

UofL L-Edit Tutorial

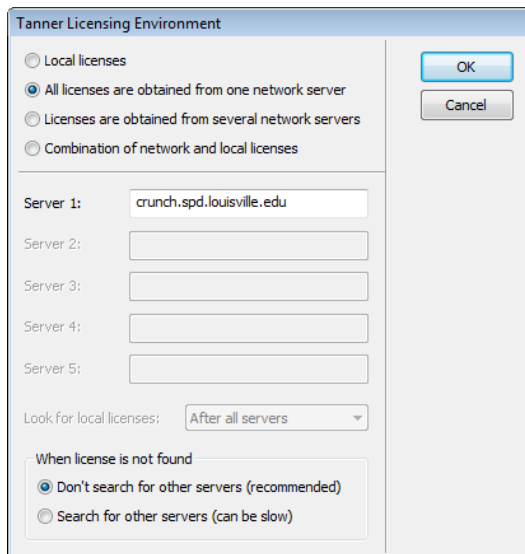
Introduction

This tutorial is meant to assist in first time users getting a background in Layout design. This tutorial should leave the user with enough knowledge to create a simple photomask design file to be created using the Kentucky NanoNet's KORE service. When the user becomes familiar enough with L-edit to need resources beyond this tutorial, it is recommended that they refer to the L-Edit User's Guide which can be found in the help menu of the L-Edit program.

Installing L-Edit

This section will cover how to download and install L-Edit using the services offered by KRUNCH. The first step will be to obtain the software. This is done by sending an email to Thomas Roussel at thomas.roussel@louisville.edu requesting the web address of the download. Type the web address into the browser and begin downloading the software. Once it is done downloading, extract the zip and select the Setup file.

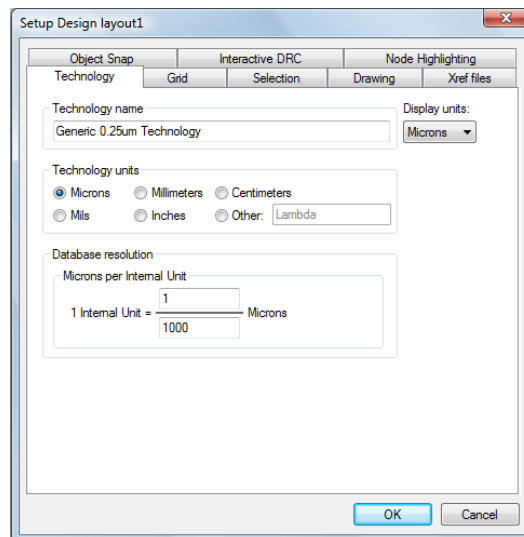
Follow the on-screen instructions when installing L-Edit. When the software requests a method for obtaining a license, select the option for accessing a license server. Once the installation is complete go to your start menu and access Tanner EDA -> Utilities -> Licensing Environment. Here you will receive a window like what is shown below. Select the option "All licenses are obtained from one network server" and input this address into the server 1 field: crunch.spd.louisville.edu. Once completed you are ready to access L-Edit under Tanner EDA -> Tanner Tools 13.1 -> L-Edit v13.1.



Getting Started

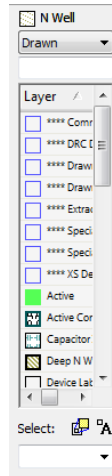
Before we can begin drawing our design, we must first setup the program with the utilities that we will need. This section will cover some of the settings that should be observed/modified before layout design.

The first setting that we are going to modify is going to be the “Design Technology”. The design technology is where we are establishing the feature size of our layout. This can be accessed by selected Setup -> Design from the drop down menu. Once this is selected you should be rewarded with a popup that looks like this:

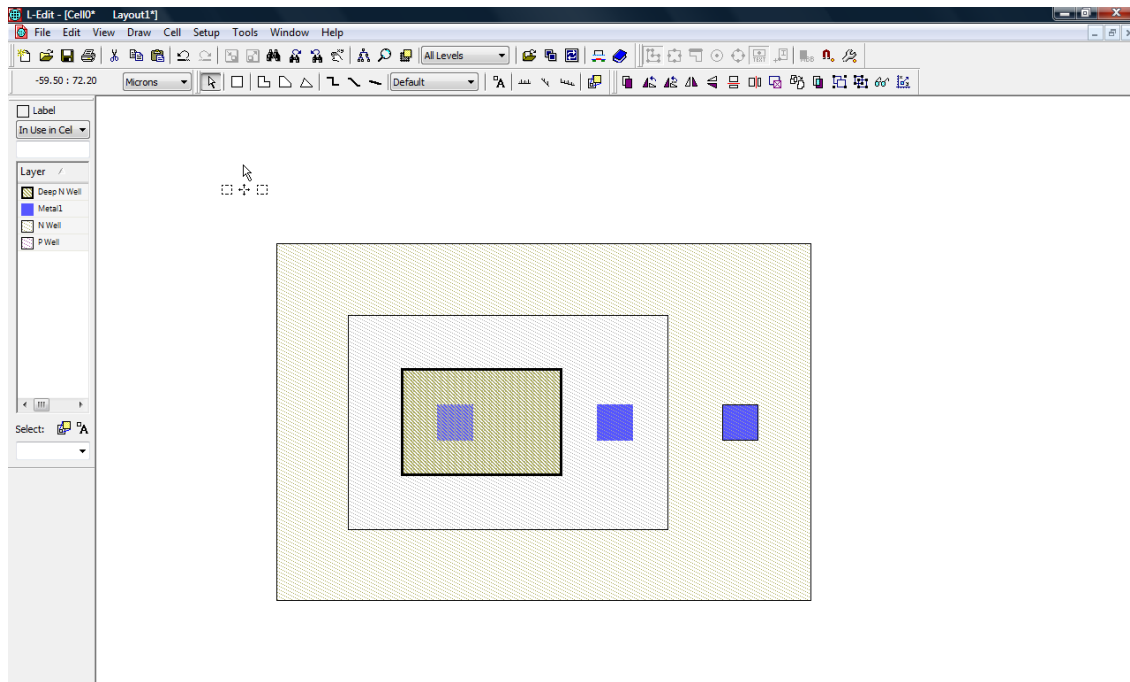


This window allows us to select exactly how the drawing is going to be scaled. This is important in order to prevent your 10 microns feature from ending up a 10 millimeter feature. For all files being sent to KORE, the window above shows the optimal settings. The “technology units” should be set to microns and one internal unit should be equal to a thousandth of a micron. This internal unit shows the smallest amount of resolution in which the software can operate.

The next setting to examine is going to be the design layers. This step begins with establishing how many masks are going to be needed. For example, if we wanted to make a simple BJT we would need three separate regions: An n+, a p, and an n++ region. Since each region will require its own photomask we will need to establish three different layers for our BJT. However, also keep in mind that we should have an additional mask used for creating contacts to these regions. Because of this we will need four masks for this example.

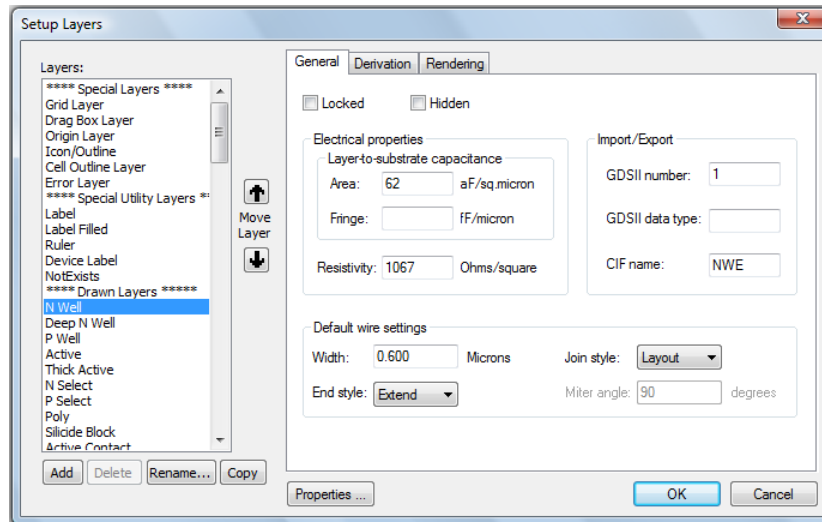


The layout palate can be seen on the left side of the screen in the window shown above. In this window, the uppermost field shows the currently selected layer (in this case “N Well”). The drop down box allows you to select which of all of the available layers are shown. By default it will display all of the potential layers, but you can also change this box to only show layers that are used in the current file which can be useful in quickly selected layers you have already written with. Finally, the list displays the available layers and clicking on any will replace the currently selected layer. For our example we are using four different layers: “N well”, “P well”, “Deep N well”, and “Metal1”:



In the example above we have created a simple representation of a BJT. We have also changed the drop-down box in the layers palate to show “In use in Cell”. The layers palate will now only show the units we have already used in this window and can make it easier to modify. Before finishing with the layers, however, it is important to be sure that each of the layers is properly defined. Most KORE

masks should be made in GDSII format, so it is important that we adjust the settings to our layers so that they can be properly exported into that format. This is done by double clicking on each of the layers that are being used to bring up a window that looks like this:

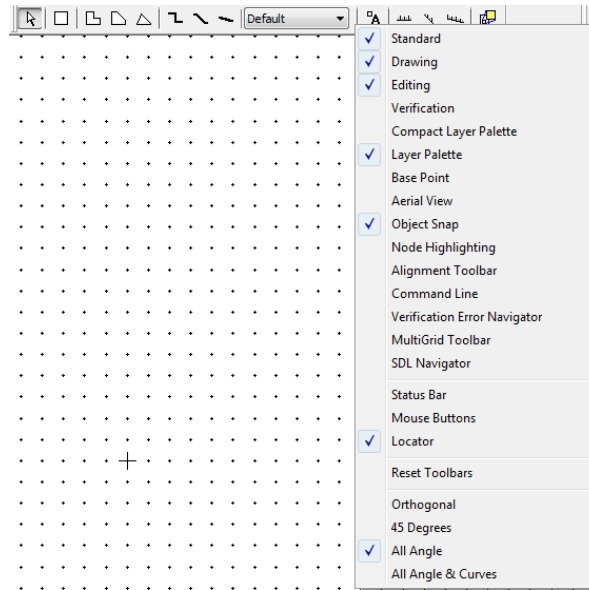


When exporting to a GDSII format, the names of the layers are lost. Instead each layer is defined by the “GDSII number” seen in this window. Therefore it is important to ensure that each layer used has a uniquely defined GDSII number and all mask instructions reference this number. The numerical value itself is not important to the mask, so it can be arbitrarily assigned so that it is uniquely defined from all other layers drawn in the file.

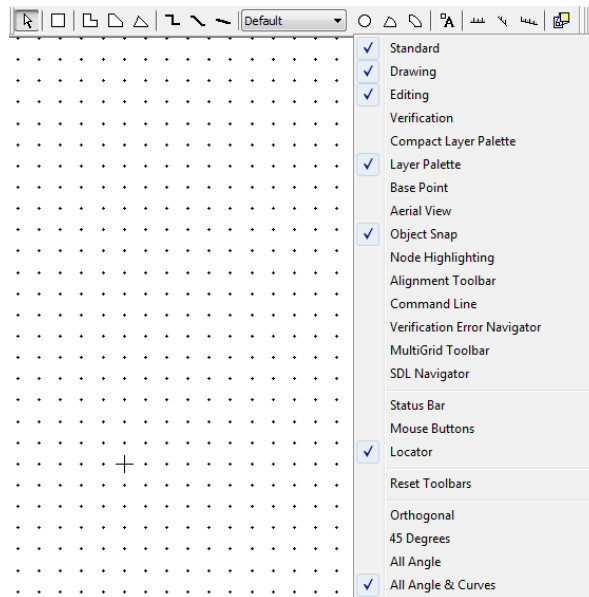
The last setting to check before designing your photomask is to ensure you have the correct toolboxes available. These toolboxes are located at the top of the display and allow you to easily draw complex structures onto your design.



These toolbars can be edited by right-clicking anywhere in the toolbar region. Right-clicking gives you the ability to define which toolbars are shown along with what is displayed within the toolbar that you right-clicked on. In the case of the following image the “drawing” toolbar was right-clicked, giving us the opportunity to define what is being displayed within that toolbar



One of the drawing tools that many people need for MEMS applications is curve tools. By default these tools are not displayed, but by selected “All Angle & Curves” from the drop-down box we can select these tools directly from our toolbar. Try displaying the different toolbars and adjusting their contents to see what is the right display to make designing easier for you.



The last area before we get into designing is to cover navigation, specifically moving across the design and zooming. The easiest way to move across the design is to use the arrow keys. Unfortunately this moves the image by a set percentage of the image, so to make fine adjustments the zoom must also be used. Zooming can be performed using the plus and minus keys

Basic Design

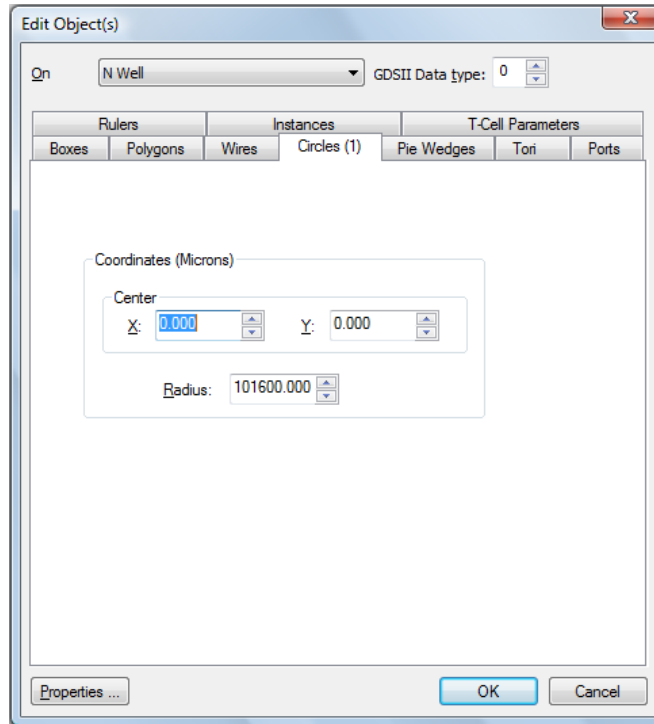
We are now finally prepared to begin designing. There are many different techniques for how to begin a photomask layout, but perhaps one of the most common is to draw a wafer so that you can better visualize where other features will be located. To begin, select a layer that you were not planning on using otherwise. This layer will only be used to assist in drawing and can be later deleted once the rest of the design is finished to satisfaction. The crosshair on the display marks the origin, so we can draw a circle originating from that point to represent our wafer. To begin drawing this circle we select the circle icon in the drawing toolbar that we modified earlier.



Now click and hold the mouse button near the origin and slowly draw it away from the origin. Wherever you let go of the mouse will determine the radius of the circle. The numerical display in the upper left corner will show the coordinates (in microns) of your mouse as you move around – use this to get your circle near the appropriate size. This display shows the distance from your previous mouse click, first the x distance, then the y distance, then the absolute distance



Unfortunately, it can be very difficult to get designs like this to be the exact right size with simply the mouse. For this reason we can use the edit command to exactly size anything we have drawn. So, after you have drawn a circle, hit Ctrl+E. This should bring up an edit screen similar to this:

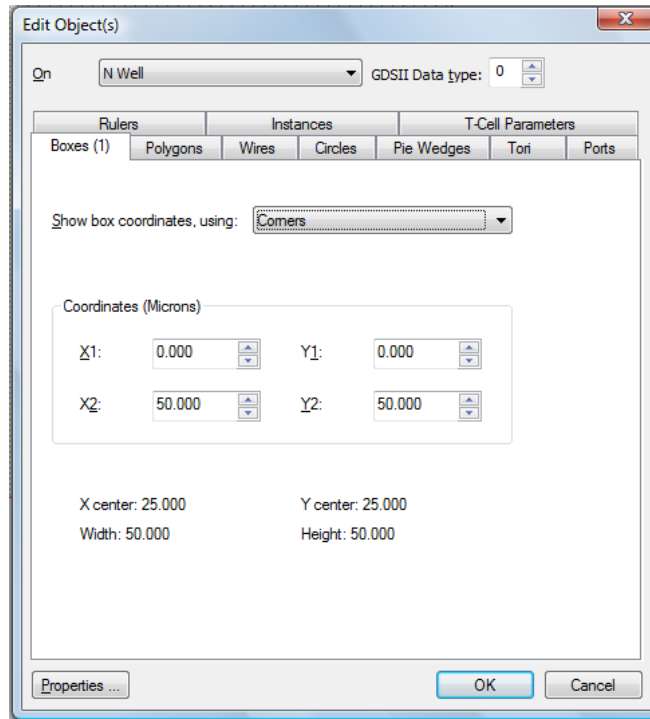


Here we can input the exact size of our desired circle. In our case we want it to start at the origin and have a radius of 101,600 microns, the rough dimensions of a 4" wafer. Therefore we simply input these values into the editor as shown above and it will automatically resize our circle. Also, if you forgot before to define the wafer as an unused layer this can be done here by changing the drop-down box located at the top of the editor. This will remain true for all drawn objects within the editor.

Now that we have our wafer, we can go into the smaller scale to draw individual features. These individual features are going to be drawn much the same way as the circle, but be sure to adjust the layer they are being drawn in. The two other most common tools for design are the rectangle and the line. Select the rectangle icon from the draw toolbox to begin drawing square features.

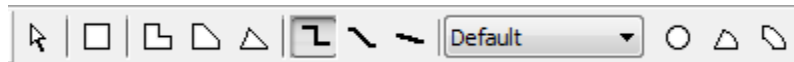


Square features are drawn much the same way by clicking at one corner of the desired rectangle and dragging the mouse to where you want the opposite corner. It is also advisable to edit the figure after it has been drawn to ensure that it is placed exactly where it needs to be and also to be sure that it connects to any necessary structure. There is no negative effect to having two objects of the same layer overlap, the software will simply treat them as a single entity. The edit screen for rectangles can be brought up with Ctrl+E and should look like this:

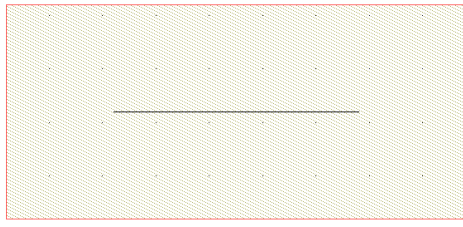


This mode allows you to edit each of the corners of the rectangle individually to ensure the correct alignment. Many other figures are drawn similar to the rectangle, so explore others to see if they can make drawing your design easier.

Drawing lines is slightly different than drawing the circles and rectangles that we have already done. The key difference is that we have to set a line width before we begin drawing. This can be done by selecting where is says default and changing it to other:



This will bring up a window that will allow you to select the width, in microns, for any future lines you draw. Now that we have set the desired line width, we can draw some of your lines. There are three types of lines to choose from: orthogonal, 45 degrees, and any angle lines. Use the simplest method for your application. All lines are drawn by selecting starting and ending points. To draw a single line, left-click at the starting point and then right click at the ending point. To draw a continuous line that turns, left-click at the starting point and left-click at each corner until you reach the ending point where you can right-click. This is a little counter-intuitive and takes some getting used to. The editing tool can be used here also to modify the coordinates of each point in the line. Another important thing to mention is that the line that the computer generates expands in all directions from the line that you draw. An example of this is shown here:

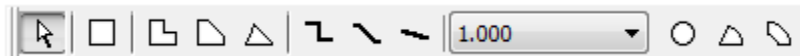


The small black line shows the actual starting and ending points the user selected. However, due to the fact that the line width was set at 1 micron, the computer adds .5 microns to all sides of your drawn line. Keep this in mind when you are trying to line up lines with other objects.

Advanced Design

As you may have noticed if you have been following all of the steps so far, it can take a long time to create an entire wafer's worth of architecture using only the basic commands. This section will help in finding ways to quickly replicate what you have already drawn to fill up your design much faster. The first command that we are going to look at is going to be the duplicate command.

Before we learn the duplicate command, we should learn how to select objects that have already been drawn. This can be done by selecting the mouse pointer in the drawing toolbar shown here:



Using the pointer we can select individual objects that we have already drawn. You can select multiple objects by holding shift while clicking on them with the mouse pointer. Once we have selected the appropriate object we are prepared to use the duplicate command. The duplicate command is in the editing toolbar shown below and only becomes visible when at least one object is selected:

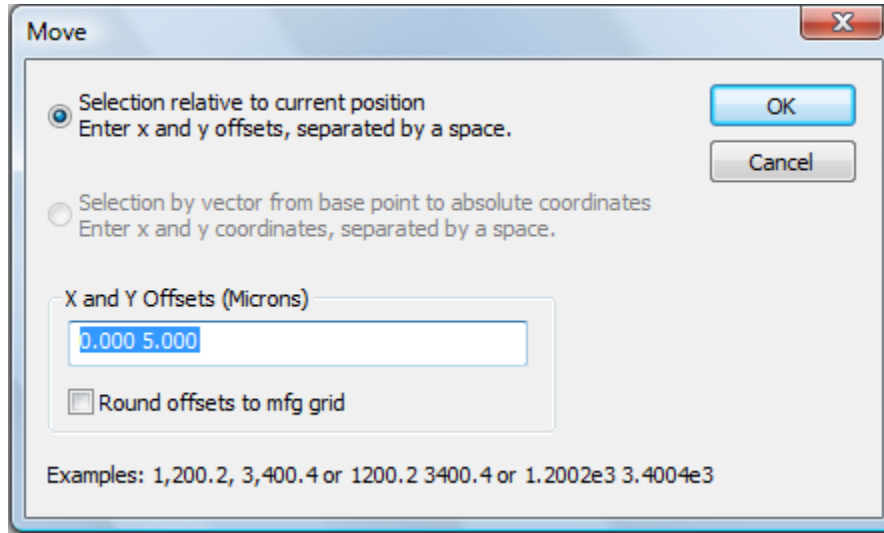


This command will take whatever object is currently highlighted and create an exact duplicate of it in the exact same coordinates. This new object can then be moved, flipped, or rotated using various commands in the editing toolbar. The move command is especially useful because it can be used to create arrays. The move command is in the editing toolbar and is shown here:



The move command allows the user to adjust the location of the currently selected object(s) by an arbitrary amount. The object(s) will retain all of their previous dimensions. Using this command

immediately after the duplicate command allows us to move the newly created object while keeping the original. The window that pops up when Move is selected should look like this:

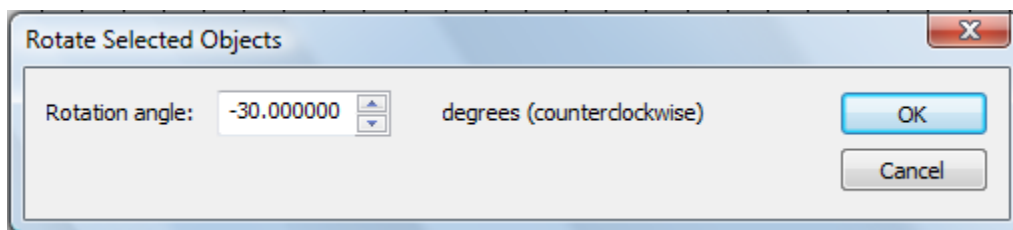


With this window we can input the change in x and the change in y we desire, making sure to separate them with a space. Hit "OK" to immediately move the object. You will notice the moved object will remain highlighted once the process is complete. This is because L-Edit has added a nice feature in that if you press duplicate again it will automatically apply the move command to the newly created object. Therefore the result of rapidly hitting the duplicate command after using the move command will be to quickly create an array of objects.

The other editing command that is worth mentioning is the rotate command. This command is very similar to the move command except that it moves the object rotationally instead of translationally. This command can be found in the editing toolbar as shown here:



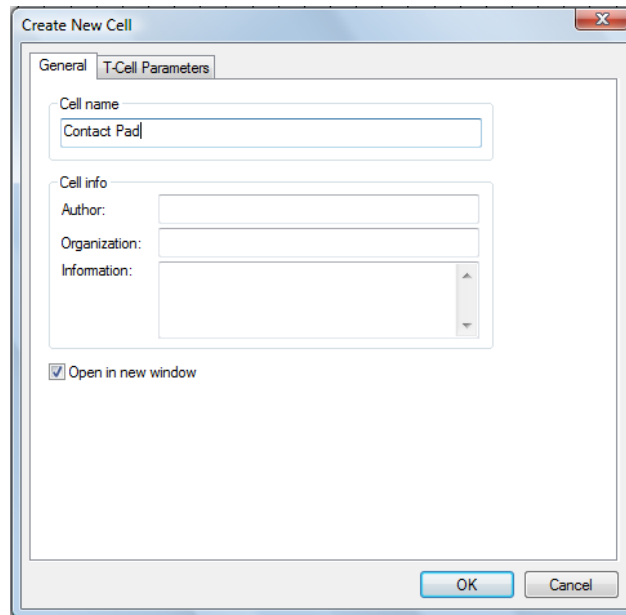
The rotation command can be applied to any selected object and will move that object by any amount specified by the user. When the command is called a window like this will come up:



Simply input the degree change you desire into the rotation angle field. Keep in mind that this rotates your object by its geometric center in a counterclockwise motion. Using this command can be much simpler than trying to create these complex structures using the basic commands. Please explore the other tools in the editing toolbar to help in making other complex designs.

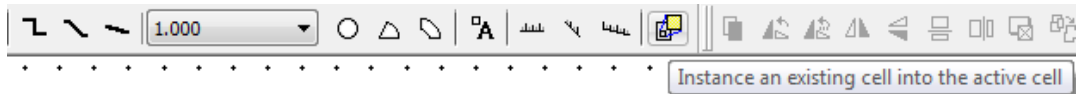
Cells

The other advanced designing area that we will cover will be in using cells. A cell is a feature in L-Edit that allows users to easily save and reuse a drawn architecture over the course of the entire design. This feature can best be visualized as a rubber stamp with a custom face, allow the user to stamp an image as many times as they want. The big advantage of using this format over the move command is that you can modify the original cell and it will carry the change to all subsequent instances of it, allow for relatively simple changes to an otherwise complex design. To begin using different cells, go to Cell -> New to receive this window:



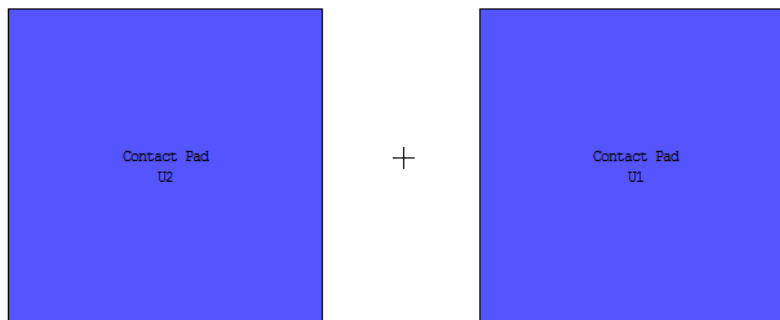
With this window we are defining the name of our new cell. For this example we are going to make test structures to see the resistance of lines of different thicknesses. For this we will be using two contact pads connected with thin lines of varying thicknesses. This will use multiple cells that each contains other cells. In the case of the first cell we are going to make a square contact pad, so we are going to name this cell "Contact Pad". This cell is simply going to contain a square that is 10000 microns wide. If at any point we decide that our contact pads need to be larger/smaller, we can come back and modify this cell and all of the contact pads will be instantly modified. After we have drawn the square in the new cell and saved it, we are ready to create our generic cell.

The generic cell will have our two contact pads separated by a specific distance. Although this cell will not be directly used in the final design, it will make creating all of the subsequent designs easier. Now we are going to create our new cell in the same way as the previous one, but we are going to title it "Generic". So once again we are greeted with a blank design. Now we can add in our contact pad design in two different locations exactly 5000 microns apart, which will be the length of our testing lines. To add in the contact pads, we are going to select the Instance command located at the end of the drawing toolbar as shown here:

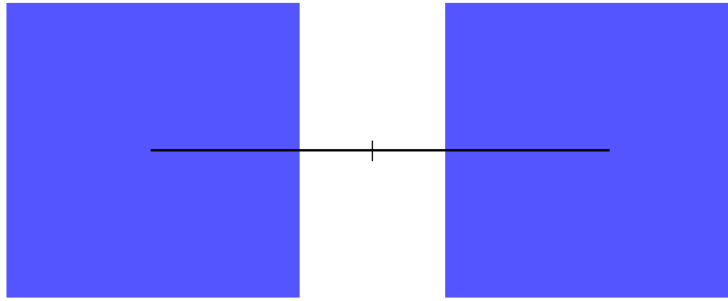


This command will bring up a window like this that will show a list of all current cells:

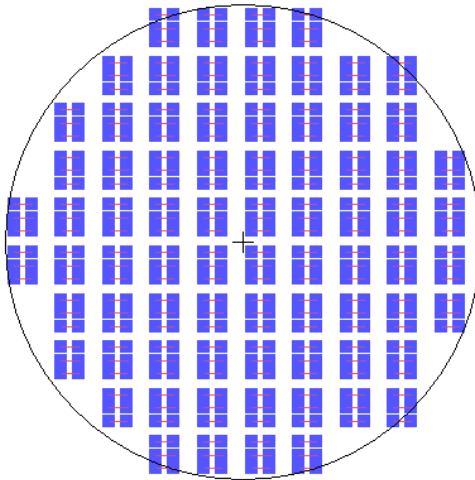
This list should contain three cells: Cell0 – the default name for the main design cell, Generic – This cell should have a red X by it to indicate that we can't instance a cell within itself, and Contact Pads – This cell has our contact pads. Select Contact Pads and hit OK to instance our previous design into this cell. Once you do this you will be given a square container that allows you to move around the Contact pads that we have created earlier. You will notice that the title to this box shares its name with the cell it originated from and that objects inside instanced areas cannot be modified. This is because the cell must be edited in the Contact Pad cell. Now we can make our generic cell by moving this contact pad to an arbitrary spot. This can be done by selecting the mouse tool from the drawing toolbox and clicking both the right and left mouse buttons over the contact pad and dragging it to any location. Once it is set we can use the duplicate and move commands like before to create another contact pad exactly 5000um away. Once finished with this we can save this cell and move on to creating different cells with different types of lines to test.



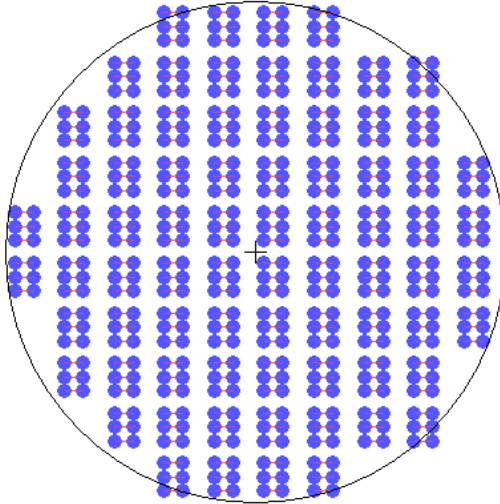
For this example we are going to create three different types of lines: one 5um wide, one 10um wide, and one 50um wide. Therefore we are going to be creating three new cells, the first of which we will title "5um test line". Once you have created this new cell, we are going to want to instance our Generic cell into this one using the same process as before. Now we can draw the line connecting our two contact pads. Select the draw line tool and choose a line width of 5um. Left click on where you want the line on one contact pad and right click on the same spot on the other. When finished you can save this cell and repeat the process for the other cells.



Now that we have all of the lower level cells completed, we can create our design cell. Go to Cell -> Open and select "Cell 0", which will contain our final design. Once here we can do several things to help us in the design, such as creating the circle in an unused layer which will represent our wafer. This is especially useful when using cells because most of the work now will be in placement of the individual cells. From here simply use a combination of the instance, duplicate, and move commands to create an array of cells that will completely fill your chosen wafer. In the end you should have a design that looks something like this:



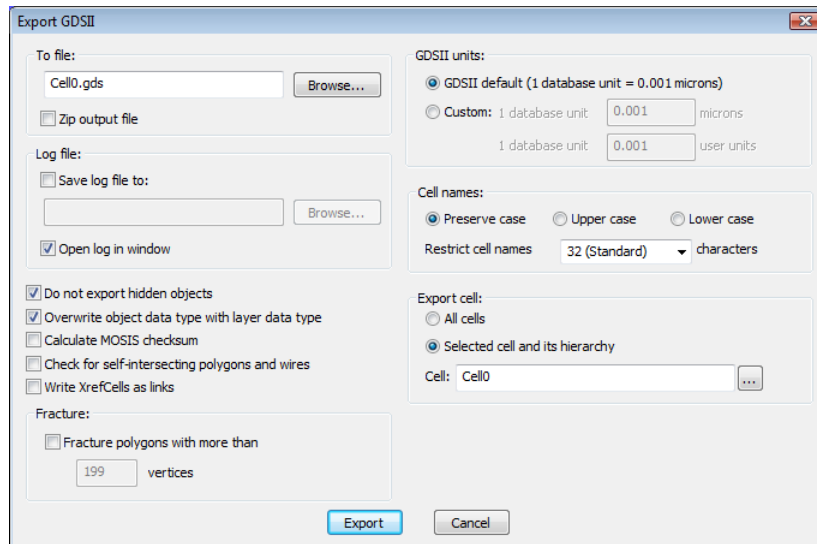
The real advantage with using cells is the ability to change the minutiae of a complex design without having to practically start over. Say for our example we for some reason wanted circular contact pads instead of square ones. If we had created this design in one cell, we would have roughly 1000 different contact pads to delete and redraw, but when using cells like we did we only have to change one. To make this change we begin by simply opening up the relevant cell by going to Cell -> Open and selecting "Contact Pads". Here we can draw a circle of the same size and delete the square. Once we save this cell, the change will propagate throughout the entire design.



There is one last important thing to remember when using cells, and that is that you must flatten your design before exporting it. Flattening is a process where the software permanently draws the contents of a cell onto the design. You can do this by selecting Cell -> Flatten. After flattening a design it will change as though everything has been drawn in that single cell instead of being comprised of other cells. Flattening is important because the exporting software will not properly read the design if it is not done. Be cautious with Flattening, however, because you will no longer be able to make changes in other cells and have the effect carry over onto your main design. It is for this reason that we recommend that the user does not flatten their cell until they are ready to export. It is also recommended to keep a saved file from before flattening in case changes need to be made in the future.

Exporting

This last section will cover what needs to be done to export the design so that it can be processed by Kentucky NanoNET's KORE facility. The exporting process itself is very simple, just select File -> Export Mask Data -> GDSII. You will be greeted with a pop-up window where you should select these settings (make sure you select your main design cell where it asks for your export cell):



Before you use this export command, it is important that you perform one last check to ensure that your file is completely ready for exporting. The two important things to remember are making sure that you have GDS labels for all your used layers and flattening your design cell. Labeling your layers was discussed in the “Getting Started” section of this guide and flattening cells was discussed at the end of the “Cells” section. Please review these sections before exporting if you have not already addressed these issues.

Conclusion

This tutorial should have provided beginning users with enough background to complete simple designs. If you wish to learn more about L-Edit, please reference the user’s guide and the examples that L-Edit provides in their software by accessing them through the help menu. Also feel free to explore with the software yourself to become more familiar with the different commands. Good luck and Happy Designing!