

## ROHM Solution Simulator

# Thermal Simulation of BD4xxMx Series Linear Regulators

This document introduces and describes the use of a simulation environment that allows simultaneous electrical and thermal simulation of BD4xxMx series linear regulators. By changing the parameters of the components, it is possible to simulate a wide range of conditions. As shown in the table below, there are six different thermal simulation circuits for the BD4xxMx series, depending on the output voltage, output current, and package. In this document, the BD433M2EFJ-C is used as a typical example.

Table 1. BD4xxMx series thermal simulation list

Product name	Output voltage	Output current	Package name	Simulation circuit
BD433M2EFJ-C	3.3V	200mA	HTSOP-J8	<a href="#">BD433M2EFJ-C thermal simulation</a>
BD450M2EFJ-C	5.0V	200mA	HTSOP-J8	<a href="#">BD450M2EFJ-C thermal simulation</a>
BD433M5FP-C	3.3V	500mA	TO252-3	<a href="#">BD433M5FP-C thermal simulation</a>
BD450M5FP-C	5.0V	500mA	TO252-3	<a href="#">BD450M5FP-C thermal simulation</a>
BD433M5FP2-C	3.3V	500mA	TO263-3	<a href="#">BD433M5FP2-C thermal simulation</a>
BD450M5FP2-C	5.0V	500mA	TO263-3	<a href="#">BD450M5FP2-C thermal simulation</a>

### 1 Simulation circuit

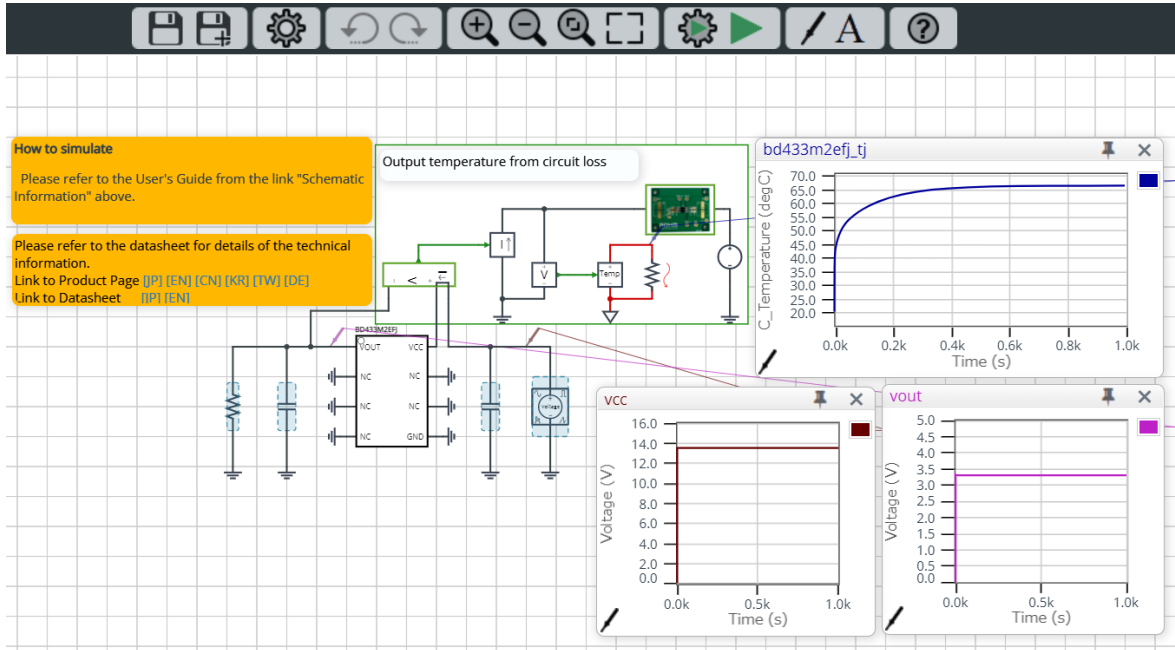


Figure 1. Simulation circuit (BD433M2EFJ-C).

In Figure 1, the area within the green line shows the thermal simulation circuit and the rest of the figure shows the electrical simulation circuit.

This circuit is a step-down operation with respect to the input voltage, providing a 3.3 V or 5.0 V output for the BD4xxMx series.

The thermal simulation circuit creates a thermal simulation model of the device losses calculated in the electrical simulation and the linear regulator mounted on the board, and calculates the temperature of the linear regulator.

### 2 Simulation method

Simulation settings such as simulation time and convergence options can be set from “Simulation Settings” shown in Figure 2, and the initial simulation settings are shown in Table 2.

If you are having problems with the convergence of the simulation, you can change the advanced options to fix the problem. The simulation temperature and various parameters of the electrical circuit are defined in “Manual Options”.

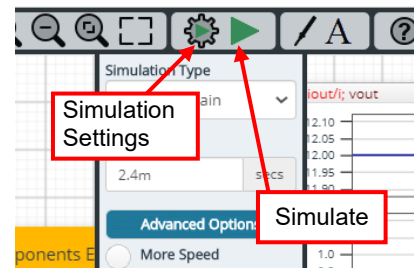


Figure 2. Simulation Settings and execution

Table 2. Initial values for Simulation Settings

Parameters	Initial values	Remarks
Simulation Type	Time-Domain	Do not change the simulation type
End time	1000 secs	
Advanced Options	More Speed	
Manual Options	.PARAM Ta	Set the ambient temperature

### 3 Simulation conditions

#### 3.1 Definition of parameters

The parameters for the components shown in blue in Figure 3 are defined in the manual options as the ambient temperature needs to be set.

Table 3 shows the initial values of the parameters. These values are written in a text box in the "Manual Options" section of the simulation settings, as shown in Figure 4.

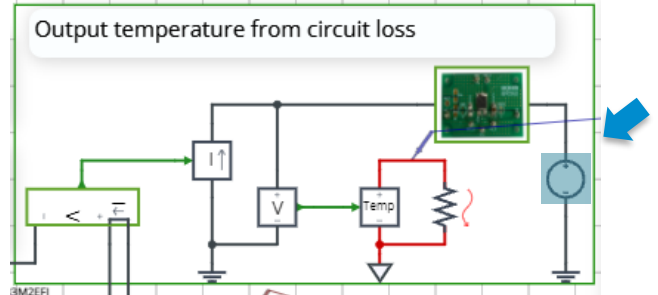


Figure 3. Definition of component parameters

Table 3. Simulation conditions

Parameters	Variable names	Initial values	Unit	Description
Temperature	Ta	20	°C	Ambient temperature

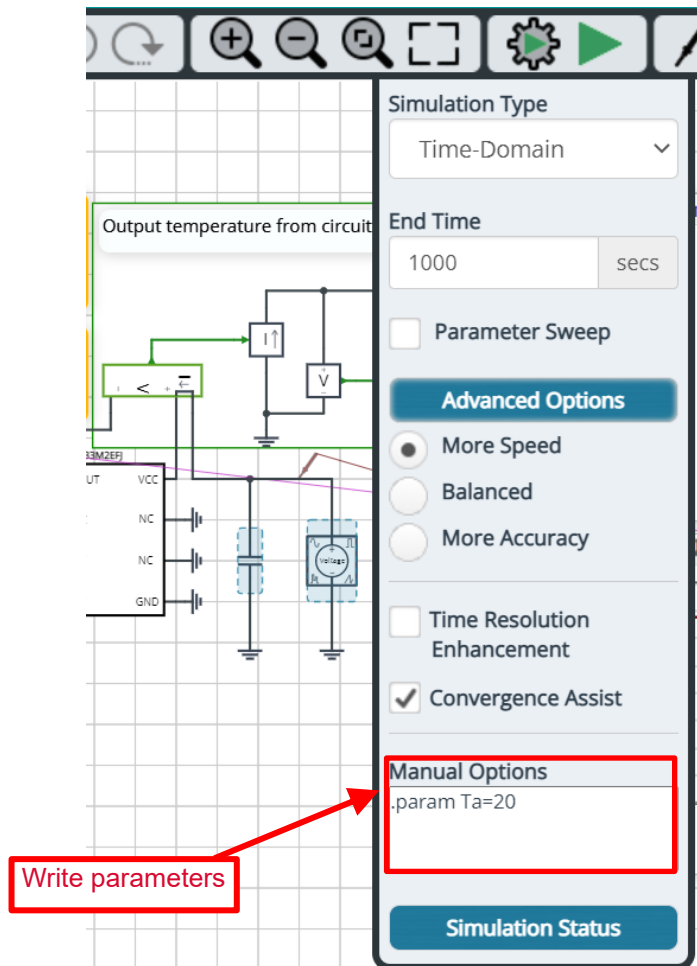


Figure 4. Definition of parameters

### 3.2 Thermal circuit

The “BD433M2EFJ” symbol in Figure 5 is the thermal simulation model of the linear regulator. Also, Table 4 shows the terminal description for this model. The nodes shown in red in Figure 5 (BD433M2EFJ\_TJ) can be used to check the temperature of the junction.

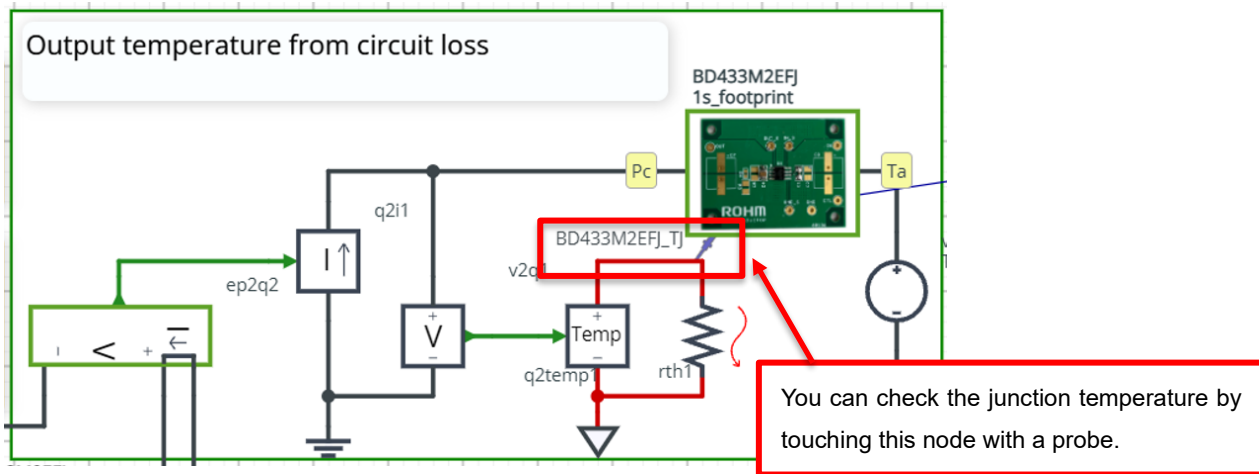


Figure 5. BD433M2EFJ-C thermal simulation model

Table 4. Terminal description of the thermal simulation model

Terminal name	Description
Pc	Input for linear regulator loss
Ta	Ambient temperature

### 3.3 Selecting a thermal simulation model

There are a number of thermal simulation models to choose from and their components are shown in Table 5. Figure 6 shows how to select one. First, right-click on the BD433M2EFJ component and select "Properties". In the "Property Editor", set the value of the "SpiceLib Part" to the name you selected from Table 5 to change the thermal simulation model. For more information on the board details for each model, see "3.4 Thermal simulation model board conditions".

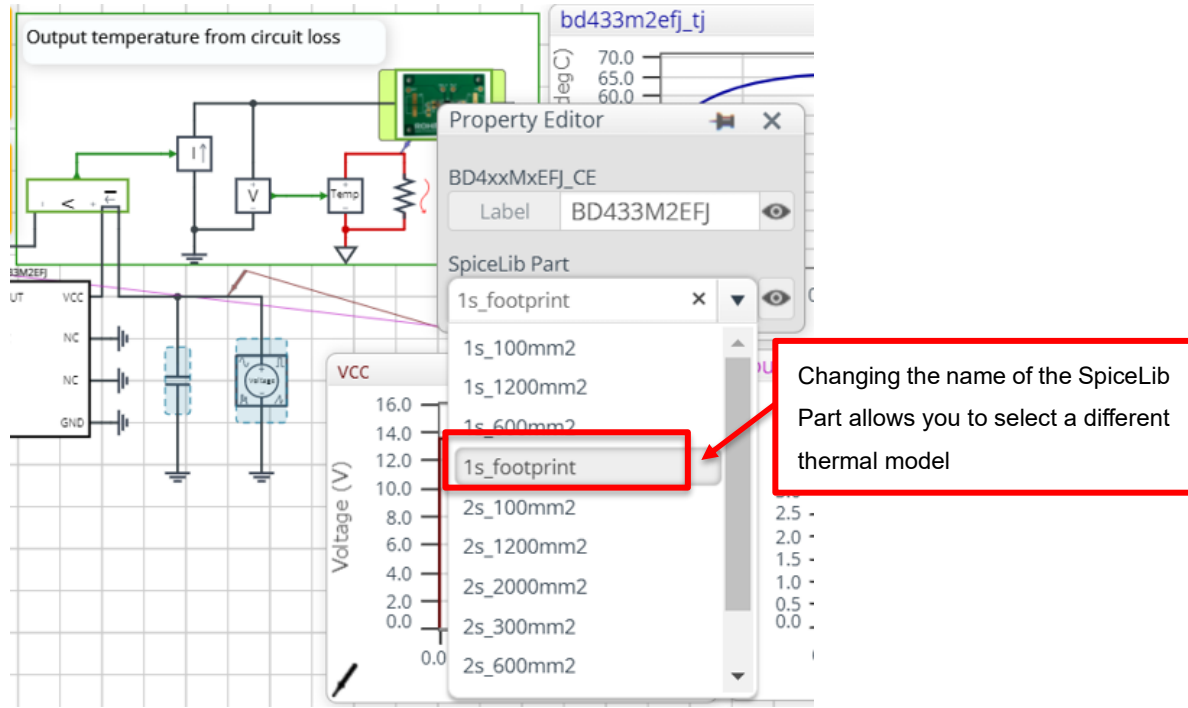


Figure 6. How to select a thermal simulation model

Table 5. List of available components

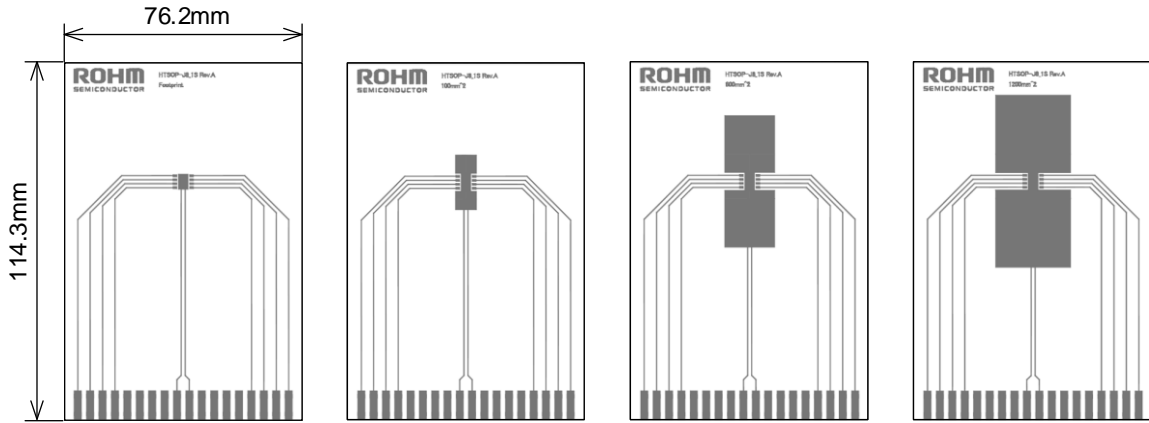
Component name	SpiceLib Part name	Description
BD433M2EFJ	1s_footprint	1-layer board, surface layer Footprint only
	1s_100mm2	1-layer board, surface layer copper foil surface area 100 mm <sup>2</sup>
	1s_600mm2	1-layer board, surface layer copper foil surface area 600 mm <sup>2</sup>
	1s_1200mm2	1-layer board, surface layer copper foil surface area 1,200 mm <sup>2</sup>
	2s_100mm2	2-layer board, surface layer Footprint only, back layer copper foil surface area 100 mm <sup>2</sup>
	2s_300mm2	2-layer board, surface layer Footprint only, back layer copper foil surface area 300 mm <sup>2</sup>
	2s_600mm2	2-layer board, surface layer Footprint only, back layer copper foil surface area 600 mm <sup>2</sup>
	2s_1200mm2	2-layer board, surface layer Footprint only, back layer copper foil surface area 1,200 mm <sup>2</sup>
	2s_2000mm2	2-layer board, surface layer Footprint only, back layer copper foil surface area 2,000 mm <sup>2</sup>
	2s_5500mm2	2-layer board, surface layer Footprint only, back layer copper foil surface area 5,500 mm <sup>2</sup>
	2s2p	4-layer board, surface layer Footprint only, other layers copper foil surface area 5,500 mm <sup>2</sup>

### 3.4 Thermal simulation model board conditions (BD4xxMxEFJ series)

BD4xxMxFP and BD4xxMxFP2 series have different board specifications. Please refer to the application notes listed in "4 Links to related documents".

#### 1 layer (1s)

Conforms to JEDEC standard JESD51-3



Copper foil area: 15.7mm<sup>2</sup>  
(Footprint)

100mm<sup>2</sup>

600mm<sup>2</sup>

1200mm<sup>2</sup>

Figure 7. Top Layer Trace

Table 6. 1 layer PCB specifications

Item	Value
Board thickness	1.57mm
Board outline dimensions	76.2mm × 114.3mm
Board material	FR-4
Trace thickness (Finished thickness)	70μm (2 oz)
Lead width	0.254mm
Copper foil area	Footprint, 100mm <sup>2</sup> , 600mm <sup>2</sup> , 1200mm <sup>2</sup>

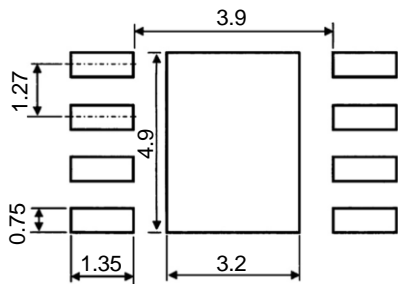


Figure 8. Footprint dimensions



Figure 9. Cross-section of 1 layer board

**2 layers (2s)**

Conforms to JEDEC standard JESD51-5, JESD51-7

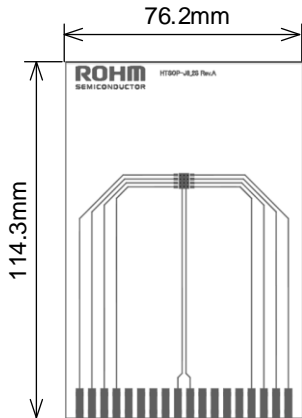
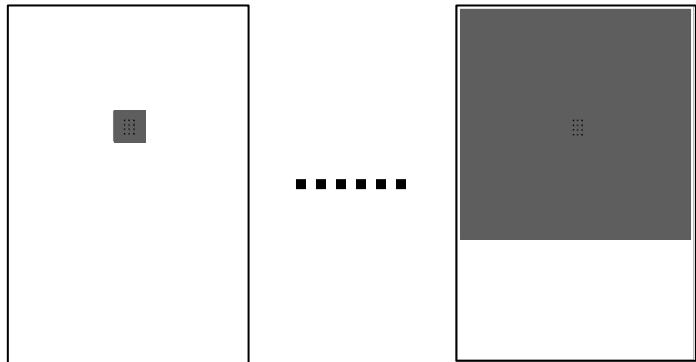


Figure 10. Top Layer Trace



Copper foil area: 100mm<sup>2</sup>

5500mm<sup>2</sup>

Figure 11. Bottom Layer Trace

Table 7. 2 layer PCB specifications

Item		Value
Board thickness		1.60mm
Board outline dimensions		76.2mm × 114.3mm
Board material		FR-4
Trace thickness (Finished thickness)	Top	70μm (2 oz)
	Bottom	70μm (2 oz)
Lead width		0.254mm
Copper foil area	Top	Footprint
	Bottom	100mm <sup>2</sup> , 300mm <sup>2</sup> , 600mm <sup>2</sup> , 1200mm <sup>2</sup> , 2000mm <sup>2</sup> , 5500mm <sup>2</sup>

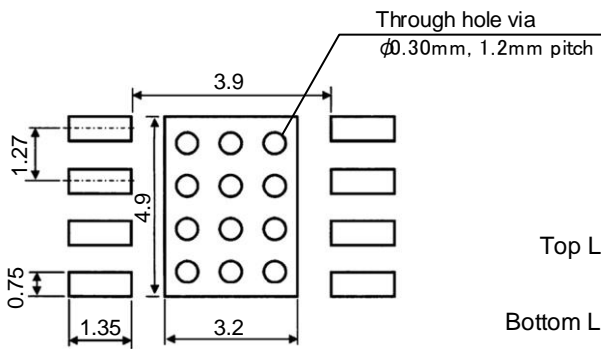


Figure 12. Footprint dimensions

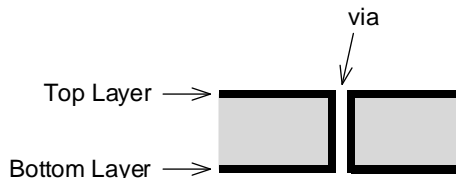


Figure 13. Cross-section of 2 layer board

4 layers (2s2p)

Conforms to JEDEC standard JESD51-5, JESD51-7

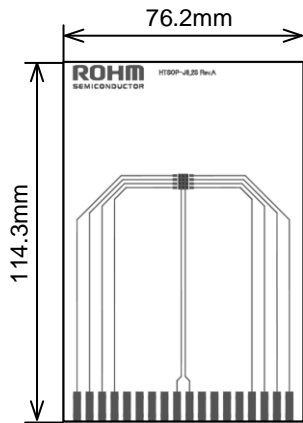


Figure 14.  
Top Layer Trace

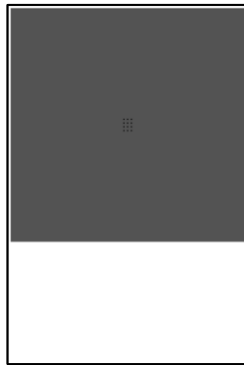


Figure 15.  
Middle 1 Layer Trace

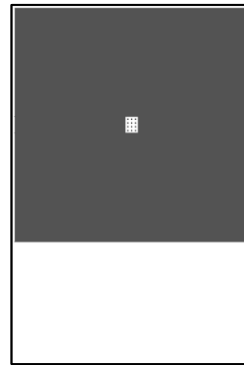


Figure 16.  
Middle 2 Layer Trace

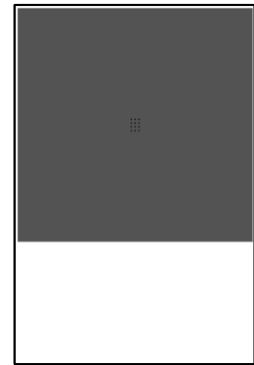


Figure 17.  
Bottom Layer Trace

Table 8. 4 layer PCB specifications

Item	Value	
Board thickness	1.60mm	
Board outline dimensions	76.2mm × 114.3mm	
Board material	FR-4	
Trace thickness (Finished thickness)	Top	70μm (2 oz)
	Middle 1	35μm (1 oz)
	Middle 2	35μm (1 oz)
	Bottom	70μm (2 oz)
Lead width	0.254mm	
Copper foil area	Top	Footprint
	Middle 1	5505mm <sup>2</sup> (74.2mm×74.2mm)
	Middle 2	5505mm <sup>2</sup> (74.2mm×74.2mm)
	Bottom	5505mm <sup>2</sup> (74.2mm×74.2mm)

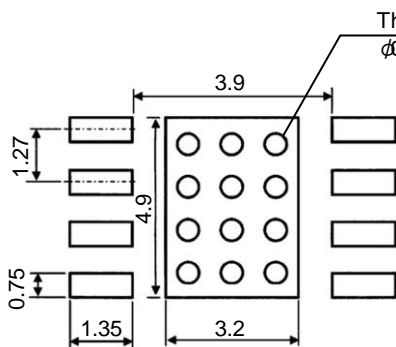


Figure 18. Footprint dimensions

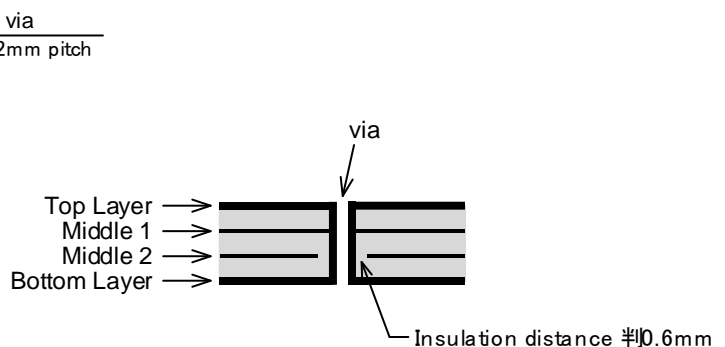


Figure 19. Cross-section of 4 layer board



## 4 Links to related documents

### 4.1 Products

[BD433M2EFJ-C](#)

[BD450M2EFJ-C](#)

[BD433M5FP-C](#)

[BD450M5FP-C](#)

[BD433M5FP2-C](#)

[BD450M5FP2-C](#)

### 4.2 Application Note

[BD4xxM2EFJ Series Thermal Resistance Application Note](#)

[BD4xxM5FP Series Thermal Resistance Application Note](#)

[BD4xxM5FP2 Series Thermal Resistance Application Note](#)

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