Power derating based on terminal part temperature

§0 Abstract

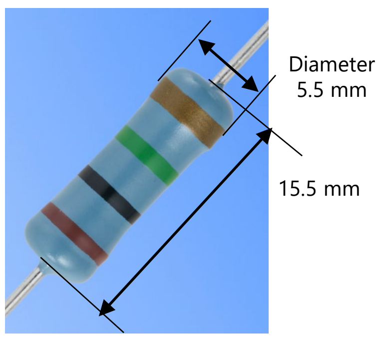
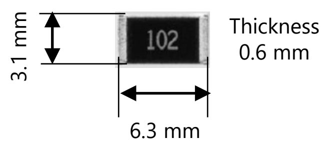
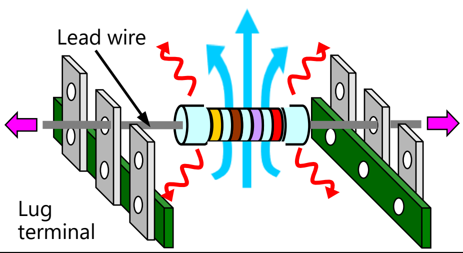
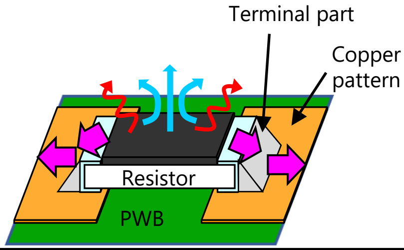
The conventional power derating for resistors, which is based on the ambient temperature, is well suited for leaded types, since they release most of the generated heat into the ambient air. On the other hand, power derating based on the terminal part temperature is suited for surface-mount resistors(SMD resistors) of which most of the heat generated is dissipated into the printed-wiring board (PWB). This Technical Note explains the reasons why the terminal part temperature is suitable as the reference for derating of SMD resistors.

§1 Rationality of terminal part temperature basis

1.1 Heat dissipation paths by types of resistors

Resistors are generally classified into leaded and SMD types, and Table 1 shows the heat dissipation paths by types of resistors. You can see that the main heat dissipation paths differ depending on the shape, size, and mounting configuration of the resistors.

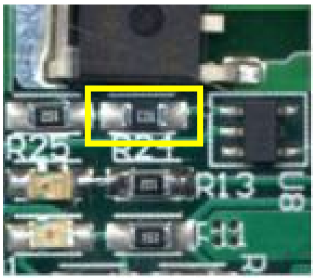
Table 1 Comparison of heat dissipation paths

Type	Leaded resistor	SMD resistor
Product	RK1	RK73BW3A
Shape and size of 1 W rated power product		
Heat dissipation path Conduction Convection Radiation		
Heat dissipation ratio	Conduction : Approx. 10% Convection : Radiation : } Approx. 90%	Conduction : 90% or more Convection : Radiation : } Less than 10%

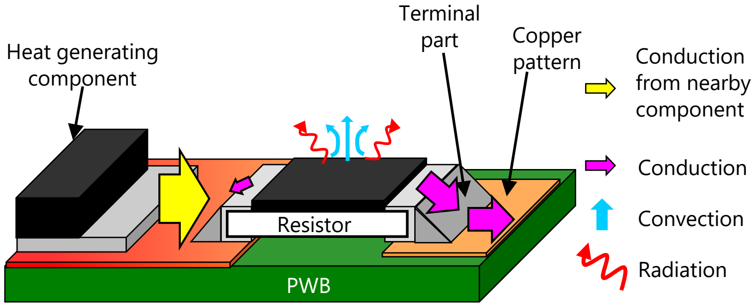
Attention : This document is subject to change without notice.
Please contact to our sales offices for more detail. https://www.koaglobal.com/corporate/offices?sc_lang=en
When using the text, we assume that you have agreed to the disclaimer on the following https://www.koaglobal.com/utility/disclaimer_TecDoc?sc_lang=en

1.2 Reference point of resistor temperature

The temperature of a resistor stabilizes at a level where the amount of heat generated balances the amount of heat dissipated. Most of the heat generated by a leaded resistor is released into the ambient air through convection and radiation, and heat dissipation by conduction through the lead wire is limited. This means that the transfer of heat generated in a resistor does not occur easily from lead wire to lug terminal and at the same time the heat of nearby components does not easily transfer into the resistor. Accordingly, the temperature of the ambient air has the most impact on the leaded resistor and thus the ambient temperature is suitable as the reference for the derating curve. Since most of the heat generated by an SMD resistor is dissipated into the PWB through conduction, heat dissipation from the surface by convection and radiation is limited. The high proportion of conduction also means that the heat of the PWB can easily transfer into resistors. For SMD components, the PWB works as the heatsink. For this reason, if an SMD resistor is placed close to a heat generating component as shown in Fig. 1(a), it is necessary to take into account the heat from the nearby component through the PWB as illustrated in Fig. 1(b).



(a) Component layout (example)



(b) Heat dissipation paths from nearby component

Fig. 1 Influence from nearby components through the PWB

The terminal parts of a flat chip resistor are pathways for both the heat from resistor to PWB (Table 1) and the heat from PWB to resistor (Fig. 1(b)). That is, the terminal part temperature of an SMD resistor is under the influence of heat from both direction. Accordingly, the terminal part temperature is appropriate as the reference temperature for SMD resistors.
Some of you may question why not use the hot spot (part of the resistor which becomes the hottest). The main reason is that the hot spot being inside the resistor and very small, its temperature cannot be accurately measured from the outside.
Figure 2 compares the size of terminal part and hot spot of a small flat chip resistor. You can see that the terminal part is much larger than the hot spot, which allows easier temperature measurement.
In the next clause, the other reason why the terminal part temperature is suitable for the temperature reference will be explained.

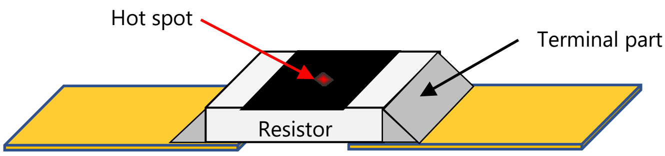


Fig. 2 Comparison of hot spot and terminal part

1.3 Temperature relations between PWB and SMD resistor

Figure 3 shows the temperature distribution of SMD resistors with different mounting conditions; heat dissipation design and mount density when the same power is applied to each resistor. Even if the mounting conditions changes, the temperature difference ΔT between the terminal part and hot spot of the SMD resistor is nearly constant. This is because the thermal resistance between the terminal part and hot spot is constant regardless of the mounting condition, and the amount of heat transfer is almost the same if the applied power is the same. It is to be noted, however, that the thermal resistance of SMD resistors are dependent on the structure and varies with the type and size.

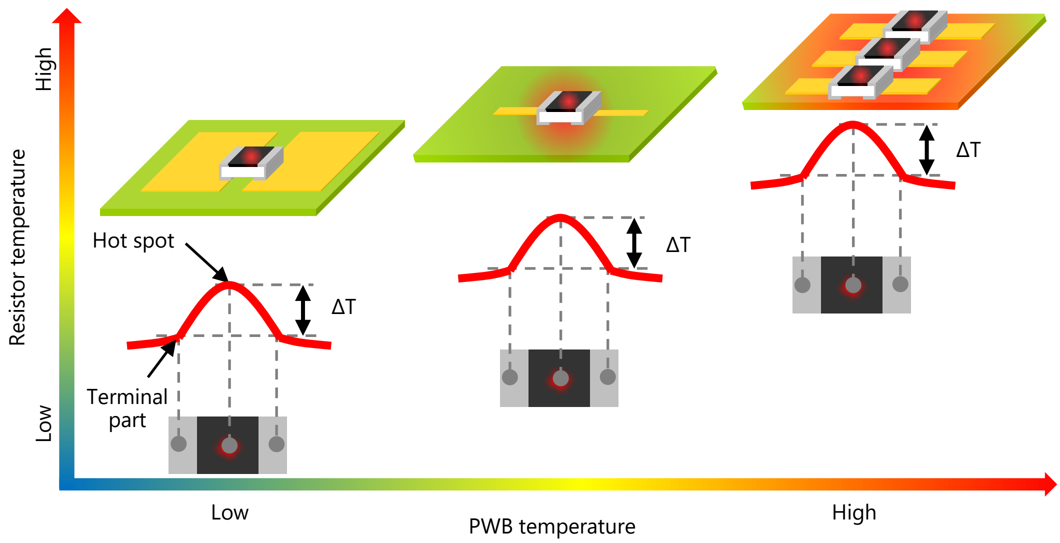


Fig. 3 Relations between PWB temperature and resistor temperature

Each electronic device may have different PWB copper patterns and component layouts. However, by choosing the terminal part temperature as the reference temperature for SMD resistors, the temperature rise can be estimated correctly regardless of the temperature of the PWB or the copper pattern. By use of a derating curve shown in Fig. 4 whose horizontal axis represents the temperature of the terminal part, you can select a suitable resistor for the PWB of your application.

For both the leaded resistors and SMD resistors, the main heat dissipation path can serve as the reference temperature of the resistors.

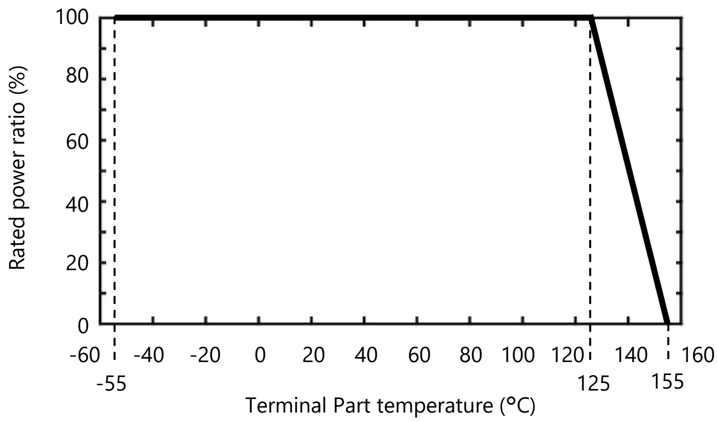


Fig. 4 Derating curve based on the terminal part temperature (example)

§2 Standardization of power derating by terminal part temperature

KOA and some other resistor manufactures employ the terminal part temperature as the reference for determining the temperature of an SMD resistor. KOA is promoting the standardization of use of the terminal part temperature as the reference of an SMD resistor. Please see the following reports published by JEITA and IEC (Fig. 5).

JEITA RCR-2114 Issued in October 2014 表面実装用固定抵抗器の負荷軽減曲線に関する考察 Study for the derating curve of fixed surface mount resistors
IEC TR 63091 : 2017 Issued in June 2017 Study for the derating curve of surface mount fixed resistors – Derating curves based on terminal part temperature

Fig. 5 Published report on terminal part temperature

The international standard IEC60115-8 for surface mounting resistors was revised in August 2023, and the idea of this terminal part temperature was reflected in the standard. The contents of the revision of the standard and background are explained on our website, so please refer to here.

Revision of an international standard related to rated power of resistors | KOA Corporation (koaglobal.com)

§3 Conclusion

The temperature of SMD resistors is strongly influenced by the layout of adjacent components and the copper pattern on the PWB. The derating curve using the terminal part temperature as a reference can reflect such influences, so it is suitable for the selection of SMD resistors.
KOA supports you with information on the method for measuring terminal part temperature. Feel free to contact us for inquiries.