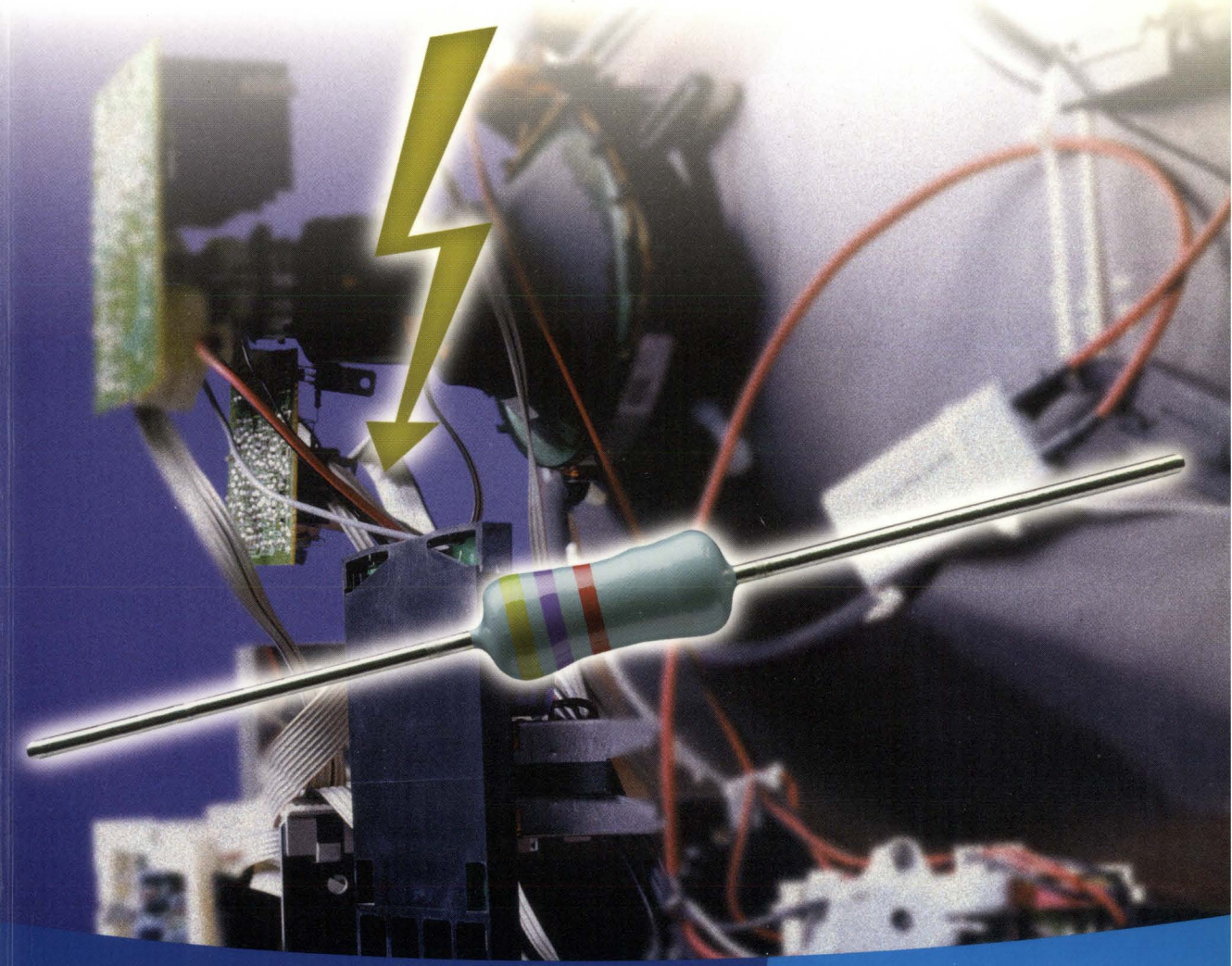
PASSIVE COMPONENTS

Leaded Fixed Linear Resistors

1998/1999

Data Handbook PA08b



PHILIPS

Let's make things better.

Welcome to the European edition of Philips Components' Leaded Resistor Data Handbook. The wide range of our 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.

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

- **Film resistors.** For all general purpose consumer and industrial equipment. They are subdivided into metal-glaze, metal-film 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 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.

Leaded Fixed Linear Resistors

CONTENTS

DEFINITIONS

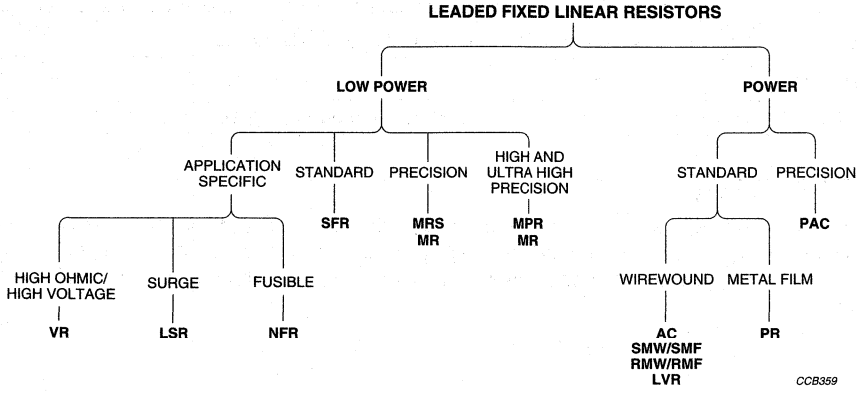
Data sheet status	
Objective specification	This data sheet contains target or goal specifications for product development.
Preliminary specification	This data sheet contains preliminary data; supplementary data may be published later.
Product specification	This data sheet contains final product specifications.
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.

Leaded fixed linear resistors

Resistor programme



Leaded fixed linear resistors — Selection guide

APPLICATION	TYPE	TOLERANCE (%)	RESISTANCE RANGE	DISSIPATION		PAGE
				at °C	W	
Metal film						
Standard	SFR16S	5	1 Ω to 3 MΩ	70	0.50	26
	SFR25		1 Ω to 10 MΩ		0.40	
	SFR25H				0.50	
Metal film	MRS16S	1	4.99 Ω to 1 MΩ	70	0.40	39
	MRS25		1 Ω to 10 MΩ		0.60	
Fusible	NFR25	5	1 Ω to 15 kΩ	70	0.33	51
	NFR25H				0.50	
Precision	MPR24	0.05; 0.02; 0.01	24 Ω to 100 kΩ	70	0.125	61
	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	68
			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 ohmic/high voltage	VR25	1; 5; 10	100 kΩ to 22 MΩ	70	0.25	91
	VR37	1; 5	100 kΩ to 33 MΩ		0.50	97
	VR68		100 kΩ to 68 MΩ		1.0	103
High voltage surge	LSR37	10; 20	900 Ω to 10 kΩ	70	0.5	109

Leaded fixed linear resistors — Selection guide

APPLICATION	TYPE	TOLERANCE (%)	RESISTANCE RANGE	DISSIPATION		PAGE
				at °C	W	
Wirewound						
Cemented	AC01	5	0.1 Ω to 2 kΩ	40	1	115
	AC03		0.1 Ω to 4.7 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 27 kΩ		10	
	AC15		0.82 Ω to 39 kΩ		15	
	AC20		1.2 Ω to 56 kΩ		20	
Precision	PAC01	1	0.22 Ω to 2.2 kΩ	25	1	137
	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	
Low ohmic values	LVR05	5	0.01 Ω to 0.10 Ω	70	5	143
Stand up						
Miniature power	SMW02; SMF02	5	0.1 Ω to 47 kΩ	70	2	150
	SMW03; SMF03				3	
	SMW05; SMF05				5	
Radial						
Power	RMW03; RMF03	5 and 10	0.22 Ω to 39 kΩ	70	3	156
	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	
	RMW15		1 Ω to 10 kΩ		15	
	RMW20		1.5 Ω to 15 kΩ		20	
Maintenance types (not for new designs)						
Metal film	MR25	0.5	1 Ω to 1 MΩ	70	0.40	164
	MR30				0.50	
MIL metal film	MR24D	1	10 Ω to 1 MΩ	70	0.125	172
	MR34D				0.25	
	MR24E/C	0.1; 0.25; 0.5; 1	49.9 Ω to 1 MΩ	125	0.1	
	MR34E/C				0.125	

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
  - Outlines
  - Mass
  - Marking
  - Mounting
- TESTS AND REQUIREMENTS

The chapters listed above are explained in this section *"General introduction Leaded fixed linear 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 60068-2-45"*.

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 60115-1 and 60115-2"*.
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.

Summarizing

DESCRIPTION	RELATIONSHIP
Dimensions and conductance of materials determine	heat resistance
Heat resistance × 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.

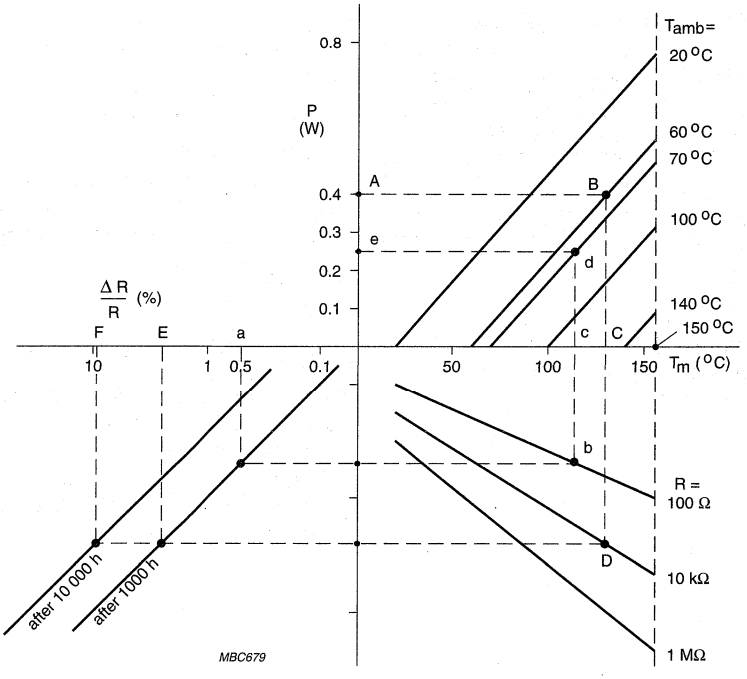


Fig.1 Performance nomogram (for a fictitious resistor) illustrating the way of specifying the performance of film resistors.

Example 1

Assume that a 10 kΩ resistor, whose characteristics are described by the nomogram, is to be operated at a power dissipation of 0.4 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 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 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 kΩ 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).

Example 2

Assume that a 100 Ω resistor, whose characteristics are described by the nomogram, is to be operated at an ambient temperature of 70 °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 Ω resistance line at point b, corresponding to a hot-spot temperature of 112 °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 °C at point d, corresponding to a maximum permissible power dissipation of 0.25 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 ($\times 10^{-6}$/K).

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

at 25 °C:

1000000 Ω (nominal = rated value)

at +155 °C:

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

at −55 °C:

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

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

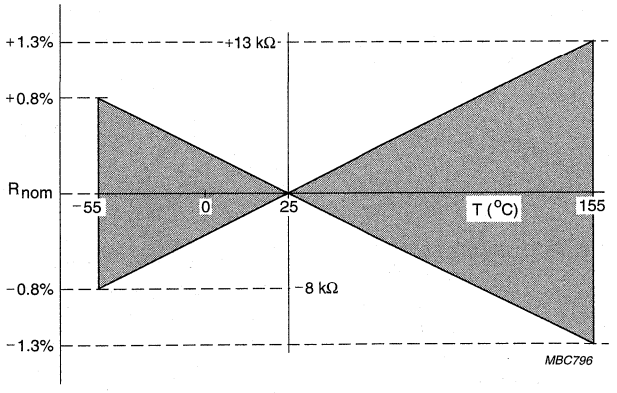


Fig.2 Temperature coefficient.

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 = 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.

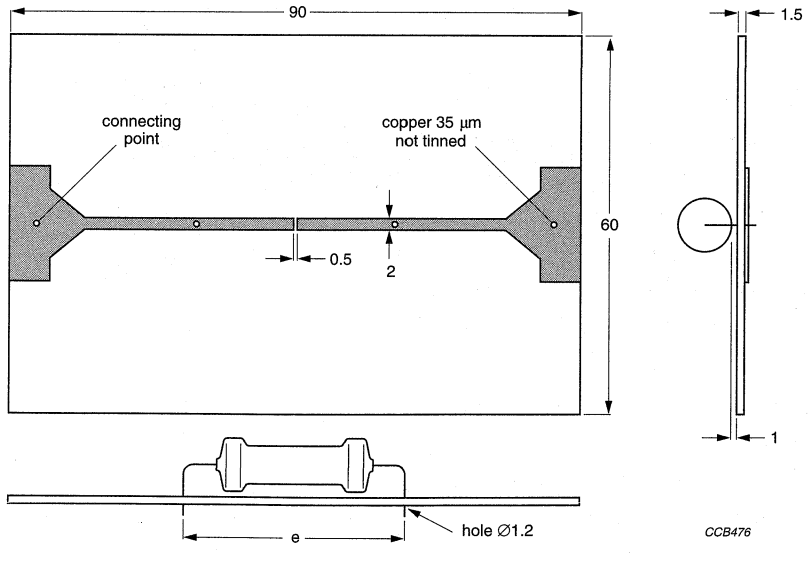
PULSE-LOAD BEHAVIOUR

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 ($\hat{P}_{max}$) 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.



Dimensions in mm.

Fig.3 Mounting dimensions.

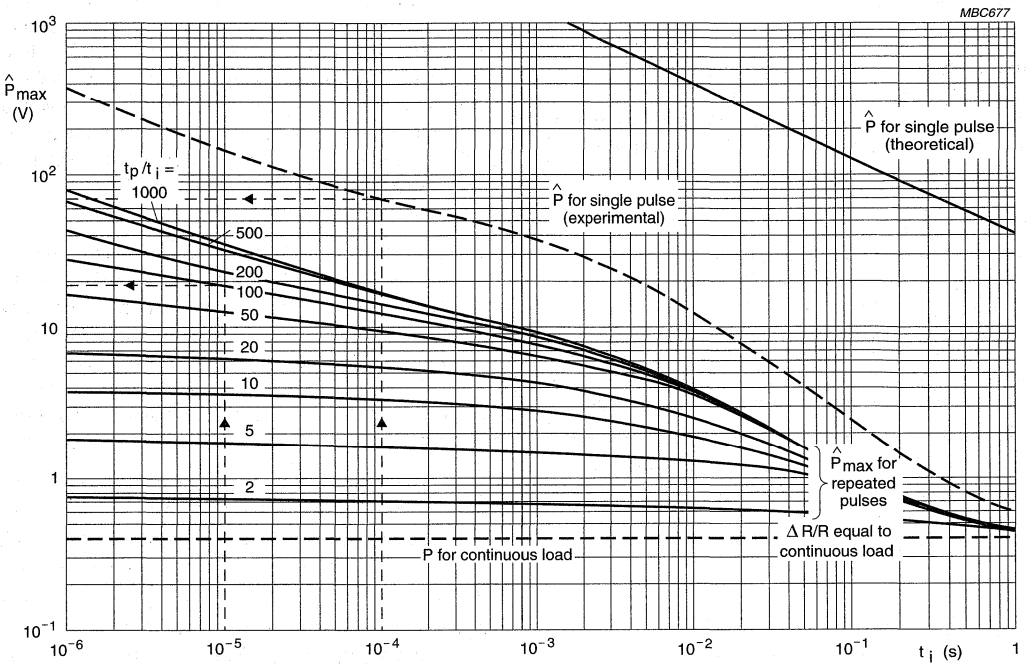


Fig.4 Maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i) for a typical resistor.

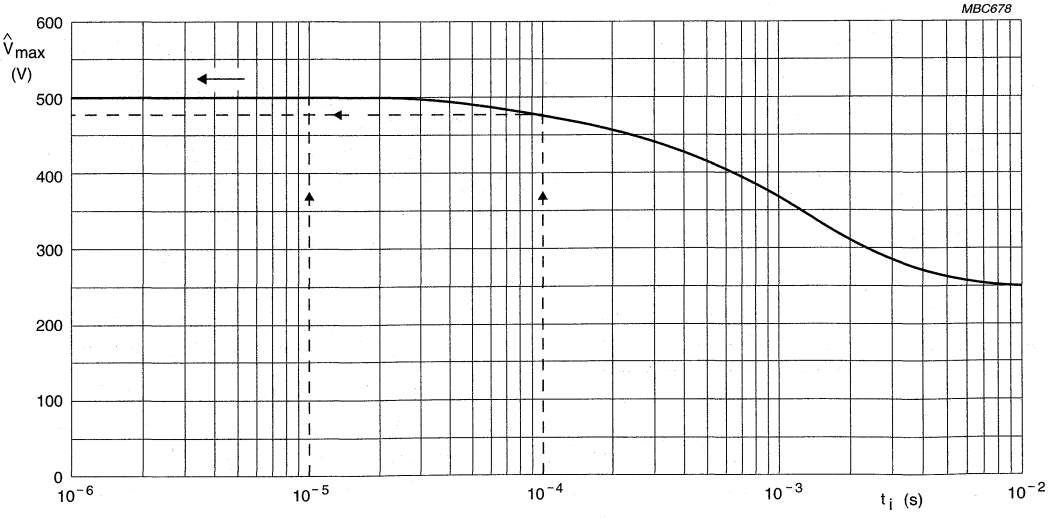


Fig.5 Maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_i) for a typical resistor.

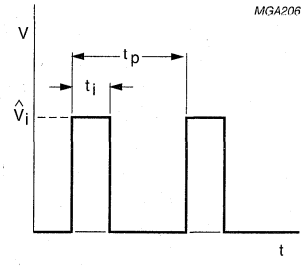


Fig.6 Rectangular pulses.

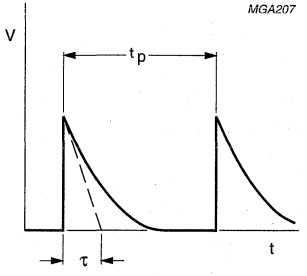


Fig.7 Exponential pulses.

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
$T_{m(max)}$	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_{amb} = 70 °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.

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:

$\hat{V}_i = 200$ V; $t_i = 10^{-4}$ 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 (∅D) and the lead diameter (∅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 60194")*.

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

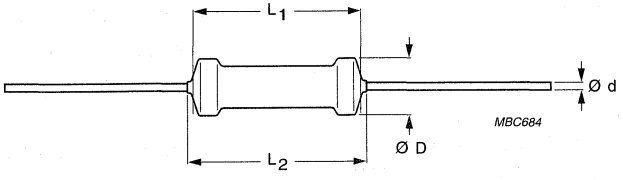
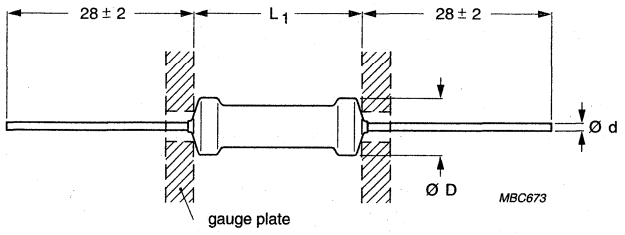


Fig.8 Component outline.



Dimensions in mm.
For dimensions see Table 1.

Fig.9 Measurement of dimension L_1.

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

∅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 60062: *"Colour code for fixed resistors"*. See also *"IEC 60115-1"*, 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.

For safety reasons the coloured tolerance rings on the types *"VR25, VR37, VR68 and LSR37"* are yellow (instead of gold) for 5% and grey (instead of silver) for 10%.

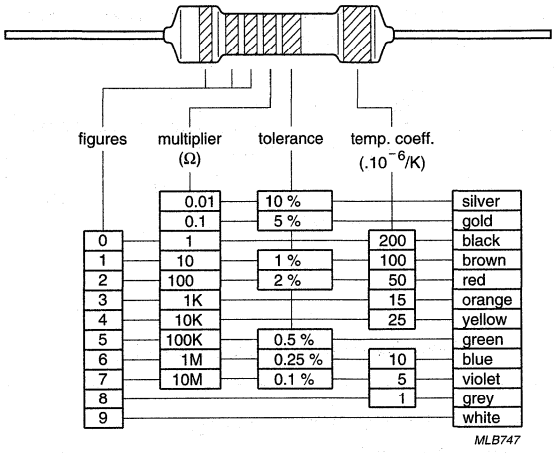


Fig.10 Marking.

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: ±2% and higher requires two bands; ±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 60063"* 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 and MR34E/C/D. Resistors outside the standard *"IEC 60063"* 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
Light green	SFR25
Grey	NFR25, NFR25H
Green	MR25, MR30, MR24E/C/D, MR34E/C/D, MPR24, MPR34, MRS16S, MRS25, AC01/03/04/05/07/10/15/20, PAC01/02/03/04/05/06
Light blue	VR25, VR37, VR68, SFR16S, LSR37
Red	PR01, PR02, PR03
Red-brown	SFR25H
Ceramic encased	LVR05, SMW/SMF02/03/05, RMW03/05/07/10/15/20, RMF03/05/07/10

Mounting

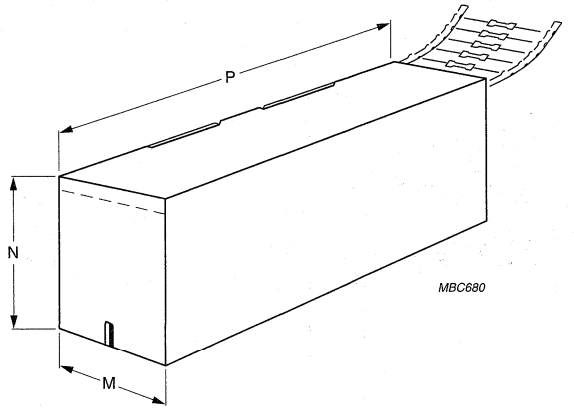
Most types with straight axial leads and most in the 'stand-up' version are suitable for processing on automatic insertion equipment, cutting and bending machines.

TESTS AND REQUIREMENTS

Essentially all tests on resistors are carried out in accordance with the schedule of *"IEC publication 60115-1"* in the specified climatic category and in accordance with IEC publication 60068: *"Recommended basic climatic and mechanical robustness testing procedure for electronic components"*. In some instances deviations from the IEC recommendations are made.

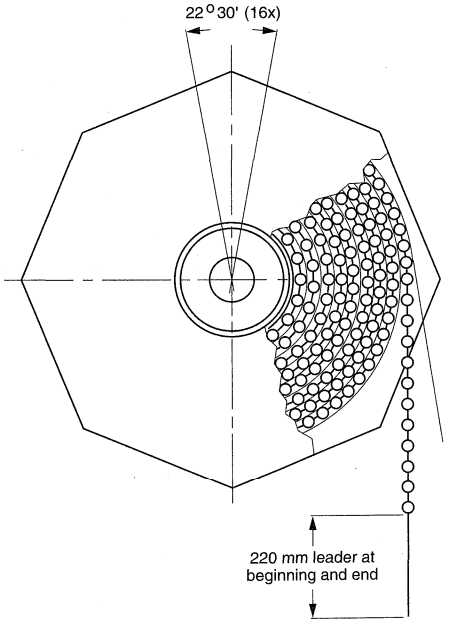
PACKAGING

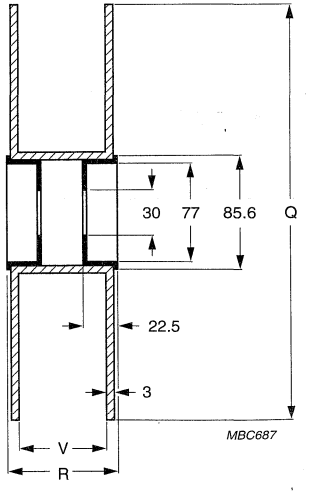
Dimensions of ammopack and reel



For dimensions see Table 1.

Fig.1 Bandolier in ammopack.

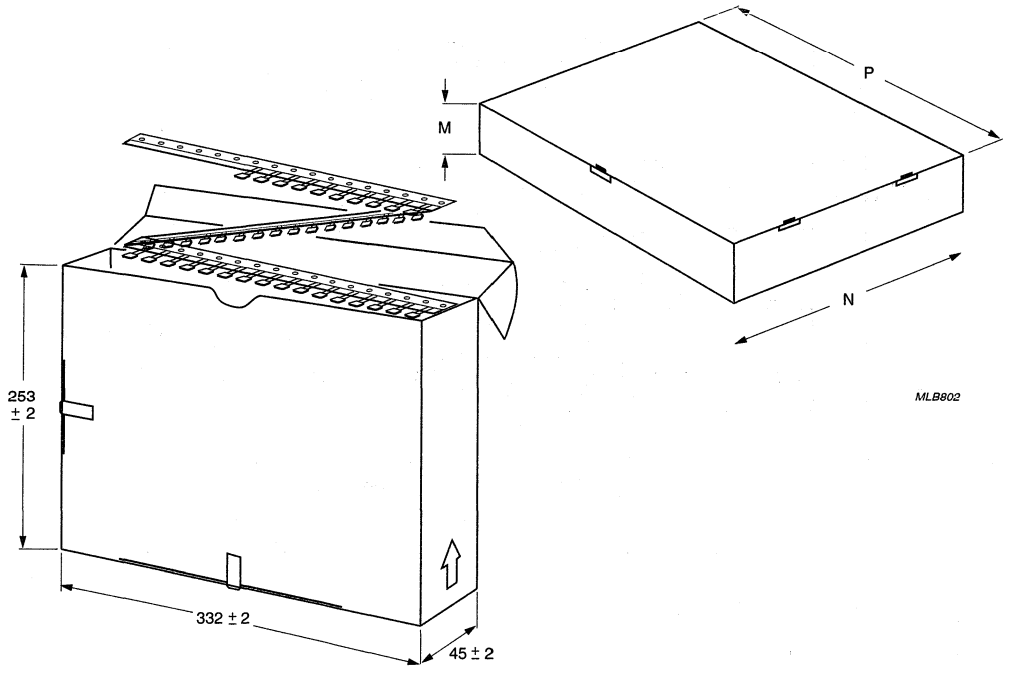




Dimensions in mm.

For dimensions see Table 2.

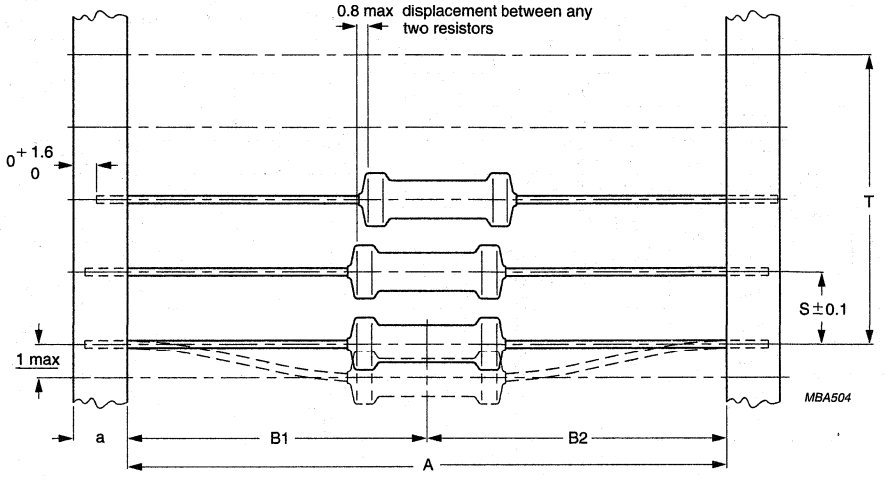
Fig.2 Bandolier on reel.



Dimensions in mm.
For dimensions see Table 5.

Fig.3 Dimensions of ammopack (radial taped).

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 ammopack; see Figs 1 and 4

PRODUCT TYPE	QUANTITY	PACKAGING DIMENSIONS						
		AXIAL TAPED ON BANDOLIER				AMMOPACK		
		a (mm)	A (mm)	$\lvert B_1 - B_2 \rvert$ (mm)	S (mm)	M (mm)	N (mm)	P (mm)
SFR16S	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
MRS16S	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

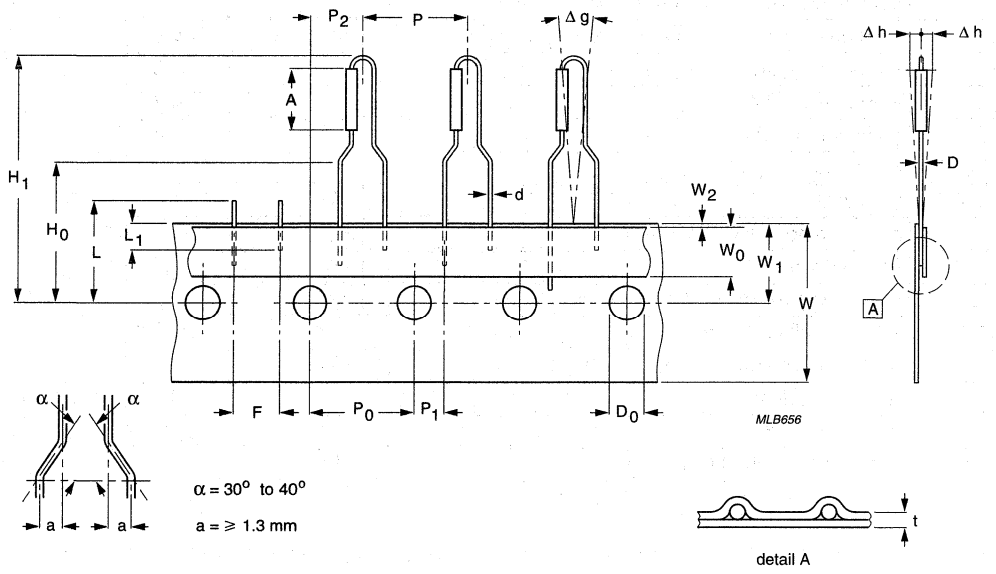
Leaded fixed linear resistors — Packaging

PRODUCT TYPE	QUANTITY	PACKAGING DIMENSIONS						
		AXIAL TAPED ON BANDOLIER				AMMOPACK		
		a (mm)	A (mm)	$\lvert B_1 - B_2 \rvert$ (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
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
LSR37	1000	6 ±0.5	52 +1.5/–0	±1.2	5	83	60	262
PR01	1000	6 ±0.5	73 ±1.5	±1.2	5	97	28	262
PR01	5000	6 ±0.5	52 +1.5/–0	±1.2	5	78	98	270
PR02	1000	6 ±0.5	73 ±1.5	±1.2	5	97	59	262
PR02	1000	6 ±0.5	52 +1.5/–0	±1.2	5	83	60	262
PR03	500	6 ±0.5	80 ±1.5	±1.2	10	99	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
PAC01	500	6 ±0.5	63 ±1	±1.2	10	85	60	263
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

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)	$\lvert B_1 - B_2 \rvert$ (mm)	S (mm)	Q (mm)	V (mm)	R (mm)
SFR16S	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
MRS16S	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	99
MPR34	5000	6 ±0.2	63.5 ±1.5	±1.2	5	356	90	99
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
LSR37	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	99

Products with radial leads



For dimensions see Tables 3 and 4.

Fig.5 Bandolier for types 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

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	±3°	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 ammopack; 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

PRODUCT SPECIFICATIONS

Standard metal film resistors SFR16S/25/25H

FEATURES

- Low cost
- Low noise
- Small size (SFR16S).

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 SFR16S; 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 60068-2045"*.

QUICK REFERENCE DATA

DESCRIPTION	VALUE		
	SFR16S	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	$\leq \pm 250 \times 10^{-6}$/K	$\leq \pm 100 \times 10^{-6}$/K	$\leq \pm 100 \times 10^{-6}$/K
4.7 Ω ≤ R ≤ 100 kΩ	$\leq \pm 100 \times 10^{-6}$/K	$\leq \pm 100 \times 10^{-6}$/K	$\leq \pm 100 \times 10^{-6}$/K
100 kΩ < R ≤ 1 MΩ	$\leq \pm 250 \times 10^{-6}$/K	$\leq \pm 100 \times 10^{-6}$/K	$\leq \pm 100 \times 10^{-6}$/K
R > 1 MΩ	$\leq \pm 250 \times 10^{-6}$/K	$\leq \pm 250 \times 10^{-6}$/K	$\leq \pm 250 \times 10^{-6}$/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 60115-1 and 60115-2		
Climatic category (IEC 60068)	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

ORDERING INFORMATION

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
SFR16S	–	22 187 73...	22 187 53...	22 187 83...
SFR25	06 184 03...	22 181 53...	22 181 43...	22 181 63...
SFR25 jumper(1)	–	–	22 181 90019	–
SFR25H	–	22 186 16...	22 186 76...	22 186 26...

Note

1. The jumper has a maximum resistance R_{max} = 10 mΩ at 5 A.

Ordering code (12NC)

- The resistors have a 12-digit ordering code starting with 23
- The subsequent 7 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

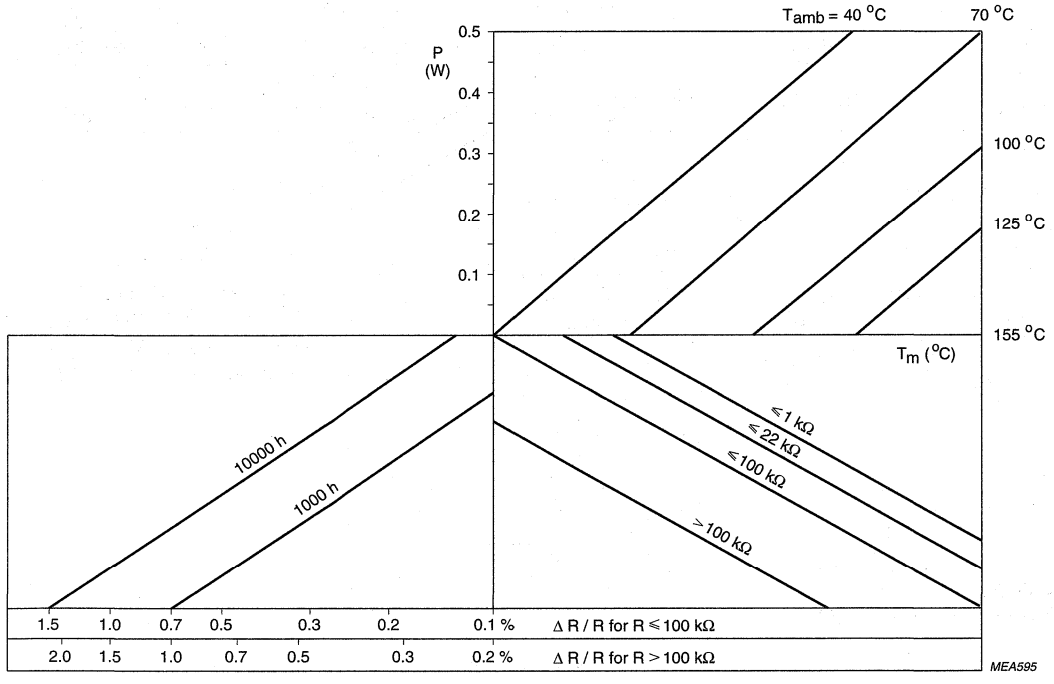
ORDERING EXAMPLE

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

FUNCTIONAL DESCRIPTION

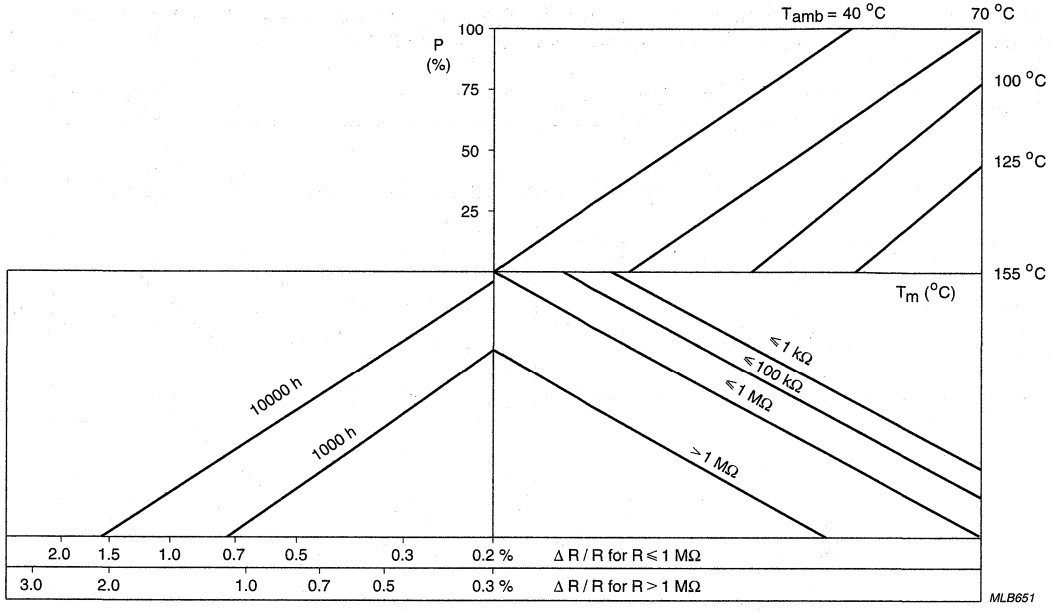
Product characterization

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 60063"*.



SFR16S

Fig.1 Drift nomogram.



SFR25(H)
P_n = 0.4 W (**SFR25**) or 0.5 W (**SFR25H**).

Fig.2 Drift nomogram.

Limiting values

TYPE	LIMITING VOLTAGE[1] (V)	LIMITING POWER (W)
SFR16S	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 60115-1"*.

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.

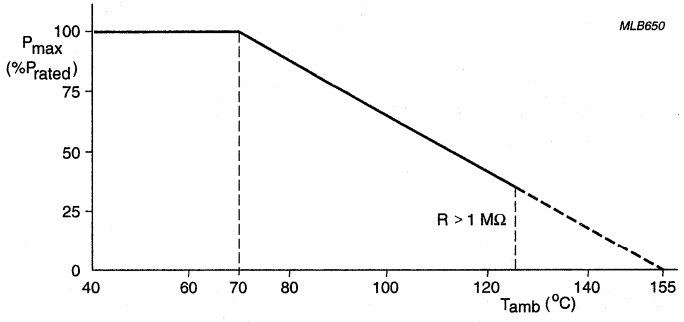
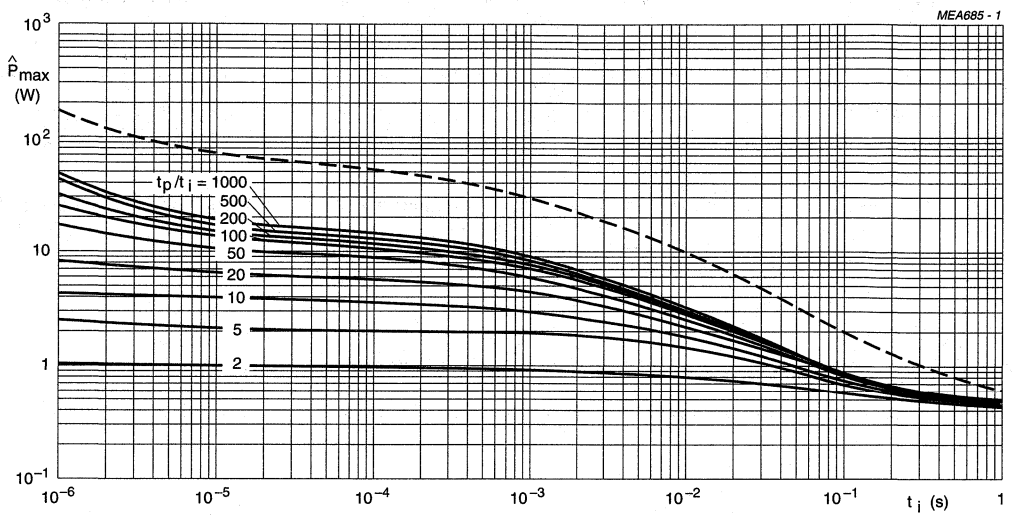


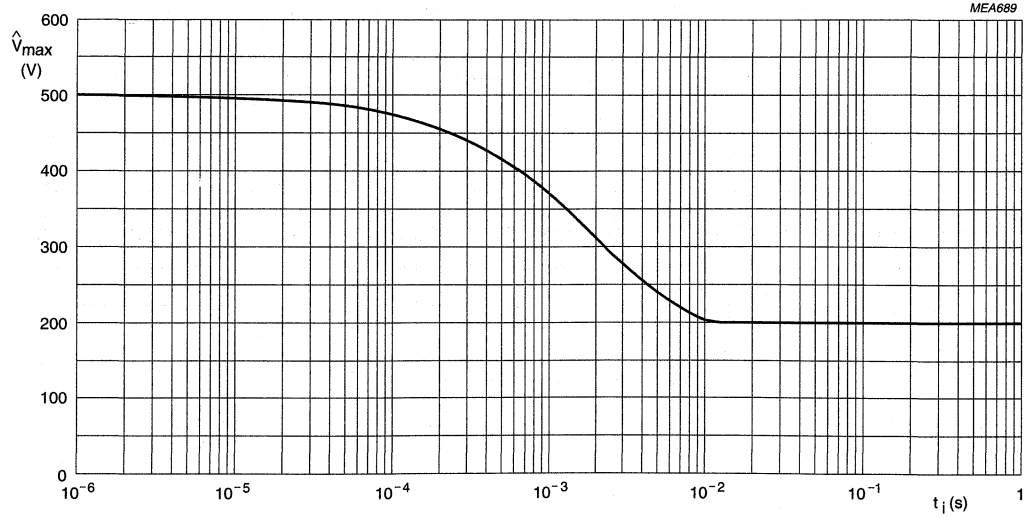
Fig.3 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

PULSE LOADING CAPABILITIES



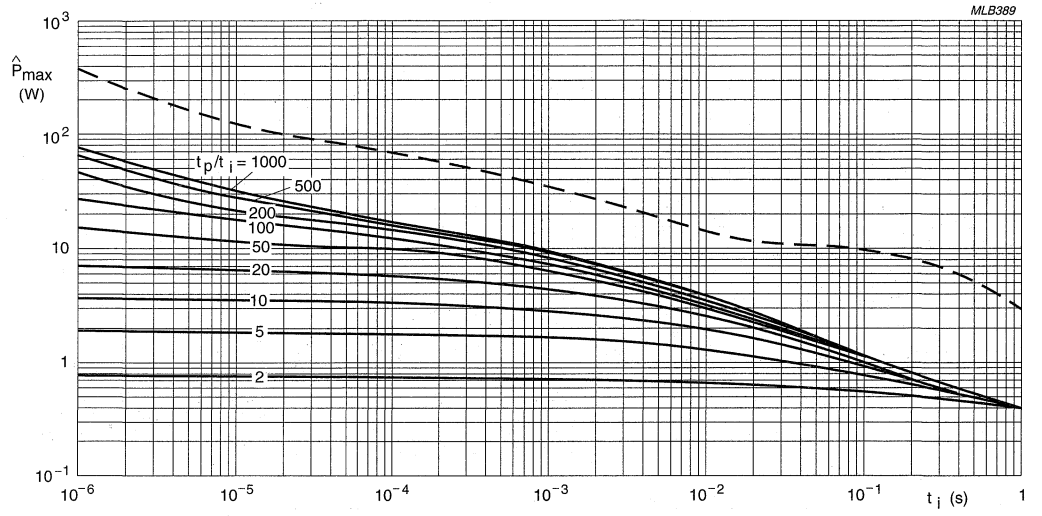
SFR16S

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



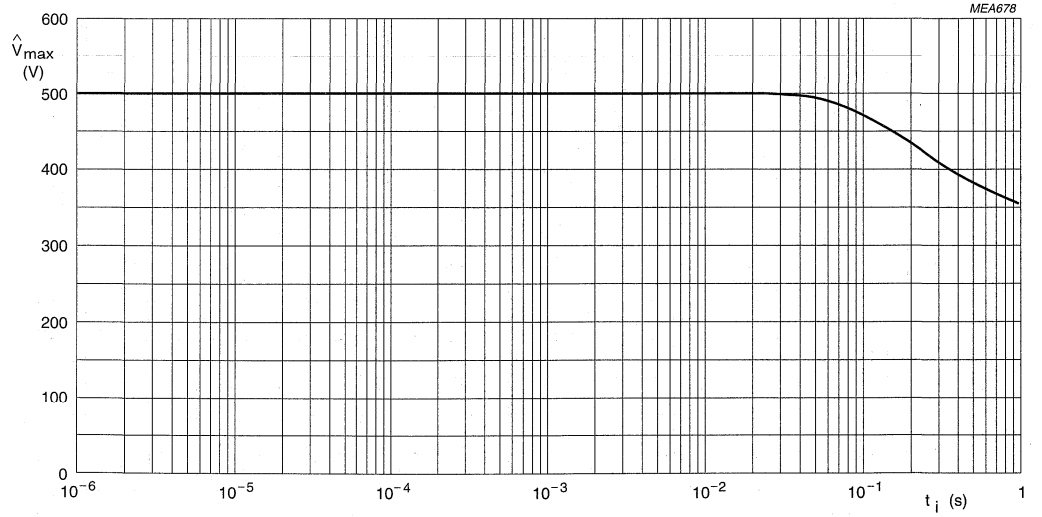
SFR16S

Fig.5 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_i).



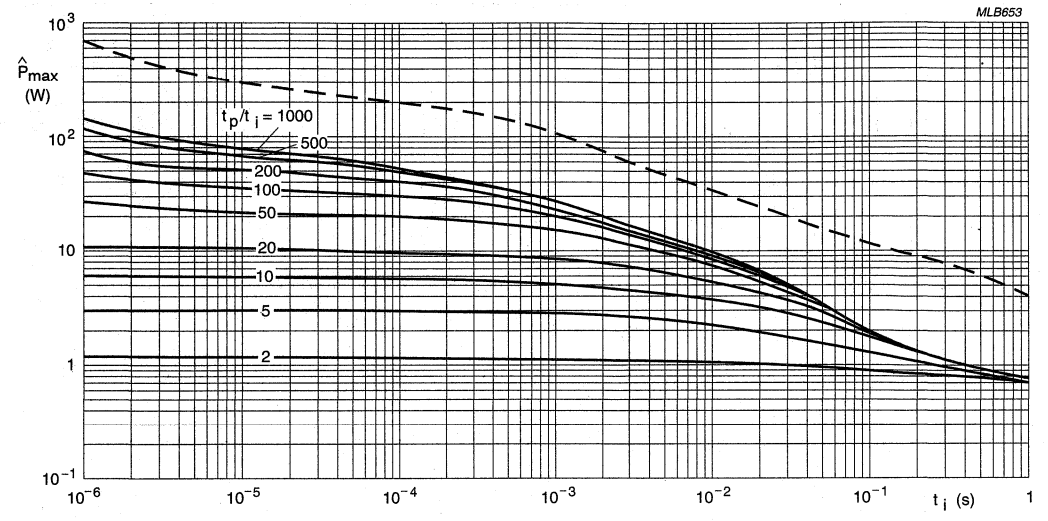
SFR25

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



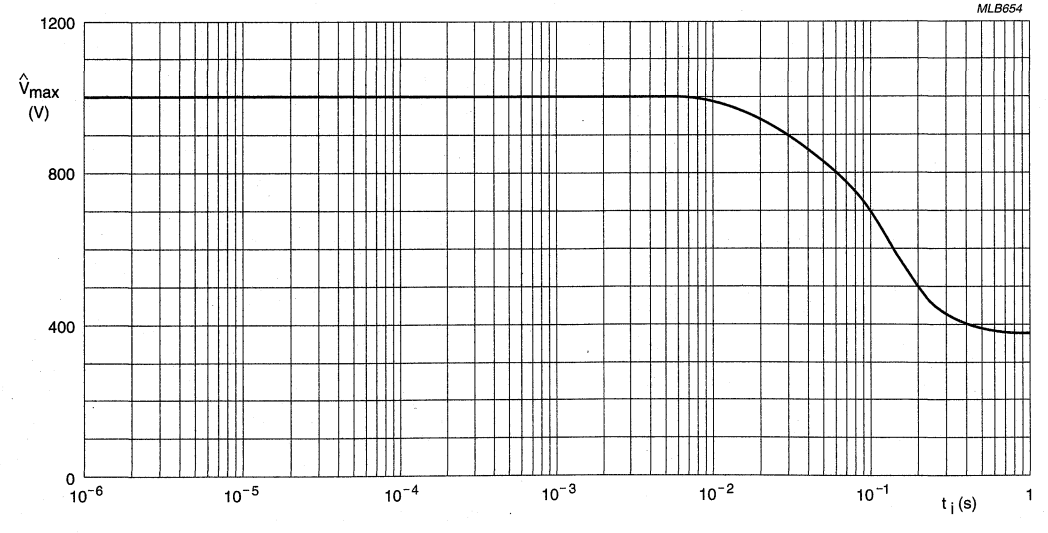
SFR25

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



SFR25H

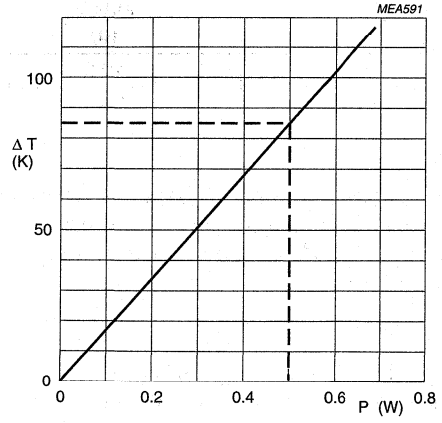
Fig.8 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i).



SFR25H

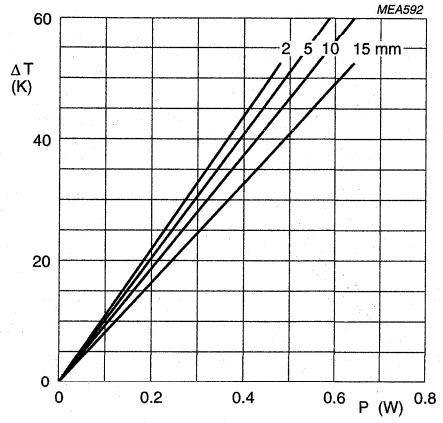
Fig.9 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_i).

Application information



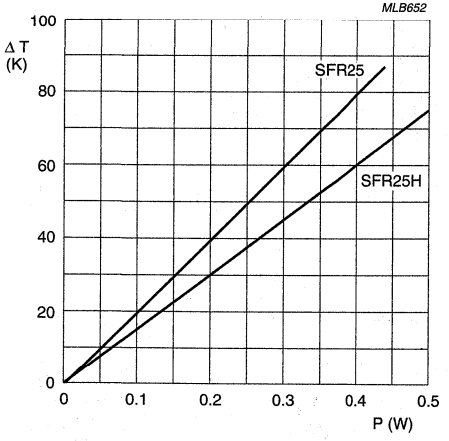
SFR16S

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



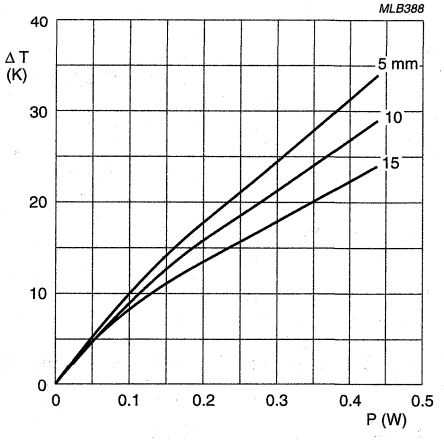
SFR16S

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



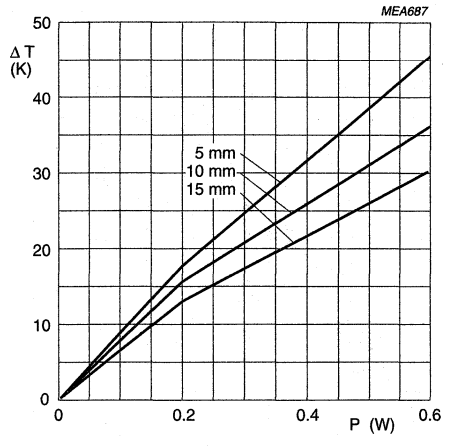
SFR25/SFR25H

Fig.12 Hot-spot temperature rise (ΔT) as a function of dissipated power.



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.



SFR25H

Fig.14 Temperature rise (ΔT) at the end of the lead (soldering point) as a function of dissipated power at various lead lengths after mounting.

MECHANICAL DATA

Mass per 100 units

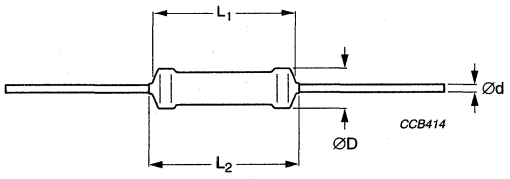
TYPE	MASS (g)
SFR16S	12.5
SFR25	25

Marking

The nominal resistance and tolerance are marked on the resistor using four or five coloured bands in accordance with IEC publication 60062 *"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 60294")*.



For dimensions see Table 3.

Fig.15 Outline.

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)
SFR16S	1.9	3.2	3.4	0.45 ±0.05
SFR25	2.5	6.5	7.0	0.58 ±0.05
SFR25H	2.5	6.5	7.0	0.58 ±0.05

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of *"IEC publication 60115-1"*, 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 60068-1"*, 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 60115-1 and 60068"*; 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 60115-1 CLAUSE	IEC 60068 TEST METHOD	TEST	PROCEDURE	RESISTANCE RANGE	REQUIREMENTS		
					SFR16S	SFR25	SFR25H
4.16	U	robustness of terminations:					
4.16.2	Ua	tensile all samples	∅0.45 mm, load 5 N; 10 s ∅0.58 mm, load 10 N; 10 s		number of failures $<10 \times 10^{-6}$		
4.16.3	Ub	bending half number of samples	∅0.45 mm, load 2.5 N; 4 × 90° ∅0.58 mm, load 5 N; 4 × 90°		number of failures $<10 \times 10^{-6}$		
4.16.4	Uc	torsion other half of samples	3 × 360° in opposite directions		no damage ΔR/R max.: ±0.25% + 0.05 Ω		
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		ΔR/R max.: ±0.25% + 0.05 Ω		
4.19	Na	rapid change of temperature	30 minutes at –55 °C and 30 minutes at +155 °C; 5 cycles		ΔR/R max.: ±0.25% + 0.05 Ω		
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		

IEC 60115-1 CLAUSE	IEC 60068 TEST METHOD	TEST	PROCEDURE	RESISTANCE RANGE	REQUIREMENTS		
					SFR16S	SFR25	SFR25H
4.23		climatic sequence:			R_{ins} min.: 1000 MΩ		
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 ≤ 1 MΩ	ΔR/R max.: ±1% + 0.05 Ω		
				R > 1 MΩ	ΔR/R max.: ±1% + 0.05 Ω		ΔR/R max.: ±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 MΩ ΔR/R max.: ±1% + 0.05 Ω		
4.25.1		endurance	1000 hours at 70 °C; P_n or V_{max}	R ≤ 1 MΩ	ΔR/R max.: ±1% + 0.05 Ω		
				R > 1 MΩ	ΔR/R max.: ±1% + 0.05 Ω		ΔR/R max.: ±2% + 0.1 Ω
4.8.4		temperature coefficient	between –55 °C and +155 °C (TC × 10^{-6}/K)	R < 4.7 Ω	≤±250	≤±100	≤±100
				R ≤ 100 kΩ	≤±100	≤±100	≤±100
				R ≤ 1 MΩ	≤±250	≤±100	≤±100
				R > 1 MΩ	≤±250	≤±250	≤±250
4.7		voltage proof on insulation	400 V (RMS) (**SFR16S**) or 600 V (RMS) (**SFR25** and **SFR25H**); during 1 minute; V-block method		no breakdown		
4.12		noise	*"IEC publication 60195"*	R < 68 kΩ	max. 0.1 μV/V	max. 0.1 μV/V	max. 0.1 μV/V
				R ≤ 100 kΩ	max. 0.5 μV/V	max. 0.1 μV/V	max. 0.1 μV/V
				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
4.6.1.1		insulation resistance	500 V (DC) during 1 minute; V-block method		R_{ins} min.: 1000 MΩ		

IEC 60115-1 CLAUSE	IEC 60068 TEST METHOD	TEST	PROCEDURE	RESISTANCE RANGE	REQUIREMENTS		
					SFR16S	SFR25	SFR25H
4.13		short time overload	room temperature; $P = 6.25 \times P_n$ (**SFR25**) or 6.25×0.25 W (**SFR16S**); 5 s on, 45 s off ($V \leq 2 \times V_{max}$); 10 cycles		ΔR/R max.: ±0.25% + 0.05 Ω		ΔR/R max.: ±1% + 0.05 Ω
		intermittent overload in accordance with *"JIS-C5202 5.8"*	16×0.16 W; 1 s on and 25 s off; 10000 ±200 cycles; V_{max} = 600 V		ΔR/R max.: ±0.75% + 0.05 Ω	–	–
see 2nd amendment to *"IEC 60115-1"*, Jan. '87		pulse load			see Figs 4, 5, 6, 7, 8 and 9		

Metal film resistors — MRS16S/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 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 60068-2-45"*.

QUICK REFERENCE DATA

DESCRIPTION	VALUE	
	MRS16S	MRS25
Resistance range	4.99 Ω to 1 MΩ	1 Ω to 10 MΩ
Resistance tolerance and series	±1%; E24/E96 series	
Maximum dissipation at T_{amb} = 70 °C	0.4 W	0.6 W
Thermal resistance (R_{th})	170 K/W	150 K/W
Temperature coefficient	$\leq \pm 50 \times 10^{-6}$/K	
Maximum permissible voltage (DC or RMS)	200 V	350 V
Basic specifications	IEC 60115-1 and 60115-2	
Climatic category (IEC 60068)	55/155/56	
Stability after:		
load:		
R ≤ 100 kΩ	ΔR/R max.: ±0.5% + 0.05 Ω	ΔR/R max.: ±0.5% + 0.05 Ω
R > 100 kΩ	ΔR/R max.: ±1% + 0.05 Ω	ΔR/R max.: ±0.5% + 0.05 Ω
climatic tests:		
R ≤ 100 kΩ	ΔR/R max.: ±0.5% + 0.05 Ω	ΔR/R max.: ±0.5% + 0.05 Ω
R > 100 kΩ	ΔR/R max.: ±1% + 0.05 Ω	ΔR/R max.: ±0.5% + 0.05 Ω
soldering:		
R ≤ 100 kΩ	ΔR/R max.: ±0.1% + 0.05 Ω	ΔR/R max.: ±0.1% + 0.05 Ω
R > 100 kΩ	ΔR/R max.: ±0.25% + 0.05 Ω	ΔR/R max.: ±0.1% + 0.05 Ω
short time overload	ΔR/R max.: ±0.25% + 0.05 Ω	ΔR/R max.: ±0.25% + 0.05 Ω

ORDERING INFORMATION

Table 1 Ordering code indicating resistor type and packaging

TYPE	ORDERING CODE 2322 15.		
	BANDOLIER IN AMMOPACK		BANDOLIER ON REEL
	1000 units	5000 units	5000 units
MRS16S	7 1....	7 2....	7 3....
MRS25	6 1....	6 2....	6 3....

Ordering code (12NC)

- The resistors have a 12-digit ordering code starting with 2322 15
- The subsequent 2 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 kΩ	2
10 to 97.6 kΩ	3
100 to 976 kΩ	4
1 to 9.76 MΩ	5
10 MΩ	6

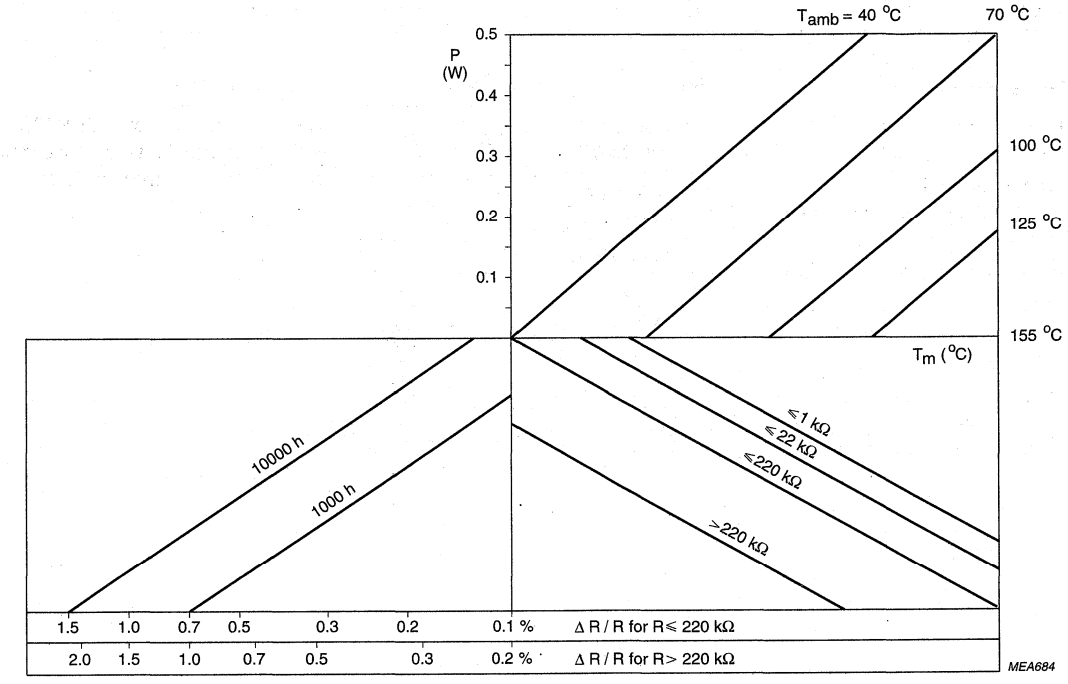
ORDERING EXAMPLE

The ordering code of a MRS16S resistor, value 750 Ω, on a bandolier of 1000 units in ammopack is: 2322 157 17501.

FUNCTIONAL DESCRIPTION

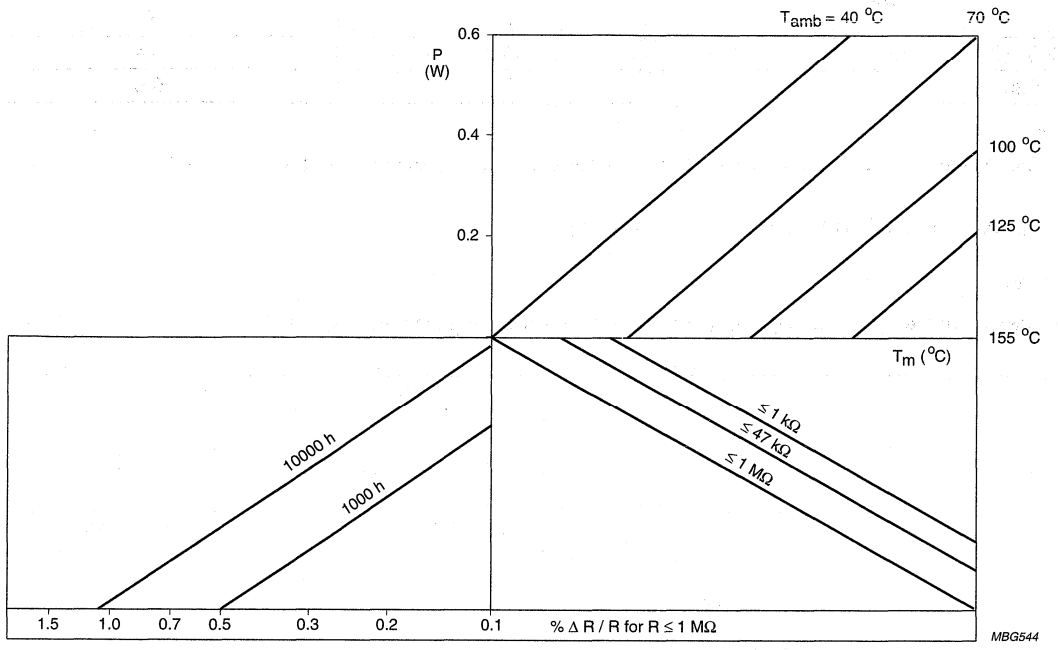
Product characterization

Standard values of nominal resistance are taken from the E24/E96 series for resistors with a tolerance of ±1%. The values of the E24/E96 series are in accordance with *"IEC publication 60063"*.



MRS16S

Fig.1 Drift nomogram.



MRS25

Fig.2 Drift nomogram.

Limiting values

TYPE	LIMITING VOLTAGE(1) (V)	LIMITING POWER (W)
MRS16S	200	0.4
MRS25	350	0.6

Note

1. The maximum voltage that may be continuously applied to the resistor element, see *"IEC publication 60115-1"*.

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.

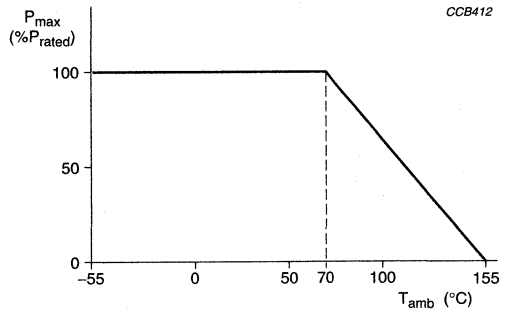
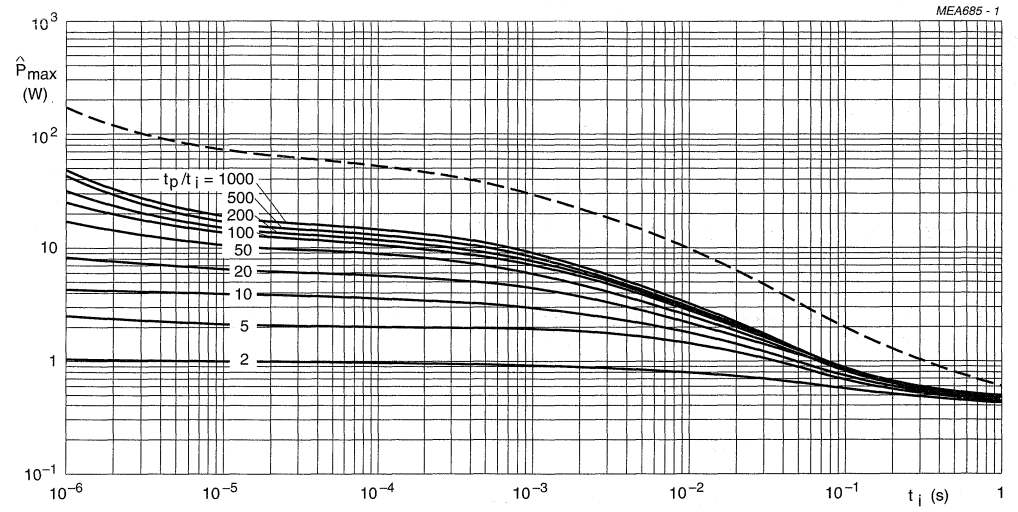


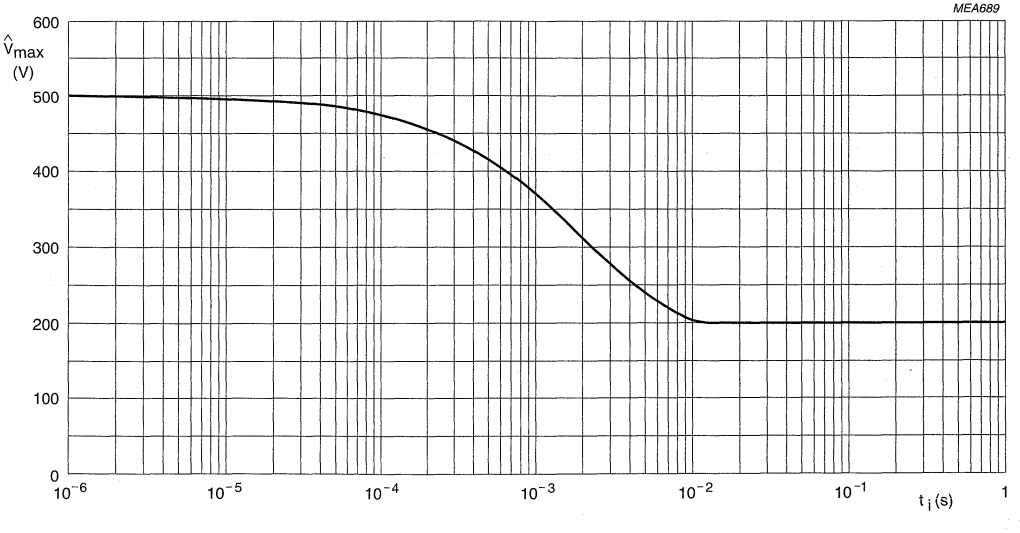
Fig.3 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

PULSE LOADING CAPABILITIES



MRS16S

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



MRS16S

Fig.5 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_j).

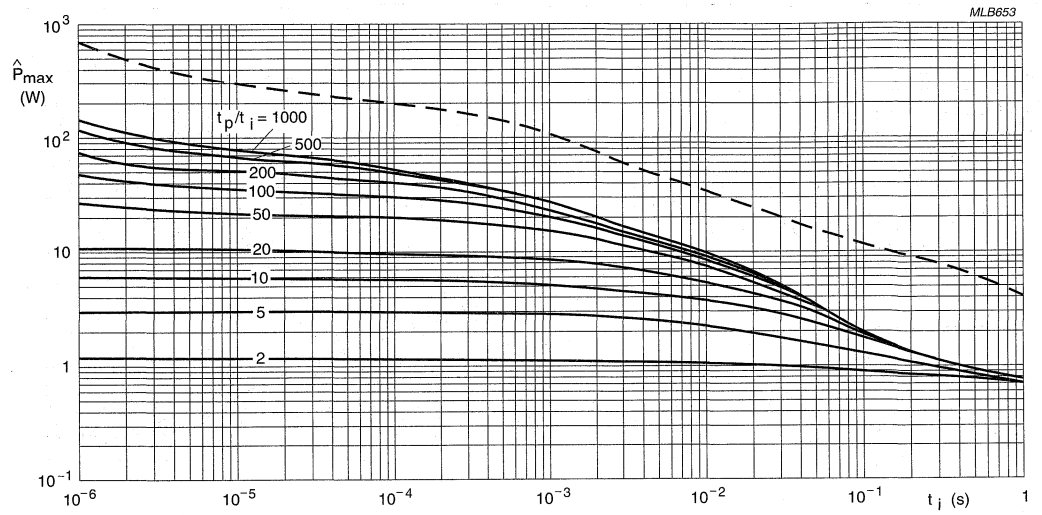


Fig.6 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i).

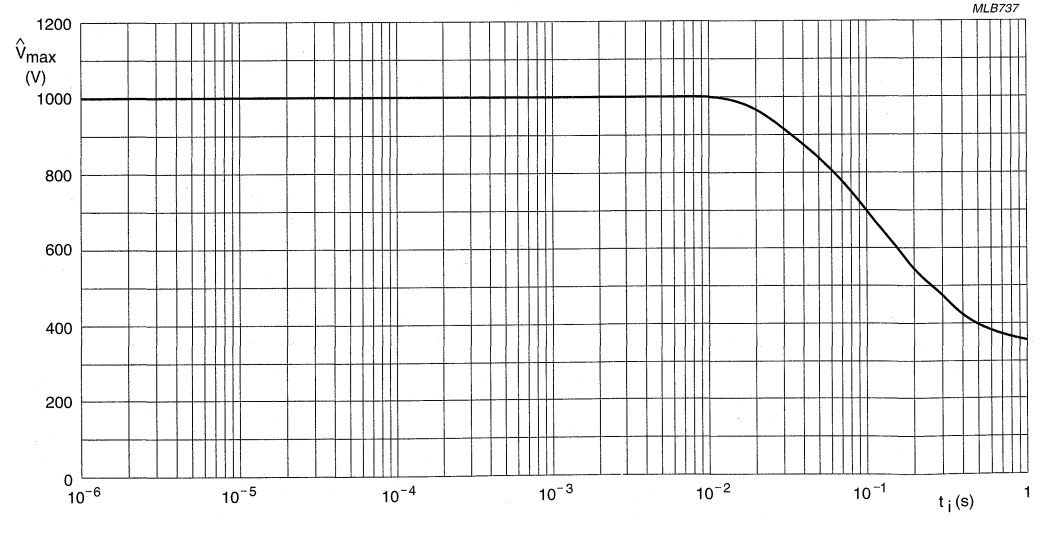
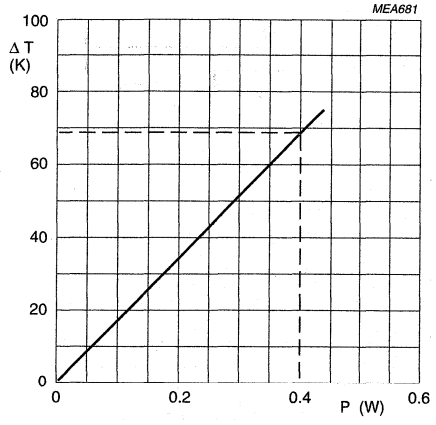


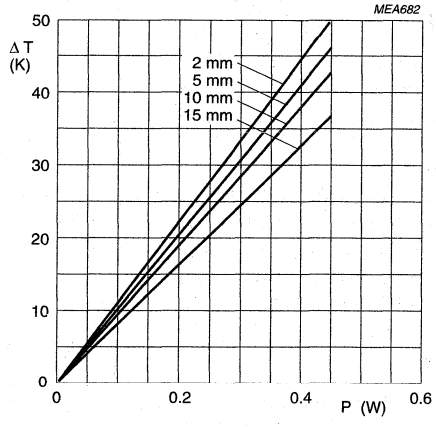
Fig.7 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_i).

Application information



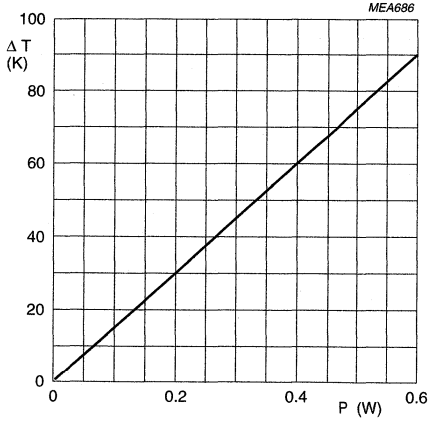
MRS16S

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



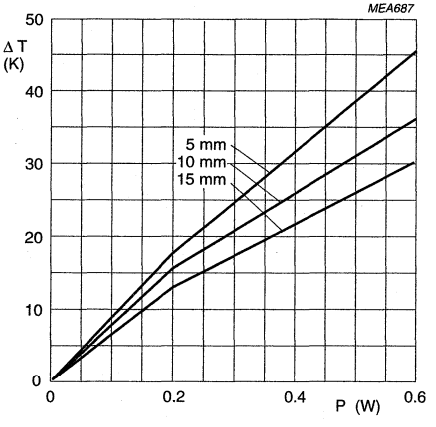
MRS16S

Fig.9 Temperature rise (ΔT) at the lead end (soldering point) as a function of dissipated power at various lead lengths after mounting.



MRS25

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



MRS25

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

MECHANICAL DATA

Mass per 100 units

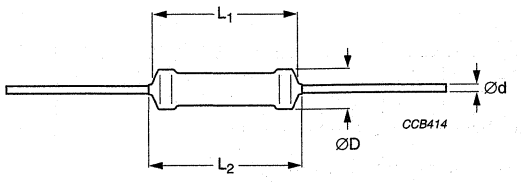
TYPE	MASS (g)
MRS16S	11
MRS25	25

Marking

The nominal resistance and tolerance are marked on the resistor using five coloured bands in accordance with IEC publication 60062 *"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 60294")*.



For dimensions see Table 3.

Fig.12 Outline.

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)
MRS16S	1.9	3.2	3.4	0.45 ±0.05
MRS25	2.5	6.5	7.0	0.58 ±0.05

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of *"IEC publication 60115-1"*, category **LCT/UCT/56** (rated temperature range: **L**ower **C**ategory **T**emperature, **U**pper **C**ategory **T**emperature; 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 60068, *"Recommended basic climatic and mechanical robustness testing procedure for electronic components"* and under standard atmospheric conditions according to *"IEC 60068-1"*, 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 60115-1 and 60068"*; 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 60115-1 CLAUSE	IEC 60068-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS	
				MRS16S	MRS25
Tests in accordance with the schedule of IEC publication 60115-1					
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	ΔR/R max.: ±0.1% + 0.05 Ω	
			R > 100 kΩ	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_2O 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 **MRS16S**, 700 V for **MRS25**	no breakdown or flashover	

IEC 60115-1 CLAUSE	IEC 60068-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS	
				MRS16S	MRS25
4.13		short time overload	room temperature; $P = 6.25 \times P_n$ (**MRS25**) or 6.25×0.25 W (**MRS16S**); 5 s on 45 s off, 10 cycles ($V \leq 2 \times V_{max}$)	$\Delta R/R$ max.: $\pm 0.25\% + 0.05\ \Omega$	
4.16	U	robustness of terminations:			
4.16.2	Ua	tensile all samples	Ø0.45 mm, load 5 N; 10 s Ø0.58 mm, load 10 N; 10 s	number of failures $<10 \times 10^{-6}$	
4.16.3	Ub	bending half number of samples	Ø0.45 mm, load 2.5 N; $4 \times 90°$ Ø0.58 mm, load 5 N; $4 \times 90°$	number of failures $<10 \times 10^{-6}$	
4.16.4	Uc	torsion other half of samples	$3 \times 360°$ in opposite directions	no damage $\Delta R/R$ max.: $\pm 0.1\% + 0.05\ \Omega$	
4.20	Eb	bump	3×1500 bumps in 3 directions; 40 g	no damage $\Delta R/R$ 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 $\Delta R/R$ 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:	no visual damage	
			$R \leq 100\ k\Omega$	$\Delta R/R$ max.: $\pm 0.1\% + 0.05\ \Omega$	
			$R > 100\ k\Omega$	$\Delta R/R$ max.: $\pm 0.25\% + 0.05\ \Omega$	$\Delta R/R$ max.: $\pm 0.1\% + 0.05\ \Omega$
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.: $10^3\ M\Omega$	
			$R \leq 100\ k\Omega$	$\Delta R/R$ max.: $\pm 0.5\% + 0.05\ \Omega$	
			$R > 100\ k\Omega$	$\Delta R/R$ max.: $\pm 1\% + 0.05\ \Omega$	$\Delta R/R$ 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):		
			$R \leq 100\ k\Omega$	$\Delta R/R$ max.: $\pm 0.5\% + 0.05\ \Omega$	
			$R > 100\ k\Omega$	$\Delta R/R$ max.: $\pm 1\% + 0.05\ \Omega$	$\Delta R/R$ max.: $\pm 0.5\% + 0.05\ \Omega$

IEC 60115-1 CLAUSE	IEC 60068-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS	
				MRS16S	MRS25
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:		
			$R \leq 100\ k\Omega$	$\Delta R/R$ max.: $\pm 0.5\% + 0.05\ \Omega$	
			$R > 100\ k\Omega$	$\Delta R/R$ max.: $\pm 1\% + 0.05\ \Omega$	$\Delta R/R$ max.: $\pm 0.5\% + 0.05\ \Omega$
4.23.2	27 (Ba)	endurance at upper category temperature	1 000 hours; no load:		
			$R \leq 100\ k\Omega$	$\Delta R/R$ max.: $\pm 0.5\% + 0.05\ \Omega$	
			$R > 100\ k\Omega$	$\Delta R/R$ max.: $\pm 1\% + 0.05\ \Omega$	$\Delta R/R$ max.: $\pm 0.5\% + 0.05\ \Omega$
4.8.4.2		temperature coefficient	at 20/LCT/20 °C and 20/UCT/20 °C ($TC \times 10^{-6}/K$)	$\leq \pm 50 \times 10^{-6}/K$	
Other tests in accordance with IEC 60115 clauses and IEC 60068 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 **MRS16S**, 500 V for **MRS25**	R_{ins} min.: $10^4\ M\Omega$	
4.12		noise	*"IEC publication 60195"* (measured with Quantech-equipment):		
			$R \leq 68\ k\Omega$	max. 0.1 μV/V	max. 0.1 μV/V
			$R \leq 100\ k\Omega$	max. 0.5 μV/V	max. 0.1 μV/V
			$R \leq 1\ M\Omega$	max. 1.5 μV/V	max. 0.1 μV/V
			$R > 1\ M\Omega$	max. 1.5 μV/V	max. 1.5 μV/V
see 2nd amendment to *"IEC 60115-1"*, 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 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 60068-2-45"*..

ORDERING INFORMATION

Ordering code (12NC)

- The resistors have a 12-digit ordering code starting with 23
- The subsequent 7 digits indicate the resistor type and packaging; see Table 1.
- The remaining 3 digits indicate the resistance values:
  - 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 kΩ	
Resistance tolerance and series	±5%; E24 series	
Maximum dissipation at T_{amb} = 70 °C	0.33 W	0.5 W
Thermal resistance (R_{th})	240 K/W	150 K/W
Temperature coefficient:		
1 Ω ≤ R ≤ 4.7 Ω	$\leq \pm 200 \times 10^{-6}$/K	$\leq \pm 200 \times 10^{-6}$/K
4.7 Ω < R ≤ 15 Ω	$\leq \pm 200 \times 10^{-6}$/K	$\leq \pm 100 \times 10^{-6}$/K
15 Ω < R ≤ 15 kΩ	$\leq \pm 100 \times 10^{-6}$/K	$\leq \pm 100 \times 10^{-6}$/K
Maximum permissible voltage (DC or RMS)	250 V	350 V
Basic specifications	IEC 60115-1 and 60115-2	
Climatic category (IEC 60068)	55/155/56	
Stability after:		
load	ΔR/R max.: ±1% + 0.05 Ω	
climatic tests	ΔR/R max.: ±1% + 0.05 Ω	
soldering	ΔR/R max.: ±0.25% + 0.05 Ω	

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	06 204 03...	22 205 13...	22 205 33...	22 205 23...
NFR25H	06 207 03...	22 207 13...	22 207 33...	22 207 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 kΩ	2
10 to 15 kΩ	3

ORDERING EXAMPLE

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

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 60063"*.

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 60115-1"*.

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.

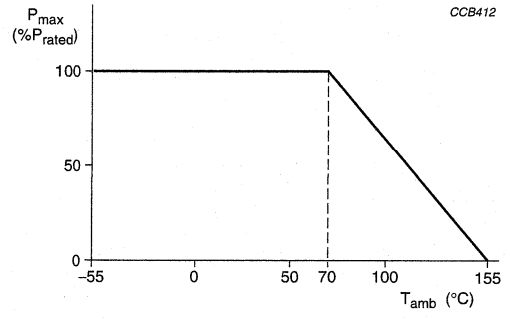
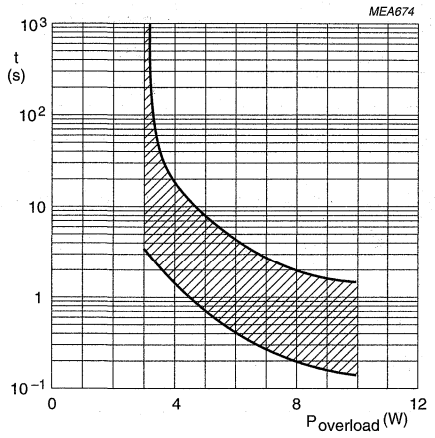


Fig.1 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

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 100 times; see Figs 2, 3 and 4.

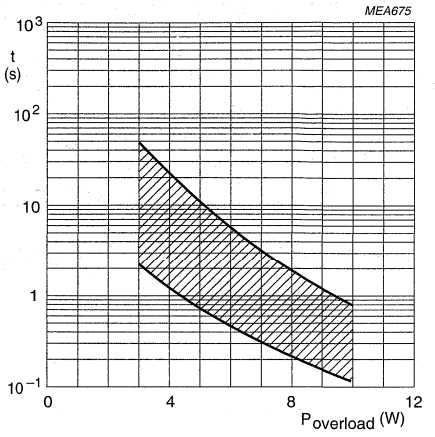
The fusing characteristic is measured under constant voltage.



NFR25

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

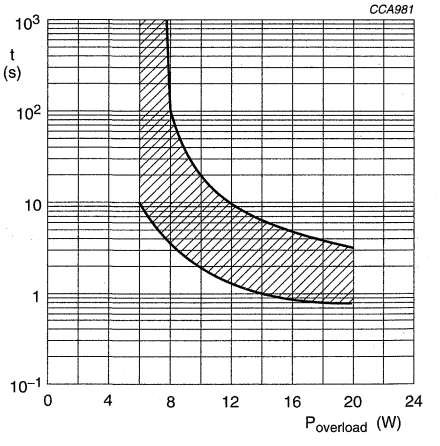
Fig.2 Fusing characteristic: 1 Ω ≤ R ≤ 15 Ω.



NFR25

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

Fig.3 Fusing characteristic: 15 Ω < R ≤ 15 kΩ.

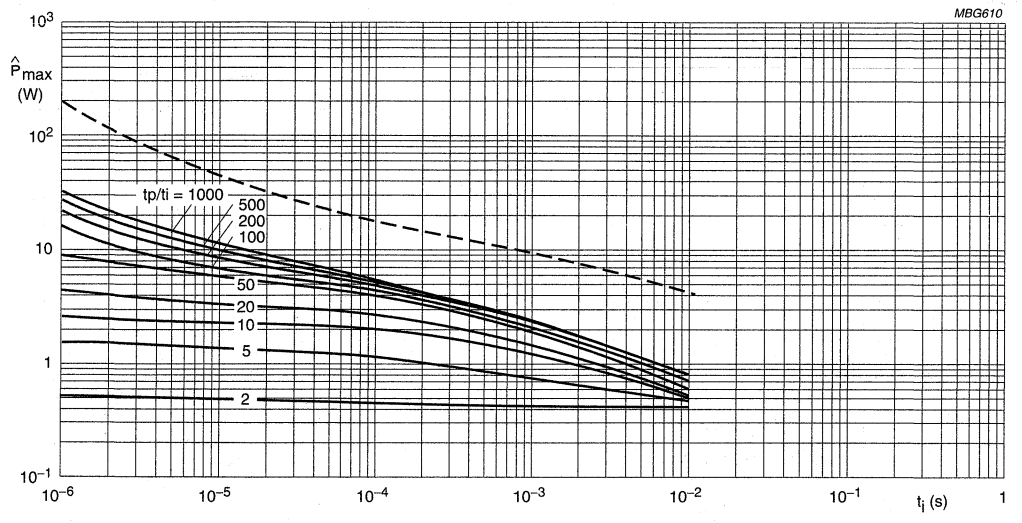


NFR25H

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

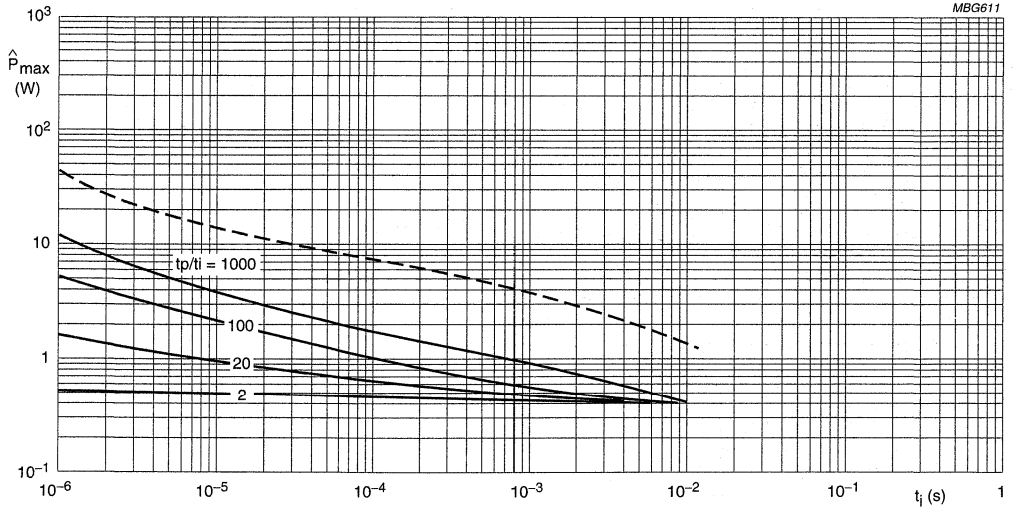
Fig.4 Fusing characteristic.

PULSE LOADING CAPABILITIES



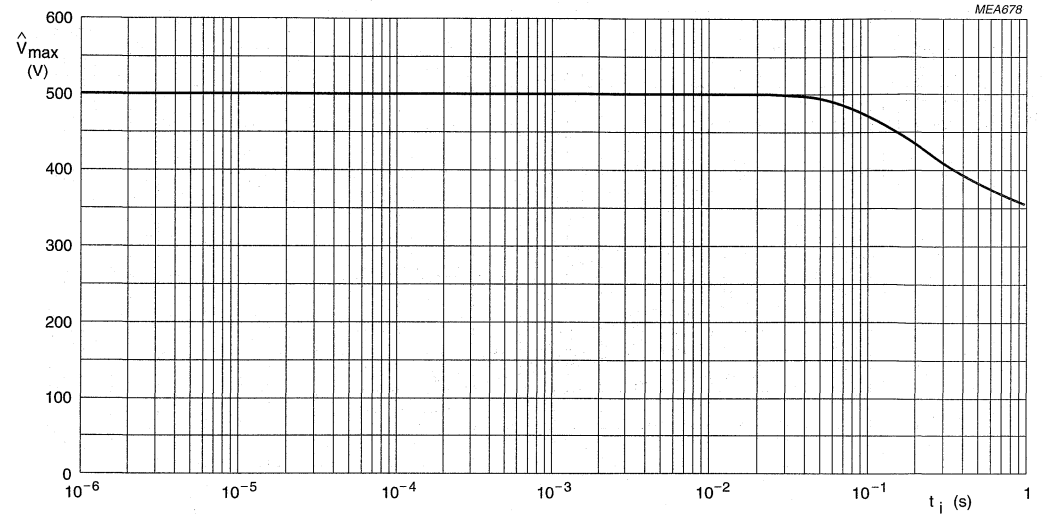
NFR25

Fig.5 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i), 1 Ω ≤ R < 15 Ω.



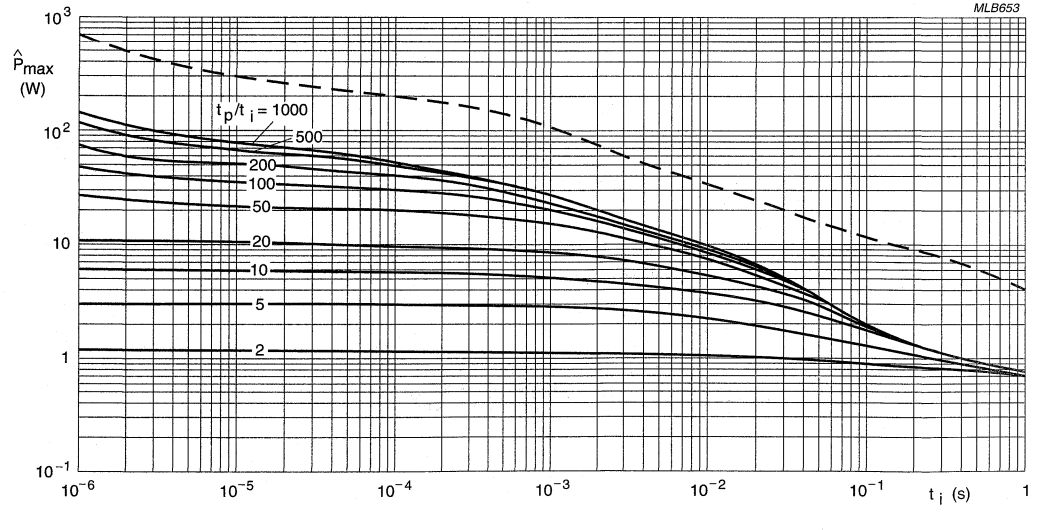
NFR25

Fig.6 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i), 15 Ω < R ≤ 15 kΩ.



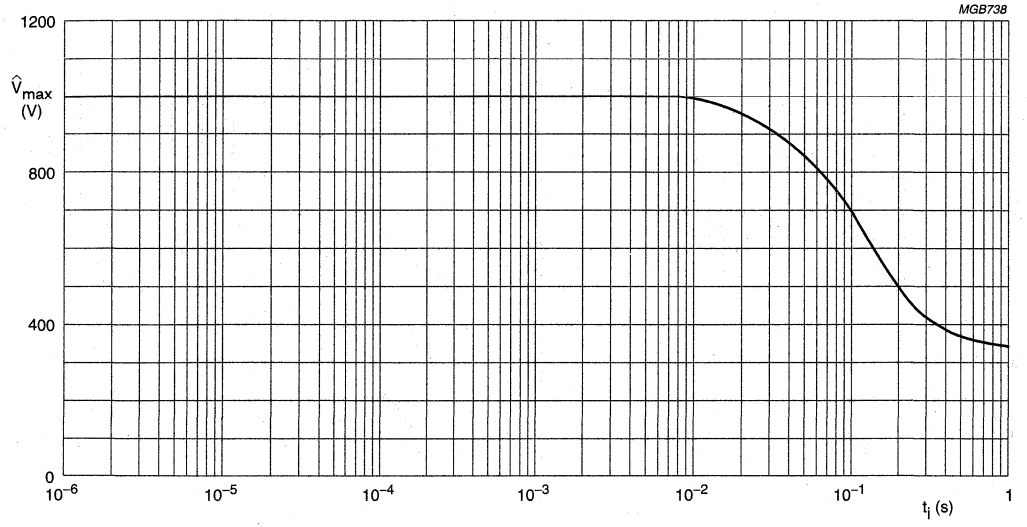
NFR25

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



NFR25H

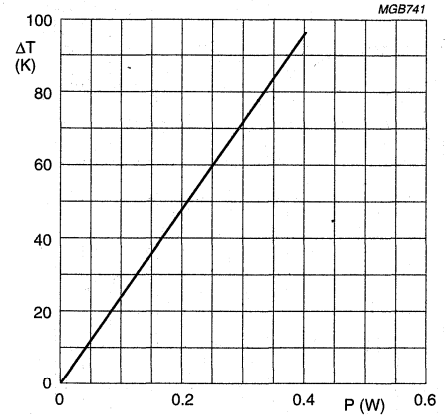
Fig.8 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i).



NFR25H

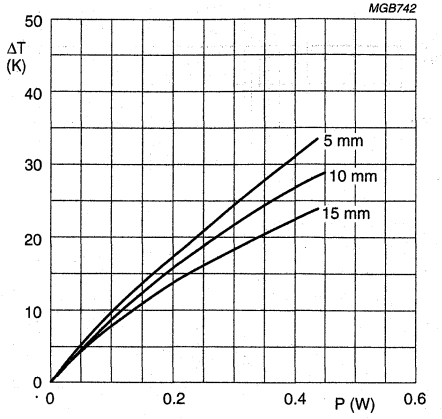
Fig.9 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_i).

Application information



NFR25

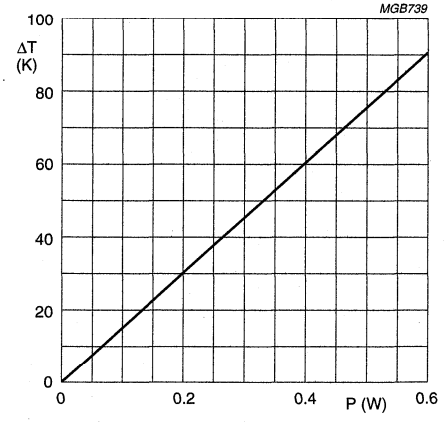
Fig.10 Hot-spot temperature rise (ΔT) as a function of dissipated power.



NFR25

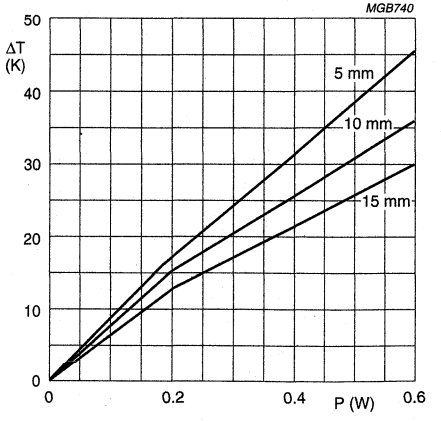
Minimum distance from resistor body to PCB = 1 mm.

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



NFR25H

Fig.12 Hot-spot temperature rise (ΔT) as a function of dissipated power.



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.

MECHANICAL DATA

Mass per 100 units

TYPE	MASS (g)
NFR25	25
NFR25H	

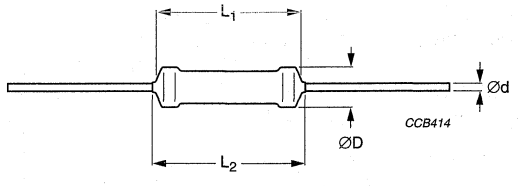
Marking

The nominal resistance and tolerance are marked on the resistor using four coloured bands in accordance with IEC publication 60062 *"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 60294")*.



For dimensions see Table 3.

Fig.14 Outline.

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	0.58 ±0.05
NFR25H				

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of *"IEC publication 60115-1"*, category **LCT/UCT/56** (rated temperature range: **L**ower **C**ategory **T**emperature, **U**pper **C**ategory **T**emperature; 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 60068, *"Recommended basic climatic and mechanical robustness testing procedure for electronic components"* and under standard atmospheric conditions according to *"IEC 60068-1"*, 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 60115-1 and 60068"*; 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 60115-1"* and to *"EN 140000, appendix D"*.

All soldering tests are performed with mildly activated flux.

Table 4 Test procedures and requirements

IEC 60115-1 CLAUSE	IEC 60068-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS	
				NFR25	NFR25H
Tests in accordance with the schedule of IEC publication 60115-8					
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_2O 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 $<10 \times 10^{-6}$	
4.16.3	Ub	bending half number of samples	load 5 N; 4 × 90°	number of failures $<10 \times 10^{-6}$	
4.16.4	Uc	torsion other half of samples	3 × 360° in opposite directions	no damage ΔR/R max.: ±0.25% + 0.05 Ω	

IEC 60115-1 CLAUSE	IEC 60068-2 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	30 (D)	climatic sequence: 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 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 60195"*	<0.1 μV/V	
4.26		accidental overload	cheese-cloth	nonflammable	
Other tests in accordance with IEC 60115 clauses and IEC 60068 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 2nd amendment to *"IEC 60115-1"*, 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 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 60068-2-45"*.

Resistors with a resistance value of ≤200 Ω and with tolerances of ±0.05%, ±0.02% and ±0.01% have low inductance.

QUICK REFERENCE DATA

DESCRIPTION	VALUE	
	MPR24	MPR34
Resistance range	4.99 Ω to 1 MΩ	
Resistance tolerance and series:		
24 Ω to 100 kΩ	±0.05%; ±0.02%; ±0.01%; all values	
4.99 Ω to 1 MΩ	±0.5%; ±0.25%; ±0.1%; all values	
Maximum dissipation at T_{amb} = 70 °C:		
±0.05%; ±0.02%; ±0.01%	0.125 W	0.25 W
±0.5%; ±0.25%; ±0.1%	0.25 W	0.4 W
Temperature coefficient characteristic between +20 and +70 °C	≤±25 × 10^{-6}/K ≤±15 × 10^{-6}/K ≤±10 × 10^{-6}/K ≤±5 × 10^{-6}/K	
Failure level:		
24 Ω to 100 kΩ	S	
4.99 Ω to 1 MΩ	R	
Maximum permissible voltage (DC or RMS)	250 V	350 V
Basic specifications	EN 140000; MIL-R-10509; MIL-R-55182; DIN 44061; IEC 60115-5	
Climatic category (IEC 60068):		
±0.05%; ±0.02%; ±0.01%	55/125/56	
±0.5%; ±0.25%; ±0.1%	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	ΔR/R max.: ±0.05% + 0.01 Ω	
climatic tests	ΔR/R max.: ±0.05% + 0.01 Ω	
soldering	ΔR/R max.: ±0.01% + 0.01 Ω	
short time overload	ΔR/R max.: ±0.01% + 0.01 Ω	

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 6.
- The subsequent 2 digits (8 and 9) indicate temperature coefficient, tolerance, marking and packaging quantity:
  - Table 7 refers to ±0.5%, ±0.25% and ±0.1% tolerance products.
  - Table 8 refers to ±0.05%, ±0.02% and ±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 5 Package type per quantity

QUANTITY	PACKAGE
20	cassette including list with individual measuring details
100	bandolier in cardboard box
500 or 1000	bandolier in ammopack
5000	bandolier on reel

Table 6 7th digit from type and quantity

TYPE	7th DIGIT	PACKAGING QUANTITY	
		TOL. ±0.5%; ±0.25%; ±0.1%	TOL. ±0.05%; ±0.02%; ±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 7 8th and 9th digit; tol. ±0.5%; ±0.25%; ±0.1%; range 4.99 Ω to 1 MΩ

TC	ORDERING CODE 8th and 9th DIGIT						PACKAGING QUANTITY
	TOL. ±0.5%		TOL. ±0.25%		TOL. ±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 8 8th and 9th digit; tol. ±0.05%; ±0.02%; ±0.01%; range 24 Ω to 100 kΩ

TC	ORDERING CODE 8th and 9th DIGIT			PACKAGING QUANTITY
	TOL. ±0.05%	TOL. ±0.02%	TOL. ±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 ±0.02%, TC = ±5 × 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.

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.15) for resistors with resistance tolerance ≥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.

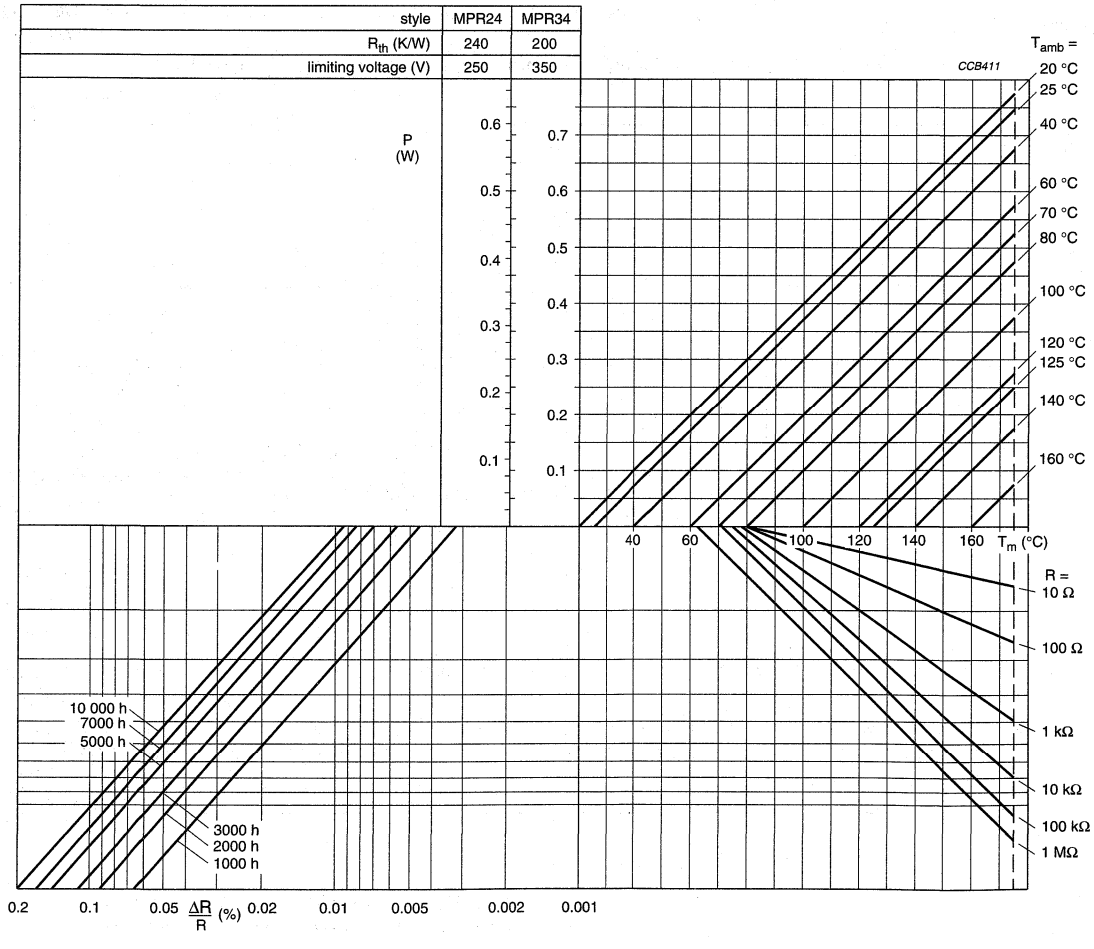


Fig.15 Drift nomogram.

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

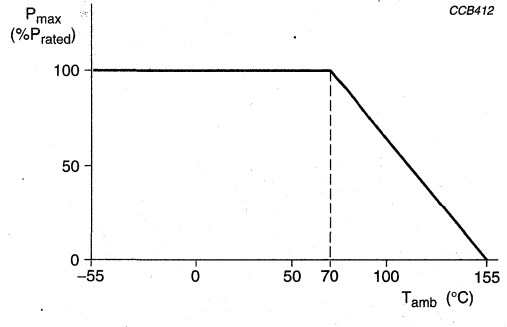
Note

1. The maximum voltage that may be continuously applied to the resistor element, see *"IEC publication 60115-1"*.

The maximum permissible hot-spot temperature is 175 °C.

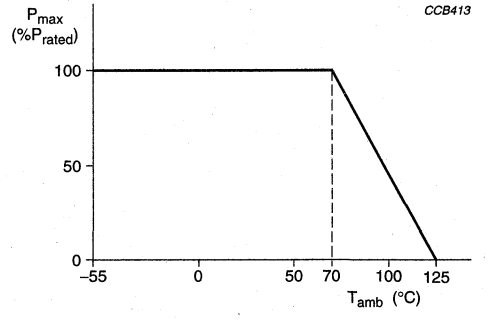
DERATING

The power that the resistor can dissipate depends on the operating temperature; see Figs 16 and 17.



For resistance tolerances of ±0.5%, ±0.25% and ±0.1%.

Fig.16 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).



For resistance tolerances of ±0.05%, ±0.02% and ±0.01%.

Fig.17 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

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 60062 *"Colour codes for fixed resistors"*.

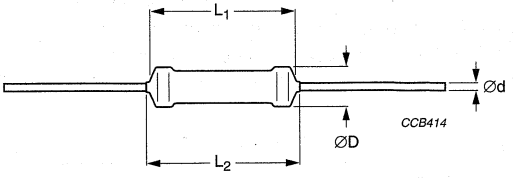
MARKING PRINT

When marked, the following details are printed on the resistors (see Fig.19):

- Manufacturers symbol
- Tolerance code (in accordance with *"IEC 60062"*)
- Temperature coefficient code TC:
  - ±25 = 1
  - ±15 = 2
  - ±10 = 3
  - ±5 = 4
  - ±2 = 5
  - ±1 = 6
  - 0 = 7
- Resistance value code (in accordance with *"IEC 60062"*), 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 60294")*.



For dimensions see Table 9.

Fig.18 Outline.

Table 9 Resistor type and relevant physical dimensions; see Fig.18

TYPE	ØD MAX. (mm)	L_1 MAX. (mm)	L_2 MAX. (mm)	Ød (mm)
MPR24	2.5	6.5	7.5	0.58 ±0.05
MPR34	3.0	10.0	11.0	0.58 ±0.05

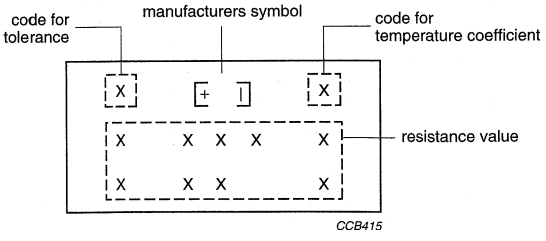


Fig.19 Marking print example.

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: **L**ower **C**ategory **T**emperature, **U**pper **C**ategory **T**emperature; damp heat, long term, **56** days) along the lines of *"EN 140000"*.

The tests are carried out in accordance with IEC publication 60068, *"Recommended basic climatic and mechanical robustness testing procedure for electronic components"* and under standard atmospheric conditions according to *"IEC 60068-1"*, 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 10 the tests and requirements are listed with reference to the relevant clauses of *"EN 140000 and IEC publication 60068"*; a short description of the test procedure is also given.

All soldering tests are performed with mildly activated flux.

Table 10 Test procedures and requirements

CECC 40000 TEST METHOD	IEC 60068-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.5		insulation resistance	voltage (DC) after 1 minute; metal block method: **MPR24**: 500 V **MPR34**: 700 V	R_{ins} min.: 10^4 MΩ
4.6		voltage proof	2 × limiting voltage (AC) during 1 minute, metal block method	no breakdown or flashover
4.7		temperature coefficient	at 20/70/20 °C	≤±25 × 10^{-6}/K: ≤±15 × 10^{-6}/K; ≤±10 × 10^{-6}/K; ≤±5 × 10^{-6}/K
			at 20/LCT/20 °C and 20/UCT/20 °C (TC × 10^{-6}/K)	≤±25 × 10^{-6}/K
4.10		noise	*"IEC publication 60195"* (measured with Quantech-equipment):	
			R ≤ 100 kΩ	max. 0.25 μV/V
			R > 100 kΩ	max. 0.5 μV/V
4.11		short time overload	room temperature; P = 6.25 × P_n; 5 s (V ≤ 2 × V_{max})	ΔR/R max.: ±0.01% + 0.01 Ω
4.16	U	robustness of terminations:		
	Ua	tensile all samples	load 10 N; 10 s	number of failures <10 × 10^{-6}
	Ub	bending half number of samples	load 5 N; 4 × 90°	number of failures <10 × 10^{-6}
	Uc	torsion other half of samples	3 × 360° in opposite directions	no damage ΔR/R max.: ±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	ΔR/R max.: ±0.01% + 0.01 Ω
4.16	Na	rapid change of temperature	30 minutes at LCT and 30 minutes at UCT; 5 cycles	no visual damage ΔR/R max.: ±0.01% + 0.01 Ω

CECC 40000 TEST METHOD	IEC 60068-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.17	Eb	bump	3 × 1500 bumps in 3 directions; 40 g	no damage ΔR/R max.: ±0.01% + 0.01 Ω
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 ΔR/R max.: ±0.01% + 0.01 Ω
4.4.1		visual examination		no holes; clean surface; no damage
4.20		climatic sequence:		
4.20.2	B	dry heat	16 hours at UCT	
4.20.3	D	damp heat (accelerated) 1st cycle	24 hours; 95 to 100% RH	
4.20.4	Aa	cold	2 hours at LCT	
4.20.5	M	low air pressure	1 hour; 8.5 kPa	
4.20.6	D	damp heat (accelerated) remaining cycles	5 days; 55 °C; 95 to 100% RH	R_{ins} min.: 10^3 MΩ ΔR/R max.: ±0.05% + 0.01 Ω
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 ΔR/R max.: ±0.05% + 0.01 Ω
4.25.1		endurance (at 70 °C)	2000 hours; loaded with P_n or V_{max}; 1.5 hours on and 0.5 hours off	R_{ins} min.: 10^3 MΩ ΔR/R max.: ±0.05% + 0.01 Ω

Power metal film resistors PR01/02/03

FEATURES

- High power in small packages
- 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 60068-2-45"*.

QUICK REFERENCE DATA

DESCRIPTION	VALUE				
	PR01	PR02		PR03	
		Cu-lead	FeCu-lead	Cu-lead	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	±1% (E96 series); ±5% (E24 series); see notes 1 and 2				
Maximum dissipation at T_{amb} = 70 °C:					
R < 1 Ω	0.6 W	1.2 W	–	1.6 W	–
1 Ω ≤ R	1 W	2 W	1.3 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 60115-1 and 60115-4				
Climatic category (IEC 60068)	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				

Notes

1. 1% tolerance is available for R_n-range from 1R upwards.
2. 2% tolerance is available on request for R_n-range from 1R upwards.

ORDERING INFORMATION

Table 1 Ordering code indicating resistor type and packaging

TYPE	LEAD ∅ (mm)	TOL (%)	ORDERING CODE 23.. ... . (BANDOLIER)							
			AMMOPACK							REEL
			RADIAL TAPED		STRAIGHT LEADS					
					52 mm	52 mm	63 mm	73 mm	80 mm	73 mm
			4000 units	3000 units	5000 units	1000 units	500 units	1000 units	500 units	5000 units
PR01	Cu 0.6	1	–	–	22 196 1....	–	–	–	–	–
		5	06 197 03...	–	22 193 14...	–	–	22 193 13...	–	22 193 23...
PR02	Cu 0.8	1	–	–	–	22 197 1....	–	–	–	–
		5	–	06 198 03...	–	22 194 14...	–	22 194 13...	–	–
	FeCu 0.6	5	–	–	–	22 194 54...	–	22 194 53...	–	–
PR03	Cu 0.8	5	–	–	–	–	22 195 14...(1)	–	22 195 13...	–
	FeCu 0.6	5	–	–	–	–	22 195 54...(1)	–	22 195 53...	–

Note

1. Available Q2 1999.

Table 2 Ordering code indicating resistor type and packaging

TYPE	LEAD ∅ (mm)	TOL (%)	ORDERING CODE 23.. ... . (LOOSE IN BOX)			
			CROPPED AND FORMED(1)		DOUBLE KINK	
			h(2) = 8 mm	h(2) = 15 mm	LARGE PITCH(1)	SMALL PITCH
			4000 units	5000 units	1000 units	500 units
PR01	Cu 0.6	5	22 193 33... (3)	–	22 193 03...	–
	FeCu 0.6	5	–	–	22 193 43...	22 193 53...
PR02	Cu 0.8	5	22 194 33...	22 194 43...	–	–
	FeCu 0.6	5	22 194 73...(3)	–	22 194 83...	–
	FeCu 0.8	5	–	–	–	22 194 63...
PR03	Cu 0.8	5	22 195 33...	22 195 43...	–	–
	FeCu 0.6	5	22 195 73...(3)	–	22 195 83...	–
	FeCu 0.8	5	–	–	–	22 195 63...

Notes

1. Maintenance types, not for new designs.
2. h = mounted height above PCB (see Fig.41).
3. Type can be replaced by double kink, large pitch.

Ordering code (12NC)

- The resistors have a 12-digit ordering code starting with 23.
- The first 7 digits indicate the resistor type and packaging; see Tables 1 and 2.
- 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 3.

Table 3 Last digit of 12NC

RESISTANCE DECADE	LAST DIGIT
0.1 to 0.91 Ω	note 1
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. 12NC available on request.

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.

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 60063"*.

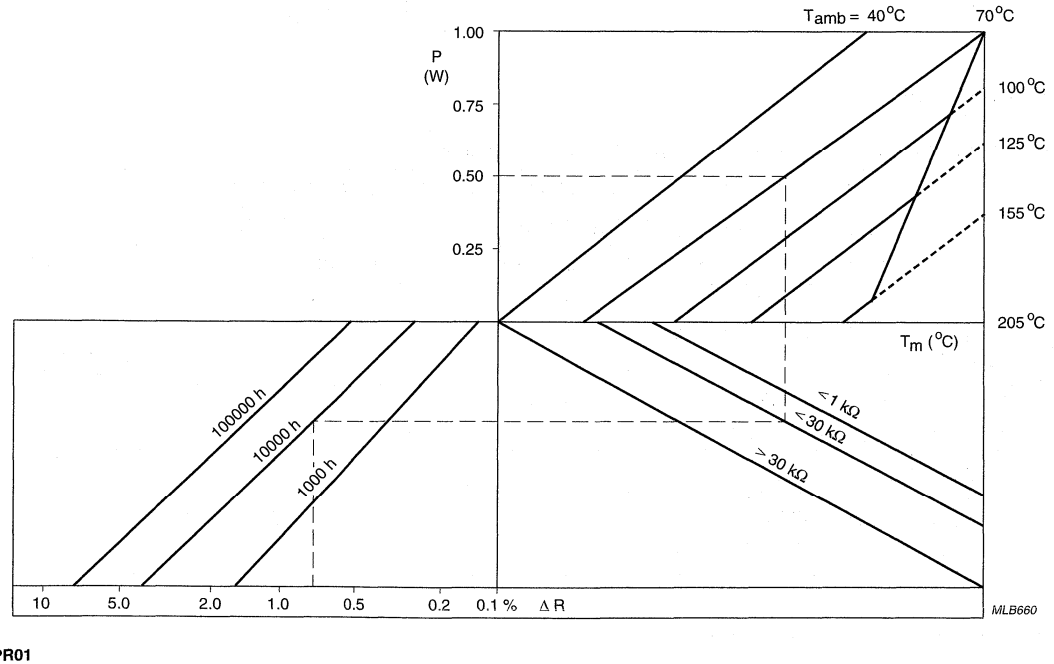
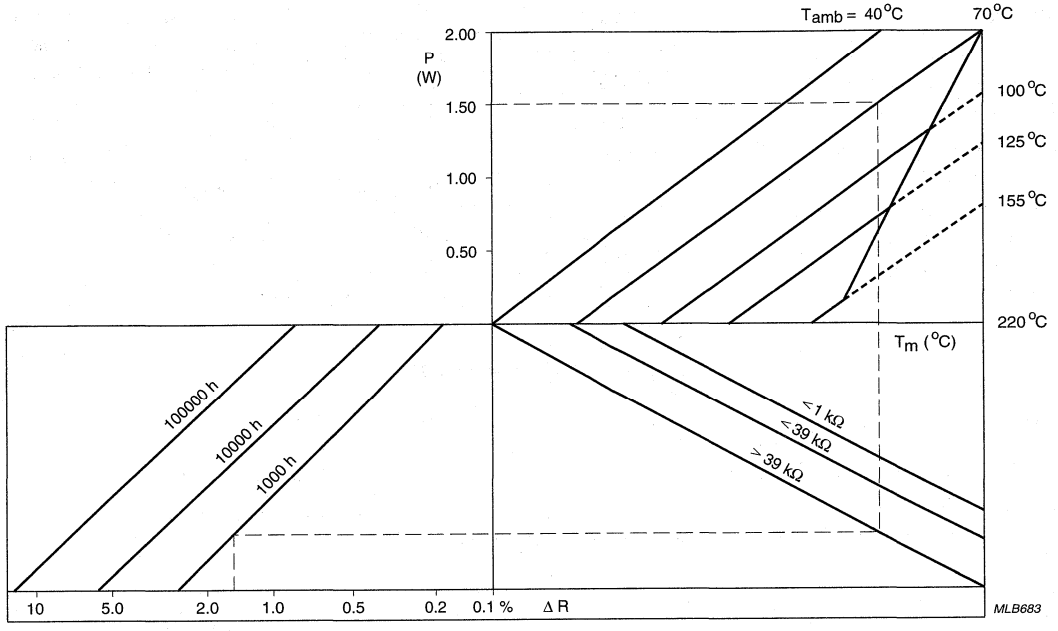
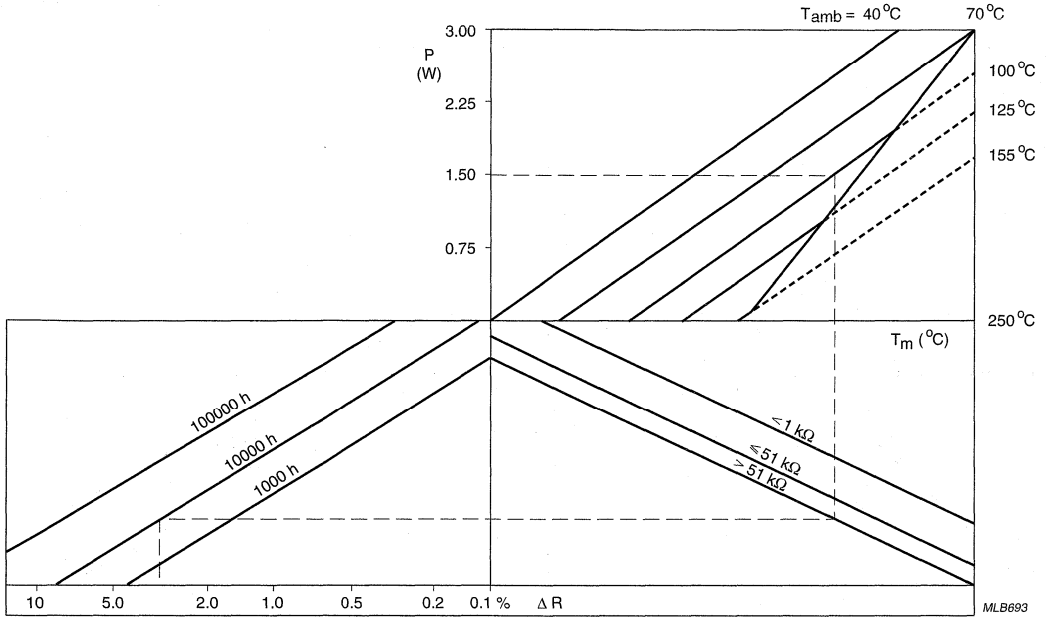


Fig.1 Drift nomogram.



PR02

Fig.2 Drift nomogram.



PR03

Fig.3 Drift nomogram.

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 60115-1"*.

The maximum permissible hot-spot temperature is 235 °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.

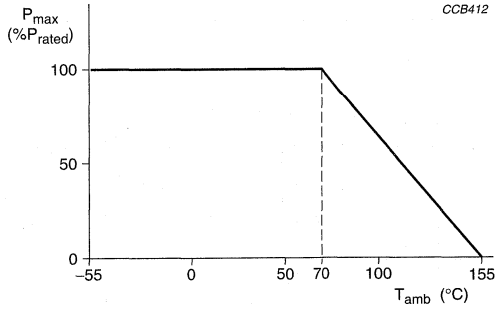


Fig.4 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

PULSE LOADING CAPABILITIES

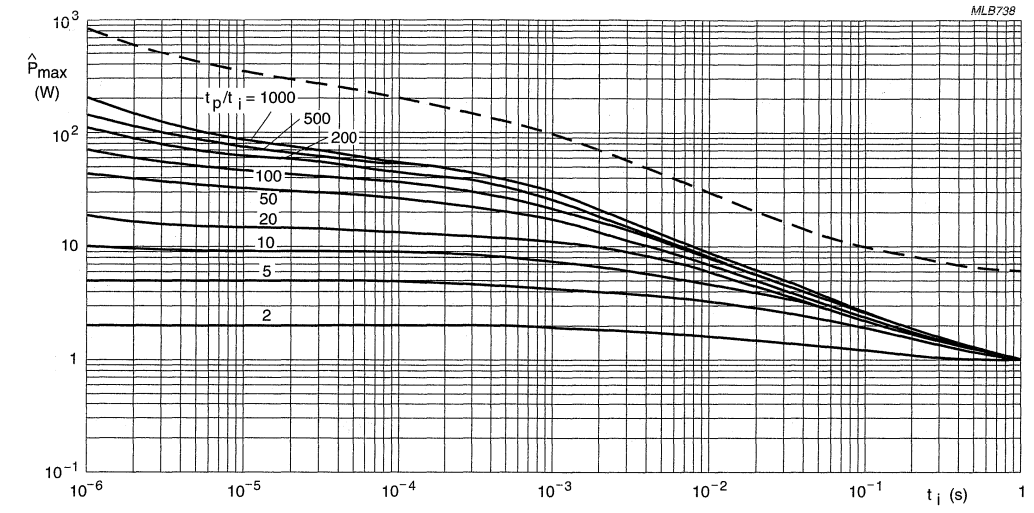


Fig.5 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i).

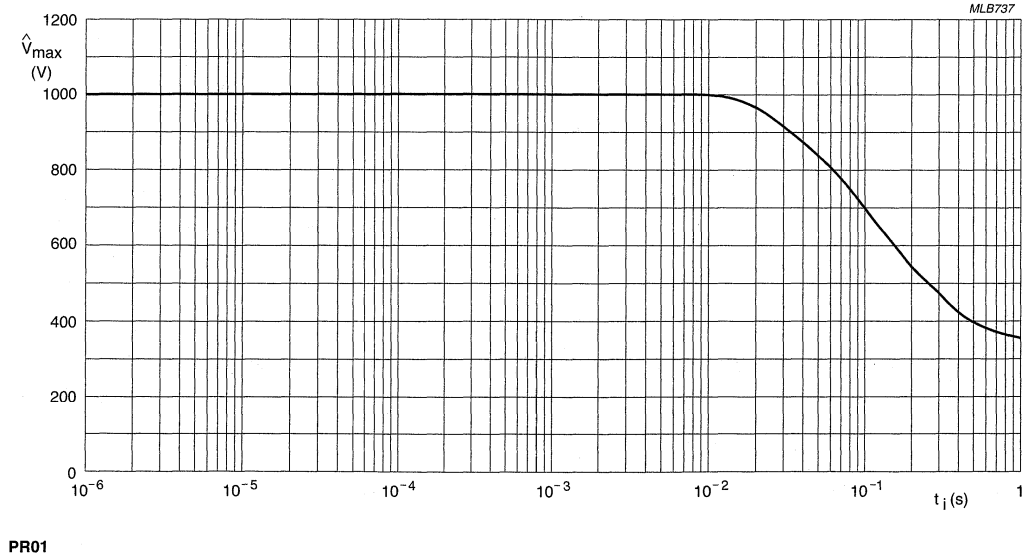
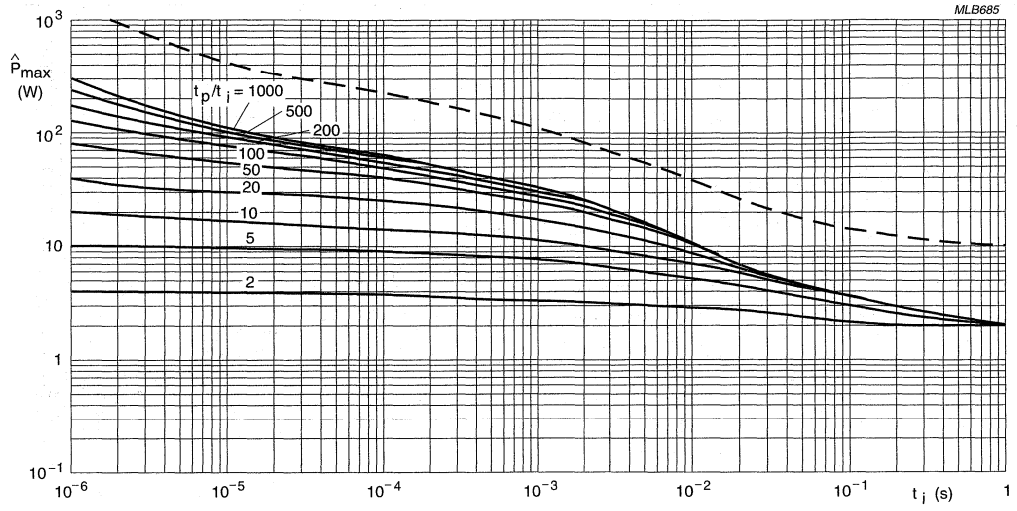
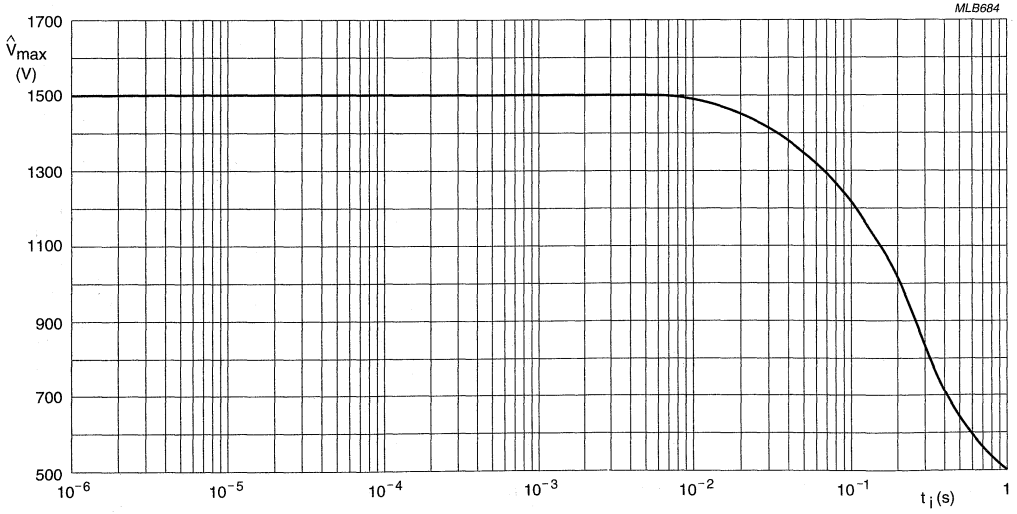


Fig.6 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_i).



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).

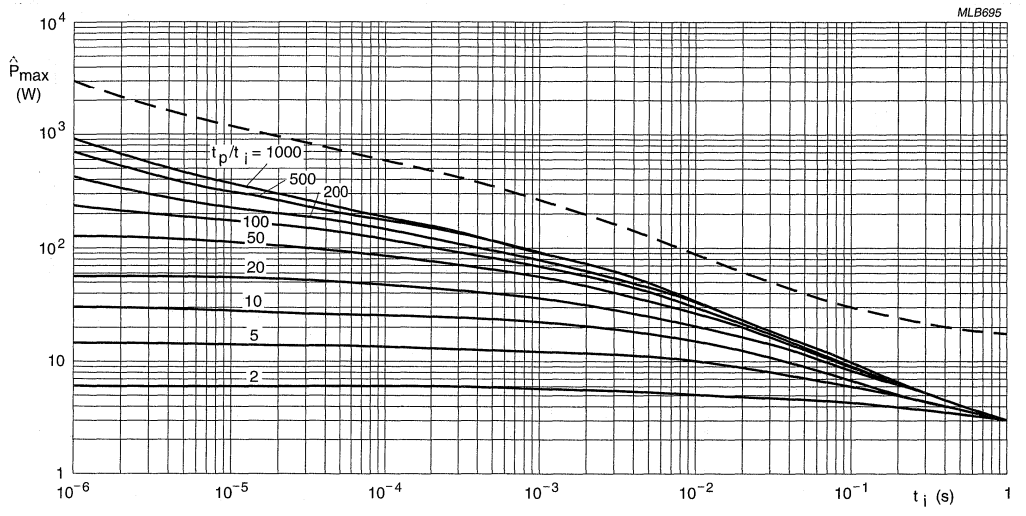


Fig.9 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i).

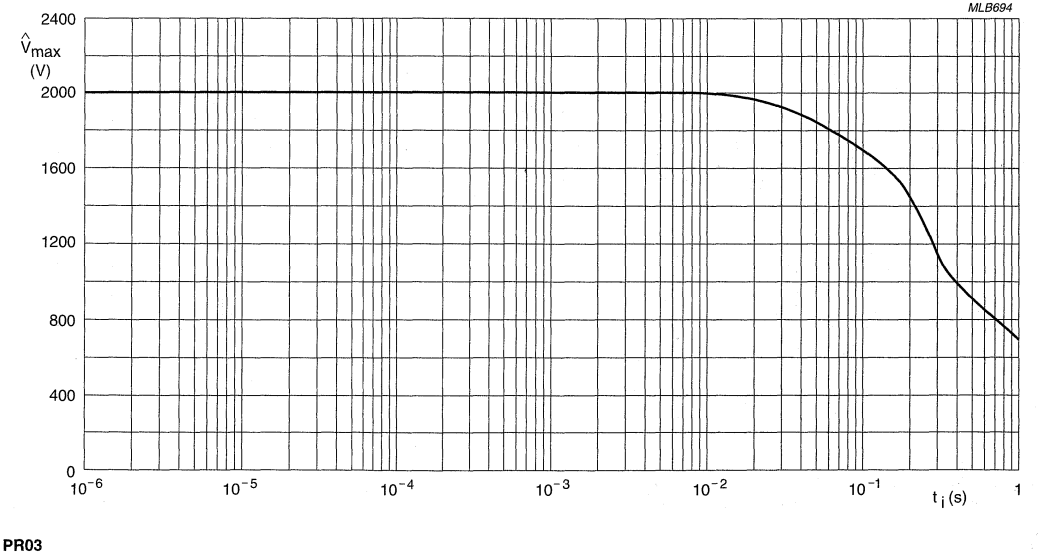
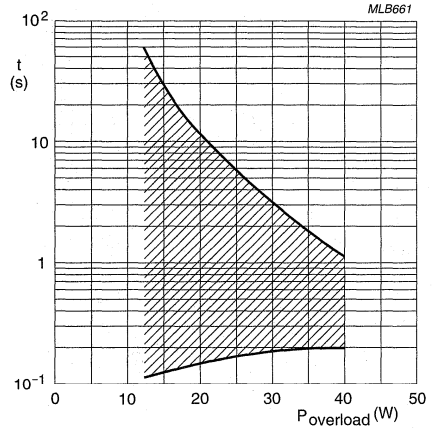


Fig.10 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_i).

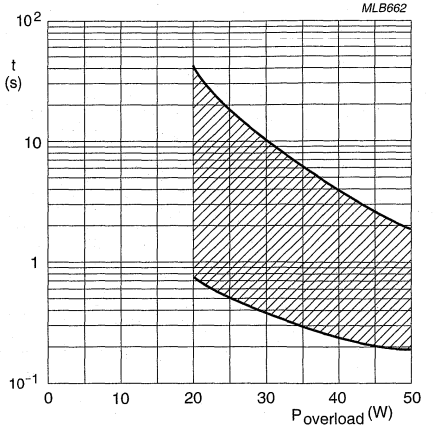
INTERRUPTION CHARACTERISTICS



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

PR01

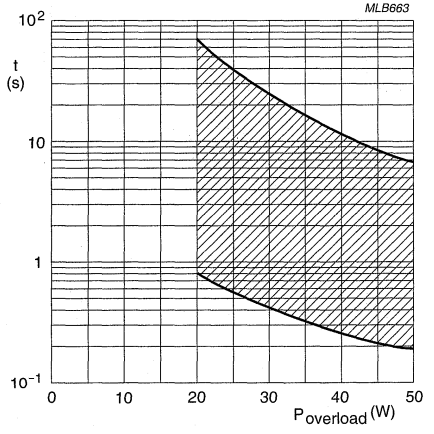
Fig.11 Time to interruption as a function of overload power for range: $0R22 \leq R_n < 1R$.



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

PR01

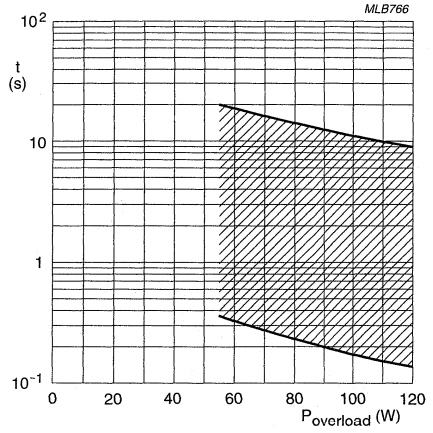
Fig.12 Time to interruption as a function of overload power for range: $1R \leq R_n \leq 15R$.



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

PR01

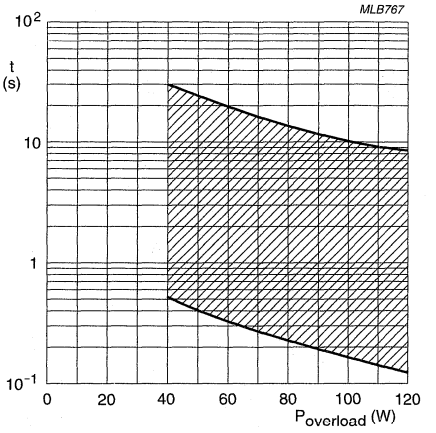
Fig.13 Time to interruption as a function of overload power for range: $16R \leq R_n \leq 560R$.



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

PR02

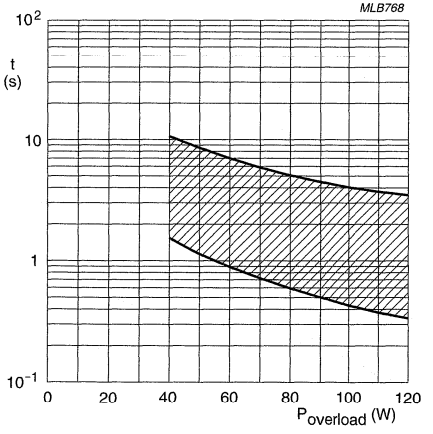
Fig.14 Time to interruption as a function of overload power for range: $0.33R \leq R_n < 5R$.



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

PR02

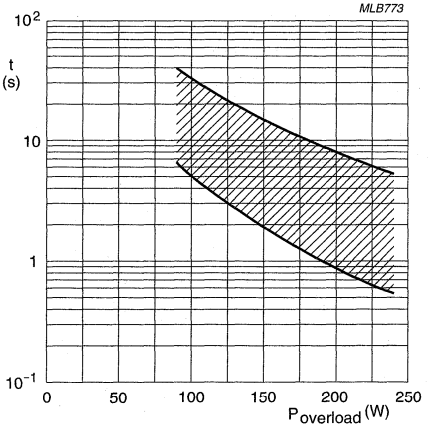
Fig.15 Time to interruption as a function of overload power for range: $5R \leq R_n < 68R$.



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

PR02

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

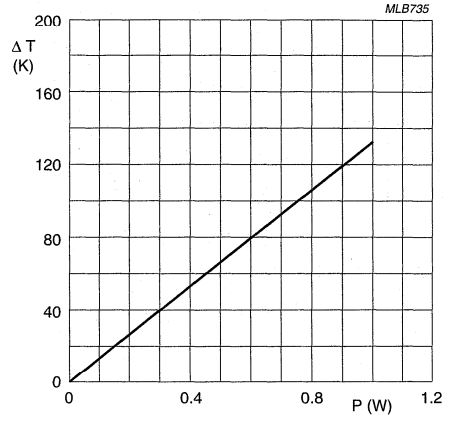


The graph is based on measured data under constant voltage conditions; these data may deviate according to the application.

PR03

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

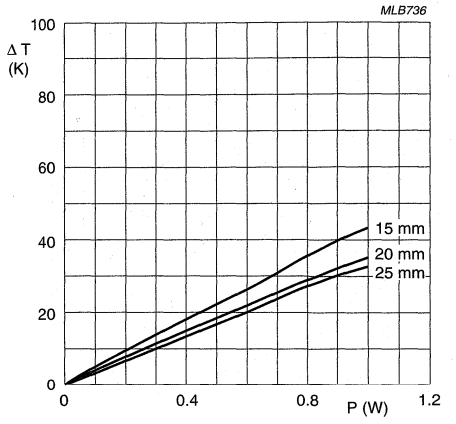
Application information



∅0.6 mm Cu-leads.

PR01

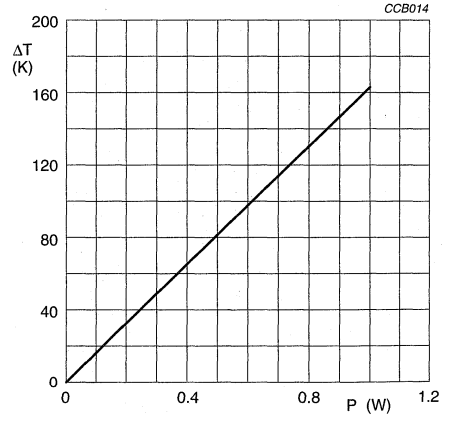
Fig.18 Hot-spot temperature rise (ΔT) as a function of dissipated power.



∅0.6 mm Cu-leads.
Minimum distance from resistor body to PCB = 1 mm.

PR01

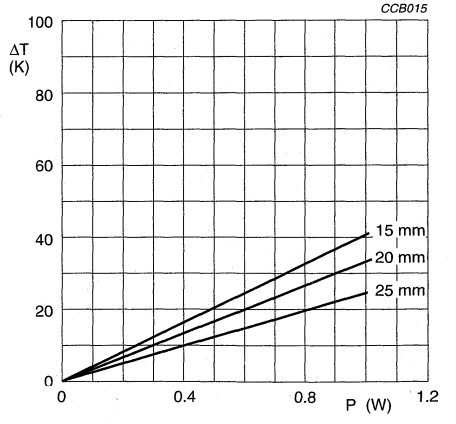
Fig.19 Temperature rise (ΔT) at the lead end (soldering point) as a function of dissipated power at various lead lengths after mounting.



∅0.6 mm FeCu-leads.

PR01

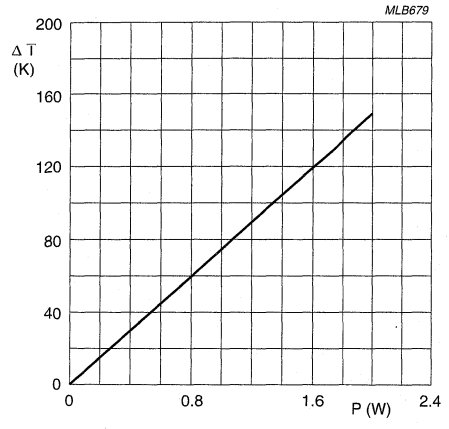
Fig.20 Hot-spot temperature rise (ΔT) as a function of dissipated power.



∅0.6 mm FeCu-leads.
Minimum distance from resistor body to PCB = 1 mm.

PR01

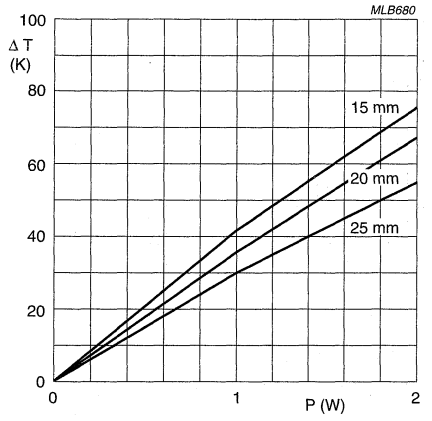
Fig.21 Temperature rise (ΔT) at the lead end (soldering point) as a function of dissipated power at various lead lengths after mounting.



∅0.8 mm Cu-leads.

PR02

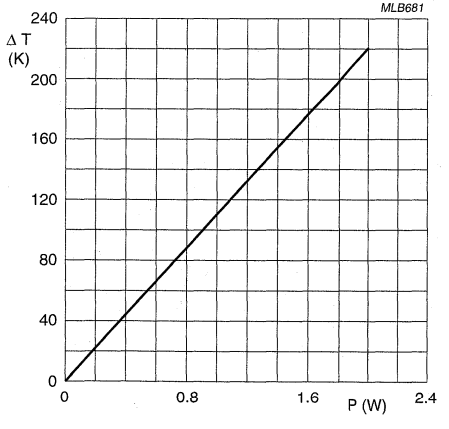
Fig.22 Hot-spot temperature rise (ΔT) as a function of dissipated power.



∅0.8 mm Cu-leads.
Minimum distance from resistor body to PCB = 1 mm.

PR02

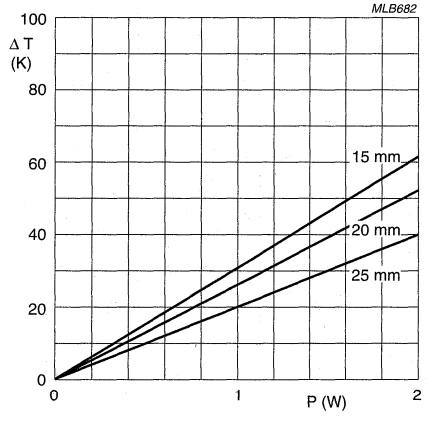
Fig.23 Temperature rise (ΔT) at the lead end (soldering point) as a function of dissipated power at various lead lengths after mounting.



∅0.6 mm FeCu-leads.

PR02

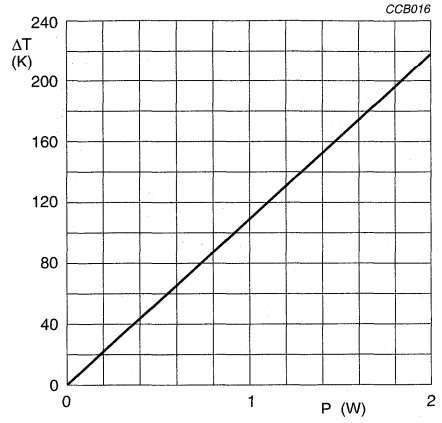
Fig.24 Hot-spot temperature rise (ΔT) as a function of dissipated power.



∅0.6 mm FeCu-leads.
Minimum distance from resistor body to PCB = 1 mm.

PR02

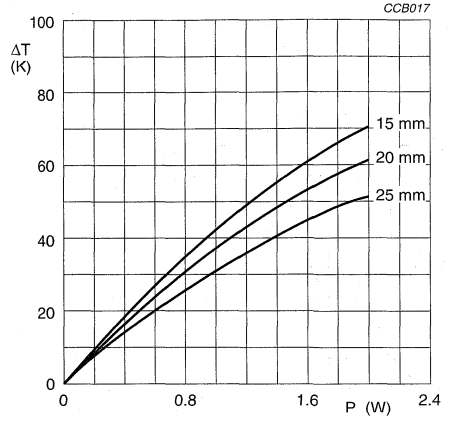
Fig.25 Temperature rise (ΔT) at the lead end (soldering point) as a function of dissipated power at various lead lengths after mounting.



∅0.8 mm FeCu-leads.

PR02

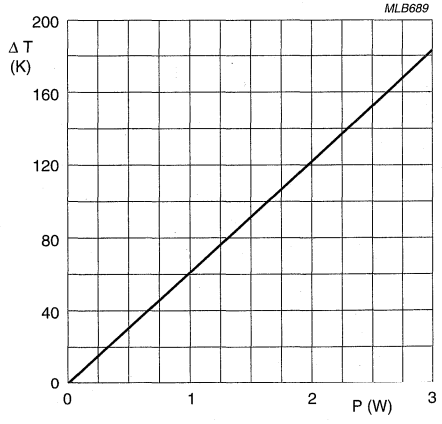
Fig.26 Hot-spot temperature rise (ΔT) as a function of dissipated power.



∅0.8 mm FeCu-leads.
Minimum distance from resistor body to PCB = 1 mm.

PR02

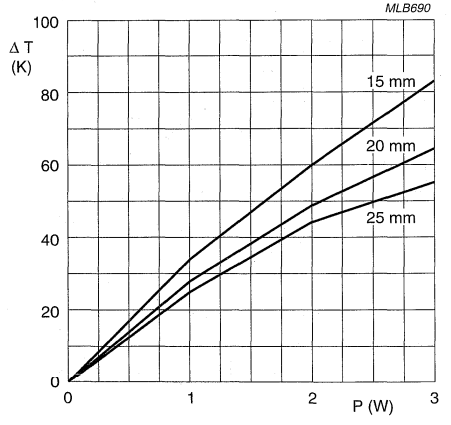
Fig.27 Temperature rise (ΔT) at the lead end (soldering point) as a function of dissipated power at various lead lengths after mounting.



∅0.8 mm Cu-leads.

PR03

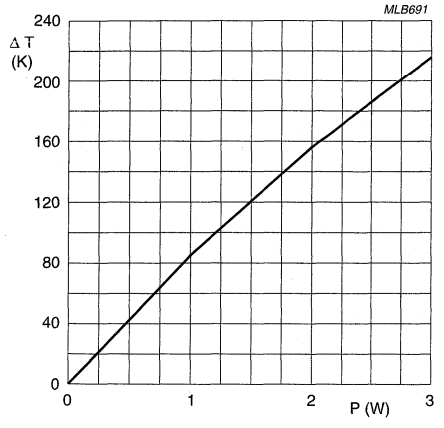
Fig.28 Hot-spot temperature rise (ΔT) as a function of dissipated power.



∅0.8 mm Cu-leads.
Minimum distance from resistor body to PCB = 1 mm.

PR03

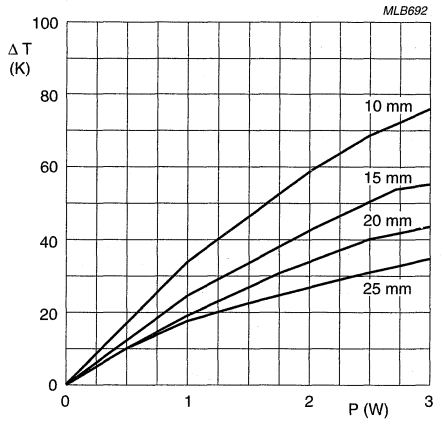
Fig.29 Temperature rise (ΔT) at the lead end (soldering point) as a function of dissipated power at various lead lengths after mounting.



∅0.6 mm FeCu-leads.

PR03

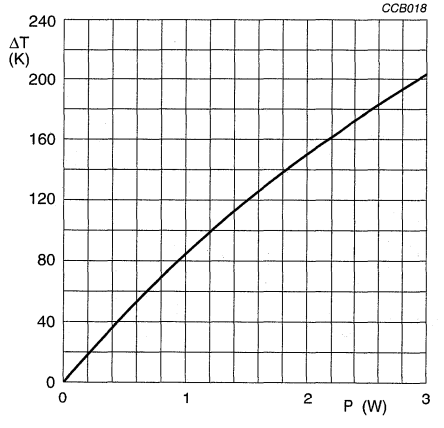
Fig.30 Hot-spot temperature rise (ΔT) as a function of dissipated power.



∅0.6 mm FeCu-leads.
Minimum distance from resistor body to PCB = 1 mm.

PR03

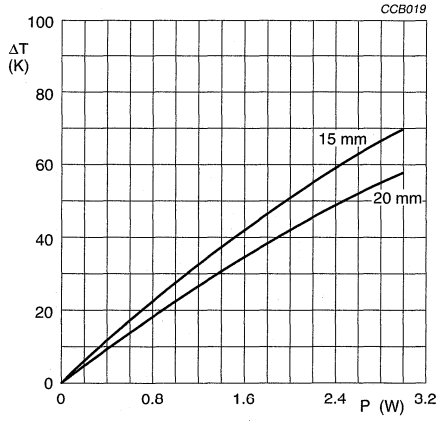
Fig.31 Temperature rise (ΔT) at the lead end (soldering point) as a function of dissipated power at various lead lengths after mounting.



∅0.8 mm FeCu-leads.

PR03

Fig.32 Hot-spot temperature rise (ΔT) as a function of dissipated power.



∅0.8 mm FeCu-leads.
Minimum distance from resistor body to PCB = 1 mm.

PR03

Fig.33 Temperature rise (ΔT) at the lead end (soldering point) as a function of dissipated power at various lead lengths after mounting.

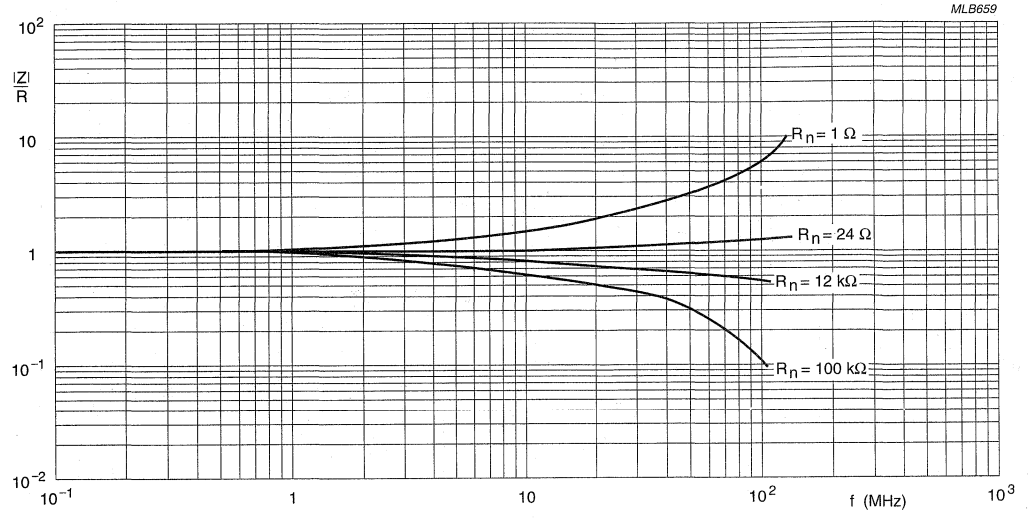


Fig.34 Impedance as a function of applied frequency.

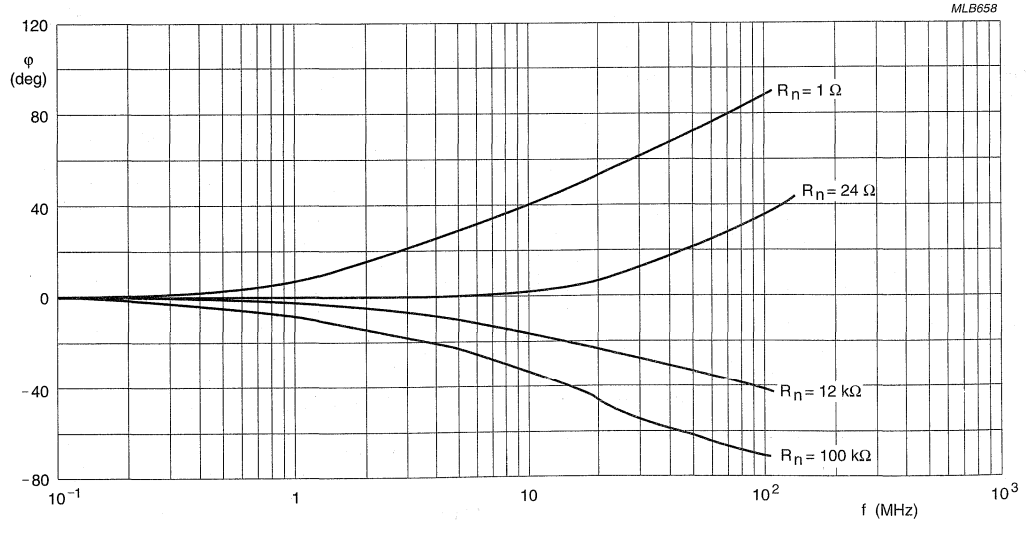
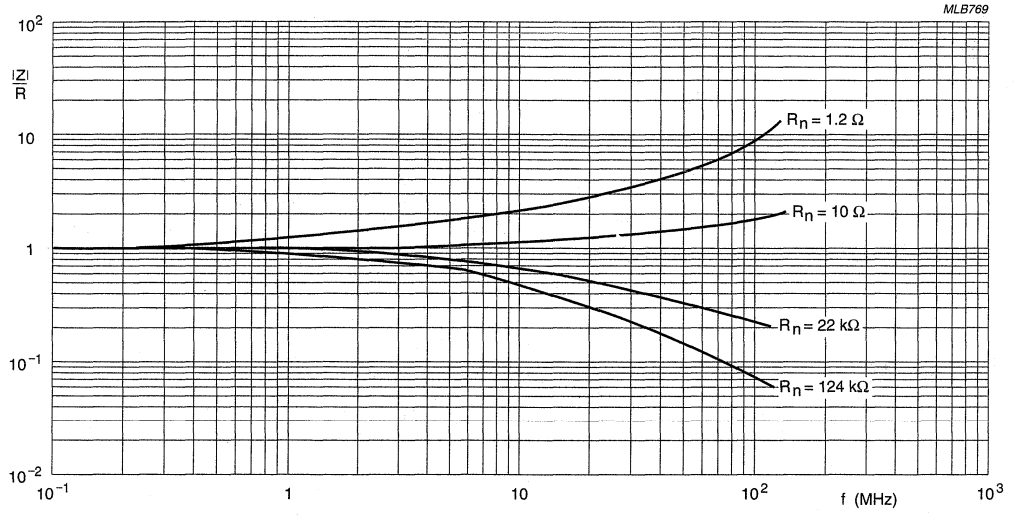
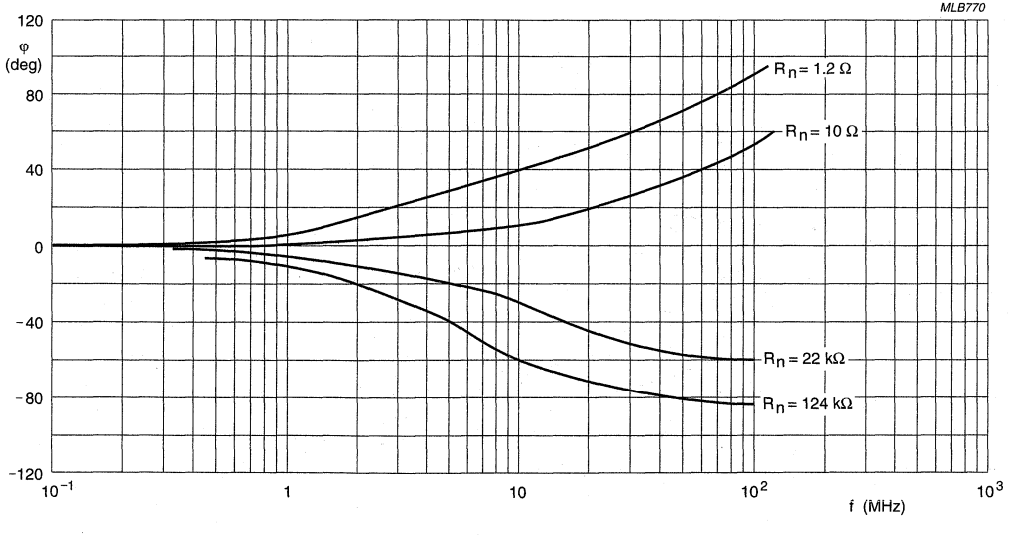


Fig.35 Phase angle as a function of applied frequency.



PR02

Fig.36 Impedance as a function of applied frequency.



PR02

Fig.37 Phase angle as a function of applied frequency.

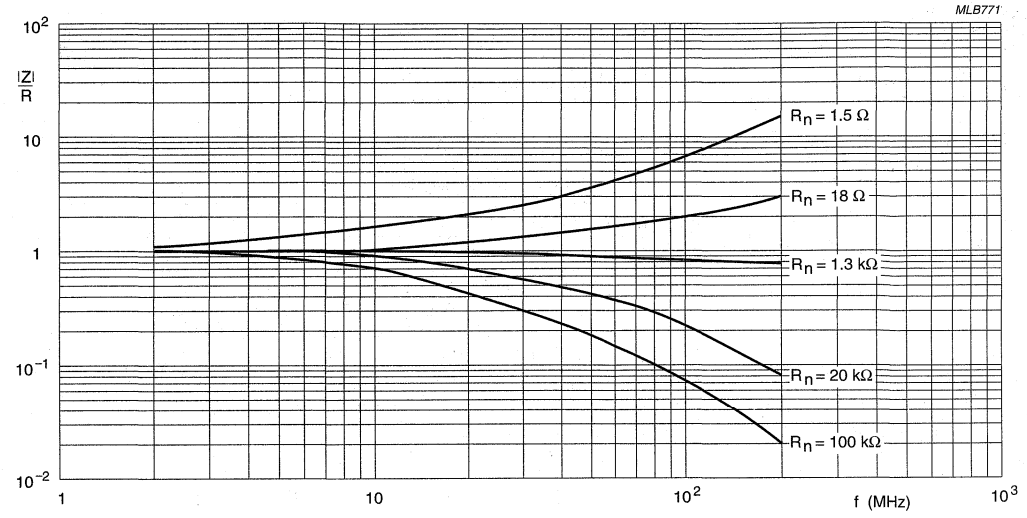


Fig.38 Impedance as a function of applied frequency.

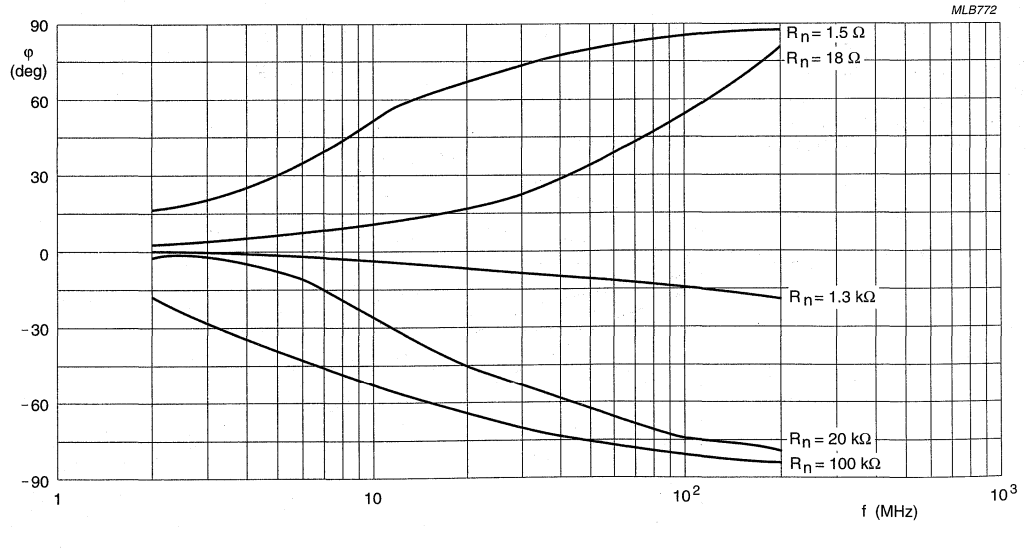


Fig.39 Phase angle as a function of applied frequency.

MECHANICAL DATA

Mass per 100 units

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

Mounting

The resistors are suitable for processing on automatic insertion equipment and cutting and bending machines.

Marking

The nominal resistance and tolerance are marked on the resistor using four coloured bands in accordance with IEC publication 60062, *"Colour codes for fixed resistors"*.

Outlines

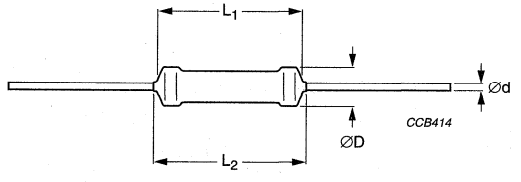
The length of the body (L_1) is measured by inserting the leads into holes of two identical gauge plates and moving these plates parallel to each other until the resistor body is clamped without deformation *("IEC publication 60294")*.

Mounting pitch

TYPE	LEAD STYLE	PITCH	
		mm	e
PR01	straight leads	12.5(1)	5(1)
	radial taped	4.8	2
	cropped and formed	17.8	7
	double kink large pitch	17.8	7
	double kink small pitch	12.5	5
PR02	straight leads	15.0(1)	6(1)
	radial taped	4.8	2
	cropped and formed	17.8	7
	double kink large pitch	17.8	7
	double kink small pitch	15.0	6
PR03	straight leads	23.0(1)	9(1)
	cropped and formed	25.4	10
	double kink large pitch	25.4	10
	double kink small pitch	20.0	8

Note

1. Recommended minimum value.

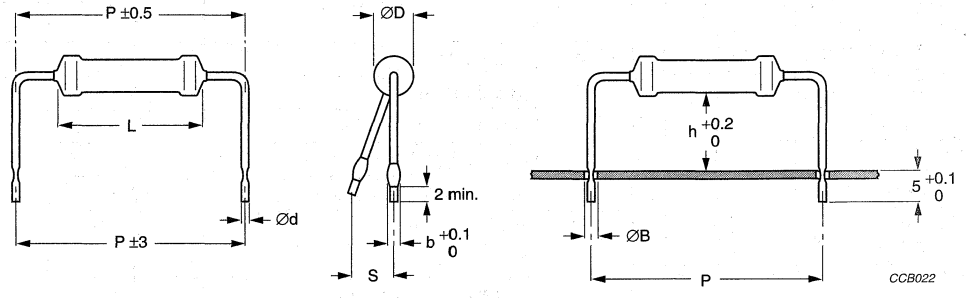


For dimensions see Table 4.

Fig.40 Type with straight leads.

Table 4 Straight lead type and relevant physical dimensions: see Fig.40

TYPE	ØD MAX. (mm)	L_1 MAX. (mm)	L_2 MAX. (mm)	Ød (mm)
PR01	2.5	6.5	8.5	0.58 ±0.05
PR02	3.9	10.0	12.0	0.8 ±0.03
				0.58 ±0.05
PR03	5.2	16.7	19.5	0.8 ±0.03
				0.58 ±0.05

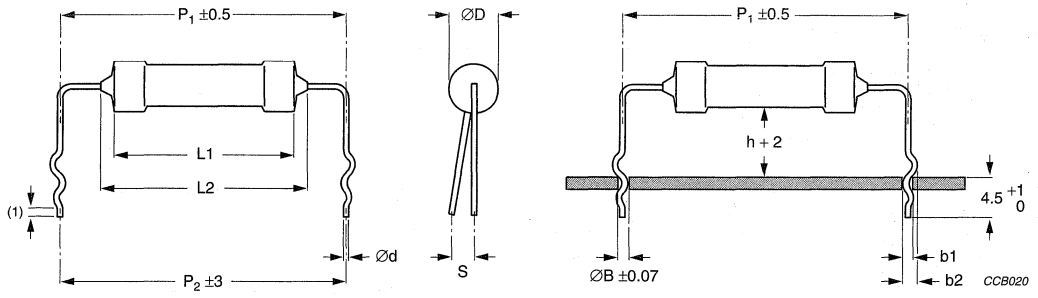


Dimensions in mm.
For dimensions see Tables 4 and 5.

Fig.41 Type with cropped and formed leads.

Table 5 Cropped and formed lead type and relevant physical dimensions; see Fig.41

TYPE	LEAD STYLE	Ød (mm)	b (mm)	h (mm)	P (mm)	S MAX. (mm)	ØB MAX. (mm)
PR01	cropped and formed	0.58 ±0.05	1.1	8	17.8	2	1.0
PR02		0.8 ±0.03	1.3	8	17.8	2	1.2
		0.8 ±0.03	1.3	15		3	1.2
		0.58 ±0.05	1.1	8		2	1.0
PR03		0.8 ±0.03	1.3	8	25.4	2	1.2
		0.8 ±0.03	1.3	15		3	1.2
		0.58 ±0.05	1.1	8		2	1.0



Dimensions in mm.
For dimensions see Tables 4 and 6.
(1) Ø0.8 to 1.4 or Ø0.6 to 1.6.

Fig.42 Type with double kink.

Table 6 Double kink lead type and relevant physical dimensions; see Fig.42

TYPE	LEAD STYLE	Ød (mm)	b1 (mm)	b2 (mm)	h (mm)	P_1 (mm)	P_2 (mm)	S MAX. (mm)	ØB (mm)
PR01	double kink large pitch	0.58 ±0.05	1.10 +0.25/–0.20	1.45 +0.25/–0.20	8	17.8	17.8	2	0.8
	double kink small pitch	0.58 ±0.05	1.10 +0.25/–0.20	1.45 +0.25/–0.20	8	12.5	12.5	2	0.8
PR02	double kink large pitch	0.58 ±0.05	1.10 +0.25/–0.20	1.45 +0.25/–0.20	8	17.8	17.8	2	0.8
	double kink small pitch	0.8 ±0.03	1.30 +0.25/–0.20	1.65 +0.25/–0.20	8	15.0	15.0	2	1.0
PR03	double kink large pitch	0.58 ±0.05	1.10 +0.25/–0.20	1.45 +0.25/–0.20	8	25.4	25.4	2	0.8
	double kink small pitch	0.8 ±0.03	1.30 +0.25/–0.20	2.15 +0.25/–0.20	8	22.0	20.0	2	1.0

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of *"IEC publication 60115-1"*, category **LCT/UCT/56** (rated temperature range: **L**ower **C**ategory **T**emperature, **U**pper **C**ategory **T**emperature; 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 60068, *"Recommended basic climatic and mechanical robustness testing procedure for electronic components"* and under standard atmospheric conditions according to *"IEC 60068-1"*, 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 7 the tests and requirements are listed with reference to the relevant clauses of *"IEC publications 60115-1 and 60068"*; 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 7 Test procedures and requirements

IEC 60115-1 CLAUSE	IEC 60068-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
Tests in accordance with the schedule of IEC publication 60115-1				
4.4.1		visual examination		no holes; clean surface; no damage
4.4.2		dimensions (outline)	gauge (mm)	see Tables 4, 5 and 6
4.5		resistance	applied voltage (+0/–10%): $R < 10\ \Omega$: 0.1 V $10\ \Omega \leq R < 100\ \Omega$: 0.3 V $100\ \Omega \leq R < 1\ k\Omega$: 1 V $1\ k\Omega \leq R < 10\ k\Omega$: 3 V $10\ k\Omega \leq R < 100\ k\Omega$: 10 V $100\ k\Omega \leq R < 1\ M\Omega$: 25 V $R = 1\ M\Omega$: 50 V	$R - R_{nom}$: max. ±5%
4.18	Tb	resistance to soldering heat	thermal shock: 3 s; 350 °C; 6 mm from body	$\Delta R/R$ max.: ±1% + 0.05 Ω
4.29	45 (Xa)	component solvent resistance	isopropyl alcohol or H_2O 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

IEC 60115-1 CLAUSE	IEC 60068-2 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 × 90°	number of failures: $<1 \times 10^{-6}$
4.16.4	Uc	torsion other half of samples	3 × 360° in opposite directions	no damage ΔR/R max.: ±0.5% + 0.05 Ω
4.20	Eb	bump	3 × 1500 bumps in three directions; 40 g	no damage ΔR/R max.: ±0.5% + 0.05 Ω
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 ΔR/R max.: ±0.5% + 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 **PR01**: ΔR/R max.: ±1% + 0.05 Ω **PR02**: ΔR/R max.: ±1% + 0.05 Ω **PR03**: ΔR/R max.: ±2% + 0.05 Ω
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 MΩ ΔR/R max.: ±3% + 0.1 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} min.: 1000 MΩ ΔR/R max.: ±3% + 0.1 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.: ±5% + 0.1 Ω
4.8.4.2		temperature coefficient	at 20/LCT/20 °C and 20/UCT/20 °C ($TC \times 10^{-6}$/K)	≤±250
Other tests in accordance with IEC 60115 clauses and IEC 60068 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 (DC) after 1 minute; metal block method	R_{ins} min.: 10^4 MΩ
see 2nd amendment to IEC 60015-1, Jan. '87		pulse load		see Figs 5, 6, 7, 8, 9 and 10

High ohmic/high voltage resistors VR25

FEATURES

- High pulse loading capability
- Small size.

APPLICATIONS

- Where high resistance, high stability and high reliability at high voltage are required
- High humidity environment
- White goods
- Power supplies.

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 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 60068-2-45"*.

QUICK REFERENCE DATA

DESCRIPTION	VALUE
Resistance range	100 kΩ to 22 MΩ
Resistance tolerance and 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
Thermal resistance, R_{th}	200 K/W
Temperature coefficient	$\leq \pm 200 \times 10^{-6}$/K
Maximum permissible voltage:	
DC	1600 V
RMS	1150 V
Dielectric withstanding voltage of the insulation for 1 minute	700 V
Basic specifications	IEC 60115-1B
Climatic category (IEC 60068)	55/155/56
Stability after:	
load (1000 hours)	ΔR/R max.: ±1.5% + 0.1 Ω
accelerated damp heat test (6 days)	ΔR/R max.: ±1.5% + 0.1 Ω
long term damp heat test (56 days)	ΔR/R max.: ±1.5% + 0.1 Ω
Noise	max. 5 μV/V

ORDERING INFORMATION

Table 1 Ordering code indicating resistor type and packaging

TYPE	TAPE WIDTH (mm)	TOL. (%)	ORDERING CODE 2322 241			
			BANDOLIER IN AMMOPACK[1]			BANDOLIER ON REEL
			1000 units	2000 units	5000 units	5000 units
VR25	52	±1	8....	–	–	–
		±5	13...	–	53...	23...
		±10	12...	–	52...	22...
	26	±5	–	43...	–	–
		±10	–	42...	–	–

Note

1. Radial taped version available on request.

Ordering code (12NC)

- The resistors have a 12-digit ordering code starting with 2322 241
- The subsequent:
  first digit for 1% tolerance products (E24 and E96 series)
  or 2 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 VR25, resistor value 7.5 MΩ, 5% tolerance, supplied on a bandolier of 1000 units in ammopack, is: 2322 241 13755.

FUNCTIONAL DESCRIPTION

Product characterization

Standard values of nominal resistance are taken from the E96/E24/E12 series for resistors with a tolerance of ±1%, 5% or 10%. The values of the E96/E24/E12 series are in accordance with *"IEC publication 60063"*.

Limiting values

TYPE	LIMITING VOLTAGE(1) (V)		LIMITING POWER (W)
	DC	RMS	
VR25	1600	1150	0.25

Note

1. The maximum voltage that may be continuously applied to the resistor element, see *"IEC publication 60115-1"*.

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.

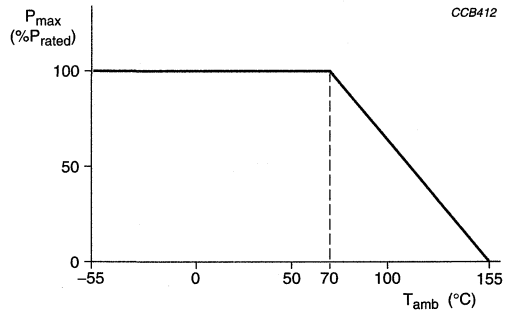


Fig.1 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

PULSE LOADING CAPABILITY

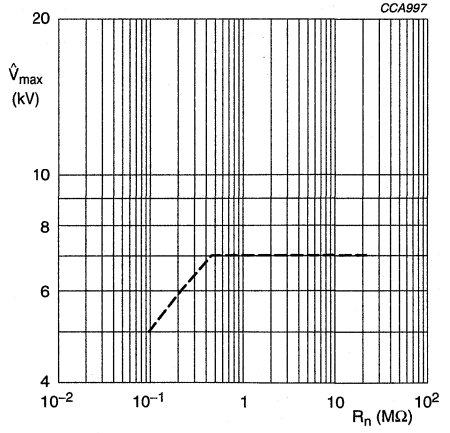
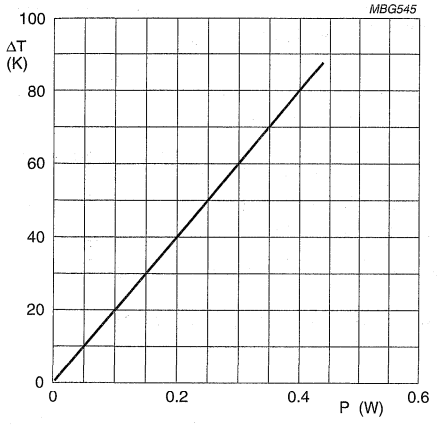


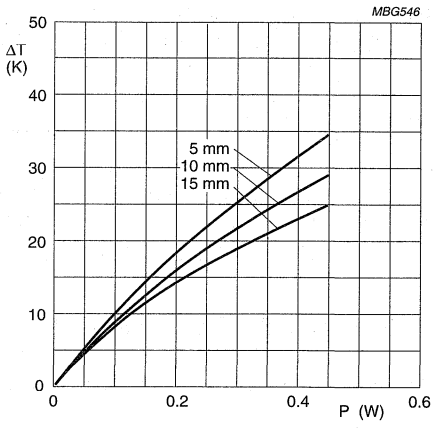
Fig.2 Maximum allowed peak pulse voltage in accordance with *"IEC 60065 chapter 14.1"*; 50 discharges from a 1 nF capacitor charged to $\hat{V}_{max}$; 12 discharges/minute (drift $\Delta R/R \leq 1\%$).

Application information



VR25

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



VR25

Fig.4 Temperature rise (ΔT) at the lead end (soldering point) as a function of dissipated power at various lead lengths after mounting.

MECHANICAL DATA

Mass per 100 units

TYPE	MASS (g)
VR25	25

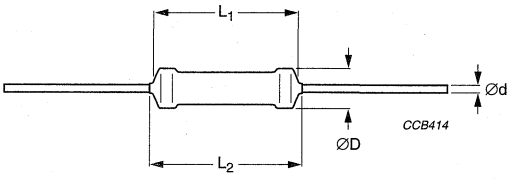
Marking

The nominal resistance and tolerance are marked on the resistor using four or five coloured bands in accordance with IEC publication 60062 *"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 60294")*.



For dimensions see Table 3.

Fig.5 Outline.

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

TYPE	ØD MAX. (mm)	L_1 MAX. (mm)	L_2 MAX. (mm)	Ød (mm)
VR25	2.5	6.5	7.5	0.58 ±0.05

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of *"IEC publication 60115-1"*, category **LCT/UCT/56** (rated temperature range: **L**ower **C**ategory **T**emperature, **U**pper **C**ategory **T**emperature; 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 60068, *"Recommended basic climatic and mechanical robustness testing procedure for electronic components"* and under standard atmospheric conditions according to *"IEC 60068-1"*, 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 60115-1 and 60068"*; 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 60115-1 CLAUSE	IEC 60068 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.16	U	robustness of terminations:		
4.16.2	Ua	tensile all samples	∅0.6 mm; load 10 N; 10 s	number of failures $<10 \times 10^{-6}$
4.16.3	Ub	bending half number of samples	∅0.6 mm; load 5 N; 4 × 90°	number of failures $<10 \times 10^{-6}$
4.16.4	Uc	torsion other half of samples	3 × 360° in opposite directions	no damage ΔR/R max.: ±0.5% + 0.05 Ω
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	ΔR/R max.: ±0.5% + 0.05 Ω
4.19	Na	rapid change of temperature	30 minutes at –55 °C and 30 minutes at +155 °C; 5 cycles	ΔR/R max.: ±0.5% + 0.05 Ω
4.20	Eb	bump	3 × 1500 bumps in 3 directions; 40 g	no damage ΔR/R max.: ±0.5% + 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.: ±0.5% + 0.05 Ω
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; 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_{ins} min.: 10^3 MΩ ΔR/R max.: ±1.5% + 0.1 Ω

IEC 60115-1 CLAUSE	IEC 60068 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.24.2	Ca	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; dissipation 0.01 P_n; limiting voltage 100 V (DC)	$\Delta R/R$ max.: ±1.5% + 0.1 Ω
4.25.1		endurance	1000 hours at 70 °C; P_n or V_{max}	$\Delta R/R$ max.: ±1.5% + 0.1 Ω
4.8.4		temperature coefficient	between −55 °C and +155 °C ($TC \times 10^{-6}$/K)	≤±200
4.7		voltage proof on insulation	700 V (RMS) during 1 minute; V-block method	no breakdown
4.12		noise	*"IEC publication 60195"*	max. 5 μV/V
4.6.1.1		insulation resistance	500 V (DC) 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 cycles; 5 s on and 45 s off	$\Delta R/R$ max.: ±0.5% + 0.05 Ω

High ohmic/high voltage resistors VR37

FEATURES

- These resistors meet the safety requirements of:
  "UL1676" (range 510 kΩ to 11 MΩ)
  "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
- Safety component in combination with high voltage
- White goods
- High humidity environment
- Power supplies.

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 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 60068-2-45"*.

QUICK REFERENCE DATA

DESCRIPTION	VALUE
Resistance range	100 kΩ to 33 MΩ; note 1
Resistance tolerance and series	±1%: E24/E96 series; ±5%: E24 series
Maximum dissipation at T_{amb} = 70 °C	0.5 W
Thermal resistance, R_{th}	120 K/W
Temperature coefficient	$\leq \pm 200 \times 10^{-6}$/K
Maximum permissible voltage:	
DC	3500 V
RMS	2500 V
Dielectric withstanding voltage of the insulation for 1 minute	700 V
Basic specifications	IEC 60115-1B
Safety requirements	UL1676 (510 kΩ to 11 MΩ); EN60065; BS60065; VDE 0860; NFC 92-130
Climatic category (IEC 60068)	55/155/56
Stability after:	
load (1000 hours)	ΔR/R max.: ±1.5% + 0.1 Ω; typ. 0.5%
accelerated damp heat test (6 days)	ΔR/R max.: ±1.5% + 0.1 Ω; typ. 0.5%
long term damp heat test (56 days)	ΔR/R max.: ±1.5% + 0.1 Ω; typ. 0.5%
Noise	max. 2.5 μV/V; typ. 0.5

Note

1. Values up to 100 MΩ are available upon request.

ORDERING INFORMATION

Table 1 Ordering code indicating resistor type and packaging

TYPE	TAPE WIDTH (mm)	TOL. (%)	ORDERING CODE 2322 242	
			BANDOLIER IN AMMOPACK	BANDOLIER ON REEL
			1000 units	5000 units
VR37	52	±1	8....	–
		±5	13...	23...

Ordering code (12NC)

- The resistors have a 12-digit ordering code starting with 2322 242
- The subsequent:
  first digit for 1% tolerance products (E24 and E96 series)
  or 2 digits for
  5% (E24 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% 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 1000 units in ammopack, is: 2322 242 13755.

FUNCTIONAL DESCRIPTION

Product characterization

Standard values of nominal resistance are taken from the E96/E24/E12 series for resistors with a tolerance of ±1% or 5%. The values of the E96/E24 series are in accordance with *"IEC publication 60063"*.

Limiting values

TYPE	LIMITING VOLTAGE[1] (V)		LIMITING POWER (W)
	DC	RMS	
VR37	3500	2500	0.5

Note

1. The maximum voltage that may be continuously applied to the resistor element, see *"IEC publication 60115-1"*.

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.

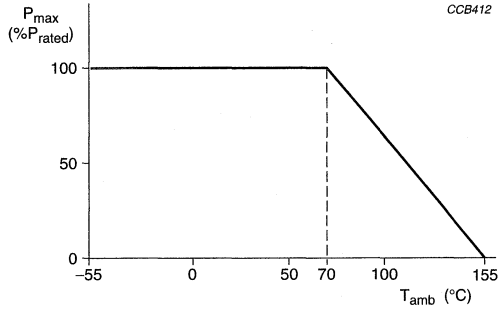


Fig.1 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

PULSE LOADING CAPABILITY

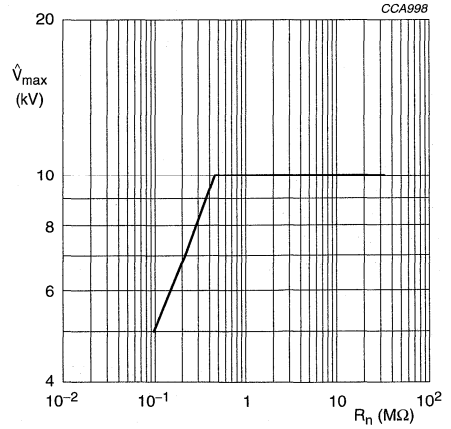


Fig.2 Maximum allowed peak pulse voltage in accordance with *"IEC 60065 chapter 14.1"*; 50 discharges from a 1 nF capacitor charged to $\hat{V}_{max}$; 12 discharges/minute (drift $\Delta R/R \leq 1\%$).

Application information

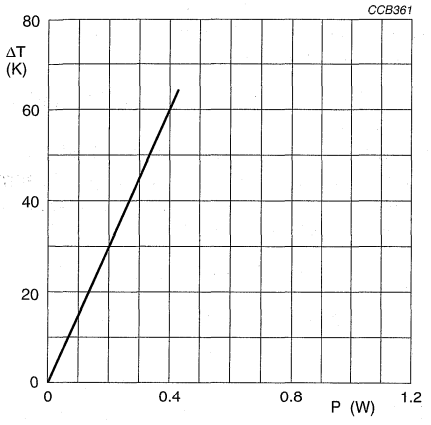


Fig.3 Hot-spot temperature rise (ΔT) as a function of dissipated power.

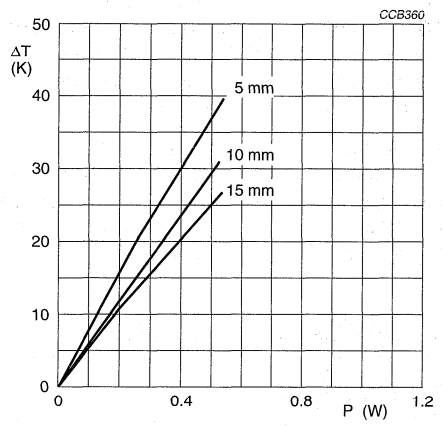


Fig.4 Temperature rise (ΔT) at the lead end (soldering point) as a function of dissipated power at various lead lengths after mounting.

MECHANICAL DATA

Mass per 100 units

TYPE	MASS (g)
VR37	48

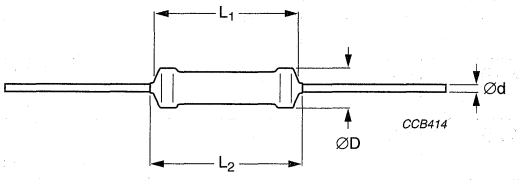
Marking

The nominal resistance and tolerance are marked on the resistor using four or five coloured bands in accordance with IEC publication 60062 *"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 60294")*.



For dimensions see Table 3.

Fig.5 Outline.

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

TYPE	ØD MAX. (mm)	L_1 MAX. (mm)	L_2 MAX. (mm)	Ød (mm)
VR37	4.0	9.0	10.0	0.7 ±0.03

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of *"IEC publication 60115-1"*, category **LCT/UCT/56** (rated temperature range: **L**ower **C**ategory **T**emperature, **U**pper **C**ategory **T**emperature; 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 60068, *"Recommended basic climatic and mechanical robustness testing procedure for electronic components"* and under standard atmospheric conditions according to *"IEC 60068-1"*, 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 60115-1 and 60068"*; 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 60115-1 CLAUSE	IEC 60068 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.16	U	robustness of terminations:		
4.16.2	Ua	tensile all samples	∅0.7 mm; load 10 N; 10 s	number of failures $<10 \times 10^{-6}$
4.16.3	Ub	bending half number of samples	∅0.7 mm; load 5 N; 4 × 90°	number of failures $<10 \times 10^{-6}$
4.16.4	Uc	torsion other half of samples	3 × 360° in opposite directions	no damage ΔR/R max.: ±0.5% + 0.05 Ω
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	ΔR/R max.: ±0.5% + 0.05 Ω
4.19	Na	rapid change of temperature	30 minutes at –55 °C and 30 minutes at +155 °C; 5 cycles	ΔR/R max.: ±0.5% + 0.05 Ω
4.20	Eb	bump	3 × 1500 bumps in 3 directions; 40 g	no damage ΔR/R max.: ±0.5% + 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.: ±0.5% + 0.05 Ω
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; 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_{ins} min.: 10^3 MΩ ΔR/R max.: ±1.5% + 0.1 Ω

IEC 60115-1 CLAUSE	IEC 60068 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.24.2	Ca	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; dissipation 0.01 P_n; limiting voltage 100 V (DC)	$\Delta R/R$ max.: ±1.5% + 0.1 Ω
4.25.1		endurance	1000 hours at 70 °C; P_n or V_{max}	$\Delta R/R$ max.: ±1.5% + 0.1 Ω
4.8.4		temperature coefficient	between −55 °C and +155 °C ($TC \times 10^{-6}$/K)	≤±200
4.7		voltage proof on insulation	700 V (RMS) during 1 minute; V-block method	no breakdown
4.12		noise	*"IEC publication 60195"*	max. 2.5 μV/V
4.6.1.1		insulation resistance	500 V (DC) 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 cycles; 5 s on and 45 s off	$\Delta R/R$ max.: ±0.5% + 0.05 Ω

High ohmic/high voltage resistors VR68

FEATURES

- These resistors meet the safety requirements of:
  "UL1676" (range 510 kΩ to 11 MΩ)
  "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
- Safety component in combination with high voltage
- Picture tubes
- High voltage bleeders
- Cascade switches.

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 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 60068-2-45"*.

QUICK REFERENCE DATA

DESCRIPTION	VALUE
Resistance range	100 kΩ to 68 MΩ; note 1
Resistance tolerance and series	±1%: E24/E96 series; ±5%; E24 series
Maximum dissipation at T_{amb} = 70 °C	1 W
Thermal resistance, R_{th}	70 K/W
Temperature coefficient	$\leq \pm 200 \times 10^{-6}$/K
Maximum permissible voltage:	
DC	10000 V
RMS	7000 V
Dielectric withstanding voltage of the insulation for 1 minute	700 V
Basic specifications	IEC 60115-1B
Safety requirements	UL1676 (510 kΩ to 11 MΩ); EN60065; BS60065; VDE 0860; NFC 92-130
Climatic category (IEC 60068)	55/155/56
Stability after:	
load (1000 hours)	ΔR/R max.: ±1.5% + 0.1 Ω; typ. 1%
accelerated damp heat test (6 days)	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; typ. 0.5%
Noise	max. 2.5 μV/V; typ. 0.5

Note

1. Values up to 220 MΩ are available upon request.

ORDERING INFORMATION

Table 1 Ordering code indicating resistor type and packaging

TYPE	TAPE WIDTH (mm)	TOL. (%)	ORDERING CODE 2322 244 .....
			BANDOLIER IN AMMOPACK
			500 units
VR68	66.7	±1	8....
		±5	13...

Ordering code (12NC)

- The resistors have a 12-digit ordering code starting with 2322 244
- The subsequent: first digit for 1% tolerance products (E24 and E96 series) or 2 digits for 5% (E24 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% 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 VR68, resistor value 7.5 MΩ, 5% tolerance, supplied on a bandolier of 500 units in ammopack, is: 2322 244 13755.

FUNCTIONAL DESCRIPTION

Product characterization

Standard values of nominal resistance are taken from the E96/E24/E12 series for resistors with a tolerance of ±1% or 5%. The values of the E96/E24 series are in accordance with *"IEC publication 60063"*.

Limiting values

TYPE	LIMITING VOLTAGE(1) (V)		LIMITING POWER (W)
	DC	RMS	
VR68	10000	7000	1.0

Note

1. The maximum voltage that may be continuously applied to the resistor element, see *"IEC publication 60115-1"*.

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.

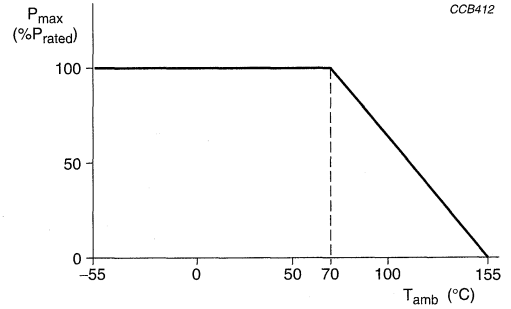


Fig.1 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

PULSE LOADING CAPABILITY

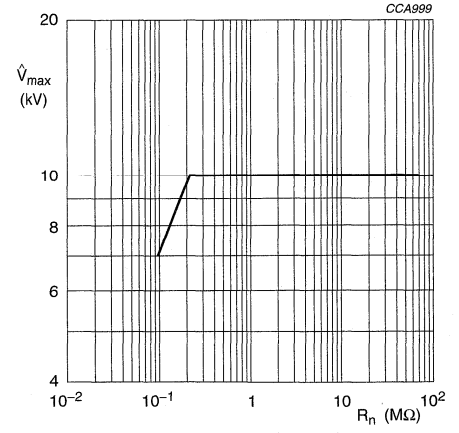


Fig.2 Maximum allowed peak pulse voltage in accordance with *"IEC 60065 chapter 14.1"*; 50 discharges from a 1 nF capacitor charged to $\hat{V}_{max}$; 12 discharges/minute (drift $\Delta R/R \leq 1\%$).

Application information

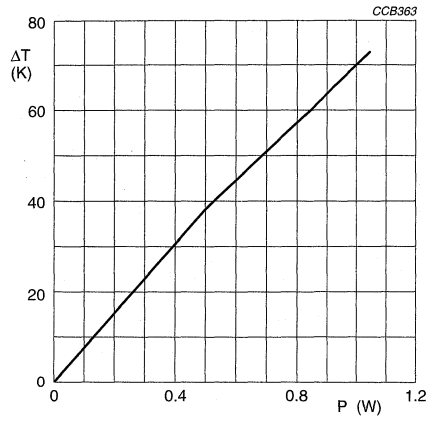


Fig.3 Hot-spot temperature rise (ΔT) as a function of dissipated power.

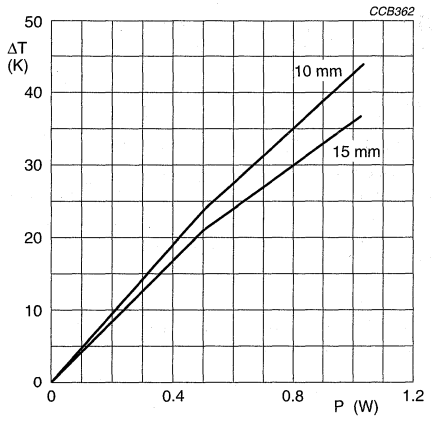


Fig.4 Temperature rise (ΔT) at the lead end (soldering point) as a function of dissipated power at various lead lengths after mounting.

MECHANICAL DATA

Mass per 100 units

TYPE	MASS (g)
VR68	148

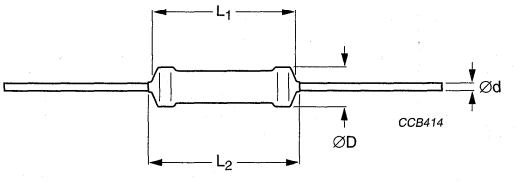
Marking

The nominal resistance and tolerance are marked on the resistor using four or five coloured bands in accordance with IEC publication 60062 *"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 60294")*.



For dimensions see Table 3.

Fig.5 Outline.

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

TYPE	ØD MAX. (mm)	L_1 MAX. (mm)	L_2 MAX. (mm)	Ød (mm)
VR68	6.8	18.0	19.0	0.8 ±0.03

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of *"IEC publication 60115-1"*, category **LCT/UCT/56** (rated temperature range: **L**ower **C**ategory **T**emperature, **U**pper **C**ategory **T**emperature; 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 60068, *"Recommended basic climatic and mechanical robustness testing procedure for electronic components"* and under standard atmospheric conditions according to *"IEC 60068-1"*, 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 60115-1 and 60068"*; 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 60115-1 CLAUSE	IEC 60068 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.16	U	robustness of terminations:		
4.16.2	Ua	tensile all samples	∅0.8 mm; load 10 N; 10 s	number of failures $<10 \times 10^{-6}$
4.16.3	Ub	bending half number of samples	∅0.8 mm; load 5 N; 4 × 90°	number of failures $<10 \times 10^{-6}$
4.16.4	Uc	torsion other half of samples	3 × 360° in opposite directions	no damage ΔR/R max.: ±0.5% + 0.05 Ω
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	ΔR/R max.: ±0.5% + 0.05 Ω
4.19	Na	rapid change of temperature	30 minutes at –55 °C and 30 minutes at +155 °C; 5 cycles	ΔR/R max.: ±0.5% + 0.05 Ω
4.20	Eb	bump	3 × 1500 bumps in 3 directions; 40 g	no damage ΔR/R max.: ±0.5% + 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.: ±0.5% + 0.05 Ω
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; 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_{ins} min.: 10^3 MΩ ΔR/R max.: ±1.5% + 0.1 Ω

IEC 60115-1 CLAUSE	IEC 60068 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.24.2	Ca	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; dissipation 0.01 P_n; limiting voltage 100 V (DC)	$\Delta R/R$ max.: ±1.5% + 0.1 Ω
4.25.1		endurance	1000 hours at 70 °C; P_n or V_{max}	$\Delta R/R$ max.: ±1.5% + 0.1 Ω
4.8.4		temperature coefficient	between −55 °C and +155 °C ($TC \times 10^{-6}$/K)	≤ ±200
4.7		voltage proof on insulation	700 V (RMS) during 1 minute; V-block method	no breakdown
4.12		noise	*"IEC publication 60195"*	max. 2.5 μV/V
4.6.1.1		insulation resistance	500 V (DC) 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; 10000 V max.); 10 cycles; 5 s on and 45 s off	$\Delta R/R$ max.: ±0.5% + 0.05 Ω

High voltage surge resistor | LSR37

FEATURES

- High pulse-loading capability (flashes)
- Good replacement for carbon-composite resistors.

APPLICATIONS

- Application for overload and high voltage pulse hazard circuits (TV-sets, monitors).

DESCRIPTION

A metal glazed film is deposited on a high grade ceramic body. After that caps are applied to the rods and electrolytic copper wires are welded to these 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 according to *"MIL-STD 202E, method 215"* and *"IEC 60068-2-45"*.

ORDERING INFORMATION

Ordering code (12NC)

- The resistors have a 12-digit ordering code staring with 2322 245
- The subsequent 2 digits indicate the resistor type and packaging; see Table 1.
- The remaining 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
Resistance range	900 Ω to 10 kΩ
Resistance tolerance and series	±10%; ±20%; E12 series
Maximum dissipation at T_{amb} = 70 °C	0.5 W
Thermal resistance, R_{th}	120 K/W
Temperature coefficient	$\leq \pm 400 \times 10^{-6}$/K
Voltage coefficient	$\leq \pm 100 \times 10^{-6}$/V
Maximum permissible voltage	$V = \sqrt{P_n \times R}$
Dielectric withstanding voltage of the insulation for 1 minute	700 V
Basic specifications	IEC 60115-1B
Climatic category (IEC 60068)	55/155/56
Stability after:	
load (1000 hours)	ΔR/R max.: ±3% + 0.1 Ω
climatic test	ΔR/R max.: ±3% + 0.1 Ω
soldering	ΔR/R max.: ±1% + 0.1 Ω
Noise	max. 2.5 μV/V

Table 1 Ordering code as function of tolerance and packaging

TYPE	TOLERANCE (%)	ORDERING CODE 2322 245	
		1000 units IN AMMOPACK	5000 units ON REEL
LSR37	±10	12...	22...
	±20	11...	21...

Table 2 Last digit of 12NC

RESISTANCE DECADE	LAST DIGIT
100 to 910 Ω	1
1 to 9.1 kΩ	2
10 kΩ	3

ORDERING EXAMPLE

The ordering code for a LSR37, resistor value 1.5 kΩ, 10% tolerance, supplied on a bandolier of 1000 units in ammopack, is: 2322 245 12152.

FUNCTIONAL DESCRIPTION

Product characterization

Standard values of rated resistance (nominal resistance) are taken from the E12 series with a tolerance of 10% or 20%.The values of the E12 series are in accordance with *"IEC publication 60063"*.

The limiting voltage DC is not applicable, because the maximum rated voltage for the maximum R_n-value of 10 KΩ at P_n = 0.5 W is only 70.7 V.

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.

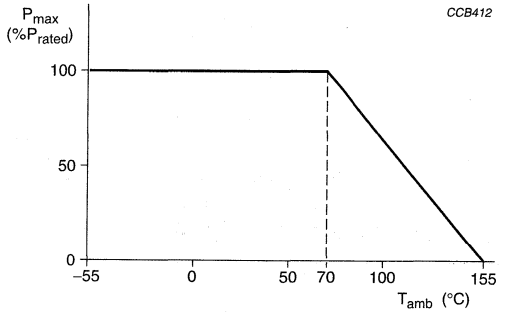


Fig.1 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

Limiting values

TYPE	LIMITING VOLTAGE(1) (V)	LIMITING POWER (W)
LSR37	$V = \sqrt{P_n \times R}$	0.5

Note

1. The maximum voltage that may be continuously applied to the resistor element, see *"IEC publication 60115-1"*.

PULSE LOADING CAPABILITY

Data not yet available.

Fig.2 Maximum allowed peak pulse voltage in accordance with *"IEC 60065 chapter 14.1"*; 50 discharges from a 1 nF capacitor charged to $\hat{V}_{max}$; 12 discharges/minute (drift $\Delta R/R \leq 1\%$).

Application information

The resistors with straight leads are suitable for processing on automatic insertion equipment and cutting and bending machines.The minimum pitch for this type is 6e (15.0 mm).

For temperature rise at soldering place see Fig.4.

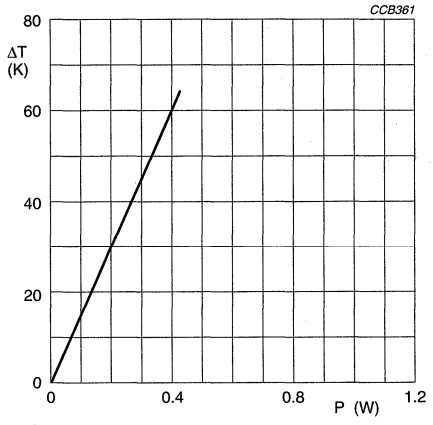


Fig.3 Hot-spot temperature rise (ΔT) as a function of dissipated power.

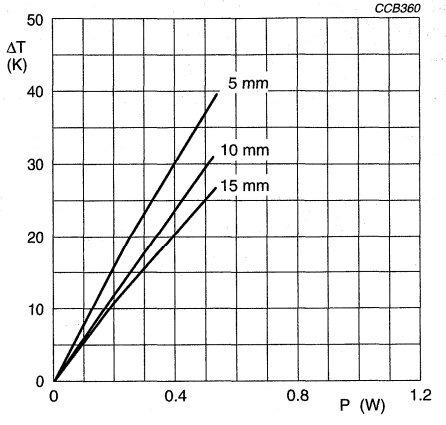


Fig.4 Temperature rise (ΔT) at the lead end (soldering point) as a function of dissipated power at various lead lengths after mounting.

MECHANICAL DATA

Mass per 100 units

TYPE	MASS (g)
LSR37	48

Marking

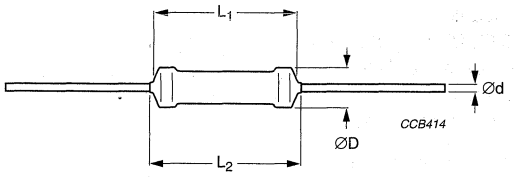
The nominal resistance and tolerance are marked on the resistor using coloured bands in accordance with IEC publication 60062 *"Colour codes for fixed resistors"*.

Three bands are used for 20% tolerance with no indication for the tolerance. Four bands are used for 10% tolerance.

Grey is used instead of silver for 10% and yellow is used instead of gold for 5% 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 60294")*.



For dimensions see Table 3.

Fig.5 Outline.

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

TYPE	ØD MAX. (mm)	L_1 MAX. (mm)	L_2 MAX. (mm)	Ød (mm)
LSR37	4.0	9.0	10.0	0.7 ±0.03

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of *"IEC publication 60115-1"*, category **LCT/UCT/56** (rated temperature range: **L**ower **C**ategory **T**emperature, **U**pper **C**ategory **T**emperature; 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 60068, *"Recommended basic climatic and mechanical robustness testing procedure for electronic components"* and under standard atmospheric conditions according to *"IEC 60068-1"*, 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 60115-1 and 60068"*; 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 60115-1 CLAUSE	IEC 60068 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.16	U	robustness of terminations:		
4.16.2	Ua	tensile all samples	∅0.7 mm; load 10 N; 10 s	number of failures $<10 \times 10^{-6}$
4.16.3	Ub	bending half number of samples	∅0.7 mm; load 5 N; 4 × 90°	number of failures $<10 \times 10^{-6}$
4.16.4	Uc	torsion other half of samples	3 × 360° in opposite directions	no damage ΔR/R max.: ±1.0% + 0.10 Ω
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	ΔR/R max.: ±1.0% + 0.10 Ω
4.19	Na	rapid change of temperature	30 minutes at –55 °C and 30 minutes at +155 °C; 5 cycles	ΔR/R max.: ±1.0% + 0.10 Ω
4.20	Eb	bump	3 × 1500 bumps in 3 directions; 40 g	no damage ΔR/R max.: ±1.0% + 0.10 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.: ±1.0% + 0.10 Ω
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; 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_{ins} min.: 10^3 MΩ ΔR/R max.: ±3.0% + 0.1 Ω

IEC 60115-1 CLAUSE	IEC 60068 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.24.2	Ca	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; dissipation 0.01 P_n; limiting voltage 100 V (DC)	ΔR/R max.: ±3.0% + 0.1 Ω
4.25.1		endurance	1000 hours at 70 °C; P_n or V_{max}	ΔR/R max.: ±3.0% + 0.1 Ω
4.8.4		temperature coefficient	between −55 °C and +155 °C ($TC \times 10^{-6}$/K)	≤±400
4.7		voltage proof on insulation	700 V (RMS) during 1 minute; V-block method	no breakdown
4.12		noise	*"IEC publication 60195"*	max. 2.5 μV/V
4.6.1.1		insulation resistance	500 V (DC) 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 cycles; 5 s on and 45 s off	ΔR/R max.: ±2.5% + 0.10 Ω
		high voltage pulse 10 kV; 1 nF; 50 × 12/min	BEAP test for R_n > 3.3 kΩ	ΔR/R max.: ±10%
		12 kV ESD test; 100 pulses	ESD contact discharge	ΔR/R max.: ±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-STD-202E, method 215"* and *"IEC 60068-2-45"*.

QUICK REFERENCE DATA

DESCRIPTION	VALUE							
	AC01	**AC03**	**AC04**	**AC05**	**AC07**	**AC10**	**AC15**	**AC20**
Resistance range	0.1 Ω to 2 kΩ	0.1 Ω to 4.7 kΩ	0.1 Ω to 6.8 kΩ	0.1 Ω to 8.2 kΩ	0.1 Ω to 15 kW	0.68 Ω to 27 kΩ	0.82 Ω to 39 kΩ	1.2 Ω to 56 kΩ
Resistance tolerance	±5%; E24 series							
Maximum permissible body temperature	350 °C							
Rated dissipation at T_{amb} = 40 °C	1 W	3 W	4 W	5 W	7 W	10 W	15 W	20 W
Rated dissipation at T_{amb} = 70 °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 60068)	40/200/56							
Basic specification	IEC 60115-1							
Stability after:								
load, 1000 hours	ΔR/R max.: ±5% + 0.1 Ω							
climatic tests	ΔR/R max.: ±1% + 0.05 Ω							
short time overload	ΔR/R max.: ±2% + 0.1 Ω							

ORDERING INFORMATION

Table 1 Ordering code indicating resistor type and packaging

TYPE	ORDERING CODE 23..			
	LOOSE IN BOX	BANDOLIER IN AMMOPACK		
	STRAIGHT LEADS	RADIAL	STRAIGHT LEADS	
	500 units	2500 units	500 units	1000 units
AC01	–	06 328 90...[2]	–	06 328 33...
AC03[1]	–	–	22 329 03...	–
AC04[1]	–	–	22 329 04...	–
AC05[1]	–	–	22 329 05...	–
AC07[1]	–	–	22 329 07...	–
AC10	–	–	22 329 10...	–
AC15	22 329 15...	–	–	–
AC20	22 329 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 starting with 23
- The subsequent 7 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 kΩ	2
10 to 56 kΩ	3

ORDERING EXAMPLE

The ordering code of an AC01 resistor, value 47 Ω, supplied in ammopack of 1000 units is: 2306 328 33479.

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

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 60063"*.

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 60266"*.

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.

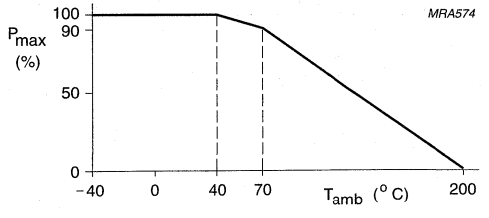


Fig.1 Maximum dissipation (P_{max}) as a function of the ambient temperature (T_{amb}).

PULSE LOADING CAPABILITIES

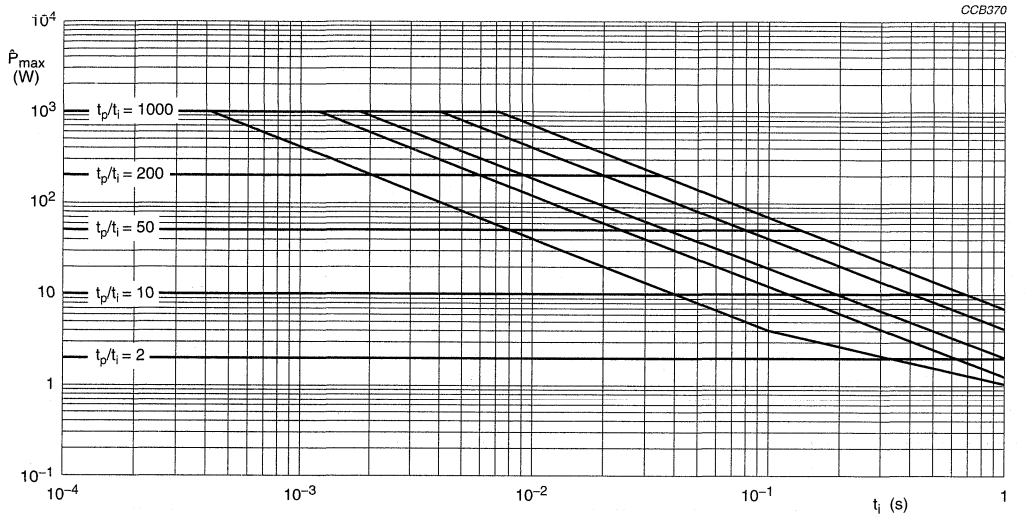


Fig.2 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i).

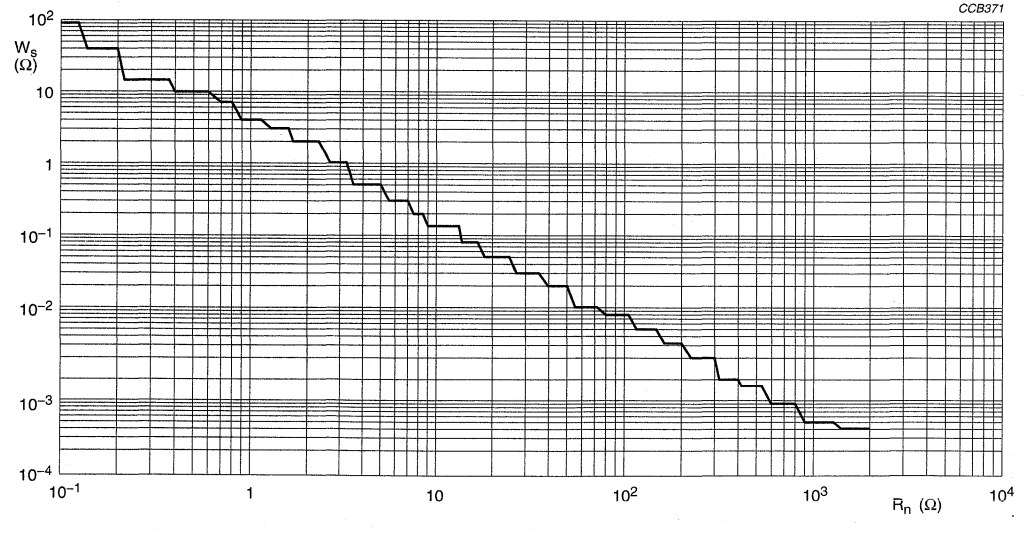


Fig.3 Pulse capability; W_s as a function of R_n.

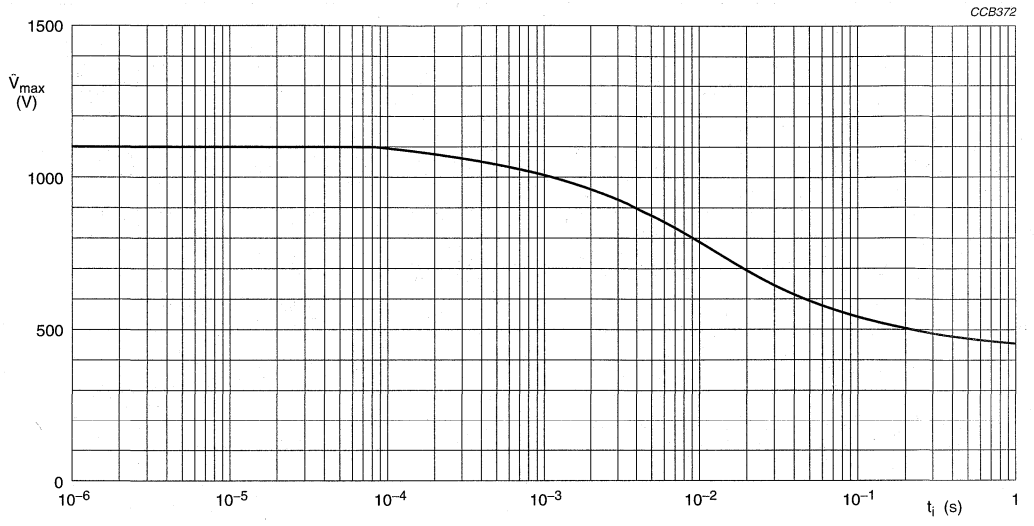


Fig.4 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_i).

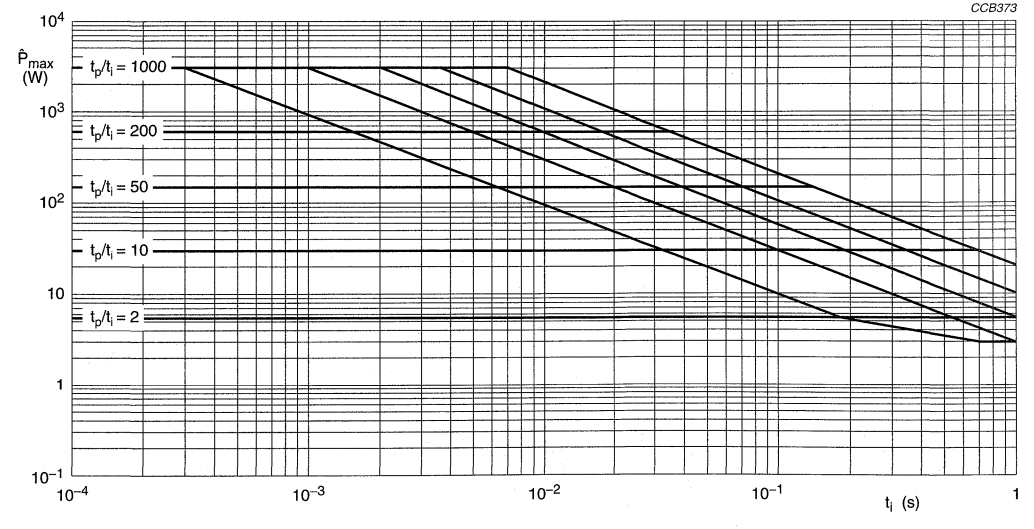


Fig.5 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i).

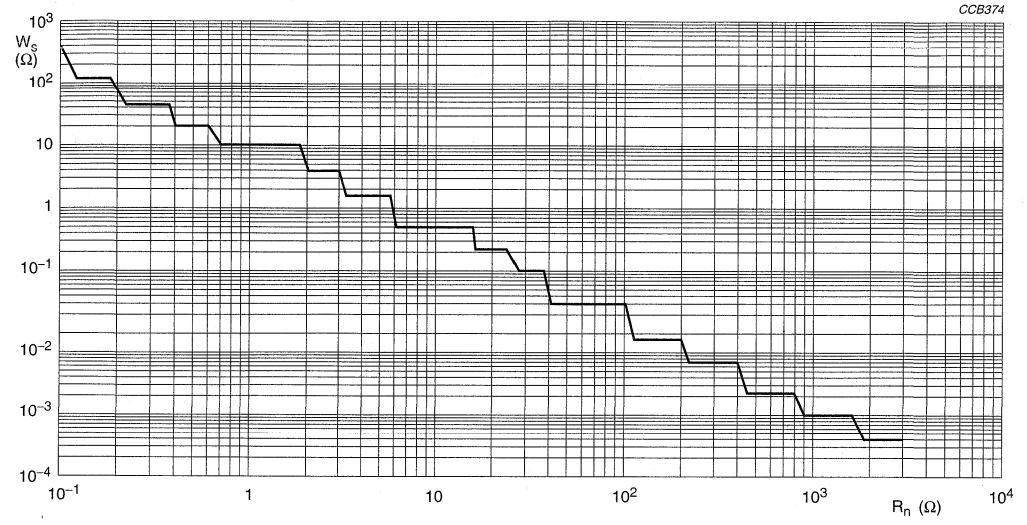


Fig.6 Pulse capability; W_s as a function of R_n.

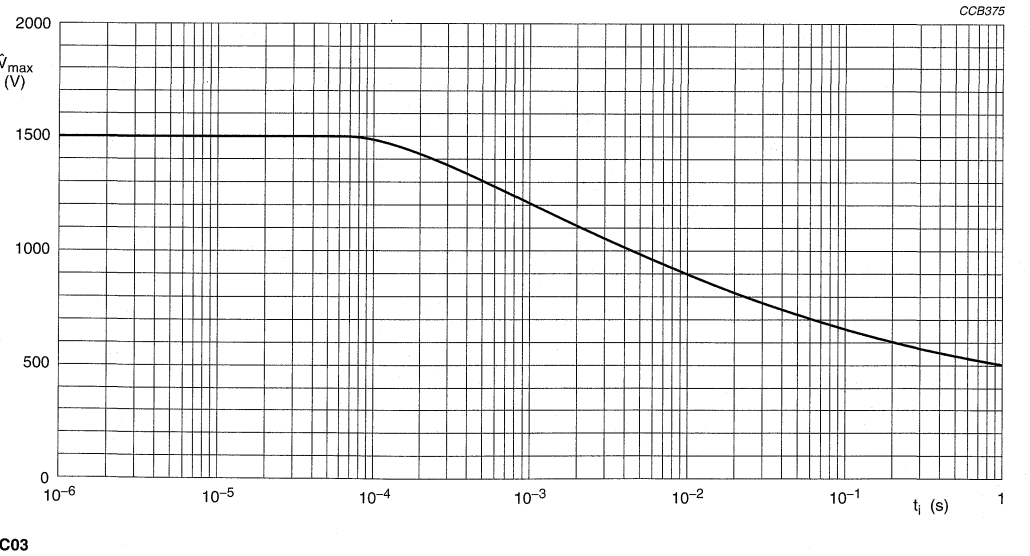


Fig.7 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_i).

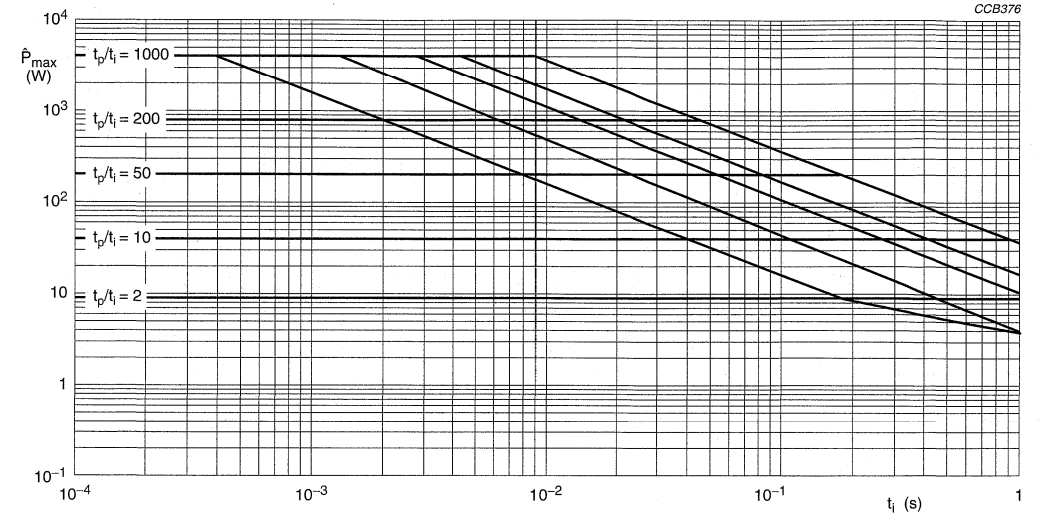


Fig.8 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i).

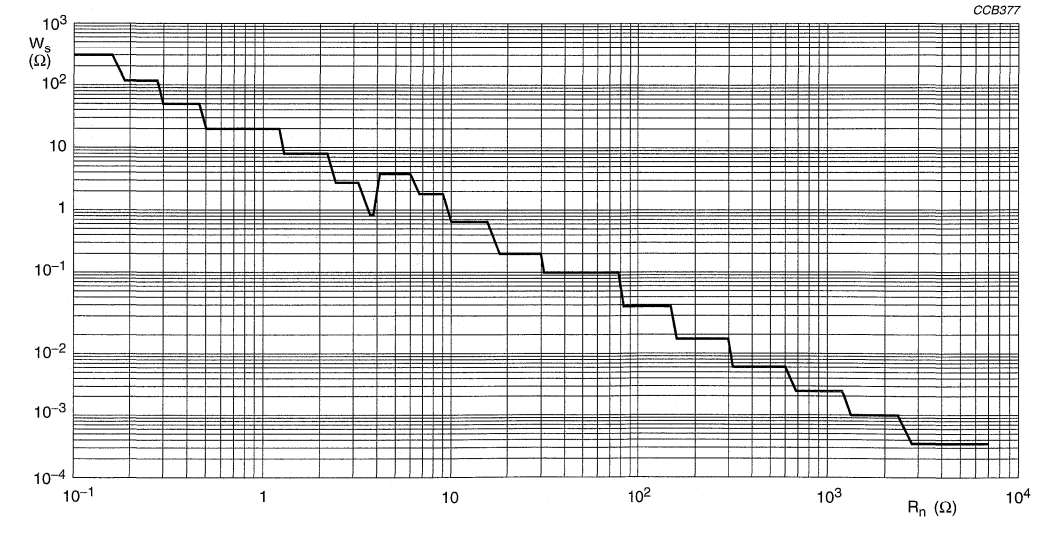


Fig.9 Pulse capability; W_s as a function of R_n.

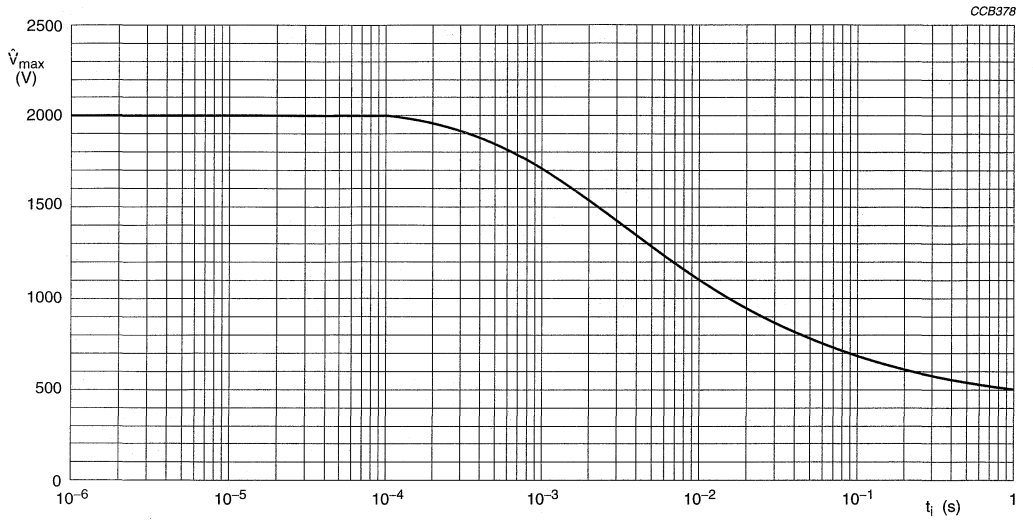


Fig.10 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_i).

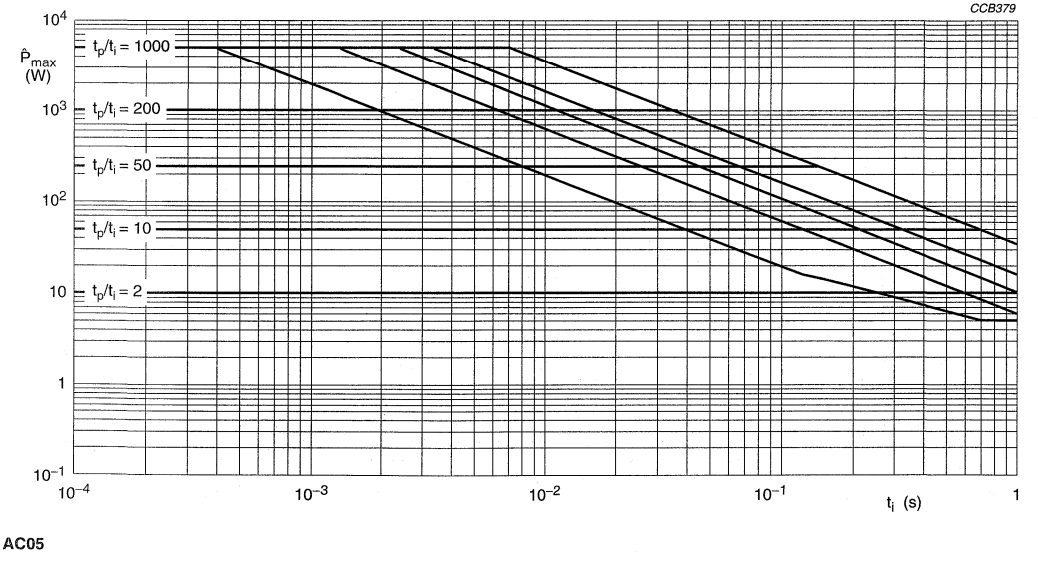


Fig.11 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i).

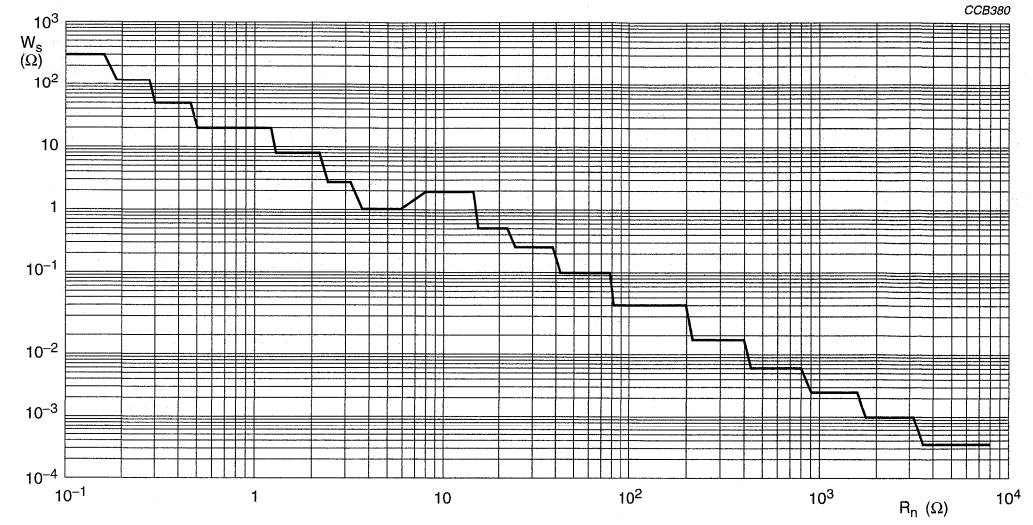


Fig.12 Pulse capability; W_s as a function of R_n.

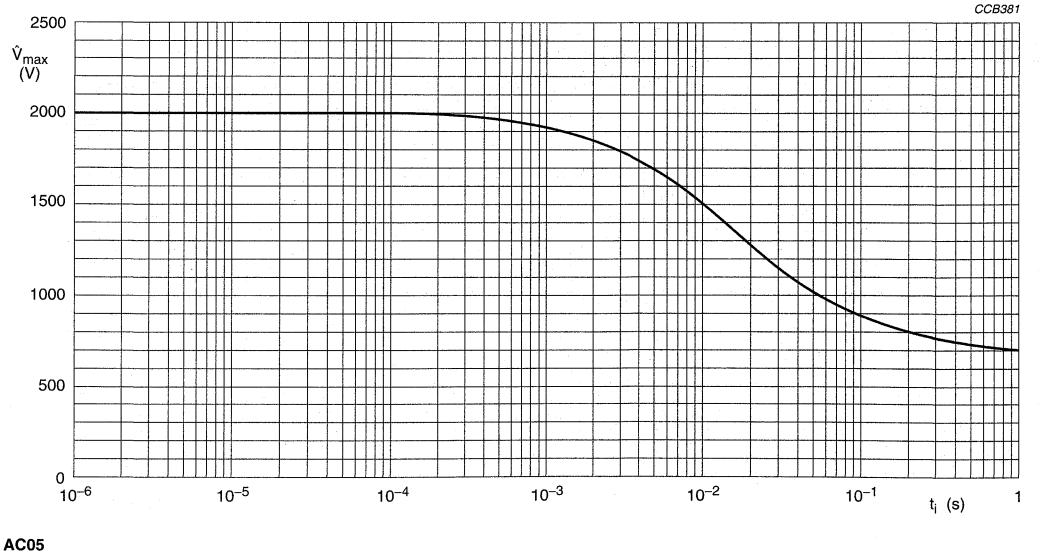


Fig.13 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_i).

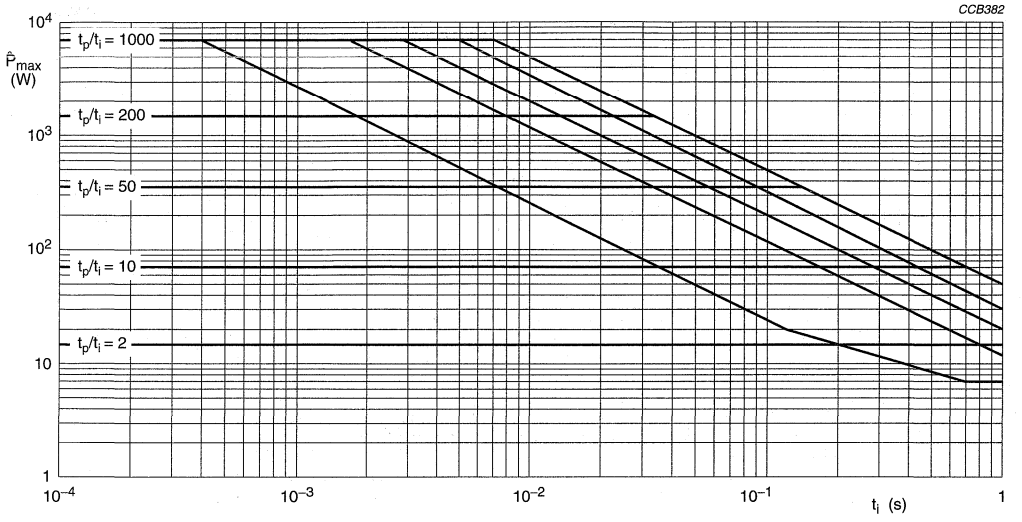


Fig.14 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i).

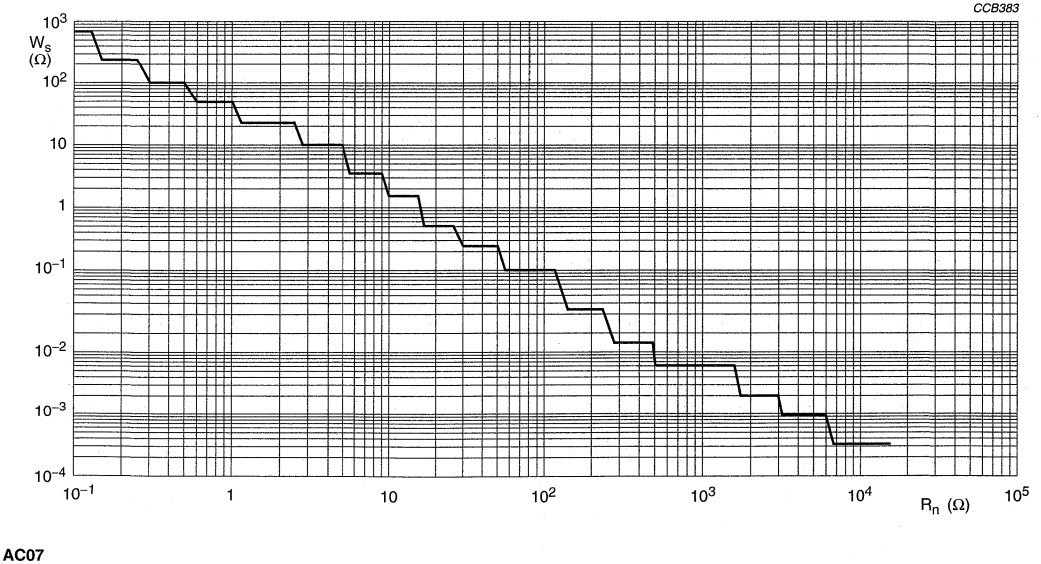


Fig.15 Pulse capability; W_s as a function of R_n.

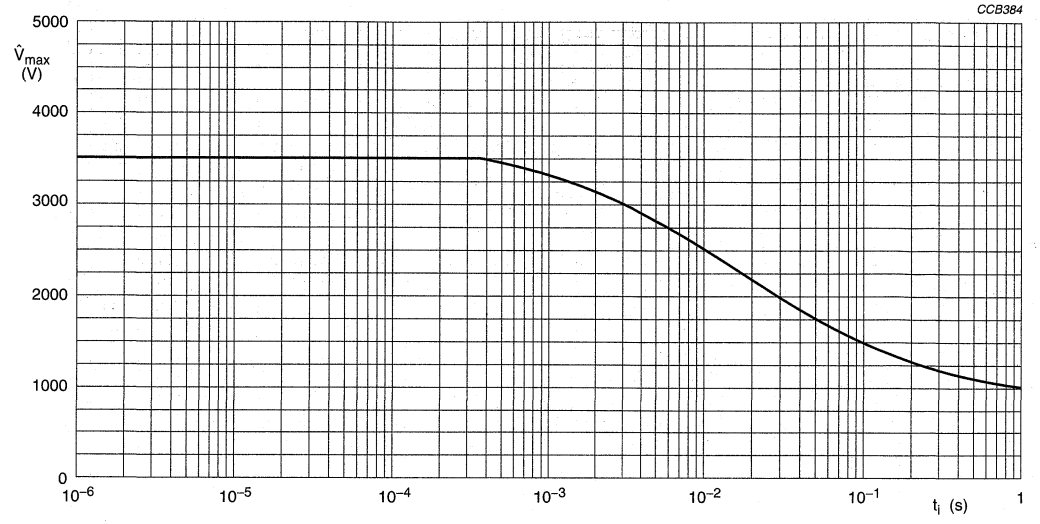


Fig.16 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_i).

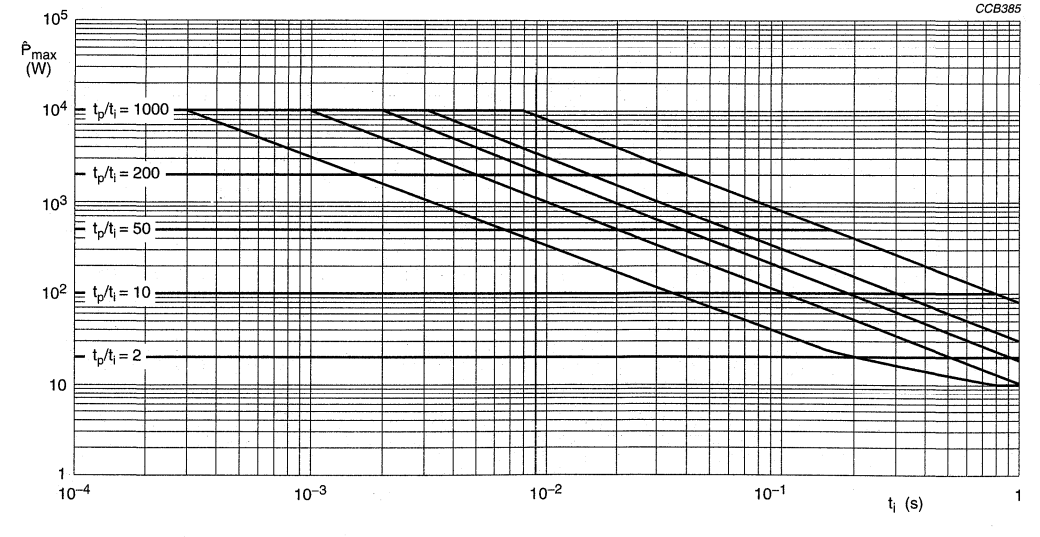


Fig.17 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i).

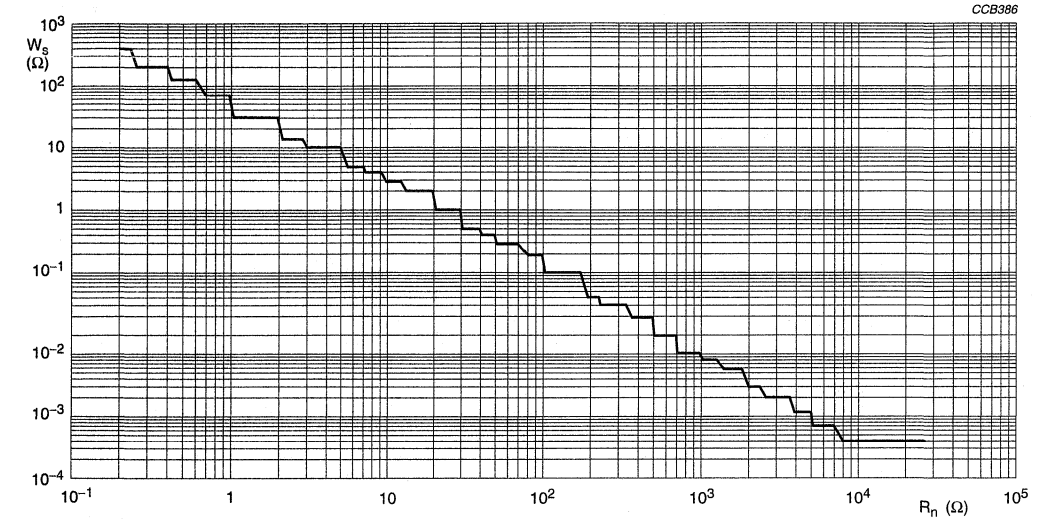


Fig.18 Pulse capability; W_s as a function of R_n.

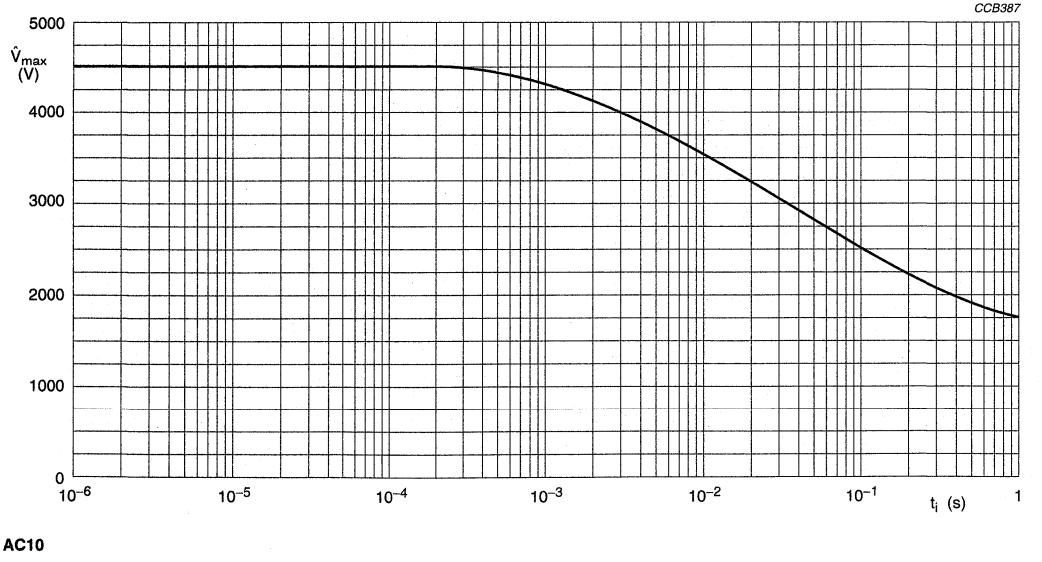


Fig.19 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_i).

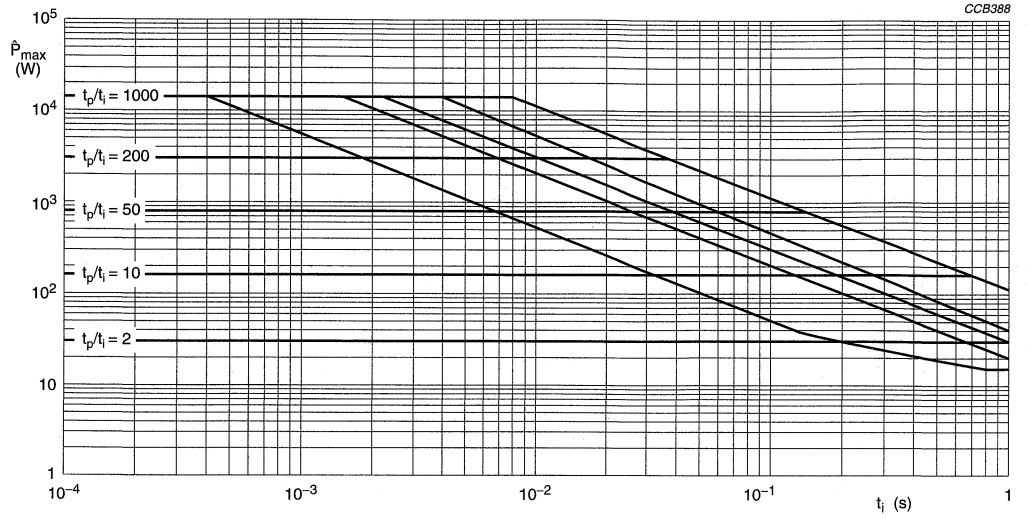


Fig.20 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i).

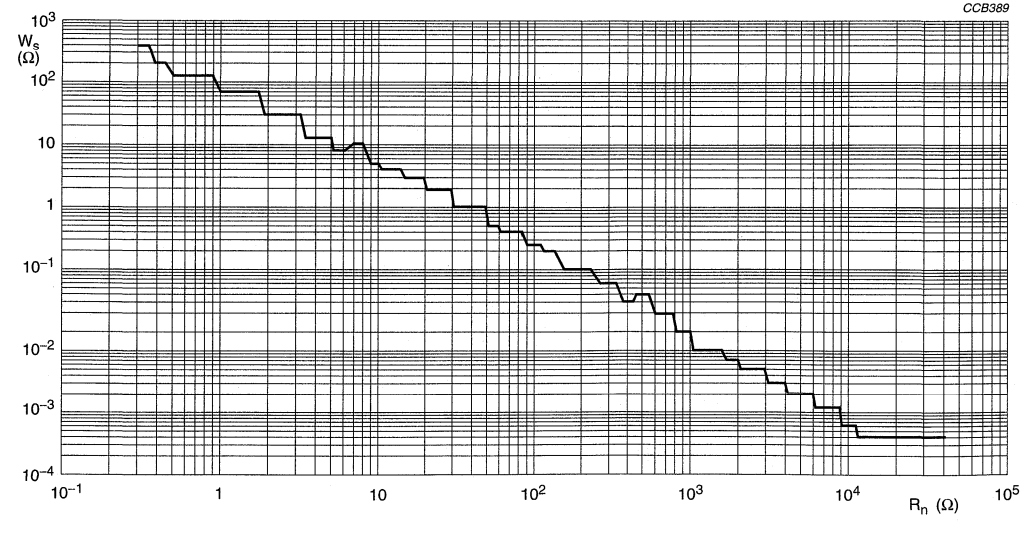


Fig.21 Pulse capability; W_s as a function of R_n.

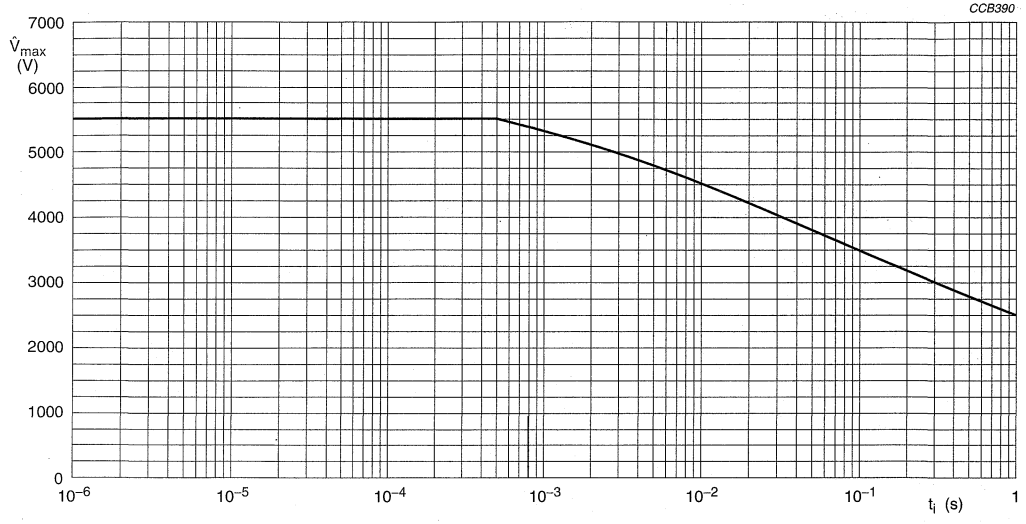


Fig.22 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_i).

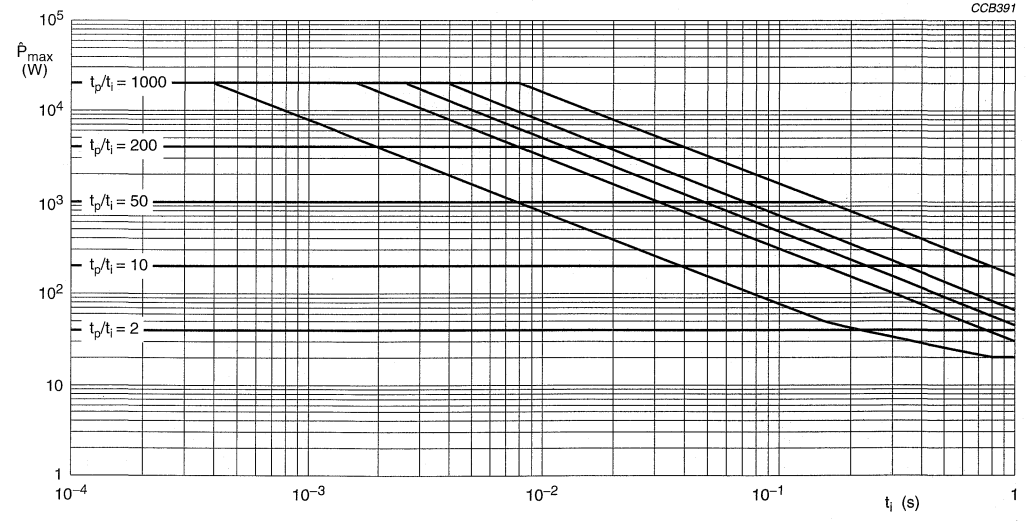


Fig.23 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i).

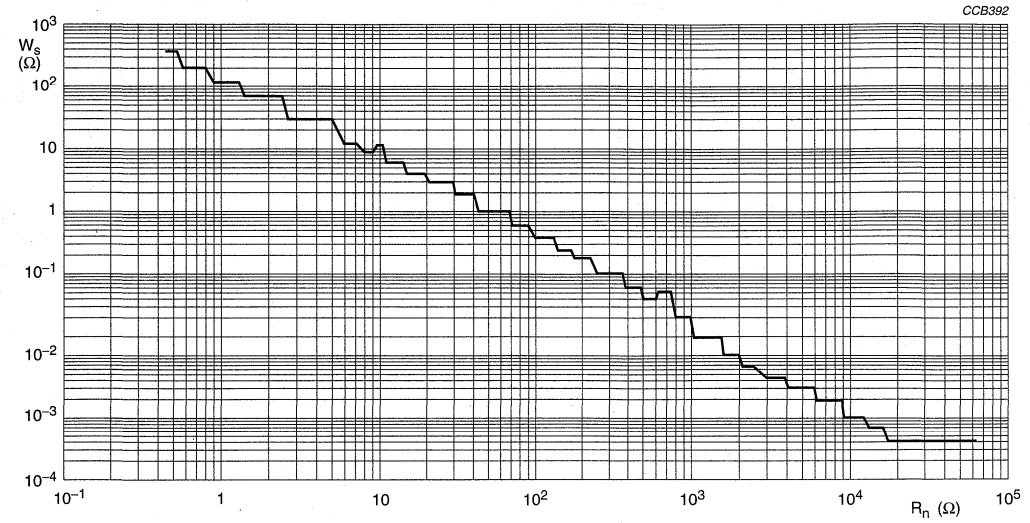


Fig.24 Pulse capability; W_s as a function of R_n.

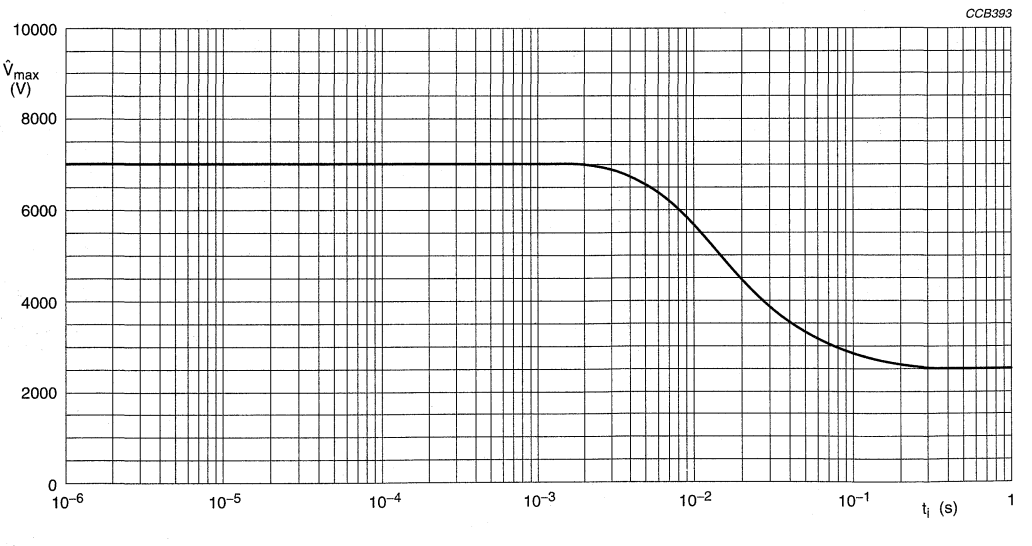


Fig.25 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_i).

Application information

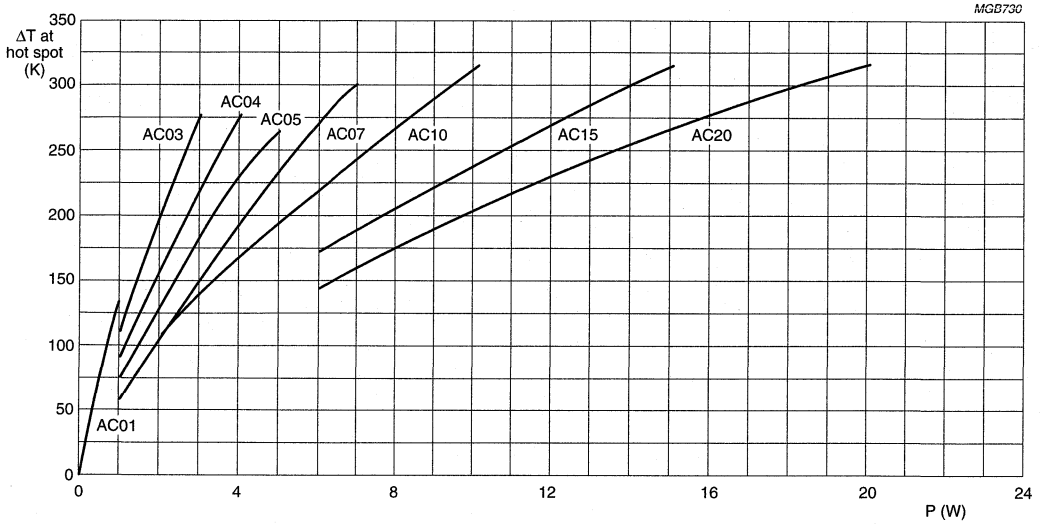
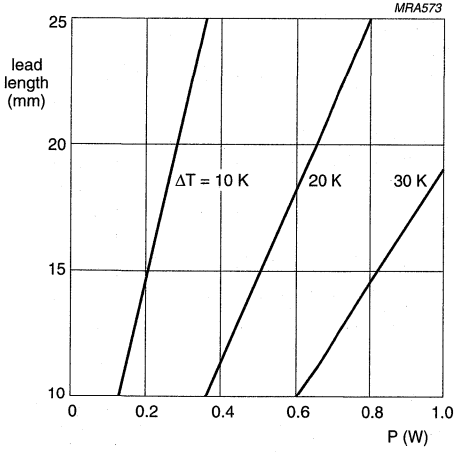
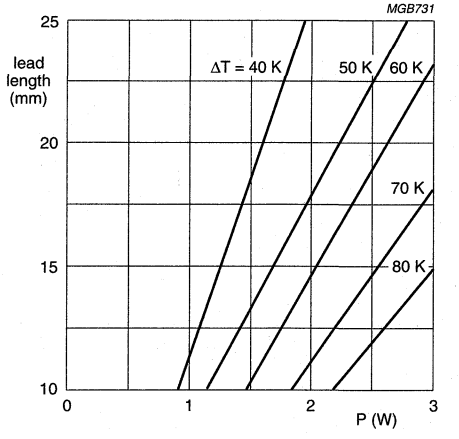


Fig.26 Temperature rise of the resistor body as a function of the dissipation.



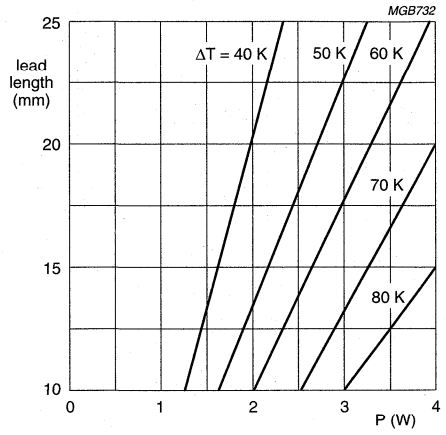
AC01

Fig.27 Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as a parameter.



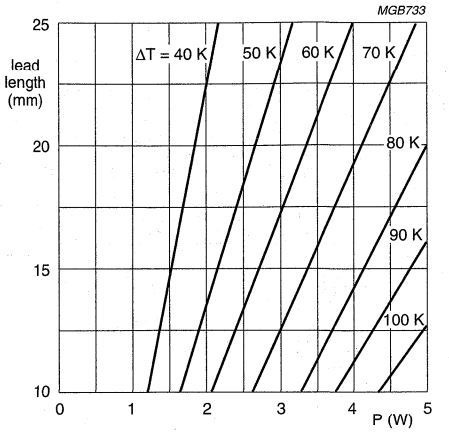
AC03

Fig.28 Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as a parameter.



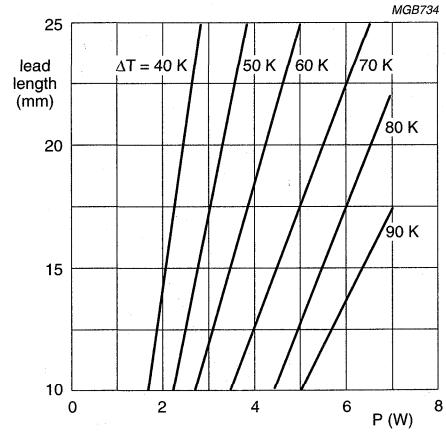
AC04

Fig.29 Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as a parameter.



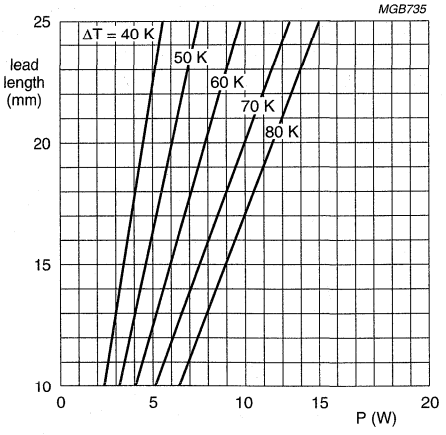
AC05

Fig.30 Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as a parameter.



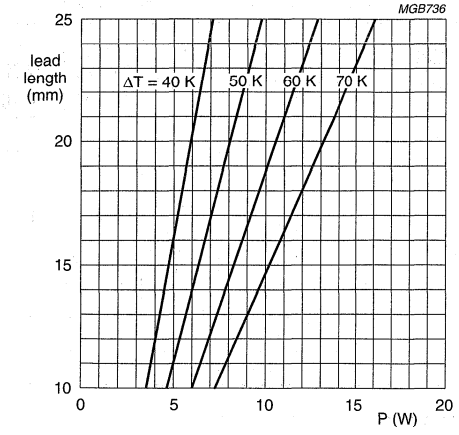
AC07

Fig.31 Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as a parameter.



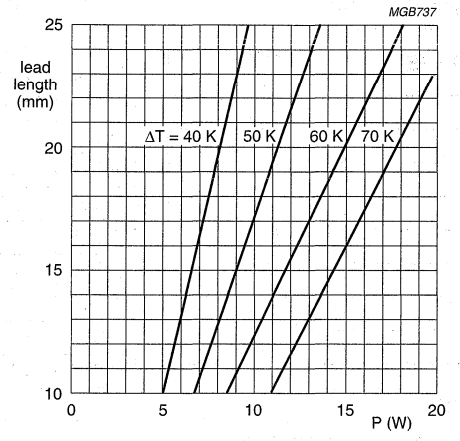
AC10

Fig.32 Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as a parameter.



AC15

Fig.33 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.34 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 26 shows the hot-spot temperature rise of the resistor body as a function of dissipated power. Figures 27 to 34 show the lead length as a function of dissipated power and temperature rise.

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 °C.

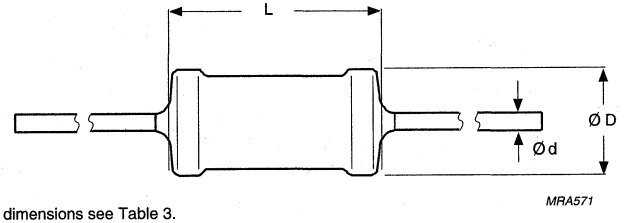
For values up to 910 Ω, the R is used as the decimal point.

For values of 1 kΩ and upwards, the letter K is used as the decimal point for the kΩ indication.

Outlines

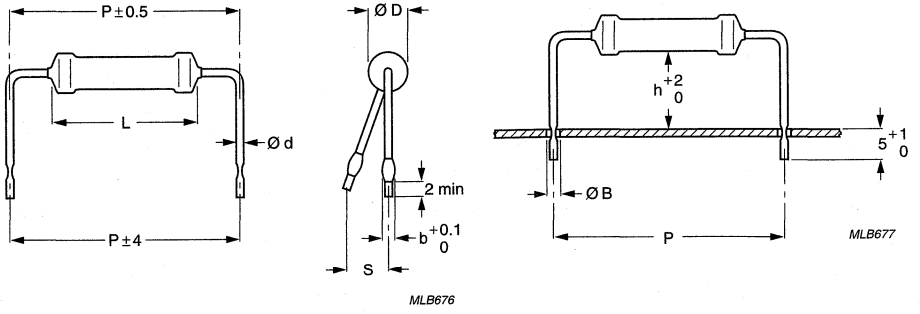
Table 3 Resistor type and relevant physical dimensions; see Figs 35 and 36

TYPE	ØD MAX. (mm)	L MAX. (mm)	Ød (mm)	b (mm)	h (mm)	P (mm)	S MAX. (mm)	ØB MAX. (mm)
AC01	4.3	10	0.8 ±0.03	–	–	–	–	–
AC03	5.5	13		1.3	8	10e	2	1.2
AC04	5.7	17						
AC05	7.5	17						
AC07	7.5	25				13e		
AC10	8	44		–	–	–	–	–
AC15	10	51		–	–	–	–	–
AC20	10	67		–	–	–	–	–



For dimensions see Table 3.

Fig.35 Type with straight leads.



Dimensions in mm.

For dimensions see Table 3.

Available on request for types: **AC03, AC04, AC05 and AC07**.

Fig.36 Type with cropped and formed leads.

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of *"IEC publications 60115-1 and 60115-4"*, category 40/200/56 (rated temperature range –40 °C to +200 °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 60068, *"Recommended basic climatic and mechanical robustness testing procedure for electronic components"* and under standard atmospheric conditions according to *"IEC 60068-1"*, subclause 5.3.

Unless otherwise specified the following values apply:

Temperature: 15 °C to 35 °C

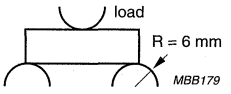
Relative humidity: 45% to 75%

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 60115-1, 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 60115-1 CLAUSE	IEC 60068 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
Tests in accordance with the schedule of IEC publication 60115-1				
4.15		robustness of resistor body	load 200 ±10 N 	no visible damage ΔR/R max.: ±0.5% + 0.05 Ω
4.16	U	robustness of terminations:		
	Ua	tensile all samples	load 10 N; 10 s	
	Ub	bending half number of samples	load 5 N 90°, 180°, 90°	
	Uc	torsion other half of samples	2 × 180° in opposite directions	no visible damage ΔR/R max.: ±0.5% + 0.05 Ω
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; 2.5 mm from body	ΔR/R max.: ±0.5% + 0.05 Ω
4.19	14 (Na)	rapid change of temperature	30 minutes at –40 °C and 30 minutes at +200 °C; 5 cycles	no visible damage ΔR/R max.: ±1% + 0.05 Ω
4.22	Fc	vibration	frequency 10 to 500 Hz; displacement 0.75 mm or acceleration 10 g; 3 directions; total 6 hours (3 × 2 hours)	no damage ΔR/R max.: ±0.5% + 0.05 Ω
4.20	Eb	bump	4000 ±10 bumps; 390 m/s^2	no damage ΔR/R max.: ±0.5% + 0.05 Ω

IEC 60115-1 CLAUSE	IEC 60068 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.23		climatic sequence:		
4.23.2	Ba	dry heat	16 hours; 200 °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; –40 °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	$\Delta R/R$ max.: ±1% + 0.05 Ω
4.24.2	3 (Ca)	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; dissipation ≤0.01 P_n	no visible damage $\Delta R/R$ max.: ±1% + 0.05 Ω
4.8.4.2		temperature coefficient	at 20/–40/20 °C, 20/200/20 °C: R < 10 Ω R ≥ 10 Ω	 TC ≤ $\pm 600 \times 10^{-6}$/K $-80 \times 10^{-6} \leq$ 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.: ±2% + 0.1 Ω
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.: ±5% + 0.1 Ω
4.25.1		endurance (at 70 °C)	1000 hours loaded with $0.9P_n$; 1.5 hours on and 0.5 hours off	no visible damage $\Delta R/R$ max.: ±5% + 0.1 Ω
4.23.2	27 (Ba)	endurance at upper category temperature	1000 hours; 200 °C; no load	no visible damage $\Delta R/R$ max.: ±5% + 0.1 Ω

IEC 60115-1 CLAUSE	IEC 60068 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
Other tests in accordance with IEC 60115 clauses and IEC 60068 test method				
4.29	45 (Xa)	component solvent resistance	70% 1.1.2 trichlorotrifluoroethane and 30% isopropyl alcohol; H_20	no visible damage
4.18	20 (Tb)	resistance to soldering heat	10 s; 260 ±5 °C; flux 600	$\Delta R/R$ 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.

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 60068-2-45"*.

QUICK REFERENCE DATA

DESCRIPTION	VALUE					
	PAC01	PAC02	PAC03	PAC04	PAC05	PAC06
Resistance range	0.22 Ω to 2.2 kΩ	0.10 Ω to 3.6 kΩ	0.10 Ω to 4.7 kΩ	0.10 Ω to 8.2 kΩ	0.68 Ω to 10 kΩ	0.68 Ω to 12 kΩ
Resistance tolerance	±1%; E24/E96 series					
Maximum permissible body temperature	275 °C					
Rated dissipation at T_{amb} = 25 °C	1 W	2 W	3 W	4 W	5 W	6 W
Temperature coefficient; note 1	$\leq \pm 100 \times 10^{-6}$/K					
Climatic category	55/200/56					
Specification based on	IEC 60115-1; MIL-R-26					
Stability after:						
load, 1000 hours	ΔR/R max.: ±0.5% + 0.05 Ω					
climatic tests	ΔR/R max.: ±0.5% + 0.05 Ω					
short time overload	ΔR/R max.: ±0.2% + 0.05 Ω					

Note

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

ORDERING INFORMATION

Table 1 Ordering code indicating type and packaging

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

Note

1. Radial taped version available on request.

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 kΩ	2
10 to 12 kΩ	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.

FUNCTIONAL DESCRIPTION

Product characterization

Standard values of nominal resistance are taken from the E24/E96 series for resistors with a tolerance of ±1%. The values of the E24/E96 series are in accordance with *"IEC publication 60063"*.

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 60115-1"*.

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.

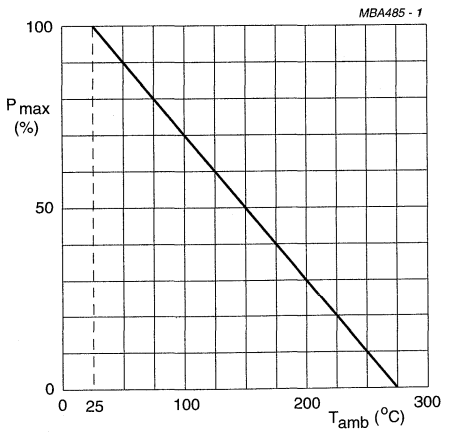


Fig.1 Maximum dissipation (P_{max}) as a function of the ambient temperature (T_{amb}).

PULSE LOADING CAPABILITY

Detailed pulse loading information is available on request.

Application information

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.

MECHANICAL DATA

Mass per 100 units

TYPE	MASS (g)
PAC01	55
PAC02	80
PAC03	100
PAC04	175
PAC05	215
PAC06	225

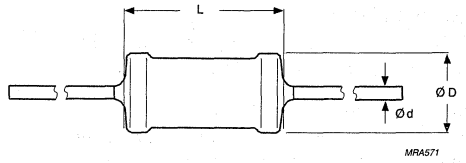
Marking

The resistor is marked with the nominal resistance value, the tolerance on the resistance and the rated dissipation at T_{amb} = 25 °C.

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.

Outline



For dimensions see Table 3.

Fig.2 Component outline.

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

TYPE	∅D MAX. (mm)	L MAX. (mm)	∅d (mm)
PAC01	4.3	10	0.8 ±0.03
PAC02	5.5	13	
PAC03	5.5	17	
PAC04	7.5	17	
PAC05	7.5	23	
PAC06	7.5	25	

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of *"IEC publications 60115-1 and 60115-4"*, category 55/200/56 (rated temperature range –55 °C to +200 °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 60068, *"Recommended basic climatic and mechanical robustness testing procedure for electronic components"* and under standard atmospheric conditions according to *"IEC 60068-1"*, subclause 5.3.

Unless otherwise specified the following values apply:

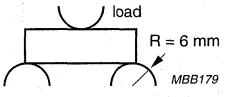
Temperature: 15 °C to 35 °C

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 60115-1, 60115-4 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 60115-1 CLAUSE	IEC 60068 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
Tests in accordance with the schedule of IEC publication 60115-1				
4.15		robustness of resistor body	load 200 ±10 N 	no visible damage ΔR/R max.: ±0.1% + 0.05 Ω
4.16	U	robustness of terminations:		
	Ua	tensile all samples	load 10 N; 10 s	
	Ub	bending half number of samples	load 5 N 90°, 180°, 90°	
	Uc	torsion other half of samples	2 × 180° in opposite directions	no visible damage ΔR/R max.: ±0.1% + 0.05 Ω
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; 2.5 mm from body	ΔR/R max.: ±0.2% + 0.05 Ω
4.19	14 (Na)	rapid change of temperature	30 minutes at –55 °C and 30 minutes at +200 °C; 5 cycles	no visible damage ΔR/R max.: ±0.5% + 0.05 Ω
4.22	Fc	vibration	frequency 10 to 500 Hz; displacement 0.75 mm or acceleration 10 g; 3 directions; total 6 hours (3 × 2 hours)	no damage ΔR/R max.: ±0.1% + 0.05 Ω
4.20	Eb	bump	4000 ±10 bumps; 390 m/s^2	no damage ΔR/R max.: ±0.1% + 0.05 Ω

IEC 60115-1 CLAUSE	IEC 60068 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.23		climatic sequence:		
4.23.2	Ba	dry heat	16 hours; 200 °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	$\Delta R/R$ max.: ±0.5% + 0.05 Ω
4.24.2	3 (Ca)	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; dissipation ≤0.01 P_n	no visible damage $\Delta R/R$ max.: ±1% + 0.05 Ω
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	$\Delta R/R$ max.: ±0.2% + 0.05 Ω
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 $\Delta R/R$ max.: ±0.5% + 0.05 Ω
4.23.2	27 (Ba)	endurance at upper category temperature	1000 hours; 200 °C; no load	no visible damage $\Delta R/R$ max.: ±1% + 0.05 Ω

Low ohmic resistor LVR05

FEATURES

- Designed to dissipate high powers in a small volume.

APPLICATIONS

- Where extremely low ohmic values and high stability are essential.
- Low temperature coefficient and low inductance.

DESCRIPTION

The resistor element is a special resistive material which is shaped to assure maximum power distribution and ohmic stability.

Tinned copper-clad iron leads are welded to the resistive element and the assembly is housed within a rectangular case which is non-flammable.

The encapsulation is resistant to all cleaning solvents according to *"MIL-STD 202E, method 215"* and *"IEC 60068-2-45"*.

QUICK REFERENCE DATA

DESCRIPTION	VALUE
Resistance range; note 1	0.01 to 0.10 Ω
Resistance tolerance and series; note 2	±5%: E24 series
Rated dissipation at T_{amb} = 40 °C	5 W
Temperature coefficient; note 3	$\pm 200 \times 10^{-6}$/K
Maximum permissible body temperature	275 °C
Operating temperature	−25 °C to +155 °C
Insulation voltage	>2000 V
Basic specifications	*IEC 60115-1B*
Climatic category (IEC 60068)	25/155/56
Stability after:	
load (1000 hours)	ΔR/R max.: ±5% + 0.1 Ω
climatic test	ΔR/R max.: ±3% + 0.1 Ω
soldering	ΔR/R max.: ±2% + 0.1 Ω
Noise	max. 2.5 μV/V

Notes

1. Lower values are available on request.
2. 1%, 2% and 3% tolerance available on request.
3. Special TC available on request.

ORDERING INFORMATION

Table 1 Ordering code indicating resistance value, tolerance, style and packaging

TYPE	RESISTANCE VALUE (Ω)	TOLERANCE (%)	CODE NUMBER 2306 288 5....
			250 UNITS IN CARDBOARD BOX
			AXIAL[1]
LVR05	0.01	±5	0001
	0.011		0002
	0.012		0003
	0.013		0004
	0.015		0005
	0.016		0006
	0.018		0007
	0.020		0008
	0.022		0009
	0.024		0011
	0.027		0012
	0.030		0013
	0.033		0014
	0.036		0015
	0.039		0016
	0.043		0017
	0.047		0018
	0.051		0019
	0.056		0021
	0.062		0022
	0.068		0023
	0.075		0024
	0.082		0025
	0.091		0026

Note

1. A radial type is available on request, code number 2306 288 9....

Ordering example

The ordering code for a LVR05, axial leaded resistor value 0.01 Ω, 5% tolerance, supplied in cardboard box of 250 units, is: 2306 288 50001.

FUNCTIONAL DESCRIPTION

Product characterization

Standard values of rated resistance (nominal resistance) are taken from the E24 series with a tolerance of 5%. The values of the E24 series are in accordance with *"IEC publication 60063"*.

The maximum permissible hot-spot temperature is 275 °C.

Limiting values

TYPE	LIMITING VOLTAGE[1] (V)	LIMITING POWER (W)
LVR05	$V = \sqrt{P_n \times R}$	5

Note

1. The maximum voltage that may be continuously applied to the resistor element, see *"IEC publication 60115-1"*.

DERATING

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

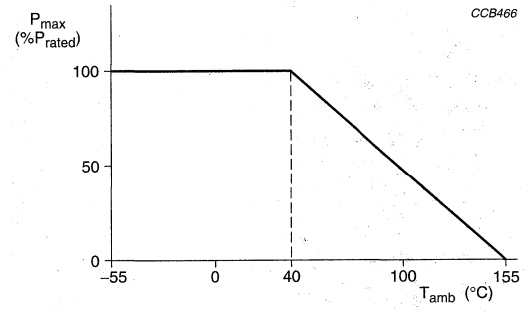


Fig.1 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

Application information

For temperature rise at soldering point see Fig.2.

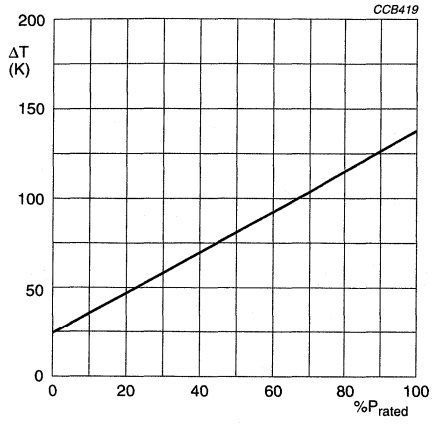


Fig.2 Temperature rise (ΔT) at the lead end (soldering point) as a function of dissipated power measured at points C; see Fig.4.

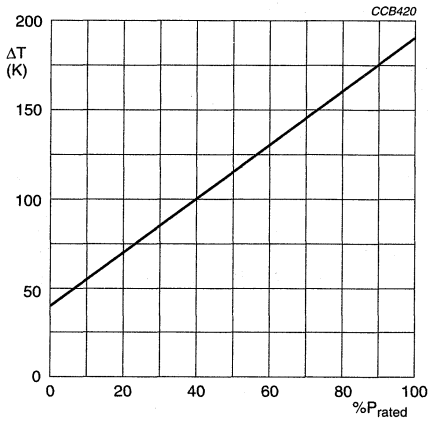


Fig.3 Temperature rise of the resistor body (ΔT) as a function of dissipated power.

Low ohmic resistor LVR05

MECHANICAL DATA

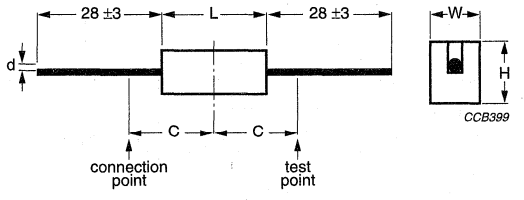
Marking

The nominal resistance, tolerance on the resistance, rated dissipation at 40 °C and the production date are printed on the resistor body. The 'R' is used as a decimal point.

Mass per 100 units

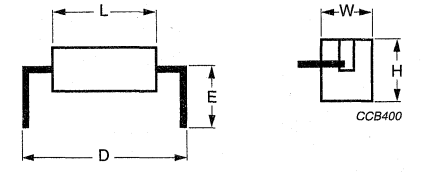
TYPE	MASS (g)
LVR05	350

Outlines



Dimensions in mm.
For dimensions see Table 2.

Fig.4 Outline; axial leads.



For dimensions see Table 2.

Fig.5 Outline; radial leads.

Table 2 Resistor type and relevant physical dimensions; see Figs 4 and 5

TYPE	L (mm)	W and H (mm)	∅d (mm)	C (mm)	D (mm)	E (mm)
LVR05	22 ±1.5	8 ±1.0	1.0 ±0.05	8 ±1.0	27.95 ±0.4	3.5 ±0.5

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of *"IEC publication 60115-1"*, category **LCT/UCT/56** (rated temperature range: **L**ower **C**ategory **T**emperature, **U**pper **C**ategory **T**emperature; damp heat, long term, **56** days).

The tests are carried out in accordance with IEC publication 60068, *"Recommended basic climatic and mechanical robustness testing procedure for electronic components"* and under standard atmospheric conditions according to *"IEC 60068-1"*, 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 60115-1 and 60068"*; 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 60115-1 CLAUSE	IEC 60068 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.15		robustness of resistor body	load 100 ±10 N	no damage ΔR/R max.: 1.0%
4.16	U	robustness of terminations:		
4.16.2	Ua	tensile all samples	load 10 N; 10 s	
4.16.3	Ub	bending half number of samples	load 5 N; 4 × 90°	
4.16.4	Uc	torsion other half of samples	2 × 180° in opposite directions	no damage ΔR/R max.: 0.5%
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	ΔR/R max.: 1%
4.19	Na	rapid change of temperature	30 minutes at –25 °C and 30 minutes at +155 °C; 5 cycles	no visible damage ΔR/R max.: 1%
4.22	Fc	vibration	frequency 10 to 55 Hz; displacement 0.75 mm or acceleration 10 g; 3 directions; total 6 hours (3 × 2 hours)	no damage ΔR/R max.: 1%
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; 90 to 100% RH	
4.23.4	Aa	cold	2 hours; –25 °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; after 24 hours at P_n	ΔR/R max.: 3%

IEC 60115-1 CLAUSE	IEC 60068 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.24.2	Ca	damp heat (steady state)	21 days; 40 °C; 90 to 95% RH; dissipation 0.01 P_n	$\Delta R/R$ max.: 3%
4.25.1		endurance (at 40 °C)	1000 hours loaded with P_n; 1.5 hours on 0.5 hours off	$\Delta R/R$ max.: 5%
4.23.2	Ba	endurance at upper category temperature	1000 hours at 155 °C, no load	no visible damage $\Delta R/R$ max.: 5%
4.8.4		temperature coefficient	between –25 °C and +155 °C ($TC \times 10^{-6}$/K)	$\pm 200 \times 10^{-6}$/K
4.6.1.1		insulation resistance	500 V (DC) during 1 minute; V-block method	R_{ins} min.: 10^2 MΩ
4.13		short time overload	room temperature; dissipation $10 \times P_n$; 5 s	$\Delta R/R$ max.: 2%

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 60068-2-45"*.

QUICK REFERENCE DATA

DESCRIPTION	VALUE					
	SMW02	SMF02	SMW03	SMF03	SMW05	SMF05
Resistance range; note 1	0.1 to 200 Ω	220 Ω to 47 kΩ	0.1 to 560 Ω	620 Ω to 47 kΩ	0.1 to 560 Ω	620 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 60068)	40/200/56					
Basic specification	IEC 60115-1					
Stability after:						
load, 1000 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					

Note

1. Higher values are available on request.

ORDERING INFORMATION

Table 1 Ordering code indicating resistor type and packaging

TYPE	ORDERING CODE 2306 34. .....
	LOOSE IN BOX
	500 units
SMW02	0 03...
SMF02	5 03...
SMW03	1 03...
SMF03	6 03...
SMW05	2 03...
SMF05	7 03...

Ordering code (12NC)

- The resistors have a 12-digit ordering code starting with 2306 34
- The subsequent 3 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 kΩ	2
10 to 47 kΩ	3

ORDERING EXAMPLE

The ordering code of a SMW02 resistor, value 47 Ω, supplied loose in box of 500 units is: 2306 340 03479.

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 60063"*.

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 60266"*.

DERATING

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

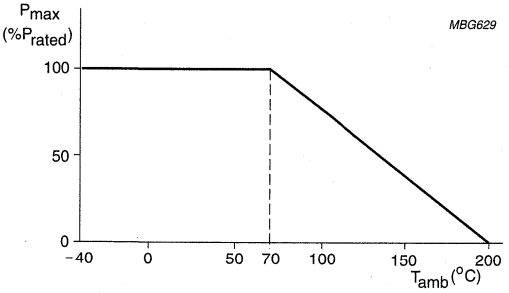


Fig.1 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

The maximum permissible hot-spot temperature is 300 °C, and the minimum breakdown voltage of the encapsulation is 2000 V.

PULSE LOADING CAPABILITY

Detailed pulse loading information is available on request.

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 as a function of dissipated power is shown in Fig.2.

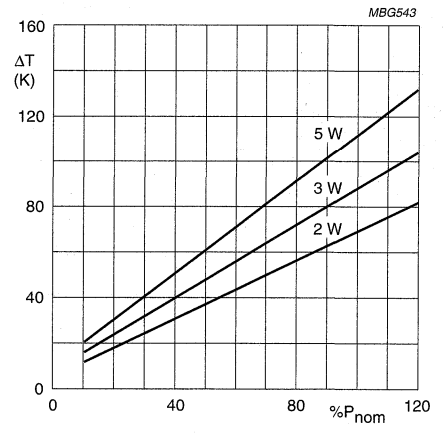


Fig.2 Solder spot temperature rise (ΔT) as a function of dissipated power.

MECHANICAL DATA

Mass per 100 units

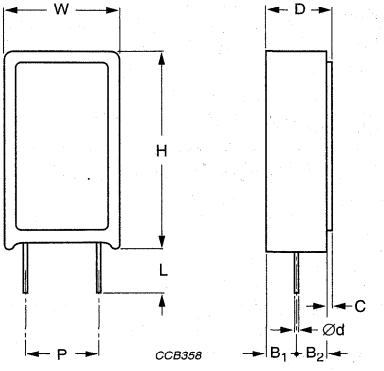
TYPE	MASS (g)
SMW02	370
SMF02	
SMW03	530
SMF03	
SMW05	640
SMF05	

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 °C.

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

Outlines



For dimensions see Table 3.

Fig.3 Outlines.

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

TYPE	W (mm)	D (mm)	C (mm)	H (mm)	$\lvert B_1 - B_2 \rvert$ (mm)	L (mm)	P (mm)	Ød (mm)
SMW02	11 ±1	7 ±1	0/+1.0	20.5 ±1.5	+0.9/–0.3	4.5 ±1.5	5 ±1	0.8 ±0.03
SMF02								
SMW03	12 ±1	8 ±1	0/+1.0	25.0 ±1.5	+1.4/–0.3			
SMF03								
SMW05	13 ±1	9 ±1	0/+1.0	25.5 ±1.5	+2.3/–0.3			
SMF05								

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of *"IEC publications 60115-1 and 60115-4"*, category 40/200/56 (rated temperature range –40 °C to +200 °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 60068, *"Recommended basic climatic and mechanical robustness testing procedure for electronic components"* and under standard atmospheric conditions according to *"IEC 60068-1"*, 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 60115-1, 60115-4 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 60115-1 CLAUSE	IEC 60068 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
Tests in accordance with the schedule of IEC publication 60115-1				
4.15		robustness of resistor body	load 200 ±10 N	no visible damage ΔR/R max.: ±0.5% + 0.05 Ω
4.16	U	robustness of terminations:		
	Ua	tensile all samples	load 10 N; 10 s	no visible damage ΔR/R max.: ±0.5% + 0.05 Ω
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; 2.5 mm from body	ΔR/R max.: ±0.5% + 0.05 Ω
4.19	14 (Na)	rapid change of temperature	30 minutes at –40 °C and 30 minutes at +200 °C; 5 cycles	no visible damage ΔR/R max.: ±1% + 0.05 Ω
4.22	Fc	vibration	frequency 10 to 500 Hz; displacement 0.75 mm or acceleration 10 g; 3 directions; total 6 hours (3 × 2 hours)	no damage ΔR/R max.: ±0.5% + 0.05 Ω
4.20	Eb	bump	4000 ±10 bumps; 390 m/s^2	no damage ΔR/R max.: ±0.5% + 0.05 Ω
4.23		climatic sequence:		
4.23.2	Ba	dry heat	16 hours; 200 °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; –40 °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	ΔR/R max.: ±3% + 0.05 Ω

IEC 60115-1 CLAUSE	IEC 60068 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.24.2	3 (Ca)	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; dissipation ≤0.01 P_n	no visible damage $\Delta R/R$ max.: ±3% + 0.1 Ω
4.8.4.2		temperature coefficient	at 20/–40/20 °C, 20/200/20 °C: **SMW**: R < 10 Ω **SMW**: R ≥ 10 Ω **SMF**	 TC ≤ ±600 × 10^{-6}/K –80 × 10^{-6} ≤ TC ≤ +140 × 10^{-6}/K TC ≤ +250 × 10^{-6}/K
4.13		short time overload	room temperature; dissipation 10 × P_n; 5 s O(voltage not more than 1000 V/25 mm)	$\Delta R/R$ max.: ±2% + 0.1 Ω
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.: ±5% + 0.1 Ω
4.23.2	Ba	endurance at upper category temperature	1000 hours; 200 °C; no load	no visible damage $\Delta R/R$ max.: ±5% + 0.1 Ω

1998 Aug 28

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 60068-2-45"*.

QUICK REFERENCE DATA

DESCRIPTION	VALUE									
	RMW03	**RMF03**	**RMW05**	**RMF05**	**RMW07**	**RMF07**	**RMW10**	**RMF10**	**RMW15**	**RMW20**
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 k to 100 kΩ	1.0 to 1.5 Ω	1 k to 150 kΩ	1.0 to 2.0 Ω	1.5 to 3.0 Ω
±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	–	2.2 Ω to 10 kΩ	3.3 Ω to 15 kΩ
Maximum permissible body temperature	275 °C									
Rated dissipation at T_{amb} = 70 °C	3 W		5 W		7 W		10 W		15 W	20 W
Climatic category (IEC 60068)	25/155/56									
Basic specification	IEC 60115-1									
Stability after:										
load, 1000 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									

ORDERING INFORMATION

Table 1 Ordering code indicating resistor type; style and length of termination

TYPE	ORDERING CODE 23..					
	TERMINATION STYLE 1			TERMINATION STYLE 2		PACKAGING
	lead length 10 mm	lead length 25 mm	lead length 30 mm	lead length 10 mm	lead length 25 mm	LOOSE IN BOX (units per box)
RMW03	22 250 11...	22 250 12...	–	22 250 21...	22 250 22...	500
RMF03	22 256 11...	22 256 12...	–	22 256 21...	22 256 22...	500
RMW05	22 251 11...	22 251 12...	–	22 251 21...	22 251 22...	500
RMF05	22 257 11...	22 257 12...	–	22 257 21...	22 257 22...	500
RMW07	22 252 11...	22 252 12...	–	22 252 21...	22 252 22...	500
RMF07	22 258 11...	22 258 12...	–	22 258 21...	22 258 22...	500
RMW10	22 253 11...	22 253 12...	–	22 253 21...	22 253 22...	400
RMF10	22 259 11...	22 259 12...	–	22 259 21...	22 259 22...	400
RMW15	–	–	06 254 11...	–	–	300
RMW20	–	–	06 254 11...	–	–	50

Ordering code (12NC)

- The resistors have a 12-digit ordering code starting with 2322 25 or 2306 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 kΩ	2
10 to 91 kΩ	3
100 to 150 kΩ	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.

FUNCTIONAL DESCRIPTION

Product characterization

Standard values of nominal resistance are taken from the E24 series for resistors with a tolerance of ±5% or ±10%. The values of the E24 series are in accordance with *"IEC publication 60063"*.

Limiting values

TYPE	LIMITING VOLTAGE(1) (V)	LIMITING POWER (W)
RMW03	$V = \sqrt{P_n \times R}$	3
RMF03	750	
RMW05	$V = \sqrt{P_n \times R}$	5
RMF05	1000	
RMW07	$V = \sqrt{P_n \times R}$	7
RMF07	1200	
RMW10	$V = \sqrt{P_n \times R}$	10
RMF10	1500	
RMW15	$V = \sqrt{P_n \times R}$	15
RMW20	$V = \sqrt{P_n \times R}$	20

Note

1. The maximum voltage that may be continuously applied to the resistor element, see *"IEC publication 60266"*.

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.

The maximum permissible hot-spot temperature is 275 °C, and the minimum breakdown voltage of the encapsulation is 2000 V.

PULSE LOADING CAPABILITY

Detailed pulse loading information is available on request.

DERATING

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

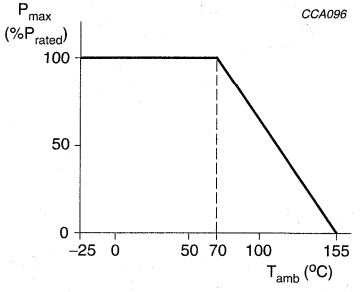


Fig.1 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

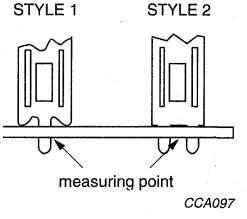
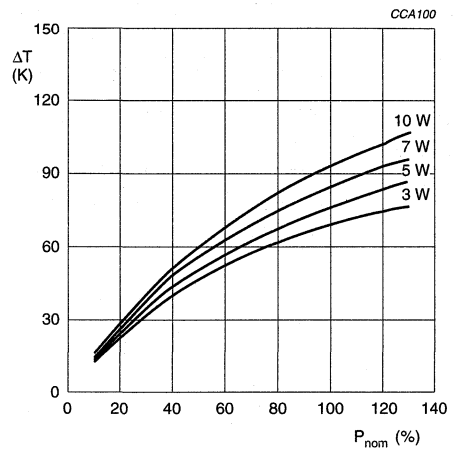


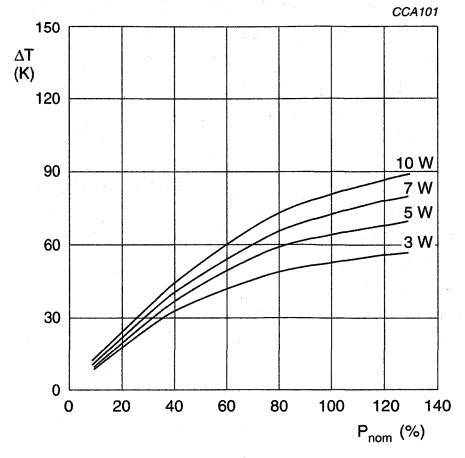
Fig.2 Measuring point of the solder spot temperature.

TEMPERATURE RISE OF SOLDER SPOT AND HOT-SPOT AS A FUNCTION OF LOAD AND LEAD LENGTH FOR STYLES 1 AND 2



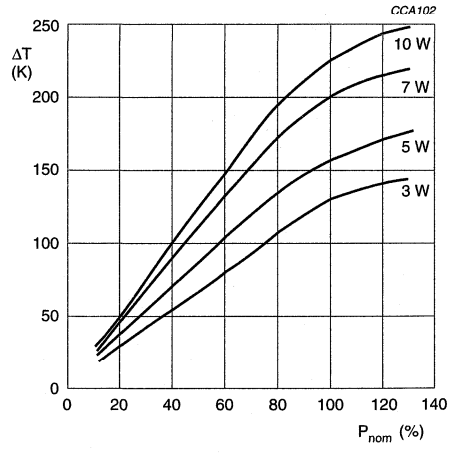
Termination length: 10 mm.

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



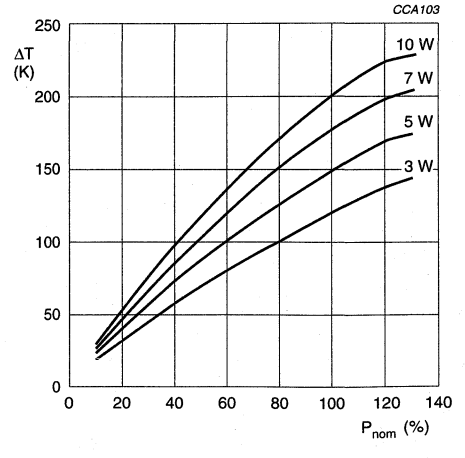
Termination length: 25 mm.

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



Termination length: 10 mm.

Fig.5 Hot-spot temperature rise (ΔT) as a function of dissipated power.



Termination length: 25 mm.

Fig.6 Hot-spot temperature rise (ΔT) as a function of dissipated power.

MECHANICAL DATA

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 °C.

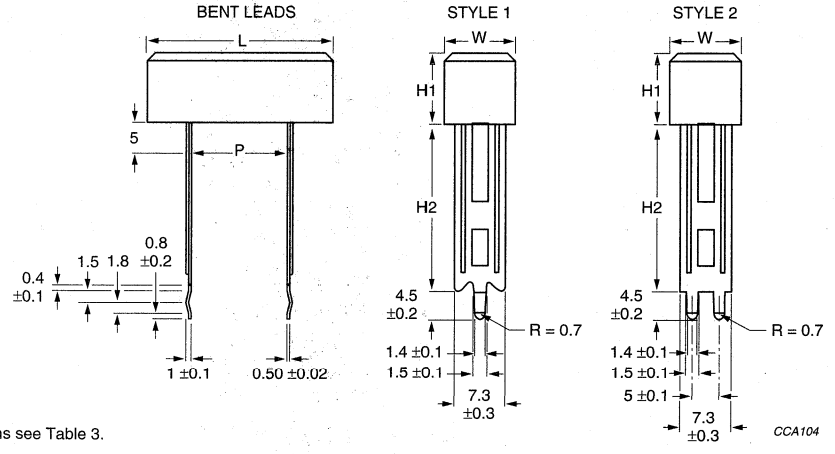
For values up to 910 Ω the R is used as a decimal point. For values of 1 kΩ or greater the letter K is used as the decimal point for the kΩ indication.

Mass per 100 units

TYPE	MASS (g)		
	10 mm LEAD	25 mm LEAD	30 mm LEAD
RMW03	700	750	–
RMF03	800	850	–
RMW05	700	750	–
RMF05	800	850	–
RMW07	800	900	–

TYPE	MASS (g)		
	10 mm LEAD	25 mm LEAD	30 mm LEAD
RMF07	900	1000	–
RMW10	1100	1150	–
RMF10	1200	1250	–
RMW15	–	–	1845
RMW20	–	–	2312

Outlines



For dimensions see Table 3.

Fig.7 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					
RMW15	12.5 ±1.2	48 ±2	12.5 ±1	30 ±1.5	32.5 ±1.5
RMW20		63.5 ±1			48 ±1.5

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of *"IEC publications 60115-1 and 60115-4"*, category 25/155/56 (rated temperature range –25 °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 60068, *"Recommended basic climatic and mechanical robustness testing procedure for electronic components"* and under standard atmospheric conditions according to *"IEC 60068-1"*, 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 60115-1, 60115-4 and 60068"*; 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 60115-1 CLAUSE	IEC 60068 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
Tests in accordance with the schedule of IEC publication 60115-1				
4.15		robustness of resistor body	load 200 ±10 N	no visible damage ΔR/R max.: ±1% + 0.05 Ω
4.16	U	robustness of terminations:		
	Ua	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 ΔR/R max.: ±0.5% + 0.05 Ω
4.18	Tb	resistance to soldering heat	thermal shock: 3 s; 350 °C	ΔR/R max.: ±1% + 0.05 Ω
4.19	14 (Na)	rapid change of temperature	30 minutes at –25 °C and 30 minutes at +155 °C; 5 cycles	no visible damage ΔR/R max.: ±1% + 0.05 Ω
4.22	Fc	vibration	frequency 10 to 55 Hz; displacement 0.75 mm or acceleration 10 g; 3 directions; total 6 hours (3 × 2 hours)	no visible damage ΔR/R max.: ±1% + 0.05 Ω
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; –25 °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	after 24 hours at P_n ΔR/R max.: ±1% + 0.05 Ω

IEC 60115-1 CLAUSE	IEC 60068 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.24.2	3 (Ca)	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; dissipation ≤0.01 P_n	no visible damage ΔR/R max.: ±3% + 0.1 Ω
4.8.4.2		temperature coefficient	at 20/–25/20 °C, 20/155/20 °C: R ≤ 1 Ω R > 1 Ω	 TC ≤ ±600 × 10^{-6}/K TC ≤ +200 × 10^{-6}/K
4.13		short time overload	room temperature; dissipation 10 × P_n; 5 s **RMF03**: V ≤ 1500 V **RMF05**: V ≤ 2000 V **RMF07**: V ≤ 2500 V **RMF10**: V ≤ 3000 V	ΔR/R max.: ±2% + 0.1 Ω
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 R/R max.: ±5% + 0.1 Ω
4.23.2	Ba	endurance at upper category temperature	1000 hours; 155 °C; no load	no visible damage ΔR/R max.: ±5% + 0.1 Ω
4.6.1.1		insulation resistance	500 V (DC); 1 minute	≥100 MΩ
4.7		voltage proof on insulation	1000 V (RMS); 1 minute	ΔR/R max.: ±0.5% + 0.05 Ω

MAINTENANCE TYPES

Metal film resistors MR25/30

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 60068-2-45"*.

QUICK REFERENCE DATA

DESCRIPTION	VALUE	
	MR25	MR30
Resistance range	1 Ω to 1 MΩ	
Resistance tolerance	±0.5%, E192 series	
Temperature coefficient:		
1 Ω ≤ R < 4.99 Ω	100×10^{-6}/K	
4.99 Ω ≤ R ≤ 1 MΩ	50×10^{-6}/K	
Absolute maximum dissipation at T_{amb} = 70 °C	0.4 W	0.5 W
Maximum permissible voltage	250 V	350 V
Basic specifications	IEC 60115-1	
Approval	CECC 40101	
Climatic category (IEC 60068)	55/155/56	
Stability after:		
load	see Fig.1	
climatic tests	ΔR/R max.: ±0.5% + 0.05 Ω	
soldering	ΔR/R max.: ±0.1% + 0.01 Ω	
short time overload	ΔR/R max.: ±0.25% + 0.05 Ω	

ORDERING INFORMATION

Table 1 Ordering code indicating resistor type and packaging

TYPE	ORDERING CODE 2322 15. .....
	BANDOLIER IN AMMOPACK
	1000 units
MR25	1 7....
MR30	2 7....

Ordering code (12NC)

- The resistors have a 12-digit ordering code starting with 2322 15
- The subsequent 2 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 kΩ	2
10 to 97.6 kΩ	3
100 to 976 kΩ	4
1 MΩ	5

Note

1. The composition of the catalogue number is not applicable for R = 49.9 Ω; the relevant catalogue numbers will be indicated on request.

ORDERING EXAMPLE

The ordering code of a MR30 resistor, value 3650 Ω ±0.5%, taped on a bandolier of 1000 units in ammopack is: 2322 152 73652.

FUNCTIONAL DESCRIPTION

Product characterization

Standard values of nominal resistance are taken from the E24/E96 series for ±1% and E192 for ±0.5%.
The values of the series are in accordance with *"IEC publication 60063"*.

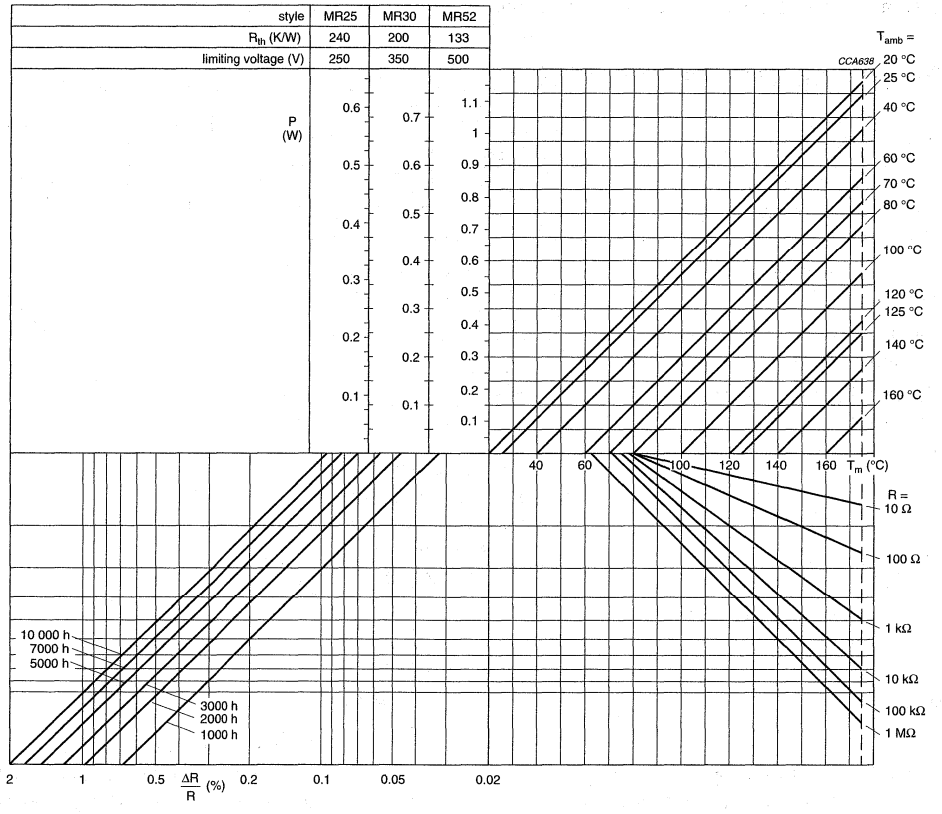


Fig.1 Drift nomogram.

NOTES ON THE 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 ΔR/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.

Limiting values

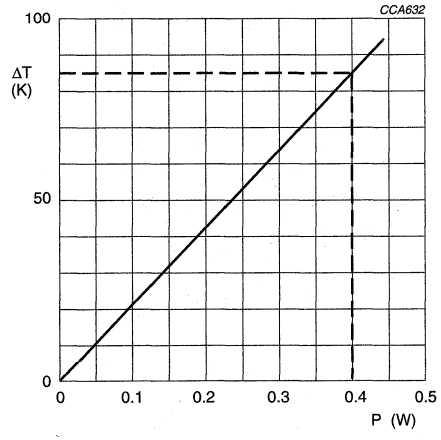
TYPE	LIMITING VOLTAGE[1] (V)	LIMITING POWER (W)
MR25	250	0.4
MR30	350	0.5

Note

1. The maximum voltage that may be applied continuously to the resistor element, see *"IEC publication 60115-1"*.

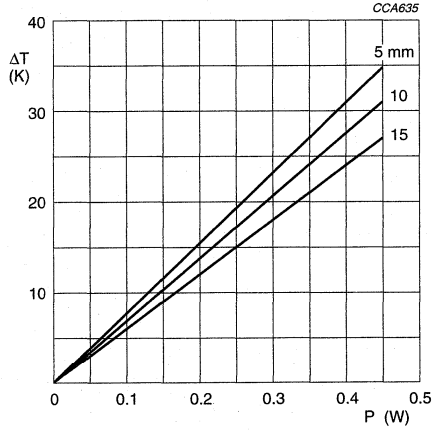
The maximum permissible hot-spot temperature is 175 °C.

Application information



MR25

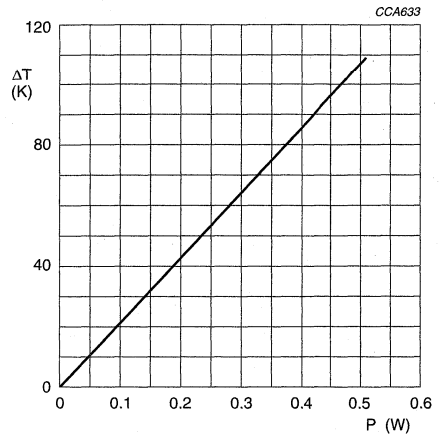
Fig.2 Hot-spot temperature rise (ΔT) as a function of dissipated power.



MR25

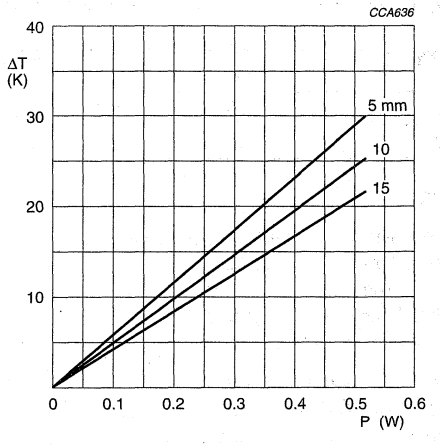
Fig.3 Temperature rise (ΔT) at the end of the lead (soldering point) as a function of dissipated power at various lead lengths after mounting.

Metal film resistors MR25/30



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.

Metal film resistors MR25/30

MECHANICAL DATA

Mass per 100 units

TYPE	MASS (g)
MR25	25
MR30	32

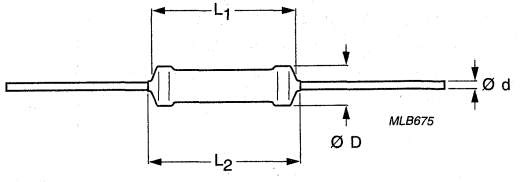
Marking

The nominal resistance and tolerance are marked on the resistor using five or six coloured bands in accordance with IEC publication 60062 *"Colour codes for fixed resistors"*.

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 60294")*.



For dimensions see Table 3.

Fig.6 Outline.

Table 3 Resistor type and relevant physical dimensions; see Fig.6

TYPE	ØD MAX. (mm)	L_1 MAX. (mm)	L_2 MAX. (mm)	Ød (mm)
MR25	2.5	6.5	7.5	0.58 ±0.05
MR30	3.0	10.0	11.0	0.58 ±0.05

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of *"IEC publication 60115-1"*, 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 60068, *"Recommended basic climatic and mechanical robustness testing procedure for electronic components"* and under standard atmospheric conditions according to *"IEC 60068-1"*, 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 60115-1 and 60068"*; 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 60115-1 CLAUSE	IEC 60068 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 × 90°	number of failures $<10 \times 10^{-6}$
4.16.4	Uc	torsion other half of samples	3 × 360° in opposite directions	no damage ΔR/R max.: ±0.1% + 0.01 Ω
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	ΔR/R max.: ±0.1% + 0.01 Ω
4.19	Na	rapid change of temperature	30 minutes at –55 °C and 30 minutes at +155 °C; 5 cycles	ΔR/R max.: ±0.1% + 0.01 Ω
4.20	Eb	bump	3 × 1500 bumps in 3 directions; 40 g	no damage ΔR/R max.: ±0.1% + 0.01 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.: ±0.1% + 0.01 Ω
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 MΩ ΔR/R max.: ±0.5% + 0.05 Ω

Metal film resistors MR25/30

IEC 60115-1 CLAUSE	IEC 60068 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	R_{ins} min.: 1000 MΩ ΔR/R max.: ±0.5% + 0.05 Ω
4.25.1		endurance	1000 hours at 70 °C; P_n or V_{max} **MR25**: 0.25 W or V_{max} **MR30**: 0.3 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 60195"*	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; 5 s on, 45 s off (V ≤ 2 × V_{max}); 10 cycles	ΔR/R max.: ±0.25% + 0.05 Ω

Lacquered metal film resistors MR24/34, 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 60068-2-45"*.

QUICK REFERENCE DATA

DESCRIPTION	VALUE
Resistance range:	
MR24/34, E/C	49.9 Ω to 1 MΩ
MR24/34, D	10 Ω to 1 MΩ
Resistance tolerance:	
MR24/34, E/C	±0.1%; 0.25%; 0.5%, E192 series; 1%, E96 series
MR24/34, D	1%, E96 series
Temperature coefficient:	
MR24/34, E	$\pm 25 \times 10^{-6}$/K
MR24/34, C	$\pm 50 \times 10^{-6}$/K
MR24/34, D	$\pm 100 \times 10^{-6}$/K
Rated dissipation at T_{amb} = 70 °C:	
MR24D	0.125 W
MR34D	0.25 W
at T_{amb} = 125 °C:	
MR24E/C	0.1 W
MR34E/C	0.125 W
Basic specifications	MIL-R-10509F
Stability after:	
load	ΔR/R max.: ±0.5% + 0.05 Ω
climatic tests	ΔR/R max.: ±0.5% + 0.05 Ω
soldering	ΔR/R max.: ±0.1% + 0.05 Ω
short time overload	ΔR/R max.: ±0.25% + 0.05 Ω

Lacquered metal film resistors MR24/34, E/C/D

ORDERING INFORMATION

Table 1 Ordering code indicating resistor type, MIL style and packaging

TYPE	MIL STYLE	ORDERING CODE 2322 16. .....
		BULK IN BOX
		100 units
MR24E	RN55E	0.....
MR24C	RN55C	1.....
MR24D	RN55D	2.....
MR34E	RN60E	3.....
MR34C	RN60C	4.....
MR34D	RN60D	5.....

Ordering code (12NC)(1)

- The resistors have a 12-digit ordering code starting with 2322 16
- The subsequent first digit indicates 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 kΩ	2
10 to 98.8 kΩ	3
100 to 988 kΩ	4
1 MΩ	5

ORDERING EXAMPLE

The ordering code of a MR24E resistor, value 505 Ω ±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, 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 ±1%, from the E192 series for resistors with a tolerance of ±0.5%, ±0.25% or ±0.1% *("MIL-R-10509F, paragraph 1.2.1.3").*

Resistors with a tolerance of ±0.1% and ±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	–
MR24E/C	200	–	0.1
MR34E/C	250	–	0.125

Note

1. The maximum voltage that may be applied continuously to the resistor element, see *"IEC publication 60115-1".*

Lacquered metal film resistors MR24/34, E/C/D

MECHANICAL DATA

Mass per 100 units

TYPE	MASS (g)
MR24E/C/D	25
MR34E/C/D	32

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 = ±0.1%
- C = ±0.25%
- D = ±0.5%
- F = ±1%.

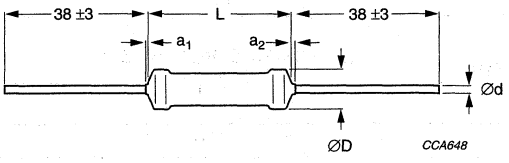
EXAMPLE

22.1 kΩ ±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 60294")*.



For dimensions see Table 5.

Fig.1 Outline.

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	0.58 ±0.05
MR34E/C/D	3.1	10.5	≤1	0.58 ±0.05

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

1. Although resistors with a temperature coefficient of 100×10^{-6}/K correspond with characteristic D resistors of *"MIL-R-10509F"*, they meet the more severe test requirement of characteristic C and E resistors.

INDEX OF ORDERING CODE

Leaded fixed linear resistors — Index of ordering code

12-DIGIT ORDERING CODE

The resistors have a 12-digit ordering code starting with 2306 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 6 or 7 digits of the ordering code

TYPE NAME	ORDERING CODE	PAGE
2306 (first 4 digits followed by next 2 or 3 digits)		
PR01	197	69
PR02	198	69
PAC01/02/03/04/05/06	327	138
AC01	328	116
AC03/04/057/10/15/20	329	116
SMW/SMF02	340	151
SMW/SMF03	341	151
SMW/SMF05	342	151
RMW15/20	254	157
2322 (first 4 digits followed by next 2 or 3 digits)		
RMW03/05/07/10	25	157
RMF03/05/07/10	25	157
MPR24	141	62
MPR34	142	62
MPR24	143	62
MPR34	144	62
MR25	151	165
MR30	152	165
MRS25	156	40
MRS16S	157	40

TYPE NAME	ORDERING CODE	PAGE
MR24E	160	173
MR24C	161	173
MR24D	162	173
MR34E	163	173
MR34C	164	173
MR34D	165	173
SFR25	181	27
SFR25H	186	27
SFR16S	187	27
PR01	193	69
PR02	194	69
PR03	195	69
PR01	196	69
PR02	197	69
NFR25	204	51
NFR25	205	51
NFR25H	207	51
VR25	241	92
VR37	242	98
VR68	244	104
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LVR05	288	144

DATA HANDBOOK SYSTEM

Data handbook system

DATA HANDBOOK SYSTEM

Philips Components data handbooks are available for selected product ranges and contain all relevant data available at the time of publication and each is revised and updated regularly.

Loose data sheets are sent to subscribers to keep them up-to-date on additions or alterations made during the lifetime of each edition.

Our data handbook titles are listed here.

Display components

Book	*Title*
DC01	Colour Television Tubes
DC02	Monochrome Monitor Tubes and Deflection Units
DC03	Television Tuners, Coaxial Aerial Input Assemblies
DC04	Colour Monitor and Multimedia Tubes
DC05	Wire Wound Components

Magnetic products

Book	*Title*
MA01	Soft Ferrites
MA03	Piezoelectric Ceramics and Specialty Ferrites
MA04	Dry-reed Switches

Passive components

Book	*Title*
PA01	Electrolytic Capacitors
PA02	Varistors, Thermistors and Sensors
PA03	Potentiometers
PA04	Variable Capacitors
PA05	Film Capacitors
PA06	Ceramic Capacitors
PA06a	Surface Mounted Ceramic Multilayer Capacitors
PA06b	Leaded Ceramic Capacitors
PA08	Fixed Resistors
PA10	Quartz Crystals
PA11	Quartz Oscillators

MORE INFORMATION FROM PHILIPS COMPONENTS?

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OVERVIEW OF PHILIPS SEMICONDUCTORS DATA HANDBOOKS

Our sister product division, Philips Semiconductors, also has a comprehensive data handbook system to support their products. Their data handbook titles are listed here.

Integrated circuits

Book	*Title*
IC01	Semiconductors for Radio, Audio and CD/DVD Systems
IC02	Semiconductors for Television and Video Systems
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^2C Peripherals
IC13	Programmable Logic Devices (PLD)
IC14	8048-based 8-bit Microcontrollers
IC15	FAST TTL Logic Series
IC16	CMOS ICs for Clocks, Watches and Real Time Clocks
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	Integrated Circuit Packages
IC27	Complex Programmable Logic Devices

Discrete semiconductors

Book	*Title*
SC01	Small-signal and Medium-power Diodes
SC02	Power Diodes
SC03	Power Thyristors and Triacs
SC04	Small-signal Transistors
SC05	Video Transistors and Modules for Monitors
SC06	High-voltage and Switching NPN Power Transistors
SC07	Small-signal Field-effect Transistors
SC13	PowerMOS Transistors
SC14	RF Wideband Transistors
SC16	Wideband Hybrid Amplifier Modules for CATV
SC17	Semiconductor Sensors
SC18	Discrete Semiconductor Packages
SC19	RF & Microwave Power Transistors, RF Power Modules and Circulators/Isolators

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NOTES

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
100	100	100	178	178	178	316	316	316	562	562	562
101			180			320			569		
102	102		182	182		324	324		576	576	
104			184			328			583		
105	105	105	187	187	187	332	332	332	590	590	590
106			189			336			597		
107	107		191	191		340	340		604	604	
109			193			344			612		
110	110	110	196	196	196	348	348	348	619	619	619
111			198			352			626		
113	113		200	200		357	357		634	634	
114			203			361			642		
115	115	115	205	205	205	365	365	365	649	649	649
117			208			370			657		
118	118		210	210		374	374		665	665	
120			213			379			673		
121	121	121	215	215	215	383	383	383	681	681	681
123			218			388			690		
124	124		221	221		392	392		698	698	
126			223			397			706		
127	127	127	226	226	226	402	402	402	715	715	715
129			229			407			723		
130	130		232	232		412	412		732	732	
132			234			417			741		
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		

E24	E12	E6	E3
10	10	10	10
11			
12	12		
13			
15	15	15	
16			
18	18		
20			
22	22	22	22
24			
27	27		
30			
33	33	33	
36			
39	39		
43			
47	47	47	47
51			
56	56		
62			
68	68	68	
75			
82	82		
91			

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