Procedure for power derating based on terminal part temperature

§0 Abstract

The temperature of surface-mount resistors (SMD resistors) are dependent on the heat dissipation performance of the printed-wiring board (PWB) and the heat generation of nearby components. The terminal part temperature, which reflects such influences accurately, is suitable as a reference for power derating of SMD resistors. Controlling the temperature of SMD resistors according to the terminal part temperature will prevent them from damage and allows to determine the proper size and number of resistors needed for each application. This Technical Note explains the procedure for power derating based on the terminal part temperature.

§1 Procedure for measuring the terminal part temperature

For using a derating curve based on the terminal part temperature as shown in Fig. 1, it is necessary to comprehend the terminal part temperature of the resistor accurately.

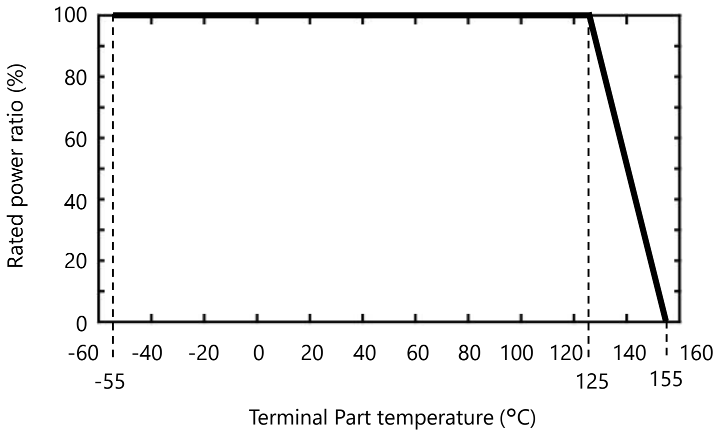


Fig. 1 Derating curve based on the terminal part temperature

1.1 Measurement of the terminal part temperature

When there is an operable PWB, first identify resistors with high temperature which may require the precise temperature control, by thermosensitive paint or infrared-thermography (Fig. 2(a)). Second, attach thermocouples to the terminal part of the identified resistors (Fig. 2(b)). Third, measure the terminal part temperature under the actual operating condition (Fig. 2(c)).

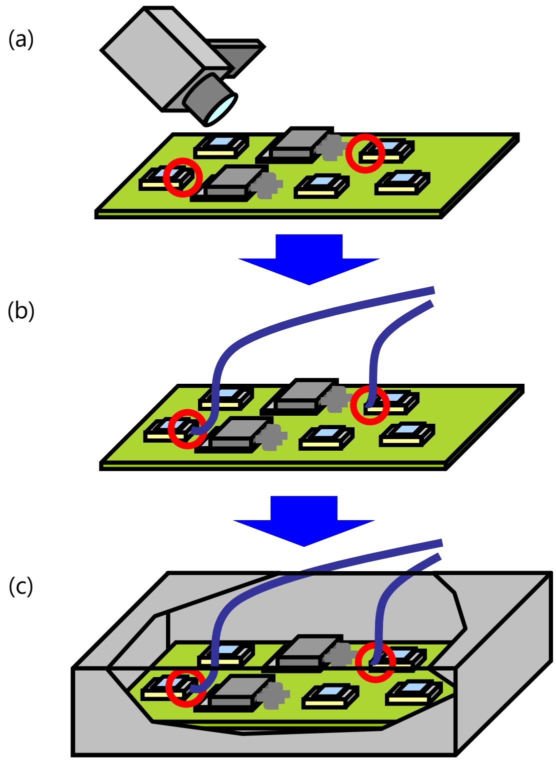


Fig. 2 Procedure for measuring terminal part temperature

By following this procedure, there is no need to measure all of the resistors. In measuring the temperature of a tiny SMD resistor, however, it is necessary to pay attention to the following points:

- If the resolution of thermography is insufficient, the temperature may be measured markedly lower than the actual value.
- If the material or diameter of thermocouple is inadequate, the terminal part temperature may be measured lower than the actual value.

Details of precautions in measuring the terminal part temperature are shown in our other Technical Note.

1.2 Temperature estimation by simulation

Use of simulation is recommended to estimate the terminal part temperature when an operable PWB is not available. However, the temperature estimated with the simulation is an approximate value, so it is required to measure the actual terminal part temperature of an SMD resistor using a thermocouple whenever the PWB becomes available. Note that even a minor change in design may cause significant change in temperature.

§2 Power derating based on the terminal part temperature

2.1 Demonstration of Downsizing and reducing the number of SMD resistors

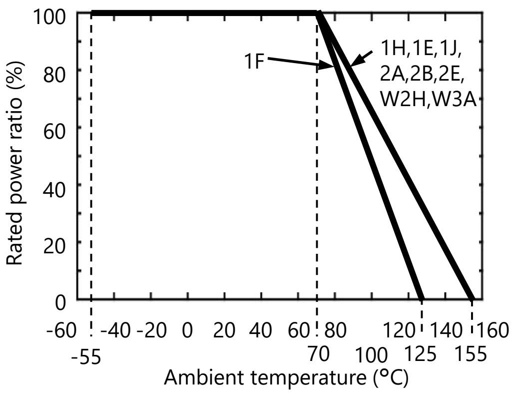
The following shows the conditions for design:

(1) Product series	:	RK73B series
(2) Ambient temperature of PWB	:	100 °C
(3) Measured terminal part temperature of flat chip resistor	:	120 °C
(4) Applied power	:	0.05 W
(5) Design margin	:	50% (*1)

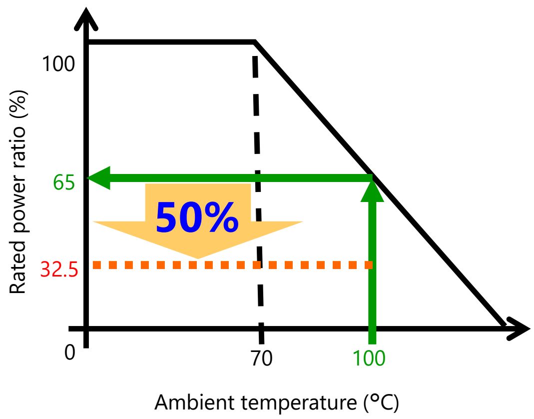
*1: An example of a typical design margin set by company rules of a customer

Demonstrating first is the conventional procedure used in selecting resistors. When employing a derating curve based on the ambient temperature, grasp the ambient temperature by measuring one or several points in the ambience of the PWB and find the rated power ratio from the derating curve. Then you multiply it by the design margin to obtain the derating ratio. Following this, necessary rated power is determined from the derating ratio and applied power. Finally an SMD resistor which satisfies the rated power is selected. Figure 3 shows the result of selection by this procedure.

I. Rated power ratio at the ambient temperature	:	65% (Fig. 3(b))
II. Rated power ratio multiplied by design margin	:	32.5% (65% × 0.5)
III. Applied power divided by II.	:	0.154 W (0.05 W ÷ 0.325)
IV. Required resistor	:	<u>One piece of 0805size (rated power of 0.25 W)</u> or <u>Two pieces of 0402size (rated power of 0.1 W)</u>



(a) Derating curve based on the ambient temperature (RK73B)



(b) Procedure based on the ambient temperature

Fig. 3 SMD resistor selection based on the ambient temperature

Procedure for power derating based on terminal part temperature

Demonstrating next, the selection procedure of SMD resistors based on the terminal part temperature. First, determine the rated power ratio from the derating curve based on the terminal part temperature.
Then multiply it by the design margin to obtain the derating ratio. Following this, necessary rated power is determined from the derating ratio and applied power. Finally an adequate SMD resistor is selected.
Figure 4 shows the result of selection by this procedure. Introducing the design based on the terminal part temperature contributes significantly to downsizing, reducing the number and space of SMD resistors (Fig. 5).

V. Rated power ratio at terminal part temperature	: 100% (Fig. 4(b))
VI. Rated power ratio multiplied by design margin	: 50% (100% × 0.5)
VII. Applied power divided by VI.	: 0.1 W (0.05 W ÷ 0.5)
VIII. Required resistor	: One piece of 0402 size, rated power of 0.1 W

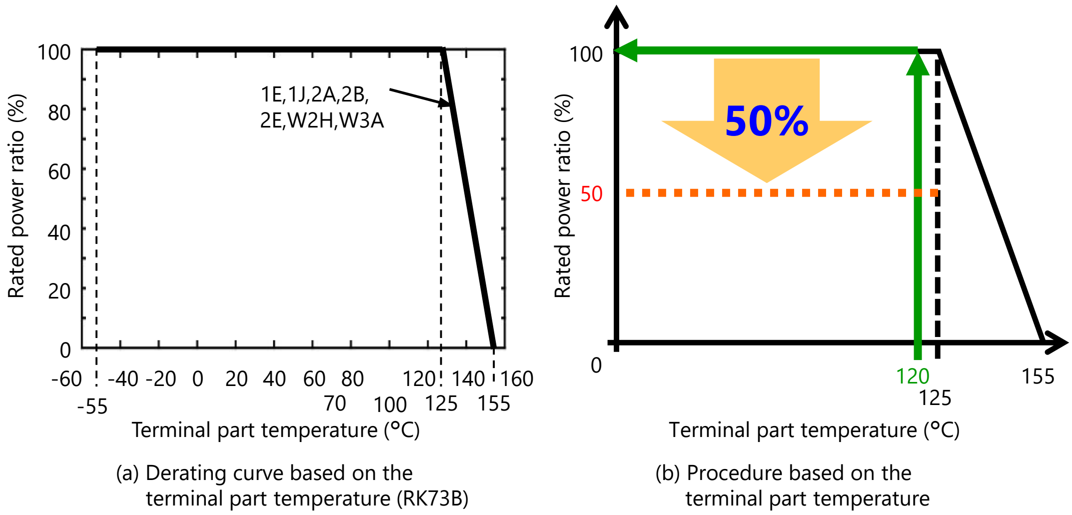


Fig. 4 SMD resistor selection based on the terminal part temperature

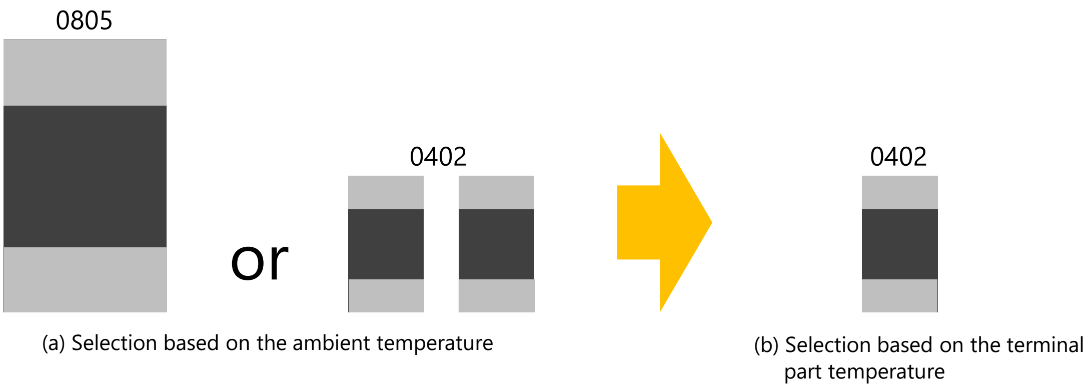


Fig. 5 Downsizing and reducing the number of SMD resistors

2.2 Downsizing by using wide terminal type flat chip resistors

Wide terminal type flat chip resistor (high power) WK73R series can be used at higher power than the general-type flat chip resistors of the same size. However, it is necessary to control the temperature of the terminal part by sufficiently designing heat dissipation of the PWB because of the small size and high power applications of the product. Hence, it is advised to employ the derating curve based on the terminal part temperature (See Table 1 and Fig. 6).

Table 1 Specifications of WK73R (high power) series

Type	Rated power (W)	Size (inch size code)	Rated terminal part temperature (°C)
WK73R2B15	1.5	0612	95
WK73R2H2	2	1020	95
WK73R3A3	3	1225	95

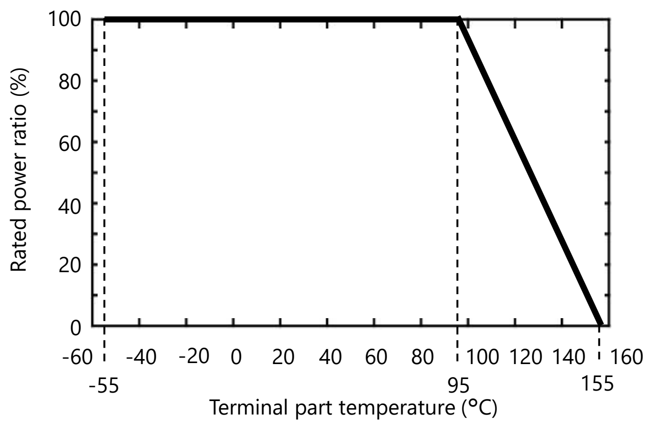


Fig. 6 WK73R series and the derating curve based on the terminal part temperature

When considering the replacement of general-type flat chip resistor RK73BW3A (rated power: 1 W) based on the specifications in Table 1, WK73R2B15 (high power, rated power: 1.5 W) is the candidate, which allows for a significant downsizing (Fig. 7).

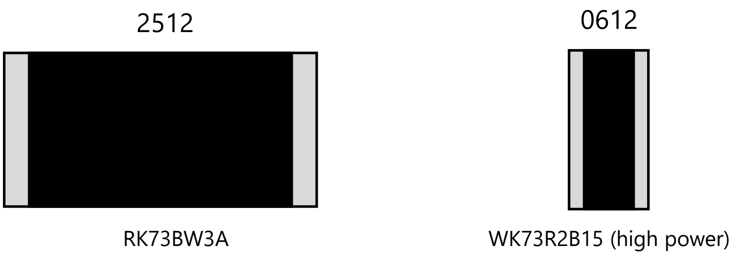


Fig. 7 Size comparison between RK73BW3A and WK73R2B15 (high power)

2.3 Choosing high rated power

Some models of KOA's flat chip resistors have two rated powers in the list of ratings (Table 2).

Table 2 Types featuring two rated powers

Type	Rated power	Rated ambient temperature	Rated terminal part temperature
SG73S 2A SG73P 2A	0.25 W	70 °C	125 °C
	0.5 W	70 °C	100 °C

The higher rated power can only be applied when PWB has high heat dissipation performance. The PWB should be multilayer or ceramic base or metal base. It can also be achieved by properly arranging the copper pattern or by adjusting layout of nearby heat generating components. In addition, the actual terminal part temperature must be controlled below the rated terminal part temperature(*2). In any case, it is recommended to employ the derating curve based on the terminal part temperature for the better use of resistors.

*2: Rated terminal part temperature: maximum terminal part temperature of the SMD resistor at which the power rating may be applied continuously. Includes the temperature rise by self heat generation.

§3 Conclusion

For SMD resistors, the terminal part temperature, which reflects the effect of heat on the resistor accurately, is a suitable reference for power derating. Adopting the power derating based on the terminal part temperature prevents the resistors from being damaged due to excessive temperature rise. It also contributes to downsizing and reducing the number of resistors. It even allows some resistors to be used at higher rated power in KOA spec by enhancing the heat dissipation performance of the PWB.
KOA supports the market with information on the method for measuring terminal part temperature and other services. Feel free to contact us for inquiries.