THERMAL MODEL FOR
BMR 350 2100/031

FLEX INC.

Contents

General

The model is an estimation for the thermal behavior of BMR 350 2100/031, which is a through hole pin design.

The model is intended for steady-state thermal simulations.

Model Description

The model is a readymade Flotherm 11.1 model. The model consists of four major components:

3D CAD Geometry

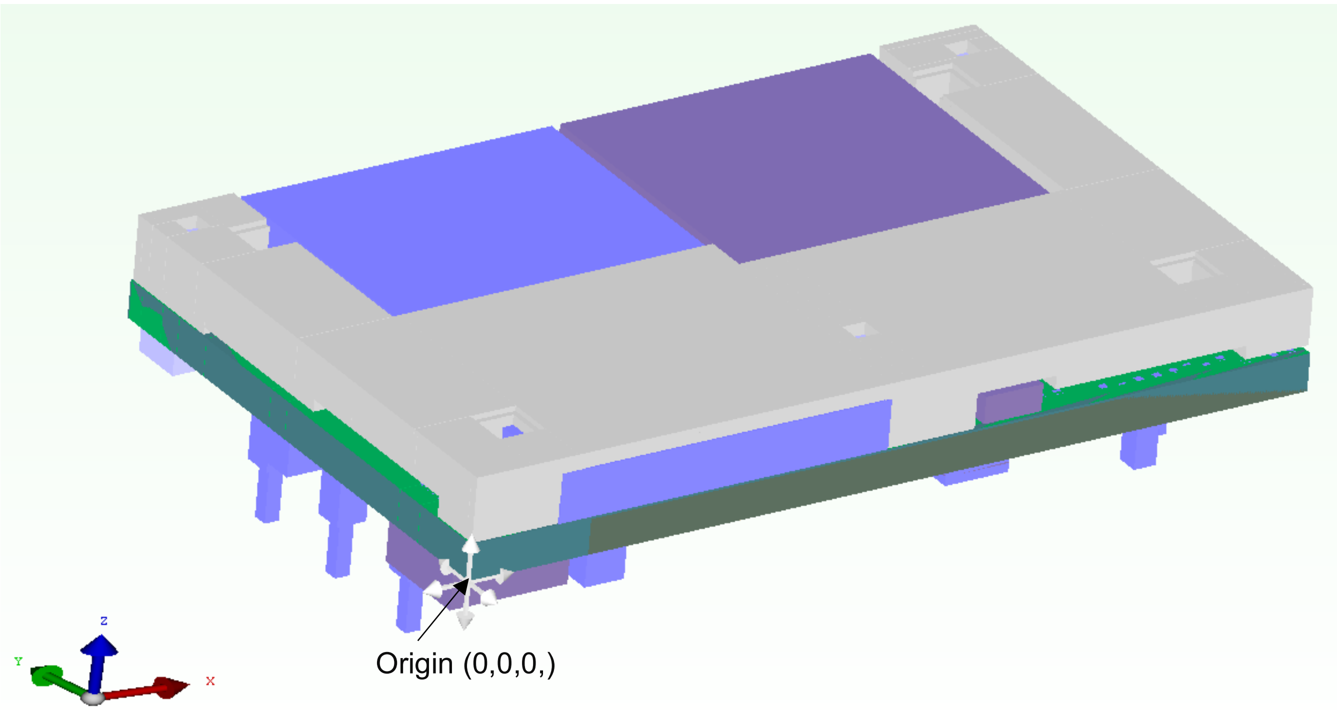

Figure 1 Model origin in lower left corner of PCB and axis orientation.

Origin has been placed so that [0,0,0] is in the lower left corner of the PCB.

Unit in file: [mm]

In the geometry most components are maintained per original design but have been simplified in FloMCAD to cuboids. The PCB has been simplified into 7 layers: Outer layers copper (detailed), next to outer layers (detailed), dielectric layers between outer and next outer layers including the blind vias, and finally a middle bulk layer. The vias in the PCB has been imported through FloMCAD as individual objects. Components considered not part of the heat transfer are collected in a hidden and ignored group “gravel”.

The model comes with a rudimentary grid constraint, which was used during the model development. It generates approx. 11 million cells. It was found difficult to capture the thermal behavior without a detailed resolution of the baseplate and the through hole vias. It is of course voluntarily to use this grid. Approximately two thirds of the grid cells are generated by the baseplate and PTH vias.

Domains of power loss distribution

There are several sources for power loss. The power loss for each of them, at certain module total power, are given in *Appendix 1 - Power Loss Distribution.*

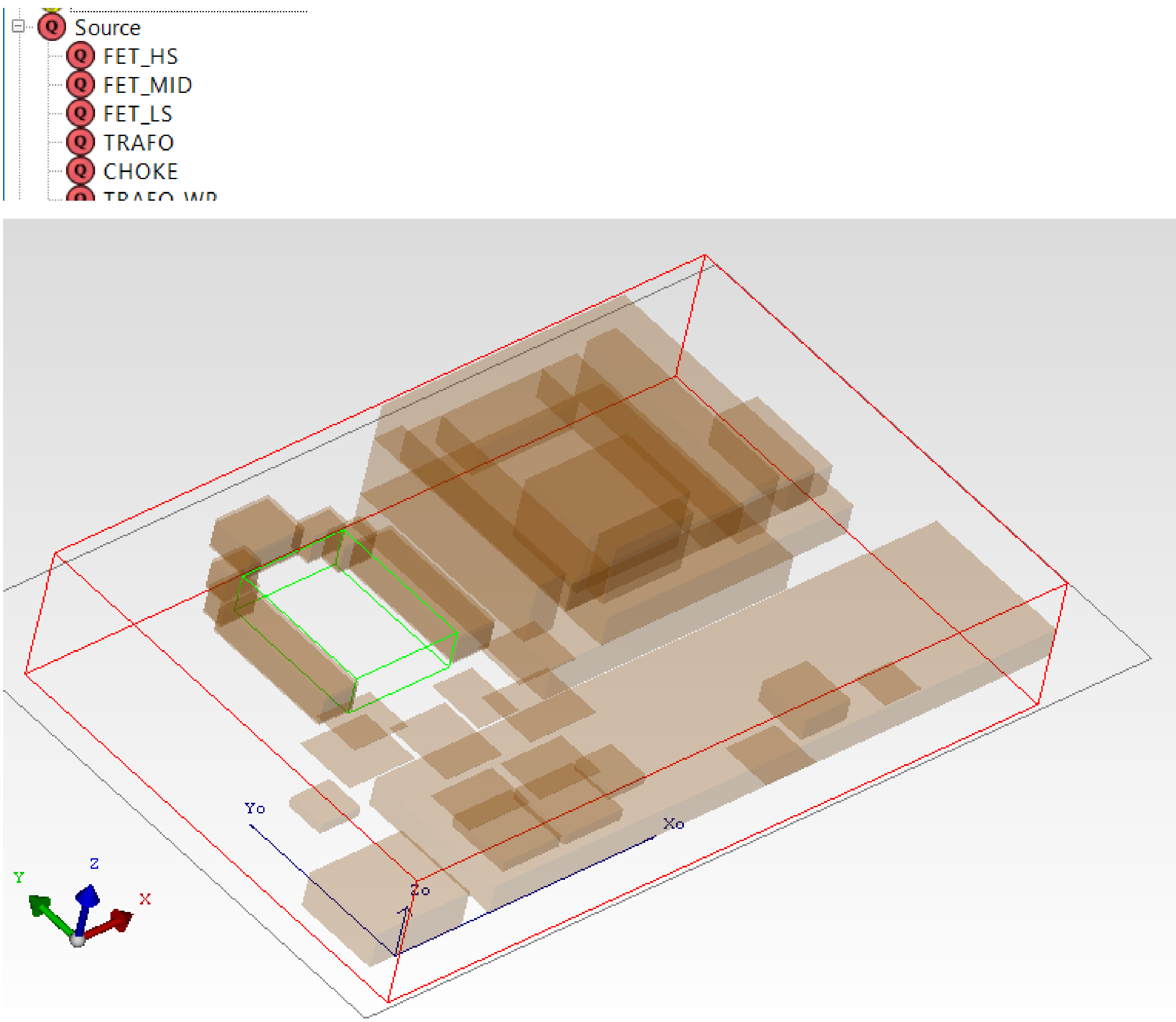

Figure 2: Heat Sources

Domains of material data

There are several material domains. The heat conductivity for each of them is given either as isotropic, or anisotropic values in x-,y-, and z-direction (x,y,z) per the following list.

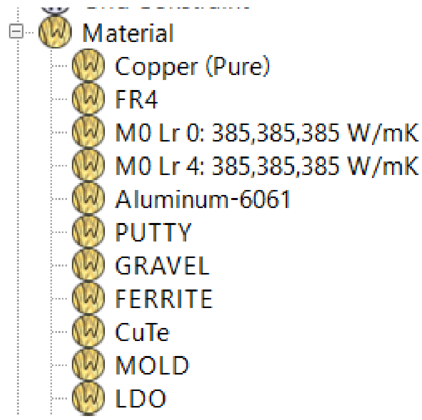

Figure 3. Domains of material data

Note. The given heat conductivities are only intended to model the temperature distribution of the module in this application. The values should not be treated as physically true or transferable to other applications.

Monitor points

The model comes with predefined monitor points:

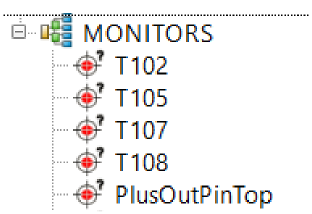

Figure 4. Probe points.

Model Calibration

The model has been calibrated to give temperatures as similar as possible compared to thermal verification document 4/102 65-BMR3502100_031 Water cooling PA1 Vout=12[V], Iout=72[A]. The calibration was done using power loss settings per Appendix 1 - Power Loss Distribution.

Calibration data: Tbpl=100[C], Tboard=85[C], Ploss=23.4[W]

Simulation temperatures are within +2/-2.6 [C] compared to measured values.

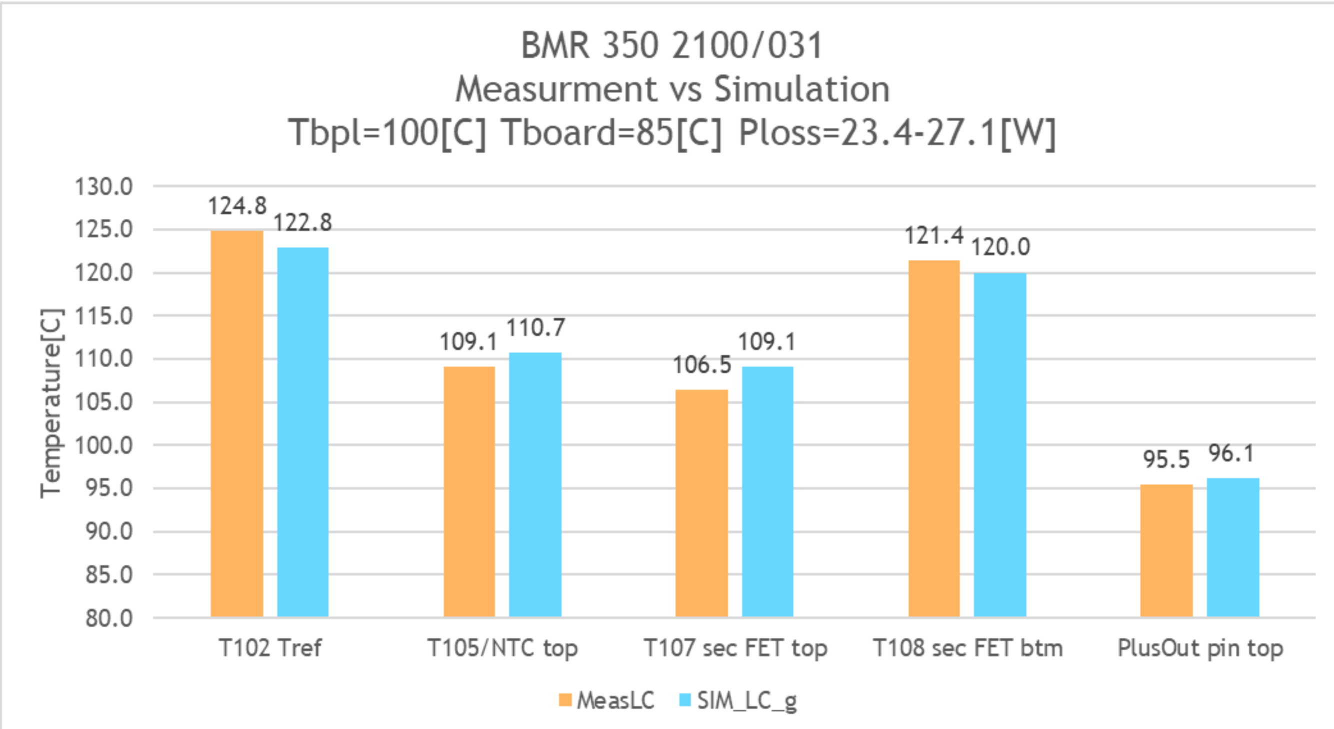

Figure 5: Model calibration result.

Model Usage

Import the *.pdml file into the desired project.

Adjust the dissipated power by altering the thermal sources per Figure 2, according to Appendix 1 - Power Loss Distribution. Default settings are for Vout=12[V], Iout=72[A], T≈100[C]

If the model is rotated, make sure that the orientation of the orthotropic materials properties are preserved (also rotated).

Do not change the order of power sources and geometry objects, as this can change the power and material settings.

The module temperatures can be monitored in predefined monitor points.

Results sanity check

It is inherently difficult to capture the thermal behavior in detail of this kind of product, without creating a model that causes a huge computational cost. An extra resource it is therefore provided in Appendix 2 - Regression model of measured data. Herein have the measured temperatures been analyzed to extract the linear dependency on input parameters such as output current, baseplate and board/pin temperatures. Since the measurements were done using liquid cooling of the baseplate and board/pin, the correlation between the input and output data is very high.

Use this model to either verify a Flotherm simulation, or input known values to get the temperatures directly, without a simulation. Note: this model covers output currents 70-100[A] and temperature range 65-100[C] only.

Additional Information

Model has been constructed with SI units.

Reference

BMR3502100_031A.pdml

Disclaimer

The model and model documentation described herein are provided for the sole purpose of facilitating thermal modeling of a structure where the referenced product is included. It should not and cannot be interpreted neither as a detailed description of the product itself, nor as a statement of the product's performance.

The model has been constructed on a best effort basis, but we cannot accept liability for any discrepancy between model predictions and actual values.

Revision history

A	2022-01-07	New document

Appendix 1 - Power Loss Distribution

Power loss distribution examples for BMR3502100/031 R1A.

V_{in}= 54V, V_{out}= 12.24V, I_{in}= 16.7A, $I_{out100\%}$= 72A, T_{ref} = 100℃

Domain	Number of domains	Per domain [W]	Total [W]
High side FET T101, T105	2	2.8	5.6
Mid FET T102, T106	2	1.5	3.0
Low side FET T103,T104,T107, T108	4	1.4	5.6
TRAFO (Core, M300)	1	1.4	1.4
CHOKE (Core, M400)	1	0.3	0.3
TRAFOWIND primary (M300)	1	0.7	0.7
TRAFOWIND secondary (M300)	1	1.5	1.5
CHOKEWIND (M400)	1	2.6	2.6
Primary driver (N107, N110)	2	0.14	0.28
Secondary driver (N104, N105)	2	0.15	0.3
Aux Circuit (N111)	1	0.4	0.4
Aux Inductor (M2)	1	0.3	0.3
LDO (N101)	1	0.15	0.15
INPUT CHOKE	1	0.2	0.2
GND PCB	1	1	1
Total [W]			**23.4**

V_{in}= 54V, V_{out}= 12.24V, I_{in}= 12.4A, $I_{out50\%}$= 54A, T_{ref} = 100℃

Domain	Number of domains	Per domain [W]	Total [W]
High side FET T101, T105	2	1.8	3.6
Mid FET T102, T106	2	1.0	2.0
Low side FET T103,T104,T107, T108	4	0.82	3.3
TRAFO (Core, M300)	1	1.4	1.4
CHOKE (Core, M400)	1	0.3	0.3
TRAFOWIND primary (M300)	1	0.4	0.4
TRAFOWIND secondary (M300)	1	0.8	0.8
CHOKEWIND (M400)	1	1.5	1.5
Primary driver (N107, N110)	2	0.14	0.28
Secondary driver (N104, N105)	2	0.15	0.3
Aux Circuit (N111)	1	0.4	0.4
Aux Inductor (M2)	1	0.3	0.3
LDO (N101)	1	0.15	0.15
INPUT CHOKE	1	0.12	0.12
GND PCB	1	0.6	0.6
Total [W]			**15.5**

V_{in}= 54V, V_{out}= 12.24V, I_{in}= 8.2A, $I_{out50\%}$= 36A, T_{ref} = 100℃

Domain	Number of domains	Per domain [W]	Total [W]
High side FET T101, T105	2	1.1	2.2
Mid FET T102, T106	2	0.6	1.2
Low side FET T103,T104,T107, T108	4	0.42	1.7
TRAFO (Core, M300)	1	1.4	1.4
CHOKE (Core, M400)	1	0.3	0.3
TRAFOWIND primary (M300)	1	0.2	0.2
TRAFOWIND secondary (M300)	1	0.4	0.4
CHOKEWIND (M400)	1	0.8	0.8
Primary driver (N107, N110)	2	0.14	0.28
Secondary driver (N104, N105)	2	0.15	0.3
Aux Circuit (N111)	1	0.4	0.4
Aux Inductor (M2)	1	0.3	0.3
LDO (N101)	1	0.15	0.15
INPUT CHOKE	1	0.05	0.05
GND PCB	1	0.3	0.3
Total [W]			**10**

Appendix 2 - Regression model of measured data for output current 70-100 [A]

The data from the measurements have been analyzed with respect to correlation. The matrix of currents and temperatures in the measurements were:

Output currents in test [A]			
	Tboard[C]		
Tbpl[C]	*65*	*75*	*85*
70	100	100	100
80	100	97	94
90	90	88	85
100	80	77	74

The measured power loss was found to correlate to input current, baseplate and board/pin temperatures according to:

Ploss linear coefficients	
Intercept	-37.00
Iout[A]	0.74
Tbpl[C]	0.071
Tboard[C]	0.024

The temperatures in turn were found to correlate to input as the table below:

Temperature linear coefficients						
	T102	T105	T107	T108	PlusOutPin	N101
Intercept	-2.14	4.17	-2.64	-2.46	3.26	7.75
Ploss[W]	1.16	0.46	0.34	0.99	-0.01	0.24
Tbpl[C]	0.76	0.82	0.97	0.78	0.75	0.61
Tboard[C]	0.22	0.13	0.03	0.22	0.22	0.33

Example

The module power loss and temperature of T_{102} at output current 74.2[A], baseplate temperature 100[C], board/pin temperature 85[C], can be calculated as

P_{loss}=[-37]+[0.74]*74.2+[0,071]*100+[0.024]*85=27.3[W]

T_{102}=[-2.14]+[1.16]*27.3+[0.76]*100+[0.22]*85=125.0[C]

The measured temperature for this example is T_{102}=124.8[C]