Max and Graphics

Translating the LCD help file

The LCD is the main drawing environment for max. It is based on the underlying Macintosh graphic routines called QuickDraw.

The drawing space is made up of numbered pixels. Each pixel has two numbers, the first is horizontal location, the second is vertical. The upper left corner is 0 0, and the pixels across the top are 0 0, 1 0, 2 0, 3 0, 4 0, etc. The right edge is 0 0, 0 1, 0 2, and so forth. This is similar to the familiar Cartesian coordinates except that y increases going down the screen. Instead of X and Y, I'm going to call the points H V.

Technically speaking the point H V refers to the upper left corner of the pixel. Thus, when you draw a line from 0 5 to 10 5, and another from 10 5 to 20 5, they will butt against each other instead of overlapping. Some commands draw inside of lines, so you occasionally find a 1 pixel difference on the right and bottom edges.

All commands are in lowercase letters. Some commands are switches that are turned on with something 1 and off with something 0.

Commands that affect the LCD itself

The size H V command will change the size of the LCD object, a bit disconcerting, but makes it easy to figure out where the edges are.
Getsize will cause the message size H V to come out the right outlet.
Clear removes all drawing and restore the background color.
Reset removes all drawings and restores all defaults for pensize, colors, etc.

Onscreen 1 starts drawing directly to the screen instead of to a hidden buffer. Drawing to a buffer gives a slicker effect because all of the pixels appear at once rather than as the computer calculates them. Also, if a buffer is used, the computer can automatically restore the contents of the LCD after it has been hidden by another window. The only advantage of onscreen mode is it saves memory, which may be important if you use a lot of LCDs. When you are in onscreen mode, the right outlet will send the message "update" when the display has been messed up. You can use that to trigger your own redrawing.

Colors

Some of the commands can take colors as arguments. There are two ways to specify color: indexed and rgb.

An rgb color is specified by three numbers, which set the intensity of the red, blue or green component. Possible values are for each color range from 0 to 255. 0 0 0 is black, 255 255 255 is white. 255 0 0 is a very intense red, and so on. Yellow is 255 255 0, magenta is 255 0 255, and Cyan is 0 255 255.

Indexed colors use a single number that refers to a set of predefined colors. The set defined is rather strange, being permutations of the values 255, 204, 153, 102, 51, and 0. That gets us up to 214. 215 to 224 are darkening shades of red, 225 to 234 are shades of green, and 235 to 244 are blues. 245 to 255 are darkening shades of gray.

There is a color designated as the foreground color. This is used by any drawing command that does not specify a color. It defaults to black, and will be changed by any color drawing. Or, it can be explicitly set by the command frgb r g b. There is a color designated as the background color with the command brgb r g b. You won't see it until you issue a clear command. The default is white.

Getpixel H V will tell the color of the pixel at H V. The response out the right outlet is "pixel r g b h v".

The pen

Drawing is done at the location of an invisible pen. To put the pen somewhere, use the command moveto H V.
Click in the LCD also moves the pen.
The similar command move H V is relative to the last location. Thus if the pen is at 15 44, move 5 5 will place it at 20 49.
Getpenloc will tell the position of the pen.

The pen starts out one pixel across. The command pensize H V changes it to a rectangle. This affects line drawing and the various frame commands. If the shape is not square, vertical lines will be a different width from horizontal ones.

Penmode sets the behavior of the pen in relation to what is already drawn. It determines whether you get the foreground or background color, or something else. Some of these functions use a third color called opcolor, which is set by the command oprgb.

The modes are called by number, but have names as shown in the help file.
The following table describes what happens with simple shapes, with effect on colored picts in parens.

0 Copy	You get the foreground (and background of the pict)
1 Or	You get the foreground of the source and destination
2 Xor	Black if over white space, white if over black (in colors, you get compliments.)
4 Bic	Background color (erases things)
5 NotCopy	Background color (negative of colors of source)
6 NotOr	Doesn't draw at all (negative of pict, destination shows through)
7 NotXor	Doesn't draw (negative of pict, negative of destination)
8 NotBic	Doesn't draw (source & destination where they overlap)
32 Blend	Gives a translucent effect , based on opcolor.
33 AddPin	Adds the source and destination -generally gives stronger colors. Uses OpColor as maximum
34 AddOver	Adds, but with "wraparound" which can be really bizarre.
35 SubPin	Gives the difference, but opcolor is the minimum. Also strange
36 transparent	Will ignore pixels in the source that match the current background. Use this when drawing PICTs if you want the original to show through.
37 Addmax	Will pass the maximum of the source and destination color, which tends toward white.
38 SubOver	Uses the difference between the colors, but if negative wraps around.
39 AdMin	Uses the lesser of the colors.

The Not and OR functions would do something if the pen is in "Pattern mode", which means something other than a solid rectangle. Pattern modes aren't implemented in LCD yet. Since all this math occurs on the individual color components, it's really hard to predict what will happen with any two colors.

Text

Text is drawn starting at the pen location, and moves to the right with each letter. If you want text to restart at the left and next line down when the right is reached, you have to do that yourself.

Font n s changes the font to number n and size s. The number for specific fonts varies from machine to machine so this will need some experimenting.. Most applications list them in alphabetical order in the font menu, which isn't the number order. The first 24 are system fonts and will be predictable. (There are third party externals to find font numbers, I'll try to chase some down)

The command [write something \, something] will write text in the LCD. Note that some punctuation, like comma, must be preceded by a backslash to be written properly.

The command ascii n n n n will translate the numbers to ascii equivalent letters and write those. There's a chart of ascii in the Max and text tutorial.

Lines

The command lineto H V draws a line from the pen location to H V.
The command line H V draws to a point H pixels right and V pixels down. H and V can be negative numbers to go the other way.
Linesegment h1 v1 h2 v2 c draws a line from h1 v1 to h2 v2 with indexed color c. Linesegment is really a moveto and a lineto.

Shapes

Various shapes can be drawn with a single command. The shapes are fitted into a rectangle you define as H V upper left and H V lower right. The shapes can be painted or framed. Paint gives a solid shape, frame gives the outline.
Paintrect
Framerect
Paintoval
Frameoval
Paintroundrect
Frameroundrect
(remember, all commands are lowercase. Bill gates won't let me start a sentence with a lowercase.)

Framearc needs two more numbers, which are starting angle and ending angle. These are given in degrees, where 0 is straight up.

The paint commands paint the area inside the bounding lines, and the frame commands draw the bounding lines, so if you paint on top of a frame with the same numbers, the right and bottom of the frame will still show. Paint commands do not move the drawing pen.

Poly

Polygons are painted with the paintpoly and framepoly commands. The arguments to the poly are a list of points (H,V) the poly will be drawn to. It's analogous to a moveto followed by series of linetos. If the lines cross, the paintpoly command will only fill areas on one side of any of its lines. It looks for the best enclosure. Note that the poly will only be closed if the last pair of numbers is the same as the first pair.

Regions

You can group a more complicated set of commands than the lines of poly. This is done by the region procedure. To do this, you issue these commands:

- Recordregion
- Any number of drawing operations
- Closeregion somename
- Paintregion somename H V

You won't see any drawing until the paintregion command. The H and V of the paint region will be added to whatever Hs and Vs were in the recorded drawing commands. You may be surprised at what you see when you include linetos in the region recording.

You can have as many named regions as you want to, but when you are done with one, you should call deleteregion to free up the memory. Clearregions deletes all regions, as does reset.

Clipping Regions

A clipping region is a area that limits drawing, sort of a cookie cutter effect. The following define clipping regions.
Cliprect
Clipoval
Cliproundrect
Clippoly

Cliparc is apparently planned for a later version.

Only one clipping region is in effect at a time. You can have a complex clipping region by making a region, and using the command:
Cliprgn somename H V

If a clipping region is in effect, the clear command only clears the clipping region. Clipping regions are not removed by the reset command, but I suspect this is a bug. The command noclip gets rid of the clipping region.

Scrollrect is similar to a region command. It copies what ever is in the specified rectangle, erases the rectangle, then draws the copy into a rectangle that is moved by the specified distance. That's all done by
Scrollrect H V H1 V1 mH mV

It's most useful for moving the entire LCD contents.

Sprites

So far all drawing has been permanent. If you draw something, change the H and V values and draw it again, you get two copies. To get rid of something, you have to draw it with the background color, and then redraw anything you wanted to keep. Sprites allow you to define drawings that will move around the screen.

To use sprites, you need to do enablesprites 1. This creates more off screen space for drawing. Then:

- recordsprite
- (a bunch of drawing commands)
- closesprite aname

will create the sprite. Drawsprite H V will draw it. Drawsprite H1 V1 will move the sprite to a different position without affecting any background. To make a sprite go away temporarily, use hidesprite. Free up its memory with deletesprite when you are done with it.

Clear and reset do not affect sprites.

If you use counters to calculate H and V, sprites will glide nicely around on the screen.

picts

Pict files are a Macintosh graphics files format. Most graphics programs such as photoshop can create them. You can use Picts in an LCD. The command

Readpict aname filename

will load the pict into the system. (It can apparently also read jpeg files.) The name you give it is just an identifier for LCD, it has nothing to do with what's on the drive.

Then drawpict will put it in the LCD. The arguments to drawpict can make some interesting changes:

Drawpict aname H V	will place the upper left corner of the pict at H and V. Many picts include white space around the edges, so you may have to allow for that. (Try transparent mode)
Drawpict aname H V H1 V1	will squeeze (or expand) the picture into the rectangle defined.

Drawpict aname 0 0 0 0 sH sV sH1 sV1	will draw only part of the picture. sH etc determine which part of the picture.
Drawpict aname H V H1 V1 sH sV sH1 sV1	will draw part of the picture in the rectangle with appropriate scaling.
Deletepict aname	removes the pict file from memory but doesn't erase it from the LCD.
Clearpicts	removes all picts from memory.

You can put a pict into a sprite. You can also tile picts with the command:

tilepict H V H1 V1 sH sV sH1 sV1

Tiling repeats the image as many times as necessary to fill the specified rectangle or the LCD. (You can shape this with a clipregion.) The sH etc. arguments determine the size of the tiles and where they come from in the image.

Once you have built up an interesting image in your LCD, you can immortalize it with the writepict command.

Mouse Actions

When the patcher is locked, you can draw directly into the LCD with the mouse. The mouse location is sent out the left outlet while drawing is going on. If the mouse button is clicked, a 1 for mouse down or a 0 for mouse up are sent out the third outlet. The command local 0 will turn mouse drawing off, but position and button messages are still sent.

If the command idle 1 has been received, the location of the mouse will be sent out the second outlet when the mouse is over the LCD but not drawing.

With these mouse features, the LCD makes a nice performance interface. You can load a pict in, and then respond when the user clicks over an interesting part of the pict.

Using Graphics Windows

There's a pretty good tutorial about graphics windows in the Max manual.

A graphics window is a separate window from your patcher. You create one by including a graphic object [graphic somename] in your patch. It doesn't have to be connected to anything. As soon as you enter it a small empty window will appear at the top left of the screen. This window can be moved around and resized, and any changes made will be remembered if you save your patch. (Bug alert! At the time of writing, patchers may become corrupted if graphic objects are moved and resized this way. Use arguments instead.)

The window may be hidden by sending the message wclose to the graphic object, and shown again with open. The open command will also bring the window to the front if it has gotten lost.

Positioning the Window

Arguments to the graphic object will set its location and size. Four arguments are needed and correspond to left, top, right, bottom edges. These numbers refer to pixels counted from the upper left corner of the screen. They define the drawing area of the window, not including the title bar and surrounding frame. The title bar is 20 pixels high, and so is the menubar, so to get all of the title to show, the top value for graphic has to be at least 40. The edges of the frame are 6 or 7 pixels, counting the shadow. Note that the visible drawing width will be the difference between the right and left edge values, and the height the difference between the bottom and top.

If you stick a 1 after the window name and before the location arguments, there will be no title bar or frame. Command dragging will move and resize such a window.

If you want to center the window in the display, you have to determine the screen resolution as set in the monitors control panel. For instance, if you want to center a 300 by 300 window in a screen set to 832 X 624, the arguments should be 266 162 566 462. The left edge is found by subtracting the window width from the screen width and dividing by 2. The right edge adds the widow width to this number. Top and bottom are found the same way.

Drawing Something

The only graphic drawing object native to Max is oval. You place it in your patcher with the name of the graphic window as the argument. Then, an int

received in the left inlet will draw an oval that fits in the box defined by it and the next three inlets. You can also use a list of four numbers to set the coordinates and draw all at once. The numbers are the familiar left, top, right, bottom, and are counted from the upper left of the graphics window. Note that if you define a graphics window 100 pixels wide, something drawn at left = 0 will touch the left edge, but something drawn at left = 100 will not show at all.

The fifth inlet to oval sets the drawing mode. This is the same as the penmode in the LCD object, and has differing effects according to the color of the object you are drawing and whatever you are drawing over.

The right inlet sets color. This is indexed color, pretty much like the index color of LCD, except the order of colors gives a smooth transition from 1 = pale blue through red to green and back to blue at 239. As with LCD, 240 to 255 are grays.

The Great rect Hoax

Rect is just like oval, filling in the rectangle defined by the values at the first four inlets. Rect doesn't really exist. It is an alias of oval, meaning that when Max sees the name rect, it really loads in an oval object and tells it to draw squares. This sometimes causes problems when you make a patcher and send it somewhere (in a collective probably) where oval can't be found. For this reason, you should always include an oval somewhere in a patcher that uses rect, even if you never draw with it. The objects ring and frame are also aliases to oval. The reasons for this are obscure, dating back to the days when Max had to run on slow computers with very little memory.

Sprites Again

Each oval type object gives you just one shape in the graphics window. If you want five ovals in the window, you need five oval objects in your patcher. However, each object creates a sprite, which is moved (and resized) every time you redraw it. Thus you can have your objects chase each other around the screen and pass in front of one another. The objects take an argument to set priority (lowest goes in back), or it can be changed with the priority message.

Any of these shapes can be made to disappear by giving it a left edge value that is larger than the right edge.

Picts

You can also open a pict in a graphics window. This is done with the pict object, which takes two arguments: the name of the graphics window, and the name of a pict file to draw. The picture is drawn when a bang or 1 is received in the left inlet. A clear or 0 will make the pict disappear. The second and third inlets set the location of the left top corner of the pict.. You can change the picture with the pict filename message, or the read message will open a file dialog. Pict also recognizes the priority and mode commands.

Filling the screen

You can't make a graphics window bigger than the screen. You can make one the same size, but when you do that, it's fiendishly difficult getting the thing lined up so there's nothing showing at the left and right, and you still have the menu bar to deal with.

You can make a patcher fill the screen, however. You do this by including a "thispatcher" object and sending it the message fullscreen 1. The menubar will disappear (command key equivalents still work) and the patcher will expand to the edges, with no title or scrollbars. Fullscreen 0 will put it back, so the easy thing to do is use fullscreen $1 with a toggle box.

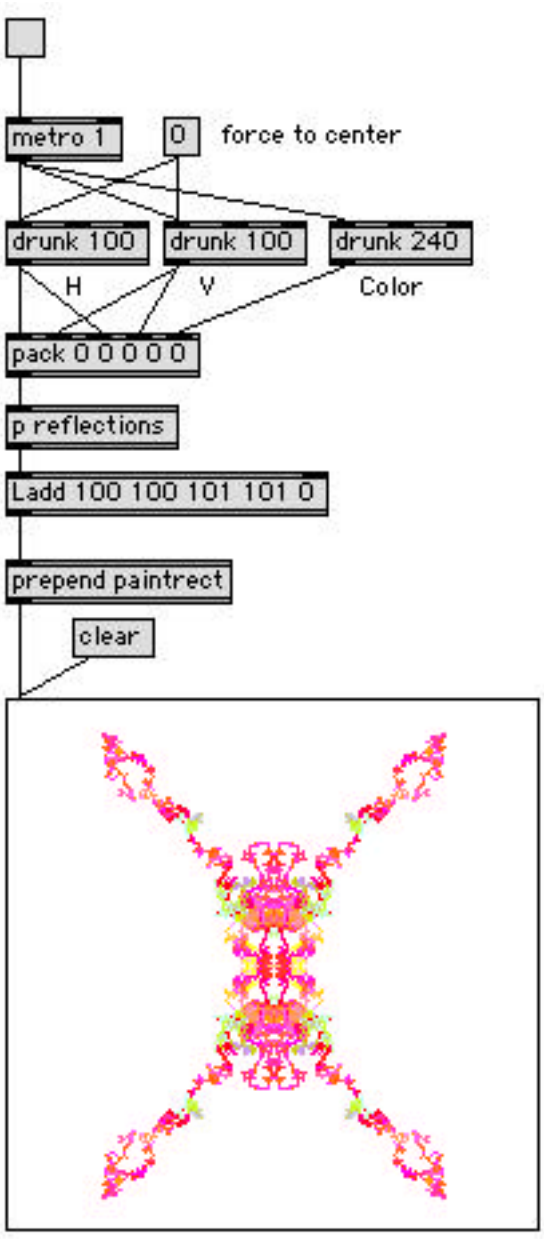
Now make everything in the patcher hide on lock. (Cmd-A, Cmd-K) This will make everything white when you lock it. Luckily, your patch will come back if you command click anywhere.

Finally, add a panel and expand it to be as big as the full screen patcher, and use the frgb message to give it the color of your choice. If you send an open message to the graphics object, it will appear in front of the patcher. It's easy to arrange all of this to happen with a series of loadbangs.

This can be done with LCDs also. In fact it's easier, because you just include the LCD in the full screen patcher. I usually keep a generic LCD patcher around, and send drawing messages to it from whatever I'm working on. Once you have made the menu bar go away, some things are difficult to do, so I usually make two versions of the display patcher, one that is full screen, and one that lets me use the menu bar.

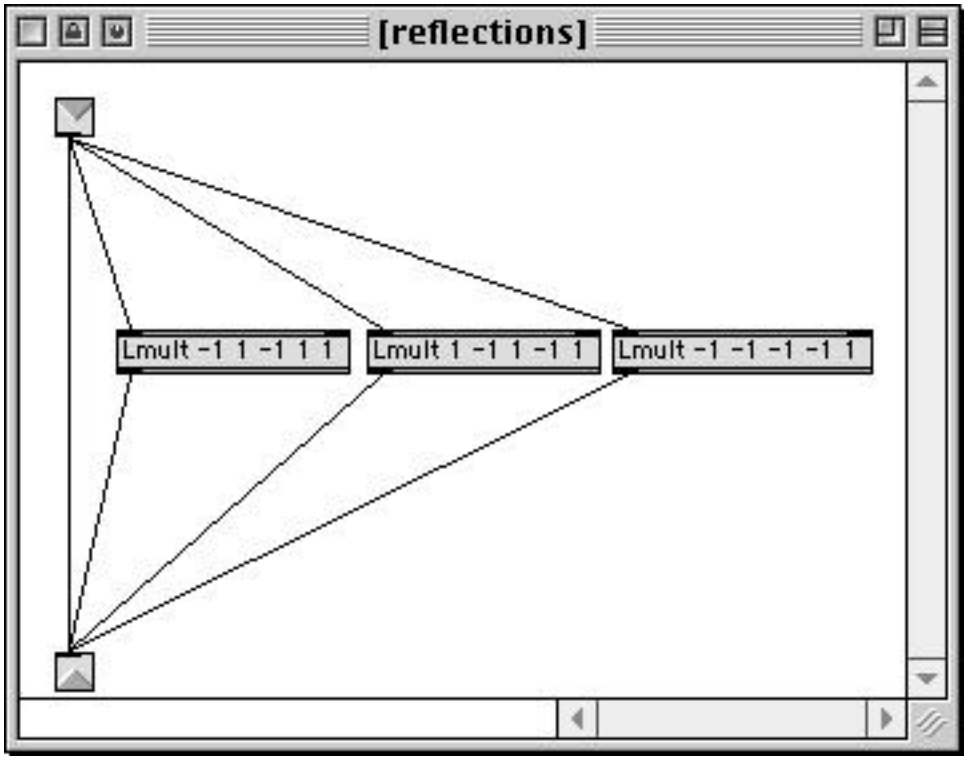
A Drawing Example

Drawing on the screen is a matter of figuring out where to put the available shapes. Some lovely patterns can be created by placing dots at mathematically determined locations. Here's an example.



This patcher uses drunk objects to generate a random scribble. These make a horizontal, vertical and color value on each metro tick. Note that the rectangle to be drawn has no dimensions at the start. This is added later. The list that comes out of the pack object is H V H V color.

The reflections subpatcher gives the characteristic symmetry of inkblots that are made by folding paper. This is what's inside:



This creates four lists and thus four rectangles will be drawn. By just changing the sign of the H, V or both values, the shapes will be reflected into four quadrants.

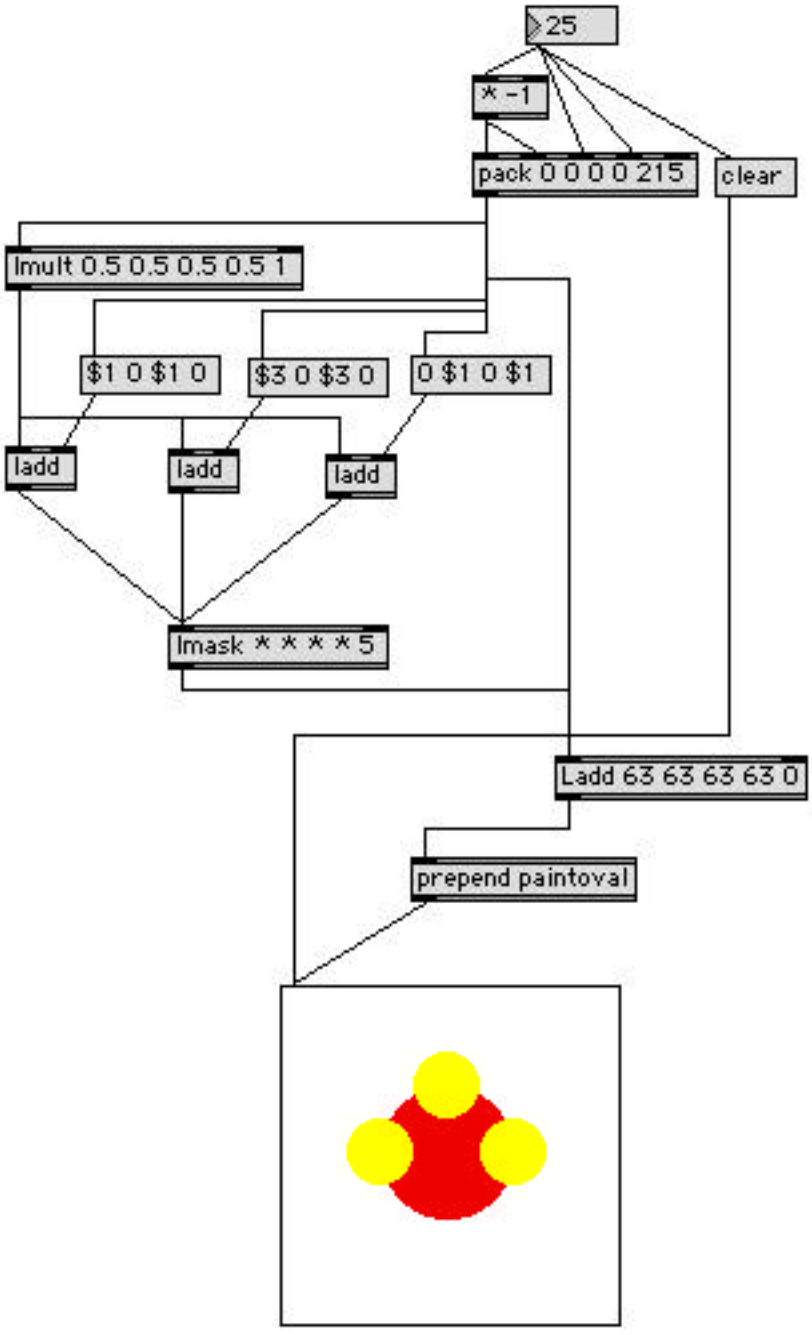
Since negative locations won't be drawn on the LCD, a final addition is performed to move the shape to the center, and at the same time give some dimension to the rectangle.

You will note that Lobjects are used to manipulate the drawing data. Individual objects could do the job, but I find it easier to keep track of what is going on when I keep the complete description of a rectangle together. When this format is used, the following operations are easy to apply:

Ladd 5 0 5 0 0	Move object right 5 pixels
Ladd 0 5 0 5 0	Move object down 5 pixels
Ladd 0 0 5 0 0	Widen object by 5 pixels
Ladd 0 0 0 5 0	Increase height by 5 pixels
Lmult 1 1 5 5 1	Make object 5 times size (only works if left top is 0 0, so this will usually be done first. You can also do this

	if you are using negative coordingates for left and top.)
Lmask * * * * 5	forces index color to be 5. (See the Lmask help window to see how to change the mask.)

Here's an example of these operations in action:

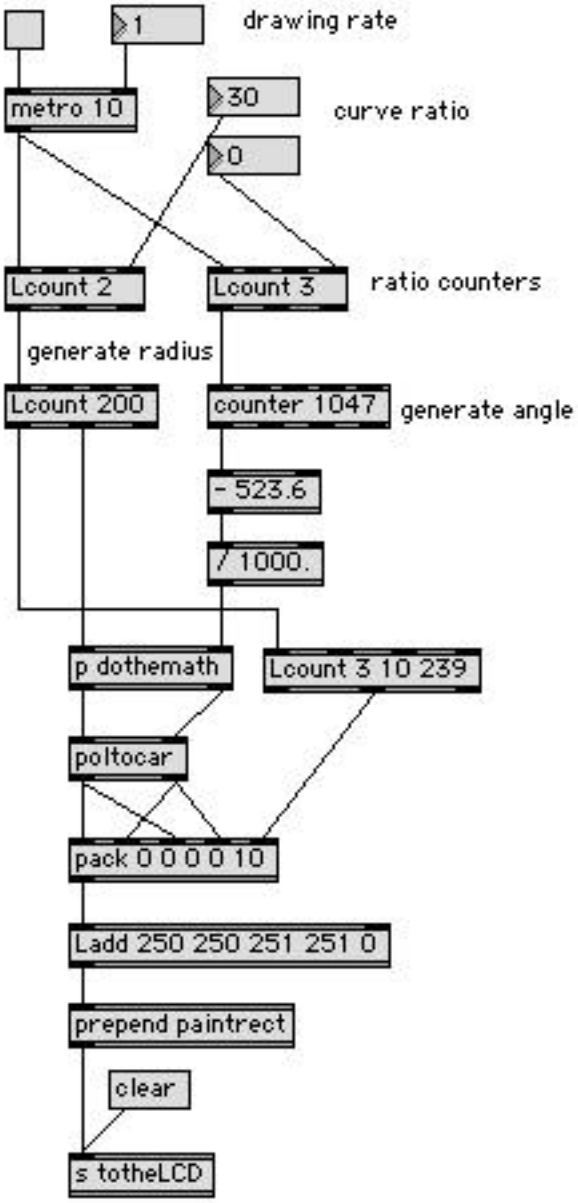


The number box at the top sets the radius of a circle. The paintoval command requires a box to inscribe the circle in, which is provided by the multiply and pack objects. I also want some circles half this size, which are created by lmult. The Ladds make three of these at different places. Note how I pick out some already calculated numbers with message objects. Lmask sets the color of the smaller circles.

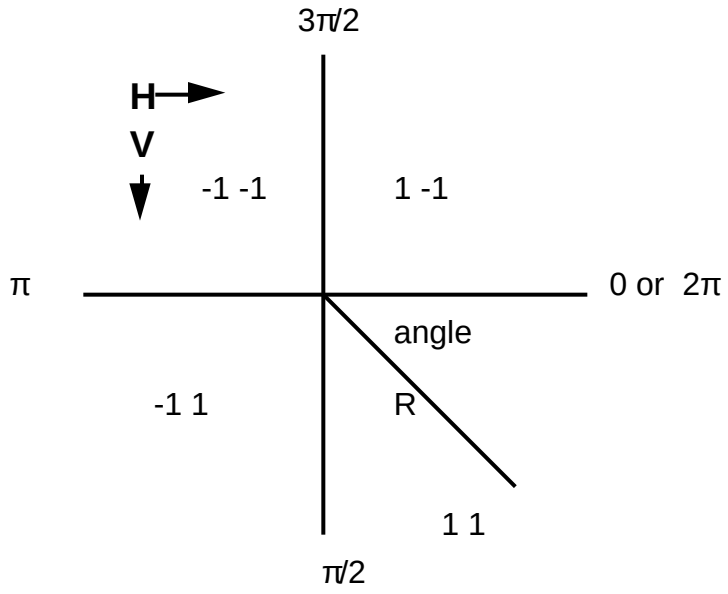
The final Ladd centers everything in the LCD. I find this approach is usually much simpler than trying to do all the math in the positive quadrant.

Polar Coordinates

Here's something a bit more complex:



It's going to draw some curves. It works by calculating an angle and radius for each point. This is how polar coordinates work in the Macintosh graphic world:

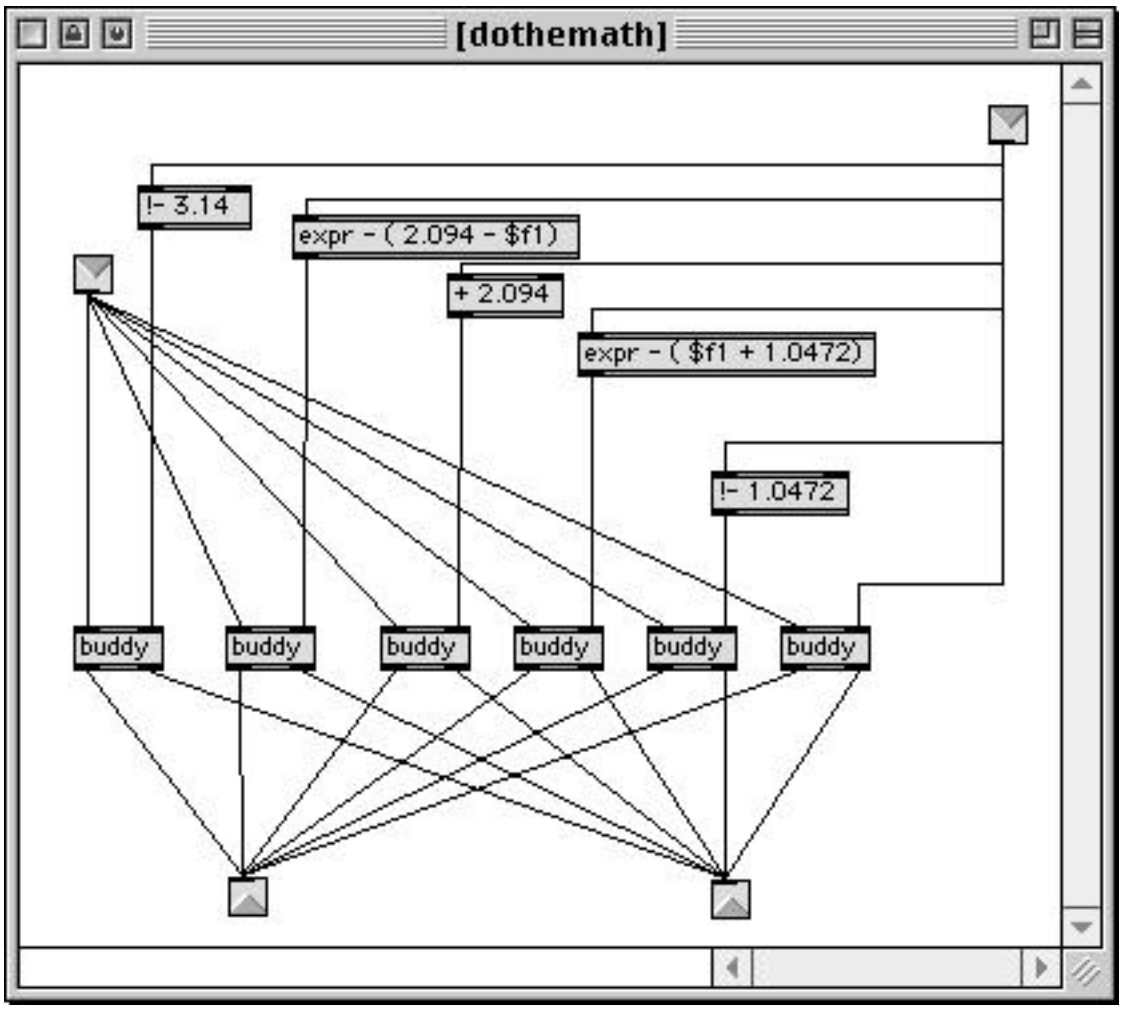


The point we are interested is found at the end of the line R. The radius R and the angle tell us where the point is. Of course, in order to draw the point, it has to be expressed in terms of H and V. H is equal to R* cos (angle) and V is R*sin(angle), but we can avoid the math with the poltocar object.

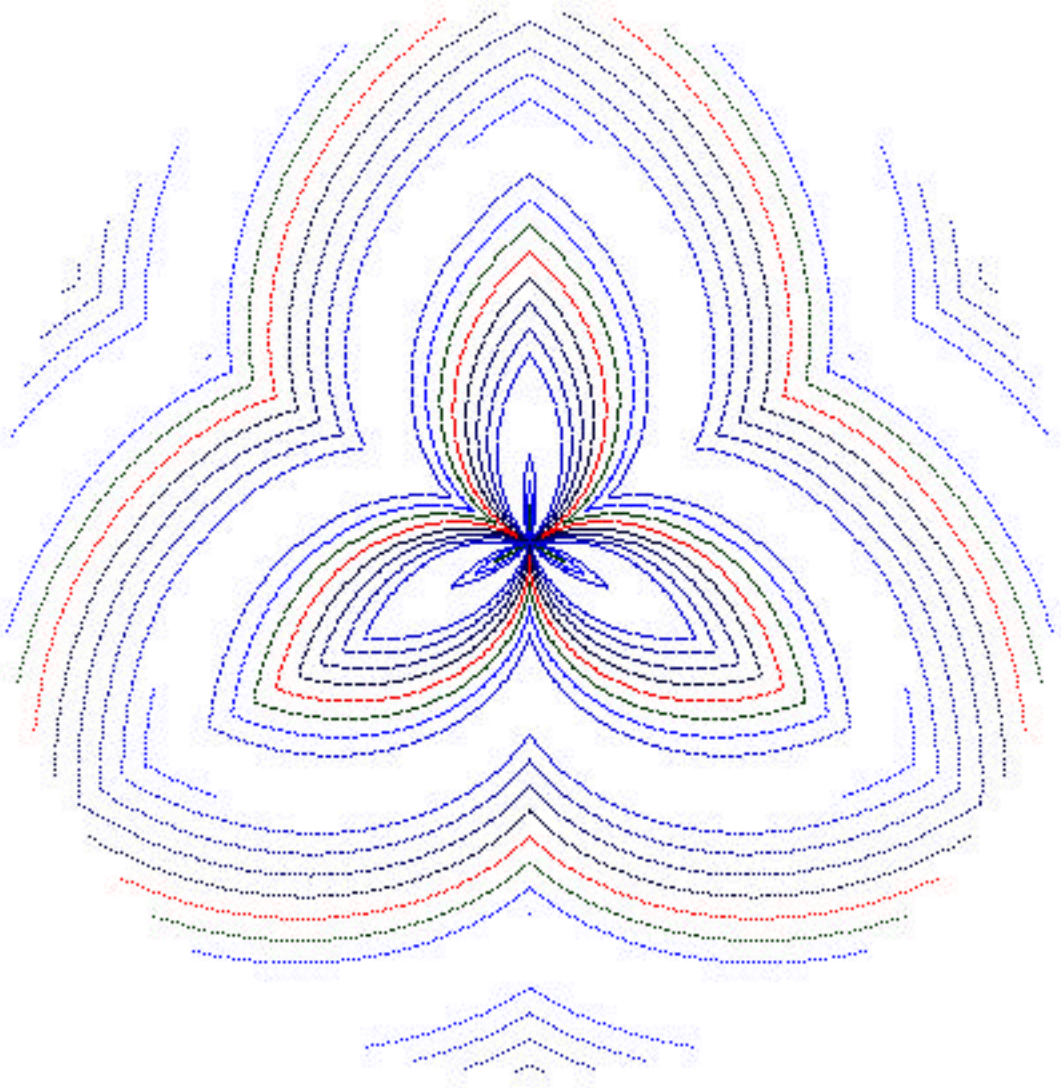
There are two things to be aware of when using polar coordinates. First off, the angle is expressed in radians, and a full circle is 6.283185307 radians. To get accurate placement out at the corners of large drawings, we should keep about 4 significant figures, so 6.283 works. We can generate angles by counting to 6283 and dividing by 100.0, or by using Lcount, which will do float counting.

The second thing is that a full circle will include negative H and V values, so we will again use the offset origin trick.

The patcher includes all of those features but the angle generated is from -π/6 to π/6 (0.5236 radians, equivalent to 30°.) Hidden away in the subpatcher you will find these operations:



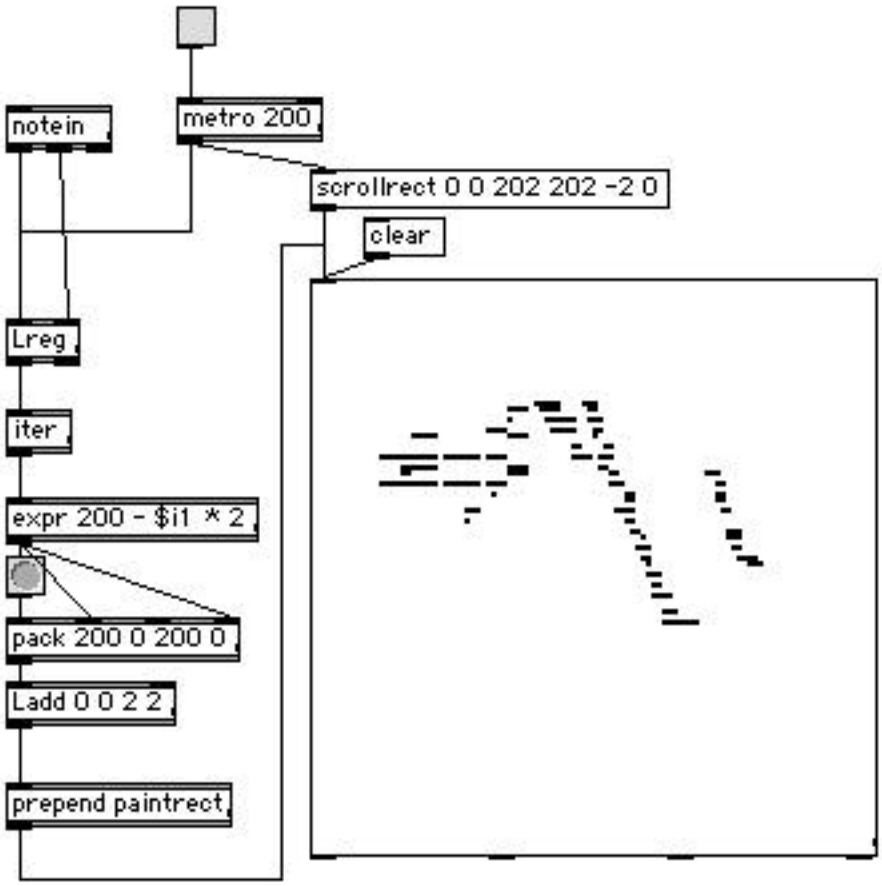
This forms 5 reflections for each point. The reflections are around axes set at 60° angles, which is the effect you get from most kaleidoscopes. The poltocar object converts these to the kind of list we are used to using, and rectangles one pixel wide are painted in the LCD. Here's the result:



The actual curves you get depends on the settings of the ratio counters. More complex patterns arise from changing these ratios at carefully chosen moments.

A real time display

The LCD object is quick enough that you can use it for metering and other real time tasks. Here's a simple piano roll patcher:



The key is the scrollrect command that moves everything to the left on each tick of the metro. Lreg maintains a list of active midi notes. (The same thing can be done with bag.) These are used to paint squares in the manner described before.