PASSIVE COMPONENTS

DATA HANDBOOK

BOOK PA08 1994

Fixed Resistors

REVISED EDITION

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

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

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

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

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

Fixed Resistors

CONTENTS

DEFINITIONS

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

LIFE SUPPORT APPLICATIONS

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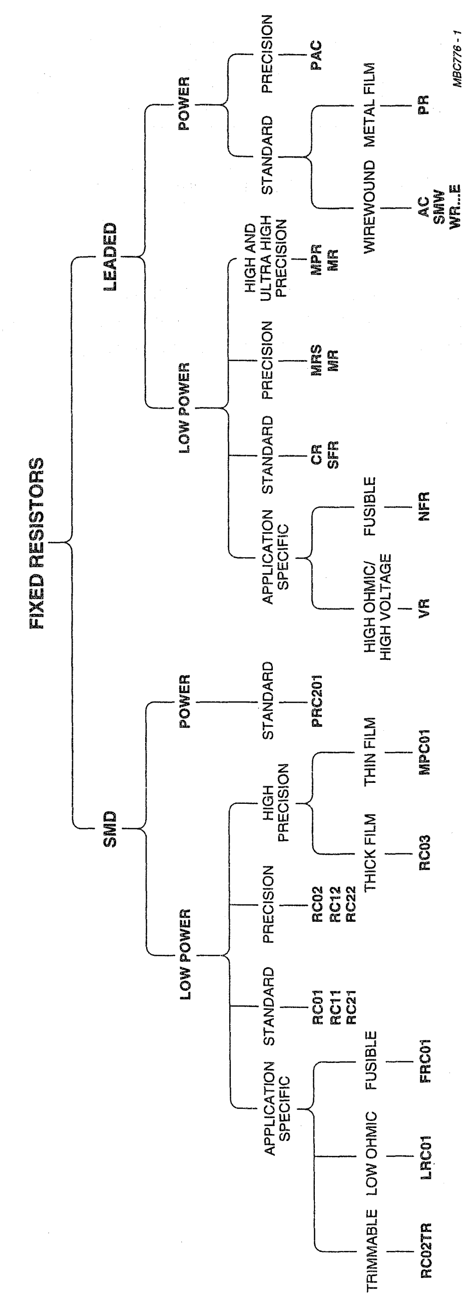
FIXED RESISTORS
SMD
LEADED
LOW POWER
POWER
APPLICATION SPECIFIC
STANDARD
PRECISION
HIGH PRECISION
TRIMMABLE
LOW OHMIC
FUSIBLE
THICK FILM
THIN FILM
RC02TR
LRC01
FRC01
RC01
RC11
RC21
RC02
RC12
RC22
RC03
MPC01
PRC201
HIGH OHMIC/ HIGH VOLTAGE
VR
NFR
CR
SFR
MRS
MR
HIGH AND ULTRA HIGH PRECISION
MPR
MR
WIREWOUND
METAL FILM
AC
SMW
WR...E
PR
PAC
MBC776 - 1

SMD CHIP RESISTORS

Fixed Resistors

Selection Guide
Chip resistors

APPLICATION	TYPE	SIZE CODE	TOL. (%)	RESISTANCE RANGE	TEMP. COEFF. ($\times 10^{-6}$/K)	MAX. (V/W)	SERIES	PAGE
Thick film								
Standard	RC01	1206	5 or 2	1 Ω to 10 MΩ	≤±200	200/0.25	E24	30
	RC11	0805		1 Ω to 10 MΩ	≤±200	150/0.1		38
	RC21	0603		1 to 10 Ω 11 Ω to 910 kΩ 1 to 6.8 MΩ	–200/+500 ±200 ±300	50/0.063		46
Precision TC100	RC02H	1206	1	1 to 4.99 Ω	≤±250	200/0.125	E24/96	56
	RC02HP			5.1 to 9.76 Ω 10 Ω to 1 MΩ 1.02 to 10 MΩ	≤±200 ≤±100 ≤±200	200/0.25		66
	RC12H	0805		1 to 4.99 Ω 5.1 to 97.6 Ω 100 Ω to 1 MΩ	≤±250 ≤±200 ≤±100	150/0.1		74
	RC22H	0603		1 to 4.99 Ω 5.1 to 97.6 Ω 100 Ω to 1 MΩ	≤±250 ≤±200 ≤±100	50/0.063		82
Precision TC50	RC02G	1206	1	100 Ω to 1 MΩ	≤±50	200/0.125		89
	RC02GP			250 Ω to 1 MΩ	≤±50	200/0.25		97
	RC12G	0805		100 to 249 Ω 255 Ω to 1 MΩ	≤±100 ≤±50	150/0.1		105
High precision	RC03G	1206	0.5	100 to 249 Ω 255 Ω to 1 MΩ	≤±100 ≤±50	200/0.125		114
Application specific	RC02TR trimmable	1206	+0/–20 or +0/–30	1 to 4.99 Ω 5.1 to 97.6 Ω 100 Ω to 1 MΩ	≤±250 ≤±200 ≤±100	200/0.25	E24	153
	LRC01 low-ohmic		5	0.1 to 0.147 Ω 0.15 to 0.392 Ω 0.4 to 0.91 Ω	≤±1000 ≤±700 ≤±250	0.125		140
	FRC01 fusible			1 to 250 Ω	≤±200	200/0.125		146
	PRC201 power	1218	5	1 to 9.1 Ω 10 Ω to 1 MΩ	≤±200 ≤±100	200/1		130
Thin film								
High precision	MPC01	1206	0.1	100 Ω to 100 kΩ	≤±25	100/0.125	all values	122

INTRODUCTION

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

- TITLE
- FEATURES
- APPLICATIONS
- QUICK REFERENCE DATA
- DESCRIPTION
- MECHANICAL DATA
  - Mass
  - Mounting
  - Marking
- ELECTRICAL DATA
  - Standard values of rated resistance and tolerance
- COMPOSITION OF THE CATALOGUE NUMBER
- PACKAGING
- TESTS AND REQUIREMENTS.

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.

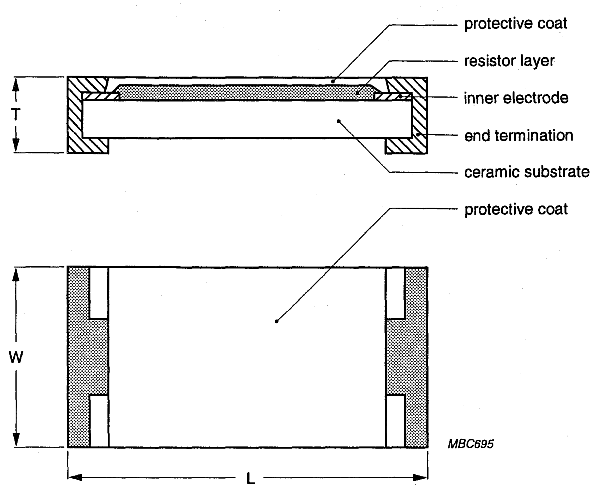

Fig.1 Component outline.

This table shows the relationship between USA case size code, sizes in mm and mass per 100 units for various types of chip resistors.

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

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 data sheets under the chapter heading “Mechanical data”.

The hot-spot temperature is important for mounting because the connections to the chip resistors will reach a temperature close to the hot-spot temperature. Heat conducted by the connections must not reach the melting point of the solder at the joints. Therefore a maximum solder joint temperature of 110 °C is advised.

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

Figures 2, 3 and 4 show the different soldering methods which may be employed when mounting chip resistors.

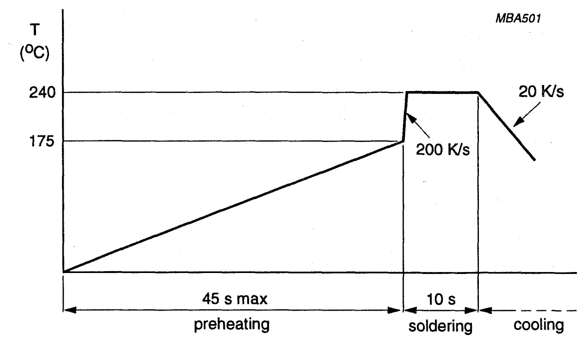

Fig.2 Infrared soldering.

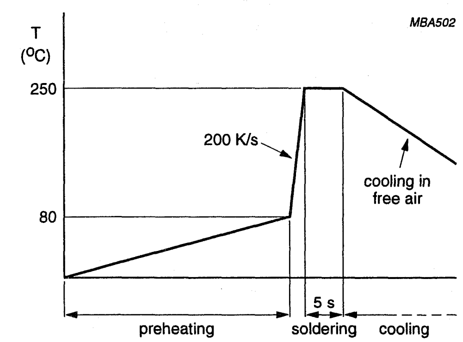

Fig.3 Wave soldering. The resistors may be soldered twice according to this method if necessary.

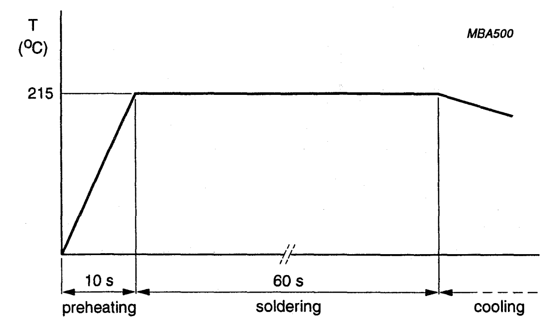

Fig.4 Vapour phase soldering.

Example of mounting effects

Assume that the maximum temperature of a PCB is 95 °C and the ambient temperature is 50 °C. In this case the maximum temperature rise that may be allowed is 45 °C. In the graph (see Fig.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 × 50 mm² (point D), is found on the horizontal axis.

Marking

Wherever possible chip resistors are provided with a **resistance code** (see Table 1). The resistance code includes the first two or three significant digits 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: ±5% requires two digits; ±2% tolerance may be marked with two or three digits; ±2% tolerance may be marked with two or three digits; ±1% and lower requires three digits.

Table 1 Resistance value indication.

INDICATOR	≥ ±2% TOLERANCE	≤ ±1% TOLERANCE
0	0.0 Ω; jumper	
R(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.

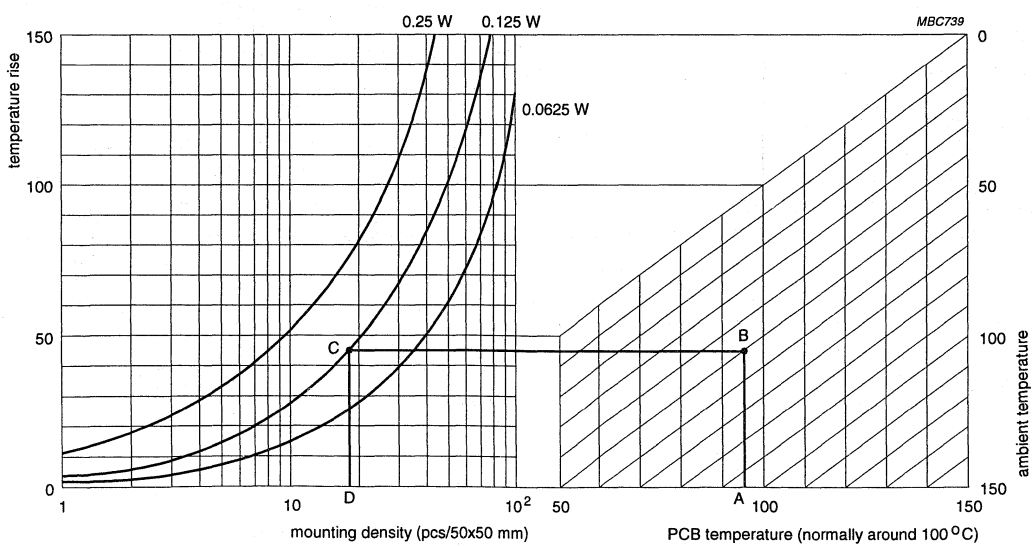

Fig.5 PCB temperature as a function of applied power, mounting density and ambient temperature.

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 115-8"*.

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

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

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

where:

T_m = hot-spot temperature

T_{amb} = ambient temperature

ΔT = temperature rise at hot-spot.

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

Summarizing.

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

Frequency behaviour

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

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

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

Typical values of capacitance and inductance.

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

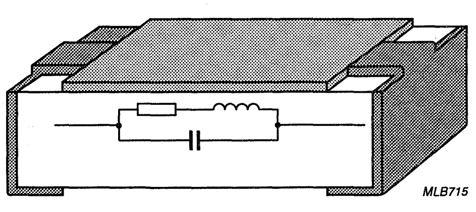

Fig.6 Equivalent circuit.

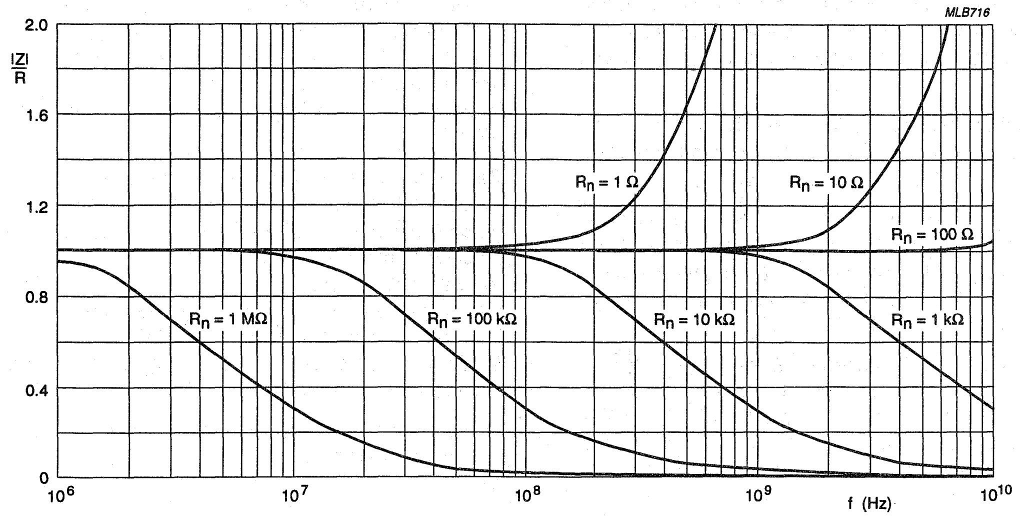

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Fig.7 Impedance as a function of frequency for a chip resistor.

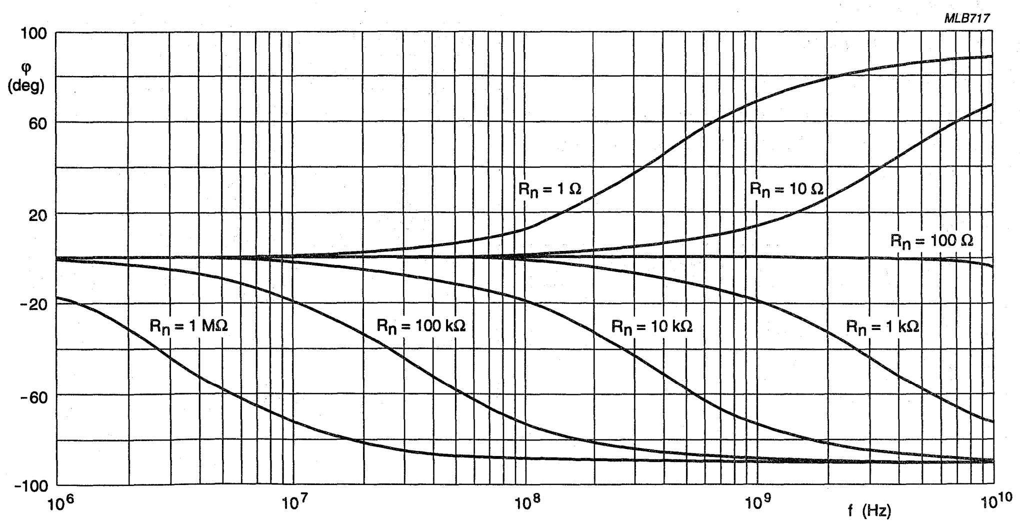

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Fig.8 Phase shift as a function of frequency for a chip resistor.

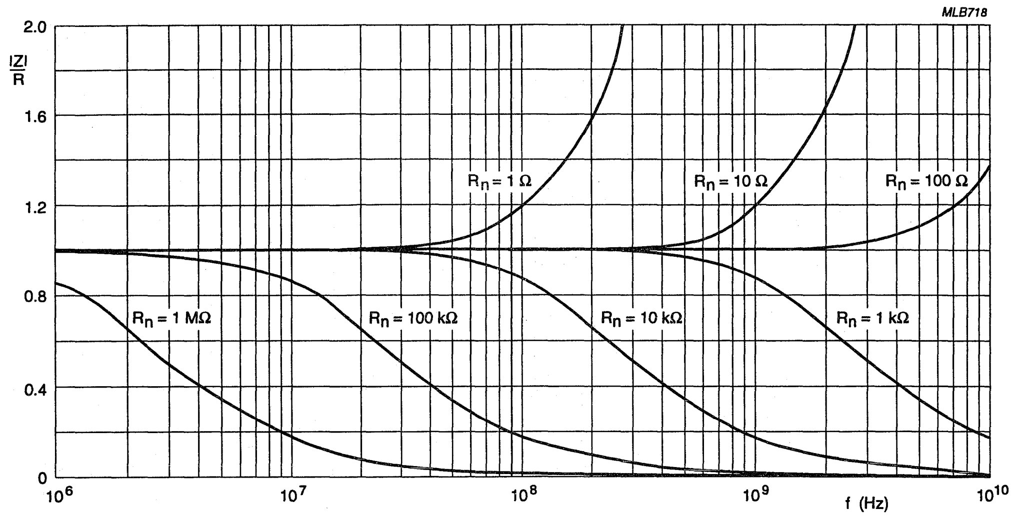

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Fig.9 Impedance as a function of frequency for a chip resistor.

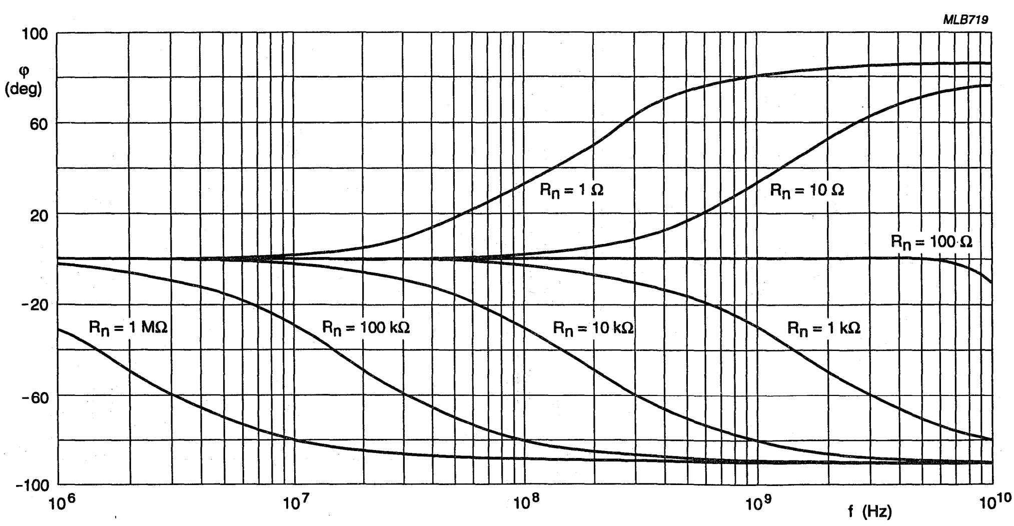

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Fig.10 Phase shift as a function of frequency for a chip resistor.

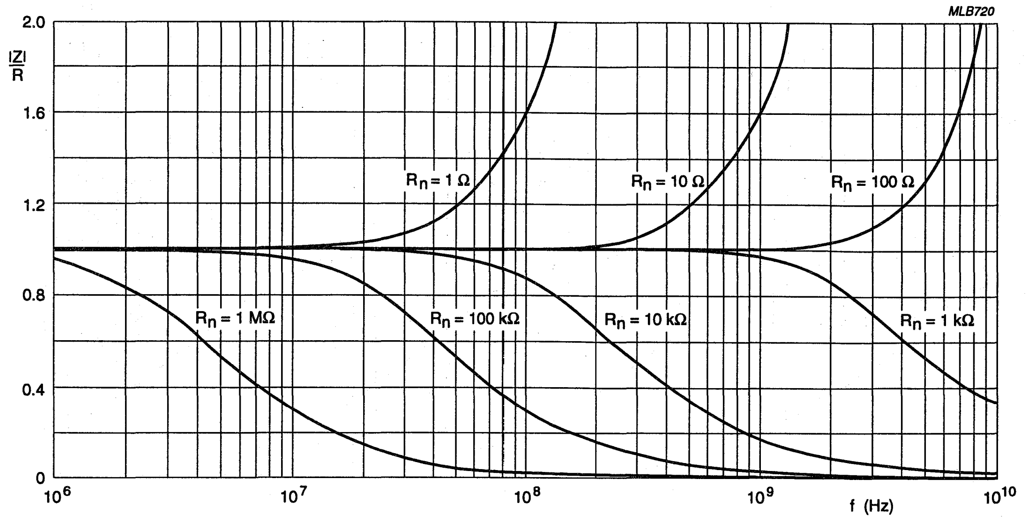

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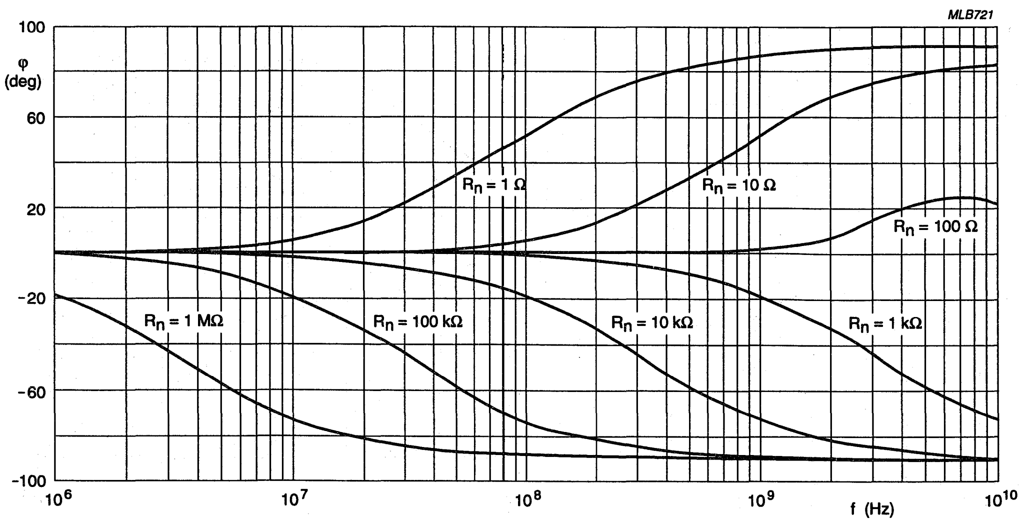
Fig.11 Impedance as a function of frequency for a chip resistor.



Size 1206.

Fig.12 Phase shift as a function of frequency for a chip resistor.

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,

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

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

The temperature coefficient

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

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

at 25 °C:

1000 Ω (nominal = rated value)

at +155 °C:

1000 Ω ±(130 × 200 × 10^{-6}) × 1000 Ω
= 1026 Ω or 974 Ω

at −55 °C:

1000 Ω ±(80 × 200 × 10^{-6}) × 1000 Ω
= 1016 Ω or 984 Ω

If the temperature coefficient is specified as ≤200 × 10^{-6}/K the resistance will be within the shaded area as shown in Fig.13.

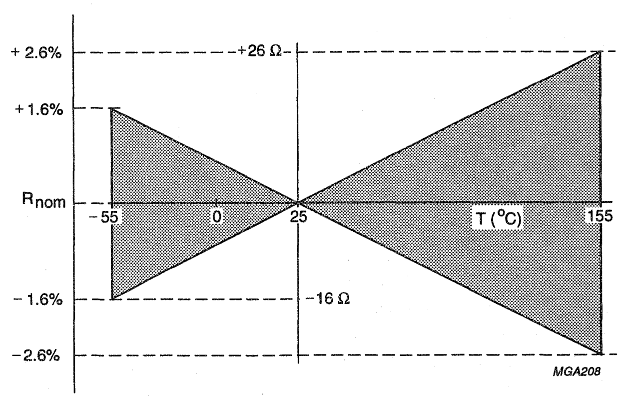


Fig.13 Temperature coefficient

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.14.

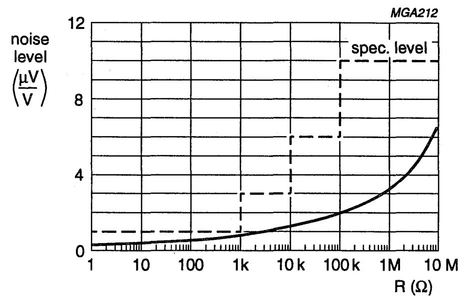


Fig.14 Typical noise levels as a function of rated resistance for the RC02.

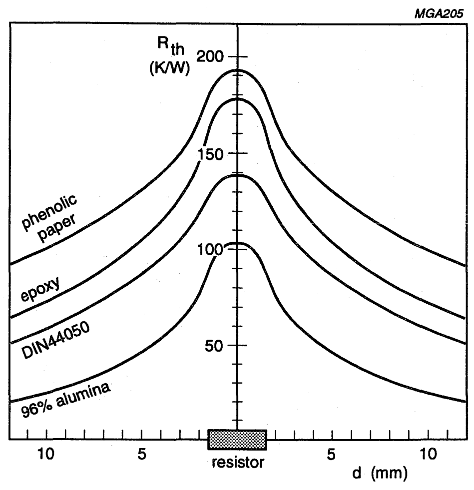


Fig.15 Heat resistance as a function of distance and material.

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 PCBs have different heat conductance. Figure 15 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 shown in Table 2.

Table 2 Pulse load limits.

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

With this test, it can be determined at which applied voltage the resistive value changes about 0.5% of its nominal value under the above mentioned pulse conditions. Figure 16 shows test results for the RC02 chip resistors. If applied regularly the load is destructive, therefore the load must not be applied regularly during the load life of the resistors. However, the magnitude of a pulse at which failure occurs is of little practical value. The maximum ‘single-pulse’ load that may be applied in a regular way can be determined in a similar manner.

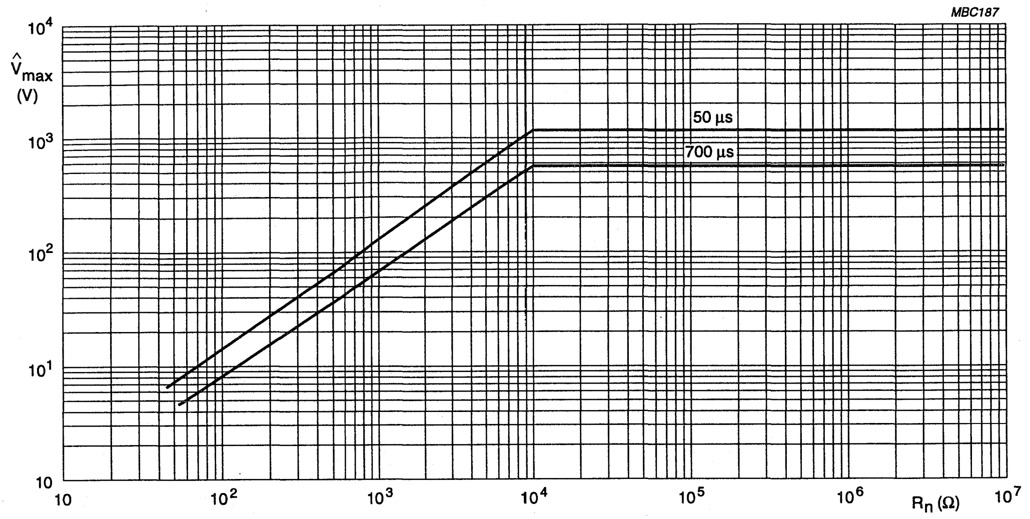


Fig.16 Normstoß (German standard); maximum permissible peak pulse voltage ($\hat{V}_{max}$) without failing to 'open circuit' for RC02.

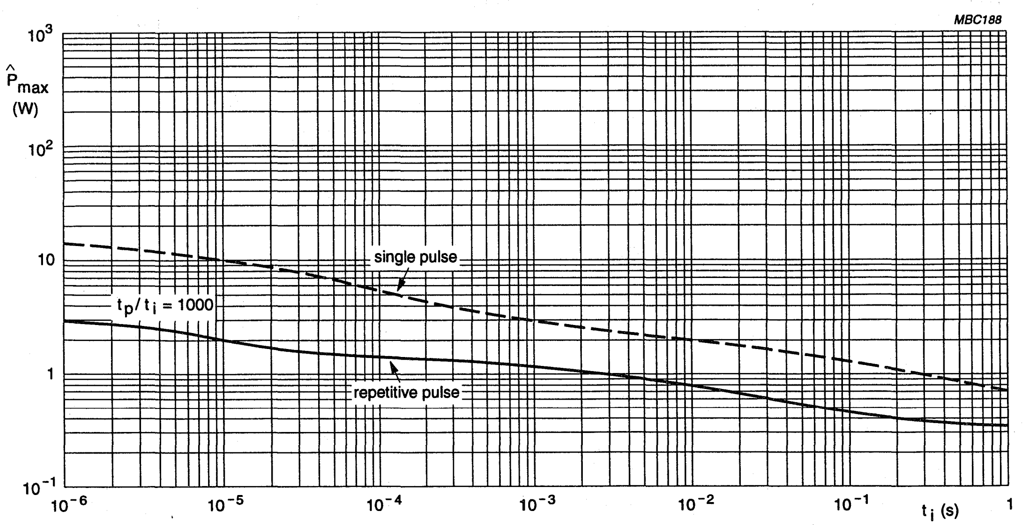


Fig.17 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration for R ≤10 kΩ, single pulse and repetitive pulse (t_p/t_i) = 1000.

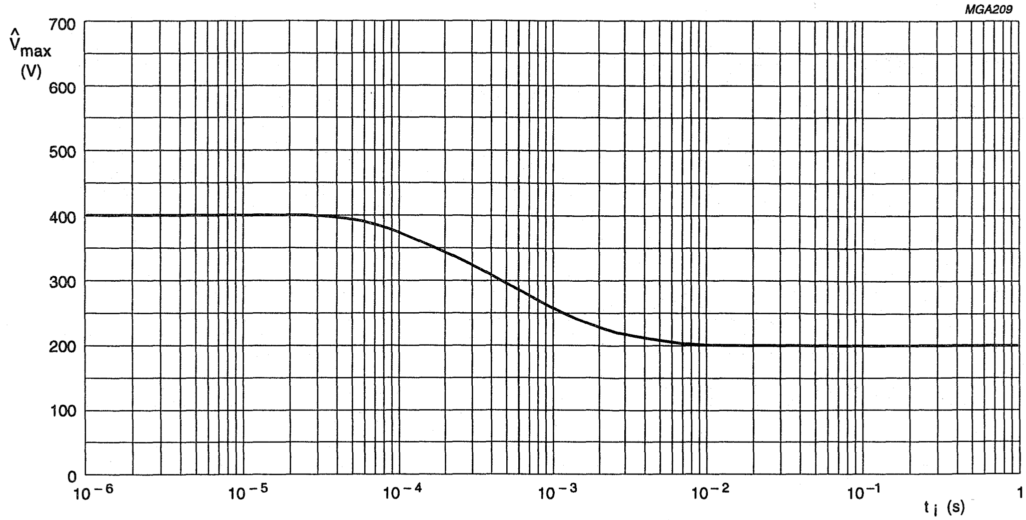


Fig.18 Pulses on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_i) for a typical RC02 resistor.

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 (approximately 1500) of pulses over long time intervals (greater than one hour).

REPETITIVE PULSE

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

The dashed line in Fig.17 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.18, should not be exceeded.

Determination of pulse-load

The graphs in Figs 17 and 18 may be used to determine the maximum pulse-load for a resistor.

- For repetitive rectangular pulses:
  - $\frac{\hat{V}_i^2}{R}$ must be lower than the value of $\hat{P}_{max}$ given by the solid lines of Fig.17 for the applicable value of t_i and duty cycle t_p/t_i.
  - $\hat{V}_i$ must be lower than the value of $\hat{V}_{max}$ given in Fig.18 for the applicable value of t_i.
- For repetitive exponential pulses:
  - As for rectangular pulses, except that $t_i = 0.5\ \tau$.
- For single rectangular pulses:
  - $\frac{\hat{V}_i^2}{R}$ must be lower than the $\hat{P}_{max}$ given by the dashed line of Fig.17 for the applicable value of t_i.
  - $\hat{V}_i$ must be lower than the value of $\hat{V}_{max}$ given in Fig.18 for the applicable value of t_i.

Definition of symbols used in Figs 17, 18, 19 and 20.

SYMBOL	DESCRIPTION
$\hat{P}$	applied peak pulse power
$\hat{P}_{max}$	maximum permissible peak pulse power (Fig.17)
$\hat{V}_i$	applied peak pulse voltage (Figs 19 and 20)
$\hat{V}_{max}$	maximum permissible peak pulse voltage (Fig.18)
R_{nom}	nominal resistance value
t_i	pulse duration (rectangular pulses)
t_p	pulse repetition time
τ	time constant (exponential pulses)
T_{amb}	ambient temperature
$T_{m(max)}$	maximum hot-spot temperature of the resistor

Examples

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

CONTINUOUS PULSE TRAIN

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

Therefore:

$$\hat{P} = \frac{40^2}{100} = 1 \text{ W and } \frac{t_p}{t_i} = \frac{10^{-2}}{10^{-5}} = 1000$$

For $t_i = 10^{-5}$ s and $\frac{t_p}{t_i} = 1000$, Fig.17 gives $\hat{P}_{max} = 2$ W and Fig.18 gives $\hat{V}_{max} = 400$ V. As the operating conditions $\hat{P} = 1$ W and $\hat{V}_i = 10$ V are lower than these limiting values, this resistor may be safely used.

SINGLE PULSE

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

Therefore:

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

The dashed curve of Fig.17 shows that at $t_i = 10^{-5}$ s, the permissible $\hat{P}_{max} = 10$ W and Fig.18 shows a permissible $\hat{V}_{max}$ of 400 V, so this resistor may be used.

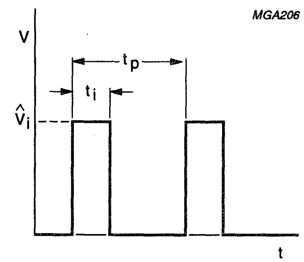


Fig.19 Rectangular pulses.

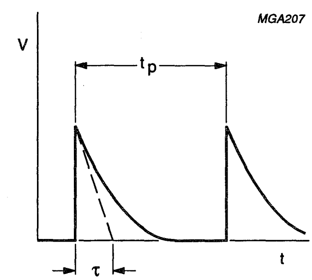


Fig.20 Exponential pulses.

TESTS AND PROCEDURES

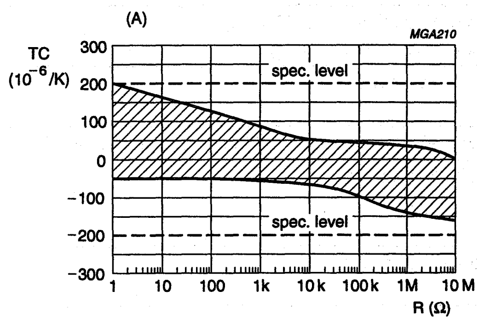
To guarantee zero defect production standards, Statistical Process Control is an essential part of our production processes. Furthermore, our production process is operating in accordance with ISO 9000.

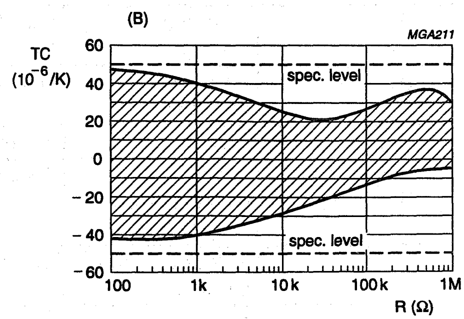
Essentially all tests on resistors are carried out in accordance with the schedule of *"IEC publication 115-1"* in the specified climatic category and in accordance with IEC publication 68, *"Recommended basic climatic and mechanical robustness testing procedure for electronic components"*. In some instances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

Table 3

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE
4.17	20 (Ta)	soldering	unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C; flux 600
		solderability	16 hours steam or 16 hours at 155 °C; unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C; flux 600
4.18	20 (Tb)	resistance to soldering heat	10 s; 260 ±5 °C; flux 600
4.19	14 (Na)	rapid change of temperature	30 minutes at −55 °C and 30 minutes at upper category temperature; 5 cycles
4.22	6 (Fc)	vibration	frequency: 10 to 500 Hz; displacement 1.5 mm or acceleration 10 g; three directions; total 6 hours
4.20	29 (Eb)	bump	3 × 1500 bumps in three directions; 40 g
4.33		bending	resistors mounted on a glass epoxy resin PCB; bending 5 mm over 90 mm
4.24		humidity load (JIS)	1000 hours; +40 °C; 90 to 95% RH; loaded with P_n or 150 V; max 1.5 hours on and 0.5 hours off
4.23		climatic sequence:	
4.23.2	2 (Ba)	dry heat	16 hours; 125 °C
4.23.3	30 (D)	damp heat (accelerated) 1st cycle	24 hours; 55 °C; 95 to 100% RH
4.23.4	1 (Aa)	cold	2 hours; −55 °C
4.23.5	13 (M)	low air pressure	1 hour; 8.5 kPa; 15 to 35 °C
4.23.6	30 (D)	damp heat (accelerated) remaining cycles	5 days; 55 °C; 95 to 100% RH
4.24.2	3 (Ca)	damp heat (steady state) (IEC)	56 days; 40 °C; 90 to 95% RH; loaded with 0.01 P_n (IEC steps: 0 to 100 V); dissipation ≤1 mW
4.25.1		endurance	1000 hours; 70 °C; nominal dissipation

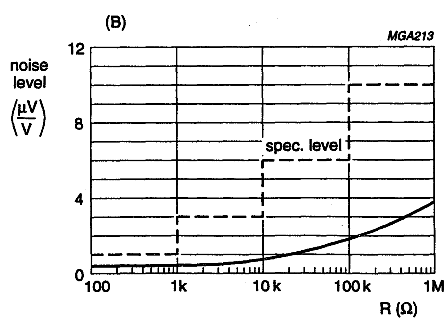
IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE
4.6.1.1		insulation resistance	100 V (DC) after 1 minute
4.13		short time overload	room temperature; dissipation 6.25 × P_n; 5 s (voltage not more than 2 × V_{max})
4.8.4.2		temperature coefficient	between –55 °C and +125 °C
4.12		noise	IEC publication 195 (measured with Quantech - equipment)
4.23.2	27 (Ba)	endurance at upper category temperature	1000 hours; 125 °C; no load
4.7		voltage proof on insulation	V_{max} (RMS) during 1 minute





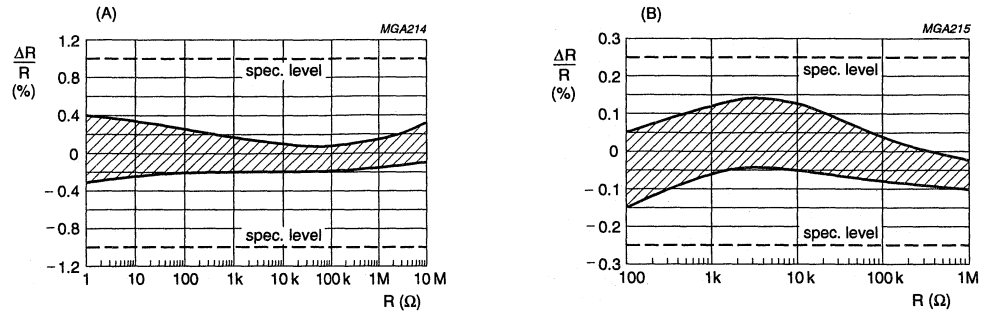
(A) RC-01.
(B) RC-02G.

Fig.21 Typical temperature coefficients between the lower and upper category temperatures.



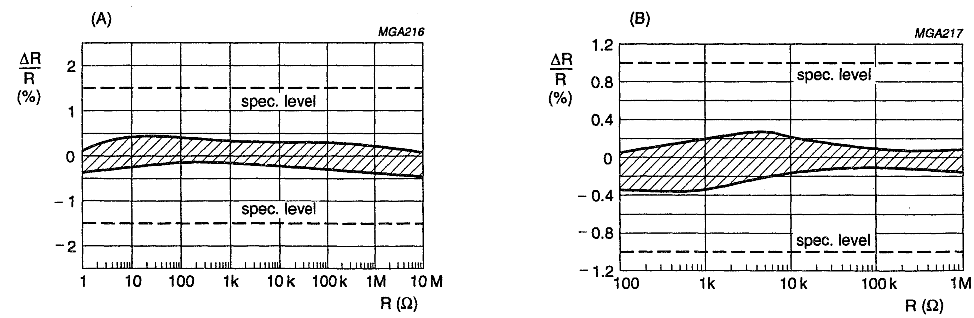
(B) RC-02G.

Fig.22 Typical noise level as a function of rated resistance measured using Quantech - equipment.



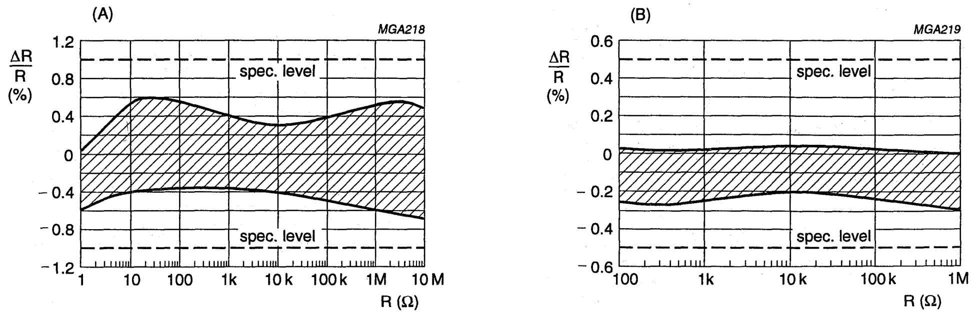
(A) RC-01.
(B) RC-02G.

Fig.23 Typical percentage change in resistance after soldering for 10 seconds at 260 °C, completely immersed.



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

Fig.24 Typical percentage change in resistance after 56 days at 40 °C and 90 to 95% relative humidity loaded with P_{nom}.



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

Fig.25 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**, a 12-digit number. In general, the packaging method and the resistance code are an integral part of this number. Exceptions to this rule are customer/application specific resistors that are not included in our standard series, such as higher ohmic values and non-standard values.

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 26, 27 and 28.

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 trailer end of the tape is at least 160 mm in length.

Peel-off force

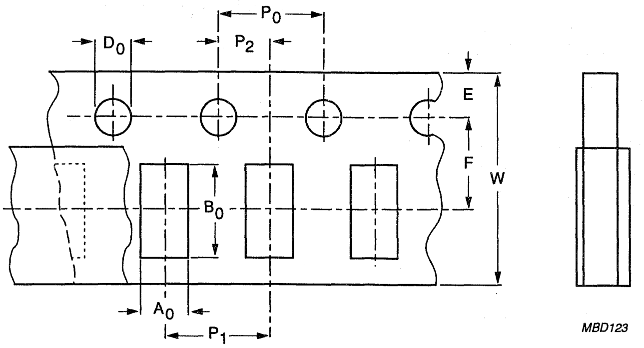
Peel-off forces of both cardboard and blister tapes are in accordance with *"IEC 286-3"*; that is, 0.1 N to 0.7 N at a peel-off speed of 120 mm/minute, and 0.2 N to 1.0 N at a peel-off speed of 300 mm/minute. For both methods, the peel-off angle should be between 165° and 180°.

ENVIRONMENTAL ISSUES

Philips reels are made of polystyrene which is suitable for recycling.

Tape material is polycarbonate blister or cardboard, which are both suitable for recycling.

PACKAGING

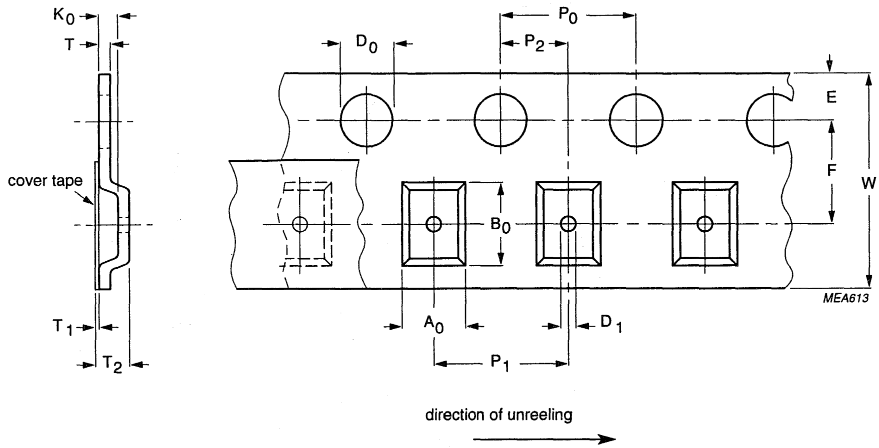


Dimensions in mm.
Cumulative tolerance over 10 holes: ±0.2 mm.
Bottom fixing tape thickness: 50 ±10 μm.
Top fixing tape thickness: 50 ±10 μm.
Carrier tape thickness:
0.75 ±0.05 mm (1206; 0805)
0.6 ±0.05 mm (0603).

Fig.26 Cardboard tape.

Table 4 Dimensions of cardboard tape, see Fig.26.

DIMENSION	TOLERANCE (mm)	CHIP SIZE (mm)		
		CODE 1206	CODE 0805	CODE 0603
A_0	+0.2/–0	1.85	1.5	1.0
B_0	+0.2/–0	3.45	2.25	1.8
W	±0.3	8	8	8
E	±0.1	1.75	1.75	1.75
F	±0.05	3.5	3.5	3.5
D_0	+0.1/–0	1.5	1.5	1.5
P_0	±0.1	4	4	4
P_1	±0.1	4	4	4
P_2	±0.05	2	2	2

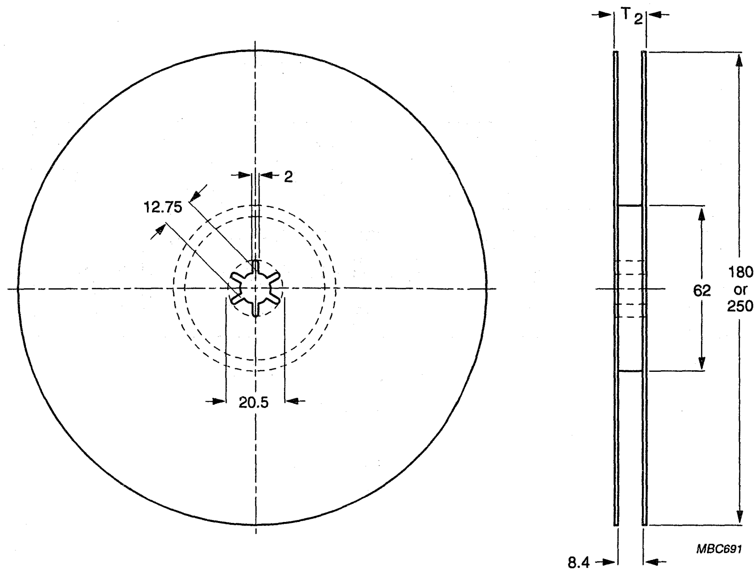


Dimensions in mm.
Cumulative pitch error: 0.2 mm over 10 pitches.
Cumulative tolerance over 10 holes: ±0.2 mm.

Fig.27 Blister tape.

Table 5 Dimensions of blister tape, see Fig.27.

DIMENSION	TOLERANCE (mm)	CHIP SIZE (mm)		
		CODE 1218	CODE 1206	CODE 0805
A_0	±0.1	3.6	1.85	1.55
B_0	±0.1	4.9	3.55	2.3
W	±0.3	12	8	8
E	±0.1	1.75	1.75	1.75
F	±0.05	3.5	3.5	3.5
D_0	±0.1/–0	1.5	1.5	1.5
D_1	–	≥1.5	≥1	≥1
P_0	±0.1	4	4	4
P_1	±0.1	8	4	4
P_2	±0.05	2	2	2
T_1	±5 μm	45 μm	45 μm	45 μm
T	–	<0.3	<0.3	<0.3
K_0	±0.05	0.7	0.7	0.7



Dimensions in mm.

Fig.28 Reel dimensions.

STANDARD

Resistor chip size 1206

RC01

FEATURES

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

APPLICATIONS

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

DESCRIPTION

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

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

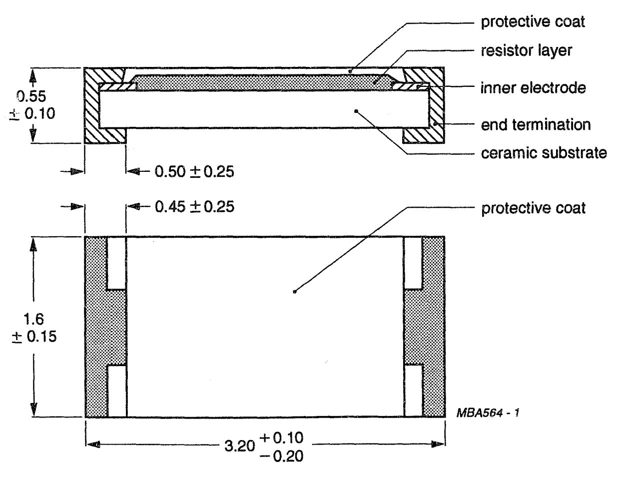
QUICK REFERENCE DATA

DESCRIPTION	VALUE
Resistance range	1 Ω to 10 MΩ and jumper (0 Ω); E24 series
Resistance tolerance	±2%, ±5%
Temperature coefficient	$\leq \pm 200 \times 10^{-6}$/K
Absolute maximum 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; note 1	IEC 115-8
Stability after:	
load, 1000 hours at T_{amb} = 70 °C	ΔR/R max.: ±1% +0.05 Ω
load, 8000 hours at T_{amb} = 70 °C	ΔR/R max.: ±2% +0.10 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% +0.10 Ω

Note

1. CECC approved version available on request. Approval no. 40401-002.

MECHANICAL DATA



Dimensions in mm.

Fig.1 Outlines.

Mass

1.00 g (per 100 units).

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 (PCBs). Electrical connection to the circuit is by wave, vapour phase or infrared soldering. The end terminations guarantee a reliable contact and the protective coating enables 'face down' mounting.

The 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 PCB and other discrete components on the reverse (mixed PCBs).

Soldering conditions

Surface Mounted Resistors RC01 are tested for solderability at 235 °C during 2 seconds. The test condition for no leaching is 260 °C for 60 seconds. Typical examples of soldering processes that provide reliable joints without any damage, are given in Figs 2, 3 and 4.

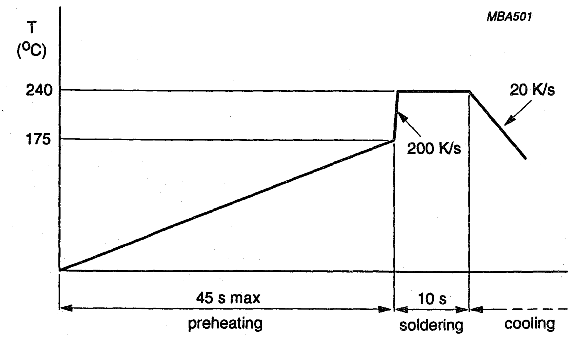


Fig.2 Infrared soldering.

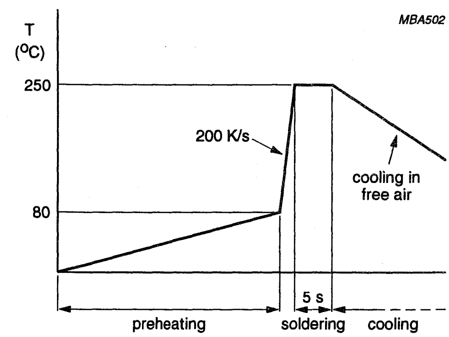


Fig.3 Wave soldering. The resistors may be soldered twice according to this method if necessary.

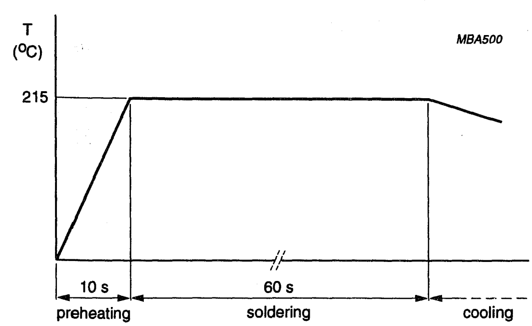


Fig.4 Vapour phase soldering.

Marking

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

3-DIGIT MARKING

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

Example.

MARKING	RESISTANCE
12R	12 Ω
471	470 Ω
823	82 kΩ

4-DIGIT MARKING

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

Example.

MARKING	RESISTANCE
12R0	12 Ω
470R	470 Ω
8202	82 kΩ

The packaging 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 200 V. This is the maximum voltage that may be continuously applied to the resistor element, see *"IEC publication 115-8"*.

Dissipation

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

Pulse load behaviour

The pulse load behaviour is determined in accordance with the method outlined in *"General Introduction"* in Section *"Chip resistors"* of handbook PA08; the results are shown in Figs 6, 7 and 8.

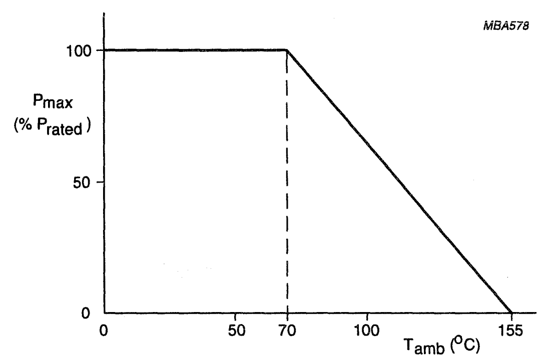


Fig.5 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

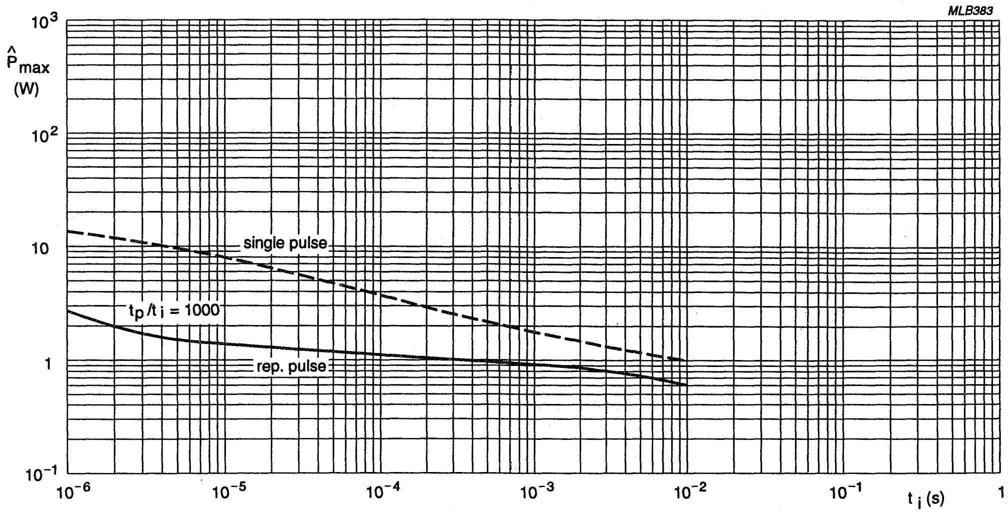


Fig.6 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration for R ≤ 10 kΩ, single pulse and repetitive pulse $t_p/t_i = 1000$.

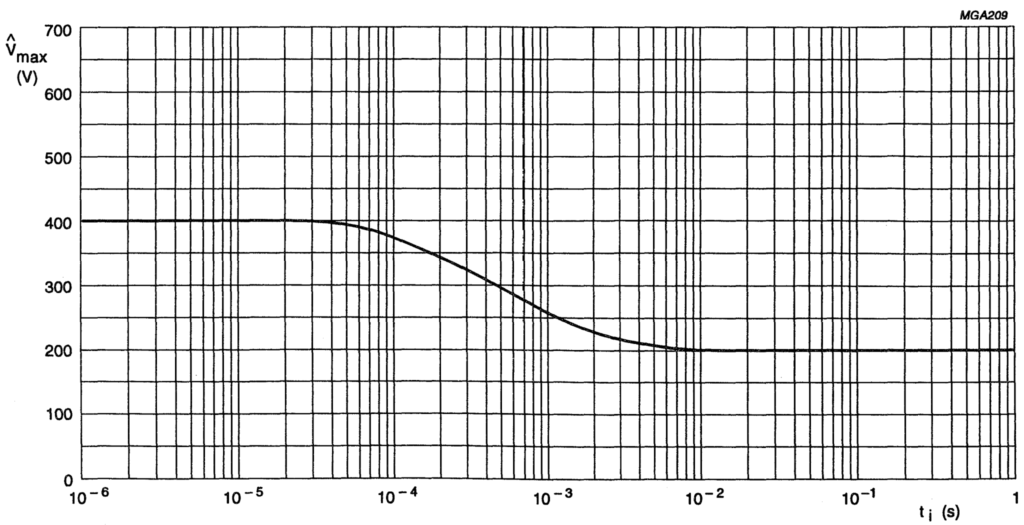
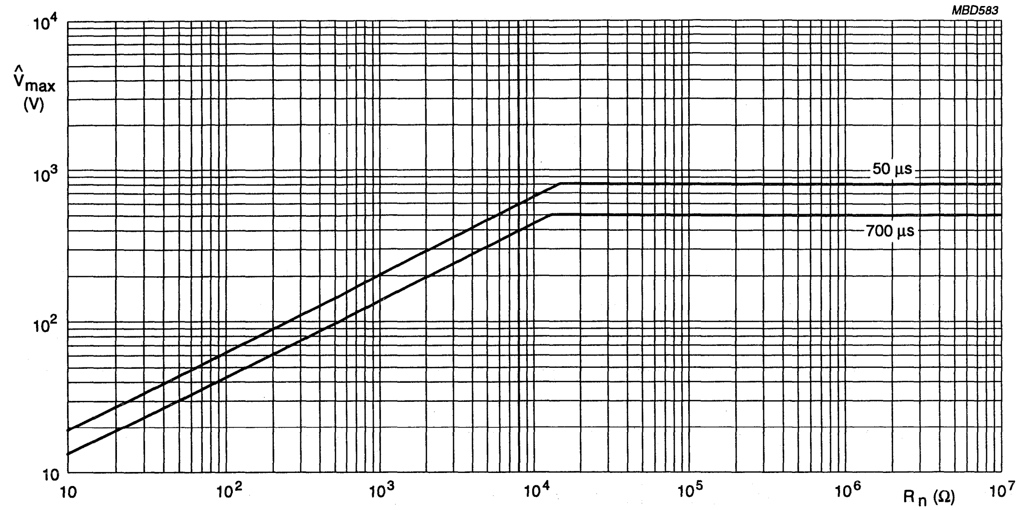


Fig.7 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration.



These pulses may not be applied on a regular basis.

Fig.8 Normstoß (German standard); maximum permissible peak pulse voltage ($\hat{V}_{max}$) without failing to 'open circuit' for RC01.

COMPOSITION OF THE CATALOGUE NUMBER

The resistors have a 12-digit catalogue number starting with 2322. The subsequent 8 digits indicate the packaging and resistance value (see Tables 1 and 2).

Table 1 First 5 digits to indicate packaging for resistances as listed.

RESISTANCE RANGE	TOLERANCE (%)	SERIES	CATALOGUE NUMBER 2322			
			CARDBOARD TAPE ON REEL 711		BLISTER TAPE ON REEL 712	
			5000 units	10000 units	5000 units	10000 units
1 Ω to 10 MΩ	±5	E24	61...	51...	61...	71...
1 Ω to 10 MΩ	±2	–	41...	71...	83...	23...
jumper 0 Ω; note 1	–	–	91032	91005	91024	91004

Note

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

To complete the catalogue number (see Table 1), replace the first two dots of the remaining 3-digit code by the first two digits of the resistance value. Replace the third dot (last digit) by a figure according to Table 2.

Table 2 Last digit of 12 NC.

RESISTANCE	LAST DIGIT
1 to 9.1 Ω	8
10 to 91 Ω	9
100 to 910 Ω	1
1 to 9.1 kΩ	2
10 to 91 kΩ	3
100 to 910 kΩ	4
1 to 9.1 MΩ	5
10 MΩ	6

Ordering example

The catalogue number of a RC01 resistor, value 3300 Ω, supplied on cardboard tape of 5000 units per reel is: 2322 711 61332.

Resistor chip size 1206

RC01

TESTS AND REQUIREMENTS

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

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

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

Air pressure: 86 kPa to 106 kPa (860 mbar to 1 060 mbar).

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

Table 3

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.17	20 (Ta)	soldering	unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C; flux 600	good tinning; no damage
4.18	20 (Tb)	resistance to soldering heat	10 s; 260 ±5 °C; flux 600	ΔR/R max.: ±1% +0.05 Ω
		leaching	unmounted chips 60 s ; 260 ±5 °C	good tinning; no leaching
4.19	14 (Na)	rapid change of temperature	30 minutes at –55 °C and 30 minutes at +155 °C; 5 cycles	ΔR/R max.: ±1.5% +0.05 Ω
4.22	6 (Fc)	vibration	frequency: 10 to 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	29 (Eb)	bump	3 × 1500 bumps in three directions; 40 g	no damage ΔR/R max.: ±0.5% +0.05 Ω
4.23		climatic sequence:		
4.23.2	2 (Ba)	dry heat	16 hours; 155 °C	
4.23.3	30 (D)	damp heat (accelerated) 1st cycle	24 hours; 55 °C; 95 to 100% RH	
4.23.4	1 (Aa)	cold	2 hours; –55 °C	
4.23.5	13 (M)	low air pressure	1 hour; 8.5 kPa; 15 to 35 °C	
4.23.6	30 (D)	damp heat (accelerated) remaining cycles	5 days; 55 °C; 95 to 100% RH	R_{ins} min.: 1000 MΩ ΔR/R max.: ±0.10% +0.05 Ω
4.24.2	3 (Ca)	damp heat (steady state) (IEC)	56 days; 40 °C; 90 to 95% RH; loaded with 0.01 P_n (IEC steps: 0 to 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; 1.5 hours on and 0.5 hours off	ΔR/R max.: ±1% +0.05 Ω
4.6.1.1		insulation resistance	100 V (DC) after 1 minute; V-block method	R_{ins} min.: 1000 MΩ

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.13		short time overload	room temperature; dissipation 6.25 × P_n; 5 s (voltage not more than 2 × V_{max})	ΔR/R max.: ±2% +0.1 Ω
4.8.4.2		temperature	between –55 °C and +155 °C	≤ ±200 × 10^{-6}/K
4.12		noise	IEC publication 195 (measured with Quantech - equipment)	R < 1 kΩ: max. 1 μV/V R < 10 kΩ: max. 3 μV/V R < 100 kΩ: max. 6 μV/V R < 1 MΩ: max. 10 μV/V
4.23.2	27 (Ba)	endurance at upper category temperature	1 000 hours; 155 °C; no load	no visual damage ΔR/R max.: ±1% +0.05 Ω
4.7		voltage proof on insulation	200 V (RMS) during 1 minute	no breakdown

Resistor chip size 0805

RC11

FEATURES

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

APPLICATIONS

- Hand held measuring equipment
- Car telephones
- Camcorders
- Portable radio, CD and cassette players.

DESCRIPTION

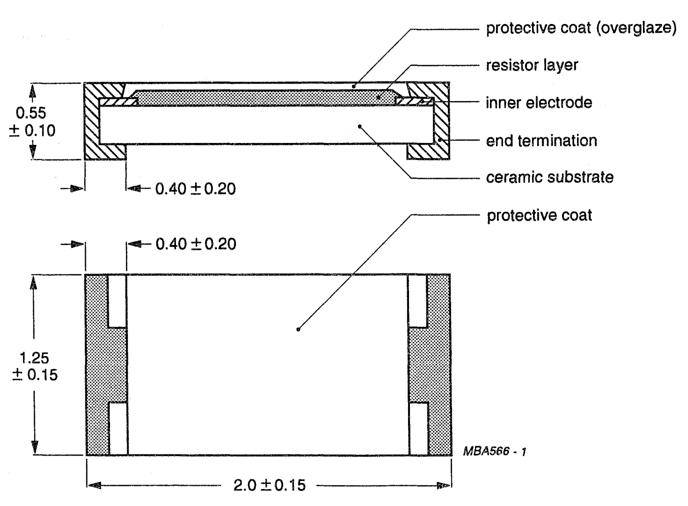
The resistors are constructed on a high grade ceramic body (aluminium oxide). Internal metal electrodes are added at each end and connected by a resistive paste which is applied to the top surface of the substrate. The composition of the paste is adjusted to give the approximate resistance required and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

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

QUICK REFERENCE DATA

DESCRIPTION	VALUE
Resistance range	1 Ω to 10 MΩ and jumper (0 Ω); E24 series
Resistance tolerance	±2%; ±5%
Temperature coefficient	$\leq \pm 200 \times 10^{-6}$/K
Absolute maximum 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 115-8
Stability after:	
load, 1 000 hours at T_{amb} = 70 °C:	
for R ≤ 1 MΩ	ΔR/R max.: ±1.5% +0.05 Ω
for R > 1 MΩ	ΔR/R max.: ±3% +0.10 Ω
climatic tests:	
for R ≤ 1 MΩ	ΔR/R max.: ±1.5% +0.05 Ω
for R > 1 MΩ	ΔR/R max.: ±3% +0.10 Ω
soldering	ΔR/R max.: ±0.5% +0.05 Ω
short time overload, 300 V max.	ΔR/R max.: ±1% +0.05 Ω

MECHANICAL DATA



Dimensions in mm.

Fig.1 Outlines.

Mass

0.55 g (per 100 units).

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 (PCBs). Electrical connection to the circuit is by wave, vapour phase or infrared soldering. The end terminations guarantee a reliable contact and the protective coating enables 'face down' mounting.

The 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 PCB and other discrete components on the reverse (mixed PCBs).

Soldering conditions

Surface Mounted Resistors RC11 are tested for solderability at 235 °C during 2 seconds. The test condition for no leaching is 260 °C for 60 seconds. Typical examples of soldering processes that provide reliable joints without any damage, are given in Figs 2, 3 and 4.

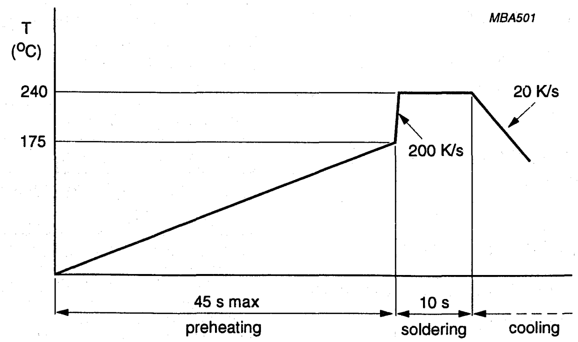


Fig.2 Infrared soldering.

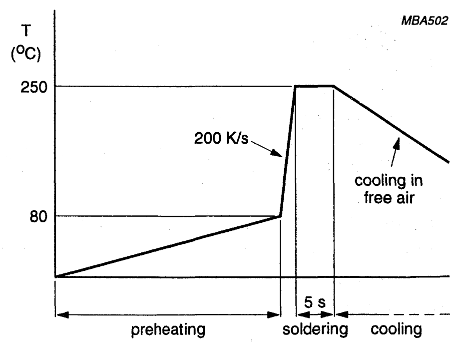


Fig.3 Wave soldering. The resistors may be soldered twice according to this method if necessary.

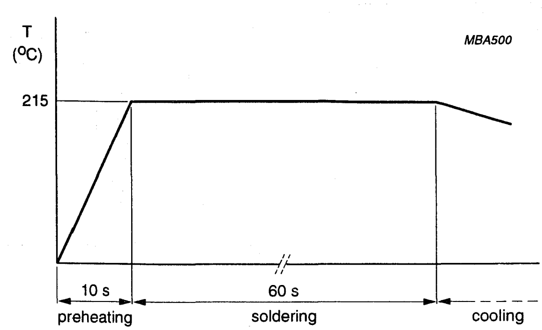


Fig.4 Vapour phase soldering.

Marking

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

3-DIGIT MARKING

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

Example.

MARKING	RESISTANCE
12R	12 Ω
471	470 Ω
823	82 kΩ

4-DIGIT MARKING

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

Example.

MARKING	RESISTANCE
12R0	12 Ω
470R	470 Ω
8202	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) s 150 V. This is the maximum voltage that may be continuously applied to the resistor element, see *"IEC publication 115-8"*.

Dissipation

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

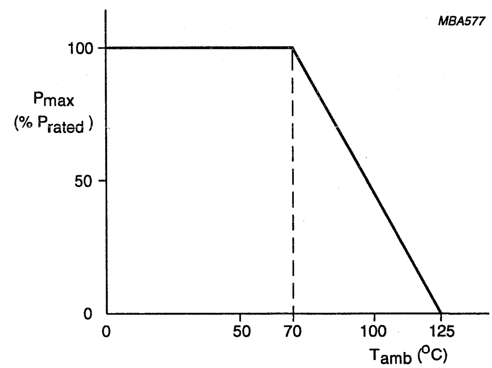


Fig.5 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

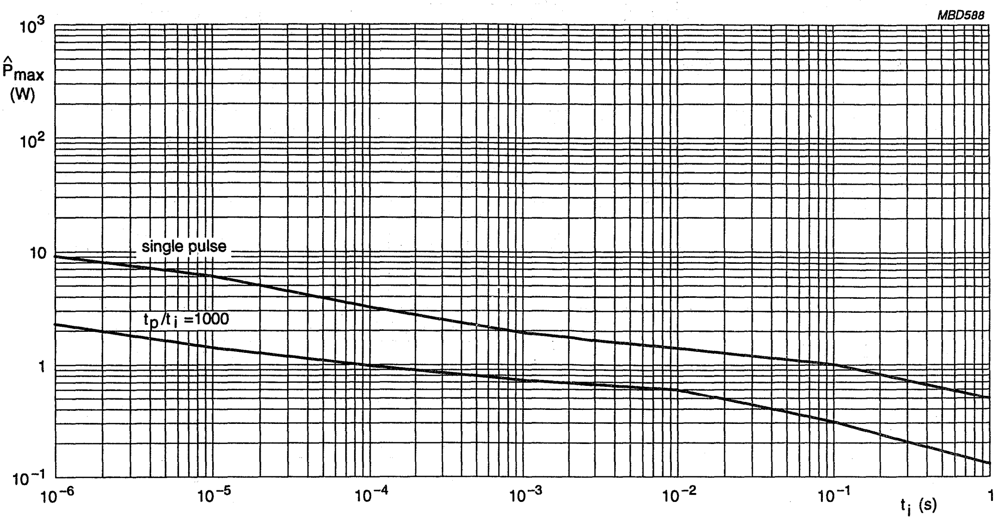


Fig.6 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration for R ≤ 10 kΩ, single pulse and repetitive pulse t_p/t_i = 1000.

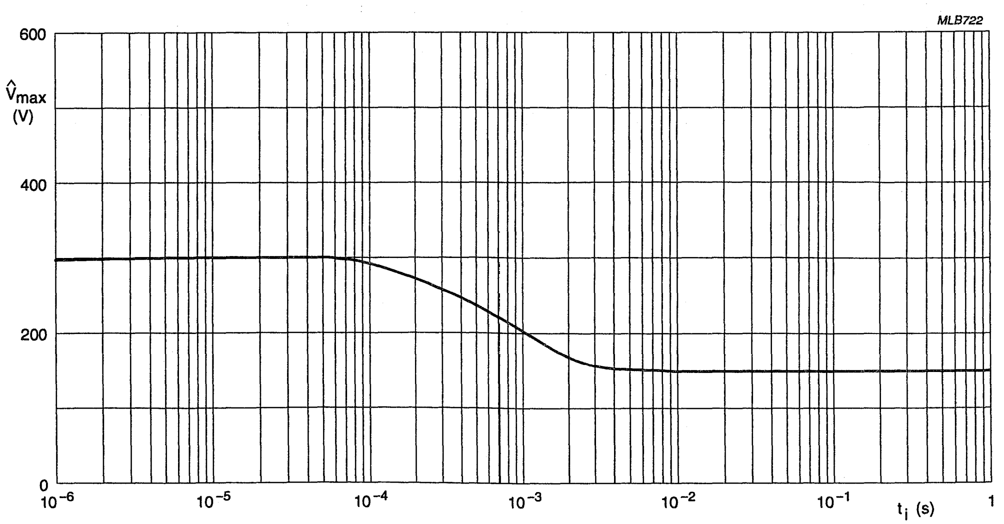
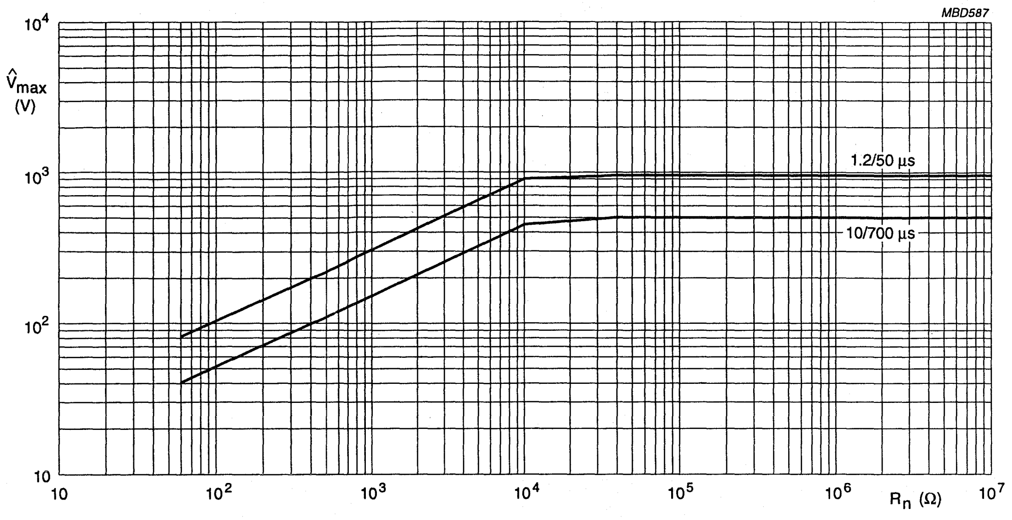


Fig.7 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration.



These pulses may not be applied on a regular basis.

Fig.8 Normstoß (German standard); maximum permissible peak pulse voltage without failing to 'open circuit' for RC11.

Resistor chip size 0805

RC11

COMPOSITION OF THE CATALOGUE NUMBER

The resistors have a 12-digit catalogue number starting with 2322. The subsequent 8 digits indicate the packaging and resistance value (see Tables 1 and 2).

Table 1 First 5 digits to indicate packaging for resistances as listed.

RESISTANCE RANGE	TOLERANCE (%)	SERIES	CATALOGUE NUMBER 2322			
			CARDBOARD TAPE ON REEL 730		BLISTER TAPE ON REEL 731	
			5000 units	10000 units	5000 units	10000 units
1 Ω to 10 MΩ	±5	E24	61...	71...	61...	71...
1 Ω to 10 MΩ	±2	E24	31...	41...	21...	41...
jumper 0 Ω; note 1	–	–	91002	91005	91003	91002

Note

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

To complete the catalogue number (see Table 1), replace the first two dots of the remaining 3-digit code by the first two digits of the resistance value. Replace the third dot (last digit) by a figure according to Table 2.

Table 2 Last digit of 12 NC.

RESISTANCE	LAST DIGIT
1 to 9.1 Ω	8
100 to 976 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

The catalogue number of a RC11 resistor, value 3300 Ω, supplied on cardboard tape of 5000 units per reel is: 2322 730 61332.

TESTS AND REQUIREMENTS

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

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

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

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

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

Table 3

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.17	20 (Ta)	soldering	unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C; flux 600	good tinning; no damage
		solderability	16 hours steam or 16 hours at +155 °C; unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C	good tinning
4.18	20 (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
4.33		bending test	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
		pull strength	30 s; 500 g on terminations	no visual damage ΔR/R max.: ±1% +0.05 Ω
4.19	14 (Na)	rapid change of temperature	30 minutes at –55 °C and 30 minutes at +125 °C; 5 cycles	ΔR/R max.: ±0.5% +0.05 Ω
		temperature cycling (JIS)	30 minutes at –55 °C; 10 minutes at 20 °C; 30 minutes at 125 °C and 10 minutes at 20 °C; 5 cycles	ΔR/R max.: ±0.5% +0.05 Ω
4.22	6 (Fc)	vibration	frequency: 10 to 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	29 (Eb)	bump	3 × 1500 bumps in three directions; 40 g	no damage ΔR/R max.: ±0.5% +0.05 Ω
		humidity load (JIS)	1000 hours at 60 °C; 90 to 95% RH; nominal dissipation	R ≤ 1 MΩ: ΔR/R max.: ±3% +0.1 Ω R > 1 MΩ: ΔR/R max.: ±5% +0.1 Ω

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.23		climatic sequence:		
4.23.2	2 (Ba)	dry heat	16 hours; 125 °C	
4.23.3	30 (D)	damp heat (accelerated) 1st cycle	24 hours; 55 °C; 95 to 100% RH	R_{ins} min.: 1000 MΩ
4.23.4	1 (Aa)	cold	2 hours; –55 °C	
4.23.5	13 (M)	low air pressure	1 hour; 8.5 kPa; 15 to 35 °C	R ≤ 1 MΩ: ΔR/R max.: ±1.5% +0.05 Ω
4.23.6	30 (D)	damp heat (accelerated) remaining cycles	5 days; 55 °C; 95 to 100% RH	R > 1 MΩ: ΔR/R max.: ±3% +0.1 Ω
4.24.2	3 (Ca)	damp heat (steady state) (IEC)	56 days; 40 °C; 90 to 95% RH; loaded with 0.01 P_n (IEC steps: 0 to 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
		damp heat (steady state) (JIS)	56 days; 40 °C; 90 to 95% RH; loaded with P_{nom} or V_{max}; 1.5 hours on and 0.5 hours off	R ≤ 1 MΩ: ΔR/R max.: ±3% +0.1 Ω R > 1 MΩ: ΔR/R max.: ±5% +0.1 Ω
4.25.1		endurance	1000 hours; 70 °C; nominal dissipation; 1.5 hours on and 0.5 hours off	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	R_{ins} min.: 1000 MΩ
4.13		short time overload	room temperature; dissipation 6.25 × P_n; 5 s (voltage not more than 2 × V_{max})	ΔR/R max.: ±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 < 1 kΩ: max. 1 µV/V R < 10 kΩ: max. 3 µV/V R < 100 kΩ: max. 6 µV/V R < 1 MΩ: max. 10 µV/V
4.23.2	27 (Ba)	endurance at upper category temperature	1000 hours; 125 °C; no load	no visual damage
4.7		voltage proof on insulation	150 V (RMS) during 1 minute	no breakdown or flashover

Resistor chip size 0603

RC21

FEATURES

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

APPLICATIONS

- Hand held measuring equipment
- Car telephones
- Camcorders.

DESCRIPTION

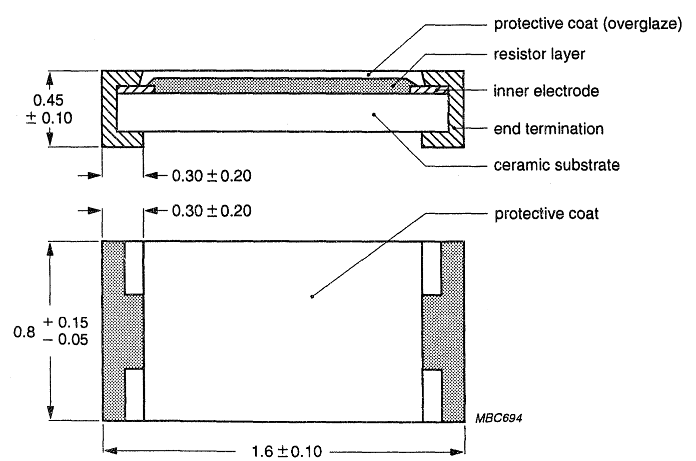
The resistors are constructed on a high grade ceramic body (aluminium oxide). Internal metal electrodes are added at each end and connected by a resistive paste which is applied to the top surface of the substrate. The composition of the paste is adjusted to give the approximate resistance required and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

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

QUICK REFERENCE DATA

DESCRIPTION	VALUE
Resistance range	1 Ω to 6.8 MΩ and jumper (0 Ω); E24 series
Resistance tolerance	±2%; ±5%
Temperature coefficient:	
$R < 10\ \Omega$	$\leq -200 \times 10^{-6}$/K to $+500 \times 10^{-6}$/K
$10\ \Omega \leq R < 1\ M\Omega$	$\leq \pm 200 \times 10^{-6}$/K
$1\ M\Omega \leq R \leq 6.8\ M\Omega$	$\leq \pm 300 \times 10^{-6}$/K
Absolute maximum dissipation at $T_{amb} = 70$ °C	0.063 W
Maximum permissible voltage	50 V (DC or RMS)
Climatic category (IEC 68)	55/125/56
Basic specification	IEC 115-8
Stability after:	
load, 1 000 hours at $T_{amb} = 70$ °C:	
for $10\ \Omega \leq R \leq 1\ M\Omega$	ΔR/R max.: ±3% +0.10 Ω
for $R < 10\ \Omega$; $R > 1\ M\Omega$	ΔR/R max.: ±5% +0.10 Ω
climatic tests: temperature cycling −55 °C to +125 °C	ΔR/R max.: ±1% +0.05 Ω
soldering	ΔR/R max.: ±1% +0.05 Ω
short time overload, 100 V max.	ΔR/R max.: ±1% +0.05 Ω
bending test, min. 5 mm	ΔR/R max.: ±1% +0.05 Ω

MECHANICAL DATA



Dimensions in mm.

Fig.1 Outlines.

Mass

0.21 g (per 100 units).

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 (PCBs). Electrical connection to the circuit is by wave, vapour phase or infrared soldering. The end terminations guarantee a reliable contact and the protective coating enables 'face down' mounting.

The 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 PCB and other discrete components on the reverse (mixed PCBs).

Soldering conditions

Surface Mounted Resistors RC21 are tested for solderability at 235 °C during 2 seconds. The test condition for no leaching is 260 °C for 60 seconds. Typical examples of soldering processes that provide reliable joints without any damage, are given in Figs 2, 3 and 4.

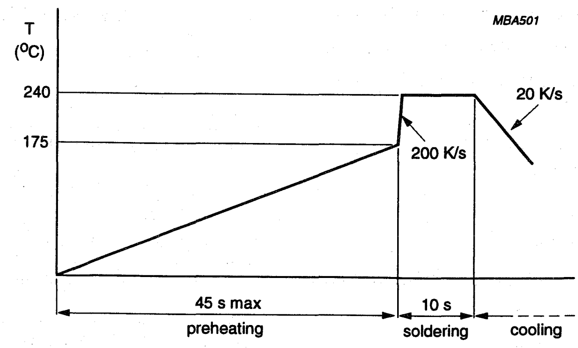


Fig.2 Infrared soldering.

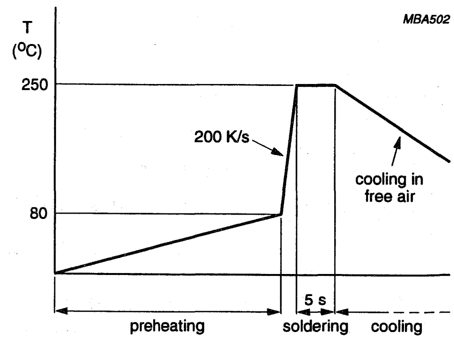


Fig.3 Wave soldering. The resistors may be soldered twice according to this method if necessary.

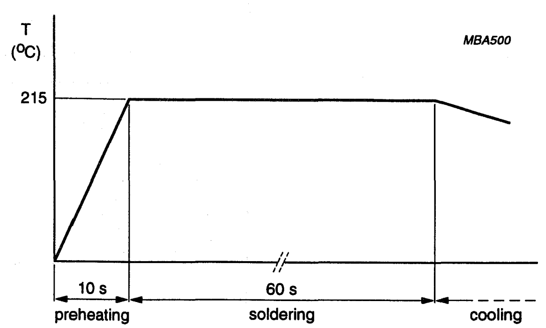


Fig.4 Vapour phase soldering.

Marking

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

3-DIGIT MARKING

For values up to 91 Ω the R is used as a decimal point. For values of 100 Ω or greater the first 2 digits apply to the resistance value and the third is an indication of magnitude.

Magnitude indicators.

RESISTANCE	INDICATOR
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 6.8 MΩ	5

Example.

MARKING	RESISTANCE
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 115-8"*.

Dissipation

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

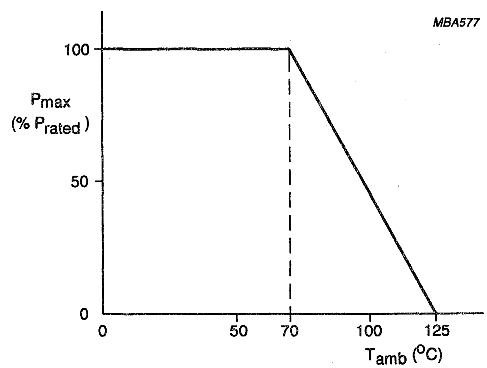


Fig.5 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

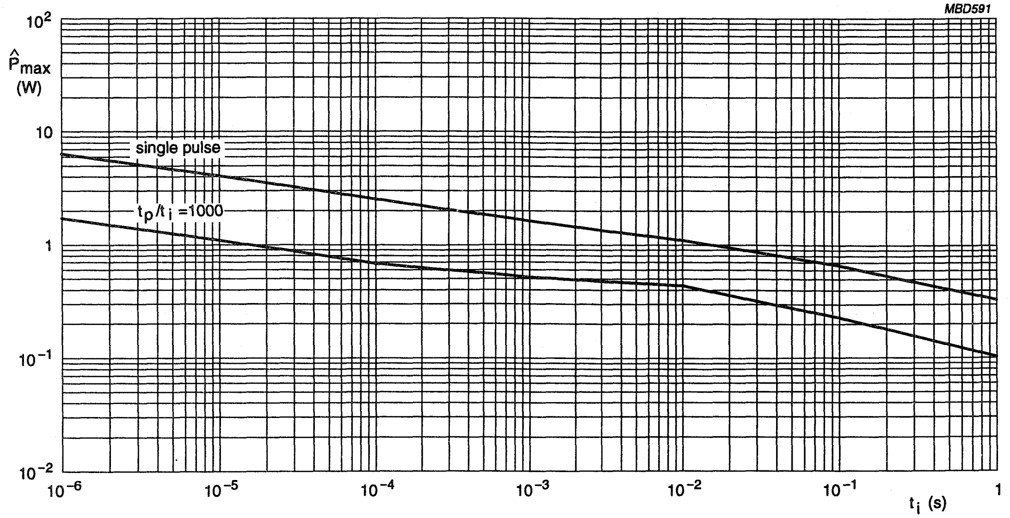


Fig.6 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration for R ≤ 10 kΩ, single pulse and repetitive pulse t_p/t_i = 1000.

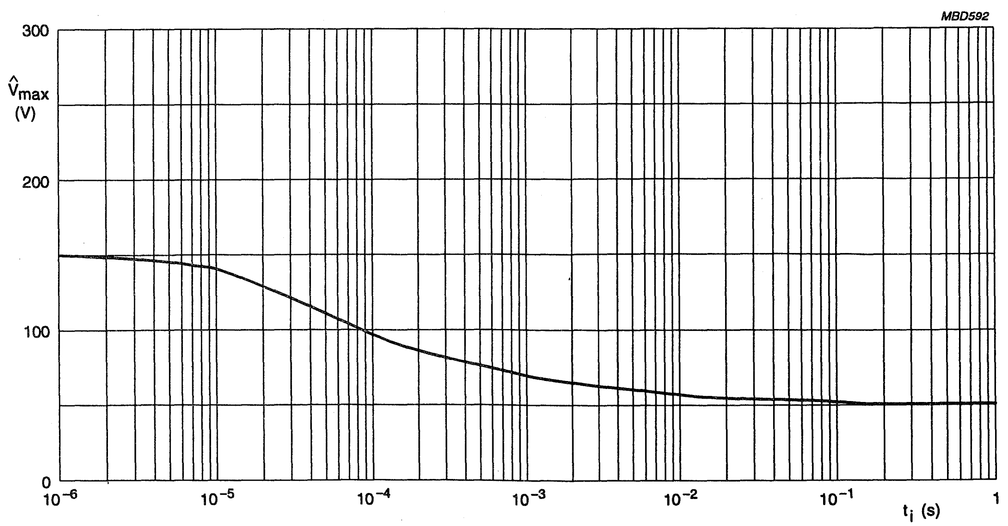
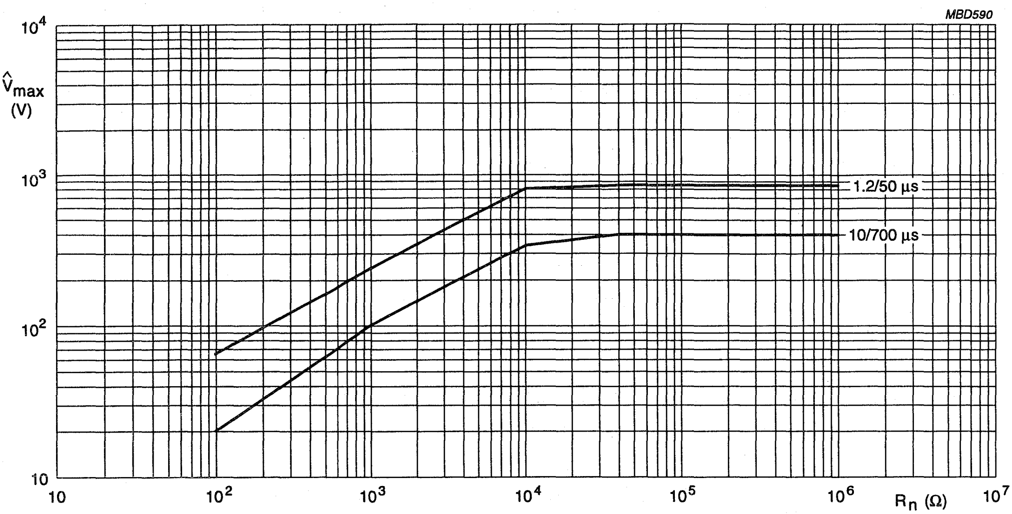


Fig.7 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration.



These pulses may not be applied on a regular basis.

Fig.8 Normstoß (German standard); maximum permissible peak pulse voltage without failing to 'open circuit' for RC21.

COMPOSITION OF THE CATALOGUE NUMBER

The resistors have a 12-digit catalogue number starting with 2322 702. The subsequent 5 digits indicate the packaging and resistance value (see Tables 1 and 2).

Table 1 First 2 digits to indicate packaging for resistances as listed.

RESISTANCE RANGE	TOLERANCE (%)	SERIES	CATALOGUE NUMBER 2322 702 ..... CARDBOARD TAPE ON REEL(2)	
			5000 units	**10000 units**
1 Ω to 6.8 MΩ	±5	E24	60...	70...
1 Ω to 6.8 MΩ	±2	E24	65...	75...
jumper 0 Ω; note 1	–	–	96001	97001

Notes

1. The jumper has a maximum resistance R_{max} = 50 mΩ and a rated current I_R = 1 A.
2. 20000 units on reel with 2 mm pitch, is available on request.

To complete the catalogue number (see Table 1), replace the first two dots of the remaining 3-digit code by the first two digits of the resistance value. Replace the third dot (last digit) by a figure according to Table 2.

Table 2 Last digit of 12 NC.

RESISTANCE	LAST DIGIT
1 to 9.1 Ω	8
10 to 91 Ω	9
100 to 910 Ω	1
1 to 9.1 kΩ	2
10 to 91 kΩ	3
100 to 910 kΩ	4
1 to 6.8 MΩ	5

Ordering example

The catalogue number of a RC21 resistor, value 3300 Ω, supplied on cardboard tape of 5000 units per reel is: 2322 702 60332.

TESTS AND REQUIREMENTS

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

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

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

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

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

Table 3

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.17	20 (Ta)	soldering	unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C; flux 600	good tinning; no damage
4.18	20 (Tb)	resistance to soldering heat	10 s; 260 ±5 °C; flux 600	ΔR/R max.: ±1% +0.05 Ω
		leaching	unmounted chips 60 s; 260 ±5 °C	good tinning; no leaching
4.19	14 (Na)	rapid change of temperature	30 minutes at –55 °C and 30 minutes at +125 °C; 5 cycles	ΔR/R max.: ±1% +0.05 Ω
4.22	6 (Fc)	vibration	frequency: 10 to 500 Hz; displacement 1.5 mm or acceleration 10 g; three directions; total 6 hours	no damage ΔR/R max.: ±1% +0.05 Ω
4.20	29 (Eb)	bump	3 × 1500 bumps in three directions; 40 g	no damage ΔR/R max.: ±1% +0.05 Ω
4.23		climatic sequence:		
4.23.2	2 (Ba)	dry heat	16 hours; 125 °C	
4.23.3	30 (D)	damp heat (accelerated) 1st cycle	24 hours; 55 °C; 95 to 100% RH	R_{ins} min.: 1000 MΩ
4.23.4	1 (Aa)	cold	2 hours; –55 °C	
4.23.5	13 (M)	low air pressure	1 hour; 8.5 kPa; 15 to 35 °C	R ≤ 1 MΩ: ΔR/R max.: ±1% +0.1 Ω
4.23.6	30 (D)	damp heat (accelerated) remaining cycles	5 days; 55 °C; 95 to 100% RH	R > 1 MΩ: ΔR/R max.: ±1% +0.1 Ω
		damp heat (steady state) (JIS)	1000 hours; +40 °C; 90 to 95% RH; nominal dissipation; 1.5 hours on and 0.5 hours off	10 Ω ≤ R ≤ 1 MΩ: ΔR/R max.: ±3% +0.1 Ω R < 10 Ω; R > 1 MΩ: ΔR/R max.: ±5% +0.1 Ω

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.25.1		endurance	1 000 hours; 70 °C; nominal dissipation; 1.5 hours on and 0.5 hours off	10 Ω ≤ R ≤ 1 MΩ: ΔR/R max.: ±3% +0.1 Ω R < 10 Ω; R > 1 MΩ: ΔR/R max.: ±5% +0.1 Ω
4.6.1.1		insulation resistance	10 V (DC) after 1 minute	R_{ins} min.: 1000 MΩ
4.13		short time overload	room temperature; dissipation 6.25 × P_n; 5 s (voltage not more than 2 × V_{max})	ΔR/R max.: ±1% +0.05 Ω
4.8.4.2		temperature	between –55 °C and +155 °C	R < 10 Ω: –200 × 10^{-6}/K to +500 × 10^{-6}/K 10 Ω ≤ R ≤ 1 MΩ: ±200 × 10^{-6}/K R > 1 MΩ: ±300 × 10^{-6}/K
4.12		noise	IEC publication 195 (measured with Quantech - equipment)	R < 1 kΩ: max. 1 µV/V R < 10 kΩ: max. 3 µV/V R < 100 kΩ: max. 6 µV/V R < 1 MΩ: max. 10 µV/V
4.23.2	27 (Ba)	endurance at upper category temperature	1 000 hours; 125 °C; no load	no visual damage ΔR/R max.: ±3% +0.1 Ω
4.7		voltage proof on insulation	50 V (RMS) during 1 minute	no breakdown or flashover

PRECISION

Precision resistor chip size 1206

RC02H

FEATURES

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

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

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

QUICK REFERENCE DATA

DESCRIPTION	VALUE
Resistance range	1 Ω to 10 MΩ; E24/E96 series
Resistance tolerance	±1%
Temperature coefficient:	
$1\ \Omega \leq R \leq 4.99\ \Omega$	$\leq \pm 250 \times 10^{-6}$/K
$5.1\ \Omega \leq R \leq 9.76\ \Omega$	$\leq \pm 200 \times 10^{-6}$/K
$10\ \Omega \leq R \leq 1\ M\Omega$	$\leq \pm 100 \times 10^{-6}$/K
$1.02\ M\Omega \leq R \leq 10\ M\Omega$	$\leq \pm 200 \times 10^{-6}$/K
Absolute maximum dissipation at T_{amb} = 70 °C	0.125 W
Maximum permissible voltage	200 V (DC or RMS)
Operating temperature range	–55 to +125 °C
Climatic category (IEC 68)	55/125/56
Basic specification	EIA 575/IEC 115-8
Stability after:	
load, 1 000 hours at T_{amb} = 70 °C	ΔR/R max.: ±0.5% +0.05 Ω
climatic tests:	
$R < 10\ \Omega$	ΔR/R max.: ±1% +0.05 Ω
$10\ \Omega \leq R \leq 1\ M\Omega$	ΔR/R max.: ±0.5% +0.05 Ω
$R > 1\ M\Omega$	ΔR/R max.: ±1.5% +0.05 Ω
resistance to soldering heat	ΔR/R max.: ±0.25% +0.05 Ω
short time overload:	
$10\ \Omega \leq R \leq 1\ M\Omega$	ΔR/R max.: ±0.25% +0.05 Ω
$R < 10\ \Omega$; $R > 1\ M\Omega$	ΔR/R max.: ±0.5% +0.05 Ω

Precision resistor chip size 1206

RC02H

MECHANICAL DATA

Mass

1.00 g (per 100 units).

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 (PCBs). Electrical connection to the circuit is by wave, vapour phase or infrared soldering. The end terminations guarantee a reliable contact and the protective coating enables 'face down' mounting.

The 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 PCB and other discrete components on the reverse (mixed PCBs).

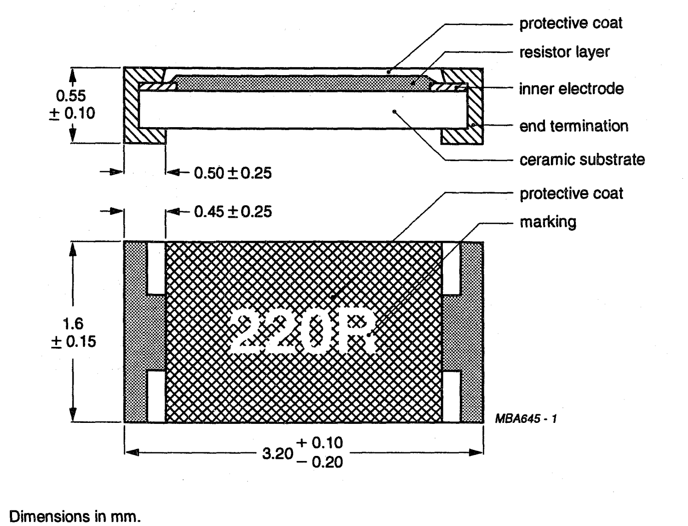


Fig.1 Outlines.

Soldering conditions

Surface Mounted Resistors RC02H are tested for solderability at 235 °C during 2 seconds. The test condition for no leaching is 260 °C for 60 seconds. Typical examples of soldering processes that provide reliable joints without any damage, are given in Figs 2, 3 and 4.

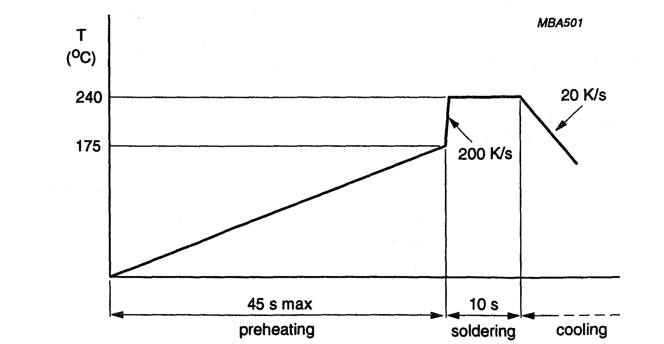


Fig.2 Infrared soldering.

Marking

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

4-DIGIT MARKING

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

Magnitude indicators.

RESISTANCE	INDICATOR
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

Example.

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

The packaging 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 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 publication 115-8"*.

Dissipation

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

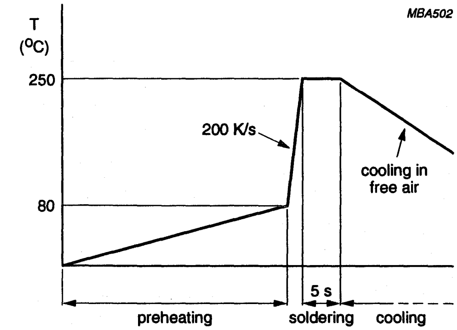


Fig.3 Wave soldering. The resistors may be soldered twice according to this method if necessary.

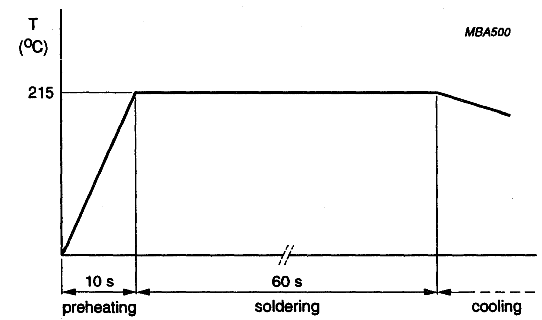


Fig.4 Vapour phase soldering.

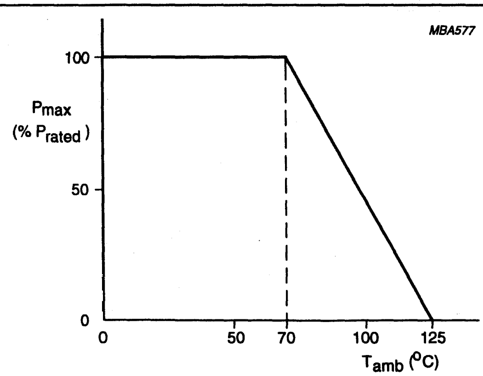


Fig.5 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

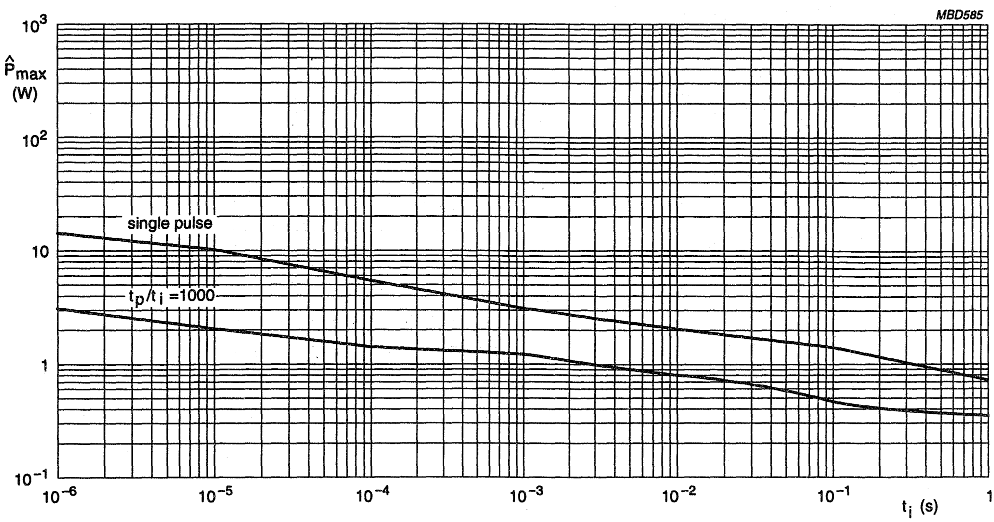


Fig.6 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration for R ≤ 10 kΩ, single pulse and repetitive pulse $t_p/t_i = 1000$.

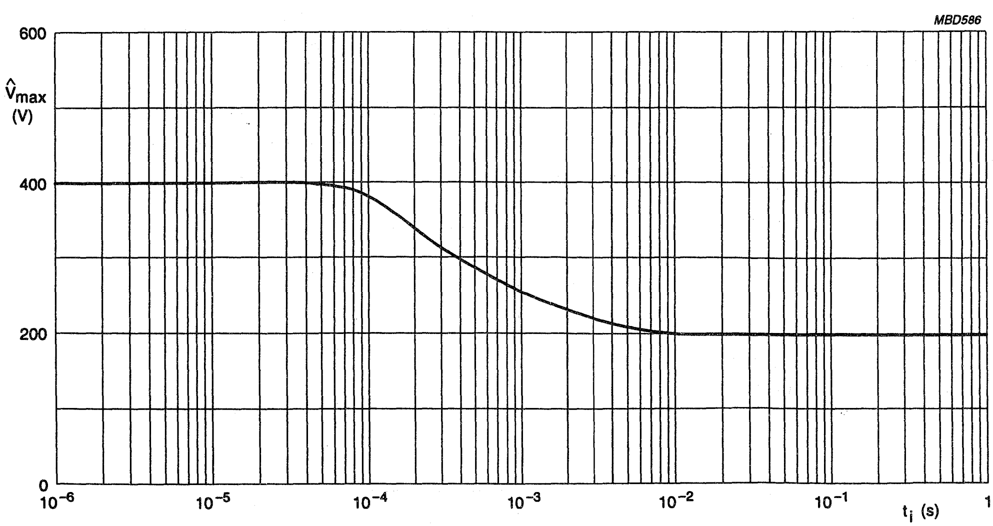
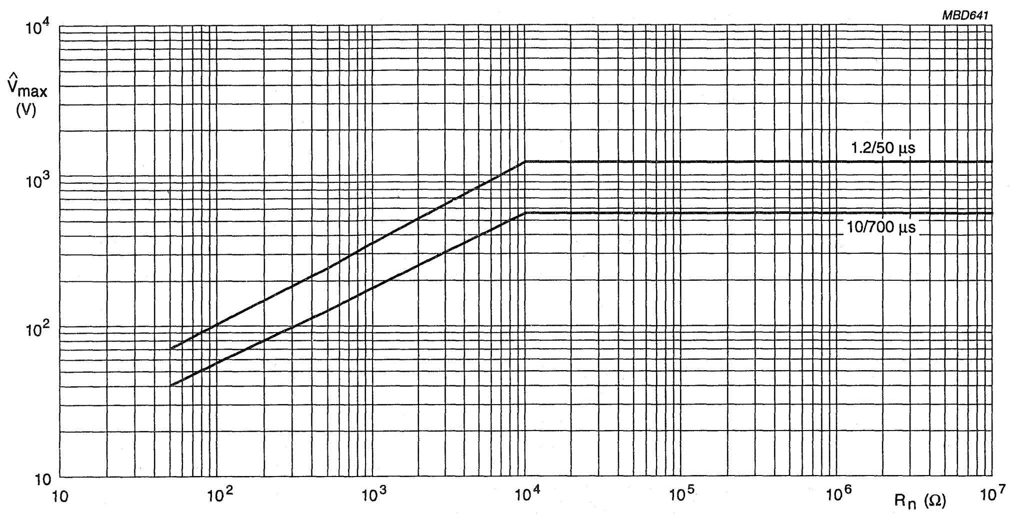


Fig.7 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration.

Precision resistor chip size 1206 RC02H



These pulses may not be applied on a regular basis.

Fig.8 Normstoß (German standard); maximum permissible peak pulse voltage without failing to ‘open circuit’ for RC02H.

COMPOSITION OF THE CATALOGUE NUMBER

The resistors have a 12-digit catalogue number starting with 2322 724. The subsequent 5 digits indicate the packaging and resistance value (see Tables 1 and 3).

Table 1 First digit to indicate packaging for resistances as listed.

RESISTANCE RANGE	TOLERANCE (%)	SERIES	CATALOGUE NUMBER 2322 724			
			CARDBOARD TAPE ON REEL		BLISTER TAPE ON REEL	
			5000 units	10000 units	5000 units	10000 units
1 Ω to 10 MΩ	±1	E24/E96	6....	7....	2....	4....
jumper 0 Ω; note 1	–	–	92006	92007	92002	92004

Note

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

Table 2 For code technical reasons the catalogue numbers for R = 49.9 Ω are as listed.

RESISTANCE	TOLERANCE (%)	CATALOGUE NUMBER 2322 724			
		CARDBOARD TAPE ON REEL		BLISTER TAPE ON REEL	
		5000 units	10000 units	5000 units	10000 units
49.9 Ω	±1	90102	90103	90098	90101

To complete the catalogue number (see Table 1), replace the first three dots of the remaining 4-digit code by the first three digits of the resistance value. Replace the fourth dot (last digit) by a figure according to Table 3.

Table 3 Last digit of 12 NC.

RESISTANCE	LAST DIGIT
1 to 9.76 Ω	8
10 to 97.6 Ω	9(1)
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

Note

1. For value of R = 49.9 Ω see Table 2.

Ordering example

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

TESTS AND REQUIREMENTS

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

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

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

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

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

Table 4

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
Tests in accordance with the schedule of IEC publication 115-8				
4.4.1		visual examination		no holes; clean surface; no damage
4.4.2		dimensions (outline)	gauge	0.45 mm ≤ T ≤ 0.65 mm 1.45 mm ≤ W ≤ 1.75 mm 3.0 mm ≤ L ≤ 3.3 mm
4.5		resistance	applied voltage (+0/−10%): R < 10 Ω: 0.1 V 10 Ω ≤ R < 100 Ω: 0.3 V 100 Ω ≤ R < 1 kΩ: 1 V 1 kΩ ≤ R < 10 kΩ: 3 V 10 kΩ ≤ R < 100 kΩ: 10 V 100 kΩ ≤ R < 1 MΩ: 25 V R ≥ 1 MΩ: 50 V	$R - R_{nom}$: max. 1%
4.18	20 (Tb)	resistance to soldering heat	10 s; 260 ±5 °C; flux 600	ΔR/R max.: ±0.25% +0.05 Ω
4.29	45 (Xa)	component solvent resistance	isopropyl alcohol; H_2O	no visible damage
4.17	20 (Ta)	solderability	unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C; flux 600	good tinning (≥95% covered); no damage
4.7		voltage proof on insulation	200 V (RMS) during 1 minute	no breakdown or flashover
4.13		short time overload	room temperature; dissipation 6.25 × P_n; 5 s (voltage not more than 2 × V_{max})	10 Ω ≤ R ≤ 1 MΩ: ΔR/R max.: ±0.25% +0.05 Ω R > 1 MΩ; R < 10 Ω: ΔR/R max.: ±0.5% +0.05 Ω
4.19	14 (Na)	rapid change of temperature	30 minutes at −55 °C and 30 minutes at +125 °C; 5 cycles	ΔR/R max.: ±0.25% +0.05 Ω

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.23		climatic sequence:		
4.23.2	2 (Ba)	dry heat	16 hours; 125 °C	
4.23.3	30 (D)	damp heat (accelerated) 1st cycle	24 hours; 55 °C; 95 to 100% RH	
4.23.4	1 (Aa)	cold	2 hours; −55 °C	$R < 10\ \Omega$: $\Delta R/R$ max.: ±1% +0.05 Ω
4.23.5	13 (M)	low air pressure	1 hour; 8.5 kPa; 15 to 35 °C	$10\ \Omega \leq R \leq 1\ M\Omega$: $\Delta R/R$ max.: ±0.5% +0.05 Ω
4.23.6	30 (D)	damp heat (accelerated) remaining cycles	5 days; 55 °C; 95 to 100% RH	$R > 1\ M\Omega$: $\Delta R/R$ max.: ±1.5% +0.05 Ω
4.6.1.1		insulation resistance	100 V (DC) after 1 minute	R_{ins} min.: 1000 MΩ
4.24.2	3 (Ca)	damp heat (steady state) (IEC)	56 days; 40 °C; 90 to 95% RH; loaded with 0.01 P_n (IEC steps: 0 to 100 V)	$\Delta R/R$ max.: ±1% +0.05 Ω
4.25.1		endurance (at 70 °C)	1000 hours; loaded with P_n or V_{max}; 1.5 hours on and 0.5 hours off	$\Delta R/R$ max.: ±0.5% +0.05 Ω
4.23.2	27 (Ba)	endurance at upper category temperature	1000 hours; 125 °C; no load	$\Delta R/R$ max.: ±0.5% +0.05 Ω
4.8.4.2		temperature coefficient	at 20/−55/20 °C and 20/125/20 °C	1 Ω to 4.99 Ω: $\Delta R/R$ max.: $\pm 250 \times 10^{-6}$/K 5.1 Ω to 9.75 Ω: $\Delta R/R$ max.: $\pm 200 \times 10^{-6}$/K 10 Ω to 1 MΩ: $\Delta R/R$ max.: $\pm 100 \times 10^{-6}$/K 1.02 MΩ to 10 MΩ: $\Delta R/R$ max.: $\pm 200 \times 10^{-6}$/K
4.17	20 (Tb)	solderability (after ageing)	16 hours steam or 16 hours at 155 °C; unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C; flux 600	good tinning (≥95% covered); no damage
4.22	6 (Fc)	vibration (mounted state)	frequency: 10 to 500 Hz; displacement 1.5 mm or acceleration 10 g; three directions; total 6 hours	no damage $\Delta R/R$ max.: ±0.25% +0.05 Ω
4.20	29 (Eb)	bump (mounted state)	3 × 1500 bumps in three directions; 40 g	no damage $\Delta R/R$ max.: ±0.25% +0.05 Ω

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.12		noise	IEC publication 195 (measured with Quantech - equipment)	R < 1 kΩ 1 µV/V R < 10 kΩ: max. 3 µV/V R < 100 kΩ: max. 6 µV/V R < 1 MΩ: max. 10 µV/V
Other applicable tests				
		leaching	unmounted chips 60 s ;260 ±5 °C	good tinning; no leaching
		damp heat (steady state) (JIS)	1 000 hours; +40 °C; 90 to 95% RH loaded with P_n or V_{max}; 1.5 hours on and 0.5 hours off	ΔR/R max.: ±1% + 0.05 Ω
		component solvent resistance according to MIL-STD-202	method 215	no visual damage

ADDITIONAL TESTS AND REQUIREMENTS

All tests in accordance with the schedule EIA-standard 575 (August 1990) are carried out on a limited part of the RC02H series (10 Ω to 1 MΩ).

In Table 5 the tests and requirements for RC02H resistors within the range 10 Ω to 1 MΩ are listed with reference to the relevant clauses. A short description of the test procedure is also given.

It should be noted that the dimensions of the RC02H resistor do not entirely fulfil EIA specifications as the allowable minimum length 3.2 +0.1/–0.2 mm is less than the EIA requirement (3.2 ±0.15 mm).

Table 5

GROUP	TEST	TEST METHOD	TEST DESCRIPTION	REQUIREMENTS
I	visual and mechanical	3.3	magnification 5×	within specification
	DC resistance	3.4	measuring equipment better than 0.02% on lowest scale	ΔR/R max.: ±1%
II	resistor mounted on FR4/1.5 mm with non-activated paste:			
	resistance temperature characteristics	3.11	15 minutes at +25/–55/+25 °C	ΔR/R max.: $\pm 100 \times 10^{-6}$/K
	thermal shock	3.5	500 cycles of: 30 minutes at –55 °C; 5 minutes at 25 °C; 30 minutes at 155 °C and 5 minutes at 25 °C	ΔR/R max.: ±0.25% +0.05 Ω
	short time overload	3.6	dissipation $6.25 \times P_{max}$; 5 s (voltage not more than $2 \times V_{max}$)	ΔR/R max.: ±0.25% +0.05 Ω

GROUP	TEST	TEST METHOD	TEST DESCRIPTION	REQUIREMENTS
III	mounted as group II; moisture resistance	3.10	10 cycles; 25/65/25/65/25 °C; 90 to 98% RH; no load; no initial conditioning (MIL-STD-202, 106E)	ΔR/R max.: ±0.5% +0.05 Ω
IV	mounted as group II; life 70 °C; loaded with P_{nom}	3.14	100/500/1 000 hours; 1.5 hours on and 0.5 hours off	ΔR/R max.: ±1% +0.05 Ω no damage
V	solderability	3.12	3 × 4 units; 2 s; 235 °C; 3 × 4 units; 3 s; 215 °C; 3 × 4 units; 5 s; 260 °C; MIL-STD-202, method 215	each face >95% new SnPb; no damage
VI	leaching	3.13	30 s; 260 °C	each face >95% new SnPb; no leaching
VII	effects of bonding	3.8	10 s; 260 °C with ‘R’ flux	ΔR/R max.: ±0.3% +0.05 Ω
VIII	terminal strength	3.9	75 mm wire; 20 g; 90°; 30 s; one top and one bottom	ΔR/R max.: ±0.5% +0.05 Ω
IX	high temperature exposure	3.7	100 hours at +125 °C; no load	ΔR/R max.: ±0.5% +0.05 Ω

Precision resistor chip size 1206

RC02HP

FEATURES

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

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

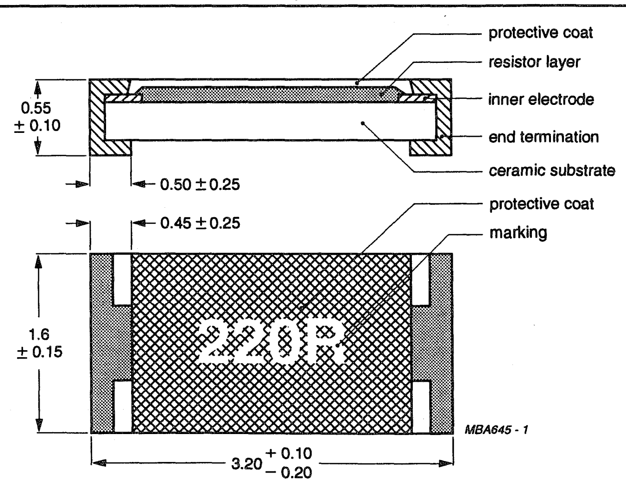
The resistors are constructed on a high grade ceramic body (aluminium oxide). Internal metal electrodes are added at each end and connected by a resistive paste which is applied to the top surface of the substrate. The composition of the paste is adjusted to give the approximate resistance required and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

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

QUICK REFERENCE DATA

DESCRIPTION	VALUE
Resistance range	1 Ω to 10 MΩ; E24/E96 series
Resistance tolerance	±1%
Temperature coefficient:	
1 Ω ≤ R ≤ 4.99 Ω	≤ ±250 × 10^{-6}/K
5.1 Ω ≤ R ≤ 9.76 Ω	≤ ±200 × 10^{-6}/K
10 Ω ≤ R ≤ 1 MΩ	≤ ±100 × 10^{-6}/K
R ≥1.01 MΩ	≤ ±200 × 10^{-6}/K
Absolute 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 115-8
Stability after:	
load, 1000 hours at T_{amb} = 70 °C	ΔR/R max.: ±1% +0.05 Ω
load, 8000 hours at T_{amb} = 70 °C	ΔR/R max.: ±2% +0.05 Ω
climatic tests:	
R ≤ 1 MΩ	ΔR/R max.: ±1% +0.05 Ω
R > 1 MΩ	ΔR/R max.: ±1.5% +0.05 Ω
soldering	ΔR/R max.: ±0.5% +0.05 Ω
short time overload, 400 V max.:	
1 Ω ≤ R ≤ 150 kΩ	ΔR/R max.: ±0.5% +0.05 Ω
150 kΩ < R ≤ 10 MΩ	ΔR/R max.: ±1% +0.05 Ω

MECHANICAL DATA



Dimensions in mm.

Fig.1 Outlines.

Mass

1.00 g (per 100 units).

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 (PCBs). Electrical connection to the circuit is by wave, vapour phase or infrared soldering. The end terminations guarantee a reliable contact and the protective coating enables 'face down' mounting.

The 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 PCB and other discrete components on the reverse (mixed PCBs).

Soldering conditions

Surface Mounted Resistors RC02HP are tested for solderability at 235 °C during 2 seconds. The test condition for no leaching is 260 °C for 60 seconds. Typical examples of soldering processes that provide reliable joints without any damage, are given in Figs 2, 3 and 4.

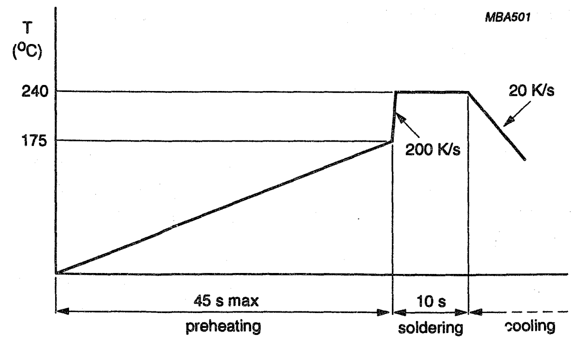


Fig.2 Infrared soldering.

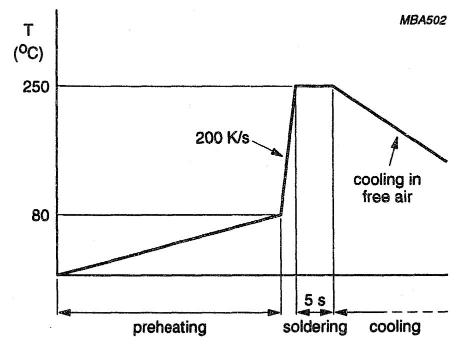


Fig.3 Wave soldering. The resistors may be soldered twice according to this method if necessary.

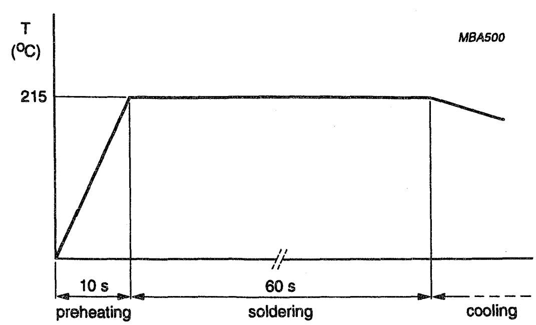


Fig.4 Vapour phase soldering.

Marking

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

4-DIGIT MARKING

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

Magnitude indicators.

RESISTANCE	INDICATOR
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

Example.

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

The packaging 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 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 publication 115-8"*.

Dissipation

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

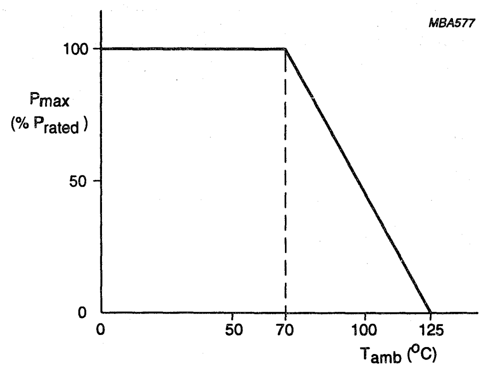


Fig.5 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

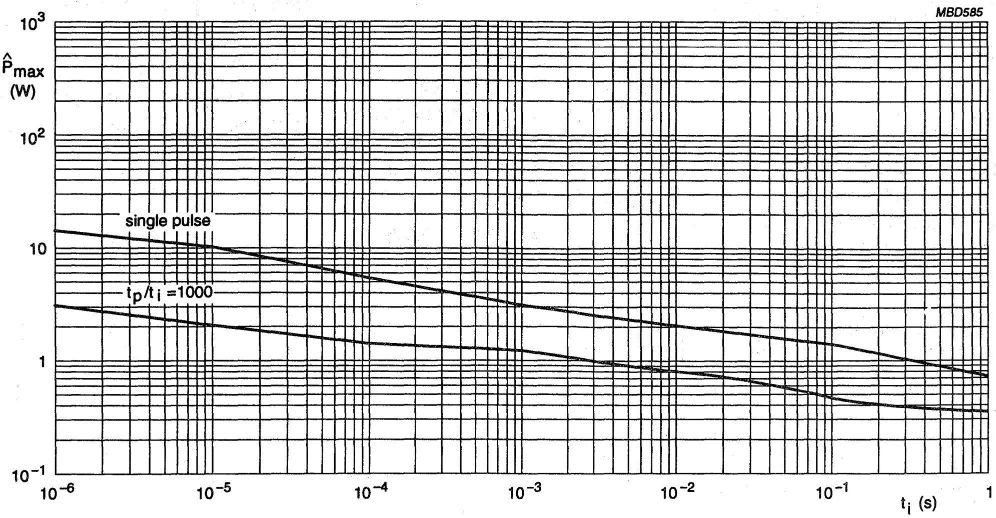


Fig.6 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration for R ≤ 10 kΩ, single pulse and repetitive pulse t_p/t_i = 1000.

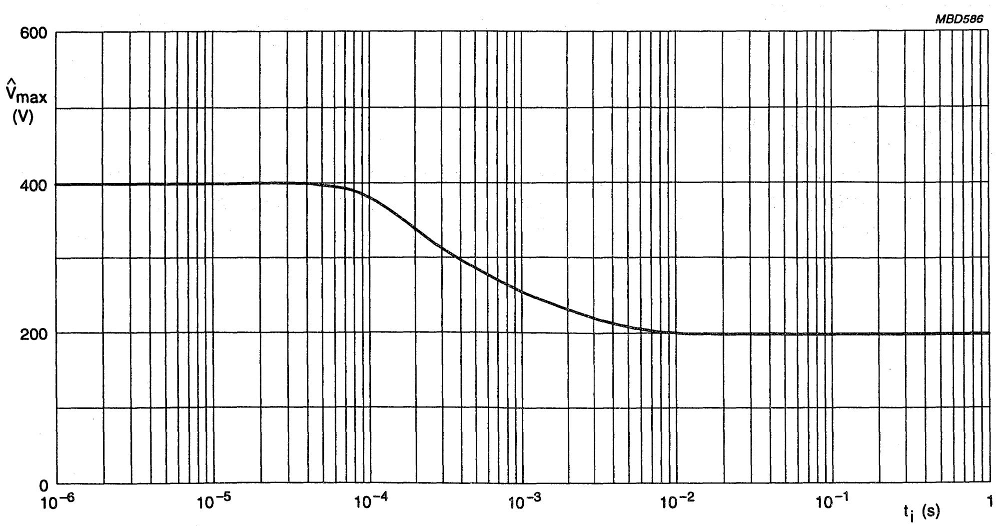
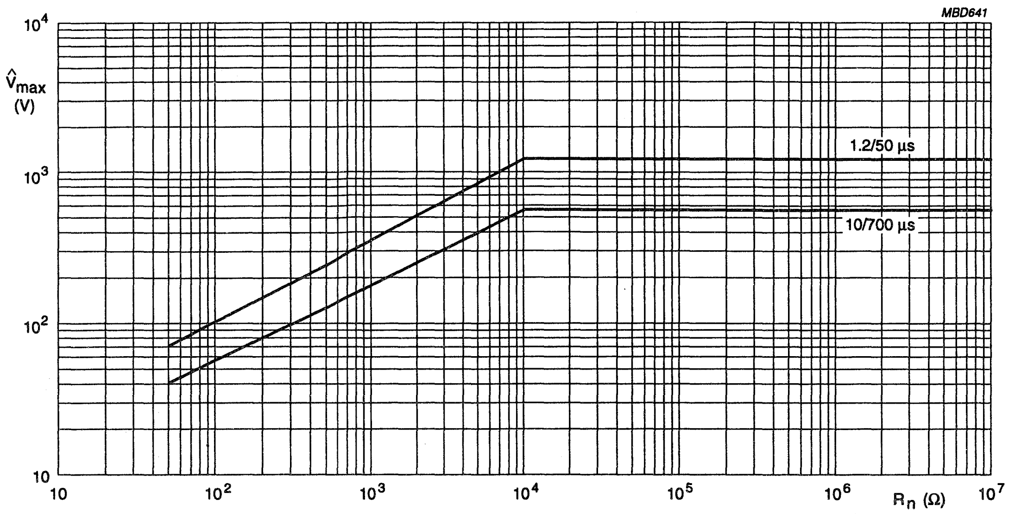


Fig.7 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration.



These pulses may not be applied on a regular basis.

Fig.8 Normstoß (German standard); maximum permissible peak pulse voltage without failing to 'open circuit' for RC02HP.

COMPOSITION OF THE CATALOGUE NUMBER

The resistors have a 12-digit catalogue number starting with 2322 726. The subsequent 5 digits indicate the packaging and resistance value (see Tables 1 and 3).

Table 1 First digit to indicate packaging for resistances as listed.

RESISTANCE RANGE	TOLERANCE (%)	SERIES	CATALOGUE NUMBER 2322 726			
			CARDBOARD TAPE ON REEL		BLISTER TAPE ON REEL	
			5000 units	10000 units	5000 units	10000 units
1 Ω to 10 MΩ	±1	E24/E96	2....	3....	1....	4....

Table 2 For code technical reasons the catalogue numbers for R = 49.9 Ω are as listed.

RESISTANCE	TOLERANCE (%)	CATALOGUE NUMBER 2322 726			
		CARDBOARD TAPE ON REEL		BLISTER TAPE ON REEL	
		5000 units	10000 units	5000 units	10000 units
49.9 Ω	±1	90003	90045	90092	90044

To complete the catalogue number (see Table 1), replace the first three dots of the remaining 4-digit code by the first three digits of the resistance value. Replace the fourth dot (last digit) by a figure according to Table 3.

Table 3 Last digit of 12 NC.

RESISTANCE	LAST DIGIT
1 to 9.76 Ω	8
10 to 97.6 Ω	9[(1)]
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

Note

1. For value of R = 49.9 Ω see Table 2.

Ordering example

The catalogue number of a RC02HP resistor, value 4750 Ω, supplied on cardboard tape of 5000 units per reel is: 2322 726 24752.

TESTS AND REQUIREMENTS

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

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

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

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

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

Table 4

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

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.24.2	3 (Ca)	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; loaded with 0.01 P_n (IEC steps: 1 to 100 V); dissipation ≤1 mW	R_{ins} min.: 1000 MΩ ΔR/R max.: ±1% +0.05 Ω
4.25.1		endurance	1000 hours; 70 °C nominal dissipation; 1.5 hours on and 0.5 hours off	ΔR/R max.: ±1% +0.05 Ω
4.6.1.1		insulation resistance	100 V (DC) after 1 minute	R_{ins} min.: 1000 MΩ
4.13		short time overload	room temperature; dissipation 6.25 × P_n; 5 s (voltage not more than 2 × V_{max})	1 Ω ≤ R ≤ 150 kΩ: ΔR/R max.: ±0.5% +0.05 Ω 150 kΩ < R ≤ 10 MΩ: ΔR/R max.: ±1% +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 ≤ 9.76 Ω: ≤ ±200 × 10^{-6}/K 10 Ω ≤ R ≤ 1 MΩ: ≤ ±100 × 10^{-6}/K R ≥1.01 MΩ: ≤ ±200 × 10^{-6}/K
4.12		noise	IEC publication 195 (measured with Quantech - equipment)	R < 1 kΩ: max. 1 μV/V R < 10 kΩ: max. 3 μV/V R < 100 kΩ: max. 6 μV/V R < 1 MΩ: max. 10 μV/V
4.23.2	27 (Ba)	endurance at upper category temperature	1000 hours; 125 °C; no load	no visual damage ΔR/R max.: ±0.5% +0.05 Ω
4.7		voltage proof on insulation	200 V (RMS) during 1 minute	no breakdown or flashover

Precision resistor chip size 0805

RC12H

FEATURES

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

APPLICATIONS

- Hand held measuring equipment
- Car telephones
- Camcorders.

DESCRIPTION

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

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

QUICK REFERENCE DATA

DESCRIPTION	VALUE
Resistance range	1 Ω to 1 MΩ; E24/E96 series
Resistance tolerance	±1%
Temperature coefficient:	
1 Ω to 4.99 Ω	$\leq \pm 250 \times 10^{-6}$/K
5.1 Ω to 97.6 Ω	$\leq \pm 200 \times 10^{-6}$/K
100 Ω to 1 MΩ	$\leq \pm 100 \times 10^{-6}$/K
Absolute maximum 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 115-8
Stability after:	
load, 1 000 hours 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.: ±0.5% +0.05 Ω
short time overload, 300 V max.	ΔR/R max.: ±1% +0.05 Ω

MECHANICAL DATA

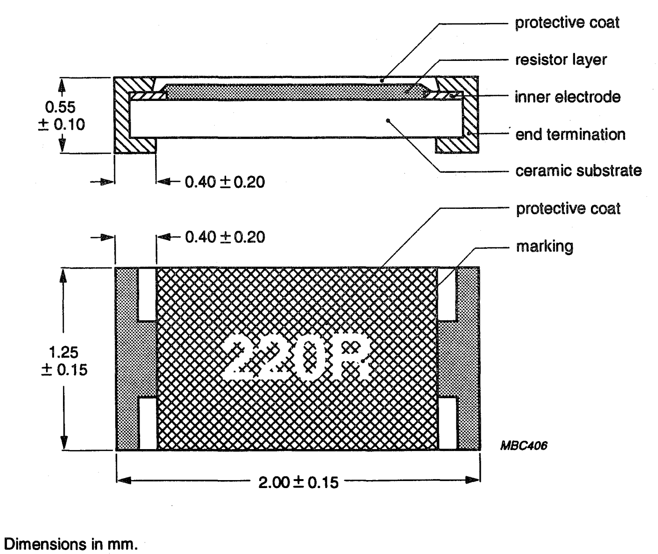


Fig.1 Outlines.

Mass

0.55 g (per 100 units).

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 (PCBs). Electrical connection to the circuit is by wave, vapour phase or infrared soldering. The end terminations guarantee a reliable contact and the protective coating enables 'face down' mounting.

The 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 PCB and other discrete components on the reverse (mixed PCBs).

Soldering conditions

Surface Mounted Resistors RC12H are tested for solderability at 235 °C during 2 seconds. The test condition for no leaching is 260 °C for 60 seconds. Typical examples of soldering processes that provide reliable joints without any damage, are given in Figs 2, 3 and 4.

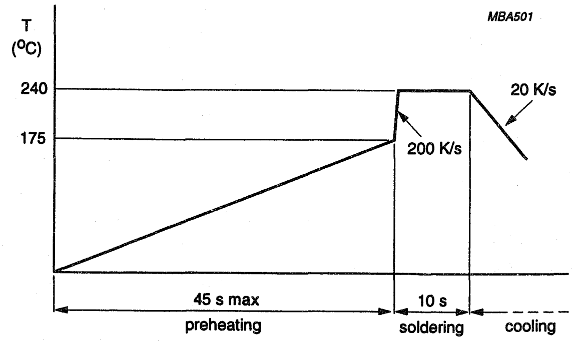


Fig.2 Infrared soldering.

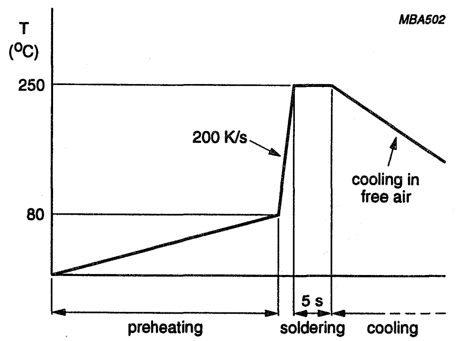


Fig.3 Wave soldering. The resistors may be soldered twice according to this method if necessary.

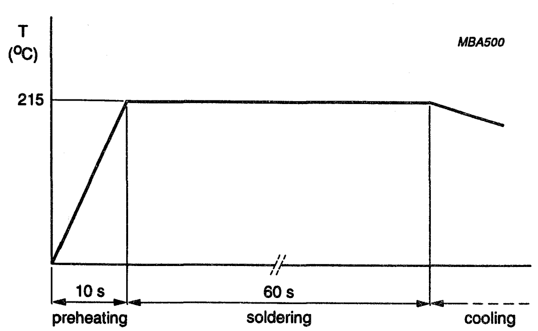


Fig.4 Vapour phase soldering.

Marking

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

4-DIGIT MARKING

For values up to 976 Ω the R is used as a decimal point. For values of 1 kΩ or greater the first 3 digits apply to the resistance value and the third is an indication of magnitude.

Magnitude indicators.

RESISTANCE	INDICATOR
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

Example.

MARKING	RESISTANCE
121R	121 Ω
4021	4.02 kΩ
7503	750 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 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 publication 115-8"*.

Dissipation

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

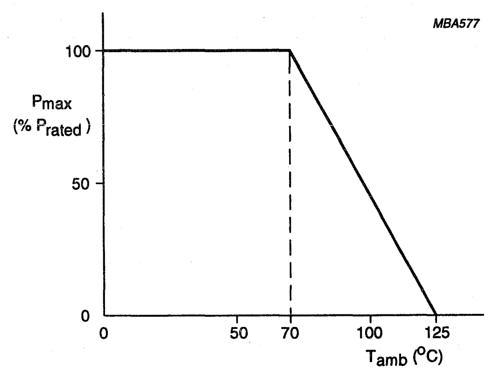


Fig.5 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

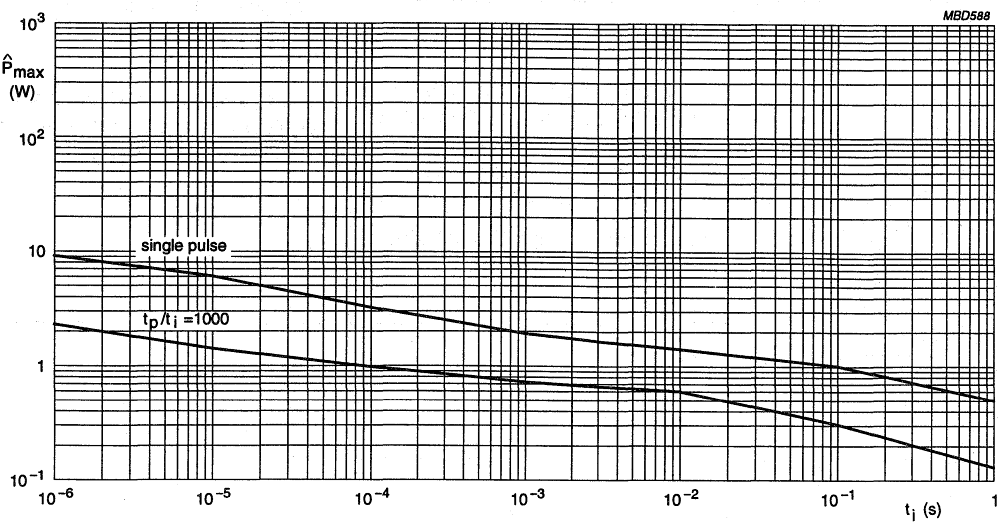


Fig.6 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration for R ≤ 10 kΩ, single pulse and repetitive pulse t_p/t_i = 1000.

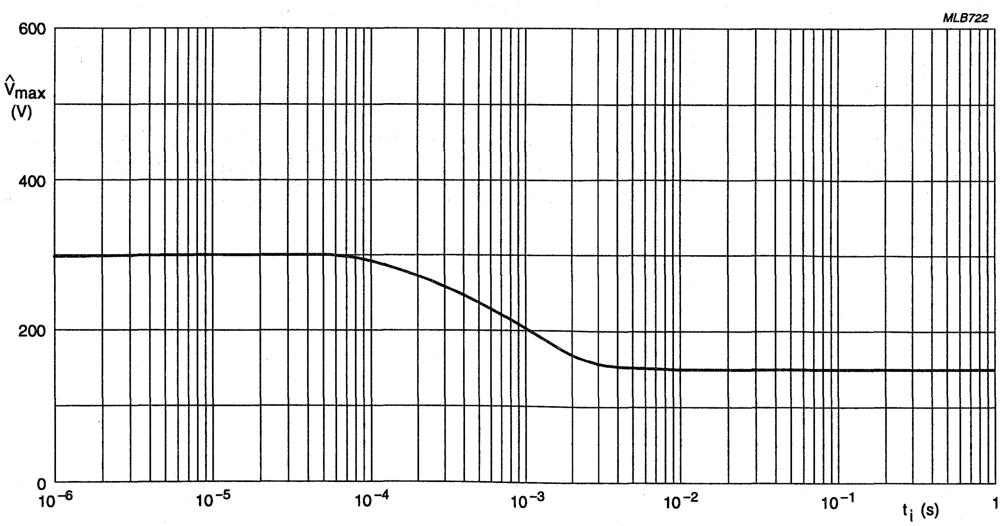
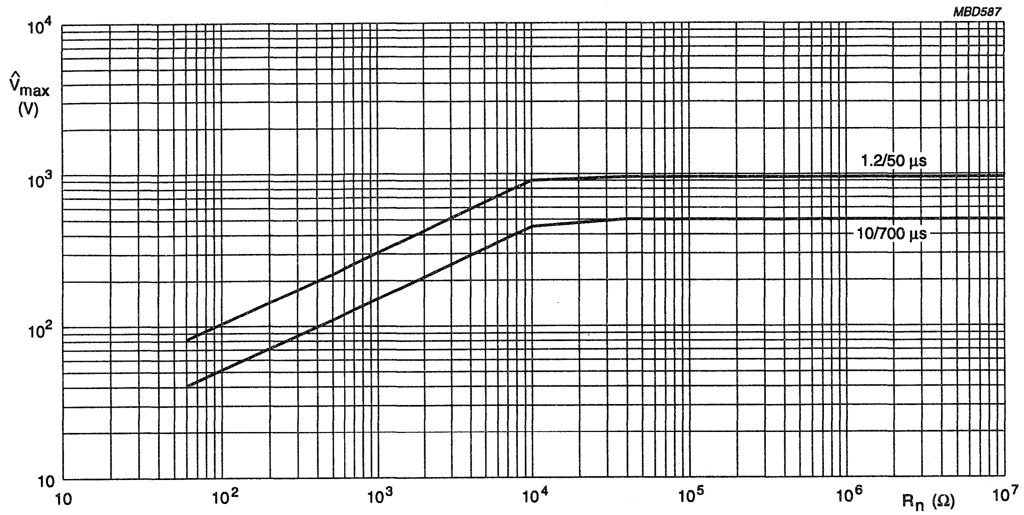


Fig.7 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration.



These pulses may not be applied on a regular basis.

Fig.8 Normstoß (German standard); maximum permissible peak pulse voltage without failing to 'open circuit' for RC12H.

COMPOSITION OF THE CATALOGUE NUMBER

The resistors have a 12-digit catalogue number starting with 2322 734. The subsequent 5 digits indicate the packaging and resistance value (see Tables 1 and 2).

Table 1 First digit to indicate packaging for resistances as listed.

RESISTANCE RANGE	TOLERANCE (%)	SERIES	CATALOGUE NUMBER 2322 734			
			CARDBOARD TAPE ON REEL		BLISTER TAPE ON REEL	
			5000 units	10000 units	5000 units	10000 units
1 Ω to 1 MΩ	±1	E24/E96	6....	7....	2....	4....
jumper 0 Ω; note 1	–	–	92006	92007	92002	92004

Note

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

To complete the catalogue number (see Table 1), replace the first three dots of the remaining 4-digit code by the first three digits of the resistance value. Replace the fourth dot (last digit) by a figure according to Table 2.

Table 2 Last digit of 12 NC.

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

Ordering example

The catalogue number of a RC12H resistor, value 4750 Ω, supplied on cardboard tape of 5000 units per reel is: 2322 734 64752.

Precision resistor chip size 0805

RC12H

TESTS AND REQUIREMENTS

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

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

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

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

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

Table 3

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.17	20 (Ta)	soldering	unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C; flux 600	good tinning (≥95% covered); no damage
		solderability	16 hours steam or 16 hours at 155 °C; unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C; flux 600	good tinning (≥95% covered); no damage
4.18	20 (Tb)	resistance to soldering heat	10 s; 260 ±5 °C; flux 600	ΔR/R max.: ±0.05% +0.05 Ω
		leaching	unmounted chips 60 s; 260 ±5 °C	good tinning; no leaching
4.19	14 (Na)	rapid change of temperature	30 minutes at –55 °C and 30 minutes at +125 °C; 5 cycles	ΔR/R max.: ±0.5% +0.05 Ω
4.22	6 (Fc)	vibration	frequency: 10 to 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	29 (Eb)	bump	3 × 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 printed-circuit board; bending 5 mm over 90 mm	no visual damage ΔR/R max.: ±0.5% +0.05 Ω
		humidity load (JIS)	1000 hours; +40 °C; 90 to 95% RH; loaded with P_n or 100 V; max 1.5 hours on and 0.5 hours off	ΔR/R max.: ±3% +0.1 Ω

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.23		climatic sequence:		
4.23.2	2 (Ba)	dry heat	16 hours; 125 °C	
4.23.3	30 (D)	damp heat (accelerated) 1st cycle	24 hours; 55 °C; 95 to 100% RH	
4.23.4	1 (Aa)	cold	2 hours; −55 °C	
4.23.5	13 (M)	low air pressure	1 hour; 8.5 kPa; 15 to 35 °C	
4.23.6	30 (D)	damp heat (accelerated) remaining cycles	5 days; 55 °C; 95 to 100% RH	R_{ins} min.: 1000 MΩ ΔR/R max.: ±1% +0.05 Ω
4.24.2	3 (Ca)	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; loaded with 0.01 P_n (IEC steps: 0 to 100 V); dissipation ≤1 mW	R_{ins} min.: 1000 MΩ ΔR/R max.: ±1% +0.05 Ω
4.25.1		endurance	1000 hours; 70 °C; nominal dissipation; 1.5 hours on and 0.5 hours off	ΔR/R max.: ±1% +0.05 Ω
4.6.1.1		insulation resistance	100 V (DC) after 1 minute	R_{ins} min.: 1000 MΩ
4.13		short time overload	room temperature; dissipation 6.25 × P_n; 5 s (voltage not more than 2 × V_{max})	ΔR/R max.: ±1% +0.05 Ω
4.8.4.2		temperature coefficient	between −55 °C and +125 °C	1 Ω to 4.99 Ω: ≤ ±250 × 10^{-6}/K 5.1 Ω to 97.6 Ω: ≤ ±200 × 10^{-6}/K 100 Ω to 1 MΩ: ≤ ±100 × 10^{-6}/K
4.12		noise	IEC publication 195 (measured with Quantech - equipment)	R < 1 kΩ: max. 1 μV/V R < 10 kΩ: max. 3 μV/V R < 100 kΩ: max. 6 μV/V R < 1 MΩ: max. 10 μV/V
4.23.2	27 (Ba)	endurance at upper category temperature	1000 hours; 125 °C; no load	no visual damage ΔR/R max.: ±0.5% +0.05 Ω
4.7		voltage proof on insulation	150 V (RMS) during 1 minute	no breakdown or flashover

Precision resistor chip size 0603

RC22H

FEATURES

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

APPLICATIONS

- Hand held measuring equipment
- Car telephones
- Camcorders
- Portable radio, CD and cassette players.

DESCRIPTION

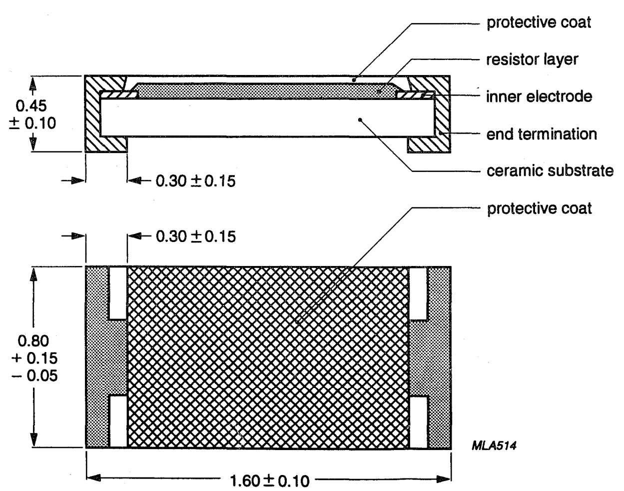
The resistors are constructed on a high grade ceramic body (aluminium oxide). Internal metal electrodes are added at each end and connected by a resistive paste which is applied to the top surface of the substrate. The composition of the paste is adjusted to give the approximate resistance required and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

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

QUICK REFERENCE DATA

DESCRIPTION	VALUE
Resistance range	1 Ω to 1 MΩ; E24/E96 series
Resistance tolerance	±1%
Temperature coefficient:	
1 Ω to 4.99 Ω	$\leq \pm 250 \times 10^{-6}$/K
5 Ω to 97.6 Ω	$\leq \pm 200 \times 10^{-6}$/K
100 Ω to 1 MΩ	$\leq \pm 100 \times 10^{-6}$/K
Absolute maximum dissipation at T_{amb} = 70 °C	0.063 W
Maximum permissible voltage	50 V (DC or RMS)
Operating temperature range	–55 °C to +125 °C
Climatic category (IEC 68)	55/125/56
Basic specification	IEC 115-8
Stability after:	
load, 1 000 hours at T_{amb} = 70 °C	ΔR/R max.: ±1% +0.05 Ω
climatic tests	ΔR/R max.: ±1% +0.05 Ω
soldering	ΔR/R max.: ±0.5% +0.05 Ω
short time overload, 100 V max.	ΔR/R max.: ±1% +0.05 Ω

MECHANICAL DATA



Dimensions in mm.

Fig.1 Outlines.

Precision resistor chip size 0603

RC22H

Mass

0.25 g (per 100 units).

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 (PCBs). Electrical connection to the circuit is by wave, vapour phase or infrared soldering. The end terminations guarantee a reliable contact and the protective coating enables 'face down' mounting.

The 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 PCB and other discrete components on the reverse (mixed PCBs).

Soldering conditions

Surface Mounted Resistors RC22H are tested for solderability at 235 °C during 2 seconds. The test condition for no leaching is 260 °C for 60 seconds. Typical examples of soldering processes that provide reliable joints without any damage, are given in Figs 2, 3 and 4.

Marking

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

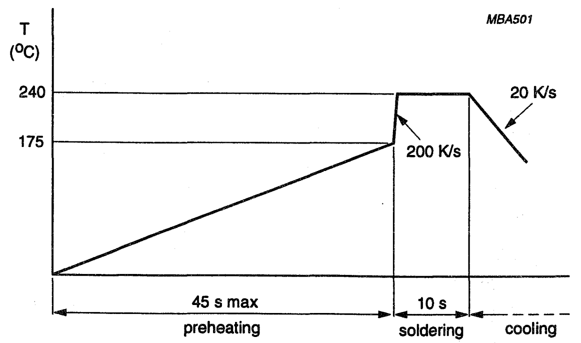


Fig.2 Infrared soldering.

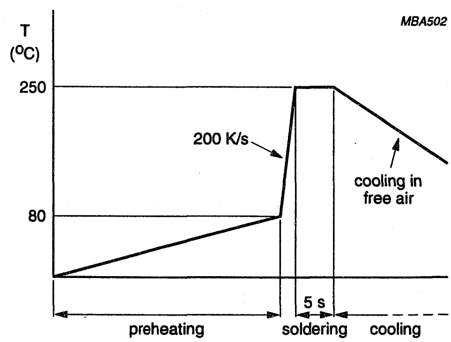


Fig.3 Wave soldering. The resistors may be soldered twice according to this method if necessary.

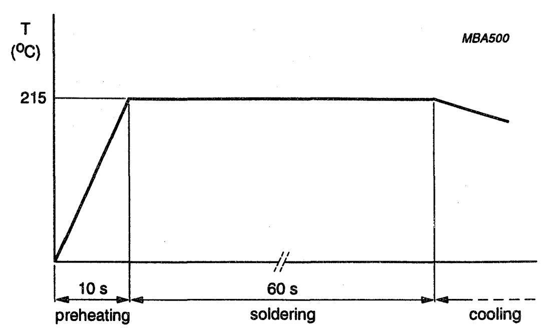


Fig.4 Vapour phase soldering.

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 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 publication 115-8"*.

Dissipation

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

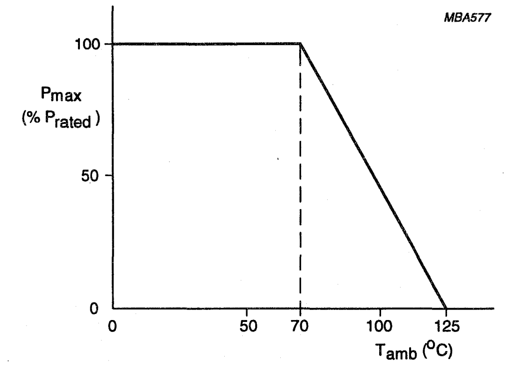


Fig.5 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

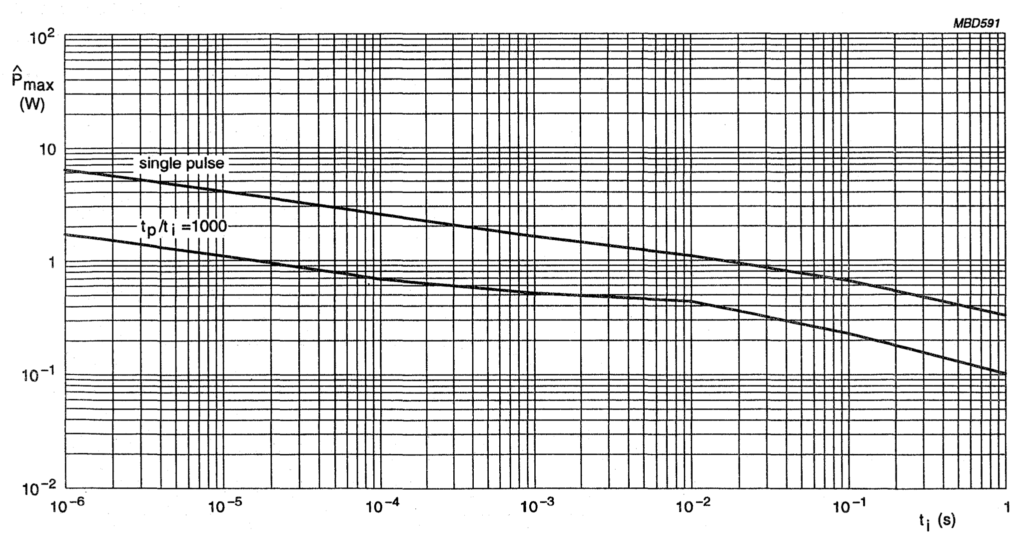


Fig.6 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration for R ≤ 10 kΩ, single pulse and repetitive pulse t_p/t_i = 1000.

Precision resistor chip size 0603

RC22H

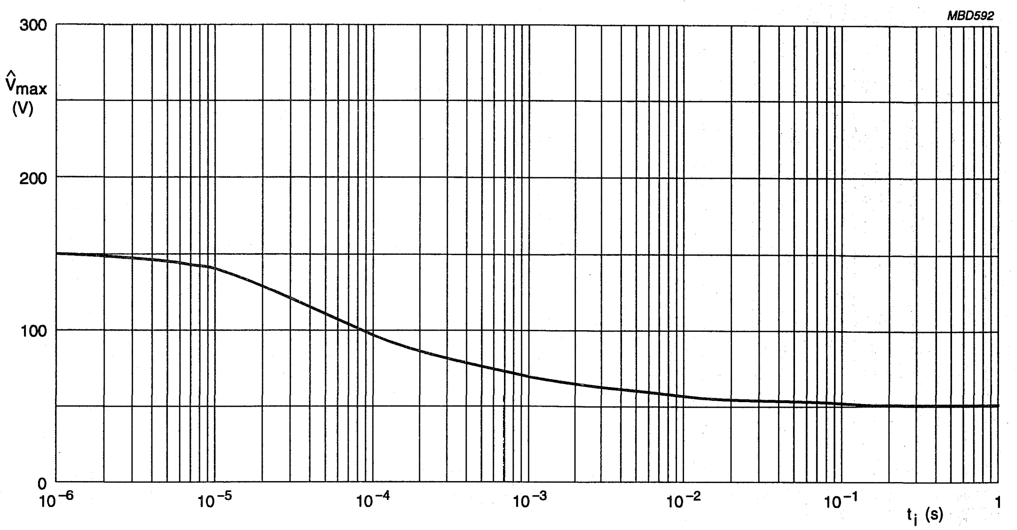
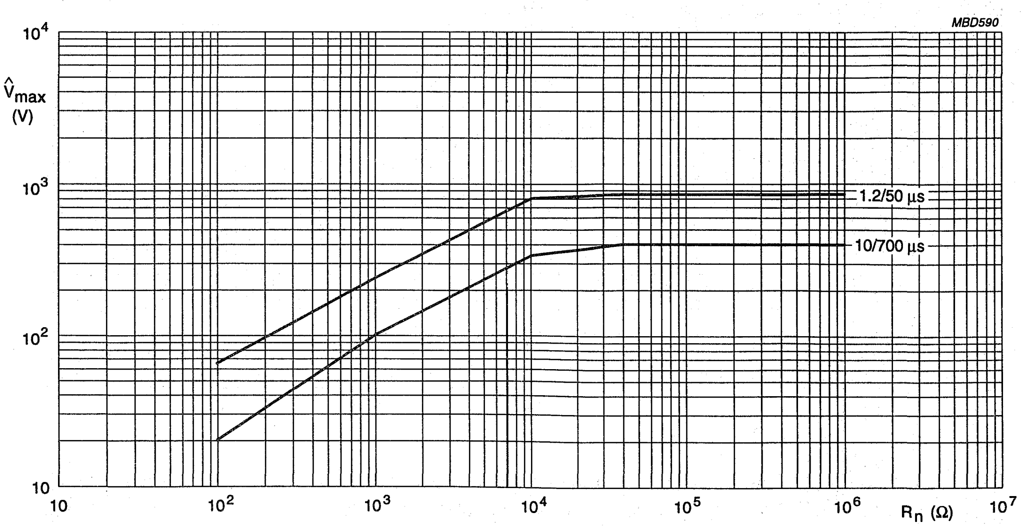


Fig.7 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration.



These pulses may not be applied on a regular basis.

Fig.8 Normstoß (German standard); maximum permissible peak pulse voltage without failing to 'open circuit' for RC22H.

COMPOSITION OF THE CATALOGUE NUMBER

The resistors have a 12-digit catalogue number starting with 2322 704. The subsequent 5 digits indicate the packaging and resistance value (see Tables 1 and 2).

Table 1 First digit to indicate packaging for resistances as listed.

RESISTANCE RANGE	TOLERANCE (%)	SERIES	CATALOGUE NUMBER 2322 704 ..... CARDBOARD TAPE ON REEL 5000 units	CATALOGUE NUMBER 2322 704 ..... CARDBOARD TAPE ON REEL 10000 units
1 Ω to 1 MΩ	±1	E24/E96	6....	7....
jumper 0 Ω; note 1	–	–	92006	92007

Note

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

To complete the catalogue number (see Table 1), replace the first three dots of the remaining 4-digit code by the first three digits of the resistance value. Replace the fourth dot (last digit) by a figure according to Table 2.

Table 2 Last digit of 12 NC.

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

Ordering example

The catalogue number of a RC22H resistor, value 4.75 kΩ, supplied on cardboard tape of 5000 units per reel is: 2322 704 64752.

Precision resistor chip size 0603

RC22H

TESTS AND REQUIREMENTS

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

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

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

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

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

Table 3

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.17	20 (Ta)	soldering	unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C; flux 600	good tinning (≥95% covered); no damage
		solderability	16 hours steam or 16 hours at 155 °C; unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C; flux 600	good tinning (≥95% covered); no damage
4.18	20 (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	14 (Na)	rapid change of temperature	30 minutes at −55 °C and 30 minutes at +125 °C; 5 cycles	ΔR/R max.: ±0.5% +0.05 Ω
4.22	6 (Fc)	vibration	frequency: 10 to 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	29 (Eb)	bump	3 × 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 printed-circuit board; bending 5 mm over 90 mm	no visual damage ΔR/R max.: ±0.5% +0.05 Ω
		humidity load (JIS)	1000 hours; +40 °C; 90 to 95% RH; loaded with P_n or 100 V; max 1.5 hours on and 0.5 hours off	ΔR/R max.: ±1% +0.05 Ω

Precision resistor chip size 0603

RC22H

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.23		climatic sequence:		
4.23.2	2 (Ba)	dry heat	16 hours; 125 °C	
4.23.3	30 (D)	damp heat (accelerated) 1st cycle	24 hours; 55 °C; 95 to 100% RH	
4.23.4	1 (Aa)	cold	2 hours; –55 °C	
4.23.5	13 (M)	low air pressure	1 hour; 8.5 kPa; 15 to 35 °C	
4.23.6	30 (D)	damp heat (accelerated) remaining cycles	5 days; 55 °C; 95 to 100% RH	R_{ins} min.: 1000 MΩ ΔR/R max.: ±1% +0.05 Ω
4.24.2	3 (Ca)	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; loaded with 0.01 P_n (IEC steps: 0 to 100 V); dissipation ≤1 mW	R_{ins} min.: 1000 MΩ ΔR/R max.: ±1% +0.05 Ω
4.25.1		endurance	1000 hours; 70 °C; nominal dissipation; 1.5 hours on and 0.5 hours off	ΔR/R max.: ±1% +0.05 Ω
4.6.1.1		insulation resistance	10 V (DC) after 1 minute	R_{ins} min.: 1000 MΩ
4.13		short time overload	room temperature; dissipation 6.25 × P_n; 5 s (voltage not more than 2 × V_{max})	ΔR/R max.: ±1% +0.05 Ω
4.8.4.2		temperature coefficient	between –55 °C and +125 °C	1 Ω to 4.99 Ω: ≤ ±250 × 10^{-6}/K 5.1 Ω to 97.6 Ω: ≤ ±200 × 10^{-6}/K 100 Ω to 1 MΩ: ≤ ±100 × 10^{-6}/K
4.12		noise	IEC publication 195 (measured with Quantech - equipment)	R < 1 kΩ: max. 1 µV/V R < 10 kΩ: max. 3 µV/V R < 100 kΩ: max. 6 µV/V R < 1 MΩ: max. 10 µV/V
4.23.2	27 (Ba)	endurance at upper category temperature	1000 hours; 125 °C; no load	no visual damage ΔR/R max.: ±1% +0.05 Ω
4.7		voltage proof on insulation	50 V (RMS) during 1 minute	no breakdown or flashover

Precision resistor chip size 1206

RC02G

FEATURES

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

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

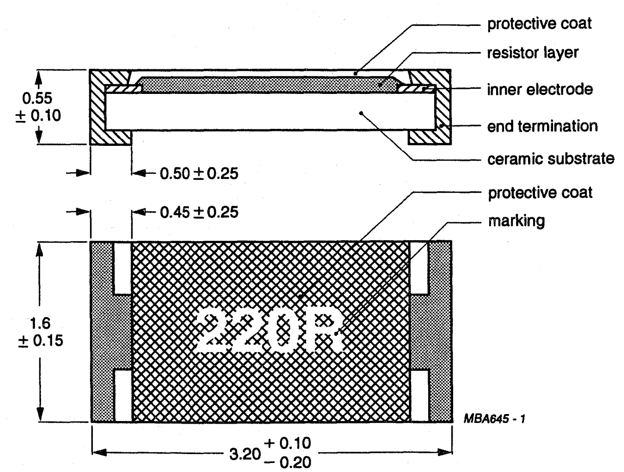
The resistors are constructed on a high grade ceramic body (aluminium oxide). Internal metal electrodes are added at each end and connected by a resistive paste which is applied to the top surface of the substrate. The composition of the paste is adjusted to give the approximate resistance required and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

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

QUICK REFERENCE DATA

DESCRIPTION	VALUE
Resistance range	100 Ω to 1 MΩ; E24/E96 series
Resistance tolerance	±1%
Temperature coefficient	$\leq \pm 50 \times 10^{-6}$/K
Absolute maximum 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 115-8
Stability after:	
load, 1000 hours at T_{amb} = 70 °C	ΔR/R max.: ±0.5% +0.05 Ω
load, 8000 hours 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

1.00 g (per 100 units).

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 (PCBs). Electrical connection to the circuit is by wave, vapour phase or infrared soldering. The end terminations guarantee a reliable contact and the protective coating enables 'face down' mounting.

The 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 PCB and other discrete components on the reverse (mixed PCBs).

Soldering conditions

Surface Mounted Resistors RC02G are tested for solderability at 235 °C during 2 seconds. The test condition for no leaching is 260 °C for 60 seconds. Typical examples of soldering processes that provide reliable joints without any damage, are given in Figs 2, 3 and 4.

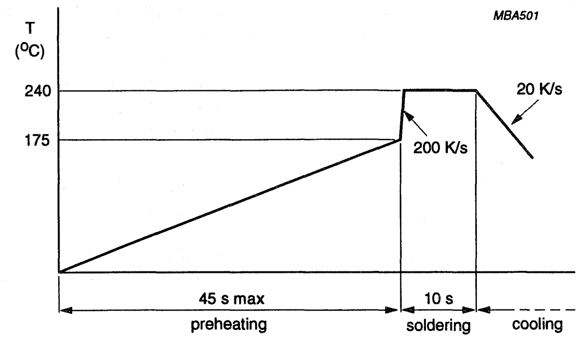


Fig.2 Infrared soldering.

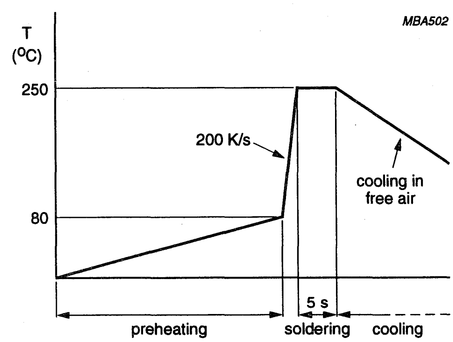


Fig.3 Wave soldering. The resistors may be soldered twice according to this method if necessary.

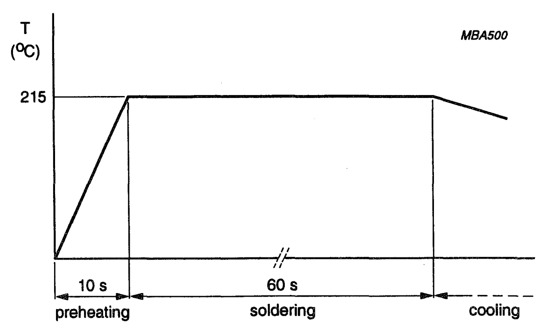


Fig.4 Vapour phase soldering.

Precision resistor chip size 1206

Marking

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

4-DIGIT MARKING

For values up to 976 Ω the R is used as a decimal point. For values of 1 kΩ or greater the first 3 digits apply to the resistance value and the third is an indication of magnitude.

Magnitude indicators.

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

Example.

MARKING	RESISTANCE
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 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 publication 115-8"*.

Dissipation

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

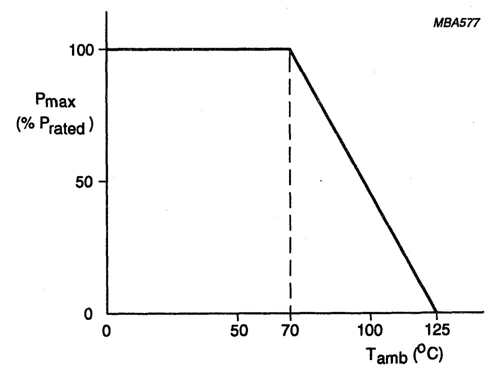


Fig.5 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

Precision resistor chip size 1206

RC02G

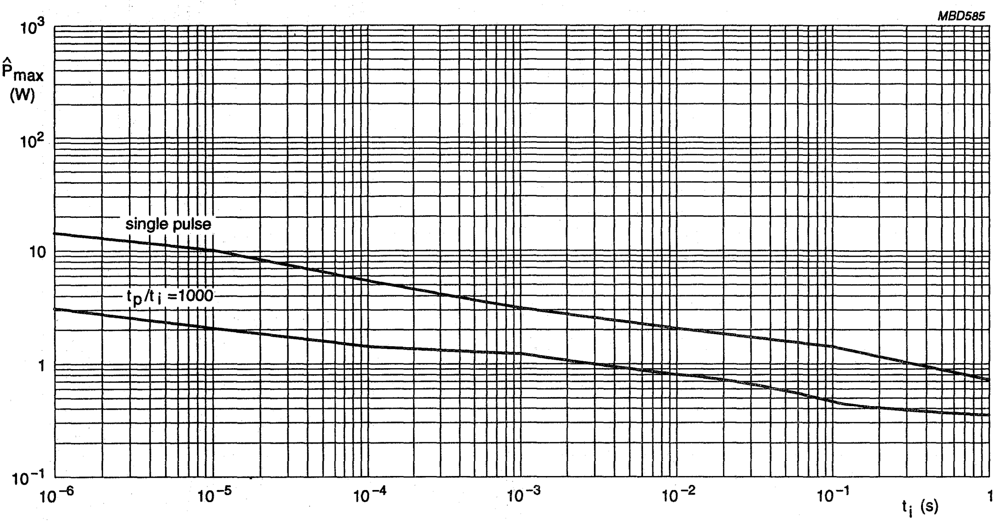


Fig.6 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration for R ≤ 10 kΩ, single pulse and repetitive pulse t_p/t_i = 1000.

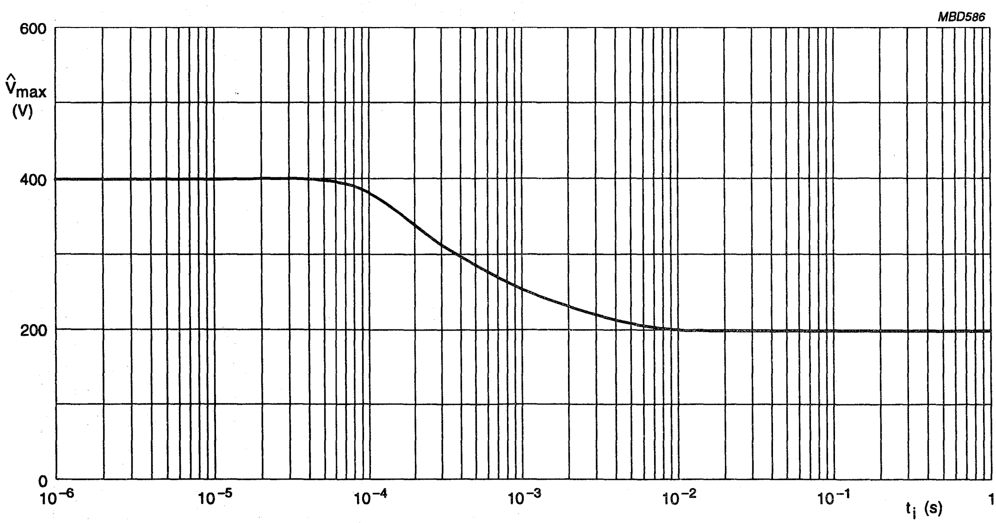
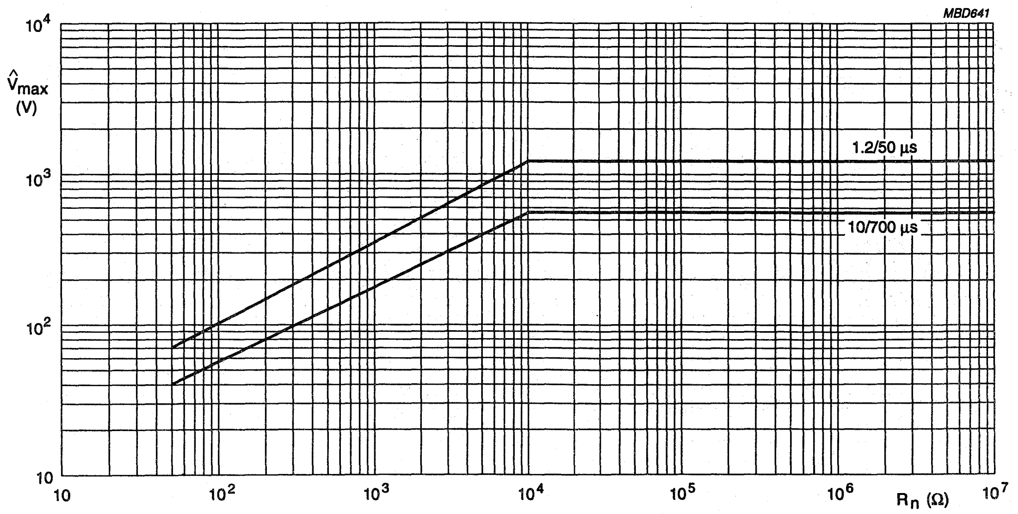


Fig.7 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration.



These pulses may not be applied on a regular basis.

Fig.8 Normstoß (German standard); maximum permissible peak pulse voltage without failing to 'open circuit' for RC02G.

COMPOSITION OF THE CATALOGUE NUMBER

The resistors have a 12-digit catalogue number starting with 2322. The subsequent 8 digits indicate the packaging and resistance value (see Tables 1 and 2).

Table 1 First 4 digits to indicate packaging for resistances as listed.

RESISTANCE RANGE	TOLERANCE (%)	SERIES	CATALOGUE NUMBER 2322			
			CARDBOARD TAPE ON REEL 722		BLISTER TAPE ON REEL 723	
			5000 units	10000 units	5000 units	10000 units
100 Ω to 1 MΩ	±1	E24/E96	2....	3....	6....	7....

To complete the catalogue number (see Table 1), replace the first three dots of the remaining 4-digit code by the first three digits of the resistance value. Replace the fourth dot (last digit) by a figure according to Table 2.

Table 2 Last digit of 12 NC.

RESISTANCE	LAST DIGIT
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

The catalogue number of a RC02G resistor, value 4750 Ω, supplied on cardboard tape of 5000 units per reel is: 2322 723 64752.

TESTS AND REQUIREMENTS

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

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

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

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

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

Table 3

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.17	20 (Ta)	soldering	unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C; flux 600	good tinning (≥95% covered); no damage
4.17	20 (Tb)	solderability	16 hours steam or 16 hours at 155 °C; unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C; flux 600	good tinning (≥95% covered); no damage
4.18	20 (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	14 (Na)	rapid change of temperature	30 minutes at –55 °C and 30 minutes at +125 °C; 5 cycles	ΔR/R max.: ±0.25% +0.05 Ω
4.22	6 (Fc)	vibration	frequency: 10 to 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	29 (Eb)	bump	3 × 1500 bumps in three directions; 40 g	no damage ΔR/R max.: ±0.25% +0.05 Ω
4.23		climatic sequence:		
4.23.2	2 (Ba)	dry heat	16 hours; 125 °C	
4.23.3	30 (D)	damp heat (accelerated) 1st cycle	24 hours; 55 °C; 95 to 100% RH	
4.23.4	1 (Aa)	cold	2 hours; –55 °C	
4.23.5	13 (M)	low air pressure	1 hour; 8.5 kPa; 15 to 35 °C	
4.23.6	30 (D)	damp heat (accelerated) remaining cycles	5 days; 55 °C; 95 to 100% RH	R_{ins} min.: 1000 MΩ ΔR/R max.: ±1% +0.05 Ω
4.24.2	3 (Ca)	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; loaded with 0.01 P_n (IEC steps: 0 to 100 V); dissipation ≤1 mW	R_{ins} min.: 1000 MΩ ΔR/R max.: ±1% +0.05 Ω

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.25.1		endurance	1000 hours; 70 °C; nominal dissipation; 1.5 hours on and 0.5 hours off	ΔR/R max.: ±0.5% +0.05 Ω
4.6.1.1		insulation resistance	100 V (DC) after 1 minute	R_{ins} min.: 1000 MΩ
4.13		short time overload	room temperature; dissipation 6.25 × P_n; 5 s (voltage not more than 2 × V_{max})	ΔR/R max.: ±0.25% +0.05 Ω
4.8.4.2		temperature coefficient	between −55 °C and +125 °C	≤ ±50 × 10^{-6}/K
4.12		noise	IEC publication 195 (measured with Quantech - equipment)	R < 1 kΩ: max. 1 µV/V R < 10 kΩ: max. 3 µV/V R < 100 kΩ: max. 6 µV/V R < 1 MΩ: max. 10 µV/V
4.23.2	27 (Ba)	endurance at upper category temperature	1000 hours; 125 °C; no load	no visual damage ΔR/R max.: ±0.5% +0.05 Ω
4.7		voltage proof on insulation	200 V (RMS) during 1 minute	no breakdown

Precision resistor chip size 1206

RC02GP

FEATURES

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

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

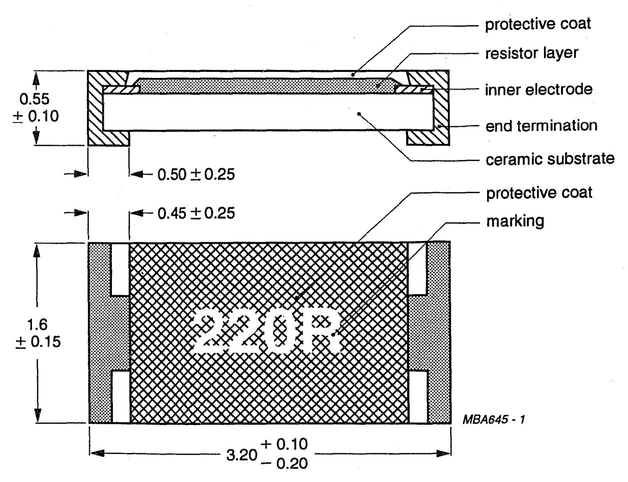
The resistors are constructed on a high grade ceramic body (aluminium oxide). Internal metal electrodes are added at each end and connected by a resistive paste which is applied to the top surface of the substrate. The composition of the paste is adjusted to give the approximate resistance required and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

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

QUICK REFERENCE DATA

DESCRIPTION	VALUE
Resistance range	250 Ω to 1 MΩ; E24/E96 series
Resistance tolerance	±1%
Temperature coefficient: 250 Ω ≤ R ≤ 1 MΩ	 $\leq \pm 50 \times 10^{-6}$/K
Absolute maximum 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 115-8
Stability after: load, 1 000 hours at T_{amb} = 70 °C load, 8 000 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.: ±0.5% +0.05 Ω ΔR/R max.: ±0.5% +0.05 Ω

MECHANICAL DATA



Dimensions in mm.

Fig.1 Outlines.

Precision resistor chip size 1206

RC02GP

Mass

1.00 g (per 100 units).

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 (PCBs). Electrical connection to the circuit is by wave, vapour phase or infrared soldering. The end terminations guarantee a reliable contact and the protective coating enables 'face down' mounting.

The 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 PCB and other discrete components on the reverse (mixed PCBs).

Soldering conditions

Surface Mounted Resistors RC02GP are tested for solderability at 235 °C during 2 seconds. The test condition for no leaching is 260 °C for 60 seconds. Typical examples of soldering processes that provide reliable joints without any damage, are given in Figs 2, 3 and 4.

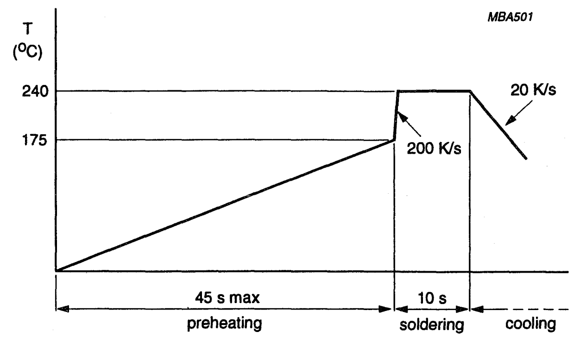


Fig.2 Infrared soldering.

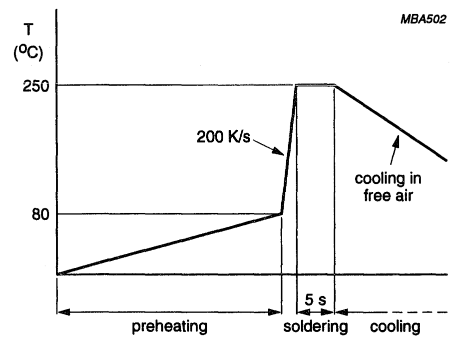


Fig.3 Wave soldering. The resistors may be soldered twice according to this method if necessary.

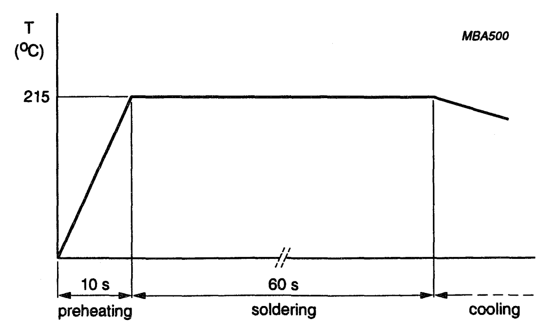


Fig.4 Vapour phase soldering.

Marking

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

4-DIGIT MARKING

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

Magnitude indicators.

RESISTANCE	INDICATOR
250 to 976 Ω	R
1 to 9.76 kΩ	1
10 to 97.6 kΩ	2
100 to 976 kΩ	3
1 MΩ	4

Example.

MARKING	RESISTANCE
4751	4.75 kΩ
1472	14.7 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 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 publication 115-8"*.

Dissipation

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

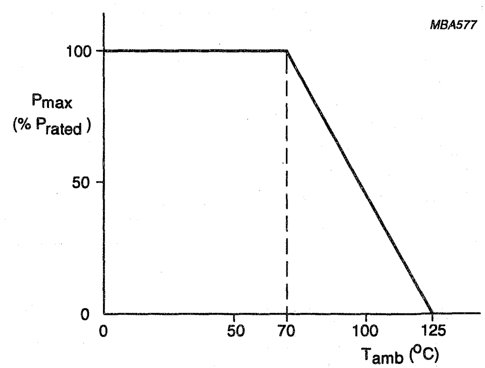


Fig.5 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

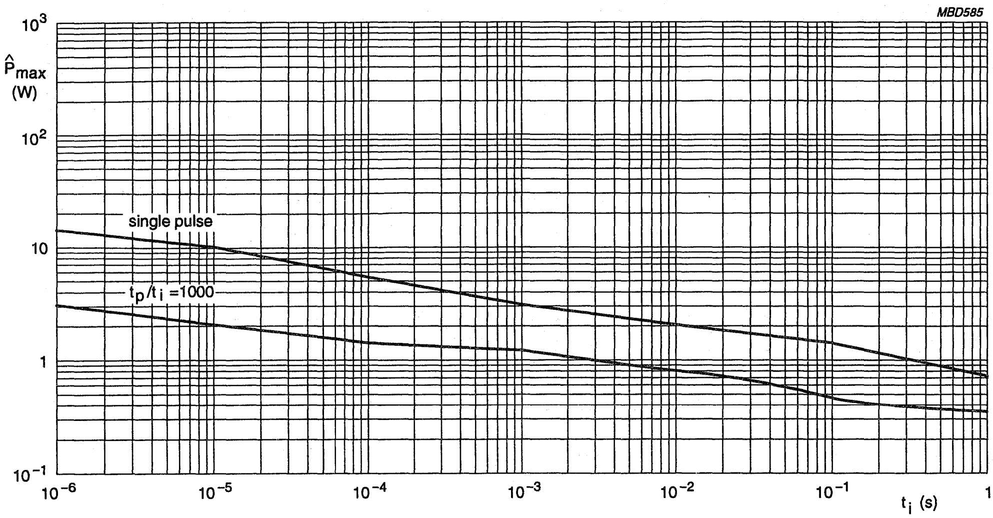


Fig.6 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration for R ≤ 10 kΩ, single pulse and repetitive pulse t_p/t_i = 1000.

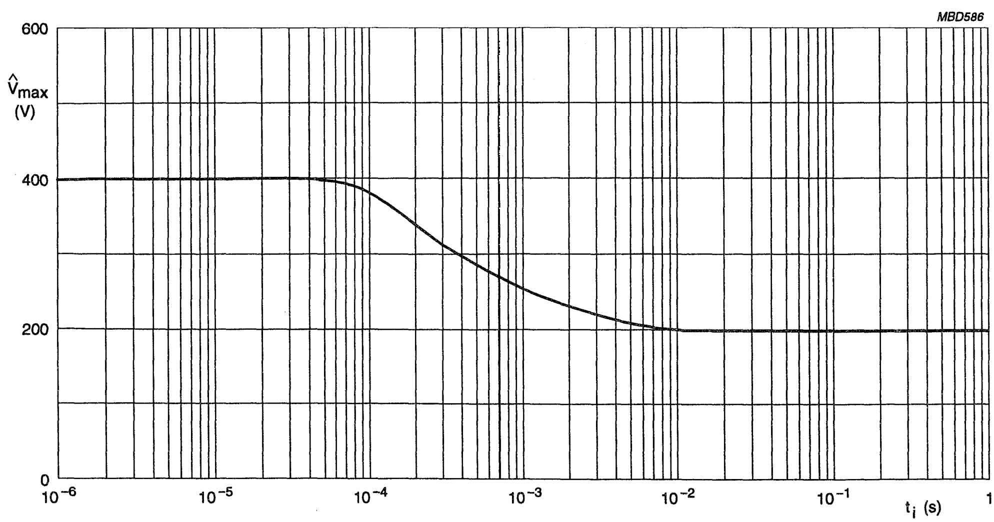
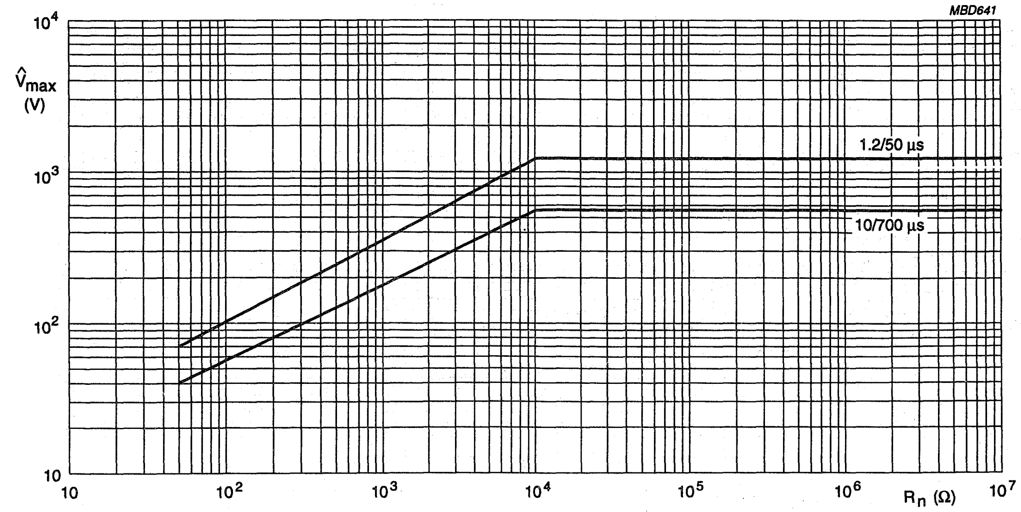


Fig.7 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration.



These pulses may not be applied on a regular basis.

Fig.8 Normstoß (German standard); maximum permissible peak pulse voltage without failing to 'open circuit' for RC02GP.

COMPOSITION OF THE CATALOGUE NUMBER

The resistors have a 12-digit catalogue number starting with 2322 727. The subsequent 5 digits indicate the packaging and resistance value (see Tables 1 and 2).

Table 1 First digit to indicate packaging for resistances as listed.

RESISTANCE RANGE	TOLERANCE (%)	SERIES	CATALOGUE NUMBER 2322 727			
			CARDBOARD TAPE ON REEL		BLISTER TAPE ON REEL	
			5000 units	10000 units	5000 units	10000 units
250 Ω to 1 MΩ	±1	E24/E96	2....	3...	1....	4....

To complete the catalogue number (see Table 1), replace the first three dots of the remaining 4-digit code by the first three digits of the resistance value. Replace the fourth dot (last digit) by a figure according to Table 2.

Table 2 Last digit of 12 NC.

RESISTANCE	LAST DIGIT
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

The catalogue number of a RC02GP resistor, value 4750 Ω, supplied on cardboard tape of 5000 units per reel is: 2322 727 64752.

TESTS AND REQUIREMENTS

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

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

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

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

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

Table 3

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.17	20 (Ta)	soldering	unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C; flux 600	good tinning (≥95% covered); no damage
		solderability	16 hours steam or 16 hours at 155 °C; unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C; flux 600	good tinning (≥95% covered); no damage
4.18	20 (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	14 (Na)	rapid change of temperature	30 minutes at −55 °C and 30 minutes at +125 °C; 5 cycles	ΔR/R max.: ±0.5% +0.05 Ω
4.22	6 (Fc)	vibration	frequency: 10 to 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	29 (Eb)	bump	3 × 1500 bumps in three directions; 40 g	no damage ΔR/R max.: ±0.5% +0.05 Ω

Precision resistor chip size 1206

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.23		climatic sequence:		
4.23.2	2 (Ba)	dry heat	16 hours; 125 °C	
4.23.3	30 (D)	damp heat (accelerated) 1st cycle	24 hours; 55 °C; 95 to 100% RH	
4.23.4	1 (Aa)	cold	2 hours; −55 °C	
4.23.5	13 (M)	low air pressure	1 hour; 8.5 kPa; 15 to 35 °C	
4.23.6	30 (D)	damp heat (accelerated) remaining cycles	5 days; 55 °C; 95 to 100% RH	R_{ins} min.: 1000 MΩ ΔR/R max.: ±1% +0.05 Ω
4.24.2	3 (Ca)	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; loaded with 0.01 P_n (IEC steps: 1 to 100 V); dissipation ≤1 mW	R_{ins} min.: 1000 MΩ ΔR/R max.: ±1% +0.05 Ω
4.25.1		endurance	1000 hours; 70 °C; nominal dissipation; 1.5 hours on and 0.5 hours off	ΔR/R max.: ±1% +0.05 Ω
4.6.1.1		insulation resistance	100 V (DC) after 1 minute	R_{ins} min.: 1000 MΩ
4.13		short time overload	room temperature; dissipation 6.25 × P_n; 5 s (voltage not more than 2 × V_{max})	ΔR/R max.: ±0.5% +0.05 Ω
4.8.4.2		temperature coefficient	between −55 °C and +125 °C	250 Ω to 1 MΩ: ≤ ±50 × 10^{-6}/K
4.12		noise	IEC publication 195 (measured with Quantech - equipment)	R < 1 kΩ: max. 1 μV/V R < 10 kΩ: max. 3 μV/V R < 100 kΩ: max. 6 μV/V R < 1 MΩ: max. 10 μV/V
4.23.2	27 (Ba)	endurance at upper category temperature	1000 hours; 125 °C; no load	no visual damage ΔR/R max.: ±0.5% +0.05 Ω
4.7		voltage proof on insulation	200 V (RMS) during 1 minute	no breakdown

Precision resistor chip size 0805

RC12G

FEATURES

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

APPLICATIONS

- Hand held measuring equipment
- Car telephones
- Camcorders.

DESCRIPTION

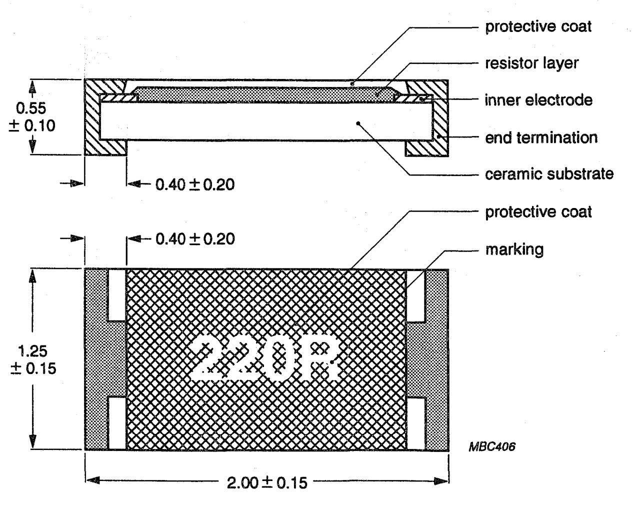
The resistors are constructed on a high grade ceramic body (aluminium oxide). Internal metal electrodes are added at each end and connected by a resistive paste which is applied to the top surface of the substrate. The composition of the paste is adjusted to give the approximate resistance required and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

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

QUICK REFERENCE DATA

DESCRIPTION	VALUE
Resistance range	100 Ω to 1 MΩ; E24/E96 series
Resistance tolerance	±1%
Temperature coefficient:	
100 Ω to 249 Ω	$\leq \pm 100 \times 10^{-6}$/K
250 Ω to 1 MΩ	$\leq \pm 50 \times 10^{-6}$/K
Absolute maximum dissipation at T_{amb} = 70 °C	0.063 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 115-8
Stability after:	
load, 1000 hours 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, 300 V max.	ΔR/R max.: ±0.5% +0.05 Ω

MECHANICAL DATA



Dimensions in mm.

Fig.1 Outlines.

Mass

0.55 g (per 100 units).

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 (PCBs). Electrical connection to the circuit is by wave, vapour phase or infrared soldering. The end terminations guarantee a reliable contact and the protective coating enables 'face down' mounting.

The 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 PCB and other discrete components on the reverse (mixed PCBs).

Soldering conditions

Surface Mounted Resistors RC12G are tested for solderability at 235 °C during 2 seconds. The test condition for no leaching is 260 °C for 60 seconds. Typical examples of soldering processes that provide reliable joints without any damage, are given in Figs 2, 3 and 4.

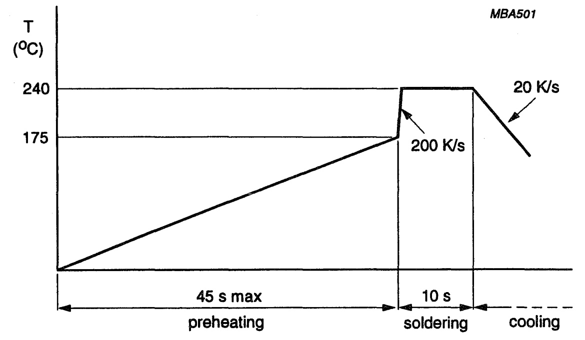


Fig.2 Infrared soldering.

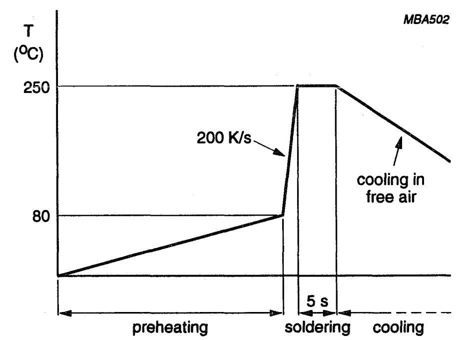


Fig.3 Wave soldering. The resistors may be soldered twice according to this method if necessary.

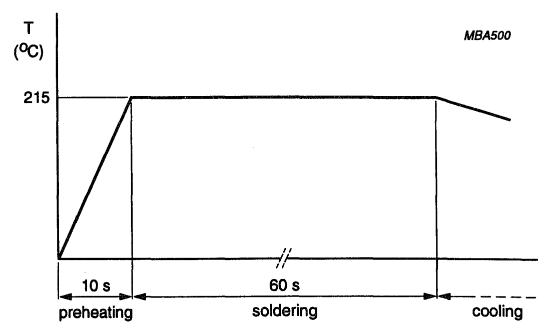


Fig.4 Vapour phase soldering.

Marking

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

4-DIGIT MARKING

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

Magnitude indicators.

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

Example.

MARKING	RESISTANCE
121R	121 Ω
4021	4.02 kΩ
7503	750 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 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 publication 115-8"*.

Dissipation

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

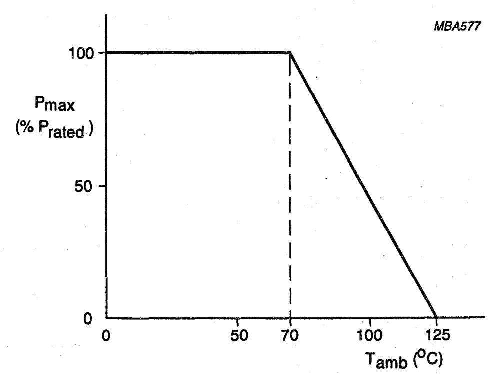


Fig.5 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

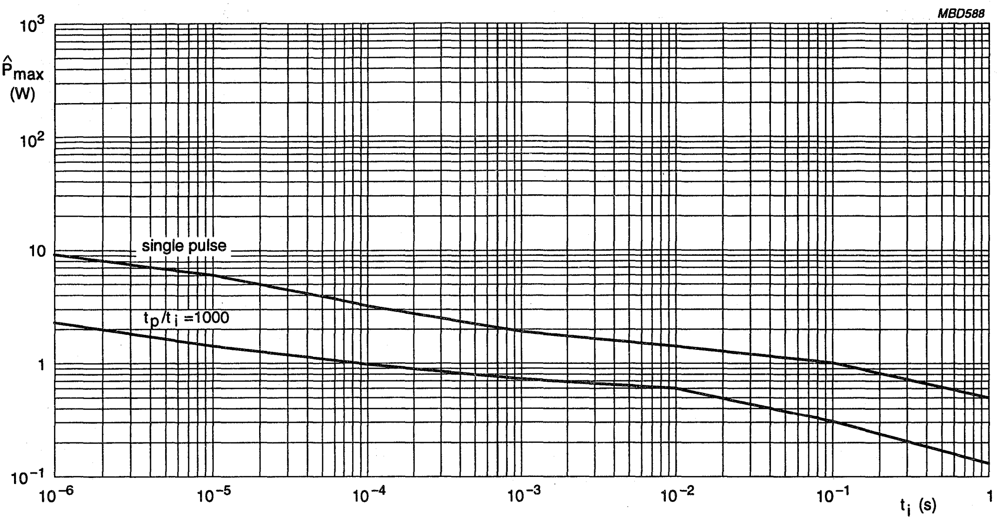


Fig.6 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration for $R \leq 10\ k\Omega$, single pulse and repetitive pulse $t_p/t_i = 1000$.

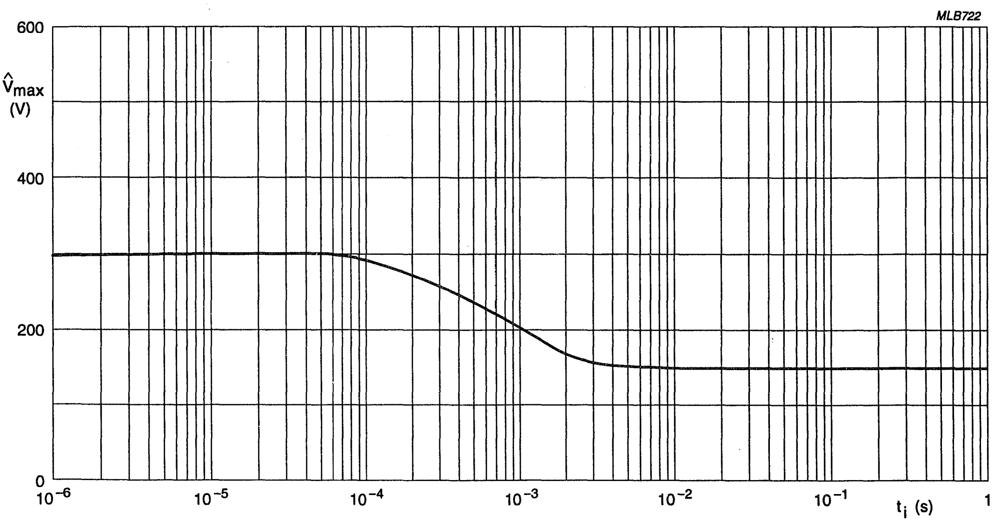
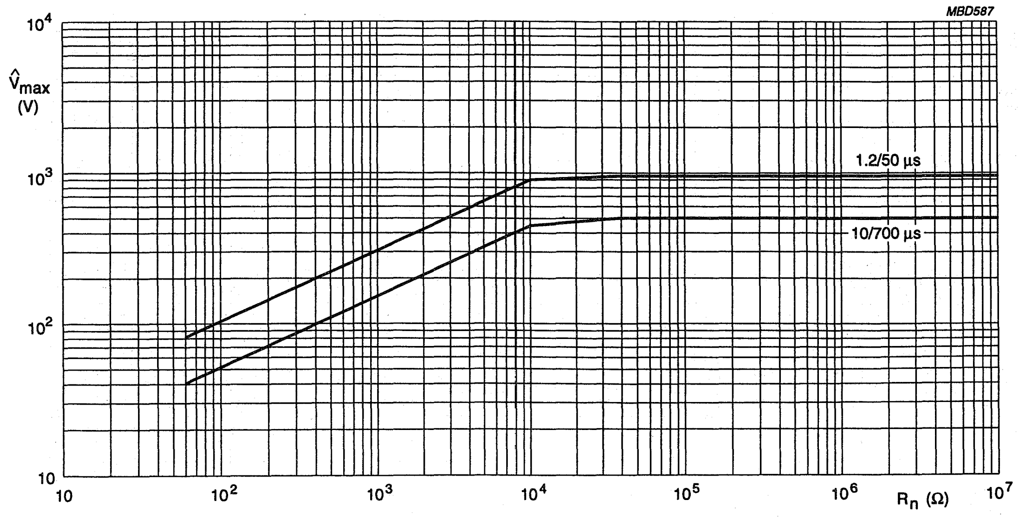


Fig.7 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration.



These pulses may not be applied on a regular basis.

Fig.8 Normstoß (German standard); maximum permissible peak pulse voltage without failing to 'open circuit' for RC12G.

COMPOSITION OF THE CATALOGUE NUMBER

The resistors have a 12-digit catalogue number starting with 2322. The subsequent 8 digits indicate the packaging and resistance value (see Tables 1 and 2).

Table 1 First 4 digits to indicate packaging for resistances as listed.

RESISTANCE RANGE	TOLERANCE (%)	SERIES	CATALOGUE NUMBER 2322			
			CARDBOARD TAPE ON REEL 732		BLISTER TAPE ON REEL 733	
			5000 units	10000 units	5000 units	10000 units
100 Ω to 1 MΩ	±1	E24/E96	6....	7....	6....	7....

To complete the catalogue number (see Table 1), replace the first three dots of the remaining 4-digit code by the first three digits of the resistance value. Replace the fourth dot (last digit) by a figure according to Table 2.

Table 2 Last digit of 12 NC.

RESISTANCE	LAST DIGIT
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

The catalogue number of a RC12G resistor, value 4750 Ω, supplied on cardboard tape of 5000 units per reel is: 2322 732 64752.

TESTS AND REQUIREMENTS

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

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

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

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

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

Table 3

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.17	20 (Ta)	soldering	unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C; flux 600	good tinning (≥95% covered); no damage
		solderability	16 hours steam or 16 hours at 155 °C; unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C; flux 600	good tinning (≥95% covered); no damage
4.18	20 (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	14 (Na)	rapid change of temperature	30 minutes at –55 °C and 30 minutes at +125 °C; 5 cycles	ΔR/R max.: ±0.25% +0.05 Ω
4.22	6 (Fc)	vibration	frequency: 10 to 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	29 (Eb)	bump	3 × 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 printed-circuit board; bending 5 mm over 90 mm	no visual damage ΔR/R max.: ±0.5% +0.05 Ω
4.24.		humidity load (JIS)	1000 hours; +40 °C; 90 to 95% RH; loaded with P_n or 150 V; max. 1.5 hours on and 0.5 hours off	ΔR/R max.: ±3% +0.1 Ω

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.23		climatic sequence:		
4.23.2	2 (Ba)	dry heat	16 hours; 125 °C	
4.23.3	30 (D)	damp heat (accelerated) 1st cycle	24 hours; 55 °C; 95 to 100% RH	
4.23.4	1 (Aa)	cold	2 hours; −55 °C	
4.23.5	13 (M)	low air pressure	1 hour; 8.5 kPa; 15 to 35 °C	
4.23.6	30 (D)	damp heat (accelerated) remaining cycles	5 days; 55 °C; 95 to 100% RH	R_{ins} min.: 1000 MΩ ΔR/R max.: ±1% +0.05 Ω
4.24.2	3 (Ca)	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; loaded with 0.01 P_n (IEC steps: 1 to 100 V); dissipation ≤1 mW	R_{ins} min.: 1000 MΩ ΔR/R max.: ±1% +0.05 Ω
4.25.1		endurance	1000 hours; 70 °C; nominal dissipation; 1.5 hours on and 0.5 hours off	ΔR/R max.: ±1% +0.05 Ω
4.6.1.1		insulation resistance	100 V (DC) after 1 minute	R_{ins} min.: 1000 MΩ
4.13		short time overload	room temperature; dissipation 6.25 × P_n; 5 s (voltage not more than 2 × V_{max})	ΔR/R max.: ±0.5% +0.05 Ω
4.8.4.2		temperature coefficient	between −55 °C and +125 °C	100 Ω to 249 Ω: ≤ ±100 × 10^{-6}/K 250 Ω to 1 MΩ: ≤ ±50 × 10^{-6}/K
4.12		noise	IEC publication 195 (measured with Quantech - equipment)	R < 1 kΩ: max. 1 µV/V R < 10 kΩ: max. 3 µV/V R < 100 kΩ: max. 6 µV/V R < 1 MΩ: max. 10 µV/V
4.23.2	27 (Ba)	endurance at upper category temperature	1000 hours; 125 °C; no load	ΔR/R max.: ±0.5% +0.05 Ω
4.7		voltage proof on insulation	150 V (RMS) during 1 minute	no breakdown or flashover

HIGH PRECISION

High precision resistor chip size 1206

RC03G

FEATURES

- Reduced size of final equipment
- Low assembly costs
- Higher component and equipment reliability.

APPLICATIONS

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

DESCRIPTION

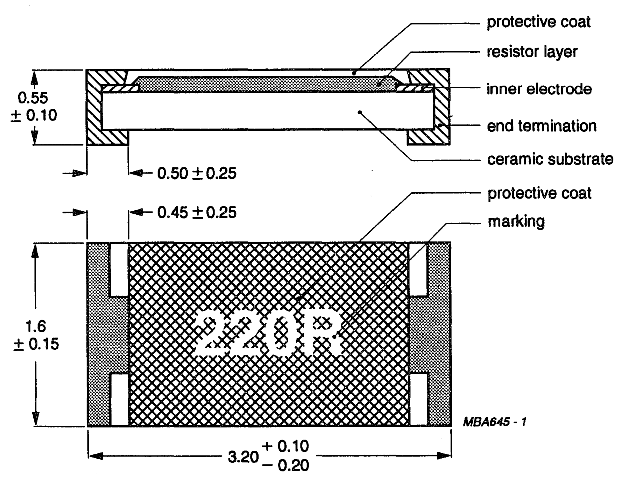
The resistors are constructed on a high grade ceramic body (aluminium oxide). Internal metal electrodes are added at each end and connected by a resistive paste which is applied to the top surface of the substrate. The composition of the paste is adjusted to give the approximate resistance required and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

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

QUICK REFERENCE DATA

DESCRIPTION	VALUE
Resistance range	100 Ω to 1 MΩ; E24/E96 series
Resistance tolerance	±0.5%
Temperature coefficient:	
100 Ω to 249 Ω	$\leq \pm 100 \times 10^{-6}$/K
250 Ω to 1 MΩ	$\leq \pm 50 \times 10^{-6}$/K
Absolute maximum 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 115-8
Stability after:	
load, 1000 hours at T_{amb} = 70 °C	ΔR/R max.: ±0.5% +0.05 Ω
load, 8000 hours 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

1.0 g (per 100 units).

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 (PCBs). Electrical connection to the circuit is by wave, vapour phase or infrared soldering. The end terminations guarantee a reliable contact and the protective coating enables 'face down' mounting.

The 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 PCB and other discrete components on the reverse (mixed PCBs).

Soldering conditions

Surface Mounted Resistors RC03G are tested for solderability at 235 °C during 2 seconds. The test condition for no leaching is 260 °C for 60 seconds. Typical examples of soldering processes that provide reliable joints without any damage, are given in Figs 2, 3 and 4.

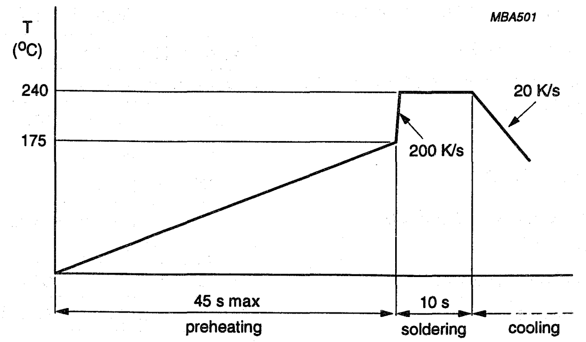


Fig.2 Infrared soldering.

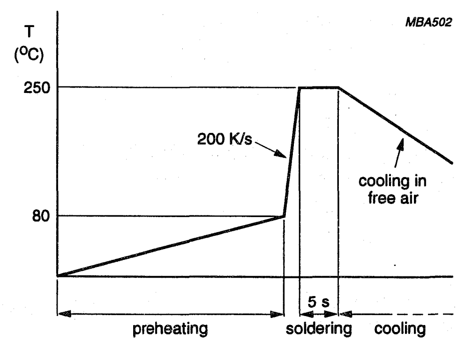


Fig.3 Wave soldering. The resistors may be soldered twice according to this method if necessary.

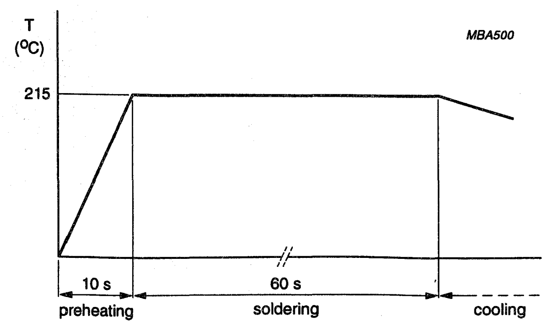


Fig.4 Vapour phase soldering.

High precision resistor chip size 1206

RC03G

Marking

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

4-DIGIT MARKING

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

Magnitude indicators.

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

Example.

MARKING	RESISTANCE
121R	121 Ω
4021	4.02 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 ±0.5%. The values of the E24 series are in accordance with *"IEC publication 63"*.

The limiting voltage (RMS) is 200 V. This is the maximum voltage that may be continuously applied to the resistor element, see *"IEC publication 115-8"*.

Dissipation

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

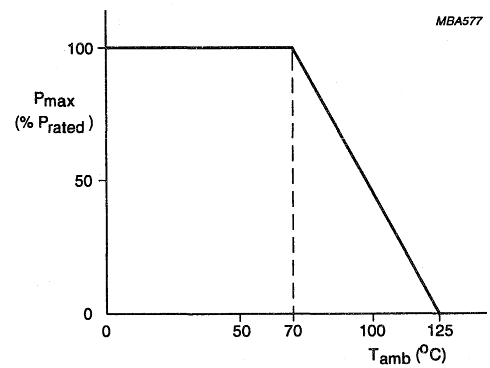


Fig.5 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

High precision resistor chip size 1206

RC03G

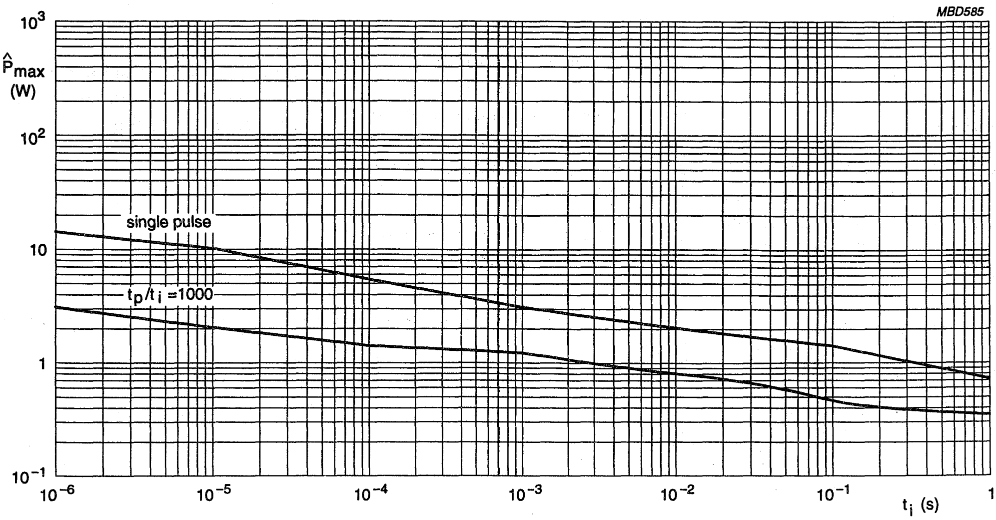


Fig.6 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration for R ≤ 10 kΩ, single pulse and repetitive pulse t_p/t_i = 1000.

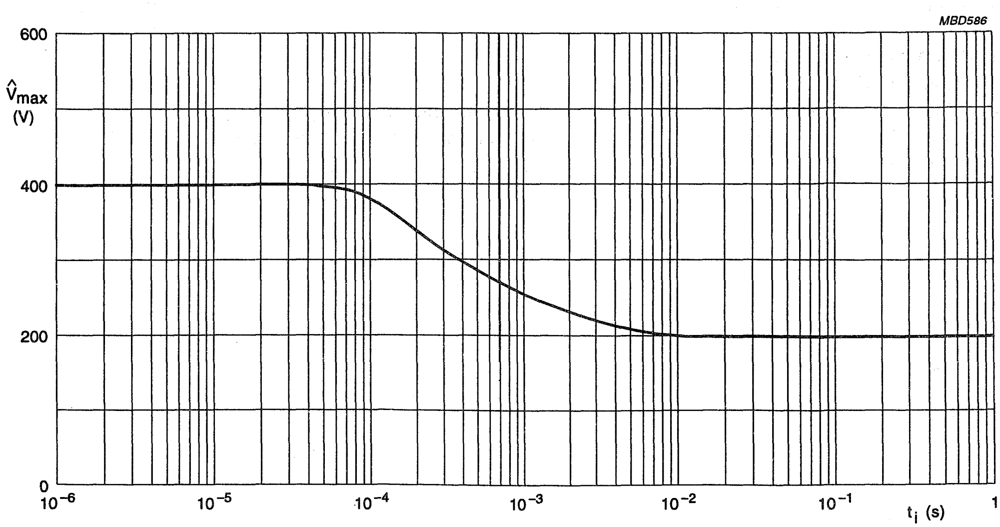
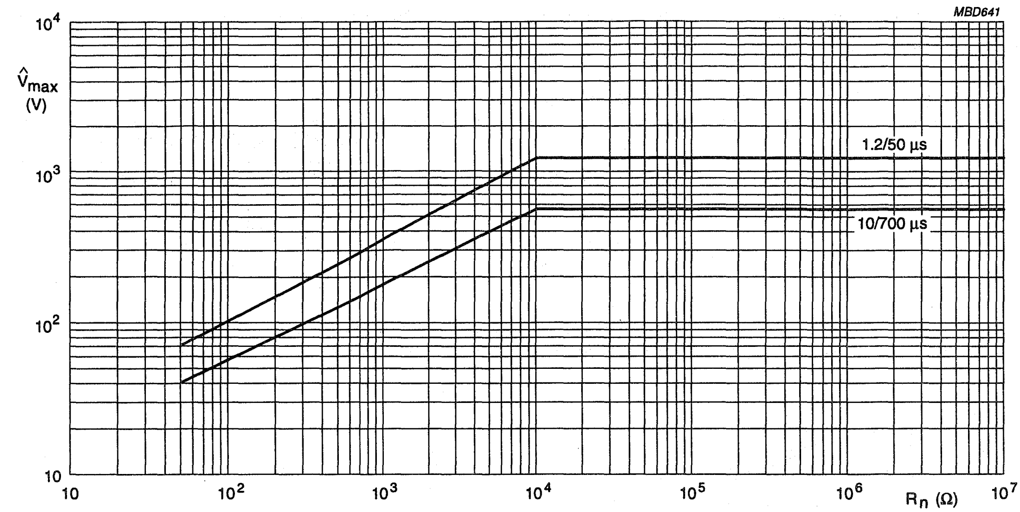


Fig.7 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration.



These pulses may not be applied on a regular basis.

Fig.8 Normstoß (German standard); maximum permissible peak pulse voltage without failing to 'open circuit' for RC03G.

High precision resistor chip size 1206

RC03G

COMPOSITION OF THE CATALOGUE NUMBER

The resistors have a 12-digit catalogue number starting with 2322 725. The subsequent 5 digits indicate the packaging and resistance value (see Tables 1 and 2).

Table 1 First digit to indicate packaging for resistances as listed.

RESISTANCE RANGE	TOLERANCE (%)	SERIES	CATALOGUE NUMBER 2322 725 ..... BLISTER TAPE ON REEL 5000 units
100 Ω to 1 MΩ	0.5	E24/E96	1....

To complete the catalogue number (see Table 1), replace the first three dots of the remaining 4-digit code by the first three digits of the resistance value. Replace the fourth dot (last digit) by a figure according to Table 2.

Table 2 Last digit of 12 NC.

RESISTANCE	LAST DIGIT
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

The catalogue number of a RC03G resistor, value 4750 Ω, supplied on cardboard tape of 5000 units per reel is: 2322 734 64752.

TESTS AND REQUIREMENTS

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

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

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

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

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

Table 3

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.17	20 (Ta)	soldering	unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±10 °C; flux 600; 0.2% Cl activated	good tinning; no damage
4.18	20 (Tb)	resistance to soldering heat	10 s; 260 ±5 °C; flux 600	ΔR/R max.: ±0.25% +0.05 Ω
4.19	14 (Na)	rapid change of temperature	30 minutes at −55 °C and 30 minutes at +125 °C; 5 cycles	ΔR/R max.: ±0.25% +0.05 Ω
4.22	6 (Fc)	vibration	frequency: 10 to 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	29 (Eb)	bump	3 × 1500 bumps in three directions; 40 g	no damage ΔR/R max.: ±0.25% +0.05 Ω
4.23		climatic sequence:		
4.23.2	2 (Ba)	dry heat	16 hours; 125 °C	
4.23.3	30 (D)	damp heat (accelerated) 1st cycle	24 hours; 55 °C; 95 to 100% RH	
4.23.4	1 (Aa)	cold	2 hours; −55 °C	
4.23.5	13 (M)	low air pressure	1 hour; 8.5 kPa; 15 to 35 °C	
4.23.6	30 (D)	damp heat (accelerated) remaining cycles	5 days; 55 °C; 95 to 100% RH	R_{ins} min.: 1000 MΩ ΔR/R max.: ±1% +0.05 Ω
4.24.2	3 (Ca)	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; dissipation ≤1.25 mW	R_{ins} min.: 1000 MΩ ΔR/R max.: ±1% +0.05 Ω
4.25.1		endurance	1000 hours; 70 °C; nominal dissipation; 1.5 hours on and 0.5 hours off	ΔR/R max.: ±0.5% +0.05 Ω
4.6.1.1		insulation resistance	100 V (DC) after 1 minute	R_{ins} min.: 1000 MΩ

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.13		short time overload	room temperature; dissipation 6.25 × P_n; 5 s (voltage not more than 2 × V_{max})	ΔR/R max.: ±0.25% +0.05 Ω
4.8.4.2		temperature coefficient	between −55 °C and +125 °C	100 Ω to 249 Ω: ≤ ±100 × 10^{-6}/K 250 Ω to 1 MΩ: ≤ ±50 × 10^{-6}/K
4.12		noise	IEC publication 195 (measured with Quantech - equipment)	R < 1 kΩ: max. 1 μV/V R < 10 kΩ: max. 3 μV/V R < 100 kΩ: max. 6 μV/V
4.23.2	27 (Ba)	endurance at upper category temperature	1000 hours; 125 °C; no load	no visual damage ΔR/R max.: ±0.5% + 0.05 Ω
4.7		voltage proof on insulation	200 V (RMS) during 1 minute	no breakdown

Metal film precision resistor chip size 1206

MPC01

FEATURES

- Reduced size of final equipment
- Lower assembly costs
- Excellent pulse stability for single pulse conditions, typical value: 100 W, 1 μs
- High stability and low temperature coefficient.

APPLICATIONS

- Computers
- Telecommunication equipment
- Test and measuring equipment.

DESCRIPTION

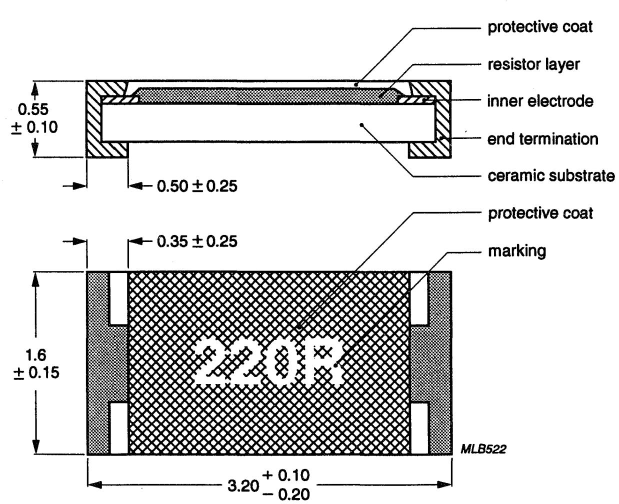
A metal film layer is deposited on a high grade ceramic body (aluminium oxide). This resistive layer is trimmed to its nominal value and on both ends a contact is made which will guarantee optimum solderability. This is achieved by applying several layers and for ease of soldering the outer layer consists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

The resistive layer is covered with a protective coat.

QUICK REFERENCE DATA

DESCRIPTION	VALUE
Resistance range	10 Ω to 100 kΩ; preferred values E24 or E96 series
Resistance tolerance	±0.1%
Temperature coefficient	≤25 × 10^{-6}/K
Absolute maximum 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 phenol PCB
Climatic category (IEC 68)	55/125/56
Basic specification	IEC 115-8
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.: ±0.10% +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.

Metal film precision resistor chip size 1206

MPC01

Mass

1.00 g (per 100 units).

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 (PCBs). Electrical connection to the circuit can be made by wave, vapour phase or infrared soldering. The end terminations guarantee a reliable contact.

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 PCB and other discrete components on the reverse (mixed PCBs).

Soldering conditions

Surface Mounted Resistors MPC01 are tested for solderability at 235 °C during 2 seconds. The test condition for no leaching is 260 °C for 60 seconds. Typical examples of soldering processes that provide reliable joints without any damage, are given in Figs 2, 3 and 4.

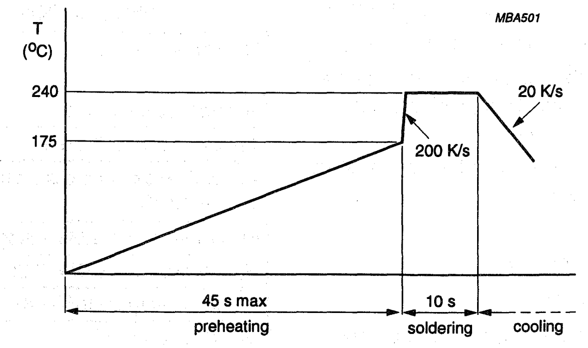


Fig.2 Infrared soldering.

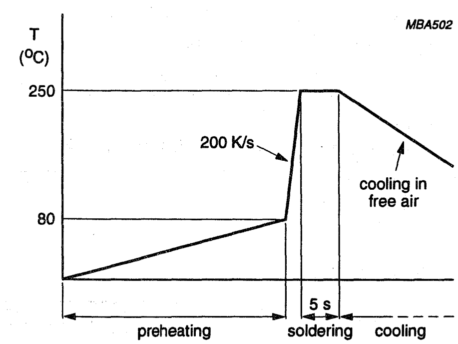


Fig.3 Wave soldering. The resistors may be soldered twice according to this method if necessary.

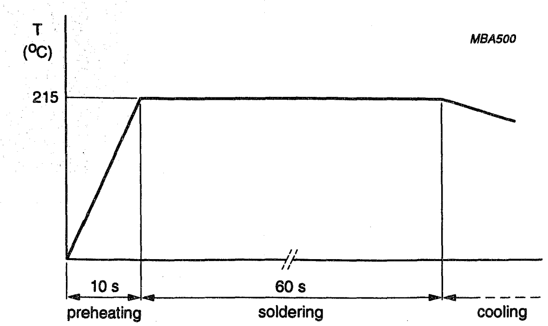


Fig.4 Vapour phase soldering.

Marking(1)

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 three digits are significant, the fourth being an indication of magnitude.

(1) Only resistors that can be marked with 3 significant numbers are marked.

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 and those with 3 significant numbers are marked with four digits. Resistors with different values are not marked.

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 publication 115-8"*.

Dissipation

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

Magnitude indicators.

RESISTANCE	INDICATOR
10 to 976 Ω	R
1 to 9.76 kΩ	1
10 to 97.6 kΩ	2
100 kΩ	3

Example.

MARKING	RESISTANCE
121R	121 Ω
4021	4.02 kΩ
1003	100 kΩ

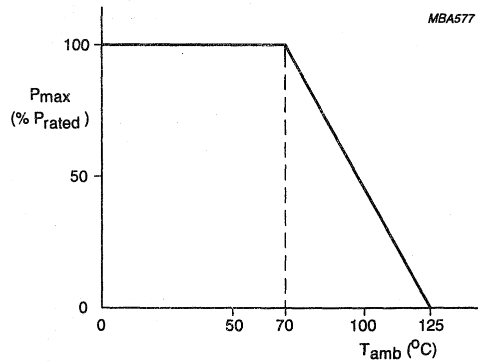


Fig.5 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

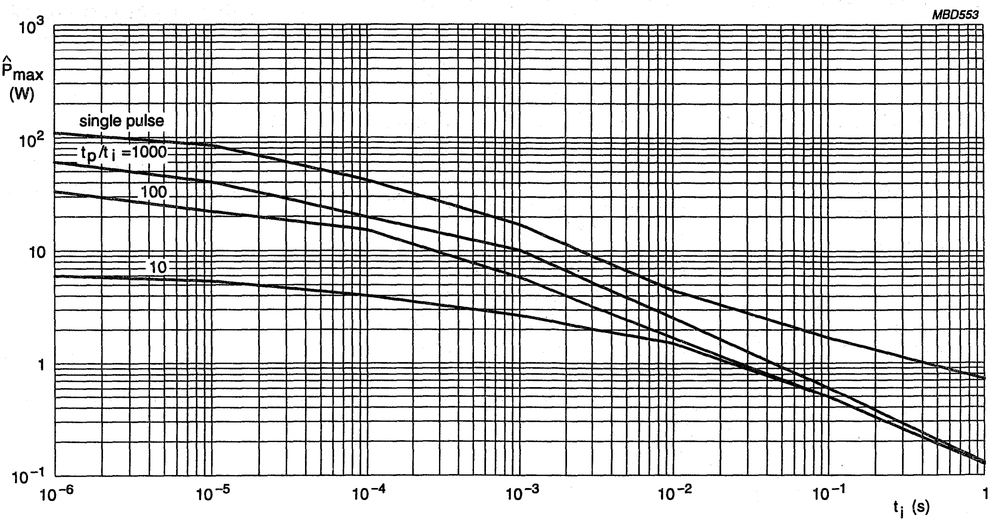


Fig.6 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration for R ≤ 10 kΩ, single pulse and repetitive pulse t_p/t_i.

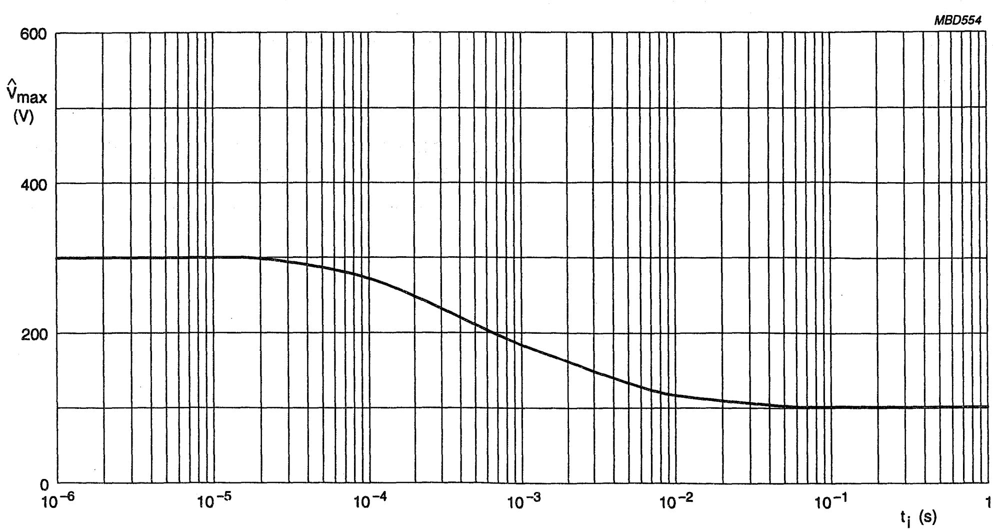
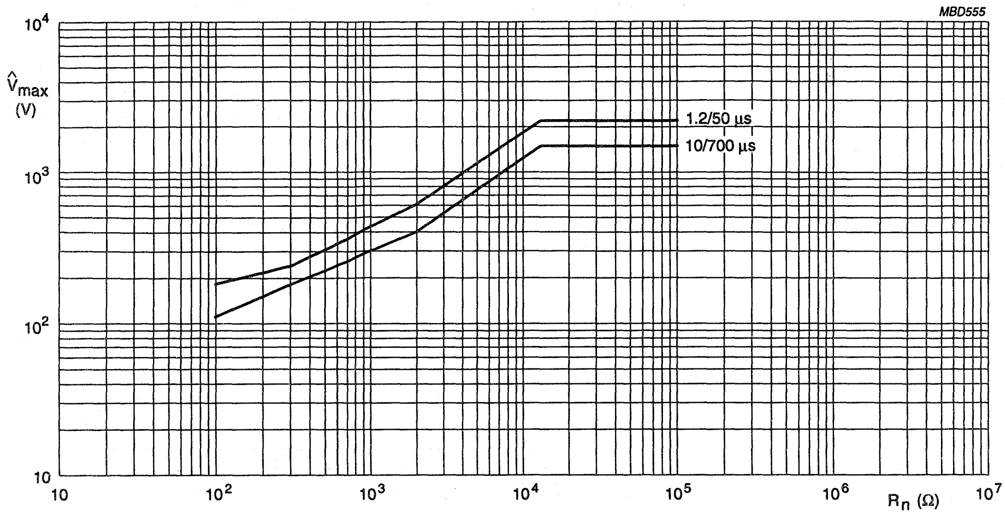


Fig.7 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration.

Metal film precision resistor chip size 1206

MPC01



These pulses may not be applied on a regular basis.

Fig.8 Normstoß (German standard); maximum permissible peak pulse voltage ($\hat{V}_{max}$) without failing to 'open circuit' for MPC01.

COMPOSITION OF THE CATALOGUE NUMBER

The resistors have a 12-digit catalogue number starting with 2322 741. The subsequent 5 digits indicate the packaging and resistance value (see Tables 1 and 2).

Table 1 First digit to indicate packaging for resistances as listed.

RESISTANCE RANGE	TOLERANCE (%)	TC (K^{-1})	CATALOGUE NUMBER 2322 741	
			BLISTER TAPE ON REEL	
			1000 units	5000 units
10 Ω to 100 kΩ	±0.1	≤25 × 10^{-6}	2....	3....

To complete the catalogue number, replace the first three dots of the remaining 4-digit code by the first three digits of the resistance value. Replace the fourth dot (last digit) by a figure according to Table 2.

Table 2 Last digit of 12 NC.

RESISTANCE	LAST DIGIT
10 to 97.6 Ω	9
100 to 976 Ω	1
1 to 9.76 kΩ	2
10 to 97.6 kΩ	3
100 kΩ	4

TESTS AND REQUIREMENTS

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

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

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

Air pressure: 86 kPa to 106 kPa (860 mbar to 1 060 mbar).

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

Table 3

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.17	20 (Ta)	soldering	unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C; flux 600	good tinning; no damage
4.18	20 (Tb)	resistance to soldering heat	10 s; 260 ±5 °C; flux 600	ΔR/R max.: ±0.10% +0.05 Ω
4.19	14 (Na)	rapid change of temperature	30 minutes at –55 °C and 30 minutes at +125 °C; 5 cycles	ΔR/R max.: ±0.10% +0.05 Ω
4.22	6 (Fc)	vibration	frequency: 10 to 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	29 (Eb)	bump	3 × 1 500 bumps in three directions; 40 g	no damage ΔR/R max.: ±0.10% +0.05 Ω
4.23		climatic sequence:		
4.23.2	2 (Ba)	dry heat	16 hours; 125 °C	
4.23.3	30 (D)	damp heat (accelerated)	24 hours; 55 °C; 95 to 100% RH	
4.23.4	1 (Aa)	cold	2 hours; –55 °C	
4.23.5	13 (M)	low air pressure	1 hour; 8.5 kPa; 15 to 35 °C	
4.23.6	30 (D)	damp heat (accelerated) remaining cycles	5 days; 55 °C; 95 to 100% RH	R_{ins} min.: 1 000 MΩ ΔR/R max.: 0.10% +0.05 Ω
4.24.2	3 (Ca)	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; dissipation ≤1.25 mW	R_{ins} min.: 1 000 MΩ ΔR/R max.: 0.25% +0.05 Ω
4.25.1		endurance	1 000 hours; 70 °C; nominal dissipation; 1.5 hours on and 0.5 hours off	ΔR/R max.: 0.10% +0.05 Ω
4.6.1.1		insulation resistance	100 V (DC) after 1 minute	R_{ins} min.: 1 000 MΩ
4.13		short time overload	room temperature; dissipation 6.25 × P_n; 5 s (voltage not more than 2 × V_{max})	ΔR/R max.: 0.10% +0.05 Ω
4.8.4.2		temperature coefficient	between –55 °C and +125 °C	≤25 × 10^{-6}/K

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.12		noise	IEC publication 195	≤0.10 μV/V
4.23.2	27 (Ba)	endurance at upper category temperature	1000 hours; 125 °C; no load	no visual damage ΔR/R max.: 0.10% +0.05 Ω
4.7		voltage proof on insulation	100 V (DC or RMS) during 1 minute	no breakdown
		JIS-pulse test	2.5 × rated voltage or max. overload; 1 s on and 25 s off; 10^4 cycles	ΔR/R max.: 0.5% +0.05 Ω

POWER

Power resistor chip size 1218

PRC201

FEATURES

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

APPLICATIONS

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

DESCRIPTION

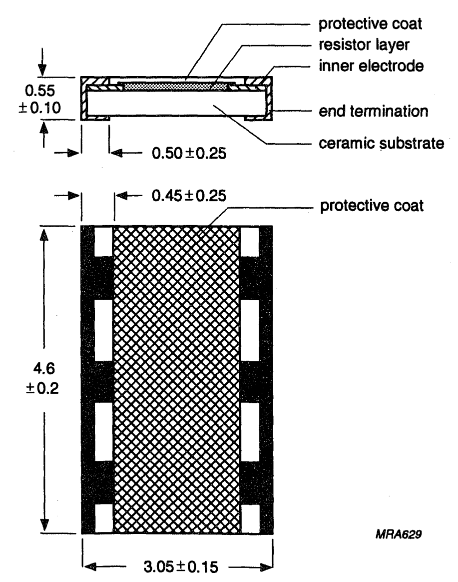
The resistors are constructed on a high grade ceramic body (aluminium oxide). Internal metal electrodes are added at each end and connected by a resistive paste which is applied to the top surface of the substrate. The composition of the paste is adjusted to give the approximate resistance required and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

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

QUICK REFERENCE DATA

DESCRIPTION	VALUE
Resistance range	1 Ω to 1 MΩ; E24 series
Resistance tolerance	±5%
Temperature coefficient:	
1 Ω to 10 Ω	$\leq \pm 200 \times 10^{-6}$/K
11 Ω to 1 MΩ	$\leq \pm 100 \times 10^{-6}$/K
Absolute maximum dissipation at T_{amb} = 70 °C	1 W
Maximum permissible voltage	200 V (DC or RMS)
Operating temperature range	−55 °C to +155 °C
Basic specification	IEC 115-8
Stability after:	
load, 1000 hours at T_{amb} = 70 °C	ΔR/R max.: ±3% +0.10 Ω
climatic tests	ΔR/R max.: ±3% +0.10 Ω
resistance to soldering heat test	ΔR/R max.: ±1% +0.05 Ω
short time overload	ΔR/R max.: ±1% +0.05 Ω

MECHANICAL DATA



Dimensions in mm.

Fig.1 Outlines.

Power resistor chip size 1218

PRC201

Mass

3 g (per 100 units).

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 (PCBs). Electrical connection to the circuit is by wave, vapour phase or infrared soldering. The end terminations guarantee a reliable contact and the protective coating enables 'face down' mounting.

Ensure that the temperature rise of the resistor body does not affect nearby components or materials by conducted or convected heat.

The hot-spot temperature and the solder joint temperature rise of the resistor body, are dependent on both the PCB material and mounting position. Figures 5, 6 and 7 show the hot-spot temperature and the solder joint temperature rise of the resistor body, horizontally mounted, as a function of dissipated power.

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 PCB and other discrete components on the reverse (mixed PCBs).

Soldering conditions

Surface Mounted Resistors PRC201 are tested for solderability at 235 °C during 2 seconds. The test condition for no leaching is 260 °C for 60 seconds. Typical examples of soldering processes that provide reliable joints without any damage, are given in Figs 2, 3 and 4.

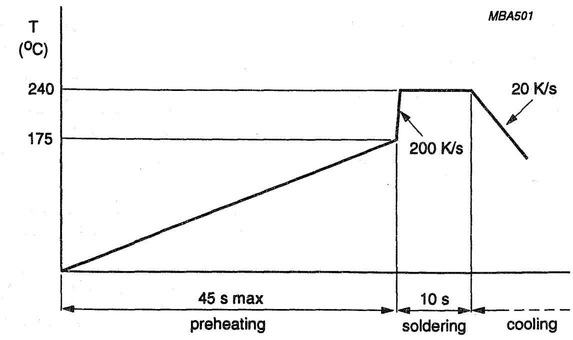


Fig.2 Infrared soldering.

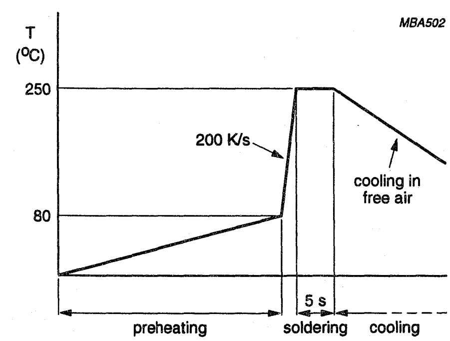


Fig.3 Wave soldering. The resistors may be soldered twice according to this method if necessary.

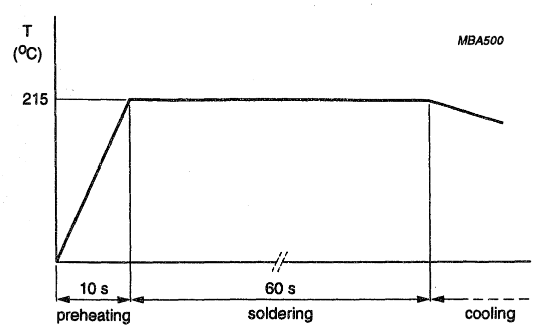


Fig.4 Vapour phase soldering.

Temperature rise

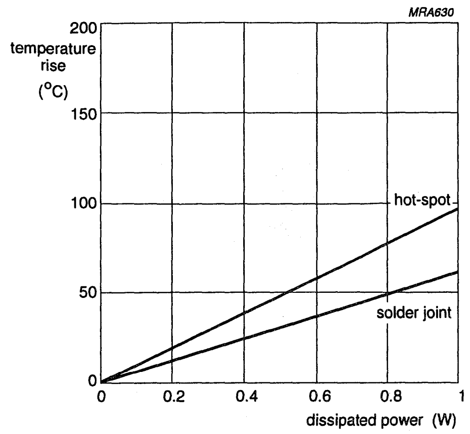


Fig.5 Temperature rise at hot-spot and solder joint as a function of dissipated power, for a PRC201 resistor mounted horizontally on ceramic PCB.

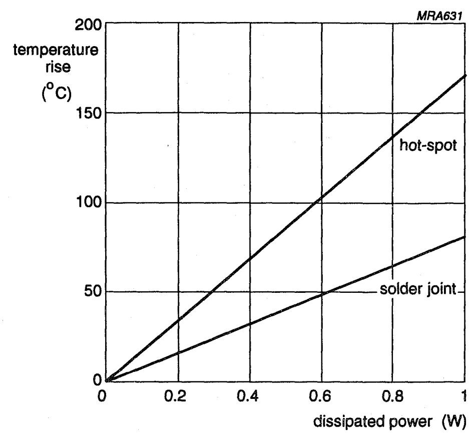


Fig.6 Temperature rise at hot-spot and solder joint as a function of dissipated power, for a PRC201 resistor mounted horizontally on a FR4 PCB.

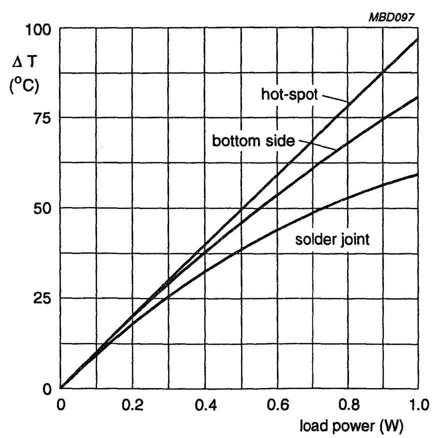
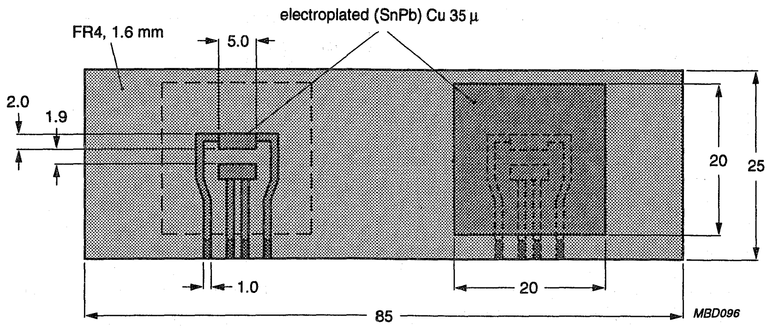


Fig.7 Temperature rise at hot-spot and solder joint as a function of dissipated power, for a PRC201 resistor horizontally mounted on the test substrate.



Dimensions in mm.

Fig.8 Test substrate layout.

Marking

Each resistor is marked with the nominal resistance value.

3-DIGIT MARKING

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

Magnitude indicators.

RESISTANCE	INDICATOR
1 to 910 Ω	R
1 to 910 kΩ	K
1 MΩ	M

Example.

MARKING	RESISTANCE
120R	120 Ω
4K70	4.70 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%. 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 publication 115-8"*.

Dissipation

The rated power that the resistor can dissipate depends on the operating temperature (see Fig.9).

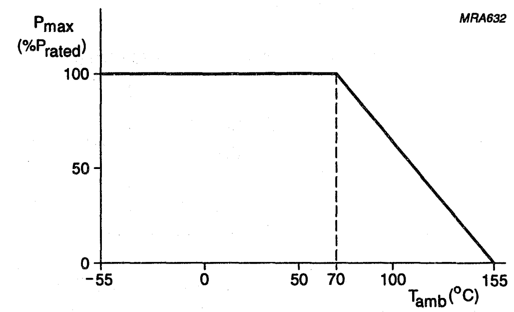
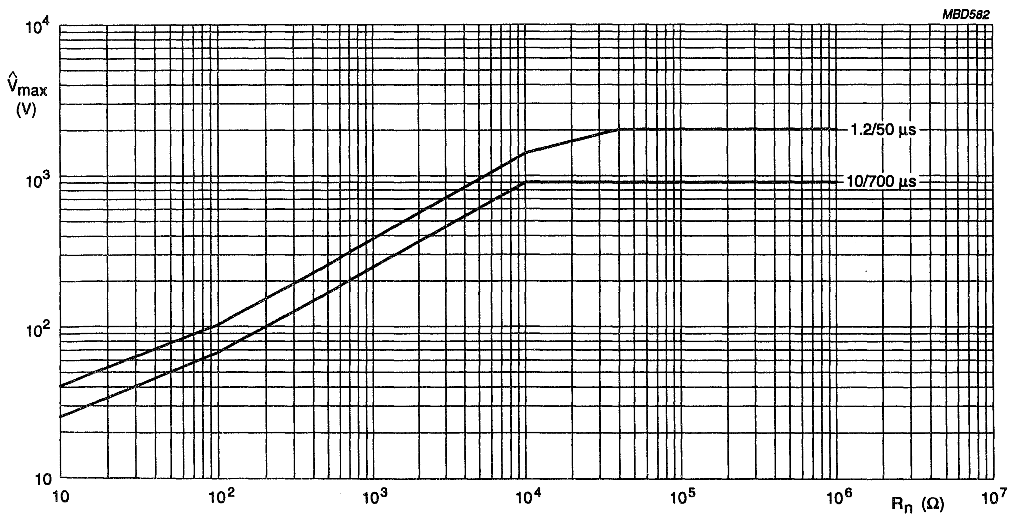


Fig.9 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).



These pulses may not be applied on a regular basis.

Fig.10 Normstoß (German standard); maximum permissible peak pulse voltage without failing to 'open circuit' for PRC201.

COMPOSITION OF THE CATALOGUE NUMBER

The resistors have a 12-digit catalogue number starting with 2322 735. The subsequent 5 digits indicate the packaging and resistance value (see Tables 1 and 2).

Table 1 First 2 digits to indicate packaging for resistances as listed.

RESISTANCE RANGE	TOLERANCE (%)	SERIES	CATALOGUE NUMBER 2322 735	
			BLISTER TAPE ON REEL	
			1000 units	5000 units
1 Ω to 1 MΩ	±5	E24	30...	60...

To complete the catalogue number (see Table 1), replace the first two dots of the remaining 3-digit code by the first two digits of the resistance value. Replace the third dot (last digit) by a figure according to Table 2.

Table 2 Last digit of 12 NC.

RESISTANCE	LAST DIGIT
1 to 9.1 Ω	8
10 to 91 Ω	9
100 to 910 Ω	1
1 to 9.1 kΩ	2
10 to 91 kΩ	3
100 to 910 kΩ	4
1 MΩ	5

Ordering example

The catalogue number of a PRC201 resistor, value 470 Ω, supplied on cardboard tape of 5000 units per reel is: 2322 735 60471.

TESTS AND REQUIREMENTS

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

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

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

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

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

Table 3

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
Tests in accordance with the schedule of IEC publication 115-8				
4.4.1		visual examination		no holes; clean surface; no damage
4.4.2		dimensions (outline)	gauge	0.45 mm ≤ T ≤ 0.65 mm 4.4 mm ≤ W ≤ 4.8 mm 2.9 mm ≤ L ≤ 3.2 mm
4.5		resistance	applied voltage (+0/–10%): R < 10 Ω: 0.1 V 10 Ω ≤ R < 100 Ω: 0.3 V 100 Ω ≤ R < 1 kΩ: 1 V 1 kΩ ≤ R < 10 kΩ: 3 V 10 kΩ ≤ R < 100 kΩ: 10 V 100 kΩ ≤ R < 1 MΩ: 25 V 1 MΩ: 50 V	$R - R_{nom}$: max. ±5%
4.18	20 (Tb)	resistance to soldering heat	10 s; 260 ±5 °C; flux 600	ΔR/R max.: ±1% +0.05 Ω
4.29	45 (Xa)	component solvent resistance	isopropyl alcohol; H_2O	no visible damage
4.17	20 (Ta)	solderability	unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C; flux 600	good tinning (≥95% covered); no damage
4.7		voltage proof on insulation	200 V (RMS) during 1 minute	no breakdown or flashover
4.13		short time overload	room temperature; dissipation 6.25 × P_n; 5 s (voltage not more than 2 × V_{max})	ΔR/R max.: ±1% +0.05 Ω
4.33		bending	resistors mounted on a glass epoxy resin printed-circuit board (FR4): bending 2 mm over 90 mm	no damage ΔR/R max.: ±1% +0.05 Ω

Power resistor chip size 1218

PRC201

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
Tests in accordance with the schedule of IEC publication 115-8				
4.19	14 (Na)	rapid change of temperature	30 minutes at –55 °C and 30 minutes at +125 °C; 5 cycles	no visible damage ΔR/R max.: ±0.1% +0.05 Ω
4.23		climatic sequence:		
4.23.2	2 (Ba)	dry heat	16 hours; 155 °C	
4.23.3	30 (D)	damp heat (accelerated) 1st cycle	24 hours; 55 °C; 95 to 100% RH	
4.23.4	1 (Aa)	cold	2 hours; –55 °C	
4.23.5	13 (M)	low air pressure	1 hour; 8.5 kPa; 15 to 35 °C	
4.23.6	30 (D)	damp heat (accelerated) remaining cycles	5 days; 55 °C; 95 to 100% RH	ΔR/R max.: ±3% +0.1 Ω
4.6.1.1		insulation resistance	100 V (DC) after 1 minute	R_{ins} min.: 1000 MΩ
4.24.2	3 (Ca)	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; loaded with 0.01 P_n (IEC steps: 4 to 100 V)	no visible damage ΔR/R max.: ±3% +0.1 Ω
4.25.1		endurance (at 70 °C)	1000 hours; loaded with P_n or V_{max}; 1.5 hours on and 0.5 hours off	no visible damage ΔR/R max.: ±3% +0.1 Ω
4.23.2	27 (Ba)	endurance at upper category temperature	1000 hours; 155 °C; no load	no visible damage ΔR/R max.: ±3% +0.1 Ω
4.8.4.2		temperature coefficient	at 20/–55/20 °C and 20/155/20 °C	1 Ω ≤ R ≤ 10 Ω: ΔR/R max.: $\pm 200 \times 10^{-6}$/K 11 Ω ≤ R: ΔR/R max.: $\pm 100 \times 10^{-6}$/K
Other tests in accordance with IEC 115 clauses and IEC 68 test method				
4.17	20 (Tb)	solderability (after ageing)	16 hours steam or 16 hours at 155 °C; unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C; flux 600	good tinning (≥95% covered); no damage
4.22	6 (Fc)	vibration (mounted state)	frequency: 10 to 500 Hz; displacement 1.5 mm or acceleration 10 g; three directions; total 6 hours	no damage ΔR/R max.: ±1% +0.05 Ω
4.20	29 (Eb)	bump (mounted state)	3 × 1500 bumps in three directions; 40 g	no damage ΔR/R max.: ±1% +0.05 Ω
Other applicable tests				
		leaching	unmounted chips 60 s; 260 ±5 °C	good tinning; no leaching

APPLICATION SPECIFIC

Low-ohmic resistor chip size 1206

LRC01

FEATURES

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

APPLICATIONS

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

DESCRIPTION

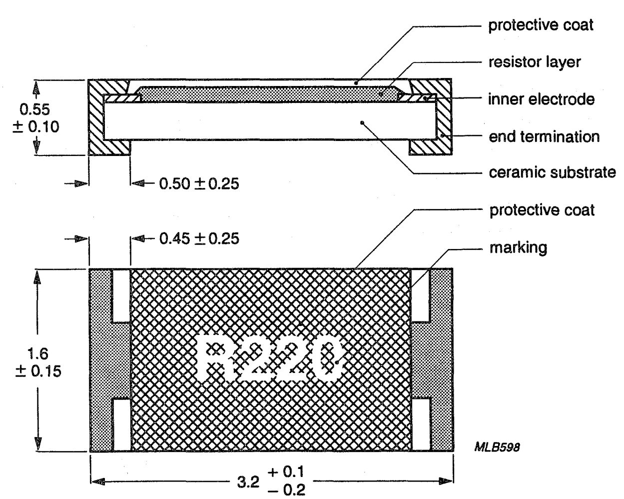
The resistors are constructed on a high grade ceramic body (aluminium oxide). Internal metal electrodes are added at each end and connected by a resistive paste which is applied to the top surface of the substrate. The composition of the paste is adjusted to give the approximate resistance required and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

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

QUICK REFERENCE DATA

DESCRIPTION	VALUE
Resistance range	100 mΩ to 910 mΩ; E24 series
Resistance tolerance	±5%
Temperature coefficient:	
100 mΩ ≤ R < 150 mΩ	≤ ±1 000 × 10^{-6}/K
150 mΩ ≤ R < 400 mΩ	≤ ±700 × 10^{-6}/K
400 mΩ ≤ R < 1 Ω	≤ ±250 × 10^{-6}/K
Absolute maximum dissipation at T_{amb} = 70 °C	0.25 W
Operating temperature range	–55 to +125 °C
Climatic category (IEC 68)	55/125/56
Basic specification	IEC 115-8
Stability after:	
load, 1 000 hours at T_{amb} = 70 °C	ΔR/R max.: ±3% +0.10 Ω (typ. 1%)
climatic tests	ΔR/R max.: ±3% +0.10 Ω (typ. 1%)
resistance to soldering heat test	ΔR/R max.: ±1% +0.05 Ω (typ. 0.25%)
short time overload	ΔR/R max.: ±1% +0.05 Ω (typ. 0.5%)

MECHANICAL DATA



Dimensions in mm.

Fig.1 Outlines.

Mass

1.00 g (per 100 units).

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 (PCBs). Electrical connection to the circuit is by wave, vapour phase or infrared soldering. The end terminations guarantee a reliable contact and the protective coating enables 'face down' mounting.

The 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 PCB and other discrete components on the reverse (mixed PCBs).

Soldering conditions

Surface Mounted Resistors LRC01 are tested for solderability at 235 °C during 2 seconds. The test condition for no leaching is 260 °C for 60 seconds. Typical examples of soldering processes that provide reliable joints without any damage, are given in Figs 2, 3 and 4.

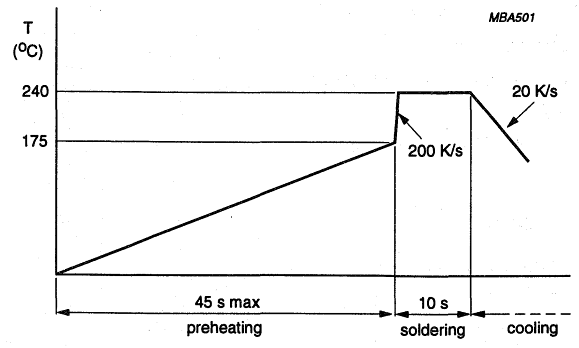


Fig.2 Infrared soldering.

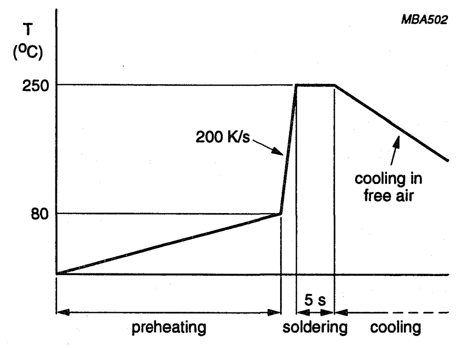


Fig.3 Wave soldering. The resistors may be soldered twice according to this method if necessary.

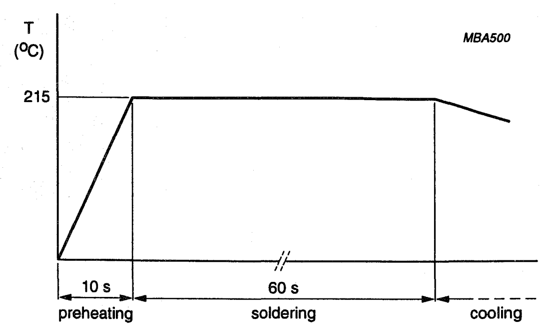


Fig.4 Vapour phase soldering.

Marking

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

4-DIGIT MARKING

For values up from 100 mΩ to 910 mΩ, the R is used as a decimal point.

Magnitude indicators.

RESISTANCE	INDICATOR
100 mΩ to 910 mΩ	R

Example.

MARKING	RESISTANCE
R210	0.210 Ω
R560	0.560 Ω

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

ELECTRICAL DATA

Standard values of resistance and tolerance

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

The limiting voltage (DC or RMS) is determined by the maximum applicable power. This is the maximum rated power that the resistor may dissipate.

Dissipation

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

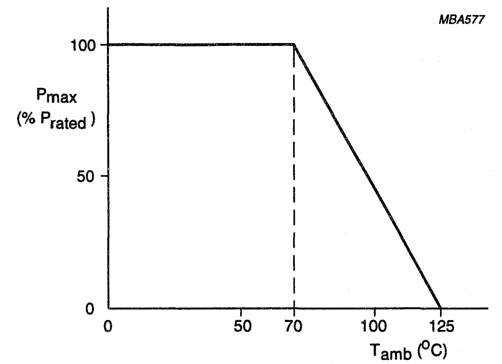


Fig.5 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

Temperature coefficient

Figure 6 shows the typical temperature coefficient of the resistor.

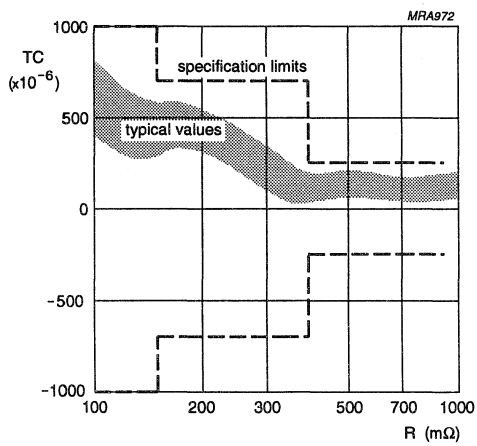


Fig.6 Typical TC as a function of resistance.

CATALOGUE NUMBERS

RESISTANCE VALUE (mΩ)	TOLERANCE (%)	SERIES	CATALOGUE NUMBER 2322 724 ..... BLISTER TAPE ON REEL 5000 units
100	±5	E24	96002
110			96003
120			96004
130			96005
150			96006
160			96007
180			96008
200			96009
220			96026
240			96011
270			96012
300			96013
330			96014
360			96015
390			96016
430			96017
470			96018
510			96019
560			96027
620			96021
680			96022
750			96023
820			96024
910			96025

TESTS AND REQUIREMENTS

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

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

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

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

In Table 1 the tests and requirements are listed with reference to the relevant clauses of *"IEC publications 115-8 and 68"*; a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

Table 1

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
Tests in accordance with the schedule of IEC publication 115-8				
4.4.1		visual examination		no holes; clean surface; no damage
4.4.2		dimensions (outline)	gauge	0.45 mm ≤ T ≤ 0.65 mm 1.40 mm ≤ W ≤ 1.80 mm 3.0 mm ≤ L ≤ 3.3 mm
4.5		resistance	applied voltage (+0/–10%): 0.1 V	$R - R_{nom}$: max. ±5%
4.18	20 (Tb)	resistance to soldering heat	10 s; 260 ±5 °C; flux 600	ΔR/R max.: ±1% +0.05 Ω
4.29	45 (Xa)	component solvent resistance	isopropyl alcohol; H_2O	no visible damage
4.17	20 (Ta)	solderability	unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C; flux 600	good tinning (≥95% covered); no damage
4.7		voltage proof on insulation	200 V (RMS) during 1 minute	no breakdown or flashover
4.13		short time overload	room temperature; dissipation 6.25 × P_n; 5 s (voltage not more than 2 × V_{max})	ΔR/R max.: ±1% +0.05 Ω
4.19	14 (Na)	rapid change of temperature	30 minutes at –55 °C and 30 minutes at +125 °C; 5 cycles	no visible damage ΔR/R max.: ±1% +0.05 Ω

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.23		climatic sequence:		
4.23.2	2 (Ba)	dry heat	16 hours; 125 °C	
4.23.3	30 (D)	damp heat (accelerated) 1st cycle	24 hours; 55 °C; 95 to 100% RH	
4.23.4	1 (Aa)	cold	2 hours; −55 °C	
4.23.5	13 (M)	low air pressure	1 hour; 8.5 kPa; 15 to 35 °C	
4.23.6	30 (D)	damp heat (accelerated) remaining cycles	5 days; 55 °C; 95 to 100% RH	$\Delta R/R$ max.: ±3% +0.1 Ω
4.6.1.1		insulation resistance	100 V (DC) after 1 minute	R_{ins} min.: 1000 MΩ
4.24.2	3 (Ca)	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; loaded with 0.01 P_n (IEC steps: 4 to 100 V)	no visible damage $\Delta R/R$ max.: ±3% +0.1 Ω
4.25.1		endurance (at 70 °C)	1000 hours; loaded with P_n or V_{max}; 1.5 hours on and 0.5 hours off	no visible damage $\Delta R/R$ max.: ±3% +0.1 Ω
4.23.2	27 (Ba)	endurance at upper category temperature	1000 hours; 125 °C; no load	no visible damage $\Delta R/R$ max.: ±3% +0.1 Ω
4.8.4.2		temperature coefficient	at 20/−55/20 °C and 20/125/20 °C	100 mΩ ≤ R < 150 mΩ: ≤ ±1000 × 10^{-6}/K 150 mΩ ≤ R < 400 mΩ: ≤ ±700 × 10^{-6}/K 400 mΩ ≤ R < 1 Ω: ≤ ±250 × 10^{-6}/K
Other tests in accordance with IEC 115 clauses and IEC 68 test method				
4.17	20 (Tb)	solderability (after ageing)	16 hours steam or 16 hours at 155 °C; unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C; flux 600	good tinning (≥95% covered); no damage
4.22	6 (Fc)	vibration (mounted state)	frequency: 10 to 500 Hz; displacement 1.5 mm or acceleration 10 g; three directions; total 6 hours	no damage $\Delta R/R$ max.: ±1% +0.05 Ω
4.20	29 (Eb)	bump (mounted state)	3 × 1500 bumps in three directions; 40 g	no damage $\Delta R/R$ max.: ±1% +0.05 Ω
Other applicable tests				
		leaching	unmounted chips 60 s; 250 ±5 °C	good tinning; no leaching
		damp heat (steady state) (JIS)	1000 hours; +40 °C; 90 to 95% RH; loaded with P_n or V_{max}; 1.5 hours on and 0.5 hours off	$\Delta R/R$ max.: ±3% +0.1 Ω

Fusible resistor chip size 1206

FRC01

FEATURES

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

APPLICATIONS

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

DESCRIPTION

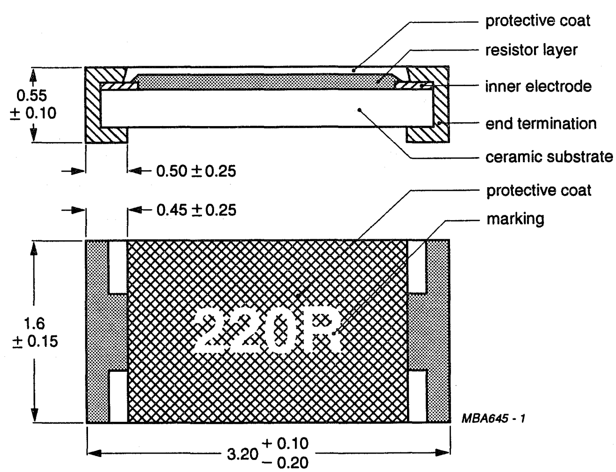
The resistors are constructed on a high grade ceramic body (aluminium oxide). Internal metal electrodes are added at each end and connected by a resistive paste which is applied to the top surface of the substrate. The composition of the paste is adjusted to give the approximate resistance required and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

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

QUICK REFERENCE DATA

DESCRIPTION	VALUE
Resistance range	1 Ω to 240 Ω; E24 series
Resistance tolerance	±5%
Temperature coefficient:	
1 Ω to 4.7 Ω	$\leq \pm 250 \times 10^{-6}$/K
5.1 Ω to 240 Ω	$\leq \pm 200 \times 10^{-6}$/K
Absolute maximum dissipation at T_{amb} = 70 °C	0.125 W
Maximum permissible voltage	200 V (DC or RMS)
Operating temperature range	–55 °C to +125 °C
Climatic category (IEC 68)	55/125/56
Basic specification	IEC 115-8
Stability after:	
load, 1 000 hours at T_{amb} = 70 °C	ΔR/R max.: ±3% +0.10 Ω
climatic tests	ΔR/R max.: ±3% +0.10 Ω
resistance to soldering heat test	ΔR/R max.: ±1% +0.05 Ω
short time overload, 400 V max.	ΔR/R max.: ±1% +0.05 Ω

MECHANICAL DATA



Dimensions in mm.

Fig.1 Outlines.

Mass

1.0 g (per 100 units).

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 (PCBs). Electrical connection to the circuit is by wave, vapour phase or infrared soldering. The end terminations guarantee a reliable contact.

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 PCB and other discrete components on the reverse (mixed PCBs).

Soldering conditions

Surface Mounted Resistors FRC01 are tested for solderability at 235 °C during 2 seconds. The test condition for no leaching is 260 °C for 60 seconds. Typical examples of soldering processes that provide reliable joints without any damage, are given in Figs 2, 3 and 4.

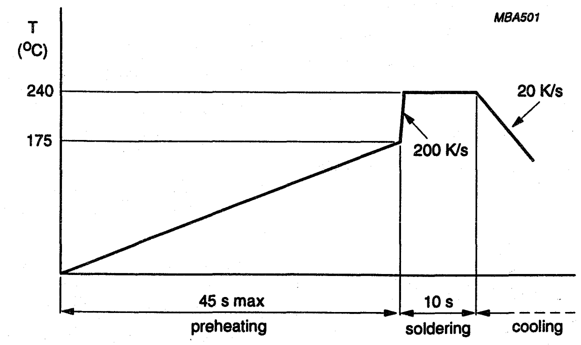


Fig.2 Infrared soldering.

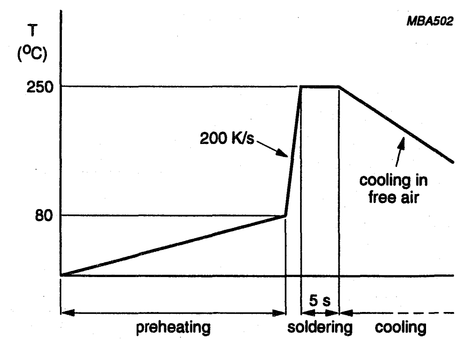


Fig.3 Wave soldering. The resistors may be soldered twice according to this method if necessary.

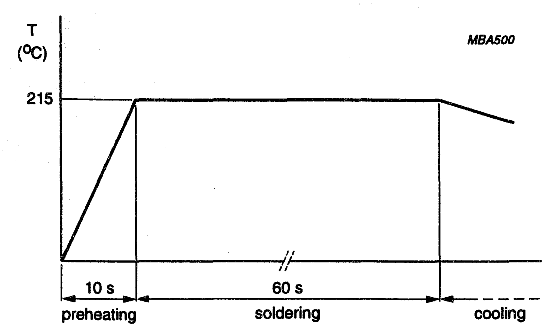


Fig.4 Vapour phase soldering.

Marking

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

4-DIGIT MARKING

The R is used as a decimal point.

Magnitude indicators.

RESISTANCE	INDICATOR
1 Ω to 240 Ω	R

Example.

MARKING	RESISTANCE
1R20	1.2 Ω
22R0	22 Ω
200R	200 Ω

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%. 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 publication 115-8"*.

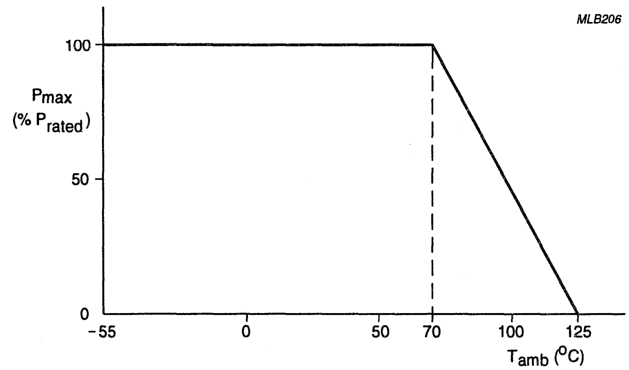


Fig.5 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

Dissipation

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

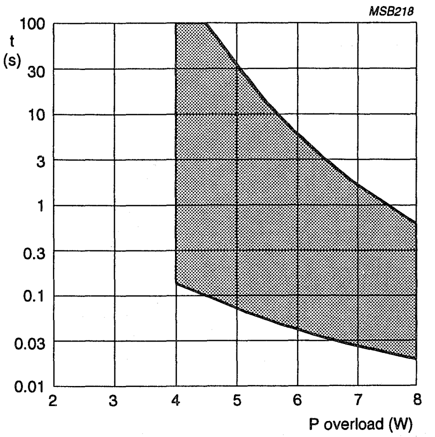
Fusing characteristics

The resistors will fuse without the risk of fire and within an indicated range of overload. Fusing means that the resistive value of the resistor increases at least 1 000 times (see Figs 6, 7 and 8).

The fusing characteristic is measured with mounted resistors on a ceramic substrate (see Fig.9).

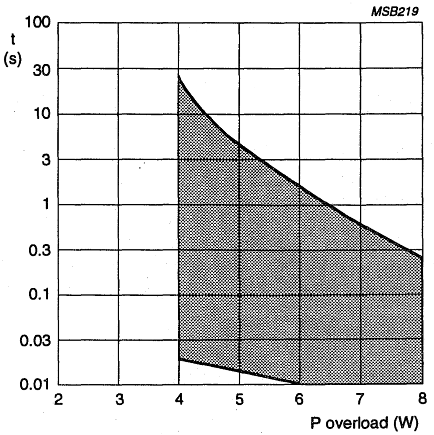
Fusible resistor chip size 1206

FRC01



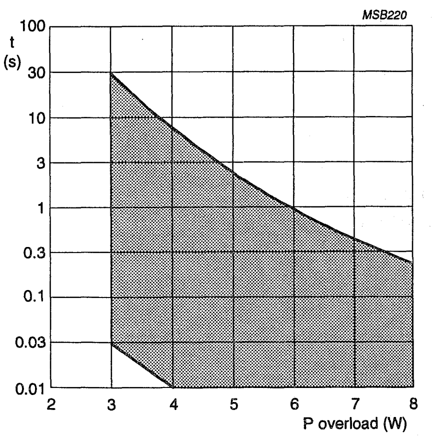
This graph is based on measured data which may deviate according to the application.

Fig.6 Fusing characteristic: 1 Ω ≤ R < 4.7 Ω.



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

Fig.7 Fusing characteristic: 4.7 Ω ≤ R < 100 Ω.



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

Fig.8 Fusing characteristic: 100 Ω ≤ R < 240 Ω.

Fusible resistor chip size 1206

FRC01

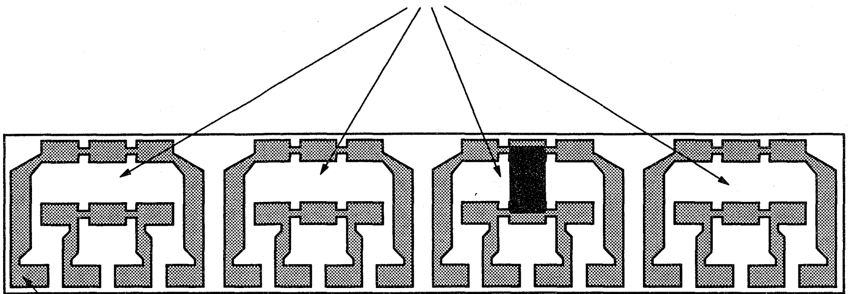


Fig.9 Test substrate layout.

COMPOSITION OF THE CATALOGUE NUMBER

The resistors have a 12-digit catalogue number starting with 2322 750. The subsequent 5 digits indicate the packaging and resistance value (see Tables 1 and 2).

Table 1 First digit to indicate packaging for resistances as listed.

RESISTANCE RANGE	TOLERANCE (%)	SERIES	CATALOGUE NUMBER 2322 750	
			BLISTER TAPE ON REEL	
			5000 units	10000 units
1 Ω to 240 Ω	±5	E24	6....	7....

To complete the catalogue number (see Table 1), replace the first three dots of the remaining 4-digit code by the first three digits of the resistance value. Replace the fourth dot (last digit) by a figure according to Table 2.

Table 2 Last digit of 12 NC.

RESISTANCE	LAST DIGIT
1 to 9.1 Ω	8
10 to 91 Ω	9
100 to 240 Ω	1

Ordering example

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

Fusible resistor chip size 1206

FRC01

TESTS AND REQUIREMENTS

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

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

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

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

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

Table 3

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
Tests in accordance with the schedule of IEC publication 115-8				
4.4.1		visual examination		no holes; clean surface; no damage
4.4.2		dimensions (outline)	gauge	0.45 mm ≤ T ≤ 0.65 mm 1.40 mm ≤ W ≤ 1.80 mm 3.0 mm ≤ L ≤ 3.3 mm
4.5		resistance	applied voltage (+0/−10%): R < 10 Ω: 0.1 V 10 Ω ≤ R < 100 Ω: 0.3 V	$R - R_{nom}$: max. ±5%
4.18	20 (Tb)	resistance to soldering heat	10 s; 260 ±5 °C; flux 600	ΔR/R max.: ± 1% +0.05 Ω
4.29	45 (Xa)	component solvent resistance	isopropyl alcohol; H_2O	no visible damage
4.17	20 (Ta)	solderability	unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C; flux 600	good tinning (≥95% covered); no damage
4.7		voltage proof on insulation	200 V (RMS) during 1 minute	no breakdown or flashover
4.13		short time overload	room temperature; dissipation 6.25 × P_n; 5 s (voltage not more than 2 × V_{max})	ΔR/R max.: ±1% +0.05 Ω
4.19	14 (Na)	rapid change of temperature	30 minutes at −55 °C and 30 minutes at +125 °C; 5 cycles	ΔR/R max.: ±1% +0.05 Ω

Fusible resistor chip size 1206

FRC01

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.23		climatic sequence:		
4.23.2	2 (Ba)	dry heat	16 hours; 125 °C	
4.23.3	30 (D)	damp heat (accelerated) 1st cycle	24 hours; 55 °C; 95 to 100% RH	
4.23.4	1 (Aa)	cold	2 hours; –55 °C	
4.23.5	13 (M)	low air pressure	1 hour; 8.5 kPa; 15 to 35 °C	
4.23.6	30 (D)	damp heat (accelerated) remaining cycles	5 days; 55 °C; 95 to 100% RH	ΔR/R max.: ±3% +0.1 Ω
4.6.1.1		insulation resistance	100 V (DC) after 1 minute	R_{ins} min.: 1000 MΩ
4.24.2	3 (Ca)	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; loaded with 0.01 P_n (IEC steps: 4 to 100 V)	no visible damage ΔR/R max.: ±3% +0.1 Ω
4.25.1		endurance (at 70 °C)	1000 hours; loaded with P_n or V_{max}; 1.5 hours on and 0.5 hours off	no visible damage ΔR/R max.: ±3% +0.1 Ω
4.23.2	27 (Ba)	endurance at upper category temperature	1000 hours; 125 °C; no load	no visible damage ΔR/R max.: ±3% +0.1 Ω
4.8.4.2		temperature coefficient	at 20/–55/20 °C and 20/125/20 °C	1 Ω ≤ R ≤ 4.7 Ω: ≤ ±250 × 10^{-6}/K 5.1 Ω ≤ R ≤ 240 Ω: ≤ ±200 × 10^{-6}/K
Tests in accordance with IEC publication 115-1				
4.17	20 (Tb)	solderability (after ageing)	16 hours steam or 16 hours at 155 °C; unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C; flux 600	good tinning (≥95% covered); no damage
4.22	6 (Fc)	vibration (mounted state)	frequency: 10 to 500 Hz; displacement 1.5 mm or acceleration 10 g; three directions; total 6 hours	no damage ΔR/R max.: ±1% +0.05 Ω
4.20	29 (Eb)	bump (mounted state)	3 × 1500 bumps in three directions; 40 g	no damage ΔR/R max.: ±1% +0.05 Ω
4.12		noise	IEC publication 195 (measured with Quantech equipment)	R ≤ 240 Ω: max. 1 µV/V
Other applicable tests				
		leaching	unmounted chips 60 s; 260 ±5 °C	good tinning; no leaching
		damp heat (steady state) (JIS)	1000 hours; +40 °C; 90 to 95% RH; loaded with P_n or 200 V; max. 1.5 hours on and 0.5 hours off	ΔR/R max.: ±5% +0.10 Ω

Trimmable resistor chip size 1206

RC02TR

FEATURES

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

APPLICATIONS

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

DESCRIPTION

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

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

Trimming instructions with YAG-laser showing typical values for:

cutting speed = 30 to 300 mm/s

laser power = 1 to 8 W

maximum trimming length = 60% of resistor film width

minimum distance between end termination and trimming cut = 0.20 mm

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

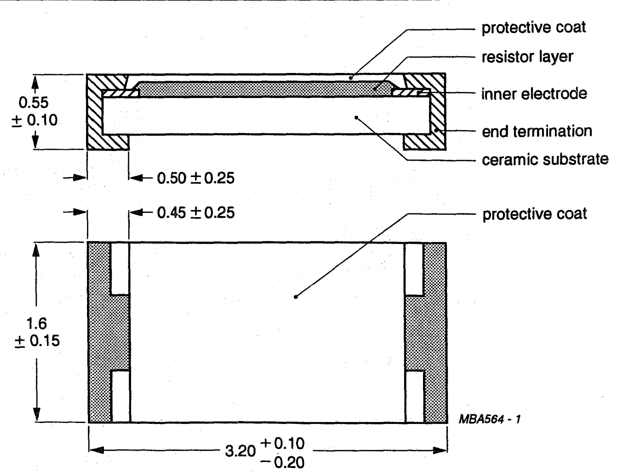
QUICK REFERENCE DATA

DESCRIPTION	VALUE
Resistance range	1 Ω to 1 MΩ; E24 series
Resistance tolerance	0/–20% and 0/–30%
Maximum trimming factor	2.0×
Temperature coefficient:	
$1\ \Omega \leq R \leq 4.99\ \Omega$	$\leq \pm 250 \times 10^{-6}$/K
$5.1\ \Omega \leq R \leq 9.76\ \Omega$	$\leq \pm 200 \times 10^{-6}$/K
$10\ \Omega \leq R \leq 1\ M\Omega$	$\leq \pm 100 \times 10^{-6}$/K
Absolute maximum 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 115-8
Stability(1) after:	
load, 1000 hours at T_{amb} = 70 °C	ΔR/R max.: ±1% +0.05 Ω
load, 8000 hours at T_{amb} = 70 °C	ΔR/R max.: ±2% +0.10 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.: ±1% +0.10 Ω

Note

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

MECHANICAL DATA



Dimensions in mm.

Fig.1 Outlines.

Mass

1.0 g (per 100 units).

Protection of laser cut

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

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 (PCBs). Electrical connection to the circuit is by wave, vapour phase or infrared soldering. The end terminations guarantee a reliable contact and the protective coating enables 'face down' mounting.

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

Soldering conditions

Surface Mounted Resistors RC02TR are tested for solderability at 235 °C during 2 seconds. The test condition for no leaching is 260 °C for 60 seconds. Typical examples of soldering processes that provide reliable joints without any damage, are given in Figs 2, 3 and 4.

Marking

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

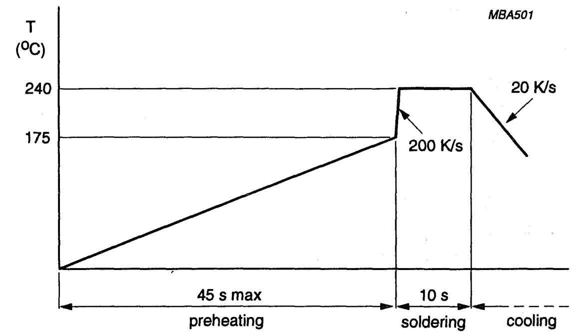


Fig.2 Infrared soldering.

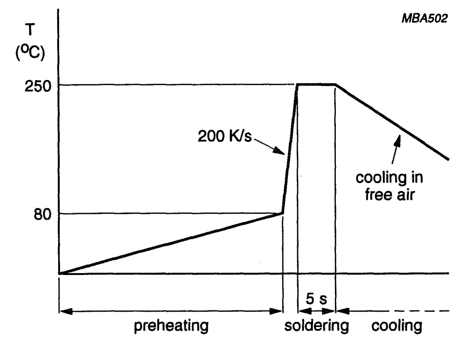


Fig.3 Wave soldering. The resistors may be soldered twice according to this method if necessary.

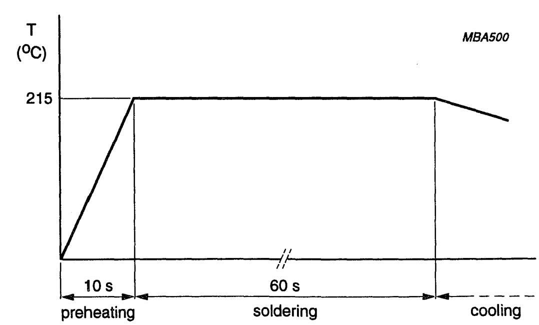


Fig.4 Vapour phase soldering.

ELECTRICAL DATA

Standard values of resistance and tolerance

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

The limiting voltage (RMS) is 200 V. This is the maximum voltage that may be continuously applied to the resistor element or the insulation, see *"IEC publication 115-8"*.

Dissipation

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

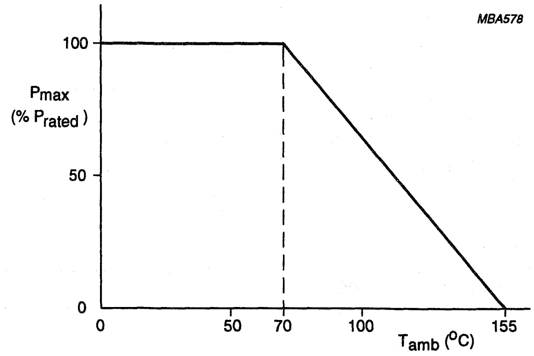


Fig.5 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

COMPOSITION OF THE CATALOGUE NUMBER

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

Table 1 First digit to indicate packaging for resistances as listed.

RESISTANCE RANGE	TOLERANCE (%)	SERIES	CATALOGUE NUMBER 2322 724 9....	
			CARDBOARD TAPE ON REEL	BLISTER TAPE ON REEL
			5000 units	5000 units
1 Ω to 1 MΩ	0/–20	E24	ON REQUEST	
	0/–30	E24		

TESTS AND REQUIREMENTS

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

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

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

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

In Table 2 the tests and requirements are listed with reference to the relevant clauses of *"IEC publications 115-8 and 68"*; a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

Table 2

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.17	20 (Ta)	soldering	unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±10 °C; flux 600; 0.2% Cl activated flux 600	good tinning no damage
4.18	20 (Tb)	resistance to soldering heat	10 s; 260 ±5 °C; flux 600	ΔR/R max.: ±1% +0.05 Ω
4.19	14 (Na)	rapid change of temperature	30 minutes at −55 °C and 30 minutes at +125 °C; 5 cycles	ΔR/R max.: ±1% +0.05 Ω
4.22	6 (Fc)	vibration	frequency: 10 to 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	29 (Eb)	bump	3 × 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 printed-circuit board (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	2 (Ba)	dry heat	16 hours; 125 °C	
4.23.3	30 (D)	damp heat (accelerated) 1st cycle	24 hours; 55 °C; 95 to 100% RH	
4.23.4	1 (Aa)	cold	2 hours; −55 °C	
4.23.5	13 (M)	low air pressure	1 hour; 8.5 kPa; 15 to 35 °C	
4.23.6	30 (D)	damp heat (accelerated) remaining cycles	5 days; 55 °C; 95 to 100% RH	R_{ins} min.: 1000 MΩ ΔR/R max.: ±1.5% +0.05 Ω
4.24.2	3 (Ca)	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; loaded with 0.01 P_n (IEC steps: 1 to 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; 1.5 hours on and 0.5 hours off	ΔR/R max.: ±1% +0.05 Ω

Trimmable resistor chip size 1206

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.6.1.1		insulation resistance	100 V (DC) after 1 minute	R_{ins} min.: 1000 MΩ
4.13		short time overload	room temperature; dissipation 6.25 × P_n; 5 s (voltage not more than 2 × V_{max})	ΔR/R max.: ±1% +0.05 Ω
4.8.4.2		temperature coefficient	between –55 °C and +155 °C	1 Ω ≤ R ≤ 4.99 Ω: ≤ ±250 × 10^{-6}/K 5.1 Ω ≤ R ≤ 9.76 Ω: ≤ ±200 × 10^{-6}/K 10 Ω ≤ R ≤ 1 MΩ: ≤ ±100 × 10^{-6}/K
4.12		noise	IEC publication 195 (measured with Quantech - equipment)	R < 1 kΩ: max. 1 μV/V R < 10 kΩ: max. 3 μV/V R < 100 kΩ: max. 6 μV/V
4.23.2	27 (Ba)	endurance at upper category temperature	1000 hours; 155 °C; no load	no visual damage ΔR/R max.: ±1% +0.05 Ω
4.7		voltage proof on insulation	200 V (RMS) during 1 minute	no breakdown

LEADED RESISTORS

APPLICATION	RESISTANCE RANGE	TOL. (%)	DISSIPATION (at °C)	DISSIPATION (W)	TYPE	PAGE
Carbon film	1 Ω to 10 MΩ	5	70	0.33	CR25	178
Standard film	1 Ω to 3 MΩ	5	70	0.50	SFR16	188
	1 Ω to 10 MΩ			0.40	SFR25	196
				0.50	SFR25H CECC	
Fusible	1 Ω to 15 kΩ	5	70	0.33	NFR25	211
				0.50	NFR25H	221
Metal film	4.99 Ω to 1 MΩ	1	70	0.40	MRS16T	231
	1 Ω to 10 MΩ			0.60	MRS25	239
	1 Ω to 1 MΩ	0.5		0.40	MR25	247
				0.50	MR30	
	4.99 Ω to 1 MΩ	1		1.0	MR52	
MIL metal film	10 Ω to 1 MΩ	1	70	0.125	MR24D	257
				0.25	MR34D	
				0.5	MR54D	
				0.75	MR74D	
	4.99 Ω to 1 MΩ	0.1; 0.25; 0.5; 1	125	0.1	MR24E/C	
				0.125	MR34E/C	
				0.25	MR54E/C	
	24.9 Ω to 1 MΩ			0.5	MR74E/C	
Precision metal film	24 Ω to 100 kΩ	0.05; 0.02; 0.01	70	0.125	MPR24	261
				0.25	MPR34	
	4.99 Ω to 1 MΩ	0.5; 0.25; 0.1		0.25	MPR24	
				0.40	MPR34	
High voltage	100 kΩ to 22 MΩ	1; 5; 10	70	0.25	VR25	273
	100 kΩ to 33 MΩ	1; 5		0.50	VR37	281
	100 kΩ to 68 MΩ			1.0	VR68	
Power metal film	0.22 Ω to 1 Ω	5	70	0.6	PR01	290
	1 Ω to 1 MΩ			1		
	0.33 Ω to 1 Ω			1.3	PR02	303
	1 Ω to 1 MΩ			2		
	0.68 Ω to 1 Ω			1.6	PR03	317
	1 Ω to 1 MΩ			3		
	1 Ω to 27 kΩ			1.60	PR37	329
	30 kΩ to 1 MΩ			1.20		
	1 Ω to 51 kΩ			2.50	PR52	338
	56 kΩ to 1 MΩ			2.00		

APPLICATION	RESISTANCE RANGE	TOL. (%)	DISSIPATION (at °C)	DISSIPATION (W)	TYPE	PAGE
Cemented wirewound	0.1 Ω to 1.5 kΩ	5	40	1.00	AC01	348
	0.1 Ω to 33 kΩ		40	3.00	AC03	357
				4.00	AC04	
				5.00	AC05	
				7.00	AC07	
				10.0	AC10	
				15.0	AC15	
				20.0	AC20	
Enamelled wirewound	4.7 Ω to 100 kΩ	5	70	4.00	WR0617E	367
				7.00	WR0825E	
				11.0	WR0842E	
				17.0	WR0865E	
Stand-up miniature power wirewound	0.1 Ω to 560 Ω	5	70	2.00	SMW02	373
				3.00	SMW03	
				5.00	SMW05	
Precision wirewound	0.22 Ω to 12 kΩ	±1	25	2.0	PAC02	380
				3.0	PAC03	
				4.0	PAC04	
				5.0	PAC05	
				6.0	PAC06	

INTRODUCTION

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

- TITLE
- FEATURES
- APPLICATION
- QUICK REFERENCE DATA
- DESCRIPTION
- MECHANICAL DATA
  - Mass
  - Mounting
  - Marking
- ELECTRICAL DATA
  - Standard values of rated resistance and tolerance
- COMPOSITION OF THE CATALOGUE 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 (see Fig.1) does include however, length (L), diameter of the body (D) and the lead diameter (d). For certain types, the length is stated as L_1 and L_2; L_1 is the body length, L_2 is the body length plus lacquer on the leads. By specifying L_1/L_2, the dimensional 'clean lead to clean lead' properties can be determined.

The length of the cylindrical body (L_1) is measured by inserting the leads into the holes of two identical gauge plates (Fig.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.

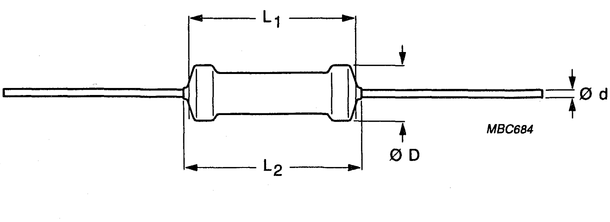
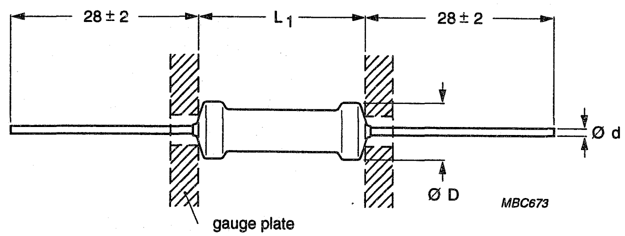
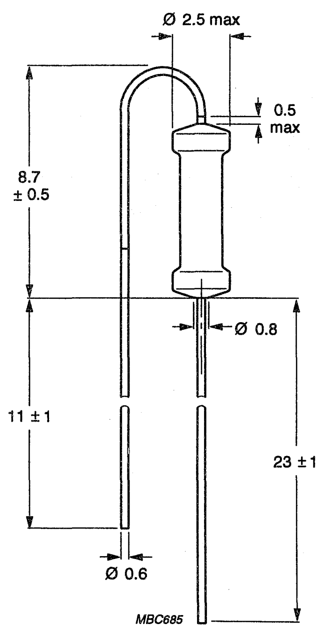


Fig.1 Component outline.



Dimensions in mm.

Fig.2 Measurement of dimension L_1.



Dimensions in mm.

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

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

Table 1 Lead diameter and hole dimensions.

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

Mass

The mass is given per 100 resistors.

Mounting

Most types with straight axial leads and most in the 'stand-up' version (radial leads; see Fig.3) 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 in accordance with IEC publication 62: *"Colour code for fixed resistors"*. See also *"IEC 115-1"*, clause 4.5. The coloured bands indicate the **nominal resistance**, the **tolerance** on the resistance and, if applicable, the **temperature coefficient**. A maximum of bands may be used, but in some instances there are fewer, e.g. if the products are too small.

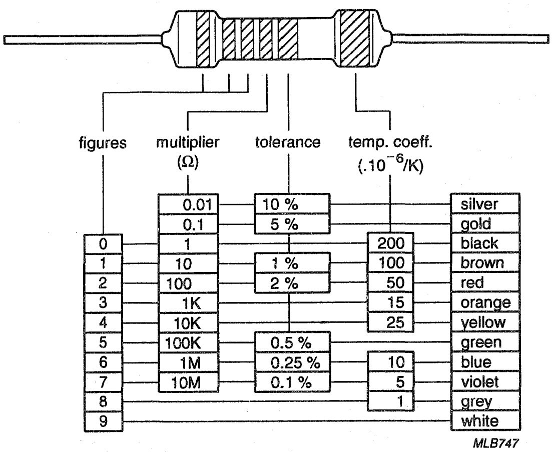


Fig.4 Marking.

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

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

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

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

Body colours

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

COLOUR	TYPE
Tan	CR25
Light green	SFR25/SFR16T
Grey	NFR25, NFR25H
Green	MR25, MR30, MR52, MR24E/C/D, MR34E/C/D, MR54E/C/D, MR74E/C/D, MPR24, MPR34, MRS16T, MRS25, AC04, AC05, AC07, AC10, AC15, AC20
Light blue	VR25, VR37, VR68, SFR16S
Red	PR37, PR52, PR01, PR02, PR03
Brown	WR0167E, WR0842E, WR0825E, WR0865E
Red-brown	SFR25H

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.

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

Performance

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

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

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

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

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

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.

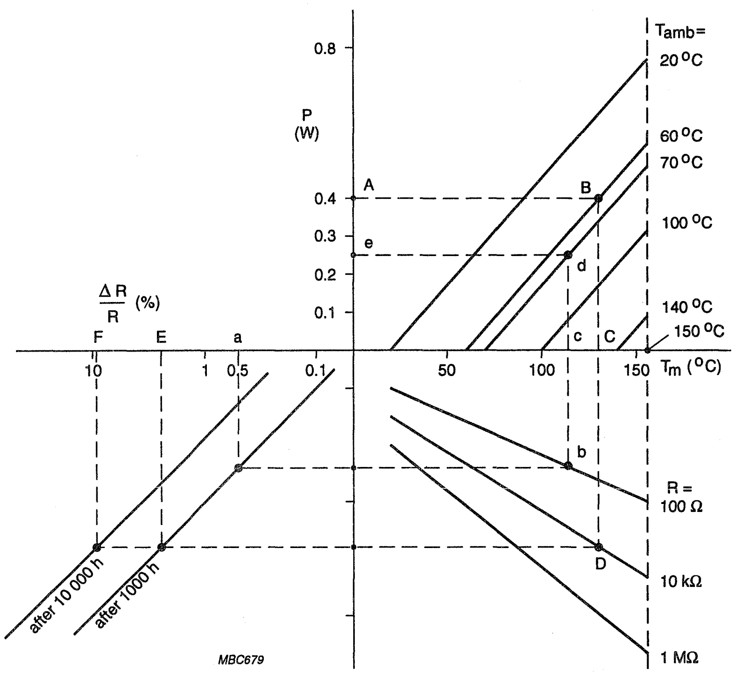


Fig.5 Performance nomogram (for a fictitious resistor) illustrating the way of specifying the performance of film resistors.

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 point A (power dissipation of 0.4 W). This line intersects the 60 °C ambient temperature line at point B, corresponding to a hot-spot temperature of 128 °C (point C). This is safely below the maximum indicated by the broken line at 155 °C; therefore a dissipation of 0.4 W at an ambient temperature of 60 °C is well within the allowable limit.

Extend line BC into the lower half of the nomogram until it intersects the 10 kΩ line at point D. Draw a horizontal line to the left from point D until it intersects the line 'after 1 000 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 1 000 hours of operation. After 10000 hours, the change will be about 9% (point F).

Example 2

Assume that a 100 Ω resistor, whose characteristics are described by the nomogram, is to be operated at an ambient temperature of 70 °C with a required stability after 1 000 h of 0.5% (point a). It is desired to find the maximum permissible power dissipation. In the lower half of the nomogram, a line that corresponds to a stability after 1 000 h of 0.5% intersects the 100 Ω resistance line at point b, corresponding to a hot-spot temperature of 112 °C (point c).

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

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

The temperature coefficient

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

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

at 25 °C:

1 000000 Ω (nominal = rated value)

at +155 °C:

$1\,000000\ \Omega \pm (130 \times 100 \times 10^{-6}) \times 1\,000000\ \Omega$
$= 1\,013000\ \Omega$ or $987\,000\ \Omega$

at −55 °C:

$1\,000000\ \Omega \pm (80 \times 100 \times 10^{-6}) \times 1\,000000\ \Omega$
$= 1\,008000\ \Omega$ or $992\,000\ \Omega$

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

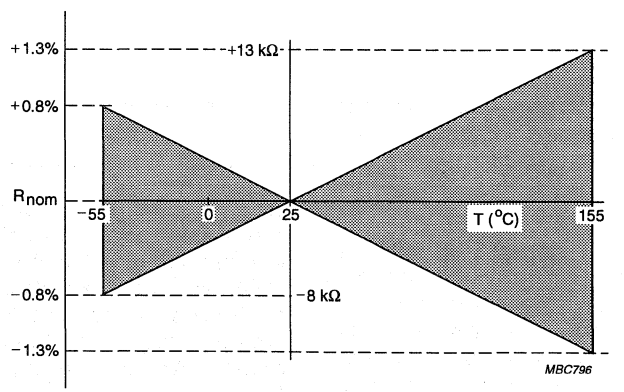


Fig.6 Temperature coefficient.

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 = dissipation) of the resistor, as follows:

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

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

The resistor is mounted on a PCB (see Fig.7) which is set up vertically, with the resistor horizontal. Using an infrared camera, a thermal image is made of the resistor, thus defining the hot-spot and solder-spot temperatures.

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

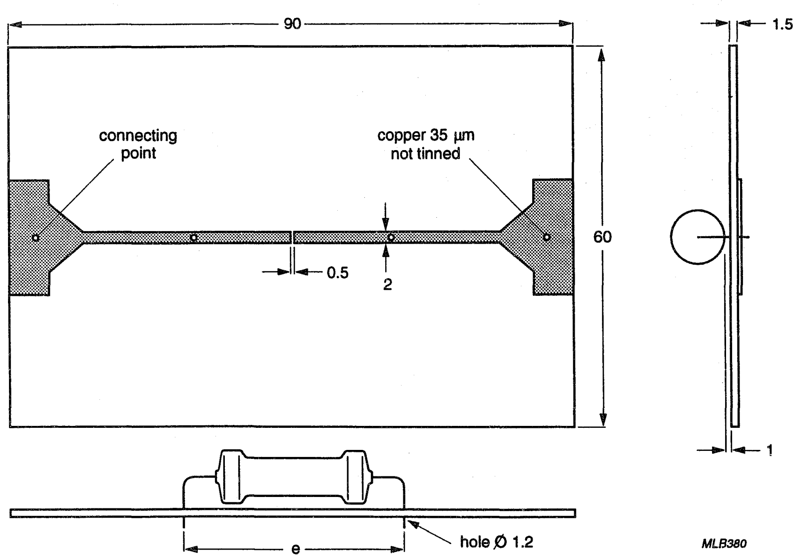
PULSE-LOAD BEHAVIOUR

Knowing the thermal characteristics of a resistor, it is possible to calculate the dissipation due to a single pulse, which will cause a resistor to fail by going open circuit. This theoretical maximum can be expressed in terms of maximum peak pulse power ($\hat{P}_{max}$) and pulse duration (t_i); the straight line in Fig.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-load.

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

Using a computer program which takes account of all factors affecting behaviour under pulse loads, curves similar to those of Fig.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.

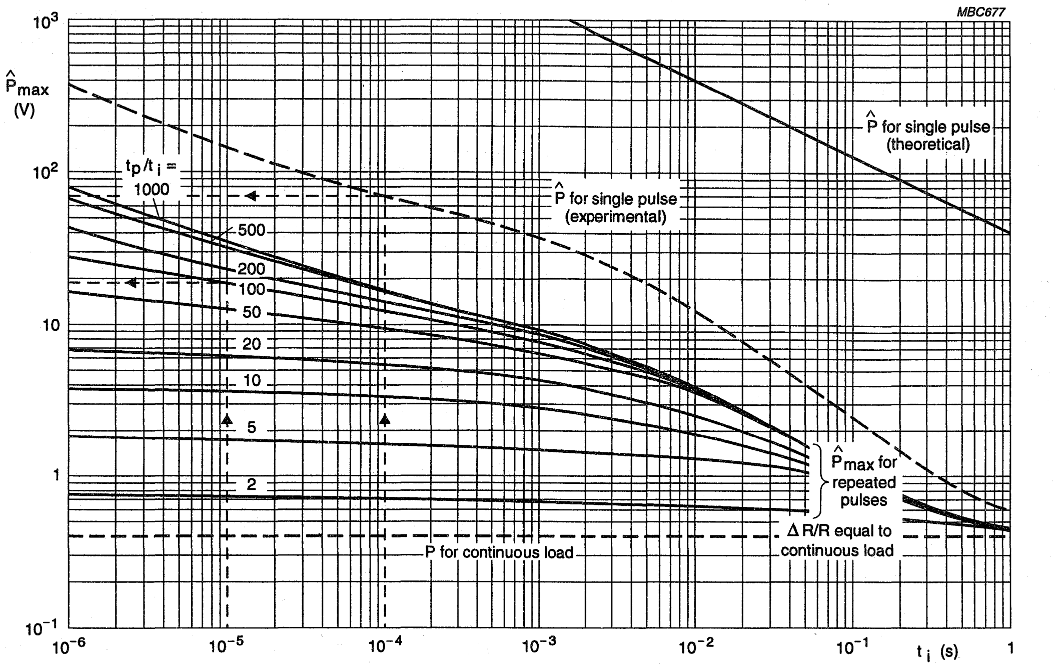


Fig.8 Maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i) for a typical resistor.

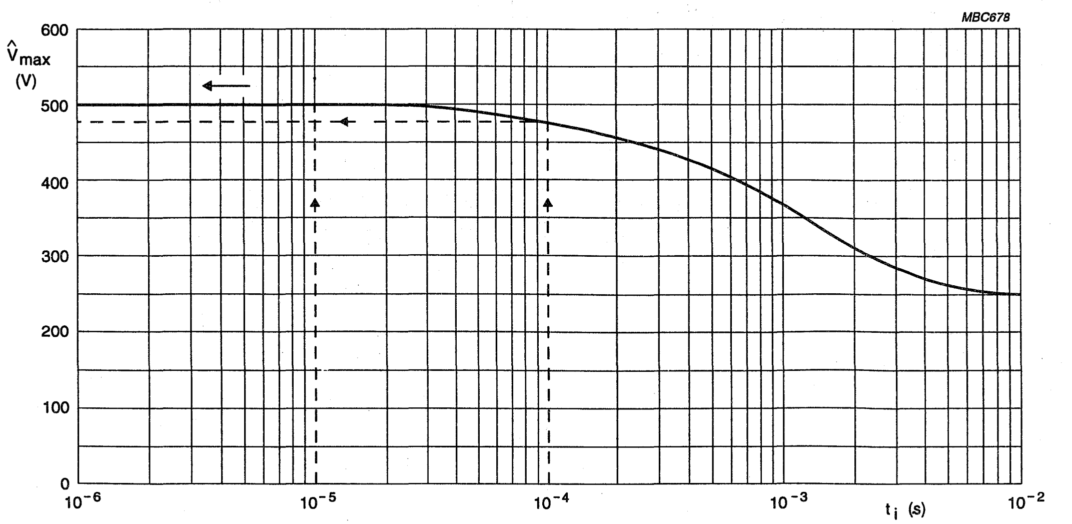


Fig.9 Maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_i) for a typical resistor.

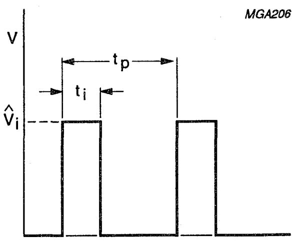


Fig.10 Rectangular pulses.

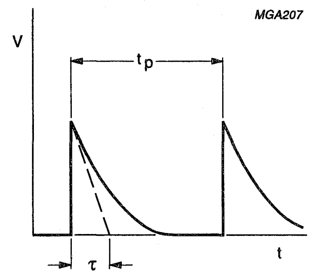


Fig.11 Exponential pulses.

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

SYMBOL	DESCRIPTION
$\hat{P}$	applied peak pulse power
$\hat{P}_{max}$	maximum permissible peak pulse power (Fig.8)
$\hat{V}_i$	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
τ	time constant (exponential pulses)
T_{amb}	ambient temperature
$T_{m(max)}$	maximum hot-spot temperature of the resistor

Definitions of pulse-load behaviour; metal film resistors

SINGLE PULSE

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

REPETITIVE PULSE

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

Determination of pulse-load

The graphs in Figs 8 and 9 may be used to determine the maximum pulse-load 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:
  - $\frac{\hat{V}_i^2}{R}$ 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.
  - $\hat{V}_i$ 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 $t_i = 0.5\ \tau$.
- For single rectangular pulses:
  - $\frac{\hat{V}_i^2}{R}$ must be lower than the $\hat{P}_{max}$ given by the dashed line of Fig.8 for the applicable value of t_i.
  - $\hat{V}_i$ 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.

CONTINUOUS PULSE TRAIN

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

Therefore:

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

For $t_i = 10^{-5}$ s and $\frac{t_p}{t_i} = 100$, Fig.8 gives $\hat{P}_{max} = 19$ W

and Fig.9 gives $\hat{V}_{max} = 500$ V. As the operating conditions $\hat{P} = 16$ W and $\hat{V}_i = 40$ V are lower than these limiting values, this resistor can be safely used.

SINGLE PULSE

A 1 000 Ω resistor is required to operate under the following conditions:

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

Therefore:

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

The dashed curve of Fig.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 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.

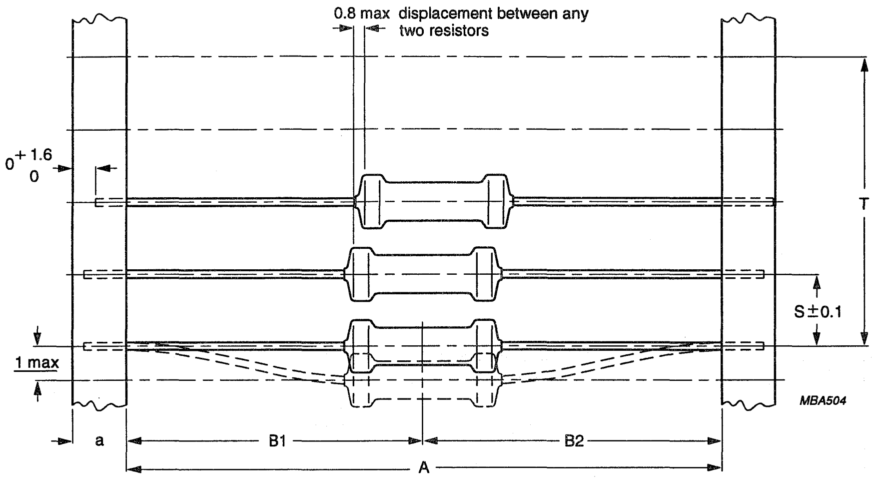
TESTS AND REQUIREMENTS

Essentially all tests on resistors are carried out 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.

STANDARD PACKAGING

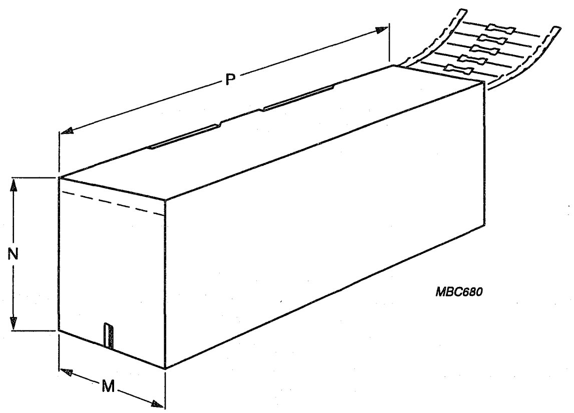
Most types may be processed automatically and are supplied on tape on a bandolier which fits most commonly used automatic mounting machines. Not all bandolier configurations are identical, the deviating parameters are given in Figs 12 and 14.

For specific details refer to the relevant data sheet.



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 = eccentricity
0.5 mm is the maximum displacement between any two resistors for types SFR16T, MRS16T and MRS16Tli.

Fig.12 Axial on tape.

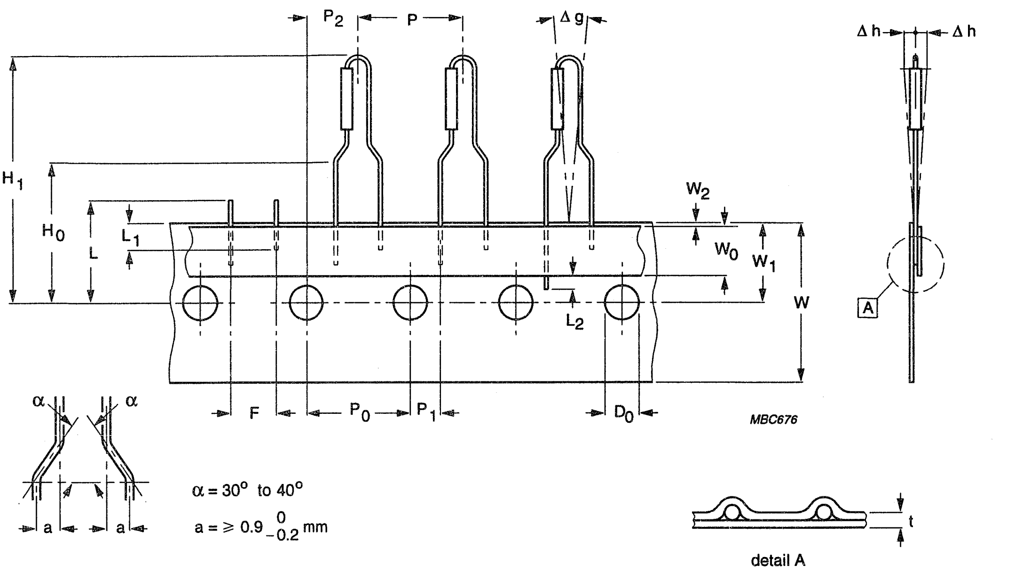


Bandoliers may be supplied concertinaed in a cardboard box ('ammopack').
Extraction force for components in the tape plane, vertically to the direction of unreeling: ≥5 N.

Fig.13 Bandolier in ammopack.

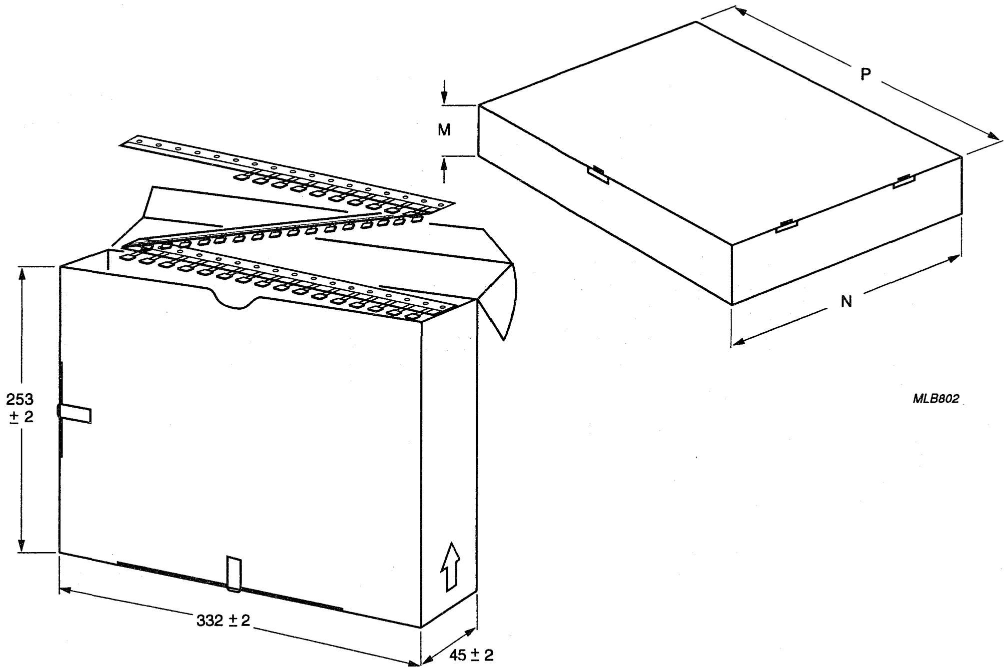
Table 3 Taping dimensions (see Figs 13 and 14).

SYMBOL	PARAMETER
D	body diameter
A	body length
d	lead wire diameter
P	pitch of components
P_0	feed-hole pitch
T	cumulative pitch error
P_1	feed-hole centre to lead at top side of the tape
P_2	feed-hole centre to body centre
F	lead-to-lead
Δh	component alignment
Δg	component alignment
W	tape width
W_0	hold down tape
W_1	hole position
W_2	hold down tape position
H_0	lead wire clinch height
H_1	component height
D_0	feed-hole diameter
t	total tape thickness
L	length of snipped lead
L_1	lead wire (tape portion) shortest lead



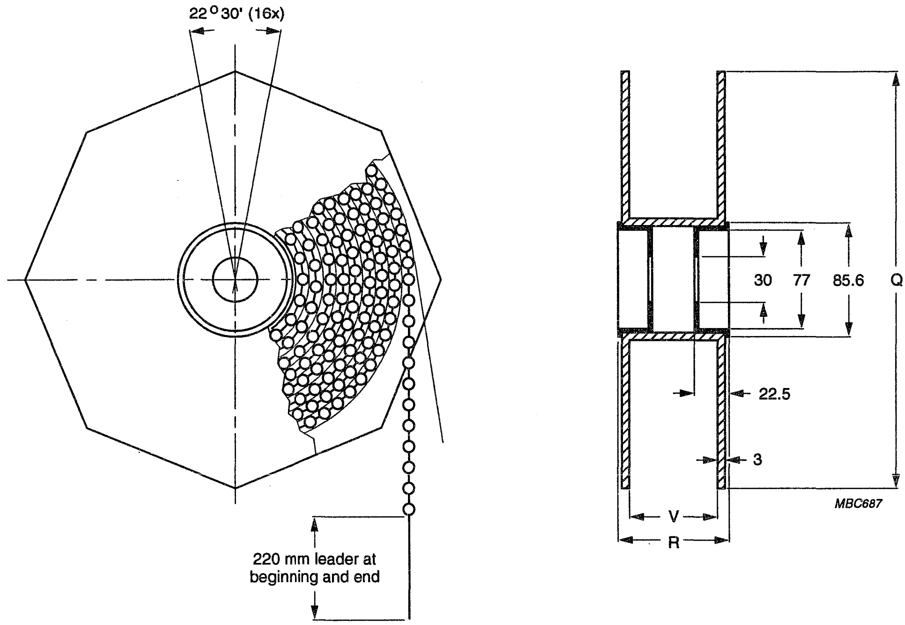
Dimensions in mm.

Fig.14 Radial on bandolier.



Dimensions in mm.

Fig.15 Dimensions of ammopack (radial taped).



Dimensions in mm.

Fig.16 Bandolier on reel.

CARBON FILM

Carbon film resistor CR25

FEATURE

- Low cost.

APPLICATIONS

- Low cost and low performance
- Commodity products.

DESCRIPTION

Resistors of 10 Ω to 1 MΩ have a homogeneous film of pure carbon deposited on a high grade ceramic body. Resistors with R < 10 Ω have an electroless-deposited nickel film; resistors with R > 1 MΩ have a film of chrome-silicon. After a helical groove has been cut in the resistive layer, tinned connecting leads of electrolytic copper are welded to the end caps.

The resistors are coated with a tan 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

Mass

23 g (per 100 units).

Mounting

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

Marking

The nominal resistance, tolerance and temperature coefficient are marked on the resistors by four coloured bands in accordance with IEC publication 62 *"Colour code for fixed resistors"*.

QUICK REFERENCE DATA

DESCRIPTION	VALUE
Resistance range	1 Ω to 10 MΩ, E24 series
Resistance tolerance	±5%
Absolute maximum dissipation at T_{amb} = 70 °C; note 1	0.33 W
Basic specifications	IEC 115-1 and 115-2
Climatic category	55/155/56
Stability after:	
load	see Fig.2
climatic tests:	
for R ≤ 220 kΩ	ΔR/R max.: ±1.5% +0.1 Ω
for 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

Note

1. 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.

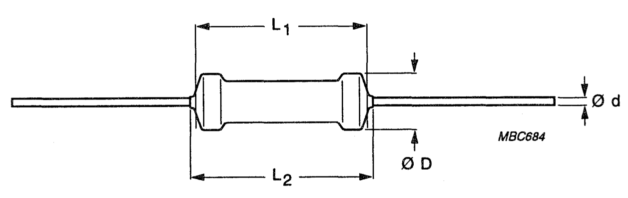


Fig.1 Component outline.

Table 1 Resistor dimensions (see Fig.1).

TYPE	D MAX.	L_1 TYP.	L_2 MAX.	d TYP.
CR25	2.5	6.5	7.5	0.6

The length of the body L_1 (see Fig. 1) 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, see *"IEC publication 294"*.

ELECTRICAL DATA

Standard values of rated resistance (nominal resistance) are taken from the E24 series within the range 1 Ω to 10 MΩ. 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 continuously applied to the resistor element, see *"IEC publication 115-1"*.

Figure 2 is a 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 1 000 hours of operation.

For continuous operation longer or shorter than 1 000 hours (t_x), the stability can be approximated by multiplying the drift ($\Delta R/R$) after 1 000 hours, with the square root of the time ratio as in the following equation:

($\Delta R/R$ after $\times$ h) =
($\Delta R/R$ after 1 000 h) $\times$ $(t_x/1\,000)^{1/2}$.

Notes on nomogram (Fig.2)

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.

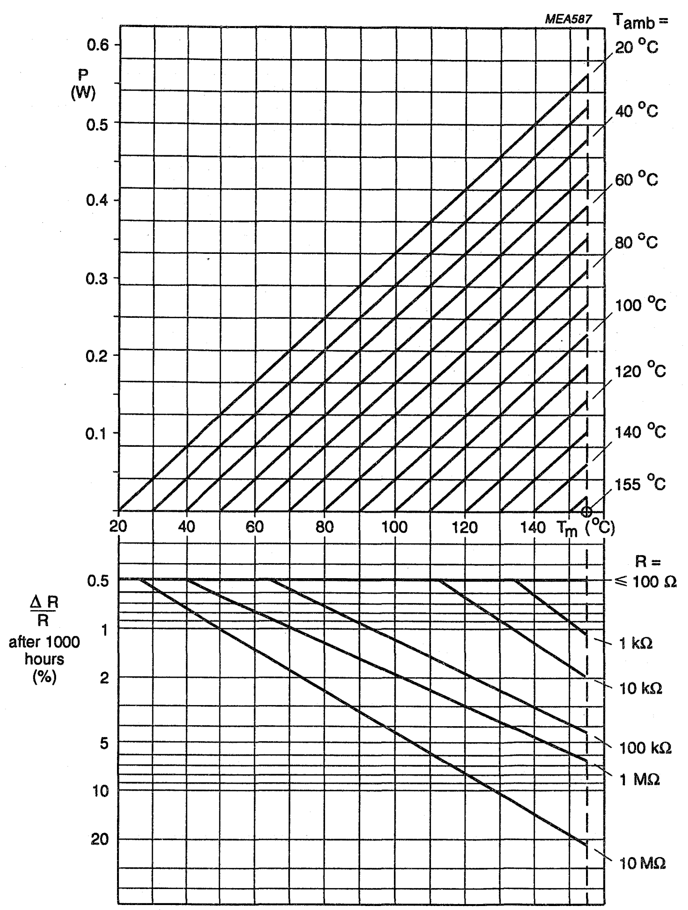


Fig.2 Drift nomogram.

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. Figure 3 is added to bridge the gap between the system of IEC 115-1 and our system. In Fig.3 the permissible dissipation at 70 °C for a resistance drift of maximum 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.

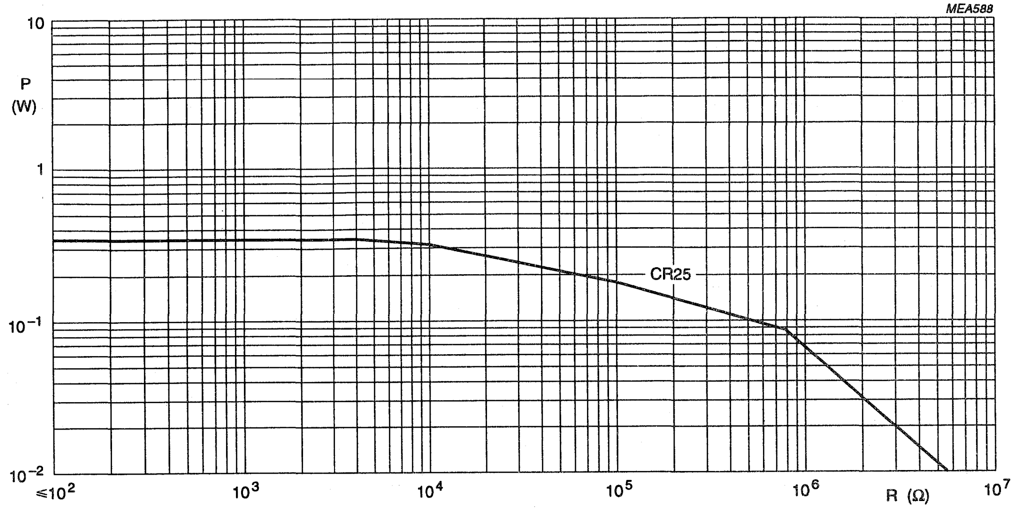
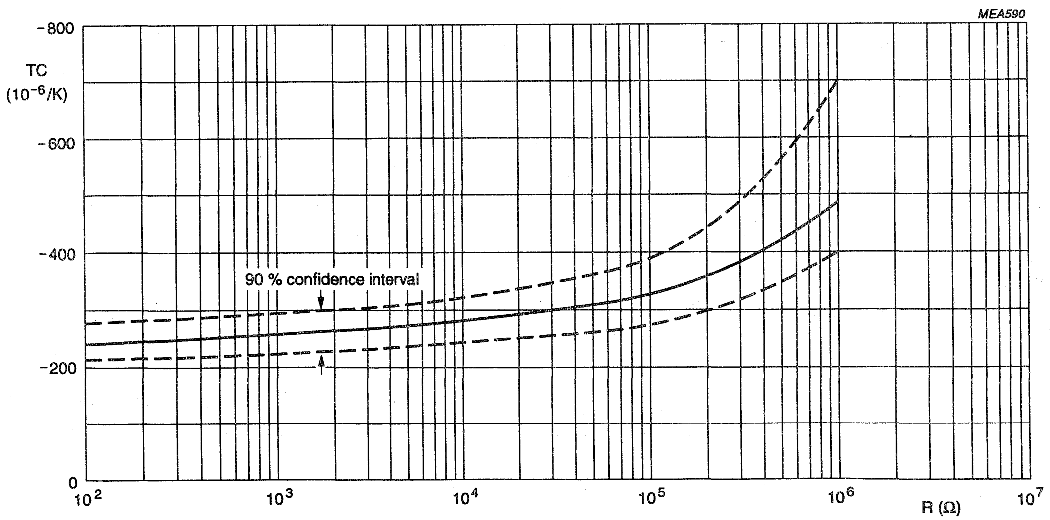
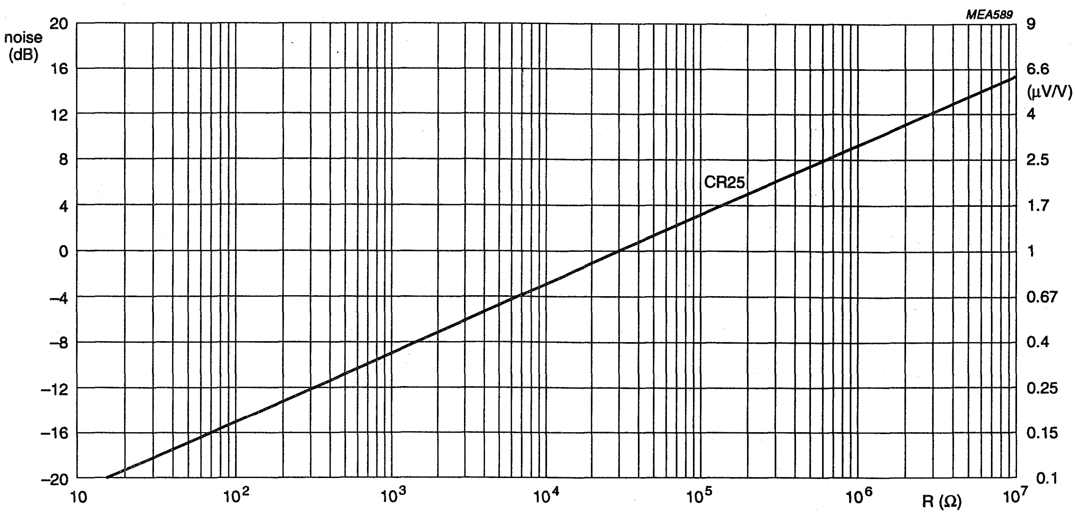


Fig.3 Maximum permissible dissipation at T_{amb} = 70 °C as a function of the resistance value for a resistance drift of 1.5% after 1000 hours, or for a maximum temperature of 155 °C without reaching the resistance drift of 1.5%; limiting voltage being taken into account.



For values < 10 Ω the temperature coefficient is ≤±200 × 10^{-6}/K.
For values > 1 MΩ the temperature coefficient is ≤±250 × 10^{-6}/K.

Fig.4 Temperature coefficient as a function of the resistance value.



95% confidence level.

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 the length of the leads, environmental stray capacitances and the measuring apparatus. These factors have to be considered when measuring. Table 2 gives typical values under test conditions at 250 MHz using the measuring arrangement shown in Fig.6. An RX-meter type 250 A of Boonton Radio Corporation is used.

Table 2 Frequency: 250 MHz.

CR25		
R_{nom} (Ω)	$\frac{\lvert z \rvert}{R_{nom}}$	∂ (deg)
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

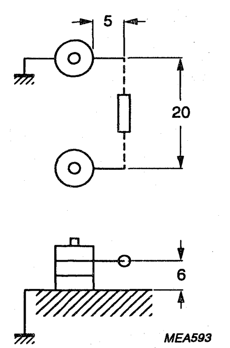


Fig.6 Measuring arrangement.

COMPOSITION OF THE CATALOGUE NUMBER

The resistors have a 12-digit catalogue number starting with 2322 211. The subsequent 5 digits indicate the packaging and resistance value (see Tables 3 and 4).

Table 3 First two digits to indicate packaging for resistances as listed.

TYPE	RESISTANCE RANGE	TOL. (%)	LIMITING VOLTAGE RMS VALUE (V)	PACKAGING(1)	QUANTITY	CATALOGUE NUMBER 2322 211 .....
CR25	1 Ω to 10 MΩ	±5	250	on reel	5000	23...
				in box	5000	73...

Note

1. Alternative packaging is available on request.

To complete the catalogue number (see Table 3), replace the first two dots of the remaining 3-digit code by the first two digits of the resistance value. Replace the third dot by a figure according to Table 4.

Table 4 Last digit of 12 NC.

RESISTANCE	LAST DIGIT
1 to 9.1 Ω	8
10 to 91 Ω	9
100 to 910 Ω	1
1 to 9.1 kΩ	2
10 to 91 kΩ	3
100 to 910 kΩ	4
1 to 9.13 MΩ	5
10 MΩ	6

Ordering example

The catalogue number of a CR25 resistor, value 5600 Ω ±5%, taped on a 52 mm bandolier packed in an ammopack of 5000 units is:
2322 211 73562.

TESTS AND REQUIREMENTS

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

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

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

Air pressure: 86 kPa to 106 kPa (860 mbar to 1 060 mbar).

In Table 5 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 5

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.16	U	robustness of terminations:		
4.16.2	Ua	tensile all samples	Ø 0.6 mm; load 10 N; 10 s	number of failures <10×10^{-6}
4.16.3	Ub	bending half number of samples	Ø 0.6 mm; load 5 N; 4 × 90°	number of failures <10×10^{-6}
4.16.4	Uc	torsion other half number of samples	3 × 360° in opposite directions	no damage ΔR/R max.: ±0.5% +0.05 Ω
4.17	Ta	solderability	2 s; 235 °C; flux 600	good tinning; no damage
4.18	Tb	resistance to soldering heat	thermal shock: 3 s; 350 °C; 6 mm from body	ΔR/R max.: ±0.5% +0.05 Ω
4.19	Na	rapid change of temperature	30 minutes at –55 °C and 30 minutes at +155 °C; 5 cycles	ΔR/R max.: ±0.5% +0.05 Ω
4.20	Eb	bump	3 × 1500 bumps in three directions; 40 g	no damage ΔR/R max.: ±0.5% +0.05 Ω
4.22	Fc	vibration	frequency 10 to 500 Hz; displacement 1.5 mm or acceleration 10 g; three directions; total 6 hours (3 × 2 hours)	no damage ΔR/R max.: ±0.5% +0.05 Ω
4.23		climatic sequence:		
4.23.2	Ba	dry heat	16 hours; 155 °C	
4.23.3	Db	damp heat (accelerated) 1st cycle	24 hours; 55 °C; 90 to 100% RH	
4.23.4	Aa	cold	2 hours; –55 °C	
4.23.5	M	low air pressure	2 hours; 8.5 kPa; 15 to 35 °C	
4.23.6	Db	damp heat (accelerated) remaining cycles	5 days; 55 °C; 95 to 100% RH	R_{ins} min.: 1000 MΩ R ≤ 220 kΩ: ΔR/R max.: ±1.5% +0.1 Ω R > 220 kΩ: ΔR/R max.: ±3%

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.24.2	Ca	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; the dissipation should not exceed 1% of the value indicated in Fig.3	R_{ins} min.: 1000 MΩ R ≤ 220 kΩ: ΔR/R max.: ±1.5% +0.1 Ω R > 220 kΩ: ΔR/R max.: ±3%
4.25.1		endurance	1000 hours at 70 °C; dissipation taken from Fig.3	R ≤ 1 MΩ: ΔR/R max.: ±1.5% +0.1 Ω R > 1 MΩ: ΔR/R max.: ±2% +0.1 Ω
4.8.4		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
4.12		noise	IEC publication 195	see Fig.5
4.6.1.1		insulation resistance	100 V (DC or RMS) during 1 minute; V-block method	R_{ins} min.: 1000 MΩ
4.13		short time overload	room temperature; dissipation 6.25 × value taken from Fig.3 (voltage not more than 2 × limiting voltage); 10 cycles; 5 s on and 45 s off	ΔR max.: ±1% +0.05 Ω
4.11		voltage coefficient		$<5 \times 10^{-6}$

PACKAGING

The resistors are supplied on bandolier; either in ammopack or on reel. For details refer to Section *"General Introduction leaded resistors"* in the data handbook PA08.

Dimensions of ammopack.

TYPE	QUANTITY	M (mm)	N (mm)	P (mm)
CR25	5000	78	98	270

Dimensions of reel.

TYPE	QUANTITY	Q (mm)	V (mm)
CR25	5000	305	73

Tape and reel data

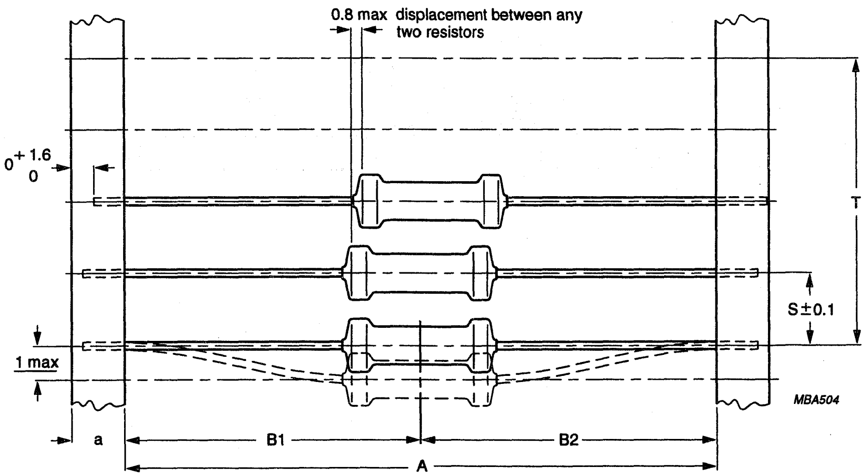


Fig.7 Axial on tape.

Dimensions of bandolier.

TYPE	a (mm)	A (mm)	$\lvert B_1 - B_2 \rvert$ (mm)	S (mm)	T (deviation of spacing)
CR25	6 ±0.5	52.5 ±1.5	max. ±1.2	5	max. 1 mm per 10 spacings

STANDARD FILM

Standard metal film resistor SFR16

FEATURES

- Small size
- Low noise.

APPLICATIONS

- Commodity products
- Equipment requiring CECC approval (SFR16T CECC only).

DESCRIPTION

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

The resistors are coated with a coloured lacquer (light-green for type T and T CECC; light-blue for type S) 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 68-2045.

QUICK REFERENCE DATA

DESCRIPTION	VALUE
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
Absolute maximum dissipation at T_{amb} = 70 °C	0.50 W
Thermal resistance, R_{th}	170 K/W
Maximum permissible voltage	200 v
Noise:	
R < 68 kΩ	max. 0.1 µV/V
68 kΩ ≤ R ≤ 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 (SFR16T CECC only)	CECC 40 101
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

MECHANICAL DATA

Mass

12.5 g (per 100 units).

Mounting

The resistors are suitable for processing on automatic insertion equipment in addition to cutting and bending machines. The minimum pitch for this type is 2e (5 mm.) Figure 5 shows the temperature rise at the soldering point.

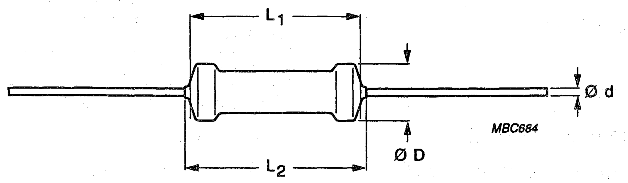
Marking

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

ELECTRICAL DATA

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"* on the back inside cover of data handbook PA08. 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 continuously applied to the resistor element, see *"IEC publication 115-1"*. The maximum permissible hot-spot temperature is 155 °C.



Dimensions in mm.

Standard version, specially made to obtain a minimum 'clean lead to clean lead' dimension L_2 (bare bottom).

Fig.1 Component outline.

Table 1 Resistor dimensions (see Fig.1).

TYPE	D MAX.	L_1 TYP.	L_2 MAX.	d TYP.
SFR16S	1.9	3.2	3.4	0.45 ±0.05
SFR16T	1.9	3.5	3.7	0.45 ±0.05
SFR16T CECC	1.9	3.5	3.7	0.5 –0.04

The length of the body L_1 (see Fig.1) 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, see *"IEC publication 294"*.

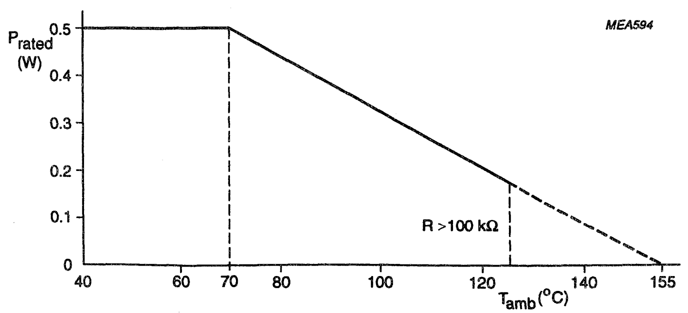


Fig.2 Maximum rated power dissipation (P_{rated}) as a function of the ambient temperature (T_{amb}).

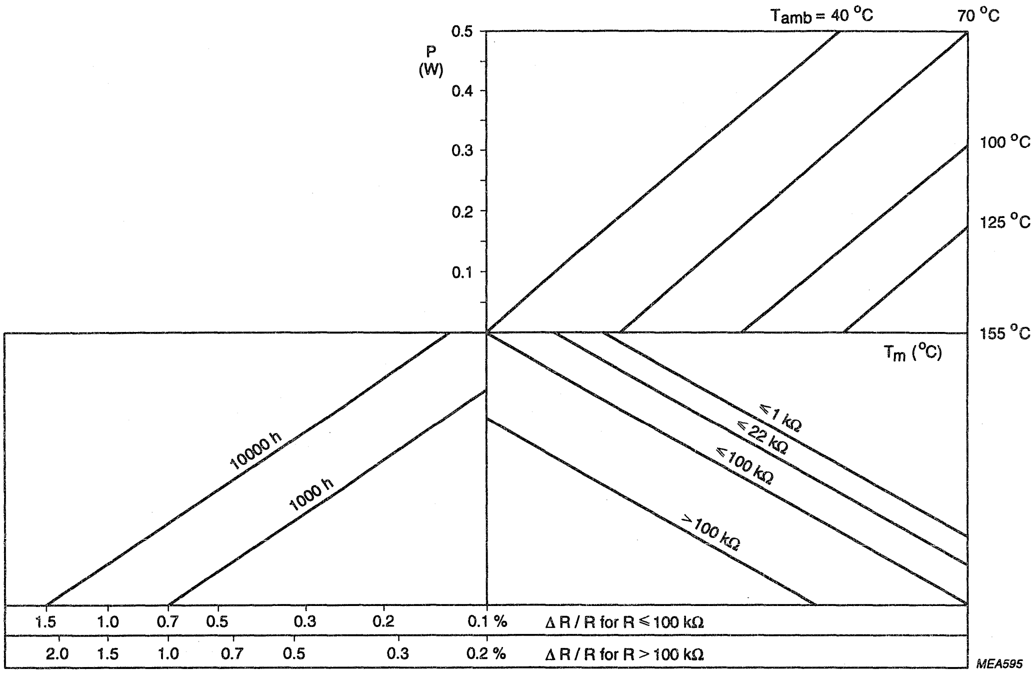


Fig.3 Drift nomogram.

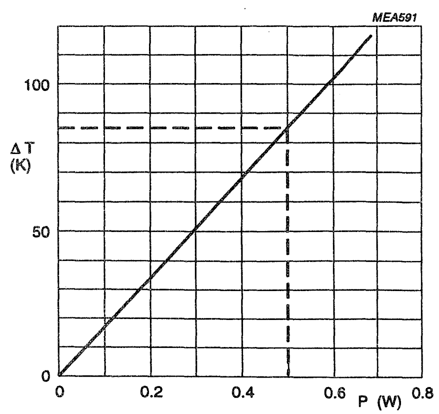


Fig.4 Hot-spot temperature rise (ΔT) as a function of dissipated power.

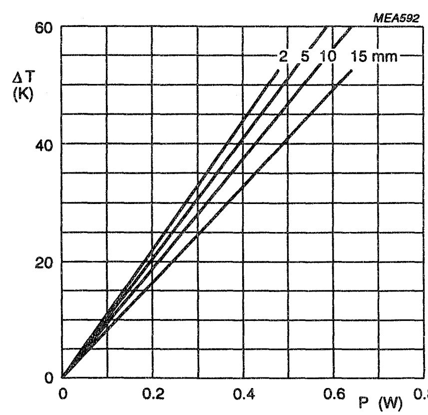


Fig.5 Temperature rise (ΔT) at the end of the lead (soldering point) as a function of dissipated power at various lead lengths after mounting.

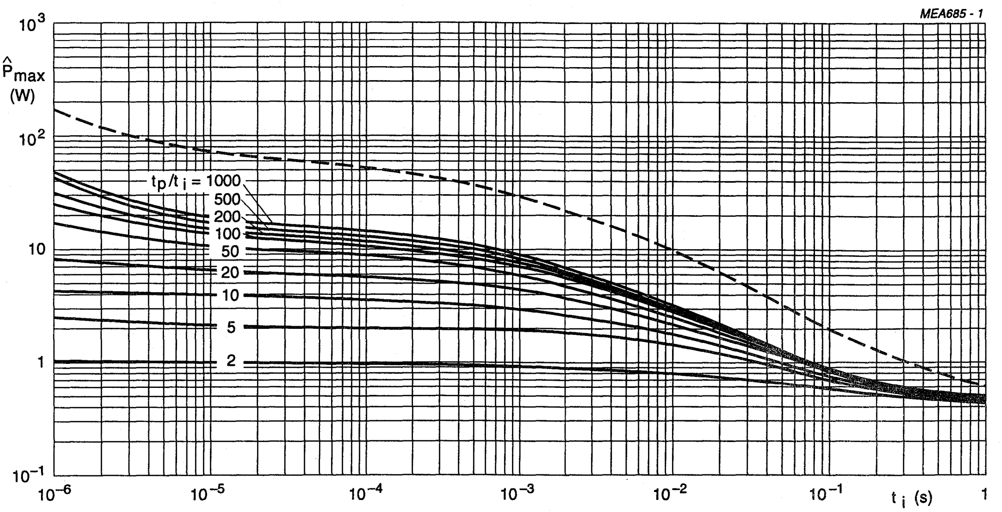


Fig.6 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i).

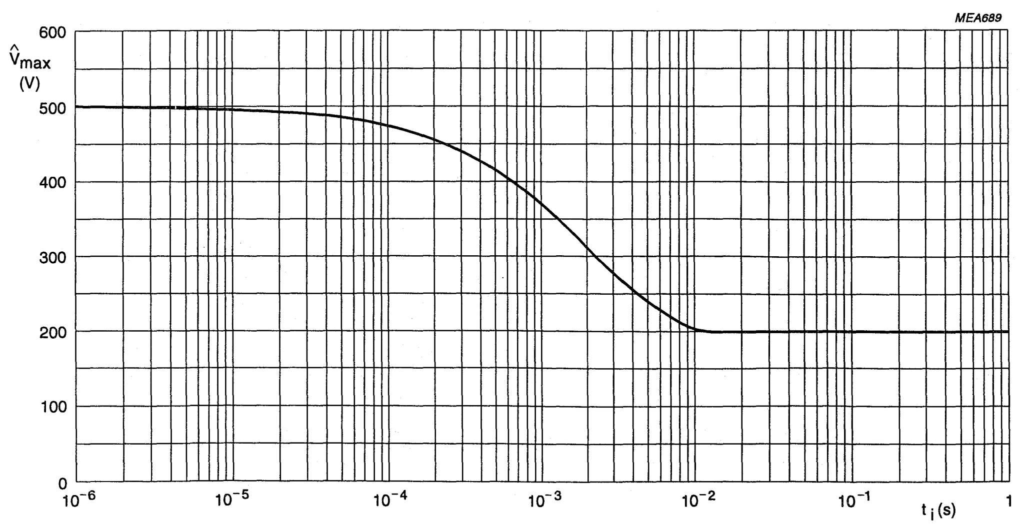


Fig.7 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_i).

Standard metal film resistor SFR16

COMPOSITION OF THE CATALOGUE NUMBER

The resistors have a 12-digit catalogue number starting with 2322. The subsequent 8 digits indicate the packaging and resistance value (see Tables 2 and 3).

Table 2 First five digits to indicate packaging for resistances as listed.

TYPE	RESISTANCE RANGE	TOL. (%)	BANDOLIER WIDTH (mm)	PACKAGING(1)	QUANTITY	CATALOGUE NUMBER 2322 ... .
SFR16S	1 Ω to 3 MΩ	±5	52	ammopack	1000	187 73...
				ammopack	5000	187 53...
				on reel	5000	187 83...
SFR16T	1 Ω to 3 MΩ	±5	52	ammopack	1000	180 73...
				ammopack	5000	180 53...
				on reel	5000	180 83...
SFR16T CECC	1 Ω to 3 MΩ	±5	52	ammopack	1000	180 76...
				ammopack	5000	180 56...
				on reel	5000	180 86...

Note

1. Alternative packaging is available on request.

To complete the catalogue number (see Table 2), replace the first two dots of the remaining 3-digit code by the first two digits of the resistance value. Replace the third dot (last digit) by a figure according to Table 3.

Table 3 Last digit of 12 NC.

RESISTANCE	LAST DIGIT
1 to 9.1 Ω	8
10 to 91 Ω	9
100 to 910 Ω	1
1 to 9.1 kΩ	2
10 to 91 kΩ	3
100 to 910 kΩ	4
1 to 3 MΩ	5

Ordering example

The catalogue number of a SFR16T resistor, value 5600 Ω ±5%, on a 52 mm bandolier of 1000 units in ammopack is: 2322 180 73562.
For a CECC approved resistor the catalogue number is:
2322 180 76562.

Standard metal film resistor SFR16

TESTS AND REQUIREMENTS

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

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

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

Air pressure: 86 kPa to 106 kPa (860 mbar to 1 060 mbar).

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

Table 4

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.16	U	robustness of terminations:		
4.16.2	Ua	tensile all samples	∅ 0.5 mm; load 5 N; 10 s	number of failures $<10 \times 10^{-6}$
4.16.3	Ub	bending half number of samples	∅ 0.5 mm; load 2.5 N; 4 × 90°	number of failures $<10 \times 10^{-6}$
4.16.4	Uc	torsion other half number of samples	3 × 360° in opposite directions	no damage ΔR/R max.: ±0.25% +0.05 Ω
4.17	Ta	solderability	2 s; 235 °C; flux 600	good tinning; no damage
4.18	Tb	resistance to soldering heat	thermal shock: 3 s; 350 °C; 6 mm from body	ΔR/R max.: ±0.25% +0.05 Ω
4.19	Na	rapid change of temperature	30 minutes at –55 °C and 30 minutes at +155 °C; 5 cycles	ΔR/R max.: ±0.25% +0.05 Ω
4.20	Eb	bump	3 × 1500 bumps in three directions; 40 g	no damage ΔR/R max.: ±0.25% +0.05 Ω
4.22	Fc	vibration	frequency 10 to 500 Hz; displacement 1.5 mm or acceleration 10 g; three directions; total 6 hours (3 × 2 hours)	no damage ΔR/R max.: ±0.25% +0.05 Ω
4.23		climatic sequence:		
4.23.2	Ba	dry heat	16 hours; 155 °C	
4.23.3	Db	damp heat (accelerated) 1st cycle	24 hours; 55 °C; 90 to 100% RH	
4.23.4	Aa	cold	2 hours; –55 °C	
4.23.5	M	low air pressure	2 hours; 8.5 kPa; 15 to 35 °C	
4.23.6	Db	damp heat (accelerated) remaining cycles	5 days; 55 °C; 95 to 100% RH	R_{ins} min.: 1 000 MΩ ΔR/R max.: ±1% +0.05 Ω
4.24.2	Ca	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; dissipation 0.01 P_n	R_{ins} min.: 1 000 MΩ ΔR/R max.: ±1% +0.05 Ω
4.25.1		endurance	1000 hours at 70 °C; P_n or V_{max}	ΔR/R max.: ±1% +0.05 Ω

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.8.4		temperature coefficient	between –55 °C and +155 °C	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
4.7		voltage proof on insulation	400 V (RMS) during 1 minute; V-block method	no breakdown
4.12		noise	IEC publication 195	R < 68 kΩ: max. 0.1 µV/V 68 kΩ ≤ R ≤ 100 kΩ: max. 0.5 µV/V R > 100 kΩ: max. 1.5 µV/V
4.6.1.1		insulation resistance	100 V (DC or RMS) during 1 minute; V-block method	R_{ins} min.: 1 000 MΩ
4.13		short time overload	room temperature; dissipation 6.25 × 0.25 W (voltage not more than 2 × limiting voltage); 10 cycles; 5 s on and 45 s off	ΔR/R max.: ±0.25% +0.05 Ω
		intermittent overload in accordance with JIS-C5202 5.8	16 × 0.16 W; 1 s on and 25 s off; 10000 ±200 cycles; V_{max} = 600 V	ΔR/R max.: ±0.75% +0.05 Ω
See 2nd amendment to IEC 115-1, Jan. '87		pulse load		Figs 6 and 7

PACKAGING

The resistors are supplied on bandolier in ammopack, or on reel. For details refer to Section *"General Introduction leaded resistors"* in data handbook PA08.

Dimensions of ammopack.

TYPE	QUANTITY	M (mm)	N (mm)	P (mm)
SFR16 (all types)	1000	75	30	140
	5000	75	73	270

Dimensions of reel.

TYPE	QUANTITY	Q (mm)	R (mm)	V (mm)
SFR16 (all types)	5000	265	75	86

Tape and reel data

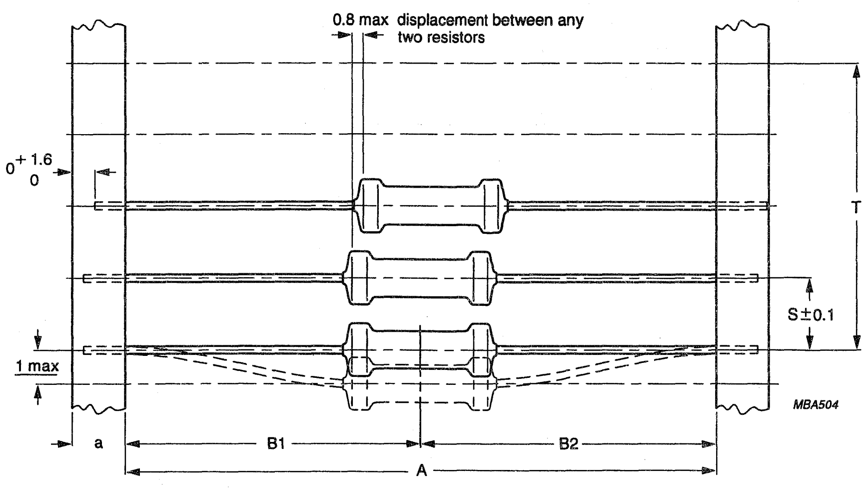


Fig.8 Axial on tape.

Dimensions of bandolier.

TYPE	a (mm)	A (mm)	$\lvert B_1 - B_2 \rvert$ (mm)	S (mm)	T (deviation of spacing)
SFR16 (all types)	6 ±0.5	52.5 ±1.5	max. ±1.2	5	max. 1 mm per 10 spacings max. 0.5 mm per 5 spacings

Standard metal film resistor SFR25

FEATURES

- Low cost
- Low noise.

APPLICATIONS

- General purpose resistor.

DESCRIPTION

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

The resistors are coated with a coloured lacquer (light-green for type SFR25; red-brown for type SFR25H CECC) 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.

QUICK REFERENCE DATA

DESCRIPTION	VALUE	
	SFR25	SFR25H CECC
Resistance range	1 Ω to 10 MΩ, E24 series and jumper (0 Ω)	
Resistance tolerance	±5%	
Temperature coefficient:		
R < 1 MΩ	$\leq \pm 100 \times 10^{-6}$/K	
R > 1 MΩ	$\leq \pm 250 \times 10^{-6}$/K	
Absolute maximum dissipation at T_{amb} = 70 °C	0.4 W	0.5 W
Thermal resistance, R_{th}	200 K/W	150 K/W
Maximum permissible voltage	250 V	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	
Approval	–	CECC 40 101
Climatic category (IEC 68)	55/155/56	
Stability for R = 1 Ω to 10 MΩ		
Stability, ΔR/R max., after:		
load	±1% +0.05 Ω	–
climatic tests	±1% +0.05 Ω	–
soldering	±0.25% +0.05 Ω	–
short time overload	±0.25% +0.05 Ω	–
Stability for R ≤ 1 MΩ		
Stability, ΔR/R max., after:		
load	–	±1% +0.05 Ω
climatic tests	–	±1% +0.05 Ω
soldering	–	±0.25% +0.05 Ω
short time overload	–	±1% +0.05 Ω
Stability for R > 1 MΩ		
Stability, ΔR/R max., after:		
load	–	±2% +0.1 Ω
climatic tests	–	±2% +0.1 Ω
soldering	–	±0.25% +0.05 Ω
short time overload	–	±1% +0.05 Ω

MECHANICAL DATA

Mass

25 g (per 100 units).

Mounting

The resistors are suitable for processing on automatic insertion equipment in addition to cutting and bending machines. The minimum pitch for this type is 4e (10.2 mm). Figures 4 and 5 show the temperature rise at the soldering point.

Marking

The nominal resistance, tolerance and temperature coefficient are marked on the resistors by four or five coloured bands in accordance with IEC publication 62 *"Colour code for fixed resistors"*.

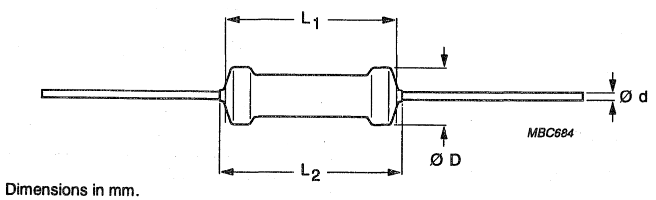


Fig.1 Component outline.

Table 1 Resistor dimensions (see Fig.1).

TYPE	D MAX.	L_1 MAX.	L_2 MAX.	d TYP.
SFR25	2.5	6.5	7.0	0.55 ±0.05
SFR25H CECC	2.5	6.5	7.0	0.6 ±0.03

The length of the body L_1 (see Fig.1) 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, see *"IEC publication 294"*.

ELECTRICAL DATA

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"* on the inside cover of the data handbook.
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 continuously applied to the resistor element, see *"IEC publication 115-1"*. The maximum permissible hot-spot temperature is 155 °C.

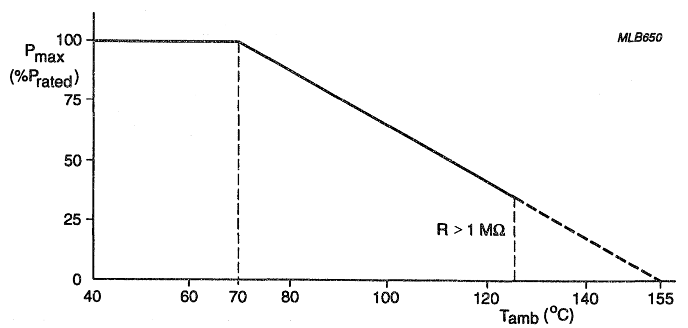
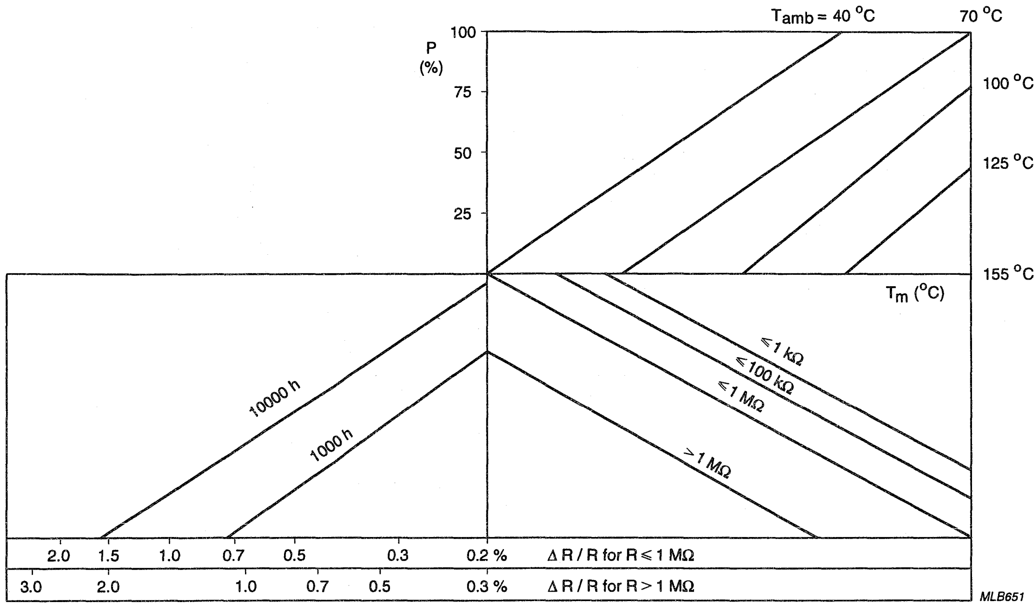


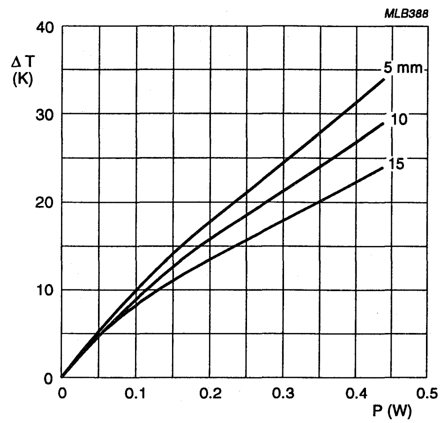
Fig.2 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).



P_n = 0.4 W (SFR25) or 0.5 W (SFR25H CECC).

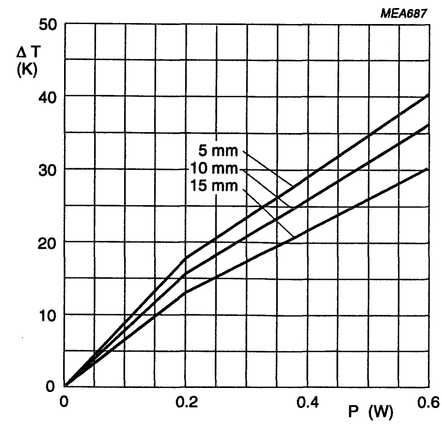
Fig.3 Drift nomogram.

Standard metal film resistor SFR25



SFR25

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



SFR25H

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

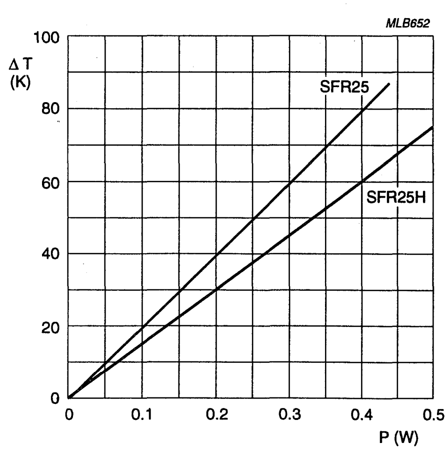
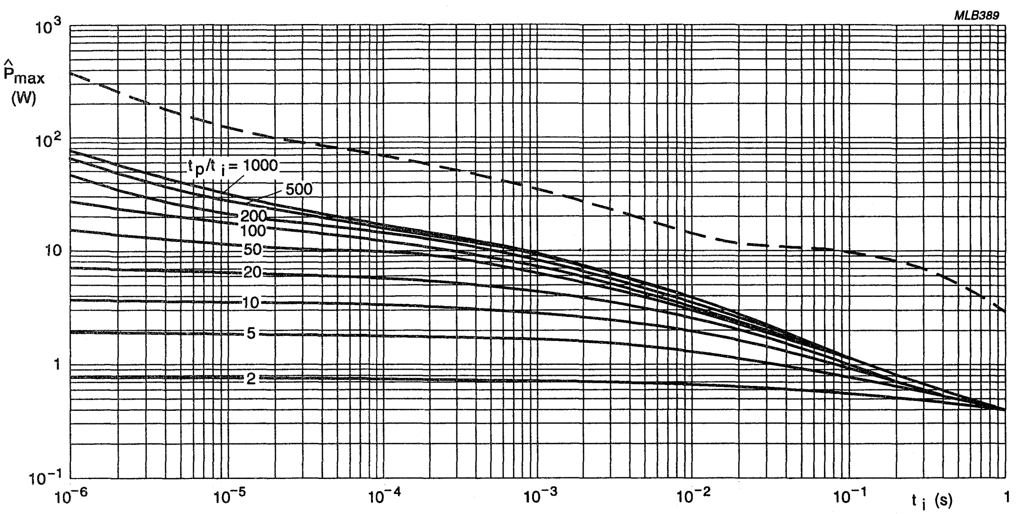
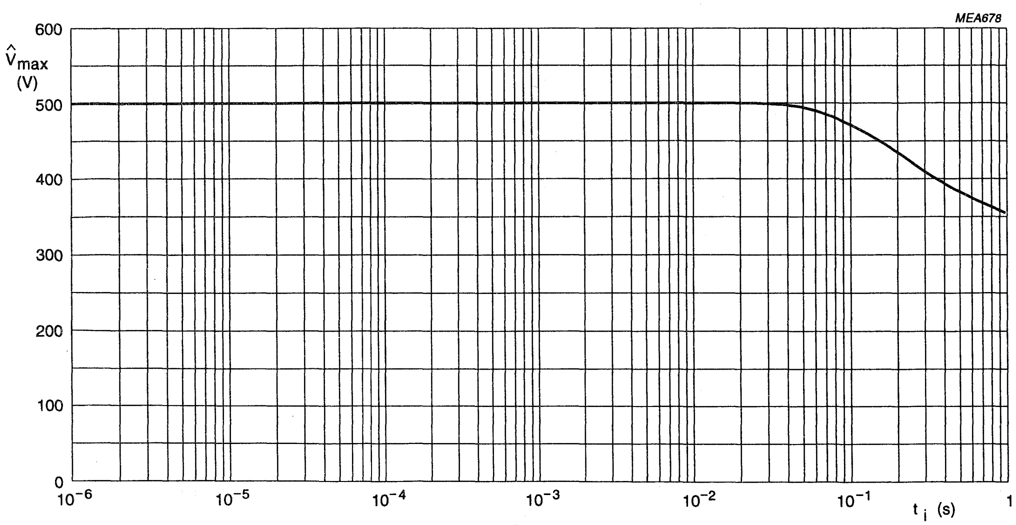


Fig.6 Hot-spot temperature rise (ΔT) as a function of dissipated power.



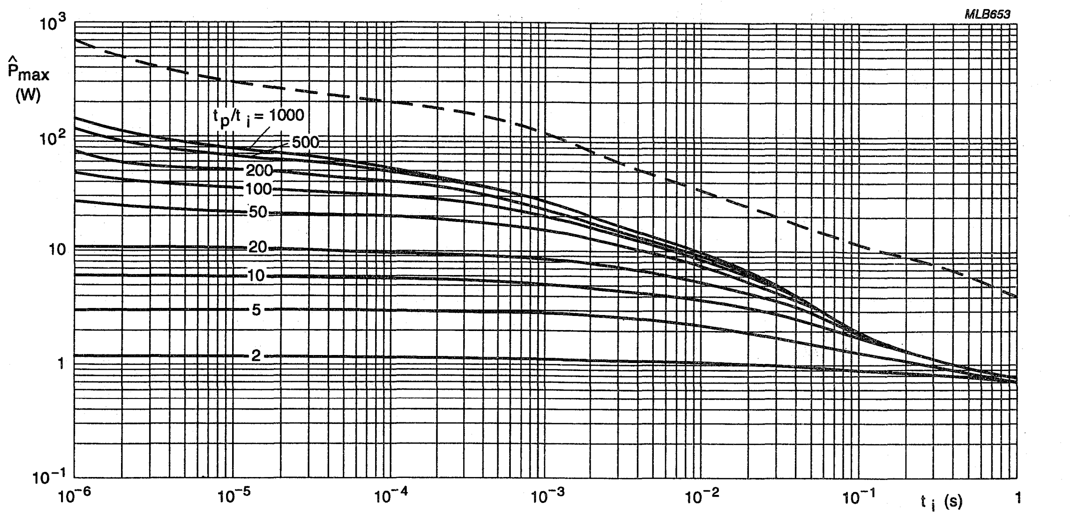
SFR25

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



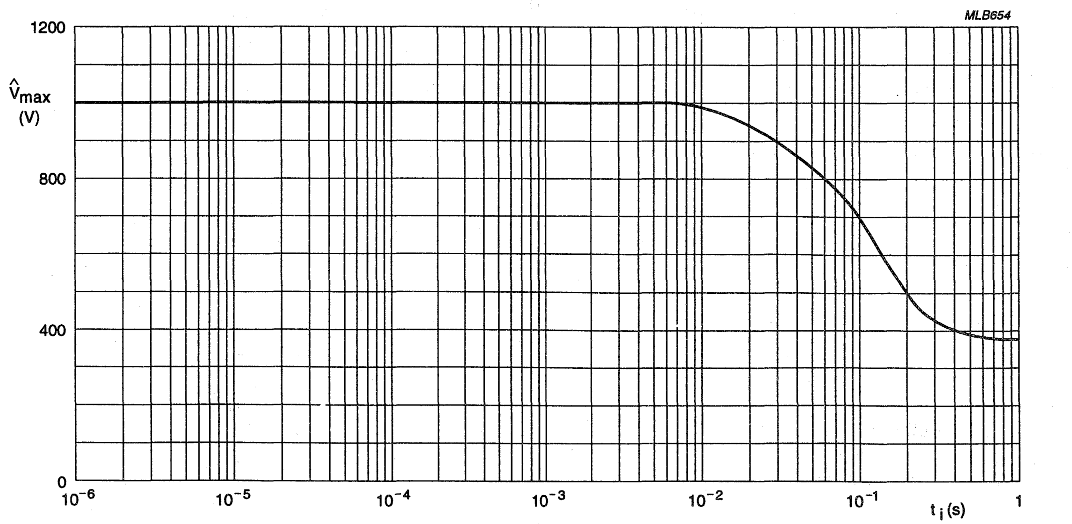
SFR25

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



SFR25H

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



SFR25H

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

COMPOSITION OF THE CATALOGUE NUMBER

The resistors have a 12-digit catalogue number starting with 2322. The subsequent 8 digits indicate the packaging and resistance value (see Tables 2 and 3).

Table 2 First five digits to indicate packaging for resistances as listed.

TYPE	RESISTANCE RANGE	TOL. (%)	BANDOLIER WIDTH (mm)	PACKAGING	QUANTITY	CATALOGUE NUMBER 2322 ... .
SFR25	1 to 10 MΩ	±5	52	ammopack	1000	181 53...
					5000	181 43...
				on reel	5000	181 63...
	jumper 0 Ω; note 1	±5	52	ammopack	5000	181 90019
SFR25H CECC	1 to 10 MΩ	±5	52	ammopack	1000	186 16...
					5000	186 76...
				on reel	5000	186 26...
SFR25AS radial taped	1 Ω to 10 MΩ	±5	–	on reel	4000	184 43...

Note

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

To complete the catalogue number (see Table 2), replace the first two dots of the remaining 3-digit code by the first two digits of the resistance value. Replace the third dot by a figure according to Table 3.

Table 3 Last digit of 12 NC.

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

Ordering example

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

TESTS AND REQUIREMENTS

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

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

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

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

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

Table 4

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.16	U	robustness of terminations:		
4.16.2	Ua	tensile all samples	∅ 0.5 mm; load 5 N; 10 s	number of failures <10 × 10^{-6}
4.16.3	Ub	bending half number of samples	∅ 0.5 mm; load 2.5 N; 4 × 90°	number of failures <10 × 10^{-6}
4.16.4	Uc	torsion other half number of samples	3 × 360° in opposite directions	no damage ΔR/R max.: ±0.25% +0.05 Ω
4.17	Ta	solderability	2 s; 235 °C; flux 600	good tinning; no damage
4.18	Tb	resistance to soldering heat	thermal shock: 3 s; 350 °C; 6 mm from body	ΔR/R max.: ±0.25% +0.05 Ω
4.19	Na	rapid change of temperature	30 minutes at –55 °C and 30 minutes at +155 °C; 5 cycles	ΔR/R max.: ±0.25% +0.05 Ω
4.20	Eb	bump	3 × 1500 bumps in three directions; 40 g	no damage ΔR/R max.: ±0.25% +0.05 Ω
4.22	Fc	vibration	frequency 10 to 500 Hz; displacement 1.5 mm or acceleration 10 g; three directions; total 6 hours (3 × 2 hours)	no damage ΔR/R max.: ±0.25% +0.05 Ω
4.23		climatic sequence:		
4.23.2	Ba	dry heat	16 hours; 155 °C	
4.23.3	Db	damp heat (accelerated) 1st cycle	24 hours; 55 °C; 90 to 100% RH	
4.23.4	Aa	cold	2 hours; –55 °C	
4.23.5	M	low air pressure	2 hours; 8.5 kPa; 15 to 35 °C	
4.23.6	Db	damp heat (accelerated) remaining cycles	5 days; 55 °C; 95 to 100% RH	R_{ins} min.: 1000 MΩ ΔR/R max.: ±1% +0.05 Ω

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.24.2	Ca	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; dissipation 0.01 P_n	R_{ins} min.: 1000 MΩ ΔR/R max.: ±1% +0.05 Ω
4.25.1		endurance	1000 hours at 70 °C; P_n or V_{max}	ΔR/R max.: ±1% +0.05 Ω
4.8.4		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	600 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 or RMS) during 1 minute; V-block method	R_{ins} min.: 1000 MΩ
4.13		short time overload	room temperature; dissipation 6.25 × P_n (voltage not more than 2 × limiting voltage); 10 cycles; 5 s on and 45 s off	SFR25: ΔR/R max.: ±0.25% +0.05 Ω SFR25H CECC: ΔR/R max.: ±1% +0.05 Ω
See 2nd amendment to IEC 115-1, Jan. '87		pulse load		Figs 7, 8, 9 and 10

PACKAGING

The resistors 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. For details refer to Section *"General Introduction leaded resistors"* in data handbook PA08.

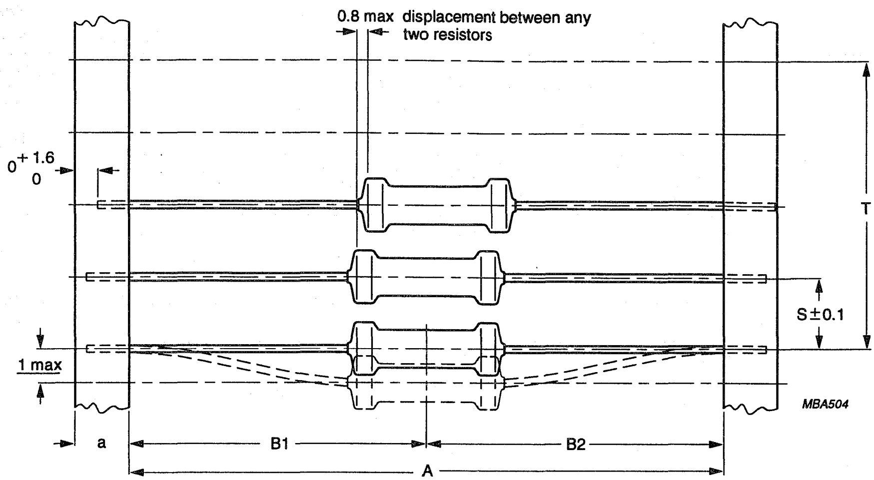
Quantities per package.

TYPE	QUANTITY	
	BANDOLIER IN AMMOPACK	BANDOLIER ON REEL
SFR25	1000 or 5000	5000
SFR25H CECC	1000 or 5000	5000
SFR25AS	–	4000

Dimensions of ammopack.

TYPE	QUANTITY	M (mm)	N (mm)	P (mm)
SFR25	5000	78	98	270
SFR25H CECC	1000	82	28	262

Tape and reel data



Dimensions in mm

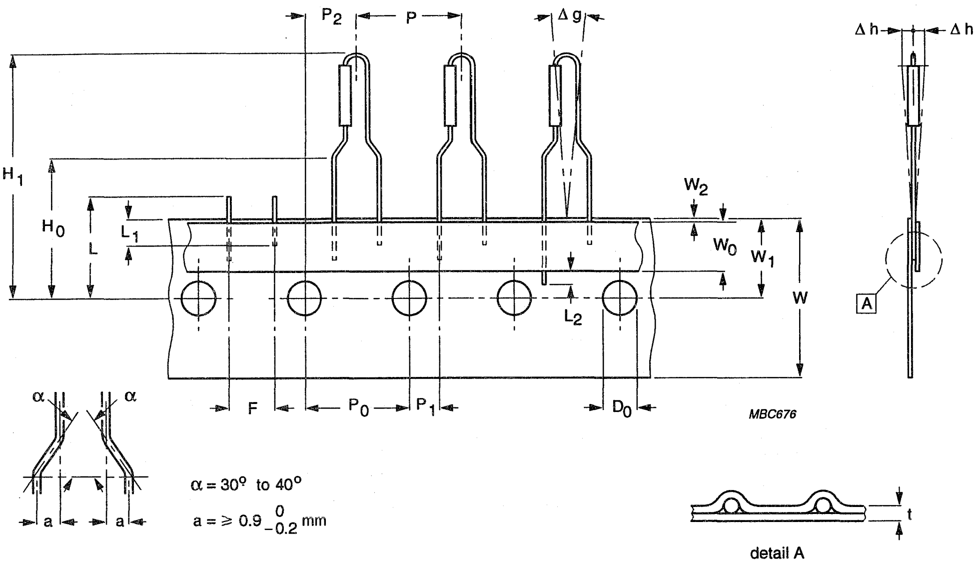
Fig.11 Axial on tape.

Dimensions of reel.

TYPE	QUANTITY	Q (mm)	R (mm)	V (mm)
SFR25	5000	305	86	75
SFR25H CECC				
SFR25AS	4000	356	49	40

Dimensions of bandolier.

TYPE	a (mm)	A (mm)	$\lvert B_1 - B_2 \rvert$ (mm)	S (mm)	T (deviation of spacing)
SFR25	6 ±0.5	52 +1.5/–0	max. ±1.2	5	max. 1 mm per 10 spacings max. 0.5 mm per 5 spacings
SFR25H CECC					



SFR25AS (Euroform).

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

For dimensions see Table 5.

Fig.12 Bandolier for types with radial leads.

Table 5 Taping dimensions; see Fig.12.

SYMBOL	PARAMETER	VALUE	TOLERANCE	UNIT
D	maximum body diameter	2.50	–	mm
A	maximum body length	7.00	–	mm
d	lead wire diameter	0.60	+0.06/–0.05	mm
P	pitch of components	12.7	±1.0	mm
P_0	feed-hole pitch	12.7	±0.2	mm
	cumulative pitch error per 20 spacings	1.0		mm
P_1	feed-hole centre to lead at topside at the tape	3.85	±0.5	mm
P_2	feed-hole centre to body centre	6.35	±1.0	mm
F	lead-to-lead distance	4.8	+0.7/–0	mm
Δh	component alignment	0	±1.2	mm
Δg	component alignment	0	±3°	deg
W	tape width	18.0	±0.5	mm
W_0	minimum hold down tape width	5.5	–	mm
W_1	hole position	9.0	±0.5	mm
W_2	maximum hold down tape position	0.5	–	mm
H_0	lead wire clinch height	16.5	±0.5	mm
H_1	component height	23 to 32		mm
D_0	feed-hole diameter	4.0	±0.2	mm
t	total tape thickness	0.4	–0/+0.5	mm
L	maximum length of snipped lead	11.0	–	mm
L_1	minimum lead wire (tape portion) shortest lead	2.5	–	mm

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 in accordance with MIL-STD-202E, method 215 and IEC 68-2-45.

MECHANICAL DATA

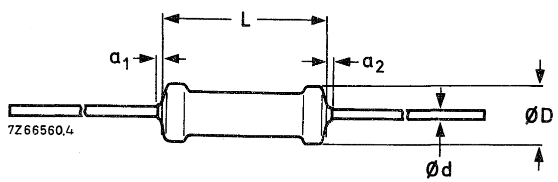


Fig. 1.

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).

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

....

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:
2322 205 13 for 1000 items on bandolier
2322 205 23 for 5000 items on reel
2322 205 33 for 5000 items in ammopack
2306 204 03 for 4000 items in ammopack
2306 204 83 for 4000 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 (mm)	packing	quantity	resistance range (Ω)	tolerance ±%	catalogue number
NFR25	52.0 +1.5/−0 52.0 +1.5/−0 52.0 +1.5/−0	ammopack reel ammopack	1000 5000 5000	1 − 15 k 1 − 15 k 1 − 15 k	5 5 5	2322 205 13 . . . 2322 205 23 . . . 2322 205 33 . . .
Radial taped						
NFR25		ammopack reel	4000 4000	1 − 15 k 1 − 15 k	5 5	2306 204 03 . . . 2306 204 83 . . .

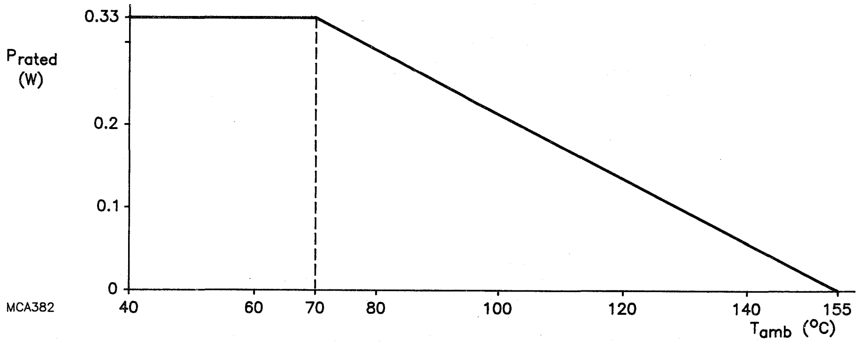


Fig.2 Maximum dissipation (P_{max}) as a function of ambient temperature (T_{amb}).

Time to interruption as a function of overload

"Interruption" means that the nominal resistance has increased at least 1000 times.

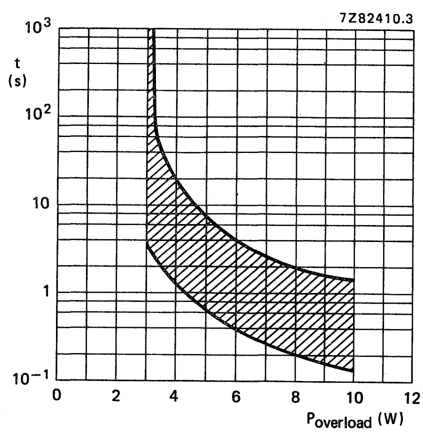


Fig.3 NFR25; R ⩽ 15 Ω.

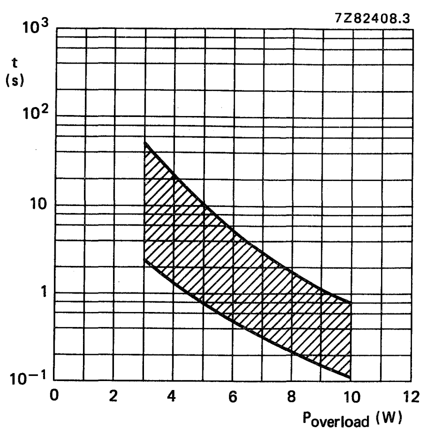


Fig.4 NFR25; 15 Ω < R ⩽ 15 kΩ.

These graphs are based on measured data which may deviate according to the application.

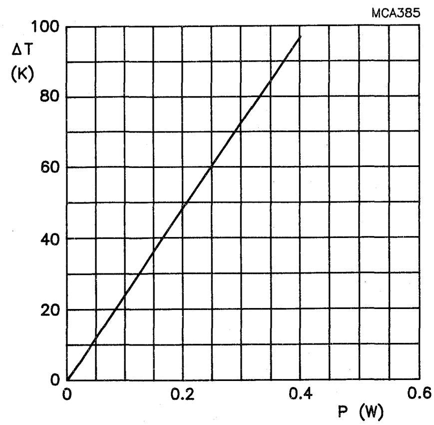


Fig.5 Hot-spot temperature rise (ΔT) as a function of dissipated power.

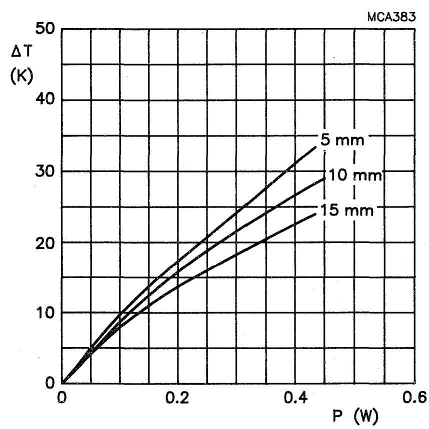


Fig.6 Temperature rise (ΔT) at the end of the lead (soldering point) as a function of dissipated power at various lead lengths after mounting.

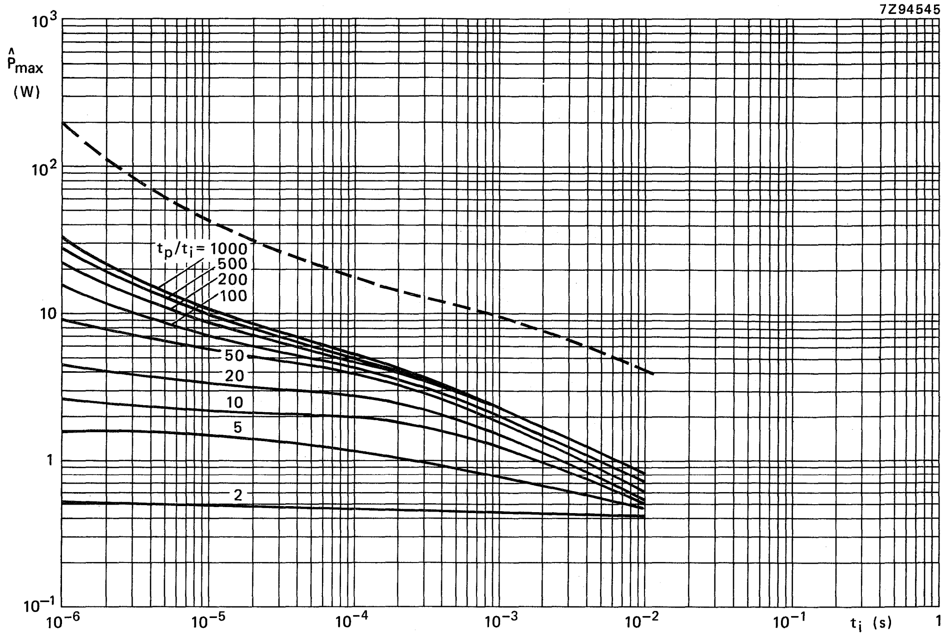


Fig.7 Max. permissible peak pulse power as a function of pulse duration for R < 15 Ω.

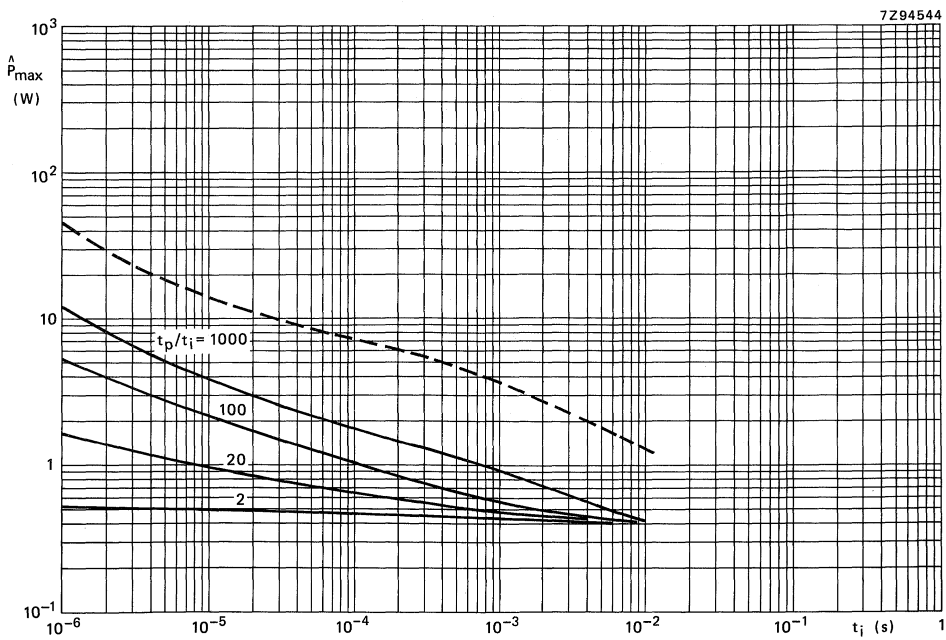


Fig.8 Max. permissible peak pulse power as a function of pulse duration for R ⩾ 15 Ω.

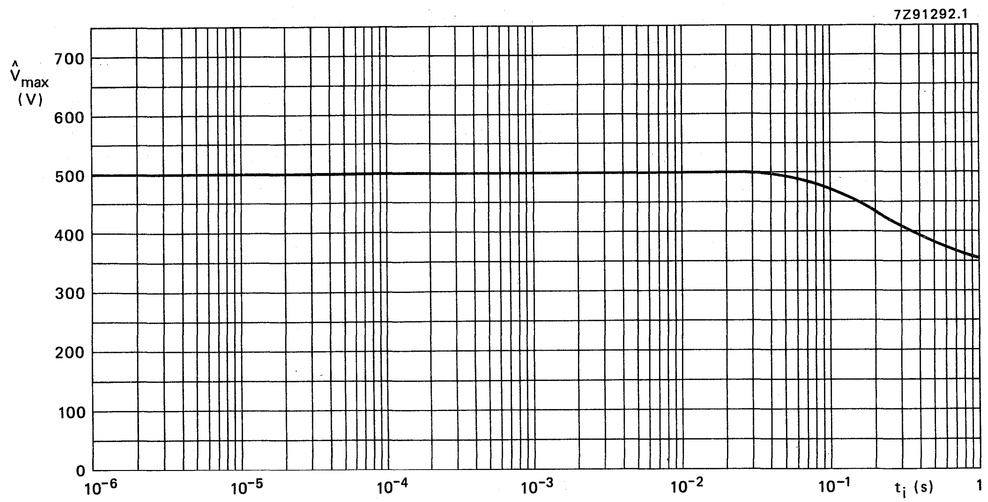


Fig.9 Maximum permissible peak pulse voltage as a function of pulse duration.

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	Solderability	solderability: 2 s 235 °C, flux 600	good tinning no damage
4.18	Tb	Resistance to soldering heat	thermal shock: 3 s 350 °C, 6 mm from body	ΔR 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 1000/5000 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)
NFR25	6	$52.0^{+1.5}_{-0}$	1.2	5	1 mm per 10 spacings, 0.5 mm per 5 spacings

Dimensions of ammopack

	Quantity	M	N	P
NFR25	1000	82	28	262
	5000	98	78	270
	4000	262	45	330

Dimensions of reel

	Quantity	Q	V	R
NFR25	5000	305	75	86
	4000	356	40	

The dimensions in above tables are in mm.

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	⩽ 200.10^{-6}/K
	R > 4.7 Ω	⩽ 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

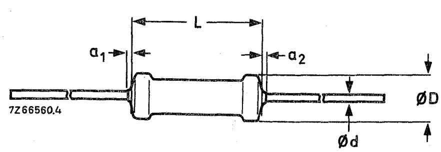


Fig. 1 Component Outline.

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).

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

....

Packing:

2322 207 13 for 1000 items in a box
2322 207 23 for 5000 items on reel
2322 207 33 for 5000 items in ammopack
2306 207 03 for 4000 items in ammopack
2306 207 83 for 4000 items on 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 13 652.

type	bandolier width (mm)	packing	quantity	resistance range (Ω)	tolerance ±%	catalogue number
NFR25H	52.0 +1.5/−0	ammopack	1000	1 − 15 k	5	2322 207 13 . . .
	52.0 +1.5/−0	reel	5000	1 − 15 k	5	2322 207 23 . . .
	52.0 +1.5/−0	ammopack	5000	1 − 15 k	5	2322 207 33 . . .
Radial taped						
NFR25H		ammopack	4000	1 − 15 k	5	2306 207 03 . . .
		reel	4000	1 − 15 k	5	2306 207 83 . . .

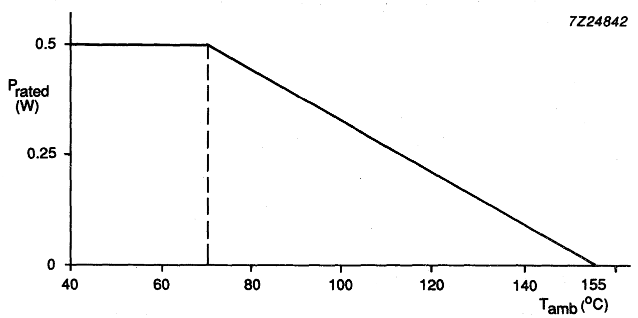
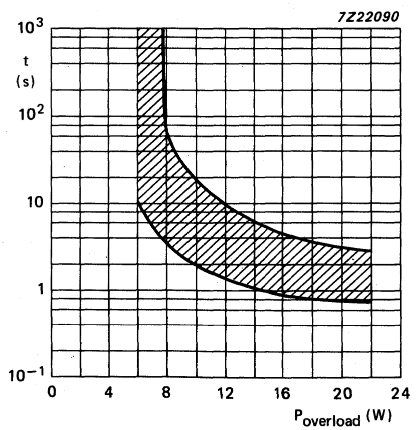


Fig.2 Maximum dissipation (P_{max}) as a function of ambient temperature (T_{amb}).

Time to interruption as a function of overload

"Interruption" means that the nominal resistance has increased at least 1000 times.



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

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

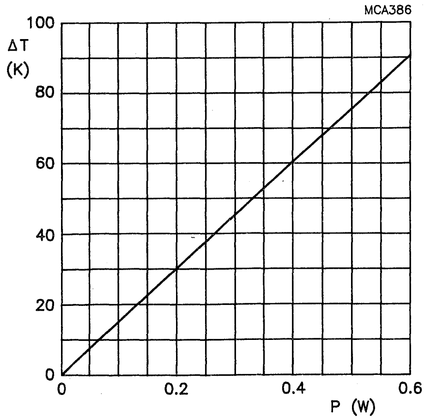


Fig.4 Hot-spot temperature rise (ΔT) as a function of dissipated power.

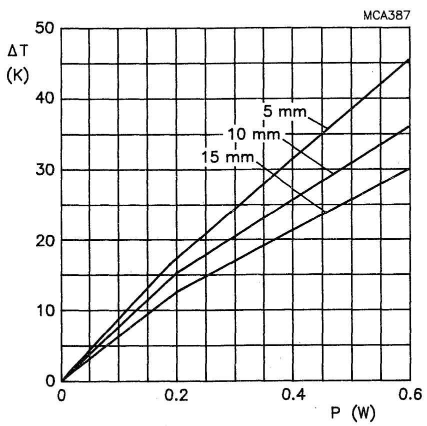


Fig.5 Temperature rise (ΔT) at the end of the lead (soldering point) as a function of dissipated power at various lead lengths after mounting.

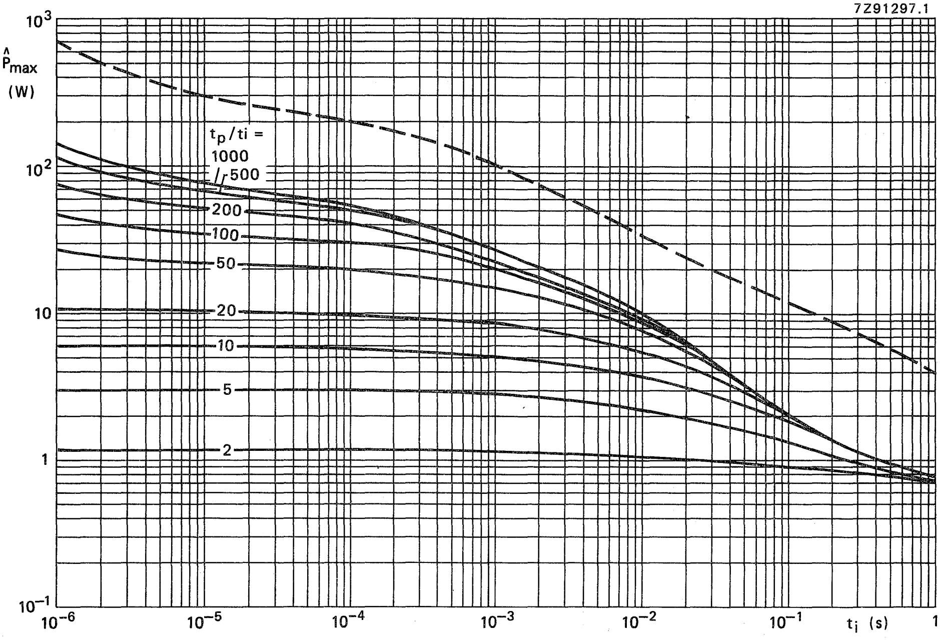


Fig.6 Maximum permissible peak pulse power as a function of pulse duration for critical value.

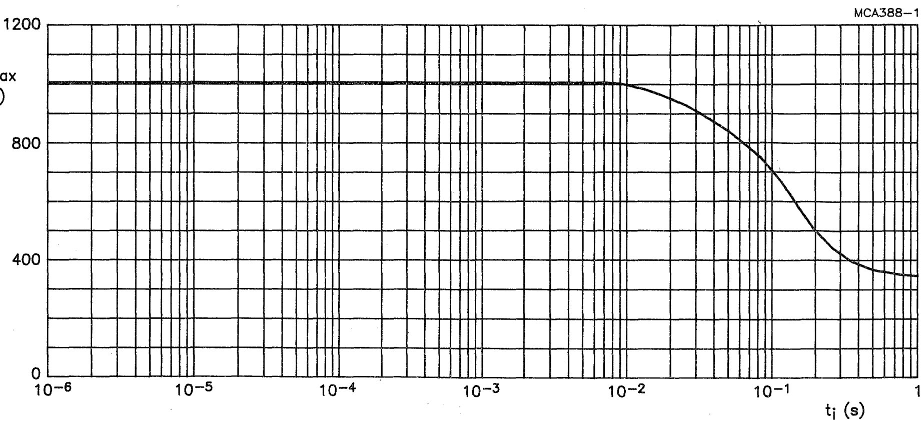


Fig.7 Maximum permissible peak pulse voltage as a function of pulse duration.

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		pulse load	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.

Dimensions of bandolier

	a ± 0.5	A	B1-B2 ± max.	S (spacing)	T (max. deviation of spacing)
NFR25H	6	$52^{+1.5}_{-0}$	1.2	5	1 mm per 10 spacings 0.5 mm per 5 spacings

Dimensions of ammopack

	Quantity	M	N	P
NFR25H	1000 5000 4000	82 98 262	28 78 45	262 270 330

Dimensions of reel

	Quantity	Q	V	R
NFR25H	5000 4000	305 356	75 40	86

Note:
The dimensions in above tables are in mm.

METAL FILM

METAL FILM RESISTORS

QUICK REFERENCE DATA

Resistance range		4.99 Ω to 1 MΩ, E24/E96 series
Resistance tolerance		± 1%
Temperature coefficient		⩽ ± 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 ⩽ 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
Approval		CECC 40101
Climatic category (IEC 68)		55/155/56

Stability after			R ⩽ 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	0.25% + 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 in accordance with MIL-STD 202E and IEC 68-2-45.

MECHANICAL DATA

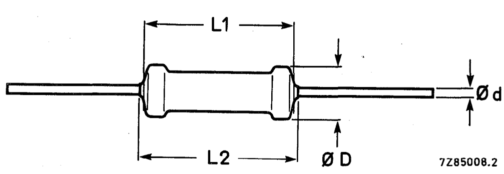


Fig. 1.

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

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).

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. 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 rated 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.

High-frequency behaviour

For better performance at high frequencies a special low inductance version MRS16TIi is developed. 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 7 and 8 give typical values under test conditions at various frequencies up to 1.3 GHz.

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....
MRS16TIi	ammopack	1000	6.80 Ω to 1 kΩ	1	2322 157 0....

Alternative packing is available on request.

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

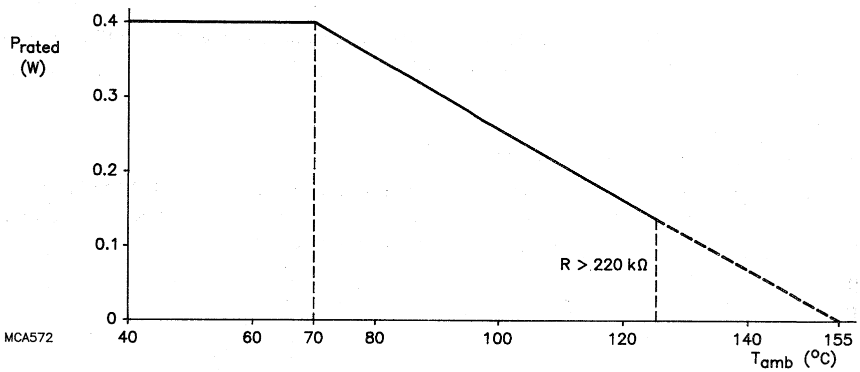


Fig.2 Maximum dissipation (P_{max}) as a function of ambient temperature (T_{amb}).

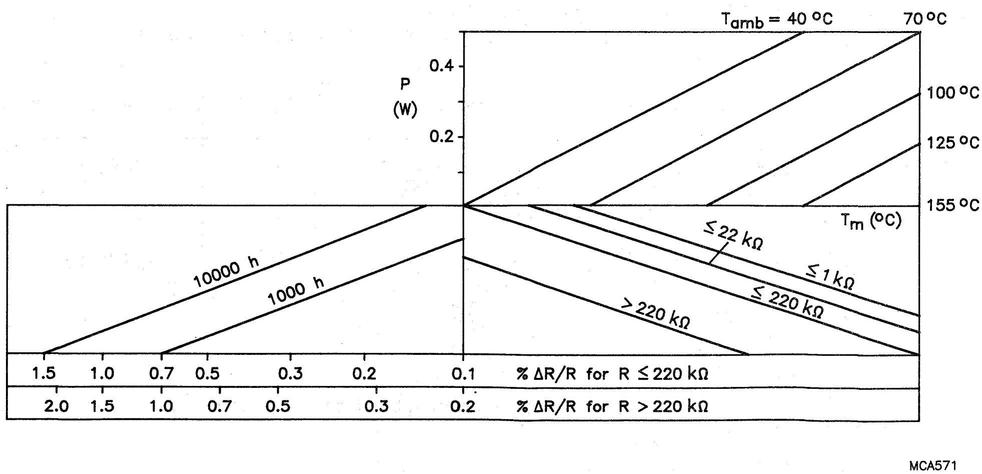


Fig.3 Drift nomogram.

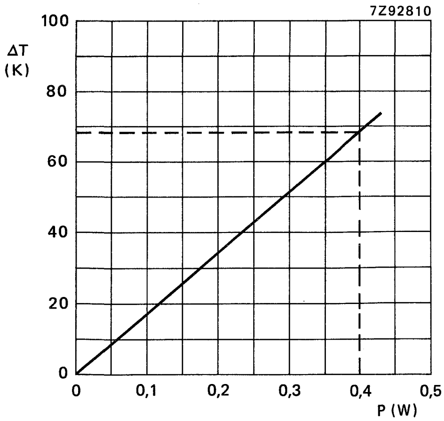


Fig.4 Hot-spot temperature rise (ΔT) as a function of dissipated power.

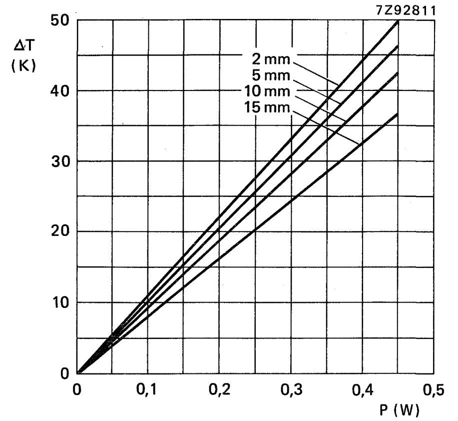


Fig.5 Temperature rise (ΔT) at the end of lead (soldering point) as a function of dissipated power, at various lead lengths after mounting.

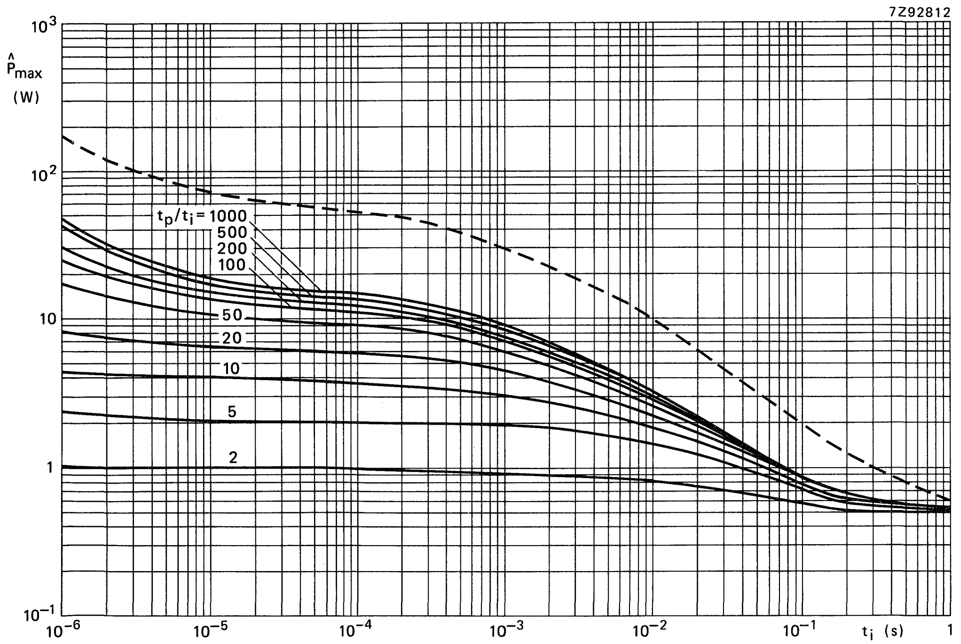


Fig.6 Max. permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i).

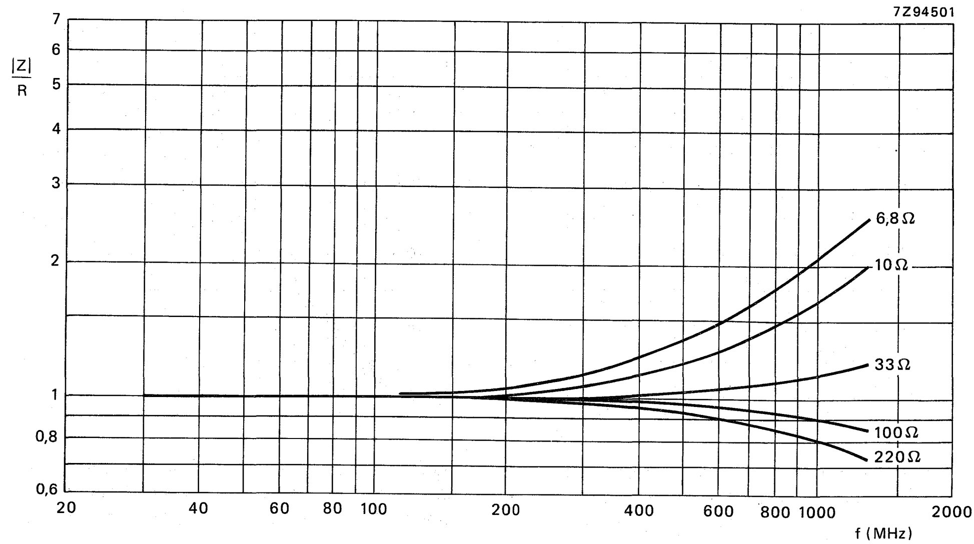


Fig.7 Impedance behaviour at high frequencies, MRS16TIi, lead length 2 mm.

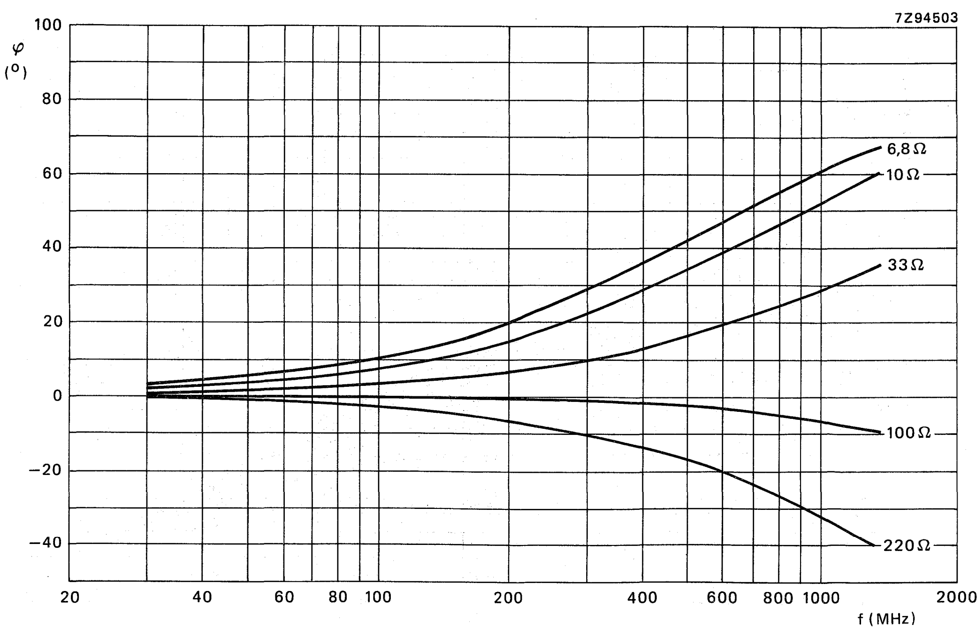


Fig.8 Phase angle behaviour at high frequencies, MRS16TIi, lead length 2 mm.

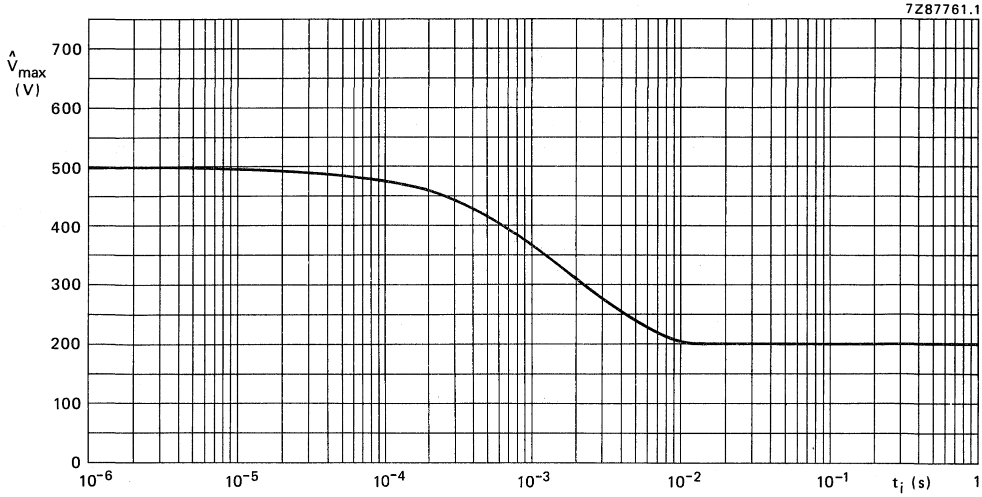


Fig.9 Maximum permissible peak pulse voltage as a function of pulse duration.

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) 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

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	$R \leqslant 100\ k\Omega$: ΔR max. 0.1% + 0.01 Ω $R > 100\ k\Omega$: 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 $R \leqslant 100\ k\Omega$: ΔR max. 0.5% + 0.05 Ω $R > 100\ k\Omega$: 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 $R \leqslant 100\ k\Omega$: ΔR max. 0.5% + 0.05 Ω $R > 100\ k\Omega$: ΔR max. 1% + 0.05 Ω
4.25.1	–	Endurance	1000 hours; 70 °C nominal dissipation or V_{max}	$R \leqslant 100\ k\Omega$: ΔR max. 0.5% + 0.05 Ω $R > 100\ k\Omega$: ΔR max. 1% + 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) during 1 minute; V-block method	no breakdown

TESTS AND REQUIREMENTS (continued)

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. $10^4\ M\Omega$
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 9

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	B1-B2 ± max.	S (spacing)	T (max. deviation of spacing)
6	52 +1.5/–0 26 +1.5/–0	0.5 0.5	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	R
5000 resistors	265	75	86

The dimensions in above tables are in mm.

METAL FILM RESISTORS

QUICK REFERENCE DATA

Resistance range		1 Ω to 10 MΩ, E24/E96 series
Resistance tolerance		± 1%
Temperature coefficient		$\leqslant 50.10^{-6}$/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		
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 has been cut in the resistive layer, tinned connecting wires of electrolytic copper are welded to the end-caps. The resistors are coated with a green lacquer which provides electrical, mechanical and climatic protection. The encapsulation is resistant to all cleaning solvents in accordance with MIL-STD 202E, method 215 and IEC 68-2-45.

MECHANICAL DATA

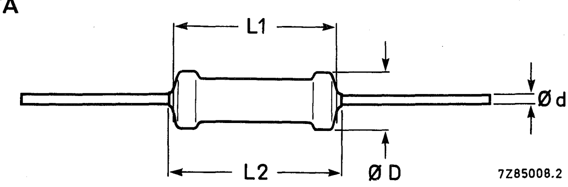


Fig. 1.

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

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).

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. 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.

High-frequency behaviour

For better performance at high frequencies a special low inductance version MRS25li is developed. 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 7 and 8 give typical values under test conditions at various frequencies up to 1.3 GHz.

Table 1

type	packing	quantity	resistance range	tolerance ±%	catalogue number
MRS25	ammopack	1000	1 Ω to 10 MΩ	1	2322 156 1....
	ammopack	5000	1 Ω to 10 MΩ	1	2322 156 2....
	on reel	5000	1 Ω to 10 MΩ	1	2322 156 3....
MRS25li	ammopack	1000	5.1 Ω to 1 kΩ	1	2322 156 0....

Alternative packing is available on request.

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)

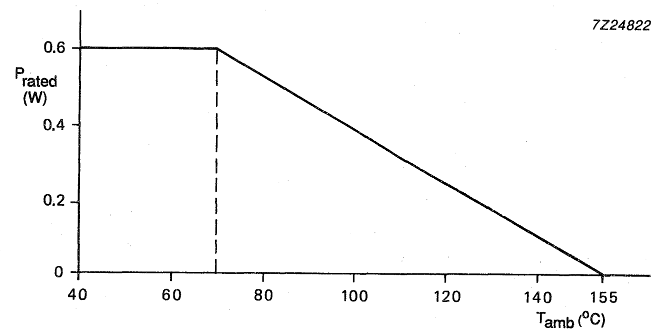


Fig.2 Maximum dissipation (P_{max}) as a function of ambient temperature (T_{amb}).

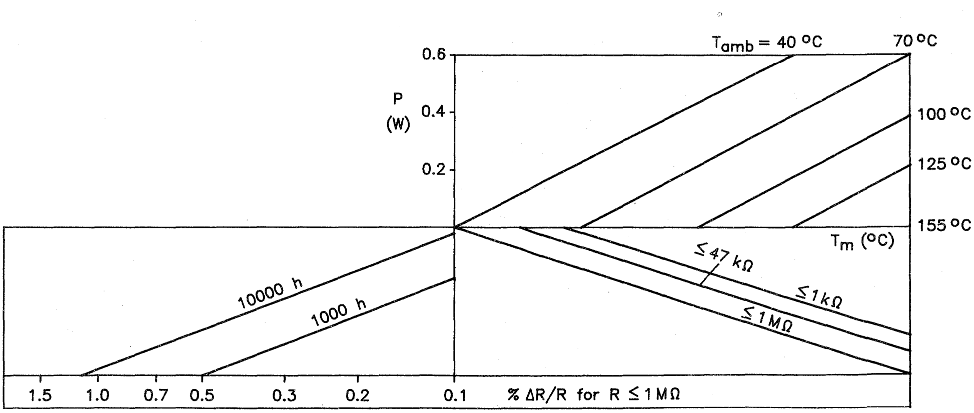


Fig.3 Drift nomogram.

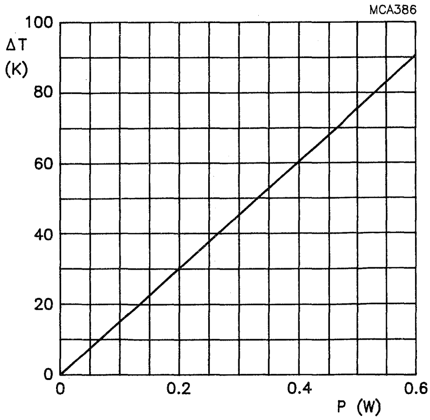


Fig.4 Hot-spot temperature rise (ΔT) as a function of dissipated power.

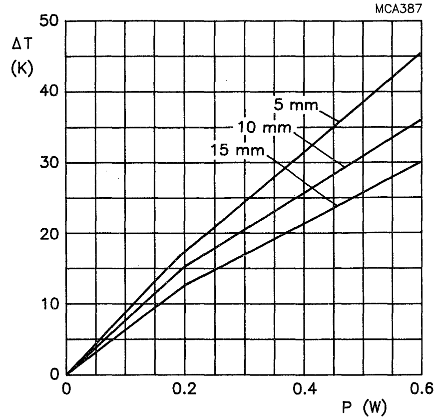


Fig.5 Temperature rise (ΔT) at the end of the lead (soldering point) as a function of dissipated power at various lead lengths after mounting.

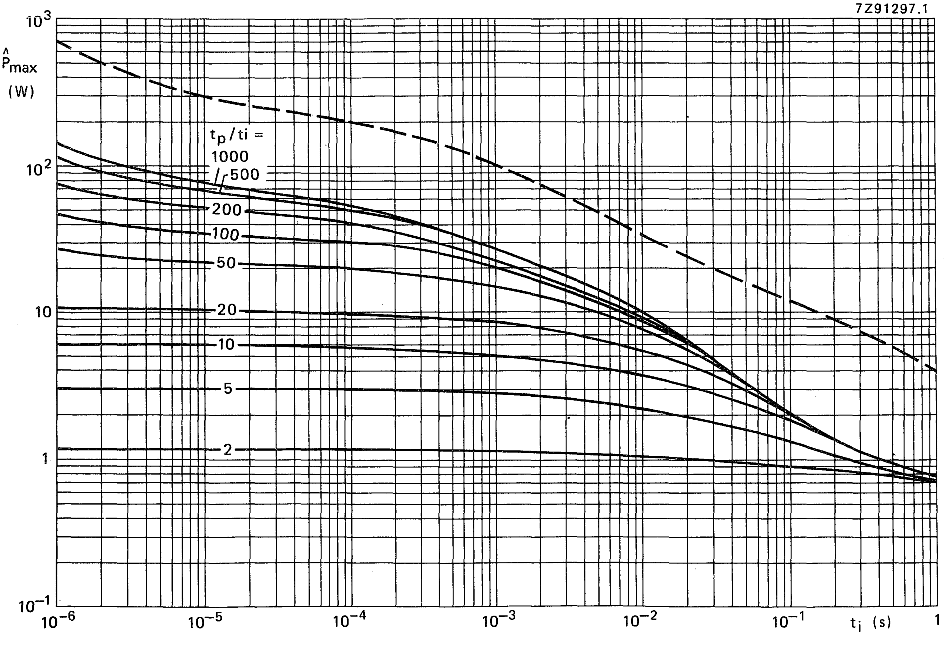


Fig.6 Maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration for critical value.

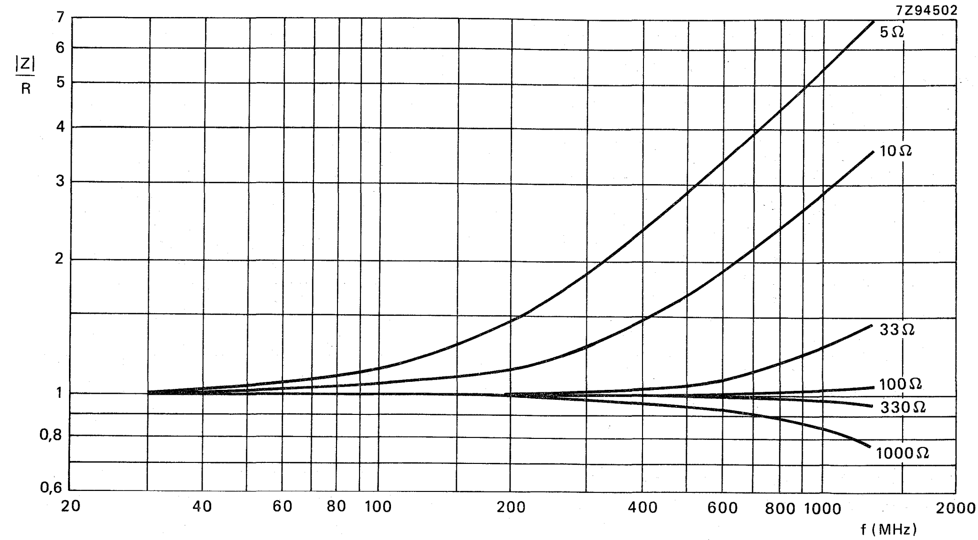


Fig.7 Impedance behaviour at high frequencies, MRS25li, lead length 4 mm.

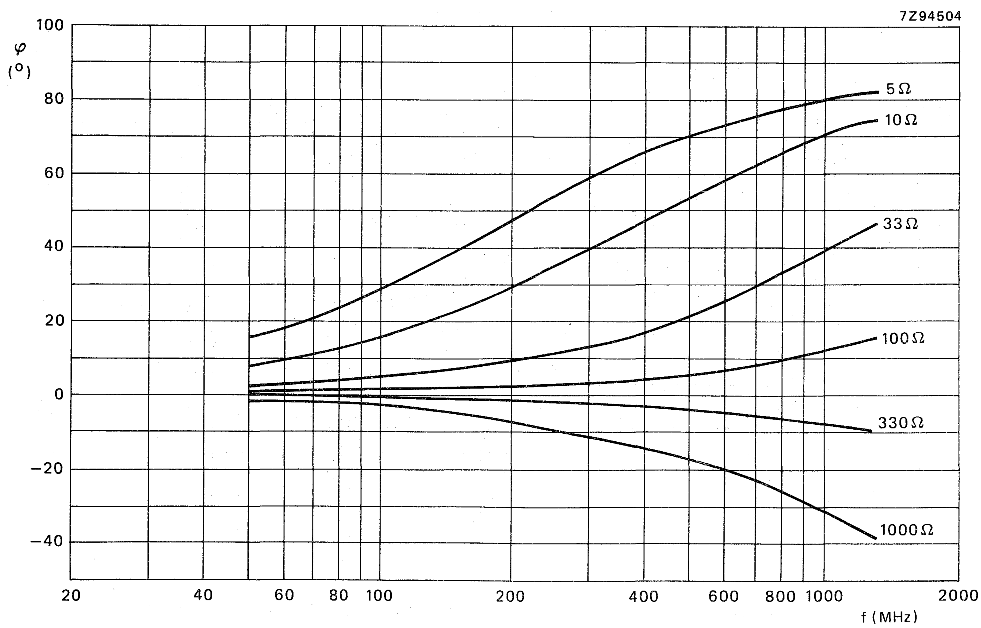


Fig.8 Phase angle behaviour at high frequencies, MRS25li, lead length 4 mm.

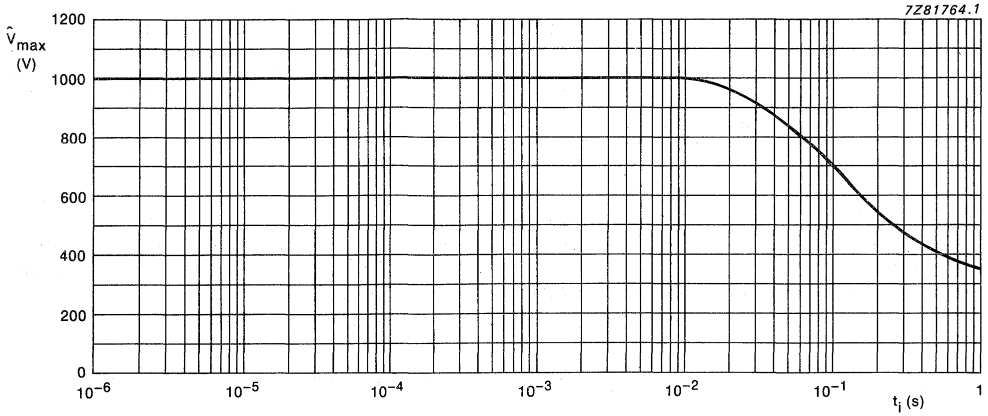


Fig.9 Maximum permissible peak pulse voltage as a function of pulse duration

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 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	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
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	D_b	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 steady state	56 days; 40 °C; 90-95% R.H. dissipation 0,01 P_{70}	R_{ins} min. 1000 MΩ ΔR max. 0,5% + 0.05 Ω
4.25.1	–	Endurance	1000 hours; 70 °C P_{70} or V_{max}	ΔR max. 0,5% + 0,05 Ω
4.8.4	–	Temperature coefficient	between –55 °C and + 155 °C	$\leqslant$ 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 9

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 +1.5/–0	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
5000 resistors	78	107	270

Dimensions of reel

	Q	R	V
5000 resistors	305	75	86

The dimensions in above tables are in mm.

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		$\pm 50.10^{-6}$/K	$\pm 50.10^{-6}$/K	$\pm 50.10^{-6}$/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 in accordance with MIL-STD 202E, method 215 and IEC 68-2-45.

MECHANICAL DATA

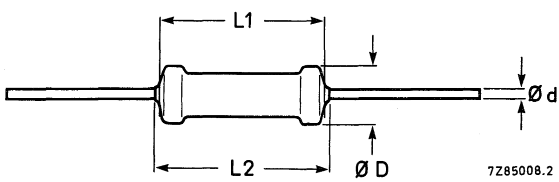


Fig. 1 This standard version is specially made to obtain a minimum "clean lead to clean lead" dimension L2.

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).

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 151 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.

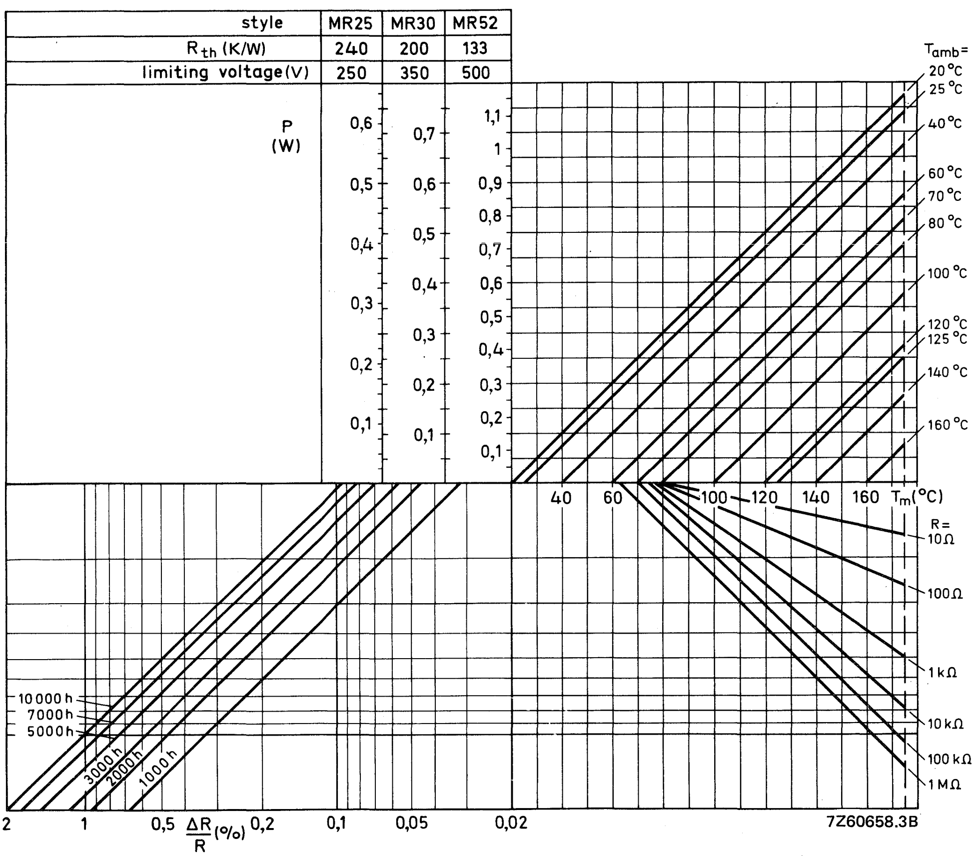


Fig. 2 Performance nomogram for different styles of resistor, showing the relationship between power dissipation P, ambient temperature T_{amb}, hot-spot temperature (T_m) and max. resistance drift ΔR/R after 1000 to 10 000 hours of operation.

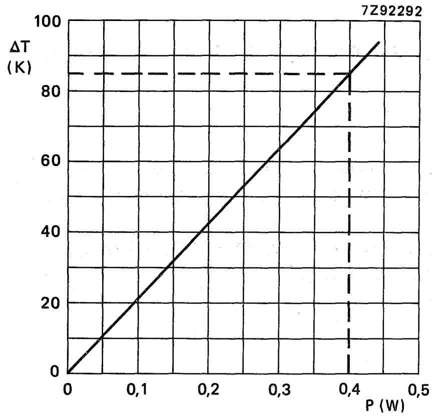


Fig. 3 MR25. Hot-spot temperature rise (ΔT) versus dissipated power.

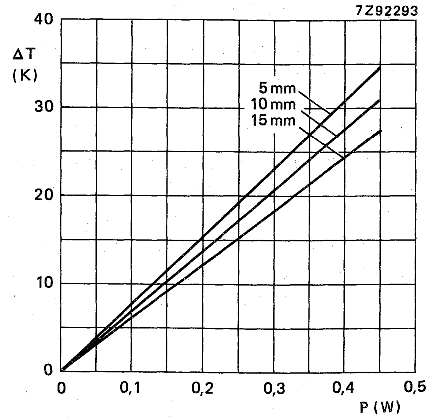


Fig. 4 MR25. Temperature rise (ΔT) at the end of lead (soldering point) versus dissipated power, at various lead lengths after mounting.

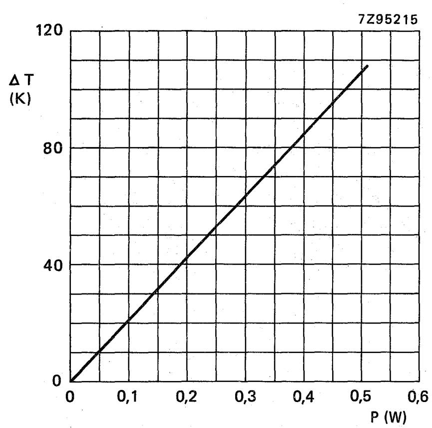


Fig. 5 MR30. Hot-spot temperature rise (ΔT) versus dissipated power.

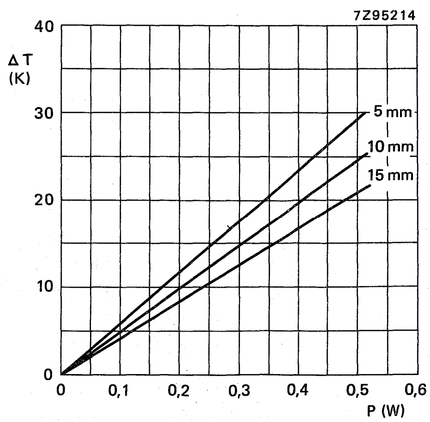


Fig. 6 MR30. Temperature rise (ΔT) at the end of lead (soldering point) versus dissipated power, at various lead lengths after mounting.

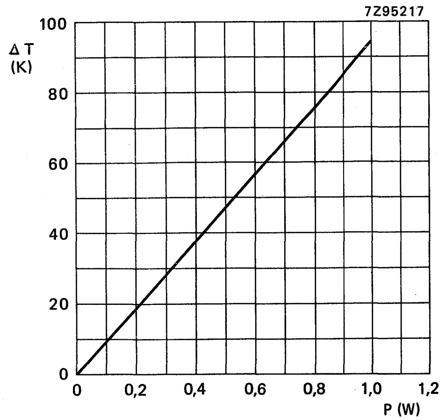


Fig. 7 MR52. Hot-spot temperature rise (ΔT) versus dissipated power.

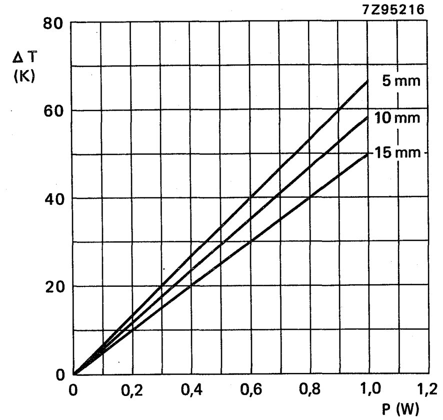


Fig. 8 MR52. Temperature rise (ΔT) at the end of lead (soldering point) versus dissipated power, at various lead lengths after mounting.

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 ^{o}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^{o}	
4.16.4	Uc	Torsion other half number of samples	3 x 360^{o} in opposite directions	no damage ΔR max. 0,1% + 0,01 Ω
4.17	Ta	Soldering	solderability: 2 s 230 ^{o}C, flux 600	good tinning no damage
4.18	Tb		thermal shock: 3 s: 350 ^{o}C, 6 mm from body	ΔR max. 0,1% + 0,01 Ω
4.19	Na	Rapid change of temperature	½ h −55 ^{o}C/½ h + 155 ^{o}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 or V_{max} MR52: 0,45 W	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 +1.5/–0	1,2	5	1 mm per 10 spacings, 0,5 mm per 5 spacings
MR30	6 ± 0,5	52 +1.5/–0	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

The dimensions in above tables are in mm.

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 in accordance with MIL-STD 202E, method 215 and IEC 68-2-45.

MECHANICAL DATA

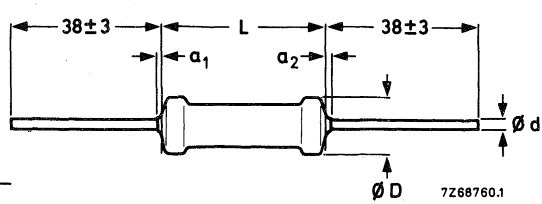


Fig. 1.

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).

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	$\Delta R \leqslant 0{,}25\% + 0{,}05\ \Omega$
4.6.5	—	Low-temperature operation	3.10	$\Delta R \leqslant 0{,}25\% + 0{,}05\ \Omega$
4.6.6	—	Short-time overload	3.11	$\Delta R \leqslant 0{,}25\% + 0{,}05\ \Omega$
4.6.7	211	Terminal strength	3.12	$\Delta R \leqslant 0{,}2\% + 0{,}05\ \Omega$
4.6.8	301/105	Dielectric withstanding voltage	3.13	$\Delta R \leqslant 0{,}25\% + 0{,}05\ \Omega$
4.6.9	302	Insulation resistance	3.14	$R_{ins} \geqslant 10\,000\ M\Omega$
4.6.10	210	Resistance to soldering heat	3.15	$\Delta R \leqslant 0{,}1\% + 0{,}05\ \Omega$
4.6.11	106	Moisture resistance	3.16	$\Delta R \leqslant 0{,}5\% + 0{,}05\ \Omega$ $R_{ins} \geqslant 100\ M\Omega$
4.6.13	108	Life	3.18	$\Delta R \leqslant 0{,}5\% + 0{,}05\ \Omega$
4.6.15	205	Shock, medium impact	3.20	$\Delta R \leqslant 0{,}25\% + 0{,}05\ \Omega$
4.6.16	204	Vibration	3.21	$\Delta R \leqslant 0{,}25\% + 0{,}05\ \Omega$

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 in accordance with 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

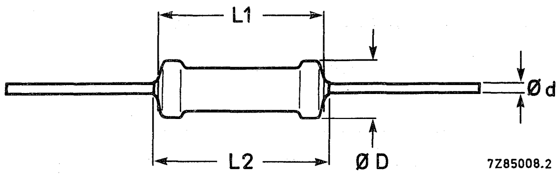


Fig. 1.

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.

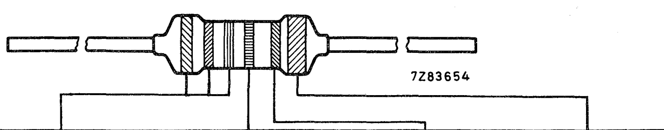
The length of the body is measured by inserting the leads into the 1 mm diameter holes of two identical gauge plates and by moving these plates parallel to each other until the resistor body is clamped without deformation (see IEC publication 294).

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.

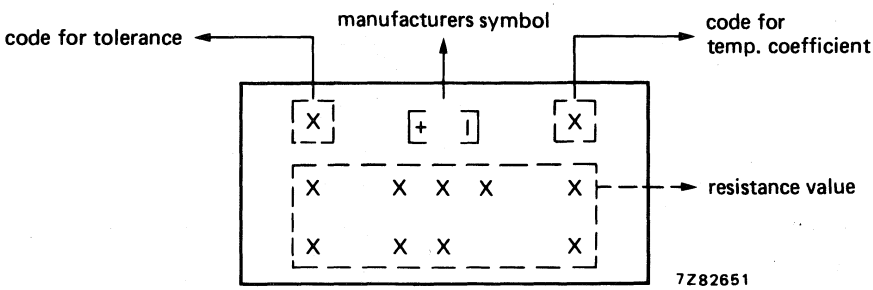
Colour coding



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 IEC62).

± 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		± 5,10,15,25 · 10^{-6}/K	± 5,10,15,25 · 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

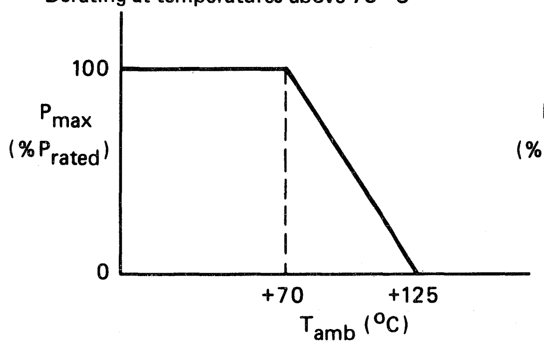


Fig. 2a Maximum dissipation (P_{max}) as a function of T_{amb} for R tolerances of 0,05, 0,02 and 0,01%.

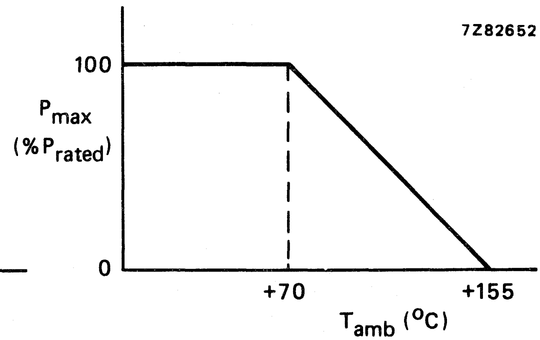
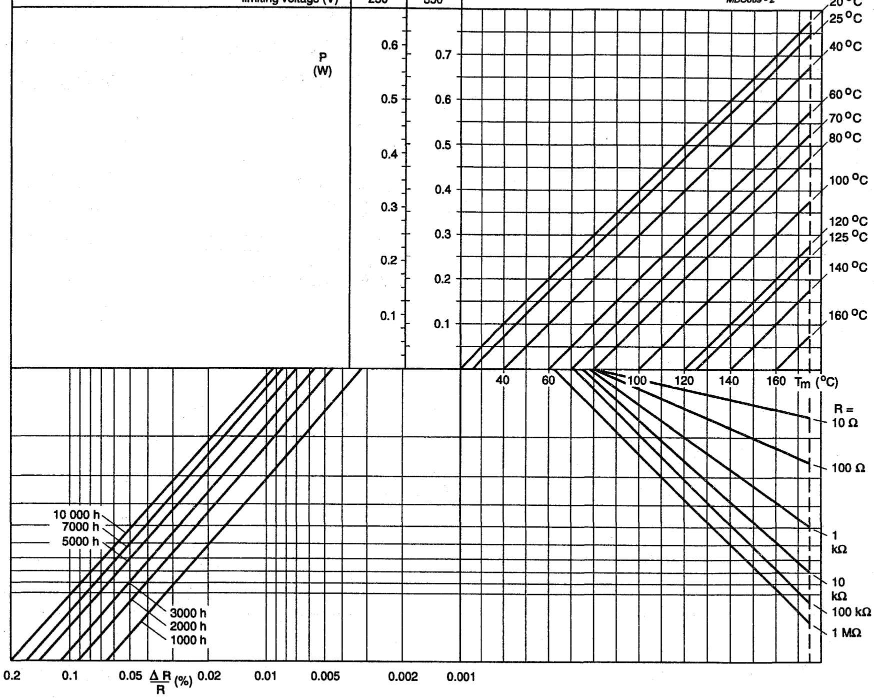


Fig. 2b Maximum dissipation (P_{max}) as a function of T_{amb} for R tolerances of 0,5, 0,25 and 0,1%.

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%.

style	MPR24	MPR34
R_{th} (K/W)	240	200
limiting voltage (V)	250	350



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	tole-ran-ce %	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%		± 0,25%		0,1%	
			colour coded	marked	colour coded	marked	colour coded	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	tole-ran-ce %	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%		± 0,25%		0,1%	
			colour coded	marked	colour coded	marked	colour coded	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	

6	± 0,05%	tolerance
7	± 0,02%	
8	± 0,01%	

0	TC $\cdot 10^{-6}$/K	± 25	20	packing
1		± 15		
2		± 10		
3		± 5		
4		± 25	100	
5		± 15		
6		± 10		
7		± 5		

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	

6	± 0,05%	tolerance
7	± 0,02%	
8	± 0,01%	

0	TC $\cdot 10^{-6}$/K	± 25	500	packing
1		± 15		
2		± 10		
3		± 5		
4		± 25	1000	
5		± 15		
6		± 10		
7		± 5		

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 $<$0.25 µV/V for R $\leqslant$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 Ω
4.14		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	3 x 360° in opposite directions	no damage $\Delta R_{max} \leqslant$ 0,01% + 0,01 Ω
4.15	Ta	Soldering	solderability: 2 S 230 °C flux 600	good timing no damage
	Tb		Thermal shock: 3 S 350 °C 6 mm from body	$\Delta R_{max} \leqslant$ 0,01% + 0,01 Ω
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 Ω $\Delta R_{max} \leqslant$ 0,01% + 0,01 Ω
4.17	Eb	Bump	3 x 1500 bumps in three directions, 40 g	no damage $\Delta R_{max} \leqslant$ 0,01% + 0,01 Ω

* (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	
MPR24	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

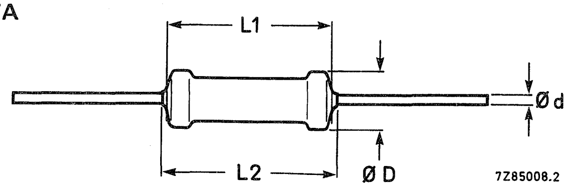


Fig. 1 Axial leads.

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).

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. 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).

Application information available on request.

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...

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

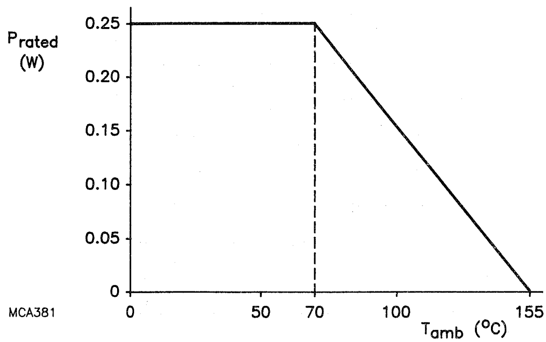


Fig. 3 Maximum dissipation (P_{max}) as a function of the ambient temperature (T_{amb}).

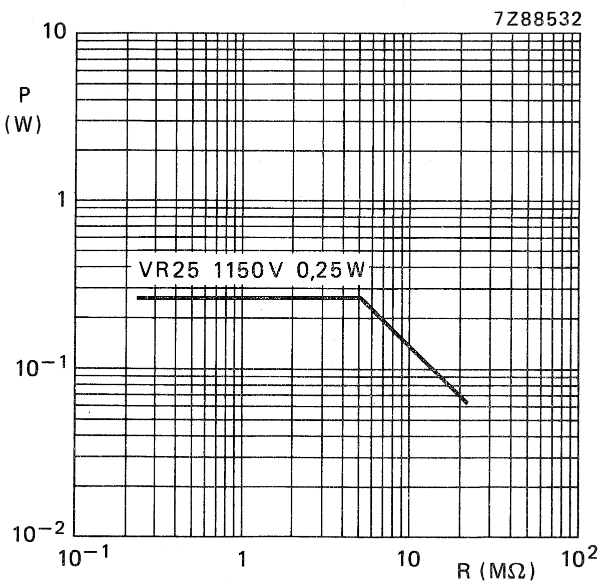


Fig. 4 Maximum permissible dissipation at T_{amb} = 70 °C as a function of the resistance.

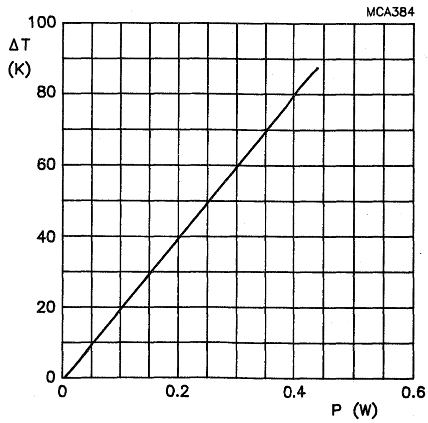


Fig.5 Hot-spot temperature rise (ΔT) as a function of dissipated power.

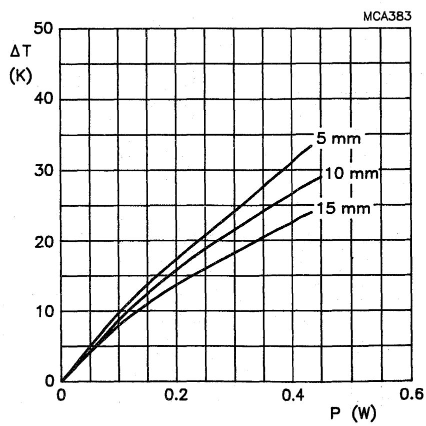


Fig.6 Temperature rise (ΔT) at the end of the lead (soldering point) as a function of various lead lengths after mounting.

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

Dimensions of bandolier

type	a ± 0,5	A	B1 - B2 ± max.	S (spacing)	T (max. deviation of spacing)
VR25	6	52 +1.5/–0	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	

The dimensions in above tables are in mm.

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

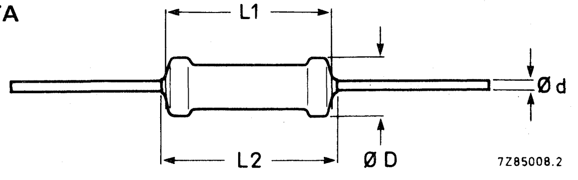


Fig. 1 Axial leads.

Table 1

type	D_{max}	$L_{1\,max}$	$L_{2\,max}$	d
VR37	4.0	9.0	10.0	0.7
VR68	6.8	18.0	19.0	0.8

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).

Mass (per 100) VR37: 48g; 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 VR37 and 10 kV (DC) or 7 kV (RMS) for type VR68.

Application information available on request.

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		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

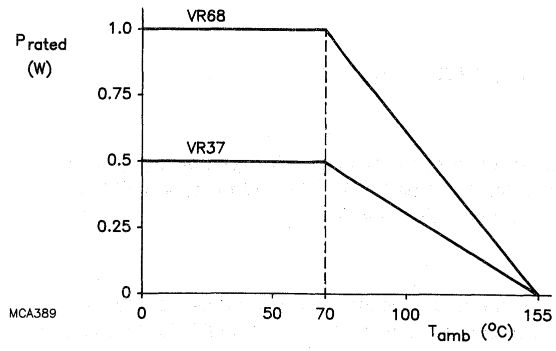


Fig. 2 Maximum dissipation (P_{max}) as a function of the ambient temperature (T_{amb}).

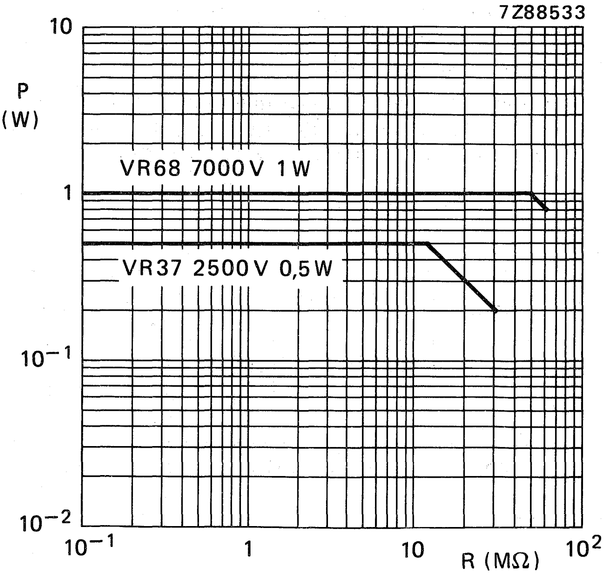


Fig. 3 Power versus resistance value of high-voltage resistors at T_{amb} = 70 °C.

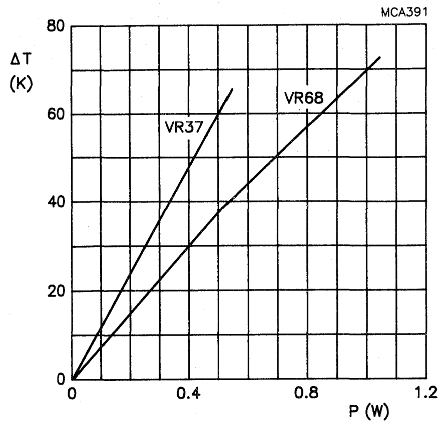


Fig.4 Hot-spot temperature rise (ΔT) as a function of dissipated power.

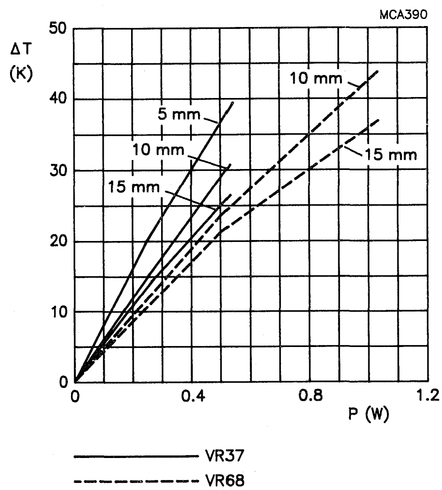


Fig.5 Temperature rise (ΔT) at the end of the lead (soldering point) as a function of dissipated power at various lead lengths after mounting.

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	B1 - B2 ± max.	S (spacing)	T (max. deviation of spacing)
VR37	6	52 +1.5/−0	1.2	5	1 mm per 10 spacings
VR68	5	66.7 ±1.5	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	

The dimensions in above tables are in mm.

POWER FILM

Power metal film resistor PR01

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

MECHANICAL DATA

Mass

29 g (per 100 units).

Mounting

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

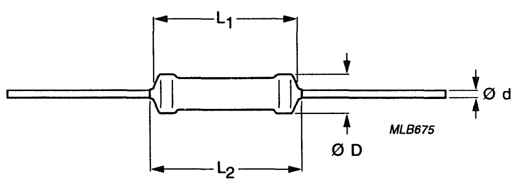
The minimum pitch for this type is 5e. Figure 5 shows the temperature rise at the solder spot as a function of lead lengths after mounting.

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"*.

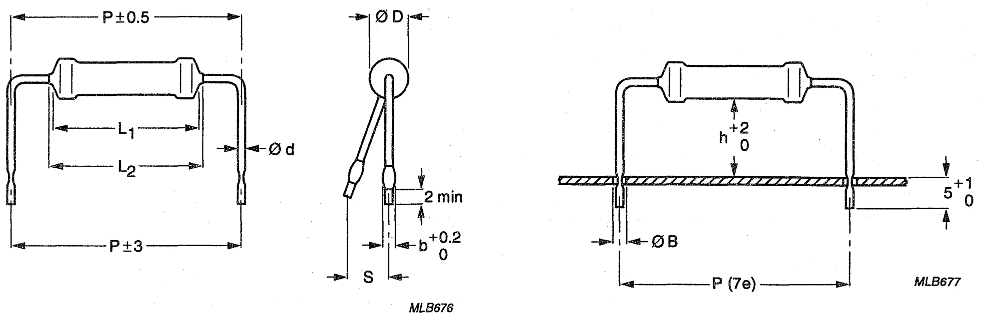
QUICK REFERENCE DATA

DESCRIPTION	VALUE
Resistance range	0.22 Ω to 1 MΩ; E24 series
Resistance tolerance	±5%
Rated dissipation at T_{amb} = 70 °C (P_{70}); see Fig.4	
0.22 Ω ≤ R < 1 Ω	0.6 W
1 Ω ≤ R ≤ 1 MΩ	1 W
Thermal resistance (R_{th})	135 K/W
Temperature coefficient	≤ ±250 × 10^{-6}/K
Maximum permissible voltage	350 V (DC or RMS)
Basic specifications	IEC 115-1 and 115-4
Approval	CECC 40101
Climatic category (IEC 68)	55/155/56
Stability after:	
load	ΔR/R max.: ±5% +0.1 Ω
climatic tests	ΔR/R max.: ±3% +0.1 Ω
soldering	ΔR/R max.: ±1% +0.05 Ω



For dimensions see Table 1.

Fig.1 Type with straight leads.



Dimensions in mm.
For dimensions see Table 1.

Fig.2 Type with cropped and formed leads.

Table 1 Physical dimensions in mm.

$ØD_{max}$	L_{1max}	L_{2max}	Ød	b	h	P	S_{max}	$ØB_{max}$
2.5	6.5	8.5	0.6	1.1	8	17.8	2	1.0

The length of the body (L_1) is measured by inserting the leads into holes of two identical gauge plates and moving these plates parallel to each other until the resistor body is clamped without deformation (*"IEC publication 294"*). Resistors with lead lengths of 73, 53 or 26 mm are available on special request.

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated (nominal) resistance are taken from the E24 series within the range 0.22 Ω to 1 MΩ. The values of the E24 series are in accordance with *"IEC publication 63"*.

The tolerance on the rated resistance is ±5%.

The limiting voltage (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.

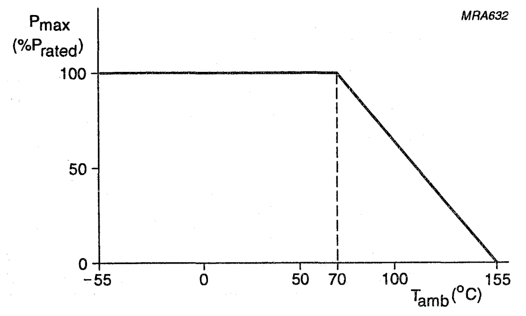


Fig.3 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

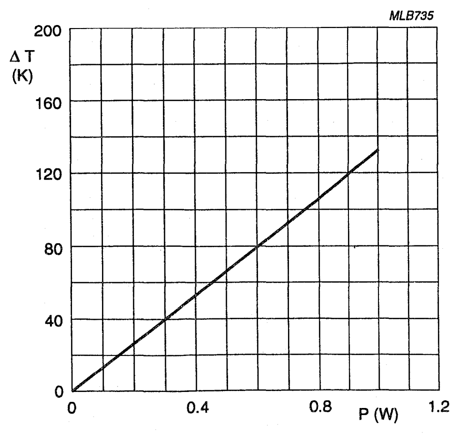


Fig.4 Hot spot temperature rise (ΔT) as a function of dissipated power.

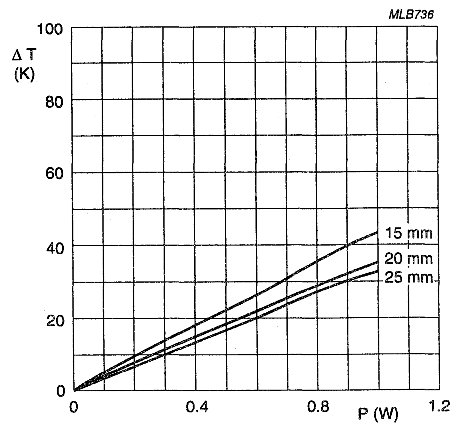


Fig.5 Temperature rise (ΔT) at the lead end (soldering point) as a function of dissipated power at various lead lengths after mounting. Resistor body-to-PCB distance: 1 mm minimum.

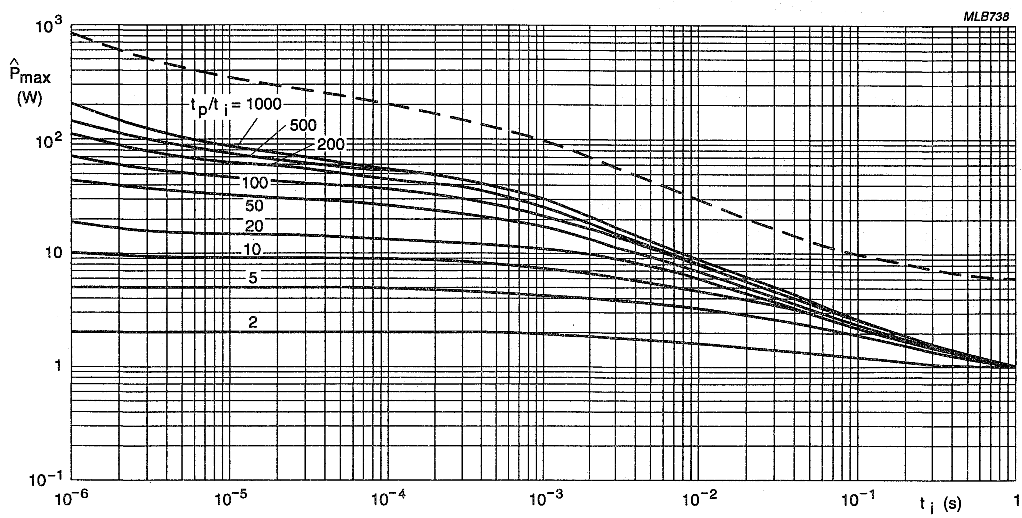


Fig.6 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i).

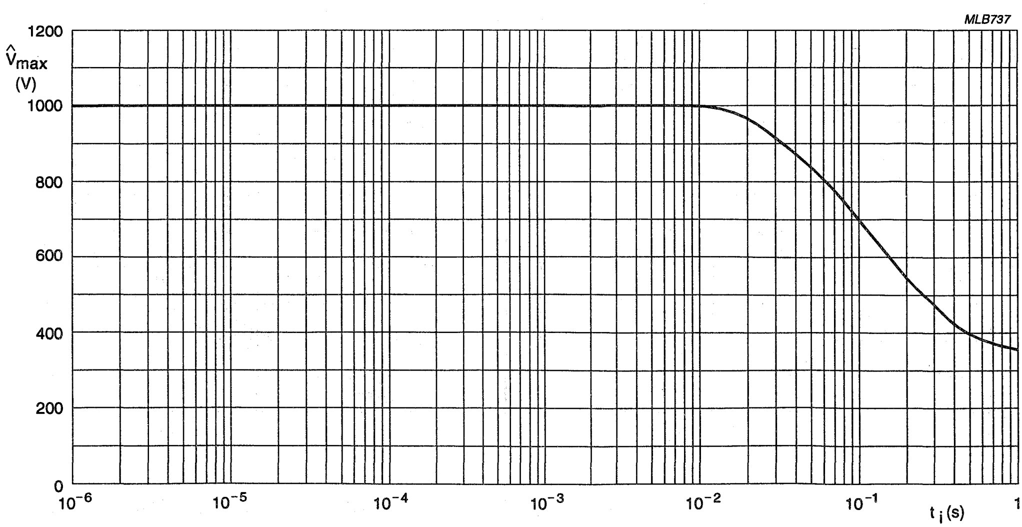


Fig.7 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_i).

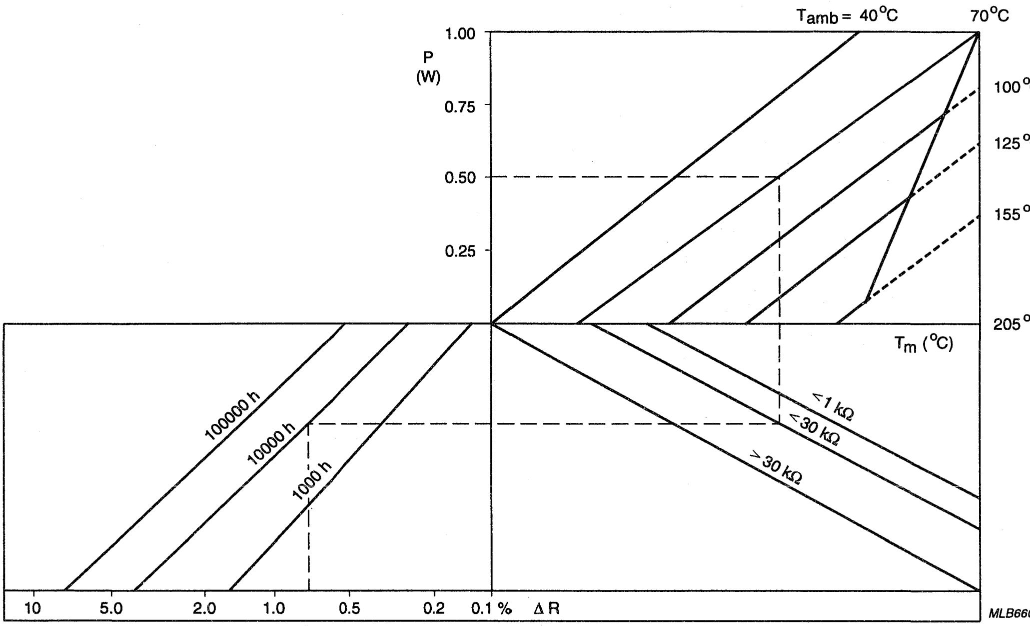
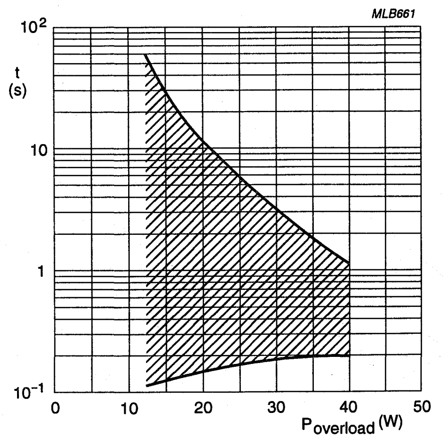
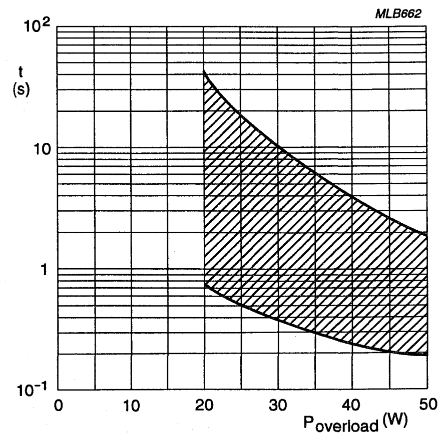


Fig.8 Drift nomogram.



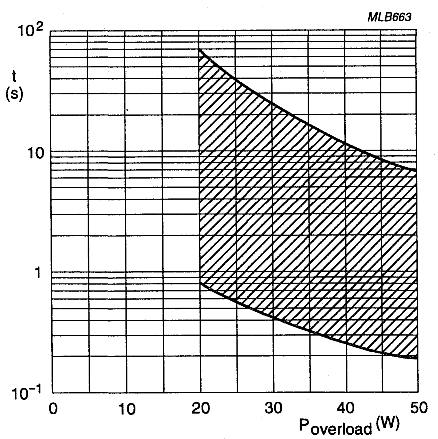
The graph is based on measured data under constant voltage conditions; these data may deviate according to the application.

Fig.9 Time to interruption as a function of overload power for range $0R22 \leq R_n < 1R$.



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

Fig.10 Time to interruption as a function of overload power for range $1R \leq R_n \leq 15R$.



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

Fig.11 Time to interruption as a function of overload power for range $16R \leq R_n \leq 560R$.

Power metal film resistor

PR01

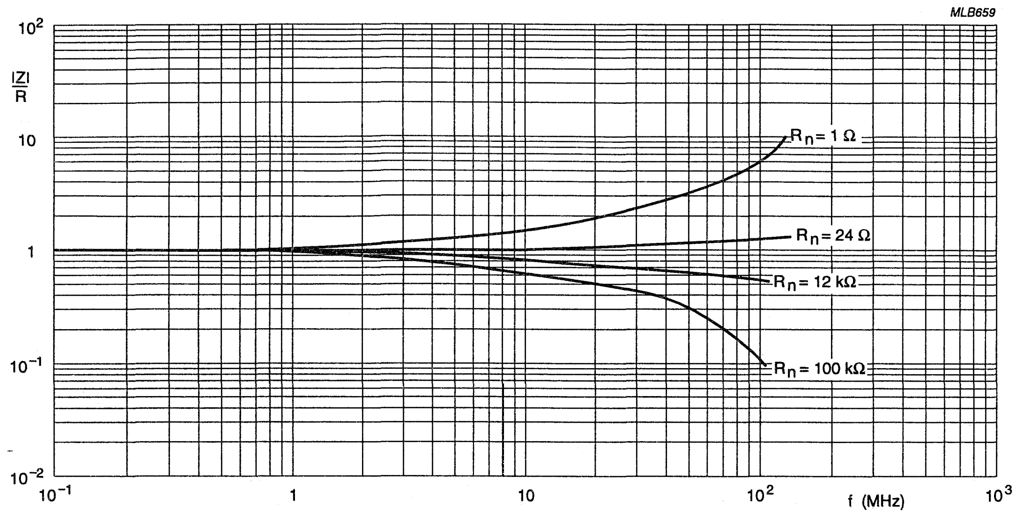


Fig.12 Impedance as a function of applied frequency.

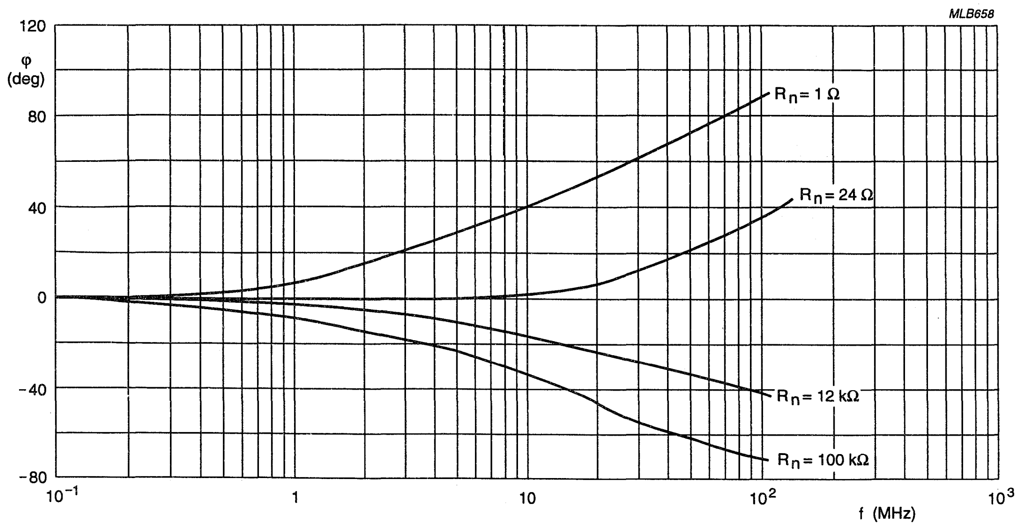


Fig.13 Phase angle as a function of applied frequency.

COMPOSITION OF THE CATALOGUE NUMBER

The resistors have a 12-digit catalogue number starting with 2322 or 2306. The subsequent 8 digits indicate the packaging and resistance value (see Tables 2 and 3).

Table 2 First 5 digits to indicate packaging for resistances as listed.

<table>
<tr><th>RESISTANCE RANGE</th><th>TOLERANCE (%)</th><th>STYLE</th><th>PACKAGING</th><th>QUANTITY</th><th>CATALOGUE NUMBER</th></tr>
<tr><td>1 Ω to 1 MΩ</td><td rowspan="9">±5</td><td rowspan="4">straight leads</td><td rowspan="2">ammopack</td><td rowspan="2">1000</td><td>2322 193 13...</td></tr>
<tr><td>0.22 Ω to 0.91 Ω</td><td>on request</td></tr>
<tr><td>1 Ω to 1 MΩ</td><td rowspan="2">reel</td><td rowspan="2">5000</td><td>2322 193 23...</td></tr>
<tr><td>0.22 Ω to 0.91 Ω</td><td>on request</td></tr>
<tr><td>1 Ω to 1 MΩ</td><td>cropped and formed</td><td>loose in box</td><td>1000</td><td>2322 193 33...</td></tr>
<tr><td>1 Ω to 1 MΩ</td><td rowspan="4">radial taped</td><td rowspan="2">ammopack</td><td rowspan="2">4000</td><td>2306 197 03...</td></tr>
<tr><td>0.33 Ω to 0.91 Ω</td><td>on request</td></tr>
<tr><td>1 Ω to 1 MΩ</td><td rowspan="2">reel</td><td rowspan="2">4000</td><td>2306 197 83...</td></tr>
<tr><td>0.33 Ω to 0.91 Ω</td><td>on request</td></tr>
</table>

To complete the catalogue number (see Table 2), replace the first two dots of the remaining 3-digit code by the first two digits of the resistance value. Replace the third dot (last digit) by a figure according to Table 3.

Table 3 Last digit of 12 NC; note 1.

RESISTANCE	LAST DIGIT
1 Ω to 9.1 Ω	8
10 Ω to 91 Ω	9
100 Ω to 910 Ω	1
1 kΩ to 9.1 kΩ	2
10 kΩ to 91 kΩ	3
100 kΩ to 910 kΩ	4
1 MΩ	5

Note

1. Tolerances of 1% and 2% are available on request.

Ordering example

The catalogue number of resistor value 750 Ω, on a bandolier of 1000 pieces, in ammopack, is: 2322 193 13751.

TESTS AND REQUIREMENTS

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

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

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

Air pressure: 86 kPa to 106 kPa (860 mbar to 1 060 mbar).

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

Table 4

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.16	U	robustness of terminations:		
4.16.2	Ua	tensile all samples	∅ 0.6 mm; load 10 N; 10 s	number of failures $<1 \times 10^{-6}$
4.16.3	Ub	bending half number of samples	∅ 0.6 mm; load 5 N; 4 × 90°	number of failures $<1 \times 10^{-6}$
4.16.4	Uc	torsion other half number of samples	3 × 360° in opposite directions	no damage ΔR/R max.: ±0.5% +0.05 Ω
4.17	Ta	solderability	2 s; 235 °C; flux 600	good tinning; no damage
4.18	Tb	resistance to soldering heat	thermal shock: 3 s; 350 °C; 6 mm from body	ΔR/R max.: ±1% +0.05 Ω
4.19	Na	rapid change of temperature	30 minutes at −55 °C and 30 minutes at +155 °C; 5 cycles	no damage ΔR/R max.: ±1% +0.05 Ω
4.20	Eb	bump	3 × 1500 bumps in three directions; 40 g	no damage ΔR/R max.: ±0.5% +0.05 Ω
4.22	Fc	vibration	frequency 10 to 500 Hz; displacement 1.5 mm or acceleration 10 g; three directions; total 6 hours (3 × 2 hours)	no damage ΔR/R max.: ±0.5% +0.05 Ω
4.23		climatic sequence:		
4.23.2	Ba	dry heat	16 hours; 155 °C	
4.23.3	Db	damp heat (accelerated) 1st cycle	24 hours; 55 °C; 90 to 100% RH	
4.23.4	Aa	cold	2 hours; −55 °C	
4.23.5	M	low air pressure	2 hours; 8.5 kPa; 15 to 35 °C	
4.23.6	Db	damp heat (accelerated) remaining cycles	5 days; 55 °C; 90 to 100% RH	R_{ins} min.: 1 000 MΩ ΔR/R max.: ±3% +0.1 Ω
4.24.2	Ca	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; dissipation 0.01 × P_{70}	R_{ins} min.: 1 000 MΩ ΔR/R max.: ±3% +0.1 Ω
4.25.1		endurance	1 000 hours; 70 °C; P_{70} or V_{max}	ΔR/R max.: ±5% +0.1 Ω

Power metal film resistor PR01

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.8.4.2		temperature coefficient	between –55 °C and +155 °C	$\leq \pm 250 \times 10^{-6}$
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 minute; V-block method	R_{ins} min.: 1000 MΩ
see 2nd amendment to IEC 115-1, Jan. '87		pulse load		see Figs 6 and 7

Power metal film resistor PR01

PACKAGING

The resistors may be supplied on bandolier in ammopack, on reel or loose in box. For details refer to Section *"General Introduction leaded resistors"* in data handbook PA08.

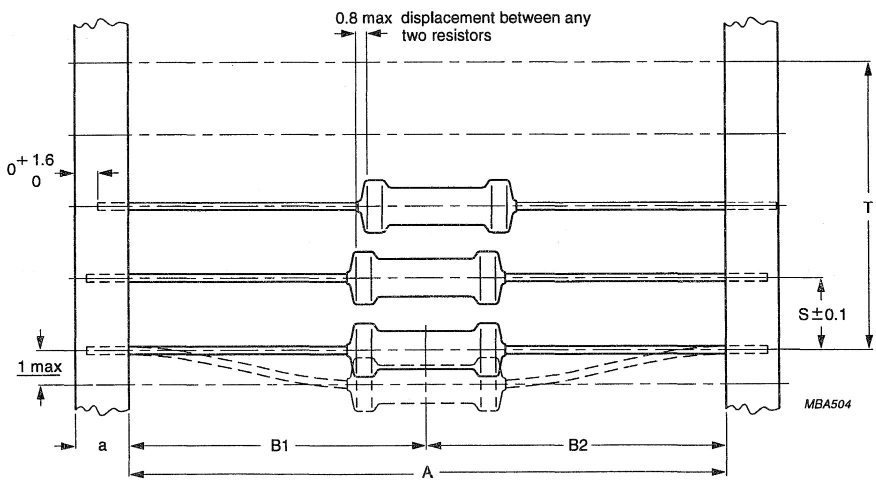
Dimensions of the ammopack.

STYLE	QUANTITY	M (mm)	N (mm)	P (mm)
Axial	1000	97	28	262
Radial	4000	262	45	330
Cropped and formed	1000	105	70	205

Dimensions of reel.

STYLE	QUANTITY	Q (mm)	V (mm)
Axial	5000	305	90
Radial	4000	356	40

Tape and reel data

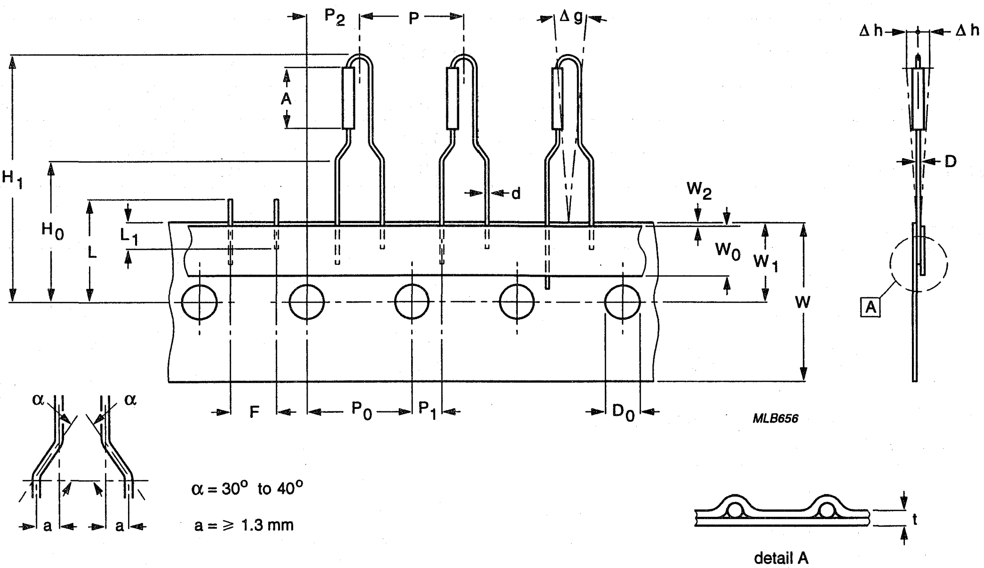


Dimensions in mm.

Fig.14 Axial style on tape.

Dimensions of bandolier.

a (mm)	A (mm)	$\lvert B_1 - B_2 \rvert$ (mm)	S (mm)	T (deviation of spacing)
6 ±0.5	73 ±1.5	±1.2	5	max. 1 mm per 10 spacings max. 0.5 mm per 5 spacings



For dimensions see Table 5.

Fig.15 Bandolier for types with radial leads.

Table 5 Taping dimensions; see Fig.15.

SYMBOL	PARAMETER	VALUE	TOLERANCE	UNIT
D	maximum body diameter	2.50	–	mm
A	maximum body length	9.00	–	mm
d	lead wire diameter	0.60	+0.06/–0.05	mm
P	pitch of components	12.7	±1.0	mm
P_0	feed hole pitch	12.7	±0.2	mm
	cumulative pitch error per 20 spacings	1.0	–	mm
P_1	feed-hole centre to lead at topside at the tape	3.85	±0.5	mm
P_2	feed-hole centre to body centre	6.35	±1.0	mm
F	lead-to-lead distance	4.8 to 5.5	–	mm
Δh	component alignment	0	±1.2	mm
Δg	component alignment	0	±3	deg
W	tape width	18.0	±0.5	mm
W_0	hold down tape width	6.0	+0.2/–0.5	mm
W_1	hole position	9.0	±0.5	mm
W_2	maximum hold down tape position	0.5	–	mm
H_0	lead wire clinch height	16.5	±0.5	mm
H_1	component height	28.0	±3.0	mm
D_0	feed-hole diameter	4.0	±0.2	mm
t	total tape thickness	0.4 to 0.9	–	mm
L	maximum length of snipped lead	11.0	–	mm
L_1	minimum lead wire (tape portion) shorter lead	2.5	–	mm

Power metal film resistors PR02

DESCRIPTION

A homogeneous film of metal alloy is deposited on a high grade ceramic body. After a helical groove has been cut in the resistive layer, tinned connecting wires of electrolytic copper or electroclad iron are welded to the end-caps. The resistors are coated with a red, inflammable lacquer which provides electrical, mechanical, and climatic protection. This coating is not resistant to aggressive fluxes. The encapsulation is resistant to all cleaning solvents in accordance with MIL-STD 202E method 215, and IEC 68-2-45.

MECHANICAL DATA

Mass

40 g (per 100 units).

Mounting

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

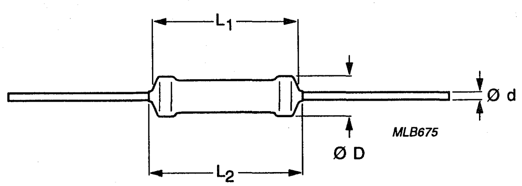
The minimum pitch for this type is 6e. Figures 6 and 7 show the temperature rise at the solder spot as a function of lead lengths after mounting.

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"*.

QUICK REFERENCE DATA

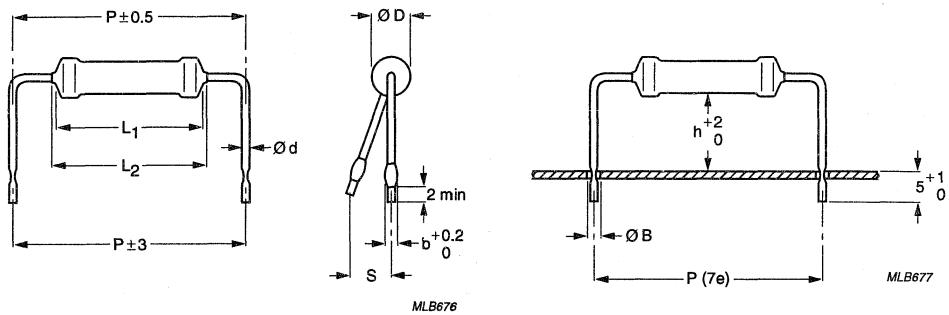
DESCRIPTION	VALUE	
	Ø 0.8 mm Cu-lead	Ø 0.6 mm FeCu-lead
Resistance range	0.33 Ω to 1 MΩ; E24 series	1 Ω to 1 MΩ; E24 series
Resistance tolerance	±5%	±5%
Rated dissipation at T_{amb} = 70 °C (P_{70}); see Fig.3:		
0.33 Ω ≤ R < 1 Ω	1.2 W	–
1 Ω ≤ R ≤ 1 MΩ	2 W	1.3 W
Thermal resistance (R_{th})	75 K/W	115 K/W
Temperature coefficient	≤ ±250 × 10^{-6}/K	
Maximum permissible voltage	500 V (DC or RMS)	
Basic specifications	IEC 115-1 and 115-4	
Approval	CECC 40101	
Climatic category (IEC 68)	55/155/56	
Stability after:		
load	ΔR/R max.: ±5% +0.1 Ω	
climatic tests	ΔR/R max.: ±3% +0.1 Ω	
soldering	ΔR/R max.: ±1% +0.05 Ω	



For dimensions see Table 1.

Fig.1 Type with straight leads.

Power metal film resistors PR02



Dimensions in mm.
For dimensions see Table 1.

Fig.2 Type with cropped and formed leads.

Table 1 Physical dimensions in mm.

$ØD_{max}$	L_{1max}	L_{2max}	Ød	b	h	P	S_{max}	$ØB_{max}$
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
3.9	10	12	0.6	1.1	8	17.8	2	1.0

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

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated (nominal) resistance are taken from the E24 series within the range 0.33 Ω to 1 MΩ. The values of the E24 series are in accordance with *"IEC publication 63"*.

The tolerance on the rated resistance is ±5%.

The limiting voltage (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.

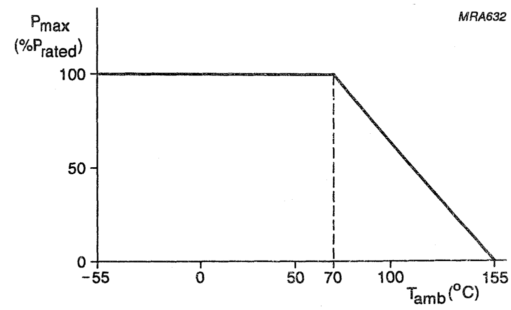
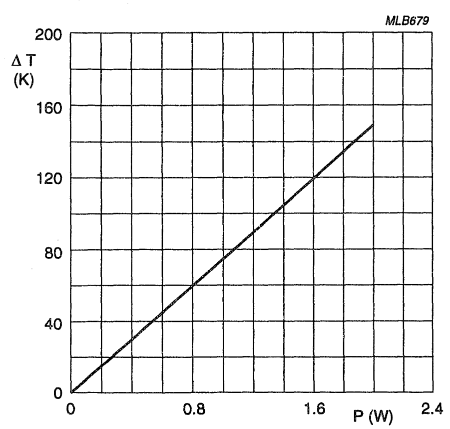
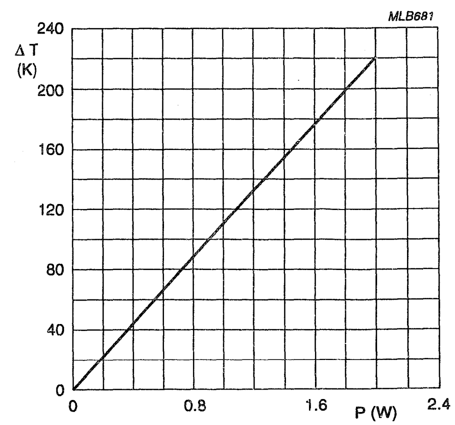


Fig.3 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).



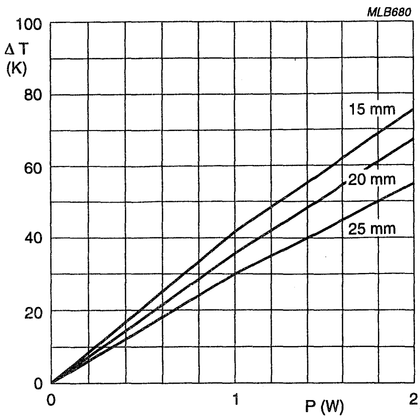
Ø 0.8 mm Cu-leads.

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



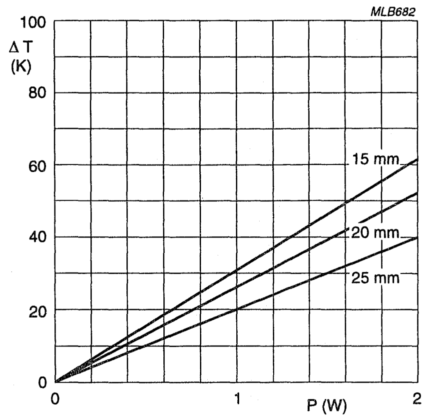
Ø 0.6 mm FeCu-leads.

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



∅ 0.8 mm Cu-leads.

Fig.6 Temperature rise (ΔT) at the lead end (soldering point) as a function of dissipated power at various lead lengths after mounting. Resistor body-to-PCB distance: 1 mm minimum.



∅ 0.6 mm FeCu-leads.

Fig.7 Temperature rise (ΔT) at the lead end (soldering point) as a function of dissipated power at various lead lengths after mounting. Resistor body-to-PCB distance: 1 mm minimum.

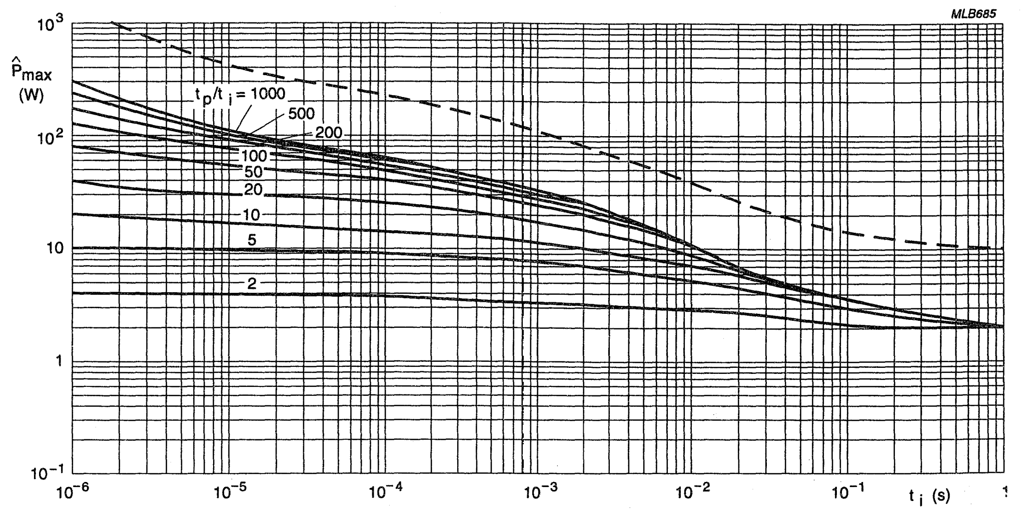


Fig.8 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i).

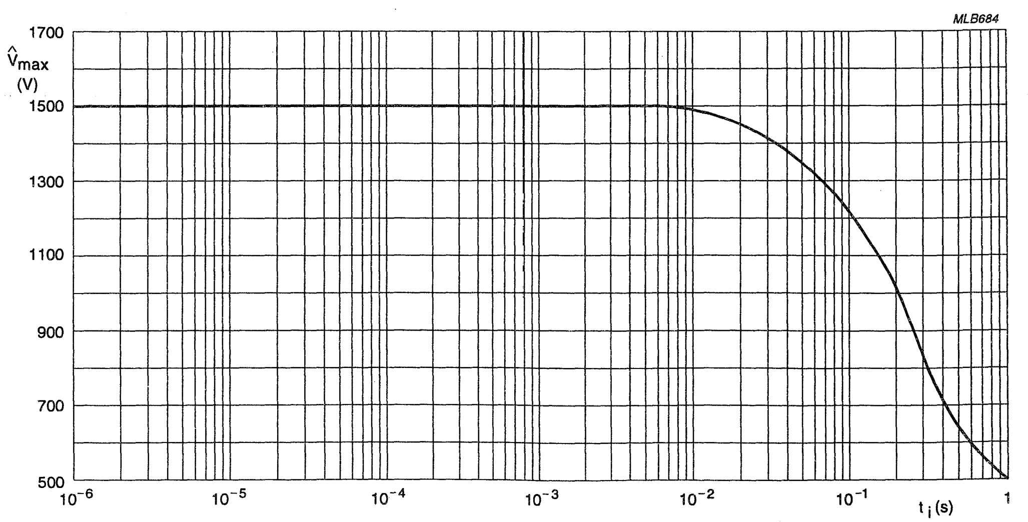


Fig.9 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_i).

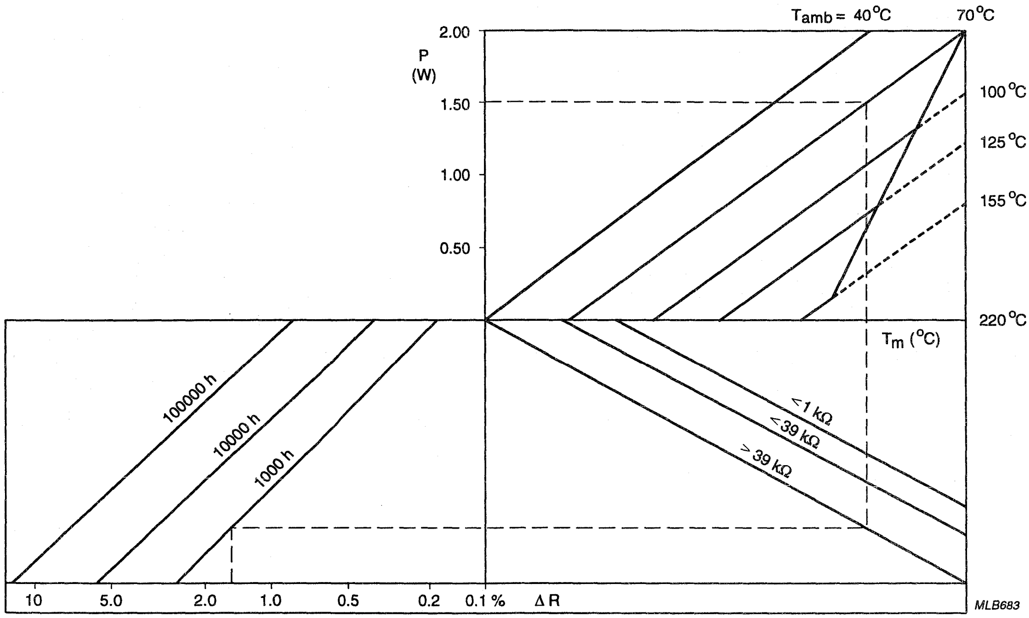
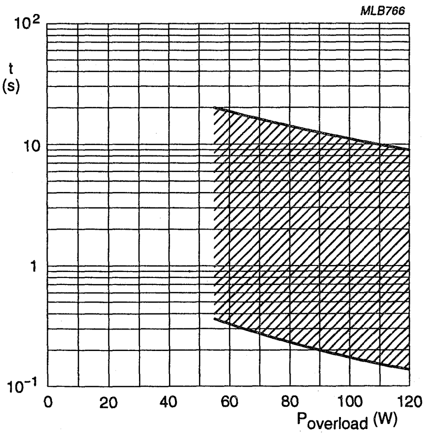
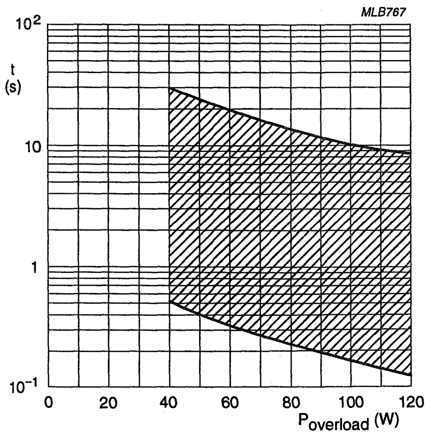


Fig.10 Drift nomogram.



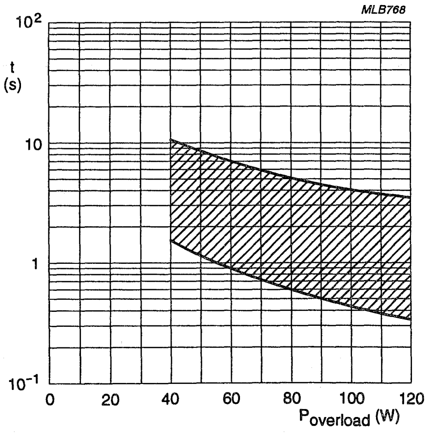
The graph is based on measured data under constant voltage conditions; these data may deviate according to the application.

Fig.11 Time to interruption as a function of overload power for range $0.33R \leq R_n < 5R$.



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

Fig.12 Time to interruption as a function of overload power for range $5R \leq R_n < 68R$.



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

Fig.13 Time to interruption as a function of overload power for range $68R \leq R_n \leq 560R$.

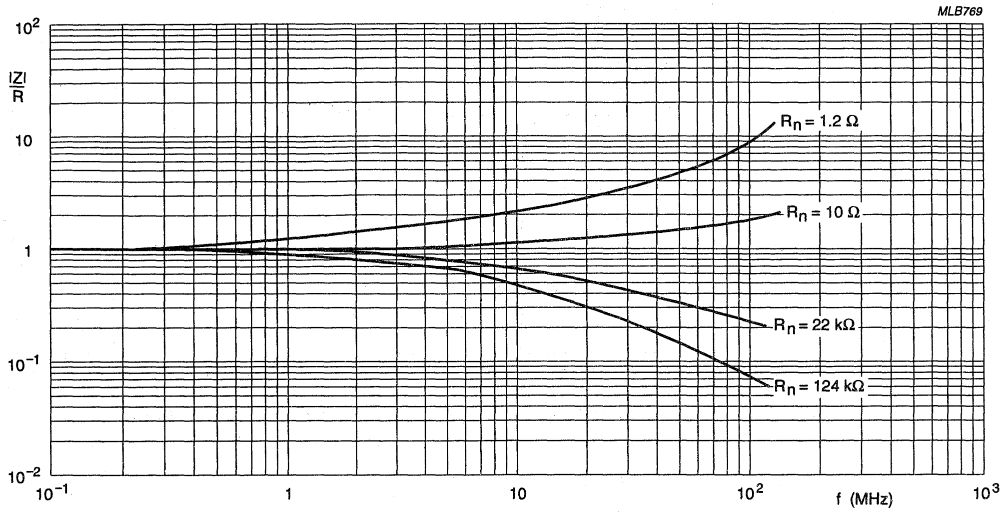


Fig.14 Impedance as a function of applied frequency.

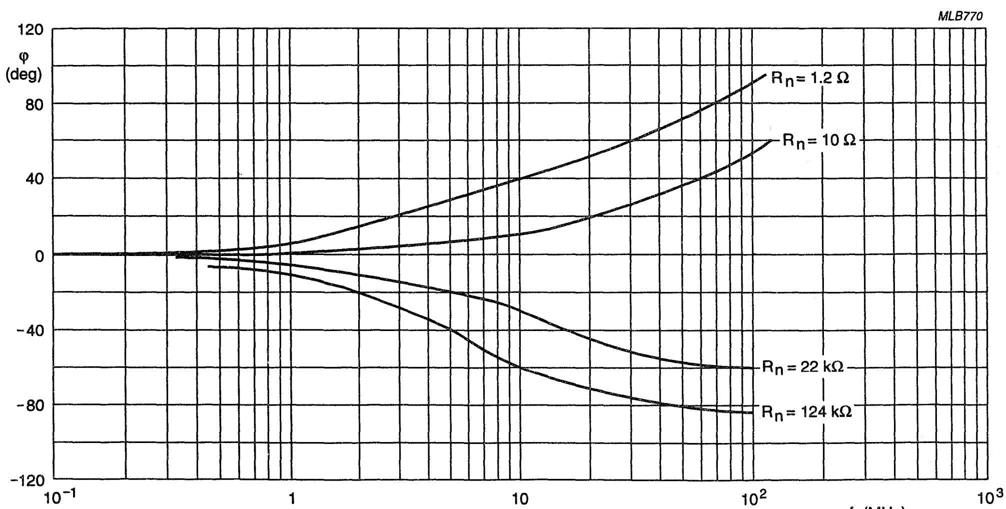


Fig.15 Phase angle as a function of applied frequency.

COMPOSITION OF THE CATALOGUE NUMBER

The resistors have a 12-digit catalogue number starting with 2322 or 2306. The subsequent 8 digits indicate the packaging and resistance value (see Tables 2 and 3).

Table 2 First 5 digits to indicate packaging for resistances as listed.

<table>
<tr><th>RESISTANCE RANGE</th><th>TOL. (%)</th><th>STYLE</th><th>PACKAGING</th><th>QUANTITY</th><th>MOUNTING HEIGHT</th><th>LEAD MATERIAL</th><th>CATALOGUE NUMBER</th></tr>
<tr><td>0.33 Ω ≤ R < 1 Ω</td><td rowspan="10">±5</td><td rowspan="2">straight leads</td><td rowspan="2">ammopack</td><td rowspan="2">1000</td><td rowspan="2">–</td><td rowspan="6">0.8 mm Cu</td><td>on request</td></tr>
<tr><td>1 Ω ≤ R ≤ 1 MΩ</td><td>2322 194 13...</td></tr>
<tr><td>0.33 Ω ≤ R < 1 Ω</td><td rowspan="4">cropped and formed</td><td rowspan="4">loose in box</td><td rowspan="2">1000</td><td rowspan="2">8 mm</td><td>on request</td></tr>
<tr><td>1 Ω ≤ R ≤ 1 MΩ</td><td>2322 194 33...</td></tr>
<tr><td>0.33 Ω ≤ R < 1 Ω</td><td rowspan="2">500</td><td rowspan="2">15 mm</td><td>on request</td></tr>
<tr><td>1 Ω ≤ R ≤ 1 MΩ</td><td>2322 194 43...</td></tr>
<tr><td>1 Ω ≤ R ≤ 1 MΩ</td><td>straight leads</td><td>ammopack</td><td>1000</td><td>–</td><td>0.6 mm FeCu</td><td>2322 194 53...</td></tr>
<tr><td>1 Ω ≤ R ≤ 1 MΩ</td><td>cropped and formed</td><td>loose in box</td><td>1000</td><td>8 mm</td><td>0.6 mm FeCu</td><td>2322 194 73...</td></tr>
<tr><td>0.33 Ω ≤ R < 1 Ω</td><td rowspan="2">radial taped</td><td rowspan="2">ammopack</td><td rowspan="2">3000</td><td rowspan="2">–</td><td rowspan="2">0.8 mm Cu</td><td>on request</td></tr>
<tr><td>1 Ω ≤ R ≤ 1 MΩ</td><td>2306 198 03...</td></tr>
</table>

To complete the catalogue number (see Table 2), replace the first two dots of the remaining 3-digit code by the first two digits of the resistance value. Replace the third dot (last digit) by a figure according to Table 3.

Table 3 Last digit of 12 NC; note 1.

RESISTANCE	LAST DIGIT
1 Ω to 9.1 Ω	8
10 Ω to 91 Ω	9
100 Ω to 910 Ω	1
1 kΩ to 9.1 kΩ	2
10 kΩ to 91 kΩ	3
100 kΩ to 910 kΩ	4
1 MΩ	5

Note

1. Tolerances of 1% and 2% are available on request.

Ordering example

The catalogue number of resistor value 750 Ω, on a bandolier of 1000 pieces, in ammopack, is: 2322 194 13751.

TESTS AND REQUIREMENTS

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

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

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

Air pressure: 86 kPa to 106 kPa (860 mbar to 1 060 mbar).

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

Table 4

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.16	U	robustness of terminations:		
4.16.2	Ua	tensile all samples	Ø 0.8 mm; load 5 N; 10 s Ø 0.6 mm; load 10 N; 10 s	number of failures $<1 \times 10^{-6}$
4.16.3	Ub	bending half number of samples	Ø 0.8 mm; load 2.5 N; 4 × 90° Ø 0.6 mm; load 5 N; 4 × 90°	number of failures $<1 \times 10^{-6}$
4.16.4	Uc	torsion other half number of samples	3 × 360° in opposite directions	no damage ΔR/R max.: ±0.5% +0.05 Ω
4.17	Ta	solderability	2 s; 235 °C; flux 600	good tinning; no damage
4.18	Tb	resistance to soldering heat	thermal shock: 3 s; 350 °C; 6 mm from body	ΔR/R max.: ±1% +0.05 Ω
4.19	Na	rapid change of temperature	30 minutes at −55 °C and 30 minutes at +155 °C; 5 cycles	no damage ΔR/R max.: ±1% +0.05 Ω
4.20	Eb	bump	3 × 1500 bumps in three directions; 40 g	no damage ΔR/R max.: ±0.5% +0.05 Ω
4.22	Fc	vibration	frequency 10 to 500 Hz; displacement 1.5 mm or acceleration 10 g; three directions; total 6 hours (3 × 2 hours)	no damage ΔR/R max.: ±0.5% +0.05 Ω
4.23		climatic sequence:		
4.23.2	Ba	dry heat	16 hours; 155 °C	
4.23.3	Db	damp heat (accelerated) 1st cycle	24 hours; 55 °C; 90 to 100% RH	
4.23.4	Aa	cold	2 hours; −55 °C	
4.23.5	M	low air pressure	2 hours; 8.5 kPa; 15 to 35 °C	
4.23.6	Db	damp heat (accelerated) remaining cycles	5 days; 55 °C; 90 to 100% RH	R_{ins} min.: 1 000 MΩ ΔR/R max.: ±3% +0.1 Ω
4.24.2	Ca	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; dissipation $0.01 \times P_{70}$	R_{ins} min.: 1 000 MΩ ΔR/R max.: ±3% +0.1 Ω

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.25.1		endurance	1000 hours; 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	$\leq \pm 250 \times 10^{-6}$
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 minute; V-block method	R_{ins} min.: 1000 MΩ
see 2nd amendment to IEC 115-1, Jan. '87		pulse load		see Figs 8 and 9

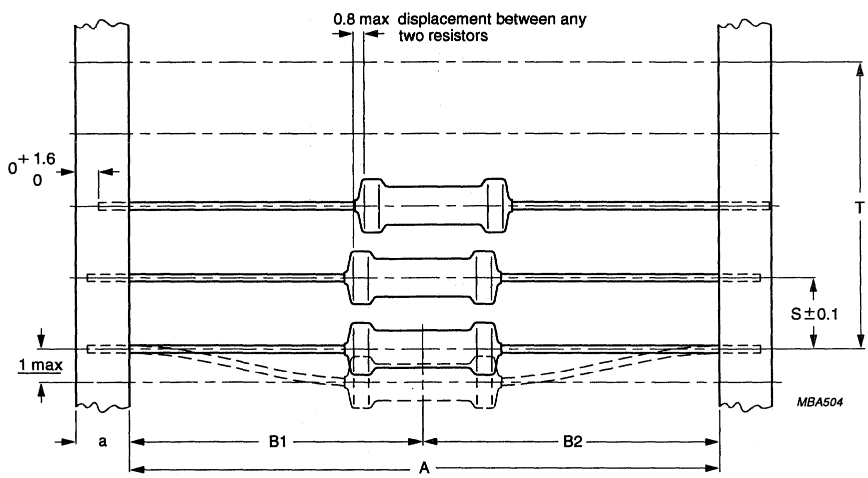
PACKAGING

The resistors may be supplied on bandolier in ammopack or loose in a box. For details refer to Section *"General Introduction leaded resistors"* in data handbook PA08.

Dimensions of the packaging.

PACKAGING	QUANTITY	M (mm)	N (mm)	P (mm)
Ammopack	1000	97	59	262
Loose in box	500 or 1000	105	70	205
Radial	3000	262	45	330

Tape and reel data

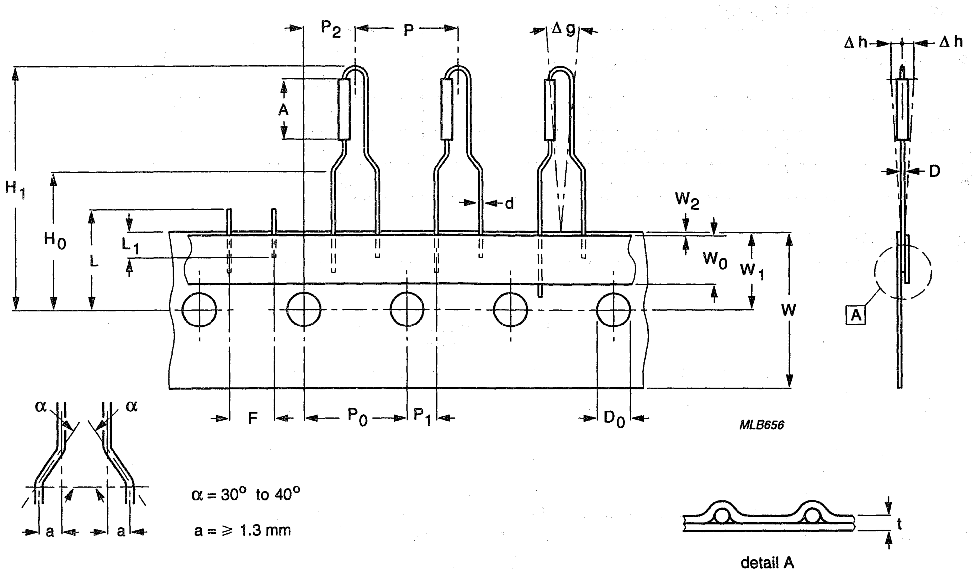


Dimensions in mm.

Fig.16 Axial style on tape.

Dimensions of bandolier.

a (mm)	A (mm)	$\lvert B_1 - B_2 \rvert$ (mm)	S (mm)	T (deviation of spacing)
6 ±0.5	73 ±1.5	±1.2	5	max. 1 mm per 10 spacings max. 0.5 mm per 5 spacings



For dimensions see Table 5.

Fig.17 Bandolier for types with radial leads.

Table 5 Taping dimensions; see Fig.17.

SYMBOL	PARAMETER	VALUE	TOLERANCE	UNIT
D	maximum body diameter	3.90	–	mm
A	maximum body length	10.0	–	mm
d	lead wire diameter	0.80	±0.02	mm
P	pitch of components	12.7	±1.0	mm
P_0	feed hole pitch	12.7	±0.2	mm
	cumulative pitch error per 20 spacings	1.0	–	mm
P_1	feed-hole centre to lead at topside at the tape	3.85	±0.5	mm
P_2	feed-hole centre to body centre	6.35	±1.0	mm
F	lead-to-lead distance	4.8 to 5.5	–	mm
Δh	component alignment	0	±1.2	mm
Δg	component alignment	0	±3	deg
W	tape width	18.0	±0.5	mm
W_0	hold down tape width	6.0	+0.2/–0.5	mm
W_1	hole position	9.0	±0.5	mm
W_2	maximum hold down tape position	0.5	–	mm
H_0	lead wire clinch height	16.5	±0.5	mm
H_1	component height	29.0	±3.0	mm
D_0	feed-hole diameter	4.0	±0.2	mm
t	total tape thickness	0.4 to 0.9	–	mm
L	maximum length of snipped lead	11.0	–	mm
L_1	minimum lead wire (tape portion) shorter lead	2.5	–	mm

Power metal film resistors — PR03

DESCRIPTION

A homogeneous film of metal alloy is deposited on a high grade ceramic body. After a helical groove has been cut in the resistive layer, tinned connecting wires of electrolytic copper or electroclad iron are welded to the end-caps. The resistors are coated with a red, inflammable lacquer which provides electrical, mechanical, and climatic protection. This coating is not resistant to aggressive fluxes. The encapsulation is resistant to all cleaning solvents in accordance with MIL-STD 202E method 215, and IEC 68-2-45.

MECHANICAL DATA

Mass

92 g (per 100 units).

Mounting

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

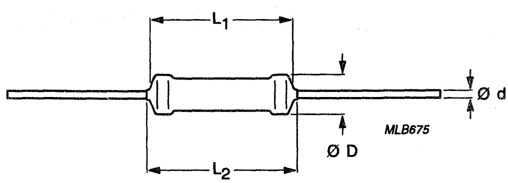
The minimum pitch for this type is 9e. Figures 6 and 7 show the temperature rise at the solder spot as a function of lead lengths after mounting.

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"*.

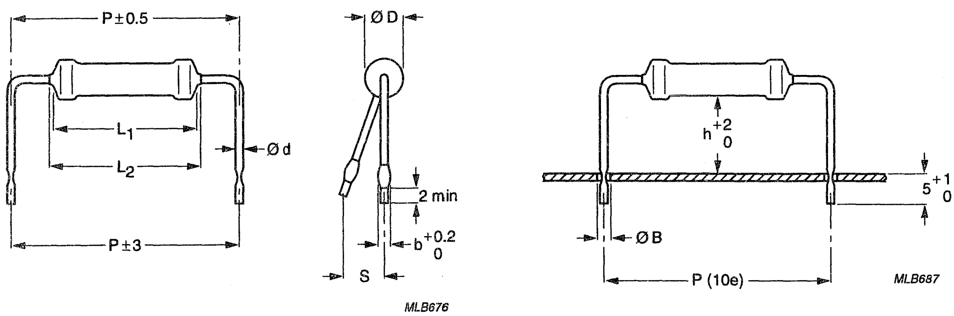
QUICK REFERENCE DATA

DESCRIPTION	VALUE	
	∅ 0.8 mm-Cu lead	∅ 0.6 mm FeCu-lead
Resistance range	0.68 Ω to 1 MΩ; E24 series	1 Ω to 1 MΩ; E24 series
Resistance tolerance	±5%	±5%
Rated dissipation at T_{amb} = 70 °C (P_{70}); see Fig.3:		
0.68 Ω ≤ R < 1 Ω	1.6 W	–
1 Ω ≤ R ≤ 1 MΩ	3 W	2.5 W
Thermal resistance (R_{th})	60 K/W	75 K/W
Temperature coefficient	$\leq \pm 250 \times 10^{-6}$/K	
Maximum permissible voltage	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	



For dimensions see Table 1.

Fig.1 Type with straight leads.



Dimensions in mm.
For dimensions see Table 1.

Fig.2 Type with cropped and formed leads.

Table 1 Physical dimensions in mm.

$\varnothing D_{max}$	L_{1max}	L_{2max}	$\varnothing d$	b	h	P	S_{max}	$\varnothing B_{max}$
5.2	16.7	19.5	0.8	1.3	8	25.4	2	1.2
5.2	16.7	19.5	0.8	1.3	15	25.4	3	1.2
5.2	16.7	19.5	0.6	1.1	8	25.4	2	1.0

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

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated (nominal) resistance are taken from the E24 series within the range 0.68 Ω to 1 MΩ. The values of the E24 series are in accordance with *"IEC publication 63"*.

The tolerance on the rated resistance is ±5%.

The limiting voltage (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.

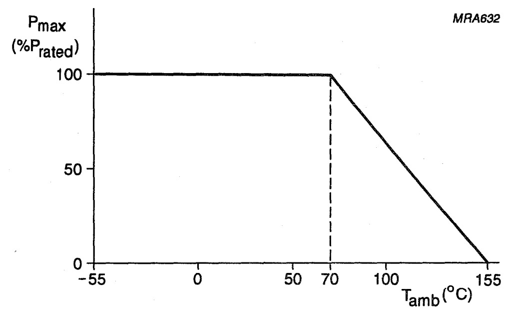
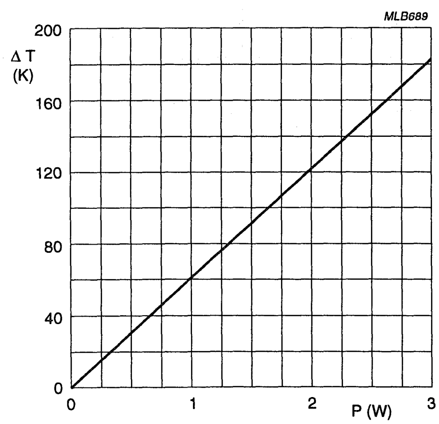
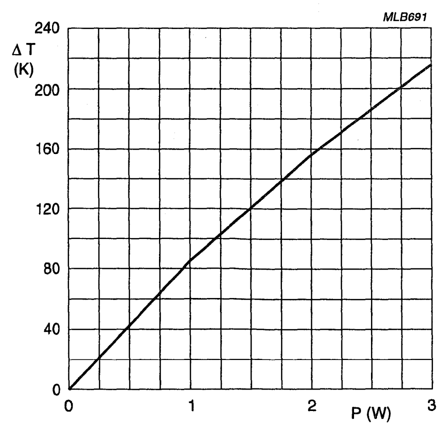


Fig.3 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).



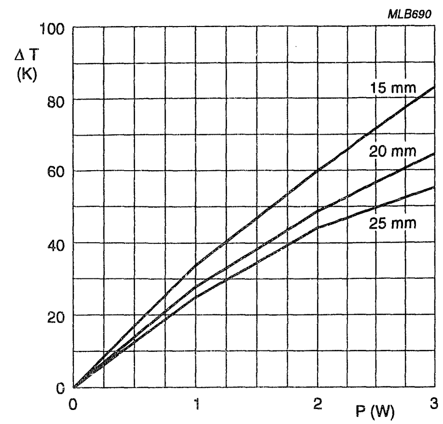
Ø 0.8 mm Cu-leads.

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



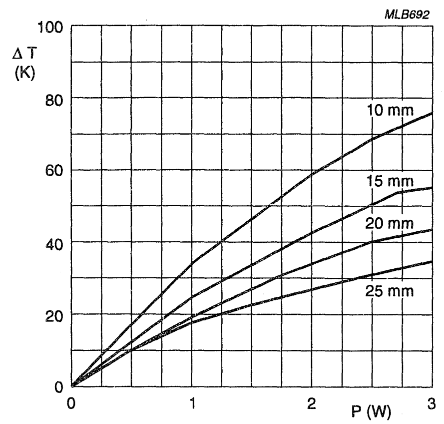
Ø 0.6 mm FeCu-leads.

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



∅ 0.8 mm Cu-leads.

Fig.6 Temperature rise (ΔT) at the lead end (soldering point) as a function of dissipated power at various lead lengths after mounting. Resistor body-to-PCB distance: 1 mm minimum.



∅ 0.6 mm FeCu-leads.

Fig.7 Temperature rise (ΔT) at the lead end (soldering point) as a function of dissipated power at various lead lengths after mounting. Resistor body-to-PCB distance: 1 mm minimum.

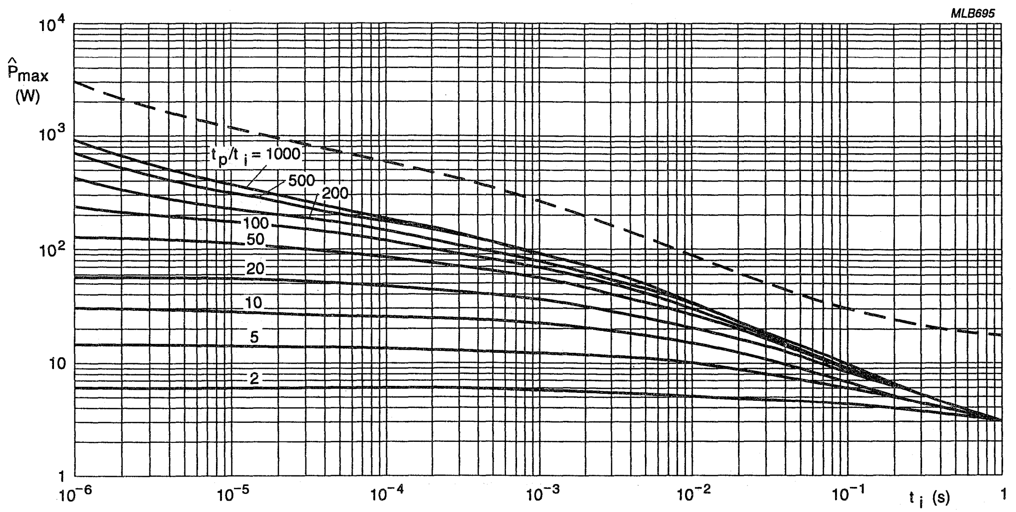


Fig.8 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i).

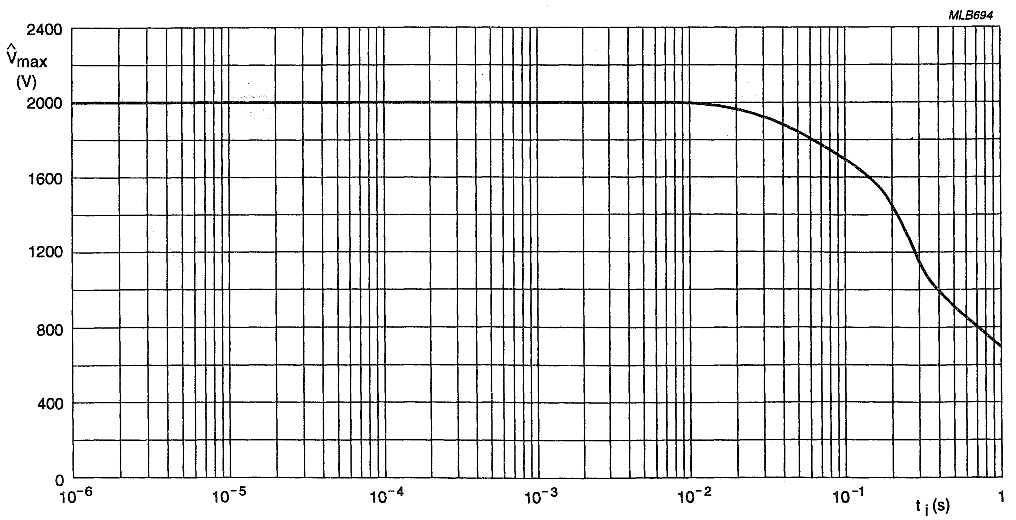


Fig.9 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_i).

Power metal film resistors PR03

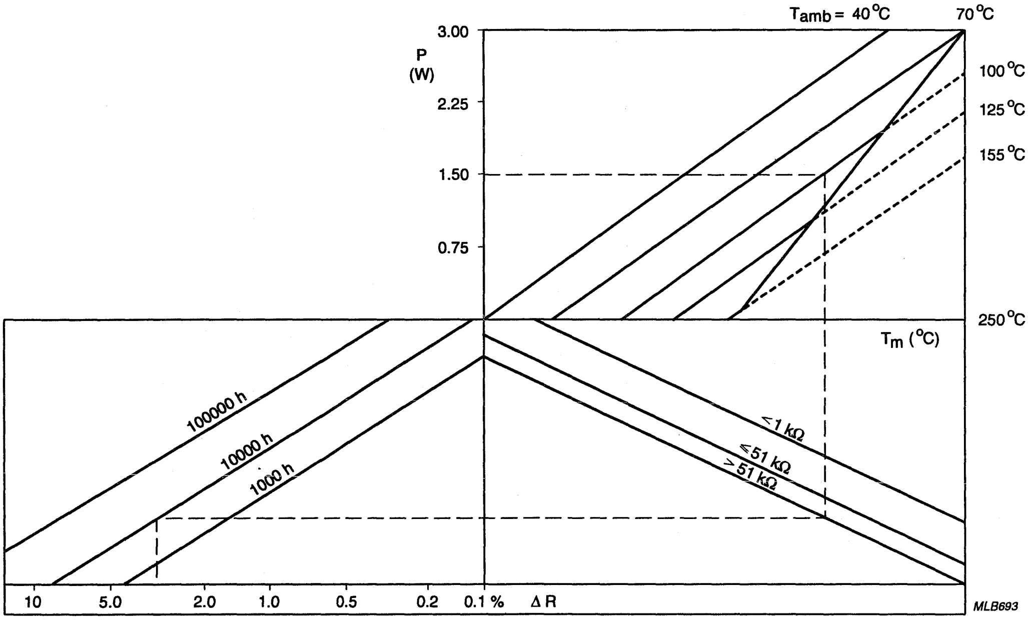
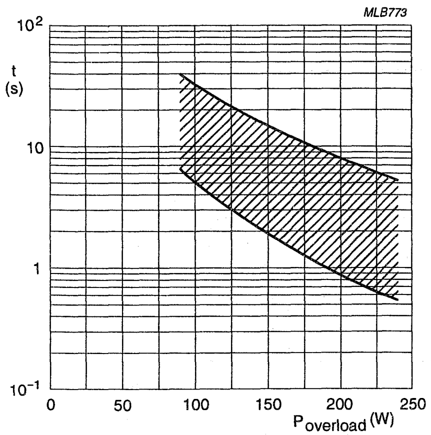


Fig.10 Drift nomogram.



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

Fig.11 Time to interruption as a function of overload power for range $0.68R \leq R_n \leq 560R$.

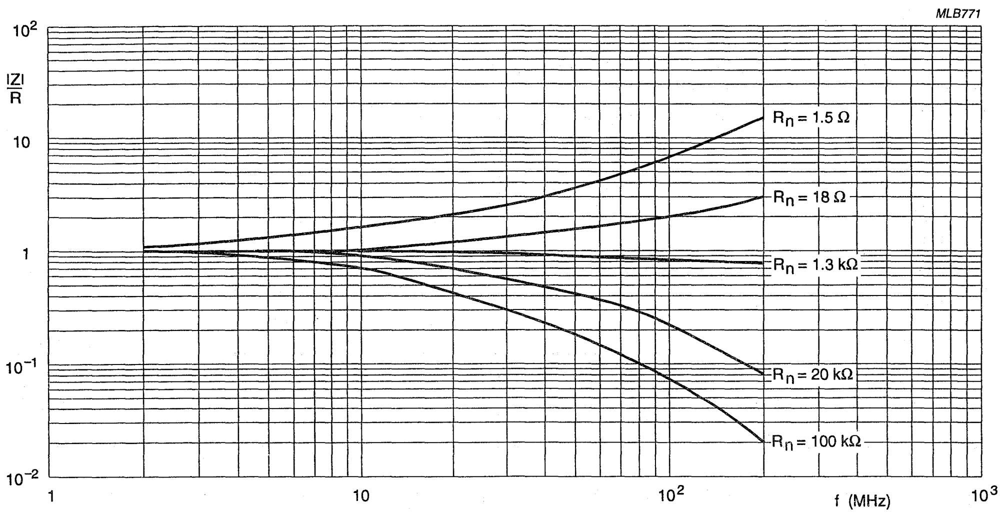


Fig.12 Impedance as a function of applied frequency.

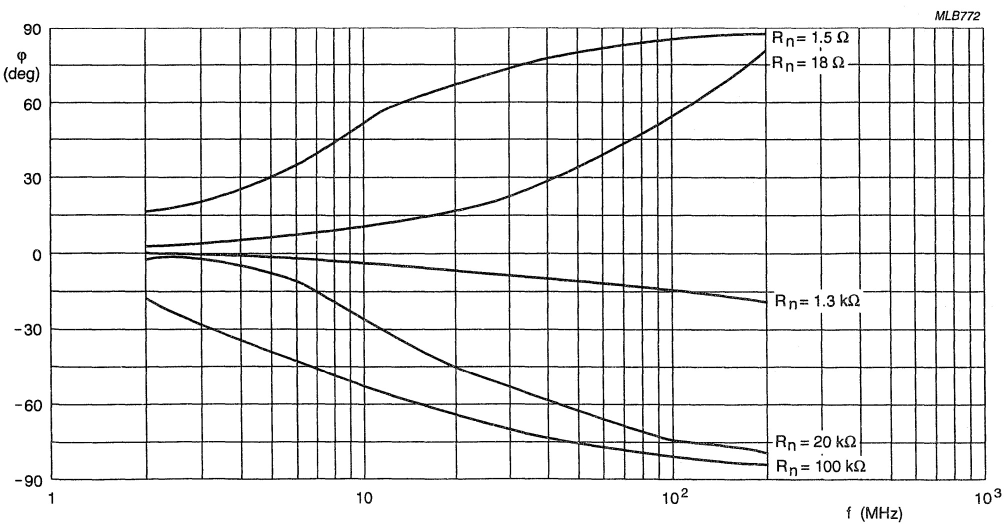


Fig.13 Phase angle as a function of applied frequency.

COMPOSITION OF THE CATALOGUE NUMBER

The resistors have a 12-digit catalogue number starting with 2322. The subsequent 8 digits indicate the packaging and resistance value (see Tables 2 and 3).

Table 2 First 5 digits to indicate packaging for resistances as listed.

<table>
<tr><th>RESISTANCE RANGE</th><th>TOL. (%)</th><th>STYLE</th><th>PACKAGING</th><th>QUANTITY</th><th>MOUNTING HEIGHT</th><th>LEAD MATERIAL</th><th>CATALOGUE NUMBER</th></tr>
<tr><td>0.68 Ω ≤ R < 1 Ω</td><td rowspan="8">±5</td><td rowspan="2">straight leads</td><td rowspan="2">ammopack</td><td rowspan="2">500</td><td rowspan="2">–</td><td rowspan="6">0.8 mm Cu</td><td>on request</td></tr>
<tr><td>1 Ω ≤ R < 1 MΩ</td><td>2322 195 13...</td></tr>
<tr><td>0.68 Ω ≤ R < 1 Ω</td><td rowspan="4">cropped and formed</td><td rowspan="4">loose in box</td><td rowspan="2">500</td><td rowspan="2">8 mm</td><td>on request</td></tr>
<tr><td>1 Ω ≤ R < 1 MΩ</td><td>2322 195 33...</td></tr>
<tr><td>0.68 Ω ≤ R < 1 Ω</td><td rowspan="2">250</td><td rowspan="2">15 mm</td><td>on request</td></tr>
<tr><td>1 Ω ≤ R < 1 MΩ</td><td>2322 195 43...</td></tr>
<tr><td>1 Ω ≤ R < 1 MΩ</td><td>straight leads</td><td>ammopack</td><td>500</td><td>–</td><td>0.6 mm FeCu</td><td>2322 195 53...</td></tr>
<tr><td>1 Ω ≤ R < 1 MΩ</td><td>cropped and formed</td><td>loose in box</td><td>500</td><td>8 mm</td><td>0.6 mm FeCu</td><td>2322 195 73...</td></tr>
</table>

To complete the catalogue number (see Table 2), replace the first two dots of the remaining 3-digit code by the first two digits of the resistance value. Replace the third dot (last digit) by a figure according to Table 3.

Table 3 Last digit of 12 NC; note 1.

RESISTANCE	LAST DIGIT
1 Ω to 9.1 Ω	8
10 Ω to 91 Ω	9
100 Ω to 910 Ω	1
1 kΩ to 9.1 kΩ	2
10 kΩ to 91 kΩ	3
100 kΩ to 910 kΩ	4
1 MΩ	5

Note

1. Tolerances of 1% and 2% are available on request.

Ordering example

The catalogue number of resistor value 750 Ω, on a bandolier of 1000 units, in ammopack, is: 2322 195 13751.

TESTS AND REQUIREMENTS

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

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

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

Air pressure: 86 kPa to 106 kPa (860 mbar to 1 060 mbar).

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

Table 4

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.16	U	robustness of terminations:		
4.16.2	Ua	tensile all samples	∅ 0.8 mm; load 10 N; 10 s ∅ 0.6 mm; load 10 N; 10 s	number of failures <1 × 10^{-6}
4.16.3	Ub	bending half number of samples	∅ 0.8 mm; load 5 N; 4 × 90° ∅ 0.6 mm; load 5 N; 4 × 90°	number of failures <1 × 10^{-6}
4.16.4	Uc	torsion other half number of samples	3 × 360° in opposite directions	no damage ΔR/R max.: ±0.5% +0.05 Ω
4.17	Ta	solderability	2 s; 235 °C; flux 600	good tinning; no damage
4.18	Tb	resistance to soldering heat	thermal shock: 3 s; 350 °C; 6 mm from body	ΔR/R max.: ±1% +0.05 Ω
4.19	Na	rapid change of temperature	30 minutes at –55 °C and 30 minutes at +155 °C; 5 cycles	no damage ΔR/R max.: ±2% +0.05 Ω
4.20	Eb	bump	3 × 1500 bumps in three directions; 40 g	no damage ΔR/R max.: ±0.5% +0.05 Ω
4.22	Fc	vibration	frequency 10 to 500 Hz; displacement 1.5 mm or acceleration 10 g; three directions; total 6 hours (3 × 2 hours)	no damage ΔR/R max.: ±0.5% +0.05 Ω
4.23		climatic sequence:		
4.23.2	Ba	dry heat	16 hours; 155 °C	
4.23.3	Db	damp heat (accelerated) 1st cycle	24 hours; 55 °C; 90 to 100% RH	
4.23.4	Aa	cold	2 hours; –55 °C	
4.23.5	M	low air pressure	2 hours; 8.5 kPa; 15 to 35 °C	
4.23.6	Db	damp heat (accelerated) remaining cycles	5 days; 55 °C; 90 to 100% RH	R_{ins} min.: 1000 MΩ ΔR/R max.: ±3% +0.1 Ω
4.24.2	Ca	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; dissipation 0.01 × P_{70}	R_{ins} min.: 1000 MΩ ΔR/R max.: ±3% +0.1 Ω

Power metal film resistors PR03

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.25.1		endurance	1000 hours; 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	$\leq \pm 250 \times 10^{-6}$
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 minute; V-block method	R_{ins} min.: 1000 MΩ
see 2nd amendment to IEC 115-1, Jan. '87		pulse load		see Figs 8 and 9

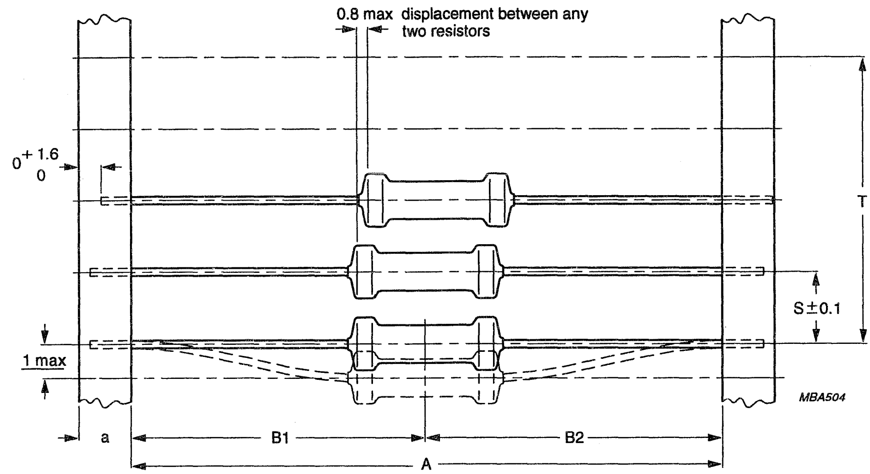
PACKAGING

The resistors may be supplied on bandolier in ammopack or loose in a box. For details refer to Section *"General Introduction leaded resistors"* in data handbook PA08.

Dimensions of the packaging.

STYLE	QUANTITY	M (mm)	N (mm)	P (mm)
Ammopack	500	99	77	259
Loose in box	250 or 500	105	70	205

Tape and reel data



Dimensions in mm.

Fig.14 Axial style on tape.

Dimensions of bandolier.

a (mm)	A (mm)	$\lvert B_1 - B_2 \rvert$ (mm)	S (mm)	T (deviation of spacing)
6 ±0.5	80 ±1.5	±1.2	10	max. 1 mm per 10 spacings max. 0.5 mm per 5 spacings

Power metal film resistors

PR37

DESCRIPTION

A homogeneous film of metal alloy is deposited on a high grade ceramic body. After a helical groove has been cut in the resistive layer, tinned connecting wires of electrolytic copper or copper-clad iron are welded to the end-caps. The resistors are coated with a red, inflammable protective silicon lacquer which can withstand 500 V (RMS). This coating is not resistant to aggressive fluxes. The encapsulation is resistant to all cleaning solvents in accordance with MIL-STD-202E method 215, and IEC 68-2-45.

MECHANICAL DATA

Mass

40 g (per 100 units).

Mounting

The resistors must be mounted stress free so as to allow thermal expansion over the wide permissible temperature range.

The minimum pitch for this type with cropped and formed leads is 7e.

Marking

The resistor is marked with the nominal resistance value and the tolerance on the resistance.

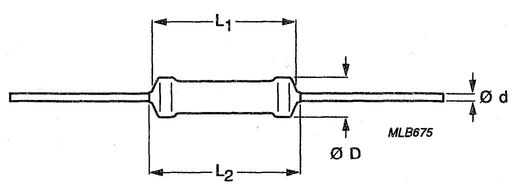
For values up to 910 Ω, the R is used as the decimal point.

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

For the value of 1 MΩ the letter M is used as the decimal point for the MΩ indication.

QUICK REFERENCE DATA

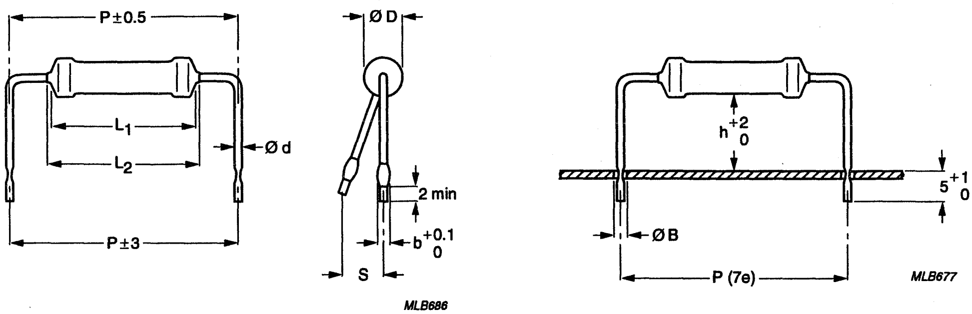
DESCRIPTION	VALUE
Resistance range	1 Ω to 1 MΩ; E24 series
Resistance tolerance	±5%
Maximum body temperature (hot-spot)	300 °C
Absolute maximum dissipation at T_{amb} = 70 °C (P_{70}); see Fig.3:	
$R \leq 27$ kΩ	1.6 W
$R > 27$ kΩ	1.2 W
Maximum permissible voltage	500 V
Basic specifications	IEC 115-4 and MIL-R-11804/2, char. G
Climatic category (IEC 68)	55/200/56
Stability after:	
load, 1000 hours	ΔR/R max.: 5% +0.1 Ω
climatic tests	ΔR/R max.: 3% +0.1 Ω
soldering	ΔR/R max.: 1% +0.05 Ω



For dimensions see Table 1.

Fig.1 Type with straight leads.

Power metal film resistors PR37



Dimensions in mm.
For dimensions see Table 1.

Fig.2 Type with cropped and formed leads.

Table 1 Physical dimensions.

LEADS	ØD MAX. (mm)	L_1 MAX. (mm)	L_2 MAX. (mm)	Ød (mm)	b (mm)	h (mm)	P (mm)	S MAX. (mm)	ØB MAX. (mm)
Copper-clad iron	3.9	10	12	0.6	1.1	8	17.8	2	1.0
						15		3	
Copper	3.9	10	12	0.8	1.3	8	17.8	2	1.2
						15		3	

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated (nominal) resistance are taken from the E24 series within the range 1 Ω to 1 MΩ. The values of the E24 series are in accordance with *"IEC publication 63"*.

The tolerance on the rated resistance is ±5%.

The limiting voltage (RMS) is 500 V. This is the maximum voltage that may be applied continuously to the resistor element, see *"IEC publications 115-1 and 115-4"*.

The maximum permissible hot-spot temperature is 300 °C.

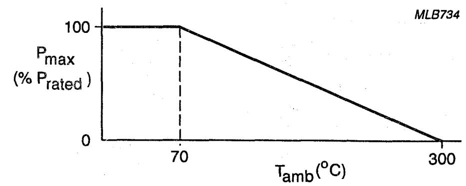
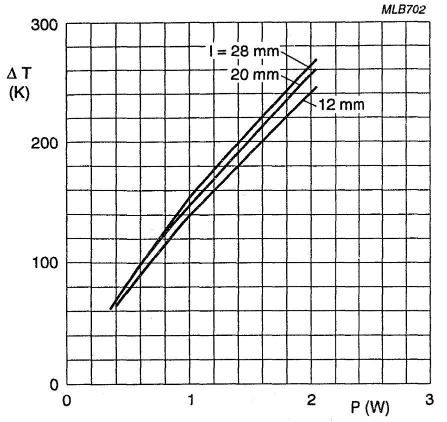


Fig.3 Rated power dissipation (P_{rated}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

Table 2

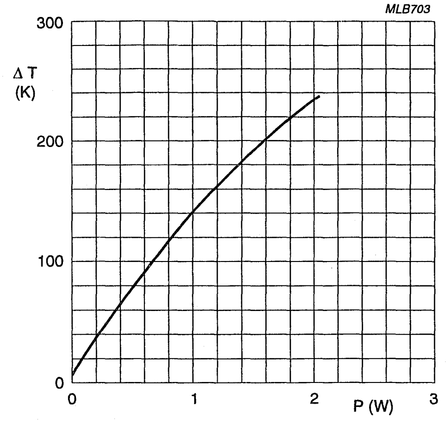
DESCRIPTION	VALUE
Temperature coefficient	R < 10 Ω: ≤ ±350 × 10^{-6}/K
	R ≥ 10 Ω: ≤ ±250 × 10^{-6}/K
Maximum body temperature (hot-spot)	300 °C
Absolute maximum dissipation at T_{amb} = 70 °C:	
R ≤ 27 kΩ	1.6 W
R > 27 kΩ	1.2 W
Limiting voltage	500 V
Dielectric withstanding minimum RMS voltage of the insulation for 1 min	500 V
Basic specifications	IEC 115-4 and MIL-R-11804/2, char. G
Climatic category (IEC 68)	55/200/56
Temperature rise (ΔT) of the resistor body as a function of dissipation	see Figs 4 and 5
Lead length (l) as a function of dissipation with temperature rise at end of lead (soldering point) as parameter	see Figs 6 and 7

Power metal film resistors



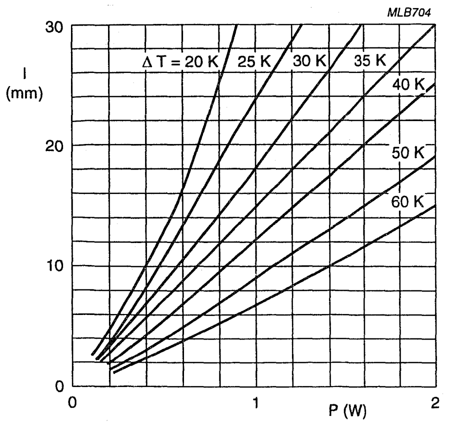
Copper-clad iron leads ∅ = 0.6 mm.

Fig.4 Hot-spot temperature rise (ΔT) as a function of dissipated power at different lead lengths (l).



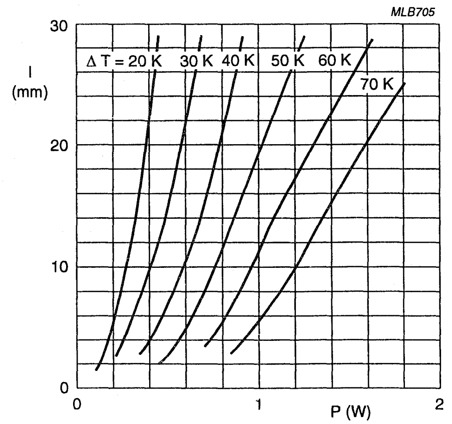
Copper leads ∅ = 0.8 mm.

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



Copper-clad iron leads ∅ = 0.6 mm.

Fig.6 Lead length (l) as a function of dissipated power with ΔT as a parameter.



Copper leads ∅ = 0.8 mm.

Fig.7 Lead length (l) as a function of dissipated power with ΔT as a parameter.

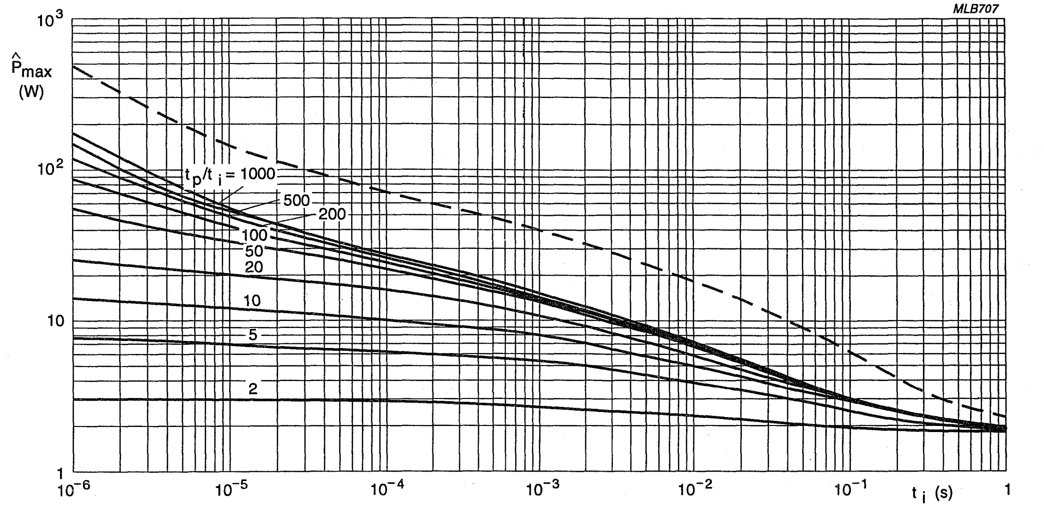


Fig.8 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i).

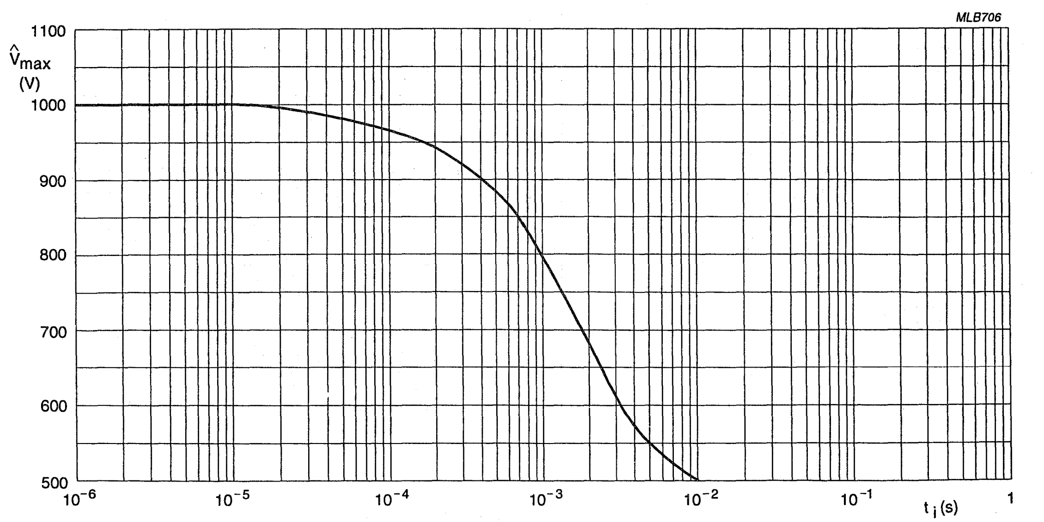


Fig.9 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_i).

Power metal film resistors PR37

COMPOSITION OF THE CATALOGUE NUMBER

2322 191 . . . . .

style code:

- 3 = straight formed copper-clad iron leads, ∅ 0.6 mm
- 4 = cropped and formed copper-clad iron leads, ∅ 0.6 mm
- 5 = straight copper leads, ∅ 0.8 mm
- 6 = cropped and formed copper leads, ∅ 0.8 mm

first two digits of the resistance value (E24 series)

mounting height (h), see Fig.2:

- 0 = 8 mm; cropped and formed version
- 1 = 15 mm; cropped and formed version
- 0 = straight lead version

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

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of "*IEC publication 115-1*", category 55/200/56 (rated temperature range –55 °C to +200 °C; damp heat, long term, 56 days). The testing also covers the requirements specified by EIA and EIAJ.

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

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

Air pressure: 86 kPa to 106 kPa (860 mbar to 1 060 mbar).

In Table 3 the tests and requirements are listed with reference to the relevant clauses of *"IEC publications 115-1 and 68"*; a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

Table 3

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.16	U	robustness of terminations:		
4.16.2	Ua	tensile all samples	load 10 N; 10 s	number of failures $<1 \times 10^{-6}$
4.16.3	Ub	bending half number of samples	load 5 N; 4 × 90°	number of failures $<1 \times 10^{-6}$
4.16.4	Uc	torsion other half number of samples	3 × 360° in opposite directions	no damage ΔR/R max.: ±0.5% +0.05 Ω
4.17	Ta	solderability	2 s; 235 °C; flux 600	good tinning; no damage
4.18	Tb	resistance to soldering heat	thermal shock: 3 s; 350 °C; 6 mm from body	ΔR/R max.: ±0.5% +0.05 Ω
4.19	Na	rapid change of temperature	30 minutes at –55 °C and 30 minutes at +155 °C; 5 cycles	no damage ΔR/R max.: ±2% +0.1 Ω
4.20	Eb	bump	3 × 1500 bumps in three directions; 40 g	no damage ΔR/R max.: ±0.5% +0.05 Ω
4.22	Fc	vibration	frequency 10 to 500 Hz; displacement 1.5 mm or acceleration 10 g; three directions; total 6 hours (3 × 2 hours)	no damage ΔR/R max.: ±0.5% +0.05 Ω
4.23		climatic sequence:		
4.23.2	Ba	dry heat	16 hours; 155 °C	
4.23.3	Db	damp heat (accelerated) 1st cycle	24 hours; 55 °C; 95 to 100% RH	
4.23.4	Aa	cold	2 hours; –55 °C	
4.23.5	M	low air pressure	1 hour; 8.5 kPa; 15 to 35 °C	
4.23.6	Db	damp heat (accelerated) remaining cycles	5 days; 55 °C; 95 to 100% RH	R_{ins} min.: 1 000 MΩ ΔR/R max.: ±3% +0.1 Ω
4.24.2	Ca	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; dissipation 0.01 × P_{70}	R_{ins} min.: 1 000 MΩ ΔR/R max.: ±3% +0.1 Ω
4.25.1		endurance	1 000 hours; 70 °C; P_{70} or V_{max}	ΔR/R max.: ±5% +0.1 Ω

Power metal film resistors PR37

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.8.4.2		temperature coefficient	between –55 °C and +155 °C	$R < 10\ \Omega$: $\leq \pm 350 \times 10^{-6}$/K $R \geq 10\ \Omega$: $\leq \pm 250 \times 10^{-6}$/K
4.7		voltage proof on insulation	500 V (RMS) for 1 minute; V-block method	no breakdown
4.12		noise	IEC publication 195	
4.6.1.1		insulation resistance	500 V (DC) for 1 minute; V-block method	R_{ins} min.: 1000 MΩ
see 2nd amendment to IEC 115-1, Jan. '87 and present 40 central office 532 & 533		pulse load		see Figs 8 and 9

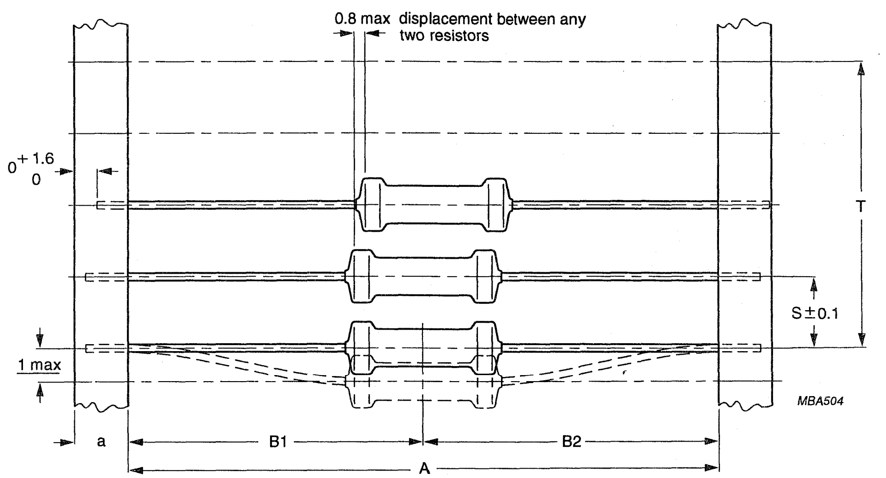
PACKAGING

The resistors may be supplied on bandolier in ammopack. Those with bent leads are supplied loose in a box. For details refer to Section *"General Introduction leaded resistors"* in data handbook PA08.

Dimensions of the packaging.

STYLE	PACKAGING	MOUNTING HEIGHT (mm)	QUANTITY PER BOX	
			ON BANDOLIER	BULK
Straight leads	ammopack	–	1000	–
Cropped and formed leads	loose in box	8	–	1000
		15	–	500

Tape and reel data



Dimensions in mm.

Fig.10 Axial style on tape.

Dimensions of bandolier.

a (mm)	A (mm)	$\lvert B_1 - B_2 \rvert$ (mm)	S (mm)	T (deviation of spacing)
6 ±0.5	73 ±1.5	±1.2	5	max. 1 mm per 10 spacings max. 0.5 mm per 5 spacings

Dimensions of box.

STYLE	QUANTITY	M (mm)	N (mm)	P (mm)
Ammopack	1000	97	59	262
Loose in box	500 or 1000	105	70	205

Power metal film resistors

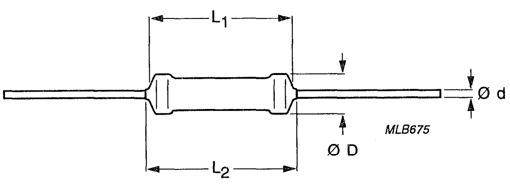
PR52

DESCRIPTION

A homogeneous film of metal alloy is deposited on a high grade ceramic body. After a helical groove has been cut in the resistive layer, tinned connecting wires of electrolytic copper or copper-clad iron are welded to the end-caps. The resistors are coated with a red, inflammable protective silicon lacquer which can withstand 500 V (RMS). This coating is not resistant to aggressive fluxes. The encapsulation is resistant to all cleaning solvents in accordance with MIL-STD 202E method 215, and IEC 68-2-45.

QUICK REFERENCE DATA

DESCRIPTION	VALUE
Resistance range	1 Ω to 1 MΩ; E24 series
Resistance tolerance	±5%
Maximum body temperature (hot-spot)	300 °C
Absolute maximum dissipation at T_{amb} = 70 °C (P_{70}); see Fig.3:	
R ≤ 51 kΩ	2.5 W
R > 51 kΩ	2.0 W
Maximum permissible voltage	750 V
Basic specifications	IEC 115-4 and MIL-R-11804/2, char. G
Climatic category (IEC 68)	55/200/56
Stability after:	
load, 1 000 hours	ΔR/R max.: 5% +0.1 Ω
climatic tests	ΔR/R max.: 3% +0.1 Ω
soldering	ΔR/R max.: 1% +0.05 Ω



For dimensions see Table 1.

Fig.1 Type with straight leads.

MECHANICAL DATA

Mass

92 g (per 100 units).

Mounting

The resistors must be mounted stress free so as to allow thermal expansion over the wide permissible temperature range.

The minimum pitch for this type with cropped and formed leads is 10e.

Marking

The resistor is marked with the nominal resistance value and the tolerance on the resistance.

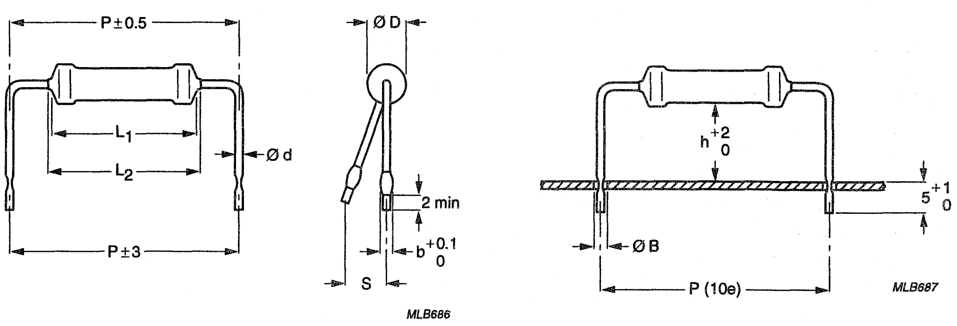
For values up to 910 Ω, the R is used as the decimal point.

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

For the value of 1 MΩ the letter M is used as the decimal point for the MΩ indication.

Power metal film resistors

PR52



Dimensions in mm.
For dimensions see Table 1.

Fig.2 Type with cropped and formed leads.

Table 1 Physical dimensions.

LEADS	ØD MAX. (mm)	L_1 MAX. (mm)	L_2 MAX. (mm)	Ød (mm)	b (mm)	h (mm)	P (mm)	S MAX. (mm)	ØB MAX. (mm)
Copper-clad iron	5.2	16.7	19.5	0.6	1.1	8	25.4	2	1.0
						15		3	
Copper	5.2	16.7	19.5	0.8	1.3	8	25.4	2	1.2
						15		3	

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated (nominal) resistance are taken from the E24 series within the range 1 Ω to 1 MΩ. The values of the E24 series are in accordance with *"IEC publication 63"*.

The tolerance on the rated resistance is ±5%.

The limiting voltage (RMS) is 750 V. This is the maximum voltage that may be applied continuously to the resistor element, see *"IEC publications 115-1 and 115-4"*.

The maximum permissible hot-spot temperature is 300 °C.

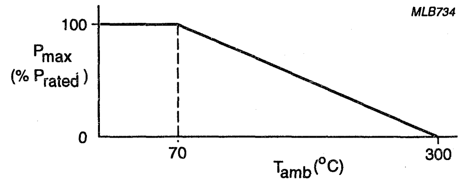


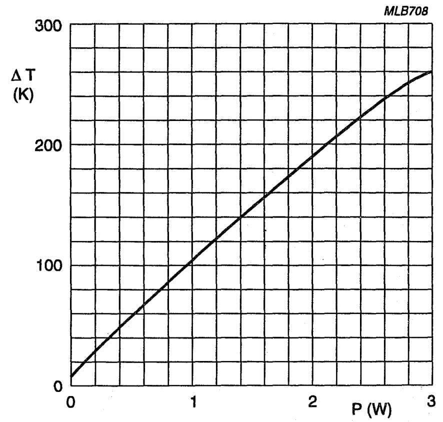
Fig.3 Rated power dissipation (P_{rated}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

Table 2

DESCRIPTION	VALUE
Temperature coefficient	R < 10 Ω: ≤ ±350 × 10^{-6}/K
	R ≥ 10 Ω: ≤ ±250 × 10^{-6}/K
Maximum body temperature (hot-spot)	300 °C
Absolute maximum dissipation at T_{amb} = 70 °C:	
R ≤ 51 kΩ	2.5 W
R > 51 kΩ	2.0 W
Limiting voltage	750 V
Dielectric withstanding minimum RMS voltage of the insulation for 1 min	500 V
Basic specifications	IEC 115-4 and MIL-R-11804/2, char. G
Climatic category (IEC 68)	55/200/56
Temperature rise (ΔT) of the resistor body as a function of dissipation	see Figs 4 and 5
Lead length (l) as a function of dissipation with temperature rise at end of lead (soldering point) as parameter	see Figs 6 and 7

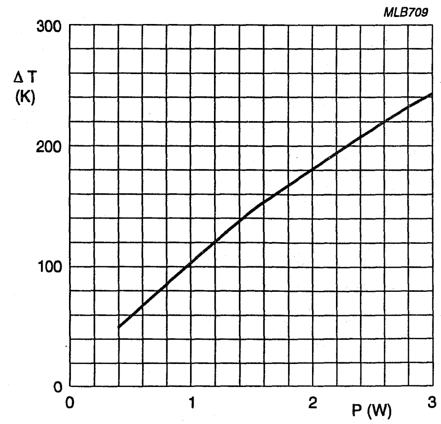
Power metal film resistors

PR52



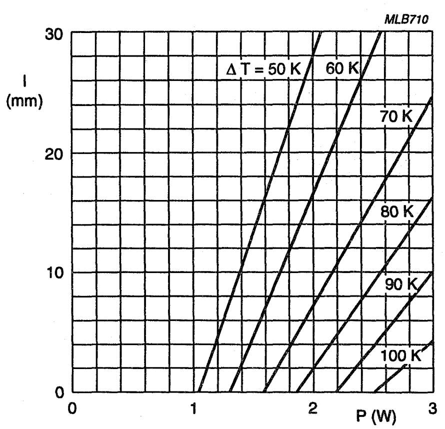
Copper-clad iron leads Ø = 0.6 mm.

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



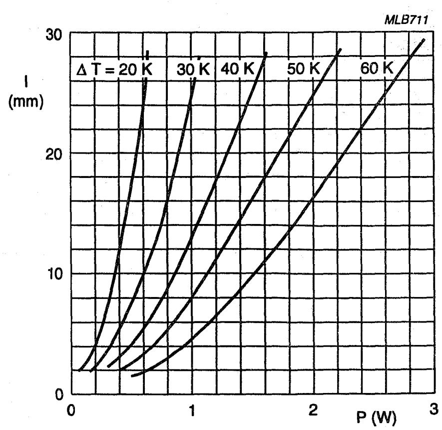
Copper leads Ø = 0.8 mm.

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



Copper-clad iron leads Ø = 0.6 mm.

Fig.6 Lead length (l) as a function of dissipated power with ΔT as a parameter.



Copper leads Ø = 0.8 mm.

Fig.7 Lead length (l) as a function of dissipated power with ΔT as a parameter.

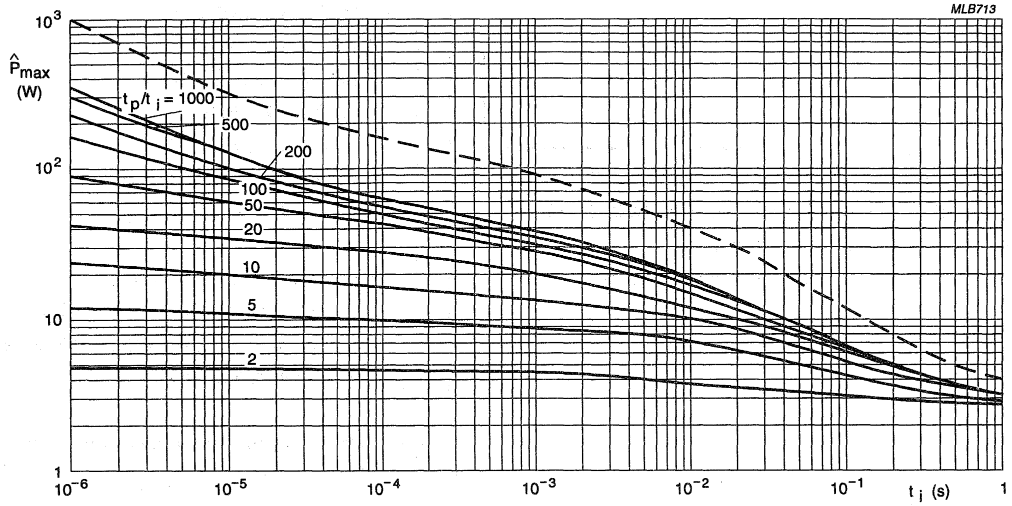


Fig.8 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i).

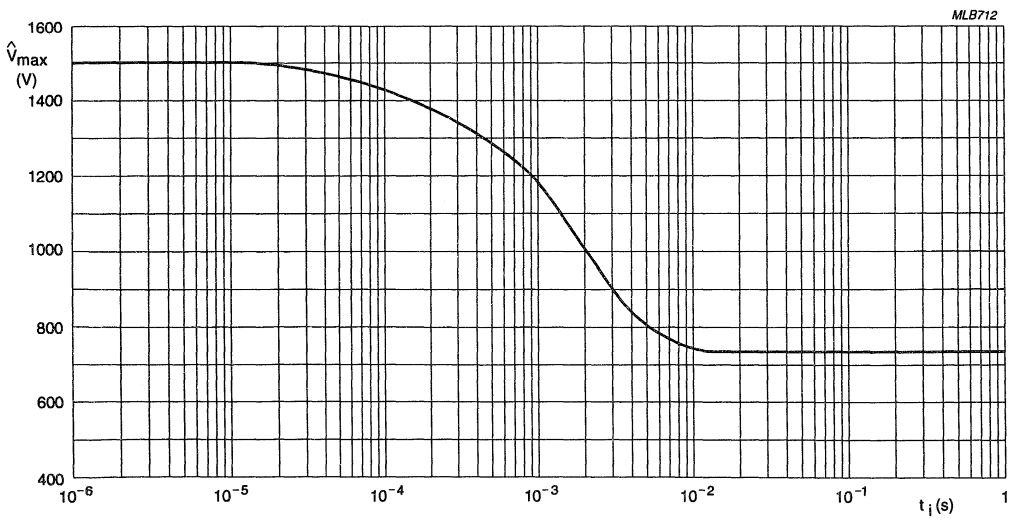


Fig.9 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_i).

Power metal film resistors

PR52

COMPOSITION OF THE CATALOGUE NUMBER

2322 192 . . . . .

style code:

3 = straight formed copper-clad iron leads, ∅ 0.6 mm
4 = cropped and formed copper-clad iron leads, ∅ 0.6 mm
5 = straight copper leads, ∅ 0.8 mm
6 = cropped and formed copper leads, ∅ 0.8 mm

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

mounting height (h), see Fig.2:

0 = 8 mm; cropped and formed version
1 = 15 mm; cropped and formed version
0 = straight lead version

first two digits of the resistance value (E24 series)

Power metal film resistors PR52

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of "*IEC publication 115-1*", category 55/200/56 (rated temperature range −55 °C to +200 °C; damp heat, long term, 56 days). The testing also covers the requirements specified by EIA and EIAJ.

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

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

Air pressure: 86 kPa to 106 kPa (860 mbar to 1 060 mbar).

In Table 3 the tests and requirements are listed with reference to the relevant clauses of *"IEC publications 115-1 and 68"*; a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

Table 3

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.16	U	robustness of terminations:		
4.16.2	Ua	tensile all samples	load 10 N; 10 s	number of failures $<1 \times 10^{-6}$
4.16.3	Ub	bending half number of samples	load 5 N; 4 × 90°	number of failures $<1 \times 10^{-6}$
4.16.4	Uc	torsion other half number of samples	3 × 360° in opposite directions	no damage ΔR/R max.: ±0.5% +0.05 Ω
4.17	Ta	solderability	2 s; 230 °C; flux 600	good tinning; no damage
4.18	Tb	resistance to soldering heat	thermal shock: 3 s; 350 °C; 6 mm from body	ΔR/R max.: ±0.5% +0.05 Ω
4.19	Na	rapid change of temperature	30 minutes at −55 °C and 30 minutes at +155 °C; 5 cycles	no damage ΔR/R max.: ±2% +0.1 Ω
4.20	Eb	bump	3 × 1500 bumps in three directions; 40 g	no damage ΔR/R max.: ±0.5% +0.05 Ω
4.22	Fc	vibration	frequency 10 to 500 Hz; displacement 1.5 mm or acceleration 10 g; three directions; total 6 hours (3 × 2 hours)	no damage ΔR/R max.: ±0.5% +0.05 Ω
4.23		climatic sequence:		
4.23.2	Ba	dry heat	16 hours; 155 °C	
4.23.3	Db	damp heat (accelerated) 1st cycle	24 hours; 55 °C; 95 to 100% RH	
4.23.4	Aa	cold	2 hours; −55 °C	
4.23.5	M	low air pressure	1 hour; 8.5 kPa; 15 to 35 °C	
4.23.6	Db	damp heat (accelerated) remaining cycles	5 days; 55 °C; 95 to 100% RH	R_{ins} min.: 1 000 MΩ ΔR/R max.: ±3% +0.1 Ω
4.24.2	Ca	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; dissipation 0.01 × P_{70}	R_{ins} min.: 1 000 MΩ ΔR/R max.: ±3% +0.1 Ω
4.25.1		endurance	1 000 hours; 70 °C; P_{70} or V_{max}	ΔR/R max.: ±5% +0.1 Ω

Power metal film resistors PR52

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.8.4.2		temperature coefficient	between –55 °C and +155 °C	$R < 10\ \Omega$: $\leq \pm 350 \times 10^{-6}$/K
				$R \geq 10\ \Omega$: $\leq \pm 250 \times 10^{-6}$/K
4.7		voltage proof on insulation	500 V (RMS) for 1 minute; V-block method	no breakdown
4.12		noise	IEC publication 195	
4.6.1.1		insulation resistance	500 V (DC) for 1 minute; V-block method	R_{ins} min.: 1000 MΩ
see 2nd amendment to IEC 115-1, Jan. '87 and present 40 central office 532 & 533		pulse load		see Figs 8 and 9

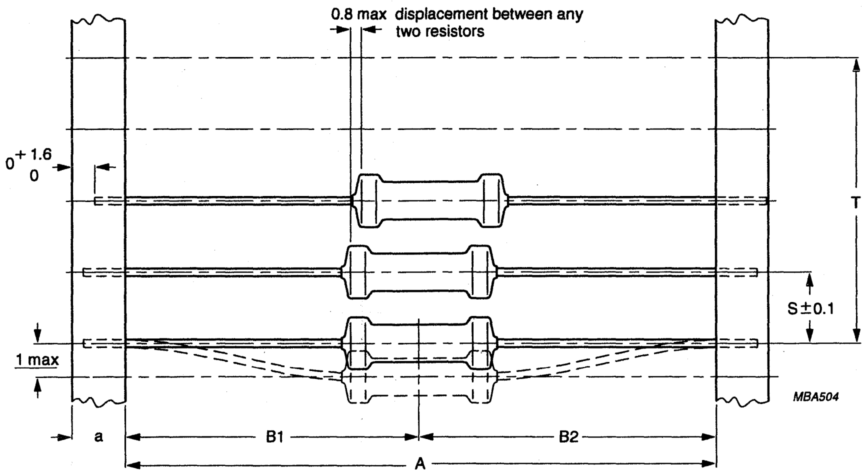
PACKAGING

The resistors may be supplied on bandolier in ammopack. Those with bent leads are supplied loose in a box. For details refer to Section *"General Introduction leaded resistors"* in data handbook PA08.

Dimensions of the packaging.

STYLE	PACKAGING	MOUNTING HEIGHT (mm)	QUANTITY PER BOX	
			ON BANDOLIER	BULK
Straight leads	ammopack	–	500	–
Cropped and formed leads	loose in box	8	–	500
		15	–	250

Tape and reel data



Dimensions in mm.

Fig.10 Axial style on tape.

Dimensions of bandolier.

a (mm)	A (mm)	$\lvert B_1 - B_2 \rvert$ (mm)	S (mm)	T (deviation of spacing)
6 ±0.5	80 ±1.5	±1.2	10	max. 1 mm per 10 spacings max. 0.5 mm per 5 spacings

Dimensions of box.

STYLE	QUANTITY	M (mm)	N (mm)	P (mm)
Ammopack	500	99	77	259
Loose in box	500	105	70	205

WIREWOUND

Cemented wirewound resistor AC01

FEATURES

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

APPLICATIONS

- Ballast switching
- Shunt in small electric motors.

DESCRIPTION

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

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

QUICK REFERENCE DATA

DESCRIPTION	VALUE
Resistance range	0.1 Ω to 1.5 kΩ; E24 series
Resistance tolerance	±5%
Maximum permissible body temperature	350 °C
Rated dissipation at T_{amb} = 40 °C	1 W
Rated dissipation at T_{amb} = 70 °C	0.9 W
Climatic category (IEC 68)	40/200/56
Basic specification	IEC 266
Stability after:	
load, 1000 hours	ΔR/R max.: ±5% +0.1 Ω
climatic tests	ΔR/R max.: ±1% +0.05 Ω
short time overload	ΔR/R max.: ±2% +0.1 Ω

MECHANICAL DATA

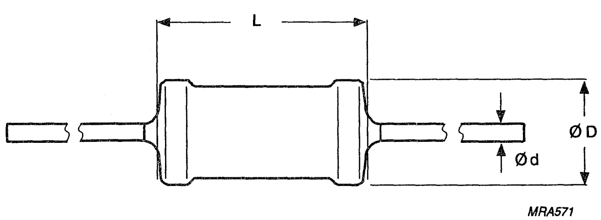


Fig.1 Outlines.

Dimensions of component.

TYPE	L MAX. (mm)	D MAX. (mm)	d TYP. (mm)
AC01	10	4.3	0.8

Mass

55 g (per 100 units).

Mounting

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

Marking

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

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

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

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

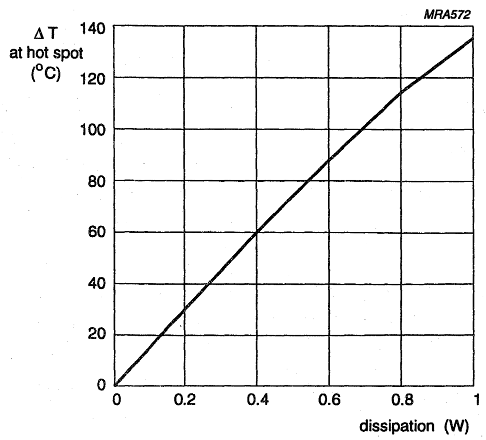


Fig.2 Hot-spot temperature rise as a function of dissipated power.

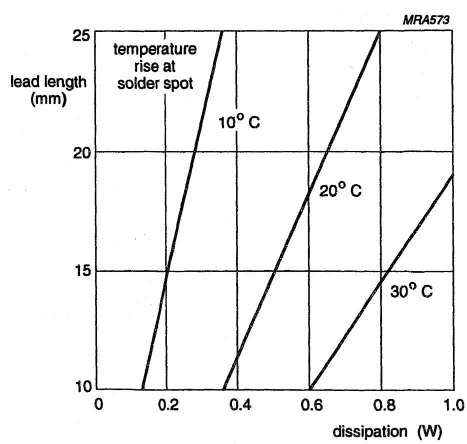


Fig.3 Lead length as a function of dissipated power and temperature rise.

ELECTRICAL DATA

Standard values of resistance and tolerance

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

The limiting voltage (DC or RMS) is

$V = \sqrt{P_n \times R}$

This is the maximum voltage that may be continuously applied to the resistor, see *"IEC publication 266"*.

Dissipation

The rated power that the resistor can dissipate depends on the operating temperature (see Fig.4).

Technical applications

Detailed information is available on request.

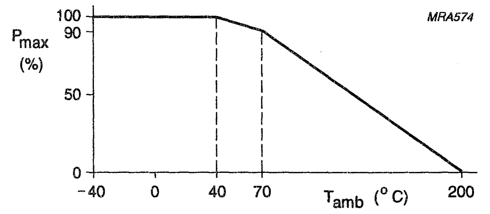


Fig.4 Maximum dissipation (P_{max}) as a function of the ambient temperature (T_{amb}).

COMPOSITION OF THE CATALOGUE NUMBER

The resistors have a 12-digit catalogue number starting with 2306 328. The subsequent 5 digits indicate the packaging and resistance value (see Tables 1 and 2).

Table 1 First two digits to indicate packaging for resistors as listed.

RESISTANCE RANGE	TOL. (%)	STYLE	PACKAGING	QUANTITY	CATALOGUE NUMBER
0.1 Ω ≤ R ≤ 1500 Ω	±5	axial	ammopack	1000	33...
0.1 Ω ≤ R ≤ 1500 Ω	±5	radial	box	2000	90...

To complete the catalogue number (see Table 1), replace the first two dots of the remaining 3-digit code with the first two digits of the resistance value. Replace the third dot (last digit) by a figure according to Table 2.

Table 2 Last digit of 12 NC.

RESISTANCE	LAST DIGIT
0.1 to 0.91 Ω	7
1 to 9.1 Ω	8
10 to 91 Ω	9
100 to 910 Ω	1
1 to 1.5 kΩ	2

Ordering example

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

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

TESTS 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 °C to +200 °C; damp heat, long term, 56 days). The testing also covers the requirements specified by EIA and EIAJ.

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

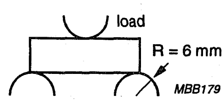
Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

Air pressure: 86 kPa to 106 kPa (860 mbar to 1 060 mbar).

In Table 3 the tests and requirements are listed with reference to the relevant clauses of *"IEC publications 266, 266A and 68"*; a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

Table 3

IEC 266 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
Test according to the schedule of IEC publication 266				
14		robustness of resistor body	load 200 ±10 N 	no visible damage ΔR/R max.: ±0.5% +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 90°, 180°, 90°	
	Uc	torsion other half number of samples	2 × 180° in opposite directions	no visible damage ΔR/R max.: ±0.5% +0.05 Ω
16	T	solderability	2 s; 235 °C; flux 600	good tinning; no damage
		resistance to soldering heat	thermal shock: 3 s; 350 °C; 2.5 mm from body	ΔR/R max.: ±0.5% +0.05 Ω
17	Na	rapid change of temperature	30 minutes at –40 °C and 30 minutes at +200 °C; 5 cycles	no visible damage ΔR/R max.: ±1% +0.05 Ω
18	Fc	vibration	frequency 10 to 500 Hz; displacement 0.75 mm or acceleration 10 g; three directions; total 6 hours (3 × 2 hours)	no damage ΔR/R max.: ±0.5% +0.05 Ω
19	Eb	bump	4000 ±10 bumps; 390 m/s^2	no damage ΔR/R max.: ±0.5% +0.05 Ω
20		climatic sequence:		
20.2	Ba	dry heat	16 hours; 200 °C	
20.3	Db	damp heat (accelerated) 1st cycle	24 hours; 55 °C; 95 to 100% RH	

IEC 266 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
20.4	Aa	cold	2 hours; −40 °C	
20.5	M	low air pressure	1 hour; 8.5 kPa; 15 to 35 °C	
20.6	Db	damp heat (accelerated) remaining cycles	5 days; 55 °C; 95 to 100% RH	ΔR/R max.: ±1% +0.05 Ω
21	Ca	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; dissipation ≤0.01 P_n	no visible damage ΔR/R max.: ±1% +0.05 Ω
13.3		temperature coefficient	at 20/−40/20 °C, 20/200/20 °C: R < 10 Ω R ≥ 10 Ω	 TCR ≤ ±600 × 10^{-6}/K −80 × 10^{-6} ≤ TCR TCR ≤ +140 × 10^{-6}/K
13.5		temperature rise	horizontally mounted, loaded with P_n	hot-spot temperature less than maximum body temperature
13.6		short time overload	room temperature; dissipation 10 × P_n; 5 s (voltage not more than 1000 V/25 mm)	ΔR/R max.: ±2% +0.1 Ω
22		endurance (at 40 °C)	1000 hours loaded with P_n; 1.5 hours on and 0.5 hours off	no visible damage ΔR/R max.: ±5% +0.1 Ω
		endurance (at 70 °C)	1000 hours loaded with 0.9 P_n; 1.5 hours on and 0.5 hours off	no visible damage ΔR/R max.: ±5% +0.1 Ω
23	Ba	endurance at upper category temperature	1000 hours; 200 °C; no load	no visible damage ΔR/R max.: ±5% +0.1 Ω
Other tests in accordance with IEC 115 clauses and IEC 68 test method				
4.29	45 (Xa)	component solvent resistance	70% 1.1.2 trichlorotrifluoroethane and 30% isopropyl alcohol; H_2O	no visible damage
4.18	20 (Tb)	resistance to soldering heat	10 s; 260 ±5 °C; flux 600	ΔR/R max.: ±0.5% +0.05 Ω
4.17	20 (Tb)	solderability (after ageing)	16 hours steam or 16 hours at 155 °C; 2 ±0.5 s in solder at 235 ±5 °C; flux 600	good tinning (≥95% covered); no damage
4.5		tolerance on resistance	applied voltage (±10%): R < 10 Ω: 0.1 V 10 Ω ≤ R < 100 Ω: 0.3 V 100 Ω ≤ R < 1 kΩ: 1 V 1 kΩ ≤ R ≤ 1.5 kΩ: 3 V	R − R_{nom}: ±5% max.
Other applicable tests				
		solvent resistance in accordance with MIL-STD-202	method 215: freon TMC trichloroethane	no visual damage

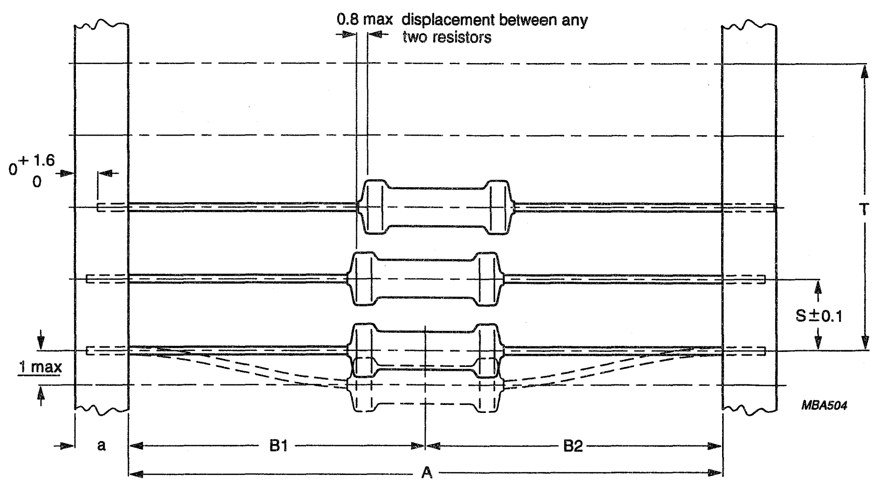
PACKAGING

The resistors are supplied on bandolier in ammopack. For details refer to Section *"General Introduction leaded resistors"* in the data handbook PA08.

Dimensions of the ammopack.

STYLE	QUANTITY	M (mm)	N (mm)	P (mm)
Axial	1000	85	60	263
Radial	2000	45	262	330

Tape and reel data

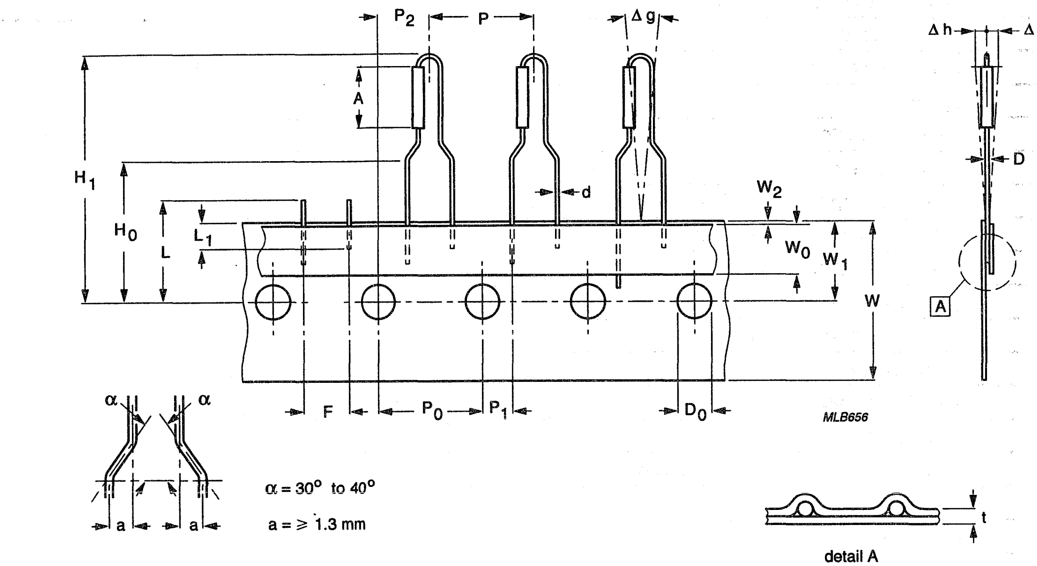


Dimensions in mm.

Fig.5 Axial on tape.

Dimensions of bandolier.

TYPE	a (mm)	A (mm)	$\lvert B_1 - B_2 \rvert$ (mm)	S (mm)	T (deviation of spacing)
AC01	5 ±0.5	63 ±4	max. 1.2	10	max. 1 mm per 10 spacings max. 0.5 mm per 5 spacings



For dimensions see Table 4.

Fig.6 Bandolier for types with radial leads.

Table 4 Taping dimensions; see Fig.6.

SYMBOL	PARAMETER	VALUE	TOLERANCE	UNIT
D	maximum body diameter	3.90	–	mm
A	maximum body length	9.8	–	mm
d	lead wire diameter	0.8	±0.02	mm
P	pitch of components	12.7	±1.0	mm
P_0	feed-hole pitch	12.7	±0.2	mm
	cumulative pitch error per 20 spacings	1.0	–	mm
P_1	feed-hole centre to lead at topside at the tape	3.85	±0.5	mm
P_2	feed-hole centre to body centre	6.35	±1.0	mm
F	lead-to-lead distance	4.8	+0.7/–0	mm
Δh	component alignment	0	±1.2	mm
Δg	component alignment	0	±3	deg
W	tape width	18.0	±0.5	mm
W_0	hold down tape width	6.0	+0.2/–0.5	mm
W_1	hole position	9.0	±0.5	mm
W_2	maximum hold down tape position	0.5	–	mm
H_0	lead wire clinch height	16.5	±0.5	mm
H_1	component height	29	±3.0	mm
D_0	feed-hole diameter	4.0	±0.2	mm
t	total tape thickness	0.4	+0.5/–0	mm
L	maximum length of snipped lead	11.0	–	mm
L_1	minimum lead wire (tape portion) shortest lead	2.5	–	mm

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 (IEC 68)	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 relatively 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, in accordance with MIL-STD-202E, method 215 and IEC68-2-45.

The lacquer is not resistant to aggressive fluxes.

MECHANICAL DATA

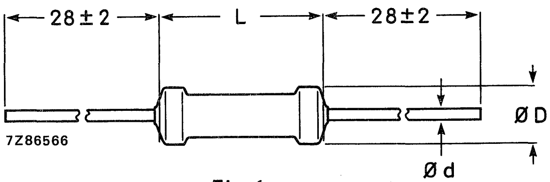


Fig. 1a.

Note: The lead length (28 ± 2 mm) only applies to untaped resistors, i.e. types AC10, AC15 and AC20.

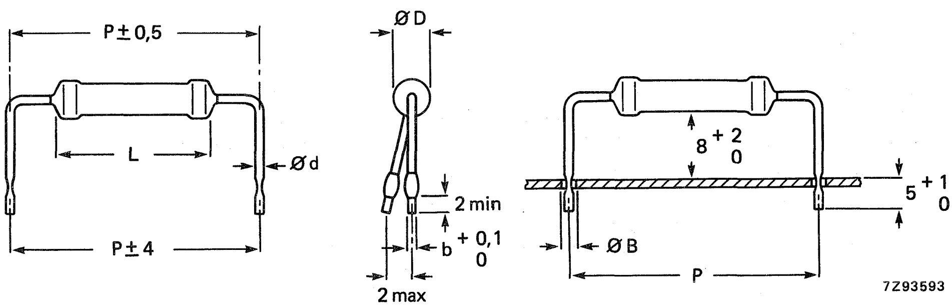


Fig. 1b Version with cropped and formed leads.
Only for AC03, AC04, AC05 and AC07; available on special request.

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			

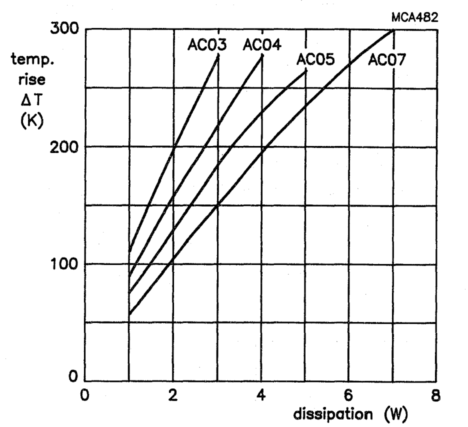
The length of the body is measured by inserting the leads into the holes of two identical gauge plates and moving these plates parallel to each other until the resistor body is clamped without deformation (IEC publication 294).

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.



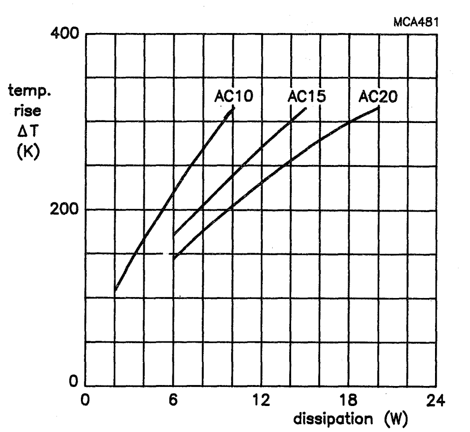


Fig. 2 Temperature rise of the resistor body as a function of the dissipation.

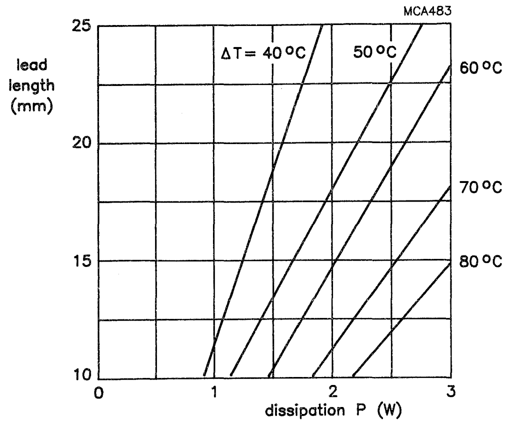


Fig. 3 Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as parameter, for style AC03.

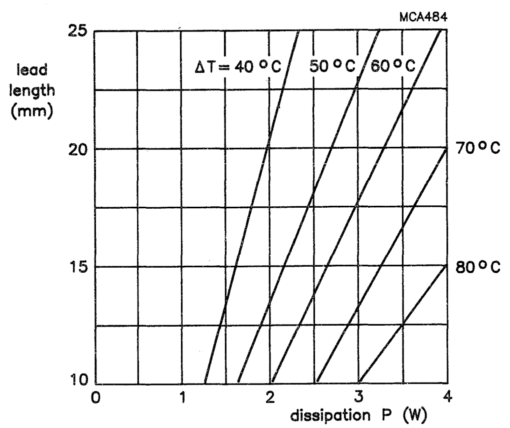


Fig. 4 Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as parameter, for style AC04.

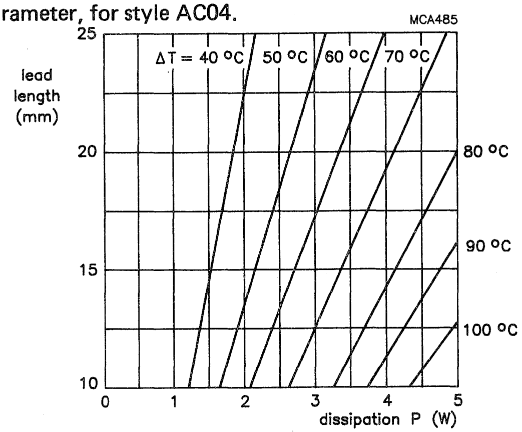


Fig. 5 Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as parameter, for style AC05.

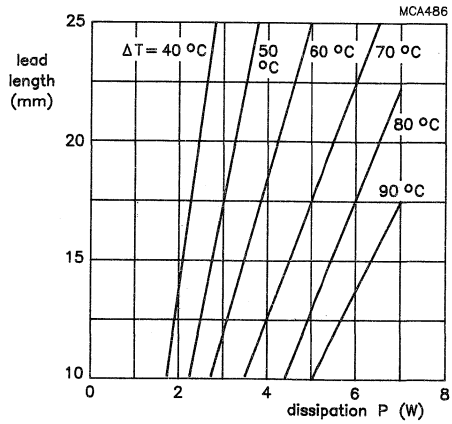


Fig. 6 Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as parameter, for style AC07.

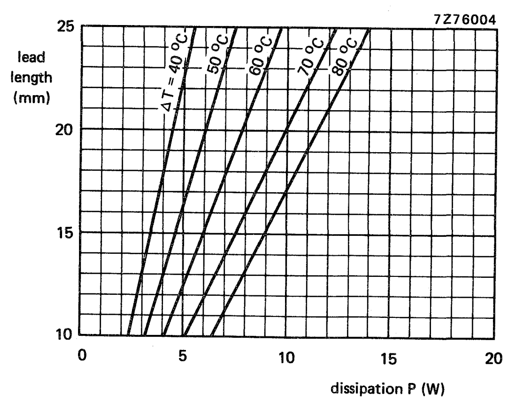


Fig. 7 Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as parameter, for style AC10.

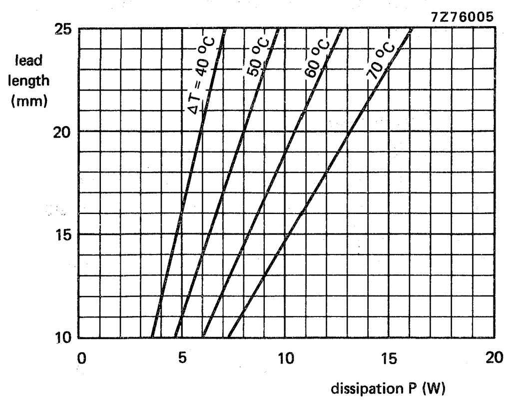


Fig. 8 Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as parameter, for style AC15.

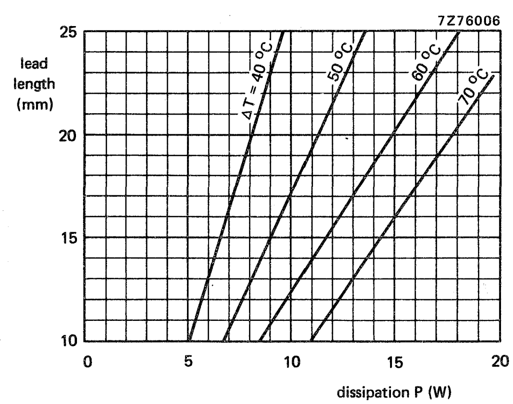


Fig. 9 Lead length as a function of the dissipation with the temperature rise at the end of the lead (soldering spot) as parameter, for style AC20.

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% 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% 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	T_{amb} = 70 °C	resistance range* Ω	tol. %	catalogue number
AC03	3	2.5	0.1 - 3000	5	2322 329 03...
AC04	4	3.5	0.1 - 6800	5	2322 329 04...
AC05	5	4.7	0.1 - 8200	5	2322 329 05...
AC07	7	5.8	0.1 - 15 000	5	2322 329 07...
AC10	10	8.4	0.68 - 15 000	5	2322 329 10...
AC15	15	12.5	0.82 - 22 000	5	2322 329 15...
AC20	20	16	1.2 - 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:

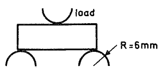
7 for R = 0,1 to 0,82 Ω
8 for R = 1 to 8,2 Ω
9 for R = 10 to 91 Ω
1 for R = 100 to 910 Ω
2 for R = 1 to 9,1 kΩ
3 for R = 10 to 33 kΩ

* 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 40 °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

The dimensions in above tables are in mm.

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

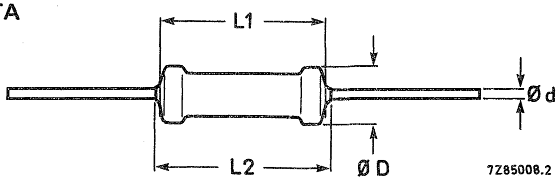


Fig. 1.

Table 1

type	D_{max}	L1 max	L2 max	d_{max}
WR0617E	6	17	23	0.7
WR0825E	8	26	32	0.8
WR0842E	8	44	50	0.8
WR0865E	8	67	73	0.8

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 5%
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 . . .
WR0825E	7	6,8 – 27 000	5	E24	2322 330 32 . . .
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

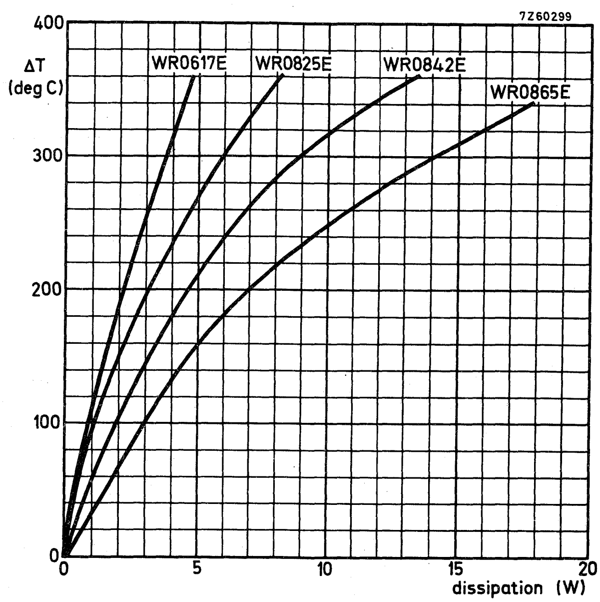
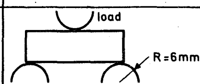


Fig. 2 Temperature rise (ΔT) of the resistor body as a function of the dissipation. Distance between cap and solder joint is 10 mm.

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	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% + 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	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% + 0.1 Ω
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% + 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 2 x P_n, 10 min.	ΔR max. 2% + 0.1 Ω

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

The dimensions in above tables are in mm.

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	ΔR/R max.	5%
climatic tests	ΔR/R max.	3%
soldering	ΔR/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

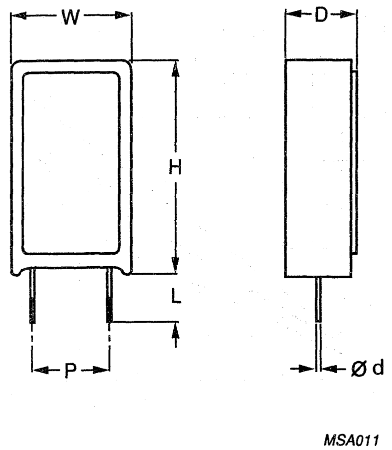


Fig.1 Component outline; see Table 1.

Table 1 Physical dimensions

type	W ± 1 mm	D ± 1 mm	H ± 1.5 mm	L ± 1.5 mm	P ± 1 mm	ϕd
SMW02	11	7	20.5	4.5	5	0.8
SMW03	12	8	25	4.5	5	0.8
SMW05	13	9	25.5	4.5	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.

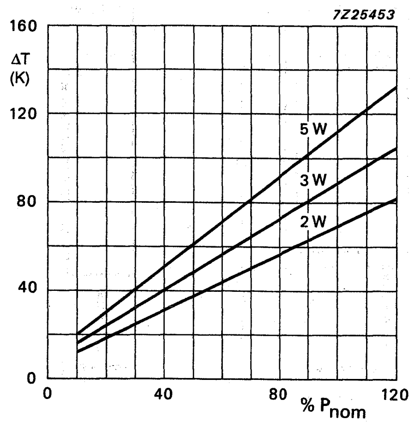


Fig.2 Solder spot temperature rise (ΔT) as a function of dissipated power.

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 ^{o}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 0.91 Ω
8 for resistance values between 1 and 9.1 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 °C	
20.3	D	damp heat (accelerated), 1st cycle	24 h, 55 °C 95-100% RH	
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 (accelerated), remaining cycles	5 days, 55 °C 95-100% RH	after 24 hrs at P_{nom} $\Delta R/R$ 3% + 0.1 Ω max.
21	Ca	damp heat steady state	56 days, 40 °C 90-95% RH; dissipation 0.01 x P_{nom}	$\Delta R/R$ 3% + 0.1 Ω max.
22 23		endurance	1000 h, 70 °C rated dissipation 1000 h, 200 °C no load	$\Delta R/R$ 5% + 0.1 Ω max. $\Delta R/R$ 5% + 0.1 Ω max.
13.6		overload	10 x P_{nom}, 5 s	$\Delta R/R$ 2% + 0.1 Ω max.

PRECISION WIREWOUND

Cemented wirewound precision resistors PAC02/03/04/05/06

APPLICATIONS

- These resistors have been designed for precision power applications.

DESCRIPTION

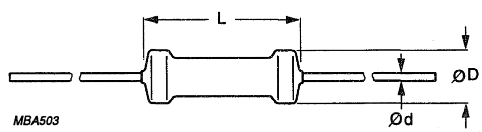
The resistor element is wound in a single layer on a ceramic rod. Metal caps are pressed over the ends of the rod. The ends of the resistance wire and the leads are connected to the caps by welding. Tinned copper-clad iron leads with poor heat conductivity are employed permitting the use of relatively short leads to obtain stable mounting.

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

QUICK REFERENCE DATA

DESCRIPTION	VALUE
Resistance range	0.22 Ω to 12 kΩ, E24 series
Resistance tolerance	±1%
Maximum 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
Specification based on	IEC 266; MIL-R-26; CCTU 04-09
Climatic category (IEC 68)	55/200/56
Stability after:	
load	ΔR/R max.: ±0.5% +0.05 Ω
climatic tests	ΔR/R max.: ±0.5% +0.05 Ω
short time overload	ΔR/R max.: ±0.2% +0.05 Ω

MECHANICAL DATA



Dimensions in mm.

Fig.1 Package outline.

Dimensions of component.

TYPE	D MAX.	L MAX.	d TYP.
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

The length of the body L (see Fig.1) 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, see *"IEC publication 294"*.

Mass (per 100 units)

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

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.

Marking

The type and nominal resistance, together with the year and week of production, are printed on the resistor body.

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

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

For example:

PAC03 27R 043
(week 43 of 1990).

ELECTRICAL DATA

Standard values of rated resistance and tolerance

The resistors are available in the E24 series in accordance with *"IEC publication 63"*, for resistors with a tolerance of ±1% within the range 0.22 Ω to 12 kΩ, see Table 1.

The limiting voltage (DC or RMS) is $V = \sqrt{P_n \times R}$

This is the maximum voltage that may be applied to the resistor body, see *"IEC publication 266"*.

Derating curve

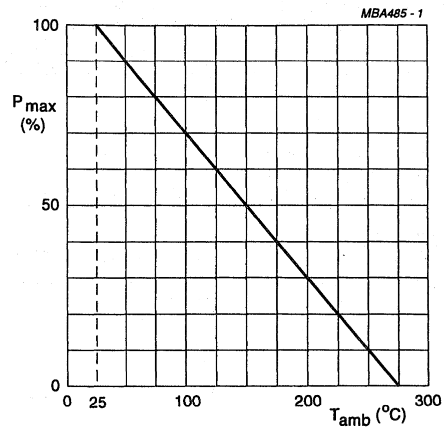


Fig.2 Maximum dissipation (P_{max}) as a function of the ambient temperature (T_{amb}).

Thermal data.

DESCRIPTION	VALUE
Maximum permissible body temperature	275 °C
Ambient temperature range	–55 to +200 °C
Temperature coefficient	$\pm 100 \times 10^{-6}$/K
Climatic category (IEC 68)	55/200/56

COMPOSITION OF THE CATALOGUE NUMBER

The resistors have a 12-digit catalogue number starting with 2306 327. The subsequent 5 digits indicate the packaging and resistance value (see Tables 1 and 2).

Table 1 First digit to indicate resistor type as listed.

TYPE	RATED DISSIPATION T_{amb} = 25 °C (W)	RESISTANCE RANGE (Ω)	TOL. (%)	CATALOGUE NUMBER 2306 327 .....
PAC02	2	0.22 to 3600	1	0....
PAC03	3	0.33 to 4700	1	1....
PAC04	4	0.43 to 8200	1	2....
PAC05	5	0.68 to 10000	1	3....
PAC06	6	0.68 to 12000	1	4....

To complete the catalogue number (see Table 1), replace the first three dots of the remaining 4-digit code with the first three figures of the resistance value. Replace the fourth dot (last digit) by a figure according to Table 2.

Table 2 Last digit of 12 NC.

RESISTANCE	LAST DIGIT
0.22 to 0.91 Ω	7
1 to 9.1 Ω	8
10 to 91 Ω	9
100 to 910 Ω	1
1 to 9.1 kΩ	2
10 to 12 kΩ	3

Ordering example

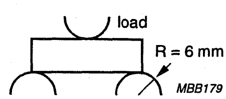
The catalogue number of a PAC03 resistor, value 750 Ω ±1% taped on a bandolier packed in an ammopack of 500 units is: 2306 327 17501.

TESTS AND REQUIREMENTS

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

In Table 3 the tests and requirements are listed with reference to the relevant clauses of *"IEC publications 266, 266A and 68"*; a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

Table 3

IEC 266 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
14		robustness of resistor body	load 200 ±10 N  	no visible damage ΔR/R 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 × 90°	
	Uc	torsion other half number of samples	2 × 180° in opposite directions	no visible damage ΔR/R max.: ±0.1% +0.05 Ω
16	T	solderability	2 s; 230 °C; flux 600	good tinning; no damage
		resistance to soldering heat	thermal shock: 3 s; 350 °C; 2.5 mm from body	ΔR/R max.: ±0.2% +0.05 Ω
17	Na	rapid change of temperature	30 minutes at −55 °C and 30 minutes at +200 °C; 5 cycles	no visible damage ΔR/R max.: ±0.5% +0.05 Ω
18	Fc	vibration	frequency 10 to 500 Hz; displacement 0.75 mm or acceleration 10 g; three directions; total 6 hours (3 × 2 hours)	no damage ΔR/R max.: ±0.1% +0.05 Ω
19	Eb	bump	4000 ±10 bumps; 390 m/s^2	no damage ΔR/R max.: ±0.1% +0.05 Ω
20		climatic sequence:		
20.2	Ba	dry heat	16 hours; 200 °C	
20.3	Db	damp heat (accelerated) 1st cycle	24 hours; 55 °C; 95 to 100% RH	
20.4	Aa	cold	2 hours; −55 °C	
20.5	M	low air pressure	1 hour; 8.5 kPa; 15 to 35 °C	
20.6	Db	damp heat (accelerated) remaining cycles	5 days; 55 °C; 95 to 100% RH	after 24 hours at P_n ΔR/R max.: ±0.5% +0.05 Ω

IEC 266 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
21	Ca	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; dissipation ≤0.01 P_n	ΔR/R max.: ±1% +0.05 Ω
22		endurance	1000 hours at 25 °C	ΔR/R max.: ±0.5% +0.05 Ω
23			1000 hours at 200 °C	ΔR/R max.: ±1% +0.05 Ω
13.6		overload	10 × P_n; 5 s	ΔR/R max.: ±0.2% +0.05 Ω

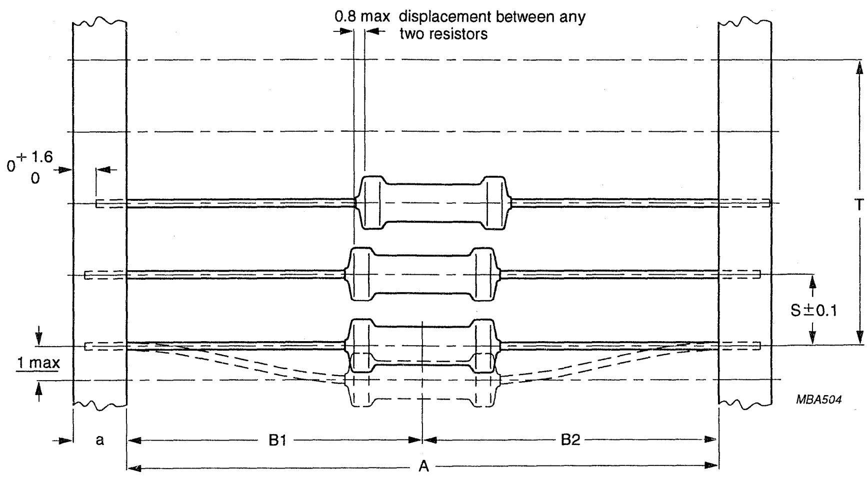
PACKAGING

The resistors are supplied on bandolier of 500 units in ammopack. For details refer to Section *"General Introduction leaded resistors"* in the data handbook PA08.

Dimensions of ammopack.

TYPE	QUANTITY	M (mm)	N (mm)	P (mm)
PAC02 PAC03	500	85	60	263
PAC04 PAC05 PAC06	500	97	120	273

Tape and reel data



Dimensions in mm.

Fig.3 Axial on tape.

Dimensions of bandolier.

TYPE	a (mm)	A (mm)	$\lvert B_1 - B_2 \rvert$ (mm)	S (mm)	T (deviation of spacing)
PAC02 PAC03	6 ±0.5	63 +1	max. ±1.2	10	max. 1 mm per 10 spacings max. 0.5 mm per 5 spacings
PAC04 PAC05 PAC06		71 +1			

INDEX OF CATALOGUE NUMBERS

12 DIGIT CATALOGUE NUMBER

The resistors have a 12-digit catalogue number starting with 2306 or 2322.

Subsequent digits indicate style, packaging, resistance value and tolerance. Refer to individual data sheets for detailed composition of the catalogue number.

In Table 1 the 12NC is referenced to the applicable page number where a detailed composition will be found.

Table 1 First 7 digits of the catalogue number.

CATALOGUE NUMBER	PAGE
2306 (first 4 digits followed by next 3 digits)	
327	382
328	350
340	376
341	376
342	376
2322 (first 4 digits followed by next 3 digits)	
141	266, 267
142	266, 267
143	266, 267
144	266, 267
151	249
152	249
153	249
156	240, 241
157	232, 233
160	259, 260
161	259, 260
162	259, 260
163	259, 260
164	259, 260
165	259, 260
166	259, 260
167	259, 260
168	259, 260
169	259, 260
170	259, 260
171	259, 260
180	192
181	202
184	202
186	202
187	192

CATALOGUE NUMBER	PAGE
191	334
192	343
193	297
194	311
195	325
197	297
198	311
204	212
205	212
207	222
211	182
241	275
242	282
244	282
329	363
330	368
702	51
704	86
711	35
712	35
722	94
723	94
724	61, 143, 155
725	119
726	71
727	102
730	43
731	43
732	110
733	110
734	79
735	135
741	126
750	150

DATA HANDBOOK SYSTEM

DATA HANDBOOK SYSTEM

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

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

Our data handbook titles are listed here.

Display components

Book	*Title*
DC01	Colour Display Components Colour TV Picture Tubes and Assemblies Colour Monitor Tube Assemblies
DC02	Monochrome Monitor Tubes and Deflection Units
DC03	Television Tuners, Coaxial Aerial Input Assemblies
DC05	Flyback Transformers, Mains Transformers and General-purpose FXC Assemblies

magnetic products

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

Passive components

PA01	Electrolytic Capacitors
PA02	Varistors, Thermistors and Sensors
PA03	Potentiometers
PA04	Variable Capacitors
PA05	Film Capacitors
PA06	Ceramic Capacitors
PA07	Quartz Crystals for Special and Industrial Applications
PA08	Fixed Resistors
PA10	Quartz Crystals for Automotive and Standard Applications
PA11	Quartz Oscillators

professional components

PC04	Photo Multipliers
PC05	Plumbicon Camera Tubes and Accessories
PC07	Vidicon and Newvicon Camera Tubes and Deflection Units
PC08	Image Intensifiers
PC12	Electron Multipliers

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Data handbook system

OVERVIEW OF PHILIPS SEMICONDUCTORS DATA HANDBOOKS

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

Integrated circuits

Book	*Title*
IC01	Semiconductors for Radio and Audio Systems
IC02	Semiconductors for Television and Video Systems
IC03	Semiconductors for Telecom Systems
IC04	CMOS HE4000B Logic Family
IC05	Advanced Low-power Schottky (ALS) Logic Series
IC06	High-speed CMOS Logic Family
IC08	100K ECL Logic Family
IC10	Memories
IC11	General-purpose/Linear ICs
IC12	Display Drivers and Microcontroller Peripherals (planned)
IC13	Programmable Logic Devices (PLD)
IC14	8048-based 8-bit Microcontrollers
IC15	FAST TTL Logic Series
IC16	ICs for Clocks and Watches
IC17	RF/Wireless Communications
IC18	Semiconductors for In-car Electronics and General Industrial Applications (planned)
IC19	Semiconductors for Datacom: LANs, UARTs, Multi-protocol Controllers and Fibre Optics
IC20	8051-based 8-bit Microcontrollers
IC21	68000-based 16-bit Microcontrollers (planned)
IC22	ICs for Multi-Media Systems (planned)
IC23	QUBIC Advanced BiCMOS Interface Logic ABT, MULTIBYTE™
IC24	Low Voltage Logic

Discrete semiconductors

SC01	Diodes
SC02	Power Diodes
SC03	Thyristors and Triacs
SC04	Small-signal Transistors
SC05	Low-frequency Power Transistors and Hybrid IC Power Modules
SC06	High-voltage and Switching NPN Power Transistors
SC07	Small-signal Field-effect Transistors
SC08a	RF Power Bipolar Transistors
SC08b	RF Power MOS Transistors

Discrete semiconductors (continued)

SC09	RF Power Modules
SC10	Surface Mounted Semiconductors
SC13	PowerMOS Transistors including TOPFETs and IGBTs
SC14	RF Wideband Transistors, Video Transistors and Modules
SC15	Microwave Transistors
SC16	Wideband Hybrid IC Modules
SC17	Semiconductor Sensors

Professional components

PC01	High-power Klystrons and Accessories
PC06	Circulators and Isolators

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NOTES

STANDARD SERIES OF VALUES IN A DECADE
for resistances and capacitances

according to IEC publication 63

E192	E96	E48	E192	E96	E48	E192	E96	E48	E192	E96	E48	E192	E96	E48
100	100	100	169	169	169	287	287	287	487	487	487	825	825	825
101			172			291			493			835		
102	102		174	174		294	294		499	499		845	845	
104			176			298			505			856		
105	105	105	178	178	178	301	301	301	511	511	511	866	866	866
106			180			305			517			876		
107	107		182	182		309	309		523	523		887	887	
109			184			312			530			898		
110	110	110	187	187	187	316	316	316	536	536	536	909	909	909
111			189			320			542			920		
113	113		191	191		324	324		549	549		931	931	
114			193			328			556			942		
115	115	115	196	196	196	332	332	332	562	562	562	953	953	953
117			198			336			569			965		
118	118		200	200		340	340		576	576		976	976	
120			203			344			583			988		
121	121	121	205	205	205	348	348	348	590	590	590			
123			208			352			597					
124	124		210	210		357	357		604	604				
126			213			361			612					
127	127	127	215	215	215	365	365	365	619	619	619			
129			218			370			626					
130	130		221	221		374	374		634	634				
132			223			379			642					
133	133	133	226	226	226	383	383	383	649	649	649			
135			229			388			657					
137	137		232	232		392	392		665	665				
138			234			397			673					
140	140	140	237	237	237	402	402	402	681	681	681			
142			240			407			690					
143	143		243	243		412	412		698	698				
145			246			417			706					
147	147	147	249	249	249	422	422	422	715	715	715			
149			252			427			723					
150	150		255	255		432	432		732	732				
152			258			437			741					
154	154	154	261	261	261	442	442	442	750	750	750			
156			264			448			759					
158	158		267	267		453	453		768	768				
160			271			459			777					
162	162	162	274	274	274	464	464	464	787	787	787			
164			277			470			796					
165	165		280	280		475	475		806	806				
167			284			481			816					

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

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Printed in The Netherlands

858010/13500/02/pp400 Date of release: May 1994
Document order number: 9398 183 93011

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