; 260 ±5 °C	no visual damage ΔR/R max.: ±0.10%	
4.29	45 (Xa)	component solvent resistance	isopropyl alcohol or H ₂ O followed by brushing in accordance with “MIL 202 F”	no visual damage	
4.17	20 (Ta)	solderability	unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C	good tinning (≥95% covered); no visual damage	
4.7		voltage proof on insulation	maximum voltage (RMS) during 1 minute metal block method	no breakdown or flashover	
4.13		short time overload	room temperature; P = 6.25 × P _n ; 5 s (V ≤ 2 × V _{max})	ΔR/R max.: ±0.1%	
4.33		bending	resistors mounted on a 90 mm glass epoxy resin PCB (FR4); bending: 2 mm	no visual damage ΔR/R max.: ±0.1%	

Metal film precision chip resistors sizes 1206 and 0805

MPC01/11

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS	
				MPC01	MPC11
4.19	14 (Na)	rapid change of temperature	30 minutes at LCT and 30 minutes at UCT; 5 cycles	no visual damage $\Delta R/R$ max.: $\pm 0.1\%$	
4.23	30 (D)	climatic sequence:	6 days; 55 °C; 95 to 98% RH	R_{ins} min.: 1000 M Ω $\Delta R/R$ max.: $\pm 0.25\%$	
4.23.3		damp heat (accelerated) 1st cycle			
4.23.6		damp heat (accelerated) remaining cycles			
4.24.2	3 (Ca)	damp heat (steady state) (IEC)	56 days; 40 °C; 90 to 95% RH; loaded with 0.01 P _n (IEC steps: 4 to 100 V)	$\Delta R/R$ max.: $\pm 0.25\%$	
4.25.1		endurance (at 70 °C)	1000 hours; loaded with P _n or V _{max} ; 1.5 hours on and 0.5 hours off	$\Delta R/R$ max.: $\pm 0.1\%$	
4.23.2	27 (Ba)	endurance at upper category temperature	1000 hours; no load	$\Delta R/R$ max.: $\pm 0.1\%$	
4.8.4.2		temperature coefficient	at 20/LCT/20 °C and 20/UCT/20 °C (TC $\times 10^{-6}/K$)	$\leq \pm 25$	
Other tests in accordance with IEC 115 clauses and IEC 68 test method					
4.17	20 (Tb)	solderability (after ageing)	8 hours steam or 16 hours 155 °C; unmounted chips completely immersed for 2 ± 0.5 s in a solder bath at 235 ± 5 °C	good tinning ($\geq 95\%$ covered); no damage	
4.6.1.1		insulation resistance	voltage (DC) after 1 minute metal block method: 100 V	R_{ins} min.: 1000 M Ω	
4.12		noise	IEC publication 195 (measured with Quantech - equipment)	max. 0.10 $\mu V/V$	
Other applicable tests					
		humidity load (steady state) (JIS)	1000 hours; +40 °C; 90 to 95% RH; loaded with P _n or V _{max} ; 1.5 hours on and 0.5 hours off	$\Delta R/R$ max.: $\pm 0.25\%$	
		leaching	unmounted chips 60 s; 260 ± 5 °C	good tinning; no leaching	
		trio damp heat test	1000 hours; +85 °C; 85% RH; loaded with 0.1 P _n or V _{max}	$\Delta R/R$ max.: $\pm 0.25\%$	
		pulse test (JIS)	2.5 $\times$ rated voltage or max. overload; 1 s on and 25 s off; 10 ⁴ cycles	$\Delta R/R$ max.: $\pm 0.5\%$	

LEADED RESISTORS

Leaded resistors

Selection guide

APPLICATION	TYPE	TOLERANCE (%)	RESISTANCE RANGE	DISSIPATION		PAGE
				(at °C)	(W)	
Metal film						
Standard	SFR16	5	1 Ω to 3 MΩ	70	0.50	134
	SFR25		1 Ω to 10 MΩ		0.40	
	SFR25H				0.50	
Metal film	MRS16T	1	4.99 Ω to 1 MΩ	70	0.40	147
	MRS25		1 Ω to 10 MΩ		0.60	
Fusible	NFR25	5	1 Ω to 15 kΩ	70	0.33	159
	NFR25H				0.50	
Precision	MPR24	0.05; 0.02; 0.01	24 Ω to 100 kΩ	70	0.125	169
	MPR34				0.25	
	MPR24	0.5; 0.25; 0.1	4.99 Ω to 1 MΩ		0.25	
	MPR34				0.40	
Power	PR01	5	0.22 Ω to 1 Ω	70	0.6	183
			1 Ω to 1 MΩ		1	
	PR02		0.33 Ω to 1 Ω		1.2	
			1 Ω to 1 MΩ		2	
	PR03		0.68 Ω to 1 Ω		1.6	
			1 Ω to 1 MΩ		3	
Metal glaze						
High voltage	VR25	1; 5; 10	100 kΩ to 22 MΩ	70	0.25	176
	VR37	1; 5	100 kΩ to 33 MΩ		0.50	
	VR68		100 kΩ to 68 MΩ		1.0	
Wirewound						
Cemented	AC01	5	0.1 Ω to 1.5 kΩ	40	1	203
	AC03		0.1 Ω to 3 kΩ		3	
	AC04		0.1 Ω to 6.8 kΩ		4	
	AC05		0.1 Ω to 8.2 kΩ		5	
	AC07		0.1 Ω to 15 kΩ		7	
	AC10		0.68 Ω to 15 kΩ		10	
	AC15		0.82 Ω to 22 kΩ		15	
	AC20		1.2 Ω to 33 kΩ		20	
Precision	PAC01	1	0.22 Ω to 2.2 kΩ	25	1	213
	PAC02		0.1 Ω to 3.6 kΩ		2	
	PAC03		0.1 Ω to 4.7 kΩ		3	
	PAC04		0.1 Ω to 8.2 kΩ		4	
	PAC05		0.68 Ω to 10 kΩ		5	
	PAC06		0.68 Ω to 12 kΩ		6	

Leaded resistors

Selection guide

APPLICATION	TYPE	TOLERANCE (%)	RESISTANCE RANGE	DISSIPATION		PAGE
				(at °C)	(W)	
Stand up						
Miniature power	SMW02; SMF02	5	0.1 Ω to 47 kΩ	70	2	219
	SMW03; SMF03				3	
	SMW05; SMF05				5	
Radial						
Power	RMW03; RMF03	5	0.22 Ω to 39 kΩ	70	3	225
	RMW05; RMF05		0.47 Ω to 51 kΩ		5	
	RMW07; RMF07		0.68 Ω to 100 kΩ		7	
	RMW10; RMF10		1 Ω to 150 kΩ		10	
Maintenance types; not for new designs						
Metal film	MR25	0.5	1 Ω to 1 MΩ	70	0.40	234
	MR30				0.50	
	MR52	1	4.99 Ω to 1 MΩ		1.0	
MIL metal film	MR24D	1	10 Ω to 1 MΩ	70	0.125	242
	MR34D				0.25	
	MR54D				0.5	
	MR24E/C	0.1; 0.25; 0.5; 1	49.9 Ω to 1 MΩ	125	0.1	
	MR34E/C				0.125	
	MR54E/C				0.25	
Power metal film	PR37	5	1 Ω to 27 kΩ	70	1.6	247
			30 kΩ to 1 MΩ		1.2	
	PR52		1 Ω to 51 kΩ		2.5	255
			56 kΩ to 1 MΩ		2.0	
Enamelled wirewound	WR0617E	5	4.7 Ω to 100 kΩ	70	4.00	263
	WR0825E				7.00	
	WR0842E				11.0	
	WR0865E				17.0	

Leaded resistors

General Introduction

INTRODUCTION

Data in data sheets is presented, whenever possible, eaccording to a 'format', in which the following chapters are stated:

- TITLE
- FEATURES
- APPLICATIONS
- DESCRIPTION
- QUICK REFERENCE DATA
- ORDERING INFORMATION
- FUNCTIONAL DESCRIPTION
 - Product characterization
 - Limiting values
- MECHANICAL DATA
 - Outlines
 - Mass
 - Marking
 - Mounting
- TESTS AND REQUIREMENTS

The chapters listed above are explained in this section "General Introduction Leaded resistors", with detailed information (including "Packaging") in the relevant data sheet.

DESCRIPTION

Most types of conventional resistors have a cylindrical ceramic body, either rod or tube. For special purposes, a high-grade aluminium ceramic is used. The resistive element is either a carbon film, metal film, thick film or a wound wire element. Film types have been trimmed to the required ohmic resistance by cutting a helical groove in the resistive layer. This process is controlled completely by computer and yields a high reliability. The terminations are usually iron end caps onto which tinned connecting wires of electrolytic copper are welded.

All resistor bodies are coated with a coloured lacquer or enamel for protection. Dependent on types, this lacquer provides electrical, mechanical and/or climatic protection, also against soldering flux and cleaning solvents, in accordance with "MIL-STD-202E", method 215 and "IEC 68-2-45".

ORDERING INFORMATION

Resistors are ordered by their **ordering code**, a 12-digit number. The packaging method and resistance code are integral parts of this number.

FUNCTIONAL DESCRIPTION

The functional description includes: nominal resistance range and tolerance, limiting voltage, temperature coefficient, absolute maximum dissipation, climatic category and stability.

The **limiting voltage** (DC or RMS) is the maximum voltage that may be continuously applied, see "IEC publications 115-1 and 115-2". Where applicable, **derating details** and **performance nomograms** are given, showing the relationship between power dissipation, ambient temperature, hot-spot temperature and maximum resistance drift after prolonged operation. For power resistors, graphs indicate the relationship between temperature rise and dissipation with lead-length or heatsinks as parameters.

The temperature rise in a resistor due to power dissipation, is determined by the laws of heat - conduction, convection and radiation. The maximum body temperature usually occurs in the middle of the resistor and is called the **hot-spot** temperature.

Heat conducted by the leads - which can be considerable in power types - must not reach the melting point of the solder at the joints. This condition may require the use of heatsinks and/or longer leads.

In the normal operating temperature range of film resistors the temperature rise at the hot-spot, ΔT , is proportional to the power dissipated: $\Delta T = A \times P$. The proportionally constant 'A' gives the temperature rise per Watt of dissipated power and can be interpreted as a thermal resistance in K/W. This thermal resistance is a function of the dimensions of the resistor, the heat conductivity of the materials used and to a lesser degree, the way of mounting. The sum of the temperature rise and the ambient temperature is:

$$T_m = T_{amb} + \Delta T$$

where:

T_m = hot-spot temperature

T_{amb} = ambient temperature

ΔT = temperature rise at hot-spot.

The stability of a film resistor during endurance tests is mainly determined by the hot-spot temperature and the resistance. The lower the resistance - other conditions remaining constant - the higher the stability due to greater film thickness.

Leaded resistors

General Introduction

Summarizing

DESCRIPTION	RELATIONSHIP
Dimensions and conductance of materials determine	heat resistance
Heat resistance $\times$ dissipation gives	temperature rise
Temperature rise + ambient temperature give	hot-spot temperature
Hot-spot temperature and resistance value determine	stability

Performance

When specifying the performance of a resistor, the dissipation is given as a function of the hot-spot temperature, with the ambient temperature as a parameter.

From $\Delta T = A \times P$ and $T_m = T_{amb} + \Delta T$ it follows that:

$$P = \frac{T_m - T_{amb}}{A}$$

If P is plotted against T_m for a constant value of A , parallel straight lines are obtained for different values of the ambient temperature.

The slope of these lines,

$$\frac{dP}{dT_m} = \frac{1}{A}$$

is the reciprocal of the heat resistance and is the characteristic for the resistor.

The stability $\frac{\Delta R}{R}$ can be determined experimentally, for instance after 1000 h, as a function of the hot-spot temperature with the resistance value as a parameter. It has been found that the resistance changes exponentially with temperature, giving a straight line

when $\log \frac{\Delta R}{R}$ is plotted against T_m .

A combination of the graphs of P and $\frac{\Delta R}{R}$ against T_m gives a nomogram from which the values of several variables can be determined for a resistor of a given size under different working conditions. An example of such a nomogram with fictitious values is given in Fig.1. The intersection of the broken line with the horizontal axis gives the hot-spot temperature under chosen conditions.

Leaded resistors

General Introduction

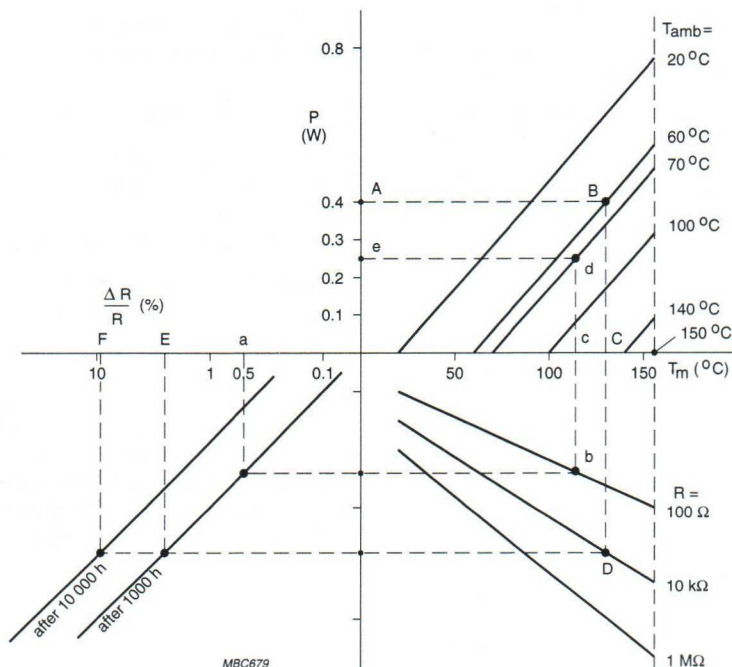


Fig.1 Performance nomogram (for a fictitious resistor) illustrating the way of specifying the performance of film resistors.

Example 1

Assume that a $10\ \text{k}\Omega$ resistor, whose characteristics are described by the nomogram, is to be operated at a power dissipation of $0.4\ \text{W}$ and an ambient temperature of 60°C . To establish whether this dissipation is allowable at this ambient temperature and, if so, what the expected stability of the resistor will be, draw a horizontal line in the upper half of the nomogram through point A (power dissipation of $0.4\ \text{W}$). This line intersects the 60°C ambient temperature line at point B, corresponding to a hot-spot temperature of 128°C (point C). This is safely below the maximum indicated by the broken line at 155°C ; therefore a dissipation of $0.4\ \text{W}$ at an ambient temperature of 60°C is well within the allowable limit.

Extend line BC into the lower half of the nomogram until it intersects the $10\ \text{k}\Omega$ line at point D. Draw a horizontal line to the left from point D until it intersects the line 'after 1000 h' and extend vertically to point E. This means that at a hot-spot temperature of 128°C a resistance change of about 2.5% (point E) can be expected after 1000 hours of operation. After 10000 hours, the change will be about 9% (point F).

Leaded resistors

General Introduction

Example 2

Assume that a $100\ \Omega$ resistor, whose characteristics are described by the nomogram, is to be operated at an ambient temperature of $70\ ^\circ\text{C}$ with a required stability after 1000 h of 0.5% (point a). It is desired to find the maximum permissible power dissipation. In the lower half of the nomogram, a line that corresponds to a stability after 1000 h of 0.5% intersects the $100\ \Omega$ resistance line at point b, corresponding to a hot-spot temperature of $112\ ^\circ\text{C}$ (point c).

Extending the line (b-c) into the upper half of the nomogram, it intersects the line indicating an ambient temperature of $70\ ^\circ\text{C}$ at point d, corresponding to a maximum permissible power dissipation of $0.25\ \text{W}$ (point e).

If the power to be dissipated exceeds the value found, a resistor of higher value should be used.

The temperature coefficient

The temperature coefficient of resistance is a ratio which indicates the rate of increase (decrease) of resistance per Kelvin (K) increase (decrease) of temperature within a specified range, and is expressed in parts per million per K ($\times 10^{-6}/\text{K}$).

Example: If the temperature coefficient of a resistor of $R_{\text{nom}} = 1\ \text{M}\Omega$ between $-55\ ^\circ\text{C}$ and $+155\ ^\circ\text{C}$ is $\pm 100 \times 10^{-6}/\text{K}$ its resistance will be,

at $25\ ^\circ\text{C}$:

$1000000\ \Omega$ (nominal = rated value)

at $+155\ ^\circ\text{C}$:

$1000000\ \Omega \pm (130 \times 100 \times 10^{-6}) \times 1000000\ \Omega$
 $= 1013000\ \Omega$ or $987000\ \Omega$

at $-55\ ^\circ\text{C}$:

$1000000\ \Omega \pm (80 \times 100 \times 10^{-6}) \times 1000000\ \Omega$
 $= 1008000\ \Omega$ or $992000\ \Omega$

If the temperature coefficient is specified as $\leq 100 \times 10^{-6}/\text{K}$ the resistance will be within the shaded area as shown in Fig.2.

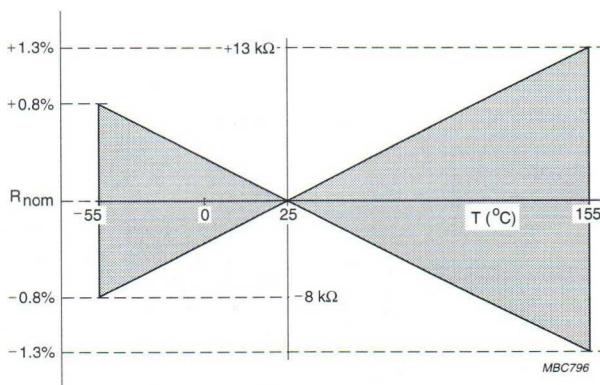


Fig.2 Temperature coefficient.

Leaded resistors

General Introduction

THERMAL RESISTANCE (R_{th})

Thermal resistance that prohibits the release of heat generated within the resistor to the surrounding environment. It is expressed in K/W and defines the surface temperature (T_{HS}) of the resistor in relation to the ambient temperature (T_{amb}) and the load (P = dissipation) of the resistor, as follows:

$$T_{HS} = T_{amb} + P \times R_{th}$$

The thermal resistance given in the specification is determined in accordance with DIN 44050 (T_{amb} between 20 and 25 °C).

The resistor is mounted on a PCB (see Fig.3) which is set up vertically, with the resistor horizontal. Using an infrared camera, a thermal image is made of the resistor, thus defining the hot-spot and solder-spot temperatures.

It should be noted that different ways of mounting give differing results, i.e. mounting with a higher heat conductance gives a lower thermal resistance figure; mounting with a lower heat conductance gives a higher thermal resistance figure.

PULSE-LOAD BEHAVIOUR

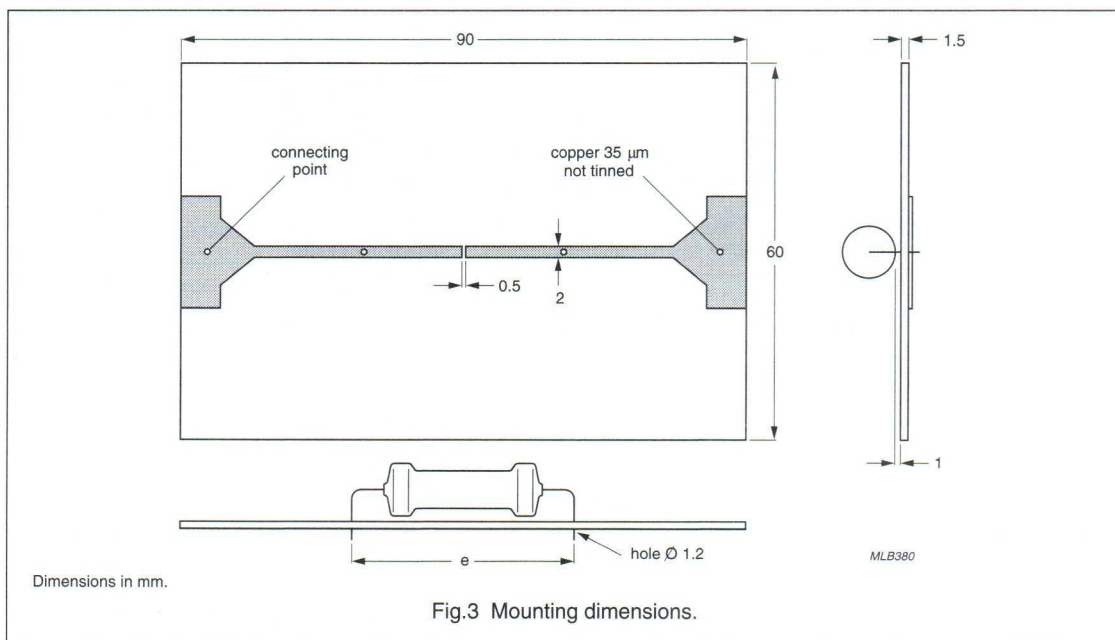
Knowing the thermal characteristics of a resistor, it is possible to calculate the dissipation due to a single pulse,

which will cause a resistor to fail by going open circuit. This theoretical maximum can be expressed in terms of maximum peak pulse power ($\dot{P}_{max}$) and pulse duration (t_i); the straight line in Fig.4 is a typical example for a film resistor. In practice, owing to variations in the resistance film, substrate, or spiralling, resistors fail at loads less than this theoretical maximum; the dashed line in Fig.4 shows the observed maximum for a resistor under single-pulse-load.

The magnitude of a single pulse at which failure occurs is of little practical value. More usually, the resistor must withstand a continuous train of pulses of repetition time t_p during which only a small resistance change is acceptable. This resistance change $\Delta R/R$ is equal to the change permissible under continuous load conditions. The continuous pulse train and small permissible resistance change both reduce the maximum handling capability.

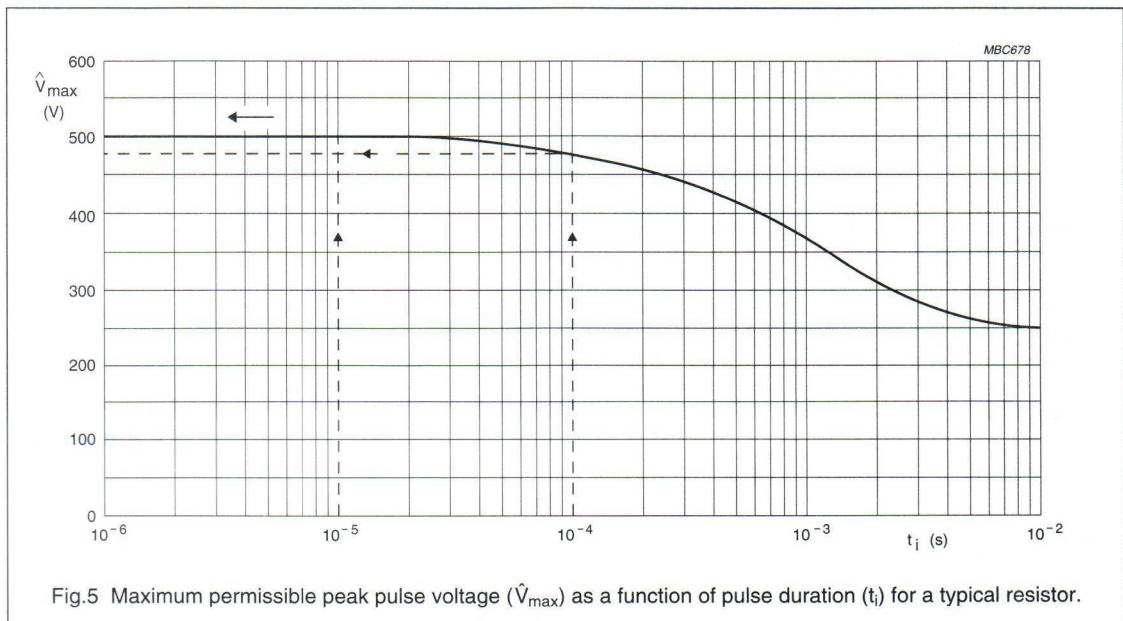
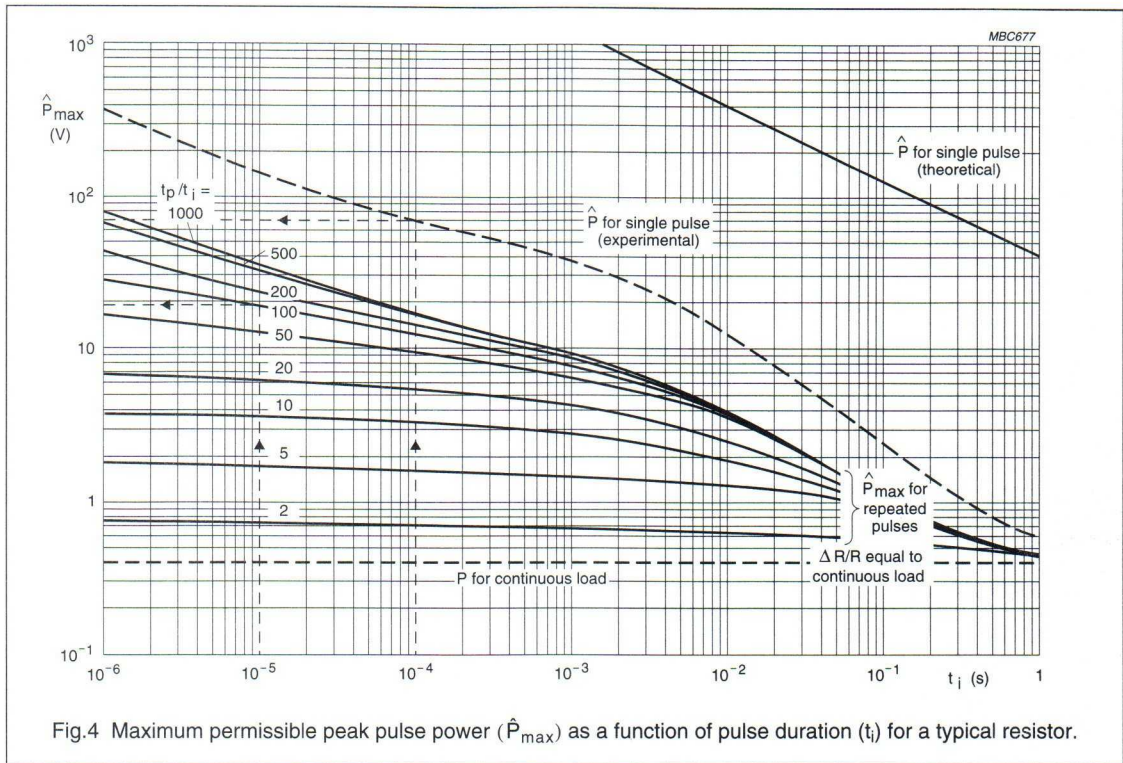
Using a computer program which takes account of all factors affecting behaviour under pulse loads, curves similar to those of Fig.4 are being produced for all resistor ranges.

Measurements have shown that the calculated value is accurate to within 10% of the true value. However, maximum peak pulses as indicated in Fig.5 should not be exceeded.



Leaded resistors

General Introduction



Leaded resistors

General Introduction

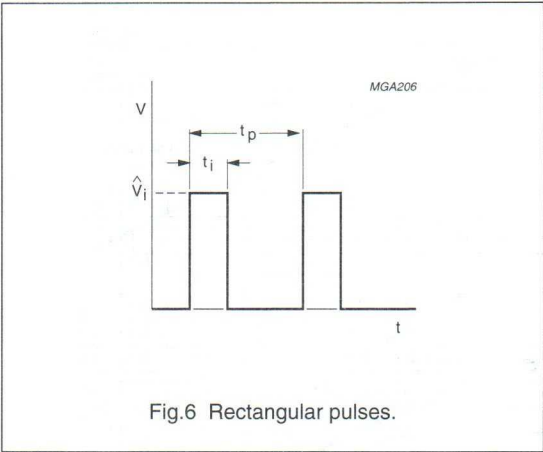


Fig.6 Rectangular pulses.

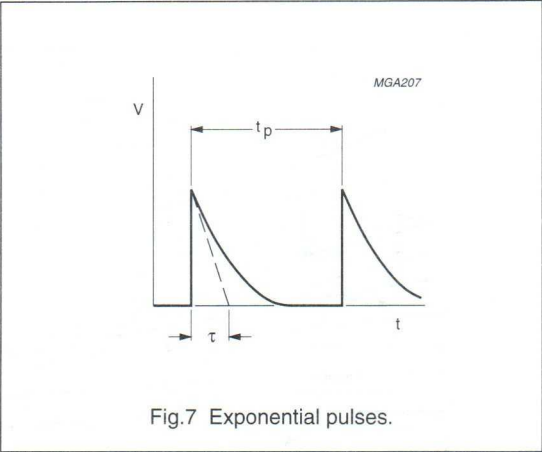


Fig.7 Exponential pulses.

Definition of symbols (see Figs 4, 5, 6 and 7)

SYMBOL	DESCRIPTION
$\hat{P}$	applied peak pulse power
$\hat{P}_{\max}$	maximum permissible peak pulse power (Fig.4)
$\hat{V}_i$	applied peak pulse voltage (Figs 6 and 7)
$\hat{V}_{\max}$	maximum permissible peak pulse voltage (Fig.5)
R_{nom}	nominal resistance value
t_i	pulse duration (rectangular pulses)
t_p	pulse repetition time
τ	time constant (exponential pulses)
T_{amb}	ambient temperature
$T_{m(\text{max})}$	maximum hot-spot temperature of the resistor

Definitions of pulse-load behaviour; metal film resistors

SINGLE PULSE

The resistor is considered to be operating under single pulse conditions if, during its life, it is loaded with a limited number (approximately 1500) of pulses over long time intervals (greater than one hour).

REPETITIVE PULSE

The resistor is operating under repetitive pulse conditions if it is loaded by a continuous train of pulses of similar power.

Determination of pulse-load

The graphs in Figs 4 and 5 may be used to determine the maximum pulse-load for a resistor. The calculations assume:

- $T_{\text{amb}} = 70\text{ }^{\circ}\text{C}$
- T_m is the maximum permissible hot-spot temperature for the relevant resistor family
- $\Delta R/R$ equal to the permitted value for 1000 hours at continuous level.

- For repetitive rectangular pulses:
 - $\frac{\hat{V}_i^2}{R}$ must be lower than the value of $\hat{P}_{\max}$ given by the solid lines of Fig.4 for the applicable value of t_i and duty cycle t_p/t_i .
 - $\hat{V}_i$ must be lower than the value of $\hat{V}_{\max}$ given in Fig.5 for the applicable value of t_i .
- For repetitive exponential pulses:
 - As for rectangular pulses, except that $t_i = 0.5\tau$.
- For single rectangular pulses:
 - $\frac{\hat{V}_i^2}{R}$ must be lower than the $\hat{P}_{\max}$ given by the dashed line of Fig.4 for the applicable value of t_i .
 - $\hat{V}_i$ must be lower than the value of $\hat{V}_{\max}$ given in Fig.5 for the applicable value of t_i .

Leaded resistors

General Introduction

Examples

Determine the stability of a typical resistor for operation under the following pulse-load conditions.

CONTINUOUS PULSE TRAIN

A 100 Ω resistor is required to operate under the following conditions: $\hat{V}_i = 40$ V; $t_i = 10^{-5}$ s; $t_p = 10^{-3}$ s.

Therefore:

$$\hat{P} = \frac{40^2}{100} = 16 \text{ W and } \frac{t_p}{t_i} = \frac{10^{-3}}{10^{-5}} = 100$$

For $t_i = 10^{-5}$ s and $\frac{t_p}{t_i} = 100$, Fig.4 gives $\hat{P}_{\max} = 19$ W

and Fig.5 gives $\hat{V}_{\max} = 500$ V. As the operating conditions $\hat{P} = 16$ W and $\hat{V}_i = 40$ V are lower than these limiting values, this resistor can be safely used.

SINGLE PULSE

A 1000 Ω resistor is required to operate under the following conditions:

$$\hat{V}_i = 200 \text{ V; } t_i = 10^{-4} \text{ s}$$

Therefore:

$$\hat{P}_{\max} = \frac{200^2}{1000} = 40 \text{ W}$$

The dashed curve of Fig.4 shows that at $t_i = 10^{-4}$ s, the permissible $\hat{P}_{\max} = 70$ W and Fig.5 shows a permissible $\hat{V}_{\max}$ of 480 V, so this resistor may be used.

MECHANICAL DATA

A dimensional sketch and if applicable, a table of dimensions is given. The lead length of axial types is not usually stated if the resistors are only available on tape.

The sketch (see Fig.8) does include however, length (L), diameter of the body ($\varnothing D$) and the lead diameter ($\varnothing d$). For certain types, the length is stated as L_1 and L_2 ; L_1 is the body length, L_2 is the body length plus lacquer on the leads. By specifying L_1/L_2 , the dimensional 'clean lead to clean lead' properties can be determined.

The length of the cylindrical body (L_1) is measured by inserting the leads into the holes of two identical gauge plates (Fig.9) and moving these plates parallel to each other, until the resistor body is clamped without deformation (*"IEC publication 194"*).

This method does not apply to rectangular resistors, 'stand-up' types and wirewound resistors with side terminations.

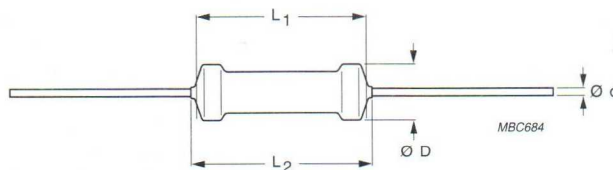
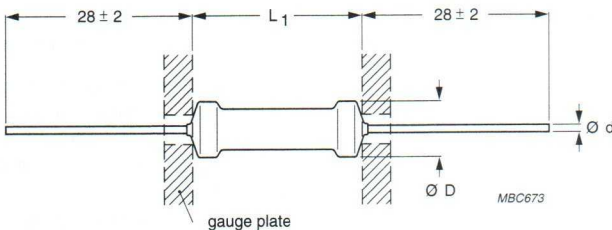
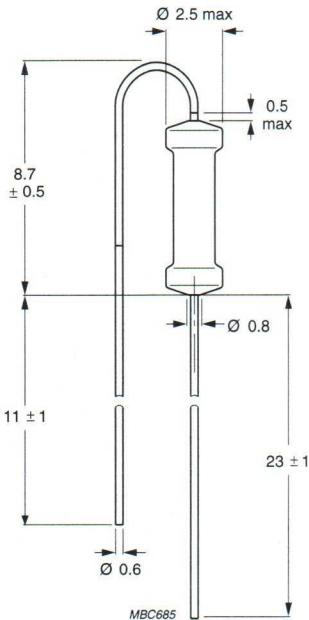


Fig.8 Component outline.



Dimensions in mm.
For dimensions see Table 1.

Fig.9 Measurement of dimension L_1 .



Dimensions in mm.

Fig.10 SFR25 and VR25A are available as 'stand-up' types and shown in the 'mounted' position.

The relationship between the diameter of the leads and the diameter of the holes in the gauge plate is shown in Table 1.

Table 1 Lead diameter and hole dimensions

$\varnothing d$ (mm)	HOLE DIAMETER (mm)
0.5	0.8
0.6	1.0
0.7	1.0
0.8	1.2

Mass

The mass is given per 100 resistors.

Marking

The resistors are either colour coded or provided with an identification stamp. The colour code consists of a number of coloured bands in accordance with IEC publication 62: "Colour code for fixed resistors". See also "IEC 115-1", clause 4.5. The coloured bands indicate the **nominal resistance**, the **tolerance** on the resistance and, if applicable, the **temperature coefficient**. A maximum of bands may be used, but in some instances there are fewer, e.g. if the products are too small.

Leaded resistors

General Introduction

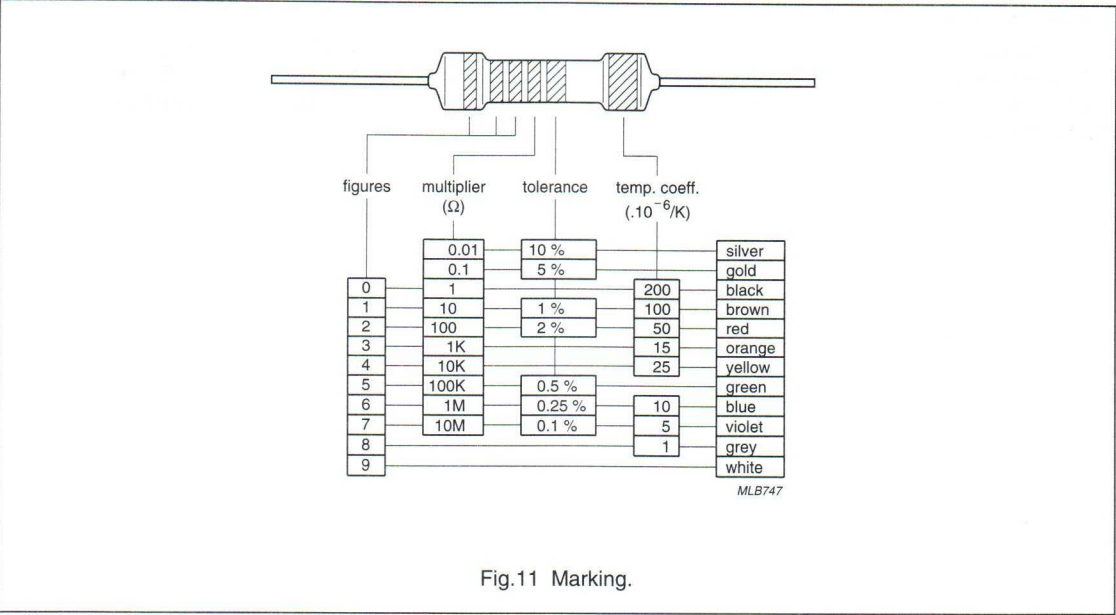


Fig.11 Marking.

The **resistance code** consists of either three or four bands and is followed by a band representing the **tolerance**. The **temperature coefficient** is to the right of the tolerance band and is usually positioned on the cap (MRS types), as a wide band. When five or six bands in total are used, the last band will always be the wider one.

The **resistance code** includes the first two or three **significant figures** of the resistance value (in ohms), followed by an **indicator**. This is a factor by which the significant-figure value must be multiplied to find the relevant resistance value. Whether two or three significant figures are represented depends on the tolerance: $\pm 2\%$ and higher requires two bands; $\pm 1\%$ and lower requires three bands.

The 'figures' refer to the first two or three digits of the resistance value of the standard series of values in a decade, in accordance with "IEC publication 63" as indicated in the relevant data sheet and shown on the inside back cover of this handbook.

Certain resistors are not coded by colour bands but by a stamp giving pertinent data (alphanumeric marking). This is adopted with MIL types MR24E/C/D, MR34E/C/D, MR54E/C/D and MR74E/C/D, as well as PR37 and PR52. Resistors outside the standard "IEC 63" series of types MPR24 and MPR34, are stamped. All wirewound resistors are stamped.

Body colours

Table 2 The resistor bodies are lacquered in different colours to simplify identification

COLOUR	TYPE
Tan	CR25
Light green	SFR25/SFR16
Grey	NFR25, NFR25H
Green	MR25, MR30, MR52, MR24E/C/D, MR34E/C/D, MR54E/C/D, MR74E/C/D, MPR24, MPR34, MRS16T, MRS25, AC04, AC05, AC07, AC10, AC15, AC20
Light blue	VR25, VR37, VR68, SFR16S
Red	PR37, PR52, PR01, PR02, PR03
Brown	WR0167E, WR0842E, WR0825E, WR0865E
Red-brown	SFR25H

Mounting

Most types with straight axial leads and most in the 'stand-up' version (radial leads; see Fig. 10) are suitable for processing on automatic insertion equipment, cutting and bending machines.

TESTS AND REQUIREMENTS

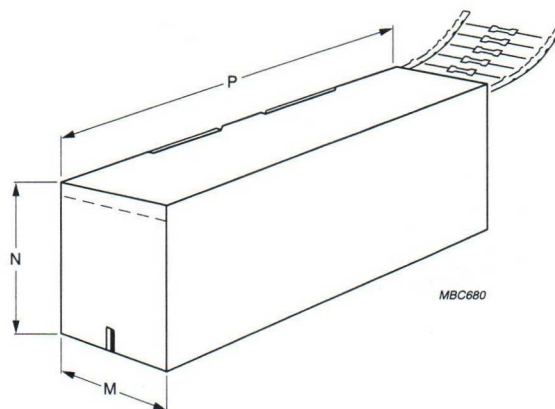
Essentially all tests on resistors are carried out in accordance with the schedule of "IEC publication 115-1" in the specified climatic category and in accordance with IEC publication 68, "*Recommended basic climatic and mechanical robustness testing procedure for electronic components*". In some instances deviations from the IEC recommendations are made.

Leaded resistors

Packaging

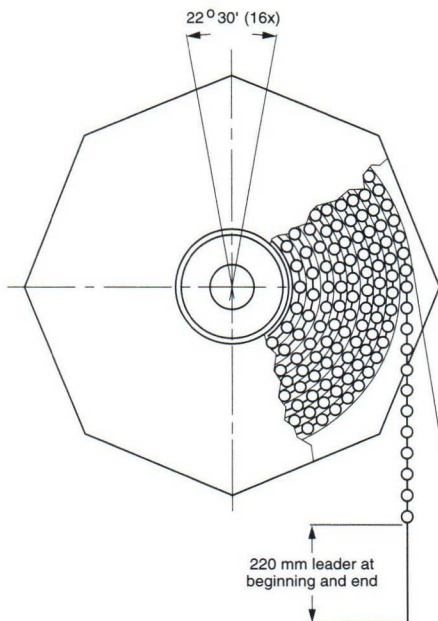
PACKAGING

Dimensions of ammpack and reel



For dimensions see Table 1.

Fig.1 Bandolier in ammpack.



Dimensions in mm.
For dimensions see Table 2.

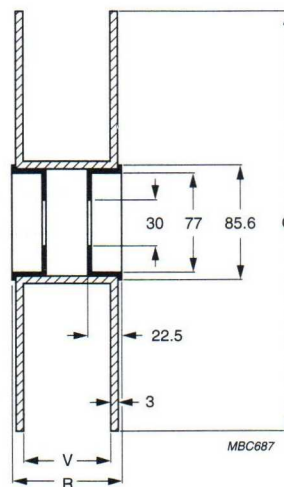
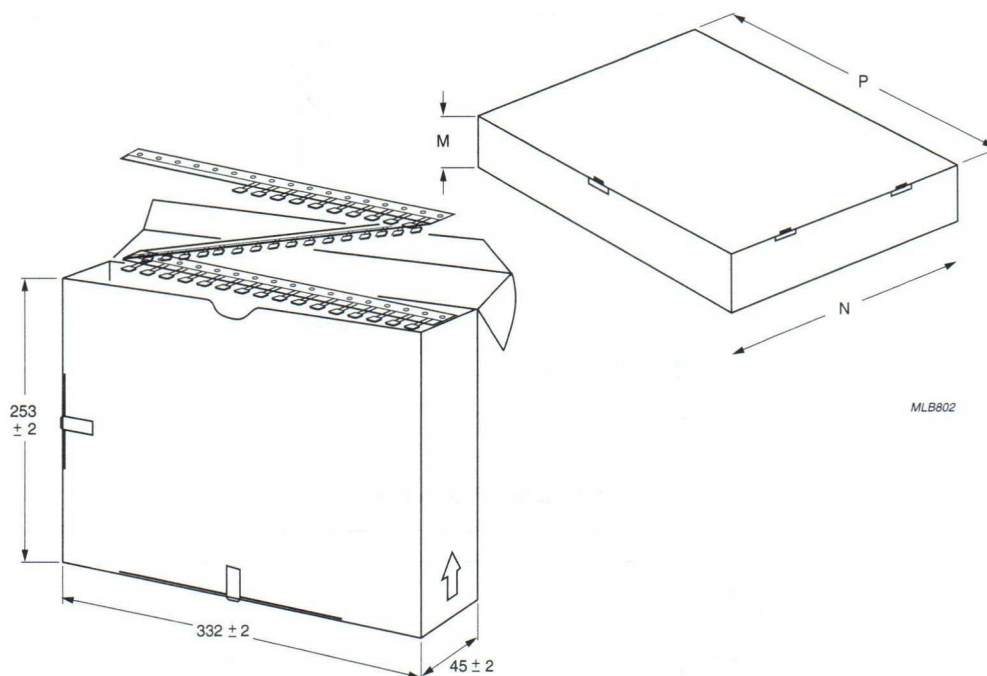


Fig.2 Bandolier on reel.

Leaded resistors

Packaging



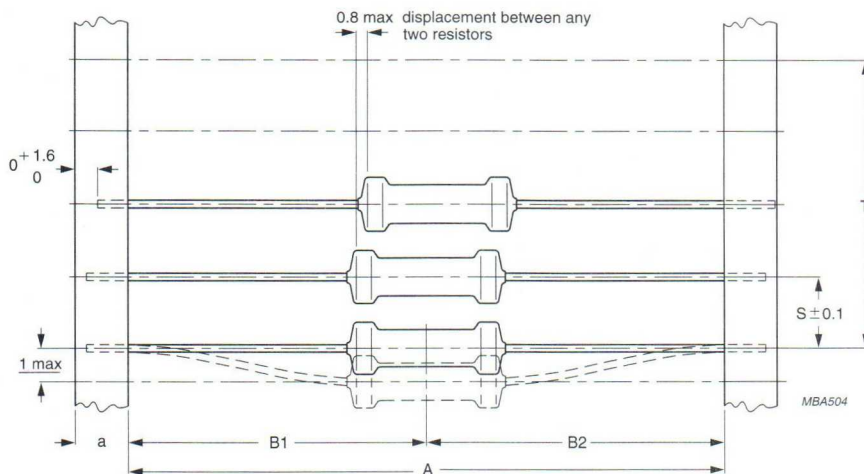
Dimensions in mm.
For dimensions see Table 5.

Fig.3 Dimensions of ammpack (radial taped).

Leaded resistors

Packaging

Products with straight leads



Dimensions in mm.

Maximum 1 mm per 10 spacings.

Maximum 0.5 mm per 5 spacings.

For dimensions see Tables 1 and 2.

Fig.4 Axial style on tape.

Table 1 Resistor type, quantities and packaging dimensions for axial taped in ammpack; see Figs 1 and 4

PRODUCT TYPE	QUANTITY	PACKAGING DIMENSIONS						
		AXIAL TAPED ON BANDOLIER				AMMOPACK		
		a (mm)	A (mm)	$ B_1 - B_2 $ (mm)	S (mm)	M (mm)	N (mm)	P (mm)
SFR16	1000	6 ± 0.5	52.5 ± 1.5	± 1.2	5	75	30	140
	5000	6 ± 0.5	52.5 ± 1.5	± 1.2	5	75	73	270
SFR25	1000	6 ± 0.5	$52 + 1.5/-0$	± 1.2	5	82	28	262
	5000	6 ± 0.5	$52 + 1.5/-0$	± 1.2	5	78	98	270
SFR25H	1000	6 ± 0.5	$52 + 1.5/-0$	± 1.2	5	82	28	262
	5000	6 ± 0.5	$52 + 1.5/-0$	± 1.2	5	78	98	270
NFR25	1000	6 ± 0.5	$52 + 1.5/-0$	± 1.2	5	82	28	262
	5000	6 ± 0.5	$52 + 1.5/-0$	± 1.2	5	78	98	270
NFR25H	1000	6 ± 0.5	$52 + 1.5/-0$	± 1.2	5	82	28	262
	5000	6 ± 0.5	$52 + 1.5/-0$	± 1.2	5	78	98	270
MRS16T	1000	6 ± 0.5	$52 + 1.5/-0$	± 0.5	5	75	30	140
	5000	6 ± 0.5	$52 + 1.5/-0$	± 0.5	5	75	73	270

Leaded resistors

Packaging

PRODUCT TYPE	QUANTITY	PACKAGING DIMENSIONS						
		AXIAL TAPED ON BANDOLIER				AMMOPACK		
		a (mm)	A (mm)	B ₁ - B ₂ (mm)	S (mm)	M (mm)	N (mm)	P (mm)
MRS25	1000	6 ±0.5	52 +1.5/-0	±1.2	5	82	28	262
	5000	6 ±0.5	52 +1.5/-0	±1.2	5	78	107	270
MR25	1000	6 ±0.5	52 +1.5/-0	±1.2	5	82	28	262
MR30	1000	6 ±0.5	52 +1.5/-0	±1.2	5	77	34	265
MR52	1000	6 ±0.5	66.7 ±1.5	±1.2	10	97	95	260
MPR24	500 or 1000	6 ±0.2	63.5 ±1.5	±1.2	5	97	29	262
MPR34	500 or 1000	6 ±0.2	63.5 ±1.5	±1.2	5	97	39	262
VR25	1000	6 ±0.5	52 +1.5/-0	±1.0	5	82	28	262
	2000	6 ±0.5	26 +1.5/-0	±1.0	5	50	50	255
	5000	6 ±0.5	52 +1.5/-0	±1.2	5	78	98	270
VR37	1000	6 ±0.5	52 +1.5/-0	±1.2	5	83	60	262
VR68	500	5 ±0.5	66.7 ±1.5	±1.2	10	85	112	258
PR01	1000	6 ±0.5	73 ±1.5	±1.2	5	97	28	262
PR02	1000	6 ±0.5	73 ±1.5	±1.2	5	97	59	262
PR03	500	6 ±0.5	80 ±1.5	±1.2	10	99	77	259
PR37	1000	6 ±0.5	73 ±1.5	±1.2	5	97	59	262
PR52	500	6 ±0.5	80 ±1.5	±1.2	10	97	77	259
AC01	1000	6 ±0.5	63 ±4	±1.2	10	85	60	263
AC03	500	6 ±0.5	63 ±4	±1.2	10	85	77	259
AC04	500	6 ±0.5	63 ±4	±1.2	10	85	77	259
AC05	500	6 ±0.5	63 ±4	±1.2	10	85	112	259
AC07	500	6 ±0.5	74 ±4	±1.2	10	93	115	259
WR0617E	500	5 ±0.5	66.7 ±1.6	±1.2	10	85	77	259
WR0825E	500	6 ±0.5	74 ±1.6	±1.2	10	93	115	259
WR0842E	100	6 ±0.5	88 ±1.6	±1.2	10	132	56	160
WR0865E	100	6 ±0.5	110 ±1.6	±1.2	10	132	56	160
PAC02	500	6 ±0.5	63 ±1	±1.2	10	85	60	263
PAC03	500	6 ±0.5	63 ±1	±1.2	10	85	60	263
PAC04	500	6 ±0.5	71 ±1	±1.2	10	97	120	273
PAC05	500	6 ±0.5	71 ±1	±1.2	10	97	120	273
PAC06	500	6 ±0.5	71 ±1	±1.2	10	97	120	273

Leaded resistors

Packaging

Table 2 Resistor type, quantities and packaging dimensions for axial taped on reel; see Figs 2 and 4

PRODUCT TYPE	QUANTITY	PACKAGING DIMENSIONS						
		AXIAL TAPED ON BANDOLIER				REEL		
		a (mm)	A (mm)	$ B_1 - B_2 $ (mm)	S (mm)	Q (mm)	V (mm)	R (mm)
SFR16	5000	6 ± 0.5	52.5 ± 1.5	± 1.2	5	265	75	86
SFR25	5000	6 ± 0.5	$52 + 1.5/-0$	± 1.2	5	305	75	86
SFR25H	5000	6 ± 0.5	$52 + 1.5/-0$	± 1.2	5	305	75	86
NFR25	5000	6 ± 0.5	$52 + 1.5/-0$	± 1.2	5	305	75	86
NFR25H	5000	6 ± 0.5	$52 + 1.5/-0$	± 1.2	5	305	75	86
MRS16T	5000	6 ± 0.5	$52 + 1.5/-0$	± 0.5	5	265	75	86
MRS25	5000	6 ± 0.5	$52 + 1.5/-0$	± 1.2	5	305	75	86
MPR24	5000	6 ± 0.2	63.5 ± 1.5	± 1.2	5	305	90	—
MPR34	5000	6 ± 0.2	63.5 ± 1.5	± 1.2	5	356	90	—
VR25	5000	6 ± 0.5	$52 + 1.5/-0$	± 1.2	5	305	75	86
VR37	5000	6 ± 0.5	$52 + 1.5/-0$	± 1.2	5	356	75	86
PR01	5000	6 ± 0.5	73 ± 1.5	± 1.2	5	305	90	—

Leaded resistors

Packaging

Products with radial leads

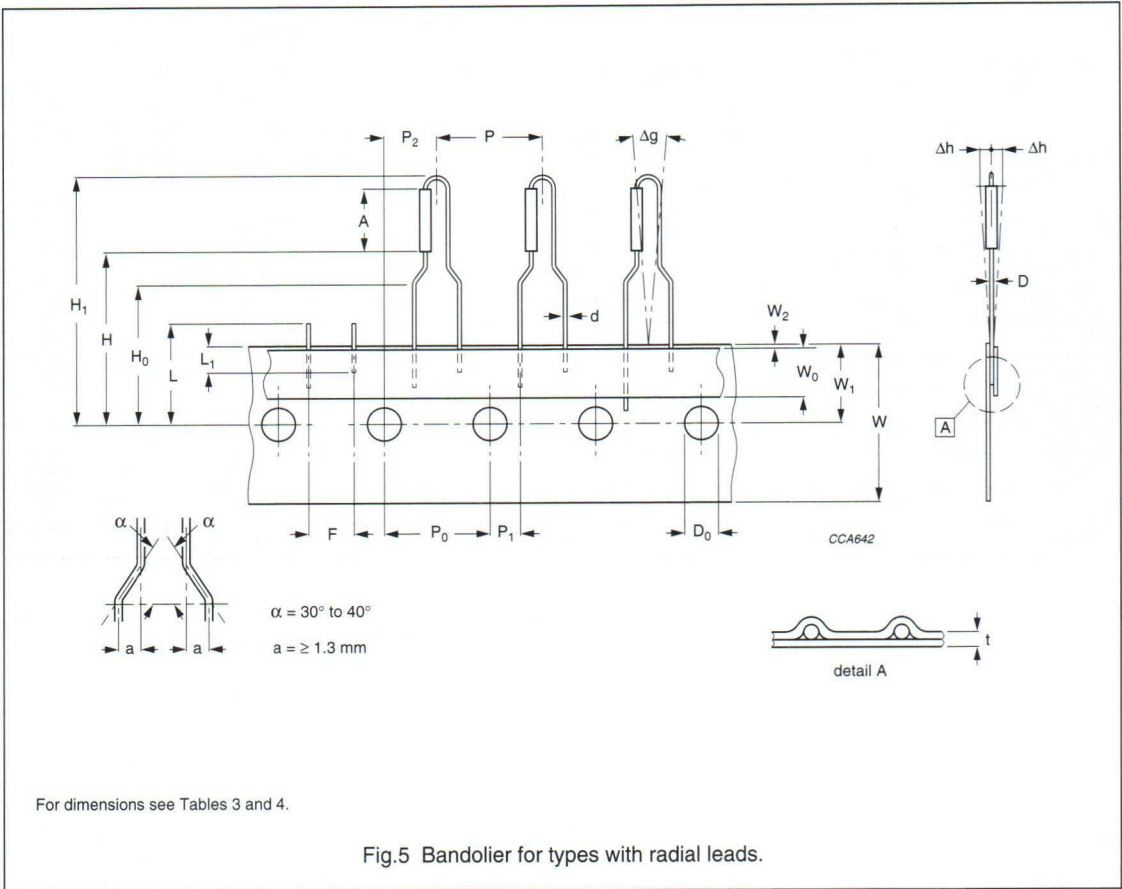


Table 3 Product dependent tape dimensions; see Fig.5

SYMBOL	PARAMETER	TYPE	VALUE	TOLERANCE	UNIT
D	maximum body diameter	see detailed product specification			mm
A	maximum body length				mm
d	lead wire diameter				mm
H ₁	component height	SFR25	29	max	mm
		NFR25	29	max	mm
		NFR25H	29	max	mm
		PR01	29	max	mm
		PR02	29	±3.0	mm
		AC01	29	±3.0	mm

Leaded resistors

Packaging

Table 4 Tape dimensions; non-product dependent; see Fig.5

SYMBOL	PARAMETER	VALUE	TOLERANCE	UNIT
P	pitch of components	12.7	± 1.0	mm
P ₀	feed-hole pitch	12.7	± 0.2	mm
	cumulative pitch error per 20 spacings		1.0	mm
P ₁	feed-hole centre to lead at topside at the tape	3.85	± 0.5	mm
P ₂	feed-hole centre to body centre	6.35	± 1.0	mm
F	lead-to-lead distance	4.8	+0.7/-0	mm
Δh	component alignment	0	± 1.2	mm
Δg	component alignment	0	$\pm 3^\circ$	deg
W	tape width	18.0	± 0.5	mm
W ₀	minimum hold down tape width	5.5	—	mm
W ₁	hole position	9.0	± 0.5	mm
W ₂	maximum hold down tape position	0.5	—	mm
H ₀	lead wire clinch height	16.5	± 0.5	mm
H	height of component from tape centre	19.5	± 1	mm
D ₀	feed-hole diameter	4.0	± 0.2	mm
t	total tape thickness	0.4	-0/+0.5	mm
L	maximum length of snipped lead	11.0	—	mm
L ₁	minimum lead wire (tape portion) shortest lead	2.5	—	mm

Table 5 Resistor type, quantities and dimensions of the packaging for radial taped in ammpack; see Fig.3

PRODUCT TYPE	QUANTITY	PACKAGING DIMENSIONS		
		AMMOPACK		
		M (mm)	N (mm)	P (mm)
SFR25	4000	45	262	330
NFR25	4000	45	262	330
NFR25H	4000	45	262	330
PR01	4000	45	262	330
PR02	3000	45	262	330
AC01	2500	45	262	330

Products with cropped and formed leads

Table 6 Resistor type, quantities and dimensions of the packaging for cropped and formed, loose in box

PRODUCT TYPE	QUANTITY	PACKAGING DIMENSIONS		
		AMMOPACK		
		M (mm)	N (mm)	P (mm)
PR01	1000	105	70	205
PR02	500 or 1000	105	70	205
PR03	250 or 500	105	70	205
PR37	500 or 1000	105	70	205
PR52	500	105	70	205



PRODUCT SPECIFICATIONS LEADED RESISTORS

Standard metal film resistors

SFR16/25

FEATURES

- Low cost
- Low noise
- Small size (SFR16).

APPLICATIONS

- General purpose resistors.

DESCRIPTION

A homogeneous film of metal alloy is deposited on a high grade ceramic body. After a helical groove has been cut in the resistive layer, tinned connecting leads of electrolytic copper are welded to the end-caps.

The resistors are coated with a coloured lacquer (light-blue for

type SFR16; light-green for type SFR25 and red-brown for type SFR25H) which provides electrical, mechanical and climatic protection. The encapsulation is resistant to all cleaning solvents, in accordance with "MIL-STD-202E", method 215 and "IEC 68-2-45".

QUICK REFERENCE DATA

DESCRIPTION	VALUE		
	SFR16	SFR25	SFR25H
Resistance range	1 Ω to 3 MΩ	1 Ω to 10 MΩ and jumper (0 Ω)	
Resistance tolerance	±5%, E24 series		
Temperature coefficient:			
R < 4.7 Ω	≤ ±250 × 10 ⁻⁶ /K	≤ ±100 × 10 ⁻⁶ /K	≤ ±100 × 10 ⁻⁶ /K
4.7 Ω ≤ R ≤ 100 kΩ	≤ ±100 × 10 ⁻⁶ /K	≤ ±100 × 10 ⁻⁶ /K	≤ ±100 × 10 ⁻⁶ /K
100 kΩ < R ≤ 1 MΩ	≤ ±250 × 10 ⁻⁶ /K	≤ ±100 × 10 ⁻⁶ /K	≤ ±100 × 10 ⁻⁶ /K
R > 1 MΩ	≤ ±250 × 10 ⁻⁶ /K	≤ ±250 × 10 ⁻⁶ /K	≤ ±250 × 10 ⁻⁶ /K
Absolute maximum dissipation at T _{amb} = 70 °C	0.5 W	0.4 W	0.5 W
Thermal resistance, R _{th}	170 K/W	200 K/W	150 K/W
Maximum permissible voltage	200 V	250 V	350 V
Noise:			
R < 68 kΩ	max. 0.1 μV/V	max. 0.1 μV/V	max. 0.1 μV/V
68 kΩ ≤ R ≤ 100 kΩ	max. 0.5 μV/V	max. 0.1 μV/V	max. 0.1 μV/V
100 kΩ ≤ R ≤ 1 MΩ	max. 1.5 μV/V	max. 0.1 μV/V	max. 0.1 μV/V
R > 1 MΩ	max. 1.5 μV/V	max. 1.5 μV/V	max. 1.5 μV/V
Basic specifications	IEC 115-1 and 115-2		
Climatic category (IEC 68)	55/155/56		
Stability, ΔR/R max., after:			
load:			
R ≤ 1 MΩ	±1% +0.05 Ω	±1% +0.05 Ω	±1% +0.05 Ω
R > 1 MΩ	±1% +0.05 Ω	±1% +0.05 Ω	±2% +0.1 Ω
climatic tests:			
R ≤ 1 MΩ	±1% +0.05 Ω	±1% +0.05 Ω	±1% +0.05 Ω
R > 1 MΩ	±1% +0.05 Ω	±1% +0.05 Ω	±2% +0.1 Ω
soldering	±0.25% +0.05 Ω	±0.25% +0.05 Ω	±0.25% +0.05 Ω
short time overload	±0.25% +0.05 Ω	±0.25% +0.05 Ω	±1% +0.05 Ω

Standard metal film resistors

SFR16/25

ORDERING INFORMATION

Table 1 Ordering code indicating resistor type and packaging

TYPE	ORDERING CODE 2306	ORDERING CODE 2322		
	BANDOLIER IN AMMOPACK			BANDOLIER ON REEL
	RADIAL TAPED	STRAIGHT LEADS		STRAIGHT LEADS
	4000 units	1 000 units	5000 units	5000 units
SFR16	—	187 73...	187 53...	187 83...
SFR25	184 03...	181 53...	181 43...	181 63...
SFR25 jumper ⁽¹⁾	—	—	181 90019	—
SFR25H	—	186 16...	186 76...	186 26...

Note

1. The jumper has a maximum resistance $R_{\text{max}} = 10 \text{ m}\Omega$ at 5 A.

Ordering code (12NC)

- The resistors have a 12-digit ordering code.
- The first 9 digits indicate the resistor type and packaging; see Table 1.
- The remaining 3 digits indicate the resistance value:
 - The first 2 digits indicate the resistance value.
 - The last digit indicates the resistance decade in accordance with Table 2.

Table 2 Last digit of 12NC

RESISTANCE DECADE	LAST DIGIT
1 to 9.76 Ω	8
10 to 97.6 Ω	9
100 to 976 Ω	1
1 to 9.76 k Ω	2
10 to 97.6 k Ω	3
100 to 976 k Ω	4
1 to 9.76 M Ω	5
10 M Ω	6

ORDERING EXAMPLE

The ordering code of a SFR25 resistor, value 5600 $\Omega \pm 5\%$, taped on a bandolier of 5000 units in ammopack is: 2322 181 43562.

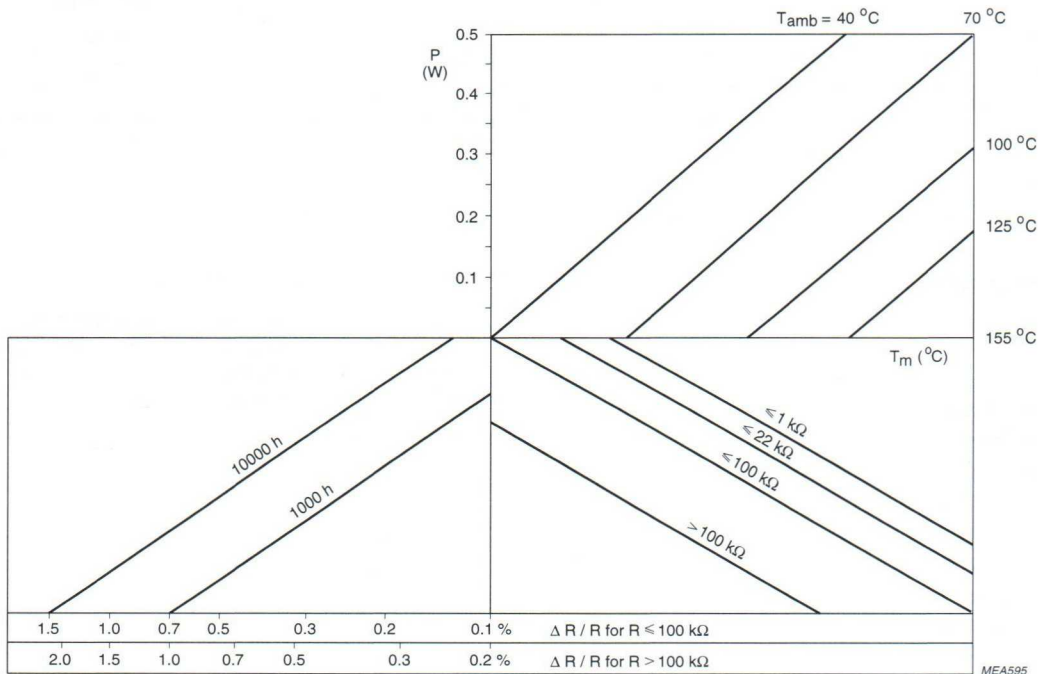
Standard metal film resistors

SFR16/25

FUNCTIONAL DESCRIPTION

Product characterization

Standard values of nominal resistance are taken from the E24 series for resistors with a tolerance of $\pm 5\%$.
The values of the E24 series are in accordance with "IEC publication 63".

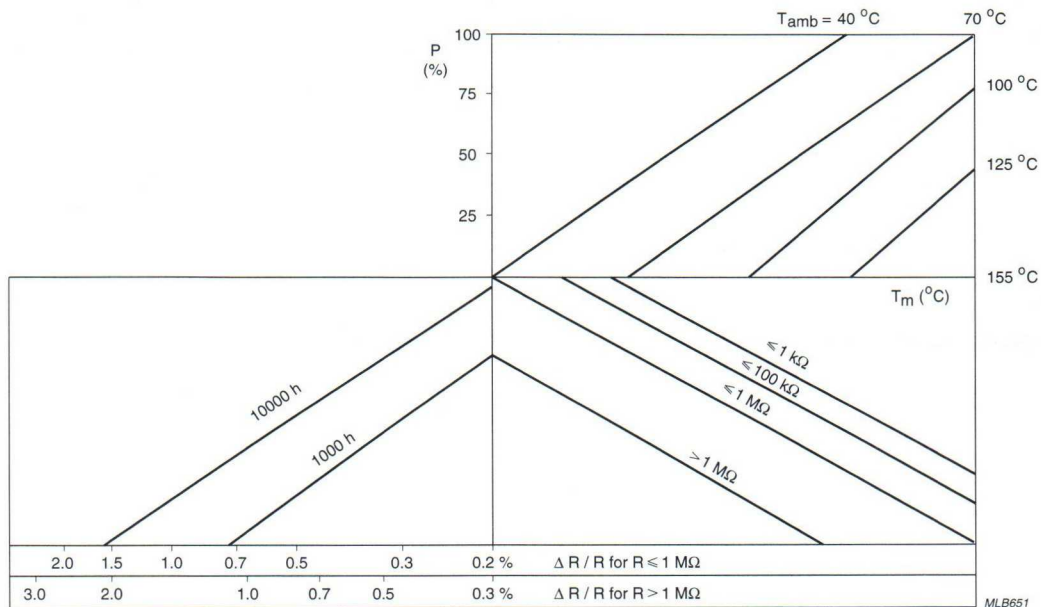


SFR16

Fig.1 Drift nomogram.

Standard metal film resistors

SFR16/25



MLB651

SFR25(H) $P_n = 0.4 \text{ W}$ (SFR25) or 0.5 W (SFR25H).

Fig.2 Drift nomogram.

Standard metal film resistors

SFR16/25

Limiting values

TYPE	LIMITING VOLTAGE ⁽¹⁾ (V)	LIMITING POWER (W)
SFR16	200	0.5
SFR25	250	0.4
SFR25H	350	0.5

Note

1. The maximum voltage that may be continuously applied to the resistor element, see "IEC publication 115-1".

The maximum permissible hot-spot temperature is 155 °C.

DERATING

The power that the resistor can dissipate depends on the operating temperature; see Fig.3.

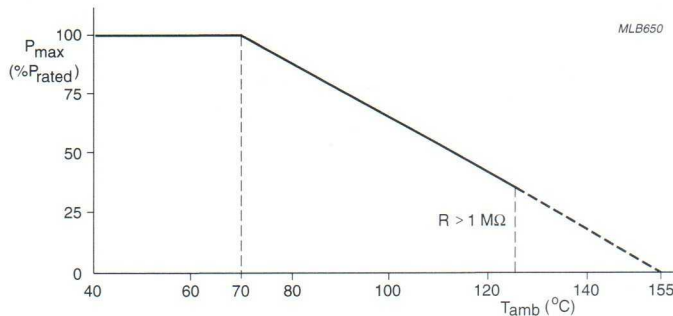
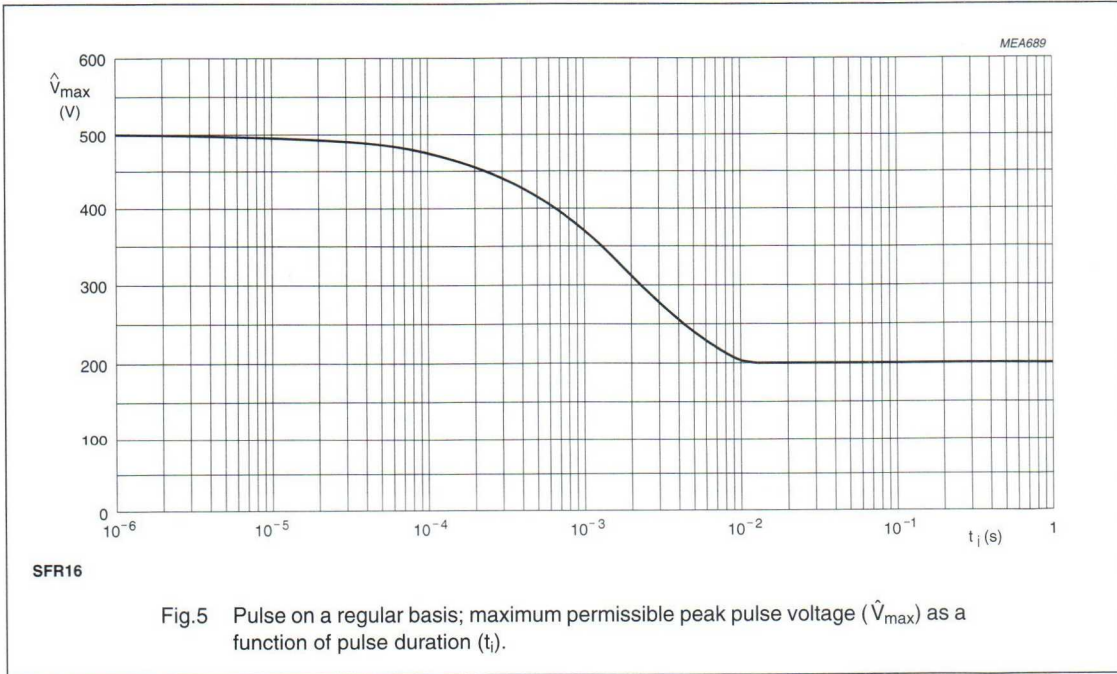
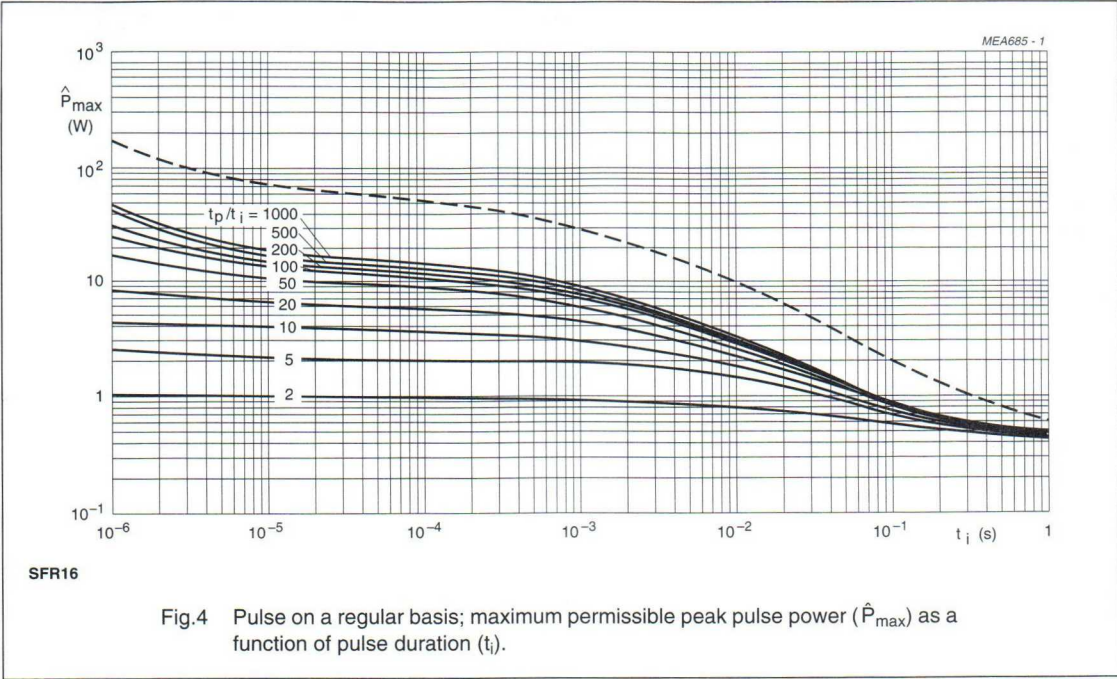


Fig.3 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

Standard metal film resistors

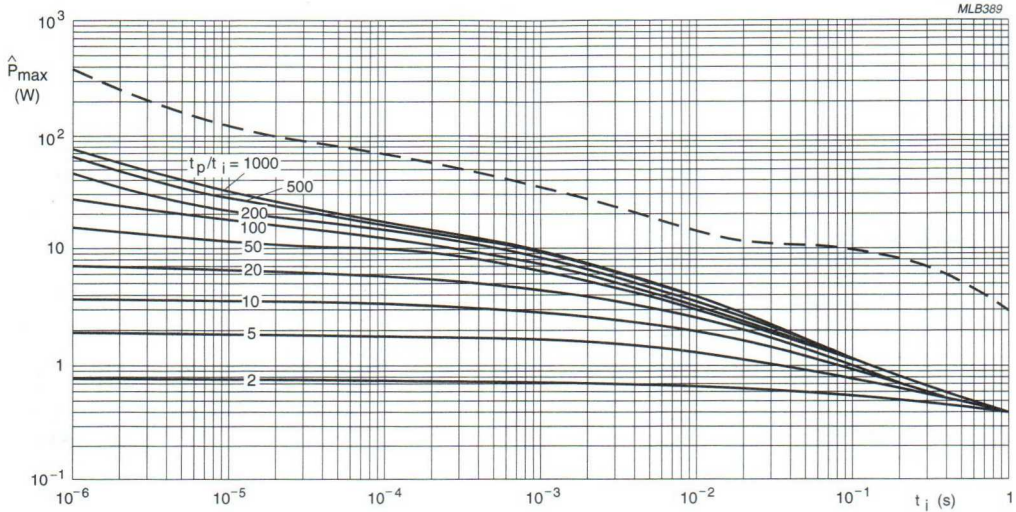
SFR16/25

PULSE LOADING CAPABILITIES



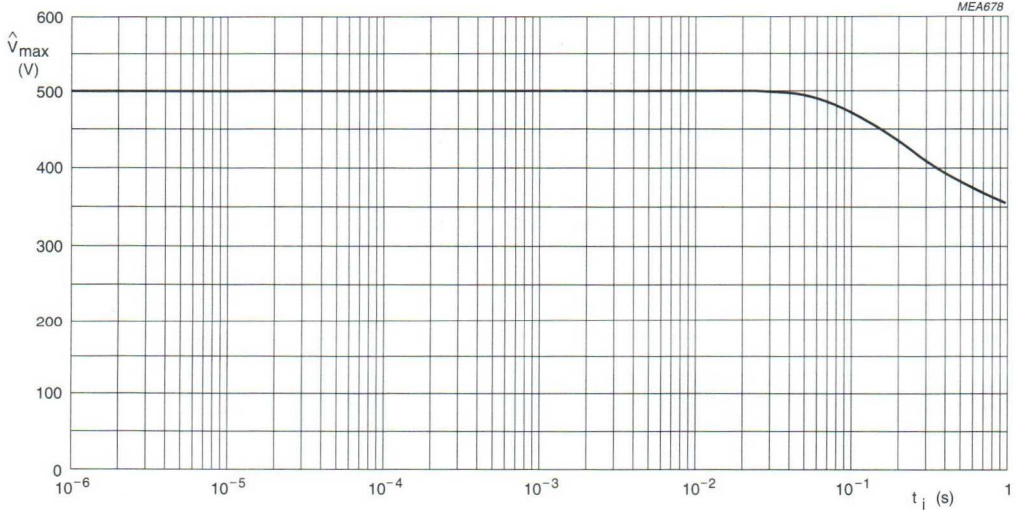
Standard metal film resistors

SFR16/25



SFR25

Fig.6 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i).

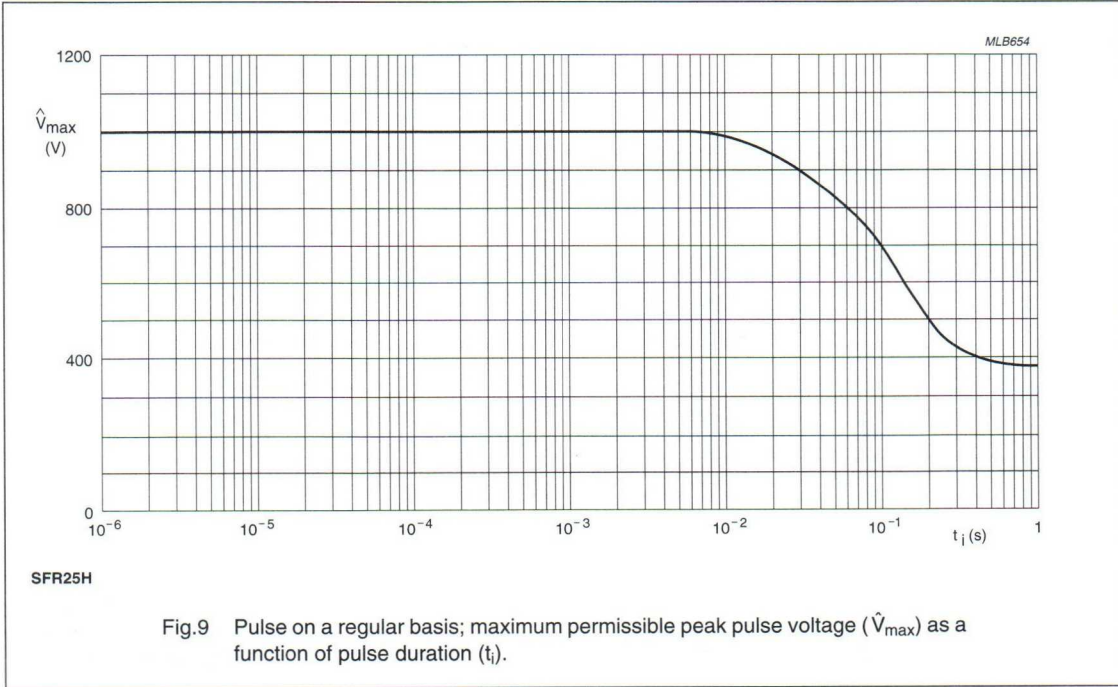
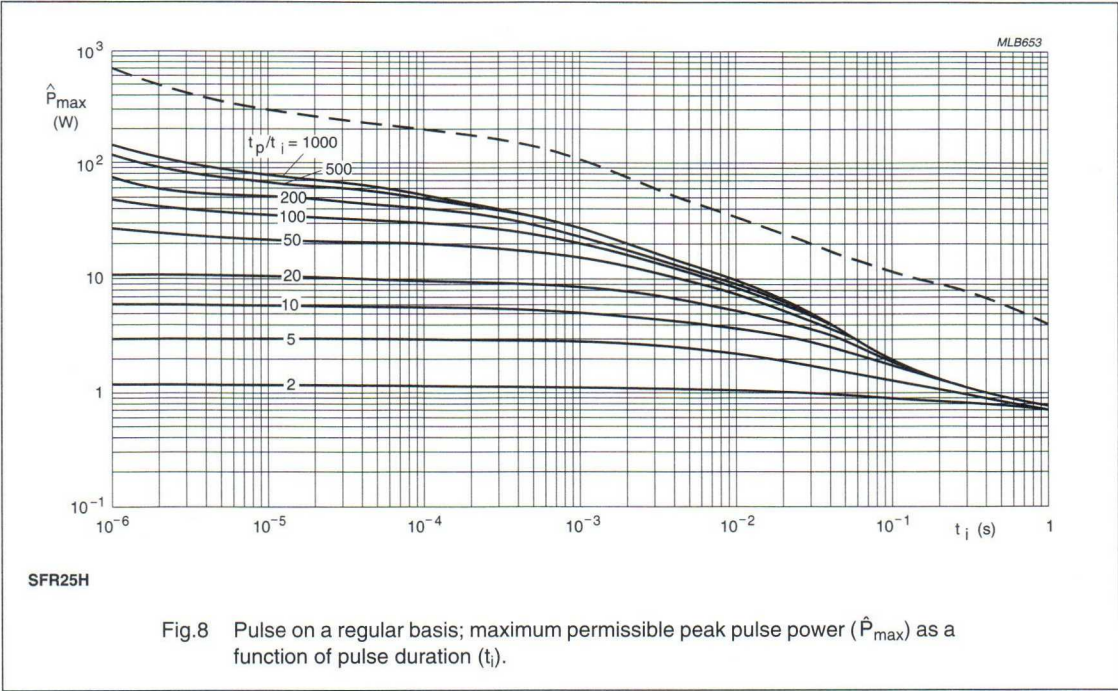


SFR25

Fig.7 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_i).

Standard metal film resistors

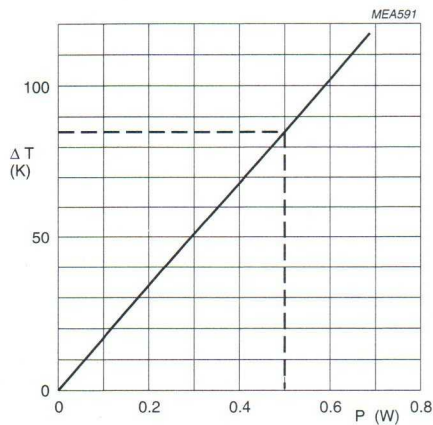
SFR16/25



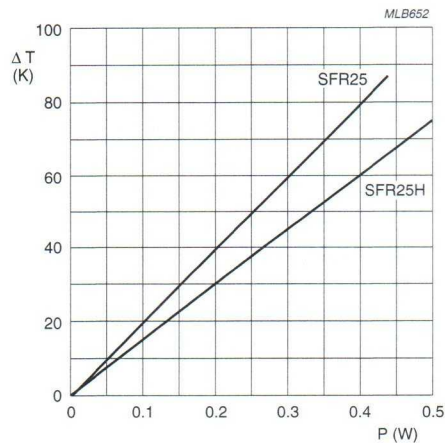
Standard metal film resistors

SFR16/25

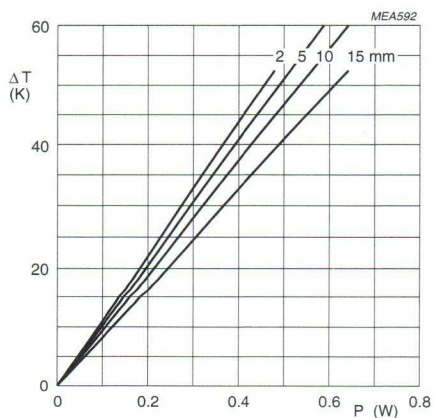
Application information



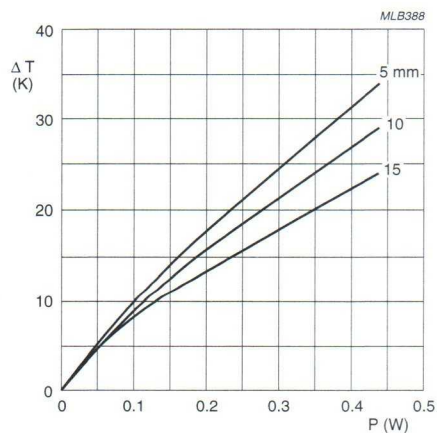
SFR16

Fig.10 Hot-spot temperature rise (ΔT) as a function of dissipated power.

SFR25/SFR25H

Fig.11 Hot-spot temperature rise (ΔT) as a function of dissipated power.

SFR16

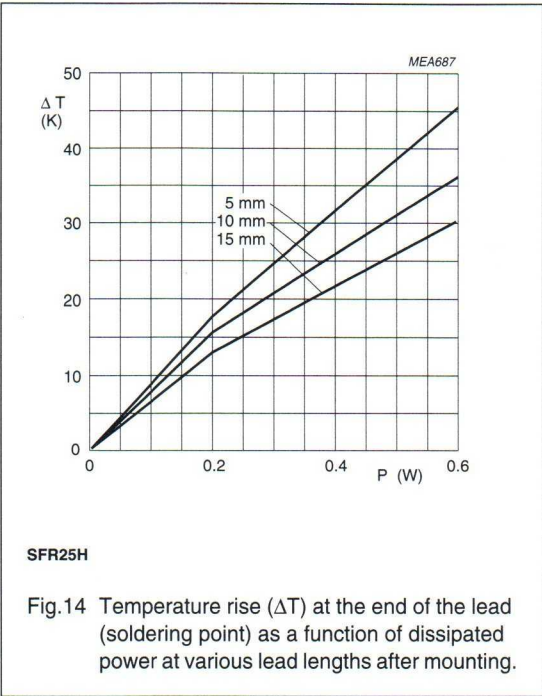
Fig.12 Temperature rise (ΔT) at the end of the lead (soldering point) as a function of dissipated power at various lead lengths after mounting.

SFR25

Fig.13 Temperature rise (ΔT) at the end of the lead (soldering point) as a function of dissipated power at various lead lengths after mounting.

Standard metal film resistors

SFR16/25



MECHANICAL DATA

Mass per 100 units

TYPE	MASS (g)
SFR16	12.5
SFR25	25

Marking

The nominal resistance and tolerance are marked on the resistor using four or five coloured bands in accordance with IEC publication 62 "Colour codes for fixed resistors".

Outlines

The length of the body (L_1) is measured by inserting the leads into holes of two identical gauge plates and moving these plates parallel to each other until the resistor body is clamped without deformation ("IEC publication 294").

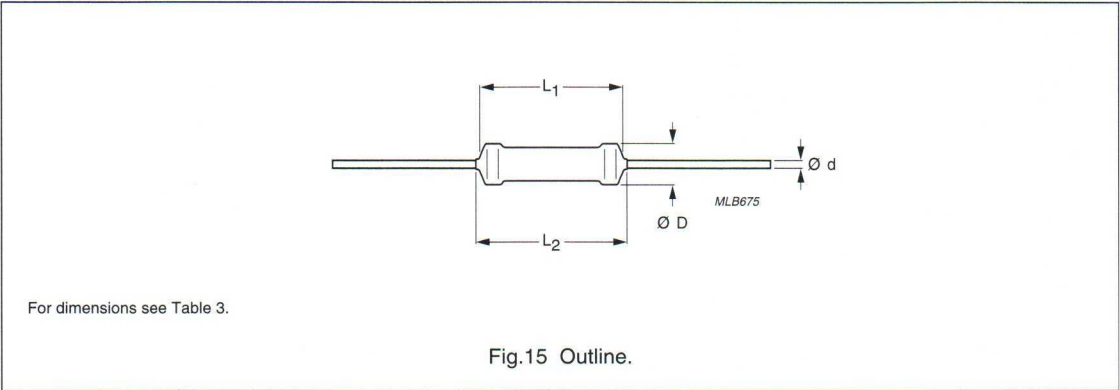


Table 3 Resistor type and relevant physical dimensions; see Fig.15

TYPE	ØD MAX. (mm)	L ₁ MAX. (mm)	L ₂ MAX. (mm)	Ød (mm)
SFR16	1.9	3.2	3.4	0.45 ±0.05
SFR25	2.5	6.5	7.0	0.55 ±0.05
SFR25H	2.5	6.5	7.0	0.6 ±0.03

Standard metal film resistors

SFR16/25

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of "IEC publication 115-1", category 55/155/56 (rated temperature range -55 °C to +155 °C; damp heat, long term, 56 days). The testing also covers the requirements specified by EIA and EIAJ.

The tests are carried out in accordance with IEC publication 68, “Recommended basic climatic and mechanical robustness testing procedure for electronic components” and under standard atmospheric conditions according to “IEC 68-1”, subclause 5.3.

Unless otherwise specified the following values apply:

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

Air pressure: 86 kPa to 106 kPa (860 mbar to 1060 mbar).

In Table 4 the tests and requirements are listed with reference to the relevant clauses of "IEC publications 115-1 and 68": a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

Table 4 Test procedures and requirements

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	RESISTANCE RANGE	REQUIREMENTS		
					SFR16	SFR25	SFR25H
4.16	U	robustness of terminations:					
4.16.2	Ua	tensile all samples	Ø0.5 mm; load 5 N; 10 s				number of failures $<10 \times 10^{-6}$
4.16.3	Ub	bending half number of samples	Ø0.5 mm; load 2.5 N; $4 \times 90^\circ$				number of failures $<10 \times 10^{-6}$
4.16.4	Uc	torsion other half of samples	$3 \times 360^\circ$ in opposite directions			no damage	
4.17	Ta	solderability	2 s; 235 °C; flux 600			$\Delta R/R$ max.: $\pm 0.25\%$ +0.05 Ω	
4.18	Tb	resistance to soldering heat	thermal shock: 3 s; 350 °C; 6 mm from body			good timing; no damage	
4.19	Na	rapid change of temperature	30 minutes at -55 °C and 30 minutes at +155 °C; 5 cycles			$\Delta R/R$ max.: $\pm 0.25\%$ +0.05 Ω	
4.20	Eb	bump	3×1500 bumps in 3 directions; 40 g			no damage	
4.22	Fc	vibration	frequency 10 to 500 Hz; displacement 1.5 mm or acceleration 10 g; 3 directions; total 6 hours (3×2 hours)			$\Delta R/R$ max.: $\pm 0.25\%$ +0.05 Ω	
						no damage	
						$\Delta R/R$ max.: $\pm 0.25\%$ +0.05 Ω	

Standard metal film resistors

SFR16/25

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	RESISTANCE RANGE	REQUIREMENTS		
					SFR16	SFR25	SFR25H
4.23		climatic sequence:			R_{ins} min.: 1000 M Ω		
4.23.2	Ba	dry heat	16 hours; 155 °C				
4.23.3	Db	damp heat (accelerated) 1st cycle	24 hours; 55 °C; 90 to 100% RH				
4.23.4	Aa	cold	2 hours; -55 °C				
4.23.5	M	low air pressure	2 hours; 8.5 kPa; 15 to 35 °C				
4.23.6	Db	damp heat (accelerated) remaining cycles	5 days; 55 °C; 95 to 100% RH	R $\leq$ 1 M Ω R > 1 M Ω	$\Delta R/R$ max.: $\pm 1\%$ +0.05 Ω		$\Delta R/R$ max.: $\pm 2\%$ + 0.1 Ω
4.24.2	Ca	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; dissipation 0.01 P _n		R_{ins} min.: 1000 M Ω $\Delta R/R$ max.: $\pm 1\%$ +0.05 Ω		
4.25.1		endurance	1000 hours at 70 °C; P _n or V _{max}	R $\leq$ 1 M Ω R > 1 M Ω	$\Delta R/R$ max.: $\pm 1\%$ +0.05 Ω		$\Delta R/R$ max.: $\pm 2\%$ + 0.1 Ω
4.8.4		temperature coefficient	between -55 °C and +155 °C (TC $\times 10^{-6}/K$)	R < 4.7 Ω R $\leq$ 100 k Ω R $\leq$ 1 M Ω R > 1 M Ω	$\leq \pm 250$ $\leq \pm 100$ $\leq \pm 250$ $\leq \pm 250$	$\leq \pm 100$ $\leq \pm 100$ $\leq \pm 100$ $\leq \pm 250$	$\leq \pm 100$ $\leq \pm 100$ $\leq \pm 100$ $\leq \pm 250$
4.7		voltage proof on insulation	400 V (RMS) (SFR16) or 600 V (RMS) (SFR25 and SFR25H); during 1 minute; V-block method		no breakdown		
4.12		noise	IEC publication 195	R < 68 k Ω R $\leq$ 100 k Ω R $\leq$ 1 M Ω R > 1 M Ω	max. 0.1 $\mu V/V$ max. 0.5 $\mu V/V$ max. 1.5 $\mu V/V$ max. 1.5 $\mu V/V$	max. 0.1 $\mu V/V$ max. 0.1 $\mu V/V$ max. 0.1 $\mu V/V$ max. 1.5 $\mu V/V$	max. 0.1 $\mu V/V$ max. 0.1 $\mu V/V$ max. 0.1 $\mu V/V$ max. 1.5 $\mu V/V$
4.6.1.1		insulation resistance	500 V (DC or RMS) during 1 minute; V-block method		R_{ins} min.: 1000 M Ω		

Standard metal film resistors

SFR16/25

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	RESISTANCE RANGE	REQUIREMENTS		
					SFR16	SFR25	SFR25H
4.13		short time overload	room temperature; $P = 6.25 \times P_n$ (SFR25) or $6.25 \times 0.25 \text{ W}$ (SFR16); ($V \leq 2 \times V_{\max}$); 5 s on 45 s off; 10 cycles		$\Delta R/R$ max.: $\pm 0.25\% + 0.05 \Omega$		$\Delta R/R$ max.: $\pm 1\% + 0.05 \Omega$
		intermittent overload in accordance with "JIS-C5202 5.8"	$16 \times 0.16 \text{ W}$; 1 s on and 25 s off; 10000 ± 200 cycles; $V_{\max} = 600 \text{ V}$		$\Delta R/R$ max.: $\pm 0.75\% + 0.05 \Omega$	—	—
see 2 nd amendment to "IEC 115-1", Jan. '87		pulse load			see Figs 4, 5, 6, 7, 8 and 9		

Metal film resistors

MRS16/25

FEATURES

- Precision resistors in small outlines
- Low noise.

APPLICATIONS

- All general purpose applications.

DESCRIPTION

A homogeneous film of metal alloy is deposited on a high grade ceramic body. After a helical groove has been cut in the resistive layer, tinned connecting wires of electrolytic copper iron are welded to the end-caps.

The resistors are coated with a green lacquer which provides electrical, mechanical, and climatic protection. The encapsulation is resistant to all cleaning solvents in accordance with "MIL-STD-202E", method 215, and "IEC 68-2-45".

QUICK REFERENCE DATA

DESCRIPTION	VALUE	
	MRS16T	MRS25
Resistance range	4.99 Ω to 1 M Ω	1 Ω to 10 M Ω
Resistance tolerance and series	$\pm 1\%$; E24/E96 series	
Maximum dissipation at $T_{amb} = 70\text{ }^{\circ}\text{C}$	0.4 W	0.6 W
Thermal resistance (R_{th})	170 K/W	150 K/W
Temperature coefficient	$\leq \pm 50 \times 10^{-6}/\text{K}$	
Maximum permissible voltage (DC or RMS)	200 V	350 V
Basic specifications	IEC 115-1 and 115-2	
Climatic category (IEC 68)	55/155/56	
Stability after:		
load:		
$R \leq 100\text{ k}\Omega$	$\Delta R/R\text{ max.: } \pm 0.5\% + 0.05\text{ }\Omega$	$\Delta R/R\text{ max.: } \pm 0.5\% + 0.05\text{ }\Omega$
$R > 100\text{ k}\Omega$	$\Delta R/R\text{ max.: } \pm 1\% + 0.05\text{ }\Omega$	$\Delta R/R\text{ max.: } \pm 0.5\% + 0.05\text{ }\Omega$
climatic tests:		
$R \leq 100\text{ k}\Omega$	$\Delta R/R\text{ max.: } \pm 0.5\% + 0.05\text{ }\Omega$	$\Delta R/R\text{ max.: } \pm 0.5\% + 0.05\text{ }\Omega$
$R > 100\text{ k}\Omega$	$\Delta R/R\text{ max.: } \pm 1\% + 0.05\text{ }\Omega$	$\Delta R/R\text{ max.: } \pm 0.5\% + 0.05\text{ }\Omega$
soldering:		
$R \leq 100\text{ k}\Omega$	$\Delta R/R\text{ max.: } \pm 0.1\% + 0.05\text{ }\Omega$	$\Delta R/R\text{ max.: } \pm 0.1\% + 0.05\text{ }\Omega$
$R > 100\text{ k}\Omega$	$\Delta R/R\text{ max.: } \pm 0.25\% + 0.05\text{ }\Omega$	$\Delta R/R\text{ max.: } \pm 0.1\% + 0.05\text{ }\Omega$
short time overload	$\Delta R/R\text{ max.: } \pm 0.25\% + 0.05\text{ }\Omega$	$\Delta R/R\text{ max.: } \pm 0.25\% + 0.05\text{ }\Omega$

Metal film resistors

MRS16/25

ORDERING INFORMATION

Table 1 Ordering code indicating resistor type and packaging

TYPE	ORDERING CODE 2322		
	BANDOLIER IN AMMOPACK		BANDOLIER ON REEL
	1 000 units	5 000 units	5 000 units
MRS16T	157 1....	157 2....	157 3....
MRS25	156 1....	156 2....	156 3....

Ordering code (12NC)

- The resistors have a 12-digit ordering code.
- The first 8 digits indicate the resistor type and packaging; see Table 1.
- The remaining 4 digits indicate the resistance value:
 - The first 3 digits indicate the resistance value.
 - The last digit indicates the resistance decade in accordance with Table 2.

Table 2 Last digit of 12NC

RESISTANCE DECADE	LAST DIGIT
1 to 9.76 Ω	8
10 to 97.6 Ω	9
100 to 976 Ω	1
1 to 9.76 k Ω	2
10 to 97.6 k Ω	3
100 to 976 k Ω	4
1 to 9.76 M Ω	5
10 M Ω	6

ORDERING EXAMPLE

The ordering code of a MRS16 resistor, value 750 Ω , on a bandolier of 1000 units in ammopack is: 2322 157 17501.

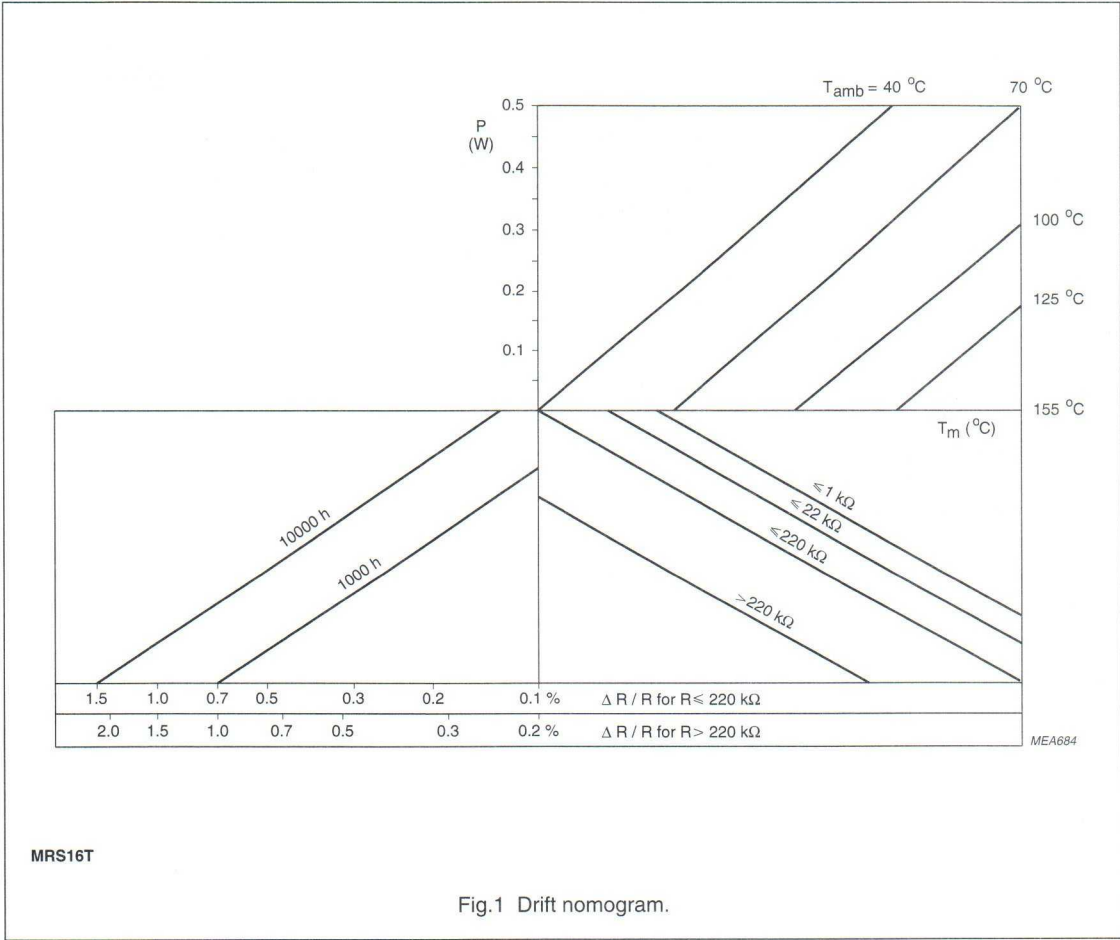
Metal film resistors

MRS16/25

FUNCTIONAL DESCRIPTION

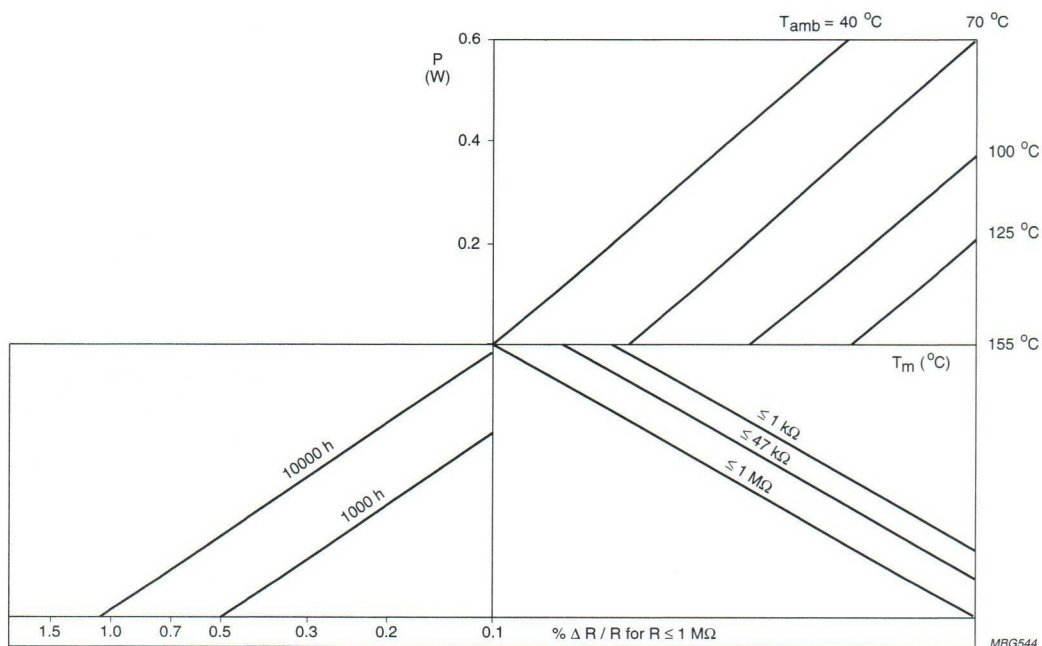
Product characterization

Standard values of nominal resistance are taken from the E24/E96 series for resistors with a tolerance of $\pm 1\%$.
The values of the E24/E96 series are in accordance with "IEC publication 63".



Metal film resistors

MRS16/25



MRS25

Fig.2 Drift nomogram.

Metal film resistors

MRS16/25

Limiting values

TYPE	LIMITING VOLTAGE ⁽¹⁾ (V)	LIMITING POWER (W)
MRS16T	200	0.4
MRS25	350	0.6

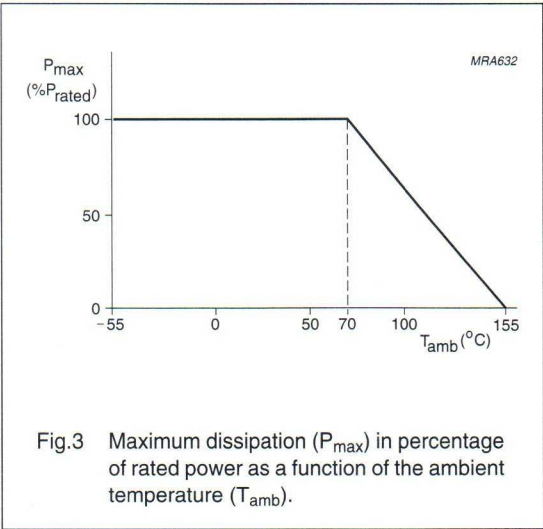
Note

1. The maximum voltage that may be continuously applied to the resistor element, see "IEC publication 115-1".

The maximum permissible hot-spot temperature is 155 °C.

DERATING

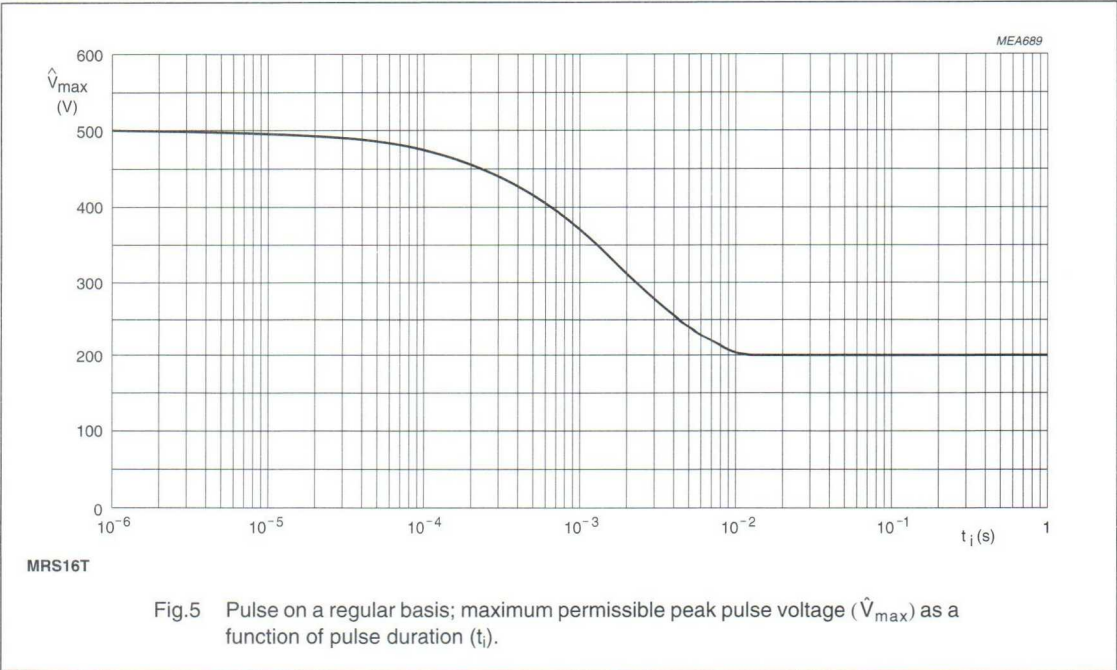
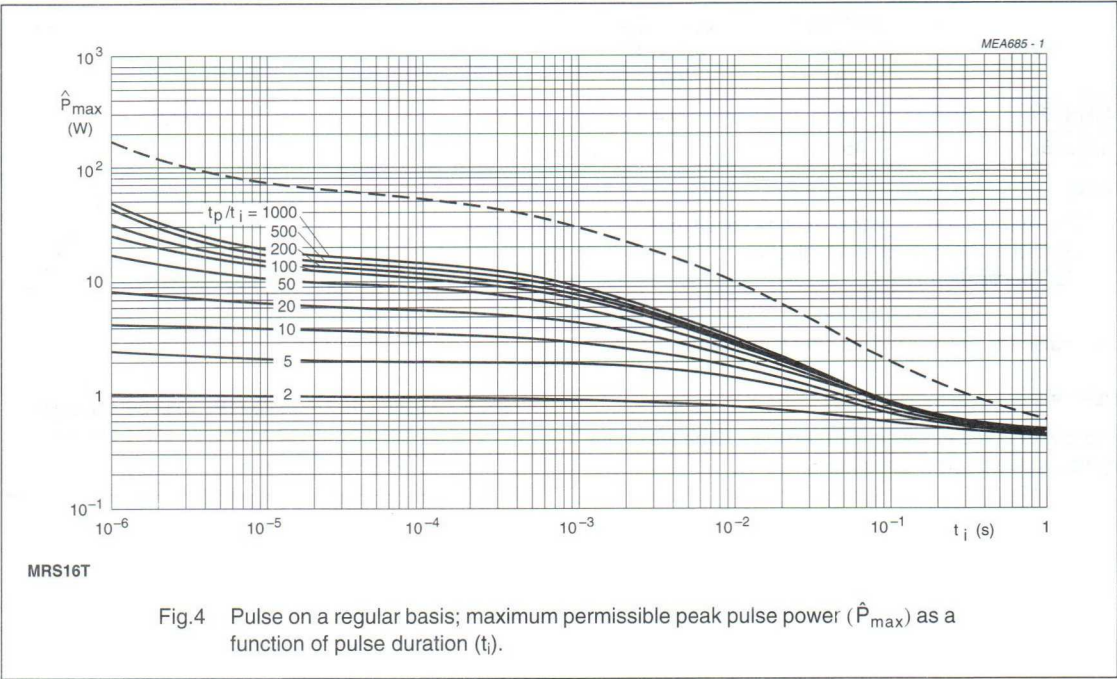
The power that the resistor can dissipate depends on the operating temperature; see Fig.3.



Metal film resistors

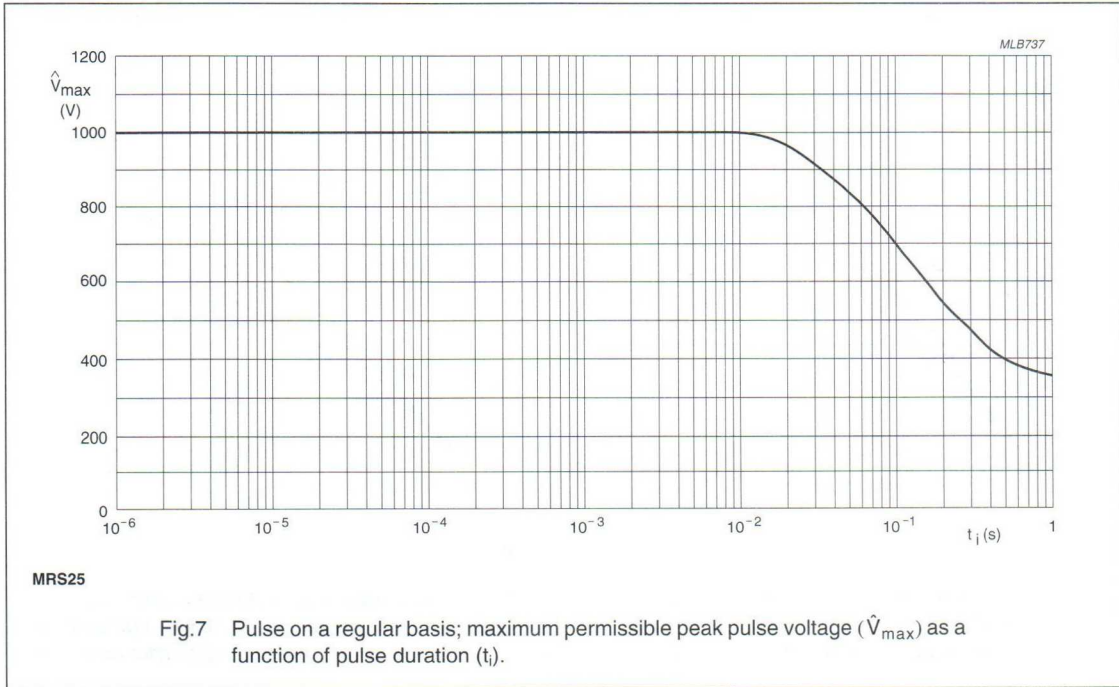
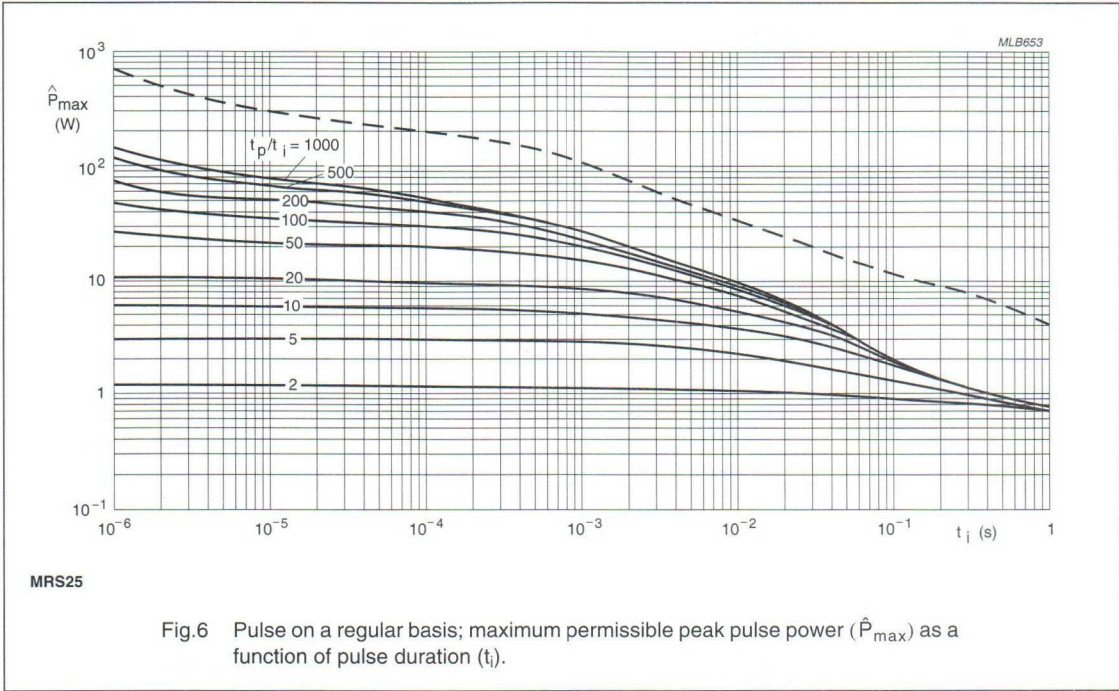
MRS16/25

PULSE LOADING CAPABILITIES



Metal film resistors

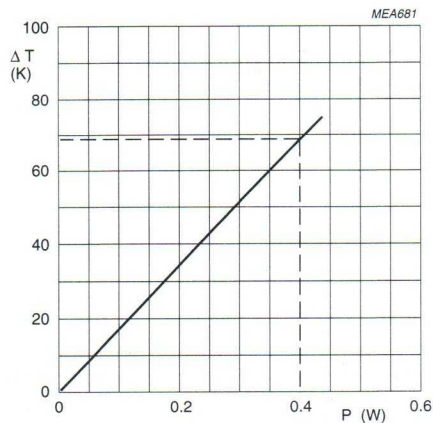
MRS16/25



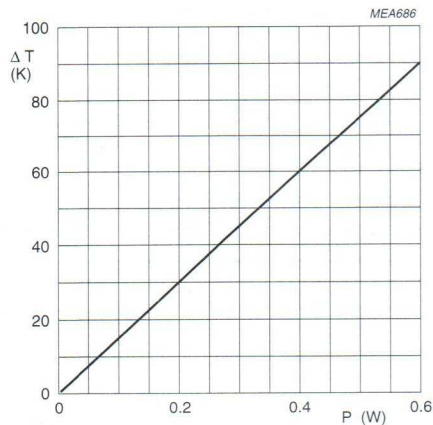
Metal film resistors

MRS16/25

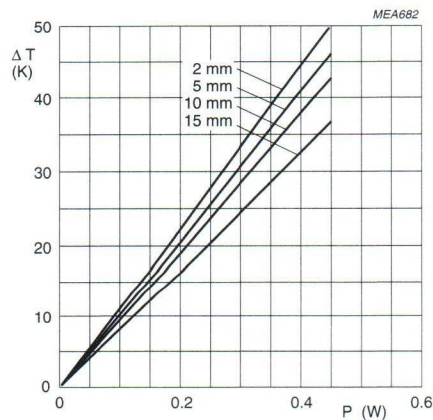
Application information



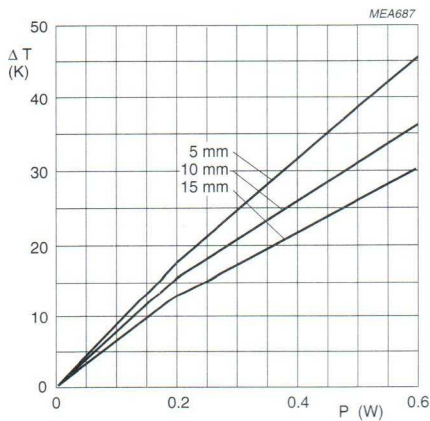
MRS16T

Fig.8 Hot-spot temperature rise (ΔT) as a function of dissipated power.

MRS25

Fig.9 Hot-spot temperature rise (ΔT) as a function of dissipated power.

MRS16T

Fig.10 Temperature rise (ΔT) at the lead end (soldering point) as a function of dissipated power at various lead lengths after mounting.

MRS25

Fig.11 Temperature rise (ΔT) at the lead end (soldering point) as a function of dissipated power at various lead lengths after mounting.

Metal film resistors

MRS16/25

MECHANICAL DATA

Mass per 100 units

TYPE	MASS (g)
MRS16T	12.5
MRS25	25

Marking

The nominal resistance and tolerance are marked on the resistor using five coloured bands in accordance with IEC publication 62 "Colour codes for fixed resistors".

Outlines

The length of the body (L_1) is measured by inserting the leads into holes of two identical gauge plates and moving these plates parallel to each other until the resistor body is clamped without deformation ("IEC publication 294").

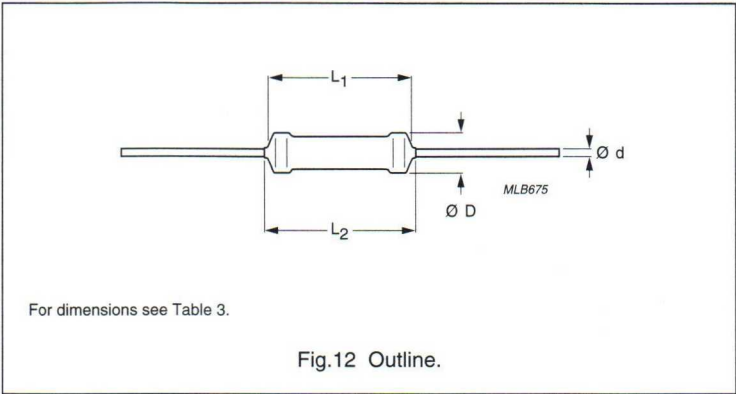


Table 3 Resistor type and relevant physical dimensions; see Fig.12

TYPE	ØD MAX. (mm)	L ₁ TYP. (mm)	L ₂ MAX. (mm)	Ød (mm)
MRS16T	1.9	3.2	3.7	0.5
MRS25	2.5	6.5	7.0	0.6

Metal film resistors

MRS16/25

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of "IEC publication 115-1", category **LCT/UCT/56** (rated temperature range: Lower Category Temperature, Upper Category Temperature; damp heat, long term, **56** days). The testing also covers the requirements specified by EIA and EIAJ.

The tests are carried out in accordance with IEC publication 68,

"Recommended basic climatic and mechanical robustness testing procedure for electronic components" and under standard atmospheric conditions according to "IEC 68-1", subclause 5.3.

Unless otherwise specified the following values apply:

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

Air pressure: 86 kPa to 106 kPa
(860 mbar to 1060 mbar).

In Table 4 the tests and requirements are listed with reference to the relevant clauses of "IEC publications 115-1 and 68"; a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

All soldering tests are performed with mildly activated flux.

Table 4 Test procedures and requirements

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS	
				MRS16T	MRS25
Tests in accordance with the schedule of IEC publication 115-8					
4.4.1		visual examination		no holes; clean surface; no damage	
4.4.2		dimensions (outline)	gauge (mm)	see Table 3	
4.5		resistance	applied voltage (+0/−10%): R < 10 Ω: 0.1 V 10 Ω ≤ R < 100 Ω: 0.3 V 100 Ω ≤ R < 1 kΩ: 1 V 1 kΩ ≤ R < 10 kΩ: 3 V 10 kΩ ≤ R < 100 kΩ: 10 V 100 kΩ ≤ R < 1 MΩ: 25 V 1 MΩ ≤ R: 50 V	R – R _{nom} : max. ±1%	
4.18	Tb	resistance to soldering heat	thermal shock: 3 s; 350 °C; 6 mm from body: R ≤ 100 kΩ R > 100 kΩ	ΔR/R max.: ±0.1% +0.05 Ω	
				ΔR/R max.: ±0.25% +0.05 Ω	ΔR/R max.: ±0.1% +0.05 Ω
4.29	45 (Xa)	component solvent resistance	isopropyl alcohol or H ₂ O followed by brushing in accordance with "MIL 202 F"	no visual damage	
4.17	Ta	solderability	2 s; 235 °C	good tinning; no damage	
4.7		voltage proof on insulation	voltage (RMS) during 1 minute, metal block method: 400 V for MRS16T , 700 V for MRS25	no breakdown or flashover	

Metal film resistors

MRS16/25

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS	
				MRS16T	MRS25
4.13		short time overload	room temperature; $P = 6.25 \times P_n$ (MRS25) or $6.25 \times 0.25 \text{ W}$ (MRS16T); ($V \leq 2 \times V_{\max}$); 5 s on 45 s off, 10 cycles	$\Delta R/R \text{ max.: } \pm 0.25\% + 0.05 \Omega$	
4.16	U	robustness of terminations:			
4.16.2	Ua	tensile all samples	load 10 N; 10 s	number of failures $< 10 \times 10^{-6}$	
4.16.3	Ub	bending half number of samples	load 5 N; $4 \times 90^\circ$	number of failures $< 10 \times 10^{-6}$	
4.16.4	Uc	torsion other half of samples	$3 \times 360^\circ$ in opposite directions	no damage	
				$\Delta R/R \text{ max.: } \pm 0.1\% + 0.05 \Omega$	
4.20	Eb	bump	3×1500 bumps in 3 directions; 40 g	no damage	
				$\Delta R/R \text{ max.: } \pm 0.1\% + 0.05 \Omega$	
4.22	Fc	vibration	frequency 10 to 500 Hz; displacement 1.5 mm or acceleration 10 g; 3 directions; total 6 hours (3×2 hours)	no damage	
				$\Delta R/R \text{ max.: } \pm 0.1\% + 0.05 \Omega$	
4.19	14 (Na)	rapid change of temperature	30 minutes at LCT and 30 minutes at UCT; 5 cycles: $R \leq 100 \text{ k}\Omega$ $R > 100 \text{ k}\Omega$	no visual damage	
				$\Delta R/R \text{ max.: } \pm 0.1\% + 0.05 \Omega$	
				$\Delta R/R \text{ max.: } \pm 0.25\% + 0.05 \Omega$	$\Delta R/R \text{ max.: } \pm 0.1\% + 0.05 \Omega$
4.23	30 (D)	climatic sequence: damp heat (accelerated) 1st cycle			
4.23.3					
4.23.6	30 (D)	damp heat (accelerated) remaining cycles	6 days; 55°C ; 95 to 98% RH: $R \leq 100 \text{ k}\Omega$ $R > 100 \text{ k}\Omega$	$R_{\text{ins min.:}} 10^3 \text{ M}\Omega$	
				$\Delta R/R \text{ max.: } \pm 0.5\% + 0.05 \Omega$	
				$\Delta R/R \text{ max.: } \pm 1\% + 0.05 \Omega$	$\Delta R/R \text{ max.: } \pm 0.5\% + 0.05 \Omega$
4.24.2	3 (Ca)	damp heat (steady state) (IEC)	56 days; 40°C ; 90 to 95% RH; loaded with $0.01 P_n$ (IEC steps: 4 to 100 V): $R \leq 100 \text{ k}\Omega$ $R > 100 \text{ k}\Omega$	$\Delta R/R \text{ max.: } \pm 0.5\% + 0.05 \Omega$	
				$\Delta R/R \text{ max.: } \pm 1\% + 0.05 \Omega$	$\Delta R/R \text{ max.: } \pm 0.5\% + 0.05 \Omega$
4.25.1		endurance (at 70°C)	1000 hours; loaded with P_n or $V_{\max}$; 1.5 hours on and 0.5 hours off: $R \leq 100 \text{ k}\Omega$ $R > 100 \text{ k}\Omega$	$\Delta R/R \text{ max.: } \pm 0.5\% + 0.05 \Omega$	
				$\Delta R/R \text{ max.: } \pm 1\% + 0.05 \Omega$	$\Delta R/R \text{ max.: } \pm 0.5\% + 0.05 \Omega$

Metal film resistors

MRS16/25

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS	
				MRS16T	MRS25
4.23.2	27 (Ba)	endurance at upper category temperature	1 000 hours; no load: R ≤ 100 kΩ R > 100 kΩ	ΔR/R max.: ±0.5% +0.05 Ω	
				ΔR/R max.: ±1% +0.05 Ω	ΔR/R max.: ±0.5% +0.05 Ω
4.8.4.2		temperature coefficient	at 20/LCT/20 °C and 20/UCT/20 °C (TC × 10 ⁻⁶ /K)	≤ ±50 × 10 ⁻⁶ /K	
Other tests in accordance with IEC 115 clauses and IEC 68 test method					
4.17	20 (Tb)	solderability (after ageing)	8 hours steam or 16 hours 155 °C; leads immersed 6 mm for 2 ±0.5 s in a solder bath at 235 ±5 °C	good tinning (≥95% covered); no damage	
4.6.1.1		insulation resistance	voltage (DC) after 1 minute, metal block method: 100 V for MRS16T , 500 V for MRS25	R _{ins} min.: 10 ⁴ MΩ	
4.12		noise	IEC publication 195 (measured with Quantech - equipment): R ≤ 68 kΩ R ≤ 100 kΩ R ≤ 1 MΩ R > 1 MΩ	max. 0.1 μV/V max. 0.5 μV/V max. 1.5 μV/V max. 1.5 μV/V	max. 0.1 μV/V max. 0.1 μV/V max. 0.1 μV/V max. 1.5 μV/V
see 2 nd amendment to "IEC 115-1", Jan.'87		pulse load		see Figs 4 and 5	see Figs 6 and 7

Fusible resistors

NFR25/25H

FEATURES

- Overload protection without risk of fire
- Wide range of overload currents.

APPLICATIONS

- Audio
- Video.

DESCRIPTION

A homogeneous film of metal alloy is deposited on a high grade ceramic body. After a helical groove has been cut in the resistive layer, tinned connecting wires of electrolytic copper iron are welded to the end-caps. The resistors are coated with a grey, flame retardant lacquer which provides electrical, mechanical, and climatic protection. The encapsulation is resistant to all cleaning solvents in accordance with "MIL-STD 202E" method 215, and "IEC 68-2-45".

ORDERING INFORMATION

Ordering code (12NC)

- The resistors have a 12-digit ordering code.
- The first 9 digits indicate the resistor type and packaging; see Table 1.
- The remaining 3 digits indicate the resistance value:
 - The first 2 digits indicate the resistance value.
 - The last digit indicates the resistance decade in accordance with Table 2.

QUICK REFERENCE DATA

DESCRIPTION	VALUE	
	NFR25	NFR25H
Resistance range	1 Ω to 15 k Ω	
Resistance tolerance and series	$\pm 5\%$; E24 series	
Maximum dissipation at $T_{amb} = 70^\circ\text{C}$	0.33 W	0.5 W
Thermal resistance (R_{th})	240 K/W	150 K/W
Temperature coefficient:		
1 $\Omega \leq R \leq 4.7 \Omega$	$\leq \pm 200 \times 10^{-6}/\text{K}$	$\leq \pm 200 \times 10^{-6}/\text{K}$
4.7 $\Omega < R \leq 15 \Omega$	$\leq \pm 200 \times 10^{-6}/\text{K}$	$\leq \pm 100 \times 10^{-6}/\text{K}$
15 $\Omega < R \leq 15 \text{ k}\Omega$	$\leq \pm 100 \times 10^{-6}/\text{K}$	$\leq \pm 100 \times 10^{-6}/\text{K}$
Maximum permissible voltage (DC or RMS)	250 V	350 V
Basic specifications	IEC 115-1 and 115-2	
Climatic category (IEC 68)	55/155/56	
Stability after:		
load	$\Delta R/R \text{ max.}: \pm 1\% + 0.05 \Omega$	
climatic tests	$\Delta R/R \text{ max.}: \pm 1\% + 0.05 \Omega$	
soldering	$\Delta R/R \text{ max.}: \pm 0.25\% + 0.05 \Omega$	

Table 1 Ordering code indicating resistor type and packaging

TYPE	ORDERING CODE 23..			
	BANDOLIER IN AMMOPACK			BANDOLIER ON REEL
	RADIAL TAPED	STRAIGHT LEADS		STRAIGHT LEADS
	4000 units	1000 units	5000 units	5000 units
NFR25	2306 204 03...	2322 205 13...	2322 205 33...	2322 205 23...
NFR25H	2306 207 03...	2322 207 13...	2322 207 33...	2322 207 23...

Table 2 Last digit of 12NC

RESISTANCE DECADE	LAST DIGIT
1 to 9.1 Ω	8
10 to 91 Ω	9
100 to 910 Ω	1
1 to 9.1 k Ω	2
10 to 15 k Ω	3

ORDERING EXAMPLE

The ordering code for a NFR25 resistor with value 750 Ω , supplied on a bandolier of 1000 units in ammpack is: 2322 205 13751.

Fusible resistors

NFR25/25H

FUNCTIONAL DESCRIPTION

Product characterization

Standard values of nominal resistance are taken from the E24 series for resistors with a tolerance of $\pm 5\%$. The values of the E24 series are in accordance with "IEC publication 63".

Limiting values

TYPE	LIMITING VOLTAGE ⁽¹⁾ (V)	LIMITING POWER (W)
NFR25	250	0.33
NFR25H	350	0.5

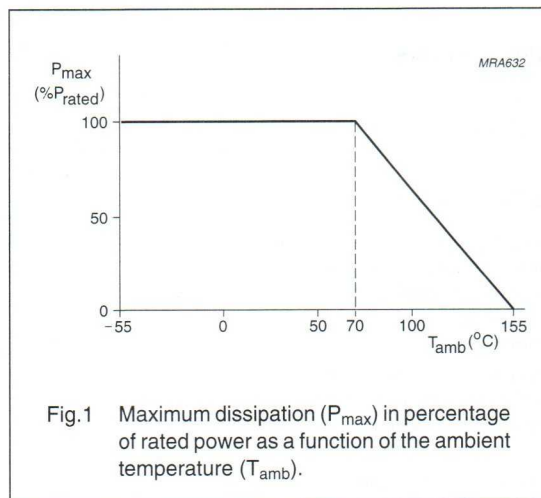
Note

1. The maximum voltage that may be continuously applied to the resistor element, see "IEC publication 115-1".

The maximum permissible hot-spot temperature is 155 °C.

DERATING

The power that the resistor can dissipate depends on the operating temperature; see Fig.1.



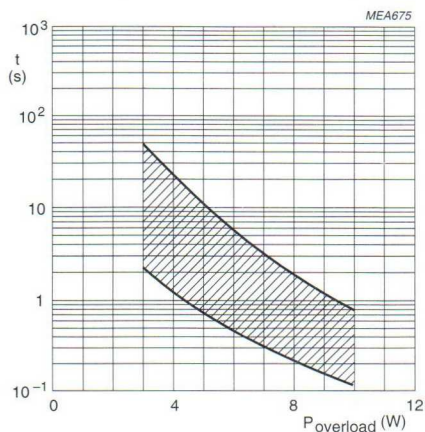
Fusible resistors

NFR25/25H

FUSING CHARACTERISTIC

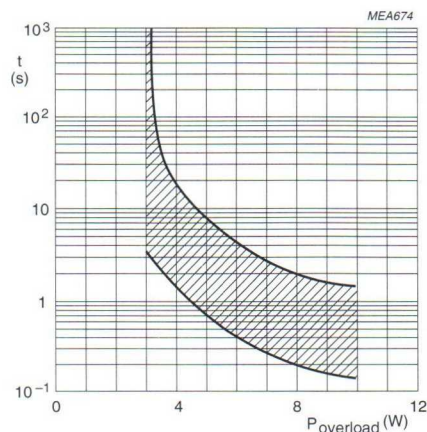
The resistors will fuse without the risk of fire and within an indicated range of overload. Fusing means that the resistive value of the resistor increases at least 1 000 times; see Figs 2, 3 and 4.

The fusing characteristic is measured under constant voltage.

**NFR25**

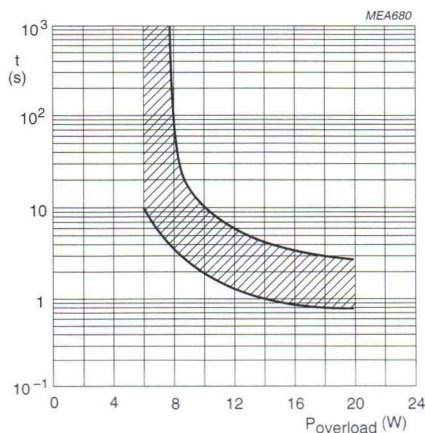
This graph is based on measured data which may deviate according to the application.

Fig. 2 Fusing characteristic: $15\ \Omega < R \leq 15\ \text{k}\Omega$.

**NFR25**

This graph is based on measured data which may deviate according to the application.

Fig. 3 Fusing characteristic: $1\ \Omega \leq R \leq 15\ \Omega$.

**NFR25H**

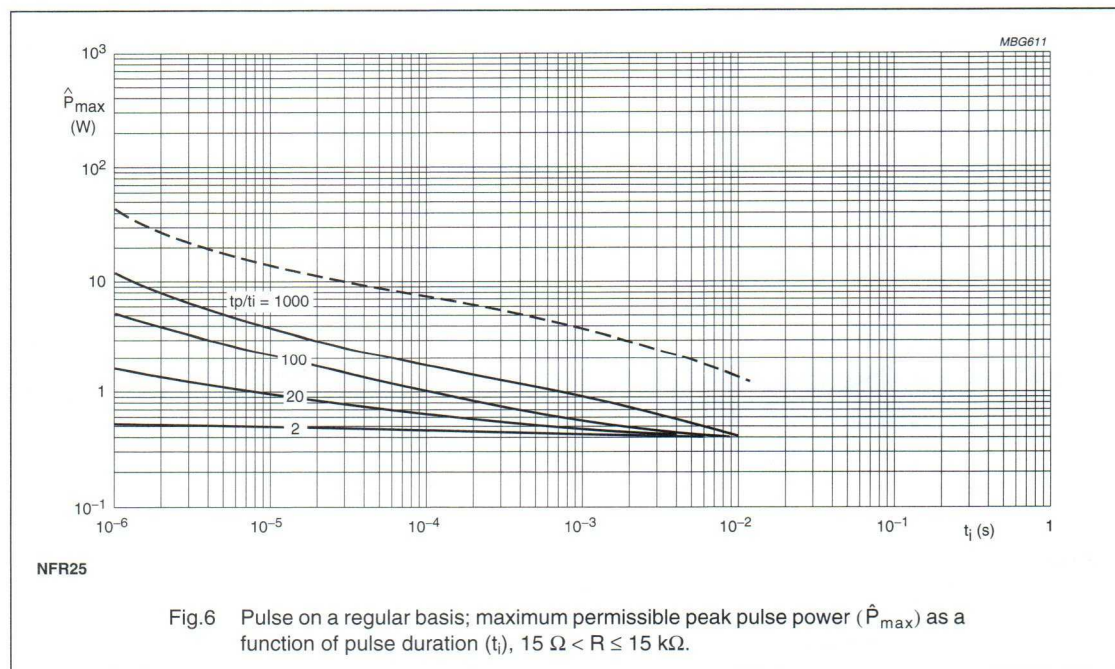
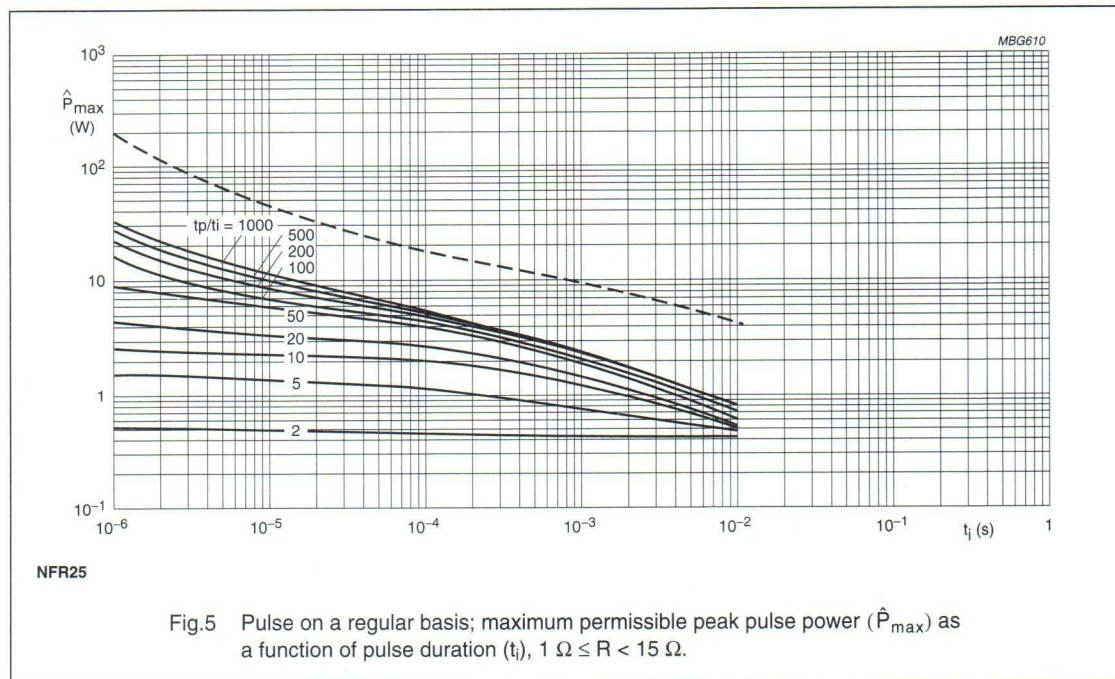
This graph is based on measured data which may deviate according to the application.

Fig. 4 Fusing characteristic.

Fusible resistors

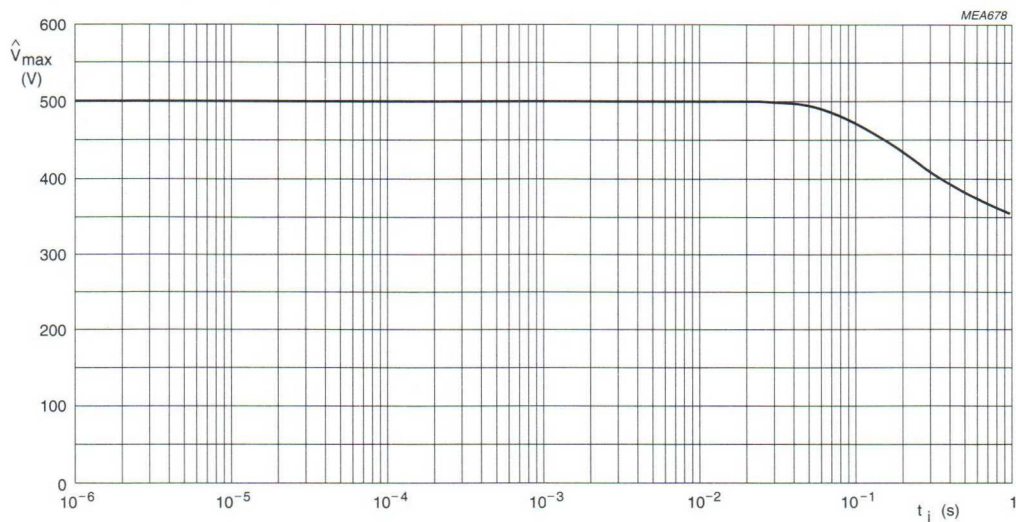
NFR25/25H

PULSE LOADING CAPABILITIES



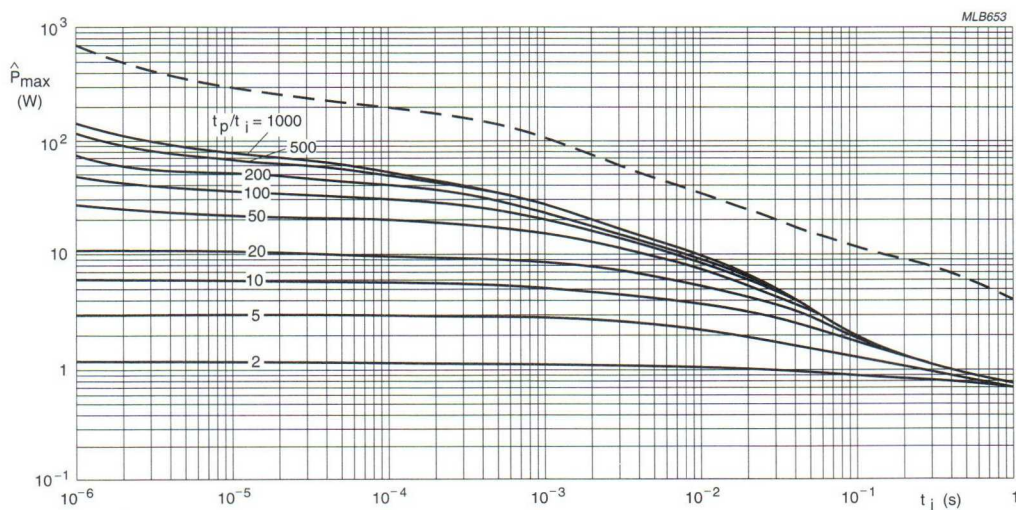
Fusible resistors

NFR25/25H



NFR25

Fig.7 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{\max}$) as a function of pulse duration (t_i).

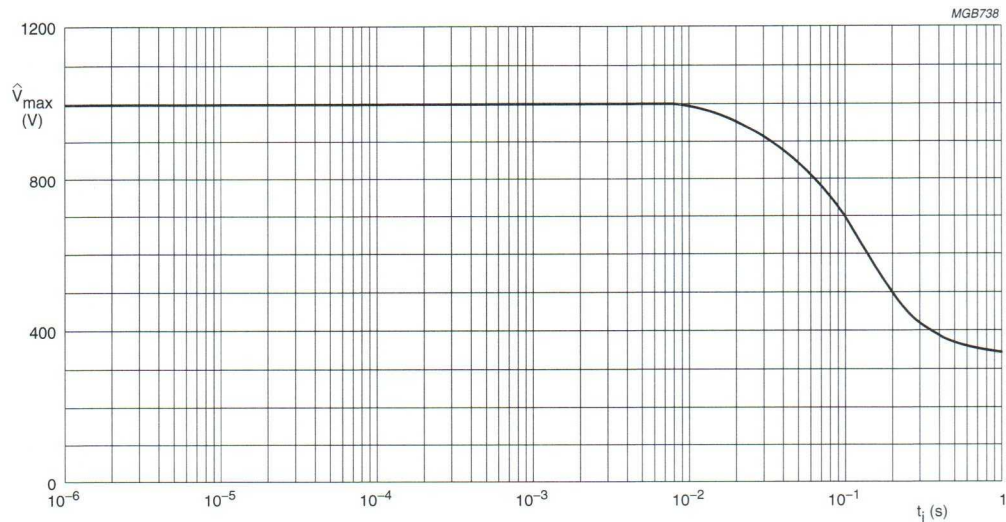


NFR25H

Fig.8 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{\max}$) as a function of pulse duration (t_i).

Fusible resistors

NFR25/25H



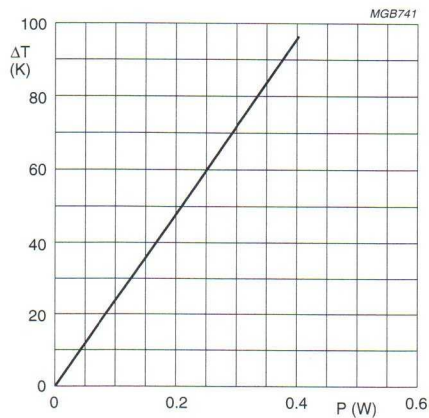
NFR25H

Fig.9 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{\max}$) as a function of pulse duration (t_i).

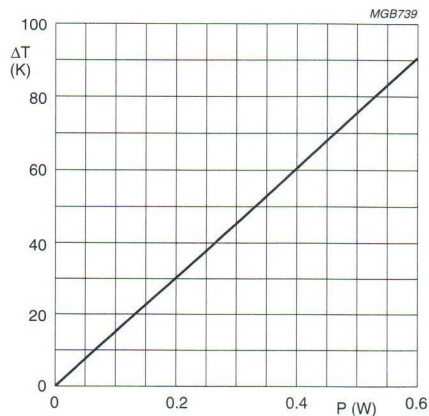
Fusible resistors

NFR25/25H

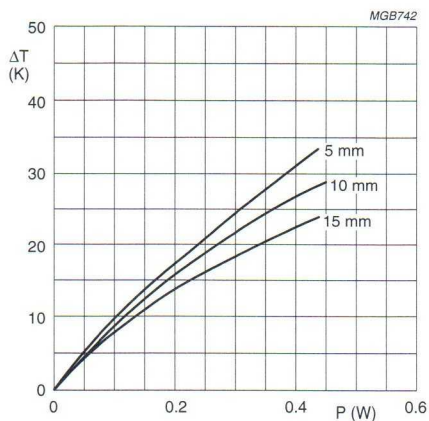
Application information



NFR25

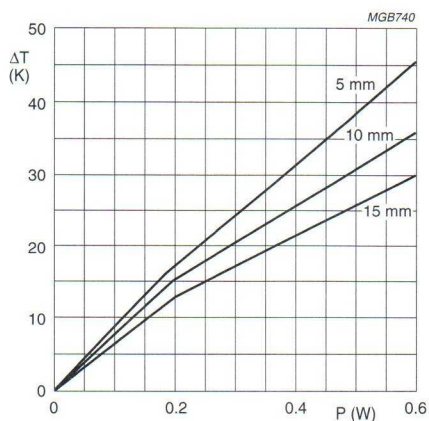
Fig.10 Hot-spot temperature rise (ΔT) as a function of dissipated power.

NFR25H

Fig.11 Hot-spot temperature rise (ΔT) as a function of dissipated power.

NFR25

Minimum distance from resistor body to PCB = 1 mm.

Fig.12 Temperature rise (ΔT) at the lead end (soldering point) as a function of dissipated power at various lead lengths after mounting.

NFR25H

Minimum distance from resistor body to PCB = 1 mm.

Fig.13 Temperature rise (ΔT) at the lead end (soldering point) as a function of dissipated power at various lead lengths after mounting.

Fusible resistors

NFR25/25H

MECHANICAL DATA

Mass per 100 units

TYPE	MASS (g)
NFR25	25
NFR25H	

Marking

The nominal resistance and tolerance are marked on the resistor using four coloured bands in accordance with IEC publication 62 "Colour codes for fixed resistors".

For ease of recognition a fifth ring is added, which is violet for type NFR25 and white for type NFR25H.

Outlines

The length of the body (L_1) is measured by inserting the leads into holes of two identical gauge plates and moving these plates parallel to each other until the resistor body is clamped without deformation ("IEC publication 294").

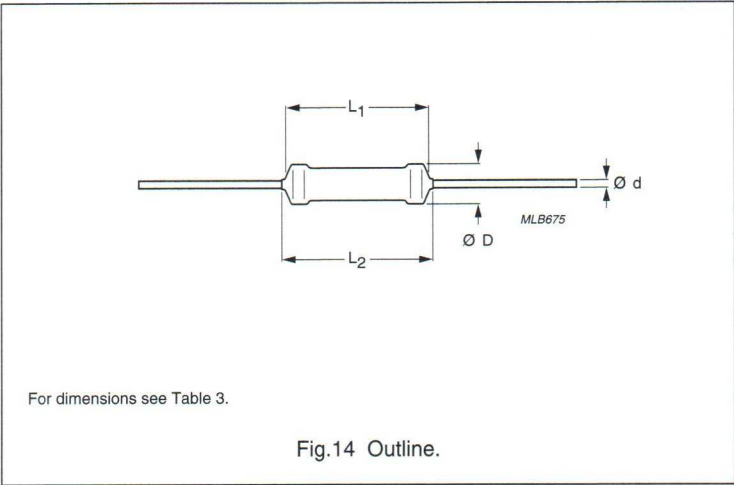


Table 3 Resistor type and relevant physical dimensions; see Fig.14

TYPE	ØD MAX. (mm)	L ₁ MAX. (mm)	L ₂ MAX. (mm)	Ød (mm)
NFR25	2.5	6.5	7.5	0.6
NFR25H				

Fusible resistors

NFR25/25H

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of "IEC publication 115-1", category **LCT/UCT/56** (rated temperature range: **Lower Category Temperature**, **Upper Category Temperature**; damp heat, long term, **56** days). The testing also covers the requirements specified by EIA and EIAJ.

The tests are carried out in accordance with IEC publication 68, "Recommended basic climatic and

mechanical robustness testing procedure for electronic components" and under standard atmospheric conditions according to "IEC 68-1", subclause 5.3.

Unless otherwise specified the following values apply:

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

Air pressure: 86 kPa to 106 kPa.

In Table 4 the tests and requirements are listed with reference to the

relevant clauses of "IEC publications 115-1 and 68"; a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying. For inflammability requirements reference is made to "IEC 115-1" and to "CECC 40000, appendix D".

All soldering tests are performed with mildly activated flux.

Table 4 Test procedures and requirements

IEC 115-1 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS	
				NFR25	NFR25H
Tests in accordance with the schedule of IEC publication 115-8					
4.4.1		visual examination		no holes; clean surface; no damage	
4.4.2		dimensions (outline)	gauge (mm)	see Table 3	
4.5		resistance	applied voltage (+0/−10%): R < 10 Ω: 0.1 V 10 Ω ≤ R < 100 Ω: 0.3 V 100 Ω ≤ R < 1 kΩ: 1 V 1 kΩ ≤ R < 10 kΩ: 3 V 10 kΩ ≤ R ≤ 15 kΩ: 10 V	R − R _{nom} : max. ±5%	
4.18	Tb	resistance to soldering heat	thermal shock: 3 s; 350 °C; 6 mm from body	ΔR/R max.: ±0.25% +0.05 Ω	
4.29	45 (Xa)	component solvent resistance	isopropyl alcohol or H ₂ O followed by brushing in accordance with “MIL 202 F”	no visual damage	
4.17	Ta	solderability	2 s; 235 °C	good tinning; no damage	
4.7		voltage proof on insulation	2 × maximum voltage (RMS) during 1 minute; metal block method	no breakdown or flashover	
4.16	U	robustness of terminations:			
4.16.2	Ua	tensile all samples	load 10 N; 10 s	number of failures <10 × 10 ^{−6}	
4.16.3	Ub	bending half number of samples	load 5 N; 4 × 90°	number of failures <10 × 10 ^{−6}	
4.16.4	Uc	torsion other half of samples	3 × 360° in opposite directions	no damage	
				ΔR/R max.: ±0.25% +0.05 Ω	

Fusible resistors

NFR25/25H

IEC 115-1 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS	
				NFR25	NFR25H
4.20	Eb	bump	3 × 1500 bumps in 3 directions; 40 g	no damage ΔR/R max.: ±0.25% +0.05 Ω	
4.22	Fc	vibration	frequency 10 to 500 Hz; displacement 1.5 mm or acceleration 10 g; 3 directions; total 6 hours (3 × 2 hours)	no damage ΔR/R max.: ±0.25% +0.05 Ω	
4.19	14 (Na)	rapid change of temperature	30 minutes at LCT and 30 minutes at UCT; 5 cycles	no visual damage ΔR/R max.: ±0.25% +0.05 Ω	
4.23 4.23.3 4.23.6	30 (D) 30 (D)	climatic sequence: damp heat (accelerated) 1st cycle damp heat (accelerated) remaining cycles	 6 days; 55 °C; 95 to 98% RH	 R _{ins} min.: 10 ³ MΩ ΔR/R max.: ±1% +0.05 Ω	
4.24.2	3 (Ca)	damp heat (steady state) (IEC)	56 days; 40 °C; 90 to 95% RH; loaded with 0.01 P _n (IEC steps: 4 to 100 V)	R _{ins} max.: 1000 MΩ ΔR/R max.: ±1% +0.05 Ω	
4.25.1		endurance (at 70 °C)	1000 hours; loaded with P _n or V _{max} ; 1.5 hours on and 0.5 hours off	ΔR/R max.: ±1% +0.05 Ω	
4.23.2	27 (Ba)	endurance at upper category temperature	1000 hours; no load	ΔR/R max.: ±1% +0.05 Ω	
4.8.4.2		temperature coefficient	at 20/LCT/20 °C and 20/UCT/20 °C (TC × 10 ⁻⁶ /K): 1 Ω ≤ R ≤ 4.7 Ω 4.7 Ω < R ≤ 15 Ω 15 Ω < R ≤ 15 kΩ	≤ ±200 × 10 ⁻⁶ /K ≤ ±200 × 10 ⁻⁶ /K ≤ ±100 × 10 ⁻⁶ /K	≤ ±200 × 10 ⁻⁶ /K ≤ ±100 × 10 ⁻⁶ /K ≤ ±100 × 10 ⁻⁶ /K
4.12		noise	"IEC publication 195"	<0.1 μV/V	
4.26		accidental overload	cheese-cloth	nonflammable	
Other tests in accordance with IEC 115 clauses and IEC 68 test method					
4.17	20 (Tb)	solderability (after ageing)	8 hours steam or 16 hours 155 °C; leads immersed 6 mm for 2 ±0.5 s in a solder bath at 235 ±5 °C	good tinning (≥95% covered); no damage	
4.6.1.1		insulation resistance	maximum voltage 500 V (DC) after 1 minute; metal block method	R _{ins} min.: 10 ⁴ MΩ	
see 2 nd amendment to IEC 115-1, Jan.'87		pulse load		see Figs 5, 6, 7, 8 and 9	

Metal film precision resistors

MPR24/34

FEATURES

- Ultra high precision resistors
- Ultra high stability
- Ultra low temperature coefficient.

APPLICATIONS

- Test and measurement
- Telecom.

DESCRIPTION

A homogeneous film of metal alloy is deposited on a high grade ceramic body. After a helical groove has been cut in the resistive layer, tinned connecting wires of electrolytic copper iron are welded to the end-caps. The resistors are coated with a green lacquer which provides electrical, mechanical, and climatic

protection. The encapsulation is resistant to all cleaning solvents in accordance with "MIL-STD 202E" method 215 and "IEC 68-2-45".

Resistors with a resistance value of $\leq 200 \Omega$ and with tolerances of $\pm 0.05\%$, $\pm 0.02\%$ and $\pm 0.01\%$ have low inductance.

QUICK REFERENCE DATA

DESCRIPTION	VALUE	
	MPR24	MPR34
Resistance range	4.99 Ω to 1 M Ω	
Resistance tolerance and series: 24 Ω to 100 k Ω 4.99 Ω to 1 M Ω	$\pm 0.05\%$; $\pm 0.02\%$; $\pm 0.01\%$; all values $\pm 0.5\%$; $\pm 0.25\%$; $\pm 0.1\%$; all values	
Maximum dissipation at $T_{amb} = 70^\circ\text{C}$: $\pm 0.05\%$; $\pm 0.02\%$; $\pm 0.01\%$ $\pm 0.5\%$; $\pm 0.25\%$; $\pm 0.1\%$	0.125 W 0.25 W	0.25 W 0.4 W
Temperature coefficient characteristic between $+20$ and $+70^\circ\text{C}$	$\leq \pm 25 \times 10^{-6}/\text{K}$ $\leq \pm 15 \times 10^{-6}/\text{K}$ $\leq \pm 10 \times 10^{-6}/\text{K}$ $\leq \pm 5 \times 10^{-6}/\text{K}$	
Failure level: 24 Ω to 100 k Ω 4.99 Ω to 1 M Ω	S R	
Maximum permissible voltage (DC or RMS)	250 V	350 V
Basic specifications	CECC 403000; MIL-R-10509; MIL-R-55182; DIN 44061; IEC 115-5	
Climatic category (IEC 68): $\pm 0.05\%$; $\pm 0.02\%$; $\pm 0.01\%$ $\pm 0.5\%$; $\pm 0.25\%$; $\pm 0.1\%$	55/125/56 55/155/56	
Vibration test	10 to 500 Hz; 0.75 or 98 m/s ²	
Air pressure (lower limit)	8.5 kN/m ²	
Stability after: load climatic tests soldering short time overload	$\Delta R/R$ max.: $\pm 0.05\% + 0.01 \Omega$ $\Delta R/R$ max.: $\pm 0.05\% + 0.01 \Omega$ $\Delta R/R$ max.: $\pm 0.01\% + 0.01 \Omega$ $\Delta R/R$ max.: $\pm 0.01\% + 0.01 \Omega$	

Metal film precision resistors

MPR24/34

ORDERING INFORMATION

Ordering code (12NC)

- The resistors have a 12-digit ordering code starting with 2322 14
- The 7th digit indicates product type and packaging quantity; see Table 2.
- The subsequent 2 digits (8 and 9) indicate temperature coefficient, tolerance, marking and packaging quantity:
 - Table 3 refers to $\pm 0.5\%$, $\pm 0.25\%$ and $\pm 0.1\%$ tolerance products.
 - Table 4 refers to $\pm 0.05\%$, $\pm 0.02\%$ and $\pm 0.01\%$ tolerance products.
- The remaining 3 digits indicate the resistance value. The number is available upon request and is fixed by the supplier.

Table 1 Quantity per package

PACKAGE	QUANTITY
Cassette including list with individual measuring details	20
Bandolier in cardboard box	100
Bandolier in ammpack	500 or 1000
Bandolier on reel	5000

Table 2 7th digit; type and quantity

TYPE	7 th DIGIT	QUANTITY	
		TOL. $\pm 0.5\%$ $\pm 0.25\%$ $\pm 0.1\%$	TOL. $\pm 0.05\%$ $\pm 0.02\%$ $\pm 0.01\%$
MPR24	1	100 or 1000	20 or 100
	3	500 or 5000	500 or 1000
MPR34	2	100 or 1000	20 or 100
	4	500 or 5000	500 or 1000

Table 3 8th and 9th digit; tol. $\pm 0.5\%$; $\pm 0.25\%$; $\pm 0.1\%$; range 4.99 Ω to 1 M Ω

TC	ORDERING CODE 8th and 9th DIGIT						PACKAGING QUANTITY
	TOL. $\pm 0.5\%$		TOL. $\pm 0.25\%$		TOL. $\pm 0.1\%$		
	colour coded	marked	colour coded	marked	colour coded	marked	
± 25	00...	04...	20...	24...	40...	44...	100 or 500
	10...	14...	30...	34...	50...	54...	1000 or 5000
± 15	01...	05...	21...	25...	41...	45...	100 or 500
	11...	15...	31...	35...	51...	55...	1000 or 5000
± 10	02...	06...	22...	26...	42...	46...	100 or 500
	12...	16...	32...	36...	52...	56...	1000 or 5000
± 5	03...	07...	23...	27...	43...	47...	100 or 500
	13...	17...	33...	37...	53...	57...	1000 or 5000

Table 4 8th and 9th digit; tol. $\pm 0.05\%$; $\pm 0.02\%$; $\pm 0.01\%$; range 24 Ω to 100 k Ω

TC	ORDERING CODE 8th and 9th DIGIT			PACKAGING QUANTITY
	TOL. $\pm 0.05\%$	TOL. $\pm 0.02\%$	TOL. $\pm 0.01\%$	
	marked			
± 25	60...	70...	80...	20 or 500
	64...	74...	84...	100 or 1000
± 15	61...	71...	81...	20 or 500
	65...	75...	85...	100 or 1000
± 10	62...	72...	82...	20 or 500
	66...	76...	86...	100 or 1000
± 5	63...	73...	83...	20 or 500
	67...	77...	87...	100 or 1000

Ordering example

The ordering code of an MPR24 resistor with tolerance of $\pm 0.02\%$, TC = $\pm 5 \times 10^{-6}/K$, taped on bandolier in box of 100 units starts with 2322 141 77...; the last 3 digits are available upon request and are fixed by the supplier.

Metal film precision resistors

MPR24/34

FUNCTIONAL DESCRIPTION

Product characterization

Any value within the range can be ordered.

The stability as a function of dissipation and ambient temperature is indicated in the performance nomogram (see Fig.1) for resistors with resistance tolerance $\geq 0.1\%$.

NOTES ON THE NOMOGRAM

- The nomogram should not be extended beyond the maximum permissible hot-spot temperature of 175 °C.
- The resistance range given by the nomogram for $P = 0$ at a particular ambient temperature is indicative of the shelf life stability of a resistor at that temperature.
- The stability lines do not give exact values but represent a probability of 95% that the real values will be smaller than those indicated in the nomogram.
- In the nomogram the limiting voltage of the resistors have not been taken into consideration.

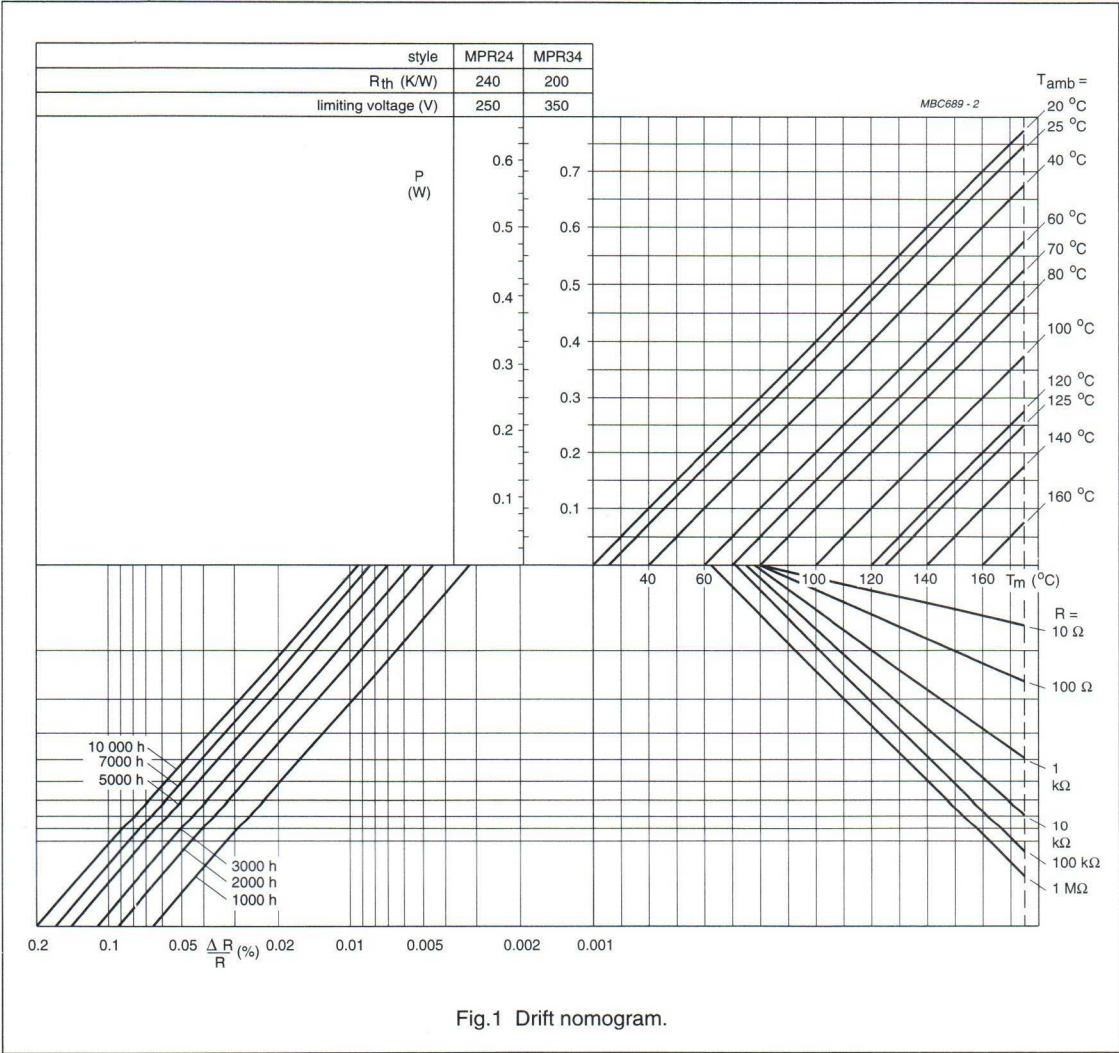


Fig.1 Drift nomogram.

Metal film precision resistors

MPR24/34

Limiting values

TYPE	LIMITING VOLTAGE ⁽¹⁾ (V)	LIMITING POWER (W)	
		TOL. (%) ±0.5; ±0.25; ±0.1	TOL. (%) ±0.05; ±0.02; ±0.01
MPR24	250	0.25	0.125
MPR34	350	0.4	0.25

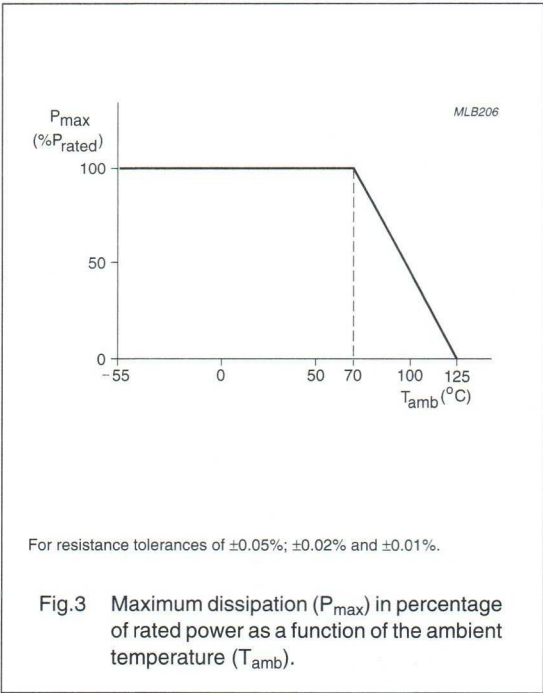
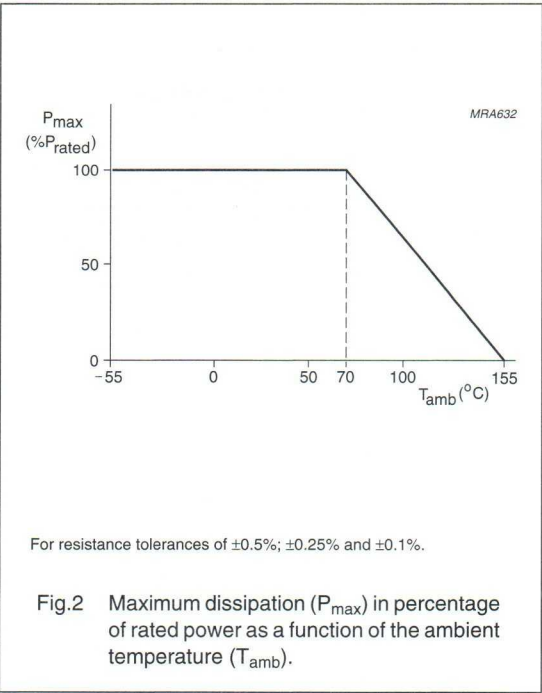
Note

1. The maximum voltage that may be continuously applied to the resistor element, see "IEC publication 115-1".

The maximum permissible hot-spot temperature is 155 °C.

DERATING

The power that the resistor can dissipate depends on the operating temperature; see Figs 2 and 3.



Metal film precision resistors

MPR24/34

MECHANICAL DATA

Mass per 100 units

TYPE	MASS (g)
MPR24	25
MPR34	30

Marking

The resistors are either colour coded or marked.

Any value within the range can be supplied colour coded, provided the resistance can be expressed in 3 coloured bands.

All other resistors are marked including those in cassette packaging.

COLOUR CODING

Colour coding is in accordance with IEC publication 62 "Colour codes for fixed resistors".

MARKING

When marked, the following details are printed on the resistors:

- Manufacturers symbol
- Tolerance code (in accordance with "IEC 62")
- Temperature coefficient code TC:
 - $\pm 25 = 1$
 - $\pm 15 = 2$
 - $\pm 10 = 3$
 - $\pm 5 = 4$
- Resistance value code (in accordance with "IEC 62"), with a maximum of nine positions.

Outlines

The length of the body (L_1) is measured by inserting the leads into holes of two identical gauge plates and moving these plates parallel to each other until the resistor body is clamped without deformation ("IEC publication 294").

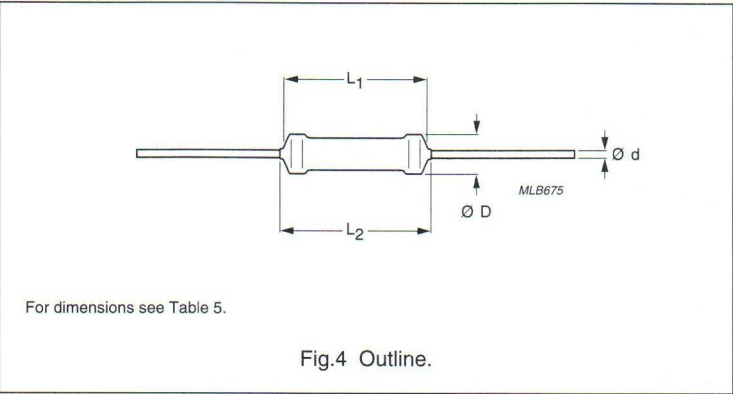


Table 5 Resistor type and relevant physical dimensions; see Fig.4

TYPE	ØD MAX. (mm)	L ₁ MAX. (mm)	L ₂ MAX. (mm)	Ød (mm)
MPR24	2.5	6.5	7.5	0.6
MPR34	3.0	10.0	11.0	0.6

Metal film precision resistors

MPR24/34

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of "CECC publication 40.300", category **LCT/UCT/56** (rated temperature range: Lower Category Temperature, Upper Category Temperature; damp heat, long term, **56** days) along the lines of "CECC 40000".

"Recommended basic climatic and mechanical robustness testing procedure for electronic components".

Unless otherwise specified the following values apply:

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

Air pressure: 86 kPa to 106 kPa
(860 mbar to 1060 mbar).

In Table 6 the tests and requirements are listed with reference to the relevant clauses of "CECC publications 40000 and IEC publication 68", a short

description of the test procedure is also given. In some instances deviations from the CECC recommendations were necessary for our method of specifying.

All soldering tests are performed with mildly activated flux.

Table 6 Test procedures and requirements

CECC 40000 TEST METHOD	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.5		insulation resistance	voltage (DC) after 1 minute; metal block method: 500 V for MPR24 , 700 V for MPR34	R_{ins} min.: 10^4 M Ω
4.6		voltage proof	$2 \times$ limiting voltage (AC) during 1 minute, metal block method	no breakdown or flashover
4.7		temperature coefficient	at 20/70/20 °C at 20/LCT/20 °C and 20/UCT/20 °C (TC $\times 10^{-6}$ /K)	$\leq \pm 25 \times 10^{-6}$ /K; $\leq \pm 15 \times 10^{-6}$ /K; $\leq \pm 10 \times 10^{-6}$ /K; $\leq \pm 5 \times 10^{-6}$ /K $\leq \pm 25 \times 10^{-6}$ /K
4.10		noise	IEC publication 195 (measured with Quantech - equipment) $R \leq 100$ k Ω $R > 100$ k Ω	max. 0.25 μ V/V max. 0.5 μ V/V
4.11		short time overload	room temperature; $P = 6.25 \times P_n$; 5 s ($V \leq 2 \times V_{max}$)	$\Delta R/R$ max.: $\pm 0.01\% + 0.01$ Ω
4.16	U Ua Ub Uc	robustness of terminations: tensile all samples bending half number of samples torsion other half of samples	load 10 N; 10 s load 5 N; $4 \times 90^\circ$ $3 \times 360^\circ$ in opposite directions	number of failures $< 10 \times 10^{-6}$ number of failures $< 10 \times 10^{-6}$ no damage $\Delta R/R$ max.: $\pm 0.01\% + 0.01$ Ω
4.15	Ta	solderability	2 s; 235 °C	good tinning; no damage
4.15	Tb	resistance to soldering heat	thermal shock: 3 s; 350 °C; 6 mm from body	$\Delta R/R$ max.: $\pm 0.01\% + 0.01$ Ω

Metal film precision resistors

MPR24/34

CECC 40000 TEST METHOD	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.16	Na	rapid change of temperature	30 minutes at LCT and 30 minutes at UCT; 5 cycles	no visual damage $\Delta R/R$ max.: $\pm 0.01\% + 0.01 \Omega$
4.17	Eb	bump	3 × 1500 bumps in 3 directions; 40 g	no damage $\Delta R/R$ max.: $\pm 0.01\% + 0.01 \Omega$
4.19	Fc	vibration	frequency 10 to 500 Hz; displacement 1.5 mm or acceleration 10 g; 3 directions; total 6 hours (3 × 2 hours)	no damage $\Delta R/R$ max.: $\pm 0.01\% + 0.01 \Omega$
4.4.1		visual examination		no holes; clean surface; no damage
4.20 4.20.2 4.20.3 4.20.4 4.20.5 4.20.6	B D Aa M D	climatic sequence: dry heat damp heat (accelerated) 1st cycle cold low air pressure damp heat (accelerated) remaining cycles	16 hours at UCT 24 hours; 95 to 100% RH 2 hours at LCT 1 hour; 8.5 kPa 5 days; 55 °C; 95 to 100% RH	 R_{ins} min.: $10^3 M\Omega$ $\Delta R/R$ max.: $\pm 0.05\% + 0.01 \Omega$
4.21	Ca	damp heat, steady state (long term exposure)	56 days; 40 °C; 90 to 95% RH; loaded with 1.25 mW max.	R_{ins} min.: 100 MΩ $\Delta R/R$ max.: $\pm 0.05\% + 0.01 \Omega$
4.25.1		endurance (at 70 °C)	2 000 hours; loaded with P_n or V_{max} ; 1.5 hours on and 0.5 hours off	R_{ins} min.: $10^3 M\Omega$ $\Delta R/R$ max.: $\pm 0.05\% + 0.01 \Omega$

High-ohmic/high-voltage resistors

VR25/37/68

FEATURES

- Types VR37 and VR68 meet the safety requirements of:
"UL 1676" (range 510 k Ω to 11 M Ω)
"EN60065"
"BS60065" (U.K.)
"NFC 92-130" (France)
"VDE 0860" (Germany)
- High pulse loading capability
- Small size.

APPLICATIONS

- Where high resistance, high stability and high reliability at high voltage are required.

DESCRIPTION

A metal glazed film is deposited on a high grade ceramic body. After a helical groove has been cut in the resistive layer, tinned electrolytic copper wires copper are welded to

the end-caps. The resistors are coated with a light blue lacquer which provides electrical, mechanical, and climatic protection.

The encapsulation is resistant to all cleaning solvents in accordance with *"MIL-STD 202E"* method 215 and *"IEC 68-2-45"*.

QUICK REFERENCE DATA

DESCRIPTION	VALUE		
	VR25	VR37	VR68
Resistance range	100 kΩ to 22 MΩ	100 kΩ to 33 MΩ	100 kΩ to 68 MΩ ⁽¹⁾
Resistance tolerance and series:		±1%: E24/E96 series; ±5%: E24 series	±1%: E24/E96 series; ±5%: E24 series
100 kΩ to 15 MΩ	±5%: E24 series	—	—
15 MΩ to 22 MΩ	±10%: E12 series	—	—
220 kΩ to 15 MΩ	±1%: E24/E96 series	—	—
Maximum dissipation at T _{amb} = 70 °C	0.25 W	0.5 W	1 W
Thermal resistance, R _{th}	200 K/W	120 K/W	70 K/W
Temperature coefficient	≤ ±200 × 10 ⁻⁶ /K		
Maximum permissible voltage:			
DC	1 600 V	3500 V	10000 V
RMS	1 150 V	2500 V	7000 V
Dielectric withstanding voltage of the insulation for 1 minute	700 V		
Basic specifications	IEC 115-1B		
Safety requirements	—	UL1676 (510 kΩ to 11 MΩ); EN60065; BS60065; VDE 0860; NFC 92-130	
Climatic category (IEC 68)	55/155/56		
Stability after:			
load (1000 hours)	ΔR/R max.: ±1.5% +0.1 Ω —	ΔR/R max.: ±1.5% +0.1 Ω typ. 0.5%	ΔR/R max.: ±1.5% +0.1 Ω typ. 1%
accelerated damp heat test (6 days)	ΔR/R max.: ±1.5% +0.1 Ω —	ΔR/R max.: ±1.5% +0.1 Ω typ. 0.5%	ΔR/R max.: ±1.5% +0.1 Ω typ. 1%
long term damp heat test (56 days)	ΔR/R max.: ±1.5% +0.1 Ω —	ΔR/R max.: ±1.5% +0.1 Ω typ. 0.5%	ΔR/R max.: ±1.5% +0.1 Ω typ. 0.5%
Noise	max. 5 μV/V	max. 2.5 μV/V; typ. 0.5	

Note

- Values up to 220 M Ω are available upon request.

High-ohmic/high-voltage resistors

VR25/37/68

ORDERING INFORMATION

Table 1 Ordering code indicating resistor type and packaging

TYPE	TAPE WIDTH (mm)	TOL. (%)	ORDERING CODE 2322				
			BANDOLIER IN AMMOPACK				BANDOLIER ON REEL
			500 units	1 000 units	2 000 units	5 000 units	5 000 units
VR25	52	±1	—	241 8...	—	—	—
		±5	—	241 13...	—	241 53...	241 23...
		±10	—	241 12...	—	241 52...	241 22...
	26	±5	—	—	241 43...	—	—
		±10	—	—	241 42...	—	—
VR37	52	±1	—	242 8....	—	—	—
		±5	—	242 13...	—	—	242 23...
VR68	66.7	±1	244 8....	—	—	—	—
		±5	244 13...	—	—	—	—

Ordering code (12NC)

- The resistors have a 12-digit ordering code starting with 2322.
- The subsequent:
 - 4 digits for 1% tolerance products (E24 and E96 series).
 - or 5 digits for 5% (E24 series) and 10% (E12 series) indicate the resistor type and packaging; see Table 1.
- The remaining digits indicate the resistance value:
 - The first 3 digits for 1% or 2 digits for 5 and 10% tolerance products indicate the resistance value.
 - The last digit indicates the resistance decade in accordance with Table 2.

Table 2 Last digit of 12NC

RESISTANCE DECADE	LAST DIGIT
100 to 976 kΩ	4
1 to 9.76 MΩ	5
≥10 MΩ	6

ORDERING EXAMPLE

The ordering code for a VR37, resistor value 7.5 MΩ, 5% tolerance, supplied on a bandolier of 1 000 units in ammopack, is: 2322 242 13755.

High-ohmic/high-voltage resistors

VR25/37/68

FUNCTIONAL DESCRIPTION

Product characterization

Standard values of nominal resistance are taken from the E96/E24/E12 series for resistors with a tolerance of $\pm 1\%$, 5% or 10%. The values of the E96/E24/E12 series are in accordance with "IEC publication 63".

Limiting values

TYPE	LIMITING VOLTAGE ⁽¹⁾ (V)		LIMITING POWER (W)
	DC	RMS	
VR25	1600	1150	0.25
VR37	3500	2500	0.5
VR68	10000	7000	1.0

Note

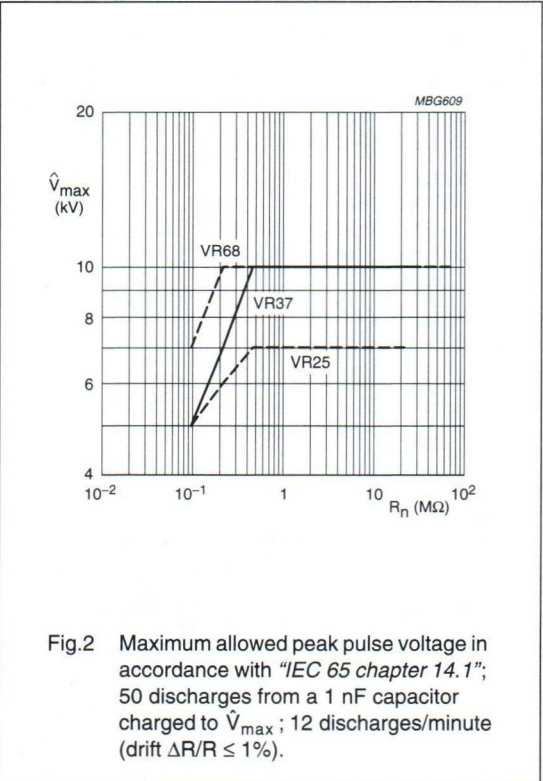
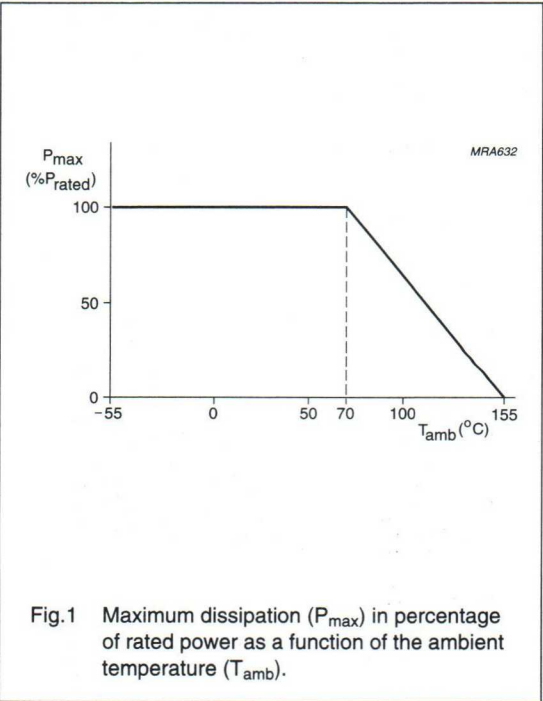
1. The maximum voltage that may be continuously applied to the resistor element, see "IEC publication 115-1".

The maximum permissible hot-spot temperature is 155 °C.

DERATING

The power that the resistor can dissipate depends on the operating temperature; see Fig.1.

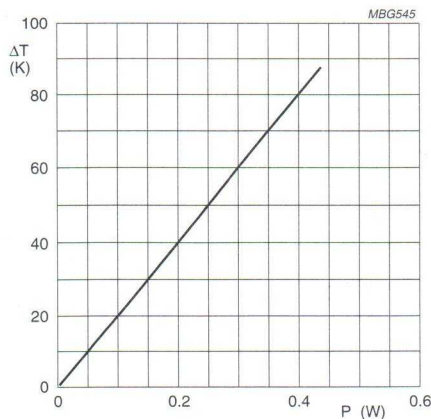
PULSE LOADING CAPABILITY



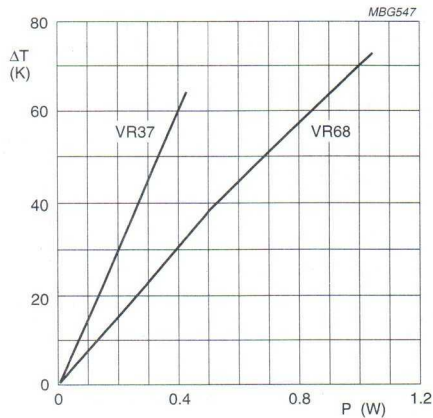
High-ohmic/high-voltage resistors

VR25/37/68

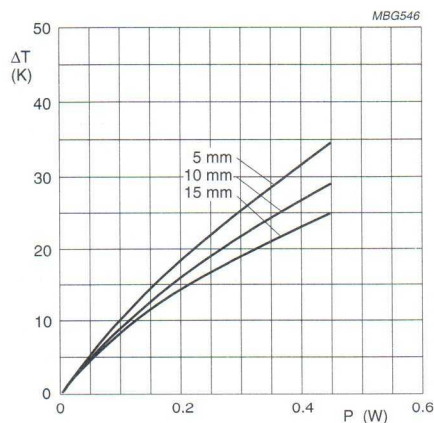
Application information



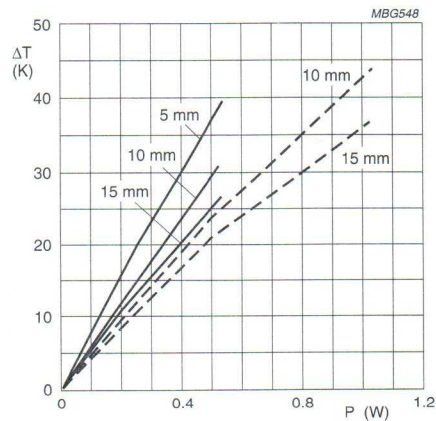
VR25

Fig.3 Hot-spot temperature rise (ΔT) as a function of dissipated power.

VR37/VR68

Fig.4 Hot-spot temperature rise (ΔT) as a function of dissipated power.

VR25

Fig.5 Temperature rise (ΔT) at the lead end (soldering point) as a function of dissipated power at various lead lengths after mounting.

VR37/VR68

Fig.6 Temperature rise (ΔT) at the lead end (soldering point) as a function of dissipated power at various lead lengths after mounting.

High-ohmic/high-voltage resistors

VR25/37/68

MECHANICAL DATA

Mass per 100 units

TYPE	MASS (g)
VR25	25
VR37	48
VR68	148

Marking

The nominal resistance and tolerance are marked on the resistor using four or five coloured bands in accordance with IEC publication 62 "Colour codes for fixed resistors".

Yellow and grey are used instead of gold and silver because metal particles in the lacquer could affect high-voltage properties.

Outlines

The length of the body (L_1) is measured by inserting the leads into holes of two identical gauge plates and moving these plates parallel to each other until the resistor body is clamped without deformation ("IEC publication 294").

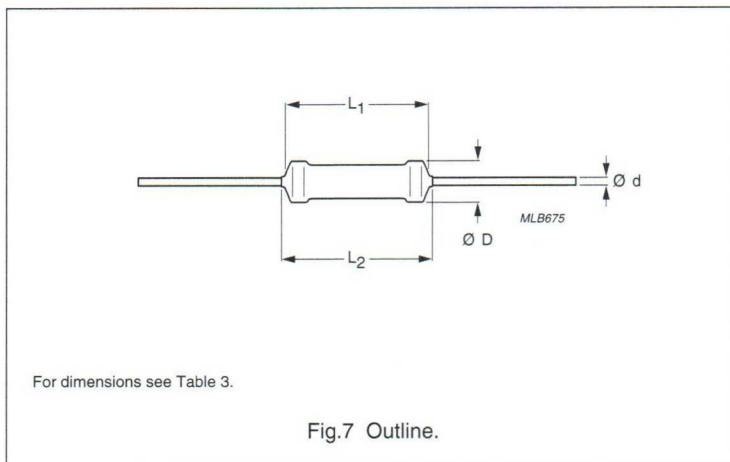


Table 3 Resistor type and relevant physical dimensions; see Fig.7

TYPE	ØD MAX. (mm)	L ₁ MAX. (mm)	L ₂ MAX. (mm)	Ød (mm)
VR25	2.5	6.5	7.5	0.6
VR37	4.0	9.0	10.0	0.7
VR68	6.8	18.0	19.0	0.8

High-ohmic/high-voltage resistors

VR25/37/68

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of "IEC publication 115-1", category **LCT/UCT/56** (rated temperature range: Lower Category Temperature, Upper Category Temperature; damp heat, long term, **56** days). The testing also covers the requirements specified by EIA and EIAJ.

The tests are carried out in accordance with IEC publication 68,

"Recommended basic climatic and mechanical robustness testing procedure for electronic components" and under standard atmospheric conditions according to "IEC 68-1", subclause 5.3.

Unless otherwise specified the following values apply:

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

Air pressure: 86 kPa to 106 kPa (860 mbar to 1060 mbar).

In Table 4 the tests and requirements are listed with reference to the relevant clauses of "IEC publications 115-1 and 68", a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

All soldering tests are performed with mildly activated flux.

Table 4 Test procedures and requirements

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS		
				VR25	VR37	VR68
4.16	U	robustness of terminations:		number of failures $<10 \times 10^{-6}$ number of failures $<10 \times 10^{-6}$ no damage $\Delta R/R$ max.: $\pm 0.5\% + 0.05 \Omega$		
4.16.2	Ua	tensile all samples	$\varnothing 0.5$ mm; load 10 N; 10 s			
4.16.3	Ub	bending half number of samples	$\varnothing 0.5$ mm; load 5 N; $4 \times 90^\circ$			
4.16.4	Uc	torsion other half of samples	$3 \times 360^\circ$ in opposite directions			
4.17	Ta	solderability	2 s; 235 °C; flux 600	good tinning; no damage		
4.18	Tb	resistance to soldering heat	thermal shock: 3 s; 350 °C; 6 mm from body	$\Delta R/R$ max.: $\pm 0.5\% + 0.05 \Omega$		
4.19	Na	rapid change of temperature	30 minutes at -55 °C and 30 minutes at +155 °C; 5 cycles	$\Delta R/R$ max.: $\pm 0.5\% + 0.05 \Omega$		
4.20	Eb	bump	3×1500 bumps in 3 directions; 40 g	no damage $\Delta R/R$ max.: $\pm 0.5\% + 0.05 \Omega$		
4.22	Fc	vibration	frequency 10 to 500 Hz; displacement 1.5 mm or acceleration 10 g; 3 directions; total 6 hours (3×2 hours)	no damage $\Delta R/R$ max.: $\pm 0.5\% + 0.05 \Omega$		
4.23		climatic sequence:		R_{ins} min.: $10^3 M\Omega$ $\Delta R/R$ max.: $\pm 1.5\% + 0.1 \Omega$		
4.23.2	Ba	dry heat	16 hours; 155 °C			
4.23.3	Db	damp heat (accelerated) 1st cycle	24 hours; 55 °C; 90 to 100% RH			
4.23.4	Aa	cold	2 hours; -55 °C			
4.23.5	M	low air pressure	2 hours; 8.5 kPa; 15 to 35 °C			
4.23.6	Db	damp heat (accelerated) remaining cycles	5 days; 55 °C; 95 to 100% RH			

High-ohmic/high-voltage resistors

VR25/37/68

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS		
				VR25	VR37	VR68
4.24.2	Ca	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; dissipation 0.01 P _n ; limiting voltage 16 V (DC)	ΔR/R max.: ±1.5% +0.1 Ω		
4.25.1		endurance	1 000 hours at 70 °C; P _n or V _{max}	ΔR/R max.: ±1.5% +0.1 Ω		
4.8.4		temperature coefficient	between –55 °C and +155 °C (TC × 10 ^{–6} /K)	≤ ±200		
4.7		voltage proof on insulation	700 V (RMS) during 1 minute; V-block method	no breakdown		
4.12		noise	IEC publication 195	max. 5 μV/V	max. 2.5 μV/V	
4.6.1.1		insulation resistance	500 V (DC or RMS) during 1 minute; V-block method	R _{ins} min.: 10 ⁴ MΩ		
4.13		short time overload	room temperature; dissipation 6.25 × P _n (voltage not more than 2 × limiting voltage; 10 000 V max.); 10 cycles; 5 s on and 45 s off	ΔR/R max.: ±0.5% +0.05 Ω		

Power metal film resistors

PR01/02/03

FEATURES

- High power in small package
- Different lead materials for different applications
- Defined interruption behaviour.

APPLICATIONS

- All general purpose power applications.

DESCRIPTION

A homogeneous film of metal alloy is deposited on a high grade ceramic body. After a helical groove has been cut in the resistive layer, tinned connecting wires of electrolytic copper or electroclad iron are welded to the end-caps. The resistors are coated with a red, nonflammable lacquer which provides electrical,

mechanical, and climatic protection. This coating is not resistant to aggressive fluxes. The encapsulation is resistant to all cleaning solvents in accordance with "MIL-STD 202E" method 215, and "IEC 68-2-45".

QUICK REFERENCE DATA

DESCRIPTION	VALUE				
	PR01	PR02		PR03	
	Ø0.6 mm Cu-lead	Ø0.8 mm Cu-lead	Ø0.6 mm FeCu-lead	Ø0.8 mm Cu-lead	Ø0.6 mm FeCu-lead
Resistance range	0.22 Ω to 1 MΩ	0.33 Ω to 1 MΩ	1 Ω to 1 MΩ	0.68 Ω to 1 MΩ	1 Ω to 1 MΩ
Resistance tolerance and series	±5%; E24 series				
Maximum dissipation at T _{amb} = 70 °C: R < 1 Ω 1 Ω ≤ R	0.6 W 1 W	1.2 W 2 W	– 1.3 W	1.6 W 3 W	– 2.5 W
Thermal resistance (R _{th})	135 K/W	75 K/W	115 K/W	60 K/W	75 K/W
Temperature coefficient	≤ ±250 × 10 ⁻⁶ /K				
Maximum permissible voltage (DC or RMS)	350 V	500 V		750 V	
Basic specifications	IEC 115-1 and 115-4				
Approval	CECC 40101				
Climatic category (IEC 68)	55/155/56				
Stability after:					
load	ΔR/R max.: ±5% +0.1 Ω				
climatic tests	ΔR/R max.: ±3% +0.1 Ω				
soldering	ΔR/R max.: ±1% +0.05 Ω				

Power metal film resistors

PR01/02/03

ORDERING INFORMATION

Table 1 Ordering code indicating resistor type and packaging

TYPE	LEAD	RANGE	ORDERING CODE 23... ..								
			BANDOLIER IN AMMOPACK				BANDOLIER ON REEL	CROPPED AND FORMED LOOSE IN BOX			
			RADIAL TAPED		STRAIGHT LEADS		STRAIGHT LEADS	H = 8 mm (note 1)		H = 15 mm (note 1)	
			4000 units	3000 units	1000 units	500 units	5000 units	1000 units	500 units	500 units	250 units
PR01	Cu	$R < 1 \Omega$	note 2	—	note 2	—	note 2	—	—	—	—
		$1 \Omega \leq R$	2306 197 03...	—	2322 193 13...	—	2322 193 23...	2322 193 33...	—	—	—
PR02	Cu	$R < 1 \Omega$		note 2	note 2	—	—	note 2	—	note 2	—
		$1 \Omega \leq R$	—	2306 198 03...	2322 194 13...	—	—	2322 194 33...	—	2322 194 43...	—
	FeCu	$1 \Omega \leq R$	—	—	2322 194 53...	—	—	2322 194 73...	—	—	—
PR03	Cu	$R < 1 \Omega$	—	—	—	note 2	—	—	note 2	—	note 2
		$1 \Omega \leq R$	—	—	—	2322 195 13...	—	—	2322 195 33...	—	2322 195 43...
	FeCu	$1 \Omega \leq R$	—	—	—	2322 195 53...	—	—	2322 195 73...	—	—

Notes

1. H = height.
2. Available on request.

Ordering code (12NC)

- The resistors have a 12-digit ordering code.
- The first 9 digits indicate the resistor type and packaging; see Table 1.
- The remaining 3 digits indicate the resistance value:
 - The first 2 digits indicate the resistance value.
 - The last digit indicates the resistance decade in accordance with Table 2.

Table 2 Last digit of 12 NC

RESISTANCE DECADE	LAST DIGIT
1 to 9.1 Ω	8
10 to 91 Ω	9
100 to 910 Ω	1
1 to 9.1 k Ω	2
10 to 91 k Ω	3
100 to 910 k Ω	4
1 M Ω	5

ORDERING EXAMPLE

The ordering code for resistor type PR02 with Cu leads and a value of 750 Ω , supplied on a bandolier of 1000 units in ammopack, is: 2322 194 13751.

Power metal film resistors

PR01/02/03

FUNCTIONAL DESCRIPTION

Product characterization

Standard values of nominal resistance are taken from the E24 series for resistors with a tolerance of $\pm 5\%$. The values of the E24 series are in accordance with "IEC publication 63".

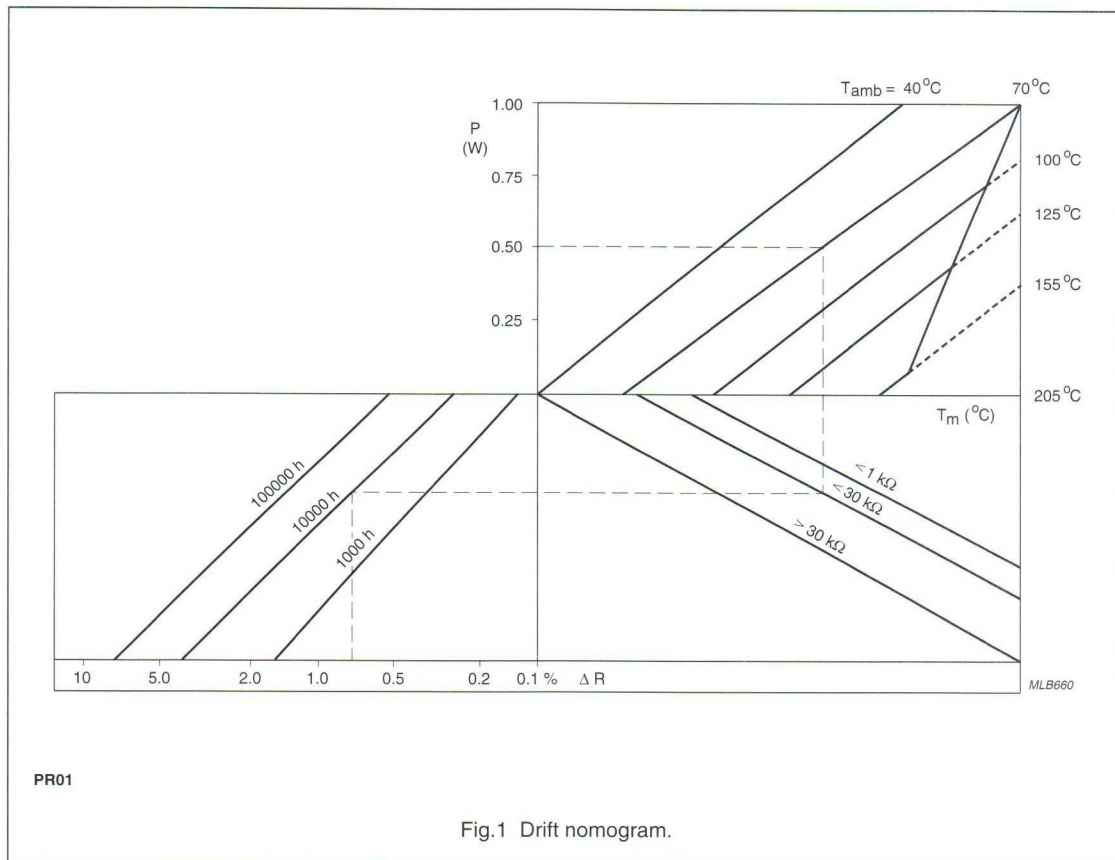
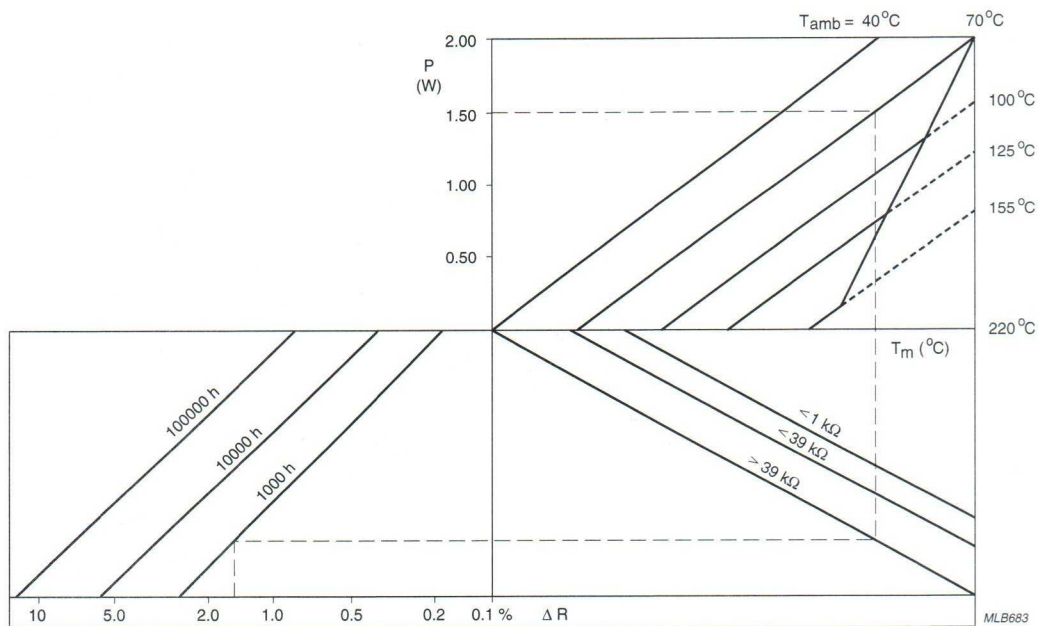


Fig.1 Drift nomogram.

Power metal film resistors

PR01/02/03

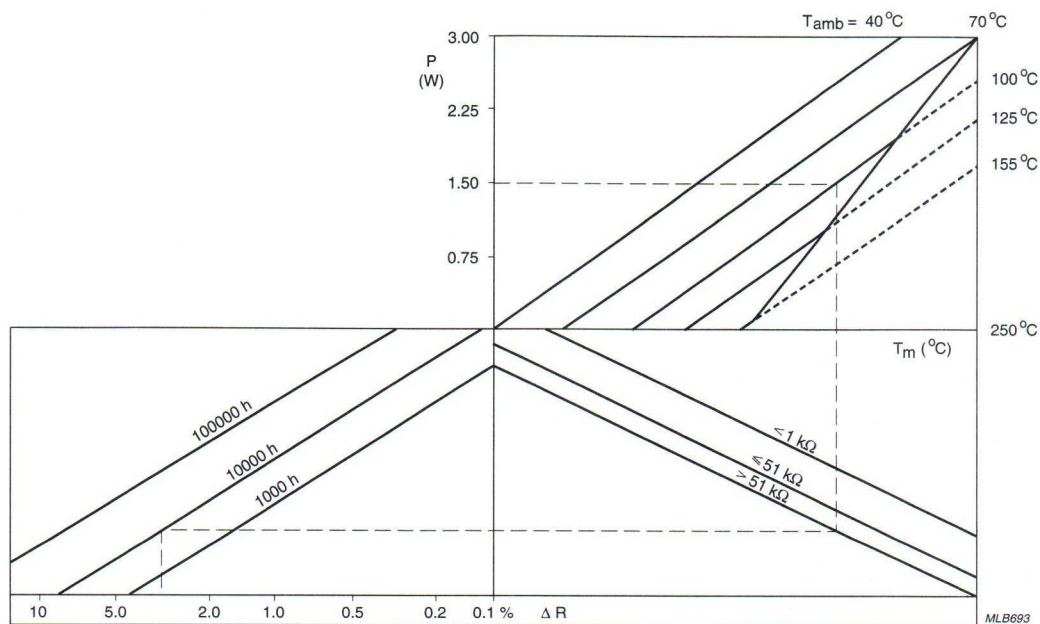


PR02

Fig.2 Drift nomogram.

Power metal film resistors

PR01/02/03



PR03

Fig.3 Drift nomogram.

Power metal film resistors

PR01/02/03

Limiting values

TYPE	LEAD MATERIAL	RANGE	LIMITING VOLTAGE ⁽¹⁾ (V)	LIMITING POWER (W)
PR01	Cu	$R < 1 \Omega$	350	0.6
		$1 \Omega \leq R$		1.0
PR02	Cu	$R < 1 \Omega$	500	1.2
		$1 \Omega \leq R$		2.0
	FeCu	$1 \Omega \leq R$		1.3
PR03	Cu	$R < 1 \Omega$	750	1.6
		$1 \Omega \leq R$		3.0
	FeCu	$1 \Omega \leq R$		2.5

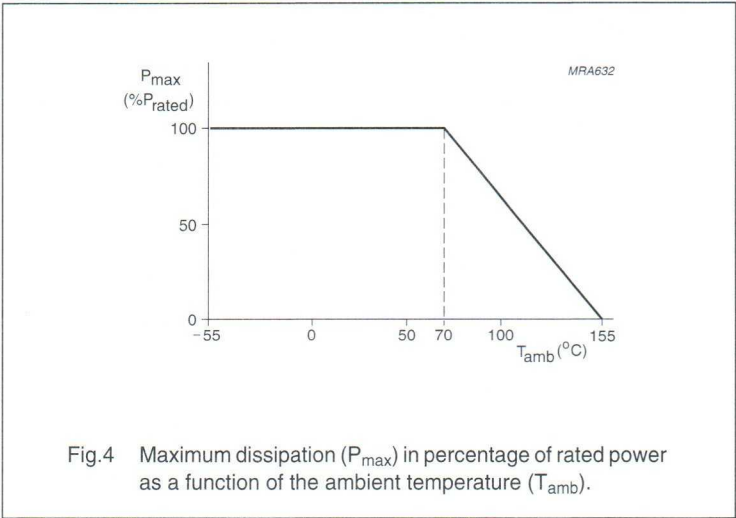
Note

1. The maximum voltage that may be continuously applied to the resistor element, see "IEC publication 115-1".

The maximum permissible hot-spot temperature is 205 °C for PR01, 220 °C for PR02 and 250 °C for PR03.

DERATING

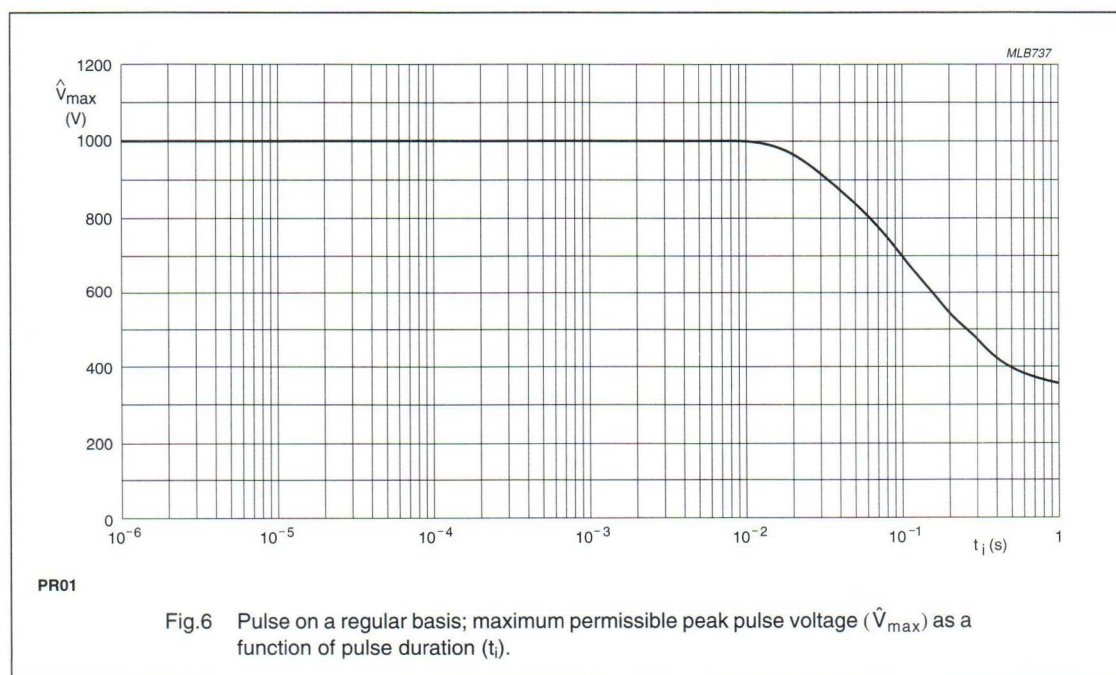
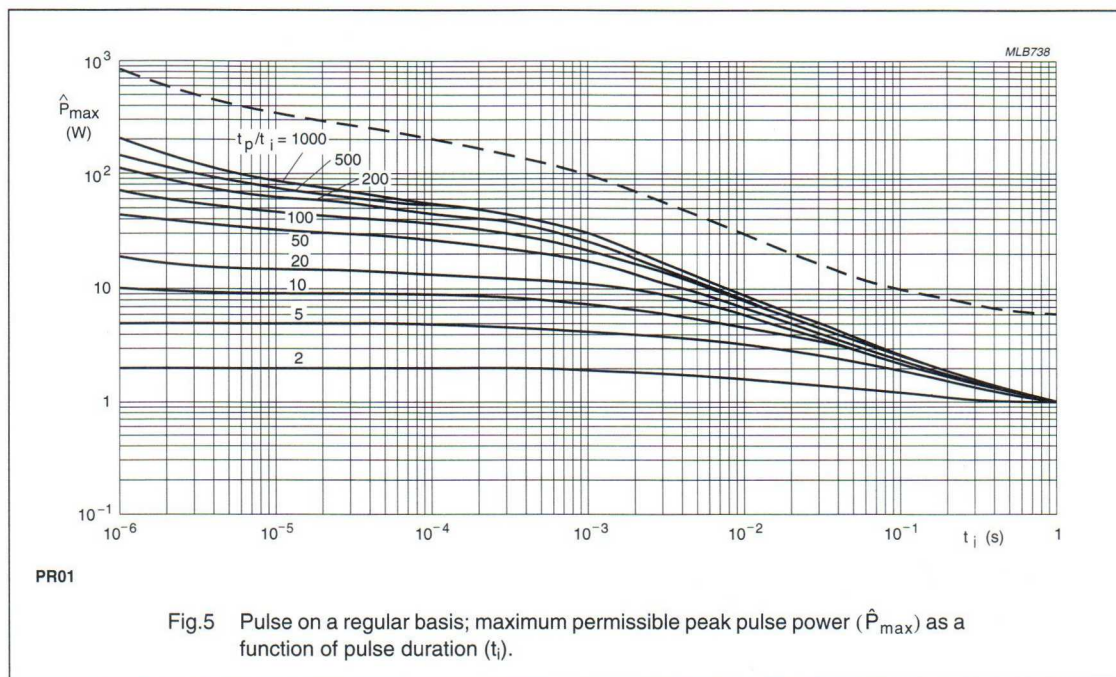
The power that the resistor can dissipate depends on the operating temperature; see Fig.4.



Power metal film resistors

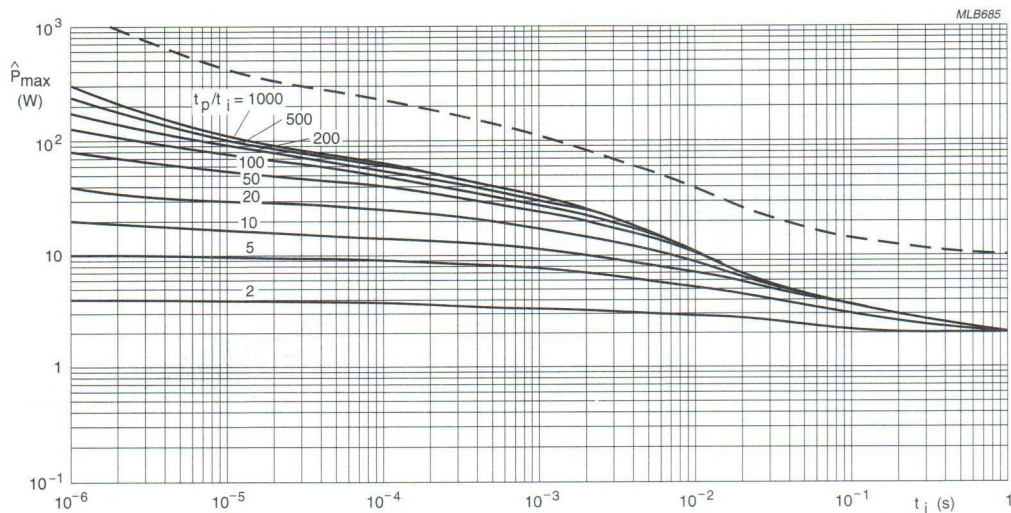
PR01/02/03

PULSE LOADING CAPABILITIES



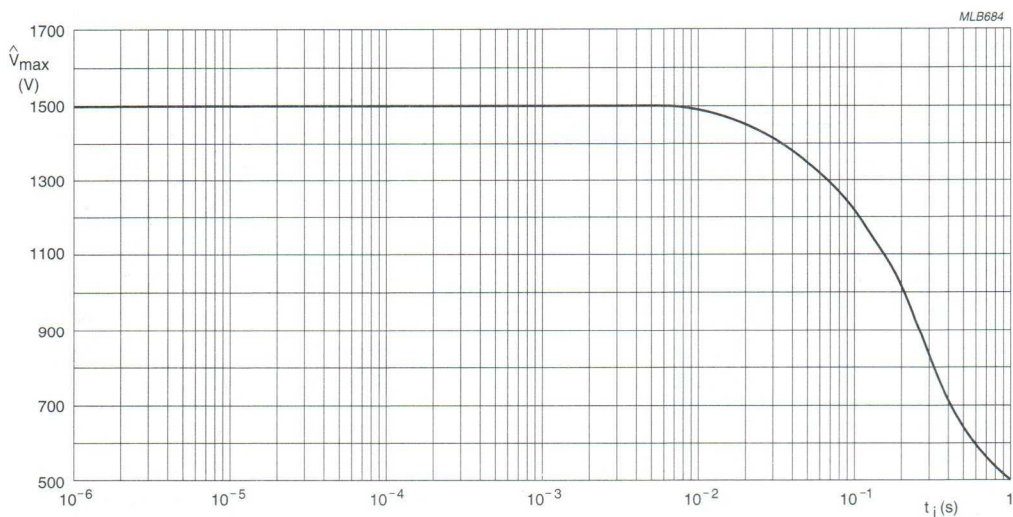
Power metal film resistors

PR01/02/03



PR02

Fig.7 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i).

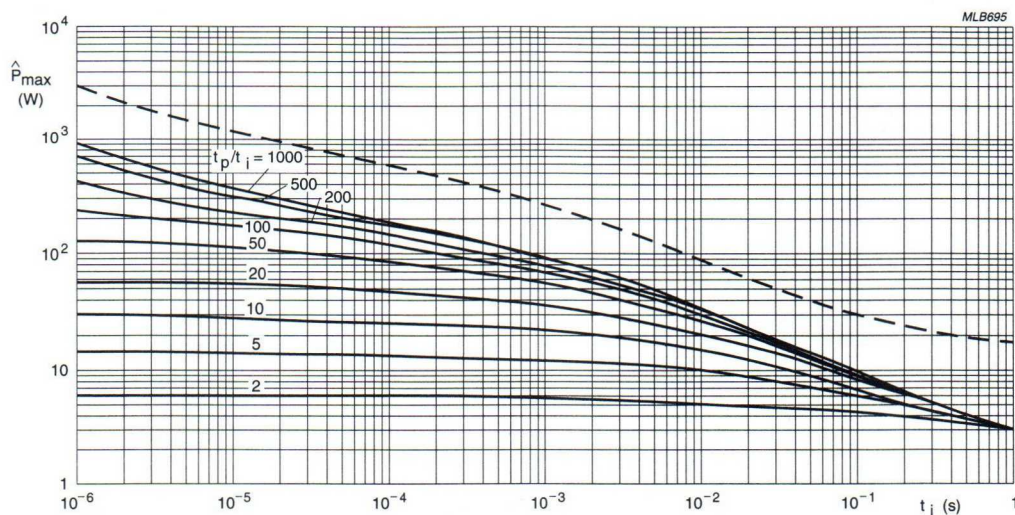


PR02

Fig.8 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_i).

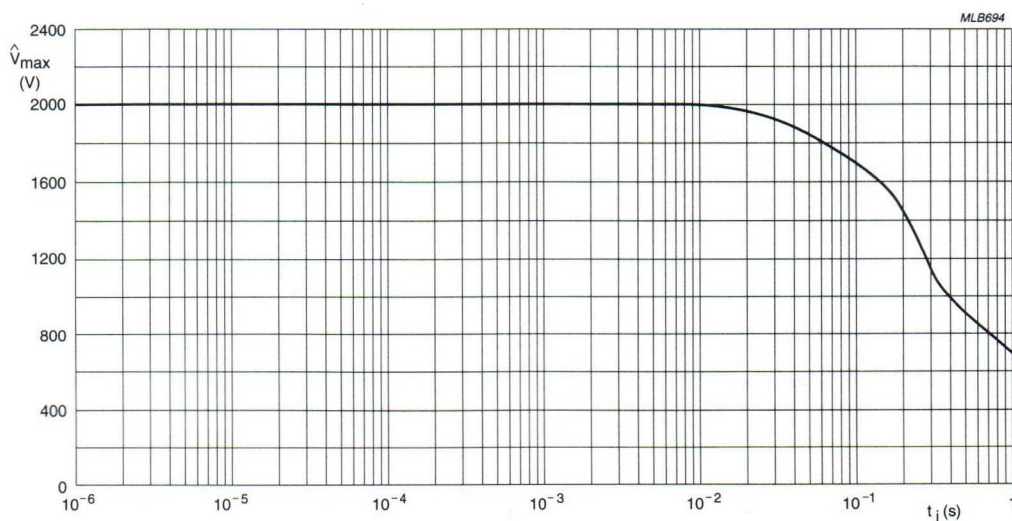
Power metal film resistors

PR01/02/03



PR03

Fig.9 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i).



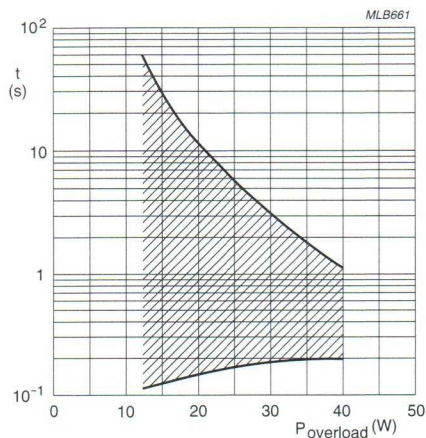
PR03

Fig.10 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_i).

Power metal film resistors

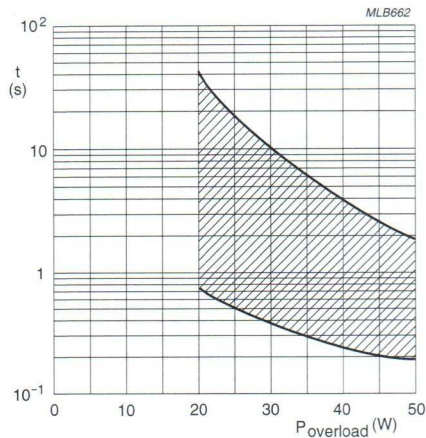
PR01/02/03

INTERRUPTION CHARACTERISTICS

**PR01**

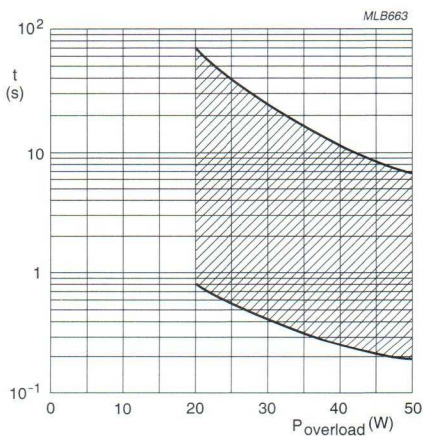
The graph is based on measured data under constant voltage conditions; these data may deviate according to the application.

Fig.11 Time to interruption as a function of overload power for range: $0R22 \leq R_n < 1R$.

**PR01**

The graph is based on measured data under constant voltage conditions; these data may deviate according to the application.

Fig.12 Time to interruption as a function of overload power for range: $1R \leq R_n \leq 15R$.

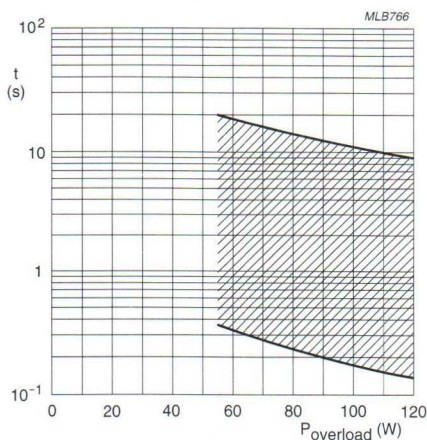
**PR01**

The graph is based on measured data under constant voltage conditions; these data may deviate according to the application.

Fig.13 Time to interruption as a function of overload power for range: $16R \leq R_n \leq 560R$.

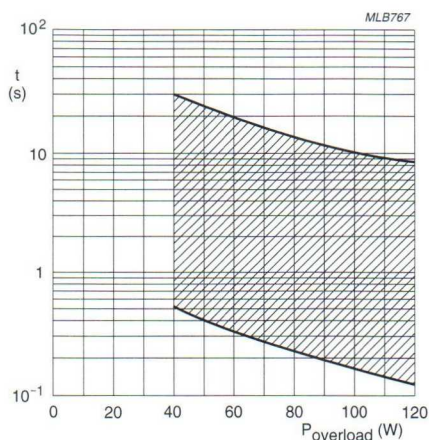
Power metal film resistors

PR01/02/03

**PR02**

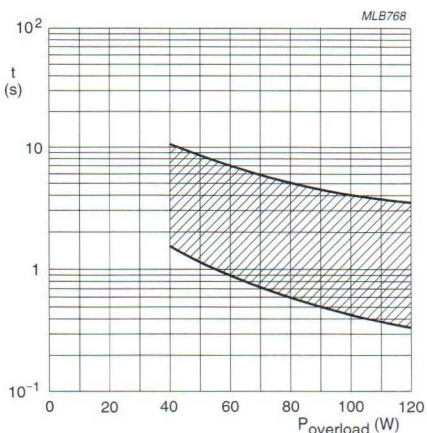
The graph is based on measured data under constant voltage conditions; these data may deviate according to the application.

Fig. 14 Time to interruption as a function of overload power for range: $0.33R \leq R_n < 5R$.

**PR02**

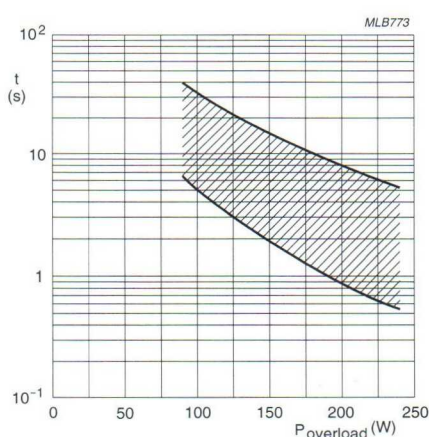
The graph is based on measured data under constant voltage conditions; these data may deviate according to the application.

Fig. 15 Time to interruption as a function of overload power for range: $5R \leq R_n < 68R$.

**PR02**

The graph is based on measured data under constant voltage conditions; these data may deviate according to the application.

Fig. 16 Time to interruption as a function of overload power for range: $68R \leq R_n \leq 560R$.

**PR03**

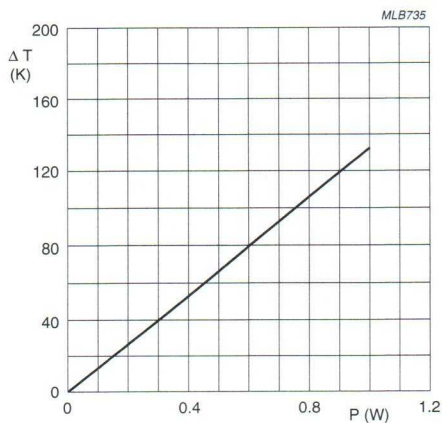
The graph is based on measured data under constant voltage conditions; these data may deviate according to the application.

Fig. 17 Time to interruption as a function of overload power for range: $0.68R \leq R_n \leq 560R$.

Power metal film resistors

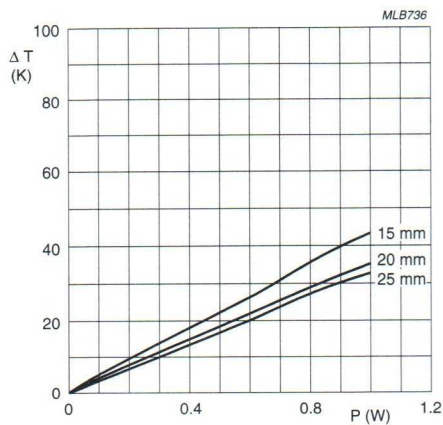
PR01/02/03

Application information



PR01

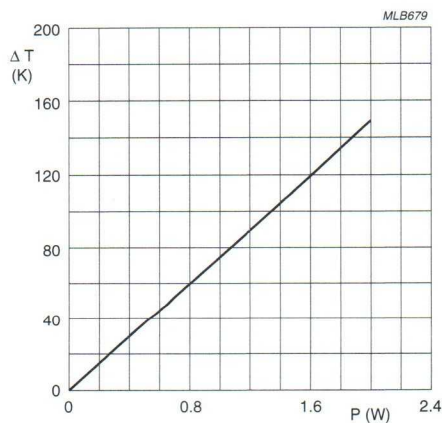
Fig. 18 Hot-spot temperature rise (ΔT) as a function of dissipated power.



PR01

Minimum distance from resistor body to PCB = 1 mm.

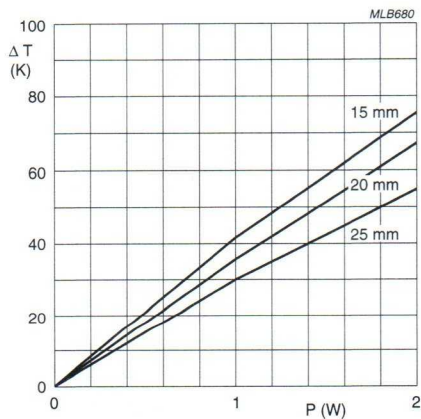
Fig. 19 Temperature rise (ΔT) at the lead end (soldering point) as a function of dissipated power at various lead lengths after mounting.



PR02

Ø0.8 mm Cu-leads.

Fig. 20 Hot-spot temperature rise (ΔT) as a function of dissipated power.



PR02

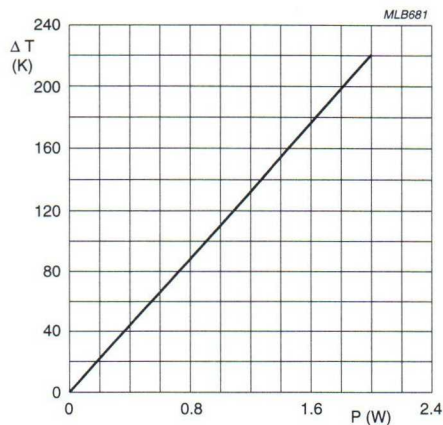
Ø0.8 mm Cu-leads.

Minimum distance from resistor body to PCB = 1 mm.

Fig. 21 Temperature rise (ΔT) at the lead end (soldering point) as a function of dissipated power at various lead lengths after mounting.

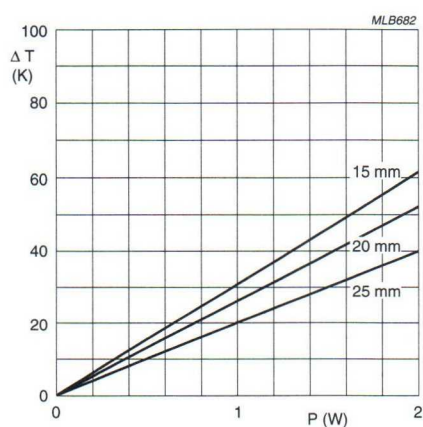
Power metal film resistors

PR01/02/03

**PR02**

Ø0.6 mm FeCu-leads.

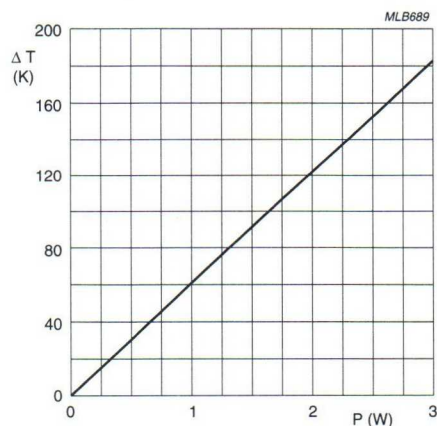
Fig.22 Hot-spot temperature rise (ΔT) as a function of dissipated power.

**PR02**

Ø0.6 mm FeCu-leads.

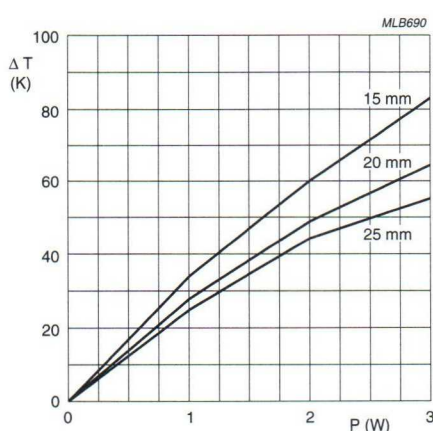
Minimum distance from resistor body to PCB = 1 mm.

Fig.23 Temperature rise (ΔT) at the lead end (soldering point) as a function of dissipated power at various lead lengths after mounting.

**PR03**

Ø0.8 mm Cu-leads.

Fig.24 Hot-spot temperature rise (ΔT) as a function of dissipated power.

**PR03**

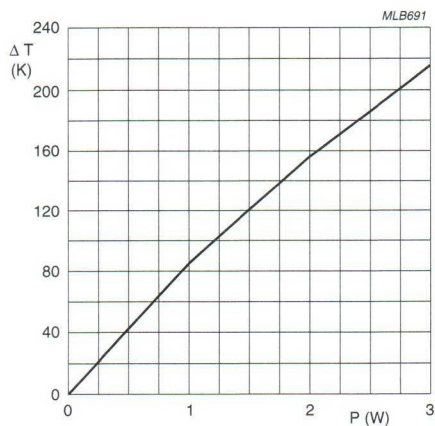
Ø0.8 mm Cu-leads.

Minimum distance from resistor body to PCB = 1 mm.

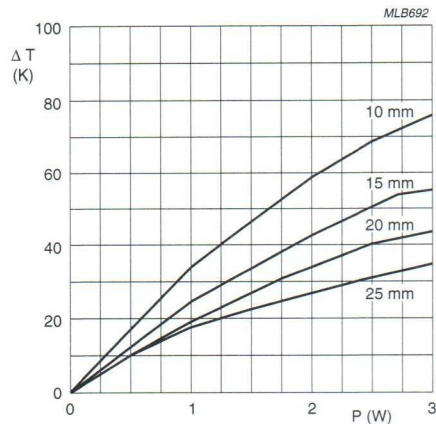
Fig.25 Temperature rise (ΔT) at the lead end (soldering point) as a function of dissipated power at various lead lengths after mounting.

Power metal film resistors

PR01/02/03

**PR03**

Ø0.6 mm FeCu-leads.

Fig.26 Hot-spot temperature rise (ΔT) as a function of dissipated power.**PR03**

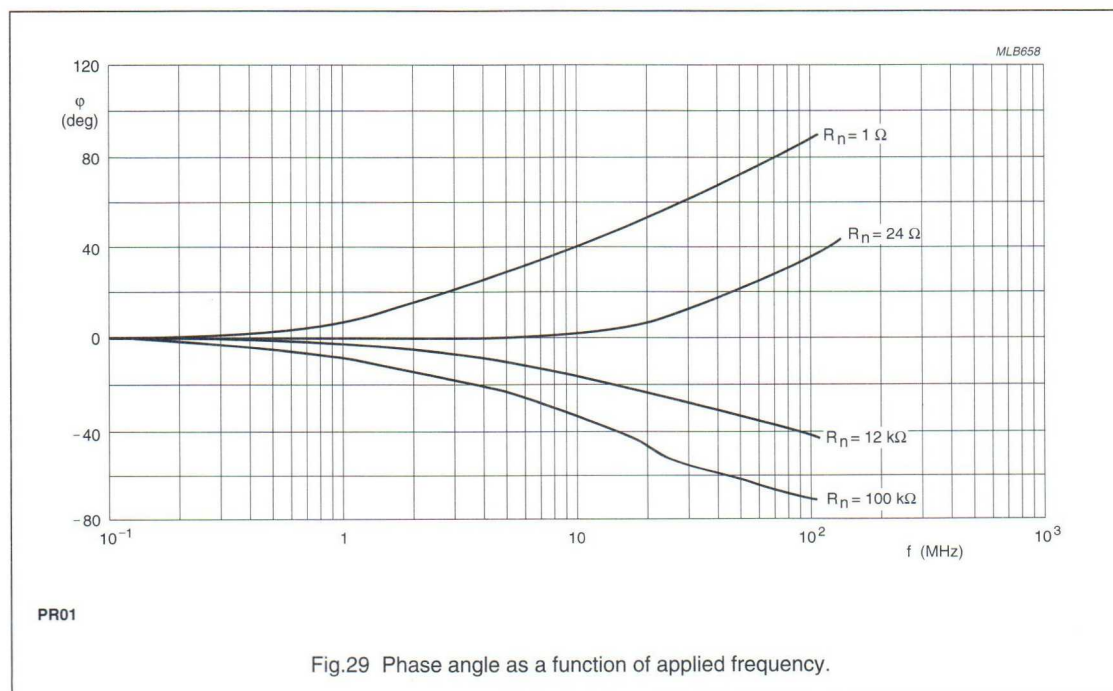
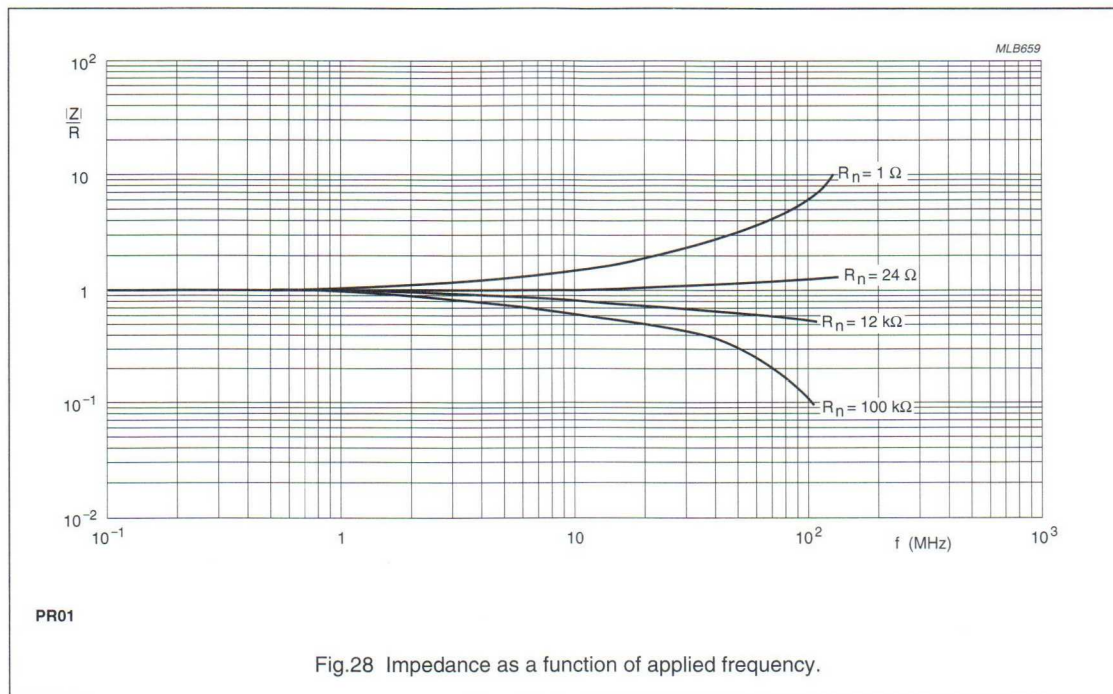
Ø0.6 mm FeCu-leads.

Minimum distance from resistor body to PCB = 1 mm.

Fig.27 Temperature rise (ΔT) at the lead end (soldering point) as a function of dissipated power at various lead lengths after mounting.

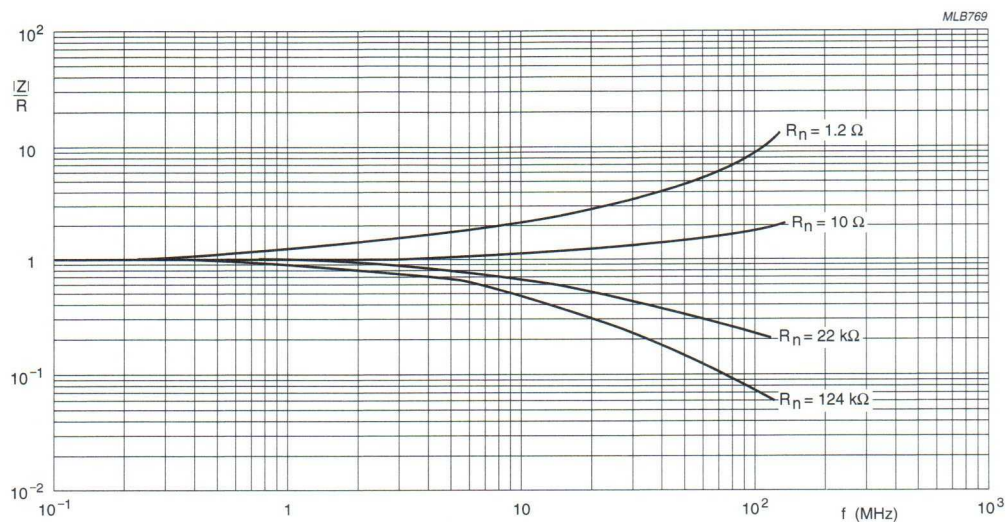
Power metal film resistors

PR01/02/03



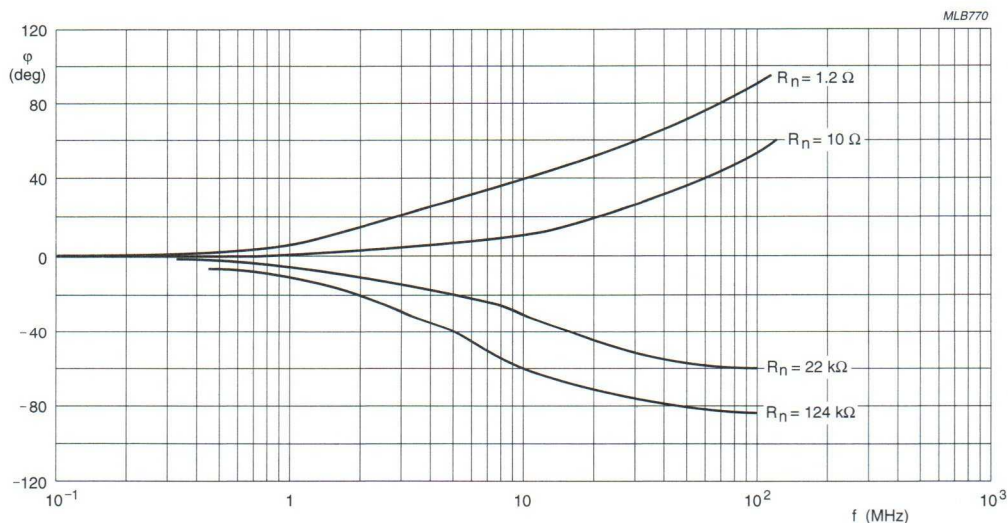
Power metal film resistors

PR01/02/03



PR02

Fig.30 Impedance as a function of applied frequency.

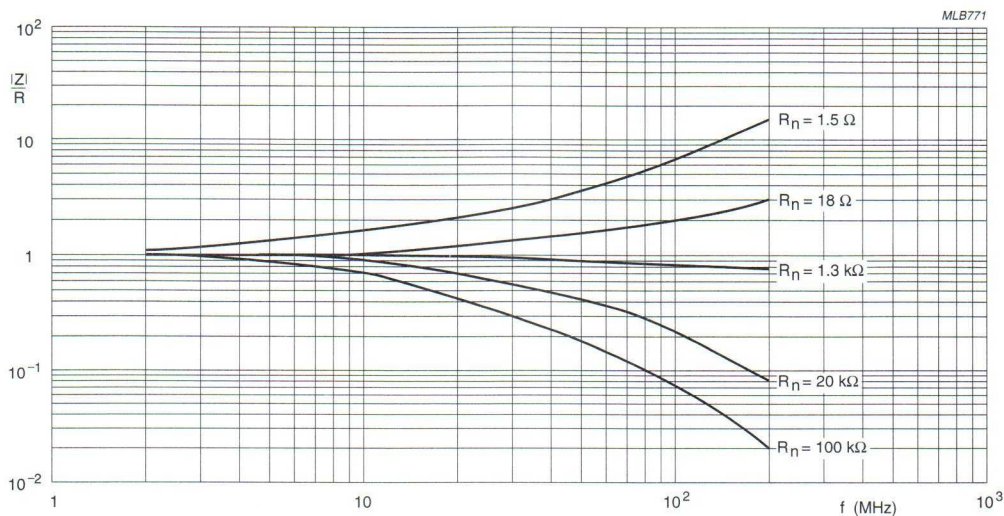


PR02

Fig.31 Phase angle as a function of applied frequency.

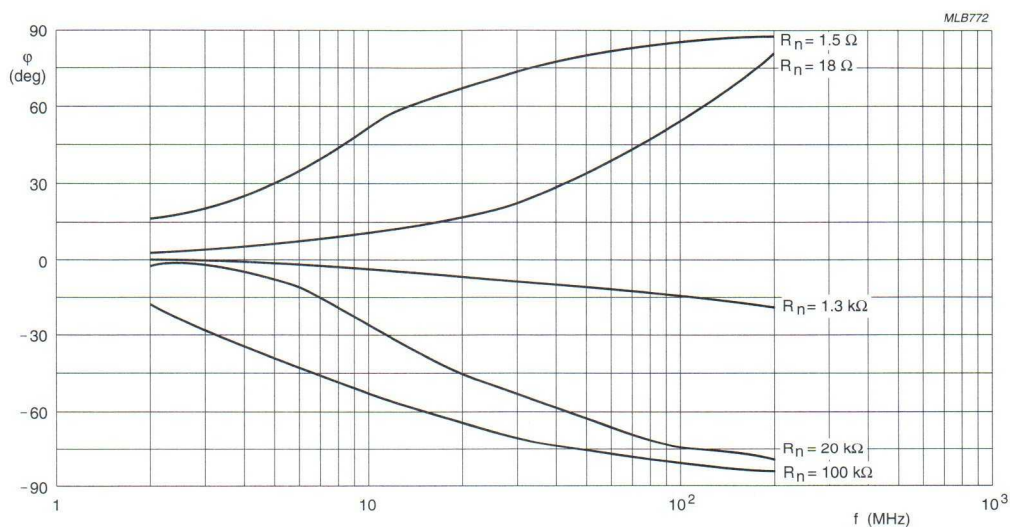
Power metal film resistors

PR01/02/03



PR03

Fig.32 Impedance as a function of applied frequency.



PR03

Fig.33 Phase angle as a function of applied frequency.

Power metal film resistors

PR01/02/03

MECHANICAL DATA

Mass per 100 units

TYPE	LEAD MATERIAL	MASS (g)
PR01	Cu	29
PR02	Cu	63
	FeCu	45
PR03	Cu	110
	FeCu	100

Marking

The nominal resistance and tolerance are marked on the resistor using four coloured bands in accordance with IEC publication 62, "Colour codes for fixed resistors".

Outlines

The length of the body (L_1) is measured by inserting the leads into holes of two identical gauge plates and moving these plates parallel to each other until the resistor body is clamped without deformation ("IEC publication 294"). Resistors with lead lengths of 73, 52 or 26 mm are available on request.

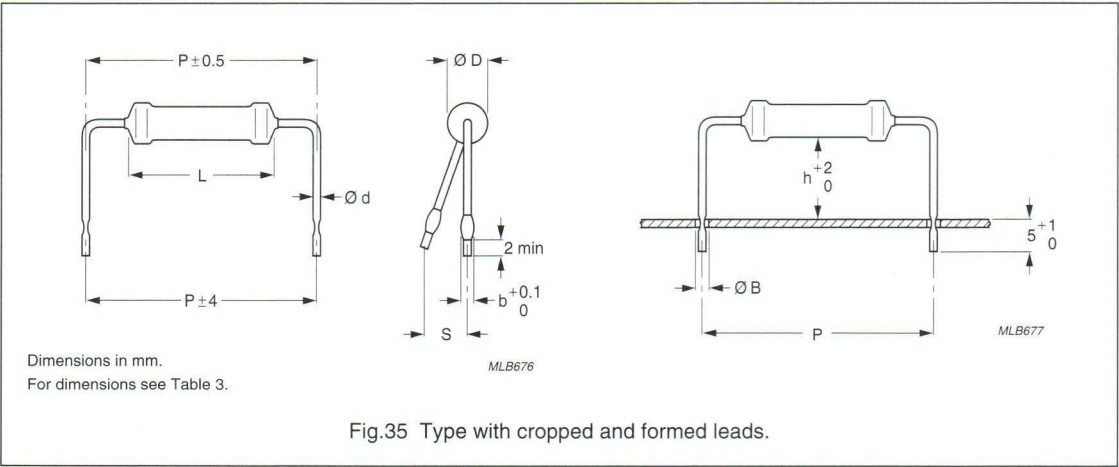
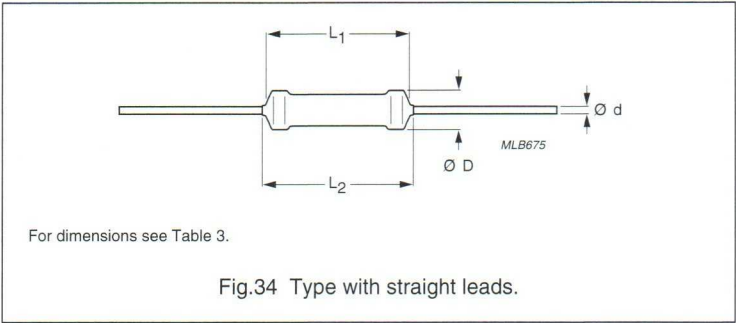


Table 3 Resistor type and relevant physical dimensions; see Figs 34 and 35

TYPE	ØD MAX. (mm)	L ₁ MAX. (mm)	L ₂ MAX. (mm)	Ød (mm)	b (mm)	h (mm)	P (mm)	S MAX. (mm)	ØB MAX. (mm)
PR01	2.5	6.5	8.5	0.6	1.1	8	17.8	2	1.0
PR02	3.9	10	12	0.8	1.3	8		2	1.2
				0.8	1.3	15		3	1.2
				0.6	1.1	8		2	1.0
PR03	5.2	16.7	19.5	0.8	1.3	8	25.4	2	1.2
				0.8	1.3	15		3	1.2
				0.6	1.1	8		2	1.0

Power metal film resistors

PR01/02/03

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of "IEC publication 115-1", category **LCT/UCT/56** (rated temperature range: **Lower Category Temperature**, **Upper Category Temperature**; damp heat, long term, **56** days). The testing also covers the requirements specified by EIA and EIAJ.

The tests are carried out in accordance with IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components" and under standard atmospheric conditions according to "IEC 68-1", subclause 5.3.

Unless otherwise specified the following values apply:

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

Air pressure: 86 kPa to 106 kPa.

In Table 4 the tests and requirements are listed with reference to the relevant clauses of "IEC publications 115-1 and 68"; a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

All soldering tests are performed with mildly activated flux.

Table 4 Test procedures and requirements

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
Tests in accordance with the schedule of IEC publication 115-8				
4.4.1		visual examination		no holes; clean surface; no damage
4.4.2		dimensions (outline)	gauge (mm)	see Table 3
4.5		resistance	applied voltage (+0/-10%): R < 10 Ω: 0.1 V 10 Ω ≤ R < 100 Ω: 0.3 V 100 Ω ≤ R < 1 kΩ: 1 V 1 kΩ ≤ R < 10 kΩ: 3 V 10 kΩ ≤ R < 100 kΩ: 10 V 100 kΩ ≤ R < 1 MΩ: 25 V R = 1 MΩ: 50 V	R – R _{nom} : max. ±5%
4.18	Tb	resistance to soldering heat	thermal shock: 3 s; 350 °C; 6 mm from body	ΔR/R max.: ±1% +0.05 Ω
4.29	45 (Xa)	component solvent resistance	isopropyl alcohol or H ₂ O followed by brushing in accordance with "MIL 202 F"	no visual damage
4.17	Ta	solderability	2 s; 235 °C	good tinning; no damage
4.7		voltage proof on insulation	maximum voltage 500 V (RMS) during 1 minute; metal block method	no breakdown or flashover

Power metal film resistors

PR01/02/03

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.16	U	robustness of terminations:		
4.16.2	Ua	tensile all samples	Ø0.8 mm; load 5 N; 10 s Ø0.6 mm; load 10 N; 10 s	number of failures $<1 \times 10^{-6}$
4.16.3	Ub	bending half number of samples	Ø0.8 mm; load 2.5 N; $4 \times 90^\circ$ Ø0.6 mm; load 5 N; $4 \times 90^\circ$	number of failures $<1 \times 10^{-6}$
4.16.4	Uc	torsion other half of samples	$3 \times 360^\circ$ in opposite directions	no damage $\Delta R/R$ max.: $\pm 0.5\% + 0.05 \Omega$
4.20	Eb	bump	3×1500 bumps in three directions; 40 g	no damage $\Delta R/R$ max.: $\pm 0.5\% + 0.05 \Omega$
4.22	Fc	vibration	frequency 10 to 500 Hz; displacement 1.5 mm or acceleration 10 g; three directions; total 6 hours (3×2 hours)	no damage $\Delta R/R$ max.: $\pm 0.5\% + 0.05 \Omega$
4.19	14 (Na)	rapid change of temperature	30 minutes at LCT and 30 minutes at UCT; 5 cycles	no visual damage PR01: $\Delta R/R$ max.: $\pm 1\% + 0.05 \Omega$ PR02: $\Delta R/R$ max.: $\pm 1\% + 0.05 \Omega$ PR03: $\Delta R/R$ max.: $\pm 2\% + 0.05 \Omega$
4.23		climatic sequence:		
4.23.3	30 (D)	damp heat (accelerated) 1st cycle		
4.23.6	30 (D)	damp heat (accelerated) remaining cycles	6 days; 55 °C; 95 to 98% RH	R_{ins} min.: $10^3 M\Omega$ $\Delta R/R$ max.: $\pm 3\% + 0.1 \Omega$
4.24.2	3 (Ca)	damp heat (steady state) (IEC)	56 days; 40 °C; 90 to 95% RH; loaded with 0.01 P_n (IEC steps: 4 to 100 V)	R_{ins} min.: 1000 $M\Omega$ $\Delta R/R$ max.: $\pm 3\% + 0.1 \Omega$
4.25.1		endurance (at 70 °C)	1000 hours; loaded with P_n or V_{max} ; 1.5 hours on and 0.5 hours off	$\Delta R/R$ max.: $\pm 5\% + 0.1 \Omega$
4.8.4.2		temperature coefficient	at 20/LCT/20 °C and 20/UCT/20 °C ($TC \times 10^{-6}/K$)	$\leq \pm 250$
Other tests in accordance with IEC 115 clauses and IEC 68 test method				
4.17	20 (Tb)	solderability (after ageing)	8 hours steam or 16 hours 155 °C; leads immersed 6 mm for 2 ± 0.5 s in a solder bath at 235 ± 5 °C	good tinning ($\geq 95\%$ covered); no damage
4.6.1.1		insulation resistance	maximum voltage (DC) after 1 minute; metal block method	R_{ins} min.: $10^4 M\Omega$
see 2 nd amendment to IEC115-1, Jan. '87		pulse load		see Figs 5, 6, 7, 8, 9 and 10

Cemented wirewound resistors

AC01/03/04/05/07/10/15/20

FEATURES

- High power dissipation in small volume
- High pulse load handling capabilities.

APPLICATIONS

- Ballast switching
- Shunt in small electric motors
- Power supplies.

DESCRIPTION

The resistor element is a resistive wire which is wound in a single layer on a ceramic rod. Metal caps are pressed over the ends of the rod. The ends of the resistance wire and the leads are connected to the caps by welding. Tinned copper-clad iron leads with poor heat conductivity are employed permitting the use of relatively short leads to obtain stable mounting without overheating the solder joint.

The resistor is coated with a green silicon cement which is not resistant to aggressive fluxes. The coating is non-flammable, will not drip even at high overloads and is resistant to most commonly used cleaning solvents, in accordance with "MIL-STD202E" method 215 and "IEC 68-2-45".

QUICK REFERENCE DATA

DESCRIPTION	VALUE							
	AC01	AC03	AC04	AC05	AC07	AC10	AC15	AC20
Resistance range	0.1 Ω to 1.5 k Ω	0.1 Ω to 3.0 k Ω	0.1 Ω to 6.8 k Ω	0.1 Ω to 8.2 k Ω	0.1 Ω to 15 k Ω	0.68 Ω to 15 k Ω	0.82 Ω to 22 k Ω	1.2 Ω to 33 k Ω
Resistance tolerance	$\pm 5\%$; E24 series							
Maximum permissible body temperature	350 $^{\circ}\text{C}$							
Rated dissipation at $T_{\text{amb}} = 40^{\circ}\text{C}$	1 W	3 W	4 W	5 W	7 W	10 W	15 W	20 W
Rated dissipation at $T_{\text{amb}} = 70^{\circ}\text{C}$	0.9 W	2.5 W	3.5 W	4.7 W	5.8 W	8.4 W	12.5 W	16 W
Climatic category (IEC 68)	40/200/56							
Basic specification	IEC 115-1							
Stability after:								
load, 1000 hours	$\Delta R/R$ max.: $\pm 5\% + 0.1 \Omega$							
climatic tests	$\Delta R/R$ max.: $\pm 1\% + 0.05 \Omega$							
short time overload	$\Delta R/R$ max.: $\pm 2\% + 0.1 \Omega$							

Cemented wirewound resistors

AC01/03/04/05/07/10/15/20

ORDERING INFORMATION

Table 1 Ordering code indicating resistor type and packaging

TYPE	ORDERING CODE			
	LOOSE IN BOX	BANDOLIER IN AMMOPACK		
	STRAIGHT LEADS	RADIAL	STRAIGHT LEADS	
	500 units	2500 units	500 units	1 000 units
AC01	—	2306 328 90...; note 2	—	2306 328 33...
AC03 ⁽¹⁾	—	—	2322 329 03...	—
AC04 ⁽¹⁾	—	—	2322 329 04...	—
AC05 ⁽¹⁾	—	—	2322 329 05...	—
AC07 ⁽¹⁾	—	—	2322 329 07...	—
AC10	—	—	2322 329 10...	—
AC15	2322 329 15...	—	—	—
AC20	2322 329 20...	—	—	—

Notes

1. Products with bent leads and loose in box, are available on request.
2. Last 3 digits available on request.

Ordering code (12NC)

- The resistors have a 12-digit ordering code.
- The first 9 digits indicate the resistor type and packaging; see Table 1.
- The remaining 3 digits indicate the resistance value:
 - The first 2 digits indicate the resistance value.
 - The last digit indicates the resistance decade in accordance with Table 2.

Table 2 Last digit of 12NC

RESISTANCE DECADE	LAST DIGIT
0.1 to 0.91 Ω	7
1 to 9.1 Ω	8
10 to 91 Ω	9
100 to 910 Ω	1
1 to 9.1 k Ω	2
10 to 33 k Ω	3

ORDERING EXAMPLE

The ordering code of an AC01 resistor, value 47 Ω , supplied in ammopack of 1 000 units is: 2306 328 33479.

Product specifications deviating from the standard values are available on request.

Cemented wirewound resistors

AC01/03/04/05/07/10/15/20

FUNCTIONAL DESCRIPTION

Product characterization

Standard values of nominal resistance are taken from the E24 series for resistors with a tolerance of ±5%. The values of the E24 series are in accordance with “IEC publication 63”.

Limiting values

TYPE	LIMITING VOLTAGE ⁽¹⁾ (V)	LIMITING POWER (W)	
		T _{amb} = 40 °C	T _{amb} = 70 °C
AC01	$V = \sqrt{P_n \times R}$	1	0.9
AC03		3	2.5
AC04		4	3.5
AC05		5	4.7
AC07		7	5.8
AC10		10	8.4
AC15		15	12.5
AC20		20	16.0

Note

1. The maximum voltage that may be continuously applied to the resistor element, see “IEC publication 266”.

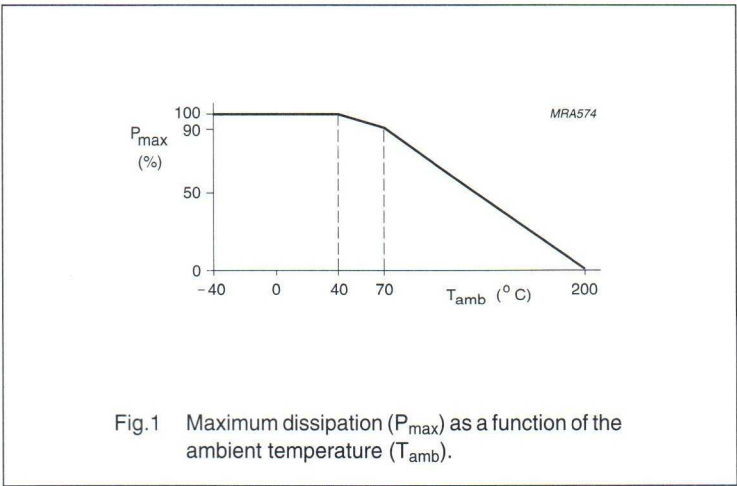
The maximum permissible hot-spot temperature is 350 °C.

DERATING

The power that the resistor can dissipate depends on the operating temperature; see Fig.1.

PULSE LOADING CAPABILITY

Detailed pulse loading information is available on request.



Cemented wirewound resistors

AC01/03/04/05/07/10/15/20

Application information

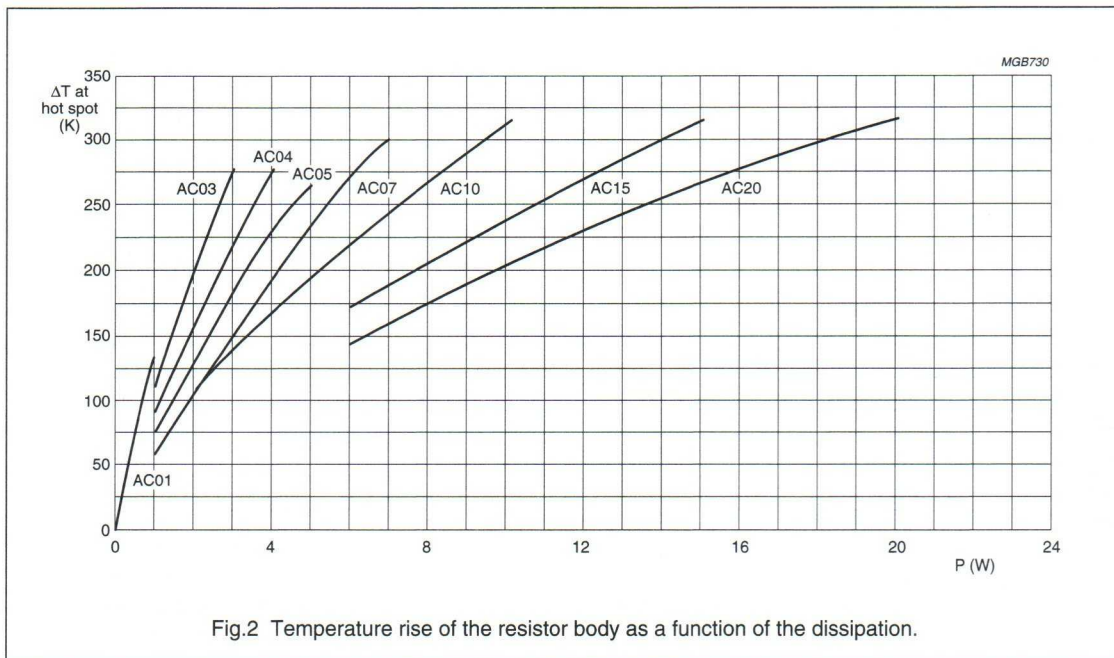
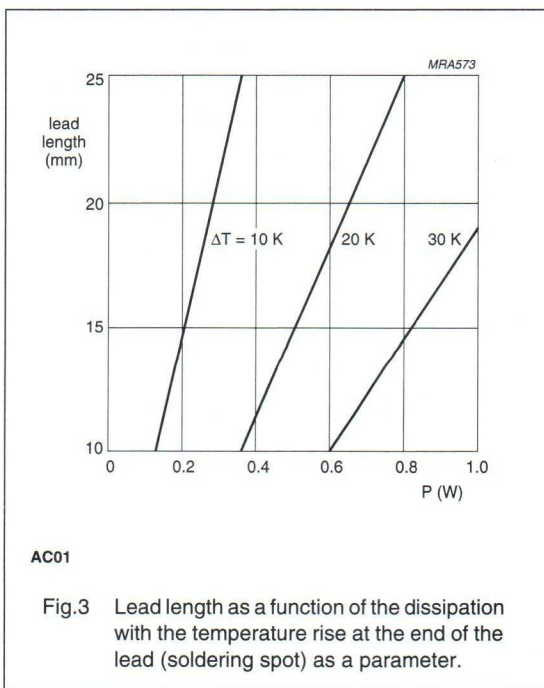
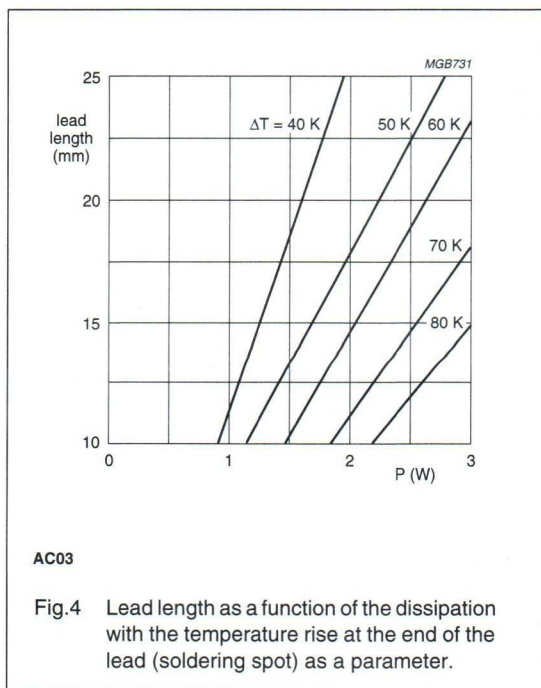


Fig.2 Temperature rise of the resistor body as a function of the dissipation.



AC01

Fig.3 Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as a parameter.

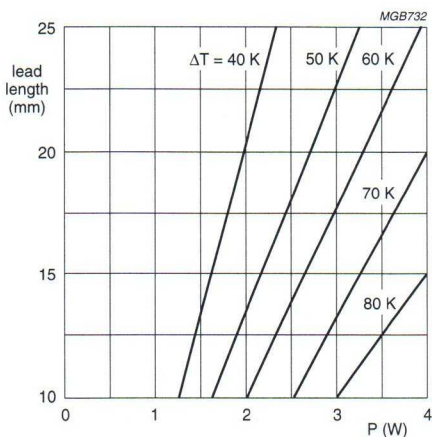


AC03

Fig.4 Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as a parameter.

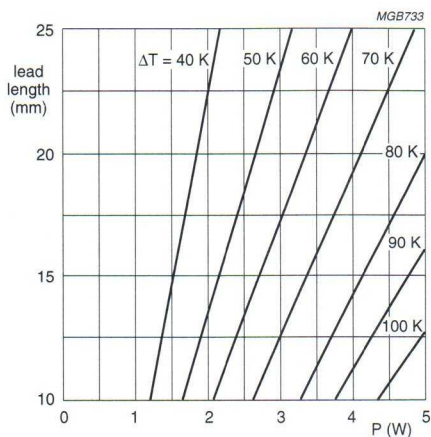
Cemented wirewound resistors

AC01/03/04/05/07/10/15/20



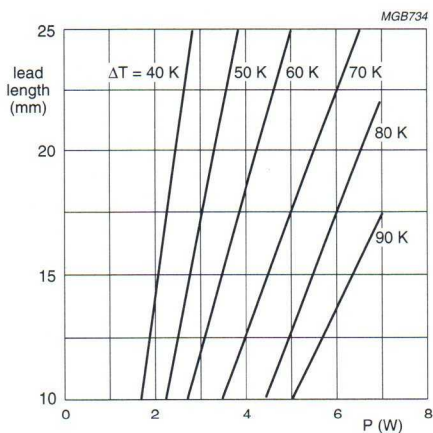
AC04

Fig.5 Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as a parameter.



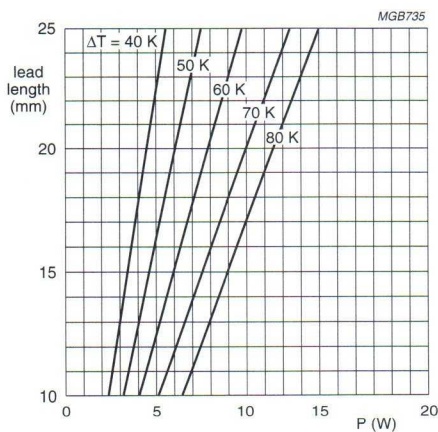
AC05

Fig.6 Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as a parameter.



AC07

Fig.7 Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as a parameter.

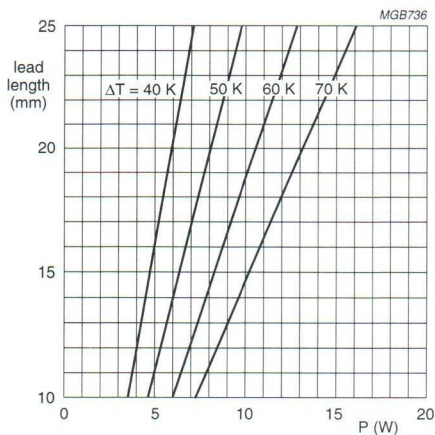


AC10

Fig.8 Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as a parameter.

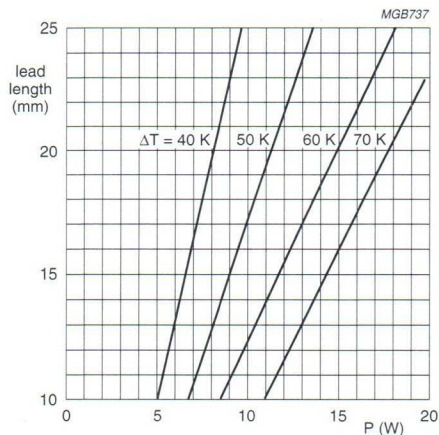
Cemented wirewound resistors

AC01/03/04/05/07/10/15/20



AC15

Fig.9 Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as a parameter.



AC20

Fig.10 Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as a parameter.

MOUNTING

The resistor is suitable for processing on cutting and bending machines. **Ensure that the temperature rise of the resistor body does not affect nearby components or materials by conducted or convected heat.** Figure 2 shows the hot spot temperature rise of the resistor body as a function of dissipated power. Figures 3 to 10 show the lead length as a function of dissipated power and temperature rise.

Cemented wirewound resistors

AC01/03/04/05/07/10/15/20

MECHANICAL DATA

Mass per 100 units

TYPE	MASS (g)
AC01	55
AC03	110
AC04	140
AC05	220
AC07	300
AC10	530
AC15	840
AC20	1090

Marking

The resistor is marked with the nominal resistance value, the tolerance on the resistance and the rated dissipation at $T_{amb} = 40\text{ }^{\circ}\text{C}$.

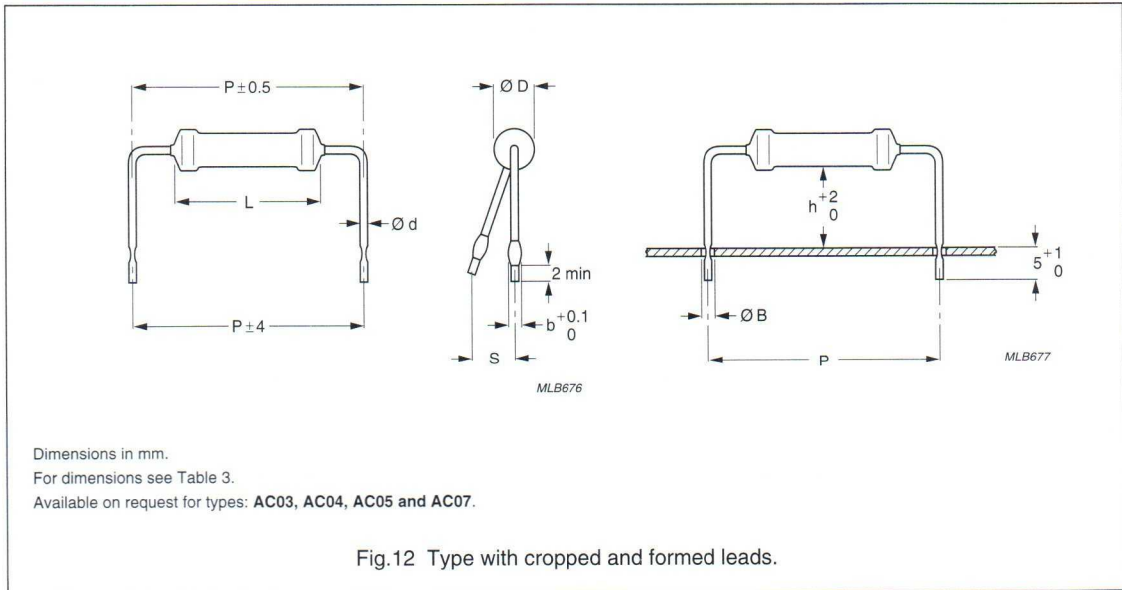
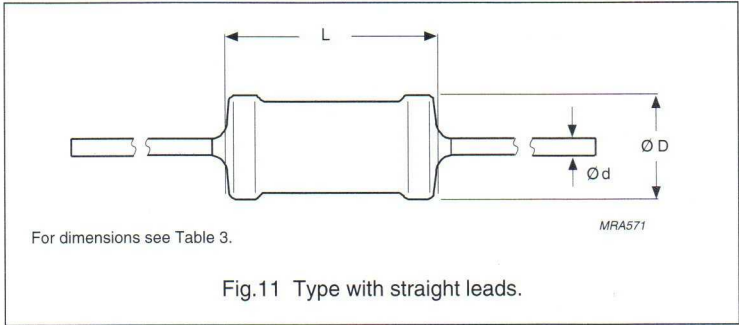
For values up to $910\text{ }\Omega$, the R is used as the decimal point.

For values of $1\text{ k}\Omega$ and upwards, the letter K is used as the decimal point for the $\text{k}\Omega$ indication.

Outlines

Table 3 Resistor type and relevant physical dimensions; see Figs 11 and 12

TYPE	$\varnothing D$ MAX. (mm)	L MAX. (mm)	$\varnothing d$ (mm)	b (mm)	h (mm)	P (mm)	S MAX. (mm)	$\varnothing B$ MAX. (mm)
AC01	4.3	10	0.8	—	—	—	—	—
AC03	5.5	13		1.3	8	10e	2	1.2
AC04	5.7	17						
AC05	7.5	17				13e		
AC07	7.7	25		—	—	—	—	—
AC10	8	44		—	—	—	—	—
AC15	10	51		—	—	—	—	—
AC20	10	67		—	—	—	—	—



Cemented wirewound resistors

AC01/03/04/05/07/10/15/20

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of "IEC publications 115-1 and 115-4", category 40/200/56 (rated temperature range $-40\text{ }^{\circ}\text{C}$ to $+200\text{ }^{\circ}\text{C}$; damp heat, long term, 56 days). The testing also covers the requirements specified by EIA and EIAJ.

The tests are carried out in accordance with IEC publication 68,

"Recommended basic climatic and mechanical robustness testing procedure for electronic components" and under standard atmospheric conditions according to "IEC 68-1", subclause 5.3.

Unless otherwise specified the following values apply:

Temperature: $15\text{ }^{\circ}\text{C}$ to $35\text{ }^{\circ}\text{C}$

Relative humidity: 45% to 75%

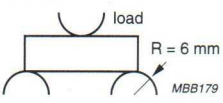
Air pressure: 86 kPa to 106 kPa
(860 mbar to 1060 mbar).

In Table 4 the tests and requirements are listed with reference to the relevant clauses of

"IEC publications 115-1, 115-4 and 68"; a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

All soldering tests are performed with mildly activated flux.

Table 4 Test procedures and requirements

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
Tests in accordance with the schedule of IEC publication 115-1				
4.15		robustness of resistor body	load $200 \pm 10\text{ N}$ 	no visible damage $\Delta R/R$ max.: $\pm 0.5\% + 0.05\text{ }\Omega$
4.16	U Ua Ub Uc	robustness of terminations: tensile all samples bending half number of samples torsion other half of samples	load 10 N ; 10 s load 5 N 90° , 180° , 90° $2 \times 180^{\circ}$ in opposite directions	no visible damage $\Delta R/R$ max.: $\pm 0.5\% + 0.05\text{ }\Omega$
4.17	Ta	solderability	2 s ; $235\text{ }^{\circ}\text{C}$; flux 600	good tinning; no damage
4.18	Tb	resistance to soldering heat	thermal shock: 3 s ; $350\text{ }^{\circ}\text{C}$; 2.5 mm from body	$\Delta R/R$ max.: $\pm 0.5\% + 0.05\text{ }\Omega$
4.19	14 (Na)	rapid change of temperature	30 minutes at $-40\text{ }^{\circ}\text{C}$ and 30 minutes at $+200\text{ }^{\circ}\text{C}$; 5 cycles	no visible damage $\Delta R/R$ max.: $\pm 1\% + 0.05\text{ }\Omega$
4.22	Fc	vibration	frequency 10 to 500 Hz ; displacement 0.75 mm or acceleration 10 g ; 3 directions ; total 6 hours ($3 \times 2\text{ hours}$)	no damage $\Delta R/R$ max.: $\pm 0.5\% + 0.05\text{ }\Omega$
4.20	Eb	bump	4000 ± 10 bumps; 390 m/s^2	no damage $\Delta R/R$ max.: $\pm 0.5\% + 0.05\text{ }\Omega$

Cemented wirewound resistors

AC01/03/04/05/07/10/15/20

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.23 4.23.2 4.23.3 4.23.4 4.23.5 4.23.6	Ba Db Aa M Db	climatic sequence: dry heat damp heat (accelerated) 1st cycle cold low air pressure damp heat (accelerated) remaining cycles	16 hours; 200 °C 24 hours; 55 °C; 95 to 100% RH 2 hours; -40 °C 1 hour; 8.5 kPa; 15 to 35 °C 5 days; 55 °C; 95 to 100% RH	$\Delta R/R$ max.: $\pm 1\% + 0.05 \Omega$
4.24.2	3 (Ca)	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; dissipation $\leq 0.01 P_n$	no visible damage $\Delta R/R$ max.: $\pm 1\% + 0.05 \Omega$
4.8.4.2		temperature coefficient	at 20/-40/20 °C, 20/200/20 °C: $R < 10 \Omega$ $R \geq 10 \Omega$	$TC \leq \pm 600 \times 10^{-6}/K$ $-80 \times 10^{-6} \leq TC$ $TC \leq +140 \times 10^{-6}/K$
		temperature rise	horizontally mounted, loaded with P_n	hot spot temperature less than maximum body temperature
4.13		short time overload	room temperature; dissipation $10 \times P_n$; 5 s (voltage not more than 1000 V/25 mm)	$\Delta R/R$ max.: $\pm 2\% + 0.1 \Omega$
4.25.1		endurance (at 40 °C)	1000 hours loaded with P_n ; 1.5 hours on and 0.5 hours off	no visible damage $\Delta R/R$ max.: $\pm 5\% + 0.1 \Omega$
4.25.1		endurance (at 70 °C)	1000 hours loaded with $0.9 P_n$; 1.5 hours on and 0.5 hours off	no visible damage $\Delta R/R$ max.: $\pm 5\% + 0.1 \Omega$
4.23.2	27 (Ba)	endurance at upper category temperature	1000 hours; 200 °C; no load	no visible damage $\Delta R/R$ max.: $\pm 5\% + 0.1 \Omega$

Cemented wirewound resistors

AC01/03/04/05/07/10/15/20

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
Other tests in accordance with IEC 115 clauses and IEC 68 test method				
4.29	45 (Xa)	component solvent resistance	70% 1.1.2 trichlorotrifluoroethane and 30% isopropyl alcohol; H ₂ O	no visible damage
4.18	20 (Tb)	resistance to soldering heat	10 s; 260 ±5 °C; flux 600	ΔR/R max.: ±0.5% +0.05 Ω
4.17	20 (Tb)	solderability (after ageing)	16 hours steam or 16 hours at 155 °C; 2 ±0.5 s in solder at 235 ±5 °C; flux 600	good tinning (≥95% covered); no damage
4.5		tolerance on resistance	applied voltage (±10%): R < 10 Ω: 0.1 V 10 Ω ≤ R < 100 Ω: 0.3 V 100 Ω ≤ R < 1 kΩ: 1 V 1 kΩ ≤ R < 10 kΩ: 3 V 10 kΩ ≤ R ≤ 33 kΩ: 10 V	R – R _{nom} : ±5% max.
Other applicable tests				
		solvent resistance in accordance with "MIL-STD-202"	method 215: freon TMC trichloroethane	no visual damage

Cemented wirewound precision resistors

PAC01/02/03/04/05/06

FEATURES

- High power dissipation in small volume
- High pulse load handling capabilities.
- TC100.

APPLICATIONS

- Where power, pulse loading capability and precision needs to be combined.

DESCRIPTION

The resistor element is a resistive wire which is wound in a single layer on a ceramic rod. Metal caps are pressed over the ends of the rod. The ends of the resistance wire and the leads are connected to the caps by welding. Tinned copper-clad iron leads with poor heat conductivity are employed permitting the use of relatively short leads to obtain stable mounting without overheating the solder joint.

The resistor is coated with a green silicon cement which is not resistant to aggressive fluxes. The coating is non-inflammable, will not drip even at high overloads and is resistant to most commonly used cleaning solvents, in accordance with "MIL-STD-202E" method 215 and "IEC 68-2-45".

QUICK REFERENCE DATA

DESCRIPTION	VALUE					
	PAC01	PAC02	PAC03	PAC04	PAC05	PAC06
Resistance range	0.22 Ω to 2.2 k Ω	0.10 Ω to 3.6 k Ω	0.10 Ω to 4.7 k Ω	0.10 Ω to 8.2 k Ω	0.68 Ω to 10 k Ω	0.68 Ω to 12 k Ω
Resistance tolerance	$\pm 1\%$; E24/E96 series					
Maximum permissible body temperature	275 $^{\circ}\text{C}$					
Rated dissipation at $T_{\text{amb}} = 25^{\circ}\text{C}$	1 W	2 W	3 W	4 W	5 W	6 W
Temperature coefficient; note 1	$\leq \pm 100 \times 10^{-6}/\text{K}$					
Climatic category	55/200/56					
Specification based on	IEC 115-1; MIL-R-26					
Stability after:						
load, 1000 hours	$\Delta R/R \text{ max.: } \pm 0.5\% + 0.05 \Omega$					
climatic tests	$\Delta R/R \text{ max.: } \pm 0.5\% + 0.05 \Omega$					
short time overload	$\Delta R/R \text{ max.: } \pm 0.2\% + 0.05 \Omega$					

Note

1. TC30, 50 or 90 is available on request for specific ranges.

Cemented wirewound precision resistors

PAC01/02/03/04/05/06

ORDERING INFORMATION

Table 1 Ordering code indicating type and packaging

TYPE	ORDERING CODE 2306 327
	BANDOLIER IN AMMOPACK
	500 units
PAC01	5....
PAC02	0....
PAC03	1....
PAC04	2....
PAC05	3....
PAC06	4....

Ordering code (12NC)

- The resistors have a 12-digit ordering code starting with 2306 327
- The subsequent first digit indicates the resistor type and packaging; see Table 1.
- The remaining 4 digits indicate the resistance value:
 - The first 3 digits indicate the resistance value.
 - The last digit indicates the resistance decade in accordance with Table 2.

Table 2 Last digit of 12NC

RESISTANCE DECADE	LAST DIGIT
0.10 to 0.976 Ω	7
1 to 9.76 Ω	8
10 to 97.6 Ω	9
100 to 976 Ω	1
1 to 9.76 k Ω	2
10 to 12 k Ω	3

ORDERING EXAMPLE

The ordering code of an PAC02 resistor, value 47 Ω , supplied in ammopack of 500 units is: 2306 327 04709.

Product specifications deviating from the standard values are available on request.

Cemented wirewound precision resistors

PAC01/02/03/04/05/06

FUNCTIONAL DESCRIPTION

Product characterization

Standard values of nominal resistance are taken from the E24/E96 series for resistors with a tolerance of $\pm 1\%$. The values of the E24/E96 series are in accordance with "IEC publication 63".

Limiting values

TYPE	LIMITING VOLTAGE ⁽¹⁾ (V)	LIMITING POWER (W)
PAC01	$V = \sqrt{P_n \times R}$	1
PAC02		2
PAC03		3
PAC04		4
PAC05		5
PAC06		6

Note

1. The maximum voltage that may be continuously applied to the resistor element, see "IEC publication 115-1".

The maximum permissible hot spot temperature is 275 °C.

DERATING

The power that the resistor can dissipate depends on the operating temperature; see Fig.1.

PULSE LOADING CAPABILITY

Detailed pulse loading information is available on request.

Application information

MOUNTING

The resistor is suitable for processing on cutting and bending machines.

Ensure that the temperature rise of the resistor body by conducted or convected heat, does not affect nearby components or materials.

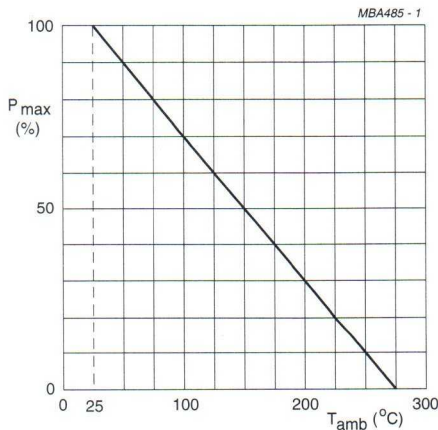


Fig.1 Maximum dissipation ($P_{\max}$) as a function of the ambient temperature (T_{amb}).

Cemented wirewound precision resistors

PAC01/02/03/04/05/06

MECHANICAL DATA

Mass per 100 units

TYPE	MASS (g)
PAC01	55
PAC02	80
PAC03	100
PAC04	175
PAC05	215
PAC06	225

Marking

The resistor is marked with the nominal resistance value, the tolerance on the resistance and the rated dissipation at $T_{amb} = 25\text{ }^{\circ}\text{C}$.

For values up to $910\text{ }\Omega$, the R is used as the decimal point.

For values of $1\text{ k}\Omega$ and upwards, the letter K is used as the decimal point for the $\text{k}\Omega$ indication.

Outline

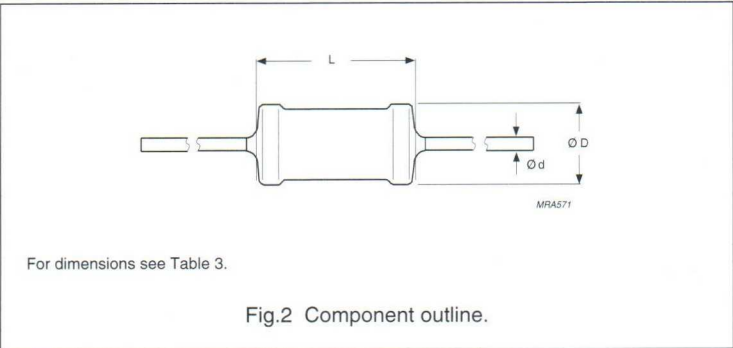


Table 3 Resistor type and relevant physical dimensions; see Fig.2

TYPE	ØD MAX. (mm)	L MAX. (mm)	Ød (mm)
PAC01	4.3	10	0.8
PAC02	5.5	13	
PAC03	5.5	17	
PAC04	7.5	17	
PAC05	7.5	23	
PAC06	7.5	25	

Cemented wirewound precision resistors

PAC01/02/03/04/05/06

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of "IEC publications 115-1 and 115-4", category 55/200/56 (rated temperature range $-55\text{ }^{\circ}\text{C}$ to $+200\text{ }^{\circ}\text{C}$; damp heat, long term, 56 days). The testing also covers the requirements specified by EIA and EIAJ.

The tests are carried out in accordance with IEC publication 68,

"Recommended basic climatic and mechanical robustness testing procedure for electronic components" and under standard atmospheric conditions according to "IEC 68-1", subclause 5.3.

Unless otherwise specified the following values apply:

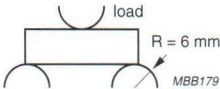
Temperature: $15\text{ }^{\circ}\text{C}$ to $35\text{ }^{\circ}\text{C}$

Relative humidity: 45% to 75%

Air pressure: 86 kPa to 106 kPa (860 mbar to 1060 mbar).

In Table 4 the tests and requirements are listed with reference to the relevant clauses of "IEC publications 115-1, 115-4 and 68"; a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

Table 4 Test procedures and requirements

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
Tests in accordance with the schedule of IEC publication 115-1				
4.15		robustness of resistor body	load $200 \pm 10\text{ N}$ 	no visible damage $\Delta R/R \text{ max.: } \pm 0.1\% + 0.05\text{ }\Omega$
4.16	U Ua Ub Uc	robustness of terminations: tensile all samples bending half number of samples torsion other half of samples	load 10 N ; 10 s load 5 N 90° , 180° , 90° $2 \times 180^{\circ}$ in opposite directions	no visible damage $\Delta R/R \text{ max.: } \pm 0.1\% + 0.05\text{ }\Omega$
4.17	Ta	solderability	2 s ; $235\text{ }^{\circ}\text{C}$; flux 600	good tinning; no damage
4.18	Tb	resistance to soldering heat	thermal shock: 3 s ; $350\text{ }^{\circ}\text{C}$; 2.5 mm from body	$\Delta R/R \text{ max.: } \pm 0.2\% + 0.05\text{ }\Omega$
4.19	14 (Na)	rapid change of temperature	30 minutes at $-55\text{ }^{\circ}\text{C}$ and 30 minutes at $+200\text{ }^{\circ}\text{C}$; 5 cycles	no visible damage $\Delta R/R \text{ max.: } \pm 0.5\% + 0.05\text{ }\Omega$
4.22	Fc	vibration	frequency $10\text{ to }500\text{ Hz}$; displacement 0.75 mm or acceleration 10 g ; 3 directions; total 6 hours ($3 \times 2\text{ hours}$)	no damage $\Delta R/R \text{ max.: } \pm 0.1\% + 0.05\text{ }\Omega$
4.20	Eb	bump	$4000 \pm 10\text{ bumps}$; 390 m/s^2	no damage $\Delta R/R \text{ max.: } \pm 0.1\% + 0.05\text{ }\Omega$

Cemented wirewound precision resistors

PAC01/02/03/04/05/06

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.23 4.23.2 4.23.3 4.23.4 4.23.5 4.23.6	Ba Db Aa M Db	climatic sequence: dry heat damp heat (accelerated) 1st cycle cold low air pressure damp heat (accelerated) remaining cycles	16 hours; 200 °C 24 hours; 55 °C; 95 to 100% RH 2 hours; -55 °C 1 hour; 8.5 kPa; 15 to 35 °C 5 days; 55 °C; 95 to 100% RH	 $\Delta R/R \text{ max.: } \pm 0.5\% + 0.05 \Omega$
4.24.2	3 (Ca)	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; dissipation $\leq 0.01 P_n$	no visible damage $\Delta R/R \text{ max.: } \pm 1\% + 0.05 \Omega$
4.8.4.2		temperature coefficient	at 20/-55/20 °C, 20/200/20 °C ($TC \times 10^{-6}/K$)	$TC \leq \pm 100 \times 10^{-6}/K$
4.13		short time overload	room temperature; dissipation $10 \times P_n$; 5 s	$\Delta R/R \text{ max.: } \pm 0.2\% + 0.05 \Omega$
4.25.1		endurance (at 25 °C)	1000 hours loaded with P_n ; 1.5 hours on and 0.5 hours off	no visible damage $\Delta R/R \text{ max.: } \pm 0.5\% + 0.05 \Omega$
4.23.2	27 (Ba)	endurance at upper category temperature	1000 hours; 200 °C; no load	no visible damage $\Delta R/R \text{ max.: } \pm 1\% + 0.05 \Omega$

Stand-up miniature power resistors

SMW02/03/05
SMF02/03/05

FEATURES

- High power dissipation in small volume
- High pulse load handling capabilities
- 2e pitch mounting
- Designed in stand-up configuration for stand-up mounting.

APPLICATIONS

- Ballast switching
- Power supplies
- Shunts.

DESCRIPTION

SMW: The resistor element is a resistive wire which is wound in a single layer on a ceramic rod. Metal caps are pressed over the ends of the rod. The ends of the resistance wire and the leads are connected to the caps by welding.

SMF: The resistor element is a metal film resistor consisting of a metal layer deposited over a high grade ceramic rod. The resistive film is adjusted to final value by means of a helical groove. The leads are connected to the caps by welding.

SMW/SMF: Tinned copper-clad iron leads with poor heat conductivity are employed permitting the use of relatively short leads to obtain stable mounting without overheating the solder joint.

The resistor body and lead ends are housed within a rectangular ceramic case which is non-flammable, will not melt even at high overloads and is resistant to most commonly used cleaning solvents, in accordance with "MIL-STD-202E" method 215 and "IEC 68-2-45".

QUICK REFERENCE DATA

DESCRIPTION	VALUE					
	SMW02	SMF02	SMW03	SMF03	SMW05	SMF05
Resistance range	0.1 to 200 Ω	220 Ω to 47 kΩ	0.1 to 560 Ω	560 Ω to 47 kΩ	0.1 to 560 Ω	560 Ω to 47 kΩ
Resistance tolerance	±5%; E24 series					
Maximum permissible body temperature	300 °C					
Rated dissipation at T _{amb} = 70 °C	2 W		3 W		5 W	
Climatic category (IEC 68)	40/200/56					
Basic specification	IEC 115-1					
Stability after:						
load, 1 000 hours	ΔR/R max.: ±5% +0.1 Ω					
climatic tests	ΔR/R max.: ±3% +0.1 Ω					
short time overload	ΔR/R max.: ±2% +0.1 Ω					
Insulation voltage	>2000 V					

Stand-up miniature power resistors

SMW02/03/05
SMF02/03/05

ORDERING INFORMATION

Table 1 Ordering code indicating resistor type and packaging

TYPE	ORDERING CODE 2306
	LOOSE IN BOX
	500 units
SMW02	340 03...
SMF02	340 90...
SMW03	341 03...
SMF03	341 90...
SMW05	342 03...
SMF05	342 90...

Ordering code (12NC)

- The resistors have a 12-digit ordering code starting with 2306
- The subsequent 5 digits indicate the resistor type; see Table 1.
- **SMW**: The remaining 3 digits indicate the resistance value:
 - The first 2 digits indicate the resistance value.
 - The last digit indicates the resistance decade in accordance with Table 2.
- **SMF**: The remaining 3 digits indicate the resistance value. The number is available upon request and is fixed by the supplier.

Table 2 Last digit of 12NC

RESISTANCE DECADE	LAST DIGIT
0.1 to 0.91 Ω	7
1 to 9.1 Ω	8
10 to 91 Ω	9
100 to 910 Ω	1
1 to 9.1 kΩ	2
10 to 47 kΩ	3

ORDERING EXAMPLE

The ordering code of an SMW02 resistor, value 47 Ω, supplied loose in box of 500 units is: 2306 340 03479.

Stand-up miniature power resistors

SMW02/03/05
SMF02/03/05

FUNCTIONAL DESCRIPTION

Product characterization

Standard values of nominal resistance are taken from the E24 series for resistors with a tolerance of $\pm 5\%$. The values of the E24 series are in accordance with "IEC publication 63".

Limiting values

TYPE	LIMITING VOLTAGE ⁽¹⁾ (V)	LIMITING POWER (W)
SMW02	$V = \sqrt{P_n \times R}$	2
SMF02	350	
SMW03	$V = \sqrt{P_n \times R}$	3
SMF03	350	
SMW05	$V = \sqrt{P_n \times R}$	5
SMF05	600	

Note

1. The maximum voltage that may be continuously applied to the resistor element, see "IEC publication 266".

The maximum permissible hot-spot temperature is 300 °C, and the minimum breakdown voltage of the encapsulation is 2000 V.

DERATING

The power that the resistor can dissipate depends on the operating temperature; see Fig.1.

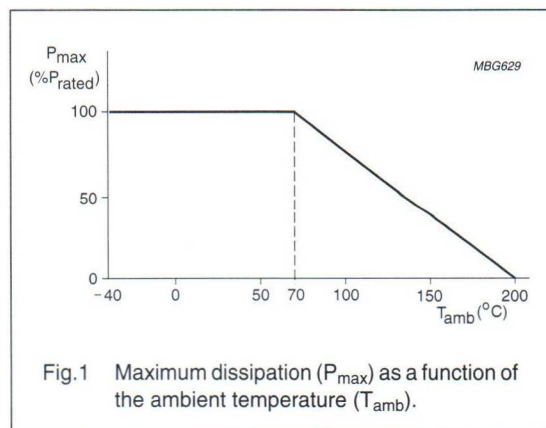


Fig.1 Maximum dissipation (P_{max}) as a function of the ambient temperature (T_{amb}).

PULSE LOADING CAPABILITY

Detailed pulse loading information is available on request.

Application information

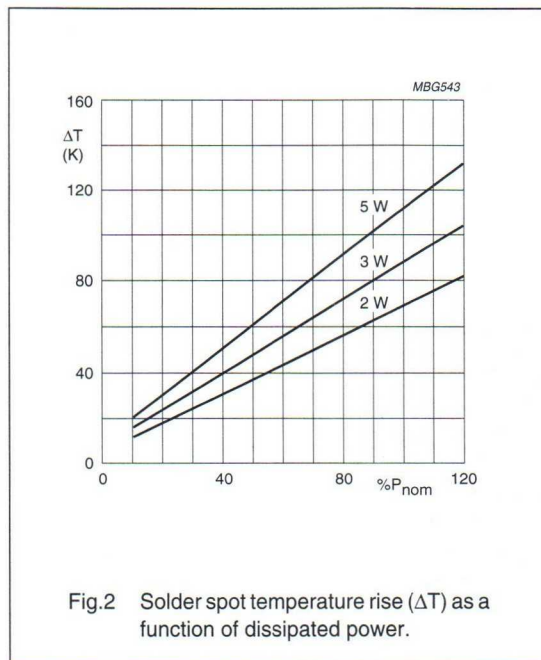


Fig.2 Solder spot temperature rise (ΔT) as a function of dissipated power.

MOUNTING

The resistors must be mounted in such a way that no stress is exerted on the leads and that thermal expansion is possible over the temperature range. **Ensure that the temperature rise of the resistor body by conducted or convected heat, does not affect nearby components or materials.** The temperature rise at the soldering point of the leads must not reach the melting point of the solder. The temperature rise at the soldering point as a function of dissipated power is shown in Fig.2.

Stand-up miniature power resistors

SMW02/03/05
SMF02/03/05

MECHANICAL DATA

Mass per 100 units

TYPE	MASS (g)
SMW02	370
SMF02	
SMW03	530
SMF03	
SMW05	640
SMF05	

Marking

The resistor is marked with the resistor type designation, the production week, nominal resistance value, the tolerance on the resistance and the rated dissipation at $T_{amb} = 70\text{ }^{\circ}\text{C}$.

For values up to $910\text{ }\Omega$ the R is used as a decimal point.
For values of $1\text{ k}\Omega$ or greater the letter K is used as the decimal point for the $\text{k}\Omega$ indication.

Outlines

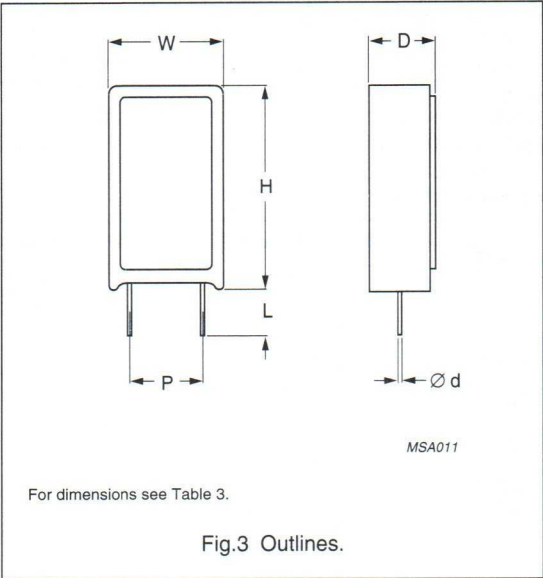


Table 3 Resistor type and relevant physical dimensions; see Fig.3

TYPE	W (mm)	D (mm)	H (mm)	L (mm)	P (mm)	Ød (mm)
SMW02	11 ± 1	7 ± 1	20.5 ± 1.5	4.5 ± 1.5	5 ± 1	0.8
SMF02						
SMW03	12 ± 1	8 ± 1	25.0 ± 1.5			
SMF03						
SMW05	13 ± 1	9 ± 1	25.5 ± 1.5			
SMF05						

Stand-up miniature power resistors

SMW02/03/05

SMF02/03/05

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of "IEC publications 115-1 and 115-4", category 40/200/56 (rated temperature range $-40\text{ }^{\circ}\text{C}$ to $+200\text{ }^{\circ}\text{C}$; damp heat, long term, 56 days). The testing also covers the requirements specified by EIA and EIAJ.

The tests are carried out in accordance with IEC publication 68,

"Recommended basic climatic and mechanical robustness testing procedure for electronic components" and under standard atmospheric conditions according to "IEC 68-1", subclause 5.3.

Unless otherwise specified the following values apply:

Temperature: $15\text{ }^{\circ}\text{C}$ to $35\text{ }^{\circ}\text{C}$

Relative humidity: 45% to 75%

Air pressure: 86 kPa to 106 kPa (860 mbar to 1060 mbar).

In Table 4 the tests and requirements are listed with reference to the relevant clauses of

"IEC publications 115-1, 115-4 and 68", a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

All soldering tests are performed with mildly activated flux.

Table 4 Test procedures and requirements

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
Tests in accordance with the schedule of IEC publication 115-1				
4.15		robustness of resistor body	load $200 \pm 10\text{ N}$	no visible damage $\Delta R/R\text{ max.: } \pm 0.5\% + 0.05\text{ }\Omega$
4.16	U Ua	robustness of terminations: tensile all samples	load 10 N ; 10 s	no visible damage $\Delta R/R\text{ max.: } \pm 0.5\% + 0.05\text{ }\Omega$
4.17	Ta	solderability	2 s ; $235\text{ }^{\circ}\text{C}$; flux 600	good tinning; no damage
4.18	Tb	resistance to soldering heat	thermal shock: 3 s ; $350\text{ }^{\circ}\text{C}$; 2.5 mm from body	$\Delta R/R\text{ max.: } \pm 0.5\% + 0.05\text{ }\Omega$
4.19	14 (Na)	rapid change of temperature	30 minutes at $-40\text{ }^{\circ}\text{C}$ and 30 minutes at $+200\text{ }^{\circ}\text{C}$; 5 cycles	no visible damage $\Delta R/R\text{ max.: } \pm 1\% + 0.05\text{ }\Omega$
4.22	Fc	vibration	frequency $10\text{ to }500\text{ Hz}$; displacement 0.75 mm or acceleration 10 g ; 3 directions; total 6 hours ($3 \times 2\text{ hours}$)	no damage $\Delta R/R\text{ max.: } \pm 0.5\% + 0.05\text{ }\Omega$
4.20	Eb	bump	$4000 \pm 10\text{ bumps}$; 390 m/s^2	no damage $\Delta R/R\text{ max.: } \pm 0.5\% + 0.05\text{ }\Omega$
4.23		climatic sequence:		
4.23.2	Ba	dry heat	16 hours ; $200\text{ }^{\circ}\text{C}$	
4.23.3	Db	damp heat (accelerated) 1st cycle	24 hours ; $55\text{ }^{\circ}\text{C}$; 95 to 100% RH	
4.23.4	Aa	cold	2 hours ; $-40\text{ }^{\circ}\text{C}$	
4.23.5	M	low air pressure	1 hour ; 8.5 kPa ; $15\text{ to }35\text{ }^{\circ}\text{C}$	
4.23.6	Db	damp heat (accelerated) remaining cycles	5 days ; $55\text{ }^{\circ}\text{C}$; 95 to 100% RH	$\Delta R/R\text{ max.: } \pm 3\% + 0.05\text{ }\Omega$

Stand-up miniature power resistors

SMW02/03/05

SMF02/03/05

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.24.2	3 (Ca)	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; dissipation $\leq 0.01 P_n$	no visible damage $\Delta R/R$ max.: $\pm 3\% + 0.1 \Omega$
4.8.4.2		temperature coefficient	at 20/-40/20 °C, 20/200/20 °C: SMW: $R < 10 \Omega$ SMW: $R \geq 10 \Omega$ SMF:	$TC \leq \pm 600 \times 10^{-6}/K$ $-80 \times 10^{-6} \leq TC$ $TC \leq +140 \times 10^{-6}/K$ $TC \leq +250 \times 10^{-6}/K$
4.13		short time overload	room temperature; dissipation $10 \times P_n$; 5 s (voltage not more than 1000 V/25 mm)	$\Delta R/R$ max.: $\pm 2\% + 0.1 \Omega$
4.25.1		endurance (at 70 °C)	1000 hours loaded with $0.9 P_n$; 1.5 hours on and 0.5 hours off	no visible damage $\Delta R/R$ max.: $\pm 5\% + 0.1 \Omega$
4.23.2	Ba	endurance at upper category temperature	1000 hours; 200 °C; no load	no visible damage $\Delta R/R$ max.: $\pm 5\% + 0.1 \Omega$

Radial mounted power resistors

RMW03/05/07/10
RMF03/05/07/10

FEATURES

- High power dissipation in small volume
- Low solder spot temperature
- Very stable mounting.

APPLICATIONS

- These resistors have been designed to dissipate high powers in a small volume, to be used in applications where low solder spot temperature and very stable mounting are essential.

DESCRIPTION

RMW: The resistor element is a resistive wire which is wound in a single layer on a fibre glass core.

RMF: The resistor element is a metal film resistor consisting of a metal layer deposited over a high grade ceramic rod. The resistive film is adjusted to final value by means of a helical groove.

RMW/RMF: The mounting terminations are crimped to the resistive body to assure a good mechanical and electrical contact.

The resistor body and lead ends are housed within a rectangular ceramic case which is non-flammable, will not melt even at high overloads and is resistant to most commonly used cleaning solvents, in accordance with "IEC 68-2-45".

QUICK REFERENCE DATA

DESCRIPTION	VALUE							
	RMW03	RMF03	RMW05	RMF05	RMW07	RMF07	RMW10	RMF10
Resistance tolerance, type and range (E24 series):								
±10%	0.22 to 1.5 Ω	—	0.47 to 1.5 Ω	—	0.68 to 1.5 Ω	1 to 100 kΩ	1.0 to 1.5 Ω	1 to 150 kΩ
±5%	1.6 Ω to 3.9 kΩ	100 Ω to 39 kΩ	1.6 Ω to 4.7 kΩ	100 Ω to 51 kΩ	1.6 Ω to 7.5 kΩ	—	1.6 Ω to 10 kΩ	—
Maximum permissible body temperature	275 °C							
Rated dissipation at T _{amb} = 70 °C	3 W		5 W		7 W		10 W	
Climatic category (IEC 68)	25/155/56							
Basic specification	IEC 115-1							
Stability after:								
load, 1 000 hours	ΔR/R max.: ±5% +0.1 Ω							
climatic tests	ΔR/R max.: ±1% +0.1 Ω							
short time overload	ΔR/R max.: ±2% +0.1 Ω							
Insulation voltage	>2000 V							

Radial mounted power resistors

RMW03/05/07/10

RMF03/05/07/10

ORDERING INFORMATION

Table 1 Ordering code indicating resistor type; style and length of termination

TYPE	ORDERING CODE 2322 25.			
	TERMINATION STYLE 1		TERMINATION STYLE 2	
	LEAD LENGTH			
	10 mm	25 mm	10 mm	25 mm
RMW03	0 11...	0 12...	0 21...	0 22...
RMF03	6 11...	6 12...	6 21...	6 22...
RMW05	1 11...	1 12...	1 21...	1 22...
RMF05	7 11...	7 12...	7 21...	7 22...
RMW07	2 11...	2 12...	2 21...	2 22...
RMF07	8 11...	8 12...	8 21...	8 22...
RMW10	3 11...	3 12...	3 21...	3 22...
RMF10	9 11...	9 12...	9 21...	9 22...

Ordering code (12NC)

- The resistors have a 12-digit ordering code starting with 2322 25
- The subsequent 3 digits indicate the resistor type, termination style and length; see Table 1.
- The remaining 3 digits indicate the resistance value:
 - The first 2 digits indicate the resistance value.
 - The last digit indicates the resistance decade in accordance with Table 2.

Table 2 Last digit of 12NC

RESISTANCE DECADE	LAST DIGIT
0.22 to 0.91 Ω	7
1 to 9.1 Ω	8
10 to 91 Ω	9
100 to 910 Ω	1
1 to 9.1 k Ω	2
10 to 91 k Ω	3
100 to 150 k Ω	4

ORDERING EXAMPLE

The ordering code of an RMW03 resistor, value 47 Ω , with standard terminations, style 1 and length 10 mm, supplied loose in box of 500 units is: 2322 250 11479.

Radial mounted power resistors

RMW03/05/07/10
RMF03/05/07/10

FUNCTIONAL DESCRIPTION

Product characterization

Standard values of nominal resistance are taken from the E24 series for resistors with a tolerance of $\pm 5\%$ or $\pm 10\%$. The values of the E24 series are in accordance with "IEC publication 63".

Limiting values

TYPE	LIMITING VOLTAGE ⁽¹⁾ (V)	LIMITING POWER (W)
RMW03	$V = \sqrt{P_n \times R}$	3
RMF03		
RMW05		5
RMF05		
RMW07		7
RMF07		
RMW10		10
RMF10		

Note

1. The maximum voltage that may be continuously applied to the resistor element, see "IEC publication 266".

The maximum permissible hot spot temperature is 275 °C, and the minimum breakdown voltage of the encapsulation is 2000 V.

Application information

MOUNTING

The resistors must be mounted in such a way that no stress is exerted on the leads and that thermal expansion is possible over the temperature range. **Ensure that the temperature rise of the resistor body by conducted or convected heat, does not affect nearby components or materials.** The temperature rise at the soldering point of the leads must not reach the melting point of the solder. The temperature rise at the soldering point and the hot spot as a function of dissipated power for the various types, are shown in Figs 3, 4, 5 and 6.

DERATING

The power that the resistor can dissipate depends on the operating temperature; see Fig.1.

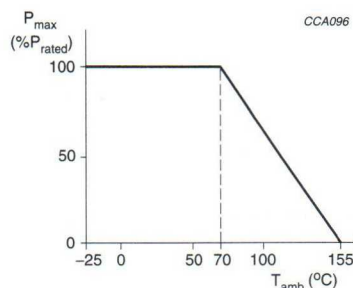


Fig.1 Maximum dissipation (P_{max}) as a function of the ambient temperature (T_{amb}).

PULSE LOADING CAPABILITY

Detailed pulse loading information is available on request.

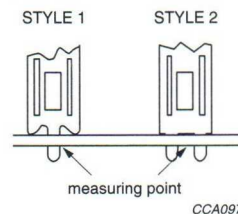
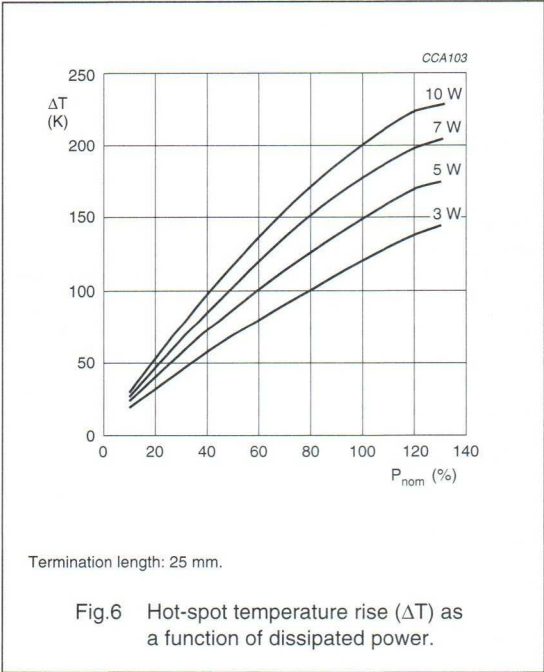
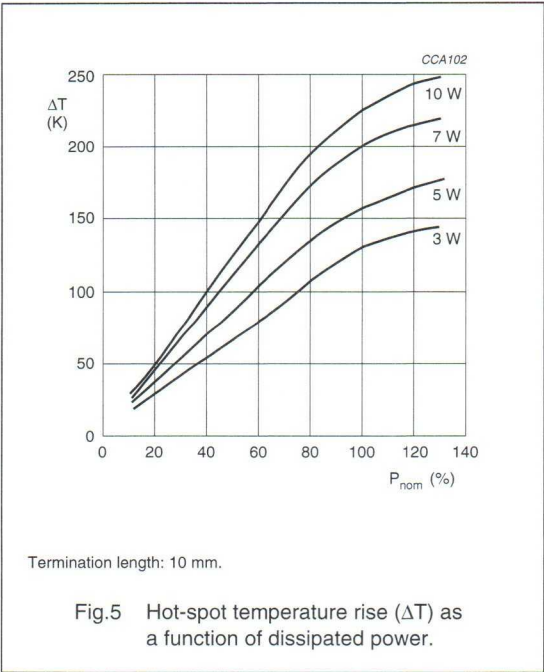
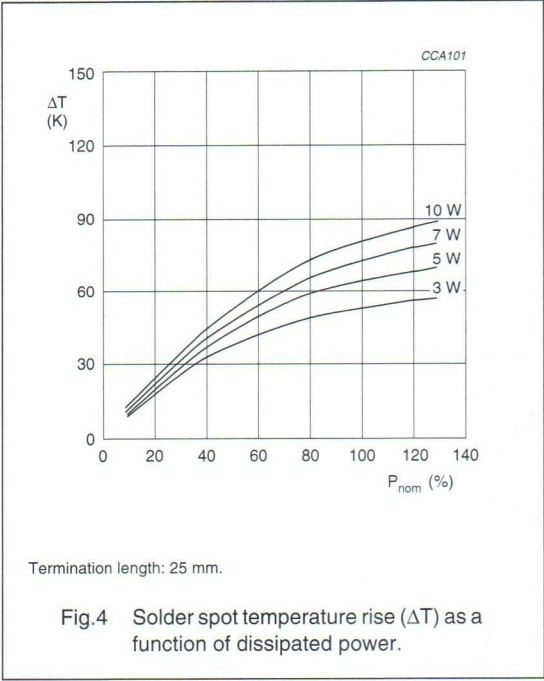
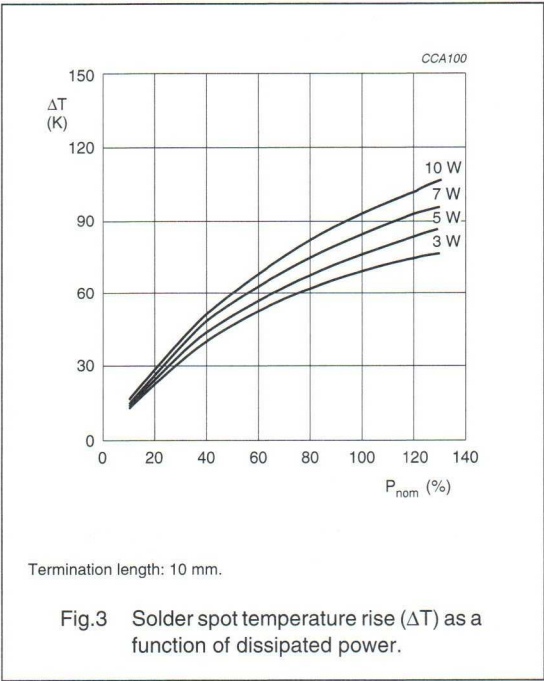


Fig.2 Measuring point of the solder spot temperature.

Radial mounted power resistors

RMW03/05/07/10
RMF03/05/07/10

TEMPERATURE RISE OF SOLDER JOINT AND HOT-SPOT AS A FUNCTION OF LOAD AND LEAD LENGTH FOR STYLES 1 AND 2



Radial mounted power resistors

RMW03/05/07/10
RMF03/05/07/10

MECHANICAL DATA

Mass per 100 units

TYPE	MASS (g)	
	10 mm LEAD	25 mm LEAD
RMW03	700	750
RMF03	800	850
RMW05	700	750
RMF05	800	850
RMW07	800	900
RMF07	900	1000
RMW10	1100	1150
RMF10	1200	1250

Marking

The resistor is marked with the resistor type designation, the production week, nominal resistance value, the tolerance on the resistance and the rated dissipation at $T_{amb} = 70\text{ }^{\circ}\text{C}$.

For values up to $910\text{ }\Omega$ the R is used as a decimal point.
For values of $1\text{ k}\Omega$ or greater the letter K is used as the decimal point for the $\text{k}\Omega$ indication.

Outlines

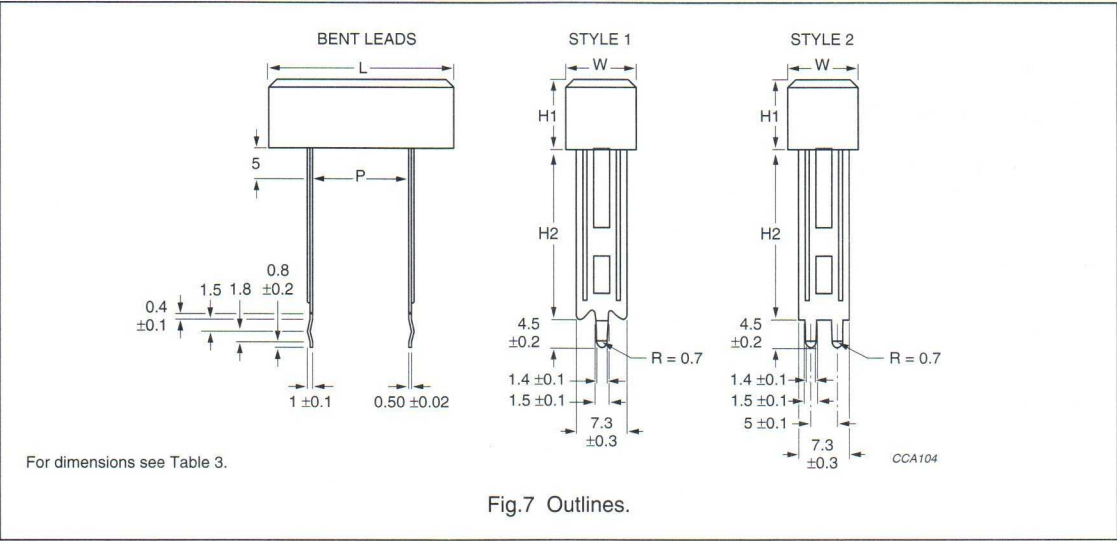


Table 3 Resistor type and relevant physical dimensions; see Fig.7

TYPE	W (mm)	L (mm)	H1 (mm)	H2 (mm)	P (mm)
RMW03	9.0 ±1	24 ±1	9.0 ±1	10 ±1.5 or 25 ±1.5	12.5 ±1
RMF03					
RMW05	9.5 ±1	27 ±1	9.5 ±1		15.0 ±1
RMF05					
RMW07	9.5 ±1	35 ±1	9.5 ±1		22.5 ±1
RMF07					
RMW10	9.5 ±1	48 ±1	9.5 ±1		35.0 ±1
RMF10					

Radial mounted power resistors

RMW03/05/07/10

RMF03/05/07/10

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of "IEC publications 115-1 and 115-4", category 25/155/56 (rated temperature range -25°C to $+155^{\circ}\text{C}$; damp heat, long term, 56 days). The testing also covers the requirements specified by EIA and EIAJ.

The tests are carried out in accordance with IEC publication 68,

"Recommended basic climatic and mechanical robustness testing procedure for electronic components" and under standard atmospheric conditions according to "IEC 68-1", subclause 5.3.

Unless otherwise specified the following values apply:

Temperature: 15°C to 35°C

Relative humidity: 45% to 75%

Air pressure: 86 kPa to 106 kPa (860 mbar to 1060 mbar).

In Table 4 the tests and requirements are listed with reference to the relevant clauses of "IEC publications 115-1, 115-4 and 68", a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

All soldering tests are performed with mildly activated flux.

Table 4 Test procedures and requirements

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
Tests in accordance with the schedule of IEC publication 115-1				
4.15		robustness of resistor body	load $200 \pm 10\text{ N}$	no visible damage $\Delta R/R$ max.: $\pm 1\% + 0.05\ \Omega$
4.16	U Ua	robustness of terminations: tensile all samples	load 45 N ; 10 s	no visible damage
4.17	Ta	solderability	2 s ; 235°C ; flux 600	good tinning; no damage $\Delta R/R$ max.: $\pm 0.5\% + 0.05\ \Omega$
4.18	Tb	resistance to soldering heat	thermal shock: 3 s ; 350°C	$\Delta R/R$ max.: $\pm 1\% + 0.05\ \Omega$
4.19	14 (Na)	rapid change of temperature	30 minutes at -25°C and 30 minutes at $+155^{\circ}\text{C}$; 5 cycles	no visible damage $\Delta R/R$ max.: $\pm 1\% + 0.05\ \Omega$
4.22	Fc	vibration	frequency $10\text{ to }55\text{ Hz}$; displacement 0.75 mm or acceleration 10 g ; 3 directions ; total 6 hours ($3 \times 2\text{ hours}$)	no damage $\Delta R/R$ max.: $\pm 1\% + 0.05\ \Omega$
4.23 4.23.2 4.23.3	Ba Db	climatic sequence: dry heat	16 hours ; 155°C	after 24 hours at P_n $\Delta R/R$ max.: $\pm 1\% + 0.05\ \Omega$
4.23.4	Aa	damp heat (accelerated) 1st cycle	24 hours ; 55°C ; $95\text{ to }100\%\text{ RH}$	
4.23.5	M	cold	2 hours ; -25°C	
4.23.6	Db	low air pressure	1 hour ; 8.5 kPa ; $15\text{ to }35^{\circ}\text{C}$	
		damp heat (accelerated) remaining cycles	5 days ; 55°C ; $95\text{ to }100\%\text{ RH}$	
4.24.2	3 (Ca)	damp heat (steady state)	56 days ; 40°C ; $90\text{ to }95\%\text{ RH}$; dissipation $\leq 0.01 P_n$	no visible damage $\Delta R/R$ max.: $\pm 3\% + 0.1\ \Omega$

Radial mounted power resistors

RMW03/05/07/10

RMF03/05/07/10

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.8.4.2		temperature coefficient	at 20/-25/20 °C, 20/155/20 °C: $R \leq 1 \Omega$ $R > 1 \Omega$	$TC \leq \pm 600 \times 10^{-6}/K$ $TC \leq +200 \times 10^{-6}/K$
4.13		short time overload	room temperature; dissipation $10 \times P_n$; 5 s	$\Delta R/R$ max.: $\pm 2\% + 0.1 \Omega$
4.25.1		endurance (at 70 °C)	1000 hours loaded with P_n ; 1.5 hours on and 0.5 hours off	no visible damage $\Delta R/R$ max.: $\pm 5\% + 0.1 \Omega$
4.23.2	Ba	endurance at upper category temperature	1000 hours; 155 °C; no load	no visible damage $\Delta R/R$ max.: $\pm 5\% + 0.1 \Omega$
4.6.1.1		insulation resistance	500 V (DC); 1 minute	$\geq 100 M\Omega$
4.7		voltage proof on insulation	1000 V (RMS); 1 minute	$\Delta R/R$ max.: $\pm 0.5\% + 0.05 \Omega$

MAINTENANCE TYPES

Metal film resistors

MR25/30/52

APPLICATIONS

- For use in professional equipment:
 - computers
 - telecommunications
 - measuring devices.

DESCRIPTION

A homogeneous film of metal alloy is deposited on a high grade ceramic body. After a helical groove has been cut in the resistive layer, tinned connecting leads of electrolytic copper are welded to the end-caps.

The resistors are coated with layers of green lacquer which provide electrical, mechanical and climatic protection. The encapsulation is resistant to all cleaning solvents, in accordance with "MIL-STD-202E", method 215 and "IEC 68-2-45".

QUICK REFERENCE DATA

DESCRIPTION	VALUE		
	MR25	MR30	MR52
Resistance range	1 Ω to 1 M Ω		4.99 Ω to 1 M Ω
Resistance tolerance	$\pm 0.5\%$, E192 series		$\pm 1\%$, E24; E96 series
Temperature coefficient: 1 $\Omega \leq R < 4.99 \Omega$ 4.99 $\Omega \leq R \leq 1 \text{ M}\Omega$	100 $\times 10^{-6}/\text{K}$ 50 $\times 10^{-6}/\text{K}$		
Absolute maximum dissipation at $T_{\text{amb}} = 70^\circ\text{C}$	0.4 W	0.5 W	1 W
Maximum permissible voltage	250 V	350 V	500 V
Basic specifications	IEC 115-1		
Approval	CECC 40101		
Climatic category (IEC 68)	55/155/56		
Stability after:	see Fig.1		
load			
climatic tests	$\Delta R/R \text{ max.}: \pm 0.5\% + 0.05 \Omega$		
soldering	$\Delta R/R \text{ max.}: \pm 0.1\% + 0.01 \Omega$		
short time overload	$\Delta R/R \text{ max.}: \pm 0.25\% + 0.05 \Omega$		

Metal film resistors

MR25/30/52

ORDERING INFORMATION

Table 1 Ordering code indicating resistor type and packaging

TYPE	ORDERING CODE 2322
	BANDOLIER IN AMMOPACK
	1 000 units
MR25	151 7....
MR30	152 7....
MR52	153 5....

Ordering code (12NC)

- The resistors have a 12-digit ordering code.
- The first 8 digits indicate the resistor type and packaging; see Table 1.
- The remaining 4 digits indicate the resistance value:
 - The first 3 digits indicate the resistance value.
 - The last digit indicates the resistance decade in accordance with Table 2.

Table 2 Last digit of 12NC

RESISTANCE DECADE	LAST DIGIT
1 to 9.76 Ω	8
10 to 97.6 Ω ⁽¹⁾	9
100 to 976 Ω	1
1 to 9.76 k Ω	2
10 to 97.6 k Ω	3
100 to 976 k Ω	4
1 M Ω	5

Note

1. The composition of the catalogue number is not applicable for $R = 49.9 \Omega$; the relevant catalogue numbers will be indicated on request.

ORDERING EXAMPLE

The ordering code of a MR52 resistor, value 3650 $\Omega \pm 0.5\%$, taped on a bandolier of 1 000 units in ammopack is: 2322 153 53652.

Metal film resistors

MR25/30/52

FUNCTIONAL DESCRIPTION

Product characterization

Standard values of nominal resistance are taken from the E24/E96 series for $\pm 1\%$ and E192 for $\pm 0.5\%$.
The values of the series are in accordance with "IEC publication 63".

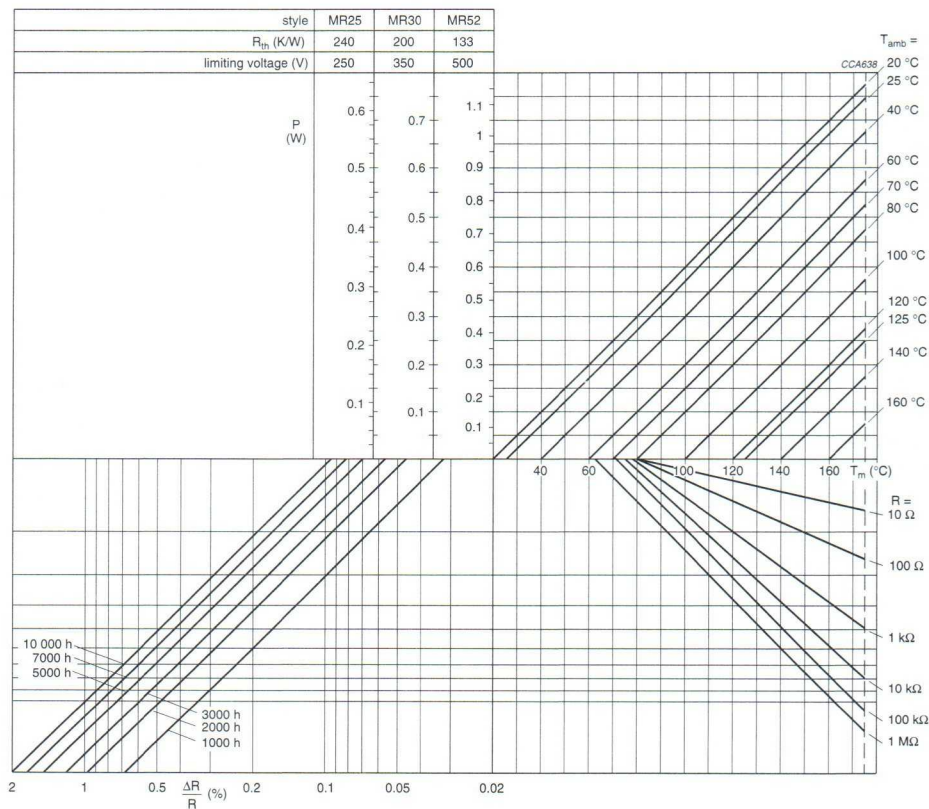


Fig.1 Drift nomogram.

NOTES ON NOMOGRAM

1. It should not be extended beyond the maximum permissible hot-spot temperature of 175 °C.
2. The change in resistance for $P = 0$ at a particular ambient temperature is indicative for shelf-life stability of a resistor at that temperature.
3. The stability lines do not give exact values of $\Delta R/R$ but represent a probability of 95% that the actual values will be smaller than those obtained from the nomogram.
4. The limiting voltage has not been taken into consideration.

Metal film resistors

MR25/30/52

Limiting values

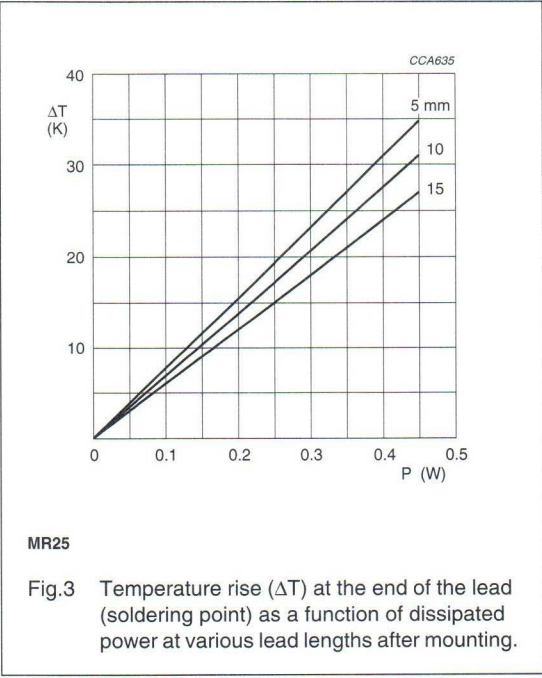
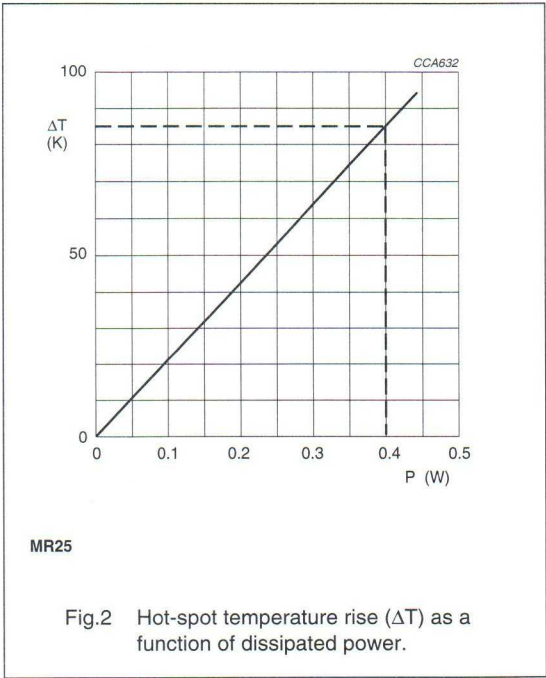
TYPE	LIMITING VOLTAGE ⁽¹⁾ (V)	LIMITING POWER (W)
MR25	250	0.4
MR30	350	0.5
MR52	500	1

Note

1. The maximum voltage that may be applied continuously to the resistor element, see “IEC publication 115-1”.

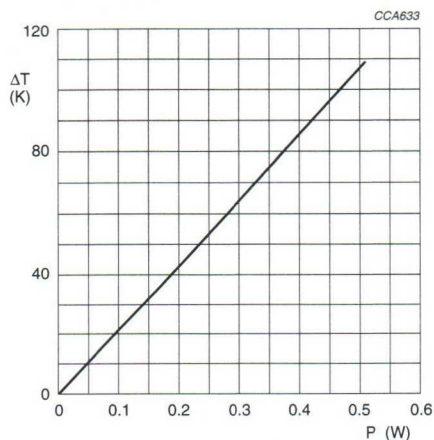
The maximum permissible hot-spot temperature is 175 °C.

Application information



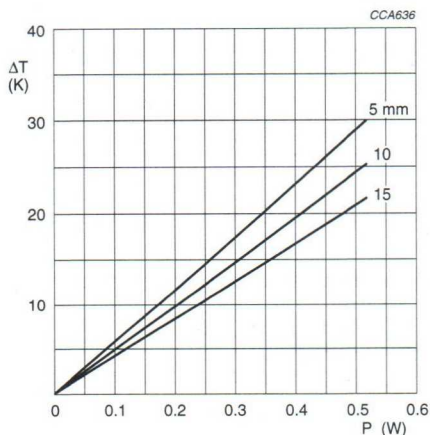
Metal film resistors

MR25/30/52



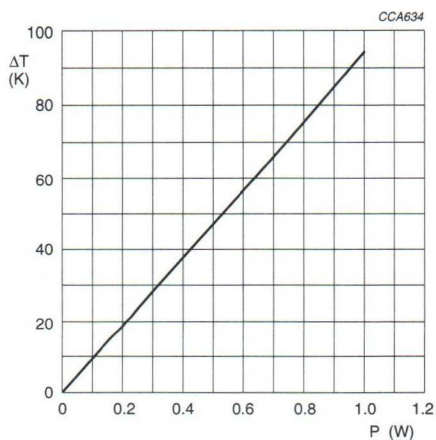
MR30

Fig.4 Hot-spot temperature rise (ΔT) as a function of dissipated power.



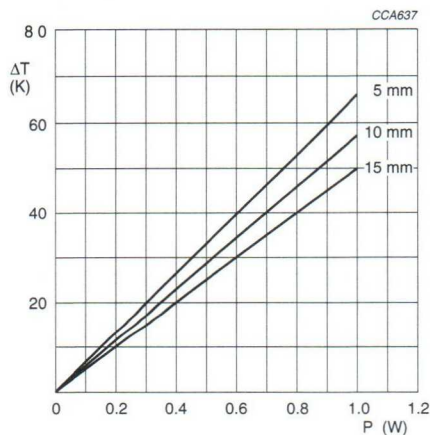
MR30

Fig.5 Temperature rise (ΔT) at the end of the lead (soldering point) as a function of dissipated power at various lead lengths after mounting.



MR52

Fig.6 Hot-spot temperature rise (ΔT) as a function of dissipated power.



MR52

Fig.7 Temperature rise (ΔT) at the end of the lead (soldering point) as a function of dissipated power at various lead lengths after mounting.

Metal film resistors

MR25/30/52

MECHANICAL DATA

Mass per 100 units

TYPE	MASS (g)
MR25	25
MR30	32
MR52	92

Marking

The nominal resistance and tolerance are marked on the resistor using five or six coloured bands in accordance with IEC publication 62 "Colour codes for fixed resistors".

Five bands are used for the MR52 type; 3 for the resistance value, 1 for multiplier and 1 brown for tolerance.

Six bands are used for resistors in MR25 and MR30 series: 3 for resistance value, 1 for multiplier, 1 for tolerance and 1 for the temperature coefficient.

Outlines

The length of the body (L_1) is measured by inserting the leads into holes of two identical gauge plates and moving these plates parallel to each other until the resistor body is clamped without deformation ("IEC publication 294").

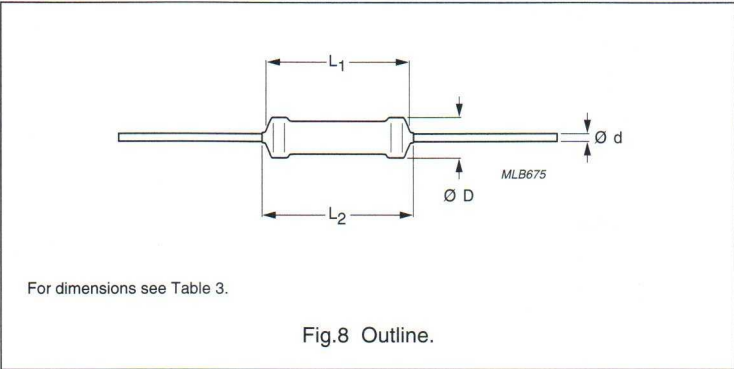


Table 3 Resistor type and relevant physical dimensions; see Fig.8

TYPE	ØD MAX. (mm)	L ₁ MAX. (mm)	L ₂ MAX. (mm)	Ød (mm)
MR25	2.5	6.5	7.5	0.6
MR30	3.0	10.0	11.0	
MR52	5.2	16.5	17.5	

Metal film resistors

MR25/30/52

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of "IEC publication 115-1", category 55/155/56 (rated temperature range -55°C to $+155^{\circ}\text{C}$; damp heat, long term, 56 days). The testing also covers the requirements specified by EIA and EIAJ.

The tests are carried out in accordance with IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components" and under standard atmospheric conditions according to "IEC 68-1", subclause 5.3.

Unless otherwise specified the following values apply:

Temperature: 15°C to 35°C

Relative humidity: 45% to 75%

Air pressure: 86 kPa to 106 kPa
(860 mbar to 1060 mbar).

In Table 4 the tests and requirements are listed with reference to the relevant clauses of "IEC publications 115-1 and 68"; a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

Table 4 Test procedures and requirements

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.16	U	robustness of terminations:		
4.16.2	Ua	tensile all samples	load 10 N; 10 s	number of failures $<10 \times 10^{-6}$
4.16.3	Ub	bending half number of samples	load 5 N; $4 \times 90^{\circ}$	number of failures $<10 \times 10^{-6}$
4.16.4	Uc	torsion other half of samples	$3 \times 360^{\circ}$ in opposite directions	no damage $\Delta R/R$ max.: $\pm 0.1\% + 0.01 \Omega$
4.17	Ta	solderability	2 s; 230°C ; flux 600	good tinning; no damage
4.18	Tb	resistance to soldering heat	thermal shock: 3 s; 350°C ; 6 mm from body	$\Delta R/R$ max.: $\pm 0.1\% + 0.01 \Omega$
4.19	Na	rapid change of temperature	30 minutes at -55°C and 30 minutes at $+155^{\circ}\text{C}$; 5 cycles	$\Delta R/R$ max.: $\pm 0.1\% + 0.01 \Omega$
4.20	Eb	bump	3×1500 bumps in 3 directions; 40 g	no damage $\Delta R/R$ max.: $\pm 0.1\% + 0.01 \Omega$
4.22	Fc	vibration	frequency 10 to 500 Hz; displacement 1.5 mm or acceleration 10 g; 3 directions; total 6 hours (3×2 hours)	no damage $\Delta R/R$ max.: $\pm 0.1\% + 0.01 \Omega$
4.23		climatic sequence:		
4.23.2	B	dry heat	16 hours; 155°C	
4.23.3	D	damp heat (accelerated) 1st cycle	24 hours; 55°C ; 95 to 100% RH	
4.23.4	Aa	cold	2 hours; -55°C	
4.23.5	M	low air pressure	1 hour; 8.5 kPa; 15 to 35°C	
4.23.6	D	damp heat (accelerated) remaining cycles	5 days; 55°C ; 95 to 100% RH	R_{ins} min.: 1000 M Ω $\Delta R/R$ max.: $\pm 0.5\% + 0.05 \Omega$

Metal film resistors

MR25/30/52

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.24.2	Ca	damp heat (long term exposure)	56 days; 40 °C; 90 to 95% RH; dissipation 0.01 P _n MR25: ≤2.5 mW MR30: ≤3 mW MR52: ≤5 mW	R _{ins} min.: 1 000 MΩ ΔR/R max.: ±0.5% +0.05 Ω
4.25.1		endurance	1 000 hours at 70 °C; P _n or V _{max} MR25: 0.25 W or V _{max} MR30: 0.3 W or V _{max} MR52: 0.45 W or V _{max}	ΔR/R max.: ±0.5% +0.05 Ω
4.8.4.2		temperature coefficient	between -55 °C and +155 °C (TC × 10 ⁻⁶ /K)	R < 4.99 Ω: ±100 × 10 ⁻⁶ /K R ≥ 4.99 Ω: ±50 × 10 ⁻⁶ /K
4.7		voltage proof on insulation	2 × limiting voltage (AC) with 750 V _{max} (RMS)	no breakdown
4.12		noise	IEC publication 195	R ≤ 100 kΩ: max. 0.25 μV/V R > 100 kΩ: max. 0.5 μV/V
4.6.1.1		insulation resistance	100 V (DC) during 1 minute; V-block method	R _{ins} min.: 10 ⁴ MΩ
4.13		short time overload	T _{amb} = 25 °C; P = 6.25 × P _n ; V ≤ 2 × V _{max} ; 5 s on, 45 s off; 10 cycles	ΔR/R max.: ±0.25% +0.05 Ω

Lacquered metal film resistors

MR24/34/54, E/C/D

APPLICATIONS

- For use in professional equipment:
 - computers
 - telecommunications
 - measuring.

DESCRIPTION

A homogeneous film of metal alloy is deposited on a high grade ceramic body. After a helical groove has been cut in the resistive layer, tinned connecting leads of electrolytic copper are welded to the end-caps.

The resistors are coated with layers of green lacquer which provide electrical, mechanical and climatic protection. The encapsulation is resistant to all cleaning solvents, in accordance with "MIL-STD-202E", method 215 and "IEC 68-2-45".

QUICK REFERENCE DATA

DESCRIPTION	VALUE
Resistance range: MR24/34/54, E/C MR24/34/54, D	49.9 Ω to 1 M Ω 10 Ω to 1 M Ω
Resistance tolerance: MR24/34/54, E/C MR24/34/54, D	$\pm 0.1\%$; 0.25%; 0.5%, E192 series; 1%, E96 series 1%, E96 series
Temperature coefficient: MR24/34/54, E MR24/34/54, C MR24/34/54, D	$\pm 25 \times 10^{-6}/K$ $\pm 50 \times 10^{-6}/K$ $\pm 100 \times 10^{-6}/K$
Rated dissipation at $T_{amb} = 70^\circ C$: MR24D MR34D MR54D at $T_{amb} = 125^\circ C$: MR24E/C MR34E/C MR54E/C	0.125 W 0.25 W 0.5 W 0.1 W 0.125 W 0.25 W
Basic specifications	MIL-R-10509F
Stability after: load climatic tests soldering short time overload	$\Delta R/R$ max.: $\pm 0.5\% + 0.05 \Omega$ $\Delta R/R$ max.: $\pm 0.5\% + 0.05 \Omega$ $\Delta R/R$ max.: $\pm 0.1\% + 0.05 \Omega$ $\Delta R/R$ max.: $\pm 0.25\% + 0.05 \Omega$

Lacquered metal film resistors

MR24/34/54, E/C/D

ORDERING INFORMATION

Table 1 Ordering code indicating resistor type, MIL style and packaging

TYPE	MIL STYLE	ORDERING CODE 2322
		BULK IN BOX
		100 units
MR24E	RN55E	160.....
MR24C	RN55C	161.....
MR24D	RN55D	162.....
MR34E	RN60E	163.....
MR34C	RN60C	164.....
MR34D	RN60D	165.....
MR54E	RN65E	166.....
MR54C	RN65C	167.....
MR54D	RN65D	168.....

Ordering code (12NC)⁽¹⁾

- The resistors have a 12-digit ordering code.
- The first 7 digits indicate the resistor type and packaging; see Table 1.
- The remaining 5 digits indicate the tolerance and resistance value:
 - The first digit indicates the tolerance in accordance with Table 2.
 - The next 3 digits indicate the resistance value.
 - The last digit indicates the resistance decade in accordance with Table 3.

(1) For the resistance values mentioned in Table 4, the last 5 digits of the ordering code are stated in full.

Table 2 8th digit of 12NC

TOLERANCE (%)	CODE
1	1
0.5	2
0.25	3
0.1	4

Table 3 Last digit of 12NC

RESISTANCE DECADE	LAST DIGIT
10 to 98.8 Ω	9
100 to 988 Ω	1
1 to 9.88 k Ω	2
10 to 98.8 k Ω	3
100 to 988 k Ω	4
1 M Ω	5

ORDERING EXAMPLE

The ordering code of a MR24E resistor, value 505 $\Omega \pm 0.5\%$, loose in box of 100 units is: 2322 160 25051.

Table 4 Last five digits of 12NC for specific resistance values

RESISTANCE VALUE (Ω)	0.1%	0.25%	0.5%	1%
29.9	92102	92122	—	—
39.9	92103	92123	—	—
49.9	92104	92124	92134	92144
59.9	92105	92125	—	—
69.9	92106	92126	—	—
79.9	92107	92127	—	—
89.9	92108	92128	—	—
99.9	92109	92129	—	—

Lacquered metal film resistors

MR24/34/54, E/C/D

FUNCTIONAL DESCRIPTION

Product characterization

The standard values of nominal resistance are taken from the E96 series for resistors with a tolerance of $\pm 1\%$, from the E192 series for resistors with a tolerance of $\pm 0.5\%$, $\pm 0.25\%$ or $\pm 0.1\%$ ("MIL-R-10509F, paragraph 1.2.1.3").

Resistors with a tolerance of $\pm 0.1\%$ and $\pm 0.25\%$ may also be requested with resistance values deviating from the E192 series, provided the value can be indicated with no more than three significant digits.

Limiting values

TYPE	LIMITING VOLTAGE ⁽¹⁾ (V)	LIMITING POWER (W)	
		T _{amb} = 70 °C	T _{amb} = 125 °C
MR24D	200	0.125	—
MR34D	300	0.25	—
MR54D	350	0.5	—
MR24E/C	200	—	0.1
MR34E/C	250	—	0.125
MR54E/C	300	—	0.25

Note

1. The maximum voltage that may be applied continuously to the resistor element, see "IEC publication 115-1".

Lacquered metal film resistors

MR24/34/54, E/C/D

MECHANICAL DATA

Mass per 100 units

TYPE	MASS (g)
MR24E/C/D	25
MR34E/C/D	32
MR54E/C/D	92

Mounting

The resistors must be mounted in such a way that no stress is exerted on the leads, so as to allow thermal expansion over the wide temperature range.

Marking

The resistors are marked in accordance with MIL specification "MIL-R-10509F". This means that the following information is printed on the resistor:

- MIL style
- Value and tolerance in MIL code
- Manufacturers' identification symbol.

In the MIL code for value and tolerance the value is indicated by four digits and a letter: first the three significant digits according to the E192 or E96 series, a fourth figure indicating the number of zeros to follow and then a letter indicating the tolerance as follows:

- B = $\pm 0.1\%$
- C = $\pm 0.25\%$
- D = $\pm 0.5\%$
- F = $\pm 1\%$.

EXAMPLE

22.1 k Ω $\pm 1\%$ is written as 2212F.

This code should not be used for ordering. Please use the ordering code as shown in Table 1.

Outlines

The length of the body (L_1) is measured by inserting the leads into holes of two identical gauge plates and moving these plates parallel to each other until the resistor body is clamped without deformation ("IEC publication 294").

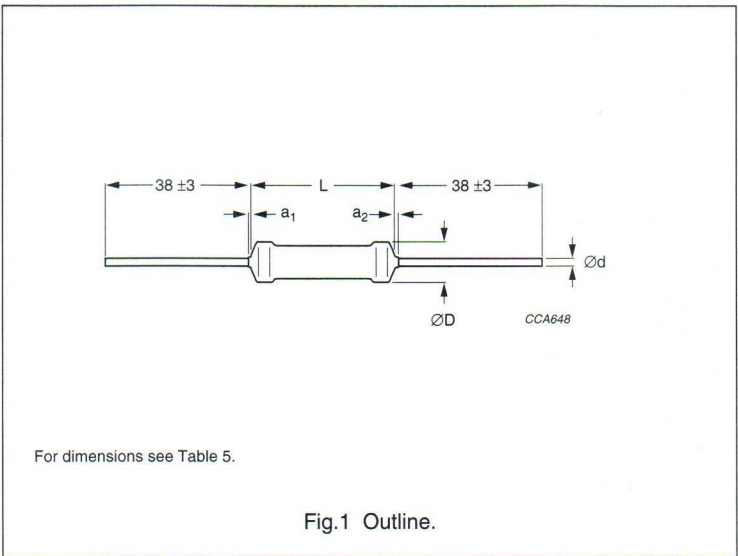


Table 5 Resistor type and relevant physical dimensions; see Fig.1

TYPE	ØD MAX. (mm)	L MAX. (mm)	a ₁ , a ₂ a ₁ + a ₂	Ød (mm)
MR24E/C/D	2.4	6.5	≤1	0.6
MR34E/C/D	3.1	10.5	≤1	
MR54E/C/D	5.2	16.5	≤1	

Lacquered metal film resistors

MR24/34/54, E/C/D

TESTS AND REQUIREMENTS

All tests are carried out in accordance with the schedule of "MIL-R-10509F, paragraph 4.4.2".

In Table 6 the tests and requirements are listed with reference to the relevant clauses of "MIL-R-10509F".

Table 6 Test procedures and requirements

MIL-R-10509F CLAUSE	MIL-STD-202E METHOD	TEST	MIL-R-10509F PARAGRAPH	REQUIREMENTS ⁽¹⁾
4.6.4	102	temperature cycling	3.9	$\Delta R \leq 0.25\% + 0.05 \Omega$
4.6.5	—	low-temperature operation	3.10	$\Delta R \leq 0.25\% + 0.05 \Omega$
4.6.6	—	short-time overload	3.11	$\Delta R \leq 0.25\% + 0.05 \Omega$
4.6.7	211	terminal strength	3.12	$\Delta R \leq 0.2\% + 0.05 \Omega$
4.6.8	301/305	dielectric withstanding voltage	3.13	$\Delta R \leq 0.25\% + 0.05 \Omega$
4.6.9	302	insulation resistance	3.14	$R_{ins} \geq 10000 M\Omega$
4.6.10	210	resistance to soldering heat	3.15	$\Delta R \leq 0.1\% + 0.05 \Omega$
4.6.11	106	moisture resistance	3.16	$\Delta R \leq 0.5\% + 0.05 \Omega$ $R_{ins} \geq 100 M\Omega$
4.6.13	108	life	3.18	$\Delta R \leq 0.5\% + 0.05 \Omega$
4.6.15	205	shock, medium impact	3.20	$\Delta R \leq 0.25\% + 0.05 \Omega$
4.6.16	204	vibration	3.21	$\Delta R \leq 0.25\% + 0.05 \Omega$

Note

- Although resistors with a temperature coefficient of $100 \times 10^{-6}/K$ correspond with characteristic D resistors of "MIL-R-10509F", they meet the more severe test requirement of characteristic C and E resistors.

Power metal film resistors

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DESCRIPTION

A homogeneous film of metal alloy is deposited on a high grade ceramic body. After a helical groove has been cut in the resistive layer, tinned connecting wires of electrolytic copper or copper-clad iron are welded to the end-caps. The resistors are coated with a red, inflammable protective silicon lacquer which can withstand 500 V (RMS). This coating is not resistant to aggressive fluxes. The encapsulation is resistant to all cleaning solvents in accordance with "MIL-STD-202E" method 215, and "IEC 68-2-45".

MECHANICAL DATA

Mass

40 g (per 100 units).

Mounting

The resistors must be mounted stress free so as to allow thermal expansion over the wide permissible temperature range.

The minimum pitch for this type with cropped and formed leads is 7e.

Marking

The resistor is marked with the nominal resistance value and the tolerance on the resistance.

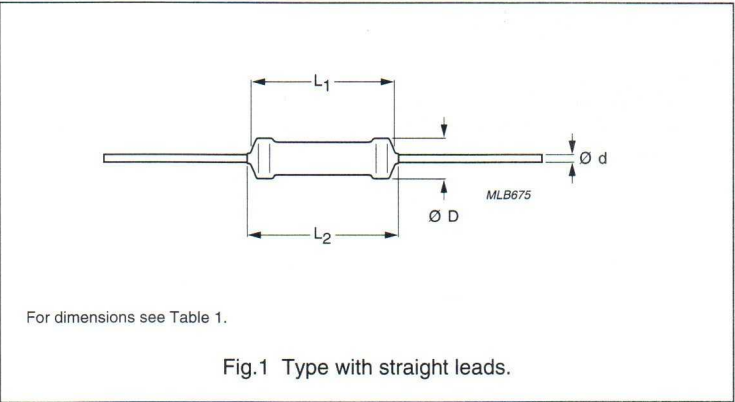
For values up to 910 Ω the R is used as the decimal point.

For values of 1 k Ω and upwards, the letter K is used as the decimal point for the k Ω indication.

For the value of 1 M Ω the letter M is used as the decimal point for the M Ω indication.

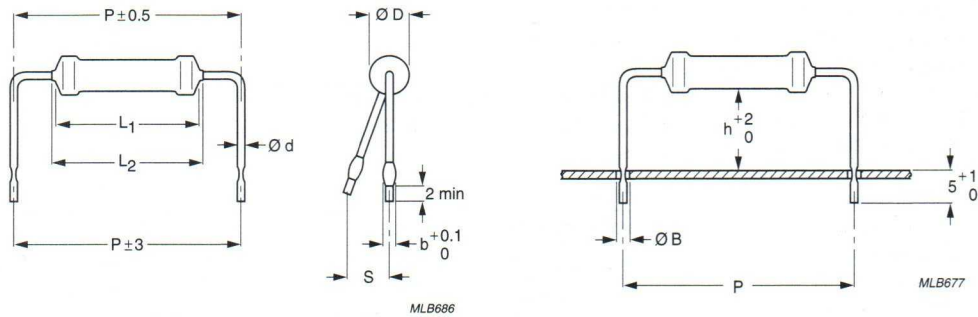
QUICK REFERENCE DATA

DESCRIPTION	VALUE
Resistance range	1 Ω to 1 M Ω ; E24 series
Resistance tolerance	$\pm 5\%$
Maximum body temperature (hot-spot)	300 $^{\circ}\text{C}$
Absolute maximum dissipation at $T_{\text{amb}} = 70\text{ }^{\circ}\text{C}$ (P_{70}); see Fig.3: $R \leq 27\text{ k}\Omega$ $R > 27\text{ k}\Omega$	 1.6 W 1.2 W
Maximum permissible voltage	500 V
Basic specifications	IEC 115-4 and MIL-R-11804/2, char. G
Climatic category (IEC 68)	55/200/56
Stability after: load, 1000 hours climatic tests soldering	 $\Delta R/R$ max.: $\pm 5\% + 0.1\text{ }\Omega$ $\Delta R/R$ max.: $\pm 3\% + 0.1\text{ }\Omega$ $\Delta R/R$ max.: $\pm 1\% + 0.05\text{ }\Omega$



Power metal film resistors

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Dimensions in mm.
For dimensions see Table 1.

Fig.2 Type with cropped and formed leads.

Table 1 Lead type and physical dimensions; see Figs 1 and 2

LEADS	$\varnothing D$ MAX. (mm)	L_1 MAX. (mm)	L_2 MAX. (mm)	$\varnothing d$ (mm)	b (mm)	h (mm)	P (mm)	S MAX. (mm)	$\varnothing B$ MAX. (mm)
Copper-clad iron	3.9	10	12	0.6	1.1	8	17.8	2	1.0
						15		3	
Copper	3.9	10	12	0.8	1.3	8	17.8	2	1.2
						15		3	

Power metal film resistors

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ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated (nominal) resistance are taken from the E24 series within the range 1 Ω to 1 MΩ. The values of the E24 series are in accordance with "IEC publication 63".

The tolerance on the rated resistance is ±5%.

The limiting voltage (RMS) is 500 V. This is the maximum voltage that may be applied continuously to the resistor element, see "IEC publications 115-1 and 115-4".

The maximum permissible hot-spot temperature is 300 °C.

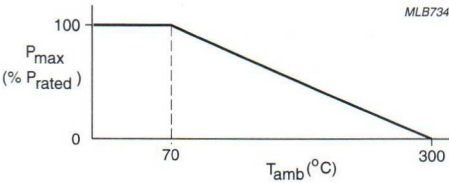


Fig.3 Rated power dissipation (P_{rated}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

Table 2 Electrical data

DESCRIPTION	VALUE
Temperature coefficient	$R < 10 \Omega: \leq \pm 350 \times 10^{-6}/K$
	$R \geq 10 \Omega: \leq \pm 250 \times 10^{-6}/K$
Maximum body temperature (hot-spot)	300 °C
Absolute maximum dissipation at $T_{amb} = 70^{\circ}C$:	
$R \leq 27 \text{ k}\Omega$	1.6 W
$R > 27 \text{ k}\Omega$	1.2 W
Limiting voltage	500 V
Dielectric withstanding minimum RMS voltage of the insulation for 1 min	500 V
Basic specifications	IEC 115-4 and MIL-R-11804/2, char. G
Climatic category (IEC 68)	55/200/56
Temperature rise (ΔT) of the resistor body as a function of dissipation	see Figs 4 and 5
Lead length (l) as a function of dissipation with temperature rise at end of lead (soldering point) as parameter	see Figs 6 and 7

Power metal film resistors

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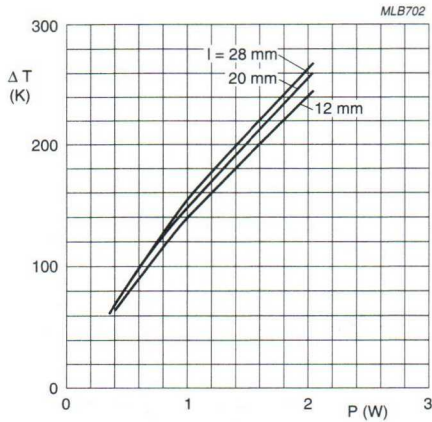
Copper-clad iron leads $\varnothing = 0.6$ mm.

Fig. 4 Hot-spot temperature rise (ΔT) as a function of dissipated power at different lead lengths (l).

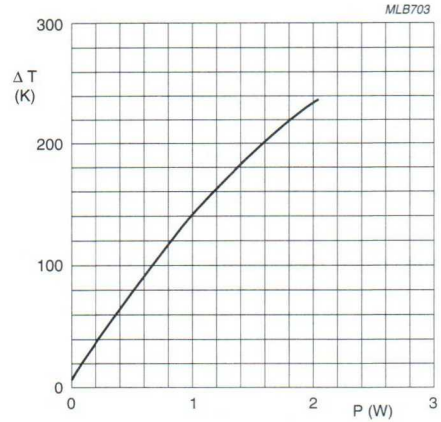
Copper leads $\varnothing = 0.8$ mm.

Fig. 5 Hot-spot temperature rise (ΔT) as a function of dissipated power (P).

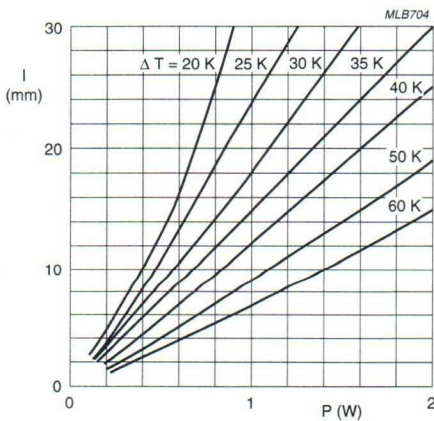
Copper-clad iron leads $\varnothing = 0.6$ mm.

Fig. 6 Lead length (l) as a function of dissipated power with ΔT as a parameter.

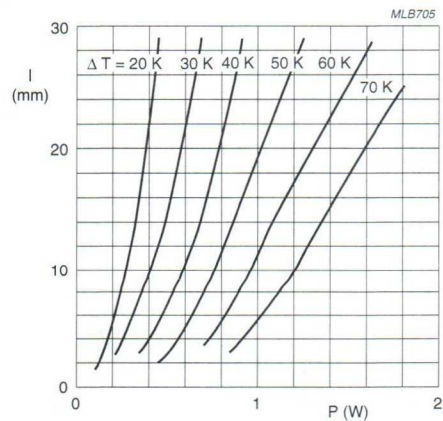
Copper leads $\varnothing = 0.8$ mm.

Fig. 7 Lead length (l) as a function of dissipated power with ΔT as a parameter.

Power metal film resistors

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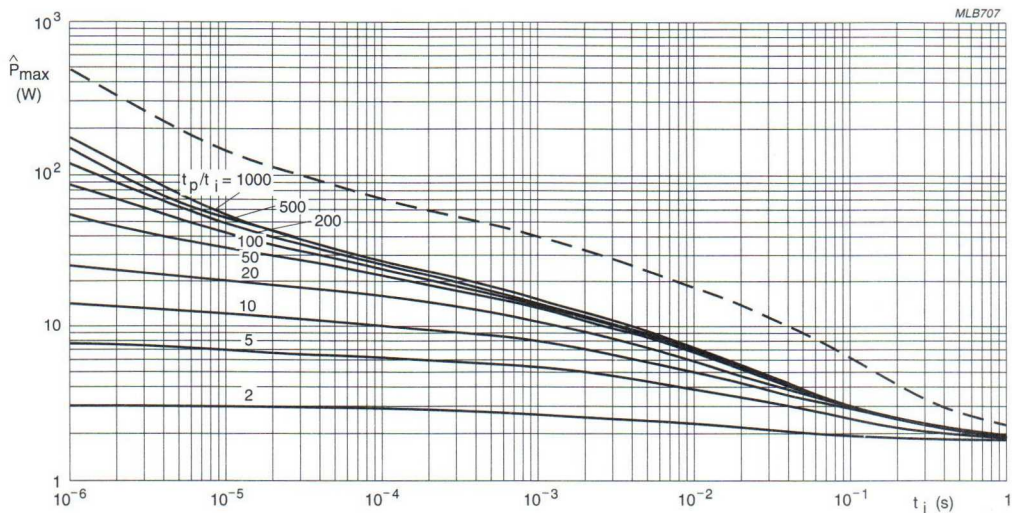


Fig.8 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i).

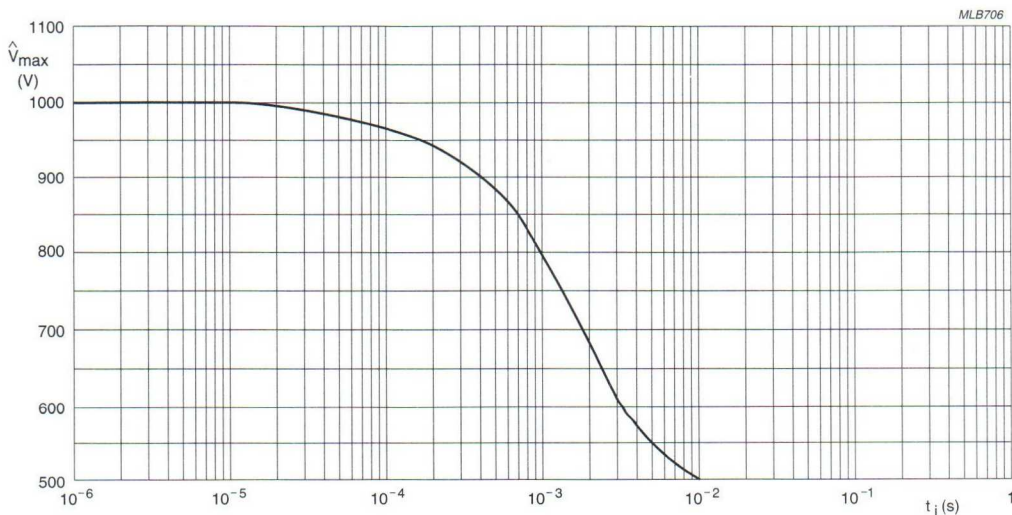
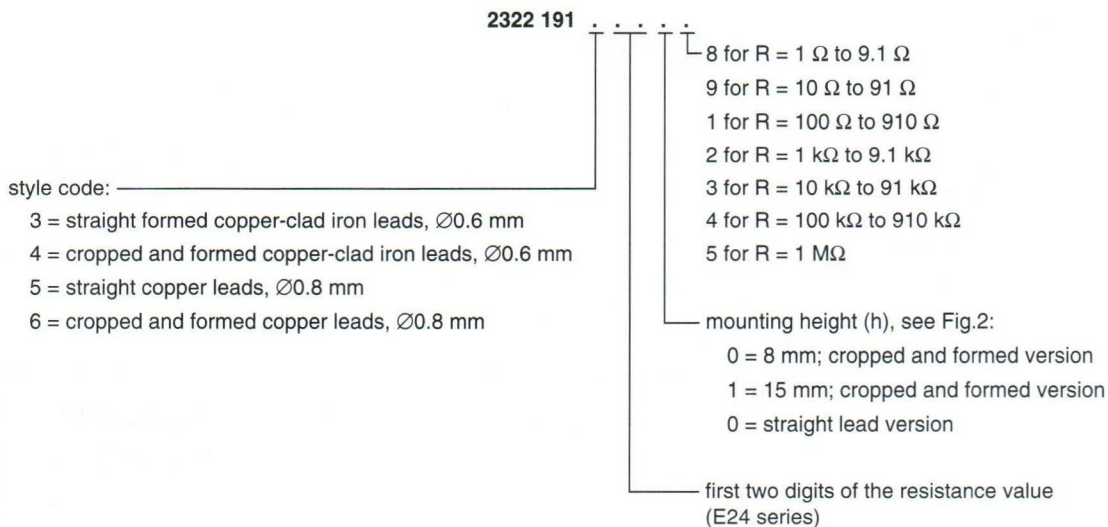


Fig.9 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_i).

Power metal film resistors

PR37

COMPOSITION OF THE CATALOGUE NUMBER



Power metal film resistors

PR37

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of "IEC publication 115-1", category 55/200/56 (rated temperature range -55°C to $+200^{\circ}\text{C}$; damp heat, long term, 56 days). The testing also covers the requirements specified by EIA and EIAJ.

The tests are carried out in accordance with IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components" and under standard atmospheric conditions according to "IEC 68-1", subclause 5.3.

Unless otherwise specified the following values apply:

Temperature: 15°C to 35°C

Relative humidity: 45% to 75%

Air pressure: 86 kPa to 106 kPa
(860 mbar to 1060 mbar).

In Table 3 the tests and requirements are listed with reference to the relevant clauses of "IEC publications 115-1 and 68", a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

Table 3 Test procedures and requirements

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.16	U	robustness of terminations:		
4.16.2	Ua	tensile all samples	load 10 N; 10 s	number of failures $<1 \times 10^{-6}$
4.16.3	Ub	bending half number of samples	load 5 N; $4 \times 90^{\circ}$	number of failures $<1 \times 10^{-6}$
4.16.4	Uc	torsion other half of samples	$3 \times 360^{\circ}$ in opposite directions	no damage $\Delta R/R$ max.: $\pm 0.5\% + 0.05 \Omega$
4.17	Ta	solderability	2 s; 235°C ; flux 600	good tinning; no damage
4.18	Tb	resistance to soldering heat	thermal shock: 3 s; 350°C ; 6 mm from body	$\Delta R/R$ max.: $\pm 0.5\% + 0.05 \Omega$
4.19	Na	rapid change of temperature	30 minutes at -55°C and 30 minutes at $+155^{\circ}\text{C}$; 5 cycles	no damage $\Delta R/R$ max.: $\pm 2\% + 0.1 \Omega$
4.20	Eb	bump	3×1500 bumps in three directions; 40 g	no damage $\Delta R/R$ max.: $\pm 0.5\% + 0.05 \Omega$
4.22	Fc	vibration	frequency 10 to 500 Hz; displacement 1.5 mm or acceleration 10 g; 3 directions; total 6 hours (3×2 hours)	no damage $\Delta R/R$ max.: $\pm 0.5\% + 0.05 \Omega$
4.23		climatic sequence:		
4.23.2	Ba	dry heat	16 hours; 155°C	
4.23.3	Db	damp heat (accelerated) 1st cycle	24 hours; 55°C ; 95 to 100% RH	
4.23.4	Aa	cold	2 hours; -55°C	
4.23.5	M	low air pressure	1 hour; 8.5 kPa; 15 to 35°C	
4.23.6	Db	damp heat (accelerated) remaining cycles	5 days; 55°C ; 95 to 100% RH	R_{ins} min.: 1000 M Ω $\Delta R/R$ max.: $\pm 3\% + 0.1 \Omega$

Power metal film resistors

PR37

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.24.2	Ca	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; dissipation $0.01 \times P_{70}$	R_{ins} min.: 1000 M Ω $\Delta R/R$ max.: $\pm 3\% + 0.1 \Omega$
4.25.1		endurance	1000 hours; 70 °C; P_{70} or V_{max}	$\Delta R/R$ max.: $\pm 5\% + 0.1 \Omega$
4.8.4.2		temperature coefficient	between -55 °C and +155 °C	$R < 10 \Omega$: $\leq \pm 350 \times 10^{-6}/K$ $R \geq 10 \Omega$: $\leq \pm 250 \times 10^{-6}/K$
4.7		voltage proof on insulation	500 V (RMS) for 1 minute; V-block method	no breakdown
4.12		noise	IEC publication 195	
4.6.1.1		insulation resistance	500 V (DC) for 1 minute; V-block method	R_{ins} min.: 1000 M Ω
see 2nd amendment to IEC 115-1, Jan. '87 and present 40 central office 532 & 533		pulse load		see Figs 8 and 9

Power metal film resistors

PR52

DESCRIPTION

A homogeneous film of metal alloy is deposited on a high grade ceramic body. After a helical groove has been cut in the resistive layer, tinned connecting wires of electrolytic copper or copper-clad iron are welded to the end-caps. The resistors are coated with a red, inflammable protective silicon lacquer which can withstand 500 V (RMS). This coating is not resistant to aggressive fluxes. The encapsulation is resistant to all cleaning solvents in accordance with "MIL-STD-202E" method 215, and "IEC 68-2-45".

MECHANICAL DATA

Mass

92 g (per 100 units).

Mounting

The resistors must be mounted stress free so as to allow thermal expansion over the wide permissible temperature range.

The minimum pitch for this type with cropped and formed leads is 10e.

Marking

The resistor is marked with the nominal resistance value and the tolerance on the resistance.

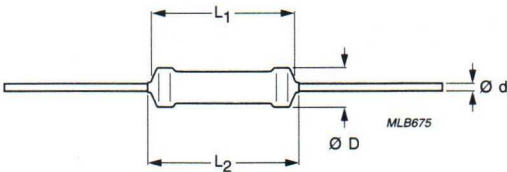
For values up to 910 Ω the R is used as the decimal point.

For values of 1 kΩ and upwards, the letter K is used as the decimal point for the kΩ indication.

For the value of 1 MΩ the letter M is used as the decimal point for the MΩ indication.

QUICK REFERENCE DATA

DESCRIPTION	VALUE
Resistance range	1 Ω to 1 MΩ; E24 series
Resistance tolerance	±5%
Maximum body temperature (hot-spot)	300 °C
Absolute maximum dissipation at T _{amb} = 70 °C (P ₇₀); see Fig.3: R ≤ 51 kΩ R > 51 kΩ	2.5 W 2.0 W
Maximum permissible voltage	750 V
Basic specifications	IEC 115-4 and MIL-R-11804/2, char. G
Climatic category (IEC 68)	55/200/56
Stability after: load, 1 000 hours climatic tests soldering	ΔR/R max.: ±5% +0.1 Ω ΔR/R max.: ±3% +0.1 Ω ΔR/R max.: ±1% +0.05 Ω

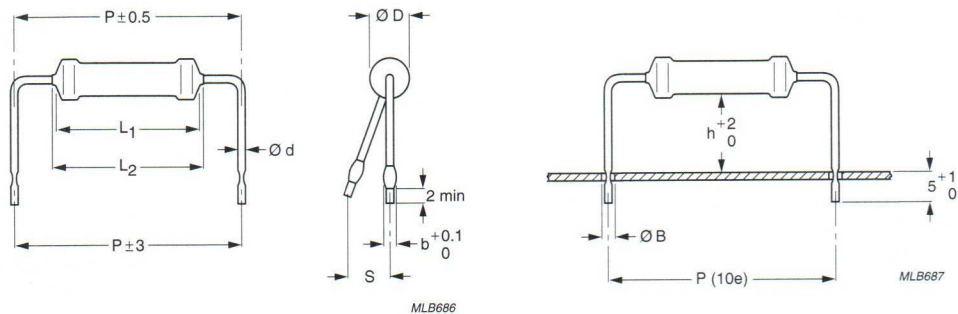


For dimensions see Table 1.

Fig.1 Type with straight leads.

Power metal film resistors

PR52



Dimensions in mm.
For dimensions see Table 1.

Fig.2 Type with cropped and formed leads.

Table 1 Lead type and physical dimensions; see Figs 1 and 2

LEADS	$\varnothing D$ MAX. (mm)	L_1 MAX. (mm)	L_2 MAX. (mm)	$\varnothing d$ (mm)	b (mm)	h (mm)	P (mm)	S MAX. (mm)	$\varnothing B$ MAX. (mm)
Copper-clad iron	5.2	16.7	19.5	0.6	1.1	8	25.4	2	1.0
						15		3	
Copper	5.2	16.7	19.5	0.8	1.3	8	25.4	2	1.2
						15		3	

Power metal film resistors

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ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated (nominal) resistance are taken from the E24 series within the range 1 Ω to 1 MΩ. The values of the E24 series are in accordance with "IEC publication 63".

The tolerance on the rated resistance is ±5%.

The limiting voltage (RMS) is 750 V. This is the maximum voltage that may be applied continuously to the resistor element, see "IEC publications 115-1 and 115-4".

The maximum permissible hot-spot temperature is 300 °C.

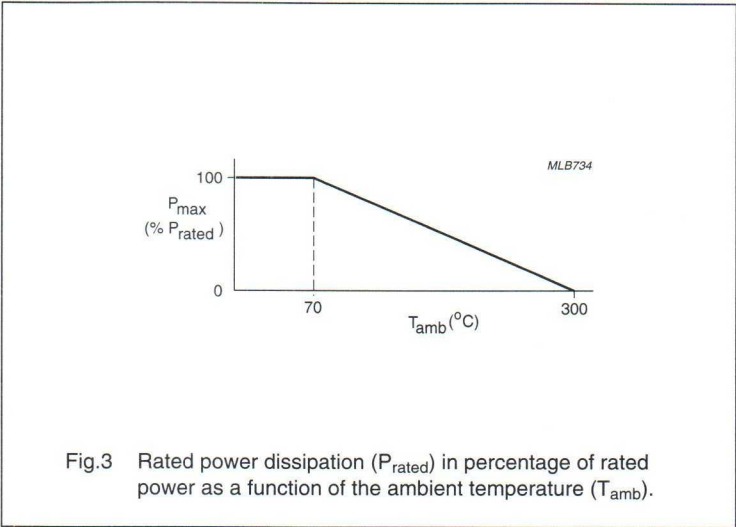
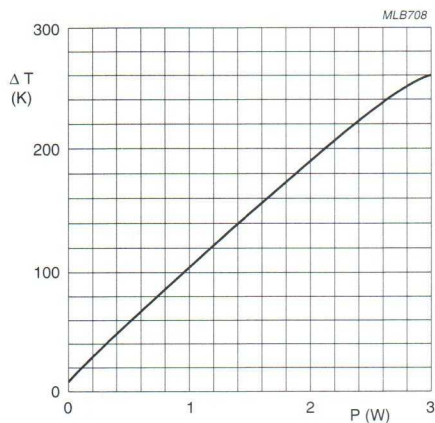
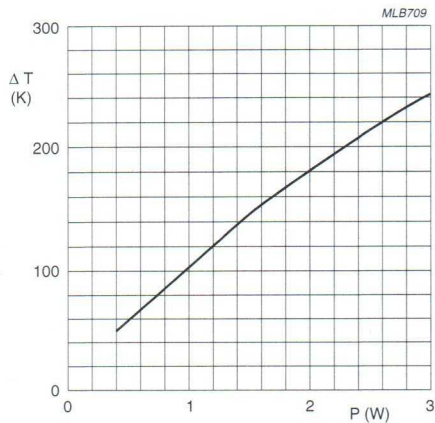
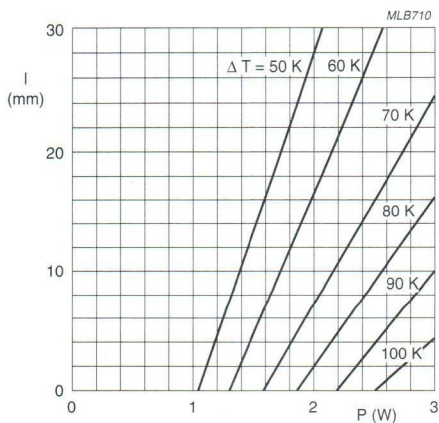
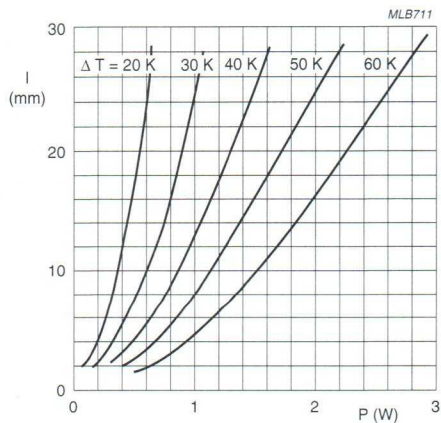


Table 2 Electrical data

DESCRIPTION	VALUE
Temperature coefficient	$R < 10 \Omega: \leq \pm 350 \times 10^{-6}/K$
	$R \geq 10 \Omega: \leq \pm 250 \times 10^{-6}/K$
Maximum body temperature (hot-spot)	300 °C
Absolute maximum dissipation at $T_{amb} = 70 \text{ °C}$:	
$R \leq 51 \text{ k}\Omega$	2.5 W
$R > 51 \text{ k}\Omega$	2.0 W
Limiting voltage	750 V
Dielectric withstanding minimum RMS voltage of the insulation for 1 min	500 V
Basic specifications	IEC 115-4 and MIL-R-11804/2, char. G
Climatic category (IEC 68)	55/200/56
Temperature rise (ΔT) of the resistor body as a function of dissipation	see Figs 4 and 5
Lead length (l) as a function of dissipation with temperature rise at end of lead (soldering point) as parameter	see Figs 6 and 7

Power metal film resistors

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Copper-clad iron leads $\varnothing = 0.6$ mm.Fig. 4 Hot-spot temperature rise (ΔT) as a function of dissipated power.Copper leads $\varnothing = 0.8$ mm.Fig. 5 Hot-spot temperature rise (ΔT) as a function of dissipated power.Copper-clad iron leads $\varnothing = 0.6$ mm.Fig. 6 Lead length (l) as a function of dissipated power with ΔT as a parameter.Copper leads $\varnothing = 0.8$ mm.Fig. 7 Lead length (l) as a function of dissipated power with ΔT as a parameter.

Power metal film resistors

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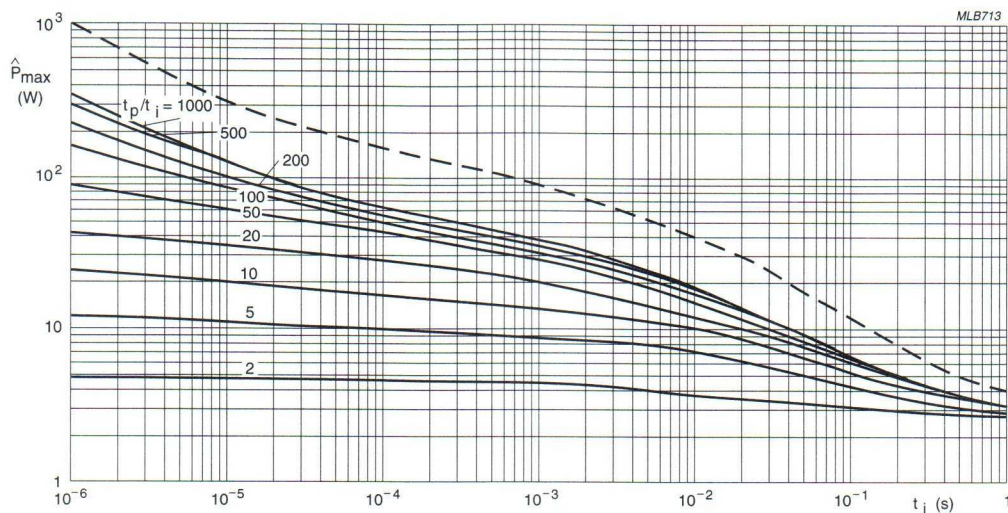


Fig.8 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i).

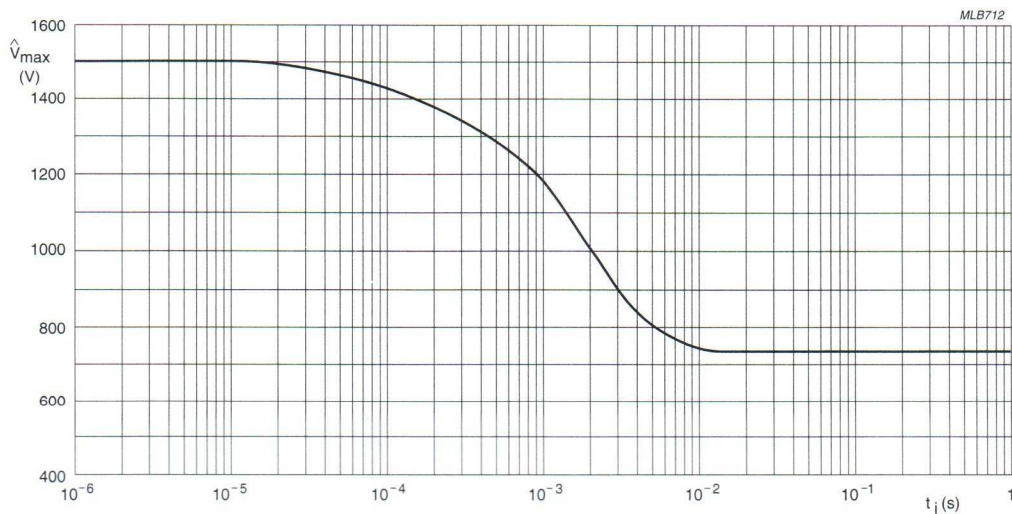
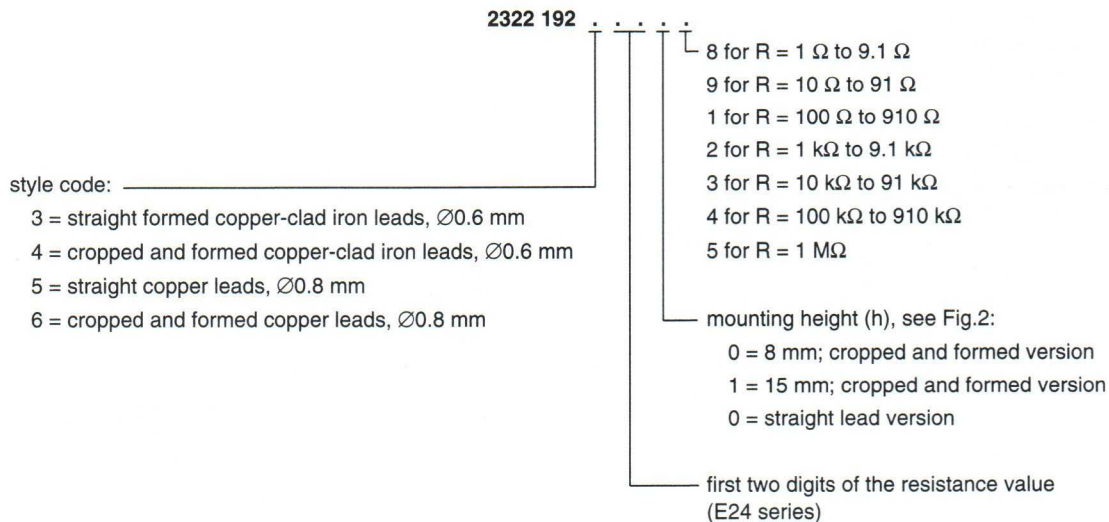


Fig.9 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_i).

Power metal film resistors

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COMPOSITION OF THE CATALOGUE NUMBER



Power metal film resistors

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TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of "IEC publication 115-1", category 55/200/56 (rated temperature range -55°C to $+200^{\circ}\text{C}$; damp heat, long term, 56 days). The testing also covers the requirements specified by EIA and EIAJ.

The tests are carried out in accordance with IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components" and under standard atmospheric conditions according to "IEC 68-1", subclause 5.3.

Unless otherwise specified the following values apply:

Temperature: 15°C to 35°C

Relative humidity: 45% to 75%

Air pressure: 86 kPa to 106 kPa
(860 mbar to 1060 mbar).

In Table 3 the tests and requirements are listed with reference to the relevant clauses of "IEC publications 115-1 and 68", a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

Table 3 Test procedures and requirements

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.16	U	robustness of terminations:		
4.16.2	Ua	tensile all samples	load 10 N; 10 s	number of failures $<1 \times 10^{-6}$
4.16.3	Ub	bending half number of samples	load 5 N; $4 \times 90^{\circ}$	number of failures $<1 \times 10^{-6}$
4.16.4	Uc	torsion other half number of samples	$3 \times 360^{\circ}$ in opposite directions	no damage $\Delta R/R$ max.: $\pm 0.5\% + 0.05 \Omega$
4.17	Ta	solderability	2 s; 230°C ; flux 600	good tinning; no damage
4.18	Tb	resistance to soldering heat	thermal shock: 3 s; 350°C ; 6 mm from body	$\Delta R/R$ max.: $\pm 0.5\% + 0.05 \Omega$
4.19	Na	rapid change of temperature	30 minutes at -55°C and 30 minutes at $+155^{\circ}\text{C}$; 5 cycles	no damage $\Delta R/R$ max.: $\pm 2\% + 0.1 \Omega$
4.20	Eb	bump	3×1500 bumps in three directions; 40 g	no damage $\Delta R/R$ max.: $\pm 0.5\% + 0.05 \Omega$
4.22	Fc	vibration	frequency 10 to 500 Hz; displacement 1.5 mm or acceleration 10 g; 3 directions; total 6 hours (3×2 hours)	no damage $\Delta R/R$ max.: $\pm 0.5\% + 0.05 \Omega$
4.23		climatic sequence:		
4.23.2	Ba	dry heat	16 hours; 155°C	
4.23.3	Db	damp heat (accelerated) 1st cycle	24 hours; 55°C ; 95 to 100% RH	
4.23.4	Aa	cold	2 hours; -55°C	
4.23.5	M	low air pressure	1 hour; 8.5 kPa; 15 to 35°C	
4.23.6	Db	damp heat (accelerated) remaining cycles	5 days; 55°C ; 95 to 100% RH	R_{ins} min.: 1000 M Ω $\Delta R/R$ max.: $\pm 3\% + 0.1 \Omega$

Power metal film resistors

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IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.24.2	Ca	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; dissipation $0.01 \times P_{70}$	R_{ins} min.: 1000 M Ω $\Delta R/R$ max.: $\pm 3\% + 0.1 \Omega$
4.25.1		endurance	1 000 hours; 70 °C; P_{70} or V_{max}	$\Delta R/R$ max.: $\pm 5\% + 0.1 \Omega$
4.8.4.2		temperature coefficient	between -55 °C and +155 °C	$R < 10 \Omega$: $\leq \pm 350 \times 10^{-6}/K$ $R \geq 10 \Omega$: $\leq \pm 250 \times 10^{-6}/K$
4.7		voltage proof on insulation	500 V (RMS) for 1 minute; V-block method	no breakdown
4.12		noise	IEC publication 195	
4.6.1.1		insulation resistance	500 V (DC) for 1 minute; V-block method	R_{ins} min.: 1000 M Ω
see 2nd amendment to IEC 115-1, Jan. '87 and present 40 central office 532 & 533		pulse load		see Figs 8 and 9

Enamelled wirewound resistors

WR0617E; WR0825E
WR0842E; WR0865E

APPLICATION

- As power resistors in electrical and electronic circuitry.

DESCRIPTION

These resistors have a single layer of resistance wire wound on a ceramic body. Leads of solder-coated copper-clad wire are secured to caps which are force-fitted on to the ends of the ceramic body. The resistor is coated with brown enamel.

QUICK REFERENCE DATA

DESCRIPTION	VALUE			
	WR0617E	WR0825E	WR0842E	WR0865E
Resistance range	4.7 Ω to 4.7 k Ω	6.8 Ω to 27 k Ω	10 Ω to 56 k Ω	15 Ω to 100 k Ω
Rated dissipation at T _{amb} = 70 °C	4 W	7 W	11 W	17 W
Resistance tolerance	$\pm 5\%$, E24 series			
Temperature coefficient	-80 to $+140 \times 10^{-6}/K$			
Ambient temperature range	-55 to $+200$ °C			
Maximum body temperature (hot-spot)	400 °C			
Basic specifications	IEC 115-1			
Climatic category (IEC 68)	55/200/56			
Stability after:				
load, 1000 hours	$\Delta R/R$ max.: 5%			
climatic tests	$\Delta R/R$ max.: 1%			
soldering	$\Delta R/R$ max.: 0.5%			
short time overload	$\Delta R/R$ max.: 2%			

Enamelled wirewound resistors

WR0617E; WR0825E
WR0842E; WR0865E

ORDERING INFORMATION

Table 1 Ordering code indicating resistor type and packaging

TYPE	ORDERING CODE 2322	
	BANDOLIER IN AMMOPACK	
	100 units	500 units
WR0617E	—	330 22...
WR0825E	—	330 32...
WR0842E	330 42...	—
WR0865E	330 52...	—

Ordering code (12NC)

- The resistors have a 12-digit ordering code.
- The first 9 digits indicate the resistor type and packaging; see Table 1.
- The remaining 3 digits indicate the resistance value:
 - The first 2 digits indicate the resistance value.
 - The last digit indicates the resistance decade in accordance with Table 2.

Table 2 Last digit of 12NC

RESISTANCE DECADE	LAST DIGIT
4.7 to 9.1 Ω	8
10 to 91 Ω	9
100 to 910 Ω	1
1 to 9.1 k Ω	2
10 to 91 k Ω	3
100 k Ω	4

ORDERING EXAMPLE

The ordering code of a WR0842E resistor, value 15 $\Omega \pm 5\%$, taped on a bandolier of 100 units in ammopack is: 2322 330 42159.

Enamelled wirewound resistors

WR0617E; WR0825E
WR0842E; WR0865E

FUNCTIONAL DESCRIPTION

Product characterization

Standard values of nominal resistance are taken from the E24 series for resistors with a tolerance of $\pm 1\%$.
The values of the E24 series are in accordance with "IEC publication 63".

Limiting values

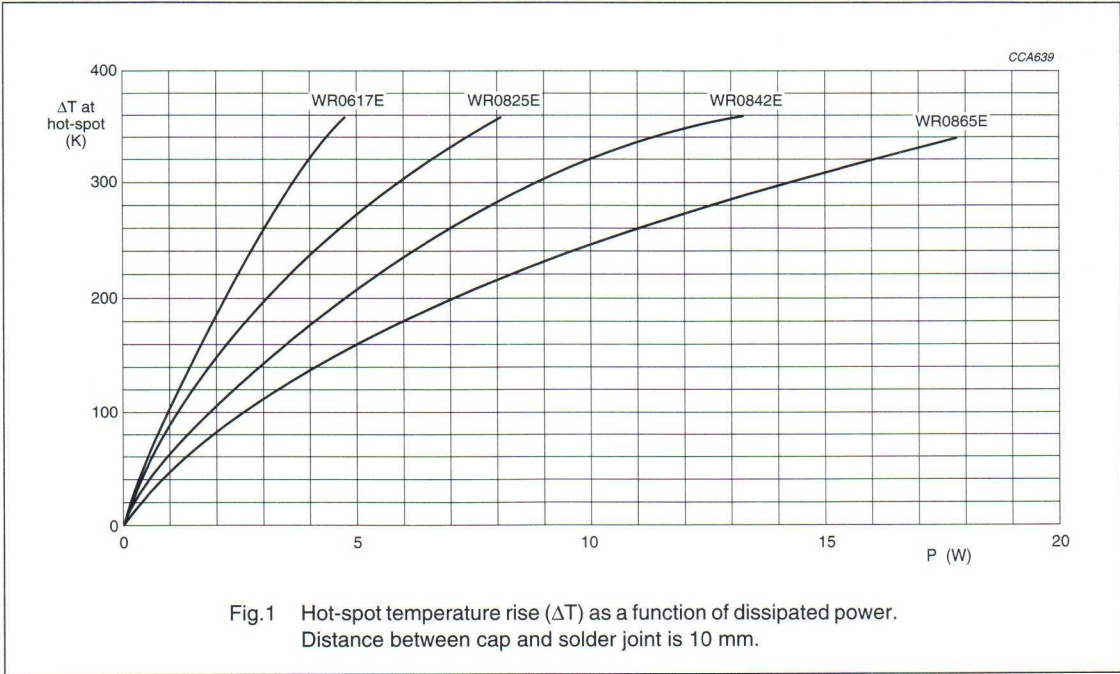
TYPE	LIMITING VOLTAGE ⁽¹⁾ (V)	LIMITING POWER (W)
WR0617E	$V = \sqrt{P_n \times R}$	4
WR0825E		7
WR0842E		11
WR0865E		17

Note

1. The maximum voltage that may be applied continuously to the resistor element, see "IEC publication 115-1".

The maximum permissible hot-spot temperature is 400 °C.

Application information



Enamelled wirewound resistors

WR0617E; WR0825E
WR0842E; WR0865E

MECHANICAL DATA

Mass per 100 units

TYPE	MASS (g)
WR0617E	115
WR0825E	210
WR0842E	335
WR0865E	450

Mounting

The resistors must be mounted in such a way that:

No stress is exerted on the leads, so as to allow thermal expansion over the wide temperature range.

Nearby components and materials are not affected by the dissipated heat.

Marking

Each resistor is marked with:

- Resistance value (R for Ω , K for $k\Omega$), e.g. $27\ \Omega = 27R$ and $27\ k\Omega = 27K$
- Tolerance on resistance in %
- Rated dissipation at $T_{amb} = 70\ ^\circ C$.

EXAMPLE

27R 5% 4W

Outlines

The length of the resistor body (L_1) is measured by inserting the leads into holes of two identical gauge plates and moving these plates parallel to each other until the resistor body is clamped without deformation ("*IEC publication 294*").

The diameter of the holes in the gauge plate is 1.0 mm.

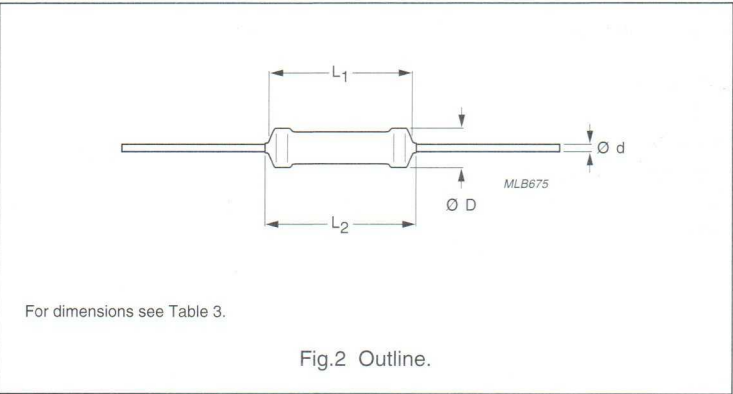


Table 3 Resistor type and relevant physical dimensions; see Fig.2

TYPE	$\varnothing D$ MAX. (mm)	L_1 MAX. (mm)	L_2 MAX. (mm)	$\varnothing d$ (mm)
WR0617E	6	17	23	0.7
WR0825E	8	26	32	0.8
WR0842E	8	44	50	0.8
WR0865E	8	67	73	0.8

Enamelled wirewound resistors

WR0617E; WR0825E
WR0842E; WR0865E

TESTS AND REQUIREMENTS

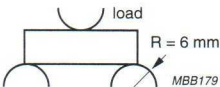
Essentially all tests are carried out in accordance with the schedule of "IEC publication 115-1", category 55/200/56 (rated temperature range -55°C to $+200^{\circ}\text{C}$; damp heat, long term, 56 days). The testing also covers the requirements specified by EIA and EIAJ.

The tests are carried out in accordance with IEC publication 68, "Recommended basic climatic and

mechanical robustness testing procedure for electronic components".

In Table 4 the tests and requirements are listed with reference to the relevant clauses of "IEC publications 115-1 and 68"; a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

Table 4 Test procedures and requirements

IEC 266 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
14		robustness of resistor body	load $200 \pm 10 \text{ N}$ 	no visible damage $\Delta R/R \text{ max.: } \pm 0.5\% \text{ or } 0.05 \Omega$
15	U Ua Ub Uc	robustness of terminations: tensile all samples bending half number of samples torsion other half of samples	load 10 N ; 10 s load 5 N ; $4 \times 90^{\circ}$ $2 \times 180^{\circ}$ in opposite directions	no visible damage $\Delta R/R \text{ max.: } \pm 0.5\% + 0.05 \Omega$
16	T	solderability	2 s ; 230°C ; flux 600	good tinning; no damage
		resistance to soldering heat	thermal shock: 3 s ; 350°C ; 6 mm from body	$\Delta R/R \text{ max.: } \pm 0.5\% + 0.05 \Omega$
17	Na	rapid change of temperature	30 minutes at -55°C and 30 minutes at $+200^{\circ}\text{C}$; 5 cycles	no visible damage $\Delta R/R \text{ max.: } \pm 1\% + 0.05 \Omega$
18	Fc	vibration	frequency $10 \text{ to } 500 \text{ Hz}$; displacement 0.75 mm or acceleration 10 g ; 3 directions ; total 6 hours ($3 \times 2 \text{ hours}$)	no visible damage $\Delta R/R \text{ max.: } \pm 0.5\% + 0.05 \Omega$
19	Eb	bump	$4000 \pm 10 \text{ bumps}$; 390 m/s^2	no damage $\Delta R/R \text{ max.: } \pm 0.5\% + 0.05 \Omega$

Enamelled wirewound resistors

WR0617E; WR0825E
WR0842E; WR0865E

IEC 266 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
20		climatic sequence:		
20.2	Ba	dry heat	16 hours; 200 °C	
20.3	D	damp heat (accelerated) 1st cycle	24 hours; 55 °C; 95 to 100% RH	
20.4	Aa	cold	2 hours; -55 °C	
20.5	M	low air pressure	1 hour; 8.5 kPa; 15 to 35 °C	
20.6	D	damp heat (accelerated) remaining cycles	5 days; 55 °C; 95 to 100% RH	after 24 hours at P_n : $\Delta R/R$ max.: $\pm 5\% + 0.1 \Omega$
21	Ca	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; dissipation $\leq 0.01 P_n$	after 24 hours at P_n : $\Delta R/R$ max.: $\pm 1\% + 0.05 \Omega$
22		endurance	1000 hours at 70 °C	$\Delta R/R$ max.: $\pm 5\% + 0.1 \Omega$
23		endurance at upper category temperature	1000 hours at 200 °C	$\Delta R/R$ max.: $\pm 5\% + 0.1 \Omega$
13.6		short time overload	dissipation $10 \times P_n$; 5 s; dissipation $2 \times P_n$; 10 minutes	$\Delta R/R$ max.: $\pm 2\% + 0.1 \Omega$

INDEX OF ORDERING CODE



Fixed Resistors

Index of ordering code

12-DIGIT ORDERING CODE

The resistors have a 12-digit ordering code starting with 2306, 2350 or 2322.

Subsequent digits indicate style, packaging, resistance value and tolerance. Refer to individual data sheets for detailed composition of the ordering code.

In Table 1 the 12NC is referenced to the applicable page number where a detailed composition will be found.

Table 1 First 7 digits of the ordering code

ORDERING CODE	PAGE
2306 (first 4 digits followed by next 3 digits)	
197	184
198	184
327	214
328	204
340	220
341	220
342	220
2350 (first 4 digits followed by next 2 digits)	
03	45
2322 (first 4 digits followed by next 3 digits)	
141	170
142	170
143	170
144	170
151	235
152	235
153	235
156	148
157	148
160	243
161	243
162	243
163	243
164	243
165	243
166	243
167	243
168	243
181	135
186	135
187	135
191	252

ORDERING CODE	PAGE
192	260
193	184
194	184
195	184
204	159
205	159
207	159
241	177
242	177
244	177
250 to 259	226
329	204
330	264
702	35
705	35
704	51
711	35
712	35
722	51
723	51
724	51, 67, 72
725	61
730	35
731	35
732	51
733	51
734	51
735	86
736	96
741	104
744	104
750	78

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DATA HANDBOOK SYSTEM

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DC04	Colour Monitor Tubes
DC05	Flyback Transformers, Mains Transformers and General-purpose FXC Assemblies

Magnetic products

MA01	Soft Ferrites
MA03	Piezoelectric Ceramics and Specialty Ferrites
MA04	Dry-reed Switches

Passive components

PA01	Electrolytic Capacitors
PA02	Varistors, Thermistors and Sensors
PA03	Potentiometers
PA04	Variable Capacitors
PA05	Film Capacitors
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IC03	Semiconductors for Wired Telecom Systems
IC04	HE4000B Logic Family CMOS
IC05	Advanced Low-power Schottky (ALS) Logic
IC06	High-speed CMOS Logic Family
IC11	General-purpose/Linear ICs
IC12	I ² C Peripherals
IC13	Programmable Logic Devices (PLD)
IC14	8048-based 8-bit Microcontrollers
IC15	FAST TTL Logic Series
IC16	CMOS ICs for Clocks and Watches
IC17	Semiconductors for Wireless Communications
IC18	Semiconductors for In-Car Electronics
IC19	ICs for Data Communications
IC20	80C51-based 8-bit Microcontrollers
IC22	Multimedia ICs
IC23	BiCMOS Bus Interface Logic
IC24	Low Voltage CMOS & BiCMOS Logic
IC25	16-bit 80C51XA Microcontrollers (eXtended Architecture)
IC26	IC Package Databook

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SC06	High-voltage and Switching NPN Power Transistors
SC07	Small-signal Field-effect Transistors
SC08a	RF Power Transistors for HF and UHF
SC08b	RF Power Transistors for UHF
SC09	RF Power Modules
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STANDARD SERIES OF VALUES IN A DECADE FOR RESISTANCES AND CAPACITANCES

According to "IEC publication 63".

E192	E96	E48	E192	E96	E48	E192	E96	E48	E192	E96	E48	E24	E12	E6	E3
100	100	100	178	178	178	316	316	316	562	562	562	10	10	10	10
101			180			320			569			11			
102	102		182	182		324	324		576	576		12	12		
104			184			328			583			13			
105	105	105	187	187	187	332	332	332	590	590	590	15	15	15	
106			189			336			597			16			
107	107		191	191		340	340		604	604		18	18		
109			193			344			612			20			
110	110	110	196	196	196	348	348	348	619	619	619	22	22	22	22
111			198			352			626			24			
113	113		200	200		357	357		634	634		27	27		
114			203			361			642			30			
115	115	115	205	205	205	365	365	365	649	649	649	33	33	33	
117			208			370			657			36			
118	118		210	210		374	374		665	665		39	39		
120			213			379			673			43			
121	121	121	215	215	215	383	383	383	681	681	681	47	47	47	47
123			218			388			690			51			
124	124		221	221		392	392		698	698		56	56		
126			223			397			706			62			
127	127	127	226	226	226	402	402	402	715	715	715	68	68	68	
129			229			407			723			75			
130	130		232	232		412	412		732	732		82	82		
132			234			417			741			91			
133	133	133	237	237	237	422	422	422	750	750	750				
135			240			427			759						
137	137		243	243		432	432		768	768					
138			246			437			777						
140	140	140	249	249	249	442	442	442	787	787	787				
142			252			448			796						
143	143		255	255		453	453		806	806					
145			258			459			816						
147	147	147	261	261	261	464	464	464	825	825	825				
149			264			470			835						
150	150		267	267		475	475		845	845					
152			271			481			856						
154	154	154	274	274	274	487	487	487	866	866	866				
156			277			493			876						
158	158		280	280		499	499		887	887					
160			284			505			898						
162	162	162	287	287	287	511	511	511	909	909	909				
164			291			517			920						
165	165		294	294		523	523		931	931					
167			298			530			942						
169	169	169	301	301	301	536	536	536	953	953	953				
172			305			542			965						
174	174		309	309		549	549		976	976					
176			312			556			988						

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