Pcb-20081128

an interactive
printed circuit board
layout system for X11

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Table of Contents

Copying

History

Pcb is a handy tool for laying out printed circuit boards.

Pcb was first written by Thomas Nau for an Atari ST in 1990 and ported to UNIX and X11 in 1994. It was not intended as a professional layout system, but as a tool which supports people who do some home-developing of hardware.

The second release 1.2 included menus for the first time. This made Pcb easier to use and thus a more important tool.

Release 1.3 introduced undo for highly-destructive commands, more straightforward action handling and scalable fonts. Layer-groups were introduced to group signal-layers together.

Release 1.4 provided support for add-on device drivers. Two layers (the solder and the component side) were added to support SMD elements. The handling of libraries was also improved in 1.4.1. Support for additional devices like GERBER plotters started in 1.4.4. The undo feature was expanded and the redo-feature added in 1.4.5.

harry eaton took over pcb development beginning with Release 1.5, although he contributed some code beginning with Release 1.4.3

Release 1.5 provides support for rats-nest generation from simple net lists. It also allows for automatic clearances around pins that pierce a polygon. A variety of other enhancements including a Gerber RS-274-X driver and NC drill file generation have also been added.

Release 1.6 provides automatic screen updates of changed regions. This should eliminate most of the need for the redraw ((*R* key). Also some changes to what order items under the cursor are selected were made for better consistency - it is no longer possible to accidentally move a line or line point that is completely obscured by a polygon laying over top of it. Larger objects on the upper most layers can be selected ahead of smaller objects on lower layers. These changes make operations more intuitive. A new mode of line creation was added that creates two line on 45 degree angles with a single click. The actual outline of the prospective line(s) are now shown during line creation. An arc creation mode was added. Drawn arcs are quarter circles and can be useful for high frequency controlled impedance lines. (You can have eighth circle arc if the source is compiled with -DARC45, but be aware that the ends of such arcs can never intersect a grid point). Two new flags for pins and vias were created - one indicates that the pin or via is purely a drill hole and has no copper annulus. You can only toggle this flag for vias - for elements, it must be an integral part of the element definition. The other flag controls whether the pad will be round or octagonal. There is also now a feature for converting the contents of a buffer into an element.

Release 1.6.1 added the ability to make groups of action commands bound to a single X11 event to be undone by a single undo. Also a simple design rule checker was added - it checks for minimum spacing and overlap rules. Plus many fixes for bugs introduced with the many changes of 1.6

Release 1.7 added support for routing tracks through polygons without touching them. It also added support for unplated drill files, and drawing directly on the silk layer. A Netlist window for easily working with netlist was also added.

Release 2.0 adds an auto-router, a new simpler library mechanism, much improved support for graphically creating (and editing) elements, viewable solder-mask layers (and editing), snap to pins and pads, netlist entry by drawing rats, element files (and libraries) that can contain whole sub-layouts, metric grids, improved user interface, a GNU autoconf/automake based build system, and a host of other improvements.

Special thanks goes to:

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who provided all sorts of help including porting `Pcb` to
several operating systems and platforms, bug fixes, library enhancement, user interface suggestions and more. In addition to these people, many others donated time for bug-fixing and other important work. Some of them can be identified in the source code files. Thanks to all of them. If you feel left out of this list, I apologize; please send me an e-mail and I'll try to correct the omission.

1 Overview

Pcb is a printed circuit board editor for the X11 window system. Pcb includes many professional features such as:

- Up to 8 copper layer designs
- RS-274-X (Gerber) output
- NC Drill output
- Centroid (X-Y) data output
- Postscript and Encapsulated Postscript output
- Autorouter
- Trace optimizer
- Rats nest
- Design Rule Checker (DRC)
- Connectivity verification
- Pcb is Free Software
- Can interoperate with free schematic capture tools such as gEDA and xcircuit

2 Introduction

Each layout consists of several, mostly independent, objects. This chapter gives an overview of the object types and their relationship to each other. For a complete description of how to use `Pcb`, refer to Chapter 3 [Getting Started], page 11. The layout is generated on-screen on a grid that can have its origin at any desired location. The X coordinate increases to the right, Y increases down to the bottom. All distances and sizes in `Pcb` are measured in mils (0.001 inch). One unit on the coordinate display is one mil in distance on the board. The grid may be set on a metric pitch, but is only correct to within the nearest `+/-` 0.01 mil because `Pcb` stores all dimensions as integer multiples of 1/100 of a mil or 0.00001 inch.

The sections in this chapter are sorted by the order of appearance of the objects within a layout file.

2.1 Symbols

The top object is the layout itself. It uses a set of symbols that resides at the first logical level. Each symbol is uniquely identified by a seven bit `ASCII` code. All layout objects share the same set of symbols. These symbols are used to form text objects on the silkscreen and copper layers. Undefined symbols are drawn as filled rectangles.

Every font file is preprocessed by a user-defined command when it is loaded. For details see '`fontCommand`', Section 6.1 [Resources], page 38.

2.2 Vias

Vias provide through-hole connectivity across all layers. While vias look a lot like element pins, don't use vias for adding elements to the layout, even if that seems easier than creating a new element. The default solder-mask will cover over vias, so you won't be able to solder to them. Of course, you can change this so that vias also have solder-mask cut-outs, but it is not the default. Vias are also useful for defining arbitrary drill points such as those used for mounting a board. Vias used in this way have a special flag set so that they have no annular copper ring, and also appear in the unplated drill file. *Ctrl-H* key over a via switches it between being a pure-mounting hole and a regular via. You can assign a name to a via, which is useful during the creation of new element definitions. Each via exists on all copper layers. (*i.e.* blind and buried vias are not supported)

2.3 Elements

Elements represent the components on a board. Elements are loaded from `ASCII` coded files in a similar manner to the layout file itself, or from the library selector window. An element is composed of lines and arcs on the silk-screen layer (used to define the package outline), pins (or pads for SMD) and three labels that define the description, the element's layout-name (which also appears on the silk-screen layer) and its value. You can choose which of the names are displayed on the screen with the **Screen** menu; however, the silk screen in the printout will always show the layout-name. Element pins are contained on the first logical level and so reside on all layers, but the pads of surface-mount elements reside on only the component or solder layers. An element can have a mixture of pins, pads (on one or both sides), and mounting holes.

A mark is used to position the element with respect to the cross hair during pasting. The mark will lie on a grid point when the element is positioned. The mark is drawn as a small diamond shape, but is only visible when *both* the `silk` and `pins/pads` layers are visible. All parts of an element are treated as one unit, except for the name. It is not possible to delete a single pin or move only part of an element on the layout. You can resize separate pieces of an element, but doing so is usually a bad idea. You can move/rotate the element name independently of the element it belongs to. When you move an element name, a line is draw from the cursor to the element mark so it is easy to tell which element the name belongs to.

Each pin and pad has two string identifiers, one is the "name" which is a functional description of the pin (*e.g.* "clock in") and the other is the "number" of the pin which is used to identify it in a netlist. The "number" is usually an integer, but it can be any string. You can edit the "name" of each pin of an element, but the "number" is embedded in the element definition and is determined when the new element is first created. Pads are similar to lines on a layer but they must be oriented either vertically or horizontally. Pads can have either rounded or square ends. Pins can be round, square, or octagonal.

Elements are supported by several special layers: `silk`, `pins/pads` and `far-side`. The `silk` layer shows the package outline and also holds legend text and element names. The `pins/pads` layer is used to toggle whether the element's pins and pads are displayed. The `far-side` layer controls visibility of objects (silkscreen and pads) that are on the far (*i.e.* not currently viewed) side of the board.

The "oldlib" style of footprint libraries distributed with `Pcb` rely upon the M4 macro processor. M4 is typically installed under the name `m4` on most unix-like operating systems. It is recommended that you use the GNU version of M4 to avoid limitations found in some vendor implementations. See the m4 man page on your system for more information. Every element file is preprocessed by a user-defined command when the file is read. For details see '`elementCommand`', Section 6.1 [Resources], page 38. `m4`, the default value of '`elementCommand`', allows you to create libraries for package definitions that are shared by all elements. The old element libraries distributed with `Pcb` expect `m4` or an equivalent to be the *elementCommand*. The new library scheme simply has each element stored in a self-contained file, so there is no need to learn `m4` to add to the libraries.

`Pcb` can create a list of all connections from one (or all) elements to the others or a list of unconnected pins. It can also verify the layout connections against a netlist file. The element's '`layout-name`' is the name used to identify the element in a netlist file (see Section 7.5 [Netlist File], page 58).

The old libraries, or very old (pre-1.6) layout files may have incorrect pin numbering since there was no concept of pin numbers when they were created. `Pcb` uses the order of appearance of the pin definitions in the layout or library file if it uses the old format, but there is no guarantee that it will be correct for these old objects.

Be aware that a few of the old library parts may still be incorrectly implemented regarding pin-numbering. All of the DIL (Dual- Inline-Pins) parts are correct and most of the others are too, but you should verify the pin numbering of any non-DIL part before using an old library part. (use the '`generate object report`' in the **Info** menu to see what `Pcb` thinks a pin's number is) All of the old library names begin with a `~`, so you can easily identify them. The old libraries also *may* contain other sorts of errors, including incorrect pin spacing, silkscreen overlapping solder areas, etc. **Check carefully any element in the old library before using it!** As the new library grows, the old library will be pared down to at least remove all of the elements with errors, but this will take time.

You can make your own element definitions graphically now. Simply draw vias for the pins, lines on the solder and/or component layers for surface-mount pads (they must be either horizontal or vertical), and lines and arcs on the silkscreen layer for the silkscreen outline. You should *name* (*N* key) each via and copper line with the pin *number*. Once you are happy with the geometry, select everything that is to become part of the element, then choose '`convert selection to element`' from the **Select** menu. Afterwords you can make pin (or pad) one square if you like, and give the element its various names. You can also give the pins and pads their functional names. Note that the element mark corresponds to the position you click after choosing the conversion from the menu, so decide where the mark goes and make sure it falls on a grid point before you request the conversion. If the vias/lines are not named, then the pin numbering will correspond to the order in which they were placed.

When you create a new element, remember that silkscreen lines should *never* overlap the copper part of the pins or pads, as this can interfere with soldering. The silkscreen should identify the maximum extent of the element package so it is easy to see how close elements can be placed together.

If you want to make an element similar to an existing one, you can break an element into constituent pieces from the **Buffer** menu. Paste the pieces to the layout, make the necessary changes, then convert it back into an element. If the pin numbers haven't changed, there is no need to name each via/line as they are pre-named when the element was broken apart. When you create a new element, you can save it to a file in order to have easy access to it the next time you run `Pcb`.

2.4 Layers

Every layout consists of several layers that can be used independently or treated as a group. Layer groups can be used to logically separate (and color-code) different traces (*e.g.* power and signal); however, all layers within a group reside on the same physical copper layer of a board, so using different layers within the same group won't provide electrical separation where they touch or overlap. For details, see '`layerGroups`', Section 6.1 [Resources], page 38. Each layer is drawn in a color defined in the resource file and identified by a name that you can change (for details see '`layerColor`', Section 6.1 [Resources], page 38.) Layers are really just containers for line, arc, polygon, and text objects. The component and solder layers contain SMD elements as well, but the file structure doesn't reflect that fact directly.

Each layer group represents a physical layer on the printed circuit board. If you want to make a four layer board, you'll need to have at least four layer groups. Connections between layer groups are established only through element pins and vias. The relationship between a specific layer and the board itself is configurable from the '`Edit layer groups`' option in the **Settings** menu. The layer groups corresponding to the physical layers: *component-side* and *solder-side* are always defined and you must map at least one logical layer to each, even if you plan to make a single-sided board. You are not obligated to put tracks on either of them. Surface mount elements always reside on either the component-side or the solder-side layer group. When you paste an element from the buffer, it will go onto whichever side of the board you are viewing. You can swap which side of the board you are viewing by pressing the *Tab* key, or by selecting '`view solder side`' from the **Screen** menu. The layer groups just have a name or number associated with them - where they are sandwiched in the board is left for you to tell the manufacturer.

The silkscreen layer is special because there are actually two silkscreen layers, one for the top (component) and one for the bottom (solder) side of the board. Which silk layer you draw on is determined by the side of the board that you are viewing. If you are viewing the component side, then drawing on the silk layer draws to the component-side silk layer.

The netlist layer is another special layer. It shows rat's-nest lines (*i.e.* guides that show how the netlist expects the element to interconnect). If you make this the active layer, you can use the Line tool to add entries into the netlist, or to delete connections from the netlist window. Except for these two purposes, you should not make the netlist layer the active layer. Usually there is no need to do this because a separate schematic package should be used to create the netlist. `Pcb` can automatically draw all of the rats from the netlist. In some cases you may want to make a small change without going to the trouble of modifying the schematic, which is why this facility is provided.

2.5 Lines

Lines are used to draw tracks on the pc board. When in the line mode, each *Btn1* press establishes one end of a line. Once the second point is defined, the line is drawn and a new line started where the first one ended. You can abandon the new starting point in favor of another by pressing *Ctrl-Btn1*, or *Btn3*, but don't use *Btn2*. The undo function (*U* key or '`undo last operation`' from the **Edit** menu) will take you back point by point if you use it while in the line mode. If you drag the pointer out of the Layout area while drawing a line, the display will auto-scroll (assuming sufficient zoom for scrolling). To stop auto-scroll, simply pass the pointer over the panner control.

New lines can be restricted to 45 degree angles if desired. You can toggle this restriction on and off while creating lines by pressing the *period* key. If the 45 degree restriction is turned on, then the / (forward slash) key can be used to cycle through three different modes of 45 degree line creation. One mode just creates a single line forced to the nearest 45 degree vector. The next mode creates two lines from the start to end points such that the first line leaves the start point at a 90 degree vector, and the second line enters the end point on a 45 degree vector. The last mode creates two lines such that the first line leaves the start point on a 45 degree vector and arrives at the end point on a 90 degree vector. You can temporarily swap between the last two modes by holding the *Shift* key down.

It is simple to edit a line object by breaking it into pieces (insert point mode), moving an end point or the whole line (*Arrow tool*), or changing the layer it resides on (*M* key moves the line under the pointer to the active layer). In the case when two line segments meet at exactly the same point you can delete the intermediate point, otherwise the delete tool removes an entire line. Feel free to experiment since `Pcb` will allow you to undo and redo anything that materially affects your work. If you switch active layers in the midst of placing lines a via will automatically be placed, when necessary, in order to continue the connection.

If you draw a line inside a polygon, it will either plow through the polygon creating a clearance, or touch the polygon. This behavior is selectable in the **Settings** menu for new lines. To change the behavior of an existing line, hit the *J* key with the cross hair over the line. You can increase the size of the clearance by 2 mils on each edge with the with the *K* key. *Shift-K* will decrease the clearance by 2 mils. The increment may be changed from 2 mils through the application resource file. The clearance can be also increased, decreased and set by the *ChangeClearSize* action.

Lines do not need to intersect the center of a pin, pad, via, or other line for `Pcb` to understand that they make electrical connection. If the connection is too tenuous, running the design rule checker will report that the connection may break if the line width shrinks slightly.

2.6 Arcs

`Pcb` can handle arcs of any angular extent, but when you create an arc with the Arc tool, it will be a quarter circle (this means they always bend a right angle). Arcs are very similar to lines otherwise. They are created on the active layer and have the same thickness that new lines will have. The various clicks for creating lines work pretty much the same way for creating arcs. In order to make the arc curve in the desired direction, drag the mouse along the tangent line from the starting position towards the end position. If the grid is too coarse, it may not be possible to distinguish whether you've moved over then up, or up then over, so if you can't seem to make the arc go in the direction you want, try pressing the *Shift* key while drawing the arc. Decreasing the grid spacing may also help. Alternatively you can draw the wrong arc, then rotate and move it where you want. Like the Line tool, after an arc is drawn a new starting point is established at the end point.

Whenever a starting point is established by either the Line or Arc tools it will be retained if you switch directly between the tools (e.g. *F2* key for Lines, *F8* key for Arcs. Arcs can either touch or clear polygons just like lines do. Of course connection searches, undo and all the other features you'd expect work with arcs too.

2.7 Polygons

Sometimes it's useful to fill large areas with solid copper. The way to do this is with polygons. Polygons can be created in either the polygon mode or the rectangle mode. In the polygon mode, you'll have to define each corner of the polygon with a mouse click (*Btn1*). When the last point is clicked exactly on top of the starting point, the polygon is finished. Since this can be hard to do, the *Shift-P* key will enter the final point for you, closing the polygon. If the 45 degree angle restriction is turned on and you try to close the polygon when it is not possible, you'll get a warning instead. If you haven't finished entering a polygon, but want to undo one (or more) of the points that you've already defined, use the undo command (*U* key).

With the rectangle tool, defining the two diagonally opposite corners is sufficient, but of course the resulting polygon is a rectangle. Like lines, a polygon can by edited by deleting, inserting and moving the points that define it. Pins and vias *always* clear through polygons without touching them when first positioned. You must add a thermal with the thermal tool in order to connect pins and vias to polygons. Thermals can be added and removed by clicking *Btn1* with the thermal tool over the pin or via. The thermal tool always places a thermal to polygons on the active layer, so if the tool doesn't seem to work, it's probably because the polygon you want to touch is not on the active layer.

`Pcb` is capable of handling complex polygons, but using a number of simpler ones improves performance of the connection tracing code. You also must be careful not to create polygons that touch or overlap themselves. The fabricated board may not look the way you expect if you violate this principle. It is always ok to have two (or more) polygons touch or overlap each other, but not for points within the same polygon to do so.

The great advantage to this new polygon behavior is that simple or complex ground and/or power planes can be easily made with polygons and seen on the screen. If you don't want this auto-clearance behavior, or you load a layout created by an early version of `Pcb`, the old behavior (shorts to all piercing pins and vias) is available. A '`ChangeSize`' operation (*S* key) toggles a polygon between the new and old polygon/pin behavior.

2.8 Text

Text objects should be used to label a layout or to put additional information on the board. Elements have their '`layout-name`' labels on the silk-screen layer. If you are making a board without a silkscreen, you can use copper text to label the elements, but you have to do this manually.

Text is always horizontal when first created, but the rotate mode can align it along 0, 90, 180 and 270 degree angles. Text on the far side of the board will automatically appear mirror-imaged.

Warning: **TEXT OBJECTS ON A COPPER LAYER CREATE COPPER LINES BUT THEY ARE NOT SCANNED FOR CONNECTIONS OR TESTED FOR CREATING SHORTS VS. THE NETLIST. NEITHER ARE TEXT OBJECTS TESTED AGAINST ANY DESIGN RULES**.

2.9 Nets

Layout files also contain the netlist that describes how the elements are supposed to be interconnected. This list of connections can be loaded from a netlist file (see Section 7.5 [Netlist File], page 58), or entered by drawing rat-lines as described previously. Each net has a name and routing style associated with it. The net contains a list of all element *layout-name* names and pin *numbers* that should be connected to the net. Loading a netlist file will replace all existing nets with the ones from the file. The *Netlist* window provides an easy way to browse through the net list. You can display the rat's-nest by selecting '`optimize rats-nest`' from the **Connects** menu. If you move or rotate elements, the rat's-nest will automatically follow the movements, but they won't necessarily show the shortest paths until you optimize them again.

3 Getting Started

The goal of this chapter is to give you enough information to learn how `Pcb` works and how to develop your layouts to make the best use of `Pcb`'s features. All event translations (*i.e.* the buttons and keys you press) refer to the default application resource file shipped with `Pcb`. There is probably no need to change this unless your window manager uses some of the button events itself; however, if you *want* to customize the behavior of `Pcb` then changing the resource file is usually the best way to do it.

Get yourself a printout of this chapter and *User Commands*, if you haven't already done so, and follow the examples.

Start `Pcb` (the actual command will use all lower-case letters) without any additional options. If you get the error message:

> can't find default font-symbol-file 'default_font'

then the font searchpath or filename in the application resource
file is wrong. Be sure that your `m4` program supports search paths. If not, get `GNU m4`. For other messages, see Section A.2 [problems], page 84. Another quick-start is provided by `pcbtest.sh` in the '`src`' directory. If some features don't seem to work, try running `pcbtest.sh`, if that works, then `Pcb` hasn't been installed properly.

3.1 The Application Window

The main window consists of six areas: the menu at the top, the panner control in the upper left corner, the layer controls located below the panner, the tool buttons located below the layer controls, the Layout area to the right of these, and the status line at the bottom of the window.

3.1.1 Menus

The menus are located at the top of the Layout area. Most, but not all, of their functions are also available from the keyboard. Similarly, some functions are only achievable through the keyboard or command entry. Some menu entries such as '`center layout`' in the **Screen** menu require a certain cross hair position. In this case a prompt message will popup at the bottom of the screen with wording similar to the following:

```
move pointer to the appropriate screen position and press a button
```

Any mouse button will do the job, whereas any key except the arrow (cursor) keys will cancel the operation. If it seems like the menu hasn't done what you expected, check to see if it is waiting for the position click. For details see Section 6.2 [Actions], page 44.

Pressing *Btn3* in the Layout area also pops up a menu with many of the most common operations (except when you're in the midst of drawing a line or arc). When a choice in the *Btn3* popup menu needs a cross hair position, it uses the position where the cross hair was when *Btn3* was pressed. For example, to get detailed information on an object, place the cross hair over the object, press *Btn3*, then choose '`object report`'. If you pop up the *Btn3* menu but don't want to take any of the actions, click on one of the headers in the menu.

File This menu offers a choice of loading, saving and printing data, saving connection information to a file or quitting the application. Most of the entries in the **File** menu are self explanatory. Selecting '`print layout`' pops up a printer control dialog. A selection of several device drivers is available from the printer control dialog. Presently *PostScript*, *encapsulated PostScript*, and *GerberX* are supported. The *GerberX* driver produces all of the files necessary to have the board professionally manufactured. The connection saving features in the **File** menu produce outputs in an arcane format that is not too useful. They do *not* produce netlist files.

Edit The **Edit** menu provides the usual cut, copy, paste which work on selections. To learn how to create complex selections, see Section 3.10 [Arrow Tool], page 27. The **Edit** menu also provides access to Undo and Redo of the last operation. These can also be accomplished with the *U* key and *Shift-R* key. Finally, the **Edit** menu allows you to change the names of: the layout, the active layer, or text objects on the layout.

Screen The **Screen** menu supports most functions related to the whole Layout area. There are various entries to change the grid to some popular values, the zoom factor, and which kind of element name is displayed. You can also re-align the grid origin and turn on and off the display of the grid. Before changing the grid alignment, I recommend that you zoom in as close as possible so that you're sure the grid points appear exactly where you want them.

The **Screen** menu also allows you to turn on and off the visibility of the solder-mask layer. When the solder-mask layer is made visible it obscures most of the layout, so only turn this on when you really want to know what the solder-mask will look like. The solder-mask that you see belongs to the side of the board you are viewing, which can be changed with the '`view solder side`' option, also found in the **Screen** menu. When the solder-mask is displayed, the pin and pad clearance adjustments (see Section 2.5 [Line Objects], page 8) alter the size of mask cut-outs.

Sizes The **Sizes** menu allows you to select a group of line thickness, via diameter, via drill size, and clearance (keepaway) (collectively called a "routing style") to be copied to the "active" sizes. You can also change the names given to the routing styles and adjust their values from this menu. The "active" sizes are also adjustable from this menu. The "active" sizes are shown in the status-line and control the initial size of new vias, drilling holes, lines, clearances, text-objects and also the maximum dimensions of the board layout.

Settings The **Settings** menu controls several operating configuration parameters. The '`edit layer groups`' entry brings up a dialog that allows you to change the way layers are grouped. Layer grouping is described in Section 2.4 [Layer Objects], page 7. The '`all-direction lines`' entry controls the clipping of lines to 45-degree angles. You can also control whether moving individual objects causes the attached lines to "rubber band" with the move or not from the **Settings** menu. Another entry controls whether the starting clip angle for the two-line mode (see Section 2.5 [Line Objects], page 8) alternates every other line. You can also control whether element names must be unique from the **Settings**

menu. When unique element names are enforced, copying a new element will automatically create a unique 'layout-name' name for it provided that the name originally ended with a digit (*e.g.* U7 or R6). The **Settings** menu allows you to control whether the cross hair will snap to pins and pads even when they are off-grid. Finally you can control whether new lines and arcs touch or clear intersecting polygons from this menu.

Select This menu covers most of the operations that work with selected objects. You may either (un)select all visible objects on a layout or only the ones which have been found by the last connection scan see . You can delete all selected objects from this menu. Other entries in the **Select** menu change the sizes of selected objects. Note that a select action only affects those objects that are selected *and* have their visibility turned on in the Layer Control panel. The **Select** menu also provides a means for selecting objects by name using unix Appendix C [Regular Expressions], page 90.

Buffer From the **Buffer** menu you may select one out of five buffers to use, rotate or clear its contents or save the buffer contents to a file. You can also use the '`break buffer element to pieces`' entry to de-compose an element into pieces for editing. Note: only objects with visibility turned on are pasted to the layout. If you have something in a buffer, then change which side of the board you are viewing, the contents of the buffer will automatically be mirrored for pasting on the side you are viewing. It is not necessary to clear a buffer before cutting or copying something into it - it will automatically be cleared first.

Connects The entries available through the **Connects** menu allow you to find connections from objects and to manipulate these. You can also optimize or erase rat's nests from this menu. Finally, the '`auto-route all rats`' entry allows you to auto-route all connections show by the rat's nest. The auto-router will use any visible copper layer for routing, so turn off the visibility of any layers you don't want it to use. The auto-router will automatically understand and avoid any traces that are already on the board, but it is not restricted to the grid. Finally, the auto-router routes using the active sizes (except for nets that have a route-style defined). `Pcb` always knows which tracks were routed by the auto-router, and you can selectively remove them without fear of changing tracks that you have manually routed with the '`rip-up all auto-routed tracks`' entry in the **Connects** menu. The '`design rule checker`' entry runs a check for copper areas that are too close together, or connections that touch too tenuously for reliable production. The DRC stops when the first problem is encountered so after fixing a problem be sure to run it again until no problems are found.

Warning: **COPPER TEXT IS IGNORED BY THE DRC CHECKER**.

Info The '`generate object report`' entry from the **Info** menu provides a way to get detailed information about an object, such as its coordinates, dimensions, etc. You can also get a report summarizing all of the drills used on the board with '`generate drill summary`'. Lastly, you can get a list of all pins, pads and vias that were found during a connection search.

Window The **Window** menu provides a way to bring each of `Pcb's` windows to the front. The *Library* window is used to bring elements from the library into the pastebuffer. The *Message Log* window holds the various messages that `Pcb` sends to the user. The *Netlist* window shows the list of connections desired.

Now that you're familiar with the various menus, it's time to try some things out. From the **File** menu choose '`load layout`', navigate to the tutorial folder, then load the file '`tut1.pcb`'.

3.1.2 The Status-line and Input-field

The status-line is located at the bottom edge of the main window. During normal operation the status information is visible there. When a selected menu operation requires an additional button click, the status-line is replaced by a message telling you to position the cursor and click. When a text input is required, the status-line is replaced by the Input-field which has a prompt for typing the input.

The status-line shows, from left to right, the side of the board that you are viewing (*Tab* key changes this), the current grid values, if new lines are restricted to 45 degrees, which type of 45 degree line mode is active, whether rubberband move and rotate mode is on (R), and the zoom factor. This information is followed by the active line-width, via-size and drilling hole, keepaway spacing, and text scaling. Last is the active buffer number and the name of the layout. An asterisk appearing at the far left indicates that the layout has been modified since the last save. Note that the name of the layout is not the same thing as the filename of the layout. Change the grid factor to 1.0 mm from the **Screen** menu. Observe how the status line shows the new grid setting. Except for the case of the metric grid, all dimensions in the status line are in units of 0.001 inch (1 mil).

The input-field pops up (temporarily replacing the status-line) whenever user input is required. Two keys are bound to the input field: the *Escape* key aborts the input, *Return* accepts it. Let's change the name of a component on the board to see how the input-field works. Position the cross hair over R5, and press the *N* key. The input field pops-up showing the name for you to edit. Go ahead and change the name, then hit return. Notice the name of the element changed. Now undo the change by pressing the *U* key. You can position the cross hair over the name, or the element before pressing the *N* key.

Now select '`realign grid`' from the **Screen** menu. Notice that the status line has been replaced with an instruction to position the cursor where you want a grid point to fall. In this case, since the cross hair can only fall on a grid point, you must move the tip of the finger cursor to the place where you want a grid point to appear. Do not worry that the cross hair is not coincident with the cursor. Click *Btn1* at your chosen location. See how the grid has shifted, and the status line has returned.

The present cross hair position is displayed in the upper right corner of the window. Normally this position is an absolute coordinate, but you can anchor a marker at the cross hair location by pressing *Ctrl-M* (try it now) and then the display will read both the absolute cross hair position as well as the difference between it and the marker. The numbers enclosed in `< >` are the X and Y distances between the cross hair and the mark, while the numbers enclosed in parenthesis are the distance and angle from the mark to the cross hair. The values displayed are always in units of 0.001 inch (1 mil). Pressing *Ctrl-M* again turns the marker off.

3.1.3 The Panner Control

The panner control, located at the upper left side of the window, is used to adjust what portion of the layout is seen in the Layout area. The outer rectangle of the panner represents the whole layout (extended to have the panner aspect ratio), while the inner control rectangle represents the portion seen through the Layout area. Slowly drag this part around with the mouse (*Btn1*) to see how it pans the layout. Release the panner control, but leave the pointer within the outer most rectangle of the control. Now hit a few keyboard arrow keys. Each arrow key moves the region seen one-half window size in the arrow direction. If you want to see a portion of the layout that is off the top of the screen, you need to drag the panner up, or hit the up arrow key.

Move the pointer back into the Layout area. Increase the zoom by hitting the *Z* key. See how the inner part of the panner becomes smaller to reflect that you are viewing a smaller part of the layout. Now zoom out by hitting *Shift-Z*. If you hit the arrow key with the pointer in the Layout area, it moves the pointer rather than scrolling the window. In general the keyboard shortcuts depend on which region of `Pcb's` window the pointer is over. For the most part, the key strokes in this manual refer to the case when the pointer is in the Layout area. You can do fine scrolling in the Layout area by dragging it directly with the Panner tool. Press the *Escape* key to select the panner tool. Now drag in the layout area with *Btn1* down. You can scroll the drawing window while the pointer is inside it with *Mod-Arrow* keys.

If you are moving or drawing an object and go beyond the drawing window borders, the window will auto-scroll. If you want to stop the auto-scrolling while the pointer is outside the Layout area, simply pass the pointer briefly over the panner control area, or a menu button.

Another way to navigate around a layout is with *Shift-Btn3*. When pressed down, the layout will zoom so the whole extent of objects is visible, and will return to the previous zoom when you release the button, but will be centered at the cross hair position where the button is released. You can do this while in the middle of drawing an object. Try it now to center near U7.

3.1.4 The Layer Controls

The layer control panel, located below the panner control, is used to turn on and off the display of layer groups and to select the active drawing layer. If a layer hasn't been named, the label `"`*(unknown)*`"` is used as the default. If this happens, it probably means the application resources are not installed properly.

The upper buttons are used to switch layers on and off. Click `<`*Btn1*`>` on one or more of them. Each click toggles the setting. If you turn off the currently active layer, another one that is visible will become active. If there are no others visible, you will not be able to turn off the active layer. When the layers are grouped, clicking on these buttons will toggle the visibility of all layers in the same group. This is a good idea because layers in the same group reside on the same physical layer of the actual board. Notice that this example has 2 groups each having 3 layers, plus two other layers named '`unused`'. Use the '`Edit layer groups`' option in the '`Settings`' menu to change the layer groupings. Note that changing the groupings can radically alter the connectivity on the board. Grouping layers is only useful for helping you to color-code signals in your layout. Note that grouping layers actually reduces the number of different physical layers available for your board, so to make an eight layer board, you cannot group any layers.

The *far side* button turns on and off the visibility of elements (including SMD pads) on the opposite (to the side you're viewing) board side, as well as silk screening on that side. It does not hide the x-ray view of the other copper layers, these must be turned off separately if desired. Use the *tab* key to view the entire board from the other side. To see a view of what the back side of the board will actually look like, make the solder layer the active layer then press *tab* until the status line says `"solder"` on the right, then turn off the visibility of all layers except solder, pins/pads, vias, and silk. Now turn them all back on.

The lowest button, named *active*, is used to change the active drawing layer. Pressing <*Btn1*> on it pops up a menu to select which layer should be active. Each entry is labeled with the layer's name and drawn in its color. The active layer is automatically made visible. The active layer is always drawn on top of the other layers, so the ordering of layers on the screen does not generally reflect the ordering of the manufactured board. Only the solder, component, silkscreen, and solder-mask layers are always drawn in their physical order. Bringing the active layer to the top makes it easier to select and change objects on the active layer. Try changing the active layer's name to *ABC* by selecting '`edit name of active layer`' from the '`Edit`' menu. Changing the active layer can also be done by pressing keys *1..MAX_LAYER*.

Turn off the visibility of the component layer. Now make the component layer the active layer. Notice that it automatically became visible. Try setting a few other layers as the active layer. You should also experiment with turning on and off each of the layers to see what happens.

The netlist layer is a special layer for adding connections to the netlist by drawing rat lines. This is not the recommended way to add to the netlist, but occasionally may be convenient. To learn how to use the netlist layer see Section 2.9 [Net Objects], page 10.

3.1.5 The Tool Selectors

The tool selector buttons reside below the layer controls. They are used to select which layout tool to use in the drawing area. Each tool performs its function when *Btn1* is pressed. Every tool gives the cursor a unique shape that identifies it. The tool selector buttons themselves are icons that illustrate their function. Each layout tool can also be selected from the keyboard:

Escape key	Panner tool
F1 key	Via tool
F2 key	Line tool
F3 key	Arc tool
F4 key	Text tool
F5 key	Rectangle tool
F6 key	Polygon tool
F7 key	Buffer tool
F8 key	Delete tool
F9 key	Rotate tool
Insert key	Insert-point tool
F10 key	Thermal tool
F11 key	Arrow tool

F12 `key` `Lock tool`

Some of the tools are very simple, such as the Via tool. Clicking *Btn1* with the Via tool creates a via at the cross hair position. The via will have the diameter and drill sizes that are active, as shown in the status line. The Buffer tool is similar. With it, <*Btn1*> copies the contents of the active buffer to the layout, but only those parts that reside on visible layers are copied. The Rotate tool allows you to rotate elements, arcs, and text objects 90 degrees counter-clockwise with each click. Holding the *Shift* key down changes the Rotate tool to clockwise operation. Anything including groups of objects can be rotated inside a buffer using the rotate buffer menu option.

The Line tool is explained in detail in Section 2.5 [Line Objects], page 8. Go read that section if you haven't already. Activate the Line tool. Set the active layer to the solder layer. Try drawing some lines. Use the *U* key to undo some of the lines you just created. Zoom in a bit closer with the *Z* key. Draw some more lines. Be sure to draw some separate lines by starting a new anchor point with *Ctrl-Btn1*. Change the '`crosshair snaps to pin/pads`' behavior in the **Settings** menu. Now draw a line. Notice that the new line points must now always be on a grid point. It might not be able to reach some pins or pads with this setting. Increase the active line thickness by pressing the *L* key. Note that the status line updates to reflect the new active line thickness. Now draw another line. Before completing the next line, make the component layer active by pressing the *4* key. Now finish the line. Notice that a via was automatically placed where you switched layers. `Pcb` does not do any checks to make sure that the via could safely be placed there. Neither does it interfere with your desire to place lines haphazardly. It is up to you to place things properly when doing manual routing with the Line tool.

The Arc tool is explained in detail in Section 2.6 [Arc Objects], page 9. Its use is very similar to the Line tool.

The Rectangle tool, Polygon tool and Thermal tool are explained in detail in Section 2.7 [Polygon Objects], page 9. Go read that section. Remember that the Thermal tool will only create and destroy thermals to polygons on the active layer. Use the Rectangle tool to make a small copper plane on the component layer. Now place a via in the middle of the plane. Notice that it does not touch the plane, and they are not electrically connected. Use the Thermal tool to make the via connect to the plane. Thermals allow the via or pin to be heated by a soldering iron without having to heat the entire plane. If solid connections were made to the plane, it could be nearly impossible to solder. Click on the via again with the Thermal tool to remove the connection to the plane.

The Insert-point tool is an editing tool that allows you to add points into lines and polygons. The Insert-point tool enforces the 45 degree line rule. You can force only the shorter line segment to 45 degrees by holding the *Shift* key down while inserting the point. Try adding a point into one of the lines you created. Since line clipping is turned on, you may need to move the cross hair quite far from the point where you first clicked on the line. Turn off the line clipping by selecting '`all-direction lines`' from the **Settings** menu (or hit the *Period* key). Now you can place an inserted point anywhere. Try adding a point to the rectangle you made earlier. Start by clicking somewhere along an edge of the rectangle, then move the pointer to a new location and click again.

The delete-mode deletes the object beneath the cursor with each *Btn1* click. If you click at an end-point that two lines have in common, it will replace the two lines with a single line spanning the two remaining points. This can be used to delete an "inserted" point in a line, restoring the previous line. Now delete one of the original corner points of the polygon you were just playing with. To do this, place the cross hair over the corner and click on it with the Delete tool. You could also use the *Backspace* key if some other tool is active. Try deleting some of the lines and intermediate points that you created earlier. Use undo repeatedly to undo all the changes that you've made. Use redo a few times to see what happens. Now add a new line. Notice that you can no longer use redo since the layout has changed since the last undo happened. The undo/redo tree is always pruned in this way (*i.e.* it has a root, but no branches).

The Arrow tool is so important, it has its own section: Section 3.10 [Arrow Tool], page 27. Go read it now.

The Lock tool allows you to lock objects on the layout. When an object is locked, it can't be selected, moved, rotated, or resized. This is useful for very large objects like ground planes, or board-outlines that are defined as an element. With such large objects, nearly anywhere you click with the Arrow tool will be on the large object, so it could be hard to draw box selections. If you lock an object, the Arrow tool will behave as if it didn't exist. You cannot unlock an object with undo. You must click on it again with the Lock tool. If an object is locked, previous changes to it cannot be undone either. When you lock an object, a report message about it is popped up and will always tell you what object it is, and that it is locked if you just locked it. Other than noticing your inability to manipulate something, the only way to tell an object is locked is with a report from the **Info** menu. Use the Lock tool sparingly.

3.1.6 Layout Area

The layout area is where you see the layout. The cursor shape depends on the active tool when the pointer is moved into the layout area. A cross hair follows the X11 pointer with respect to the grid setting. Select a new grid from the *Screen* menu. The new value is updated in the status line. A different way to change the grid is *Shift*<*Key*>*g* to decrease or <*Key*>*g* to increase it, but this only works for English (integer mil) grids. The grid setting is saved along with the data when you save a pcb layout. For homemade layouts a value around 50 is a good setting. The cursor can also be moved in the layout area with the cursor (arrow) keys or, for larger distances, by pressing the *Shift* modifier together with a cursor key.

3.2 Log Window

This optional window is used to display all kind of messages including the ones written to *stderr* by external commands. The main advantage of using it is that its contents are saved in a scrolling list until the program exits. Disabling this feature by setting the resource *useLogWindow* to *false* will generate popup windows to display messages. The *stderr* of external commands will appear on `Pcb`s *stderr* which normally is the parent shell. I suggest you iconify the log window after startup for example by setting **log.iconic* to *true* in the resource file. If *raiseLogWindow* is set *true*, the window will deiconify and raise itself whenever new messages are to be displayed.

3.3 Library Window

The library window makes loading elements (or even partial layouts) easy. Just click the appropriate library from the list on the left. A list of its elements then appears on the right. Select an element from the list by clicking on its description. Selecting an element from the library will also automatically copy the element into the active buffer, then invoke the *Buffer* tool so you can paste it to the layout. Elements in the old library should be taken with a grain of salt (*i.e.* check them carefully before using). The old library names all begin with `~` so you can easily distinguish between the old and new libraries. All of the elements in the new library should be thoroughly vetted, so you can use them with confidence. The new libraries are stored simply as directories full of element files, so making additions to the new library is easy since there is no need to learn `m4`. For details on the old libraries, check-out Section 7.7 [Library File], page 58 and Section 7.6 [Library Contents File], page 58. For details on the format of an element file used for the new libraries, see Section 7.3 [Element File], page 57.

3.4 Netlist Window

The netlist window is very similar to the library window. On the left is a list of all of the nets, on the right is the list of connections belonging to the chosen net. The chosen net is highlighted in the list and also shown on the second line of the window in red. If the net name has a star to the left of it then it is "disabled". A disabled net is treated as if it were not in the net list. This is useful, for example, if you plan to use a ground plane and don't want the ground net showing up in the rat's nest. You can enable/disable individual nets by double-clicking the net name. If you want to enable or disable all nets at once, there are two buttons at the top of the netlist window for this purpose.

The button labeled '`Sel Net On Layout`' can be used to select (on the layout) everything that is connected (or is supposed to be connected) to the net. If you click on a connection in the connection list, it will select/deselect the corresponding pin or pad in the layout and also center the layout window where it is located. If you "Find" ('`lookup connection to object`' in the **Connects** menu [also *F* key]), a pin or pad it will also choose the net and connection in the netlist window if it exists in the netlist.

If no netlist exists for the layout, then the netlist window does not appear. You can load a netlist from a file from the **File** menu. The format for netlist files is described in Section 7.5 [Netlist File], page 58.

3.5 Drawing and Removing Basic Objects

hace begging gutting here, and do a real-world tutorial example.

There are several ways of creating new objects: you can draw them yourself, you can copy an existing object (or selection), or you can load an element from a file or from the Library window. Each type of object has a particular tool for creating it.

The active tool can be selected from the tool selectors in the bottom left corner or by one of the function keys listed earlier in this chapter. Each <*Btn1*> press with the tool tells the application to create or change the appropriate object or at least take the first step to do so. Each tools causes the cursor to take on a unique shape and also causes the corresponding tool selector button to be highlighted. You can use either cue to see which tool is active.

Insert mode provides the capability of inserting new points into existing polygons or lines. The 45 degree line clipping is now enforced when selected. Press and hold the shift key while positioning the new point to only clip the line segment to the nearer of the two existing points to 45 degrees. You can also toggle the 45-degree clipping in the middle of a point insertion by pressing the <*Key*>. If the shift key is not depressed and the 45 degree line clipping mode is on, both new line segments must be on 45 degree angles - greatly restricting where the new point may be placed. In some cases this can cause confusion as to whether an insertion has been started since the two new lines may be forced to lie parallel on top of the original line until the pointer is moved far from the end points.

Removing objects, changing their size or moving them only applies to objects that are visible when the command is executed.

3.5.1 Common Drawing and Removing Methods

There are several keystrokes and button events referring to an *object* without identifying its type. Here's a list of them:

<*Btn1*> creates (or deletes) an object depending on the current mode.

<*Key*>*BackSpace* or <*Key*>*Delete* removes the visible object at the cursor location. When more than one object exists at the location, the order of removal is: via, line, text, polygon and element. The drawn layer order also affects the search - whatever is top - most (except elements) is affected before lower items. Basically all this means that what is removed is probably just what you expect. If for some reason it isn't, undo and try again. Only one object is removed for each keystroke. If two or more of the same type match, the newest one is removed.

Use <*Key*>*s* and *Shift*<*Key*>*s* to change the size (width) of lines, arcs, text objects, pins, pads and vias, or to toggle the style of polygons (whether pins and vias automatically have clearances).

<*Key*>*n* changes the name of pins, pads, vias, the string of a text object, or the currently displayed label of an element.

<*Key*>*m* moves the line, arc, or polygon under the cross hair to the active layer if it wasn't on that layer already.

<*Key*>*u* (undo) recovers from an unlimited number of operations such as creating, removing, moving, copying, selecting etc. It works like you'd expect even if you're in the midst of creating something.

Shift<*Key*>*r* restores the last undone operation provided no other changes have been made since the undo was performed.

<*Key*>*tab* changes the board side you are viewing.

For a complete list of keystrokes and button events see Section 6.3 [Translations], page 54.

3.5.2 Lines

To draw new lines you have to be in *line-mode*. Get there either by selecting it from the *Tool palette* or by pressing <*Key*>*F2*. Each successive *notify* event creates a new line. The adjustment to 45 degree lines is done automatically if it is selected from the *Display* menu. You can toggle the 45 degree mode setting by pressing the <*Key*>*.* (That is the period key). When 45 degree enforcement is turned on there are three distinct modes of line creation: a single line on the closest 45 degree vector towards the cross hair (but not necessarily actually ending at the cross hair), two lines created such that the first leaves the start point on a 90 degree vector and the second arrives at the cross hair on a 45 degree vector, and finally two lines created such that the first leaves the start point on a 45 degree vector and the second arrives at the cross hair on a 90 degree vector. These last two modes always connect all the way from the start and end points, and all lines have angles in 45 degree multiples. The <*Key*>*/* cycles through the three modes. The status line shows a text icon to indicate which of the modes is active and the lines following the cross hair motion show the outline of the line(s) that will actually be created. Press <*Key*>*Escape* to leave line-mode.

<*Key*>*l*, *Shift*<*Key*>*l* and the entries in the *Sizes* menu change the initial width of new lines. This width is also displayed in the status line.

3.5.3 Arcs

An Arc is drawn with the *arc-tool*. Get there either by selecting it from the *Tool palette* or by pressing <*Key*>*F8*. Press *Btn1* to define the starting point for the arc. Drag the mouse towards the desired end point along the path you want the arc to follow. The outline of the arc that will be created is shown on the screen as you move the mouse. Arcs are always forced to be 90 degrees and have symmetrical length and width (i.e. they are a quarter circle). The next *Btn1* click creates the arc. It will have the same width as new lines (displayed in the status line) and appear on the active layer. The arc leaves the starting point towards the cross hair along the axis whose distance from the cross hair is largest. Normally this means that if you drag along the path you want the arc to follow, you'll get what you want. If the grid is set to the arc radius, then the two distances will be equal and you won't be able to get all of the possible directions. If this is thwarting your desires, reduce the grid spacing (*!Shift*<*Key*>*G*) and try again.

3.5.4 Polygons and Rectangles

A polygon is drawn by defining all of its segments as a series of consecutive line segments. If the first point matches a new one and if the number of points is greater than two, then the polygon is closed. Since matching up with the first point may be difficult, you may use *Shift*<*Key*>*p* to close the polygon. The *Shift*<*Key*>*p* won't work if clipping to 45 degree lines is selected and the final segment cannot match this condition. I suggest you create simple convex polygons in order to avoid a strong negative impact on the performance of the connection scanning routines. The *rectangle-mode* is just an easy way to generate rectangular polygons. *Polygon-mode* also is selected by <*Key*>*F6* whereas *rectangle-mode* uses <*Key*>*F4*. Pressing a <*Btn1*> at two locations creates a rectangle by defining two of its corners. <*Key*>*Insert* brings you to *insert-point-mode* which lets you add additional points to an already existing polygon. Single points may be removed by moving the cross hair to them and selecting one of the delete actions *(remove-mode, BackSpace, or Delete*. This only works if the remaining polygon will still have three or more corners. Pressing <*Key*>*u* or <*Key*>*p* while entering a new polygon brings you back to the previous corner. Removing a point does not force clipping to 45 degree angles (because it's not generally possible). Newly created polygons will not connect to pins or vias that pierce it unless you create a thermal (using the thermal mode) to make the connection. If the edge of a polygon gets too close to a pin or via that lies outside of it, a warning will be issued and the pin will be given a special color. Increasing the distance between them will remove the warning color.

3.5.5 Text

Pressing *<Key>F5* or clicking one of the text selector buttons changes to *text-mode*. Each successive notify event (*<Btn1>*) pops up the input line at the bottom and queries for a string. Enter it and press *<Key>Return* to confirm or *<Key>Escape* to abort. The text object is created with its upper left corner at the current pointer location. The initial scaling is changed by *<Key>t* and *Shift<Key>t* or from the *Sizes* menu.

Now switch to *rotate-mode* and press *<Btn1>* at the text-objects location. Text objects on the solder side of the layout are automatically mirrored and flipped so that they are seen correctly when viewing the solder-side.

Use *<Key>n* to edit the string.

TEXT OBJECTS ON COPPER LAYERS CREATE COPPER LINES BUT THEY ARE NOT SCANNED FOR CONNECTIONS. If they are moved to the silkscreen layer, they no longer create copper.

3.5.6 Vias

The initial size of new vias may be changed by *<Key>v* and *Shift<Key>v* or by selecting the appropriate entry from the *Sizes* menu. *Mod1<Key>v* and *Mod1 Shift<Key>v* do the same for the drilling hole of the via. The statusline is updated with the new values. Creating a via is similar to the other objects. Switch to *via-mode* by using either the selector button or *<Key>F1* then press *<Key>]* or *<Btn1>* to create one. *<Key>n* changes the name of a via. If you want to create a mounting hole for your board, then you can place a via where you want the hole to be then convert the via into a hole. The conversion is done by pressing *!Ctrl<Key>h* with the cross hair over the via. Conceptually it is still a via, but it has no copper annulus. If you create such a hole in the middle of two polygons on different layers, it will short the layers. Theoretically you could arrange for such a hole not to be plated, but a metal screw inserted in the hole would still risk shorting the layers. A good rule is to realize that holes in the board really are vias between the layers and so place them where they won't interfere with connectivity. You can convert a hole back into a normal via with the same keystroke used to convert it in the first place.

3.5.7 Elements

Some of the functions related to elements only work if both the package layer and the pin layer are switched on.

Now that you're familiar with many of the basic commands, it is time to put the first element on the layout. First of all, you have to load data into the paste buffer. There are four ways to do this:

```
1) load the data from a library
2) load the data from a file
3) copy data from an already existing element
4) convert objects in the buffer into an element
```

We don't have any elements on the screen yet nor anything in the buffer, so we use number one.

Select *lsi* from the menu in the library window press *<Btn1>* twice at the appropriate text-line to get the MC68030 CPU. The data is loaded and the mode is switched to *pastebuffer-mode*. Each notify event now creates one of these beasts. Leave the mode by selecting a different one or by <*Key*>*Escape* which resets all modes.. The cross hair is located at the *mark* position as defined by the data file. Rotating the buffer contents is done by selecting the *rotate* entry of the *Buffer* menu or by pressing *Shift*<*Key*>*F3*. The contents of the buffer are valid until new data is loaded into it either by a cut-to-buffer operation, copy-to-buffer operation or by loading a new data file. There are 5 buffers available (possibly more or less if changed at compile time with the `MAX_BUFFER` variable in '`globalconfig.h`'). Switching between them is done by selecting a menu entry or by *Shift*<*Key*>*1..MAX_BUFFER*. Each of the two board sides has its own buffers.

The release includes all data files for the circuits that are used by the demo layout. The elements in the LED example are not found in the library, but you can lift them from the example itself if you want. If you have problems with the color of the cross hair, change the resource *cross hairColor* setting to a different one.

Now load a second circuit, the MC68882 FPU for example. Create the circuit as explained above. You now have two different unnamed elements. Unnamed means that the layout-name of the element hasn't been set yet. Selecting *description* from the *Display* menu displays the description string of the two circuits which are CPU and FPU. The values of the circuits are set to MC68030 and MC68882. Each of the names of an element may be changed by <*Key*>*n* at the elements location and editing the old name in the bottom input line. Naming pins and vias is similar to elements. You can hide the element name so that it won't appear on the board silkscreen by pressing <*key*>*h* with the cursor over the element. Doing so again un-hides the element name.

Entering *`:le`* and selecting an element data file is the second way to load circuits.

The third way to create a new element is to copy an existing one. Please refer to Section 3.6 [Moving and Copying], page 24.

The fourth way to create a new element is to convert a buffer's contents into an element. Here's how it's done: Select the Via-tool from the *Tool pallet*. Set the grid spacing to something appropriate for the element pin spacing. Now create a series of vias where the pins go. Create them in pin number order. It is often handy to place a reference point (*!Ctrl*<*Key*>*m*) in the center of the first pin in order to measure the location of the other pins. Next make a solder-side layer the active layer from the *active-layer* popup menu. Now draw the outline of the element using lines and arcs. When you're done, select everything that makes up the element with a box selection (<*Btn3Down*> *drag,* <*Btn3Up*>). Now select `"cut selection to buffer"` from the *Buffer* menu. Position the cursor over the center of pin 1 and press the left button to load the data into the buffer. Finally select `"convert buffer to element"` from the *Buffer* menu. You'll only want to create elements this way if they aren't already in the library. It's also probably a good idea to do this before starting any of the other aspects of a layout, but it isn't necessary.

To display the pinout of a circuit move to it and press *Shift*<*Key*>*d* or select *show pinout* from the *Objects* menu. A new window pops up and displays the complete pinout of the element. This display can be difficult to read if the component has been rotated 90 degrees :-(therefore, the new window will show an un-rotated view so the pin names are readable. <*Key*>*d* displays the name of one or all pins/pads inside the Layout area, this is only for display on-screen, it has no effect on any printing of the layout.

You also may want to change a pin's or pad's current size by pressing <*Key*>*s* to increase or *Shift*<*Key*>*s* to decrease it. While this is possible, it is not recommended since care was probably taken to define the element structure in the first place. You can also change the thickness of the element's silkscreen outline with the same keys. You can change whether a pin or SMD pad is rounded or square with the <*Key*>*q*. SMD pads should usually have squared ends. Finally, you can change whether the non-square pins are round or octagonal with the *!Ctrl*<*Key*>*o*.

SMD elements and silkscreen objects are drawn in the "invisible object" color if they are located on the opposite side of the board.

For information on element connections refer to Section 3.9 [Connection Lists], page 27.

3.5.8 Pastebuffer

The line-stack and element-buffer of former releases have been replaced by 5 (possibly more or less if changed at compile time with the `MAX_BUFFER` variable in '`globalconfig.h`') multi-purpose buffers that are selected by *Shift*<*Key*>*1..MAX_BUFFER*. The status line shows which buffer is the active one. You may load data from a file or layout into them. Cut-and-paste works too. If you followed the instructions earlier in this chapter you should now have several objects on the screen. Move the cross hair to one of them and press <*Btn3Down*> to toggle its selection flag. (If you drag the mouse while the button is down, a box selection will be attempted instead of toggling the selection.) The object is redrawn in a different color. You also may want to try moving the pointer while holding the third button down and release it on a different location. This selects all objects inside the rectangle and unselects everything else. If you want to add a box selection to an existing selection, drag with *Mod1*<*Btn3Down*> instead. Dragging *Shift Mod1*<*Btn3Down*> unselects objects in a box. Now change to *pastebuffer-mode* and select some operations from the *Buffer* menu. Copying objects to the buffer is available as *Mod1*<*Key*>*c* while cutting them uses *Mod1*<*Key*>*x* as shortcut. Both clear the buffer before new data is added. If you use the menu entries, you have to supply a cross hair position by pressing a mouse button. The objects are attached to the pastebuffer relative to that cross hair location. Element data or PCB data may be merged into an existing layout by loading the datafiles into the pastebuffer. Both operations are available from the *File* menu or as user commands.

3.6 Moving and Copying

All objects can be moved including element-names, by <*Btn2Down*>, dragging the pointer while holding the button down and releasing it at the new location of the object. If you use *Mod1*<*Btn2Down*> instead, the object is copied. Copying does not work for element-names of course. You can move all selected objects with *Shift* <*Btn1*>. This uses the Pastebuffer, so it will remove whatever was previously in the Pastebuffer. Please refer to Section 3.5.8 [Pastebuffer], page 24. If you want to give a small nudge to an object, but you don't think that the mouse will give you the fine level of control that you want, you can position the cursor over the object, press <*Key*>*[*, move it with the arrow keys, then press <*Key*>*]* when it's at the desired position. Remember that all movements are forced onto grid coordinates, so you may want to change the grid spacing first.

To move a trace or group of traces to a different layer, first select the tracks to be moved. It's easiest to do this if you shut off everything but that layer first (i.e. silk, pins, other layers, etc). Now set the current layer to be the new layer. Press Shift-M to move all the selected tracks to the current layer. See the *MoveToCurrentLayer* action for more details.

3.7 Loading and Saving

After your first experience with `Pcb` you will probably want to save your work. *`:s name`* passes the data to an external program which is responsible for saving it. For details see *saveCommand* in Section 6.1 [Resources], page 38. Saving also is available from the *File* menu, either with or without supplying a filename. `Pcb` reuses the last filename if you do not pass a new one to the save routine.

To load an existing layout either select *load layout data* from the *File* menu or use *`:l filename`*. A file select box pops up if you don't specify a filename. Merging existing layouts into the new one is supported either by the *File* menu or by *`:m filename`*.

`Pcb` saves a backup of the current layout at a user specified interval. The backup filename is created by appending a dash, "-", to the '`.pcb`' filename. For example, if you are editing the layout in '`projects/board.pcb`' then the backup file name will be '`projects/board.pcb-`'. If the layout is new and has not been saved yet, then the backup file name is '`PCB.####.backup`' where the "####" will be replaced by the process ID of the currenting running copy of `Pcb`. This default backup file name may be changed at compilation time via the `BACKUP_NAME` variable in '`globalconfig.h`'). During critical sections of the program or when data would be lost it is saved as '`PCB.%i.save`'. This file name may be changed at compile time with the `SAVE_NAME` variable in '`globalconfig.h`'.

3.8 Printing

`Pcb` now has support for device drivers, `PostScript`, *encapsulated PostScript*, and *Gerber RS-274-X* drivers are available so far. The *Gerber RS-274-X* driver additionally generates a numerical control (NC) drill file for automated drilling, a bill of materials file to assist in materials procurement and inventory control, and a centroid (X-Y) file which includes the centroid data needed by automatic assembly (pick and place) machines. I recommend the use of `GhostScript` if you don't have a `PostScript` printer for handling the PostScript output. Printing always generates a complete set of files for a specified driver. See the page about the *Print()* action for additional information about the filenames. The control panel offers a number of options. Most of them are not available for Gerber output because it wouldn't make sense, for example, to scale the gerber output (you'd get an incorrectly made board!) The options are:

'`device`' The top menu button selects from the available device drivers.

'`rotate`' Rotate layout 90 degrees counter-clockwise before printing (default).

'`mirror`' Mirror layout before printing. Use this option depending on your production line.

'`color`' Created colored output. All colors will be converted to black if this option is inactive.

'`outline`' Add a board outline to the output file. The size is determined by the maximum board size changeable from the *sizes* menu. The outline appears on the top and bottom sides of the board, but not on the internal layers. An outline can be useful for determining where to shear the board from the panel, but be aware that it creates a copper line. Thus it has the potential to cause short circuits if you don't leave enough room from your wiring to the board edge. Use a viewer to see what the output outline looks like if you want to know what it looks like.

'`alignment`'
: Additional alignment targets are added to the output. The distances between the board outline is set by the resource *alignmentDistance*. Alignment targets should only be used if you know for certain that YOU WILL BE USING THEM YOURSELF. It is extremely unlikely that you will want to have alignment targets if you send gerber files to a commercial pcb manufacture to be made.

'`scaling`'
: It's quite useful to enlarge your printout for checking the layout. Use the scrollbar to adjust the scaling factor to your needs.

'`media`'
: Select the size of the output media from this menu. The user defined size may be set by the resource *media* either from one of the well known paper sizes or by a `X11` geometry specification. This entry is only available if you use `X11R5` or later. For earlier releases the user defined size or, if not available, *A4* is used. Well known size are:

  A3
  A4
  A5
  letter
  tabloid
  ledger
  legal
  executive

'`offset`'
: Adjust the offsets of the printout by using the panner at the right side of the dialog box. This entry is only available if you use `X11R5` or later. A zero offset is used for earlier releases.

'`8.3 filenames`'
: Select this button to generate DOS compatible filenames for the output files. The *command* input area will disappear if selected.

'`commandline`'
: Use this line to enter a command (starts with `|`) or a filename. A %f is replaced by the current filename. The default is set by the resource *printCommand*.

The created file includes some labels which are guaranteed to stay unchanged

'`PCBMIN`'
: identifies the lowest x and y coordinates in mil.

'`PCBMAX`'
: identifies the highest x and y coordinates in mil.

'`PCBOFFSET`'
: is set to the x and y offset in mil.

'`PCBSCALE`'
: is a floating point value which identifies the scaling factor.

'`PCBSTARTDATA`'
'`PCBENDDATA`'
: all layout data is included between these two marks. You may use them with an `awk` script to produce several printouts on one piece of paper by duplicating the code and putting some `translate` commands in front. Note, the normal `PostScript` units are 1/72 inch.

3.9 Connection Lists

After completing parts of your layout you may want to check if all drawn connections match the ones you have in mind. This is probably best done in conjunction with a net-list file: see Section 3.11 [Rats Nest], page 28. The following examples give more rudimentary ways to examine the connections.

```
1) create at least two elements and name them
2) create some connections between their pins
3) optionally add some vias and connections to them
```

Now select *lookup connection* from the *Connections* menu, move the cursor to a pin or via and press any mouse button. `Pcb` will look for all other pins and/or vias connected to the one you have selected and display the objects in a different color. Now try some of the reset options available from the same menu.

There also is a way to scan all connections of one element. Select *a single element* from the menu and press any button at the element's location. All connections of this element will be saved to the specified file. Either the layout name of the element or its canonical name is used to identify pins depending on the one which is displayed on the screen (may be changed by *Display* menu).

An automatic scan of all elements is initiated by choosing *all elements*. It behaves in a similar fashion to scanning a single element except the resource *resetAfterElement* is used to determine if connections should be reset before a new element is scanned. Doing so will produce very long lists because the power lines are rescanned for every element. By default the resource is set to *false* for this reason.

To scan for unconnected pins select *unused pins* from the same menu.

3.10 Arrow Tool

Some commands mentioned earlier in this chapter also are able to operate on all selected and visible objects. The Arrow tool is used to select/deselect objects and also to move objects or selections. If you click and release on an object with the Arrow tool, it will unselect everything else and select the object. Selected objects change color to reflect that they are selected. If you *Shift* click, it will add the object to (or remove) the object from the existing selection. If you drag with the mouse button down with the Arrow tool, one of several things could happen: if you first pressed the button on a selected object, you will be moving the selection to where you release the button. If you first pressed the button on an unselected object, you will be moving that object. If you first pressed the button over empty space, you will be drawing a box to select everything inside the box. The *Shift* key works the same way with box selections as it does with single objects.

Moving a single un-selected object is different from moving a selection. First of all, you can move the end of line, or a point in a polygon this way which is impossible by moving selections. Secondly, if rubber banding is turned on, moving a single object will rubber-band the attached lines. Finally, it is faster to move a single object this way since there is no need to select it first.

You can select any visible object unless it is locked. If you select an object, then turn off its visibility with the Layer controls, it won't be moved if you move the remaining visible selection.

If you have not configured to use strokes in the `Pcb` user interface, then the middle mouse button is automatically bound to the arrow tool, regardless of the active tool (which is bound to the first mouse button). So using the middle button any time is just like using the first mouse button with the Arrow tool active.

The entries of the *Selection* menu are hopefully self-explanatory. Many of the *Action Commands* can take various key words that make them function on all or some of the selected items.

3.11 Rats Nest

If you have a netlist that corresponds to the layout you are working on, you can use the rats-nest feature to add rat-lines to the layout. First you will need to load a netlist file (see *:rn*, Chapter 4 [User Commands], page 33). <*Key*>*w* adds rat-lines on the active layer using the current line thickness shown in the status line (usually you'll want them to be thin lines). Only those rat-lines that fill in missing connectivity (since you have probably routed some connections already) are added. If the layout is already completely wired, nothing will be added, and you will get a message that the wiring is complete.

Rat-lines are lines having the special property that they only connect to pins and pads at their end points. Rat-lines are drawn on the screen with a stippled pattern to make them easier to identify since they have special behavior and cannot remain in a completed layout. Rat-lines are added in the minimum length straight-line tree pattern (always ending on pins or pads) that satisfies the missing connectivity in the circuit. Used in connection with moves and rotates of the elements, they are extremely useful for deciding where to place elements on the board. The rat-lines will always automatically rubberband to the elements whether or not the rubberband mode is on. The only way for you to move them is by moving the parts they connect to. This is because it is never desirable to have the rat-lines disconnected from their element pins. Rat-lines will normally criss-cross all over which gives rise to the name "rats nest" describing a layout connected with them. If a SMD pad is unreachable on the active layer, a warning will be issued about it and the rat-line to that pad will not be generated.

A common way to use rats nests is to place some elements on the board, add the rat-lines, and then use a series of moves/rotates of the elements until the rats nest appears to have minimum tangling. You may want to iterate this step several times. Don't worry if the layout looks messy - as long as you can get a sense for whether the criss-crossing is better or worse as you move things, you're fine. After moving some elements around, you may want to optimize the rats nest <*Key*>*o* so that the lines are drawn between the closest points (this can change once you've moved components). Adding rat-lines only to selected pads/pins (*Shift*<*Key*>*w*) is often useful to layout a circuit a little bit at a time. Sometimes you'll want to delete all the rat-lines (<*Key*>*e*) or selected rat-lines (*Shift*<*Key*>*e*) in order to reduce confusion. With a little practice you'll be able to achieve a near optimal component placement with the use of a rats nest.

Rat-lines are not only used for assisting your element placement, they can also help you to route traces on the board. Use the <*Key*>*m* to convert a rat-line under the cursor into a normal line on the active layer. Inserting a point into a rat-line will also cause the two new lines to be normal lines on the board. Another way that you can use rat-lines is to use the <*Key*>*f* with the cursor over a pad or pin. All of the pins and pads and rat-lines belonging to that net will be highlighted. This is a helpful way to distinguish one net from the rest of the rats nest. You can then route those tracks, turn off the highlighting (*Shift<Key>f*) and repeat the process. This will work even if the layer that the rat-lines reside on is made invisible - so only the pins and pads are highlighted. Be sure to erase the rat-lines (*<Key>e* erases them all) once you've duplicated their connectivity by adding your own lines. When in doubt, the *<Key>o* will delete only those rat-lines that are no longer needed.

If connections exist on the board that are not listed in the netlist when *<Key>w* is pressed, warning messages are issued and the affected pins and pads are drawn in a special *warnColor* until the next *Notify()* event. If the entire layout agrees completely with the netlist, a message informs you that the layout is complete and no rat-lines will be added (since none are needed). If the layout is complete, but still has rat-lines then you will be warned that rat-lines remain. If you get no message at all it's probably because some elements listed in the net list can't be found and where reported in an earlier message. There shouldn't be any rat-lines left in a completed layout, only normal lines.

The *Shift<Key>w* is used to add rat-lines to only those missing connections among the selected pins and pads. This can be used to add rat-lines in an incremental manner, or to force a rat-line to route between two points that are not the closest points within the net. Often it is best to add the rats nest in an incremental fashion, laying out a sub-section of the board before going further. This is easy to accomplish since new rat-lines are never added where routed connectivity already makes the necessary connections.

3.12 Design Rule Checking

After you've finished laying out a board, you may want to check to be certain that none of your interconnections are too closely spaced or too tenuously touching to be reliably fabricated. The design rule checking (DRC) function does this for you. Use the command ":DRC()" (without the quotes of course) to invoke the checker. If there are no problem areas, you'll get a message to that effect. If any problem is encountered, you will get a message about it and the affected traces will be highlighted. One part of the tracks of concern will be selected, while the other parts of concern will have the "FindConnection" highlighting. The screen will automatically be centered in the middle of the object having the "FindConnection" (Green) highlighting. The middle of the object is also the coordinates reported to be "near" the problem. The actual trouble region will be somewhere on the boundary of this object. If the two parts are from different nets then there is some place where they approach each other closer than the minimum rule. If the parts are from the same net, then there is place where they are only barely connected. Find that place and connect them better.

After a DRC error is found and corrected you must run the DRC again because the search for errors is halted as soon as the first problem is found. Unless you've been extremely careless there should be no more than a few design rule errors in your layout. The DRC checker does not check for minimum spacing rules to copper text, so always be very careful when adding copper text to a layout. The rules for the DRC are specified in the application resource file. The minimum spacing value (in mils) is given by the *Settings.Bloat* value. The default is 7 mils. The minimum touching overlap (in mils) is given by the *Settings.Shrink* value. This value defaults to 5 mils. Check with your fabrication process people to determine the values that are right for you.

If you want to turn off the highlighting produced by the DRC, perform an undo (assuming no other changes have been made). To restore the highlighting, use redo. The redo will restore the highlighting quickly without re-running the DRC checker.

3.13 Trace Optimizer

PCB includes a flexible trace optimizer. The trace optimizer can be run after auto routing or hand routing to clean up the traces.

Auto-Optimize
: Performs debumpify, unjaggy, orthopull, vianudge, and viatrim, in that order, repeating until no further optimizations are performed.

Debumpify
: Looks for U shaped traces that can be shortened or eliminated.

Unjaggy
: Looks for corners which could be flipped to eliminate one or more corners (i.e. jaggy lines become simpler).

Vianudge
: Looks for vias where all traces leave in the same direction. Tries to move via in that direction to eliminate one of the traces (and thus a corner).

Viatrim
: Looks for traces that go from via to via, where moving that trace to a different layer eliminates one or both vias.

Orthopull
: Looks for chains of traces all going in one direction, with more traces orthogonal on one side than on the other. Moves the chain in that direction, causing a net reduction in trace length, possibly eliminating traces and/or corners.

SimpleOpts
: Removing unneeded vias, replacing two or more trace segments in a row with a single segment. This is usually performed automatically after other optimizations.

Miter
: Replaces 90 degree corners with a pair of 45 degree corners, to reduce RF losses and trace length.

3.14 Searching for elements

To locate text or a specific element or grouping of similar elements choose '`Select by name`' from the **Select** menu, then choose the appropriate subsection. At the bottom of the screen the prompt *pattern:* appears. Enter the text or Appendix C [Regular Expressions], page 90 of the text to be found. Found text will be highlighted.

3.15 Measuring distances

To measure distances, for example the pin-to-pin pitch of a part to validate a footprint, place the cursor at the starting measurement point, then press *!Ctrl<Key>m*. This marks the current location with a *X*. The *X* mark is now the zero point origin for the relative cursor position display. The cursor display shows both absolute position and position relative to the mark as the mouse is moved away from the mark. If a mark is already present, the mark is removed and the cursor display stops displaying relative cursor coordinates.

3.16 Vendor Drill Mapping

`Pcb` includes support for mapping drill holes to a specified set of sizes used by a particular vendor. Many PCB manufacturers have a prefered set of drill sizes and charge extra when others are used. The mapping can be performed on an existing design and can also be enabled to automatically map drill holes as vias and elements are instantiated.

The first step in using the vendor drill mapping feature is to create a resource file describing the capabilities of your vendor. The file format is the resource file format described in Section B.1 [Resource Syntax], page 87. A complete example is given below.

```
# Optional name of the vendor
vendor = "Vendor Name"

# units for dimensions in this file.
# Allowed values:  mil/inch/mm
units = mil

# drill table
drillmap = {
   # When mapping drill sizes, select the nearest size
   # or always round up.  Allowed values:  up/nearest
   round = up

   # The list of vendor drill sizes.  Units are as specified
   # above.
   20
   28
   35
   38
   42
   52
   59.5
   86
  125
  152

   # optional section for skipping mapping of certain elements
   # based on reference designator, value, or description
   # this is useful for critical parts where you may not
   # want to change the drill size.  Note that the strings
   # are regular expressions.
   skips = {
      {refdes "^J3$"}  # Skip J3.
      {refdes "J3"}  # Skip anything with J3 as part of the refdes.
      {refdes "^U[1-3]$" "^X.*"} # Skip U1, U2, U3, and anything starting with X.
      {value "^JOHNSTECH_.*"} # Skip all Johnstech footprints based on the value of a part.
      {descr "^AMP_MICTOR_767054_1$"} # Skip based on the description.
   }
```

```
}

# If specified, this section will change the current DRC
# settings for the design.  Units are as specified above.
drc = {
   copper_space = 7
   copper_width = 7
   silk_width = 10
   copper_overlap = 4
}
```

The vendor resource is loaded using the *LoadVendor* action. This is invoked by entering:

```
:LoadVendor(vendorfile)
```

from within `Pcb`. Substitute the file name of your vendor resource file for '`vendorfile`'. This action will load the vendor resource and modify all the drill holes in the design as well as the default via hole size for the various routing styles.

Once a vendor drill map has been loaded, new vias and elements will automatically have their drill hole sizes mapped to the vendor drill table. Automatic drill mapping may be disabled under the "Settings" menu. To re-apply an already loaded vendor drill table to a design, choose "Apply vendor drill mapping" from the "Connects" menu.

See Section 6.2 [Actions], page 44 for a complete description of the actions associated with vendor drill mapping.

Note that the expressions used in the `skips` section are regular expressions. See Appendix C [Regular Expressions], page 90 for an introduction to regular expressions.

4 User Commands

The entering of user-commands is initiated by the action routine *Command()* (the `(":")` character) and finished by either <*Key*>*Return* or <*Key*>*Escape* to confirm or to abort. These two key-bindings cannot be changed from the resource file. The triggering event, normally a key press, is ignored. The input area will replace the bottom statusline. It pops up when *Command()* is called. The arguments of the user-commands are passed to the external commands without modification. See also, the resource *saveInTMP*.

There are simple *usage* dialogs for each command and one for the complete set of commands.

'`l [filename]`'
: Loads a new datafile (layout) and, if confirmed, overwrites any existing unsaved data. The filename and the searchpath (*filePath*) are passed to the command defined by *fileCommand*. If no filename is specified a file select box will popup.

'`le [filename]`'
: Loads an element description into the paste buffer. The filename and the searchpath (*elementPath*) are passed to the command defined by *elementCommand*. If no filename is specified a file select box will popup.

'`m [filename]`'
: Loads an layout file into the paste buffer. The filename and the searchpath (*filePath*) are passed to the command defined by *fileCommand*. If no filename is specified a file select box will popup.

'`q[!]`'
: Quits the program without saving any data (after confirmation). q! doesn't ask for confirmation, it just quits.

'`s [filename]`'
: Data and the filename are passed to the command defined by the resource *saveCommand*. It must read the layout data from *stdin*. If no filename is entered, either the last one is used again or, if it is not available, a file select box will pop up.

'`rn [filename]`'
: Reads in a netlist file. If no filename is given a file select box will pop up. The file is read via the command defined by the *RatCommand* resource. The command must send its output to *stdout*.

  Netlists are used for generating rat's nests (see Section 3.11 [Rats Nest], page 28) and for verifying the board layout (which is also accomplished by the *Ratsnest* command).

'`w[q] [filename]`'
: These commands have been added for the convenience of `vi` users and have the same functionality as *s* combined with *q*.

'`actionCommand`'
: Causes the actionCommand to be executed. This allows you to initiate actions for which no bindings exist in the resource file. It can be used to initiate any action with whatever arguments you enter. This makes it possible to do

things that otherwise would be extremely tedious. For example, to change the drilling hole diameter of all vias in the layout to 32 mils, you could select everything using the selection menu, then type "*:ChangeDrillSize(SelectedVias, 32)*". (This will only work provided the via's diameter is sufficiently large to accommodate a 32 mil hole). Another example might be to set the grid to 1 mil by typing "*:SetValue(Grid, 1)*". Note that some actions use the current cursor location, so be sure to place the cursor where you want before entering the command. This is one of my favorite new features in 1.5 and can be a powerful tool. Study the Section 6.2 [Actions], page 44 section to see what actions are available.

5 Command-Line Options

There are several resources which may be set or reset in addition to the standard toolkit command-line options. For a complete list refer to Section 6.1 [Resources], page 38.

The synopsis is:

`pcb [-option ...] [-toolkit_option ...] [layout-file]`

or

`pcb -specialoption`

5.1 Options

'`-alldirections/+alldirections`'
: Disables or enables line clipping to 45 degree angles. Overwrites the resource *allDirectionLines*.

'`-background file`'
: Selects a PPM file to be displayed as the board background (for tracing). See backgroundImage in Section 6.1 [Resources], page 38 for details.

'`-backup value`'
: Time between two backups in seconds. Passing zero disables the backup feature. Overwrites the resource *backupInterval*.

'`-c value`'
: Number of characters per output line. The resource *charactersPerLine* is overwritten.

'`-fontfile filename`'
: The default set of symbols (font) for a new layout is read from this file. All directories as defined by the resource *fontPath* are scanned for the file. The scan is only performed if the filename doesn't contain a directory component. The *fontFile* resource is changed.

'`-lelement command-line`'
: Sets the command to be executed when an element is loaded from a file to the paste buffer. The command may contain %f and %p to pass the requested filename and the searchpath to the command. It must write the data to its standard output. The related resource is *elementCommand*.

'`-lfile command-line`'
: Sets the command to be executed when a new layout is loaded from a file. The command may contain %f and %p to pass the requested filename and the searchpath to the command. It must write the data to its standard output. The related resource is *fileCommand*.

'`-lfont command-line`'
: Sets the command to be executed when a font is loaded from a file. The command may contain %f and %p to pass the requested filename and the searchpath to the command. It must write the data to its standard output. The related resource is *fontCommand*.

'`-lg layergroups`'
: This option overwrites the resource *layerGroups*. See its description for more information. The value is used for new layouts only.

'`-libname filename`'
: The default filename for the library. Overwrites the resource *libraryFilename*.

'`-libpath path`'
: The default search path for the the library. Overwrites the resource *libraryPath*.

'`-llib command-line`'
: Sets the command to be executed when an element is loaded from the library. The command may contain %f and %p to pass the requested filename and the searchpath to the command. %a is replaces by the three arguments *template*, *value* and *package*. The command must write the data to its standard output. The related resource is *libraryCommand*.

'`-llibcont command-line`'
: The command lists the contents of the library. The command may contain %f and %p to pass the library filename and the searchpath to the command. Also refer to Section 7.7 [Library File], page 58 and Section 7.6 [Library Contents File], page 58. The related resource is *libraryContentsCommand*.

'`-loggeometry geometry`'
: Determines the geometry of the log window.

'`-pnl value`'
: Restricts the displayed length of the name of a pin in the pinout window to the passed value. See also, the resource *pinoutNameLength*.

'`-pz value`'
: Sets the zoom factor for the pinout window according to the formula: scale = 1:(2 power value). The related resource is *pinoutZoom*.

'`-reset/+reset`'
: If enabled, all connections are reset after each element is scanned. This feature is only used while scanning connections to all elements. See also, *resetAfterElement*.

'`-ring/+ring`'
: Overrides the resource *ringBellWhenFinished*. If enabled, the bell sounds when connection searching has finished.

'`-rs string`'
: Overrides the resource *routeStyle*. The string defines a colon separated list of route styles. The route styles consist of a comma separated list of name, line thickness, via diameter, and via drill size. e.g. "Fat,50,100,40:Skinny,8,35,20:75Ohm,110,110,20"

'`-s/+s`'
: Enables/Disables the saving of the previous commandline. Overrides the *saveLastCommand* resource.

'`-save/+save`'
: See the resource description of *saveInTMP* for details.

'`-sfile command-line`'
: Sets the command to be executed when an layout file is saved. The command may contain %f which is replaced by the filename. The command must read its data from the standard input. The resource *saveCommand* is overwritten.

'`-script filename`'
: Specifies a script file containing PCB actions to be executed upon startup. Overwrites the resource *scriptFilename*.

'`-size <width>x<height>`'
: Overrides the resource *size* which determines the maximum size of a layout.

'`-v value`' Sets the volume of the X speaker. The value is passed to `XBell()` and must be in the range -100..100.

5.2 Special Options

There are some special options available in addition to normal command line options. Each of these must be the only option specified on a command line. The available special options are:

'`-copyright`'
: Prints out the copyright notice and terminates.

'`-version`'
: Prints out the version ID and terminates.

'`-help`' Prints out the usage message and terminates.

6 X11 Interface

This chapter gives an overview about the additional `X11` resources which are defined by `Pcb` as well as the defined action routines.

6.1 Non-Standard X11 Application Resources

In addition to the toolkit resources, `Pcb` defines the following resources:

'`absoluteGrid (boolean)`'
: Selects if either the grid is relative to the position where it has changed last or absolute, the default, to the origin (0,0).

'`alignmentDistance (dimension)`'
: Specifies the distance between the boards outline to the alignment targets.

'`allDirectionLines (boolean)`'
: Enables (default) or disables clipping of new lines to 45 degree angles.

'`backgroundImage (string)`'
: If specified, this image will be drawn as the background for the board. The purpose of this option is to allow you to use a scan of an existing layout as a prototype for your new layout. To do this, there are some limitations as to what this image must be. The image must be a PPM binary image (magic number '`P6`'). It must have a maximum pixel value of 255 or less (i.e. no 16-bit images). It must represent the entire board, as it will be scaled to fit the board dimensions exactly. Note that it may be scaled unevenly if the image doesn't have the same aspect ratio of your board. You must ensure that the image does not use more colors than are available on your system (mostly this is for pseudo-color displays, like old 8-bit displays). For best results, I suggest the following procedure using The Gimp: Load your image (any type). Image->Scale if needed. Image->Colors->Curves and for each of Red, Green, and Blue channel move the lower left point up to about the 3/4 line (value 192). This will make your image pale so it doesn't interfere with the traces you'll be adding. Image->Mode->Indexed and select, say, 32 colors with Normal F-S dithering. File->Save As, file type by extension, use '`.ppm`' as the extension. Select Raw formatting.

'`backupInterval (int)`'
: `Pcb` has an automatic backup feature which saves the current data every n seconds. The default is *300* seconds. A value of zero disables the feature. The backup file is named '`/tmp/PCB.%i.backup`' by default (this may have been changed at compilation time via the `BACKUP_NAME` variable in '`globalconfig.h`'). *%i* is replaced by the process ID. See also, the command-line option *-backup*.

'`Bloat (dimension)`'
: Specifies the minimum spacing design rule in mils.

'`charactersPerLine (int)`'
: `Pcb` uses this value to determine the page width when creating lists. N, the number of characters per line, defaults to *80*. See also, the command-line option *-c*.

'`connectedColor (color)`'
: All pins, vias, lines and rectangles which are selected during a connection search are drawn with this color. The default value is determined by *XtDefaultForeground*.

'`cross hairColor (color)`'
: This color is used to draw the cross hair cursor. The color is a result of a *XOR* operation with the contents of the Layout area. The result also depends on the default colormap of the `X11` server because only the colormap index is used in the boolean operation and `Pcb` doesn't create its own colormap. The default setting is *XtDefaultForeground*.

'`elementColor (color)`'
'`elementSelectedColor (color)`'
: The elements package part is drawn in these colors, for normal and selected mode, respectively, which both default to *XtDefaultForeground*.

'`elementCommand (string)`'
: `Pcb` uses a user defined command to read element files. This resources is used to set the command which is executed by the users default shell. Two escape sequences are defined to pass the selected filename (%f) and the current search path (%p). The command must write the element data to its standard output. The default value is

```
M4PATH="%p";export M4PATH;echo 'include(%f)' | m4
```

Using the GNU version of `m4` is highly recommended. See also, the command-line option *-lelement*.

'`elementPath (string)`'
: A colon separated list of directories or commands (starts with '`|`'). The path is passed to the program specified in *elementCommand* together with the selected element name. A specified command will be executed in order to create entries for the fileselect box. It must write its results to *stdout* one entry per line. See also, the user-command *le[!]*.

'`fileCommand (string)`'
: The command is executed by the user's default shell whenever existing layout files are loaded. Data is read from the command's standard output. Two escape sequences may be specified to pass the selected filename (%f) and the current search path (%p). The default value is:

```
cat %f
```

See also, the command-line option *-lfile*.

'`filePath (string)`'
: A colon separated list of directories or commands (starts with '`|`'). The path is passed to the program specified in *fileCommand* together with the selected

filename. A specified command will be executed in order to create entries for the fileselect box. It must write its results to *stdout* one entry per line. See also, the user-command *l[!]*.

'`fontCommand (string)`'
: Loading new symbol sets also is handled by an external command. You again may pass the selected filename and the current search path by passing %f and %p in the command string. Data is read from the commands standard output. This command defaults to

```
cat %f
```

See also, the command-line option *-lfont*.

'`fontFile (string)`'
: The default font for new layouts is read from this file which is searched in the directories as defined by the resource *fontPath*. Searching is only performed if the filename does not contain a directory component. The default filename is '`default_font`'. See also, the command-line option *-fontfile*.

'`fontPath (string)`'
: This resource, a colon separated list of directories, defines the searchpath for font files. See also, the resource *fontFile*.

'`grid (int)`'
: This resources defines the initial value of one cursor step. It defaults to *100 mil* and any changes are saved together with the layout data.

'`gridColor (color)`'
: This color is used to draw the grid. The color is a result of a *INVERT* operation with the contents of the Layout area. The result also depends on the default colormap of the `X11` server because only the colormap index is used in the boolean operation and `Pcb` doesn't create its own colormap. The default setting is *XtDefaultForeground*.

'`elementColor (color)`'
: Elements located on the opposite side of the board are drawn in this color. The default is *XtDefaultForeground*.

'`layerColor1..MAX_LAYER (color)`'
'`layerSelectedColor1..MAX_LAYER (color)`'
: These resources define the drawing colors of the different layers in normal and selected state. All values are preset to *XtDefaultForeground*.

'`layerGroups (string)`'
: The argument to this resource is a colon separated list of comma separated layer numbers (1..MAX_LAYER). All layers within one group are switched on/off together. The default setting is *1:2:3:...:MAX_LAYER* which means all layers are handled separately. Grouping layers one to three looks like *1,2,3:4:...:MAX_LAYER* See also, the command-line option *-lg*.

'`layerName1..MAX_LAYER (string)`'
: The default name of the layers in a new layout are determined by these resources. The defaults are empty strings.

'libraryCommand (string)'
: Pcb uses a command to read element data from libraries. The resources is used to set the command which is executed by the users default shell. Three escape sequences are defined to pass the selected filename (%f), the current search path (%p) as well (%a) as the three parameters *template*, *value* and *package* to the command. It must write the element data to its standard output. The default value is

```
NONE/share/pcb/oldlib/QueryLibrary.sh %p %f %a
```

'libraryContentsCommand (string)'
: Similar to *libraryCommand*, Pcb uses the command specified by this resource to list the contents of a library.

```
NONE/share/pcb/oldlib/ListLibraryContents.sh %p %f
```

is the default.

'libraryFilename (string)'
: The resource specifies the name of the library. The default value is *pcblib* unless changed at compile time with the LIBRARYFILENAME variable in 'globalconfig.h'.

'libraryPath (string)'
: A colon separated list of directories that will be passed to the commands specified by *elementCommand* and *elementContentsCommand*.

'lineThickness (dimension)'
: The value, in the range [1..250] (the range may be changed at compile time with the MIN_LINESIZE and MAX_LINESIZE variables in 'globalconfig.h'), defines the initial thickness of new lines. The value is preset to *ten mil*.

'media (<predefined> | <width>x<height>+-<left_margin>+-<top_margin>)'
: The default (user defined) media of the PostScript device. Predefined values are *a3*, *a4*, *a5*, *letter*, *tabloit*, *ledger*, *legal*, and *executive*. The second way is to specify the medias width, height and margins in mil. The resource defaults to *a4* size unless changed at compile time with the DEFAULT_MEDIASIZE variable in 'globalconfig.h'.

'offLimitColor (color)'
: The area outside the current maximum settings for width and height is drawn with this color. The default value is determined by *XtDefaultBackground*.

'pinColor (color)'
'pinSelectedColor(color)'
: This resource defines the drawing color of pins and pads in both states. The values are preset to *XtDefaultForeground*.

'pinoutFont (string)'
: This fonts are used to display pin names. There is one font for each zoom value. The values are preset to *XtdefaultFont*.

'`pinoutNameLength (int)`'
: This resource limits the number of characters which are displayed for pin names in the pinout window. By default the string length is limited to *eight* characters per name. See also, the command-line option *-pnl*.

'`pinoutOffsetX (int)`'
'`pinoutOffsetY (int)`'
: These resources determine the offset in *mil* of the circuit from the upper left corner of the window when displaying pinout information. Both default to *100 mil*.

'`pinoutTextOffsetX (int)`'
'`pinoutTextOffsetY (int)`'
: The resources determine the distance in mil between the drilling hole of a pin to the location where its name is displayed in the pinout window. They default to *X:50* and *Y:0*.

'`pinoutZoom (int)`'
: Sets the zoom factor for the pinout window according to the formula: scale = 1:(2 power value). Its default value is *two* which results in a *1:4* scale. See also, the command-line option *-pz*.

'`printCommand (string)`'
: Default file for printouts. If the name starts with a '`|`' the output is piped through the command. A %f is replaced by the current filename. There is no default file or command.

'`raiseLogWindow (boolean)`'
: The log window will be raised when new messages arrive if this resource is set *true*, the default.

'`ratCommand (string)`'
: Default command for reading a netlist. A %f is replaced by the netlist filename. Its default value is "*cat %f*".

'`ratPath (string)`'
: Default path to look for netlist files. It's default value is "."

'`resetAfterElement (boolean)`'
: If set to *true*, all found connections will be reset before a new element is scanned. This will produce long lists when scanning the whole layout for connections. The resource is set to *false* by default. The feature is only used while looking up connections of all elements. See also, the command-line option *-reset, +reset*.

'`ringBellWhenFinished (boolean)`'
: Whether to ring the bell (the default) when a possibly lengthy operation has finished or not. See also, the command-line option *-ring, +ring*.

'`routeStyle (string)`'
: Default values for the menu of routing styles (seen in the sizes menu). The string is a comma separated list of name, line thickness, via diameter, and via drill size. e.g. "Fat,50,100,40:Skinny,8,35,20:75Ohm,110,110,20" See also, the command-line option *-rs* and *Sizes Menu*

'`rubberBandMode (boolean)`'
Whether rubberband move and rotate (attached lines stretch like rubberbands) is enabled (the default).

'`saveCommand (string)`'
This command is used to save data to a layout file. The filename may be indicated by placing `%f` in the string. It must read the data from its standard input. The default command is:

```
cat - > %f
```

See also, the command-line option *-sfile*.

'`saveInTMP (boolean)`'
Enabling this resource will save all data which would otherwise be lost in a temporary file '`/tmp/PCB.%i.save`'. The file name may be changed at compile time with the `EMERGENCY_NAME` variable in '`globalconfig.h`'. . *%i* is replaced by the process ID. As an example, loading a new layout when the old one hasn't been saved would use this resource. See also, the command-line option *-save, +save*.

'`saveLastCommand (boolean)`'
Enables the saving of the last entered user command. The option is *disabled* by default. See also, the command-line option *-s, +s*.

'`Shrink (dimension)`'
Specifies the minimum overlap (touching) design rule in mils.

'`size (<width>x<height>)`'
Defines the width and height of a new layout. The default is *7000x5000* unless changed at compile time with the `DEFAULT_SIZE` variable in '`globalconfig.h`'.

'`stipllePolygons (boolean)`'
Determines whether to display polygons on the screen with a stippled pattern. Stippling can create some amount of transparency so that you can still (to some extent) see layers beneath polygons. It defaults to False.

'`textScale (dimension)`'
The font scaling in percent is defined by this resource. The default is *100* percent.

'`useLogWindow (boolean)`'
Several subroutines send messages to the user if an error occurs. This resource determines if they appear inside the log window or as a separate dialog box. See also, the resource *raiseLogWindow* and the command line option *-loggeometry*. The default value is *true*.

'`viaColor (color)`'
'`viaSelectedColor (color)`'
This resource defines the drawing color of vias in both states. The values are preset to *XtDefaultForeground*.

'viaThickness (dimension)'
'viaDrillingHole (dimension)'
: The initial thickness and drilling hole of new vias. The values must be in the range [30..400] (the range may be changed at compile time with the MIN_PINORVIASIZE and MAX_PINEORVIASIZE variables in 'globalconfig.h'), with at least 20 mil of copper. The default thickness is *40 mil* and the default drilling hole is *20 mil*.

'volume (int)'
: The value is passed to XBell() which sets the volume of the X speaker. The value lies in the range -100..100 and it defaults to the maximum volume of *100*.

'warnColor (color)'
: This resources defines the color to be used for drawing pins and pads when a warning has been issued about them.

'zoom (int)'
: The initial value for output scaling is set according to the following formula: scale = 1:(2 power value). It defaults to *three* which results in an output scale of *1:8*.

Refer also to Chapter 5 [Command-Line Options], page 35.

6.2 Actions

All user accessible commands may be bound to almost any X event. Almost no default binding for commands is done in the binaries, so it is vital for the application that at least a system-wide application resource file exists. This file normally resides in the 'share/pcb' directory and is called 'Pcb'. The bindings to which the manual refers to are the ones as defined by the shipped resource file. Besides binding an action to an X11 event, you can also execute any action command using a ":" command (see Chapter 4 [User Commands], page 33).

Take special care about translations related to the functions keys and the pointer buttons because most of the window managers use them too. Change the file according to your hardware/software environment. You may have to replace all occurances of *baseTranslations* to *translations* if you use a X11R4 server.

Passing *Object* as an argument to an action routine causes the object at the cursor location to be changed, removed or whatever. If more than one object is located at the cross hair position the smallest type is used. If there are two of the same type the newer one is taken. *SelectedObjects* will handle all selected and visible objects.

'AddRats(AllRats|SelectedRats)'
: Adds rat-lines to the layout using the loaded netlist file (see the *:rn*, Chapter 4 [User Commands], page 33.). Rat lines are added on the active layer using the current line thickness shown in the status line. Only missing connectivity is added by the AddRats command so if, for example, the layout is complete nothing will be added. Rat lines are drawn on the screen with a stippled pattern to make them easier to identify since they cannot appear in a completed layout. The rat-lines are added in the minimum length straight-line tree pattern (always ending on pins or pads) that satisfies the missing connectivity in the circuit. If

a SMD pad is unreachable on the active layer, a warning will be issued about it and the rat-line to that pad will not be generated. If connections exist on the board which are not listed in the netlist while AllRats are being added, warning messages will be issued and the affected pins and pads will be drawn in a special *warnColor* until the next *Notify()* event. If the entire layout agrees completely with the net-list a message informs you that the layout is complete and no rat-lines are added (since none are needed). If *SelectedRats* is passed as the argument, only those missing connections that might connect among the selected pins and pads are drawn. Default:

```
None<Key>w:  AddRats(AllRats)
!Shift<Key>w:  AddRats(SelectedRats)
None<Key>o:  DeleteRats(AllRats) AddRats(AllRats)
!Shift<Key>o:  DeleteRats(SelectedRats) AddRats(SelectedRats)
```

'`ApplyVendor()`'
: Applies an already loaded vendor drill map to the design.

```
ApplyVendor()
```

'`Atomic(Save|Restore|Block|Close)`'
: Controls the undo grouping of sequences of actions. Before the first action in a group, Atomic(Save) should be issued. After each action that might be undoable, Atomic(Restore) should be issued. Atomic(Block) concludes and save the undo grouping if there was anything in the group to undo. Atomic(Close) concludes and save the undo grouping even if nothing was actually done. Thus it might produce an "empty" undo. This can be useful when you want to use undo in a group of actions.

'`Bell([-100..100])`'
: Rings the bell of your display. If no value is passed the setting of the resource *volume* will be used.

'`ChangeClearSize(Object, value[, unit])`'
'`ChangeClearSize(SelectedPins|SelectedVias, value[, unit])`'
: The effect of this action depends on if the soldermask display is presently turned on or off. If soldermask is displayed, then the soldermask relief size will be changed. If soldermask display is turned off, then the clearance to polygons will be changed. *unit* is "mil" or "mm". If not specified the units will default to the internal unit of 0.01 mil.

```
!Mod1<Key>k:      ChangeClearSize(Object, +2, mil)
!Mod1 Shift<Key>k: ChangeClearSize(Object, -2, mil)
```

'`ChangeDrillSize(Object, value[, unit])`'
'`ChangeDrillSize(SelectedPins|SelectedVias, value[, unit])`'
: This action routine changes the drilling hole of pins and vias. If *value* starts with `+` or `-`, then it adds (or subtracts) *value* from the current hole diameter, otherwise it sets the diameter to the value. *unit* is "mil" or "mm". If not specified the units will default to the internal unit of 0.01 mil. Default:

```
!Mod1<Key>s:       Change2ndSize(Object, +5, mil)
```

```
!Mod1 Shift<Key>s: Change2ndSize(Object, -5, mil)
```

'`ChangeFlag(Object|SelectElements|SelectedPins|SelectedVias|Selected,thermal|octagon|square,0|1)`'
: Sets/clears the indicated flag. This adds/removes thermals, adds/removes the flag which indicates a pin/pad should be square, or adds/removes the flag which indicates a pin/pad should be octagonal.

```
:ChangeFlag(SelectedVias,thermal,1)
:ChangeFlag(SelectedPads,square,0)
```

'`ChangeHole(Object|SelectedVias)`'
: This action routine converts a via to and from a hole. A hole is a via that has no copper annulus. The drill size for the via determines the hole diameter.

```
!Ctrl<Key>h:  ChangeHole(Object)
```

'`ChangeName(Object)`'
'`ChangeName(Layer|Layout)`'
: Changes the name of the visible object at the cursor location. A text object doesn't have a name therefore the text string itself is changed. The element name currently used for display is always the one changed with this command. See *Display(Description|NameOnPCB|Value)* for details. Passing *Layer* changes the current layers name. Default:

```
None<Key>n: ChangeName(Object)
```

'`ChangeOctagon(Object|SelectElements|SelectedPins|SelectedVias|Selected)`'
: Toggles what shape the affected pin(s) or via(s) will be drawn when they are not square. The shape will either be round or octagonal. Default:

```
!Ctrl<Key>o: ChangeOctagon(Object)
```

'`ChangePinName(ElementName, PinNumber, PinName)`'
: Changes the name for a specified pin or pad number on a specified element. This action is typically used to forward annotate pin/pad names from a schematic to the layout.

```
ChangePinName(U1, 14, VDD)
```

'`ChangeSize(Object, value[, unit])`'
'`ChangeSize(SelectedLines|SelectedPins|SelectedVias, value[, unit])`'
'`ChangeSize(SelectedPads|SelectedTexts|SelectedNames, value[, unit])`'
'`ChangeSize(SelectedElements, value[, unit])`'
: To change the size of an object you have to bind these action to some `X` event (or use :ChangeSize(...)). If *value* begins with a `+` or `-` then the value will be added (or subtracted) from the current size, otherwise the size is set equal to *value*. Range checking is done to insure that none of the maximum/minimums of any size are violated. If *Object* is passed then a single object at the cursor location is changed. If any of the *Selected* arguments are passed then all selected and visible objects of that type are changed. If the type being modified is an element, then the thickness of the silkscreen lines defining the element is changed. *unit* is "mil" or "mm". If not specified the units will default to the internal unit of 0.01 mil. Default:

```
None<Key>s:   ChangeSize(Object, +5)
!Shift<Key>s: ChangeSize(Object, -5)
```

'`ChangeSquare(Object|SelectedElements|SelectedPins)`'

Toggles the setting of the square flag. The flag is used to identify a certain pin, normally the first one, of circuits. It is also used to make SMD pads have square ends.

```
None<Key>q:   ChangeSquare(Object)
```

'`ClrFlag(Object|SelectElements|SelectedPins|SelectedVias|Selected,thermal|octagon|square)`'

Clears the indicated flag. This removes thermals, removes the flag which indicates a pin/pad should be square, or removes the flag which indicates a pin/pad should be octagonal.

```
:ClrFlag(SelectedVias,thermal)
```

'`Command()`'

Calling *Command()* pops up an input line at the bottom of the window which allows you to enter commands. Including all action commands! The dialog ends when *None<Key>Return* to confirm or *None<Key>Escape* to abort is entered. Default:

```
<Key>colon: Command()
```

'`Connection(Find)`'

'`Connection(ResetFoundLinesAndRectangles|ResetPinsViasAndPads|Reset)`'

The *Connection()* action is used to mark all connections from one pin, line or via to others. The *ResetFoundLinesAndRectangles, ResetFoundPinsAndVias* and *Reset* arguments may be used to reset all marked lines and rectangles, vias and pins or all of them. The search starts with the pin or via at the cursor position. All found objects are drawn with the color defined by the resource *connectedColor*. See also, *Display(Description|NameOnPCB|Value)*. Default:

```
!Shift<Key>c: Connection(Reset)
None<Key>f:   Connection(Find)
!Shift<Key>f: Connection(Reset)
```

'`DeleteRats(AllRats|SelectedRats)`'

This routine deletes either all rat-lines in the layout, or only the selected and visible ones. Non-rat-lines and other layout objects are unaffected. Default:

```
None<Key>e:   DeleteRats(AllRats)
!Shift<Key>e: DeleteRats(SelectedRats)
```

'`DisableVendor()`'

Disables automatic drill size mapping to the loaded vendor drill table.

```
DisableVendor()
```

'`DisperseElements(All|Selected)`'

Disperses either all elements or only the selected elements in the layout. This action should be used at the start of a design to spread out all footprints before any placement or routing is done.

```
DisperseElements(All)
```

'Display(Description|NameOnPCB|Value)'
'Display(Toggle45Degree|CycleClip)'
'Display(Grid|ToggleGrid)'
'Display(ToggleRubberBandMode)'
'Display(Center|ClearAndRedraw|Redraw)'
'Display(Pinout|PinOrPadName)'

This action routines handles some output related settings. It is used to center the display around the cursor location and to redraw the output area optionally after clearing the window. Centering is done with respect to the *grid* setting. Displaying the grid itself may be switched on and off by *Grid* but only if the distance between two pixels exceeds 4 pixels. `Pcb` is able to handle several labels of an element. One of them is a description of the functionality (eg resistor), the second should be a unique identifier (R1) whereas the last one is a value (100k). The *Display()* action selects which of the names is displayed. It also controls which name will be affected by the *ChangeName* command. If *ToggleGrid* is passed, `Pcb` changes between relative ('rel' in the statusline) and absolute grid (an 'abs' in the statusline). Relative grid means the pointer position when the command is issued is used as the grid origin; while (0,0) is used in the absolute grid case. Passing *Pinout* displays the pinout of the element at the current cursor location whereas *PinOrPadName* toggles displaying of the pins or pads name under the cursor. If none of them matches but the cursor is inside of an element, the flags is toggled for all of its pins and pads. For details about rubberbands see also the details about *Mode*. Default:

```
None<Key>c:  Display(Center)
None<Key>d:  Display(PinOrPadName)
!Shift<Key>d: Display(Pinout)
None<Key>r:  Display(ClearAndRedraw)
None<Key>.:  Display(Toggle45Degree)
None<Key>/:  Display(CycleClip)
```

'DRC()' Initiates design rule checking of the entire layout. Must be repeated until no errors are found.

'ExecuteFile(filename)'

Executes the PCB actions contained in the specified file. This can be used to automate a complex sequence of operations.

```
:ExecuteFile(custom.cmd)
```

The command file contains a list of PCB actions. Blank lines are ignored and lines starting with a # are treated as comment lines. For example

```
# This is a comment line
Display(Grid)
SetValue(Zoom,2)
DRC()
```

'EditLayerGroups()'

Pops up a dialog box to edit the layergroup setting. The function is also available from the *Objects* menu. There are no defaults.

‘EnableVendor()’

Enables automatic drill size mapping to the loaded vendor drill table.

```
EnableVendor()
```

‘Load(ElementToBuffer|Layout|LayoutToBuffer|Nelist)’

This routine pops up a fileselect box to load layout, element data, or netlist. The passed filename for layout data is saved and may be reused. *ElementToBuffer* and *LayoutToBuffer* load the data into the current buffer. There are no defaults.

‘LoadVendor(vendorfile)’

Loads the specified vendor resource file.

```
LoadVendor(myvendor.res)
```

‘MarkCrosshair()’

This routine marks the current cursor location with an X, and then the cursor display shows both absolute position and position relative to the mark. If a mark is already present, this routine removes it and stops displaying relative cursor coordinates. Defaults:

```
!Ctrl<key>m:  MarkCrosshair()
```

‘Mode(Copy|InsertPoint|Line|Move|None|PasteBuffer|Polygon|Thermal)’
‘Mode(Remove|Rectangle|RubberbandMove|Text|Via)’
‘Mode(Cycle)’
‘Mode(Notify)’
‘Mode(Save|Restore)’

Switches to a new mode of operation. The active mode is displayed by a thick line around the matching mode selector button. Most of the functionality of `Pcb` is implemented by selecting a mode and calling *Mode(Notify)*. The arguments *Line*, *Polygon*, *Rectangle*, *Text* and *Via* are used to create the appropriate object whenever *Mode(Notify)* is called. Some of them, such as *Polygon*, need more than one call for one object to be created. *InsertPoint* adds points to existing polygons or lines. *Save* and *Restore* are used to temporarily save the mode, switch to another one, call *Mode(Notify)* and restore the saved one. Have a look at the application resource file for examples. *Copy* and *Move* modes are used to change an object's location and, optionally, to create a new one. The first call of *Mode(Notify)* attaches the object at the pointer location to the cross hair whereas the second one drops it to the layout. The *rubberband* version of move performs the move while overriding the current rubberband mode. Passing *PasteBuffer* attaches the contents of the currently selected buffer to the cross hair. Each call to *Mode(Notify)* pastes this contents to the layout. *Mode(Cycle)* cycles through the modes available in the mode-button pallet. *Mode(None)* switches all modes off. Default:

```
<Key>Escape:             Mode(None)
<Key>space:              Mode(Cycle)
None<Key>BackSpace:      Mode(Save) Mode(Remove) Mode(Notify) Mode(Restore)
None<Key>Delete:         Mode(Save) Mode(Remove) Mode(Notify) Mode(Restore)
None<Key>F1:             Mode(Via)
None<Key>F2:             Mode(Line)
```

```
None<Key>F3:            Mode(PasteBuffer)
None<Key>F4:            Mode(Rectangle)
None<Key>F5:            Mode(Text)
None<Key>F6:            Mode(Polygon)
None<Key>F7:            Mode(Thermal)
None<Key>F8:   Mode(Arc)
None<Key>Insert:        Mode(InsertPoint)
None<Key>[:             Mode(Save) Mode(Move) Mode(Notify)
None<Key>]:             Mode(Notify) Mode(Restore)
None<Btn1>:         Mode(Notify)
!Shift Ctrl<Btn1>:   Mode(Save) Mode(Remove) Mode(Notify) Mode(Restore)
None<Btn2Down>:         Mode(Save) Mode(Move) Mode(Notify)
None<Btn2Up>:           Mode(Notify) Mode(Restore)
!Mod1<Btn2Down>:      Mode(Save) Mode(Copy) Mode(Notify)
!Mod1<Btn2Up>:        Mode(Notify) Mode(Restore)
Shift BTNMOD<Btn2Down>: Mode(Save) Mode(RubberbandMove) Mode(Notify)
```

'MovePointer(delta_x, delta_y)'
: With this function it is possible to move the cross hair cursor by using the cursor keys. The X server's pointer follows because the necessary events are generated by Pcb. All movements are performed with respect to the currently set grid value. Default:

```
None<Key>Up:      MovePointer(0, -1)
!Shift<Key>Up:    MovePointer(0, -10)
None<Key>Down:    MovePointer(0, 1)
!Shift<Key>Down:  MovePointer(0, 10)
None<Key>Right:   MovePointer(1, 0)
!Shift<Key>Right: MovePointer(10, 0)
None<Key>Left:    MovePointer(-1, 0)
!Shift<Key>Left:  MovePointer(-10, 0)
```

'MoveToCurrentLayer(Object|SelectedObjects)'
: The function moves a single object at the cross hair location or all selected objects to the current layer. Elements are not movable by this function. They have to be deleted and replaced on the other side. If a line segment is moved and the movement would result in a loss of connectivity to another segment then via(s) are automatically added to maintain the connectivity.

```
None<Key>m:       MoveToCurrentLayer(Object)
!Shift<Key>m:     MoveToCurrentLayer(SelectedObjects)
```

'New()'
: Clear the current layout and starts a new one after entering its name. Refer to the resource *backup* for more information. No defaults.

'PasteBuffer(AddSelected|Clear|1..5)'
'PasteBuffer(Rotate, 1..3)'
'PasteBuffer(Convert)'
: This action routine controls and selects the pastebuffer as well as all cut-and-paste operations. Passing a buffer number selects one in of the range 1..5. The statusline is updated with the new number. *Rotate* performs a number

of 90 degree counter clockwise rotations of the buffer contents. *AddSelected* as first argument copies all selected and visible objects into the buffer. Passing *Clear* removes all objects from the currently selected buffer. *Convert* causes the contents of the buffer (lines, arc, vias) to be converted into an element definition. Refer to Section 3.5.8 [Pastebuffer], page 24 for examples. Default:

```
!Ctrl<Key>x:       PasteBuffer(Clear) PasteBuffer(AddSelected)
   Mode(PasteBuffer)
!Shift Ctrl<Key>x: PasteBuffer(Clear) PasteBuffer(AddSelected)
   RemoveSelected() Mode(PasteBuffer)
!Mod1<Key>c:       PasteBuffer(Clear) PasteBuffer(AddSelected)
!Mod1<key>x:       PasteBuffer(Clear) PasteBuffer(AddSelected)
   RemoveSelected()
!Shift<Key>1:      PasteBuffer(1)
!Shift<Key>2:      PasteBuffer(2)
!Shift<Key>3:      PasteBuffer(3)
!Shift<Key>4:      PasteBuffer(4)
!Shift<Key>5:      PasteBuffer(5)
None<Key>F3:       Mode(PasteBuffer)
```

'`Polygon((Close|PreviousPoint)`'

Polygons need a special action routine to make life easier. Calling *Polygon(PreviousPoint)* resets the newly entered corner to the previous one. The Undo action will call Polygon(PreviousPoint) when appropriate to do so. *Close* creates the final segment of the polygon. This may fail if clipping to 45 degree lines is switched on, in which case a warning is issued. Default:

```
None<Key>p:             Polygon(Close)
!Shift<Key>p:           Polygon(Close)
```

'`Print()`' Pops up a print control box that lets you select the output device, scaling and many more options. Each run creates all files that are supported by the selected device. These are mask files as well as drilling files, silk screens and so on. The table shows the filenames for all possible files:

```
POSIX (extension)            8.3 filename
---------------------------------------------
*_componentmask.*            cmsk.*
*_componentsilk.*            cslk.*
*_soldermask.*               smsk.*
*_soldersilk.*               sslk.*
*_drill.*                    dril.*
*_groundplane.*              gpl.*
*_group[1..8].*     [..8].*
```

The output may be sent to a post-processor by starting the filename with the *pipe* (`"|"`) character. Any `"%f"` in a command is replaced with the current filename. The function is available from the *file* menu. There are no defaults.

'`Quit()`' Quits the application after confirming the operation. Default:

```
<Message>WM_PROTOCOLS: Quit()
```

'Redo()' This routine allows you to recover from the last undo command. You might want to do this if you thought that undo was going to revert something other than what it actually did (in case you are confused about which operations are un-doable), or if you have been backing up through a long undo list and over-shoot your stopping point. Any change that is made since the undo in question will trim the redo list. For example if you add ten lines, then undo three of them you could use redo to put them back, but if you move a line on the board before performing the redo, you will lose the ability to "redo" the three "undone" lines. Default:

```
!Shift<Key>r:  Redo()
```

'RemoveSelected()'
This routine removes all visible and selected objects. There are no defaults.

'Report(Object|DrillReport)'
This routine pops up a dialog box describing the various characteristics of an object (or piece of an object such as a pad or pin) in the layout at the cursor position, or a report about all of the drill holes in the layout. There are no defaults.

'RouteStyle(1|2|3|4)'
This routine copies the sizes corresponding to the numbered route style into the active line thickens, via diameter, and via drill size. Defaults:

```
!Ctrl<Key>1: RouteStyle(1)
...
!Ctrl<Key>NUM_STYLES: RouteStyle(NUM_STYLES)
```

The variable `NUM_STYLES` is set at compile time in '`globalconfig.h`'.

'Save(Layout|LayoutAs)'
'Save(AllConnections|AllUnusedPins|ElementConnections)'
Passing *Layout* saves the layout using the file from which it was loaded or, if it is a new layout, calls *Save(LayoutAs)* which queries the user for a filename. The values: *AllConnections*, *AllUnusedPins* and *ElementConnections* start a connection scan and save all connections, all unused pins or the connections of a single element to a file. There are no defaults.

'Select(All|Block|Connection|ToggleObject)'
'Select(ElementByName|ObjectByName|PadByName|PinByName)'
'Select(TextByName|ViaByName)'
Toggles either the selection flag of the object at the cross hair position (*ToggleObject*) or selects all visible objects, all inside a rectangle or all objects which have been found during the last connection scan. The *ByName* functions use a Appendix C [Regular Expressions], page 90 search, always case insensitive, to select the objects. Default:

```
None<Btn3Down>:  Select(ToggleObject)
```

```
None<Btn3Down>,None<Btn3Motion>: See resource file - this is complex
```

‘SetFlag(Object|SelectElements|SelectedPins|SelectedVias|Selected,thermal|octagon|square)’

Sets the indicated flag. This adds thermals, sets the flag which indicates a pin/pad should be square, or sets the flag which indicates a pin/pad should be octagonal.

```
:SetFlag(Selected,thermal)
```

‘SetValue(Grid|LineSize|TextScale|ViaDrillingHole|ViaSize|Zoom, value)’

Some internal values may be changed online by this function. The first parameter specifies which data has to be changed. The other one determines if the resource is set to the passed value, if *value* is specified without sign, or increments/decrements if it is specified with a plus or minus sign. The function doesn't change any existing object only the initial values of new objects. Use the *ChangeSize()* and *ChangeDrillSize()* to change existing objects. Default:

```
None<Key>g:        SetValue(Grid, +5)
!Shift<Key>g:      SetValue(Grid, -5)
None<Key>l:        SetValue(LineSize, +5)
!Shift<Key>l:      SetValue(LineSize, -5)
None<Key>t:        SetValue(TextScale, +10)
!Shift<Key>t:      SetValue(TextScale, -10)
None<Key>v:        SetValue(ViaSize, +5)
!Shift<Key>v:      SetValue(ViaSize, -5)
!Mod1<Key>v:       SetValue(ViaDrillingHole, +5)
!Mod1 Shift<Key>v: SetValue(ViaDrillingHole, -5)
None<Key>z:        SetValue(Zoom, -1)
!Shift<Key>z:      SetValue(Zoom, +1)
```

‘SwapSides()’

This routine changes the board side you are viewing. Default:

```
None<Key>Tab:      SwapSides()
```

‘SwitchDrawingLayer(value)’

Makes layer number 1..MAX_LAYER the current one. Default:

```
None<Key>1:        SwitchDrawingLayer(1)
...
None<Key>MAX_LAYER:        SwitchDrawingLayer(MAX_LAYER)
```

‘ToggleHideName(Object|SelectedElements)’

Toggles whether the element's name is displayed or hidden. If it is hidden you won't see it on the screen and it will not appear on the silk layer when you print the layout.

```
None<Key>h:  ToggleHideName(Object)
!Shift<Key>h:  ToggleHideName(SelectedElements)
```

‘ToggleVendor()’

Toggles automatic drill size mapping to the loaded vendor drill table.

```
ToggleVendor()
```

‘ToggleVisibility(Layer)’

Toggles the visibility of the layer.

```
Mod1<Key>1:  ToggleVisibility(1)
Mod1<Key>2:  ToggleVisibility(2)
Mod1<Key>3:  ToggleVisibility(3)
Mod1<Key>4:  ToggleVisibility(4)
```

‘Undo()’
‘Undo(ClearList)’

The unlimited undo feature of Pcb allows you to recover from most operations that materially affect you work. Calling *Undo()* without any parameter recovers from the last (non-undo) operation. *ClearList* is used to release the allocated memory. *ClearList* is called whenever a new layout is started or loaded. See also *Redo*. Default:

```
None<Key>u:        Undo()
!Shift Ctrl<Key>u: Undo(ClearList)
```

‘UnloadVendor()’

Unloads the loaded vendor drill table.

```
UnloadVendor()
```

‘Unselect(All|Block|Connection)’

Unselects all visible objects, all inside a rectangle or all objects which have been found during the last connection scan. Default:

```
!Shift <Btn3Down>: Mode(Save) Mode(None) Unselect(Block)
!Shift <Btn3Up>:   Unselect(Block) Mode(Restore)
```

6.3 Default Translations

This section covers some default translations of key and button events as defined in the shipped default application resource file. Most of them have already been listed in Section 6.2 [Actions], page 44. Pcb makes use of a nice X11 feature; calling several action routines for one event.

‘None<Key>BackSpace:’
‘None<key>Delete:’
‘!Shift<Key>BackSpace:’
‘!Shift Ctrl<Btn1>:’

The object at the cursor location is removed by *None<Key>BackSpace* or *Shift Ctrl<Btn1>* whereas *Shift<Key>BackSpace* also removes all other objects that are fully-connected to the one at the cursor location.

‘!Mod1 Ctrl<Key>Left:’
‘!Mod1 Ctrl<Key>Right:’
‘!Mod1 Ctrl<Key>Up:’
‘!Mod1 Ctrl<Key>Down:’

Scroll one page in one of the four directions.

‘None<Key>Left:, !Shift<Key>Left:’
‘None<Key>Right:, !Shift<Key>Right:’
‘None<Key>Up:, !Shift<Key>Up:’
‘None<Key>Down:, !Shift<Key>Down:’

Move cross hair either one or ten points in grid.

‘None<Key>Return:’

Finished user input, selects the ’default’ button of dialogs.

‘None<Key>Escape:’

Mode(Reset), aborts user input, selects the ’abort’ button of dialogs or resets all modes.

‘None<Btn2Down>, Btn2<Motion>, None<Btn2Up>:’
‘!Mod1<Btn2Down>, Btn2<Motion>, !Mod1<Btn2Up>:’

The first sequence moves the object or element name at the cursor location. The second one copies the objects. Copying isn’t available for element names.

7 File Formats

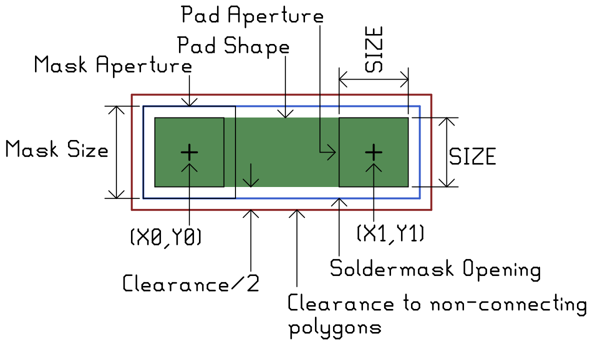
All files used by Pcb are read from the standard output of a command or written to the standard input of one as plain seven bit ASCII. This makes it possible to use any editor to change the contents of a layout file. It is the only way for element or font description files to be created. To do so you'll need to study the example files '`example/*`' and '`default_font`' which are shipped with Pcb. For an overview refer to Chapter 2 [Intro], page 5.

The following sections provide the necessary information about the syntax of the files. Netlist files are not created by Pcb, but it does use them. For information on the format of a netlist file see the *:rn*, Chapter 4 [User Commands], page 33. Rat lines are added on the current layer using the current The commands described allow you to add almost any additional functionality you may need. Examples are compressed read and write access as well as archives. The commands themselves are defined by the resources *elementCommand*, *fileCommand*, *fontCommand*, *libraryCommand*, *libraryContentsCommand* and *saveCommand*. Note that the commands are not saved along with the data. It is considered an advantage to have the layout file contain all necessary information, independent of any other files.

One thing common to all files is they may include comments, newlines, and carriage returns at any place except within quoted strings.

7.1 Pad and Line Representation

Pads and lines (copper traces, silk screen lines, etc) are represented by the line end points and the aperture used to draw the line. It is important to understand this when creating the pads for a new footprint. The following figure illustrates a pad or line which is drawn using a square aperture. The end points (X0,Y0), (X1,Y1) specify the center of the aperture. The size parameter specifies the size of the aperture.



Pads and lines are represented in this way because this is how lines are specified in RS-274-X (Gerber) files which are used for creating the masks used in board manufacturing. In fact, older mask making equipment created lines in precisely this fashion. A physical aperture was used to pass light through onto a photosensitive film.

7.2 Layout File Format

The layout file describes a complete layout including symbols, vias, elements and layers with lines, rectangles and text. This is the most complex file of all. As Pcb has evolved, the file format has changed several times to accommodate new features. Pcb has always been able to read all older versions of the `.pcb` file. This allows the migration of older designs to newer versions of the program. Obviously older versions of `Pcb` will not be able to properly read layout files stored in newer versions of the file format.

In practice it is very common for footprint libraries to contain elements which have been defined in various versions of the `Pcb` file format. When faced with trying to understand an element file or layout file which includes syntax not defined here, the best approach is to examine the file '`src/parse_y.y`' which is the definitive definition of the file format.

The PCB layout file contains the following contents, in this order (individual items are defined in Section 7.8 [File Syntax], page 59:

`PCB` This names the board and sets its size

`Grid` Optional.

`Cursor` Optional.

`Flags` Optional.

`Groups` Optional.

`Styles` Optional.

`Symbols` Optional.

`Vias, Rats, Layers, and Elements`
These may occur in any order, at this point in the file.

`Netlists` Optional.

7.3 Element File Format

Element files are used to describe one component which then may be used several times within one or more layouts. You will normally split the file into two parts, one for the pinout and one for the package description. Using `m4` allows you to define pin names as macros in one file and include a package description file which evaluates the macros. See the resource *elementCommand* for more information. The pins (and pads) must appear in sequential order in the element file (new in 1.5) so that pin 1 must be the first PIN(...) in the file.

Doing things this way makes it possible to use one package file for several different circuits. See the sample files '`dil*`'.

The lowest x and y coordinates of all sub-objects of an element are used as an attachment point for the cross hair cursor of the main window, unless the element has a mark, in which case that's the attachment point.

7.4 Font File Format

A number of user defined Symbols are called a font. There is only one per layout. All symbols are made of lines. See the file '`default_font`' as an example.

The lowest x and y coordinates of all lines of a font are transformed to (0,0).

7.5 Netlist File Format

Netlists read by `Pcb` must have this simple text form:

```
netname [style] NAME-PINNUM NAME2-PINNUM2 NAME3-PINNUM3 ... [\]
```

for each net on the layout.
where "netname" is the name of the net which must be unique for each net, [style] is an optional route-style name, NAME is the layout-name name given to an element, and PINNUM is the (usually numeric) pin number of the element that connects to the net (for details on pin numbering see Section 2.3 [Element Objects], page 5). Spaces or tabs separate the fields. If the line ends with a "\" the net continues on the next line and the "\" is treated exactly as if it were a space. If a NAME ends with a lower-case letter, all lower-case letters are stripped from the end of the NAME to determine the matching layout-name name. For example:

```
Data U1-3 U2abc-4 FLOP1a-7 Uabc3-A9
```

specifies that the net called "Data" should have pin 3 of U1 connected to pin 4 of U2, to pin 7 of FLOP1 and to pin A9 of Uabc3. Note that element name and pin number strings are case-sensitive. It is up to you to name the elements so that their layout-name names agrees with the netlist.

7.6 Library Contents File Format

There is nothing like a special library format. The ones that have been introduced in 1.4.1 just use some nice (and time consuming) features of GNU `m4`. The only predefined format is the one of the contents file which is read during startup. It is made up of two basic line types:

```
menu entry      = "TYPE="name
contents line   = template":"package":"value":"description
name            = String
template        = String
package         = String
value           = String
description     = String
String          = <anything except ":", "\n" and "\r">
```

No leading white spaces or comments are allowed in this file. If you need either one, define a command that removes them before loading. Have a look to the *libraryContentsCommand* resource.

The menu entry will appear in the selection menu at the top and of the library window.

7.7 Library File Format

This section provides an overview about the existing `m4` definitions of the elements. There are basically two different types of files. One to define element specific data like the pinout, package and so on, the other to define the values. For example the static RAM circuits 43256 and 62256 are very similar. They therefore share a common definition in the macro file but are defined with two different value labels.

The macro file entry:

```
define(`Description_43256_dil', `SRAM 32Kx8')
define(`Param1_43256_dil', 28)
define(`Param2_43256_dil', 600)
define(`PinList_43256_dil', ``pin1', `pin2', ...')
```

And the list file:

```
43256_dil:N:43256:62256
```

The macro must define a description, the pin list and up to two additional parameters that are passed to the package definitions. The first one is the number of pins whereas the second one defines for example the width of a package.

It is very important to select a unique identifier for each macro. In the example this would be *43256_dil* which is also the templates name. It is required by some low-level macros that *Description_*, *Param1_*, *Param2_* and *PinList_* are perpended.

The list file uses a syntax:

```
template:package:value[:more values]
```

This means that the shown example will create two element entries with the same package and pinout but with different names.

A number of packages are defined in '`common.m4`'. Included are:

```
DIL packages with suffix D, DW, J, JD, JG, N, NT, P
PLCC
TO3
generic connectors
DIN 41.612 connectors
zick-zack (SD suffix)
15 pin multiwatt
```

If you are going to start your own library please take care about `m4` functions. Be aware of quoting and so on and, most important check your additional entry by calling the macro:

```
CreateObject(`template', `value', `package suffix')
```

If quoting is incorrect an endless loop may occur (broken by a out-of-memory message).

The scripts in the '`lib`' directory handle the creation of libraries as well as of their contents files. Querying is also supported.

I know quite well that this description of the library implementation is not what some out there expect. But in my opinion it's much more useful to look at the comments and follow the macros step by step.

7.8 File Syntax

A special note about units: Older versions of `pcb` used mils (1/1000 inch) as the base unit; a value of 500 in the file meant half an inch. Newer versions uses a "high resolution" syntax, where the base unit is 1/100 of a mil (0.000010 inch); a value of 500 in the file means 5 mils. As a general rule, the variants of each entry listed below which use square brackets are the high resolution formats and use the 1/100 mil units, and the ones with parentheses are the older variants and use 1 mil units. Note that when multiple variants are listed, the most recent (and most preferred) format is the first listed.

Symbolic and numeric flags (SFlags and NFlags) are described in Section 7.9 [Object Flags], page 69.

7.8.1 Arc

```
Arc [X Y Width Height Thickness Clearance StartAngle DeltaAngle SFlags]
Arc (X Y Width Height Thickness Clearance StartAngle DeltaAngle NFlags)
Arc (X Y Width Height Thickness StartAngle DeltaAngle NFlags)
```

X Y Coordinates of the center of the arc.

Width Height
The width and height, from the center to the edge. The bounds of the circle of which this arc is a segment, is thus $2 * Width$ by $2 * Height$.

Thickness The width of the copper trace which forms the arc.

Clearance The amount of space cleared around the arc when the line passes through a polygon. The clearance is added to the thickness to get the thickness of the clear; thus the space between the arc and the polygon is $Clearance/2$ wide.

StartAngle
The angle of one end of the arc, in degrees. In PCB, an angle of zero points left (negative X direction), and 90 degrees points down (positive Y direction).

DeltaAngle
The sweep of the arc. This may be negative. Positive angles sweep counterclockwise.

SFlags Symbolic or numeric flags.

NFlags Numeric flags.

7.8.2 Attribute

```
Attribute ("Name" "Value")
```

Attributes allow boards and elements to have arbitrary data attached to them, which is not directly used by PCB itself but may be of use by other programs or users.

Name The name of the attribute

Value The value of the attribute. Values are always stored as strings, even if the value is interpreted as, for example, a number.

7.8.3 Connect

```
Connect ("PinPad")
```

PinPad The name of a pin or pad which is included in this net. Pin and Pad names are named by the refdes and pin name, like `"U14-7"` for pin 7 of U14, or `"T4-E"` for pin E of T4.

7.8.4 Cursor

```
Cursor [X Y Zoom]
Cursor (X Y Zoom)
```

X Y Location of the cursor when the board was saved.

Zoom The current zoom factor. Note that a zoom factor of "0" means 1 mil per screen pixel, N means 2^N mils per screen pixel, etc. The first variant accepts floating point numbers. The special value "1000" means "zoom to fit"

7.8.5 DRC

```
DRC [Bloat Shrink Line Silk Drill Ring]
DRC [Bloat Shrink Line Silk]
DRC [Bloat Shrink Line]
```

Bloat Minimum spacing between copper.

Shrink Minimum copper overlap to guarantee connectivity.

Line Minimum line thickness.

Silk Minimum silk thickness.

Drill Minimum drill size.

Ring Minimum width of the annular ring around pins and vias.

7.8.6 Element

```
Element [SFlags "Desc" "Name" "Value" MX MY TX TY TDir TScale TSFlags] (
Element (NFlags "Desc" "Name" "Value" MX MY TX TY TDir TScale TNFlags) (
Element (NFlags "Desc" "Name" "Value" TX TY TDir TScale TNFlags) (
Element (NFlags "Desc" "Name" TX TY TDir TScale TNFlags) (
Element ("Desc" "Name" TX TY TDir TScale TNFlags) (
   . . . contents . . .
)
```

SFlags Symbolic or numeric flags, for the element as a whole.

NFlags Numeric flags, for the element as a whole.

Desc The description of the element. This is one of the three strings which can be displayed on the screen.

Name The name of the element, usually the reference designator.

Value The value of the element.

MX MY The location of the element's mark. This is the reference point for placing the element and its pins and pads.

TX TY The upper left corner of the text (one of the three strings).

TDir The relative direction of the text. 0 means left to right for an unrotated element, 1 means up, 2 left, 3 down.

TScale Size of the text, as a percentage of the "default" size of of the font (the default font is about 40 mils high). Default is 100 (40 mils).

TSFlags Symbolic or numeric flags, for the text.

TNFlags Numeric flags, for the text.

Elements may contain pins, pads, element lines, element arcs, attributes, and (for older elements) an optional mark. Note that element definitions that have the mark coordinates in the element line, only support pins and pads which use relative coordinates. The pin and pad coordinates are relative to the mark. Element definitions which do not include the mark coordinates in the element line, may have a Mark definition in their contents, and only use pin and pad definitions which use absolute coordinates.

7.8.7 ElementArc

```
ElementArc [X Y Width Height StartAngle DeltaAngle Thickness]
ElementArc (X Y Width Height StartAngle DeltaAngle Thickness)
```

X Y Coordinates of the center of the arc. These are relative to the Element's mark point for new element formats, or absolute for older formats.

Width Height
The width and height, from the center to the edge. The bounds of the circle of which this arc is a segment, is thus $2 * Width$ by $2 * Height$.

StartAngle
The angle of one end of the arc, in degrees. In PCB, an angle of zero points left (negative X direction), and 90 degrees points down (positive Y direction).

DeltaAngle
The sweep of the arc. This may be negative. Positive angles sweep counterclockwise.

Thickness The width of the silk line which forms the arc.

7.8.8 ElementLine

```
ElementLine [X1 Y1 X2 Y2 Thickness]
ElementLine (X1 Y1 X2 Y2 Thickness)
```

X1 Y1 X2 Y2
Coordinates of the endpoints of the line. These are relative to the Element's mark point for new element formats, or absolute for older formats.

Thickness The width of the silk for this line.

7.8.9 FileVersion

```
FileVersion[Version]
```

Version File format version. This version number represents the date when the pcb file format was last changed.

Any version of pcb build from sources equal to or newer than this number should be able to read the file. If this line is not present in the input file then file format compatibility is not checked.

7.8.10 Flags

```
Flags(Number)
```

Number A number, whose value is normally given in hex, individual bits of which represent pcb-wide flags as defined in Section 7.10 [PCBFlags], page 70.

7.8.11 Grid

/* %start-doc pcbfile PCB

```
PCB ["Name" Width Height]
PCB ("Name" Width Height]
PCB ("Name")
```

Name Name of the PCB project

Width Height
Size of the board

If you don't specify the size of the board, a very large default is chosen.

```
Grid [Step OffsetX OffsetY Visible]
Grid (Step OffsetX OffsetY Visible)
Grid (Step OffsetX OffsetY)
```

Step Distance from one grid point to adjacent points. This value may be a floating point number for the first two variants.

OffsetX OffsetY
The "origin" of the grid. Normally zero.

Visible If non-zero, the grid will be visible on the screen.

7.8.12 Groups

```
Groups("String")
```

String

Encodes the layer grouping information. Each group is separated by a colon, each member of each group is separated by a comma. Group members are either numbers from `1`..N for each layer, and the letters `c` or `s` representing the component side and solder side of the board. Including `c` or `s` marks that group as being the top or bottom side of the board.

```
Groups("1,2,c:3:4:5,6,s:7,8")
```

7.8.13 Layer

```
Layer (LayerNum "Name") (
  . . . contents . . .
)
```

LayerNum The layer number. Layers are numbered sequentially, starting with 1. The last two layers (9 and 10 by default) are solder-side silk and component-side silk, in that order.

Name The layer name.

contents The contents of the layer, which may include lines, arcs, rectangles, text, and polygons.

7.8.14 Line

```
Line [X1 Y1 X2 Y2 Thickness Clearance SFlags]
Line (X1 Y1 X2 Y2 Thickness Clearance NFlags)
Line (X1 Y1 X2 Y2 Thickness NFlags)
```

X1 Y1 X2 Y2

The end points of the line

Thickness The width of the line

Clearance The amount of space cleared around the line when the line passes through a polygon. The clearance is added to the thickness to get the thickness of the clear; thus the space between the line and the polygon is $Clearance/2$ wide.

SFlags Symbolic or numeric flags

NFlags Numeric flags.

7.8.15 Mark

```
Mark [X Y]
Mark (X Y)
```

X Y Coordinates of the Mark, for older element formats that don't have the mark as part of the Element line.

7.8.16 Net

```
Net ("Name" "Style") (
   . . . connects . . .
)
```

Name The name of this net.

Style The routing style that should be used when autorouting this net.

7.8.17 Netlist

```
Netlist ( ) (
   . . . nets . . .
)
```

7.8.18 Pad

```
Pad [rX1 rY1 rX2 rY2 Thickness Clearance Mask "Name" "Number" SFlags]
Pad (rX1 rY1 rX2 rY2 Thickness Clearance Mask "Name" "Number" NFlags)
Pad (aX1 aY1 aX2 aY2 Thickness "Name" "Number" NFlags)
Pad (aX1 aY1 aX2 aY2 Thickness "Name" NFlags)
```

rX1 rY1 rX2 rY2
Coordinates of the endpoints of the pad, relative to the element's mark. Note that the copper extends beyond these coordinates by half the thickness. To make a square or round pad, specify the same coordinate twice.

aX1 aY1 aX2 aY2
Same, but absolute coordinates of the endpoints of the pad.

Thickness width of the pad.

Clearance add to thickness to get clearance width.

Mask width of solder mask opening.

Name name of pin

Number number of pin

SFlags symbolic or numerical flags

NFlags numerical flags only

7.8.19 Pin

```
Pin [rX rY Thickness Clearance Mask Drill "Name" "Number" SFlags]
Pin (rX rY Thickness Clearance Mask Drill "Name" "Number" NFlags)
Pin (aX aY Thickness Drill "Name" "Number" NFlags)
Pin (aX aY Thickness Drill "Name" NFlags)
Pin (aX aY Thickness "Name" NFlags)
```

rX rY coordinates of center, relative to the element's mark

aX aY absolute coordinates of center.

Thickness outer diameter of copper annulus

Clearance add to thickness to get clearance diameter

Mask diameter of solder mask opening

Drill diameter of drill

Name name of pin

Number number of pin

SFlags symbolic or numerical flags

NFlags numerical flags only

7.8.20 PolyArea

```
PolyArea [Area]
```

Area Minimum area of polygon island to retain. If a polygon has clearances that cause an isolated island to be created, then will only be retained if the area exceeds this minimum area.

7.8.21 Polygon

```
Polygon (SFlags) (
   ... (X Y) ...
   ... [X Y] ...
)
```

SFlags Symbolic or numeric flags.

X Y Coordinates of each vertex. You must list at least three coordinates.

7.8.22 Rat

```
Rat [X1 Y1 Group1 X2 Y2 Group2 SFlags]
Rat (X1 Y1 Group1 X2 Y2 Group2 NFlags)
```

X1 Y1 X2 Y2
: The endpoints of the rat line.

Group1 Group2
: The layer group each end is connected on.

SFlags Symbolic or numeric flags.

NFlags Numeric flags.

7.8.23 Styles

```
Styles("String")
```

String

Encodes the four routing styles `pcb` knows about. The four styles are separated by colons. Each style consists of five parameters as follows:

Name The name of the style.

Thickness Width of lines and arcs.

Diameter Copper diameter of pins and vias.

Drill Drill diameter of pins and vias.

Keepaway Minimum spacing to other nets. If omitted, 10 mils is the default.

```
Styles("Signal,10,40,20:Power,25,60,35:Fat,40,60,35:Skinny,8,36,20")
Styles["Logic,1000,3600,2000,1000:Power,2500,6000,3500,1000:
   Line,4000,6000,3500,1000:Breakout,600,2402,1181,600"]
```

Note that strings in actual files cannot span lines; the above example is split across lines only to make it readable.

7.8.24 Symbol

```
Symbol [Char Delta] (
Symbol (Char Delta) (
   . . . symbol lines . . .
)
```

Char The character or numerical character value this symbol represents. Characters must be in single quotes.

Delta Additional space to allow after this character.

7.8.25 SymbolLine

```
SymbolLine [X1 Y1 X2 Y1 Thickness]
SymbolLine (X1 Y1 X2 Y1 Thickness)
```

X1 Y1 X2 Y2
The endpoints of this line.

Thickness The width of this line.

7.8.26 Text

```
Text [X Y Direction Scale "String" SFlags]
Text (X Y Direction Scale "String" NFlags)
Text (X Y Direction "String" NFlags)
```

X Y The location of the upper left corner of the text.

Direction 0 means text is drawn left to right, 1 means up, 2 means right to left (i.e. upside down), and 3 means down.

Scale Size of the text, as a percentage of the "default" size of of the font (the default font is about 40 mils high). Default is 100 (40 mils).

String The string to draw.

SFlags Symbolic or numeric flags.

NFlags Numeric flags.

7.8.27 Thermal

```
Thermal [Scale]
```

Scale Relative size of thermal fingers. A value of 1.0 makes the finger width twice the clearance gap width (measured across the gap, not diameter). The normal value is 0.5, which results in a finger width the same as the clearance gap width.

7.8.28 Via

```
Via [X Y Thickness Clearance Mask Drill "Name" SFlags]
Via (X Y Thickness Clearance Mask Drill "Name" NFlags)
Via (X Y Thickness Clearance Drill "Name" NFlags)
Via (X Y Thickness Drill "Name" NFlags)
Via (X Y Thickness "Name" NFlags)
```

X Y coordinates of center

Thickness outer diameter of copper annulus

Clearance add to thickness to get clearance diameter

Mask diameter of solder mask opening

Drill diameter of drill

Name string, name of via (vias have names?)

SFlags symbolic or numerical flags

NFlags numerical flags only

7.9 Object Flags

Note that object flags can be given numerically (like `0x0147`) or symbolically (like `"found,showname,square"`. Some numeric values are reused for different object types. The table below lists the numeric value followed by the symbolic name.

`0x0001 pin`
: If set, this object is a pin. This flag is for internal use only.

`0x0002 via`
: Likewise, for vias.

`0x0004 found`
: If set, this object has been found by `FindConnection()`.

`0x0008 hole`
: For pins and vias, this flag means that the pin or via is a hole without a copper annulus.

`0x0010 rat`
: If set for a line, indicates that this line is a rat line instead of a copper trace.

`0x0010 pininpoly`
: For pins and pads, this flag is used internally to indicate that the pin or pad overlaps a polygon on some layer.

`0x0010 clearpoly`
: For polygons, this flag means that pins and vias will normally clear these polygons (thus, thermals are required for electrical connection). When clear, polygons will solidly connect to pins and vias.

`0x0010 hidename`
: For elements, when set the name of the element is hidden.

`0x0020 showname`
: For elements, when set the names of pins are shown.

`0x0020 clearline`
: For lines and arcs, the line/arc will clear polygons instead of connecting to them.

`0x0020 fullpoly`
: For polygons, the full polygon is drawn (i.e. all parts instead of only the biggest one).

`0x0040 selected`
: Set when the object is selected.

`0x0080 onsolder`
: For elements and pads, indicates that they are on the solder side.

`0x0080` `auto`
: For lines and vias, indicates that these were created by the autorouter.

`0x0100` `square`
: For pins and pads, indicates a square (vs round) pin/pad.

`0x0200` `rubberend`
: For lines, used internally for rubber band moves.

`0x0200` `warn`
: For pins, vias, and pads, set to indicate a warning.

`0x0400` `usetherm`
: Obsolete, indicates that pins/vias should be drawn with thermal fingers.

`0x0400`
: Obsolete, old files used this to indicate lines drawn on silk.

`0x0800` `octagon`
: Draw pins and vias as octagons.

`0x1000` `drc`
: Set for objects that fail DRC.

`0x2000` `lock`
: Set for locked objects.

`0x4000` `edge2`
: For pads, indicates that the second point is closer to the edge. For pins, indicates that the pin is closer to a horizontal edge and thus pinout text should be vertical.

`0x8000` `marker`
: Marker used internally to avoid revisiting an object.

`0x10000` `nopaste`
: For pads, set to prevent a solderpaste stencil opening for the pad. Primarily used for pads used as fiducials.

7.10 PCBFlags

`0x00001`
: Pinout displays pin numbers instead of pin names.

`0x00002`
: Use local reference for moves, by setting the mark at the beginning of each move.

`0x00004`
: When set, only polygons and their clearances are drawn, to see if polygons have isolated regions.

`0x00008`
: Display DRC region on crosshair.

`0x00010`
: Do all move, mirror, rotate with rubberband connections.

`0x00020`
: Display descriptions of elements, instead of refdes.

`0x00040`
: Display names of elements, instead of refdes.

`0x00080`
: Auto-DRC flag. When set, PCB doesn't let you place copper that violates DRC.

`0x00100`	Enable 'all-direction' lines.
`0x00200`	Switch starting angle after each click.
`0x00400`	Force unique names on board.
`0x00800`	New lines/arc clear polygons.
`0x01000`	Crosshair snaps to pins and pads.
`0x02000`	Show the solder mask layer.
`0x04000`	Draw with thin lines.
`0x08000`	Move items orthogonally.
`0x10000`	Draw autoroute paths real-time.
`0x20000`	New polygons are full ones.

8 Library Creation

This chapter provides a detailed look at how footprint libraries are created and used. The chapter is split into two section, the first section covers the "old" style libraries which use the `m4` macro processor and the second section covers the "new" style libraries.

Despite the names "old" and "new", both styles of libraries are useful and the "old" style should not be discounted because of its name. The advantage of the old style libraries is that one can define a family of footprints, say a DIP package, and then quickly produce all the members of that family. Because the individual packages make use of a base definition, corrections made to the base definition propagate to all the members of a family. The primary drawback to using this library approach is that the effort to create a single footprint is more than a graphical interface and may take even longer if the user has not used the `m4` macro language previously.

The new style of footprint libraries stores each footprint in its own file. The footprints are created graphically by placing pads and then converting a group of pads to a component. This library method has the advantage of being quick to learn and it is easily to build single footprints quickly. If you are building a family of parts, however, the additional effort in creating each one individually makes this approach undesirable. In addition, creating a part with a large pin count can be quite tedious when done by hand.

8.1 Old Style (m4) Libraries

The old style libraries for pcb use the `m4` macro processor to allow the definition of a family of parts. There are several files associated with the old style library. The file '`common.m4`' is the top level file associated with the library. '`common.m4`' defines a few utility macros which are used by other portions of the library, and then includes a predefined set of library files (the lines like `include(geda.inc)`).

8.1.1 Overview of Oldlib Operation

The big picture view of the old style library system is that the library is simply a collection of macro definitions. The macros are written in the `m4` macro language. An example of a macro and what it expands to is the following. One of the predefined footprints in the library which comes with PCB is the `PKG_SO8` macro. Note that all the footprint macros begin with `PKG_`. For this particular example, `PKG_SO8` is a macro for an 8-pin small outline surface mount package. All of the footprint macros take 3 arguments. The first is the canonical name of the footprint on the board. In this case "SO8" is an appropriate name. The second argument is the reference designator on the board such as "U1" or "U23". The third and final argument is the value. For an integrated circuit this is usually the part number such as "MAX4107" or "78L05" and for a component such as a resistor or capacitor it is the resistance or capacitance. The complete call to the macro in our example is '`PKG_SO8(SO8, U1, MAX4107)`'. When processed by `m4` using the macros defined in the PCB library, this macro expands to

```
Element(0x00 "SO8" "U1" "MAX4107" 146 50 3 100 0x00)
(
Pad(10 25 38 25 20 "1" 0x00)
Pad(10 75 38 75 20 "2" 0x100)
```

```
Pad(10 125 38 125 20 "3" 0x100)
Pad(10 175 38 175 20 "4" 0x100)
Pad(214 175 242 175 20 "5" 0x100)
Pad(214 125 242 125 20 "6" 0x100)
Pad(214 75 242 75 20 "7" 0x100)
Pad(214 25 242 25 20 "8" 0x100)
ElementLine(0 0 151 0 10)
ElementArc(126 0 25 25 0 180 10)
ElementLine(101 0 252 0 10)
ElementLine(252 0 252 200 10)
ElementLine(252 200 0 200 10)
ElementLine(0 200 0 0 10)
Mark(29 25)
)
```

which is the actual definition of the footprint that the PCB program works with. As a user of PCB the only time you will need or want to run `m4` directly is when you are debugging a new library addition. In normal operation, the calls to `m4` are made by helper scripts that come with PCB.

Tools such as `gsch2pcb` (used to interface the gEDA schematic capture program to PCB layout) will call `m4` to produce an initial PCB layout that includes all the components on a schematic. In addition, when manually instantiating parts from within PCB, `m4` will be called by PCB's helper scripts to produce the footprints.

8.1.2 The Library Scripts

There are several scripts that are used for processing the m4 libraries. This section briefly describes these scripts and details how they are used by PCB.

8.1.2.1 Scripts Used During Compilation

The scripts described in this section are used during compilation of PCB. They are run automatically by the build system, but are described here to help document the complete library processing that occurs. During the build of PCB, the following actions are taken. The `CreateLibrary.sh` script is run to produce an M4 "frozen file". This frozen file is simply a partially processed M4 input file which can be loaded by M4 more quickly than the original input file.

A typical call to `CreateLibrary.sh` used during the compilation of PCB is:

```
./CreateLibrary.sh -I . pcblib ./common.m4 TTL_74xx_DIL.m4
connector.m4 crystal.m4 generic.m4 genericsmt.m4 gtag.m4
jerry.m4 linear.m4 logic.m4 lsi.m4 memory.m4 optical.m4 pci.m4
resistor_0.25W.m4 resistor_adjust.m4 resistor_array.m4
texas_inst_amplifier.m4 texas_inst_voltage_reg.m4
transistor.m4 geda.m4
```

The '`-I .`' says to search in the current directory for the '`.m4`' files. The output frozen file is '`pcblib`'. The main '`common.m4`' file is listed as well as all of the '`*.m4`' files which define the components in the library.

In addition, a library contents file is created during the build with the `CreateLibraryContents.sh` script. A typical call to `CreateLibrary.sh` used during the compilation of PCB is:

```
./CreateLibraryContents.sh -I . ./common.m4 TTL_74xx_DIL.list
connector.list crystal.list generic.list genericsmt.list gtag.list
jerry.list linear.list logic.list lsi.list memory.list optical.list
pci.list resistor_0.25W.list resistor_adjust.list resistor_array.list
texas_inst_amplifier.list texas_inst_voltage_reg.list transistor.list
geda.list > pcblib.contents
```

The '`pcblib.contents`' file is used by the PCB program to define the libraries and components which will be displayed when you bring up the library window from within PCB. An example of part of the '`pcblib.contents`' file is:

```
TYPE=~TTL 74xx DIL
7400_dil:N:7400:4 dual-NAND
7401_dil:N:7401:4 dual-NAND OC
7402_dil:N:7402:4 dual-NOR
TYPE=~geda
geda_DIP6:DIP6:DIP6:Dual in-line package, narrow (300 mil)
geda_DIP8:DIP8:DIP8:Dual in-line package, narrow (300 mil)
geda_DIP14:DIP14:DIP14:Dual in-line package, narrow (300 mil)
geda_ACY300:ACY300:ACY300:Axial non-polar component,
```

The `TYPE=` lines define the library name that will show up in the library window in PCB. The other lines define the actual components in the library.

8.1.2.2 Scripts Used by PCB at Runtime

When PCB is first executed, it makes a call to the `ListLibraryContents.sh` script. This script provides the PCB program with the contents of the library contents file created when PCB was compiled. A typical call to `ListLibraryContents.sh` is

```
../lib/ListLibraryContents.sh .:/tmp/pcb-20030903/src/../lib pcblib
```

This command says to search the path '`.:/tmp/pcb-20030903/src/../lib`' for a file called '`pcblib.contents`' (the '`.contents`' part is added automatically) and display the contents of the file. PCB parses this output and generates the library window entries.

When you pick a library component from the library window, PCB calls the `QueryLibrary.sh` script to actually pull the footprint into the layout. For example, when the ACY300 component is selected from the `~geda` library, the generated call may be:

```
/tmp/pcb-20030903/src/../lib/QueryLibrary.sh
.:/tmp/pcb-20030903/src/../lib pcblib geda_ACY300 ACY300
ACY300
```

If you were to run this command by hand you would see the PCB code for the element:

```
Element(0x00 "Axial non-polar component," "" "ACY300" 245 70 0 100 0x00)
(
Pin(0 25 50 20 "1" 0x101)
Pin(300 25 50 20 "2" 0x01)
```

```
ElementLine(0 25 75 25 10)
ElementLine(225 25 300 25 10)

ElementLine(75 0 225 0 10)
ElementLine(225 0 225 50 10)
ElementLine(225 50 75 50 10)
ElementLine(75 50 75 0 10)

#       ElementArc(X1 Y 50 50 270 180 10)
#       ElementArc(X2 Y 50 50 90 180 10)

Mark(75 25)
)
```

8.1.3 Creating an Oldlib Footprint

This section provides a complete example of defining a family of footprints using the M4 style library. As a vehicle for this example, a family of footprints for surface mount resistors and capacitors will be developed. The file '`example.inc`' should have been installed on your system as '`$prefix/share/examples/oldlib/example.inc`' where '`$prefix`' is often times '`/usr/local`'.

The '`example.inc`' file defines a macro called `COMMON_PKG_RCSMT` which is a generic definition for a surface mount footprint with two identical, rectangular pads. This macro will be called with different parameters to fill out the family of parts. The arguments to the `COMMON_PKG_RCSMT` are:

```
# -------------------------------------------------------------------
# the definition for surface mount resistors and capacitors
# $1: canonical name
# $2: name on PCB
# $3: value
# $4: pad width   (in direction perpendicular to part)
# $5: pad length  (in direction parallel with part)
# $6: pad spacing (center to center)
# $7: distance from edge of pad to silk (in direction
#     perpendicular to part)
# $8: distance from edge of pad to silk (in direction parallel
#     with part)
# $9: Set to "no" to skip silk screen on the sides of the part

define(`COMMON_PKG_RCSMT',
`define(`XMIN', `eval( -1*`$6'/2 - `$5'/2 - `$8')')
define(`XMAX', `eval(  `$6'/2 + `$5'/2 + `$8')')
define(`YMIN', `eval(-1*`$4'/2 - `$7')')
define(`YMAX', `eval(   `$4'/2 + `$7')')
Element(0x00 "$1" "$2" "$3" eval(XMIN+20) eval(YMAX+20) 0 100 0x00)
(
ifelse(0, eval($4>$5),
# Pads which have the perpendicular pad dimension less
```

```
# than or equal to the parallel pad dimension
Pad(eval(-1*(   $6 + $5 - $4)/2) 0
    eval((-1*$6 + $5 - $4)/2) 0 eval($4) "1" 0x100)
Pad(eval(-1*(-1*$6 + $5 - $4)/2) 0
    eval((   $6 + $5 - $4)/2) 0 eval($4) "2" 0x100)
,
# Pads which have the perpendicular pad dimension greater
# than or equal to the parallel pad dimension
Pad(eval(-1*$6/2) eval(-1*($4 - $5)/2)
    eval(-1*$6/2)  eval(($4 - $5)/2) eval($5) "1" 0x100)
Pad(eval(   $6/2) eval(-1*($4 - $5)/2)
    eval(   $6/2)  eval(($4 - $5)/2) eval($5) "2" 0x100)
)

# silk screen
# ends
ElementLine(XMIN YMIN XMIN YMAX 10)
ElementLine(XMAX YMAX XMAX YMIN 10)
# sides
ifelse($9,"no",
#skip side silk
,
ElementLine(XMIN YMIN XMAX YMIN 10)
ElementLine(XMAX YMAX XMIN YMAX 10)
)
Mark(0 0)
)')
```

Note that the part has been defined with the mark located at `(0,0)` and that the pads have been placed with the mark at the common centroid of the footprint. While not a requirement, this is highly desirable when developing a library that will need to interface with a pick and place machine used for factory assembly of a board.

The final part of '`example.inc`' defines particular versions of the generic footprint we have created. These particular versions correspond to various industry standard package sizes.

```
# 0402 package
#
# 30x30 mil pad, 15 mil metal-metal spacing=>
# 15 + 15 + 15 = 45 center-to-center
define(`PKG_RC0402',
  `COMMON_PKG_RCSMT(`$1', `$2', `$3', 30, 30, 45, 0, 10, "no")')

# 0603 package
#
# 40x40 mil pad, 30 mil metal-metal spacing=>
#  30 + 20 + 20 = 70 center-to-center
define(`PKG_RC0603',
```

```
  `COMMON_PKG_RCSMT(`$1', `$2', `$3', 40, 40, 70, 10, 10)')

# 1206 package
#
# 40x60 mil pad, 90 mil metal-metal spacing=>
#  90 + 20 + 20 = 130 center-to-center
define(`PKG_RC1206',
  `COMMON_PKG_RCSMT(`$1', `$2', `$3', 60, 40, 130, 10, 10)')
```

At this point, the '`example.inc`' file could be used by third party tools such as `gsch2pcb`. However to fully integrate our footprints into PCB we need to create the '`example.m4`' and '`example.list`' files. The '`example.m4`' file defines descriptions for the new footprints.

```
define(`Description_my_RC0402',
  ``Standard SMT resistor/capacitor (0402)'')
define(`Description_my_RC0603',
  ``Standard SMT resistor/capacitor (0603)'')
define(`Description_my_RC1206',
  ``Standard SMT resistor/capacitor (1206)'')
```

Finally we need to create the '`example.list`' file.

```
my_RC0402:RC0402:RES0402
my_RC0402:RC0402:CAP0402
my_RC0603:RC0603:RES0603
my_RC0603:RC0603:CAP0603
my_RC1206:RC1206:RES1206
my_RC1206:RC1206:CAP1206
```

The first field in the list file has the name corresponding to the Description definitions in '`example.m4`'. The second field is the template name which corresponds to the macros `PKG_*` we defined in '`example.inc`' with the leading `PKG_` removed. It is the second field which controls what footprint will actually appear on the board. The final field is the name of the part type on the board. The first line in our '`example.list`' file will produce a menu entry in the library window that reads:

```
CAP0402, Standard SMT resistor/capacitor (0402)
```

The `CAP0402` portion comes directly from the third field in `example.list` and the longer description comes from descriptions macros in `example.m4`. Please note that any extra white space at the end of a line in the '`.list`' files will cause them to not work properly.

8.1.4 Troubleshooting Old Style Libraries

A powerful technique to help debug problems with libraries is to invoke the `m4` processor directly. This approach will provide error output which is not visible from within PCB. The following example shows how one might try to debug an 8 pin small outline (SO8) package. The macro name for the package is PKG_SO8. In this example, the canonical name that is to be associated with the part is SO8, the reference designator is U1, and the value is MAX4107 (the part number).

```
echo "PKG_SO8(SO8, U1, MAX4107)" | \
   gm4 common.m4 - | \
   awk '/^[ \t]*$/ {next} {print}' | \
```

```
more
```

The `awk` call simply removes blank lines which make the output hard to read.

For this particular example, the output is:

```
Element(0x00 "SO8" "U1" "MAX4107" 146 50 3 100 0x00)
(
Pad(10 25 38 25 20 "1" 0x00)
Pad(10 75 38 75 20 "2" 0x100)
Pad(10 125 38 125 20 "3" 0x100)
Pad(10 175 38 175 20 "4" 0x100)
Pad(214 175 242 175 20 "5" 0x100)
Pad(214 125 242 125 20 "6" 0x100)
Pad(214 75 242 75 20 "7" 0x100)
Pad(214 25 242 25 20 "8" 0x100)
ElementLine(0 0 151 0 10)
ElementArc(126 0 25 25 0 180 10)
ElementLine(101 0 252 0 10)
ElementLine(252 0 252 200 10)
ElementLine(252 200 0 200 10)
ElementLine(0 200 0 0 10)
Mark(29 25)
)
```

8.2 New Style Libraries

Footprints for the new style library are created graphically using the PCB program. A single footprint is saved in each file.

8.2.1 Creating Newlib Footprints

To create

1. Start PCB with an empty layout.
2. Make the component layer active.
3. For a leaded part, select the via tool and place vias where the pads for the part should go. For surface mount pads, draw line segments. Note that until the footprint is completed, the surface mount pads will remain rounded. Currently a rectangle or polygon may not be used as a pad.
4. For each via and line segment which will become a pad, select it and press 'n' to be able to enter a name. Enter the pin number and press enter.
5. Make the silk layer active.
6. Using the line and arc tools, draw a silk screen outline for the part.
7. Using the selection tool, select all of the pins and silk screen for the part.
8. Place the pointer above the reference point for the part. This is typically the common centroid. Keeping the pointer there, shift-right-click to bring up the popup menu and choose `"convert selection to element"`.
9. At this point, the vias, line segments, and silk screen will have been converted to an element. To change any of the line segments to have square ends rather than round

ends, select the pads by holding down the shift key and clicking each pad with the center mouse button. Now under the Select menu, "Change square-flag of selected objects" section, choose "Pins".

10. Select the element, shift-right-click to bring up the popup menu, and choose "Copy Selection to Buffer". Now left-click on the center of the new element.
11. Under the buffer menu, choose "save buffer elements to file" to save the new footprint to a file.
12. Press ESC to exit from buffer mode.

8.2.2 Modifying Newlib Footprints

1. In the `Pcb` program, instantiate the footprint you wish to modify.
2. Using the selection tool, select the footprint.
3. Now left-click on the selected element, this brings up a popup menu, choose "Cut Selection to Buffer" from the popup menu.
4. Under the buffer menu, choose "break buffer element to pieces", and then left-click to place the broken apart footprint to an open area of the layout. Note that you must use the items under the buffer menu, the items with the same names in the popup menu do not work.
5. Make your desired modifications to the footprint and then convert the pieces back to an element using the same procedure as when starting from scratch on a new footprint.

9 Schematic Capture for PCB

When designing a circuit board of any complexity, a schematic capture front-end for the design is highly desired. Any schematic capture program which is able to generate a netlist in a user defined format as well as a bill of materials can be made to work with PCB. Currently, we are aware of two freely available schematic capture programs which can interface with PCB. This chapter shows how a design can be taken from start to finish using either of these two tools for schematic capture and PCB for layout.

9.1 gEDA

This section shows how to use gEDA as the schematic capture front-end for a PCB design. This section is not intended to be complete documentation on gEDA and it is assumed that the user has at least some familiarity with the gEDA suite of programs.

The basic steps in a gEDA + PCB design flow are:

1. Set up project directories
2. Set up gEDA (gschem/gnetlist) config files
3. Set up gsch2pcb config files
4. Capture schematics using `gschem` (part of gEDA)
5. Create any unique PCB footprints needed for the design
6. Generate initial PCB design using `gsch2pcb` (part of gEDA)
7. Layout circuit board using `pcb`
8. Make any additional schematic changes with `gschem` and forward annotate to PCB with `gsch2pcb`
9. Generate photoplot files (RS-274-X, also known as "Gerber") for board vendor

9.1.1 Set Up Project Directories

Although not required, a typical project directory will contain the schematics and board layout at the top level. Schematic symbols and circuit board footprints which are unique to this project are stored in subdirectories. For this example, '`sym`' contains the project specific schematic symbols and '`pkg`' contains the project specific footprints. Set up the project subdirectory and subdirectories by executing:

```
mkdir ~/myproj
cd ~/myproj
mkdir sym
mkdir pkg
mkdir pkg/newlib
mkdir pkg/m4
```

9.1.2 Set Up gEDA Config Files

The gEDA tools, specifically `gschem` and `gnetlist`, use configuration files to set the search path for symbol libraries in addition to other user preferences. Create a file in the top level project directory called '`gschemrc`'. Add the following lines to that file:

```
;; list libraries here.  Order matters as it sets the
;; search order
(component-library "./sym")
```

This sets the local search path for the schematic capture program `gschem`. Now the netlister, `gnetlist`, must also be configured. This can be done by copying the file '`gschemrc`' to '`gnetlistrc`' by running '`cp gschemrc gnetlistrc`'. Alternatively, you can create a soft link so only a single file needs to be updated if additional symbol paths are added. The link is created by running '`ln -s gschemrc gnetlistrc`'.

9.1.3 Set Up `gsch2pcb` Config Files

The program `gsch2pcb`, not to be confused with the older `gschem2pcb` script, is used to link the schematic to layout. `gsch2pcb` is responsible for creating the netlist used to provide connectivity information to PCB as well creating an initial layout with all components instantiated in the design. Forward annotation of schematic changes to the layout is also done using `gsch2pcb`. `gsch2pcb` uses a project file to set up the schematic file names, PCB library locations, and output file names. Create a project file called '`project`' using the following as an example:

```
# List all the schematics to be netlisted
# and laid out on the pc board.
schematics      first.sch second.sch third.sch

# For an output-name of foo, gsch2pcb generates files
# foo.net, foo.pcb, and foo.new.pcb.  If there is no
# output-name specified, the file names are derived from
# the first listed schematic, i.e. first.net, etc.
output-name  preamp
```

9.1.4 Capture Schematics Using `gschem`

This section is fairly brief and assumes familiarity with using the `gschem` schematic capture program. As you are creating your schematics, be sure to observe the following rules:

- Make sure that each component in the schematic has a `footprint` attribute that corresponds to a footprint in the PCB library or a footprint you plan on creating.
- Make sure all reference designators are unique. One way to ensure this is to run the `refdes_renum` script (part of gEDA) after the schematics are created.

9.1.5 Create Any Unique PCB Footprints

Create the new footprints you design needs using either the m4 style or newlib style of PCB libraries. Refer to Chapter 8 [Library Creation], page 72 for details on this process. For m4 style footprints, store them in the '`pkg/m4`' subdirectory and for newlib footprints, store them in the '`pkg/newlib`' subdirectory.

9.1.6 Generate Initial PCB Design Using gsch2pcb

The `gsch2pcb` program connects the schematic and layout. It basic operation is to call `gnetlist` to generate the connectivity netlist that PCB used to verify connectivity and to instantiate all elements found in the schematic to a new layout. The default, as of `gsch2pcb` version 0.9, is to use any found m4 style parts first and then search for newlib style if no old style part was found. By using the `--use-files` or `-f` flag to `gsch2pcb` priority is given to newlib style parts even if m4 style are found. You may wish to verify this in the `gsch2pcb` documentation in case this changes in the future. To start your layout, run '`gsch2pcb project`' where '`project`' is the project file created previously. This will create a new netlist file, '`preamp.net`', and a new layout file, '`preamp.pcb`'.

9.1.7 Layout Circuit Board

Run PCB on the new layout by running '`pcb preamp.pcb`'. Load the netlist file by selecting "load netlist file" from the "file" menu. In the file selection dialog box, choose '`preamp.net`'. This loads connectivity information into PCB.

Using the selection tool, grab and move apart the various footprints with the middle mouse button. Once the parts are moved apart from each other, choose "optimize rats-nest" from the "Connects" menu. This menu choice will display and optimize the rats nest. Use the rats nest to help guide placement of the parts. You may wish to re-run the "optimize rats-nest" command after moving parts around.

After the placement is complete, use the line tool to add traces to the board. As traces are added, the corresponding rats line will disappear.

9.2 Forward Annotation of Schematic Changes

If schematic changes are made after the layout has started, `gsch2pcb` can be used to forward annotate these changes to the layout. To forward annotate schematic changes, run '`gsch2pcb project`'. This command will create the files '`preamp.new.pcb`', '`preamp.net`', and modify the file '`preamp.pcb`'. The modifications to '`preamp.pcb`' include forward annotation of schematic component value changes, adds any new components, and removes any deleted components.

9.2.1 Generate Photoplot Files (RS-274-X)

After the layout is complete, choose "edit layer-groupings" from the "Settings" menu. The LayerGroups form lets you specify which layers will appear in each output layer group. For example, in the default form, layer group 1 has "front" and "front side" in it. The output file '`1.gbr`' if DOS file names are used, or '`somename_front.gbr`' if long file names are used will contain the "front" and "front side" layers in it. Usually the defaults are sufficient, but this form is still a useful reference.

Choose "print layout..." from the "File" menu. In the print dialog box, select "Gerber/RS-274X" for the device driver. Select the "outline", "alignment", and "drillhelper" options. To get DOS compatible file names, select the "DOS (8.3) names" option, otherwise enter "preamp" for the filename. Press "OK".

The following output files should have been created in the project directory. The names in parentheses correspond to the DOS compatible output file names.

'preamp_frontsilk.gbr (csilk.gbr)'
: Top side silk screen.

'preamp_frontmask.gbr (cmask.gbr)'
: Top side soldermask relief.

'preamp_front.gbr (1.gbr)'
: Top copper.

'preamp_backmask.gbr (smask.gbr)'
: Bottom side soldermask relief.

'preamp_back.gbr (2.gbr)'
: Bottom Copper.

'preamp_fab.gbr (fab.gbr)'
: Fabrication drawing. Also known as the drill drawing. This drawing is used for reference by the board vendor but is not directly used in the fabrication process.

'preamp_plated-drill.cnc (pdrill.cnc)'
: NC Drill format file for the plated through holes.

'preamp_unplated-drill.cnc (udrill.cnc)'
: NC Drill format file for the unplated through holes.

'preamp_bom.txt (bom.txt)'
: A bill of materials for the layout.

'preamp_xy.txt (xy.txt)'
: Centroid (X-Y) data for driving automated assembly equipment.

9.3 xcircuit

If anyone cares to contribute this section, it will get added. Please submit changes to the bug tracking system at the sourceforge project page for PCB which can be found from the PCB homepage at http://pcb.sourceforge.net.

Appendix A Installation and Troubleshooting

Compiling and installing the package should be straightforward. If any problems occur, please contact the author `Thomas.Nau@rz.uni-ulm.de`, or the current maintainer `haceaton@aplcomm.jhuapl.edu` to find a solution and include it into the next release.

A.1 Compiling and Installing

This section covers the steps which are necessary to compile the package.

A.1.1 Quick Start

Starting with version 2.0, `Pcb` has switched to a GNU autoconf/automake build system. Installation of `Pcb` consists of three steps: configuration, building, and installing. In a typical installation, these steps are as simple as

```
./configure
make
make install
```

A.1.2 Running the configure Script

The `configure` script accepts all of the standard GNU configure options. For a complete list of configuration options, run `./configure --help`.

'`INFOLIBDIR`'
: must be set to the directory where your GNU info files are located.

'`PCBLIBDIR`'
: is the path of a directory where the font files will be installed.

'`DEFAULTFONT`'
: the name of the default font file.

'`DEFAULTLIBRARY`'
: the name of the default library.

'`GNUM4`' the name of GNUs m4 version.

'`BTNMOD`' If your window manager has already bound *Mod1* together with some function keys you may want to change this setting. This is true for HP-VUE.

If you find things which must be changed to compile on your system, please add the appropriate autoconf tests (if you are familiar with that) and mail a copy to the maintainer, harry eaton, at `haceaton@aplcomm.jhuapl.edu`.

If you do not have the appropriate permissions you should run '`./pcbtest.sh`' in the '`src`' directory to run `Pcb` from the installation directory.

A.2 Troubleshooting

There are some known problems. Most of them are related to missing parts of a standard `X11` distribution. Some others are caused by third party applications such as `X` servers. To make this list more complete please mail your problems and, if available, solutions to the author. The mail address may be found at the beginning of this chapter. In any case, read Section A.2.8 [X11], page 86.

By the way, you MUST HAVE AN ANSI COMPILER to make Pcb work.

Another source of problems are older versions of flex and bison. Pcb definitely works with flex-2.4.7 and bison-1.22 or later. The problems will result in a *syntax error* while parsing files. This should only be a problem if you have modified the flex or bison input files.

The following list gives you just an idea because I'm not able to test all Pcb releases on all platforms.

A.2.1 HP Series 700 and 800

You have to install several X11 include files or, better, install a complete X11R5 release. Hewlett-Packard doesn't support the Athena Widgets. So the header files and libraries are missing from the application media, but they are available as a patch. They also do not ship the ANSI compiler with the normal operating system release so you have to buy one or use GCC. Some of the tools are available as patches.

In addition, Pcb has been successfully tested on these platforms with HPUX 9.*, 10.* running self-compiled X11R5.

A.2.2 Sun SPARC architecture

There are no known problems with Sun machines if they use X11R5 instead of OpenWindows. Pcb compiled successfully with all kinds of SPARCstations Solaris-2.[345].

For problems with OpenWindows refer to Section A.2.8 [X11], page 86.

A.2.3 Silicon Graphics

Pcb has been tested on some boxes running either IRIX-4.0.5 or IRIX-5.3. The former one uses a X11R4 server. There are no problems. For known problems with X11R4, see Section A.2.8 [X11], page 86.

A.2.4 DEC Alpha

Pcb compiled and runs without problems on DEC UNIX V3.2c.

A.2.5 SCO Unix

John DuBois <spcecdt@deeptht.armory.com> wrote:

```
SCO-ODT-3.0 requires the latest version of tls003, the Athena
widget library (available from sosco.sco.com). The main problems
I have encountered are it core dumps fairly often, especially
while loading/dropping elements...
```

I'll see what I am able to do as soon as I have access to an SCO system.

A.2.6 Linux

Since the X11 version of Pcb has been developed on a Linux system here are no known problems.

A.2.7 FreeBSD and NetBSD

`Pcb` has been tested on NetBSD and works without any problems. You may also be able to find a NetBSD package at `ftp://ftp.netbsd.org/pub/NetBSD/packages/cad/pcb/README.html` or a FreeBSD port at `http://www.freebsd.org/cgi/url.cgi?ports/cad/pcb/pkg-descr`.

A.2.8 Problems related to X11

There are a some problems related to `X11R4` or systems derived from `X11` such as `OpenWindows`. See Section A.2.2 [Sun], page 85. You at least have to change all occurances of *baseTranslations* in the resource files to *translations* if you are using a `X11R4` server. Look at the `X11R5` *Intrinsics* manual for details.

The panner widget (print dialog box) appears only in release `X11R5` and later. It really simplifies adjusting the offsets. With earlier releases the printout will always appear in the center of the page.

You may have some problems in a mixed `X11-OpenWindows` environment.

`Pcb` has been tested successfully with `X11R6` under Linux 1.1.59 and later.

A.2.9 Problems related to TeX

If your `TeX` installation complains about a missing '`texinfo.tex`' file copy the one included in this release (directory '`doc`' to your `TeX` macro directory. Note, there are probably newer versions of this file available from some FTP sites. `TeX-3.0` failed, `TeX-3.14` worked just fine. Check our FTP server *ftp.uni-ulm.de* for ready-to-print versions of the manuals.

Appendix B Customizing the Menus

The menu system is driven off a data file that contains *resources*. A resource is a hierarchical description of a data tree which, in this case, is mapped to the hierarchical menus used by Pcb.

B.1 Resource Syntax

A resource file is a simple text file. It contains curly braces to group things, spaces between things, and double quotes when strings need to include spaces. There are four fundamental ways of adding data to a resource.

First, a string (either a single word or a quoted string with spaces, we call both "strings" in this appendix) can be added all by itself, to add a string resource to the current resource. This is used, for example, to define the string printed on a menu button. In this example, four strings are added to the *File* resource:

```
File = {
  Sample
  "longer sample"
  some text
}
```

Second, a named string may be added by giving two strings separated by an equals sign. This is used to specify X resources and a few other optional parameters of menus, for example. Note that a string all by itself is thus an "unnamed" string.

```
{"Layer groups" foreground=red sensitive=false}
```

Third, an unnamed subresource may be added. This is used to create submenus and menu buttons. To add a subresource, simply group other things in curly braces. This example describes a resource containing one string and three subresources:

```
{File
  {New do_new()}
  {Save do_save()}
  {Quit do_quit()}
}
```

Lastly, a named subresource may be added by prefixing an unnamed subresource with a string and an equals sign, just as when naming strings. This syntax is used to name the resources used for the main menu and popup menus:

```
MainMenu = {
  ...
  }
```

Additionally, the menu parser allows for "hooks" whereby portions of the menu system can be programmatically created at runtime by the application. These hooks are invoked by a single word proceeded by an at sign, such as this example where most of the Sizes menu is created automatically:

```
{Sizes
    @sizes
    {"Adjust active sizes ..." AdjustStyle(0)}
```

```
    }
```

In addition to all that, any unquoted pound sign (#) begins a comment. Commented text continues until the end of the containing line. Comments may begin at the beginning of a line, or after other text on the line:

```
# This is a comment
MainMenu = { # This is also a comment
```

B.2 Menu Definitions

To best understand this section, you should find the 'pcb-menu.res' file that your Pcb uses and refer to it for examples (see Section B.3 [Menu Files and Defaults], page 89).

A resource defines a menu when it meets certain semantic requirements. The menu hierarchy is reflected as a hierarchy of unnamed subresources, with the first string of each subresource defining the label used for the menu button. A subresource that itself contains subresources becomes a submenu, a subresource that does not becomes a button.

A submenu should only contain subresources for the buttons or submenus within that submenu. Two exceptions are allowed: an initial string sets the label, and the string "-" (a single dash) will create a separator.

A button should not contain subresources, but will contain many strings, named and unnamed. The first member shall be an unnamed string which is the label for the button. Any other unnamed strings within the button's resource will be used as actions (much like the .Xdefaults action strings), which are functions that will be called when the button is pressed (or popped up, or created, depending on the action). As a convenience, if a left parenthesis is seen, the current "word" will continue at least until the matching right parenthesis. This allows you to pass strings with spaces as arguments to actions without needing to quote the action.

Named resources in button resources will be used as X resources. Such resources can be used to set the font, color, and spacing of buttons. As a convenience, "fg" can be used as an abbreviation for "foreground".

Within the menu's resource file, Pcb will look for a few key named subresources. At the moment, the only one it looks for is one called MainMenu. This will be used for the main menu bar. In the future, other named subresources will be used for popup resources.

Given all this, a small sample 'pcb-menu.res' would be:

```
MainMenu = {
  {File
    {"Load layout" Load(Layout)}
    -
    {"Quit Program" Quit() fg=red font=10x20}
  }
}
```

Within the Pcb sources are specially crafted comments that mark all the actions, flags, menu hooks, and whatnot that Pcb offers. Read the file 'src/gather-actions' in the Pcb source tree for documentation for these comments.

B.3 Menu Files and Defaults

Pcb will look for a file which defines its menus, trying the following names:

```
./pcb-menu.res
$HOME/.pcb-menu.res
$PCBLIBDIR/pcb-menu.res
<internal>
```

Note that *pcblibdir* defaults to '/usr/local/share/pcb' (hence, '/usr/local/share/pcb/pcb-menu.res'). The '<internal>' entry refers to a menu definition within the Pcb application itself. The master file for all this is the file 'src/pcb-menu.res' in the Pcb source tree. This master source is used to create the internal menu definition as well as being installed in '$pcblibdir'.

You can view the internal menu definition (the default) by running 'pcb' with the -dumpmenu option, like this:

```
pcb -dumpmenu
```

Appendix C Element Search/Regular Expressions

C.1 Element Search/Regular Expressions

`Pcb`'s search is based on POSIX 1003.2 Regular Expressions. Full POSIX Regular Expressions are supported by `Pcb` if the regex library was available when `Pcb` was built. One difference from the regular expressions found in tools like awk or grep is that PCB implicitly adds a "^" to the begining of a regular expression and "$" to the end of the regular expression. For example if you enter "C1", the actual regular expression used internally is "^C1$". It is easier to show by example how to search than explain POSIX 1003.2. The following table shows the most common Regular Expression characters used to find elements in `Pcb`:

'\' Indicates next character should not be interpreted literally if it normally is, and should be interpreted literally if it normally isn't.

'*' Matches 0 or more instances of preceding character.

'+' Matches 1 or more instances of preceding character.

'?' Matches 0 or 1 instances of preceding character.

'.' Matches any single character other than the newline character.

The following examples illustrate how regular expressions are used to specify element names (reference designators) to search for.

'`Search for the element whose name is exactly ''C1''.`'
Enter "C1".

'`Search for all elements that start with ''C'', such as capacitors:`'
Enter "C.*".

'`Search for all elements that start with ''C'' and end with ''1'', such as ''C1'', or ''C51'':`'
Enter "C.*1".

'`Search for only R1 or R10, will not match R100:`'
Enter "R10?".

'`Search for all parts starting with ''R12'' and ending with the number eight, or eighty-eight etc:`'
Enter "R128+".

'`Search for all terminal blocks having a one digit designator`'
such as "TB1", "TB2", or "TBx": `"TB."`.

'`Search for all terminal blocks having a two digit designator such as TB21 or TB15:`'
`"TB.."`.

Appendix D Standard Drill Size Tables

D.1 American Standard Wire Size Drills

Drill Size	Diameter (inches)	Drill Size	Diameter (inches)	Drill Size	Diameter (inches)
97	.0059	96	.0063	95	.0067
94	.0071	93	.0075	92	.0079
91	.0083	90	.0087	89	.0091
88	.0095	87	.0100	86	.0105
85	.0110	84	.0115	83	.0120
82	.0125	81	.0130	80	.0135
79	.0145	78	.0160	77	.0180
76	.0200	75	.0210	74	.0225
73	.0240	72	.0250	71	.0260
70	.0280	69	.0292	68	.0310
67	.0320	66	.0330	65	.0350
64	.0360	63	.0370	62	.0380
61	.0390	60	.0400	59	.0410
58	.0420	57	.0430	56	.0465
55	.0520	54	.0550	53	.0595
52	.0635	51	.0670	50	.0700
49	.0730	48	.0760	47	.0785
46	.0810	45	.0820	44	.0860
43	.0890	42	.0935	41	.0960
40	.0980	39	.0995	38	.1015
37	.1040	36	.1065	35	.1100
34	.1110	33	.1130	32	.1160
31	.1200	30	.1285	29	.1360
28	.1405	27	.1440	26	.1470
25	.1495	24	.1520	23	.1540
22	.1570	21	.1590	20	.1610
19	.1660	18	.1695	17	.1730
16	.1770	15	.1800	14	.1820
13	.1850	12	.1890	11	.1910
10	.1935	9	.1960	8	.1990
7	.2010	6	.2040	5	.2055
4	.2090	3	.2130	2	.2210
1	.2280				

D.2 American Standard Letter Size Drills

Drill Size	Diameter (inches)	Drill Size	Diameter (inches)	Drill Size	Diameter (inches)
A	.2340	B	.2380	C	.2420

D	.2460	E	.2500	F	.2570
G	.2610	H	.2660	I	.2720
J	.2770	K	.2810	L	.2900
M	.2950	N	.3020	O	.3160
P	.3230	Q	.3320	R	.3390
S	.3480	T	.3580	U	.3680
V	.3770	W	.3860	X	.3970
Y	.4040	Z	.4130		

D.3 Fractional Inch Size Drills

Drill Size	Diameter (inches)	Drill Size	Diameter (inches)	Drill Size	Diameter (inches)
1/64	.0156	1/32	.0313	3/64	.0469
1/16	.0625	5/64	.0781	3/32	.0938
7/64	.1094	1/8	.1250	9/64	.1406
5/32	.1562	11/64	.1719	3/16	.1875
13/64	.2031	7/32	.2188	15/64	.2344
1/4	.2500	17/64	.2656	9/32	.2812
19/64	.2969	5/16	.3125	21/64	.3281
11/32	.3438	23/64	.3594	3/8	.3750
25/64	.3906	13/32	.4062	27/64	.4219
7/16	.4375	29/64	.4531	15/32	.4688
31/64	.4844	1/2	.5000	33/64	.5156
17/32	.5313	35/64	.5469	9/16	.5625
37/64	.5781	19/32	.5938	39/64	.6094
5/8	.6250	41/64	.6406	21/32	.6562
43/64	.6719	11/16	.6875	45/64	.7031
23/32	.7188	47/64	.7344	3/4	.7500
49/64	.7656	25/32	.7812	51/64	.7969
13/16	.8125	53/64	.8281	27/32	.8438
55/64	.8594	7/8	.8750	57/64	.8906
29/32	.9062	59/64	.9219	15/16	.9375
61/64	.9531	31/32	.9688	63/64	.9844
1	1.0000				

D.4 Metric Drills

Drill Size	Diameter (inches)	Drill Size	Diameter (inches)	Drill Size	Diameter (inches)
0.20 mm	.00787	0.25 mm	.00984	0.30 mm	.0118
0.35 mm	.0138	0.40 mm	.0158	0.45 mm	.0177
0.50 mm	.0197	0.55 mm	.0217	0.60 mm	.0236
0.65 mm	.0256	0.70 mm	.0276	0.75 mm	.0295
0.80 mm	.0315	0.85 mm	.0335	0.90 mm	.0354
0.95 mm	.0374	1.00 mm	.0394	1.05 mm	.0413

1.10 mm	.0433	1.15 mm	.0453	1.20 mm	.0472
1.25 mm	.0492	1.30 mm	.0512	1.35 mm	.0531
1.40 mm	.0551	1.45 mm	.0571	1.50 mm	.0591
1.55 mm	.0610	1.60 mm	.0630	1.65 mm	.0650
1.70 mm	.0669	1.75 mm	.0689	1.80 mm	.0709
1.85 mm	.0728	1.90 mm	.0748	1.95 mm	.0768
2.00 mm	.0787	2.05 mm	.0807	2.10 mm	.0827
2.15 mm	.0846	2.20 mm	.0866	2.25 mm	.0886
2.30 mm	.0906	2.35 mm	.0925	2.40 mm	.0945
2.45 mm	.0965	2.50 mm	.0984	2.55 mm	.1004
2.60 mm	.1024	2.65 mm	.1043	2.70 mm	.1063
2.75 mm	.1083	2.80 mm	.1102	2.85 mm	.1122
2.90 mm	.1142	2.95 mm	.1161	3.00 mm	.1181
3.10 mm	.1220	3.15 mm	.1240	3.20 mm	.1260
3.25 mm	.1280	3.30 mm	.1299	3.40 mm	.1339
3.50 mm	.1378	3.60 mm	.1417	3.70 mm	.1457
3.75 mm	.1476	3.80 mm	.1496	3.90 mm	.1535
4.00 mm	.1575	4.10 mm	.1614	4.20 mm	.1654
4.25 mm	.1673	4.30 mm	.1693	4.40 mm	.1732
4.50 mm	.1772	4.60 mm	.1811	4.70 mm	.1850
4.75 mm	.1870	4.80 mm	.1890	4.90 mm	.1929
5.00 mm	.1969	5.10 mm	.2008	5.20 mm	.2047
5.25 mm	.2067	5.30 mm	.2087	5.40 mm	.2126
5.50 mm	.2165	5.60 mm	.2205	5.70 mm	.2244
5.75 mm	.2264	5.80 mm	.2283	5.90 mm	.2323
6.00 mm	.2362	6.10 mm	.2402	6.20 mm	.2441
6.25 mm	.2461	6.30 mm	.2480	6.40 mm	.2520
6.50 mm	.2559	6.60 mm	.2598	6.70 mm	.2638
6.75 mm	.2657	6.80 mm	.2677	6.90 mm	.2717
7.00 mm	.2756	7.10 mm	.2795	7.20 mm	.2835
7.25 mm	.2854	7.30 mm	.2874	7.40 mm	.2914
7.50 mm	.2953	7.60 mm	.2992	7.70 mm	.3031
8.00 mm	.3150	8.10 mm	.3189	8.20 mm	.3228
8.25 mm	.3248	8.30 mm	.3268	8.40 mm	.3307
8.50 mm	.3346	8.60 mm	.3386	8.70 mm	.3425
8.75 mm	.3445	8.80 mm	.3465	8.90 mm	.3504
9.00 mm	.3543	9.10 mm	.3583	9.20 mm	.3622
9.25 mm	.3642	9.30 mm	.3661	9.40 mm	.3701
9.50 mm	.3740	9.60 mm	.3780	9.70 mm	.3819
9.75 mm	.3839	9.80 mm	.3858	9.90 mm	.3898
10.00 mm	.3937	10.10 mm	.3976	10.20 mm	.4016
10.25 mm	.4035	10.30 mm	.4055	10.40 mm	.4094
10.50 mm	.4134	10.60 mm	.4173	10.70 mm	.4213
10.80 mm	.4252	10.90 mm	.4291	11.00 mm	.4331
11.10 mm	.4370	11.20 mm	.4409	11.25 mm	.4429
11.30 mm	.4449	11.40 mm	.4488	11.50 mm	.4528
11.60 mm	.4567	11.70 mm	.4606	11.75 mm	.4626

11.80 mm	.4646	11.90 mm	.4685	12.00 mm	.4724
12.50 mm	.4921	13.00 mm	.5118	13.50 mm	.5315
14.00 mm	.5512	14.50 mm	.5709	15.00 mm	.5906
15.50 mm	.6102	16.00 mm	.6299	16.50 mm	.6496
17.00 mm	.6693	17.50 mm	.6890	18.00 mm	.7087
18.50 mm	.7283	19.00 mm	.7480	19.50 mm	.7677
20.00 mm	.7874	20.50 mm	.8071	21.00 mm	.8268
21.50 mm	.8465	22.00 mm	.8661	22.50 mm	.8858
23.00 mm	.9055	23.50 mm	.9252	24.00 mm	.9449
24.50 mm	.9646	25.00 mm	.9843		

Appendix E Centroid (X-Y) File Format

E.1 Overview

E.2 File Format

The centroid output file is in a standard comma seperated values (CSV) format. Comment lines begin with a "#". The output file contains a header with an RCS Id tag (useful for those who will check the file into a version control system), a version number for the file format, some comments containing the author and title of the board, and a comment describing the remainder of the file format.

An example centroid file is shown below.

```
# $Id$
# PcbXY Version 1.0
# Date: Fri Jul 22 03:40:08 2005 UTC
# Author: PCB User
# Title: MyBoard - PCB X-Y
# RefDes, Description, Value, X, Y, rotation, top/bottom
# X,Y in mils.  rotation in degrees.
# --------------------------------------------
R61,"0603","10",2610.00,3560.00,90,top
J5,"AMPHENOL_ARFX1231","unknown",2390.00,4220.00,180,top
C13,"0402","0.01u",2340.00,3014.00,270,top
```

E.3 Computation of Centroid and Rotation

The center of each element is found by averaging the (X,Y) coordinates for the center of each pin and pad in the element. For example if an element has 2 pins, 1 at (1,0) and another at (1,4) then the centroid will be at (1,2).

The calculation of rotation is a bit more complex. Currently a rotation is not stored for each element but rather the rotated element is stored. In other words if the element from the library has a pin at (0,0) and (0,2) and it has been rotated by 90 degrees, then the '.pcb' file will store (0,0) and (2,0) for the pin locations with no indication that they have been rotated from the original.

In the event that the element has only 1 pin, then the rotation is set to zero. If the element has only one pad (as opposed to a through-hole pin), then the rotation of the pad is used.

When the element has multiple pins, the location of pin #1 is placed in the coordinate system which has the centroid of the part at (0,0). Then which quadrant pin #1 falls in determines the rotation. Zero degrees of rotation is defined as pin #1 being in the upper left quadrant. Increasing angles correspond to counterclockwise rotation so a rotation of 90 degrees places pin #1 in the lower left quadrant. Currently, the only allowed rotations are 0, 90, 180, and 270 degrees.

If pin #1 happens to be at the centroid of the part, then pin #2 is examined to see which quadrant it is located in. The same rules apply for the definitions of rotation. In other words, when pin #1 is at the centroid of the part and pin #2 is in the upper left quadrant, the rotation is declared to be zero degrees.

Appendix F Action Reference

Many actions take a `delta` parameter as the last parameter, which is an amount to change something. That `delta` may include units, as an additional parameter, such as `Action(Object,5,mm)`. If no units are specified, the default is PCB's native units (currently 1/100 mil). Also, if the delta is prefixed by `+` or `-`, the size is increased or decreased by that amount. Otherwise, the size size is set to the given amount.

```
Action(Object,5,mil)
Action(Object,+0.5,mm)
Action(Object,-1)
```

Actions which take a `delta` parameter which do not accept all these options will specify what they do take.

Many actions act on indicated objects on the board. They will have parameters like `ToggleObject` or `SelectedVias` to indicate what group of objects they act on. Unless otherwise specified, these parameters are defined as follows:

`Object`
`ToggleObject`
: Affects the object under the mouse pointer. If this action is invoked from a menu or script, the user will be prompted to click on an object, which is then the object affected.

`Selected`
`SelectedObjects`
: Affects all objects which are currently selected. At least, all selected objects for which the given action makes sense.

`SelectedPins`
`SelectedVias`
`Selected`*`Type`*
`etc`
: Affects all objects which are both selected and of the *Type* specified.

F.1 Core actions

F.1.1 AddRats

AddRats(AllRats|SelectedRats|Close)

Add one or more rat lines to the board.

`AllRats`
: Create rat lines for all loaded nets that aren't already connected on with copper.

`SelectedRats`
: Similarly, but only add rat lines for nets connected to selected pins and pads.

`Close`
: Selects the shortest unselected rat on the board.

F.1.2 ApplyVendor

```
ApplyVendor()
```

Applies the currently loaded vendor drill table to the current design.

This will modify all of your drill holes to match the list of allowed sizes for your vendor.

F.1.3 Atomic

```
Atomic(Save|Restore|Close|Block)
```

Save or restore the undo serial number.

This action allows making multiple-action bindings into an atomic operation that will be undone by a single Undo command. For example, to optimize rat lines, you'd delete the rats and re-add them. To group these into a single undo, you'd want the deletions and the additions to have the same undo serial number. So, you `Save`, delete the rats, `Restore`, add the rats - using the same serial number as the deletes, then `Block`, which checks to see if the deletions or additions actually did anything. If not, the serial number is set to the saved number, as there's nothing to undo. If something did happen, the serial number is incremented so that these actions are counted as a single undo step.

`Save` Saves the undo serial number.

`Restore` Returns it to the last saved number.

`Close` Sets it to 1 greater than the last save.

`Block` Does a Restore if there was nothing to undo, else does a Close.

F.1.4 AutoPlaceSelected

```
AutoPlaceSelected()
```

Auto-place selected components.

Attempts to re-arrange the selected components such that the nets connecting them are minimized. Note that you cannot undo this.

F.1.5 AutoRoute

```
AutoRoute(AllRats|SelectedRats)
```

Auto-route some or all rat lines.

`AllRats` Attempt to autoroute all rats.

`SelectedRats`
Attempt to autoroute the selected rats.

Before autorouting, it's important to set up a few things. First, make sure any layers you aren't using are disabled, else the autorouter may use them. Next, make sure the current line and via styles are set accordingly. Last, make sure "new lines clear polygons" is set, in case you eventually want to add a copper pour.

Autorouting takes a while. During this time, the program may not be responsive.

F.1.6 ChangeClearSize

```
ChangeClearSize(Object, delta)
ChangeClearSize(SelectedPins|SelectedPads|SelectedVias, delta)
ChangeClearSize(SelectedLines|SelectedArcs, delta
ChangeClearSize(Selected|SelectedObjects, delta)
```

Changes the clearance size of objects.

If the solder mask is currently showing, this action changes the solder mask clearance. If the mask is not showing, this action changes the polygon clearance.

F.1.7 ChangeDrillSize

```
ChangeDrillSize(Object, delta)
ChangeDrillSize(SelectedPins|SelectedVias|Selected|SelectedObjects, delta)
```

Changes the drilling hole size of objects.

F.1.8 ChangeFlag

```
ChangeFlag(Object|Selected|SelectedObjects, flag, value)
ChangeFlag(SelectedLines|SelectedPins|SelectedVias, flag, value)
ChangeFlag(SelectedPads|SelectedTexts|SelectedNames, flag, value)
ChangeFlag(SelectedElements, flag, value)
flag = square | octagon | thermal | join
"“value = 0 | 1
```

Sets or clears flags on objects.

Toggles the given flag on the indicated object(s). The flag may be one of the flags listed above (square, octagon, thermal, join). The value may be the number 0 or 1. If the value is 0, the flag is cleared. If the value is 1, the flag is set.

F.1.9 ChangeHole

```
ChangeHole(ToggleObject|Object|SelectedVias|Selected)
```

Changes the hole flag of objects.

The "hole flag" of a via determines whether the via is a plated-through hole (not set), or an unplated hole (set).

F.1.10 ChangeJoin

```
ChangeJoin(ToggleObject|SelectedLines|SelectedArcs|Selected)
```

Changes the join (clearance through polygons) of objects.

The join flag determines whether a line or arc, drawn to intersect a polygon, electrically connects to the polygon or not. When joined, the line/arc is simply drawn over the polygon, making an electrical connection. When not joined, a gap is drawn between the line and the polygon, insulating them from each other.

F.1.11 ChangeName

```
ChangeName(Object)
"“ChangeName(Layout|Layer)
```

Sets the name of objects.

`Object` Changes the name of the element under the cursor.

`Layout` Changes the name of the layout. This is printed on the fab drawings.

`Layer` Changes the name of the currently active layer.

F.1.12 ChangeOctagon

```
ChangeOctagon(Object|ToggleObject|SelectedObjects|Selected)
ChangeOctagon(SelectedElements|SelectedPins|SelectedVias)
```

Changes the octagon-flag of pins and vias.

Pins, pads, and vias can have various shapes. All may be round. Pins and pads may be square (obviously "square" pads are usually rectangular). Pins and vias may be octagonal. When you change a shape flag of an element, you actually change all of its pins and pads.

Note that the square flag takes precedence over the octagon flag, thus, if both the square and octagon flags are set, the object is square. When the square flag is cleared, the pins and pads will be either round or, if the octagon flag is set, octagonal.

F.1.13 ChangePaste

```
ChangePaste(ToggleObject|Object|SelectedPads|Selected)
```

Changes the no paste flag of objects.

The "no paste flag" of a pad determines whether the solderpaste stencil will have an opening for the pad (no set) or if there wil be no solderpaste on the pad (set). This is used for things such as fiducial pads.

F.1.14 ChangePinName

```
ChangePinName(ElementName,PinNumber,PinName)
```

Sets the name of a specific pin on a specific element.

This can be especially useful for annotating pin names from a schematic to the layout without requiring knowledge of the pcb file format.

```
ChangePinName(U3, 7, VCC)
```

F.1.15 ChangeSize

```
ChangeSize(Object, delta)
ChangeSize(SelectedObjects|Selected, delta)
ChangeSize(SelectedLines|SelectedPins|SelectedVias, delta)
ChangeSize(SelectedPads|SelectedTexts|SelectedNames, delta)
ChangeSize(SelectedElements, delta)
```

Changes the size of objects.

For lines and arcs, this changes the width. For pins and vias, this changes the overall diameter of the copper annulus. For pads, this changes the width and, indirectly, the length. For texts and names, this changes the scaling factor. For elements, this changes the width of the silk layer lines and arcs for this element.

F.1.16 ChangeSquare

```
ChangeSquare(ToggleObject)
ChangeSquare(SelectedElements|SelectedPins)
ChangeSquare(Selected|SelectedObjects)
```

Changes the square flag of pins and pads.

Note that `Pins` means both pins and pads.

Pins, pads, and vias can have various shapes. All may be round. Pins and pads may be square (obviously "square" pads are usually rectangular). Pins and vias may be octagonal. When you change a shape flag of an element, you actually change all of its pins and pads.

Note that the square flag takes precedence over the octagon flag, thus, if both the square and octagon flags are set, the object is square. When the square flag is cleared, the pins and pads will be either round or, if the octagon flag is set, octagonal.

F.1.17 ClearOctagon

```
ClearOctagon(ToggleObject|Object|SelectedObjects|Selected)
ClearOctagon(SelectedElements|SelectedPins|SelectedVias)
```

Clears the octagon-flag of pins and vias.

Pins, pads, and vias can have various shapes. All may be round. Pins and pads may be square (obviously "square" pads are usually rectangular). Pins and vias may be octagonal. When you change a shape flag of an element, you actually change all of its pins and pads.

Note that the square flag takes precedence over the octagon flag, thus, if both the square and octagon flags are set, the object is square. When the square flag is cleared, the pins and pads will be either round or, if the octagon flag is set, octagonal.

F.1.18 ClearSquare

```
ClearSquare(ToggleObject|SelectedElements|SelectedPins)
```

Clears the square-flag of pins and pads.

Note that `Pins` means pins and pads.

Pins, pads, and vias can have various shapes. All may be round. Pins and pads may be square (obviously "square" pads are usually rectangular). Pins and vias may be octagonal. When you change a shape flag of an element, you actually change all of its pins and pads.

Note that the square flag takes precedence over the octagon flag, thus, if both the square and octagon flags are set, the object is square. When the square flag is cleared, the pins and pads will be either round or, if the octagon flag is set, octagonal.

F.1.19 ClrFlag

```
ClrFlag(Object|Selected|SelectedObjects, flag)
ClrFlag(SelectedLines|SelectedPins|SelectedVias, flag)
ClrFlag(SelectedPads|SelectedTexts|SelectedNames, flag)
ClrFlag(SelectedElements, flag)
flag = square | octagon | thermal | join
```

Clears flags on objects.

Turns the given flag off, regardless of its previous setting. See `ChangeFlag`.

```
ClrFlag(SelectedLines,join)
```

F.1.20 Connection

```
Connection(Find|ResetLinesAndPolygons|ResetPinsAndVias|Reset)
```

Searches connections of the object at the cursor position.

Connections found with this action will be highlighted in the “connected-color” color and will have the “found” flag set.

`Find` The net under the cursor is “found”.

`ResetLinesAndPolygons`
: Any “found” lines and polygons are marked “not found”.

`ResetPinsAndVias`
: Any “found” pins and vias are marked “not found”.

`Reset` All "found" objects are marked "not found".

`Measure` The net under the cursor is found and measured (the lengths of all line segments are added together)

F.1.21 Delete

Delete(Object|Selected)
Delete(AllRats|SelectedRats) ;

Delete stuff.

F.1.22 DeleteRats

DeleteRats(AllRats|Selected|SelectedRats)

Delete rat lines.

F.1.23 DisableVendor

DisableVendor()

Disables automatic drill size mapping.

When drill mapping is enabled, new instances of pins and vias will have their drill holes mapped to one of the allowed drill sizes specified in the currently loaded vendor drill table.

F.1.24 DisperseElements

DisperseElements(All|Selected)

Disperses elements.

Normally this is used when starting a board, by selecting all elements and then dispersing them. This scatters the elements around the board so that you can pick individual ones, rather than have all the elements at the same 0,0 coordinate and thus impossible to choose from.

F.1.25 Display

```
Display(NameOnPCB|Description|Value)
Display(Grid|Redraw)
Display(CycleClip|Toggle45Degree|ToggleStartDirection)
Display(ToggleGrid|ToggleRubberBandMode|ToggleUniqueNames)
Display(ToggleMask|ToggleName|ToggleClearLine|ToggleFullPoly|ToggleSnapPin)
Display(ToggleThindraw|ToggleThindrawPoly|ToggleOrthoMove|ToggleLocalRef)
Display(ToggleCheckPlanes|ToggleShowDRC|ToggleAutoDRC)
Display(ToggleLiveRoute|LockNames|OnlyNames)
Display(Pinout|PinOrPadName)
"“Display(Scroll, Direction)
```

Several display-related actions.

`NameOnPCB`
`Description`
`Value` Specify whether all elements show their name, description, or value.

`Redraw` Redraw the whole board.

`Toggle45Degree`
: When clear, lines can be drawn at any angle. When set, lines are restricted to multiples of 45 degrees and requested lines may be broken up according to the clip setting.

`CycleClip`
: Changes the way lines are restricted to 45 degree increments. The various settings are: straight only, orthogonal then angled, and angled then orthogonal. If AllDirections is set, this action disables it.

`ToggleRubberBandMode`
: If set, moving an object moves all the lines attached to it too.

`ToggleStartDirection`
: If set, each time you set a point in a line, the Clip toggles between orth-angle and angle-ortho.

`ToggleUniqueNames`
: If set, you will not be permitted to change the name of an element to match that of another element.

`ToggleSnapPin`
: If set, pin centers and pad end points are treated as additional grid points that the cursor can snap to.

`ToggleLocalRef`
: If set, the mark is automatically set to the beginning of any move, so you can see the relative distance you've moved.

`ToggleThindraw`
: If set, objects on the screen are drawn as outlines (lines are drawn as center-lines). This lets you see line endpoints hidden under pins, for example.

`ToggleThindrawPoly`
: If set, polygons on the screen are drawn as outlines.

`ToggleShowDRC`
: If set, pending objects (i.e. lines you're in the process of drawing) will be drawn with an outline showing how far away from other copper you need to be.

`ToggleLiveRoute`
: If set, the progress of the autorouter will be visible on the screen.

`ToggleAutoDRC`
: If set, you will not be permitted to make connections which violate the current DRC and netlist settings.

`ToggleCheckPlanes`
: If set, lines and arcs aren't drawn, which usually leaves just the polygons. If you also disable all but the layer you're interested in, this allows you to check for isolated regions.

`ToggleOrthoMove`
: If set, the crosshair is only allowed to move orthogonally from its previous position. I.e. you can move an element or line up, down, left, or right, but not up+left or down+right.

`ToggleName`
: Selects whether the pinouts show the pin names or the pin numbers.

`ToggleMask`
: Turns the solder mask on or off.

`ToggleClearLine`
: When set, the clear-line flag causes new lines and arcs to have their "clear polygons" flag set, so they won't be electrically connected to any polygons they overlap.

`ToggleFullPoly`
: When set, the full-poly flag causes new polygons to have their "full polygon" flag set, so all parts of them will be displayed instead of only the biggest one.

`ToggleGrid`
: Resets the origin of the current grid to be wherever the mouse pointer is (not where the crosshair currently is). If you provide two numbers after this, the origin is set to that coordinate. The numbers are in PCB internal units, currently 1/100 mil.

`Grid`
: Toggles whether the grid is displayed or not.

`Pinout`
: Causes the pinout of the element indicated by the cursor to be displayed, usually in a separate window.

`PinOrPadName`
: Toggles whether the names of pins, pads, or (yes) vias will be displayed. If the cursor is over an element, all of its pins and pads are affected.

`Step <direction> <amount> <units>`
: Steps the crosshair in the given direction, with 1=down/left, 2=down, etc, according to the numeric keypad layout. If amount is not given, the crosshair steps along the grid.

F.1.26 djopt

```
djopt(debumpify|unjaggy|simple|vianudge|viatrim|orthopull)
djopt(auto) - all of the above
"“djopt(miter)
```

Perform various optimizations on the current board

The different types of optimizations change your board in order to reduce the total trace length and via count.

`debumpify`
: Looks for U-shaped traces that can be shortened or eliminated.

`unjaggy`
: Looks for corners which could be flipped to eliminate one or more corners (i.e. jaggy lines become simpler).

`simple`
: Removing uneeded vias, replacing two or more trace segments in a row with a single segment. This is usually performed automatically after other optimizations.

`vianudge`
: Looks for vias where all traces leave in the same direction. Tries to move via in that direction to eliminate one of the traces (and thus a corner).

`viatrim`
: Looks for traces that go from via to via, where moving that trace to a different layer eliminates one or both vias.

`orthopull`
: Looks for chains of traces all going in one direction, with more traces orthogonal on one side than on the other. Moves the chain in that direction, causing a net reduction in trace length, possibly eliminating traces and/or corners.

`splitlines`
: Looks for lines that pass through vias, pins, or pads, and splits them into separate lines so they can be managed separately.

`auto`
: Performs the above options, repeating until no further optimizations can be made.

`miter`
: Replaces 90 degree corners with a pair of 45 degree corners, to reduce RF losses and trace length.

F.1.27 DRC

```
DRC()
```

Invoke the DRC check.

Note that the design rule check uses the current board rule settings, not the current style settings.

F.1.28 DumpLibrary

```
DumpLibrary()
```

Display the entire contents of the libraries.

F.1.29 EnableVendor

```
EnableVendor()
```

Enables automatic drill size mapping.

When drill mapping is enabled, new instances of pins and vias will have their drill holes mapped to one of the allowed drill sizes specified in the currently loaded vendor drill table. To enable drill mapping, a vendor resource file containing a drill table must be loaded first.

F.1.30 ExecuteFile

```
ExecuteFile(filename)
```

Run actions from the given file.

Lines starting with # are ignored.

F.1.31 Flip

```
Flip(Object|Selected|SelectedElements)
```

Flip an element to the opposite side of the board.

Note that the location of the element will be symmetric about the cursor location; i.e. if the part you are pointing at will still be at the same spot once the element is on the other side. When flipping multiple elements, this retains their positions relative to each other, not their absolute positions on the board.

F.1.32 FontEdit

```
FontEdit()
```

Convert the current font to a PCB for editing

F.1.33 FontSave

```
FontSave()
```

Convert the current PCB back to a font

F.1.34 GlobalPuller

```
GlobalPuller()
```

Pull all traces tight.

F.1.35 h

```
h
```

Print a help message for commands.

This is one of the command box helper actions. While it is a regular action and can be used like any other action, its name and syntax are optimized for use with the command box (:) and thus the syntax is documented for that purpose.

F.1.36 l

```
l [name]
```

Loads layout data.

Loads a new datafile (layout) and, if confirmed, overwrites any existing unsaved data. The filename and the searchpath (*filePath*) are passed to the command defined by *fileCommand*. If no filename is specified a file select box will popup.

This is one of the command box helper actions. While it is a regular action and can be used like any other action, its name and syntax are optimized for use with the command box (:) and thus the syntax is documented for that purpose.

F.1.37 le

```
le [name]
```

Loads an element into the current buffer.

The filename and the searchpath (*elementPath*) are passed to the command defined by *elementCommand*. If no filename is specified a file select box will popup.

This is one of the command box helper actions. While it is a regular action and can be used like any other action, its name and syntax are optimized for use with the command box (:) and thus the syntax is documented for that purpose.

F.1.38 LoadFrom

```
LoadFrom(Layout|LayoutToBuffer|ElementToBuffer|Netlist|Revert,filename)
```

Load layout data from a file.

This action assumes you know what the filename is. The various GUIs should have a similar `Load` action where the filename is optional, and will provide their own file selection mechanism to let you choose the file name.

`Layout` Loads an entire PCB layout, replacing the current one.

`LayoutToBuffer`
Loads an entire PCB layout to the paste buffer.

`ElementToBuffer`
Loads the given element file into the paste buffer. Element files contain only a single `Element` definition, such as the "newlib" library uses.

`Netlist` Loads a new netlist, replacing any current netlist.

`Revert` Re-loads the current layout from its disk file, reverting any changes you may have made.

F.1.39 LoadVendorFrom

```
LoadVendorFrom(filename)
```

Loads the specified vendor resource file.

filename Name of the vendor resource file. If not specified, the user will be prompted to enter one.

F.1.40 m

```
m [name]
```

Loads a layout into the current buffer.

The filename and the searchpath (*filePath*) are passed to the command defined by *fileCommand*. If no filename is specified a file select box will popup.

This is one of the command box helper actions. While it is a regular action and can be used like any other action, its name and syntax are optimized for use with the command box (`:`) and thus the syntax is documented for that purpose.

F.1.41 MarkCrosshair

```
MarkCrosshair()
"“MarkCrosshair(Center)
```

Set/Reset the Crosshair mark

The "mark" is a small X-shaped target on the display which is treated like a second origin (the normal origin is the upper let corner of the board). The GUI will display a second set of coordinates for this mark, which tells you how far you are from it.

If no argument is given, the mark is toggled - disabled if it was enabled, or enabled at the current cursor position of disabled. If the `Center` argument is given, the mark is moved to the current cursor location.

F.1.42 Message

```
Message(message)
```

Writes a message to the log window.

This action displays a message to the log window. This action is primarily provided for use by other programs which may interface with PCB. If multiple arguments are given, each one is sent to the log window followed by a newline.

F.1.43 MinMaskGap

```
MinMaskGap(delta)
"“MinMaskGap(Selected, delta)
```

Ensures the mask is a minimum distance from pins and pads.

Checks all specified pins and/or pads, and increases the mask if needed to ensure a minimum distance between the pin or pad edge and the mask edge.

F.1.44 Mode

```
Mode(Arc|Arrow|Copy|InsertPoint|Line|Lock|Move|None|PasteBuffer)
Mode(Polygon|Rectangle|Remove|Rotate|Text|Thermal|Via)
Mode(Notify|Release|Cancel|Stroke)
"“Mode(Save|Restore)
```

Change or use the tool mode.

`Arc`
`Arrow`
`Copy`
`InsertPoint`
`Line`
`Lock`
`Move`
`None`
`PasteBuffer`
`Polygon`
`Rectangle`
`Remove`
`Rotate`
`Text`
`Thermal`
`Via` Select the indicated tool.

`Notify` Called when you press the mouse button, or move the mouse.

`Release` Called when you release the mouse button.

`Cancel` Cancels any pending tool activity, allowing you to restart elsewhere. For example, this allows you to start a new line rather than attach a line to the previous line.

`Escape` Similar to Cancel but calling this action a second time will return to the Arrow tool.

`Stroke` If your `pcb` was built with libstroke, this invokes the stroke input method. If not, this will restart a drawing mode if you were drawing, else it will select objects.

`Save` Remembers the current tool.

`Restore` Restores the tool to the last saved tool.

F.1.45 MorphPolygon

```
MorphPolygon(Object|Selected)
```

Converts dead polygon islands into separate polygons.

If a polygon is divided into unconnected "islands", you can use this command to convert the otherwise disappeared islands into separate polygons. Be sure the cursor is over a portion of the polygon that remains visible. Very small islands that may flake off are automatically deleted.

F.1.46 MoveLayer

```
MoveLayer(old,new)
```

Moves/Creates/Deletes Layers

Moves a layer, creates a new layer, or deletes a layer.

`old` The is the layer number to act upon. Allowed values are:

- `c` Currently selected layer.
- `-1` Create a new layer.
- `number` An existing layer number.

`new` Specifies where to move the layer to. Allowed values are:

- `-1` Deletes the layer.
- `up` Moves the layer up.
- `down` Moves the layer down.
- `c` Creates a new layer.

F.1.47 MoveObject

```
MoveObject(X,Y,dim)
```

Moves the object under the crosshair.

The `X` and `Y` are treated like `delta` is for many other objects. For each, if it's prefixed by `+` or `-`, then that amount is relative. Otherwise, it's absolute. Units can be `mil` or `mm`; if unspecified, units are PCB's internal units, currently 1/100 mil.

F.1.48 MoveToCurrentLayer

```
MoveToCurrentLayer(Object|SelectedObjects)
```

Moves objects to the current layer.

Note that moving an element from a component layer to a solder layer, or from solder to component, won't automatically flip it. Use the `Flip()` action to do that.

F.1.49 Netlist

```
Net(find|select|rats|norats[,net[,pin]])
```

Perform various actions on netlists.

Each of these actions apply to a specified set of nets. *net* and *pin* are patterns which match one or more nets or pins; these patterns may be full names or regular expressions. If an exact match is found, it is the only match; if no exact match is found, *then* the pattern is tried as a regular expression.

If neither *net* nor *pin* are specified, all nets apply. If *net* is specified but not *pin*, all nets matching *net* apply. If both are specified, nets which match *net* and contain a pin matching *pin* apply.

`find` Nets which apply are marked *found* and are drawn in the `connected-color` color.

`select` Nets which apply are selected.

`rats` Nets which apply are marked as available for the rats nest.

`norats` Nets which apply are marked as not available for the rats nest.

F.1.50 New

```
New([name])
```

Starts a new layout.

If a name is not given, one is prompted for.

F.1.51 OptAutoOnly

```
OptAutoOnly()
```

Toggles the optimize-only-autorouted flag.

The original purpose of the trace optimizer was to clean up the traces created by the various autorouters that have been used with PCB. When a board has a mix of autorouted and carefully hand-routed traces, you don't normally want the optimizer to move your hand-routed traces. But, sometimes you do. By default, the optimizer only optimizes autorouted traces. This action toggles that setting, so that you can optimize hand-routed traces also.

F.1.52 PasteBuffer

```
PasteBuffer(AddSelected|Clear|1..MAX_BUFFER)
PasteBuffer(Rotate, 1..3)
PasteBuffer(Convert|Save|Restore|Mirror)
PasteBuffer(ToLayout, X, Y, units)
```

Various operations on the paste buffer.

There are a number of paste buffers; the actual limit is a compile-time constant `MAX_BUFFER` in '`globalconst.h`'. It is currently `5`. One of these is the "current" paste buffer, often referred to as "the" paste buffer.

`AddSelected`
: Copies the selected objects to the current paste buffer.

`Clear`
: Remove all objects from the current paste buffer.

`Convert`
: Convert the current paste buffer to an element. Vias are converted to pins, lines are converted to pads.

`Restore`
: Convert any elements in the paste buffer back to vias and lines.

`Mirror`
: Flip all objects in the paste buffer vertically (up/down flip). To mirror horizontally, combine this with rotations.

`Rotate`
: Rotates the current buffer. The number to pass is 1..3, where 1 means 90 degrees counter clockwise, 2 means 180 degrees, and 3 means 90 degrees clockwise (270 CCW).

`Save`
: Saves any elements in the current buffer to the indicated file.

`ToLayout`
: Pastes any elements in the current buffer to the indicated X, Y coordinates in the layout. The `X` and `Y` are treated like `delta` is for many other objects. For each, if it's prefixed by `+` or `-`, then that amount is relative to the last location. Otherwise, it's absolute. Units can be `mil` or `mm`; if unspecified, units are PCB's internal units, currently 1/100 mil.

`1..MAX_BUFFER`
: Selects the given buffer to be the current paste buffer.

F.1.53 Polygon

```
Polygon(Close|PreviousPoint)
```

Some polygon related stuff.

Polygons need a special action routine to make life easier.

`Close` Creates the final segment of the polygon. This may fail if clipping to 45 degree lines is switched on, in which case a warning is issued.

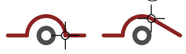
`PreviousPoint`
Resets the newly entered corner to the previous one. The Undo action will call Polygon(PreviousPoint) when appropriate to do so.

F.1.54 Puller

```
Puller()
```

Pull an arc-line junction tight.

The `Puller()` action is a special-purpose optimization. When invoked while the crosshair is over the junction of an arc and a line, it will adjust the arc's angle and the connecting line's endpoint such that the line intersects the arc at a tangent. In the example below, the left side is "before" with the black target marking where to put the crosshair:



The right side is "after" with the black target marking where the arc-line intersection was moved to.

F.1.55 q

```
q
```

Quits the application after confirming.

If you have unsaved changes, you will be prompted to confirm (or save) before quitting.

This is one of the command box helper actions. While it is a regular action and can be used like any other action, its name and syntax are optimized for use with the command box (`:`) and thus the syntax is documented for that purpose.

F.1.56 q!

```
q!
```

Quits the application without confirming.

Note that this command neither saves your data nor prompts for confirmation.

This is one of the command box helper actions. While it is a regular action and can be used like any other action, its name and syntax are optimized for use with the command box (`:`) and thus the syntax is documented for that purpose.

F.1.57 Quit

```
Quit()
```

Quits the application after confirming.

If you have unsaved changes, you will be prompted to confirm (or save) before quitting.

F.1.58 Redo

```
Redo()
```

Redo recent "undo" operations.

This routine allows you to recover from the last undo command. You might want to do this if you thought that undo was going to revert something other than what it actually did (in case you are confused about which operations are un-doable), or if you have been backing up through a long undo list and over-shoot your stopping point. Any change that is made since the undo in question will trim the redo list. For example if you add ten lines, then undo three of them you could use redo to put them back, but if you move a line on the board before performing the redo, you will lose the ability to "redo" the three "undone" lines.

F.1.59 RemoveSelected

```
RemoveSelected()
```

Removes any selected objects.

F.1.60 Renumber

```
Renumber()
"“Renumber(filename)
```

Renumber all elements. The changes will be recorded to filename for use in backannotating these changes to the schematic.

F.1.61 Report

```
Report(Object|DrillReport|FoundPins|NetLength)
```

Produce various report.

`Object` The object under the crosshair will be reported, describing various aspects of the object.

`DrillReport`
A report summarizing the number of drill sizes used, and how many of each, will be produced.

`FoundPins`
A report listing all pins and pads which are marked as “found” will be produced.

`NetLength`
The name and length of the net under the crosshair will be reported to the message log.

F.1.62 ReportDialog

```
ReportDialog()
```

Report on the object under the crosshair

This is a shortcut for `Report(Object)`.

F.1.63 RipUp

```
RipUp(All|Selected|Element)
```

Ripup auto-routed tracks, or convert an element to parts.

`All` Removes all lines and vias which were created by the autorouter.

`Selected` Removes all selected lines and vias which were created by the autorouter.

`Element` Converts the element under the cursor to parts (vias and lines). Note that this uses the highest numbered paste buffer.

F.1.64 rn

```
rn [name]
```

Reads netlist.

If no filename is given a file select box will pop up. The file is read via the command defined by the *RatCommand* resource. The command must send its output to *stdout*.

Netlists are used for generating rat’s nests (see Section 3.11 [Rats Nest], page 28) and for verifying the board layout (which is also accomplished by the *Ratsnest* command).

This is one of the command box helper actions. While it is a regular action and can be used like any other action, its name and syntax are optimized for use with the command box (`:`) and thus the syntax is documented for that purpose.

F.1.65 RouteStyle

```
RouteStyle(1|2|3|4)
```

Copies the indicated routing style into the current sizes.

F.1.66 s

```
s [name]
```

Saves layout data.

Data and the filename are passed to the command defined by the resource *saveCommand*. It must read the layout data from *stdin*. If no filename is entered, either the last one is used again or, if it is not available, a file select box will pop up.

This is one of the command box helper actions. While it is a regular action and can be used like any other action, its name and syntax are optimized for use with the command box (`:`) and thus the syntax is documented for that purpose.

F.1.67 SaveSettings

```
SaveSettings()
"“SaveSettings(local)
```

Saves settings.

If you pass no arguments, the settings are stored in `$HOME/.pcb/settings`. If you pass the word `local` they're saved in `./pcb.settings`.

F.1.68 SaveTo

```
SaveTo(Layout|LayoutAs,filename)
SaveTo(AllConnections|AllUnusedPins|ElementConnections,filename)
SaveTo(PasteBuffer,filename)
```

Saves data to a file.

`Layout` Saves the current layout.

`LayoutAs` Saves the current layout, and remembers the filename used.

`AllConnections`
Save all connections to a file.

`AllUnusedPins`
List all unused pins to a file.

`ElementConnections`
Save connections to the element at the cursor to a file.

`PasteBuffer`
: Save the content of the active Buffer to a file. This is the graphical way to create a footprint.

F.1.69 Select

```
Select(ToggleObject)
Select(All|Block|Connection)
Select(ElementByName|ObjectByName|PadByName|PinByName)
Select(ElementByName|ObjectByName|PadByName|PinByName, Name)
Select(TextByName|ViaByName)
Select(TextByName|ViaByName, Name)
"“Select(Convert)
```

Toggles or sets the selection

`ElementByName`
`ObjectByName`
`PadByName`
`PinByName`
`TextByName`
`ViaByName`
: These all rely on having a regular expression parser built into `pcb`. If the name is not specified then the user is prompted for a pattern, and all objects that match the pattern and are of the type specified are selected.

`Object`

`ToggleObject`
: Selects the object under the cursor.

`Block` Selects all objects in a rectangle indicated by the cursor.

`All` Selects all objects on the board.

`Connection`
: Selects all connections with the “found” flag set.

`Convert` Converts the selected objects to an element. This uses the highest numbered paste buffer.

F.1.70 SetFlag

```
SetFlag(Object|Selected|SelectedObjects, flag)
SetFlag(SelectedLines|SelectedPins|SelectedVias, flag)
SetFlag(SelectedPads|SelectedTexts|SelectedNames, flag)
SetFlag(SelectedElements, flag)
flag = square | octagon | thermal | join
```

Sets flags on objects.

Turns the given flag on, regardless of its previous setting. See `ChangeFlag`.

```
SetFlag(SelectedPins,thermal)
```

F.1.71 SetOctagon

```
SetOctagon(Object|ToggleObject|SelectedElements|Selected)
```

Sets the octagon-flag of objects.

Pins, pads, and vias can have various shapes. All may be round. Pins and pads may be square (obviously "square" pads are usually rectangular). Pins and vias may be octagonal. When you change a shape flag of an element, you actually change all of its pins and pads.

Note that the square flag takes precedence over the octagon flag, thus, if both the square and octagon flags are set, the object is square. When the square flag is cleared, the pins and pads will be either round or, if the octagon flag is set, octagonal.

F.1.72 SetSame

```
SetSame()
```

Sets current layer and sizes to match indicated item.

When invoked over any line, arc, polygon, or via, this changes the current layer to be the layer that item is on, and changes the current sizes (thickness, keepaway, drill, etc) according to that item.

F.1.73 SetSquare

```
SetSquare(ToggleObject|SelectedElements|SelectedPins)
```

sets the square-flag of objects.

Note that `Pins` means pins and pads.

Pins, pads, and vias can have various shapes. All may be round. Pins and pads may be square (obviously "square" pads are usually rectangular). Pins and vias may be octagonal. When you change a shape flag of an element, you actually change all of its pins and pads.

Note that the square flag takes precedence over the octagon flag, thus, if both the square and octagon flags are set, the object is square. When the square flag is cleared, the pins and pads will be either round or, if the octagon flag is set, octagonal.

F.1.74 SetThermal

```
SetThermal(Object|SelectedPins|SelectedVias|Selected, Style)
```

Set the thermal (on the current layer) of pins or vias to the given style. Style = 0 means no thermal. Style = 1 has diagonal fingers with sharp edges. Style = 2 has horizontal and vertical fingers with sharp edges. Style = 3 is a solid connection to the plane.Style = 4 has diagonal fingers with rounded edges. Style = 5 has horizontal and vertical fingers with rounded edges.

This changes how/whether pins or vias connect to any rectangle or polygon on the current layer. The first argument can specify one object, or all selected pins, or all selected vias, or all selected pins and vias. The second argument specifies the style of connection. There are 5 possibilities: 0 - no connection, 1 - 45 degree fingers with sharp edges, 2 - horizontal & vertical fingers with sharp edges, 3 - solid connection, 4 - 45 degree fingers with rounded corners, 5 - horizontal & vertical fingers with rounded corners.

Pins and Vias may have thermals whether or not there is a polygon available to connect with. However, they will have no effect without the polygon.

F.1.75 SetValue

```
SetValue(Grid|Line|LineSize|Text|TextScale|ViaDrillingHole|Via|ViaSize, delta)
```

Change various board-wide values and sizes.

`ViaDrillingHole`
: Changes the diameter of the drill for new vias.

`Grid`
: Sets the grid spacing.

`Line`

`LineSize`
: Changes the thickness of new lines.

`Via`

`ViaSize`
: Changes the diameter of new vias.

`Text`

`TextScale`
: Changes the size of new text.

F.1.76 ToggleHideName

```
ToggleHideName(Object|SelectedElements)
```

Toggles the visibility of element names.

If names are hidden you won't see them on the screen and they will not appear on the silk layer when you print the layout.

F.1.77 ToggleVendor

```
ToggleVendor()
```

Toggles the state of automatic drill size mapping.

When drill mapping is enabled, new instances of pins and vias will have their drill holes mapped to one of the allowed drill sizes specified in the currently loaded vendor drill table. To enable drill mapping, a vendor resource file containing a drill table must be loaded first.

F.1.78 Undo

```
Undo()
""Undo(ClearList)
```

Undo recent changes.

The unlimited undo feature of `Pcb` allows you to recover from most operations that materially affect you work. Calling `Undo()` without any parameter recovers from the last (non-undo) operation. `ClearList` is used to release the allocated memory. `ClearList` is called whenever a new layout is started or loaded. See also `Redo` and `Atomic`.

Note that undo groups operations by serial number; changes with the same serial number will be undone (or redone) as a group. See `Atomic`.

F.1.79 UnloadVendor

```
UnloadVendor()
```

Unloads the current vendor drill mapping table.

F.1.80 Unselect

```
Unselect(All|Block|Connection)
Unselect(ElementByName|ObjectByName|PadByName|PinByName)
Unselect(ElementByName|ObjectByName|PadByName|PinByName, Name)
Unselect(TextByName|ViaByName)
""Unselect(TextByName|ViaByName, Name)
```

unselects the object at the pointer location or the specified objects

`All` Unselect all objects.

`Block` Unselect all objects in a rectangle given by the cursor.

`Connection`
: Unselect all connections with the "found" flag set.

`ElementByName`
`ObjectByName`
`PadByName`
`PinByName`
`TextByName`
`ViaByName`
: These all rely on having a regular expression parser built into `pcb`. If the name is not specified then the user is prompted for a pattern, and all objects that match the pattern and are of the type specified are unselected.

F.1.81 w

```
w [name]
```

Saves layout data.

This commands has been added for the convenience of `vi` users and has the same functionality as `s`.

This is one of the command box helper actions. While it is a regular action and can be used like any other action, its name and syntax are optimized for use with the command box (`:`) and thus the syntax is documented for that purpose.

F.1.82 wq

```
wq
```

Saves the layout data and quits.

This command has been added for the convenience of `vi` users and has the same functionality as `s` combined with `q`.

This is one of the command box helper actions. While it is a regular action and can be used like any other action, its name and syntax are optimized for use with the command box (`:`) and thus the syntax is documented for that purpose.

F.2 common actions

F.2.1 LayersChanged

```
LayersChanged()
```

Tells the GUI that the layers have changed.

This includes layer names, colors, stacking order, visibility, etc.

This is one of a number of actions which are part of the HID interface. The core functions use these actions to tell the current GUI when to change the presented information in response to changes that the GUI may not know about. The user normally does not invoke these directly.

F.2.2 LibraryChanged

```
LibraryChanged()
```

Tells the GUI that the libraries have changed.

This is one of a number of actions which are part of the HID interface. The core functions use these actions to tell the current GUI when to change the presented information in response to changes that the GUI may not know about. The user normally does not invoke these directly.

F.2.3 NetlistChanged

```
NetlistChanged()
```

Tells the GUI that the netlist has changed.

This is one of a number of actions which are part of the HID interface. The core functions use these actions to tell the current GUI when to change the presented information in response to changes that the GUI may not know about. The user normally does not invoke these directly.

F.2.4 PCBChanged

```
PCBChanged()
```

Tells the GUI that the whole PCB has changed.

This is one of a number of actions which are part of the HID interface. The core functions use these actions to tell the current GUI when to change the presented information in response to changes that the GUI may not know about. The user normally does not invoke these directly.

F.2.5 RouteStylesChanged

```
RouteStylesChanged()
```

Tells the GUI that the routing styles have changed.

This is one of a number of actions which are part of the HID interface. The core functions use these actions to tell the current GUI when to change the presented information in response to changes that the GUI may not know about. The user normally does not invoke these directly.

F.3 gtk actions

F.3.1 gtk About

```
About()
```

Tell the user about this version of PCB.

This just pops up a dialog telling the user which version of `pcb` they're running.

F.3.2 gtk AdjustStyle

```
AdjustStyle()
```

Open the window which allows editing of the route styles

Opens the window which allows editing of the route styles.

F.3.3 gtk Center

```
Center()
```

Moves the pointer to the center of the window.

Move the pointer to the center of the window, but only if it's currently within the window already.

F.3.4 gtk Cursor

```
Cursor(Type,DeltaUp,DeltaRight,Units)
```

Move the cursor.

This action moves the mouse cursor. Unlike other actions which take coordinates, this action's coordinates are always relative to the user's view of the board. Thus, a positive *DeltaUp* may move the cursor towards the board origin if the board is inverted.

Type is one of '`Pan`' or '`Warp`'. '`Pan`' causes the viewport to move such that the crosshair is under the mouse cursor. '`Warp`' causes the mouse cursor to move to be above the crosshair.

Units can be one of the following:

'`mil`'
'`mm`' The cursor is moved by that amount, in board units.

'`grid`' The cursor is moved by that many grid points.

'`view`' The values are percentages of the viewport's view. Thus, a pan of '`100`' would scroll the viewport by exactly the width of the current view.

'`board`' The values are percentages of the board size. Thus, a move of '`50,50`' moves you halfway across the board.

F.3.5 gtk DoWindows

```
DoWindows(1|2|3|4)
DoWindows(Layout|Library|Log|Netlist|Preferences)
```

Open various GUI windows.

`1`
`Layout` Open the layout window. Since the layout window is always shown anyway, this has no effect.

`2`
`Library` Open the library window.

`3`
`Log` Open the log window.

`4`
`Netlist` Open the netlist window.

`5`
`Preferences`
Open the preferences window.

F.3.6 gtk EditLayerGroups

```
EditLayerGroups()
```

Open the preferences window which allows editing of the layer groups

Opens the preferences window which is where the layer groups are edited. This action is primarily provides to provide menu resource compatibility with the lesstif HID.

F.3.7 gtk GetXY

```
GetXY()
```

Get a coordinate.

Prompts the user for a coordinate, if one is not already selected.

F.3.8 gtk Popup

```
Popup(MenuName, [Button])
```

Bring up the popup menu specified by `MenuName`. If called by a mouse event then the mouse button number must be specified as the optional second argument.

This just pops up the specified menu. The menu must have been defined as a named subresource of the Popups resource in the menu resource file. If called as a response to a mouse button click, the mouse button number must be specified as the second argument.

F.3.9 gtk Print

```
Print()
```

Print the layout.

This will find the default printing HID, prompt the user for its options, and print the layout.

F.3.10 gtk PrintCalibrate

```
PrintCalibrate()
```

Calibrate the printer.

This will print a calibration page, which you would measure and type the measurements in, so that future printouts will be more precise.

F.3.11 gtk Save

```
Save()
Save(Layout|LayoutAs)
Save(AllConnections|AllUnusedPins|ElementConnections)
Save(PasteBuffer)
```

Save layout and/or element data to a user-selected file.

This action is a GUI front-end to the core's `SaveTo` action (see Section F.1.68 [SaveTo Action], page 117). If you happen to pass a filename, like `SaveTo`, then `SaveTo` is called directly. Else, the user is prompted for a filename to save, and then `SaveTo` is called with that filename.

F.3.12 gtk SelectLayer

```
SelectLayer(1..MAXLAYER|Silk|Rats)
```

Select which layer is the current layer.

The specified layer becomes the currently active layer. It is made visible if it is not already visible

F.3.13 gtk SetUnits

```
SetUnits(mm|mil)
```

Set the default measurement units.

`mil` Sets the display units to mils (1/1000 inch).

`mm` Sets the display units to millimeters.

F.3.14 gtk SwapSides

```
SwapSides(|v|h|r)
```

Swaps the side of the board you're looking at.

This action changes the way you view the board.

`v` Flips the board over vertically (up/down).

`h` Flips the board over horizontally (left/right), like flipping pages in a book.

`r` Rotates the board 180 degrees without changing sides.

If no argument is given, the board isn't moved but the opposite side is shown.

Normally, this action changes which pads and silk layer are drawn as true silk, and which are drawn as the `"invisible"` layer. It also determines which solder mask you see.

As a special case, if the layer group for the side you're looking at is visible and currently active, and the layer group for the opposite is not visible (i.e. disabled), then this action will also swap which layer group is visible and active, effectively swapping the "working side" of the board.

F.3.15 gtk ToggleView

```
ToggleView(1..MAXLAYER)
ToggleView(layername)
ToggleView(Silk|Rats|Pins|Vias|Mask|BackSide)
```

Toggle the visibility of the specified layer or layer group.

If you pass an integer, that layer is specified by index (the first layer is `1`, etc). If you pass a layer name, that layer is specified by name. When a layer is specified, the visibility of the layer group containing that layer is toggled.

If you pass a special layer name, the visibility of those components (silk, rats, etc) is toggled. Note that if you have a layer named the same as a special layer, the layer is chosen over the special layer.

F.3.16 gtk Zoom

```
Zoom()
Zoom(factor)
```

Various zoom factor changes. Changes the zoom (magnification) of the view of the board. If no arguments are passed, the view is scaled such that the board just fits inside the visible window (i.e. "view all"). Otherwise, *factor* specifies a change in zoom factor. It may be prefixed by `+`, `-`, or `=` to change how the zoom factor is modified. The *factor* is a floating point number, such as `1.5` or `0.75`.

+factor Values greater than 1.0 cause the board to be drawn smaller; more of the board will be visible. Values between 0.0 and 1.0 cause the board to be drawn bigger; less of the board will be visible.

-factor Values greater than 1.0 cause the board to be drawn bigger; less of the board will be visible. Values between 0.0 and 1.0 cause the board to be drawn smaller; more of the board will be visible.

=factor

> The *factor* is an absolute zoom factor; the unit for this value is "PCB units per screen pixel". Since PCB units are 0.01 mil, a *factor* of 1000 means 10 mils (0.01 in) per pixel, or 100 DPI, about the actual resolution of most screens - resulting in an "actual size" board. Similarly, a *factor* of 100 gives you a 10x actual size.

Note that zoom factors of zero are silently ignored.

F.4 lesstif actions

F.4.1 lesstif About

```
About()
```

Tell the user about this version of PCB.

This just pops up a dialog telling the user which version of `pcb` they're running.

F.4.2 lesstif AdjustSizes

```
AdjustSizes()
```

Let the user change the board size, DRC parameters, etc

Displays a dialog box that lets the user change the board size, DRC parameters, and text scale.

The units are determined by the default display units.

F.4.3 lesstif AdjustStyle

```
AdjustStyle()
```

Displays the route style adjustment window.

F.4.4 lesstif Benchmark

```
Benchmark()
```

Benchmark the GUI speed.

This action is used to speed-test the Lesstif graphics subsystem. It redraws the current screen as many times as possible in ten seconds. It reports the amount of time needed to draw the screen once.

F.4.5 lesstif Command

```
Command()
```

Displays the command line input window.

The command window allows the user to manually enter actions to be executed. Action syntax can be done one of two ways:

> Follow the action name by an open parenthesis, arguments separated by commas, end with a close parenthesis. Example: `Abc(1,2,3)`
>
> Separate the action name and arguments by spaces. Example: `Abc 1 2 3`.

The first option allows you to have arguments with spaces in them, but the second is more "natural" to type for most people.

Note that action names are not case sensitive, but arguments normally are. However, most actions will check for "keywords" in a case insensitive way.

There are three ways to finish with the command window. If you press the `Enter` key, the command is invoked, the window goes away, and the next time you bring up the command window it's empty. If you press the `Esc` key, the window goes away without invoking anything, and the next time you bring up the command window it's empty. If you change focus away from the command window (i.e. click on some other window), the command window goes away but the next time you bring it up it resumes entering the command you were entering before.

F.4.6 lesstif Cursor

```
Cursor(Type,DeltaUp,DeltaRight,Units)
```

Move the cursor.

This action moves the mouse cursor. Unlike other actions which take coordinates, this action's coordinates are always relative to the user's view of the board. Thus, a positive *DeltaUp* may move the cursor towards the board origin if the board is inverted.

Type is one of '`Pan`' or '`Warp`'. '`Pan`' causes the viewport to move such that the crosshair is under the mouse cursor. '`Warp`' causes the mouse cursor to move to be above the crosshair.

Units can be one of the following:

'`mil`'
'`mm`' The cursor is moved by that amount, in board units.

'`grid`' The cursor is moved by that many grid points.

'`view`' The values are percentages of the viewport's view. Thus, a pan of '`100`' would scroll the viewport by exactly the width of the current view.

'`board`' The values are percentages of the board size. Thus, a move of '`50,50`' moves you halfway across the board.

F.4.7 lesstif Debug

```
Debug(...)
```

Debug action.

This action exists to help debug scripts; it simply prints all its arguments to stdout.

F.4.8 lesstif DebugXY

```
DebugXY(...)
```

Debug action, with coordinates

Like `Debug`, but requires a coordinate. If the user hasn't yet indicated a location on the board, the user will be prompted to click on one.

F.4.9 lesstif DoWindows

```
DoWindows(1|2|3|4)
DoWindows(Layout|Library|Log|Netlist)
```

Open various GUI windows.

`1`
`Layout` Open the layout window. Since the layout window is always shown anyway, this has no effect.

`2`
`Library` Open the library window.

`3`
`Log` Open the log window.

`4`
`Netlist` Open the netlist window.

F.4.10 lesstif DumpKeys

```
DumpKeys()
```

Dump Lesstif key bindings.

Causes the list of key bindings (from `pcb-menu.res`) to be dumped to stdout. This is most useful when invoked from the command line like this:

```
pcb --action-string DumpKeys
```

F.4.11 lesstif EditLayerGroups

```
EditLayerGroups()
```

Let the user change the layer groupings

Displays a dialog that lets the user view and change the layer groupings. Each layer (row) can be a member of any one layer group (column). Note the special layers `solder` and `component` allow you to specify which groups represent the top and bottom of the board.

See Section F.1.11 [ChangeName Action], page 100.

F.4.12 lesstif Export

```
Export()
```

Export the layout.

Prompts the user for an exporter to use. Then, prompts the user for that exporter's options, and exports the layout.

F.4.13 lesstif GetXY

```
GetXY()
```

Get a coordinate.

Prompts the user for a coordinate, if one is not already selected.

F.4.14 lesstif LibraryShow

```
LibraryShow()
```

Displays the library window.

F.4.15 lesstif Load

```
Load()
Load(Layout|LayoutToBuffer|ElementToBuffer|Netlist|Revert)
```

Load layout data from a user-selected file.

This action is a GUI front-end to the core's `LoadFrom` action (see Section F.1.38 [LoadFrom Action], page 108). If you happen to pass a filename, like `LoadFrom`, then `LoadFrom` is called directly. Else, the user is prompted for a filename to load, and then `LoadFrom` is called with that filename.

F.4.16 lesstif LoadVendor

```
LoadVendor()
```

Loads a user-selected vendor resource file.

The user is prompted for a file to load, and then `LoadVendorFrom` is called (see Section F.1.39 [LoadVendorFrom Action], page 109) to load that vendor file.

F.4.17 lesstif NetlistShow

```
NetlistShow(pinname|netname)
```

Selects the given pinname or netname in the netlist window.

F.4.18 lesstif Print

```
Print()
```

Print the layout.

This will find the default printing HID, prompt the user for its options, and print the layout.

F.4.19 lesstif PrintCalibrate

```
PrintCalibrate()
```

Calibrate the printer.

This will print a calibration page, which you would measure and type the measurements in, so that future printouts will be more precise.

F.4.20 lesstif PromptFor

```
PromptFor([message[,default]])
```

Prompt for a response.

This is mostly for testing the lesstif HID interface. The parameters are passed to the `prompt_for()` HID function, causing the user to be prompted for a response. The respose is simply printed to the user's stdout.

F.4.21 lesstif Return

```
Return(0|1)
```

Simulate a passing or failing action.

This is for testing. If passed a 0, does nothing and succeeds. If passed a 1, does nothing but pretends to fail.

F.4.22 lesstif Save

```
Save()
Save(Layout|LayoutAs)
Save(AllConnections|AllUnusedPins|ElementConnections)
Save(PasteBuffer)
```

Save layout data to a user-selected file.

This action is a GUI front-end to the core's `SaveTo` action (see Section F.1.68 [SaveTo Action], page 117). If you happen to pass a filename, like `SaveTo`, then `SaveTo` is called directly. Else, the user is prompted for a filename to save, and then `SaveTo` is called with that filename.

F.4.23 lesstif SelectLayer

```
SelectLayer(1..MAXLAYER|Silk|Rats)
```

Select which layer is the current layer.

The specified layer becomes the currently active layer. It is made visible if it is not already visible

F.4.24 lesstif SetUnits

```
SetUnits(mm|mil)
```

Set the default measurement units.

`mil` Sets the display units to mils (1/1000 inch).

`mm` Sets the display units to millimeters.

F.4.25 lesstif SwapSides

```
SwapSides(|v|h|r)
```

Swaps the side of the board you're looking at.

This action changes the way you view the board.

`v` Flips the board over vertically (up/down).

`h` Flips the board over horizontally (left/right), like flipping pages in a book.

`r` Rotates the board 180 degrees without changing sides.

If no argument is given, the board isn't moved but the opposite side is shown.

Normally, this action changes which pads and silk layer are drawn as true silk, and which are drawn as the `"invisible"` layer. It also determines which solder mask you see.

As a special case, if the layer group for the side you're looking at is visible and currently active, and the layer group for the opposite is not visible (i.e. disabled), then this action will also swap which layer group is visible and active, effectively swapping the "working side" of the board.

F.4.26 lesstif ToggleView

```
ToggleView(1..MAXLAYER)
ToggleView(layername)
ToggleView(Silk|Rats|Pins|Vias|Mask|BackSide)
```

Toggle the visibility of the specified layer or layer group.

If you pass an integer, that layer is specified by index (the first layer is `1`, etc). If you pass a layer name, that layer is specified by name. When a layer is specified, the visibility of the layer group containing that layer is toggled.

If you pass a special layer name, the visibility of those components (silk, rats, etc) is toggled. Note that if you have a layer named the same as a special layer, the layer is chosen over the special layer.

F.4.27 lesstif Zoom

```
Zoom()
Zoom(factor)
```

Various zoom factor changes.

Changes the zoom (magnification) of the view of the board. If no arguments are passed, the view is scaled such that the board just fits inside the visible window (i.e. "view all"). Otherwise, *factor* specifies a change in zoom factor. It may be prefixed by `+`, `-`, or `=` to change how the zoom factor is modified. The *factor* is a floating point number, such as `1.5` or `0.75`.

`+factor` Values greater than 1.0 cause the board to be drawn smaller; more of the board will be visible. Values between 0.0 and 1.0 cause the board to be drawn bigger; less of the board will be visible.

`-factor` Values greater than 1.0 cause the board to be drawn bigger; less of the board will be visible. Values between 0.0 and 1.0 cause the board to be drawn smaller; more of the board will be visible.

`=factor`

The *factor* is an absolute zoom factor; the unit for this value is "PCB units per screen pixel". Since PCB units are 0.01 mil, a *factor* of 1000 means 10 mils (0.01 in) per pixel, or 100 DPI, about the actual resolution of most screens - resulting in an "actual size" board. Similarly, a *factor* of 100 gives you a 10x actual size.

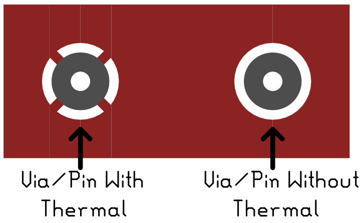
Note that zoom factors of zero are silently ignored.

Appendix G Glossary

Footprint
The pattern of metal, silkscreen, soldermask relief, and drills which defines where you place a component on a circuit board. Footprints are the placed by the user onto the PC board during the placement phase of PCB layout.

Gerber File
The file format used in the industry to convey a board database to the manufacturer is RS-274-X (which replaces the now obsolete RS-274-D format). This file format was originally developed by Gerber for their photo plotters and thus RS-274-D and RS-274-X format files are often times refered to as “Gerber” files.

Thermal, Thermal Relief
A thermal relief is a way of connecting a pin to a ground or power plane. Instead of directly connecting to the plane, small "spokes" are used to increase the thermal resistance between the pin and the plane. Often times these connections are refered to as simply a thermal. By increasing the thermal resistance to the plane, it becomes easier to solder to the pin. The drawing below shows an example of a thermal relief.



Index of Resources

Index of Actions, Commands and Options

Index of Concepts

/

A

B

C

D

E

F

G

H

I

K

L

M

N

O

P

Q

R

S