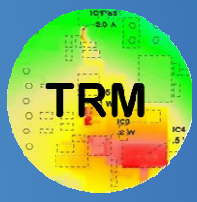
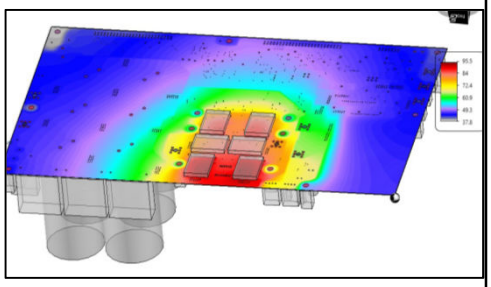
ADAM Research

THERMAL RISK MANAGEMENT IN ELECTRONICS



Passion
Knowledge
Precision

TRM



Your Software for Thermal Analysis of
Printed Circuit Boards and Assemblies

Components and currents heat up the circuit board — but how hot does it get?

Are the temperature limits being observed?

Do you think to take a look at the data sheet or an Appnote is enough? ...

... Never!

No data sheet in the world can tell you the temperature for your circuit board and layout!

Why you should read this brochure?

You want to see heat, understand and improve.

You are an electrical engineer and are afraid of using finite element software and meshing.

You have no time to loose for prototyping.

You cannot delegate without extra work.

You want to delegate, but not wait forever.

You want to get started easily with defaults.

You want some expert features.

You want a fair price that includes support.

Components >
Current >
Time dependent >
Technology >
Inductance >
Voltage drop >
Special setups >
User >
CAD Import >
Features >
Contact >

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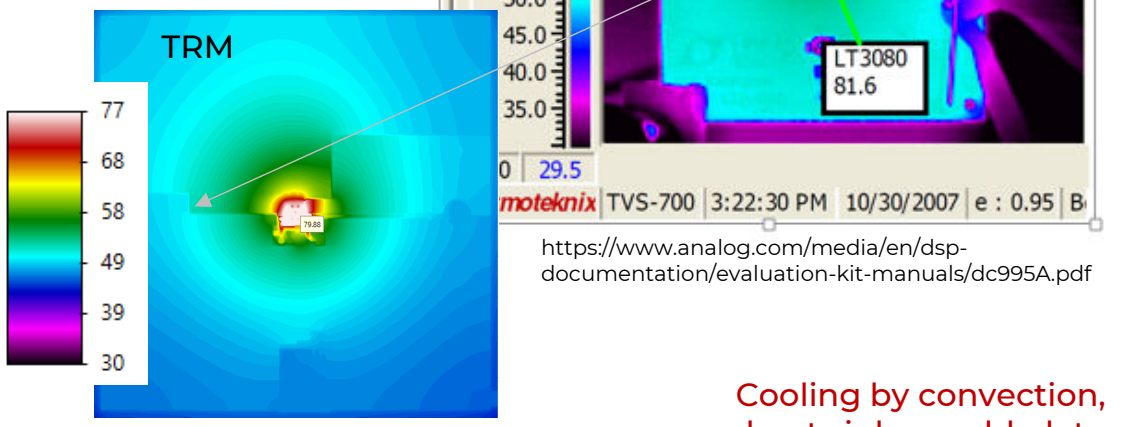
> Components

TRM is calculating 3D heat spreading in the entire volume of the PCB.

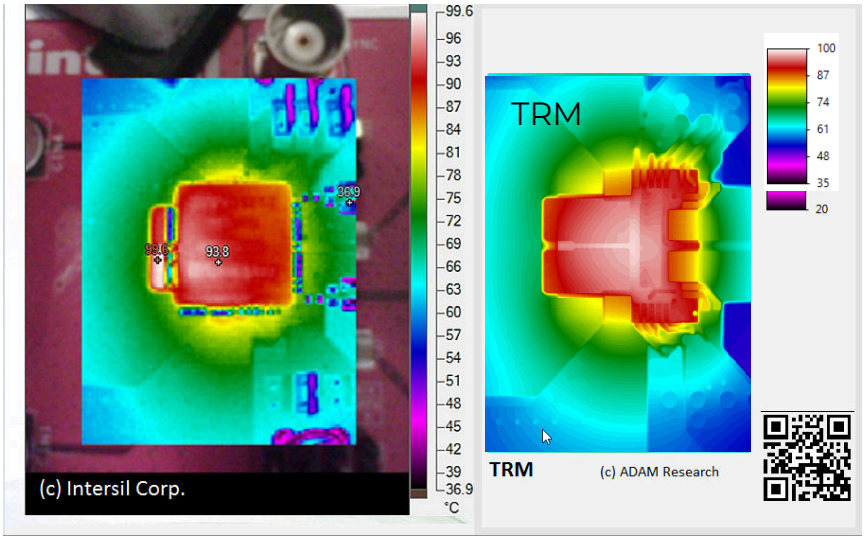
All layers, all prepregs, all via.

Consistent with measurement - without CAD model of the component.



https://www.analog.com/media/en/dsp-documentation/evaluation-kit-manuals/dc995A.pdf

Cooling by convection, heat sink or cold plate



http://www.intersil.com/content/dam/Intersil/documents/an19/an1922.pdf
https://www.adam-research.de/pdfs/TRM_CaseStudy1.pdf

Material data is stored in a customizable material database

How much power loss leads to what temperature?

What temperature corresponds to what power loss?

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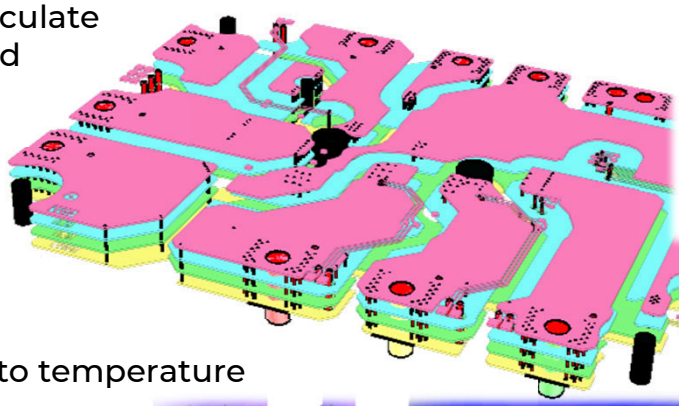
> Current

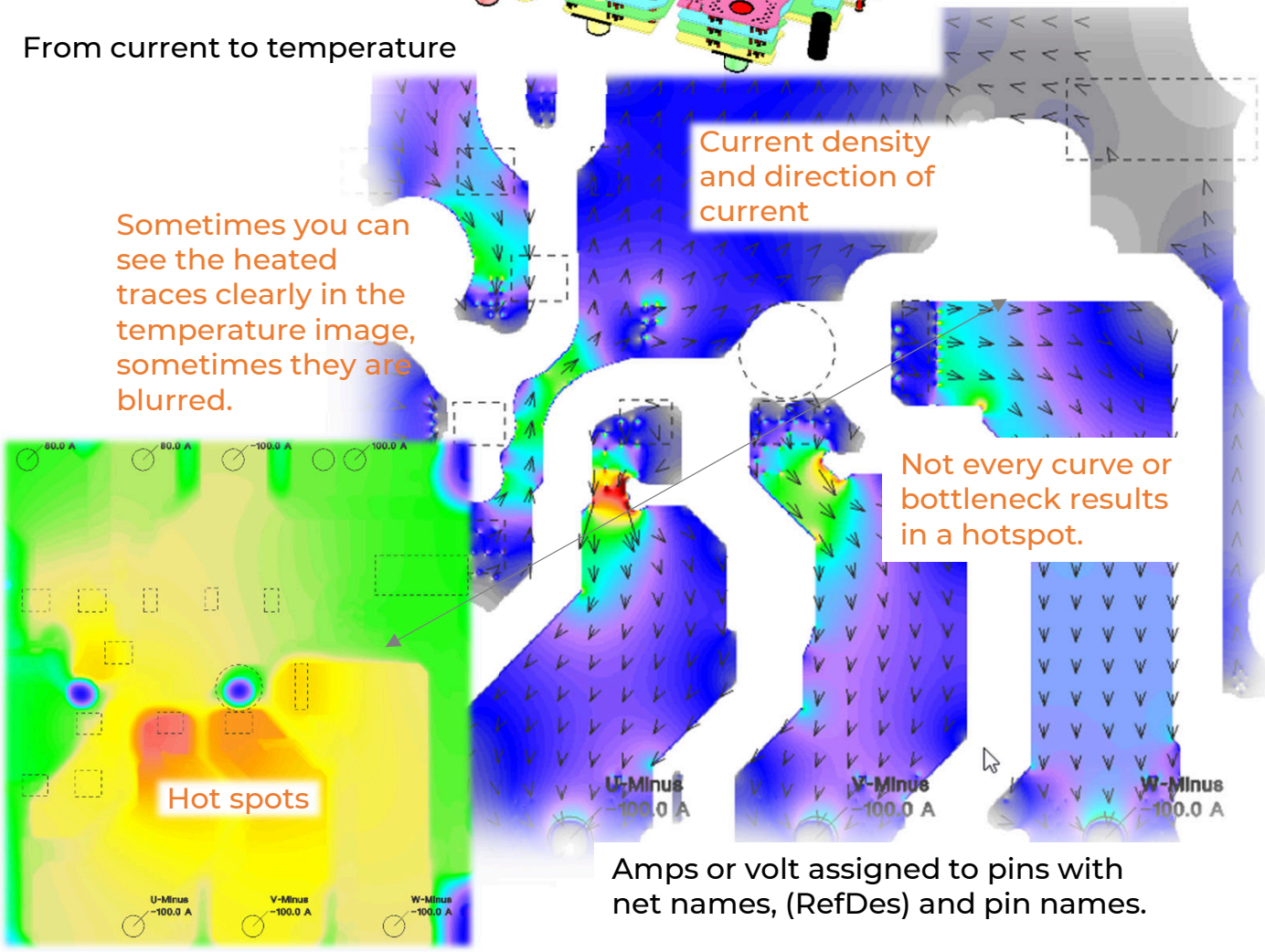
Electric current creates local heat (Joule).

TRM takes amp or volt settings to calculate DC voltage and current.



4-layer printed circuit board module for power distribution to a 3-phase motor

From current to temperature

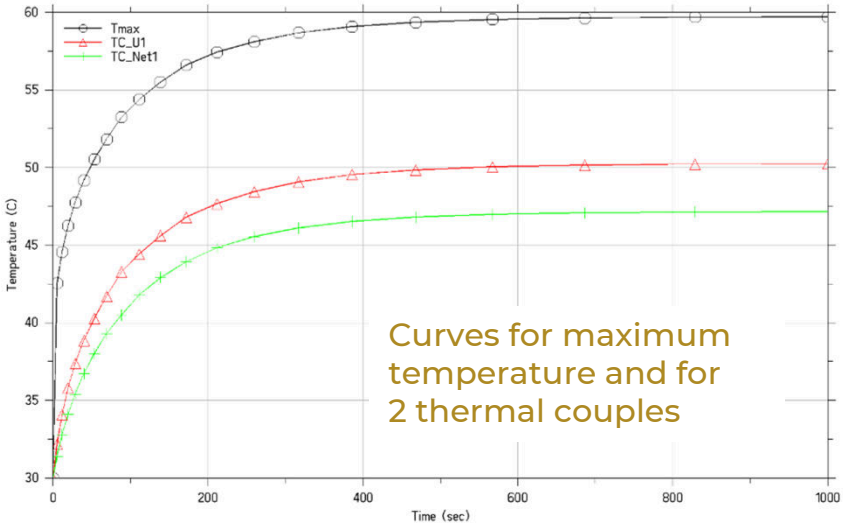


Amps or volt assigned to pins with net names, (RefDes) and pin names.

> Transient

TRM can calculate the time-dependent heating or cooling behavior. Either use constant current and heat sources or supply time profiles in a file. A wizard menu helps to select the time steps.

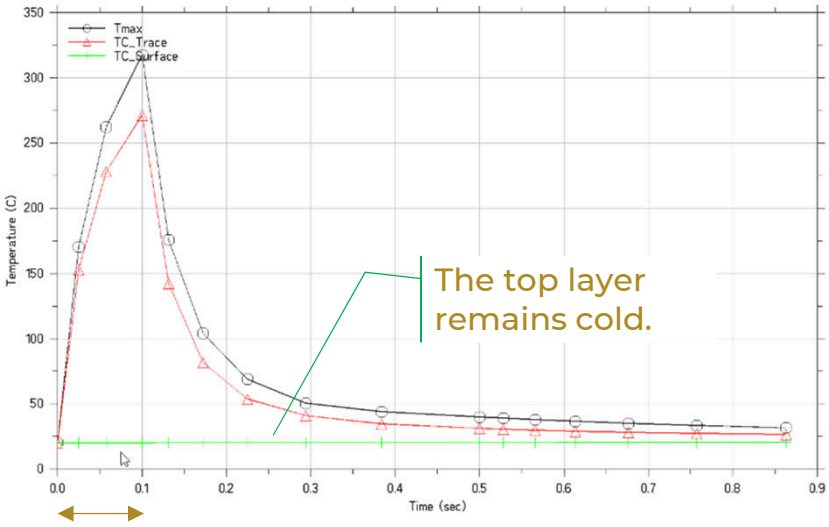
Heating curve with permanent losses.



Pictures and thermal couples record the transient and store it.

Curves for maximum temperature and for 2 thermal couples

100 ms current surge in inner layer



100 milliseconds is not enough time for the heat wave to reach the surface and be detected by instruments.

The top layer remains cold.

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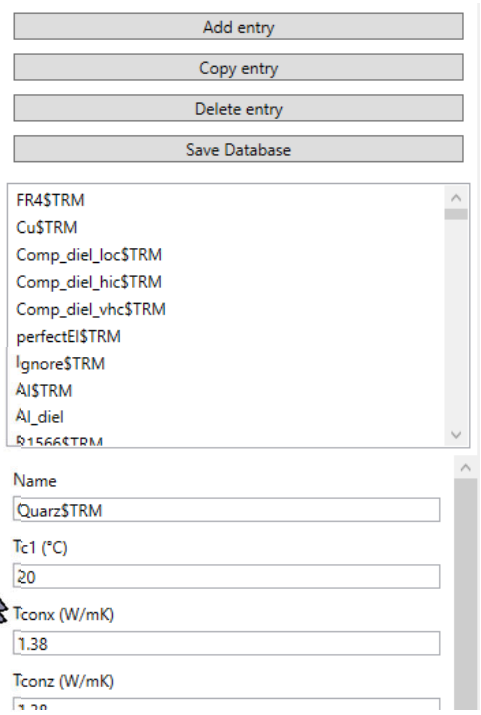
> Technology

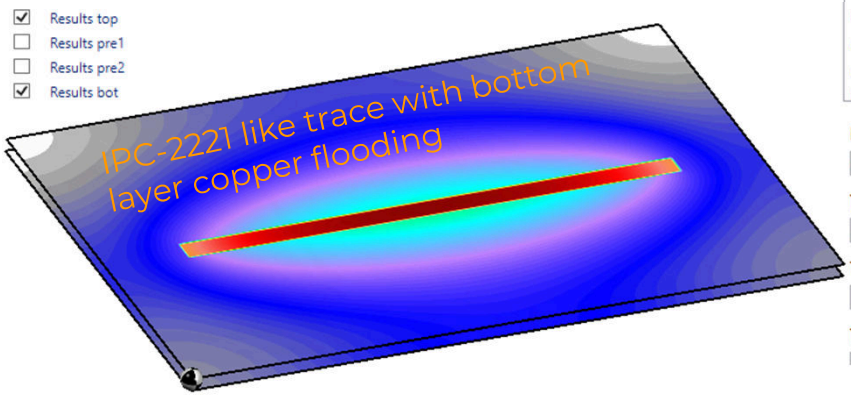
TRM can be used for purely technological investigations.

Even without layout data.

Create traces, planes and circles by keyboard and coordinates. or feed rectangles and circles graphically or from ASCII files.

Materials database



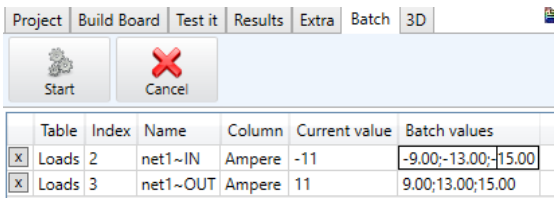


Deeper analysis with tables

```
Report by levels
  1 Top Layer            0.088 W
  2 Dielectric           0.000 W
  3 Mid Layer 1          0.020 W
  4 Dielectric           0.001 W
  5 Mid Layer 2          0.014 W
  6 Dielectric           0.000 W
  7 Bottom Layer         0.004 W
    Total Joule Heat=    0.127 W
```

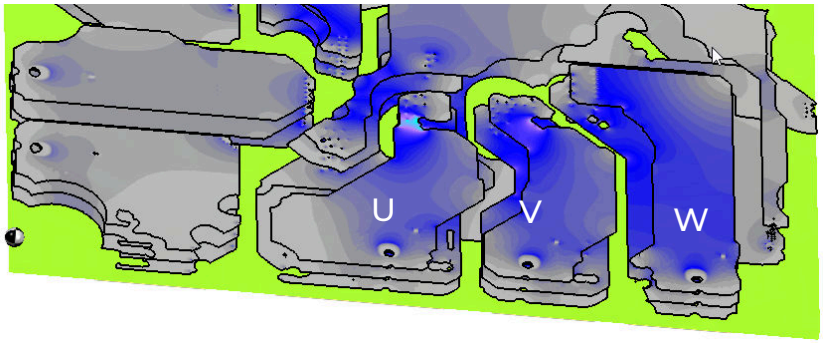
```
Report of Electric Results per Net
  Net              Flux(A)>0     Vmin(V)      Vmax(V)     Vdrop(mV)    RDC(mOhm)    PJoule(W)
 1 AGND              10.000       0.000        0.013       12.960        1.296        0.127
   Total Heat                                                                        0.127
```

Batch runs

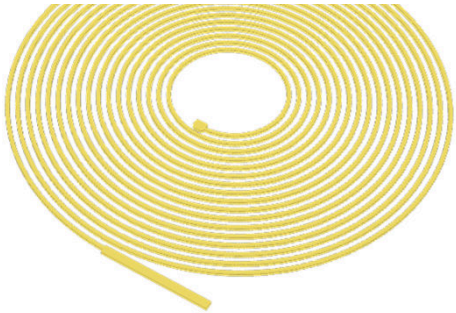


> Inductance (Inductivity)

Self inductance and mutual inductance depend on the shape of traces and the 3D flow of current.



TRM: 6.0 µH
EM software: 5.9 µH
Measured: 5.07 µH

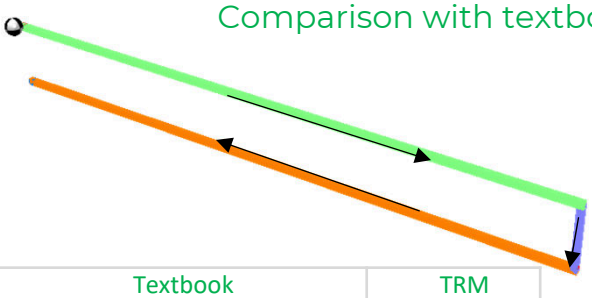


$$\mathbf{L} = \begin{pmatrix} 9.4 & 5.1 & -7.4 \\ 5.1 & 17 & -5.7 \\ -7.4 & -5.7 & 38 \end{pmatrix} \text{nH}$$

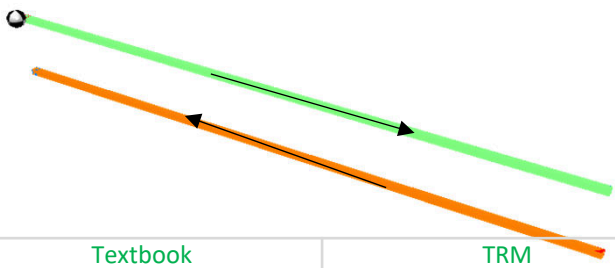
Inductance matrix for phases (U,V,W)

TRM calculates L values precisely from the electric flow pattern.

Comparison with textbook



Textbook Dual line	TRM
$L \approx \frac{\mu\ell}{4\pi}\left(1 + \text{In}\left(\frac{d-a}{a}\right)\right)$ = 128 nH	L=122 nH

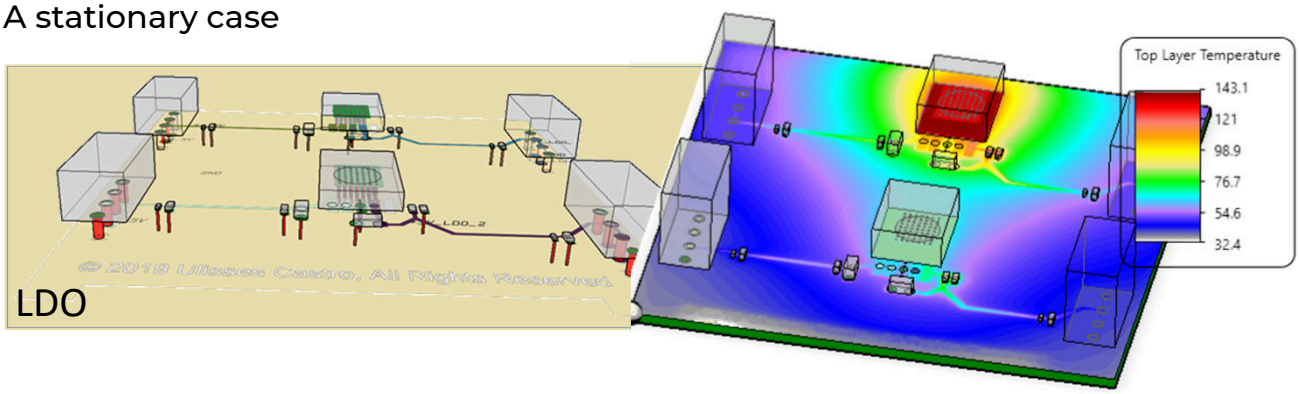


Textbook	TRM
Single line $Lself \approx \frac{\mu\ell}{2\pi}\left(\text{In}\left(\frac{2\ell}{w+t}\right) + \frac{1}{2}\right)$=102	L_{11}=L_{22} = 102 nH
	Self- and mutual inductance $\mathbf{L} = \begin{pmatrix} 102 & -41 \\ -41 & 102 \end{pmatrix}$ nH
Dual line $L \approx \frac{\mu\ell}{4\pi}\left(1 + \text{In}\left(\frac{d-a}{a}\right)\right)$= 128 nH	Total of matrix elements 102+102-41-41= *122* nH

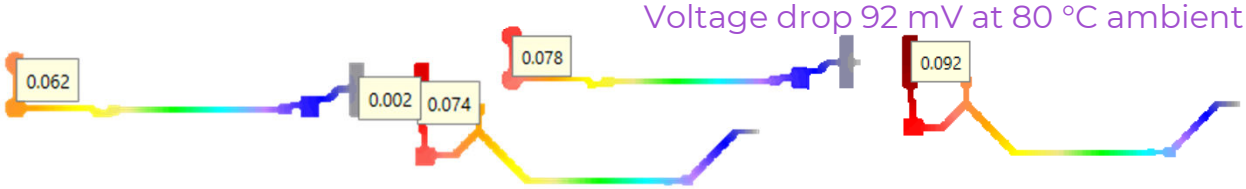
> Voltage Drop and Temperature

The electrical resistance of copper depends on temperature.
TRM can take it into account.

A stationary case

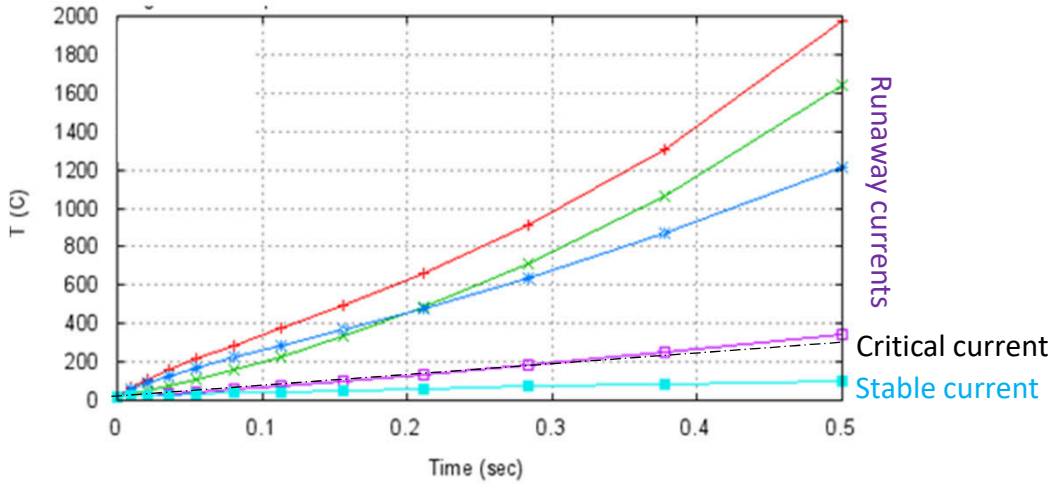


Voltage drop 92 mV at 80 °C ambient



Voltage drop 74 mV at 20 °C ambient

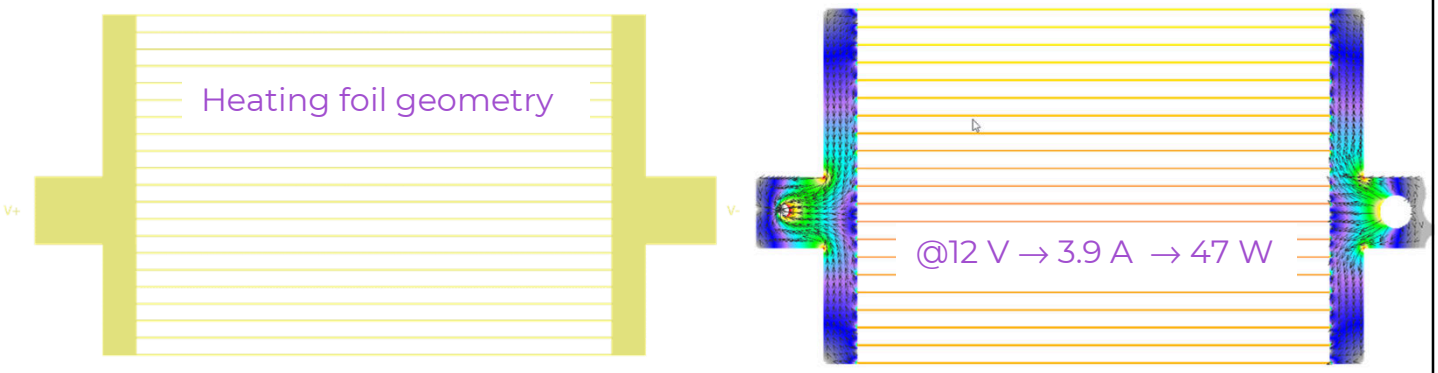
A thermal runaway event if a critical current is exceeded



> Special Setups

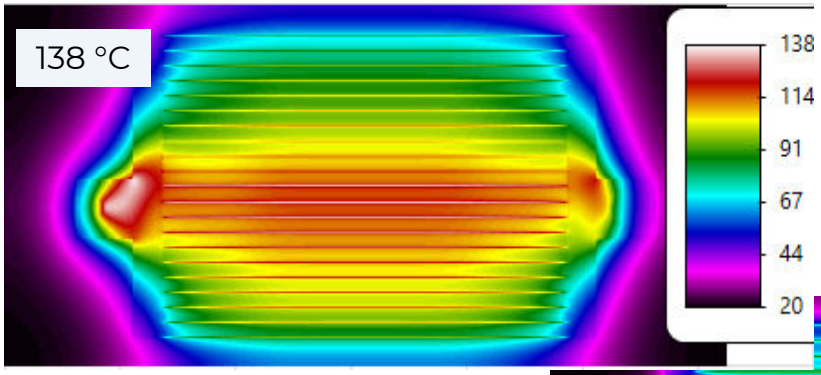
Practitioners who want to see how surfaces heat but are not interested in circuit boards or electronics can prepare conducting patterns using 2D drawing programs and import them from bitmaps.

Then they are ready to simulate.



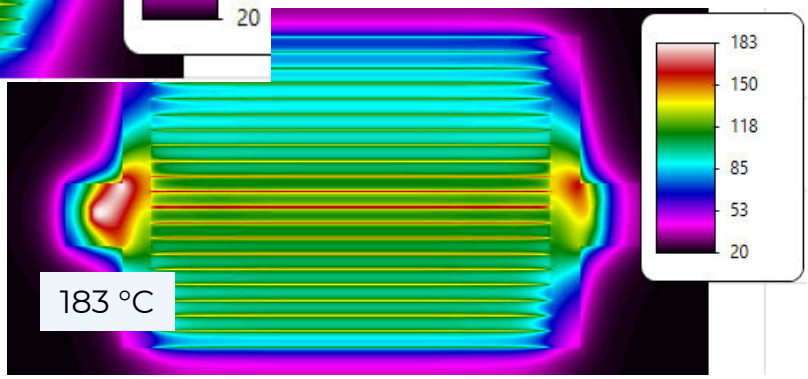
Heating foil on substrates
(from bitmap sketch)

Foil on 0.5 mm glass substrate



This design proposal does not seem to be the best solution.

Foil on 0.5 mm plastics sustrate

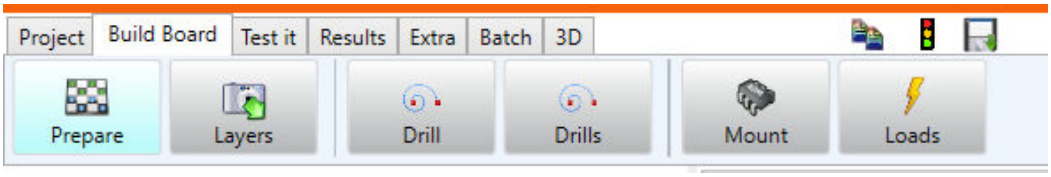


> User Actions

TRM offers a lot for both thermal beginners and thermal experts.

TRM is *not* intended to be an integrated tool.

Add files of your choice from multiple data sources.

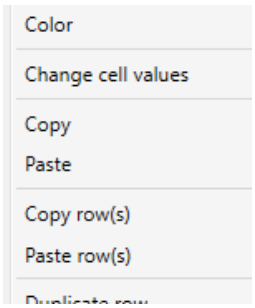


Fill tables and Edit.

English, German, traditional & simplified Chinese.

	Level	Name	Type	File	View	FR4 white	Thick (um)	Conductor	Dielectric
+ x	1	Top	ger	copper_l1.gbr	View	☑	35	Cu$TRM	FR4$TRM
+ x	2	Pre1	pre		View	☑	1500	Cu$TRM	FR4$TRM
+ x	3	Bottom	ger	copper_l2.gbr	View	☑	35	Cu$TRM	FR4$TRM

Drop down menus for many actions



Drillfile	View	Tech
Arduino_MEGA2560_ref.drd	View	TH

Table with Amps and Watts

	Index	Name	PosX	PosY	Di	Di	He	Be	Er	M	Form	K/W-board	K/W-air	Watt	Celsius	Ampere	Volt
+ x	345	PL6~XIOL-11	96.52	22.86	1.2	-1	2	1	99	Cu!	c	-1	-1			0	
+ x	346	PL7~IC3-42	52.8	20.35	0.2	-1	2	1	1	Cu!	c	-1	-1			1	
+ x	347	PL7~XIOL-12	93.98	22.86	1.2	-1	2	1	99	Cu!	c	-1	-1			-1	
+ x	348	PWRIN~D1-A	16.21	12.07	1.9	-1	2	1	1	Cu!	c	-1	-1			0	
+ x	349	PWRIN~X1-2	11.68	8.31	3.8	-1	2	1	99	Cu!	c	-1	-1			0	
+ x	350	RD+~IC4-29	15.99	37.85	0.2	-1	2	1	1	Cu!	c	-1	-1			0	

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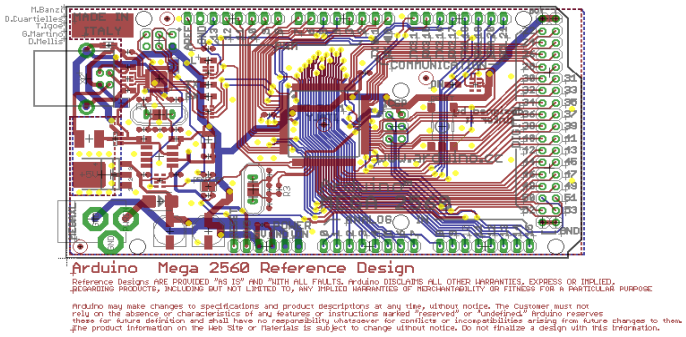
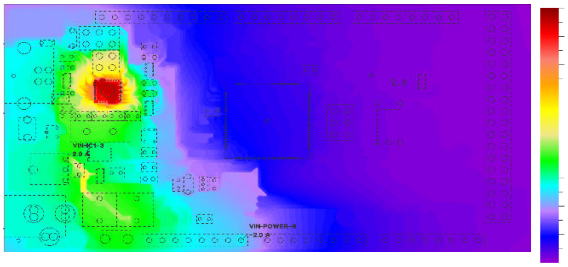
> CAD Import 1/4

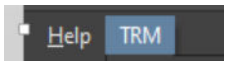
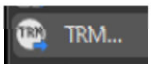
From design ...



... to result in a minute or two.



TRM offers a bunch of import „Wizards“

Altium	
Allegro + OrCAD	
Eagle	
Zuken	
Pulsonix	

Associated scripts are available to output the data in a controlled format.

A wizard fills the major tables: Layers, Drill, Mount and Loads and completes the import process automatically .

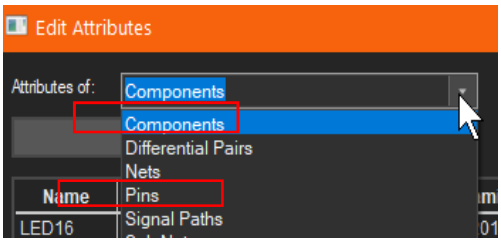
If they wish, users of other CAD systems can create simplified templates themselves and use them to fill in the tables.

All data can be manually changed and supplemented after import

> CAD Import 2/4

Some scripts can also export attribute values: net names and pins with electrical attributes, as well as components with thermal values.

Pulsonix



Components

0.1 W on each LED

Edit Attributes

Attributes of: Components

Name	Part Name	Description	Family	Footprint	<Component Height>	Category	TRM-POWER	<Hyp
LED1	KP-2012PBC	LED SMD CHIP BLUE	KP-2012	LED2x1.25	1.1mm	Led	0.1	
LED2	KP-2012PBC	LED SMD CHIP BLUE	KP-2012	LED2x1.25	1.1mm	Led	0.1	
LED3	KP-2012PBC	LED SMD CHIP BLUE	KP-2012	LED2x1.25	1.1mm	Led	0.1	
LED4	KP-2012PBC	LED SMD CHIP BLUE	KP-2012	LED2x1.25	1.1mm	Led	0.1	
LED5	KP-2012PBC	LED SMD CHIP BLUE	KP-2012	LED2x1.25	1.1mm	Led	0.1	
LED6	KP-2012PBC	LED SMD CHIP BLUE	KP-2012	LED2x1.25	1.1mm	Led	0.1	

Pins and Nets

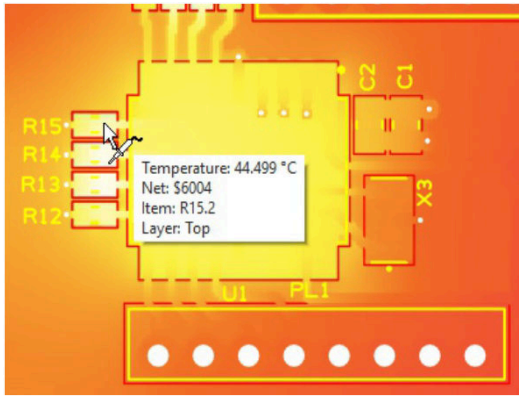
1.2 A on each signal

Edit Attributes

Attributes of: Pins

Name	Pin	Net	TRM-VALUE
Q1	1	feedP7	-1.2A
Q2	1	feedP6	-1.2A
Q3	1	feedP5	-1.2A
Q4	1	feedP4	-1.2A
Q5	1	feedP3	-1.2A
Q6	1	feedP2	-1.2A
Q7	1	feedP1	-1.2A
Q8	1	feedP	-1.2A
LED1	1	feedP	0.1A
LED2	1	feedP	0.1A
LED3	1	feedP	0.1A
LED4	1	feedP1	0.1A
LED5	1	feedP1	0.1A
LED6	1	feedP2	0.1A

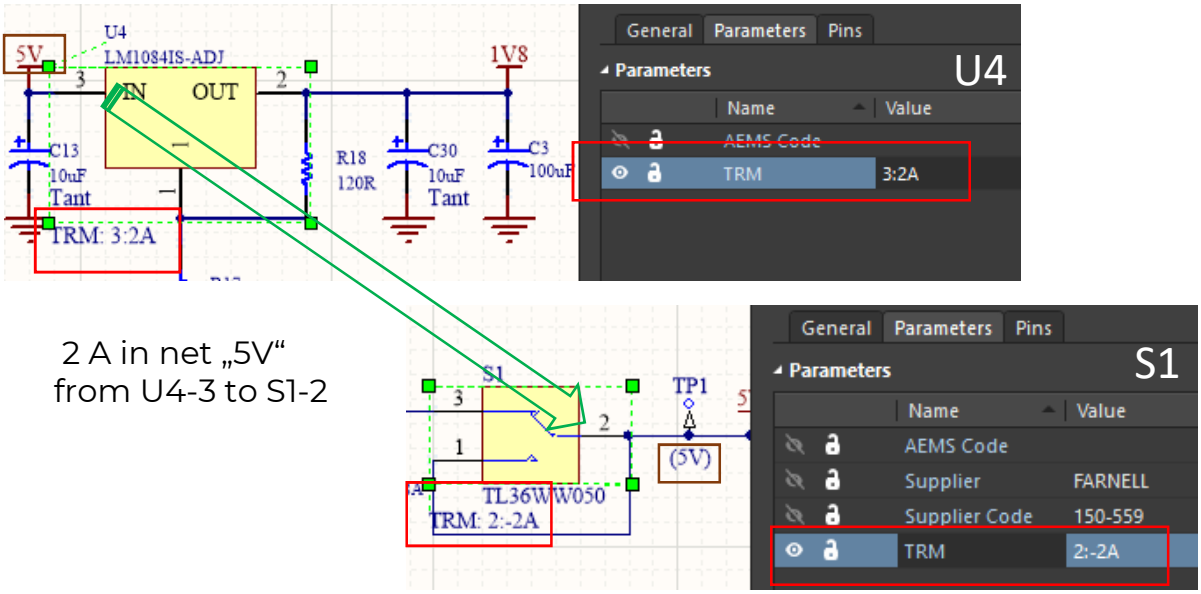
Pulsonix is also able to import and to visualize TRM results



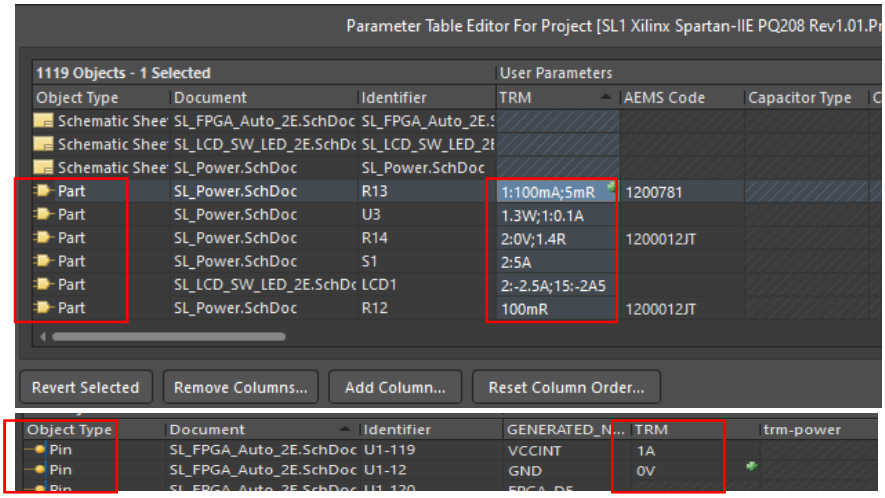
> CAD Import 3/4

Altium Designer

Values in schematics ...



... or with Parameter Manager



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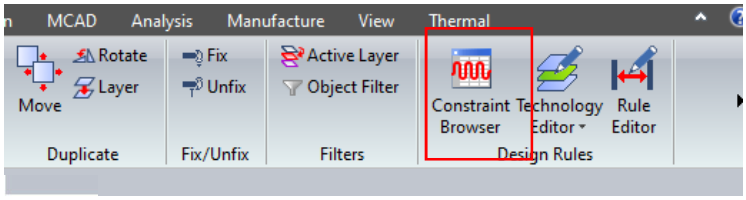
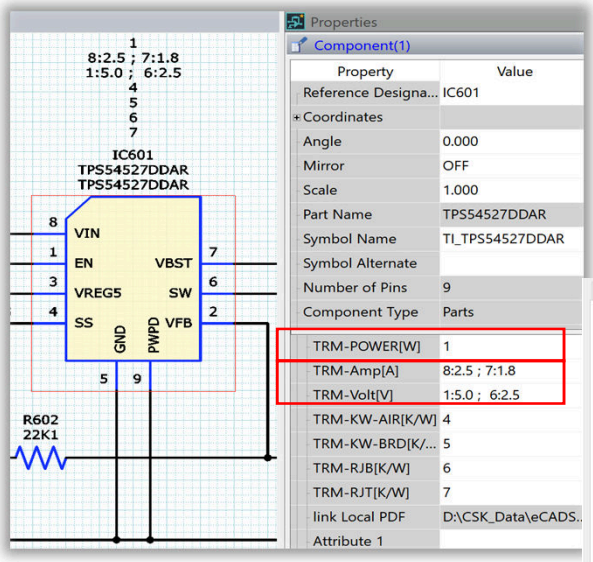
> CAD Import 4/4

ZUKEN e-CADSTAR

Use Schematic Editor and Constraint Browser

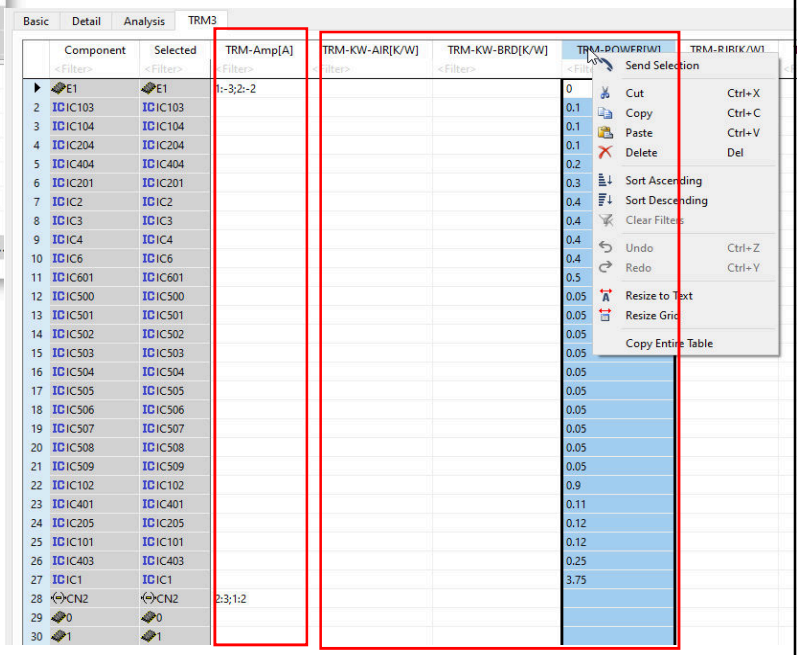


Schematic Editor



Constraint Browser

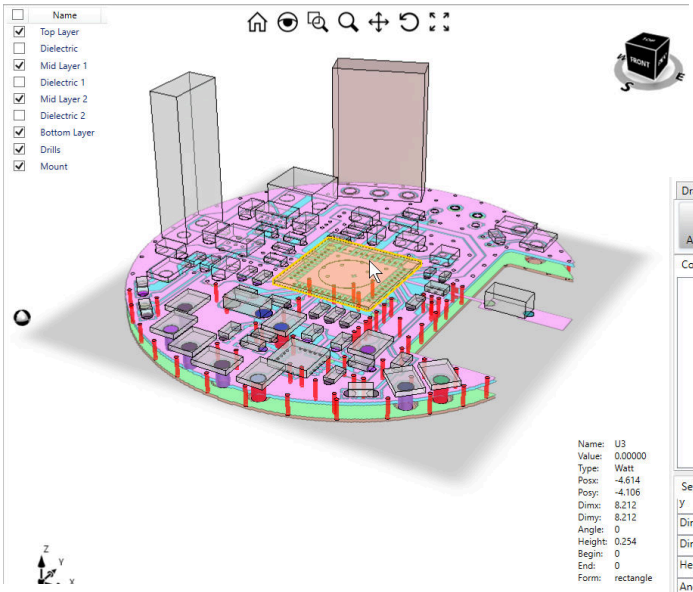
Electric Thermal



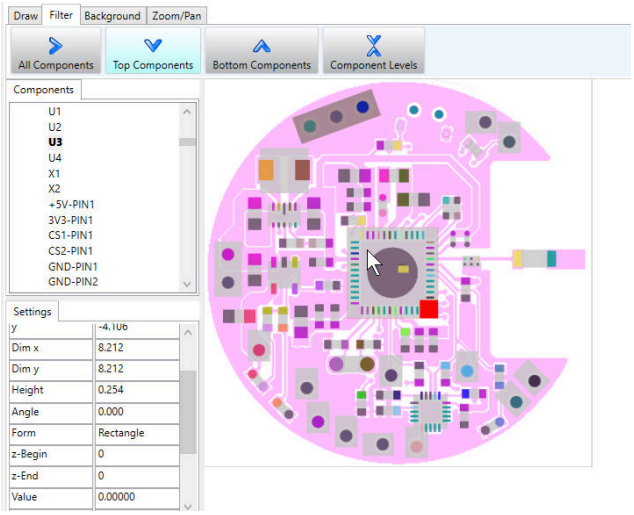
Forward - Backward annotation.

> CAD Import 5/5

Check import data in 3D ...



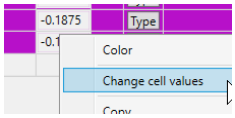
... and 2D



... or manipulate (move, delete, copy, add/remove values or materials, ...)

watt>0 or ampere<>0

	Index	Name	PosX (mm)	PosY (mm)	DimX (mm)	DimY (mm)	He	Be	En	Materia	Form	K/	K/	Watt	Celsius	Ampere	Volt	Type
+ x	61	U3	-4.614	-4.106	8.212	8.212	0.2	0	0	Comp_di	r	-1	-1	2.3				Type
+ x	286	+3V3~3V3-1	-7.239	-13.462	1.12	-1	2	1	1	Cu$TRM	c	-1	-1			1.5		Type
+ x	307	+3V3~U3-1	-3.355	-3.765	0.194	0.728	2	1	1	Cu$TRM	r	-1	-1			-0.1875		Type
+ x	308	+3V3~U3-20	2.529	0.653	0.728	0.194	2	1	1	Cu$TRM	r	-1	-1			-0.1875		Type
+ x	309	+3V3~U3-23	2.529	2.153	0.728	0.194	2	1	1	Cu$TRM	r	-1	-1			-0.1875		Type
+ x	310	+3V3~U3-34	-2.355	3.037	0.194	0.728	2	1	1	Cu$TRM	r	-1	-1			-0.1875		Type
+ x	311	+3V3~U3-35	-2.855	3.037	0.194	0.728	2	1	1	Cu$TRM	r	-1	-1			-0.1875		Type
+ x	312	+3V3~U3-40	-4.273	1.153	0.728	0.194	2	1	1	Cu$TRM	r	-1	-1			-0.1875		Type
+ x	313	+3V3~U3-48	-4.273	-2.847	0.728	0.194	2	1	1	Cu$TRM	r	-1	-1			-0.1875		Type
+ x	314	+3V3~U3-8	0.145	-3.765	0.194	0.728	2	1	1	Cu$TRM	r	-1	-1			-0.1875		Type



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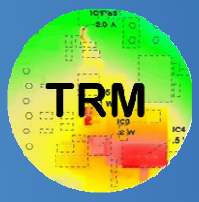
THERMAL RISK MANAGEMENT IN ELECTRONICS



Passion
Knowledge
Precision

Precision by Physics and Geometry

TRM3.10 Feature summary

Input

- Individual Gerber and drill files
- Your own drawings
- Manual actions (similar to Excel) and file import
- Import Wizards for Allegro, Altium, Eagle, e-CADSTAR, Pulsonix

Analysis modes

- Field calculation in all layers and prepregs in high resolution
- Trace heating (Ampacity) and component heating
- DC Voltage drop and flow of current in requested traces
- Steady state and transient
- Switching states (current by time or phase interval)
- Temperature dependent material properties
- Inductance Matrix
- Batch runs

Selective environmental conditions

- Convection Cooling
- Conduction cooling and heat sinks
- Radiation into vacuum
- Combinations

Results

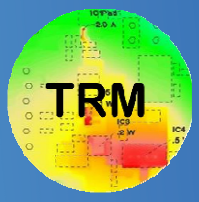
- 2D diagrams, 3D exploded view
- Tables of results
- Efficient computation times even on large designs

Licensing

- Floating licenses on the user company's license server.
- No external data transfer.

ADAM Research

THERMAL RISK MANAGEMENT IN ELECTRONICS



Passion
Knowledge
Precision

TRM is more than just software.

Software can help you …

… by watching results and experimenting you will learn a lot about your board and the technologies you used

- How to do thermal PCB design
- Weak points
- Alternatives
- Savings potential
- Ideas for the next design

Beyond that

- See and understand Thermal Management
- Test the benefits of new thermal products
- Learn how to read and evaluate data sheets, application notes, and advertisements.

More examples
Videos: https://www.youtube.com/@adamresearch-thermalriskma7955/videos
Linkedin: www.linkedin.com/in/johannes-adam-ab4991123

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