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TECHNICAL REPORT

Study for the derating curve of surface mount fixed resistors – Derating curves based on terminal part temperature

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STUDY FOR THE DERATING CURVE OF SURFACE MOUNT FIXED RESISTORS –

Derating curves based on terminal part temperature

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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IEC TR 63091, which is a technical report, has been prepared by IEC technical committee 40: Capacitors and resistors for electronic equipment.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
40/2502/DTR	40/2532/RVDTR

Full information on the voting for the approval of this technical report can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

INTRODUCTION

Work began in 2012 to adopt the new derating curve suitable for the surface mount fixed resistors that use the terminal part temperature as the horizontal axis.

The derating curves for surface mount fixed resistors are defined in JIS C 5201-8:2014.

However, the principle of the derating curve was established when the resistors were cylindrically shaped, wired in the air and the heat was dissipated directly from the resistor body into the ambient environment. Therefore, it is not suitable for the surface mount fixed resistors that use the printed circuit boards as the main heat path.

It is necessary to fulfill the demands from the electric and electronic device manufacturers for raising the power ratings safely. Additionally, it is required to establish a new derating curve that is suitable for the surface mount fixed resistors so that they can be used safely in a high temperature environment, typically in automotive electronic devices.

Making a change of the temperature rule for evaluation of the fixed resistors from the ambient temperature to the temperature of the connection point (terminal part temperature of the resistor) will affect many defined contents of multiple standards in the IEC 60115 series. Additionally, it will mean changing the users' evaluation rules, so the impact will be enormous. Therefore, it has been decided to issue the Technical Report first to attract attention of the relevant market players and then, we will start working on changing the defined contents of the IEC 60115 series.

STUDY FOR THE DERATING CURVE OF SURFACE MOUNT FIXED RESISTORS –

Derating curves based on terminal part temperature

1 Scope

This Technical Report is applicable to SMD resistors with sizes equal or smaller than the RR6332M, including the typical rectangular and cylindrical SMD resistors mentioned in IEC 60115-8.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60115-1:2008, *Fixed resistors for use in electronic equipment – Part 1: Generic specification*

IEC 60115-8:2009, *Fixed resistors for use in electronic equipment – Part 8: Sectional specification: Fixed chip resistors*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
terminal part temperature
T_{t}
temperature of terminal part of the resistor

3.2
rated terminal part temperature
terminal part temperature of the resistor at the time of the rated load life test

3.3
hotspot of the resistor
hottest part of the resistor that is caused by the Joule heat generated from the resistive element when the current is applied and is generally located inside resistor's body

3.4
hotspot temperature
T_{hs}
temperature of the internal hotspot of the resistor

3.5
surface hotspot of the resistor
hottest part on the surface of the resistor generally near the hotspot

3.6
surface hotspot temperature
T_{shs}
temperature of the surface hotspot of the resistor

Note 1 to entry: Generally, the internal hotspot temperature is higher than the surface hotspot temperature.

3.7
thermal resistance of the resistor
R_{th}
restraint of the thermal flow from the resistor's hotspot to the environment

Note 1 to entry: Thermal resistance is calculated by dividing the difference between the surface hotspot temperature T_{shs} and the terminal part temperature T_t by the applied power P and usually expressed in K/W.

3.8
thermally sensitive point temperature
T_{sp}
temperature of the part the most sensitive to temperature rise in the resistor

3.9
maximum allowable temperature
MAT
ideal maximum temperature at which the resistor is able to keep its function

3.10
maximum terminal part temperature
MTT
maximum temperature of the terminal part of the resistor

4 Study for the derating curve of surface mount fixed resistors

4.1 General

The electric/electronic device designers are reducing the power applied to the resistor below the level shown in the derating curves provided by the resistor manufacturer based on the ambient temperature of the unloaded resistor, but the ambient temperature of the board rises when they use SMD resistors.

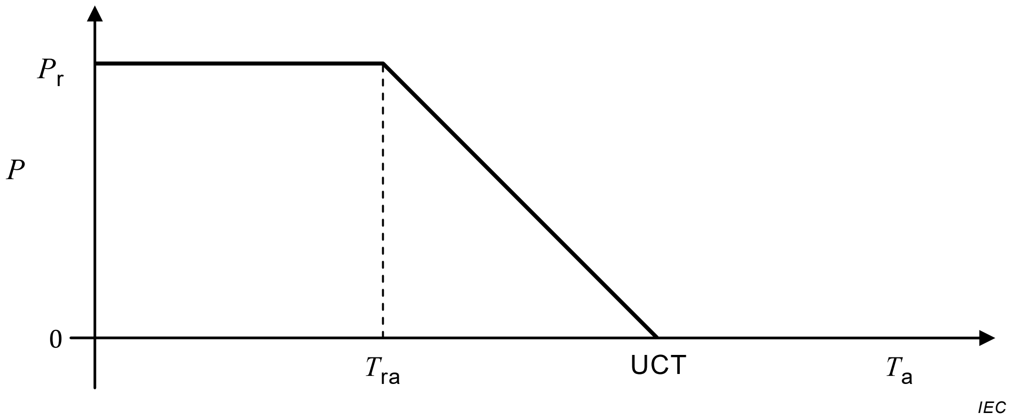
But, the body temperature of the SMD resistor may become higher than the temperature verified in the test implemented by the resistor manufacturer even when this rule is observed. On the other hand, in some cases excessive derating is requested and an extremely large margin is set.

In this Technical Report, the reasons why the derating curves, which are defined in 2.2.4 of IEC 60115-1:2008 and in 2.2.3 of IEC 60115-8:2009, provided by the resistor manufacturers sometimes cannot be used by electric/electronic device designers in their design activity will be given, and the method of changing them into a practical designing tool will be suggested.

There are three key points. The first and most important point is to use the derating curve based on the terminal temperature instead of the ambient temperature. The second point is the measuring method of the terminal part temperature of the SMD mounted on the printed circuit board. The third point is the measuring method of the thermal resistance $R_{th\ shs\text{-}t}$ of the resistor terminal part to the surface hotspot. The second and third points are the issues that need to be defined in association with the first point.

4.2 Using the derating curve based on the terminal part temperature

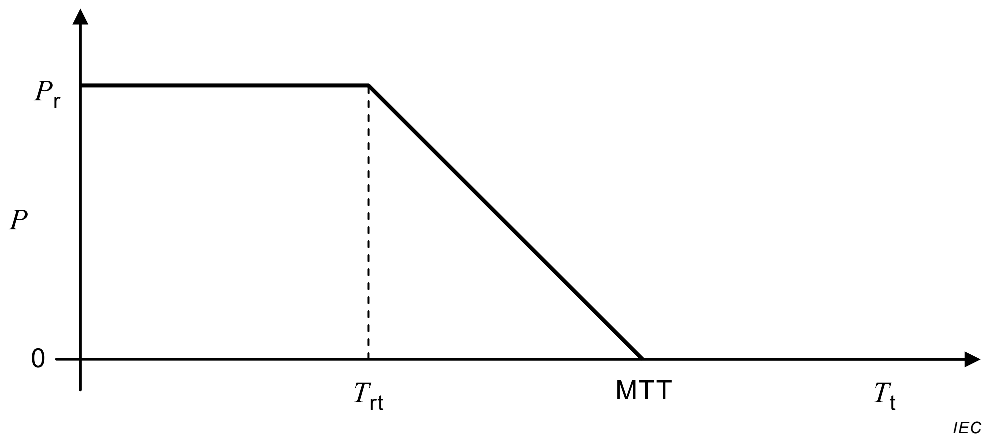
Using Figure 2 instead of Figure 1 is suggested for the design of high-power applications of the SMD resistors in excess of the conventional rated dissipation (e.g. 100 mW for RR1608M). The validity of using the derating curve based on the terminal part temperature is explained in Annex E.



Key

P	Applied power
P_r	Rated power
T_a	Ambient temperature
UCT	Upper category temperature
T_{ra}	Rated ambient temperature

Figure 1 – Existing derating curve based on ambient temperature



Key

P	Applied power
P_r	Rated power
T_t	Terminal part temperature
MTT	Maximum terminal temperature
T_{rt}	Rated terminal temperature

Figure 2 – Suggested derating curve based on terminal temperature

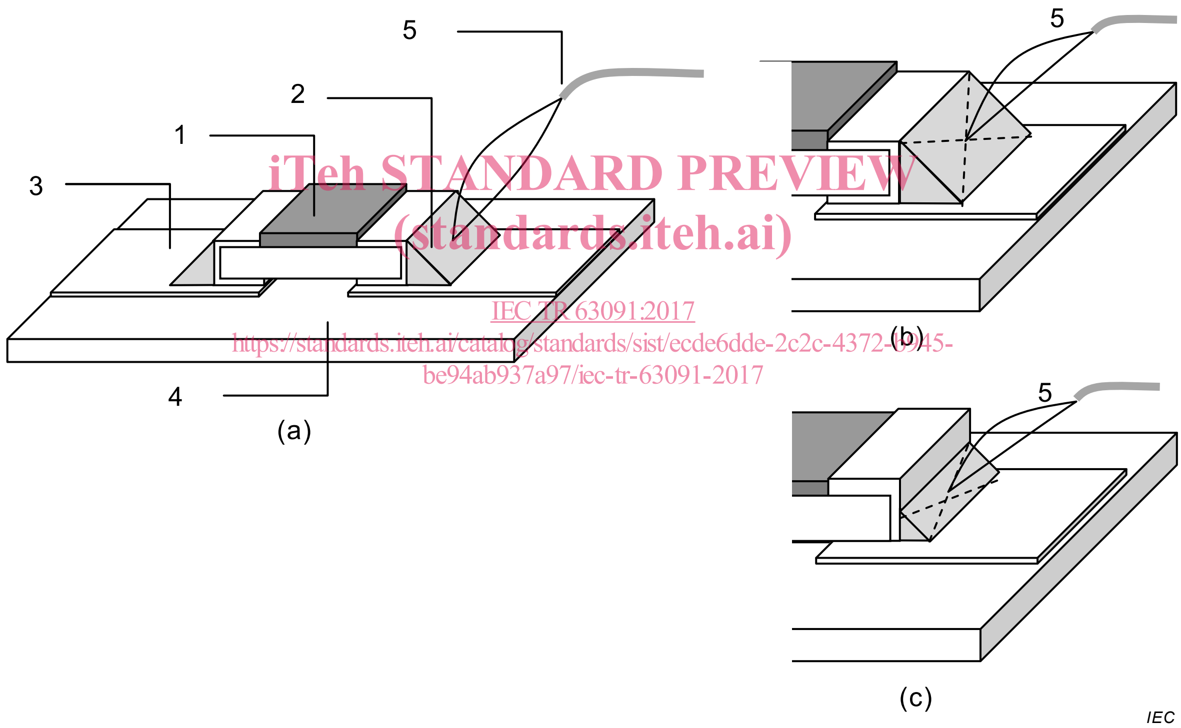
4.3 Measuring method of the terminal part temperature of the SMD resistor

The measurement will be done on the commonly-used printed circuit board, but the resistor manufacturer can replace it with the board defined in the standard. The temperature measurement position will be the centre part of the fillet regardless of the size. The measurement sensor will be the thermocouple. The measurement point is shown in Figure 3.

A type K thermocouple with a wire diameter (single wire) of 0,1 mm is recommended. As in Figure 4, the tips of the type K thermocouple should be spot-welded and pre-treated by applying suitable flux and dipped in melted solder so that it can be surely and directly soldered to the fillet of the target resistor.

This report is based on the use of type K thermocouples due to their low thermal conductivity. If other thermocouples are to be used, their thermal properties need to be considered, as shown for type T thermocouples in Annex I.

The measured value should be corrected as necessary by estimating the influence of the heat dissipation through the thermocouple. The method will be mentioned in Formula (1).



Key

1 Resistor

2 Solder fillet

3 Copper pattern

4 Printed board

5 Thermocouple (Tip is the measuring point)

(b) Attachment position of the thermocouple when fillet is large (centre of solder meniscus)

(c) Attachment position of the thermocouple when fillet is small (centre of solder meniscus)

Figure 3 – Attachment position of the thermocouple when measuring the temperature of the terminal part