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	
		Cu-lead	FeCu-lead	Cu-lead	FeCu-lead
Resistance range	0.22 Ω to 1 MΩ	0.33 Ω to 1 MΩ	1 Ω to 1 MΩ	0.68 Ω to 1 MΩ	1 Ω to 1 MΩ
Resistance tolerance and series	±5%; E24 series (1)				
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				

Notes

1. Other tolerances and values on request

ORDERING INFORMATION

Table 1 Ordering code indicating resistor type and packaging

TYPE	LEAD	ORDERING CODE						
		BANDOLIER			LOOSE IN BOX			
		AMMOPACK		REEL	CROPPED AND FORMED(1)		DOUBLE KINK	
		RADIAL TAPED	STRAIGHT LEADS	STRAIGHT LEADS	h(2) = 8 mm	h(2) = 15 mm	LARGE PITCH(1)	SMALL PITCH
PR01	Cu ∅0.6 mm	2306 197 03...	2322 193 13...	2322 193 23...	2322 193 33... (3)	–	2322 193 03...	–
	FeCu ∅0.6 mm	–	–	–	–	–	2322 193 43...	2322 193 53...
PR02	Cu ∅0.8 mm	2306 198 03...	2322 194 13...	–	2322 194 33...	2322 194 43...	–	–
	FeCu ∅0.6 mm	–	2322 194 53...	–	2322 194 73... (3)	–	2322 194 83...	
	FeCu ∅0.8 mm	–	–	–	–	–	–	2322 194 63...
PR03	Cu ∅0.8 mm	–	2322 195 13...	–	2322 195 33...	2322 195 43...	–	–
	FeCu ∅0.6 mm	–	2322 195 53...	–	2322 195 73... (3)	–	2322 195 83...	–
	FeCu ∅0.8 mm	–	–	–	–	–	–	2322 195 63...

Notes

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

Ordering code (12NC)

- The resistors have a 12-digit ordering code
- 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
0.1 to 0.91 Ω	note 1
1 to 9.1 Ω	8
10 to 91 Ω	9
100 to 910 Ω	1
1 to 9.1 kΩ	2
10 to 91 kΩ	3
100 to 910 kΩ	4
1 MΩ	5

Notes

1. 12NC available on request.

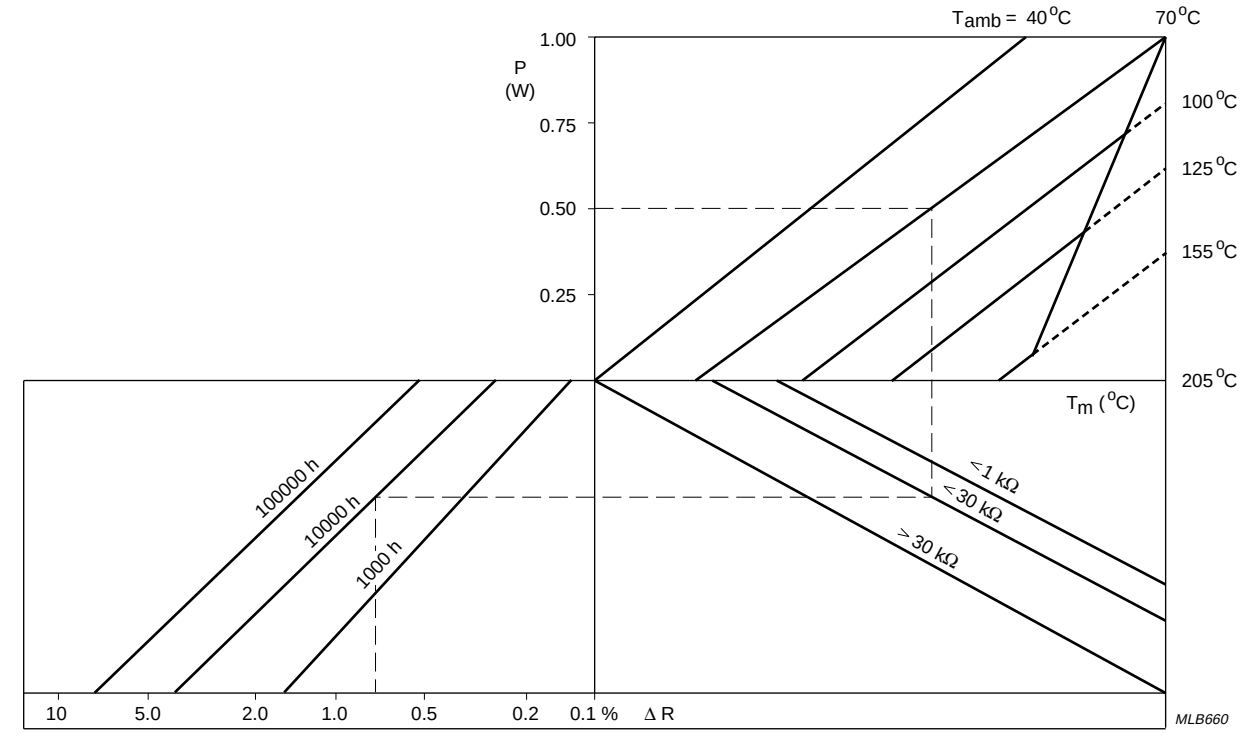
ORDERING EXAMPLE

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

FUNCTIONAL DESCRIPTION

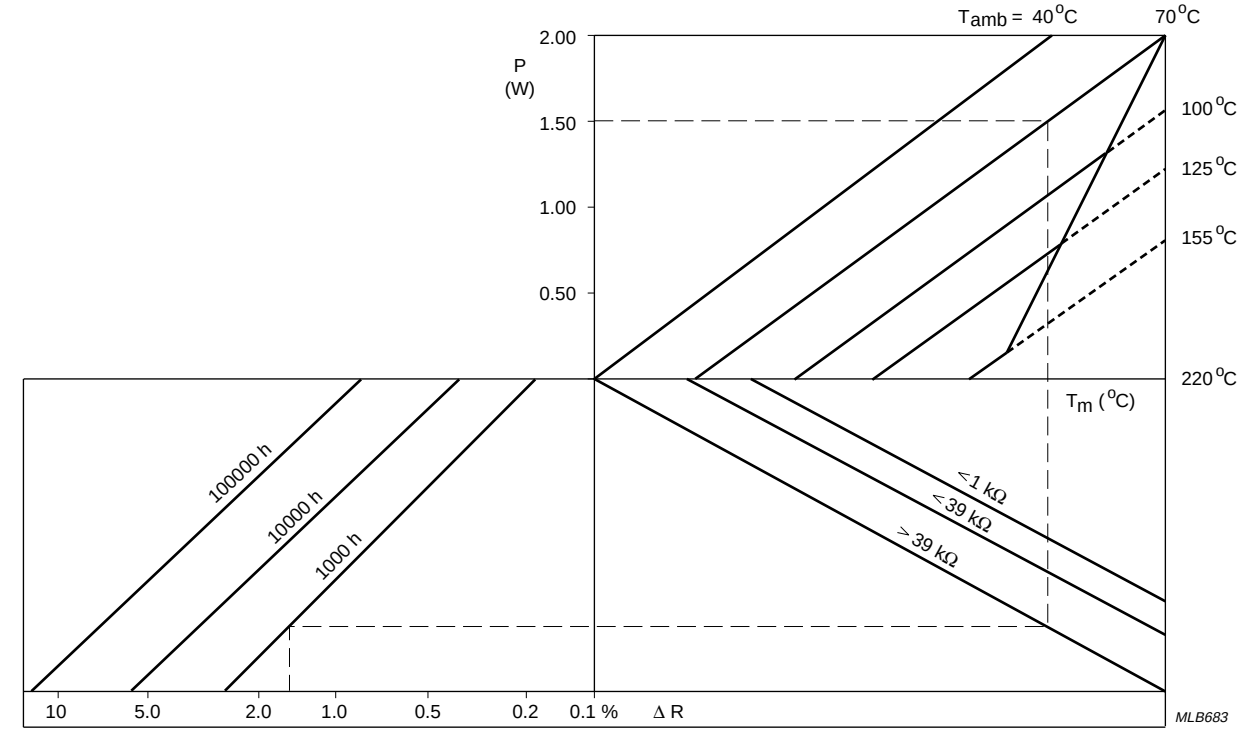
Product characterization

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



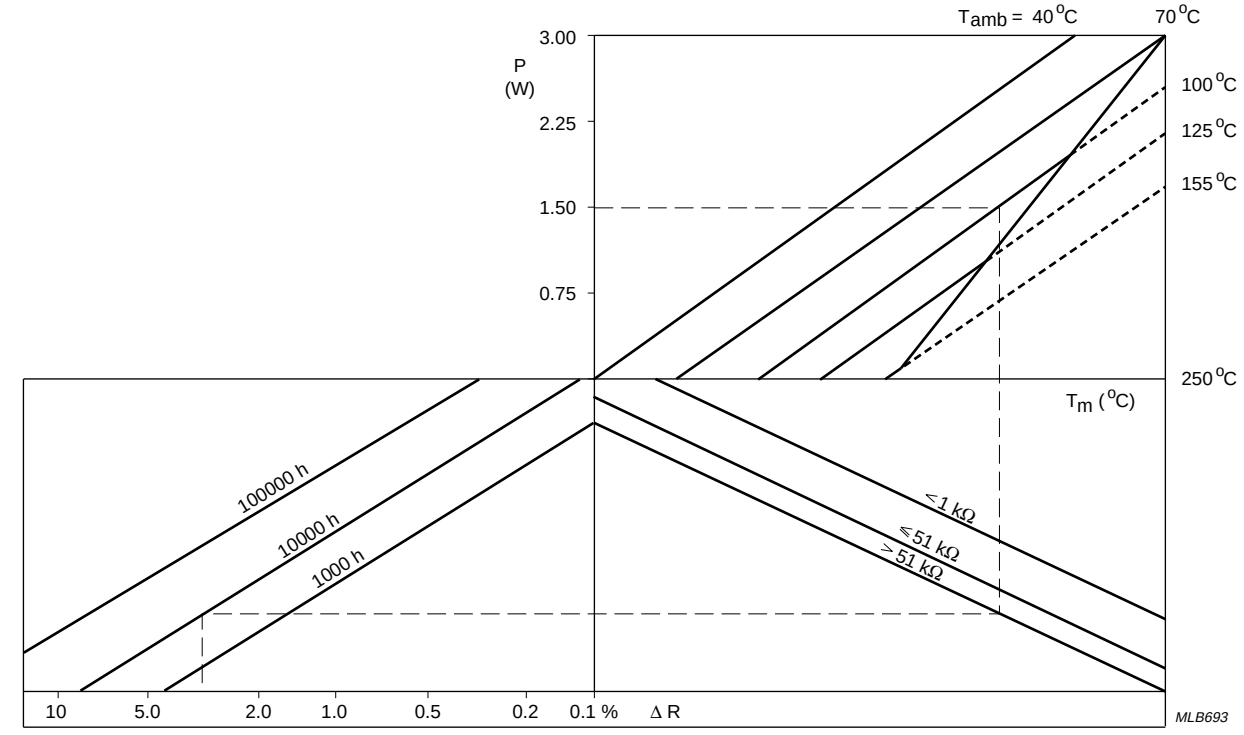
PR01

Fig.1 Drift nomogram.



PR02

Fig.2 Drift nomogram.



PR03

Fig.3 Drift nomogram.

Limiting values

TYPE	LEAD MATERIAL	RANGE	LIMITING VOLTAGE(1) (V)	LIMITING POWER (W)
PR01	Cu	R < 1 Ω	350	0.6
		1 Ω ≤ R		1.0
PR02	Cu	R < 1 Ω	500	1.2
		1 Ω ≤ R		2.0
	FeCu	1 Ω ≤ R		1.3
PR03	Cu	R < 1 Ω	750	1.6
		1 Ω ≤ R		3.0
	FeCu	1 Ω ≤ 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 235 °C for PR01, 220 °C for PR02 and 250 °C for PR03.

DERATING

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

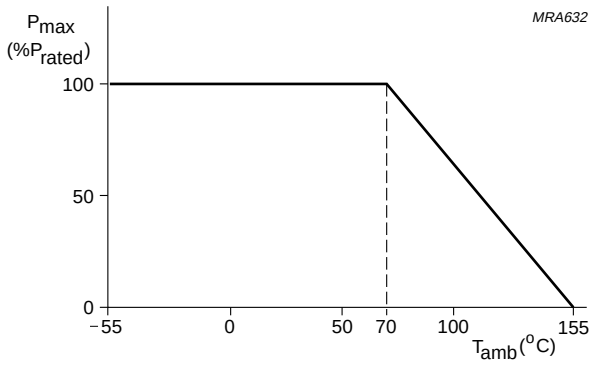
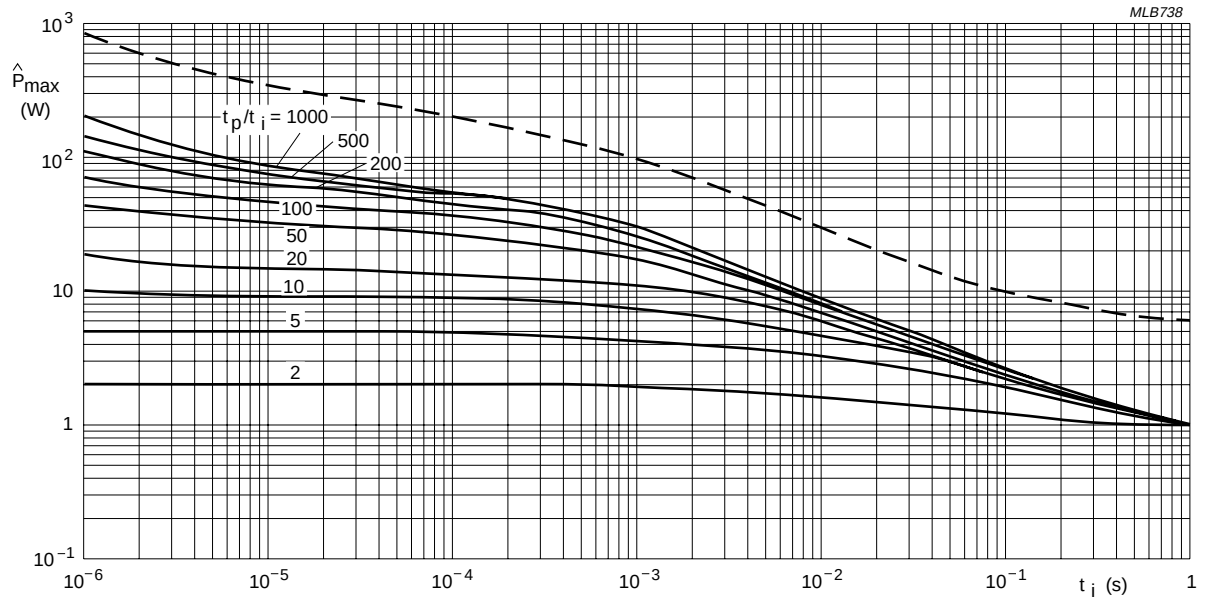


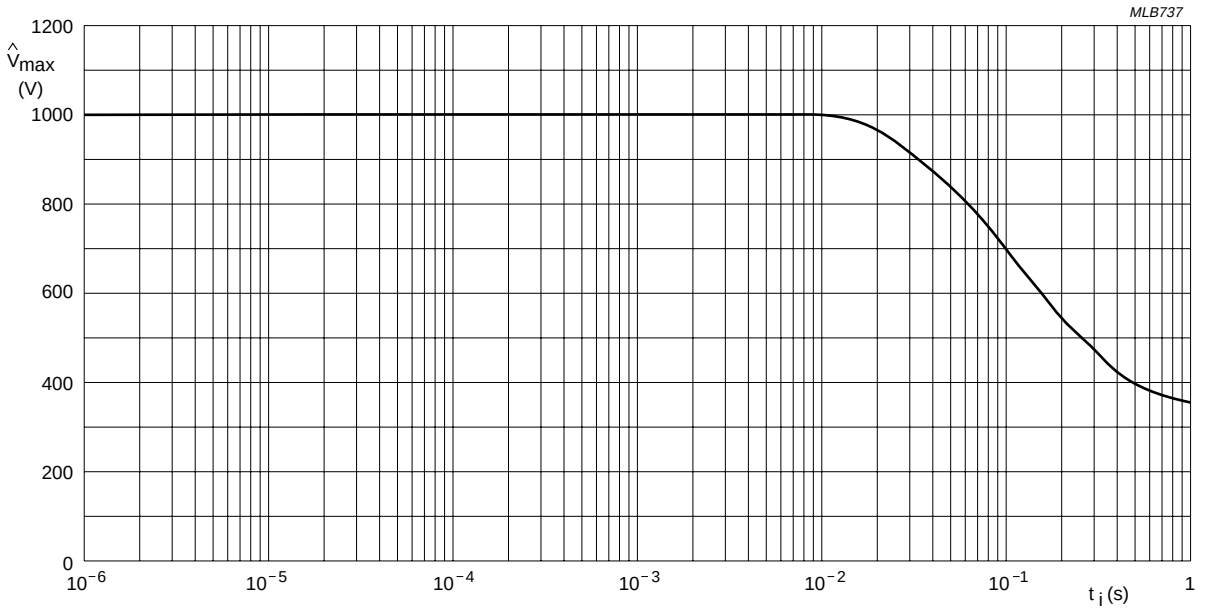
Fig.4 Maximum dissipation (P_{max}) in percentage of rated power as a function of the ambient temperature (T_{amb}).

PULSE LOADING CAPABILITIES



PR01

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



PR01

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

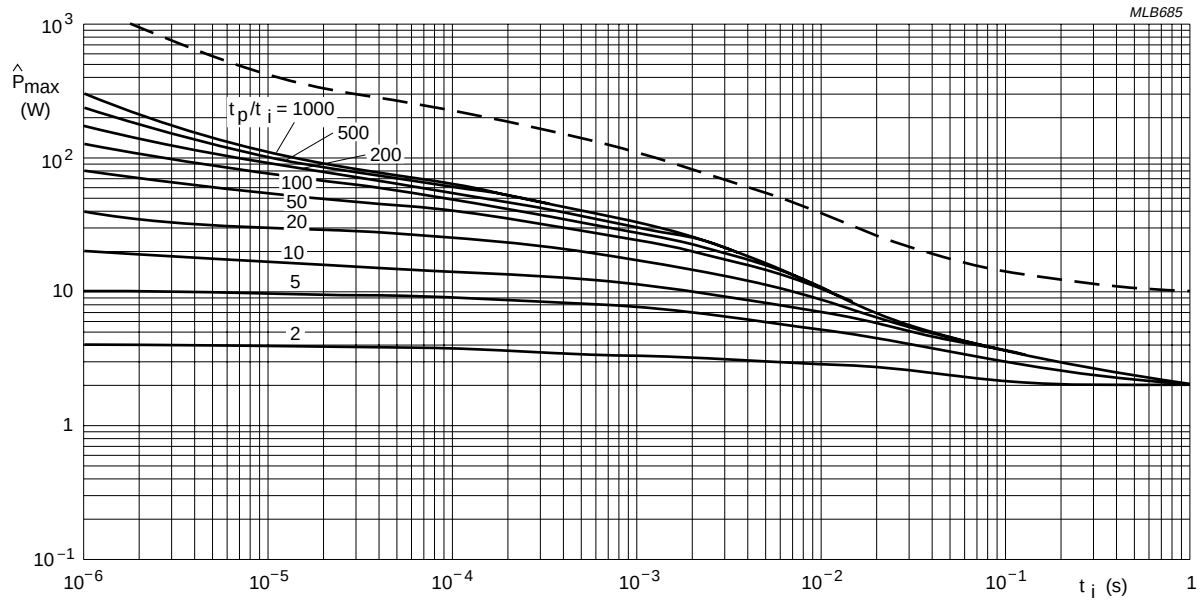


Fig.7 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i).

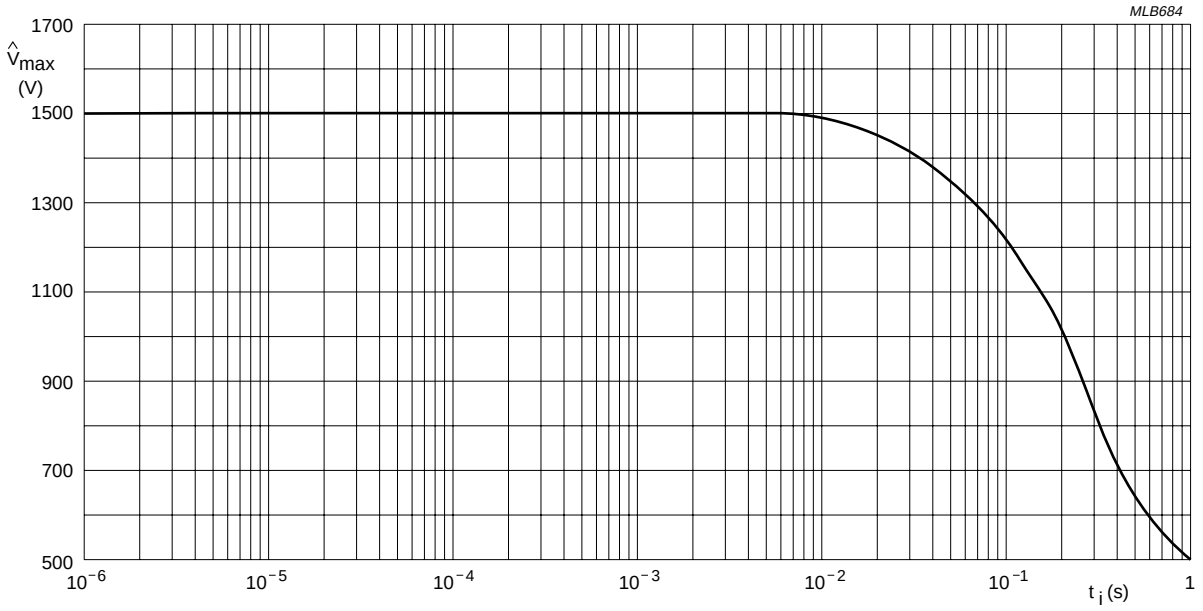


Fig.8 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_i).

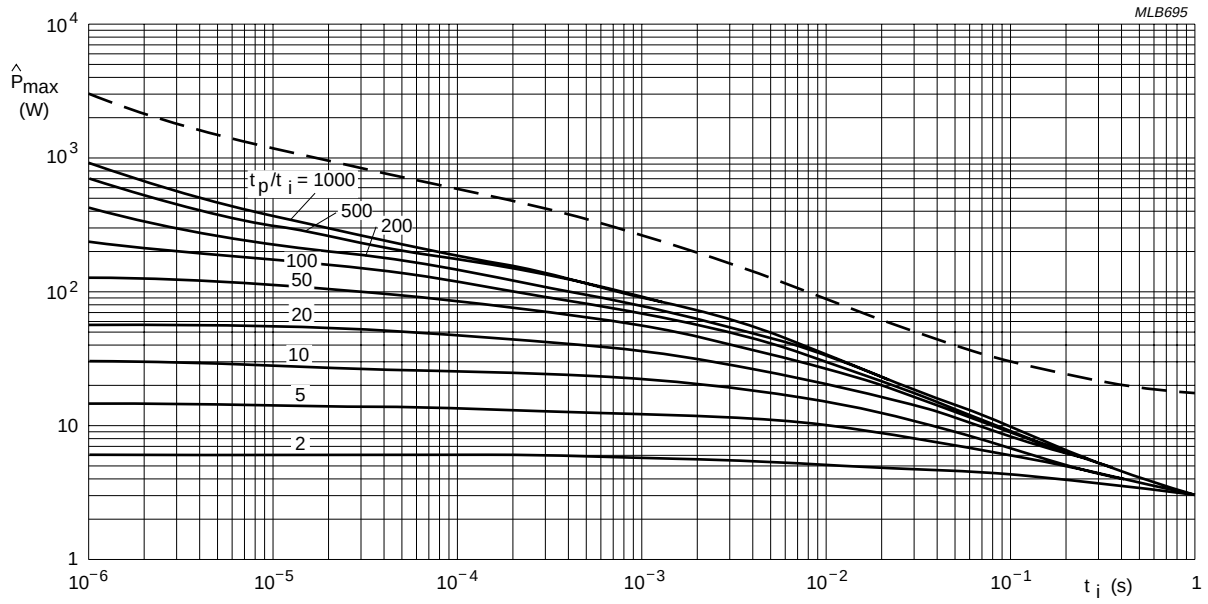


Fig.9 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max}$) as a function of pulse duration (t_i).

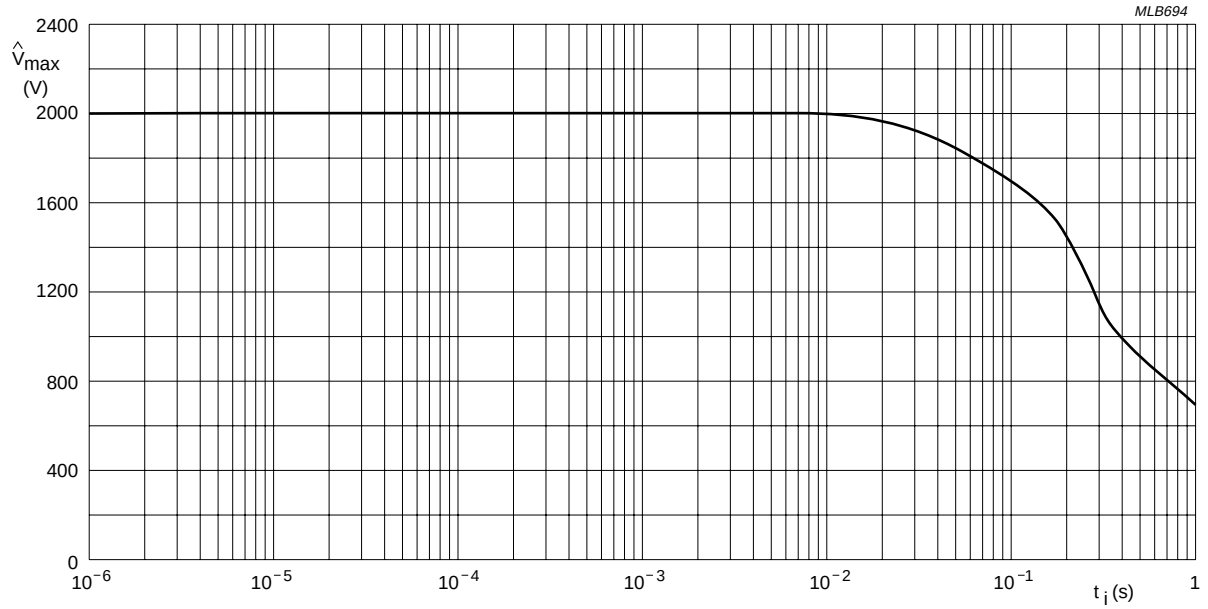
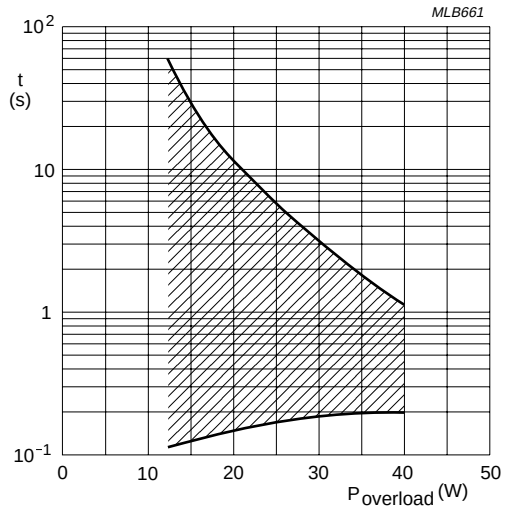


Fig.10 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_i).

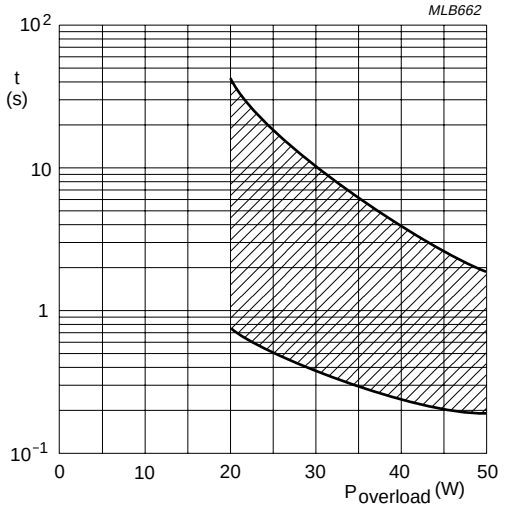
INTERRUPTION CHARACTERISTICS



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

PR01

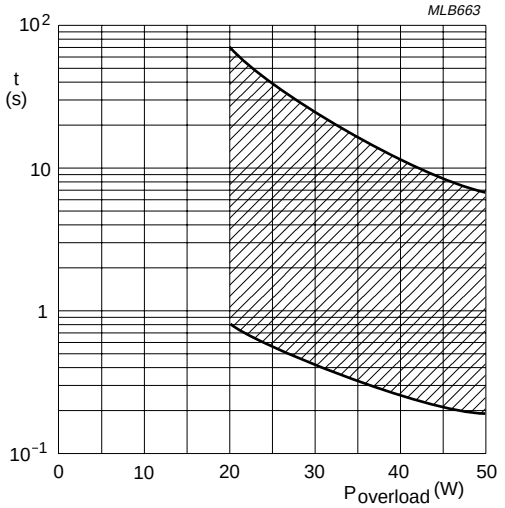
Fig.11 Time to interruption as a function of overload power for range: $0R22 \leq R_n < 1R$.



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

PR01

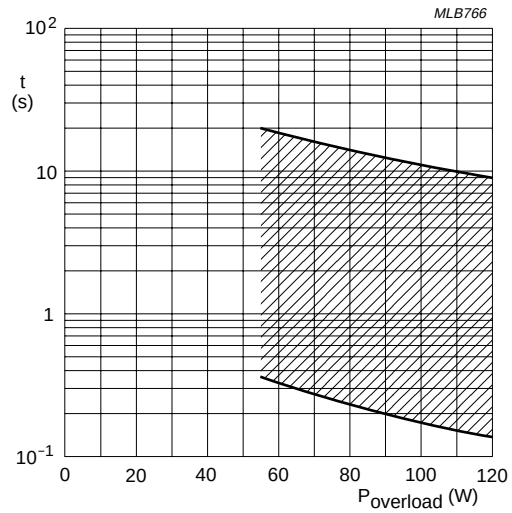
Fig.12 Time to interruption as a function of overload power for range: $1R \leq R_n \leq 15R$.



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

PR01

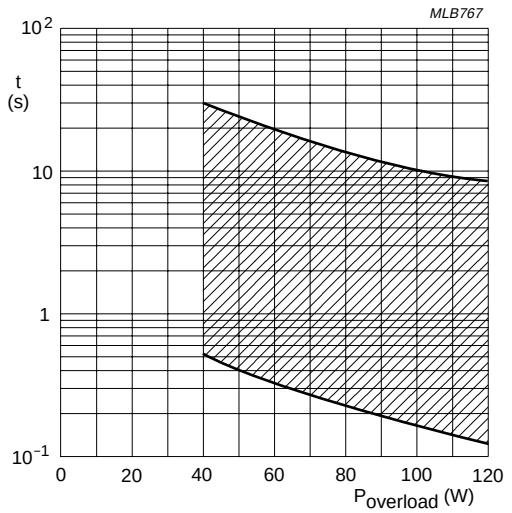
Fig.13 Time to interruption as a function of overload power for range: $16R \leq R_n \leq 560R$.



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

PR02

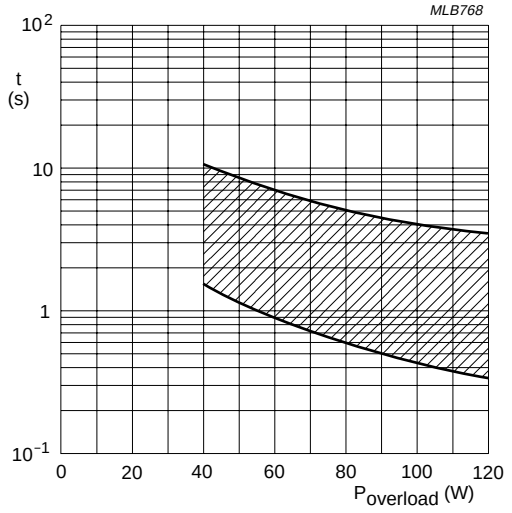
Fig.14 Time to interruption as a function of overload power for range: $0.33R \leq R_n < 5R$.



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

PR02

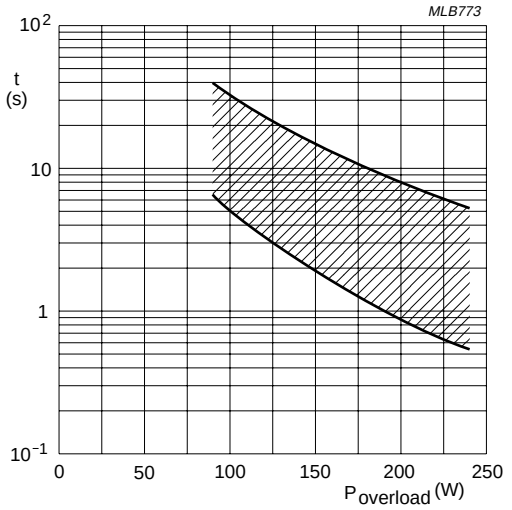
Fig.15 Time to interruption as a function of overload power for range: $5R \leq R_n < 68R$.



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

PR02

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

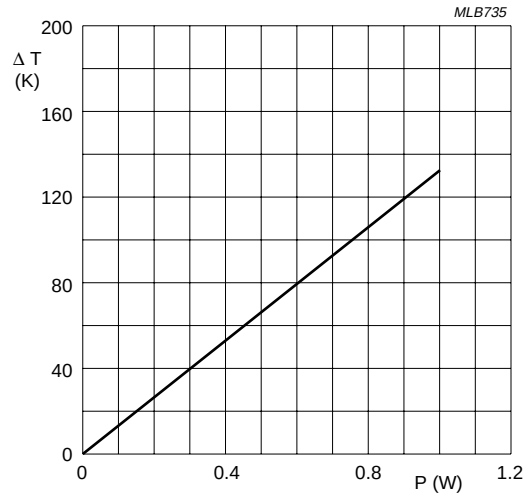


The graph is based on measured data under constant voltage conditions; these data may deviate according to the application.

PR03

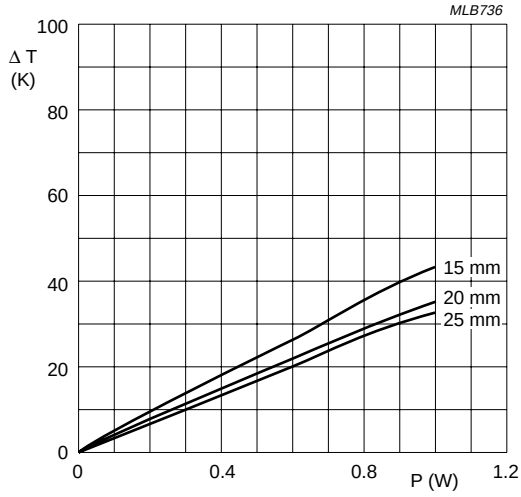
Fig.17 Time to interruption as a function of overload power for range: $0.68R \leq R_n \leq 560R$.

Application information



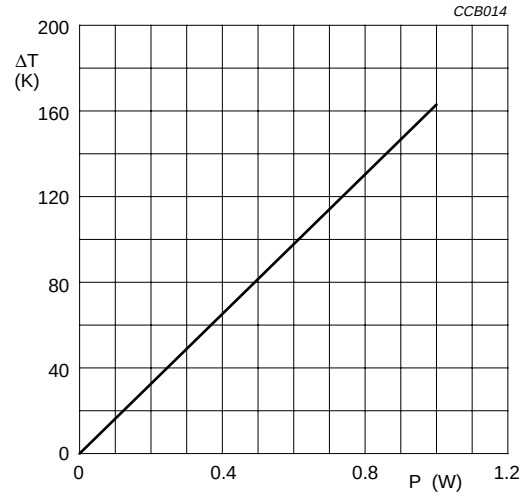
∅ 0.6 mm Cu-leads.
PR01

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



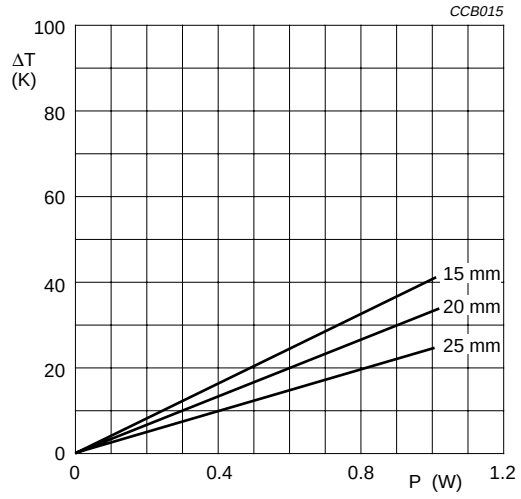
∅ 0.6 mm Cu-leads.
Minimum distance from resistor body to PCB = 1 mm.
PR01

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



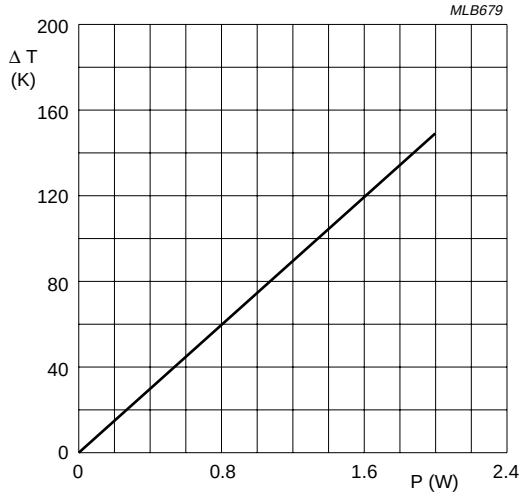
∅ 0.6 mm FeCu-leads.
PR01

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



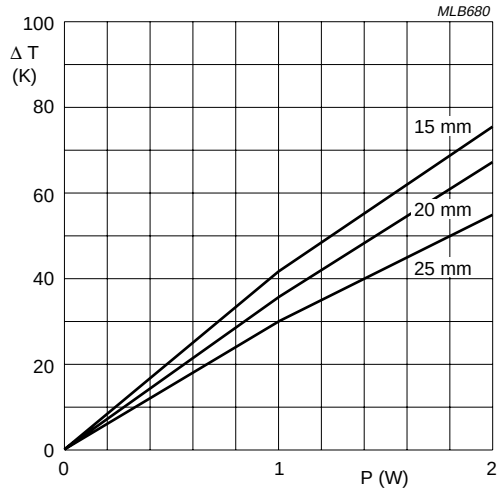
∅ 0.6 mm FeCu-leads.
Minimum distance from resistor body to PCB = 1 mm.
PR01

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



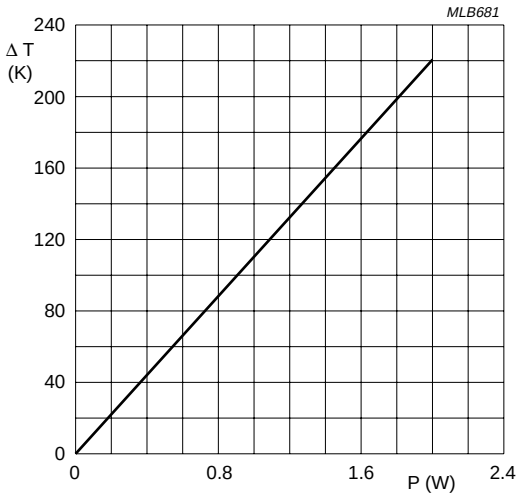
∅ 0.8 mm Cu-leads.
PR02

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



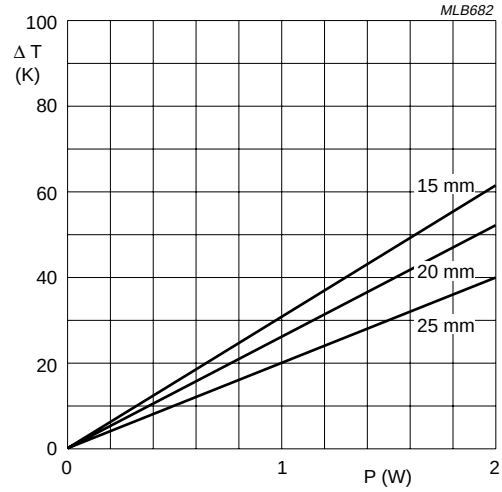
∅ 0.8 mm Cu-leads.
Minimum distance from resistor body to PCB = 1 mm.
PR02

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



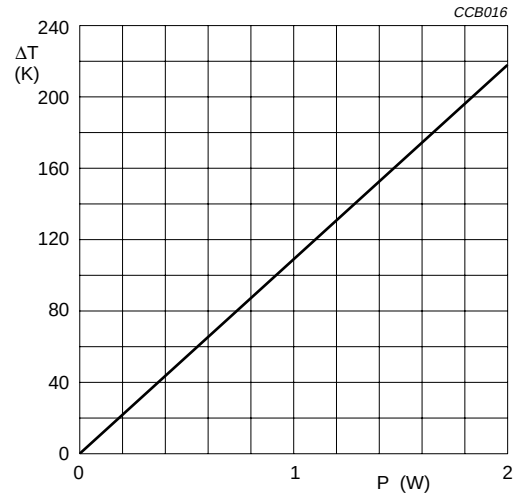
∅ 0.6 mm FeCu-leads.
PR02

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



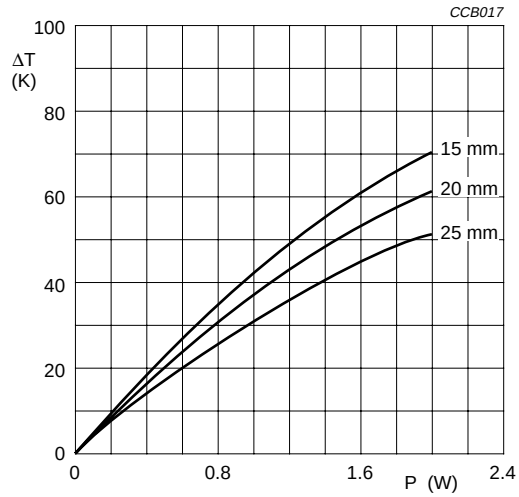
∅ 0.6 mm FeCu-leads.
Minimum distance from resistor body to PCB = 1 mm.
PR02

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



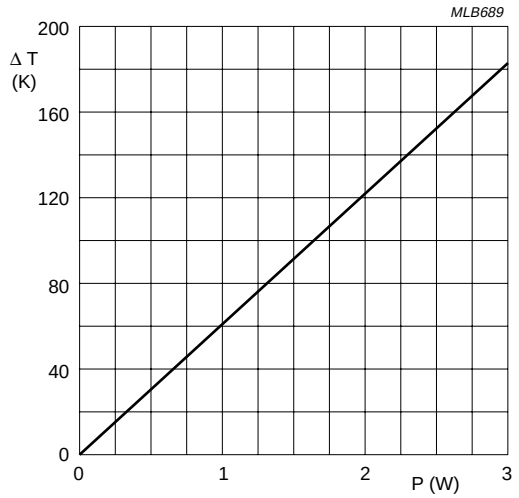
∅ 0.8 mm FeCu-leads.
PR02

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



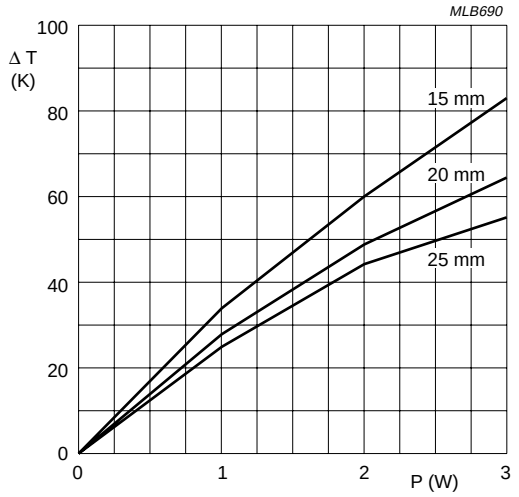
∅ 0.8 mm FeCu-leads.
Minimum distance from resistor body to PCB = 1 mm.
PR02

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



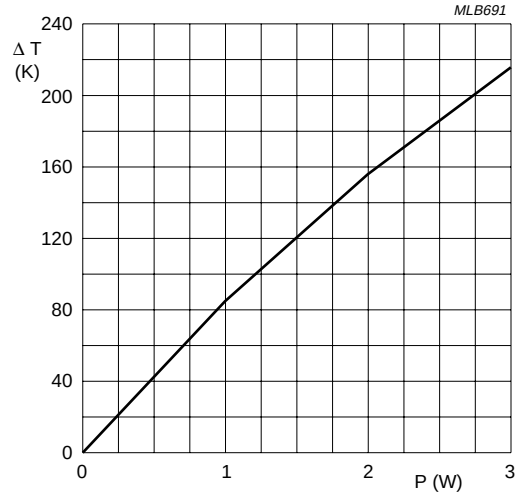
∅ 0.8 mm Cu-leads.
PR03

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



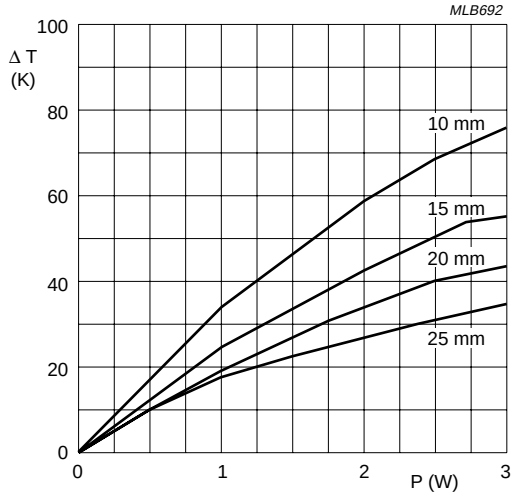
∅ 0.8 mm Cu-leads.
Minimum distance from resistor body to PCB = 1 mm.
PR03

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



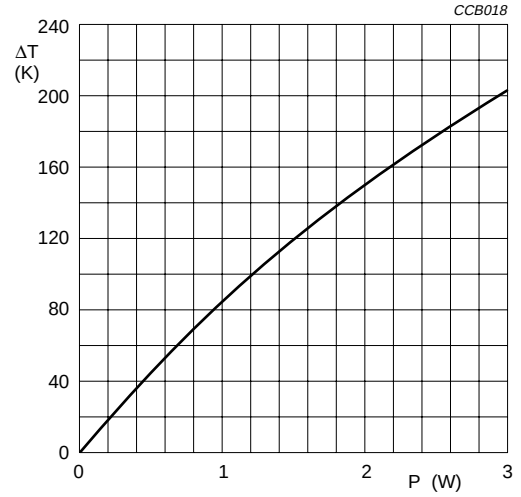
∅ 0.6 mm FeCu-leads.
PR03

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



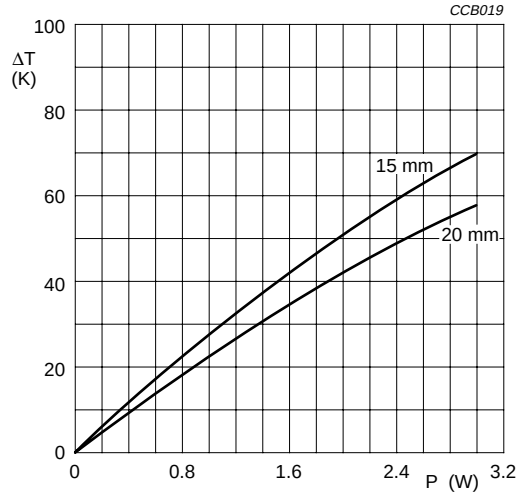
∅ 0.6 mm FeCu-leads.
Minimum distance from resistor body to PCB = 1 mm.
PR03

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



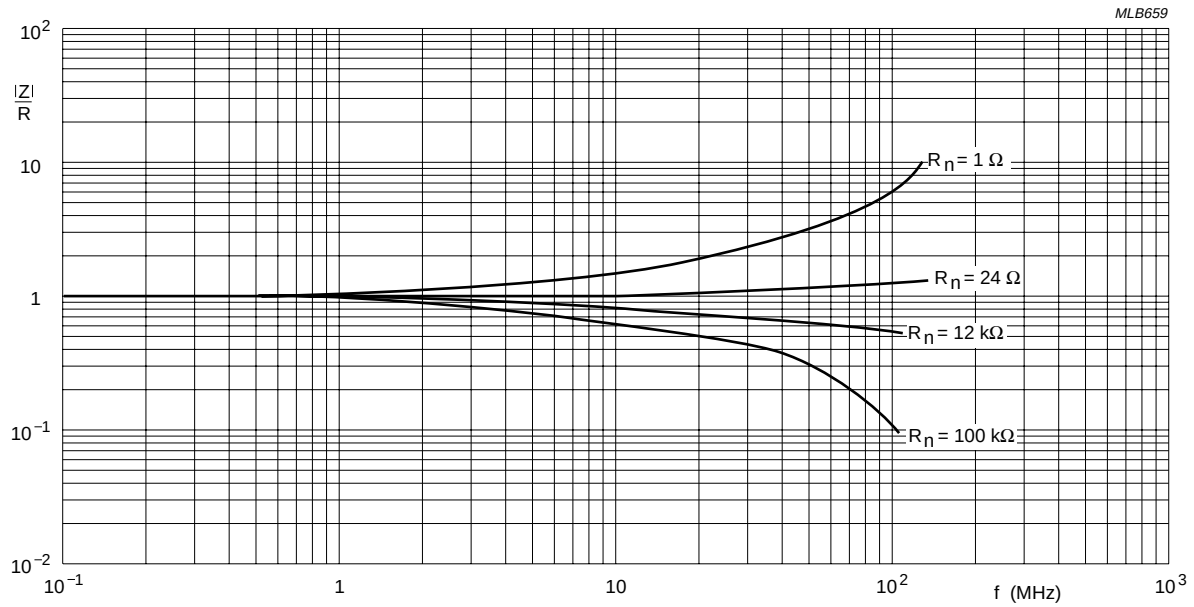
∅ 0.8 mm FeCu-leads.
PR03

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



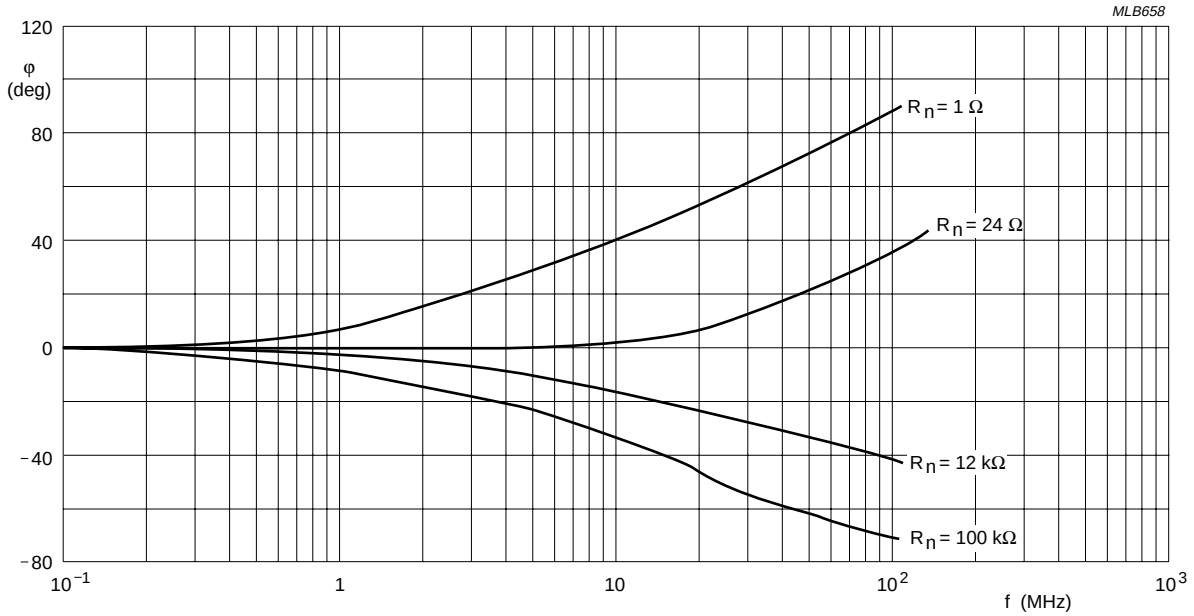
∅ 0.8 mm FeCu-leads.
Minimum distance from resistor body to PCB = 1 mm.
PR03

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



PR01

Fig.34 Impedance as a function of applied frequency.



PR01

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

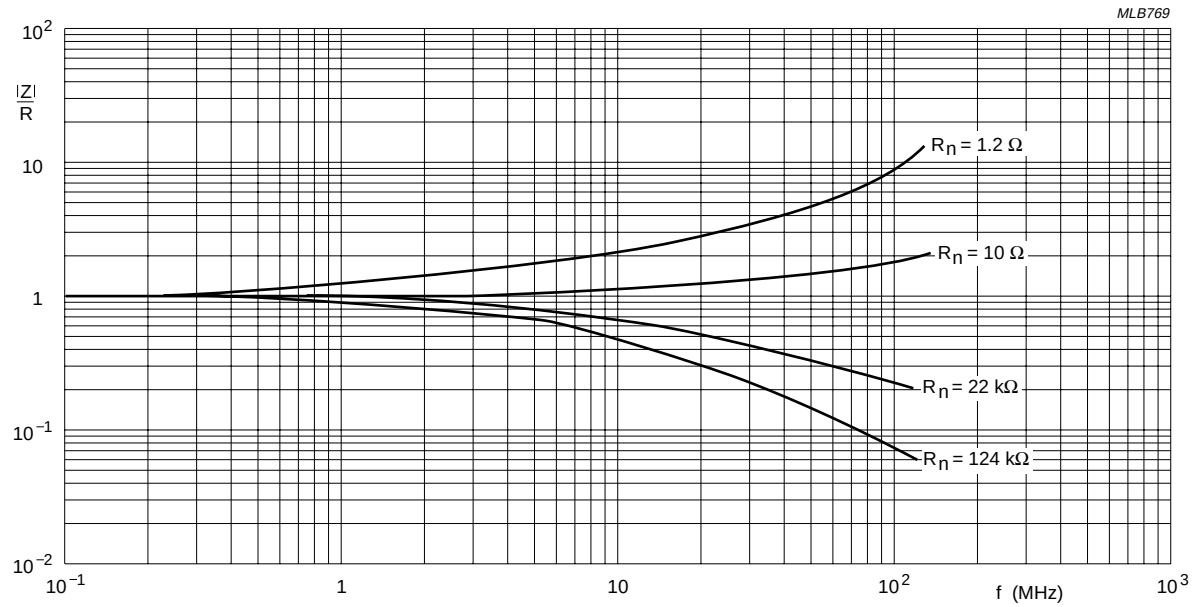


Fig.36 Impedance as a function of applied frequency.

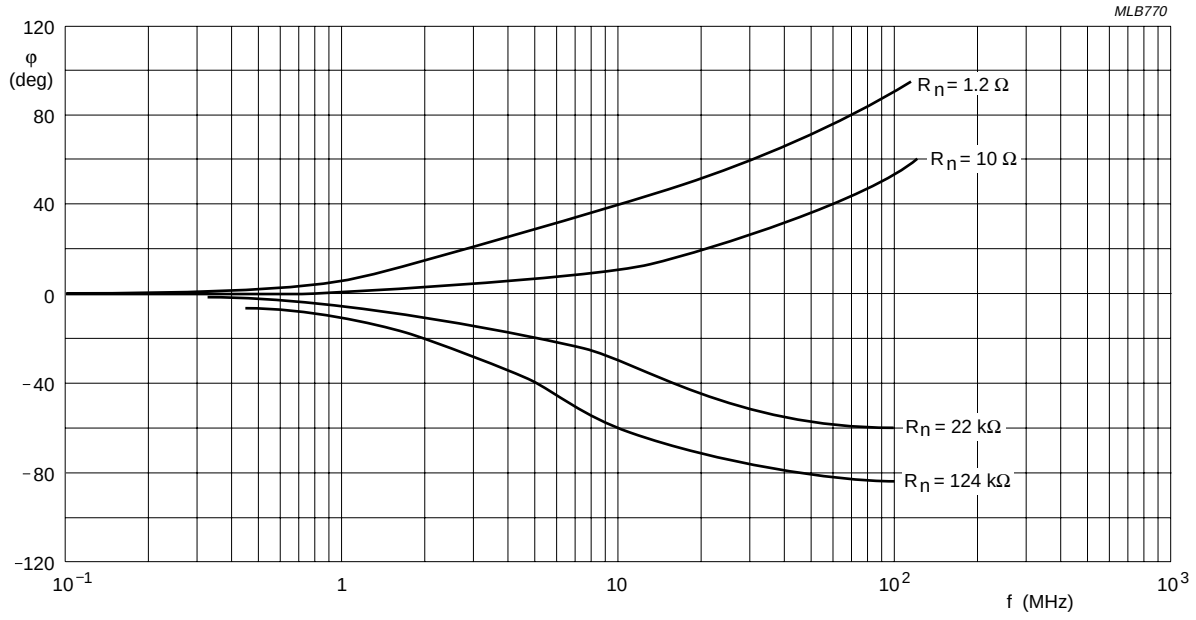
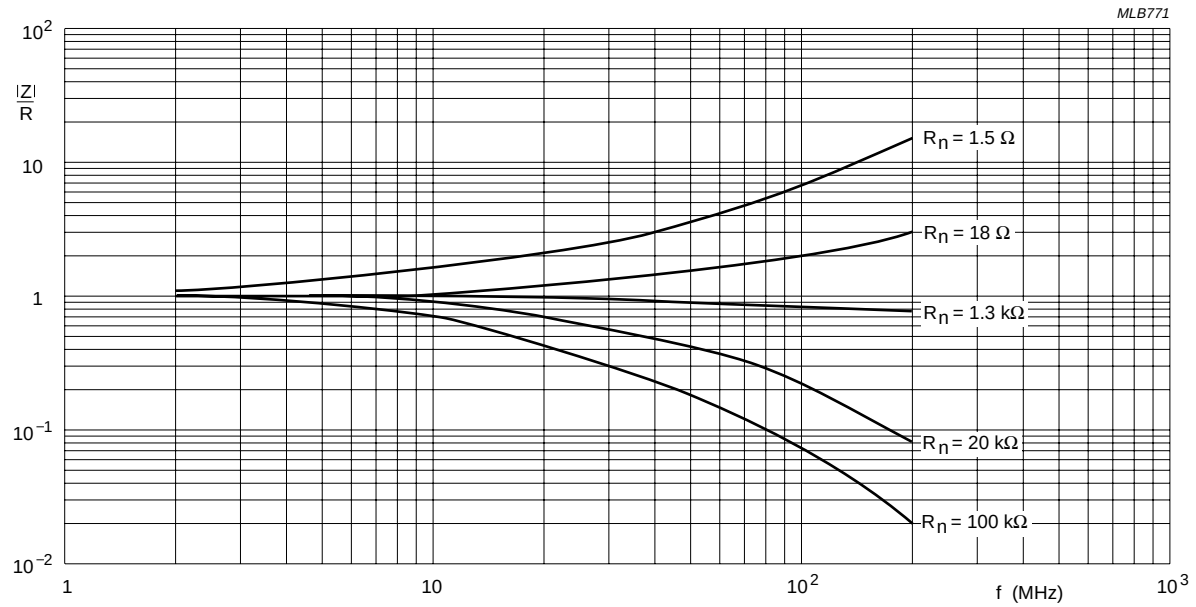
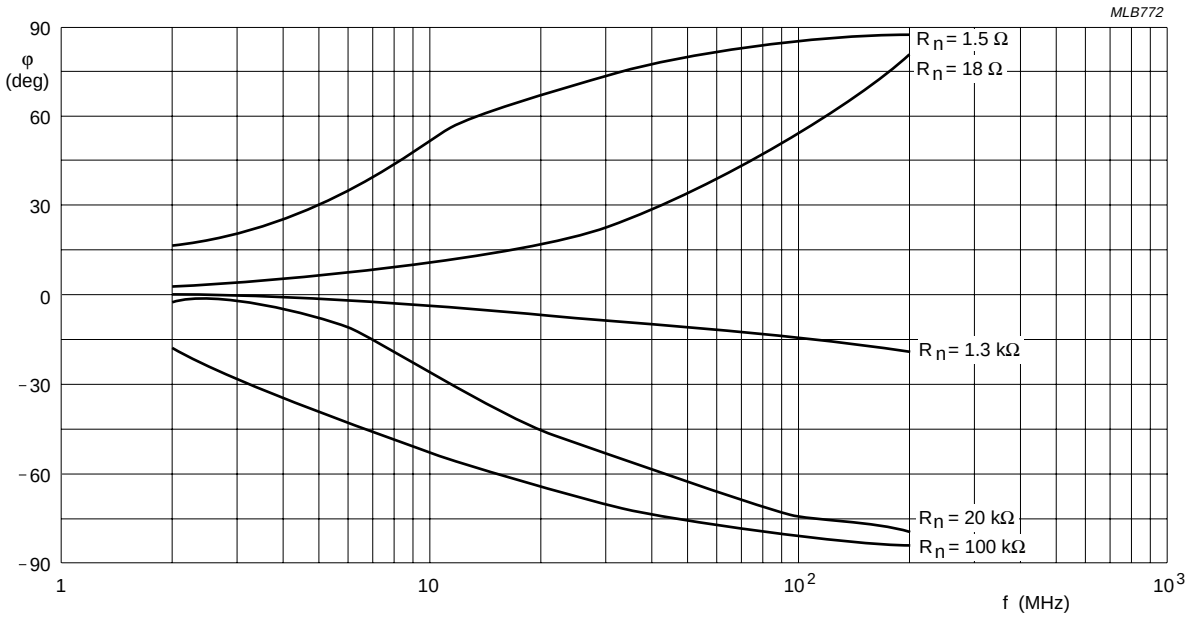


Fig.37 Phase angle as a function of applied frequency.



PR03

Fig.38 Impedance as a function of applied frequency.



PR03

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

MECHANICAL DATA

Mass per 100 units

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

Mounting

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

Marking

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

Outlines

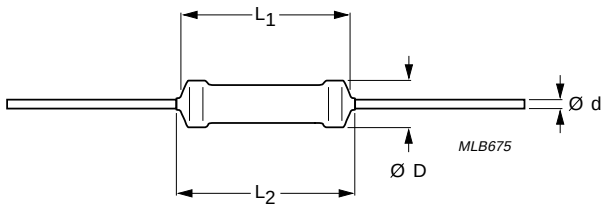
The length of the body (L_1) is measured by inserting the leads into holes of two identical gauge plates and moving these plates parallel to each other until the resistor body is clamped without deformation (*"IEC publication 294"*). Resistors with lead lengths of 73, 52 or 26 mm are available on request.

Mounting pitch

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

Note

1. Recommended minimum value.

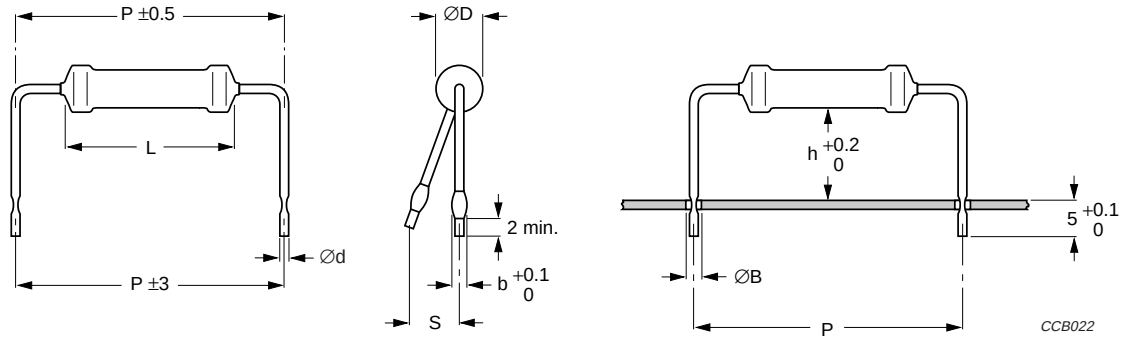


For dimensions see Table 3.

Fig.40 Type with straight leads.

Table 3 Straight lead type and relevant physical dimensions: see Fig 40

TYPE	∅D MAX. (mm)	L_1 MAX. (mm)	L_2 MAX. (mm)	∅d (mm)
PR01	2.5	6.5	8.5	0.6 ±0.03
PR02	3.9	10	12	0.8 ±0.03
				0.6 ±0.03
PR03	5.2	16.7	19.5	0.8 ±0.03
				0.6 ±0.03



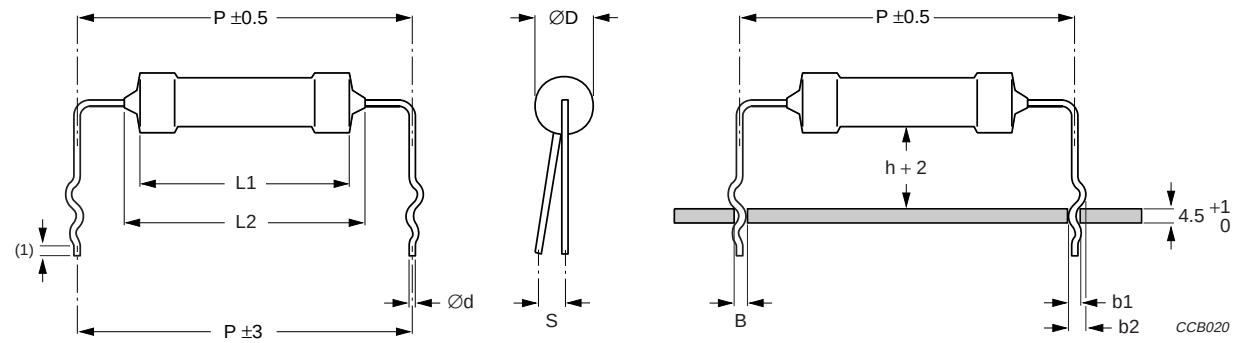
Dimensions in mm.

For dimensions see Tables 3 and 4.

Fig.41 Type with cropped and formed leads.

Table 4 Cropped and formed lead type and relevant physical dimensions; see Fig 41

TYPE	LEAD STYLE	∅d (mm)	b (mm)	h (mm)	P (mm)	S MAX. (mm)	∅B MAX. (mm)
PR01	cropped and formed	0.6 ±0.03	1.1	8	17.8	2	1.0
PR02		0.8 ±0.03	1.3	8	17.8	2	1.2
		0.8 ±0.03	1.3	15		3	1.2
		0.6 ±0.03	1.1	8		2	1.0
PR03		0.8 ±0.03	1.3	8	25.4	2	1.2
		0.8 ±0.03	1.3	15		3	1.2
		0.6 ±0.03	1.1	8		2	1.0



Dimensions in mm.

For dimensions see Tables 3 and 5.

(1) ∅0.8 to 1.4
∅0.6 to 1.6

Fig.42 Type with double kink.

Table 5 Double kink lead type and relevant physical dimensions; see Fig 42

TYPE	LEAD STYLE	∅d (mm)	b1 (mm)	b2 (mm)	h (mm)	P (mm)	S MAX. (mm)	∅B MAX. (mm)
PR01	double kink large pitch	0.6 ±0.03	1.10 +0.25/ −0.20	1.45 +0.25/ −0.20	8	17.8	2	1.0
	double kink small pitch	0.6 ±0.03	1.10 +0.25/ −0.20	1.45 +0.25/ −0.20	8	12.5	2	1.0
PR02	double kink large pitch	0.6 ±0.03	1.10 +0.25/ −0.20	1.45 +0.25/ −0.20	8	17.8	2	1.0
	double kink small pitch	0.8 ±0.03	1.30 +0.25 −0.20	1.65 +0.25/ −0.20	8	15.0	2	1.2
PR03	double kink large pitch	0.6 ±0.03	1.10 +0.25/ −0.20	1.45 +0.25/ −0.20	8	25.4	2	1.0
	double kink small pitch	0.8 ±0.03	1.30 +0.25/ −0.20	2.15 +0.25/ −0.20	8	20.0	2	1.2

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 6 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 6 Test procedures and requirements

IEC 115-1 CLAUSE	IEC 68-2 TEST METHOD	TEST	PROCEDURE	REQUIREMENTS
Tests in accordance with the schedule of IEC publication 115-1				
4.4.1		visual examination		no holes; clean surface; no damage
4.4.2		dimensions (outline)	gauge (mm)	see Tables 3, 4 and 5
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
4.16	U	robustness of terminations:		
4.16.2	Ua	tensile all samples	∅0.8 mm; load 5 N; 10 s ∅0.6 mm; load 10 N; 10 s	number of failures $<1 \times 10^{-6}$
4.16.3	Ub	bending half number of samples	∅0.8 mm; load 2.5 N; 4 × 90° ∅0.6 mm; load 5 N; 4 × 90°	number of failures $<1 \times 10^{-6}$

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