PASSIVE COMPONENTS

DATA HANDBOOK

Fixed Resistors

BOOK PA08 1992

Philips Components

PHILIPS

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

QUALITY ASSURED

Although the initial cost of resistors is generally low, the large number used in a typical circuit means 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 our customers. We work according to the ISO 9000 standard, and support our resistor production by means of statistical process control (SPC) procedures at all key points in the production process.

CUSTOMER SERVICE

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

ADVANCED RESISTOR TECHNOLOGIES

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

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

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

Fixed Resistors

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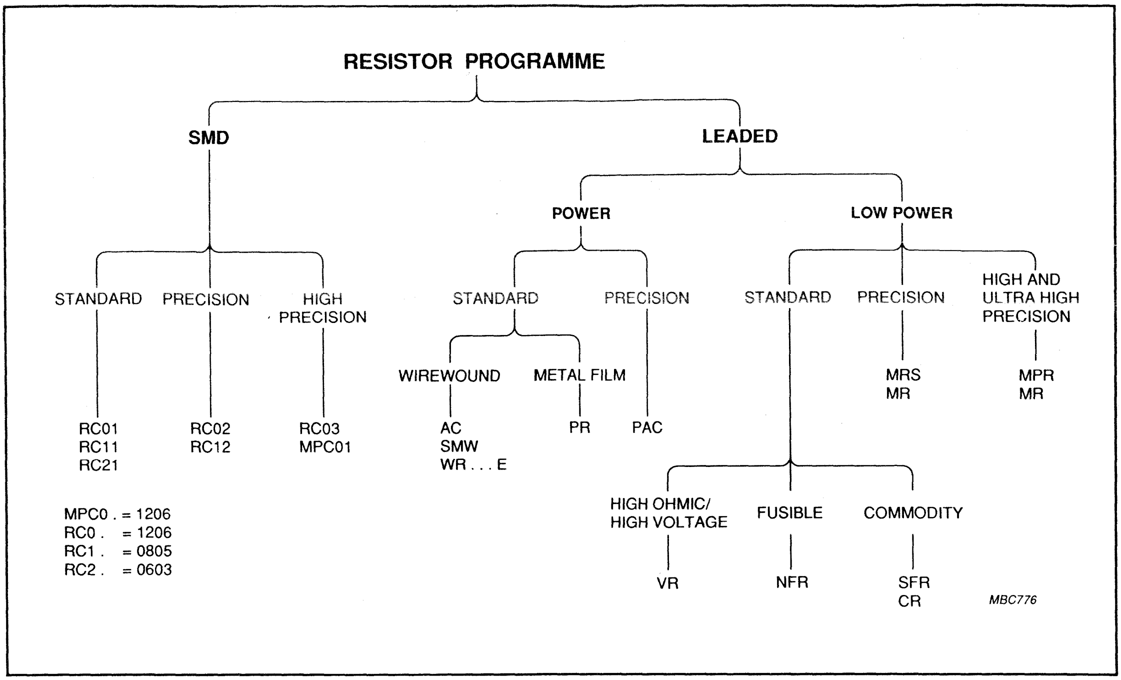


SMD CHIP RESISTORS

Fixed Resistors

Selection Guide - chip resistors

TECH.	USE	TYPE	SIZE (inch)	TOL. (%)	RANGE (Ω)	TEMP. COEFF. (x 10^{-6}/K)	MAX. (V/W)	SERIES E	PAGE
Thick Film	Standard	RC01	1206	5 2	1 - 10 M 10 - 1 M	≤±200	200/0.25	24	27
		RC11	0805	5 2	1 - 10 M 10 - 1 M	≤±200	150/0.1		35
		RC21	0603	5	1.2 - 10 11 - 910 k 1 M - 6.9 M	≤–200/+500 ≤±200 ≤±300	50/0.063		41
	Precision TC100	RC02H	1206	1	1 - 4.99 5.1 - 97.6 100 - 1 M 1.02 M - 10 M	≤±250 ≤±200 ≤±100 ≤±200	200/0.125	24/96	49
		RC02HP					200/0.25		55
		RC12H	0805		1 - 4.99 5.1 - 97.6 100 - 1 M	≤±250 ≤±200 ≤±100	150/0.1		61
	Precision TC50	RC02G	1206	1	100 - 1 M	≤±50	200/0.125		67
		RC02GP			250 - 150 k		200/0.25		73
		RC12G	0805		100 - 249 255 - 1 M	≤±100 ≤±50	150/0.1		79
	High Precision	RC03G	1206	0.5	100 - 249 255 - 1 M	≤±100 ≤±50	200/0.125		87
	Application Specific	RC02TR trimmable	1206	+0/–20 or +0/–30	1 - 4.99 5.1 - 97.6 100 - 1 M	≤±250 ≤±200 ≤±100	200/0.25	24	93
Thin Film	High Precision	MPC01	1206	0.1	100 - 100 k	≤±25	100/0.125	all values	99

INTRODUCTION

The data are presented - whenever possible - according to a "format", in which the following items are stated:

TITLE
QUICK REFERENCE DATA
APPLICATION
DESCRIPTION
MECHANICAL DATA
  Mass
  Mounting
  Marking
ELECTRICAL DATA
  Standard values of rated resistance and tolerance
COMPOSITION OF THE TYPE NUMBER
TESTS AND REQUIREMENTS
PACKAGING

DESCRIPTION

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

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

MECHANICAL DATA

A dimensional sketch and a table of dimensions are given.

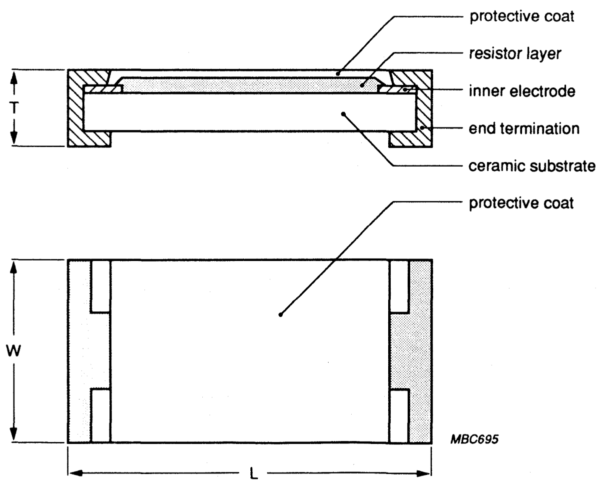


Fig.1 Component outline.

The relationship between U.S. case size reference (inch), sizes in mm and mass per 100 resistors for various types of chip resistors are shown below

TYPE	U.S. CASE SIZE	L (mm)	W (mm)	T (mm)	MASS (g)
RC0 .	1206	3.2	1.6	0.6	1.0
RC1 .	0805	2.0	1.25	0.6	0.55
RC2 .	0603	1.6	0.8	0.45	0.4

Mounting

Chip resistors are designed for handling by automatic chip placement systems.

The temperature rise in a resistor due to power dissipation, is determined by the laws of heat - conduction, convection and radiation. The maximum body temperature usually occurs in the middle of the resistor and is called the **hot-spot** temperature.
The hot-spot temperature depends on the ambient temperature and the dissipated power. This is described in the ELECTRICAL DATA section.
The hot-spot temperature is important for mounting because the connections to the chip resistors will reach a temperature close to the hot-spot temperature. Heat conducted by the connections must not reach the melting point of the solder at the joints. Therefore a maximum solder joint temperature of 110 °C is advised. The ambient temperature on large or very dense printed circuit boards (PCB's) is influenced by the dissipated power. The ambient temperature will again influence the hot-spot temperature. Therefore, the packing density that is allowed on the PCB is influenced by the dissipated power.
Figures 2, 3 and 4 show the different soldering methods which may be employed when mounting chip resistors.

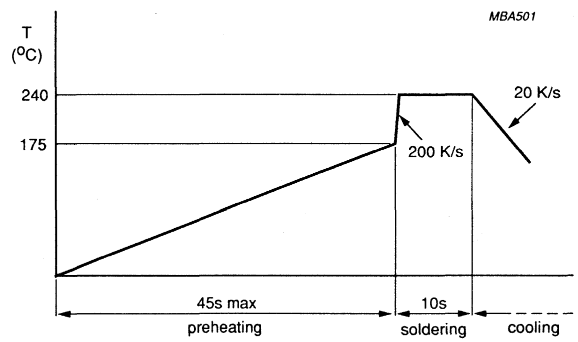


Fig.2 Infrared soldering.

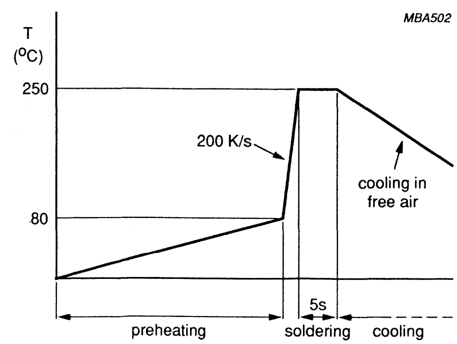


Fig.3 Wave soldering. The resistors may be soldered twice according to this method if necessary.

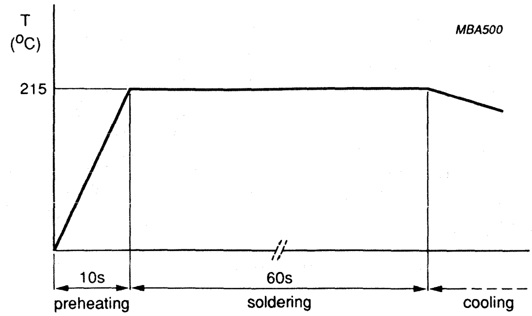


Fig.4 Vapour phase soldering.

Example

Assume that the maximum temperature of a PCB is 95 °C and the ambient temperature is 50 °C. In this case the maximum temperature rise that may be allowed is 45 °C. In the graph (Fig.5), this point is found by drawing the line from point A (PCB 95 °C) to point B (T_{amb} 50 °C) and from here to the left axis.

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

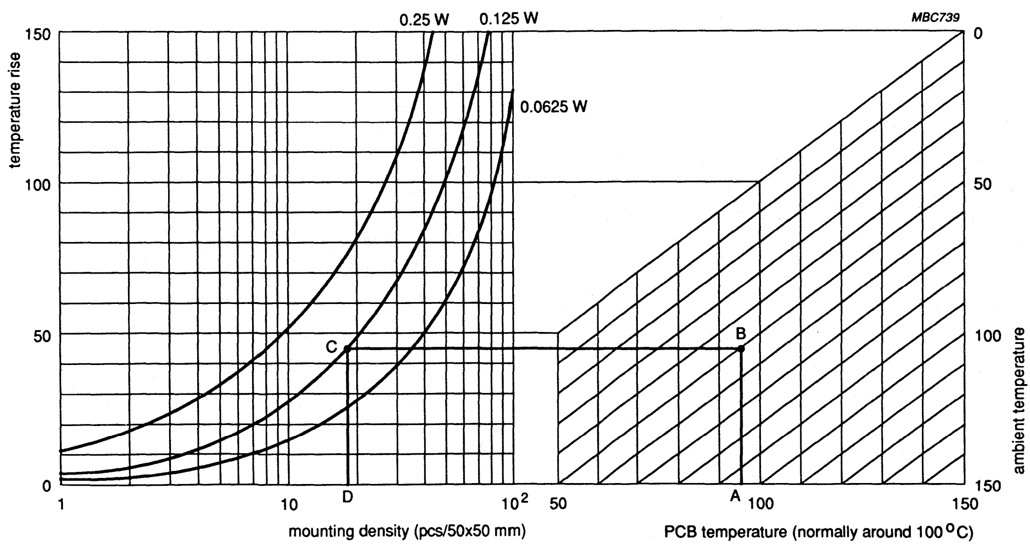


Fig.5 Printed circuit board (PCB) temperature as a function of applied power, mounting density and ambient temperature.

Marking

Almost all chip resistors are provided with a **resistance code** (see Table 1). The resistance code includes the first two or three significant figures of the resistance value (in ohms) followed by an indicator. The indicator denominates the power of ten by which the significant value has to be multiplied to find the relevant resistance value. Whether two or three significant values are represented depends on the tolerance: ±2% and higher requires two digits; ±1% and lower requires three digits.

Table 1 Resistance value indication

DECADE INDICATOR	≥± 2% TOLERANCE VALUE 2 DIGITS	≤± 1% TOLERANCE VALUE 3 DIGITS
0	0.0 Ω, jumper	
R (note 1)	1 to 91 Ω	1 to 976 Ω
1	100 to 910 Ω	1 to 9.76 kΩ
2	1 to 9.1 kΩ	10 to 97.6 kΩ
3	10 to 91 kΩ	100 to 976 kΩ
4	100 to 910 kΩ	1 MΩ
5	1 to 9.1 MΩ	
6	10 MΩ	

Note

1. R denotes the decimal point.

ELECTRICAL DATA

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

The **limiting voltage** (DC or RMS) is the maximum voltage that may be continuously applied to the resistor element, see IEC publications 115-1 and 115-2.

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

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

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

where

T_m = hot-spot temperature
T_{amb} = ambient temperature
ΔT = temperature rise at hot-spot.

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

Summarizing

dimensions, conductance of materials and mounting determine	heat resistance
heat resistance x dissipation	= temperature rise
temperature rise + ambient temperature	= hot-spot temperature

Frequency behaviour

Every resistor can be represented as a linear resistor switched in series with a coil, which is parallel to a capacitor.

Typical values for a RC11 are:

The impedance and phase shift measurements of the resistor are plotted in Figs 6 and 7 respectively.

L = 1 nH
C = 0.09 pF to 0.02 pF

However, individual resistors may have differing behavioural patterns because of both layer thicknesses and laser grooves. In general, the environment the resistor is in has more impact on the frequency behaviour.

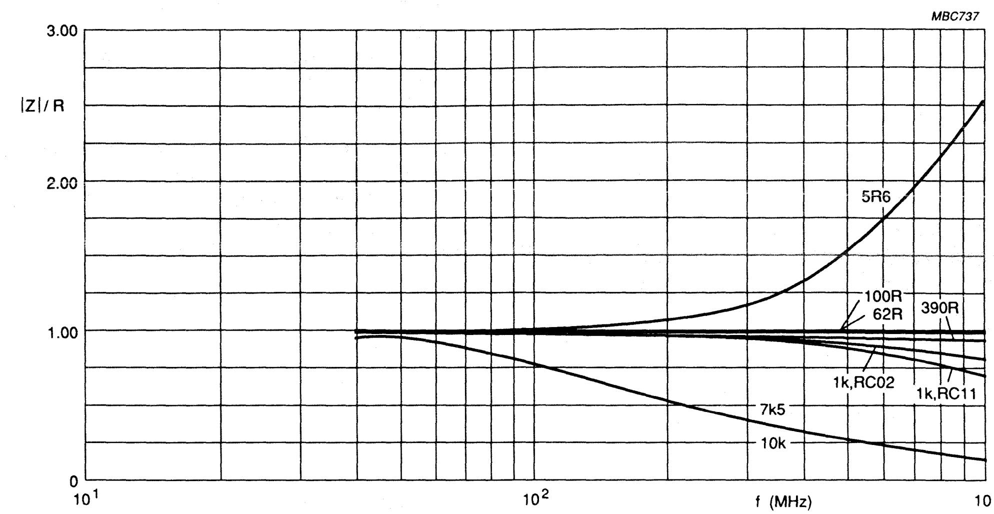


Fig.6 Impedance.

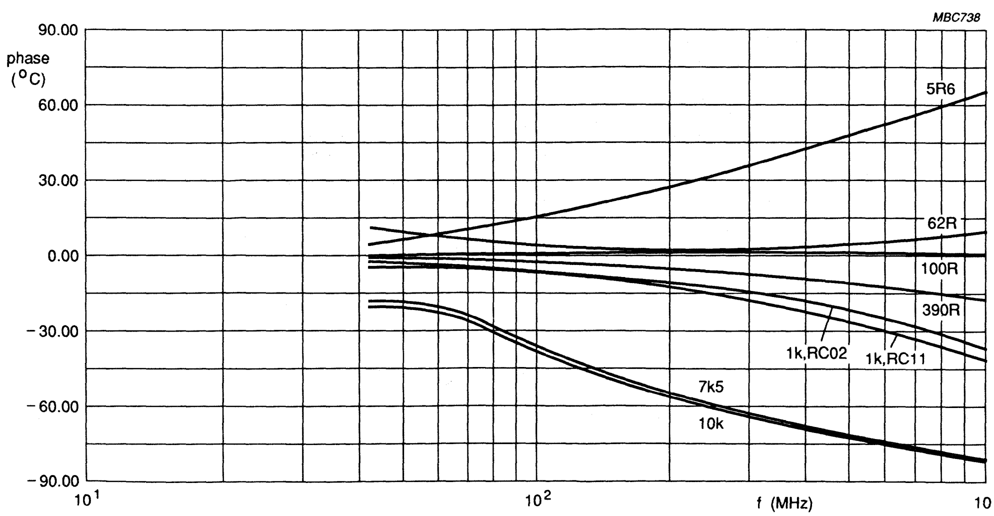


Fig.7 Phase shift.

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,

$$\frac{dP}{dT_m} = \frac{I}{A} \text{ is the reciprocal}$$

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

The temperature coefficient

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

Example: If the temperature coefficient of a resistor of R_{nom} = 1 kΩ between −55 °C and +155 °C is ±200 . 10^{-6}/K and the resistor has the actual resistance value 1 kΩ, its resistance will be:

at 25 °C:
1 000 Ω (nominal = rated value)

at +155 °C:
1 000 Ω ±(130 . 200 . 10^{-6}) x 1 000 Ω
= 1 026 Ω or 974 Ω

at −55 °C:
1 000 Ω ±(80 . 200 . 10^{-6}) x 1 000 Ω
= 1 016 Ω or 984 Ω

If the temperature coefficient is specified as ≤200 . 10^{-6}/K the resistance will be within the shaded area. This behaviour is shown in Fig.8.

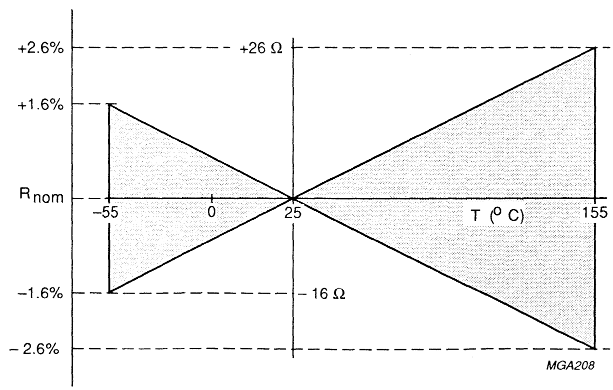


Fig.8 Temperature coefficient.

Noise

Most resistors generate noise due to the passage of current through the resistor. This noise is dependent on the amount of current, the resistive material and the physical construction of the resistor. The physical construction is partly influenced by the laser trimming process which cuts a groove in the resistive material. Typical current noise levels are shown in Fig.9.

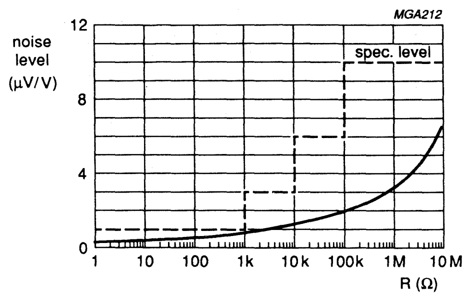


Fig.9 Typical noise levels as a function of rated resistance for the RC02G.

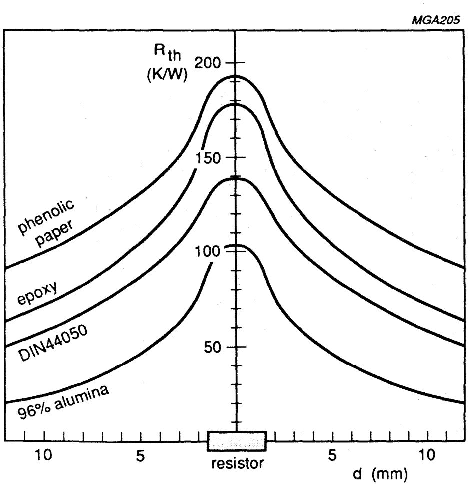


Fig.10 Heat resistance as a function of distance and material.

HEAT RESISTANCE (R_{th})

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

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

Due to their direct contact with the solder spot, chip resistors dissipate over 85% of their heat via conduction to the solder spot and hence to the PCB. Thus the PCB on which the chip resistor is mounted functions as a heat sink. Different PCB's have different heat conductance. Figure 10 shows the different values of heat resistance per material type. Substrates with a higher heat conductance give lower thermal resistance figures; substrates with a lower heat conductance give higher thermal resistance figures.

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

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

PULSE-LOAD BEHAVIOUR

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

Exponential time constant	50 µs	700 µs
Repetition time	12 s	25 s
Amount of pulses	5	10

With this test, it can be determined at which applied voltage the resistive value changes about 0.5% of its nominal value under the above mentioned pulse conditions. Figure 11 shows test results for the RC02G chip resistors. If applied regularly, the load is destructive. Therefore the load must not be applied regularly during the load life of the resistors.

However, the magnitude of a pulse at which failure occurs is of little practical value. The maximum "single-pulse" load that may be applied in a regular way can be determined in a similar fashion.

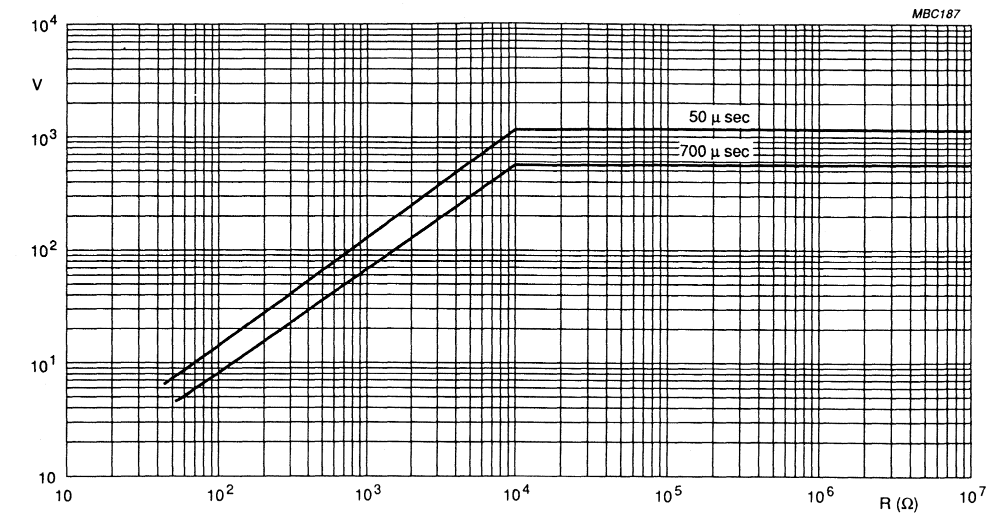


Fig.11 Maximum pulse power without failing to "open circuit" for RC02G.

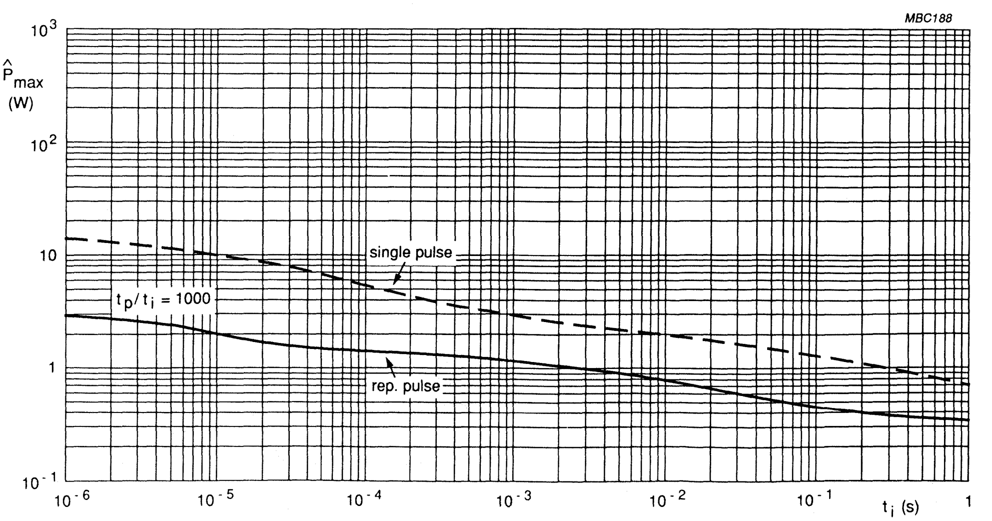


Fig.12 Maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i) for a typical RC02G resistor (R ≤10 kΩ).

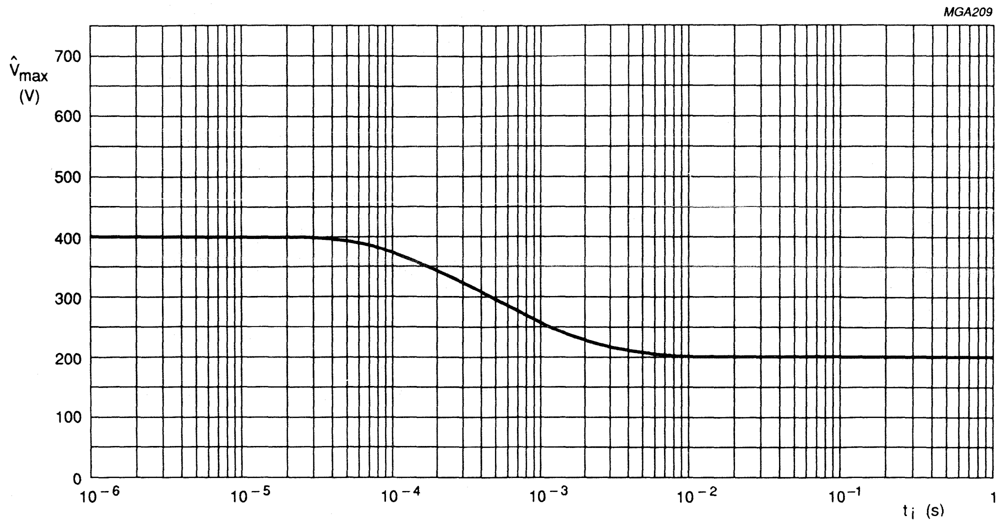


Fig.13 Maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_i) for a typical RC02G resistor.

Definitions of pulses

SINGLE PULSE

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

REPETITIVE PULSE

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

The dashed line in Fig.12 shows the observed maximum load for the RC02G chip resistors under single-pulse loading.

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

The continuous pulse train maximum handling capacity of chip resistors has been determined experimentally.

Measurements have shown that the handling capacity varies with the resistive value applied. However, maximum peak pulse voltages as indicated in Fig.13, should not be exceeded.

Determination of pulse loading

The graphs in Figs 12 and 13 may be used to determine the maximum pulse loading for a resistor.

- For repetitive rectangular pulses:

  – $\frac{V_i^2}{R}$ must be lower than the value of $\hat{P}_{max}$ given by the solid lines of Fig.12 for the applicable value of t_i and duty cycle t_p/t_i.

  – V_i must be lower than the value of $\hat{V}_{max}$ given in Fig.13 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:

  – $\frac{V_i^2}{R}$ must be lower than the $\hat{P}_{max}$ given by the dashed line of Fig.12 for the applicable value of t_i.

  – V_i must be lower than the value of $\hat{V}_{max}$ given in Fig.13 for the applicable value of t_i.

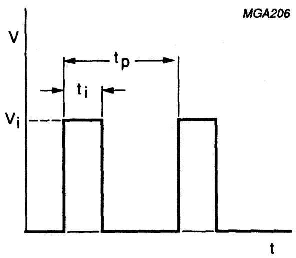


Fig.14 Rectangular pulses.

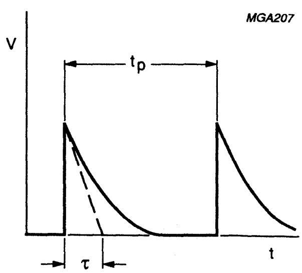


Fig.15 Exponential pulses.

Definition of symbols used in Figs 12, 13, 14 and 15

P = applied peak pulse power
$\hat{P}_{max}$ = maximum permissible peak pulse power (Fig.12)
V_i = applied peak pulse voltage (Figs 14 and 15)
$\hat{V}_{max}$ = maximum permissible peak pulse voltage (Fig.13)
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_{hsp} = maximum hot-spot temperature of the resistor

Examples

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

1. CONTINUOUS PULSE TRAIN

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

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

For

$$t_i = 10^{-5}\text{ s and } \frac{t_p}{t_i} = 1000$$

Figure 12 gives $\hat{P}_{max}$ = 2 W and Fig.13 gives $\hat{V}_{max}$ = 400 V. As the operating conditions P = 1 W and V_i = 10 V are lower than these limiting values, this resistor can be safely used.

SINGLE PULSE

A 10 kΩ resistor is required to operate under the following conditions:
V_i = 250 V; $t_i = 10^{-5}$.
Therefore:

$$P_{max} = \frac{250^2}{10000} = 6.25\,W.$$

The dashed curve of Fig.12 shows that at $t_i = 10^{-5}$ s, the permissible $\hat{P}_{max}$ = 10 W and Fig.13 shows a permissible $\hat{V}_{max}$ of 400 V, so again this resistor may be used.

TESTS and PROCEDURES

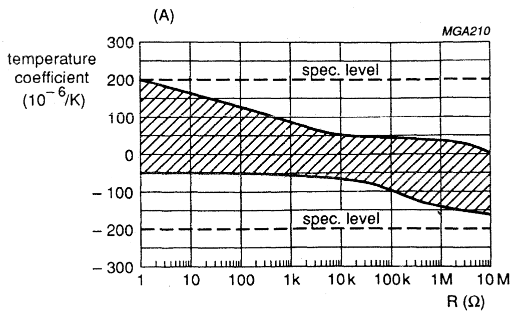
To guarantee zero defect production standards, Statistical Process Control is an essential part of our production processes. Furthermore, our production process is operating in accordance with ISO 9000.

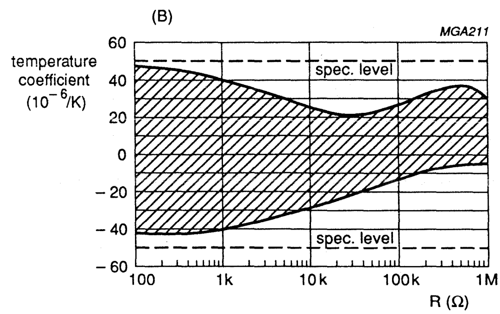
Essentially all tests on resistors are carried out in accordance with the schedule of IEC publication 115-1 in the specified climatic category and in accordance with IEC publication 68, *"Recommended basic climatic and mechanical robustness testing procedure for electronic components"*. In some instances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

Table 2

IEC 115-1 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE
4.17	Ta 2.20	soldering	unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C; flux 600
		soldering	16 hours steam or 16 hours 155 °C; unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C; flux 600
4.18	Tb	resistance to soldering heat	10 s; 260 ±5 °C; flux 600
		leaching	unmounted chips 60 s; 250 ±5 °C
4.19	Na 2.14	rapid change of temperature	30 minutes at −55 °C/ 30 minutes at +125 °C; 5 cycles
4.22	Fc 2.6	vibration	frequency: 10-500 Hz; displacement 1.5 mm or acceleration 10 g, 3 directions; total 6 hours
4.20	Eb 2.29	bump	3 x 1500 bumps in 3 directions; 40 g
		bending	resistors mounted on a glass epoxy resin PCB; bending 5 mm over 90 mm
		humidity load (JIS)	1 000 hours; +40 °C; 90-95% R.H.; loaded with Pn or 150 V; max. 1.5 hours on, 0.5 hours off

IEC 115-1 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE
4.23		climatic sequence	
4.23.2	Ba 2.2	dry heat	16 hours; 125 °C
4.23.3	D 2.30	damp heat (accel.) 1st cycle	24 hours; 55 °C; 95-100% R.H.
4.23.4	Aa 2.1	cold	2 hours; –55 °C
4.23.5	M 2.13	low air pressure	1 hour; 8.5 kPa; 15-35 °C
4.23.6	D 2.30	damp heat (accel.) remaining cycles	5 days; 55 °C; 95-100% R.H.
4.24.2	Ca 2.3	damp heat (steady state)	56 days; 40 °C; 90-95% R.H.; loaded with 0.01 Pn (IEC steps; 1-100 V); dissipation ≤1 mW
4.25.1		endurance	1000 hours; 70 °C; nominal dissipation
4.6.1.1		insulation resistance	100 V (DC) after 1 minute
4.13		short time overload	room temperature; dissipation 6.25 x 0.1 W; 5 s (voltage not more than 2 x V_{max})
4.8.4.2		temperature coefficient	between –55 °C and +125 °C
4.12		noise	IEC publication 195 (measured with Quantech - equipment)
4.23.2	Ba	endurance at upper category temperature	1000 hours; 125 °C; no load
4.7		voltage proof on insulation	V_{max} (DC or RMS) during 1 minute





(A) RC-01.

(B) RC-02G.

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

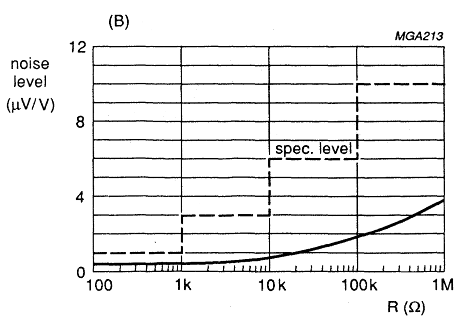
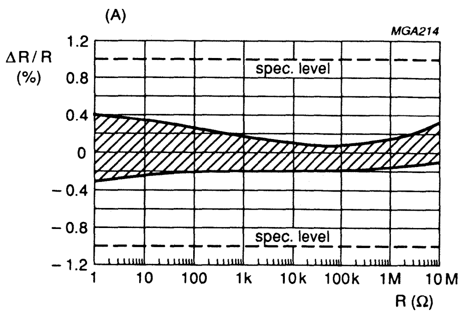
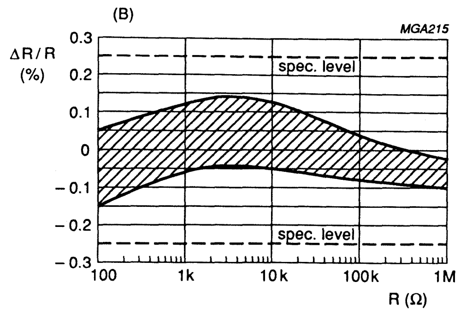


Fig.17 Typical noise level as a function of rated resistance measured using Quantech equipment.

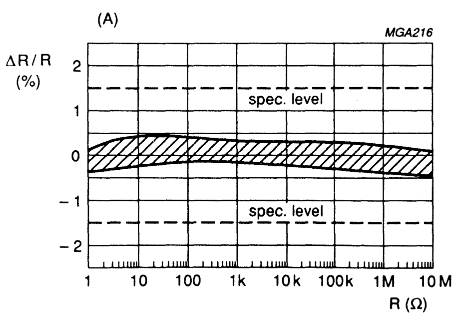


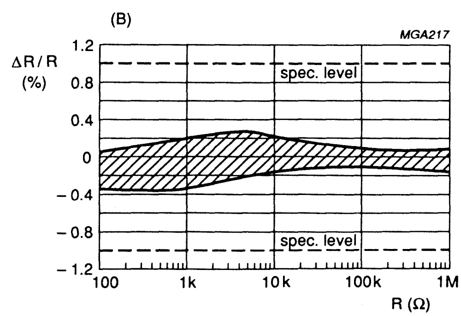


(A) RC-01.

(B) RC-02G.

Fig.18 Typical percentage change in resistance after soldering for 10 seconds at 260 °C, completely immersed.

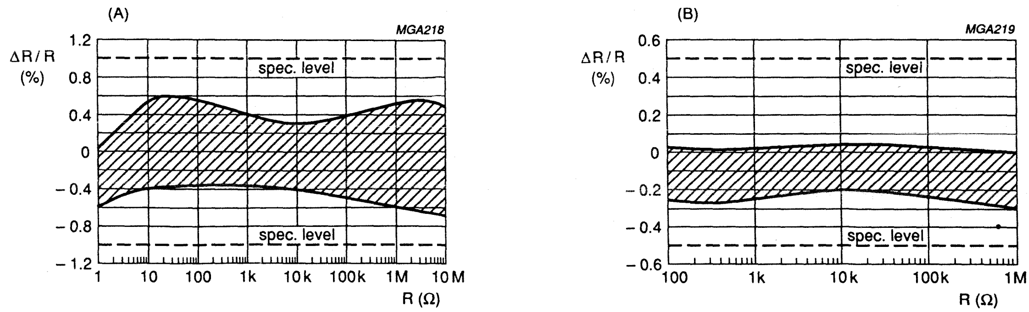




(A) RC-01.

(B) RC-02G.

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



(A) RC-01.
(B) RC-02G.

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

COMPOSITION of the CATALOGUE NUMBER

Resistors are ordered by their **catalogue number**, which consists of 12-digits. In general, the packaging method is an integral part of this number, as well as the resistance code. Exceptions to this rule are customer/application specific resistors that are not included in our standard series, such as higher ohmic values and non standard values.

STANDARD PACKAGING

All types may be processed automatically and are supplied on tape for this purpose.

1. Cardboard tape (style 1); quantity 5 000 per reel; reel diameter 180 mm (see Figs 21 and 23).
2. Cardboard tape (style 1); quantity 10 000 per reel; reel diameter 250 mm (see Figs 21 and 23).
3. Blister tape (style 2); quantity 5 000 per reel; reel diameter 180 mm (see Figs 22 and 23).
4. Blister tape (style 2); quantity 10 000 per reel; reel diameter 250 mm (see Figs 22 and 23).
5. Bulk, in bag; quantity 1000.

Tape and reel specifications

All tape and reel specifications are in accordance with the first edition of IEC 286-3, and amendments as proposed in IEC 40 (Secretariat) 570. Basic dimensions are given in Figs 21, 22 and 23.

Tape leader and trailer

The leader end of the tape is at least 400 mm in length and contains a minimum of 40 empty compartments. The end of the tape is at least 40 mm in length.

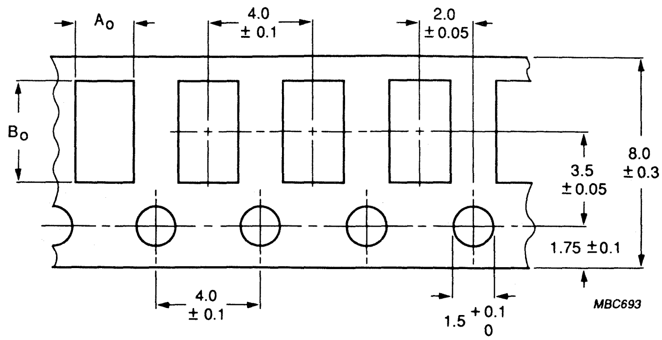
Peel-off force

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

ENVIRONMENTAL ISSUES

The PHILIPS reels are made of polystyrene which is suitable for recycling.

Style 1



Dimensions in mm.

Cumulative tolerance over 10 holes: ±0.2 mm.

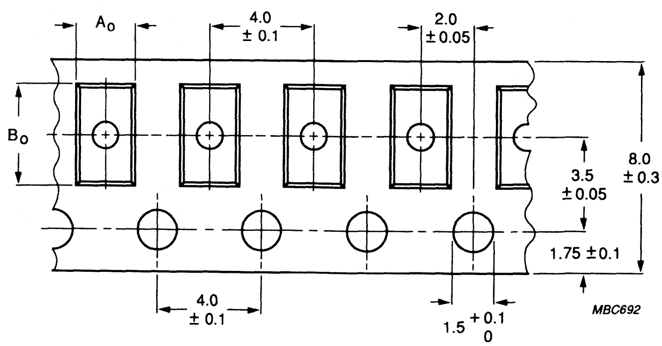
Bottom fixing tape (thickness 50 ±10 μm).

Top fixing tape (thickness 50 ±10 μm).

Carrier tape (thickness 0.7 +0.05 mm).

Fig.21 Cardboard tape.

Style 2



Dimensions in mm.

Cumulative pitch error: 0.2 mm over 10 pitches.

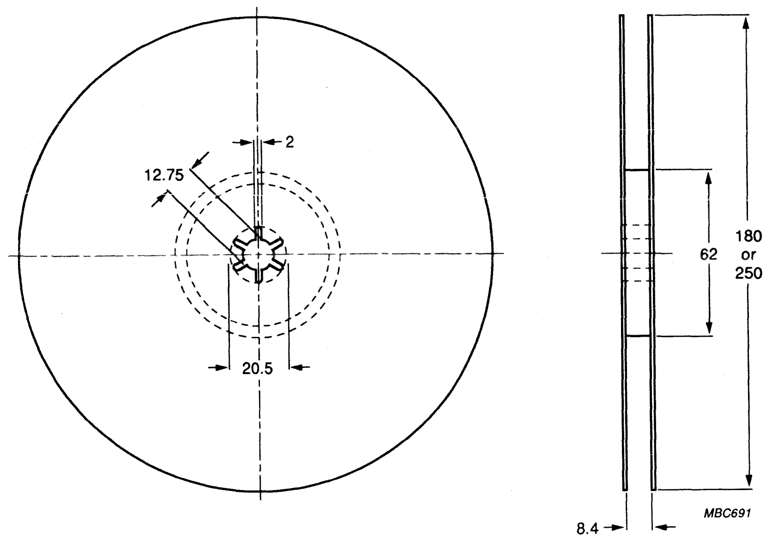
Cumulative tolerance over 10 holes: ±0.2 mm.

Top fixing tape.

Blister tape.

Depth of compartments: 0.7 mm.

Fig.22 Blister tape.



Dimensions in mm.

Fig.23 Reel dimensions.

STANDARD

SMD Resistor RC01

FEATURES

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

APPLICATIONS

- Television
- Radio recorders
- Telecommunication equipment
- Automotive industry
- Pocket calculators.

QUICK REFERENCE DATA

Resistance range	1 Ω to 10 MΩ and jumper (0 Ω); E24 Series
Resistance tolerance	±2%, ±5%
Temperature coefficient	< $\pm 200.10^{-6}$/K
Abs. max. dissipation at T_{amb} = 70 °C	0.25 W
Maximum permissible voltage	200 V (DC or RMS)
Climatic category (IEC 68)	55/155/56
Basic specification	IEC 115-1
Stability after:	
load;	
1000 hours at T_{amb} = 70 °C	ΔR/R max. 1% +0.05 Ω
8000 hours at T_{amb} = 70 °C	ΔR/R max. 2% +0.1 Ω
climatic tests	ΔR/R max. 1.5% +0.05 Ω
soldering	ΔR/R max. 1% +0.05 Ω
short time overload, 400 V max.	ΔR/R max. 2% +0.1 Ω

DESCRIPTION

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

The resistive layer is covered with a protective coating and printed with the resistance value. Finally, the two external end terminations are added. For ease of soldering the outer layer of these end terminations is a (40%) lead (60%) tin alloy.

This surface mounted resistor is available in two styles, which have different dimensions of the bottom terminations.

MECHANICAL DATA

Dimensions in mm.

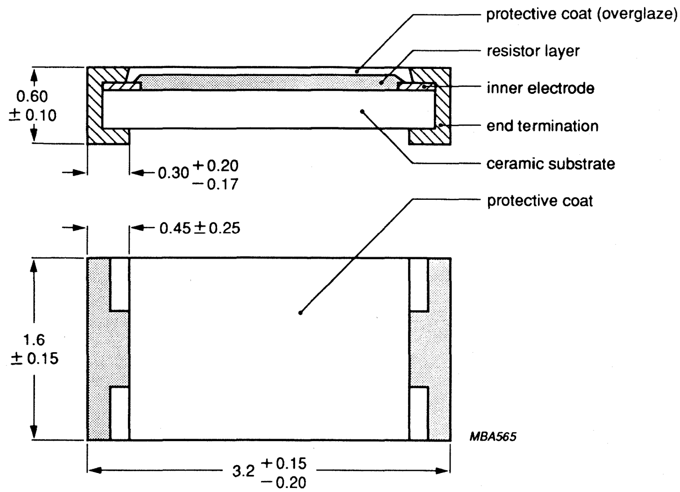


Fig.1 Physical dimensions, style 1.

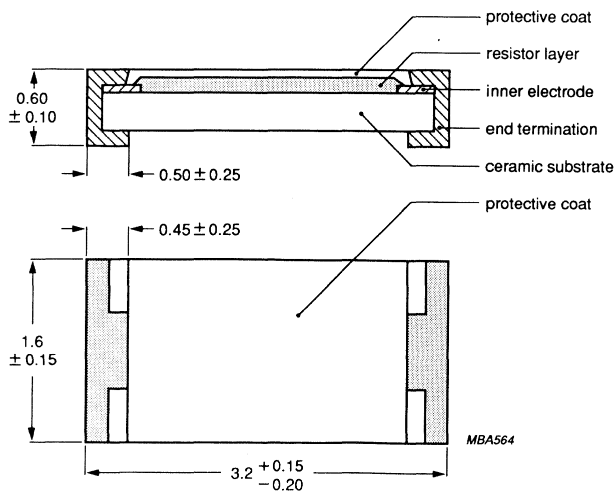


Fig.2 Physical dimensions, style 2.

Mass (per 100): 1.0 gram

Mounting

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

The robust construction of the device allows it to be completely immersed in a solder bath of 250 °C for up to one minute. Therefore, it is possible to mount Surface Mounted Resistors on one side of a printed-circuit board and other discrete components on the reverse (mixed prints).

Marking

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

For values up to 91 Ω the R is used as a decimal point.

For values of 100 Ω or greater, the first 2 digits apply to the resistance value and the third is an indication of magnitude.

1 to 91 Ω = R
100 to 910 Ω = 1
1 to 9.1 kΩ = 2
10 to 91 kΩ = 3
100 to 910 kΩ = 4
1 to 9.1 MΩ = 5
10 MΩ = 6

EXAMPLES:

12R = 12 Ω

471 = 470 Ω

823 = 82 kΩ

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

Soldering conditions

Surface Mounted Resistors are tested for solderability at a temperature of 235 °C during 2 seconds. The test condition for no-leaching is 250 °C for 60 seconds. Typical examples of soldering processes that provide reliable joints without any damage, are given in Figs 3, 4 and 5.

ELECTRICAL DATA

Standard values of resistance and tolerance.

The resistors are available in the E24 series for resistors with a tolerance of ±5% and ±2%. The values of the E24 series are in accordance with IEC publication 63.

The limiting voltage (DC or RMS) is 200 V. This is the maximum voltage that may be continuously applied to the resistor element (see IEC publications 115-1 and 115-2).

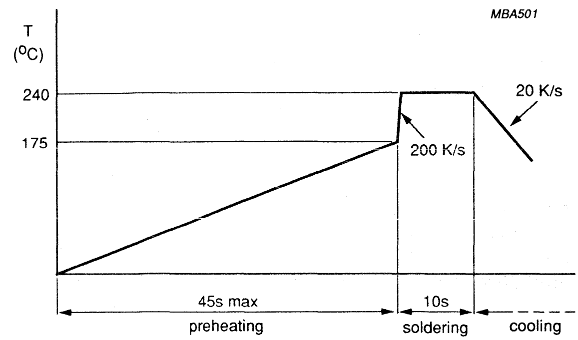


Fig.3 Infrared soldering.

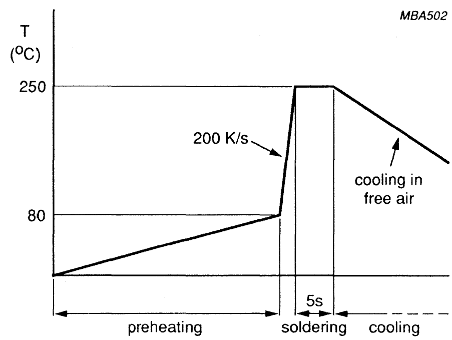


Fig.4 Wave soldering. The resistors may be soldered twice according to this method if necessary.

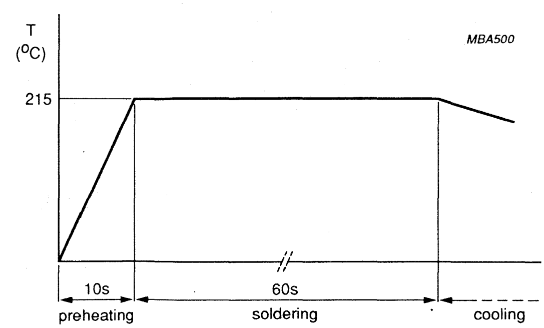


Fig.5 Vapour phase soldering.

Dissipation

The rated power that the resistor can dissipate depends on the operating temperature; see Fig 6.

Pulse-load behaviour

The pulse load behaviour is determined in accordance with the method outlined in the "General" section, data handbook PA08 Fixed Resistors; the results are shown in Figs 7 and 8.

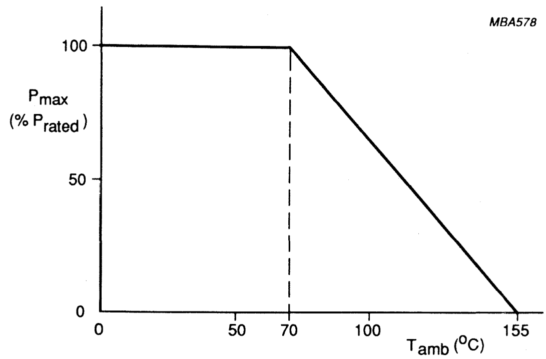


Fig.6 Maximum dissipation (P_{max}) as a function of the ambient temperature (T_{amb}).

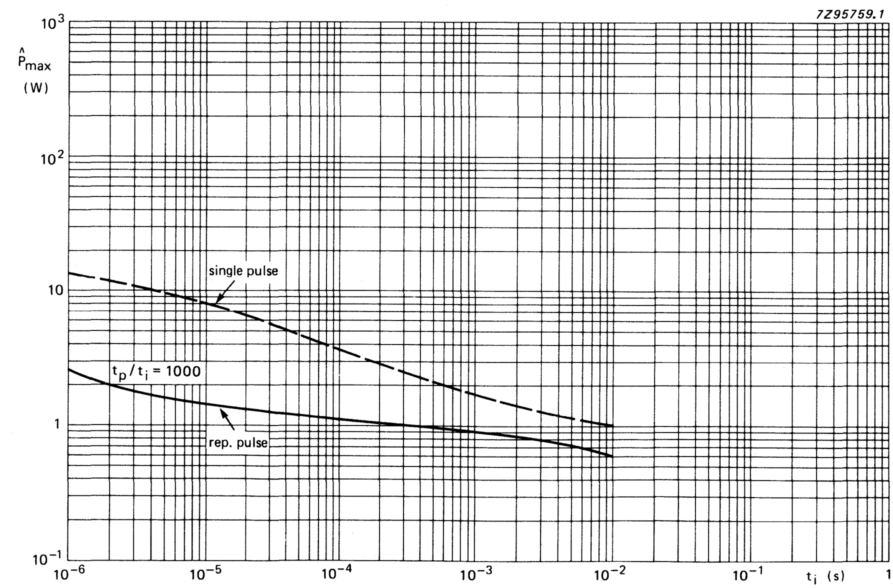


Fig.7 Maximum permissible peak pulse power versus pulse duration for R ≤10 kΩ, single pulse and repetitive pulse t_p/t_i = 1000.

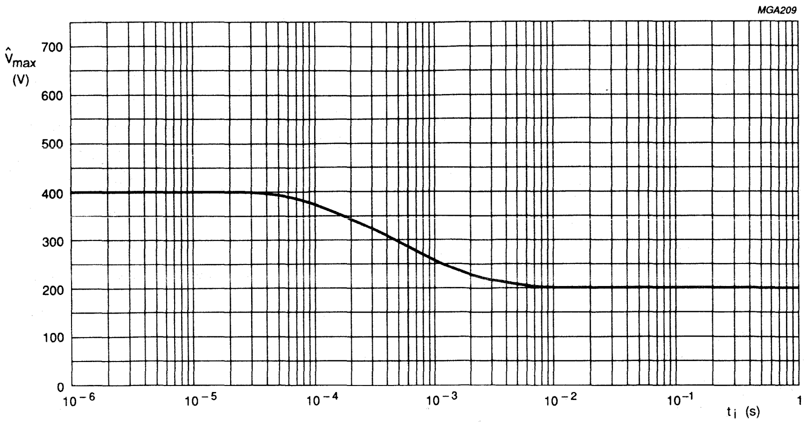


Fig.8 Maximum permissible peak pulse voltage versus pulse duration.

COMPOSITION of the CATALOGUE NUMBER

Table 1 The resistors have a 12-digit catalogue number starting with 2322. Subsequent digits indicate packaging and resistance as listed in this table

STYLE	RESISTANCE RANGE	TOL. ±%	SERIES	CATALOGUE NUMBER 2322			
				CARDBOARD TAPE 711		BLISTER TAPE 712	
				5 000 reel	10 000 reel	5 000 reel	10 000 reel
1	1 Ω to 10 MΩ 10 Ω to 1 MΩ jumper (0 Ω) [1]	5 2	E24 E24	60... 40... 90032	50... 70... 90005	60... 82... 90024	70... 22... 90004
2	1 Ω to 10 MΩ 10 Ω to 1 MΩ jumper (0 Ω) [1]	5 2	E24 E24	61... 41... 91032	51... 71... 91005	61... 83... 91024	71... 23... 91004

Note

[1] The jumper has a maximum resistance R_{max} = 50 mΩ at a rated current I_R = 2 A.

To complete the catalogue number (see Table 1), replace the first two dots of the remaining code by the first two digits of the resistance value. Replace the third dot by a figure according to the following table:

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 to	9.1 MΩ	5
	10 MΩ	6

Ordering Example

To order a RC01 resistor style 1, supplied on cardboard tape of 5000 units per reel with a resistance value of 3k3 Ω, the ordering code is: 2322 711 60332.

Packaging details are specified in chapter "PACKING", data handbook PA08 Fixed Resistors.

TESTS and REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publication 115-1, category 55/155/56 (rated temperature range –55 to +155 °C; damp heat, long term, 56 days) and CECC publications 1929/1930/1931. The IEC publications are in preparation as documents 40 numbers 620/621 and 623. The testing also meets the requirements specified by EIA and EIAJ.

The tests are carried out in accordance with IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components".

In Table 2 the tests and requirements are listed with reference to the relevant clauses of IEC publications 115-1 and 68: a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

Table 2

IEC 115-1 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.17	Ta 2.20	soldering	unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C; flux 600	good tinning, no damage
4.18	Tb	resistance to soldering heat	10 s; 260 ±5 °C; flux 600	ΔR/R max. ±1% +0.05 Ω
		leaching	unmounted chips 60 s; 250 ±5 °C	good tinning, no leaching
4.19	Na 2.14	rapid change of temperature	30 minutes –55 °C/30 minutes +155 °C; 5 cycles	ΔR/R max. ±1.5% +0.05 Ω
4.22	Fc 2.6	vibration	frequency: 10-500 Hz; displacement 1.5 mm or acceleration 10 g, 3 directions; total 6 hours	no damage ΔR/R max. ±0.5% +0.05 Ω
4.20	Eb 2.29	bump	3 x 1500 bumps in three directions; 40 g	no damage, ΔR/R max. ±0.5% +0.05 Ω
4.23		climatic sequence		
4.23.2	Ba 2.2	dry heat	16 hours; 125 °C	
4.23.3	D 2.30	damp heat (accel.) 1st cycle	24 hours; 55 °C; 95-100% R.H.	
4.23.4	Aa 2.1	cold	2 hours; –55 °C	
4.23.5	M 2.13	low air pressure	1 hour; 8.5 kPa; 15-35 °C	
4.23.6	D 2.30	damp heat (accel.) remaining cycles	5 days; 55 °C; 95-100% R.H.	R_{ins} = min. 1000 MΩ ΔR/R max. ±1.5% +0.05 Ω
4.24.2	Ca 2.3	damp heat (steady state) (IEC)	56 days; 40 °C; 90-95% R.H.; loaded with 0.01 Pn (IEC steps: 1-100 V)	R_{ins} = min. 1000 MΩ ΔR/R max. ±1.5% +0.05 Ω
4.25.1		endurance	1000 hours; 70 °C; nominal dissipation	ΔR/R max. ±1% +0.05 Ω

IEC 115-1 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.6.1.1		insulation resistance	100 V (DC) after 1 minute; V block method	min. 10^4 MΩ
4.13		short time overload	room temperature, dissipation 6.25 x Pn; 5 s (voltage not more than 2 x V_{max})	ΔR/R max. ±2% +0.1 Ω
4.8.4.2		temperature coefficient	between –55 °C and +155 °C	$\leq \pm 200.10^{-6}$/K
4.12		noise	IEC publication 195 (measured with Quantech - equipment)	R <1k: max. 1 μV/V R <10k: max. 3 μV/V R <100k: max. 6 μV/V R ≤2M: max. 10 μV/V
4.23.2	Ba	endurance at upper category temperature	1000 hours, 155 °C; no load	ΔR/R max. ±1% +0.05 Ω no visual damage
4.7		voltage proof on insulation	200 V (DC or RMS) during 1 minute	no breakdown

SMD Resistor RC11

FEATURES

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

APPLICATIONS

- Hand held measuring equipment
- Carphones
- Camcorders.

DESCRIPTION

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

The resistive layer is covered with a protective coating and printed with the resistance value. Finally, the two external end terminations are added. For ease of soldering the outer layer of these end terminations is a (40%) lead (60%) tin alloy.

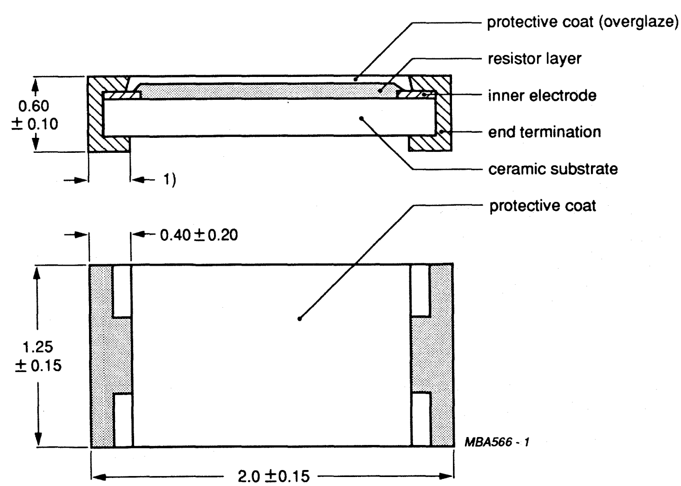
The surface mounted resistor is available in two styles with different dimensions of the bottom terminations (see Fig.1).

QUICK REFERENCE DATA

Resistance range	1 Ω to 10 MΩ and jumper (0 Ω); E24 Series
Resistance tolerance	±5%
Temperature coefficient	≤ ±200.10^{-6}/K
Abs. max. dissipation at T_{amb} = 70 °C	0.10 W
Maximum permissible voltage	150 V (DC or RMS)
Climatic category (IEC 68)	55/125/56
Basic specification	IEC 115-1
Stability after: load, 1000 hours at T_{amb} = 70 °C for R ≤1 MΩ for R >1 MΩ climatic tests for R ≤1 MΩ for R >1 MΩ soldering short time overload, 300 V max.	 ΔR/R max. ±1.5% +0.05 Ω ΔR/R max. ±3% +0.1 Ω ΔR/R max. ±1.5% +0.05 Ω ΔR/R max. ±3% +0.1 Ω ΔR/R max. 0.5% +0.05 Ω ΔR/R max. ±1% +0.05 Ω

MECHANICAL DATA

Dimensions in mm.



1) = 0.25 ±0.15 for style 1
0.40 ±0.20 for style 2.

Fig.1 Component outline and physical dimensions.

Mass (per 100): 0.55 gram

Mounting

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

The robust construction of the device allows it to be completely immersed in a solder bath of 250 °C for up to one minute. Therefore, it is possible to mount Surface Mounted Resistors on one side of a printed-circuit board and other discrete components on the reverse (mixed prints).

Soldering conditions

Surface Mounted Resistors are tested for solderability at a temperature of 235 °C during 2 seconds. The test condition for no-leaching is 250 °C for 60 seconds. Typical examples of soldering processes that provide reliable joints without any damage, are given in Figs 2, 3 and 4.

Marking

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

For values up to 91 Ω the R is used as a decimal point.

For values of 100 Ω or greater, the first 2 digits apply to the resistance

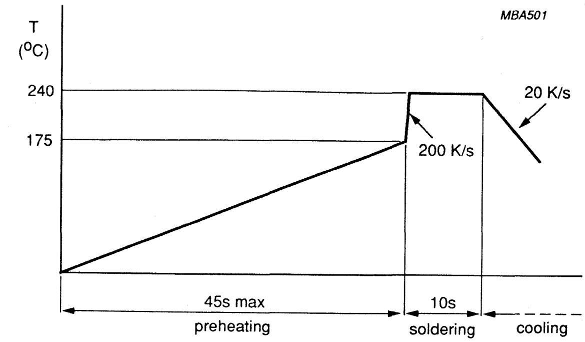


Fig.2 Infrared soldering.

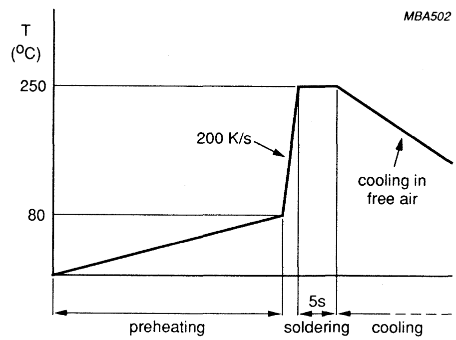


Fig.3 Wave soldering. The resistors may be soldered twice according to this method if necessary.

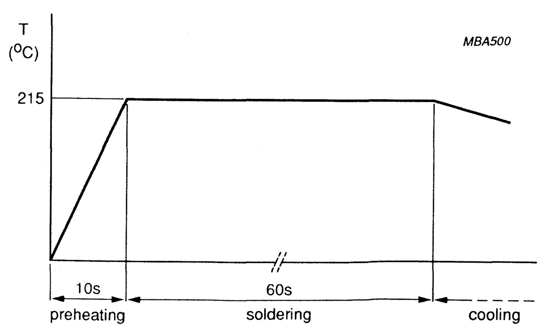


Fig.4 Vapour phase soldering.

value and the third is an indication of magnitude.

1 to 91 Ω = R

100 to 910 Ω = 1

1 to 9.1 kΩ = 2

10 to 91 kΩ = 3

100 to 910 kΩ = 4

1 to 9.1 MΩ = 5

10 MΩ = 6

EXAMPLES:

12R = 12 Ω

471 = 470 Ω

823 = 82 kΩ

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

ELECTRICAL DATA

Standard values of resistance and tolerance.

The resistors are available in the E24 series for resistors with a tolerance of ±5% and ±2%. The values of the E24 series are in accordance with IEC publication 63.

The limiting voltage (DC or RMS) is 150 V. This is the maximum voltage that may be continuously applied to the resistor element (see IEC publications 115-1 and 115-2).

Dissipation

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

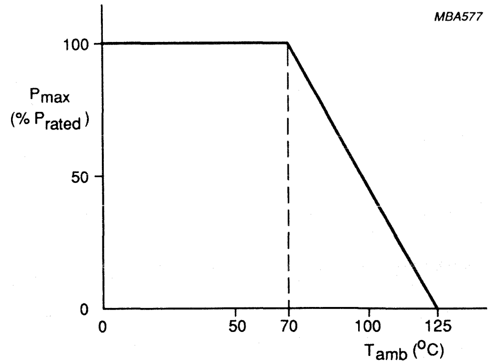


Fig.5 Maximum dissipation (P_{max}) as a function of the ambient temperature (T_{amb}).

COMPOSITION of the CATALOGUE NUMBER

To complete the catalogue number (see Table 1), replace the first two dots of the remaining code by the first two digits of the resistance value. Replace the third dot by a figure according to the following table:

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 to	9.1 MΩ	5
	10 MΩ	6

Ordering Example

To order a RC11 resistor style 1, supplied on cardboard tape of 5000 units per reel with a resistance value of 3k3 Ω, the ordering code is: 2322 730 60332.

Packaging details are specified in chapter "PACKING", data handbook PA08 Fixed Resistors.

Table 1 The resistors have a 12-digit catalogue number starting with 2322. Subsequent digits indicate packaging and resistance as listed in this table

STYLE	RESISTANCE RANGE	TOL. ±%	SERIES	CATALOGUE NUMBER 2322			
				CARDBOARD TAPE 730		BLISTER TAPE 731	
				5 000 reel	10 000 reel	5 000 reel	10 000 reel
1	1 Ω to 10 MΩ 10 Ω to 1 MΩ jumper 0 Ω [1]	5 2	E24 E24	60... 30... 90002	70... 40... 90003	60... 20... 90003	70... 40... 90002
2	1 Ω to 10 MΩ 10 Ω to 1 MΩ jumper 0 Ω [1]	5 2	E24 E24	61... 31... 91002	71... 41... 91003	61... 21... 91003	71... 41... 91002

Note

[1] The jumper has a maximum resistance R_{max} = 50 mΩ at a rated current I_R = 2 A.

TESTS and REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publication 115-1, category 55/125/56 (rated temperature range −55 to +125 °C; damp heat, long term, 56 days) and CECC publications 1929/1930/1931. The IEC publications are in preparation as documents 40 numbers 620/621 and 623. The testing also meets the requirements specified by EIA and EIAJ.

The tests are carried out in accordance with IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components".

In Table 2 the tests and requirements are listed with reference to the relevant clauses of IEC publications 115-1 and 68: a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

Table 2

IEC 115-1 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.17	Ta 2.20	soldering	unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C; flux 600	good tinning, no damage
4.18	Tb	resistance to soldering heat	10 s; 260 ±5 °C; flux 600	ΔR/R max. ±0.5% +0.05 Ω
		leaching	unmounted chips 60 s; 250 ±5 °C	good tinning, no leaching
4.19	Na 2.14	rapid change of temperature	30 minutes −55 °C/30 minutes +125 °C; 5 cycles	ΔR/R max. ±0.5% +0.05 Ω
4.22	Fc 2.6	vibration	frequency: 10-500 Hz; displacement 1.5 mm or acceleration 10 g, 3 directions; total 6 hours	no damage ΔR/R max. ±0.5% +0.05 Ω
4.20	Eb 2.29	bump	3 x 1500 bumps in 3 directions; 40 g	no damage, ΔR/R max. ±0.5% +0.05 Ω

IEC 115-1 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.23		climatic sequence		
4.23.2	Ba 2.2	dry heat	16 hours; 125 °C	
4.23.3	D 2.30	damp heat (accel.) 1st cycle	24 hours; 55 °C; 95-100% R.H.	R_{ins} min. 1000 MΩ
4.23.4	Aa 2.1	cold	2 hours; –55 °C	R ≤1 MΩ
4.23.5	M 2.13	low air pressure	1 hour; 8.5 kPa; 15-35 °C	ΔR/R max. ±1.5% +0.05 Ω
4.23.6	D 2.30	damp heat (accel.) remaining cycles	5 days; 55 °C; 95-100% R.H.	R >1 MΩ: ΔR/R max. ±3% +0.1 Ω
		damp heat (steady state) (JIS)	56 days; 40 °C; 90-95% R.H.; loaded with P_{nom} or V_{max}, 1.5 hours on, 0.5 hours off	R ≤1 MΩ ΔR/R max. ±3% +0.1 Ω R >1 MΩ ΔR/R max. ±5% +0.1 Ω
4.24.2	Ca 2.3	damp heat (steady state) (IEC)	56 days; 40 °C; 90-95% R.H.; loaded with 0.01 Pn (IEC steps: 1-100 V); dissipation ≤1 mW	R_{ins} = min. 1000 MΩ R ≤1 MΩ: ΔR/R max. ±1.5% +0.05 Ω R >1 MΩ ΔR/R max. ±3% +0.05 Ω
4.25.1		endurance	1000 hours; 70 °C; nominal dissipation	R ≤1 MΩ: ΔR/R max. ±1.5% +0.05 Ω R >1 MΩ: ΔR/R max. ±3% +0.1 Ω
4.6.1.1		insulation resistance	100 V (DC) after 1 minute; V block method	min. 10^4 MΩ
4.13		short time overload	room temperature, dissipation 6.25 x 0.1 W; 5 s (voltage not more than 2 x V_{max} = 300 V)	ΔR/R max. ±1% +0.05 Ω
4.8.4.2		temperature coefficient	between –55 °C and +125 °C	≤200.10^{-6}/K
4.12		noise	IEC publication 195 (measured with Quantech - equipment)	R <1k: max. 1 µV/V R <10k: max. 3 µV/V R <100k: max. 6 µV/V R <1 MΩ: max. 10 µV/V
4.23.2	Ba	endurance at upper category temperature	1000 hours, 125 °C; no load	no visual damage R ≤1 MΩ: ΔR/R max. ±1.5% +0.05 Ω R >1 MΩ: ΔR/R max. ±3% +0.1 Ω
4.7		voltage proof on insulation	150 V (DC or RMS) during 1 minute	no breakdown

SMD Resistor RC21

FEATURES

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

APPLICATIONS

- Hand held measuring equipment
- Carphones
- Camcorders.

DESCRIPTION

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

The resistive layer is covered with a protective coating and printed with the resistance value. Finally, the two external end terminations are added. For ease of soldering the outer layer of these end terminations is a (40%) lead (60%) tin alloy.

The surface mounted resistor is available in two styles with different dimensions of the bottom terminations (see Fig.1).

QUICK REFERENCE DATA

Resistance range	1.2 Ω to 6.8 MΩ and jumper (0 Ω); E24 Series
Resistance tolerance	±5%
Temperature coefficient for R <10 Ω for 10 Ω ≤R <1 MΩ for 1 MΩ ≤R ≤6.8 MΩ	 $\leq -200.10^{-6}$ $+500.10^{-6}$ $\leq \pm 200.10^{-6}$ $\leq \pm 300.10^{-6}$
Abs. max. dissipation at T_{amb} = 70 °C	0.062 W
Maximum permissible voltage	50 V (DC or RMS)
Climatic category (IEC 68)	55/125/56
Basic specification	IEC 115-1
Stability after: load, 1000 hours at T_{amb} = 70 °C for 10 Ω ≤R ≤1 MΩ for R <10 Ω; R >1 MΩ climatic tests temperature cycling −55 +125 °C soldering short time overload, 100 V max. bending test, min. 5 mm	 ΔR/R max. ±3% ±0.1 Ω ΔR/R max. ±5% ±0.1 Ω ΔR/R max. ±1% +0.05 Ω ΔR/R max. ±1% ±0.05 Ω ΔR/R max. ±1% +0.05 Ω ΔR/R max. ±1% +0.05 Ω

MECHANICAL DATA

Dimensions in mm.

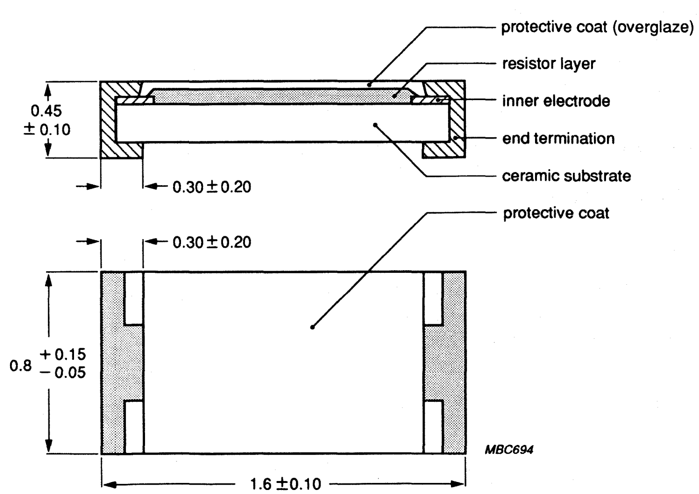


Fig.1 Component outline and physical dimensions.

Mass (per 100): 0.25 gram

Mounting

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

The robust construction of the device allows it to be completely immersed in a solder bath of 250 °C for up to one minute. Therefore, it is possible to mount Surface Mounted Resistors on one side of a printed-circuit board and other discrete components on the reverse (mixed prints).

Soldering conditions

Surface Mounted Resistors are tested for solderability at a temperature of 235 °C during 2 seconds. The test condition for no-leaching is 250 °C for 60 seconds. Typical examples of soldering processes that provide reliable joints without any damage, are given in Figs 2, 3 and 4.

Marking

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

For values up to 91 Ω the R is used as a decimal point.

For values of 100 Ω or greater, the first 2 digits apply to the resistance

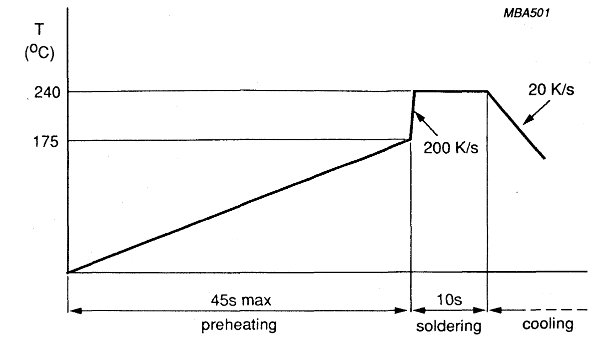


Fig.2 Infrared soldering.

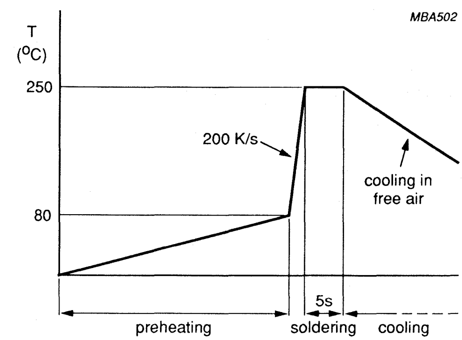


Fig.3 Wave soldering. The resistors may be soldered twice according to this method if necessary.

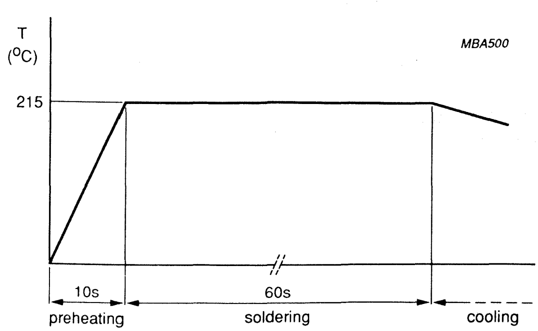


Fig.4 Vapour phase soldering.

value and the third is an indication of magnitude.

1.2 to 91 Ω = R
100 to 910 Ω = 1
1 to 9.1 kΩ = 2
10 to 91 kΩ = 3
100 to 910 kΩ = 4
1 to 6.8 MΩ = 5

EXAMPLES:

12R = 12 Ω
471 = 470 Ω
823 = 82 kΩ

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

ELECTRICAL DATA

Standard values of resistance and tolerance.

The resistors are available in the E24 series for resistors with a tolerance of ±5% and ±2%. The values of the E24 series are in accordance with IEC publication 63.

The limiting voltage (DC or RMS) is 50 V. This is the maximum voltage that may be continuously applied to the resistor element (see IEC publications 115-1 and 115-2).

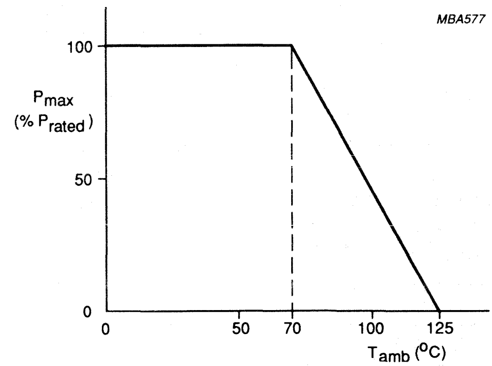


Fig.5 Maximum dissipation (P_{max}) as a function of the ambient temperature (T_{amb}).

Dissipation

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

COMPOSITION of the CATALOGUE NUMBER

To complete the catalogue number (see Table 1), replace the first two dots of the remaining code by the first two digits of the resistance value. Replace the third dot by a figure according to the following table:

1.2 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 to	6.8 MΩ	5

Ordering Example

To order a RC21 resistor, supplied on cardboard tape of 5000 units per reel with a resistance value of 3k3 Ω, the ordering code is: 2322 702 60332.

Packaging details are specified in chapter "PACKING", data handbook PA08 Fixed Resistors.

Table 1 The resistors have a 12-digit catalogue number starting with 2322 702 and are supplied on cardboard tape. Subsequent digits indicate packing and resistance, as listed in this table

RESISTANCE RANGE	TOL. ±%	SERIES	CATALOGUE NUMBER 2322 702	
			5 000 reel	**10 000 reel**
1.2 Ω to 6.8 MΩ jumper 0 Ω [1]	5	E24	60... 96001	70... 97001

Note

1) The jumper has a maximum resistance R_{max} = 50 mΩ at a rated current I_R = 2 A.

TESTS and REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publication 115-1, category 55/125/56 (rated temperature range −55 to +125 °C; damp heat, long term, 56 days) and CECC publications 1929/1930/1931. The IEC publications are in preparation as documents 40 numbers 620/621 and 623. The testing also meets the requirements specified by EIA and EIAJ.

The tests are carried out in accordance with IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components".

In Table 2 the tests and requirements are listed with reference to the relevant clauses of IEC publications 115-1 and 68: a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

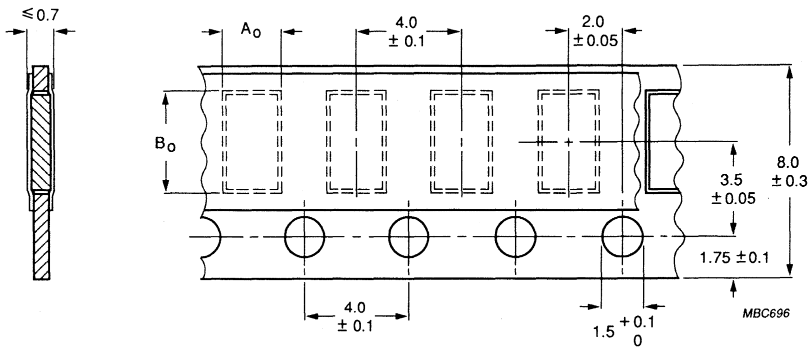
Table 2

IEC 115-1 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.17	Ta 2.20	soldering	unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C; flux 600	good tinning, no damage
4.18	Tb	resistance to soldering heat	10 s; 260 ±5 °C; flux 600	ΔR/R max. ±1% +0.05 Ω
		leaching	unmounted chips 60 s; 250 ±5 °C	good tinning, no leaching
4.19	Na 2.14	rapid change of temperature	30 minutes −55 °C/30 minutes +125 °C; 5 cycles	ΔR/R max. ±1% +0.05 Ω
4.22	Fc 2.6	vibration	frequency: 10-500 Hz; displacement 1.5 mm or acceleration 10 g, 3 directions; total 6 hours	no damage ΔR/R max. ±1% +0.05 Ω
4.20	Eb 2.29	bump	3 x 1500 bumps in 3 directions; 40 g	no damage, ΔR/R max. ±1% +0.05 Ω
4.23		climatic sequence		
4.23.2	Ba 2.2	dry heat	16 hours; 125 °C	
4.23.3	D 2.30	damp heat (accel.) 1st cycle	24 hours; 55 °C; 95-100% R.H.	R_{ins} min. 1000 MΩ
4.23.4	Aa 2.1	cold	2 hours; −55 °C	R ≤1 MΩ
4.23.5	M 2.13	low air pressure	1 hour; 8.5 kPa; 15-35 °C	ΔR/R max. ±1% +0.1 Ω
4.23.6	D 2.30	damp heat (accel.) remaining cycles	5 days; 55 °C; 95-100% R.H.	R >1 MΩ: ΔR/R max. ±1% +0.1 Ω
		damp heat (steady state) (JIS)	1000 hours; +40 °C; 90-95% R.H.; (nominal dissipation) 1.5 hours on, 0.5 hours off	10 ≤R ≤1 MΩ ΔR/R max. ±3% +0.1 Ω R <10, R >1 MΩ ΔR/R max. ±5% +0.1 Ω

IEC 115-1 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.25.1		endurance	1000 hours; 70 °C; nominal dissipation	10 ≤R ≤1 MΩ ΔR/R max. ±3% +0.1 Ω R <10, R >1 MΩ ΔR/R max. ±5% +0.1 Ω
4.6.1.1		insulation resistance	100 V (DC) after 1 minute; V block method	min. 10^4 MΩ
4.13		short time overload	room temperature, dissipation 6.25 x 0.062 W; 5 s (voltage not more than 2 x V_{max} = 100 V)	ΔR/R max. ±1% +0.05 Ω
4.8.4.2		temperature coefficient	between −55 °C and +125 °C	R <10 Ω: $-200.10^{-6}/+500.10^{-6}$ 10 ≤R ≤1 M: 200.10^{-6} R >1 M: 300.10^{-6}
4.12		noise	IEC publication 195 (measured with Quantech - equipment)	R <1k: max. 1 µV/V R <10k: max. 3 µV/V R <100k: max. 6 µV/V R <1 MΩ: max. 10 µV/V
4.23.2	Ba	endurance at upper category temperature	1000 hours, 125 °C; no load	ΔR/R max. ±3% +0.1 Ω no visual damage
4.7		voltage proof on insulation	50 V (DC or RMS) during 1 minute	no breakdown

STANDARD PACKING

Quantities: 5000 or 10 000 units per reel.



A_o = 1.10 +0.1/−0
B_o = 2.00 +0.2/−0.

Fig.6 Reel dimensions in mm.

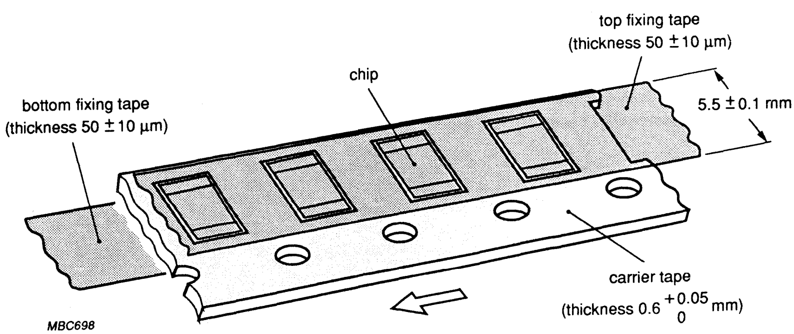


Fig.7 Cardboard tape dimensions.

PRECISION

SMD Resistor RC02H

FEATURES

- Reduced size of final equipment
- Lower assembly costs
- Higher component and equipment reliability
- Improved performance at high frequencies.

APPLICATIONS

- Television (tuners)
- Radio (hi-fi, slim-line and portable)
- Radio recorders
- Watches
- Video cameras
- Electric shavers
- Pocket calculators
- Measuring instruments
- Telecommunication equipment
- Medical equipment
- Military equipment
- Automotive industry.

DESCRIPTION

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

The resistive layer is covered with a protective coating and printed with the resistance value. Finally, the two external end terminations are added. For ease of soldering the outer layer of these end terminations is a (40%) lead (60%) tin alloy.

QUICK REFERENCE DATA

Resistance range	1 Ω to 10 MΩ; E24/E96 series
Resistance tolerance	±1%
Temperature coefficient	
R ≤4.99 Ω	≤ ±250.10^{-6}/K
5.1 Ω ≤R ≤976 Ω	≤ ±200.10^{-6}/K
100 Ω ≤R ≤1 MΩ	≤ ±100.10^{-6}/K
1.02 MΩ ≤R	≤ ±200.10^{-6}/K
Abs. max. dissipation at T_{amb} = 70 °C	0.125 W
Maximum permissible voltage	200 V (DC or RMS)
Climatic category (IEC 68)	55/125/56
Basic specification	IEC 115-1
Stability after:	
load, 1 000 h at T_{amb} = 70 °C	ΔR/R max. 0.5% +0.05 Ω
load, 8 000 h at T_{amb} = 70 °C	ΔR/R max. 1% +0.05 Ω
climatic tests	
R ≤1 MΩ	ΔR/R max. 1% +0.05 Ω
1.02 MΩ ≤R	ΔR/R max. 1.5% +0.05 Ω
soldering	ΔR/R max. 0.5% +0.05 Ω
short time overload, 400 V max.	ΔR/R max. 0.5% +0.05 Ω

MECHANICAL DATA

Dimensions in mm.

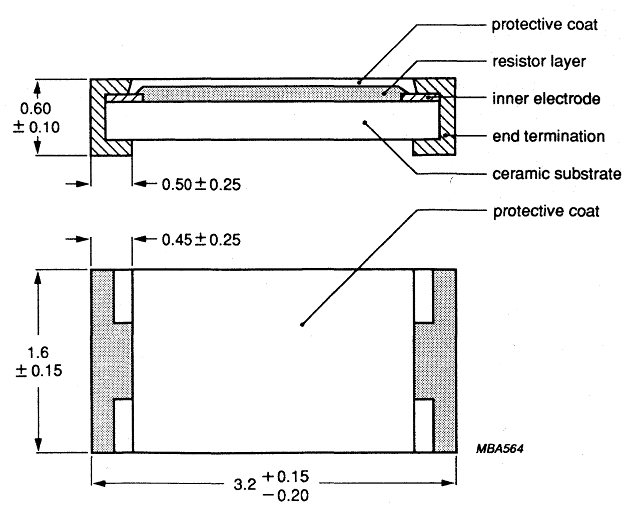


Fig.1 Outlines.

Mass (per 100 items): 1.00 g

Mounting

Due to their rectangular shape and small tolerances on the dimensions, Surface Mounted Resistors are suitable for handling by automatic placement systems. Chip placement is possible on ceramic substrates and printed-circuit boards. Electrical connection to the circuit is made by wave, vapour phase or reflow soldering. The end terminations guarantee a reliable contact and the protective coating enables "face down" mounting.

The robust construction of the device allows it to be completely immersed in a solder bath of 250 °C for one minute. Therefore, it is possible to mount Surface Mounted Resistors on one side of a printed-circuit board and other discrete components on the reverse (mixed prints).

Soldering conditions

Surface Mounted Resistors are tested for solderability at a temperature of 235 °C during 2 seconds. The test condition for no-leaching is 250 °C for 60 seconds. Typical examples of soldering processes that provide reliable joints without any damage, are given in Figs 2, 3 and 4.

Marking

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

For values up to 976 Ω the R is used as a decimal point.

For values of 1 kΩ and upwards the first 3 digits are significant, the

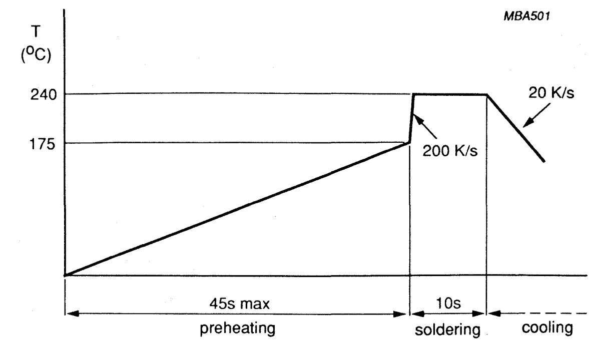


Fig.2 Infrared soldering.

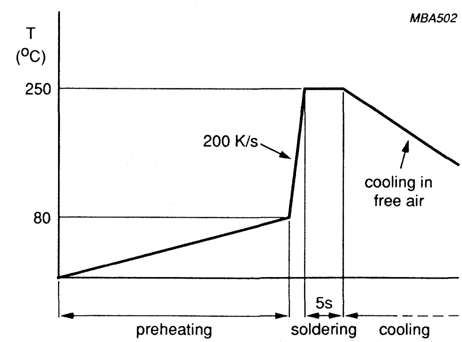


Fig.3 Wave soldering. The resistors may be soldered twice according to this method if necessary.

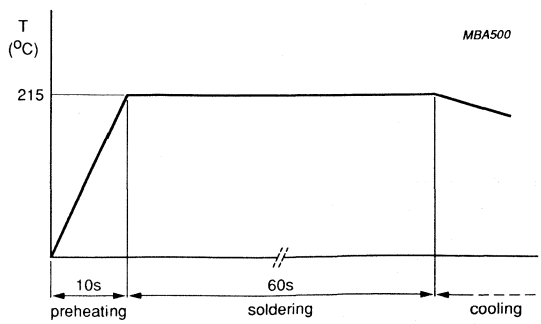


Fig.4 Vapour phase soldering.

fourth being an indication of magnitude.

1 for 1 K to 9.76
2 for 10 K to 97.6
3 for 100 K to 976
4 for 1 M to 9.76
5 for 10 M

EXAMPLE:

121R = 121 Ω
4021 = 4.02 kΩ
1503 = 150 kΩ

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

ELECTRICAL DATA

Standard values of resistance and tolerance.

Standard values of nominal resistance are taken from the E24/E96 series for resistors with a tolerance of ±1%. The values of these series are according to IEC publication 63.

The limiting voltage (DC or RMS) is 200 V. This is the maximum voltage that may be continuously applied to the resistor element; (see IEC publications 115-1 and 115-2).

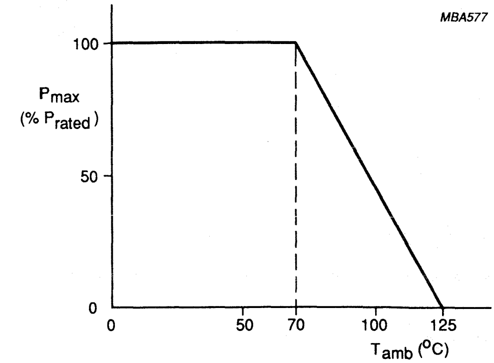


Fig.5 Maximum dissipation (P_{max}) as a function of the ambient temperature (T_{amb}).

Dissipation

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

COMPOSITION of the CATALOGUE NUMBER

To complete the catalogue number, replace the first three dots of the remaining code by the first three digits of the resistance value. Replace the fourth dot by a figure according to the following table:

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

To order a RC02H resistor supplied on cardboard tape of 5000 units per reel with a resistance of 4k75 Ω; the ordering code is: 2322 724 64752.

Packaging details are specified in chapter "PACKING", data handbook PA08 Fixed Resistors.

Table 1 The resistors have a 12-digit catalogue number starting with 2322. Subsequent digits indicate packing and resistance, as listed in this table

RESISTANCE RANGE	TOL. ±%	SERIES	CATALOGUE NUMBER 2322			
			CARDBOARD TAPE 724		BLISTER TAPE 724	
			5 000 reel	10 000 reel	5 000 reel	10 000 reel
1 Ω to 10 MΩ	1	E24/E96	6....	7....	2....	4....

TESTS and REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publication 115-1, category 55/125/56 (rated temperature range −55 to +155 °C; damp heat (long term) 56 days) and CECC publications 1929/1930/1931. The IEC publications are in preparation as documents 40 numbers 620/621 and 623. The testing also meets the requirements specified by EIA and EIAJ.

The tests are carried out in accordance with IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components".

In Table 2 the tests and requirements are listed with reference to the relevant clauses of IEC publications 115-1 and 68: a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

Table 2

IEC 115-1 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.17	Ta 2.20	soldering	unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C; flux 600	good tinning, (≥95% covered) no damage
		soldering	16 hours steam or 16 hours 155 °C; unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C; flux 600	good tinning, (≥95% covered) no damage
4.18	Tb	resistance to soldering heat	10 s; 260 ±5 °C; flux 600	ΔR/R max. ±0.5% +0.05 Ω
		leaching	unmounted chips 60 s; 250 ±5 °C	good tinning no leaching
4.19	Na 2.14	rapid change of temperature	30 minutes −55 °C/30 minutes +125 °C; 5 cycles	ΔR/R max. ±0.5% +0.05 Ω
4.22	Fc 2.6	vibration	frequency: 10-500 Hz; displacement 1.5 mm or acceleration 10 g, 3 directions; total 6 hours	no damage ΔR/R max. ±0.5% +0.05 Ω
4.20	Eb 2.29	bump	3 x 1500 bumps in three directions; 40 g	no damage, ΔR/R max. ±0.5% +0.05 Ω

IEC 115-1 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.23		climatic sequence		
4.23.2	Ba 2.2	dry heat	16 hours; 125 °C	
4.23.3	D 2.30	damp heat (accel.) 1st cycle	24 hours; 55 °C; 95-100% R.H.	
4.23.4	Aa 2.1	cold	2 hours; –55 °C	
4.23.5	M 2.13	low air pressure	1 hour; 8.5 kPa; 15-35 °C	
4.23.6	D 2.30	damp heat (accel.) remaining cycles	5 days; 55 °C; 95-100% R.H.	R_{ins} = min. 1000 MΩ ΔR/R max. ±1% +0.05 Ω
4.24.2	Ca 2.3	damp heat (steady state) (IEC)	56 days; 40 °C; 90-95% R.H. loaded with 0.01 Pn (IEC steps 1-100 V);	R_{ins} = min. 1000 MΩ ΔR/R max. ±1% +0.05 Ω
4.25.1		endurance	1000 hours; 70 °C; nominal dissipation	ΔR/R max. ±0.5% +0.05 Ω
4.6.1.1		insulation resistance	100 V (DC) after 1 minute	min. 10^4 MΩ
4.13		short time overload	room temperature, dissipation 6.25 x Pn; 5 s (voltage not more than 2 x V_{max} = 400 V)	ΔR/R max. ±0.5% +0.05 Ω
4.8.4.2		temperature coefficient	between –55 °C and +125 °C	R ≤4.99 Ω: ≤ ±250.10^{-6}/K 5.1 Ω ≤R ≤976 Ω: ≤ ±200.10^{-6}/K 100 Ω ≤R ≤1 MΩ: ≤ ±100.10^{-6}/K 1.02 MΩ ≤R: ≤ ±200.10^{-6}/K
4.12		noise	IEC publication 195 (measured with Quantech - equipment)	R <1 k: max. 1 µV/V R <10 k: max. 3 µV/V R <100 k: max. 6 µV/V R <1 M: max. 10 µV/V
4.23.2	Ba	endurance at upper category temperature	1000 hours, 125 °C no load	ΔR/R max. ±0.5% +0.05 Ω no visual damage
4.7		voltage proof on insulation	200 V (DC or RMS) during 1 minute	no breakdown

SMD Resistor RC02HP

FEATURES

- Reduced size of final equipment
- Lower assembly costs
- Higher component and equipment reliability
- Improved performance at high frequencies.

APPLICATIONS

- Television (tuners)
- Radio (hi-fi, slim-line and portable)
- Radio recorders
- Watches
- Video cameras
- Electric shavers
- Pocket calculators
- Measuring instruments
- Telecommunication equipment
- Medical equipment
- Military equipment
- Automotive industry.

DESCRIPTION

The resistors are constructed on a high grade ceramic body (aluminium oxide) substrate. Internal metal electrodes are added at each end and connected by a resistive paste which is applied to the top surface of the substrate. The composition of the paste is adjusted to give the approximate resistance required and the value is trimmed to within tolerance, by laser cutting of this resistive layer.The resistive layer is covered with a protective coating and printed with the resistance value. Finally, the two external end terminations are added. For ease of soldering the outer layers of these end terminations is a (40%) lead (60%) tin alloy.

Mass (per 100 items): 1.00 g

QUICK REFERENCE DATA

Resistance range	1 Ω to 10 MΩ; E24/E96 series
Resistance tolerance	±1%
Temperature coefficient 1 Ω ≤R ≤4.99 Ω 5.1 Ω ≤R ≤97.6 Ω 100 Ω ≤R ≤1MΩ 1.01 MΩ ≤R	 $\leq 250.10^{-6}$/K $\leq 200.10^{-6}$/K $\leq 100.10^{-6}$/K $\leq 200.10^{-6}$/K
Abs. max. dissipation at T_{amb} = 70 °C	0.25 W
Maximum permissible voltage	200 V (DC or RMS)
Climatic category (IEC 68)	55/125/56
Basic specification	IEC 115-1
Stability after: load, 1 000 h at T_{amb} = 70 °C load, 8 000 h at T_{amb} = 70 °C climatic tests R ≤1 MΩ 1 MΩ <R soldering short time overload, 400 V max. 1 Ω ≤R ≤150 kΩ 150 kΩ <R ≤10 MΩ	 ΔR/R max. 1% +0.05 Ω ΔR/R max. 2% +0.05 Ω ΔR/R max. 1% +0.05 Ω ΔR/R max. 1.5% +0.05 Ω ΔR/R max. 0.5% +0.05 Ω ΔR/R max. 0.5% +0.05 Ω ΔR/R max. 1% +0.05 Ω

MECHANICAL DATA

Dimensions in mm.

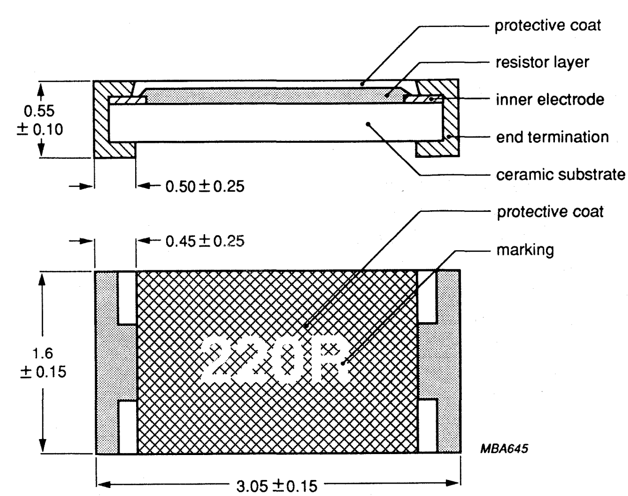


Fig.1 Outlines.

Mounting

Due to their rectangular shape and small tolerances on the dimensions, Surface Mounted Resistors are suitable for handling by automatic placement systems. Chip placement is possible on ceramic substrates and printed-circuit boards. Electrical connection to the circuit is by wave, vapour phase or reflow soldering. The end terminations guarantee a reliable contact and the protective coating enables "face down" mounting.The robust construction of the device allows it to be completely immersed in a solder bath of 250 °C for one minute. Therefore, it is possible to mount Surface Mounted Resistors on one side of a printed-circuit board and other discrete components on the reverse (mixed prints).

Soldering conditions

Surface Mounted Resistors are tested for solderability at a temperature of 235 °C during 2 seconds. The test condition for no-leaching is 250 °C for 60 seconds. Typical examples of soldering processes that provide reliable joints without any damage, are given in Figs 2, 3 and 4.

Marking

Each resistor is marked with a four digit code on the protective coating to designate the nominal resistance value.For values up to 976 Ω the R is used as a decimal point.For values of 1 kΩ and upwards the first 3 digits are significant, the fourth being an indication of magnitude.

1 to 976 Ω = R

1 to 9.76 kΩ = 1

10 to 97.6 kΩ = 2

100 to 976 kΩ = 3

1 to 9.76 MΩ = 4

10 MΩ = 5

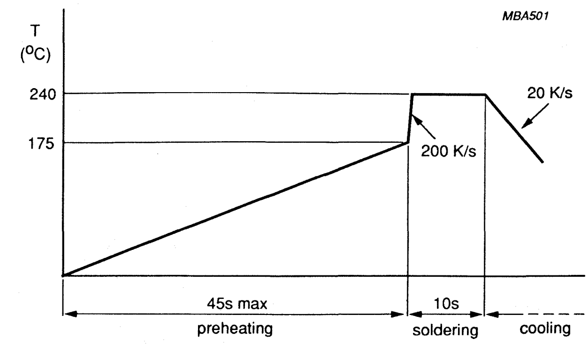


Fig.2 Infrared soldering.

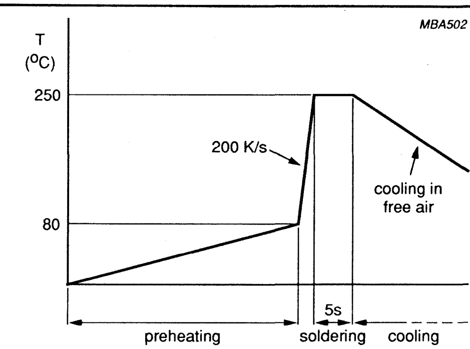


Fig.3 Wave soldering. The resistors may be soldered twice according to this method if necessary.

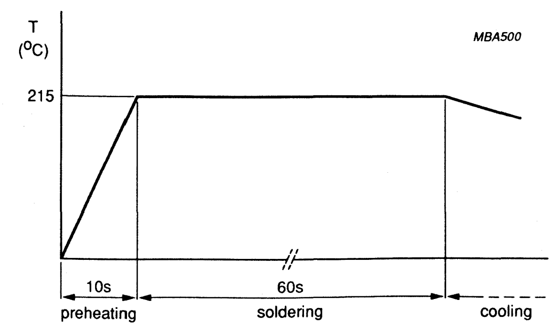


Fig.4 Vapour phase soldering.

EXAMPLE:

121R = 121 Ω

4021 = 4.02 kΩ

1503 = 150 kΩ

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

ELECTRICAL DATA

Standard values of resistance and tolerance.

Standard values of nominal resistance are taken from the E24/E96 series for resistors with a tolerance of ±1%. The values of these series are according to IEC publication 63.

The limiting voltage (DC or RMS) is 200 V. This is the maximum voltage that may be continuously applied to the resistor element (see IEC publications 115-1 and 115-2).

Dissipation

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

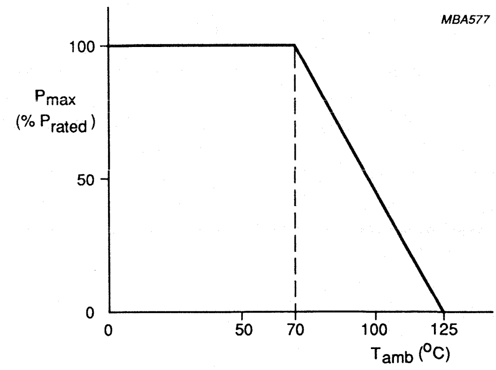


Fig.5 Maximum dissipation (P_{max}) as a function of the ambient temperature (T_{amb}).

COMPOSITION of the CATALOGUE NUMBER

To complete the catalogue number, replace the first three dots of the remaining code by the first three digits of the resistance value. Replace the fourth dot by a figure according to the following table:

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 MΩ to 9.76 MΩ	5
10 MΩ	6

Ordering Example

To order a RC02HP resistor supplied on cardboard tape of 5000 units per reel with a resistance value of 4k75 Ω, the ordering code is: 2322 726 24752.

Table 1 The resistors have a 12-digit catalogue number starting with 2322. Subsequent digits indicate packaging and resistance as listed in this table

RESISTANCE RANGE	TOL. ±%	SERIES	CATALOGUE NUMBER 2322			
			CARDBOARD TAPE 726		BLISTER TAPE 726	
			5 000 reel	10 000 reel	5 000 reel	10 000 reel
1 Ω to 10 MΩ	1	E24/96	2....	3....	1....	4....

Note

For code-technical reasons the catalogue number for RC02HP resistors of 49.9 Ω is:

1 000 ammopack	2322 726 90001		
5 000 blister reel	2322 726 90002	10 000 blister reel	2322 726 90044
5 000 paper reel	2322 726 90003	10 000 paper reel	2322 726 90045

TESTS and REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publication 115-1, category 55/125/56 (rated temperature range −55 to +155 °C; damp heat, long term, 56 days) and CECC publications 1929/1930/1931. The IEC publications are in preparation as documents 40 numbers 620/621 and 623. The testing also meets the requirements specified by EIA and EIAJ.

The tests are carried out in accordance with IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components".

In Table 2 the tests and requirements are listed with reference to the relevant clauses of IEC publications 115-1 and 68: a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

Table 2

IEC 115-1 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.17	Ta 2.20	soldering	unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C; flux 600	good tinning, (≥95% covered) no damage
		soldering	16 hours steam or 16 hours 155 °C; unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C; flux 600	good tinning, (≥95% covered) no damage
4.18	Tb	resistance to soldering heat	10 s; 260 ±5 °C; flux 600	ΔR/R max. ±0.5% +0.05 Ω
		leaching	unmounted chips 60 s; 250 ±5 °C	good tinning no leaching
4.19	Na 2.14	rapid change of temperature	30 minutes at −55 °C/ 30 minutes at +125 °C; 5 cycles	ΔR/R max. ±0.5% +0.05 Ω
4.22	Fc 2.6	vibration	frequency: 10-500 Hz; displacement 1.5 mm or acceleration 10 g, 3 directions; total 6 hours	no damage ΔR/R max. ±0.5% +0.05 Ω
4.20	Eb 2.29	bump	3 x 1500 bumps in 3 directions; 40 g	no damage, ΔR/R max. ±0.5% +0.05 Ω
4.23		climatic sequence		
4.23.2	Ba 2.2	dry heat	16 hours; 125 °C	
4.23.3	D 2.30	damp heat (accel.) 1st cycle	24 hours; 55 °C; 95-100% R.H.	
4.23.4	Aa 2.1	cold	2 hours; −55 °C	
4.23.5	M 2.13	low air pressure	1 hour; 8.5 kPa; 15-35 °C	
4.23.6	D 2.30	damp heat (accel.) remaining cycles	5 days; 55 °C; 95-100% R.H.	R_{ins} = min. 1000 MΩ ΔR/R max. ±1% +0.05 Ω

SMD Resistor RC02HP

IEC 115-1 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.24.2	Ca 2.3	damp heat (steady state)	56 days; 40 °C; 90-95% R.H. loaded with 0.01 Pn (IEC steps; 1-100 V); dissipation ≤1mW	R_{ins} = min. 1000 MΩ ΔR/R max. ±1.% +0.05 Ω
4.25.1		endurance	1000 hours; 70 °C; nominal dissipation	ΔR/R max. ±1% +0.05 Ω
4.6.1.1		insulation resistance	100 V (DC) after 1 minute	min. 10^4 MΩ
4.13		short time overload	room temperature, dissipation 6.25 x 0.1 W; 5 s (voltage not more than 2 x V_{max} = 400 V)	ΔR/R max. ±0.5% +0.05 Ω
4.8.4.2		temperature coefficient	between –55 °C and +125 °C	1 Ω ≤R ≤4.99 Ω: ≤250.10^{-6}/K 5.1 Ω ≤R ≤97.6 Ω: ≤200.10^{-6}/K 100 Ω ≤R ≤1MΩ: ≤100.10^{-6}/K 1.01 MΩ ≤R: ≤200.10^{-6}/K
4.12		noise	IEC publication 195 (measured with Quantech - equipment)	R <1k: max. 1 µV/V R <10k: max. 3 µV/V R <100k: max. 6 µV/V R <1M: max. 10 µV/V
4.23.2	Ba	endurance at upper category temperature	1000 hours, 125 °C, no load	ΔR/R max. ±0.5% +0.05 Ω no visual damage
4.7		voltage proof on insulation	200 V (DC or RMS) during 1 minute	no breakdown

SMD Resistor RC12H

FEATURES

- Reduced size of final equipment
- Lower assembly costs
- Higher component and equipment reliability
- Improved performance at high frequencies.

APPLICATIONS

- Hand held measuring equipment
- Carphones
- Camcorders.

DESCRIPTION

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

The resistive layer is covered with a protective coating and printed with the resistance value. Finally, the two external end terminations are added. For ease of soldering the outer layer of these end terminations is a (40%) lead (60%) tin alloy.

QUICK REFERENCE DATA

Resistance range	1 Ω to 1 MΩ; E24/E96 series
Resistance tolerance	±1%
Temperature coefficient 1 Ω - 4.99 Ω 5.1 Ω - 97.6 Ω 100 Ω - 1 MΩ	 ≤250.10^{-6}/K ≤200.10^{-6}/K ≤100.10^{-6}/K
Abs. max. dissipation at T_{amb} = 70 °C	0.1 W
Maximum permissible voltage	150 V (DC or RMS)
Operating temperature range	−55 °C to +125 °C
Climatic category (IEC 68)	55/125/56
Basic specification	IEC 115-1
Stability after: load, 1000 hours at T_{amb} = 70 °C climatic tests soldering short time overload, 300 V max.	 ΔR/R max. 1.0% +0.05 Ω ΔR/R max. 1.0% +0.05 Ω ΔR/R max. 0.5% +0.05 Ω ΔR/R max. 1.0% +0.05 Ω

MECHANICAL DATA

Dimensions in mm.

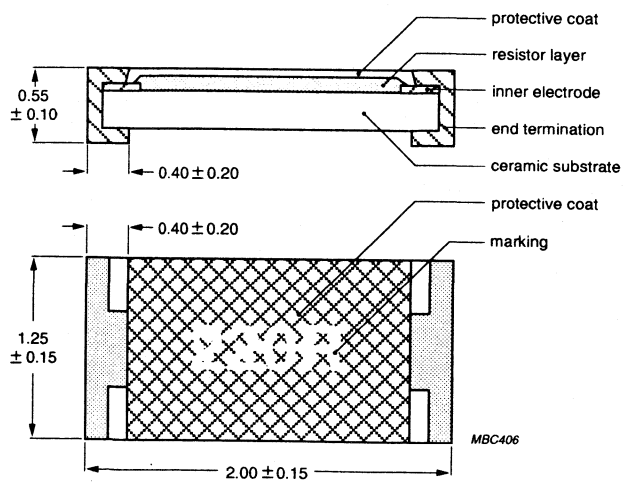


Fig.1 Outlines.

Mounting

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

The robust construction of the device allows it to be completely immersed in a solder bath of 260 °C for one minute. Therefore, it is possible to mount Surface Mounted Resistors on one side of a printed-circuit board and other discrete components on the reverse (mixed prints).

Marking

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

For values up to 976 Ω the R is used as a decimal point.

For values of 1 kΩ and upwards the first 3 digits are significant, the fourth being an indication of magnitude.

1 to 976 Ω = R
1 to 9.76 kΩ = 1
10 to 97.6 kΩ = 2
100 to 976 kΩ = 3
1 MΩ = 4

EXAMPLES:

121R = 121 Ω
4021 = 4.02 kΩ
7503 = 750 kΩ

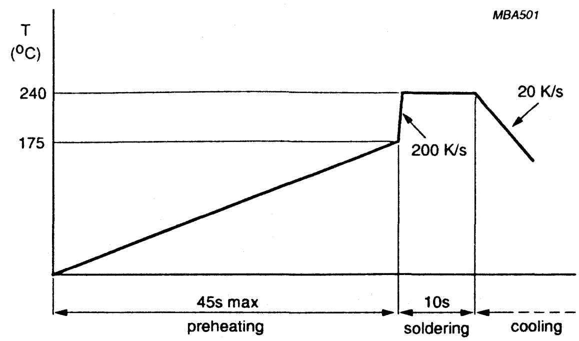


Fig.2 Infrared soldering.

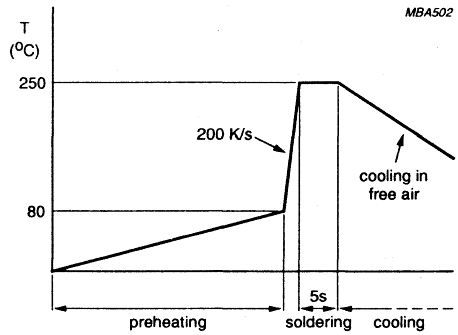


Fig.3 Wave soldering. The resistors may be soldered twice according to this method if necessary.

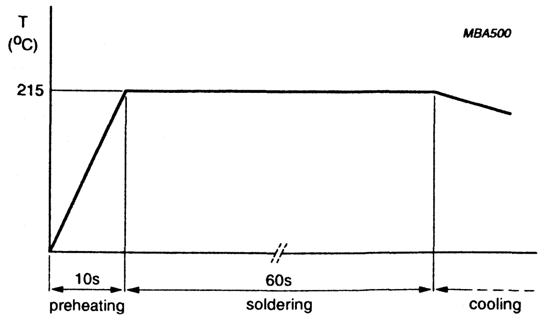


Fig.4 Vapour phase soldering.

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

Soldering conditions

Surface Mounted Resistors are tested for solderability at a temperature of 230 °C during 2 seconds. The test condition for no-leaching is 260 °C for 60 seconds. Typical examples of soldering processes that provide reliable joints without any damage, are given in Figs 2, 3 and 4.

Dissipation

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

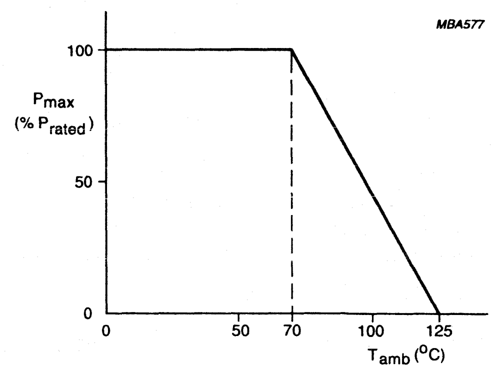


Fig.5 Maximum dissipation (P_{max}) as a function of the ambient temperature (T_{amb}).

ELECTRICAL DATA

Standard values of resistance and tolerance.

The resistors are available in the E24/E96 series for resistors with a tolerance of ±1%. The values of the E24/E96 series are according to IEC publication 63.

The limiting voltage (DC or RMS) for element is the maximum voltage that may be applied continuously to the resistor element (see IEC publications 115-1 and 115-2). This voltage is 150 V.

COMPOSITION of the CATALOGUE NUMBER

To complete the catalogue number (see Table 1), replace the first three dots of the remaining code by the first three digits of the resistance value. Replace the fourth dot by a figure according to the following table:

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 MΩ	5

Example

To order a RC12H resistor, value 4.70 kΩ, supplied in a bag of 1 000, the ordering code is 2322 734 34702.

Table 1 The resistors have a 12-digit catalogue number starting with 2322. Subsequent digits indicate packaging and resistance as listed in this table

RESISTANCE RANGE	TOL. ±%	SERIES	CATALOGUE NUMBER FOLLOWED BY				
			CARDBOARD TAPE 2322 734		BLISTER TAPE 2322 734		BULK 2322 734
			5 000 reel	10 000 reel	5 000 reel	10 000 reel	1 000 bag
1 Ω to 1 MΩ	1	E24/96	6....	7....	2....	4....	3....

TESTS and REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publication 115-1, category 55/125/56 (rated temperature range –55 to +125 °C; damp heat, long term, 56 days) and CECC publications 1929/1930/1931. The IEC publications are in preparation as documents 40 numbers 620/621 and 623. The testing also meets the requirements specified by EIA and EIAJ.

The tests are carried out along the lines of IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components".

In Table 2 the tests and requirements are listed with reference to the relevant clauses of IEC publications 115-1 and 68: a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

Table 2

IEC 115-1 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.17	Ta 2.20	soldering	unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 230 ±5 °C; flux 600	good tinning (≥95% covered) no damage
		soldering	16 hours steam or 16 hours 155 °C; unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 230 ±5 °C; flux 600	good tinning (≥95% covered) no damage
4.18	Tb	resistance to soldering heat	10 s; 260 ±5 °C; flux 600	ΔR/R max. ±0.5% +0.05 Ω
		leaching	unmounted chips 60 s; 260 ±5 °C	good tinning, no leaching
4.19	Na 2.14	rapid change of temperature	30 minutes –55 °C/30 minutes +125 °C; 5 cycles	ΔR/R max. ±0.5% +0.05 Ω
4.22	Fc 2.6	vibration	frequency: 10-500 Hz; displacement 1.5 mm or acceleration 10 g, three directions; total 6 hours	no damage ΔR/R max. ±0.5% +0.05 Ω
4.20	Eb 2.29	bump	3 x 1500 bumps in three directions; 40 g	no damage, ΔR/R max. ±0.5% +0.05 Ω
		bending	resistors mounted on a glass epoxy resin PCB; bending 5 mm over 90 mm	no visual damage ΔR/R max. ±0.5% +0.05 Ω
		humidity load (JIS)	1 000 hours, +40 °C; 90-95% R.H. loaded with Pn or 150 V; max. 1.5 hours on, 0.5 hours off	ΔR/R max. ±3% +0.1 Ω

IEC 115-1 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.23		climatic sequence		
4.23.2	Ba 2.2	dry heat	16 hours; 125 °C	
4.23.3	D 2.30	damp heat (accel.) 1st cycle	24 hours; 55 °C; 95-100% R.H.	
4.23.4	Aa 2.1	cold	2 hours; –55 °C	
4.23.5	M 2.13	low air pressure	1 hour; 8.5 kPa; 15-35 °C	
4.23.6	D 2.30	damp heat (accel.) remaining cycles	5 days; 55 °C; 95-100% R.H.	R_{ins} = min. 1000 MΩ ΔR/R max. ±1% +0.05 Ω
4.24.2	Ca 2.3	damp heat (steady state)	56 days; 40 °C; 90-95% R.H.; loaded with 0.01 Pn (IEC steps: 1-100 V). dissipation ≤1mW	R_{ins} = min. 1000 MΩ ΔR/R max. ±1.0% +0.05 Ω
4.25.1		endurance	1000 hours; 70 °C; nominal dissipation	ΔR/R max. ±1% +0.05 Ω
4.6.1.1		insulation resistance	100 V(DC) after 1 minute	min. 10^4 MΩ
4.13		short time overload	room temperature, dissipation 6.25 x 0.1 W; 5 s (voltage not more than 2 x V_{max} = 300 V)	ΔR/R max. ±1.0% +0.05 Ω
4.8.4.2		temperature coefficient	between –55 °C and +125 °C	1 Ω - 4.99 Ω: ≤250.10^{-6}/K 5.1 Ω - 97.6 Ω: ≤200.10^{-6}/K 100 Ω - 1 MΩ: ≤100.10^{-6}/K
4.12		noise	IEC publication 195 (measured with Quantech - equipment)	R<1k: max.1 μV/V R<10k: max.3 μV/V R<100k: max.6 μV/V R<1M: max.10s μV/V
4.23.2	Ba	endurance at upper category temperature	1000 hours, 125 °C, no load	ΔR/R max. ±0.5% +0.05 Ω no visual damage
4.7		voltage proof on insulation	150 V (DC or RMS) during 1 minute	no breakdown

SMD Resistor RC02G

FEATURES

- Reduced size of final equipment
- Lower assembly costs
- Higher component and equipment reliability
- Improved performance at high frequencies.

APPLICATIONS

- Television (tuners)
- Radio (hi-fi, slim-line and portable)
- Radio recorders
- Watches
- Video cameras
- Electric shavers
- Pocket calculators
- Measuring instruments
- Telecommunication equipment
- Medical equipment
- Military equipment
- Automotive industry.

DESCRIPTION

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

The resistive layer is covered with a protective coating and printed with the resistance value. Finally, the two external end terminations are added. For ease of soldering the outer layers of these end terminations is a (40%) lead (60%) tin alloy.

QUICK REFERENCE DATA

Resistance range	100 Ω to 1 MΩ; E24/E96 series
Resistance tolerance	±1%
Temperature coefficient	≤ $\pm 50.10^{-6}$/K
Abs. max. dissipation at T_{amb} = 70 °C	0.125 W
Maximum permissible voltage	200 V (DC or RMS)
Climatic category (IEC 68)	55/125/56
Basic specification	IEC 115-1
Stability after:	
load, 1 000 h at T_{amb} = 70 °C	ΔR/R max. 0.5% +0.05 Ω
load, 8 000 h at T_{amb} = 70 °C	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
short time overload, 400 V max.	ΔR/R max. 0.25% +0.05 Ω

MECHANICAL DATA

Dimensions in mm.

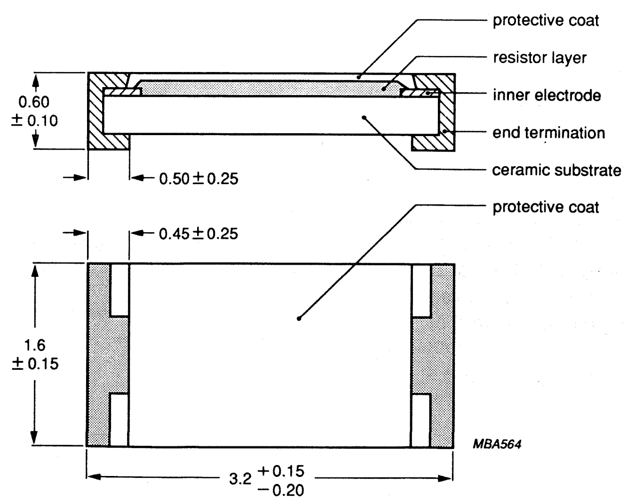


Fig.1 Outlines.

Mass (per 100 items): 1.00 g

Mounting

Due to their rectangular shape and small tolerances on the dimensions, Surface Mounted Resistors are suitable for handling by automatic placement systems. Chip placement is possible on ceramic substrates and printed-circuit boards. Electrical connection to the circuit is made by wave, vapour phase or reflow soldering. The end terminations guarantee a reliable contact and the protective coating enables "face down" mounting.

The robust construction of the device allows it to be completely immersed in a solder bath of 250 °C for one minute. Therefore, it is possible to mount Surface Mounted Resistors on one side of a printed-circuit board and other discrete components on the reverse (mixed prints).

Soldering conditions

Surface Mounted Resistors are tested for solderability at a temperature of 235 °C during 2 seconds. The test condition for no-leaching is 250 °C for 60 seconds. Typical examples of soldering processes that provide reliable joints without any damage, are given in Figs 2, 3 and 4.

Marking

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

For values up to 976 Ω the R is used as a decimal point.

For values of 1 kΩ and upwards the first 3 digits are significant, the fourth being an indication of magnitude.

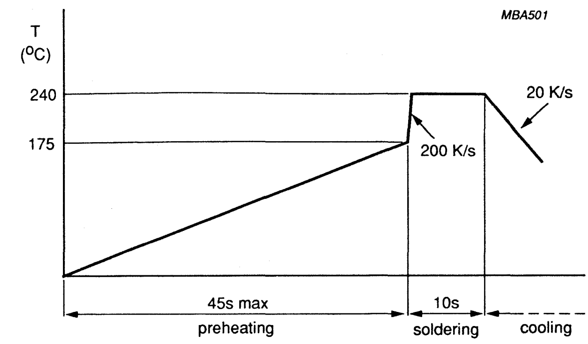


Fig.2 Infrared soldering.

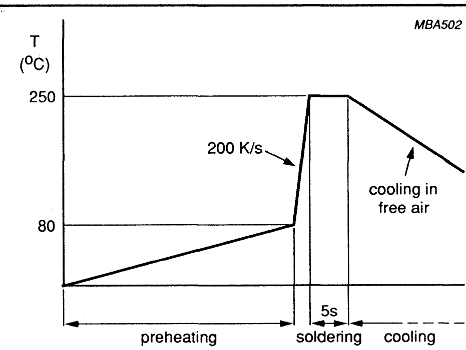


Fig.3 Wave soldering. The resistors may be soldered twice according to this method if necessary.

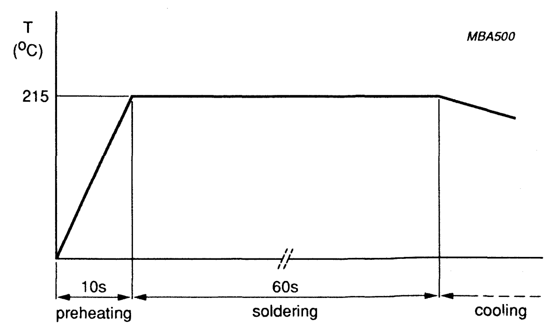


Fig.4 Vapour phase soldering.

100 to 976 Ω = R
1 to 9.76 kΩ = 1
10 to 97.6 kΩ = 2
100 to 976 kΩ = 3
1 M = 4

EXAMPLE:

121R = 121 Ω
4021 = 4.02 kΩ
1503 = 150 kΩ

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

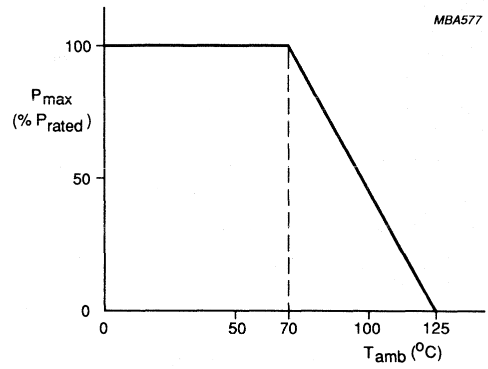


Fig.5 Maximum dissipation (P_{max}) as a function of the ambient temperature (T_{amb}).

ELECTRICAL DATA

Standard values of resistance and tolerance.

Standard values of nominal resistance are taken from the E24/E96 series for resistors with a tolerance of ±1%. The values of these series are according to IEC publication 63.

The limiting voltage (DC or RMS) is 200 V. This is the maximum voltage that may be continuously applied to the resistor element (see IEC publications 115-1 and 115-2).

Dissipation

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

COMPOSITION of the CATALOGUE NUMBER

To complete the catalogue number (see Table 1), replace the first three dots of the remaining code by the first three digits of the resistance value. Replace the fourth dot by a figure according to the following table:

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

Ordering Example

To order a RC02G resistor supplied on blister tape of 5000 units per reel with a resistance value of 4k75 Ω; the ordering code is: 2322 723 64752.

Packaging details are specified in chapter "PACKING", data handbook PA08 Fixed Resistors.

Table 1 The resistors have a 12-digit catalogue number starting with 2322. Subsequent digits indicate packing and resistance, as listed in this table

RESISTANCE RANGE	TOL. ±%	SERIES	CATALOGUE NUMBER 2322			
			CARDBOARD TAPE 722		BLISTER TAPE 723	
			5 000 reel	10 000 reel	5 000 reel	10 000 reel
100 Ω to 1 MΩ	1	E96/E24	2....	3....	6....	7....

TESTS and REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publication 115-1, category 55/125/56 (rated temperature range –55 to +155 °C; damp heat (long term) 56 days) and CECC publications 1929/1930/1931. The IEC publications are in preparation as documents 40 numbers 620/621 and 623. The testing also meets the requirements specified by EIA and EIAJ.

The tests are carried out in accordance with IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components".

In Table 2 the tests and requirements are listed with reference to the relevant clauses of IEC publications 115-1 and 68: a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

Table 2

IEC 115-1 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.17	Ta 2.20	soldering	unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C; flux 600	good tinning, (≥95% covered) no damage
		soldering	16 hours steam or 16 hours 155 °C; unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C; flux 600	good tinning, (≥95% covered) no damage
4.18	Tb	resistance to soldering heat	10 s; 260 ±5 °C; flux 600	ΔR/R max. ±0.25% +0.05 Ω
		leaching	unmounted chips 60 s; 250 ±5 °C	good tinning no leaching
4.19	Na 2.14	rapid change of temperature	30 minutes at –55 °C/ 30 minutes at +125 °C; 5 cycles	ΔR/R max. ±0.25% +0.05 Ω
4.22	Fc 2.6	vibration	frequency: 10-500 Hz; displacement 1.5 mm or acceleration 10 g, 3 directions; total 6 hours	no damage ΔR/R max. ±0.25% +0.05 Ω
4.20	Eb 2.29	bump	3 x 1500 bumps in three directions; 40 g	no damage, ΔR/R max. ±0.25% +0.05 Ω

IEC 115-1 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.23		climatic sequence		
4.23.2	Ba 2.2	dry heat	16 hours; 125 °C	
4.23.3	D 2.30	damp heat (accel.) 1st cycle	24 hours; 55 °C; 95-100% R.H.	
4.23.4	Aa 2.1	cold	2 hours; –55 °C	
4.23.5	M 2.13	low air pressure	1 hour; 8.5 kPa; 15-35 °C	
4.23.6	D 2.30	damp heat (accel.) remaining cycles	5 days; 55 °C; 95-100% R.H.	R_{ins} = min. 1000 MΩ ΔR/R max. ±1% +0.05 Ω
4.24.2	Ca 2.3	damp heat (steady state) (IEC)	56 days; 40 °C; 90-95% R.H. loaded with 0.01 Pn (IEC steps; 1-100 V); dissipation ≤1.25 mW	R_{ins} = min. 1000 MΩ ΔR/R max. ±1.0% +0.05 Ω
4.25.1		endurance	1000 hours; 70 °C; nominal dissipation	ΔR/R max. ±0.5% +0.05 Ω
4.6.1.1		insulation resistance	100 V (DC) after 1 minute	min. 10^4 MΩ
4.13		short time overload	room temperature, dissipation 6.25 x 0.125 W; 5 s (voltage not more than 2 x V_{max} = 400 V)	ΔR/R max. ±0.25% +0.05 Ω
4.8.4.2		temperature coefficient	between –55 °C and +125 °C	≤50.10^{-6}/K
4.12		noise	IEC publication 195 (measured with Quantech - equipment)	R <1 k: max. 1 μV/V R <10 k: max. 3 μV/V R <100 k: max. 6 μV/V R <1 M: max. 10 μV/V
4.23.2	Ba	endurance at upper category temperature	1000 hours, 125 °C no load	ΔR/R max. ±0.5% +0.05 Ω no visual damage
4.7		voltage proof on insulation	200 V (DC or RMS) during 1 minute	no breakdown

SMD Resistor RC02GP

FEATURES

- Reduced size of final equipment
- Lower assembly costs
- Higher component and equipment reliability
- Improved performance at high frequencies
- Precision resistor with high stability.

APPLICATIONS

- Television (tuners)
- Radio (hi-fi slim-line and portable)
- Radio recorders
- Watches
- Video cameras
- Electric shavers
- Pocket calculators
- Instruments
- Telecommunication equipment
- Medical equipment
- Military equipment
- Automotive industry.

DESCRIPTION

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

The resistive layer is covered with a protective coating and printed with the resistance value. Finally, the two external end terminations are added. For ease of soldering the outer layer of these end terminations is a (40%) lead (60%) tin alloy.

QUICK REFERENCE DATA

Resistance range	250 Ω to 150 kΩ; E24/E96 series
Resistance tolerance	±1%
Temperature coefficient 250 Ω ≤R ≤150 kΩ	 $\leq 50.10^{-6}$/K
Abs. max. dissipation at T_{amb} = 70 °C	0.25 W
Maximum permissible voltage	200 V (DC or RMS)
Climatic category (IEC 68)	55/125/56
Basic specification	IEC 115-1
Stability after: load, 1000 hours at T_{amb} = 70 °C load, 8000 hours at T_{amb} = 70 °C climatic tests soldering short time overload, 400 V max.	 ΔR/R max. 1% +0.05 Ω ΔR/R max. 2% +0.05 Ω ΔR/R max. 1% +0.05 Ω ΔR/R max. 0.50% +0.05 Ω ΔR/R max. 0.50% +0.05 Ω

MECHANICAL DATA

Dimensions in mm.

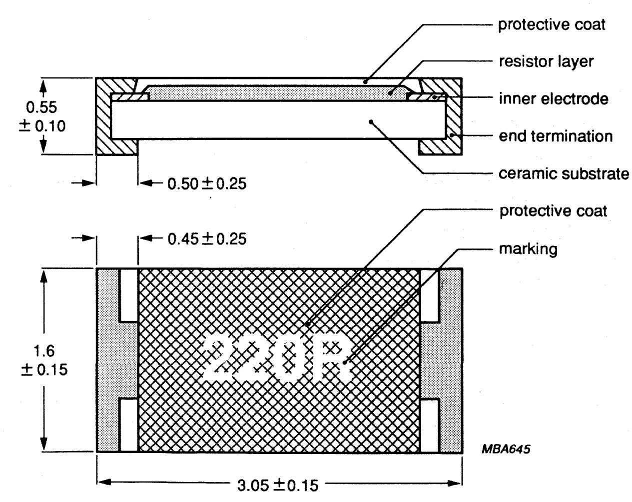


Fig.1 Outlines.

Mass (per 100 items): 1.00 g

Mounting

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

The robust construction of the device allows it to be completely immersed in a solder bath of 250 °C for one minute. Therefore, it is possible to mount Surface Mounted Resistors on one side of a printed-circuit board and other discrete components on the reverse (mixed prints).

Soldering conditions

Surface Mounted Resistors are tested for solderability at a temperature of 235 °C during 2 seconds. The test condition for no-leaching is 250 °C for 60 seconds. Typical examples of soldering processes that provide reliable joints without any damage, are given in Figs 2, 3 and 4.

Marking

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

For values up to 976 Ω the R is used as a decimal point.

For values of 1 kΩ and upwards the first 3 digits are significant, the fourth being an indication of magnitude.

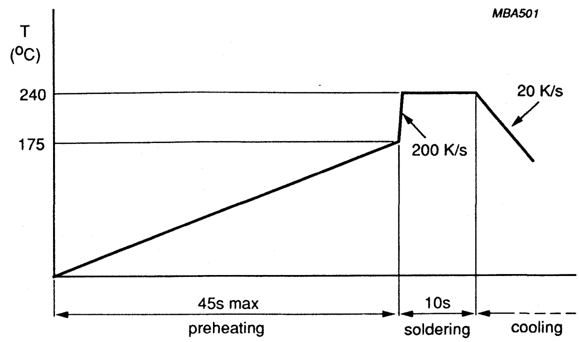


Fig.2 Infrared soldering.

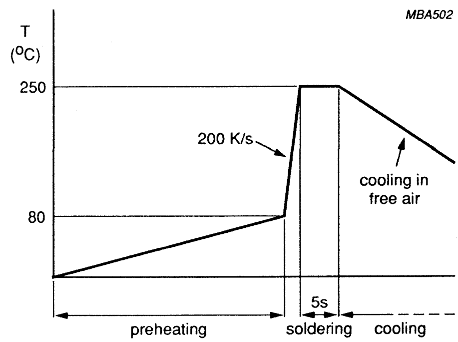


Fig.3 Wave soldering. The resistors may be soldered twice according to this method, if necessary.

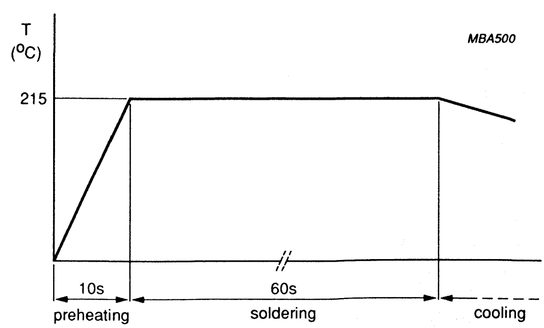


Fig.4 Vapour phase soldering.

250 to 976 Ω = R
1 to 9.76 kΩ = 1
10 to 97.6 kΩ = 2
100 to 150 kΩ = 3

EXAMPLES:

4751 = 4.75 Ω
1472 = 47.5 kΩ
1373 = 137 kΩ

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

ELECTRICAL DATA

Standard values of resistance and tolerance.

Standard values of nominal resistance are taken from the E24/E96 series for resistors with a tolerance of ±1%. The values of these series are according to IEC publication 63.

The limiting voltage (DC or RMS) is 200 V. This is the maximum voltage that may be continuously applied to the resistor element (see IEC publications 115-1 and 115-2).

Dissipation

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

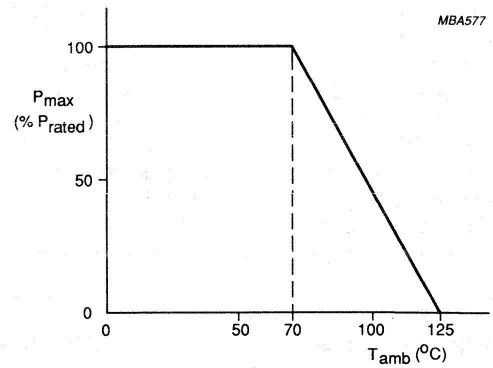


Fig.5 Maximum dissipation (P_{max}) as a function of the ambient temperature (T_{amb}).

COMPOSITION of the CATALOGUE NUMBER

To complete the catalogue number (see Table 1), replace the first three dots of the remaining code by the first three digits of the resistance value. Replace the fourth dot by a figure according to the following table:

250 to 976 Ω	1
1 to 9.76 kΩ	2
10 to 97.6 kΩ	3
100 to 150 kΩ	4

Ordering Example

To order a RC02GP resistor value 4k75 Ω, supplied on a reel of 5000 units packed in blister tape, the ordering code is 2322 727 14752.

Table 1 The resistors have a 12-digit catalogue number starting with 2322. Subsequent digits indicate packaging and resistance as listed in this table

RESISTANCE RANGE	TOL. ±%	SERIES	CATALOGUE NUMBER 2322			
			CARDBOARD TAPE 727		BLISTER TAPE 727	
			5 000 reel	10 000 reel	5 000 reel	10 000 reel
250 Ω to 150 kΩ	1	E24/96	2....	3....	1....	4....

TESTS and REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publication 115-1, category 55/125/56 (rated temperature range –55 to +155 °C; damp heat (long term) 56 days) and CECC publications 1929/1930/1931. The IEC publications are in preparation as documents 40 numbers 620/621 and 623. The testing also meets the requirements specified by EIA and EIAJ.

The tests are carried out in accordance with IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components".

In Table 2 the tests and requirements are listed with reference to the relevant clauses of IEC publications 115-1 and 68: a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

Table 2

IEC 115-1 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.17	Ta 2.20	soldering	unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C; flux 600	good tinning (≥95% covered) no damage
		soldering	16 hours steam or 16 hours 155 °C; unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 230 ±5 °C; flux 600	good tinning (≥95% covered) no damage
4.18	Tb	resistance to soldering heat	10 s; 260 ±5 °C; flux 600	ΔR/R max. ±0.5% +0.05 Ω
		leaching	unmounted chips 60 s; 250 ±5 °C	good tinning no leaching
4.19	Na 2.14	rapid change of temperature	30 minutes –55 °C/30 minutes +125 °C; 5 cycles	ΔR/R max. ±0.5% +0.05 Ω
4.22	Fc 2.6	vibration	frequency: 10-500 Hz; displacement 1.5 mm or acceleration 10 g, 3 directions; total 6 hours	no damage ΔR/R max. ±0.5% +0.05 Ω
4.20	Eb 2.29	bump	3 x 1500 bumps in 3 directions; 40 g	no damage ΔR/R max. ±0.5% +0.05 Ω

IEC 115-1 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.23		climatic sequence		
4.23.2	Ba 2.2	dry heat	16 hours; 125 °C	
4.23.3	D 2.30	damp heat (accel.) 1st cycle	24 hours; 55 °C; 95-100% R.H.	
4.23.4	Aa 2.1	cold	2 hours; –55 °C	
4.23.5	M 2.13	low air pressure	1 hour; 8.5 kPa; 15-35 °C	
4.23.6	D 2.30	damp heat (accel.) remaining cycles	5 days; 55 °C; 95-100% R.H.	R_{ins} = min. 1000 MΩ ΔR/R max. ±1% +0.05 Ω
4.24.2	Ca 2.3	damp heat (steady state)	56 days; 40 °C; 90-95% R.H; loaded with 0.01 Pn (IEC steps; 1-100 V). dissipation ≤1mW	R_{ins} = min. 1000 MΩ ΔR/R max. ±1% +0.05 Ω
4.25.1		endurance	1000 hours; 70 °C; nominal dissipation	ΔR/R max. ±1% +0.05 Ω
4.6.1.1		insulation resistance	100 V (DC) after 1 minute	min. 10^4 MΩ
4.13		short time overload	room temperature, dissipation 6.25 x 0.1 W; 5 s (voltage not more than 2 x V_{max} = 400 V)	ΔR/R max. ±0.5% +0.05 Ω
4.8.4.2		temperature coefficient	between –55 °C and +125 °C	250 Ω - 1 MΩ: ≤50.10^{-6}/K
4.12		noise	IEC publication 195 (measured with Quantech - equipment)	R <1 k: max. 1 µV/V R <10 k: max. 3 µV/V R <100 k: max. 6 µV/V R <1 M: max. 10 µV/V
4.23.2	Ba	endurance at upper category temperature	1000 hours, 125 °C; no load	ΔR/R max. ±0.5% +0.05 Ω no visual damage
4.7		voltage proof on insulation	200 V (DC or RMS) during 1 minute	no breakdown

SMD Resistor RC12G

FEATURES

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

APPLICATIONS

- Hand held measuring equipment
- Carphones
- Camcorders.

DESCRIPTION

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

The resistive layer is covered with a protective coating and printed with the resistance value. Finally, the two external end terminations are added. For ease of soldering the outer layer of these end terminations is a (40%) lead (60%) tin alloy.

QUICK REFERENCE DATA

Resistance range	100 Ω to 1 MΩ; E24/E96 series
Resistance tolerance	±1%
Temperature coefficient 100 Ω - 249 Ω 250 Ω - 1 MΩ	 $\leq 100.10^{-6}$/K $\leq 50.10^{-6}$/K
Abs. max. dissipation at T_{amb} = 70 °C	0.1 W
Maximum permissible voltage	150 V (DC or RMS)
Operating temperature range	−55 °C to +125 °C
Climatic category (IEC 68)	55/125/56
Basic specification	IEC 115-1
Stability after: load, 1000 hours at T_{amb} = 70 °C climatic tests soldering short time overload, 300 V max.	 ΔR/R max. 1.0% +0.05 Ω ΔR/R max. 1.0% +0.05 Ω ΔR/R max. 0.25% +0.05 Ω ΔR/R max. 0.5% +0.05 Ω

MECHANICAL DATA

Dimensions in mm.

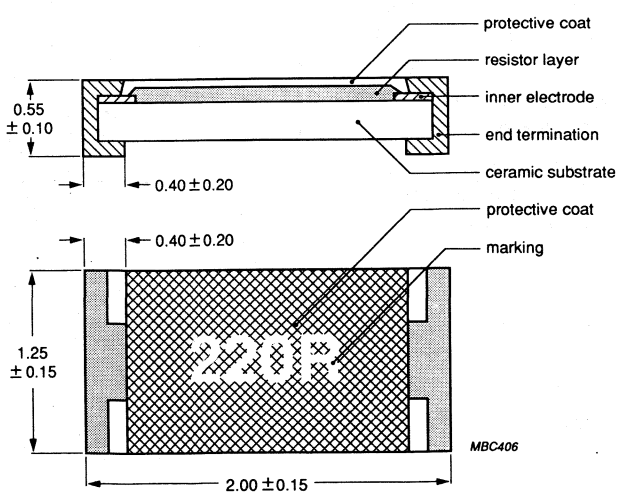


Fig.1 Outlines.

Mounting

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

The robust construction of the device allows it to be completely immersed in a solder bath of 260 °C for one minute. Therefore, it is possible to mount Surface Mounted Resistors on one side of a printed-circuit board and other discrete components on the reverse (mixed prints).

Marking

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

For values up to 976 Ω the R is used as a decimal point.

For values of 1 kΩ and upwards the first 3 digits are significant, the fourth being an indication of magnitude.

1 to 976 Ω = R
1 to 9.76 kΩ = 1
10 to 97.6 kΩ = 2
100 to 976 kΩ = 3
1 MΩ = 4

EXAMPLES:

121R = 121 Ω
4021 = 4.02 kΩ
7503 = 750 kΩ

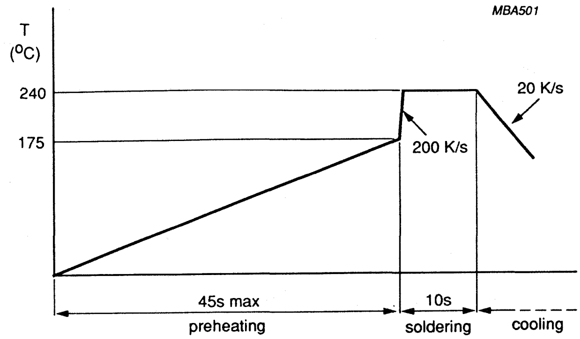


Fig.2 Infrared soldering.

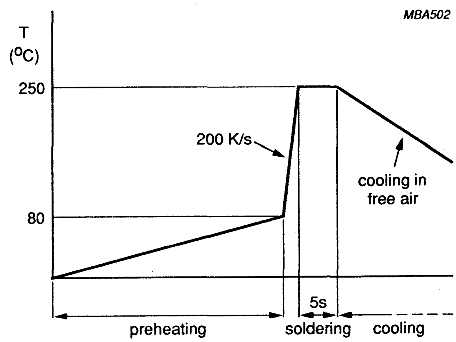


Fig.3 Wave soldering. The resistors may be soldered twice according to this method if necessary.

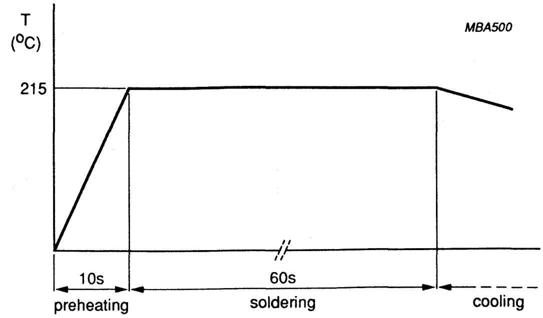


Fig.4 Vapour phase soldering.

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

Soldering conditions

Surface Mounted Resistors are tested for solderability at a temperature of 230 °C during 2 seconds. The test condition for no-leaching is 260 °C for 60 seconds. Typical examples of soldering processes that provide reliable joints without any damage, are given in Figs 2, 3 and 4.

Dissipation

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

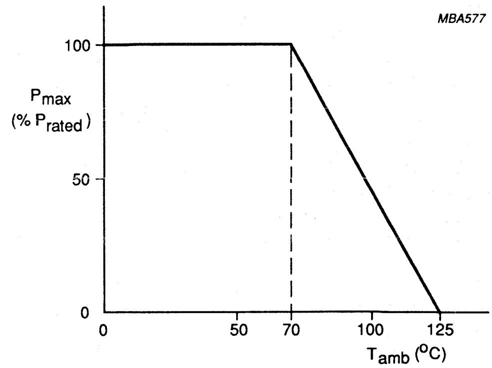


Fig.5 Maximum dissipation (P_{max}) as a function of the ambient temperature (T_{amb}).

ELECTRICAL DATA

Standard values of resistance and tolerance.

The resistors are available in the E24/E96 series for resistors with a tolerance of ±1%. The values of the E24/E96 series are according to IEC publication 63.

The limiting voltage (DC or RMS) for element is the maximum voltage that may be applied continuously to the resistor element (see IEC publications 115-1 and 115-2). This voltage is 150 V.

COMPOSITION of the CATALOGUE NUMBER

To complete the catalogue number (see Table 1), replace the first three dots of the remaining code by the first three digits of the resistance value. Replace the fourth dot by a figure according to the following table:

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 MΩ	5

Example

To order a RC12G resistor, value 4.70 kΩ, supplied in a bag of 1 000, the ordering code is 2322 733 34702.

Table 1 The resistors have a 12-digit catalogue number starting with 2322. Subsequent digits indicate packaging and resistance as listed in this table

RESISTANCE RANGE	TOL. ±%	SERIES	CATALOGUE NUMBER FOLLOWED BY				
			CARDBOARD TAPE 2322 732		BLISTER TAPE 2322 733		BULK 2322 733
			5 000 reel	10 000 reel	5 000 reel	10 000 reel	1 000 bag
100 Ω to 1 MΩ	1	E24/96	6....	7....	6....	7....	3....

TESTS and REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publication 115-1, category 55/125/56 (rated temperature range −55 to +125 °C; damp heat, long term, 56 days) and CECC publications 1929/1930/1931. The IEC publications are in preparation as documents 40 numbers 620/621 and 623. The testing also meets the requirements specified by EIA and EIAJ.

The tests are carried out along the lines of IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components".

In Table 2 the tests and requirements are listed with reference to the relevant clauses of IEC publications 115-1 and 68: a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

Table 2

IEC 115-1 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.17	Ta 2.20	soldering	unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 230 ±5 °C; flux 600	good tinning (≥95% covered), no damage
		soldering	16 hours steam or 16 hours 155 °C; unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 230 ±5 °C; flux 600	good tinning (≥95% covered), no damage
4.18	Tb	resistance to soldering heat	10 s; 260 ±5 °C; flux 600	ΔR/R max. ±0.25% +0.05 Ω
		leaching	unmounted chips 60 s; 260 ±5 °C	good tinning, no leaching
4.19	Na 2.14	rapid change of temperature	30 minutes −55 °C/30 minutes +125 °C; 5 cycles	ΔR/R max. ±0.25% +0.05 Ω
4.22	Fc 2.6	vibration	frequency: 10-500 Hz; displacement 1.5 mm or acceleration 10 g, three directions; total 6 hours	no damage ΔR/R max. ±0.25% +0.05 Ω
4.20	Eb 2.29	bump	3 x 1500 bumps in three directions; 40 g	no damage, ΔR/R max. ±0.25% +0.05 Ω
		bending	resistors mounted on a glass epoxy resin PCB; bending 5 mm over 90 mm	no visual damage ΔR/R max. ±0.5% +0.05 Ω
		humidity load (JIS)	1 000 hours, +40 °C; 90-95% R.H.; loaded with Pn or 150 V; max. 1.5 hours on, 0.5 hours off	ΔR/R max. ±3% +0.1 Ω

IEC 115-1 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.23		climatic sequence		
4.23.2	Ba 2.2	dry heat	16 hours; 125 °C	
4.23.3	D 2.30	damp heat (accel.) 1st cycle	24 hours; 55 °C; 95-100% R.H.	
4.23.4	Aa 2.1	cold	2 hours; –55 °C	
4.23.5	M 2.13	low air pressure	1 hour; 8.5 kPa; 15-35 °C	
4.23.6	D 2.30	damp heat (accel.) remaining cycles	5 days; 55 °C; 95-100% R.H.	R_{ins} = min. 1000 MΩ ΔR/R max. ±1% +0.05 Ω
4.24.2	Ca 2.3	damp heat (steady state)	56 days; 40 °C; 90-95% R.H.; loaded with 0.01 Pn (IEC steps: 1-100 V). dissipation ≤1 mW	R_{ins} = min. 1000 MΩ ΔR/R max. ±1.0% +0.05 Ω
4.25.1		endurance	1000 hours; 70 °C; nominal dissipation	ΔR/R max. ±1% +0.05 Ω
4.6.1.1		insulation resistance	100 V(DC) after 1 minute	min. 10^4 MΩ
4.13		short time overload	room temperature, dissipation 6.25 x 0.1 W; 5 s (voltage not more than 2 x V_{max} = 300 V)	ΔR/R max. ±0.5% +0.05 Ω
4.8.4.2		temperature coefficient	between –55 °C and +125 °C	100 Ω - 249 Ω: ≤100.10^{-6}/K 250 Ω - 1 MΩ: ≤50.10^{-6}/K
4.12		noise	IEC publication 195 (measured with Quantech - equipment)	R<1k: max.1 µV/V R<10k: max.3 µV/V R<100k: max.6 µV/V R<1M: max.10µV/V
4.23.2	Ba	endurance at upper category temperature	1000 hours, 125 °C; no load	ΔR/R max. ±0.5% +0.05 Ω no visual damage
4.7		voltage proof on insulation	150 V (DC or RMS) during 1 minute	no breakdown

HIGH PRECISION

Resistor Chip

RC-03G

APPLICATIONS

Resistor chips are used in a wide scale of equipment. Important considerations for using chip resistors are:

- Decrease of size and mass of equipment
- Reduction of assembly costs of equipment
- Specific electrical requirements (such as HF characteristics)

The main application areas for resistor chips are:
TV (tuner), radio (hi-fi slim-line and portable), radio recorders, watches, video cameras, shavers, pocket calculators, instrumentrs, telecommunication, medical equipment, military equipment and automotive industry.

DESCRIPTION

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

The resistive glaze is adjusted using laser trimming techniques to give the required nominal value. The resistive layer is covered with a protective coat. Finally, two end electrodes are added, the composition of which has been designed to provide ease of soldering.

Mass (per 100): 1.0 g

QUICK REFERENCE DATA

Resistance range	100 Ω to 100 kΩ E24/E96 series
Resistance tolerance	±0.5%
Temperature coefficient R ≤ 249 Ω R > 249 Ω ≤ 100 kΩ	 ≤ ±100 x 10^{-6}/K ≤ ±50 x 10^{-6}/K
Abs. max. dissipation at T_{amb} = 70 °C	0.125 W
Maximum permissible voltage	200 V (RMS)
Climatic category (IEC 68)	55/125/56
Basic specification	IEC 115-1
Stability after: load, 1000 h at T_{amb} = 70 °C load, 8000 h at T_{amb} = 70 °C climatic tests soldering short time overload, 400 V max.	 ΔR/R max. 0.5% + 0.05 Ω ΔR/R max. 1% + 0.05 Ω ΔR/R max. 1% + 0.05 Ω ΔR/R max. 0.25% + 0.05 Ω ΔR/R max. 0.25% + 0.05 Ω

MECHANICAL DATA

Outlines

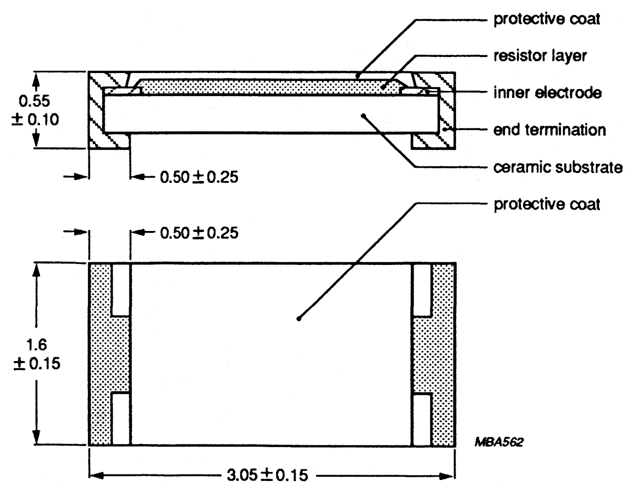


Fig.1 Dimensions in mm.

Marking

Each chip is marked on the top of the protective coating to designate the resistance value.

For values up to 976 Ω the R is used as a decimal point.

For values of 1 kΩ and upwards the first 3 digits are significant and the fourth being a multiplier.

1 for 1 K to 9.76

2 for 10 K to 97.6

3 for 100 K.

Examples: 121R = 121 Ω; 4021 = 4.02 kΩ

Each resistor is marked with a red dot to indicate the tolerance of 0.5%

The packing is also marked and includes resistance value, tolerance, catalogue number, quantity, production period and origin source code.

Soldering conditions

RC-03 resistors are tested for solderability at 230 °C during 2 s. The test condition for no-leaching is 260 °C for 60 s. Typical examples of soldering processes that result into reliable joints without any damage are given in Figs 2, 3 and 4.

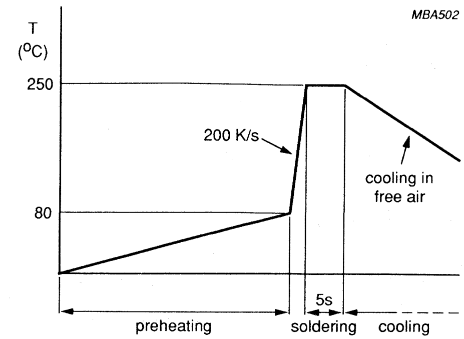


Fig.2 Wave soldering. The resistors may be soldered twice according to this method if necessary.

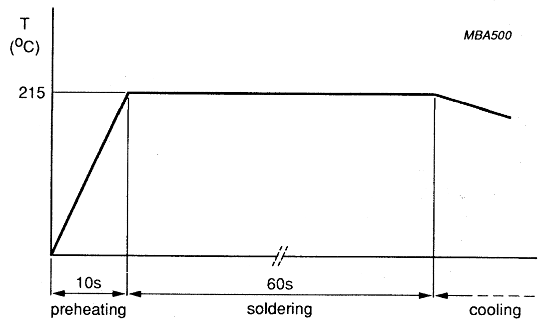


Fig.3 Vapour phase soldering.

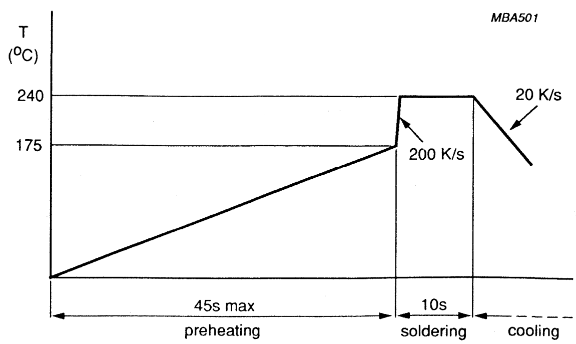


Fig.4 Infrared soldering.

Resistor Chip RC-03G

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of nominal resistance are taken from the E24/96 series for resistors with a tolerance ±0.5%. The values of these are according to IEC publication 63.

The limiting voltage (RMS) for element and insulation is the maximum voltage that may be applied continuously to the resistor element or the insulation. See publication 115-1 and 115-2. This voltage is 200 V.

The temperature coefficient is:

- $\leq \pm 100 \times 10^{-6}$/K for R values between 100 Ω and 249 Ω
- $\leq \pm 50 \times 10^{-6}$/K for R values between 249 Ω and 100 kΩ

COMPOSITION OF THE CATALOGUE NUMBER

In the above mentioned catalogue number, replace the first three dots by the first three digits of the resistance value. Replace the fourth dot by a figure according to the following table

100 to 976 Ω: 1
1 to 9.76 kΩ: 2
10 to 97.6 kΩ: 3
100 kΩ: 4

Table 1

RESISTANCE RANGE	TOL. ±%	SERIES	CATALOGUE NUMBER 2322 725 FOLLOWED BY	
			BLISTER TAPE	BULK
			5000	1000
100 Ω to 100 kΩ	0.5%	E24/96	1....	0....

TESTS AND REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publication 115-1. This means: rated temperature range −55 to +125 °C; damp heat, (long term) 56 days (see IEC publication 115-2 clause 4.1). The tests are carried out along the lines of IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components".

In Table 2 the tests and requirements are listed with reference to the relevant clauses of IEC publications 115-1 and 68: a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

Table 2

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.17	Ta	soldering	unmounted chips completely immersed for 2 ±0.5 s in a solder bath of 230 ±10 °C; flux 600; 0.2% Cl activated	good tinning no damage
4.18	Tb	resistance to soldering heat	10 s; 260 ±5 °C flux 600	ΔR/R max. 0.25% +0.05 Ω
4.19	Na	rapid change of temperature	1/2 h −55 °C/1/2 h +125 °C 5 cycles	ΔR/R max. 0.25% +0.05 Ω
4.22	Fc	vibration	frequency: 10-500 Hz; displacement 1.5 mm or acceleration 10 g, three directions; total 6 h	no damage ΔR/R max. 0.25% +0.05 Ω
4.20	Eb	bump	3 x 1500 bumps in three directions; 40 g	no damage, ΔR/R max. 0.25% +0.05 Ω
4.23		climatic sequence		
4.23.2	Ba	dry heat	16 h; 125 °C	
4.23.3	D	damp heat (accel.) 1st cycle	24 h; 55 °C; 95-100% R.H.	
4.23.4	Aa	cold	2 h; −55 °C	
4.23.5	M	low air pressure	1 h; 8.5 kPa; 15-35 °C	
4.23.6	D	damp heat (accel.) remaining cycles	5 days; 55 °C; 95-100% R.H.	R_{ins} = min. 1000 MΩ ΔR/R max. 1% +0.05 Ω
4.24.2	Ca	damp heat (steady state)	56 days; 40 °C; 90-95% R.H. dissipation ≤ 1.25 mW	R_{ins} = min. 1000 MΩ ΔR/R max. 1% +0.05 Ω
4.25.1		endurance	1000 h; 70 °C; nominal dissipation	ΔR/R max. 0.5% +0.05 Ω

Resistor Chip RC-03G

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.6.1.1		insulation resistance	200 V (DC)	min. 10^4M Ω
4.13		short time overload	5 s, 2.5 x rated voltage or twice the limiting element voltage	ΔR/R max. 0.25% 0.05 Ω
4.8.4.2		temperature coefficient	between −55 °C and +125 °C	≤ ±100 x 10^{-6}/K for R values between 100 Ω and 249 Ω ≤ ±50 x 10^{-6}/K for R values between 249 Ω and 100 kΩ
4.12		noise	IEC publication 195	R ≤ 1 kΩ: max. 1 μV/V R ≤ 10 kΩ: max. 3 μV/V R ≤ 100 kΩ: max. 6 μV/V
4.23.2	Ba	dry heat	1000 h, 125 °C no load	ΔR/R max. 0.5% +0.05 Ω no visual damage
4.7		voltage proof on insulation	200 V (RMS) during 1 minute	no breakdown

Surface Mounted Resistor

RC02 TR

APPLICATIONS

Surface Mounted Resistors are used in a wide range of equipment. Important considerations for using Surface Mounted Resistors are:

- Decrease of size and mass of equipment
- Reduction of assembly costs of equipment
- Specific electrical requirements (such as HF characteristics)

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

DESCRIPTION

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

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

QUICK REFERENCE DATA

Resistance range	1 R to 1 M E24 range
Resistance tolerance	0/–20% and 0/–30%
Max. trimming factor	2.0x
Temperature coefficient R_n 1R ≤ 4.99 R R_n 5.1R ≤ 97.6 R 100R ≤ 1M	 ≤ ±250. 10^{-6} ≤ ±200. 10^{-6} ≤ ±100. 10^{-6}
Abs. max. dissipation at T_{amb} = 70 °C	0.25 W
Maximum permissible voltage	200 V (RMS)
Climatic category (IEC 68)	55/155/56
Basic specification	IEC 115-1
Stability after: load, 1000 h at T_{amb} = 70 °C load, 8000 h at T_{amb} = 70 °C climatic tests soldering short time overload, 400 V max.	 ΔR/R max. ±1.0% + 0.05 Ω ΔR/R max. ±2.0% + 0.1 Ω ΔR/R max. ±1.5% + 0.05 Ω ΔR/R max. ±1.0% + 0.05 Ω ΔR/R max. ±1.0% + 0.1 Ω

Note

These stability data are valid for non-trimmed resistors. Some properties can change after trimming because of insufficient lacquering.

Surface Mounted Resistor RC02 TR

Trimming instructions: With YAG-laser, typical values for;

cutting-speed = 30-300 mm/sec

laser-power = 1-8 Watt

max. trimming-length = 60% of res. film width

min. distance from end term of trimming-cut = 0.20 mm

min. distance between cuts (double-cut) = 0.50 mm.

Protection of laser-cut:

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

Mass (per 100): 1.0 g

Mounting

The rectangular shape and accurate dimensions of this device makes it suitable for use with automatic placement machines. The resistors can be mounted on either ceramic substrates or printed-circuit boards and because of their protective coating, may be placed "face-down" if desired.

The devices may be connected to the circuit using a number of techniques. The robust construction of the device allows it to be immersed in a solder bath at a maximum temperature of 255 °C for up to one minute. This allows the surface mounted resistors to be mounted on one side of a printed-circuit board, whilst at the same time, other discrete components may be installed on the opposite side.

MECHANICAL DATA

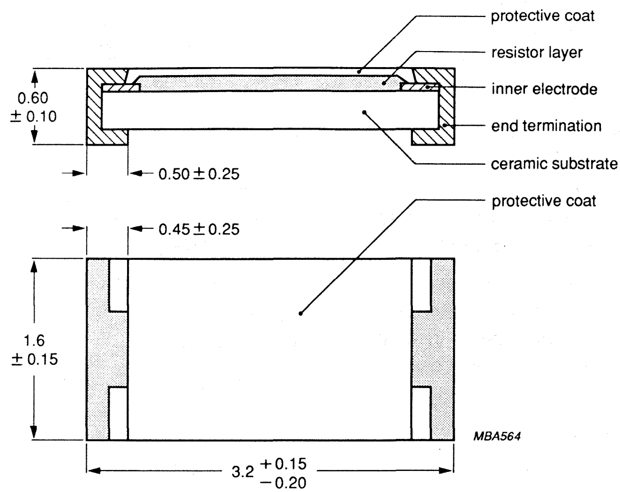


Fig.1 Outlines.

Marking

These resistors are not marked

The packing is marked and includes resistance value, tolerance, catalogue number, quantity, production period and code of origin.

Soldering conditions

Surface Mounted Resistors are tested for solderability at a temperature of 230 °C for a period of two seconds.
The test condition for no-leaching is 255 °C for a period of 60 seconds.
Typical examples of soldering processes that result into reliable joints without any damage are given in Figs 2,3 and 4.

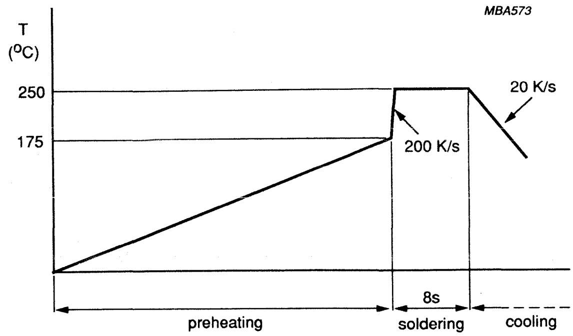


Fig.2 Reflow soldering.

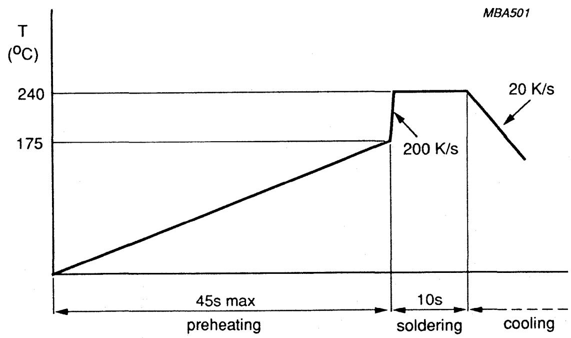


Fig.3 Wave soldering. The resistors may be soldered twice in accordance with this method.

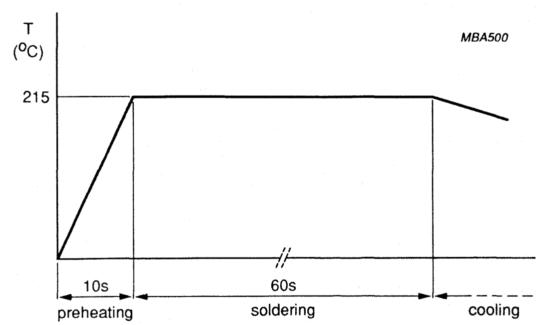
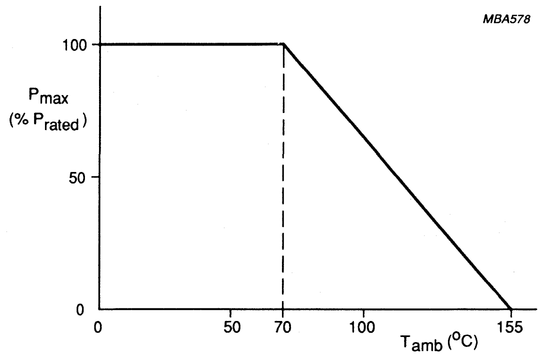


Fig.4 Vapour phase soldering. If necessary, the resistors may be soldered twice in accordance with this method.



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

Fig.5 RC02TR Trimmable resistor.

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of nominal resistance are taken from the E24 series with a tolerance 0/–20%, 0/–30%.

The limiting voltage (RMS) for element and insulation is the maximum voltage that may be applied continuously to the resistor element or the insulation (see publication 115-1 and 115-2). This voltage is 200 V.

Table 1

RESISTANCE RANGE	TOL. %	SERIES	CATALOGUE NUMBER 2322 724 9....		
			CARDBOARD TAPE	BLISTER TAPE	BULK
			5000 reel	5000 reel	1000 bag
1 Ω to 1 M	0/–20	E24	ON REQUEST		
1 Ω to 1 M	0/–30	E24			

CATALOGUE NUMBER:

On request.

TESTS AND REQUIREMENTS

Generally all tests are carried out in accordance with the schedule of IEC publication 115-1. This means: rated temperature range –55 to +155 °C; damp heat, (long term) 56 days (see IEC publication 115-2 clause 4.1). The tests are carried out in accordance with IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components".

In Table 2 the tests and requirements are listed with reference to the relevant clauses of IEC publications 115-1 and 68: a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

Table 2

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.17	Ta	soldering	unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 230 ±10 °C; flux 600	good tinning no damage
4.18	Tb	resistance to soldering heat	10 s at 260 °C flux 600	ΔR/R max. ± (1.0% + 0.05 Ω)
4.19	Na	rapid change of temperature	30 min. at –55 °C 30 min. at +155 °C 5 cycles	ΔR/R max. ± (1.0% + 0.05 Ω)
4.22	Fc	vibration	frequency: 10-500 Hz; displacement 1.5 mm or acceleration 10 g, three directions; total 6 h	no damage ΔR/R max.± (0.5% + 0.05 Ω)
4.20	Eb	bump	3 x 1500 bumps in three directions; 40 g	no damage ΔR/R max. ± (0.5% + 0.05 Ω)
	-	bending	resistors mounted on a glass epoxy resin PCB (JIS-C5200) bending 5 mm over 90 mm	no visual damage ΔR/R max. ± (1% + 0.05 Ω)
4.23		climatic sequence		
4.23.2	Ba	dry heat	16 h; 125 °C	
4.23.3	D	damp heat (accel.) 1st cycle	24 h; 55 °C; 95-100% R.H.	
4.23.4	Aa	cold	2 h; –55 °C	
4.23.5	M	low air pressure	1 h; 8.5 kPa; 15-35 °C	
4.23.6	D	damp heat (accel.) remaining cycles	5 days; 55 °C; 95-100% R.H.	R_{ins} = min. 1000 M ΔR/R max. ± (1.5% + 0.05 Ω)
4.24.2	Ca	damp heat (steady state)	56 days; 40 °C; 90-95% R.H. loaded with 0.01 Pn (IEC steps; 1-100 V)	R_{ins} = min. 1000 M ΔR/R max. ± (1.5% + 0.05 Ω)
4.25.1		endurance	1000 h; 70 °C; nominal dissipation	ΔR/R max. ± (1.0% + 0.05 Ω)
4.6.1.1	-	insulation resistance	100 V (DC)	min. 10^4 M
4.13	-	short time overload	room temperature, dissipation 6.25 x 0.25 W; 5 s (voltage not more than 2 x limiting voltage)	ΔR/R max. ± (1.0% + 0.05 Ω)

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.8.4.2	-	temperature coefficient	between −55 °C and +155 °C	1R $\leq$ 4.99R $\pm 250.\ 10^{-6}$ 5.1R $\leq$ 97.6R $\pm 200.\ 10^{-6}$ 100R $\leq$ 1M $\pm 100.\ 10^{-6}$
4.12	-	noise	IEC publication 195	R < 1 K: max. 1 μV/V R < 10 K: max. 3 μV/V R < 100 K: max. 6 μV/V R < 2 M: max. 10 μV/V
4.23.2	Ba	stability at upper category temperature	1000 h, +155 °C no load	no visual damage $\Delta R/R$ max. ± (1% + 0.05 Ω)
4.7	-	voltage proof on insulation	200 V (RMS) during 1 minute	no breakdown

Metalfilm Precision Chip Resistor

MPC 01

FEATURES

- Reduced size of final equipment
- Lower assembly costs
- Excellent pulse stability for single pulse conditions, typical value: 200 W, 1μs
- High stability and low temperature coefficient.

APPLICATIONS

- Computers
- Telecommunication equipment
- Test and measuring equipment.

DESCRIPTION

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

QUICK REFERENCE DATA

Resistance range	100 Ω to 100 kΩ; preferred values E24 or E96 series
Resistance tolerance	±0.1%
Temperature coefficient	<25 x 10^{-6}/K
Abs. max. dissipation at T_{amb} = 70 °C	0.125 W
Maximum permissible voltage	100 V (DC or RMS)
R_{th} according to DIN 44050	170 K/W on epoxy fenol board
Climatic category (IEC 68)	55/125/56
Basic specification	IEC 115-1
Stability after:	
load, 1000 hours at T_{amb} = 70 °C	ΔR/R max. 0.10% +0.05 Ω
load, 8000 hours at T_{amb} = 70 °C	ΔR/R max. 0.25% +0.05 Ω
climatic tests	ΔR/R max. 0.25% +0.05 Ω
soldering	ΔR/R max. 0.10% +0.05 Ω
short time overload, 200 V max.	ΔR/R max. 0.10% +0.05 Ω

MECHANICAL DATA

Dimensions in mm.

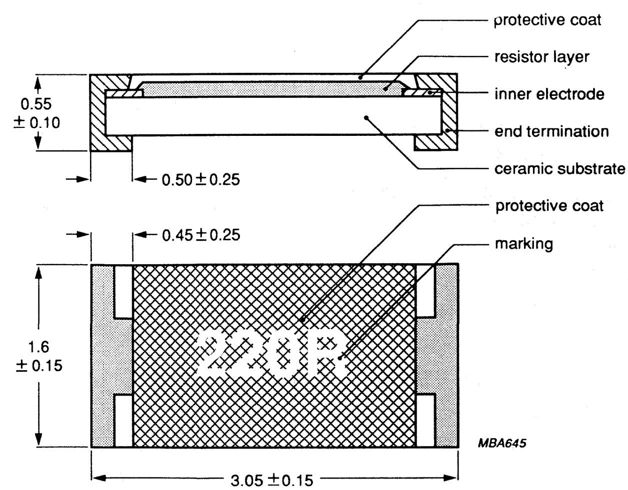


Fig.1 Outlines.

Mounting

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

The robust construction of the device allows it to be completely immersed in a solder bath of 250 °C for one minute. Therefore, it is possible to mount Surface Mounted Resistors on one side of a printed-circuit board and other discrete components on the reverse (mixed prints).

Marking

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

For values up to 976 Ω the R is used as a decimal point.

For values of 1 kΩ and upwards the first 3 digits are significant, the fourth being an indication of magnitude.

100 to 976 Ω = R
1 K to 9.76 kΩ = 1
10 K to 97.6 kΩ = 2
100 KΩ = 3

EXAMPLES:

121R = 121 Ω
4021 = 4.02 kΩ
1003 = 100 kΩ

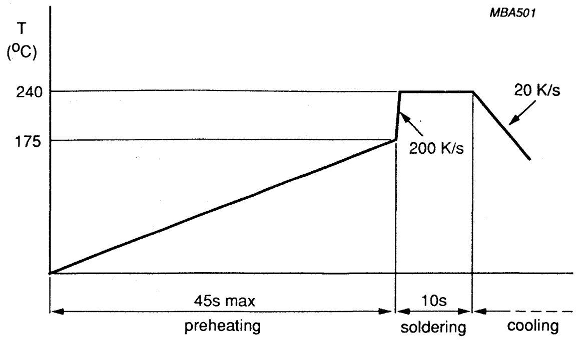


Fig.2 Infrared soldering.

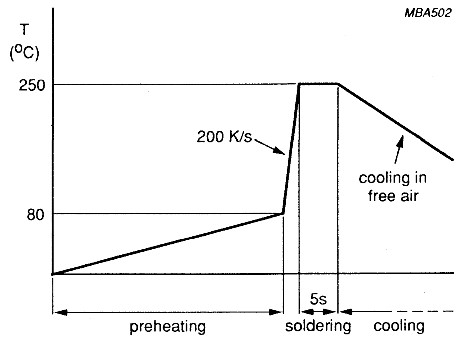


Fig.3 Wave soldering. The resistors may be soldered twice according to this method if necessary.

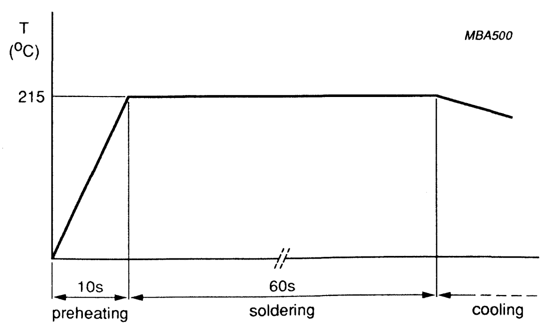


Fig.4 Vapour phase soldering.

The packing is also marked and includes resistance value, tolerance, catalogue number, style, quantity, production period and origin source code.

Note

Only resistors from the E24 or E96 series are marked.

Mass (per 100): 1.00 g

Soldering conditions

Surface Mounted Resistors MPC01 are tested for solderability at 235 °C during 2 s. The test condition for no-leaching is 250 °C for 60 s. Typical examples of soldering processes that provide reliable joints without any damage, are given in Figs 2, 3 and 4.

ELECTRICAL DATA

Standard values of resistance and tolerance.

Any value in the range can be supplied, provided that the resistance value may be expressed in three significant digits and an indication of magnitude. Values which cannot be expressed in this way, are available upon request. Resistors from the E24 or E96 series are marked with four digits. Resistors outside these series are not marked.

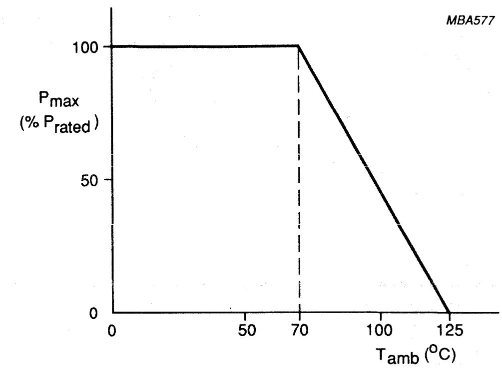


Fig.5 Maximum dissipation (P_{max}) as a function of the ambient temperature (T_{amb}).

The limiting voltage (DC or RMS) is 100 V. This is the maximum voltage that may be continuously applied to the resistor element (see IEC publications 115-1 and 115-2).

Dissipation

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

COMPOSITION of the CATALOGUE NUMBER

To complete the catalogue number (see Table 1), replace the first three dots of the remaining code by the first three digits of the resistance value. Replace the fourth dot by a figure according to the following table:

Note

For code technical reasons the catalogue numbers for the following resistance values are different: 19.9 Ω, 29.9 Ω, 39.9 Ω, 49.9 Ω, 59.9 Ω, 69.9 Ω, 79.9 Ω, 89.9 Ω and 99.9 Ω. These codenumbers are available upon request.

100 to	976 Ω	1
1 to	9.76 Ω	2
10 to	97.6 kΩ	3
100	kΩ	4

Table 1 The resistors have a 12-digit catalogue number starting with 2322. Subsequent digits indicate packaging and resistance as listed in this table

RESISTANCE RANGE	TOL. ±%	T.C.R.	CATALOGUE NUMBER 2322		
			BLISTER TAPE 741		BULK 741
			1 000 reel	5 000 reel	1 000 pcs.
100 Ω to 100 kΩ	0.1	±25	2....	3....	1....

Metalfilm Precision Chip Resistor | MPC 01

TESTS and REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publication 115-1, category 55/125/56 (rated temperature range –55 to +125 °C; damp heat, long term, 56 days) (see IEC publication 115-2 clause 4.1). The tests are carried out in accordance with IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components".

In Table 2 the tests and requirements are listed with reference to the relevant clauses of IEC publications 115-1 and 68: a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

Table 2

IEC 115-1 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.17	Ta 2.20	soldering	unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C; flux 600	good tinning, no damage
4.18	Tb	resistance to soldering heat	10 s; 260 ±5 °C; flux 600	ΔR/R max. ±0.10% +0.05 Ω
4.19	Na 2.14	rapid change of temperature	30 minutes –55 °C/ 30 minutes +125 °C; 5 cycles	ΔR/R max. ±0.10% +0.05 Ω
4.22	Fc 2.6	vibration	frequency: 10-500 Hz; displacement 1.5 mm or acceleration 10 g, three directions; total 6 hours	no damage ΔR/R max. ±0.10% +0.05 Ω
4.20	Eb 2.29	bump	3 x 1500 bumps in three directions; 40 g	no damage, ΔR/R max. ±0.10% +0.05 Ω
4.23		climatic sequence		
4.23.2	Ba 2.2	dry heat	16 hours; 125 °C	
4.23.3	D 2.30	damp heat (accel.) 1st cycle	24 hours; 55 °C; 95-100% R.H.	
4.23.4	Aa 2.1	cold	2 hours; –55 °C	
4.23.5	M 2.13	low air pressure	1 hour; 8.5 kPa; 15-35 °C	
4.23.6	D 2.30	damp heat (accel.) remaining cycles	5 days; 55 °C; 95-100% R.H.	R_{ins} = min. 1000 MΩ ΔR/R max. 0.10% +0.05 Ω
4.24.2	Ca 2.3	damp heat (steady state)	56 days; 40 °C; 90-95% R.H.; dissipation ≤1.25 mW	R_{ins} = min. 1000 MΩ ΔR/R max. 0.25% +0.05 Ω
4.25.1		endurance	1000 hours; 70 °C; nominal dissipation	ΔR/R max. 0.10% +0.05 Ω

IEC 115-1 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.6.1.1		insulation resistance	100 V (DC) after 1 minute	min. 10^4 MΩ
4.13		short time overload	5 s; rated voltage or twice the limiting element voltage	ΔR/R max. 0.10% +0.05 Ω
4.8.4.2		temperature coefficient	between −55 °C and +125 °C	≤25.10^{-6}/K
4.12		noise	IEC publication 195	≤0.10 µV/V
4.23.2	Ba	endurance at upper category temperature	1000 hours, 125 °C; no load	ΔR/R max. 0.10% +0.05 Ω no visual damage
4.7		voltage proof on insulation Jis-pulse test	100 V (DC or RMS) during 1 minute 2.5 x rated voltage or max. overload; 1 s on/25 s off, 10^4 cycles	no breakdown ΔR/R max. 0.5% +0.1 Ω

LEADED RESISTORS

SELECTION GUIDE

resistor type	resistance range Ω	tolerance %	dissipation at °C	W	type number or basic catalogue number	page
Carbon film	1 to 10 M	5; 2	70	0.33	CR25	125
Standard film	1 to 2.4 M	5; 1	70	0.50	SFR16S	135
	1 to 3 M	5		0.50	SFR16T	141
					SFR16TCECC	149
	1 to 10 M	5; 2; 1		0.40	SFR25	157
		5; 2		0.40	SFR25CECC	167
		5; 2		0.50	SFR25H	169
		5; 2		0.50	SFR25HCECC	177
Fusible	1 to 15 k	5	70	0.33	NFR25	181
				0.50	NFR25H	191
Metal film	4.99 to 1 M	1	70	0.40	MRS16T	201
	1 to 10 M			0.60	MRS25	209
	6.8 to 1 k			0.40	MRS16TIi	217
	5.1 to 1 k			0.60	MRS25Ii	217
	1 to 1 M	0.5		0.40	MR25	229
				0.50	MR30	229
	4.99 to 1 M	1		1.0	MR52	229
MIL metal film	10 to 1 M	1	70	0.125	MR24D	239
				0.25	MR34D	239
				0.5	MR54D	239
				0.75	MR74D	239
	49.9 to 1 M	0.1; 0.25;	125	0.1	MR24E/C	239
		0.5		0.125	MR34E/C	239
				0.25	MR54E/C	239
	24.9 to 1 M	1		0.5	MR74E/C	239
Precision metal film	24 to 100 k	0.05; 0.02;	70	0.125	MPR24	243
		0.01		0.25	MPR34	243
	4.99 to 1 M	0.5; 0.25;		0.25	MPR24	243
		0.1		0.40	MPR34	243
High voltage	100 k to 22 M	1; 5; 10	70	0.25	VR25	255
	100 k to 33 M	1; 5		0.50	VR37	263
	100 k to 68 M			1.0	VR68	263

resistor type	resistance range Ω	tolerance %	dissipation at °C	W	type number or basic catalogue number	page
Power metal film	1 to 1 M	5	70	1.0	PR01	273
				2.0	PR02	281
				3.0	PR03	289
	1 to 27 k			1.60	PR37	297
	30 k to 1 M			1.20	PR37	297
	1 to 51 k			2.50	PR52	305
	56 k to 1 M			2.00	PR52	305
Cemented wirewound	0.1 to 33 k	5; 10	40	3.00	AC03	315
				4.00	AC04	315
				5.00	AC05	315
				7.00	AC07	315
				10.0	AC10	315
				15.0	AC15	315
				20.0	AC20	315
Enamelled wirewound	4.7 to 100 k	5; 10	70	4.00	WR0617E	325
				7.00	WR0825E	325
		5		11.0	WR0842E	325
				17.0	WR0865E	325
Stand-up miniature power wirewound	0.1 to 560	5	70	2.00	SMW02	331
				3.00	SMW03	331
				5.00	SMW05	331
Precision wirewound	0.22 to 12 kΩ	± 1	25	2.0	PAC02	339
				3.0	PAC03	339
				4.0	PAC04	339
				5.0	PAC05	339
				6.0	PAC06	339

Reference may also be made to the index of catalogue numbers at the back of this handbook.

INTRODUCTION

The data are presented - whenever possible - according to a "format", in which the following items are stated:

TITLE
QUICK REFERENCE DATA
APPLICATION
DESCRIPTION
MECHANICAL DATA
  Mass
  Mounting
  Marking
ELECTRICAL DATA
  Standard values of rated resistance and tolerance
COMPOSITION OF THE TYPE NUMBER
TESTS AND REQUIREMENTS
PACKAGING

DESCRIPTION

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

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

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 does include however, length (L), diameter of the body (D) and the lead diameter (d). For certain types, the length is stated as L1 and L2; L1 is the body length, L2 is the body length plus lacquer on the leads. By specifying L1/L2, the dimensional "clean lead to clean lead" properties can be determined.
The length of the cylindrical body (L1) is measured by inserting the leads into the holes of two identical gauge plates (Fig.2) and moving these plates parallel to each other, until the resistor body is clamped without deformation (IEC publication 194).

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

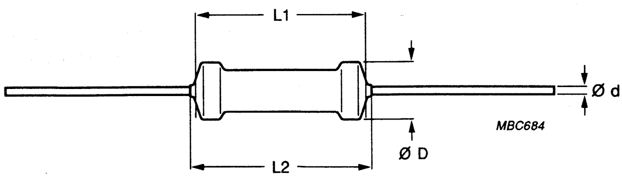
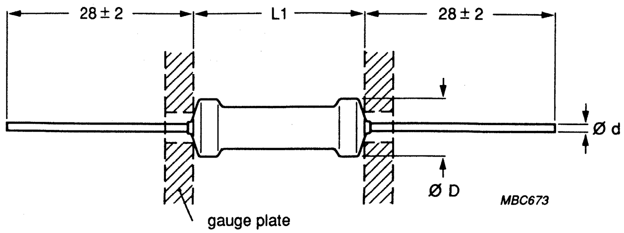
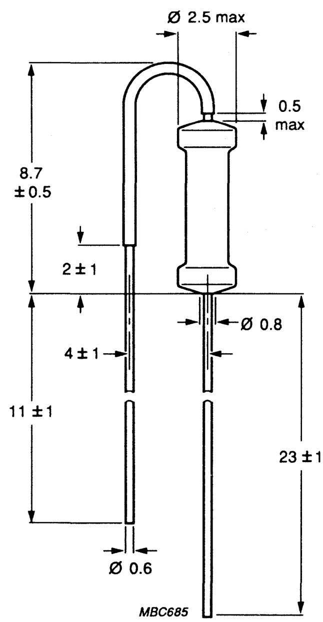


Fig.1 Component outline.



Dimensions in mm.

Fig.2 Measurement of dimension (L1).



Dimensions in mm.

The bent lead is partially covered with insulating lacquer having a breakdown voltage of at least 50 V (DC).

Fig.3 (SFR25, VR25A) are available as "stand-up" types and shown in the 'mounted' position.

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

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

Mass

The mass weight is given per 100 resistors.

Mounting

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

Marking

The resistors are either colour coded or provided with an identification stamp. The colour code consists of a number of coloured bands according to IEC publication 62: "Colour code for fixed resistors". See also IEC 115-1 clause 4.5. The coloured bands indicate the **nominal resistance**, the **tolerance** on the resistance and, if applicable, the **temperature coefficient**. A maximum of bands may be used, but in some instances there are fewer, e.g. if the products are too small. 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 63 and as indicated in the relevant data sheet and printed at the back of this book.

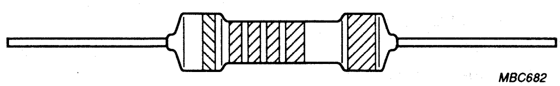


Fig.4 Marking.

Body colours

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

tan	CR25
light green	SFR25/SFR16T/SFR16S
grey	NFR25, NFR25H
green	MR25, MR30, MR52, MR24E/C/D, MR34E/C/D, MR54E/C/D, MR74E/C/D, MPR24, MPR34, MRS16T, MRS25, AC04, AC05, AC07, AC10, AC15, AC20
light blue	VR25, VR37, VR68
red	PR37, PR52, PR01, PR02, PR03
brown	WR0167E, WR0842E, WR0825E, WR0865E
red-brown	SFR25H

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

ELECTRICAL DATA

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

The **limiting voltage** (DC or RMS) is the maximum voltage that may be continuously applied; see IEC publications 115-1 and 115-2. Where applicable, **derating details** and **performance nomograms** are given, showing the relationship between power dissipation, ambient temperature, hot-spot temperature and maximum resistance drift after prolonged operation. For power resistors, graphs indicate the relationship between temperature rise and dissipation with lead-length or heatsinks as parameters.
The temperature rise in a resistor due to power dissipation, is determined by the laws of heat - conduction, convection and radiation. The maximum body temperature usually occurs in the middle of the resistor and is called the **hot-spot** temperature.

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

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

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

where

T_m = hot-spot temperature
T_{amb} = ambient temperature
ΔT = temperature rise at hot-spot.

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

Summarizing

dimensions and conductance of materials determine	heat resistance
heat resistance x dissipation	= temperature rise
temperature rise + ambient temperature	= 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,

$\frac{dP}{dT_m} = \frac{l}{A}$ 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.5. The intersection of the broken line with the horizontal axis gives the hot-spot temperature under chosen conditions.

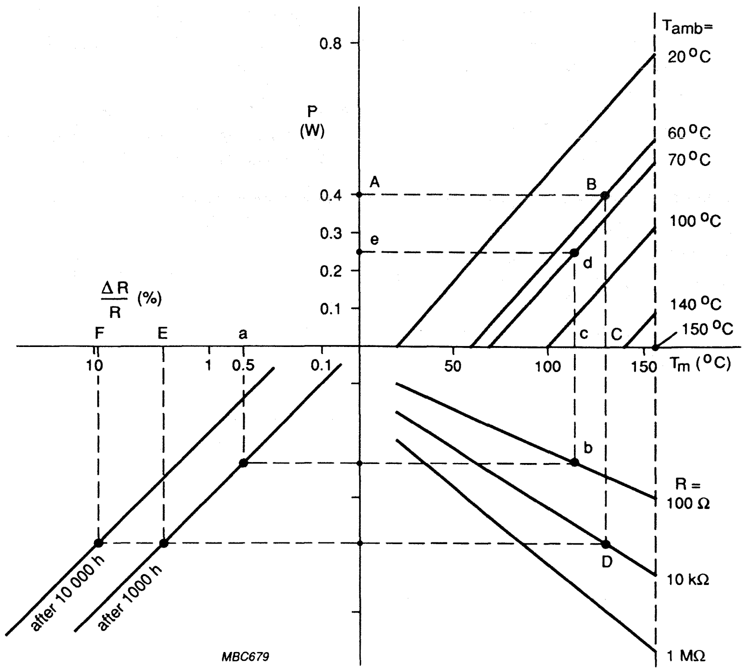


Fig.5 Performance nomogram (for a fictitious resistor) illustrating the way of specifying the performance of film resistors.

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 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 10 000 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 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 °C increase (decrease) of temperature within a specified range, and is expressed in parts per million per K ($.10^{-6}$/K).

Example: If the temperature coefficient of a resistor of R_{nom} = 1 MΩ between –55 °C and +155 °C is ±100 . 10^{-6}/K its resistance will be:

at 25 °C:
1 000 000 Ω (nominal = rated value)
at +155 °C:
1 000 000 Ω ±(130 . 100 . 10^{-6}) x 1 000 000 Ω
= 1 013 000 Ω or 987 000 Ω
at –55 °C:
1 000 000 Ω ±(80 . 100 . 10^{-6}) x 1 000 000 Ω
or 1 008 000 Ω

If the temperature coefficient is specified as ≤100 . 10^{-6}/K the resistance will be within the shaded area.

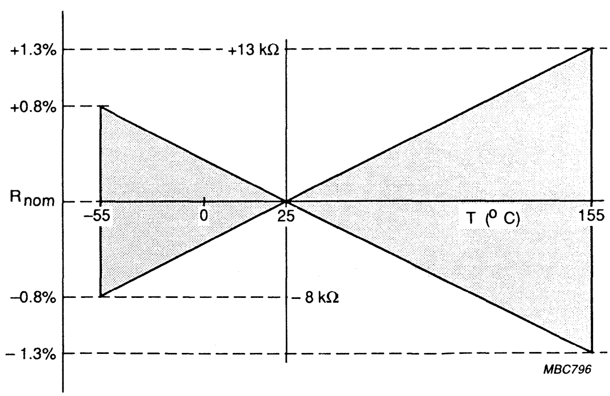


Fig.6 Temperature coefficient.

HEAT RESISTANCE (R_{th})

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

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

The thermal resistance given in the specification is determined according to the following arrangement (Part DIN 44050) (T_{amb} between 20 and 25 °C).

The resistor is mounted on a PCB 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.

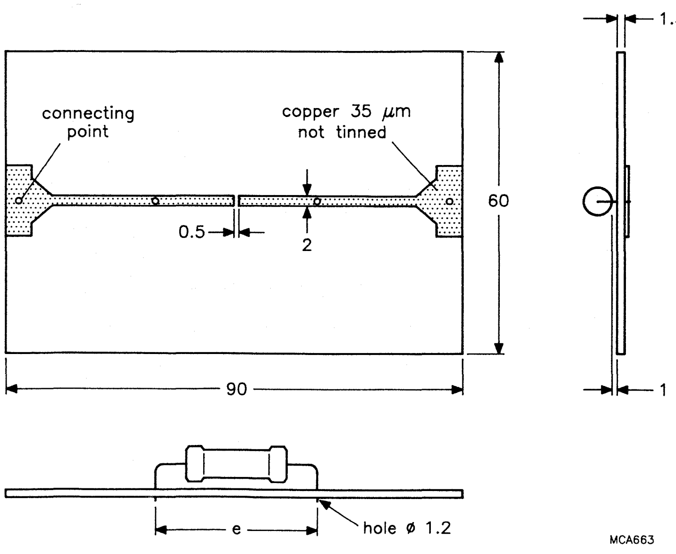
PULSE-LOAD BEHAVIOUR

Knowing the thermal characteristics of a resistor, it is possible to calculate the load 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 peak pulse power, P, and pulse duration, t_i; the straight line in Fig.8 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.8 shows the observed maximum for a resistor under single-pulse loading.

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.8 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.9, should not be exceeded.



Dimensions in mm.

Fig.7 Mounting dimensions.

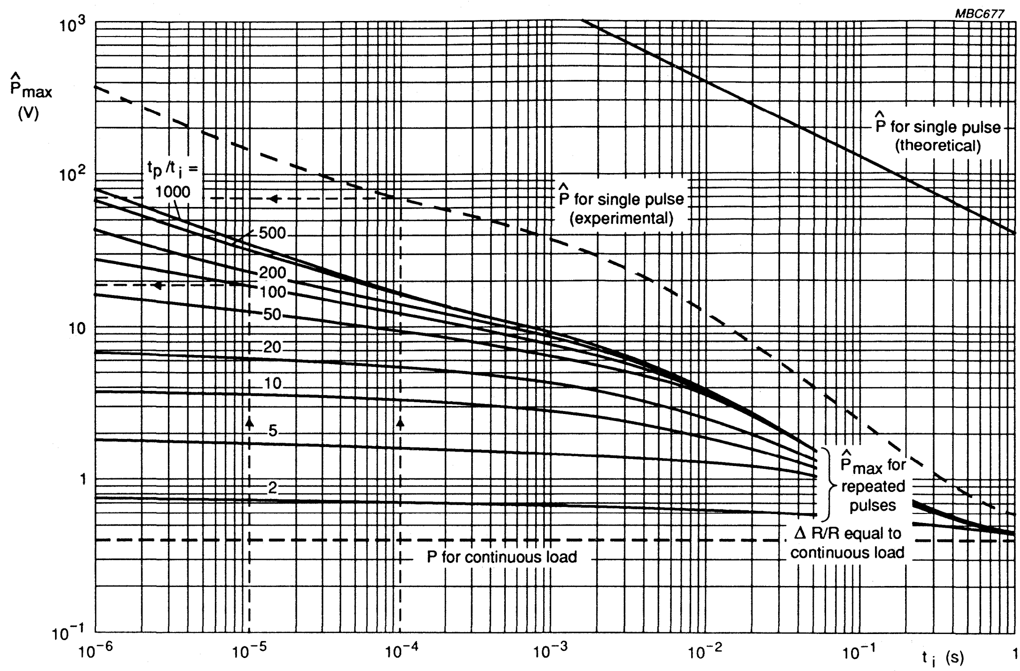


Fig.8 Max. permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i) for a typical resistor.

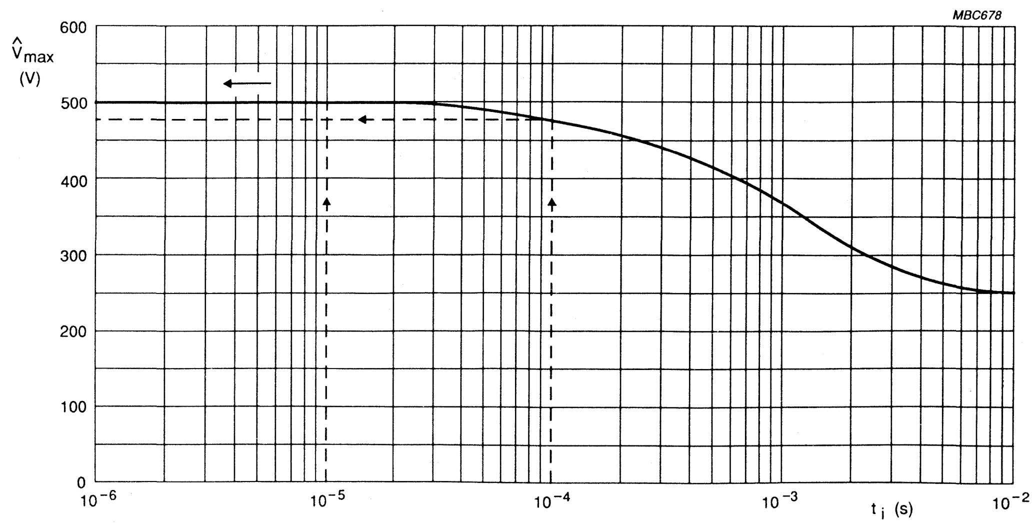


Fig.9 Max. permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_i) for a typical resistor.

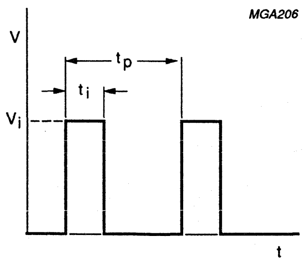


Fig.10 Rectangular pulses.

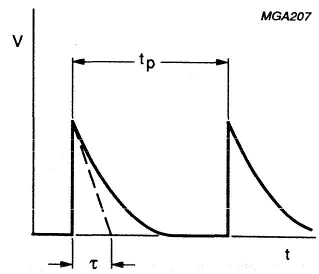


Fig.11 Exponential pulses.

Definition of symbols used in Figs 8, 9, 10 and 11

- P = applied peak pulse power
- $\hat{P}_{max}$ = maximum permissible peak pulse power (Fig.8)
- V_i = applied peak pulse voltage (Figs 10 and 11)
- $\hat{V}_{max}$ = maximum permissible peak pulse voltage (Fig.9)
- R_{nom} = nominal resistance value
- t_i = pulse duration (rectangular pulses)
- t_p = pulse repetition time
- r = time constant (exponential pulses)
- T_{amb} = ambient temperature
- T_{hsp} = maximum hot-spot temperature of the resistor.

Definitions of pulse load behaviour; metal film resistors (R >10 Ω)

SINGLE PULSE

The resistor is considered to be operating under single pulse conditions if, during its life, it is loaded with a limited number (approx. 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 loading

The graphs in Figs 8 and 9 may be used to determine the maximum pulse loading for a resistor. The calculations assume:

– T_{amb} = 70 °C

– T_{hsp} is the maximum permissible hot-spot temperature for the relevant resistor family

– ΔR/R equal to the permitted value for 1000 hours at continuous level.

- For repetitive rectangular pulses:

  – $\frac{V_i^2}{R}$ must be lower than the value of $\hat{P}_{max}$ given by the solid lines of Fig.8 for the applicable value of t_i and duty cycle t_p/t_i.

  – V_i must be lower than the value of $\hat{V}_{max}$ given in Fig.9 for the applicable value of t_i.
- For repetitive exponential pulses:

  – As for rectangular pulses, except that t_i = 0.5 r.
- For single rectangular pulses:

  – $\frac{V_i^2}{R}$ must be lower than the $\hat{P}_{max}$ given by the dashed line of Fig.8 for the applicable value of t_i.

  – V_i must be lower than the value of $\hat{V}_{max}$ given in Fig.9 for the applicable value of t_i.

Examples

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

1. CONTINUOUS PULSE TRAIN

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

Therefore:

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

For

$t_i = 10^{-5}$ s and $\frac{t_p}{t_i} = 100$

Figure 8 gives $\hat{P}_{max}$ = 19 W and Fig.9 gives $\hat{V}_{max}$ = 500 V. As the operating conditions P = 16 W and 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:

V_i = 200 V; $t_i = 10^{-4}$.

Therefore:

$$P_{max} = \frac{200^2}{1000} = 40W.$$

The dashed curve of Fig.8 shows that at $t_i = 10^{-4}$ s, the permissible $\hat{P}_{max}$ = 70 W and Fig.9 shows a permissible $\hat{V}_{max}$ of 480 V, so again this resistor may be used.

COMPOSITION OF THE CATALOGUE NUMBER

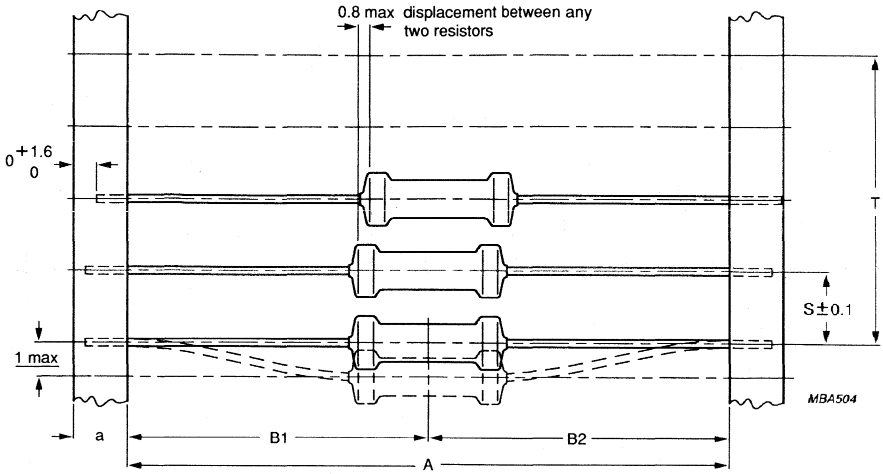
Resistors are ordered by their **catalogue number**, a 12-digit number. The packaging method is an integral part of this number, and so is the resistance code.

TESTS AND REQUIREMENTS

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

STANDARD PACKING

Most types may be processed automatically and are supplied on tape for this purpose, i.e. a bandolier which fits most commonly used automatic mounting machines. Not all bandolier configurations are identical, the deviating parameters are given in Figs 12 and 13.



Dimensions in mm.

S = spacing

T = maximum deviation of spacing: 1 mm per 10 spacings or 0.5 mm per 5 spacings

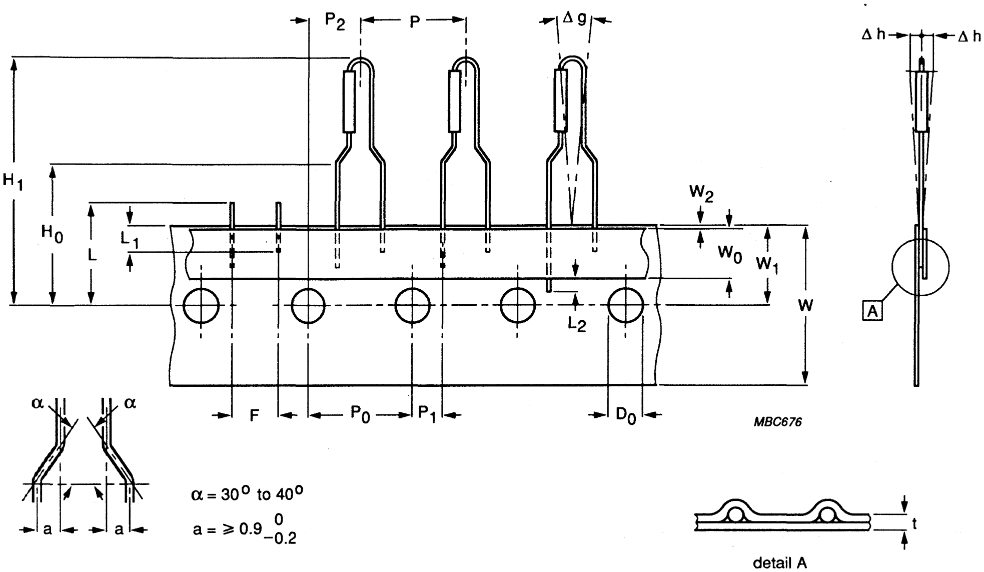
a = tape width

A = tape distance

B1 - B2 = centricity

0.5 mm is the maximum displacement between any two resistors for types SFR16T, MRS16T, and MRS16TIi.

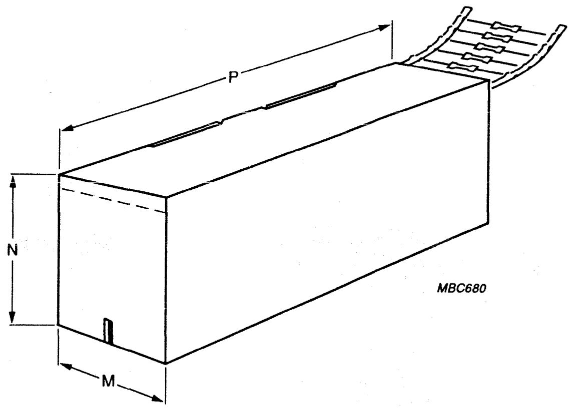
Fig.12 Axial on tape.



Dimensions in mm.

Fig.13 Radial on bandolier, (see Table 3).

Extraction force for components in the tape plane, vertically to the direction of unreeling: ≥5N.

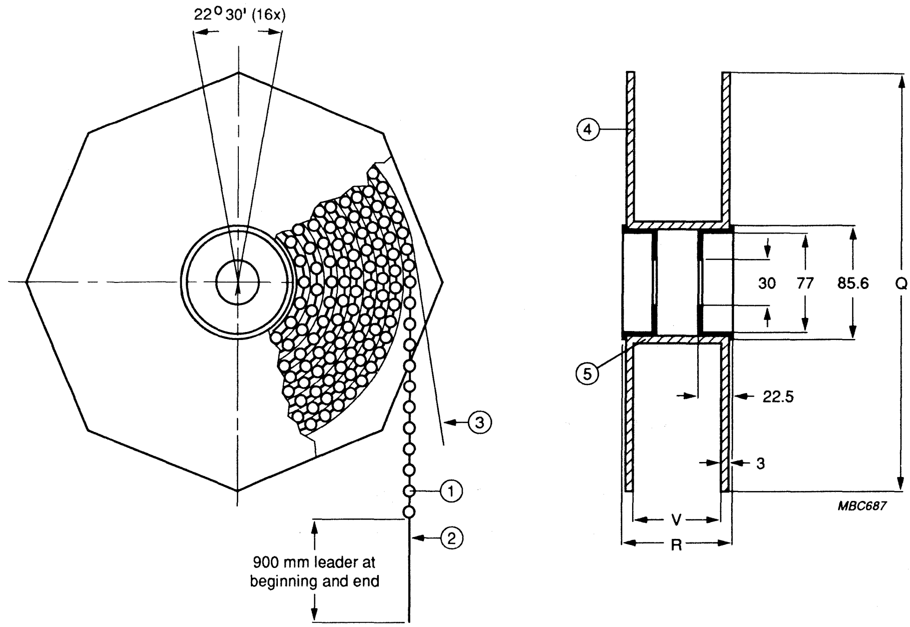


Bandoliers may be supplied concertinaed in a cardboard box ("ammopack").

Fig.14 Bandolier in ammopack.

Table 3 Taping dimensions

Body diameter	D
Body length	A
Lead wire diameter	d
Pitch of components	P
Feed hole pitch	P_O
Cummulative pitch error	T
Feed hole centre to lead at topside of the tape	P_1
Feed hole centre to body centre	P_2
Lead to lead distance	F
Component alignment	Δh
Component alignment	Δg
Tape width	W
Hold down tape	W_O
Hole position	W_1
Hold down tape position	W_2
Lead wire clinch height	H_O
Component height	H_1
Feed hole diameter	D_O
Total tape thickness	t
Length of snipped lead	L
Lead wire (tape portion) shortest lead	L_1



Dimensions in mm.

Fig.15 Bandolier on reel.

CARBON FILM

CARBON FILM RESISTORS

QUICK REFERENCE DATA

Resistance ranges			1 Ω to 10 MΩ; E24 series
Resistance tolerance			± 5% and ± 2%; E24 series
Absolute maximum dissipation at T_{amb} = 70 °C*			0.33 W
Basic specification			IEC 115-1 and 115-2
Climatic category			55/155/56
Stability after			
load			see nomogram (Fig. 2)
climatic tests	R ⩽ 220 kΩ	ΔR/R	max. 1.5% + 0.1 Ω
	R > 220 kΩ	ΔR/R	max. 3%
soldering		ΔR/R	max. 0.5% + 0.05 Ω
short time overload		ΔR/R	max. 1% + 0.05 Ω

DESCRIPTION

Resistors of 10 Ω to 1 MΩ have a homogeneous film of pure carbon deposited on a high grade ceramic body. Resistors R < 10 Ω have an electroless-deposited nickel film; resistors R > 1 MΩ have a film of chrome-silicium. 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 tan lacquer which provides electrical, mechanical and climatological protection. The encapsulation is resistant to all cleaning solvents according to MIL-STD-202E, method 215 and IEC 68-2-45.

MECHANICAL DATA

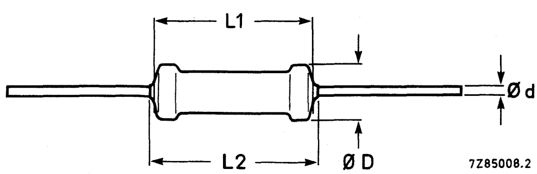


Fig.1.

type	D max.	L1	L2 max.	d
CR25	2.5	6.5	7.5	0.6

* Dissipation at T_{amb} = 70 °C which causes the maximum permissible hot-spot temperature of 155 °C to occur, irrespective of the resistance drift provoked by this condition.

The length of the body is measured by inserting the leads into holes of 1.0 mm dia. in two identical gauge plates and moving these plates parallel to each other until the resistor body is clamped without deformation (see IEC publication 294).

Mass 23 g per 100 resistors

Mounting

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

Marking

The nominal resistance and the tolerance are marked on the resistors by means of four coloured bands according to IEC publication 62: "Colour code for fixed resistors". See General Section.

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated resistance (nominal resistance) are taken from the E24 series within the range 1 Ω to 1 MΩ. These values are given in the table "Standard series of values in a decade" at the back of the handbook.
The tolerance on the nominal resistance is ± 5% or ± 2%.
The limiting voltage (DC or RMS) is 250 V. This is the maximum voltage that may be applied continuously to the resistor element; see IEC publications 115-1 and 115-4.

Table

type	packing	quantity	resistance range	limiting voltage V RMS	tolerance %	series	catalogue number
CR25	in box	1000	1 Ω - 10 MΩ	250	5	E24	2322 211 13 . . .
		1000	1 Ω - 1 MΩ	250	2	E24	2322 211 14 . . .
	on reel	5000	1 Ω - 10 MΩ	250	5	E24	2322 211 23 . . .
		5000	1 Ω - 1 MΩ	250	2	E24	2322 211 24 . . .
	in box	5000	1 Ω - 10 MΩ	250	5	E24	2322 211 33 . . .
		5000	1 Ω - 1 MΩ	250	2	E24	2322 211 34 . . .
	in box	2000	1 Ω - 10 MΩ	250	5	E24	2322 211 43 . . .
		2000	1 Ω - 1 MΩ	250	2	E24	2322 211 44 . . .
	in box	1000	1 Ω - 1 MΩ	250	2	E24	2322 211 54 . . .
	in box	5000	1 Ω - 10 MΩ	250	5	E24	2322 211 73 . . .
		5000	1 Ω - 1 MΩ	250	2	E24	2322 211 74 . . .

COMPOSITION OF THE CATALOGUE NUMBER

In the above-mentioned catalogue number, replace the first two dots by the first two digits of the resistance value. Replace the third dot by a figure according to the following table:

1 - 9.1 Ω	8	10 - 91 kΩ	3
10 - 91 Ω	9	100 - 910 kΩ	4
100 - 910 Ω	1	1 - 9.1 MΩ	5
1 - 9.1 kΩ	2	> 10 MΩ	6

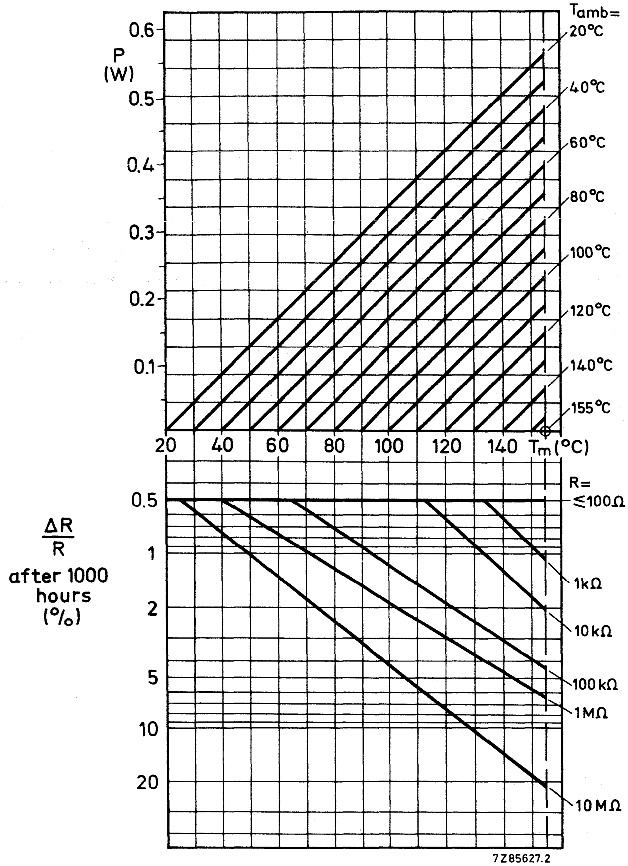


Fig. 2.

Performance nomogram showing the relationship between power dissipation P, ambient temperature T_{amb}, hot-spot temperature T_m, resistance value R, and maximum resistance drift $\Delta R/R$ after 1000 h of operation.

For continuous operation longer or shorter than 1000 h, t_x, the stability can be approximated by multiplying the drift $\Delta R/R$ after 1000 h with the square root of the time ratio, so:

$$(\Delta R/R \text{ after x h}) = (\Delta R/R \text{ after 1000 h}) \cdot (t_x/1000)^{1/2}$$

See also following notes.

Notes on nomogram

1. The nomogram should not be extended beyond the maximum permissible hot-spot temperature of 155 °C.
2. The resistance change 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.
3. The stability lines do not give exact values for $\Delta R/R$, but represent a probability of 95% that the real values will be smaller than those obtained from the nomogram.
4. In the nomogram the limiting voltage of the resistors has not been taken into consideration.
5. IEC publication 115-1 is still based on the conventional method of rating resistors by a fixed "rated dissipation" at 70 °C requiring at that dissipation a fixed maximum permissible drift. In our specification, however, the rated dissipation is no longer specified and also the guaranteed resistance drift is made dependent on the working conditions. To bridge the gap between the system of IEC 115-1 and our system, Fig. 3 is added. In this figure the permissible dissipation at 70 °C for a resistance drift of max. 1.5% after 1000 hours is given, taking into consideration that the hot-spot temperature should not rise above 155 °C (horizontal part of the curve). In our specification the curve of Fig. 3 replaces the rated dissipation.

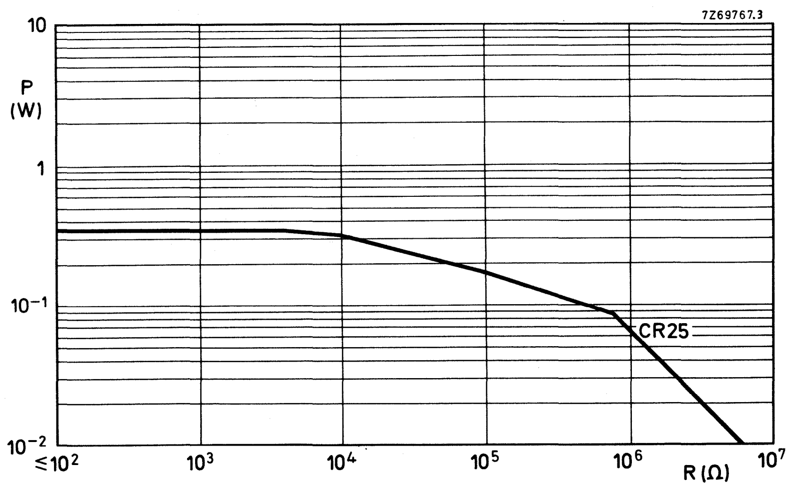


Fig. 3 Maximum permissible dissipation at T_{amb} = 70 °C as a function of the resistance value for a resistance drift of 1.5% after 1000 hours or for a maximum temperature of 155 °C without reaching the resistance drift of 1.5%, limiting voltage being taken into account.

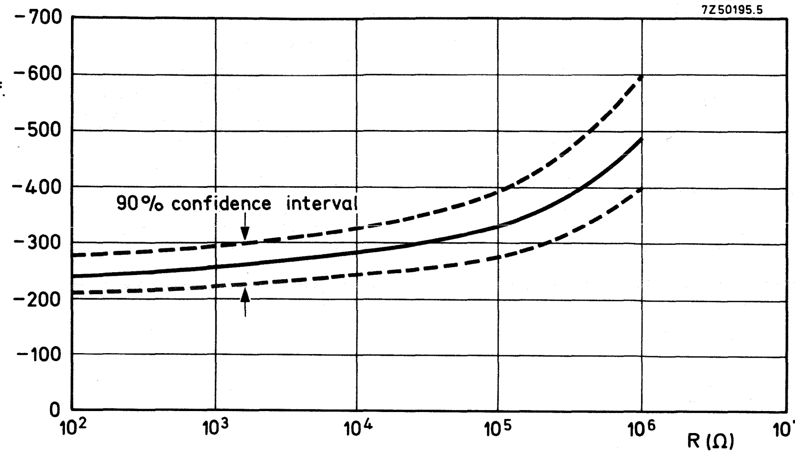


Fig. 4 Temperature coefficient as a function of the resistance value.
For values < 10 Ω the temperature coefficient is $\leqslant + 200 \cdot 10^{-6}$/K;
for values > 1 MΩ the temperature coefficient is $\leqslant 250.10^{-6}$/K.

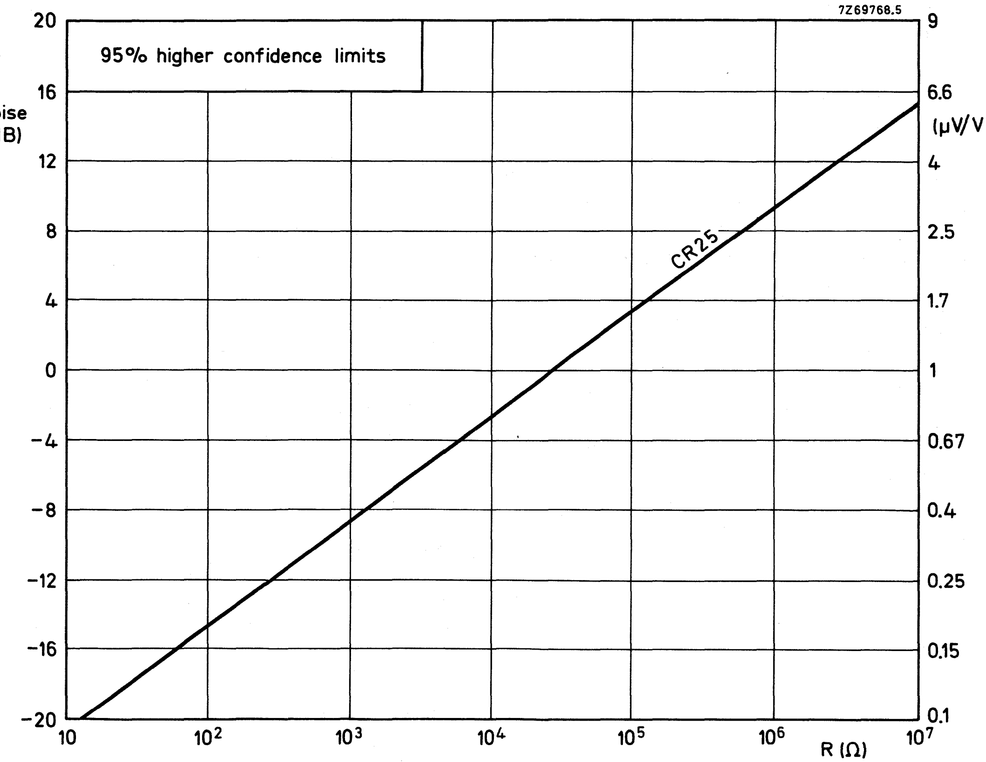


Fig. 5 Noise as a function of the resistance value; 0 dB = 1 μV/V.

High-frequency behaviour

The behaviour of a resistor at high frequencies is influenced not only by its construction but also by external factors such as length of leads, environmental stray capacitances and the measuring apparatus. Thus these factors have to be considered when measuring. The following table gives typical values under test conditions at 250 MHz using the measuring arrangement shown below. An RX-meter type 250 A of Boonton Radio Corporation is used.

Frequency: 250 MHz

	CR25	
R_{nom} (Ω)	$\frac{\lvert Z \rvert}{R_{nom}}$	φ^o
10	2,97	70
22	1,61	51
56	1,07	28
100	1,02	22
220	0,99	9
560	0,97	−5
1000	0,92	−15
2200	0,82	−35
5600	0,41	−66

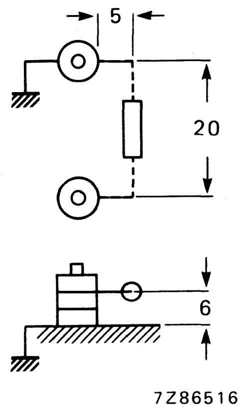


Fig. 6 Measuring arrangement.

TESTS AND REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publication 115-1, category 55/155/56 (rated temperature range −55 to + 155 °C; damp heat, long term, 56 days) and along the lines of IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components". In the following table the tests are listed with reference to the relevant clauses of IEC publications 115-1 and 68; a short description is also given of the test procedure and requirements. In some instances deviations from the IEC specification were necessary for our method of specifying.

Table

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
4.16		Robustness of terminations		
4.16.2	Ua	Tensile all samples	ϕ 0.5 mm: load 5 N; 10 s ϕ 0.6 mm: load 10 N; 10 s	number of failures $< 10 \cdot 10^{-6}$
4.16.3	Ub	Bending half number of samples	ϕ 0.5 mm: load 2.5 N; 4 x 90° ϕ 0.6 mm: load 5 N; 4 x 90°	
4.16.3	Uc	Torsion other half number of samples	3 x 360° in opposite directions	no damage ΔR max. 0.5% + 0.05 Ω

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
4.17	Ta	Soldering	solderability: 2 s 235 °C, flux 600	good tinning, no damage
4.18	Tb		thermal shock: 3 s 350 °C, 6 mm from body	ΔR max. 0.5% + 0.05 Ω
4.19	Na	Rapid change of temperature	½ h - 55 °C/½h + 155 °C, 5 cycles	ΔR max. 0.5% + 0.05 Ω
4.22	Fc	Vibration	frequency 10 to 500 Hz; displacement 1.5 mm or acceleration 10g, three directions; total 6 h	no damage ΔR max. 0.5% + 0.05 Ω
4.20	Eb	Bump	3 x 1500 bumps in three directions, 40 g	no damage ΔR max. 0.5% + 0.05 Ω
4.23		Climatic sequence		
4.23.2	Ba	Dry heat	16 hours 155 °C	
4.23.3	D	Damp heat (accel.) 1st cycle	24 hours; 55 °C; 95 to 100% R.H.	
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 (accel.) remaining cycles	5 days; 55 °C; 95 to 100% R.H.	R_{ins} = min. 1000 MΩ ΔR max. 1.5% + 0.1 Ω for R ⩽ 220 kΩ max. 3% for R > 220 kΩ
4.24.2	Ca	Damp heat (steady state)	56 days; 40 °C; 90 to 95% R.H. The dissipation should not exceed 1% of the value indicated by Fig.3	R_{ins}: min. 1000 MΩ ΔR max.: 1.5% + 0.1 Ω for R ⩽ 220 kΩ; ΔR max. 3% ± 0.1 Ω for R > 220 kΩ
4.25.1	–	Endurance	1000 hours; 70 °C; dissipation taken from Fig.3	for R ⩽ 1 MΩ ΔR max.: 1.5% + 0.1 Ω for R > 1 MΩ ΔR max.: 2% ± 0.1 Ω
4.8.4.2	–	Temperature coefficient	between –55 °C and + 155 °C	see Fig.4
4.7	–	Voltage proof on insulation	500 V (RMS) during 1 minute; V-block method	no breakdown

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
4.14	–	Noise	IEC publication 195	see Fig. 5
4.6.1.1	–	Insulation resistance	100 V (DC) during 1 minute; V-block method	min. 10^4 MΩ
4.13	–	Short time overload	room temperature, dissipation 6.25 x value taken from Fig. 3, (voltage not more than 2 x limiting voltage), 10 cycles, 5 s on, 45 s off	ΔR max. 1% + 0.05 Ω
4.11	–	Voltage coefficient	–	$< 5 \cdot 10^{-6}$

PACKING

The resistors are supplied on bandolier, either 1000, 2000 or 5000 resistors in ammopack and 5000 on reel. See General Section for details.

Dimensions of bandolier

type	a ± 0.5	A ± 1.5	B1 to B2 ± max	S (spacing)	T (max. deviation of spacing)
CR25	6	52,5	1.2	5	1 mm per 10 spacings
CR25	6	26 + 1.5 – 0	1.2	5	0.5 mm per 5 spacings

Dimensions of ammopack

	M	N	P
1000 resistors	82	28	262
2000 resistors	50	50	255
5000 resistors	78	98	270

Dimensions of reel

type	quantity	Q	V
CR25	5000	305	73

STANDARD FILM

STANDARD FILM RESISTORS

metal film

QUICK REFERENCE DATA

Resistance range			1 Ω to 2.4 MΩ, E24 series
Resistance tolerance			± 5% (E24); ± 1% (E24/E96)
Temperature coefficient			
R ⩽ 4.7 Ω			⩽ ± 250.10^{-6}/K
4.7 Ω < R ⩽ 100 kΩ			⩽ ± 100.10^{-6}/K
R > 100 kΩ			⩽ ± 250.10^{-6}/K
Nominal dissipation, P_n at T_{amb} = 70 °C*			0.50 W
Thermal resistance, R_{th}			170 K/W
Noise			
R ⩽ 68 kΩ		max.	0.1 μV/V
R > 68 kΩ ⩽ 100 kΩ		max.	0.5 μV/V
R > 100 kΩ		max.	1.5 μV/V
Basic specifications			IEC 115-1 and 115-2
Climatic category (IEC 68)			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
short time overload	ΔR/R	max.	0.25% + 0.05 Ω

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 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 68-2045.

MECHANICAL DATA

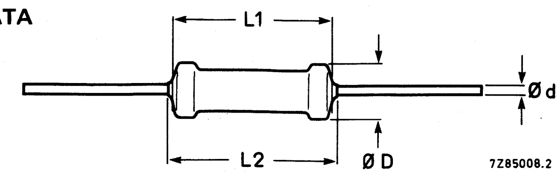


Fig. 1 Standard version, specially made to obtain a minimum "clean lead to clean lead" dimension L2 (bare bottom).

type and style	D	L1	L2 max	d
SFR16S	1.7 $^{+0.2}_{-0.1}$	3.2	3.4	0.45 ± 0.05

* See Fig.2 in datasheet SFR16T.

The length of the body is measured by inserting the leads into holes of two identical gauge plates and moving these plates parallel to each other until the resistor body is clamped without deformation (IEC publication 294). For leads of 0.5 mm diameter, the diameter of the holes in the gauge plates is 1.0 mm.

Mass 12.5 g per 100 resistors

Mounting

The resistors are suitable for processing on automatic insertion equipment and cutting and bending machines. The minimum pitch is 2e (5 mm). For temperature rise at soldering point, see Fig.3.

Marking

The nominal resistance and the tolerance are marked on the resistors by four or five coloured bands according to IEC publication 62 "Colour code for fixed resistors".

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated resistance (nominal resistance) are taken from the E24 series for R ± 5% and from the E96 series for R ± 1% within the range 1 Ω to 2.4 MΩ. E24 and E96 series of values are given in the table "Standard series of values in a decade" at the back of the handbook.

The limiting voltage (DC or RMS) is 200 V. This is the maximum voltage that may be applied continuously to the resistor element; see IEC publications 115-1 and 115-4.

type	bandolier width	packing	quantity	resistance range	tolerance ± %	catalogue number
SFR16S	26 mm	ammopack	5000 2000	1 Ω - 2.4 MΩ	5	2322 187 43 . . . 2322 187 63 . . .
	52 mm	ammopack	5000 1000 5000 1000	1 Ω - 2.4 MΩ	5 5 1 1	2322 187 53 . . . 2322 187 73 . . . 2322 187 2 . . . . 2322 187 1 . . . .
	52 mm	reel	5000 5000	1 Ω - 2.4 MΩ	5 1	2322 187 83 . . . 2322 187 3 . . . .

COMPOSITION OF THE CATALOGUE NUMBER

The catalogue number in the above table is completed by inserting the resistance code: the first two figures (for 1% tolerance, the first three figures) of the resistance (in Ω) followed by:

8 for R = 1 to 9.76 Ω
9 for R = 10 to 97.6 Ω
1 for R = 100 to 976 Ω
2 for R = 1 to 9.76 kΩ
3 for R = 10 to 97.6 kΩ
4 for R = 100 to 976 kΩ
5 for R = 1 to 2.4 MΩ

Examples

The catalogue number of a resistor SFR16S of 5600 Ω ± 5%, on a 52 mm bandolier of 1000 items, supplied in ammopack, is 2322 180 73562.

The catalogue number of a resistor SFR16S of 750 Ω ± 1% on a bandolier of 1000 items, supplied in ammopack, is 2322 187 17501.

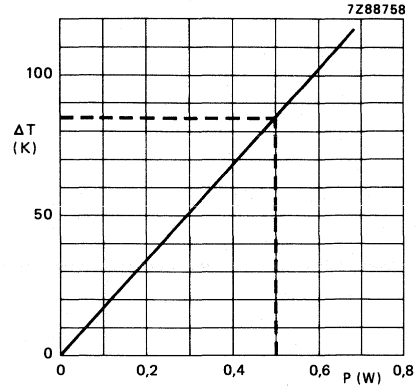


Fig.2 Hot-spot temperature rise (ΔT) as a function of dissipated power.

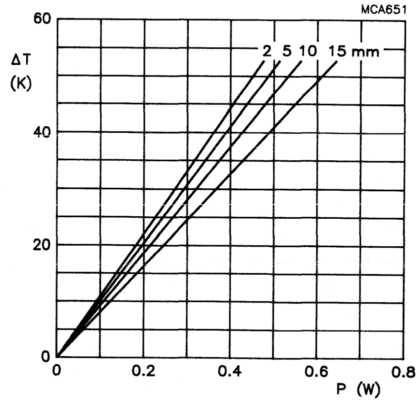


Fig.3 Temperature rise (ΔT) at the end of lead (soldering point) as a function of dissipated power, at various lead lengths after mounting.

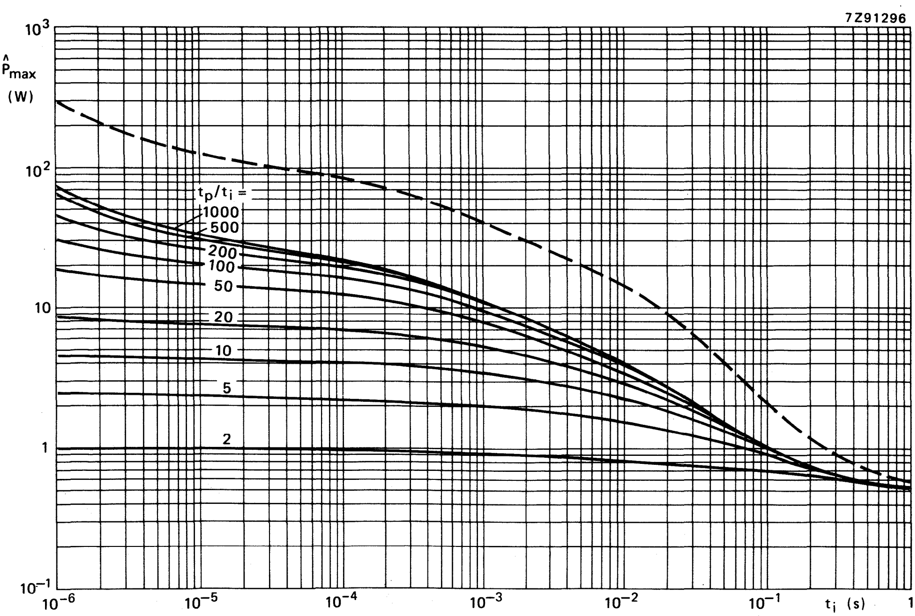


Fig.4 Max. permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i).

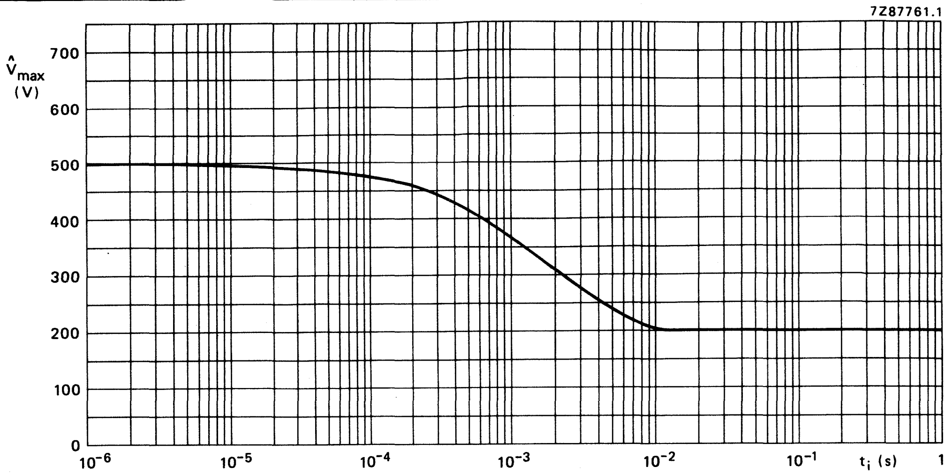


Fig.5 Maximum permissible peak pulse voltage as a function of pulse duration.

TESTS AND REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publication 115-1, category 55/155/56 (rated temperature range –55 to + 155 °C; damp heat, long term, 56 days) and along the lines of IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components". In the following table the tests are listed with reference to the relevant clauses of IEC publications 115-1 and 68; a short description is also given of the test procedure and requirements. In some instances deviations from the IEC recommendation were necessary for our method of specifying.

Table 4

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
4.16		Robustness of terminations		
4.16.2	Ua	Tensile all samples	ϕ 0.5 mm; load 5 N; 10 s	number of failures < 10 ppm
4.16.3	Ub	Bending half number of samples	ϕ 0.5 mm; load 2,5 N; 4 x 90°	
4.16.4	Uc	Torsion other half number of samples	3 x 360° in opposite directions	no damage ΔR max. 0.25% + 0.05 Ω
4.17	T_a	Soldering	solderability: 2 s 235 °C, flux 600	good tinning, no damage
4.18	T_b		thermal shock: 3 s 350 °C, 6 mm from body	ΔR max. 0.25% + 0.05 Ω
4.19	Na	Rapid change of temperature	½ h –55 °C/½ h + 155 °C, 5 cycles	ΔR max. 0.25% + 0.05 Ω

IEC115-1 clause	IEC68 test method	test	procedure	requirements
4.22	Fc	Vibration	frequency 10-500 Hz, displacement 1.5 mm or acceleration 10g, three directions; total 6 h (3 x 2 h)	no damage ΔR max. 0.25% + 0.05 Ω
4.20	Eb	Bump	3 x 1500 bumps in three directions, 40g	no damage ΔR max. 0.25% + 0.05 Ω
4.23		Climatic sequence		
4.23.2	Ba	Dry heat	16 h, 155 ^{o}C	
4.23.3	D	Damp heat (accel) 1st cycle	24 h; 55 ^{o}C; 90-100% R.H.	
4.23.4	Aa	Cold	2 h; –55 ^{o}C	
4.23.5	M	Low air pressure	2 h; 8.5 kPa; 15-35 ^{o}C	
4.23.6	D	Damp heat (accel) remaining cycles	5 days; 55 ^{o}C; 95-100% R.H.	R_{ins}min. 1000 MΩ ΔR max. 1% + 0.05 Ω
4.24.2	Ca	Damp heat steady state	56 days; 40 ^{o}C; 90-95% R.H. dissipation 0.01 P_n	R_{ins}min. 1000 MΩ ΔR max. 1% + 0.05 Ω
4.25.1	–	Endurance	1000 hours; 70 ^{o}C P_n or V_{max}	ΔR max. 1% + 0.05 Ω
4.8.4.2	–	Temperature coefficient	between –55 ^{o}C and + 155 ^{o}C	$R \leqslant 4.7\ \Omega$: $\leqslant \pm 250.10^{-6}$/K $4.7\ \Omega < R \leqslant 100$ kΩ: $\leqslant \pm 100.10^{-6}$/K $R > 100$ kΩ: $\leqslant \pm 250.10^{-6}$/K
4.7	–	Voltage proof on insulation	400 V (RMS) during 1 minute V block method	no breakdown
4.12	–	Noise	IEC publication 195	$R \leqslant 68$ kΩ: max. 0.1 μV/V 68 k$\Omega < R \leqslant 100$ kΩ: max. 0.5 μV/V $R > 100$ kΩ: max. 1.5 μV/V
4.6.1.1	–	Insulation resistance	100 V (DC) during 1 min. V block period	min. 10^4 MΩ

IEC115-1	IEC 68 test method	test	procedure	requirements
4.13	–	Short time overload	Room temperature, dissipation 6.25 x 0.25 W (voltage not more than 2 x limiting voltage), 10 cycles 5 s on, 45 s off	ΔR max. 0.25% + 0.05 Ω
		Intermittent overload acc. to JIS-C5202 5.8	3 x 0.25 W; 1 s on – 25 s off; 10 000 ± 200 cycles V max. 600 V	ΔR max. 0.75% + 0.05 Ω
			4 x 0.16 W; 1 s on – 25 s off; 10 000 ± 200 cycles V max. 600 V	ΔR max. 0.75% + 0.05 Ω
See 2nd amendment to IEC 115-1, Jan.87.		Pulse load		See Figs 4 and 5

PACKING

The resistors are supplied on bandolier in ammopack or on reel. See General section for details.

type	quantity per box		
	in ammopack on bandolier 52 mm	26 mm	52 mm bandolier on reel and ammopack
SFR16S	1000	2000	5000

Dimensions of bandolier

	a ± 0.5	A	B1-B2 ± max.	S (spacing)	T (max. deviation of spacing)
	6	52.5 ± 1.5	0.5	5	1 mm per 10 spacings
	6	26 + 1.5 – 0	0.5	5	0.5 mm per 5 spacings

Dimensions of ammopack

	M	N	P
1000 resistors	75	30	140
2000 resistors	50	34	256
5000 resistors	51	73	255
5000 resistors	75	73	270

Dimensions of reel

	Q	V	R
5000 resistors	265	65	86

STANDARD FILM RESISTORS

metal film

QUICK REFERENCE DATA

Resistance range			1 Ω to 3 MΩ, E24 series
Resistance tolerance			± 5%
Temperature coefficient			
R ⩽ 4.7 Ω			⩽ ± 250.10^{-6}/K
4.7 Ω < R ⩽ 100 kΩ			⩽ ± 100.10^{-6}/K
R > 100 kΩ			⩽ ± 250.10^{-6}/K
Rated dissipation, P_n at T_{amb} = 70 °C*			0.50 W
Thermal resistance, R_{th}			170 K/W
V_{max}			200 V
Noise			
R ⩽ 68 kΩ		max.	0.1 μV/V
R > 68 kΩ ⩽ 100 kΩ		max.	0.5 μV/V
R > 100 kΩ		max.	1.5 μV/V
Basic specifications			IEC 115-1 and 115-2
Climatic category (IEC 68)			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
short time overload	ΔR/R	max.	0.25% + 0.05 Ω

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 light-green 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 68-2045.

MECHANICAL DATA

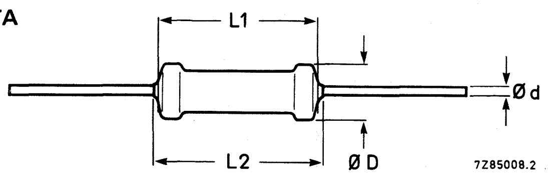


Fig. 1 Standard version, specially made to obtain a minimum "clean lead to clean lead" dimension L2 (bare bottom).

type and style	D	L1	L2 max	d
SFR16T	1.9	3.5	3.7	0.45 ± 0.05

* See Fig.2.

The length of the body is measured by inserting the leads into holes of two identical gauge plates and moving these plates parallel to each other until the resistor body is clamped without deformation (IEC publication 294). For leads of 0.5 mm diameter, the diameter of the holes in the gauge plates is 0.8 mm.

Mass 12.5 g per 100 resistors.

Mounting

The resistors are suitable for processing on automatic insertion equipment and cutting and bending machines. The minimum pitch is 2e (5 mm). For temperature rise at soldering point, see Fig.5.

Marking

The nominal resistance and the tolerance are marked on the resistors by four coloured bands according to IEC publication 62 "Colour code for fixed resistors".

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated resistance (nominal resistance) are taken from the E24 series within the range 1 Ω to 3 MΩ. E24 series of values is given in the table "Standard series of values in a decade" at the back of the handbook. The tolerance on the rated resistance is ± 5%.

The limiting voltage (DC or RMS) is 200 V. This is the maximum voltage that may be applied continuously to the resistor element; see IEC publications 115-1 and 115-4. The maximum permissible hot-spot temperature is 155 °C.

type	bandolier width	packing	quantity	resistance range	tolerance ± %	catalogue number
SFR16T	26 mm	ammopack	2000	1 Ω to 3 MΩ	5	2322 180 63 . . .
	26 mm	ammopack	5000	1 Ω to 3 MΩ	5	2322 180 43 . . .
	52 mm	ammopack	1000	1 Ω to 3 MΩ	5	2322 180 73 . . .
	52 mm	ammopack	5000	1 Ω to 3 MΩ	5	2322 180 53 . . .
	52 mm	on reel	5000	1 Ω to 3 MΩ	5	2322 180 83 . . .

COMPOSITION OF THE CATALOGUE NUMBER

The catalogue number in the above table is completed by inserting the resistance code: the first two figures of the resistance (in Ω) followed by:

8 for R = 1 to 9.1 Ω
9 for R = 10 to 91 Ω
1 for R = 100 to 910 Ω
2 for R = 1 to 9.1 kΩ
3 for R = 10 to 91 kΩ
4 for R = 100 to 910 kΩ
5 for R = 1 to 3 MΩ

Example

The catalogue number of a resistor SFR16T of 5600 Ω ± 5%, on a 52 mm bandolier of 1000 items, supplied in ammopack, is 2322 180 73562.

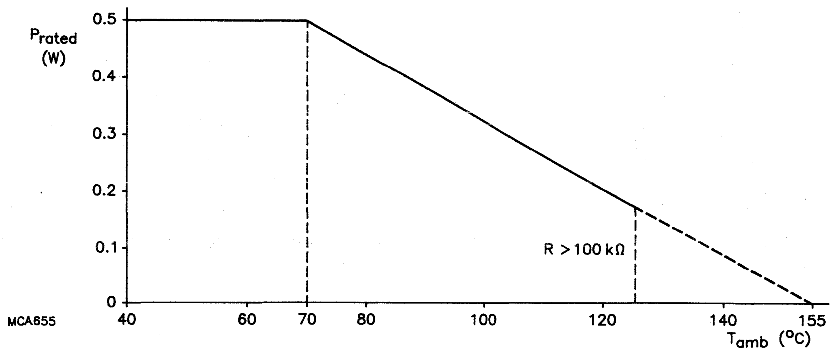


Fig.2 Maximum dissipation (P_{max}) as a function of ambient temperature (T_{amb}).

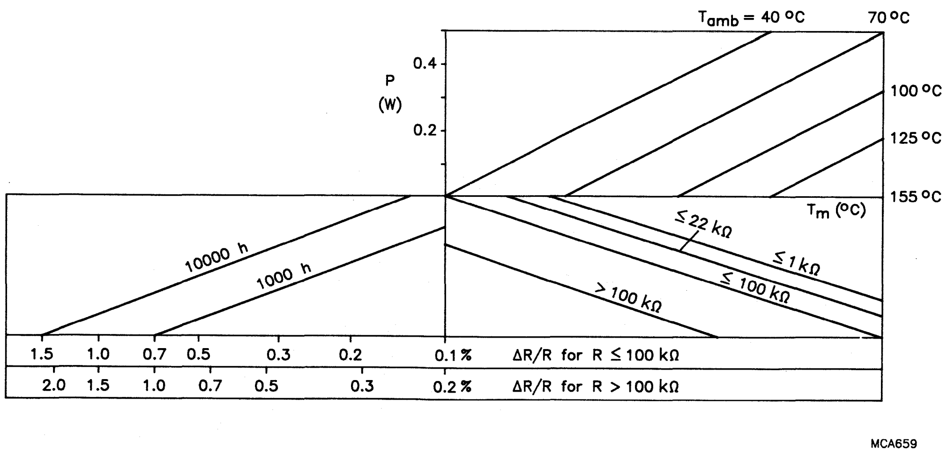


Fig.3 Drift nomogram.

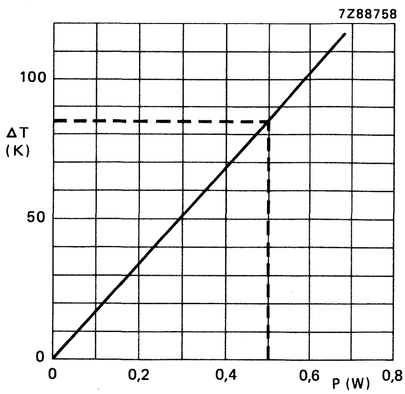


Fig.4 Hot-spot temperature rise (ΔT) as a function of dissipated power.

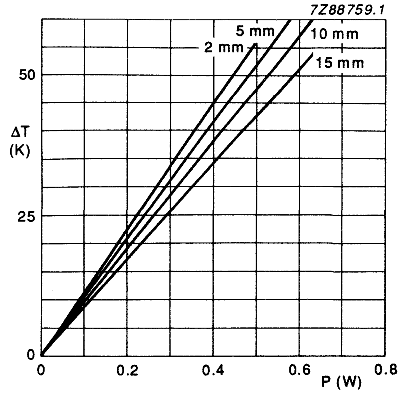


Fig.5 Temperature rise (ΔT) at the end of lead (soldering point) as a function of dissipated power, at various lead lengths after mounting.

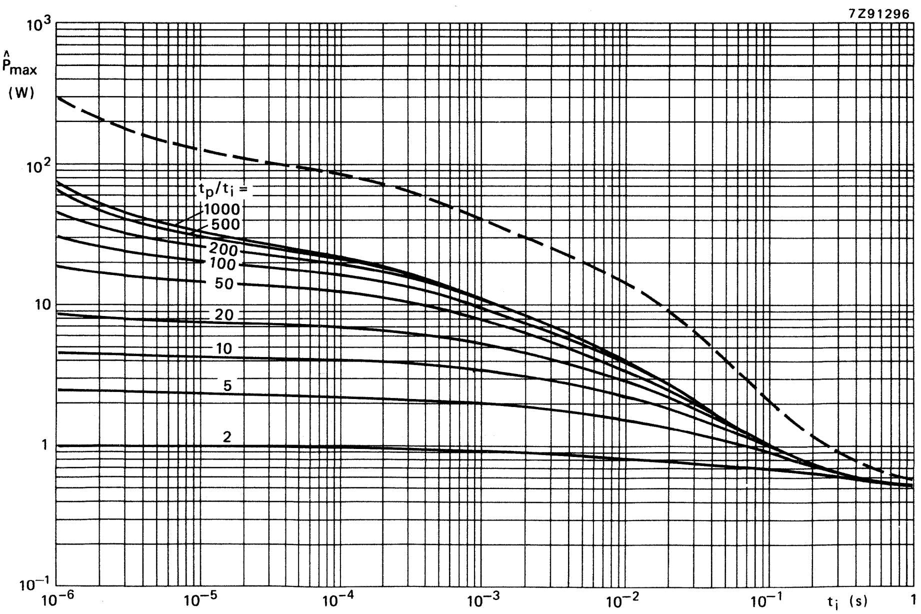


Fig.6 Max. permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i).

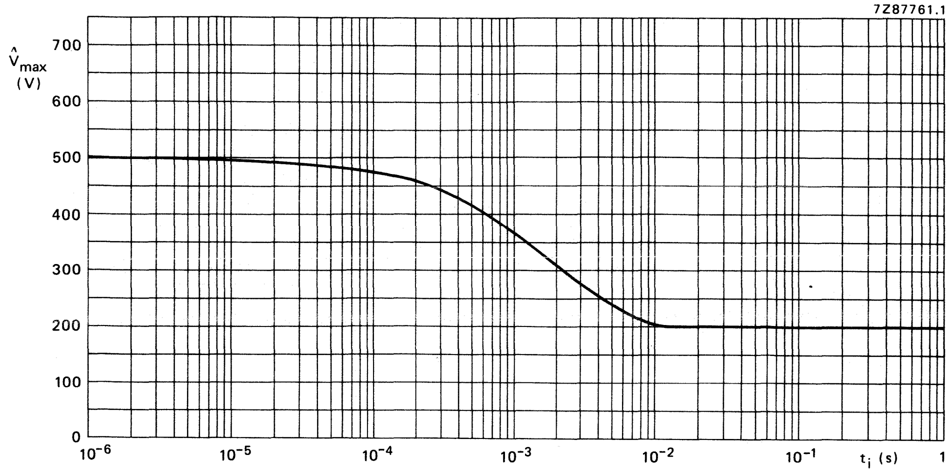


Fig.7 Maximum permissible peak pulse voltage as a function of pulse duration.

TESTS AND REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publication 115-1, category 55/155/56 (rated temperature range −55 to + 155 °C; damp heat, long term, 56 days) and along the lines of IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components". In the following table the tests are listed with reference to the relevant clauses of IEC publications 115-1 and 68; a short description is also given of the test procedure and requirements. In some instances deviations from the IEC recommendation were necessary for our method of specifying.

Table 4

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
4.16		Robustness of terminations		
4.16.2	Ua	Tensile all samples	ϕ 0.5 mm; load 5 N; 10 s	number of failures < 10 ppm (4.16.2 and 4.16.3)
4.16.3	Ub	Bending half number of samples	ϕ 0.5 mm; load 2,5 N; 4 x 90°	
4.16.4	Uc	Torsion other half number of samples	3 x 360° in opposite directions	no damage ΔR max. 0.25% + 0.05 Ω
4.17	T_a	Soldering	solderability: 2 s 235 °C, flux 600	good tinning, no damage
4.18	T_b		thermal shock: 3 s 350 °C, 6 mm from body	ΔR max. 0.25% + 0.05 Ω
4.19	Na	Rapid change of temperature	½ h −55 °C/½ h + 155 °C, 5 cycles	ΔR max. 0.25% + 0.05 Ω

IEC115-1 clause	IEC68 test method	test	procedure	requirements
4.22	Fc	Vibration	frequency 10-500 Hz, displacement 1.5 mm or acceleration 10g, three directions; total 6 h (3 x 2 h)	no damage ΔR max. 0.25% + 0.05 Ω
4.20	Eb	Bump	3 x 1500 bumps in three directions, 40g	no damage ΔR max. 0.25% + 0.05 Ω
4.23		Climatic sequence		
4.23.2	Ba	Dry heat	16 h, 155 °C	
4.23.3	D	Damp heat (accel) 1st cycle	24 h; 55 °C; 90-100% R.H.	
4.23.4	Aa	Cold	2 h; –55 °C	
4.23.5	M	Low air pressure	2 h; 8.5 kPa; 15-35 °C	
4.23.6	D	Damp heat (accel) remaining cycles	5 days; 55 °C; 95-100% R.H.	R_{ins}min. 1000 MΩ ΔR max. 1% + 0.05 Ω
4.24.2	Ca	Damp heat steady state	56 days; 40 °C; 90-95% R.H. dissipation 0.01 P_n	R_{ins}min. 1000 MΩ ΔR max. 1% + 0.05 Ω
4.25.1	–	Endurance	1000 hours; 70 °C P_n or V_{max}	ΔR max. 1% + 0.05 Ω
4.8.4.2	–	Temperature coefficient	between –55 °C and + 155 °C	$R \leqslant 4.7\ \Omega$: $\leqslant \pm 250.10^{-6}$/K $4.7\ \Omega < R \leqslant 100\ k\Omega$: $\leqslant \pm 100.10^{-6}$/K $R > 100\ k\Omega$: $\leqslant \pm 250.10^{-6}$/K
4.7	–	Voltage proof on insulation	400 V (RMS) during 1 minute V block method	no breakdown
4.12	–	Noise	IEC publication 195	$R \leqslant 68\ k\Omega$: max. 0.1 μV/V $68\ k\Omega < R \leqslant 100\ k\Omega$: max. 0.5 μV/V $R > 100\ k\Omega$: max. 1.5 μV/V
4.6.1.1	–	Insulation resistance	100 V (DC) during 1 min. V block method	min. 10^4 MΩ

IEC115-1 clause	IEC 68 test method	test	procedure	requirements
4.13	–	Short time overload	Room temperature, dissipation 6.25 x 0.25 W (voltage not more than 2 x limiting voltage), 10 cycles 5 s on, 45 s off	ΔR max. 0.25% + 0.05 Ω
		Intermittent overload acc. to JIS-C5202 5.8	16 x 0.16 W; 1 s on – 25 s off; 10 000 ± 200 cycles V max. 600 V	ΔR max. 0.75% + 0.05 Ω
See 2nd amendment to IEC 115-1, Jan.87		Pulse load		See Figs 6 and 7

PACKING

The resistors are supplied on bandolier in ammopack or on reel. See General section for details.

type	quantity per box		
	in ammopack on bandolier 52 mm	26 mm	52 mm bandolier on reel and ammopack
SFR16T	1000	2000	5000

Dimensions of bandolier

	a ± 0.5	A	B1-B2 ± max.	S (spacing)	T (max. deviation of spacing)
	6	52.5 ± 1.5	0.5	5	1 mm per 10 spacings
	6	26 + 1.5 – 0	0.5	5	0.5 mm per 5 spacings

Dimensions of ammopack

	M	N	P
1000 resistors	75	30	140
2000 resistors	50	34	256
5000 resistors	75	73	270

Dimensions of reel

	Q	V	R
5000 resistors	265	75	86

STANDARD FILM RESISTORS

metal film

QUICK REFERENCE DATA

Resistance range			1 Ω to 3 MΩ, E24 series
Resistance tolerance			± 5%
Temperature coefficient			
$R \leqslant 4.7\ \Omega$			$\leqslant \pm\ 250.10^{-6}$/K
$4.7\ \Omega < R \leqslant 100\ k\Omega$			$\leqslant \pm\ 100.10^{-6}$/K
$R > 100\ k\Omega$			$\leqslant \pm\ 250.10^{-6}$/K
Rated dissipation			
at T_{amb} = 70 °C *			0.50 W
Thermal resistance, R_{th}			170 K/W
V_{max}			200 V
Noise			
$R \leqslant$ 68 kΩ		max.	0.1 μV/V
$R >$ 68 kΩ $\leqslant$ 100 kΩ		max.	0.5 μV/V
$R >$ 100 kΩ		max.	1.5 μV/V
Basic specifications			IEC 115-1 and 115-2
Climatic category (IEC 68)			55/155/56
Approval			CECC 40101
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
short time overload	ΔR/R	max.	0.25% + 0.05 Ω

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 light-green 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 68-2045.

MECHANICAL DATA

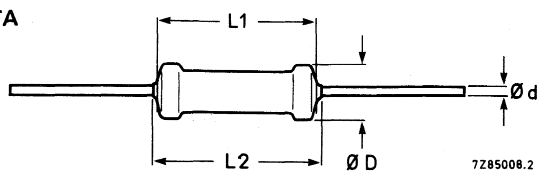


Fig. 1 Standard version, specially made to obtain a minimum "clean lead to clean lead" dimension L2 (bare bottom).

type and style	D	L1	L2 max	d
SFR16T	1.9	3.5	3.7	0.5 – 0.04

* See Fig.2.

The length of the body is measured by inserting the leads into holes of two identical gauge plates and moving these plates parallel to each other until the resistor body is clamped without deformation (IEC publication 294). For leads of 0.5 mm diameter, the diameter of the holes in the gauge plates is 0.8 mm.

Mass 12.5 g per 100 resistors.

Mounting

The resistors are suitable for processing on automatic insertion equipment and cutting and bending machines. The minimum pitch is 2e (5 mm). For temperature rise at soldering point, see Fig.5.

Marking

The nominal resistance and the tolerance are marked on the resistors by four coloured bands according to IEC publication 62 "Colour code for fixed resistors".

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated resistance (nominal resistance) are taken from the E24 series within the range 1 Ω to 3 MΩ. E24 series of values is given in the table "Standard series of values in a decade" at the back of the handbook. The tolerance on the rated resistance is ± 5%.

The limiting voltage (DC or RMS) is 200 V. This is the maximum voltage that may be applied continuously to the resistor element; see IEC publications 115-1 and 115-4. The maximum permissible hot-spot temperature is 155 °C.

type	bandolier width	packing	quantity	resistance range	tolerance ± %	catalogue number
SFR16T	52 mm	ammopack	1000	1 Ω to 3 MΩ	5	2322 180 76 . . .
CECC	52 mm	ammopack	5000	1 Ω to 3 MΩ	5	2322 180 56 . . .
	52 mm	on reel	5000	1 Ω to 3 MΩ	5	2322 180 86 . . .

COMPOSITION OF THE CATALOGUE NUMBER

The catalogue number in the above table is completed by inserting the resistance code: the first two figures of the resistance (in Ω) followed by:

8 for R = 1 to 9.1 Ω
9 for R = 10 to 91 Ω
1 for R = 100 to 910 Ω
2 for R = 1 to 9.1 kΩ
3 for R = 10 to 91 kΩ
4 for R = 100 to 910 kΩ
5 for R = 1 to 3 MΩ

Example

The catalogue number of a resistor SFR16TCECC of 5600 Ω ± 5%, on a 52 mm bandolier of 1000 items, supplied in ammopack, is 2322 180 73562.

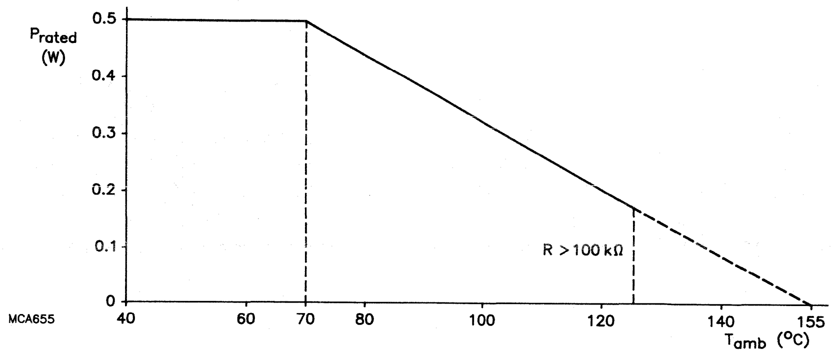


Fig.2 Maximum dissipation (P_{max}) as a function of ambient temperature (T_{amb}).

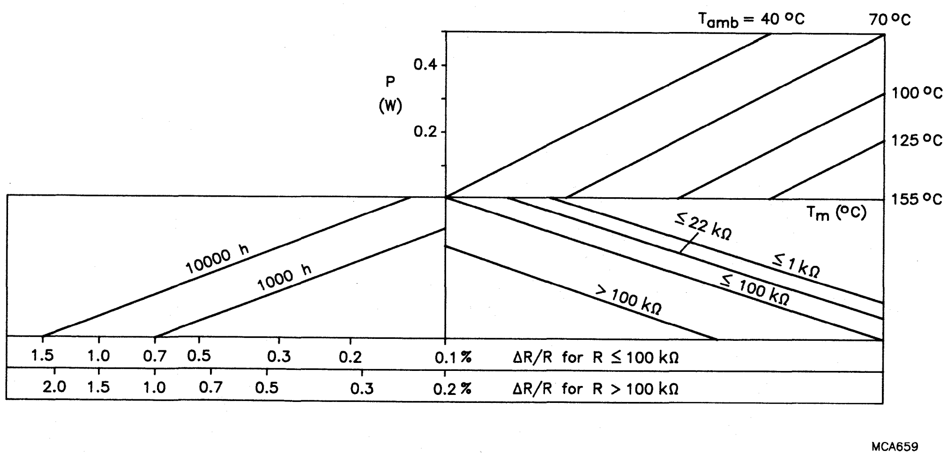


Fig.3 Drift nomogram.

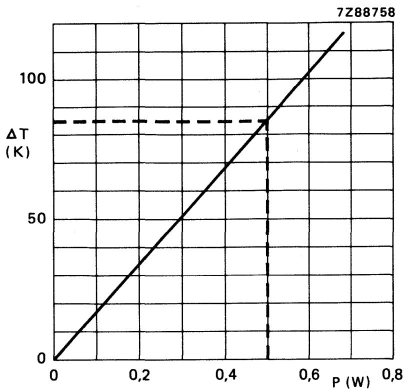


Fig.4 Hot-spot temperature rise (ΔT) as a function of dissipated power.

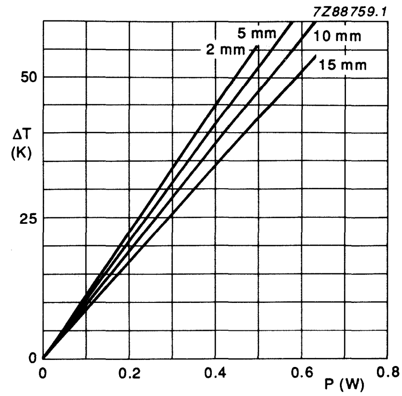


Fig.5 Temperature rise (ΔT) at the end of lead (soldering point) as a function of dissipated power, at various lead lengths after mounting.

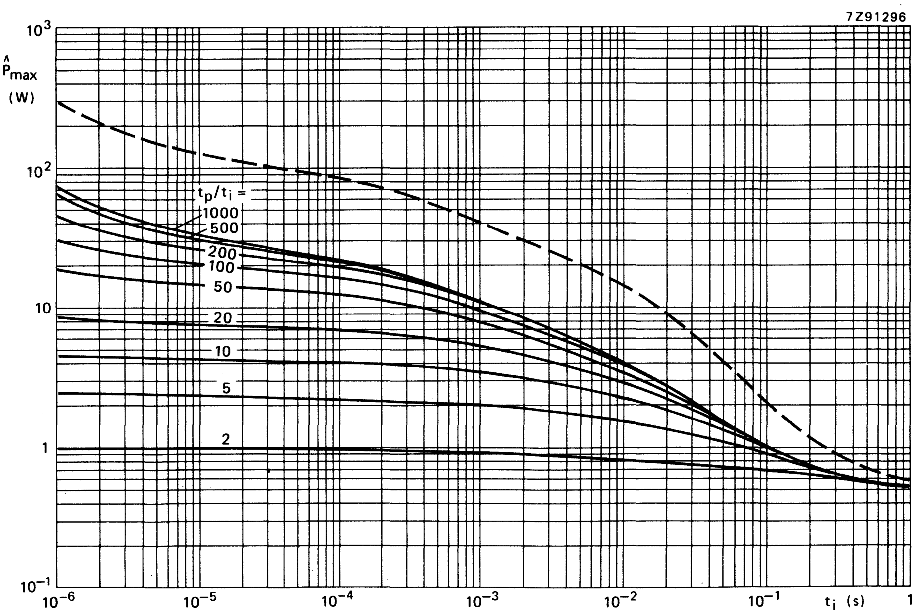


Fig.6 Max. permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i).

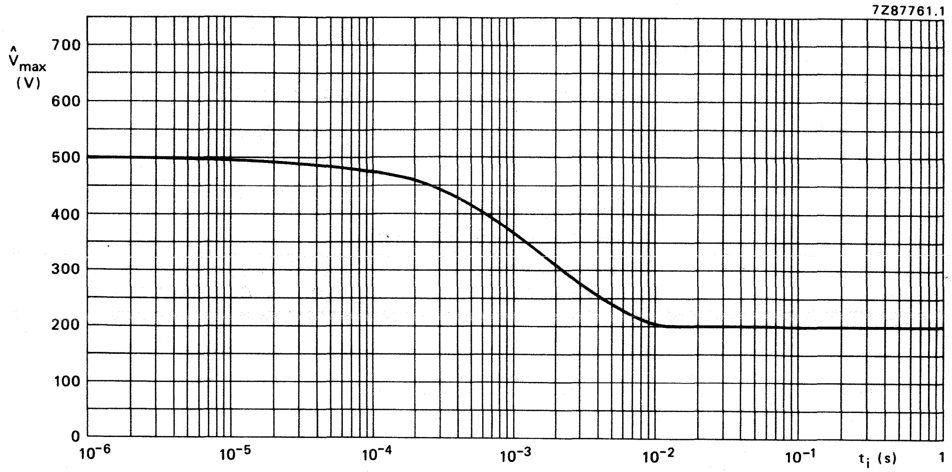


Fig.7 Maximum permissible peak pulse voltage as a function of pulse duration.

TESTS AND REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publication 115-1, category 55/155/56 (rated temperature range −55 to + 155 °C; damp heat, long term, 56 days) and along the lines of IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components". In the following table the tests are listed with reference to the relevant clauses of IEC publications 115-1 and 68; a short description is also given of the test procedure and requirements. In some instances deviations from the IEC recommendation were necessary for our method of specifying.

Table 4

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
4.16		Robustness of terminations		
4.16.2	Ua	Tensile all samples	ϕ 0.5 mm; load 5 N; 10 s	number of failures < 10 ppm
4.16.3	Ub	Bending half number of samples	ϕ 0.5 mm; load 2,5 N; 4 x 90°	
4.16.4	Uc	Torsion other half number of samples	3 x 360° in opposite directions	no damage ΔR max. 0.25% + 0.05 Ω
4.17	T_a	Soldering	solderability: 2 s 235 °C, flux 600	good tinning, no damage
4.18	T_b		thermal shock: 3 s 350 °C, 6 mm from body	ΔR max. 0.25% + 0.05 Ω
4.19	Na	Rapid change of temperature	½ h −55 °C/½ h + 155 °C, 5 cycles	ΔR max. 0.25% + 0.05 Ω

IEC115-1 clause	IEC 68 test method	test	procedure	requirements
4.22	Fc	Vibration	frequency 10-500 Hz, displacement 1.5 mm or acceleration 10g, three directions; total 6 h (3 x 2 h)	no damage ΔR max. 0.25% + 0.05 Ω
4.20	Eb	Bump	3 x 1500 bumps in three directions, 40g	no damage ΔR max. 0.25% + 0.05 Ω
4.23		Climatic sequence		
4.23.2	Ba	Dry heat	16 h, 155 °C	
4.23.3	D	Damp heat (accel) 1st cycle	24 h; 55 °C; 90-100% R.H.	
4.23.4	Aa	Cold	2 h; –55 °C	
4.23.5	M	Low air pressure	2 h; 8.5 kPa; 15-35 °C	
423.6	D	Damp heat (accel) remaining cycles	5 days; 55 °C; 95-100% R.H.	R_{ins}min. 1000 MΩ ΔR max. 1% + 0.05 Ω
4.24.2	Ca	Damp heat steady state	56 days; 40 °C; 90-95% R.H. dissipation 0.01 P_n	R_{ins}min. 1000 MΩ ΔR max. 1% + 0.05 Ω
4.25.1	–	Endurance	1000 hours, 70 °C P_n or V_{max}	ΔR max. 1% + 0.05 Ω
4.8.4.2	–	Temperature coefficient	between –55 °C and + 155 °C	$R \leqslant 4.7\ \Omega$: $\leqslant \pm\ 250.10^{-6}$/K $4.7\ \Omega < R \leqslant 100\ k\Omega$: $\leqslant \pm\ 100.10^{-6}$/K $R > 100\ k\Omega$: $\leqslant \pm\ 250.10^{-6}$/K
4.7	–	Voltage proof on insulation	400 V (RMS) during 1 minute V block method	no breakdown
4.12	–	Noise	IEC publication 195	$R \leqslant 68\ k\Omega$: max. 0.1 µV/V $68\ k\Omega < R \leqslant 100\ k\Omega$: max. 0.5 µV/V $R > 100\ k\Omega$: max. 1.5 µV/V
4.6.1.1	–	Insulation resistance	100 V (DC) during 1 min. V block method	min. 10^4 MΩ

IEC115-1 clause	IEC 68 test methode	test	procedure	requirements
4.13	–	Short time overload	Room temperature, dissipation 6.25 x 0.25 W (voltage not more than 2 x limiting voltage), 10 cycles 5 s on, 45 s off	ΔR max. 0.25% + 0.05 Ω
		Intermittent overload acc. to JIS-C5202 5.8	16 x 0.16 W; 1 s on – 25 s off; 10 000 ± 200 cycles V max. 600 V	ΔR max. 0.75% + 0.05 Ω
See 2nd amendment to IEC 115-1, Jan.87		Pulse load		See Figs 6 and 7

PACKING

The resistors are supplied on bandolier in ammopack or on reel. See General section for details.

type	quantity per box	
	in ammopack on bandolier 52 mm 26 mm	52 mm bandolier on reel and ammopack
SFR16T	1000 2000	5000

Dimensions of bandolier

	a ± 0.5	A	B1-B2 ± max.	S (spacing)	T (max. deviation of spacing)
	6	52.5 ± 1.5	0.5	5	1 mm per 10 spacings
	6	26 + 1.5 – 0	0.5	5	0.5 mm per 5 spacings

Dimensions of ammopack

	M	N	P
1000 resistors	75	30	140
2000 resistors	50	34	256
5000 resistors	75	73	270

Dimensions of reel

	Q	V	R
5000 resistors	265	75	86

STANDARD FILM RESISTORS

metal film

QUICK REFERENCE DATA

Resistance range			1 Ω to 10 MΩ, E24 series and jumper (zero Ω)
Resistance tolerance			± 5% and ± 2% (E24); ± 1% (E24/E96)
Temperature coefficient			
R ⩽ 1 MΩ			⩽ 100 . 10^{-6}/K
R > 1 MΩ			⩽ 250 . 10^{-6}/K
Rated dissipation			
at T_{amb} = 70 °C *			0.4 W
V_{max}			250 V
Noise			
R ⩽ 1 MΩ		max.	0.1 μV/V
R > 1 MΩ		max.	1.5 μV/V
Thermal resistance		R_{th}	200 K/W
Basic specifications			IEC 115-1 and 115-2
Climatic category (IEC 68)			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
short time overload	ΔR/R	max.	0.25% + 0.05 Ω

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 light-green 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 68-2-45.

MECHANICAL DATA

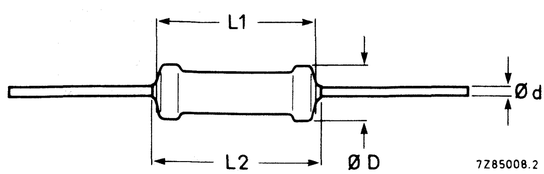


Fig. 1.

type	D_{max}	L1 max	L2 max	d
SFR25	2.5	6.5	7.0	0.55 ± 0.05

* See Fig.4.

The length of the body is measured by inserting the leads into holes of two identical gauge plates and moving these plates parallel to each other until the resistor body is clamped without deformation (IEC publication 294). For leads of 0.6 mm diameter, the diameter of the holes in the gauge plates is 1.0 mm.

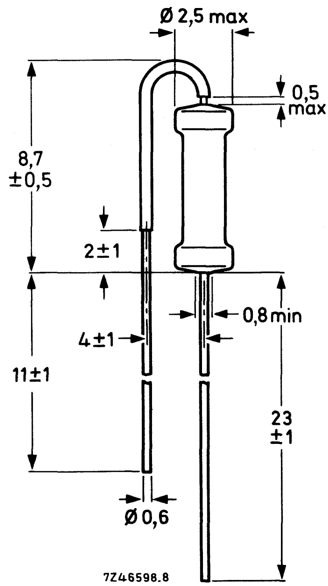


Fig.2 "Stand-up" type SFR25A, for vertical mounting. The bent lead is partially covered with an insulating lacquer with a breakdown voltage of at least 50 V (DC); resistor shown in 'mounted' situation.

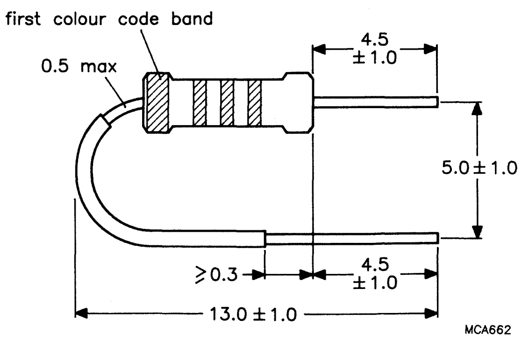


Fig.3 SFR25AF.

Mass 25 g per 100 resistors.

Mounting

The resistors are suitable for processing on automatic insertion equipment and cutting and bending machines. The minimum pitch is 4e (10.2 mm). The "stand-up" type, SFR25A, can be inserted into holes with a pitch of 1e. The types SFR25AS and SFR25AF can be inserted into holes with a pitch of 2e. For temperature rise at soldering point, see Fig.7.

Marking

The nominal resistance and the tolerance are marked on the resistors by four or five coloured bands according to IEC publication 62 "Colour code for fixed resistors". See also General Section.

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated resistance (nominal resistance) are taken from the E24 series within the range 1 Ω to 10 MΩ. E24 series of values is given in the table "Standard series of values in a decade" at the back of the handbook. The tolerance on the rated resistance is ± 5%, ± 2% or ± 1%.

The limiting voltage (DC or RMS) is 250 V. This is the maximum voltage that may be applied continuously to the resistor element; see IEC publications 115-1 and 115-4. The maximum permissible hot-spot temperature is 155 °C.

type	packing	quantity	resistance range	tolerance ± %	catalogue number
SFR25*	ammopack	1000	1 Ω to 10 MΩ	5	2322 181 53 . . .
52 mm bandolier		5000		5	2322 181 43 . . .
		1000		2	2322 181 54 . . .
		5000		2	2322 181 44 . . .
	on reel	5000		5	2322 181 63 . . .
		5000		2	2322 181 64 . . .
SFR25	ammopack	2000	1 Ω to 10 MΩ	5	2322 181 03 . . .
26 mm bandolier		2000		2	2322 181 04 . . .
SFR25A	in box	1000	1 Ω to 10 MΩ	5	2322 181 33 . . .
"stand-up"	(loose)	1000		2	2322 181 34 . . .
SFR25AF	in box (loose)	4000	1 Ω to 10 MΩ	5	2322 184 13 . . .
SFR25AS	in box	2000	1 Ω to 10 MΩ	5	
radial taped	on reel	4000		5	2322 184 43 . . .
SFR25	ammopack	1000	1 Ω to 10 MΩ	1	2322 188 1 . . . .
52 mm bandolier		5000		1	2322 188 2 . . . .
	on reel	5000		1	2322 188 3 . . . .

COMPOSITION OF THE CATALOGUE NUMBER

The catalogue number in the above table is completed by inserting the resistance code: the first two figures (for 1% tolerance, the first three figures) of the resistance (in Ω) followed by:

8 for R = 1 to 9.76 Ω
9 for R = 10 to 97.6 Ω
1 for R = 100 to 976 Ω
2 for R = 1 to 9.76 kΩ
3 for R = 10 to 97.6 kΩ
4 for R = 100 to 976 kΩ
5 for R = 1 to 9.76 MΩ
6 for R = 10 MΩ

Example

The catalogue number of a resistor SFR25 of 5600 Ω ± 5%, taped on a bandolier of 1000 items, supplied in ammopack, is 2322 181 53562.

* A jumper (zero Ω resistor, max. 10 mΩ at 5 A) is available:
1000 items on bandolier in ammopack, catalogue number 2322 181 90018
5000 items on bandolier in ammopack, catalogue number 2322 181 90019

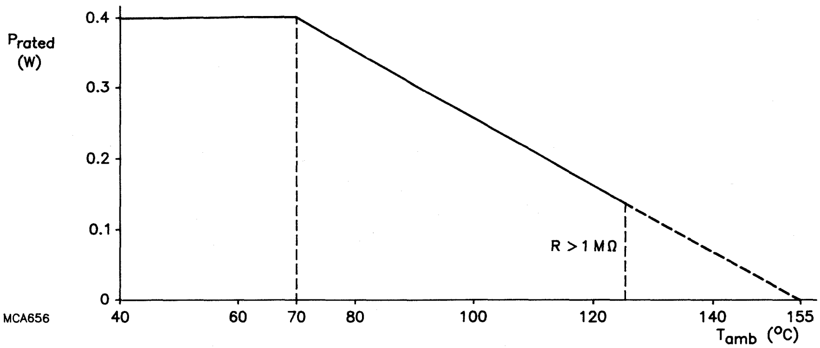


Fig.4 Maximum dissipation (P_{max}) as a function of ambient temperature (T_{amb}).

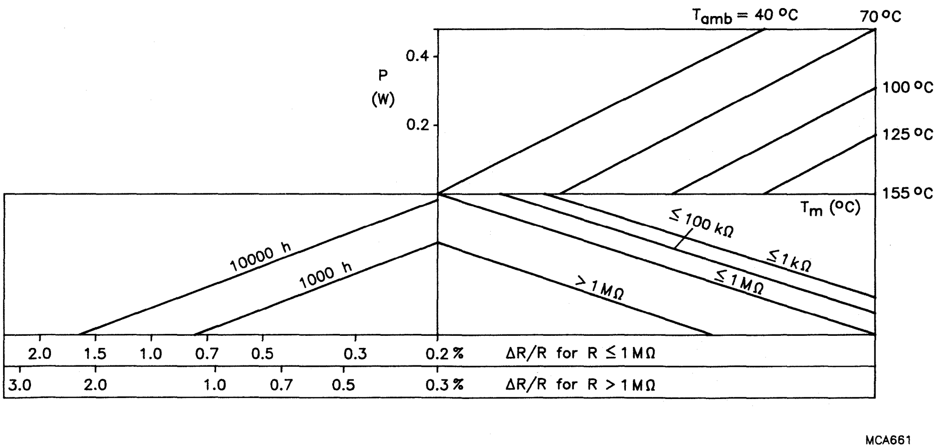


Fig.5 Drift nomogram.

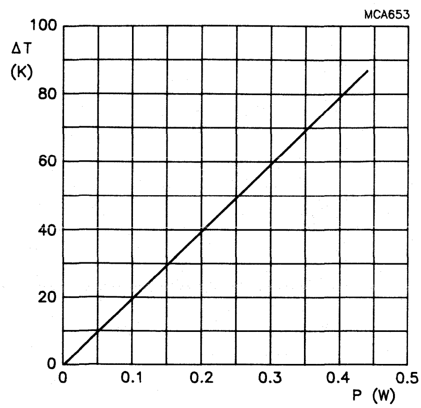


Fig.6 Hot-spot temperature rise (ΔT) as a function of dissipated power.

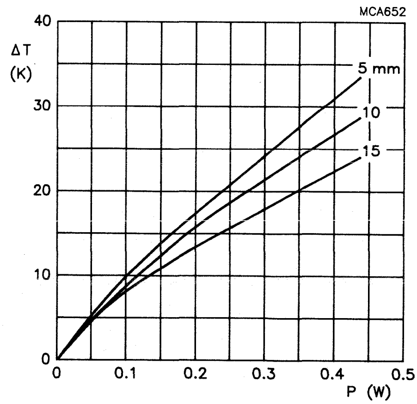


Fig.7 Temperature rise (ΔT) at the end of the lead (soldering point) as a function of dissipated power, at various lead lengths after mounting.

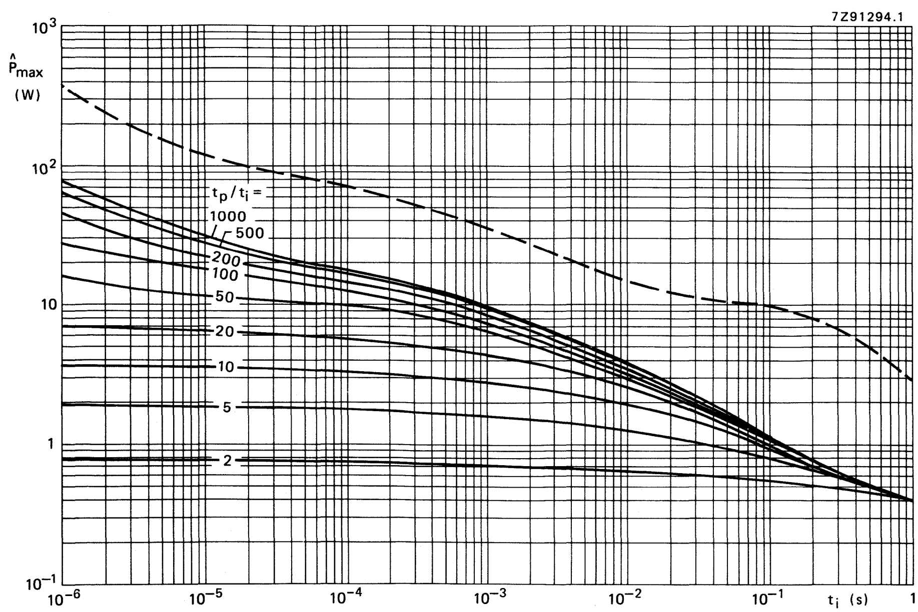


Fig.8 Maximum permissible peak pulse power as a function of pulse duration.

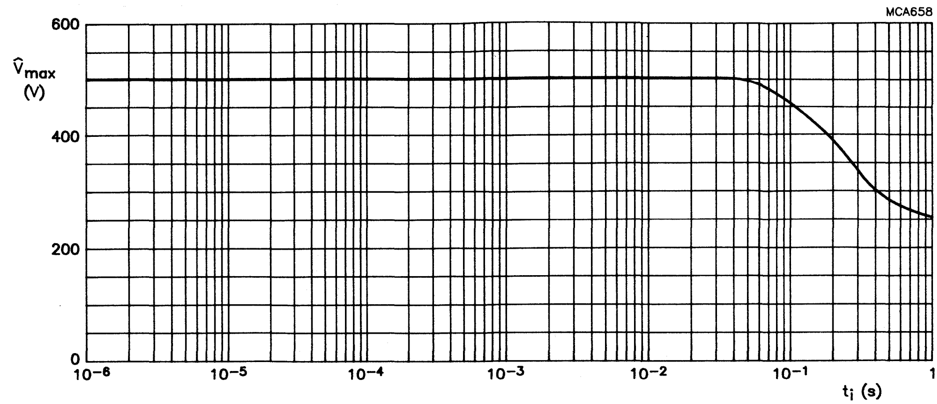


Fig.9 Maximum permissible peak pulse voltage versus pulse duration.

TESTS AND REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publication 115-1, category 55/155/56 (rated temperature range −55 to +155 °C; damp heat, long term, 56 days) and along the lines of IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components". In the following table the tests are listed with reference to the relevant clauses of IEC publications 115-1 and 68; a short description is also given of the test procedure and requirements. In some instances deviations from the IEC recommendation were necessary for our method of specifying.

Table 4

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
4.16		Robustness of terminations		
4.16.2	Ua	Tensile all samples	ϕ 0.6 mm; load 10N; 10 s	number of failures < 10 ppm
4.16.3	Ub	Bending half number of samples	ϕ 0.6 mm; load 5N; 4 x 90°	
4.16.4	Uc	Torsion other half number of samples	3 x 360° in opposite directions	no damage ΔR max. 0.25% + 0.05 Ω
4.17	Ta	Soldering	solderability: 2 s 235 °C, flux 600	good tinning, no damage
4.18	Tb		thermal shock: 3 s 350 °C, 6 mm from body	ΔR max. 0.25% + 0.05 Ω

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
4.19	Na	Rapid change of temperature	½ h −55 °C/½ h + 155 °C 5 cycles	ΔR max. 0.25% + 0.05 Ω
4.22	Fc	Vibration	frequency 10-500 Hz, displacement 1.5 mm or acceleration 10g, three directions; total 6 h (3 x 2 h)	no damage ΔR max. 0.25% + 0.05 Ω
4.20	Eb	Bump	3 x 1500 bumps in three directions, 40g	no damage ΔR max. 0.25% + 0.05 Ω
4.23		Climatic sequence		
4.23.2	Ba	Dry heat	16 h, 155 °C	
4.23.3	D	Damp heat (accel) 1st cycle	24 h; 55 °C; 95-100% R.H.	
4.23.4	Aa	Cold	2 h; −55 °C	
4.23.5	M	Low air pressure	2 h; 8.5 kPa; 15-35 °C	
4.23.6	D	Damp heat (accel) remaining cycles	5 days; 55 °C; 95-100% R.H.	R_{ins} min. 1000 MΩ ΔR max. 1% + 0.05 Ω
4.24.2	Ca	Damp heat steady state	56 days; 40 °C; 90-95% R.H. dissipation 0.01 P_n	R_{ins} min. 1000 MΩ ΔR max. 1% + 0.05 Ω
4.25.1	—	Endurance	1000 hours; 70 °C nominal dissipation or V_{max}	ΔR max. 1% + 0.05 Ω
4.8.4.2	—	Temperature coefficient	between −55 °C and + 155 °C	R ⩽ 1 MΩ: ⩽ $100 \cdot 10^{-6}$/K R > 1 MΩ: ⩽ $250 \cdot 10^{-6}$/K
4.7	—	Voltage proof on insulation	600 V (RMS) during 1 min., V-block method	no breakdown
4.12	—	Noise	IEC publication 195	R ⩽ 1 MΩ: max. 0.1 μV/V R > 1 MΩ: max. 1.5 μV/V
4.6.1.1	—	Insulation resistance	500 V (DC) during 1 min., V-block method	min. 10^4 MΩ
4.13	—	Short time overload	Room temperature, dissipation 6.25 P_n (voltage not more than 2 x limiting voltage), 10 cycles 5 s on, 45 s off	ΔR max. 0.25% + 0.05 Ω
See 2nd amendment to IEC 115-1, Jan. 87		Pulse load		see Figs 8 and 9

PACKING

Resistors with axial leads are supplied on bandolier in ammopack or on reel; those with radial leads are either loose in a cardboard box or, with bent leads, on a bandolier in ammopack. See General section for details.

type	quantity per box		
	on bandolier ammopack	bulk loose	bandolier on reel
SFR25	1000/2000/5000	–	5000
SFR25A	–	1000	–
SFR25AS		–	4000

Dimensions of bandolier

type	a ± 0.5	A	B1-B2 ± max.	S (spacing)	T (max. deviation of spacing)
SFR25	6	52.5 ± 1.5	1.2	5	1 mm per 10 spacings
SFR25	6	26 + 1.5 – 0	1.0	5	0.5 mm per 5 spacings

Dimensions of ammopack

	M	N	P
1000 resistors	82	28	262
2000 resistors	50	50	255
5000 resistors	78	98	270

Dimensions of reel

type	quantity	Q	V
SFR25	5000	305	75
SFR25AS	4000	356	40

Radial leads

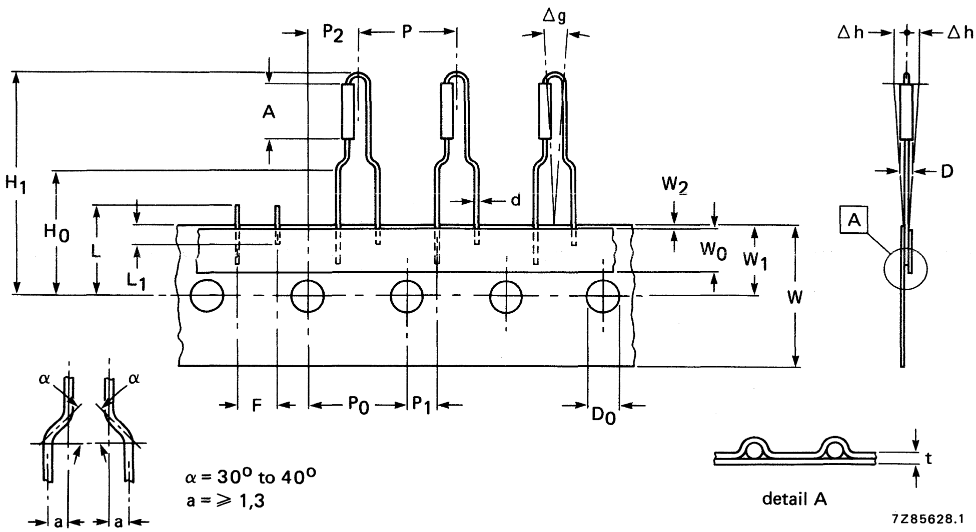


Fig.10 Bandolier for types with radial leads, SFR25AS (Euroform).

Body diameter	D	max.	2.50
Body length	A	max.	7.00
Lead wire diameter	d		0.60 + 0.06 − 0.05
Pitch of components	P		12.7 ± 1.0
Feed hole pitch	P_0		12.7 ± 0.2
Cumulative pitch error			1.0 per 20 spacings
Feed hole centre to lead at topside at the tape	P_1		3.85 ± 0.5
Feed hole centre to body centre	P_2		6.35 ± 1.0
Lead to lead distance	F		4.8 – 5.5
Component alignment	Δh		0 ± 1.2
Component alignment	Δg		0 ± 3°
Tape width	W		18.0 ± 0.5
Hold down tape width	W_0	min.	5.5
Hole position	W_1		9.0 ± 0.5
Hold down tape position	W_2	max.	0.5
Lead wire clinch height	H_0		16.5 ± 0.5
Component height	H_1		19.5 to 32
Feed hole diameter	D_0		4.0 ± 0.2
Total tape thickness	t		0.4 – 0.9
Length of snipped lead	L	max.	11.0
Lead wire (tape portion) shortest lead	L_1	min.	2.5

Extraction force for components in the tape plane, vertically to the direction of unreeling: ⩾ 5N.

STANDARD FILM RESISTORS

metal film

QUICK REFERENCE DATA

Resistance range			1 Ω to 10 MΩ, E24 series and jumper (zero Ω)
Resistance tolerance			± 5% and ± 2%
Temperature coefficient			
$R \leqslant 1$ MΩ			$\leqslant 100 \,.\, 10^{-6}$/K
$R > 1$ MΩ			$\leqslant 250 \,.\, 10^{-6}$/K
Rated dissipation			
at $T_{amb} = 70\ ^{o}C$ *			0.4 W
Thermal resistance		R_{th}	200 K/W
Noise			
$R \leqslant 1$ MΩ		max.	0.1 μV/V
$R > 1$ MΩ		max.	1.5 μV/V
V_{max}			250 V
Basic specifications			IEC 115-1 and 115-2
Approval			CECC 40101
Climatic category (IEC 68)			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
short time overload	ΔR/R	max.	0.25% + 0.05 Ω

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 light-green 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 68-2-45.

MECHANICAL DATA

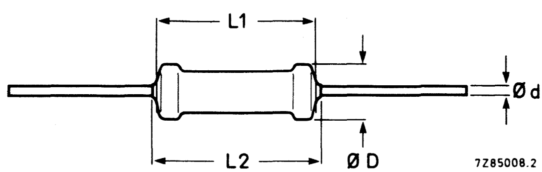


Fig. 1.

type	D_{max}	L1 max	L2 max	d
SFR25CECC	2.5	6.5	7.0	0.6 ± 0.03

* See Electrical Data.

The length of the body is measured by inserting the leads into holes of two identical gauge plates and moving these plates parallel to each other until the resistor body is clamped without deformation (IEC publication 294). For leads of 0.6 mm diameter, the diameter of the holes in the gauge plates is 1.0 mm.

Mass 25 g per 100 resistors.

Mounting

The resistors are suitable for processing on automatic insertion equipment and cutting and bending machines. The minimum pitch is 4e (10.2 mm).

Marking

The nominal resistance and the tolerance are marked on the resistors by four coloured bands according to IEC publication 62 "Colour code for fixed resistors". See also General Section.

ELECTRICAL DATA

For electrical properties and packing of the SFR25CECC, see the relevant sections of the standard SFR25 datasheet.

type	packing	quantity	resistance range	tolerance ± %	catalogue number
SFR25	ammopack	1000	1 Ω to 10 MΩ	5	2322 183 13 . . .
CECC approved		1000	1 Ω to 1 MΩ	2	2322 183 14 . . .
40101		5000	1 Ω to 10 MΩ	5	2322 183 43 . . .
52 mm bandolier		5000	1 Ω to 1 MΩ	2	2322 183 44 . . .
	on reel	5000	1 Ω to 10 MΩ	5	2322 183 63 . . .
		5000	1 Ω to 1 MΩ	2	2322 183 64 . . .

COMPOSITION OF THE CATALOGUE NUMBER

The catalogue number in the above table is completed by inserting the resistance code: the first two figures of the resistance (in Ω) followed by:

8 for R = 1 to 9.1 Ω
9 for R = 10 to 91 Ω
1 for R = 100 to 910 Ω
2 for R = 1 to 9.1 kΩ
3 for R = 10 to 91 kΩ
4 for R = 100 to 910 kΩ
5 for R = 1 to 9.1 MΩ
6 for R = 10 MΩ

Example

The catalogue number of a resistor SFR25CECC of 750 Ω ± 5%, on a bandolier of 1000 items, supplied in ammopack, is 2322 183 13751.

STANDARD FILM RESISTORS

metal film

QUICK REFERENCE DATA

Resistance range			1 Ω to 10 MΩ, E24 series	
Resistance tolerance			± 5% and ± 2%	
Temperature coefficient				
$R \leqslant 1$ MΩ			$\leqslant 100 \cdot 10^{-6}$/K	
$R > 1$ MΩ			$\leqslant 250 \cdot 10^{-6}$/K	
Rated dissipation at T_{amb} = 70 °C; P_{70} *			0.50 W	
Thermal resistance			150 K/W	
Noise				
$R \leqslant 1$ MΩ		max.	0.1 μV/V	
$R > 1$ MΩ		max.	1.5 μV/V	
Basic specifications			IEC 115-1 and 115-2	
Climatic category (IEC 68)			55/155/56	
V_{max}			350 V	
Stability after			$R \leqslant 1$ MΩ	$R > 1$ MΩ
load	ΔR/R	max.	1% + 0.05 Ω	2% + 0.1 Ω
climatic tests	ΔR/R	max.	1% + 0.05 Ω	2% + 0.1 Ω
soldering	ΔR/R	max.	0.25% + 0.05 Ω	0.25% + 0.05 Ω
short time overload	ΔR/R	max.	1% + 0.05 Ω	1% + 0.05 Ω

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 red-brown 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 68-2-45.

MECHANICAL DATA

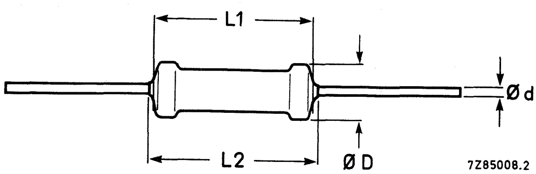


Fig. 1.

type	D_{max}	L1 max.	L2 max.	d
SFR25H	2.5	6.5	7.0	0.55 ± 0.05

*See Fig.2.

The length of the body is measured by inserting the leads into holes of two identical gauge plates and moving these plates parallel to each other until the resistor body is clamped without deformation (IEC publication 294). For leads of 0.6 mm diameter, the diameter of the holes in the gauge plates is 1.0 mm.

Mass 25 g per 100 resistors.

Mounting

The resistors are suitable for processing on automatic insertion equipment and cutting and bending machines. The minimum pitch for this type is 4e (10.2 mm). For temperature rise at soldering point, see Fig.5.

Marking

The nominal resistance and the tolerance are marked on the resistors by four coloured bands according to IEC publication 62 "Colour code for fixed resistors". See also General Section.

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated resistance (nominal resistance) are taken from the E24 series within the range 1 Ω to 10 MΩ. E24 series of values is given in the table "Standard series of values in a decade" at the back of the handbook. The tolerance on the rated resistance is either ± 5% or ± 2%.

The limiting voltage (DC or RMS) is 350 V. This is the maximum voltage that may be applied continuously to the resistor element; see IEC publications 115-1 and 115-4. The maximum permissible hot-spot temperature is 155 °C.

Table 1

type	packing	quantity	resistance range	tolerance ± %	catalogue number
SFR25H	ammopack	1000	1 Ω to 10 MΩ	5	2322 186 13 . . .
52 mm		1000	1 Ω to 1 MΩ	2	2322 186 14 . . .
bandolier		5000	1 Ω to 10 MΩ	5	2322 186 73 . . .
		5000	1 Ω to 1 MΩ	2	2322 186 74 . . .
	on reel	5000	1 Ω to 10 MΩ	5	2322 186 23 . . .
		5000	1 Ω to 1 MΩ	2	2322 186 24 . . .

COMPOSITION OF THE CATALOGUE NUMBER

The catalogue number in the above table is completed by inserting the resistance code: the first two figures of the resistance (in Ω) followed by:

8 for R = 1 to 9.1 Ω
9 for R = 10 to 91 Ω
1 for R = 100 to 910 Ω
2 for R = 1 to 9.1 kΩ
3 for R = 10 to 91 kΩ
4 for R = 100 to 910 kΩ
5 for R = 1 to 9.1 MΩ
6 for R = 10 MΩ

Example

The catalogue number of a resistor SFR25H of 5600 Ω ± 5% on a bandolier of 1000 items, supplied in ammopack, is 2322 186 13562.

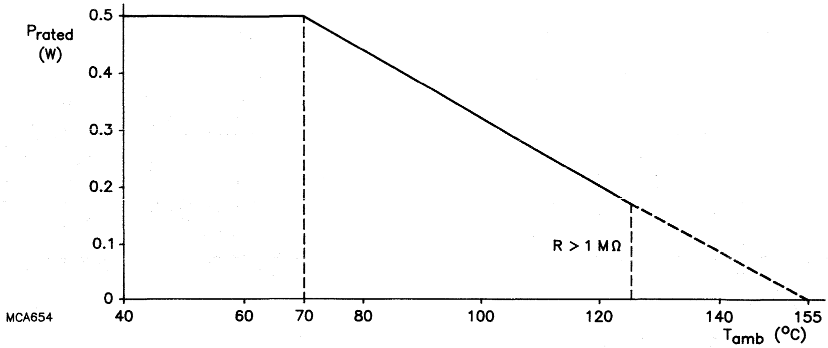


Fig.2 Maximum dissipation (P_{max}) as a function of ambient temperature (T_{amb}).

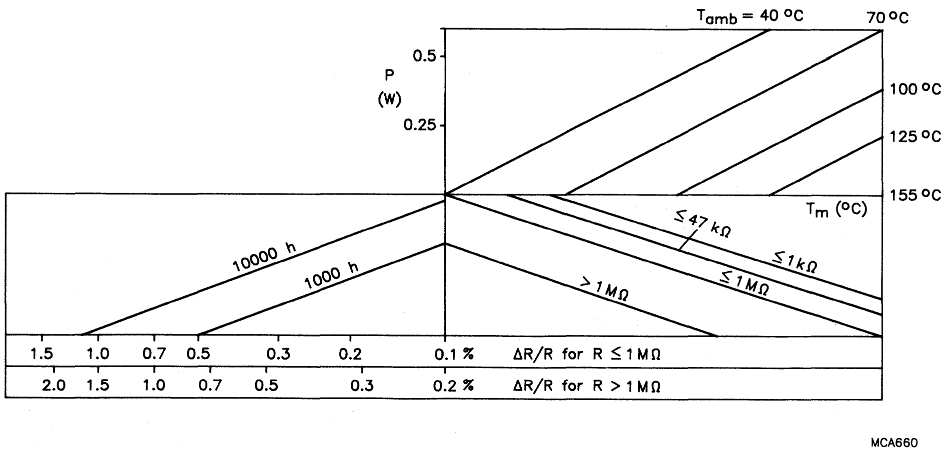


Fig.3 Drift nomogram.

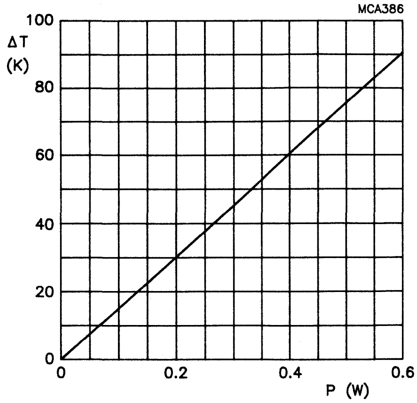


Fig.4 Hot-spot temperature rise (ΔT) as a function of dissipated power.

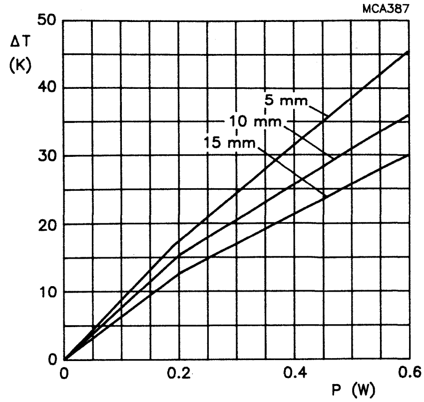


Fig.5 Temperature rise (ΔT) at the end of the lead (soldering point) as a function of dissipated power, at various lead lengths after mounting.

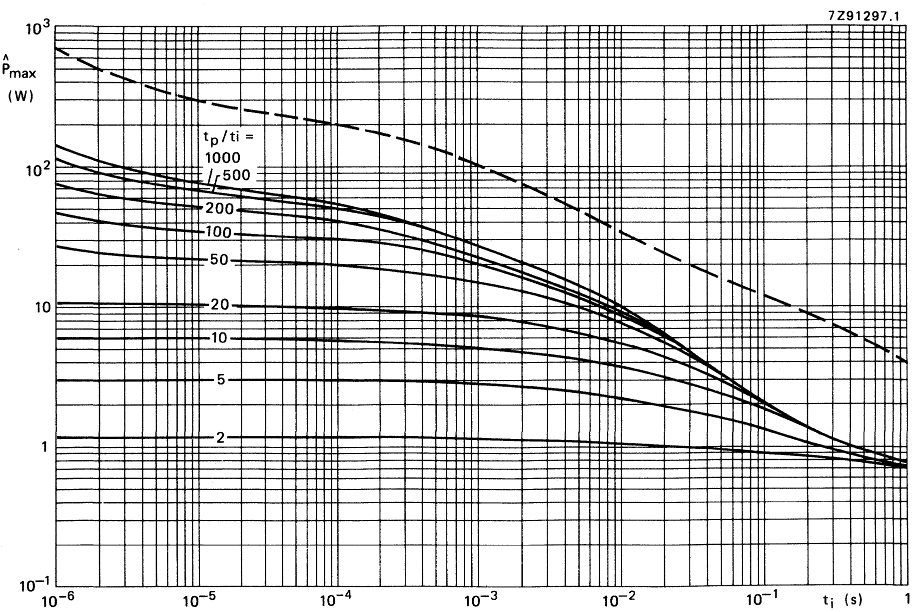


Fig.6 Max. permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i).

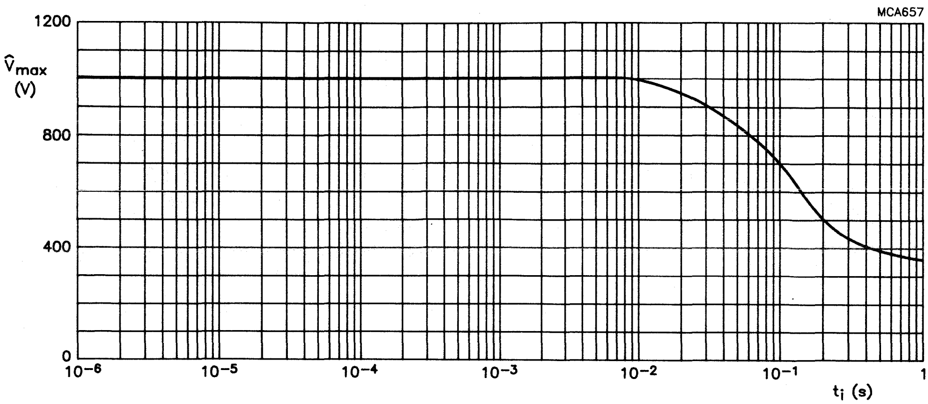


Fig.7 Max. permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_i).

TESTS AND REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publication 115-1, category 55/155/56 (rated temperature range −55 to + 155 °C; damp heat, long term, 56 days) and along the lines of IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components". In the following table the tests are listed with reference to the relevant clauses of IEC publications 115-1 and 68; a short description is also given of the test procedure and requirements. In some instances deviations from the IEC recommendation were necessary for our method of specifying.

Table 2

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
4.16		Robustness of terminations		
4.16.2	Ua	Tensile all samples	ϕ 0.6 mm; load 10N; 10 s	number of failures < 10 ppm
4.16.3	Ub	Bending half number of samples	ϕ 0.6 mm; load 5N; 4 x 90°	
4.16.4	Uc	Torsion other half number of samples	3 x 360° in opposite directions	no damage ΔR max. 0.25% + 0.05 Ω
4.17	Ta	Soldering	solderability: 2 s 235 °C, flux 600	good tinning no damage
4.18	Tb		thermal shock: 3 s 350 °C, 6 mm from body	ΔR max. 0.25% + 0.05 Ω

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
4.19	Na	Rapid change of temperature	½ h –55 °C/½ h + 155 °C 5 cycles	R ⩽ 1 MΩ: ΔR max. 0.25% + 0.05 Ω R > 1 MΩ: ΔR max. 0.5% + 0.05 Ω
4.22	Fc	Vibration	frequency 10-500 Hz, displacement 1.5 mm or acceleration 10g, three directions; total 6 h (3 x 2 h)	no damage ΔR max. 0.25% + 0.05 Ω
4.20	Eb	Bump	3 x 1500 bumps in three directions, 40g	no damage ΔR max. 0.25% + 0.05 Ω
4.23		Climatic sequence		
4.23.2	Ba	Dry heat	16 h, 155 °C	
4.23.3	D	Damp heat (accel) 1st cycle	24 h; 55 °C; 95-100% R.H.	
4.23.4	Aa	Cold	2 h; –55 °C	
4.23.5	M	Low air pressure	2 h; 8.5 kPa; 15-35 °C	
4.23.6	D	Damp heat (accel) remaining cycles	5 days; 55 °C; 95-100% R.H.	R_{ins} min. 1000 MΩ R ⩽ 1 MΩ: ΔR max. 1% + 0.05 Ω R > 1 MΩ: ΔR max. 2% + 0.1 Ω
4.24.2	Ca	Damp heat steady state	56 days; 40 °C; 90-95% R.H. dissipation 0.01 P_n	R_{ins} min. 1000 MΩ R ⩽ 1 MΩ: ΔR max. 1% + 0.05 Ω R > 1 MΩ: ΔR max. 2% + 0.1 Ω
4.25.1	–	Endurance	1000 hours; 70 °C nominal dissipation or V_{max}	R ⩽ 1 MΩ: ΔR max. 1% + 0.05 Ω R > 1 MΩ: ΔR max. 2% + 0.1 Ω
4.8.4.2	–	Temperature coefficient	between –55 °C and + 155 °C	R ⩽ 1 MΩ: ⩽ 100.10^{-6}/K R > 1 MΩ: ⩽ 250.10^{-6}/K
4.7	–	Voltage proof on insulation	700 V (RMS) during 1 minute; V block method	no breakdown
4.12	–	Noise	IEC publication 195	R ⩽ 1 MΩ: max. 0.1 μV/V R > 1 MΩ: max. 1.5 μV/V
4.6.1.1	–	Insulation resistance	500 V (DC) during 1 minute; V block method	min. 10^4 MΩ

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
4.13	–	Short time overload	Room temperature, dissipation 6.25 P_n (voltage not more than 2 x limiting voltage). 10 cycles 5 s on, 45 s off.	ΔR max. 1% + 0.05 Ω
See 2nd amendment to IEC 115-1, Jan. 87		Pulse load		See Figs 6 and 7

PACKING

The resistors are supplied on bandolier, either 1000 or 5000 resistors in ammopack and 5000 on reel. See General section for details.

Dimensions of bandolier

type	a ± 0.5	A ± 1.5	B1-B2 ± max.	S (spacing)	T (max. deviation of spacing)
SFR25H	6	52.5	1.2	5	1 mm per 10 spacings 0.5 mm per 5 spacings

Dimensions of ammopack

	M	N	P
1000 resistors	82	28	262
5000 resistors	78	98	270

Dimensions of reel

	Q	V	R
5000 resistors	305	73	86

STANDARD FILM RESISTORS

metal film

QUICK REFERENCE DATA

Resistance range			1 Ω to 10 MΩ, E24 series	
Resistance tolerance			± 5% and ± 2%	
Temperature coefficient				
R ⩽ 1 MΩ			⩽ 100 · 10^{-6}/K	
R > 1 MΩ			⩽ 250 · 10^{-6}/K	
Nominal dissipation			0.50 W	
Thermal resistance			150 K/W	
V_{max}			350 V	
Noise				
R ⩽ 1 MΩ		max.	0.1 μV/V	
R > 1 MΩ		max.	1.5 μV/V	
Basic specifications			IEC 115-1 and 115-2	
Climatic category (IEC 68)			55/155/56	
Approval			CECC 40101	
Stability after			R ⩽ 1 MΩ	R > 1 MΩ
load	ΔR/R	max.	1% + 0.05 Ω	2% + 0.1 Ω
climatic tests	ΔR/R	max.	1% + 0.05 Ω	2% + 0.1 Ω
soldering	ΔR/R	max.	0.25% + 0.05 Ω	0,25% + 0.05 Ω
short time overload	ΔR/R	max.	1% + 0.05 Ω	1% + 0.05 Ω

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 red-brown 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 68-2-45.

MECHANICAL DATA

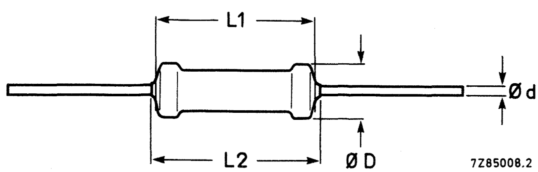


Fig. 1.

type	D_{max}	L1 max.	L2 max.	d
SFR25H	2.5	6.5	7.0	0.6 ± 0.03

The length of the body is measured by inserting the leads into holes of two identical gauge plates and moving these plates parallel to each other until the resistor body is clamped without deformation (IEC publication 294). For leads of 0.6 mm diameter, the diameter of the holes in the gauge plates is 1.0 mm.

Mass 25 g per 100 resistors.

Mounting

The resistors are suitable for processing on automatic insertion equipment and cutting and bending machines. The minimum pitch for this type is 4e (10.2 mm).

Marking

The nominal resistance and the tolerance are marked on the resistors by four coloured bands according to IEC publication 62 "Colour code for fixed resistors". See also General Section.

ELECTRICAL DATA

For electrical properties and packing of the SFR25HCECC, see the relevant sections of the standard SFR25H datasheet.

Table 1

type	packing	quantity	resistance range	tolerance ± %	catalogue number
SFR25H	ammopack	1000	1 Ω to 10 MΩ	5	2322 186 16 . . .
CECC		1000	1 Ω to 1 MΩ	2	2322 186 17 . . .
		5000	1 Ω to 10 MΩ	5	2322 186 76 . . .
		5000	1 Ω to 1 MΩ	2	2322 186 77 . . .
52 mm	on reel	5000	1 Ω to 10 MΩ	5	2322 186 26 . . .
bandolier		5000	1 Ω to 1 MΩ	2	2322 186 27 . . .

COMPOSITION OF THE CATALOGUE NUMBER

The catalogue number in the above table is completed by inserting the resistance code: the first two figures of the resistance (in Ω) followed by:

8 for R = 1 to 9.1 Ω
9 for R = 10 to 91 Ω
1 for R = 100 to 910 Ω
2 for R = 1 to 9.1 kΩ
3 for R = 10 to 91 kΩ
4 for R = 100 to 910 kΩ
5 for R = 1 to 9.1 MΩ
6 for R = 10 MΩ

Example

The catalogue number of a resistor SFR25HCECC of 750 Ω ± 5%, on a bandolier of 1000 items, supplied in ammopack, is 2322 186 16751.

FUSIBLE

FUSIBLE RESISTORS

metal film

QUICK REFERENCE DATA

Resistance range		1 Ω to 15 kΩ, E24 series
Resistance tolerance		± 5%
Temperature coefficient	R > 15 Ω	≤ 100. 10^{-6}/K
	R ≤ 15 Ω	≤ 200. 10^{-6}/K
Thermal resistance	R_{th}	240 K/W
V_{max}		250 V
Noise	max.	0.1 μV/V
Absolute maximum dissipation at T_{amb} = 70 °C*		0.33 W
Basic specifications		IEC 115-1 and 115-2
Climatic category (IEC 68)		55/155/56
Stability after		
endurance test	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

APPLICATION

These resistors have been designed to meet the safety requirements in audio and video applications, in circuits where protection against overloads is needed, e.g. in power supply circuits. The resistors will become open circuit within a certain range of overload, without the risk of fire. Although there is a difference in interruption characteristics for the various resistor values, it can be said that they become open-circuit within approximately 30 seconds and 10 seconds at 4 W and 6 W, respectively.

DESCRIPTION

A homogenous 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 according to MIL-STD-202E, method 215 and IEC 68-2-45.

MECHANICAL DATA

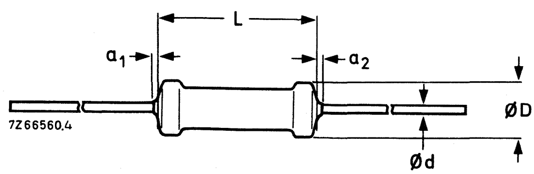


Fig. 1.

type	D_{max}	L_{max}	d	$a_1 + a_2$
NFR25	2.5	6.5	0.6	≤ 1

* See Fig.2.

The length of the body is measured by inserting the leads into holes of two identical gauge plates and moving these plates parallel to each other until the resistor body is clamped without deformation (IEC publication 294). For leads of 0.6 diameter, the holes in the gauge plates are 1.0 mm.

Mass

25 g per 100

Mounting

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

Since these resistors are used in applications where overloads can occur, it is not advisable to mount the resistors against other components or against printed circuit boards. For temperature rise at soldering point, see Fig.6.

Marking

The nominal resistance and the tolerance are marked on these resistors by means of four coloured bands according to IEC publication 62 "Colour code for fixed resistors". See also General Section. To indicate the NFR type, there is an additional, fifth, colour-ring, the colour of which is violet.

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated resistance (nominal resistance) are taken from the E24 series within the range 1 Ω to 15 kΩ. E24 series of values is given in the table "Standard series of values in a decade" at the back of this book. The tolerance on the rated resistance is ± 5%.

The limiting voltage (DC or RMS) is 250 V. This is the maximum voltage that may be applied continuously to the resistor element; see IEC publications 115-1 and 115-4. The maximum permissible hot-spot temperature is 155 °C.

Composition of the catalogue number

2322 205 . . . . .

resistance code: first two figures of the resistance (in Ω) followed by
8 for R of 1 to 9.1 Ω
9 for R of 10 to 91 Ω
1 for R of 100 to 910 Ω
2 for R of 1 to 9.1 kΩ
3 for R of 10 to 15 kΩ

packing:
13 for 1000 items on bandolier
23 for 5000 items on reel

Example

The catalogue number of a resistor NFR25 of 5600 Ω, taped on a bandolier of 1000 items, supplied in ammopack, is 2322 205 13562.

type	bandolier width	packing	quantity	resistance range (Ω)	tolerance %	catalogue number
NFR25	52.5 ± 1.5	ammopack	1000	1 – 15 k	5	2322 205 13 . . .
	52.5 ± 1.5	reel	5000	1 – 15 k	5	2322 205 23 . . .

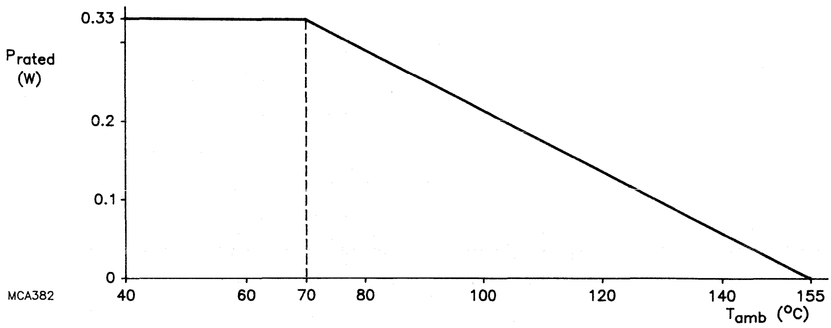


Fig.2 Maximum dissipation (P_{max}) as a function of ambient temperature (T_{amb}).

Time to interruption as a function of overload

"Interruption" means that the nominal resistance has increased at least 100 times.

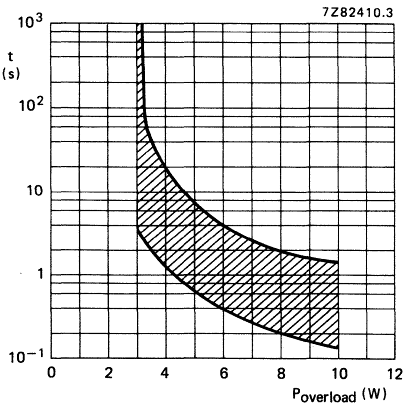


Fig.3 NFR25; R ⩽ 15 Ω.

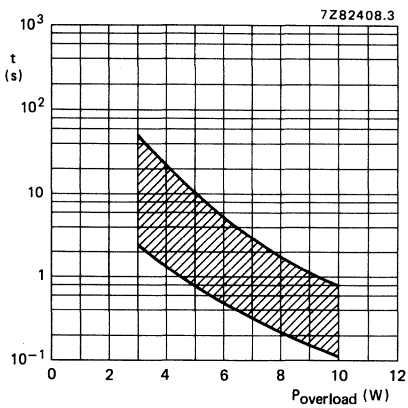


Fig.4 NFR25; 15 Ω < R ⩽ 15 kΩ.

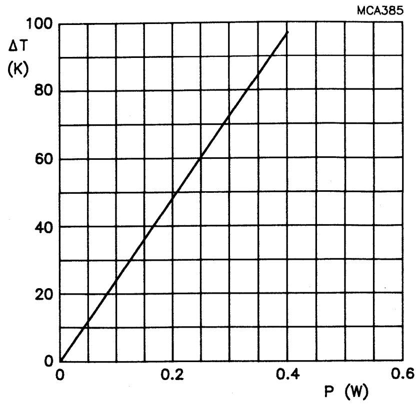


Fig.5 Hot-spot temperature rise (ΔT) as a function of dissipated power.

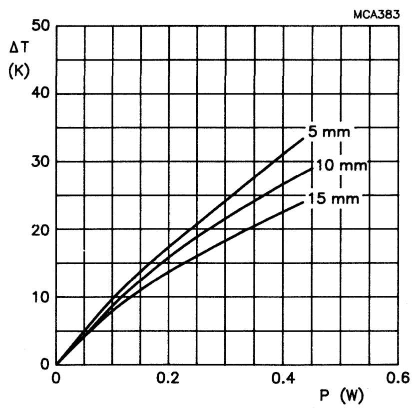


Fig.6 Temperature rise (ΔT) at the end of the lead (soldering point) as a function of dissipated power at various lead lengths after mounting.

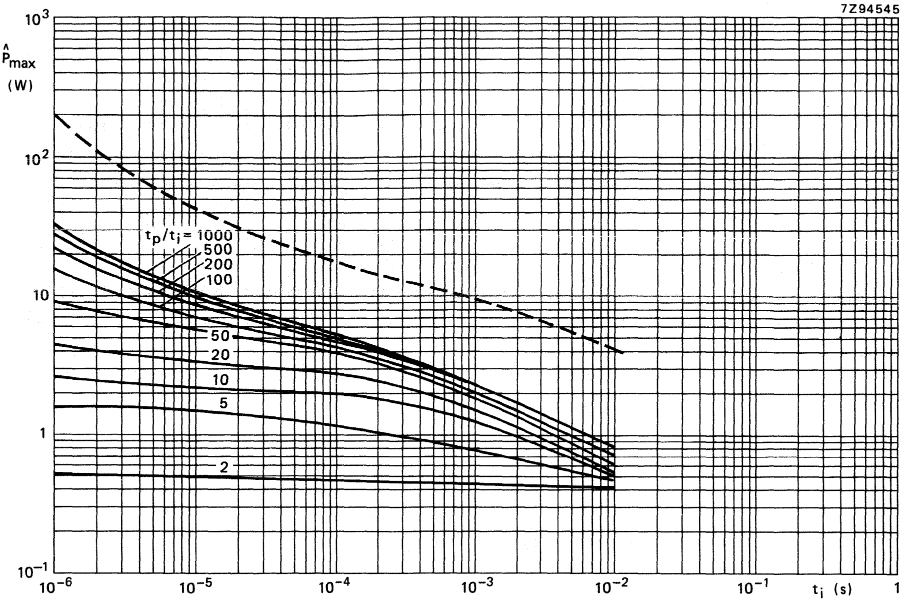


Fig.7 Max. permissible peak pulse power as a function of pulse duration for $R < 15\ \Omega$.

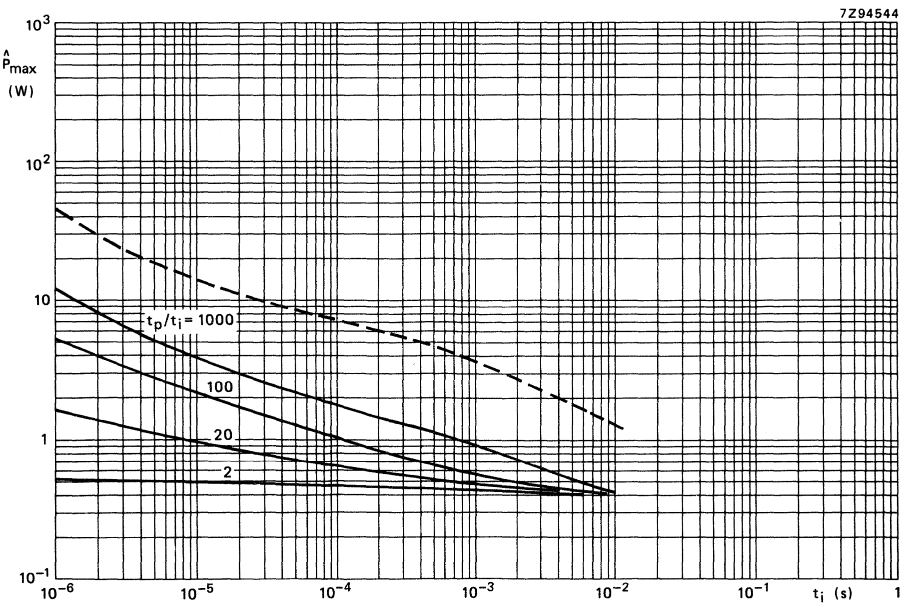


Fig.8 Max. permissible peak pulse power as a function of pulse duration for $R \geqslant 15\ \Omega$.

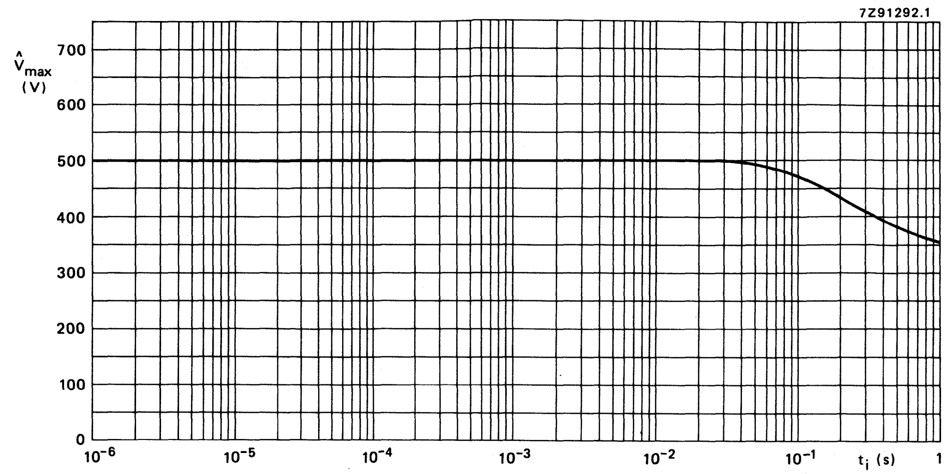


Fig.9 Maximum permissible peak pulse voltage as a function of pulse duration.

TESTS AND REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publication 115-1, category 55/155/56 (rated temperature range −55 to + 155 °C; damp heat, long term, 56 days) and along the lines of IEC publications 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components". In the following table the tests are listed with reference to the relevant clauses of IEC publications 115-1 and 68; a short description is also given of the test procedure and requirements. In some instances deviations from the IEC recommendation were necessary for our method of specifying. For inflammability requirements reference is made to IEC 115-1 and to CECC 40000, appendix D.

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
4.16		Robustness of terminations		
4.16.2	Ua	Tensile all samples	load 10 N, 10 s	number of failures < 10 ppm
4.16.3	Ub	Bending half number of samples	load 5 N, 4 x 90°	
4.16.4	Uc	Torsion other half number of samples	3 x 360° in opposite directions	no damage ΔR max. 0.25% + 0.05 Ω
4.17	Ta	Soldering	solderability: 2 s 235 °C, flux 600	good tinning no damage
4.18	Tb		thermal shock: 3 s 350 °C, 6 mm from body	ΔR max. 0.25% + 0.05 Ω
4.19	Na	Rapid change of temperature	½ h −55 °C/½ h + 155 °C 5 cycles	ΔR max. 0.25% + 0.05 Ω
4.22	Fc	Vibration	frequency 10-500 Hz, displacement 1,5 mm or acceleration 10g, three directions; total 6 h (3 x 2 h)	no damage ΔR max. 0.25% + 0.05 Ω
4.20	Eb	Bump	3 x 1500 bumps in three directions, 40g	no damage ΔR max. 0.25% + 0.05 Ω

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
4.23		Climatic sequence		
4.23.2	Ba	Dry heat	16 h; 155 °C	
4.23.3	Db	Damp heat (accel) 1st cycle	24 h; 55 °C; 95-100% R.H.	
4.23.4	Aa	Cold	2 h; –55 °C	
4.23.5	M	Low air pressure	2 h; 8,5 kPa; 15-35 °C	
4.23.6	Db	Damp heat (accel) remaining cycles	5 days; 55 °C; 95-100% R.H.	R_{ins} min. 1000 MΩ ΔR max. 1.0% + 0.05 Ω
4.24.2	Ca	Damp heat (steady state)	56 days; 40 °C; 90-95% R.H. dissipation 0,01 P_n	R_{ins} min. 1000 MΩ ΔR max. 1.0% + 0.05 Ω
4.25.1	–	Endurance	1000 hours; 70 °C; nominal dissipation or V_{max}	ΔR max. 1.0% + 0.05 Ω
4.8.4.2	–	Temperature coefficient	between –55 °C and + 155 °C	R > 15 Ω: ≤ 100. 10^{-6}/K R ≤ 15 Ω: ≤ 200. 10^{-6}/K
4.7	–	Voltage proof on insulation	500 V (RMS) 1 minute V block method	no breakdown
4.12	–	Noise	IEC publication 195	< 0.1 μV/V
4.6.1.1	–	Insulation resistance	500 V (DC) 1 minute V block method	min. 10^4 MΩ
4.2.6	–	Accidental overload	cheese cloth	no inflammation
See 2nd amendment to IEC 115-1, Jan.87.		pulse load		see Figs 7 to 9

PACKING

The resistors are supplied on bandolier; either 1000 resistors in ammopack or 5000 resistors on reel. For details see General section.

Dimensions of bandolier

type	a ± 0.5	A ± 1.5	B1-B2 ± max.	S (spacing)	T (max. deviation of spacing)
NFR25	6	52.5	1.2	5	1 mm per 10 spacings, 0.5 mm per 5 spacings

Dimensions of ammopack

	M	N	P
NFR25	82	28	262

Dimensions of reel

	Q	V	R
NFR25	305	75	86

SUPERSEDES DATA OF OCTOBER 1987

FUSIBLE RESISTOR

QUICK REFERENCE DATA

Resistance range		1 Ω to 15 kΩ, E24 series
Resistance tolerance		± 5%
Nominal dissipation at T_{amb} = 70 °C*		0.5 W
Thermal resistance	R_{th}	150 K/W
V_{max}		350 V
Temperature coefficient	R ⩽ 4.7 Ω	$\leqslant 200.10^{-6}$/K
	R > 4.7 Ω	$\leqslant 100.10^{-6}$/K
Noise	max.	0.1 μV/V
Basic specifications		IEC 115-1 and 115-2
Climatic category (IEC68)		55/155/56
Stability after		
endurance test	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

APPLICATION

These resistors have been designed to meet the safety requirements in audio and video applications in circuits where protection against overloads is required, e.g. in power supply circuits. The resistors will become open circuit within a certain range of overload, without the risk of fire (see Fig.3). It can be said that the resistors become open circuit within approximately 30 seconds and 10 seconds at 9 W and 12 W, respectively.

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 68-2-45.

MECHANICAL DATA

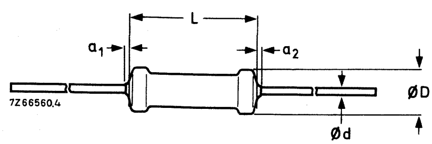


Fig. 1 Component Outline.

Table 1 Physical Dimensions

type	$D_{max.}$	$L_{max.}$	d	$a_1 + a_2$
NFR25H	2,5	6,5	0,6	⩽ 1

* See Fig.2.

MECHANICAL DATA (continued)

The length of the body (L) is measured by inserting the leads into holes of two identical gauge plates, and moving these plates parallel to each other until the resistor body is clamped without deformation (IEC publication 294). For leads of 0,6 mm diameter, the diameter of the holes in the gauge plate is 1,0 mm.

Mass

25 g per 100

Mounting

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

Since these resistors are used in applications where overloads can occur, it is not advisable to mount the resistors against other components or directly on to printed circuit boards. For temperature rise at soldering point, see Fig.5.

Marking

The nominal resistance and tolerance are marked on these resistors by four coloured bands in accordance with IEC publication 62, "Marking codes for resistors and capacitors".

To indicate the NFR25H type, a fifth colour ring is added; the colour of this ring is white.

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated resistance (nominal resistance) are taken from the E24 series within the range 1 Ω to 15 kΩ.

The tolerance on the rated resistance is ± 5%.

The limiting voltage (DC or RMS) is 350 V. This is the maximum voltage that may be applied continuously to the resistor element; see IEC publications 115-1 and 115-4. The maximum permissible hot-spot temperature is 155 °C.

Composition of the catalogue number

2322 207 .. ...

Packing:

13 for 1000 items in a box
23 for 5000 items on a reel

resistance code: first two figures of the code represent the first two figures of the resistance value (Ω) followed by:

8 for R values 1 to 9,1 Ω
9 for R values 10 to 91 Ω
1 for R values 100 to 910 Ω
2 for R values 1 to 9,1 kΩ
3 for R values 10 to 15 kΩ

Example:

The catalogue number of a resistor NFR25H, value 5,6 kΩ, taped on a bandolier of 1000 items, supplied in a box, is 2322 207 13 562.

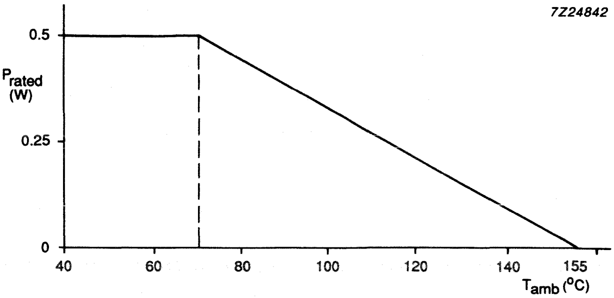


Fig.2 Maximum dissipation (P_{max}) as a function of ambient temperature (T_{amb}).

Time to interruption as a function of overload

"Interruption" means that the nominal resistance has increased at least 100 times.

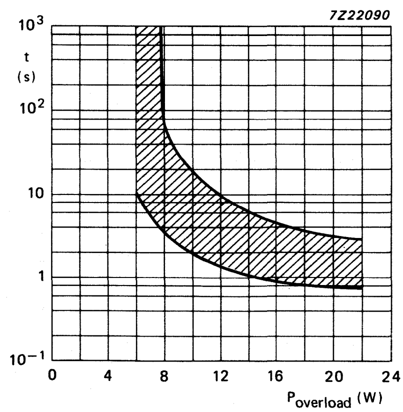


Fig.3 Time to interruption as a function of power overload.

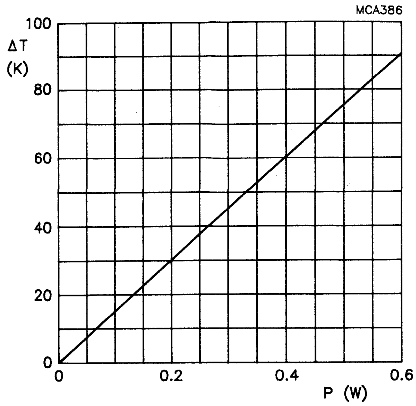


Fig.4 Hot-spot temperature rise (ΔT) as a function of dissipated power.

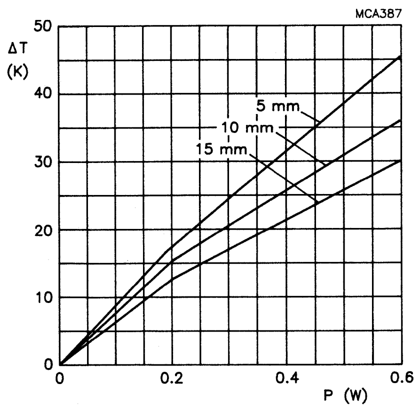


Fig.5 Temperature rise (ΔT) at the end of the lead (soldering point) as a function of dissipated power at various lead lengths after mounting.

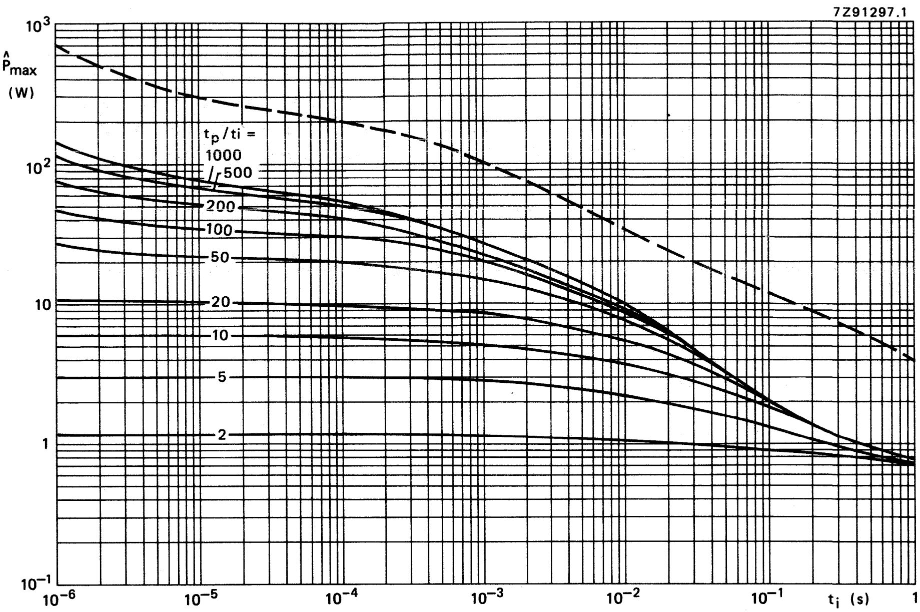


Fig.6 Maximum permissible peak pulse power as a function of pulse duration for critical value.

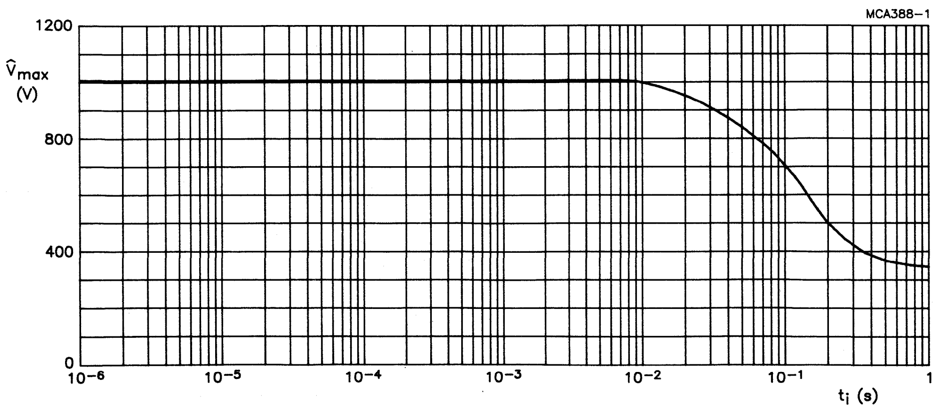


Fig.7 Maximum permissible peak pulse voltage as a function of pulse duration.

TESTS AND REQUIREMENTS

Essentially, all tests are carried out in accordance with the schedule of IEC publication 115-1, category 55/155/56 (rated temperature range −55 °C to + 155 °C; damp heat, long term, 56 days), and in line with IEC publication 68. "Recommended basic climatic and mechanical robustness testing procedure for electronic components". In Table 2, the tests are listed with reference to the relevant clauses of IEC publications 115-1 and 68; a short description is also given of the test procedure and requirements. In some instances, deviations from the IEC recommendations were necessary for our method of specifying.

For inflammability requirements, reference is made to IEC 115-1, clause 4.26, and to CECC 40 000 Appendix D.

Table 2 Tests and requirements

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
4.16		robustness of terminations		
4.16.2	Ua	tensile all samples	load 10 N, 10 s	number of failures $< 10^{-6}$
4.16.3	Ub	bending half number of samples	load 5 N, 4 x 90°	
4.16.4	Uc	torsion other half number of samples	3 x 360°, opposite directions	no damage ΔR/R max. 0,25% + 0,05 Ω
4.17	Ta	soldering	solderability 2 s, 235 °C flux 600	good tinning, no damage
4.18	Tb		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	0,5 hour −55 °C 0,5 hour + 155 °C 5 cycles	ΔR/R max. 0,25% + 0,05 Ω
4.22	Fc	vibration	frequency 10-500 Hz, displacement 1,5 mm, or acceleration 10 g three directions; 6 hours (3 x 2 hours)	no damage ΔR/R max. 0,25% + 0,05 Ω
4.20	Eb	bump	3 x 1500 bumps in three directions, 40 g	no damage ΔR/R max. 0,25% + 0,05 Ω

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
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 - 100 % relative humidity	
4.23.4	Aa	cold	2 hours, −55 °C	
4.23.5	M	low air pressure	2 hours, 85 mbar 15 - 35 °C	
4.23.6	Db	damp heat (accelerated) remaining cycles	5 days, + 55 °C 95 - 100% relative humidity	R_{ins} > 1000 MΩ ΔR/R max. 1% + 0,05 Ω
4.24.2	Ca	damp heat (steady state)	56 days, + 40 °C 90 - 95% relative humidity dissipation 0,01 P_n	R_{ins} > 1000 MΩ ΔR/R max. 1% + 0,05 Ω
4.25.1	–	endurance	1000 hours, + 70 °C dissipation 0,5 W	ΔR/R max. 1% + 0,05 Ω
4.8.4.2	–	temperature coefficient	between −55 °C and + 155 °C	$\leqslant 100 \cdot 10^{-6}$/K for R > 4.7 Ω $\leqslant 200 \cdot 10^{-6}$/K for R ⩽ 4.7 Ω
4.7	–	voltage proof on insulation	700 V (RMS) 1 min. V-block method	no breakdown
4.12	–	noise	IEC publication 195	< 0,1 μV/V
4.6.1.1	–	insulation resistance	500 V (DC) 1 min., V-block method	min. 10^4 MΩ
4.26	–	accidental overload	cheese-cloth	non-inflammable
See 2nd amendment to IEC 115-1 and TC40 central office 532 and 533		pulseload	see RSV-41/4013	see Figs 6 and 7

PACKING

The resistors are supplied on bandolier; either 1000 resistors in a box or 5000 resistors on reel. For details, see General Section.

Table 3 Dimensions of Bandolier

type	a ± 0,5	A ± 1,5	B1-B2 ± max.	S (spacing)	T (maximum deviation of spacing)
NFR25H	6	52,5	1,2	5	1 mm per 10 spacings 0,5 mm per 5 spacings

Table 4 Dimensions of Box

type	M	N	P
NFR25H	82	28	262

Table 5 Dimensions of Reel

type	Q	R	V
NFR25H	305	86	75

METAL FILM

METAL FILM RESISTORS

QUICK REFERENCE DATA

Resistance range			4.99 Ω to 1 MΩ, E24/E96 series	
Resistance tolerance			± 1%	
Temperature coefficient			$\leqslant \pm 50.10^{-6}$/K	
Nominal dissipation, P_n at T_{amb} = 70 °C*			0.40 W	
Thermal resistance, R_{th}			170 K/W	
V_{max}			200 V	
Noise				
$R \leqslant 68$ kΩ		max.	0.1 μV/V	
$R > 68$ kΩ $\leqslant 100$ kΩ		max.	0.5 μV/V	
$R > 100$ kΩ		max.	1.5 μV/V	
Basic specifications			IEC 115-1 and 115-2	
Approval			CECC 40101	
Climatic category (IEC 68)			55/155/56	
Stability after			$R \leqslant 100$ kΩ	$R > 100$ kΩ
load	ΔR/R	max.	0.5% + 0.05 Ω	1.0% + 0.05 Ω
climatic tests	ΔR/R	max.	0.5% + 0.05 Ω	1.0% + 0.05 Ω
soldering	ΔR/R	max.	0.1% + 0.01 Ω	0.2% + 0.05 Ω
short-term overload	ΔR/R	max.	0.25% + 0.05 Ω	0.25% + 0.05 Ω

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 according to MIL-STD 202E and IEC 68-2-45.

MECHANICAL DATA

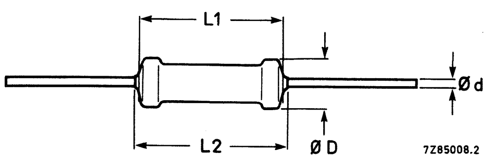


Fig. 1.

type and style	D	L1	L2 max	d
MRS16T	$1.7^{+0.2}_{-0.1}$	$3.5^{+0.2}_{-0.15}$	3.7	$0.5^{+0.00}_{-0.04}$

* See Fig.2.

The length of the body (L1, see Fig. 1) is measured by inserting the leads into holes of two identical gauge plates and moving these plates parallel to each other until the resistor body is clamped without deformation (IEC publication 294). For leads of 0.5 mm diameter, the diameter of the holes in the gauge plates is 0.8 mm.

Mass 12.5 g per 100 resistors.

Mounting

The resistors are suitable for processing on automatic insertion equipment and cutting and bending machines. The minimum pitch is 2e (5 mm). See Fig.5 for temperature rise at soldering place.

Marking

The nominal resistance and the tolerance are marked on the resistors by five coloured bands according to IEC publication 62 "Colour code for fixed resistors".

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated resistance (nominal resistance) are taken from the E24/E96 series within the range 4.99 Ω to 1 MΩ. These values are given in the table "Standard series of values in a decade" at the back of the handbook. The tolerance on the rates resistance is ± 1%.

The limiting voltage (DC or RMS) is 200 V. This is the maximum voltage that may be applied continuously to the resistor element; see IEC publications 115-1 and 115-4. The maximum permissible hot-spot temperature is 155 °C.

type	packing	quantity	resistance range	tolerance ± %	catalogue number
MRS16T	ammopack	1000	4.99 Ω to 1 MΩ	1	2322 157 1....
	ammopack	5000	4.99 Ω to 1 MΩ	1	2322 157 2....
	on reel	5000	4.99 Ω to 1 MΩ	1	2322 157 3....

COMPOSITION OF THE CATALOGUE NUMBER

The catalogue number in the above is completed by inserting the resistance code: the first three figures of the resistance (in Ω) followed by:

8 for R = 4,99 to 9.76 Ω
9 for R = 10 to 97.6 Ω
1 for R = 100 to 976 Ω
2 for R = 1 to 9.76 kΩ
3 for R = 10 to 97.6 kΩ
4 for R = 100 to 976 kΩ
5 for R = 1 MΩ

Example

The catalogue number of a resistor MRS16T of 750 Ω ± 1%, on a bandolier of 1000 items, supplied in ammopack, is 2322 157 17501.

Note

For code-technical reasons the catalogue number for resistors of 49.9 Ω is:

1000 in ammopack: 2322 157 91011
5000 in ammopack: 2322 157 92011
5000 on reel: 2322 157 93011

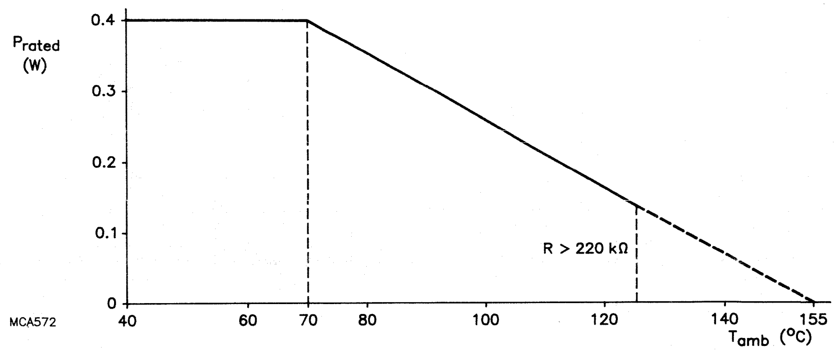


Fig.2 Maximum dissipation (P_{max}) as a function of ambient temperature (T_{amb}).

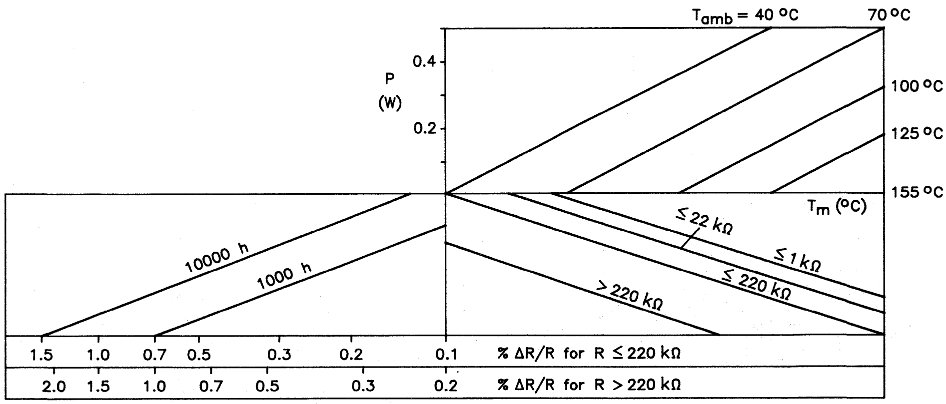


Fig.3 Drift nomogram.

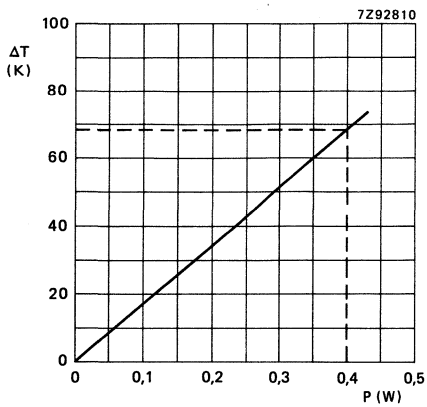


Fig.4 Hot-spot temperature rise (ΔT) as a function of dissipated power.

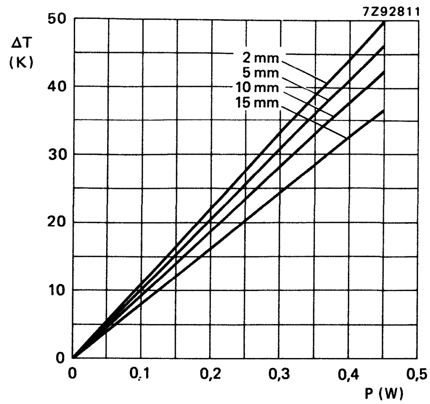


Fig.5 Temperature rise (ΔT) at the end of lead (soldering point) as a function of dissipated power, at various lead lengths after mounting.

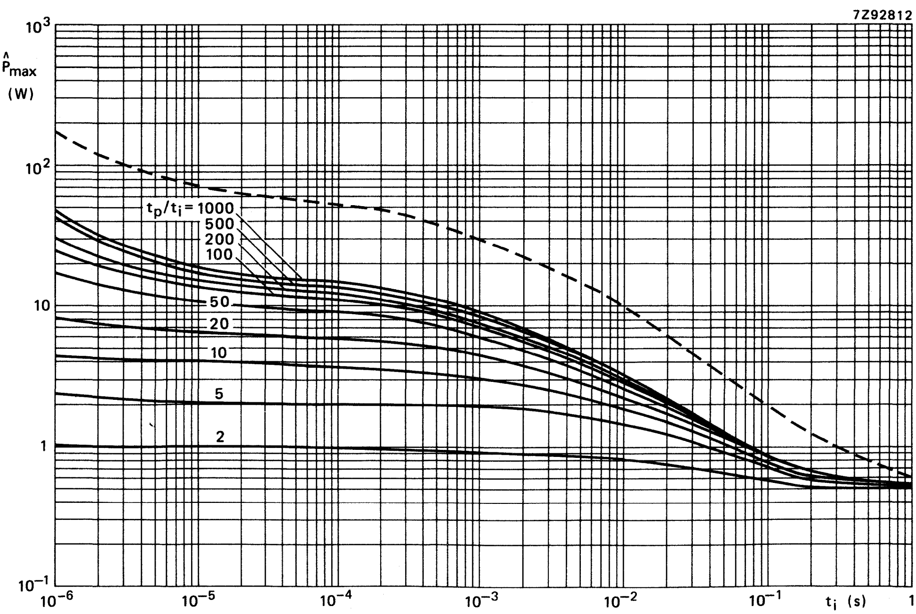


Fig.6 Max. permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i).

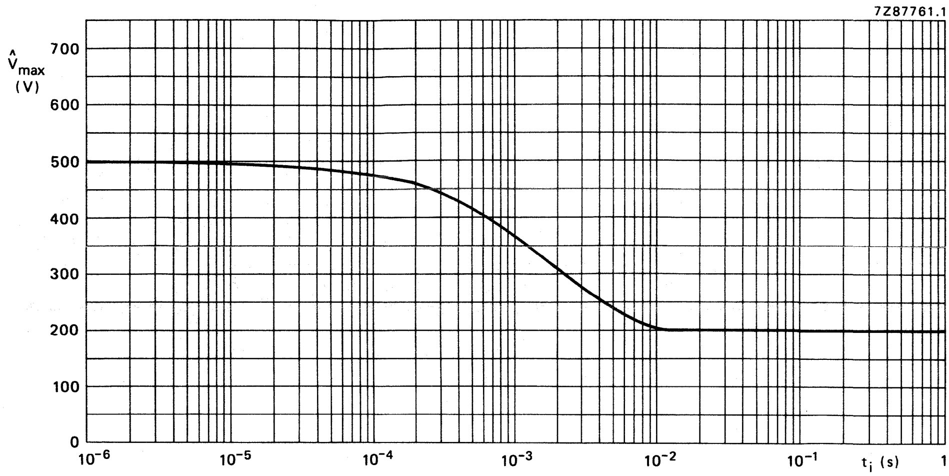


Fig.7 Maximum permissible peak pulse voltage as a function of pulse duration.

TESTS AND REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publication 115-1, category 55/155/56 (rated temperature range −55 to + 155 °C: damp heat, long term, 56 days) are carried out and along the lines of IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components". In the following table the tests are listed with reference to the relevant clauses of IEC publications 115-1 and 68; a short description is also given of the test procedure and requirements. In some instances deviations from the IEC specification were necessary for our method of specifying.

Table

IEC 115-1-4 clause	IEC 68 test method	test	procedure	requirements
		Robustness of terminations		
4.16.2	Ua	Tensile all samples	ϕ 0.5 mm; load 5N; 10 s	number of failures < 10 ppm
4.16.3	Ub	Bending half number of samples	ϕ 0.5 mm; load 2.5N; 4 x 90°	
4.16.4	Uc	Torsion other half number of samples	3 x 360° in opposite directions	no damage ΔR max. 0.1% + 0.01 Ω
4.17	T_a	Soldering	solderability: 2 s 235 °C, flux 600	good tinning, no damage
4.18	T_b		thermal shock: 3 s 350 °C, 6 mm from body	R ⩽ 100 kΩ: ΔR max. 0.1% + 0.01 Ω R > 100 kΩ: ΔR max. 0.25% + 0.05 Ω

TESTS AND REQUIREMENTS (continued)

IEC 115-1-4 clause	IEC 68 test method	test	procedure	requirements
4.19	Na	Rapid change of temperature	½ h –55 °C/½ h + 155 °C 5 cycles	R ⩽ 100 kΩ: ΔR max. 0.1% + 0.01 Ω R > 100 kΩ: ΔR max. 0.25% + 0.05 Ω
4.20	Eb	Bump	3 x 1500 bumps in three directions, 40g	no damage ΔR max. 0.1% + 0.01 Ω
4.22	Fc	Vibration	frequency 10-500 Hz, displacement 1.5 mm or acceleration 10g, three directions; total 6 h (3 x 2 h)	no damage ΔR max. 0.1% + 0.01 Ω
4.23		Climatic sequence		
4.23.2	Ba	Dry heat	16 h, 155 °C	
4.23.3	D_b	Damp heat (accel) 1st cycle	24 h; 55 °C; 95-100% R.H.	
4.23.4	Aa	Cold	2 h; –55 °C	
4.23.5	M	Low air pressure	2 h; 8,5 kPa; 15-35 °C	
4.23.6	D_b	Damp heat (accel) remaining cycles	5 days; 55 °C; 95-100% R.H.	R_{ins} min. 1000 MΩ R ⩽ 100 kΩ: ΔR max. 0.5% + 0.05 Ω R > 100 kΩ: ΔR max. 1% + 0.05 Ω
4.24.2	Ca	Damp heat steady state	56 days; 40 °C; 90-95% R.H. dissipation 0.01 P_n	R_{ins} min. 1000 kΩ R ⩽ 100 kΩ: ΔR max. 0.5% + 0.05 Ω R > 100 kΩ: ΔR max. 1% + 0.05 Ω
4.25.1	–	Endurance	1000 hours; 70 °C nominal dissipation or V_{max}	R ⩽ 100 kΩ: ΔR max. 0.5% + 0.05 Ω R > 100 kΩ: ΔR max. 1% + 0.05 Ω
4.8.4.2	–	Temperature coefficient	between –55 °C and + 155 °C	⩽ 50.10^{-6}/K
4.7	–	Voltage proof on insulation	400 V (RMS) during 1 minute; V-block method	no breakdown

IEC 115-1-4 clause	IEC 68 test method	test	procedure	requirements
4.12	–	Noise	IEC publication 195	$R \leqslant 68\ k\Omega$: max. 0.1 $\mu V/V$ $68\ k\Omega < R \leqslant 100\ k\Omega$: max. 0.5 $\mu V/V$ $R > 100\ k\Omega$: max. 1.5 $\mu V/V$
4.6.1.1	–	Insulation resistance	100 V (DC) 1 minute; V-block method	min. 10^4 MΩ
4.13	–	short-term	room temp. diss. 6.25 x 0.25 W (voltage not more than 2 x limiting voltage). 10 cycles: 5 s on, 45 s off	ΔR max. 0.25% + 0.05 Ω
See 2nd amendment to IEC 115-1, Jan. '87		Pulse load		see Figs 6 and 7

PACKING

The resistors are supplied on bandolier; either 1000/5000 resistors in ammopack or 5000 resistors on reel.

Dimensions of bandolier

a ± 0.5	A ± 1.5	B1-B2 ± max.	S (spacing)	T (max. deviation of spacing)
6	52.5	0.5	5	1 mm per 10 spacings 0.5 mm per 5 spacings

Dimensions of ammopack

	M	N	P
1000 resistors	75	30	140
5000 resistors	75	73	270

Dimensions of reel

	Q	V
5000 resistors	265	75

SUPERSEDES DATA OF OCTOBER 1986

METAL FILM RESISTORS

QUICK REFERENCE DATA

Resistance range	1 Ω to 10 MΩ, E24/E96 series
Resistance tolerance	± 1%
Temperature coefficient	
$R < 4{,}99\ \Omega$	$\leqslant 100.10^{-6}$/K
$R > 4{,}99\ \Omega$	$\leqslant 50.10^{-6}$/K
Rated dissipation at T_{amb} = 70 °C*	0,60 W
Thermal resistance R_{th}	150 K/W
V_{max}	350 V
Noise	
$R \leqslant 1$ MΩ	max. 0,1 μV/V
$R > 1$ MΩ	max. 1,5 μV/V
Basic specifications	IEC 115-1 and 115-2
Climatic category (IEC 68)	55/155/56
Approval	CECC 40101

Stability after		$R \leqslant 1$ MΩ	$R > 1$ MΩ
load	ΔR/R max.	0.5% + 0.05 Ω	1.0% + 0.05 Ω
climatic tests	ΔR/R max.	0.5% + 0.05 Ω	1.0% + 0.05 Ω
soldering	ΔR/R max.	0.1% + 0.01 Ω	0.1% + 0.01 Ω
short-term overload	ΔR/R max.	0.25% + 0.05 Ω	0.25% + 0.05 Ω

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 according to MIL-STD 202E, method 215 and IEC 68-2-45.

MECHANICAL DATA

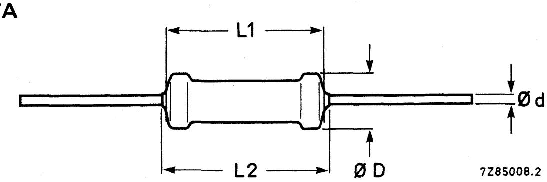


Fig. 1.

type	D	L1	L2 max	d
MRS25	2,5	6,5	7,0	0,6 ± 0,03

* See Fig.2.

The length of the body L1 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 (see IEC publication 294). For leads of 0,6 mm diameter, the diameter of the holes in the gauge plates is 1,0 mm.

Mass 25 g per 100 resistors

Mounting

The resistors are suitable for processing on automatic insertion equipment and cutting and bending machines. The minimum pitch for this type is 4e (10 mm). For temperature rise at soldering point, see Fig.3.

Marking

The nominal resistance, tolerance and temperature coefficient are marked on the resistors by six coloured bands according to IEC publication 62 "Colour code for fixed resistors".

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated resistance (nominal resistance) are taken from the E24/E96 series within the range 1 Ω to 10 MΩ. Series of values is given in the table "Standard series of values in a decade" at the back of this handbook. The tolerance on the rated resistance is 1%.

The limiting voltage (DC or RMS) is 350 V. This is the maximum voltage that may be applied continuously to the resistor element; see IEC publications 115-1 and 115-4. For temperature rise at soldering point, see Fig. 5.

Table 1

type	packing	quantity	resistance range	tolerance ± %	catalogue number
MRS25	ammopack	1000	1 Ω to 10 MΩ	1	2322 156 1....
		5000	1 Ω to 10 MΩ	1	2322 156 2....
	on reel	5000	1 Ω to 10 MΩ	1	2322 156 3....
MRS25ST	ammopack	2000	1 Ω to 10 MΩ	1	2322 156 4....

COMPOSITION OF THE CATALOGUE NUMBER

The catalogue number in the above table is completed by inserting the resistance code: the first three figures of the resistance (in Ω), followed by:

8 for R = 1 to 9,76 Ω
9 for R = 10 to 97,6 Ω
1 for R = 100 to 976 Ω
2 for R = 1 to 9,76 kΩ
3 for R = 10 to 97,6 kΩ
4 for R = 100 to 976 kΩ
5 for R = 1 to 9,76 MΩ
6 for R = 10 MΩ

Example

The catalogue number of a resistor MRS25 of 750 Ω ± 1%, on a bandolier of 1000 items, supplied in ammopack, is 2322 156 17501.

Note

For code-technical reasons the catalogue number for resistors of 49,9 Ω is:

1000 in ammopack: 2322 156 91011
5000 in ammopack: 2322 156 92011
5000 on reel: 2322 156 93011
2000 in ammopack: 2322 156 94011 (Panasert)

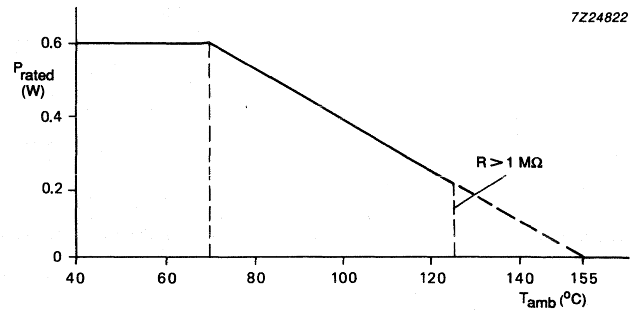


Fig.2 Maximum dissipation (P_{max}) as a function of ambient temperature (T_{amb}).

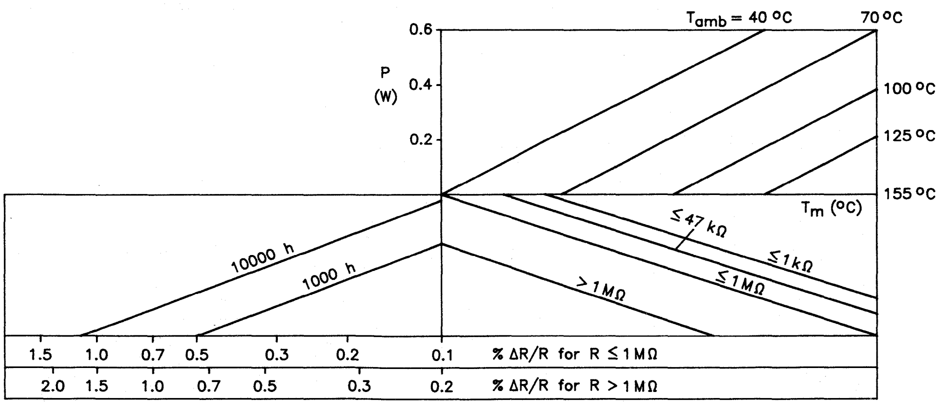


Fig.3 Drift nomogram.

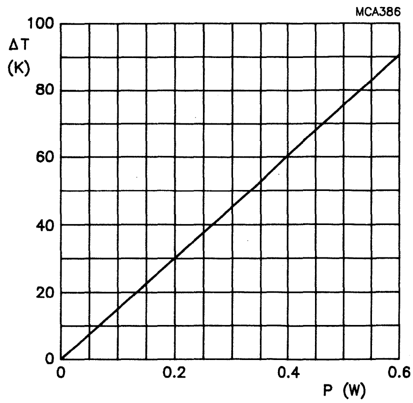


Fig.4 Hot-spot temperature rise (ΔT) as a function of dissipated power.

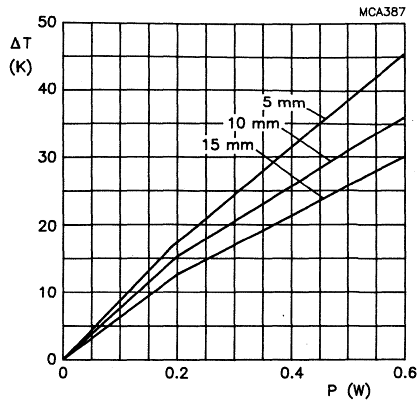


Fig.5 Temperature rise (ΔT) at the end of the lead (soldering point) as a function of dissipated power at various lead lengths after mounting.

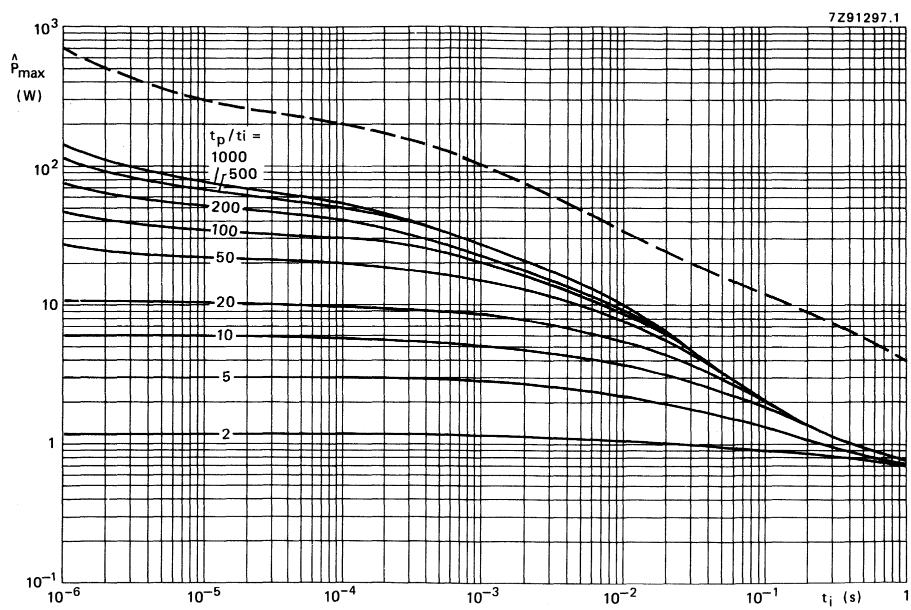


Fig.6 Maximum permissible peak pulse power (P_{max}) as a function of pulse duration for critical value.

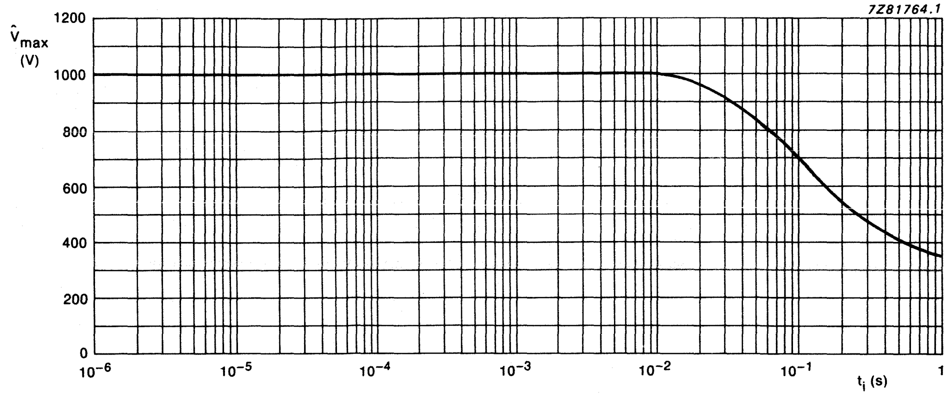


Fig.7 Maximum permissible peak pulse voltage as a function of pulse duration.

TESTS AND REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publication 115-1, category 55/155/56 (rated temperature range --55 to + 155 °C; damp heat, long term, 56 days) and along the lines of IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components". In the following table the test are listed with reference to the relevant clauses of IEC publications 115-1 and 68; a short description is also given of the test procedure and requirements. In some instances deviations from the IEC recommendation were necessary for our method of specifying.

Table 2

IEC 115-1-4 clause	IEC 68 test method	test	procedure	requirements
		Robustness of terminations		
4.16.2	Ua	Tensile all samples	ϕ 0,6 mm; load 10N; 10 s	number of failures < 10 ppm
4.16.3	Ub	Bending half number of samples	ϕ 0,6 mm; load 5N; 4 x 90°	
4.16.4	Uc	Torsion other half number of samples	3 x 360° in opposite directions	no damage ΔR max. 0,1% + 0,01 Ω
4.17	T_a	Soldering	solderability: 2 s 235 °C, flux 600	good tinning, no damage
4.18	T_b		thermal shock: 3 s 350 °C, 6 mm from body	ΔR max. 0,1% + 0,01 Ω

IEC 115-1-4 clause	IEC 68 test method	test	procedure	requirements
4.19	Na	Rapid change of temperature	½ h −55 °C/½ h + 155 °C 5 cycles	$R \leqslant 1$ MΩ: ΔR max. 0,1% + 0,01 Ω $R > 1$ MΩ: ΔR max. 0,25% + 0,05 Ω
4.20	Eb	Bump	3 x 1500 bumps in three directions, 40g	no damage ΔR max. 0,1% + 0,01 Ω
4.22	Fc	Vibration	frequency 10-500 Hz, displacement 1,5 mm or acceleration 10g, three directions; total 6 h (3 x 2 h)	no damage ΔR max. 0,1% + 0,01 Ω
4.23		Climatic sequence		
4.23.2	Ba	Dry heat	16 h, 155 °C	
4.23.3	Db	Damp heat (accel) 1st cycle	24 h; 55 °C; 95-100% R.H.	
4.23.4	Aa	Cold	2 h; −55 °C	
4.23.5	M	Low air pressure	2 h; 8,5 kPa; 15-35 °C	
4.23.6	Db	Damp heat (accel) remaining cycles	5 days; 55 °C; 95-100% R.H.	R_{ins} min. 1000 MΩ $R \leqslant 1$ MΩ: ΔR max. 0,5% + 0,05 Ω $R > 1$ MΩ: ΔR max. 1% + 0,05 Ω
4.24.2	Ca	Damp heat steady state	56 days; 40 °C; 90-95% R.H. dissipation 0,01 P_{70}	R_{ins} min. 1000 MΩ $R \leqslant 1$ MΩ: ΔR max. 0,5% + 0,05 Ω $R > 1$ MΩ: ΔR max. 1,0% + 0,05 Ω
4.25.1	−	Endurance	1000 hours; 70 °C P_{70} or V_{max}	$R \leqslant 1$ MΩ: ΔR max. 0,5% + 0,05 Ω $R > 1$ MΩ: ΔR max. 1,0% + 0,05 Ω
4.8.4	−	Temperature coefficient	between −55 °C and + 155 °C	$R < 4{,}99\ \Omega \leqslant 100.10^{-6}$/K $R \geqslant 4{,}99\ \Omega \leqslant 50.10^{-6}$/K
4.7	−	Voltage proof on insulation	700 V (RMS) during 1 minute; V-block method	no breakdown
4.12	−	Noise	IEC publication 195	$R \leqslant 1$ MΩ max. 0,1 μV/V $R > 1$ MΩ max. 1,5 μV/V
4.6.1.1	−	Insulation resistance	500 V (DC) during 1 minute; V-block method	min. 10^4 MΩ

TESTS AND REQUIREMENTS (continued)

IEC 115-1-4 clause	IEC68 test method	test	procedure	requirements
4.13	–	Short time overload	Room temperature, dissipation 6,25 P_n (voltage not more than 2 x limiting voltage) 10 cycles, 5 s on, 45 s off	ΔR max. 0,25% + 0.05 Ω
See 2nd amendment to IEC 115-1, Jan. 87.		Pulse-load		see Figs 6 and 7

PACKING

The resistors are supplied on bandolier; either 1000/5000 resistors in ammopack or 5000 resistors on reel. For details see General section.

Dimensions of bandolier

type	a ± 0,5	A	B1-B2 ± max.	S (spacing)	T (max. deviation of spacing)
MRS25	6	52,5 ± 1,5	1,2	5	1 mm per 10 spacings
MRS25ST	6	$26\ ^{+1,5}_{-0}$	0,8	5	0,5 mm per 5 spacings

Dimensions of ammopack

	M	N	P
1000 resistors	82	28	262
2000 resistors	50	50	255
5000 resistors	78	98	270

Dimensions of reel

	Q	R	V
5000 resistors	305	86	75

METAL FILM RESISTORS

low-inductance versions

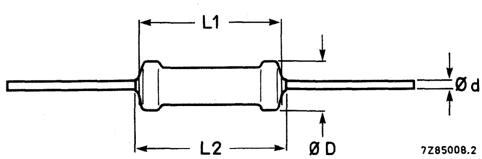
QUICK REFERENCE DATA

			MRS16TIi	MRS25Ii
Type			MRS16TIi	MRS25Ii
Resistance range, E24/96 series			6,8 Ω to 1 kΩ	5,1 Ω to 1 kΩ
Resistance tolerance			± 1%	± 1%
Temperature coefficient			$\leqslant 50.10^{-6}$/K	$\leqslant 50.10^{-6}$/K
Rated dissipation at T_{amb} = 70 °C*			0,4 W	0,6 W
Thermal resistance, R_{th}			170 K/W	150 K/W
V_{max}			200 V	350 V
Noise		max.	0,1 μV/V	
Basic specifications			IEC 115-1 and 115-2	
Approval			CECC 40101	
Climatic category (IEC 68)			55/155/56	
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% + 0,01 Ω	
short-term overload	ΔR/R	max.	0,25% + 0,05 Ω	

DESCRIPTION

A homogeneous film of metal alloy is deposited on a high grade ceramic body. After a helical groove (max. 2 turns) has been cut in the resistive layer, tinned connecting wires of electrolytic copper are welded to the endcaps. The resistors are coated with a green 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 68-2-45.

MECHANICAL DATA



type and style	D	L	L2 max.	d
MRS16TIi	1,7 $^{+0,2}_{-0,1}$	3,5 $^{+0,2}_{-0,15}$	3,7	0,5 −0,04
MRS25Ii	2,5 max.	6,5 max.	7,0	0,6 ± 0,03

* See Figs 2 and 4.

The length of the body (L1, see Fig. 1) is measured by inserting the leads into holes of two identical gauge plates and moving these plates parallel to each other until the resistor body is clamped without deformation (IEC publication 294). For leads of 0,5 mm diameter, the diameter of the holes in the gauge plates is 0,8 mm. For leads of 0,6 mm diameter, the holes are 1,0 mm.

Mass

MRS16TIi: 12,5 g per 100 resistors
MRS25Ii : 25 g per 100 resistors

Mounting

The resistors are suitable for processing on automatic insertion equipment and cutting and bending machines. The minimum pitch is 2e (5 mm) for MRS16TIi and 4e (10 mm) for MRS25Ii

- Temperature rise (ΔT) of the resistor-body as a function of the dissipation — See Figs 6a and 6b
- Temperature rise (ΔT) at the end of lead (soldering place) as a function of the dissipation — See Figs 7a and 7b

Marking

The nominal resistance and the tolerance are marked on the resistors either by five coloured bands (MRS16TIi) or six coloured bands (MRS25Ii) according to IEC publication 62 "Colour code for fixed resistors".

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated resistance (nominal resistance) are taken from the E24/E96 series within the range of 6,8 Ω to 1 kΩ for MRS16TIi and 5,1 Ω to 1 kΩ for MRS25Ii. These values are given in the table "Standard series of values in a decade" at the back of the handbook. The tolerance on the rated resistance is ± 1%.

The limiting voltage (DC or RMS) is 200 V for MRS16TIi and 350 V for MRS25Ii. This is the maximum voltage that may be applied continuously to the resistor element; see IEC publications 115-1 and 115-4. The maximum permissible hot-spot temperature is 155 °C.

High-frequency behaviour

The behaviour of a resistor at high frequencies is influenced not only by its construction, but also by external factors such as length of leads, environmental stray capacitances and the measuring apparatus. Thus these factors have to be considered when measuring.
Figs 6 and 7 give typical values under test conditions at various frequencies up to 1,3 GHz.

type	packing	quantity	resistance range	tolerance ± %	catalogue number
MRS16TIi	ammopack	1000	6,8 Ω to 1 kΩ	1	2322 157 0 . . . .
MRS25Ii	ammopack	1000	5,1 Ω to 1 kΩ	1	2322 156 0 . . . .

COMPOSITION OF THE CATALOGUE NUMBER

The catalogue number in the above is completed by inserting the resistance code: the first three figures of the resistance (in Ω) followed by: 8 for R up to 9,76 Ω; 9 for R = 10 to 97,6 Ω; 1 for R = 100 to 976 Ω and 2 for R = 1 kΩ.
Example

The catalogue number of a resistor MRS16TIi of 750 Ω ± 1%, on a bandolier of 1000 items, supplied in ammopack, is 2322 157 07501.

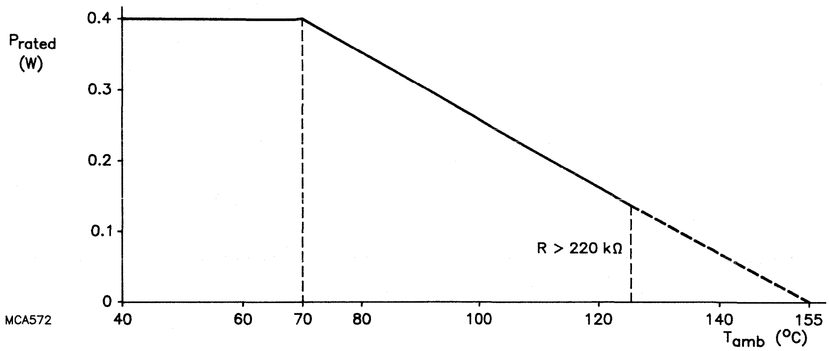


Fig.2 Maximum dissipation (P_{max}) as a function of ambient temperature (T_{amb}); MRS16TIi.

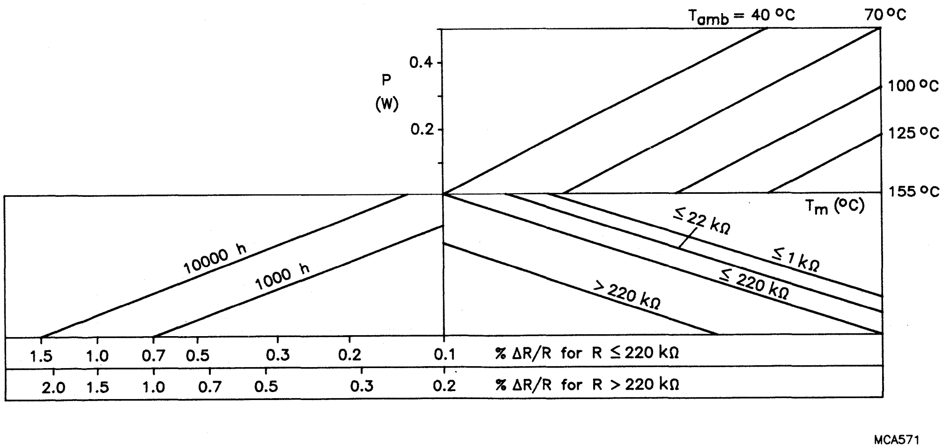


Fig.3 Drift nomogram; MRS16TIi.

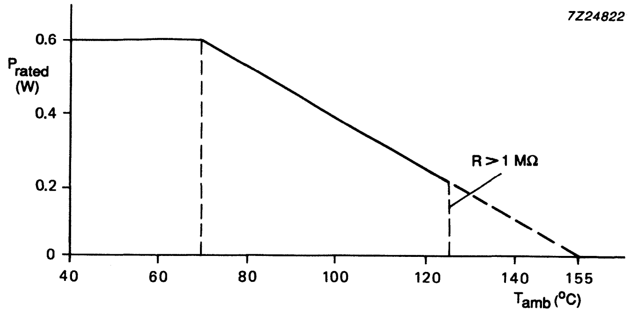


Fig.4 Maximum dissipation (P_{max}) as a function of ambient temperature (T_{amb}); MRS25Ii.

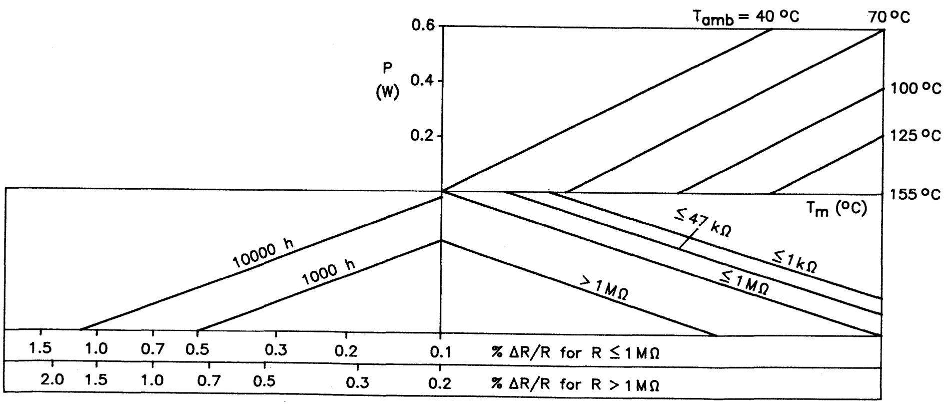


Fig.5 Drift nomogram; MRS25Ii.

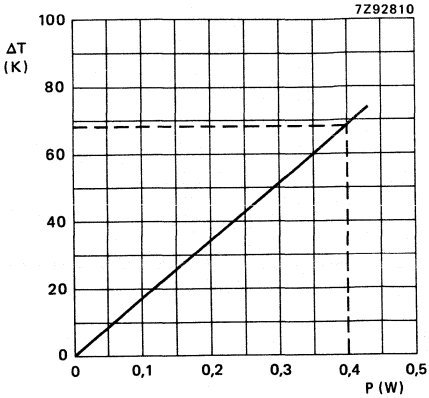


Fig.6a Hot-spot temperature rise (ΔT) as a function of dissipated power, MRS16TIi.

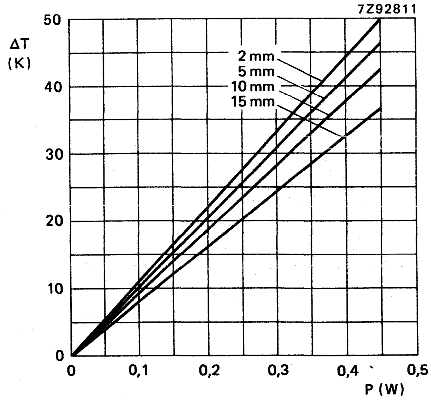


Fig.7a Temperature rise (ΔT) at the end of the lead (soldering point) as a function of dissipated power at various lead lengths after mounting, MRS16TIi.

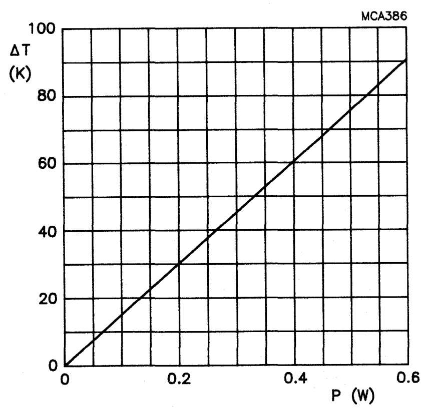


Fig.6b Hot-spot temperature rise (ΔT) as a function of dissipated power, MRS25Ii.

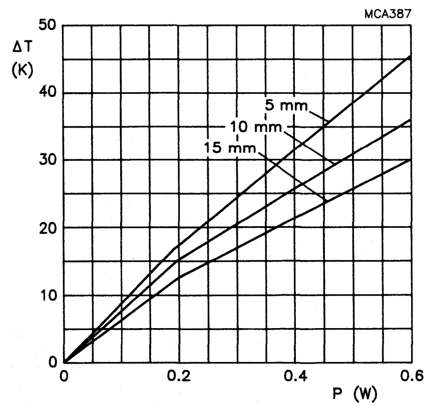


Fig.7b Temperature rise (ΔT) at the end of the lead (soldering point) as a function of dissipated power at various lead lengths after mounting, MRS25Ii.

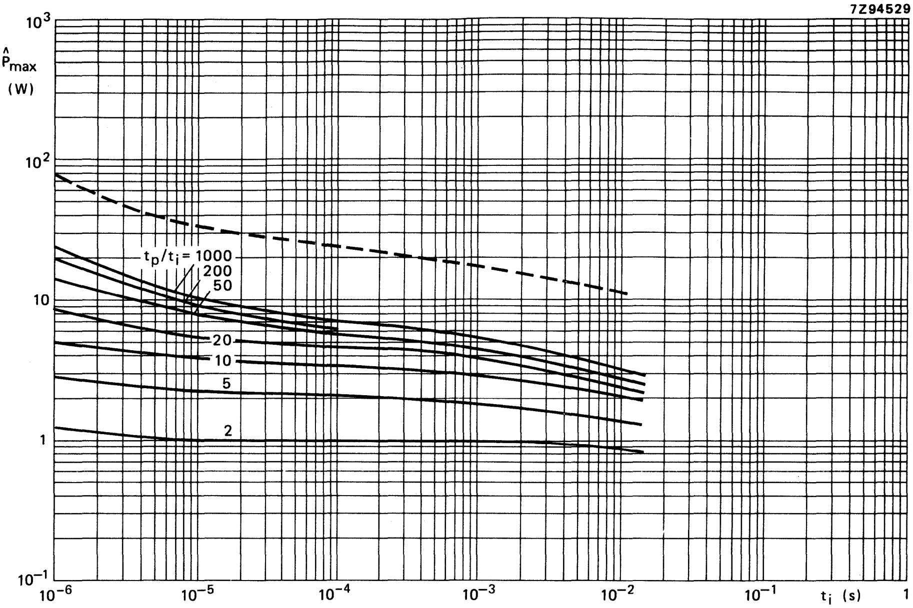


Fig.8a Maximum permissible peak pulse power as a function of pulse duration, MRS16TIi.

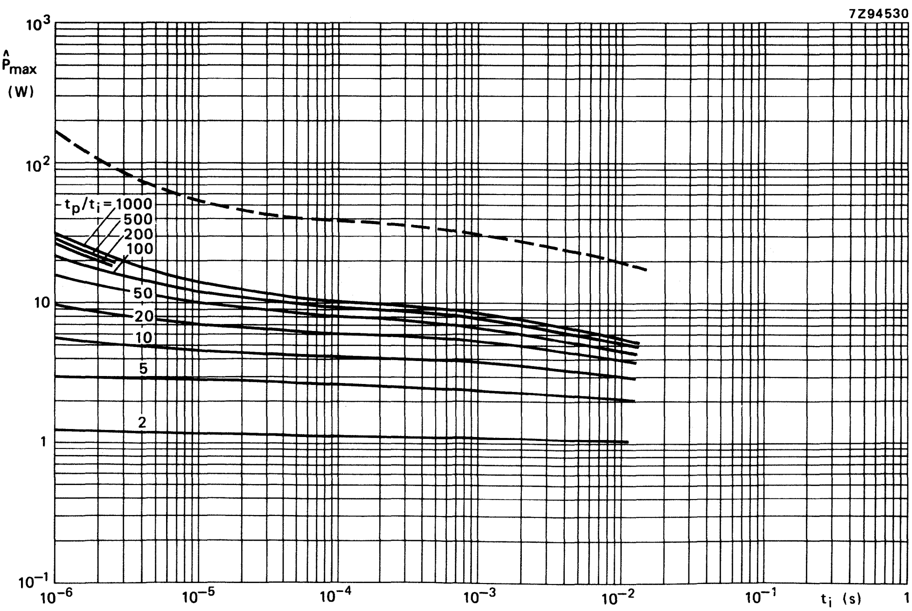


Fig.8b Maximum permissible peak pulse power as a function of pulse duration, MRS25Ii.

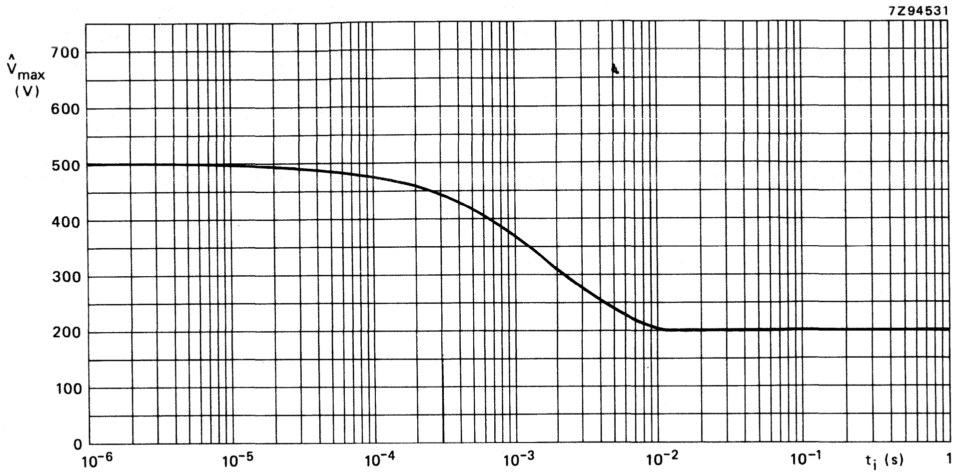


Fig.9a Maximum permissible peak pulse voltage as a function of pulse duration, MRS16TIi.

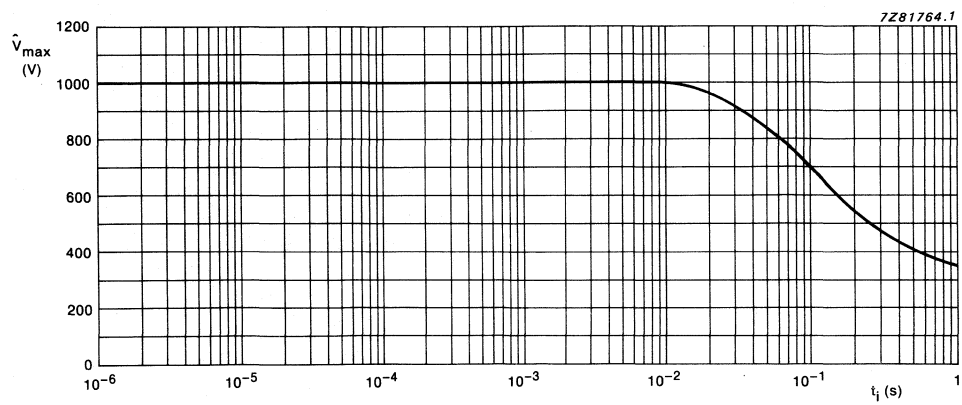


Fig.9b Maximum permissible peak pulse voltage as a function of pulse duration, MRS25Ii.

TESTS AND REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publication 115-1, category 55/155/56 (rated temperature range −55 to + 155 °C: damp heat, long term, 56 days) are carried out and along the lines of IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components". In the following table the tests are listed with reference to the relevant clauses of IEC publications 115-1 and 68; a short description is also given of the test procedure and requirements. In some instances deviations from the IEC specification were necessary for out method of specifying.

Table

IEC 115-1-4 clause	IEC 68 test method	test	procedure	requirements
		Robustness of terminations		
4.16.2	Ua	Tensile all samples	ϕ 0,5 mm; load 5N; 10 s ϕ 0,6 mm; load 10N; 10 s	number of failure < 10 ppm
4.16.3	Ub	Bending half number of samples	ϕ 0,5 mm; load 2,5N; 4 x 90° ϕ 0,6 mm; load 5N; 4 x 90°	
4.16.4	Uc	Torsion other half number of samples	3 x 360° in opposite directions	no damage ΔR max. 0,1% + 0,01 Ω
4.17	T_a	Soldering	solderability: 2 s 235 °C, flux 600	good tinning, no damage
4.18	T_b		thermal shock: 3 s 350 °C, 6 mm from body	ΔR max. 0,1% + 0,01 Ω
4.19	Na	Rapid change of temperature	½ h −55 °C/½ h + 155 °C 5 cycles	ΔR max. 0,1% + 0,01 Ω
4.20	Eb	Bump	3 x 1500 bumps in three directions, 40g	no damage ΔR max. 0,1% + 0,01 Ω
4.22	Fc	Vibration	frequency 10-500 Hz, displacement 1,5 mm or acceleration 10g, three directions; total 6 h (3 x 2 h)	no damage ΔR max. 0,1% + 0,01 Ω

IEC 115-1-4 clause	IEC 68 test method	test	procedure	requirements
4.23		Climatic sequence		
4.23.2	Ba	Dry heat	16 h, 155 °C	
4.23.3	Db	Damp heat (accel) 1st cycle	24 h; 55 °C; 95-100% R.H.	
4.23.4	Aa	Cold	2 h; −55 °C	
4.23.5	M	Low air pressure	2 h; 8,5 kPa; 15-35 °C	
4.23.6	Db	Damp heat (accel) remaining cycles	5 days; 55 °C; 95-100% R.H.	R_{ins} min. 1000 MΩ ΔR max. 0,5% + 0,05 Ω
4.24.2	Ca	Damp heat	56 days; 40 °C; 90-95% R.H. dissipation 0.01 P_n	R_{ins} min. 1000 MΩ ΔR max. 0,5% + 0,05 Ω
4.25.1	–	Endurance	1000 hours; 70 °C nominal dissipation or V_{max}	ΔR max. 0,5% + 0,05 Ω
4.8.4.2	–	Temperature coefficient	between −55 °C and + 155 °C	$\leqslant 50.10^{-6}$/K
4.7	–	Voltage proof on insulation	400 V (RMS) MRS16TIi 700 V (RMS) MRS25Ii during 1 minute; V-block method	no breakdown
4.12	–	Noise	IEC publication 195	max. 0,1 µV/V
4.6.1.1	–	Insulation resistance	100 V (DC) MRS16TIi 500 V (DC) MRS25Ii 1 minute; V-block method	min. 10^4 MΩ
4.13	–	Short-term overload	Room temp., dissipation 6,25 x 0,6 W (MRS25Ii) and 6,25 x 0,25 W (MRS16TIi), voltage not more than 2 x limiting voltage, 10 cycles, 5 s ON, 45 s OFF	ΔR max. 0,25% + 0,05 Ω
See 2nd amendment to IEC 115-1, Jan. 87		Pulse load		see Figs 8 and 9

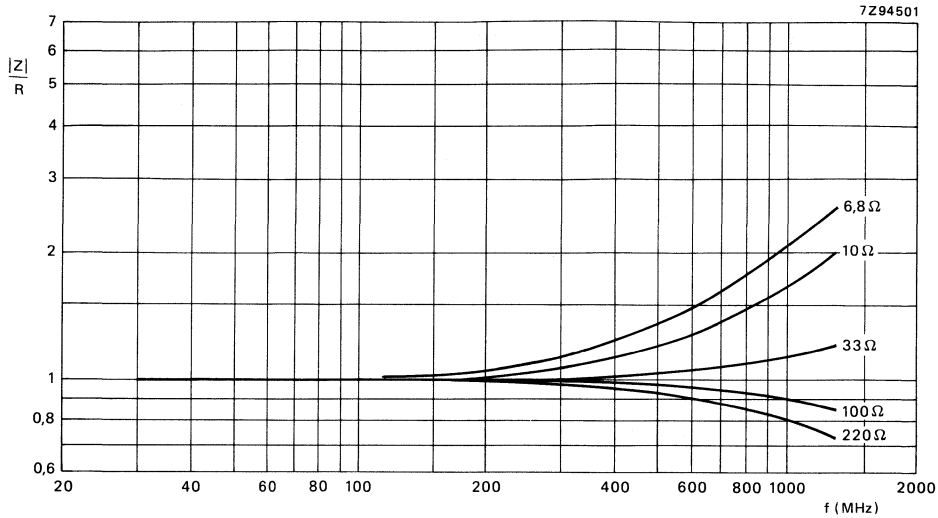


Fig.10a Impedance behaviour at high frequencies, MRS16TIi, lead length 2 mm.

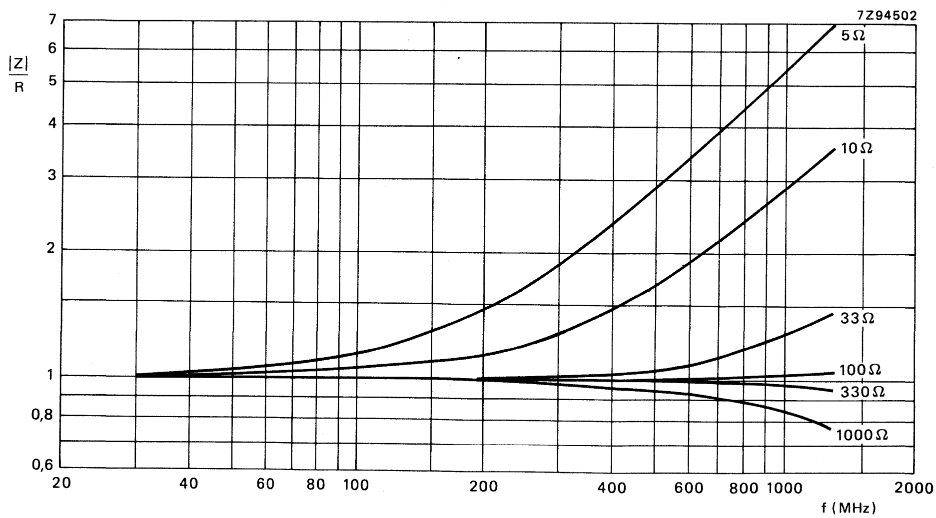


Fig.10b Impedance behaviour at high frequencies, MRS25Ii, lead length 4 mm.

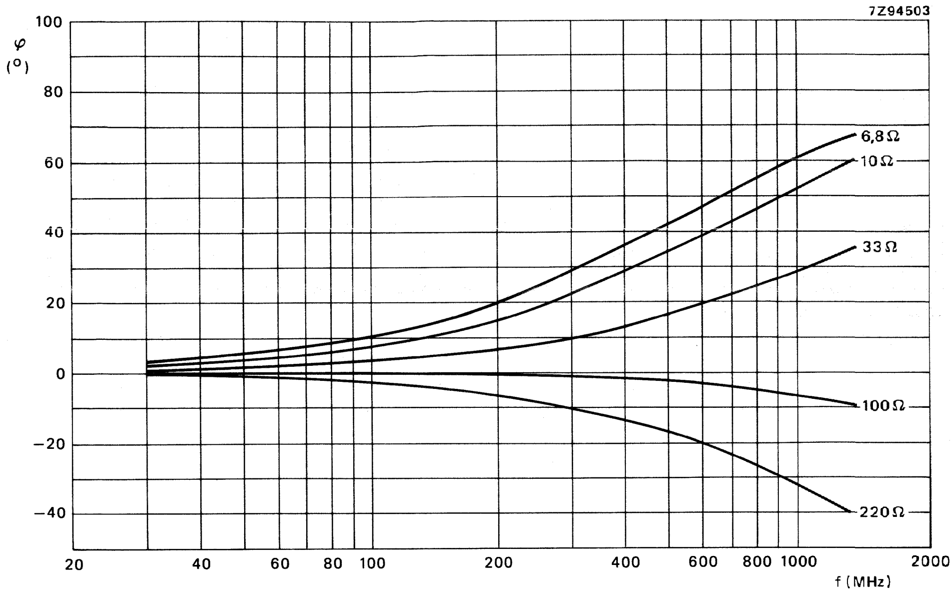


Fig.11a Phase angle behaviour at high frequencies, MRS16TIi, lead length 2 mm.

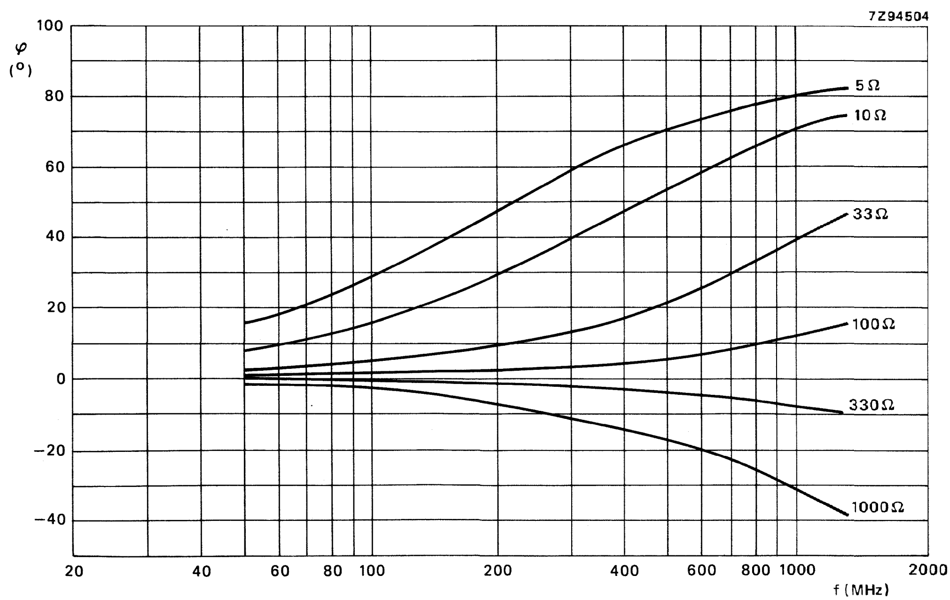


Fig.11b Phase angle behaviour at high frequencies, MRS25Ii, lead length 4 mm.

PACKING

The resistors are supplied on bandolier; 1000 resistors in ammopack. For details see General section.

Dimensions of bandolier

type and style	a ± 0,5	A ± 1,5	B1-B2 ± max.	S (spacing)	T (max. deviation of spacing)
MRS16TIi	6	52,5	0,5	5	1 mm per 10 spacings
MRS25Ii	6	52,5	1,2	5	0,5 mm per 5 spacings

Dimensions of ammopack

	M	N	P
MRS16TIi	75	30	140
MRS25Ii	82	28	262

METAL FILM RESISTORS

QUICK REFERENCE DATA

Type		MR25	MR30	MR52
Resistance range		1 Ω to 1 MΩ	1 Ω to 1 MΩ	4,99 Ω to 1 MΩ
Series		E192	E192	E24; E96
Resistance tolerance		± 0,5%	± 0,5%	± 1%
Temperature coefficient		± 50.10^{-6}/K	± 50.10^{-6}/K	± 50.10^{-6}/K
Absolute max. dissipation at T_{amb} = 70 °C		0,4 W	0,5 W	1 W
Basic specification		IEC 115-1		
Climatic category (IEC 68)		55/155/56		
Approval		CECC 40101		
Stability after				
load	ΔR/R	see nomogram		
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		

APPLICATION

For use in professional equipment: computers, telecom, measuring, etc.

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 layers of green 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 68-2-45.

MECHANICAL DATA

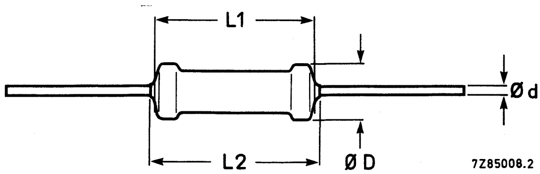


Fig. 1 This standard version is specially made to obtain a minimum "clean lead to clean lead" dimension L2.

Table 1

type	D_{max}	$L1_{max}$	$L2_{max}$	d
MR25	2,5	6,5	7,5	0,6
MR30	3,0	10,0	11,0	0,6
MR52	5,2	16,5	17,5	0,6

* Dissipation at T_{amb} = 70 °C which causes the maximum permissible hot-spot temperature of 175 °C to occur, irrespective of the resistance drift provoked by this condition.

The length of the body is measured by inserting the leads into the holes of two identical gauge plates and moving these plates parallel to each other until the resistor body is clamped without deformation (IEC publication 294). For leads of 0,5 mm dia the diameter of the holes in the gauge plate is 0,8 mm and for leads of 0,6 mm dia these holes are 1,0 mm dia.

Mass

type MR25 : 25 g per 100 resistors
MR30 : 32 g per 100
MR52 : 92 g per 100

Mounting

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

Marking

The nominal resistance and tolerance are marked on the resistors by five or six coloured bands according to IEC publication 62 "Colour code for fixed resistors". Five bands are used for the MR52 type; 3 for the resistance value, 1 for multiplier and 1 brown for tolerance.

Six bands are used for resistors in MR25 and MR30 series: 3 for resistance value, 1 for multiplier, 1 for tolerance and 1 for the temperature coefficient.

See General Section.

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated resistance (nominal resistance) are taken from the E24/E96 series for ± 1% and from the E192 series for ± 0,5%. The values of these series are given in the table "Standard series of values in a decade" at the back of the handbook. The limiting voltage (DC or RMS)* is the maximum voltage that may be applied continuously to the resistor element; see IEC publications 115-1 and 115-4.

* (see table 2).

Table 2

type	packing	quantity	resistance range	tol. %	series	temp. coefficient $\cdot 10^{-6}$/K	limiting voltage V	catalogue number 2322 followed by:
MR25	ammopack	1000	1 Ω to 1 MΩ	0,5	E192	± 50*	250	151 7....
MR30	ammopack	1000	1 Ω to 1 MΩ	0,5	E192	± 50*	350	152 7....
MR52	ammopack	1000	4,99 Ω to 1 MΩ	1	E24/96	± 50	500	153 5....

COMPOSITION OF THE CATALOGUE NUMBER

The catalogue number in the above table is completed by inserting the resistance code: the first three figures of the resistance in Ω followed by

8 for R = 1 to 9,76 Ω
9 for R = 10 to 97,6 Ω (see note)
1 for R = 100 to 976 Ω
2 for R = 1 to 9,76 kΩ
3 for R = 10 to 97,6 kΩ
4 for R = 100 to 976 kΩ
5 for R = 1 MΩ

Example: the catalogue number of a resistor MR52 of 3650 Ω ± 0,5% in ammopack of 1000 is 2322 153 73652

Note
The composition of catalogue number is not applicable for R = 49,9 Ω the relevant catalogue numbers will be indicated on request.

* For R < 4,99 Ω: 100.10^{-6}/K.

DISSIPATION AND STABILITY

The stability as a function of dissipation and ambient temperature is indicated in the performance nomogram of Fig. 2.

Notes on nomogram

1. It should not be extended beyond the maximum permissible hot-spot temperature of 175 °C.
2. The change in resistance for P = 0 at a particular ambient temperature is indicative for the 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.

style	MR25	MR30	MR52
R_{th} (K/W)	240	200	133
limiting voltage (V)	250	350	500

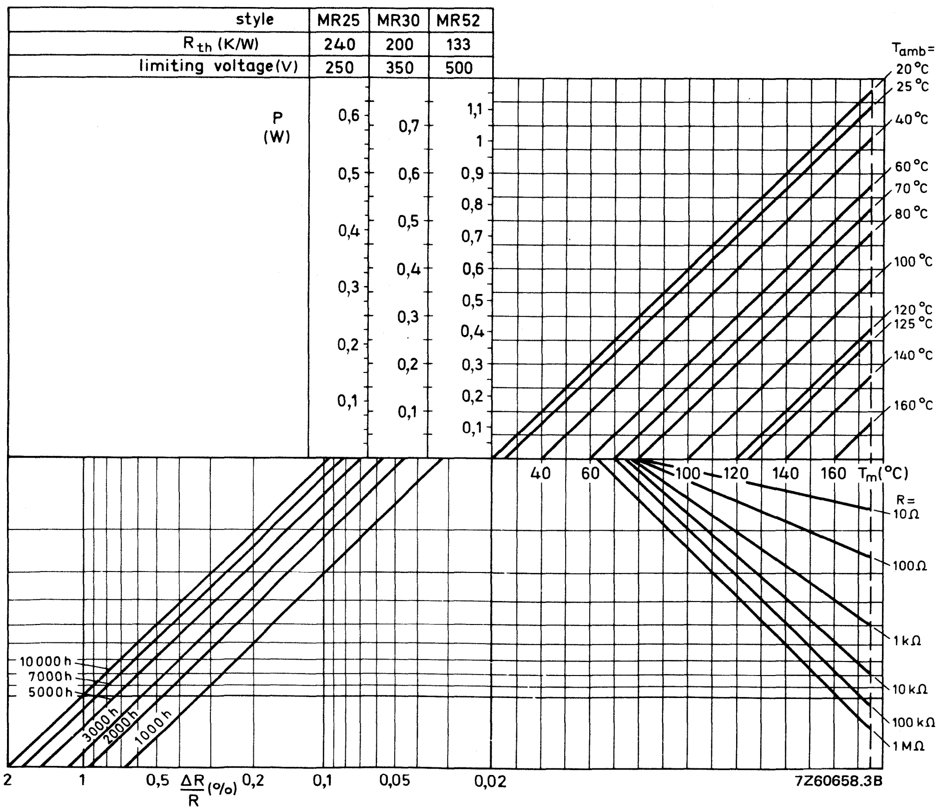


Fig. 2 Performance nomogram for different styles of resistor, showing the relationship between power dissipation P, ambient temperature T_{amb}, hot-spot temperature (T_m) and max. resistance drift ΔR/R after 1000 to 10 000 hours of operation.

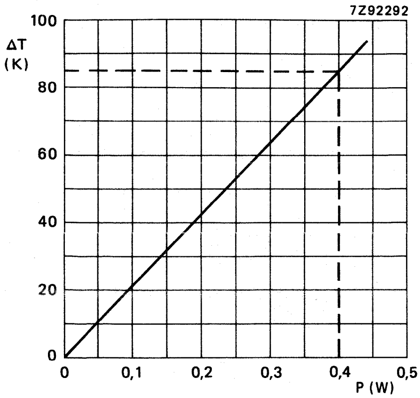


Fig. 3 MR25. Hot-spot temperature rise (ΔT) versus dissipated power.

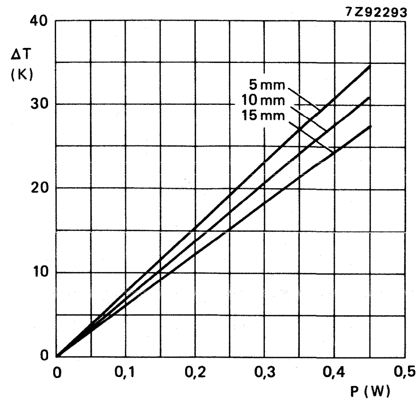


Fig. 4 MR25. Temperature rise (ΔT) at the end of lead (soldering point) versus dissipated power, at various lead lengths after mounting.

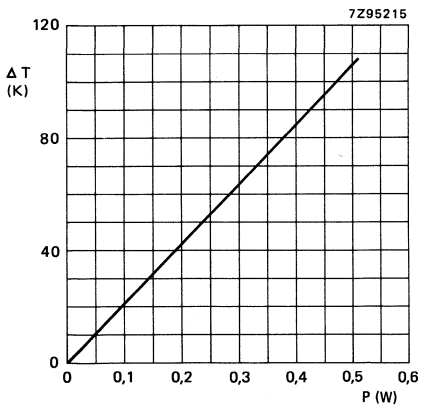


Fig. 5 MR30. Hot-spot temperature rise (ΔT) versus dissipated power.

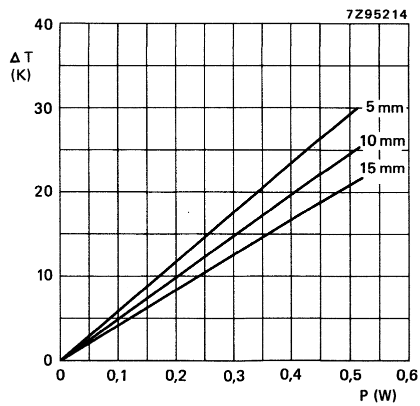


Fig. 6 MR30. Temperature rise (ΔT) at the end of lead (soldering point) versus dissipated power, at various lead lengths after mounting.

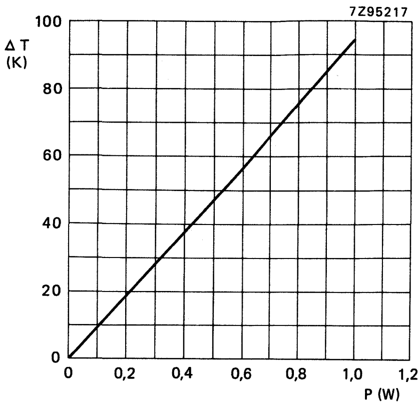


Fig. 7 MR52. Hot-spot temperature rise (ΔT) versus dissipated power.

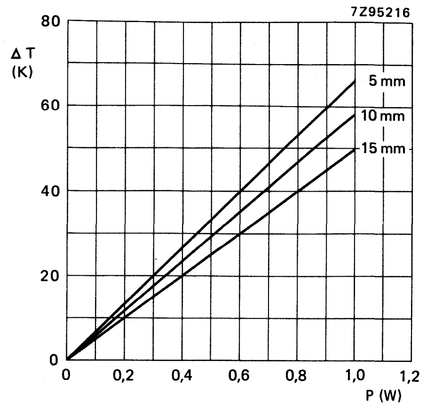


Fig. 8 MR52. Temperature rise (ΔT) at the end of lead (soldering point) versus dissipated power, at various lead lengths after mounting.

TESTS AND REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publication 115-1, category 55/155/56 (rated temperature range −55 to + 155 °C, damp heat, long term, 56 days) are carried out along the lines of IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components". In the following table the tests are listed with reference to the relevant clauses of IEC publications 115-1 and 68; a short description is also given of the test procedure and requirements. In some instances deviations from the IEC specification were necessary for our method of specifying.

Table 3

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
4.16		Robustness of terminations		
4.16.2	Ua	Tensile all samples	load 10 N, 10 s	number of failures < 10 ppm
4.16.3	Ub	Bending half number of samples	load 5 N, 4 x 90°	
4.16.4	Uc	Torsion other half number of samples	3 x 360° in opposite directions	no damage ΔR max. 0,1% + 0,01 Ω
4.17	Ta	Soldering	solderability: 2 s 230 °C, flux 600	good tinning no damage
4.18	Tb		thermal shock: 3 s. 350 °C, 6 mm from body	ΔR max. 0,1% + 0,01 Ω
4.19	Na	Rapid change of temperature	½ h −55 °C/½ h + 155 °C, 5 cycles	ΔR max. 0,1% + 0,01 Ω
4.22	Fc	Vibration	frequency 10-500 Hz, displacement 1,5 mm or acceleration 10g, three directions; total 6 h	no damage ΔR max. 0,1% + 0,01 Ω
4.20	Eb	Bump	3 x 1500 bumps in three directions, 40g	no damage ΔR max. 0,1% + 0,01 Ω

Table 3 (continued)

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
4.23		Climatic sequence		
4.23.2	B	Dry heat	16 h; 155 °C	
4.23.3	D	Damp heat (accel.) 1st cycle	 24 h; 55 °C; 95-100% R.H.	
4.23.4	Aa	Cold	2 h; –55 °C	
4.23.5	M	Low air pressure	1 h; 8,5 kPa; 15-35 °C	
4.23.6	D	Damp heat (accel.) remaining cycles	5 days; 55 °C; 95-100% R.H.	R_{ins} min. 1000 MΩ ΔR max. 0,5% + 0,05 Ω
4.24.2	Ca	Damp heat (long-term exposure)	56 days; 40 °C; 90-95% R.H. dissipation: MR25: ≤ 2,5 mW MR30: ≤ 3 mW MR52: ≤ 5 mW	R_{ins} min. 1000 MΩ ΔR max. 0,5% + 0,05 Ω
4.25.1	–	Endurance	1000 h: 70 °C: dissipation: MR25: 0,25 W MR30: 0,3 W MR52: 0,45 W or V_{max}	ΔR max. 0,5% + 0,05 Ω
4.8.4.2	–	Temperature coefficient	between –55 °C and + 155 °C	± 50.10⁻⁶/K
4.7	–	Voltage proof	2 x limiting voltage (a.c.) with a maximum of 750 V (r.m.s.)	no breakdown
4.12	–	Noise	IEC publication 195 R ≤ 100 kΩ R > 100 kΩ	 max. 0,25 μV/V max. 0,5 μV/V
4.6.1.1	–	Insulation resistance	100 V (DC) 1 min; V-block method	min. 10^4 MΩ
4.13	–	Short-time overload	T_{amb} = 25 °C dissipation 6,25 x P_{nom} voltage ≤ 2 x limiting voltage 10 cycles: 5 s on - 45 s off	ΔR max. 0,25% + 0,05 Ω

PACKING

For details see General Section.

The resistors are supplied on bandolier; either in ammopack or on reel, see Table 2.

Dimensions of bandolier

type	a	A	B1 – B2 ± max.	S (spacing)	T (max. deviation of spacing)
MR25	6 ± 0,5	52,4 ± 1,5	1,2	5	1 mm per 10 spacings, 0,5 mm per 5 spacings
MR30	6 ± 0,5	52,4 ± 1,5	1,2	5	
MR52	6 ± 0,5	66,7 ± 1,5	1,2	10	

Dimensions of ammopack

	M	N	P
MR25, 1000 resistors	82	28	262
MR30, 1000 resistors	77	34	265
MR52, 1000 resistors	97	95	260

LACQUERED METAL FILM RESISTORS

according to MIL-R-10509F

QUICK REFERENCE DATA

Resistance range		10 Ω to 1 MΩ, E96 and E192 series
Resistance tolerance		± 0,1; 0,25; 0,5; 1%
Rated dissipation at		
T_{amb} = 70 °C	MR24D	0,125 W
	MR34D	0,25 W
	MR54D	0,5 W
	MR74D	0,75 W
T_{amb} = 125 °C	MR24E/C	0,1 W
	MR34E/C	0,125 W
	MR54E/C	0,25 W
	MR74E/C	0,5 W
Basic specification		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

APPLICATION

For use in professional equipment: computers, telecom, measuring, etc.

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 layers of green lacquer which provide electrical, mechanical and climatic protection. The encapsulation is resistant to all cleaning solvents according to MIL-STD 202E, method 215 and IEC 68-2-45.

MECHANICAL DATA

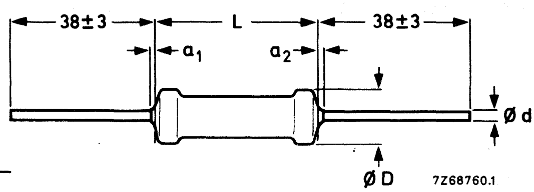


Fig. 1.

Table 1

type	D_{max}	L_{max}	a_1, a_2 $a_1 + a_2$	d
MR24E/C/D	2,4	6,5	⩽ 1	0,6
MR34E/C/D	3,1	10,5	⩽ 1	0,6
MR54E/C/D	5,2	16,5	⩽ 1	0,6
MR74E/C/D	6,8	20,5	⩽ 1	0,8

The length of the body is measured by inserting the leads into the holes of two identical gauge plates and by moving these plates parallel to each other until the resistor body is clamped without deformation (see IEC publication 294). For leads of 0,6 mm diameter the diameter of the holes in the gauge plate is 1,0 mm and for leads of 0,8 mm these holes are 1,2 mm diameter.

Mass

MR24E/C/D	25 g per 100
MR34E/C/D	32 g per 100
MR54E/C/D	92 g per 100
MR74E/C/D	200 g per 100

Mounting

The resistors must be mounted stress free so as to allow thermal expansion over the wide permissible temperature range.

Marking

The resistors are marked according to the 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 figures and a letter: first the three significant figures 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% and F = ± 1%.

Example: 22,1 kΩ ± 1% is written as 2212 F.
This code should not be used for ordering. Please use the catalogue number (see next page) for this purpose.

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated resistance (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 para 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 figures. The values of the E96 and E192 series are given at the back of this book.

Table 2

style	rated dissipation W	maximum temperature coefficient $. 10^{-6}/K$	resistance range and tolerance	max. voltage V	MIL style	catalogue number 2322 followed by
	at 125 °C	±	0,1/0,25/0,5% E192 series 1% E96 series			
MR24E	0,1	25	49,9 Ω to 1 MΩ	200	RN55E	160 . . . . .
MR24C	0,1	50	49,9 Ω to 1 MΩ	200	RN55C	161 . . . . .
MR34E	0,125	25	49,9 Ω to 1 MΩ	250	RN60E	163 . . . . .
MR34C	0,125	50	49,9 Ω to 1 MΩ	250	RN60C	164 . . . . .
MR54E	0,25	25	49,9 Ω to 1 MΩ	300	RN65E	166 . . . . .
MR54C	0,25	50	49,9 Ω to 1 MΩ	300	RN65C	167 . . . . .
MR74E	0,5	25	24,9 Ω to 1 MΩ	350	RN70E	169 . . . . .
MR74C	0,5	50	24,9 Ω to 1 MΩ	350	RN70C	170 . . . . .
	at 70 °C	±	1% E96 series			
MR24D	0,125	100	10 Ω to 1 MΩ	200	RN55D	162 . . . . .
MR34D	0,25	100	10 Ω to 1 MΩ	300	RN60D	165 . . . . .
MR54D	0,5	100	10 Ω to 1 MΩ	350	RN65D	168 . . . . .
MR74D	0,75	100	10 Ω to 1 MΩ	500	RN70D	171 . . . . .

COMPOSITION OF THE CATALOGUE NUMBER

The catalogue number in the above table is completed by inserting the tolerance and resistance code:

2322 . . . .

style code
see Table 2

tolerance code
1 for ± 1%
2 for ± 0,5%
3 for ±0,25%
4 for ± 0,1%

resistance value code: first three significant figures of the resistance value (in Ω) followed by
9 for R of 10 to 98,8 Ω
1 for R of 100 to 988 Ω
2 for R of 1 to 9,88 kΩ
3 for R of 10 to 98,8 kΩ
4 for R of 100 to 988 kΩ
5 for R of 1 MΩ

For the resistance values mentioned in Table 3 the "Composition of the catalogue number" is not applicable. In this table the last 5 digits of the catalogue number are stated in full.

Table 3

resistance value Ω	last 5 digits of the catalogue number			
	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		

TESTS AND REQUIREMENTS

All tests are carried out according to the schedule of MIL-R-10509F para 4.4.2. In the table below the tests and requirements are listed with reference to the relevant paragraphs of this specification.

Table 4

MIL method			requirement	
R 10509F paragraph	STD 202 method	procedure	MIL-R-10509F paragraph	requirement*
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	301/105	Dielectric withstanding voltage	3.13	$\Delta R \leq 0{,}25\% + 0{,}05\ \Omega$
4.6.9	302	Insulation resistance	3.14	$R_{ins} \geq 10\,000\ M\Omega$
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	$\Delta R \leq 0{,}25\% + 0{,}05\ \Omega$

PACKAGING

Bulk packing, 100 per box.

* 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 requirements of characteristic C and E resistors.

METAL FILM PRECISION RESISTORS

QUICK REFERENCE DATA

Resistance range		24 Ω to 100 kΩ	4,99 Ω to 1 MΩ
Resistance tolerance		± 0,05; 0,02; 0,01%	± 0,5; 0,25; 0,1%
Category		25/125/56	55/155/56
Failure level		S	R
Absolute maximum dissipation at T_{amb} = 70 °C	MPR24	0,125 W	0,250 W
	MPR34	0,25 W	0,40 W
Specification based on		CECC 40300 MIL-R-10509 MIL-R-55182 DIN 44061 IEC 115-5	
Temperature characteristic between + 20 and + 70 °C		ΔR/R max. ± 0,125% (TC ± 25) ΔR/R max. ± 0,075% (TC ± 15) ΔR/R max. ± 0,050% (TC ± 10) ΔR/R max. ± 0,025% (TC ± 5)	
Vibration test		10 Hz to 500 Hz; 0,75 mm 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 test		ΔR/R max. 0,01% + 0,01 Ω	
short overload		ΔR/R max. 0,01% + 0,01 Ω	

APPLICATION

These resistors have been developed for highly professional applications such as computers, test and telecommunication equipment, where high stability and low temperature coefficient are essential.

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 layers of green 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 68-2-45.

Resistors ⩽ 200 Ω with tolerances of 0,05, 0,02 and 0,01% have a low inductance.

MECHANICAL DATA

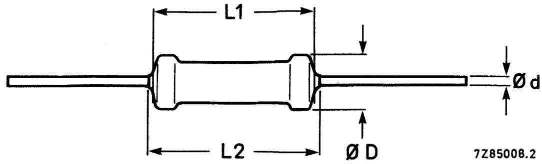


Fig. 1.

type	D	L1	L2 max	d
MPR24	2,5	6,5	7,5	0,6
MPR34	3,0	10,0	11,0	0,6

The lead length (38 ± 3 mm) only applies to untaped resistors, i.e. those packed in a cassette. See Standard Packing.

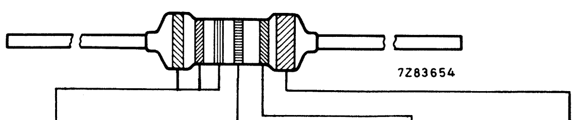
The length of the body is measured by inserting the leads into the 1 mm diameter holes of two identical gauge plates and by moving these plates parallel to each other until the resistor body is clamped without deformation (see IEC publication 294).

Mass (per 100 items): MPR24 – 25g
MPR34 – 30g

Coding

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 according to IEC publication 62 "Colour code for fixed resistors". See also General Section. All other resistors, including those in cassette packing, are marked.

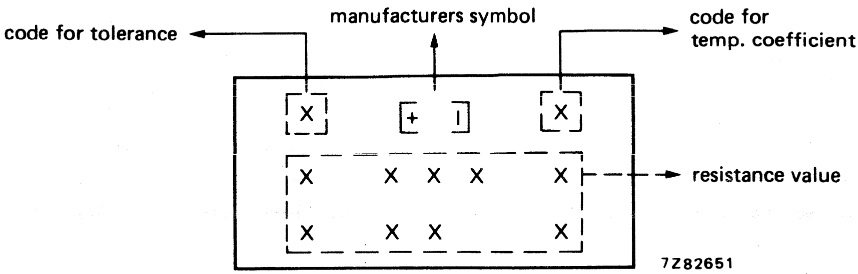
Colour coding



colour	significant figures	multiplier	tol. %	TC $. 10^{-6}/K$
black	0	1 x		
brown	1	10 x		
red	2	100 x		± 50
orange	3	1 000 x		± 15
yellow	4	10 000 x		± 25
green	5	100 000 x	± 0,5	
blue	6	1 000 000 x	± 0,25	± 10
violet	7		± 0,1	± 5
grey	8			
white	9			
silver	–	0,01 x		
gold	–	0,1 x		

Marking

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



Tolerance: (acc IEC 62).

± 0,5 % = D
± 0,25% = C
± 0,1 % = B
± 0,05% = W
± 0,02% = P
± 0,01% = L

Temperature coefficient:

TC ± 25 = 1
TC ± 15 = 2
TC ± 10 = 3
TC ± 5 = 4

Resistors with other temperature coefficients are available on request.

Resistance value:

Nine positions are available for the resistance value according to IEC 62.
Example: 4R99 = 4,99 Ω
K2751 = 275,1 Ω
27R83 = 27,83 Ω

ELECTRICAL DATA

Maximum permissible voltage			
MPR24		250	V
MPR34		350	V
Insulation voltage (RMS)			
MPR24		500	V
MPR34		700	V

Resistance range		24 Ω to 100 kΩ	4,99 Ω to 1 MΩ
Resistance tolerance		± 0,05; 0,02; 0,01%	± 0,5; 0,25; 0,1%
Climatic category (IEC68)		25/125/56	55/155/56
Failure level		S	R
Absolute maximum dissipation at T_{amb} = 70 °C	MPR24	0,125 W	0,250 W
	MPR34	0,25 W	0,40 W
Temperature coefficient		$\pm 5,10,15,25 \cdot 10^{-6}$/K	$\pm 5,10,15,25 \cdot 10^{-6}$/K

Resistors in the range 24 Ω to 200 Ω, tolerance < 0,1%, are of low inductance.

Derating at temperatures above 70 °C

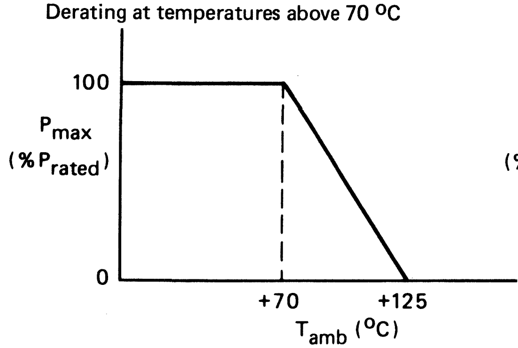


Fig. 2a Maximum dissipation (P_{max}) as a function of T_{amb} for R tolerances of 0,05, 0,02 and 0,01%.

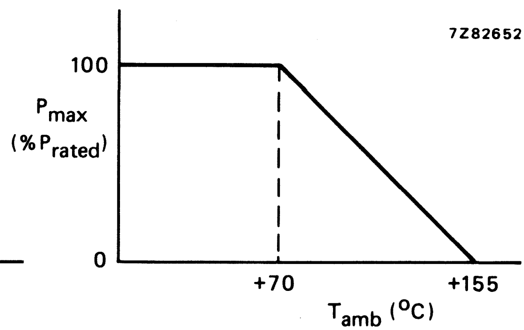
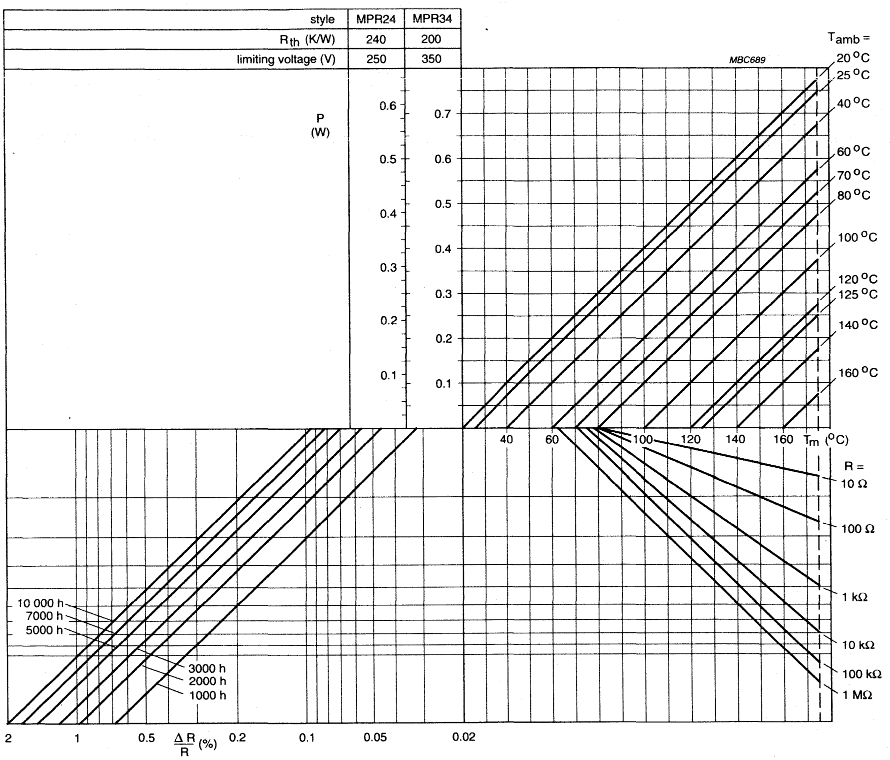


Fig. 2b Maximum dissipation (P_{max}) as a function of T_{amb} for R tolerances of 0,5, 0,25 and 0,1%.

Dissipation and stability

The stability as a function of dissipation and ambient temperature is indicated in the performance nomogram of Fig. 3 for resistors with R tolerance ⩾ 0,1%.



Notes on nomogram

1. The nomogram should not be extended beyond the maximum permissible hot-spot temperature of 175 °C.
2. The resistance change 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.
3. The stability lines do not give exact values ΔR/R, but represent a probability of 95% that the real values will be smaller than those obtained from the nomogram.
4. In the nomogram the limiting voltage of the resistors has not been taken into consideration.

COMPOSITION OF THE CATALOGUE NUMBER

a. For tolerances ± 0,5; ± 0,25 and ± 0,1%

2322 14X XXXXX

bandoliers of 100 and 1000 resistors

1	MPR24	style
2	MPR34	

0	tolerance %	0.5	100	packing
1			1000	
2		0.25	100	
3			1000	
4		0.1	100	
5			1000	

0	TC $\cdot 10^{-6}$/K	± 25	colour coded
1		± 15	
2		± 10	
3		± 5	
4		± 25	marked
5		± 15	
6		± 10	
7		± 5	

Any value within the range can be supplied in colour-coded versions provided the resistance value can be expressed in 3-colour-code bands. All other resistors are available as marked versions only.

XXX in the catalogue number denotes the 10th to 12th digits which are fixed by the supplier.

Tolerance < 0,1%; the values 24 Ω to 200 Ω are of low inductance value.

resistance range	T.C. $\cdot 10^{-6}$/K	standard packing	± 0,5% colour coded	± 0,5% marked	± 0,25% colour coded	± 0,25% marked	0,1% colour coded	0,1% marked
			8th and 9th digit of the catalogue number					
4,99 Ω to 1 MΩ	± 25	100	00xxx	04xxx	20xxx	24xxx	40xxx	44xxx
		1000	10xxx	14xxx	30xxx	34xxx	50xxx	54xxx
	± 15	100	01xxx	05xxx	21xxx	25xxx	41xxx	45xxx
		1000	11xxx	15xxx	31xxx	35xxx	51xxx	55xxx
	± 10	100	02xxx	06xxx	22xxx	26xxx	42xxx	46xxx
		1000	12xxx	16xxx	32xxx	36xxx	52xxx	56xxx
	± 5	100	03xxx	07xxx	23xxx	27xxx	43xxx	47xxx
		1000	13xxx	17xxx	33xxx	37xxx	53xxx	57xxx

bandoliers of 500 and 5000 resistors

2322 14X XXXXX

3	MPR24	style
4	MPR34	

0	tolerance %	0.5	500	packing
1			5000	
2		0.25	500	
3			5000	
4		0.1	500	
5			5000	

0	TC $\cdot 10^{-6}$/K	± 25	colour coded
1		± 15	
2		± 10	
3		± 5	
4		± 25	marked
5		± 15	
6		± 10	
7		± 5	

resistance range	T.C. $\cdot 10^{-6}$/K	standard packing	± 0,5% colour coded	± 0,5% marked	± 0,25% colour coded	± 0,25% marked	0,1% colour coded	0,1% marked
			8th and 9th digit of the catalogue number					
4,99 Ω to 1 MΩ	± 25	500	00xxx	04xxx	20xxx	24xxx	40xxx	44xxx
		5000	10xxx	14xxx	30xxx	34xxx	50xxx	54xxx
	± 15	500	01xxx	05xxx	21xxx	25xxx	41xxx	45xxx
		5000	11xxx	15xxx	31xxx	35xxx	51xxx	55xxx
	± 10	500	02xxx	06xxx	22xxx	26xxx	42xxx	46xxx
		5000	12xxx	16xxx	32xxx	36xxx	52xxx	56xxx
	± 5	500	03xxx	07xxx	23xxx	27xxx	43xxx	47xxx
		5000	13xxx	17xxx	33xxx	37xxx	53xxx	57xxx

b. For tolerances ± 0,05; ± 0,02 and ± 0,01%

2322 14X XXXXX

cassettes of 20 resistors
and
bandoliers of 100

1	MPR24	style
2	MPR34	style

6	± 0,05%	tolerance
7	± 0,02%	tolerance
8	± 0,01%	tolerance

0	TC $\cdot 10^{-6}$/K	± 25	20	packing
1		± 15	20	
2		± 10	20	
3		± 5	20	
4		± 25	100	
5		± 15	100	
6		± 10	100	
7		± 5	100	

Any value within the range will be supplied in marked versions provided the resistance value can be expressed in 3-colour-code bands. All other resistors are available as marked versions only.

XXX in the catalogue number denotes the 10th to 12th digits which are fixed by the supplier.

Tolerance < 0,1%; the values 24 Ω to 200 Ω are of low inductance value.

Quantities of 20 are accompanied by a list with individual measuring details.

resistance range	T.C.	standard packing	± 0,05%	± 0,02%	± 0,01%
			MARKED		
			8th and 9th digit of the catalogue number		
24 Ω to 100 kΩ	± 25	20	60xxx	70xxx	80xxx
	± 15	20	61xxx	71xxx	81xxx
	± 10	20	62xxx	72xxx	82xxx
	± 5	20	63xxx	73xxx	83xxx
	± 25	100	64xxx	74xxx	84xxx
	± 15	100	65xxx	75xxx	85xxx
	± 10	100	66xxx	76xxx	86xxx
	± 5	100	67xxx	77xxx	87xxx

bandoliers of 500
and 1000 resistors

2322 14X XXXXX

3	MPR24	style
4	MPR34	style

6	± 0,05%	tolerance
7	± 0,02%	tolerance
8	± 0,01%	tolerance

0	TC $\cdot 10^{-6}$/K	± 25	500	packing
1		± 15	500	
2		± 10	500	
3		± 5	500	
4		± 25	1000	
5		± 15	1000	
6		± 10	1000	
7		± 5	1000	

resistance range	T.C.	standard packing	± 0,05%	± 0,02%	± 0,01%
			MARKED		
			8th and 9th digit of the catalogue number		
24 Ω to 100 kΩ	± 25	500	60xxx	70xxx	80xxx
	± 15	500	61xxx	71xxx	81xxx
	± 10	500	62xxx	72xxx	82xxx
	± 5	500	63xxx	73xxx	83xxx
	± 25	1000	64xxx	74xxx	84xxx
	± 15	1000	65xxx	75xxx	85xxx
	± 10	1000	66xxx	76xxx	86xxx
	± 5	1000	67xxx	77xxx	87xxx

TESTS AND REQUIREMENTS

Essentially all tests are carried out according to the schedule of the CECC publication 40.300 category 55/155/56 (for the 0,5%, 0,25% and 0,1% tolerance classes) and category 25/125/56 (for the 0,05%, 0,02% and 0,01% tolerance classes) along the lines of CECC 40.000, "Recommended basic climatic and mechanical robustness testing procedure for electronic components".
In the following table the tests are listed with reference to the relevant clauses of CECC publication 40.000 and IEC publication 68; a short description is also given on the test procedure and requirements. In some instances deviations from the CECC were necessary for our method of specifying.

Table 2

CECC 40.000 test method	IEC 68 test method	test	procedure	requirements
4.5		Insulation resistance	MPR24: 500 V (d.c.) MPR34: 700 V (d.c.) during 1 min; V-block method	min. 10^4 MΩ
4.6		Voltage proof	2 x limiting voltage (a.c.) with a maximum of 750 V (r.m.s.) during 1 minute. V block method	no breakdown
4.7		Temperature coefficient	(a) between + 20 °C and + 70 °C (b) between −55 °C and + 155 °C *	$\leqslant\pm 25, \leqslant\pm 15, \leqslant\pm 10, \leqslant\pm 5 \cdot 10^{-6}$/K $\leqslant\pm 25, 10^{-6}$/K
4.10		Noise	IEC publication 195	$<$0.50 μV/V for R $>$100 K
4.11		Overload	5 s, 6,25 x P_{nom} or 2 x limiting voltage (whichever the less)	$\Delta R_{max} \leqslant 0{,}01\% + 0{,}01\ \Omega$
4.14	 Ua Ub Uc	Robustness of terminations Tensile all samples Bending half number of samples Torsion other half number of samples	 load 10N, 10 S load 5N, 4 x 90° 3 x 360° in opposite directions	no damage $\Delta R_{max} \leqslant 0{,}01\% + 0{,}01\ \Omega$
4.15	Ta Tb	Soldering	solderability: 2 S 230 °C flux 600 Thermal shock: 3 S 350 °C 6 mm from body	good timing no damage $\Delta R_{max} \leqslant 0{,}01\% + 0{,}01\ \Omega$
4.16	Na	Rapid change of temperature	(a) ½ h −25 °C/½ h + 125 °C 5 cycles (b) ½ h −55 °C/½ h + 155 °C 5 cycles *	$\Delta R_{max} \leqslant 0{,}01\% + 0{,}01\ \Omega$ $\Delta R_{max} \leqslant 0{,}01\% + 0{,}01\ \Omega$
4.17	Eb	Bump	3 x 1500 bumps in three directions, 40 g	no damage $\Delta R_{max} \leqslant 0{,}01\% + 0{,}01\ \Omega$

* (a) and (b) refer to the tolerance groups mentioned in Composition of the Catalogue Number.

CECC 40 000 test method	IEC 68 test method	test	procedure	requirements
4.19	Fc	Vibration	frequency 10 - 500 Hz, displacing 1,5 mm or deceleration 10g, three directions; total 6 h	no damage $\Delta R_{max} \leqslant 0{,}01\% + 0{,}01\ \Omega$
4.20		Climatic sequence		
*4.20.2	B	Dry heat	(a) 16 h; 125 °C (b) 16 h; 155 °C	
4.20.3	D	Damp heat (accel.) 1st cycle	24 h; 95 - 100% R.H.	
4.20.4	Aa	Cold	(a) 2 h; –25 °C (b) 2 h; –55 °C	
4.20.5	M	Low air pressure	1 h; 8,5 kPa; 15 - 35 °C	
4.20.6	D	Damp heat (accel.) remaining cycles	5 days; 95 - 100% R.H.	R_{ins} min. 100 MΩ $\Delta R_{max} \leqslant 0{,}05\% + 0{,}01\ \Omega$
4.21	Ca	Damp heat, Steady state (long term exposure)	56 days 40 °C; 90 - 95% R.H. dissipation $\leqslant$1,25 mW	R_{ins} min. 100 M $\Delta R_{max} \leqslant 0{,}05\% + 0{,}01\ \Omega$
4.24		Endurance 1½ h on/½ h off	2000 h dissipation at 70 °C MPR24: 0,125 W MPR34: 0,250 W	R_{ins} min 100 MΩ $\Delta R_{max} \leqslant 0{,}05\% + 0{,}01\ \Omega$

STANDARD PACKING

100 resistors on bandolier in a cardboard box; 500 and 1000 resistors on bandolier in ammopack, 5000 resistors on bandolier on reel, or 20 resistors in cassette, including list with individual measuring details. See General section for details.

Dimensions of bandolier

type	a ± 0,2	A ± 1,5	B1 – B2 ± max.	S spacing	T max. deviation of spacing
MPR24	6	63,5	1,2	5	1 mm per 10 spacings
MPR34	6	63,5	1,2	5	0,5 mm per 5 spacings

Dimensions of ammopack

	M	N	P
MPR24	97	29	262
MPR34	97	39	262

Dimensions of reel

	Q	V	
MPR	305	90	
MPR34	356	90	

* (a) and (b) refer to the tolerance groups mentioned in Composition of the Catalogue Number.

HIGH VOLTAGE

HIGH-OHMIC/HIGH-VOLTAGE RESISTORS

QUICK REFERENCE DATA

Resistance range	220 kΩ to 15 MΩ, E24/E96 series 100 kΩ to 10 MΩ, E24 series 12 MΩ to 22 MΩ, E12 series
Resistance tolerance	± 1% (E24/E96), ± 5% (E24), ± 10% (E12)
Max. permissible body temperature (hot spot)	155 °C
Temperature coefficient	$\pm 200 \cdot 10^{-6}$/K
Rated dissipation at T_{amb} = 70 °C	0,25 W
Limiting voltage	1600 V (DC) or 1150 V (RMS)
Dielectric withstanding voltage of the insulation for 1 minute	min. 700 V (RMS)
Basic specification	IEC 115, type 1B
Climatic category (IEC 68)	55/155/56
Stability after:	
1000 h max. load	ΔR/R max. 1.5%
accelerated damp heat test (6 days)	ΔR/R max. 1.5%
long-term damp heat test (56 days)	ΔR/R max. 1.5%
Noise	max. 5 μV/V

APPLICATION

These resistors are for applications in which high resistance, high stability and reliability are required at high voltages. The resistors meet the safety requirements of IEC 65 par. 14-1B, 4th edition; NFC 92-130 (France); VDE 0860 (Germany); BS 415 (U.K.).

DESCRIPTION

A metal-glazed film is deposited on a high grade ceramic body; tinned electrolytic copper connecting wires are welded to the end caps. The resistors are coated with a light-blue insulating lacquer which also provides protection against environmental effects.

MECHANICAL DATA

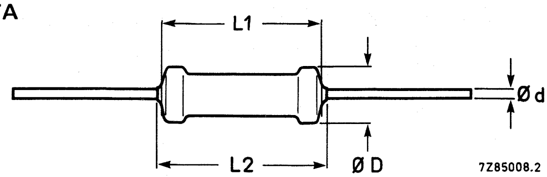


Fig. 1 Axial leads.

Table 1

type	D_{max}	$L_{1\,max}$	$L_{2\,max}$	d
VR25	2,5	6,5	7,5	0,6

The length of the body is measured by inserting the leads into holes of two identical gauge plates and moving these plates parallel to each other until the resistor body is clamped without deformation (IEC publication 294). For leads of 0,6 mm diameter, the diameter of the holes in the gauge plates is 1,0 mm.

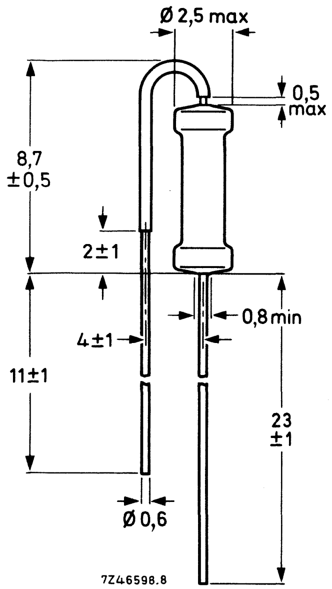


Fig. 2 "Stand-up" type VR25A, for vertical mounting; resistor shown in the mounted position. The bent lead is partly covered with an insulating lacquer with a breakdown voltage of at least 50 V (DC).

Mass 23 g per 100 resistors

Mounting

The resistors are suitable for processing on automatic insertion equipment and cutting and bending machines. The minimum pitch for the type with axial leads is 5 e (12,7 mm). The "stand-up" type, VR25A, can be inserted into holes with a pitch of 1 e.

Marking

The nominal resistance and the tolerance are marked on these resistors by four or five coloured bands according to IEC publication 62 "Colour code for fixed resistors". See General Section.

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

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated resistance (nominal resistance) are taken from the
E12 series within the range 12 MΩ to 22 MΩ for R ± 10%,
E24 series within the range 100 kΩ to 10 MΩ for R ± 5% and
E24/E96 series within the range 220 kΩ to 15 MΩ for R ± 1%
See the table "Standard series of values in a decade" at the back of the book.
The limiting voltage for resistor element is the maximum voltage that may be applied continuously to the resistor element; see IEC publications 115-1 and 115-2. This voltage is 1600 V (DC) or 1150 V (RMS).

Table 2

type	packing	quantity	resistance range	tolerance ± %	series	catalogue number 2322 followed by:
VR25	ammopack	1000	220 kΩ to 15 MΩ	1	E24/E96	241 8....
			100 kΩ to 10 MΩ	5	E24	241 13...
			12 MΩ to 22 MΩ	10	E12	241 12...
		5000	100 kΩ to 10 MΩ	5	E24	241 53...
			12 MΩ to 22 MΩ	10	E12	241 52...
	on reel	5000	100 kΩ to 10 MΩ	5	E24	241 23...
			12 MΩ to 22 MΩ	10	E12	241 22...
VR25 26 mm bandolier	ammopack	2000	100 kΩ to 10 MΩ	5	E24	241 43...
		2000	12 MΩ to 22 MΩ	10	E12	241 42...
VR25A "stand-up"	in box (loose)	1000	100 kΩ to 10 MΩ	5	E24	241 33...
			12 MΩ to 22 MΩ	10	E12	241 32...

COMPOSITION OF THE CATALOGUE NUMBER

The catalogue number in the above table is completed by inserted the resistance code: the first two figures (for 1% tolerance first three figures) of the resistance, followed by:

4 for R = 100 kΩ to 976 kΩ
5 for R = 1 MΩ to 9,76 MΩ
6 for R ⩾ 10 MΩ

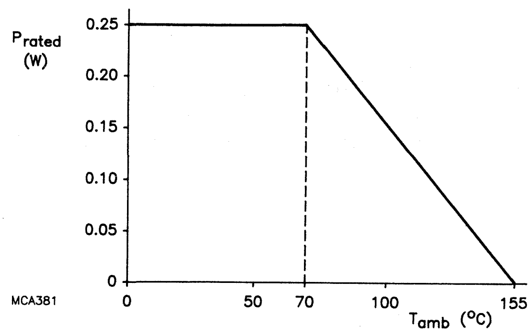


Fig. 3 Maximum dissipation (P_{max}) as a function of the ambient temperature (T_{amb}).

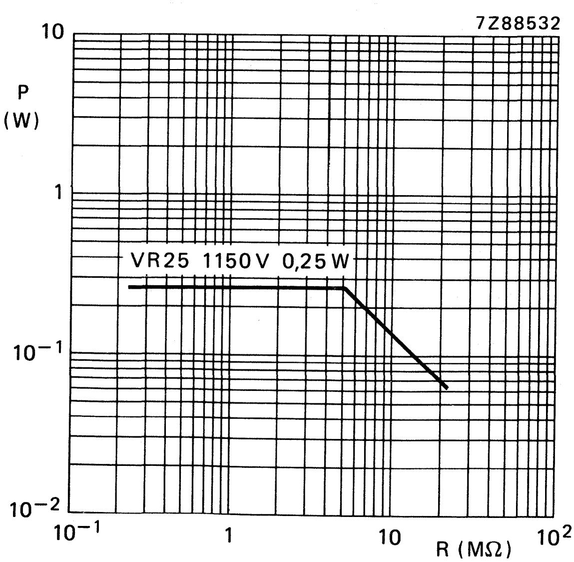


Fig. 4 Maximum permissible dissipation at T_{amb} = 70 °C as a function of the resistance.

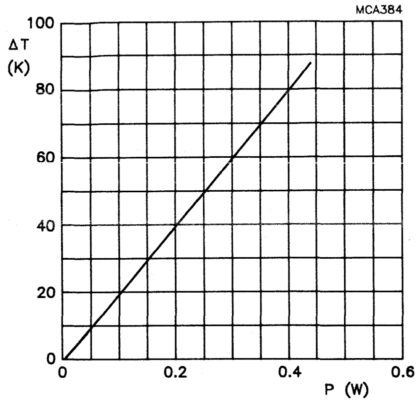


Fig.5 Hot-spot temperature rise (ΔT) as a function of dissipated power.

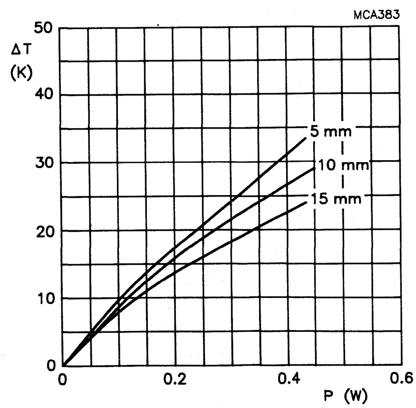


Fig.6 Temperature rise (ΔT) at the end of the lead (soldering point) as a function of various lead lengths after mounting.

TESTS AND REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publication 115-1, category 55/155/56 (rated temperature range −55 to + 155 °C; damp heat, long term, 56 days) and along the lines of IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components". In the following table the tests are listed with reference to the relevant clauses of IEC publications 115-1 and 68; a short description is also given of the test procedure and requirements. In some instances deviations from the IEC recommendation were necessary for our method of specifying.

Table 4

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
4.16		Robustness of terminations		
4.16.2	Ua	Tensile all samples	load 10N; 10 s	number of failures: < 10 ppm
4.16.3	Ub	Bending half number of samples	load 5N; 4 x 90°	
4.16.4	Uc	Torsion other half number of samples	3 x 360° in opposite directions	no damage ΔR max. 0,5% + 0,05 Ω
4.17	Ta	Soldering	solderability: 2 s 235 °C, flux 600	good tinning, no damage
4.18	Tb		thermal shock: 3 s 350 °C, 6 mm from body	ΔR max. 0,5% + 0,05 Ω
4.19	Na	Rapid change of temperature	½ h −55 °C/½ h + 155 °C, 5 cycles	ΔR max. 0,5% + 0,05 Ω
4.22	Fc	Vibration	frequency 10-500 Hz, displacement 1,5 mm or acceleration 10g, three directions; total 6 h (3 x 2 h)	no damage ΔR max. 0,5% + 0,05 Ω
4.20	Eb	Bump	3 x 1500 bumps in three directions, 40g	no damage ΔR max. 0,5% + 0,05 Ω

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
4.23		Climatic sequence		
4.23.2	Ba	Dry heat	16 h, 155 °C	
4.23.3	D	Damp heat (accel.) 1st cycle	24 h; 55 °C; 95-100% R.H.	
4.23.4	Aa	Cold	2 h; –55 °C	
4.23.5	M	Low air pressure	2 h; 8,5 kPa; 15-35 °C	
4.23.6	D	Damp heat (accel.) remaining cycles	5 days; 55 °C; 95-100% R.H.	R_{ins} min. 1000 MΩ ΔR max. 1.5%
4.24.2	Ca	Damp heat steady state	56 days; 40 °C; 90-95% R.H. dissipation $\leqslant$ 0,01 P_n limiting voltage 16 V (DC)	R_{ins} min. 1000 MΩ ΔR max. 1.5%
4.25.1	–	Endurance	1000 hours; 70 °C nominal dissipation or V_{max}	ΔR max. 1.5%
4.8.4.2	–	Temperature coefficient	between –55 °C and +155 °C	± 200.10^{-6}/K
4.7	–	Voltage proof on insulation	700 V (RMS), 1 minute V block method	no breakdown
4.12	–	Noise	IEC publication 195	max. 5 μV/V
4.6.1.1	–	Insulation resistance	500 V (DC) 1 minute; V block method	min. 10^4 MΩ
4.13	–	Short time overload	Room temperature, dissipation 6,25 P_n (voltage not more than 2 x limiting voltage), 10 cycles 5 s on, 45 s off	ΔR max. 0,5% + 0,05 Ω

PACKING

Resistors with axial leads are supplied on bandolier in ammopack or on reel; those with radial leads are either loose in a cardboard box or — with bent leads — on a bandolier in ammopack. See General section for details.

type	quantity per box		
	bandolier ammopack	bulk loose	bandolier on reel
VR25	1000/2000/5000	–	5000
VR25A	–	1000	–

Dimensions of bandolier

type	a ± 0,5	A	B1 - B2 ± max.	S (spacing)	T (max. deviation of spacing)
VR25	6	52,5 ± 1,5	1,2	5	1 mm per 10 spacings
VR25	6	26 + 1,5 – 0	1,0	5	0,5 mm per 5 spacings

Dimensions of ammopack

	M	N	P
1000 resistors	82	28	262
2000 resistors	50	50	255
5000 resistors	78	98	270

Dimensions of reel

	Q	V	
5000 resistors	305	75	

HIGH-OHMIC/HIGH-VOLTAGE RESISTORS

QUICK REFERENCE DATA

Type		VR37	VR68
Resistance range			
	E24 series	100 kΩ to 33 MΩ	100 kΩ to 68 MΩ
	E24/E96 series	100 kΩ to 33 MΩ	100 kΩ to 68 MΩ
Resistance tolerance			
	E24 series	± 5%	± 5%
	E24/E96 series	± 1%	± 1%
Thermal resistance		120 K/W	70 K/W
Max. permissible body temperature (hot spot)		155 °C	155 °C
Temperature coefficient		$\pm 200.10^{-6}$/K	$\pm 200.10^{-6}$/K
Rated dissipation at T_{amb} = 70 °C*		0.5 W	1.0 W
Limiting voltage			
DC		3.5 kV	10 kV
RMS		2.5 kV	7 kV
Dielectric withstanding voltage of the insulation for 1 minute	min.	700 V	700 V
Basic specification		IEC 115-1B	IEC 115-1B
Climatic category (IEC 68)		55/155/56	55/155/56
Stability after:			
1000 h max. load	ΔR/R max. (req.: 1.5%) + 0.1 Ω	typ. 0.5%	typ. 1%
6 days damp-heat test	ΔR/R max. (req.: 1.5%) + 0.1 Ω	typ. 0.5%	typ. 1%
56 days damp-heat test	ΔR/R max. (req.: 1.5%) + 0.1 Ω	typ. 0.5%	typ. 0.5%
Noise	max. (req.: 2.5 μV/V)	typ. 0.5 μV/V	typ. 0.5 μV/V

APPLICATION

Where high resistance, high stability and high reliability at high voltage are required. The resistors meet the safety requirements of IEC 65, 4th edition; NFC 92.130; BS415; VDE 0860.

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.

MECHANICAL DATA

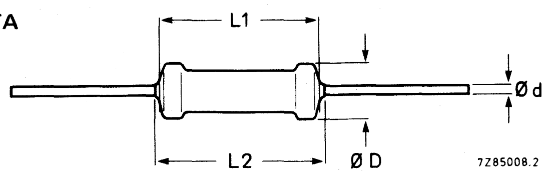


Fig. 1 Axial leads.

Table 1

type	D_{max}	$L_{1\,max}$	$L_{2\,max}$	d
VR37	3.7	9.0	10.0	0.7
VR68	6.8	18.0	19.0	0.8

* See Fig.2.

The length of the body is measured by inserting the leads into holes of two identical gauge plates and moving those plates parallel to each other until the resistor body is clamped without deformation (IEC publication 294). For leads of 0.7 mm diameter, the diameter of the holes in the gauge plates is 1.0 mm; for leads of 0.8 mm diameter, the holes are 1.2 mm.

Mass (per 100) VR37: 42g; VR68: 148g

Mounting

The resistors are suitable for processing on automatic insertion equipment and cutting and bending machines. The minimum pitch for type VR37 is 6e and for type VR68 9e.
For temperature rise at soldering point, see Fig.5.

Marking

The nominal resistance and the tolerance are marked on these resistors by four (E24 series) or five (E96 + E24) coloured bands according to IEC publication 62 "Colour code for fixed resistors". See General Section.
Yellow and grey are used instead of gold and silver, because metal particles in the lacquer could affect high-voltage properties.

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated resistance (nominal resistance) are taken from the E24/E96 series (tolerance ± 1%) and E24 series (tolerance ± 5%) within the range 100 kΩ to 33 MΩ for type VR37 and 100 kΩ to 68 MΩ for type VR68. Values up to 220 MΩ are available on request. See the table "Standard series of values in a decade" at the back of the book.

The limiting voltage for resistor element is the maximum voltage that may be supplied continuously to the resistor element; see IEC publications 115-1 and 115-2. This voltage is 3500 V (DC) or 2500 V (RMS) for type V37 and 10 kV (DC) or 7 kV (RMS) for type VR68.

Table 2

type	packing	quantity	resistance range	tolerance ± %	series	catalogue number 2322 followed by:
VR37	ammopack	1000	100 kΩ to 33 MΩ	1	E24/E96	242 8 . . . .
				5	E24	242 13 . . .
	on reel	5000	100 kΩ to 33 MΩ	1	E24/E96	242 7 . . . .
		5000		5	E24	242 23 . . .
VR68	ammopack	500	100 kΩ to 68 MΩ	1	E24/E96	244 8 . . . .
				5	E24	244 13 . . .

COMPOSITION OF THE CATALOGUE NUMBER

The catalogue number in the above table is completed by inserting the resistance code: the first two figures (E24 series) resp. first three figures (E24/E96) of the resistance (in Ω) followed by:
4 for R = 100 kΩ to 976 kΩ
5 for R = 1 MΩ to 9.76 MΩ
6 for R = 10 MΩ to 68 MΩ

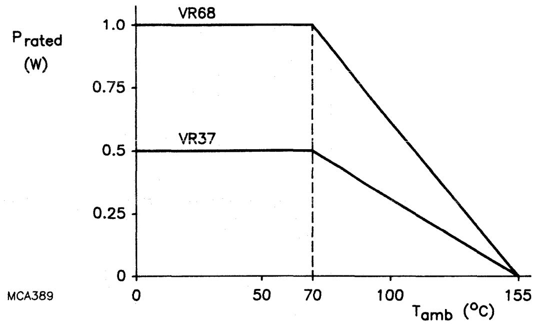


Fig. 2 Maximum dissipation (P_{max}) as a function of the ambient temperature (T_{amb}).

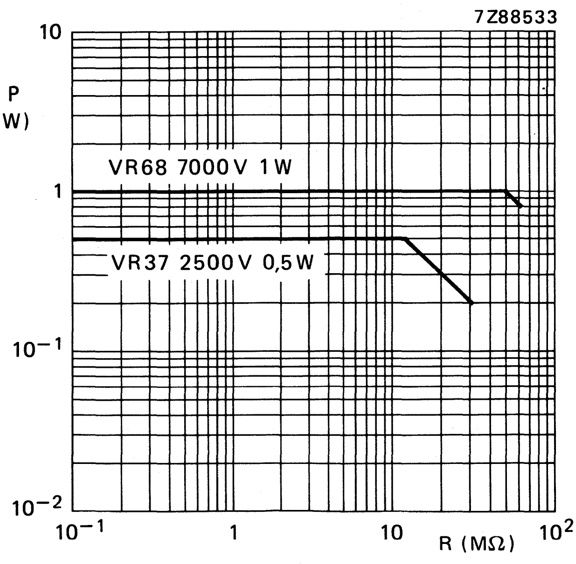


Fig. 3 Power versus resistance value of high-voltage resistors at T_{amb} = 70 °C.

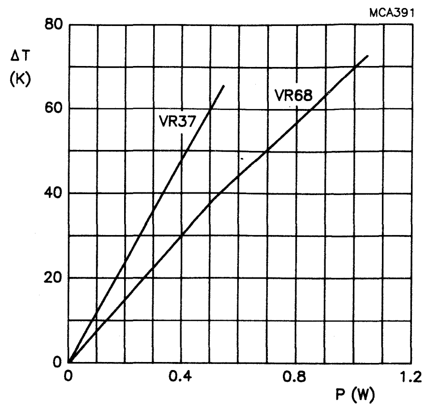


Fig.4 Hot-spot temperature rise (ΔT) as a function of dissipated power.

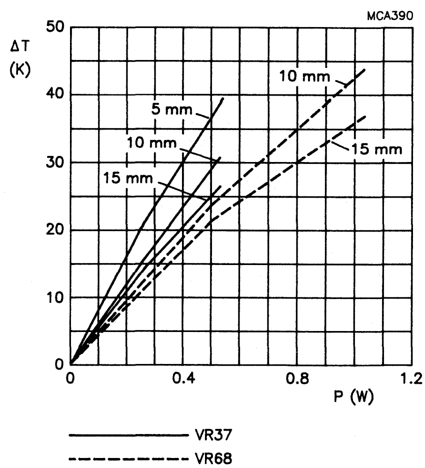


Fig.5 Temperature rise (ΔT) at the end of the lead (soldering point) as a function of dissipated power at various lead lengths after mounting.

TESTS AND REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publication 115-1, category 55/155/56 (rated temperature range −55 to + 155 °C; damp heat, long term, 56 days) and along the lines of IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components". In the following table the tests are listed with reference to the relevant clauses of IEC publications 115-1 and 68; a short description is also given of the test procedure and requirements. In some instances deviations from the IEC recommendation were necessary for our method of specifying.

Table 4

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
18		Robustness of terminations		
	Ua	Tensile all samples	load 10N; 10 s	number of failures: < 10 ppm
	Ub	Bending half number of samples	load 5N; 4 x 90°	
	Uc	Torsion other half number of samples	3 x 360° in opposite directions	no damage ΔR max. 0.5% + 0.05 Ω
19	T	Soldering	solderability: 2 s 235 °C, flux 600 thermal shock: 3 s 350 °C, 6 mm from body	good tinning, no damage ΔR max. 0.5% + 0.05 Ω
20	Na	Rapid change of temperature	½ h −55 °C/½ h + 155 °C, 5 cycles	ΔR max. 0.5% + 0.05 Ω
22	Fc	Vibration	frequency 10-500 Hz, displacement 1.5 mm or acceleration 10g, three directions; total 6 h (3 x 2 h)	no damage ΔR max. 0.5% + 0.05 Ω
21	Eb	Bump	3 x 1500 bumps in three directions, 40g	no damage ΔR max. 0.5% + 0.05 Ω

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
23		Climatic sequence		
23.2	Ba	Dry heat	16 h, 155 °C	
23.3	Db	Damp heat (accel) 1st cycle	24 h; 55 °C; 95-100% R.H.	
23.4	Aa	Cold	2 h; −55 °C	
23.5	M	Low air pressure	2 h; 8.5 kPa; 15-35 °C	
23.6	Db	Damp heat (accel) remaining cycles	5 days; 55 °C; 95-100% R.H.	R_{ins} min. 1000 MΩ ΔR max. 1.5% + 0.1 Ω
24.2	Ca	Damp heat steady state	56 days; 40 °C; 90-95% R.H. dissipation $\leqslant 0.01\ P_n$ limiting voltage 16 V (DC)	R_{ins} min. 1000 MΩ ΔR max. 1.5% + 0.1 Ω
26.2	–	Endurance	1000 hours; 70 °C nominal dissipation or V_{max}	ΔR max. 1.5% + 0.1 Ω
11	–	Temperature coefficient	between −55 °C and + 155 °C	$\pm 200.10^{-6}$/K
10	–	Voltage proof on insulation	700 V (RMS), 1 minute	no breakdown
14	–	Noise	IEC publication 195	max. 2.5 μV/V
9	–	Insulation resistance		min. 10^4 MΩ

STANDARD PACKING

The resistors are supplied on bandolier in ammopack or on reel.

type	quantity per box	
	bandolier ammopack	bandolier on reel
VR37	1000	5000
VR68	500	

Dimensions of bandolier

type	a ± 0.5	A ± 1.5	B1 - B2 ± max.	S (spacing)	T (max. deviation of spacing)
VR37	6	52.5	1.2	5	1 mm per 10 spacings
VR68	5	66.7	1.2	10	0.5 mm per 5 spacings

Dimensions of ammopack

	M	N	P
VR37	83	60	262
VR68	85	112	258

Dimensions of reel

	Q	V	
VR37	356	75	

POWER FILM

POWER METAL FILM RESISTOR

QUICK REFERENCE DATA

Resistance range		1 Ω to 1 MΩ, E24 series
Resistance tolerance		± 5%
Rated dissipation at T_{amb} = 70 °C; P_{70}*		1 W
Thermal resistance R_{TH}		135 K/W
Temperature coefficient		$\leqslant \pm 250 \times 10^{-6}$/K
$V_{max.}$		350 V (DC or RMS)
Basic specifications		IEC 115-1 and 115-4
Climatic category (IEC 68)		55/155/56
Stability after:		
load	ΔR/R	max. 5% + 0.1 Ω
climatic tests	ΔR/R	max. 3% + 0.1 Ω
soldering	ΔR/R	max. 1% + 0.05 Ω

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 red, non-inflammable lacquer which provides electrical, mechanical, and climatic protection. The encapsulation is resistant to all cleaning solvents in accordance with MIL-STD 202E method 215, and IEC 68-2-45.

COMPOSITION OF THE CATALOGUE NUMBER

Table 1 Composition of the catalogue number

type	bandolier width	packing	quantity	resistance range	tolerance	catalogue number
PR01	73.5 73.5	ammopack reel	1000 5000	1 Ω to 1 MΩ 1 Ω to 1 MΩ	± 5% ± 5%	2322 193 13 . . . 2322 193 23 . . .

The catalogue number in the above table is completed by inserting the first two digits of the numerical resistor value followed by:

8 for R values between 1 Ω and 9.1 Ω
9 for R values between 10 Ω and 91 Ω
1 for R values between 100 Ω and 910 Ω
2 for R values between 1 kΩ and 9.1 kΩ
3 for R values between 10 kΩ and 91 kΩ
4 for R values between 100 kΩ and 910 kΩ
5 for R value of 1 MΩ

Example:

The catalogue number of resistor value 750 Ω, on a bandolier of 1000 pieces, in ammopack, is 2322 193 13751.

* See Fig.3.

MECHANICAL DATA

All dimensions in mm

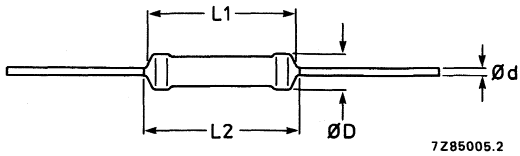


Fig. 1 Version with straight leads, see Table 2.

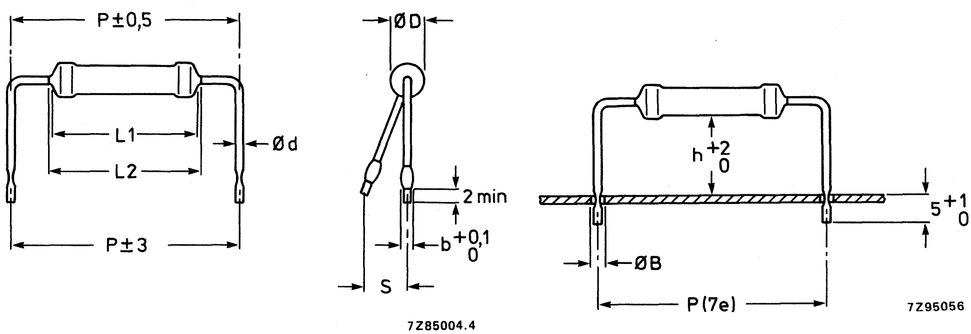


Fig. 2 Version with cropped and formed leads; see Table 2.

Table 2 Physical dimensions

type	ϕD_{max}	L1	$L2_{max}$	ϕd	b	h	P	S_{max}	ϕB_{max}
PR01	2.5	6.5	9.0	0.6					
	2.5	6.5	9.0	0.6	1.1	8	17.8	2	1.0 m

The length of the body L1 is measured by inserting the leads into holes of two identical gauge plates and moving these plates parallel to each other until the resistor body is clamped without deformation (IEC publication 294). For leads of 0.6 mm diameter, the diameter of the holes in the gauge plates is 1.0 mm. Resistors with lead lengths of 64/53/26 mm are available on special request.

Mass:

29 grams per 100 pieces.

Mounting

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

The minimum pitch for this type is 5e (12.5 mm). Fig. 4 shows the temperature rise experienced at the end of leads of differing lengths during the soldering process.

Marking

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

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated (nominal) resistance are taken from the E24 series within the range 1 Ω to 1 MΩ . The values of this series are given in the table "Standard series of values in a decade" at the back of the handbook.

The tolerance on the rated resistance is ± 5%

The limiting voltage (DC or RMS) is 350 V. This is the maximum voltage that may be applied continuously to the resistor element; see IEC publications 115-1 and 115-4.

The maximum permissible hot spot temperature is 205 °C.

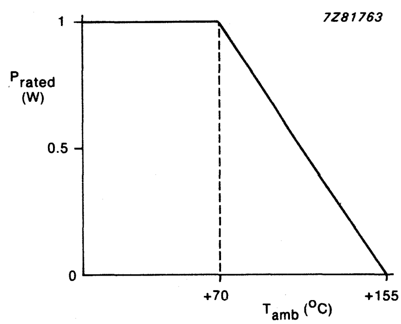


Fig. 3 P_{rated} as a function of T_{amb}.

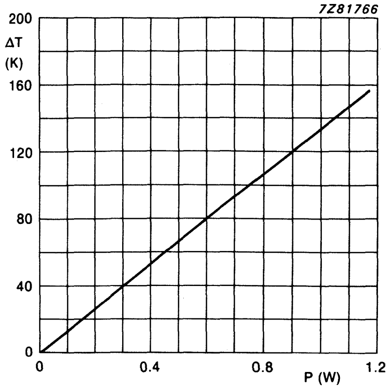


Fig. 4 Hot spot temperature rise (ΔT) as a function of dissipated power.

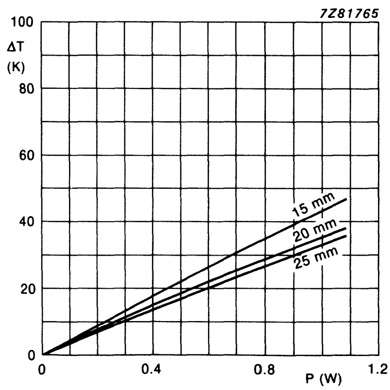


Fig. 5 Temperature rise (ΔT) at the lead end (soldering point) as a function of dissipated power at various lead lengths after mounting.
Resistor body print distance 1 mm minimum.

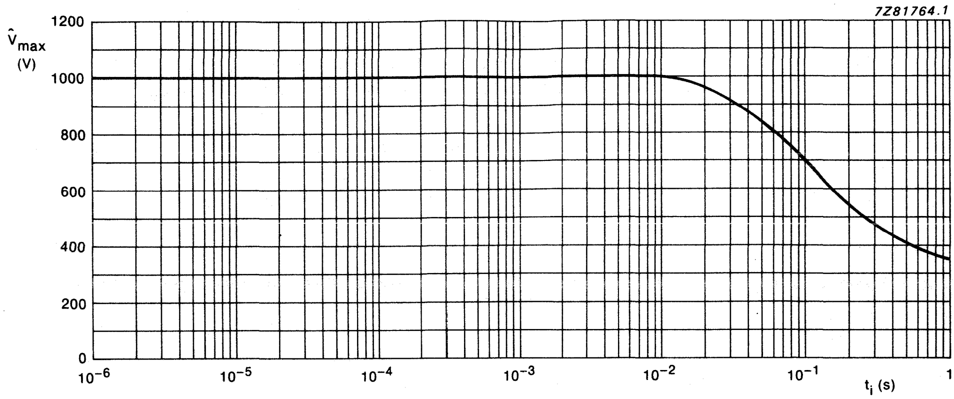


Fig. 6 Maximum permissible peak pulse voltage (V_{max}) as a function of pulse duration (t_i).

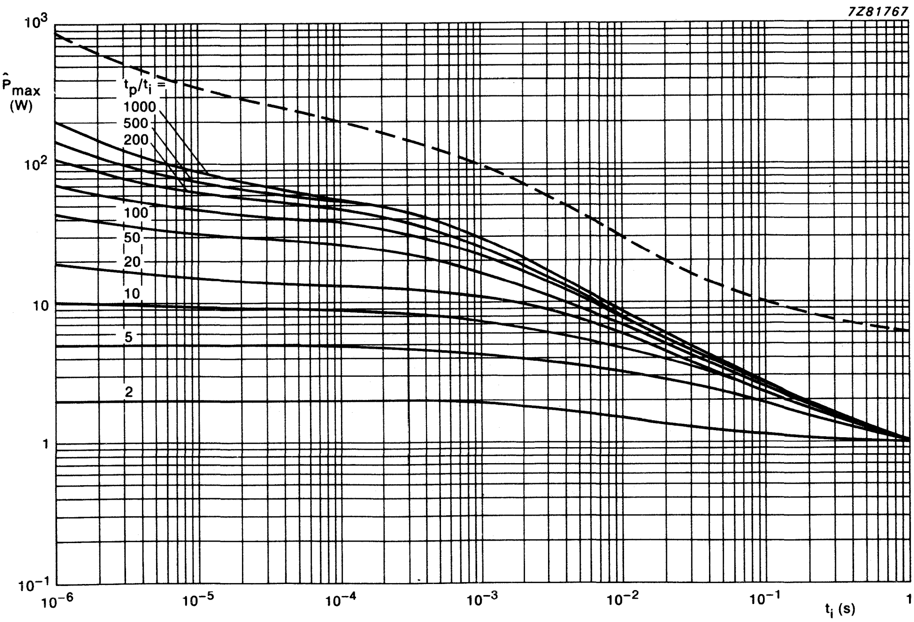


Fig. 7 Maximum permissible peak pulse power (P_{max}) as a function of pulse duration (t_i).

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of IEC publication 115-1, category 55/155/56 (rated temperature range −55 °C to + 155 °C; damp heat, long term, 56 days), and along the lines of IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components".

In Table 3, the tests are listed with reference to the relevant clauses of IEC publications 115-1 and 68. A short description of the test procedures and requirements is also given. In some cases, deviations from the IEC publication were necessary for our method of specifying results.

Table 3 Tests and requirements

IEC 115-1-4 method	IEC 68 test method	test	procedure	requirements
4.16		robustness of terminations		
4.16.2	Ua	tensile all samples	ϕ 0.6 mm, load 10 N, 10 s	total number of failures $< 10^{-6}$
4.16.3	Ub	bending half number of samples	ϕ 0.6 mm, load 5 N, 4 x 90°	
4.16.4	Uc	torsion other half number of samples	3 x 360° in opposite directions	no damage, ΔR/R max. 0.5% + 0.05 Ω
4.17	Ta	soldering	solderability, 2 s at 235 °C, flux 600	good tinning, no damage
4.18	Tb		thermal shock, 3 s at 350 °C, 6 mm from body	ΔR/R max. 1% + 0.05 Ω
4.19	Na	rapid change of temperature	0.5 hour at −55 °C 0.5 hour at + 155 °C 5 cycles	no damage ΔR/R max. 1% + 0.05 Ω
4.20	Eb	bump	3 x 1500 bumps in three directions, 40 g	no damage ΔR/R max. 0.5% + 0.05 Ω
4.22	Fc	vibration	frequency 10 - 500 Hz, displacement 1.5 mm or acceleration 10 g, three directions, total 6 hours (3 x 2 hours)	no damage ΔR/R max. 0.5% + 0.05 Ω
4.23		climatic sequence		
4.23.2	Ba	dry heat	16 hours at + 155 °C	
4.23.3	Db	damp heat (accelerated), 1st cycle	24 hours at + 55 °C, 90 - 100% relative humidity	
4.23.4	Aa	cold	2 hours at −55 °C	
4.23.5	M	low air pressure	2 hours, 8.5 kPa, 15 - 35 °C	
4.23.6	Db	damp heat (accelerated), remaining cycles	5 days at + 55 °C, 90 - 100% relative humidity	R_{ins} min. 1000 MΩ ΔR/R max. 3% + 0.1 Ω
4.24.2	Ca	damp heat (steady state)	56 days at + 40 °C, 90 - 95% relative humidity dissipation 0.01 P_{70}	R_{ins} min. 1000 MΩ ΔR/R max. 3% + 0.1 Ω

Table 3 (continued)

IEC 115-1-4 method	IEC 68 test method	test	procedure	requirements
4.25.1	––	endurance	1000 hours at + 70 °C, P_{70} or V_{max}.	$\Delta R/R$ max. 5% + 0.1 Ω
4.8.4.2	––	temperature coefficient	between –55 °C and + 155 °C	$\leqslant \pm 250 \times 10^{-6}$
4.7	––	voltage proof on insulation	500 V (RMS) for 1 minute, V-block method	no breakdown
4.6.1.1	––	insulation resistance	500 V (DC) for 1 min., V-block method	min. 10^4 MΩ
see 2nd amendment to IEC 115-1, Jan. 87		pulse load		See Figs. 6 and 7

PACKING

The resistors may be supplied on bandolier in ammopack or on a reel.

Table 4 Dimensions of bandolier

type	a ± 0.5 mm	A ± 1.5 mm	B1 - B2 ± max mm	S spacing mm	T maximum deviation of spacing
PR01	6	73.0	1.2	5	1 mm per 10 spacings 0.5 mm per 5 spacings

Table 5 Dimensions of reel

quantity	Q	V
5000 pieces	305 mm	90 mm

Table 6 Dimensions of ammopack

Quantity	M	N	P
1000 pieces	97 mm	28 mm	262 mm

POWER METAL FILM RESISTOR

QUICK REFERENCE DATA

Resistance range		1 Ω to 1 MΩ, E24 series
Resistance tolerance		± 5%
Rated dissipation at T_{amb} = 70 °C; P_{70}*		2 W
Thermal resistance R_{TH}		75 K/W
Temperature coefficient		≤ ± 250 x 10^{-6}/K
$V_{max.}$		500 V (DC or RMS)
Basic specifications		IEC 115-1 and 115-4
Climatic category (IEC 68)		55/155/56
Stability after:		
load	ΔR/R	max. 5% + 0.1 Ω
climatic tests	ΔR/R	max. 3% + 0.1 Ω
soldering	ΔR/R	max. 1% + 0.05 Ω

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 red, non-inflammable lacquer which provides electrical, mechanical, and climatic protection. The encapsulation is resistant to all cleaning solvents in accordance with MIL-STD 202E method 215, and IEC 68-2-45.

COMPOSITION OF THE CATALOGUE NUMBER

Table 1 Composition of the catalogue number

style	packing	quantity	mounting height	tolerance	catalogue number
straight leads	ammopack	1000		± 5%	2322 194 13 . . .
cropped and	loose/box	1000	8 mm	± 5%	2322 194 33 . . .
formed	loose/box	500	15 mm	± 5%	2322 194 43 . . .

The catalogue number in Table 1 is completed by inserting the first two digits of the numerical resistor value followed by:

8 for R values between 1 Ω and 9.1 Ω
9 for R values between 10 Ω and 91 Ω
1 for R values between 100 Ω and 910 Ω
2 for R values between 1 kΩ and 9.1 kΩ
3 for R values between 10 kΩ and 9.1 kΩ
4 for R values between 100 kΩ and 910 kΩ
5 for R value of 1 MΩ

Example:

The catalogue number of resistor value 750 Ω, on a bandolier of 1000 pieces, in ammopack, is 2322 194 13751.

* See Fig.3.

MECHANICAL DATA

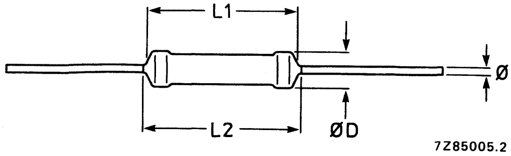


Fig.1 Version with straight leads, see Table 2.

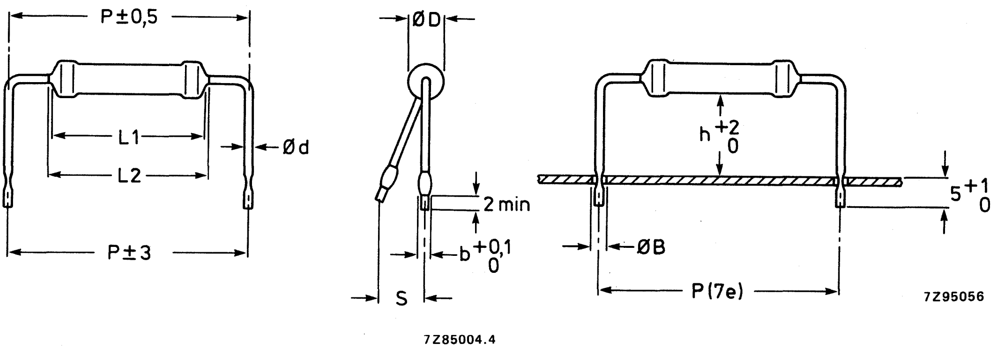


Fig.2 Version with cropped and formed leads.

Table 2 Physical dimensions

ϕD_{max}	$L1_{max}$	$L2_{max}$	ϕd	b	h	P	S_{max}	ϕB_{max}
3.9	10	12	0.8	1.3	8	17.8	2	1.2
3.9	10	12	0.8	1.3	15	17.8	3	1.2

The length of the body L1 is measured by inserting the leads into holes of two identical gauge plates and moving these plates parallel to each other until the resistor body is clamped without deformation (IEC publication 294). For leads of 0.8 mm diameter, the diameter of the holes in the gauge plates is 1.2 mm. Resistors with lead lengths of 64/53/26 mm are available on special request.

Mass:

40 grams per 100 pieces

Mounting

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

The minimum pitch for this type is 6e (15.2 mm). Fig. 5 shows the temperature rise experienced at the end of leads of differing lengths during the soldering process.

Marking

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

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated (nominal) resistance are taken from the E24 series within the range 1 Ω to 1 MΩ. The values of this series are given in the table "Standard series of values in a decade" at the back of the handbook.

The tolerance on the rated resistance is ± 5%.

The limiting voltage (DC or RMS) is 500 V. This is the maximum voltage that may be applied continuously to the resistor element; see IEC publications 115-1 and 115-4.

The maximum permissible hot spot temperature is 220 °C.

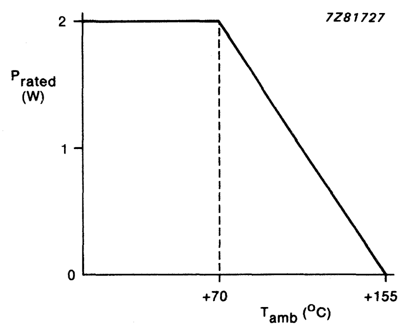


Fig.3 P_{rated} as a function of T_{amb}.

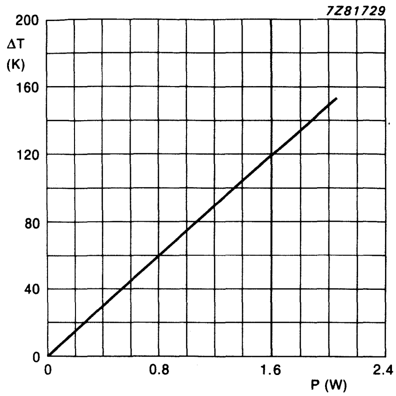


Fig.4 Hot spot temperature rise (ΔT) as a function of dissipated power.

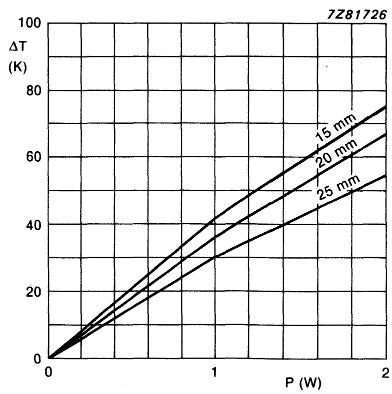


Fig.5 Temperature rise (ΔT) at the lead end (soldering point) as a function of dissipated power at various lead lengths after mounting.
Resistor body print distance 1 mm minimum.

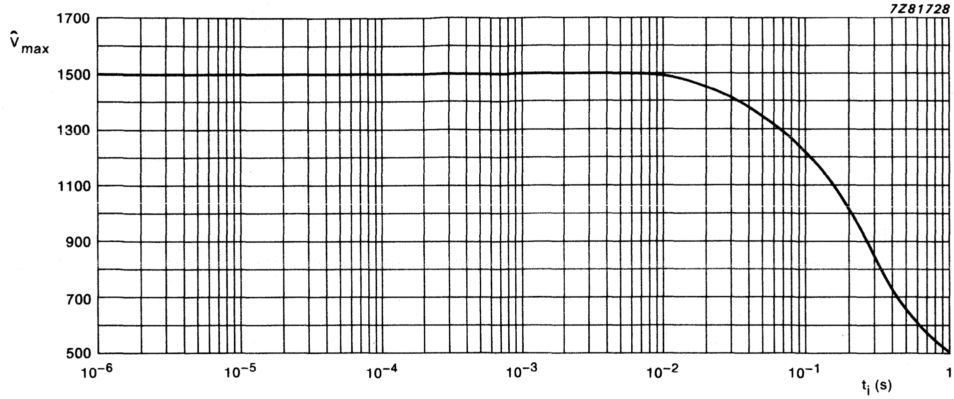


Fig.6 Maximum permissible peak pulse voltage ($\hat{V}_{max}$) versus pulse duration (t_i).

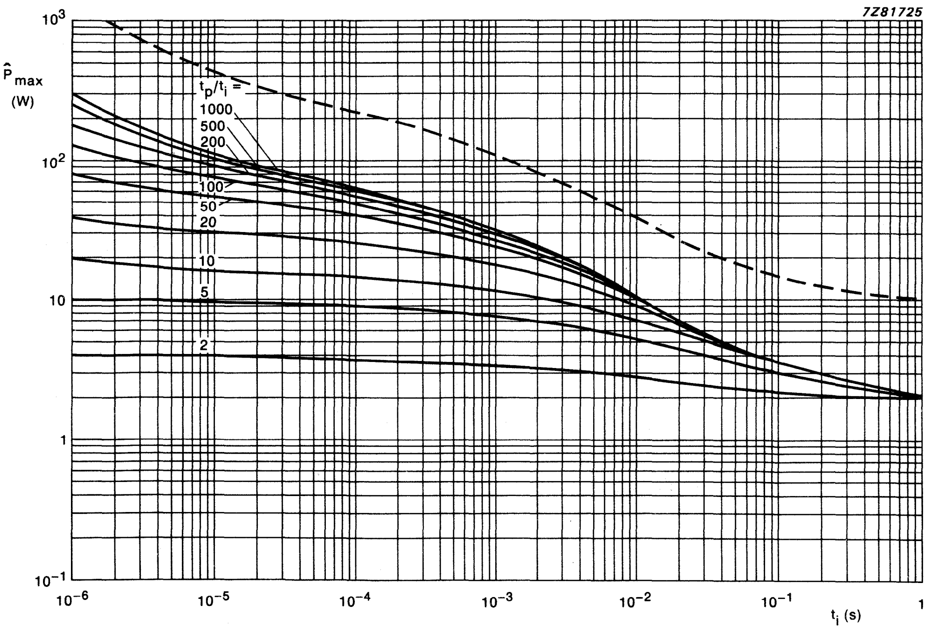


Fig.7 Maximum permissible peak pulse power ($\hat{P}_{max}$) versus pulse duration (t_i).

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of IEC publication 115-1, category 55/155/56 (rated temperature range –55 °C to + 155 °C; damp heat, long term, 56 days), and along the lines of IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components".

In Table 2, the tests are listed with reference to the relevant clauses of IEC publications 115-1 and 68. A short description of the test procedures and requirements is also given. In some cases, deviations from the IEC publication were necessary for our method of specifying results.

Table 3 Tests and requirements

IEC 115-1-4 method	IEC 68 test method	test	procedure	requirements
4.16		robustness of terminations		
4.16.2	Ua	tensile all samples	ϕ0.8 mm, load 5 N, 10 s	total number of failures $< 10^{-6}$
4.16.3	Ub	bending half number of samples	ϕ0.8 mm, load 2.5 N, 4 x 90°	
4.16.4	Uc	torsion other half number of samples	3 x 360° in opposite directions	no damage, ΔR/R max. 0.5% + 0.05 Ω
4.17	Ta	soldering	solderability, 2 s at 235 °C, flux 600	good tinning, no damage
4.18	Tb		thermal shock, 3 s at 350 °C, 6 mm from body	ΔR/R max. 1% + 0.05 Ω
4.19	Na	rapid change of temperature	0.5 hour at –55 °C 0.5 hour at + 155 °C 5 cycles	no damage ΔR/R max 1% + 0.05 Ω
4.20	Eb	bump	3 x 1500 bumps in three directions, 40 g	no damage ΔR/R max. 0.5% + 0.05 Ω
4.22	Fc	vibration	frequency 10 - 500 Hz, displacement 1.5 mm or acceleration 10 g, three directions, total 6 hours (3 x 2 hours)	no damage ΔR/R max. 0.5% + 0.05 Ω
4.23		climatic sequence		
4.23.2	Ba	dry heat	16 hours at + 155 °C	
4.23.3	Db	damp heat (accelerated), 1st cycle	24 hours at + 55 °C, 90 - 100% relative humidity	
4.23.4	Aa	cold	2 hours at –55 °C	
4.23.5	M	low air pressure	2 hours, 8.5 kPa, 15 - 35 °C	
4.23.6	Db	damp heat (accelerated), remaining cycles	5 days at + 55 °C, 90 - 100% relative humidity	R_{ins} min. 1000 MΩ ΔR/R max. 3% + 0.1 Ω
4.24.2	Ca	damp heat (steady state)	56 days at + 40 °C, 90 - 95% relative humidity dissipation 0.01 P_{70}	R_{ins} min. 1000 MΩ ΔR/R max. 3% + 0.1 Ω

Table 3 (continued)

IEC 115-1-4 method	IEC 68 test method	test	procedure	requirements
4.25.1	––	endurance	1000 hours at + 70 °C, P_{70} or V_{max}.	ΔR/R max. 5% + 0.1 Ω
4.8.4.2	––	temperature coefficient	between –55 °C and + 155 °C	⩽ ± 250 x 10^{-6}
4.7	––	voltage proof on insulation	500 V (RMS) for 1 minute, V-block method	no breakdown
4.6.1.1	––	insulation resistance	500 V (DC) for 1 min., V-block method	min. 10^4 MΩ
see 2nd amendment to IEC 115-1, Jan. 87.		pulse load		see Figs. 6 and 7

PACKING

The resistors may be supplied on bandolier in ammopack or loose in a box.

Table 4 Dimensions of bandolier

type	a ± 0.5 mm	A ± 1.5 mm	B1 - B2 ± max mm	S spacing mm	T maximum deviation of spacing
PR02	6	73.0	1.2	5	1 mm per 10 spacings 0.5 mm per 5 spacings

Table 5 Dimensions of ammopack

quantity	M	N	P
1000 pieces	97	59	262

POWER METAL FILM RESISTOR

QUICK REFERENCE DATA

Resistance range		1 Ω to 1 MΩ, E24 series
Resistance tolerance		± 5%
Rated dissipation at T_{amb} = 70 °C; P_{70}*		3 W
Thermal resistance R_{TH}		60 K/W
Temperature coefficient		⩽ ± 250 x 10^{-6} /K
$V_{max.}$		750 V (DC or RMS)
Basic specifications		IEC 115-1 and 115-4
Climatic category (IEC 68)		55/155/56
Stability after:		
load	ΔR/R	max. 5% + 0.1 Ω
climatic tests	ΔR/R	max. 3% + 0.1 Ω
soldering	ΔR/R	max. 1% + 0.05 Ω

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 red, non-inflammable lacquer which provides electrical, mechanical, and climatic protection. The encapsulation is resistant to all cleaning solvents in accordance with MIL-STD 202E method 215, and IEC 68-2-45.

COMPOSITION OF THE CATALOGUE NUMBER

Table 1 Composition of the catalogue number

style	packing	quantity	mounting height	tolerance	catalogue number
straight leads	ammopack	500		± 5%	2322 195 13 . . .
cropped and formed	loose/box	500	8 mm	± 5%	2322 195 33 . . .
	loose/box	250	15 mm	± 5%	2322 195 43 . . .

The catalogue number in Table 1 is completed by inserting the first two digits of the numerical resistor value followed by:

8 for R values between 1 Ω and 9.1 Ω
9 for R values between 10 Ω and 91 Ω
1 for R values between 100 Ω and 910 Ω
2 for R values between 1 kΩ and 9.1 kΩ
3 for R values between 10 kΩ and 91 kΩ
4 for R values between 100 kΩ and 910 kΩ
5 for R value of 1 MΩ

Example:

The catalogue number of resistor value 750 Ω, on a bandolier of 1000 pieces, in ammopack, is 2322 195 13751.

* See Fig.3.

MECHANICAL DATA

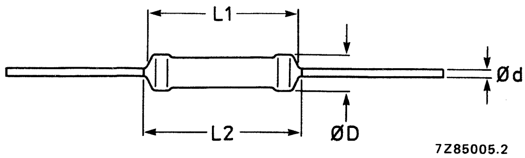


Fig.1 Version with straight leads, see Table 2.

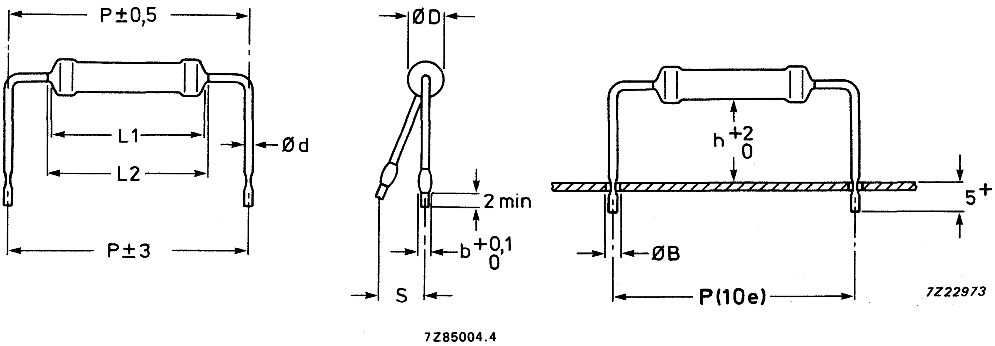


Fig.2 Version with cropped and formed leads.

Table 2 Physical dimensions

ϕD_{max}	$L1_{max}$	$L2_{max}$	ϕd	b	h	P	S_{max}	ϕB_{max}
5.2	16.7	20.0	0.8	1.3	8	25.4	2	1.2
5.2	16.7	20.0	0.8	1.3	15	25.4	3	1.2

The length of the body L1 is measured by inserting the leads into holes of two identical gauge plates and moving these plates parallel to each other until the resistor body is clamped without deformation (IEC publication 294). For leads of 0.8 mm diameter, the diameter of the holes in the gauge plates is 1.2 mm.

Mass:

92 grams per 100 pieces

Mounting

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

The minimum pitch for this type is 9e (22.8 mm). Fig.5 shows the temperature rise experienced at the end of leads of differing lengths during the soldering process.

Marking

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

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated (nominal) resistance are taken from the E24 series within the range 1 Ω to 1 MΩ. The values of this series are given in the table "Standard series of values in a decade" at the back of the handbook.

The tolerance on the rated resistance is ± 5%.

The limiting voltage (DC or RMS) is 750 V. This is the maximum voltage that may be applied continuously to the resistor element; see IEC publications 115-1 and 115-4.

The maximum permissible hot spot temperature is 250 °C.

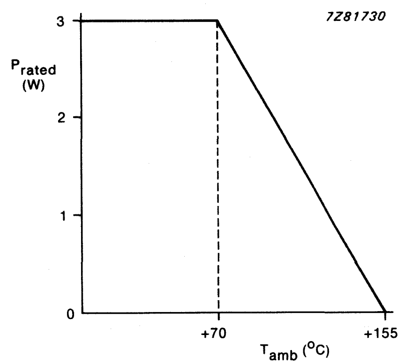


Fig.3 P_{rated} as a function of T_{amb}.

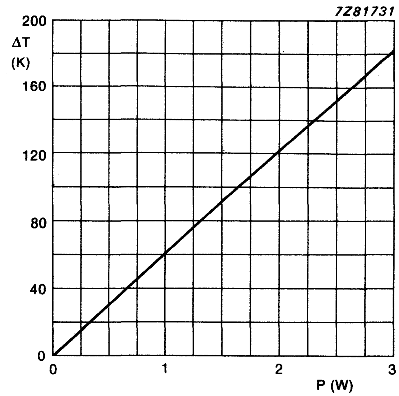


Fig.4 Hot spot temperature rise (ΔT) as a function of dissipated power.

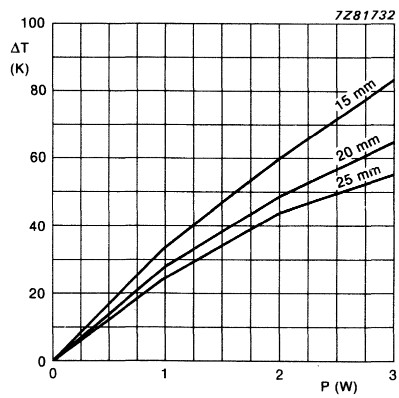


Fig.5 Temperature rise (ΔT) at the lead end (soldering point) as a function of dissipated power at various lead lengths after mounting.

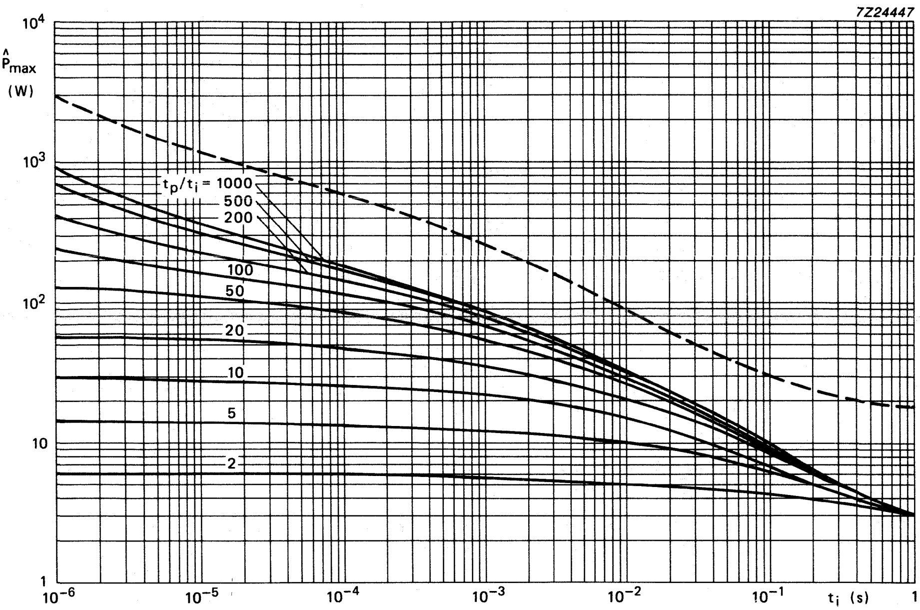


Fig.6 Maximum permissible peak pulse power as a function of pulse duration for critical value.

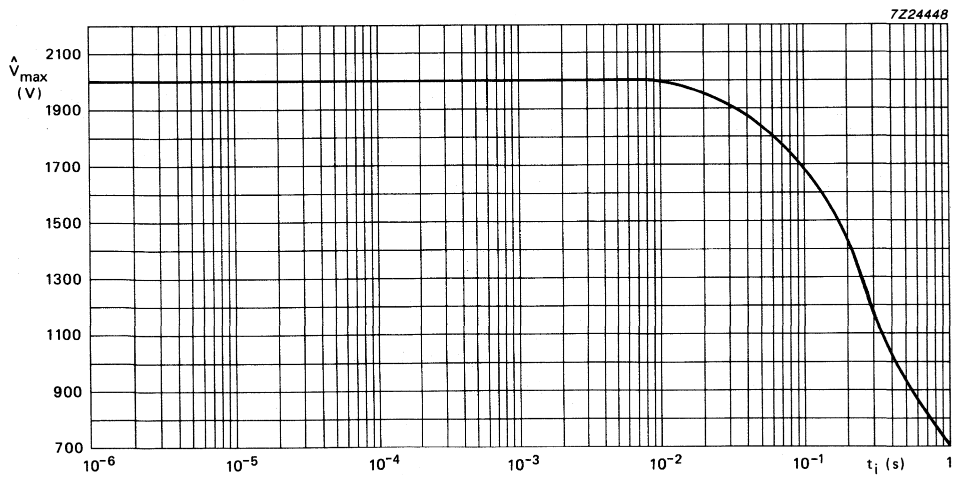


Fig.7 Maximum permissible peak pulse voltage as a function of pulse duration.

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of IEC publication 115-1, category 55/155/56 (rated temperature range −55 °C to + 155 °C; damp heat, long term, 56 days), and along the lines of IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components".

In Table 3, the tests are listed with reference to the relevant clauses of IEC publications 115-1 and 68. A short description of the test procedures and requirements is also given. In some cases, deviations from the IEC publication were necessary for our method of specifying results.

Table 3 Tests and requirements

IEC 115-1-4 method	IEC 68 test method	test	procedure	requirements
4.16		robustness of terminations		
4.16.2	Ua	tensile all samples	ϕ 0.8 mm, load 10 N, 10 s	total number of failures $< 10^{-6}$
4.16.3	Ub	bending half number of samples	ϕ 0.8 mm, load 5 N, 4 x 90°	
4.16.4	Uc	torsion other half number of samples	3 x 360° in opposite directions	no damage, $\Delta R/R$ max. 0.5% + 0.05 Ω
4.17	Ta	soldering	solderability, 2 s at 235 °C, flux 600	good tinning, no damage
4.18	Tb		thermal shock, 3 s at 350 °C, 6 mm from body	$\Delta R/R$ max. 0.5% + 0.05 Ω
4.19	Na	rapid change of temperature	0.5 hour at −55 °C 0.5 hour at + 155 °C 5 cycles	no damage $\Delta R/R$ max. 2% + 0.05 Ω
4.20	Eb	bump	3 x 1500 bumps in three directions, 40 g	no damage $\Delta R/R$ max. 0.5% + 0.05 Ω
4.22	Fc	vibration	frequency 10 - 500 Hz, displacement 1.5 mm or acceleration 10 g, three directions, total 6 hours (3 x 2 hours)	no damage $\Delta R/R$ max. 0.5% + 0.05 Ω
4.23		climatic sequence		
4.23.2	Ba	dry heat	16 hours at + 155 °C	
4.23.3	Db	damp heat (accelerated), 1st cycle	24 hours at + 55 °C, 90 - 100% relative humidity	
4.23.4	Aa	cold	2 hours at −55 °C	
4.23.5	M	low air pressure	2 hours, 8.5 kPa, 15 - 35 °C	
4.23.6	Db	damp heat (accelerated), remaining cycles	5 days at + 55 °C, 90 - 100% relative humidity	R_{ins} min. 1000 MΩ $\Delta R/R$ max. 3% + 0.1 Ω
4.24.2	Ca	damp heat (steady state)	56 days at + 40 °C, 90 - 95% relative humidity dissipation 0.01 P_{70}	R_{ins} min. 1000 MΩ $\Delta R/R$ max. 3% + 0.1 Ω

Table 3 (continued)

IEC 115-1-4 method	IEC 68 test method	test	procedure	requirements
4.25.1	––	endurance	1000 hours at + 70 °C, P_{70} or V_{max}.	ΔR/R max. 5% + 0.1 Ω
4.8.4.2	––	temperature coefficient	between –55 °C and + 155 °C	⩽ ± 250 x 10^{-6}
4.7	––	voltage proof on insulation	500 V (RMS) for 1 minute, V-block method	no breakdown
4.6.1.1	––	insulation resistance	500 V (DC) for 1 min., V-block method	min. 10^4 MΩ
see 2nd amendment to IEC 115-1, Jan. 87.		pulse load		see Figs 6 and 7

PACKING

The resistors may be supplied on bandolier in ammopack or loose in a box.

Table 4 Dimensions of bandolier

type	a ± 0.5 mm	A ± 1.5 mm	B1 - B2 ± max mm	S spacing mm	T maximum deviation of spacing
PR03	6	80.0	1.2	10	1 mm per 10 spacings 0.5 mm per 5 spacings

Table 5 Dimensions of ammopack

quantity	M	N	P
500 pieces	99	77	259

POWER METAL FILM RESISTORS

QUICK REFERENCE DATA

Resistance range	1 Ω to 1 MΩ, E24 series
Resistance tolerance	± 5%
Max. body temperature (hot spot)	300 °C
Rated dissipation at T_{amb} = 70 °C	
R ⩽ 27 kΩ	1,6 W
R > 27 kΩ	1,2 W
V_{max}	500 V
Basic specification	IEC 115-4 and MIL-R-11804/2, char. G
Climatic category (IEC 68)	55/200/56

		requirement	typical values	
Stability after,			R ⩽ 27 kΩ	R > 27 kΩ
1000 h max. load	ΔR/R	max. 5%	⩽ 2,5%	⩽ 5%
climatic tests	ΔR/R	max. 3%	⩽ 0,5%	⩽ 1%
soldering test	ΔR/R	max. 1%	⩽ 0,1%	⩽ 0,1%

DESCRIPTION

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

The resistor has a red non-inflammable coating of a protective silicon lacquer which can withstand 500 V (r.m.s.) and is resistant against most of the commonly used cleaning solvents according to MIL-STD-202E, method 215 and IEC 68-2-45.

COMPOSITION OF THE CATALOGUE NUMBER

2322 191 . . . . .

8 for R =	1	to	9,1	Ω
9 for R =	10	to	91	Ω
1 for R =	100	to	910	Ω
2 for R =	1 000	to	9 100	Ω
3 for R =	10 000	to	91 000	Ω
4 for R =	100 000	to	910 000	Ω
5 for R =	1000 000	Ω		

style code
3 = straight copper-clad iron leads, ϕ 0,6
4 = cropped and formed copper-clad iron leads ϕ 0,6
5 = straight copper leads, ϕ 0,8
6 = cropped and formed copper leads, ϕ 0,8

mounting height (h), Fig. 2
0 = 8, 1 = 15: cropped and formed version
0 = straight lead version

first two digits of the resistance value (E24 series)

MECHANICAL DATA

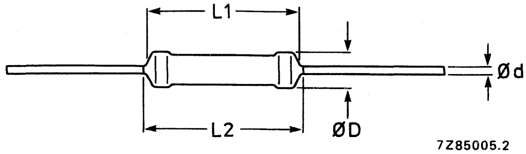


Fig. 1 Version with straight leads, see Table 1.

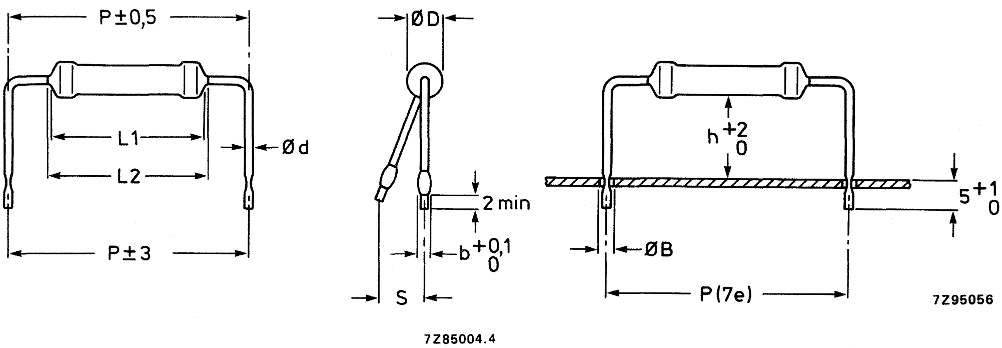


Fig. 2 Version with cropped and formed leads.

Table 1

type	leads	D_{max}	L_{1max}	L_{2max}	d	b	h	S_{max}	P	B ϕ_{max}
PR37	copper-clad iron	3,9	10	11	0,6	1,1	8	2	17,8	1,0
		3,9	10	11	0,6	1,1	15	3	17,8	1,0
	copper	3,9	10	11	0,8	1,3	8	2	17,8	1,2
		3,9	10	11	0,8	1,3	15	3	17,8	1,2

Mass (per 100): 40 g

Mounting

The resistors must be mounted stress free so as to allow thermal expansion over the wide permissible temperature range. The mounting pitch of version with cropped and formed leads is 7 e (17,8 mm).

Marking

Each resistor is marked with:

– resistance value (R for Ω, K for kΩ and M for MΩ).
– tolerance on resistance in %.

Example: 27 R ± 5%.

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated resistance (nominal resistance) are taken from the E24 series within the range 2,2 Ω to 1 MΩ. E24 series of values is given in the table "Standard series of values in a decade" at the back of the handbook. The tolerance on the rated resistance is ± 5%.

Table 2

type	leads			mounting height (h, Fig. 2)	resistance range	catalogue number 2322 followed by
	style	dia. mm	material			
PR37	straight	0,6	copper-clad iron	–	1 Ω to 1 MΩ	191 3 . . 0 .
		0,8	copper	–		191 5 . . 0 .
	cropped and formed	0,6	copper-clad iron	8	1 Ω to 1 MΩ	191 4 . . 0 .
		0,8	copper	8		191 6 . . 0 .
		0,6	copper-clad iron	15		191 4 . . 1 .
		0,8	copper	15		191 6 . . 1 .

To complete the catalogue number, see Composition of the Catalogue Number. For quantities and packing see Standard packaging.

Temperature coefficient		
$R \geqslant 10\ \Omega$		max. ± 250.10^{-6}/K
$R < 10\ \Omega$		max. ± 350.10^{-6}/K
Maximum body temperature (hot spot)		300 °C
Rated dissipation at T_{amb} = 70 °C	$R \leqslant 27$ kΩ	1,6 W
	$R > 27$ kΩ	1,2 W
Maximum voltage		500 V
Dielectric withstanding RMS voltage of the insulation for 1 min		min. 500 V
Basic specification		IEC 115-4 and MIL-R-11804/E, char. G
Climatic category (IEC 68)		55/200/56
Temperature rise (ΔT) of the resistor body as a function of dissipation		see Figs 4 and 5
Lead length (l) as a function of dissipation with temperature rise at end of lead (soldering place) as parameter		see Figs 6 and 7

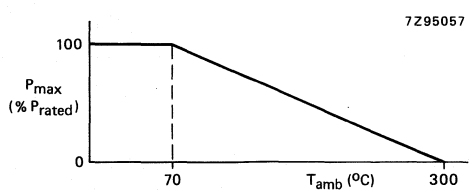


Fig. 3 Maximum dissipation (P_{max}) as a function of the ambient temperature (T_{amb}).

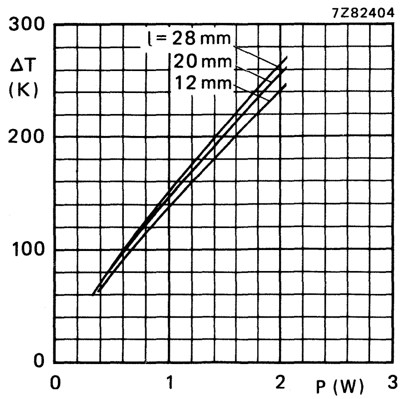


Fig. 4 Hot-spot temperature rise (ΔT) versus dissipated power (P) at different lead lengths (l), copper-clad iron leads ϕ = 0,6 mm.

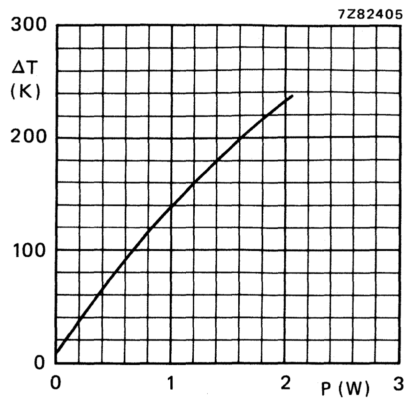


Fig. 5 Hot-spot temperature rise (ΔT) versus dissipated power (P), copper leads ϕ = 0,8 mm.

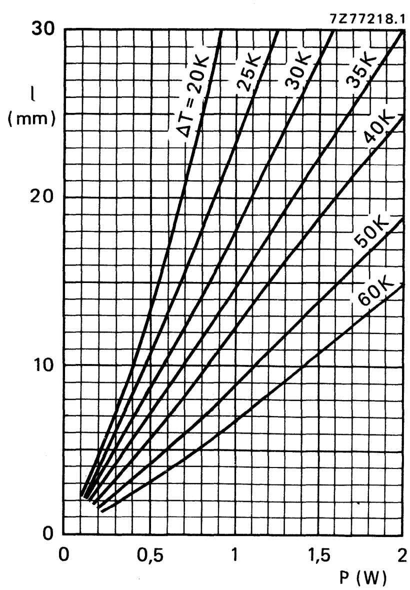


Fig. 6 Lead length l versus dissipated power with ΔT as a parameter, copper-clad iron leads ϕ = 0,6 mm.

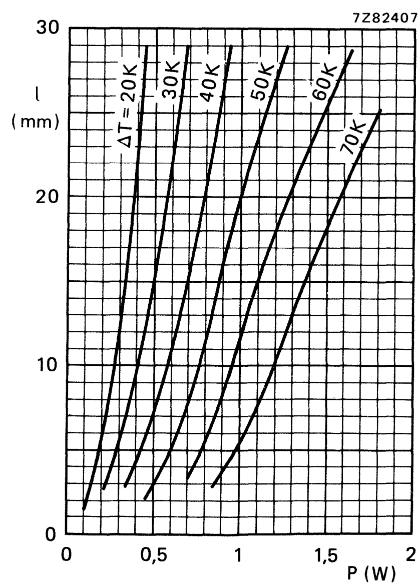


Fig. 7 Lead length l versus dissipated power with ΔT as a parameter, copper leads ϕ = 0,8 mm.

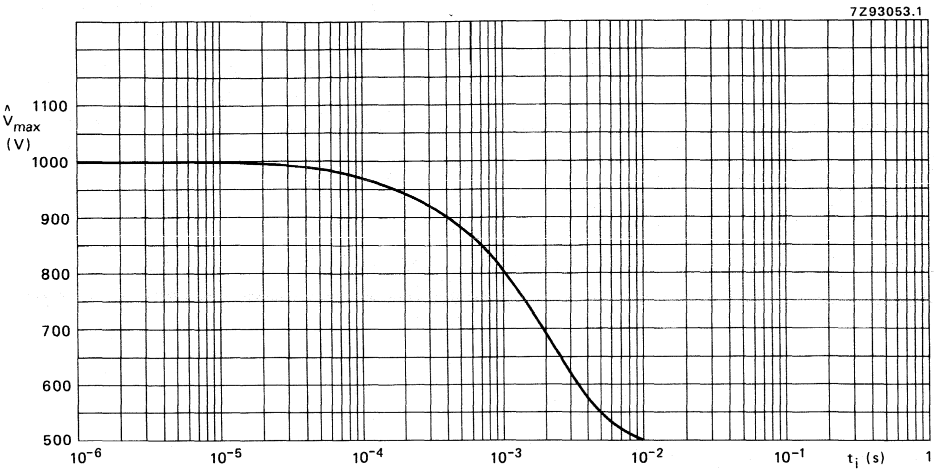


Fig. 8 Max. permissible peak pulse voltage ($\hat{V}_{max}$) versus pulse duration (t_i).

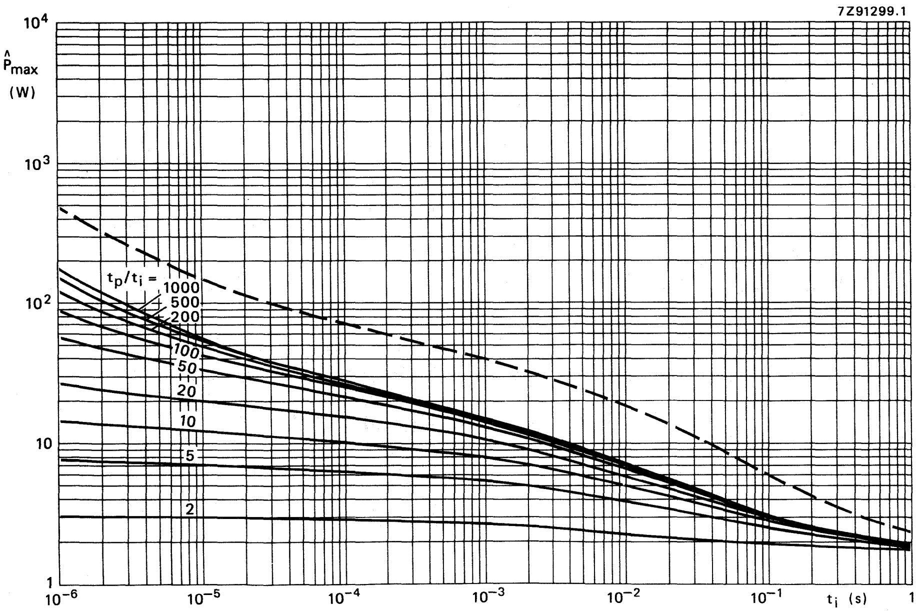


Fig. 9 Max. permissible peak pulse power ($\hat{P}_{max}$) versus pulse duration (t_i).

TESTS AND REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publication 115-1, category 55/200/56 (rated temperature range −55 to + 200 °C; damp heat, long term, 56 days) and along the lines of IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components". In the following table the tests are listed with reference to the relevant clauses of IEC publications 115-1 and 68; a short description is also given of the test procedure and requirements. In some instances deviations from the IEC recommendation were necessary for our method of specifying.

Table 4

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
4.16		Robustness of terminations		
4.16.2	Ua	Tensile all samples	load 10N; 10 s	number of failures < 10 ppm
4.16.3	Ub	Bending half number of samples	load 5N; 4 x 90°	
4.16.4	Uc	Torsion other half number of samples	3 x 360° in opposite directions	no damage ΔR max. 0,5% + 0,05 Ω
4.17	Ta	Soldering	solderability: 2 s 230 °C, flux 600	good tinning, no damage
4.18	Tb		thermal shock: 3 s 350 °C, 6 mm from body	ΔR max. 0,5% + 0,05 Ω
4.19	Na	Rapid change of temperature	½ h −55 °C/½ h + 155 °C, 5 cycles	ΔR max. 2% no damage
4.20	Eb	Bump	3 x 1500 bumps in three directions, 40g	no damage ΔR max. 0,5% + 0,05 Ω
4.22	Fc	Vibration	frequency 10-500 Hz, displacement 1,5 mm or acceleration 10g, three dimensions; total 6 h (3 x 2 h)	no damage ΔR max. 0,5% + 0,05 Ω

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
4.23		Climatic sequence		
4.23.2	Ba	Dry heat	16 h, 155 °C	
4.23.3	Db	Damp heat (accel.) 1st cycle	24 h; 55 °C; 95-100% R.H.	
4.23.4	Aa	Cold	2 h; −55 °C	
4.23.5	M	Low air pressure	1 h; 8,5 kPa; 15-35 °C	
4.23.6	Db	Damp heat (accel.) remaining cycles	5 days; 55 °C; 95-100% R.H.	R_{ins} min. 1000 MΩ ΔR max. 3%
4.24.2	Ca	Damp heat steady state	56 days; 40 °C; 90-95% R.H. dissipation 0,01 P_n	R_{ins} min. 1000 MΩ ΔR max. 3%
4.25.1	–	Endurance	1000 hours; 70 °C P_n or V_{max}	ΔR max. 5%
4.8.4.2	–	Temperature coefficient	between −55 °C and +155 °C	R ⩽ 10 Ω: ⩽ ± 350.10⁻⁶/K R > 10 Ω: ⩽ ± 250.10⁻⁶/K
4.7	–	Voltage proof on insulation	500 V (RMS) during 1 min., V. block method	no breakdown
4.12	–	Noise	IEC publication 195	
4.6.1.1	–	Insulation resistance	500 V (DC) during 1 minute V block method	min. 10^4 MΩ
*	–	Pulse load		see Figs 8 and 9

*See 2nd amendment to IEC 115-1 and present 40 central office 532 & 533.

STANDARD PACKING

The resistors with straight leads are supplied on bandolier in ammopack. Those with bent leads are supplied loose in a box. For details see General section.

type and style	quantity per box	
	on bandolier ammopack	bulk loose
straight leads	1000	
cropped and formed leads, h = 8 mm		1000
h = 15 mm		500

Dimensions of bandolier

type	a ± 0,5	A ± 1,5	B1 - B2 ± max.	S (spacing)	T (max. deviation of spacing)
PR37	6	73	1,2	5	1 mm per 10 spacings 0,5 mm per 5 spacings

Dimensions of ammopack

	M	N	P
1000 resistors	97	59	262

POWER METAL FILM RESISTORS

QUICK REFERENCE DATA

Resistance range	1 Ω to 1 MΩ, E24 series
Resistance tolerance	± 5%
Max. body temperature (hot spot)	300 °C
Rated dissipation at T_{amb} = 70 °C	
R ⩽ 51 kΩ	2,5 W
R > 51 kΩ	2,0 W
V_{max}	750 V
Basic specification	MIL-R-11804/2, char. G and IEC 115-4
Climatic category (IEC 68)	55/200/56

		requirement	typical values	
Stability after,			R ⩽ 51 kΩ	R > 51 kΩ
1000 h max. load	ΔR/R	max. 5%	⩽ 2,5%	⩽ 2,5%
climatic tests	ΔR/R	max. 3%	⩽ 0,5%	⩽ 1%
soldering test	ΔR/R	max. 1%	⩽ 0,1%	⩽ 0,1%

DESCRIPTION

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

The resistor has a red non-inflammable coating of a protective silicon lacquer which can withstand 500 V (r.m.s.) and is resistant against most of the commonly used cleaning solvents according to MIL-STD-202E, method 215 and IEC 68-2-45.

COMPOSITION OF THE CATALOGUE NUMBER

2322 192 . . . . .

style code
3 = straight copper-clad iron leads, ϕ 0,6
4 = cropped and formed copper-clad iron leads ϕ 0,6
5 = straight copper leads, ϕ 0,8
6 = cropped and formed copper leads, ϕ 0,8

first two digits of the resistance value (E24 series)

mounting height (h), Fig. 2
0 = 8 } cropped and formed version
1 = 15 }
0 = straight lead version

8 for R =	1	to	9,1	Ω
9 for R =	10	to	91	Ω
1 for R =	100	to	910	Ω
2 for R =	1 000	to	9 100	Ω
3 for R =	10 000	to	91 000	Ω
4 for R =	100 000	to	910 000	Ω
5 for R =	1000 000	Ω		

MECHANICAL DATA

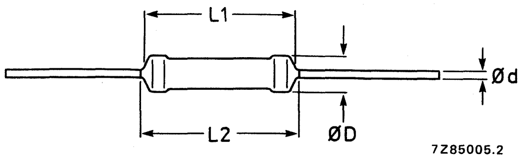


Fig. 1 Version with straight leads, see Table 1.

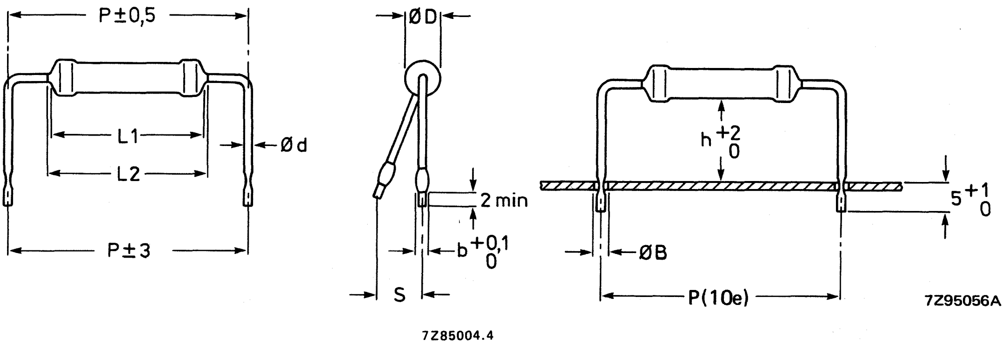


Fig. 2 Version with cropped and formed leads.

Table 1

type	leads	D_{max}	L_{1max}	L_{2max}	d	b	h	S_{max}	P	B ϕ_{max}
PR52	copper-clad iron	5,2	16,7	17,9	0,6	1,1	8	2	25,4	1,0
		5,2	16,7	17,9	0,6	1,1	15	3	25,4	1,0
	copper	5,2	16,7	17,9	0,8	1,3	8	2	25,4	1,2
		5,2	16,7	17,9	0,8	1,3	15	3	25,4	1,2

Mass 92 g per 100 resistors

Mounting

The resistors must be mounted stress free so as to allow thermal expansion over the wide permissible temperature range. The mounting pitch of version with cropped and formed leads is 10e (25,4 mm).

Marking

Each resistor is marked with:
- resistance value (R for Ω, K for kΩ and M for MΩ).
- tolerance on resistance in %.

Example: 27 R ± 5%.

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated resistance (nominal resistance) are taken from the E24 series within the range 2,2 Ω to 1 MΩ. E24 series of values is given in the table "Standard series of values in a decade" at the back of the handbook. The tolerance on the rated resistance is ± 5%.

Table 2

type	leads			mounting height (h, Fig. 2)	resistance range	catalogue number 2322 followed by
	style	dia. mm	material			
PR52	straight	0,6	copper-clad iron	–	1 Ω to 1 MΩ	192 3 . . 0 .
		0,8	copper	–		192 5 . . 0 .
	cropped and formed	0,6	copper-clad iron	8	1 Ω to 1 MΩ	192 4 . . 0 .
		0,8	copper	8		192 6 . . 0 .
		0,6	copper-clad iron	15		192 4 . . 1 .
		0,6	copper	15		192 6 . . 1 .

To complete the catalogue number, see Composition of the Catalogue Number. For quantities and packing see Standard packaging.

Temperature coefficient		
$R \geqslant 10\ \Omega$		max. ± 250.10^{-6}/K
$R < 10\ \Omega$		max. ± 350.10^{-6}/K
Maximum body temperature (hot spot)		300 °C
Rated dissipation at T_{amb} = 70 °C	$R \leqslant 51$ kΩ	2,5 W
	$R > 51$ kΩ	2,0 W
Dielectric withstanding RMS voltage of the installation for 1 min		min. 500 V
Maximum voltage		750 V
Basic specification		IEC 115-4 and MIL-R-11804/E, char. G
Climatic category (IEC 68)		55/200/56
Temperature rise (ΔT) of the resistor body as a function of dissipation		see Figs 4 and 5
Lead length (l) as a function of dissipation with temperature rise at end of lead (soldering place) as parameter		see Figs 6 and 7

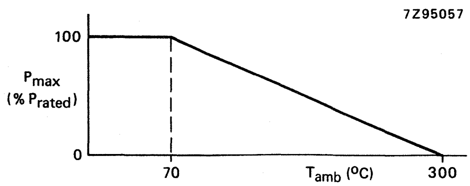


Fig. 3 Maximum dissipation (P_{max}) as a function of the ambient temperature (T_{amb}).

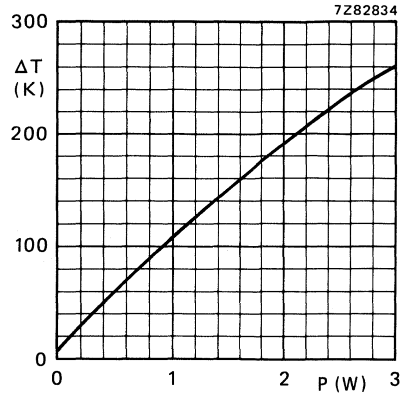


Fig. 4 Hot-spot temperature rise (ΔT) versus dissipated power (P) copper-clad iron leads ϕ = 0,6 mm.

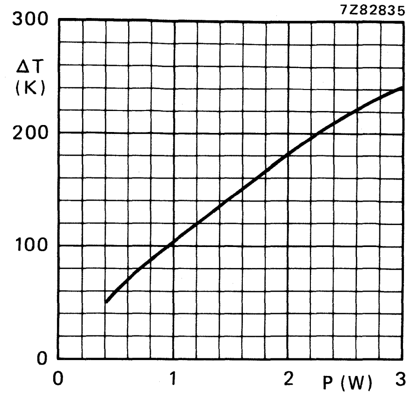


Fig. 5 Hot-spot temperature rise (ΔT) versus dissipated power (P), copper leads ϕ = 0,8 mm.

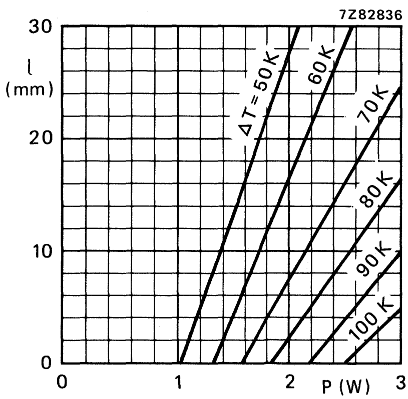


Fig. 6 Lead length l versus dissipated power with ΔT as a parameter, copper-clad iron leads ϕ = 0,6 mm.

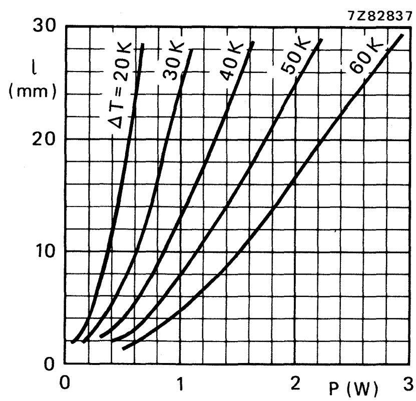


Fig. 7 Lead length l versus dissipated power with ΔT as a parameter, copper leads ϕ = 0,8 mm.

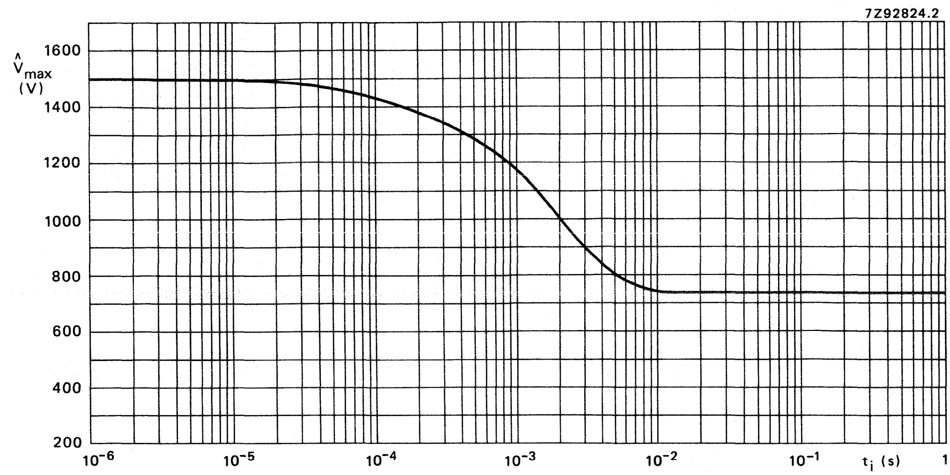


Fig. 8 Max. permissible peak pulse voltage ($\hat{V}_{max}$) versus pulse duration (t_i).

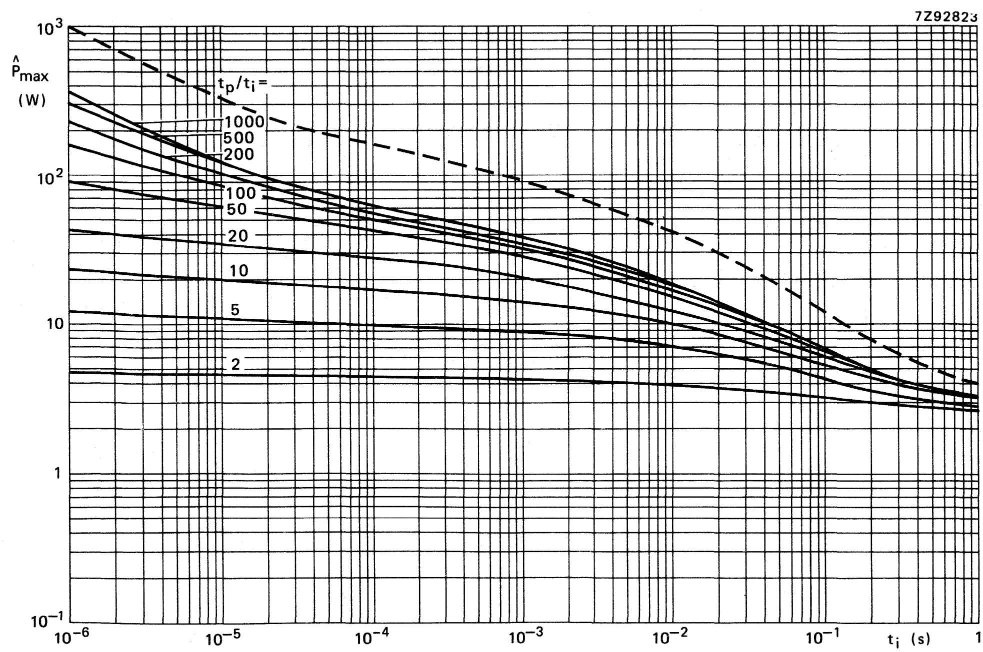


Fig. 9 Max. permissible peak pulse power ($\hat{P}_{max}$) versus pulse duration (t_i).

TESTS AND REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publication 115-1, category 55/200/56 (rated temperature range −55 to + 200 °C; damp heat, long term, 56 days) and along the lines of IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components". In the following table the tests are listed with reference to the relevant clauses of IEC publications 115-1 and 68; a short description is also given of the test procedure and requirements. In some instances deviations from the IEC recommendation were necessary for out method of specifying.

Table 4

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
4.16		Robustness of terminations		
4.16.2	Ua	Tensile all samples	load 10N; 10s	number of failures < 10 ppm
4.16.3	Ub	Bending half number of samples	load 5N; 4 x 90°	
4.16.4	Uc	Torsion other half number of samples	3 x 360° in opposite directions	no damage ΔR max. 0,5% + 0,05 Ω
4.17	Ta	Soldering	solderability: 2 s 230 °C, flux 600	good tinning. no damage
4.18	Tb		thermal shock: 3 s 350 °C, 6 mm from body	ΔR max. 0,5% + 0,05 Ω
4.19	Na	Rapid change of temperature	½ h −55 °C/½ h + 155 °C. 5 cycles	ΔR max. 2% no damage
4.20	Eb	Bump	3 x 1500 bumps in three directions, 40g	no damage ΔR max. 0,5% + 0,05 Ω
4.22	Fc	Vibration	frequency 10-500 Hz, displacement 1,5 mm or acceleration 10g, three dimensions; total 6 h (3 x 2 h)	no damage ΔR max. 0,5% + 0,05 Ω

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
4.23		Climatic sequence		
4.23.2	Ba	Dry heat	16 h, 155 °C	
4.23.3	Db	Damp heat (accel.) 1st cycle	24 h; 55 °C; 95-100% R.H.	
4.23.4	Aa	Cold	2 h; –55 °C	
4.23.5	M	Low air pressure	1 h; 8,5 kPa; 15-35 °C	
4.23.6	Db	Damp heat (accel.) remaining cycles	5 days; 55 °C; 95-100% R.H.	R_{ins} min. 1000 MΩ ΔR max. 3%
4.24.2	Ca	Damp heat steady state	56 days; 40 °C; 90-95% R.H. dissipation 0,01 P_n	R_{ins} min. 1000 MΩ ΔR max. 3%
4.25.1	–	Endurance	1000 hours; 70 °C P_n or V_{max}	ΔR max. 5%
4.8.4.2	–	Temperature coefficient	between –55 °C and + 155 °C	$R \leqslant 10\,\Omega \leqslant \pm 350\ 10^{-6}$/K $R > 10\,\Omega \leqslant \pm 250\ 10^{-6}$/K
4.7	–	Voltage proof on insulation	500 (RMS) during 1 min., V. block method	no breakdown
4.12	–	Noise	IEC publication 195	
4.6.1.1	–	Insulation resistance	500 V (DC) during 1 minute V block method	min. 10^6 MΩ
*	–	Pulse load		see Figs 8 and 9

* See 2nd amendment to IEC 115-1 and present 40 Central Office 532 & 533.

STANDARD PACKING

The resistors with straight leads are supplied on bandolier in ammopack. Those with bent leads are supplied loose in a box. For details see General section.

type and style	quantity per box	
	on bandolier ammopack	bulk loose
straight leads	500	
cropped and formed leads, h = 8 mm		500
h = 15 mm		250

Dimensions of bandolier

type	a ± 0,5	A ± 1,5	B1 - B2 ± max.	S (spacing)	T (max. deviation of spacing)
PR52	6	80	1,2	10	1 mm per 10 spacings 0,5 mm per 5 spacings

Dimensions of ammopack

	M	N	P
500 resistors	99	77	259

WIREWOUND

CEMENTED WIREWOUND RESISTORS

QUICK REFERENCE DATA

Resistance range	0,1 Ω to 33 kΩ, E24 series
Resistance tolerance	± 5% or ± 10%
Max. permissible body temperature (hot spot)	350 °C
Rated dissipation at T_{amb} = 40 °C	AC03: 3 W AC04: 4 W, AC10 = 10 W AC05: 5 W, AC15 = 15 W AC07: 7 W, AC20 = 20 W
Basic specification	IEC 266
Climatic category (IEC68)	40/200/56
Stability after	
load	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

APPLICATION

These resistors have been designed to dissipate high powers in a small volume.

DESCRIPTION

The resistor element 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 relativity short leads to obtain stable mounting. The resistor is coated with a green silicon cement which is non-inflammable and cannot drip even at high overloads, and is resistant to most commonly used cleaning solvents, according to MIL-STD-202E, method 215 and IEC68-2-45.

MECHANICAL DATA

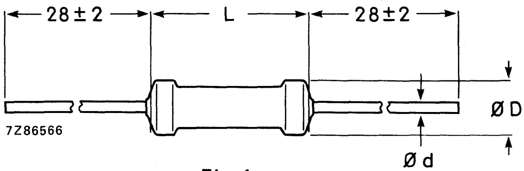


Fig. 1a.

Note: The lead length (28 ± 2 mm) only applies to untaped resistors, i.e. types AC10, AC15 and AC20.

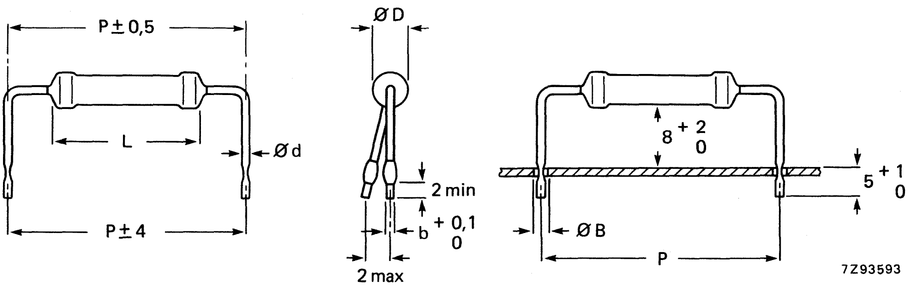


Fig. 1b Version with cropped and formed leads.
Only for AC03, AC04, AC05 and AC07; available on special request.

Table 1

type	Fig.	D_{max}	L_{max}	d	b	P	B ϕ max
AC03	1a	5,5	13	0,8	1,3	10e	1,2
AC04	1a, 1b	5,5	17	0,8	1,3	10e	1,2
AC05	1a, 1b	7,5	17	0,8	1,3	10e	1,2
AC07	1a, 1b	7,5	25	0,8	1,3	13e	1,2
AC10	1a	8	44	0,8			
AC15	1a	10	51	0,8			
AC20	1a	10	67	0,8			

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

Mass (per 100)

AC03	80 g
AC04	100 g
AC05	175 g
AC07	225 g
AC10	530 g
AC15	840 g
AC20	1090 g

Mounting

The resistors AC03, AC04, AC05 and AC07 are suitable for processing on cutting and bending machines. Care should be taken that the temperature rise of the resistor body does not affect nearby components or materials by conducted or convected heat. The temperature rise of the resistor body and of leads of different lengths is given as a function of the dissipation in Fig. 2.

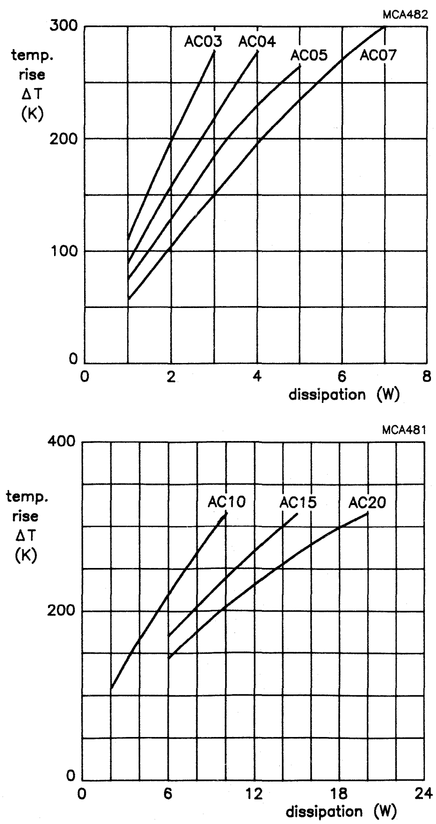


Fig. 2 Temperature rise of the resistor body as a function of the dissipation.

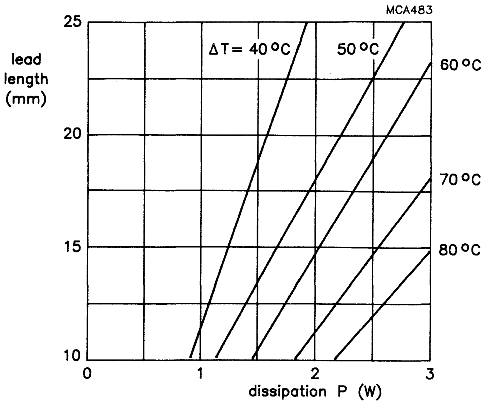


Fig. 3 Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as parameter, for style AC03.

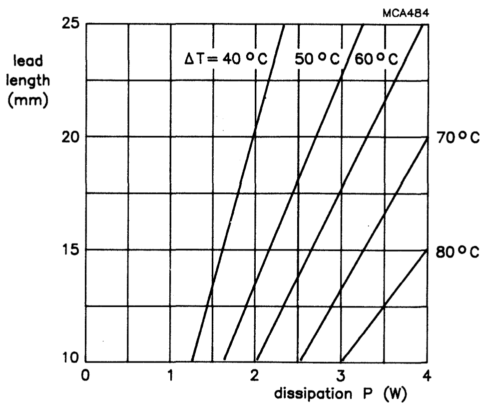


Fig. 4 Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as parameter, for style AC04.

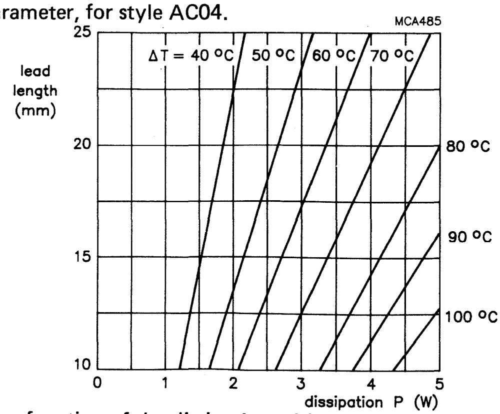


Fig. 5 Lead length as a function of the dissipation with the temperature rise at tne end of the lead (soldering spot) as parameter, for style AC05.

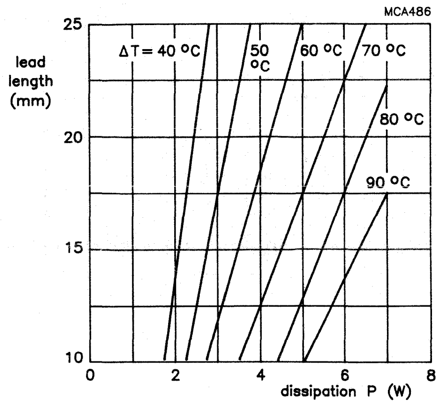


Fig. 6 Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as parameter, for style AC07.

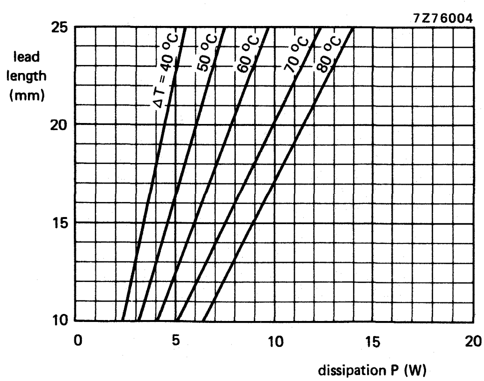


Fig. 7 Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as parameter, for style AC10.

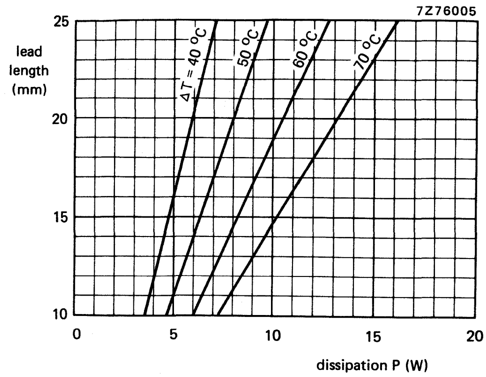


Fig. 8 Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as parameter, for style AC15.

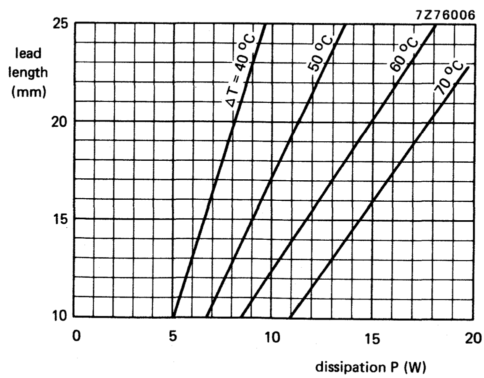


Fig. 9 Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as parameter, for style AC20.

Marking

The nominal resistance (R for Ω, K for kΩ), the tolerance on the resistance and the rated dissipation at T_{amb} = 40 °C are printed on the resistor body, e.g. 27 R 5% 4 W.

ELECTRICAL DATA

Standard values of rated resistance and tolerance

For AC03, AC04, AC05 and AC07, standard values of rated resistance (nominal resistance) are taken from the E24 series, tolerance ± 5% or ± 10% within the range 0.1 Ω to 15 kΩ as per Table 2.
For AC10, AC15 and AC20, standard values of rated resistance (nominal resistance) are taken from the E24 series for ± 5% and E12 series for ± 10% within the range 0.68 Ω to 33 kΩ as per Table 2.
See the Table "Standard series of values in a decade", at the back of the data handbook.

Table 2

type	rated dissipation (W) T_{amb} = 40 °C	rated dissipation (W) T_{amb} = 70 °C	resistance range Ω	tol. %	catalogue number
AC03	3	2,5	0,1 - 8,2	10	2322 329 33 . . .
			10 - 3000	5	2322 329 03 . . .
AC04	4	3,5	0,1 - 8,2	10	2322 329 34 . . .
			10 - 6800	5	2322 329 04 . . .
AC05	5	4,7	0,1 - 8,2	10	2322 329 35 . . .
			10 - 8200	5	2322 329 05 . . .
AC07	7	5,8	0,1 - 8,2	10	2322 329 37 . . .
			10 - 15 000	5	2322 329 07 . . .
AC10	10	8,4	0,68 - 8,2	10	2322 329 40 . . .
			10 - 15 000	5	2322 329 10 . . .
AC15	15	12,5	0,82 - 8,2	10	2322 329 45 . . .
			10 - 22 000	5	2322 329 15 . . .
AC20	20	16	1,2 - 8,2	10	2322 329 50 . . .
			10 - 33 000	5	2322 329 20 . . .

Limiting voltage	
AC03	1000 V
AC04, AC05	1500 V
AC07	2500 V
Maximum permissible body temperature	350 °C
Ambient temperature range	–40 to + 200 °C
Temperature coefficient	–80 to + 140 · 10^{-6}/K
Values < 10 Ω	+600 · 10^{-6}/K
Climatic category (IEC68)	40/200/56

COMPOSITION OF THE CATALOGUE NUMBER

The catalogue number in the above table is completed by inserting the resistance code: the first two figures of the resistance followed by:

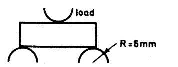
7 for R = 0,1 to 0,82 Ω
8 for R = 1 to 8,2 Ω
9 for R = 10 to 91 Ω
1 for R = 100 to 910 Ω
2 for R = 1 to 9,1 kΩ
3 for R = 10 to 33 kΩ

* Values from 25 mΩ to 100 mΩ are available on request.

TESTS AND REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publications 266 and 266A category 40/200/56 (rated temperature range –40 to + 200 °C; damp heat, long term, 56 days) and along the lines of IEC publication 68. "Recommended basic climatic and mechanical robustness testing procedure for electronic components". In the following table the tests are listed with reference to the relevant clauses of IEC publications 266, 266A and 68; a short description is also given of the test procedure and requirements. In some instances deviations from the IEC recommendation were necessary for our method of specifying.

Table 4

IEC 266 clause	IEC 68 test method	test	procedure	requirements
14		Robustness of resistor body	 load 200 ± 10 N	no visible damage $\Delta R \leqslant 0{,}5\% + 0{,}05\ \Omega$
15	U	Robustness of terminations:		
	Ua	Tensile all samples	load 10 N; 10 s	
	Ub	Bending half number of samples	load 5 N; 4 x 90°	
	Uc	Torsion other half number of samples	2 x 180° in opposite directions	no visible damage ΔR max. 0,5% + 0,05 Ω
16	T	Soldering	solderability: 2 s 230 °C, flux 600 thermal shock: 3 s 350 °C, 2,5 mm from body	good tinning, no damage ΔR max. 0,5% + 0,05 Ω
17	Na	Rapid change of temperature	½ h –40 °C/½ h + 200 °C, 5 cycles	no visible damage ΔR max. 1% + 0,05 Ω
18	Fc	Vibration	frequency 10-500 Hz, displacement 0,75 mm or acceleration 10g, three directions; total 6 h (3 x 2 h)	no visible damage ΔR max. 0,5% + 0,05 Ω
19	Eb	Bump	4000 ± 10 bumps 390 m/s^2	no visible damage ΔR max. 0,5% + 0,05 Ω

IEC 266 clause	IEC 68 test method	test	procedure	requirements
20		Climatic sequence		
20.2	Ba	Dry heat	16 h, 200 °C	
20.3		Damp heat (accel) 1st cycle	24 h; 55 °C; 95-100% R.H.	
20.4	Aa	Cold	2 h; −40 °C	
20.5	M	Low air pressure	1 h; 8,5 kPa; 15-35 °C	
20.6	D	Damp heat (accel) remaining cycles	5 days; 55 °C; 95-100% R.H.	after 24 h at P_n ΔR max. 1% + 0,05 Ω
21	Ca	Damp heat steady state	56 days; 40 °C; 90-95% R.H. dissipation $\leqslant 0{,}01\ P_n$	ΔR max. 1% + 0,05 Ω
22	—	Endurance	1000 h at 70 °C	ΔR max. 5% + 0.1 Ω
23			1000 h at 200 °C	ΔR max. 5% + 0.1 Ω
13.6		Overload	10 x P_n, 5 s	ΔR max. 2% + 0.1 Ω

STANDARD PACKING

The resistors AC03, AC04, AC05 and AC07 with straight leads are supplied on bandolier of 500 in ammopack. Those with bent leads are supplied loose in a box.
The resistors AC10, AC15 and AC20 with straight leads are supplied loose in a box of 100.

Dimensions of bandolier

type	a ± 0,5	A ± 4	B1 - B2 ± max.	S (spacing)	T (max. deviation of spacing)
AC03	5	66	1,2	10	1 mm per 10 spacings 0,5 mm per 5 spacings
AC04	5 or 6	66	1,2	10	
AC05	6	66	1,2	10	
AC07	6	74	1,2	10	

Dimensions of ammopack

	M	N	P
AC03	85	77	259
AC04	85	77	259
AC05	85	115	259
AC07	93	115	259

ENAMELLED WIREWOUND RESISTORS

QUICK REFERENCE DATA

Resistance ranges		4,7 Ω to 100 kΩ, E24 or E12 series
Resistance tolerance		±5% or ±10%
Max. body temperature (hot spot)		400 °C
Rated dissipation at T_{amb} = 70 °C	WR0617E	4 W
	WR0825E	7 W
	WR0842E	11 W
	WR0865E	17 W
Basic specification		IEC publication 266, type 2
Climatic category (IEC 68)		55/200/56
Stability after:		
1000 h max. load		ΔR/R max. 5%
climatic tests		ΔR/R max. 1%
dip-soldering test		ΔR/R max. 0,5%
short time overload		ΔR/R max. 2%

APPLICATION

As power resistors in electrical and electronic circuitry.

DESCRIPTION

These resistors have a single layer of resistance wire wound on a ceramic body. Leads of solder-coated copper-clad wire are secured to caps which are force-fitted on to the ends of the ceramic body. The resistor is coated with brown enamel.

MECHANICAL DATA

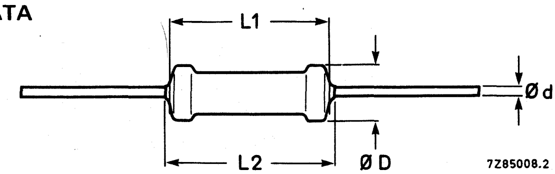


Fig. 1.

Table 1

type	D_{max}	L1 max	L2 max	a_{max}
WR0617E	6	17	23	3
WR0825E	8	26	32	3
WR0842E	8	44	50	3
WR0865E	8	67	73	3

The length of the resistor body is measured by inserting the leads into the holes of two identical gauge plates and by moving these plates parallel to each other until the resistor body is clamped without deformation (see IEC publication 294). The diameter of the holes in the gauge plate is 1,0 mm.

Mass (per 100 pieces)

WR0617E	115 g
WR0825E	210 g
WR0842E	335 g
WR0865E	450 g

Mounting

The resistors must be mounted in such a way that:

- no stress is exerted on the leads so as to allow thermal expansion over the wide temperature range.
- nearby components and materials are not affected by the dissipated heat.

Marking

Each resistor is marked with:

- resistance value (R for Ω, K for kΩ)
  e.g. 27 Ω = 27R
  27 kΩ = 27K
- tolerance on resistance in %
- rated dissipation at T_{amb} = 70 °C

Example: 27R 10%
4W

ELECTRICAL DATA

Table 2

type	rated dissipation at T_{amb} = 70 °C W	resistance range Ω	tol. %	series *	catalogue number
WR0617E	4	4,7 – 4700	5	E24	2322 330 22 . . .
		4,7 – 47	10	E12	2322 330 21 . . .
WR0825E	7	6,8 – 27 000	5	E24	2322 330 32 . . .
		6,8 – 27	10	E12	2322 330 31 . . .
WR0842E	11	10 – 56 000	5	E24	2322 330 42 . . .
WR0865E	17	15 – 100 000	5	E24	2322 330 52 . . .

Maximum body temperature (hot spot)	400 °C
Ambient temperature range	–55 to +200 °C
Temperature coefficient	–80 to +140 $.10^{-6}$/K
Climatic category (IEC 68)	55/200/56

* See the table "Standard series of values in a decade" at the back of this book.

COMPOSITION OF THE CATALOGUE NUMBER

The catalogue number in Table 2 is completed by inserting the resistance code: the first two significant figures of the resistance value (in Ω) followed by:

8 for R of	4,7	to	9,1	Ω
9 for R of	10	to	91	Ω
1 for R of	100	to	910	Ω
2 for R of	1	to	9,1	kΩ
3 for R of	10	to	91	kΩ
4 for R of			100	kΩ

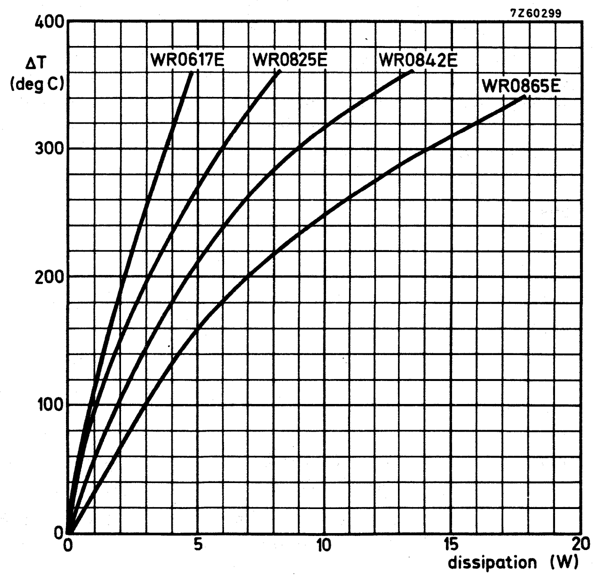
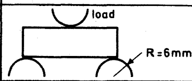


Fig. 2 Temperature rise (ΔT) of the resistor body as a function of the dissipation. Distance between cap and solder joint is 10 mm.

TESTS AND REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publications 266 and 266A, category 55/200/56 (rated temperature range –55 °C to +200 °C; damp heat, long term, 56 days) and along the lines of IEC publication 68, "Recommended basic climatic and mechanical robustness testing procedure for electronic components". In the following table the tests are listed with reference to the relevant clauses of IEC publications 266, 266A and 68; a short description is also given of the test procedure and requirements. In some instances deviations from the IEC recommendation were necessary for our method of specifying.

Table 3

IEC 266 clause	IEC 68 test method	test	procedure	requirements
14		Robustness of resistor body	 load 200 ± 10 N	no visible damage ΔR ⩽ 0,5% or 0,05 Ω
15	U	Robustness of terminations		
	Ua	Tensile all samples	load 10N; 10 s	
	Ub	Bending half number of samples	load 5N; 4 x 90°	
	Uc	Torsion other half number of samples	2 x 180° in opposite directions	no visible damage ΔR max. 0,5% + 0,05 Ω
16	T	Soldering	solderability: 2 s 230 °C, flux 600 thermal shock: 3 s 350 °C, 6 mm from body	good tinning, no damage ΔR max. 0,5% + 0,05 Ω
17	Na	Rapid change of temperature	½ h –55 °C/½ h + 200 °C, 5 cycles	no visible damage ΔR max. 1%
18	Fc	Vibration	frequency 10-500 Hz, displacement 0,75 mm or acceleration 10g, three directions; total 6 h (3 x 2 h)	no visible damage ΔR max. 0,5% + 0,05 Ω
19	Eb	Bump	4000 ± 10 bumps 390 m/s²	no visible damage ΔR max. 0,5% + 0,05 Ω

IEC 266 clause	IEC 68 test method	test	procedure	requirements
20		Climatic sequence		
20.2	Ba	Dry heat	16 h, 200 °C	
20.3	D	Damp heat (accel) 1st cycle	24 h; 55 °C; 95-100% R.H.	
20.4	Aa	Cold	2 h; –55 °C	
20.5	M	Low air pressure	1 h; 8,5 kPa; 15-35 °C	
20.6	D	Damp heat (accel) remaining cycles	5 days; 55 °C; 95-100% R.H.	after 24 h at P_n ΔR max. 5%
21	Ca	Damp heat steady state	56 days; 40 °C; 90-95% R.H. dissipation $\leqslant$ 0,01 P_n	after 24 h at P_n ΔR max. 1%
22	–	Endurance	1000 h at 70 °C	ΔR max. 5%
23			1000 h at 200 °C	ΔR max. 5%
13.6	–	Overload	10 x P_n, 5 s 2 x P_n, 10 min.	ΔR max. 2%

STANDARD PACKING

The resistors are supplied on bandolier in ammopack. For details see General section.

type	number per box
	bandolier
WR0617E	500
WR0825E	500
WR0842E	100
WR0865E	100

Dimensions of bandolier

type	a ± 0,5	A ± 1,6	B1 - B2 ± max.	S (spacing)	T (max. deviation of spacing)
WR0617E	5	66,7	1,2	10	1 mm per 10 spacings 0,5 mm per 5 spacings
WR0825E	6	74	1,2	10	
WR0842E	6	88	1,2	10	
WR0865E	6	110	1,2	10	

Dimensions of ammopack

type	M	N	P
WR0617E	85	77	259
WR0825E	93	115	259
WR0842E	132	56	160
WR0865E	132	56	160

STAND-UP MINIATURE POWER RESISTORS

QUICK REFERENCE DATA

Resistance range		0.1 Ω to 560 Ω (E24 series)
Resistance tolerance		± 5%
Maximum permissible body (hot spot) temperature		300 °C
Rated dissipation at T_{amb} = 70 °C	SMW02	2 W
	SMW03	3 W
	SMW05	5 W
Basic specification		IEC 266
Climatic category (IEC 68)		40/200/56
Stability after		
load	$\Delta R/R$ max.	5%
climatic tests	$\Delta R/R$ max.	3%
soldering	$\Delta R/R$ max.	2%

APPLICATION

These resistors have a high factor of heat dissipation in comparison to their size, and are supplied in a 'stand-up' configuration for vertical mounting.

DESCRIPTION

The resistor element is wound in a single layer on a ceramic rod, metal end-caps are fitted over both ends of the rod. The ends of the resistance wire and the leads are welded to the metal end-caps. Tinned copper-clad iron leads are used; since these leads have a poor heat conductivity, heat dissipation usually caused at the soldering point is restricted, thus the lead length can be kept relatively short permitting stable mounting.

The resistor body and lead ends are housed within a rectangular ceramic case which is non-flammable and will not melt, even at high overloads.

The resistor is resistant to most commonly used cleaning solvents in accordance with MIL-STD 202E method 215, and IEC 68-2-45.

MECHANICAL DATA

Dimensions in mm

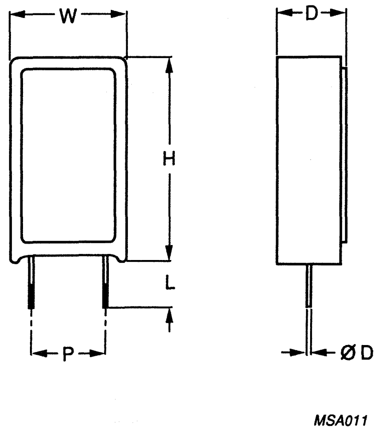


Fig.1 Component outline; see Table 1.

Table 1 Physical dimensions

type	W ± 1 mm	D ± 1 mm	H ± 1.5 mm	L* ± 0.15 mm	P + 2/−1 mm	ϕd
SMW02	11	7	20.5	2.75	5	0.8
SMW03	12	8	25	2.75	5	0.8
SMW05	13	9	25.5	2.75	5	0.8

Mass

SMW02: 370 g per 100 resistors
SMW03: 530 g per 100 resistors
SMW05: 640 g per 100 resistors

Mounting

The resistors must be mounted in such a way that no stress is exerted on the leads; that thermal expansion is possible over the permissible temperature range; and that adjacently mounted components are not affected by the dissipated heat. The temperature 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.

* Longer leads are available on request.

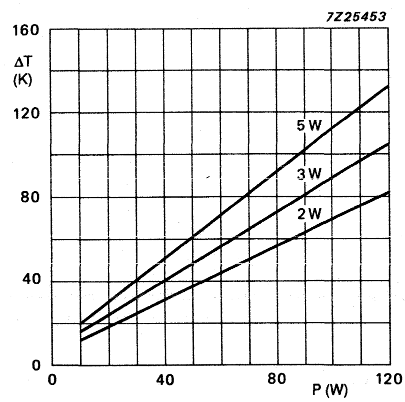


Fig.2 Hot spot temperature rise (ΔT) as a function of dissipated power.

Marking

The nominal resistance value is marked using alphanumeric values 'R', to indicate Ω or 'k' to indicate kΩ. The tolerance, style and production week are also marked on the resistor.

Example:

A resistor having a value of 27 Ω, a tolerance of ± 5% and a power of 2 W at 70 °C is marked:

SMW02
27R 5%
904

ELECTRICAL DATA

Breakdown voltage of encapsulation (RMS)	min. 2000 V
Maximum permissible body temperature (hot spot)	300 °C
Ambient temperature range	−40 to + 200 °C
Temperature coefficient	
0.1 Ω to 10 Ω	max. 600 · 10^{-6}/K
1 Ω to 560 Ω	max. 140 · 10^{-6}/K
Climatic category (IEC 68)	40/200/56

Standard values of rated resistance

Standard values of rated (nominal) resistance are taken from the E24 series of values, with a tolerance of ± 5%. The ranges are shown in Table 2.

The values of this series are shown at the back of the handbook and are in accordance with IEC publication 63.

Table 2 Ordering information

type	range SMW (Ω)	tol (%)	series	catalogue number
SMW02	0.1-200	5	E24	2306 340 03 . . .
SMW03	0.1-560	5	E24	2306 341 03 . . .
SMW05	0.1-560	5	E24	2306 342 03 . . .

COMPOSITION OF THE CATALOGUE NUMBER

The catalogue number given in Table 2 is completed by inserting the first two figures of the resistance value required, followed by one of the figures listed below dependent on the resistance multiplier.

7 for resistance values between 0.1 and 0.82 Ω
8 for resistance values between 1 and 8.2 Ω
9 for resistance values between 10 and 91 Ω
1 for resistance values between 100 and 560 Ω

TEST AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of IEC Publications 266 and 266A, category 40/200/56 (rated temperature range –40 to + 200 °C, damp heat, long term, 56 days) and along the lines of IEC Publication 68, 'Recommended basic climatic and mechanical robustness testing procedures for electronic components'. In Table 3, the tests are listed with reference to the relevant clauses of IEC Publications 266, 266A and 68; a short description of the testing procedure is also provided. In some cases, deviations from the IEC recommendation were necessary for our method of specifying.

Table 3 Test and requirements

IEC 266 clause	IEC 68 test method	test	procedure	requirements
14		robustness of resistor body	load 200 N ± 10 N	no visible damage ΔR/R 0.5% + 0.05 Ω max.
15	U	robustness of terminations		
	Ua	tensile (all samples)	load 10 N; 10 s	no visible damage ΔR/R 0.5% + 0.05 Ω max.
16	T	soldering	solderability 230 °C, flux 600 thermal shock 3 s at 350 °C, up to restposition	good tinning, no damage ΔR/R 0.5% + 0.05 Ω max.
17	Na	rapid change of temperature	0.5 h at –40 °C 0.5 h at + 200 °C 5 cycles	no visible damage ΔR/R 1% + 0.05 Ω max.
18	Fc	vibration	frequency 10-500 Hz displacement 0.75 mm or acceleration 10 g in three directions; total 6 h (3 x 2 h)	no visible damage ΔR/R 0.5% + 0.05 Ω max.

Table 3 (continued)

IEC 266 clause	IEC 68 test method	test	procedure	requirements
19	Eb	bump	4000 ± 10 bumps acceleration 390 m/s^2	no visible damage $\Delta R/R$ 0.5% + 0.05 Ω max.
20		climatic sequence		
20.2	Ba	dry heat	16 h, 200 ^oC	
20.3	D	damp heat (accelerated), 1st cycle	24 h, 55 ^oC 95-100% RH	
20.4	Aa	cold	2 h, −40 ^oC	
20.5	M	low air pressure	1 h, 8.5 kPa; 15-35 ^oC	
20.6	D	damp heat (accelerated), remaining cycles	5 days, 55 ^oC 95-100% RH	after 24 hrs at P_{nom} $\Delta R/R$ 3% max.
21	Ca	damp heat steady state	56 days, 40 ^oC 90-95% RH; dissipation 0.01 x P_{nom}	$\Delta R/R$ 3% max.
22 23		endurance	1000 h, 70 ^oC rated dissipation 1000 h, 200 ^oC no load	$\Delta R/R$ 5% max. $\Delta R/R$ 5% max.
13.6		overload	10 x P_{nom}, 5 s	$\Delta R/R$ 2% max.

PRECISION WIREWOUND

Cemented wirewound precision resistors

PAC 02/3/4/5/6

APPLICATIONS

- These resistors have been designed for precision power applications.

DESCRIPTION

The resistor element 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. The resistor is coated with a green silicon cement which is non-inflammable, cannot drip even at high overloads and is resistant to most commonly used cleaning solvents, according to MIL-STD-202E, method 215 and IEC 68-2-45.

QUICK REFERENCE DATA

Resistance range	0.22 Ω to 12 kΩ, E24 series
Resistance tolerance	±1%
Max. permissible body temperature (hot spot)	275 °C
Rated dissipation at T_{amb} = 25 °C	PAC02; 2 W PAC03; 3 W PAC04; 4 W PAC05; 5 W PAC06; 6 W
Basic specification	IEC 266 MIL-R-26 CCTU 04-09
Climatic category (IEC 68)	55/200/56
Stability after load climatic tests short time overload	 ΔR/R max. 0.5% + 0.05 Ω ΔR/R max. 0.5% + 0.05 Ω ΔR/R max. 0.2% + 0.05 Ω

MECHANICAL DATA

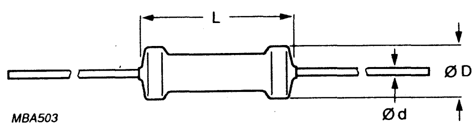


Fig.1 Package outline.

Table 1

TYPE	D_{max}	L_{max}	d
PAC02	5.5	13	0.8
PAC03	5.5	17	0.8
PAC04	7.5	17	0.8
PAC05	7.5	23	0.8
PAC06	7.5	25	0.8

Dimensions in mm.

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

Mass (per 100)

PAC02 80 g
PAC03 100 g
PAC04 175 g
PAC05 215 g
PAC06 225 g

Mounting

The resistors are suitable for processing on cutting and bending machines. Care should be taken that the temperature rise of the resistor body does not affect nearby components or materials by conducted or convected heat.

Derating curve

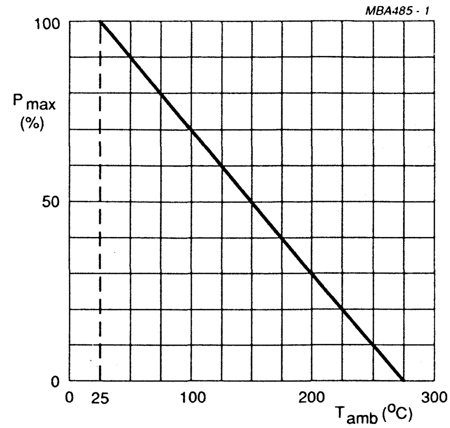


Fig.2 Maximum dissipation (P_{max}) as a function of T_{amb}.

Cemented wirewound precision resistors

PAC 02/3/4/5/6

Marking

The type, the nominal resistance (R for Ω, K for kΩ), and the year and week of production, are printed on the resistor body, e.g.
PAC03 27R 043 (week 43 of 1990).

ELECTRICAL DATA

Standard values of rated resistance and tolerance.

Standard values of rated resistance (nominal resistance) are taken from the E24 series, tolerance ±1% within the range 0.22 Ω to 12 kΩ as per Table 2.

Table 2

TYPE	RATED DISSIPATION (W) T_{amb} = 25 °C	RESISTANCE RANGE (Ω)	TOL. (%)	CATALOGUE NUMBER
PAC02	2	0.22 - 3600	1	2306 327 0....
PAC03	3	0.33 - 4700	1	2306 327 1....
PAC04	4	0.43 - 8200	1	2306 327 2....
PAC05	5	0.68 - 10 000	1	2306 327 3....
PAC06	6	0.68 - 12 000	1	2306 327 4....

Limiting voltage

$V = \sqrt{P_n \, x \, R}$

Maximum permissible body temperature	275 °C
Ambient temperature range	–55 to +200 °C
Temperature coefficient	±100 • 10^{-6}/K
Climatic category (IEC 68)	55/200/56

COMPOSITION OF THE CATALOGUE NUMBER

The catalogue number in the above table is completed by inserting the resistance code: the first THREE figures of the resistance followed by:

7 for R = 0.22 to 0.91 Ω
8 for R = 1 to 9.1 Ω
9 for R = 10 to 91 Ω
1 for R = 100 to 910 Ω
2 for R = 1 to 9.1 kΩ
3 for R = 10 to 12 kΩ

TESTS AND REQUIREMENTS

Essentially all tests are carried out according to the schedule of IEC publications 266 and 266A category 55/200/56 (rated temperature range −55 to +200 °C; damp heat, long term, 56 days) and along the lines of IEC publication 68 "Recommended basic climatic and mechanical robustness testing procedure for electronic components". In the following table the tests are listed with reference to the relevant clauses of IEC publications 266, 266A and 68; a short description is also given of the test procedure and requirements. In some instances deviations from the IEC recommendation were necessary for our method of specifying.

Table 3

IEC 266 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
14		robustness of resistor body	Fig.3 load 200 ±10 N	no visible damage ΔR max. 0.1% + 0.05 Ω
15	U	robustness of terminations		
	Ua	tensile all samples	load 10 N; 10 s	
	Ub	bending half number of samples	load 5 N; 4 x 90°	
	Uc	torsion other half number of samples	2 x 180 ° in opposite directions	no visible damage ΔR max. 0.1% + 0.05 Ω
16	T	soldering	solderability: 2 s 230 °C, flux 600	good tinning, no damage
			thermal shock: 3 s 350 °C, 2.5 mm from body	ΔR max. 0.2% + 0.05 Ω
17	Na	rapid change of temperature	1/2 h −55 °C/1/2 h + 200 °C, 5 cycles	no visible damage ΔR max. 0.5% + 0.05 Ω
18	Fc	vibration	frequency 10 • 500 Hz, displacement 0.75 mm or acceleration 10 g, three directions; total 6 h (3 x 2 h)	no visible damage ΔR max. 0.1% + 0.05 Ω
19	Eb	bump	4000 ±10 bumps 390 m/s^2	no visible damage ΔR max. 0.1% + 0.05 Ω

IEC 266 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
20		climatic sequence		
20.2	Ba	dry heat	16 h, 200 °C	
20.3		damp heat (accel) 1st cycle	24 h; 55 °C; 95-100% R.H.	
20.4	As	cold	2 h; –55 °C	
20.5	M	low air pressure	1 h; 8.5 kPa; 15-35 °C	
20.6	D	damp heat (accel) remaining cycles	5 days; 55 °C; 95-100% R.H.	after 24 h at P_n ΔR max. 0.5% + 0.05 Ω
21	Ca	damp heat steady state	56 days; 40 °C; 90-95% R.H. dissipation ≤0.01 P_n	ΔR max. 1% + 0.05 Ω
22		endurance	1000 h at 25 °C	ΔR max. 0.5% + 0.05 Ω
23			1000 h at 200 °C	ΔR max. 1% + 0.05 Ω
13.6		overload	10 x P_n, 5 s	ΔR max. 0.2% + 0.05 Ω

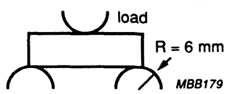


Fig.3 Method for testing robustness of resistor body.

Cemented wirewound precision resistors

PAC 02/3/4/5/6

STANDARD PACKING

The resistors are supplied on bandolier of 500 in ammopack

Table 4 Dimensions of bandolier

TYPE	a ±0.5	A +1	B_1 - B_2 ±max.	S (spacing)	T MAX. DEVIATION OF SPACING
PAC02	6	63	1.2	10	1 mm per 10 spacings 0.5 mm per 5 spacings
PAC03	6	63	1.2	10	
PAC04	6	63	1.2	10	
PAC05	6	71	1.2	10	
PAC06	6	71	1.2	10	

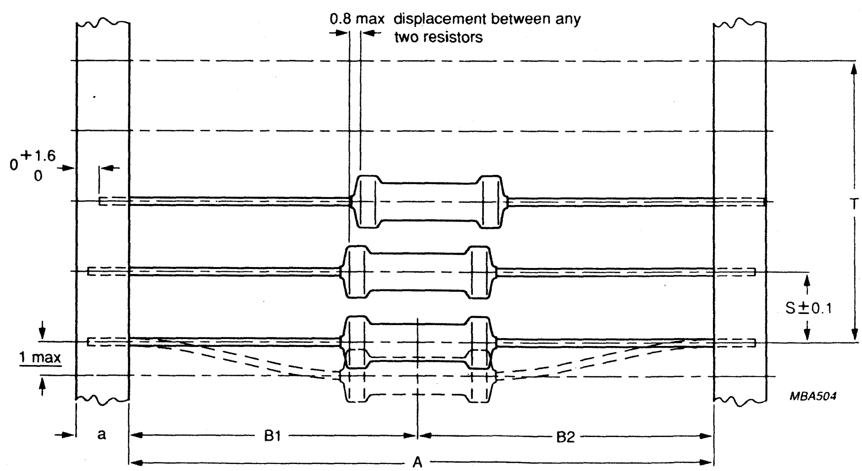


Fig.4 Dimensions of bandolier in mm.

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Fixed Resistors

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Data handbook system

INTRODUCTION

Our data handbook system comprises more than 65 books with subjects including electronic components, subassemblies and magnetic products. The handbooks are classified into seven series:

- INTEGRATED CIRCUITS;
- DISCRETE SEMICONDUCTORS;
- DISPLAY COMPONENTS;
- PASSIVE COMPONENTS;
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for resistances and capacitances

according to IEC publication 63

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