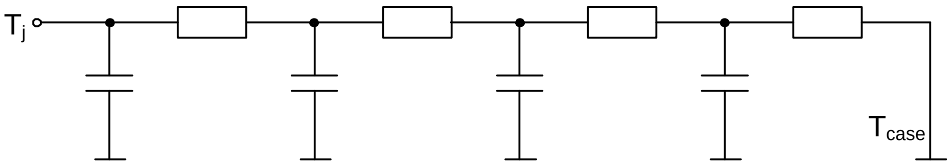
Thermal Impedance Models

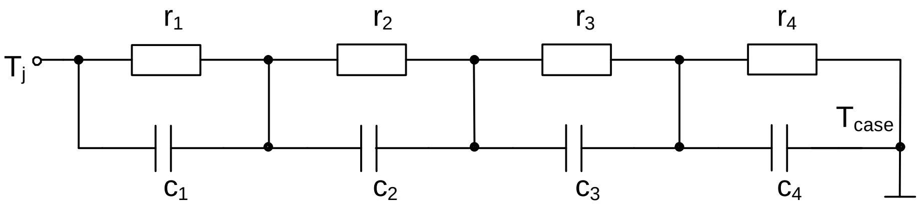
The thermal behavior of semiconductors can be described by two different models:

Continued fraction model



The above shown model reflects the physical layer structure of a semiconductor – thermal capacitances with thermal resistances in between. The RC-elements are unambiguously assigned to the layer structure of the module (chip, solder, substrate, baseplate).

Partial fraction model



The separate RC-elements in this representation have no physical meaning. Their values are extracted from the measured heating-up curve of the module by a corresponding analysis tool.

The data sheets show these partial fraction coefficients ($\tau_n = r_n c_n$) in tabular form. The thermal impedance curve is given as diagramm Z(t) e.g:

i		1	2	3	4
r_i [K/kW]	: IGBT	1,56	4,25	1,26	1,44
τ_i [sec]	: IGBT	0,0068	0,0642	0,3209	2,0212
r_i [K/kW]	: Diode	3,11	8,49	2,52	2,88
τ_i [sec]	: Diode	0,0068	0,0642	0,3209	2,0212

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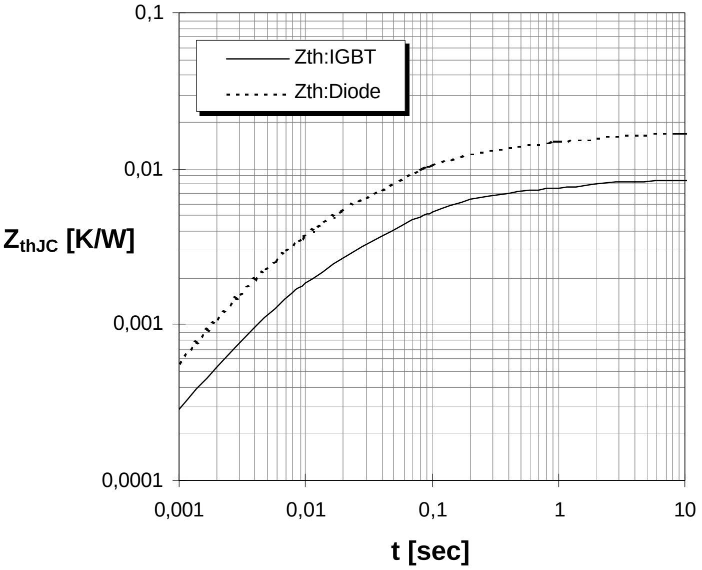
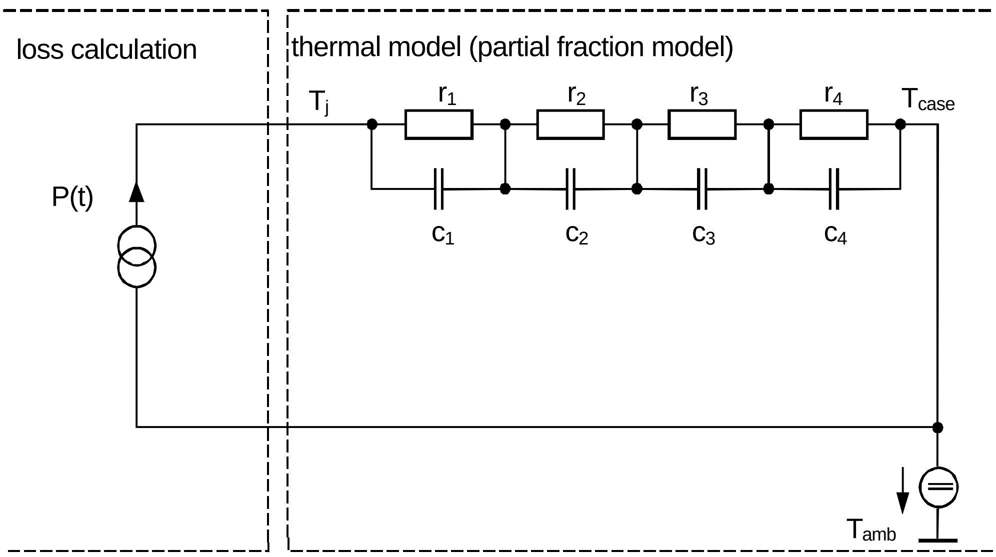
THERMAL IMPEDANCE MODELS



$$Z_{\text{thjc}}(t) = \sum_{i=1}^{n} R_{\text{thjc,i}} \times (1 - \mathrm{e}^{-\frac{t}{t_i}})$$

Considering the switching and conducting losses and the modeling of the heat-sink the junction temperature T_j can be calculated according to the following sketch:



$$T_j(t) = P(t) * Z_{thjc}(t) + T_{case} = P(t) * \sum_{i=1}^{n} R_i (1 - e^{-\frac{t}{t_i}}) + T_{case}$$

THERMAL IMPEDANCE MODELS

If a heat sink should be considered in the calculation, models of both IGBT and heat sink have to be linked together by applying their continued fraction models.