



### Rated Resistance

Resistance value indicated upon the resistor

### Critical Resistance

Resistance value at which the rated voltage is equal to the limiting element voltage

### Resistance Tolerance

Permitted variation of the nominal resistance value expressed as a percentage of that value

### Nominal Dissipation

Maximum permitted load at a defined ambient temperature e.g.  $T_{@} = 70^{\circ}\text{C}$ , which ensures that resistance stability limits in the relevant specification are not exceeded.

### Limiting Element Voltage

Maximum d.c. or a.c. effective voltage which can be applied continuously to the resistor

### Temperature Coefficient

The permissible change of the resistance value depending on temperature and can be described by the following equation:

$$TC (10^{-6}/K) = (R_{\vartheta} - R_{TREF}) / (R_{TREF} * \Delta\vartheta) * 10^{-6}$$

$\Delta\vartheta$  is the difference between Reference Temperature ( $T_{REF}$ ) and the corresponding ambient temperature.

The maximum permissible increase of the resistance value by the TC, in case of electric load can be determined by way of the maximum permissible film temperature. The change of resistance value is calculated by:

$$R_{\vartheta_{max}} = R_N[(1+(\vartheta_{smax}-20^{\circ}\text{C}) * TC_{max})]$$

Consequently the maximum permissible current for the voltage for  $P_{70}$  can be calculated by  $R_{\vartheta_{max}}$ .

### Insulation Voltage

Maximum peak voltage which may be applied under continuous operating conditions between the resistor terminations and any conducting mounting surface.

### Insulation Resistance

Electrical resistance value of the encapsulant measured between the terminations of the resistor and applied V-block according to IEC60115-1

### Derating

Boundary curve of maximum allowable dissipation at  $T_{@}$  between upper and lower category temperatures.

### Thermal Resistance

Under electrical load a film resistor generates heat which increases the film temperature. At the same time heat is dissipated to the environment, so that with constant electric load and constant convection a thermal balance appears between the heat, generated by the electrical load and the heat lost by convection.

These proportions are characterized by the thermal resistance. The thermal resistance is defined by the mechanical dimensions of a resistor, the heat dissipation by the wire leads as well as the convection, radiation and the mounting of the resistor.

The thermal resistance  $R_{th}$  is defined as follows:

$$R_{th} = (\vartheta_s - \vartheta_u) / P = \vartheta_{\bar{u}} / P$$

$\vartheta_s$  = film temperature in  $^{\circ}\text{C}$

$\vartheta_u$  = ambient temperature in  $^{\circ}\text{C}$

$\vartheta_{\bar{u}}$  = temperature rise

P = load in Watts

The thermal resistance measurement is made under defined conditions according to DIN.

The maximum power rating can be calculated using the following equation:

$$P_{max} = (\vartheta_s - \vartheta_u) / R_{th}$$

Thus, the maximum permissible power rating  $P_{max}$  is dependant on the maximum permissible film temperature, the ambient temperature  $\vartheta_u$  and the thermal resistance.

### Current Noise

The current noise voltage expressed in  $\mu\text{V}$ , is that portion of noise voltage that arises from d.c. current in a resistor in addition to the thermal noise voltage. The relative noise voltage, expressed in  $\mu\text{V}/\text{V}$  is independent of the applied dc-voltage  $U_{=}$

### Non linearity $A_3$

The harmonic index and the voltage coefficient of resistors are a criteria for the non-linearity of the current voltage characteristic. The harmonic index is defined as the logarithm of the ratio of the fundamental  $U_1$  to the 3<sup>rd</sup> harmonic  $E_3$ . It is specified in dB:

$$A_3 = 20 \lg ( U_1 / E_3 ) \text{ in dB}$$

Measurements are according to IEC 60440

### Stability

The change of resistance values at certain loads and ambient temperatures can be obtained from the Stability Nomogram which consists of 4 diagrams; these can also be used independently. The stability nomogram for different products can be seen on the relevant data sheets. Additionally the limiting values stated in the data sheets such as maximum load, surface temperature etc., have to be observed. The following examples show how to use a nomogram:

#### Example 1:

Known: size D  
 $R = 1\text{K}\Omega$ ,  $P = 0.5\text{W}$ ,  $U_{\text{LEV}} = 350\text{V}$ ,  $t = 5000\text{h}$ ,  $\vartheta_U = 70^\circ\text{C}$

Unknown:  $\Delta R / R$  after 5000h

From Diagram A we see a temperature rise of  $\vartheta_U = 65^\circ\text{C}$  for size D at  $P = 0.5\text{W}$

From Diagram B a surface temperature of  $135^\circ\text{C}$  can be obtained for  $\vartheta_U = 70^\circ\text{C}$

From Diagram D a  $\Delta R / R$  after 5000h of 0.4% can be obtained for a surface temperature of  $135^\circ\text{C}$  of a  $1\text{K}\Omega$  resistor (see solid line in nomogram)

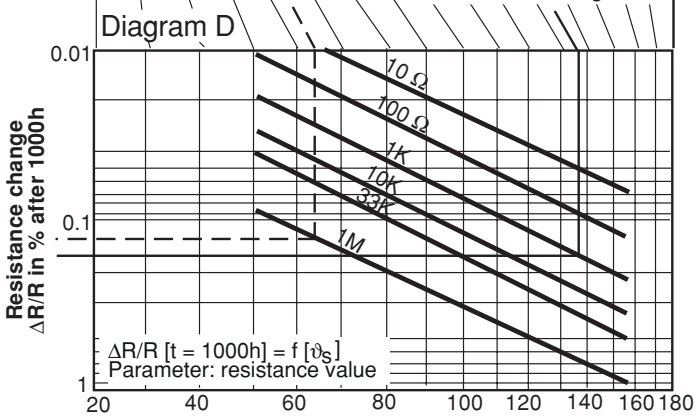
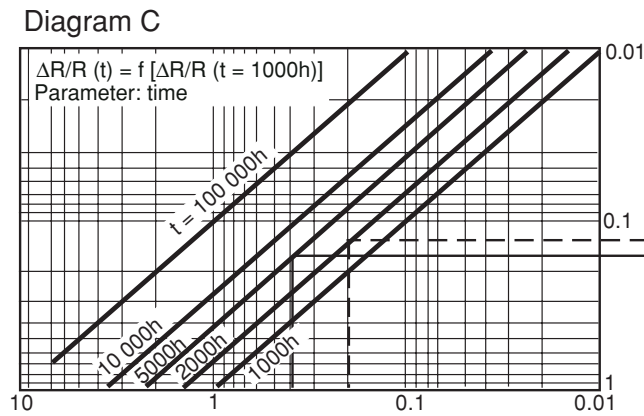
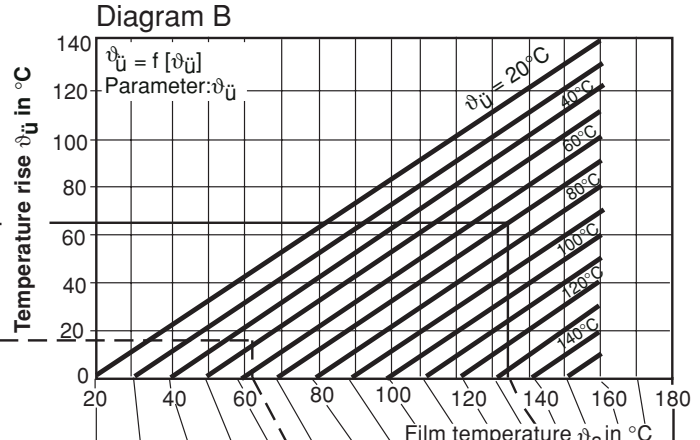
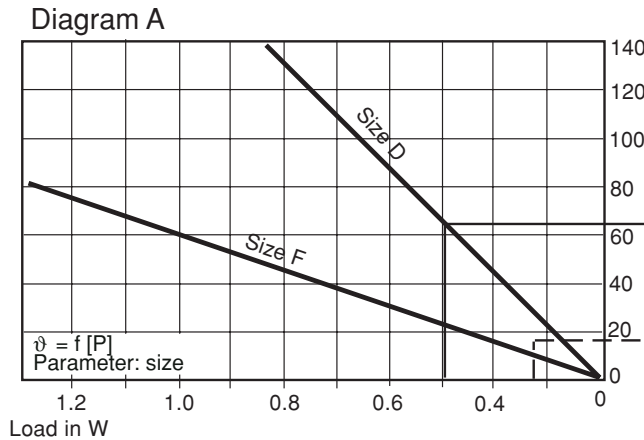
#### Example 2:

Known: size F;  $R = 1\text{M}$ ,  $P_{70} = 1.5\text{W}$ ,  $U_{\text{LEV}} = 500\text{V}$ ,  
 $t = 2000\text{h}$  at  $\vartheta_U = 50^\circ\text{C}$

Unknown:  $\Delta R / R$  after 2000h

For  $R = 1\text{M}$  the following equation applies:

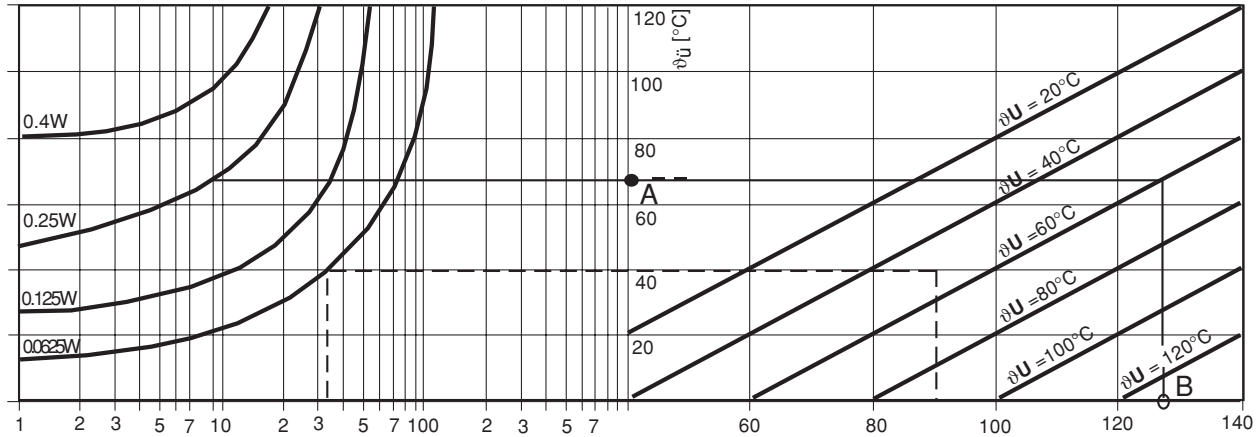
$P = (U_{\text{LEV}}^2 / R) = 0.25\text{W}$  as  $U = \sqrt{P \cdot R} > U_{\text{LEV}}$  (see the dotted line in the nomogram).



Stability nomogram typical values

## Packaging density

The temperature rise in respect of the surface temperature of the hottest SMD component on the board can be obtained from the nomogram below. It is necessary that the components are distributed uniformly over the whole circuit board.



### Example 1:

Known: 9 resistors each rated at 0.25W

$\vartheta_u = 60^\circ\text{C}$

Unknown: temp.rise  $\vartheta_{\bar{u}}$ , surface temp.  $\vartheta_s$  of the hottest component

$\vartheta_u = 65^\circ\text{C}$  (A),  $\vartheta_s = 125^\circ\text{C}$  (B), see solid line

### Example 2:

Load of each resistor = 0.0625W,  $\vartheta_u = 50^\circ\text{C}$  maximum admissible surface temperature  $90^\circ\text{C}$

How many components may be mounted?

- 33 pcs, see dotted line

## Pulse Load

When a resistor is subjected to impulses the following points have to be observed:

1. The maximum pulse load permissible  $P_{\max}^{\wedge}$  depends on the pulse duration  $t_i$

This also applies to the maximum permissible pulse voltage  $U_{\max}^{\wedge}$

2. The average load  $P$  may not exceed the corresponding nominal load. For resistors with resistance values greater than the critical value the nominal value is determined by the critical value and the maximum operating voltage permissible.

Required

$$\bar{P} = \frac{1}{t_p \cdot R} \int_{t_1}^{t_2} U^2(t) dt P_{\vartheta}$$

Explanations:

R = nominal value

$t_p$  = period of time

U (t) = pulse voltage

$P_{\vartheta}$  = nominal load of the resistor for the ambient temperature  $\vartheta$   $t_2 - t_1$  = pulse duration  $t_i$

3. Differences arise when resistors are subject to single shot (switching-on processes) or repetitive pulses.

Approximate values for the load with rectangular pulses for each model are stated in the appropriate sections of the catalog.

All other pulses have to be converted to rectangular pulses which show the same energy content and the same pulse voltage.

Example: Exponential pulse

$$\tau U_s^2 / 2R = t_i U_s^2 / R \quad \text{e.g. } t_i = \tau / 2$$

Explanations:

$\tau$  = time constant of the exponential pulse

$t_i$  = pulse duration or the rectangular pulse

$\hat{U}_s$  = peak voltage

R = nominal value of the resistor

The maximum permissible pulse voltages  $\hat{U}_{\max}$  are also stated. The permissible pulse loads have been fixed in such way that the changes which appear in resistance values are comparable to those stated for the electrical long time load according to IEC 60115-1.