HyperLynx Thermal User Manual

Software Version 9.0

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Chapter 1
Getting Started with HyperLynx Thermal

Use HyperLynx Thermal to analyze board-level thermal problems on placed, partially routed, or fully routed PCB designs from all popular PCB layout environments.

Temperature profiles, gradients, and excess temperature maps enable you to resolve board and component overheating early in the design process.

This section contains the following topics:

HyperLynx Thermal Basics

This section contains the following:

Product Overview

HyperLynx Thermal performs a detailed analysis of the air convection from the pins and the thermal conduction through component sides, pins and the bottom air gap to the board. Flow conditions used can be forced or can be by natural convection. The natural convective flow is always calculated. In all cases, the total flow velocity is the combined result of natural convective flow and the forced flow.

The board is very important in conducting heat among components and to the air. The heat transfer properties of the board are evaluated by considering all of the layers of materials across the board thickness. The layers considered are the copper wires and the base board material (which may be epoxy or some other, similar, material).

Environment conditions must be controlled to perform an accurate thermal analysis of a PCB design. The air velocity, air inlet temperature, and board-to-board spacing all influence the thermal performance of a designed board significantly. You may change these environment conditions to achieve the desired results.

Stand Alone Use

HyperLynx Thermal can be used without an imported board. You can make your own board, and place your own components about the board. Boards with 20 to 30 components take very little time at all. For some more in-depth explanation and hands on demonstrations, see "Creating a New Board" on page 14.

Use With Interfaced File

You can import a board from an external interface from the **File > Import** menu. The board placement file will be extracted through the ECAD interface program, and will automatically be loaded into HyperLynx Thermal when the file is opened. Set the operating environment in the Environment Condition Definition Dialog Box. Also specify the board properties in the Board Property Definition Dialog Box.

Review all of your components in the Edit Working Library Dialog Box for correct powers and other entries. Power can be imported from a text file, or entered manually. Now you can run the analysis and check the results.

Starting HyperLynx Thermal

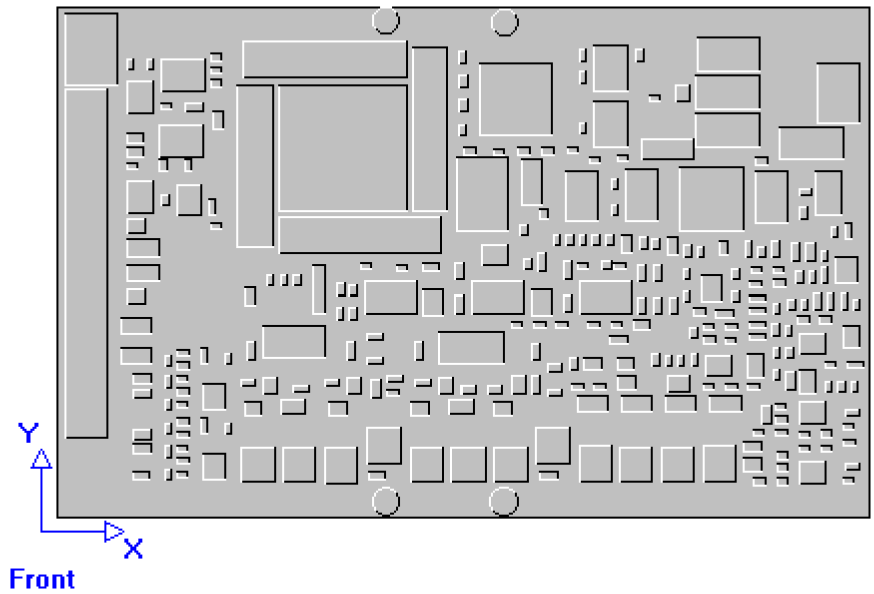
You can create your own design from scratch, open an existing design, or import a design from an ECAD interface. Once you save your design inside HyperLynx Thermal, it will have a .HLT extension.

- To open an existing .HLT design, choose **File** > **Open**.
- To import a board that was created in another environment, choose **File > Import > IDF Interface** (see "Importing a Design" on page 19).
- To create a board from scratch, choose **File** > **New** (see "Creating a New Board" on page 14).

Navigating HyperLynx Thermal

This example goes through the basic usage of HyperLynx Thermal.

1. Open HyperLynx Thermal.
2. Choose **File** > **Open** and open a board, if you don't have a board, select Help > **Sample Design**.



Note

You can also change Units and Temperature Scale from the File Menu.

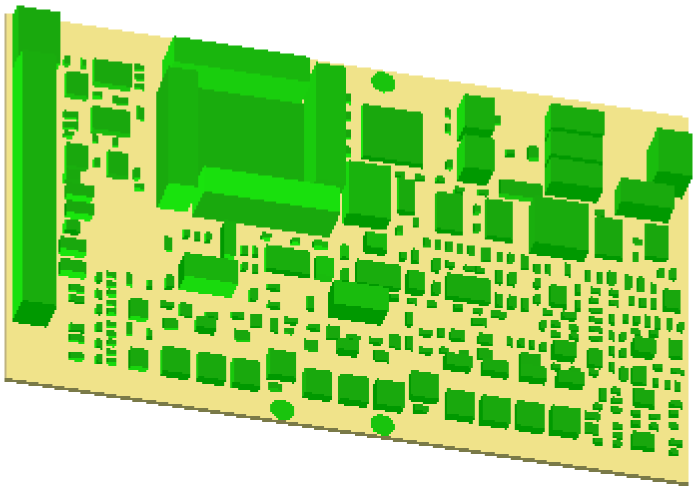
3. Choose **View** > **Side** > **Back Side**. Notice that there is another set of components on the back side of the board.

Note

The View Menu also lets you select different layers in the design.

4. Choose **View** > **Side** > **Front Side** to return to the front view of the board. You can also click

5. Click . As you move your mouse around the viewing window, the board will rotate around in 3 dimensions.



6. Right-click on the board to lock the board in place.

7. Choose **View** > **Reset** to set the board back to its original position. Notice the bottom of the screen shows the x and y coordinates on the location at the tip of the arrow, the number of components on that side of the board, and the total power dissipation for this side of the board.

8. Choose **View** > **Power** or click .This view shows the power of each component. All of the analysis output views are available from the View Menu and the toolbar.

9. Click . This highlights the components that will have a specific refined output in the .loc file.

10. Click . This shows the component temperature.

11. Click .This shows the excess component temperature - the amount by which the component is exceeding its maximum temperature.

12. Click . This shows a thermal map of the temperature of the board.

13. Click . This shows the thermal gradients on the board. This view is especially useful for locating stress points in the board, which can lead to board warpage or cracking.

14. Choose **Library** > **Master**. This opens the Master Library.

    The master library contains thousands of components with their pertinent parameters. You can add new components by parameter. The **Copy** command allows you to copy a component under a different name while keeping the same parameters, and **Edit** lets you change the parameters. **Save to disk** saves your updated library on the hard drive.

15. To close the Master Library, click **OK**.

16. Choose **Library** > **Working**.

The working library contains the components on your board and operates like the master library. They fully interact together, and you can shuffle components back and forth between them. Update from Master matches your board's components with similar ones in the master library and sets their parameters accordingly. The conductivity of most materials is stored in the material library. The material library is also accessible from several screens that require conductivity information of materials.

17. To close the working library, click **OK**.
18. Choose **Board** > **Property**. This opens the Board Property Definition Dialog Box.

    The Board Property Definition dialog box allows you to change layer thicknesses and conductivities of your board.

    Choosing **Board** > **Local Property** lets you create areas of greater metal volume (such as with thermal vias) on a per-layer basis.

    Choosing **Board** > **Cut out** or **Trim corner** let you change the shape of the board.
19. Click OK.
20. Click the **Placement** menu. You will notice that this allows for the placement of components on the board, as well as heat sinks, heat pipes, and screws, which can be selected from the drop-down box in the toolbar. To move a placed component, click on the component, hold down the mouse button, and drag the component to a new location.
21. Right-click a component in the board. This opens the Component Properties Dialog Box.

    The component reference designator, part name, location, power, and temperature are all listed in the component information.

    You can edit the part model for a component on the fly in the component info section by clicking **Edit this part**.
22. From the Component Properties dialog box, click **Edit this part**. In the Edit part dialog box, all the dimensions and thermal properties of the component are listed and can be edited.
23. To close both dialog boxes, click **OK**.
24. Choose **Environment** > **Condition**. This opens the Environment Condition Definition Dialog Box.

    The Environment Condition window lets you set up the environment in which the board is placed. You can set up whether or not the board is placed in a case, as well as the surrounding air. You can also set up boundary conditions to simulate other edge-connected components which might affect the thermal properties of the board, such as a wedge lock or sink.
25. Click **OK**.

You have now been familiarized with all of the required setup for performing a thermal analysis on a board using HyperLynx Thermal. Should you wish to perform the analysis at this point, you would simply choose **Run** from the **Analyze** menu. Since the analysis has already been performed on CARD.INP.HLT, that is not necessary.

Creating a New Board

1. From the menu area, choose **FILE** > **NEW**.
2. To define the board size and properties, choose **BOARD** > **Property**. Enter your board size, thickness, layer thickness and conductivity. The values shown previously are default values.
3. Before adding components to a board, you must add components to the Working library. Choose **Library** >**Working**, this opens the Working Library.
    - From the Master Library area, choose the components you wish to add to the Working Library and click >> to bring them over to the working library.
    - To add your own components, click **Add by parameters** and enter the parameters directly.
4. You have a board and components, now the components need to be placed on the board. To place a component, pick a component from working library toolbar, choose **Placement** > Component and place with the left mouse button or by entering coordinates directly.

Note

You can add components, heat sinks, thermal screws, and heat pipes from the Placement Menu. You can place the object anywhere you like or as many times as you like.

5. To add components to the back side of the board, from the View Menu, choose **Side > Back Side** and add components.
6. When finished, choose **File** > **SAVE AS**, and name your board.

Related Topics

"Preparing a Board for Thermal Analysis" on page 15

"Performing Thermal Analysis and Reviewing the Results" on page 17

Preparing a Board for Thermal Analysis

To prepare you board for thermal analysis, you must specify board properties, setup the operating environment, specify boundary conditions, and review components in the working library for correct powers and other properties.

To configure a board for thermal analysis:

1. Open the board.
2. Set your Units and temperature Scale from the **File** menu. For more in depth information see the “File Menu” on page 55.

Note

The bottom right of the screen shows the x and y coordinates for the location at the tip of the arrow, the number of components on that side of the board, and the total power dissipation for this side of the board.

3. Choose **Board** > **Property** (or right-click anywhere on the board). This opens the Board Property Definition Dialog Box. Define the following:
   - Maximum board dimensions
   - Thickness of layers
   - Conductivity of layers
   - Metal volume fraction, see “Metal Volume Fraction in Boards” on page 29
   - Default component casing limit
   - Default component junction limit

Note

You can also specify board information for each layer by choosing a layer from the View menu (**View > Layer > Layer #**) and choosing **Board** > **Property**. Then choose the layer you are defining properties for from the **Layer** pull-down menu in the Board Property Definition Dialog Box.

4. For each component, right-click to open the Component Properties Dialog Box and specify component properties. Note that to modify the power dissipation for a placed component, you must specify an Input power scaling factor.
5. To setup the operating environment, choose **Environment** > **Condition** or click . This opens the Environment Condition Definition Dialog Box.

   There are many different set up options for the environment conditions. The important Parameters are:

- **Incoming Air Temperature (open), or Initial Temperature of Iteration (close) –** For an open system, this is the incoming air temperature. For closed system, this is the initial temperature of the iteration. If an analysis gives a result, the averaged temperature of board can be estimated. To ensure a better result, user should set the initial iteration temperature the same as the evaluated average board temperature such that effective convergence will occur.
- **Air Pressure & Gravity –** usually default value are sufficient
- **Accuracy control –** should always be set to .01 or lower (.001)
- **Air comes from –** direction the airflow is coming from
- **Board Location In rack** (with boards on both sides), single board (casing walls on both sides), or right (left) of rack (board on one side and case wall on the other)
- **Board Placed –** Horizontal or Vertical orientation
- **System –** either open (air flow) or closed (no air flow)
- **Board Spacing –** spacing to adjacent board or case wall on either side of the board
- **Adjacent board emissivities –** the emissivities of the adjacent boards or walls are important for radiation heat transfer. Low values (0.1-0.3) for polished metals, higher values (0.6-0.9) for organic surfaces, and the oxidized metal surface is close to organic materials.
- **Adjacent board power dissipation –** If In rack, Right or Left of Rack input adjacent board power
- **Temperature of Case wall –** The adjacent wall temperatures. This parameter can also be used in place of **Adjacent board power dissipation** if the temperature of the adjacent board(s) is known.
- **Incoming Air Velocity –** Velocity at leading edge of the board for each side. These are very important in a commercial type of application for open systems cooled with airflow. If the systems are sealed closed, there will be no airflow and this setting should be 0.0.

6. To define thermal boundary conditions at the edges of your board, choose **Environment** > Boundary.

    a. Click twice to select beginning and ending boundary coordinates for an edge of your board, this opens the Boundary Condition Definition Dialog Box.

    b. Enter Thermal parameter values and click **OK**.

Note

Boundary conditions are very important when you are analyzing a sealed (closed) system. For a sealed system, cooling is usually provided at the edges of the board. Without some mechanism for dissipating heat, the board will usually reach unacceptably high temperatures due to ineffective thermal radiation. This is a frequently happened error when user model a closed system but without addressing where the heat goes away from the board eventually. The coordinates of the boundary condition sink temperature, and the thermal resistance all need to be set here. For more information, see "Specifying Boundary Conditions" on page 72. If you are modeling an open system, you may not need to specify boundary conditions.

Performing Thermal Analysis and Reviewing the Results

1. To analyze the board, choose **Analyze** > **Run** or click . After the analysis completes, the board becomes colored to show board temperature and a color scale displays on the left hand side of the screen.

   To manually display the temperature at each location on the board, choose **View** > **Board Temperature** or click .

2. To display the power of each component, choose **View > Power** or click . The color scale will change to reflect Power.

3. To view the temperature for each component, choose **View** > **Component Temperature**.

4. To view the numerical analysis results, choose **Analyze** > **Numerical output**.

Note

For a complete list of analysis options, see "View Menu" on page 57.

For a list of modeling techniques that you can apply to decrease the thermal output of your board, see "Advanced Modeling" on page 33.

Tips on using HyperLynx Thermal

1. Be sure to look through the HyperLynx Thermal Menus, HyperLynx Thermal Dialog Boxes, and Critical Parameters chapters in the documentation if you have any trouble.

2. Pay attention to the critical parameters such as: Power Dissipation, THETAjc - Junction to Casing Thermal Resistance, Metal Volume Fraction in Boards, Air Flow / Temperature at Boundary, etc.

3. Make sure all components are placed inside the board outline. For details regarding what occurs when components are placed outside the board outline, see Analysis of Components Placed Outside the Board Outline.
4. Review the Advanced Modeling chapter to see if you handled design variations correctly.
5. Be sure to glance over the parameters for your main components in the Working Library, (see the “Edit Working Library Dialog Box” on page 81), to make sure everything is correct.
    - Verify the pin number and dimensions for your hot components.
6. Periodically save your file while working on it.

Chapter 2
Importing and Setting up a Board

This section contains the following topics:

The Expedition PCB Interface to HyperLynx Thermal

You can export designs directly from Expedition PCB to HyperLynx Thermal. The Expedition PCB interface to HyperLynx Thermal is embedded in the Expedition software. No additional files are necessary.

1. From Expedition, open the printed circuit board that you want to translate to HyperLynx Thermal.
2. Select **Analysis > Export to HyperLynx Thermal**.

   This opens HyperLynx Thermal and loads the exported design.

The interface will create a HLT file in the PCB folder for that particular design. You can open the HLT file from the **File** > **Open** menu in HyperLynx Thermal.

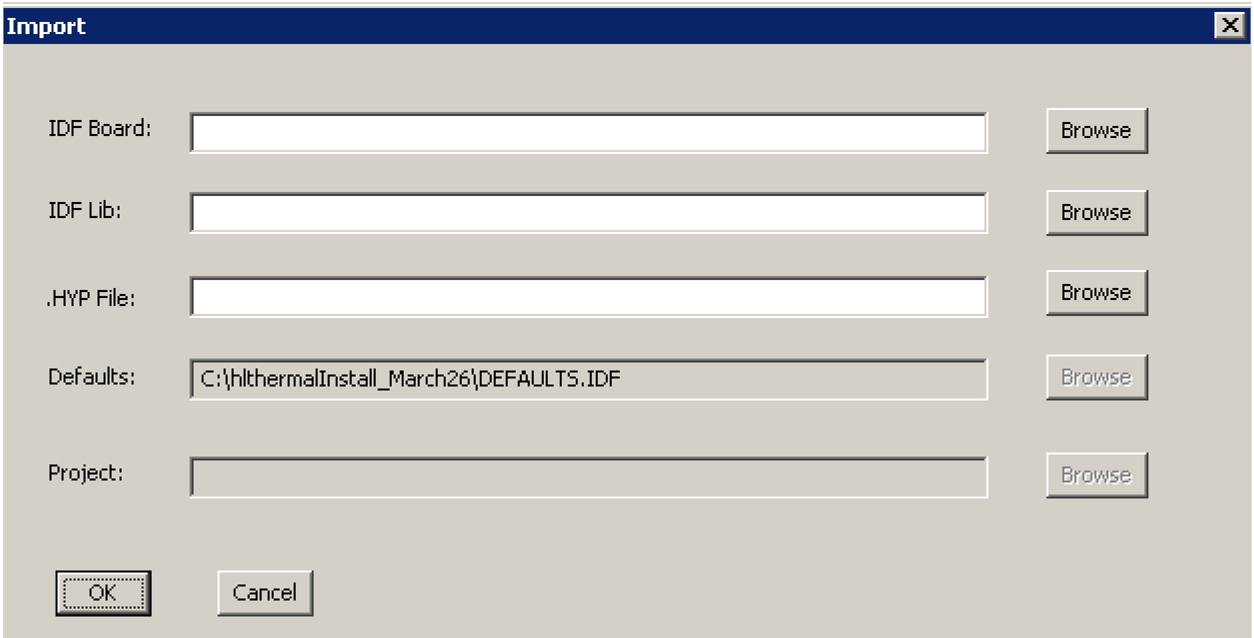
Importing a Design

This section explains how to import a design using the **File** > **Import** > **IDF Interface** menu in HyperLynx Thermal.

The IDF Interface into HyperLynx Thermal

This interface is compatible with any ECAD/MCAD placement software that will export two IDF files (a board file and a library file). For example, Expedition, Board Station, OrCAD, Allegro, Pro-E and CR 5000 all have an IDF output available.

1. To initiate the import, select **File** > **Import** > **IDF Interface**. This opens the Import dialog box.



2. Enter the path for or browse to you IDF Board, the library will be added automatically. This imports the board information.
3. Optionally, select a HYP File. This imports the stackup, trace, and plane information for the board. This option also enables the tool to automatically calculate the Metal Volume Fraction based on the actual copper that is in the board.
4. Click **OK**.
5. The design will open in HyperLynx Thermal and a HLT file will be created in the directory where HyperLynx Thermal resides.

Preparing an Interfaced Case for Analysis

Once you are in HyperLynx Thermal, you want to check briefly for any possible overlapping of the components due to any possible imperfection of the CAD Interface.

Some parameters needed for thermal analysis but not available in the ECAD placement file may be still at the default values. Go to **Library** > **Working** to review each component and set their powers (or import the power from ASCII file as shown in the next section of help) before you run the ANALYSIS for preliminary thermal results. You may edit the thermal resistance and other parameters such as height, pin dimensions and air gaps etc. at the same time.

Importing a Power file

Once a file is imported from the CAD interface, the power dissipation of each component can be entered manually in the working library or it can be imported using a text file. This section describes the format of the text file that may import power dissipation into HyperLynx Thermal as well as the import procedure.

1. Create a file using DOS Edit, Word, WordPad or another software that generates text files. This file is of a free format.
2. Power can be imported using the component partname and/or the reference designator. The first line of the text document should read, **Component**. Click **Enter** or, you can leave a space then put your own note following the word **Component** on this first line.
3. The lines following the **Component** line should have the component partname followed by the power dissipation in watts. Each component should have its own line. After you have entered every component, click **Enter**. The power of these components will come into the Working Library of this board when the file is imported.

Note

Components of the same part type must have the same power dissipation.

4. You may now enter power by reference designator. The first line following the partnames should read, **Reference**. Again, you may add your own comments on the remainder of this line.
5. Each line after that should contain the reference designator followed by its power in watts. This information will come into the power factor of each component with respect to the nominal power stated in the Working Library.

   Here is an example of how your text file should look:

Component	
4077B	100
74150DW	5
7476	2
R1/4W	50
Reference	
B1	100
G1	100
K1	100
M1	100

R1	100
RF1	100

6. Once the text file is complete, choose **File** > **Import** > **Power read in**.
7. Locate the file that you created and click **Open**.
8. The power dissipations should be entered to update each component.

Chapter 3
Library Names, Units, and Files

This section contains the following topics:

Component Naming Guidelines

The total capacity of the Master library is unlimited and there are already 2,500 components provided. Notice: all names are not Case sensitive. (All Upper Cases.) Followings are the standard naming guidelines. Typical JDEC name are used in Library.

Package Types

Although there could be thousands of components used in your design, there are only a few hundred component shapes.

DEFAULT
The default shape geometry

CBGA
The ceramic Ball Grid Array

CDIP
Ceramic Dual-In-line Package

CLCC
Ceramic Leadless Chip Carrier

CLDCC
Ceramic Leaded Chip Carrier

CPGA
Ceramic Pin Grid Array

PDIP
Plastic Dual-In-line Package

PLCC
Plastic Leadless Chip Carrier

PPGA
Plastic Pin Grid Array

PQFP
Plastic Quad Flat Pack

Rxxx
Resistor, through hole, xxx Watt

SIP
Single-In-line Package

SO
Small Outline package

TO-xxx
TO package of metal caps

Part Name Suffixes

JDEC names are used generally. Component names have all upper case letters (no differentiation of upper or lower case names). Suffixes are usually only applied to surface mount components. The suffix is not used if the component is of a conventional DIP component.

The typical suffixes are:

- D or DW
- Small Outline
- FK
- Chip Carrier, Flat Pack
- FN
- PLCC

Prefixes

The names of logic devices all begin with the number 74. To insure uniformity, 74 always substitutes a prefix of 54.

A single entry represents both the military and commercial versions of each component or package. This is because both military and commercial packages share the same dimensions and power dissipation rates.

For standard CMOS components, the symbols are named 4081 without using manufacturer-specific prefix names.

Microprocessors

For microprocessors or microcomputers, the starting prefix of the component is frequently 68, 80, etc. This is enough information to identify specific microprocessors.

Units

The parameters in the HyperLynx Thermal can be Mixed or SI units, at your option. Watts and degree C are always used, even though the English units are used elsewhere in the Mixed Unit situation.

Table 3-1. Parameter Units

Parameter	**Mixed Units**	**SI Units**
Length	inch	mm
Velocity	ft/min	mm/s
Pressure	atm.	mmHg.
Comp. Power	Watt	Watt
THETA	^{o}C/Watt	^{o}C/Watt

Table 3-2. Boundary Condition Units

Parameter	**Mixed Units**	**SI Units**
Thermal Resistance at Edge	^{o}Cin/W	^{o}Cmm/W
Temp of Sink	^{o}C	^{o}C

Conversion of Units

1 F	=	5.0/9.0 C
N F	=	(N-32.0)*5.0/9.0 C
1 mm	=	0.03937 inch
1 m/s	=	1000 mm/s
1 m/s	=	196.8 ft/min
1 mHg	=	1000 mmHg
1 mHg	=	1.32 atm
1 W/m	=	0.001 W/mm
1 W/m	=	1.0403 BTU/hrft
1 W/mC	=	0.001 W/mmC
1 W/mC	=	0.0254 W/inC

Files

For you to check or maintain your files, the following are the suffixes to your file names.

.HLT - output file for HyperLynx Thermal

.HYP - input file for importing stackup and board copper (traces and planes) information (optional)

.INP - input file of component placement, (optional, old format)

.GRF - output file of graphical output

.OUT - output file of numerical output for records.

.PWR – power import text file (optional)

.LOC - output file of Refined components. (if exists)

.RVW – output file that displays the iterations of the analysis. This file is useful in reading the error message should your analysis crash.

Note

For backwards compatibility, HyperLynx Thermal supports the .INP, .INL, .INB, and .INT file formats.

Chapter 4
Critical Parameters

There are several parameters that can drastically effect results, please go through each and make sure they are set correctly.

This section contains the following topics:

Metal Volume Fraction in Boards

HyperLynx Thermal requires that the Metal Volume Fraction in your board must be specified in order to facilitate accurate calculations throughout the analysis. Approximations will be made, especially before the routing is conducted. The thermal Conductivity of metal (for example copper) in the board is 100 times more than that of the non-metal (for example epoxy). For conventional PCB, a change of 1% Metal Volume Fraction in the Board-Properties menu will affect the results significantly. Beyond 10% MVF, the marginal effects are small. A typical board of 0.064 inch thickness, 1 oz. copper is equivalent to about 2% MVF.

Note

If you import a HYP file with your board, HyperLynx Thermal will calculate the MVF for the board based on the actual copper that is in the board.

Air Flow / Temperature at Boundary

When air convection is strong, heat leaves a component mainly by direct convection to the air. The major input parameters are the velocity of forced air approaching the board, air direction, and incoming air temperature in the Environment Condition Definition Dialog Box. (A typical ratio of heat flow by direct convection to air, conduction to the board, and radiation to surroundings, is 70 to 25 to 5. When only the natural convection occurs, this ratio may typically be 40 to 40 to 20.) For conduction to board edges, the major inputs are the sink temperature and thermal resistance between the sink and the board edge in the Boundary Condition Definition Dialog Box. For a closed system, if there are no specifications of edge cooling or thermal screw cooling, the only heat released will be radiation. In this case, the board could be excessively hot. Therefore, it is important to specify the cooling path for a closed system.

Power Dissipation

The power dissipation of two types of components is the most critical. They are the ones with high power and those of small sizes. The former ones give off much heat and could be very hot, the latter ones have high power per surface area and also can be very hot. If electronic simulation is made on the board, the accurate power can be obtained easily. It is desirable to import the power of components through **File** > **Import** menu with a text file generated by user. Otherwise, estimated maximum power can be made through the Edit Master Library Dialog Box, data book or by experience. For large boards, it is reasonable to only find accurate power of components in areas showing high temperatures through first cut analysis.

Pin Dimensions / Component Height

For those components whose temperatures are high after the first analysis, it is suggested to review their pin dimensions and conductivity in the Working library for better accuracy. Also, the air gap under the component may be checked. The less the convective cooling, the more the importance of these parameters due to the significant conduction to the board.

The component height is important when strong convection occurs because the air from the free stream will likely hit on the tall component. In this situation the heat transfer coefficient is high and the free stream temperature is low.

THETAjc - Junction to Casing Thermal Resistance

To get a correct junction temperature, you need a correct power and THETAjc. THETAjc means the thermal resistance between the component junction to casing. This value can be obtained from the manufacturer of the component. This is dependent on the particular package shapes of a component. Also plastic and ceramic packages make a significant difference. Notice that the accuracy of THETAjc will affect the junction temperature but will not affect the calculated Casing temperature of component.

THETAsa - Sink to Air Thermal Resistance

This input is necessary if a heat sink is added to component. THETAsa is the thermal resistance between a heat sink and the air when the heat sink is applied to a component and should be provided by the manufacturer of the heat sink. The THETAsa value is a function of air velocity, usually provided by the manufacturer of the heat sink. The values at 3 ft/sec and the value at 10 ft/sec should be entered in the Working library. HyperLynx Thermal does conversions for other air velocities automatically during analysis.

Chapter 5
Advanced Modeling

This section contains the following topics:

Decreasing the Thermal Output of a Component

The following topics discuss ways to decrease the thermal output of a component on a board:

Relocating Overheated Components

If you do not intend to add heat sinks or conduction pads, an alternative solution is to relocate the very hot components.

To move a hot component:

1. Double-click on the component and drag the mouse to the new location.
2. You may move other components to better locations.

3. When you are finished, re-run the analysis to find the new temperature distribution.

Conduction Pads

One way to help cool a component is to put conduction pads between the component and the board.

To prepare for this input:

- Go to the Edit Working Library Dialog Box and enter the conductivity of the material inserted in the gap.

Heat Sink

Another way to help cool a component is to place heat sinks near the component. The term "heatsink" is used very generally in the electronics industry referring to anything from wedgelocks to heat spreaders to finned heatsinks. In HyperLynx Thermal, the term "heatsink" refers only to the finned heatsink.

To add a heat sink to a board:

1. Go to the Edit Working Library Dialog Box (Library > Working).
2. Enter the heat sink specifications into the Wokring Library.
   a. Enter values for THETAsa, dimensions, and percent of effective height for that particular sink.
   b. If an extruded-fin heat sink is oriented parallel to the air flow, the effective height of the fins should be about 50 to 70 percent of the fin height, depending upon whether the fins are spaced densely or loosely.
   c. For a pin-fin sink, the effective height of the pins depends upon whether the pins are in-line or staggered with respect to the flow stream. For total blockage of air flow, set to 1.0,
3. To place a heat sink, select **Placement** > **Heat Sink**.

Note
You must place your heat sink such that it overlaps at least one component.

Related Topics

"Heat Sinks on Top of Components" on page 35

"Heat sink standing alone or with components mounted on the sink" on page 36

"One Heat sink on top of several components" on page 36

"Chip Fan on heat sink" on page 37

Heat Sinks on Top of Components

Heat Sink –Air Cooled (pin or fin type Heat Sink)

For a heat sink, the most important input is the Sink to air thermal resistance at the two specified air velocities (3ft/s & 10ft/s). These values can be obtained from the manufactures data sheet of the heat sink, which is a plot of Resistance vs. Air Velocity. Set these two resistances and HyperLynx PCB Thermal will interpolate or extrapolate for the real operational condition. Effective height of the heat sink is also very important because the blockage in the flow stream may affect other parts at surrounding.

Parameter definitions (the bold parameters are most critical):

1. Class - Must select heat sink, when modeling a heat sink, this controls the part definition
2. Length - Length or dimension in X direction
3. Width - Width or dimension in Y direction
4. Height - The total height of the heat sink alone
5. Number of Pins – Not a relevant number, but use a high number to ensure good contact
6. Pin thermal conductivity, Pin thickness, Pin width, pin Length. Leave as defaults
7. Air gap- should be set to about zero with a conductive material between the heat sink and the component.
8. Power - should be set to Zero
9. Sink to air thermal resistance @ 3ft/s. - Value taken from heatsink data sheet in degree C/W
10. Sink to air thermal resistance @ 10ft/s - Taken from data sheet in degree C/W
11. Radiative Emissivity – Not important, leave as default or use .1 for polished metal

Effective height, fraction of (DZ) – A value between 0.0 & 1.0 based upon what type of heatsink is used. This value estimates the amount of blockage the heatsink will have on the air stream. A minimum number of 0.5 should be assigned. For full blockage in the airflow direction, set this to 1.0. For extruded fins aligned with the air flow, set to 0.5.

Heat sink standing alone or with components mounted on the sink

When several components are mounted on one large heat sink, it is usually true that the heat sink will have a rather uniform temperature due to its effective heat spreading capability. In this situation, you will model this with in terms of one heat sink. The description of this modeling is shown below. If the heat distribution is expected to be very non-uniform on the heat sink, you may model it with several heat sinks. Each covers an estimated territory of the overall heat sink. This modeling is discussed at the end of this section.

A heat sink with several components mounted on it, will be modeled by placing a thin fictitious component on the board, and then place this sink on its top. This fictitious component will have a power dissipation of the sum of the power of all the components on top of the heat sink.

The above example is that of a heat sink where the component power is rather evenly distributed. However, if the distribution of power and therefore heat is more concentrated in one or another region and uneven temperature distribution is expected on the heat sink, two or more fictitious components should be modeled depending on the distribution of heat and the estimated territory of each temperature zone. The summation of all the powers of the fictitious components should be equal to the total power. When you model the original heat sink with several smaller heat sinks, you must increase the THETAsa of each sink by a factor that is the inverse of the fraction, which is the area ratio of the small heat sink to the original heat sink. For example, if the original THETAsa is 2 C/Watt and the small sink is 1/3 of the original area, the THETAsa of the small one will be 6 C/Watt.

The final result of the heat sink temperature will be the casing temperature of all the components on it. If you want to know the respective junction temperature, simply hand calculate the difference of junction to casing temperatures and add onto the casing temperature. The temperature difference is the component power (in watts) multiplied by the THETAjc.

One Heat sink on top of several components

The casing temperatures of all the components will be about the same as the heat sink temperature. Therefore, the modeling will be:

1. Add the total number of pins for all components that are under the heatsink.
2. Add the total height of the component + heatsink. For example, if there are 8 components are all 1” height and the heatsink is 1”, the height that you should use is 2”.
3. Add the powers of all the components together.
4. Eliminate all of the original 8 components from your board.
5. Place a fictitious component at the location of the heat sink with the same length and width as the sink but very little height, and the pin number equal to the total number of pins from #1.
   Assign the total power from statement #3 to this component.

6. Design this heat sink with its height equal to the total height minus the height of the fictitious component. Then place this heat sink on the fictitious component.
7. Run the analysis.
8. You will get an overall temperature of the heatsink. This will be the casing temperature of each individual component that is touching the heatsink.

The junction temperatures of each original components under the sink, can be evaluated from junction to casing temperature difference, which is the power multiply the THETAjc.

Chip Fan on heat sink

Modeling a fan on top of a heatsink

1. The heatsink and fan combination will be modeled as a single heatsink.
2. The manufacturer should provide a new THETAsa for the fan/fin combination. Use this value for the Sink to air thermal resistance when defining the heatsink.

Add the height of the fan to the height of the original heatsink and input that value under the height of the heatsink.

Thermal Screw

Thermal Screws can be added to the board with the other end links to external heat sinks. The screws' specifications, such as size, and sink temperature, must first be entered into the Working Library.

To place a screw:

1. Go to the **Placement** menu and choose **Screw**.
2. Move the screw to the desired location and press the left mouse button to place it. This opens the Component Properties Dialog Box.
3. Enter the properties for your screw.

Modeling a thermal screw

For a Thermal Screw, the most important inputs are the class, temperature at end, and thermal resistance across the screw. You should specify the size of the screw and leave a few pins so that the thermal screw has good contact to the board. The pin dimensions should be sufficient to let heat pass from the board. The thermal resistance across the screw should calculated by L/kA where L is length of screw, k is screw conductivity, and A is the cross sectional area. The end temperature of the screw is the sink temperature attached to the end.

Parameter definitions (the bold parameters are most critical):

1. **Class** - Must select screw when modeling a thermal screw, this is the part definition
2. **Length** - Length or dimension in X direction
3. **Width** - Width or dimension in Y direction
4. **Height** - The total height of the thermal screw above the board surface
5. Number of Pins – Not a critical number, but use a high number to ensure good contact with board.
6. Pin thermal conductivity, Pin thickness, Pin width, pin Length, should ensure good conduction with board occurs.
7. Power - should be set to Zero
8. **Thermal resistance across the screw -** The thermal resistance of the screw as calculated by L/kA
9. Radiative Emissivity – Not important, leave as default or use .1 for polished metal
10. **Temperature at end –** The sink temperature that the screw is attached to.

Heat pipe

To place a heat pipe on the board the heat pipe must first be defined in the working library. The setting of heat pipe properties is shown at the next section.

1. Select the **Placement** > **Heat pipe** menu
2. Select a heat pipe from the pull down working library on the tool bar.
3. Drag your mouse to the area on the board where you would you're your heat pipe to be placed.
4. A window will pop up allowing you to assign a reference designator name up to 5 characters long.

To place a heat pipe on the Back Side of the board, you must first go to **View** > **Back side**, then place the heat pipe in the same manner described above.

Modeling a heat pipe

For a heat pipe, the most important parameters are the physical size of the heat pipe, and the air gap & gap conductivity. Our program assumes the heat pipe to be similar to a perfect conductor. The part should be built in the library, then placed in the correct location on the board. The heat pipe will easily carry the heat to another location.

Parameter definitions (the bold parameters are most critical): Notice that many of the parameters are not used and grayed out.

1. **Class** - Must select heatpipe, which is the part definition
2. **Length** - Length or dimension in X direction
3. **Width** - Width or dimension in Y direction
4. **Height** - The total height of the heatpipe when attached to the board
5. **Air gap** – The distance between the heatpipe and the board (usually there if a filler material (thermal epoxy or adhesive) used to attach the heatpipe to the board)
6. Power - Usually set to Zero
7. Emissivity - dependent on outer material, use .1 for a polished metal
8. **Gap Conductivity** - The conductivity of the material used to attach the heatpipe to the board

Modeling a Chip or MCM on the Board

HyperLynx Thermal can model such a board without a cover because its structure is similar to a board. Chips soldered onto the boards are considered a single component, but with conduction pads underneath. If a MCM is attached to a board, treat the whole MCM as one component first on the mother board with the total power of MCM assigned to this single representative component. Then the local thermal environment can be obtained through the Refine command. This local environment will then be used for the environment of this MCM.

Modeling Daughter Boards

The following sections describe how to model either a parallel or perpendicular daughter board in HyperLynx Thermal.

Modeling Parallel Daughter Boards

A daughter board should be entered in the Working library.

To place a daughter board:

1. Select the name of your daughter board from the **Component** pull down menu.
2. Go to the **Placement** menu and select **Componen**t.
3. Drag the daughter board to the desired location on the mother board and left click the mouse; this opens the **Component Properties** dialog box.
4. In the Component Properties dialog box, you must select the **Refined output** checkbox.

> **Tip**: When the analysis is run, you may look into the numerical output to view detailed information regarding the daughter board.

5. Enter the following parameter values in the Component Properties dialog box:
    a. **Class** - Must select Daughter Board when modeling a daughter board.
    b. **Length** - Length or dimension of daughter board in X direction
    c. **Width** - Width or dimension of daughter board in Y direction
    d. **Number of pins** - depends on how the daughter board is attached
    e. **Air gap** - distance from top of mother board to bottom of daughter board
    f. **Power** - The sum of the powers of each component on the daughter board
    g. S**ink to air thermal resistance @ 3ft/s** - set to zero
    h. **Sink to air thermal resistance @ 10ft/s** - set to zero

i. **Gap conductivity** - set to zero

Modeling Perpendicular Daughter Boards

Daughter boards, consisting of many components and attached to the mother board perpendicularly, can first be modeled as one component. The size of the daughter board, including component heights and total power, will be used for this representative component. The number of pins and pin dimensions will represent how the daughter board is attached to the mother board. Also, the Refined option will be used. The analysis will produce a report in .LOC file for the local environment of this component. Finally, the daughter board is analyzed as a single board in detail with the local environment applied. The mother board temperature at this location will be applied to the edge of the daughter board as a boundary condition.

Metal Core or Thick Ground Plane in Boards

Go to the BOARD menu and choose the Property sub-menu where you are able to assign the physical layers of the board. You may have an 8 layer PCB attached to a metal core with another 6 layer PCB at the back side. Therefore, the first physical layer is the 8 layer PCB at front side, the second layer is the metal core, and the third layer is the 6 layer PCB at back side. You may assign the thermal conductivity for each layer. To assign the metal core, select the Layer 2 from the View menu, then go to Local Properties menu and assign a 100% metal faction to the whole board area. This also can be applied to a ground plane where a high metal volume fraction will exist.

Metal Strips on the Board

You may have a PCB of 8 layers with a metal strip set in layer 4. If you don't have stackup information, divide the layers such that the first 3 layers are one physical layer, layer 4 is set as the second layer, and the rest is the third physical layer. Set them in the PROPERTY command.

Go to the same BOARD menu and choose the command LOCAL PROPERTY. Go to the first layer and use the cursor to set a rectangle for this metal strip. Within this rectangular zone, the metal content becomes, for example, 30% to represent the effects of this metal strip. The conductivity that you assign in the Board-Local Property menu will override that default nominal value assigned in the Board-Property menu in that area. You may assign other metal strips in a similar manner.

An-isotropic Wiring

In a region where most wires are in one direction, you may use the **Board** > **Local Property** menu to set the rectangle for this region. If the wires along the x direction are twice as many as those in the y direction, set the Kx to Ky ratio to 2, to model the an-isotropic heat conduction. To determine the wire ratio, you may draw a square on a location of the board and count how many wire go East-West versus North-South.

Adjacent Board or Wall Effects

The effects of an adjacent wall or board are set at the **Environment** > **Condition** menu. First you should indicate the position of the board in the rack; such as "in rack" or end of a rack, or simply a single board. Then the input is made to the adjacent wall or board. For a board, the power is needed. For a wall the wall temperature and emissivity are required. If you know the temperature of an adjacent board and would like to use that value instead of the power dissipation, choose as end of rack and enter the temperature as if you were using a wall. You may also set different air velocities at each side of the board and the respective board-to-board spacing.

Chapter 6
Industry Tips

Depending upon what type of industry your company deals in, the procedure in modeling might vary slightly; look over your industry to get a good feel on how to model your case.

This section contains the following topics:

Avionic/Space Applications

Avionic and space applications deal mainly with closed systems at high elevations with variations in air condition and gravity. Specific considerations are:

Closed System

If the board is in a closed system, the only method of heat loss is by conduction and radiation. The heat loss at the edge of the board must be specified in the Boundary Condition Definition Dialog Box (**Environment** > **Boundary**). If thermal screws are mounted at the board and attached to heat sinks, it must be specified in the Working Library - Class. For closed systems, the iteration limit is recommended to set to high in the Environment Condition Definition Dialog Box **(Environment** > **Condition**).

Air Conditions

The pressure of air and gravity are specified in the Environment Condition Definition Dialog Box (**Environment** > **Condition** menu). For a space board, the air pressure and gravity should both be set to “0”. Air should come from the “Bottom”.

Component Details

The emissivities of components, the air gap, use of conduction pads, and pin dimensions must be set carefully in the Working Library. It is very important to set the correct pin geometries and conductivity when dealing with closed systems.

Board Structure

The emissivity of the board is specified in the Environment Condition Definition Dialog Box (**Environment** > **Condition** menu). If the board has a sandwiched aluminum core, please consider it as the 2nd layers in the **Board** > Property menu. Usually the Aluminum core can be the layer 2. If there are metal strips at particular locations on the board, use the **Board** > Local Property menu to set it.

Others

The critical parameters stated before, Metal Volume Fraction in Boards, Power, THETAjc - Junction to Casing Thermal Resistance, etc., should also be specified carefully.

Computer/Instrumentation Applications

The computer and instrumentation industries deal mainly with high power and tight packaging. Considerations are:

“Heat Sink or Chip Fan” on page 44

“Adjacent Boards/Walls” on page 45

“Short-Cut for Large Boards” on page 45

Heat Sink or Chip Fan

For a few very high power components, heat sink or chip fan can be installed. Heat sink is specified in the Working Library menu with a proper Class. The effective height and THETAsa are needed. The heat sink is placed on top of regular components in the **Placement** > Heat Sink menu. The Chip Fan is handled the same as the heat sink. The proper equivalent THETAsa, provided by manufacturer, needs to be specified.

Adjacent Boards/Walls

The spacing needs to be specified. For an adjacent board, the power needs to be specified. For an adjacent wall, the temperature and emissivity need to be specified. All the inputs are in the Environment > Condition.

Short-Cut for Large Boards

If user prepared the text file of component powers from Simulation, the power of all components could be interfaced from **File** > **Import** > **Power and Th-Resist** menu. But if such power import is not available and the board is large with lots of components, after interfaced from ECAD, the estimated power should be given to major components that are either high power or sensitive to temperature. The result of first-cut analysis reveals the problem areas on this board which have high temperatures. Then those components in the problem areas are examined in detail with careful inputs.

Telecom/Industrial-Control Applications

Telecom and industrial control deal with large component numbers on boards, and closed or open systems. You need to consider natural convective cooling.

Natural Convective Cooling

At natural convective cooling, the input of incoming air velocity in the Environment Condition Definition Dialog Box (**Environment** > **Condition** menu) should be set to 0.0. The Analysis will calculate the final natural convective temperature due to the chimney effects automatically. (For any forced flow with fan the analysis will calculate the combined forced and natural flow velocity automatically.) In this situation, the board orientation of vertical or horizontal should be specified correctly and the forced flow is zero. The incoming air temperature is also the ambient air temperature, which induces the natural draft.

Power Supplies / Automotive Applications

Power supply and automotive industries deal with high power and thus, high heat. They also incorporate high power traces in some designs. You need to consider high current traces on the board.

High Current Traces on the Board

For high currents on traces, you need to consider the heat generation of the traces.

Chapter 7
Background on Thermal Modeling

This section contains the following topics:

Heat Transfer Background

There are three mechanisms, which determine the transfer of heat: conduction, convection, and radiation.

Conduction

Heat is transferred through solids by conduction. The rate of conduction is proportional to the thermal conductivity of the material and the cross-section of the conduction path, and is inversely proportional to the length of the path.

The thermal conductivity of materials such as copper and epoxy (prominent materials used in most PCB designs) are drastically different. When a heat source is present in a subject, all generated heat per unit of time should leave the subject if a steady state temperature is maintained in that subject.

Convection

Heat is transferred through fluids by convection. The cooling of a subject by the movement of air flowing over its surface is of great interest. The heat convection from the subject to the air flowing over its surface increases as the difference in temperature between the solid surface and the mean temperature of the air increases.

The hot air wake of hot solids at the upstream also reduces the local heat convection. For this reason, one subject standing in the flow stream can be cooled easily while another subject embedded in its hot wakes may not get sufficient cooling. Another factor in convection is the velocity of the airflow. With high velocities, the convective wash is strong and the cooling becomes significant.

All of these flow-related effects are represented in a single factor called the heat transfer coefficient. This factor is usually described in very complicated formulations based on conditions or circumstances specific to a particular situation.

Radiation

Radiation transfers heat directly, much like the transmission of light. Radiating heat transfer increases with the temperature difference between two subjects, but transfer is directly related to the fourth power of the absolute value of the temperature. For this reason, high temperature subjects usually have significantly greater radiating heat transfer rates than room temperature subjects. However, if all subjects are not very hot and their conductive and convective heat transfer rates are small near room temperature, the radiative heat transfer contribution may become relatively significant, and must be considered.

One very important feature of radiative heat transfer in any subject is its strong dependence upon the condition of the surface of the material in question. This is known as the emissivity of the surface. The emissivity of materials such as plastics or ceramics is close to 0.9, while that of polished metal can be as low as 0.2. On the other hand, a fully oxidized metal surface has a high emissivity rating of approximately 0.3 to 0.8.

Heat Transfer On Electronic Boards

In steady state calculations, all of the heat generated in a component per unit of time should leave that component by the following means: 1.) Conduction through the pins (legs) of the component and the air gap between the component and the board 2.) Convection to the air from the surfaces of component and the pins, and 3.) Radiative transfer to adjacent boards if they are colder than the component. An equilibrium temperature of the component is eventually reached, such that, the rate of heat generation equals the overall rate at which heat leaves the component.

Heat is conducted in an electronic board through the mixture of metal wire and material of which the board is made. When many components are found on a board, the heat transfer interaction between them becomes very complicated. For example, a component with little power dissipation which is located near a very hot component may receive conducted heat from the hot component through the board and may release this heat to the air through convection. In analyzing heat transfer and interaction in PCB’s, it is important to realize that the board also eventually releases this heat to the air by convection.

On a board, the heat convection of a component is very dependent upon the thermal characteristics of the components near it and in its upstream area of airflow. If the upstream components are tall and hot, any components located in the hot wake of that component will be difficult to cool. Three-dimensional effects such as these have been fully modeled in this program.

Reliability Background

Two major objectives of electronic designs are the functionality of the system and the reliability of the operations. Electronic reliability depends upon various factors, but the most influential one is the I.C. temperature. The component failure rate increases exponentially with the increase of junction temperatures.

Reliability is a statistical quantity. Its measurements are based upon the failure rate (number of failures per million hours) for components, or mean time between failure (hours) for a board or a system analysis indicates where the reliability is a problem; however, thermal analysis reveals the means to reduce the temperature at the problem locations. You need both to do good design work. For further details, please review the MIL-HDBK-217E Handbook.

Interfacing a HyperLynx Thermal file into RELEX Reliability Software

RELEX Reliability software has the ability to bring in junction temperatures from a HyperLynx Thermal output file.

To begin, a RELEX project and a HyperLynx Thermal project should be created, both of which having the same reference designator names.

1. Run the HyperLynx Thermal analysis so that temperature results are achieved.
2. Open “Windows Explorer” and go to the directory in which your HyperLynx Thermal file resides.
3. Double click on “XXXXX.out” where “XXXXX” is your HyperLynx Thermal filename.

Anyone using RELEX version 7.5 or earlier should follow steps 4, 5, and 6

1. Scroll down to a few lines past “Output of Board Analysis” to the line that reads “Side Ref.Des. Tc(C) …”
2. Place your cursor immediately after the “e” in “Side” and add a space and the word “Name”
3. Save and close your “XXXXX.out” file
4. Open the RELEX file that corresponds to the HyperLynx Thermal file.
5. Select the “System” tab.
6. Go to “File-Import”
7. At the bottom of the window that pops up, there is a drag menu titled “Files of Type”. Select “All files”.

8. Go to the directory where your “XXXXX.out” file resides, highlight that file, and click “Import”.
9. Select “I want to update the selected assembly” from the first group and “Import reliability prediction information” from the second group”.
10. Click “Next”.
11. From the drag menu, select “Betasoft” and click “Next”.
12. Click “Finish”.

Chapter 8
Troubleshooting and Technical Support

Many users have tested HyperLynx Thermal in the past several years, and we have compiled a list of the common problems that these users have encountered. It is very likely that you will find the solution to your particular problem here.

If the analysis works, but it indicates that components overlap:

Please go back to the Placement Menu and move components to resolve the overlaps. A few overlaps will not crash the program, but they will decrease accuracy in the analysis.

If the analysis crashes during iteration:

Don't panic! There is a 95% chance that you have simply specified some component parameters that are not meaningful. Please go to the Working Library, select a component, click Edit part and review each type of component individually.

For example, some typical problems include: the component height is negative, the number of pins is 0.0, or all the parameters are 0.0 etc.

Still More Troubles

If you are still having trouble at this point, please contact Mentor Graphics technical support by visiting http://supportnet.mentor.com.

Technical Support

Please contact Mentor Graphics technical support by visiting http://supportnet.mentor.com.

Chapter 9
Program Specifications and Requirements

The specifications of HyperLynx Thermal as related to various parameters are described in the following sections.

Package types supported

The package types supported range from conventional through hole and surface mount, with both being either rectangular or circular.

Types of air flow supported

The various types of airflow supported are: Natural, forced, combined, or fully closed, at ground, avionic or space applications.

Chapter 10
HyperLynx Thermal Menus

The following menus are available from the HyperLynx Thermal application:

- Analyze Menu
- Board Menu
- Environment Menu
- File Menu
- Library Menu
- Placement Menu
- View Menu

File Menu

From the file menu, you can load files, save files, import files, and set the scale of displays and the units. You also can print from this menu.

Table 10-1. File Menu Contents

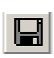
Menu Item	Description
New 	Select to create a new HyperLynx Thermal design.
Open 	Select to open an existing HyperLynx Thermal (.HLT) design.
Save (as) 	Select to save a design.
Units	You can choose to have your values in Mixed units or in Standard International (SI) units. Mixed units are generally in American units, except for quantities such as °C and Watts, while SI units are essentially Metric units.
Scale	Opens the Display Scale Setting dialog box. Set the current maximum and minimum limits on the displayed color bars for: • Temperature scale • Gradient scale • Excess temperature scale • Power display scale • Trace power scale

Table 10-1. File Menu Contents

Menu Item	Description
Import	• Select **IDF Interface** to import a board from any ECAD/MCAD placement software that exports two IDF files (a board file and a library file). See “Importing a Design” on page 19. • Select **Power and Th-Resist** to import a text file that specifies power dissipation of each component. See “Importing a Power file” on page 21.
Print	Select to print the screen.
Print Preview	--
Exit	Select to close HyperLynx Thermal.

View Menu

Table 10-2. View Menu Contents

Menu Item	Description
Side	• Select **Front** to view and define properties for the front side of the board. • Select **Back** to view and define properties for the back side of the board.
Layer	Select **Layer**, move to the right and select a Layer number. This lets you choose which layer you are currently viewing and defining properties for. This command is mainly used when you work on the Board-Local Property menu. After using the Local Property menu, you may click the layer to reset the display, or press the ESC key to reset.
Redraw	Select to refresh the screen and clean things up.
Reset 	Select to return to the last saved view.
Zoom 	Select to zoom in or out. • To zoom in, click the mouse on the lower right corner of the area that you would like to zoom into, then drag to the upper left corner and release. You can zoom in as many times as you wish. • To zoom out, click the mouse on the upper left corner of the area that you would like to zoom out of, then drag to the lower right corner and release.
Pan 	Select and then left click and move the board.
Reference Name	Enable this option to display the reference designators on the corner of components. To disable, select it again.
Grid	Enable this option to identify the intersections of the mesh lines on the board. This helps the user to be more aware of where cutouts, local property differences and very small components will be recognized by the software. Please notice that this grid is determined automatically according to the board size by the program to optimize the accuracy and analysis time. It will appear only after the analysis was made the first time.

Table 10-2. View Menu Contents

Menu Item	Description
Power 	Select the **Power** command to display the power of the components. Click **Power** to see the component power displayed, and click **Power** again to view without showing power. To change power of all of one type of component, do so in Working Library. To change this one only, right click this component, then change the power scale factor input. This value will be the percent of the power defined in the working library. Please notice that the Power can also be input externally through a text file.
Refined 	Select to specify particular components for refined data. These values will be saved in the text file xxxx.loc after the analysis is run. For refined components, the data that will appear in the xxxx.loc file is as follows: local temperatures of the gas, component, and board; the air gap; and the heat transfer coefficients for each side of this component.
Component Temperature 	Select to display the component temperatures. If you have provide the junction to casing thermal resistance of a component in the Working Library, a small rectangle within the component displays the junction temperature. To know the exact details of a component including component partname, reference designator, power, location, and casing and junction temperature, right click the component.
Excess Temperature 	This command allows you to monitor the junction and casing temperatures of your components against their limits. Excess will indicate how much each casing and junction temperature has exceeded their respective limits. The individual limits are set from the Working Library; the general default limits are set in the Board > Property menu.

Table 10-2. View Menu Contents

Menu Item	Description
Board Temperature 	Selecting this command provides a graphical display of the boards' temperature map on the screen. This display is the "average" temperature across the board thickness. The color values shown on the temperature scale indicate a temperature range. The area on the temperature map where the color changes from one to another is the exact value indicated on the temperature scale. For example, if light green is the temperature range from 58.6 to 65.2 and yellow is the temperature range from 65.2 to 71.7, then the area on the temperature map that changes from green to yellow is actually 65.2 degrees. Component temperatures can also be viewed at the same time as the board temperatures if the Component > Temperature command is also selected.
Board Temp. Gradient 	Select to display a local maximum slope of the temperature distribution at any particular point on the board. The value indicated is the temperature variation per unit length (ºC per inch, or per mm). This is very helpful in indicating areas of thermal stress concentrations, which may result in board cracks.
Trace Power	Select to display the power of hot traces.
Trace Temperature	Select to display the temperature of hot traces. Hot traces are traces that you add from the **Board** > **Add Trace** menu.

Table 10-2. View Menu Contents

Menu Item	Description
Search Component	This command allows you to search for components by part name or reference designator. 1. Choose **View** > **Search Component** and select the partname that you wish to identify from the list. 2. Click **OK**. All of the components of that particular partname or reference designator will be marked with an "X". If you then press the Delete key, you may be allowed to delete all components of this particular partname. To delete all components of a partname: 1. Choose **View** > **Search by Component Name** and select the partname that you wish to identify from the list. 2. Click **OK**. All of the components of that particular partname will be marked with an "X". 3. Click the **Delete** key on your keyboard after the component is identified. 4. You will be asked to confirm that you would like to delete all components of that partname. Click **Yes** and all of that partname will be removed from the board.
Toolbar	The Toolbar command displays the toolbar on the top of the screen. The toolbar can be used for easy and quick executions of various, often used commands. You can click here to display or hide the toolbar.
Status bar	The Status bar is displayed on the bottom of the screen. You may see the instruction on how to proceed with the present command. It also lets you know at what location the present cursor is with respect to the origin of the board, which is the lower left corner of the board. The unit of location is set at file-unit menu.

Library Menu

The Master Library stores the information of all the interested components. The Working Library only contains the components of the current board. Components can be updated from the Master to the Working Library or copied from the Working Library to the Master Library. The Material Library lists the conductivities of many commonly used materials.

Table 10-3. Library Menu Contents

Menu Item	Desciption
Master	Opens the Edit Master Library Dialog Box. The master library contains thousands of components, along with all their pertinent parameters, saved within it.
Working	Opens the Edit Working Library Dialog Box. The working library only contains the components of the current board. The Components can be updated from the Master to the Working Library or copied from the Working Library to the Master Library.
Material	Opens the Edit Material Library Dialog Box. The Material Library lists the conductivities of many commonly used materials. You can add new materials, edit the conductivity of existing materials, and delete materials.

Board Menu

This menu lets you specify the detailed structure of the board for your applications.

Table 10-4. Board Menu Contents

Menu Item	Desciption
Property	Opens the Board Property Definition Dialog Box, which is where you input the general properties of the board.
Local Property	Opens the Local Property Definition Dialog Box. The Local Property command allows for a detailed evaluation of a finely described board. You can assign non-homogeneous or an-isotropic local properties to any layer of a board. On each layer, the local metal volume fraction and the x to y conductivity ratio can be set in arbitrary rectangles.
Thermal Via	Select and click a region on the board to open the Thermal Via Definition Dialog Box and calculate the metal volume fraction in an area containing thermal vias. Thermal vias are similar to conventional vias but they are placed to enhance the conduction across the board locally. Frequently, the inside of the vias is filled with solder.

Table 10-4. Board Menu Contents

Menu Item	Description
Cut Out	An odd shaped board can be approximated by many cuts, which can be overlapped, each of rectangular or rounded shape. Up to 25 cuts can be made on the board. Very small cuts, whose dimensions are smaller than a mesh size, will be ignored in analysis. Mesh size can be viewed by using the **View** > **Grid** menu. This shows the intersections of the mesh lines. A cut should cover the territory of at least one mesh area on the grid-view to be considered in analysis. Mesh size is also usually stated in the Numerical Output. 1. Select **Board** > **Cutout**. 2. Click the upper left corner of the area you would like to remove from the board. 3. Move the mouse to the lower right corner of the area. 4. Click again to set the cut out area. A window will pop up allowing you to modify the location or size of the cutout if necessary. You may also specify if the cutout is round in this screen. 5. You may right-click on any cutout to see its detailed specification. If you want to remove this cutout, then press the delete key. You can use a number of overlapped cutouts to form a special shape of cutout.
Trim Corner	The Trim Corner command allows you to round off the corners of your board. 1. Select **Board** > **Trim corner**. 2. Click the corner of the board. 3. Move the mouse till you are satisfied. 4. Click the mouse to finalize it. You may click a trimmed corner to see its specification and then press the delete key to restore it.
Trace Properties	Opens the Trace Properties Dialog Box. Assign the properties of the trace in terms of thickness, conductivities of trace and non-trace, and temperature coefficient of trace conductivity, etc.

Table 10-4. Board Menu Contents

Menu Item	**Desciption**
Add Trace	Add a trace to the board. You may assign the traces on the board at front and back sides respectively. You may also assign the power density in this menu. Notice that the trace is considered as an extra thin layer on top of the front and back surface of the board. They are not one of the Layers of a board. To assign trace: 1. Select **Board** > **Add Trace**. The Trace Power Density dialog box opens. 2. Enter the Trace power density for power per unit area on the trace and click **OK**. 3. A grid over the entire board will appear. Click the squares to add trace. **Note** The traces that are added will turn red in color. You can remove traces by right clicking on the trace that you wish to remove.
Trace Power Density	After the Add Trace command is initiated, you may change to a new power density of trace to assign on the board.

Placement Menu

Use this menu to place components, heat sinks, screws, and heat pipes on the board.

Note

To place an object on the board, you must define the object in the working library.

Note

To place an object on the back side of the board, change the view so you are looking at the back side of the board (**View** > **Back Side**).

Table 10-5. Placement Menu Contents

Menu Item	Description
Component	Select to place a component on the board. To place a component: 1. Select the **Placement** > **Component** menu. 2. Select a component from the pull down working library on the tool bar. 3. Drag your mouse to the area on the board where you want your component to be placed. 4. Click to place it. 5. A window will pop up allowing you to assign a reference designator name up to 5 characters long. You can also modify the specifications.
Heat Sink	Select to place a heat sink on the board. **Note**: You must place heat sinks so they overlap at least part of one component. See "Heat Sink" on page 34.
Screw	Select to place a thermal screw on the board. See "Thermal Screw" on page 37.
Heat Pipe	Select to place a heat pipe on the board. See "Heat pipe" on page 38.

Table 10-5. Placement Menu Contents

Menu Item	Description
Shift Components	Opens the Shift Components Definition dialog box. Use to shift all of the components in the x or y direction while maintaining the orientation of the components. • Enter a positive number in the x direction to move the components to the right. • Enter a negative number in the x direction will move the components to the left. • Enter a positive number in the y direction to move the components up. • Enter a negative number in the y direction to move the components down. **Note**: If you shift components outside the board outline, they will not contribute to the analysis.

Environment Menu

Use the Environment menu to define boundary and environment conditions for the board.

Table 10-6. Environment Menu Contents

Menu Item	Description
Boundary 	Opens the Boundary Condition Definition Dialog Box. Use this to define thermal boundary conditions on the edges of your board.
Condition 	Opens the Environment Condition Definition Dialog Box. Use this to define environment conditions for the board.

Analyze Menu

Use the analyze menu to perform your thermal analysis and review the results.

Table 10-7. Analyze Menu Contents

Menu Item	Desciption
Run	Selecting RUN starts the thermal analysis of your board. For a closed system or for one which uses natural convection, a high number of iterations are appropriate. The analysis terminates automatically when the difference between the results of the current iteration and a previous iteration is less than a pre-set limit, or when the iteration number reaches the limit you specified in the Environment Condition Definition Dialog Box.
Review	This option allows you to view the iterations of the most recent analysis. This is all the text that appeared in the DOS file as the analysis ran, including any error message that was received at the end.
Numerical Output	The numerical output represents the results of your analysis. It is located in the file with the extension.OUT for your board. This file lists the following in ASCII form: the operational conditions, details of the components on the board and of their temperatures, and the board's IC junction temperatures. The temperatures on the board along the vertical center line are also listed as a reference. You must exit HyperLynx PCB Thermal, and view the numerical output using Windows Explorer. Some special items in the numerical output file need specific explanation. Boundary conditions are listed on each side of the board for each of its edges, and are displayed in terms of the mesh number which corresponds to their locations. The natural air draft flow is always calculated and combined with the forced flow to provide a combined velocity figure. The average exit air temperature is averaged across the top edge of the board and also takes into account the board spacing. The thermal wake exit temperature is also provided for your reference. This is the averaged air temperature in the thermal wakes (or thermal boundary layer) across the exit edge of the board.

Chapter 11
HyperLynx Thermal Dialog Boxes

The following dialog boxes are available from the HyperLynx Thermal application:

- Board Property Definition Dialog Box
- Boundary Condition Definition Dialog Box
- Component Properties Dialog Box
- Edit Master Library Dialog Box
- Edit Material Library Dialog Box
- Edit Part Dialog Box
- Edit Working Library Dialog Box
- Environment Condition Definition Dialog Box
- Local Property Definition Dialog Box
- Thermal Via Definition Dialog Box
- Trace Power Density Dialog Box
- Trace Properties Dialog Box

Board Property Definition Dialog Box

Access: **Board** > **Property**

Define general properties for your board.

Table 11-1. Board Property Definition Dialog Box Contents

Parameter	Description
Maximum board length, Xmax	This value is the measurement of the board length in the X direction. The value may be recorded in inches or millimeters.
Maximum board width, Ymax	This value is the measurement of the board width in the Y direction. The value may be recorded in inches or millimeters.
Layer	Select the board layer that you are defining properties for.
Type	Displays the layer type for the selected layer.
Thickness	Specify the thickness of the selected layer.
Conductivity	This value is the conductivity of the board material in the specified layer. The conductivity can be determined using the material library by clicking **Specify conductivity by select material** and selecting the material.
Specify conductivity by select material	Clicking this button opens the Select Material dialog box. • To specify the conductivity for the selected layer, select a material and click **OK**.
Use constant volume fraction of metal	If you select this, the software will compute the metal volume fraction for the board.

Table 11-1. Board Property Definition Dialog Box Contents

Parameter	Description
Volume fraction of metal	This value is the nominal or default percent (in decimal form) of metal traces in the board. Please do not include any local ground planes, thermal vias, etc. They should be specified in the Local Property menu. **Note** If the ground or power planes extend over the full board, and their material is the same as that of the traces, only then may their contribution to the metal volume fraction be included here too. The default metal volume fraction is usually 1% to 3% for an average PCB with no ground plane or metal core. For a typical board of 0.064 inch thickness and 1oz copper, the metal volume fraction is about 2%. Metal Volume Fraction is a critical parameter and is discussed separately. See Metal Volume Fraction in Boards.
Default component casing limit	This is the default temperature limit for every component casing on the board. The casing limit can be set for individual components in the Working library and will override this value if specified. The amount that the component exceeded its limit can be viewed by selecting the **View** > Excess Temperature menu.
Default component junction limit	This is the default temperature limit for every component junction on the board. The junction temperature limit can be set for individual components in the Working library and will override this value if specified. The amount that the junction exceeded its limit can be viewed by selecting the **View** > Excess Temperature menu.

Boundary Condition Definition Dialog Box

Access:

Environment > **Boundary**. A cross hair will appear on the screen.
Click twice to specify the starting and ending points for the boundary you are defining.
The Boundary Condition Definition dialog box opens.

In the numerical output, boundary conditions are listed on each side of the board for each of its edges, and are displayed in terms of the mesh number which corresponds to their locations.

Table 11-2. Boundary Condition Definition Dialog Box Contents

Parameter	**Description**
Begin coordinate	Starting coordinate for the boundary
End coordinate	Ending coordinate for the boundary
Thermal resistance of wedge lock at edge	The wedge lock applied to the edge of board has a thermal resistance between the edge of the board and the heat sink. The typical unit is C-mm/Watt. See Thermal resistance of wedge lock at edge for more details.
Temperature of sink at edge	The temperature of the heat sink connected by the wedge lock to the edge of the board. The wedge lock usually connects the board edge and the heat sink. You must specify the temperature of this heat sink.

Specifying Boundary Conditions

Boundary conditions may not be important in cases of strong air convection, but they are critical when a sealed (closed) system is being analyzed. For a sealed system, cooling is usually provided at the edges of the board. Without some mechanism for dissipating heat, the board will usually reach unacceptably high temperatures due to ineffective thermal radiation. This frequently happens when you model a closed system without specifying how the board dissipates heat. The coordinates of the boundary condition sink temperature, and the thermal resistance all need to be set here.

The wedge lock is usually connecting between the board edge and the heat sink, which could be a chase wall or cooling fins etc. This heat sink temperature must be specified.

The wedge lock usually has a thermal resistance. The value of the total thermal resistance of a wedge lock, Rtotal, could be presented in the form of

DT = Q x Rtotal

The DT is the temperature difference between the edge of the board to the sink; the Q is the total heat flow rate. Therefore, the Rtotal shall have a unit of C/Watt.

The wedge lock may cover a length along the edge of board, for example S mm. For each unit length (mm), the thermal resistance shall be higher than the total thermal resistance. This is because the longer the wedge lock, the larger the cross section of the heat flow and the less the total thermal resistance. (Resistance is inversely proportional to the cross section but proportional to the length of heat flow path.) Therefore, the thermal resistance per unit length Rlength is related with the Rtotal as

Rtotal = Rlength / L

Where the L is the length of the wedge lock along the edge of the board.

Finally, the unit of thermal resistance per unit length along the board is C-mm/Watt, which is the input in this dialog box.

Component Properties Dialog Box

Access: Right-click component and choose **Properties**.

Use to view and modify component information. **See also**: "Analysis of Components Placed Outside the Board Outline" on page 75.

Table 11-3. Component Properties Dialog Box Contents

Parameter	Description
General Information	
Reference designator	Enter a unique ID for the part.
Part name	Select the name of the part you want to use.
Edit this part	Opens the Edit Part Dialog Box.
Placement and Visualization	
X =	Left point of component. (X = 0 at left edge of the board)
Y =	Bottom point of component. (Y = 0 at bottom of the board).
On Front Side/On Back Side	Select to specify which side of the board the component is placed on.
Refined output	Select to create additional output data. For refined components, the data that will appear in the xxxx.loc file is as follows: local temperatures of the gas, component, and board; the air gap; and the heat transfer coefficients for each side of this component.
Angle	Specify a rotation angle in degrees. 0 is equivalent to no rotation.
Thermal characteristics	
Component temperature	Displays the temperature of the component.
Junction temperature	Displays the temperature at the junction.
Default power in working library is	Displays the default power.
Input power scaling factor	Enter a value to scale the power dissipation for an instance of a part. The power dissipation is multiplied by this number. See Power dissipation.

Analysis of Components Placed Outside the Board Outline

If component is placed outside, or partially outside, of the board outline, it may be ignored during the analysis. Details are below:

- The component will not contribute, or will partially contribute, proportionally to percentage of it's area inside board outline, to heat source distribution, so the power dissipation for the component will be ignored.
- The junction-to-case and sink-to-air thermal resistances for the component will be ignored.
- The component temperature will be set equal to temperature of the air in the computational grid cell nearest to the location of the particular component.

Edit Master Library Dialog Box

Access: **Library** > **Master**

The Master Library has thousands of components, along with all their pertinent parameters, saved within it. This library contains the standard names from the Motorola handbook. Since every company uses different names for their components, we chose to use Motorola's as the standard. This library can be expanded by adding your own components into it.

Table 11-4. Edit Master Library Dialog Box Contents

Parameter	Description
Add by parameters	Opens the Edit Part Dialog Box. You can add a new component to the master library with this command. You will need to input specific parameters such as size, power, package type, number of pins, etc.
Copy part	This command will allow you to copy the parameters of a specific component under another name. If the name in the master library isn't the one you use, you can copy it to your preferred name.
Edit part	Opens the Edit Part Dialog Box so you can modify parameters for a component. Highlight the component in the library column and click **Edit Component**. Any changes that you make to the component will be temporarily saved when you click **OK**. You can permanently save the changes by choosing **File** > **Save**, **File** > **Save As**, or running an analysis.
Delete part	Click to delete a selected part from the Library. You will be asked to confirm that you would like to delete that component from the master library.
Save to disk	Lets you save your current library and updates the old library file on the hard drive. The Master library is saved in betasoft.mlb.

Edit Material Library Dialog Box

Access: **Library** > **Material**

The material library lists the names and conductivities of many commonly used components. The library can be expanded infinitely.

Table 11-5. Edit Material Library Contents

Parameter	Description
Add	This command allows you to add a material to the material library. When selected, you will be prompted for the name of the new material and the conductivity of that material. Then, select **OK**. Any new materials will only be saved if **Save to library (Disk)** is selected. This library can be expanded indefinitely.
Edit	This command allows you to edit any material that already exists in the material library. Highlight the material that you would like to make changes to and select **Edit**. Make the desired changes and select **OK**. The changes will only be saved if **Save to library (Disk)** is selected.
Remove	The Remove command allows you to eliminate any entry from the material library. Highlight the material that you wish to delete and select **Remove**. You will be asked to confirm that you wish to remove that item. Click **OK** and the material will be deleted. The material will only be permanently deleted if you choose the **Save to library (Disk)** command.
Save to library (DISK)	This command saves any changes that you have made in the material library. If you wish to make any changes that you made permanent, you must use this command before you close HyperLynx Thermal. This command is initiated by clicking on **Save to library (Disk**). The material library is saved under the name, “betasoft.clb” and should be backed up before installing any other version of HyperLynx Thermal.

Edit Part Dialog Box

Access: From the Edit Master Library Dialog Box click Add by parameters or Edit part.

Use this to create a new master library component or edit an existing component.

Table 11-6. Edit Part Dialog Box Contents

Parameter	Description
General Parameters	
Name of part	Displays the part name. You can not modify this field.
Class	The class refers to the specific configuration of a type of package. See "Class" on page 90.
Geometry Parameters	
Round Component	Select to enter the dimensions for a round component.
Left	For a rectangular component, enter the coordinate for the left side.
Bottom	For a rectangular component, enter the coordinate for the bottom.
Right	For a rectangular component, enter the coordinate for the right side.
Top	For a rectangular component, enter the coordinate for the top.
Diameter	If you selected **Round Component**, enter the diameter of the component.
Height (DZ)	This is the dimension of the package in the Z direction. This is the final height of the package after mounted on the board. If a socket is used under a component, you must add the height of the socket to this parameter for the component in the Working library. If a heat sink is added on top of this component, the extra height of the sink is specified separately. The effective height of heat sink is only used to evaluate its influence to the airflow.

Table 11-6. Edit Part Dialog Box Contents

Parameter	**Description**
Effective height (0-1)	For a Heat Sink, specify the effective height of the heat sink to the airflow. The value will be a percent in decimal form with 1 being total blockage and 0 being no blockage. For extruded fins oriented perpendicular to the airflow that all the air is blocked, this is the total height. The value will be 100%. If the extruded fins are parallel to airflow, this value is usually about 50% if wide spacing of fins occurs. For example, in a pin fin with a staggered array, this is close to 100%. For an in-line array and parallel to flow, 80% is a good approximation.
Pin Parameters	
Number of pins	Enter the number of pins the component has.
Pin length	The average length of the pins on the package or component that are exposed to air.
Pin Width	The width of the pins on the component or package.
Pin Thickness	The thickness of the pins on the component or package.
Pin thermal conductivity	Enter the thermal conductivity of the pin or click **Specify conductivity by select material** and select a material.
Thermal Parameters	
Power dissipation	The heat dissipation rate for this package. If you just interfaced from ECAD, this value will be a default. **Note**: You can not specify different power dissipation values for the same type of part. Each instance of a particular part may have a different power dissipation. To modify the power dissipation for an instance of a part, enter an Input power scaling factor for the part. The actual power dissipation for an instance of a part is equal to the power dissipation assigned in the part library multiplied by the input power scaling factor that is assigned for a specific instance of that part.

Table 11-6. Edit Part Dialog Box Contents

Parameter	Description
Junction to casing thermal resistance	Also known as the THETAjc value, this is the thermal resistance between the IC junction and the component casing in degC/Watt. This value is very dependent upon the testing method used. The present THETAjc values in the library are derived from the “Semi-Therm Proceedings”, TI and Signetics DataBooks, etc. If unknown, set to 0.0. This is not the junction to ambient resistance.
Sink to air thermal resistance @3ft/s	The heat-sink-to-air thermal resistance measured in C/Watt. This value is a function of heat sink design and of air speed. Enter the value at 3 ft/s air velocities. In the analysis, the adequate values at local air velocity will be evaluated automatically.
Sink to air thermal resistance @10ft/s	The heat-sink-to-air thermal resistance measured in C/Watt. This value is a function of heat sink design and of air speed. Enter the value at 10 ft/sec air velocities. In the analysis, the adequate values at local air velocity will be evaluated automatically.
Radiative Emissivity	The averaged emissivity of the component, a value between 0 and 1.
Casing temperature limit	The limiting temperature of the component casing, beyond which the Temperature Excess Display will show the warning colors.
Junction temperature limit	The limiting temperature set for the junctions of a component. If this limit is exceeded, it will be displayed in the Excess Temp. screen.
Temperature at end	The temperature set at the other end of the thermal screw.
Gap Parameters	
Air gap	The gap between the bottom of the package and the board.
Gap conductivity	When conduction pads or paste are inserted into the gap beneath the component, this is the conductivity of the conduction pads or paste.

Edit Working Library Dialog Box

Access: **Library** > **Working**

The Working Library has all of the components on your board. This library can be expanded by adding more components, and saved into the Master Library for future use.

Table 11-7. Edit Working Library Dialog Box Contents

Parameter	Description
Update from Master	Matches your board's components with similar ones in the master library and sets their parameters accordingly.
Add by parameters	Opens the Edit Part Dialog Box. You can add a new component to the master library with this command. You will need to input specific parameters such as size, power, package type, number of pins, etc.
Copy part	This command will allow you to copy the parameters of a specific component under another name. If the name in the master library isn't the one you use, you can copy it to your preferred name.
Edit part	Opens the Edit Part Dialog Box so you can modify parameters for a component. Highlight the component in the library column and click **Edit Component**. Any changes that you make to the component will be temporarily saved when you click **OK**. You can permanently save the changes by choosing **File** > **Save**, **File** > **Save As**, or running an analysis.
Delete part	Click to delete a selected part from the Library. You will be asked to confirm that you would like to delete that component from the master library.
Save Master	Lets you save your current library and updates the old library file on the hard drive. The Master library is saved in betasoft.mlb.

Environment Condition Definition Dialog Box

Access: **Environment** > **Condition**

Environment Conditions Parameters describe the conditions of ambient air and affect modeling of air temperature distribution, and conductive and convective heat flux to air.

Analysis Parameters affect the iteration process of the solver and the precision of it's final result.

Casing Parameters describe two things - board placement (relative to adjacent boards, airflow, gravity vector etc.) and thermal parameters of the board environment (power dissipation of adjacent boards, temperature of the walls, etcetera).

Table 11-8. Environment Condition Definition Dialog Box Contents

Parameter	**Description**
Environment Conditions Parameters	
Incoming Air Temperature (open) Initial Temp. of Iteration (closed)	This is the temperature of the airflow before arriving at the board surface. • For open system, this is the incoming air temperature. • For closed system, this is the initial temperature of the iteration. If an analysis gives a result, the averaged temperature of board can be estimated. To ensure a better result, user should set the initial iteration temperature the same as the evaluated average board temperature such that effective convergence will occur.
Air pressure	The air pressure at the location you will use the board. At earths surface, the default air pressure of 1atm should be fine.
Gravity	The gravity for the location the board will be placed.
Humidity ratio	The percent humidity of the environment where you will place the board. 1.0 means fully saturated air. It affects air density and hence affects many aspects of airflow modeling.
Incoming air velocity	Velocity of air before reaching the board surface. This parameter is very important in a commercial type of application for open systems cooled with airflow. If the systems are sealed closed, there will be no airflow and this setting should be 0.0.
Air comes from	The direction the airflow is coming from.
Analysis Parameters	
Analysis accuracy control (deg C)	Set to .01 or lower (.001)

Table 11-8. Environment Condition Definition Dialog Box Contents

Parameter	Description
Casing Parameters	
Board location	The board location: • In rack - with boards on both sides • Single board - casing walls on both sides • Right (left) of rack - board on one side and case wall on the other
Card guide width	The width of the incoming airflow in the direction orthogonal to board's surface.
Comp. at front channel	Specifies how many adjacent boards are have components placed on the side facing your board.
Board placed	The placement orientation of the board • Horizontal • Vertical
Emissivity of this board	The emissivity of the board. This parameter is related to the radiative heat flux. According to the Stefan-Boltzmann law, body having a temperature T is radiating following amount of power per unit of it's area: $J = \varepsilon * \sigma * T^4$ Where ε is this emissivity coefficient between 0 and 1. For an ideal black body ε is 1, for any real body it is less than 1. ε is a dimensionless parameter.
System	Either open (air flow) or closed (no air flow)
Board spacing	Spacing to adjacent board or case wall on either side of the board
Adjacent board emissivity	The emissivities of the adjacent boards or walls are important for radiation heat transfer. Low values (0.1-0.3) for polished metals, higher values (0.6-0.9) for organic surfaces, and the oxidized metal surface is close to organic materials.
Adjacent board power dissipation	If In rack, Right or Left of Rack input adjacent board power
Temperature of casing wall	The adjacent wall temperatures. This parameter can also be used in place of “Adjacent board power dissipation” if the temperature of the adjacent board(s) is known.

Local Property Definition Dialog Box

The Local Property command allows for a detailed evaluation of a finely described board. You can assign non-homogeneous or an-isotropic local properties to any layer of a board. On each layer, the local metal volume fraction and the x to y conductivity ratio can be set in arbitrary rectangles.

As default conditions, the properties of a board are considered to be isotropic (i.e., the same conductivity in any direction), which is generally a good assumption, considering the traces in the x direction and in the y direction are of similar amount.

Table 11-9. Local Property Definition Dialog Box Contents

Parameter	Description
Location X	Left point of selected area. (X = 0 at left edge of the board)
Location Y	Bottom point of selected area. (Y = 0 at bottom of the board).
Local property is round	Select this if the area you are defining is round.
Length, Width	If you did not select Local property is round, enter the length and width of the region.
Diameter	If you select Local property is round, enter the diameter of the region.
Length (DX), Width (DY)	If you did not select Local property is round, enter the length and width of the region.
Metal volume fraction	If you import a HYP file with your design, HyperLynx Thermal automatically computes the percentage of metal on your board. To manually specify the fmetal volume fraction for your board, select the **Use constant volume fraction of Metal** checkbox and enter the Metal Volume Fraction for the selected area.
Kx/Ky ratio of conductivity	Enter the ratio of conductivity, see Kx/Ky.

Specifying a local property

To specify a local property:

1. Select the **View** > **Layer** menu and select a layer.
2. Select **Board** > **Local Property**.
3. Click the upper left corner of the area you wish to define.

4. Move the mouse to the lower right corner of the local property to complete the area.
5. Click the mouse again, a window will pop up asking for the local metal volume fraction (this value will override the nominal metal volume fraction specified in the **Board** > **Property** menu for the whole board) and the Kx/Ky ratio of conductivity. You may also specify if the local area is round in this area. If you have multiple local properties on top of one another, the uppermost local property will always prevail. If there are locally embedded thermal vias, see the "Thermal Via Definition Dialog Box" on page 85.

To exit the Local Property command, click **ESC** on the keyboard, or go to **View** > **Layer** and choose the layer you are viewing.

Thermal Via Definition Dialog Box

Calculates the metal volume fraction in an area containing thermal vias.

Access by selecting **Board** > **Thermal Via** and selecting an area on the board.

Table 11-10. Thermal Via Definition Dialog Box Contents

Parameter	Description
Location X	Left point of selected area. (X = 0 at left edge of the board)
Y	Bottom point of selected area. (Y = 0 at bottom of the board).
Local property is round	Select to specify a round region and then enter the diameter of the region.
Length (DX), Width (DY)	If you did not select Local property is round, enter the length and width of the region.
Diameter	If you select Local property is round, enter the diameter of the region.
Total number of thermal vias in this area	The number of thermal vias within this local area.
Outside diameter of the via	The "outside diameter of the via" is the total diameter including the outer rim and the filler.
Thickness of the plating near the outside diameter of via	The "thickness of the plating near the outside diameter of the via" is the thickness of the plating on only one side. The relation is, diameter of the filler + (2x thickness of the plating) = total outside diameter of the thermal via.
Thermal conductivity of the plating material	The thermal conductivities of the plating material and of the filler can be determined by accessing the material library by clicking on "Specify by select material".

Table 11-10. Thermal Via Definition Dialog Box Contents

Parameter	Description
Thermal Conductivity of the material filling the via holes	Enter a value or click **Specify by select material** to enter based on the material.
From layer	Starting layer for the vias
To layer	Ending layer for the vias

Trace Power Density Dialog Box

Access: **Board** > **Trace Power Density**

Table 11-11. Trace Power Density Dialog Box Contents

Parameter	Description
Trace Power Density	The power per unit area on the trace. (watt/in^2)

Trace Properties Dialog Box

Access: **Board** > **Trace Properties**

Assign the properties for a trace.

Table 11-12. Trace Properties Dialog Box Contents

Parameter	Description
Mesh Multiplier	Displays the value of the mesh multiplier.
Trace thickness (front side)	The thickness of the trace. The trace is not a layer; it is an extra skin on the board.
Trace thickness (back side)	The thickness of the trace. The trace is not a layer; it is an extra skin on the board.
Conductivity of trace	Specify the conductivity of the trace. The trace is considered as on the outside of a board (on top of the skin), which does not belong to any of the 3 layers.
Conductivity of non-trace	Specify the conductivity of the non-trace.
Temperature coefficient of resistance (1/degC)	On the traces, the electric conductivity varies with the temperature. Therefore, the power is also changed when the temperature is changed. The temperature coefficient is the one for the electric resistance or power at constant current as temperature changes.

Glossary of Terms

Adjacent Board Emissivity

The average radiative emissivity, a value between 0.0 and 1.0 for the adjacent board. Low values (0.1-0.3) for polished metal surface, higher values (0.6-0.9) for organic surfaces, and the oxidized metal surface is close to the organic materials. Conformal coating is an organic surface.

Adjacent Board Power Dissipation

If the adjacent is a board, its power dissipation in watt should be given.

Air Comes From

The convective air coming from a side of board.

Air Gap

The gap between the bottom of the package and the board.

Air Pressure

The air pressure, based on a pressure of 1 atmosphere at sea level. This value is expressed in terms of atmospheres (atm). For satellite use, p is 0.0. A small value can be assigned at high elevations for avionic electronics.

Analysis Accuracy Control

This is the iteration accuracy in degrees Celsius.

BGA

Classification for all ball grid array or pin grid array components.

Board Location

To identify if a board is inside of a rack in which both sides face other boards, or at the left of the rack where the left side faces a wall and the right side faces a board, or at the right of a rack, or a single board which faces walls at both sides.

Board Placed

The board is placed horizontally or vertically with respect to the gravity. The gravity is vertically down.

Board Spacing

The distance between this board and the adjacent boards or walls. This is measured from the surface of this board to the surface of the adjacent board/wall.

Card Guide Width

The width of the card guide (if any) attached to the bottom and top edges of the board. If no such crossbar exists, set this value to the thickness of the board.

Casing Temperature Limit

The limiting temperature of the component casing, beyond which the Temperature Excess Display will show the warning colors.

Class

The class refers to the specific configuration of a type of package.

DIP-Through hole is made up of components whose pins are located at two opposite sides and go through the thickness of the board. Any component with pins which appear on all four sides, or on the bottom of the component, belongs to one of the next several SMD classes.

SMD Long Leads is for components with pins on four sides, with these long pins stop on the surface of the board and these pins are exposed to air convection. For SMD classes if the component is rectangular in shape, the longer sides are normally set as the North/South sides.

SMD Medium leads is for components similar to SMD Long Leads, but whose pin surfaces are only partially exposed to the air convection. This includes surface-mount components with short leads.

SMD Leadless is made up of components whose pins are along the four side but not exposed, or are only slightly exposed, to air convection. This includes leadless surface-mount components, and metal-capped, vertically oriented components whose pins are located on the bottom of the component. This class also includes all surface mount resistors and capacitors.

SMD Small Outline is made up of surface-mount components whose leads are located on two opposite sides only.

BGA is for all ball grid array or pin grid array components, whose pins are in the area under the components.

Screw is for thermal screws, which are attached to the board and a heat sink.

Heat sink is for heat sinks mounted on a component with convective air coolings.

Heat pipe is for all heat pipes.

Daughter Board is for all parallel or perpendicular daughter boards.

Components at front channel

This parameter indicates if the airflow channel at the front side has packages on only one wall or both walls. If it is One Side, the front side of the board faces the backside of the adjacent board, which has no components. Otherwise, this parameter is Both Sides, which means that components are also present on the backside of the left adjacent board.

Conductivity of metal at a layer

This is the thermal conductivity of the metals in the wires or ground/power planes on the board at this layer. When there are 3 layers, this value is either for layer 1 and 3, or for layer 2. For copper, a good value for this parameter is 227 Btu/hrftF, or 393 W/mC. For Aluminum, it is 125 Btu/hrftF or 216 W/mC. Please see the Material Library for more conductivity values.

Conductivity of non-metals at a layer

This parameter sets the thermal conductivity of the base organic material of the board. When there are three layers, this value is used either for layers 1 and 3 or layer 2. Values for epoxy is about 0.115 Btu/hrftF or 0.2 W/mC. Please see the Material Library for more conductivity values. They are usually two orders of magnitude smaller than metals. Therefore, metal volume fraction in board is very influential to overall conductivity

Conductivity of traces or non-traces

They are defined similarly to the conductivities at a layer. The trace is considered as on the outside of a board (on top of the skin), which does not belong to any of the 3 layers.

Daughter Board

A classification for all parallel or perpendicular daughter boards. In the Library, the class of daughter board is for a parallel daughter board. A perpendicular daughter board should be modeled as a component of the total dimension, with power equal to the sum of the powers of the components on this daughter board. The analysis gives the board temperature under this component, which is the edge boundary temperature of this perpendicular daughter board. Then, if needed, a separate analysis can be made to this daughter board with the edge temperature specified. It surrounding air conditions can be obtained from the Local command.

Default component casing or junction limits

You may set a uniform default limiting temperature for all the component casings and another one for junctions. If an individual component has its own limits, those limits will apply to that component only and can be entered in the working library.

DIP

DIP is a through hole component, which is made up of components whose pins are located at two opposite sides and go through the thickness of the board. Any component with pins, which appear on all four sides, or on the bottom of the component, belongs to one of the other SMD classes.

DX

The dimensions of the package in the X direction are measured in inches or millimeters. The dimension does not include the leads. For DIP or SMD Leadless packages, the DX is measured on the edge where pins are located. This is usually the longer side of a DIP package. If the shape of SMD packages is rectangular, the longer side is used. For round components, this location of input will become the diameter.

DY

The dimensions of the package in the Y direction are measured in inches or millimeters. This dimension does not include the leads. For a round component, this value is grayed.

DZ

This is the dimension of the package in the Z direction. This is the final height of the package after mounted on the board. If a socket is used under a component, you must add the height of the socket to this parameter for the component in the Working library. If a heat sink is added on top of this component, the extra height of the sink is specified in Working Lib separately. The effective height of heat sink is only used to evaluate its influence to the airflow.

Effective Height

This is the effective height of heat sink to the airflow. The value will be a percent in decimal form with 1 being total blockage and 0 being no blockage. For extruded fins set perpendicular to the airflow that all the air is blocked, this is the total height. The value will be 100%. If the extruded fins are parallel to airflow, this value is usually about 50% if wide spacing of fins occurs. For example, in a pin fin with a staggered array, this is close to 100%. For an in-line array and parallel to flow, 80% is a good approximation.

Em

This is the surface emissivity of this component, a value between 0.0 and 1.0

Emissivity of this board

The emissivity of the board surface, not considering the components. For organic boards, it is usually between 0.5 and 0.9

Gap

See Air Gap.

Gap Conductivity

When conduction pads or paste are inserted into the gap beneath the component, this is the conductivity of the conduction pads or paste.

Gravity

Gravity at this location, a value between 0 and 20 can be considered. For space, it is 0. For rocket launching, it could be as high as 20. Gravity is assumed in vertical downward direction in the program.

Grid

The screen in which the intersections of mesh lines are identified.

Heat pipe

Classification for all heat pipes.

Heat sink

Classification for all heat sinks mounted on a component with convective air coolings.

Height

The height of a component after installed on the board, DZ.

Humidity Ratio

The relative humidity, a value between 0.0 and 1.0. Note that 1.0 represents total saturation of water vapor or steam.

Import

The ability to bring in either the design from your CAD placement software, or the power dissipation from an external ASCII file by component name and/or reference designator.

Incoming Air Temperature (or initial temperature of iteration)

The temperature of the approaching air for an open system. For a closed system, this is the temperature that the board temperature iteration will start from. It is desirable to have this initial value close to the averaged temperature of the board after analysis that high accuracy is ensured. This could be set through a couple of iteration of analysis. This value is expressed in degrees Centigrade. The minimum recommended value is -20 C.

Incoming Air Velocity

Velocity of the incoming forced air, generally expressed in ft/min. If there is no induced airflow (i.e., natural convection), the value for this parameter is zero. For reliable results, conventional values not far beyond 900 ft/min. are recommended.

Initial temperature of iteration (or incoming air temperature)

See Incoming Air Temperature (or initial temperature of iteration)

Junction Temperature Limit

The limiting temperature set for the junctions of a component. If this limit is exceeded, it will be displayed in the Excess Temp. screen. This may be specified in the “Board-Property” menu for default of all components or may be set uniquely to particular components in the “Library-Working” menu.

Junction to Casing Thermal Resistance

Also known as the THETAjc value, this is the junction-to-casing thermal resistance for the component or package, measured in C/Watt. This is not the junction to ambient resistance. See THETAjc - Junction to Casing Thermal Resistance.

Kair

Conductivity of the air.

Kpin

Conductivity of the pin material

Kx/Ky

The ratio of board conductivity in the X direction to that of board conductivity in the Y direction in a local zone. You can determine a correct setting for this value by imagining that you are drawing a square on the board at this location. For example, if two times as many wires run in the East/West direction of this imaginary square than run in the North/South direction, the value could be 2.0.

Length

The length of the component, DX.

Maximum Board Length/Width

The maximum length of a board in the x direction or width in the y direction.

Mixed

Mixed units of English and Metric are used. However, the watt and C are always used in all the cases.

Metal Volume Fraction

A value of averaged volumetric fraction of metal in the board or at a particular location. This is the fraction, by volume, of the metal in the board itself. For a printed wire board, this value is usually on the order of 0.01. Generally, a value lower than 0.07 is used. Typically, for a board of 0.064 inch thickness, 1 oz. of copper has an equivalent metal volume fraction of 2%. If a metal plate or plane cover the full area is used on the board, you may include the metal plate volume in this value. Otherwise, you shall set the plate as a Local one of the layers. The board temperature displayed on screen represents the average temperature across the thickness of the board.

Name of Component

This is the part number of a component. This must be less than 16 alphanumeric characters in length. You can review the list of all components in the library and see the Component Naming Guidelines.

Number of Pins

The total number of pins on the package or component.

No. of Iteration

This parameter determines the maximum number of iterations allowed. In a strong convective system, this parameter may be set to low or medium. For a closed system with mainly conduction, setting this parameter to high is recommended. To insure accuracy, a value of high is recommended for most cases.

Partname

Name of Component with up to 16 alphanumerical characters.

Pin

Number of Pins. See Number of Pins.

Pin Length

The average length of the pins on the package or component that are exposed to air.

Pin Thermal Conductivity

The thermal conductivity of the pins on the component or package. This parameter should be modified if the material from which the pins are made is not copper.

Pin Thickness

The thickness of the pins on the component or package.

Pin Width

The width of the pins on the component or package.

Power Dissipation

The likely heat dissipation rate for this package. If you just interfaced from ECAD, this value will be a default. You should update from the Master Library to update them, set a new value in Working Library, or import a text file through “File-Import” menu.

Radiative Emissivity
The averaged emissivity of the component, a value between 0 and 1.

Rotation
The nominal orientation of a package in the Working Library has the long side in the X direction and the shorter one in Y direction. To rotate allows for a 90-degree turn.

Scaling Factor for Power
This parameter is the scaling factor for the power dissipation of this component with respect to the nominal value of power for this type of component in the working library. 0.5 means only 50% power of the nominal value in Working Library. A value between 0.01 and 99 can be assigned.

Screw
Thermal screws attached to the board and connected to an external heat sink.

Search by component name
The ability to locate all components of a particular partname on a board. Frequently, many components are of the same component name. This is also useful in deleting all components of a same partname.

Search by Reference Designator
The ability to locate a particular component on a board by its unique reference designator.

Shift all Components in a direction
To Shift all the current components on the board in the x or y direction by a specified amount. Positive value means moving in the positive x or y direction.

SI
Standard International Units, similar to Metric Units.

Sink to Air Thermal Resistance
The heat-sink-to-air thermal resistance measured in C/Watt. This value is a function of heat sink design and of air speed. Usually users enter the values at 3 ft/s and 10 ft/sec air velocities. In the analysis, the adequate values at local air velocity will be evaluated automatically.

SMD Long Leads
Classification for components with pins on four sides, with the surfaces of these pins exposed to air convection. For SMD classes if the component is rectangular in shape, the longer sides are normally set as the North/South sides.

SMD Medium leads
Classification for components similar to SMD Long Leads, but whose pin surfaces are only partially exposed to the air convection. This includes surface-mount components with short leads.

SMD Leadless

Classification for components whose pins are not exposed, or are only slightly exposed, to air convection. This includes BGA, PGA, leadless surface-mount components, and metal-capped, vertically oriented components whose pins are located on the bottom of the component. This class also includes all SMD resistors and capacitors which have their longer sides set to two sides of the component.

SMD Small Outline

Classification for surface-mount components whose leads are only located on two opposite sides.

System

This environment parameter indicates whether the system is open to allow for air convection. For closed (sealed) systems, you should be aware that some cooling boundary conditions should be set at the edges of the board. If no cooling boundary conditions are set, the board will have only radiative cooling and will be very hot.

Temperature at end

The temperature set at the other end of the thermal screw.

Temperature Coefficient

On the traces, the electric conductivity varies with the temperature. Therefore, the power is also changed when the temperature is changed. The temperature coefficient is the one for the electric resistance or power at constant current as temperature changes.

Temperature of Casing Wall

The temperature of the wall of the system casing.

Temperature of Sink at Edge

The temperature of the heat sink connected by the wedge lock to the edge of the board.

Thermal Resistance of Wedge Lock

The wedge lock applied to the edge of board has a thermal resistance between the edge of the board and the heat sink. The typical unit is C-mm/Watt. See Thermal resistance of wedge lock at edge for more details.

Thickness of Layer

This is the thickness of this physical layer of the board. Notice that a physical layer can be several layers of a board.

THETAcb

This value appears in the numerical output when you have a system that is closed on the front side and the backside. It is the thermal resistance from component to board. This value is TAIR(C) when there is an open system on at least one side.

THETAjc

The thermal resistance between the IC junction and the component casing in degC/Watt. This value is very dependent upon the testing method used. The present THETAjc values in the library are derived from the “Semi-Therm Proceedings”, TI and Signetics DataBooks, etc. If unknown, set to 0.0. See THETAjc - Junction to Casing Thermal Resistance for more details.

THETAsa

Thermal resistance between sink to air. See THETAsa - Sink to Air Thermal Resistance for more details.

Trace Power Density

The power per unit area on the trace.

Trace Thickness

The thickness of the trace. The trace is not a layer; it is an extra skin on the board.

Volume Fraction of Metal, nominal

The default value set for the metal volume fraction of the board at this location. See Metal Volume Fractionfor more details.

Width

The width of the component, or the width of the local zone set into layers. See DYfor more details.

X

The X location of the mouse cursor or the package on the board. The location of the package is measured from the lower left corner of the package to the lower left corner of the board. On side 2, locations are still measured in respect to their position on side 1 as if the board is transparent.

Y

The Y location of the mouse cursor or the package on the board. The location of the package is measured from the lower left corner of the package to the lower left corner of the board. On side 2, locations are still measured in respect to their position on side 1 as if the board is transparent.

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