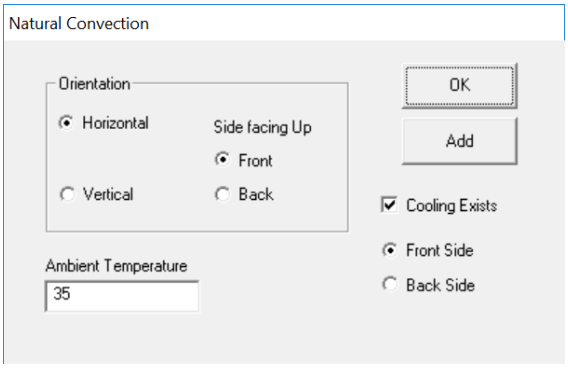
Simulating Natural Convection in SolariaPCB

Natural convection is defined as heat transfer from a surface to a fluid where the fluid movement is buoyancy induced. As the surface of a PCB heats up, it heats the surrounding air. As the air heats, its density reduces which causes it to rise. This air movement induces better heat transfer from the surface to the fluid. As the surface heats, the air movement increases, which intern enhances the heat transfer. This phenomenon is simulated by calculating a heat transfer coefficient that is a function of the temperature difference between the surface and the fluid.

Important note:

As explained above, natural convection is a function of the board temperature. It is also effected by obstacles near the board which can hinder air flow. If this happens then higher temperatures can result. On the other hand, pure natural convection is actually difficult to achieve. Any slight forced air movement near the board can create more air movement than that induced by the buoyancy. This can result in lower temperatures than those predicted. The equations used in the calculation of the temperature difference heat transfer coefficient are empirically formulated.

This can be simulated in SolariaPCB by selecting PCB>Add>Define Nat Convection.

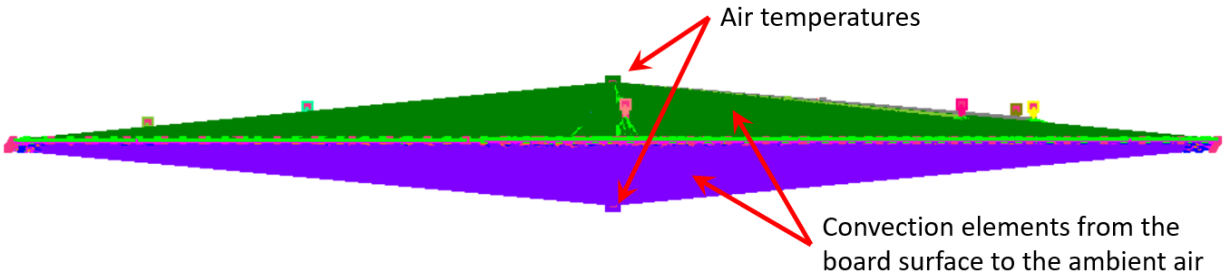


The efficiency of natural convection depends on the orientation of the board. First define if the board is horizontal or vertical. If it is vertical, then appropriate factors are used. If the board is horizontal, then the side that is facing up must be defined. Heat transfer from the top side of the board is more efficient than the side facing down and appropriate factors are used.

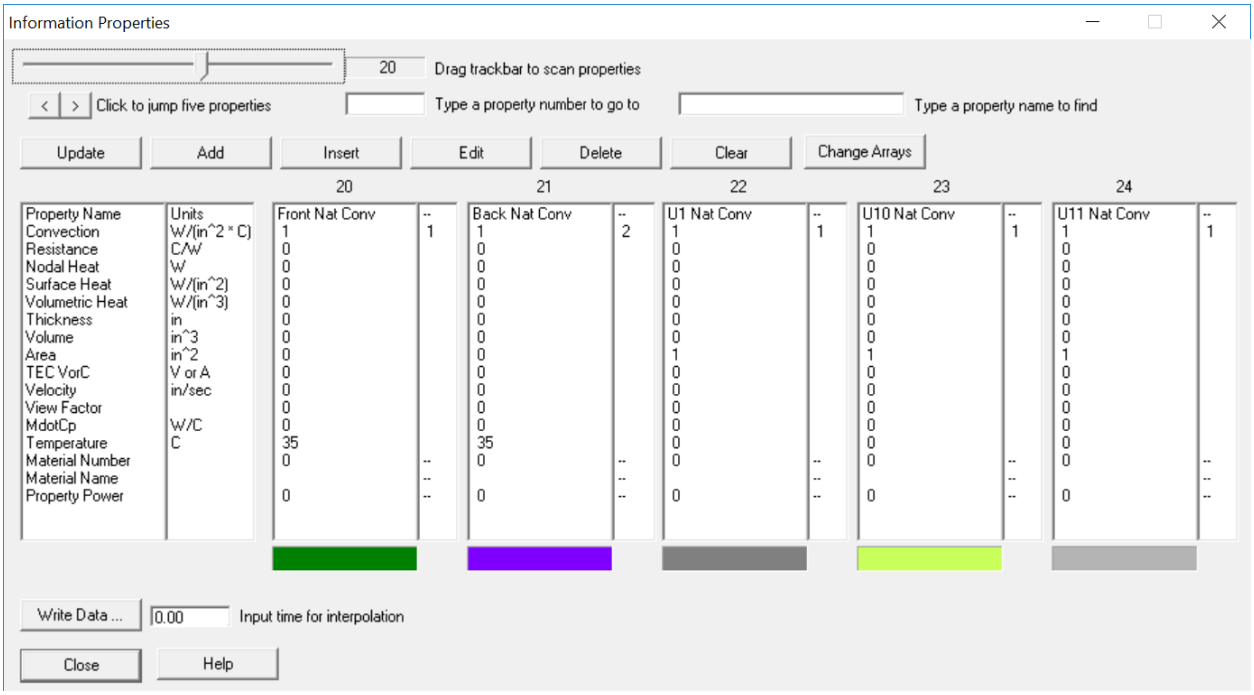
You can define natural convection from the front and/or back of the board. Select Front Side then define the conditions, including the ambient temperature. Next check Cooling Exists then hit the Add button. Do the same if there is similar heat transfer from the other side by selecting the Back Side radio button.

How natural convection is represented in the Solaria model

Below shows an edge view of a board that has natural convection on both sides of the board. Boundary Nodes are created on either side of the board at the defined temperatures.

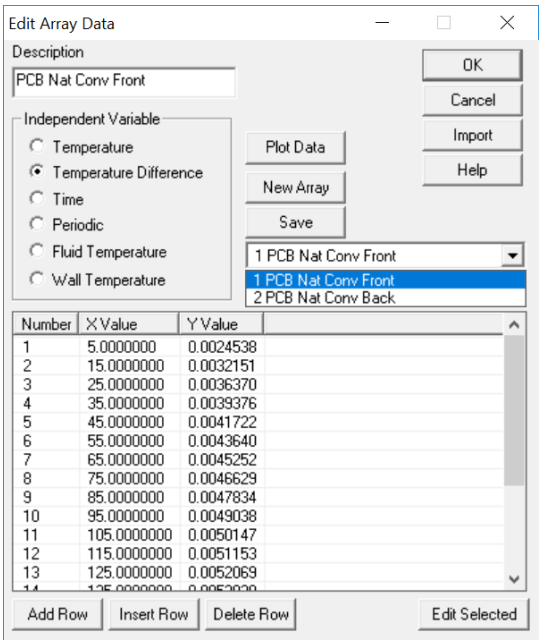


The Boundary Nodes reference a Property where the temperature is defined. The Convection elements from each side reference the same Property. As seen, the Convection heat transfer coefficient references an array.

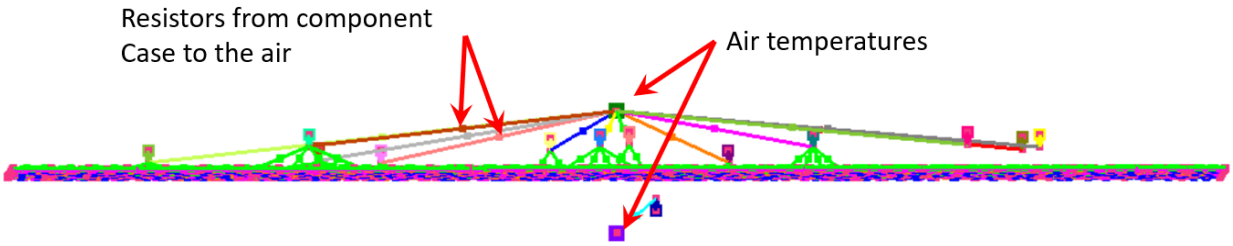


		20		21		22		23		24	
Property Name	Units	Front Nat Conv	--	Back Nat Conv	--	U1 Nat Conv	--	U10 Nat Conv	--	U11 Nat Conv	--
Convection	W/(in^2 * C)	1	1	1	2	1	1	1	1	1	1
Resistance	C/W	0		0		0		0		0	
Nodal Heat	W	0		0		0		0		0	
Surface Heat	W/(in^2)	0		0		0		0		0	
Volumetric Heat	W/(in^3)	0		0		0		0		0	
Thickness	in	0		0		0		0		0	
Volume	in^3	0		0		0		0		0	
Area	in^2	0		0		1		1		1	
TEC VorC	V or A	0		0		0		0		0	
Velocity	in/sec	0		0		0		0		0	
View Factor		0		0		0		0		0	
MdotCp	W/C	0		0		0		0		0	
Temperature	C	35		35		0		0		0	
Material Number		0	--	0	--	0	--	0	--	0	--
Material Name			--		--		--		--		--
Property Power		0	--	0	--	0	--	0	--	0	--

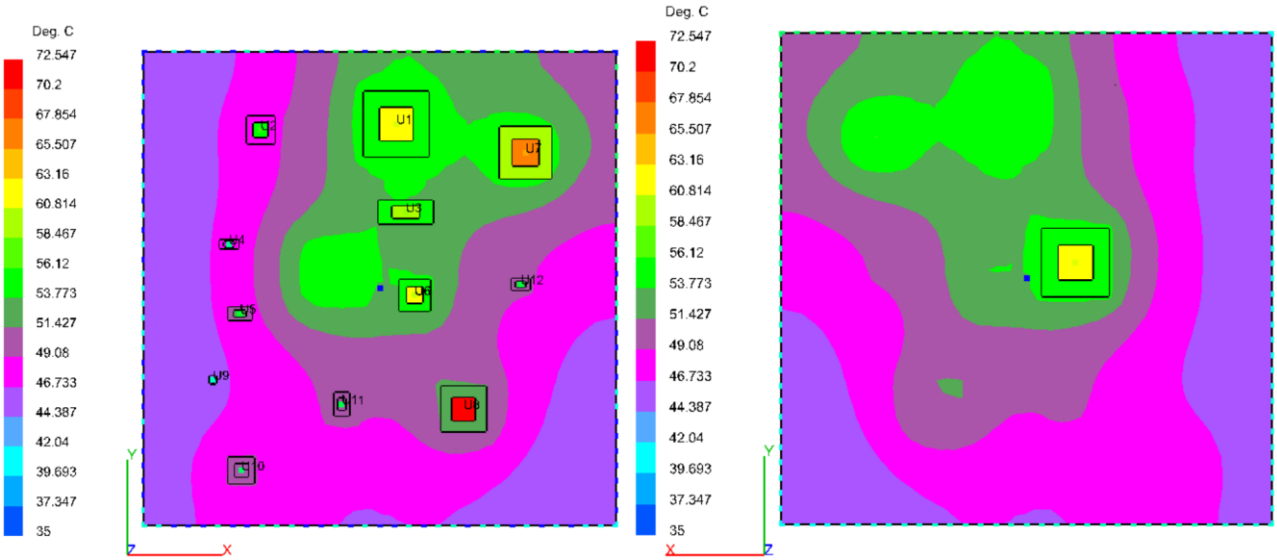
Shown below is the array that is referenced. You can see that the heat transfer coefficient is a function of the temperature difference between the board surface and the air. During the solution, this data is used to calculate the appropriate heat transfer coefficient based on the board and air temperatures.



The figure below shows the Resistors that represent the components on the board. In this case there are many components on the front of the board and one on the back of the board. Resistor elements are automatically created from the component Case nodes to the air. This Resistor element references a Property. In the Property dialog shown above, each component Resistor references a new Property which has the reference designator for that component in the name. You can see the Resistor element resistance is also a function of the temperature difference between the Case node and the air. The surface area of the component is calculated using the component geometry data.



Below shows the resultant temperatures.



SolariaPCB Results Summary

RefDes	Name	Pdiss	Junction	Case	Board	Air	C-B Res
U1	BGA676PLDOB.05	1.3	61.839	55.338	55.306		.025
U10	TQFP120PHPGW.016	.5	50.058	49.559	49.277		.564
U11	TSOP32P.49BWGW.02	.3	51.12	50.823	50.333		1.631
U12	TSSOP28P.24BWGW.025	.1	51.428	49.74	49.567		1.735
U13	BGA676PLDOB.05	1.5	61.986	54.484	54.446		.025
U2	BGA100PCD.06	.2	55.392	48.79	48.756		.17
U3	DIP24P.6W.1	.24	59.259	54.22	53.433		3.278
U4	FDP7042L	.02	48.298	48.265	48.243		1.053
U5	FP20CGW.05	.04	52.203	51.325	47.319		100.141
U6	LCC44PADRJ.05	.5	61.014	54.163	54.147		.032
U7	PGA121CSOCU.1	1.2	66.531	59.572	55.274		3.582
U8	QFP132PLPGW.025	1	72.547	52.551	51.54		1.01
U9	SO2P.17BWLPCB	.01	46.463	46.455	46.426		2.949

Cancel

Help

1 NatConvNEW

Save Data

Display temperatures