# Power Metal Film Resistors

## FEATURES

- High power in small packages (1 W/0207 size to 3 W/0617 size)
- Different lead materials for different applications
- Defined interruption behaviour
- Lead (Pb)-free solder contacts
- Pure tin plating provides compatibility with lead (Pb)-free and lead containing soldering processes
- Compatible with "Restriction of the use of Hazardous Substances" (RoHS) directive 2002/95/EC (issue 2004)

## APPLICATIONS

- All general purpose power applications
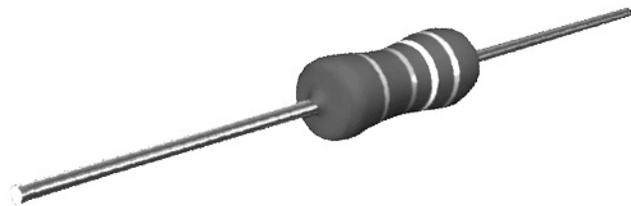
## DESCRIPTION

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 copper-clad iron are welded to the end-caps. The resistors are coated with a red, nonflammable lacquer which provides electrical, mechanical and climatic protection. This coating is not resistant to aggressive fluxes. The encapsulation is resistant to all cleaning solvents in accordance with "MIL-STD-202E, method 215", and "IEC 60068-2-45".

## TECHNICAL SPECIFICATIONS

| DESCRIPTION | VALUE | | | | |
|---|---|---|---|---|---|
| | PR01 | PR02 | | PR03 | |
| | | Cu-lead | FeCu-lead | Cu-lead | FeCu-lead |
| Resistance Range [2] | 0.22 Ω to 1 MΩ | 0.33 Ω to 1 MΩ | 1 Ω to 1 MΩ | 0.68 Ω to 1 MΩ | 1 Ω to 1 MΩ |
| Resistance Tolerance and Series | ± 1 % (E24, E96 series); ± 5 % (E24 series) [1] | | | | |
| Maximum Dissipation at $T_{amb}$ = 70 °C: | | | | | |
| $R < 1\ \Omega$ | 0.6 W | 1.2 W | - | 1.6 W | - |
| $1\ \Omega \le R$ | 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 | $\le \pm 250 \times 10^{-6}$/K | | | | |
| Maximum Permissible Voltage (DC or RMS) | 350 V | 500 V | | 750 V | |
| Basic Specifications | IEC 60115-1 and 60115-4 | | | | |
| Climatic Category (IEC 60068) | 55/155/56 | | | | |
| Stability After: | | | | | |
| Load | $\Delta R$ max.: ± (5 % $R$ + 0.1 Ω) | | | | |
| Climatic Tests | $\Delta R$ max.: ± (3 % $R$ + 0.1 Ω) | | | | |
| Soldering | $\Delta R$ max.: ± (1 % $R$ + 0.05 Ω) | | | | |

**Notes:**

[1] 1 % tolerance is available for $R_n$-range from 1 $R$ upwards

[2] Ohmic values (other than resistance range) are available on request

- $R$ value is measured with probe distance of 24 ± 1 mm using 4-terminal method

## 12NC INFORMATION

The resistors have a 12-digit numeric code starting with 23
For 5 % tolerance:

- The next 7 digits indicate the resistor type and packing
- The remaining 3 digits indicate the resistance value:
  - The first 2 digits indicate the resistance value
  - The last digit indicates the resistance decade

For 1 % tolerance:

- The next 6 digits indicate the resistor type and packing
- The remaining 4 digits indicate the resistance value:
  - The first 3 digits indicate the resistance value
  - The last digit indicates the resistance decade

### Last Digit of 12NC Indicating Resistance Decade

| RESISTANCE DECADE | LAST DIGIT |
|---|---|
| 0.22 to 0.91 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 97.6 kΩ | 3 |
| 100 to 976 kΩ | 4 |
| 1 MΩ | 5 |

### 12NC Example

The 12NC for resistor type PR02 with Cu leads and a value of 750 Ω with 5 % tolerance, supplied on a bandolier of 1000 units in ammopack, is: 2306 198 53751.

## 12NC - Resistor Type and Packaging [1]

| TYPE | LEAD Ø mm | TOL (%) | ORDERING CODE 23.. ... ...... (BANDOLIER) | | | | | REEL |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | | | AMMOPACK | | | | | |
| | | | RADIAL TAPED | | STRAIGHT LEADS | | | |
| | | | | | 52 mm | 52 mm | 63 mm | 52 mm |
| | | | 4000 units | 3000 units | 5000 units | 1000 units | 500 units | 5000 units |
| PR01 | Cu 0.6 | 1 | – | – | **22 196 1....** | 06 191 2.... | – | 06 191 5.... |
| | | 5 | 06 197 03... | – | **22 193 14...** | 06 197 53... | – | **06 197 23...** |
| PR02 | Cu 0.8 | 1 | – | 22 197 2.... | – | **22 197 1....** | – | 06 192 5.... |
| | | 5 | – | **06 198 03...** | – | **06 198 53...** | – | **06 198 23...** |
| | FeCu 0.6 | 5 | – | – | – | 22 194 54... | – | – |
| PR03 | Cu 0.8 | 5 | – | – | – | – | **22 195 14...** | – |
| | | 1 | – | – | – | – | 06 199 6... | – |
| | FeCu 0.6 | 5 | – | – | – | – | 22 195 54... | – |

**Notes:**
[1] Other packaging versions are available on request
• Preferred types in bold

## 12NC - Resistor Type and Packaging

| TYPE | LEAD Ø mm | TOL (%) | ORDERING CODE 23.. ... ...... (LOOSE IN BOX) | | | |
| --- | --- | --- | --- | --- | --- | --- |
| | | | DOUBLE KINK | | | |
| | | | PITCH = 17.8 mm | PITCH = 25.4 mm | PITCH [2] [3] [4] | |
| | | | 1000 units | 500 units | 1000 units | 500 units |
| PR01 | Cu 0.6 | 5 | 22 193 03... | – | – | – |
| | FeCu 0.6 | 5 | 22 193 43... | – | **22 193 53...** [2] | – |
| PR02 | Cu 0.8 | 5 | 22 194 23... | – | – | – |
| | FeCu 0.6 | 5 | 22 194 83... | – | – | – |
| | FeCu 0.8 | 5 | – | – | **22 194 63...** [3] | – |
| PR03 | Cu 0.8 | 5 | – | 22 195 23... | – | – |
| | FeCu 0.6 | 5 | – | 22 195 83... | – | – |
| | FeCu 0.8 | 5 | – | – | – | **22 195 63...** [4] |

**Notes:**
[2] PR01 pitch 12.5 mm
[3] PR02 pitch 15.0 mm
[4] PR03 pitch 20.0 mm, with reversed kinking direction as opposed to the drawing for the type with double kink figure
• Preferred types in bold

## PART NUMBER AND PRODUCT DESCRIPTION

**PART NUMBER: PR02000201001JA100**

| P | R | 0 | 2 | 0 | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 1 | J | A | 1 | 0 | 0 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |

| MODEL/SIZE | SPECIAL CHARACTE | WIRE TYPES | TCR/MATERIAL | VALUE | TOLERANCE | PACKAGING [1] | SPECIAL |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **PR0100** **PR0200** **PR0300** | **0** = Neutral **Z** = Value overflow (Special) | **1** = Cu 0.6 **2** = Cu 0.8 **3** = FeCu 0.6 **4** = FeCu 0.8 | **0** = Standard | **3 digit value** **1 digit multiplier** MULTIPLIER<br><br>**7** = $*10^{-3}$ **2** = $*10^{2}$<br>**8** = $*10^{-2}$ **3** = $*10^{3}$<br>**9** = $*10^{-1}$ **4** = $*10^{4}$<br>**0** = $*10^{0}$ **5** = $*10^{5}$<br>**1** = $*10^{1}$ | **F** = ± 1 % **J** = ± 5 % | **N4** **R5**<br>**N3** **L1**<br>**A5** **DC**<br>**A1** **K1**<br>**AC** **B1**<br>**R5** **PC** | The 2 digits are used for all special parts.<br>**00** = Standard |

**PRODUCT DESCRIPTION: PR02 5 % A1 1K0**

| **PR02** | **5 %** | **A1** | **1K0** |
| --- | --- | --- | --- |
| MODEL/SIZE | TOLERANCE | PACKAGING [1] | RESISTANCE VALUE |
| **PR01** **PR02** **PR03** | ± 1 % ± 5 % | **N4** **L1**<br>**N3** **DC**<br>**A5** **K1**<br>**A1** **B1**<br>**AC** **PC**<br>**R5** | **1K0** = 1 kΩ **4K75** = 4.75 kΩ |

**Notes:**
[1] Please refer to table PACKAGING for details
• The PART NUMBER is shown to facilitate the introduction of a unified part numbering system for ordering products

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## PACKAGING

| CODE | PIECES | DESCRIPTION | MODEL/SIZE |
|------|--------|-------------|------------|
| N4 | 4000 | Bandolier in ammopack radial taped | PR01 |
| N3 | 3000 | Bandolier in ammopack radial taped | PR02 |
| A5 | 5000 | Bandolier in ammopack straight leads 52 mm | PR01 |
| A1 | 1000 | Bandolier in ammopack straight leads 52 mm | PR01, PR02 |
| AC | 500 | Bandolier in ammopack straight leads 63 mm | PR03 |
| R5 | 5000 | Bandolier on reel straight leads 52 mm | PR01, PR02 |
| L1 | 1000 | Loose in box with Double Kink, pitch 17.8 mm | PR01, PR02 |
| DC | 500 | Loose in box with Double Kink, pitch 25.4 mm | PR03 |
| K1 | 1000 | Loose in box with Double Kink, pitch 12.5 mm | PR01 |
| B1 | 1000 | Loose in box with Double Kink, pitch 15.0 mm | PR02 |
| PC | 500 | Loose in box with Double Kink, pitch 20.0 mm | PR03 |

## DIMENSIONS
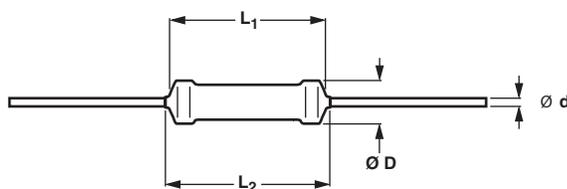


Type with straight leads

## DIMENSIONS - straight lead type and relevant physical dimensions; see straight leads outline

| TYPE | $\varnothing D_{max.}$ (mm) | $L_1$ max. (mm) | $L_2$ max. (mm) | $\varnothing d$ (mm) | |
|------|------|------|------|------|------|
| | | | | Cu | FeCu |
| PR01 | 2.5 | 6.5 | 8.5 | 0.58 ± 0.05 | - |
| PR02 | 3.9 | 10.0 | 12.0 | 0.78 ± 0.05 | 0.58 ± 0.05 |
| PR03 | 5.2 | 16.7 | 19.5 | 0.78 ± 0.05 | 0.58 ± 0.05 |
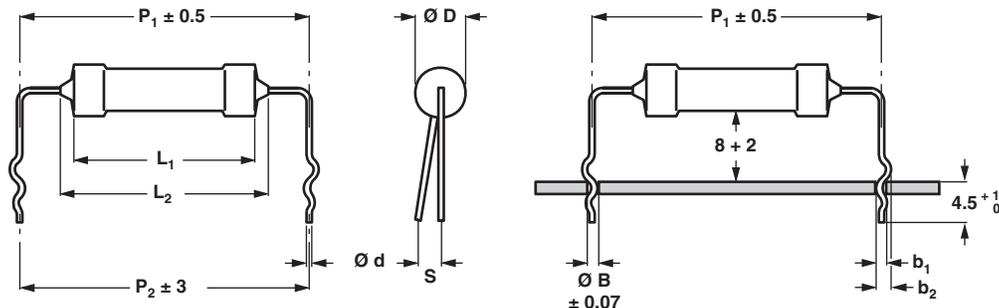


Type with double kink     Dimensions in millimeters

## DIMENSIONS - double kink lead type and relevant physical dimensions; see double kinked outline

| TYPE | LEAD STYLE | $\varnothing d$ (mm) | | $b_1$ (mm) | $b_2$ (mm) | $\varnothing D_{max.}$ (mm) | $P_1$ (mm) | $P_2$ (mm) | $S_{max.}$ (mm) | $\varnothing B$ (mm) |
|------|------------|------|------|------|------|------|------|------|------|------|
| | | Cu | FeCu | | | | | | | |
| PR01 | double kink large pitch | 0.58 ± 0.05 | 0.58 ± 0.05 | 1.10 + 0.25/- 0.20 | 1.45 + 0.25/- 0.20 | 2.5 | 17.8 | 17.8 | 2 | 0.8 |
| | double kink small pitch | - | 0.58 ± 0.05 | 1.10 + 0.25/- 0.20 | 1.45 + 0.25/- 0.20 | | 12.5 | 12.5 | 2 | 0.8 |
| PR02 | double kink large pitch | 0.78 ± 0.05 | 0.58 ± 0.05 | 1.10 + 0.25/- 0.20 | 1.45 + 0.25/- 0.20 | 3.9 | 17.8 | 17.8 | 2 | 0.8 |
| | double kink small pitch | - | 0.78 ± 0.05 | 1.30 + 0.25/- 0.20 | 1.65 + 0.25/- 0.20 | | 15.0 | 15.0 | 2 | 1.0 |
| PR03 | double kink large pitch | 0.78 ± 0.05 | 0.58 ± 0.05 | 1.10 + 0.25/- 0.20 | 1.65 + 0.25/- 0.20 | 5.2 | 25.4 | 25.4 | 2 | 1.0 |
| | double kink small pitch | - | 0.78 ± 0.05 | 1.30 + 0.25/- 0.20 | 2.15 + 0.25/- 0.20 | | 22.0 | 20.0 | 2 | 1.0 |

## MASS PER 100 UNITS

| TYPE | MASS (g) |
|---|---|
| PR01 Cu 0.6 mm | 21.2 |
| PR01 FeCu 0.6 mm | 20.7 |
| PR02 Cu 0.8 mm | 50.4 |
| PR02 FeCu 0.6 mm | 40.6 |
| PR02 FeCu 0.8 mm | 49.6 |
| PR03 Cu 0.8 mm | 119.2 |
| PR03 FeCu 0.6 mm | 107.9 |
| PR03 FeCu 0.8 mm | 118.5 |

## MARKING

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

## OUTLINES

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

## MOUNTING

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

### MOUNTING PITCH

| TYPE | LEAD STYLE | PITCH mm | PITCH e |
|---|---|---|---|
| PR01 | straight leads | 12.5 [1] | 5 [1] |
| | radial taped | 4.8 | 2 |
| | 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 |
| | double kink large pitch | 17.8 | 7 |
| | double kink small pitch | 15.0 | 6 |
| PR03 | straight leads | 23.0 [1] | 9 [1] |
| | double kink large pitch | 25.4 | 10 |
| | double kink small pitch | 20.0 | 8 |

**Note:**
[1] Recommended minimum value.

## FUNCTIONAL DESCRIPTION

## PRODUCT CHARACTERIZATION

Standard values of nominal resistance are taken from the E96/E24 series for resistors with a tolerance of ± 1 % or ± 5 %.

The values of the E96/E24 series are in accordance with "IEC publication 60063".

## FUNCTIONAL PERFORMANCE
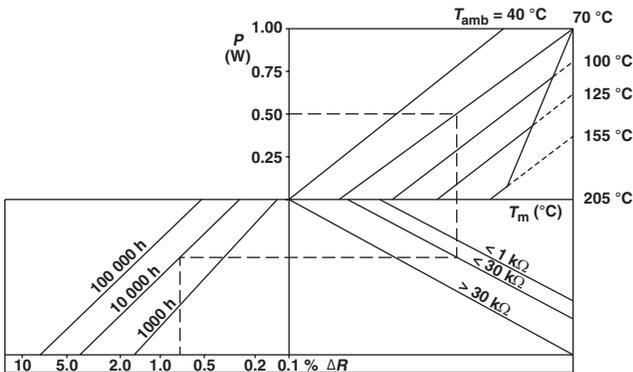


**PR01** Drift nomogram
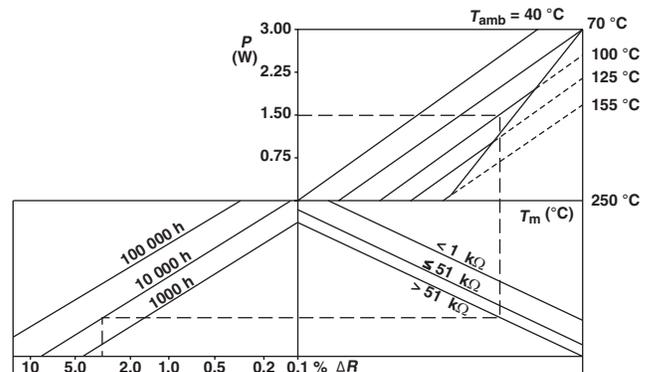


**PR03** Drift nomogram
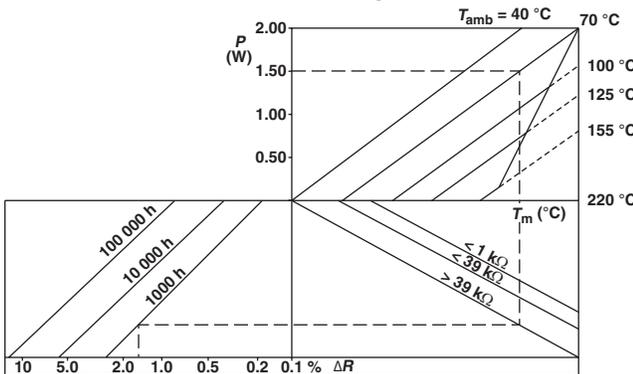


**PR02** Drift nomogram

### LIMITING VALUES

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

**Note:**
[1] The maximum voltage that may be continuously applied to the resistor element, see "IEC publication 60115-1".
- The maximum permissible hot-spot temperature is 205 °C for PR01, 220 °C for PR02 and 250 °C for PR03.

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The power that the resistor can dissipate depends on the operating temperature.
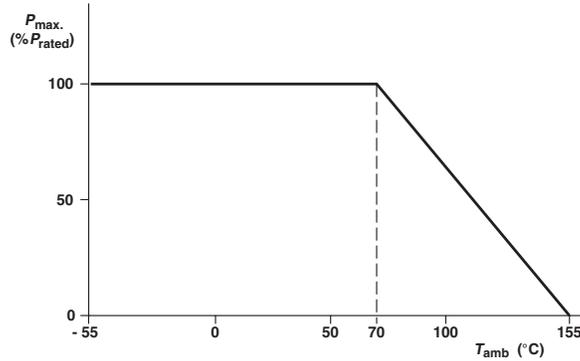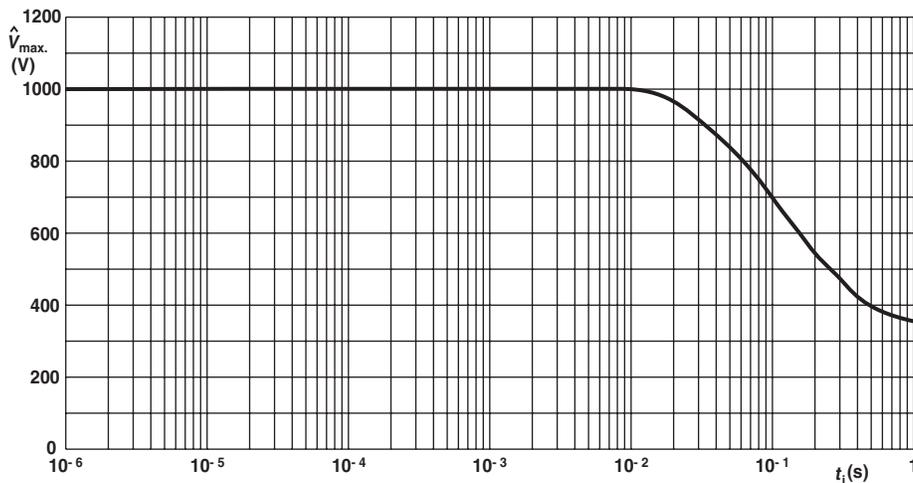


Maximum dissipation ($P_{max.}$) in percentage of rated power as a function of the ambient temperature ($T_{amb}$)
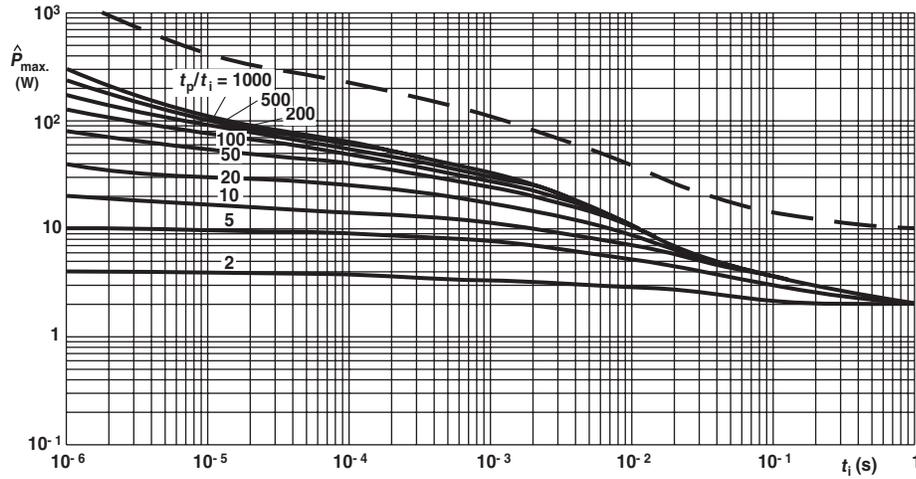
## Derating
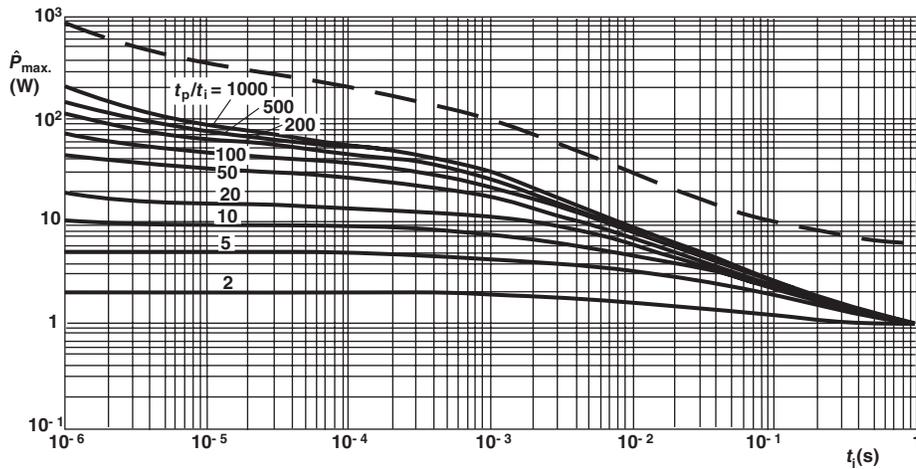


**PR01** Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max.}$) as a function of pulse duration ($t_i$)
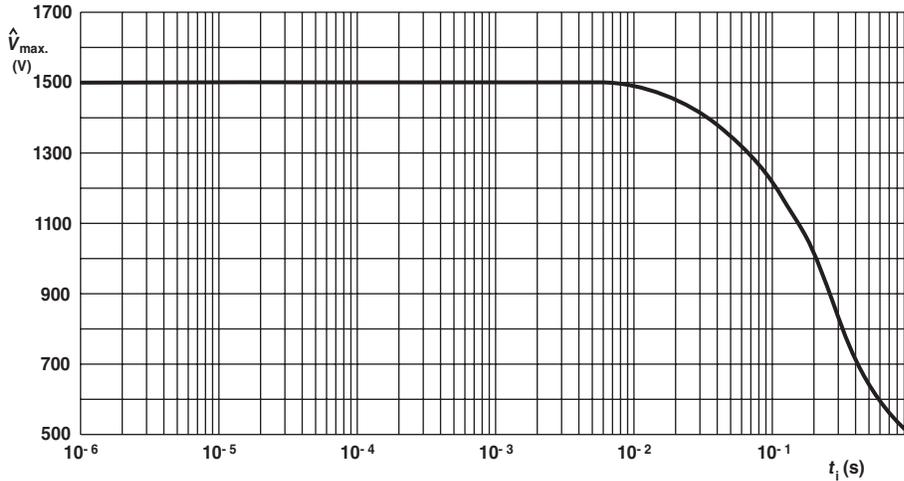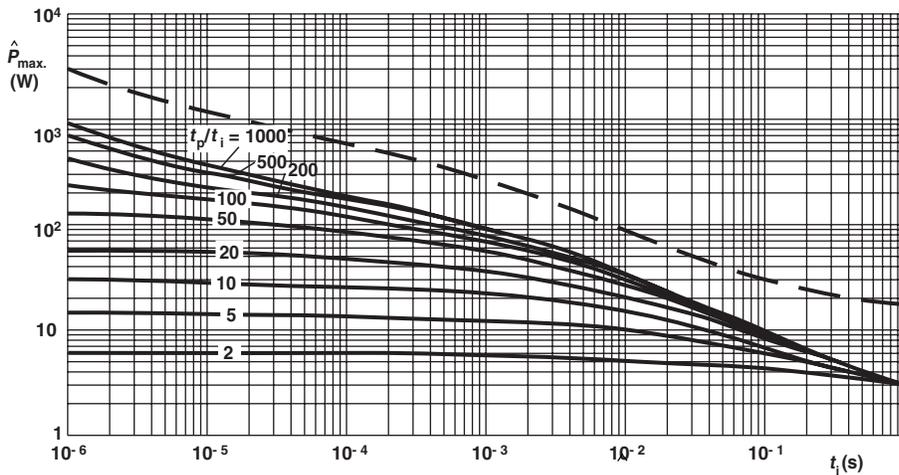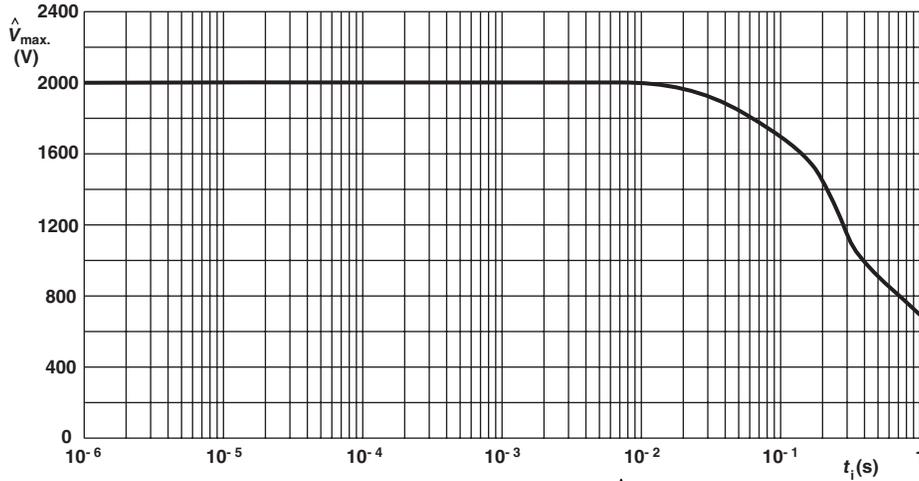


**PR01** Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max.}$) as a function of pulse duration ($t_i$)

## Pulse Loading Capabilities

**PR02** Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max.}$) as a function of pulse duration ($t_i$)



**PR02** Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max.}$) as a function of pulse duration ($t_i$)



**PR03** Pulse on a regular basis; maximum permissible peak pulse power ($P_{max.}$) as a function of pulse duration ($t_i$)

## Pulse Loading Capabilities

PR03 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max.}$) as a function of pulse duration ($t_i$)

## Pulse Loading Capabilities
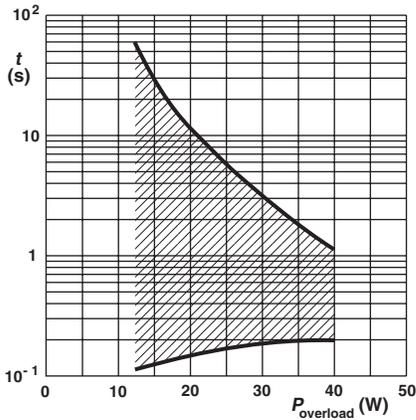


PR01 Time to interruption as a function of overload power
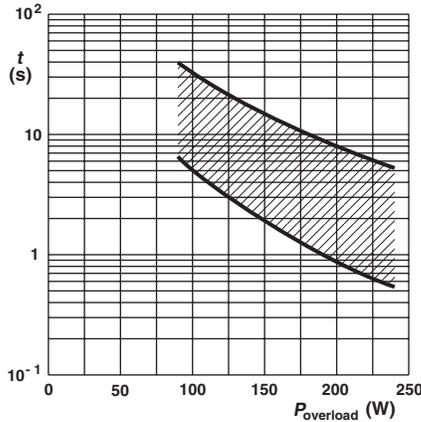for range: 0 $R$ 22 $\leq R_n <$ 1 $R$

This graph is based on measured data under constant voltage conditions; the data may deviate according to the applications.
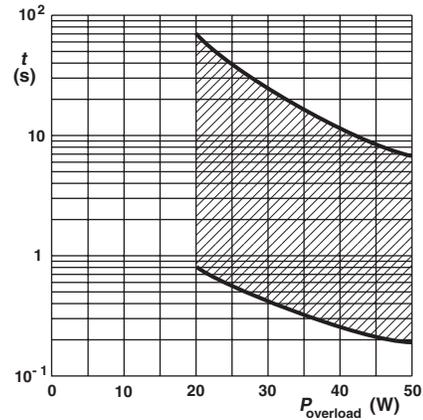


PR01 Time to interruption as a function of overload power
for range: 16 $R \leq R_n \leq$ 560 $R$

This graph is based on measured data under constant voltage conditions; the data may deviate according to the applications.
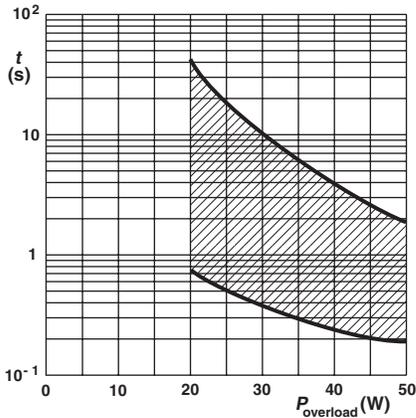


PR01 Time to interruption as a function of overload power
for range: 1 $R \leq R_n \leq$ 15 $R$

This graph is based on measured data under constant voltage conditions; the data may deviate according to the applications.
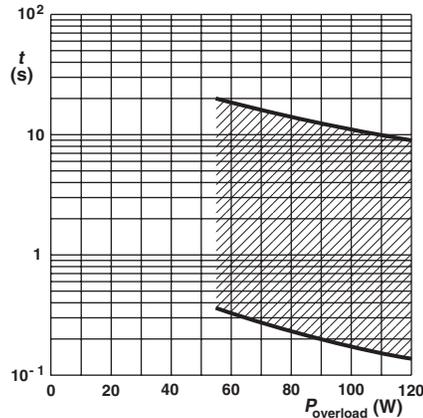


PR02 Time to interruption as a function of overload power
for range: 0.33 $R \leq R_n <$ 5 $R$

This graph is based on measured data under constant voltage conditions; the data may deviate according to the applications.

## Interruption Characteristics
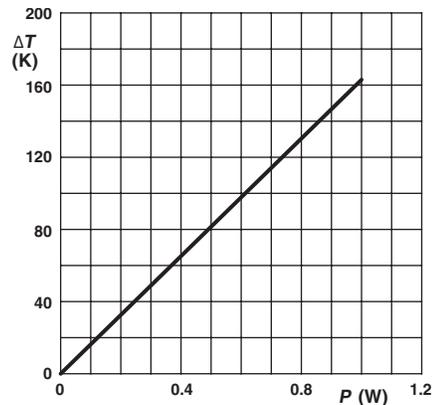
Power Metal Film Resistors          Vishay BCcomponents
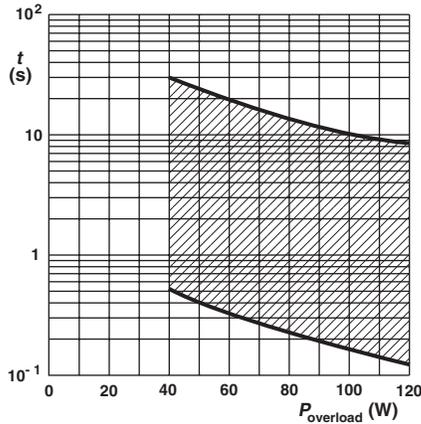


**PR02** Time to interruption as a function of overload power
for range: $5\ R \leq R_n < 68\ R$

This graph is based on measured data under constant voltage conditions; the data may deviate according to the applications.
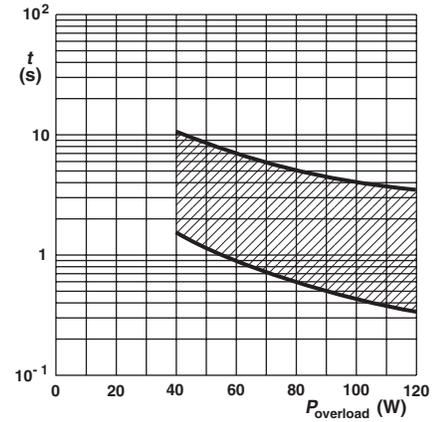


**PR02** Time to interruption as a function of overload power
for range: $68\ R \leq R_n \leq 560\ R$

This graph is based on measured data under constant voltage conditions; the data may deviate according to the applications.

## Interruption Characteristics



**PR03** Time to interruption as a function of overload power
for range: $0.68\ R \leq R_n \leq 560\ R$

This graph is based on measured data under constant voltage conditions; the data may deviate according to the applications.
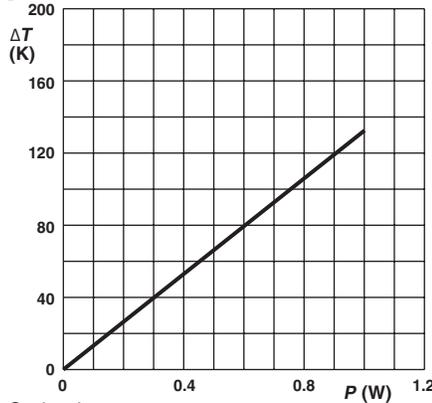


Ø 0.6 mm Cu-leads

**PR01** Hot-spot temperature rise ($\Delta T$) as a function
of dissipated power.
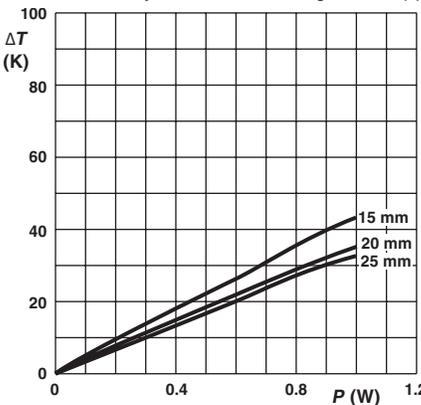


Ø 0.6 mm Cu-leads
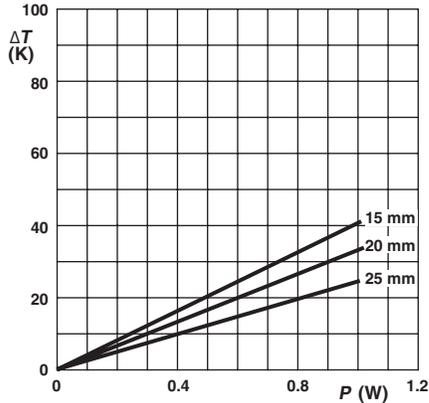Minimum distance from resistor body to PCB = 1 mm

**PR01** Temperature rise ($\Delta T$) at the lead end (soldering point) as a
function of dissipated power at various lead lengths after mounting.



Ø 0.6 mm FeCu-leads

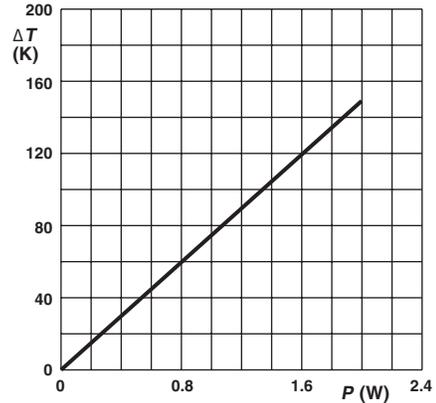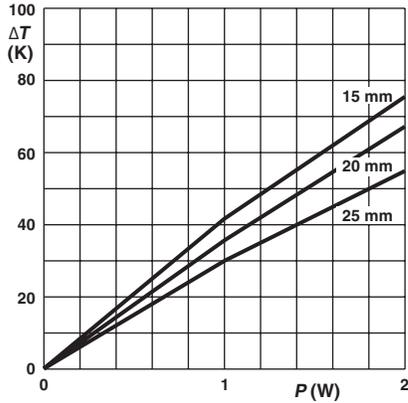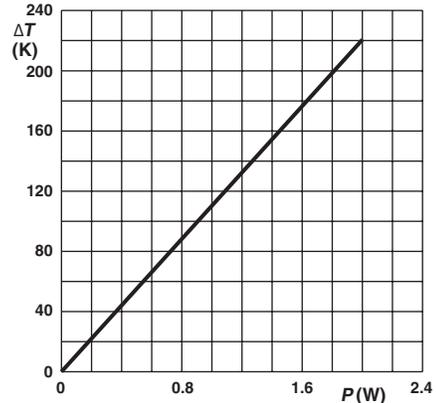**PR01** Hot-spot temperature rise ($\Delta T$) as a function
of dissipated power.

## Application Information

Power Metal Film Resistors

**VISHAY.**



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

**PR01** Temperature rise ($\Delta T$) 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** Hot-spot temperature rise ($\Delta T$) as a function of dissipated power.
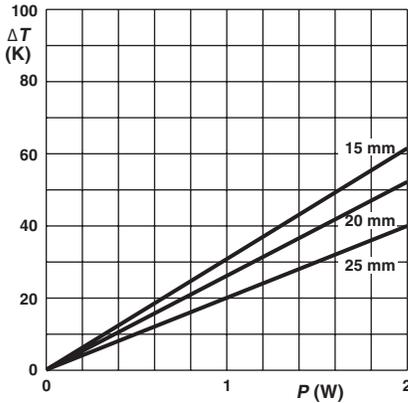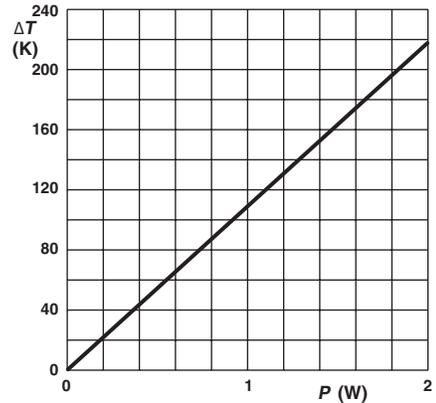


Ø 0.8 mm Cu-leads
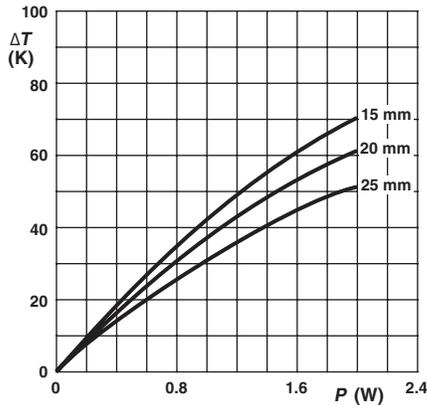Minimum distance from resistor body to PCB = 1 mm

**PR02** Temperature rise ($\Delta T$) 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** Hot-spot temperature rise ($\Delta T$) as a function of dissipated power.



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

**PR02** Temperature rise ($\Delta T$) at the lead end (soldering point) as a function of dissipated power at various lead lengths after mounting.
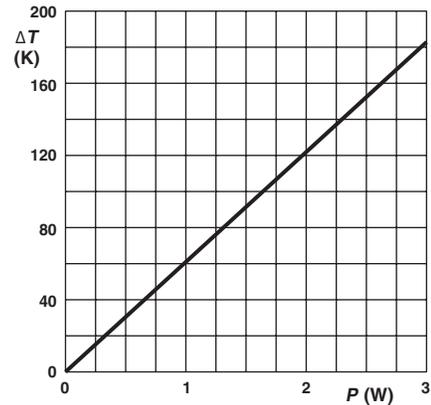


Ø 0.8 mm FeCu-leads

**PR02** Hot-spot temperature rise ($\Delta T$) as a function of dissipated power.
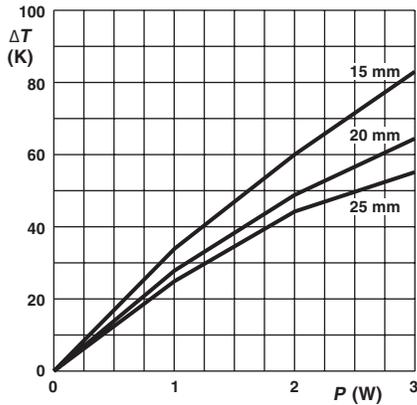
## Application Information

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

**PR02** Temperature rise (ΔT) at the lead end (soldering point) as a function of dissipated power at various lead lengths after mounting.
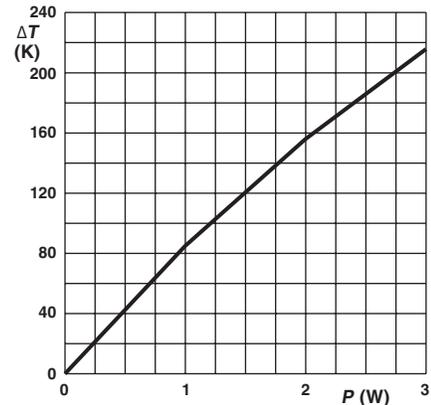
Ø 0.8 mm Cu-leads

**PR03** 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** 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** 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** 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 FeCu-leads

**PR03** Hot-spot temperature rise (ΔT) as a function of dissipated power.
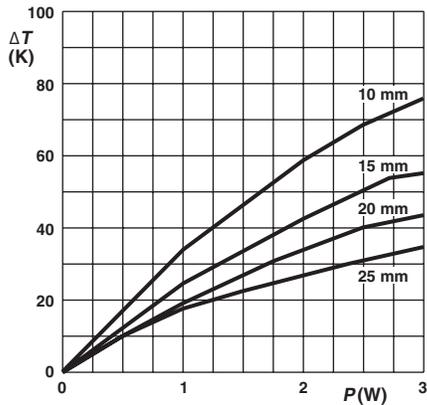
## Application Information

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

**PR03** Temperature rise ($\Delta T$) at the lead end (soldering point) as a function
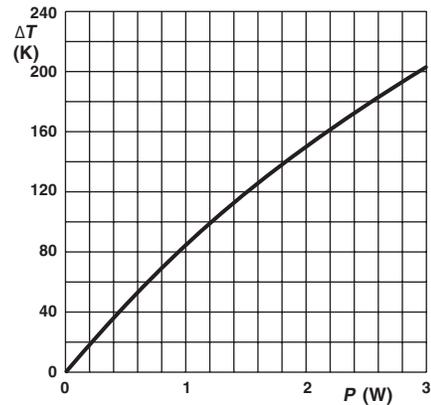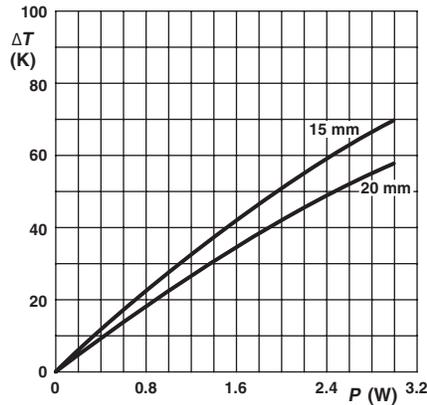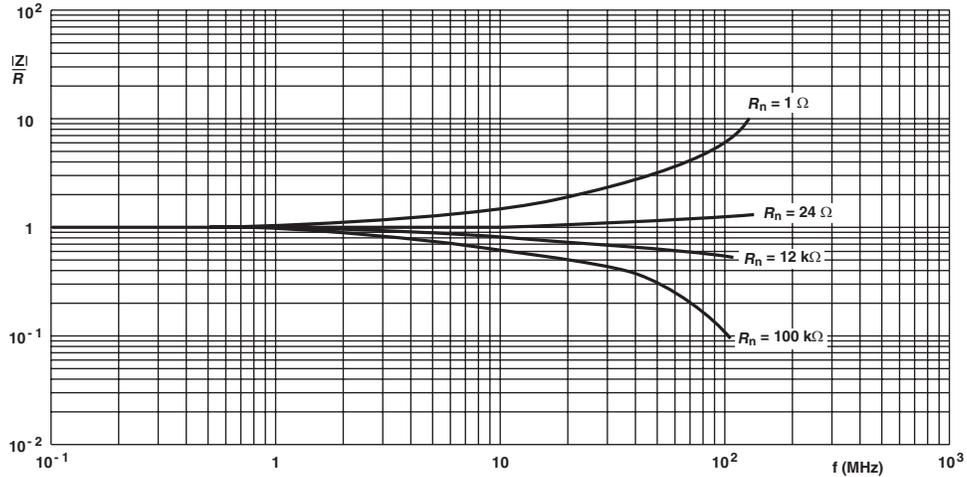of dissipated power at various lead lengths after mounting.

**PR01** Impedance as a function of applied frequency
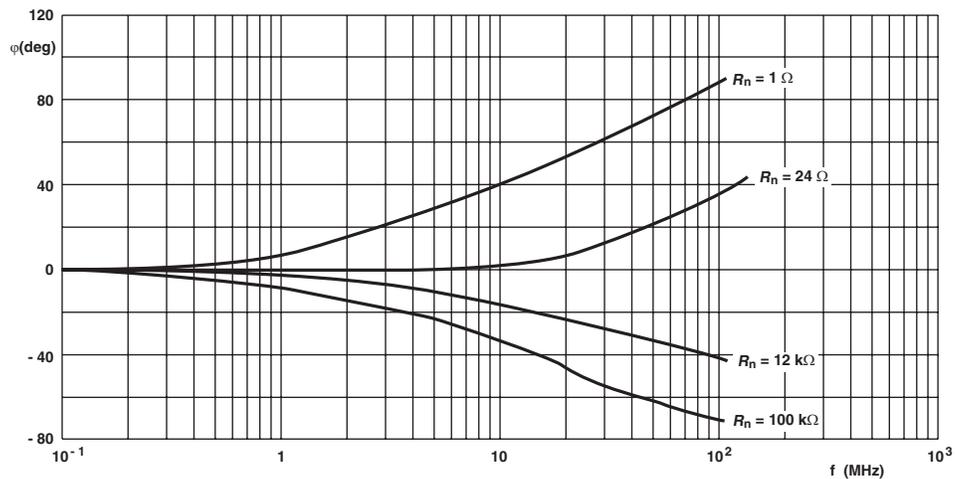
**PR01** Phase angle as a function of applied frequency

## Application Information

**PR02** Impedance as a function of applied frequency

**PR02** Phase angle as a function of applied frequency

**PR03** Impedance as a function of applied frequency

## Application Information

**PR03** Phase angle as a function of applied frequency

## Application Information

### TESTS AND REQUIREMENTS

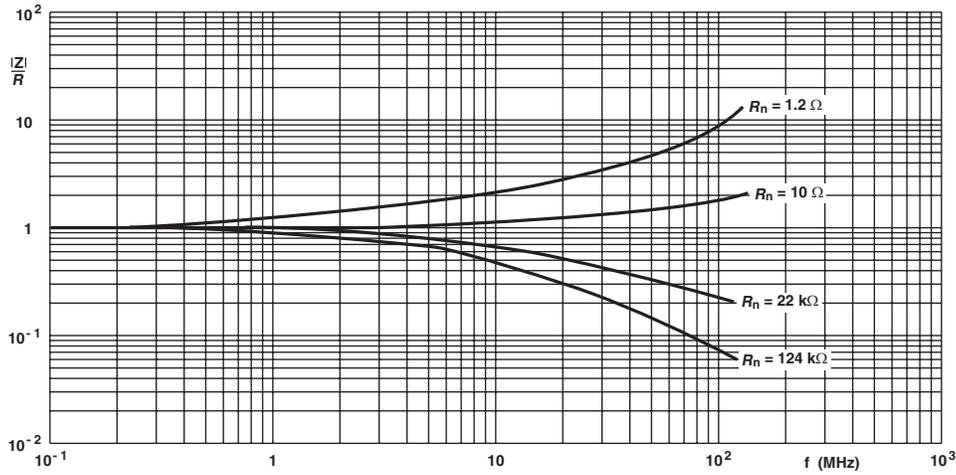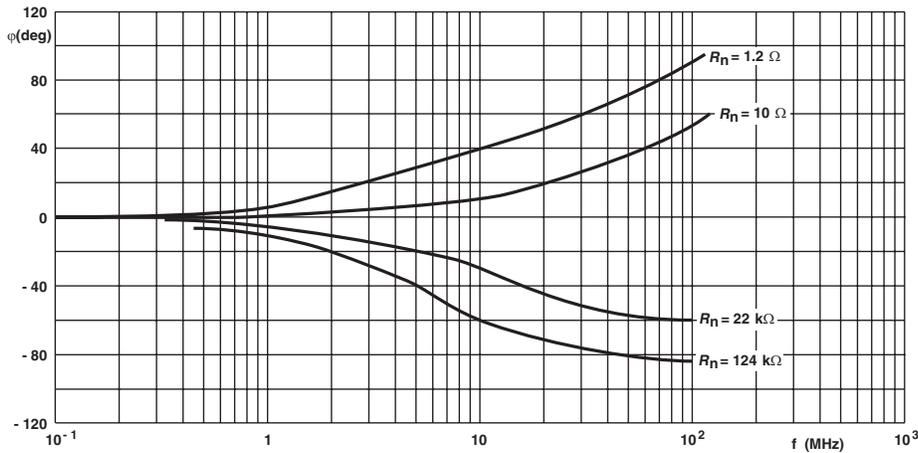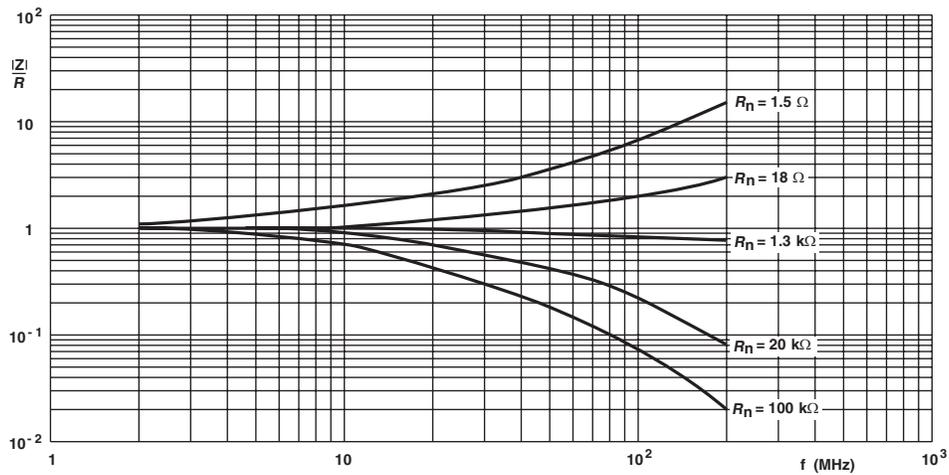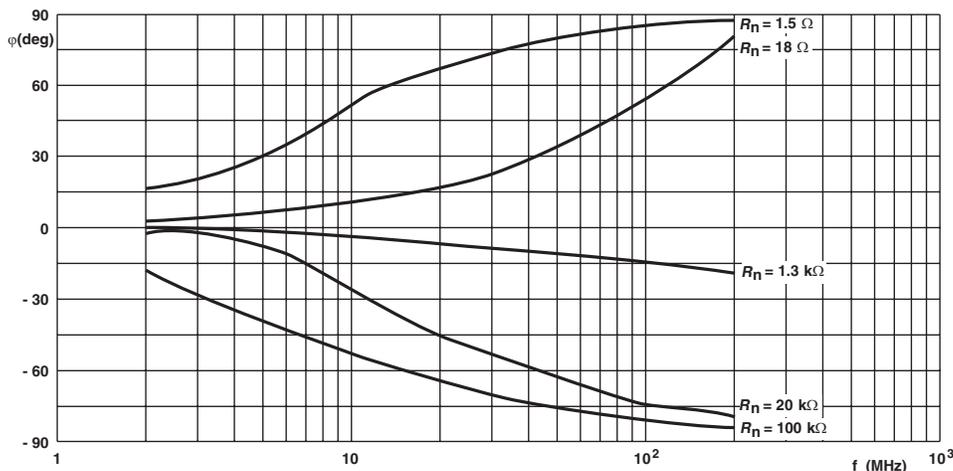Essentially all tests are carried out in accordance with the schedule of "IEC publication 60115-1", category LCT/UCT/56 (rated temperature range: Lower Category Temperature, Upper Category Temperature; damp heat, long term, 56 days). The testing also covers the requirements specified by EIA and EIAJ.

The tests are carried out in accordance with IEC publication 60068-2, "Recommended basic climatic and mechanical robustness testing procedure for electronic components" and

under standard atmospheric conditions according to "IEC 60068-1", subclause 5.3.

In the Test Procedures and Requirements table, tests and requirements are listed with reference to the relevant clauses of "IEC publications 60115-1 and 60068-2"; 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.

## TEST PROCEDURES AND REQUIREMENTS

| IEC 60115-1 CLAUSE | IEC 60068-2 TEST METHOD | TEST | PROCEDURE | REQUIREMENTS |
|---|---|---|---|---|
| **TESTS IN ACCORDANCE WITH THE SCHEDULE OF IEC PUBLICATION 60115-1** | | | | |
| 4.4.1 | | visual examination | | no holes; clean surface; no damage |
| 4.4.2 | | dimensions (outline) | gauge (mm) | see Straight and Kinked Dimensions tables |
| 4.5 | | resistance (refer note on first page for measuring distance) | applied voltage (+ 0/- 10 %):<br>$R < 10\ \Omega$: 0.1 V<br>$10\ \Omega \leq R < 100\ \Omega$: 0.3 V<br>$100\ \Omega \leq R < 1\ k\Omega$: 1 V<br>$1\ k\Omega \leq R < 10\ k\Omega$: 3 V<br>$10\ k\Omega \leq R < 100\ k\Omega$: 10 V<br>$100\ k\Omega \leq R < 1\ M\Omega$: 25 V<br>$R = 1\ M\Omega$: 50 V | $R - R_{nom}$: max. ± 5 % |
| 4.18 | 20 (Tb) | resistance to soldering heat | thermal shock: 3 s; 350 °C; 3 mm from body | $\Delta R$ max.: ± (1 % $R$ + 0.05 $\Omega$) |
| 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 | 2 s; 235 °C | good tinning; no damage |
| 4.7 | | voltage proof on insulation | maximum voltage 500 $V_{RMS}$ during 1 min; metal block method | no breakdown or flashover |

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## TEST PROCEDURES AND REQUIREMENTS

| IEC 60115-1 CLAUSE | IEC 60068-2 TEST METHOD | TEST | PROCEDURE | REQUIREMENTS |
|---|---|---|---|---|
| 4.16 | 21 (U) | robustness of terminations: | | |
| 4.16.2 | 21 (Ua1) | tensile all samples | load 10 N; 10 s | number of failures: < 1 x $10^{-6}$ |
| 4.16.3 | 21 (Ub) | bending half number of samples | load 5 N; 4 x 90° | number of failures: < 1 x $10^{-6}$ |
| 4.16.4 | 21 (Uc) | torsion other half of samples | 3 x 360° in opposite directions | no damage $\Delta R$ max.: ± (0.5 % $R$ + 0.05 $\Omega$) |
| 4.20 | 29 (Eb) | bump | 3 x 1500 bumps in three directions; 40 g | no damage $\Delta R$ max.: ± (0.5 % $R$ + 0.05 $\Omega$) |
| 4.22 | 6 (Fc) | vibration | frequency 10 to 500 Hz; displacement 1.5 mm or acceleration 10 g; three directions; total 6 h (3 x 2 h) | no damage $\Delta R$ max.: ± (0.5 % $R$ + 0.05 $\Omega$) |
| 4.19 | 14 (Na) | rapid change of temperature | 30 min at LCT and 30 min at UCT; 5 cycles | no visual damage **PR01**: $\Delta R$ max.: ± (1 % $R$ + 0.05 $\Omega$) **PR02**: $\Delta R$ max.: ± (1 % $R$ + 0.05 $\Omega$) **PR03**: $\Delta R$ max.: ± (2 % $R$ + 0.05 $\Omega$) |
| 4.23 | | climatic sequence: | | |
| 4.23.3 | 30 (Db) | damp heat (accelerated) 1st cycle | | |
| 4.23.6 | 30 (Db) | damp heat (accelerated) remaining cycles | 6 days; 55 °C; 95 to 98 % RH | $R_{ins}$ min.: $10^3$ M$\Omega$ $\Delta R$ max.: ± (3 % $R$ + 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 M$\Omega$ $\Delta R$ max.: ± (3 % $R$ + 0.1 $\Omega$) |
| 4.25.1 | | endurance (at 70 °C) | 1000 h; loaded with $P_n$ or $V_{max.}$; 1.5 h ON and 0.5 h OFF | $\Delta R$ max.: ± (5 % $R$ + 0.1 $\Omega$) |
| 4.8.4.2 | | temperature coefficient | at 20/LCT/20 °C and 20/UCT/20 °C (TC x $10^{-6}$/K) | $\leq$ ± 250 |
| **OTHER TESTS IN ACCORDANCE WITH IEC 60115 CLAUSES AND IEC 60068 TEST METHOD** | | | | |
| 4.17 | 20 (Tb) | solderability (after ageing) | 8 h steam or 16 h 155 °C; leads immersed 6 mm for 2 ± 0.5 s in a solder bath at 235 ± 5 °C | good tinning ($\geq$ 95 % covered); no damage |
| 4.6.1.1 | | insulation resistance | maximum voltage (DC) after 1 min; metal block method | $R_{ins}$ min.: $10^4$ M$\Omega$ |
| see 2nd amendment to IEC 60115-1, Jan. '87 | | pulse load | | see Pulse Load Capabilities graphs |

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