Resistive Thermal Via viart

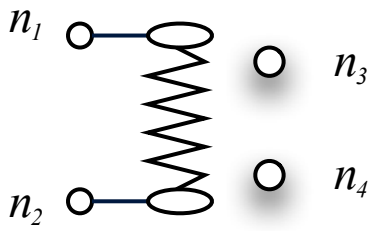

Figure 1: viart — Resistive electro-thermal via element.

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Description:
This element implements a via as an electro-thermal resistance.

Form: `viart:`⟨`instance name`⟩ n_1 n_2 n_3 n_4 ⟨`parameter list`⟩
instance name is the model name,
n_1, n_2, n_3 and n_4 are the element terminals,
n_1 and n_2 are element electrical terminals,
n_3 and n_4 are element thermal terminals,
n_2 is the element local reference node,
n_4 is the element thermal reference node.

Parameters:

Parameter	Type	Default value	Required?
d: Diameter of via (m)	DOUBLE	1 μm	no
h: Height of via (m)	DOUBLE	n/a	yes
tm: Thickness of metal layer (m)	DOUBLE	0.3 μm	no
rho: Resistivity of metal ($\Omega - m$)	DOUBLE	n/a	no
metal: Metal (Silver, Copper, Gold, Aluminum)	STRING	copper	no
t: System temperature (^0C)	DOUBLE	20	no
tnom: Initial system temperature (^0C)	DOUBLE	20	no
tc: Temperature coefficient ($1/^0C$)	DOUBLE	0	no
pdr: Thermal element flag	BOOLEAN	false	no

Example:

```
viart: vrt1 2 0 3 "tref"  l = 20u  metal = "copper"
```

Details:
The resistive thermal via is modeled as resistive only, the metal via is made by a kind of metal, which includes silver, copper, gold, and aluminum that are predefined in the model.

This is an electro-thermal element is modeled differently depending on the setting of the Parameter `pdr`.

`pdr` = false/true.

When `pdr` is false (the default) the resistance of via is calculated as a resistor by giving height and resistivity or metal selection.
When `pdr` is true, the resistance of via is modeled as electro-thermal resistor by giving height, resistivity or metal selection, and system temperature. The diameter and thickness of metal sheet are predefined in the model. Resistance calculation is based on the electrical parameters and system temperature. The power dissipation and heat flux are modeled with thermal terminals.

Resistance of the via:

$$A = \frac{\pi}{4} \cdot (D_{outer}^2 - D_{inner}^2), \quad R = \frac{\rho \cdot h}{A}$$

Electro-thermal resistance of the via with temperature coefficient:

$$R = \frac{\rho \cdot h}{A} \cdot [1 + \beta \cdot (t - t_0)]$$

```
viart: vrt1 2 0 3 "tref" h = 1u  metal = "copper"
```

Here terminals '0' and 'tref' are the local reference terminals of the element. Terminal '0' is the global ground. Terminal 'tref' is a thermal local reference terminal of the element. An example netlist is:

```
.ref "tref"
.ref 0

vsource 1 0 vac = 1 f = 5GHz
res:r1 1 2 r=50
vrt:vrt1 2 0 1000 "tref" l = 1m metal = "copper" pdr=1
```

References:

1. Houssam S.Kanj. fREEDA element ResistorT, "*elements\r\ResistorT*".
2. Tony Mulder, Travis Lentz. fREEDA element CmosInvT, "*elements\c\CmosInvT*"

Example of Transient Analysis (.TRAN2) Fixed times steps, time-stepping nonlinear analysis.
netlist file: viart.net:

```
*** Transient ViaRT test

*** Transient Analysis
.tran2 tstop=4e-6 tstep=10e-9 out_steps=5
```

```
.options InitTmp=300

.ref "tref"
.ref 0

*** Sources
vpulse:Vp 1 0 v1=1 v2=2 per=2e-6 pw=1e-6 tr=0.05e-6 tf=0.05e-6

*** Network
resistor:rs 1 2 r=50
viart:vrt1 2 0 1000 "tref" h=1e-6 metal="copper" pdr=1

*** Thermal network
resistor:rt1 1000 1001 r=6e3
vsource:vt1 1001 "tref" vdc=InitTmp
capacitor:ct1 1000 1001 c=1e-12

*** Transient Output
.options gnuplot
.out plot term 2 vt element "viart:vrt1" 0 it div in "trans_res.out"
.out plot element "viart:vrt1" 1 ut in "trans_temp.out"

.end
```

The output log file is

```
**********  fREEDA 1.3 running on Tue Apr 29 14:00:12 2008  **********

**  Environment variables: **
FREEDA_HOME = /mbs/freeda
FREEDA_LIBRARY = /mbs/freeda/library
FREEDA_PROJECTS = /mbs/freeda/projects
FREEDA_PATH = /mbs/freeda/freeda-1.3
FREEDA_BIN = /mbs/freeda/freeda-1.3/bin
FREEDA_SIMULATOR = /mbs/freeda/freeda-1.3/simulator
FREEDA_ELEMENTS = /mbs/freeda/freeda-1.3/simulator/elements
FREEDA_DOCUMENTATION = /mbs/freeda/doc
FREEDA_WEB_DOCUMENTATION = /mbs/freeda/doc
FREEDA_BROWSER = cygstart

*** Transient ViaRT test

*** Transient ViaRT test

*** Transient Analysis
.tran2 tstop=4e-6 tstep=10e-9 out_steps=5

.options inittmp=300

.ref "tref"
.ref 0
```

```
*** Sources
vpulse:vp 1 0 v1=1 v2=2 per=2e-6 pw=1e-6 tr=0.05e-6 tf=0.05e-6

*** Network
resistor:rs 1 2 r=50
viart:vrt1 2 0 1000 "tref" h=1e-6 metal="copper" pdr=1
viart:vrt1 2 0 1000 "tref" h=1e-6 metal="copper" pdr=1
                                                    ^

  Parse Error near line 17
  Element type viart does not exist.
```

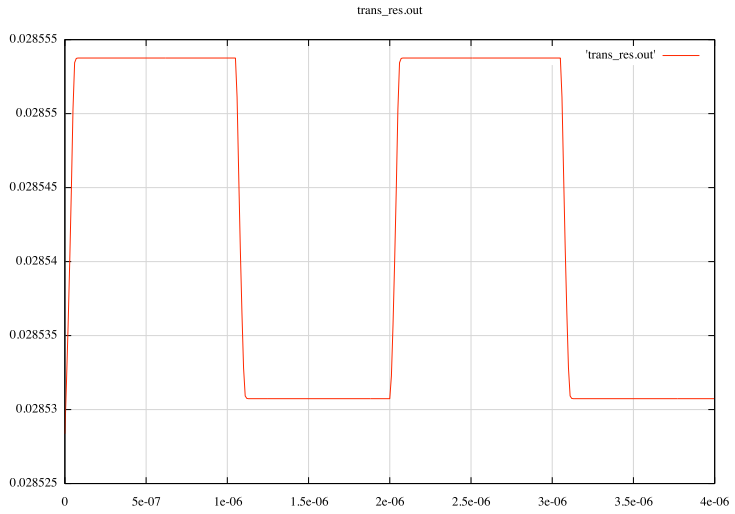

Figure 2: Transient Analysis - Resistance variation of thermal via

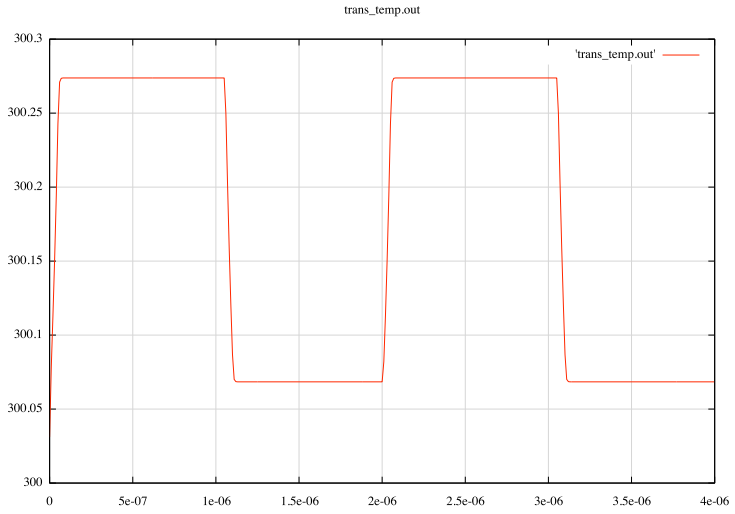

Figure 3: Transient Analysis - Temperature variation of via

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Credits:

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