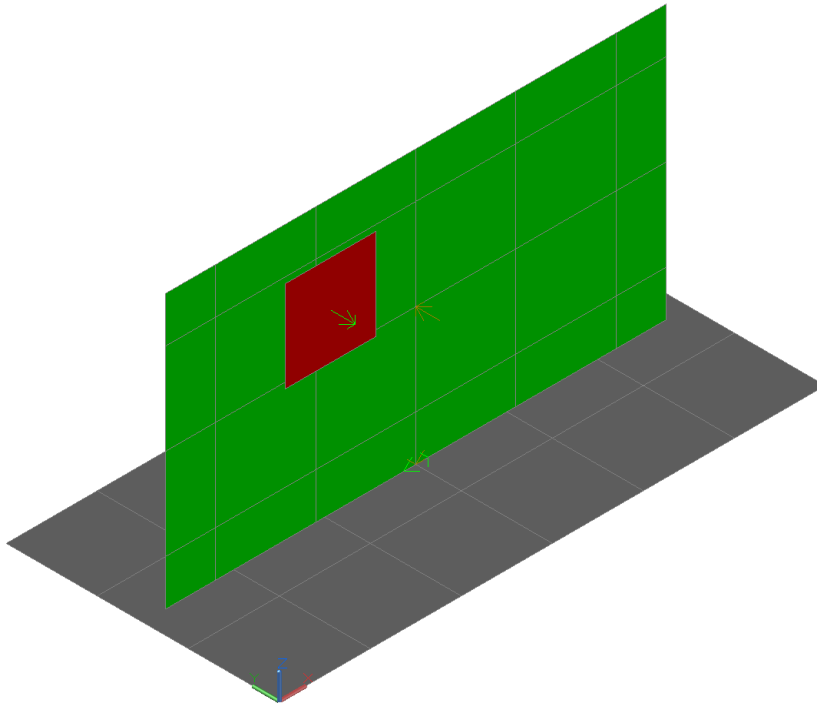


# Modeling a Circuit Board with Aggregate or Laminate Properties

This model starts with the completed Circuit Board tutorial. Copy the `board.dwg` file and the `TdThermo.tdp` file to a new folder (the new folder should be somewhere like My Documents or Desktop so the user has full read/write access). Open the new copy of `board.dwg`.



For this example, the circuit board is 1.59 mm thick with two 1-oz/ft<sup>2</sup> copper layers (35  $\mu$ m, each). The conductivity of the copper is 390 W/m $\cdot$ K and the FR-4 is 0.25 W/m $\cdot$ K. Using standard methods of combining the conductivities, the in-plane conductivity should be approximately 17.4 W/m $\cdot$ K and the through-thickness conductivity should be approximately 0.26 W/m $\cdot$ K.

Since the assumptions of this example are in SI units, the model units can be changed to SI.

1. Select **Thermal > Preferences**
2. On the **Units** tab, select the **SI** button in the **Reset Units To** region.
3. Select **OK**.

## Create Basic Properties – Copper

1. Open Thermophysical Properties (Thermal > Thermophysical Properties > Edit Property Data...)

Edit Thermophysical Properties

Current Thermophysical Property Database:  
TdThermo.tdp

New property to add:  Add

Name	Cond [W/m/K]	Dens [kg/m <sup>3</sup> ]	Cp [J/kg/K]	Eff Emiss	Type	Comment
Aluminum	237	2702	900			
chip	0	2000	837.32			
In 4 2 oz. copper	17.7	0	0			

Edit Delete Copy Rename Import OK Cancel Help

2. Type **copper** into the **New property to add** field and press <ENTER>.
3. Complete the **Edit Thermophysical Property – copper** dialog as shown below.
4. Select **OK**.

Edit Thermophysical Property - copper

Property: copper Set Color...

Comment: copper for conducting plane

Use Properties: Basic Properties for Material

Basic Thermoelectric Stress

Conductivity [W/m/K]

k 390 Edit Table... ☐ Use Table Pressure... ☐ Use Pressure Scale: 1

ky 1 Edit Table... ☐ Use Table Pressure... ☐ Use Pressure Scale: 1

kz 1 Edit Table... ☐ Use Table Pressure... ☐ Use Pressure Scale: 1

☒ Isotropic ☐ Anisotropic

Specific Heat [J/kg/K]

cp 385 Edit Table... ☐ Use Table Fusion... ☐ Use Fusion

Density [kg/m<sup>3</sup>]

rho 8933 Scale: 1

## Create Basic Properties – FR4

1. Type **FR4** into the **New property to add** field and press **<ENTER>**.
2. Complete the **Edit Thermophysical Property – FR4** dialog as shown.
3. Click **OK**.

**Edit Thermophysical Property - FR4**

Property: FR4 Set Color...

Comment:

Use Properties: Basic Properties for Material

**Basic** Thermoelectric Stress

**Conductivity [W/m/K]**

k	<input type="text" value="0.25"/>	<span>Edit Table...</span>	<input type="checkbox"/> Use Table	<span>Pressure...</span>	<input type="checkbox"/> Use Pressure	Scale: <input type="text" value="1"/>
ky	<input type="text" value="1"/>	<span>Edit Table...</span>	<input type="checkbox"/> Use Table	<span>Pressure...</span>	<input type="checkbox"/> Use Pressure	Scale: <input type="text" value="1"/>
kz	<input type="text" value="1"/>	<span>Edit Table...</span>	<input type="checkbox"/> Use Table	<span>Pressure...</span>	<input type="checkbox"/> Use Pressure	Scale: <input type="text" value="1"/>

☒ Isotropic  
☐ Anisotropic

**Specific Heat [J/kg/K]**

cp	<input type="text" value="1210"/>	<span>Edit Table...</span>	<input type="checkbox"/> Use Table	<span>Fusion...</span>	<input type="checkbox"/> Use Fusion
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**Density [kg/m^3]**

rho	<input type="text" value="1850"/>	Scale: <input type="text" value="1"/>
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## Create Laminate Property

1. Type **Laminate Circuit Board – 2 copper planes** into the **New property to add** field and press <ENTER>.
2. Select **Laminate** from the **Use Properties** drop-down.
3. Increase the **Number of Layers** field to **2** using the arrows.
4. Beside **Layer 1**, choose **copper** for the **Material**.
5. Under **Thickness**, enter **7e-5**.
6. Beside **Layer 2**, choose **FR4** for the **Material**.
7. Under **Thickness**, enter **0.00152** (0.00159 – 7e-5).
8. Verify the conductivity values by switching to the **Basic** tab.
9. Select **OK**.

Property: Laminate Circuit Board

Comment: laminate from copper and FR4

Use Properties: Laminate

Basic | Laminate

Number of Layers: 2

	Material	Orientation Angle [Degrees]	Thickness [m]
Layer 1	copper	0.	7e-5
Layer 2	FR4	0.	0.00152

OK Cancel Help

Property: Laminate Circuit Board

Comment: laminate from copper and FR4

Use Properties: Laminate

Basic | Laminate

Conductivity [W/m/K]

$k_x/k_u$	17.4088	Edit Table...	<input type="checkbox"/> Use Table	Pressure...	<input type="checkbox"/> Use Pressure	Scale: 1
$k_y/k_v$	17.4088	Edit Table...	<input type="checkbox"/> Use Table	Pressure...	<input type="checkbox"/> Use Pressure	Scale: 1
$k_z/k_w$	0.261505	Edit Table...	<input type="checkbox"/> Use Table	Pressure...	<input type="checkbox"/> Use Pressure	Scale: 1

☐ Isotropic  
☒ Anisotropic

The equivalent orientation angle for the laminate is 0.

## Create Aggregate Property

Aggregate materials can be used to create laminates since materials can be arranged in parallel or series in the primary directions. Instead of layer thicknesses, the user must provide volume fraction.

1. Type **Aggregate Circuit Board – 2 copper planes** into the **New property to add** field and press <ENTER>.
2. Select **Aggregate** from the **Use Properties** drop-down.
3. Increase the **Number of Materials** field to **2** using the arrows.
4. Type **1** for **Kx scaling** and **Ky scaling** (the materials are parallel)
5. Type **0** for **Kz scaling** (the materials are in series)
6. Beside **Layer 1**, choose **copper** for the **Material**.
7. Under **Volume Fraction**, enter **0.044** (7 $\mu$ m/1.59mm).
8. Beside **Layer 2**, choose **FR4** for the **Material**.
9. Under **Volume Fraction**, enter **0.956**.
10. Verify the conductivity values by switching to the **Basic** tab.
11. Select **OK**.

Property: Aggregate Circuit Board - 2 copper planes Set Color...

Comment:

Use Properties: Aggregate ☐ Override Conductivity Calcs ☐ Override Specific Heat/Density Calcs

Basic Aggregate

Number of materials: 2 Weight Properties: Volume

Scaling factor from Serial to Parallel Conductivity

Kx scaling: 1 Ky scaling: 1 Kz scaling: 0

	Material	Volume Fraction (Sum to 1.)
Material 1	copper	0.044
Material 2	FR4	0.956

OK Cancel Help

Edit Thermophysical Property - Aggregate Circuit Board - 2 copper planes

Property: Aggregate Circuit Board - 2 copper planes

Comment:

Use Properties: Aggregate ☐ Override Conductivity Calcs ☐ Override Specific Heat/Density C

Basic **Aggregate**

Conductivity [W/m/K]

kx/ky 17.399

ky/kv 17.399

kz/kw 0.261499

☐ Use Table  ☐ Use Pressure Scale:

☐ Use Table  ☐ Use Pressure Scale:

☐ Use Table  ☐ Use Pressure Scale:

☐ Isotropic ☒ Anisotropic

## Create a property alias

A property alias allows switching between multiple materials from case to case. Using an alias, you can run cases with each of the material definitions and compare the results.

1. Expand Common panel and select Thermophysical Property Alias.
2. Click Add.
3. Type **alias Circuit Board** for Alias Name and select one of the following properties for Select Property:
  - Aggregate Circuit Board – 2 copper planes
  - Fr4 2 oz copper
  - Laminate Circuit Board – 2 copper planes

## Apply the property alias

Property aliases are applied just like materials.

1. Edit the green circuit board.
2. On the **Cond/Cap** tab, select **alias Circuit Board** for **Material**.

**Note:** Placing the cursor over the Material name will show which material the alias is currently referencing.

## Overriding a Property Alias in a Case Set

Each case set can have its own assignment of materials to aliases.

**Note:** This model will require a boundary node and conductor from the boundary to a surface to run. If you wish to run the model, you must add those items.

1. Edit a case set.
2. On the Props tab, click Alias under Thermophysical Properties
3. Double-click the alias to assign. You can double-click in either column.
4. Choose the material to use for the case set.

**Note:** The Alias button will contain an asterisk (\*) if an alias is set in the Alias Override window.

## Closing the model

The tutorial is complete. You may close the model with or without saving.