ThermalBlockRC thermalblockrc

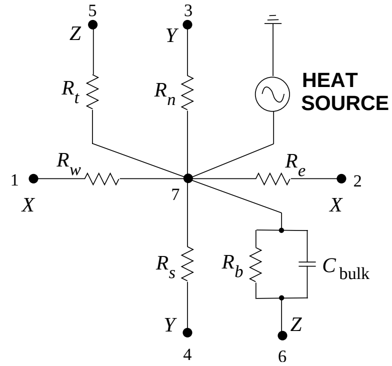

Figure 1: Schematic of the thermal macromodel.

Freeda Form: `thermalblockrc`:⟨`instance name`⟩ ⟨ n_1 n_2 n_3 n_4 n_5 n_6 n_7⟩ ⟨`parameter list`⟩

n_1 `is terminal 3 in Figure 1`
n_2 `is terminal 4 in Figure 1`
n_3 `is terminal 1 in Figure 1`
n_4 `is terminal 2 in Figure 1`
n_5 `is terminal 5 in Figure 1`
n_6 `is terminal 6 in Figure 1`
n_7 `is terminal 7 in Figure 1`

Example:

```
ThermalBlockRC:b100 1001 2 1003 4 1005 6 1007 dn= 2.1406 ds= 0.0000 de= 2.3902
+dw= 0.0000 dt= 0.0000 db= 0.0000 kmx = 146 kmy = 146 kmz = 170 kild = 1.1
+kbulk = 1.1 dfactor=vdf lx=246.7u ly=261.915u habove= 0.4u hbelow = 6.24u
+rho = 2300 cbulk = 710
```

Model Parameters:

Name	Description	Units	Default
dn	Density of metal in the North direction	metal/m2	0
ds	Density of metal in the South direction	metal/m2	0
de	Density of metal in the East direction	metal/m2	0
dw	Density of metal in the West direction	metal/m2	0
dt	Density of metal in the Top direction	metal/m2	0
db	Density of metal in the Bottom direction	metal/m2	0
kmx	Thermal conductivity of metal in direction x	W/m.K	0
kmy	Thermal conductivity of metal in direction y	W/m.K	0
kmz	Thermal conductivity of metal in direction z	W/m.K	0
kild	Thermal conductivity of active layer dielectric	W/m.K	0
kbulk	Thermal conductivity of bulk material	W/m.K	0
lx	Length of block(metal) in X direction	m	0.0
ly	Length of block(metal) in Y direction	m	0.0
habove	Height of tier above the Silicon island in Z direction	m	0.0
hbelow	Height of tier below the Silicon island in Z direction	m	0.0
dmx	Distance between metal in X direction	m	0.0
dmy	Distance between metal in Y direction	m	0.0
rho	Density of bulk material	kg/m3	0.00
cbulk	Heat capacity of bulk material	J/kg.K	0.0
dfactor	Vertical Metal density factor		0

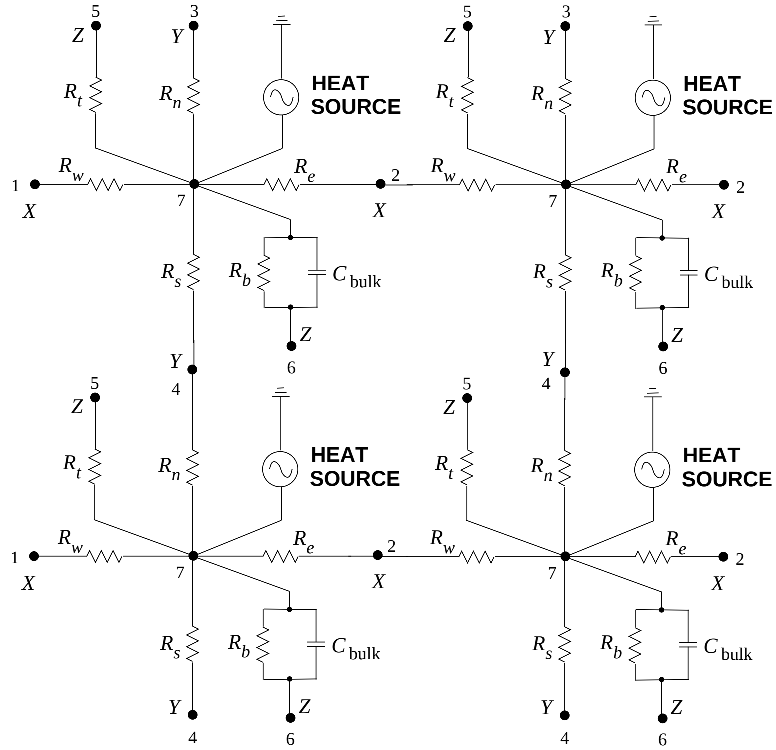

Figure 2: Schematic of 4 horizontally adjacent grid blocks in the X-Y direction of a layer.

Standard Calculations

Calculation of cross-sectional areas from % density numbers:

$$A_{N-metal} = \frac{m\rho_N}{100} * l_y * (h_{above} + h_{below}) \tag{1}$$

$$A_{N-die} = \frac{100 - m\rho_N}{100} * l_y * (h_{above} + h_{below}) \tag{2}$$

$$A_{S-metal} = \frac{m\rho_S}{100} * l_x * (h_{above} + h_{below}) \tag{3}$$

$$A_{S-die} = \frac{100 - m\rho_S}{100} * l_x * (h_{above} + h_{below}) \tag{4}$$

$$A_{E-metal} = \frac{m\rho_E}{100} * l_x * (h_{above} + h_{below}) \tag{5}$$

$$A_{E-die} = \frac{100 - m\rho_E}{100} * l_x * (h_{above} + h_{below}) \tag{6}$$

$$A_{W-metal} = \frac{m\rho_W}{100} * l_x * (h_{above} + h_{below}) \tag{7}$$

$$A_{W-die} = \frac{100 - m\rho_W}{100} * l_x * (h_{above} + h_{below}) \tag{8}$$

$$A_{top-metal} = \frac{m\rho_{top}}{100} * l_x * l_y \tag{9}$$

$$A_{top-die} = \frac{100 - m\rho_{top}}{100} * l_x * l_y \tag{10}$$

$$A_{bottom-metal} = \frac{m\rho_{bottom}}{100} * l_x * l_y \tag{11}$$

$$A_{bottom-die} = \frac{100 - m\rho_{bottom}}{100} * l_x * l_y \tag{12}$$

Calculation of metal and die resistances:

$$R_{N-metal} = \frac{l_x}{2 * k_{mx} * A_{N-metal}} \tag{13}$$

$$R_{N-die} = \frac{l_x}{2 * k_{bulk} * A_{N-die}} \tag{14}$$

$$R_{S-metal} = \frac{l_x}{2 * k_{mx} * A_{S-metal}} \tag{15}$$

$$R_{S-die} = \frac{l_x}{2 * k_{bulk} * A_{S-die}} \tag{16}$$

$$R_{E-metal} = \frac{l_y}{2 * k_{my} * A_{E-metal}} \tag{17}$$

$$R_{E-die} = \frac{l_y}{2 * k_{bulk} * A_{E-die}} \tag{18}$$

$$R_{W-metal} = \frac{l_y}{2 * k_{my} * A_{W-metal}} \tag{19}$$

$$R_{W-die} = \frac{l_y}{2 * k_{bulk} * A_{W-die}} \tag{20}$$

$$R_{top-metal} = \frac{h_{above}}{2 * k_{mz} * A_{top-metal}} \tag{21}$$

$$R_{top-die} = \frac{h_{above}}{2 * k_{bulk} * A_{top-die}} \tag{22}$$

$$R_{below-metal} = \frac{h_{below}}{2 * k_{mz} * A_{below-metal}} \tag{23}$$

$$R_{below-die} = \frac{h_{below}}{2 * k_{ild} * A_{below-die}} \tag{24}$$

Total Thermal Resistance: If the cross-sectional area of metal is zero, the resistance is the same as the die resistance. If not the resistance is calculated as the parallel combination of the metal and die resistances in direction d:

$$R_d = \frac{R_{d-metal} * R_{d-die}}{R_{d-metal} + R_{d-die}} \tag{25}$$

Effective Thermal Conductivities:

$$k_{effx} = \frac{l_x/(R_N + R_S)}{l_y * (h_{above} + h_{below})} \tag{26}$$

$$k_{effy} = \frac{l_y/(R_E + R_W)}{l_a * (h_{above} + h_{below})} \tag{27}$$

$$k_{effz} = \frac{(h_{above} + h_{below})/(R_{top} + R_{bottom})}{l_x * l_y} \tag{28}$$

Thermal Capacitance:

$$C_{bulk} = \rho * c * l_x * l_y * h_{above} + h_{below} \tag{29}$$

Version:

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Credits:

Name	Affiliation	Date	
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