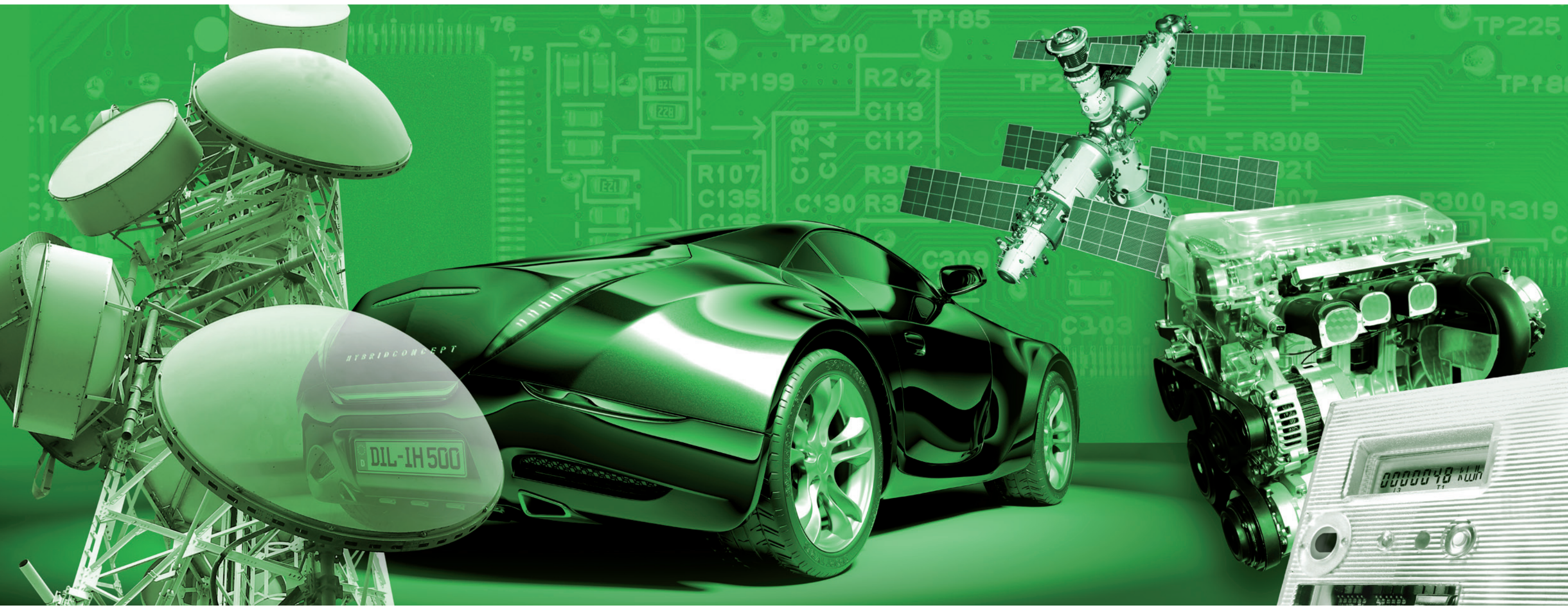

LOW-OHMIC PRECISION AND POWER RESISTORS

APPLICATION NOTE // HEAT DISSIPATION OF VMX POWER RESISTOR

This application note explains the heat dissipation and overall temperature rise of a VMx resistor mounted on a PCB.

When applying current on a shunt resistor, heat will be generated inside the shunt and causes a thermal flow from the hot-spot into the part terminals. This thermal flow (delta T) represents the internal heat resistance of the power resistor and is defined by the **Rthi**.

Rthi = (T1 – T0) / P [K/W]

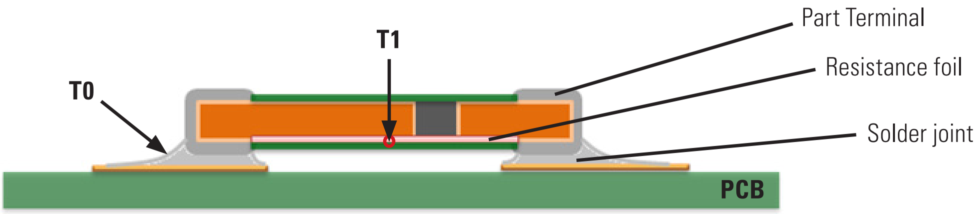

Fig. 1: Cross-section view of an ISA-PLAN resistor type VMS soldered on a PCB

T1 [°C] Temperature of the hot-spot in the center of the resistor on the resistance foil side
T0 [°C] Temperature of the solder joint next to the resistor
P [W] Rated Power of the resistor

The lower the Rthi value, the better the heat dissipation from the hot-spot into the terminals and the higher the power rating of the part.

Please note:
The temperature **T0** is the terminal temperature $\mathbf{T_K}$ and not the environmental or ambient temperature! Please also see also the latest VMS datasheet on our homepage.

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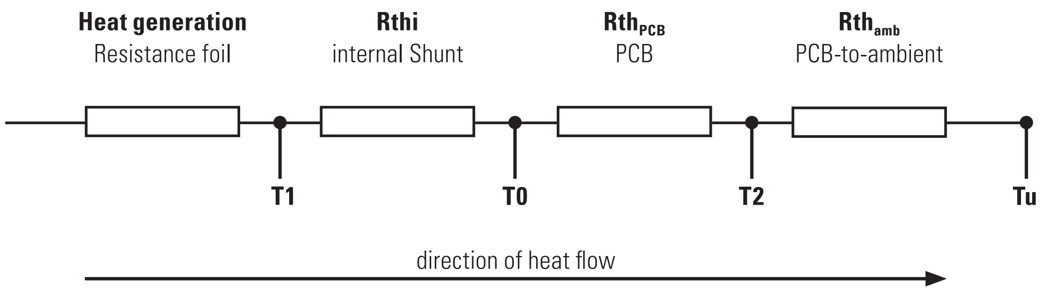
HEAT FLOW

In the actual application the heat is conducted to the termination (solder joint) of the part and from there into the PCB. This heat flow causes a temperature rise due to the limited heat conduction within the PC-board (mainly given by the length, width and thickness of the copper tracks) and expressed with **Rth_{PCB}**.

Finally the heat leaves the PC-board via convection or radiation to the environment which again is expressed in a third heat resistance **Rth_{amb} (PCB-to-ambient)**.

Direction of the heat flow



All heat resistance components are linked in series as shown and the single temperature differences can be calculated as follows:

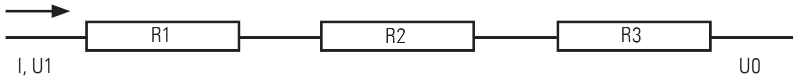
T1 – T0 = Rthi * P **T0 – T2 = RthPCB * P** **T2 – Tu = RthPCB_ambient * P**

The overall temperature rise of the resistor hot spot **T1** relating to the ambient temperature **Tu** is the sum of all these temperature differences:

T1 – Tu = (Rthi + RthPCB + RthPCB_ambient) * P

The situation is analogous to the series connection of electrical resistors if you replace the heat resisitance by the electrical resisitance, the temperature **T** by the voltage **U** and the power **P** (heat current) by the electrical **I**.

The equivalent electrical circuit diagram is represented as follows:



U1 – U0 = (R1 + R2 + R3) * I

INTERNAL HEAT RESISTANCE OF VMX-PART IN PRACTICE

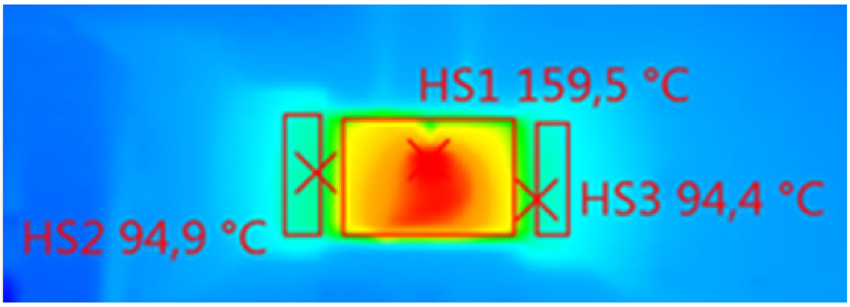
From the IR-picture it can be seen that the VMS resistor has a pretty uniform temperature distribution and the main temperature gradient is outside on the PC-board. This illustrates the fact that the dominant heat resisitance is the $\mathbf{Rth_{PCB}}$ of the PC-board.

Fig. 2: ISA-PLAN® resistor type VMS with R020 soldered on a PCB upside down with visible trimming cut above

Note: In order to detect the heating up of the resistance material via IR camera, the component was mounted in reverse on the PCB for testing purposes. See Fig.2.

The actual mounting direction is the other way around where the V-shape is on top and the resistance material faces the PCB. See basic construction of the part in Fig.1.

Fig. 3: IR-picture of ISA-PLAN® resistor type VMS with R020 soldered onto a PCB with rated power of 3 Watts



Calculation of the Rthi based on the IR-picture:

Rthi = (T1 – T0) / P [K/W] = (159.5°C – 94.4°C) / 3W = 21.7 K/W

Rthi according to data sheet: <25 K/W

Note: Please be aware that the above description is simplified and does not consider the dynamic behavior nor the heat resistance of the solder joint itself.

But it clearly shows the importance of a proper and void-free solder joint of low-ohmic power resistors.
This ensures a lossless current flow throughout the shunt and an ideal heat dissipation via the terminals into the PCB.

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