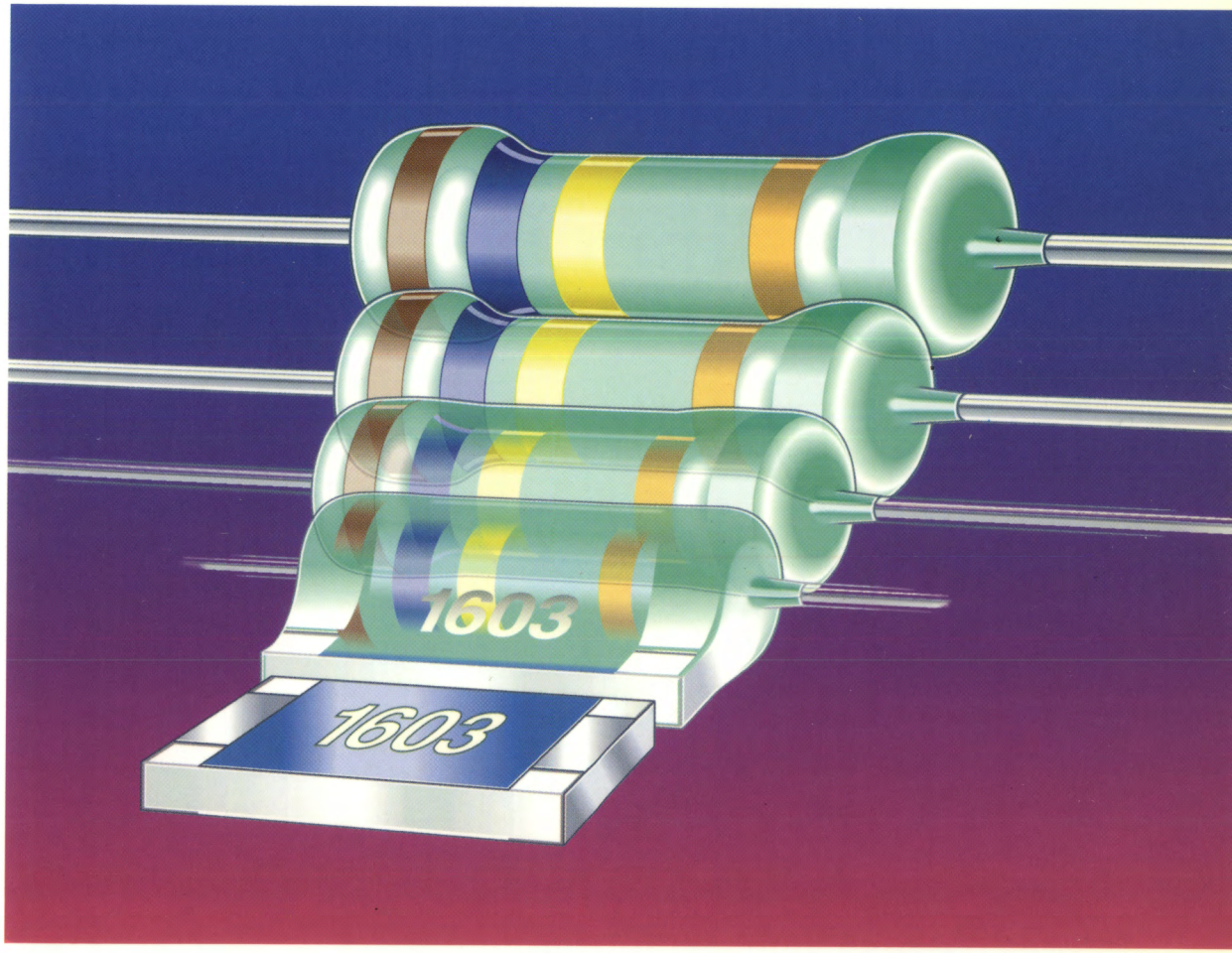
PASSIVE COMPONENTS

Fixed Resistors



1996

DATA HANDBOOK PA08

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.

CUSTOMER SERVICE

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

ADVANCED RESISTOR TECHNOLOGIES

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

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

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

Fixed Resistors

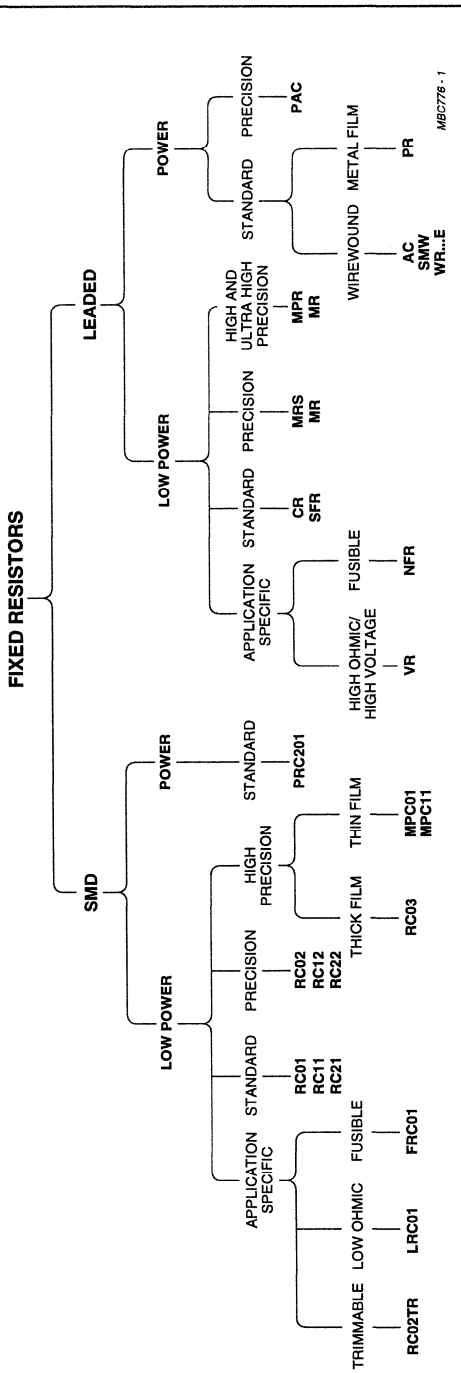
CONTENTS

DEFINITIONS

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

LIFE SUPPORT APPLICATIONS

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


FIXED RESISTORS
SMD
LOW POWER
APPLICATION SPECIFIC
TRIMMABLE
RC02TR
LOW OHMIC
LRC01
FUSIBLE
FRC01
STANDARD
RC01
RC11
RC21
PRECISION
RC02
RC12
RC22
HIGH PRECISION
THICK FILM
RC03
THIN FILM
MPC01
MPC11
POWER
STANDARD
PRC201
LEADED
LOW POWER
APPLICATION SPECIFIC
HIGH OHMIC/ HIGH VOLTAGE
VR
FUSIBLE
NFR
STANDARD
CR
SFR
PRECISION
MRS
MR
HIGH AND ULTRA HIGH PRECISION
MPR
MR
POWER
WIREWOUND
AC
SMW
WR...E
STANDARD
METAL FILM
PR
PRECISION
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 to 4.7 Ω 5.1 Ω to 10 MΩ	≤±250	200/0.25	E24	36
	RC11	0805		1 to 4.7 Ω 5.1 Ω to 10 MΩ	≤±200	150/0.125		36
	RC21	0603		1 to 10 Ω 11 Ω to 910 kΩ 1 to 10 MΩ	–200/+500 ±200 ±300	50/0.063		36
Precision TC100	RC02H	1206	1	1 to 4.99 Ω 5.1 to 9.76 Ω 10 Ω to 1 MΩ 1.02 to 10 MΩ	≤±250 ≤±200 ≤±100 ≤±200	200/0.25	E24/96	48
	RC12H	0805		1 to 4.99 Ω 5.1 to 9.76 Ω 10 Ω to 1 MΩ 1.02 to 10 MΩ	≤±250 ≤±200 ≤±100 ≤±200	150/0.125		48
	RC22H	0603		1 to 4.99 Ω 5.1 to 9.76 Ω 10 Ω to 1 MΩ	≤±250 ≤±200 ≤±100	50/0.063		48
Precision TC50	RC02G	1206	1	250 Ω to 1 MΩ	≤±50	200/0.25		48
	RC12G	0805				150/0.125		48
High precision	RC03G	1206	0.5	100 to 249 Ω 255 Ω to 1 MΩ	≤±100 ≤±50	200/0.125		59
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	65
	LRC01 low-ohmic		5	0.051 to 0.075 Ω 0.082 to 0.091 Ω 0.1 to 0.147 Ω 0.15 to 0.392 Ω 0.4 to 0.91 Ω	≤±2000 ≤±1500 ≤±1000 ≤±700 ≤±250	0.25		70
	FRC01 fusible		5	1 to 250 Ω	≤±200	200/0.125		76
	PRC201 power	1218	5	1 to 9.1 Ω 10 Ω to 1 MΩ	≤±200 ≤±100	200/1		83
Thin film								
High precision	MPC01	1206	0.1	10 Ω to 100 kΩ	≤±25	100/0.125	all values	94
	MPC11	0805		14 Ω to 30 kΩ		100/0.1		100

INTRODUCTION

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

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

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

DESCRIPTION

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

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

ORDERING INFORMATION

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

FUNCTIONAL DESCRIPTION

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

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

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

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

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

where:

T_m = hot-spot temperature

T_{amb} = ambient temperature

ΔT = temperature rise at hot-spot.

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

Summarizing

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

Performance

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

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

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

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

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

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

The temperature coefficient

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

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

at 25 °C:

1000 Ω (nominal = rated value)

at +155 °C:

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

at –55 °C:

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

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

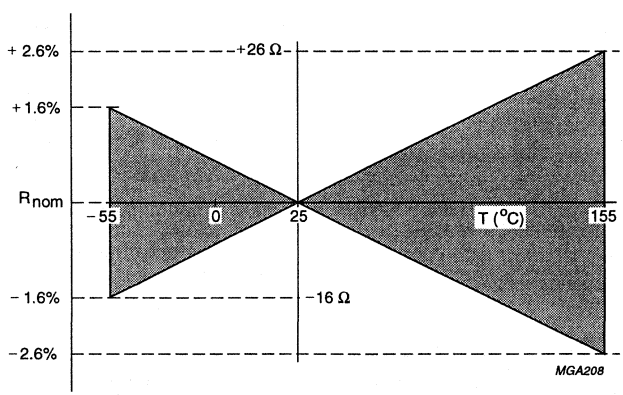


Fig.1 Temperature coefficient.

Noise

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

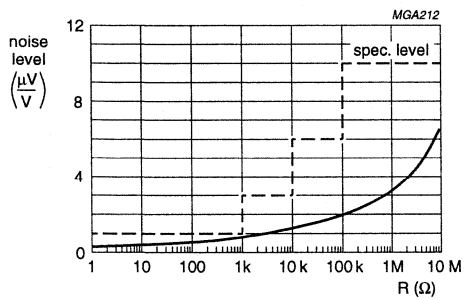


Fig.2 Typical noise levels as a function of rated resistance.

Frequency behaviour

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

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

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

Typical values of capacitance and inductance

QUANTITY	CHIP PROPERTIES			
	THIN FILM	THICK FILM		
	1206 R < 1 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

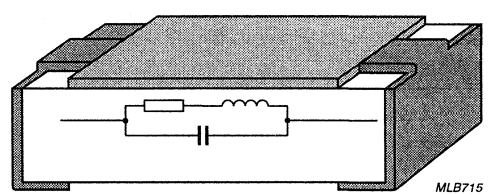
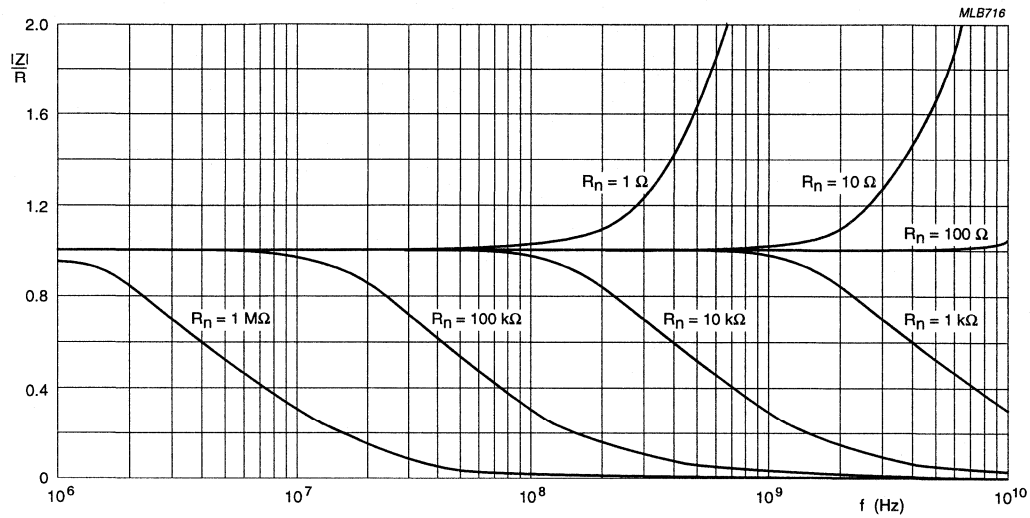
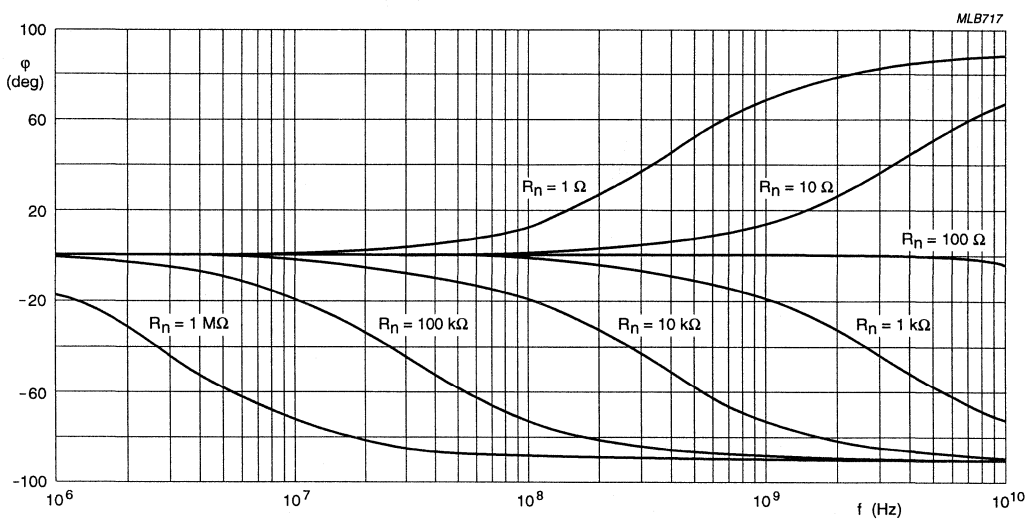


Fig.3 Equivalent circuit.



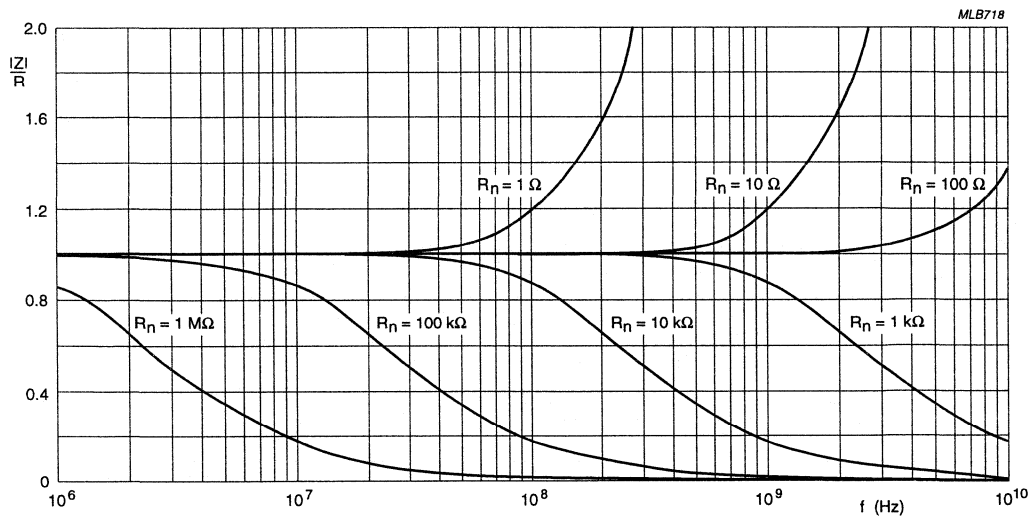
Size 0603

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



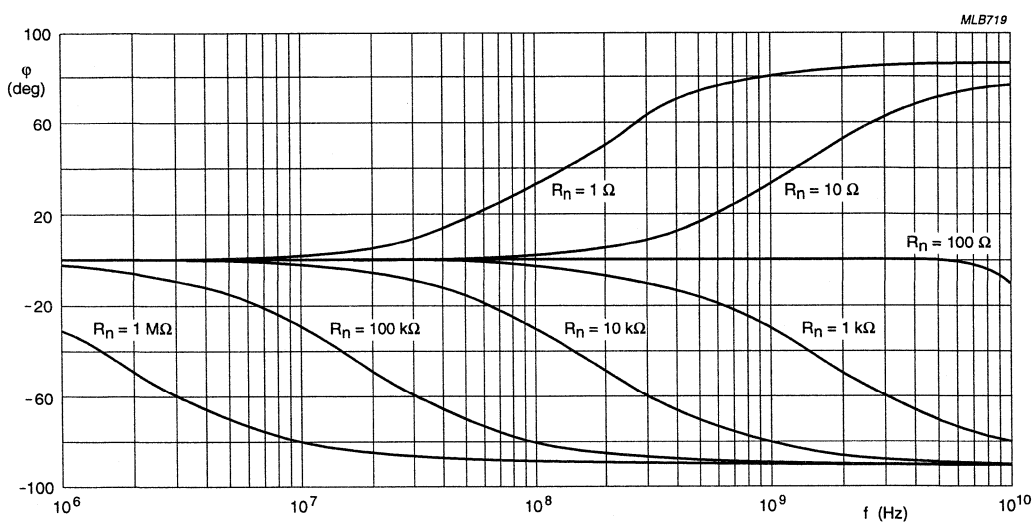
Size 0603

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



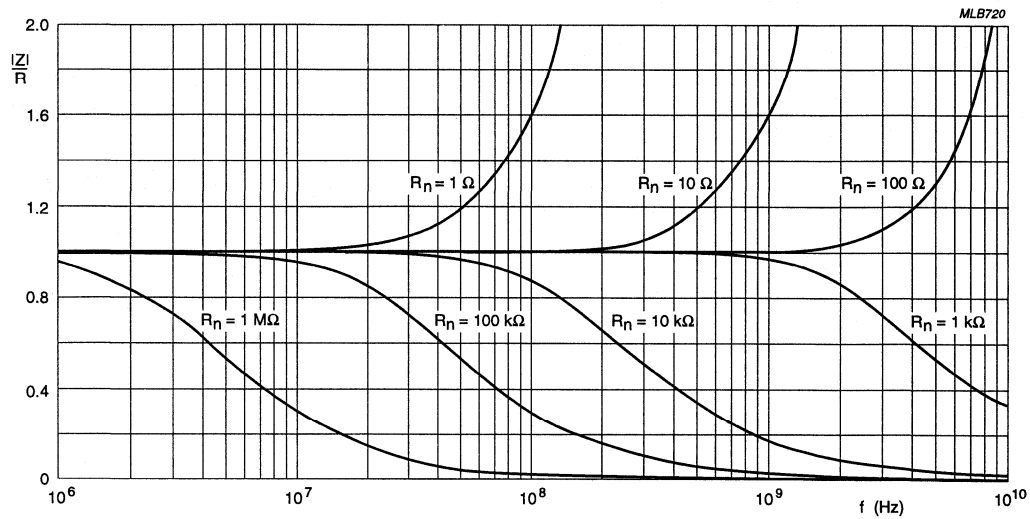
Size 0805

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



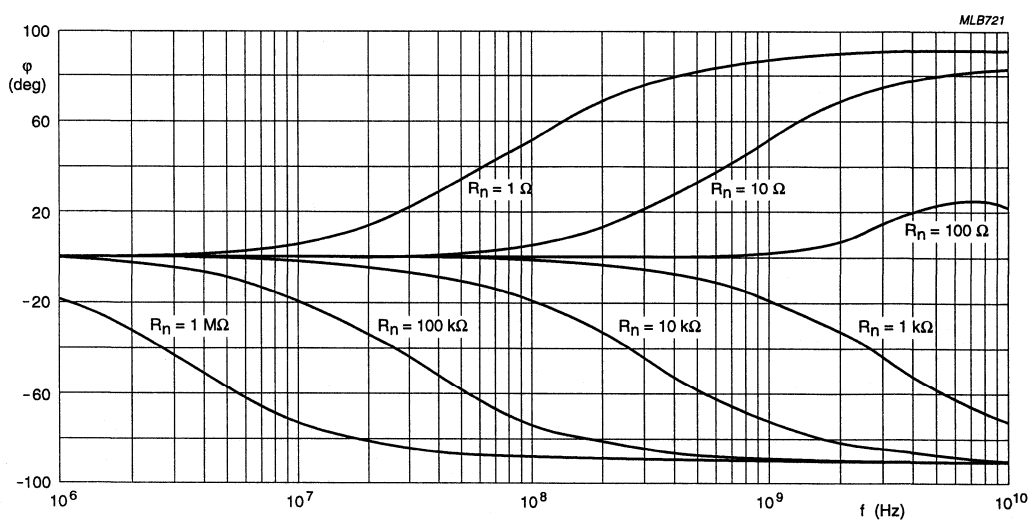
Size 0805

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



Size 1206

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



Size 1206

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

PULSE-LOAD BEHAVIOUR

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

Table 1 Pulse load limits

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

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

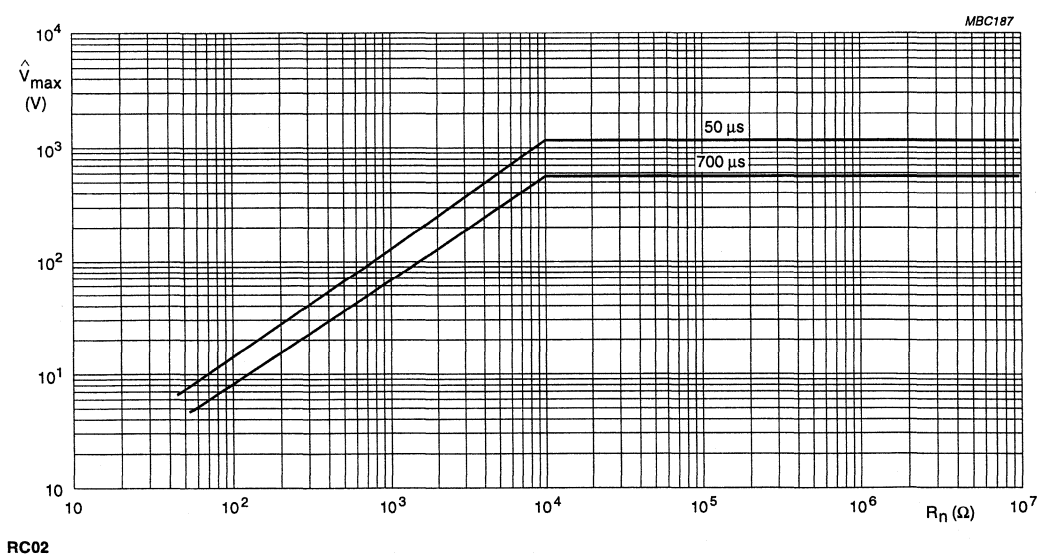


Fig.10 Maximum permissible peak pulse voltage ($\hat{V}_{max}$) without failing to 'open circuit' in accordance with DIN IEC 40 (CO) 533.

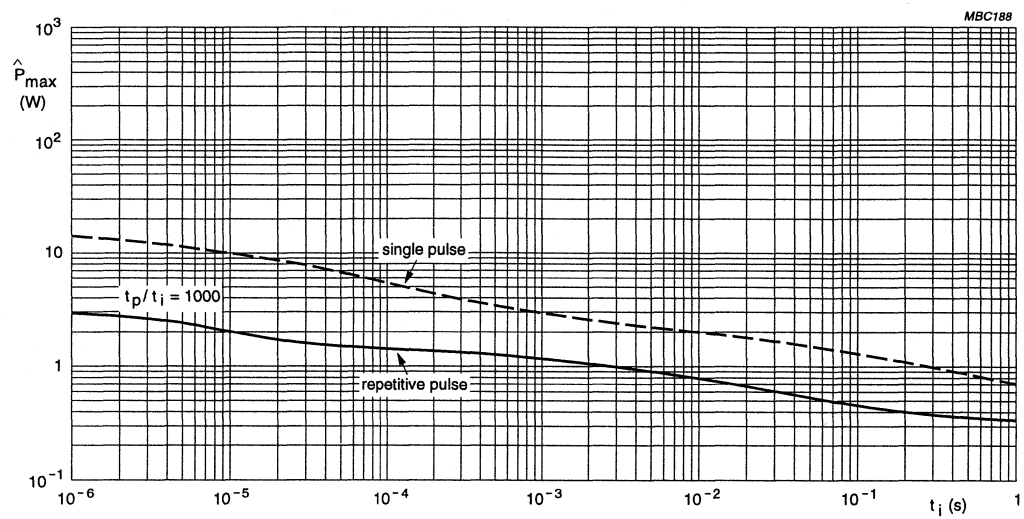


Fig.11 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration for R ≤ 10 kΩ, single pulse and repetitive pulse t_p/t_i = 1000.

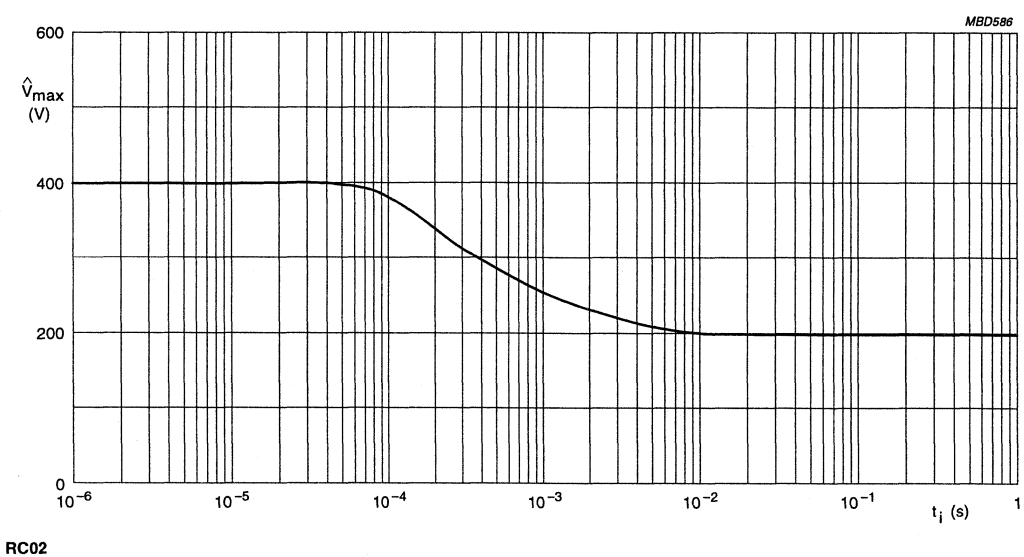


Fig.12 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_i).

Definitions of pulses

SINGLE PULSE

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

REPETITIVE PULSE

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

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

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

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

Determination of pulse-load

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

- For repetitive rectangular pulses:
  - $\frac{\hat{V}_i^2}{R}$ must be lower than the value of $\hat{P}_{max}$ given by the solid lines of Fig.11 for the applicable value of t_i and duty cycle t_p/t_i.
  - $\hat{V}_i$ must be lower than the value of $\hat{V}_{max}$ given in Fig.12 for the applicable value of t_i.
- For repetitive exponential pulses:
  - As for rectangular pulses, except that $t_i = 0.5\ \tau$.
- For single rectangular pulses:
  - $\frac{\hat{V}_i^2}{R}$ must be lower than the $\hat{P}_{max}$ given by the dashed line of Fig.11 for the applicable value of t_i.
  - $\hat{V}_i$ must be lower than the value of $\hat{V}_{max}$ given in Fig.12 for the applicable value of t_i.

Definition of symbols used in Figs 11, 12, 13 and 14

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

Examples

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

CONTINUOUS PULSE TRAIN

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

Therefore:

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

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

SINGLE PULSE

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

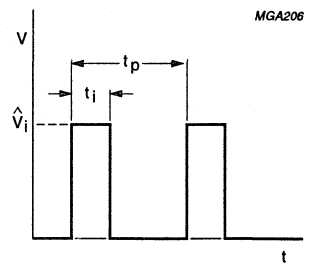


Fig.13 Rectangular pulses.

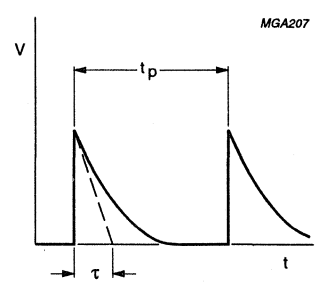
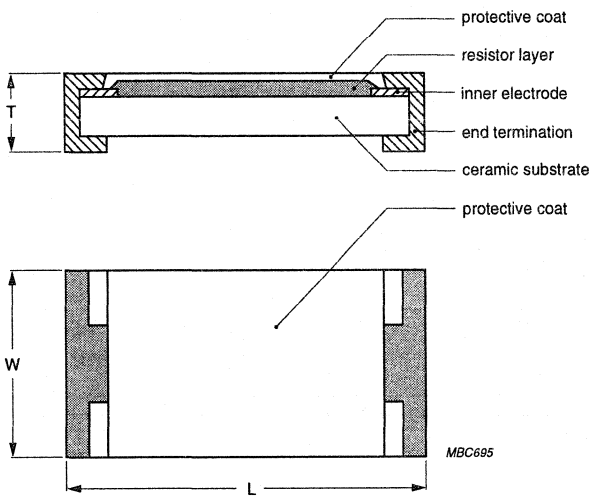


Fig.14 Exponential pulses.

MECHANICAL DATA

Outlines



For dimensions see Table 2.

Fig.15 Component outline.

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

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

Marking

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

INDICATOR	TOL. ≥ ±2%	TOL. ≤ ±1%
0	0.0 Ω; jumper	–
R[1]	1 to 91 Ω	1 to 976 Ω
1	100 to 910 Ω	1 to 9.76 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.

TESTS AND PROCEDURES

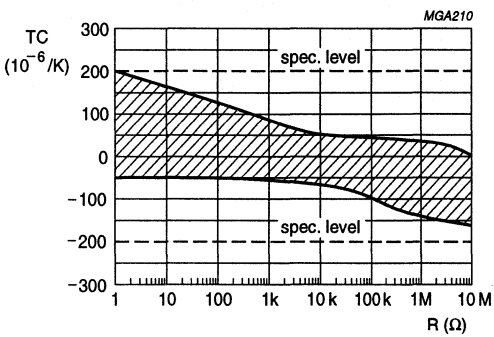
To guarantee zero defect production standards, Statistical Process Control is an essential part of our production processes. Furthermore, our production process is operating in accordance with *"ISO 9000"*.

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.

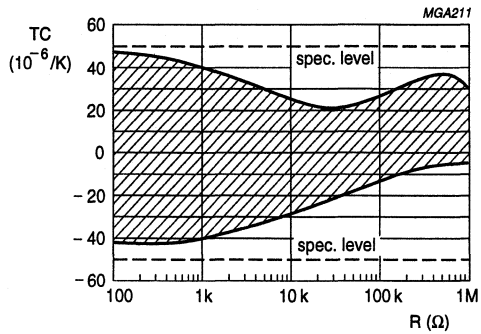
Table 4 Test procedures

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; 3 directions; total 6 hours
4.20	29 (Eb)	bump	3 × 1500 bumps in 3 directions; 40 g
4.33		bending	resistors mounted on a 90 mm glass epoxy resin PCB, bending: 5 mm
4.24		humidity load (JIS)	1000 hours; +40 °C; 90 to 95% RH; loaded with P_n or 150 V; maximum 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

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE
4.24.2	3 (Ca)	damp heat (steady state) (IEC)	56 days; 40 °C; 90 to 95% RH; loaded with $0.01P_n$ (IEC steps: 0 to 100 V); dissipation ≤1 mW
4.25.1		endurance	1000 hours; 70 °C; nominal dissipation
4.6.1.1		insulation resistance	100 V (DC) after 1 minute
4.13		short time overload	room temperature; dissipation $6.25 \times P_n$; 5 s (voltage not more than $2 \times V_{max}$)
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

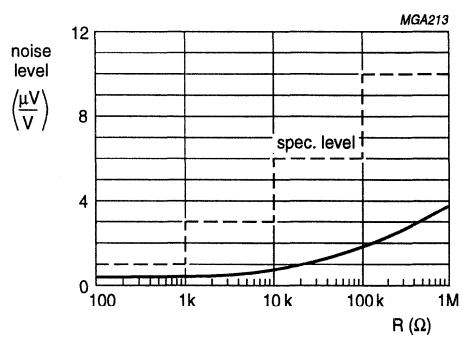


a. RC-01.



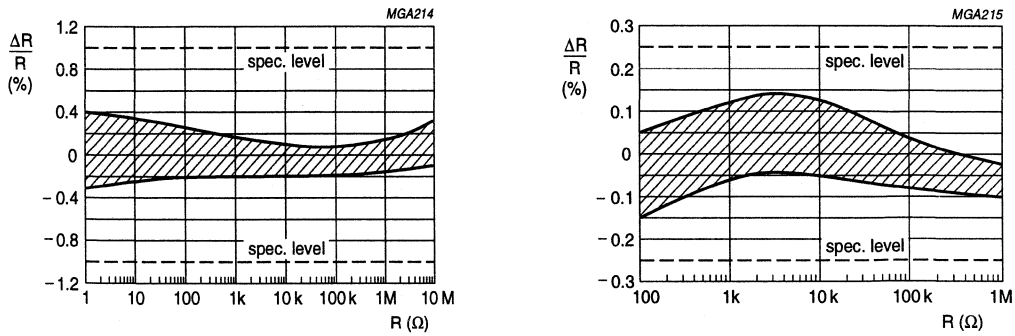
b. RC-02G.

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



RC-02G.

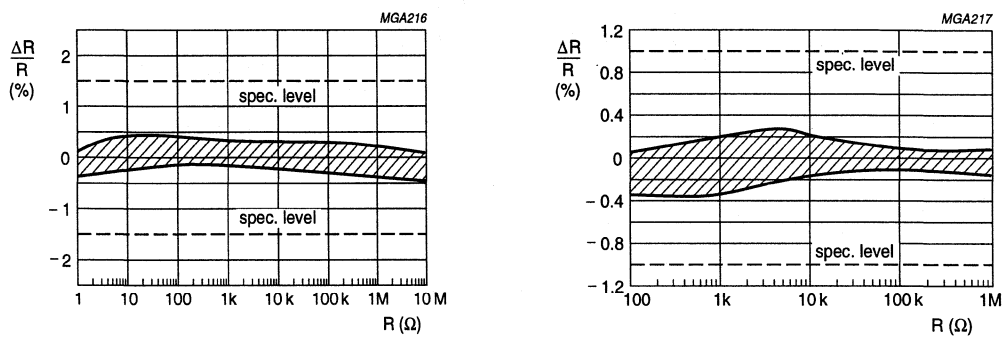
Fig.17 Typical noise level as a function of rated resistance measured using Quantech - equipment.



a. RC-01.

b. RC-02G.

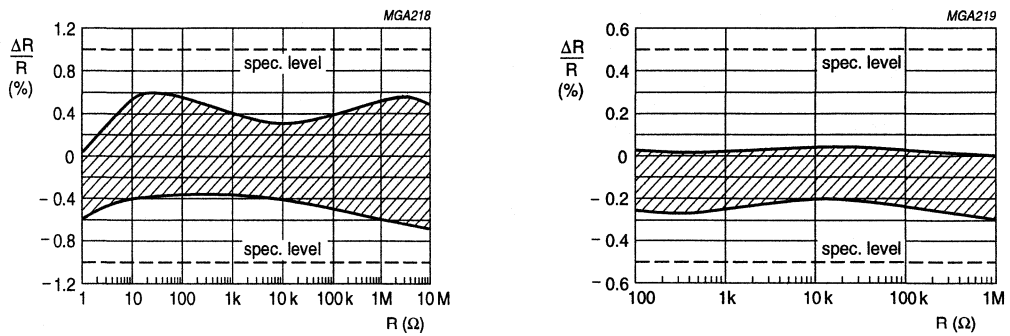
Fig.18 Typical percentage change in resistance after soldering for 10 seconds at 260 °C, completely immersed.



a. RC-01.

b. RC-02G.

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



a. RC-01.

b. RC-02G.

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

MOUNTING

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 "Functional description".

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

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

Example of mounting effects

Assume that the maximum temperature of a PCB is 95 °C and the ambient temperature is 50 °C. In this case the maximum temperature rise that may be allowed is 45 °C. In the graph (see Fig.21), 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 units/50 × 50 mm^2 (point D), is found on the horizontal axis.

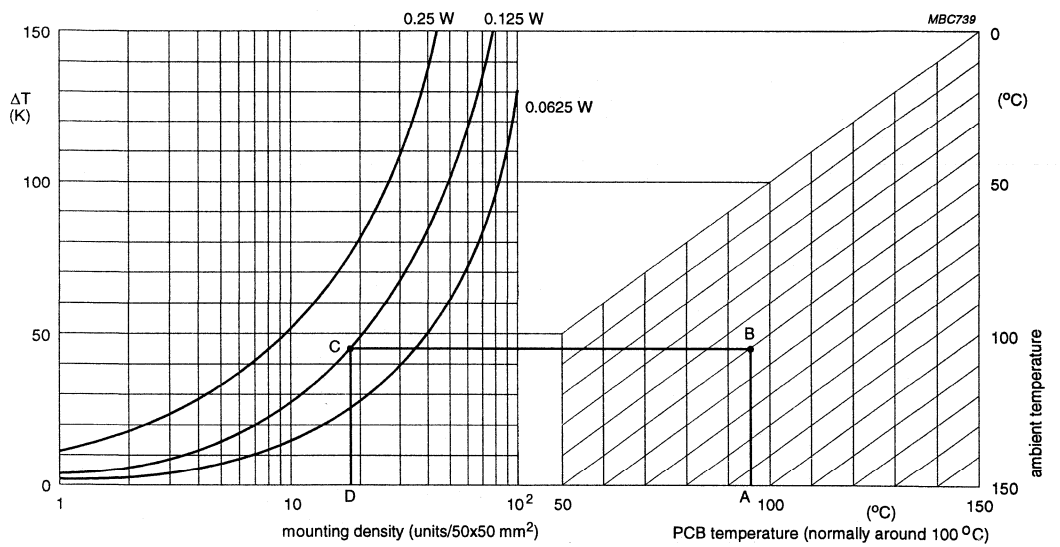


Fig.21 PCB temperature as a function of applied power, mounting density and ambient temperature.

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 22 shows the different values of heat resistance per material type. Substrates with a higher heat conductance give lower thermal resistance figures; substrates with a lower heat conductance give higher thermal resistance figures.

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

T_{amb} (which is also dependent on the packing density)

R_{th} of the PCB

maximum solder spot temperature (generally 110 °C).

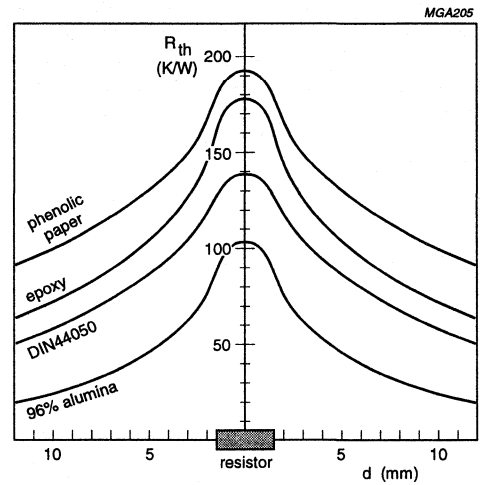
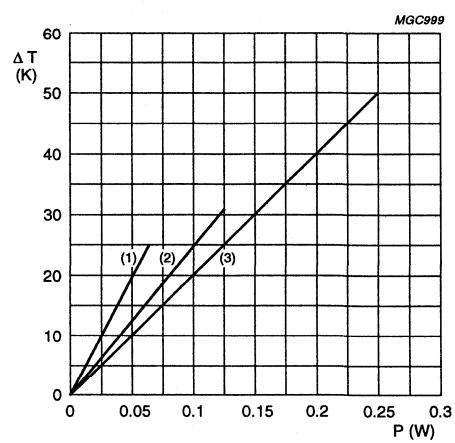


Fig.22 Heat resistance for 1206 sized resistors as a function of distance and material.



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

Fig.23 Hot-spot temperature rise (ΔT) as a function of dissipated power.

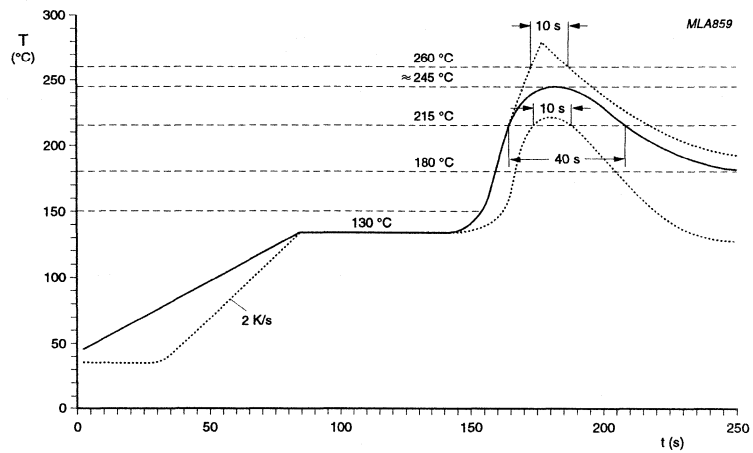
MOUNTING

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).

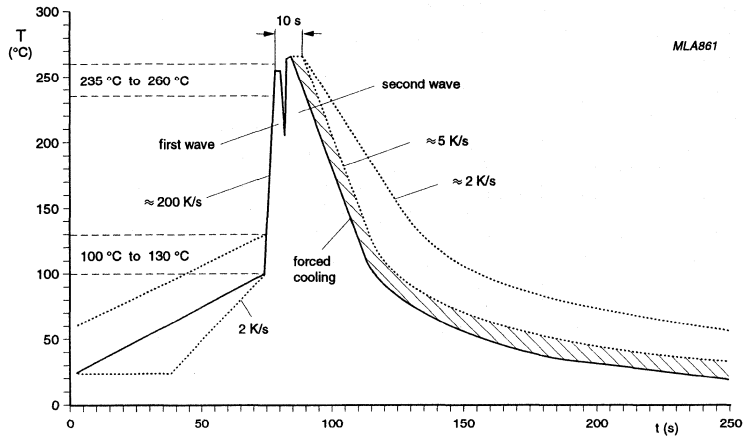
SOLDERING CONDITIONS

Surface Mounted Resistors 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 24, 25 and 26.



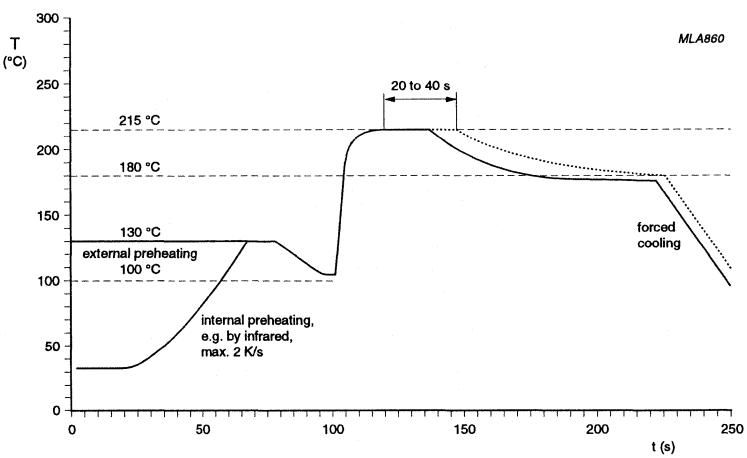
Typical values (solid line).
Process limits (dotted lines).

Fig.24 Infrared soldering.



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

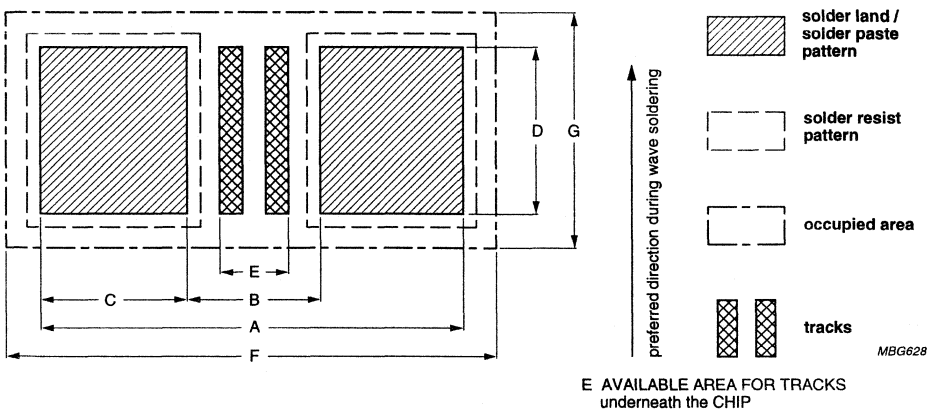
Fig.25 Double wave soldering.



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

Fig.26 Vapour phase soldering.

FOOTPRINT DIMENSIONS



For dimensions see Tables 5 and 6.

Fig.27 Recommended dimensions of footprints.

Table 5 Reflow soldering; for dimensions see also Fig.27

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

Table 6 Wave soldering (no dummy tracks allowed for the high voltage series); for dimensions see also Fig.27

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

PACKAGING

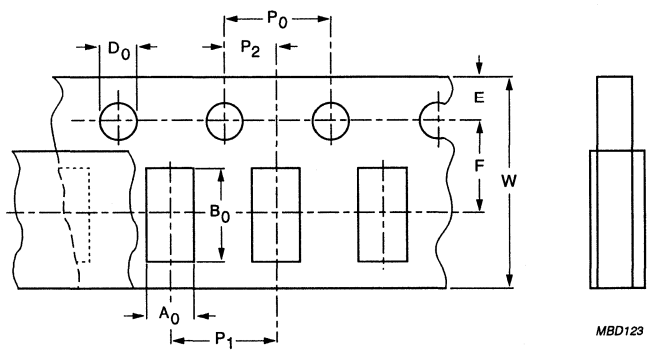
Tape and reel specifications

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 28, 29, 31 and Tables 7, 8 and 10.

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°.

Cardboard tape



Cumulative tolerance over 10 holes: ±0.2 mm.
Bottom fixing tape thickness: 50 ±10 μm.
Top fixing tape thickness: 50 ±10 μm.
For dimensions see Table 7.
Carrier tape thickness:
0.6 ±0.05 mm (0603)
0.75 ±0.05 mm (1206; 0805).

Fig.28 Cardboard tape.

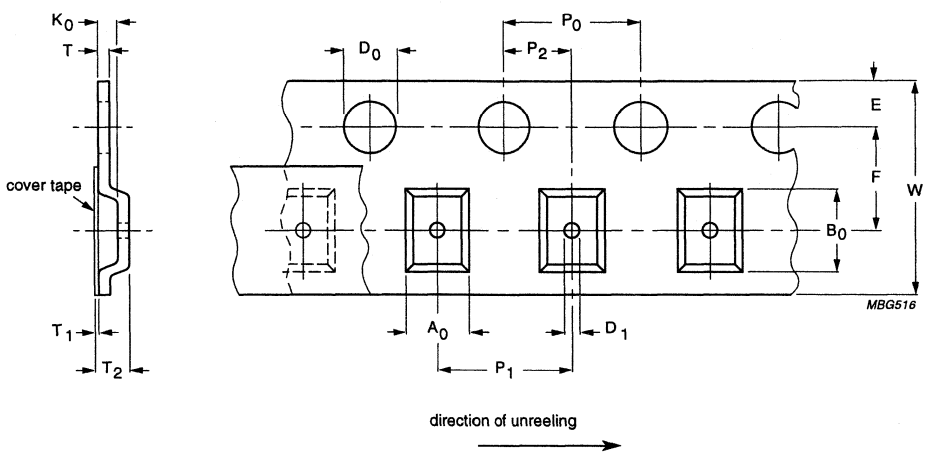
Table 7 Physical dimensions of cardboard tape for relevant chip size; see Fig.28

SYMBOL	PRODUCT SIZE CODE			TOLERANCE	UNIT
	06036	0805	1206		
A_0	1.0	1.5	1.85	+0.2/–0	mm
B_0	1.8	2.25	3.45	+0.2/–0	mm
W	8	8	8	±0.3	mm
E	1.75	1.75	1.75	±0.1	mm
F	3.5	3.5	3.5	±0.05	mm
D_0	1.5	1.5	1.5	+0.1/–0	mm
P_0	4	4	4	±0.1	mm
P_1	4	4	4	±0.1	mm
P_2	2	2	2	±0.05	mm

Embossed carrier tape

ENVIRONMENTAL CONSIDERATIONS

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



Cumulative pitch error: 0.2 mm over 10 pitches.
Cumulative tolerance over 10 holes: ±0.2 mm.
K_0: so chosen that the orientation of the component cannot change.
For W = 8 mm: T_2 = 2.5 mm max.
For W = 12 mm: T_2 = 4.5 mm max.
For dimensions see Table 8.

Fig.29 Embossed carrier tape.

Table 8 Physical dimensions of embossed carrier tape for relevant chip size; see Fig.29

SYMBOL	PRODUCT SIZE CODE			TOLERANCE	UNIT
	0805	1206	1218		
A_0 nominal clearance; note 1	0.30			–	mm
B_0 nominal clearance; note 1	0.20			–	mm
K_0 minimum clearance; note 1	0.10			–	mm
W	8.1	8.1	12	±0.2	mm
E	1.75	1.75	1.75	±0.1	mm
F	3.5	3.5	3.5	±0.05	mm
D_0	1.5	1.5	1.5	+0.1/–0.0	mm
D_1	≥1	≥1	≥1.5	+0.1/–0.0	mm
P_0; note 2	4	4	4	±0.1	mm
P_1	4	4	8	±0.1	mm
P_2	2	2	2	±0.05	mm

Notes

1. Possible product displacement in pocket.
2. P_0 pitch tolerance over any 10 pitches is ±0.2 mm.

Leader/trailer tape specification

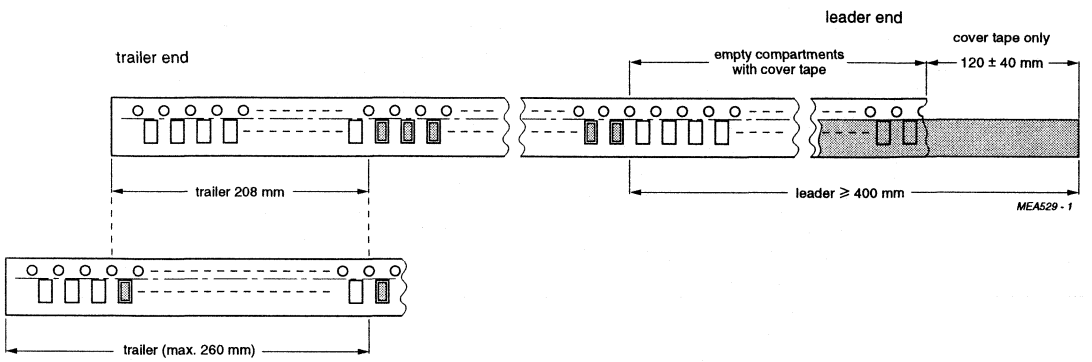
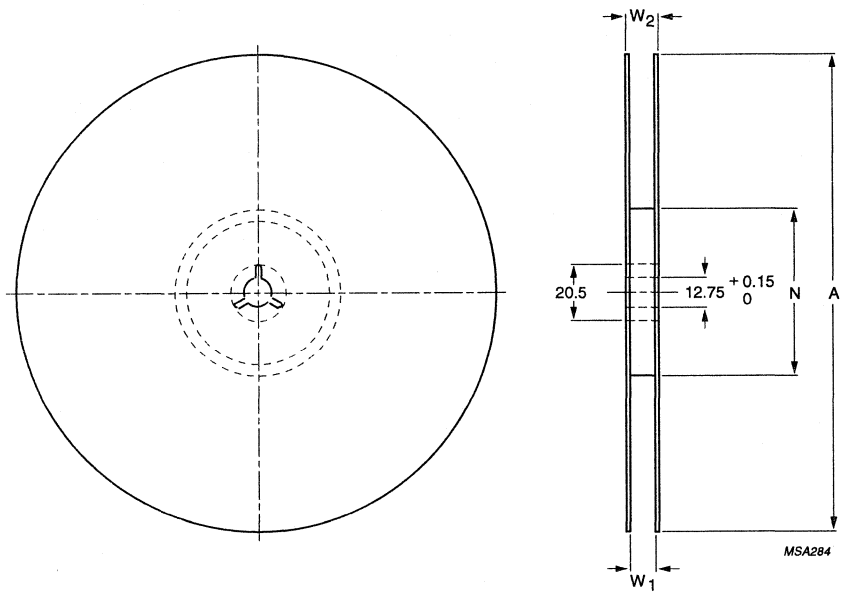


Fig.30 Leader/trailer tape.

Table 9 Leader/trailer tape data

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

REEL SPECIFICATIONS



Dimensions in mm.
For dimensions see Table 10.

Fig.31 Reel.

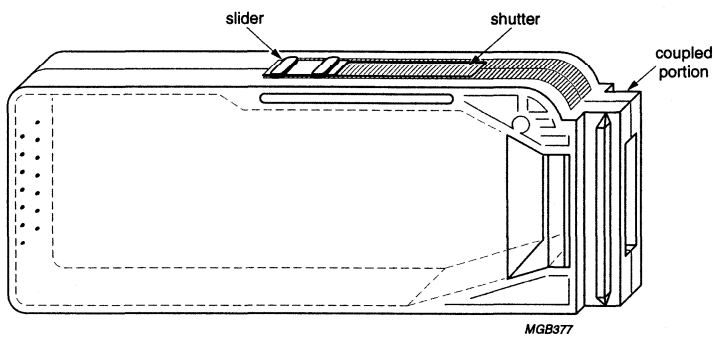
Table 10 Reel dimensions; see Fig.31

PRODUCT SIZE CODE	UNITS PER REEL	TAPE WIDTH (mm)	A (mm)	N (mm)	W_1 (mm)	W_2 MAX. (mm)
0603	10000	8	250	62 ±1.5	8.4 +1.5/–0.0	14.4
1206; 0805	5000		180			
1218	1000	12	180		12.4 +2/–0.0	18.4
	5000		260			

BULK CASE SPECIFICATION

Features and benefits:

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



For dimensions see Table 11.

Fig.32 Bulk case outlines.

Table 11 Bulk case dimensions; see Fig.32

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

Table 12 Product size versus packaged quantity

PRODUCT SIZE CODE	UNITS PER CASE
0603	25000
0805	10000

PRODUCT SPECIFICATIONS THICK FILM SMD

Standard chip resistors sizes 1206, 0805 and 0603

RC01/11/21

FEATURES

- Low assembly costs
- High component and equipment reliability
- Excellent performance at high frequency, especially the RC21
- Complete standard SMD family.

APPLICATIONS

- All general purpose applications.

DESCRIPTION

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

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

QUICK REFERENCE DATA

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

ORDERING INFORMATION

Table 1 Ordering code indicating resistor type and packaging

TYPE	TOL. (%)	ORDERING CODE 2322					
		CARDBOARD TAPE ON REEL		EMBOSSED CARRIER TAPE ON REEL		BULK CASE	
		5000 units	10000 units	5000 units	10000 units	10000 units	25000 units
RC01	±5	711 61...	711 51...	712 61...	712 71...	–	–
	±2	711 41...	711 71...	712 83...	712 23...	–	–
RC11	±5	730 61...	730 71...	731 61...	731 71...	731 81...	–
	±2	730 31...	730 41...	730 21...	731 41...	731 51...	–
RC21	±5	702 60...	702 70...	–	–	–	702 80...
	±2	702 65...	–	–	–	–	702 55...
Jumper 0 Ω							
RC01; note 1	–	711 91032	711 91005	712 91024	712 91004	–	–
RC11; note 1	–	730 91002	730 91003	731 91003	731 91002	731 91006	–
RC21; note 2	–	702 96001	702 97001	–	–	–	702 91002

Notes

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

Ordering code (12NC)

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

Table 2 Last digit of 12NC

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

ORDERING EXAMPLE

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

FUNCTIONAL DESCRIPTION

Product characterization

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

Limiting values

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

Note

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

DERATING

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

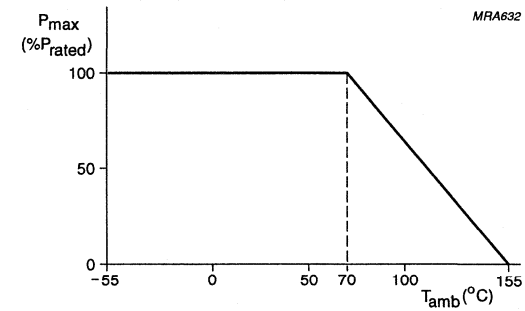
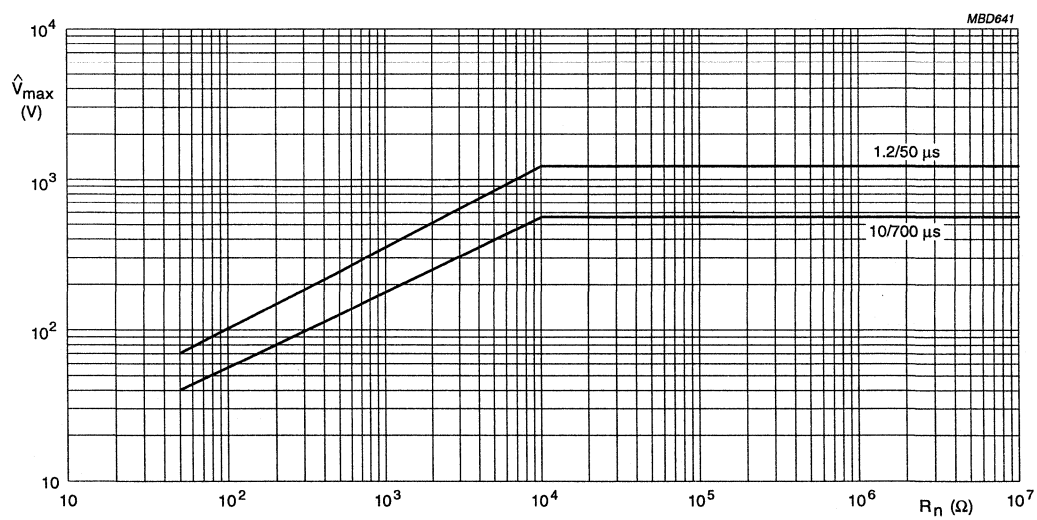


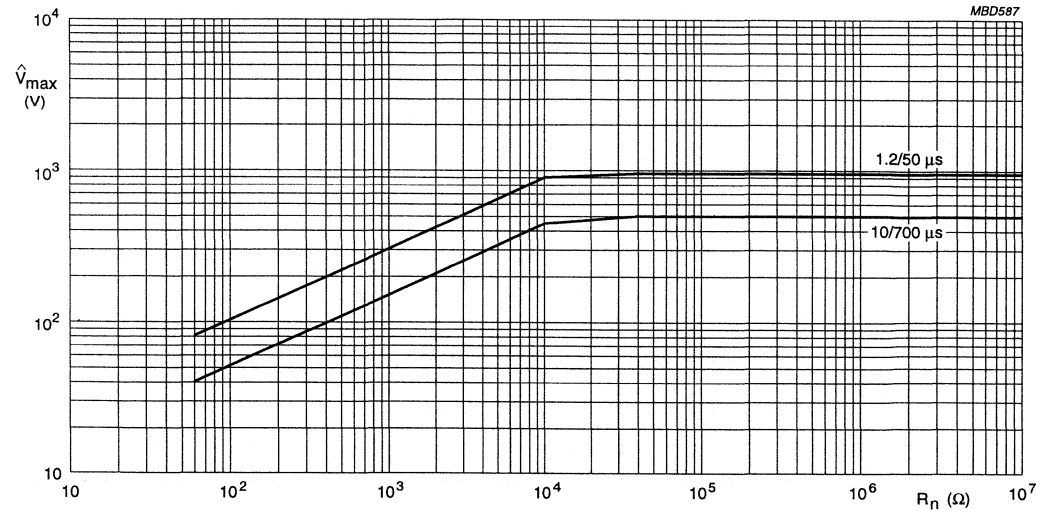
Fig.1 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

PULSE LOADING CAPABILITIES



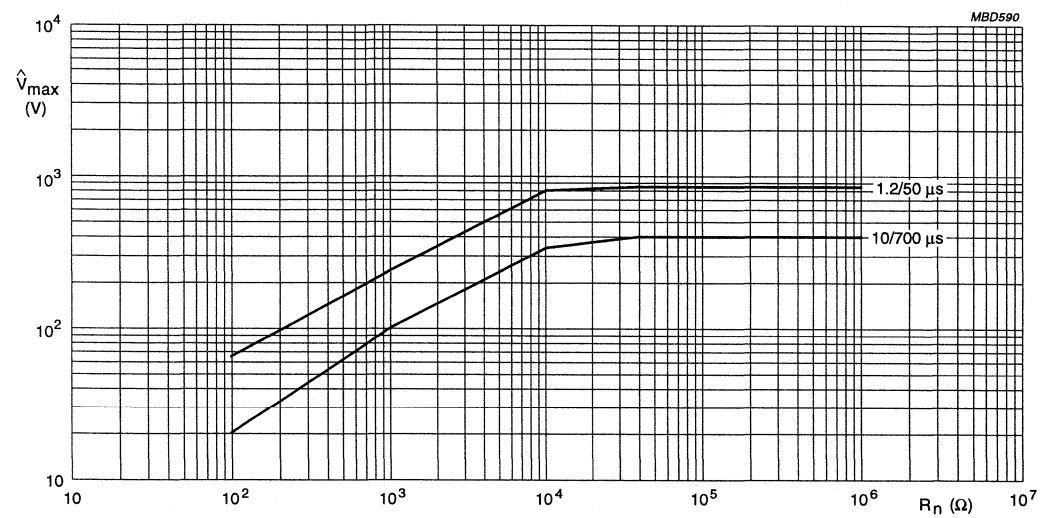
These pulses may not be applied on a regular basis.

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



These pulses may not be applied on a regular basis.

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



These pulses may not be applied on a regular basis.

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

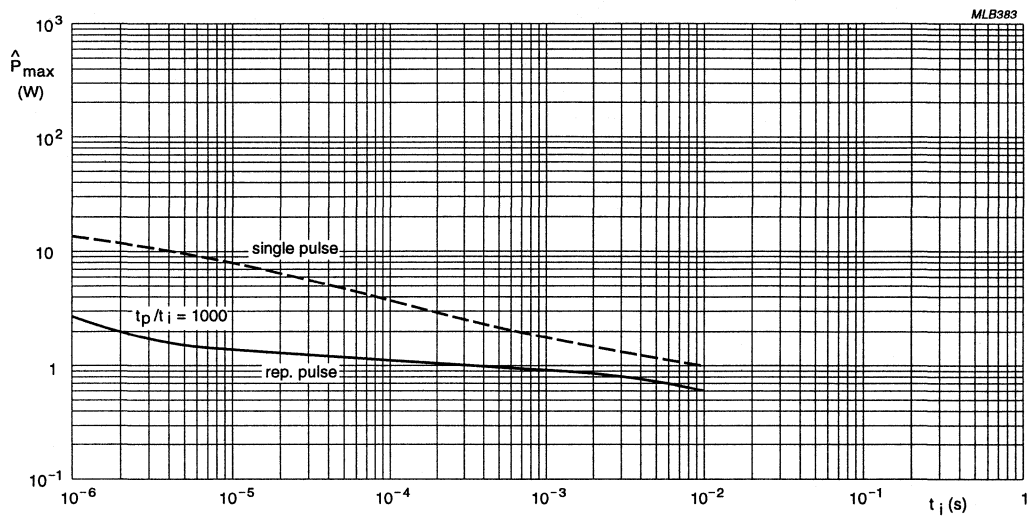


Fig.5 Pulse on a regular basis for type: **RC01**; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration for R ≤ 10 kΩ, single pulse and repetitive pulse t_p/t_i = 1000.

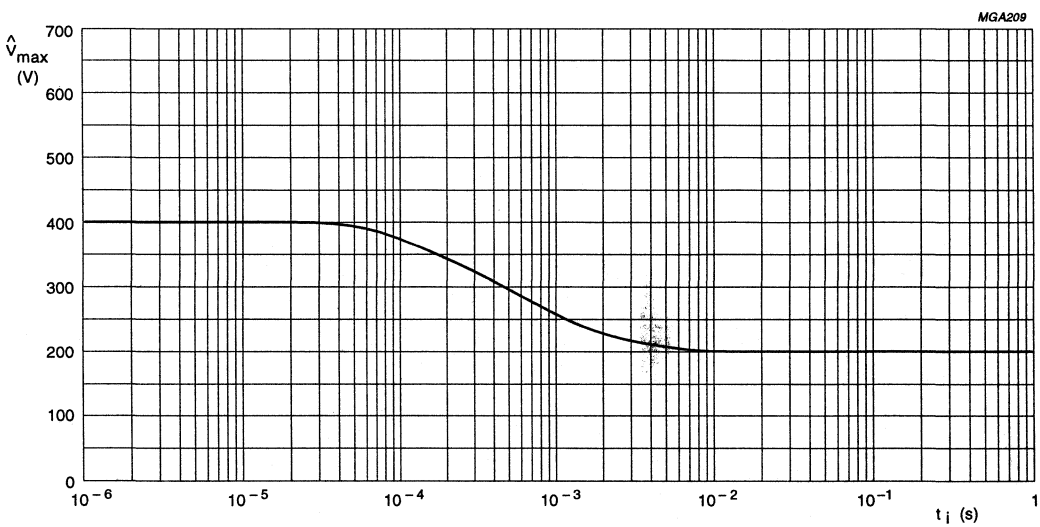


Fig.6 Pulse on a regular basis for type: **RC01**; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration.

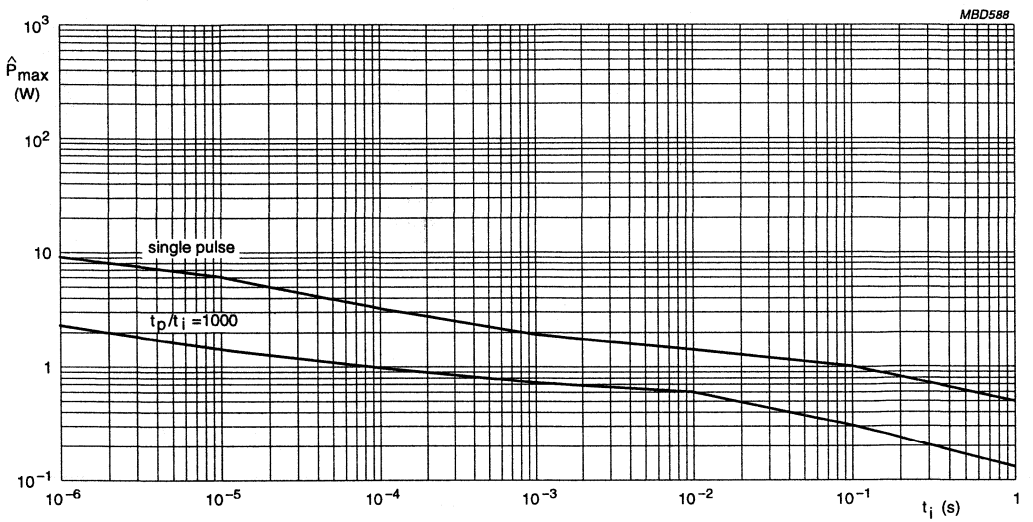


Fig.7 Pulse on a regular basis for type: **RC11**; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration for R ≤ 10 kΩ, single pulse and repetitive pulse t_p/t_i = 1000.

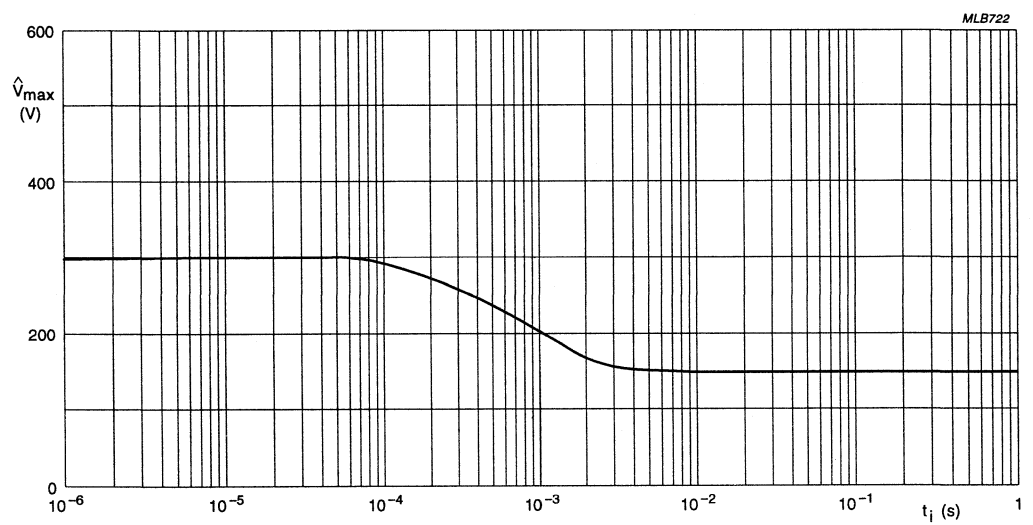


Fig.8 Pulse on a regular basis for type: **RC11**; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration.

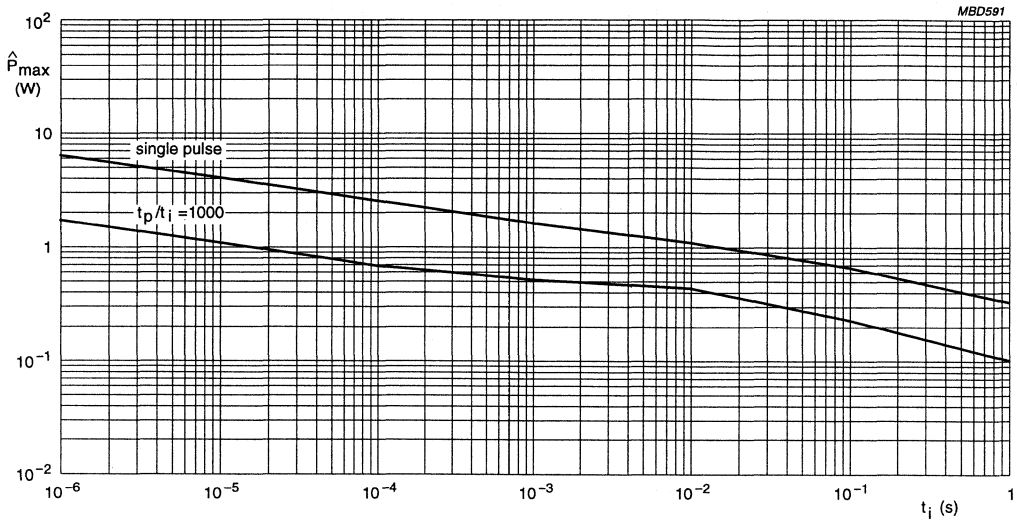


Fig.9 Pulse on a regular basis for type: **RC21**; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration for R ≤ 10 kΩ, single pulse and repetitive pulse t_p/t_i = 1000.

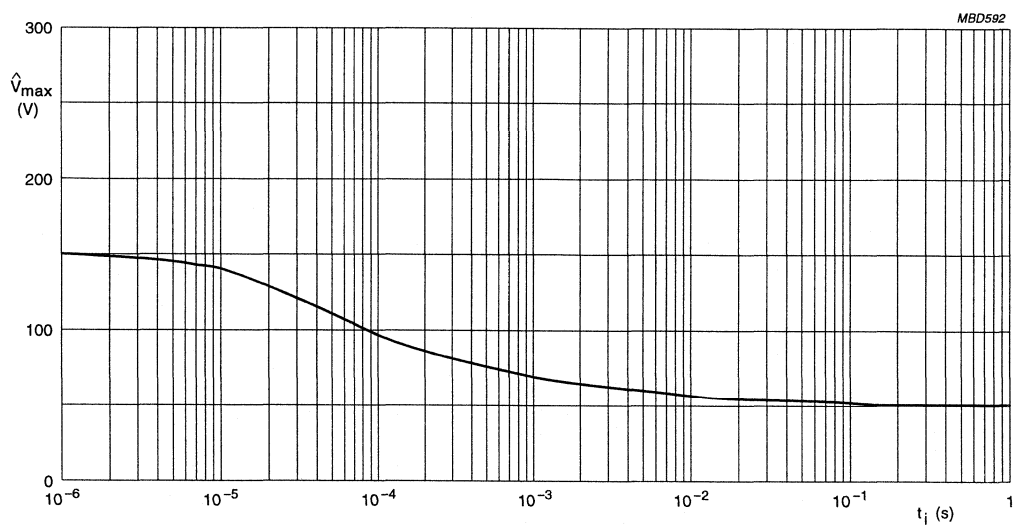


Fig.10 Pulse on a regular basis for type: **RC21**; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration.

MECHANICAL DATA

Mass per 100 units

TYPE	MASS (g)
RC01	1.0
RC11	0.55
RC21	0.25

Marking

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

3-DIGIT MARKING

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

Example

MARKING	RESISTANCE
12R	12 Ω
823	82 kΩ

4-DIGIT MARKING

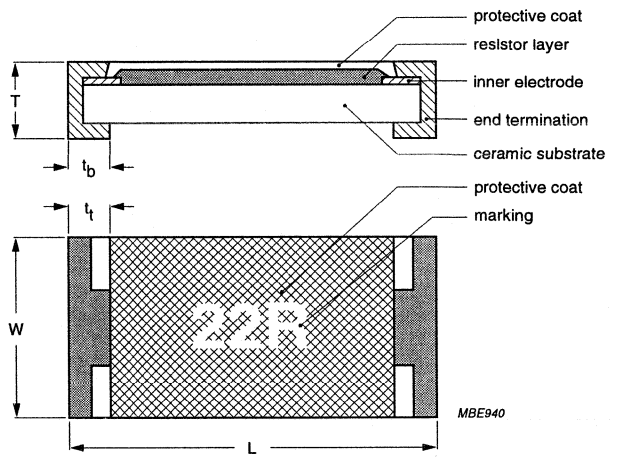
For values up to 976 Ω the R is used as a decimal point. For values of 1 kΩ or greater the first 3 digits are significant, the fourth indicates the number of zeros to follow.

Example

MARKING	RESISTANCE
12R0	12 Ω
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.

Outlines



For dimensions see Table 3.

Fig.11 Outlines.

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

TYPE	L (mm)	W (mm)	T (mm)	t_t (mm)	t_b (mm)
RC01	3.20 +0.10/–0.20	1.60 ±0.15	0.55 ±0.10	0.45 ±0.25	0.50 ±0.25
RC11	2.00 ±0.15	1.25 ±0.15	0.55 ±0.10	0.40 ±0.20	0.40 ±0.20
RC21	1.60 ±0.10	0.80 +0.15/–0.05	0.45 ±0.10	0.30 ±0.20	0.30 ±0.20

TESTS AND REQUIREMENTS

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

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

Unless otherwise specified the following values apply:

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

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

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

All soldering tests are performed with mildly activated flux.

Table 4 Test procedures and requirements

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	RESISTANCE RANGE	REQUIREMENTS		
					RC01	RC11	RC21
Tests in accordance with the schedule of IEC publication 115-8							
4.4.1		visual examination			no holes; clean surface; no damage		
4.4.2		dimensions (outline; see Fig.11)	gauge (mm)		$0.45 \leq T \leq 0.65$ $1.45 \leq W \leq 1.75$ $3.0 \leq L \leq 3.3$	$0.45 \leq T \leq 0.65$ $1.10 \leq W \leq 1.40$ $1.85 \leq L \leq 2.15$	$0.35 \leq T \leq 0.55$ $0.75 \leq W \leq 0.95$ $1.50 \leq L \leq 1.70$
4.5		resistance	applied voltage (+0/–10%): $R < 10\ \Omega$: 0.1 V $10\ \Omega \leq R < 100\ \Omega$: 0.3 V $100\ \Omega \leq R < 1\ k\Omega$: 1 V $1\ k\Omega \leq R < 10\ k\Omega$: 3 V $10\ k\Omega \leq R < 100\ k\Omega$: 10 V $100\ k\Omega \leq R < 1\ M\Omega$: 25 V $R \geq 1\ M\Omega$: 50 V		$R - R_{nom}$: max. ±2% or $R - R_{nom}$: max. ±5%		
4.18	20 (Ta)	resistance to soldering heat	unmounted chips; 10 s; 260 ±5 °C		no visual damage $\Delta R/R$ max.: ±0.5% +0.05 Ω;		
4.29	45 (Xa)	component solvent resistance	isopropyl alcohol or H_2O followed by brushing in accordance with *"MIL 202 F"*		no visual damage		

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	RESISTANCE RANGE	REQUIREMENTS		
					RC01	RC11	RC21
4.17	20 (Ta)	solderability	unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C		good tinning (≥95% covered); no visual damage		
4.7		voltage proof on insulation	maximum voltage (RMS) during 1 minute metal block method		no breakdown or flashover		
4.13		short time overload	room temperature; $P = 6.25 \times P_n$; 5 s ($V \leq 2 \times V_{max}$)		ΔR/R max.: ±1% +0.05 Ω		
4.33		bending	resistors mounted on a 90 mm glass epoxy resin PCB (FR4), bending: 3 mm for **RC01** and 5 mm for **RC11** and **RC21**		no visual damage ΔR/R max.: ±1% +0.05 Ω		
4.19	14 (Na)	rapid change of temperature	30 minutes at LCT and 30 minutes at UCT; 5 cycles		no visual damage ΔR/R max.: ±0.5% +0.05 Ω		
4.23		climatic sequence:					
4.23.3	30 (D)	damp heat (accelerated) 1st cycle					
4.23.6	30 (D)	damp heat (accelerated) remaining cycles	6 days; 55 °C; 95 to 98% RH		R_{ins} min.: 10^4 MΩ		
				R ≤ 1 MΩ	ΔR/R max.: ±1.5% +0.1 Ω		
				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: 4 to 100 V)	R ≤ 1 MΩ	ΔR/R max.: ±1.5% +0.1 Ω		
				R > 1 MΩ	ΔR/R max.: ±3% +0.1 Ω		
4.25.1		endurance (at 70 °C)	1000 hours; loaded with P_n or V_{max}; 1.5 hours on and 0.5 hours off	R ≤ 1 MΩ	ΔR/R max.: ±1.5% +0.1 Ω		
				R > 1 MΩ	ΔR/R max.: ±3% +0.1 Ω		
4.23.2	27 (Ba)	endurance at upper category temperature	1000 hours; no load	R ≤ 1 MΩ	ΔR/R max.: ±1.5% +0.1 Ω		
				R > 1 MΩ	ΔR/R max.: ±3% +0.1 Ω		
4.8.4.2		temperature coefficient	at 20/LCT/20 °C and 20/UCT/20 °C ($TC \times 10^{-6}$/K)	R < 5 Ω	≤ ±250		
				R ≤ 10 MΩ	≤ ±200		

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	RESISTANCE RANGE	REQUIREMENTS		
					RC01	RC11	RC21
Other tests in accordance with IEC 115 clauses and IEC 68 test method							
4.17	20 (Tb)	solderability (after ageing)	8 hours steam or 16 hours 155 °C; unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C		good tinning (≥95% covered); no damage		
4.6.1.1		insulation resistance	voltage (DC) after 1 minute, metal block method: 100 V for **RC01** and **RC11**, 50 V for **RC21**		R_{ins} min.: 10^3 MΩ		
4.12		noise	IEC publication 195 (measured with Quantech - equipment)	R ≤ 1 kΩ R ≤ 10 kΩ R ≤ 100 kΩ R ≤ 1 MΩ	max. 1 μV/V max. 3 μV/V max. 6 μV/V max. 10 μV/V		
Other applicable tests							
	(JIS)	humidity load (steady state)	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	R ≤ 1 MΩ R > 1 MΩ	ΔR/R max.: ±3% +0.1 Ω ΔR/R max.: ±5% +0.1 Ω		
		leaching	unmounted chips; 60 s; 260 ±5 °C		good tinning; no leaching		
		trio damp heat test	1 000 hours; +85 °C; 85% RH; loaded with 0.1 P_n or V_{max}	R ≤ 1 MΩ R > 1 MΩ	ΔR/R max.: ±3% +0.1 Ω ΔR/R max.: ±5% +0.1 Ω		

NOTES

Precision chip resistors sizes 1206, 0805 and 0603

RC02/12/22

FEATURES

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

APPLICATIONS

- All general purpose applications.

DESCRIPTION

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

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

QUICK REFERENCE DATA

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

Note

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

ORDERING INFORMATION

Table 1 Ordering code indicating type and packaging

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

Notes

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

Ordering code (12NC)

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

ORDERING EXAMPLE

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

Table 2 Last digit of 12NC

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

Type designation

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

FUNCTIONAL DESCRIPTION

Product characterization

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

Limiting values

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

Note

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

DERATING

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

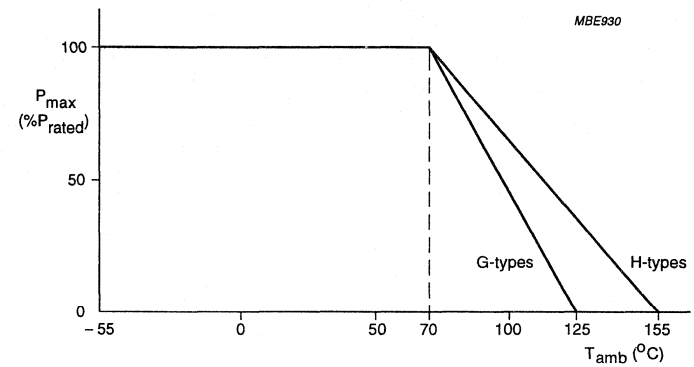
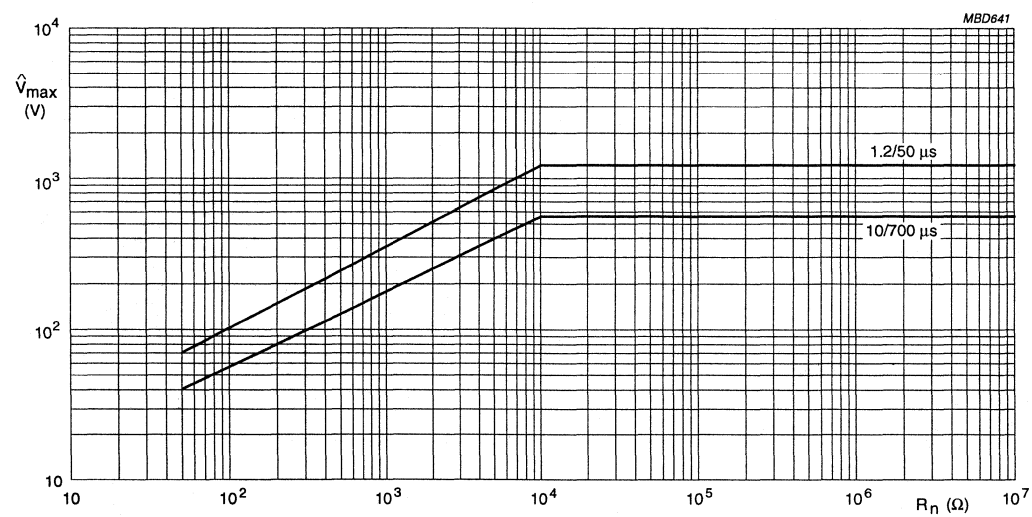


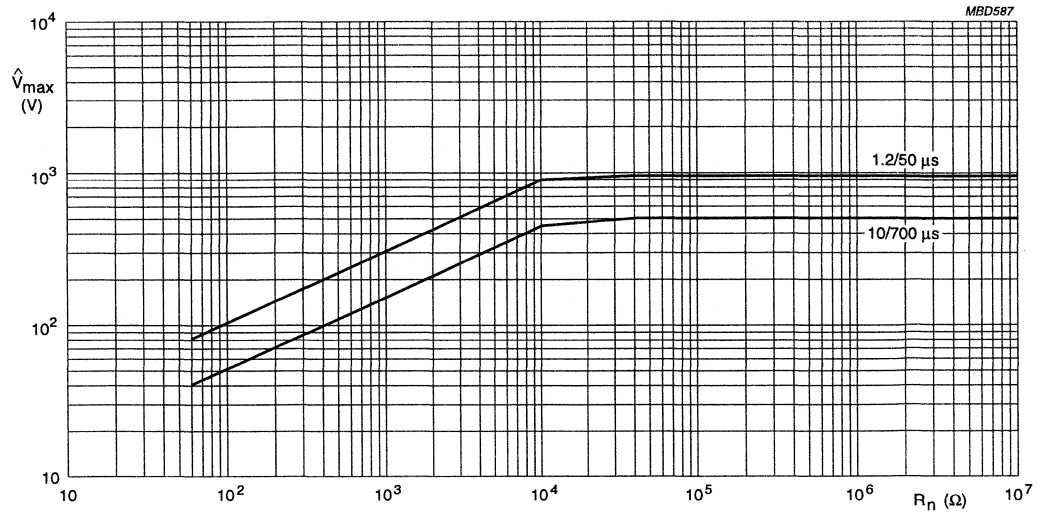
Fig.1 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

PULSE LOADING CAPABILITIES



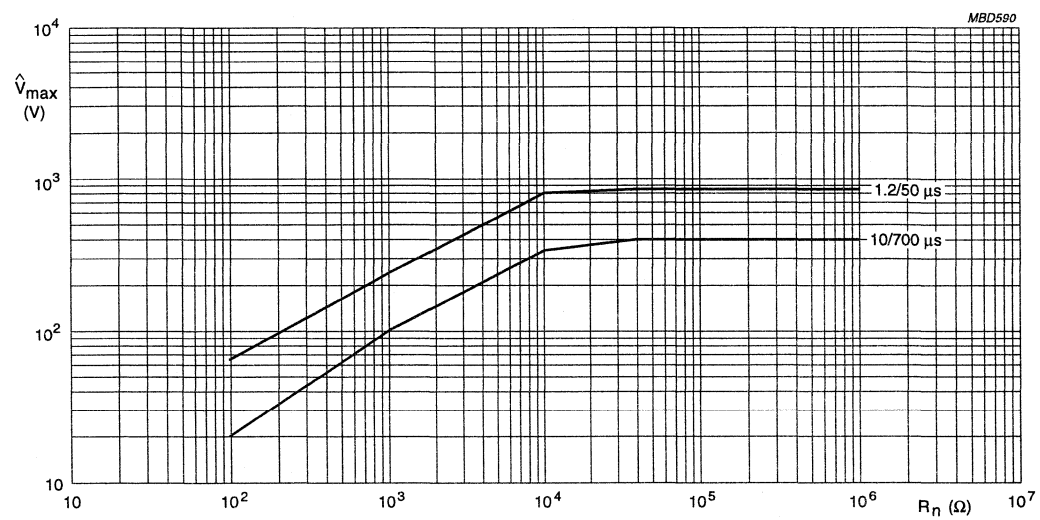
These pulses may not be applied on a regular basis.

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



These pulses may not be applied on a regular basis.

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



These pulses may not be applied on a regular basis.

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

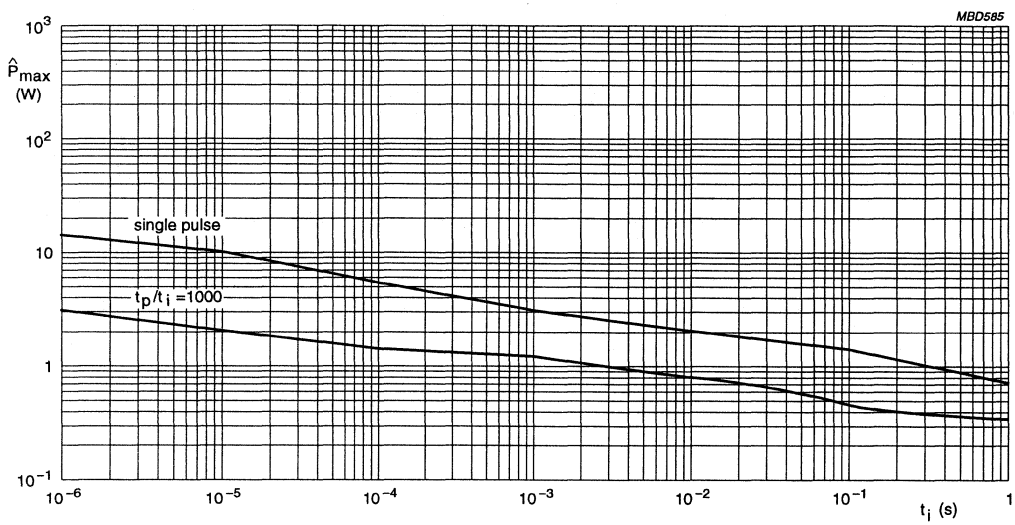


Fig.5 Pulse on a regular basis for type: **RC02**; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration for R ≤ 10 kΩ, single pulse and repetitive pulse t_p/t_i = 1000.

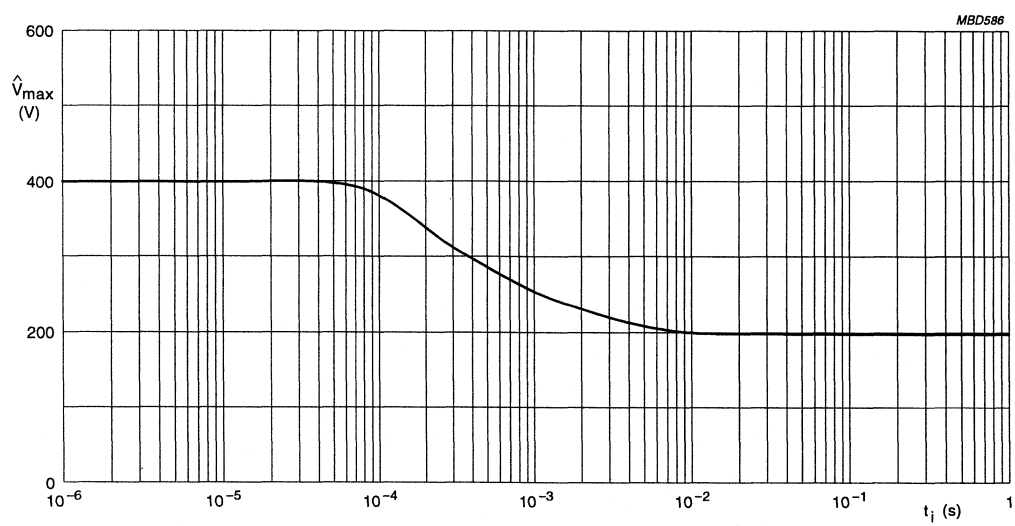


Fig.6 Pulse on a regular basis for type: **RC02**; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration.

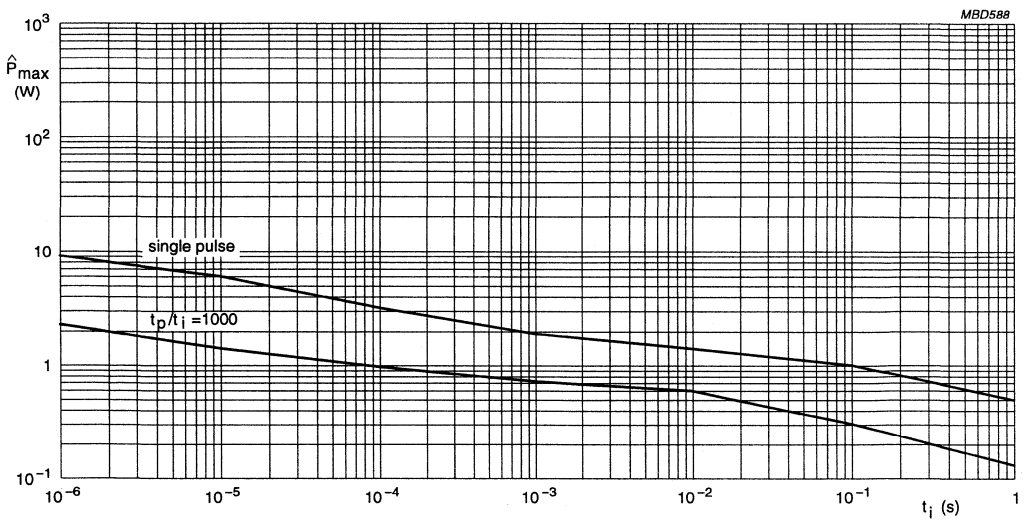


Fig.7 Pulse on a regular basis for type: **RC12**; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration for R ≤ 10 kΩ, single pulse and repetitive pulse t_p/t_j = 1 000.

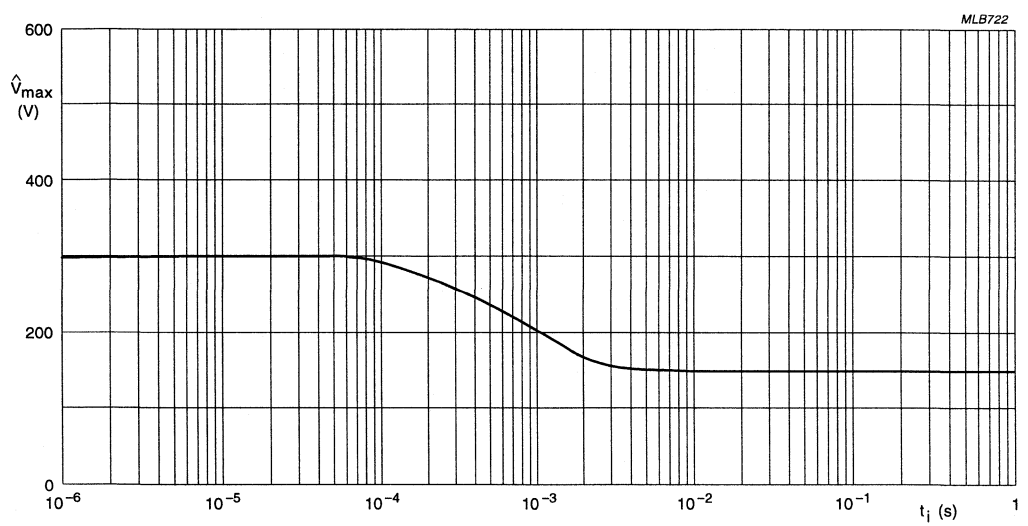


Fig.8 Pulse on a regular basis for type: **RC12**; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration.

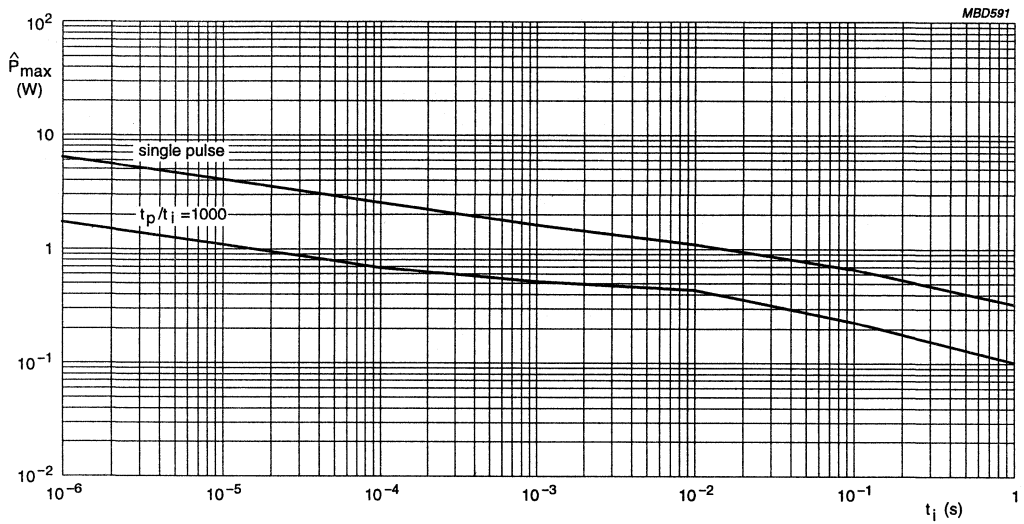


Fig.9 Pulse on a regular basis for type: **RC22**; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration for R ≤ 10 kΩ, single pulse and repetitive pulse t_p/t_i = 1000.

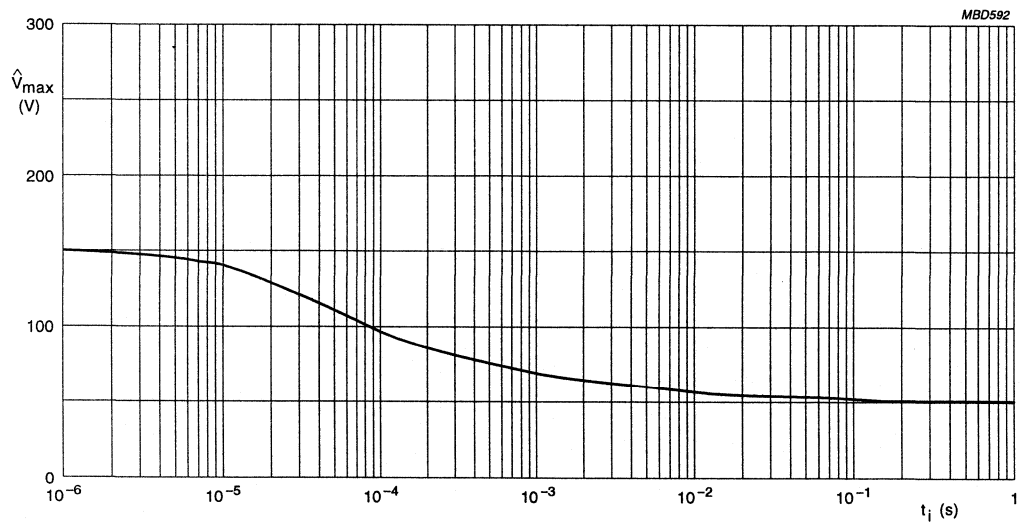


Fig.10 Pulse on a regular basis for type: **RC22**; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration.

MECHANICAL DATA

Mass per 100 units

TYPE	MASS (g)
RC02	1.0
RC12	0.55
RC22	0.25

Marking

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

4-DIGIT MARKING

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

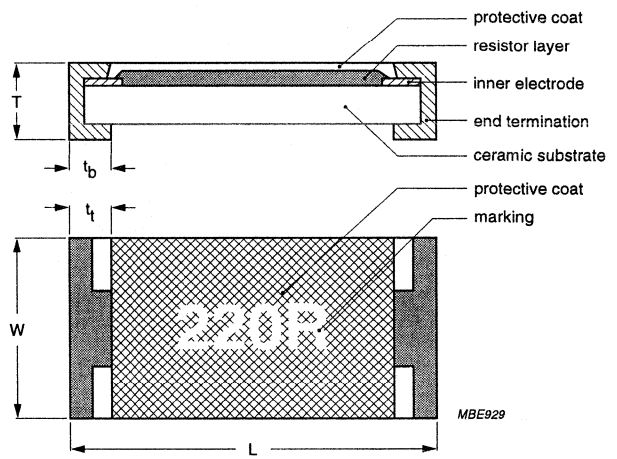
Example

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

PACKAGE MARKING

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

Outlines



For dimensions see Table 3.

Fig.11 Outlines.

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

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

TESTS AND REQUIREMENTS

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

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

Unless otherwise specified the following values apply:

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

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

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

All soldering tests are performed with mildly activated flux.

Table 4 Test procedures and requirements

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	RESISTANCE RANGE	REQUIREMENTS				
					RC02H	RC02G	RC12H	RC12G	RC22H
Tests in accordance with the schedule of IEC publication 115-8									
4.4.1		visual examination			no holes; clean surface; no damage				
4.4.2		dimensions (outline; see Fig.11)	gauge (mm)		0.45 ≤ T ≤ 0.65 1.45 ≤ W ≤ 1.75 3.0 ≤ L ≤ 3.3		0.45 ≤ T ≤ 0.65 1.10 ≤ W ≤ 1.40 1.85 ≤ L ≤ 2.15		0.35 ≤ T ≤ 0.55 0.75 ≤ W ≤ 0.95 1.50 ≤ L ≤ 1.70
4.5		resistance	applied voltage (+0/–10%): R < 10 Ω: 0.1 V 10 Ω ≤ R < 100 Ω: 0.3 V 100 Ω ≤ R < 1 kΩ: 1 V 1 kΩ ≤ R < 10 kΩ: 3 V 10 kΩ ≤ R < 100 kΩ: 10 V 100 kΩ ≤ R < 1 MΩ: 25 V R ≥ 1 MΩ: 50 V		$R - R_{nom}$: max. ±1%				
4.18	20 (Ta)	resistance to soldering heat	unmounted chips; 10 s; 260 ±5 °C		no visual damage ΔR/R max.: ±0.5% +0.05 Ω				
4.29	45 (Xa)	component solvent resistance	isopropyl alcohol or H_2O followed by brushing in accordance with *"MIL 202 F"*		no visual damage				

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

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

High precision chip resistor size 1206

RC03G

FEATURES

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

APPLICATIONS

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

DESCRIPTION

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

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

QUICK REFERENCE DATA

DESCRIPTION	VALUE
Resistance range	100 Ω to 1 MΩ
Resistance tolerance and E-series	±0.5%; E24/E96 series
Temperature coefficient	
100 Ω ≤ R < 250 Ω	≤ ±100 × 10^{-6}/K
250 Ω ≤ R ≤ 1 MΩ	≤ ±50 × 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	$\Delta R/R_{max.}$: ±0.5% +0.05 Ω
climatic tests	$\Delta R/R_{max.}$: ±1% +0.05 Ω
resistance to soldering heat	$\Delta R/R_{max.}$: ±0.25% +0.05 Ω
short time overload	$\Delta R/R_{max.}$: ±0.25% +0.05 Ω

ORDERING INFORMATION

Table 1 Ordering code indicating resistor type and packaging

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

Ordering code (12NC)

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

Table 2 Last digit of 12 NC

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

ORDERING EXAMPLE

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

High precision chip resistor size 1206

RC03G

FUNCTIONAL DESCRIPTION

Product characterization

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

Limiting values

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

Note

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

DERATING

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

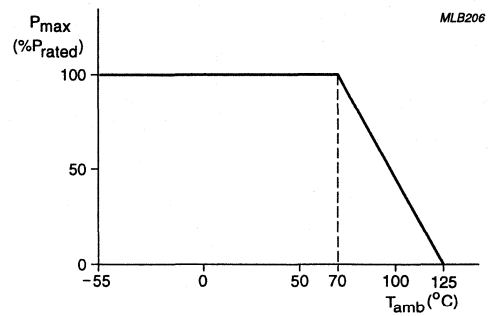
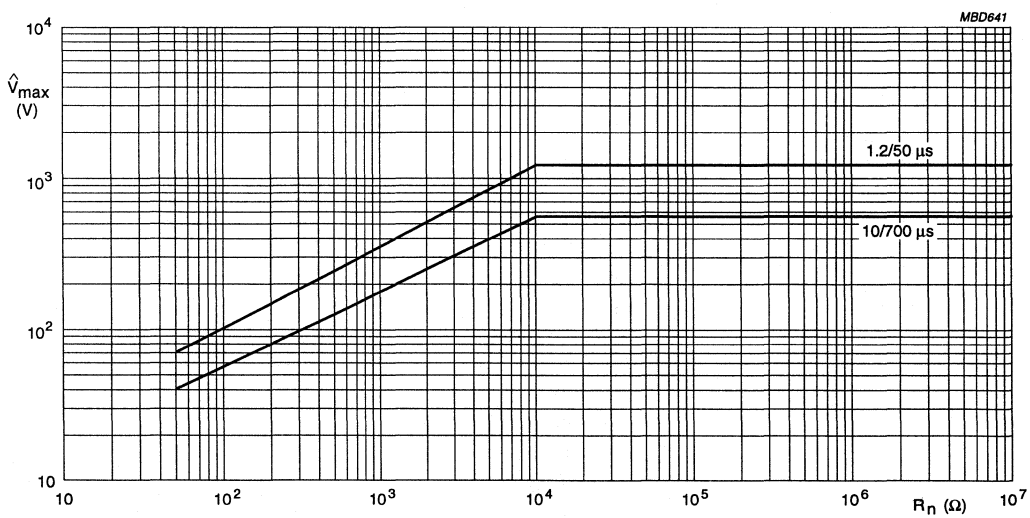


Fig.1 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

PULSE LOADING CAPABILITIES



These pulses may not be applied on a regular basis.

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

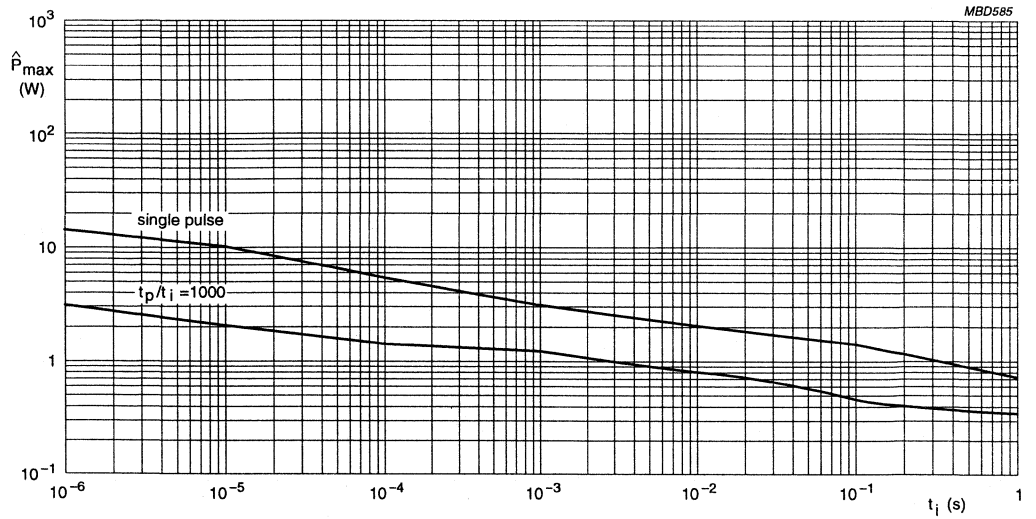


Fig.3 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration for R ≤ 10 kΩ, single pulse and repetitive pulse t_p/t_i = 1 000.

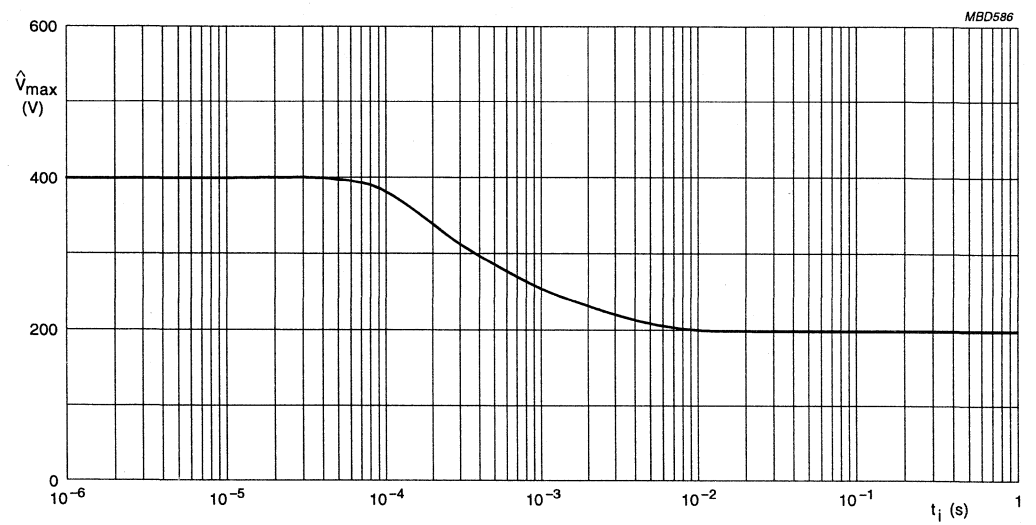


Fig.4 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration.

High precision chip resistor size 1206

RC03G

MECHANICAL DATA

Mass per 100 units

TYPE	MASS (g)
RC03G	1

Marking

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

4-DIGIT MARKING

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

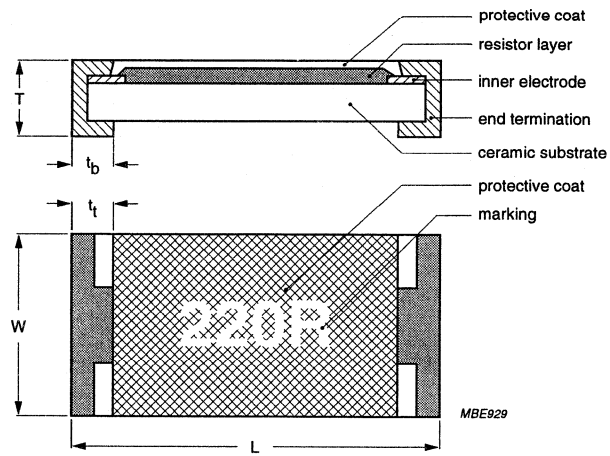
Example

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

PACKAGE MARKING

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

Outlines



For dimensions see Table 3.

Fig.5 Outlines.

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

TYPE	L (mm)	W (mm)	T (mm)	t_t (mm)	t_b (mm)
RC03G	3.20 +0.10/–0.20	1.60 ±0.15	0.55 ±0.10	0.45 ±0.25	0.50 ±0.25

TESTS AND REQUIREMENTS

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

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

Unless otherwise specified the following values apply:

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

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

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

All soldering tests are performed with mildly activated flux.

Table 4 Test procedures and requirements

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.17	20 (Ta)	soldering	unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C; flux 600	good tinning (≥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; 3 directions; total 6 hours	no damage ΔR/R max.: ±0.25% +0.05 Ω
4.20	29 (Eb)	bump	3 × 1500 bumps in 3 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

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.24.2	3 (Ca)	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; loaded with $0.01P_n$ (IEC steps: 0 to 100 V); dissipation ≤1 mW	R_{ins} min.: 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
4.13		short time overload	room temperature; dissipation $6.25 \times P_n$; 5 s (voltage not more than $2 \times V_{max}$)	ΔR/R max.: ±0.25% +0.05 Ω
4.8.4.2		temperature coefficient	between –55 °C and +125 °C	R < 250 Ω: ≤ $\pm 100 \times 10^{-6}$/K 250 Ω ≤ R: ≤ $\pm 50 \times 10^{-6}$/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

Trimmable chip resistor size 1206

RC02TR

FEATURES

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

APPLICATIONS

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

DESCRIPTION

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

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

QUICK REFERENCE DATA

DESCRIPTION	VALUE
Resistance range	1 Ω to 1 MΩ; E24 series
Resistance tolerance	0/–20% and 0/–30%
Maximum trimming factor	2×
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
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. This stability data is valid for non-trimmed resistors. Some properties can change after trimming because of insufficient lacquering.

ORDERING INFORMATION

Ordering code (12NC)

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

Table 1 Ordering code indicating resistor type and packaging

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

FUNCTIONAL DESCRIPTION

Product characterization

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

Limiting values

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

Note

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

DERATING

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

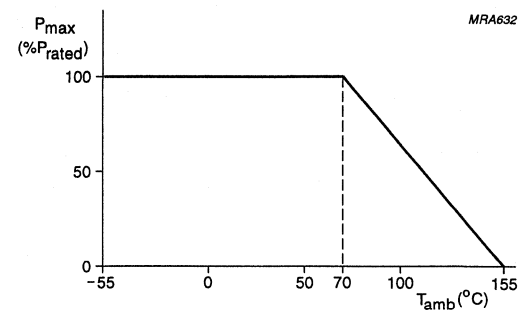


Fig.1 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

Application information

TRIMMING INSTRUCTIONS WITH YAG-LASER

Typical values for:

Cutting speed = 30 to 300 mm/s

Laser power = 1 to 8 W

Maximum trimming length = 60% of resistor film width

Minimum distance between end termination and trimming cut = 0.20 mm

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

PROTECTION OF LASER CUT

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

Trimmable chip resistor size 1206

RC02TR

MECHANICAL DATA

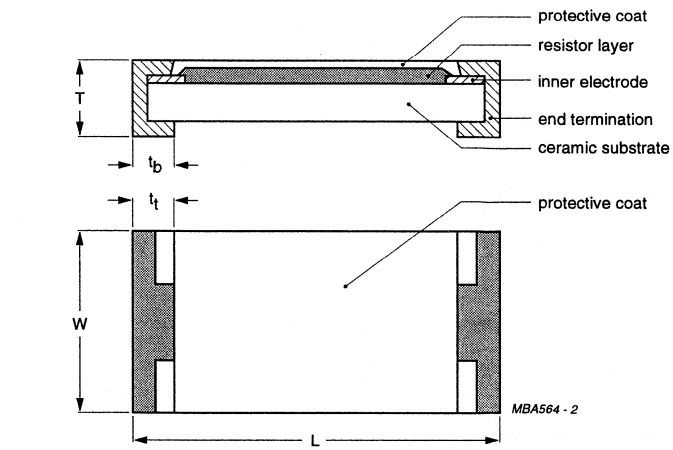
Mass per 100 units

TYPE	MASS (g)
RC02TR	1

Marking

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

Outlines



For dimensions see Table 2.

Fig.2 Outlines.

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

TYPE	L (mm)	W (mm)	T (mm)	t_t (mm)	t_b (mm)
RC02TR	3.20 +0.10/–0.20	1.60 ±0.15	0.55 ±0.10	0.45 ±0.25	0.50 ±0.25

TESTS AND REQUIREMENTS

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

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

Unless otherwise specified the following values apply:

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

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

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

All soldering tests are performed with mildly activated flux.

Table 3 Test procedures and requirements

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.17	20 (Ta)	soldering	unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±10 °C; flux 600; 0.2% 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 +155 °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; 3 directions; total 6 hours	no damage ΔR/R max.: ±0.5% +0.05 Ω
4.20	29 (Eb)	bump	3 × 1500 bumps in 3 directions; 40 g	no damage ΔR/R max.: ±0.25% +0.05 Ω
		bending	resistors mounted on a 90 mm glass epoxy resin printed-circuit board (JIS-c5200); bending: 3 mm	no visual damage ΔR/R max.: ±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	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

Trimmable chip resistor size 1206

RC02TR

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.: ±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 +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

Low-ohmic chip resistor 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.

ORDERING INFORMATION

Ordering code (12NC)

The resistors have a 12 digit ordering code starting with 2322 724. The following 5 digits are indicated in Table 1.

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

QUICK REFERENCE DATA

DESCRIPTION	VALUE
Resistance range	50 mΩ to 910 mΩ; E24 series
Resistance tolerance	±5%
Temperature coefficient:	
50 mΩ ≤ R < 75 mΩ	$\leq \pm 2000 \times 10^{-6}$/K
75 mΩ ≤ R < 100 mΩ	$\leq \pm 1500 \times 10^{-6}$/K
100 mΩ ≤ R < 150 mΩ	$\leq \pm 1000 \times 10^{-6}$/K
150 mΩ ≤ R < 400 mΩ	$\leq \pm 750 \times 10^{-6}$/K
400 mΩ ≤ R < 1 Ω	$\leq \pm 250 \times 10^{-6}$/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, 1000 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%)

Table 1 Resistance values and relevant ordering code

VALUE (mΩ)	ORDERING CODE 2322 724 .....
51	96032
56	96033
62	96034
68	96035
75	96036
82	96037
91	96038
100	96002
110	96003
120	96004
130	96005
150	96006
160	96007
180	96008
200	96009
220	96026

VALUE (mΩ)	ORDERING CODE 2322 724 .....
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

FUNCTIONAL DESCRIPTION

Product characterization

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"*.

Limiting values

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

Note

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

DERATING

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

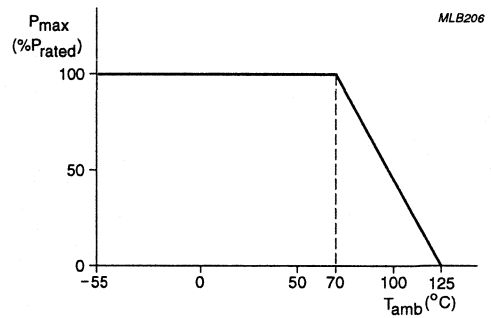


Fig.1 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

Temperature coefficient

Figure 2 shows the typical temperature coefficient of the resistor.

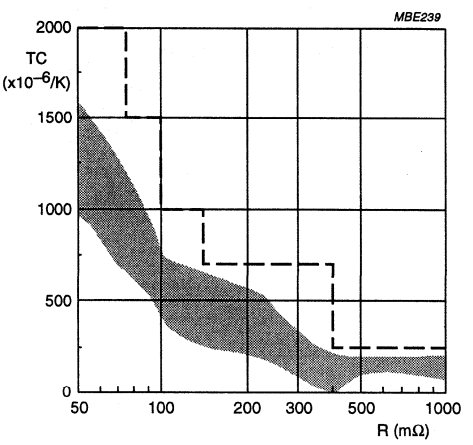


Fig.2 Typical TC as a function of resistance.

Low-ohmic chip resistor size 1206

LRC01

MECHANICAL DATA

Mass per 100 units

TYPE	MASS (g)
LRC01	1

Marking

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

4-DIGIT MARKING

The R is used as a decimal point.

Magnitude indicators

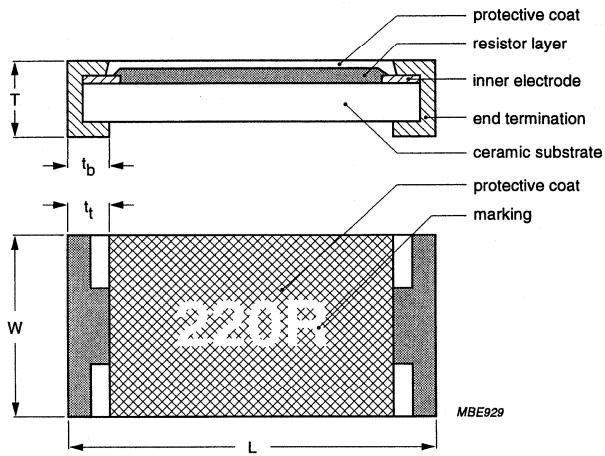
RESISTANCE	INDICATOR
50 mΩ to 910 mΩ	R

Example

MARKING	RESISTANCE
R210	0.210 Ω
R560	0.560 Ω

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

Outlines



For dimensions see Table 2

Fig.3 Outlines.

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

TYPE	L (mm)	W (mm)	T (mm)	t_t (mm)	t_b (mm)
LRC01	3.20 +0.10/–0.20	1.60 ±0.15	0.55 ±0.10	0.45 ±0.25	0.50 ±0.25

TESTS AND REQUIREMENTS

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

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

Unless otherwise specified the following values apply:

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

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

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

All soldering tests are performed with mildly activated flux.

Table 3 Test procedures and requirements

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
Tests in accordance with the schedule of IEC publication 115-8				
4.4.1		visual examination		no holes; clean surface; no damage
4.4.2		dimensions (outline)	gauge	0.45 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%): 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

Low-ohmic chip resistor size 1206

LRC01

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 $0.01P_n$ (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	50 mΩ ≤ R < 75 mΩ: ≤ $\pm 2000 \times 10^{-6}$/K 75 mΩ ≤ R < 100 mΩ: ≤ $\pm 1500 \times 10^{-6}$/K 100 mΩ ≤ R < 150 mΩ: ≤ $\pm 1000 \times 10^{-6}$/K 150 mΩ ≤ R < 400 mΩ: ≤ $\pm 750 \times 10^{-6}$/K 400 mΩ ≤ R < 1 Ω: ≤ $\pm 250 \times 10^{-6}$/K

Low-ohmic chip resistor size 1206

LRC01

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
Other tests in accordance with IEC 115 clauses and IEC 68 test method				
4.17	20 (Tb)	solderability (after ageing)	16 hours steam or 16 hours at 155 °C; unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C; flux 600	good tinning (≥95% covered); no damage
4.22	6 (Fc)	vibration (mounted state)	frequency: 10 to 500 Hz; displacement 1.5 mm or acceleration 10 g; 3 directions; total 6 hours	no damage $\Delta R/R$ max.: ±1% +0.05 Ω
4.20	29 (Eb)	bump (mounted state)	3 × 1500 bumps in 3 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 chip resistor size 1206

FRC01

FEATURES

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

APPLICATIONS

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

DESCRIPTION

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

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

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

QUICK REFERENCE DATA

DESCRIPTION	VALUE
Resistance range	1 to 240 Ω; E24 series
Resistance tolerance	±5%
Temperature coefficient:	
1 to 4.7 Ω	$\leq \pm 250 \times 10^{-6}$/K
5.1 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, 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, 400 V max.	ΔR/R max.: ±1% +0.05 Ω

ORDERING INFORMATION

Table 1 Ordering code indicating type and packaging

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

Ordering code (12NC)

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

Table 2 Last digit of 12NC

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

ORDERING EXAMPLE

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

Fusible chip resistor size 1206

FRC01

FUNCTIONAL DESCRIPTION

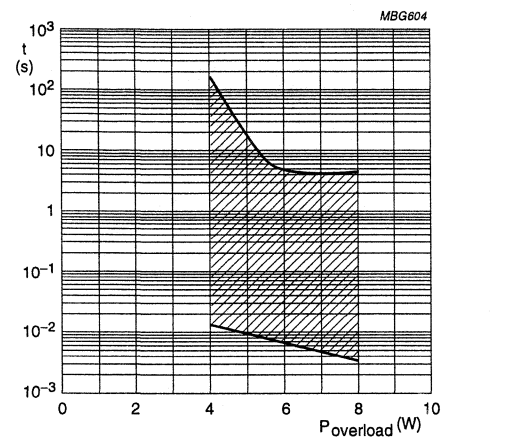
Product characterization

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

Fusing characteristics

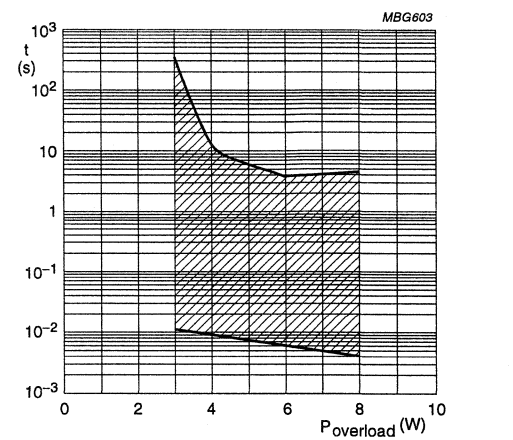
The resistors will fuse without the risk of fire and within an indicated range of overload. Fusing means that the resistive value of the resistor increases at least 1000 times; see Figs 1 and 2.

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



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

Fig.1 Fusing characteristic: 10 Ω ≤ R < 240 Ω, measured using ceramic board material.



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

Fig.2 Fusing characteristic: 1 Ω ≤ R < 240 Ω, measured using glass epoxy (FR4) board material.

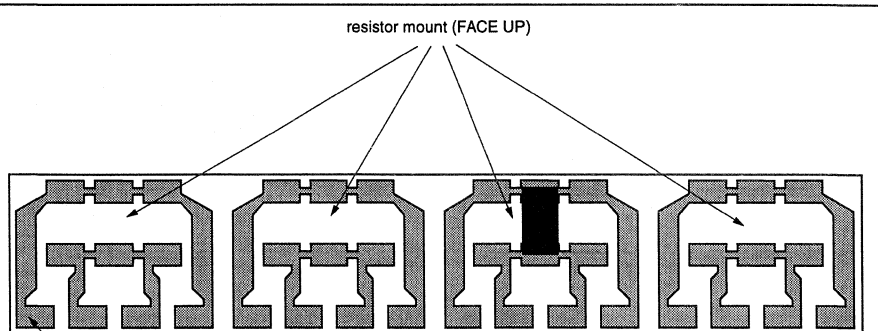


Fig.3 Test substrate layout.

Limiting values

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

Notes

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

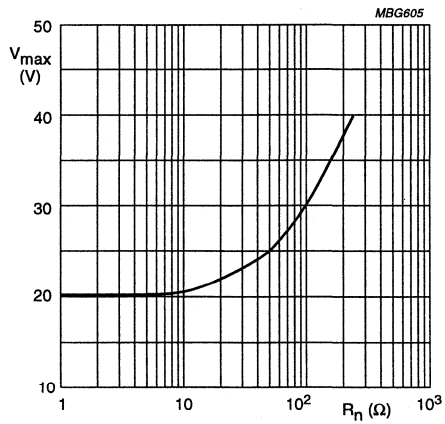


Fig.4 Maximum applicable voltage after fusing.

DERATING

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

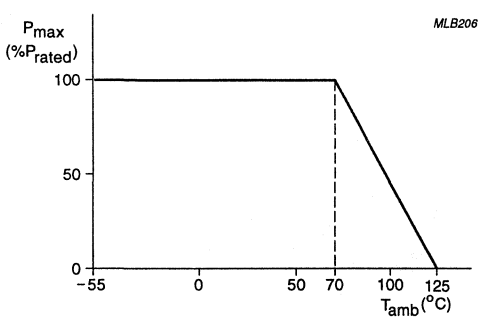
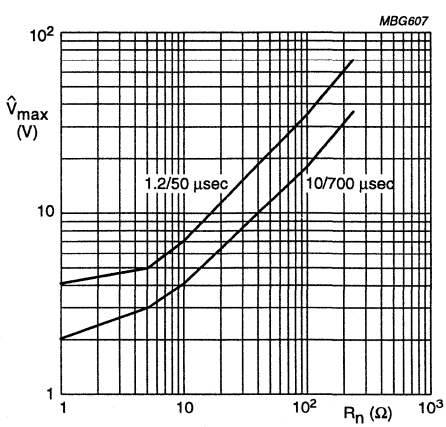


Fig.5 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

PULSE LOADING CAPABILITIES



These pulses may not be applied on a regular basis.

Fig.6 Maximum permissible peak pulse voltage without failing to 'open circuit' in accordance with DIN IEC 40 (CO) 533.

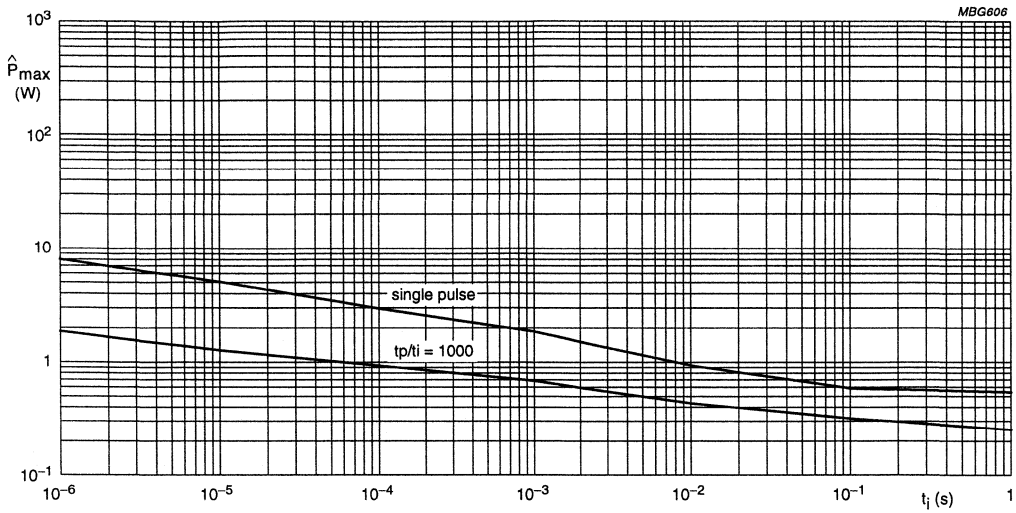


Fig.7 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration, single pulse and repetitive pulse $t_p/t_i = 1000$.

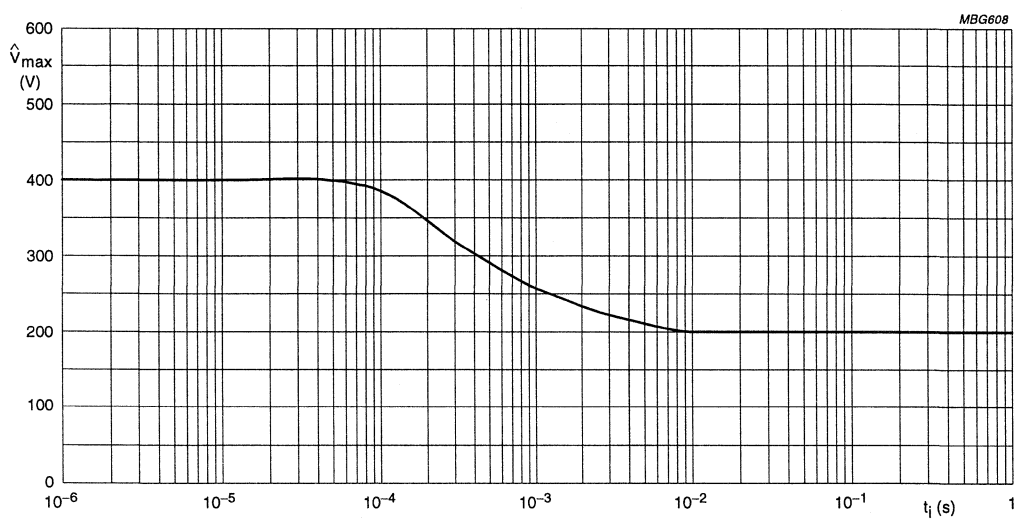


Fig.8 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration.

Fusible chip resistor size 1206

FRC01

MECHANICAL DATA

Mass per 100 units

TYPE	MASS (g)
FRC01	1.0

Marking

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

4-DIGIT MARKING

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

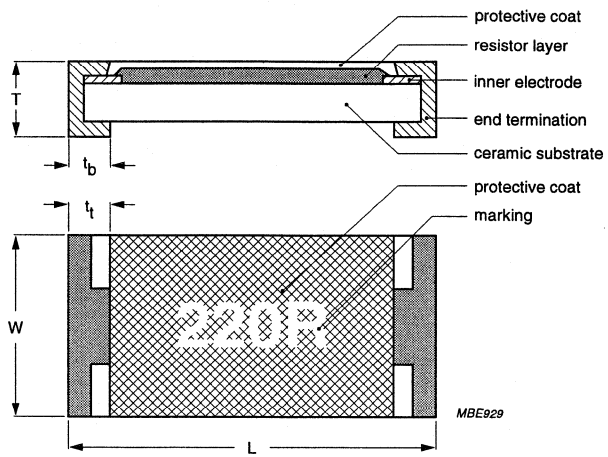
Example

MARKING	RESISTANCE
120R	120 Ω

PACKAGE MARKING

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

Outlines



For dimensions see Table 3.

Fig.9 Outlines.

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

TYPE	L (mm)	W (mm)	T (mm)	t_t (mm)	t_b (mm)
FRC01	3.20 +0.10/−0.20	1.60 ±0.15	0.55 ±0.10	0.45 ±0.25	0.50 ±0.25

TESTS AND REQUIREMENTS

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

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

Unless otherwise specified the following values apply:

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

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

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

All soldering tests are performed with mildly activated flux.

Table 4 Test procedures and requirements

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
Tests in accordance with the schedule of IEC publication 115-8				
4.4.1		visual examination		no holes; clean surface; no damage
4.4.2		dimensions (outline)	gauge (mm)	$0.45 \leq T \leq 0.65$ $1.45 \leq W \leq 1.75$ $3.0 \leq L \leq 3.3$
4.5		resistance	applied voltage (+0/–10%): $R < 10\ \Omega$: 0.1 V $10\ \Omega \leq R < 100\ \Omega$: 0.3 V $100\ \Omega \leq R < 240\ \Omega$: 1 V	$R - R_{nom}$: max. ±5%
4.18	20 (Ta)	resistance to soldering heat	unmounted chips; 10 s; 260 ±5 °C	no visual damage $\Delta R/R$ max.: ±1% +0.05 Ω
4.29	45 (Xa)	component solvent resistance	isopropyl alcohol or H_2O followed by brushing in accordance with *"MIL 202 F"*	no visual damage
4.17	20 (Ta)	solderability	unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C	good tinning (≥95% covered); no visual damage
4.7		voltage proof on insulation	maximum voltage (RMS) during 1 minute metal block method	no breakdown or flashover
4.13		short time overload	room temperature; $P = 6.25 \times P_n$; 5 s ($V \leq 2 \times V_{max}$)	$\Delta R/R$ max.: ±1% +0.05 Ω
4.33		bending	resistors mounted on a 90 mm glass epoxy resin PCB (FR4), bending: 3 mm	no visual damage $\Delta R/R$ max.: ±1% +0.05 Ω
4.19	14 (Na)	rapid change of temperature	30 minutes at LCT and 30 minutes at UCT; 5 cycles	no visual damage $\Delta R/R$ max.: ±1% +0.05 Ω

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

Power chip resistor size 1218

PRC201

FEATURES

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

APPLICATIONS

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

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
Resistance tolerance and series	±5%; E24 series
Temperature coefficient:	
$1\ \Omega \leq R < 10\ \Omega$	$\leq \pm 200 \times 10^{-6}$/K
$10\ \Omega \leq R \leq 1\ M\Omega$	$\leq \pm 100 \times 10^{-6}$/K
Absolute maximum dissipation at T_{amb} = 70 °C	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, 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	ΔR/R max.: ±1% +0.05 Ω

ORDERING INFORMATION

Table 1 Ordering code indicating resistor type and packaging

TYPE	ORDERING CODE 2322 735	
	EMBOSSED CARRIER TAPE ON REEL	
	1000 units	5000 units
PRC201	30...	60...

Ordering code (12NC)

- The resistors have a 12-digit ordering code starting with 2322 735
- The subsequent two digits indicate the resistor type and packaging; see Table 1
- The remaining 3 digits indicate the resistance value:
  - The first 2 digits indicate the resistance value
  - The third digit indicates the resistance decade in accordance with Table 2.

Table 2 Last digit of 12NC

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

ORDERING EXAMPLE

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

Power chip resistor size 1218

PRC201

FUNCTIONAL DESCRIPTION

Product characterization

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

Limiting values

TYPE	LIMITING VOLTAGE(1) (V)	LIMITING POWER (W)
PRC201	200	1

Note

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

DERATING

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

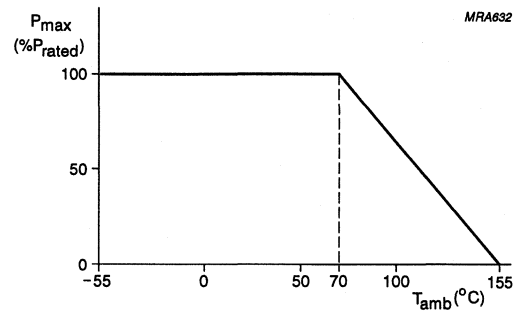
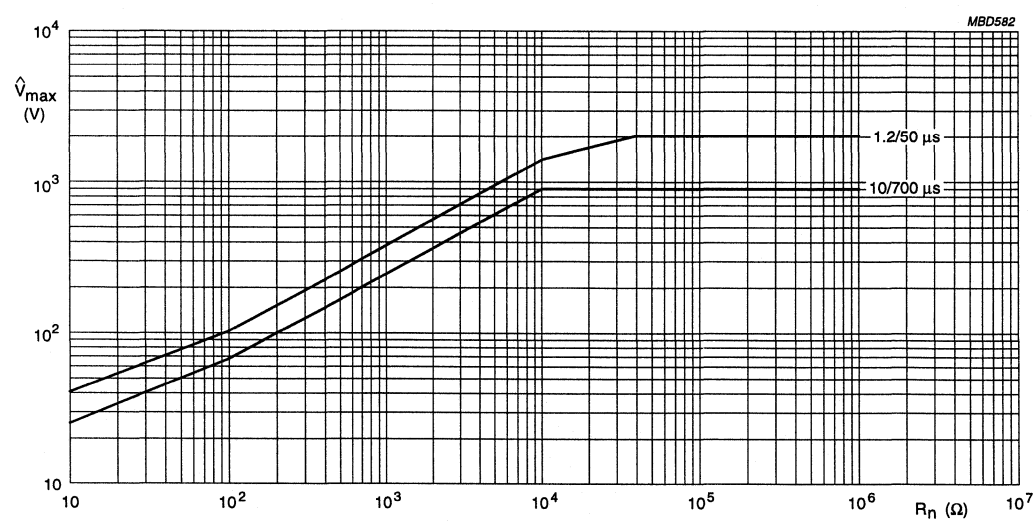


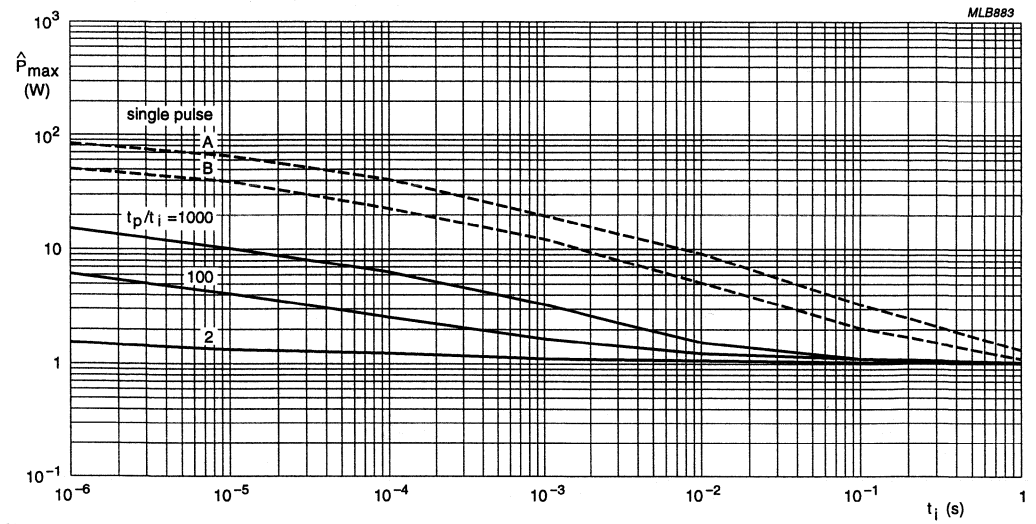
Fig.1 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

PULSE LOADING CAPABILITIES



These pulses may not be applied on a regular basis.

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



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

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

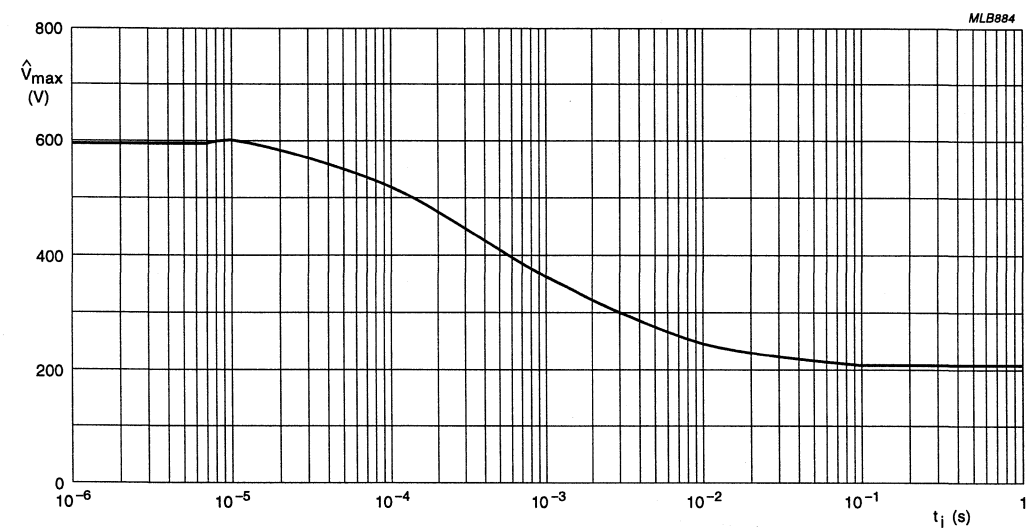


Fig.4 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration.

Application information

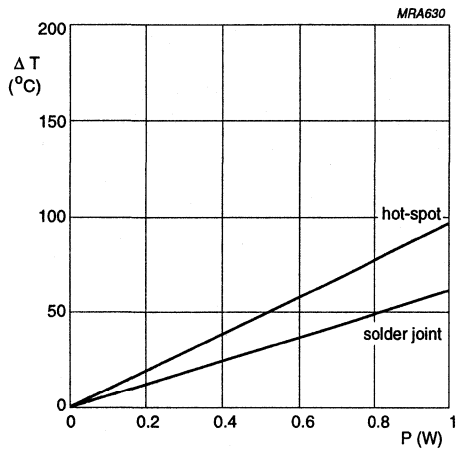


Fig.5 Temperature rise at hot-spot and solder joint as a function of dissipated power, for a resistor mounted horizontally on ceramic PCB.

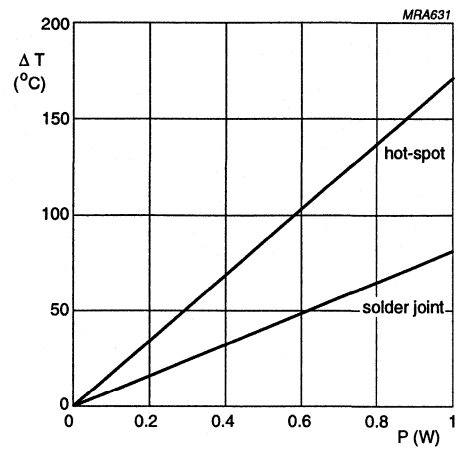


Fig.6 Temperature rise at hot-spot and solder joint as a function of dissipated power, for a resistor mounted horizontally on a FR4 PCB.

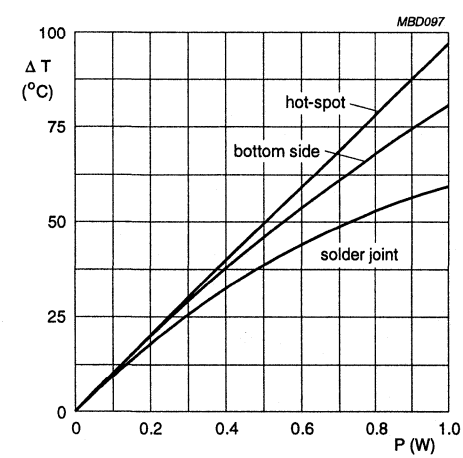


Fig.7 Temperature rise at hot-spot and solder joint as a function of dissipated power, for a resistor horizontally mounted on the test substrate; see Fig.8.

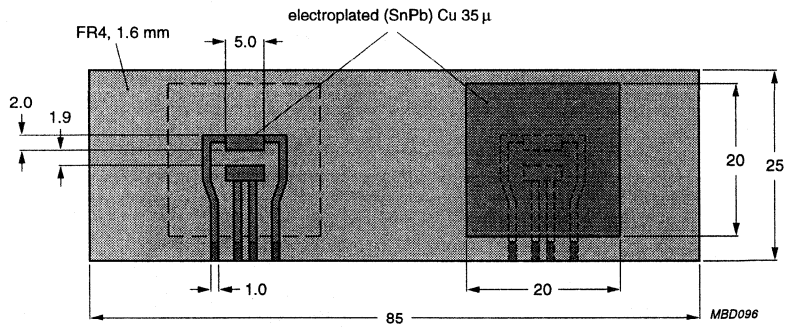


Fig.8 Test substrate layout.

Power chip resistor size 1218

PRC201

MECHANICAL DATA

Mass per 100 units

TYPE	MASS (g)
PRC201	3

Marking

Each resistor is marked with the nominal resistance value.

4-DIGIT MARKING

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

Magnitude indicators

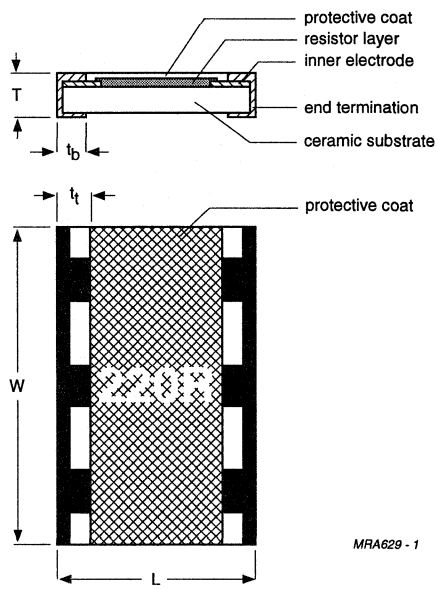
RESISTANCE	INDICATOR
1 to 910 Ω	R
1 to 910 kΩ	K
1 MΩ	M

Example

MARKING	RESISTANCE
120R	120 Ω
4K70	4.70 kΩ

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

Outlines



For dimensions see Table 3.

Fig.9 Outlines.

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

TYPE	L (mm)	W (mm)	T (mm)	t_t (mm)	t_b (mm)
PRC201	3.05 ±0.15	4.60 ±0.20	0.55 ±0.10	0.45 ±0.25	0.50 ±0.25

TESTS AND REQUIREMENTS

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

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

Unless otherwise specified the following values apply:

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

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

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

All soldering tests are performed with mildly activated flux.

Table 4 Test procedures and requirements

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
Tests in accordance with the schedule of IEC publication 115-8				
4.4.1		visual examination		no holes; clean surface; no damage
4.4.2		dimensions (outline)	gauge	0.45 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

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.33		bending	resistors mounted on a 90 mm glass epoxy resin PCB (FR4), bending: 2 mm	no damage $\Delta R/R$ max.: ±1% +0.05 Ω
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 +155 °C; 5 cycles	no visible damage $\Delta R/R$ max.: ±1.0% +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	$\Delta R/R$ 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 $0.01P_n$ (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; 155 °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 20/155/20 °C	1 Ω ≤ R < 10 Ω: $\Delta R/R$ max.: $\pm 200 \times 10^{-6}$/K 10 Ω ≤ R: $\Delta R/R$ max.: $\pm 100 \times 10^{-6}$/K

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
Other tests in accordance with IEC 115 clauses and IEC 68 test method				
4.17	20 (Tb)	solderability (after ageing)	16 hours steam or 16 hours at 155 °C; unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C; flux 600	good tinning (≥95% covered); no damage
4.22	6 (Fc)	vibration (mounted state)	frequency: 10 to 500 Hz; displacement 1.5 mm or acceleration 10 g; 3 directions; total 6 hours	no damage ΔR/R max.: ±1% +0.05 Ω
4.20	29 (Eb)	bump (mounted state)	3 × 1500 bumps in 3 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

PRODUCT SPECIFICATIONS THIN FILM SMD

Metal film precision chip resistor 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
Resistance tolerance	±0.1%; all values; preferred values E24 or E96 series
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.: ±0.25% +0.05 Ω
soldering	ΔR/R max.: ±0.10% +0.05 Ω
short time overload, 200 V max.	ΔR/R max.: ±0.10% +0.05 Ω

Table 1 First digit to indicate packaging for resistances as listed

TYPE	ORDERING CODE 2322 741	
	EMBOSSED CARRIER TAPE ON REEL	
	1000 units	5000 units
MPC01	2....	3....

ORDERING INFORMATION

Ordering code (12NC)

- The resistors have a 12-digit ordering code starting with 2322 741.
- The subsequent first digit indicates the resistor packaging; see Table 1.
- The remaining 4 digits indicate the resistance value:
  - The first 3 digits indicate the resistance value.
  - The last digit indicates the resistance decade in accordance with Table 2.

Table 2 Last digit of 12NC

RESISTANCE DECADE	LAST DIGIT
10 Ω ≤ R < 100 Ω	9
100 Ω ≤ R < 1 kΩ	1
1 kΩ ≤ R < 10 kΩ	2
10 kΩ ≤ R < 100 kΩ	3
100 kΩ	4

ORDERING EXAMPLE

The ordering code of a MPC01 resistor, value 50 Ω, supplied on embossed carrier tape of 5000 units per reel is: 2322 741 35009.

FUNCTIONAL DESCRIPTION

Product characterization

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

Limiting values

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

Note

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

DERATING

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

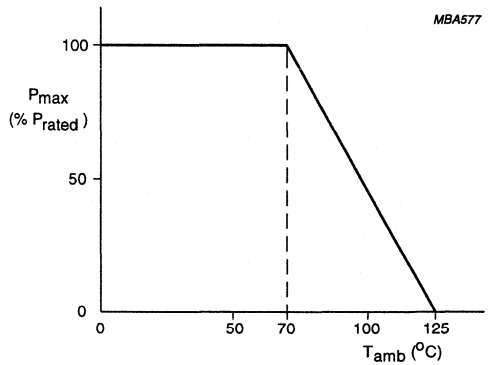
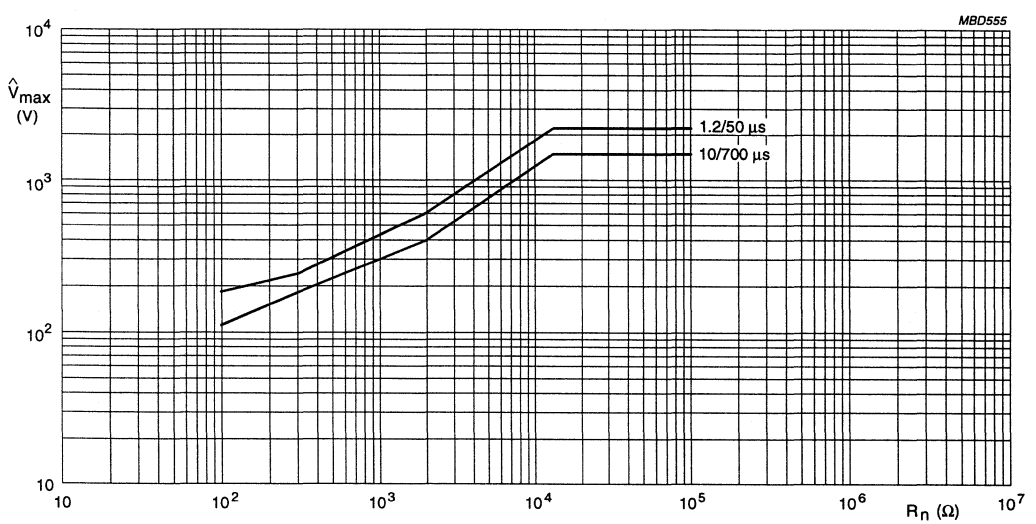


Fig.1 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

PULSE LOADING CAPABILITIES



These pulses may not be applied on a regular basis.

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

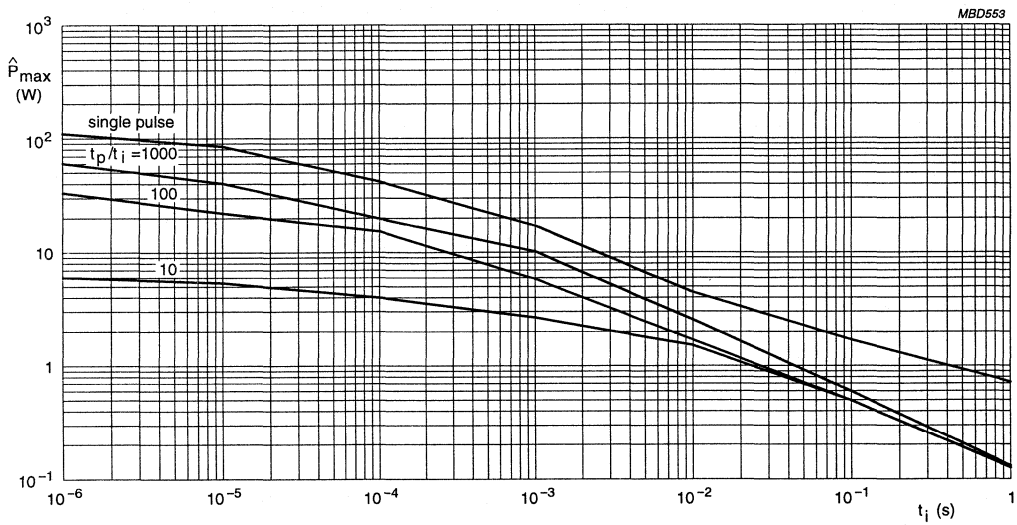


Fig.3 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration for R ≤ 10 kΩ, single pulse and repetitive pulse t_p/t_i.

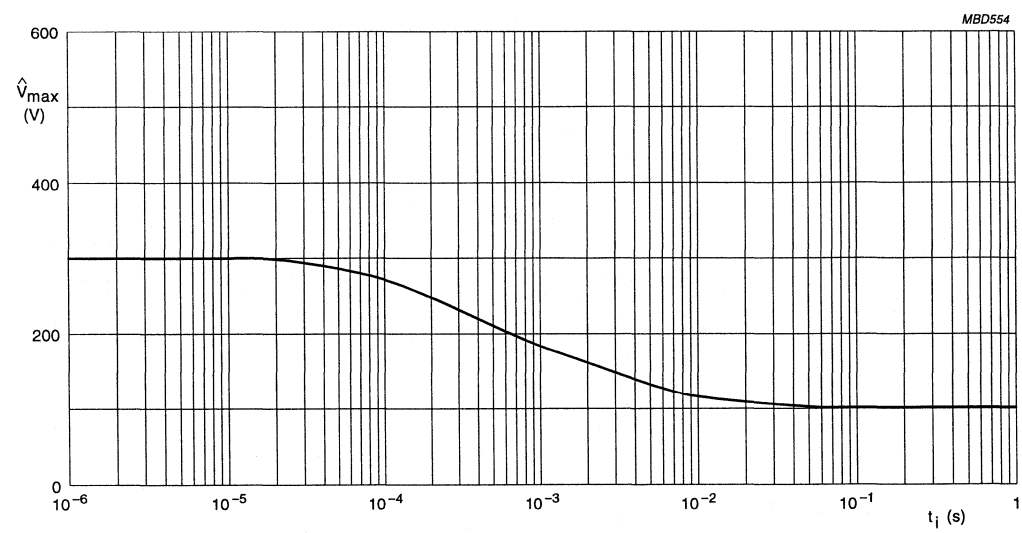


Fig.4 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration.

Metal film precision chip resistor size 1206

MPC01

MECHANICAL DATA

Mass per 100 units

TYPE	MASS (g)
MPC01	1.0

Marking

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

4-DIGIT MARKING

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

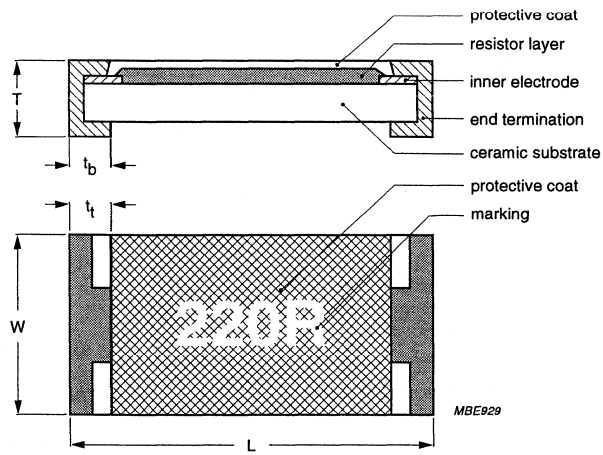
Example

MARKING	RESISTANCE
50R0	50 Ω
4029	402 Ω
1502	15 kΩ

PACKAGE MARKING

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

Outlines



For dimensions see Table 3.

Fig.5 Outlines.

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

TYPE	L (mm)	W (mm)	T (mm)	t_t (mm)	t_b (mm)
MPC01	3.20 +0.10/–0.20	1.60 ±0.15	0.55 ±0.10	0.35 ±0.25	0.50 ±0.25

TESTS AND REQUIREMENTS

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

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

Unless otherwise specified the following values apply:

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

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

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

All soldering tests are performed with mildly activated flux.

Table 4 Test procedures and requirements

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
Tests in accordance with the schedule of IEC publication 115-8				
4.4.1		visual examination		no holes; clean surface; no damage
4.4.2		dimensions (outline)	gauge (mm)	$0.45 \leq T \leq 0.65$ $1.45 \leq W \leq 1.75$ $3.0 \leq L \leq 3.3$
4.5		resistance	applied voltage (+0/–10%): $10\ \Omega \leq R < 100\ \Omega$: 0.3 V $100\ \Omega \leq R < 1\ k\Omega$: 1 V $1\ k\Omega \leq R < 10\ k\Omega$: 3 V $10\ k\Omega \leq R < 100\ k\Omega$: 10 V $100\ k\Omega$: 25 V	$R - R_{nom}$: max. ±0.1%
4.18	20 (Ta)	resistance to soldering heat	unmounted chips; 10 s; 260 ±5 °C	no visual damage $\Delta R/R$ max.: ±0.10% +0.05 Ω
4.29	45 (Xa)	component solvent resistance	isopropyl alcohol or H_2O followed by brushing in accordance with *"MIL 202 F"*	no visual damage
4.17	20 (Ta)	solderability	unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C	good tinning (≥95% covered); no visual damage
4.7		voltage proof on insulation	maximum voltage (RMS) during 1 minute metal block method	no breakdown or flashover
4.13		short time overload	room temperature; $P = 6.25 \times P_n$; 5 s ($V \leq 2 \times V_{max}$)	$\Delta R/R$ max.: ±0.1% +0.05 Ω
4.33		bending	resistors mounted on a 90 mm glass epoxy resin PCB (FR4), bending: 2 mm	no visual damage $\Delta R/R$ max.: ±0.1% +0.05 Ω

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.19	14 (Na)	rapid change of temperature	30 minutes at LCT and 30 minutes at UCT; 5 cycles	no visual damage $\Delta R/R$ max.: ±0.1% +0.05 Ω
4.23 4.23.3 4.23.6	 30 (D) 30 (D)	climatic sequence: damp heat (accelerated) 1st cycle damp heat (accelerated) remaining cycles	 6 days; 55 °C; 95 to 98% RH	 R_{ins} min.: 1000 MΩ $\Delta R/R$ max.: ±0.25% +0.05 Ω
4.24.2	3 (Ca)	damp heat (steady state) (IEC)	56 days; 40 °C; 90 to 95% RH; loaded with 0.01 P_n (IEC steps: 4 to 100 V)	$\Delta R/R$ max.: ±0.25% +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.: ±0.1% +0.05 Ω
4.23.2	27 (Ba)	endurance at upper category temperature	1000 hours; no load	$\Delta R/R$ max.: ±0.1% +0.05 Ω
4.8.4.2		temperature coefficient	at 20/LCT/20 °C and 20/UCT/20 °C ($TC \times 10^{-6}$/K)	≤ ±25
Other tests in accordance with IEC 115 clauses and IEC 68 test method				
4.17	20 (Tb)	solderability (after ageing)	8 hours steam or 16 hours 155 °C; unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C	good tinning (≥95% covered); no damage
4.6.1.1		insulation resistance	voltage (DC) after 1 minute metal block method: 100 V	R_{ins} min.: 1000 MΩ
4.12		noise	IEC publication 195 (measured with Quantech - equipment)	max. 0.10 μV/V
Other applicable tests				
	(JIS)	humidity load (steady state)	1000 hours; +40 °C; 90 to 95% RH; loaded with P_n or V_{max}; 1.5 hours on and 0.5 hours off	$\Delta R/R$ max.: ±0.25% +0.05 Ω
		leaching	unmounted chips 60 s; 260 ±5 °C	good tinning; no leaching
		trio damp heat test	1000 hours; +85 °C; 85% RH; loaded with 0.1 P_n or V_{max}	$\Delta R/R$ max.: ±0.25% +0.05 Ω
	(JIS)	pulse test	2.5 × rated voltage or max. overload; 1 s on and 25 s off; 10^4 cycles	$\Delta R/R$ max.: ±0.5% +0.05 Ω

Metal film precision chip resistor size 0805

MPC11

FEATURES

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

APPLICATIONS

- Computers
- Telecommunication equipment
- Test and measuring equipment.

DESCRIPTION

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

The resistive layer is covered with a protective coat.

ORDERING INFORMATION

Ordering code (12NC)

- The resistors have a 12-digit ordering code starting with 2322 744.
- The subsequent first digit indicates the resistor packaging; see Table 1.
- The remaining 4 digits indicate the resistance value.
  - The first 3 digits indicate the resistance value
  - The last digit indicates the resistance decade in accordance with Table 2.

QUICK REFERENCE DATA

DESCRIPTION	VALUE
Resistance range	14 Ω to 30 kΩ
Resistance tolerance	±0.1%; all values; preferred values E24 or E96 series
Temperature coefficient	$\leq 25 \times 10^{-6}$/K
Absolute maximum dissipation at T_{amb} = 70 °C	0.1 W
Maximum permissible voltage	100 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.: ±0.10% +0.05 Ω
load, 8000 hours at T_{amb} = 70 °C	ΔR/R max.: ±0.25% +0.05 Ω
climatic tests	ΔR/R max.: ±0.25% +0.05 Ω
soldering	ΔR/R max.: ±0.10% +0.05 Ω
short time overload, 200 V max.	ΔR/R max.: ±0.10% +0.05 Ω

Table 1 Ordering code indicating type and packaging

TYPE	ORDERING CODE 2322 744	
	EMBOSSED CARRIER TAPE ON REEL	
	1000 units	5000 units
MPC11	2....	3....

Table 2 Last digit of 12NC

RESISTANCE DECADE	LAST DIGIT
14 Ω ≤ R < 100 Ω	9
100 Ω ≤ R < 1 kΩ	1
1 kΩ ≤ R < 10 kΩ	2
10 kΩ ≤ R ≤ 30 kΩ	3

ORDERING EXAMPLE

The ordering code of a MPC11 resistor, value 50 Ω, supplied on embossed carrier tape of 5000 units per reel is: 2322 744 35009.

FUNCTIONAL DESCRIPTION

Product characterization

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

Limiting values

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

Note

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

DERATING

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

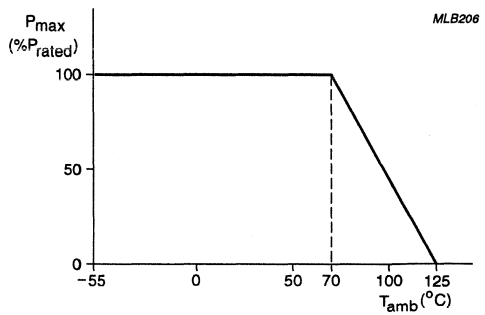


Fig.1 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

PULSE LOADING CAPABILITIES

EXPECTED EARLY 1996

These pulses may not be applied on a regular basis.

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

EXPECTED EARLY 1996

Fig.3 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.

EXPECTED EARLY 1996

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

Metal film precision chip resistor size 0805

MPC11

MECHANICAL DATA

Mass per 100 units

TYPE	MASS (g)
MPC11	0.55

Marking

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

4-DIGIT MARKING

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

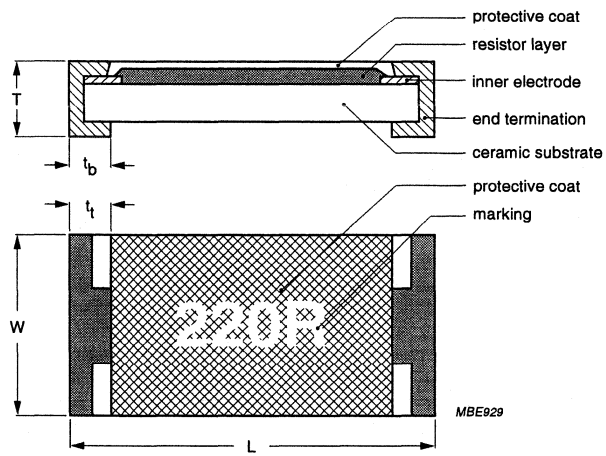
Example

MARKING	RESISTANCE
50R0	50 Ω
4029	402 Ω
1502	15 kΩ

PACKAGE MARKING

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

Outlines



For dimensions see Table 3.

Fig.5 Outlines.

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

TYPE	L (mm)	W (mm)	T (mm)	t_t (mm)	t_b (mm)
MPC11	2.00 ±0.15	1.25 ±0.15	0.55 ±0.10	0.30 ±0.20	0.40 ±0.20

TESTS AND REQUIREMENTS

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

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

Unless otherwise specified the following values apply:

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

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

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

All soldering tests are performed with mildly activated flux.

Table 4 Test procedures and requirements

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
Tests in accordance with the schedule of IEC publication 115-8				
4.4.1		visual examination		no holes; clean surface; no damage
4.4.2		dimensions (outline)	gauge (mm)	$0.45 \leq T \leq 0.65$ $1.10 \leq W \leq 1.40$ $1.85 \leq L \leq 2.15$
4.5		resistance	applied voltage (+0/–10%): $10\ \Omega \leq R < 100\ \Omega$: 0.3 V $100\ \Omega \leq R < 1\ k\Omega$: 1 V $1\ k\Omega \leq R < 10\ k\Omega$: 3 V $10\ k\Omega \leq R < 100\ k\Omega$: 10 V 100 kΩ: 25 V	$R - R_{nom}$: max. ±0.1%
4.18	20 (Ta)	resistance to soldering heat	unmounted chips; 10 s; 260 ±5 °C	no visual damage ΔR/R max.: ±0.10% +0.05 Ω
4.29	45 (Xa)	component solvent resistance	isopropyl alcohol or H_2O followed by brushing in accordance with *"MIL 202 F"*	no visual damage
4.17	20 (Ta)	solderability	unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C	good tinning (≥95% covered); no visual damage
4.7		voltage proof on insulation	maximum voltage (RMS) during 1 minute, metal block method	no breakdown or flashover
4.13		short time overload	room temperature; $P = 6.25 \times P_n$; 5 s ($V \leq 2 \times V_{max}$)	ΔR/R max.: ±0.1% +0.05 Ω
4.33		bending	resistors mounted on a 90 mm glass epoxy resin PCB (FR4), bending: 5 mm	no visual damage ΔR/R max.: ±0.1% +0.05 Ω

Metal film precision chip resistor size 0805 MPC11

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.19	14 (Na)	rapid change of temperature	30 minutes at LCT and 30 minutes at UCT; 5 cycles	no visual damage $\Delta R/R$ max.: ±0.1% +0.05 Ω
4.23 4.23.3 4.23.6	 30 (D) 30 (D)	climatic sequence: damp heat (accelerated) 1st cycle damp heat (accelerated) remaining cycles	 6 days; 55 °C; 95 to 98% RH	 R_{ins} min.: 1000 MΩ $\Delta R/R$ max.: ±0.25% +0.05 Ω
4.24.2	3 (Ca)	damp heat (steady state) (IEC)	56 days; 40 °C; 90 to 95% RH; loaded with 0.01 P_n (IEC steps: 4 to 100 V)	$\Delta R/R$ max.: ±0.25% +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.: ±0.1% +0.05 Ω
4.23.2	27 (Ba)	endurance at upper category temperature	1000 hours; no load	$\Delta R/R$ max.: ±0.1% +0.05 Ω
4.8.4.2		temperature coefficient	at 20/LCT/20 °C and 20/UCT/20 °C ($TC \times 10^{-6}$/K)	≤±25
Other tests in accordance with IEC 115 clauses and IEC 68 test method				
4.17	20 (Tb)	solderability (after ageing)	8 hours steam or 16 hours 155 °C; unmounted chips completely immersed for 2 ±0.5 s in a solder bath at 235 ±5 °C	good tinning (≥95% covered); no damage
4.6.1.1		insulation resistance	voltage (DC) after 1 minute, metal block method: 100 V	R_{ins} min.: 1000 MΩ
4.12		noise	IEC publication 195 (measured with Quantech - equipment)	max. 0.10 μV/V
Other applicable tests				
	(JIS)	humidity load (steady state)	1000 hours; +40 °C; 90 to 95% RH loaded with P_n or V_{max}; 1.5 hours on and 0.5 hours off	$\Delta R/R$ max.: ±0.25% +0.05 Ω
		leaching	unmounted chips 60 s; 260 ±5 °C	good tinning; no leaching
		trio damp heat test	1000 hours; +85 °C; 85% RH loaded with 0.1P_n or V_{max}	$\Delta R/R$ max.: ±0.25% +0.05 Ω
	(JIS)	pulse test	2.5 × rated voltage or max. overload; 1 s on and 25 s off; 10^4 cycles	$\Delta R/R$ max.: ±0.5% +0.05 Ω

LEADED RESISTORS

Fixed Resistors

Selection Guide
Leaded resistors

APPLICATION	TYPE	TOLERANCE (%)	RESISTANCE RANGE	DISSIPATION		PAGE
				(at °C)	(W)	
Carbon film	CR25	5	1 Ω to 10 MΩ	70	0.33	128
Standard metal film	SFR16	5	1 Ω to 3 MΩ	70	0.5	136
	SFR25		1 Ω to 10 MΩ		0.4	
	SFR25H				0.5	
Fusible	NFR25	5	1 Ω to 15 kΩ	70	0.33	149
	NFR25H				0.5	
Metal film	MRS16T	1	4.99 Ω to 1 MΩ	70	0.4	160
	MRS25		1 Ω to 10 MΩ		0.6	
	MR25	0.5	1 Ω to 1 MΩ		0.4	172
	MR30				0.5	
	MR52	1	4.99 Ω to 1 MΩ		1	
MIL metal film	MR24D	1	10 Ω to 1 MΩ	70	0.125	181
	MR34D				0.25	
	MR54D				0.5	
	MR74D				0.75	
	MR24E/C	0.1; 0.25; 0.5; 1	49.9 Ω to 1 MΩ	125	0.1	
	MR34E/C				0.125	
	MR54E/C				0.25	
	MR74E/C		24.9 Ω to 1 MΩ		0.5	
Metal film precision	MPR24	0.05; 0.02; 0.01	24 Ω to 100 kΩ	70	0.125	186
	MPR34				0.25	
	MPR24	0.5; 0.25; 0.1	4.99 Ω to 1 MΩ		0.25	
	MPR34				0.4	
High-ohmic/high-voltage	VR25	1; 5; 10	100 kΩ to 22 MΩ	70	0.25	194
	VR37	1; 5	100 kΩ to 33 MΩ		0.5	
	VR68		100 kΩ to 68 MΩ		1	
Power metal film	PR01	5	0.22 Ω to 1 Ω	70	0.6	202
			1 Ω to 1 MΩ		1	
	PR02		0.33 Ω to 1 Ω		1.2	
			1 Ω to 1 MΩ		2	
	PR03		0.68 Ω to 1 Ω		1.6	
			1 Ω to 1 MΩ		3	
	PR37		1 Ω to 27 kΩ		1.6	222
			30 kΩ to 1 MΩ		1.2	
	PR52		1 Ω to 51 kΩ		2.5	231
			56 kΩ to 1 MΩ		2	

APPLICATION	TYPE	TOLERANCE (%)	RESISTANCE RANGE	DISSIPATION		PAGE
				(at °C)	(W)	
Cemented wirewound	AC01	5	0.1 Ω to 33 kΩ	40	1	240
	AC03				3	
	AC04				4	
	AC05				5	
	AC07				7	
	AC10				10	
	AC15				15	
	AC20				20	
Enamelled wirewound	WR0617E	5	4.7 Ω to 100 kΩ	70	4	250
	WR0825E				7	
	WR0842E				11	
	WR0865E				17	
Stand-up miniature power	SMW02; SMF02	5	0.1 Ω to 47 kΩ	70	2	256
	SMW03; SMF03				3	
	SMW05; SMF05				5	
Precision wirewound	PAC02	1	0.1 Ω to 12 kΩ	25	2	262
	PAC03				3	
	PAC04				4	
	PAC05				5	
	PAC06				6	

INTRODUCTION

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

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

The items listed above are explained in this section *"General Introduction Leaded resistors"*, with detailed information in the relevant data sheet. The sections "Mounting" and "Packaging" are only detailed in the *"General Introduction Leaded resistors"*.

DESCRIPTION

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

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

ORDERING INFORMATION

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

FUNCTIONAL DESCRIPTION

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

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

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

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

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

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

where:

T_m = hot-spot temperature

T_{amb} = ambient temperature

ΔT = temperature rise at hot-spot.

The stability of a film resistor during endurance tests is mainly determined by the hot-spot temperature and the resistance. The lower the resistance - other conditions

remaining constant - the higher the stability due to greater film thickness.

Summarizing

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

Performance

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

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

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

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

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

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

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

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

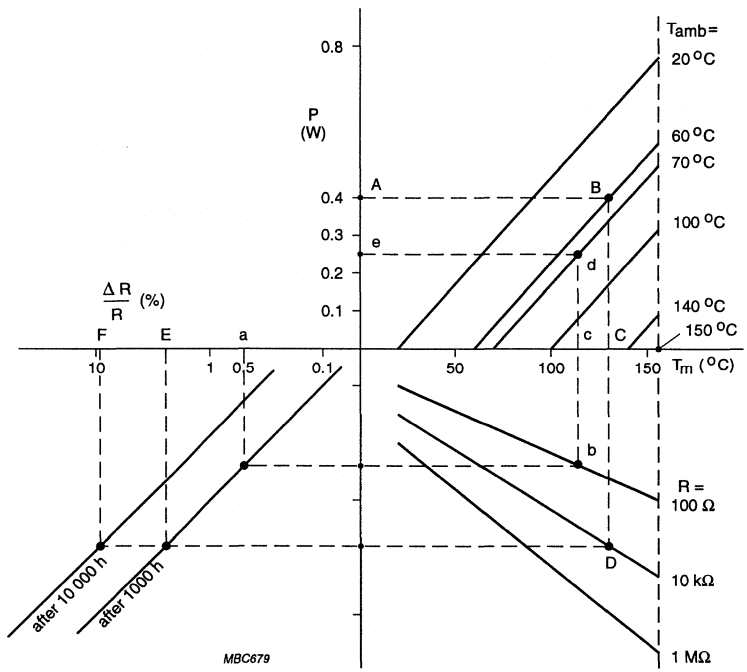


Fig.1 Performance nomogram (for a fictitious resistor) illustrating the way of specifying the performance of film resistors.

Example 1

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

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

Example 2

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

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

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

The temperature coefficient

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

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

at 25 °C:

1000000 Ω (nominal = rated value)

at +155 °C:

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

at −55 °C:

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

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

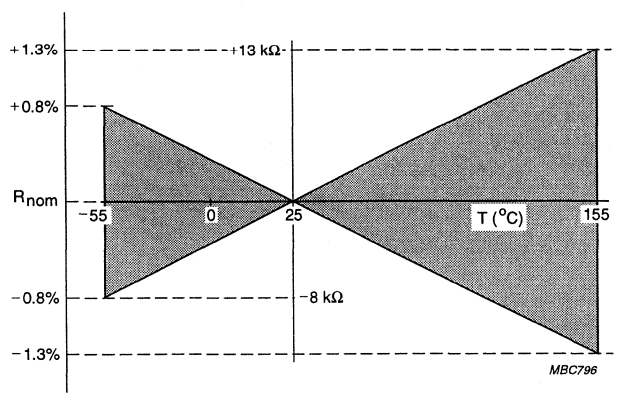


Fig.2 Temperature coefficient.

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

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

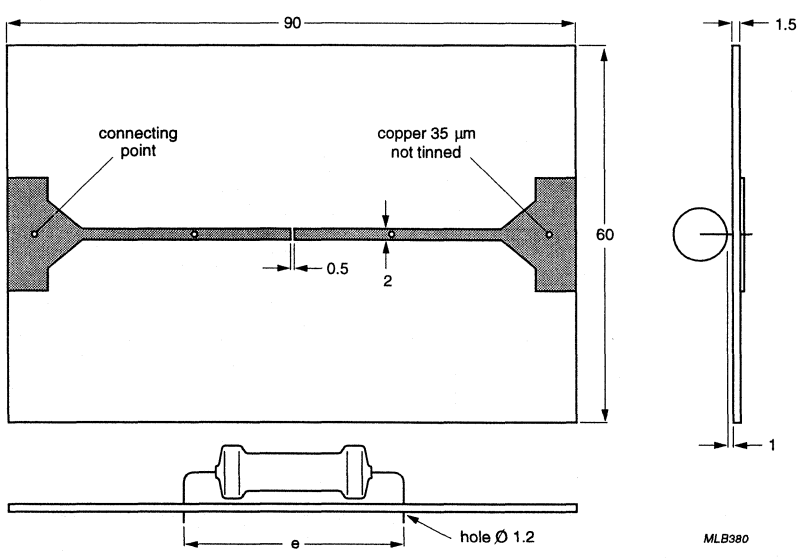
PULSE-LOAD BEHAVIOUR

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

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

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

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



Dimensions in mm.

Fig.3 Mounting dimensions.

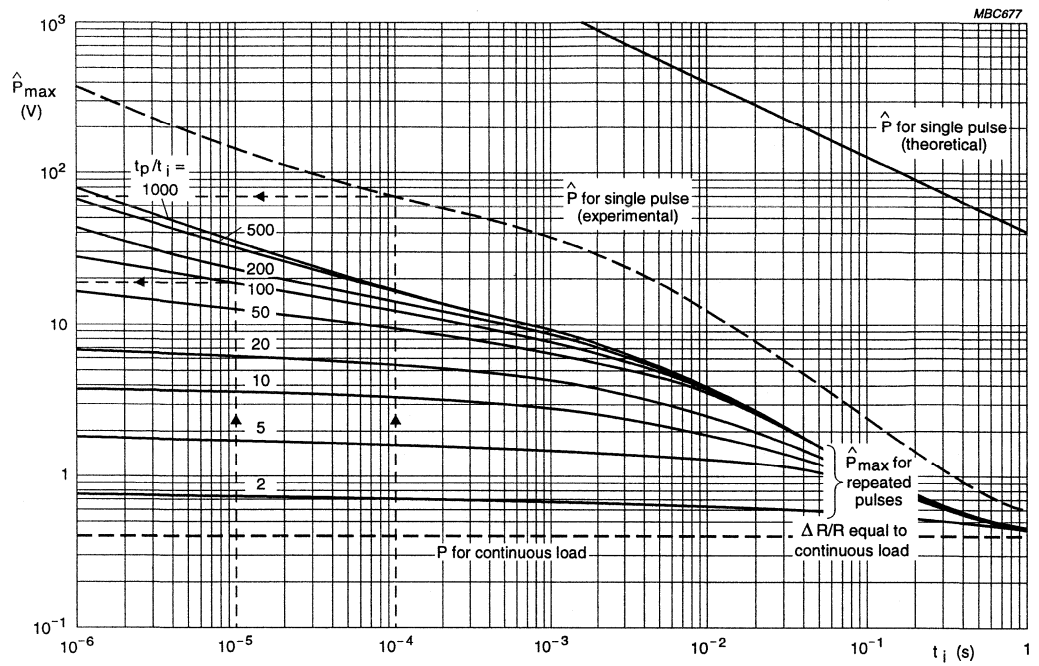


Fig.4 Maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i) for a typical resistor.

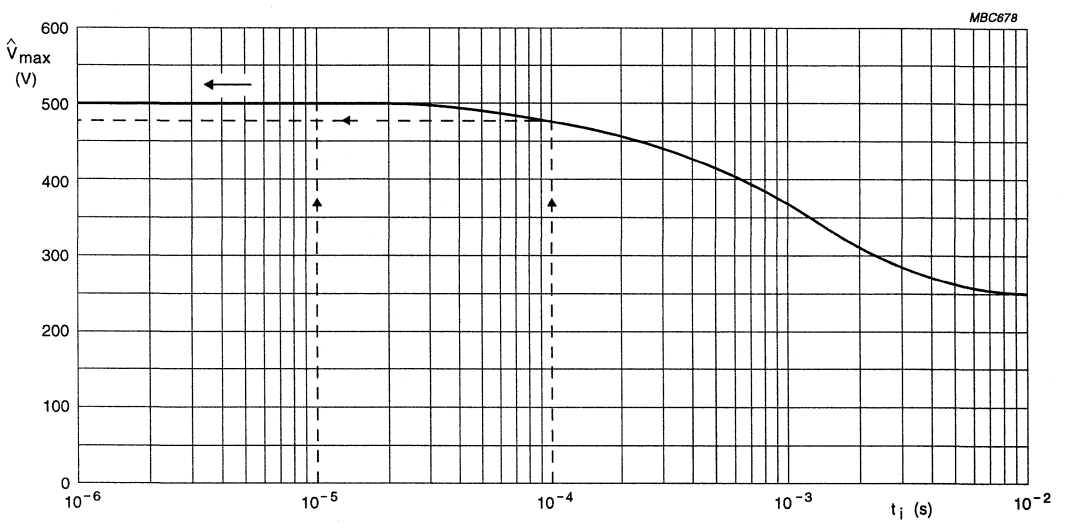


Fig.5 Maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_i) for a typical resistor.

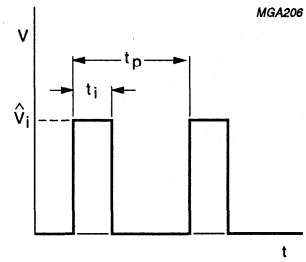


Fig.6 Rectangular pulses.

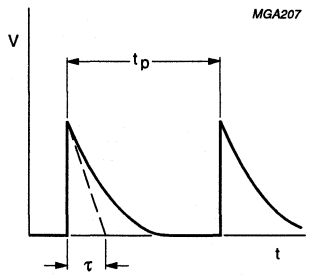


Fig.7 Exponential pulses.

Definition of symbols used in Figs 4, 5, 6 and 7

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

Definitions of pulse-load behaviour; metal film resistors

SINGLE PULSE

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

REPETITIVE PULSE

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

Determination of pulse-load

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

T_{amb} = 70 °C

T_m is the maximum permissible hot-spot temperature for the relevant resistor family

$\Delta R/R$ equal to the permitted value for 1000 hours at continuous level.

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

Examples

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

CONTINUOUS PULSE TRAIN

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

Therefore:

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

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

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

SINGLE PULSE

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

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

Therefore:

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

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

MECHANICAL DATA

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

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

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

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

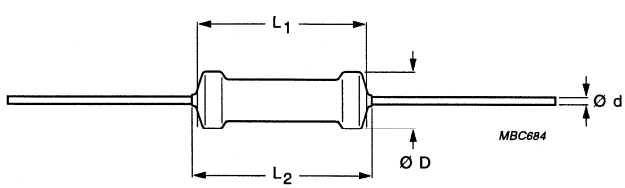
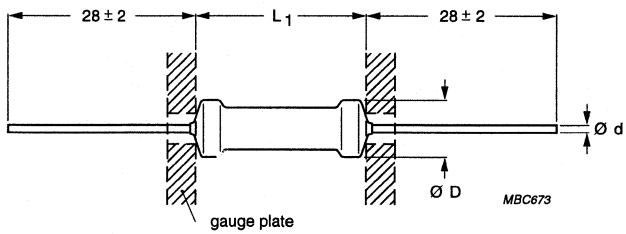
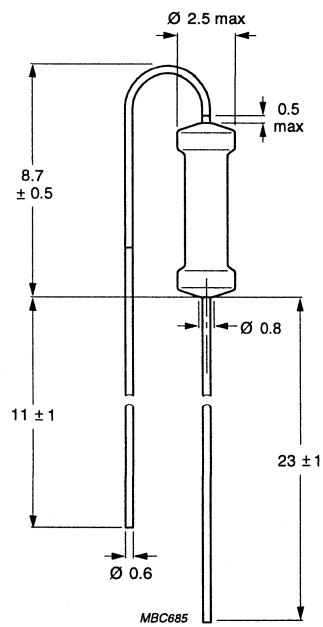


Fig.8 Component outline.



Dimensions in mm.
For dimensions see Table 1.

Fig.9 Measurement of dimension L_1.



Dimensions in mm.

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

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

Table 1 Lead diameter and hole dimensions

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

Mass

The mass is given per 100 resistors.

Marking

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

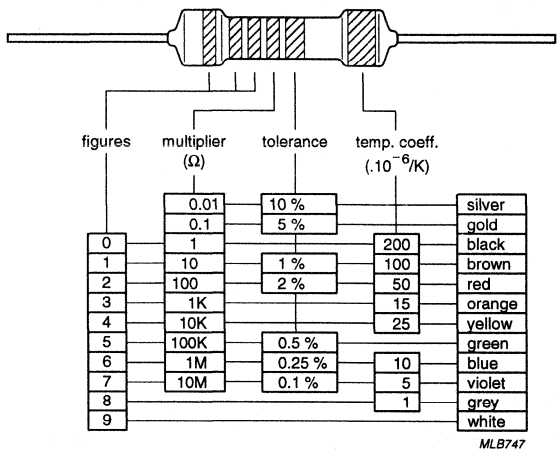


Fig.11 Marking.

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

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

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

Body colours

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

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

Mounting

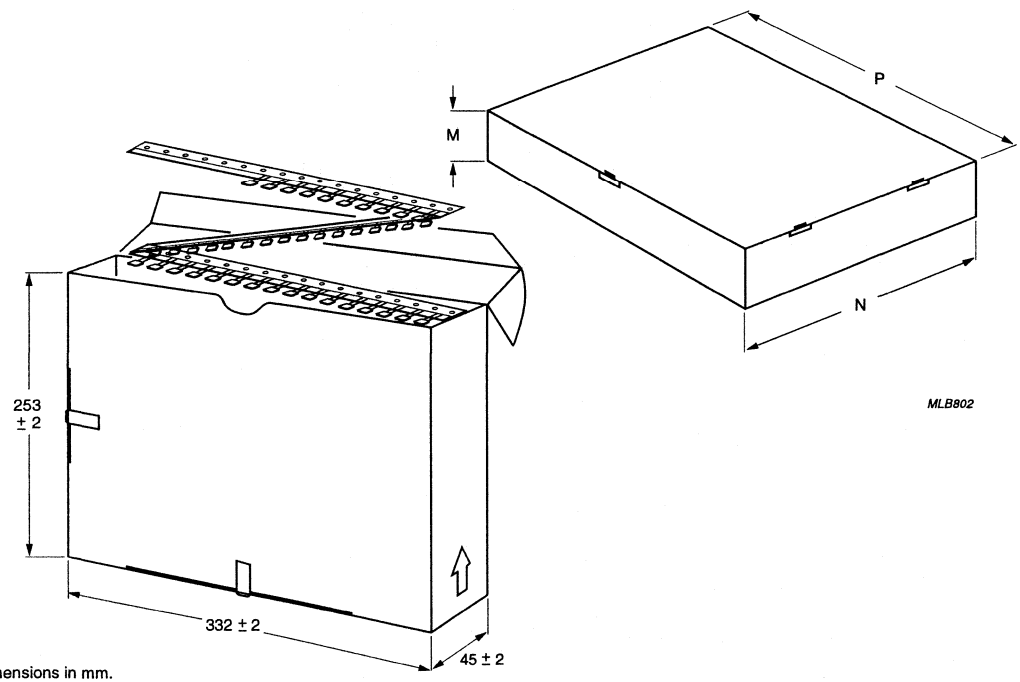
Most types with straight axial leads and most in the 'stand-up' version (radial leads; see Fig.10) are suitable for processing on automatic insertion equipment, cutting and bending machines.

TESTS AND REQUIREMENTS

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

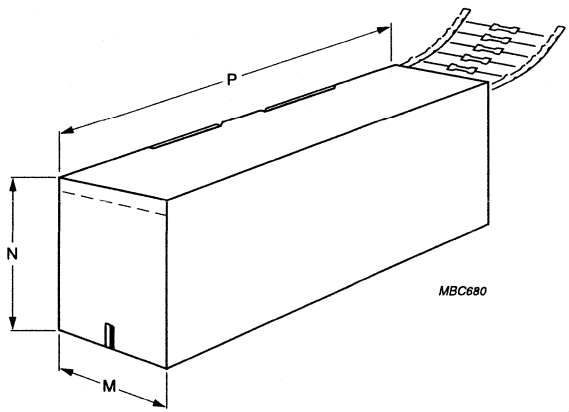
PACKAGING

Dimensions of ammopack and reel



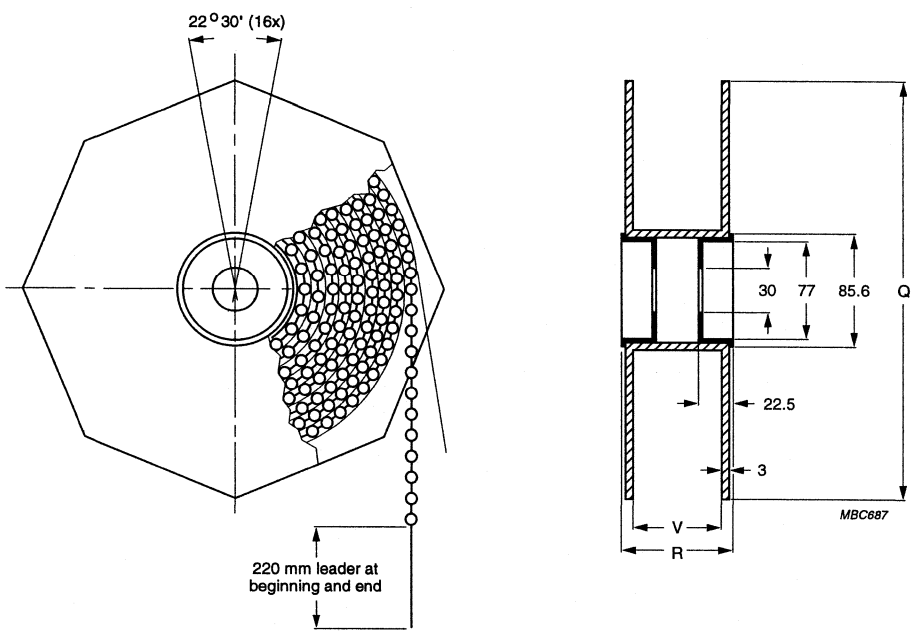
Dimensions in mm.
For dimensions see Table 7.

Fig.12 Dimensions of ammopack (radial taped).



For dimensions see Table 3.

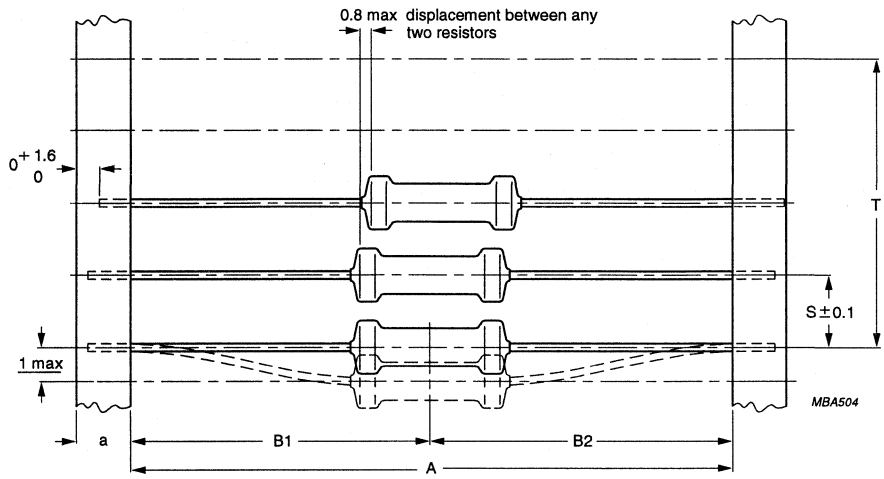
Fig.13 Bandolier in ammopack.



Dimensions in mm.
For dimensions see Table 4.

Fig.14 Bandolier on reel.

Products with straight leads



Dimensions in mm.
Maximum 1 mm per 10 spacings.
Maximum 0.5 mm per 5 spacings.
For dimensions see Tables 3 and 4.

Fig.15 Axial style on tape.

Table 3 Resistor type, quantities and packaging dimensions for axial taped in ammopack; see Figs 13 and 15

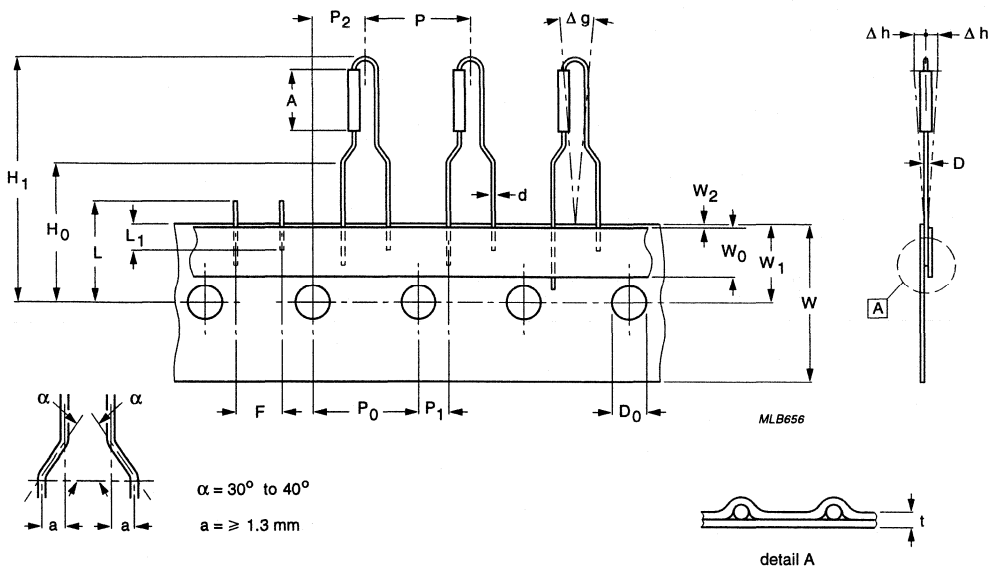
PRODUCT TYPE	QUANTITY	PACKAGING DIMENSIONS						
		AXIAL TAPED ON BANDOLIER				AMMOPACK		
		a (mm)	A (mm)	$\lvert B_1 - B_2 \rvert$ (mm)	S (mm)	M (mm)	N (mm)	P (mm)
CR25	5000	6 ±0.5	52.5 ±1.5	±1.2	5	78	98	270
SFR16	1000	6 ±0.5	52.5 ±1.5	±1.2	5	75	30	140
	5000	6 ±0.5	52.5 ±1.5	±1.2	5	75	73	270
SFR25	1000	6 ±0.5	52 +1.5/–0	±1.2	5	82	28	262
	5000	6 ±0.5	52 +1.5/–0	±1.2	5	78	98	270
SFR25H	1000	6 ±0.5	52 +1.5/–0	±1.2	5	82	28	262
	5000	6 ±0.5	52 +1.5/–0	±1.2	5	78	98	270
NFR25	1000	6 ±0.5	52 +1.5/–0	±1.2	5	82	28	262
	5000	6 ±0.5	52 +1.5/–0	±1.2	5	78	98	270
NFR25H	1000	6 ±0.5	52 +1.5/–0	±1.2	5	82	28	262
	5000	6 ±0.5	52 +1.5/–0	±1.2	5	78	98	270
MRS16T	1000	6 ±0.5	52 +1.5/–0	±0.5	5	75	30	140
	5000	6 ±0.5	52 +1.5/–0	±0.5	5	75	73	270

PRODUCT TYPE	QUANTITY	PACKAGING DIMENSIONS						
		AXIAL TAPED ON BANDOLIER				AMMOPACK		
		a (mm)	A (mm)	$\lvert B_1 - B_2 \rvert$ (mm)	S (mm)	M (mm)	N (mm)	P (mm)
MRS25	1000	6 ±0.5	52 +1.5/–0	±1.2	5	82	28	262
	5000	6 ±0.5	52 +1.5/–0	±1.2	5	78	98	270
MR25	1000	6 ±0.5	52 +1.5/–0	±1.2	5	82	28	262
MR30	1000	6 ±0.5	52 +1.5/–0	±1.2	5	77	34	265
MR52	1000	6 ±0.5	66.7 ±1.5	±1.2	10	97	95	260
MPR24	500 or 1000	6 ±0.2	63.5 ±1.5	±1.2	5	97	29	262
MPR34	500 or 1000	6 ±0.2	63.5 ±1.5	±1.2	5	97	39	262
VR25	1000	6 ±0.5	26 +1.5/–0	±1.0	5	82	28	262
	2000	6 ±0.5	26 +1.5/–0	±1.0	5	50	50	255
	5000	6 ±0.5	52 +1.5/–0	±1.2	5	78	98	270
VR37	1000	6 ±0.5	52 +1.5/–0	±1.2	5	83	60	262
VR68	500	5 ±0.5	66.7 ±1.5	±1.2	10	85	112	258
PR01	1000	6 ±0.5	73 ±1.5	±1.2	5	97	28	262
PR02	1000	6 ±0.5	73 ±1.5	±1.2	5	97	59	262
PR03	500	6 ±0.5	80 ±1.5	±1.2	10	99	77	259
PR37	1000	6 ±0.5	73 ±1.5	±1.2	5	97	59	262
PR52	500	6 ±0.5	68 ±1.5	±1.2	10	97	77	259
AC01	1000	6 ±0.5	63 ±4	±1.2	10	85	60	263
AC03	500	6 ±0.5	63 ±4	±1.2	10	85	77	259
AC04	500	6 ±0.5	63 ±4	±1.2	10	85	77	259
AC05	500	6 ±0.5	63 ±4	±1.2	10	85	115	259
AC07	500	6 ±0.5	74 ±4	±1.2	10	93	115	259
WR0617E	500	5 ±0.5	66.7 ±1.6	±1.2	10	85	77	259
WR0825E	500	6 ±0.5	74 ±1.6	±1.2	10	93	115	259
WR0842E	100	6 ±0.5	88 ±1.6	±1.2	10	132	56	160
WR0865E	100	6 ±0.5	110 ±1.6	±1.2	10	132	56	160
PAC02	500	6 ±0.5	63 ±1	±1.2	10	85	60	263
PAC03	500	6 ±0.5	63 ±1	±1.2	10	85	60	263
PAC04	500	6 ±0.5	71 ±1	±1.2	10	97	120	273
PAC05	500	6 ±0.5	71 ±1	±1.2	10	97	120	273
PAC06	500	6 ±0.5	71 ±1	±1.2	10	97	120	273

Table 4 Resistor type, quantities and packaging dimensions for axial taped on reel; see Figs 14 and 15

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

Products with radial leads



For dimensions see Tables 5 and 6.

Fig.16 Bandolier for types with radial leads.

Table 5 Product dependent tape dimensions; see Fig.16

SYMBOL	PARAMETER	TYPE	VALUE	TOLERANCE	UNIT
D	maximum body diameter	See detailed product specification			mm
A	maximum body length				mm
d	lead wire diameter				mm
H_1	component height	SFR25	28	±3.0	mm
		NFR25	28	±3.0	mm
		NFR25H	28	±3.0	mm
		PR01	28	±3.0	mm
		PR02	29	±3.0	mm
		AC01	29	±3.0	mm

Table 6 Tape dimensions; non-product dependent; see Fig.16

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

Table 7 Resistor type, quantities and dimensions of the packaging for radial taped in ammopack; see Fig.12

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

Products with cropped and formed leads

Table 8 Resistor type, quantities and dimensions of the packaging for cropped and formed, loose in box; see Fig.12

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

PRODUCT SPECIFICATION LEADED

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"*.

Ordering code (12NC)

- The resistors have a 12-digit ordering code starting with 2322 211
- The subsequent 2 digits indicate the packaging; see Table 1
- The remaining 3 digits indicate the resistance value:
  - The first 2 digits indicate the resistance value
  - The last digit indicates the resistance decade in accordance with Table 2.

QUICK REFERENCE DATA

DESCRIPTION	VALUE
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.1
climatic tests:	
R ≤ 220 kΩ	ΔR/R max.: ±1.5% +0.1 Ω
R > 220 kΩ	ΔR/R max.: ±3%
soldering	ΔR/R max.: ±0.5% +0.05 Ω
short time overload	ΔR/R max.: ±1% +0.05 Ω

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.

ORDERING INFORMATION

Table 1 Ordering code indicating resistor type and packaging; note 1

TYPE	ORDERING CODE 2322 ... .
	BANDOLIER IN AMMOPACK
	5000 units
CR25	73...

Note

1. Alternative packaging is available on request.

Table 2 Last digit of 12NC

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

ORDERING EXAMPLE

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

FUNCTIONAL DESCRIPTION

Product characterization

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

Figure 1 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 1000 hours of operation.

NOTES ON NOMOGRAM (Fig.1)

1. The nomogram should not be extended beyond the maximum permissible hot-spot temperature of 155 °C.
2. The resistance change given by the nomogram for P = 0 at a particular ambient temperature is indicative of the shelf life stability of a resistor at that temperature.
3. The stability lines do not give exact values for $\Delta R/R$, but represent a probability of 95% that the real values will be smaller than those obtained from the nomogram.
4. In the nomogram the limiting voltage of the resistors has not been taken into consideration.
5. *"IEC publication 115-1"* is still based on the conventional method of rating resistors by a fixed 'rated dissipation' at 70 °C requiring at that dissipation a fixed maximum permissible drift. In our specification, however, the rated dissipation is no longer specified and also the guaranteed resistance drift is made dependent on the working conditions. Figure 4 is added to bridge the gap between the system of IEC 115-1 and our system. In Fig.4 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.4 replaces the rated dissipation.

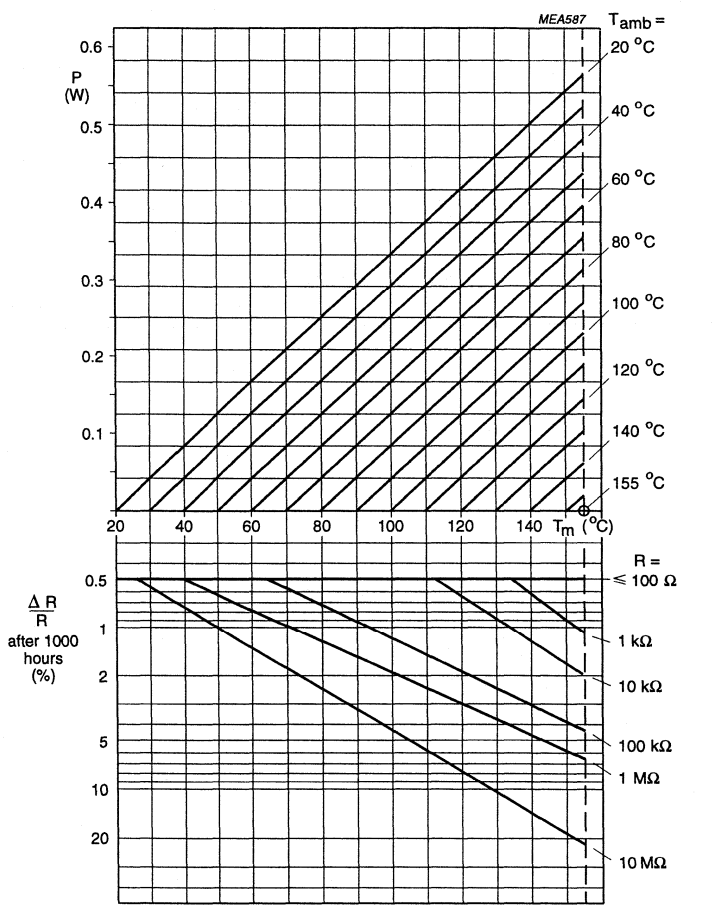


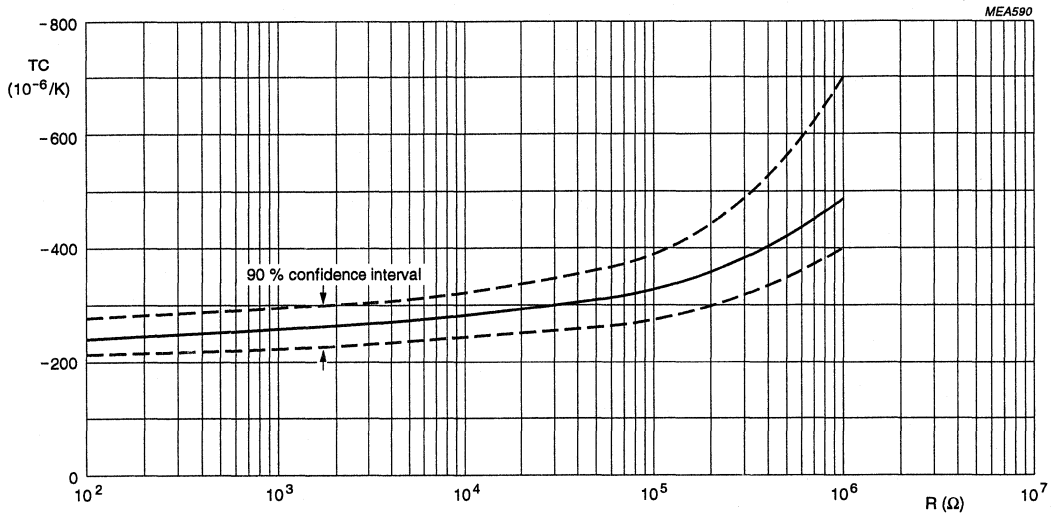
Fig.1 Drift nomogram.

LONG TERM CONTINUOUS OPERATION

For continuous operation longer or shorter than 1000 hours (t_x), the stability can be approximated by multiplying the drift ($\Delta R/R$) after 1000 hours, with the square root of the time ratio as in the following equation:

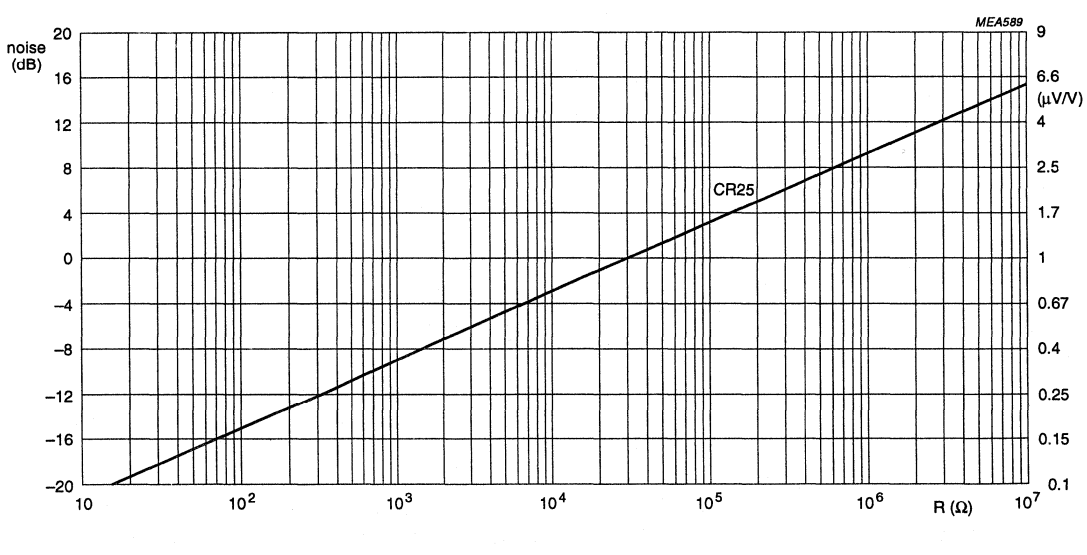
($\Delta R/R$ after $\times$ h) =
($\Delta R/R$ after 1000 h) $\times$ $(t_x/1000)^{1/2}$.

Additional electrical data



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.2 Temperature coefficient as a function of the resistance value.



95% confidence level.

Fig.3 Noise as a function of the resistance value; 0 dB = 1 μV/V.

Limiting values

TYPE	LIMITING VOLTAGE(1) (V)	LIMITING POWER (W)
CR25	250	0.33

Note

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

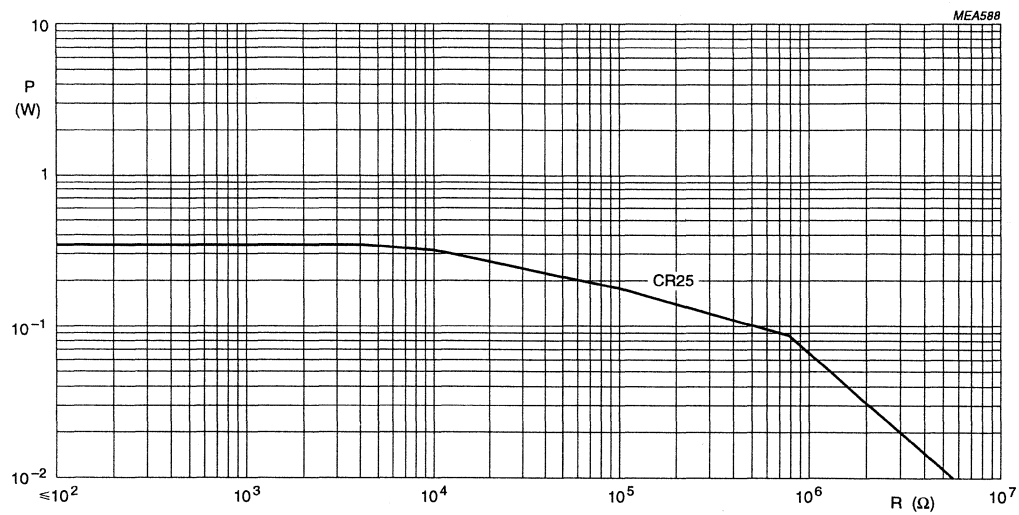


Fig.4 Maximum permissible dissipation at T_{amb} = 70 °C as a function of the resistance value for a resistance drift of 1.5% after 1000 hours, or for a maximum temperature of 155 °C without reaching the resistance drift of 1.5%; limiting voltage being taken into account.

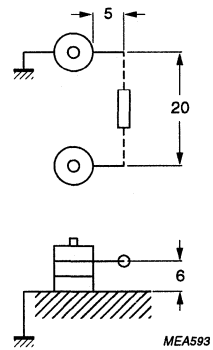
Application information

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 3 gives typical values under test conditions at 250 MHz using the measuring arrangement shown in Fig.5. An RX-meter type 250 A of Boonton Radio Corporation is used.

Table 3 CR25 measured at 250 MHz

R_{nom} (Ω)	$\frac{\lvert z \rvert}{R_{nom}}$	φ (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



Dimensions in mm.

Fig.5 Measuring arrangement.

MECHANICAL DATA

Mass per 100 units

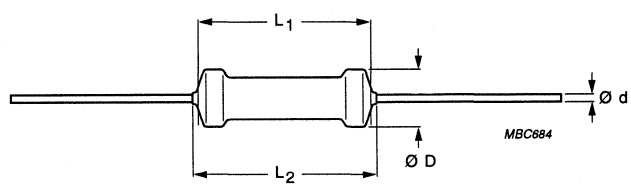
TYPE	MASS (g)
CR25	25

Marking

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

Outlines

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



For dimensions see Table 4.

Fig.6 Component outline.

Table 4 Resistor type and relevant physical dimensions; see Fig.6

TYPE	ØD MAX. (mm)	L_1 MAX. (mm)	L_2 MAX. (mm)	Ød (mm)
MRS25	2.5	6.5	7.5	0.6

TESTS AND REQUIREMENTS

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

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

Unless otherwise specified the following values apply:

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

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

In Table 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.

All soldering tests are performed with mildly activated flux.

Table 5 Test procedures and requirements

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.16	U	robustness of terminations:		
4.16.2	Ua	tensile all samples	Ø0.6 mm; load 10 N; 10 s	number of failures $<10 \times 10^{-6}$
4.16.3	Ub	bending half number of samples	Ø0.6 mm; load 5 N; 4 × 90°	number of failures $<10 \times 10^{-6}$
4.16.4	Uc	torsion other half of samples	3 × 360° in opposite directions	no damage ΔR/R max.: ±0.5% +0.05 Ω
4.17	Ta	solderability	2 s; 235 °C	good tinning; no damage
4.18	Tb	resistance to soldering heat	thermal shock: 3 s; 350 °C; 6 mm from body	ΔR/R max.: ±0.5% +0.05 Ω
4.19	Na	rapid change of temperature	30 minutes at –55 °C and 30 minutes at +155 °C; 5 cycles	ΔR/R max.: ±0.5% +0.05 Ω
4.20	Eb	bump	3 × 1500 bumps in 3 directions; 40 g	no damage ΔR/R max.: ±0.5% +0.05 Ω
4.22	Fc	vibration	frequency 10 to 500 Hz; displacement 1.5 mm or acceleration 10 g; 3 directions; total 6 hours (3 × 2 hours)	no damage ΔR/R max.: ±0.5% +0.05 Ω

Carbon film resistor CR25

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; 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%
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.4	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.4	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.2
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.3
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.4 (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		$<5 \times 10^{-6}$

NOTES

Standard metal film resistors SFR16/25

FEATURES

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

APPLICATIONS

- General purpose resistors.

DESCRIPTION

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

The resistors are coated with a coloured lacquer (light-blue for type SFR16; light-green for type SFR25 and red-brown for type SFR25H) which provides electrical, mechanical and climatic protection. The encapsulation is resistant to all cleaning solvents, in accordance with *"MIL-STD-202E"*, method 215 and *"IEC 68-2045"*.

QUICK REFERENCE DATA

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

ORDERING INFORMATION

Table 1 Ordering code indicating resistor type and packaging

TYPE	ORDERING CODE 2322			
	BANDOLIER IN AMMOPACK			BANDOLIER ON REEL
	RADIAL TAPED	STRAIGHT LEADS		STRAIGHT LEADS
	4000 units	1000 units	5000 units	5000 units
SFR16	–	187 73...	187 53...	187 83...
SFR25	184 03...	181 53...	181 43...	181 63...
SFR25 jumper[1]	–	–	181 90019	–
SFR25H	–	186 16...	186 76...	186 26...

Note

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

Ordering code (12NC)

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

Table 2 Last digit of 12NC

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

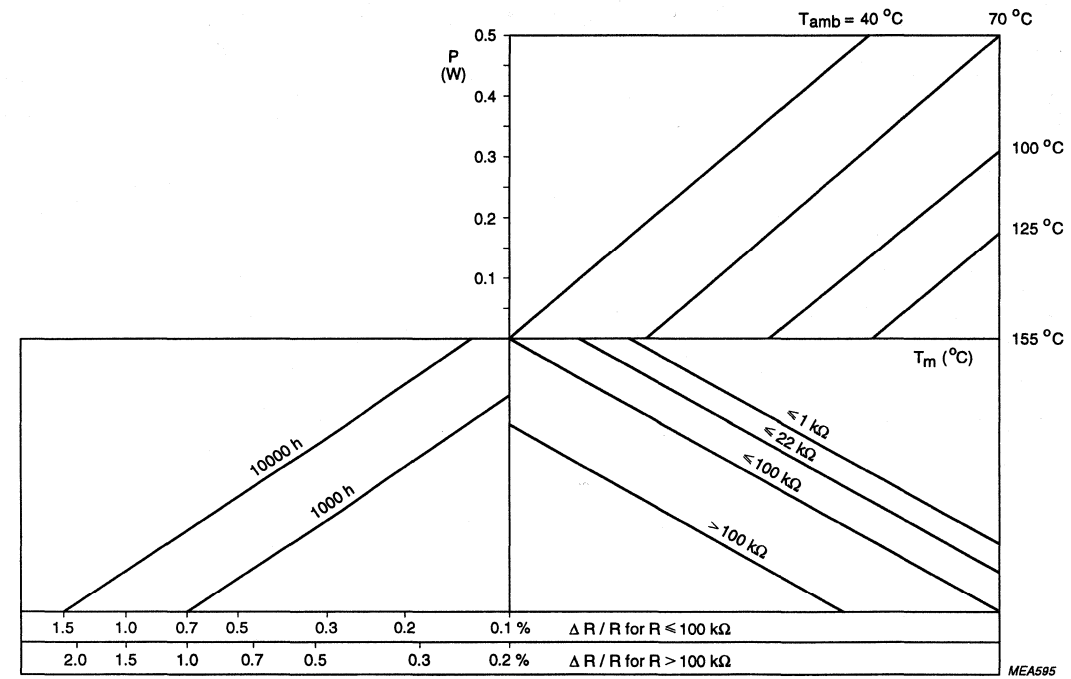
ORDERING EXAMPLE

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

FUNCTIONAL DESCRIPTION

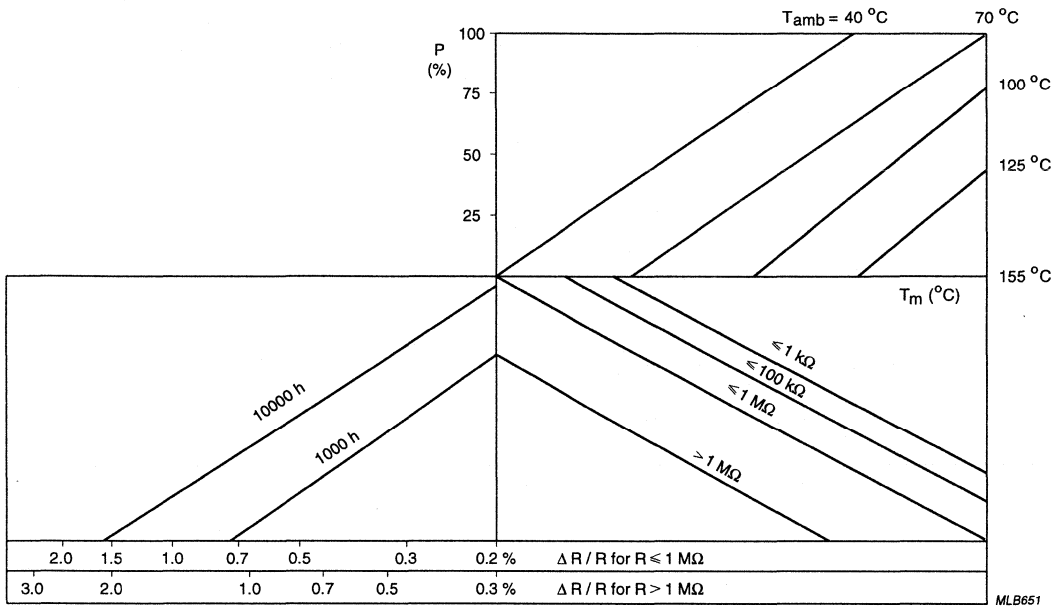
Product characterization

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



SFR16

Fig.1 Drift nomogram.



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

Fig.2 Drift nomogram.

Limiting values

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

Note

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

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

DERATING

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

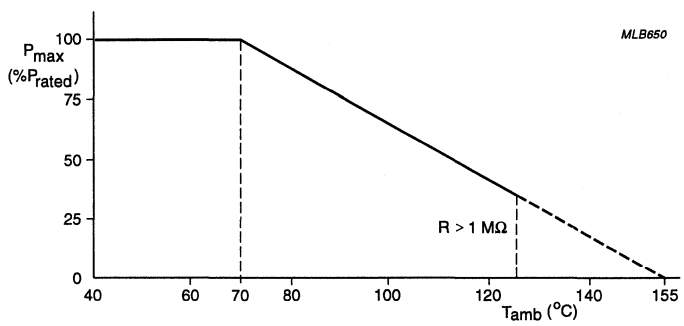


Fig.3 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

PULSE LOADING CAPABILITIES

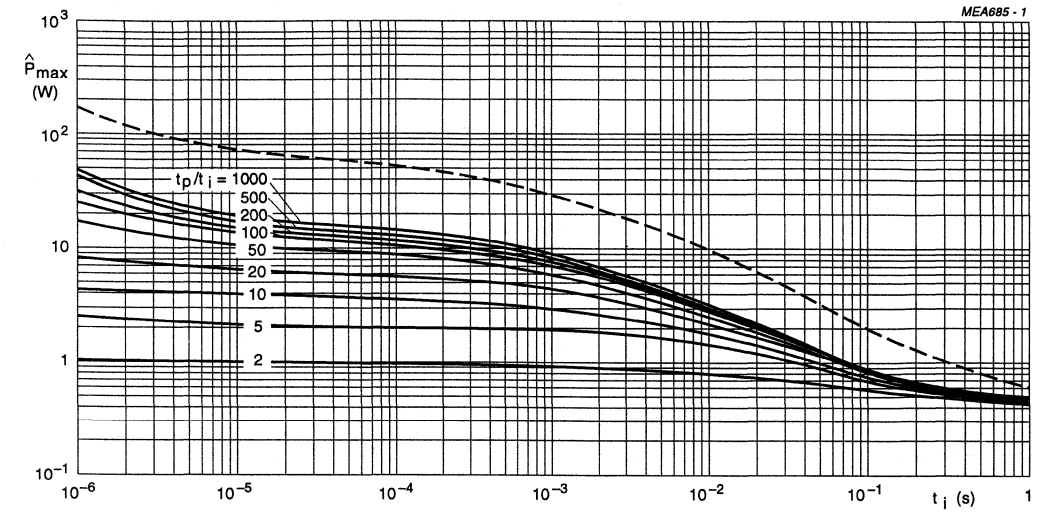


Fig.4 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_j).

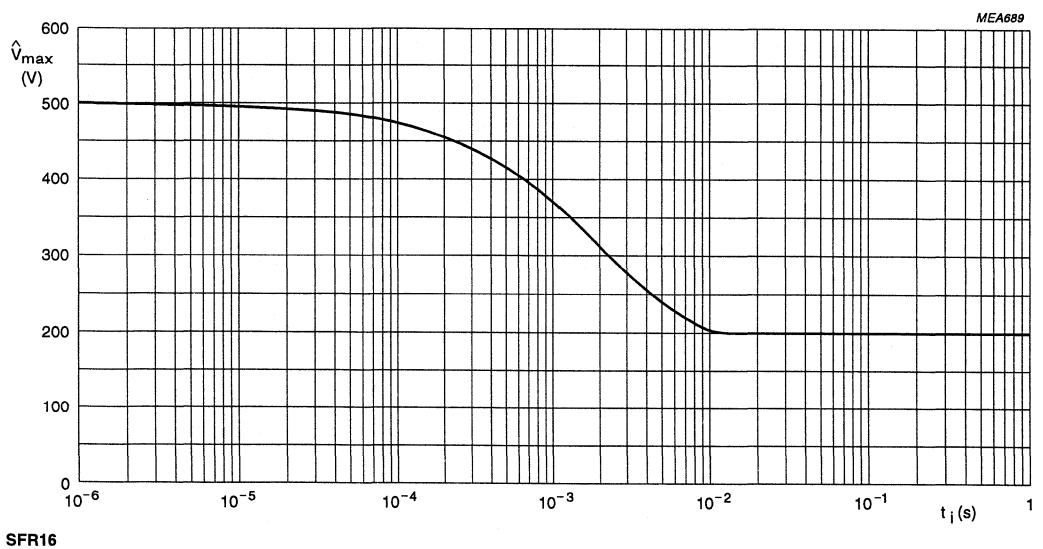
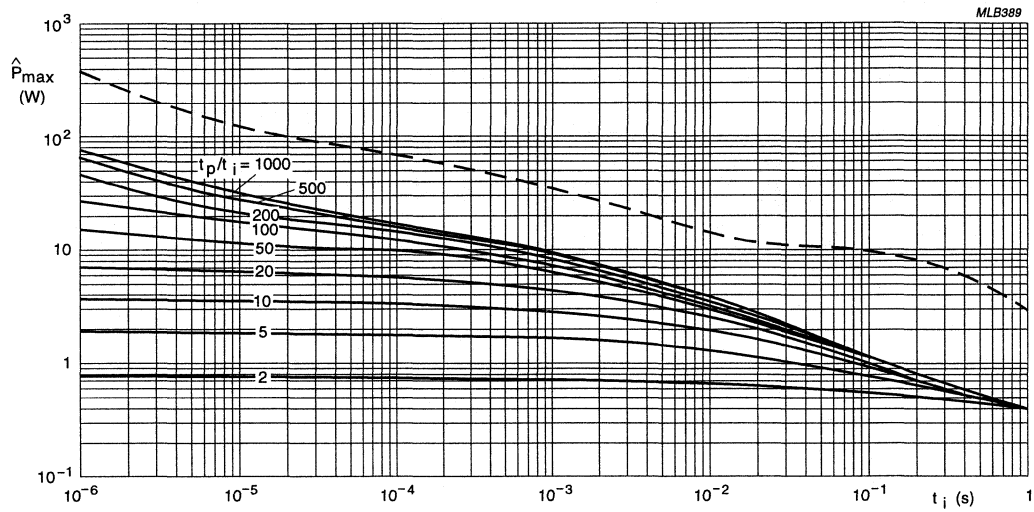
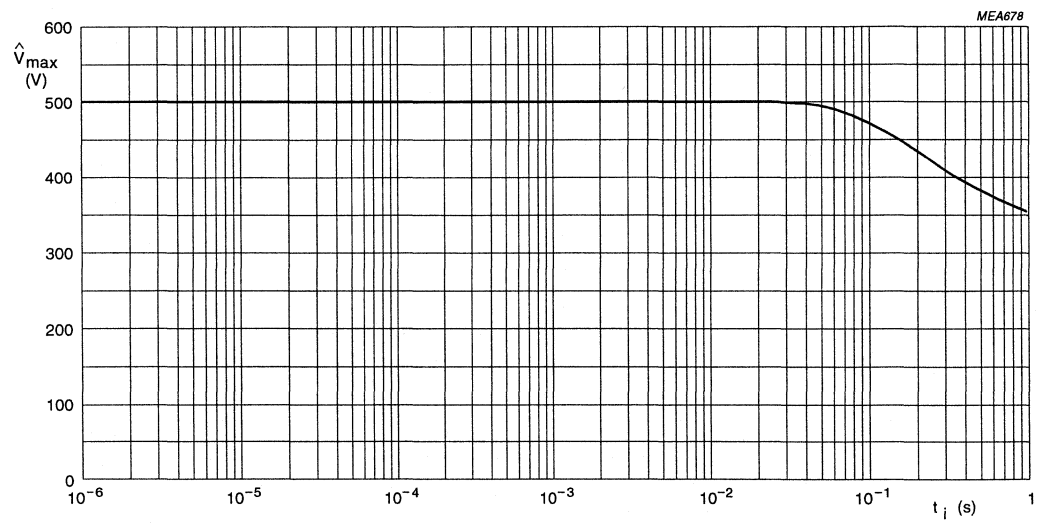


Fig.5 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_j).



SFR25

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



SFR25

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

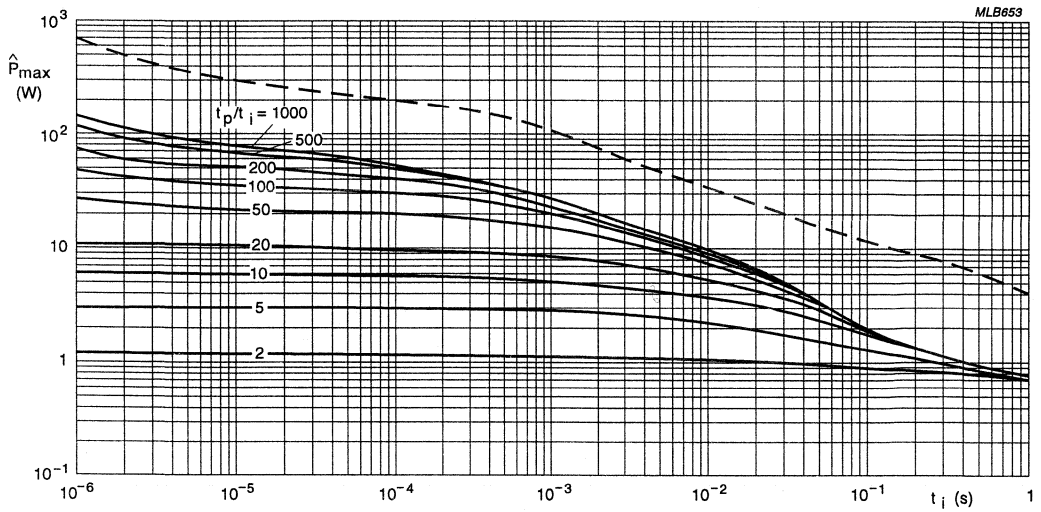


Fig.8 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i).

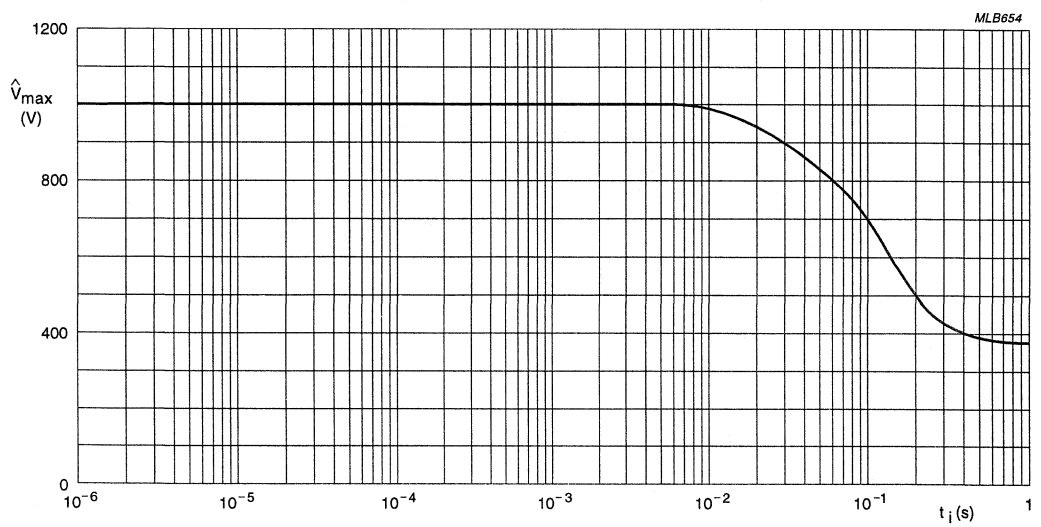
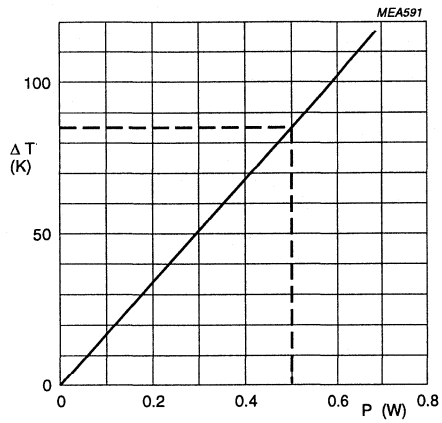


Fig.9 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_i).

Application information



SFR16

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

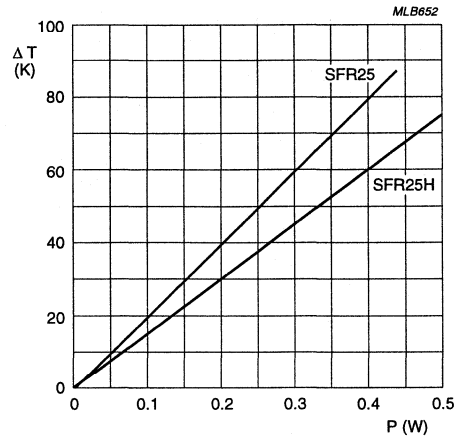
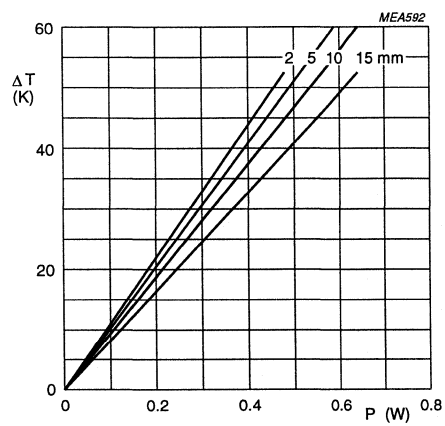
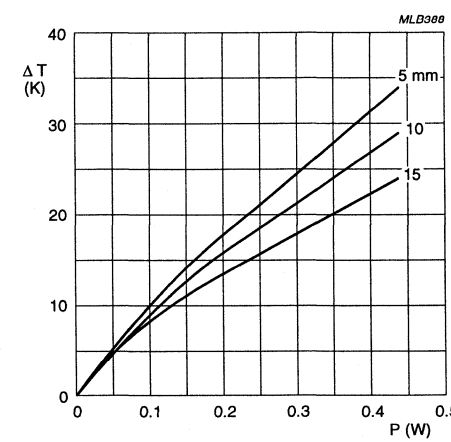


Fig.11 Hot-spot temperature rise (ΔT) as a function of dissipated power.



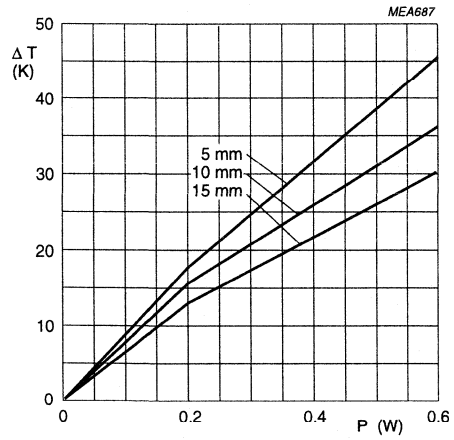
SFR16

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



SFR25

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



SFR25H

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

MECHANICAL DATA

Mass per 100 units

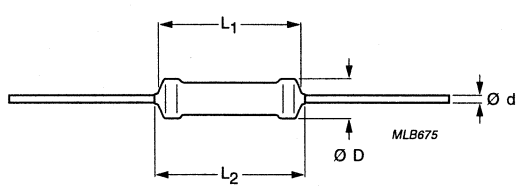
TYPE	MASS (g)
SFR16	12.5
SFR25	25

Marking

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

Outlines

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



For dimensions see Table 3.

Fig.15 Outlines.

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

TYPE	ØD MAX. (mm)	L_1 MAX. (mm)	L_2 MAX. (mm)	Ød (mm)
SFR16	1.9	3.2	3.4	0.45 ±0.05
SFR25	2.5	6.5	7.0	0.55 ±0.05
SFR25H	2.5	6.5	7.0	0.6 ±0.03

TESTS AND REQUIREMENTS

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

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

Unless otherwise specified the following values apply:

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

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

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

Table 4 Test procedures and requirements

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

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	RANGE	REQUIREMENTS		
					SFR16	SFR25	SFR25H
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		
4.24.2	Ca	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; dissipation 0.01P_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 ($TC \times 10^{-6}$/K)	R < 4.7 Ω	≤ ±250	≤ ±100	≤ ±100
				R ≤ 100 kΩ	≤ ±100	≤ ±100	≤ ±100
				R ≤ 1 MΩ	≤ ±200	≤ ±100	≤ ±100
				R > 1 MΩ	≤ ±200	≤ ±200	≤ ±200
4.7		voltage proof on insulation	600 V (RMS) during 1 minute; V-block method		no breakdown		
4.12		noise	IEC publication 195	R < 68 kΩ	max. 0.1 mV/V	max. 0.1 mV/V	max. 0.1 mV/V
				R ≤ 100 kΩ	max. 0.5 mV/V	max. 0.1 mV/V	max. 0.1 mV/V
				R ≤ 1 MΩ	max. 1.5 mV/V	max. 0.1 mV/V	max. 0.1 mV/V
				R > 1 MΩ	max. 1.5 mV/V	max. 1.5 mV/V	max. 1.5 mV/V
4.6.1.1		insulation resistance	500 V (DC or RMS) during 1 minute; V-block method		R_{ins} min.: 1000 MΩ		

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	RANGE	REQUIREMENTS		
					SFR16	SFR25	SFR25H
4.13		short time overload	room temperature; dissipation 6.25 × P_n (voltage not more than 2 × limiting voltage); 10 cycles; 5 s on and 45 s off		ΔR/R max.: ±0.25% +0.05 Ω		ΔR/R max.: ±0.1% +0.05 Ω
		intermittent overload in accordance with *"JIS-C5202 5.8"*	16 × 0.16 W; 1 s on and 25 s off; 10000 ±200 cycles; V_{max} = 600 V		ΔR/R max.: ±0.75% +0.05 Ω	–	–
See 2nd amendment to *"IEC 115-1"*, Jan. '87		pulse load			see Figs 4, 5, 6, 7, 8 and 9		

Fusible resistors NFR25/25H

FEATURES

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

APPLICATIONS

- Audio
- Video.

DESCRIPTION

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

ORDERING INFORMATION

Ordering code (12NC)

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

QUICK REFERENCE DATA

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

Table 1 Ordering code indicating resistor type and packaging

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

Table 2 Last digit of 12NC

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

ORDERING EXAMPLE

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

FUNCTIONAL DESCRIPTION

Product characterization

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

Limiting values

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

Note

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

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

DERATING

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

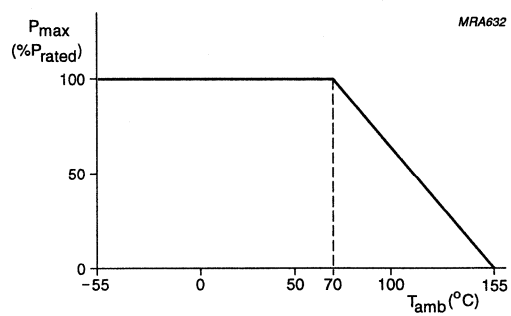
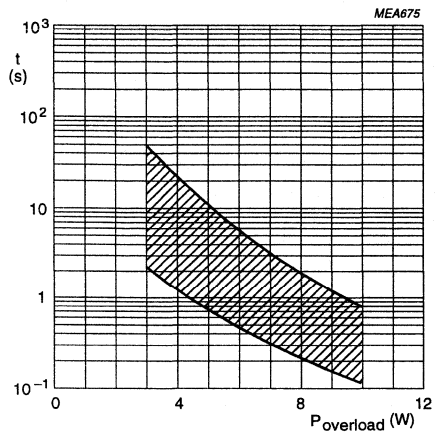


Fig.1 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

FUSING CHARACTERISTIC

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

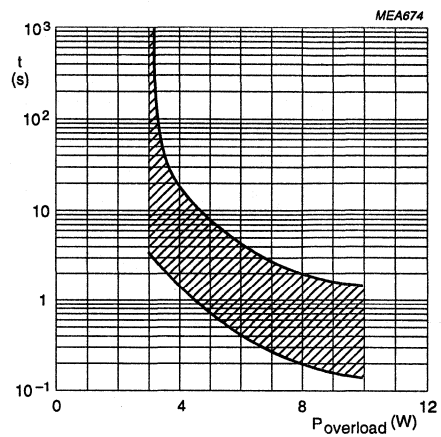
The fusing characteristic is measured under constant voltage.



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

NFR25

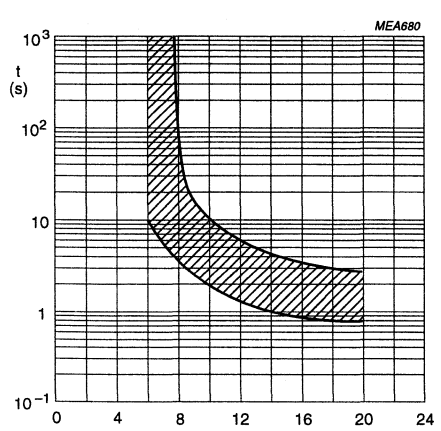
Fig.2 Fusing characteristic: 15 Ω < R ≤ 15 kΩ.



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

NFR25

Fig.3 Fusing characteristic: 1 Ω ≤ R ≤ 15 Ω.



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

NFR25H

Fig.4 Fusing characteristic.

PULSE LOADING CAPABILITIES

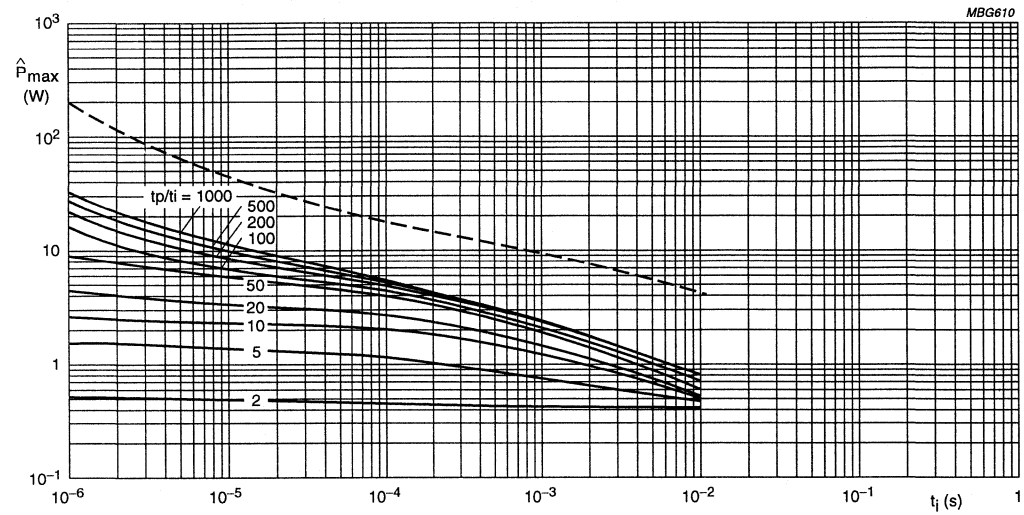


Fig.5 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i), 1 Ω ≤ R < 15 Ω.

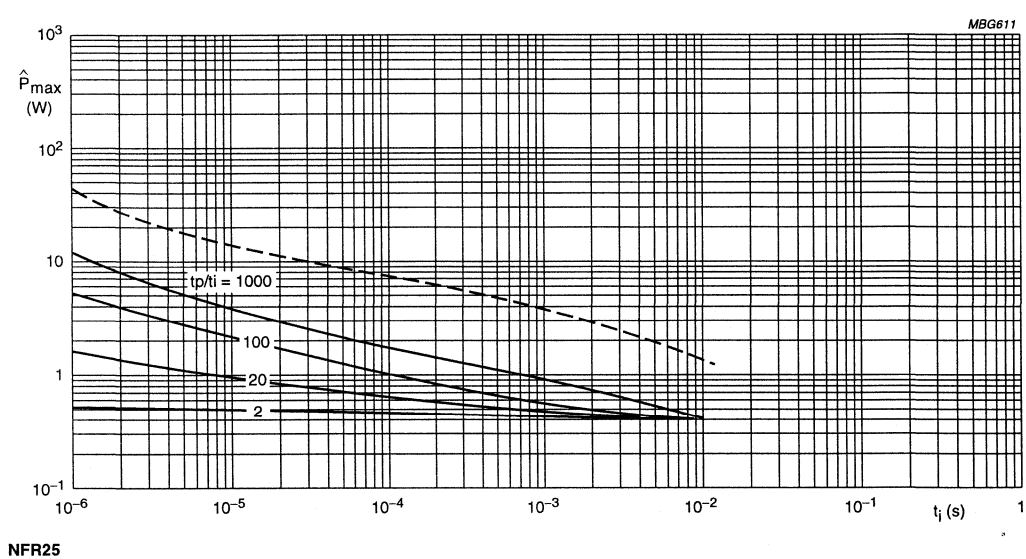
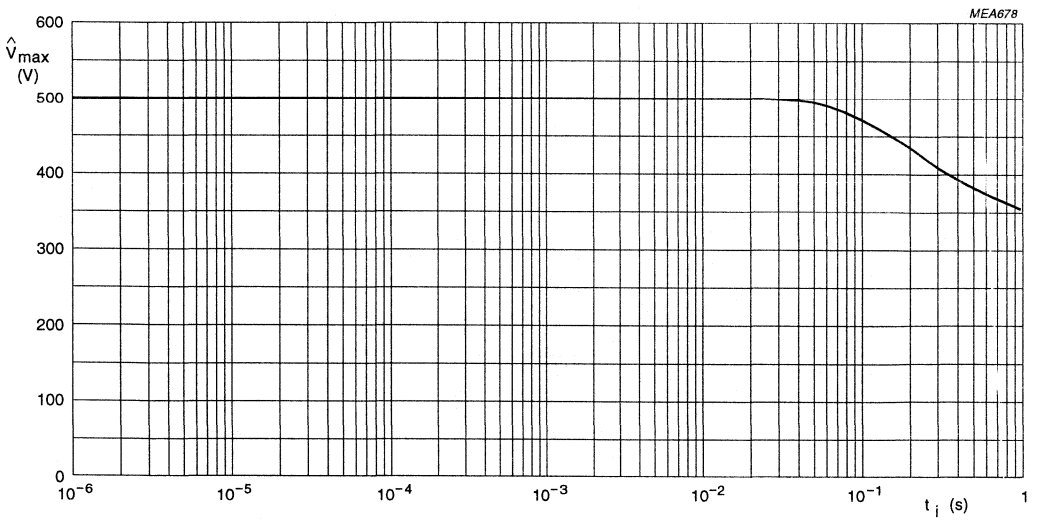
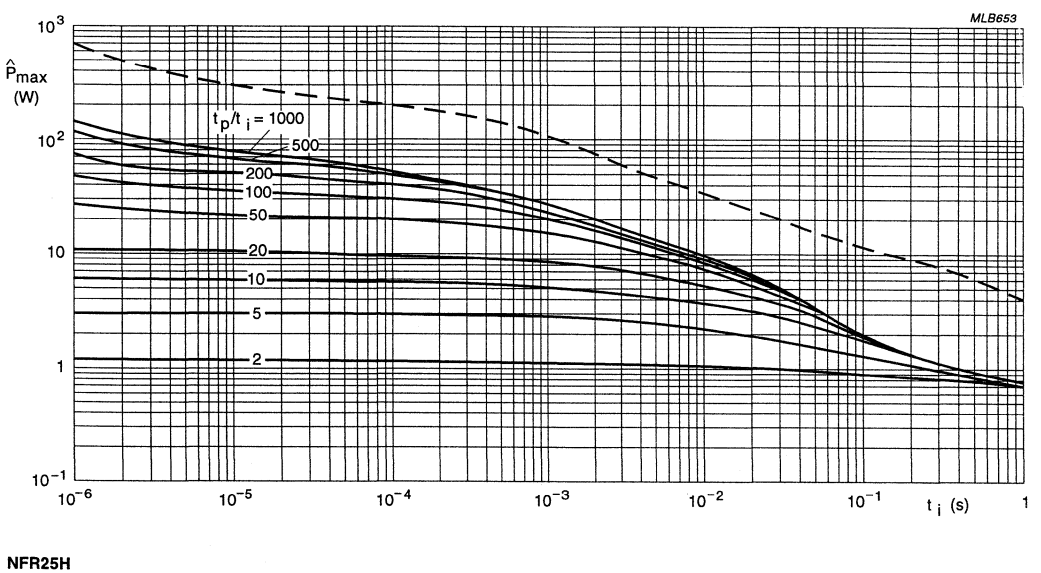


Fig.6 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i), 15 Ω < R ≤ 15 kΩ.



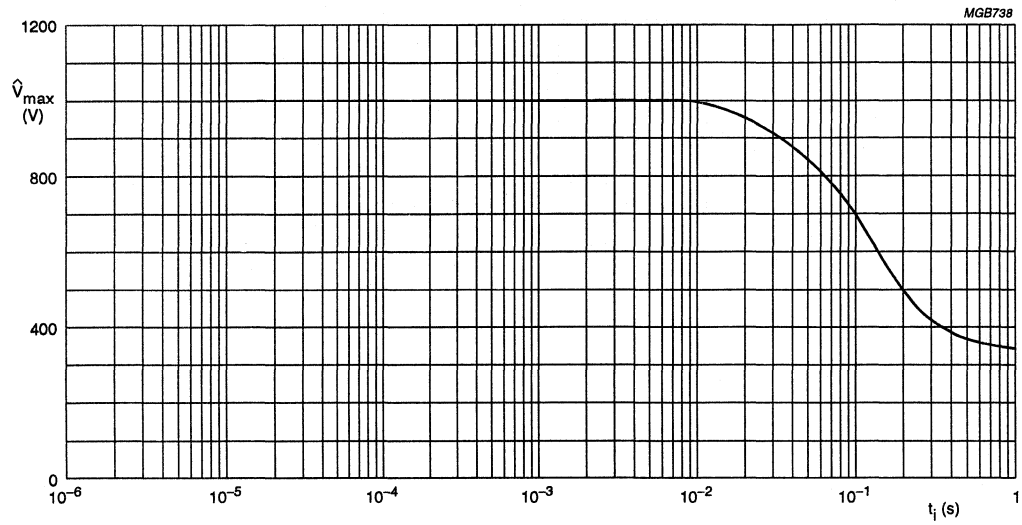
NFR25

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



NFR25H

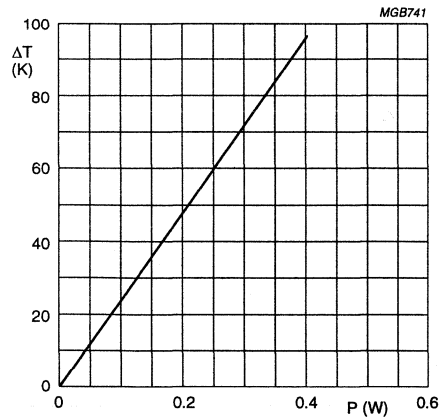
Fig.8 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i).



NFR25H

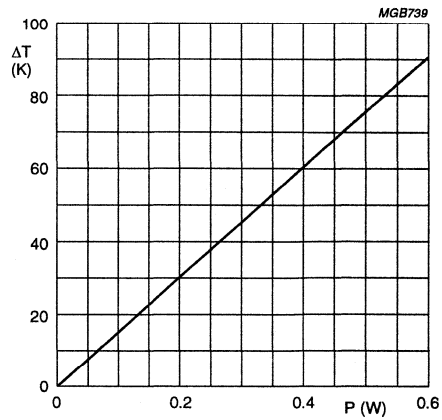
Fig.9 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_i).

Application information



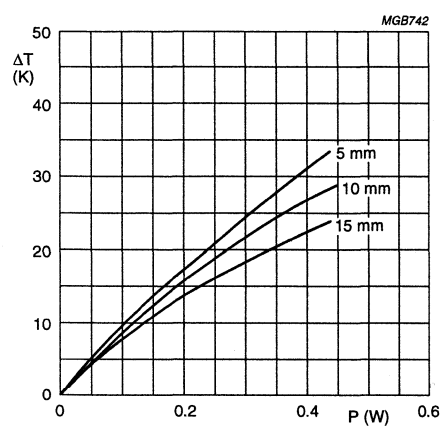
NFR25

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



NFR25H

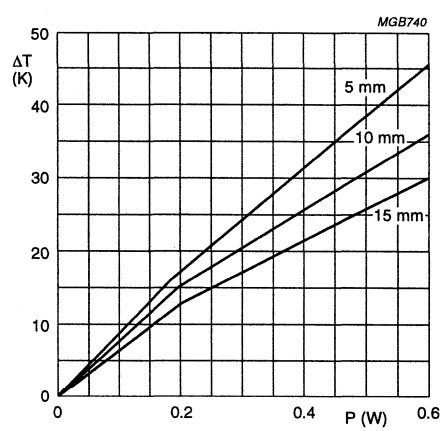
Fig.11 Hot spot temperature rise (ΔT) as a function of dissipated power.



Minimum distance from resistor body to PCB = 1 mm.

NFR25

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



Minimum distance from resistor body to PCB = 1 mm.

NFR25H

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

MECHANICAL DATA

Mass per 100 units

TYPE	MASS (g)
NFR25	25
NFR25H	

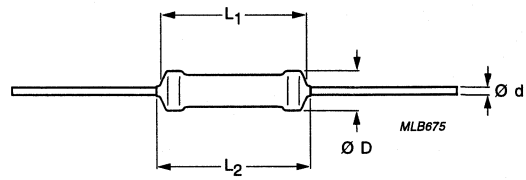
Marking

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

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

Outlines

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



For dimensions see Table 3.

Fig.14 Outline.

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

TYPE	ØD MAX. (mm)	L_1 MAX. (mm)	L_2 MAX. (mm)	Ød (mm)
NFR25	2.5	6.5	7.5	0.6
NFR25H				

TESTS AND REQUIREMENTS

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

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

Unless otherwise specified the following values apply:

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

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

In Table 4 the tests and requirements are listed with reference to the relevant clauses of *"IEC publications 115-1 and 68"*; a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying. For inflammability requirements reference is made to *"IEC 115-1"* and to *"CECC 40000, appendix D"*.

All soldering tests are performed with mildly activated flux.

Table 4 Test procedures and requirements

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS	
				NFR25	NFR25H
Tests in accordance with the schedule of IEC publication 115-8					
4.4.1		visual examination		no holes; clean surface; no damage	
4.4.2		dimensions (outline)	gauge (mm)	see Table 3	
4.5		resistance	applied voltage (+0/–10%): R < 10 Ω: 0.1 V 10 Ω ≤ R < 100 Ω: 0.3 V 100 Ω ≤ R < 1 kΩ: 1 V 1 kΩ ≤ R < 10 kΩ: 3 V 10 kΩ ≤ R ≤ 15 kΩ: 10 V	$R - R_{nom}$: max. ±5%	
4.18	Tb	resistance to soldering heat	thermal shock: 3 s; 350 °C; 6 mm from body	ΔR/R max.: ±0.25% +0.05 Ω	
4.29	45 (Xa)	component solvent resistance	isopropyl alcohol or H_2O followed by brushing in accordance with *"MIL 202 F"*	no visual damage	
4.17	Ta	solderability	2 s; 235 °C	good tinning; no damage	
4.7		voltage proof on insulation	2 × maximum voltage (RMS) during 1 minute; metal block method	no breakdown or flashover	
4.16	U	robustness of terminations:			
4.16.2	Ua	tensile all samples	load 10 N; 10 s	number of failures $<10 \times 10^{-6}$	
4.16.3	Ub	bending half number of samples	load 5 N; 4 × 90°	number of failures $<10 \times 10^{-6}$	
4.16.4	Uc	torsion other half of samples	3 × 360° in opposite directions	no damage ΔR/R max.: ±0.25% +0.05 Ω	

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

NOTES

Metal film resistors MRS16/25

FEATURES

- Precision resistors in small outlines
- Low noise.

APPLICATIONS

- All general purpose applications.

DESCRIPTION

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

QUICK REFERENCE DATA

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

ORDERING INFORMATION

Table 1 Ordering code indicating resistor type and packaging

TYPE	ORDERING CODE 2322		
	BANDOLIER IN AMMOPACK		BANDOLIER ON REEL
	1000 units	5000 units	5000 units
MRS16T	157 1....	157 2....	157 3....
MRS25	156 1....	156 2....	156 3....

Ordering code (12NC)

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

Table 2 Last digit of 12NC

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

ORDERING EXAMPLE

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

FUNCTIONAL DESCRIPTION

Product characterization

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

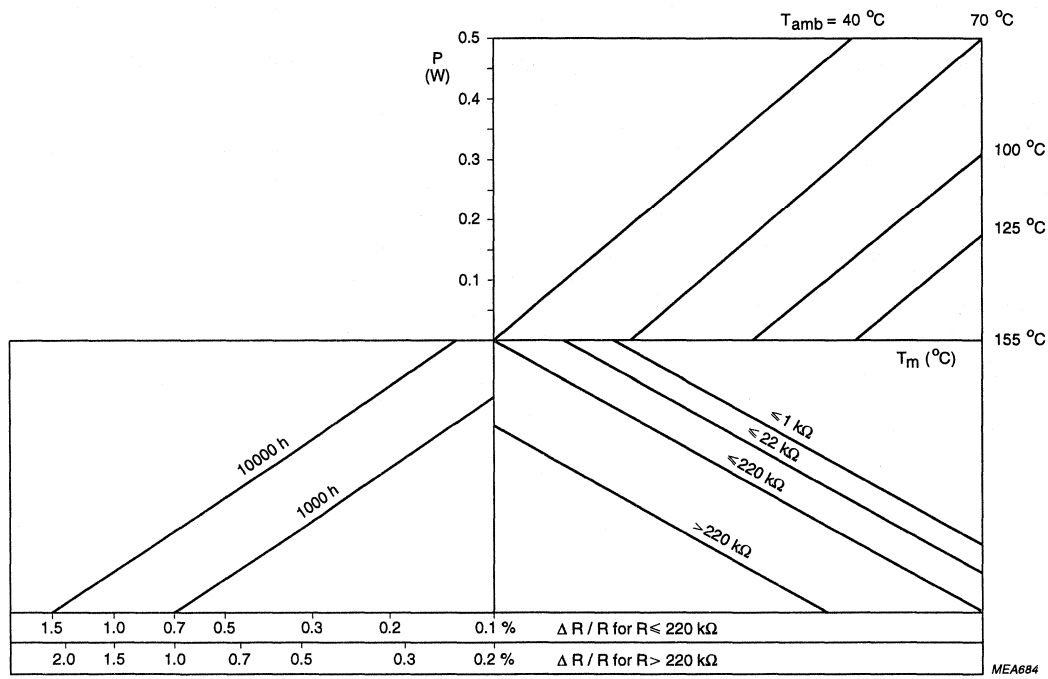
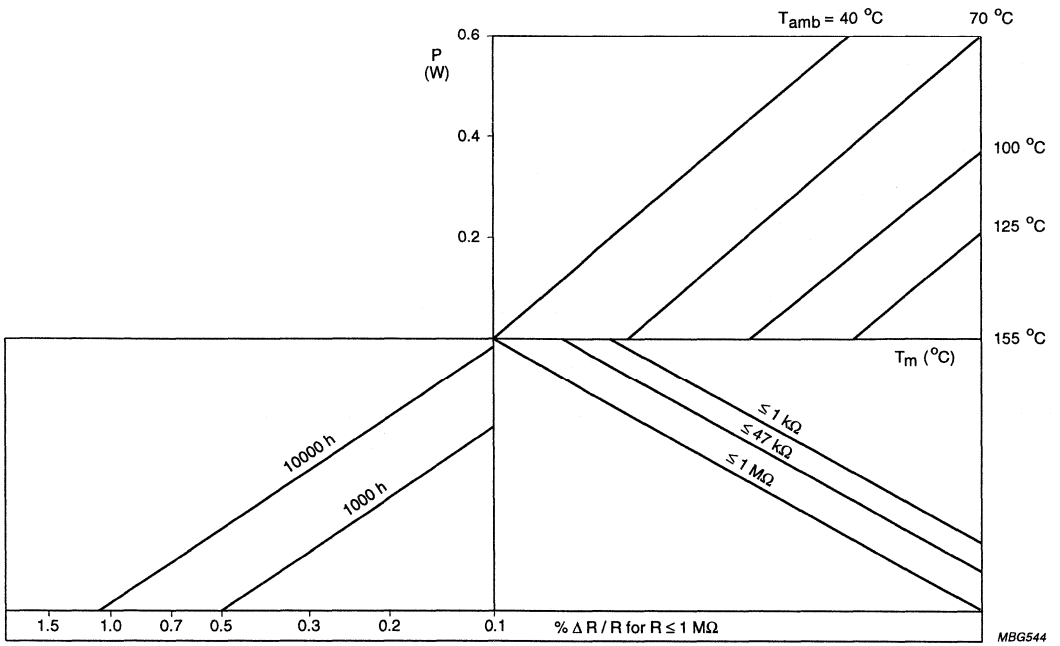


Fig.1 Drift nomogram.



MRS25

Fig.2 Drift nomogram.

Limiting values

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

Note

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

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

DERATING

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

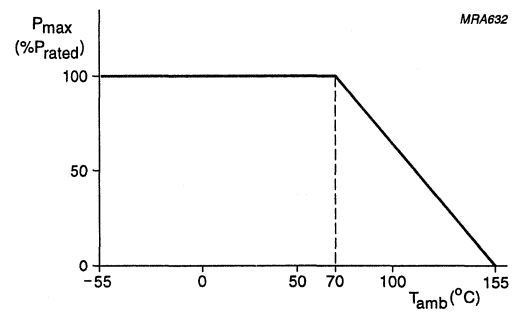
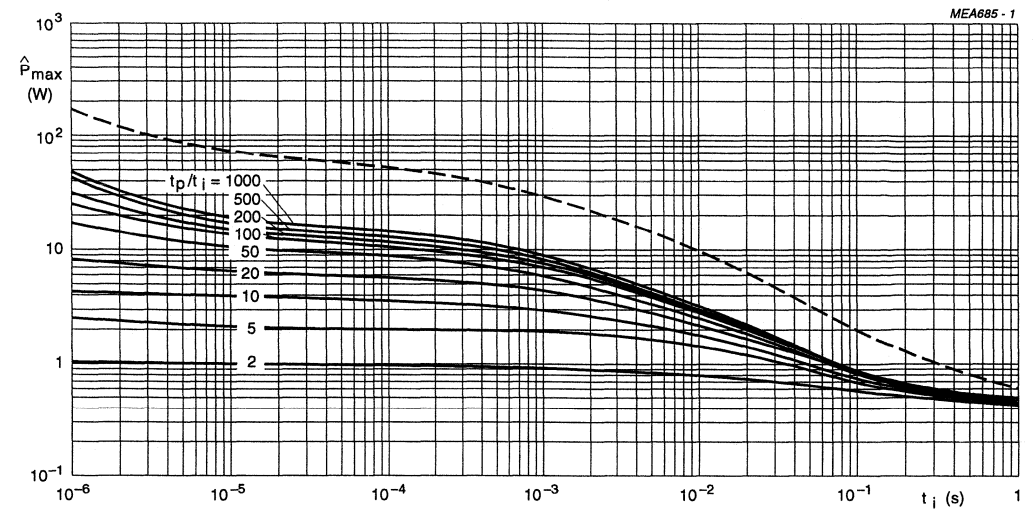


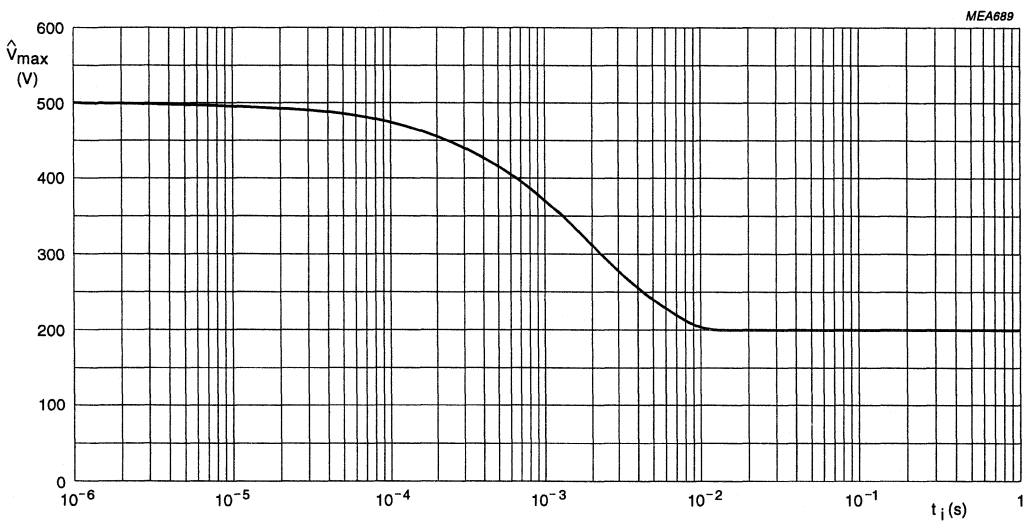
Fig.3 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

PULSE LOADING CAPABILITIES



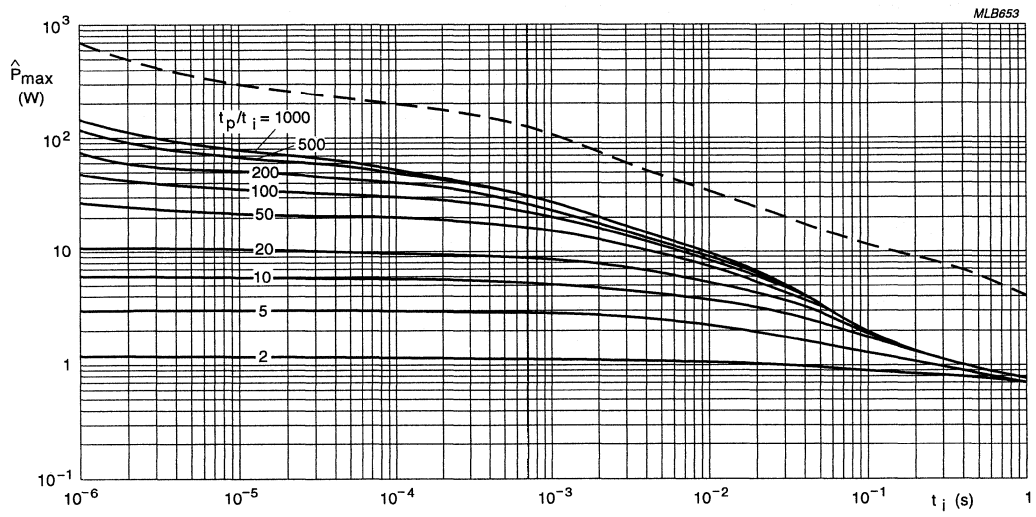
MRS16T

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



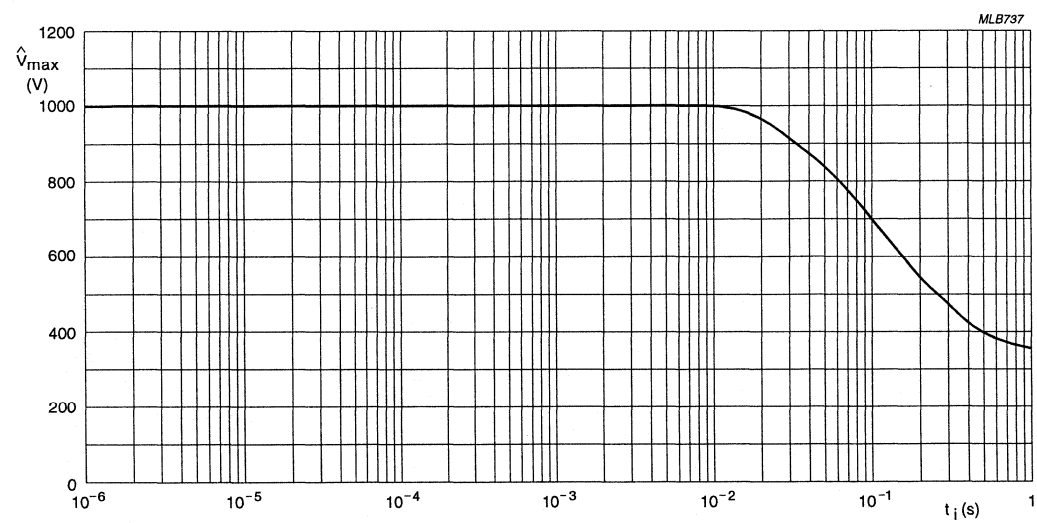
MRS16T

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



MRS25

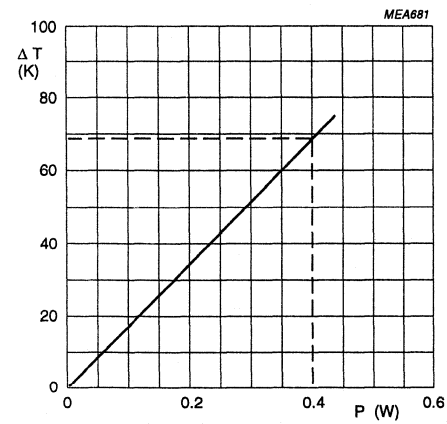
Fig.6 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i).



MRS25

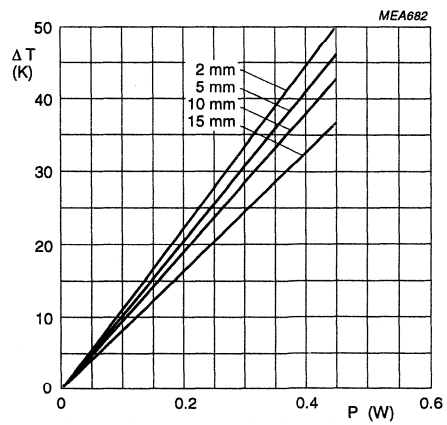
Fig.7 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_i).

Application information



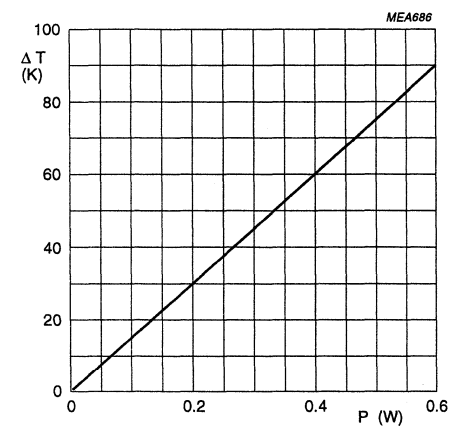
MRS16T

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



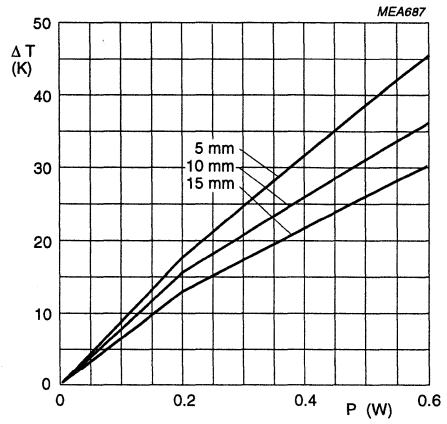
MRS16T

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



MRS25

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



MRS25

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

MECHANICAL DATA

Mass per 100 units

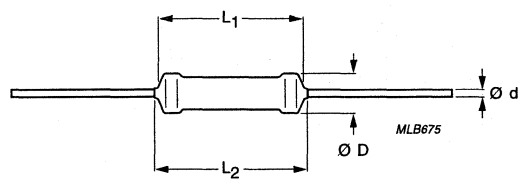
TYPE	MASS (g)
MRS16T	12.5
MRS25	25

Marking

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

Outlines

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



For dimensions see Table 3.

Fig.12 Outlines

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

TYPE	ØD MAX. (mm)	L_1 MAX. (mm)	L_2 MAX. (mm)	Ød (mm)
MRS16T	1.9	3.7	3.7	0.5
MRS25	2.5	6.5	7.0	0.6

TESTS AND REQUIREMENTS

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

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

Unless otherwise specified the following values apply:

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

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

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

All soldering tests are performed with mildly activated flux.

Table 4 Test procedures and requirements

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS	
				MRS16T	MRS25
Tests in accordance with the schedule of IEC publication 115-8					
4.4.1		visual examination		no holes; clean surface; no damage	
4.4.2		dimensions (outline)	gauge (mm)	see Table 3	
4.5		resistance	applied voltage (+0/–10%): R < 10 Ω: 0.1 V 10 Ω ≤ R < 100 Ω: 0.3 V 100 Ω ≤ R < 1 kΩ: 1 V 1 kΩ ≤ R < 10 kΩ: 3 V 10 kΩ ≤ R < 100 kΩ: 10 V 100 kΩ ≤ R < 1 MΩ: 25 V 1 MΩ ≤ R: 50 V	$R - R_{nom}$: max. ±1%	
4.18	Tb	resistance to soldering heat	thermal shock: 3 s; 350 °C; 6 mm from body		
			R ≤ 100 kΩ	ΔR/R max.: ±0.1% +0.05 Ω	
			R > 100 kΩ	ΔR/R max.: ±0.25% +0.05 Ω	ΔR/R max.: ±0.1% +0.05 Ω
4.29	45 (Xa)	component solvent resistance	isopropyl alcohol or H_2O followed by brushing in accordance with *"MIL 202 F"*	no visual damage	
4.17	Ta	solderability	2 s; 235 °C	good tinning; no damage	
4.7		voltage proof on insulation	voltage (DC) during1 minute, metal block method: 400 V for **MRS16T**, 700 V for **MRS25**	no breakdown or flashover	
4.13		short time overload	room temperature; $P = 6.25 \times P_n$; 5 s $(V \leq 2 \times V_{max})$	ΔR/R max.: ±0.25% +0.05 Ω	

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

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS	
				MRS16T	MRS25
4.23.2	27 (Ba)	endurance at upper category temperature	1 000 hours; no load		
			$R \leq 100\ k\Omega$	$\Delta R/R$ max.: $\pm 0.5\% + 0.05\ \Omega$	
			$R > 100\ k\Omega$	$\Delta R/R$ max.: $\pm 0.1\% + 0.05\ \Omega$	$\Delta R/R$ max.: $\pm 0.5\% + 0.05\ \Omega$
4.8.4.2		temperature coefficient	at 20/LCT/20 °C and 20/UCT/20 °C ($TC \times 10^{-6}/K$)	$\leq \pm 50 \times 10^{-6}/K$	
Other tests in accordance with IEC 115 clauses and IEC 68 test method					
4.17	20 (Tb)	solderability (after ageing)	8 hours steam or 16 hours 155 °C; leads immersed 6 mm for 2 ±0.5 s in a solder bath at 235 ±5 °C	good tinning (≥95% covered); no damage	
4.6.1.1		insulation resistance	voltage (DC) after 1 minute, metal block method: 100 V for **MRS16T**, 500 V for **MRS25**	R_{ins} min.: $10^3\ M\Omega$	
4.12		noise	IEC publication 195 (measured with Quantech - equipment)		
			$R \leq 68\ k\Omega$	max. 0.1 µV/V	max. 0.1 µV/V
			$R \leq 100\ k\Omega$	max. 0.5 µV/V	max. 0.1 µV/V
			$R \leq 1\ M\Omega$	max. 1.5 µV/V	max. 0.1 µV/V
			$R > 1\ M\Omega$	max. 1.5 µV/V	max. 1.5 µV/V
see 2nd amendment to *"IEC 115-1"*, Jan. '87		pulse load		see Figs 4 and 5	see Figs 6 and 7

Metal film resistors MR25; MR30; MR52

QUICK REFERENCE DATA

Type		MR25	MR30	MR52
Resistance range		1 Ω to 1 MΩ	1 Ω to 1 MΩ	4,99 Ω to 1 MΩ
Series		E192	E192	E24; E96
Resistance tolerance		±0,5%	±0,5%	± 1%
Temperature coefficient		± 50.10^{-6}/K	± 50.10^{-6}/K	± 50.10^{-6}/K
Absolute max. dissipation at T_{amb} = 70 °C		0,4 W	0,5 W	1 W
Basic specification		IEC 115-1		
Climatic category (IEC 68)		55/155/56		
Approval		CECC 40101		
Stability after				
load	ΔR/R	see nomogram		
climatic tests	ΔR/R	max. 0,5% + 0,05 Ω		
soldering	ΔR/R	max. 0,1% + 0,01 Ω		
short time overload	ΔR/R	max. 0,25% + 0,05 Ω		

APPLICATION

For use in professional equipment: computers, telecom, measuring, etc.

DESCRIPTION

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

MECHANICAL DATA

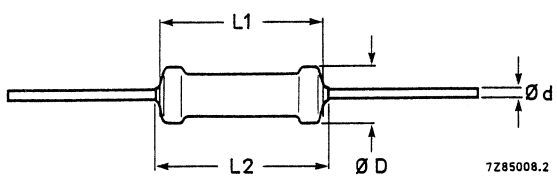


Fig. 1 This standard version is specially made to obtain a minimum "clean lead to clean lead" dimension L2.

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 $\Delta R/R$ but represent a probability of 95% that the actual values will be smaller than those obtained from the nomogram.
4. The limiting voltage has not been taken into consideration.

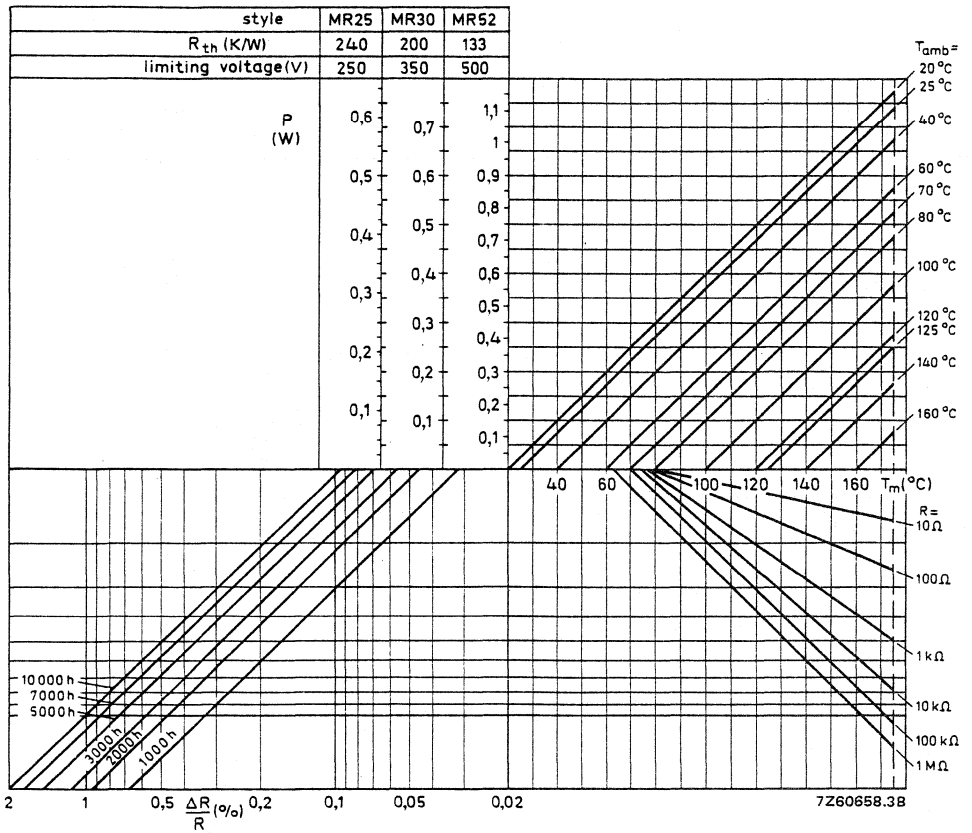


Fig. 2 Performance nomogram for different styles of resistor, showing the relationship between power dissipation P, ambient temperature T_{amb}, hot-spot temperature (T_m) and max. resistance drift $\Delta R/R$ after 1000 to 10 000 hours of operation.

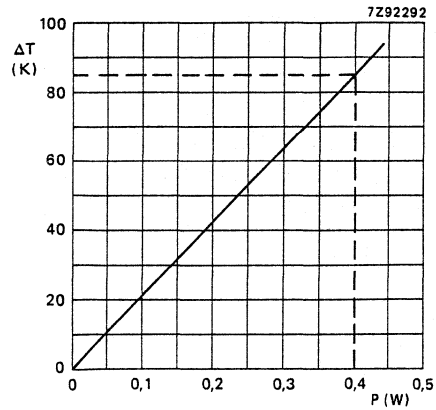


Fig. 3 MR25. Hot-spot temperature rise (ΔT) versus dissipated power.

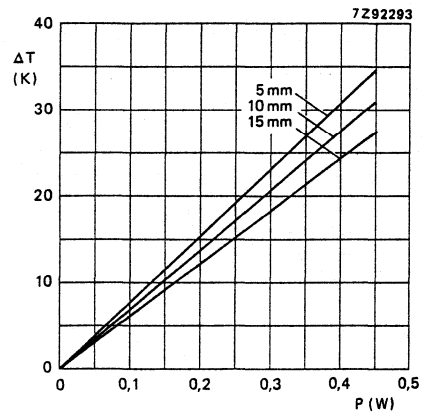


Fig. 4 MR25. Temperature rise (ΔT) at the end of lead (soldering point) versus dissipated power, at various lead lengths after mounting.

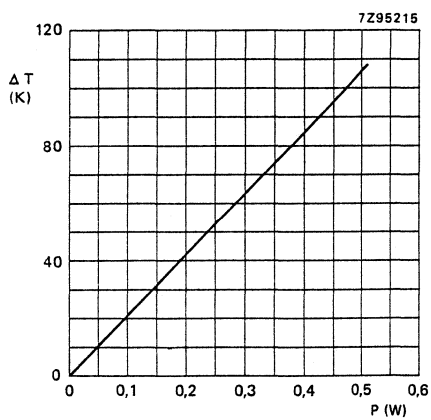


Fig. 5 MR30. Hot-spot temperature rise (ΔT) versus dissipated power.

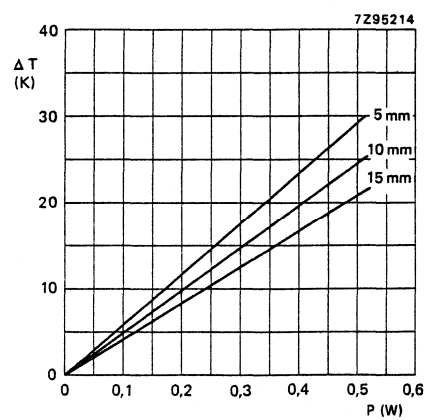


Fig. 6 MR30. Temperature rise (ΔT) at the end of lead (soldering point) versus dissipated power, at various lead lengths after mounting.

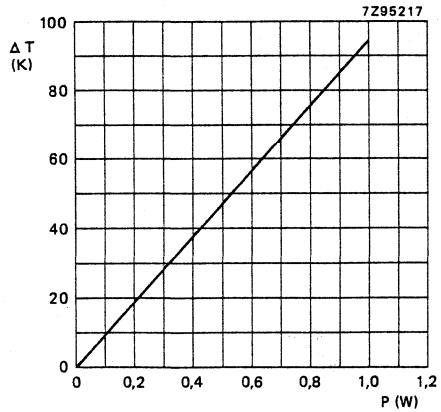


Fig. 7 MR52. Hot-spot temperature rise (ΔT) versus dissipated power.

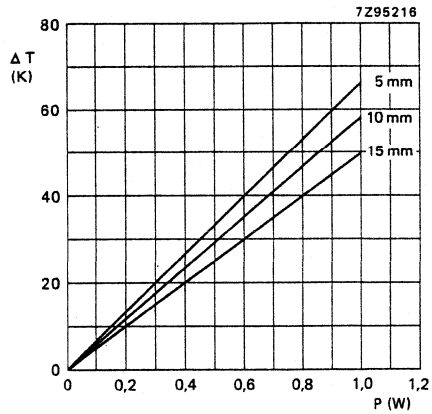


Fig. 8 MR52. Temperature rise (ΔT) at the end of lead (soldering point) versus dissipated power, at various lead lengths after mounting.

TESTS AND REQUIREMENTS

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

Table 3

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
4.16		Robustness of terminations		
4.16.2	Ua	Tensile all samples	load 10 N, 10 s	number of failures < 10 ppm
4.16.3	Ub	Bending half number of samples	load 5 N, 4 x 90°	
4.16.4	Uc	Torsion other half number of samples	3 x 360° in opposite directions	no damage ΔR max. 0,1% + 0,01 Ω
4.17	Ta	Soldering	solderability: 2 s 230 °C, flux 600	good tinning no damage
4.18	Tb		thermal shock: 3 s. 350 °C, 6 mm from body	ΔR max. 0,1% + 0,01 Ω
4.19	Na	Rapid change of temperature	½ h −55 °C/½ h + 155 °C, 5 cycles	ΔR max. 0,1% + 0,01 Ω
4.22	Fc	Vibration	frequency 10-500 Hz, displacement 1,5 mm or acceleration 10g, three directions; total 6 h	no damage ΔR max. 0,1% + 0,01 Ω
4.20	Eb	Bump	3 x 1500 bumps in three directions, 40g	no damage ΔR max. 0,1% + 0,01 Ω

Table 3 (continued)

IEC 115-1 clause	IEC 68 test method	test	procedure	requirements
4.23		Climatic sequence		
4.23.2	B	Dry heat	16 h; 155 °C	
4.23.3	D	Damp heat (accel.) 1st cycle	24 h; 55 °C; 95-100% R.H.	
4.23.4	Aa	Cold	2 h; −55 °C	
4.23.5	M	Low air pressure	1 h; 8,5 kPa; 15-35 °C	
4.23.6	D	Damp heat (accel.) remaining cycles	5 days; 55 °C; 95-100% R.H.	R_{ins} min. 1000 MΩ ΔR max. 0,5% + 0,05 Ω
4.24.2	Ca	Damp heat (long-term exposure)	56 days; 40 °C; 90-95% R.H. dissipation:	R_{ins} min. 1000 MΩ
			MR25: ⩽ 2,5 mW MR30: ⩽ 3 mW MR52: ⩽ 5 mW	ΔR max. 0,5% + 0,05 Ω
4.25.1	–	Endurance	1000 h: 70 °C: dissipation:	ΔR max. 0,5% + 0,05 Ω
			MR25: 0,25 W MR30: 0,3 W MR52: 0,45 W } or V_{max}	
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

MR24E/C/D; MR34E/C/D MR54E/C/D; MR74E/C/D

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

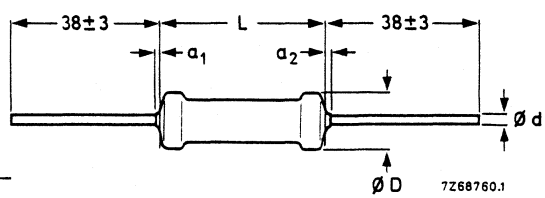


Fig. 1.

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.

NOTES

Metal film precision resistors MPR24/34

FEATURES

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

APPLICATIONS

- Test and measurement
- Telecom.

DESCRIPTION

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

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

QUICK REFERENCE DATA

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

ORDERING INFORMATION

Ordering code (12NC)

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

Table 1 Quantity per package

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

Table 2 7th digit; type and quantity

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

Table 3 8th and 9th digit; tol. ±0.5%; ±0.25%; ±0.1%; range 4.99 Ω to 1 MΩ

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

Table 4 8th and 9th digit; tol. ±0.05%; ±0.02%; ±0.01%; range 24 Ω to 100 kΩ

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

Ordering example

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

FUNCTIONAL DESCRIPTION

Product characterization

Any value within the range can be ordered.

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

NOTES ON THE NOMOGRAM

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

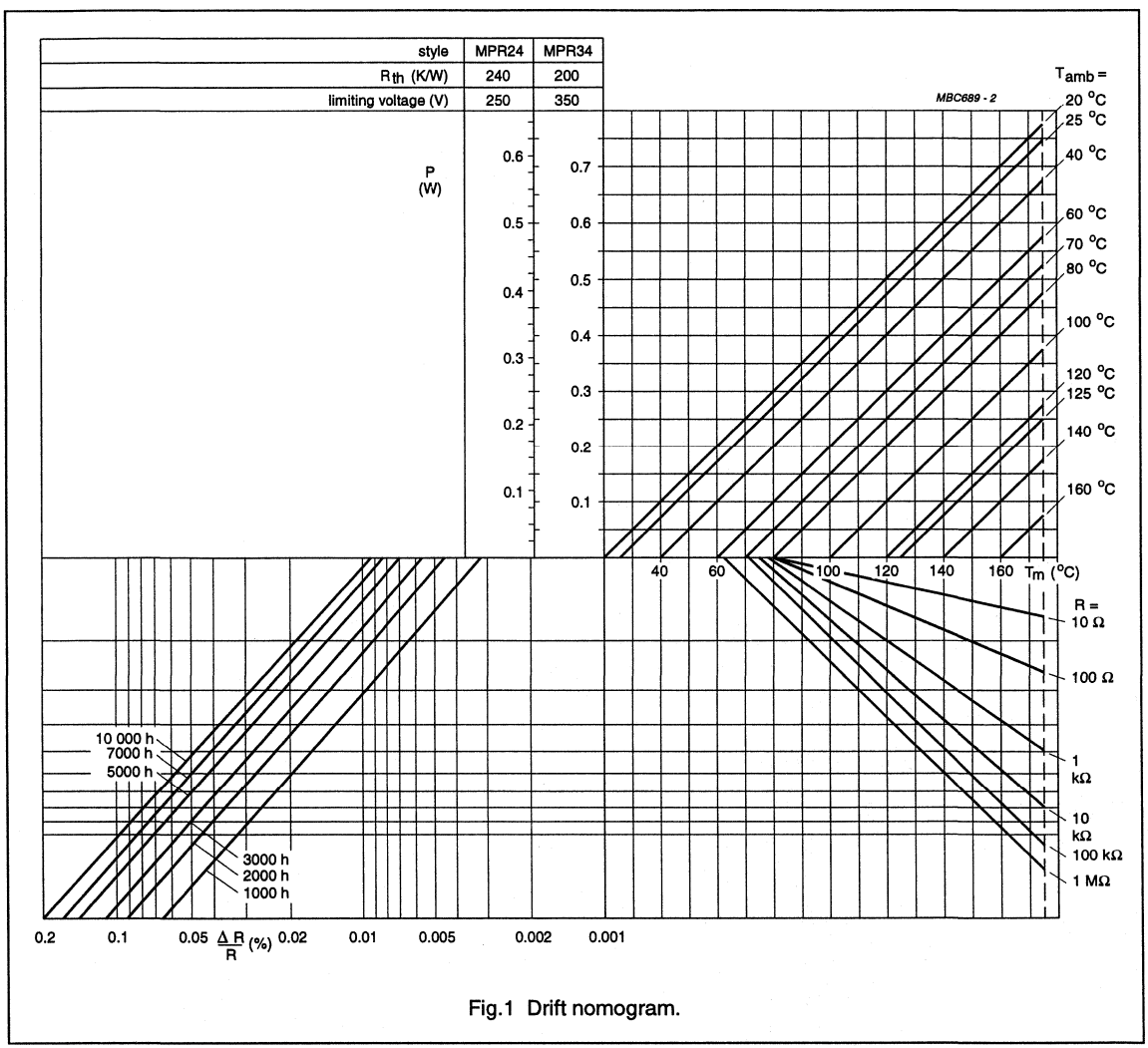


Fig.1 Drift nomogram.

Limiting values

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

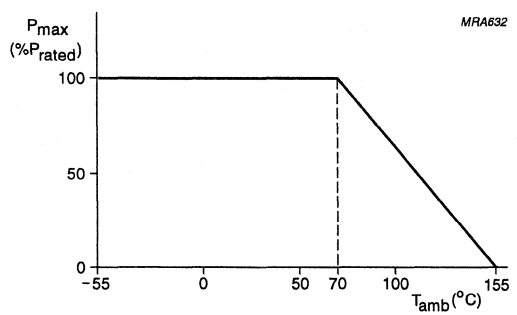
Note

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

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

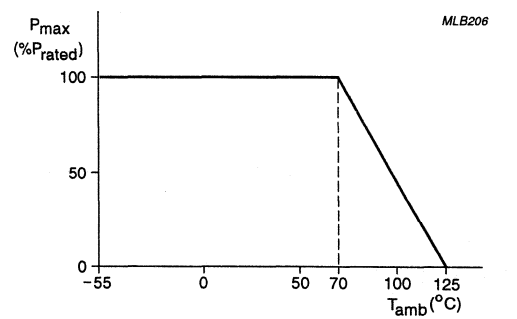
DERATING

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



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

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



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

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

MECHANICAL DATA

Mass per 100 units

TYPE	MASS (g)
MPR24	25
MPR34	30

Marking

The resistors are either colour coded or marked.

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

All other resistors are marked including those in cassette packaging.

COLOUR CODING

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

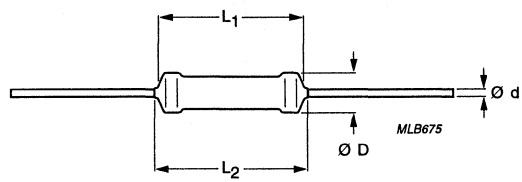
MARKING

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

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

Outlines

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



For dimensions see Table 5.

Fig.4 Outlines.

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

TYPE	ØD MAX. (mm)	L_1 MAX. (mm)	L_2 MAX. (mm)	Ød (mm)
MPR24	2.5	6.5	7.5	0.6
MPR34	3.0	10.0	11.0	0.6

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of *"CECC publication 40.300"*, category **LCT/UCT/56** (rated temperature range: **L**ower **C**ategory **T**emperature, **U**pper **C**ategory **T**emperature; damp heat, long term, **56** days) along the lines of *"CECC 40000"*. *"Recommended basic climatic and mechanical robustness testing procedure for electronic components"*.

Unless otherwise specified the following values apply:

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

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

In Table 6 the tests and requirements are listed with reference to the relevant clauses of *"CECC publications 40000 and IEC publication 68"*; a short description of the test procedure is also given.

In some instances deviations from the CECC recommendations were necessary for our method of specifying.

All soldering tests are performed with mildly activated flux.

Table 6 Test procedures and requirements

CECC 40000 TEST METHOD	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.5		insulation resistance	voltage (DC) after 1 minute; metal block method: 500 V for **MPR24**, 700 V for **MPR34**	R_{ins} min.: 10^4 MΩ
4.6		voltage proof	2 × limiting voltage (AC) during1 minute, metal block method	no breakdown or flashover
4.7		temperature coefficient	at 20/70/20 °C at 20/LCT/20 °C and 20/UCT/20 °C ($TC \times 10^{-6}$/K)	≤ ±25 × 10^{-6}/K: ≤ ±15 × 10^{-6}/K; ≤ ±10 × 10^{-6}/K; ≤ ±5 × 10^{-6}/K ≤ ±25 × 10^{-6}/K
4.10		noise	IEC publication 195 (measured with Quantech - equipment) R ≤ 100 kΩ R > 100 kΩ	 max. 0.25 μV/V max. 0.5 μV/V
4.11		short time overload	room temperature; P = 6.25 × P_n; 5 s ($V \leq 2 \times V_{max}$)	ΔR/R max.: ±0.01% +0.01 Ω
4.16	U	robustness of terminations:		
	Ua	tensile all samples	load 10 N; 10 s	number of failures <10 × 10^{-6}
	Ub	bending half number of samples	load 5 N; 4 × 90°	number of failures <10 × 10^{-6}
	Uc	torsion other half of samples	3 × 360° in opposite directions	no damage ΔR/R max.: ±0.01% +0.01 Ω
4.15	Ta	solderability	2 s; 235 °C	good tinning; no damage
4.15	Tb	resistance to soldering heat	thermal shock: 3 s; 350 °C; 6 mm from body	ΔR/R max.: ±0.01% +0.01 Ω

CECC 40000 TEST METHOD	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.16	Na	rapid change of temperature	30 minutes at LCT and 30 minutes at UCT; 5 cycles	no visual damage $\Delta R/R$ max.: ±0.01% +0.01 Ω
4.17	Eb	bump	3 × 1500 bumps in 3 directions; 40 g	no damage $\Delta R/R$ max.: ±0.01% +0.01 Ω
4.19	Fc	vibration	frequency 10 to 500 Hz; displacement 1.5 mm or acceleration 10 g; 3 directions; total 6 hours (3 × 2 hours)	no damage $\Delta R/R$ max.: ±0.01% +0.01 Ω
4.4.1		visual examination		no holes; clean surface; no damage
4.20		climatic sequence:		
4.20.2	B	dry heat	16 hours at UCT	
4.20.3	D	damp heat (accelerated) 1st cycle	24 hours; 95 to 100% RH	
4.20.4	Aa	cold	2 hours at LCT	
4.20.5	M	low air pressure	1 hour; 8.5 kPa	
4.20.6	D	damp heat (accelerated) remaining cycles	5 days; 55 °C; 95 to 100% RH	R_{ins} min.: 10^3 MΩ $\Delta R/R$ max.: ±0.05% +0.01 Ω
4.21	Ca	damp heat, steady state (long term exposure)	56 days; 40 °C; 90 to 95% RH; loaded with 1.25 mW max.	R_{ins} min.: 100 MΩ $\Delta R/R$ max.: ±0.05% +0.01 Ω
4.25.1		endurance (at 70 °C)	2000 hours; loaded with P_n or V_{max}; 1.5 hours on and 0.5 hours off	R_{ins} min.: 10^3 MΩ $\Delta R/R$ max.: ±0.05% +0.01 Ω

NOTES

High-ohmic/high-voltage resistors VR25/37/68

FEATURES

- High pulse loading capability
- Small size
- Types VR37 and VR68 meet the safety requirements of:
  "IEC 65, 4th edition";
  "NFC 92-130" (France);
  "VDE 0860" (Germany);
  "BS 415" (U.K.).

APPLICATIONS

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

DESCRIPTION

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

QUICK REFERENCE DATA

DESCRIPTION	VALUE		
	VR25	VR37	VR68
Resistance range	100 kΩ to 22 MΩ	100 kΩ to 33 MΩ	100 kΩ to 68 MΩ
Resistance tolerance and series:		±1%: E24/E96 series; ±5%: E24 series	±1%: E24/E96 series; ±5%; E24 series
100 kΩ to 15 MΩ	±5%: E24 series	–	–
15 MΩ to 22 MΩ	±10%: E12 series	–	–
220 kΩ to 15 MΩ	±1%: E24/E96 series	–	–
Maximum dissipation at T_{amb} = 70 °C	0.25 W	0.5 W	1 W
Thermal resistance, R_{th}	200 K/W	120 K/W	70 K/W
Temperature coefficient	≤ ±200 × 10^{-6}/K		
Maximum permissible voltage:			
DC	1600 V	3500 V	10000 V
RMS	1150 V	2500 V	7000 V
Dielectric withstanding voltage of the insulation for 1 minute	700 V		
Basic specifications	IEC 115-1B		
Safety requirements	–	IEC 65, 4th edition; NFC 92-130; VDE 0860; BS 415	
Climatic category (IEC 68)	55/155/56		
Stability after:			
load (1000 hours)	ΔR/R max.: ±1.5% +0.1 Ω	ΔR/R max.: ±1.5% +0.1 Ω	ΔR/R max.: ±1.5% +0.1 Ω
	–	typ. 0.5%	typ. 1%
accelerated damp heat test (6 days)	ΔR/R max.: ±1.5% +0.1 Ω	ΔR/R max.: ±1.5% +0.1 Ω	ΔR/R max.: ±1.5% +0.1 Ω
	–	typ. 0.5%	typ.1%
long term damp heat test (56 days)	ΔR/R max.: ±1.5% +0.1 Ω	ΔR/R max.: ±1.5% +0.1 Ω	ΔR/R max.: ±1.5% +0.1 Ω
	–	typ. 0.5%	typ. 0.5%
Noise	max. 5 μV/V	max. 2.5 μV/V; typ. 0.5	

ORDERING INFORMATION

Table 1 Ordering code indicating resistor type and packaging

TYPE	TAPE WIDTH (mm)	TOL. (%)	ORDERING CODE 2322				
			BANDOLIER IN AMMOPACK				BANDOLIER ON REEL
			500 units	1000 units	2000 units	5000 units	5000 units
VR25	52	±1	–	241 8....	–	–	–
		±5	–	241 13...	–	241 53...	241 23...
		±10	–	241 12...	–	241 52...	241 22...
	26	±5	–	–	241 43...	–	–
		±10	–	–	241 42...	–	–
VR37	52	±1	–	242 8....	–	–	–
		±5	–	242 13...	–	–	242 23...
VR68	52	±1	244 8....	–	–	–	–
		±5	244 13...	–	–	–	–

Ordering code (12NC)

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

Table 2 Last digit of 12NC

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

ORDERING EXAMPLE

The ordering code for a VR37, resistor value 7.5 MΩ, 5% tolerance, supplied on a bandolier of 1000 units in ammopack, is: 2322 242 13755.

FUNCTIONAL DESCRIPTION

Product characterization

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

Limiting values

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

Note

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

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

DERATING

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

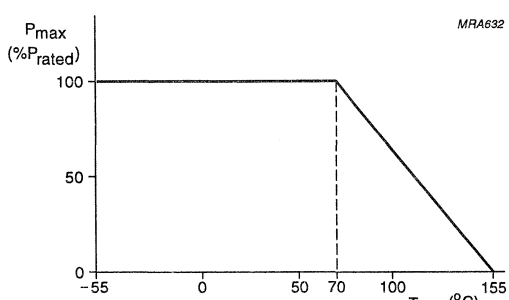


Fig.1 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

PULSE LOADING CAPABILITY

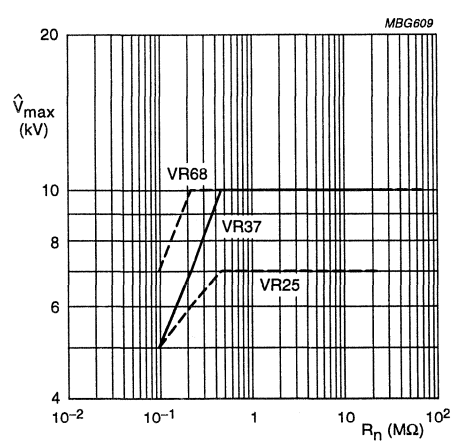
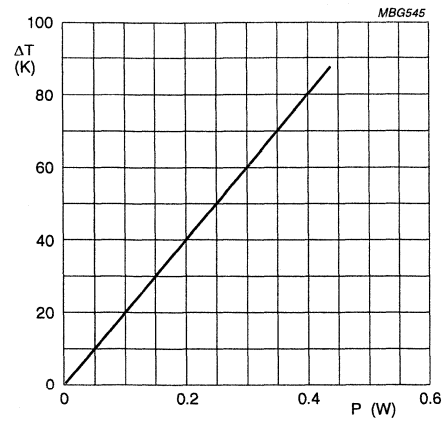


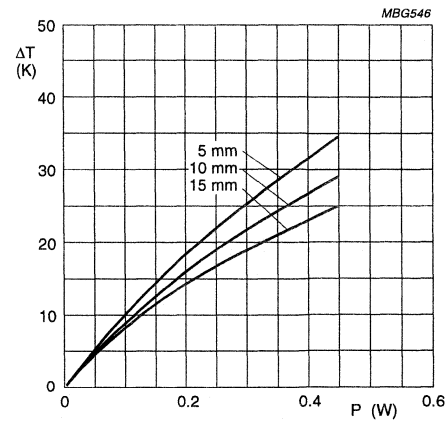
Fig.2 Maximum allowed peak pulse voltage in accordance with *"IEC 65 chapter 14.1"*; 50 discharges from a 1 nF capacitor charged to $\hat{V}_{max}$; 12 discharges/minute (drift $\Delta R/R \leq 1\%$).

Application information



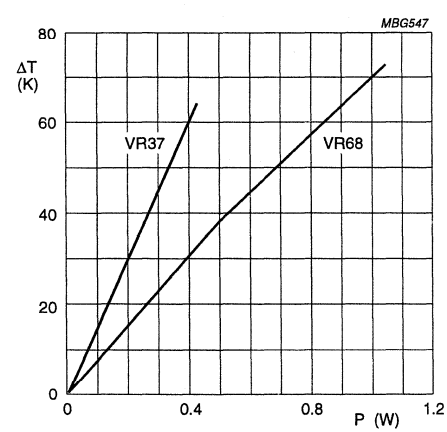
Type: **VR25.**

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



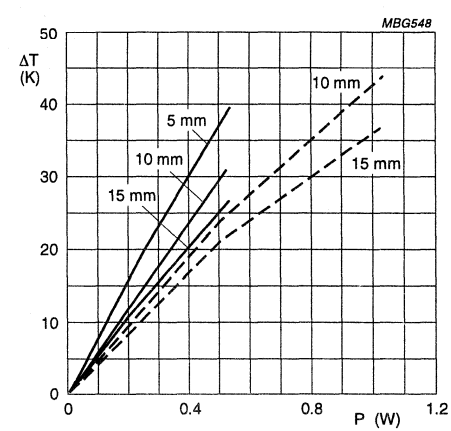
Type: **VR25.**

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



Types: **VR37 and 68.**

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



Types: **VR37 and 68.**

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

MECHANICAL DATA

Mass per 100 units

TYPE	MASS (g)
VR25	25
VR37	48
VR68	148

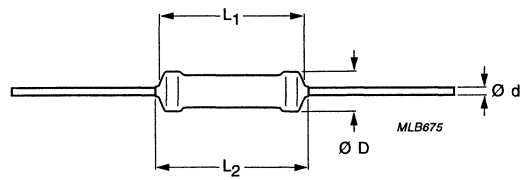
Marking

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

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

Outlines

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



For dimensions see Table 3.

Fig.7 Outlines.

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

TYPE	ØD MAX. (mm)	L_1 MAX. (mm)	L_2 MAX. (mm)	Ød (mm)
VR25	2.5	6.5	7.5	0.6
VR37	4.0	9.0	10.0	0.7
VR68	6.8	18.0	19.0	0.8

TESTS AND REQUIREMENTS

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

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

Unless otherwise specified the following values apply:

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

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

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

All soldering tests are performed with mildly activated flux.

Table 4 Test procedures and requirements

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS		
				VR25	VR37	VR68
4.16	U	robustness of terminations:				
4.16.2	Ua	tensile all samples	Ø0.5 mm; load 10 N; 10 s	number of failures $<10 \times 10^{-6}$		
4.16.3	Ub	bending half number of samples	Ø0.5 mm; load 5 N; 4 × 90°	number of failures $<10 \times 10^{-6}$		
4.16.4	Uc	torsion other half of samples	3 × 360° in opposite directions	no damage ΔR/R max.: ±0.5% +0.05 Ω		
4.17	Ta	solderability	2 s; 235 °C; flux 600	good tinning; no damage		
4.18	Tb	resistance to soldering heat	thermal shock: 3 s; 350 °C; 6 mm from body	ΔR/R max.: ±0.5% +0.05 Ω		
4.19	Na	rapid change of temperature	30 minutes at –55 °C and 30 minutes at +155 °C; 5 cycles	ΔR/R max.: ±0.5% +0.05 Ω		
4.20	Eb	bump	3 × 1500 bumps in 3 directions; 40 g	no damage ΔR/R max.: ±0.5% +0.05 Ω		
4.22	Fc	vibration	frequency 10 to 500 Hz; displacement 1.5 mm or acceleration 10 g; 3 directions; total 6 hours (3 × 2 hours)	no damage ΔR/R max.: ±0.5% +0.05 Ω		

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS		
				VR25	VR37	VR68
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 $\Delta R/R$ max.: ±1.5% +0.1 Ω		
4.24.2	Ca	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; dissipation 0.01 P_n; limiting voltage 16 V (DC)	R_{ins} min.: 1000 MΩ $\Delta R/R$ max.: ±1.5% +0.1 Ω		
4.25.1		endurance	1000 hours at 70 °C; P_n or V_{max}	$\Delta R/R$ max.: ±1.5% +0.1 Ω		
4.8.4		temperature coefficient	between –55 °C and +155 °C ($TC \times 10^{-6}$/K)	≤ ±200		
4.7		voltage proof on insulation	700 V (RMS) during 1 minute; V-block method	no breakdown		
4.12		noise	IEC publication 195	max. 5 μV/V	max. 2.5 μV/V	
4.6.1.1		insulation resistance	500 V (DC or RMS) during 1 minute; V-block method	R_{ins} min.: 1000 MΩ		
4.13		short time overload	room temperature; dissipation 6.25 × P_n (voltage not more than 2 × limiting voltage; 10000 V max.); 10 cycles; 5 s on and 45 s off	$\Delta R/R$ max.: ±0.5% +0.05 Ω		

NOTES

Power metal film resistors PR01/02/03

FEATURES

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

APPLICATIONS

- All general purpose power applications.

DESCRIPTION

A homogeneous film of metal alloy is deposited on a high grade ceramic body. After a helical groove has been cut in the resistive layer, tinned connecting wires of electrolytic copper or electroclad iron are welded to the end-caps. The resistors are coated with a red, nonflammable lacquer which provides electrical, mechanical, and climatic protection. This coating is not resistant to aggressive fluxes. The encapsulation is resistant to all cleaning solvents in accordance with *"MIL-STD 202E"* method 215, and *"IEC 68-2-45"*.

QUICK REFERENCE DATA

DESCRIPTION	VALUE				
	PR01	PR02		PR03	
	∅0.6 mm Cu-lead	∅0.8 mm Cu-lead	∅0.6 mm FeCu-lead	∅0.8 mm Cu-lead	∅0.6 mm FeCu-lead
Resistance range	0.22 Ω to 1 MΩ	0.33 Ω to 1 MΩ	1 Ω to 1 MΩ	0.68 Ω to 1 MΩ	1 Ω to 1 MΩ
Resistance tolerance and series	±5%; E24 series				
Maximum dissipation at T_{amb} = 70 °C					
R < 1 Ω	0.6 W	1.2 W	–	1.6 W	–
1 Ω ≤ R	1 W	2 W	1.3 W	3 W	2.5 W
Thermal resistance (R_{th})	135 K/W	75 K/W	115 K/W	60 K/W	75 K/W
Temperature coefficient	≤ ±250 × 10^{-6}/K				
Maximum permissible voltage (DC or RMS)	350 V	500 V		750 V	
Basic specifications	IEC 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				

ORDERING INFORMATION

Table 1 Ordering code indicating resistor type and packaging

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

Notes

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

Ordering code (12NC)

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

Table 2 Last digit of 12 NC

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

ORDERING EXAMPLE

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

FUNCTIONAL DESCRIPTION

Product characterization

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

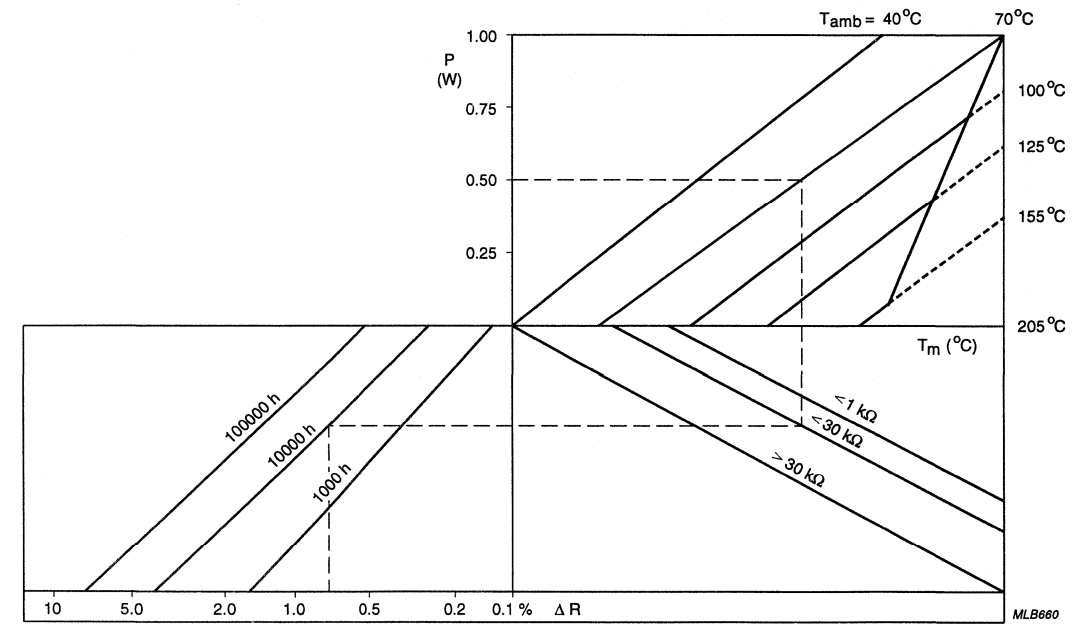


Fig.1 Drift nomogram.

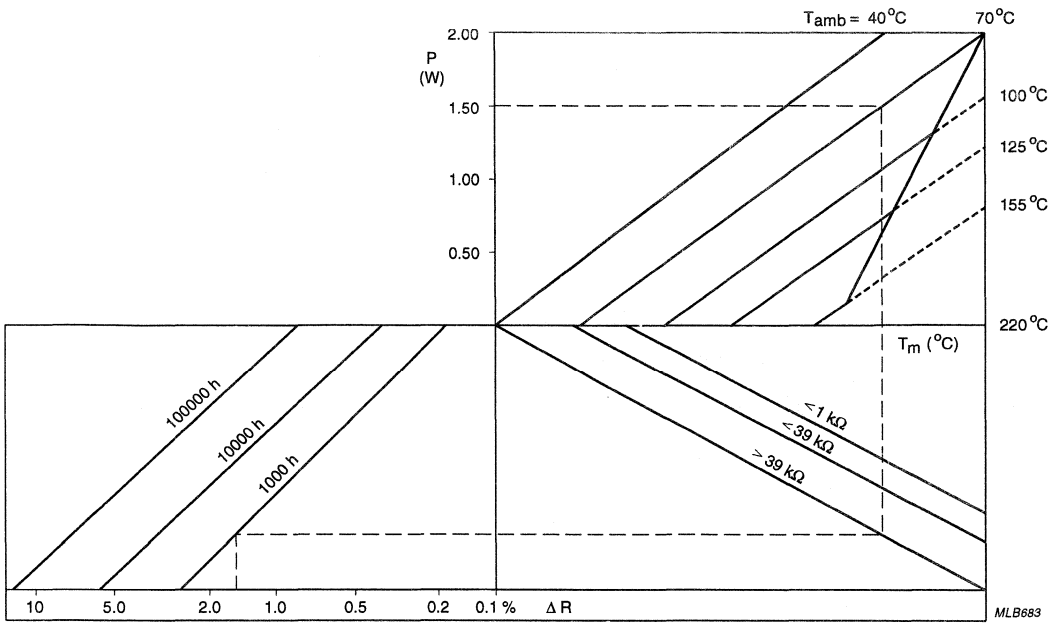


Fig.2 Drift nomogram.

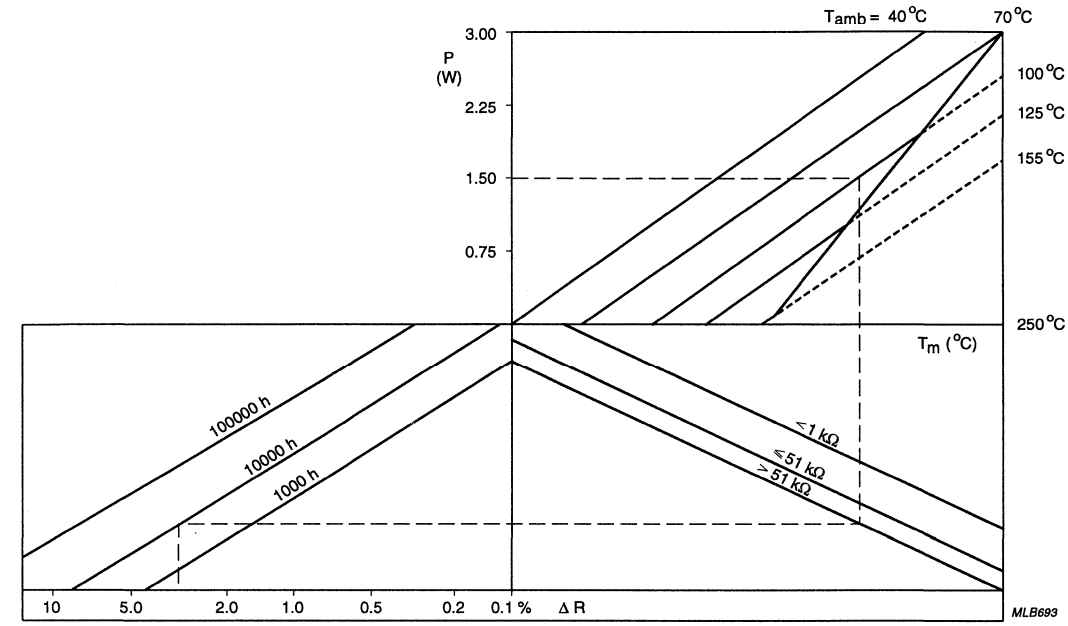


Fig.3 Drift nomogram.

Limiting values

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

Note

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

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

DERATING

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

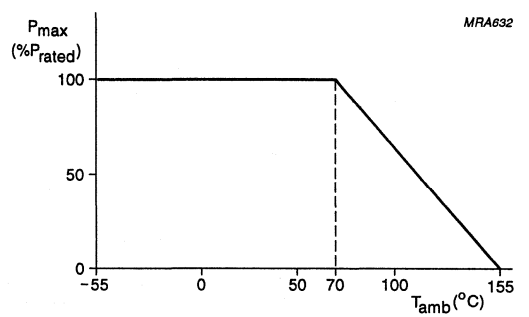


Fig.4 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

PULSE LOADING CAPABILITIES

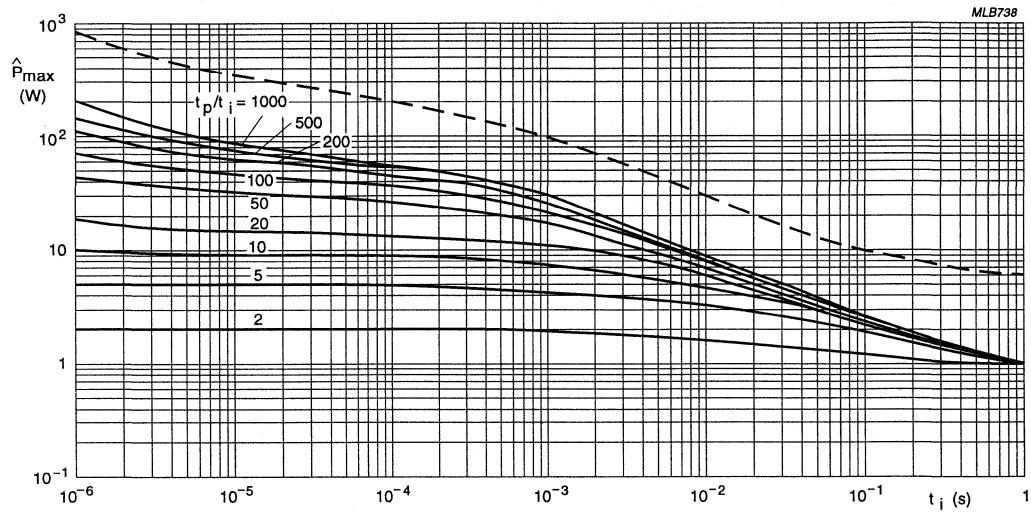


Fig.5 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i).

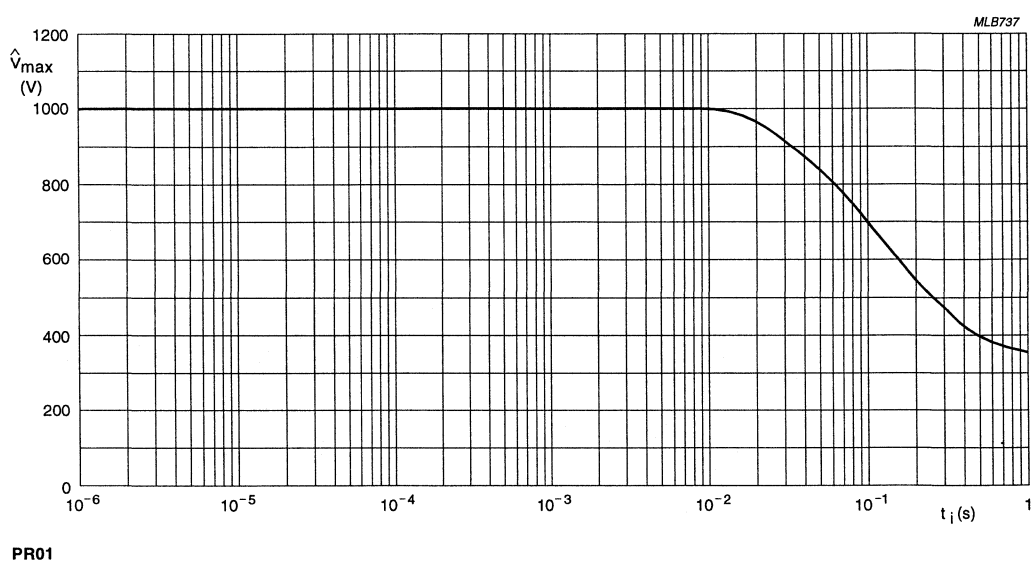
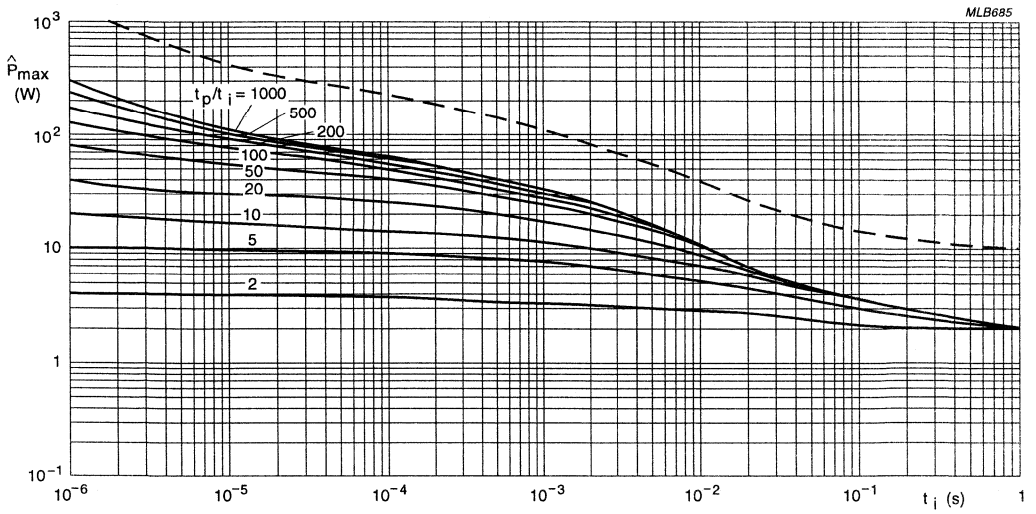
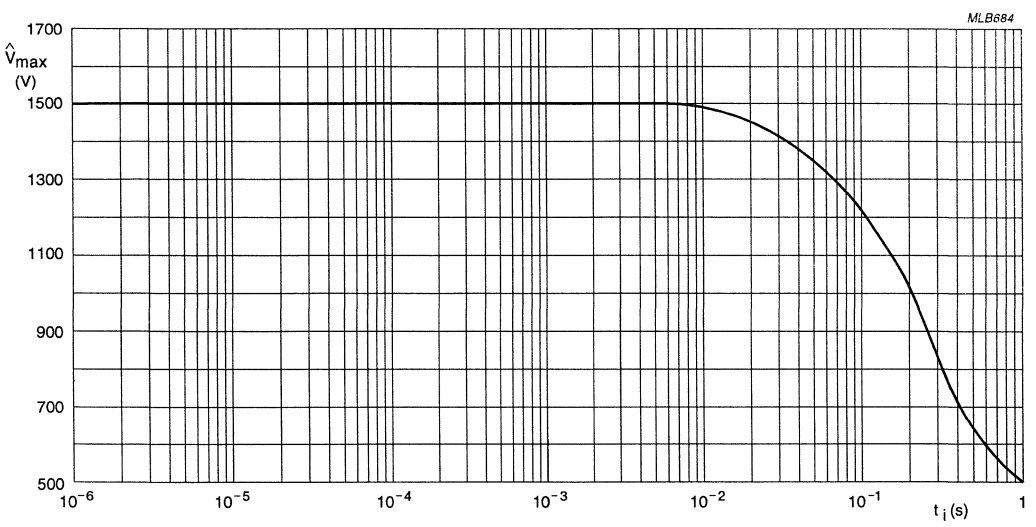


Fig.6 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_i).



PR02

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



PR02

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

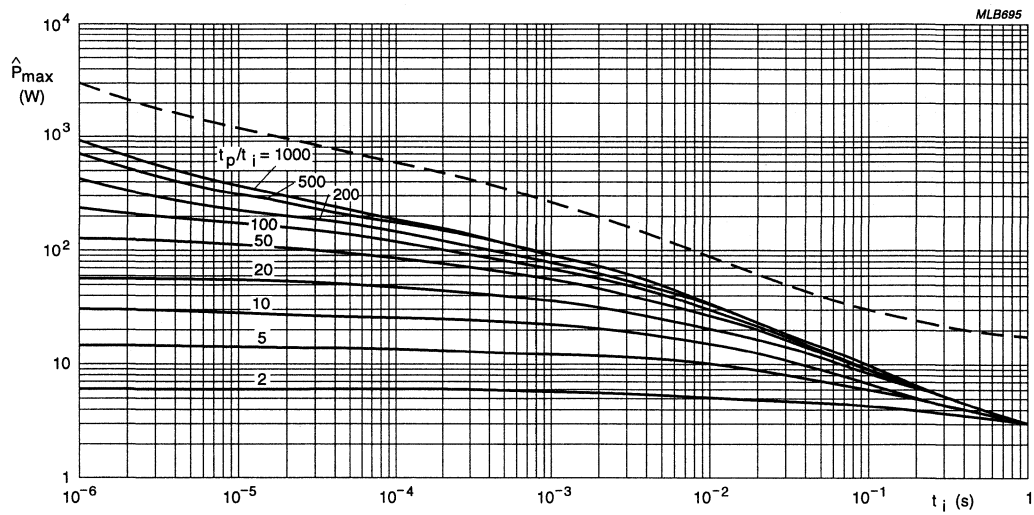


Fig.9 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i).

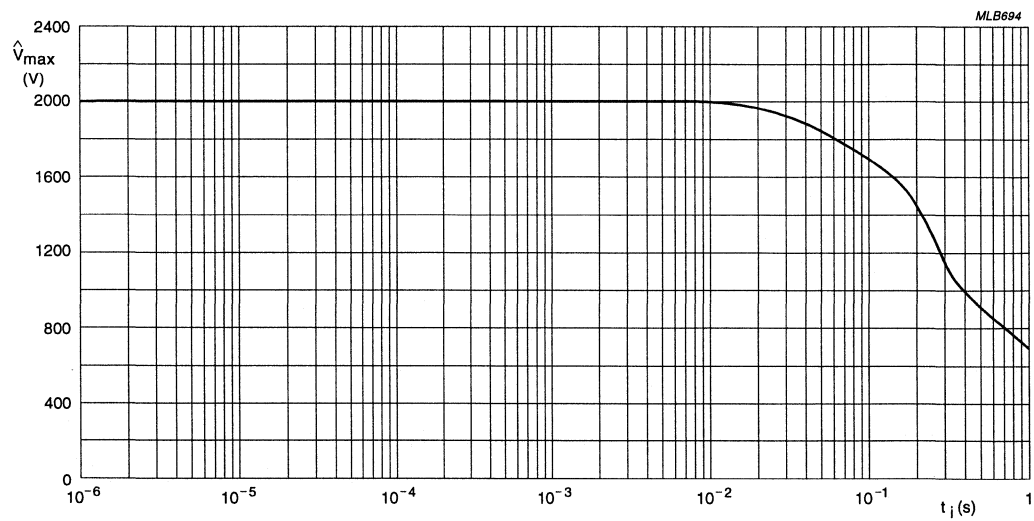
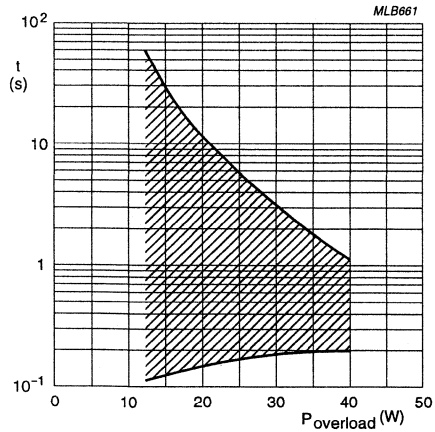


Fig.10 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_i).

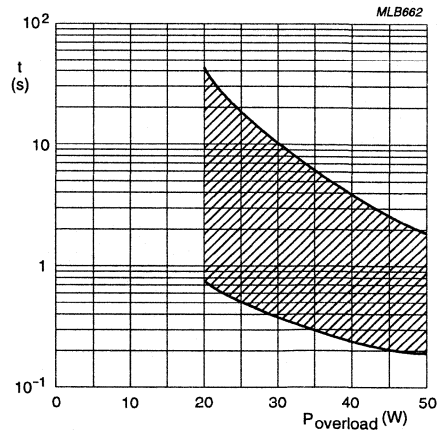
INTERRUPTION CHARACTERISTICS



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

PR01

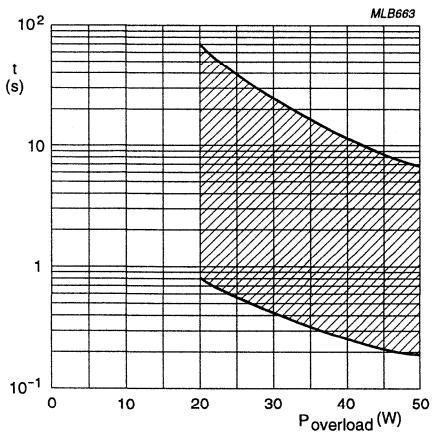
Fig.11 Time to interruption as a function of overload power for range: $0R22 \leq R_n < 1R$.



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

PR01

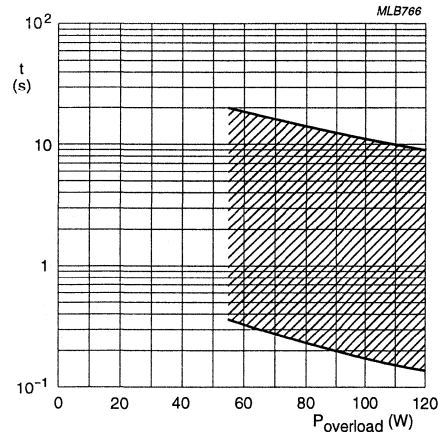
Fig.12 Time to interruption as a function of overload power for range: $1R \leq R_n \leq 15R$.



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

PR01

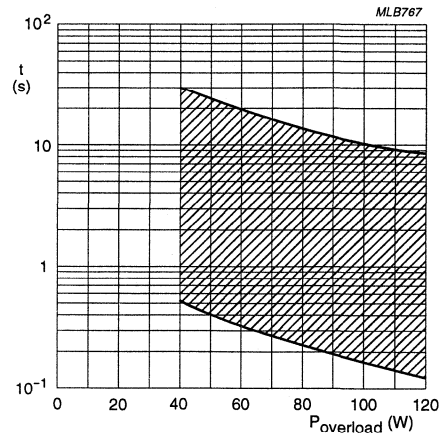
Fig.13 Time to interruption as a function of overload power for range: $16R \leq R_n \leq 560R$.



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

PR02

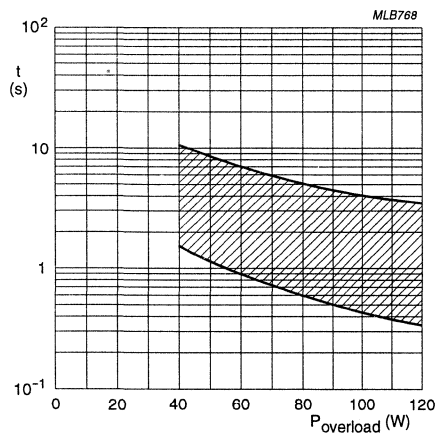
Fig.14 Time to interruption as a function of overload power for range: $0.33R \leq R_n < 5R$.



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

PR02

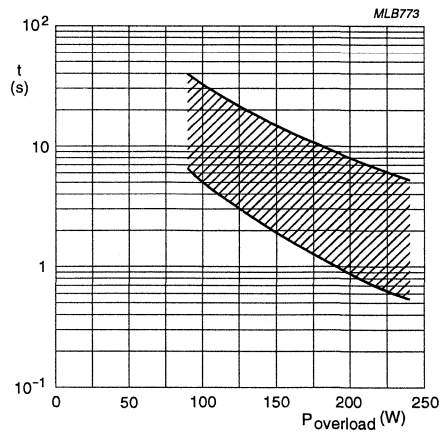
Fig.15 Time to interruption as a function of overload power for range: $5R \leq R_n < 68R$.



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

PR02

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

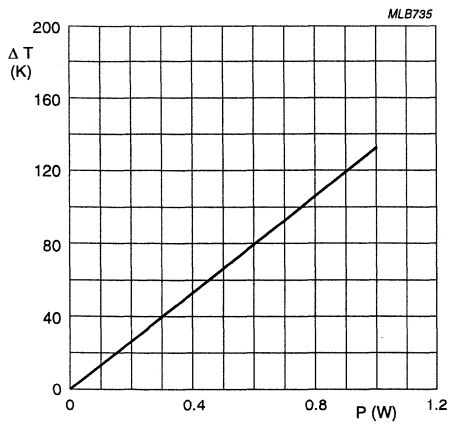


The graph is based on measured data under constant voltage conditions; these data may deviate according to the application.

PR03

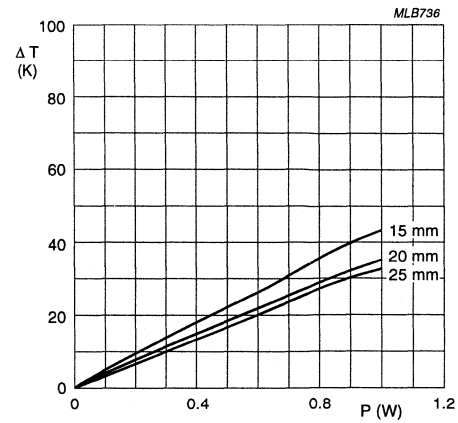
Fig.17 Time to interruption as a function of overload power for range: $0.68R \leq R_n \leq 560R$.

Application information



PR01

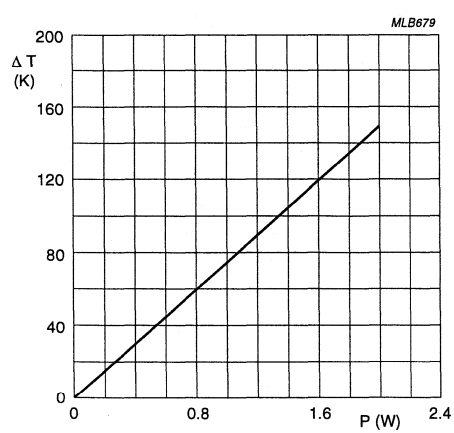
Fig.18 Hot-spot temperature rise (ΔT) as a function of dissipated power.



Minimum distance from resistor body to PCB = 1 mm.

PR01

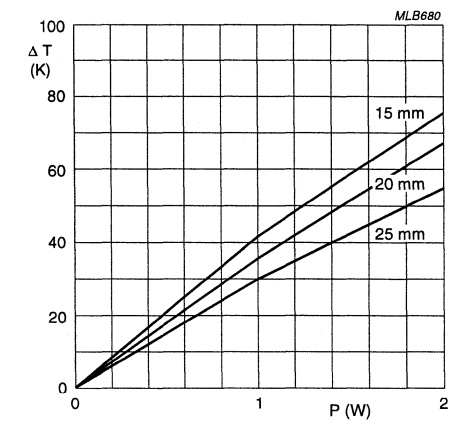
Fig.19 Temperature rise (ΔT) at the lead end (soldering point) as a function of dissipated power at various lead lengths after mounting.



Ø 0.8 mm Cu-leads.

PR02

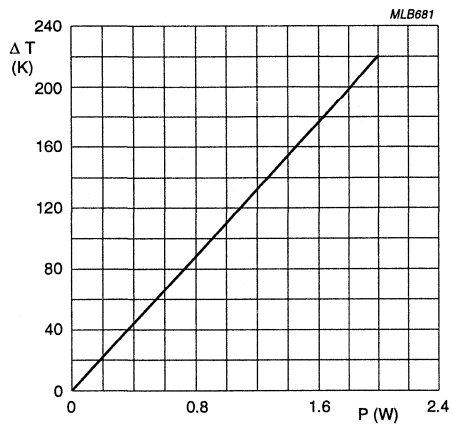
Fig.20 Hot-spot temperature rise (ΔT) as a function of dissipated power.



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

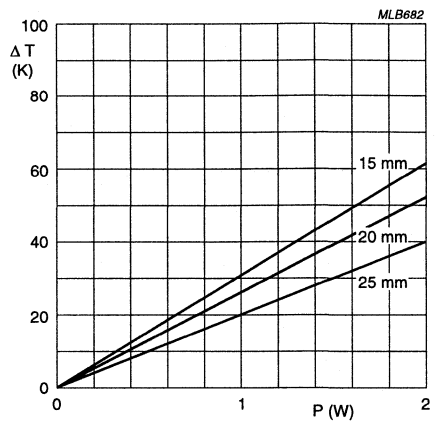
PR02

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



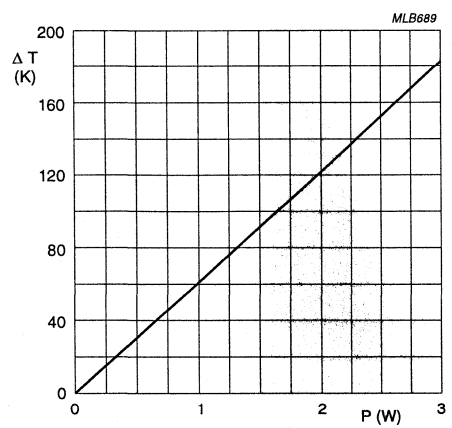
Ø 0.6 mm FeCu-leads.
PR02

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



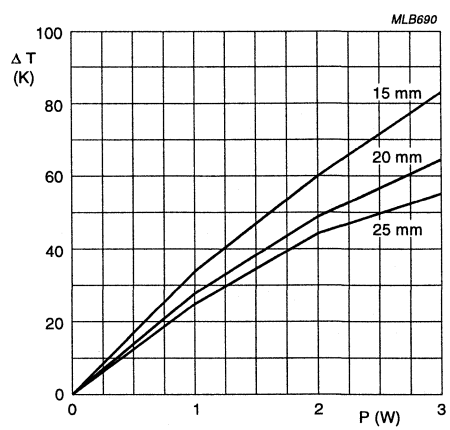
Ø 0.6 mm FeCu-leads.
Minimum distance from resistor body to PCB = 1 mm.
PR02

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



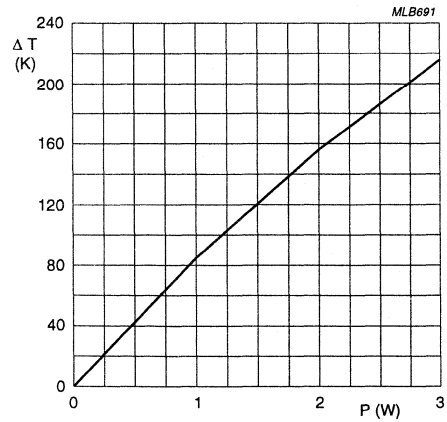
Ø 0.8 mm Cu-leads.
PR03

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



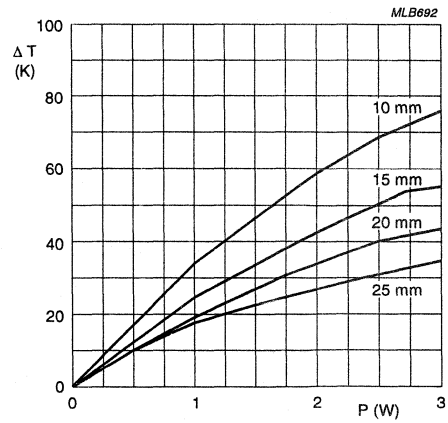
Ø 0.8 mm Cu-leads.
Minimum distance from resistor body to PCB = 1 mm.
PR03

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



Ø 0.6 mm FeCu-leads.
PR03

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



Ø 0.6 mm FeCu-leads.
Minimum distance from resistor body to PCB = 1 mm.
PR03

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

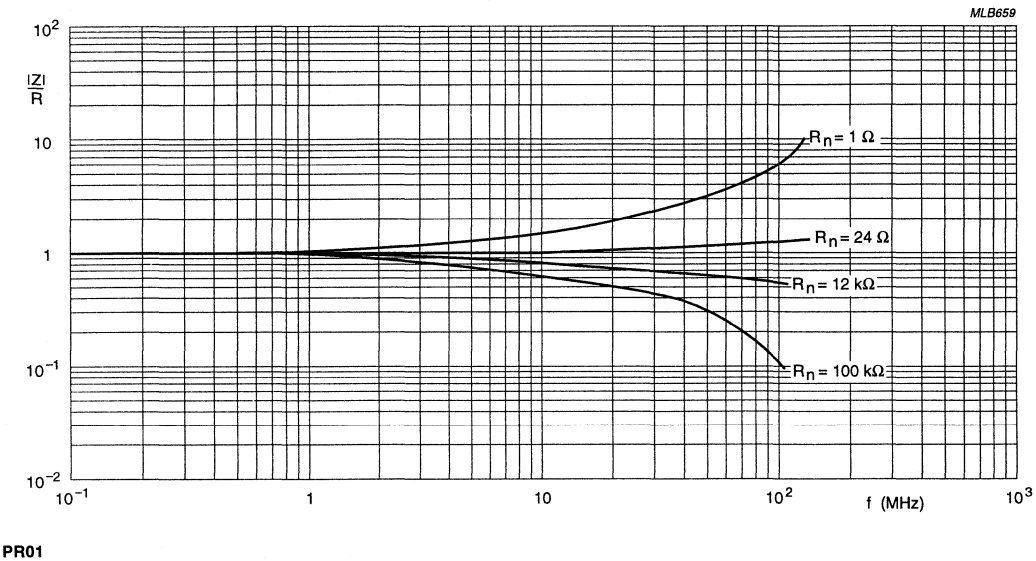


Fig.28 Impedance as a function of applied frequency.

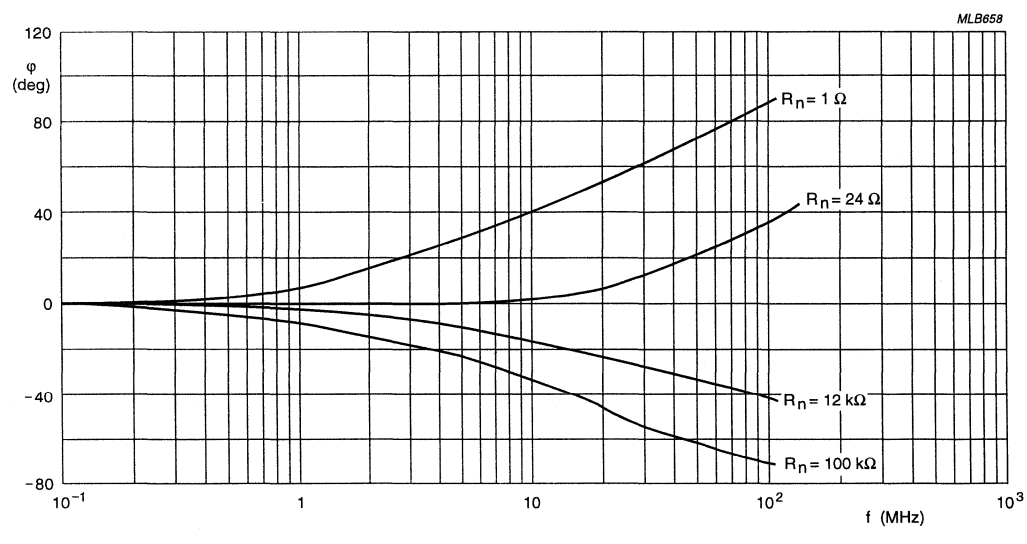


Fig.29 Phase angle as a function of applied frequency.

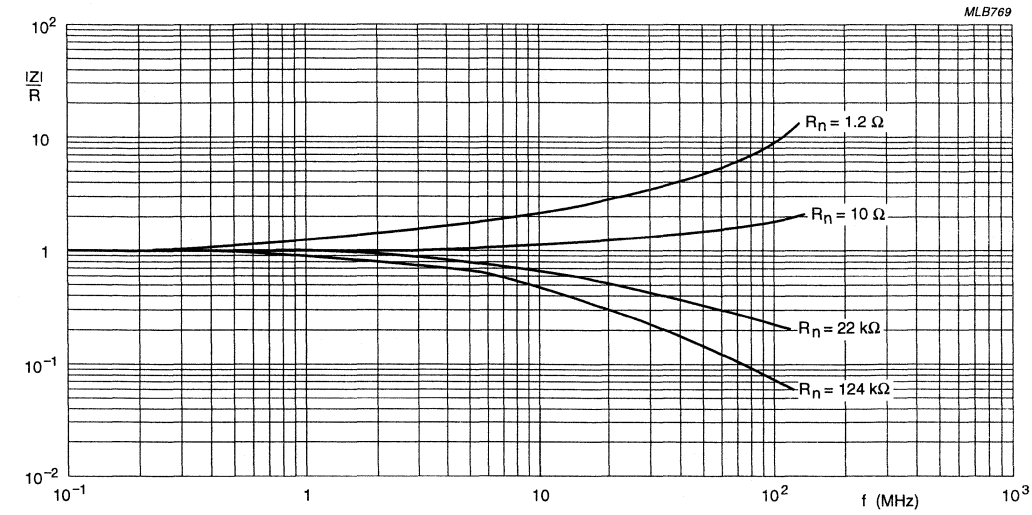


Fig.30 Impedance as a function of applied frequency.

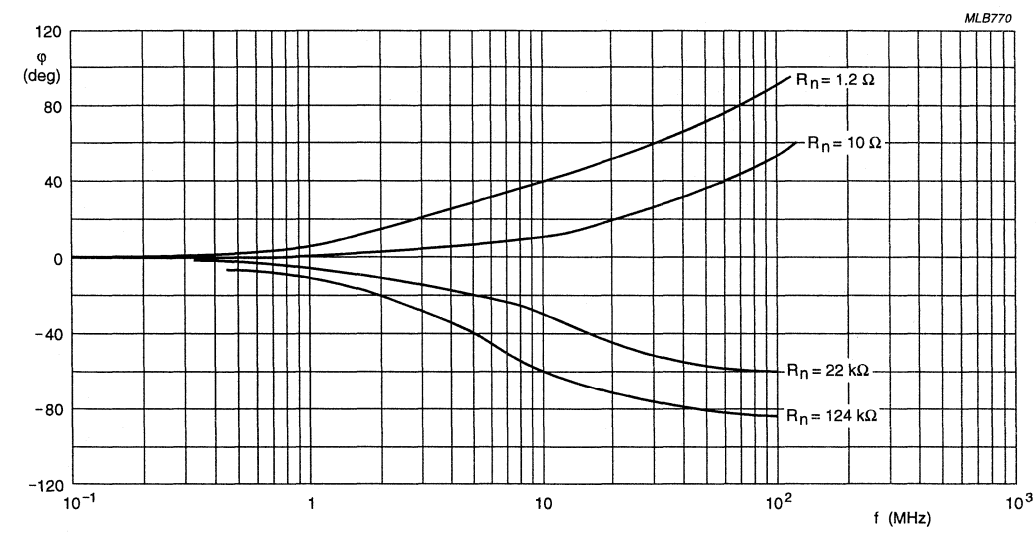


Fig.31 Phase angle as a function of applied frequency.

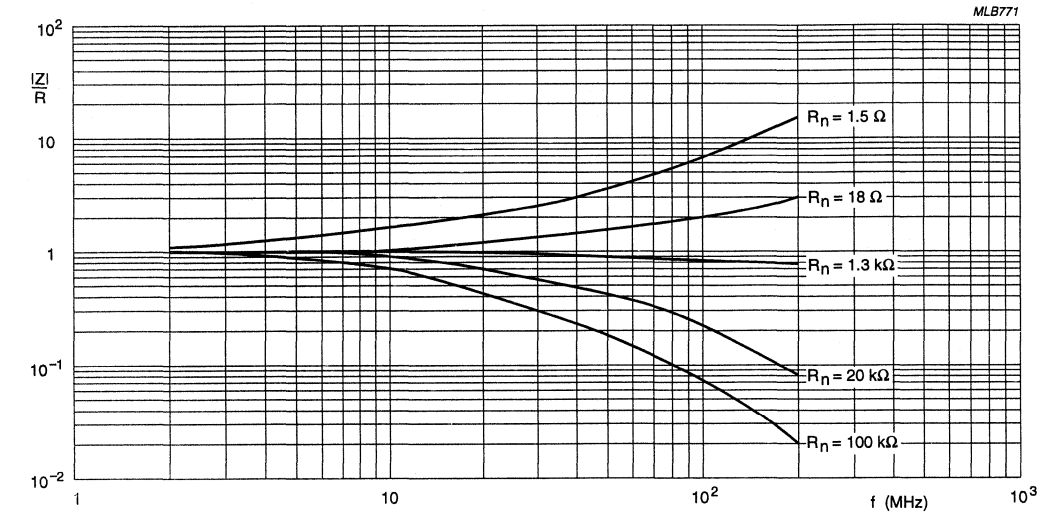


Fig.32 Impedance as a function of applied frequency.

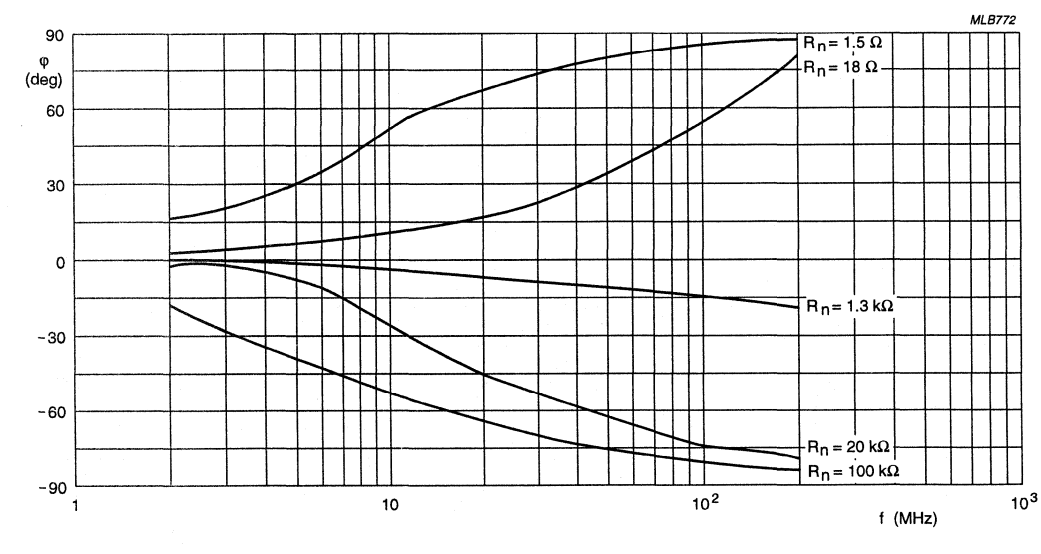


Fig.33 Phase angle as a function of applied frequency.

MECHANICAL DATA

Mass per 100 units

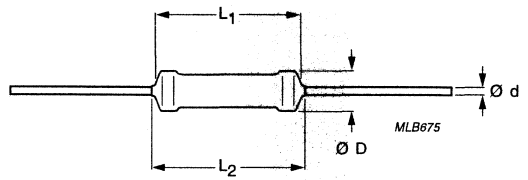
TYPE	LEAD MATERIAL	MASS (g)
PR01	Cu	29
PR02	Cu	63
	FeCu	45
PR03	Cu	110
	FeCu	100

Marking

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

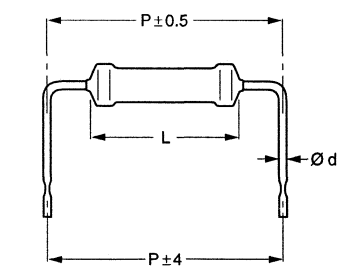
Outlines

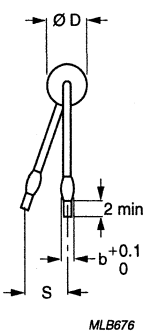
The length of the body (L_1) is measured by inserting the leads into holes of two identical gauge plates and moving these plates parallel to each other until the resistor body is clamped without deformation (*"IEC publication 294"*). Resistors with lead lengths of 73, 52 or 26 mm are available on request.

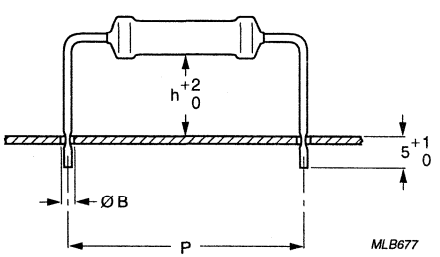


For dimensions see Table 3.

Fig.34 Type with straight leads.







Dimensions in mm.
For dimensions see Table 3.

Fig.35 Type with cropped and formed leads.

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

TYPE	ØD MAX. (mm)	L_1 MAX. (mm)	L_2 MAX. (mm)	Ød (mm)	b (mm)	h (mm)	P (mm)	S MAX. (mm)	ØB MAX. (mm)
PR01	2.5	6.5	8.5	0.6	1.1	8	17.8	2	1.0
PR02	3.9	10	12	0.8	1.3	8		2	1.2
				0.8	1.3	15		3	1.2
				0.6	1.1	8		2	1.0
PR03	5.2	16.7	19.5	0.8	1.3	8	25.4	2	1.2
				0.8	1.3	15		3	1.2
				0.6	1.1	8		2	1.0

TESTS AND REQUIREMENTS

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

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

Unless otherwise specified the following values apply:

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

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

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

All soldering tests are performed with mildly activated flux.

Table 4 Test procedures and requirements

IEC 115-8 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
Tests in accordance with the schedule of IEC publication 115-8				
4.4.1		visual examination		no holes; clean surface; no damage
4.4.2		dimensions (outline)	gauge (mm)	see Table 3
4.5		resistance	applied voltage (+0/–10%): $R < 10\ \Omega$: 0.1 V $10\ \Omega \leq R < 100\ \Omega$: 0.3 V $100\ \Omega \leq R < 1\ k\Omega$: 1 V $1\ k\Omega \leq R < 10\ k\Omega$: 3 V $10\ k\Omega \leq R < 100\ k\Omega$: 10 V $100\ k\Omega \leq R < 1\ M\Omega$: 25 V $R = 1\ M\Omega$: 50 V	$R - R_{nom}$: max. ±5%
4.18	Tb	resistance to soldering heat	thermal shock: 3 s; 350 °C; 6 mm from body	$\Delta R/R$ max.: ±1% +0.05 Ω
4.29	45 (Xa)	component solvent resistance	isopropyl alcohol or H_2O followed by brushing in accordance with *"MIL 202 F"*	no visual damage
4.17	Ta	solderability	2 s; 235 °C	good tinning; no damage
4.7		voltage proof on insulation	maximum voltage 500 V (RMS) during 1 minute; metal block method	no breakdown or flashover

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

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.

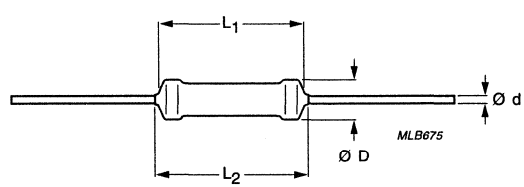
For values up to 910 Ω the R is used as the decimal point.

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

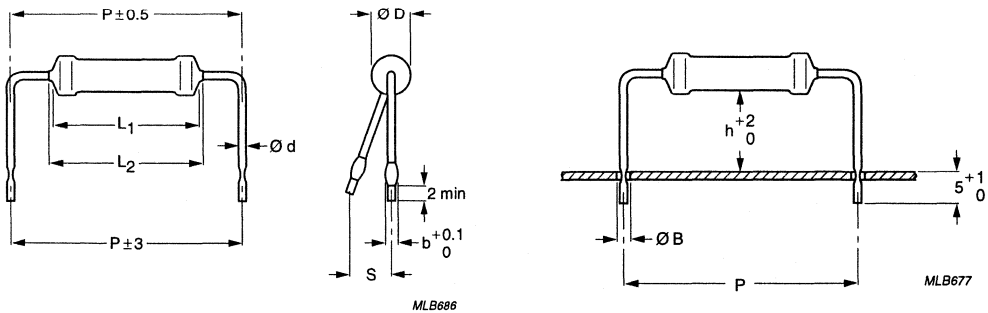
DESCRIPTION	VALUE
Resistance range	1 Ω to 1 MΩ; E24 series
Resistance tolerance	±5%
Maximum body temperature (hot-spot)	300 °C
Absolute maximum dissipation at T_{amb} = 70 °C (P_{70}); see Fig.3:	
R ≤ 27 kΩ	1.6 W
R > 27 kΩ	1.2 W
Maximum permissible voltage	500 V
Basic specifications	IEC 115-4 and MIL-R-11804/2, 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 Lead type and physical dimensions; see Figs 1 and 2

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	

Power metal film resistors PR37

ELECTRICAL DATA

Standard values of rated resistance and tolerance

Standard values of rated (nominal) resistance are taken from the E24 series within the range 1 Ω to 1 MΩ. The values of the E24 series are in accordance with *"IEC publication 63"*.

The tolerance on the rated resistance is ±5%.

The limiting voltage (RMS) is 500 V. This is the maximum voltage that may be applied continuously to the resistor element, see *"IEC publications 115-1 and 115-4"*.

The maximum permissible hot-spot temperature is 300 °C.

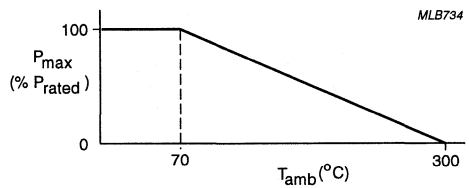
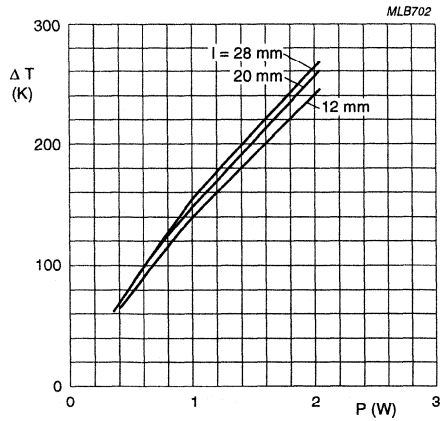


Fig.3 Rated power dissipation (P_{rated}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

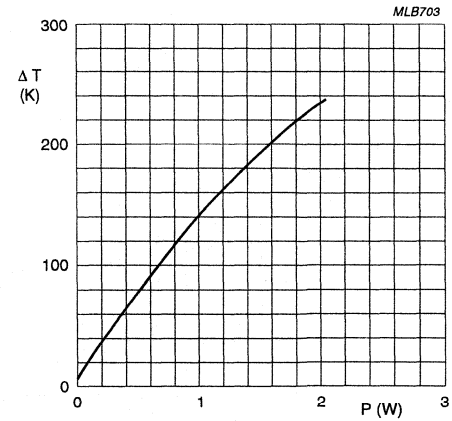
Table 2 Electrical data

DESCRIPTION	VALUE
Temperature coefficient	$R < 10\ \Omega$: $\leq \pm 350 \times 10^{-6}$/K
	$R \geq 10\ \Omega$: $\leq \pm 250 \times 10^{-6}$/K
Maximum body temperature (hot-spot)	300 °C
Absolute maximum dissipation at T_{amb} = 70 °C:	
$R \leq 27\ k\Omega$	1.6 W
$R > 27\ k\Omega$	1.2 W
Limiting voltage	500 V
Dielectric withstanding minimum RMS voltage of the insulation for 1 min	500 V
Basic specifications	IEC 115-4 and MIL-R-11804/2, char. G
Climatic category (IEC 68)	55/200/56
Temperature rise (ΔT) of the resistor body as a function of dissipation	see Figs 4 and 5
Lead length (l) as a function of dissipation with temperature rise at end of lead (soldering point) as parameter	see Figs 6 and 7



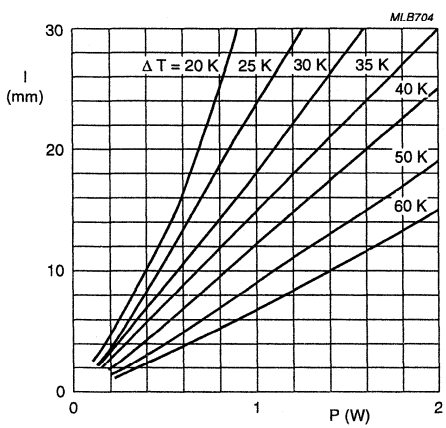
Copper-clad iron leads Ø = 0.6 mm.

Fig.4 Hot-spot temperature rise (ΔT) as a function of dissipated power at different lead lengths (l).



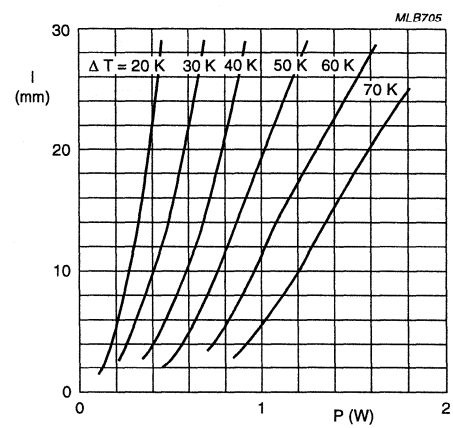
Copper leads Ø = 0.8 mm.

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.

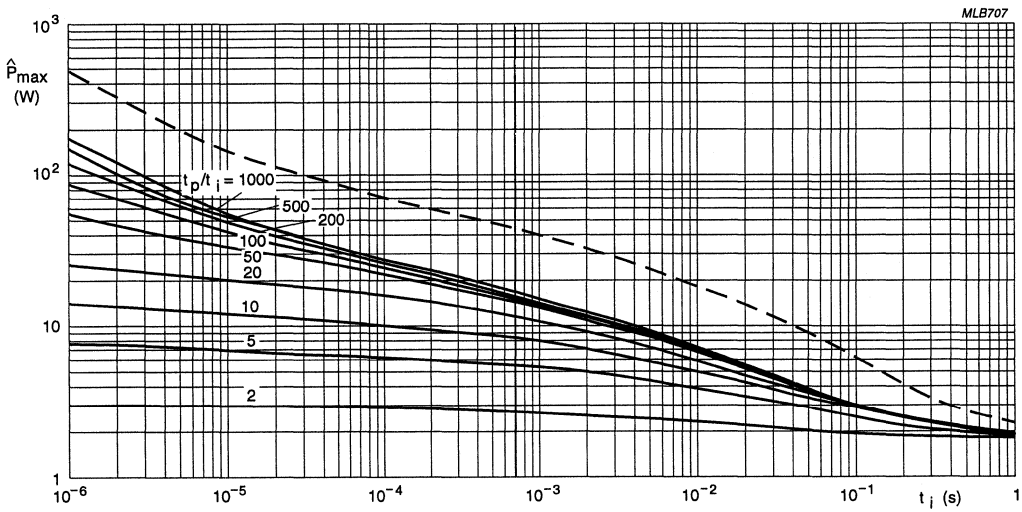


Fig.8 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i).

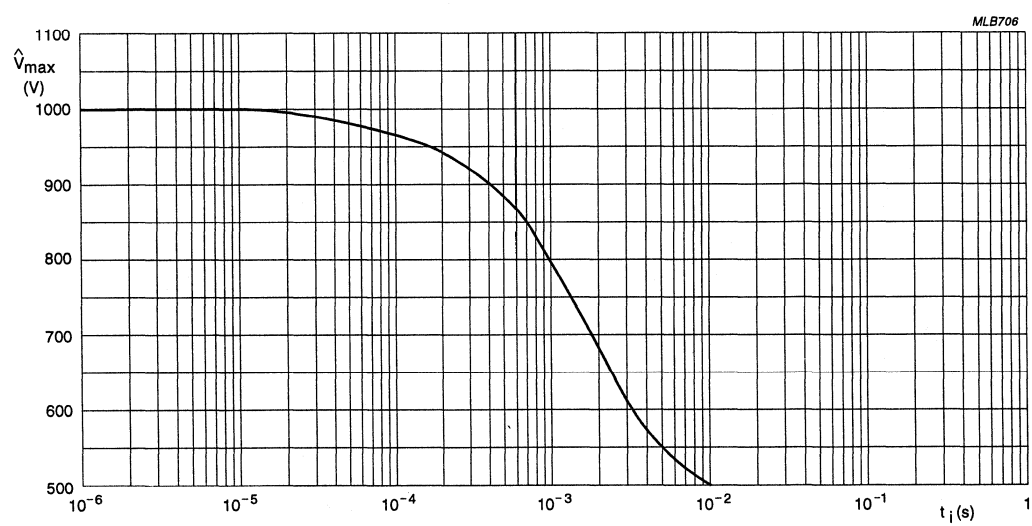


Fig.9 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_i).

Power metal film resistors PR37

COMPOSITION OF THE CATALOGUE NUMBER

2322 191 . . . . .

- style code:
  - 3 = straight formed copper-clad iron leads, Ø0.6 mm
  - 4 = cropped and formed copper-clad iron leads, Ø0.6 mm
  - 5 = straight copper leads, Ø0.8 mm
  - 6 = cropped and formed copper leads, Ø0.8 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 the following values apply:

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

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

In Table 3 the tests and requirements are listed with reference to the relevant clauses of *"IEC publications 115-1 and 68"*; a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

Table 3 Test procedures and requirements

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.16	U	robustness of terminations:		
4.16.2	Ua	tensile all samples	load 10 N; 10 s	number of failures $<1 \times 10^{-6}$
4.16.3	Ub	bending half number of samples	load 5 N; 4 × 90°	number of failures $<1 \times 10^{-6}$
4.16.4	Uc	torsion other half of samples	3 × 360° in opposite directions	no damage ΔR/R max.: ±0.5% +0.05 Ω
4.17	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; 3 directions; total 6 hours (3 × 2 hours)	no damage ΔR/R max.: ±0.5% +0.05 Ω
4.23		climatic sequence:		
4.23.2	Ba	dry heat	16 hours; 155 °C	
4.23.3	Db	damp heat (accelerated) 1st cycle	24 hours; 55 °C; 95 to 100% RH	
4.23.4	Aa	cold	2 hours; –55 °C	
4.23.5	M	low air pressure	1 hour; 8.5 kPa; 15 to 35 °C	
4.23.6	Db	damp heat (accelerated) remaining cycles	5 days; 55 °C; 95 to 100% RH	R_{ins} min.: 1000 MΩ ΔR/R max.: ±3% +0.1 Ω

Power metal film resistors PR37

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.24.2	Ca	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; dissipation 0.01 × P_{70}	R_{ins} min.: 1000 MΩ ΔR/R max.: ±3% +0.1 Ω
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	R < 10 Ω: ≤ ±350 × 10^{-6}/K
				R ≥ 10 Ω: ≤ ±250 × 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

Power metal film resistors PR37

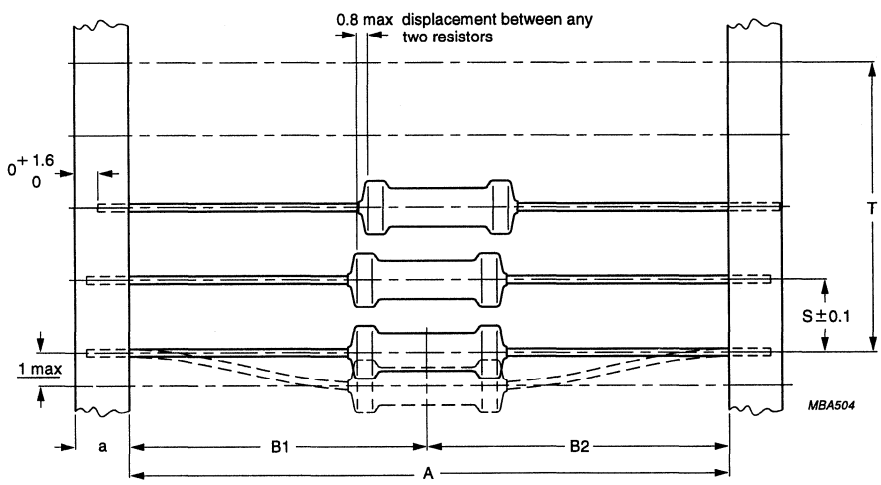
PACKAGING

The resistors may be supplied on bandolier in ammopack. Those with bent leads are supplied loose in a box. For details refer to this handbook, section *"General Introduction leaded resistors"*.

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"*.

MECHANICAL DATA

Mass

92 g (per 100 units).

Mounting

The resistors must be mounted stress free so as to allow thermal expansion over the wide permissible temperature range.

The minimum pitch for this type with cropped and formed leads is 10e.

Marking

The resistor is marked with the nominal resistance value and the tolerance on the resistance.

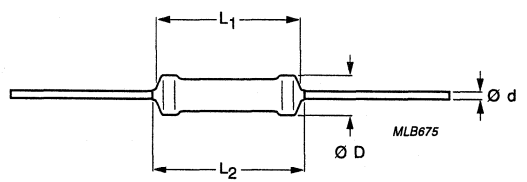
For values up to 910 Ω the R is used as the decimal point.

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

For the value of 1 MΩ the letter M is used as the decimal point for the MΩ indication.

QUICK REFERENCE DATA

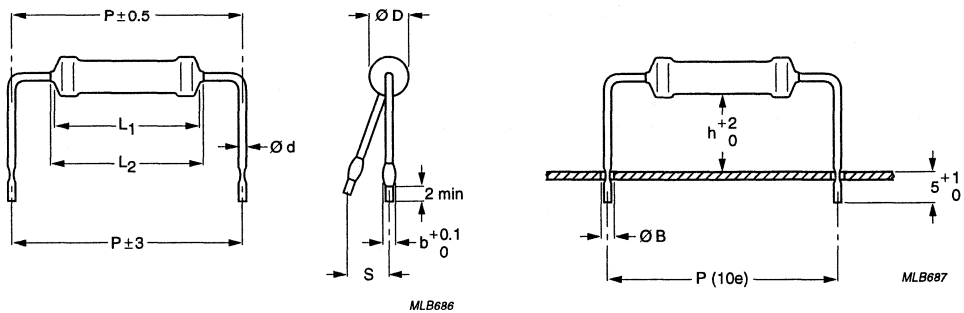
DESCRIPTION	VALUE
Resistance range	1 Ω to 1 MΩ; E24 series
Resistance tolerance	±5%
Maximum body temperature (hot-spot)	300 °C
Absolute maximum dissipation at T_{amb} = 70 °C (P_{70}); see Fig.3:	
R ≤ 51 kΩ	2.5 W
R > 51 kΩ	2.0 W
Maximum permissible voltage	750 V
Basic specifications	IEC 115-4 and MIL-R-11804/2, 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.

Power metal film resistors PR52



Dimensions in mm.
For dimensions see Table 1.

Fig.2 Type with cropped and formed leads.

Table 1 Lead type and physical dimensions; see Figs 1 and 2

LEADS	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.

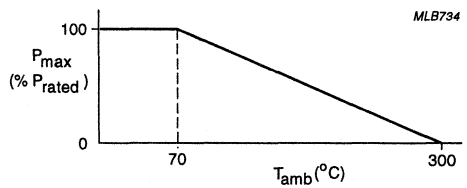
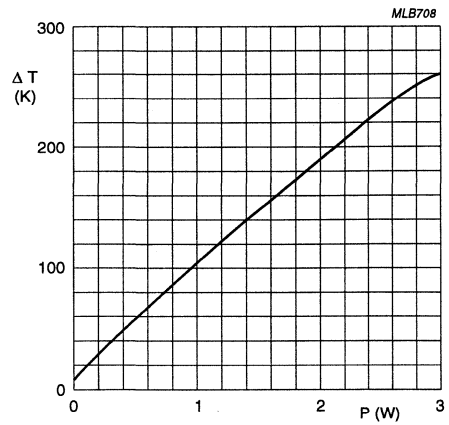


Fig.3 Rated power dissipation (P_{rated}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

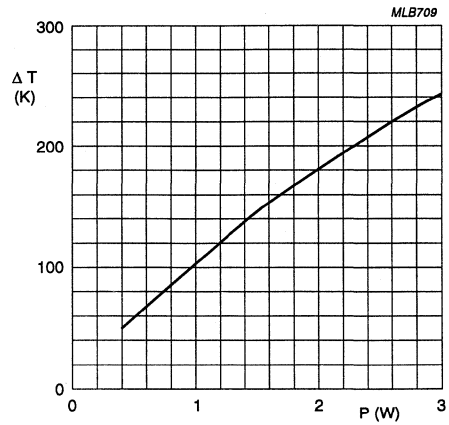
Table 2 Electrical data

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



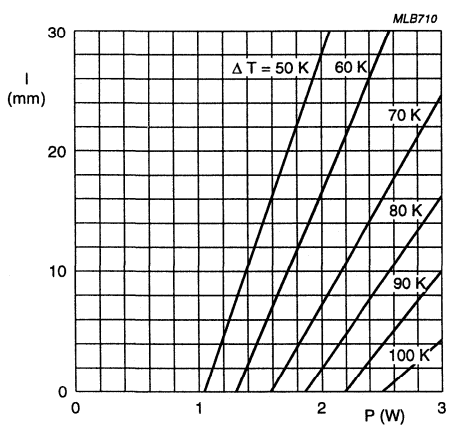
Copper-clad iron leads Ø = 0.6 mm.

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



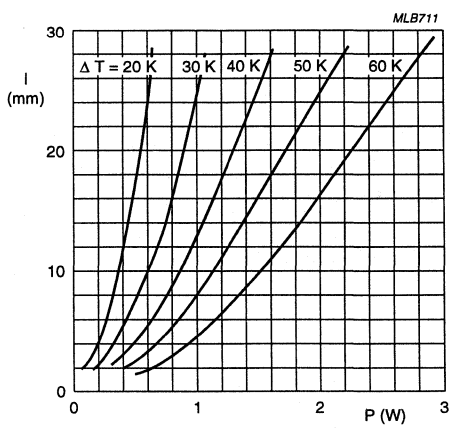
Copper leads Ø = 0.8 mm.

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



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.

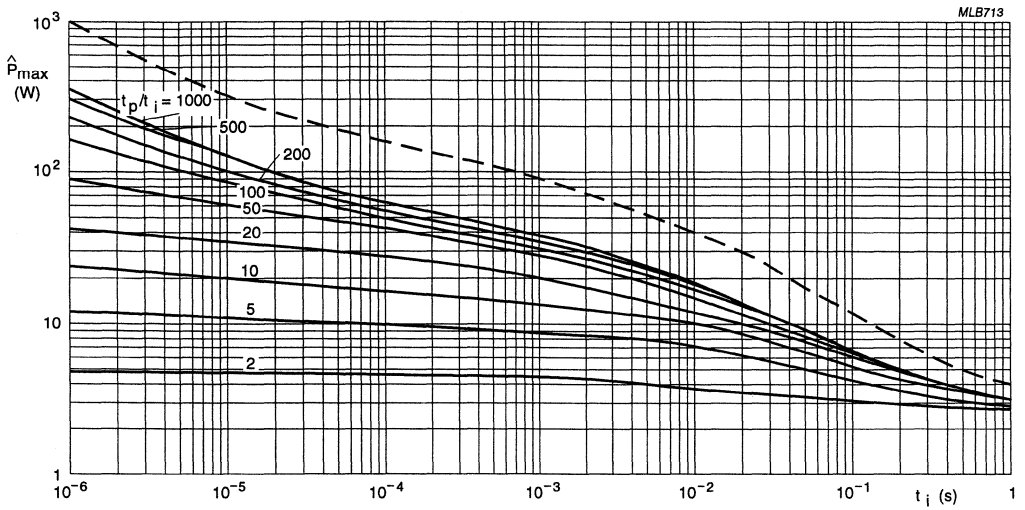


Fig.8 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i).

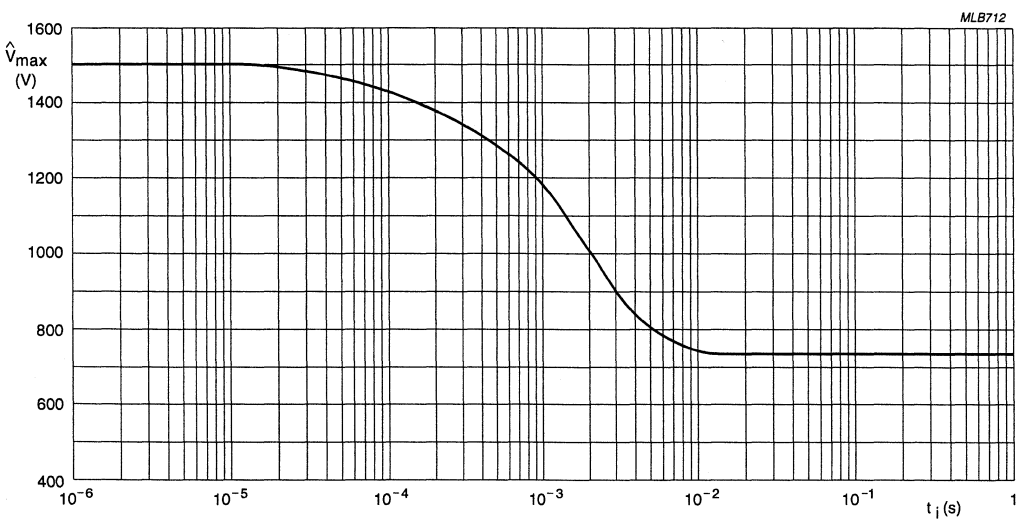


Fig.9 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_i).

Power metal film resistors PR52

COMPOSITION OF THE CATALOGUE NUMBER

2322 192 . . . . .

style code:
- 3 = straight formed copper-clad iron leads, Ø 0.6 mm
- 4 = cropped and formed copper-clad iron leads, Ø 0.6 mm
- 5 = straight copper leads, Ø 0.8 mm
- 6 = cropped and formed copper leads, Ø 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 the following values apply:

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

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

In Table 3 the tests and requirements are listed with reference to the relevant clauses of *"IEC publications 115-1 and 68"*; a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

Table 3 Test procedures and requirements

IEC 115-1 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
4.16	U	robustness of terminations:		
4.16.2	Ua	tensile all samples	load 10 N; 10 s	number of failures $<1 \times 10^{-6}$
4.16.3	Ub	bending half number of samples	load 5 N; 4 × 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 $\Delta R/R$ 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	$\Delta R/R$ 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 $\Delta R/R$ max.: ±2% +0.1 Ω
4.20	Eb	bump	3 × 1500 bumps in three directions; 40 g	no damage $\Delta R/R$ max.: ±0.5% +0.05 Ω
4.22	Fc	vibration	frequency 10 to 500 Hz; displacement 1.5 mm or acceleration 10 g; 3 directions; total 6 hours (3 × 2 hours)	no damage $\Delta R/R$ 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.: 1000 MΩ $\Delta R/R$ max.: ±3% +0.1 Ω

Power metal film resistors PR52

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_{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
4.8.4.2		temperature coefficient	between –55 °C and +155 °C	R < 10 Ω: ≤ ±350 × 10^{-6}/K
				R ≥ 10 Ω: ≤ ±250 × 10^{-6}/K
4.7		voltage proof on insulation	500 V (RMS) 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.: 1 000 MΩ
see 2nd amendment to IEC 115-1, Jan. '87 and present 40 central office 532 & 533		pulse load		see Figs 8 and 9

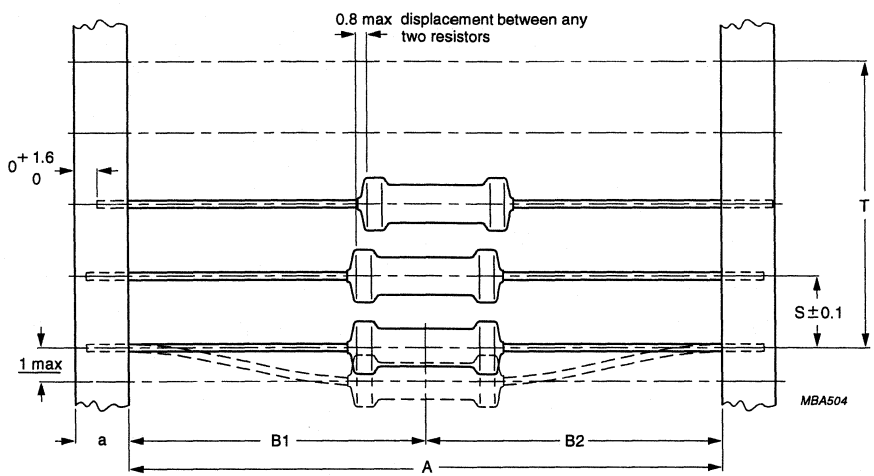
PACKAGING

The resistors may be supplied on bandolier in ammopack. Those with bent leads are supplied loose in a box.
For details refer to this handbook, section *"General Introduction leaded resistors"*.

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

Cemented wirewound resistors AC01/03/04/05/07/10/15/20

FEATURES

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

APPLICATIONS

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

DESCRIPTION

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

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

QUICK REFERENCE DATA

DESCRIPTION	VALUE							
	AC01	AC03	AC04	AC05	AC07	AC10	AC15	AC20
Resistance range	0.1 Ω to 1.5 kΩ	0.1 Ω to 3.0 kΩ	0.1 Ω to 6.8 kΩ	0.1 Ω to 8.2 kΩ	0.1 Ω to 15 kΩ	0.68 Ω to 15 kΩ	0.82 Ω to 22 kΩ	1.2 Ω to 33 kΩ
Resistance tolerance	±5%; E24 series							
Maximum permissible body temperature	350 °C							
Rated dissipation at T_{amb} = 40 °C	1 W	3 W	4 W	5 W	7 W	10 W	15 W	20 W
Rated dissipation at T_{amb} = 70 °C	0.9 W	2.5 W	3.5 W	4.7 W	5.8 W	8.4 W	12.5 W	16 W
Climatic category (IEC 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							

ORDERING INFORMATION

Table 1 Ordering code indicating resistor type and packaging

TYPE	ORDERING CODE			
	LOOSE IN BOX	BANDOLIER IN AMMOPACK		
	STRAIGHT LEADS	RADIAL	STRAIGHT LEADS	
	100 units	2500 units	500 units	1000 units
AC01	–	2306 328 90...;note (2)	–	2306 328 33...
AC03(1)	–	–	2322 329 03...	–
AC04(1)	–	–	2322 329 04...	–
AC05(1)	–	–	2322 329 05...	–
AC07(1)	–	–	2322 329 07...	–
AC10	2322 329 10...	–	–	–
AC15	2322 329 15...	–	–	–
AC20	2322 329 20...	–	–	–

Note

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

Ordering code (12NC)

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

Table 2 Last digit of 12NC

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

ORDERING EXAMPLE

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

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

FUNCTIONAL DESCRIPTION

Product characterization

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

Limiting values

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

Note

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

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

DERATING

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

PULSE LOADING CAPABILITY

Detailed pulse loading information is available on request.

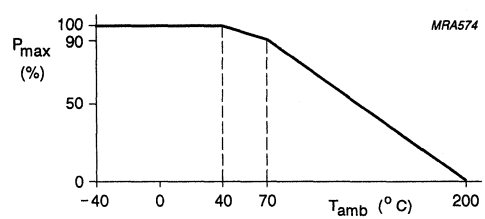


Fig.1 Maximum dissipation (P_{max}) as a function of the ambient temperature (T_{amb}).

Application information

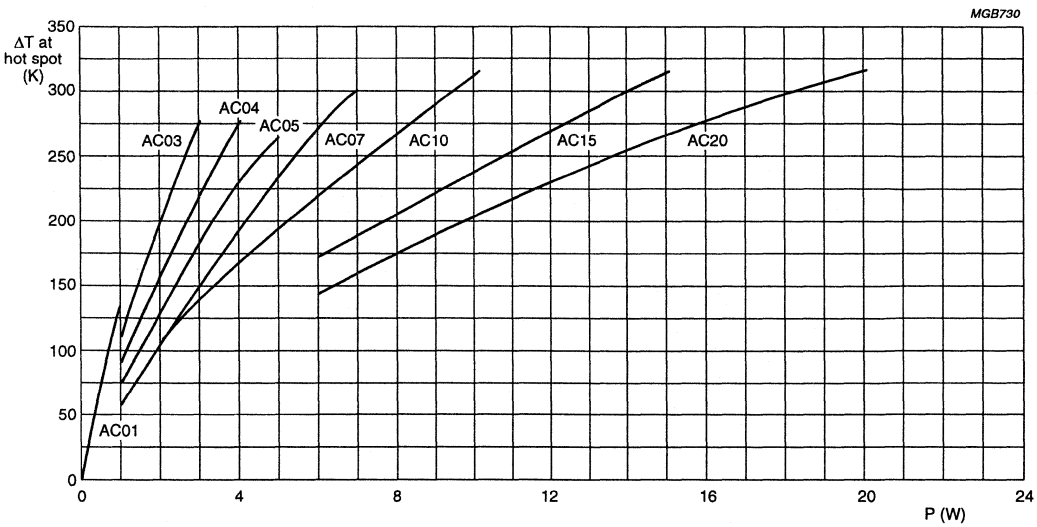
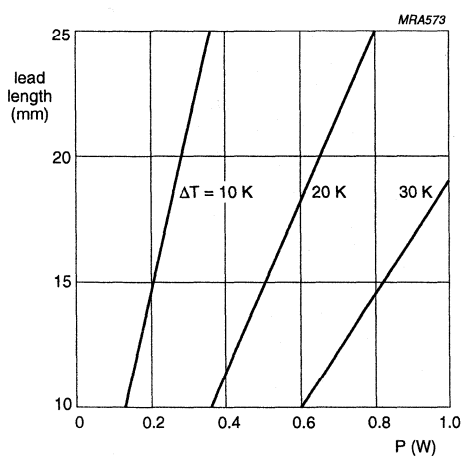
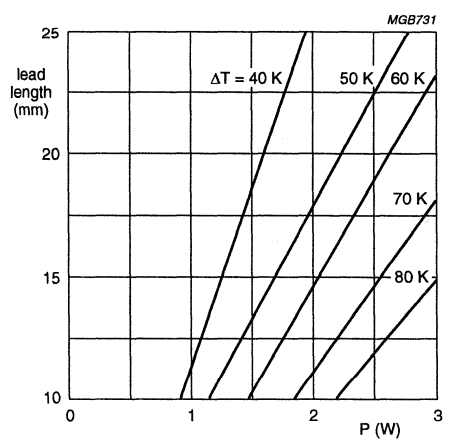


Fig.2 Temperature rise of the resistor body as a function of the dissipation.



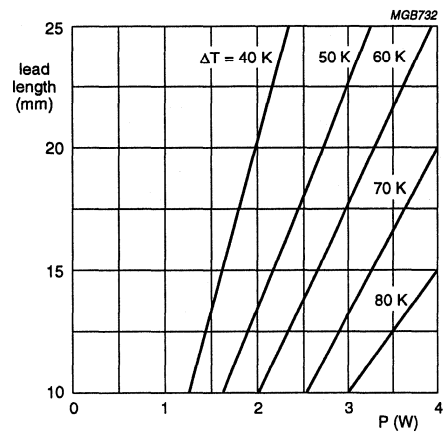
AC01

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



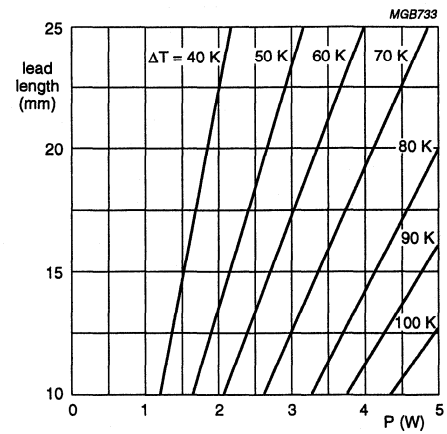
AC03

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



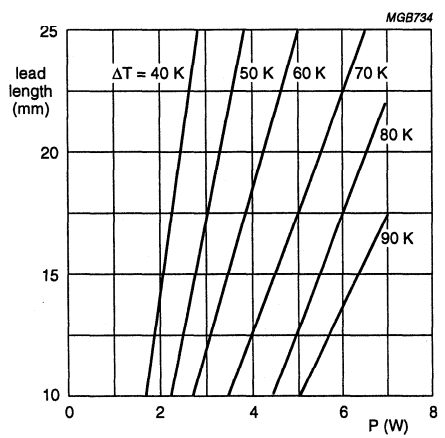
AC04

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



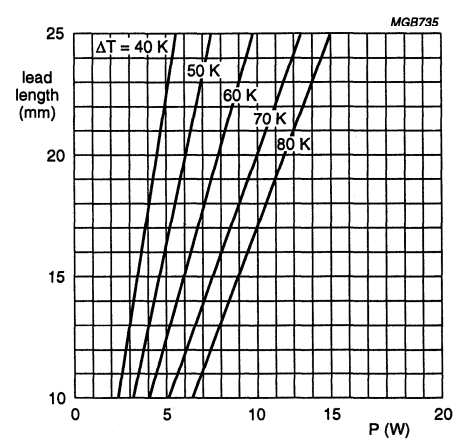
AC05

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



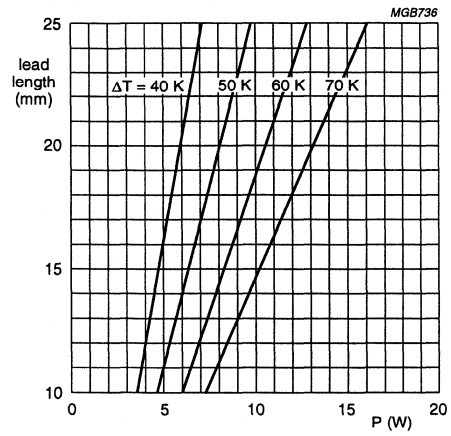
AC07

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



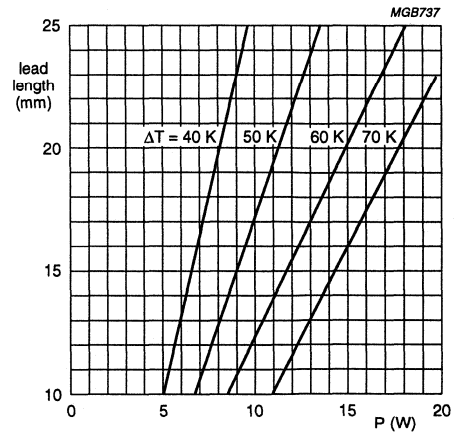
AC10

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



AC15

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



AC20

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

MOUNTING

The resistor is suitable for processing on cutting and bending machines. **Ensure that the temperature rise of the resistor body does not affect nearby components or materials by conducted or convected heat.** Figure 2 shows the hot-spot temperature rise of the resistor body as a function of dissipated power. Figures 3, 4, 5, 6, 7, 8, 9 and 10 show the lead length as a function of dissipated power and temperature rise.

MECHANICAL DATA

Mass per 100 units

TYPE	MASS (g)
AC01	55
AC03	80
AC04	100
AC05	175
AC07	225
AC10	530
AC15	840
AC20	1090

Marking

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

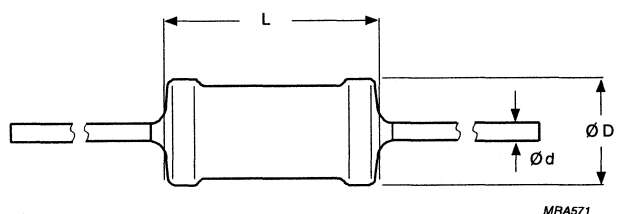
For values up to 910 Ω, the R is used as the decimal point.

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

Outlines

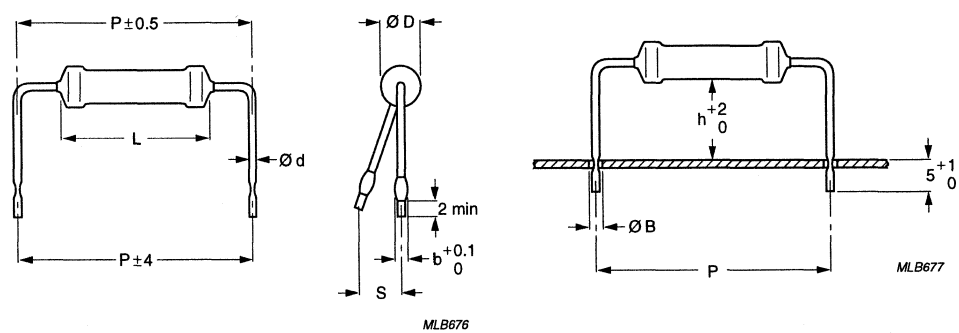
Table 3 Resistor type and relevant physical dimensions; see Figs 11 and 12

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



For dimensions see Table 3.

Fig.11 Type with straight leads.



Dimensions in mm.

For dimensions see Table 3.

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

Fig.12 Type with cropped and formed leads.

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 the following values apply:

Temperature: 15 °C to 35 °C

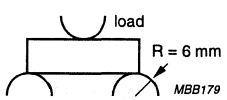
Relative humidity: 45% to 75%

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

In Table 4 the tests and requirements are listed with reference to the relevant clauses of *"IEC publications 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.

All soldering tests are performed with mildly activated flux.

Table 4 Test procedures and requirements

IEC 266 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
Tests in accordance with 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 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; 3 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

IEC 266 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
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; −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	$\Delta R/R$ max.: ±1% +0.05 Ω
21	Ca	damp heat (steady state)	56 days; 40 °C; 90 to 95% RH; dissipation $\leq 0.01 P_n$	no visible damage $\Delta R/R$ max.: ±1% +0.05 Ω
13.3		temperature coefficient	at 20/−40/20 °C, 20/200/20 °C: $R < 10\ \Omega$ $R \geq 10\ \Omega$	 $TC \leq \pm 600 \times 10^{-6}/K$ $-80 \times 10^{-6} \leq TC \leq +140 \times 10^{-6}/K$
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 $10 \times P_n$; 5 s (voltage not more than 1000 V/25 mm)	$\Delta R/R$ 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 $\Delta R/R$ 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 $\Delta R/R$ max.: ±5% +0.1 Ω
23	Ba	endurance at upper category temperature	1000 hours; 200 °C; no load	no visible damage $\Delta R/R$ max.: ±5% +0.1 Ω

IEC 266 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
Other tests in accordance with IEC 115 clauses and IEC 68 test method				
4.29	45 (Xa)	component solvent resistance	70% 1.1.2 trichlorotrifluoroethane and 30% isopropyl alcohol; H_20	no visible damage
4.18	20 (Tb)	resistance to soldering heat	10 s; 260 ±5 °C; flux 600	$\Delta R/R$ max.: ±0.5% +0.05 Ω
4.17	20 (Tb)	solderability (after ageing)	16 hours steam or 16 hours at 155 °C; 2 ±0.5 s in solder at 235 ±5 °C; flux 600	good tinning (≥95% covered); no damage
4.5		tolerance on resistance	applied voltage (±10%): R < 10 Ω: 0.1 V 10 Ω ≤ R < 100 Ω: 0.3 V 100 Ω ≤ R < 1 kΩ: 1 V 1 kΩ ≤ R < 10 kΩ: 3 V 10 kΩ ≤ R ≤ 33 kΩ: 10 V	$R - R_{nom}$: ±5% max.
Other applicable tests				
		solvent resistance in accordance with *"MIL-STD-202"*	method 215: freon TMC trichloroethane	no visual damage

Enamelled wirewound resistors

WR0617E; WR0842E WR0825E; WR0865E

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

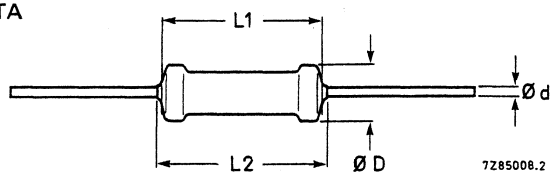


Fig. 1.

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

Enamelled wirewound resistors

WR0617E; WR0842E WR0825E; WR0865E

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

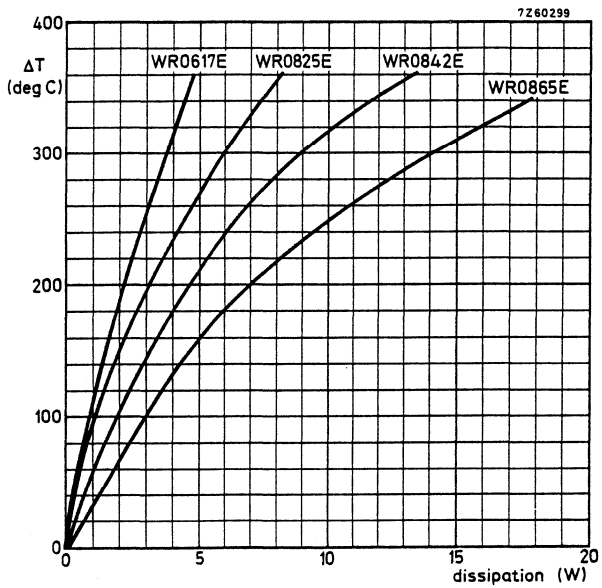
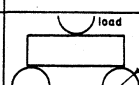


Fig. 2 Temperature rise (ΔT) of the resistor body as a function of the dissipation. Distance between cap and solder joint is 10 mm.

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 $\Delta R \leqslant 0{,}5\%$ 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/s²	no visible damage ΔR max. 0,5% + 0,05 Ω

Enamelled wirewound resistors

WR0617E; WR0842E WR0825E; WR0865E

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

Enamelled wirewound resistors

WR0617E; WR0842E WR0825E; WR0865E

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 SMW/SMF 02/03/05

FEATURES

- High power dissipation in small volume
- High pulse load handling capabilities
- 2e pitch mounting
- Designed in stand-up configuration for stand-up mounting.

APPLICATIONS

- Ballast switching
- Power supplies
- Shunts.

DESCRIPTION

SMW: The resistor element is a resistive wire which is wound in a single layer on a ceramic rod. Metal caps are pressed over the ends of the rod. The ends of the resistance wire and the leads are connected to the caps by welding.

SMF: The resistor element is a metal film resistor consisting of a metal layer deposited over a high grade ceramic rod. The resistive film is adjusted to final value by means of a helical groove. The leads are connected to the caps by welding.

SMW/SMF: Tinned copper-clad iron leads with poor heat conductivity are employed permitting the use of relatively short leads to obtain stable mounting without overheating the solder joint.

The resistor body and lead ends are housed within a rectangular ceramic case which is non-flammable, will not melt even at high overloads and is resistant to most commonly used cleaning solvents, in accordance with *"MIL-STD-202E"* method 215 and *"IEC 68-2-45"*.

QUICK REFERENCE DATA

DESCRIPTION	VALUE					
	SMW02	SMF02	SMW03	SMF03	SMW05	SMF05
Resistance range	0.1 to 200 Ω	220 Ω to 47 kΩ	0.1 to 560 Ω	560 Ω to 47 kΩ	0.1 to 560 Ω	560 Ω to 47 kΩ
Resistance tolerance	±5%; E24 series					
Maximum permissible body temperature	300 °C					
Rated dissipation at T_{amb} = 70 °C	2 W		3 W		5 W	
Climatic category (IEC 68)	40/200/56					
Basic specification	IEC 266					
Stability after:						
load, 1000 hours	ΔR/R max.: ±5% +0.1 Ω					
climatic tests	ΔR/R max.: ±3% +0.1 Ω					
short time overload	ΔR/R max.: ±2% +0.1 Ω					
Insulation voltage	>2000 V					

ORDERING INFORMATION

Table 1 Ordering code indicating resistor type and packaging

TYPE	ORDERING CODE 2306 ... .
	LOOSE IN BOX
	500 units
SMW02	340 03...
SMF02	340 90...
SMW03	341 03...
SMF03	341 90...
SMW05	342 03...
SMF05	342 90...

Ordering code (12NC)

- The resistors have a 12-digit ordering code starting with 2306
- The subsequent 5 digits indicate the resistor type; see Table 1
- **SMW**: The remaining 3 digits indicate the resistance value:
  - The first 2 digits indicate the resistance value
  - The last digit indicates the resistance decade in accordance with Table 2
- **SMF**: The remaining 3 digits indicate the resistance value. The number is available upon request and is fixed by the supplier.

Table 2 Last digit of 12NC

RESISTANCE DECADE	LAST DIGIT
0.1 to 0.91 Ω	7
1 to 9.1 Ω	8
10 to 91 Ω	9
100 to 910 Ω	1
1 to 9.1 kΩ	2
10 to 47 kΩ	3

ORDERING EXAMPLE

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

FUNCTIONAL DESCRIPTION

Product characterization

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

Limiting values

TYPE	LIMITING VOLTAGE(1) (V)	LIMITING POWER (W)
SMW02	$V = \sqrt{P_n \times R}$	2
SMF02	350	
SMW03	$V = \sqrt{P_n \times R}$	3
SMF03	350	
SMW05	$V = \sqrt{P_n \times R}$	5
SMF05	600	

Note

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

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

DERATING

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

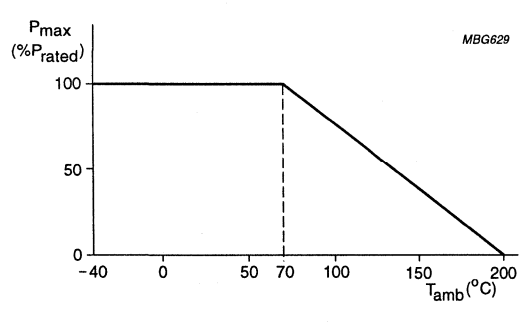


Fig.1 Maximum dissipation (P_{max}) as a function of the ambient temperature (T_{amb}).

PULSE LOADING CAPABILITY

Detailed pulse loading information is available on request.

Application information

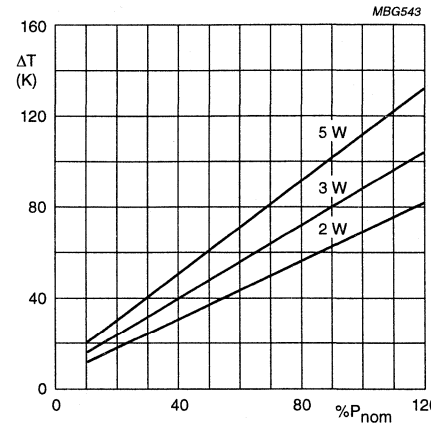


Fig.2 Solder spot temperature rise (ΔT) as a function of dissipated power.

MOUNTING

The resistors must be mounted in such a way that no stress is exerted on the leads and that thermal expansion is possible over the temperature range. **Ensure that the temperature rise of the resistor body by conducted or convected heat, does not affect nearby components or materials.** The temperature rise at the soldering point of the leads must not reach the melting point of the solder. The temperature rise at the soldering point as a function of dissipated power is shown in Fig.2.

MECHANICAL DATA

Mass per 100 units

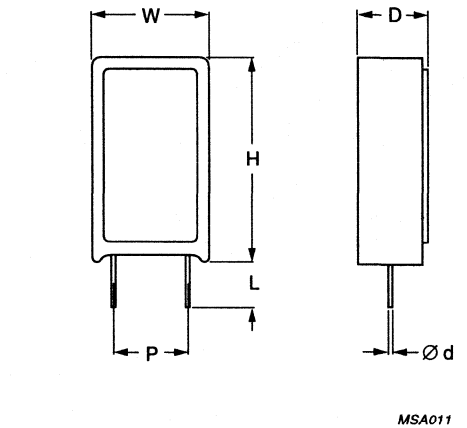
TYPE	MASS (g)
SMW02	370
SMF02	
SMW03	530
SMF03	
SMW05	640
SMF05	

Marking

The resistor is marked with the resistor type designation, the production week, nominal resistance value, the tolerance on the resistance and the rated dissipation at T_{amb} = 70 °C.

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

Outlines



For dimensions see Table 3.

Fig.3 Outlines.

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

TYPE	W (mm)	D (mm)	H (mm)	L (mm)	P (mm)	Ød (mm)
SMW02	11 ±1	7 ±1	20.5 ±1.5	4.5 ±1.5	5 ±1	0.8
SMF02						
SMW03	12 ±1	8 ±1	25.0 ±1.5			
SMF03						
SMW05	13 ±1	9 ±1	25.5 ±1.5			
SMF05						

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 the following values apply:

Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

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

In Table 4 the tests and requirements are listed with reference to the relevant clauses of *"IEC publications 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.

All soldering tests are performed with mildly activated flux.

Table 4 Test procedures and requirements

IEC 266 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
Tests in accordance with 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 Ua	robustness of terminations: tensile all samples	load 10 N; 10 s	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; 3 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	
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.: ±3% +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 $\leq 0.01 P_n$	no visible damage $\Delta R/R$ max.: ±3% +0.1 Ω
13.3		temperature coefficient	at 20/–40/20 °C, 20/200/20 °C: **SMW**: R < 10 Ω **SMW**: R ≥ 10 Ω **SMF**:	 $TC \leq \pm 600 \times 10^{-6}/K$ $-80 \times 10^{-6} \leq TC$ $TC \leq +140 \times 10^{-6}/K$ $TC \leq +250 \times 10^{-6}/K$
13.6		short time overload	room temperature; dissipation $10 \times P_n$; 5 s (voltage not more than 1000 V/25 mm)	$\Delta R/R$ max.: ±2% +0.1 Ω
22		endurance (at 70 °C)	1000 hours loaded with $0.9 P_n$; 1.5 hours on and 0.5 hours off	no visible damage $\Delta R/R$ max.: ±5% +0.1 Ω
23	Ba	endurance at upper category temperature	1000 hours; 200 °C; no load	no visible damage $\Delta R/R$ max.: ±5% +0.1 Ω

Cemented wirewound precision resistors PAC02/03/04/05/06

FEATURES

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

APPLICATIONS

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

DESCRIPTION

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

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

QUICK REFERENCE DATA

DESCRIPTION	VALUE				
	PAC02	PAC03	PAC04	PAC05	PAC06
Resistance range	0.10 Ω to 3.6 kΩ	0.10 Ω to 4.7 kΩ	0.10 Ω to 8.2 kΩ	0.68 Ω to 10 kΩ	0.68 Ω to 12 kΩ
Resistance tolerance	±1%; E24 series				
Maximum permissible body temperature	275 °C				
Rated dissipation at T_{amb} = 25 °C	2 W	3 W	4 W	5 W	6 W
Climatic category (IEC 68)	55/200/56				
Specification based on	IEC 266; MIL-R-26; CCTU 04-09				
Stability after:					
load, 1 000 hours	ΔR/R max.: ±0.5% +0.05 Ω				
climatic tests	ΔR/R max.: ±0.5% +0.05 Ω				
short time overload	ΔR/R max.: ±0.2% +0.05 Ω				

ORDERING INFORMATION

Ordering code (12NC)

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

ORDERING EXAMPLE

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

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

Table 1 Ordering code indicating type and packaging

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

Table 2 Last digit of 12NC

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

FUNCTIONAL DESCRIPTION

Product characterization

Standard values of nominal resistance are taken from the E24 series for resistors with a tolerance of ±1%. The values of the E24 series are in accordance with *"IEC publication 63"*.

Limiting values

TYPE	LIMITING VOLTAGE(1) (V)	LIMITING POWER (W)
PAC02	$V = \sqrt{P_n \times R}$	2
PAC03		3
PAC04		4
PAC05		5
PAC06		6

Note

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

The maximum permissible hot spot temperature is 275 °C.

DERATING

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

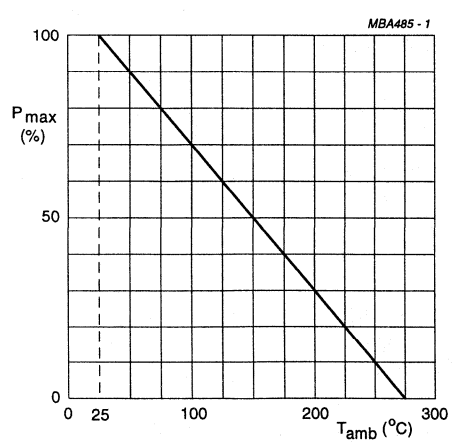


Fig.1 Maximum dissipation (P_{max}) as a function of the ambient temperature (T_{amb}).

PULSE LOADING CAPABILITY

Detailed pulse loading information is available on request.

Application information

MOUNTING

The resistor is suitable for processing on cutting and bending machines.

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

MECHANICAL DATA

Mass per 100 units

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

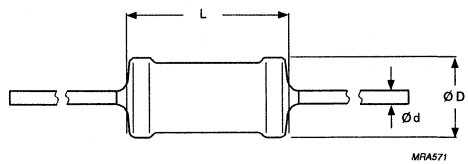
Marking

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

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

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

Outline



For dimensions see Table 3.

Fig.2 Component outline.

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

TYPE	ØD MAX. (mm)	L MAX. (mm)	Ød (mm)
PAC02	5.5	13	0.8
PAC03	5.5	17	
PAC04	7.5	17	
PAC05	7.5	23	
PAC06	7.5	25	

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of *"IEC publications 266 and 266A"*, 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 the following values apply:

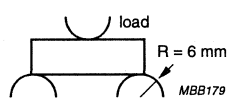
Temperature: 15 °C to 35 °C

Relative humidity: 45% to 75%

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

In Table 4 the tests and requirements are listed with reference to the relevant clauses of *"IEC publications 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 4 Test procedures and requirements

IEC 266 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
Tests in accordance with the schedule of IEC publication 266				
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 90°, 180°, 90°	
	Uc	torsion other half of samples	2 × 180° in opposite directions	no visible damage ΔR/R max.: ±0.1% +0.05 Ω
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.: ±0.2% +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; 3 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

IEC 266 CLAUSE	IEC 68 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
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	$\Delta R/R$ max.: ±0.5% +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 $\Delta R/R$ max.: ±1% +0.05 Ω
13.3		temperature coefficient	at 20/–55/20 °C, 20/200/20 °C ($TC \times 10^{-6}/K$)	$TC \leq \pm 100 \times 10^{-6}/K$
13.6		short time overload	room temperature; dissipation $10 \times P_n$; 5 s	$\Delta R/R$ max.: ±0.2% +0.05 Ω
22		endurance (at 25 °C)	1000 hours loaded with P_n; 1.5 hours on and 0.5 hours off	no visible damage $\Delta R/R$ max.: ±0.5% +0.05 Ω
23	Ba	endurance at upper category temperature	1000 hours; 200 °C; no load	no visible damage $\Delta R/R$ max.: ±1% +0.05 Ω

INDEX OF ORDERING CODE

12 DIGIT ORDERING CODE

The resistors have a 12-digit ordering code starting with 2306 or 2322.

Subsequent digits indicate style, packaging, resistance value and tolerance. Refer to individual data sheets for detailed composition of the ordering code.

In Table 1 the 12NC is referenced to the applicable page number where a detailed composition will be found.

Table 1 First 7 digits of the ordering code

ORDERING CODE	PAGE
2306 (first 4 digits followed by next 3 digits)	
197	203
198	203
327	262
328	241
340	257
341	257
342	257
2322 (first 4 digits followed by next 3 digits)	
141	187
142	187
143	187
144	187
151	174
152	174
153	174
156	161
157	161
160	183
161	183
162	183
163	183
164	183
165	183
166	183
167	183
168	183
169	183
170	183
171	183
181	137
186	137

ORDERING CODE	PAGE
187	137
191	227
192	236
193	203
194	203
195	203
204	149
205	149
207	149
211	129
241	195
242	195
244	195
329	241
330	251
702	37
704	49
711	37
712	37
722	37
723	37
724	37, 65, 70
725	59
730	37
731	37
732	49
733	49
734	49
735	83
741	94
744	100
750	76

DATA HANDBOOK SYSTEM

Data handbook system

DATA HANDBOOK SYSTEM

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

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

Our data handbook titles are listed here.

Display components

Book	*Title*
DC01	Colour TV Picture Tubes and Assemblies Colour Monitor Tubes
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

MORE INFORMATION FROM PHILIPS COMPONENTS?

For more information about Philips Components data handbooks, catalogues and subscriptions, please contact your nearest Philips Components sales organization **(see address list on the back cover of this handbook).**

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
IC06	High-speed CMOS Logic Family
IC11	General-purpose/Linear ICs
IC12	I^2C Peripherals
IC13	Programmable Logic Devices (PLD)
IC14	8048-based 8-bit Microcontrollers
IC15	FAST TTL Logic Series
IC16	CMOS Integrated Circuits for Clocks and Watches
IC17	Wireless Communications
IC18	Semiconductors for In-Car Electronics
IC19	ICs for Data Communications
IC20	80C51-based 8-bit Microcontrollers
IC22	Desktop Video
IC23	BiCMOS Bus Interface Logic
IC24	Low Voltage CMOS & BiCMOS Logic
IC25	16-bit 80C51XA Microcontrollers (eXtended Architecture)

Discrete semiconductors

SC01	Diodes
SC02	Power Diodes
SC03	Thyristors and Triacs
SC04	Small-signal Transistors
SC05	Videol Transistors
SC06	High-voltage and Switching NPN Power Transistors
SC07	Small-signal Field-effect Transistors
SC08a	RF Power Bipolar Transistors
SC08b	RF Power MOS Transistors
SC09	RF Power Modules
SC10	Surface Mounted Semiconductors
SC13	PowerMOS Transistors including TOPFETs and IGBTs

Discrete semiconductors (continued)

SC14	RF Wideband Transistors
SC15	Microwave Transistors
SC16	Wideband Hybrid IC Modules
SC17	Semiconductor Sensors

Professional components

PC01	High-power Klystrons and Accessories
PC06	Circulators and Isolators

MORE INFORMATION FROM PHILIPS SEMICONDUCTORS?

For more information contact your nearest Philips Semiconductors national organization shown in the following list.

Argentina: Buenos Aires, Tel. (541) 786 7633, Fax. (541)786 9367
Australia: NORTH RYDE, Tel. (02)805 4455, Fax. (02)805 4466
Austria: WIEN, Tel. (01)60 101-1236, Fax. (01)60 101-1211
Belgium: EINDHOVEN (Netherlands), Tel. (31)40 2783749, Fax. (31)40 2788399
Brazil: SÃO PAULO, Tel. (011)821-2333, Fax. (011)829-1849
Canada: SCARBOROUGH, Ontario, IC's: Tel. (800)234-7381, Fax. (708)296-8556; SC's: Tel. (0416)292-5161 ext. 2336, Fax. (0416)292-4477
Chile: SANTIAGO, Tel. (02)773 816, Fax. (02)777 6730
China/Hong Kong: HONG KONG, Tel. (852)2319 7888, Fax. (852)2319 7700
Colombia: BOGOTA, Tel. (571)249 7624/(571)217 4609, Fax. (571)217 4549
Denmark: COPENHAGEN, Tel. (032)88 2636, Fax. (031)57 1949
Finland: ESPOO, Tel. (358)0-615 800, Fax. (358)0-61580 920
France: SURESNES, Tel. (01)4099 6161, Fax. (01)4099 6427
Germany: HAMBURG, Tel. (040)3296-0, Fax. (040)3296 213
Greece: TAVROS, Tel. (01)4894 339/4894 911, Fax. (01)4814 240
India: BOMBAY, Tel. (022)4938 541, Fax. (022)4938 722
Indonesia: JAKARTA, Tel. (021)5201 122, Fax. (021)5205 189
Ireland: DUBLIN, Tel. (01)7640 000, Fax. (01)7640 200
Italy: MILANO, Tel. (0039)267 52 2531, Fax. (0039)267 52 2557
Japan: TOKIO, Tel. (03)3740 5028, Fax. (03)3740 0580
Korea (Republic of)**:** SEOUL, Tel. (02)794 5011, Fax. (02)798 8022
Malaysia: SELANGOR, Tel. (03)750 5214, Fax. (03)757 4880
Mexico: EL PASO, TEXAS, Tel. 9-5(800)234 7381, Fax. (708)296 8556
Netherlands: EINDHOVEN, Tel. (040)2783749, Fax. (040)2788399
New Zealand: AUCKLAND, Tel. (09)849 4160, Fax. (09)849 7811
Norway: OSLO, Tel. (022)74 8000, Fax. (022)74 8341
Pakistan: KARACHI, Tel. (021)587 4641-49, Fax. (021)577035/5874546
Philippines: MANILA, Tel. (63) 2 816 6380, Fax. (63) 2 817 3474
Portugal: Linda-A-Velha, Tel. (01)14163160/4163333, Fax. (01)14163174/4163366
Singapore: SINGAPORE, Tel. (65)350 2000, Fax. (65)251 6500
South Africa: JOHANNESBURG, Tel. (011)470 5911, Fax. (011)470 5494
Spain: BARCELONA, Tel. (03)301 6312, Fax. (03)301 42 43
Sweden: STOCKHOLM, Tel. (0)8-632 2000, Fax. (0)8-632 2745
Switzerland: ZÜRICH, Tel. (01)488 2211, Fax. (01)481 77 30
Taiwan: TAIPEI, Tel. (886) 2 382 4443, Fax. (886) 2 382 4444
Thailand: BANGKOK, Tel. (66) 2 745-4090, Fax. (66) 2 398-0793
Turkey: ISTANBUL, Tel. (0212)279 2770, Fax. (0212)282 6707
Ukraine: KIEV, Tel. 380-44-4760297, Fax. 380-44-4766991
United Kingdom: HAYES, Middlesex, Tel. (0181)730-5000, Fax. (0181)323 03 42
United States: Integrated Circuits – SUNNYVALE, Tel. (800)234-7381, Fax. (708)296-8556;
Discrete Semiconductors – RIVIERA BEACH, Tel. (800)447-3762 and (407)881-3200, Fax. (407)881-3300
Uruguay: MONTEVIDEO, Tel. (02)70-4044, Fax. (02)92-0601

Internet: http://www.semiconductors.philips.com/ps/

For all other countries apply to: **Philips Semiconductors**, International Marketing and Sales, Building BE-p, P.O. Box 218, 5600 MD EINDHOVEN, The Netherlands, Telex 35000 phtcnl, Fax. +31-40-2724825

NOTES

STANDARD SERIES OF VALUES IN A DECADE FOR RESISTANCES AND CAPACITANCES

According to *"IEC publication 63"*.

E192	E96	E48	E192	E96	E48	E192	E96	E48	E192	E96	E48
100	100	100	178	178	178	316	316	316	562	562	562
101			180			320			569		
102	102		182	182		324	324		576	576	
104			184			328			583		
105	105	105	187	187	187	332	332	332	590	590	590
106			189			336			597		
107	107		191	191		340	340		604	604	
109			193			344			612		
110	110	110	196	196	196	348	348	348	619	619	619
111			198			352			626		
113	113		200	200		357	357		634	634	
114			203			361			642		
115	115	115	205	205	205	365	365	365	649	649	649
117			208			370			657		
118	118		210	210		374	374		665	665	
120			213			379			673		
121	121	121	215	215	215	383	383	383	681	681	681
123			218			388			690		
124	124		221	221		392	392		698	698	
126			223			397			706		
127	127	127	226	226	226	402	402	402	715	715	715
129			229			407			723		
130	130		232	232		412	412		732	732	
132			234			417			741		
133	133	133	237	237	237	422	422	422	750	750	750
135			240			427			759		
137	137		243	243		432	432		768	768	
138			246			437			777		
140	140	140	249	249	249	442	442	442	787	787	787
142			252			448			796		
143	143		255	255		453	453		806	806	
145			258			459			816		
147	147	147	261	261	261	464	464	464	825	825	825
149			264			470			835		
150	150		267	267		475	475		845	845	
152			271			481			856		
154	154	154	274	274	274	487	487	487	866	866	866
156			277			493			876		
158	158		280	280		499	499		887	887	
160			284			505			898		
162	162	162	287	287	287	511	511	511	909	909	909
164			291			517			920		
165	165		294	294		523	523		931	931	
167			298			530			942		
169	169	169	301	301	301	536	536	536	953	953	953
172			305			542			965		
174	174		309	309		549	549		976	976	
176			312			556			988		

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

Philips Components – a worldwide company

Argentina: IEROD, Av. Juramento, 1991-14.B, (1428) BUENOS AIRES, Tel. (541) 786 7635, Fax. (541)786 9367.
Australia: PHILIPS COMPONENTS PTY Ltd, 34 Waterloo Road, NORTH RYDE NSW 2113, Tel. (02)805 4455, Fax. (02)805 4466.
Austria: PHILIPS COMPONENTS, Vertriebsgesellschaft m.b.H., Triester Strasse 64, A-1101 WIEN, P.O. Box 213, Tel. (01)601 01 12 12, Fax. (01)60 101 12 10.
Belgium: PHILIPS NEDERLAND B.V., Philips Components & Semiconductors, Postbus 90050, 5600 PB EINDHOVEN, Netherlands, Tel. (31)40 2783 749, Fax. (31)40 2788 399.
Brazil: PHILIPS COMPONENTS, Rua do Rocio 220 - 5th floor, 04552-903 - SÃO PAULO - SP, Tel. (011)821 2333, Fax. (011)829 1849.
Canada: PHILIPS ELECTRONICS Ltd., Philips Components, 601 Milner Ave., SCARBOROUGH, Ontario, M1B 1M8, Tel. (0416)292 5161, Fax. (0416)754 6248.
Chile: PHILIPS CHILENA S.A., Av. Santa Maria 0760, SANTIAGO, Tel. (02)77 38 16, Fax. (02)735 3594.
China: PHILIPS COMPANY, Philips Components MSO PRC, 6F Building 2, No. 889 Yi Shan Road, SHANGHAI 200233, Tel. (21)6 485 0600, Fax. (21)6 485 1014.
Colombia: IPRELENSO LTDA, Diagonal 59, No. 20-27, P.O. Box 77621, SANTAFE DE BOGOTA, Tel. (57)(1)345 8713, Fax. (57)(1)345 8712.
Denmark: PHILIPS COMPONENTS A/S, Prags Boulevard 80, P.O Box 1919, 2300 COPENHAGEN S, Tel. 32 88 3333, Fax. 31 57 1949.
Finland: PHILIPS COMPONENTS, Sinikalliontie 3, FIN-02630 ESPOO, Tel. (9)0-615 800, Fax. (9)0-615 80920.
France: PHILIPS COMPOSANTS, 4 Rue du Port-aux-Vins, BP317, 92156 SURESNES, Cedex, Tel. (01)4099 6161, Fax. (01)4099 6427.
Germany: PHILIPS COMPONENTS UB der Philips G.m.b.H., P.O. Box 10 63 23, 20043 HAMBURG, Tel. (040)3296-0, Fax. (040)3296 213.
Greece: PHILIPS HELLENIQUE S.A., Components Division, No. 15, 25th March Street, GR 17778 TAVROS, Tel. (01)4894 339/(01)4894 911, Fax. (01)4815 180.
Hong Kong: PHILIPS HONG KONG, Components Division, Unit 003-005, G/F, Hong Kong Ind. Technology Centre, 72 Tat Chee Avenue, Kowloon Tong, KOWLOON, Tel. (852)2784 3000, Fax. (852)2784 3003.
India: Philips INDIA Ltd., Components Dept., Shivsagar Estate, A Block, Dr. Annie Besant Rd. Worli, Bombay 400 018, Tel. (022)4938 541, Fax. (022)4938 722.
Indonesia: P.T. PHILIPS DEVELOPMENT CORPORATION, Philips House, Jalan H.R. Rasuna Said Kav. 3-4, P.O. Box 4252, JAKARTA 12950, Tel. (021)5201122, Fax. (021)5205189.
Ireland: PHILIPS ELECTRONICS (IRELAND) Ltd., Components Division, Newstead, Clonskeagh, DUBLIN 14, Tel. (01)76 40 203, Fax. (01)76 40 210.
Israel: Rapac Electronics Ltd., 7 Kehilat Saloniki St. P.O. Box 18053, TEL AVIV 61180, Tel. (03)6450 444, Fax. (03)6491 007.
Italy: PHILIPS COMPONENTS S.r.l., Piazza IV Novembre 3, 20124 MILANO, Tel. (02)6752 2531, Fax. (02)6752 2557.
Japan: PHILIPS JAPAN Ltd., Components Division, Philips Bldg 13-37, Kohnan 2-chome, Minato-ku, TOKYO 108, Tel. (03)3740 5028, Fax. (03)3740 0580.
Korea: (Republic of): PHILIPS ELECTRONICS (KOREA) Ltd., Components Division, Philips House, 260-199 Itaewon-dong, Yongsan-ku, SEOUL, Tel. (02)709 -1472, Fax. (02)709 1479.
Malaysia: PHILIPS MALAYSIA SDN BERHAD, Components Division, No. 76 Jalan Universiti, 46200 Petaling Jaya, KUALA LUMPUR, Tel. (03)757 5511, Fax. (03)757 4880.
PHILIPS MALAYSIA SDN BERHAD, Components Division, 345 Jalan Gelugor, PULAU PINANG, Tel. (04)870 055, Fax. (04)879 215.
Mexico: PHILIPS COMPONENTS, 5900 Gateway East, Suite 200, EL PASO, TX 79905, U.S.A., Tel. (915)772 4020, Fax. (915)772 4332.
Netherlands: PHILIPS NEDERLAND B.V., Philips Components & Semiconductors, Bldg. VB Postbus 90050, 5600 PB EINDHOVEN, Tel. (040)2783 749, Fax. (040)2788 399.
New Zealand: PHILIPS NEW ZEALAND Ltd., Components Division, 2 Wagener Place, C.P.O. Box 1041, AUCKLAND, Tel. (09)849 4160, Fax. (09)849 7811.
Norway: NORSK A/S PHILIPS, Philips Components, Box 1, Manglerud 0612, OSLO, Tel. 22 74 8000, Fax. 22 74 8341.
Pakistan: Philips Electrical Industries of Pakistan Ltd., Exchange Bldg. ST-2/A, Block 9, KDA Scheme 5, Clifton, KARACHI 75600, Tel. (021)587 4641-49, Fax. (021)577035/5874546.
Philippines: PHILIPS SEMICONDUCTORS PHILIPPINES Inc., 106 Valero St. Salcedo Village, P.O. Box 2108 MCC, MAKATI, Metro MANILA, Tel. (02)810-0161, Fax. (02)817-3474.
Portugal: PHILIPS PORTUGUESA, S.A., Rua dr. António Loureiro Borges 5, Arquiparque - Miraflores, Apartado 300, 2795 LINDA-A-VELHA, Tel. (01)4163160/4163333, Fax. (01)4163174/4163366.
Singapore: PHILIPS SINGAPORE, Pte Ltd., Components Division, Lorong 1, Toa Payoh, SINGAPORE 1231, Tel. (65)350 2000, Fax. (65)355 1758.
South Africa: S.A. PHILIPS Pty Ltd., Components Division, 195-215 Main Road Martindale, 2092 JOHANNESBURG, P.O. Box 7430 Johannesburg 2000, Tel. (011)470-5911, Fax. (011)470-5494.
Spain: PHILIPS COMPONENTS, Balmes 22, 08007 BARCELONA, Tel. (93)301 63 12, Fax. (93)301 42 43.
Sweden: PHILIPS COMPONENTS AB, Kottbygatan 7, Akalla. Postal address: S-164 85 STOCKHOLM, Tel. (+46)8 632 2000, Fax. (+46)8 632 2745.
Switzerland: PHILIPS COMPONENTS AG, Allmendstrasse 140, CH-8027 ZÜRICH, Tel. (01)488 22 11, Fax. (01)481 77 30.
Taiwan: PHILIPS TAIWAN Ltd., 23-30F, 66, Chung Hsiao West Road, Sec. 1. Taipei, Taiwan ROC, P.O. Box 22978, TAIPEI 100, Tel. (02)388 7666, Fax. (02)382 4382.
Thailand: PHILIPS ELECTRONICS (THAILAND) Ltd., 209/2 Sanpavuth-Bangna Road Prakanong, Bangkok 10260, THAILAND, Tel. (66)2 745 4090, Fax. (66)2 398 0793.
Turkey: Türk Philips Ticaret A.S., Components Department, Talatpasa Cad. No. 5, 80640 GÜLTEPE/ISTANBUL, Tel. 90-212-279-27-70, Fax. 90-212-282-67-07.
United Kingdom: PHILIPS COMPONENTS Ltd., The Mullard Building, Dorking Business Park, DORKING, Surrey, RH4 1HJ, Tel: (01306)512000, Fax: (01306)512345.
United States: PHILIPS COMPONENTS, Division Headquarters, 1440 Indiantown road Jupiter, FL 33458, Tel. (407)744 4200, Fax. (407)743 2113.
For literature: (800)447 3762.
PHILIPS DISPLAY COMPONENTS COMPANY, 1600 Huron Parkway, ANN ARBOR, Michigan 48105-2590, Tel. (313)996 9400, Fax. (313)761 2776.
Uruguay: PHILIPS COMPONENTS, Coronel Mora 433, MONTEVIDEO, Tel. (02)70-4044, Fax. (02)920 601.

For all other countries apply to: Philips Components, Marketing Communications, P.O. Box 218, 5600 MD EINDHOVEN, The Netherlands, Telex 35000 phtcnl, Fax. +31-40-2724 547.

Printed in The Netherlands

858010/17500/02/pp272 Date of release: 1995 Nov 13
Document order number: 9398 184 02011

Let's make things better.

Philips Components

PHILIPS

PHILIPS