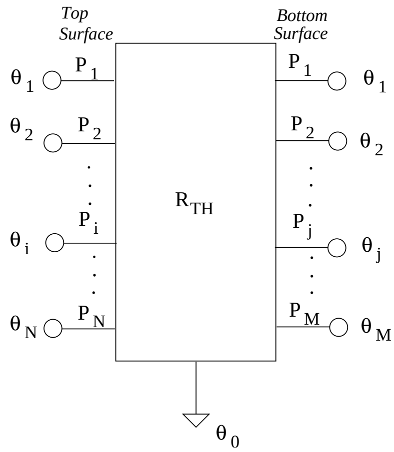

Figure 1: Vertically matched Thermal N-port generated directly from analytical solution of the heat diffusion equation, and represented by thermal impedance matrix, $R_{TH_{ij}}(s)$ with varying temperatures at the top and bottom surface.

*f*REEDA™*Form:* `thermalblock:`⟨instance name⟩ ⟨ `power generating device terminals, top surface discretization terminals, top terminals for patch1, top terminals for patch2, bottom surface discretization terminals, bottom terminals for patch1, bottom terminals for patch2, thermal ground`⟩ ⟨`parameter list`⟩

Example:

```
thermalblock:test1 1 2 3 4 5 101 102 103 104 105 106 107 108 109 110 111 112 113 114 +115 116
117 201 202 203 204 205 206 207 +208 209 210 211 212 213 214 215 216 217 1002
+Ntimesteps=nsteps dt=deltat Tambient=temp time_d=1 msubstrate=3 read_input=0
+filename="Die_Rth.dat" l=1624e-6 w=1470e-6 d=100e-6 rho=5320 c=350 ks=46 xi=0 ndevices=5
+mmax=50 nmax=50 ppatch=2
```

Model Parameters:

Name	Description	Units	Default
ntimesteps	Number of time steps in transient simulation		0
dt	Length of timestep	s	0.0
tambient	Ambient Temperature	K	300.0
time_d	Flag if true calculate in the time domain.		False
read_input	Flag read_input thermal resistance matrices from file.		False
l	Substrate x-dimension.	m	0.05
w	Substrate y-dimension.	m	0.05
d	Substrate z-dimension.	m	0.0016
Ks	Thermal conductivity	W/m.K	0.294
rho	Density	(kg.m-3)	1900
C	Specific heat	J/kg.K	1150
xi	Adjustment for T**4 non linearity		1.3
eta	Adjustment for natural convection		3.0
epsilon	Emissivity		0.7
narray	Order of NxN grid array		4
ndevices	Number of heat dissipating devices		16
msubstrate	Order of MxM substrate surface discretisation		3
b	Exponent of temperature dependence of thermal conductivity		0.0
nmax	Maximum number of basis states in X direction		100
mmax	Maximum number of basis states in Y direction		100
filename	Filename to read the Rth from		
ppatch	Order of MxM patch surface discretisation		0
ofilename	Filename to write the temperature to		

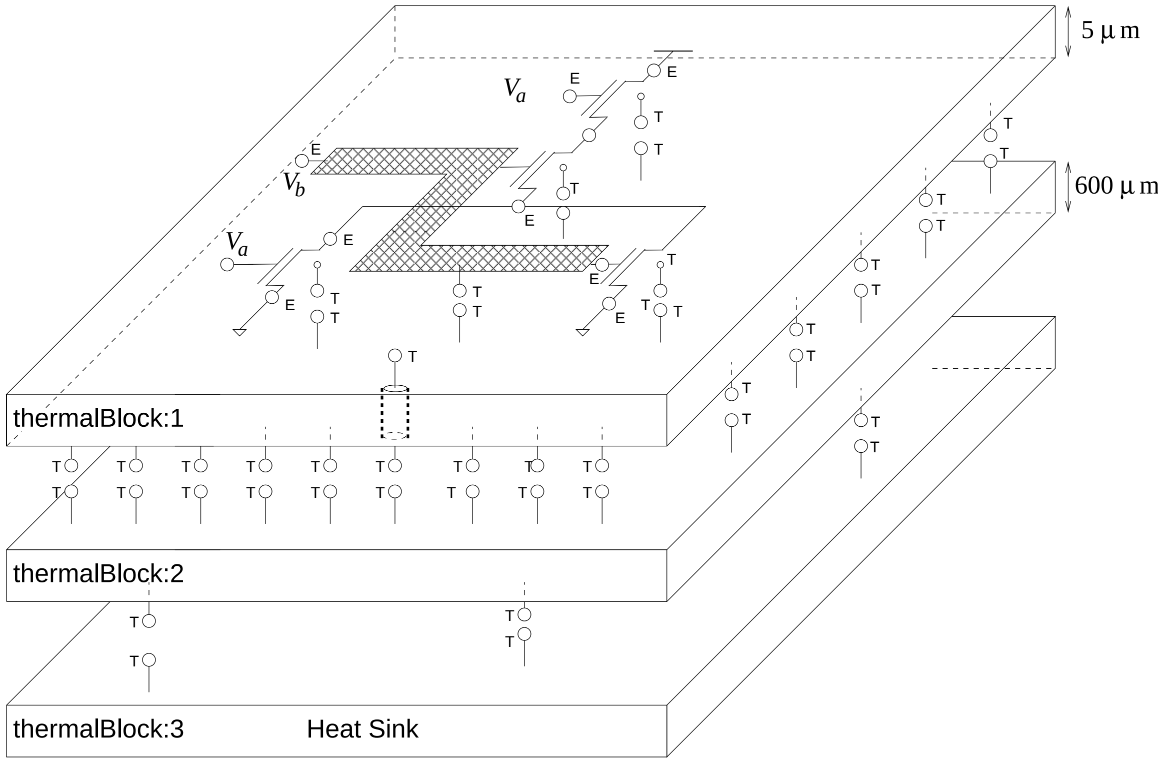

Figure 2: Connecting multiple thermal Nport elements.

Standard Calculations

$$R^{00}_{TH_{ii'}} = \frac{1}{\kappa_s LW} \sum_{mn} \frac{4\coth\gamma_{mn}D}{(1+\delta_{m0})(1+\delta_{n0})\gamma_{mn}} \frac{I^{0i}_{mn}}{I^{0i}_{00}} \frac{I^{0i'}_{mn}}{I^{0j}_{00}} \tag{1}$$

$$R^{0D}_{TH_{ij}} = \frac{1}{\kappa_s LW} \sum_{mn} \frac{-4cosech\gamma_{mn}D}{(1+\delta_{m0})(1+\delta_{n0})\gamma_{mn}} \frac{I^{0i}_{mn}}{I^{0i}_{00}} \frac{I^{Dj}_{mn}}{I^{Dj}_{00}} \tag{2}$$

$$R^{D0}_{TH_{ji}} = \frac{1}{\kappa_s LW} \sum_{mn} \frac{4cosech\gamma_{mn}D}{(1+\delta_{m0})(1+\delta_{n0})\gamma_{mn}} \frac{I^{Dj}_{mn}}{I^{Dj}_{00}} \frac{I^{0i}_{mn}}{I^{0i}_{00}} \tag{3}$$

$$R^{DD}_{TH_{jj'}} = \frac{1}{\kappa_s LW} \sum_{mn} \frac{-4\coth\gamma_{mn}D}{(1+\delta_{m0})(1+\delta_{n0})\gamma_{mn}} \frac{I^{Dj}_{mn}}{I^{Dj}_{00}} \frac{I^{Dj'}_{mn}}{I^{Dj'}_{00}} \tag{4}$$

Bugs:

Frequency domain model not implemented.

Number of patches hardwired as 2.

Position of the power generating devices fixed.

Version:
2006.05.01

Credits:

Name	Affiliation	Date
Sonali Luniya	North Carolina State University	May 2006
William Batty	Filtronic Compound Semiconductors, UK	May 2006
Carlos Christoffersen	Lakehead University, Canada	May 2006

Publications:

1. Sonali Luniya, William Batty, Vincent Caccamesi, Mikael Garcia, Carlos Christoffersen, Samson Melamed, W. Rhett Davis, and Michael Steer, ‘‘Compact Electrothermal Modeling of an X-band MMIC,’’ *2006 IEEE International Microwave Symposium*, June 11 2006.