Pix2Net Documentation

Release 1.10.07

MicroNet Solutions Inc

Apr 16, 2018

CONTENTS

CHAPTER

ONE

GETTING STARTED

1.1 System Requirements

Operating System	Windows (7 or newer)
Architecture	64-bit (32-bit no longer supported)
Processor	Intel Core 2 Duo 2.00 GHz (or equivalent)
RAM	8GB
Hard Drive Space	300 MB (not including projects)
Graphics Card	OpenGL 3.0 - compatible
Java Runtime	1.8

Note: Pix2Net is an graphics-intensive program that is meant to be run locally. If you attempt to use it with remote display software, such as NoMachine NX, Pix2Net is not guaranteed to be responsive (or even work).

1.1.1 Windows

Run the `Windows` installer. If this is the first time you are installing Pix2Net, make sure the `Visual Studio 2010 redistributable`, `Java Runtime Environment 8`, and the `Sentinel HASP Run-time` packages are selected for installation.

After the installation, insert the security dongle into your computer. Launch Pix2Net by double-clicking the Pix2Net shortcut on the desktop, or by going to Start → All Programs → Pix2Net → Pix2Net.

Troubleshooting

If you experience rendering issues while using Pix2Net (i.e. you see white squares where images are supposed to be), try updating the drivers for your graphics card. To find out what driver you are currently using, open the Start menu, type in `dxdiag` and hit Enter. Click `Display 1`, look at the `Drivers` group on the right, and note the `Version` field. Then go to the appropriate website for your graphics card and make sure that you are using the latest version of the driver:

- AMD/ATI
- Intel
- NVidia
- S3 Graphics

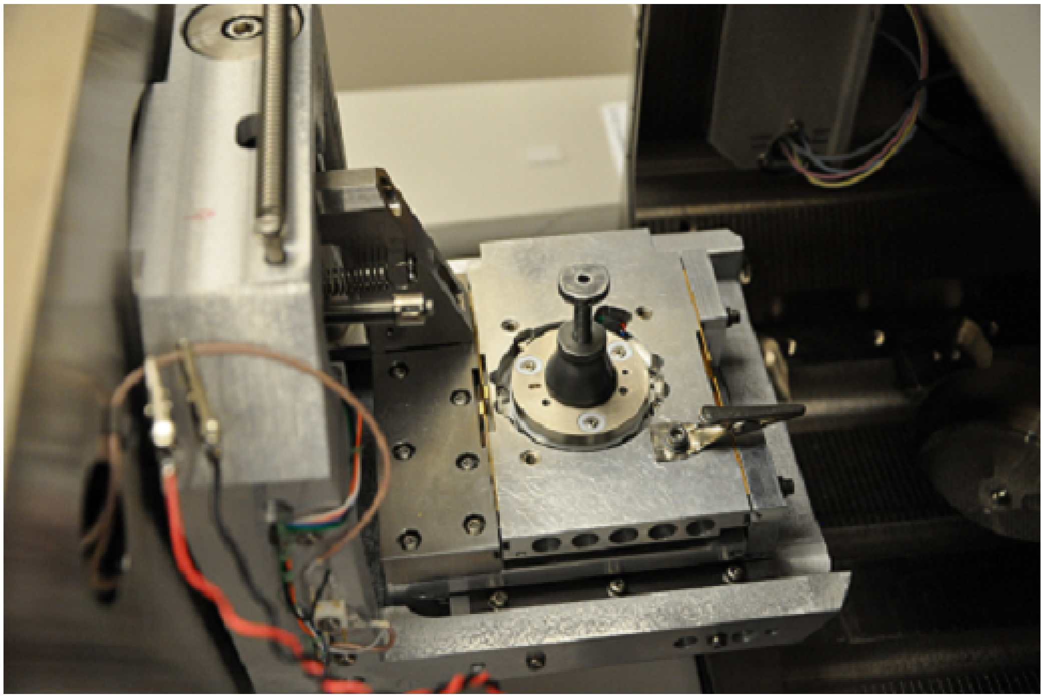
CHAPTER TWO

GUIDED TOUR

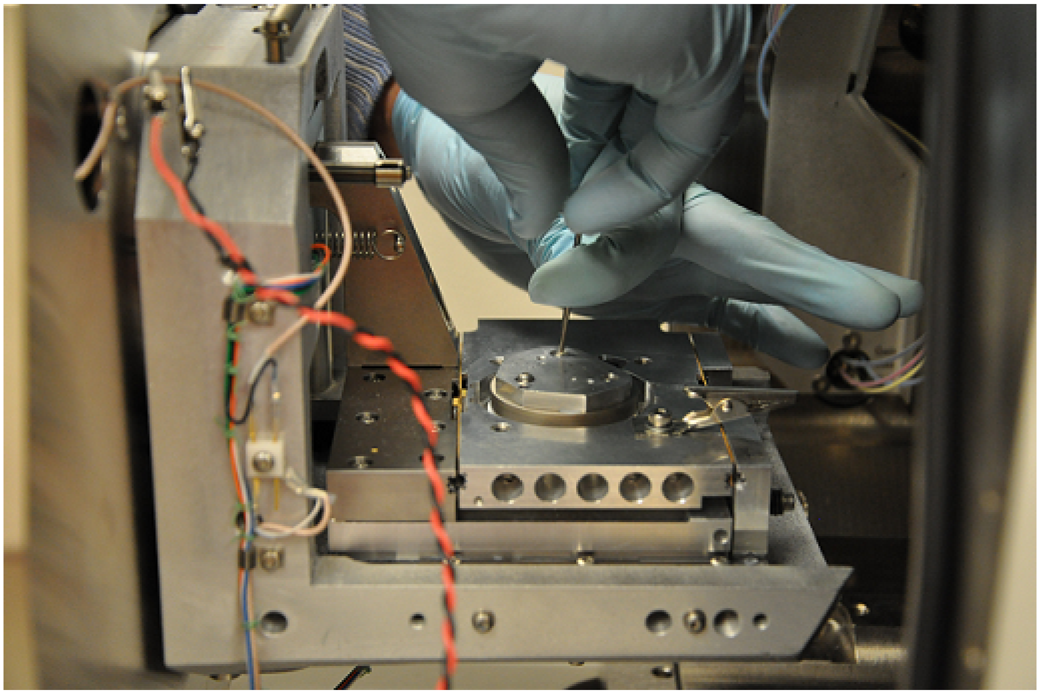
2.1 Pix2Net Stage Installation

Before installation of the stage you'll need to HOME the FIB/SEM stage. The HOME button can be found in the stage tab of the FIB/SEM (HOME w/rotation).

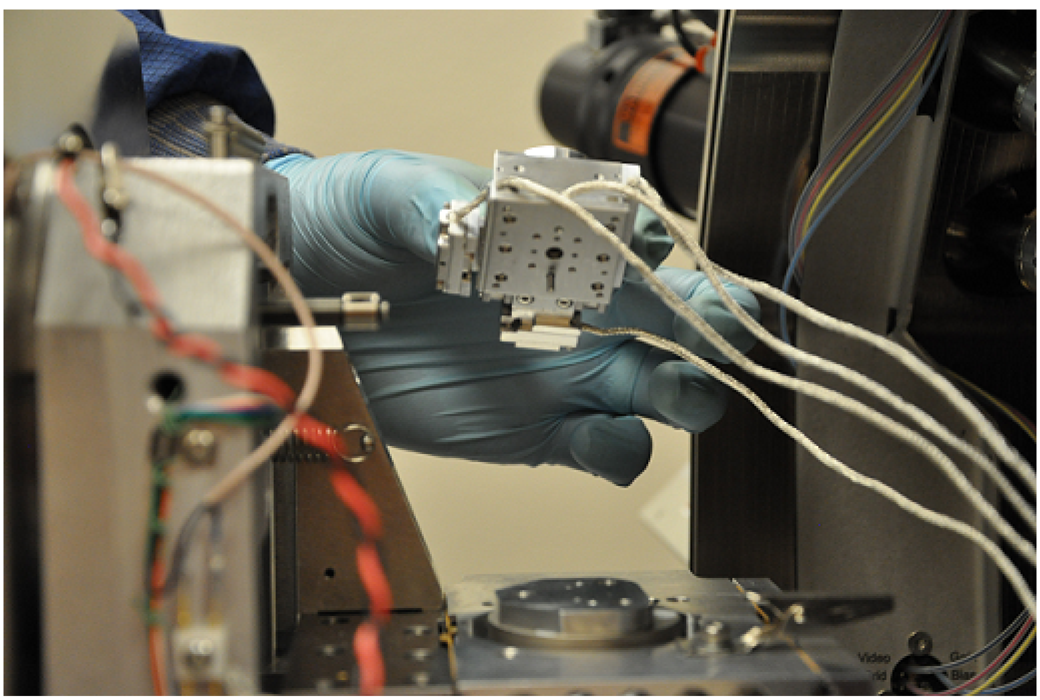
1. After venting the FIB/SEM chamber, begin by removing the stage mount from the base of the FIB/SEM stage. Safely store the stage mount

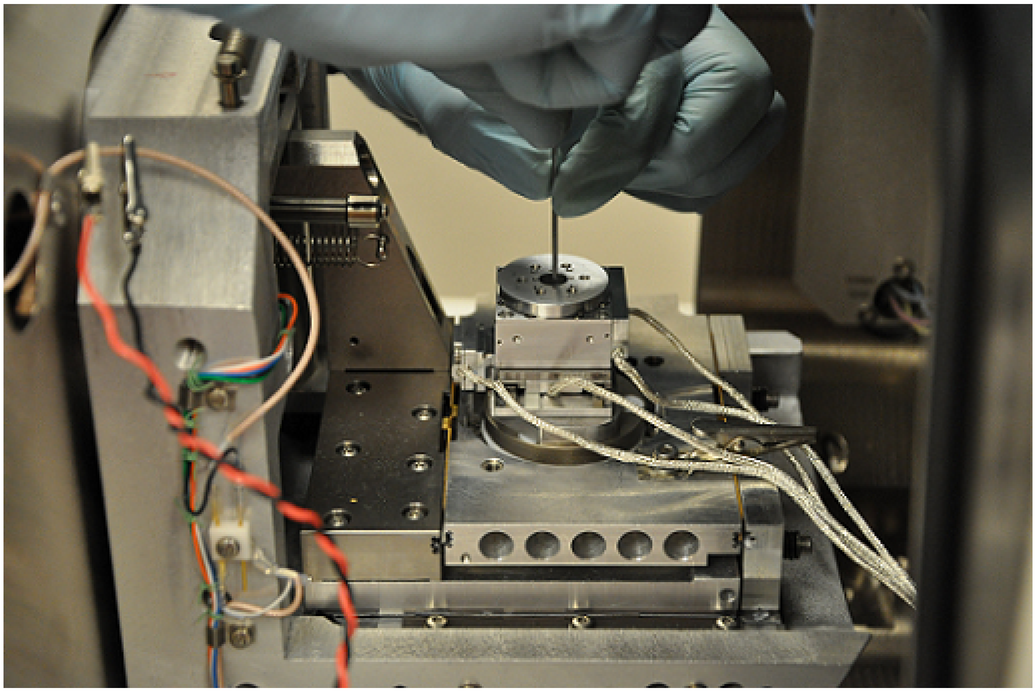


2. Attach the stage base plate to the FIB/SEM stage base using the three (3) hex bolts provided. You'll need to manually rotate the FIB/SEM stage so that red arrow on the base plate is pointing at FIB/SEM chamber entrance.

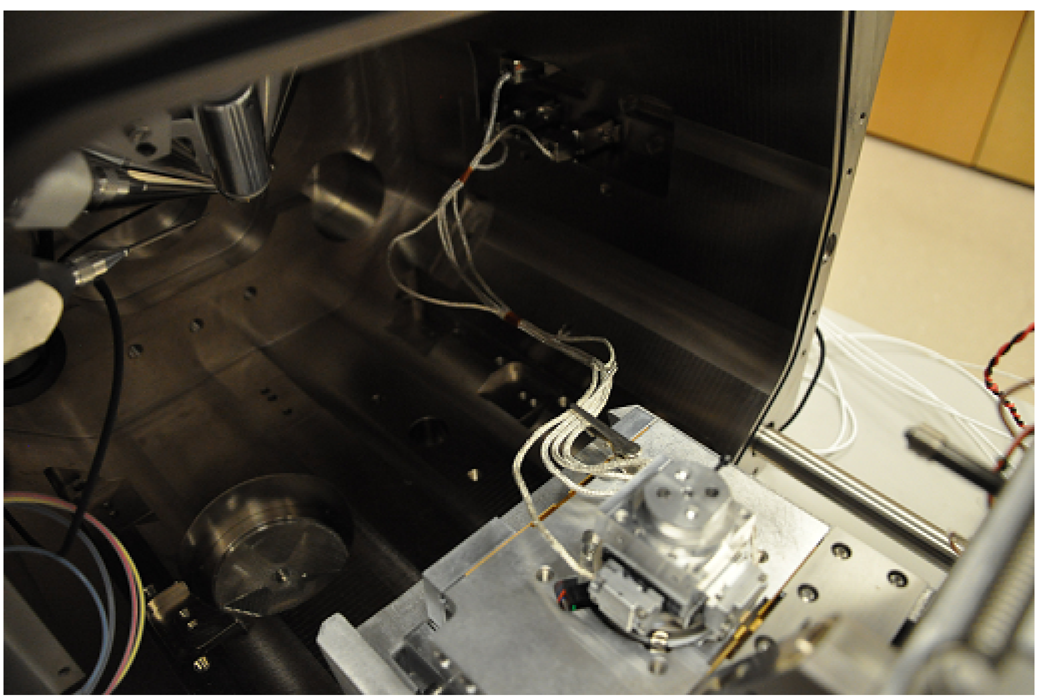


3. Attach the stage to the recently installed base plate using the M2 bolts provided. There are two (2) bolts to attach. Slide the stage left and drop in an M2 bolt to attach to base plate. Do not tighten fully as you will need to slide stage to the right and will have to adjust the stage to drop in the 2nd M2 bolt. NOTE: as long as the stage is powered off it is okay to manipulate it manually to get in the correct positions for the install.

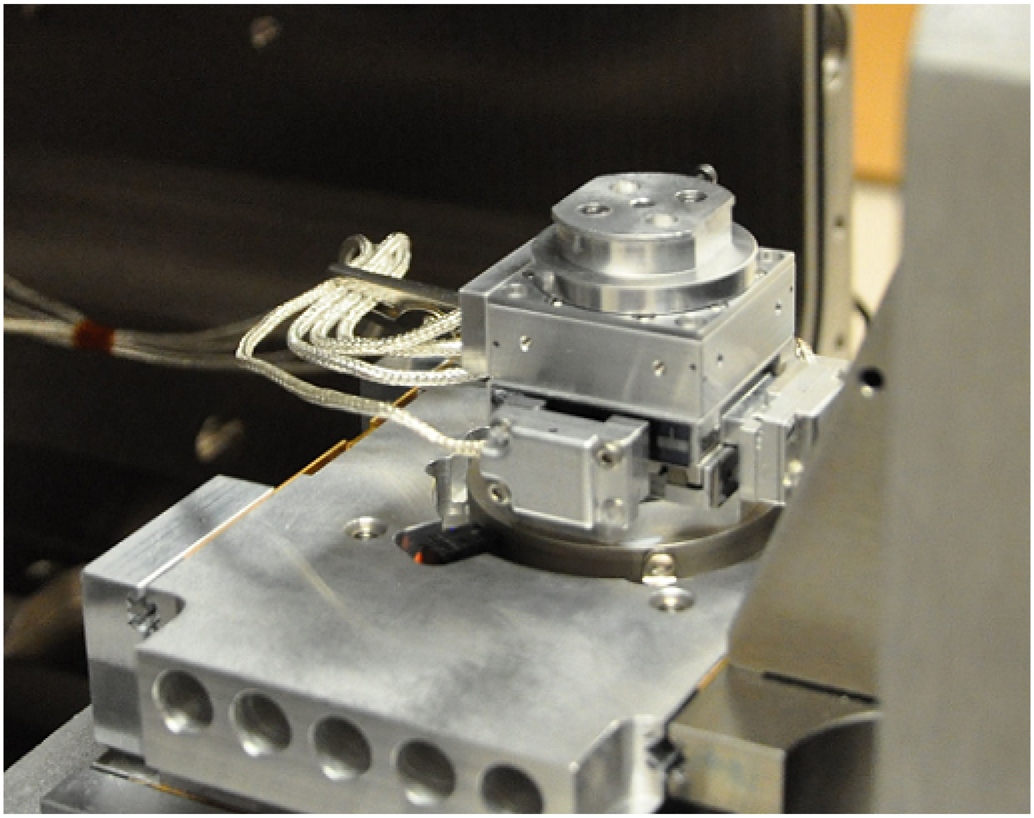




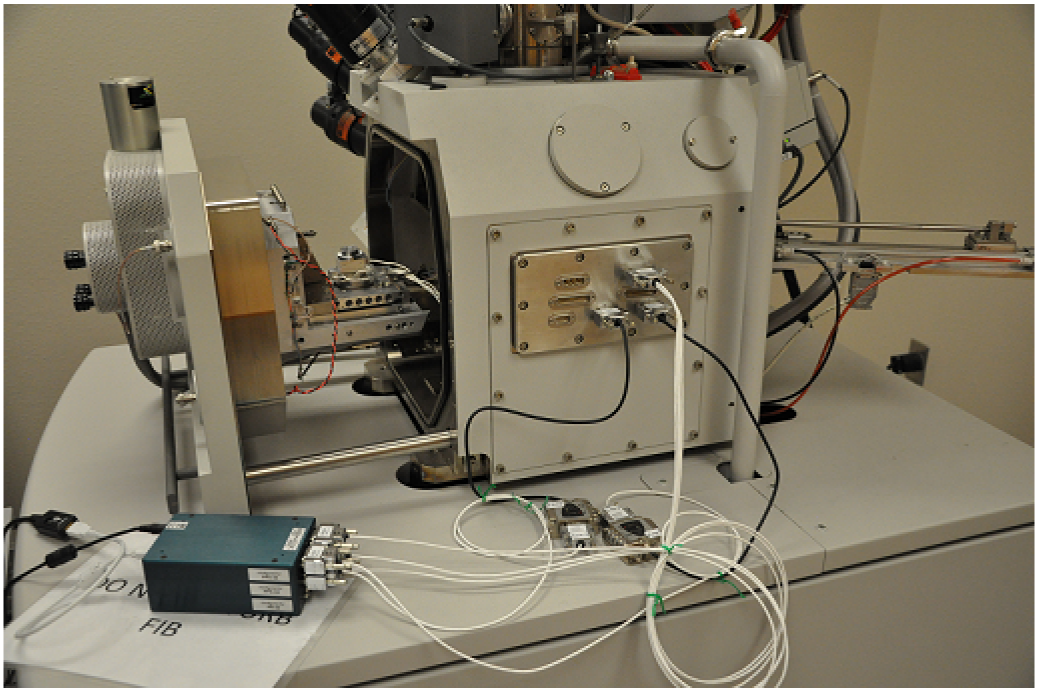
4. Attach the wire stress relief clip to the FIB/SEM stage. Set the stage wires to an appropriate length.
5. All stage wires should be attached to the FIB/SEM internally already but you should verify this before proceeding. Motor 1 connects to Axis 1 (X): Motor 2 connects to Axis 2 (Y): Motor 3 connects to Axis 2 (Rotation) of the green stage controller box. NOTE: we generally leave all wire connections intact and just store the stage itself in the back of the FIB/SEM chamber when not being used.

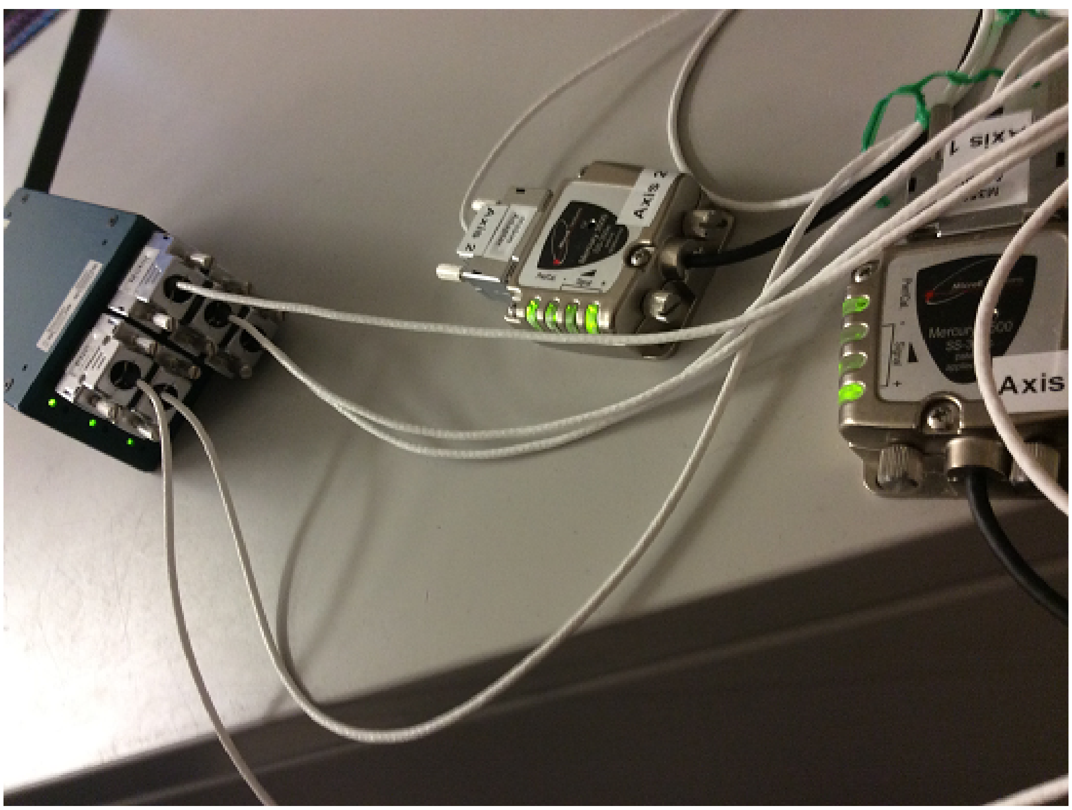


6. Attach the extension stage mount (new extension) onto the rotation stage.



7. Attach and center your sample stage onto the new extension stage and then tighten your set screw to secure your sample.
8. You may now connect the USB wire from the support computer and the power supply to the green controller box. You will notice the lights on the back of the green controller box are red when first powered on. If your connections are correct these lights will convert to green indicating that your setup is correct. If any lights remain red, check your wire connections and retry until all lights are green.

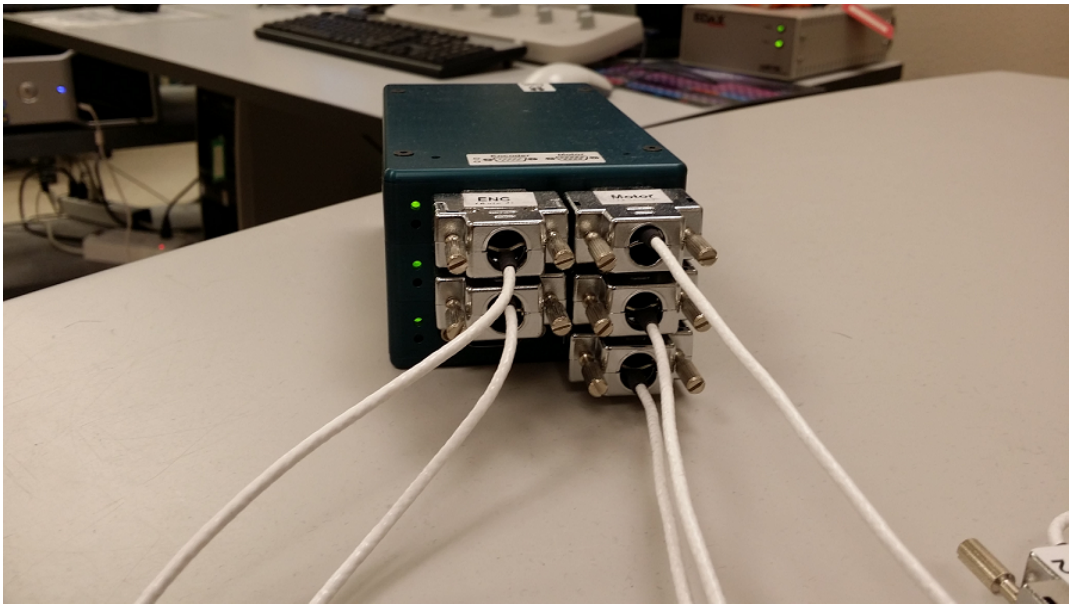




9. Before sealing the FIB/SEM chamber, check and make sure your sample is grounded properly using a multi-meter (continuity).
10. Seal the FIB/SEM chamber and begin image acquisition. NOTE: make sure all wires are clear when sealing FIB/SEM chamber.

2.2 Pix2Net Automation Operation

1. Be sure to check that there is enough space to store the project you will be working on. On the support CPU (cart) you will want to check the C: drive. Before proceeding make sure the Pix2Net Stage Installation instructions are read *Pix2Net Stage Installation* and performed correctly. All light indicators on the controller box should be green.



2. Disconnect the long white network cable from the FEI support CPU and connect it to the bottom most port on the MSI support CPU (cart). This will allow the SEM and support CPU (cart) to communicate through the Z: drive. If the Z: drive is not active you will need to run a batch file to make it active. Located on the desktop of the support CPU (cart) Z Drive.bat.
3. Open the Pix2Net software by clicking the icon on the desktop Pix2Net.bat. Create a new project or open a recent project.
4. Click on the Capture tab and you will notice the header changes. Now click the stage icon and a drop menu selection appears. (All settings for the SEM)

   Type: Pix2Net/ w rotation

   Axis Swap: Place a check mark in box

   Port: Com 7

   Cycle Power on Error: Place a check mark in box

   Sense: Invert Y

   Home on Connect: Place a check mark in box

5. After your parameters have been set connect the stage. It should begin a Homing procedure of the Pix2Net stage that will take about a minute to complete.
6. Once the Homing procedure is complete, verify the stage moves as intended.
7. Begin the leveling and rotation of your sample. Using a sample feature such as a metal line that runs the entire width of the sample is the best method. Start by using the XT align feature of the SEM to give you a straight image in the SEM. It is located in the Stage tab of the SEM. Place the line or feature your using to level under the center crosshair of the SEM. Using the Pix2Net stage move the sample in the X axis along the line you are using to level. Generally use small movements(50um) to start and gradually move farther in the X axis as

the sample becomes more level. Determine which direction the rotation needs to move in order to correct the leveling(Clockwise or Counterclockwise). In adjusting the rotation of your sample the SEM image will need rotation of the SEM to make the sample straight again. Repeat the XT align feature as needed.

8. Once a good alignment has been achieved, begin gathering the information required to get an entire imaging run captured. All information can be stored and saved in the Capture config. window under the Capture tab. Record the device name, device height, device width, magnification, accelerating voltage, brightness, contrast and the scale.
9. To determine the scale of an imaging run, zoom to the magnification level you intend use and set the scan level at 2us and freeze the image. Click on the file tab of the SEM and enter the image properties. Record the values given under Pixel height and Pixel width and divide by 1000. Example: Mag/2000 – Pixel height / 72.85nm – (1000/72.85= 13.726 pixels per micron) place this value in the scale window under the Capture Config tab of the Pix2Net software.
10. The first Quad (upper left) of the imaging windows on the SEM is the image capture window. Most imaging runs are shot under the backscatter detector (VCD) of the FIB. Set the first quad to the appropriate detector (VCD or ETD). Begin adjusting contrast and brightness levels for the intended imaging run. Lines and Vias are usually set as white as possible against a black back-round.
11. Begin connecting the SEM camera to the Pix2Net software. Minimize the SEM UI (user interface) and connect to the Shortcut to Run Pix2Net Server.bat located on the SEM desktop. Large cmd window should open.
12. Once you have opened the server you may connect the SEM camera to the Pix2Net software. Begin by clicking on the camera tab and a drop down menu appears. Select the camera you intend to use (microscope). Pix2Net expects the SEM to be in a paused state prior to image acquisition.
13. Once connected the SEM camera will take a test image and then should be ready. The camera icon will let you know when it is ready. Click on the camera ready tab to execute an image capture.
14. Make final adjustments needed for your imaging run. Verify your images will convert to GDS2 if required. Make sure sample is within area you designated for the imaging run (check corners). Good idea to double check that all values entered onto the capture config window are correct before any imaging run is started.
15. Click the Start tab to begin your run. Once the run has begun do not move the mouse on the SEM CPU anymore. The Pix2Net software has taken control of the mouse and needs it pause and begin another image capture. Disturbing the mouse will cause the camera to fail.

2.3 Setting Up Pix2Net Server

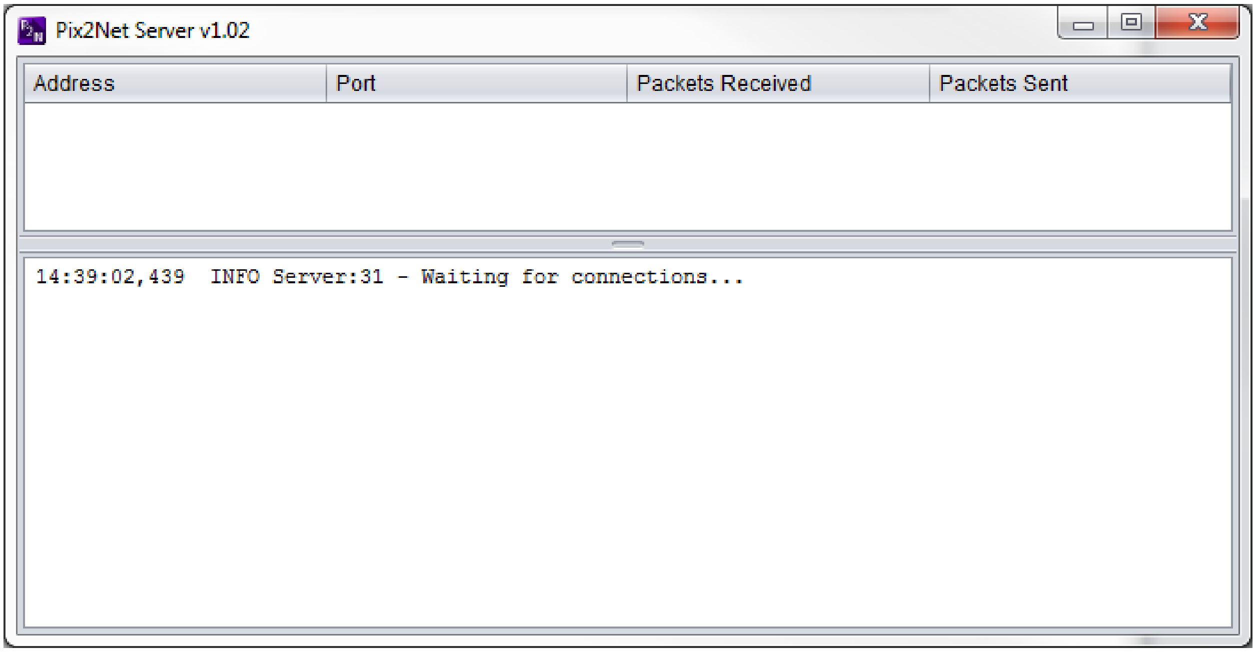
This tutorial will show you how to capture an image from a scanning electron microscope.

2.3.1 Install and Run the Pix2Net Server

Note To use Pix2Net, the user must have Java installed.

In order for Pix2Net to control the SEM, the Pix2Net Server application must be running on your SEM's support computer.

The Pix2Net server files are located in `C:\Program Files\Pix2Net\server`. Copy these files to a directory on the SEM's support machine, and then double-click `RunPix2NetServer.bat`. The Pix2Net Server application should start up.



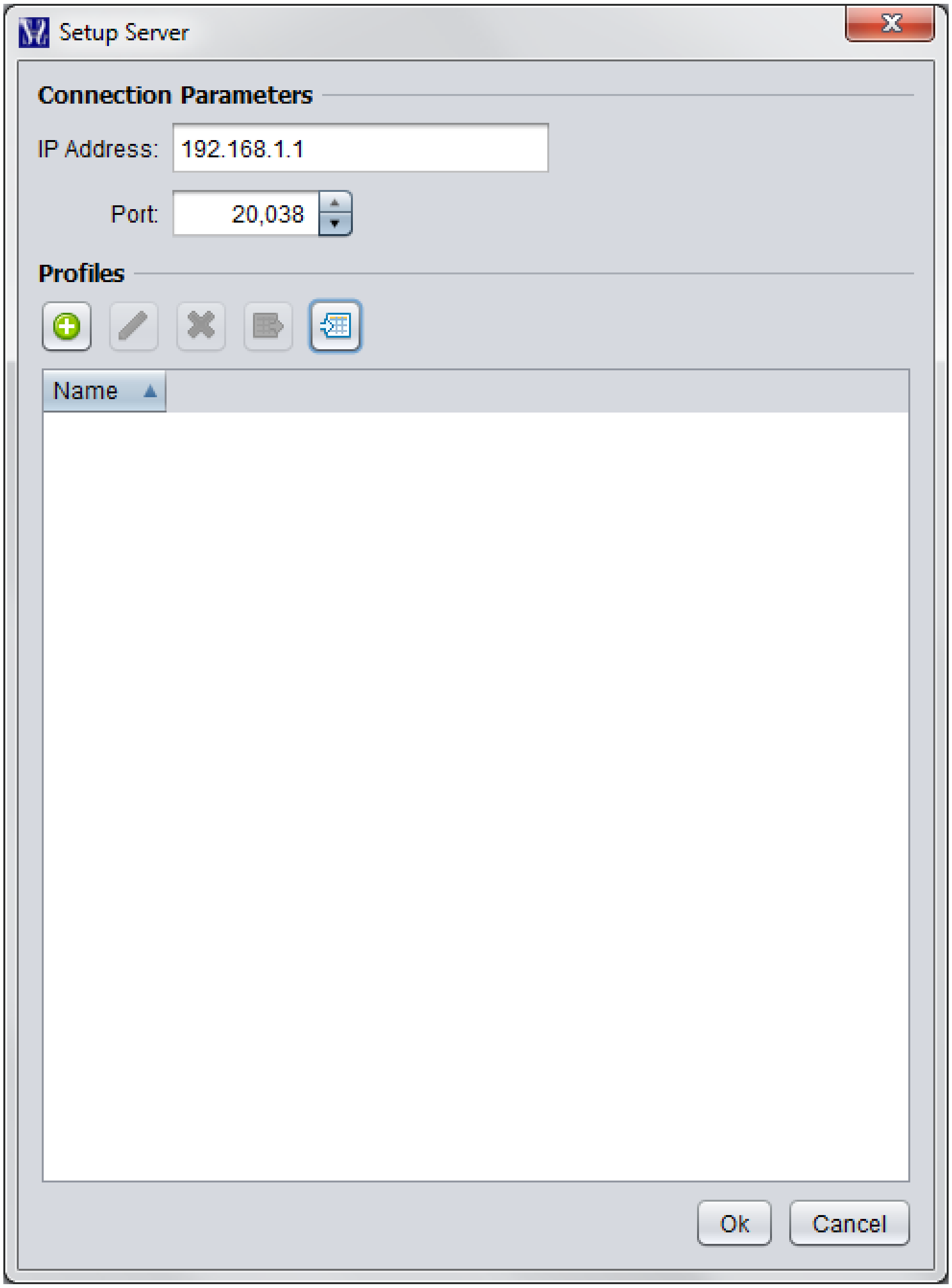
The Pix2Net Server is now waiting for Pix2Net to connect to it on port 20038. You should also note the IP address of the SEM's support computer. You can obtain the IP address by typing `ipconfig` in a dos prompt.

2.3.2 Connect to the Pix2Net Server

1. Start Pix2Net and go to the `Capture` tab. Press the `Setup Server` button.

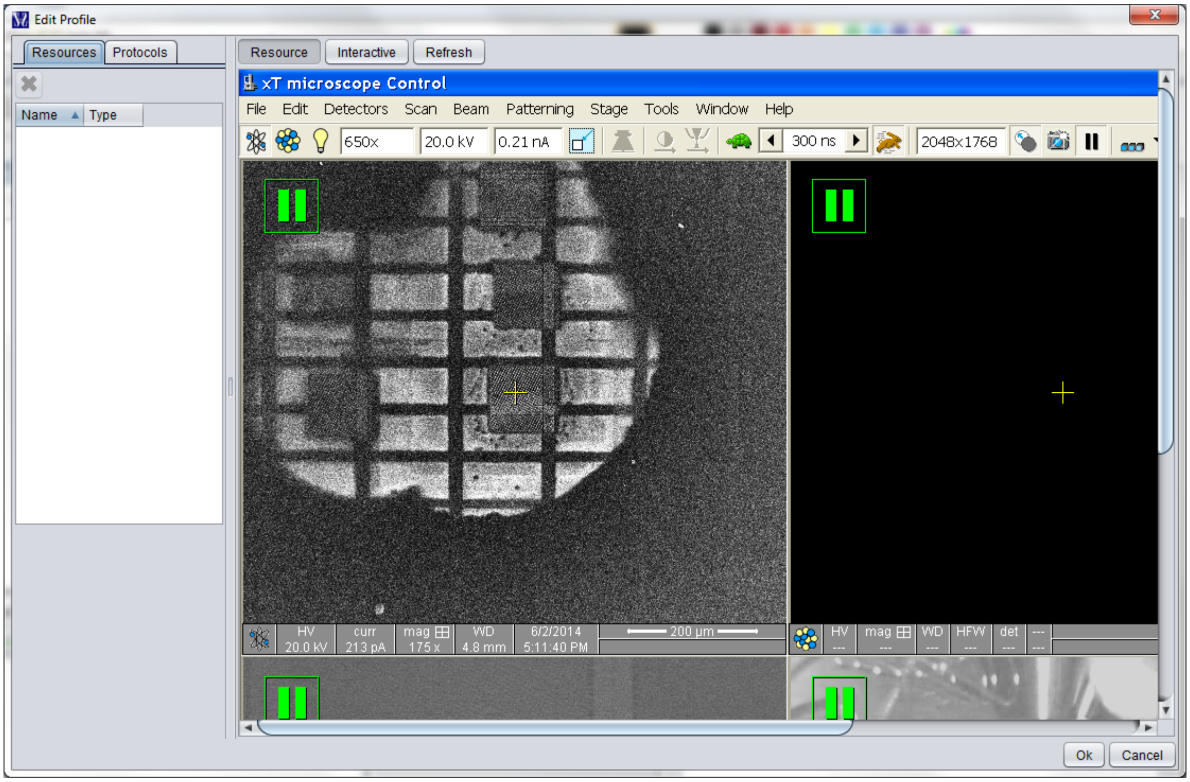
   

   The Setup Server dialog should appear:



2. Make sure the `IP Address` field matches the IP address of the machine the Pix2Net Server is running on.
3. Click the `Add Profile` button to add a new profile. Enter the name of your SEM (e.g. FIB).

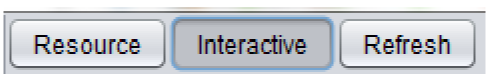
   If Pix2Net was able to connect to the server, then the `Edit Profile` window will appear, with a snapshot of the SEM support computer's desktop:



To get back to the ''Edit Profile'' window, press on the pencil button in the ''Setup Server'' window.

2.3.3 Preparing the SEM

You need to begin by putting the SEM in a state where you can capture a test image. For example, you may want to turn the beam on. You can do this from the Edit Profile window if you switch to interactive mode by pressing the `Interactive` button.



In interactive mode, whenever you click somewhere on the image of the support computer, that mouse click will be sent to the support computer, and the screen will be refreshed. It is similar to a Remote Desktop session, except the screen will only be refreshed once after each mouse press.

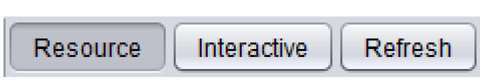
Once you are ready to capture an image, you can start entering the necessary steps into Pix2Net.

2.3.4 Entering Steps

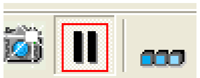
Your SEM is most likely different from ours, so you will need to come up with your own set of steps. However, for the purposes of the following example, assume that you can capture an image with your SEM by pressing a Resume button.

You must tell Pix2Net what the Resume button looks like, and where it is. You can accomplish this by adding a resource.

1. Switch to the resource mode by pressing the `Resource` button.



2. Draw a box around the Resume button by clicking and dragging. The box does not have to be perfect.

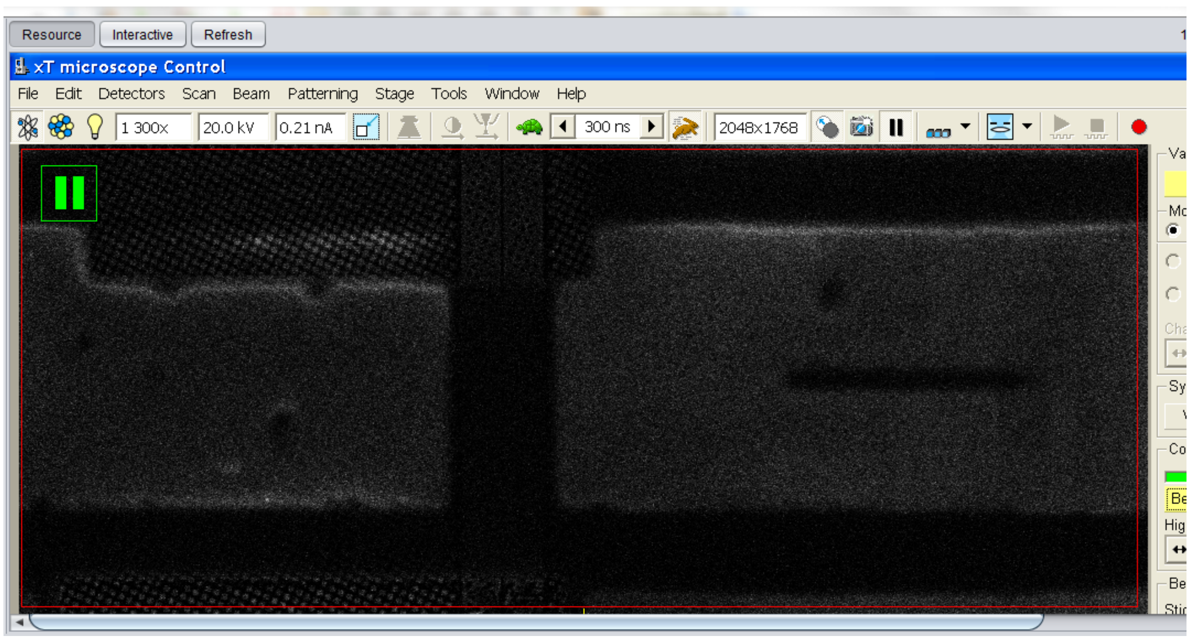


3. Enter a name, such as `Resume Button`, set the type to `Fixed Image`, and click `Add`.

By specifying `Fixed Image`, we are telling Pix2Net that it can assume that resume button will always be at exactly the same place on the screen. If it is not safe for Pix2Net to make that assumption, then we could have specified `Floating Image`. In that case, Pix2Net would scan the screen for the first set of pixels that match the image of the resume button.

Another resource we will add at this time is a region that represents the `Preview` area. This is the area of the SEM's GUI that shows a preview of the area that will be captured.

1. Click and drag to draw a bounding box around the area of the GUI that shows a preview of the image to be captured.



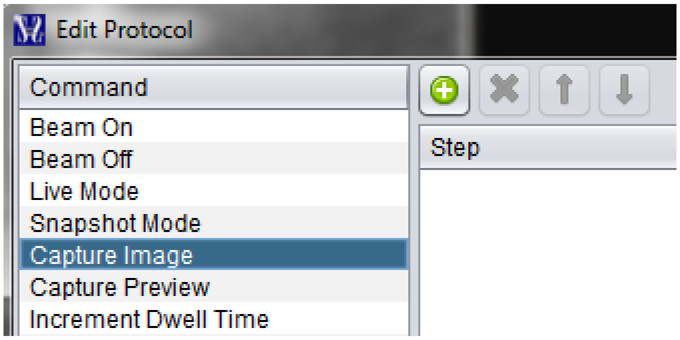
2. Enter a name, such as `Preview`, set the type to `Region`, and click `Add`.

By specifying `Region`, we are telling Pix2Net that this resource is purely a bounding box and not an image.

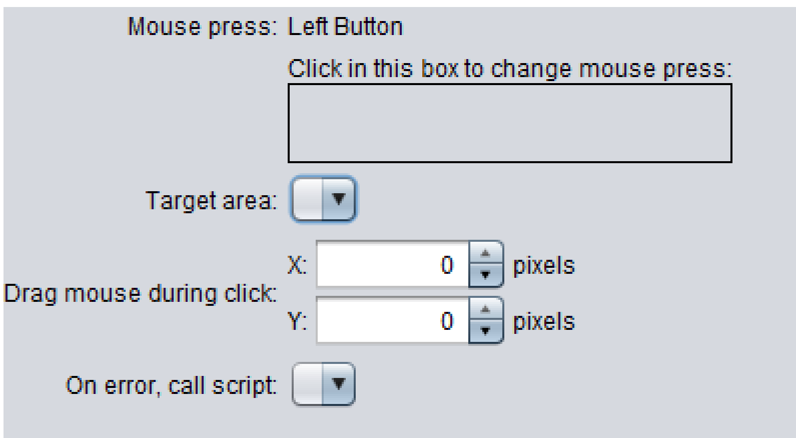
Now, let's start creating the protocol (a set of mapping of commands to what actually happens on screen):

1. Click on the Protocols tab and then click the `Add` button.

2. Choose a name for the protocol, such as `Standard`, and click Ok. In general, you will only need one protocol.
3. You will now see a list of commands that can be defined. Select `Capture Image`.



4. Click the `New Step` button, choose `Press Mouse Button`, and click `Ok`.
5. In the settings for `Press Mouse Button`, set the target area to the resource you defined for the resume button.



6. Click the `New Step` button, choose `Delay`, and choose some amount of time for Pix2Net to wait for the image to be captured.
7. Click the `New Step` button, choose `Read Image`, and enter the directory the image will be saved to. Pix2Net will grab the latest .bmp file from this directory. The image will be deleted after reading by default, so that Pix2Net does not accidentally read the same image again in a future image capture.
8. Select the `Capture Preview` command.
9. Click the `New Step` button, choose `Grab screenshot`, and set the region to the resource you created for the preview area. Ignore the Remove horizontal line checkbox, because that is a very specialized feature.
10. Add steps for each script that is desired.
11. Click `Ok` to close the Edit Protocol window.
12. Click `Ok` to close the Edit Profile window
13. Click `Ok` to close the Setup Server window

2.3.5 Testing the Capture

1. In the `Capture` tab, click the `Control Microscope` button.

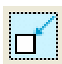
2. Click the `Capture Image` button.

The image should be successfully captured. If you receive an error message, you may need to go back and edit the steps in the Edit Profile window.

2.3.6 Setting up Auto-Focus

Here are the steps for setting Pix2Net up to automatically adjust the focus during a run:

1. In the `Edit Profile` screen, in `Resource` mode, draw a box around the button that turns on reduced area.

   Give it a name such as "Turn on Reduced Area", and add it as a `Fixed Image` resource.

1. Switch to `Interactive` mode and click on the reduced area button. Once the SEM is in reduced area mode, switch back to `Resource` mode, draw a box around the button that turns reduced area mode off, give it a name such as "Turn off Reduced Area", and add it as a `Fixed Image` resource.

2. Click the `Protocols` tab, select the main protocol, and click the `Edit Protocol` button.

3. Select the `Auto-Focus` command and add the following steps:

Step	Fields	Description
Press keys	Key sequence: F5+Shift	This step will turn the crosshair off.
Mouse press	Left button, Target area: SafeArea.	This step will go to the safe area (i.e. a place on the screen that can be safely clicked without doing anything).
Mouse press	Left button, Target area: Turn on reduced area.	This step will put the SEM into reduced area mode.
Mouse press	Left button, Target area: SafeArea.	This step will go to the safe area.
Wait for image to match	Fixed image: Turn off reduced area, Time to wait: 5,000 ms.	This step will wait up to 5 seconds for the SEM to enter reduced area mode.
Mouse press	Left button, Target area: Unpause button.	This step will put the SEM into live mode.
Mouse press	Left button, Target area: SafeArea.	This step will go to the safe area.
Wait for image to match	Fixed image: Pause button, Time to wait: 5,000 ms.	This step will wait up to 5 seconds for the SEM to enter live mode.
Adjust focus in reduced area	Color of rectangle: Green, Full area: Preview.	The `Preview` resource should be a bounding box around the place in the SEM's GUI where the SEM image is drawn. During this step, Pix2Net will identify the reduced area bounding box by its color, which should match the color specified for `Color of Rectangle`. Pix2Net will move the reduced area box to a suitable location on the screen, and then it will perform the `Increment Focus` and `Decrement Focus` commands until the reduced image is a sharp as possible. In order for this to work, it is important that the SEM's crosshair is hidden, the SEM is in reduced area mode, and the SEM is in live mode.
Mouse press	Left button,	This step will pause the SEM.

You can test this command by returning to the `Capture` tab, clicking `Control Microscope`, and then clicking the `Auto-Focus` button.

2.4 Navigating a Project

This tutorial will introduce you to the basics: How to open projects, toggle layers, toggle cells, add bookmarks, add rulers, and configure shortcut keys to commands.

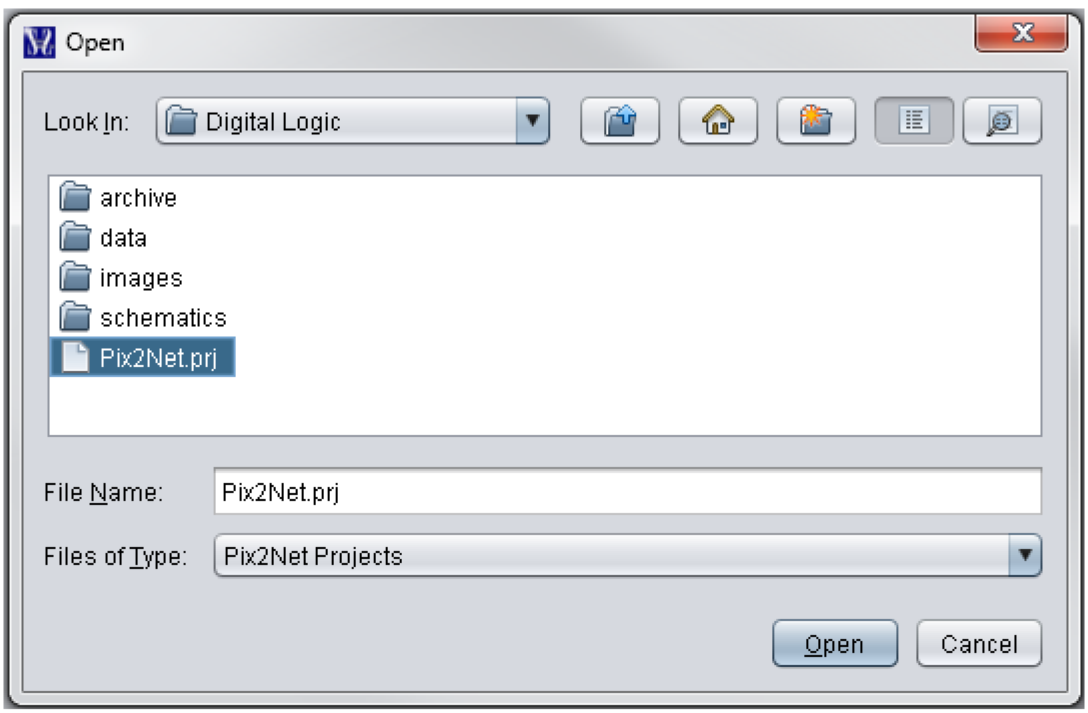
2.4.1 Unzipping the Examples

Unzip `examples.zip` to a directory on your computer. On Windows, use an unzipping program such as 7-Zip.

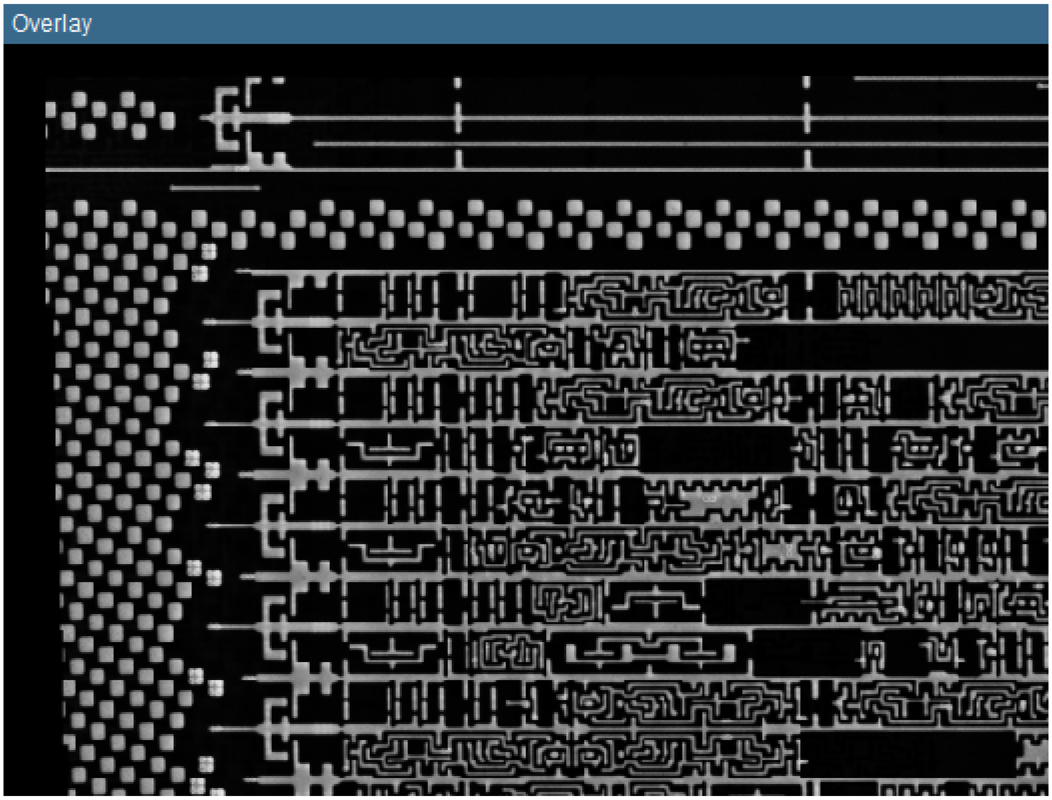
2.4.2 Opening a Project

1. Go to the `File` tab and click `Open Project`.

2. Browse to `examples\Digital Logic\Pix2Net.prj`, and double-click the `Pix2Net.prj` icon or click the Open button.



3. When the project finishes loading, the `Overlay` window will appear.



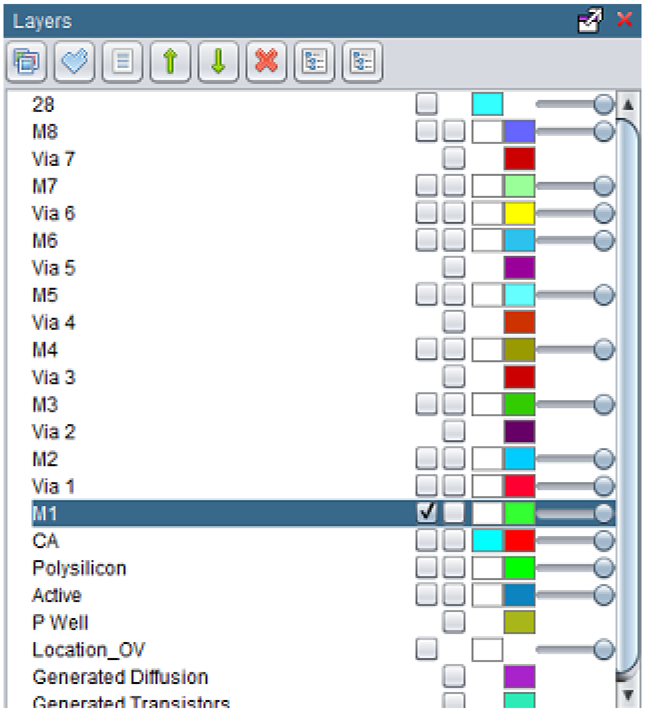
To pan around in the Overlay window, hold down the middle mouse button and drag the screen in the desired direction. To zoom in and out, use the mouse wheel. To zoom in finely, hold shift and scroll forwards and backwards on the mouse wheel. If there is no mouse wheel, use CTRL and the hold the right-click on the mouse to pan, and use + and - to zoom in and out. *NOTE* If the mouse that is being used is touch (instead of click), use two fingers to represent the right-click.

By default, the `Zoom to Area` tool should be selected. Select the `Home` tab to verify. If not, select `Zoom to Area`.

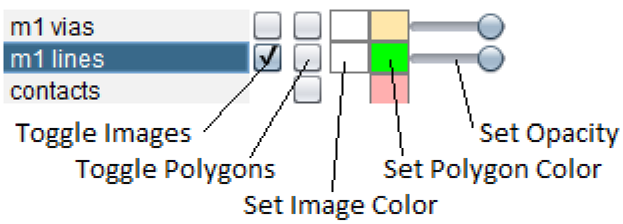
To use this tool, hold down the left mouse button and draw a rectangle around the area you want to magnify. Press the `Home` key to restore the original magnification.

2.4.3 Viewing Layers

The layers are controlled in the `Layers` window.

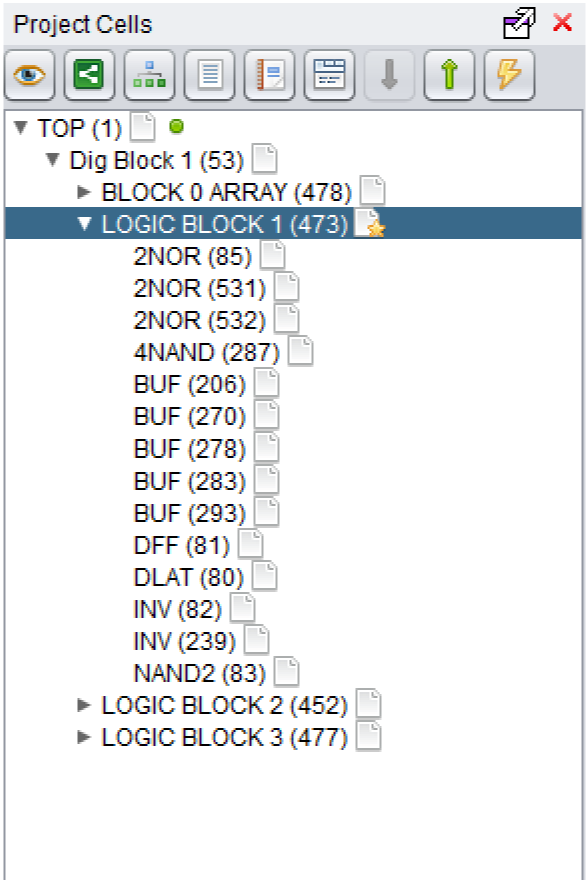


Try turning different layers on and off, and changing their display settings.

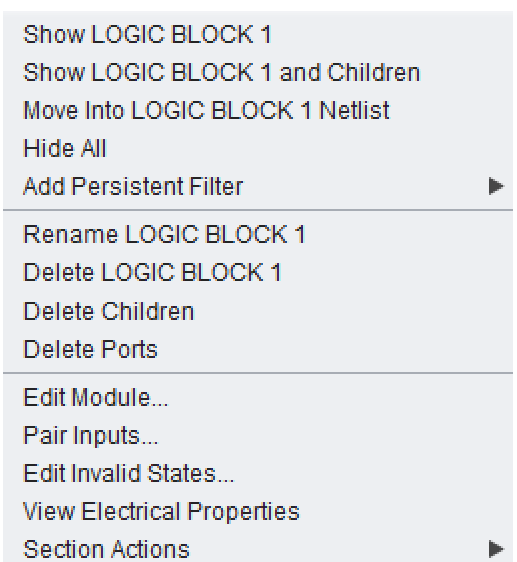


2.4.4 Viewing Cells

The cells are controlled in the `Project Cells` window.

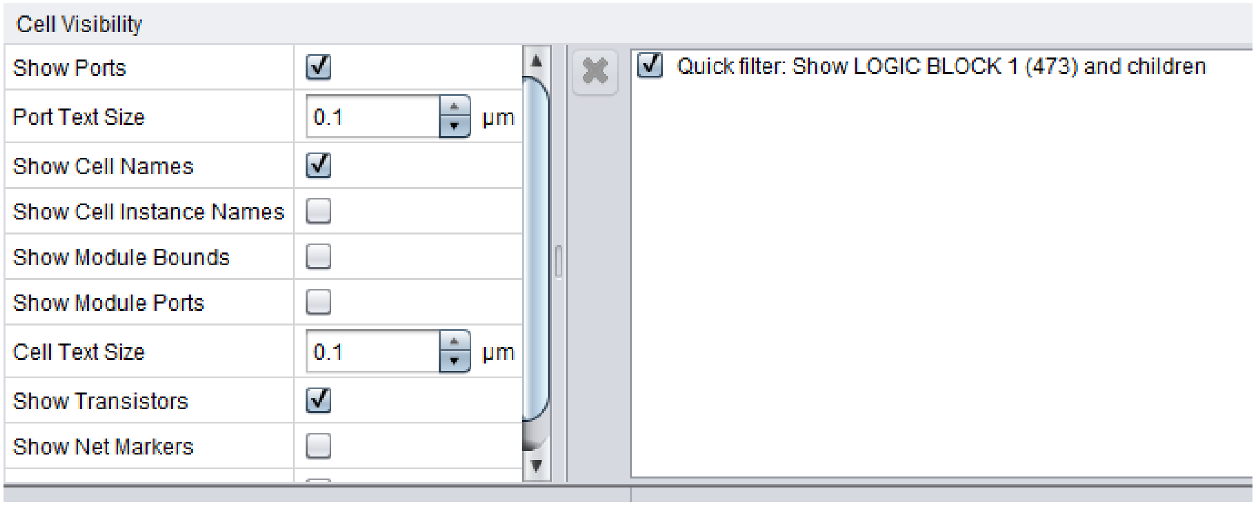


Right click on AND2X2MHT to bring up the context menu:



1. Click `Show AND2X2MHT` to show all instances of that cell.
2. Click `Hide All` in the context menu to hide all of the cells.
3. Click `Add Persistent Filter` to show all instances of the cell persistently. (Until you click `Hide All` again)

4. Repeat with other cells. To turn on/off persistent cells, click the  icon to open the `Cell Visibility` pane. Toggle cell visibilty with the check boxes.

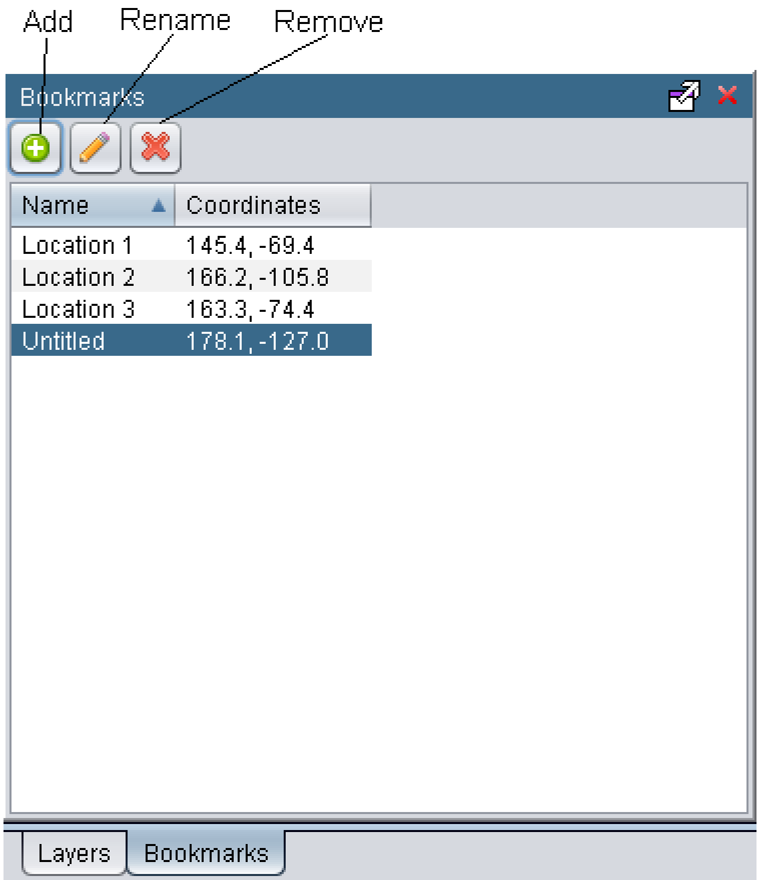


1. Close the `Cell Visibility` pane by clicking the red x in the upper right corner of the pane.

2.4.5 Adding Bookmarks

1. In the Overlay, move to a random location and zoom in.
2. Go to the `View` tab and click `Bookmarks`.

3. Click on the green plus sign to add a bookmark (a window will pop up asking for a name) and name it `Untitled`.
4. Highlight `Untitled`, select the pencil, and rename the bookmark to `My Location`.

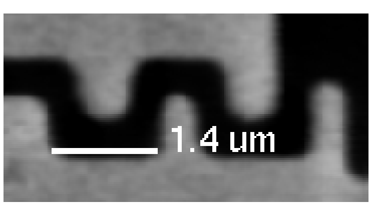


5. Move to a different location in the Overlay.
6. Double-click `My Location` in the Bookmarks window. In the Overlay, the camera will snap back to the original location.
7. Highlight `My Location` and click the red 'x' to remove the bookmark.
8. Close the Bookmarks window by clicking the red x in the upper right corner.

2.4.6 Adding Rulers

1. Go to the `Home` tab and click `Micron Ruler`.

2. Click and drag in the Overlay window to create a ruler. Hold down `shift` to force an orthogonal line.



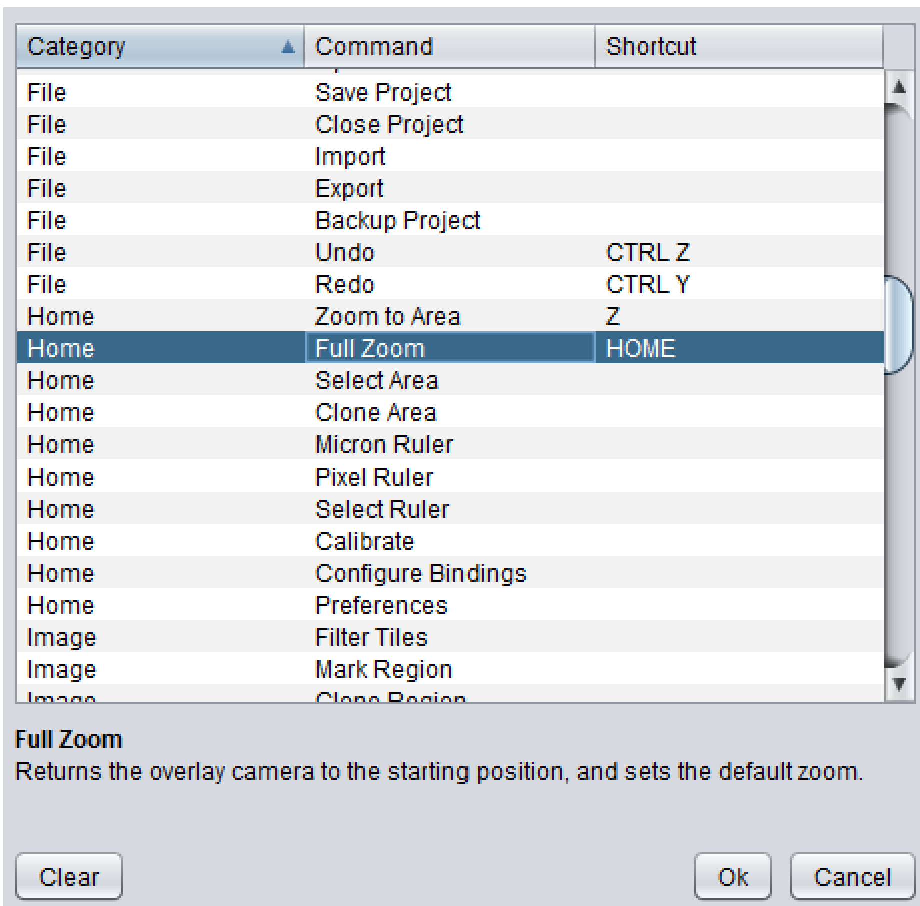
3. Click `Select Ruler`.

4. Click and drag in the Overlay window to draw a box around the ruler. The ruler should now be selected.
5. Right-click in the Overlay to bring up the context menu. Click `Selected Ruler` → `Delete`. Or, hit the delete key.

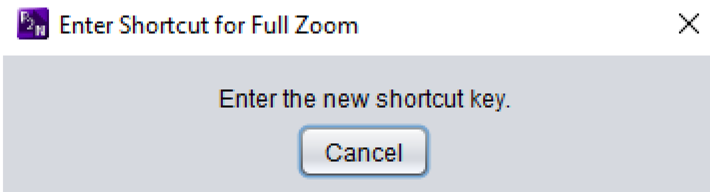
2.4.7 Configuring Shortcuts

1. Click `Configure Shortcuts`.

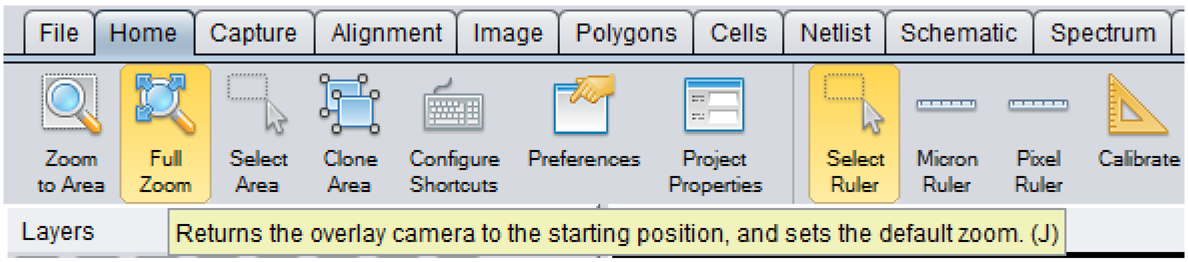
2. In the Configure Shortcuts dialog, scroll down to the `Full Zoom` command.



3. Click on `HOME`, in the right-hand column. You will be asked to enter a new shortcut key. Press the `J` key.



4. Press the Ok button to close the dialog.
5. Hover over the `Full Zoom` button to see the updated tool tip.

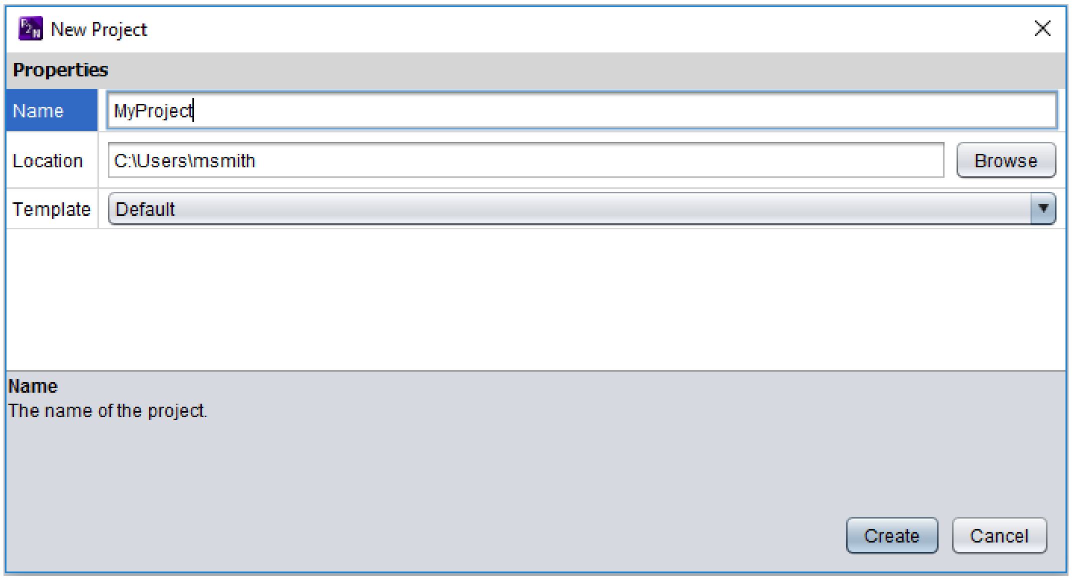


6. Press the `J` key. The `Full Zoom` command should be executed, causing the camera to zoom out to the original position.
7. Open the Configure Shortcuts dialog again, and set the `Full Zoom` command back to the `Home` key.

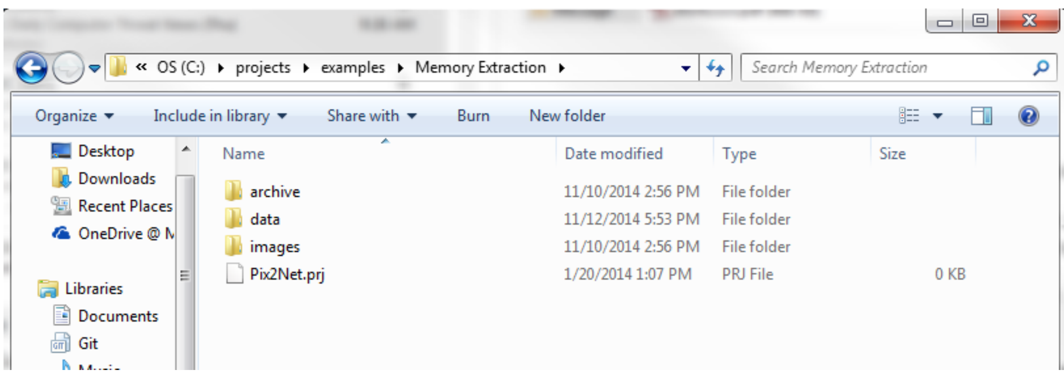
2.5 Starting a New Project

1. On the "File" tab click the "New Project" icon to begin the new project.

2. Select the location of where the project will be saved. The template can be set at this time. Pix2Net comes pre-loaded with a standard template for capturing a layer. If the default template does not match the user's needs, it can be changed. Please see *Templates* for more information.



3. A new Pix2Net project is a directory consisting of 3 subdirectories and a Pix2Net.prj file.



archive Stores zip files for backup purposes

data The database files

images Images stored as an enumerated directory for each image layer

2.6 Capturing a Layer

This tutorial will show you how to capture a layer.

Note: Before proceeding a new project must be created :ref: *starting-a-new-project*

2.6.1 Connecting the Stage

Note: Stages X-axis and Y-axis will vary from system to system - user will need to determine correct settings for their specific system.

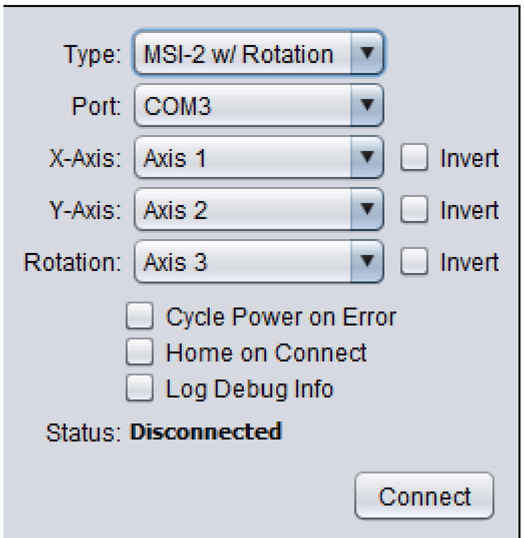
1. Go to the `Capture` tab and click the `Stage` button.

2. Set `Type` to `MSI-2 w/Rotation`.

   Set `Port` to the com port that is connected to the stage. The stage must be powered up when Pix2Net is started, or else you will not see the stage's com port in this list. If you are unsure about the correct com port, you can go to Control Panel -> Device Manager and look at the entries under Ports (COM & LPT). If you connect and disconnect the stage's USB cable, then one of the com ports should appear and disappear.

   The Y-Axis should be inverted, so that the screen will pan down as the y coordinate increases, and the screen will pan up as the y coordinate decreases.

   The `Home on Connect` button should be checked if this is the first time you are connecting to the stage after the stage has been turned on.

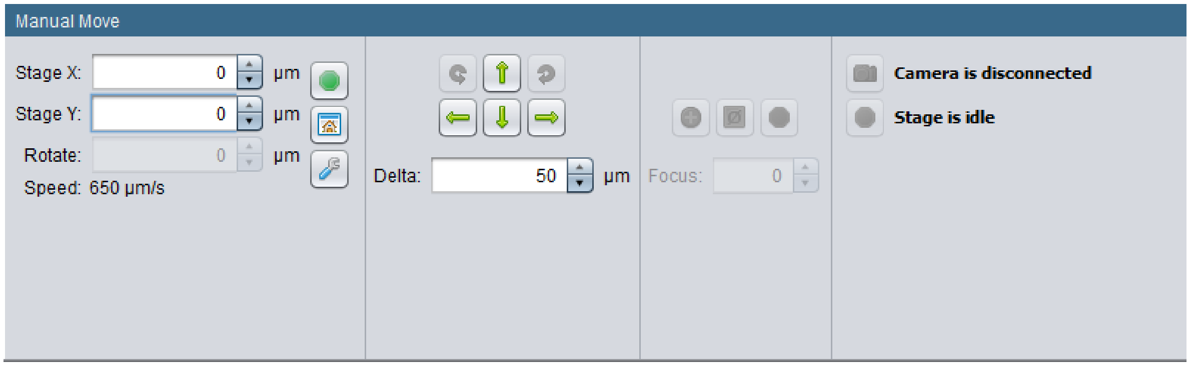
   

   Click the `Connect` button to connect to the stage. It will do a homing process that takes a minute, and then the stage will be ready.

3. Click the `Manual Move` button.

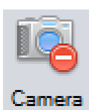
4. In the `Manual Move` panel, enter coordinates into the `Stage X` and `Stage Y` fields. Press the green button to move the stage to those coordinates.



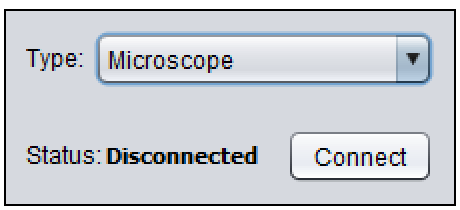
The SEM image should move right if the x coordinate increases, and left if the x coordinate decreases. The SEM image should move down if the y coordinate increases, and up if the y coordinate decreases.

2.6.2 Connecting the Camera

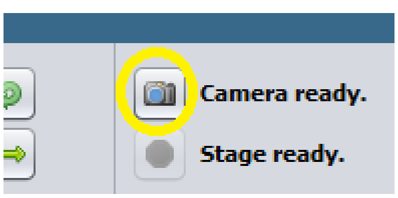
1. Start the Pix2Net Server on the SEM computer. For more information about the Pix2Net Server, see the tutorial on *Setting Up Pix2Net Server*.
2. Click the `Camera` button.



3. Set the `Type` to `Microscope` and click the `Connect` button.



4. To capture a test image, click the capture button in the `Manual Move` panel.

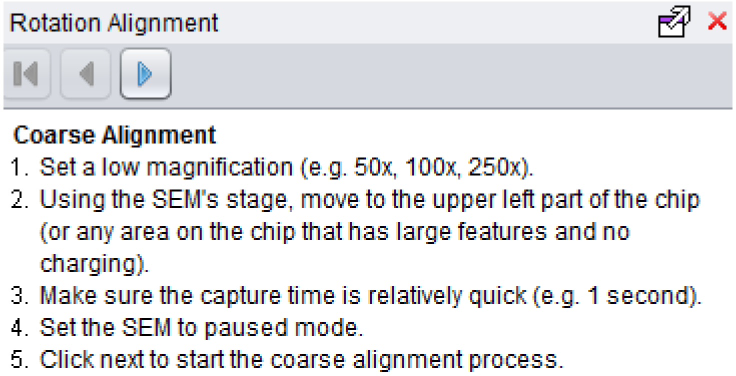


2.6.3 Aligning the XY Stage to the Device

Before capturing the layer, you must use the Pix2Net rotation stage to rotate the device until the device is aligned with the Pix2Net XY stage. You can not use the SEM's rotation stage to accomplish this, because the SEM's rotation stage will rotate the Pix2Net stage and the device simultaneously. You can adjust the Pix2Net's rotation stage manually in the `Manual Move` panel, but it is usually easier to use the `Rotation Alignment` feature.

1. Click the `Rotation Alignment` button.

2. Follow the instructions in the `Rotation Alignment` window, and then click the `Next Step` button to perform coarse alignment.

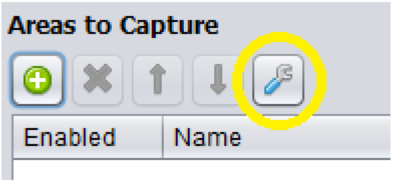


3. Continue to follow the instructions in the next two steps to perform fine alignment.

2.6.4 Setting up a Run

1. Click the `Capture Config` button.

2. Click the `Show options` button to bring up the options.

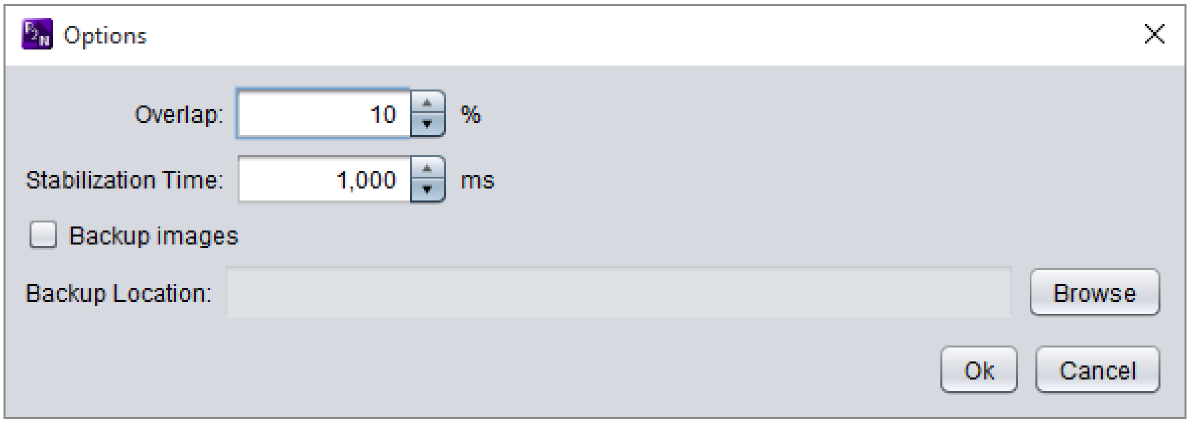


3. In general, these options rarely need to be changed, but it is good to be aware of these settings:

   `Overlap` determines how much the images should overlap with their neighbors.

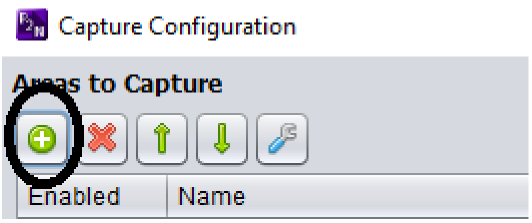
   `Stabilization Time` determines how long Pix2Net should wait for the stage to stop moving before it captures an image. If this amount of time is too short, the stage may still be moving slightly as the image is captured.

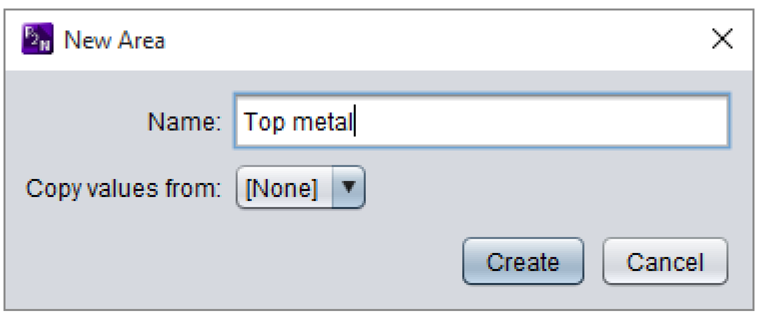
   If you turn on `Backup Images`, and specify `Backup Location`, then a copy will be made of each captured image in the backup location.



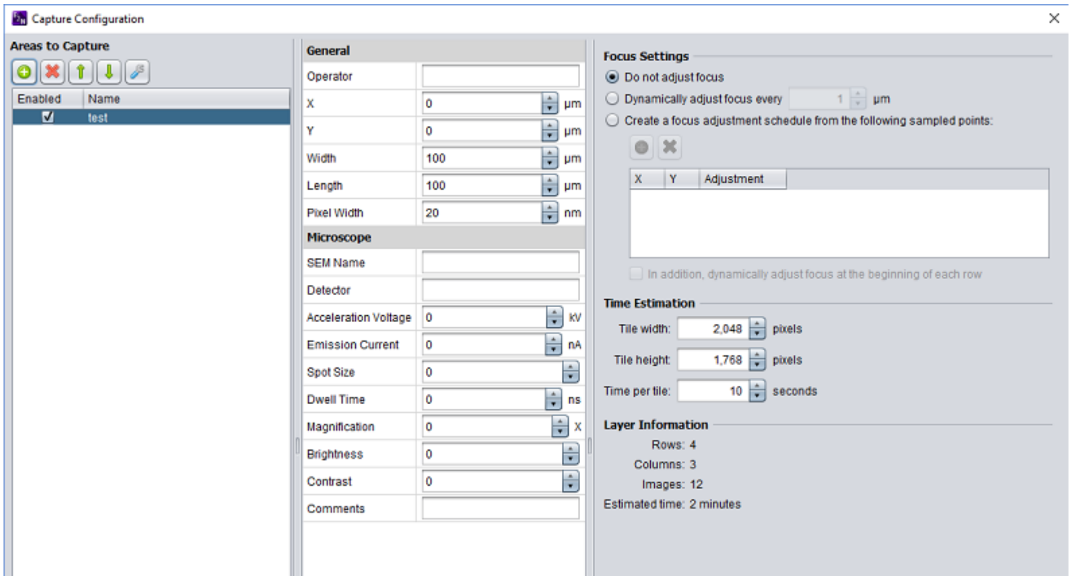
Click `Cancel` to close the options dialog, click `Ok` if changes were made to save.

4. Click the `Add Area` button. Enter a name for the new area. The `Copy values from` field allows you to initialize an area with the values from an existing area, but since this is the first area you are creating, it must be set to `[None]`. Click `Create`.

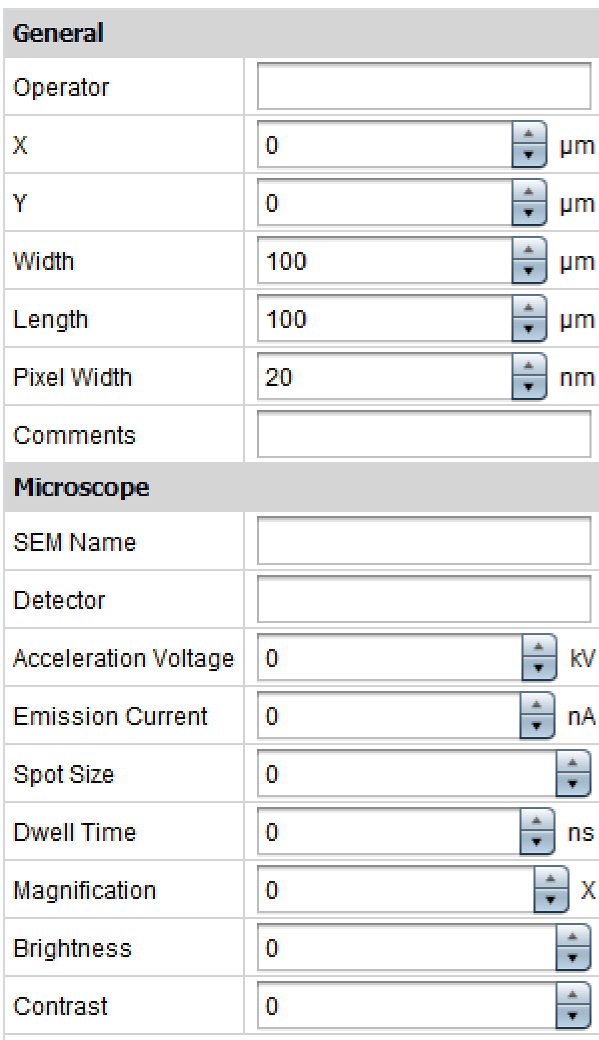




5. The *Capture Configuration* property list should appear.



6. Fill out the layer properties.

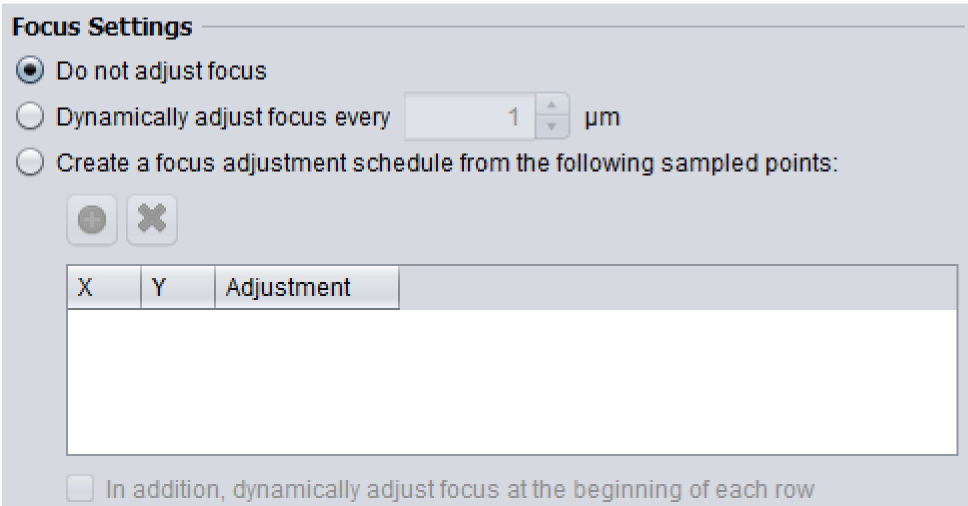


The `X`, `Y`, `Width`, and `Length` properties define the location and size of this area.

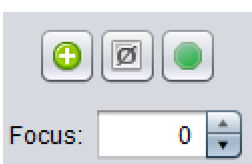
`Pixel Width` will be used to determine the number of images that must be shot to capture this area.

The rest of the properties are optional.

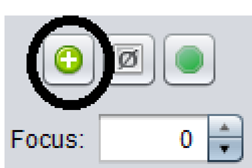
7. Fill out the focus settings.



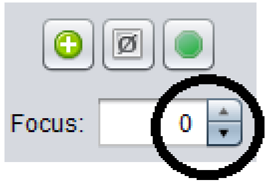
- `Do not adjust focus` - If you select this option, then Pix2Net will not adjust the focus during the run.
- `Dynamically adjust focus` - If you select this option, then the focus will be automatically adjusted every time that Pix2Net moves the stage the specified distance along each row. For example, suppose that the specified distance is 5 um and every row is 12 um long. In that case, the stage will be adjusted 3 times during each row: Once at 0 um, again at 5 um, and one last time at 10 um.
- `Create a focus adjustment schedule` - If you select this option, then you can create a focus adjustment schedule by specifying the desired focus amount at different locations on the device. The nice thing about specifying a focus adjustment schedule is that a scheduled focus adjustment is faster and more reliable than attempting to dynamically adjust the focus. You can manually add points to the table, but an easier way to fill out the table is to use the focus adjustment controls in the `Manual Move` panel. Go ahead and click `Save` to save this area, and then look for the focus controls on the `Manual Move` panel:

  Move the stage to the upper left corner of the device, make sure that the focus looks good, and then click the `Add Focus point` to add this point to the table.

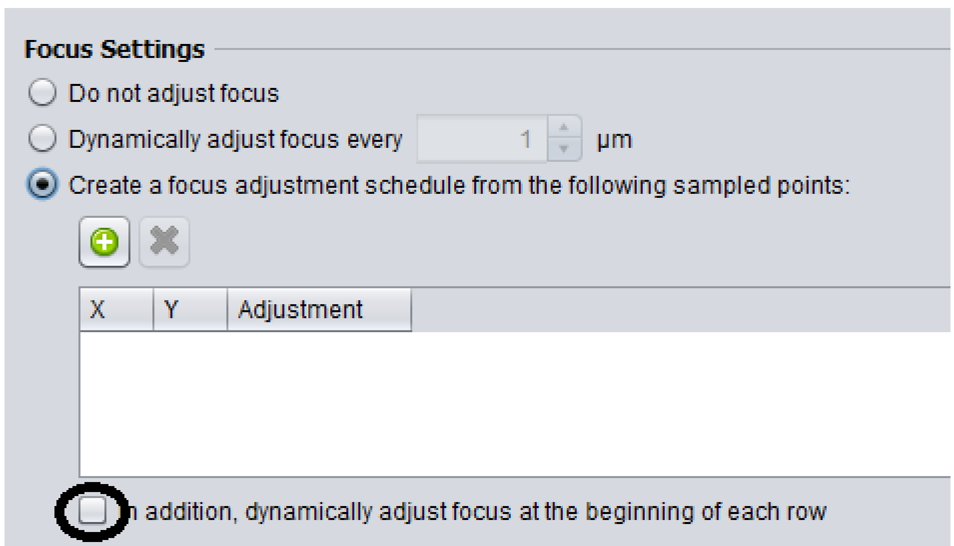
  Move to the upper right corner of the device, adjust using the focus field.



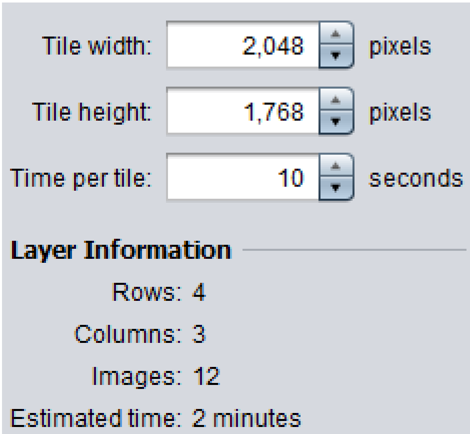
Click the `Go to specified focus value` button to adjust the focus, and then add another focus point.

Repeat this procedure for the lower left and lower right corners of the device. Open the `Capture Config` window again. You should now have four sampled points in the sampled focus point table.

Finally, if you are worried that the ideal focus will change over time, you can select `In addition, dynamically adjust focus at the beginning of each row.` In that case, when Pix2Net moves the stage to the beginning of a row, it will apply the scheduled focus adjustment first, and then it will dynamically adjust the focus.



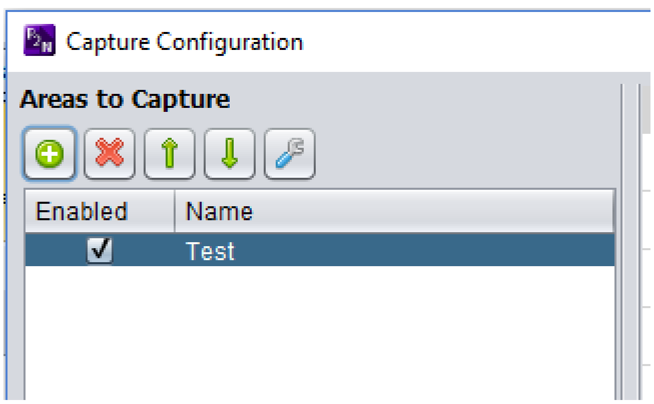
8. You can get an estimated capture time by setting the correct `Tile width`, `Tile height`, and `Time per tile`.



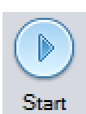
9. Click the `Save` button to save the area you just created.

2.6.5 Starting a Run

Ensure the layer you want captured is selected before starting the run.



Click the `Start` button to start the capture.



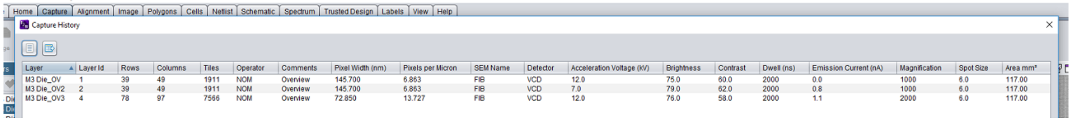
Pix2Net will start (or resume) the first enabled area in the list of areas to capture. Once Pix2Net finishes that area, it will disable it, and move to the next enabled area. If there are no more enabled areas, Pix2Net will stop capturing.

2.6.6 Viewing Capture History

After you have captured some layers, you can view and export the information for those layers at any time.

1. In the `Layers` window, click the `Show Capture History` button.

2. The Capture History window will show information about each layer that has been captured with the fields populated by the template used.



3. You can use the Select columns button to edit the columns that are shown. By default, the settings will be the column settings that you specified when you created the template.

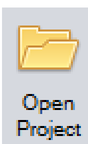
4. You can use the Export button to export the columns to a csv file, which can be opened as a spreadsheet by Microsoft Excel.

2.7 Importing and Stitching Images

This tutorial will show you how to import images and stitch them.

2.7.1 Open the Example Project

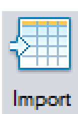
1. Go to the File tab and click Open Project.



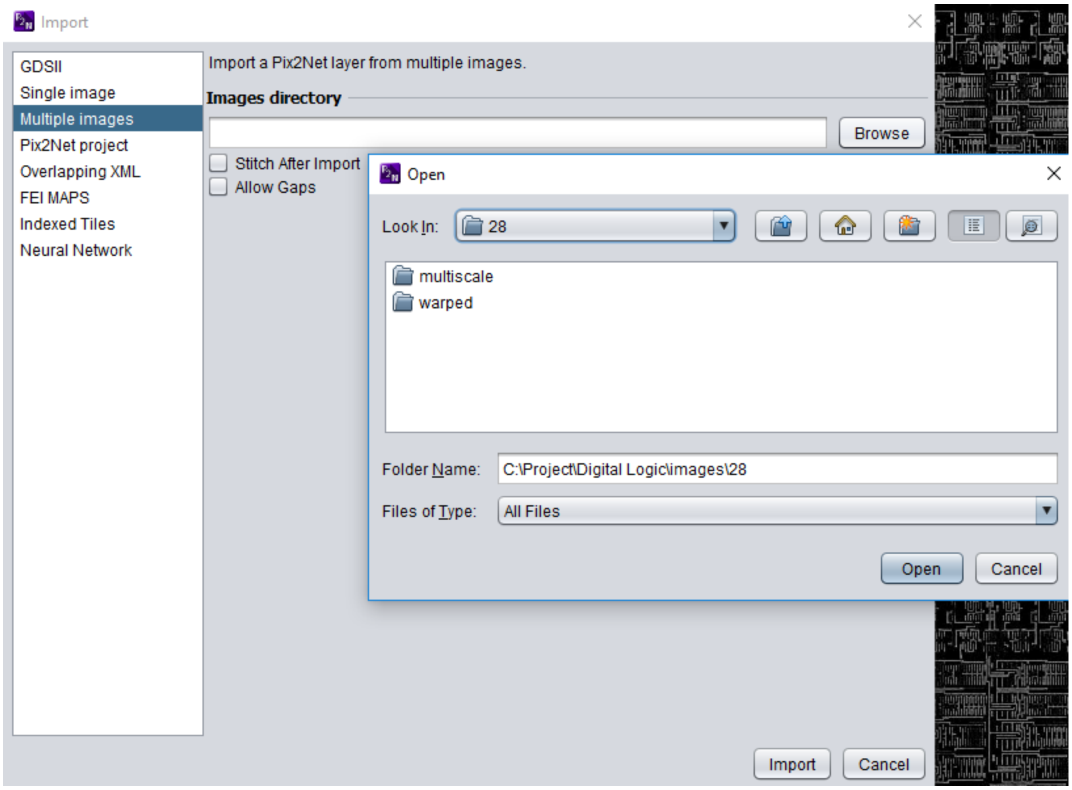
2. Open the project file Digital Logic

2.7.2 Importing Images

1. Click Import and select Multiple images....

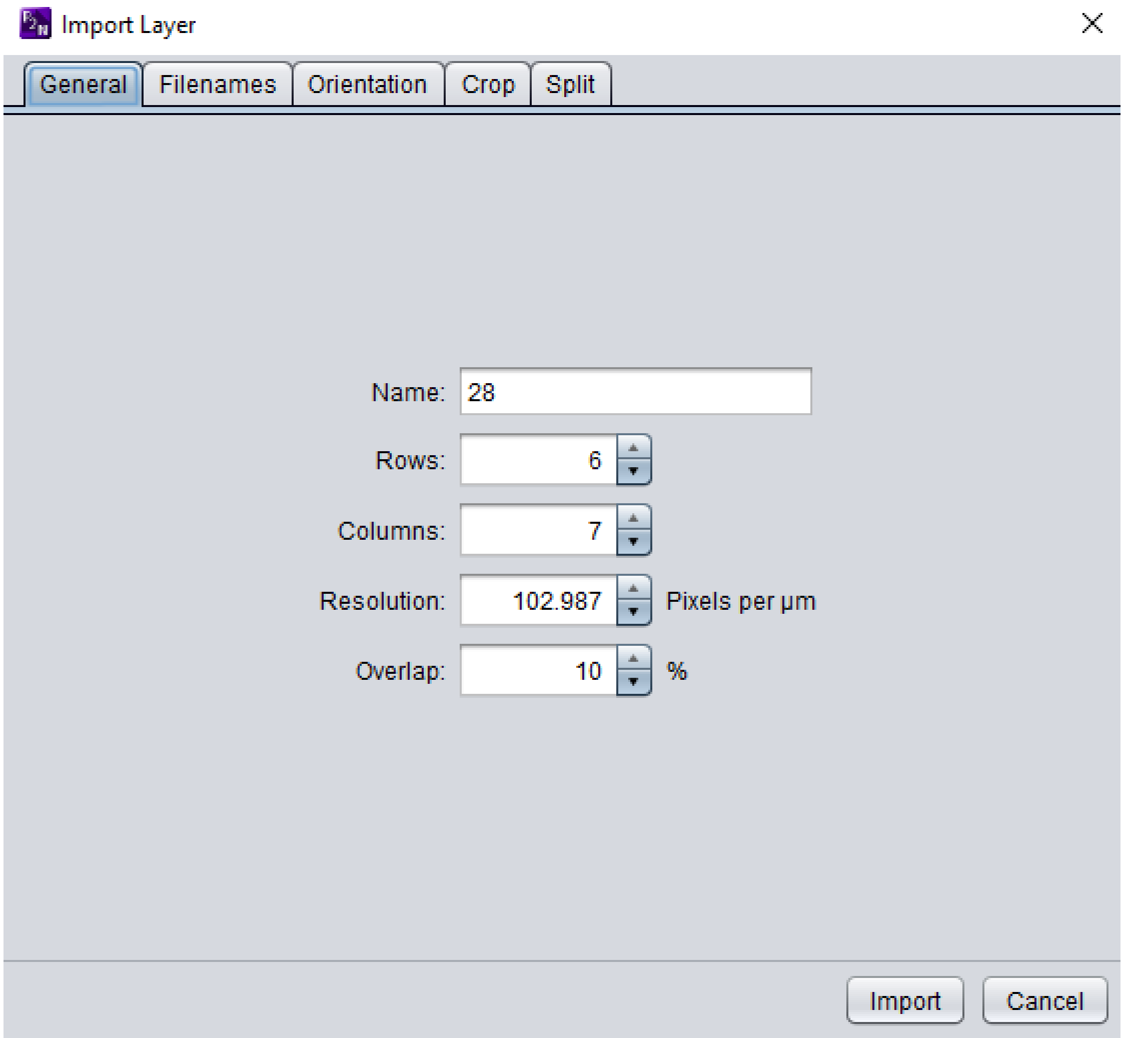


2. Browse to Digital Logic\images\28 and click the Open button.



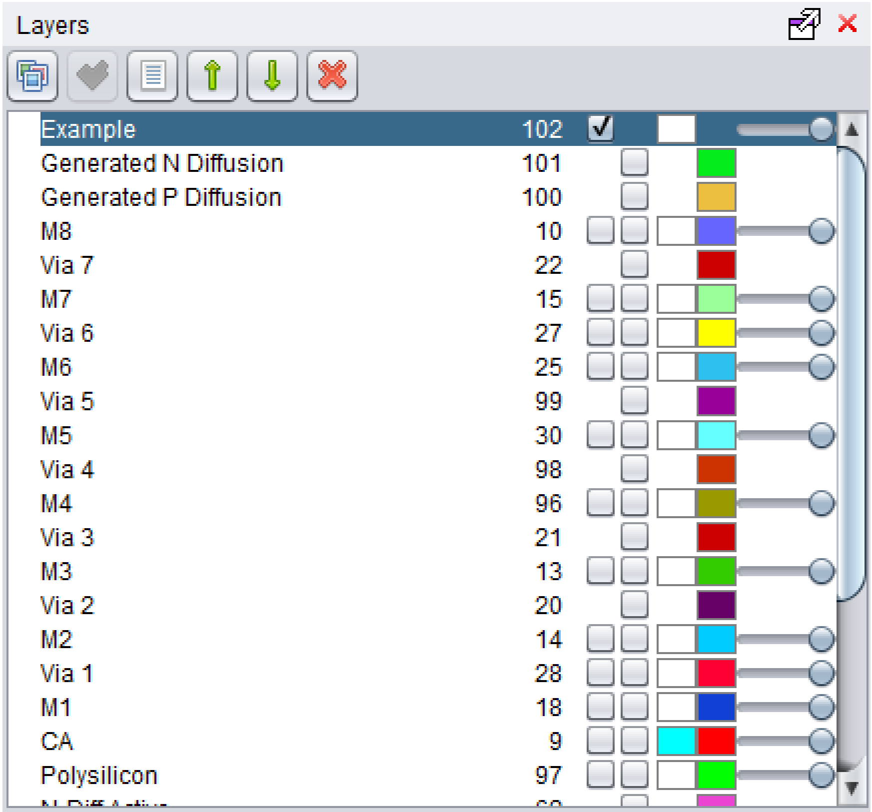
3. In the General tab, set Rows to 6, Columns to 7, and Resolution to 102.987.

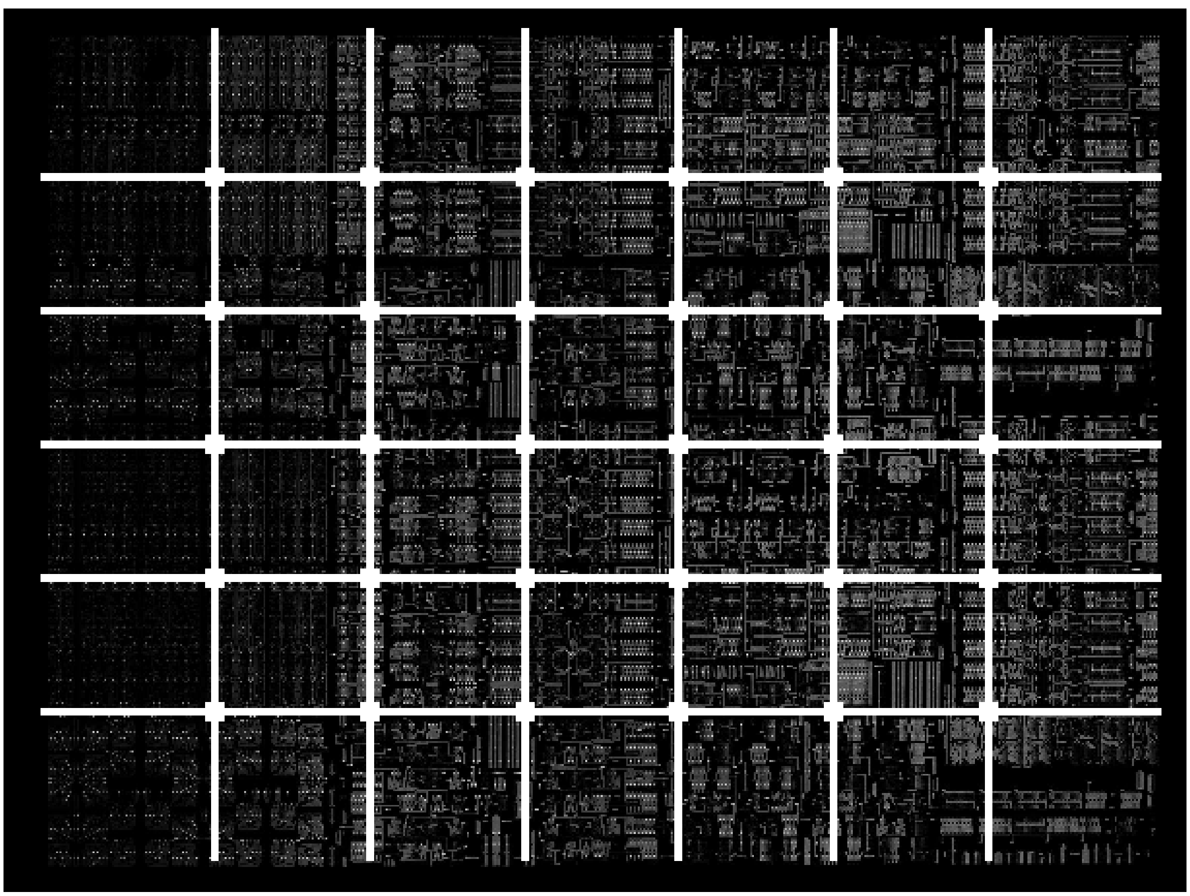
   If the image capture was completed by Pix2Net then these values are auto-completed, otherwise the user will need to manually input the values.



4. Click the Import button. For the example project, the import process should take less than 15 seconds. On regular projects it depends on the size of the layer.
5. Go to the `View` tab, the `Overlay` option should be highlighted. If not, select `Overlay`.

6. In the Layers window, ensure the layer to be stitched (the `example` layer) is enabled. If not, click checkbox to enable.

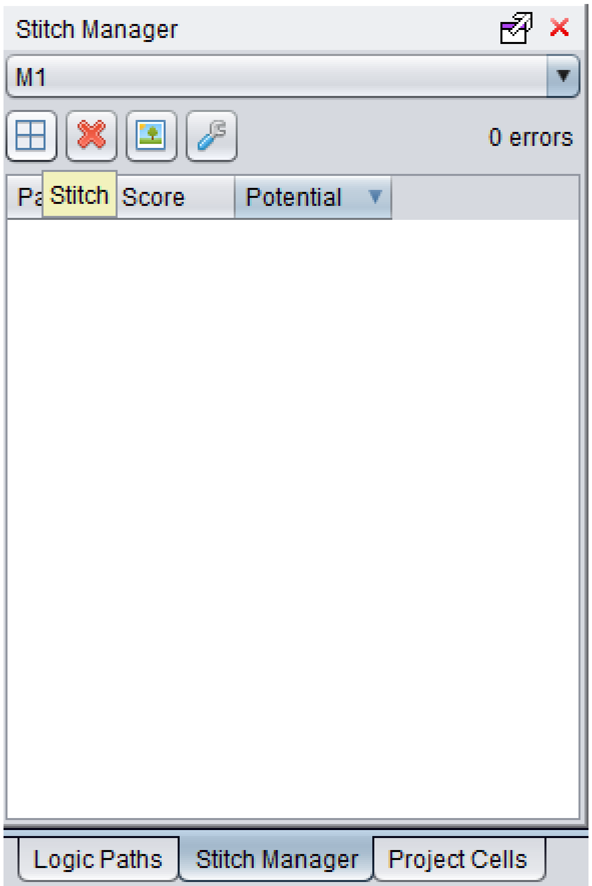

Layers
Example 102
Generated N Diffusion 101
Generated P Diffusion 100
M8 10
Via 7 22
M7 15
Via 6 27
M6 25
Via 5 99
M5 30
Via 4 98
M4 96
Via 3 21
M3 13
Via 2 20
M2 14
Via 1 28
M1 18
CA 9
Polysilicon 97

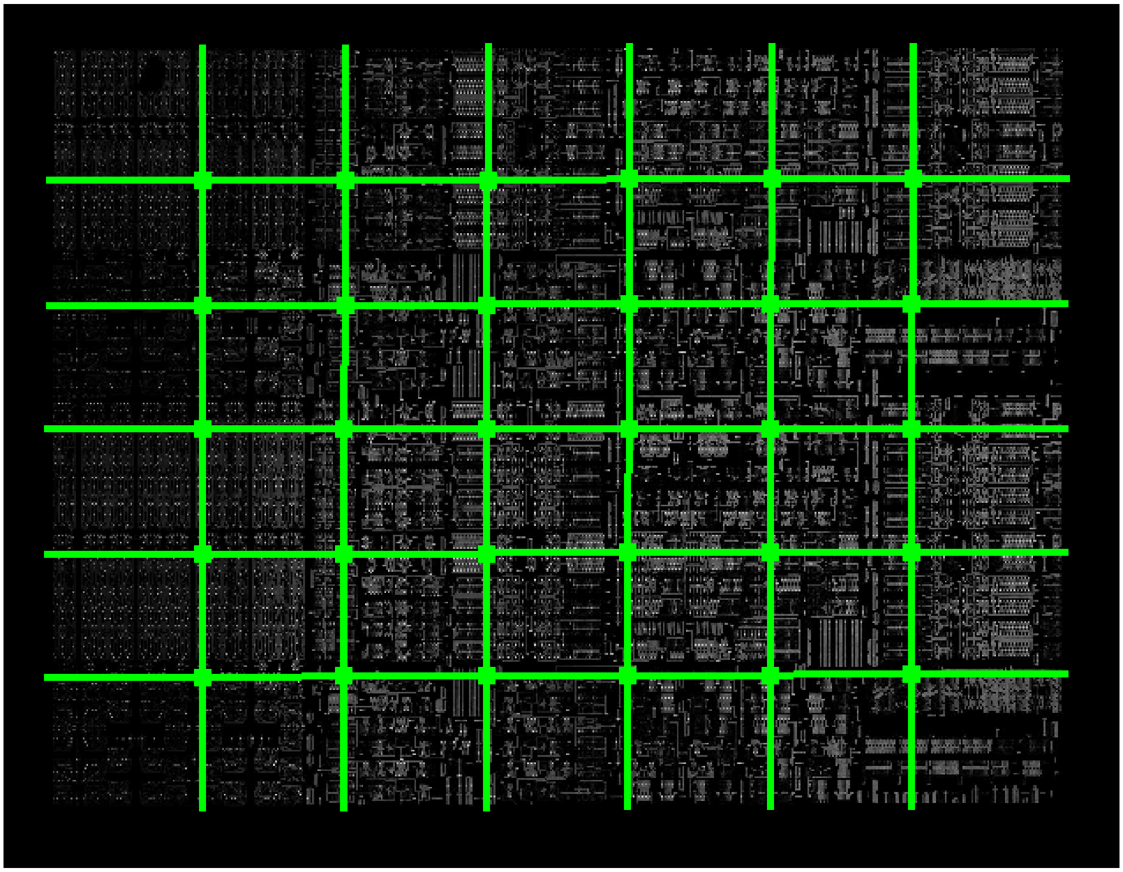


We have successfully imported an image layer into the project. However, the layer doesn't look right, because the tile boundaries are not flush (when zoomed in). To fix that, we need to stitch the images.

2.7.3 Stitching Images

In the alignment tab, open the Stitch Manager and press the Stitch button.





All green lines means that it was stitched perfectly. You can now zoom in and out and see the difference.

2.7.4 See More

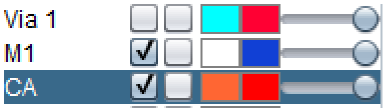
For more information on stitching, see the *Stitching* reference.

2.8 Aligning Layers

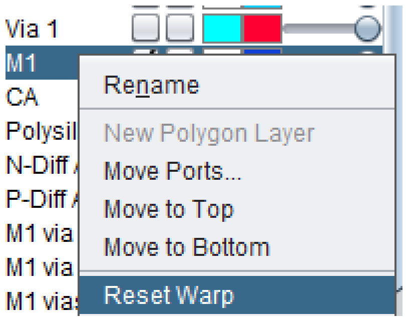
This tutorial will show you how to use the tools in the alignment panel to align two image layers.

2.8.1 Moving Layers

1. Open the `Digital Logic` project.
2. In the Layers window, set the `m1` and `CA` image layers to visible. Set a orange color for the `CA` image layer.



3. In the Layers window, right-click on `m1` to bring up the context menu. Choose `Reset Warp`.



4. Go to the `Alignment` tab and click `Move`.

5. Click and drag to move the `m1` layer around. If you want to undo a move, use `Ctrl+Z`.

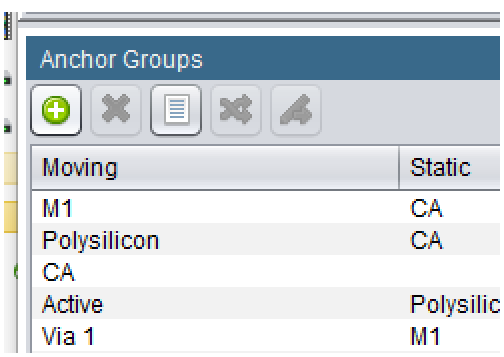
2.8.2 Using Anchors

The Move, Scale, and Warp tools work for smaller image layers, but they are difficult to use with large image layers. On the other hand, the anchor system allows users to align two large image layers very quickly.

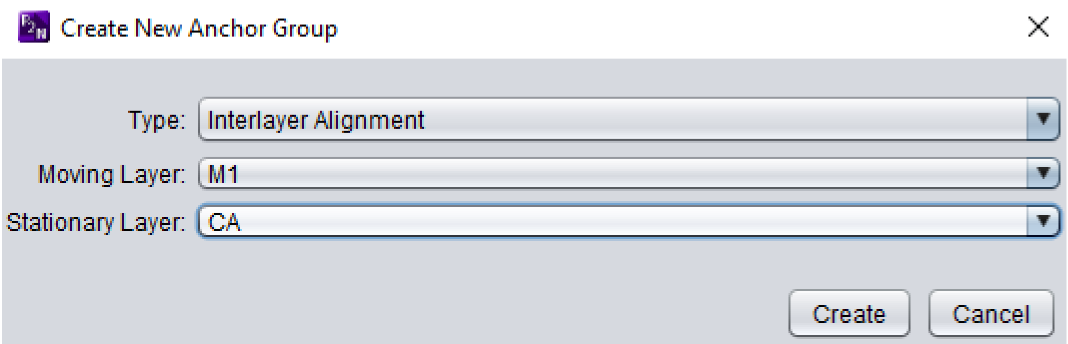
NOTE The user must have *View Anchor* and *Add Anchor* turned on to place and add anchors. It is recommended to use the *Alignment Review* as well to help shorten the alignment process and to look at each anchor's bend percentage. See *Alignment Review*

1. Select `View Anchors`.

2. Click the add button in the Anchors window.

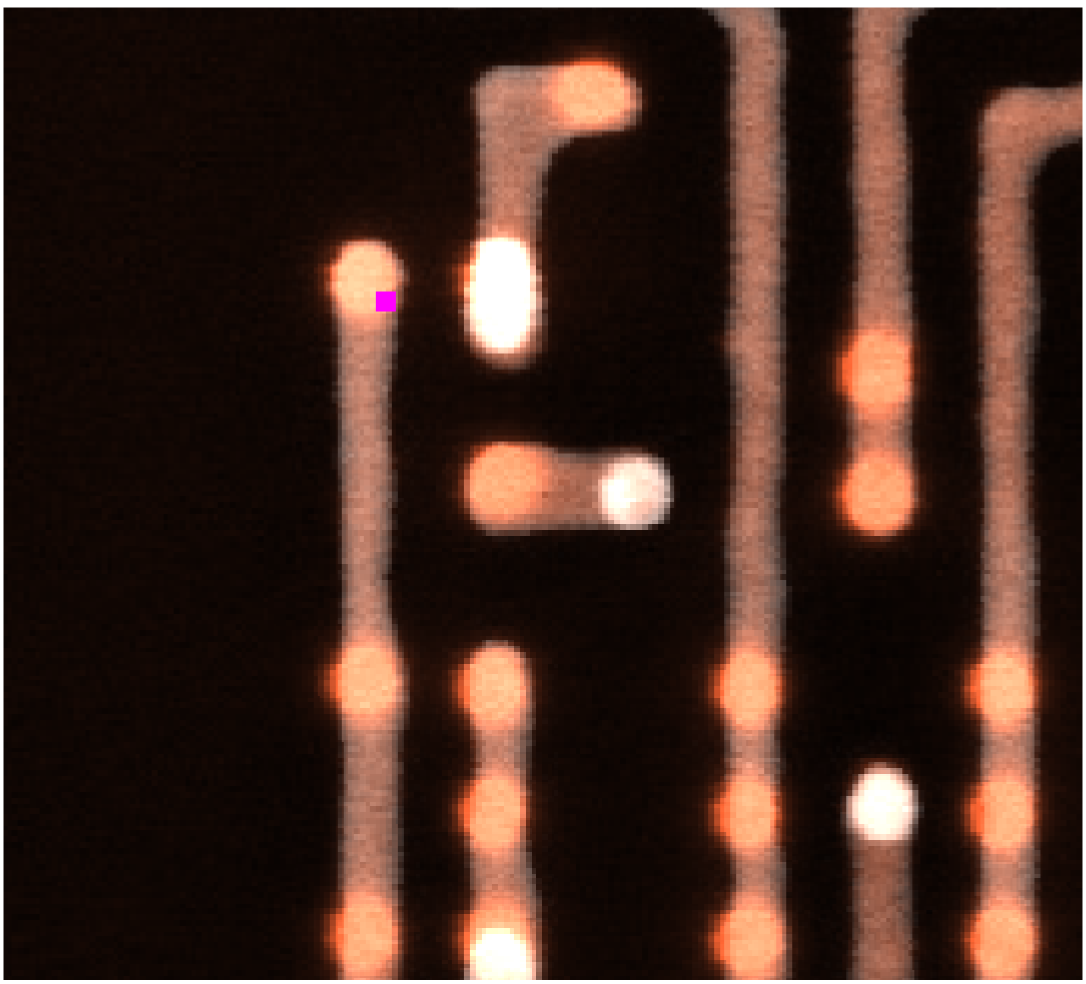


3. Leave anchor mode as `Interlayer Alignment` and set `m1` as the `Moving Layer`, and `CA` as the `Stationary Layer`. Click the Create button.



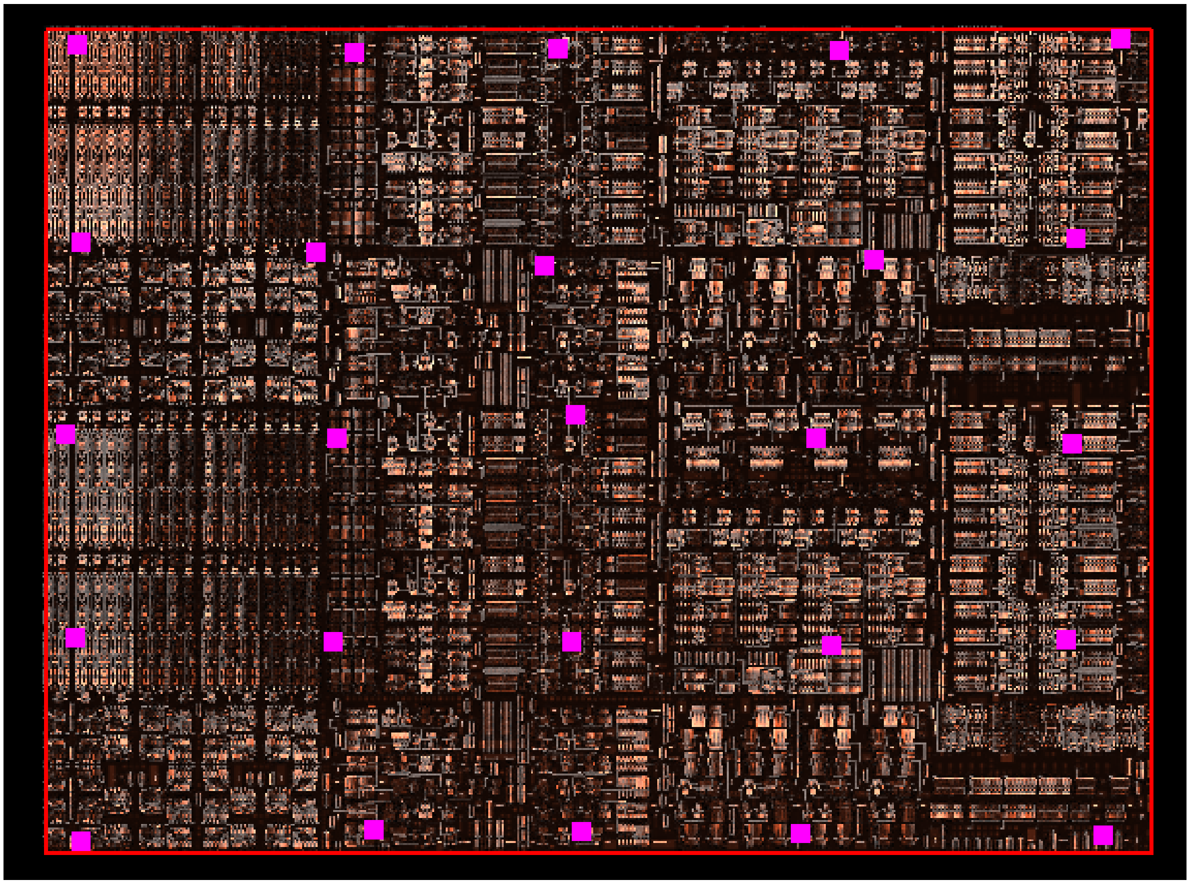
4. Select the `m1 - CA` group in the Anchors window. Click `Add Anchor`.

5. In the upper left corner, click and drag to move the `m1` layer until it is lined up with the `CA` layer. An anchor point will be added when the mouse button is released.

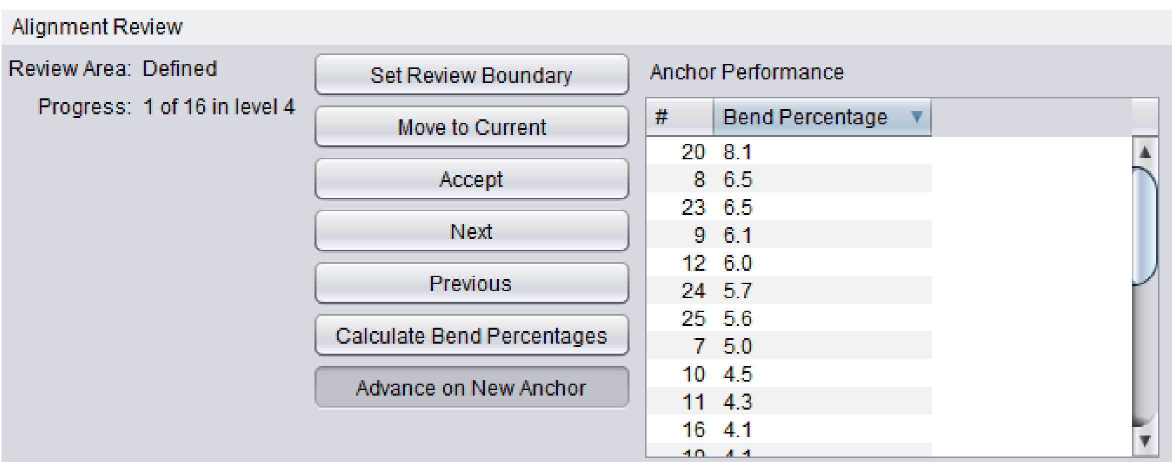


6. **Continue to add anchors until the `m1` layer is aligned to the `CA` layer.** *NOTE* Always lay out the corner anchors before moving on to the middle anchors, if the first anchor is at the top left, place the next anchor

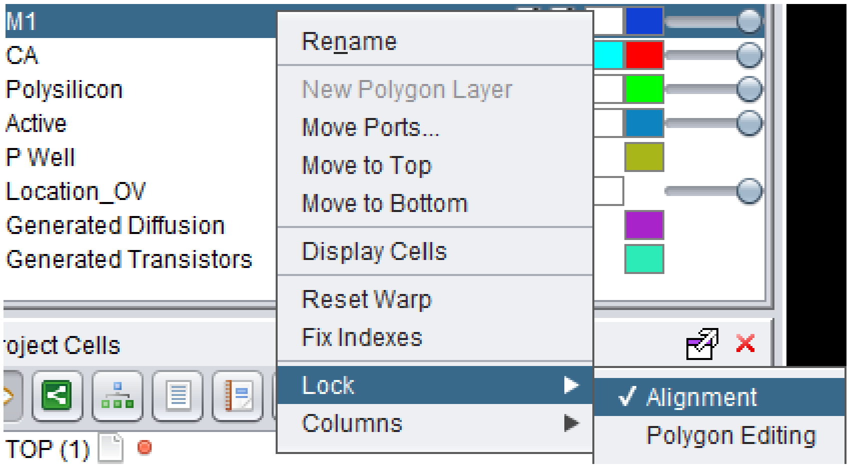
in the bottom right (so, always place the second anchor in the opposite corner). For this small layer, 20 points are enough.



7. To check the bend percentage between the anchors, click on `Alignment Review` in the Alignment tab, and then *Calculate Bend Percentages*. See *Alignment Review*

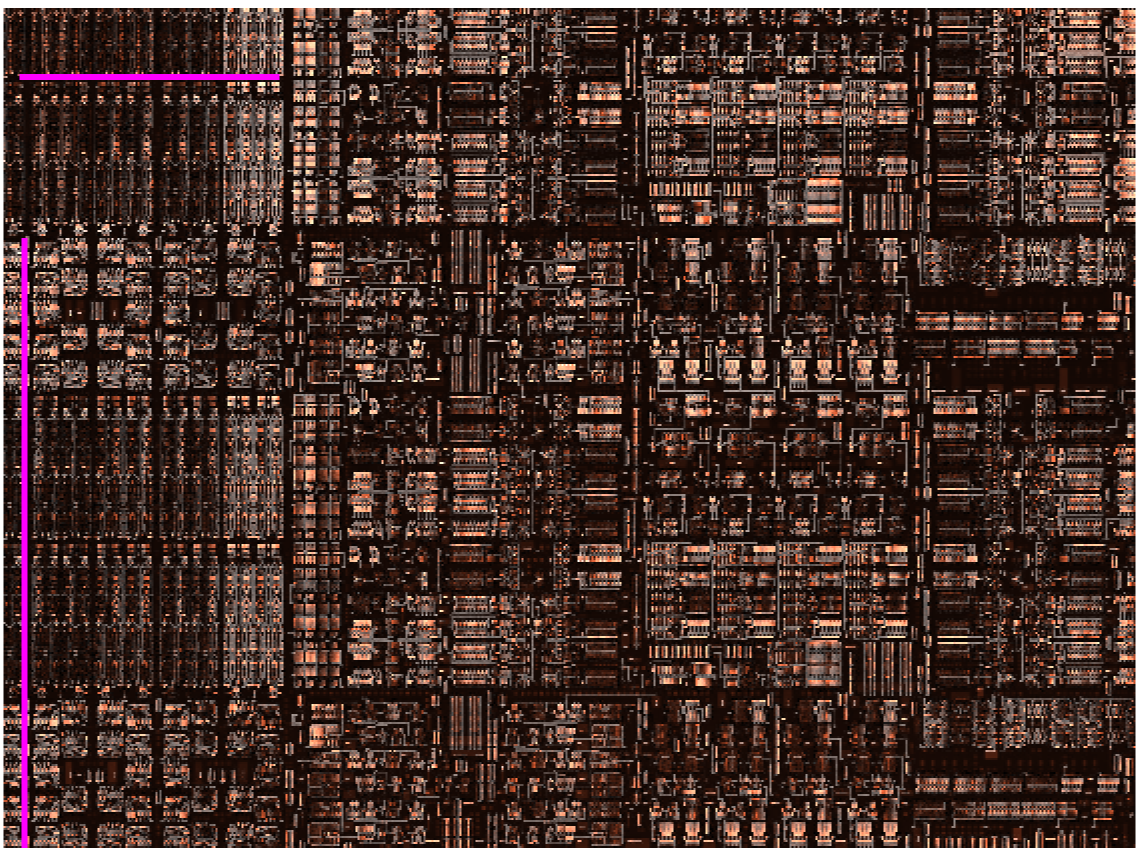


8. After the moving layer is aligned to the stationary layer, it is recommended that the user right-clicks on the recently aligned layers and click on `Lock --> Alignment` to ensure that the layers will not move.



2.8.3 Layer Orthogonal Tool

Using this tool allows the user to straighten the image. To do this, click the + sign in the *Anchor Groups* and then select the layer that is to be straightened. The easiest way to straighten the image is to try and find a line or straight segment that runs through the whole image. Left clicking and dragging the orthogonal anchor through the straight line will force the image to become straightened to that line. When using the orthogonal tool, most images only require two lines, one horizontal and one vertical.



2.8.4 Cell Alignment

The "cell" alignment type for anchor groups is used to align a collection of cells to an image layer. The primary use case for this form of alignment is in conjunction with the "fill with memory grid" tool, which creates a grid of child cells within a parent cell. The created cells may not be perfectly aligned with the structures they are meant to bound, but there could be too many to adjust by hand. By using a cell alignment anchor group, these cells can be aligned in the same way that two layers can be aligned. When creating the group, the user must select a stationary image layer and a parent cell. The parent cell is the cell containing the child cells which are misaligned with the stationary image layer. Once the anchor group has been created, the standard anchor tools can be used to place anchors to align the cells to the image. There is one caveat, though. Because aligning cells can be a long-running operation, the system will not automatically execute an alignment operation after a cell anchor has been placed. Instead, the cells will snap back to their former position to allow the user to continue to add anchors. The apparent cell alignment will not improve unless the user clicks the "align anchors" button to perform the alignment.

2.8.5 More Information

For more information please click this link *View Anchors*

2.9 Polygon Extraction

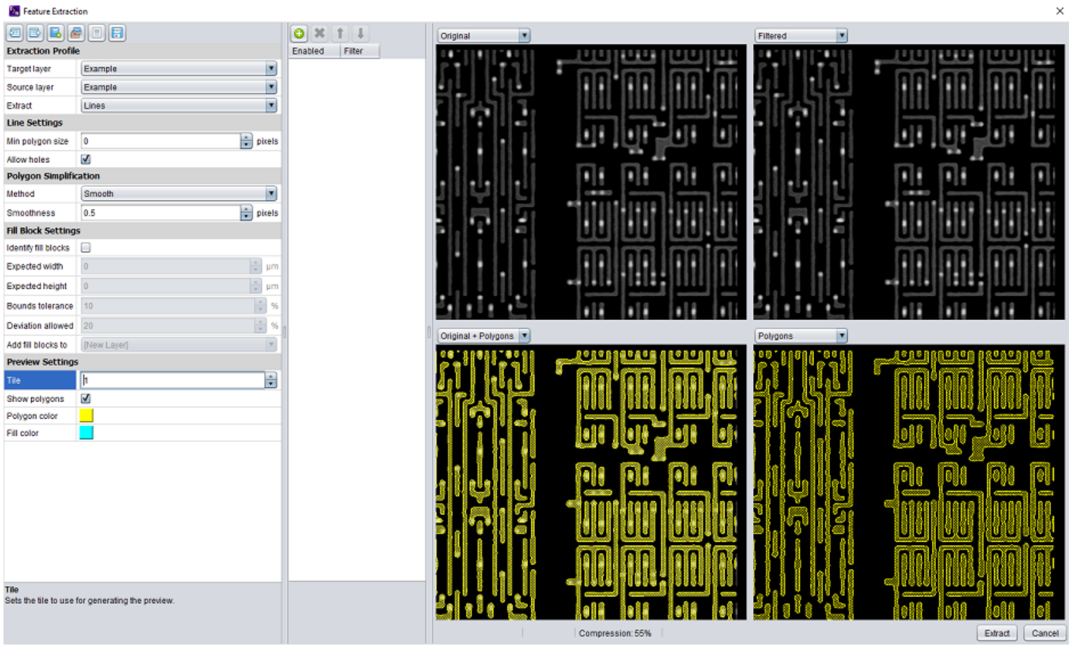
The following tools are available for Polygon extraction:

- *Filtering and Edge Detection*
- *Neural Network*
- *More Details About Extracting*

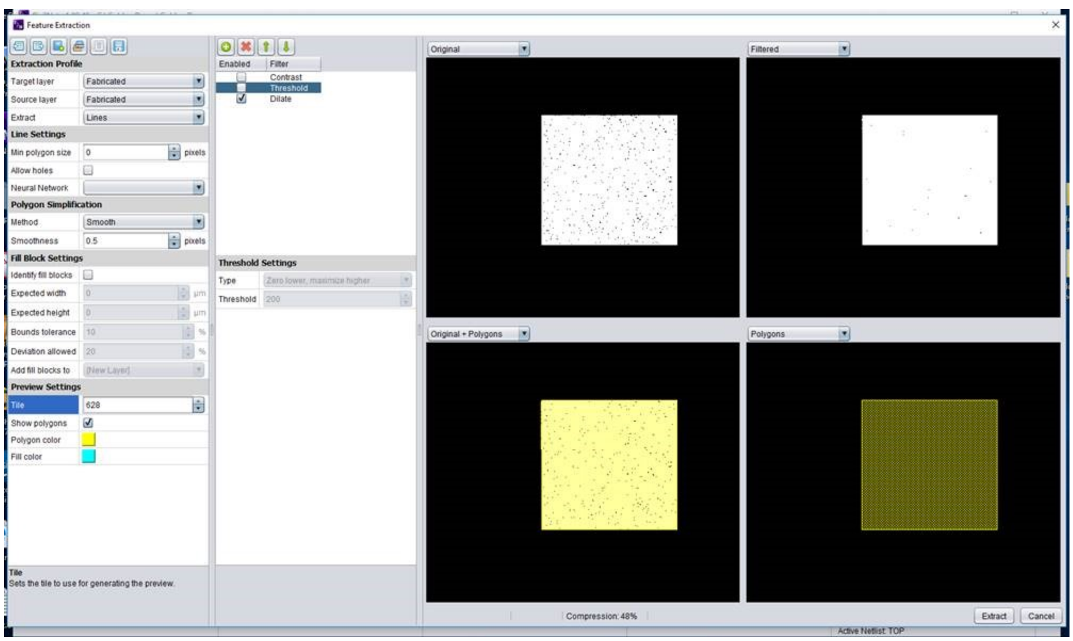
2.9.1 Filtering and Edge Detection

1. Before starting, make sure that the example Pix2Net project `Digital Logic` is opened
2. Turn on the example layer that was created in the importing and stitching section of the tutorial
3. Go into the image tab and press `Extract Polygons`

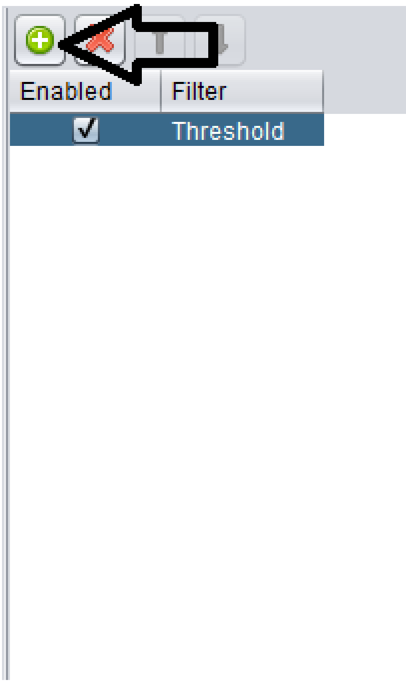
4. A feature extraction window will open



5. Make sure to check `Show polygons` and that under extract `lines` is selected (select vias when extracting vias). The polygons will appear in the bottom left and right hand corners of the window.
6. If large lines or squares do not convert to polygons, it's due to small voids in the material. If you use a dilate filter it fixes the problem. see *Filters*

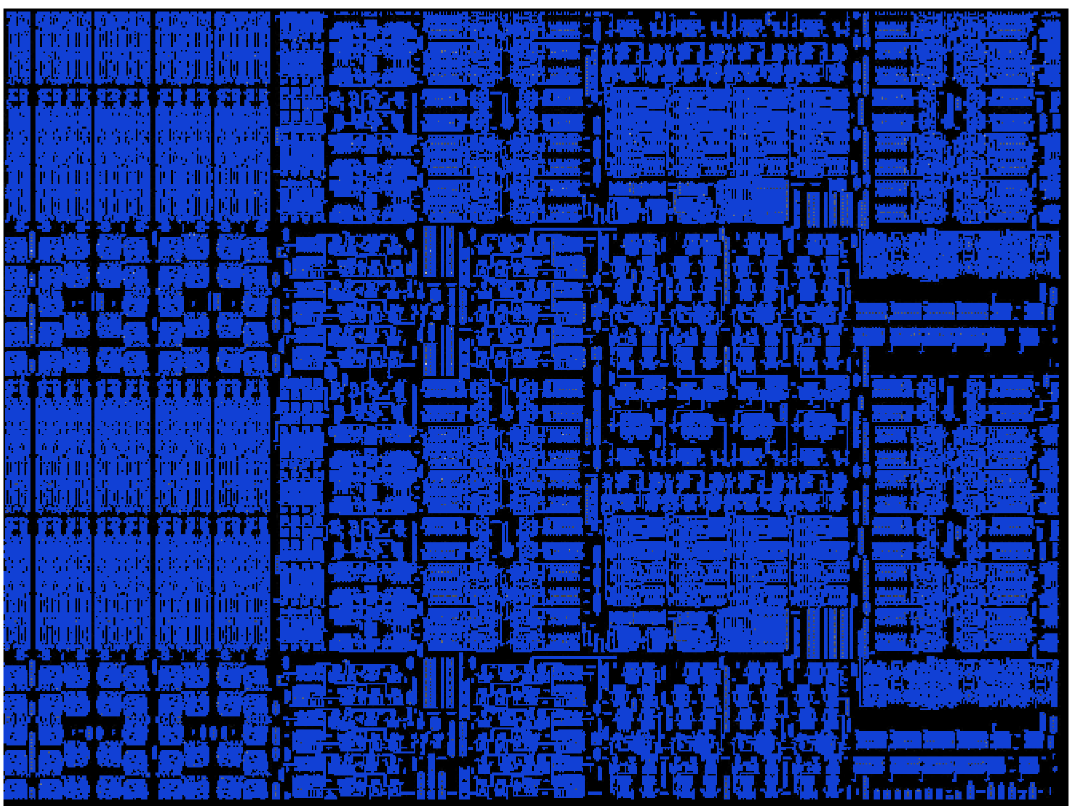


7. Look around at the polygons to make sure that there is no bridging or open spaces. Do this by looking at different tiles to check how the polygons will look when extracted
8. The extraction will not always be 100% accurate, so the user may have to put a filter



9. There are many different filters that each have a unique way in helping extract the polygons to make the image look better.

10. Once the polygons in the feature extraction look like they are ready, press the extract button.

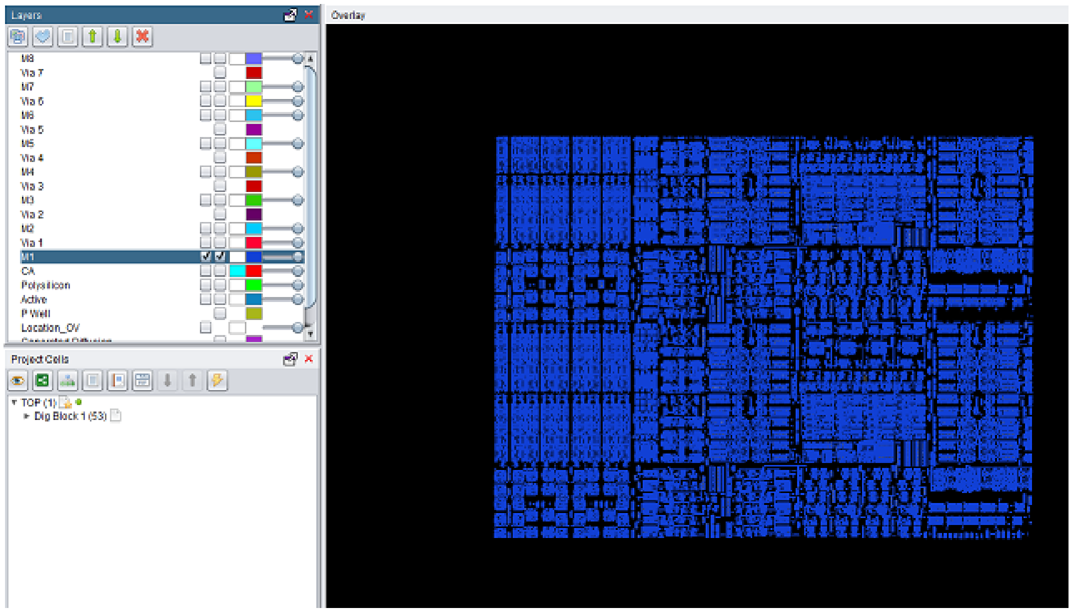


2.9.2 Neural Network

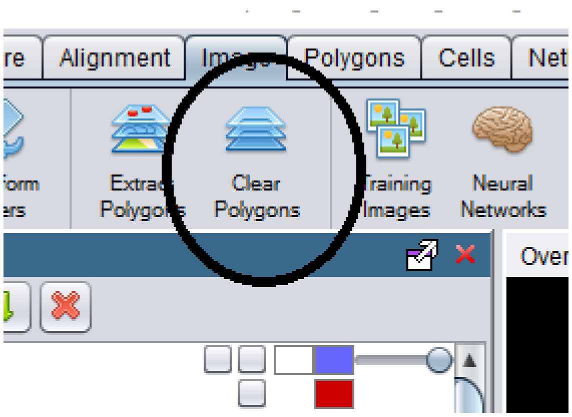
Before starting create a restore point for the project. *Add Restore Point*

Neural networking allows the Pix2Net program

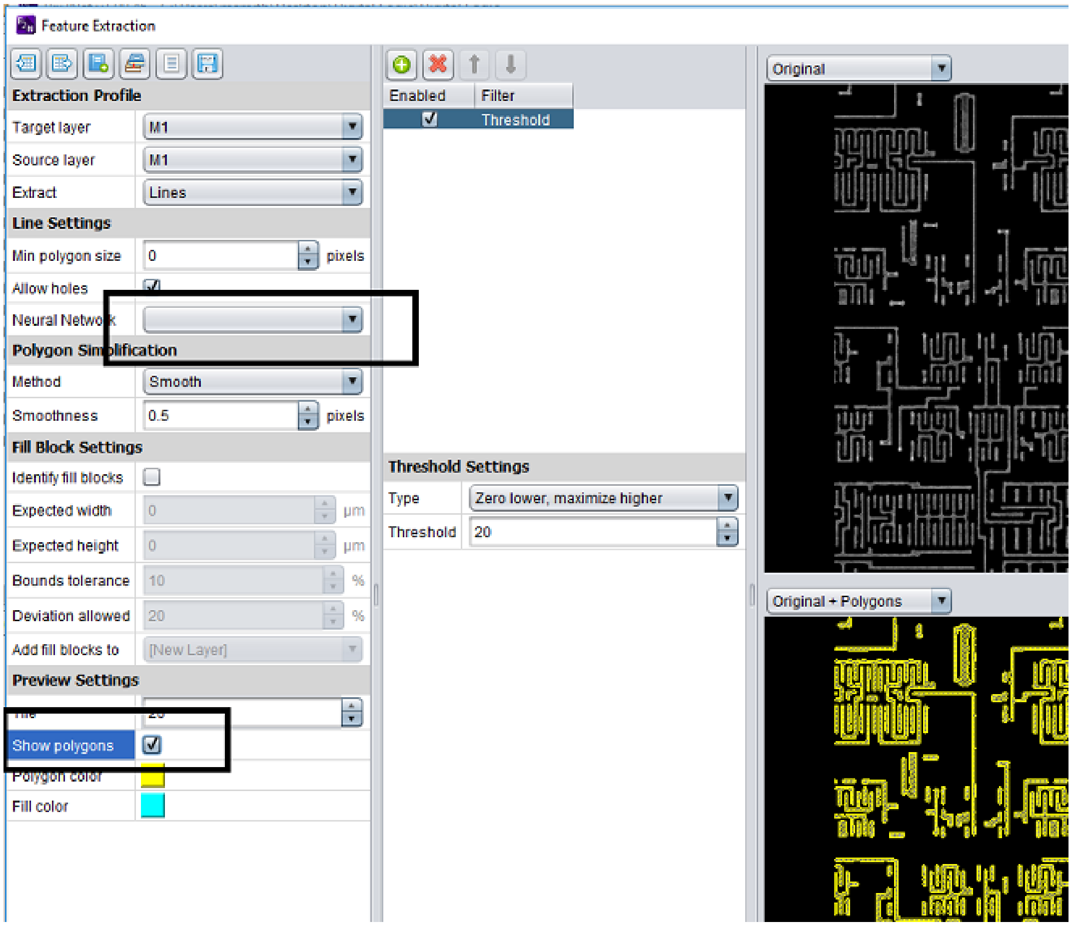
1. Select image layer for extraction - for this training exercise, choose M1.



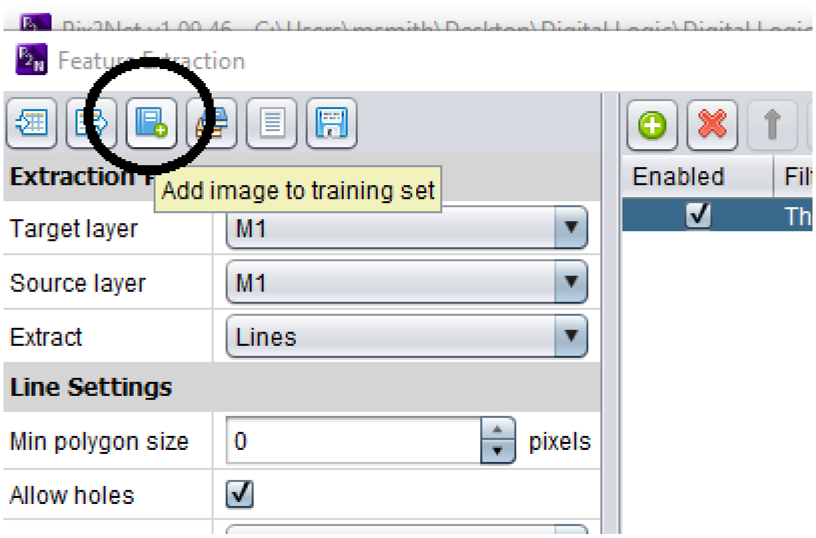
2. Under the "Image" tab, select "Clear Polygons". NOTE: Before confirming deletion of polygons, create a restore point.

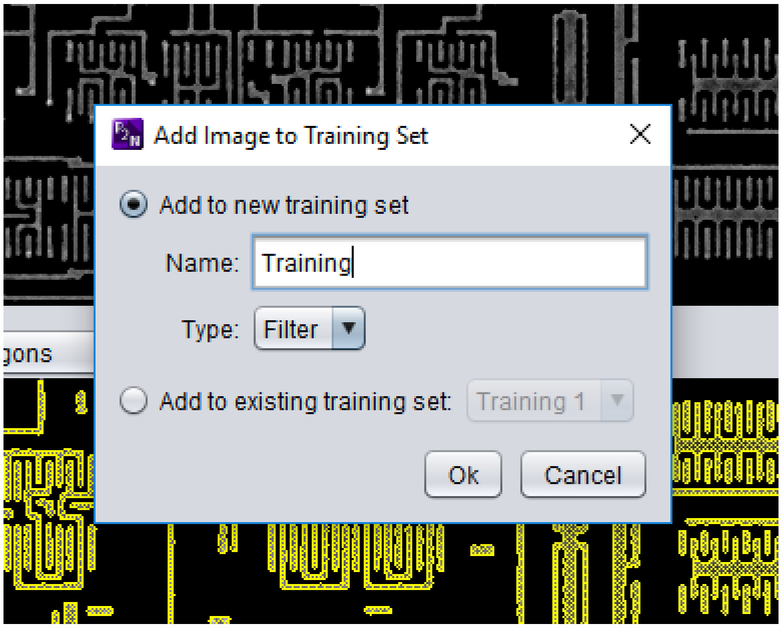


3. After polygons are cleared, select "Extract Polygons". Neural Network drop down under "Line Settings" should be blank. Select "Show Polygons" should be checked.

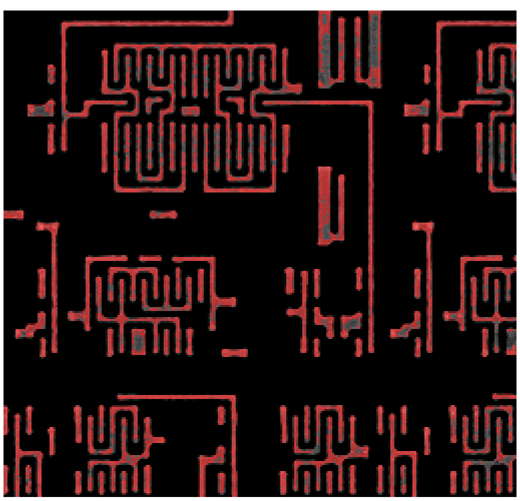


4. Select "Add Image to Training Set". Enter "Training" to name. "Type" should be on filter (filter=lines, vias=vias).

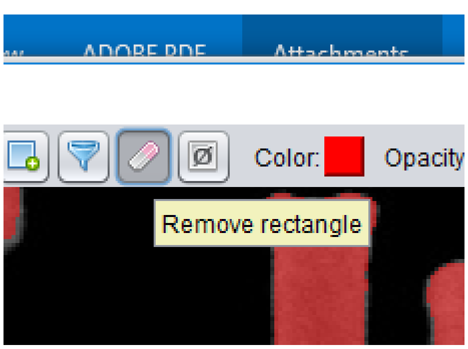


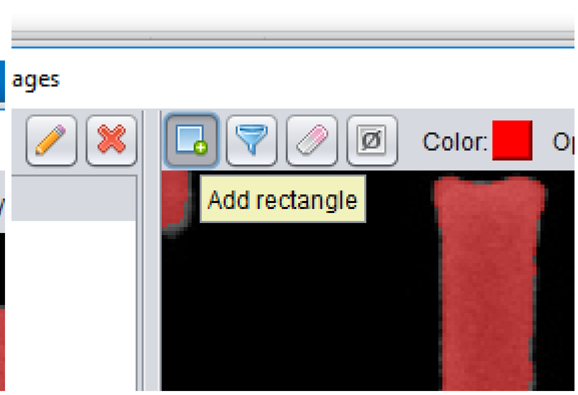


5. Clean up image (training exercise doesn't allow this, but these examples show what would need to be cleaned up).

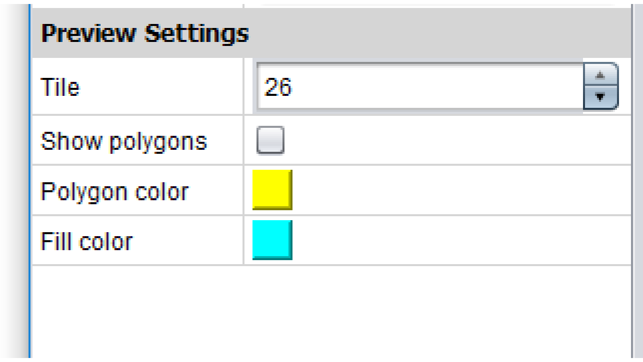


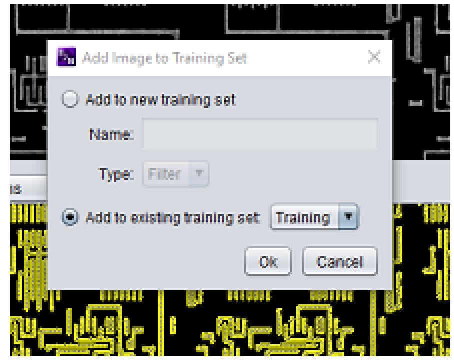
6. There is a "erase" and "add" tool to help with the cleanup.



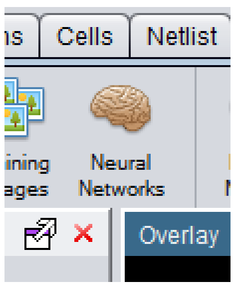


7. Once the image is cleaned - select close.
8. Choose another image by entering a new tile number into the "Preview Settings". Select "Add Image to Training Set", but this time select "Add to existing training set" and select set that was created.



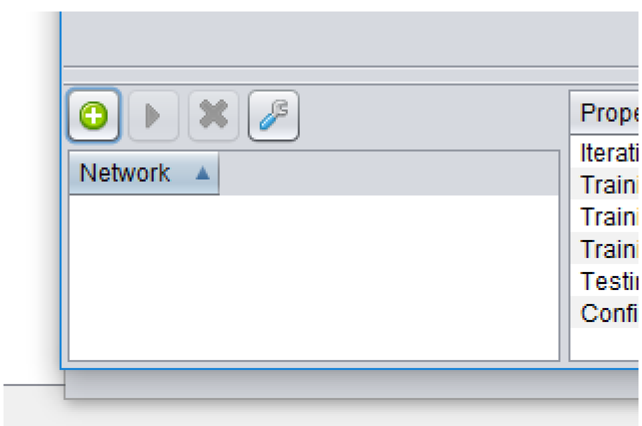


9. Clean up image and continue the process until there is a minimum of 3 images in the training set.
10. Select "Cancel" - do not click "Extract".
11. Select the "Neural Network" icon.

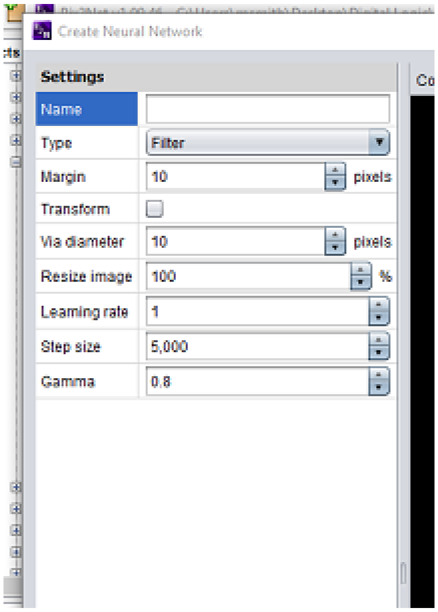


NOTE: At this point the user will need a computer with CUDA (Compute Unified Device Architecture).

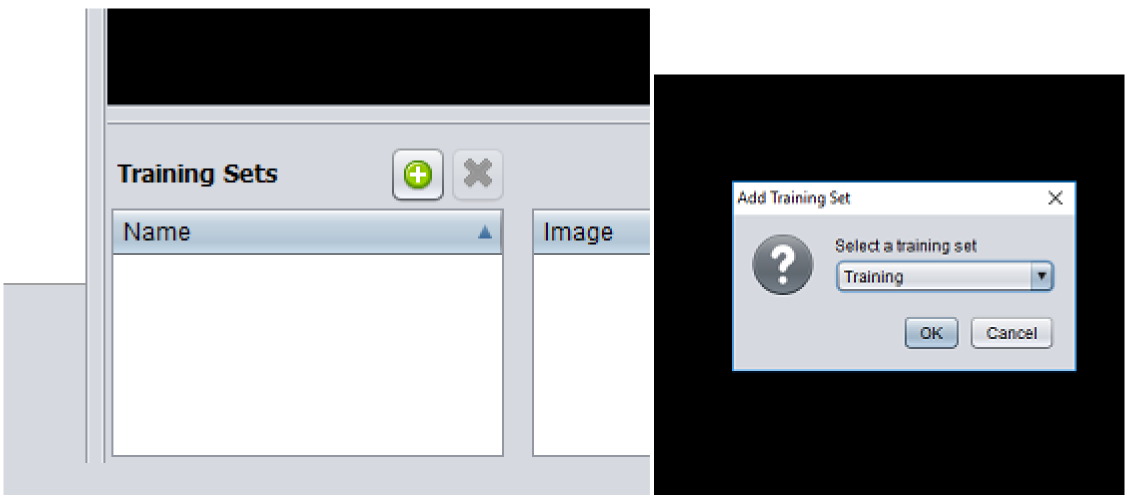
12. Click "+" to add neural network



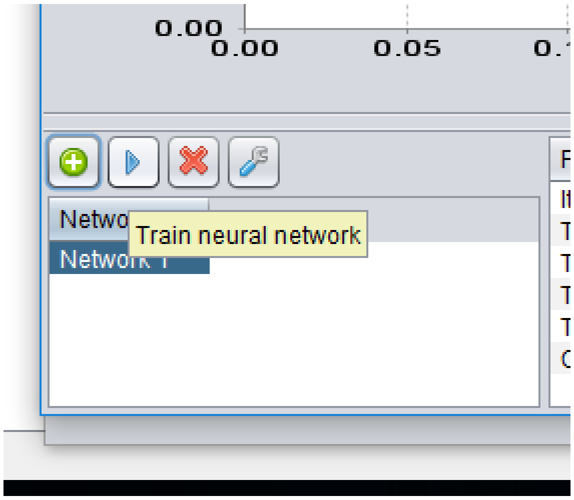
13. Name the neural network. Adjust the settings for the demo to the following: Resize image to 50% and Step Size to 500.



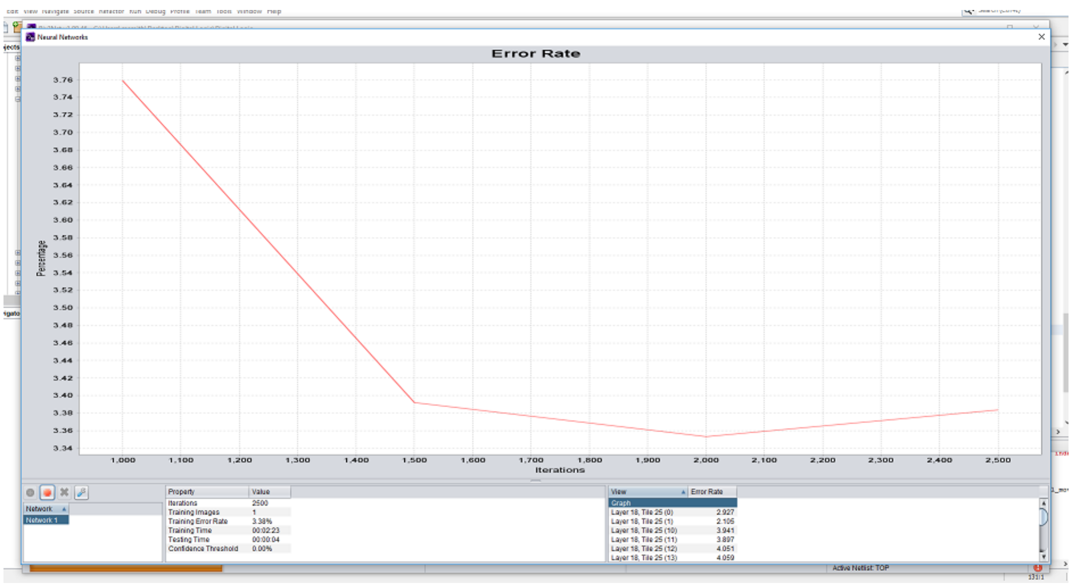
14. In the Training Sets window click "+". Select the training set that was cleaned up in the extract window.

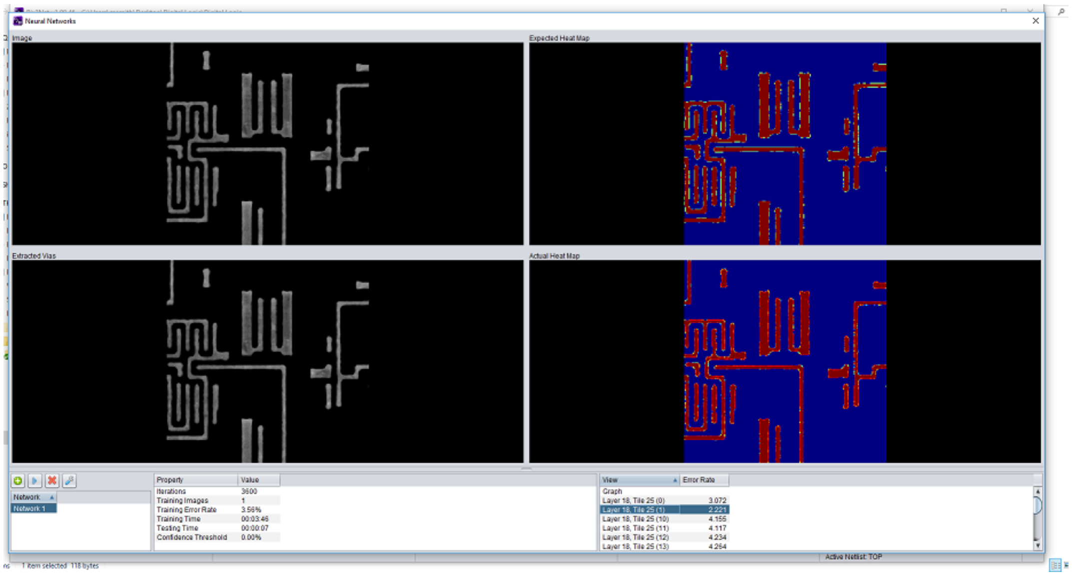


15. "Create". On the next pop-window, select the neural network that was just created and click the "Train Neural Network".

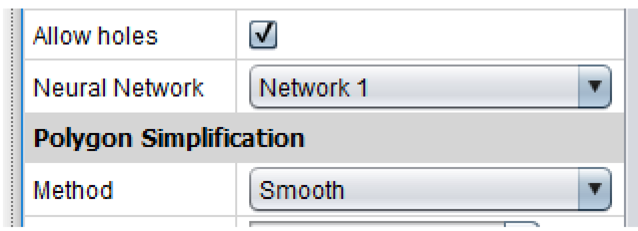


Neural Network should run until the results hover around 1% or lower, or until the results stop getting better.

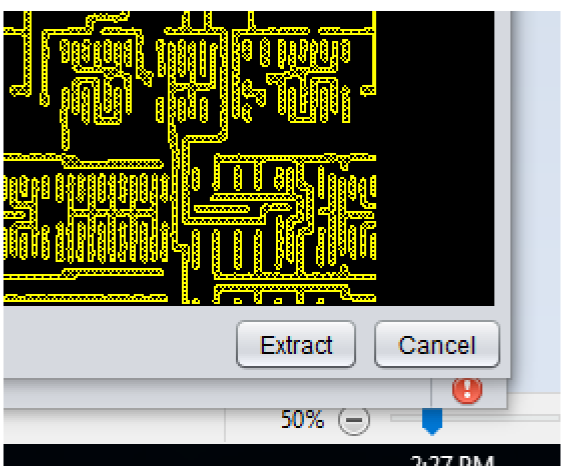




16. Click "Stop". Close window. Choose the "Extract Polygons" icon in the tool bar.
17. Under "Line Settings" select the Neural Network created for the training.



18. Click "Extract".



2.9.3 More Details About Extracting

For more information on extracting polygons, extracting only vias, filters, and more, please see *Extract Polygons*.

2.10 Synchronization

2.10.1 Synchronize Mode

Synchronization mode must be turned on if you are doing collaboration and you are not the master project.

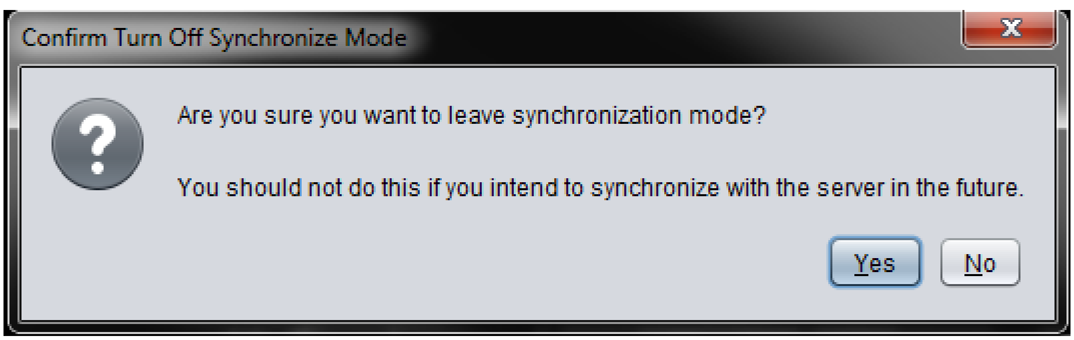
When highlighted any commands that are not recognized by the synchronization system will be grayed out.

2.10.2 Synchronize

Synchronize is intended to divide up the work on the project. Start with a project that has layers stitched, aligned and polygons extracted. Archive the project (*Recovery System*) then make as many copies as desired of this *master* project.

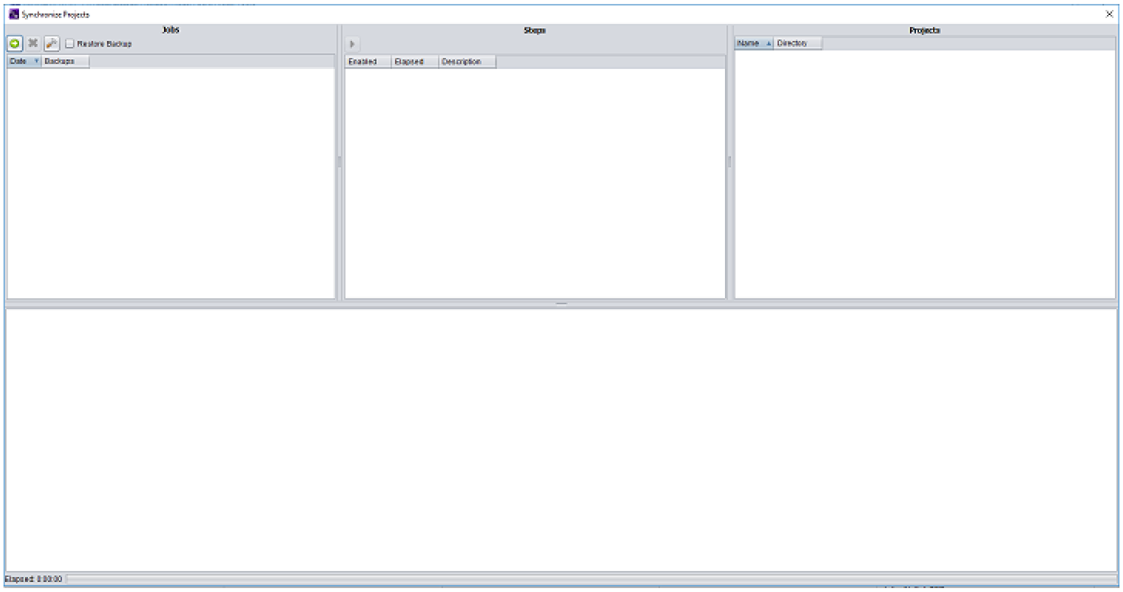
The designated master project may perform any operations. All of the copy projects should click on the *Synchronize Mode* icon to prevent performing operations that do not synchronize. The icon will be highlighted as shown:

To exit synchronize mode, click the *Synchronize Mode* icon again. The following confirmation will appear:

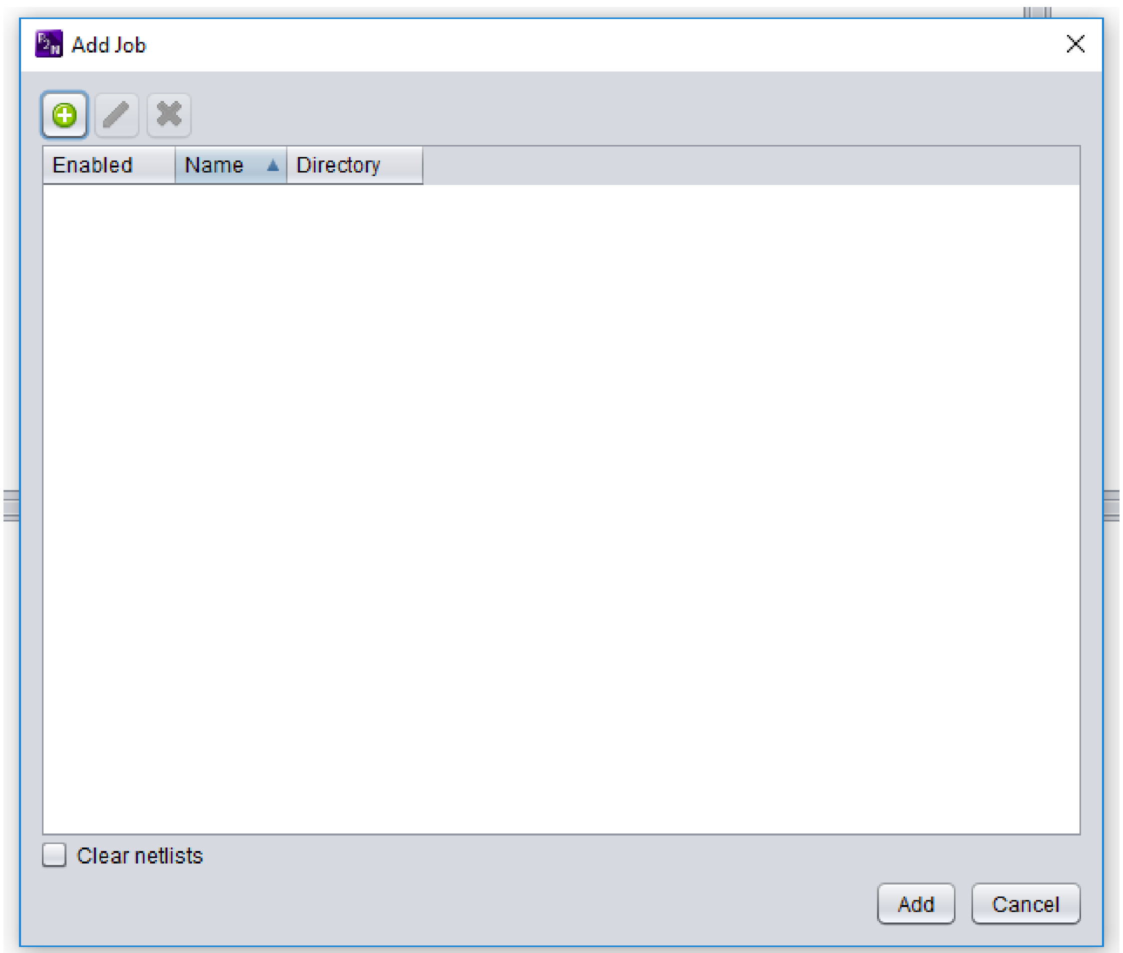


When ready to synchronize a copy project, click the *Synchronize* icon. You must have the "Master" project opened.

This will bring up the Sychronize Projects window. Click on the *Add* button to Add New Job.

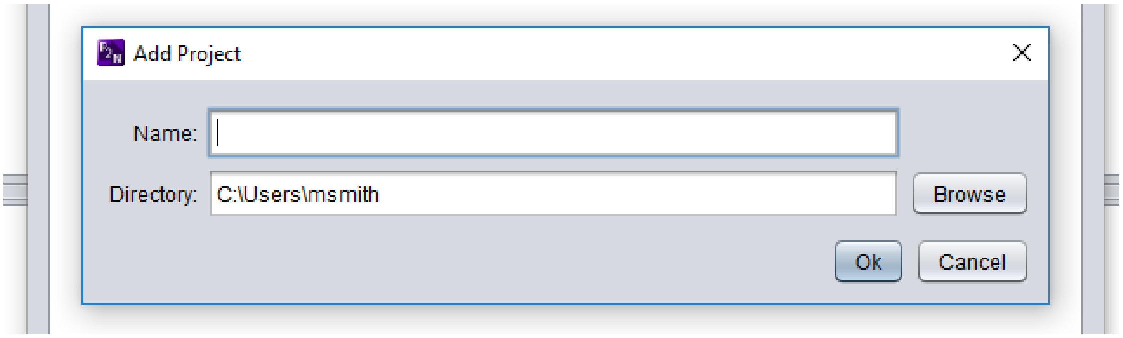


Click *Add* again to Add Project.

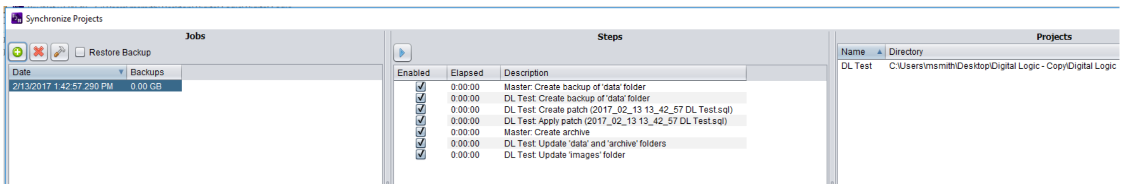


Name is the identifier for the instance of the project. This is for user reference and is arbitrary.

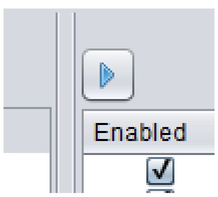
Directory should be the file system or network path to the Pix2Net project file.



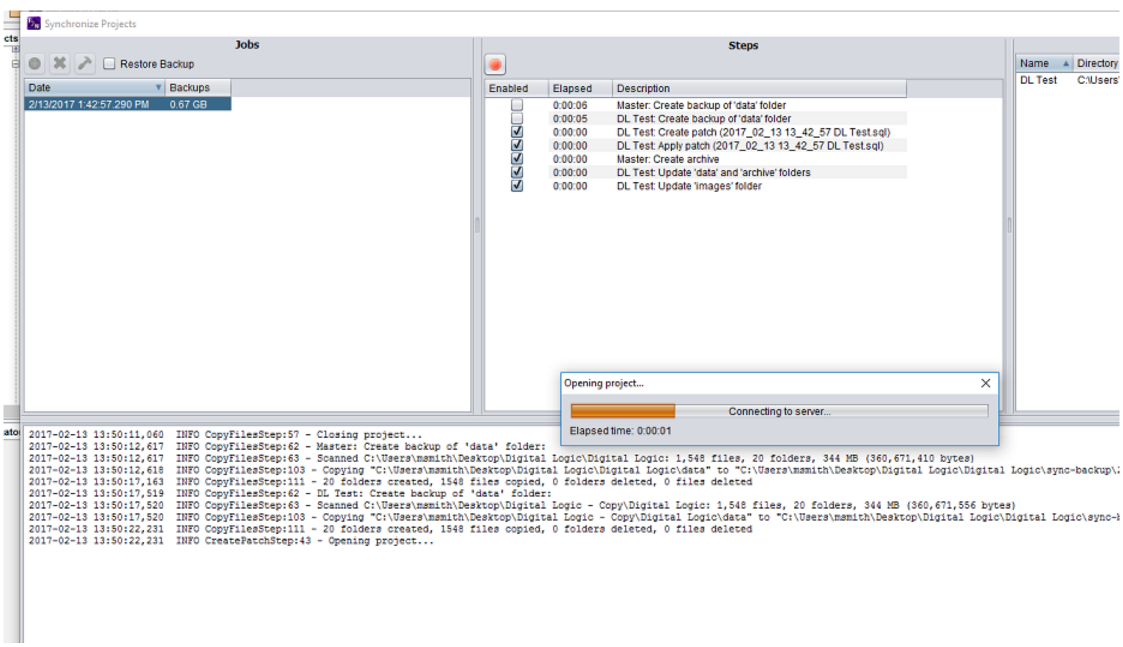
Synchronization job will be created.



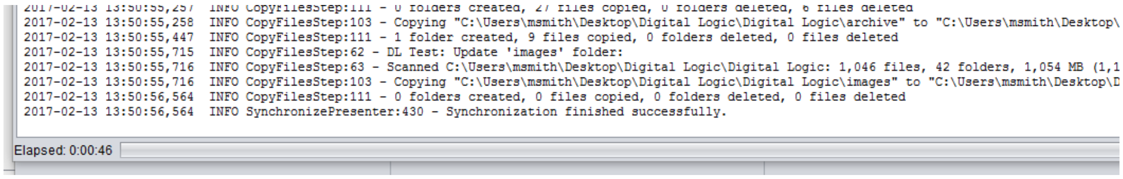
Click *Run*.



Sync process will vary from project to project, depending on file size.



Pix2Net will confirm successful synchronization.

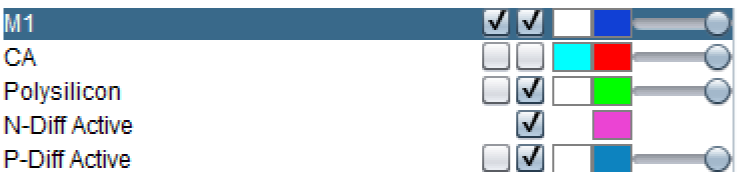


2.11 Identify Cells by Truth Table

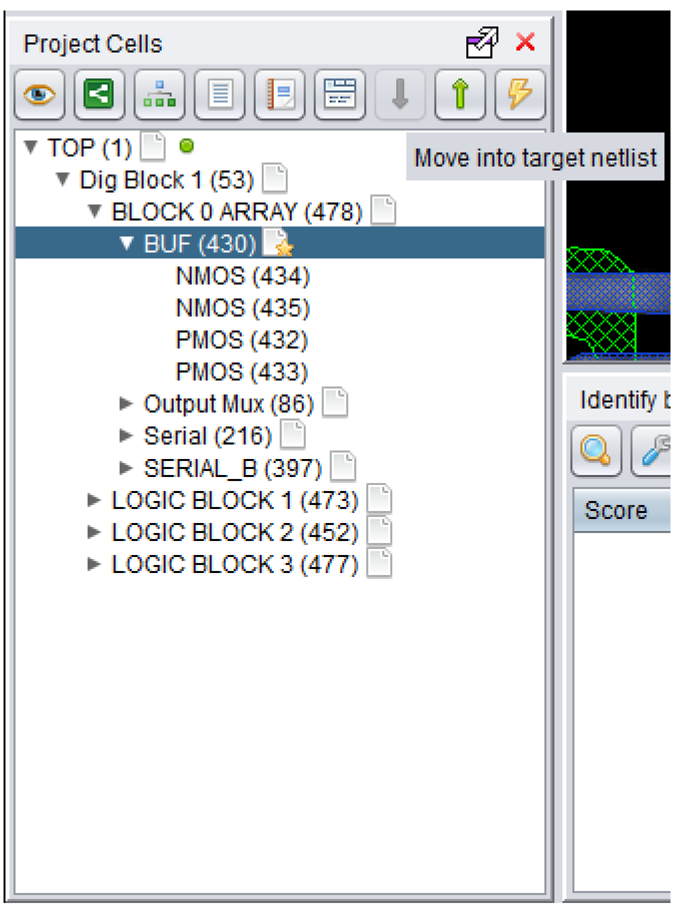
This tutorial will show you how to automatically identify a cell. You will learn how to create a cell and how to use the cell identifier.

2.11.1 Creating the Cell

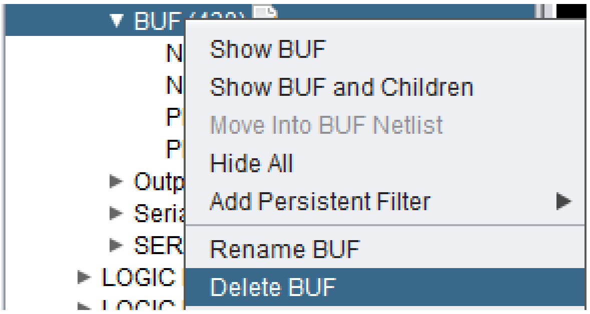
1. In the Layers window, turn on the `m1` image layer.



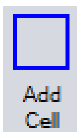
2. In the `Project Cells` window, click the down arrow on dig block, block 0 array, and then buf. Then, click the down arrow in the window that moves the user into the target netlist.



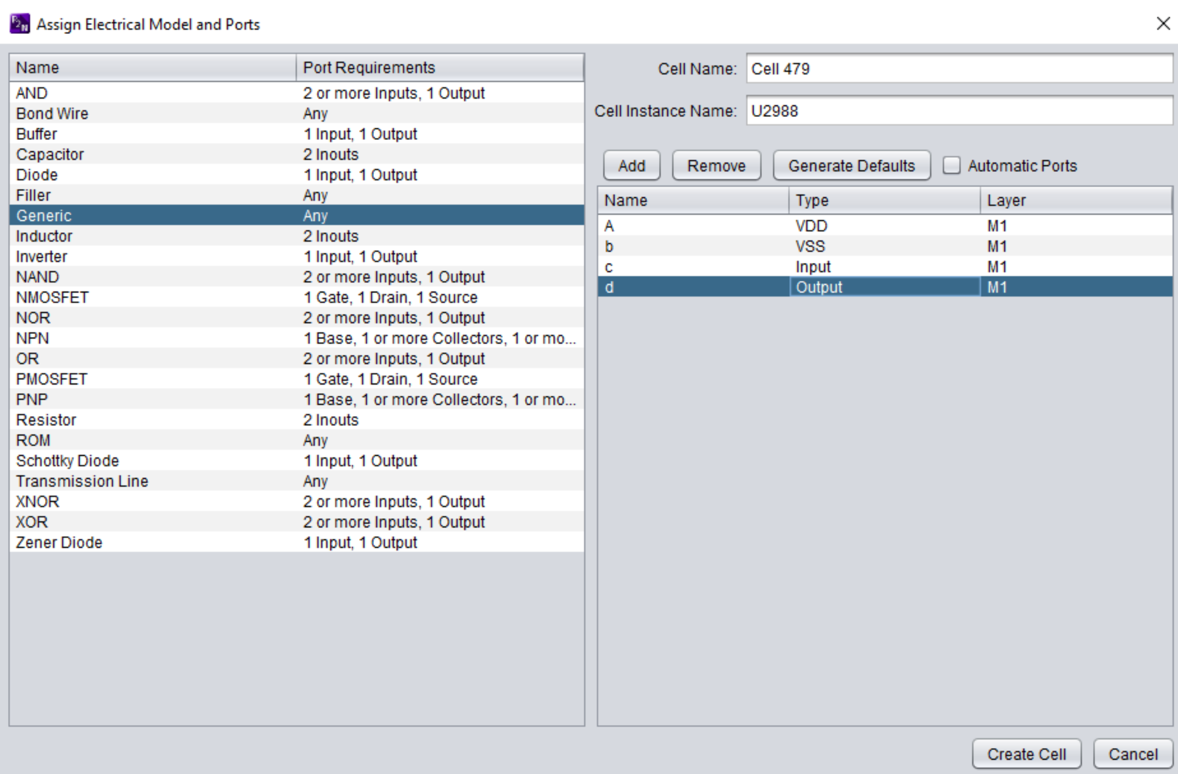
3. Remove the old cell. In the `Project Cells` window, right-click on BUF (430), and choose `Delete BUF`.



4. Go to the `Cells` tab and click `Add Cell`.



5. Click-and-drag to add a new cell and a window like this will appear:



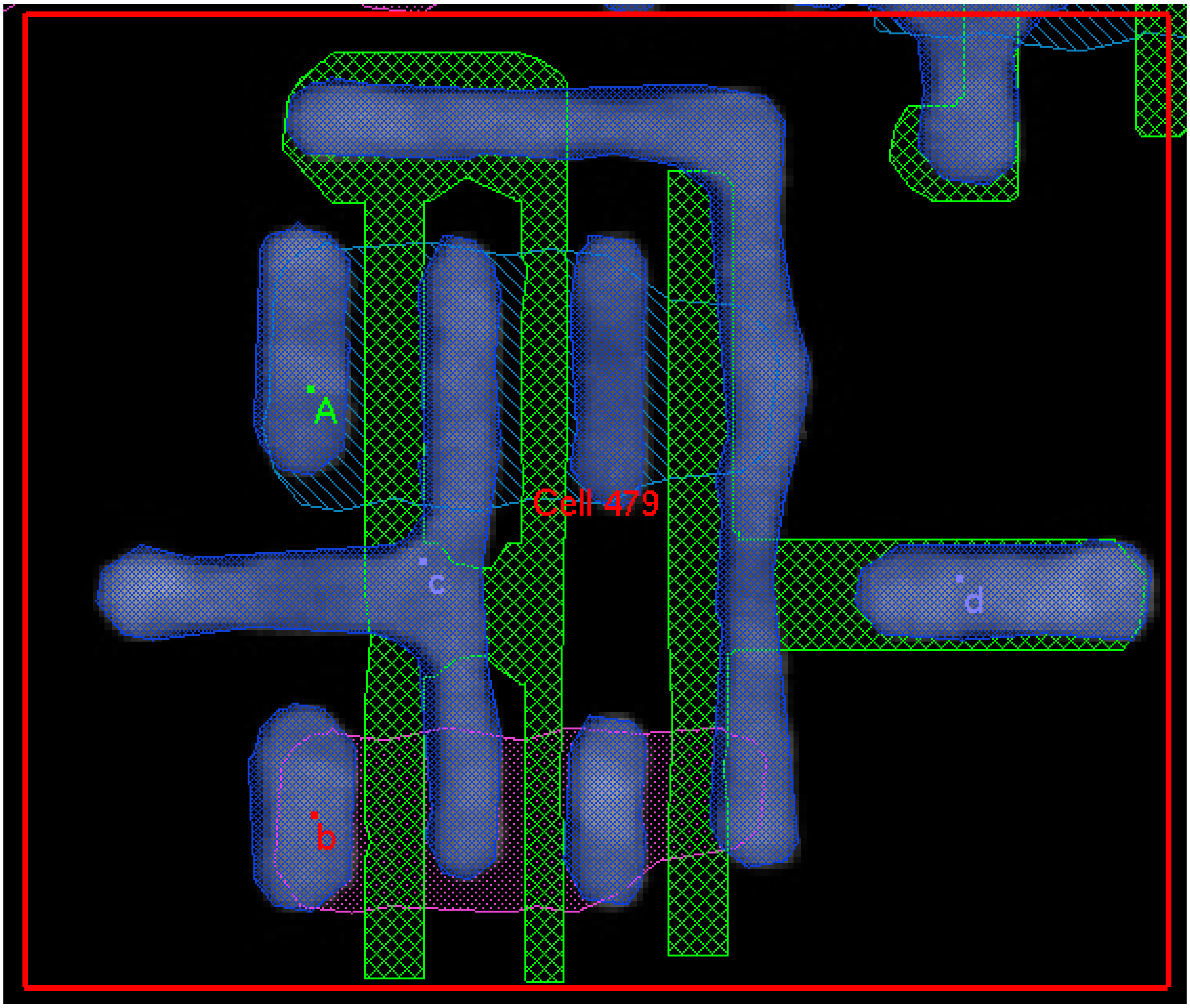
6. Make sure that Automatic ports are turned off and then press `add` four times

7. Next, name the ports A, B, C, and D, and their types as VDD, VSS, input, and output, respectfully.

8. Click `create cell`.

9. Make sure that once the cell is created, in project manager the cell visibility button has `show port names` checked.

10. Now, move A, B, C, and D into the following spots:

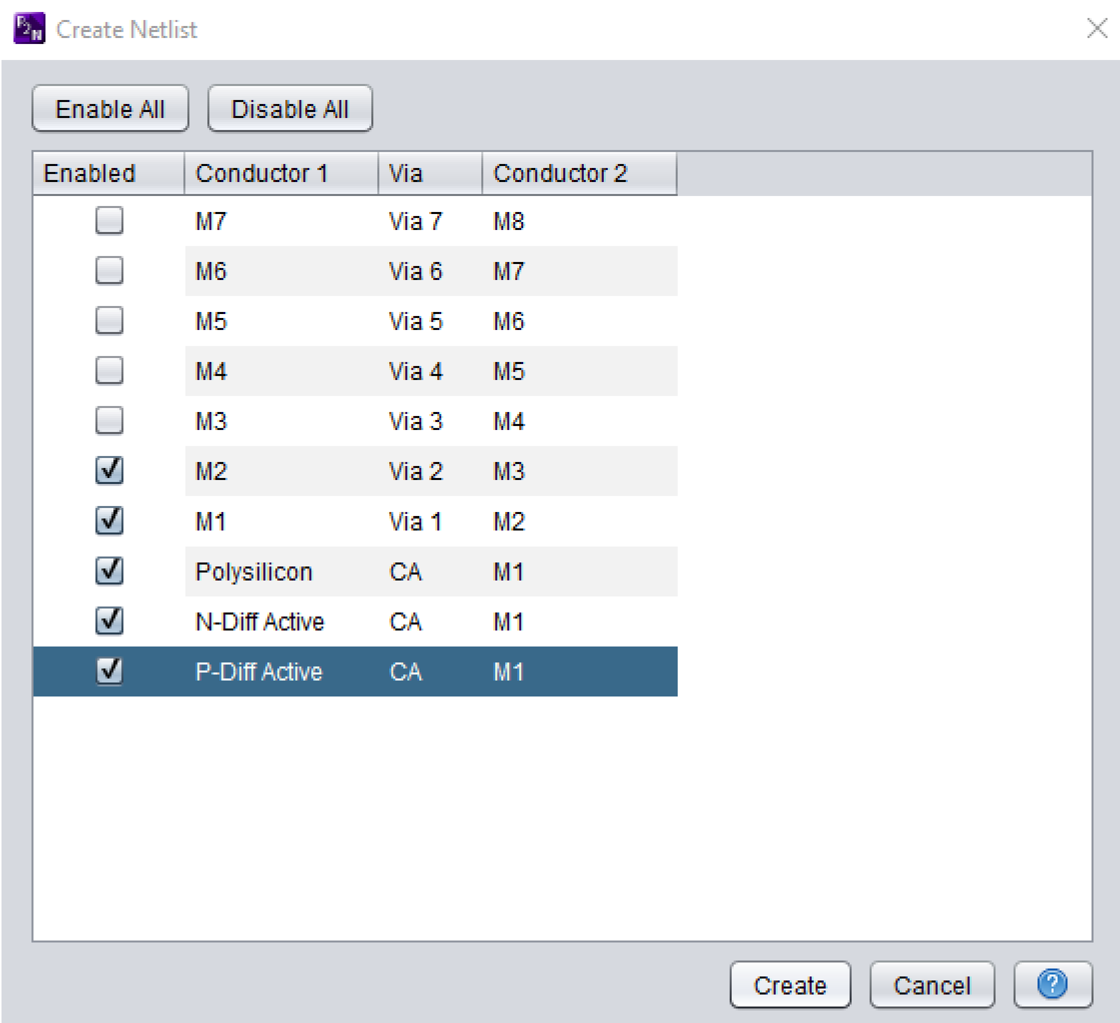


2.11.2 Creating the Netlist

1. Open the `Netlist` tab click `Create Netlist`.

2. In the `Create Netlist` window click `M2, M1, Polysilicon, N-Diff Active, and P-Diff Active` to include all layers in this cell.

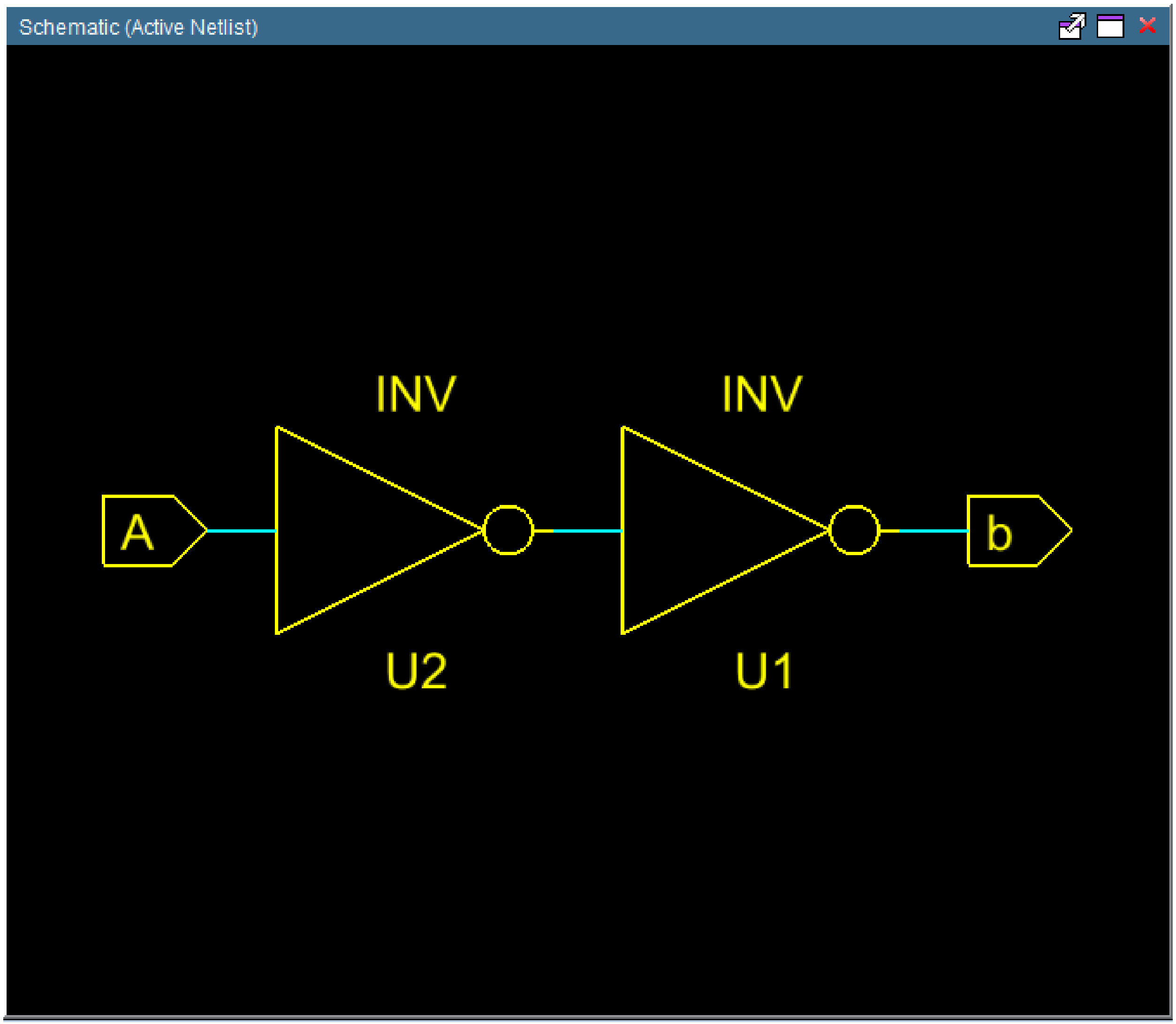


3. Click `Create` to have the software generate the netlist for this cell.

2.11.3 Identifying a Cell

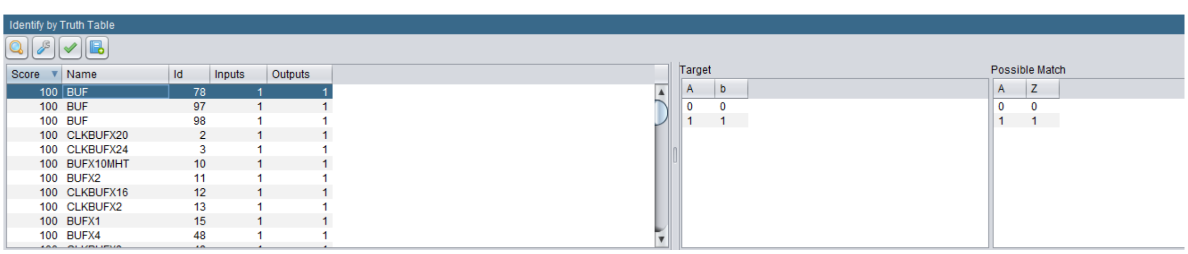
1. In the `Netlist` tab, click the `Find Transistors` button then `Find`. This process will identify and place all of the transistors.

2. Now make sure that everything looks good. Press `Show Schematic` and a window like this should appear:

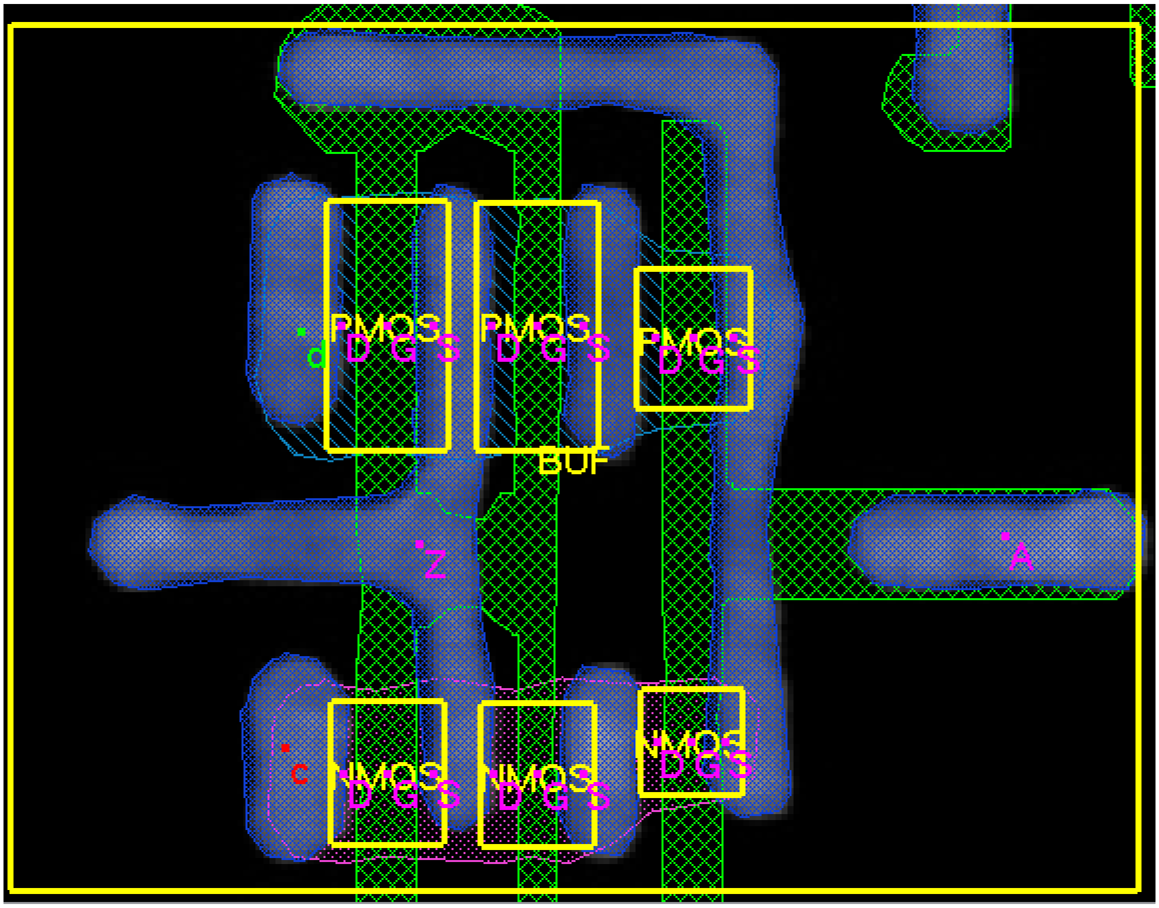


1. After the transistors have been placed the software can browse the reference library to see if an instance of this cell has already been cataloged. To do this click `Identify by Truth Table`.

2. If the cell found a match a window will pop out giving you the option to keep the cell name, ports and the schematic image identical to the instance in the reference library. Click on the first BUF and then press the green checkmark to confirm, then press `copy`.



3. The user will see that the Pix2Net changed the cell to what it should be officially identified as



1. Go to the `File` tab and click `Recovery System`. Restore the backup of the project to undo your changes.

2.12 Adding a Cell and Searching for its Instances

This tutorial will show you how to add a cell and search for its instances.

This tutorial includes the following:

- *Adding the First Cell*

The rest is over the `Digital Logic` project

- *Adding a Cell*
- *Identifying the Cell*
- *Performing a Cell Search*
- *Adding Key Points Manually*
- *Viewing Cell Instances*
- *Editing Cell Instances*

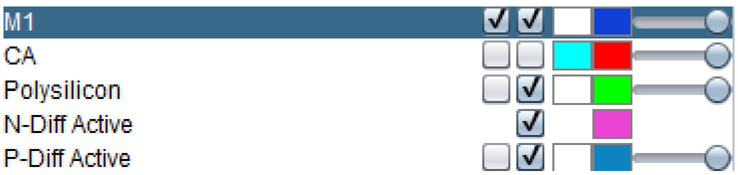
2.12.1 Adding the First Cell

Recommended the user should have cell identification knowledge before placing cells.

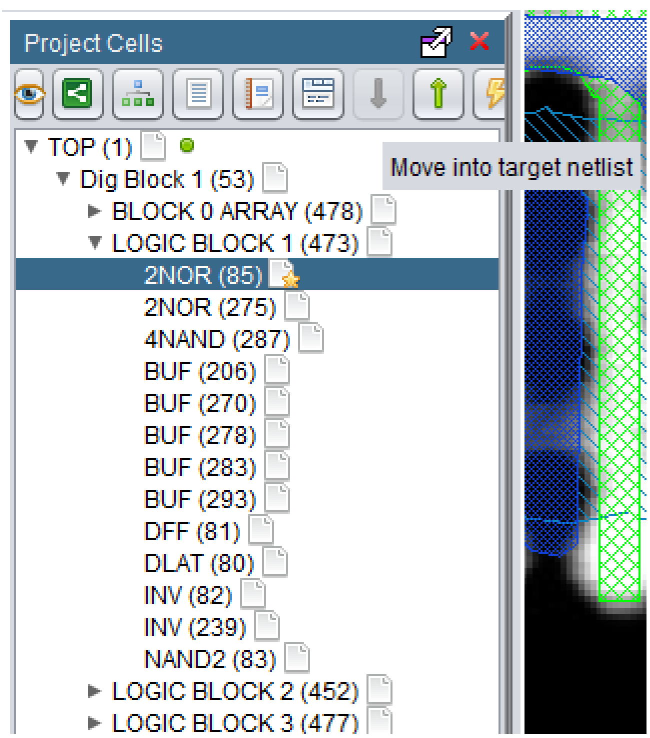
2.12.2 Adding a Cell

1. Open the `Digital Logic` project.
2. Add a restore point so that all changes made in this tutorial can be reverted. To do this click the `Add Restore Point` icon in the `File` tab. Notes can be added to the restore point to keep documentation of the progress.

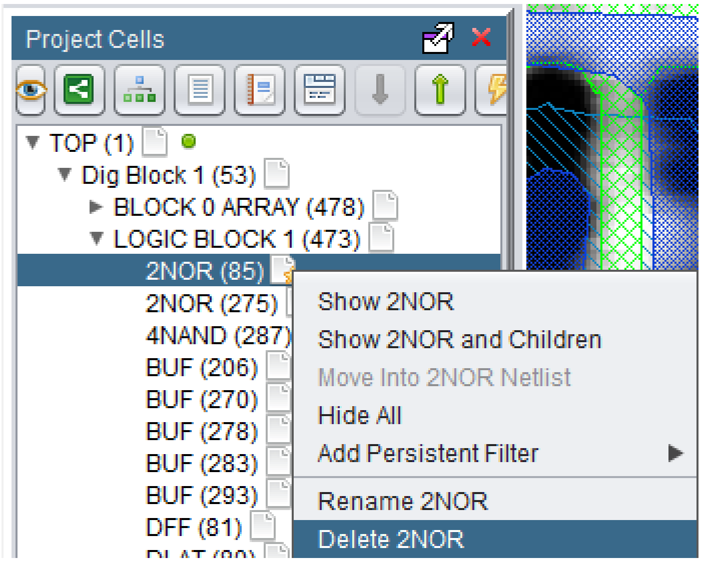
3. In the Layers window, turn on the `m1` image layer.



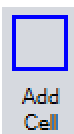
4. In the `Project Cells` window, click the down arrow on Dig Block, Logic Block 1, and then click and highlight 2NOR (85). Then, click the green down arrow in the window; this moves the user into the target netlist.



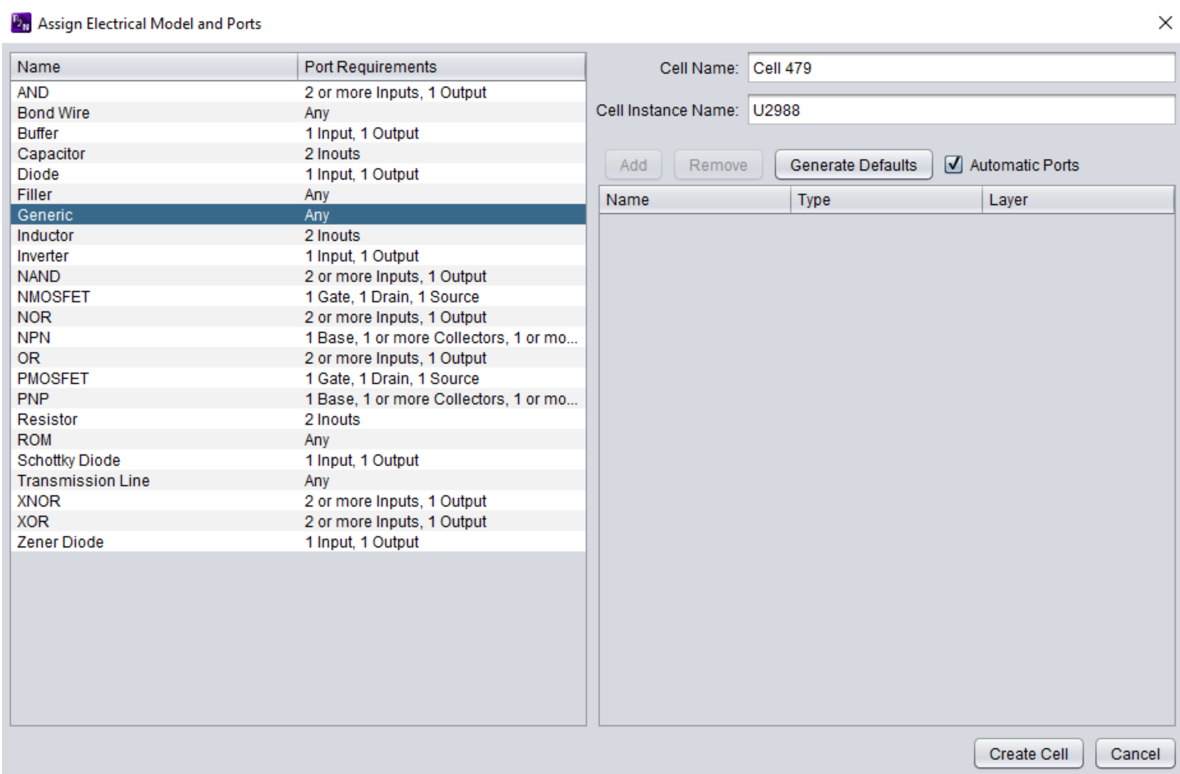
5. Remove the old cell. In the `Project Cells` window, select 2NOR (85) then right click and select `Delete 2NOR`, yes.



6. Next, go to the `Cells` tab and select `Add Cell`. Draw a box over the 2NOR that was just deleted.

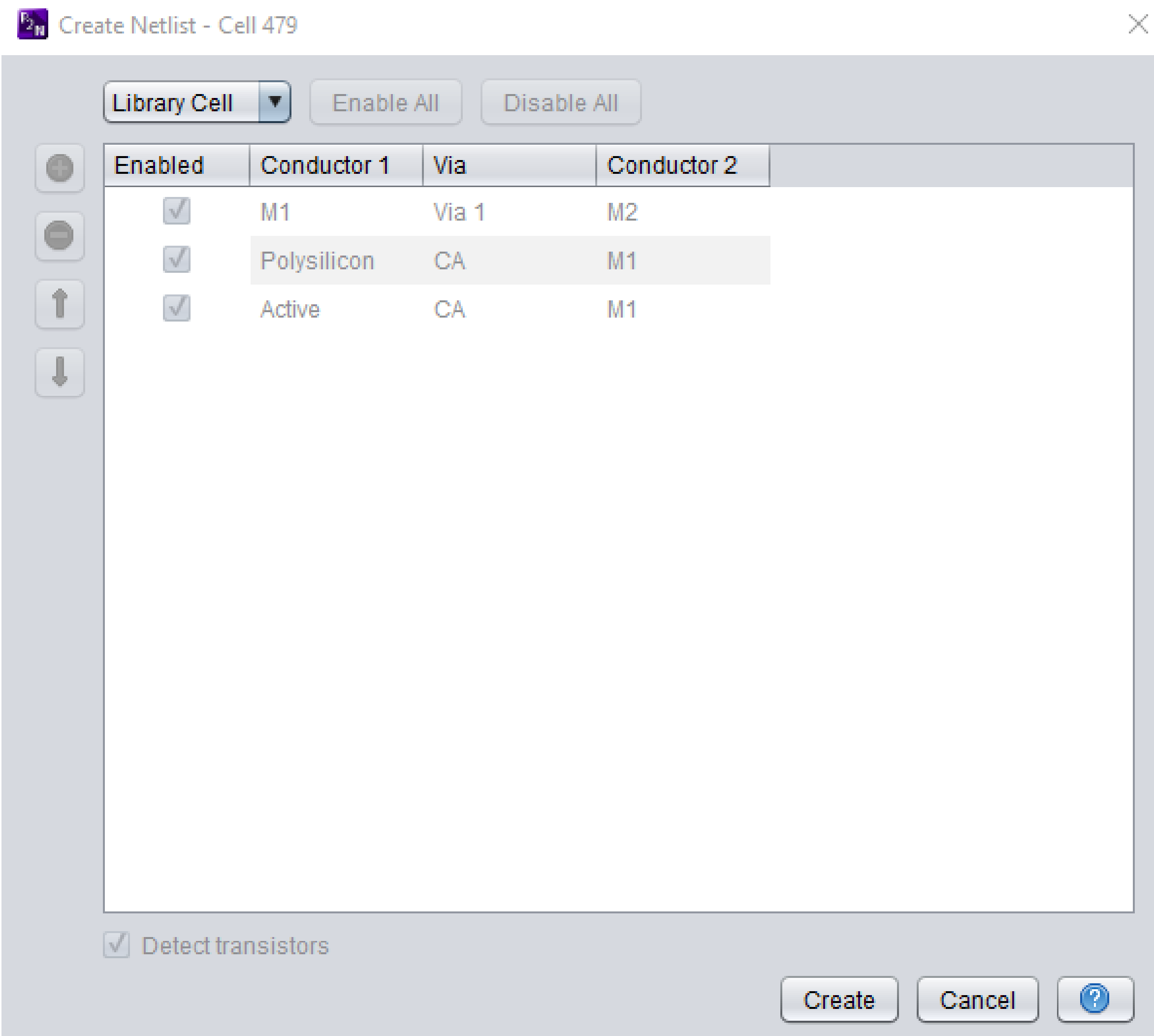


7. A window will pop up, generic should be automatically highlighted. Click `Create Cell`.



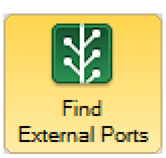
8. While the new cell is selected, press on `Create Netlist`. Library Cell should be selected in the drop down. Active, Polysilicon, and M1 should be enabled and set to correct conductors through the correct vias. Click on `Create` if everything looks correct. If not, the user is able to click on the drop down bar and select `Custom` to

make any changes necessary. It should look like this:



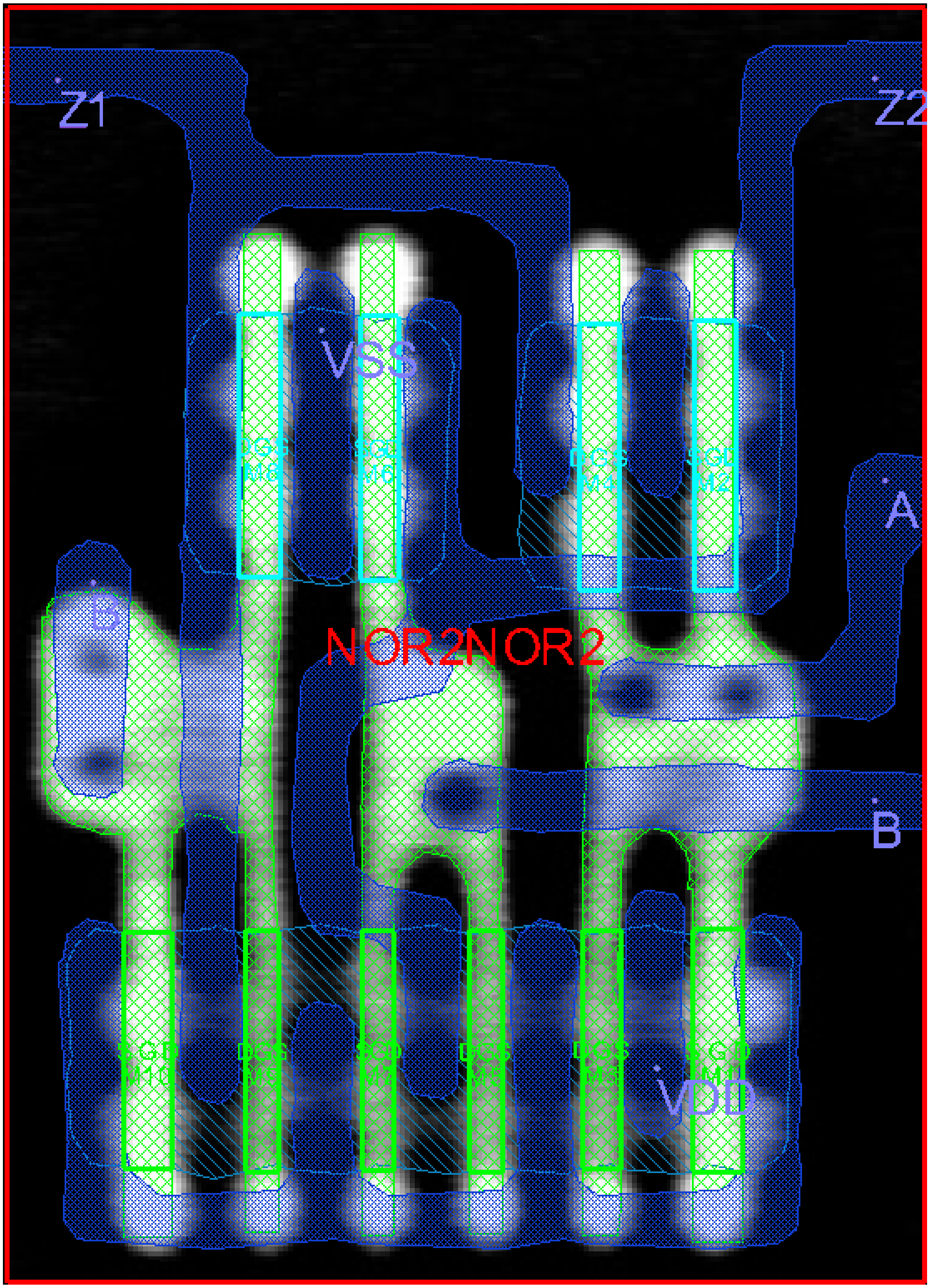
2.12.3 Identifying the Cell

1. Now, click on `Find External Ports`, make sure "Cell type" - "Library Cell" bullet is checked, then select `Find Ports`, and Pix2Net will add the necessary amount of ports onto the cell. (The user can make sure that all the ports are correct by pressing on `Show Schematic` to see how each port is connected.)



2. Next, click on `Identify Cell` and press `Confirm`. Pix2Net will figure out what type of cell it is. In this case, there is a NOR2NOR2, or a 2NOR.

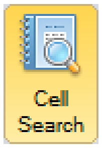

Identify
Cell


Z1
Z2
VSS
A
B
NOR2NOR2
B
VDD

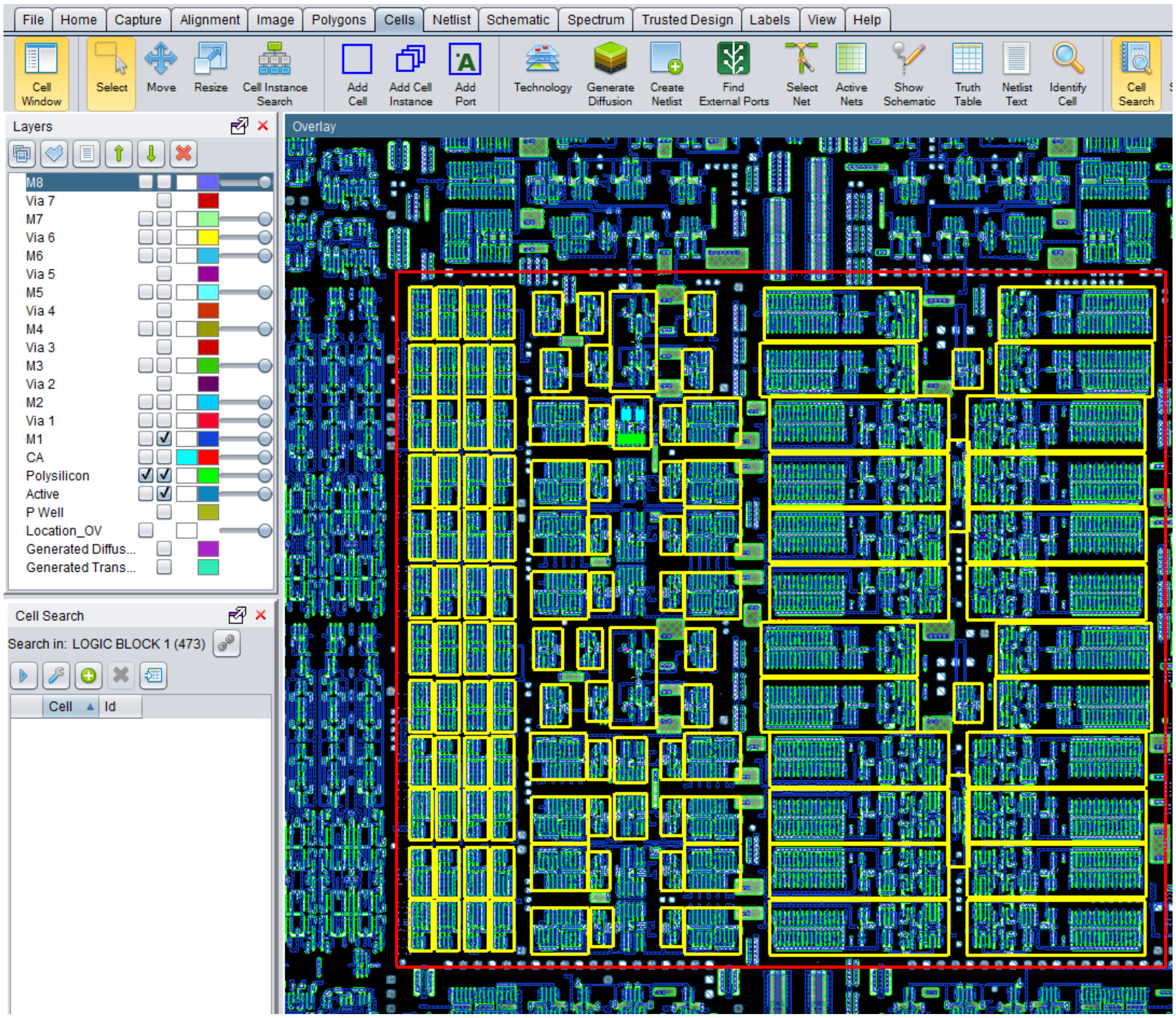
2.12.4 Performing a Cell Search

Now that there has been an identified cell within Logic Block 1, the user is able to find all the other cells exactly like the cell that was just created.

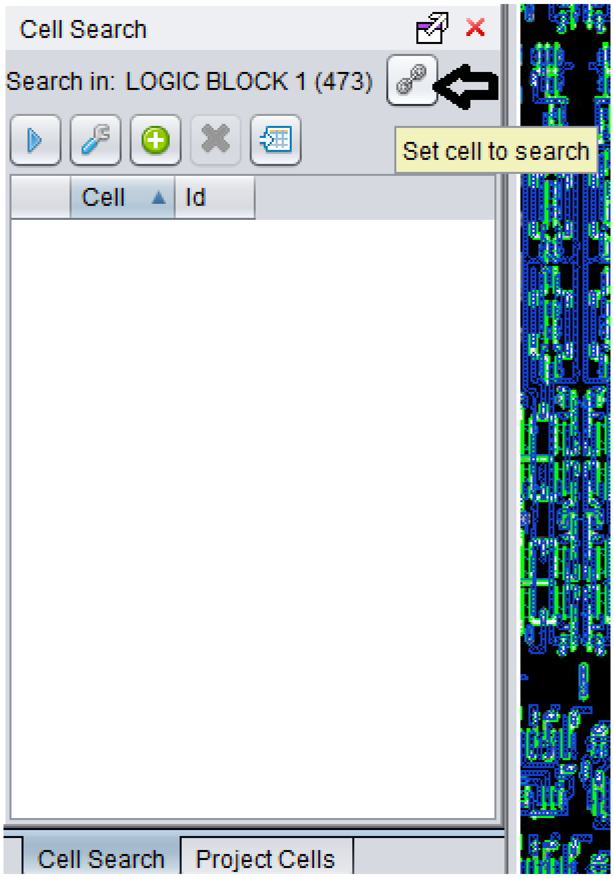
1. Click `Cell Search`.



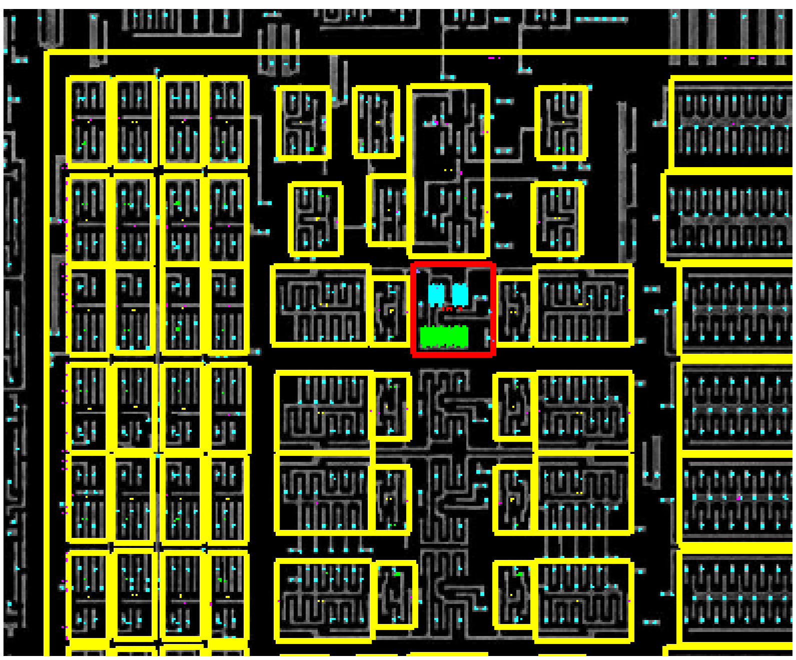
2. Select the whole Logic Block 1 cell by having select highlighted, and then clicking once inside the cell (where there are no other cells).



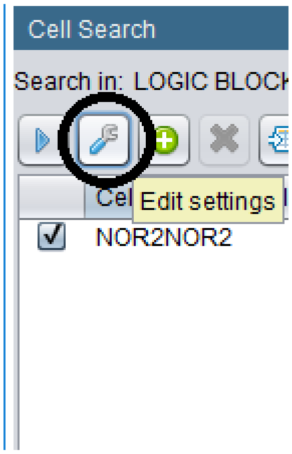
3. In the Cell Search window, press on the Cell Link icon to tell Pix2Net to search in the area selected. In this case, it is Logic Block 1



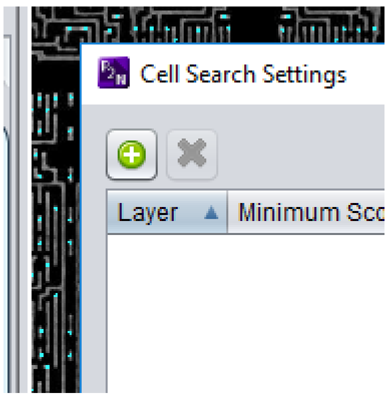
4. Go to the 2NOR and select it and then press the green plus button to add it to the cell search and click on 2NOR to highlight it.



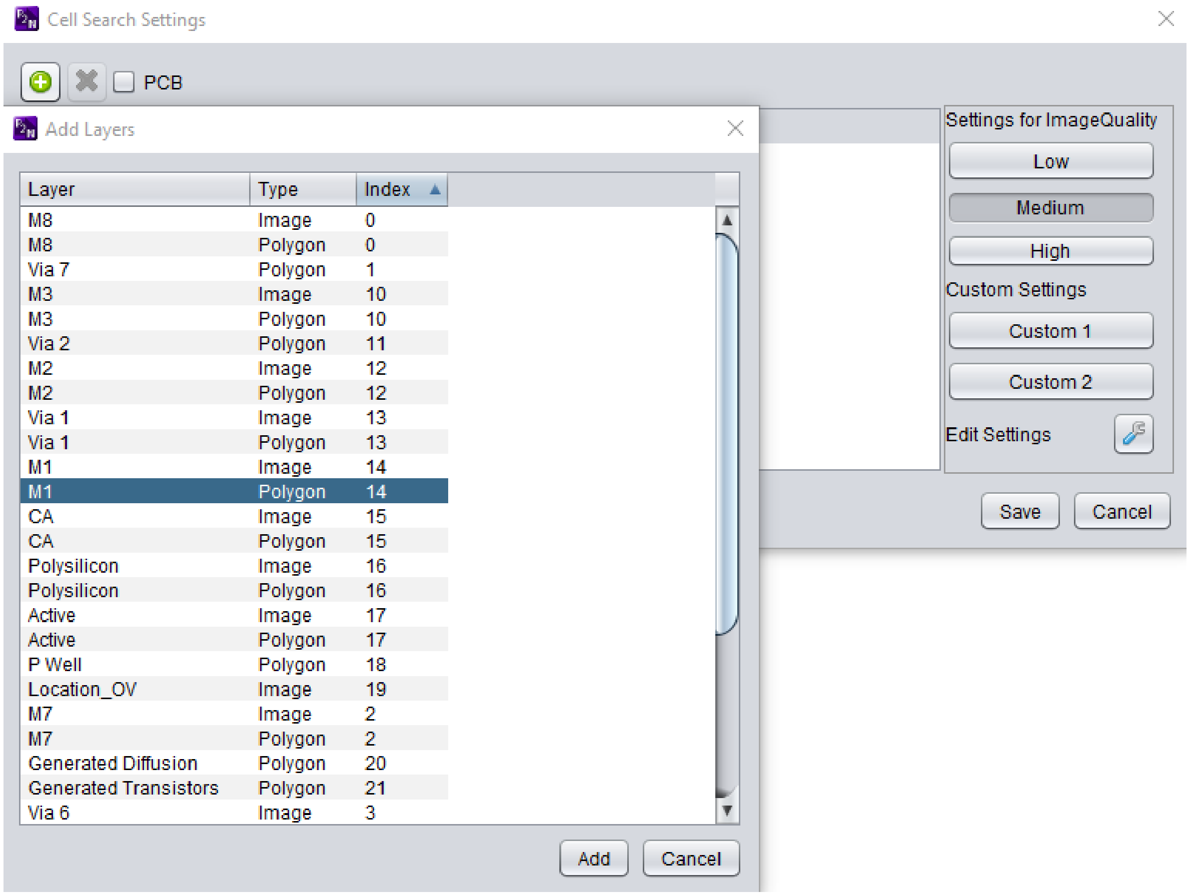
5. Open Cell Search Settings.



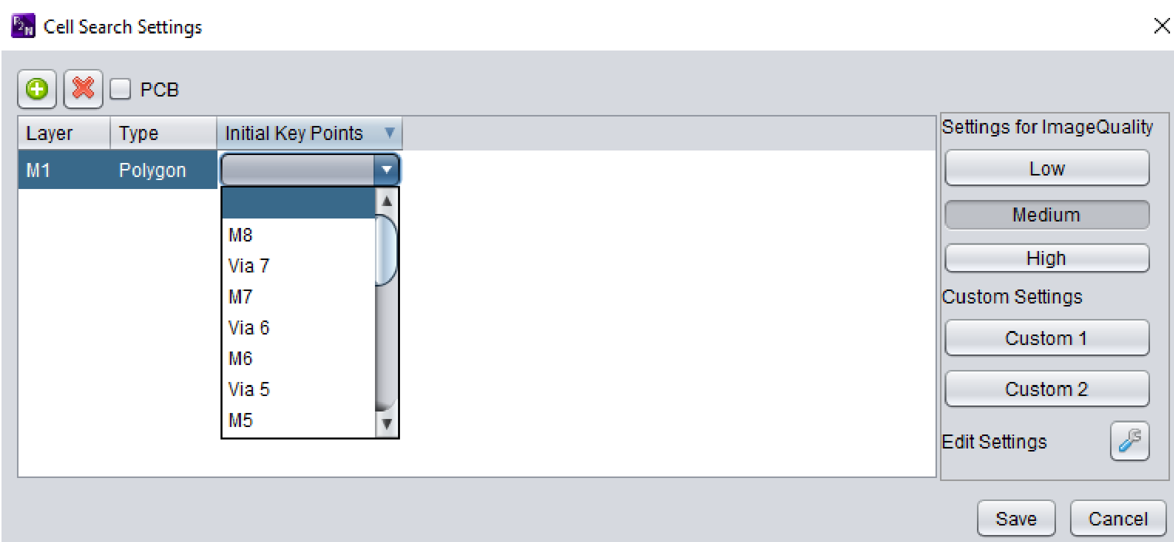
6. Click + to add new layer search.



7. Select image layer (the layer(s) that uniquely identify the cells) for cell search. Click “Add”.

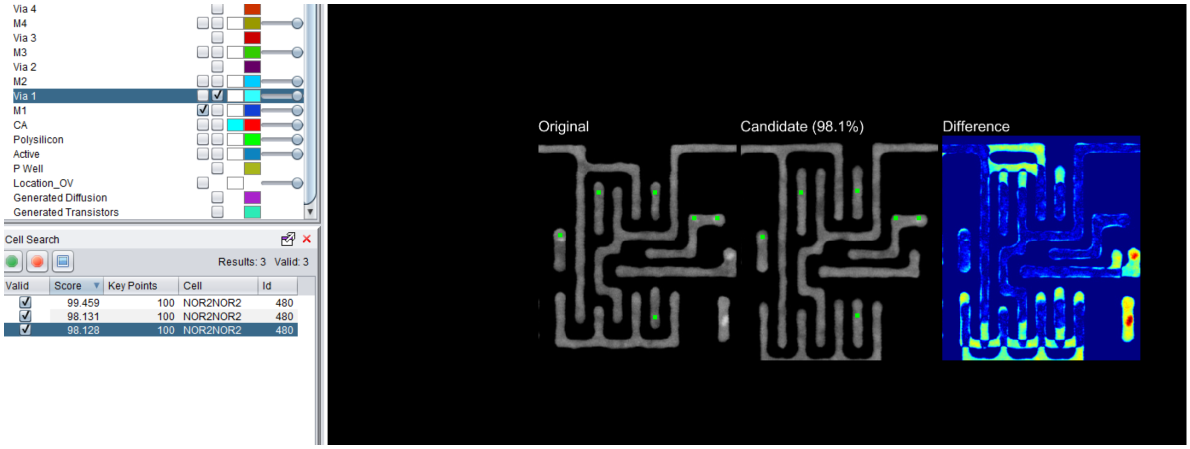


8. Click "Initial Key Points" and select polygon layer to use as reference for key points. Click "Save"



NOTE To see key points, make sure that the cell is highlighted in the `Cell Search` window, key points are defined in the settings of the `Cell Search`, and the image layer is turned on. The user can double-click on the cell in the cell search to have Pix2Net move the overlay to where the cell is.

9. Click the play button (start search) The results should look like this:



10. Check the results and make sure that the identified cell(s) look as they should. If everything is correct, click on the green octagon to confirm the results. Pix2Net will automatically place the ports and identify it as the same type of cell.

2.12.5 Adding Key Points Manually

Before adding key points

When doing a cell search, the user can add Key Points to tell Pix2Net to look for selected specific points when searching for cells. In order to see key points, the user needs to have the "Cell Search" window open, and have one of the cells selected in the list. (Double-clicking on that cell will take the user to the correct place in the overlay.) Finally, the image layer that was added the key points to must be visible. If the key points are not showing up, then the most likely causes are that the cell is not selected in the "Cell Search" window, or the image layer the key points were added to is not visible

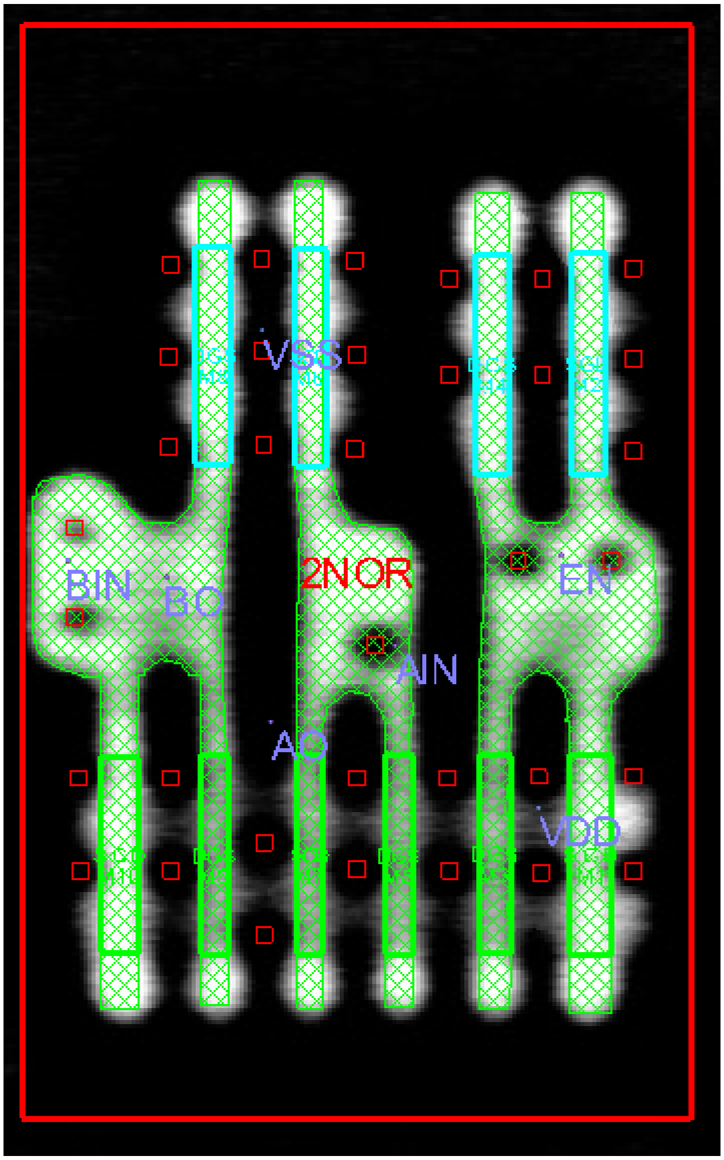
If the key points that were added automatically within the cell search settings under `Initial Key Points` are not to the user's satisfaction, then the user can manually add the key points themselves.

NOTE We do not recommend manually adding key points unless the automatically added key points were not placed correctly, did not help the cell search, or if there is no layer to reference key points to.

In this part of the tutorial, all of the steps above can be applied, but instead, start after step 6, do not do step 7.

7. Press the green down arrow on the 2NOR in the `Project Cells` window (if this has not already been done).

(In this example the Polysilicon image and polygon layers are on, as well as the Contact polygon layer to show the user where we would recommend placing the key points)



8. Go to the `Cells` tab and click on *Add Key Points*.
9. Add the key points within the cell to tell Pix2Net to specifically look for similar points while searching for the same cell.
10. Make sure that 2NOR is highlighted in the cell search window, then press on the play button (start search) and Pix2Net will find all other cells that are the same.

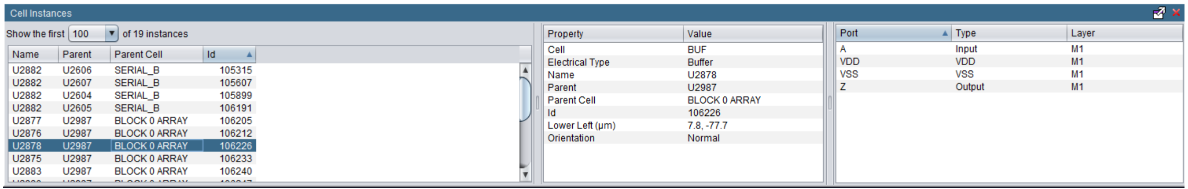
(This will be the exact same way of searching as above, but the user manually places the key points instead of having Pix2Net do it.)

2.12.6 Viewing Cell Instances

1. To review the results, go to the Project Cells window and click the `Cell Instances` button.

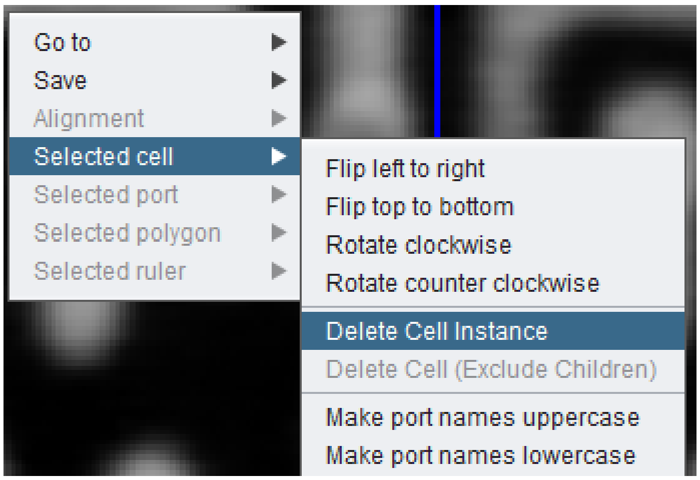
2. Click on an instance in the Cell Instances window to visit it.



2.12.7 Editing Cell Instances

1. If you find an instance that has been incorrectly added by the Cell Search algorithm, you can delete it manually.

   Make sure the instance is selected. Then right-click it and select `Delete Cell Instance`.

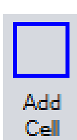


2.13 Extracting Memory from Images

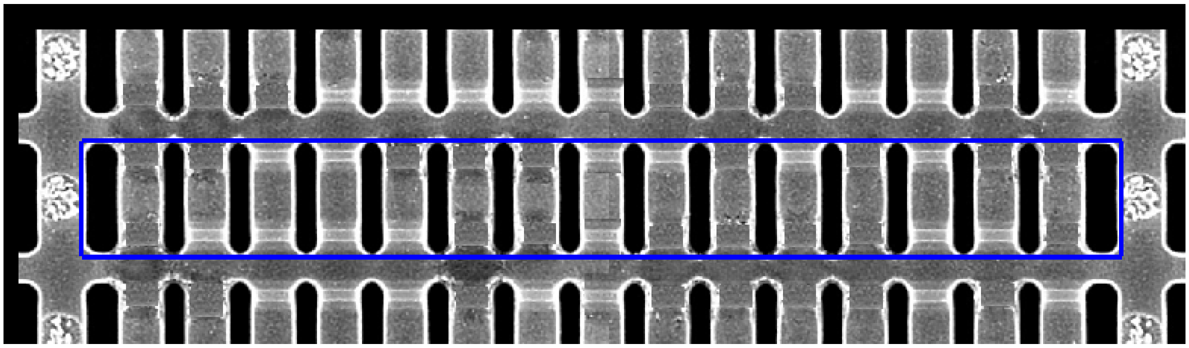
This tutorial will show you how to extract the bit values from an image layer of memory blocks. You will learn how to setup the memory extraction, perform the memory extraction, manually edit uncertain bits, and export the results to an Excel file.

2.13.1 Adding Template Cells

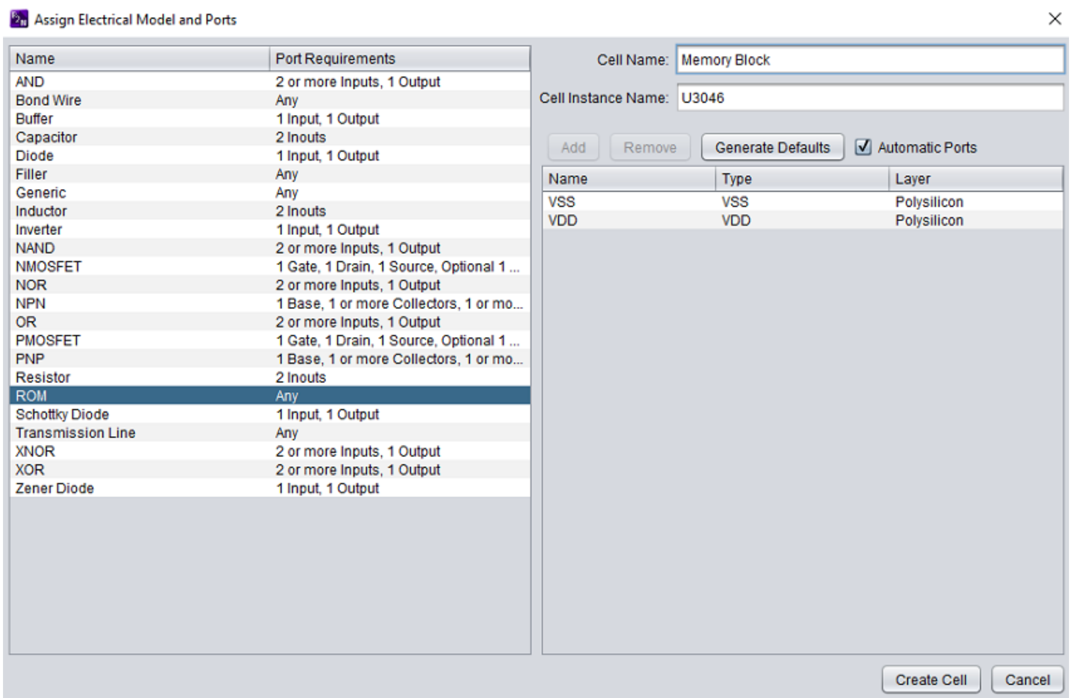
1. Open `examples\Memory Extraction\Pix2Net.prj`.
2. Go to the `Cell` tab and click `Add Cell`.



3. In the Overlay window, click-and-drag in the upper left corner to create a cell around the block in the upper left corner.



4. An *Assign Electrical Model and Ports* window will pop up.



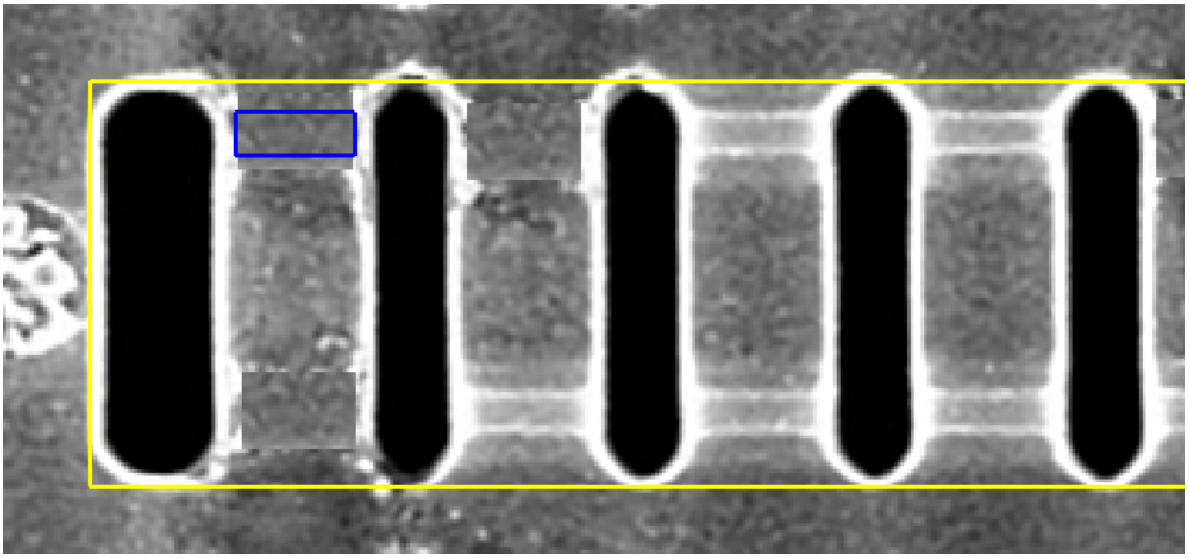
5. Click on the *Cell Name* and name the cell `Memory Block`.

6. Click on ROM under *Name* and click *Create Cell*

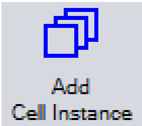
7. Right-click in the Overlay window to bring up a context menu. Choose Selected Cell → Identify as Origin Block. This tells Pix2Net that this cell will act as the upper-left corner of the region of interest.

8. Bring up the context menu again and choose Selected Cell → Identify as Contrast Block. This tells Pix2Net that this cell is a good template for the other blocks; it is neither extremely dark nor extremely bright. For this demo, we are able to use our origin block as our contrast block, but that will not always be the case.

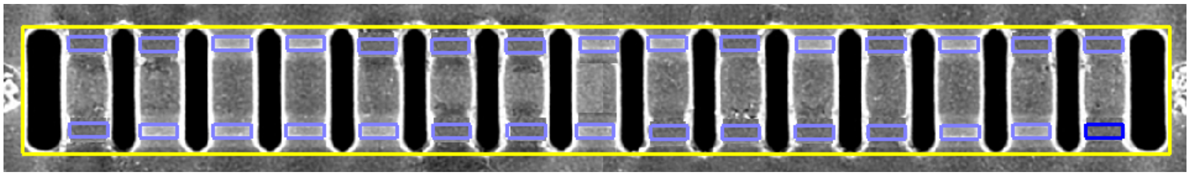
9. In the Overlay window, add a new cell around the first bit.



10. In the Project Cells window, rename the new cell to `Memory Bit`.
11. Select the `Add Cell Instance` tool.

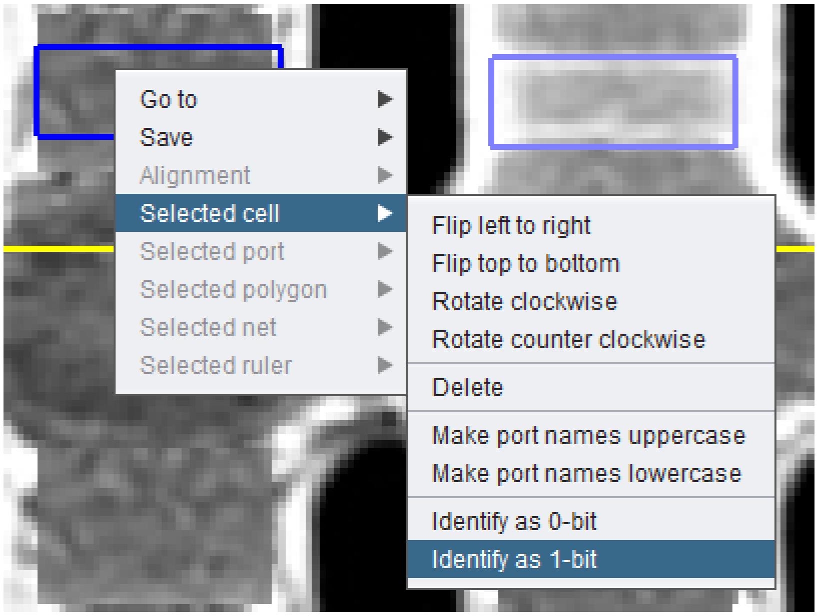


12. Add more `Memory Bit` instances by clicking on each bit. If you make a mistake, use the `Move` tool to move the instance into the correct place.



13. Select the `Select` tool.

14. Click on a dark instance to select it. Right-click to bring up the context menu. Choose Selected Cell → Identify as 1-bit. Repeat the same process for a light instance, except choose Selected Cell → Identify as 0-bit. Pix2Net will use these templates to decide if a bit is a 0 or a 1.



2.13.2 Extracting Memory

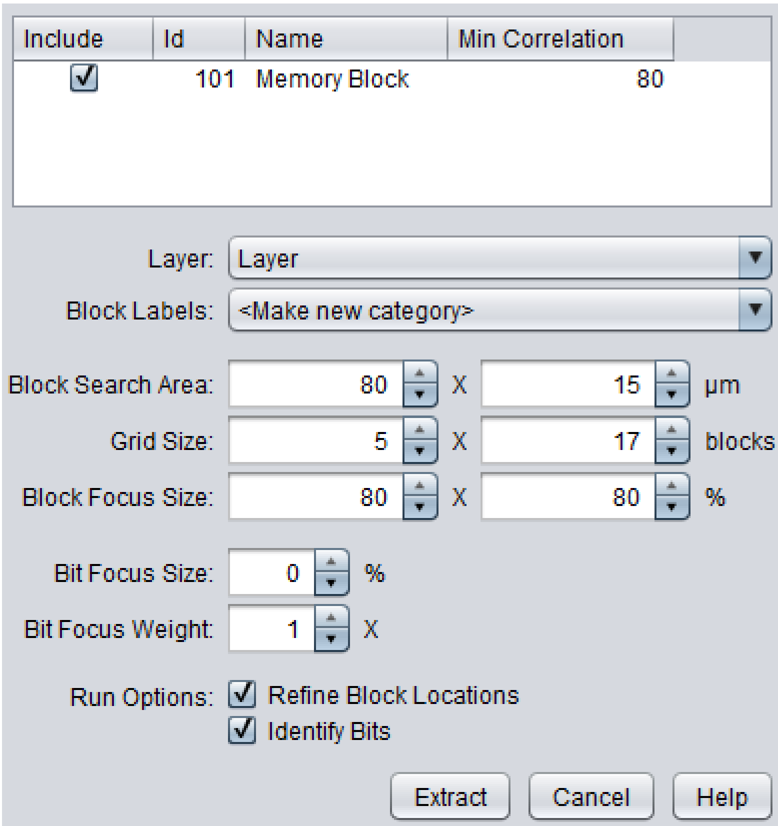
1. Go to the `Image` tab and click `Extract Memory`.

2. We need to fill out the dialog:

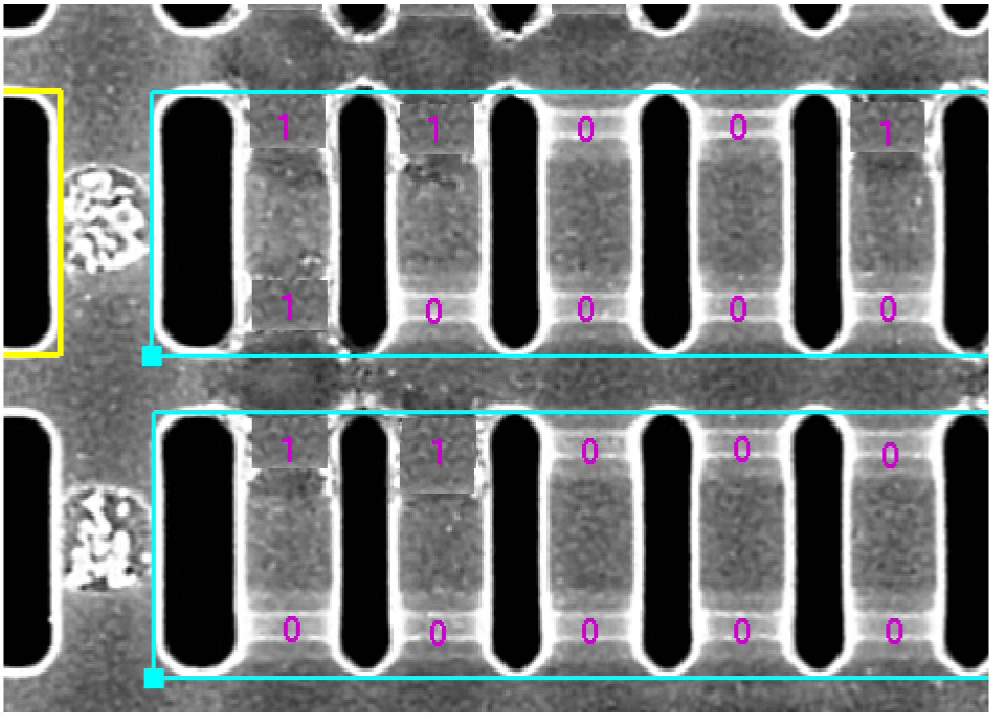
   - The first table in the dialog shows the cells we'll be searching the images for (only cells of type `ROM` will be listed). The default `Min Correlation` of 80 is fine for this example.
   - `Layer` specifies the image layer to use. There is only one layer in the project, so this is an easy choice.
   - `Block Labels` specifies the label category to add our results to. Since this is the first time we're doing an extraction, we have no choice but to create a new category.
   - `Block Search Area` is the width and height, in microns, of the search area. When the cell search starts, you will see a little red box that shows you where Pix2Net is looking for the next block. We are setting the width and height of that box here. We will use 80 and 15 microns.
   - `Grid Size` is the width and height of the region of interest, in terms of blocks. Our grid is 5 blocks wide and 17 blocks tall.
   - `Block Focus Size` is for bit identification. When Pix2Net is trying to determine if a bit is dark or light, it is using the intensity of the contrast block as a base line. However, the contrast block may have bad pixels around its edges. We'll stick with the defaults, which means we're telling Pix2Net to use the middle 80% of the contrast block when calculating the base line.
   - `Bit Focus Size` is for bit identification.
   - `Bit Focus Weight` is for bit identification.
   - To understand what `Refine Block Locations` does, you must understand the memory extraction process. First, Pix2Net will find all of the blocks along the edges of the region of interest. Then it will

estimate where all of the inner blocks are by using interpolation. `Refine Block Locations` tells Pix2Net to improve on this interpolation by individually examining each block and adjusting its placement.

- `Identify Bits` tells Pix2Net to perform bit identification after the blocks have been found.

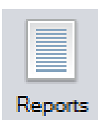


3. Press the Extract button to start extraction. After the process completes, you should see the detected bits:

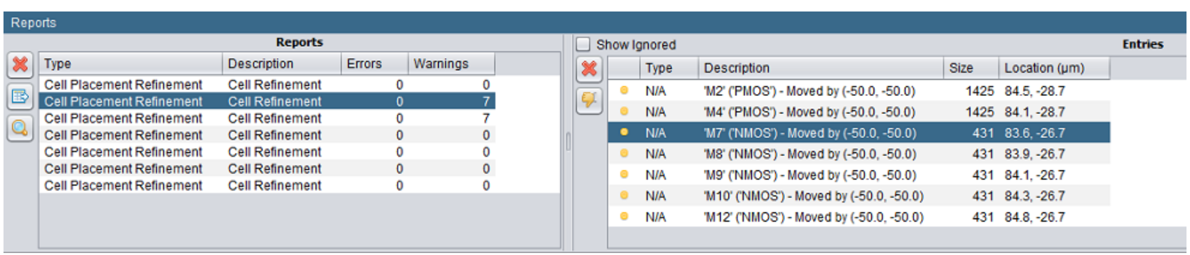


2.13.3 Editing Bits

1. Go to the `View` tab and click `Reports`.



2. A report of uncertain bits has been generated. Click on the report to see the list of potential problems.



3. Click on a problem to go straight to the uncertain bit. If the bit is wrong, go to the `Labels` tab and click on `Select Label`.

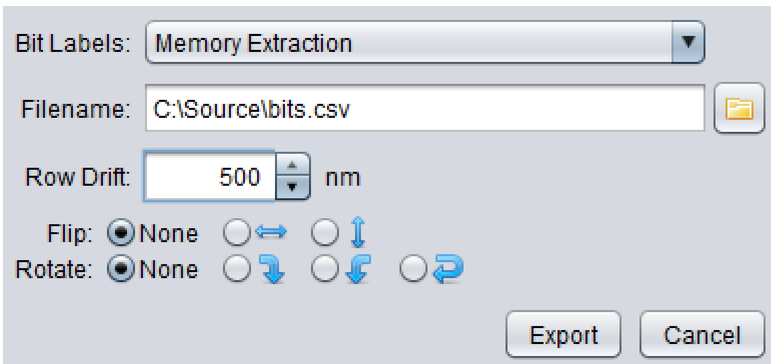
4. Click on the bit label to select it. Click `Edit Label`, change the value to the correct value, and then click the Save button.

2.13.4 Exporting Bits

Note: This feature has been temporarily disabled.

1. Go to the `Image` tab and click `Export Bits`.

2. Set the filename to the desired location. Row Drift determines, going from left to right, how far two consecutive bits can differ vertically and still be in the same row. Let's use a value of 500. Finally, leave the default values for Flip and Rotate, because we don't want to flip or rotate the values.

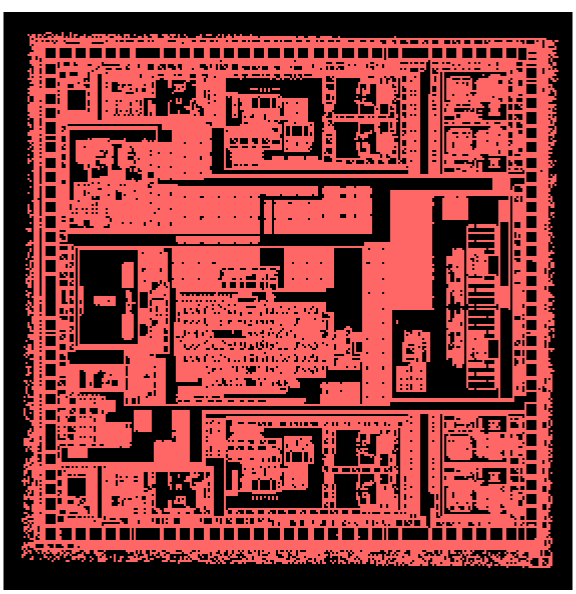


3. Click the Export button. A csv file will be generated, which can be opened in Excel.

2.14 Comparing a Layer to a Golden Layer

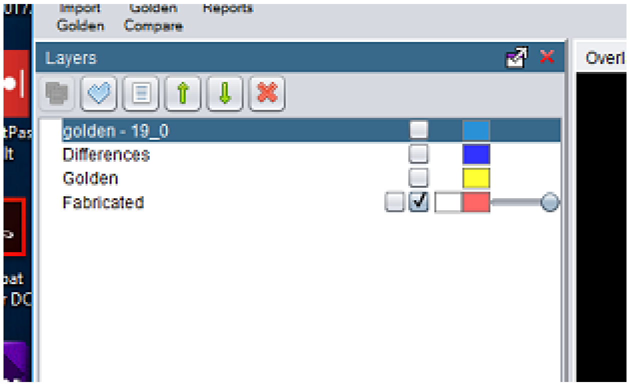
2.14.1 Importing the Golden Layer

1. Open the `examples\Golden Demo\Pix2Net.prj` project. You should see the fabricated layer.

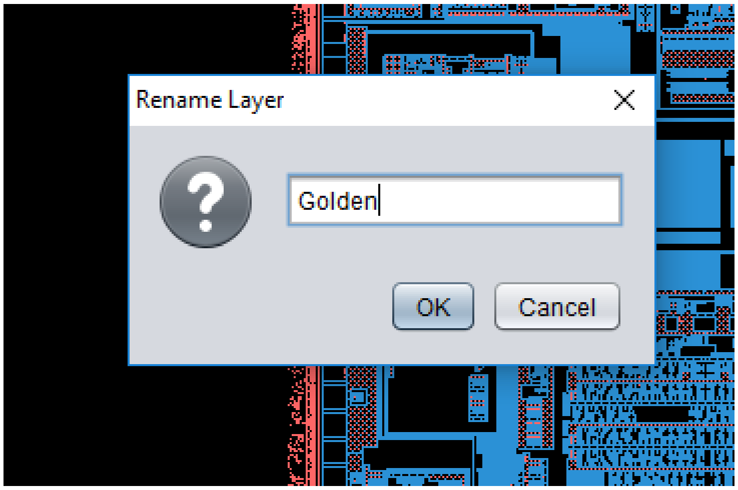


2. Go to the `Trusted Design` tab and click `Import Golden`.

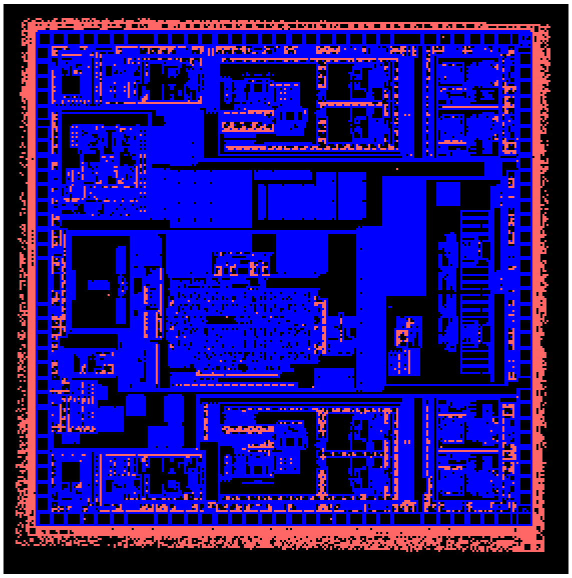
3. Browse to `examples\Golden Demo\golden.gds` and click the Open button. The golden GDSII file will be imported into Pix2Net.



4. In the Layers window, right-click `19_0` and choose `Rename`. Rename the layer to `Golden`.



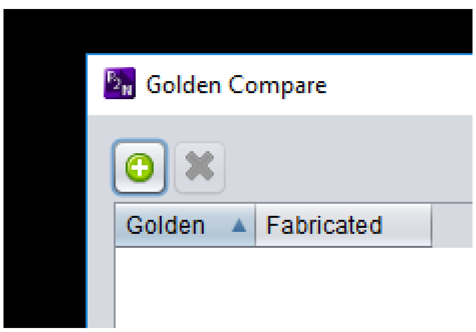
5. Turn on polygon layer.



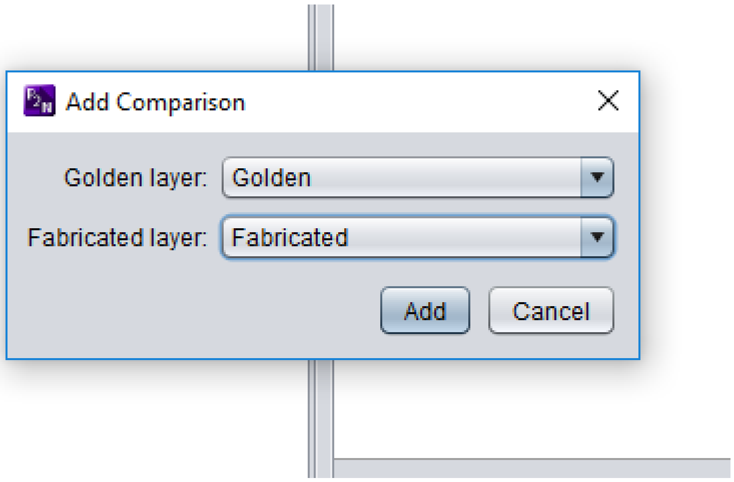
2.14.2 Running a Golden Compare

1. Click `Golden Compare`.

2. Click "+" to add new comparison.

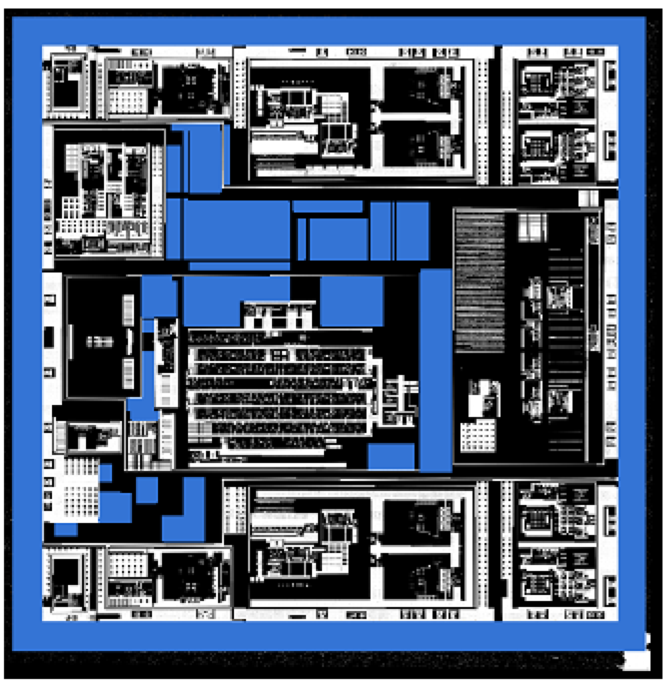


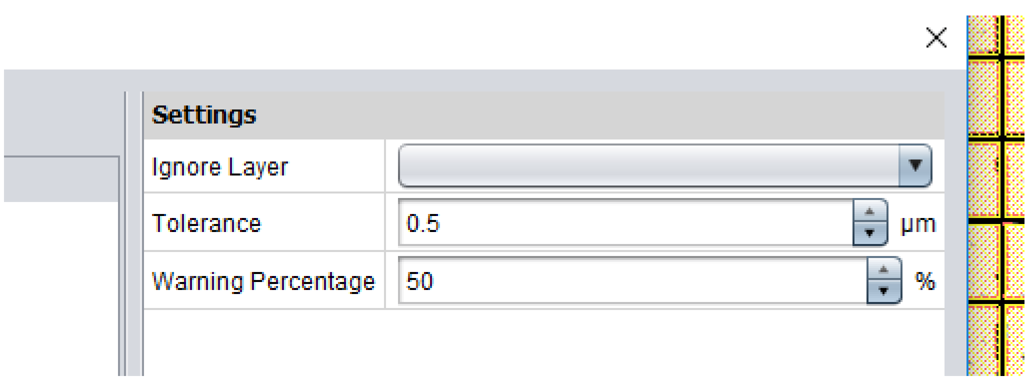
3. Set the Golden layer to `Golden` and the Fab layer to `Fabricated`. Click "Add".



Note: If there is an area which you do not want compared in the process, you'll need to create an "ignore" layer. See: Create Layer.

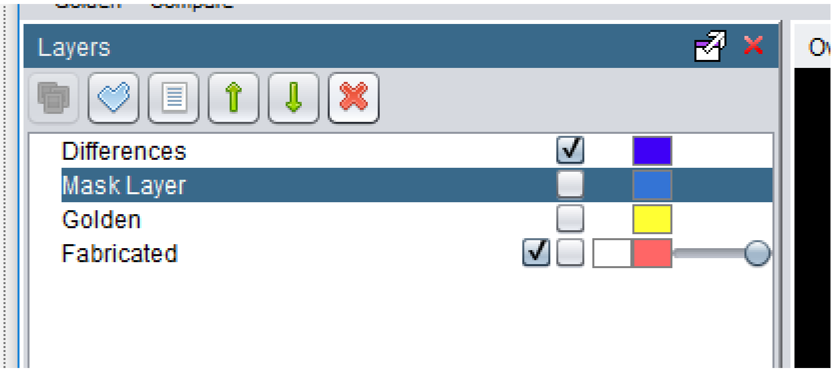
Once the layer is created, add polygons to the area you want "ignored".





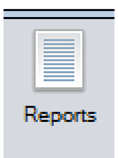
1. Select the "Ignore Layer".

2. Set the "Tolerance". This will determine how much difference between the golden and fabricated layer is needed before an error is flagged.
3. Click the "Run" button.
4. The compare process will take several minutes. A `Differences` layer will be generated.

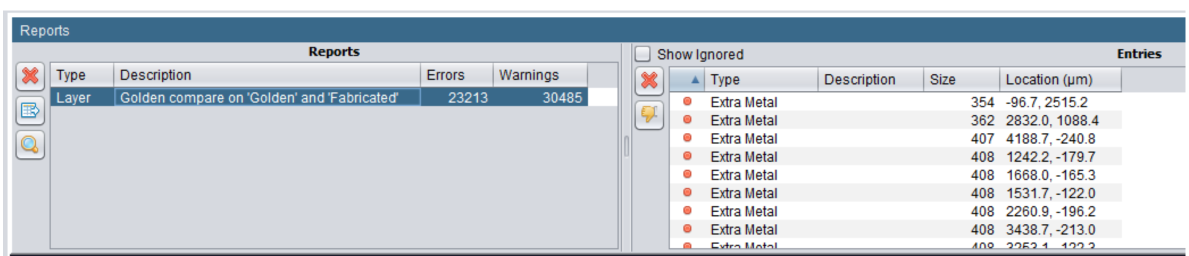


2.14.3 Viewing Differences

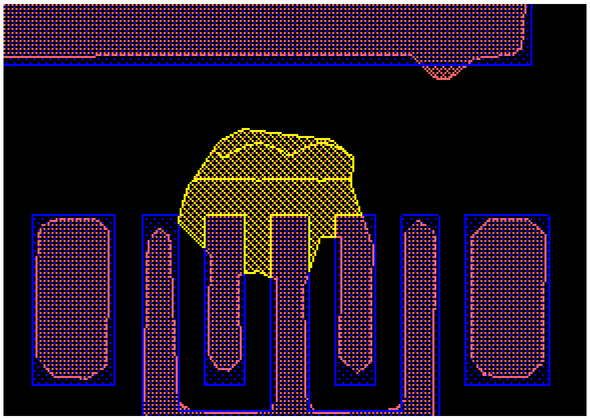
1. Click `Reports`.



2. The Reports/Entries window will appear. Click on the report to see the list of differences. Click the first column, so that it is highlighted in blue, to see the red dots (errors) first.



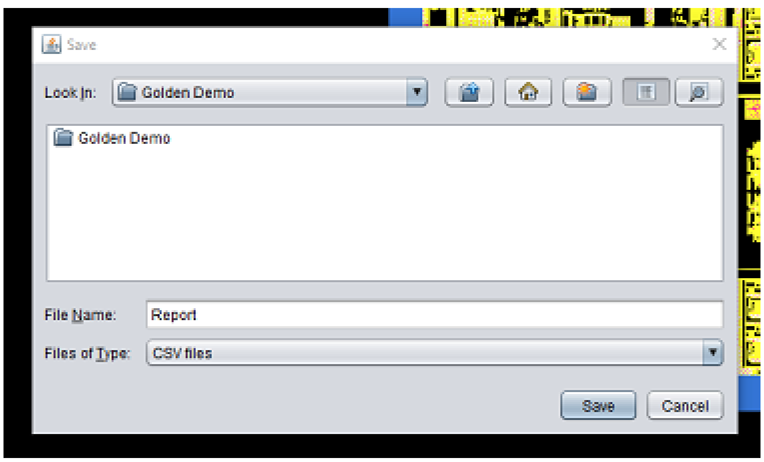
3. Click on a difference in order to go directly to it. See *Types of Differences* for more information about what the differences mean.



2.14.4 Exporting Differences

1. In the Polygon Reports window, click the Export button.

2. Select folder where report is to be saved.



3. Type in `report` and click the Save button.
4. Browse to the output folder and open `report.csv` with your preferred program.

	A	B	C	D	E	F
1	Level	Type	Description	Size	X	Y
2	Warning	Extra Metal	Difference #0000	641	94.7	620.3
3	Warning	Gap	Difference #0001	28767	3.9	73.8
4	Warning	Extra Metal	Difference #0002	699	601.6	156.4
5	Warning	Extra Metal	Difference #0003	933	496.8	204
6	Warning	Extra Metal	Difference #0004	699	485.7	76.1
7	Warning	Extra Metal	Difference #0005	1166	318.3	205.8
8	Warning	Gap	Difference #0006	16269	453.3	252.3
9	Warning	Extra Metal	Difference #0007	2204	463	740
10	Warning	Extra Metal	Difference #0008	582	70.4	746.9
11	Warning	Extra Metal	Difference #0009	641	927.9	238.4
12	Warning	Extra Metal	Difference #0010	642	751	421.4
13	Error	Extra Metal	Difference #0011	4329	1118.5	591.7
14	Warning	Extra Metal	Difference #0012	990	1061.6	561.7

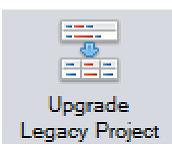
2.15 Legacy Project

This tutorial will only be used when upgrading Pix2Net projects from v0.19 to v0.20.

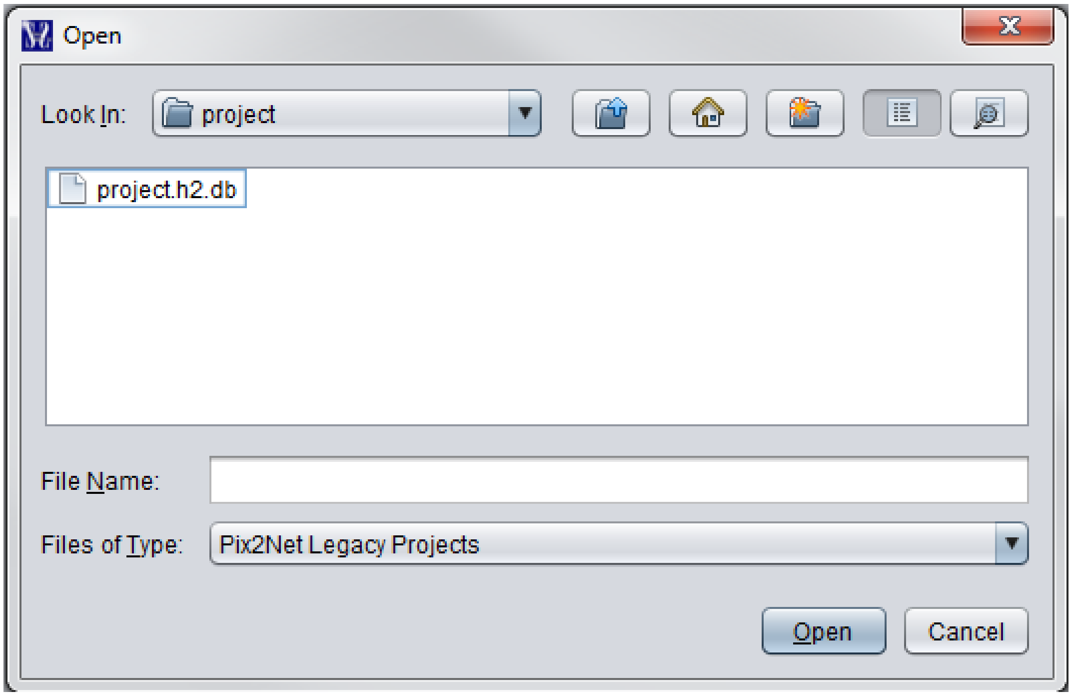
> *Make a spare copy of the project in case the upgrade process is unsuccessful. The upgrade process is irreversible and will alter files in the project directory.*

2.15.1 Opening the old project file

1. Go to the `File` tab and click `Upgrade Legacy Project`.



2. Browse to `project\project.h2.db`



Note: Pix2Net will become unresponsive while upgrade process executes.

3. To continue opening the project refer to *Opening a Project*.

2.16 Identify Cells by Layout

This tutorial will show you how to use the layout matcher to identify project cells by their layout. Only use if you have a gdsii library to compare against.

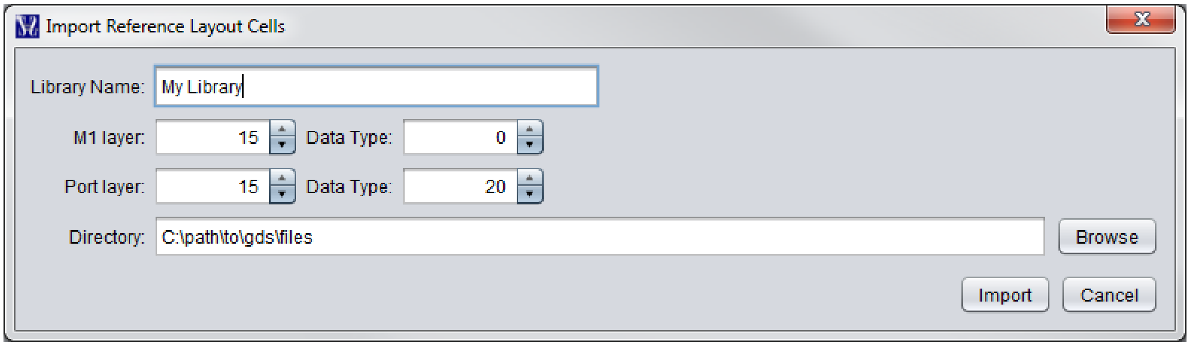
2.16.1 Import GDSII Files into the Reference Library

The first step is to import a library of GDSII files into the reference library.

1. In the `Netlist tab`, click the `Golden Lib GDS` button:

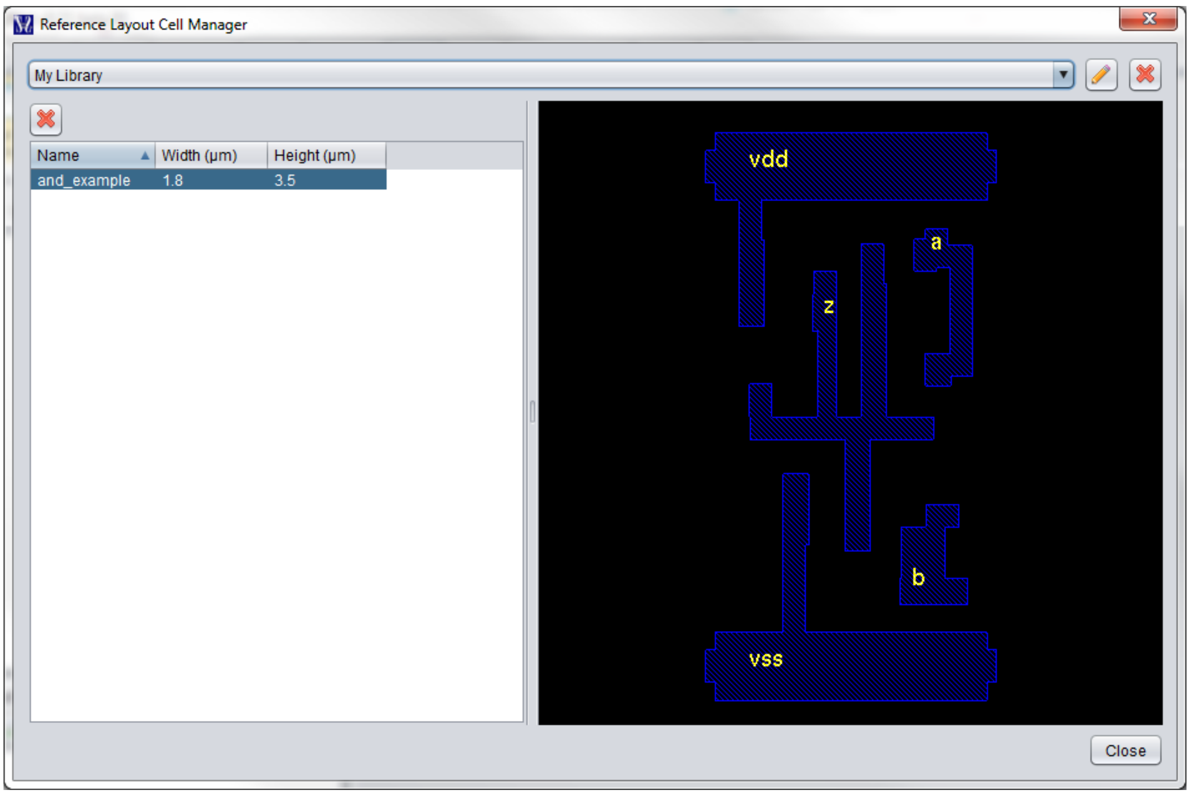
2. In the `Golden Lib GDS` window, click the `Import Layout Reference Cells` button:

3. In the `Import Reference Layout Cells` dialog, specify a library name for the layouts to import. Set the layer number and data type that corresponds to the m1 layout, and the layer number and data type that corresponds to the text layer with the port names. Finally, set the directory the GDSII files are stored in, and click the `Import` button.



4. In the `Golden Lib GDS Results` window, click the `Manage Layout Reference Cells` button:

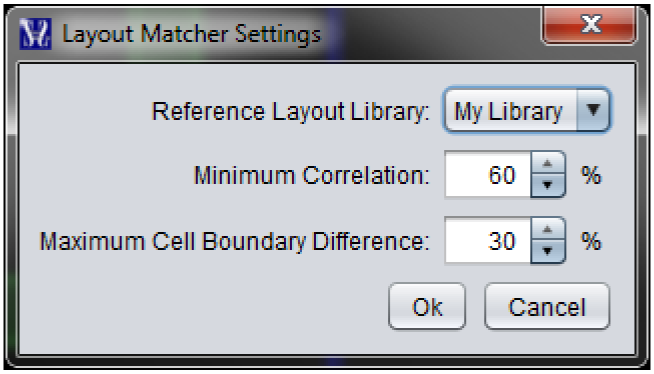
5. The imported layout reference cells can be viewed in the manager window:



Click the `Close` button after verifying that the layout cells were imported correctly.

2.16.2 Settings

1. Open a project.
2. In the `Golden Lib GDS Results` window, click the `Golden Lib GDS Settings` button to bring up the settings window:



3. Set the Reference Layout Library that should be used by the Golden Lib GDS.
4. During the matching process, any match with a correlation score below the Minimum Correlation will automatically be discarded.
5. During the matching process, any reference cell that has a width or height that differs by more than the Maximum Cell Boundary Difference from the target cell's width or height will automatically be discarded. This constraint makes the matching process go much faster, because fewer correlations need to be performed.
6. Click the `Ok` button to save the settings.

2.16.3 Technology

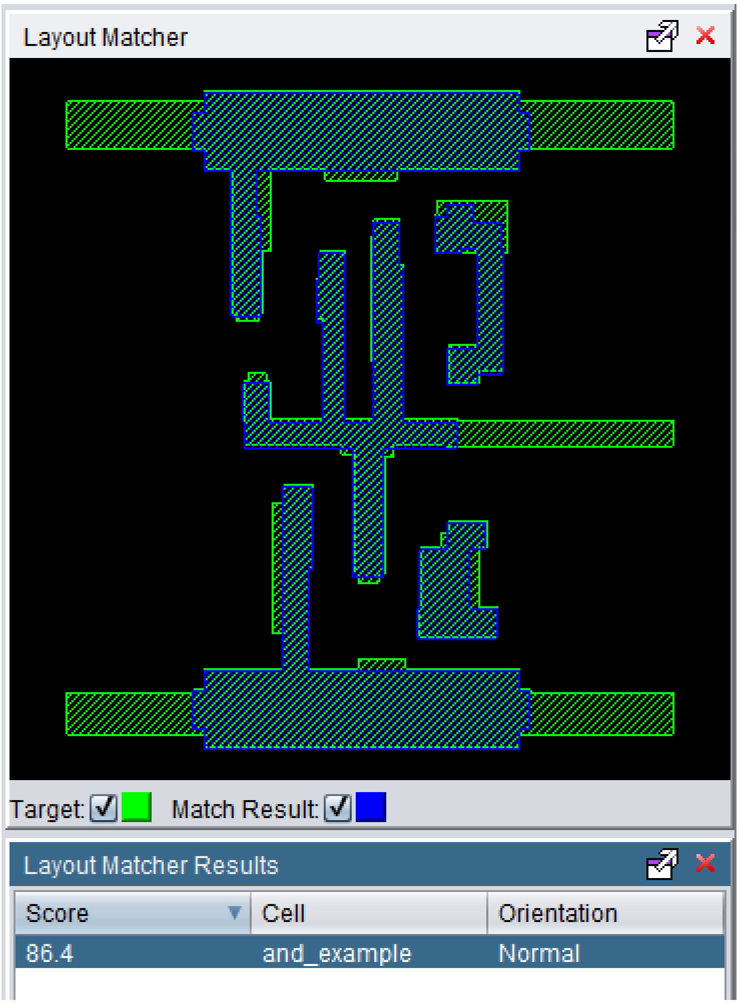
1. In the `Cells` tab, click the `Technology` button.
2. Make sure that the `Metal 1` layer has been specified in the project.
3. Click the `Ok` button.

2.16.4 Compare Cell

1. Select a target cell instance in the project.
2. In the `Golden Lib GDS Results` window, click the `Identify the selected cell` button:

3. The possible matches will be displayed:

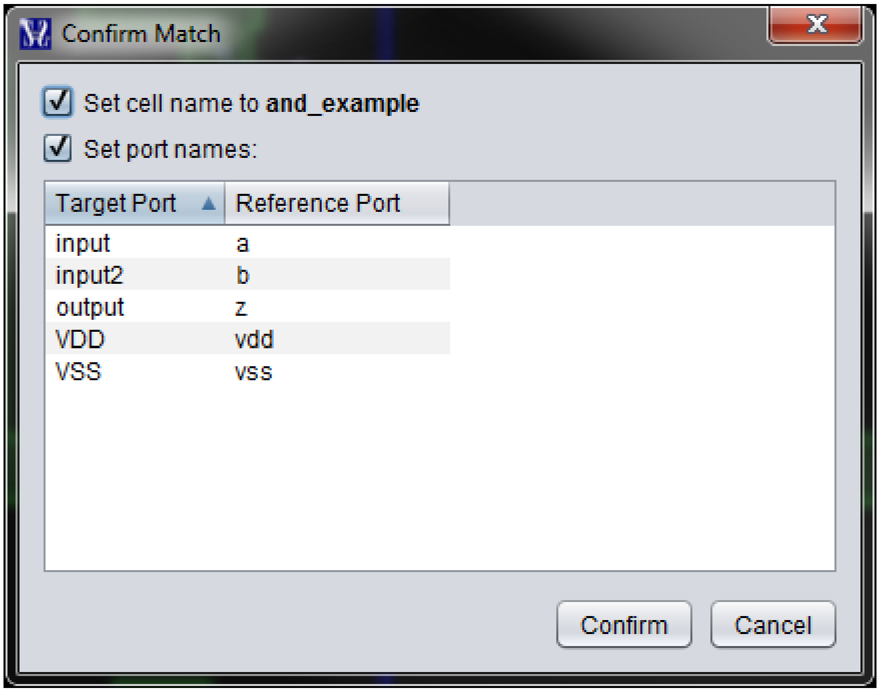


2.16.5 Confirm Result

1. Click the `Confirm the selected match` button to confirm the selected match as valid.

2. The `Confirm Match` dialog displays the identified cell name and port mapping:

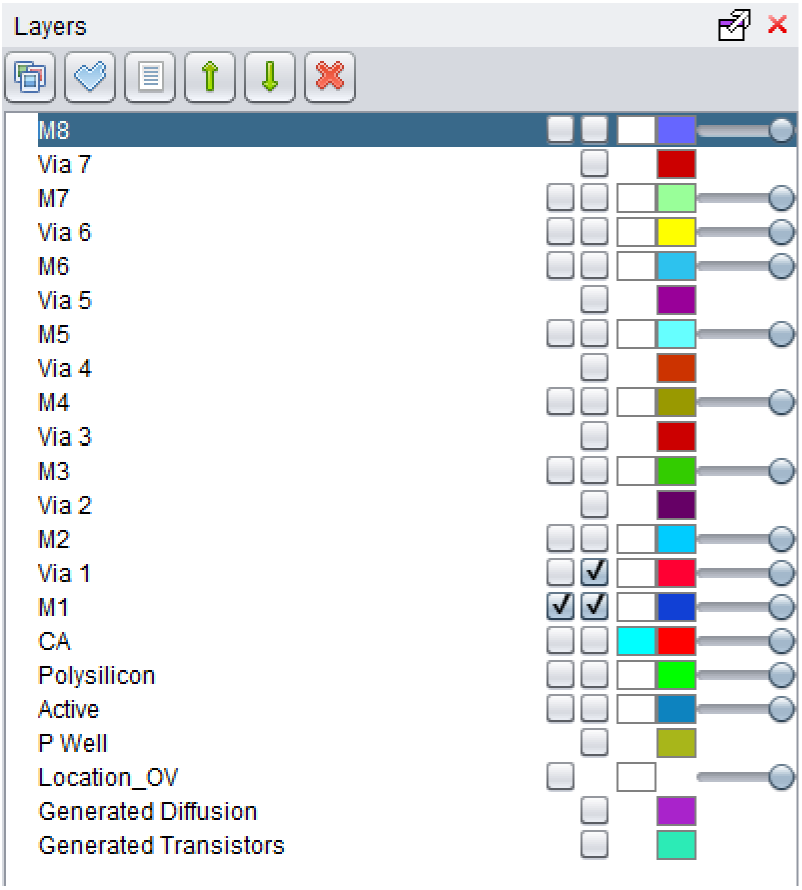


3. Click the `Confirm` button to rename the cell and ports.

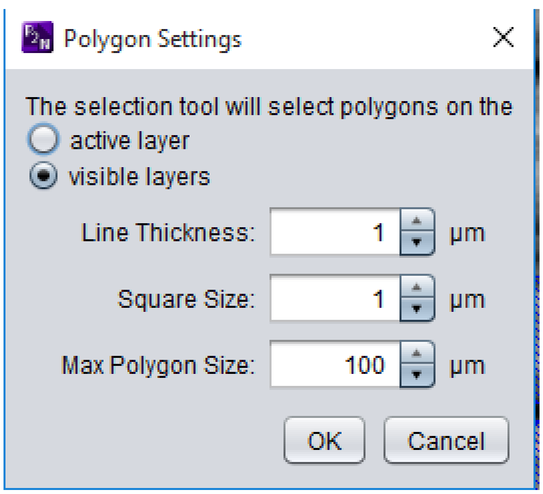
2.17 Polygon Placement

This tutorial is aimed to help the user make polygon placement a faster process and to show how some Pix2Net Polygon functions work.

1. Go to Examples/Digital Logic/ Pix2Net.prj for this tutorial.
2. Before starting, make sure that the M1 layer and polygons are on, as well as the Via 1 polygons.

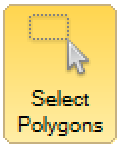


3. Go into settings under the Polygon tab and make sure that the *visible layers* settings is highlighted.

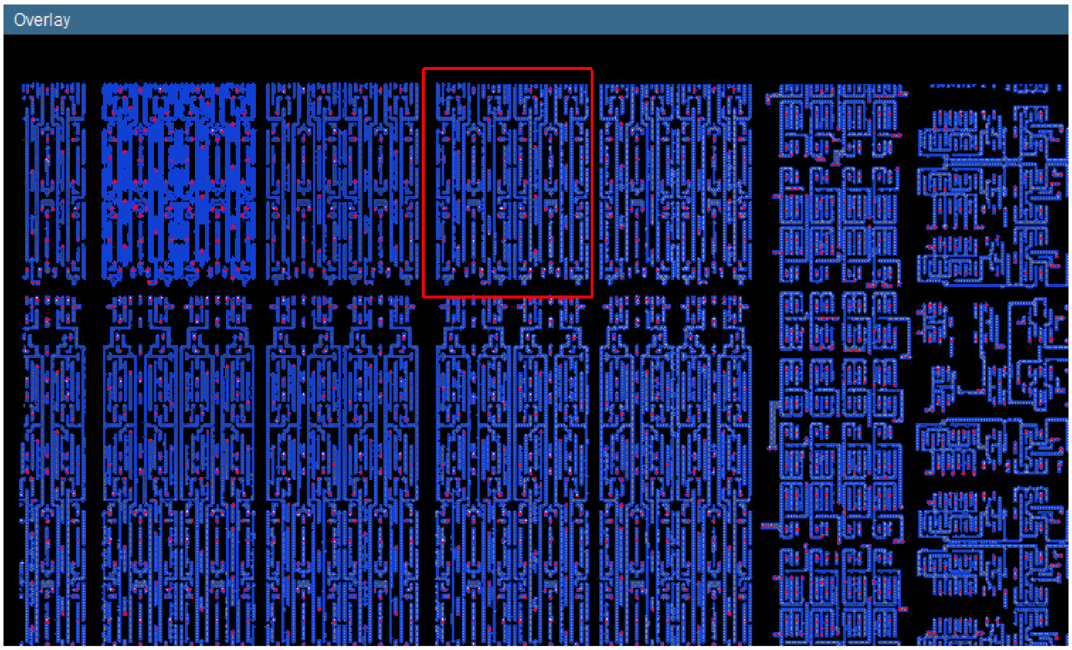


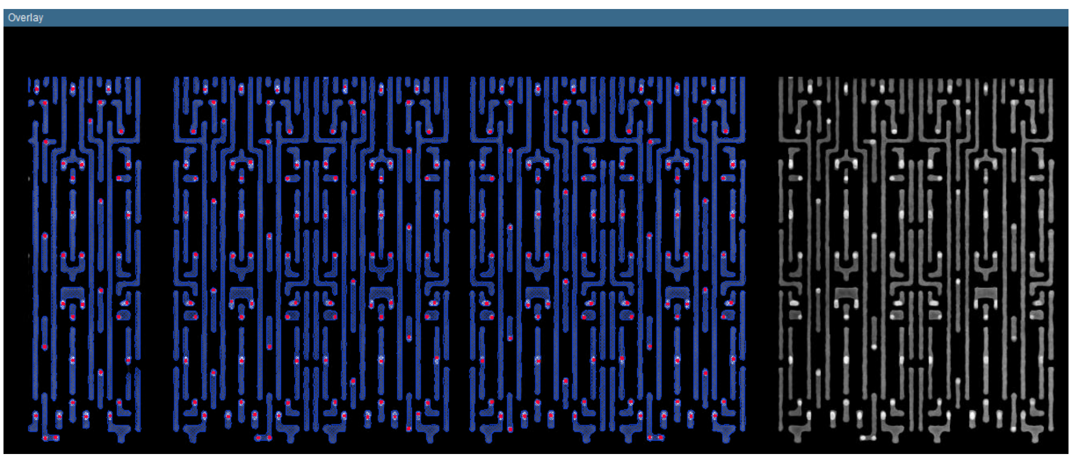
2.17.1 Polygon Placement Tutorial

Selecting, moving, and cloning polygons:

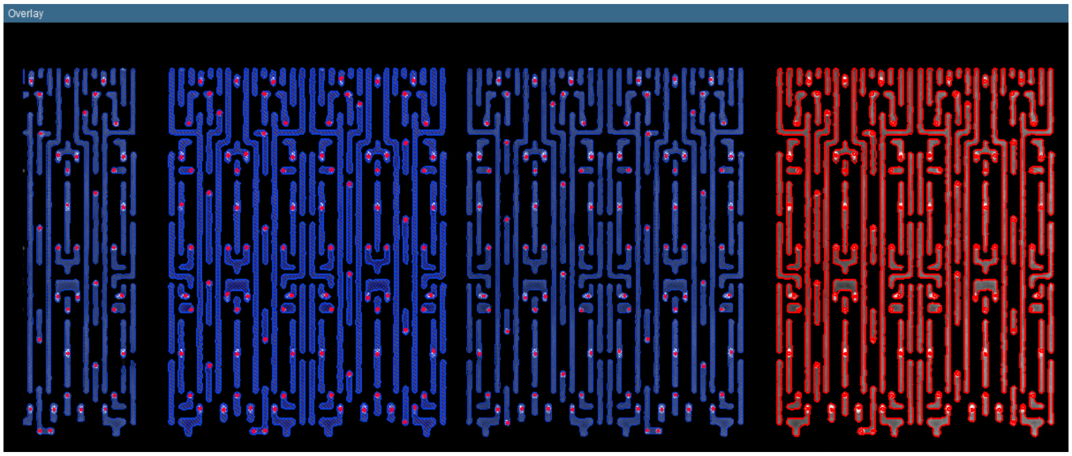


1. Go to the top left of the Digital Logic in the overlay.
2. Use the `Select Polygons` tool to select the third half-column polygons on M1 and on Via 1. Once selected, press delete on the keyboard.

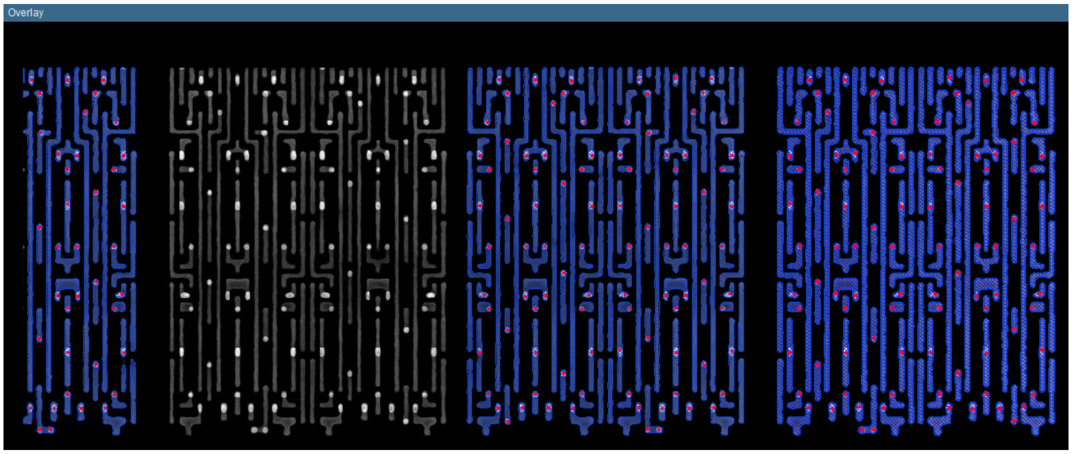




3. Now, select the section of polygons two to the left of the column that was just deleted. (This is because the polygons directly to the left do not match exactly to the polygons just deleted.)
4. Click on the `Move Polygons` tool to move over the selected polygons to the right.



The overlay should look like this:



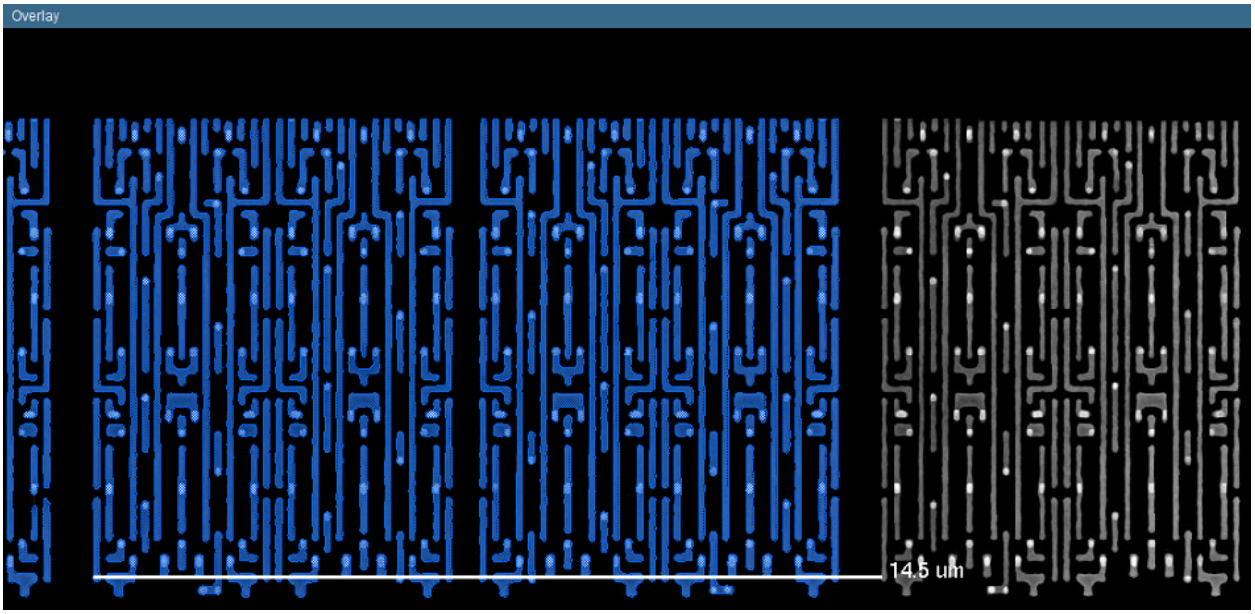
5. The polygons that were just moved should still be selected (if not, re-select them). Press on the `Clone Polygons` tool and clone the polygons back to the place that they were originally by clicking once inside the overlay and moving the mouse to correctly place the polygons.

2.17.2 Cloning Arrays

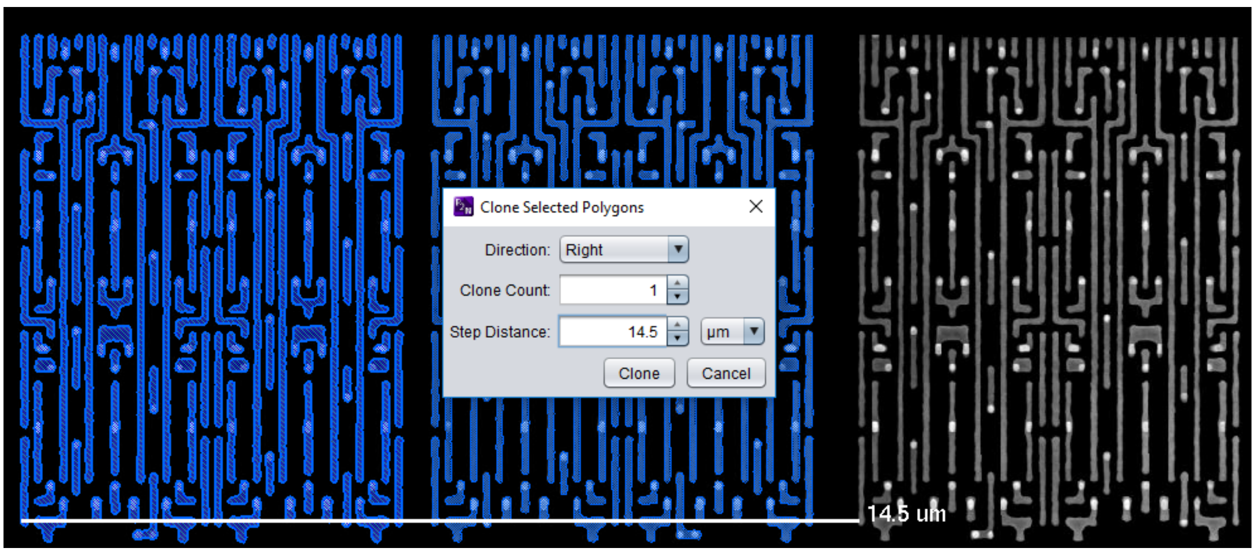
Cloning multiple polygons in different directions:

In this tutorial, start out the same way as above, but this will continue right after step 3, and will not include vias (turn the via polygon layer off).

4. Go to the `Home Tab` and select the `Micron Ruler`.
5. Draw a line from the beginning of the first half-column to the exact same point at the beginning of the third half-column. (Hold shift to make the ruler straight) It should look something like this:



6. Now, click on the `Clone Array` tool in the `Polygons Tab`.
7. A window will pop up, use these numbers provided:



(The direction is right because the polygons are being cloned from left to right, the clone count is 1 because there is only 1 clone of the selected polygons needed, and the step distance is 14.5 um, which is what the micron ruler shows.)

8. Click on *Clone*.

Note

This feature is very specific on how many units the user wants to move, if the polygons that were cloned are slightly off, either use the `Select Polygons` and `Move Polygons` tools, or try again (Ctrl + Z first) by putting a more specific value that will help the polygons match up.

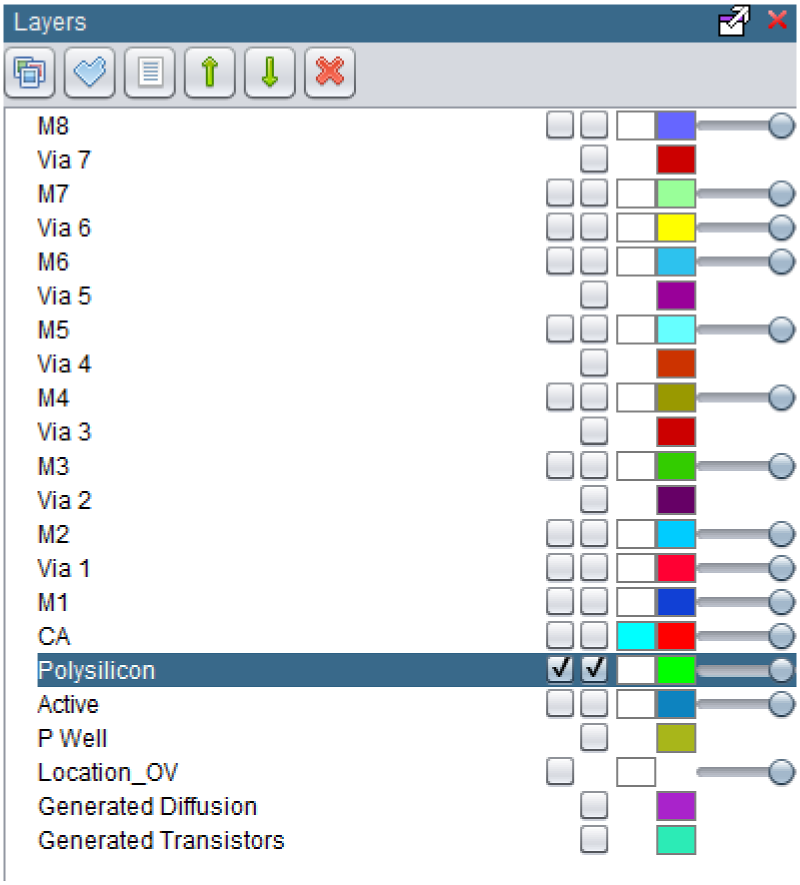
2.17.3 Right-Clicking

The Use of Right-Clicking in Polygon Placement:

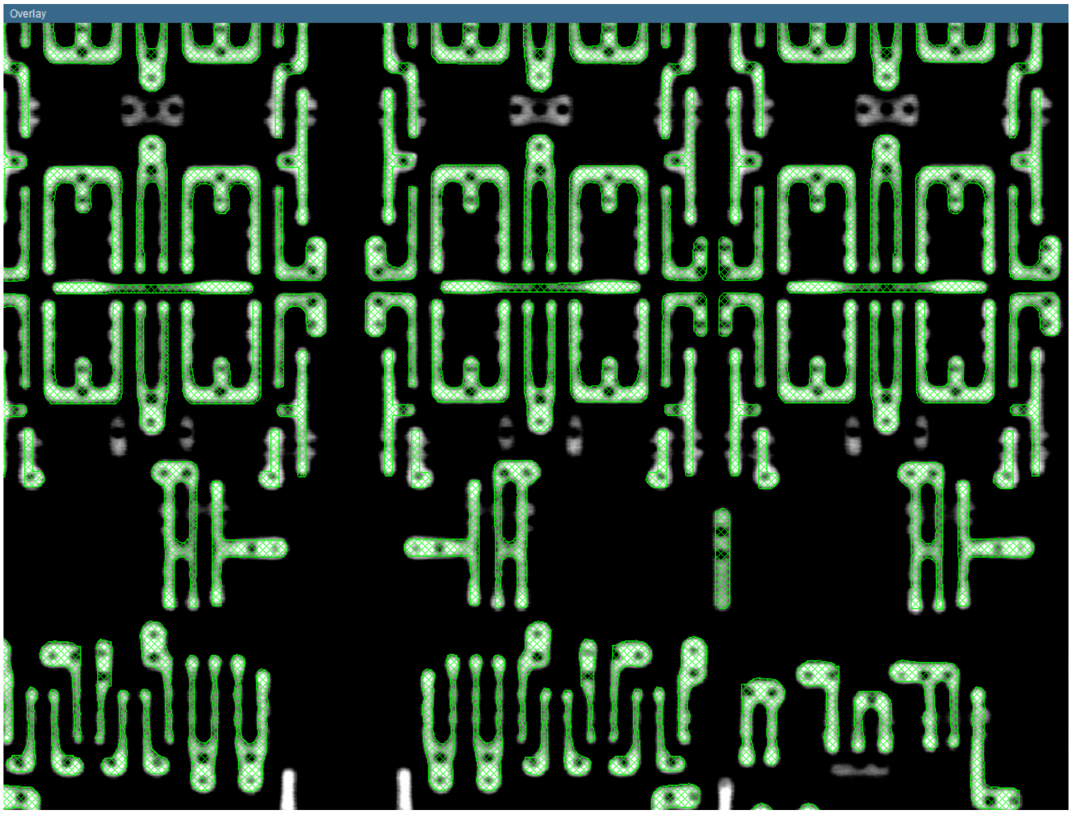
The tools in the `Polygons Tab` are useful to the user for placing and copying polygons to get further in laying out the GDSII, but right-clicking could be just as helpful in some situations.

In this tutorial, there will be quick transitions to different locations in the overlay by using tiles, we recommend to use: 'go to - coordinates' in bigger projects.

1. Turn on the Polysilicon layer and polygons.

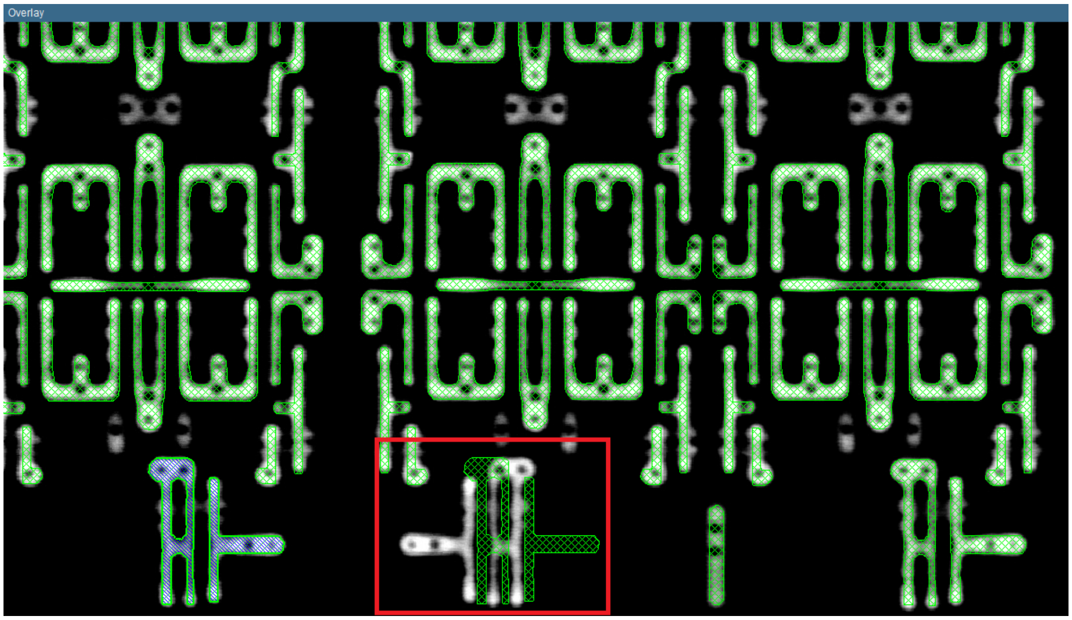


2. (Make sure to be fairly zoomed into the *Overlay*) Right-click in the *Overlay*, hover over *Go-to*, *Tile* and click. An *Input Window* will pop up, type in 8 and press *ok*. This is what it should look like:

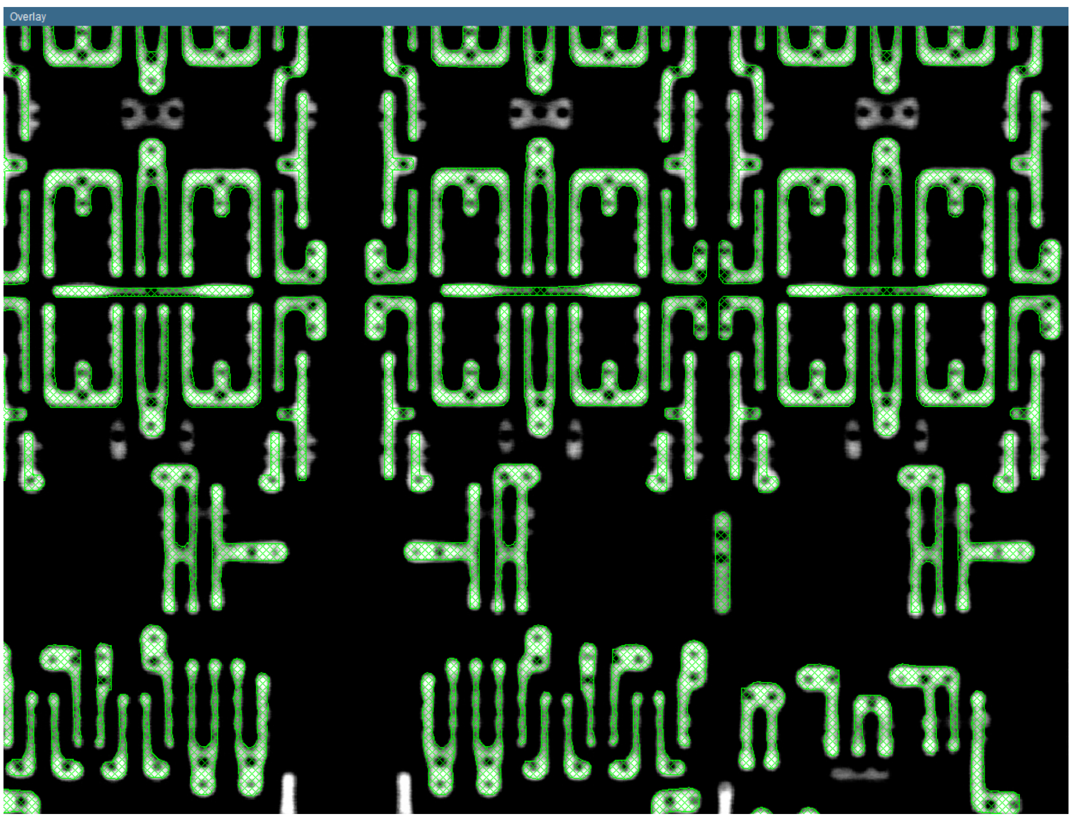


3. Now, use the `Select Polygons` tool to delete the polygons in the middle (either press the delete key or right click and go to *selected polygon*, *remove*).

4. Select the polygons that look similar, to the left, of those that were just deleted.
5. Clone those polygons over to the space where the polygons were deleted.



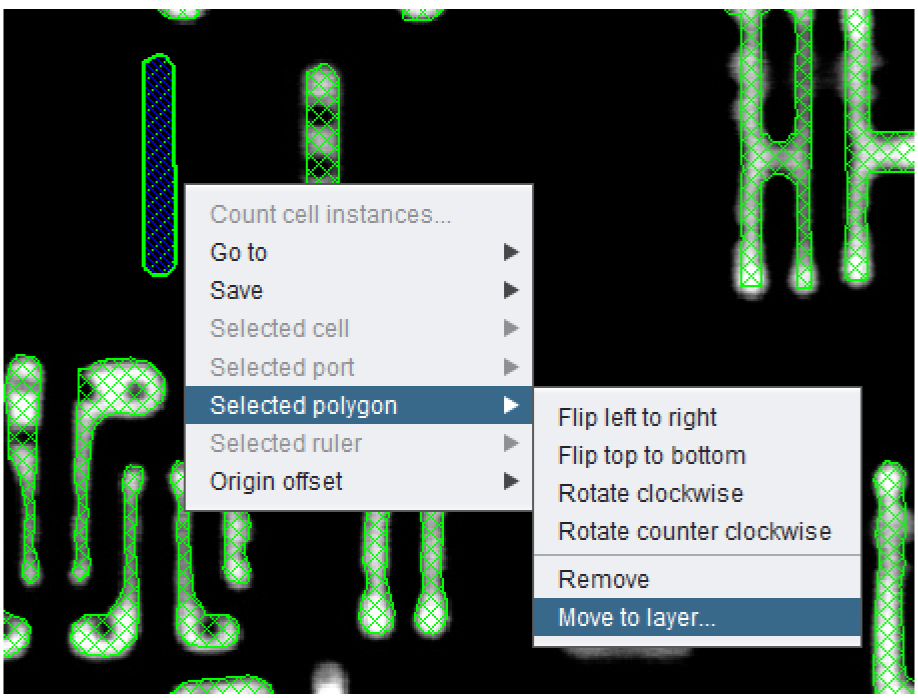
6. Select the polygons that were just cloned over and then right-click. Go to *Selected polygon*, *Flip left to right*.
7. It should look the same as the polygons that were deleted earlier. Use the `Move Polygons` tool to move the polygons to the correct place.



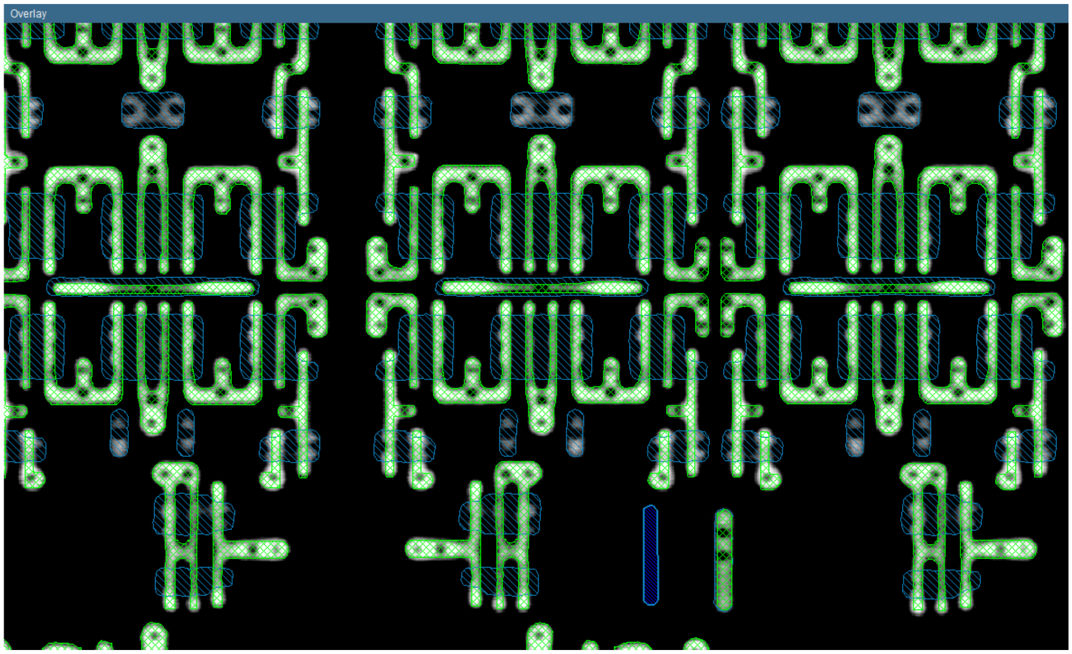
8. Now, at the same location, use the `Select Polygons` tool to select the polygon in the middle-right section

of the *Overlay*.

9. Clone that polygon to the black space to the left.
10. Select the cloned polygon and right-click. Go to *Selected polygon*, *Move to layer*.



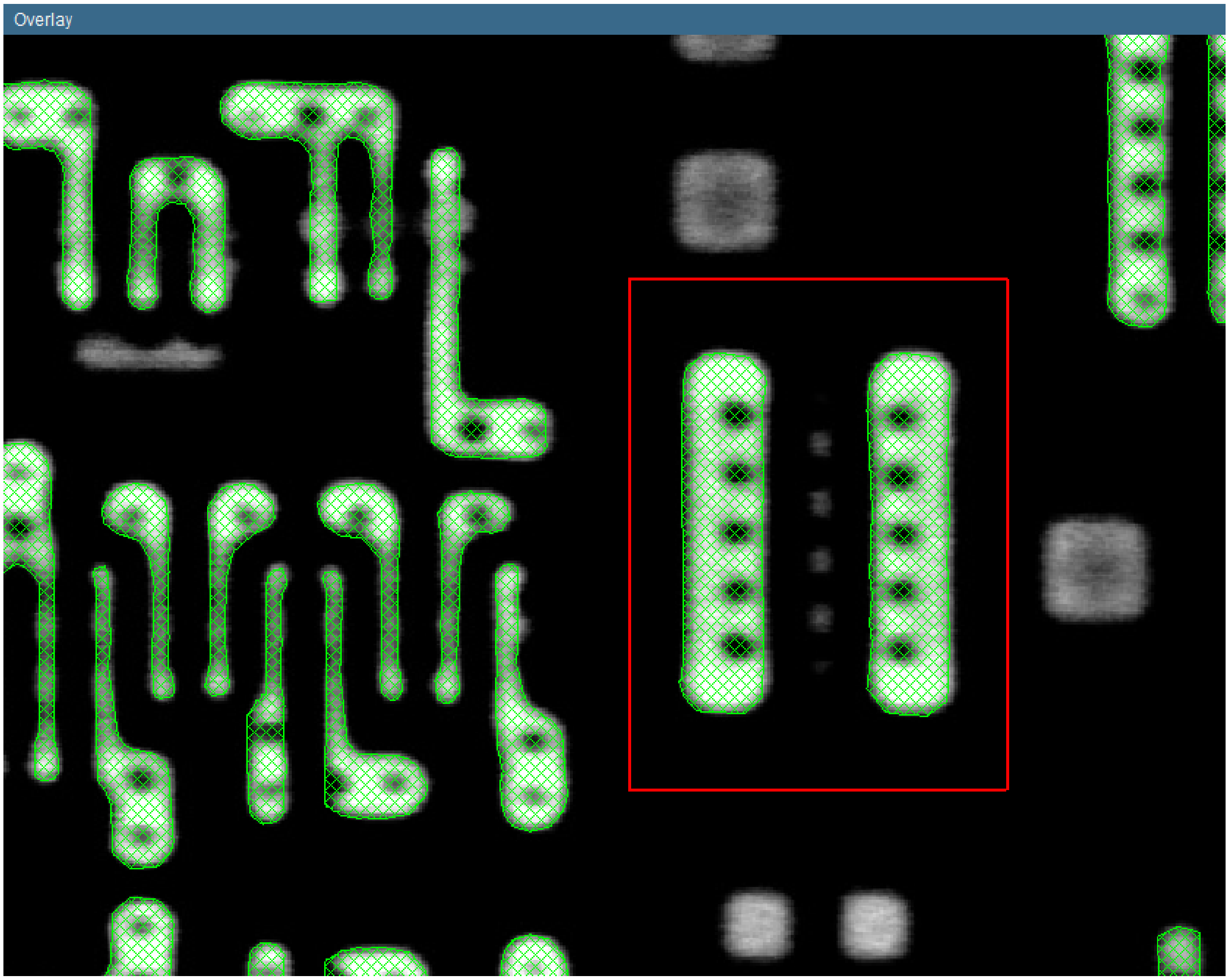
11. A `Move to Layer` window will pop up, select *Active* and then *ok*.
12. Turn on the Active layer and polygons and select the polygon that was just moved to that layer.



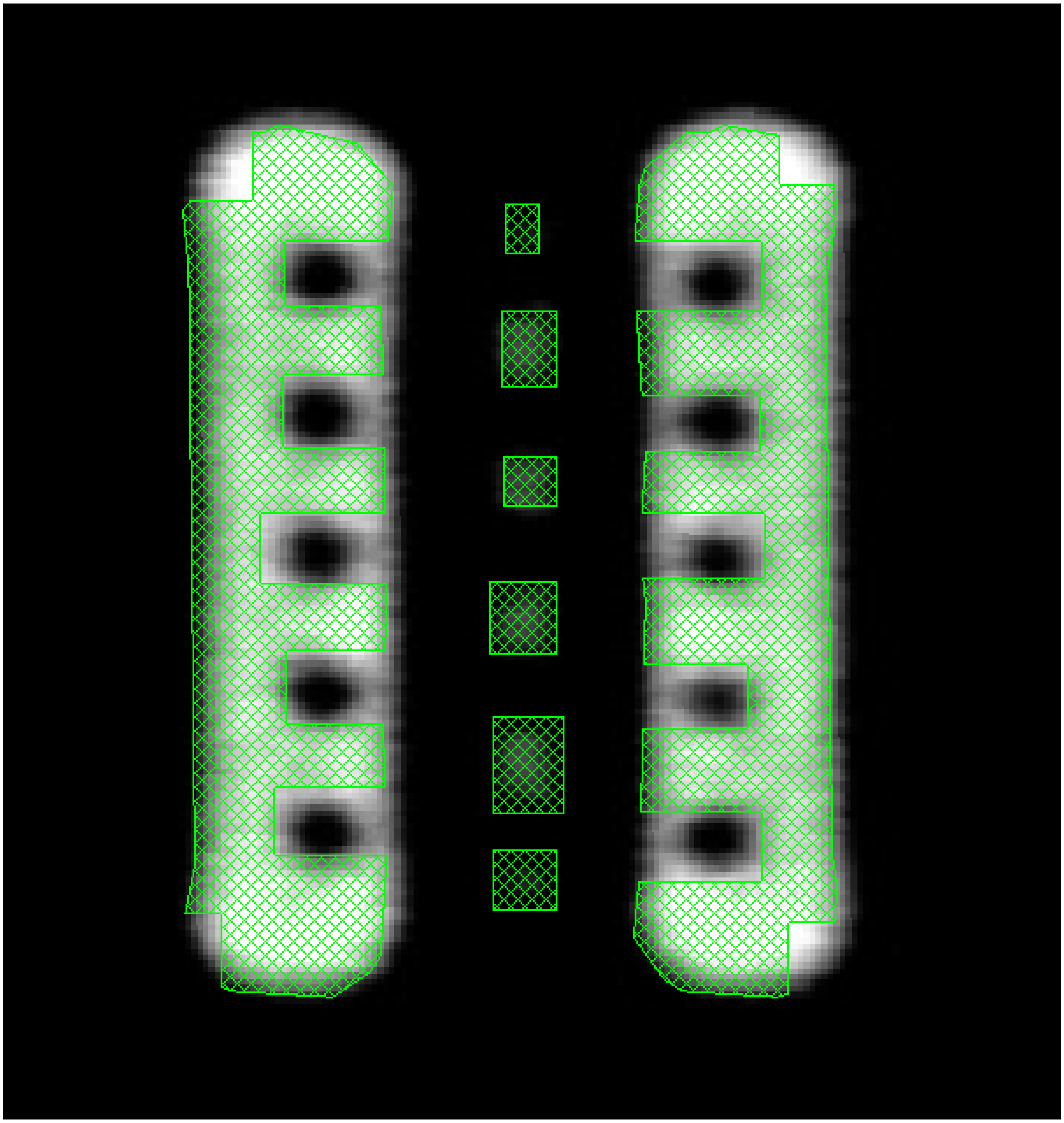
13. Move the polygon back to the place that it was originally, and then that polygon will be on both the active and polysilicon layers.

2.17.4 Selecting and Cloning Areas

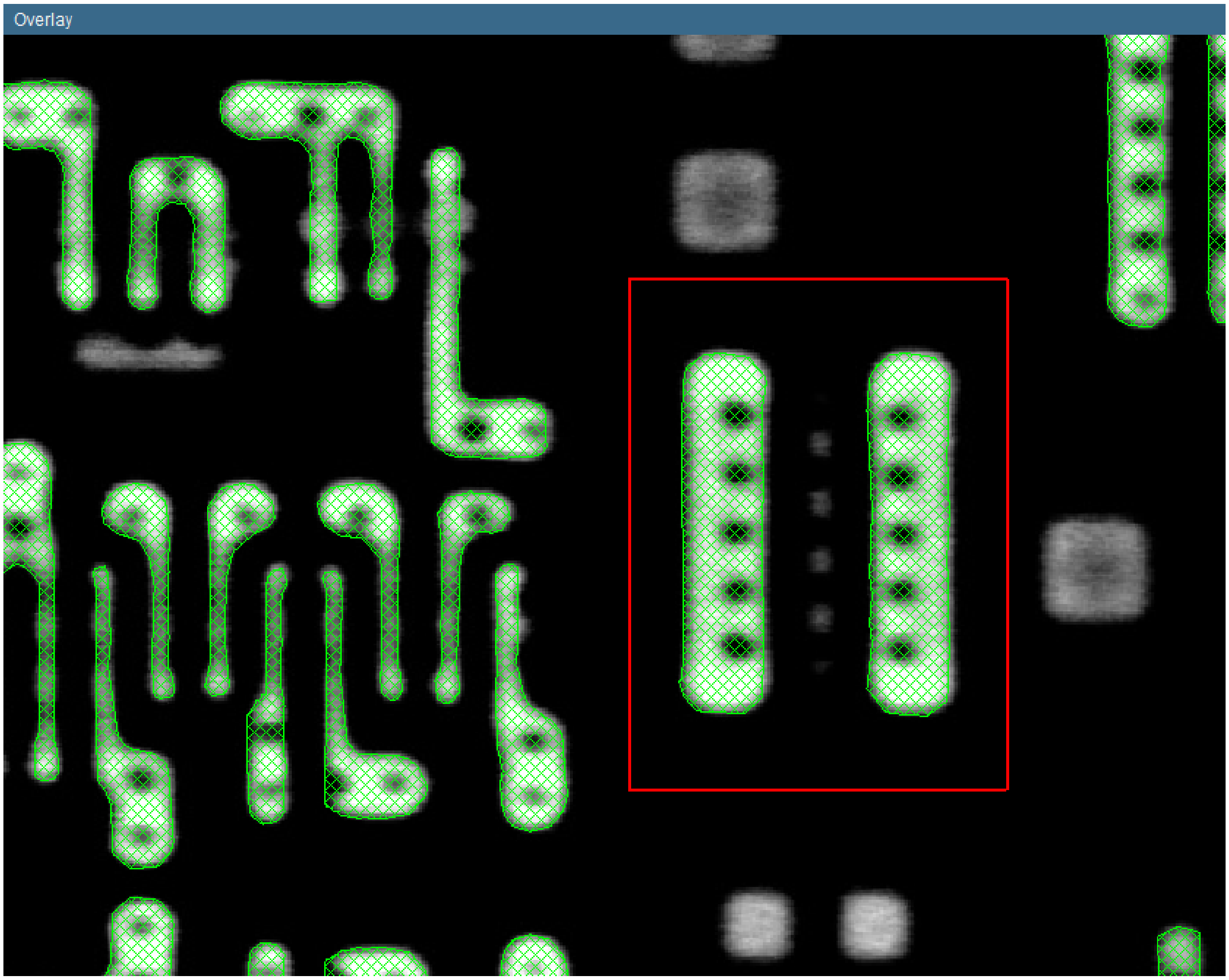
Select the *Select Area* tool and select an area around some polygons.



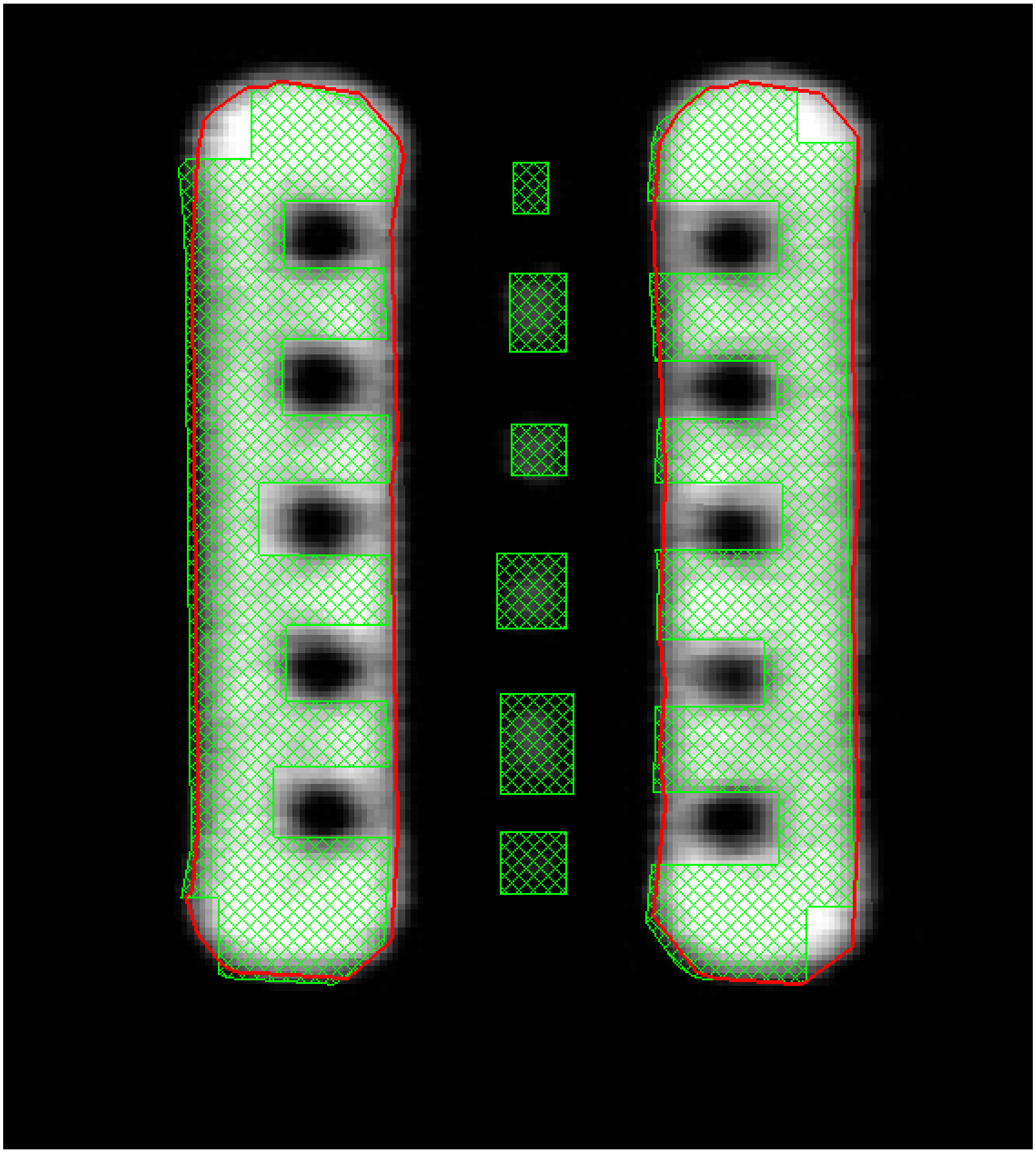
Here is an area where polygons were not correctly extracted. Looking at the picture, the two lines should be completely filled and the middle should not have polygons.

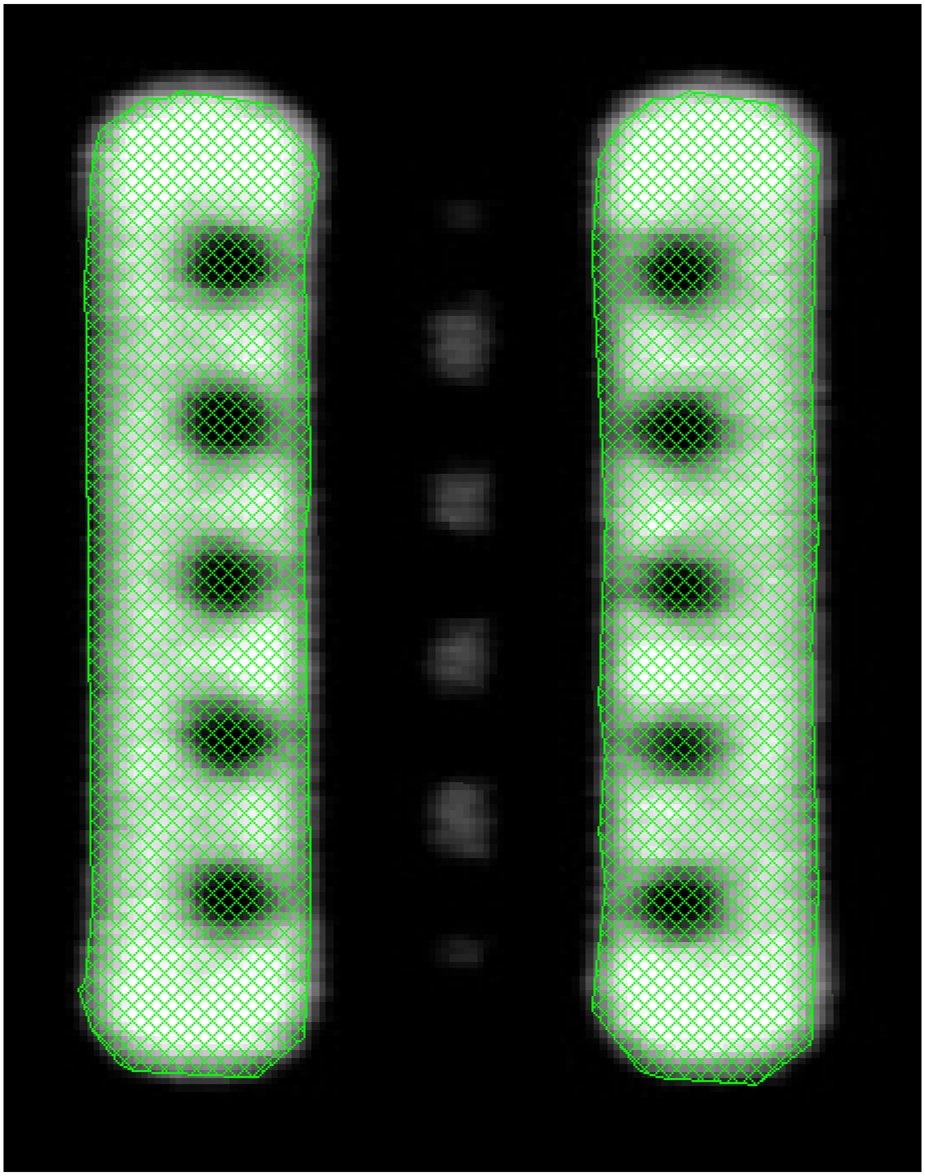


Going back to the picture of the selected area, there is a perfect fit to what is needed.

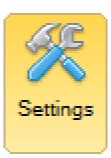


Once placed, the incorrect polygon extraction will then turn into the exact same as whatever was inside the selected area.





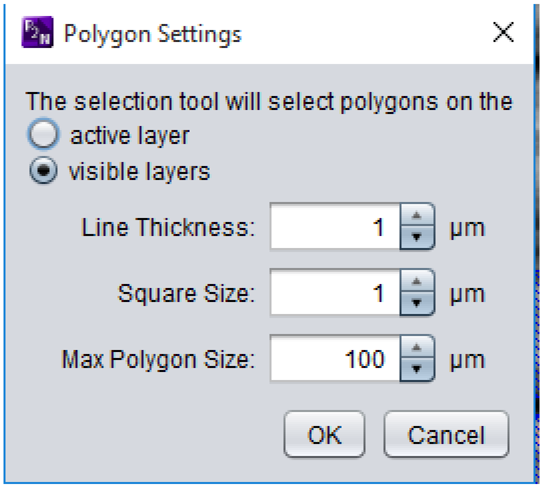
2.17.5 Settings



The polygon settings windows allows adjustment to the line thickness and square size in microns. There is also a setting to adjust the maximum polygon size

The max polygon size determines the maximum width and height of the polygons in the project. If a tool attempts to create a polygon larger than this size, the polygon will automatically be split until its dimensions no longer exceed the max polygon size. If this value is too high then polygon rendering and netlisting will start to become inefficient.

Select *active layer* to tell Pix2Net that when selecting layers, the user only wants to select the active layer. Select *visible layers* to be able to select all visible layers with polygons.



2.17.6 More Information

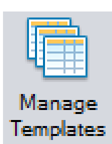
For more info on other functions in the polygon tab, see *Polygon Tab*

2.18 Templates

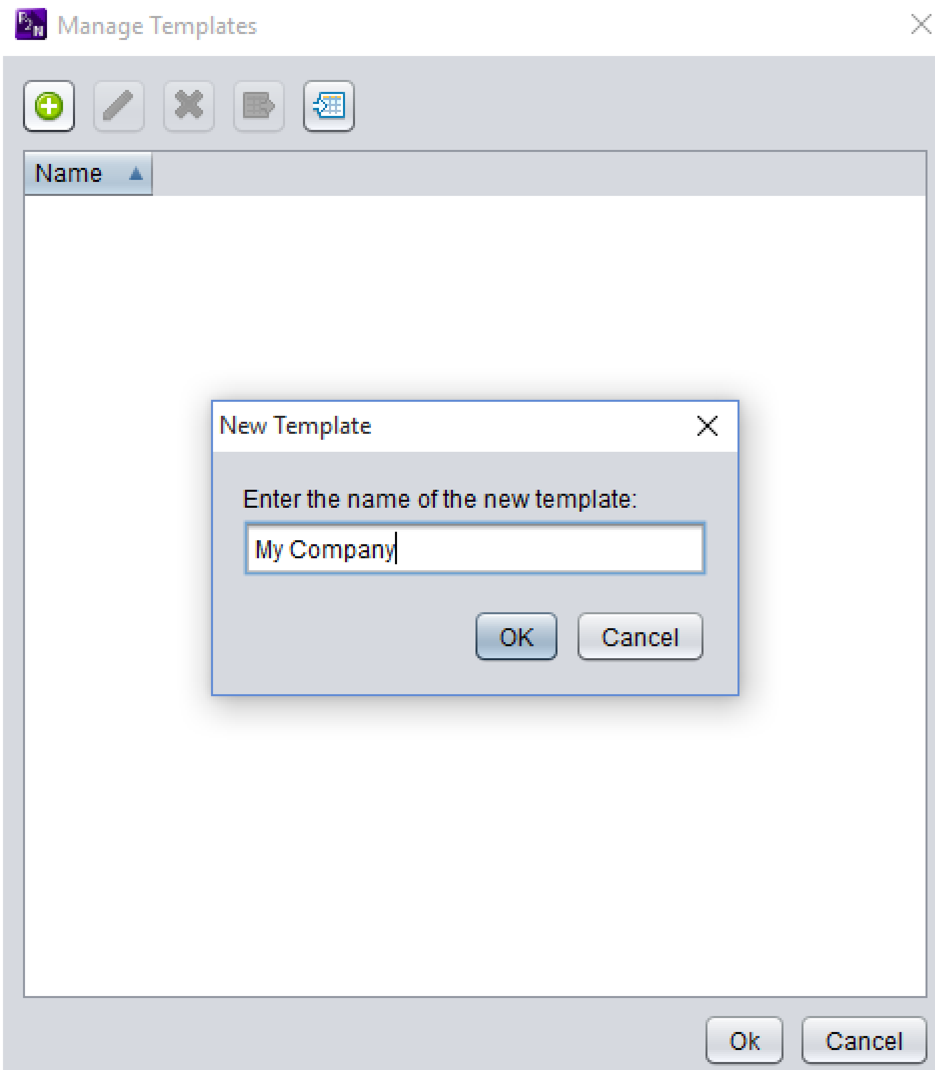
This tutorial will show you how to use a project template to attach extra information to your project and your captured layers. For example, you can use a project template to associate a part number with every project.

2.18.1 Creating a Project Template

1. Go to the `Home` tab and click `Manage Templates`.

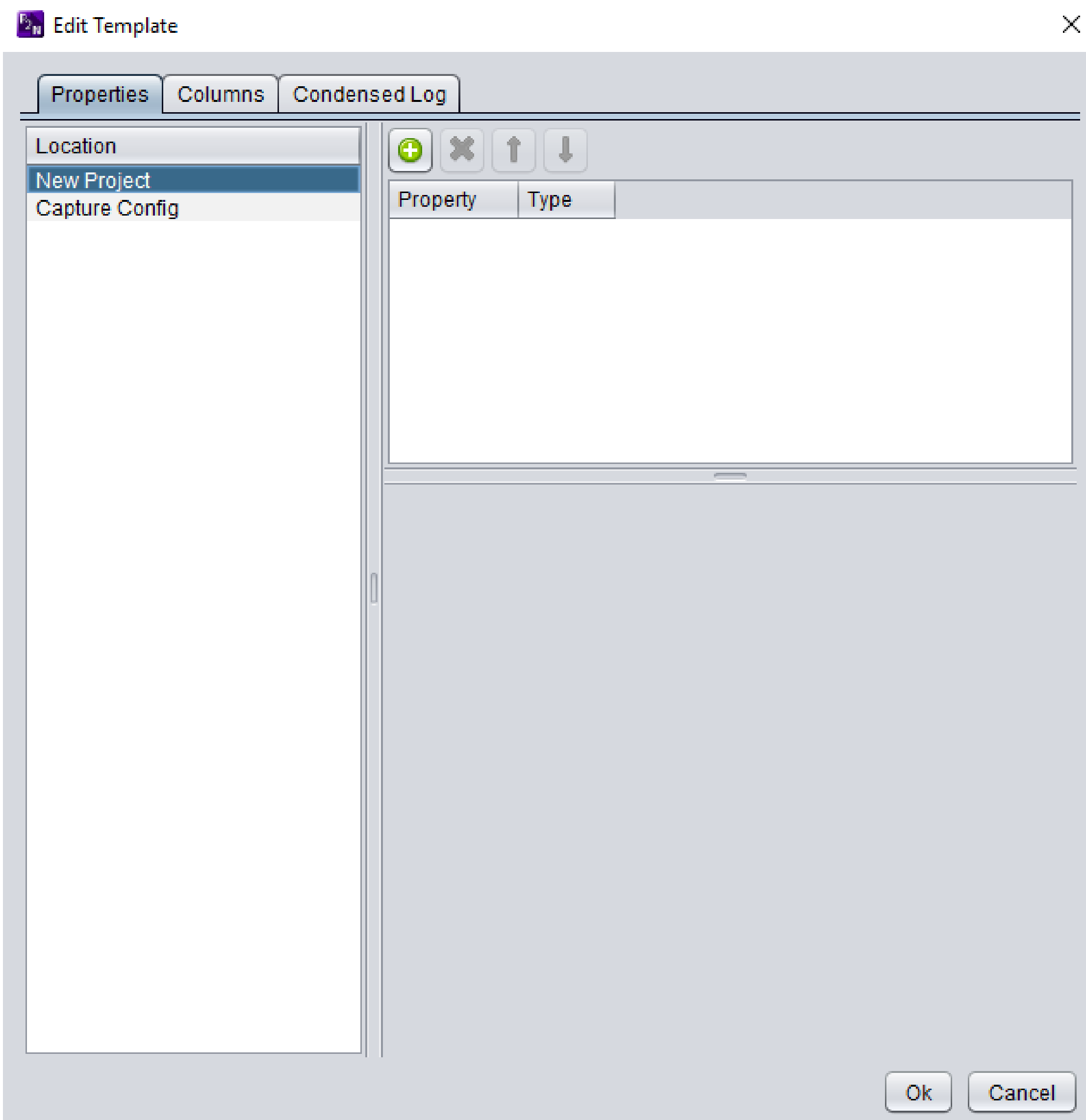


2. Click the `Add Template` button to add a new template. Enter a name for the template and press `Ok`.



2.18.2 Adding Properties

You should now be looking at the `Edit Template` window:



You can use the `Edit Template` window to add properties to a template. A property is a variable (e.g. "Part Number") that an operator can fill out.

There are two property lists that you can add properties to:

- `New Project` - The operator will enter these properties when creating a new project. The properties in this list should be the same for every layer.
- `Capture Config` - The operator will enter these properties when they are setting up a new run in the capture config window. The properties in this list should vary from layer to layer.

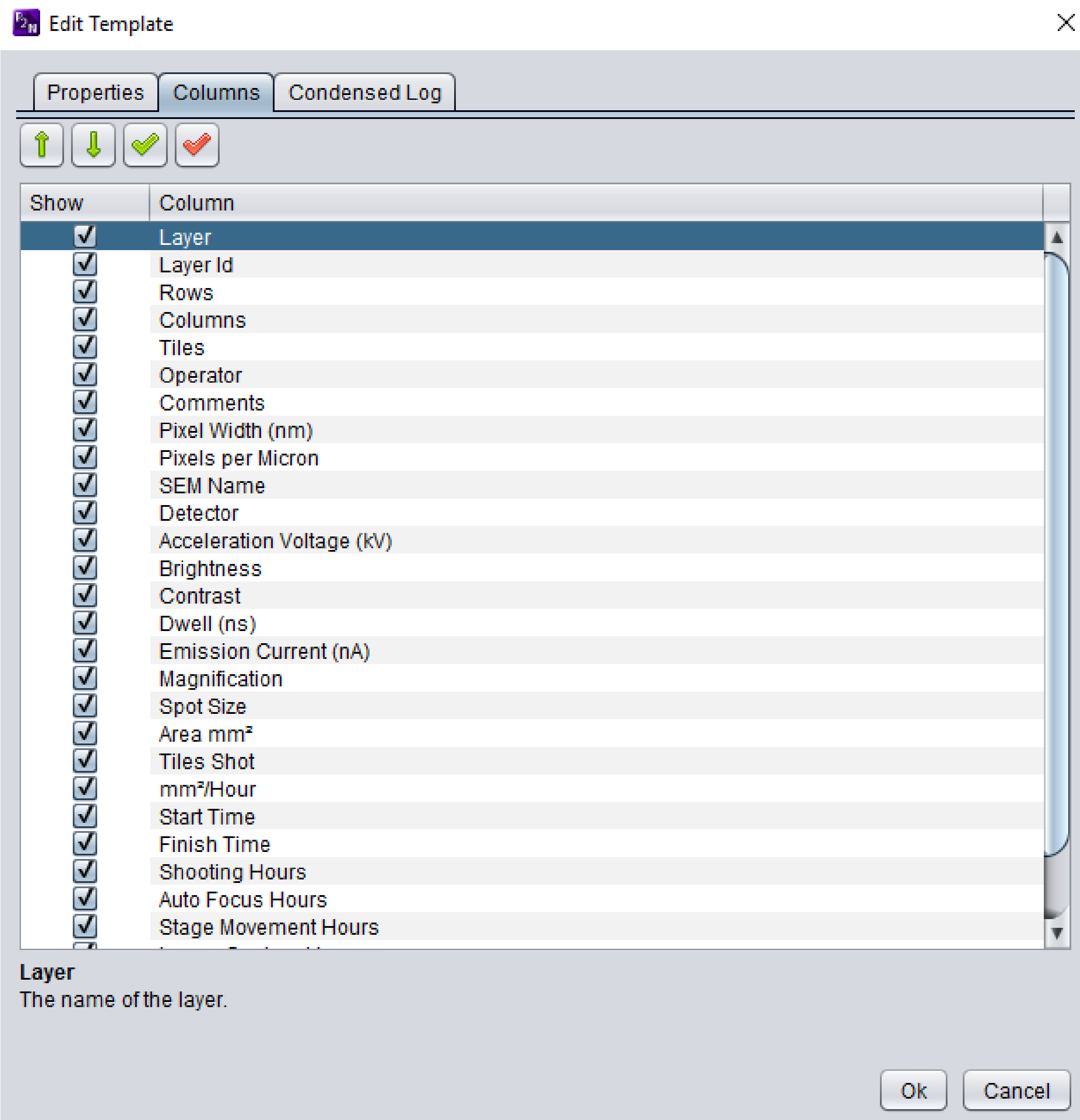
You can add a property by clicking the `Add property` button. There are two types of properties you can create:

- `Text` - A text property is the default type of property. The user can set this property to any value they want to.
- `Multiple Choice` - A multiple choice property is a special property that has a fixed set of possible values. For example, if the property is "Location", then you could force the user to choose one of the following values: "Lab A", "Lab B", or "Lab C". Each possible value should be entered on a new line in the `Choices` text box.

You can use the arrow buttons to change the order the properties are listed in. When the properties are shown to the operator, they will be in the order that you specify here.

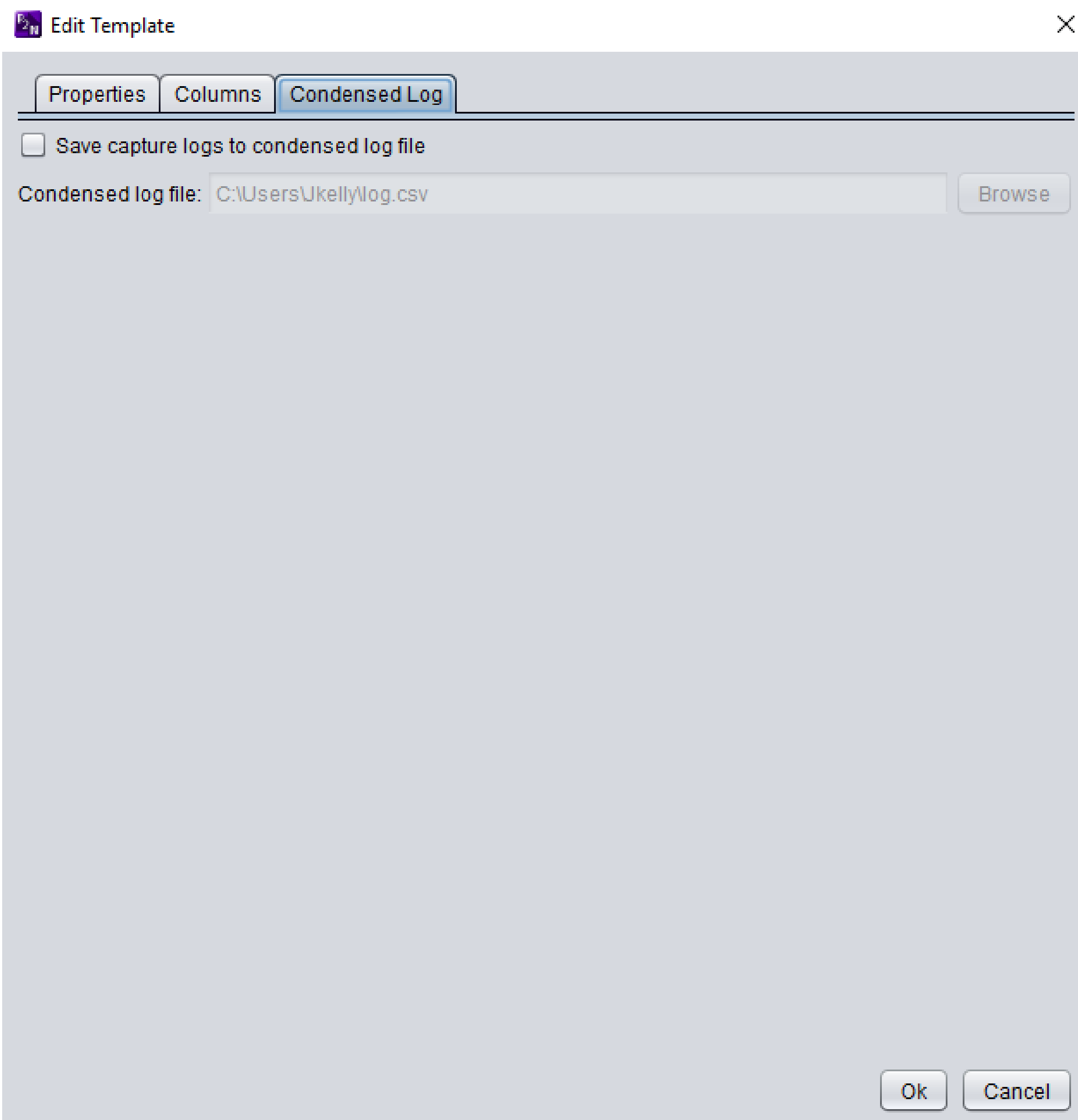
2.18.3 Managing Columns

Click the `Columns` tab to see the list of spreadsheet columns defined by this template. When an operator exports the information for all of the layers to a spreadsheet, this list will determine which columns will be exported, and what order they will be in.



You can include or exclude a column from the spreadsheet by toggling its checkbox, and you can use the arrow keys to change the order of the columns.

Any properties that you have added to this template will also be available as columns in this list.



This allows the user to save capture logs to a condensed file.

When you are finished, click `Ok` to save this template.

2.18.4 Managing Templates

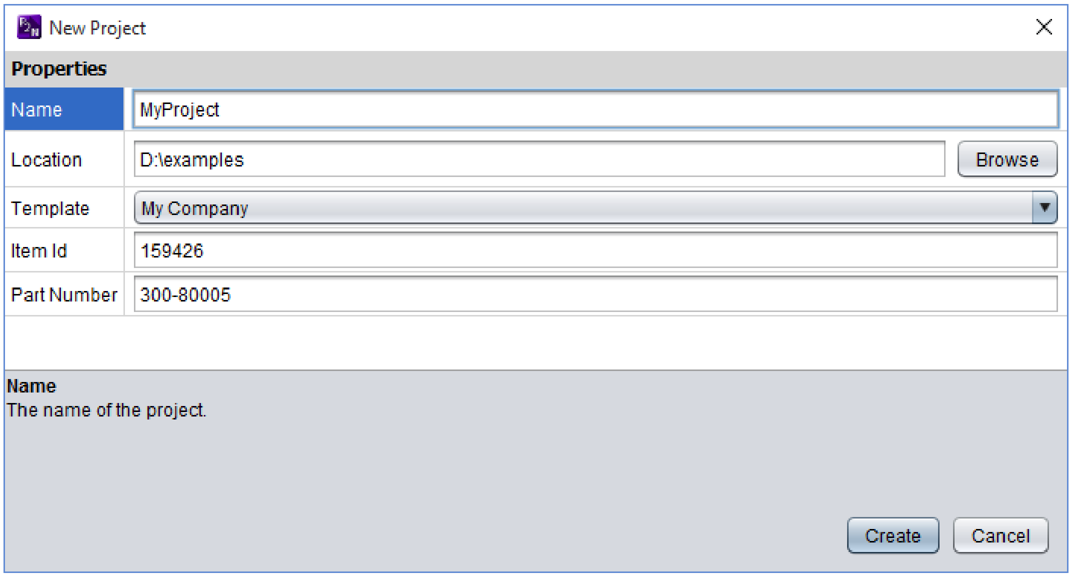
The template you just created should now be displayed in the `Manage Templates` window. This template will now be available as an option whenever you create a new project using this user account.

If this is the only computer you use to create new Pix2Net projects from, then you don't have to do anything else. However, if you need to create new Pix2Net projects from another computer, then you can use the `Export template` and `Import template` buttons to copy this template to other computers.

Click `Ok` to return to the main window.

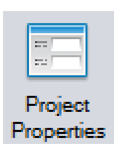
2.18.5 Creating a New Project

1. Go to the `File` tab and click the `New Project` button. Select the template you created and fill in the properties you added. Click `Create` to create the project.

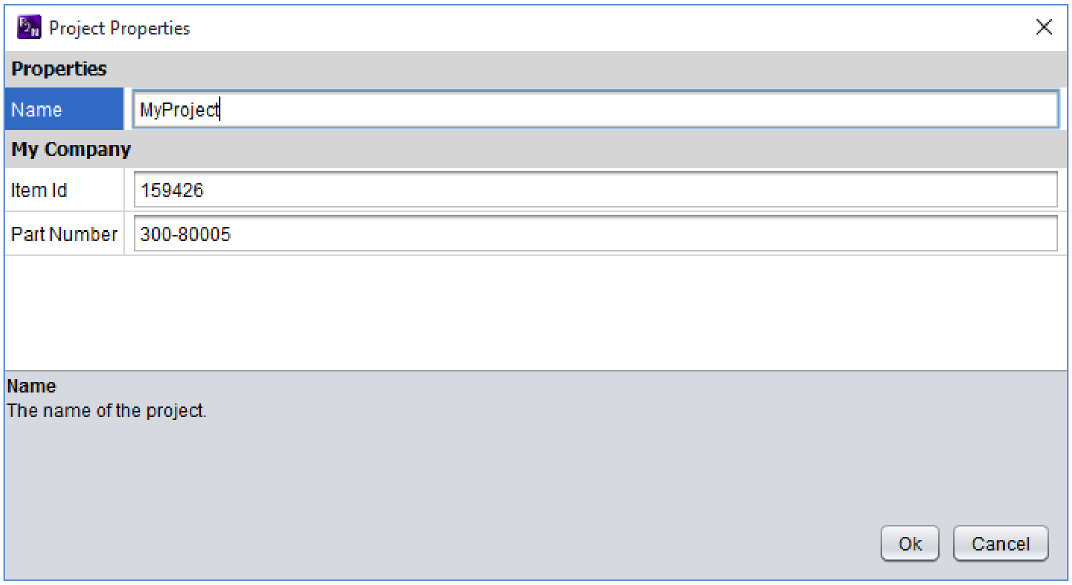


Note: A copy of the template was passed into the project you just created, and that copy can no longer be changed. You can still makes changes to the original template in the `Manage Templates` window, but those changes will only apply to future projects.

2. After the project is created, go to the `Home` tab and click `Project Properties`.



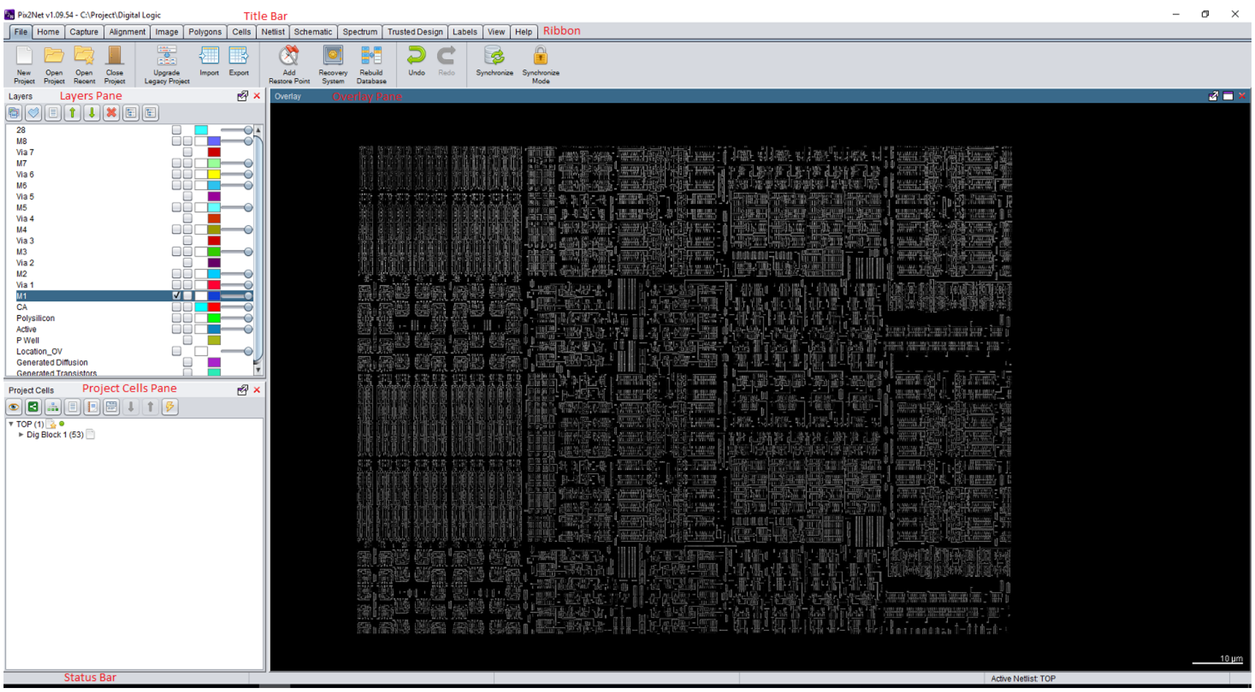
3. If you ever need to review or modify the project properties, you can do it in this window:



4. Click `Cancel` to close the `Project Properties` window.

REFERENCE

3.1 User Interface



The title bar shows the name of the program, its current version, and the file name of the currently loaded project.

The overlay shows image layers, polygon layers and netlist properties. See *Overlay Windows*.

The layers pane allows control of the layers and their properties. See *Layers Window*.

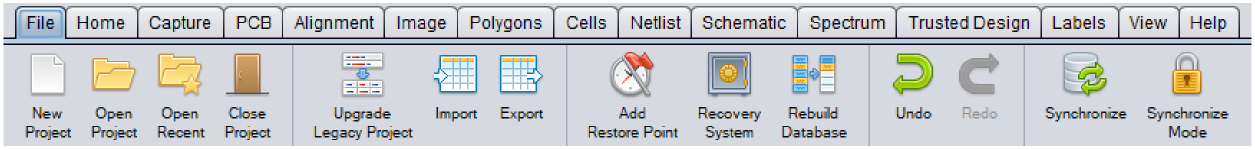
The Project Cells Pane allows for the browsing, viewing, and setting of properties of cell. See *Project Cells Window*.

3.1.1 Ribbon

The ribbon is the large tool bar at the top of the screen. The ribbon is divided into tabs.

File Tab

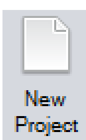
The file tab accesses all interactions with project related files, including the Pix2Net project file, image files, gds, etc.



The following tools are available in the *File* tab:

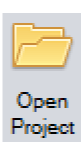
- *New Project*
- *Open Project*
- *Open Recent*
- *Close Project*
- *Upgrade Legacy Project*
- *Import*
- *Export*
- *Add Restore Point*
- *Recovery System*
- *Rebuild Database*
- *Undo*
- *Redo*
- *Synchronize*

New Project



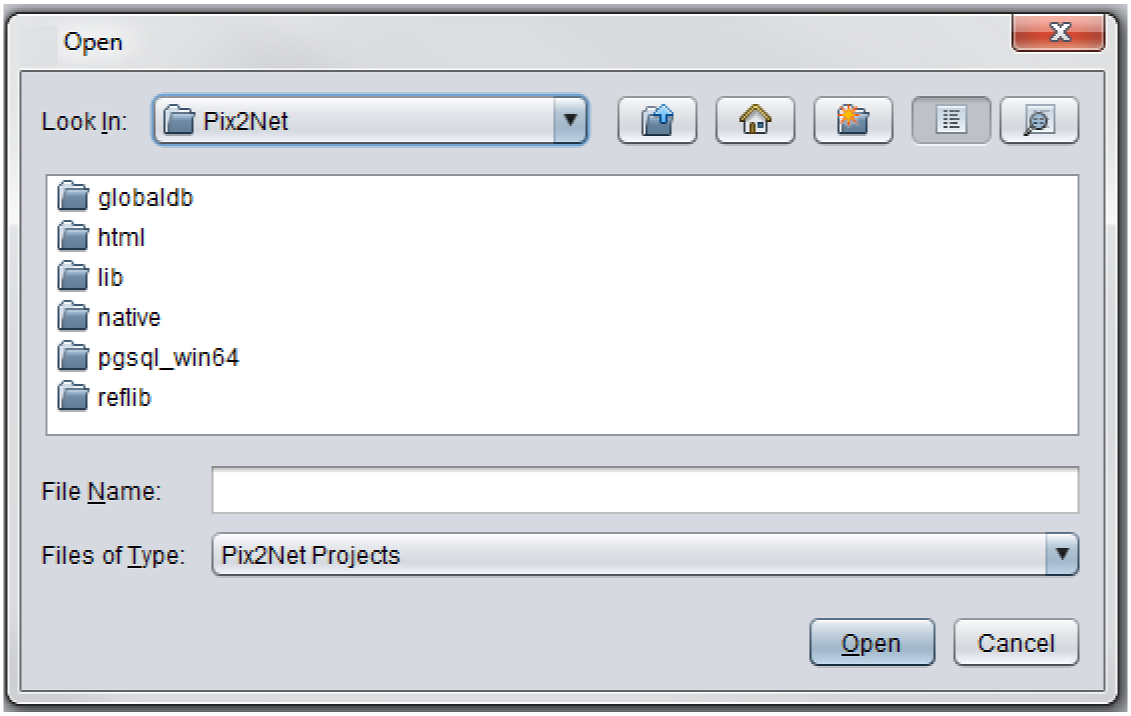
The New Project icon creates a new Pix2Net project. For a tutorial see: *Starting a New Project*

Open Project



The Open Project icon pops up a browser to navigate to, and open an existing Pix2Net project file.

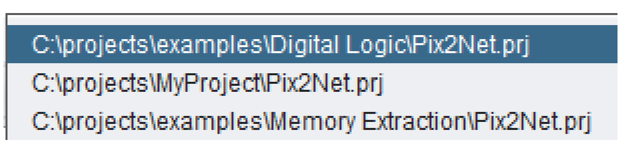
For a tutorial see: *Navigating a Project*



The Pix2Net project files are stored as *Pix2Net.prj*

Open Recent

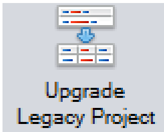
The Open Recent icon opens a menu of the five most recent projects opened in Pix2Net.



Close Project

The Close Project icon will close the current project. All changes are automatically saved.

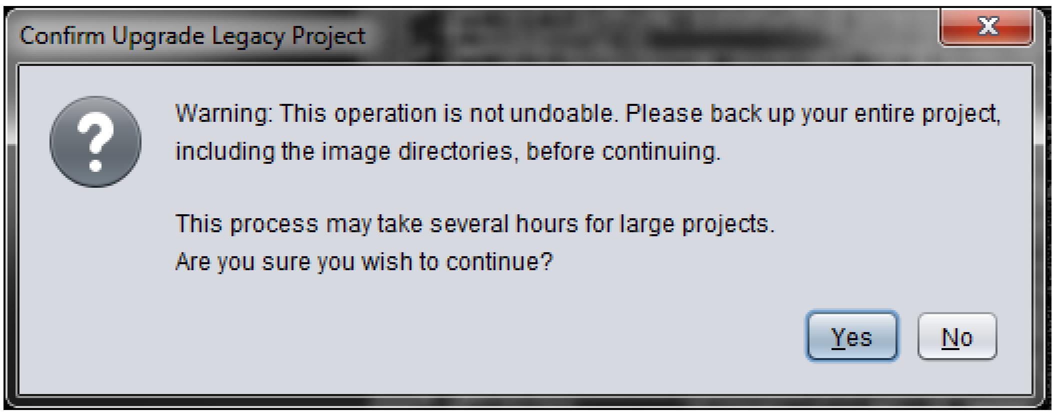
Upgrade Legacy Project



The Upgrade Legacy Project icon is for upgrading h2 database projects to the current postgres database. Pix2Net files in the older h2 format will have the extension .h2.db. This will upgrade to the current, more efficient database.

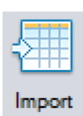
The current database was updated in May of 2014. Any version prior to v0.20 will require an upgrade to the new database.

When the icon is clicked the following confirmation dialogue will pop up:



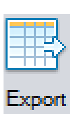
Be sure to save a complete copy of the project directory before upgrading!

Import



This is used to import images, GDSII polygon layers, projects, XML files, FEI MAPS, indexed files, and neural networks. For more information over different ways to import, please see *Importing*

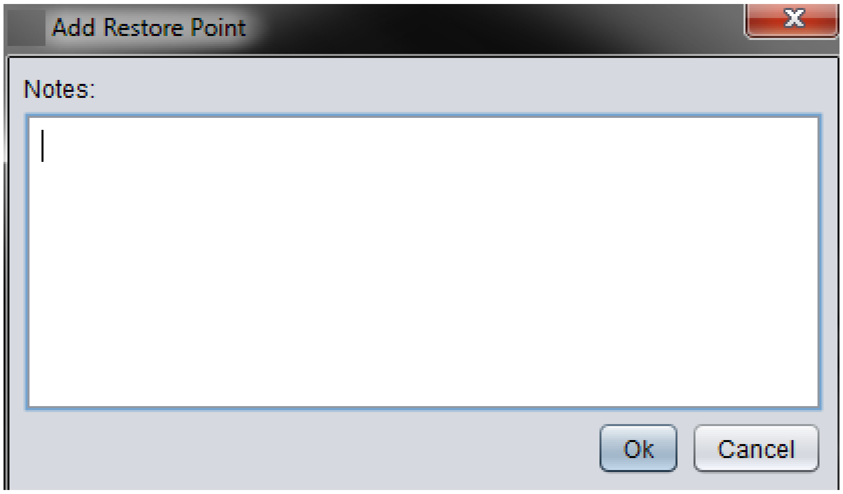
Export



This allows the user to export various types of files, cells, and images. For more information on exporting GDSII, cells, images, etc., please seee *Exporting*

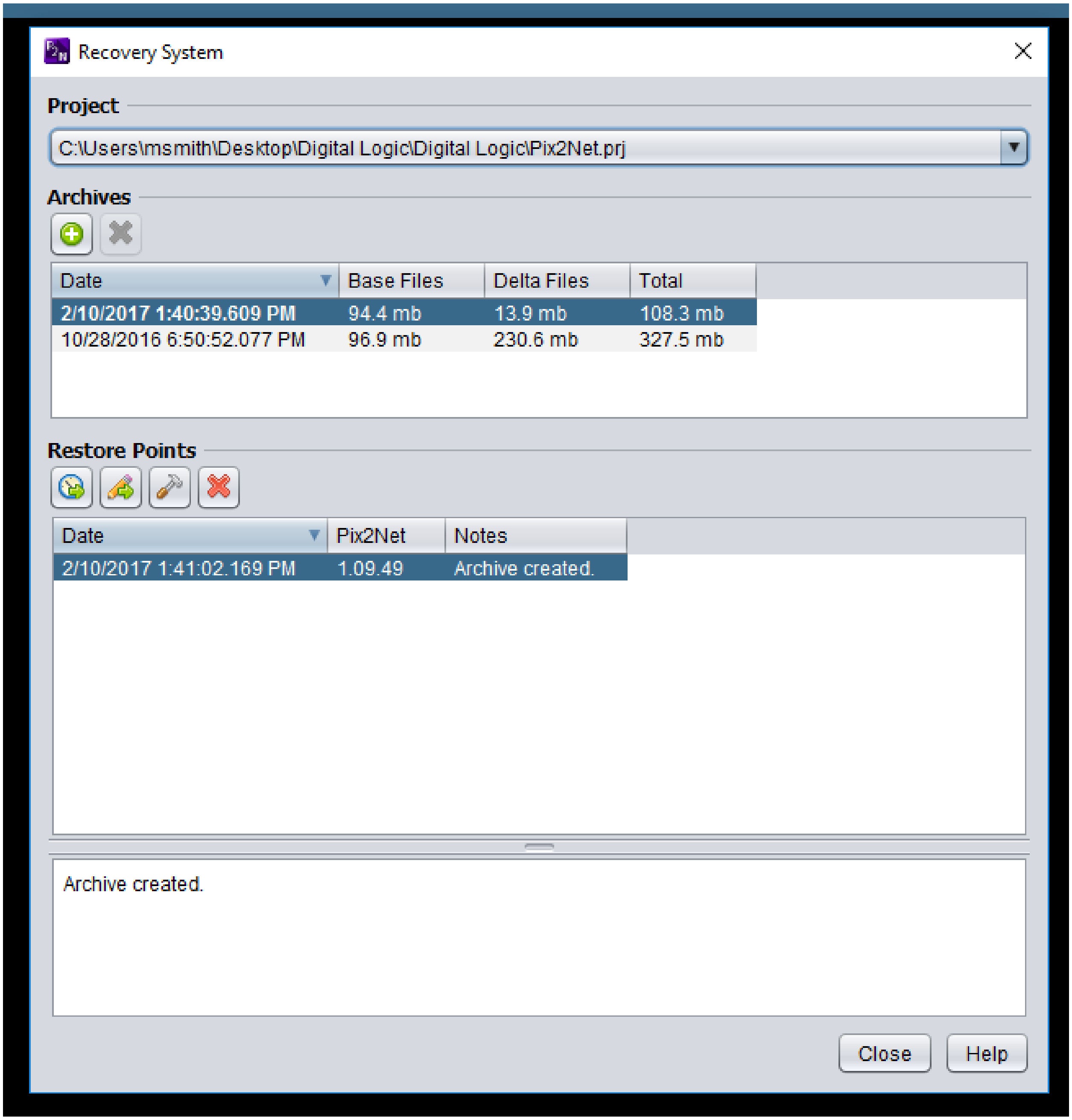
Add Restore Point

Adds a point in the current archive to restore to back to a certain date and time.



Recovery System

The recovery system manages archives and restoration points.

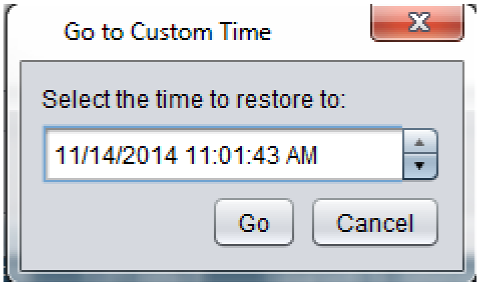


Archives- lists the existing archive files. to make a new archive click the green plus sign.

Restore Points- lists the restore points in the selected archive.

To restore to a point, select the icon .

To restore to a time, select the icon . The following dialogue will appear:



To rebuild the database, select the icon .

The following columns will be displayed for each archive:

Date	The date the archive was created on.
Base Files	The size of the base files.
Delta Files	The size of the delta files.
Total	The total file size of the archive with the delta files.

You are given the option to add a new archive or delete old archives.

The following columns are displayed for each restore point:

Date	The date the restore point was created on.
Pix2Net	The version of Pix2Net that was used to create the restore point.
Notes	The notes that were attached to the restore point.

You are give the option to open a restore point, restore the project from a specific time, or delete a restore point.

Rebuild Database

In the event the project encounters an issue this feature allows the database to be rebuilt. This should be done only if necessary and the project is corrupted.

Undo

Undoes the last command. To view command history click on the view tab and select *Command History*.

Redo

Redoes the last command. To view command history click on the view tab and select *Command History*. *View Tab*

Synchronize

Synchronize is intended to divide up the work on the project. Start with a project that has layers stitched, aligned and polygons extracted. Archive the project (*Recovery System*) then make as many copies as desired of this *master* project.

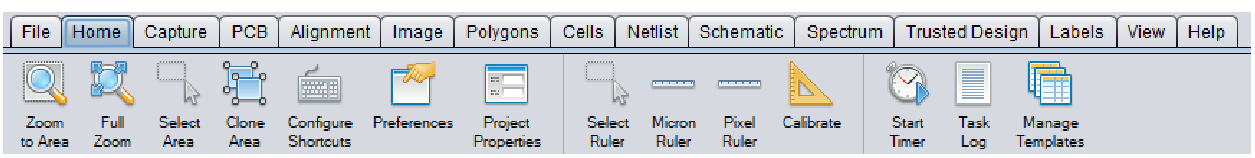
The designated master project may perform any operations. All of the copy projects should click on the *Synchronize Mode* icon to prevent performing operations that do not synchronize. The icon will be highlighted as shown:

When ready to synchronize a copy project, click the *Synchronize* icon:

See *Synchronization*

Home Tab

The *Home* tab gives general zoom features, configurable shortcuts, properties and measurement tools.



The following tools are available in the *Home* tab:

- *Zoom to Area*
- *Full Zoom*
- *Select Area*
- *Clone Area*
- *Configure Shortcuts*
- *Preferences*
- *Project Properties*
- *Select Ruler*
- *Micron Ruler*

- *Pixel Ruler*
- *Calibrate*
- *Start/Stop Timer*
- *Task Log*
- *Manage Templates*

Zoom to Area

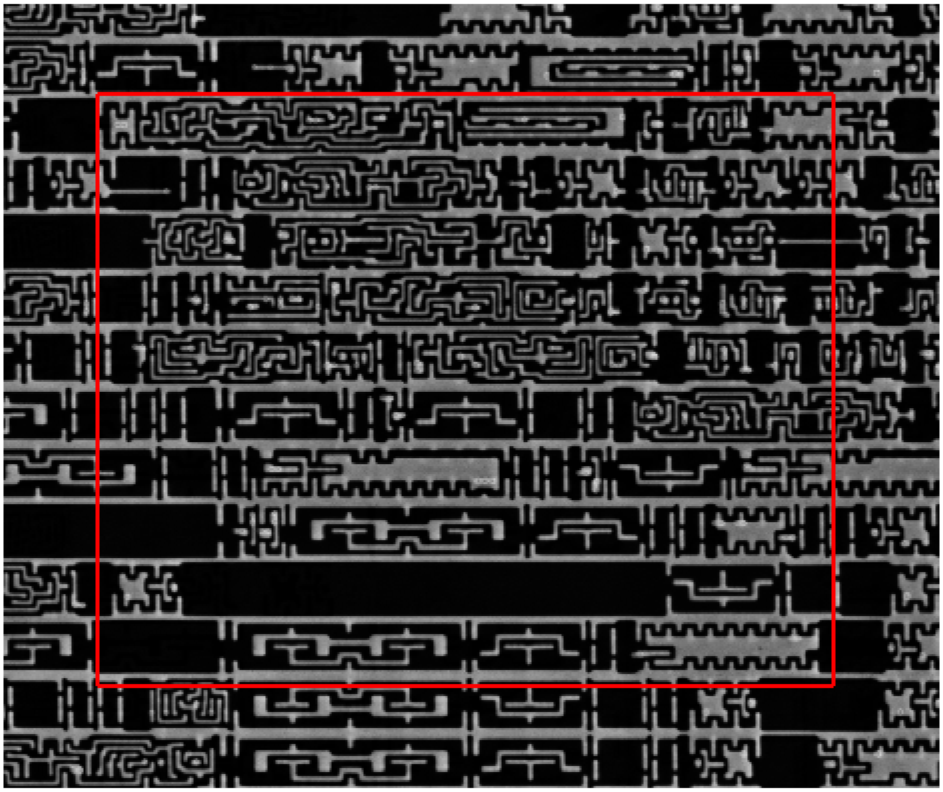
Left click and drag a box around an area of interest. When satisfied release the mouse button and the overlay window will be zoomed into that location.

Full Zoom

Returns the zoom level to the default setting.

Select Area

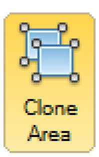
Click and drag to select an area that will be used in various Pix2Net features.



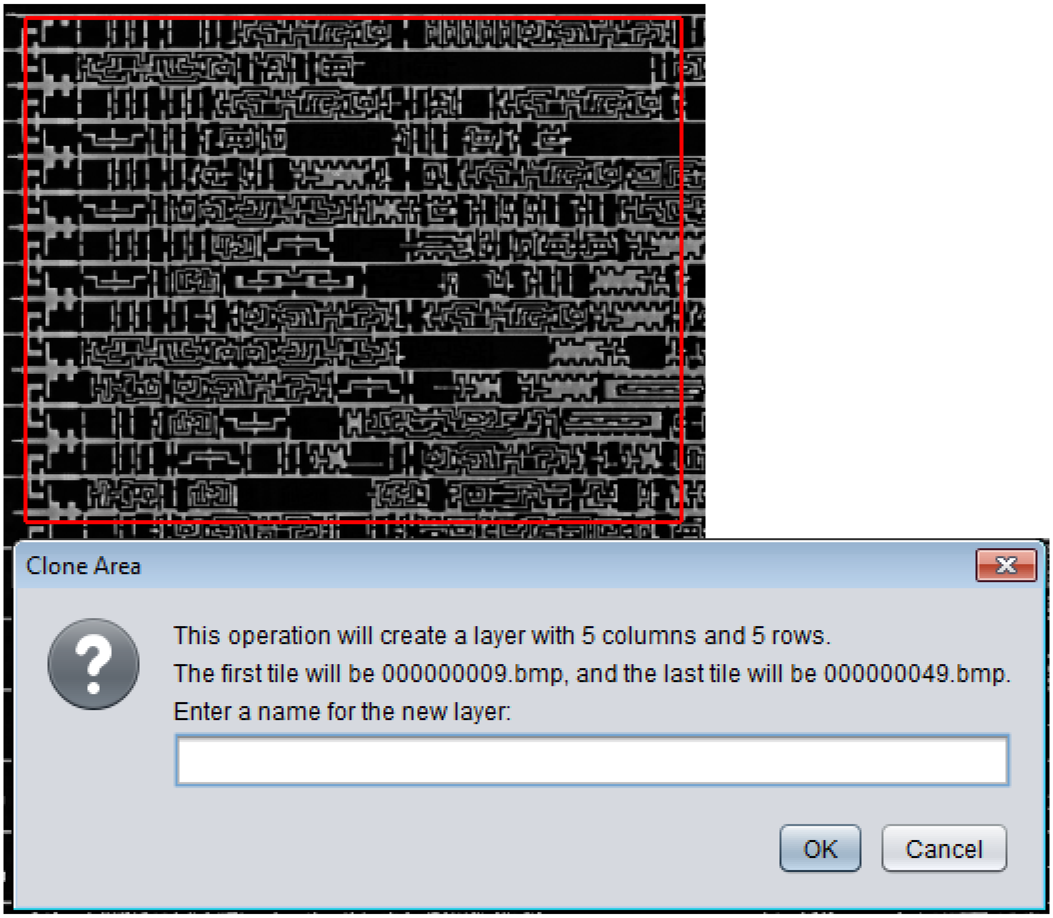
This box acts as a boundary for the following tools:

- Count Cell Instances *Cell Instance Search*
- Set Review Boundary: *Alignment Review*
- Polygon Extraction *Extract Polygons*
- Filter Layer *Filter Layer*
- Identify Fill Blocks *Extract Polygons* (see identify fill blocks)
- Export Non-Overlapping Tiles *Export* (see non-overlapping tiles)
- Export Single Image *Export* (see single image export)

Clone Area



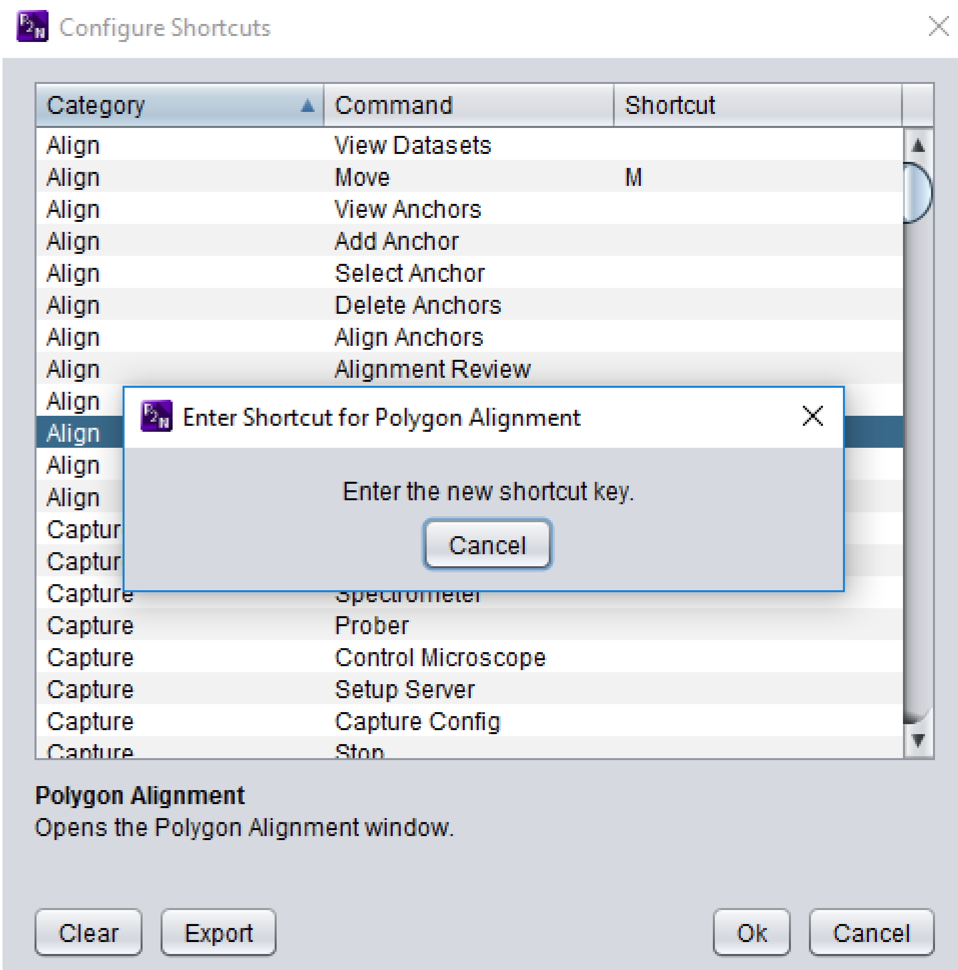
Creates a new image layer from the selected area of an existing layer.



A confirmation window will pop-up giving the details of the new layer and the option to enter the name for this new layer.

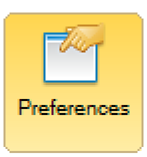
Configure Shortcuts

Brings up a window that allows shortcuts to be added or customized.

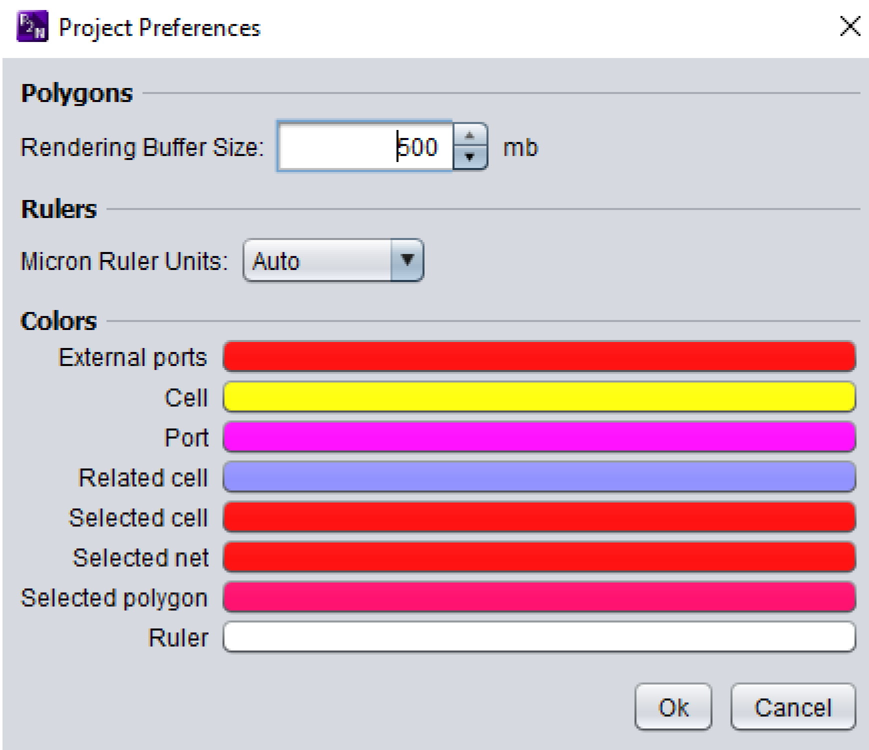


Shortcuts can be organized by the category they belong to, command name or shortcut key(s) given. To add or change a shortcut, click the existing shortcut or the whitespace in the *Shortcut* column then press the key(s) to bind this shortcut. To clear all shortcuts, press the *Clear* button. *Export* will create a .csv file listing all of the current bindings that are set.

Preferences



Displays the current default color scheme for various cell boundaries, nets, rulers and text markings.

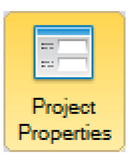


Double clicking any of these colors will bring up a color palette allowing a different color to be selected.

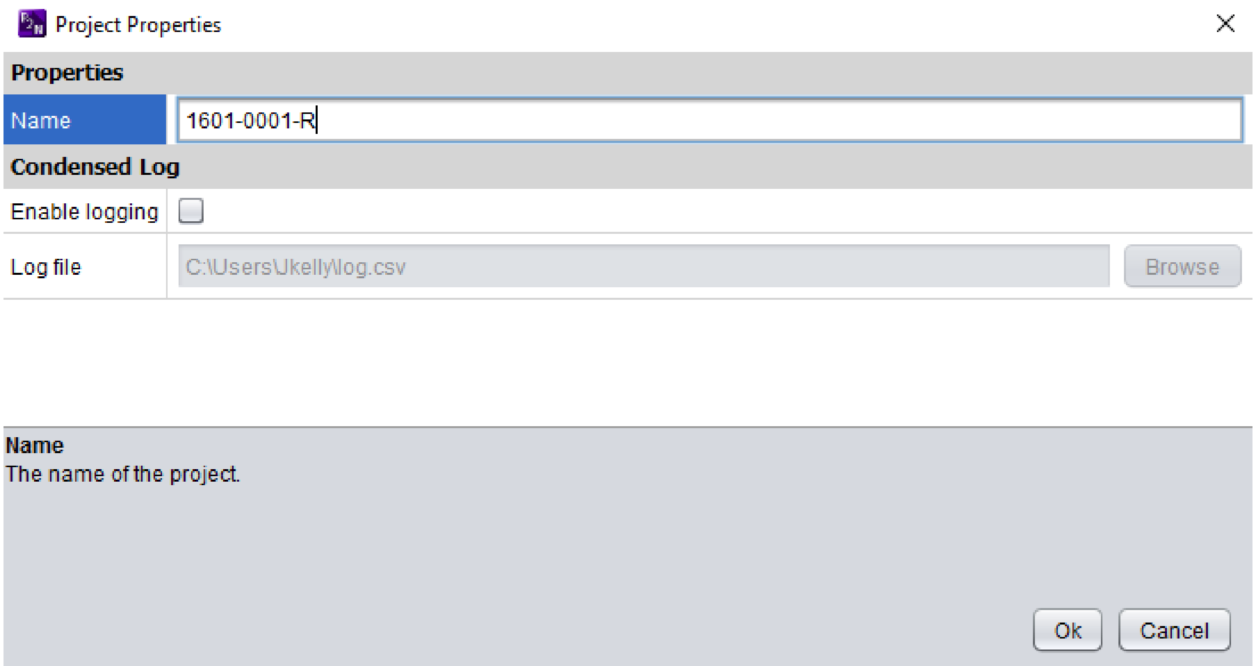
The user can change the ruler units. The following are available: auto, nano, micron, milli.

The *Rendering Buffer Size* allows the user to allocate as much or as little memory desired to the rendering (displaying) of polygons.

Project Properties

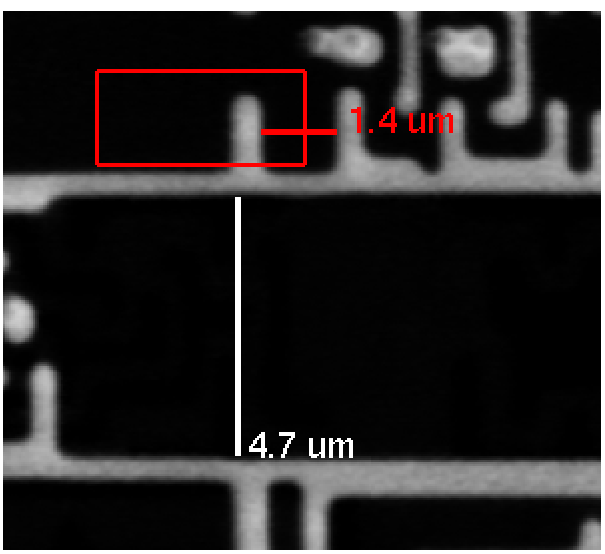


Allows the user to change the name of the project and to enable condensed logging by choosing a path to the file.

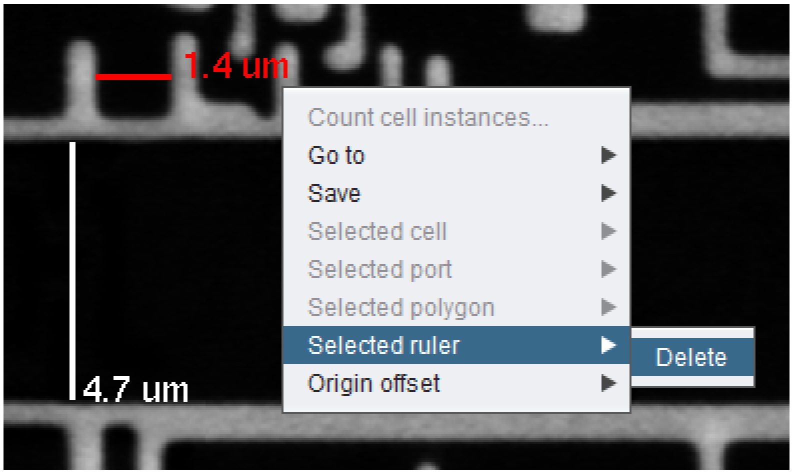


Select Ruler

Drag a box to highlight any unwanted rulers (micron or pixel).



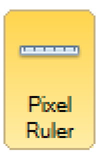
Right clicking will bring a dialogue box with an option to delete selected rulers, or the user can simply hit the *delete* key.



Micron Ruler

Adds a micron ruler by clicking a start point and dragging to the endpoint. Press *shift* while dragging the mouse to lock the ruler to be horizontal or vertical.

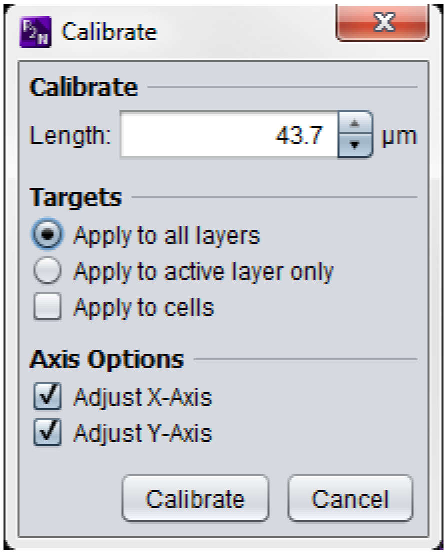
Pixel Ruler



Adds a pixel ruler by clicking a start point and dragging to the endpoint. Press *shift* while dragging the mouse to lock the ruler to be horizontal or vertical.

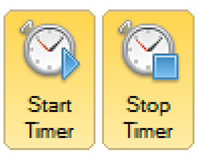
Calibrate

Allows a layer to be rescaled to accurately match with known dimensions of a feature.

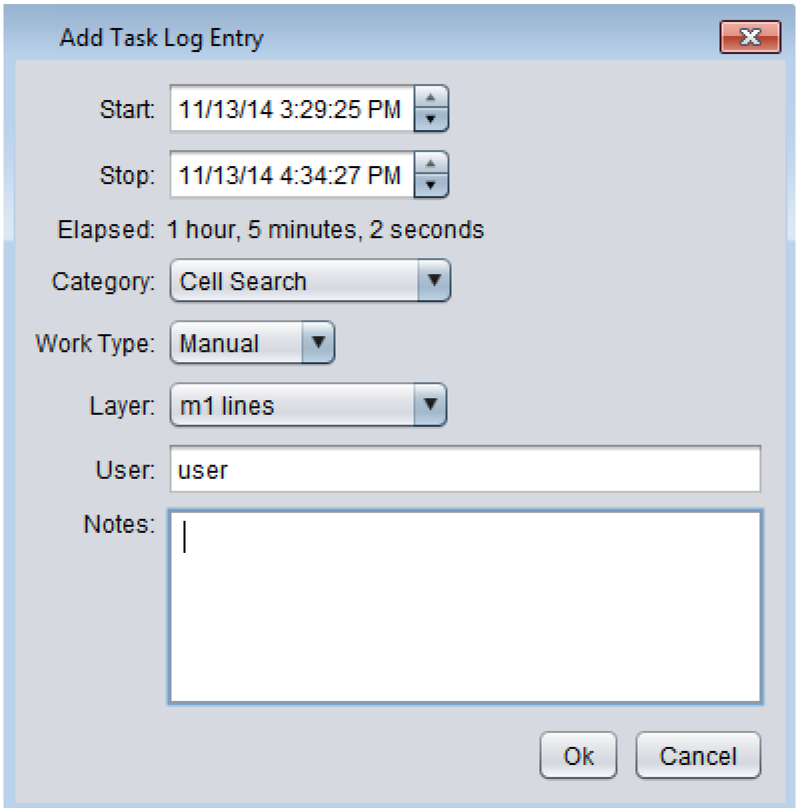


To use this feature draw a line across a known length or width and enter the actual value in the *Calibrate* pop-up window. This calibration can affect either the active layer or all layers in the project and either adjust the X-axis, Y-axis or both.

Start/Stop Timer

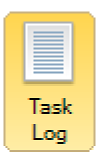


When first pressed a timer will activate pressing this again will stop the timer and bring up a *Task Log Entry* window.

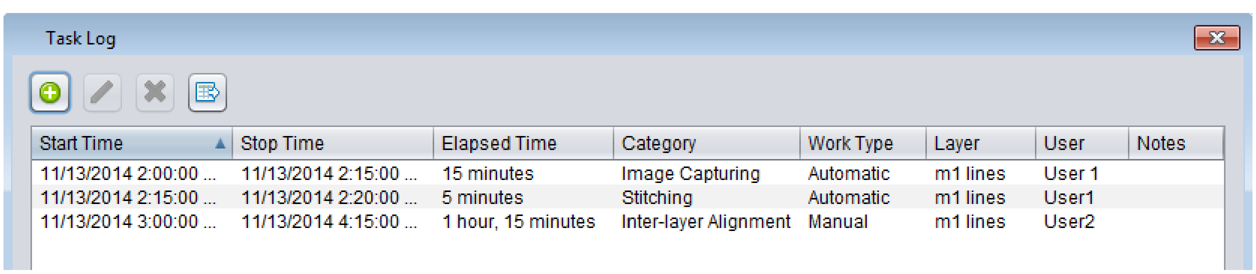


In this window the start and stop times can be edited and the category, type of work and what layer was affected can be chosen. The users name will appear and any notes may be added.

Task Log

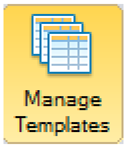


This opens the task log window.



New entries can be added, any entry can be edited or deleted and the list can be exported as a .CSV list.

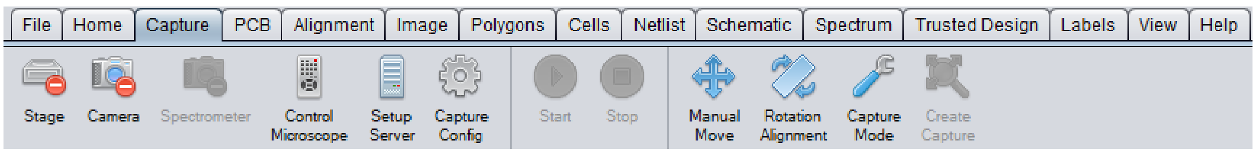
Manage Templates



Brings up the *Manage Templates* window. This feature helps the user add, edit, remove, export, and import templates. *Templates*

Capture Tab

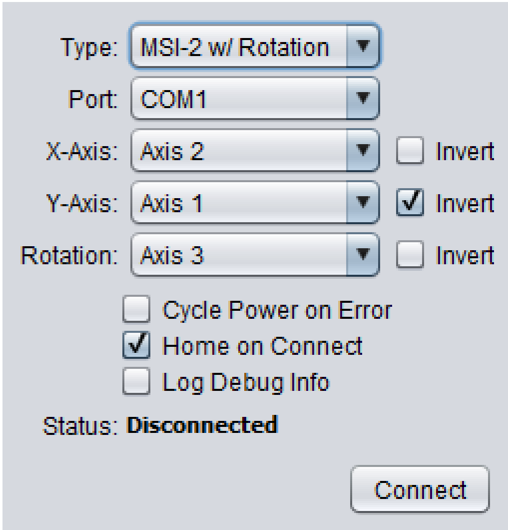
The *Capture* tab allows you to connect a stage, a camera and set control features in Pix2Net to allow automated image runs.



The following tools are available in the *Capture* tab:

- *Stage*
- *Camera*
- *Spectrometer*
- *Control Microscope*
- *Setup Server*
- *Capture Config*
- *Start*
- *Stop*
- *Manual Move*
- *Rotation Alignment*
- *Capture Mode*
- *Create Capture*

Stage



The stage menu gives the following options:

Type: Select the type of stage you are connecting to.

Port: Select the COM port connected to the stage.

Sense: Set the direction of the stage movement (X, Y, and Rotation).

- Normal
- Invert with a check mark.

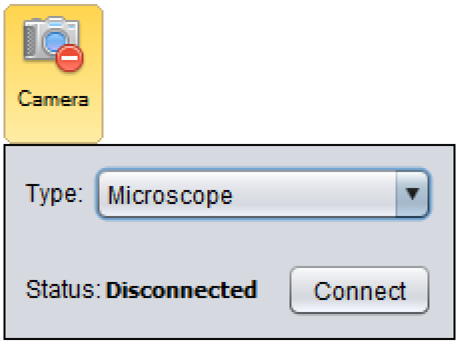
Cycle Power on Error: Allows Pix2Net to control a Power USB brand power strip that the stage is plugged into. In event of an error, Pix2Net can cut power to the stage and reapply it, effectively rebooting the device's controller.

Home on Connect: Will cause the stage to execute a home-finding procedure as soon as you connect to the stage. The stage must do this at least once per power-on state in order to know where it is. Homing will cause the stage to physically move to its positive and negative limits, then return to the center. It is not necessary to do it again if the user has just disconnected without removing power from the stage. Pix2Net has no way to know what the state of the stage is on connection, so it relies on the user to tell it to home or not.

Log Debug Info: Causes the Application Log to show all of the communication with the stage device. It does not need to be turned on unless there is an error that needs troubleshooting.

Camera

The camera menu lets you link a camera with Pix2Net software.



If a SEM is being connected a Pix2Net server must be created and set up properly.

If a Spot Camera is connecting no server needs to be created.

Spectrometer

Prior to beginning spectrometer scan, the sample must be measured.

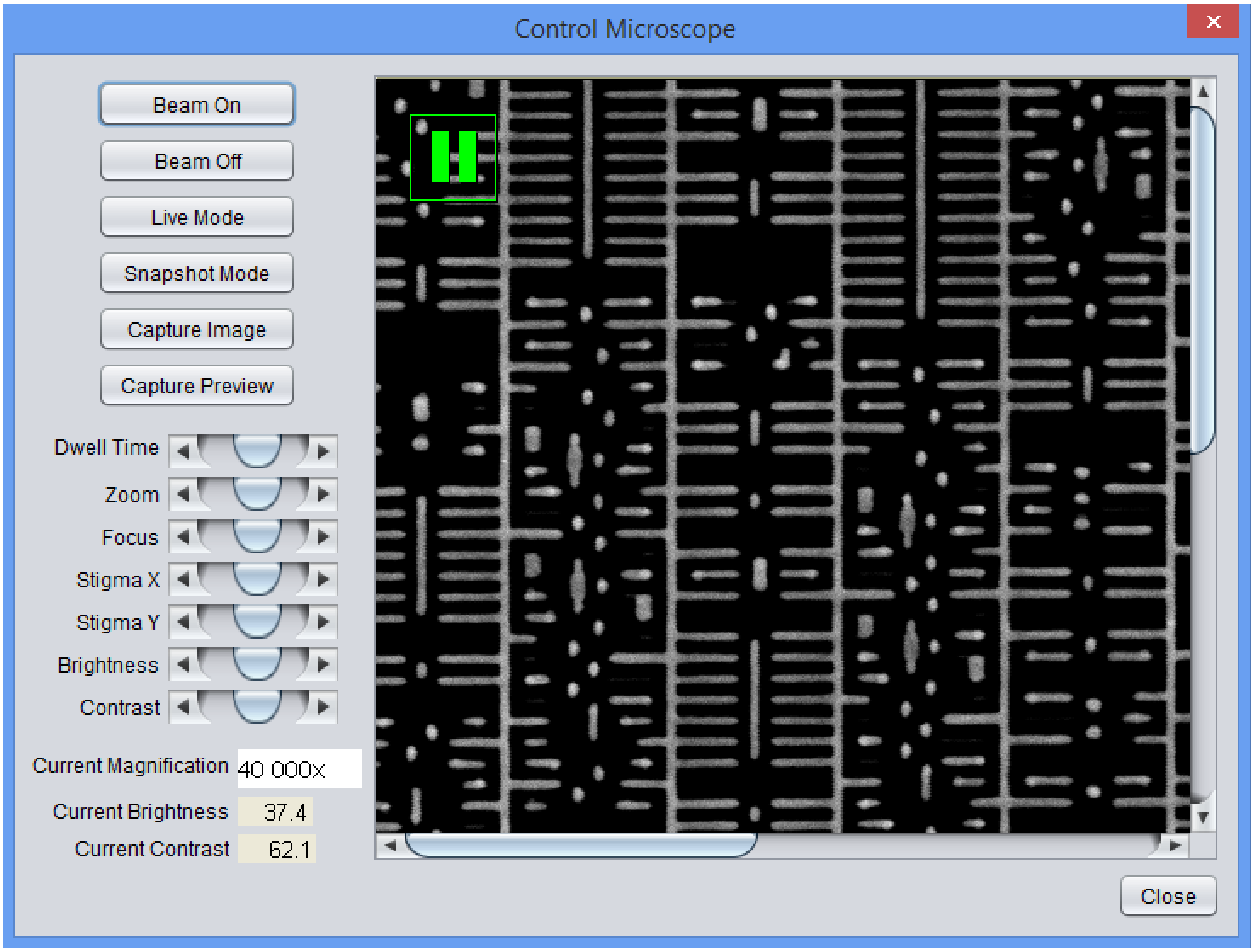
After connecting the spectrometer stage, then the Spectrometer menu allows you to connect to the spectrometer connected to the computer operating Pix2Net.

Using the *Manual Move*, position the sample into field of view.

Proceed to *Create Capture*

Control Microscope

Control Microscope brings up a user interface similar to a remote desktop that allows control via remote access. Using control microscope features help verify that the commands specified in `Setup Server` are correct.



The *Control Microscope* window can remotely do the following actions:

- Turn on the SEM beam.
- Turn off the SEM beam.
- Put the SEM in live capture mode.
- Pause the SEM capture.
- Capture one full scan on the SEM.
- Take an instantaneous screen shot of the SEM window.

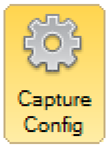
Control Microscope can also adjust the dwell time, zoom, focus, X and Y stigmation, brightness and contrast using the left and right buttons.

This window also displays the current magnification, brightness and contrast.

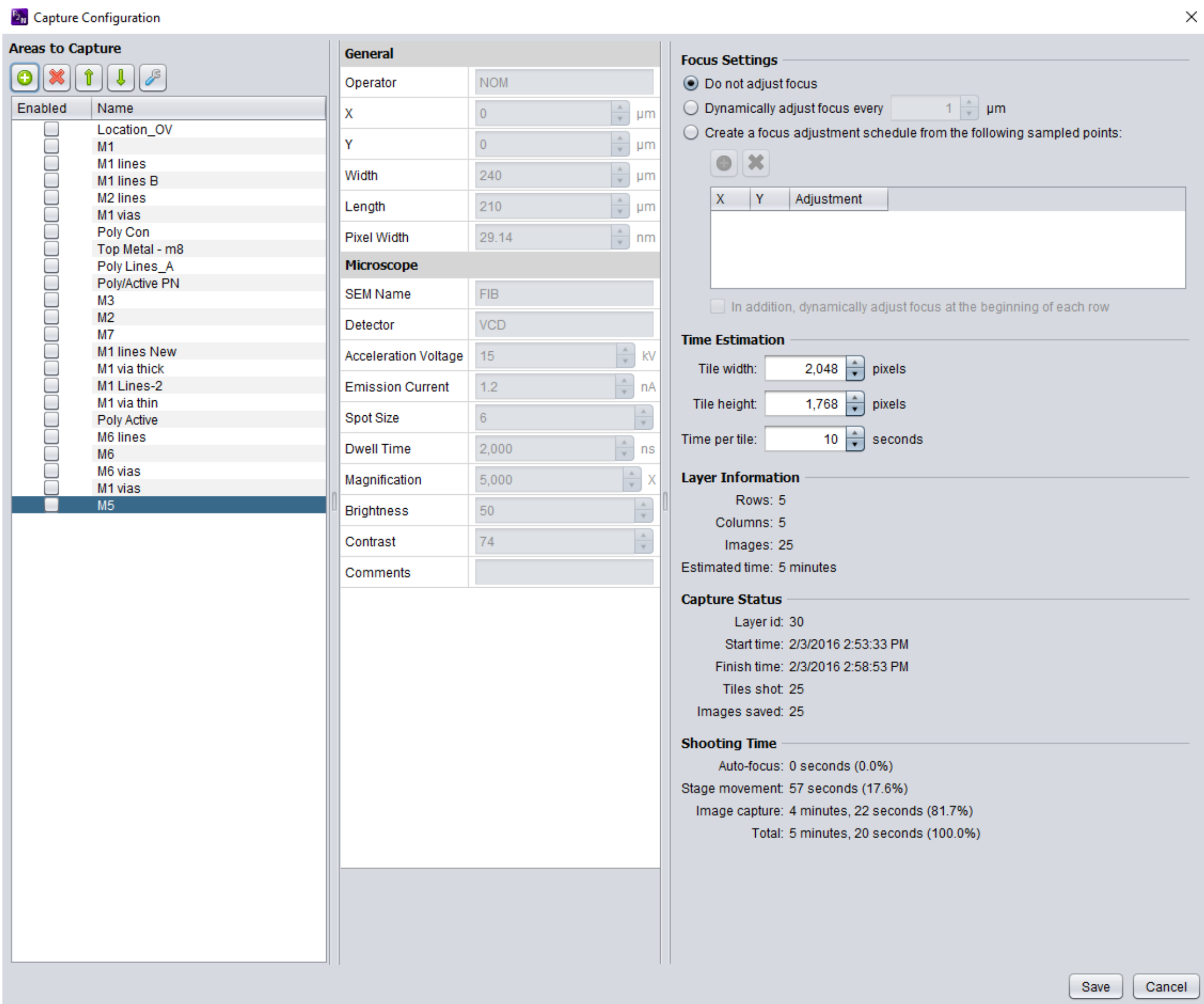
Setup Server

Opens a window to setup a Pix2Net server that will control the SEM remotely. See the tutorial: *Setting Up Pix2Net Server*

Capture Config



Capture Configuration lets you specify the parameters that will be used for an image capture run.

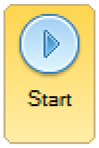


The *General* column records information that Pix2Net will use for the image run. This includes the width and length of the area of interest, X and Y starting positions, and the pixel width

The *Microscope* column records information for future reference. This information is saved in the *Capture History* for that particular layer

The *Focus Settings* column is used for making automatic adjustments to the focus of the sample to compensate for any leveling issues.

Start



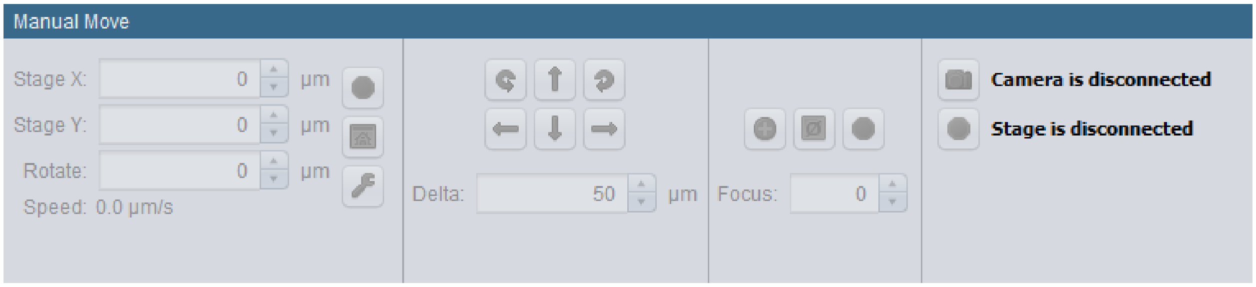
When the start button the pressed a new image run will start using the *Capture Parameters* specified.

Stop

Stops the current capture. Capture can be continued using the *Resume* button.

Manual Move

Opens a panel that allows you to move the stage manually, and snap single images with the camera.



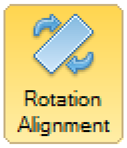
The X, Y, rotation, and stage velocity values can be entered manually and take affect when the green button is pressed. The home button will return the *Stage X* and *Stage Y* values to zero, but will have no affect on the *Rotate* values.

A movement value can be entered in the *Delta* box and the six directional buttons will change the location or rotation by the delta value.

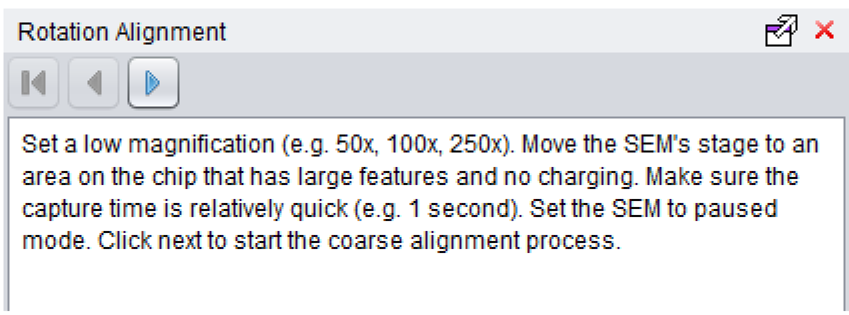
The third column allows the user to set a focus point and go directly to it.

The last two icons give the status of the camera and stage. Once a camera is connected single images can be captured by pressing the camera icon.

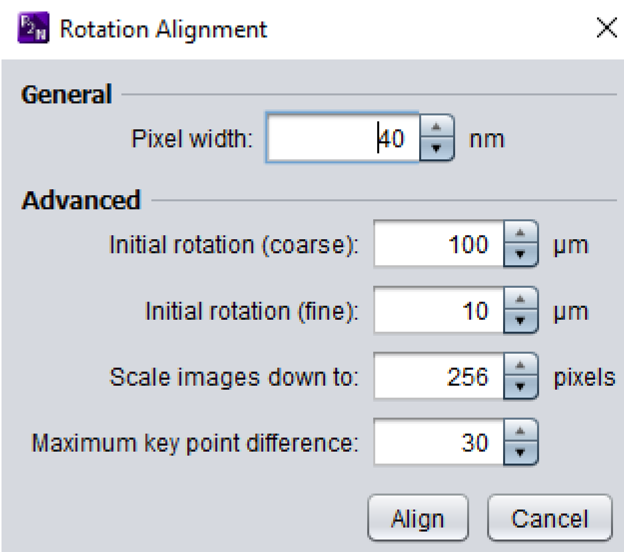
Rotation Alignment



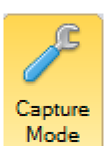
Opens the *Rotation Alignment* window. This feature acts as a wizard to help adjust the alignment of the sample. Follow the on screen prompts to assist the tool in automatic alignment of the sample.



When the blue right button is pressed (the next step) this window will pop up:



Capture Mode



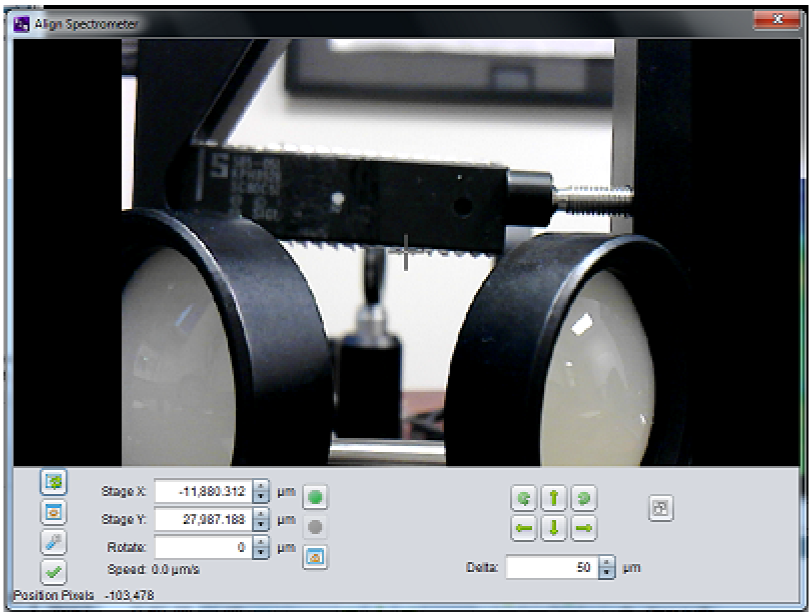
Allows the user to change between (turn on) image, spectrum, and measurement capture modes.

Create Capture

Allows user to capture a spectrum image.

Prior to beginning the create capture, the sample must be measured in microns(um).

Click on "Create Capture" icon, "Align Spectrometer" window appears.



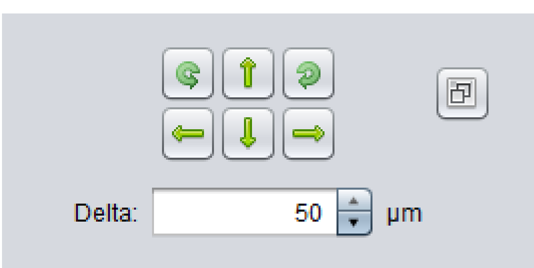
"Move Sample to Offset" - move sample to current existing offset

"Return Stage to Starting Position" - moves stage back to original position before using manual move in "Align Spectrometer" window.

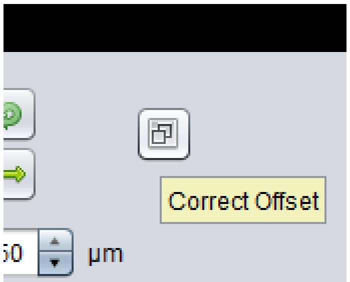
"Alignment Settings" - sets parameters for spectrum capture (see next steps).

"Create Capture" - starts the spectrum capture

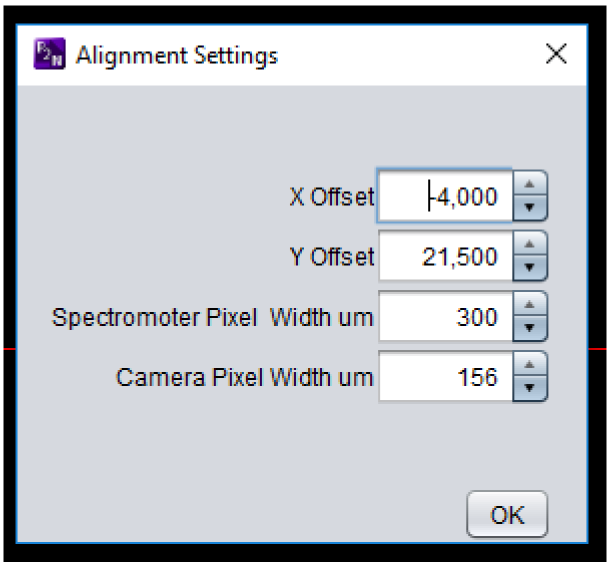
Using the manual move within the "Align Spectrometer" window, move the cross-hairs to the center of the sample.



Click the "Correct Offset" button.



Set the alignment settings.



"X Offset" - set when using manual move in "Align Spectrometer" window.

"Y Offset" - set when using manual move in "Align Spectrometer" window.

"Spectrometer Pixel Width um" - defaults to 300. Lower number achieves higher resolution and slower capture.

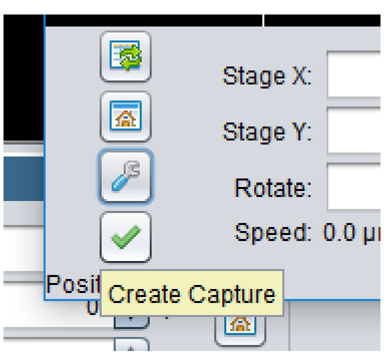
Higher number achieves lower resolution and faster capture.

"Camera Pixel Width um" - this number is determined by pixel width/size of device in um.

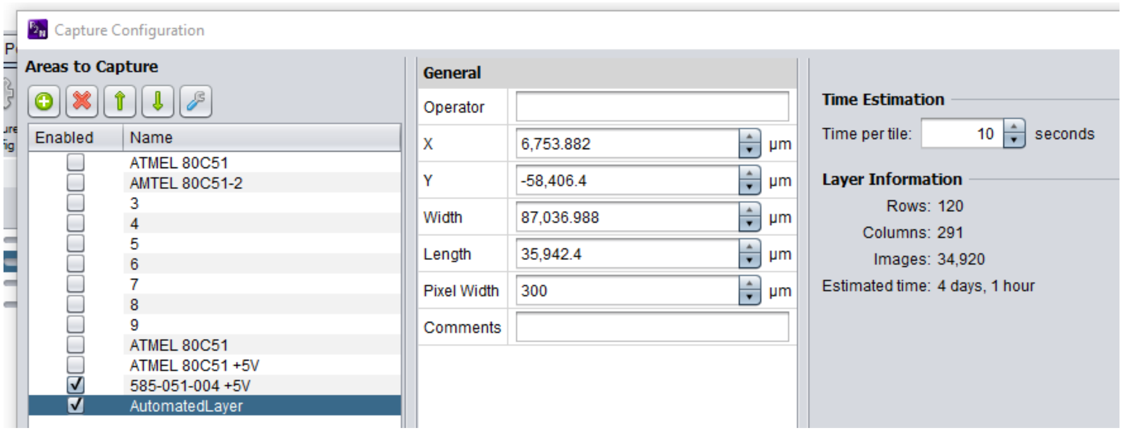
Click "OK".

Click and drag a large capture area slightly past the area of the device.

Click "Create Capture".

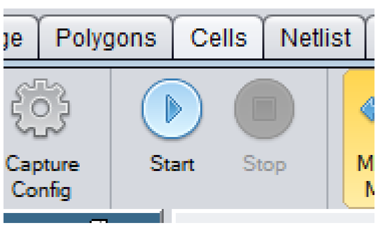


"Capture Configuration" window will appear pre-populated with the information for the capture in the "General" section.



Click "Save".

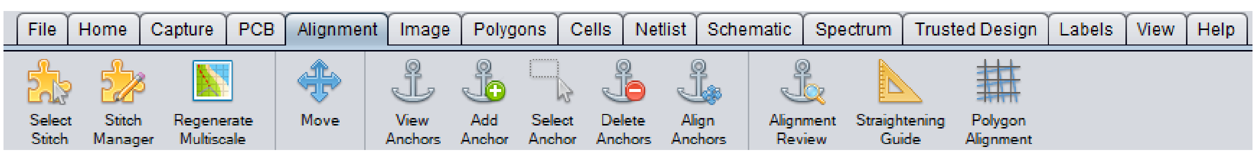
Click "Start".



Once spectrum capture is complete, you can process the data from the scan on the *Spectrum Tab*

Alignment Tab

The *Alignment* tab has features that deal with stitching images, moving layers and aligning one layer to another.



The following tools are available in the *Alignment* tab:

- *Select Stitch*
- *Stitch Manager*
- *Regenerate Multiscale*
- *Move*
- *View Anchors*
- *Add Anchor*
- *Select Anchor*
- *Delete Anchors*
- *Align Anchors*

- *Alignment Review*
- *Straightening Guide*
- *Polygon Alignment*

Select Stitch

Selects the node where four tiles have been stitched together.

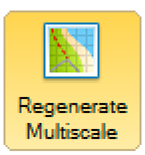
For more information, see: *The Stitching Process*

Stitch Manager

Opens the *Stitch Manager* window.

For more information on stitching and manual edits, see: *Stitching*

Regenerate Multiscale



The multiscale is a set of images that depict a layer when zoomed out. This makes zooming and scrolling operations faster than if all individual tiles were displayed.

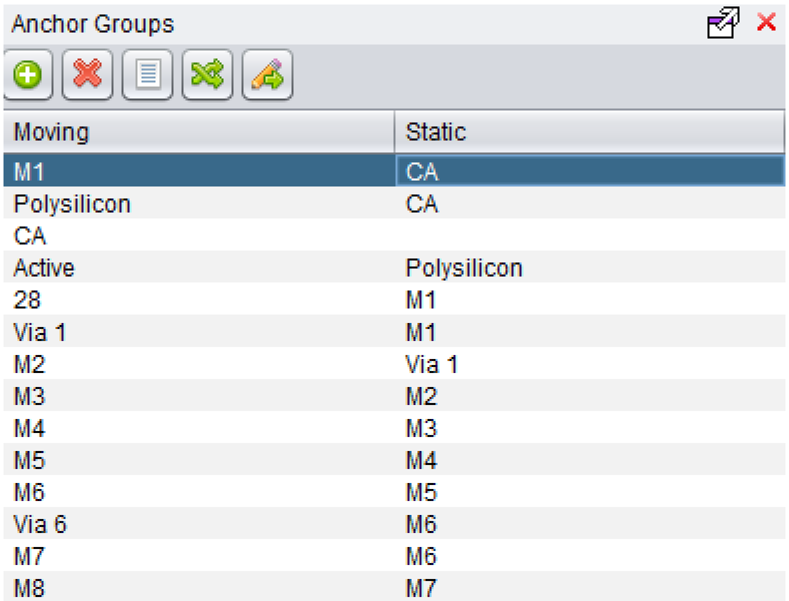
The multiscale needs to be regenerated if captured tiles are modified to update the zoomed out view.

Move

This tool moves the selected layer by clicking and dragging it.

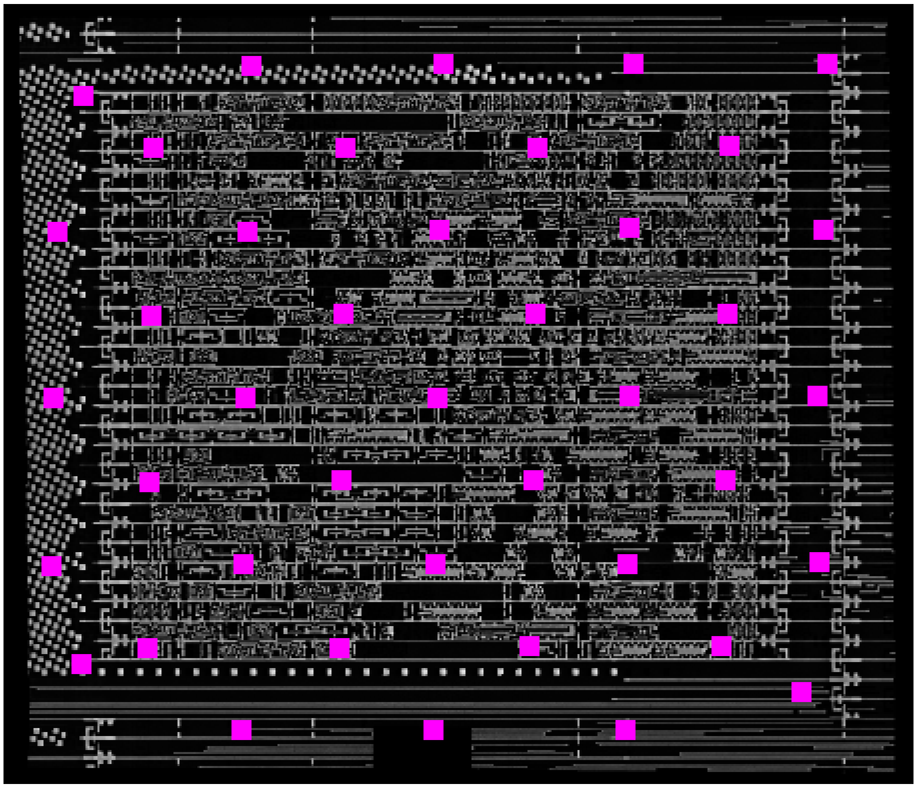
View Anchors

Opens the *Anchor Groups* window. Here all the anchor groups that have been created throughout the project are displayed.

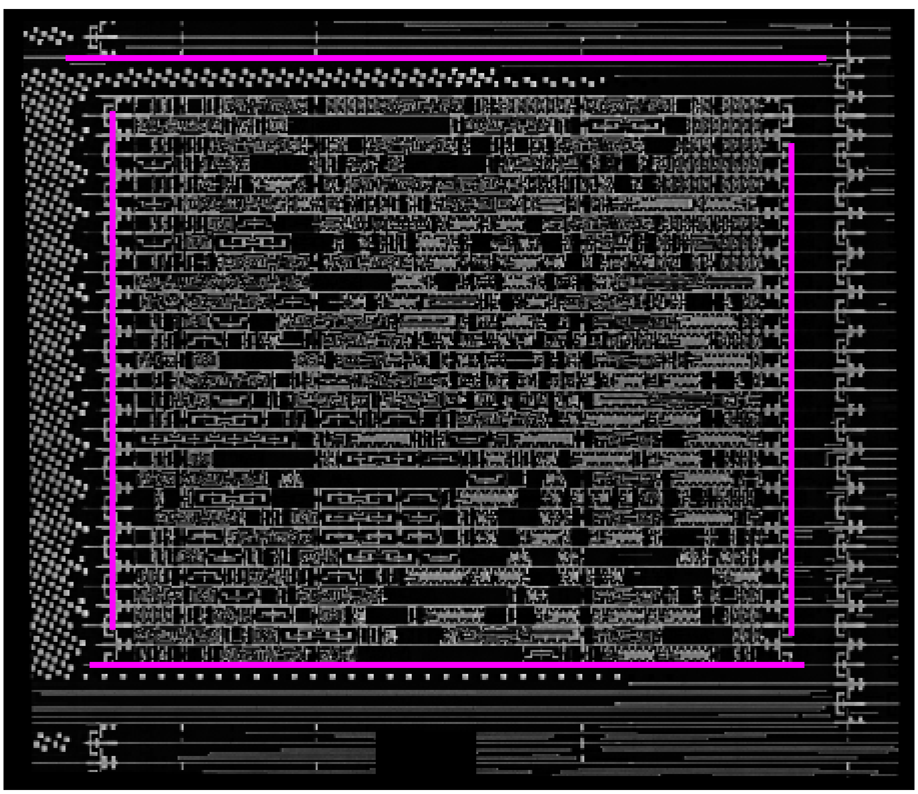


Moving	Static
M1	CA
Polysilicon	CA
CA	
Active	Polysilicon
28	M1
Via 1	M1
M2	Via 1
M3	M2
M4	M3
M5	M4
M6	M5
Via 6	M6
M7	M6
M8	M7

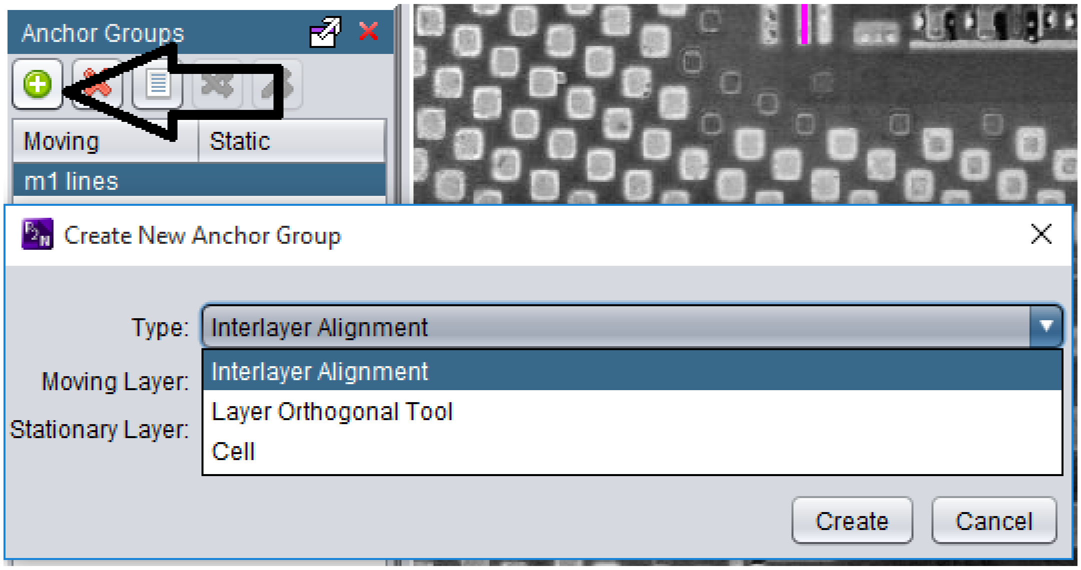
Once highlighted the anchors for that group are displayed in the overlay window.



When the user selects M1 lines, the anchors for that group are displayed in the overlay window. It says only "M1 lines" instead of M1 lines - M2 lines because it is an orthogonal alignment.

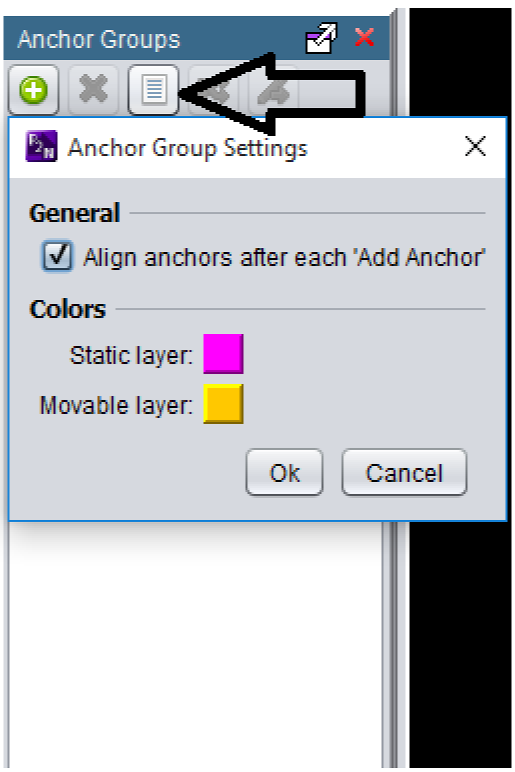


To add an anchor press the + button and a window will pop up like this:



The user then has to decide whether they want an interlayer alignment, a layer orthogonal tool, or a cell alignment (these are talked about in aligning layers).

In the 'Anchor Group Settings', the user can specify if 'Align Anchors' should be performed after each 'Add Anchor'. This option should usually be turned on, but you can turn it off if the 'Align Anchors' process is taking too long.



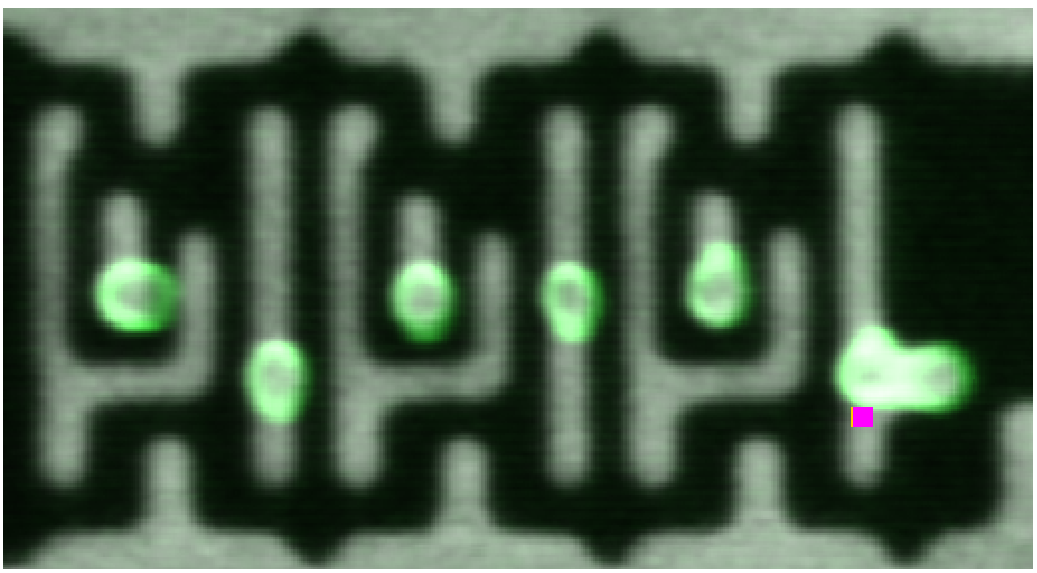
The last button in the *Anchor Group Settings* is to copy the selected to a new anchor group with a different stationary layer.

For more information on anchors, anchor groups and layer orthogonality, see: *Aligning Layers*

Add Anchor

Adds a set of anchor points for the active anchor group.

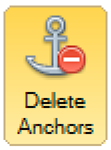
Anchors are key in aligning two layers to one another



Select Anchor

Click and drag a box over any unwanted anchors. The anchors selected will now be highlighted in red.

Delete Anchors



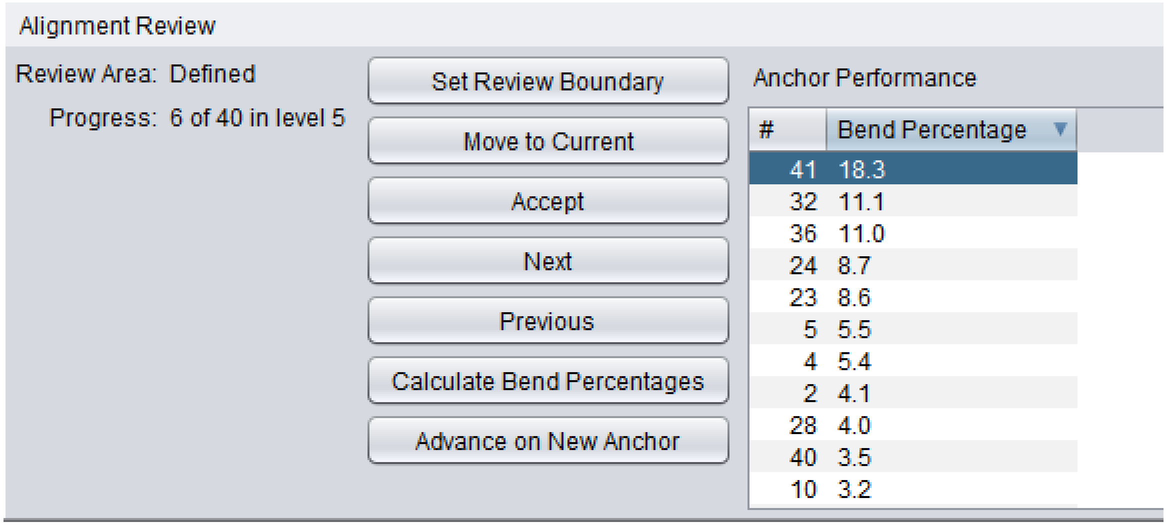
Click to delete any highlighted anchors. Only anchors that have been selected using the *Select Anchor* tool are affected (The user can also use the delete key).

Align Anchors

If a bad anchor or group of anchors was removed the layer undergoing alignment will still be warped incorrectly. Clicking align anchors will snap back to fit the unaltered anchor points.

Alignment Review

Alignment Review opens a window with features that assist in aligning one layer to another.



Set Review Boundary: Use the *Select Area* tool in the *Home* tab to set a boundary of review points for making the anchor grid.

Move to current: Moves the overlay window to center on the current alignment review point.

Accept: if the alignment does not need adjustment *Accept* will add an anchor at the review point.

Next: Move to the next review point.

Previous: Returns to the previous review point.

***Calculate Bend Percentages:* Under the *Anchor Performance* column a value is calculated for each anchor placed. The high**
the more warping the anchor caused.

***Advance on New Anchor:* Clicking this box will turn this feature on. Every time an anchor is placed or accepted the overla**
location an anchor should be placed for alignment consistency.

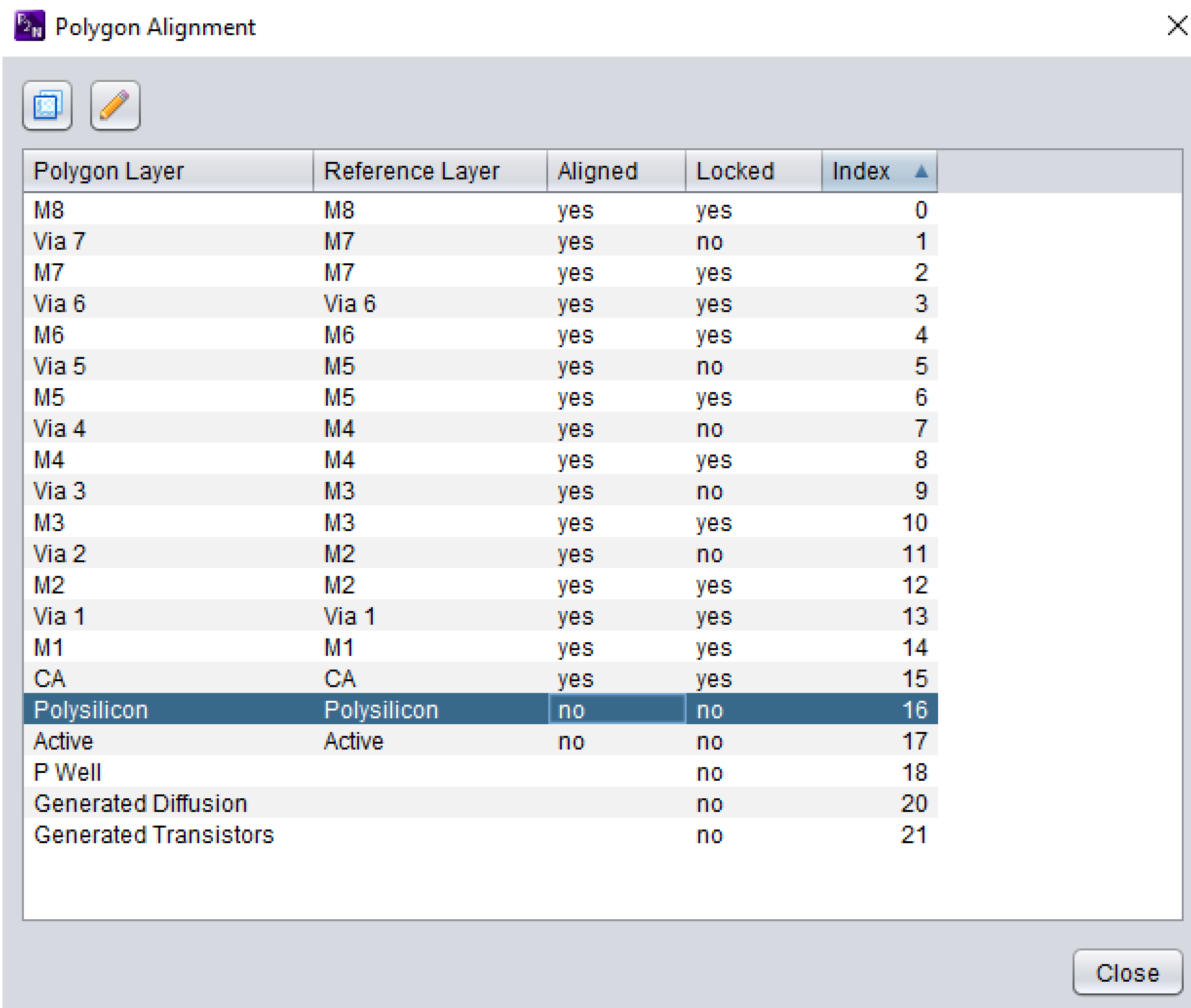
Straightening Guide

Displays a horizontal and vertical line that can be dragged around the screen. This tool is used to help verify the orthogonality of each layer.

Polygon Alignment

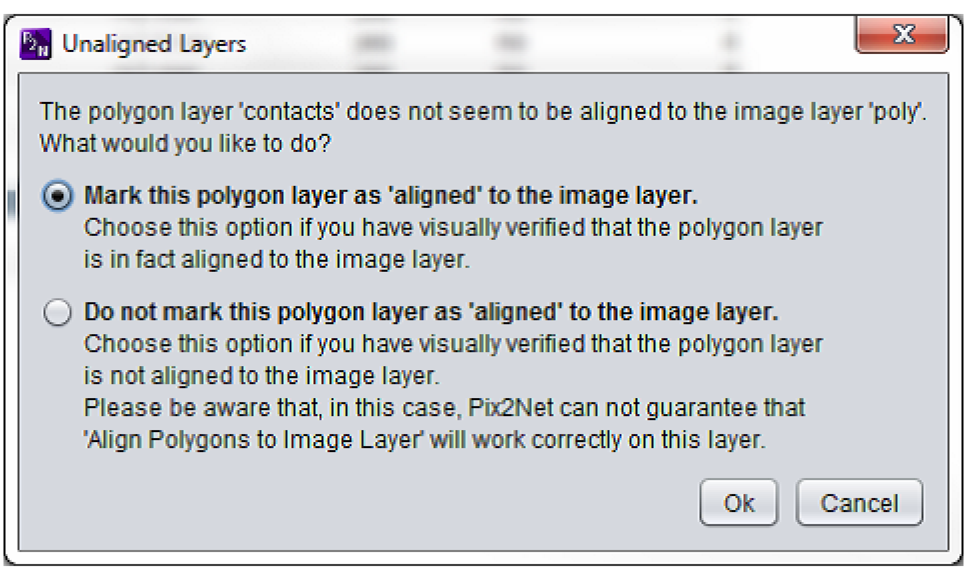
Polygon alignment is controlled by the Polygon Alignment window in the “Alignment” tab.

This tool is used for any case that a polygon and a reference layer that were already aligned, get moved, or to tell Pix2Net that the layers are aligned. Here’s what the polygon alignment window looks like:



Polygon Layer	Reference Layer	Aligned	Locked	Index
M8	M8	yes	yes	0
Via 7	M7	yes	no	1
M7	M7	yes	yes	2
Via 6	Via 6	yes	yes	3
M6	M6	yes	yes	4
Via 5	M5	yes	no	5
M5	M5	yes	yes	6
Via 4	M4	yes	no	7
M4	M4	yes	yes	8
Via 3	M3	yes	no	9
M3	M3	yes	yes	10
Via 2	M2	yes	no	11
M2	M2	yes	yes	12
Via 1	Via 1	yes	yes	13
M1	M1	yes	yes	14
CA	CA	yes	yes	15
Polysilicon	Polysilicon	no	no	16
Active	Active	no	no	17
P Well			no	18
Generated Diffusion			no	20
Generated Transistors			no	21

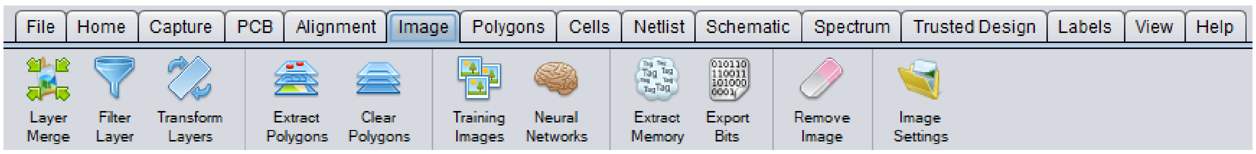
The  tool will tell Pix2Net to set a reference layer to a polygon layer of the user's choice. If the user sets the reference layer to anything different from the polygon layer and it is not aligned, a message like this will appear:



This should really only be an issue for existing projects. For future projects, the reference layer will be set when the polygon layer is created, so the user should not see a dialog like this. Marking the polygons as 'aligned' means that the user is saying that the reference layer is aligned correctly with the polygon layer. If the image layer is moved, the next time the Polygon Alignment button is pressed, you will see "No" under the "Aligned" column. When you click the  button, it will align the polygons back to the reference layer. The aligned portion will then say "yes" and the two layers will be aligned how they were before.

Image Tab

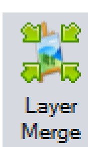
The image tab houses image related operations including polygon extraction.



The following tools are available in the *Image* tab:

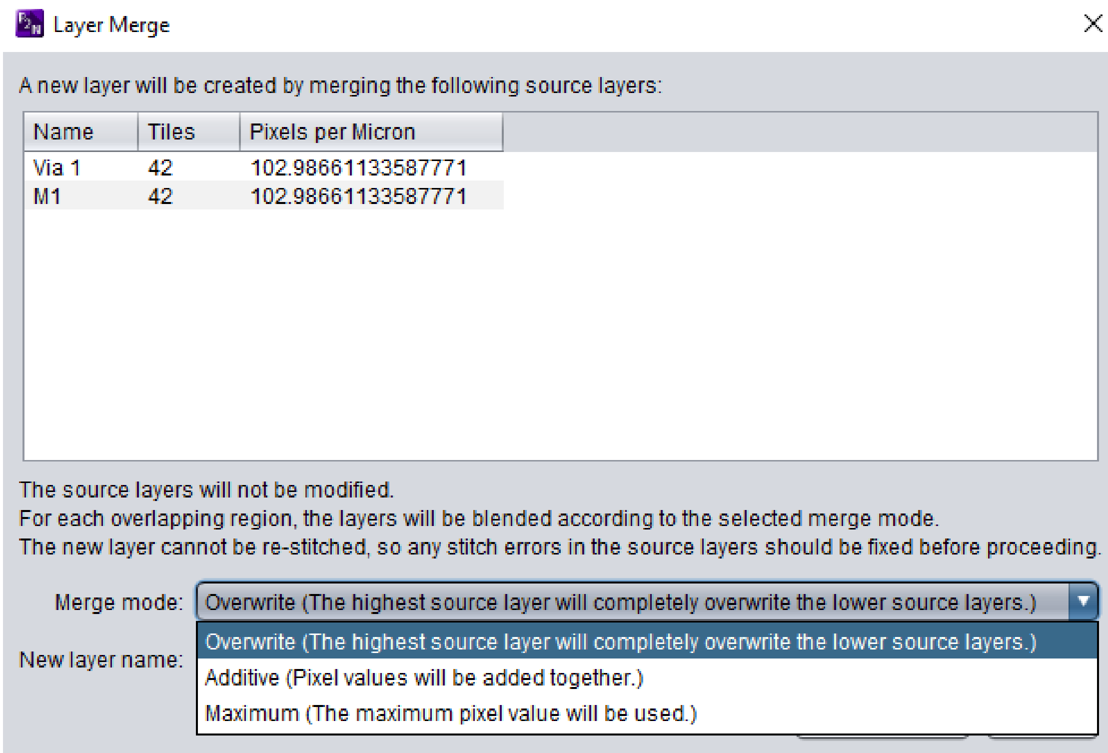
- *Layer Merge*
- *Filter Layer*
- *Transform Layers*
- *Extract Polygons*
- *Clear Polygons*
- *Training Images*
- *Neural Networks*
- *Extract Memory*
- *Export Bits*
- *Remove Image*
- *Image Settings*

Layer Merge



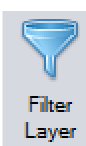
The intent of the layer merge is to make one cohesive layer out of two or more existing layers. Turn on the layers to merge, and make sure all other layers are off. Do this by toggling the visibility checkmark in the *Layers* window. (See *Layer Window*)

Select *Layer Merge* and the window will pop up.

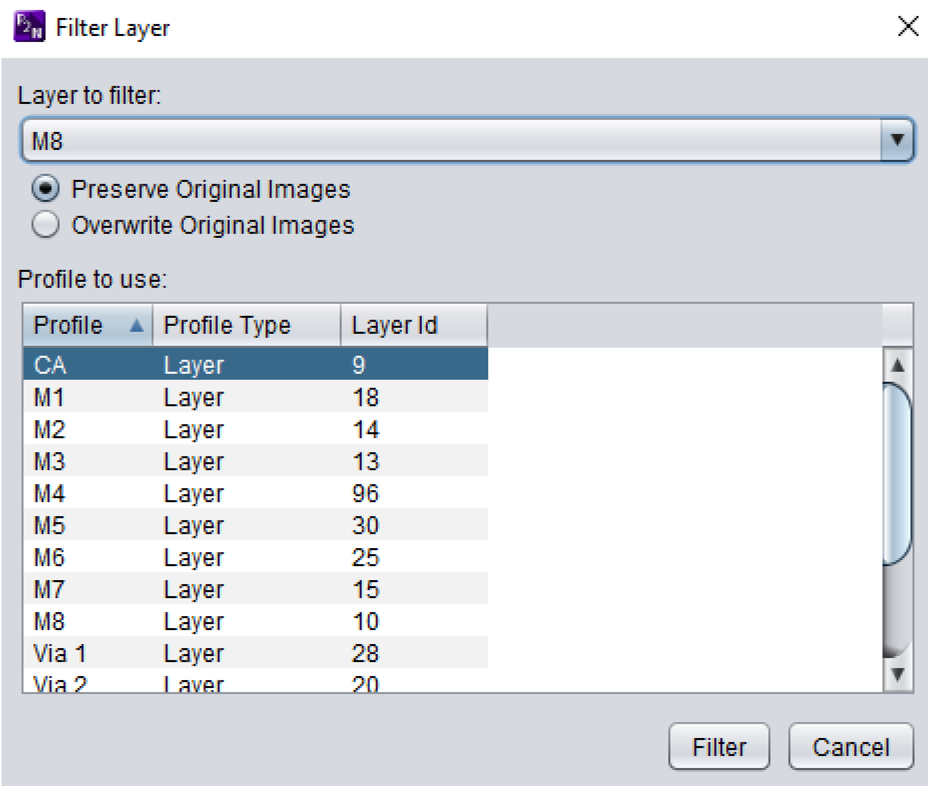


The drop-down bar for *Merge mode* helps the user choose which type of merge they would like to see in the new created layer. Once the mode is selected, the user can name the merge in the blank box. The *Merge Layers* button will make a new layer without modifying the existing layers.

Filter Layer



Selecting the *Filter Layer* icon pops up the following window:



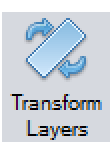
Select the *Layer to filter* in the drop down menu.

The user can also select to preserve the original images or overwrite them after the layer has been filtered.

Use a profile listed. The profiles are created using *Extract Polygons*. See *Extract Polygons*

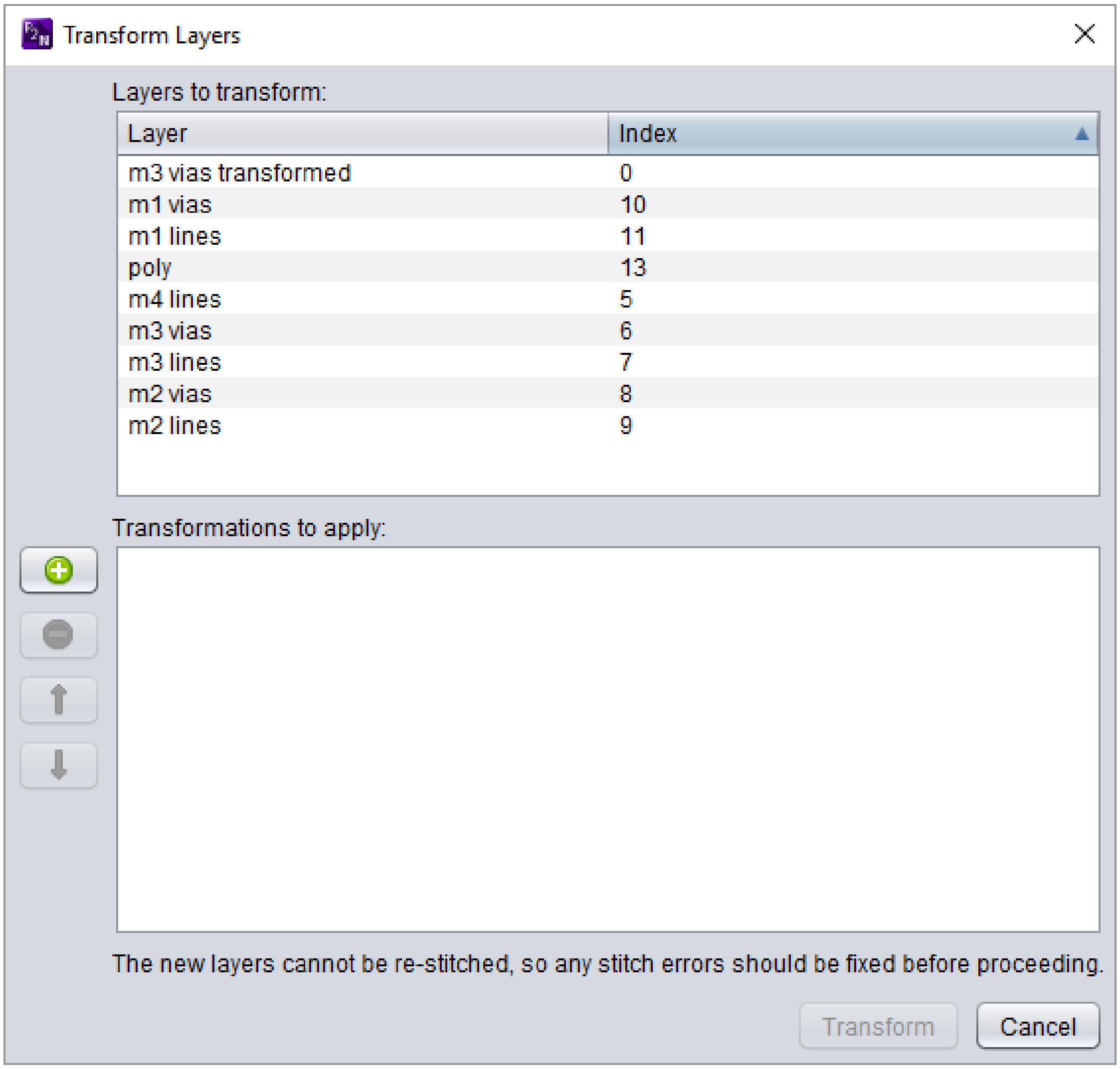
Click *Filter* to apply the profile to the layer. This will overwrite the viewing information (warped directory) so the tiles look filtered in Pix2Net, yet the original data is maintained.

Transform Layers

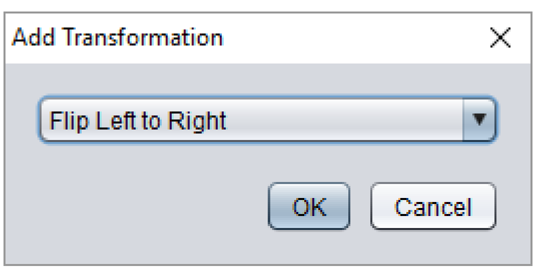


The user can flip or rotate an entire image layer by using *Transform Layers*. This is useful if a layer is imaged in the wrong orientation, or you would like to add a backside image to a data set that was imaged topside.

Clicking the *Transform Layers* button opens the *Transform Layers Window*:

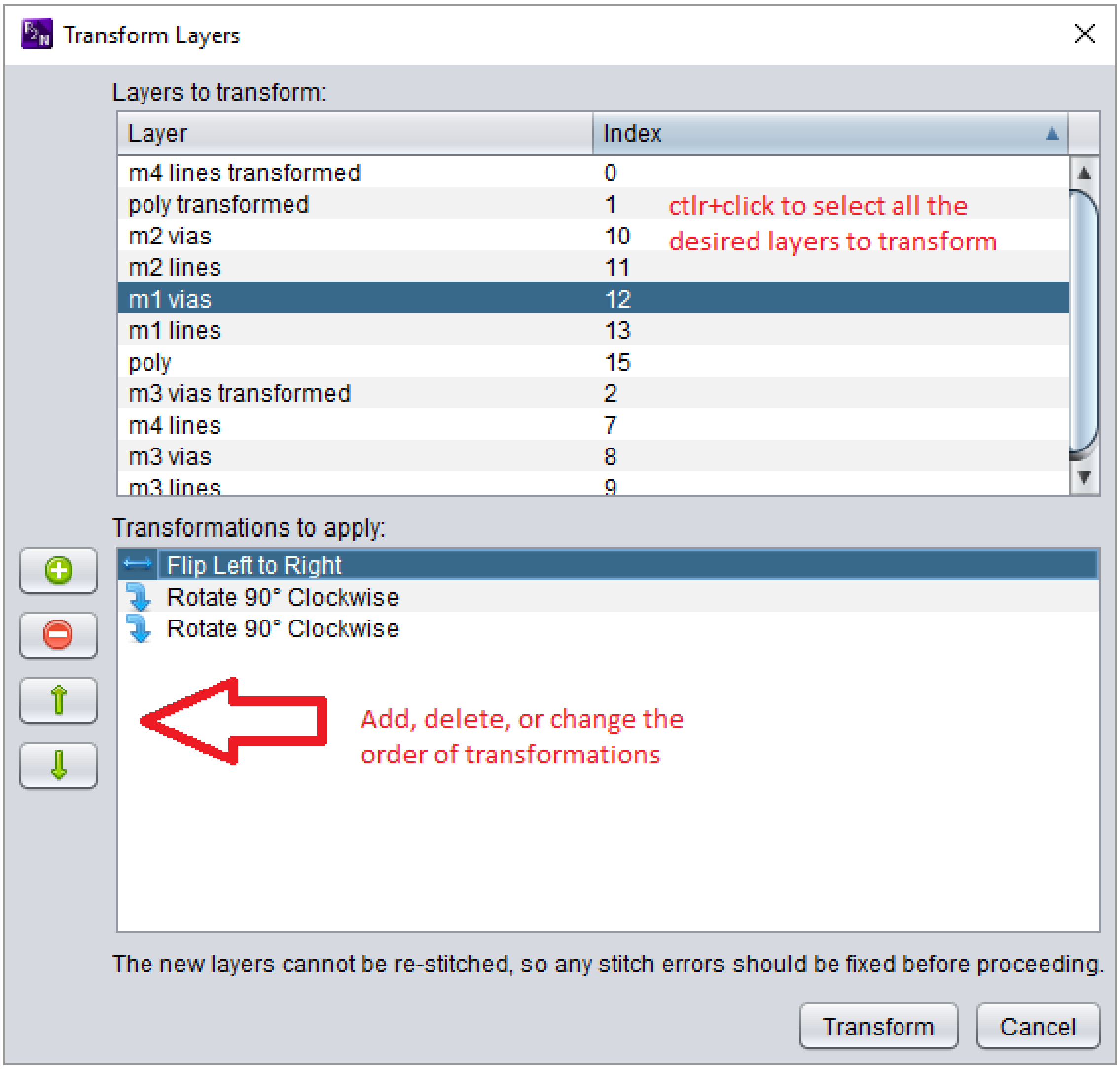


Click on the green + to pull up the *Add Transformation Window*:



The user may select between:

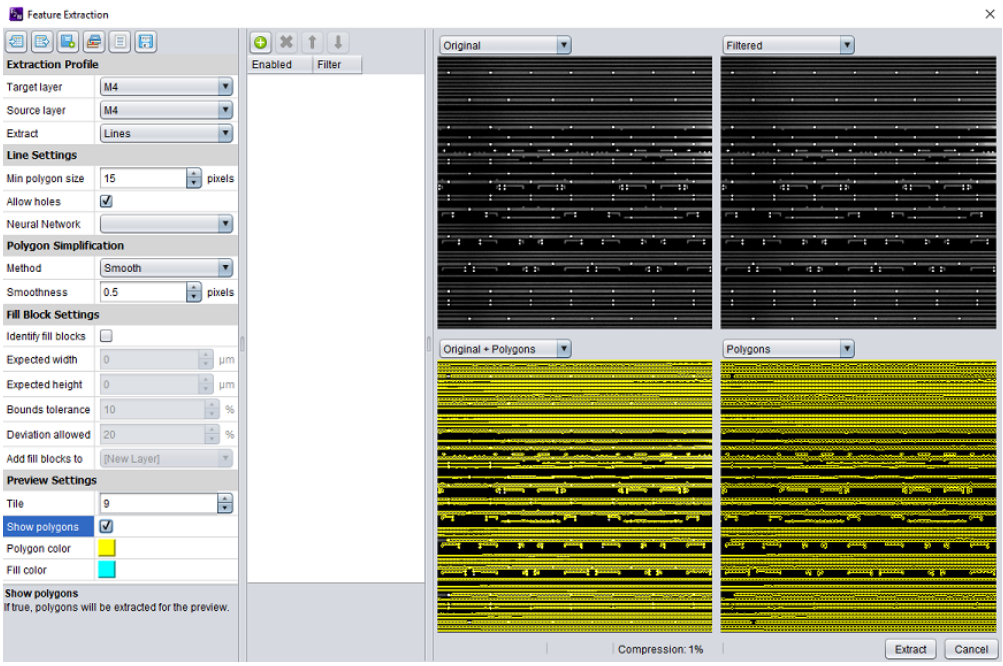
1. Flip Left to Right
2. Flip Top to Bottom
3. Rotate 90deg Clockwise
4. Rotate 90deg Counter-Clockwise



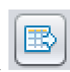
Click *Transform* and all of the transformations will be performed in order for the selected layers, and a new layer will be created.

Extract Polygons

Click the *Extract Polygons* Icon to open the *Feature Extraction* window.

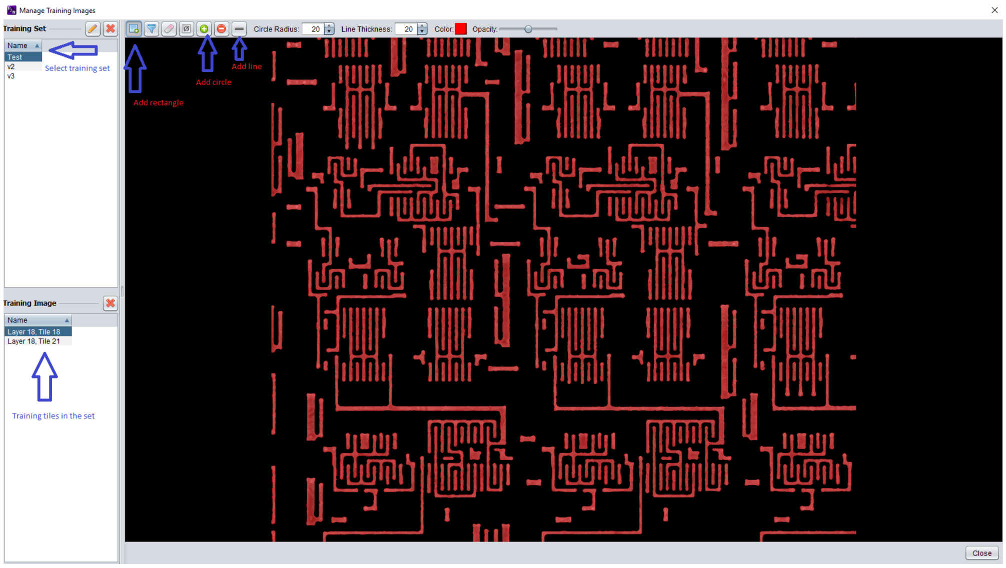


The upper left icon  allows the user to load settings from another layer. This can help give a baseline for the filters to apply.

To save the settings, click on the *Save a copy of this profile* icon . Enter a name for the profile and click *Save*. Note, the extraction settings used are automatically saved.

For neural network via or line extraction, the user can add an image to the training set by clicking this icon . Enter the name of the training set, or add the image to an existing training set. The *Manage Training Images* Window will automatically pop up.

To manage the training sets, click on the *Manage training sets* icon . This will open the *Manage Training Images* Window:



To view the report click on the icon . Select between training sets to view the desired report.

The save icon  allows the user to save a copy of the image. The user can save the original,filtered, or edges of the image.

Extraction Profile	
Target layer	m1 lines ▾
Source layer	m1 lines ▾
Extract	Lines ▾

The *Target layer* is the layer that the feature extraction will be applied to. The user may want multiple extractions from the same dataset, i.e. vias and lines extracted from the same images.

The *Source layer* is the image set used for the extraction.

The *Extract* menu allows the user to pick between extracting Lines or Vias. Via extraction assumes bright white vias in the image.

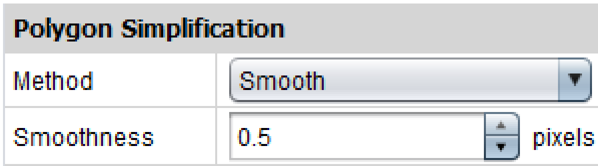
Line Extraction

Line Settings		
Min polygon size	0	pixels
Smoothness	0.5	pixels
Allow holes	☑	

Min polygon size is used to filter out all noise with a width or length smaller than the value entered

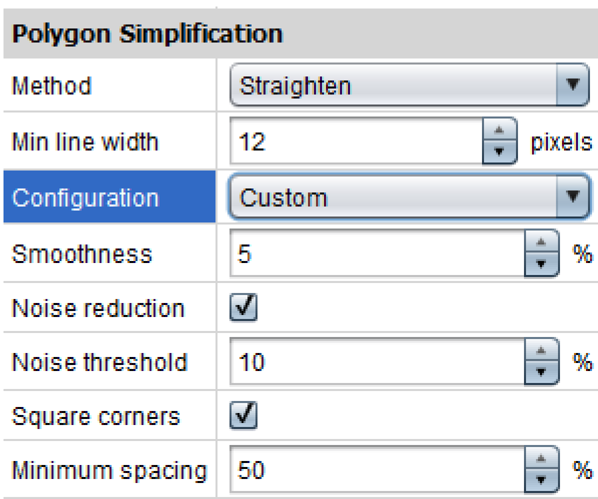
Smoothness sets the amount of pixel deviation that will be "smoothed" out when extracting the polygons. The higher this number is, the fewer points drawn for each polygon. If the number is too high, notches or jut outs will be lost in the extraction.

Allow holes is checked when holes should be allowed in metal, and left unchecked when the holes should be filled in due to delayering artifacts.

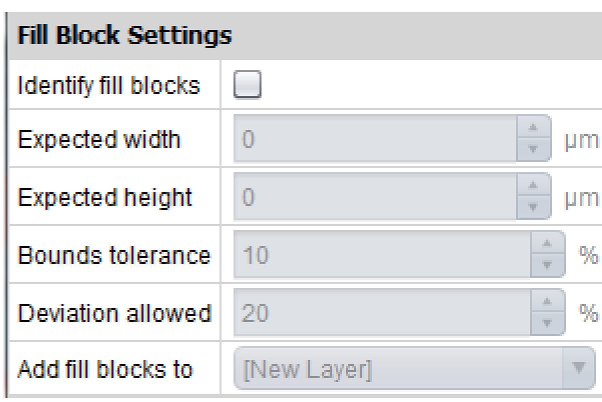


There are two methods of polygon simplification, *Smooth* and *Straighten*. *Smooth* is pretty straightforward, the higher the *smoothness* the fewer points in each polygon. Keep an eye on the preview, because there will be a threshold where there are too few points and the polygons will not make good connection with other layers.

Straighten allows the user to extract polygons to look more orthogonal. The user inputs the minimum polygon width, and can choose the standard option or the custom option. HIghlighting each category will provide a brief description in the bottom left of the *Feature Extraction* window.



Here the user can adjust the smoothness, noise reduction, noise threshold, square corners, and minimum spacing.



Fill block settings are for fill patterns containing repeating rectangles of the uniform size.

Identify fill blocks is checked to identify fill and place it on its own separate layer.

Expected width is the width of an average fill block in um.

Expected height is the height of an average fill block in um.

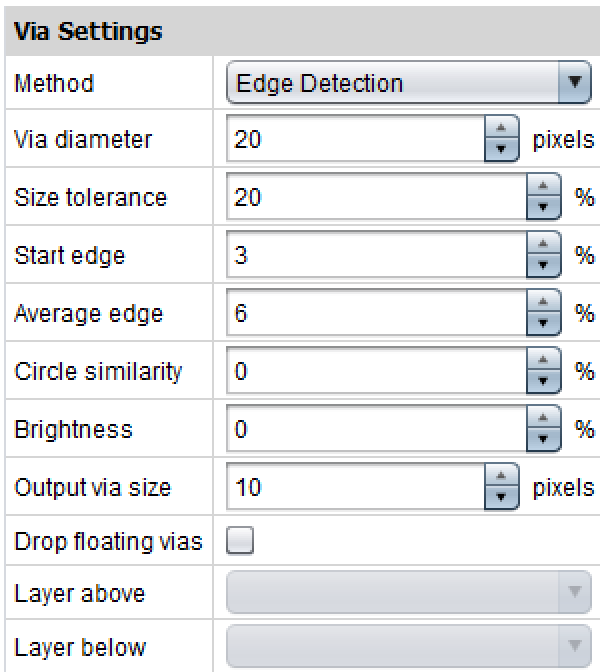
Bounds tolerance describes the percentage of deviation allowed in the length and width of a polygon to be considered as fill.

Deviation allowed describes the percentage of deviation allowed in the calculated area of the fill blocks. (Meant to help when fill block shape is slightly irregular due to deprocessing)

Add fill blocks to allows selection of a new or existing layer to add the fill block polygons to.

Via Extraction

Method- Choose between edge detection and neural network.



Edge Detection

This algorithm attempts to identify vias by tracing the edge around white dots in the image. The following parameters are used in this method:

Via diameter- This is the expected diameter of each via, in pixels.

Size tolerance- This is the percentage that the diameter is allowed to vary by. For example, if the via diameter is 20, and the size tolerance is 10%, then vias with diameters ranging from 18 to 22 will be identified.

Start edge- This is the minimum edge intensity pix2net will consider as it looks for places to start tracing an edge that may turn out to be via. If this value is too high, then Pix2Net will miss vias that are very faint. If this value is too low, then it will take longer to extract vias, because the number of edges that Pix2Net has to trace will increase.

Average edge- This is the minimum average edge intensity that a via must have in order for it to be considered valid.

Circle similarity- This is how similar the shape of a via must be to a circle in order to be considered valid. 0% means that all via shapes are allowed;

100% means that only perfectly circular vias are allowed.

Brightness- This is how bright a via must be in order to be considered valid. 0% means that any via brightness is allowed; 100% means that only bright white vias are allowed.

Output via size- This is the size of the via polygon that will be placed in pixels.

Drop floating vias- When checked, select the metal layers above and below the via layer to automatically drop any floating (not making contact with both metal layers) vias detected.

How to extract vias using *Edge Detection*:

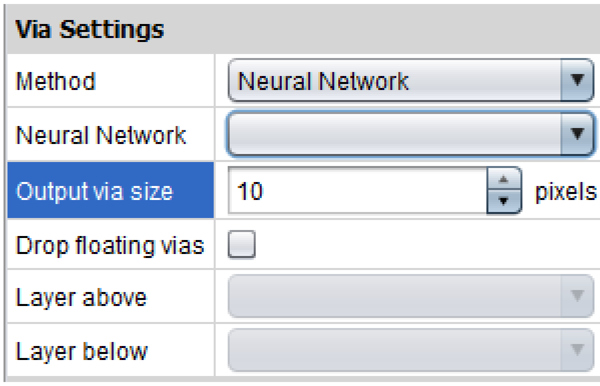
The best way to determine the correct values for these thresholds is to use the “Show via report” feature. To do so, you must create a training image. Here are the steps:

1. Click ‘Show polygons’. This will extract an initial set of vias with the current settings.
2. Click the “Add image to training set” button. Enter a name for the new training set, and then click “Ok”.
3. The “Manage Training Images” dialog will appear. Make sure that the correct “Training Set” and “Training Image” is selected. Use the “Add point” and “Remove points” tools to add missing vias and remove extra vias. (Note: You can’t use “Undo” or “Redo” here). When you’re finished, click “Close”.
4. Click the ‘Show via report” button. Make sure that you have the correct image selected, and then click “Ok”.

The via report will list three statistics at the top: “Valid” is the number of vias that were correctly identified, “Missing” is the number of vias that were not extracted, and “Extra” is the number of edges that were incorrectly identified as vias.

For each entry in the table, you will see its type (valid, missing, or extra), its location in pixel coordinates, its size (the via diameter), the edge intensity, the circle similarity, and the brightness. When you click on an entry, you will see three views of the same area: The original image, the filtered image, and the edge intensity image. You will also see an “Edge points” list, which is the edge intensity at each point along the via’s boundary.

If you want to figure out a good brightness threshold, for example, you can click the “Brightness” column to sort the entries on brightness. If you notice that all of the vias with a brightness below 70% are “Extra”, and all of the vias with a brightness above 70% are “Valid”, then 70% is definitely a good value to use for a “Brightness” threshold.



Neural Network NOTE For a tutorial with a step-by-step process with pictures, please see: *Neural Network*

The new method for extracting vias is to use neural networks. The nice thing about neural networks is that you do not have to manually specify thresholds; you simply have to create training images.

To create a training image, follow these steps:

1. With the "Method" to "Edge Detection", click 'Show polygons'. This will extract an initial set of vias with the current settings. Make sure that you note the diameter of the via here, because you will need that information in step 6. If your image contains black vias, you may choose to use an "Invert" filter for this step, because the "Edge detection" method only detects white vias.

2. Click the "Add image to training set" button. Enter a name for the new training set, and then click "Ok".

3. The "Manage Training Images" dialog will appear. Make sure that the correct "Training Set" and "Training Image" is selected. Use the "Add point" and "Remove points" tools to add missing vias and remove extra vias. (Note: You can't use "Undo" or "Redo" here). When you're finished, click "Close".

4. Click "Cancel" to close the Feature Extraction window.

5. Click the "Neural Networks" button to open the Mange Neural Networks dialog. Click "Add Network".

6. Set the "Via diameter" to the same value that you used in step 1. Click the add button next to "Training Sets" to add the training set that you created. On the right side of the window, you can now cycle through every via in each image of the training set. You should now adjust the "Downsample" and "Patch size" parameters:

   Downsample is the number of times the image on the right will be zoomed out. You should choose the zoom level that makes each via as easily recognizable as possible.

   Patch size is the size of the image on the right. You should try to make the patch size as small as possible (so that the neural network runs as quickly as possible), without making the patch size so small that the vias are no longer easily recognizable.

   When you're finished tweaking the settings, click "Create".

7. You have created the network, but now you need to train it. Select the network and then click the "Start training" button. The neural network will be trained in

the background. When you start training, the vias will be randomly divided into a “training set” and a “testing set”. The “Training accuracy” is the network’s accuracy on the training images, and the “Testing accuracy” is the network’s accuracy on the testing images. In general, the “Testing accuracy” is the most useful statistic, because that measures how accurate the network is on via images that it has never seen before. The training will stop when the number of epochs reaches 10. (An epoch is a single pass through the entire training set).

8. When the network is finished training, click the “View samples” button to visually inspect the results. You will see the following columns for each entry:

   Sample - A unique number for each entry in the table Type - “Training” if the sample was in the training set, and “Testing” if the sample was in the testing set.

   Confidence - A percentage, from 0 to 100, the describes how confident the network is that it labeled the sample correctly.

   Correct - This is true if “Network label” matches “User label”.

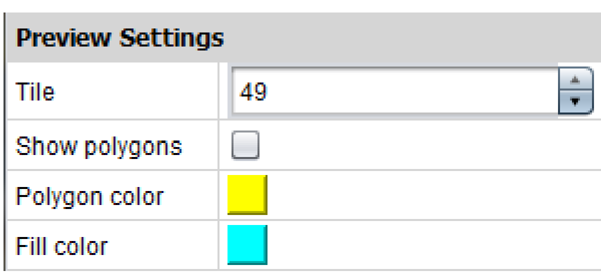
   Network label - The label (“via” or “non-via”) that the neural network chose for this sample.

   User label - The label (“via” or “non-via”) that the user specified for this sample in the training image.

   Click “Close” to close the dialog.

9. Click “Close” to close the Manage Neural Networks dialog. Click “Extract Polygons”. Change the “Method” to “Neural Networks”, and set “Neural Network” to the network you just added. If you used an “Invert” filter in step 1, then you should now remove that “Invert” filter, because the neural network has been trained on the raw, unfiltered image, so that is what it expects as its input.

10. Click “Show polygons” to extract the vias using the neural network. Don’t worry if vias near the edge were not identified; the neural network will not try to identify vias at the edge, because it does not have enough context. If you notice that some vias are missing, but the “Testing accuracy” was very high, then the problem is probably not the neural network; the problem is probably in the algorithm that determines which image patches are possible vias that should be passed to the neural network. This is a known issue that will be fixed in the future.



Tile- tile being previewed in the four image panes to the right

Show polyogns- toggles the Polygons pane on or off.

Polygon color- click the square to select the preferred preview color

Fill color- click the square to select a color for the fill blocks when using *identify fill blocks*

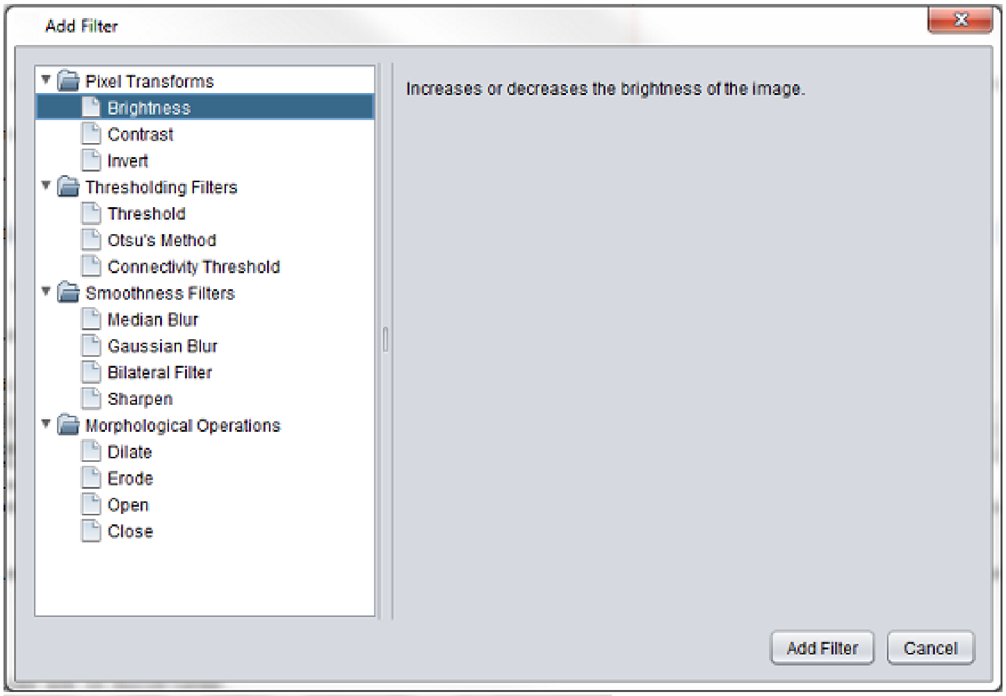
The center section houses the applied filters for extraction. To add a filter click the green plus sign and the *Add Filter* window will appear:

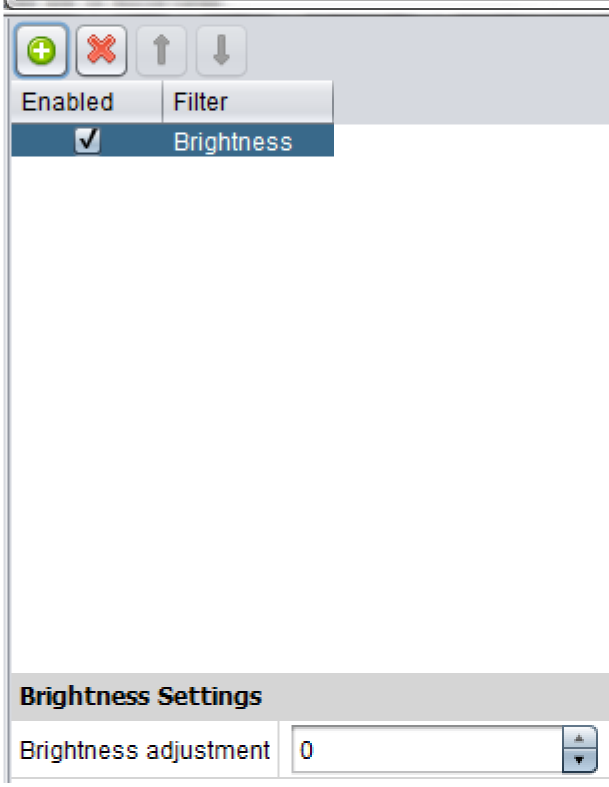
Filters

The filters are sorted by four types - Pixel Transforms, Thresholding Filters, Smoothness Filters, and Morphological Operations. Once the desired filter is added, highlight the filter to change the settings.

Pixel Transforms- filters that apply a formula to each pixel regardless of the surrounding pixels.

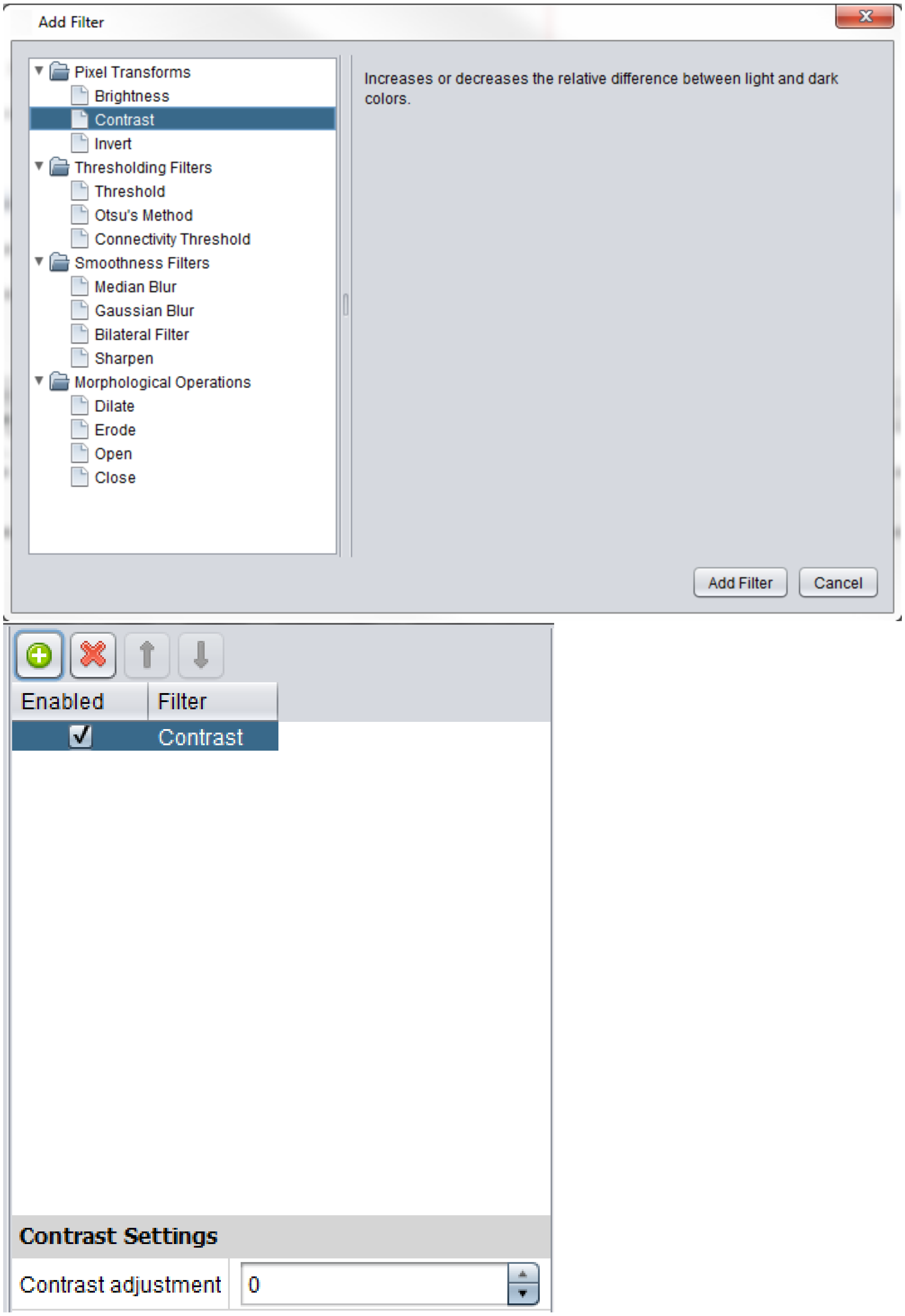
Brightness





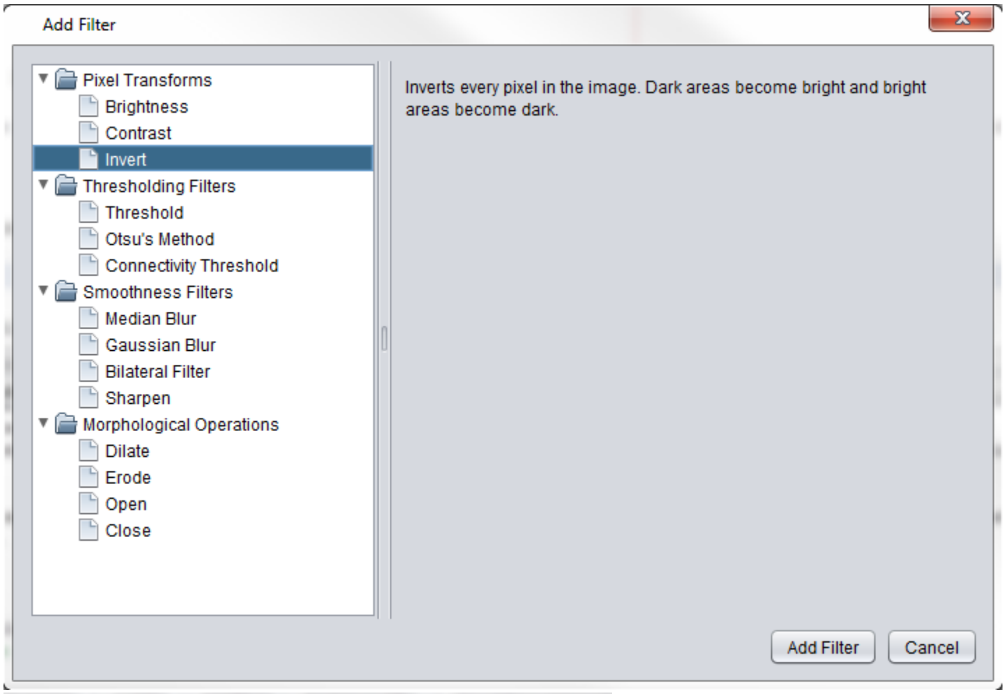
Negative values dim the image while positive values brighten the image.

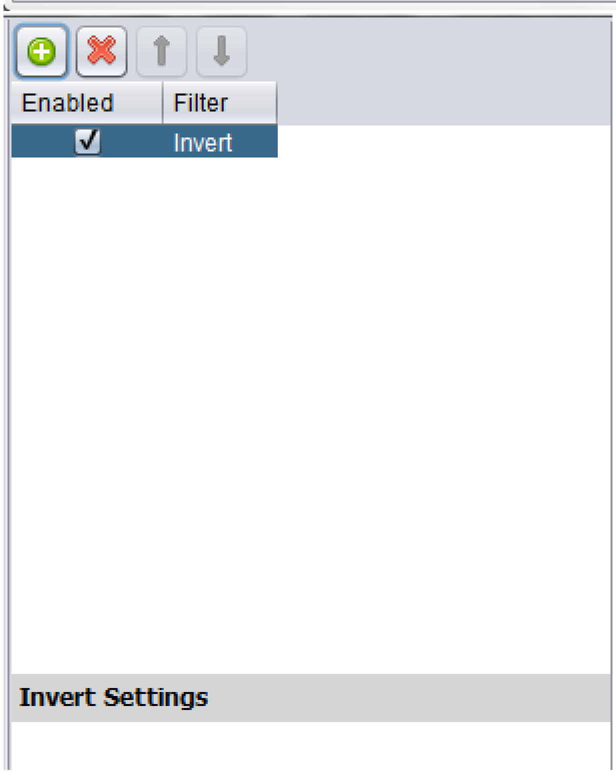
Contrast



Negative values decrease the difference between pixels, while positive values will increase the difference.

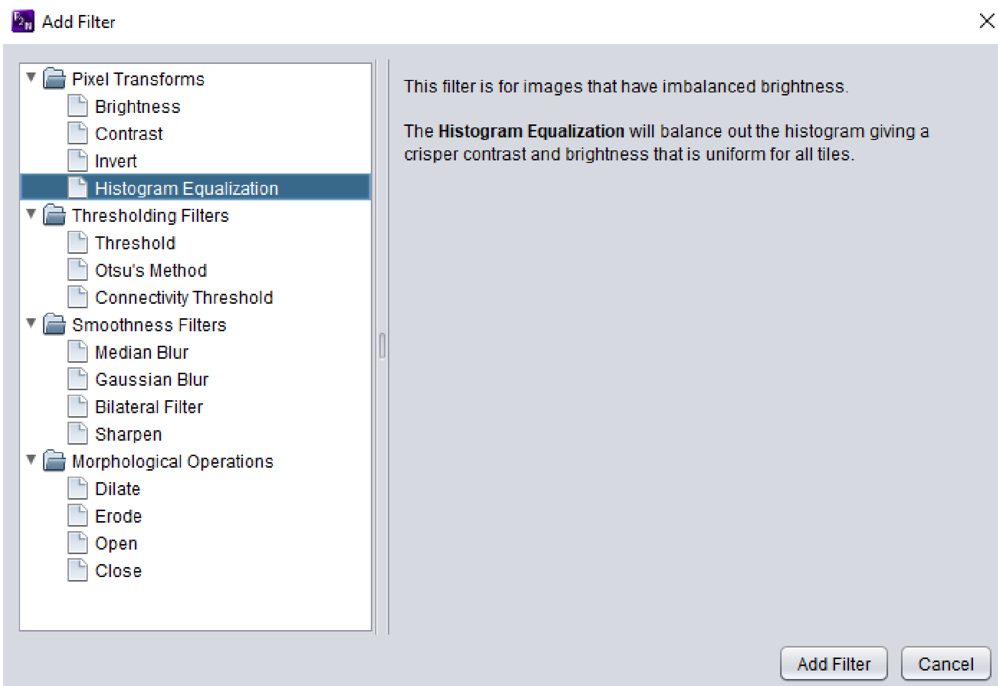
Invert

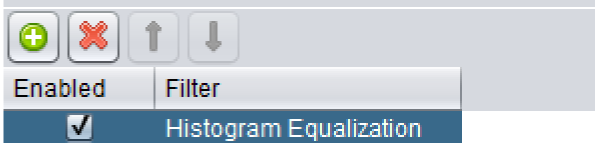


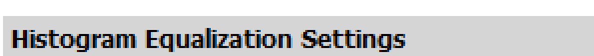


This operation has no additional settings.

Histogram Equalization



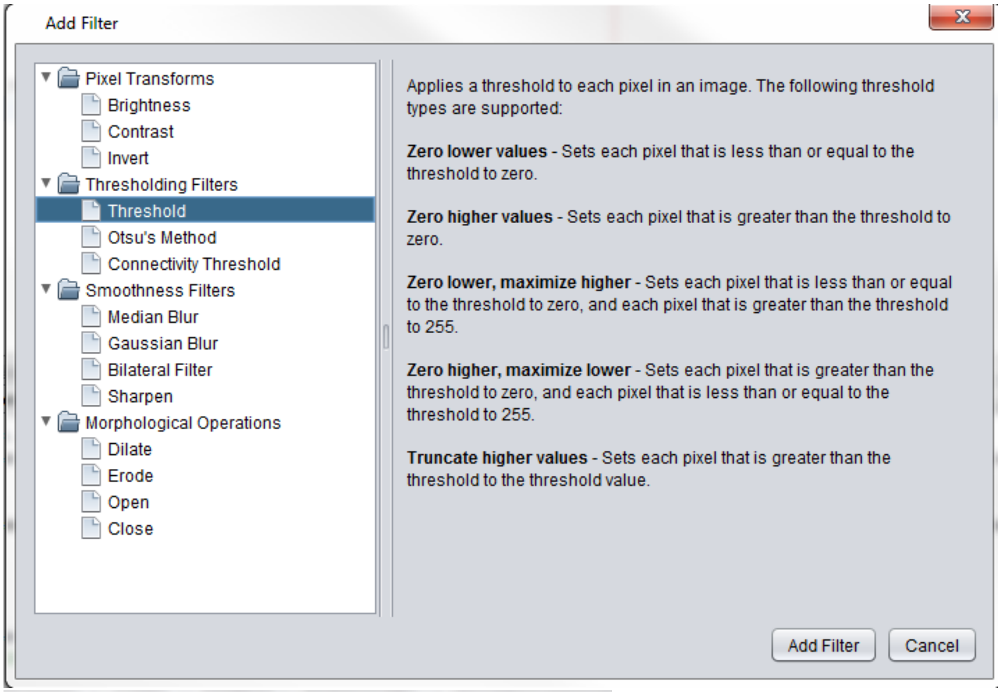


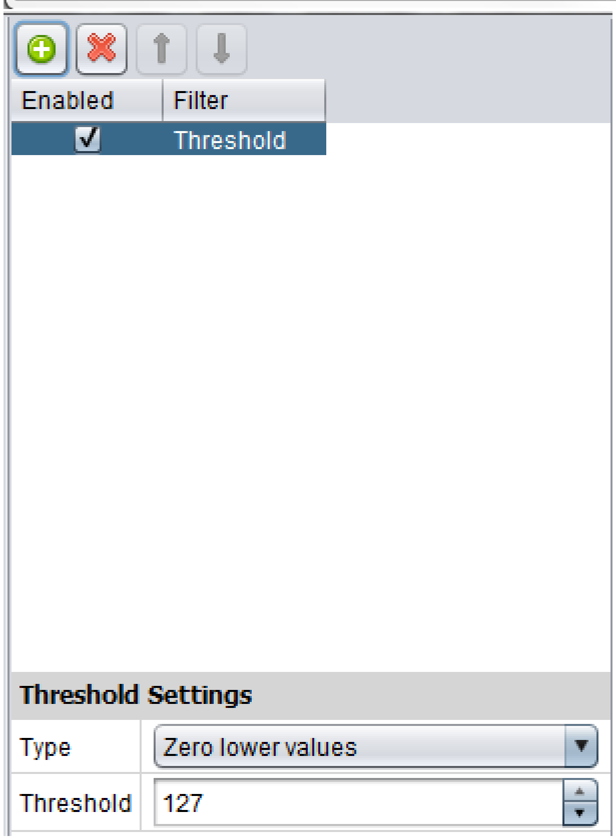


This operation helps balance image layers with inconsistent brightness and contrast across their images. There are no additional settings for this operation.

Thresholding Filters- transform each pixel according to whether it is below or above a certain value.

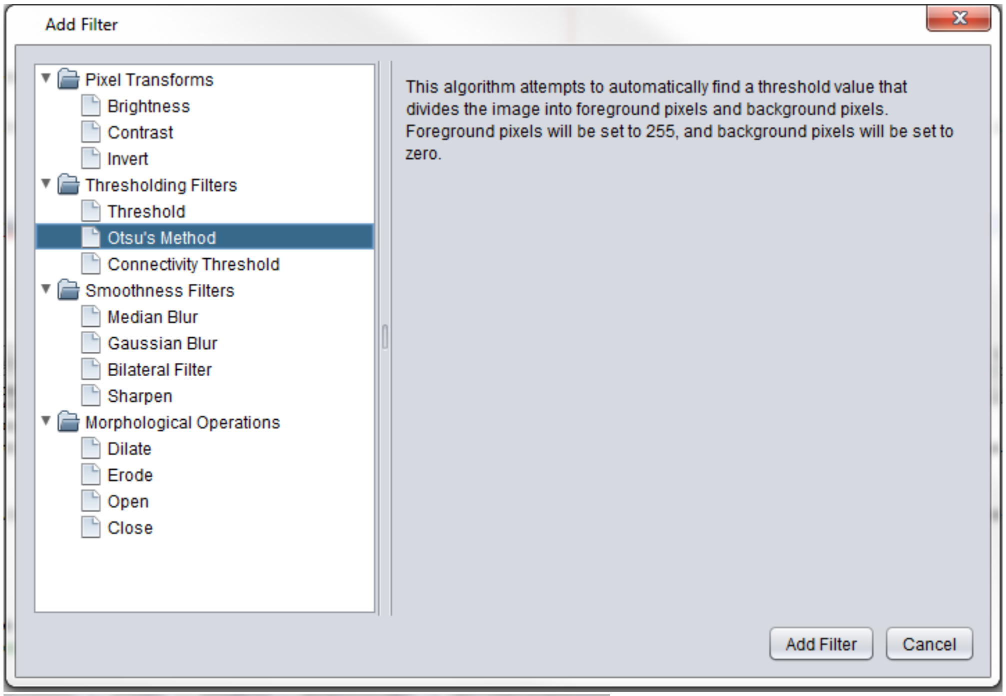
Threshold

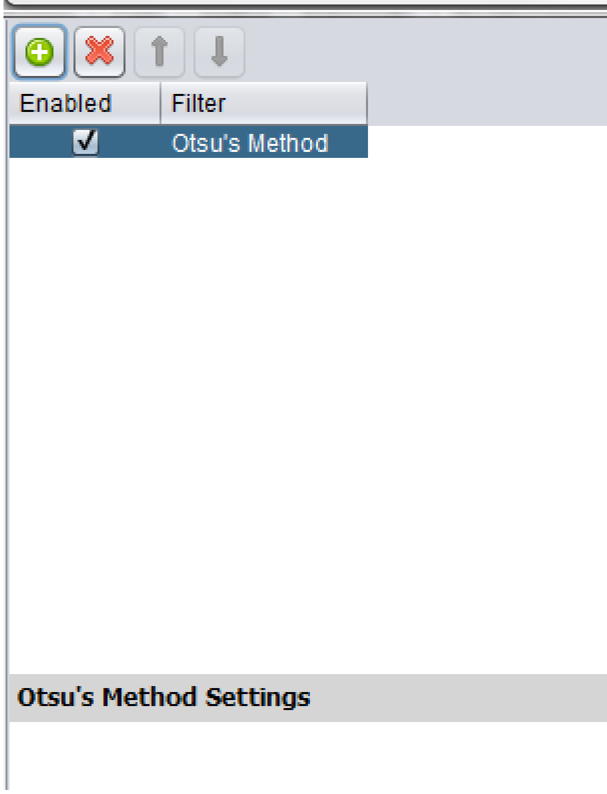




Type is a drop down menu allowing the selection of the different types of thresholding. *Threshold* is the value between 0 and 255. Look at the *Filtered* pane to see the effect.

Otsu's Method

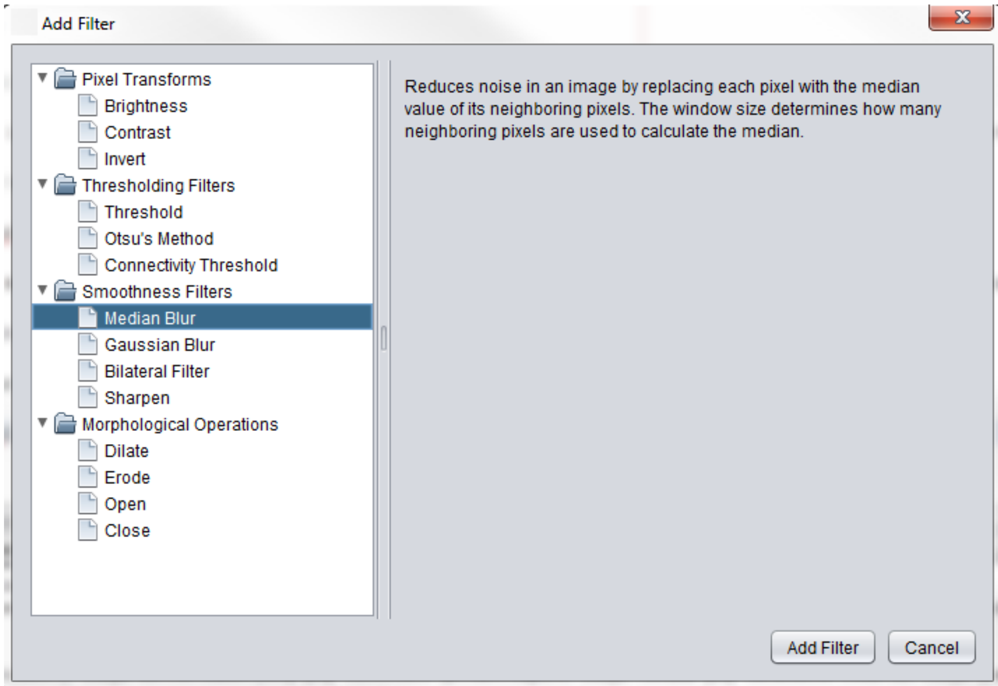


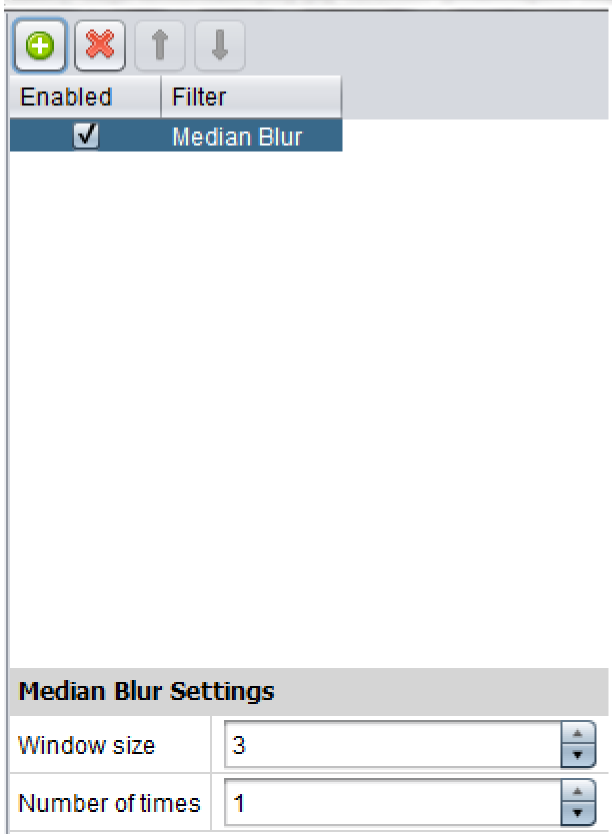


Otsu's method produces black and white images using automatically detected settings. There are no additional user settings for this filter.

Smoothness Filters- affect the rate of change of pixels across an image

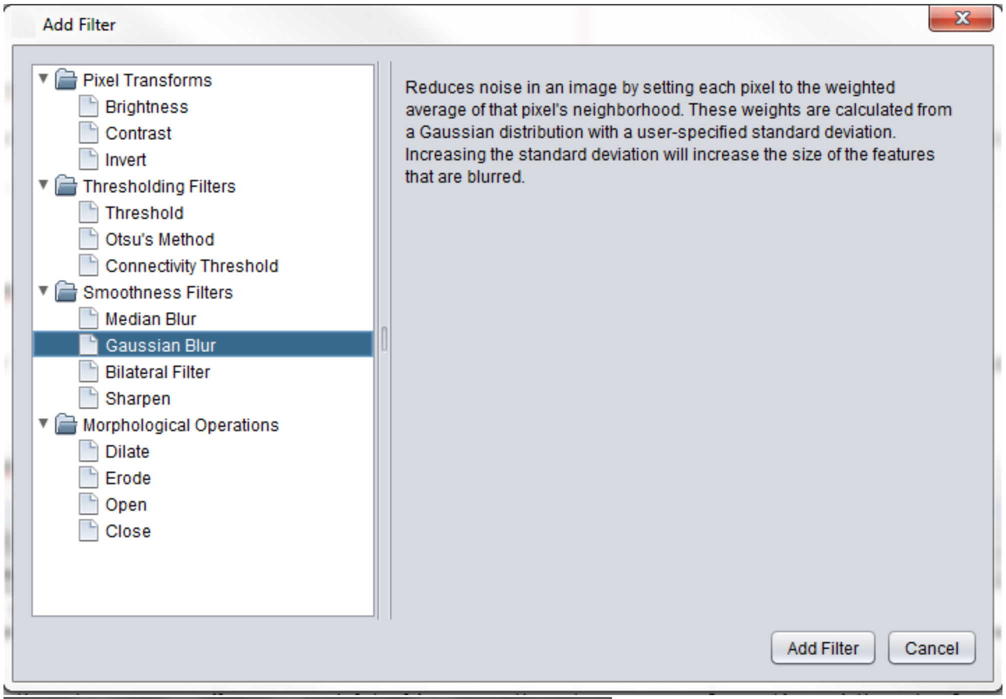
Median Blur



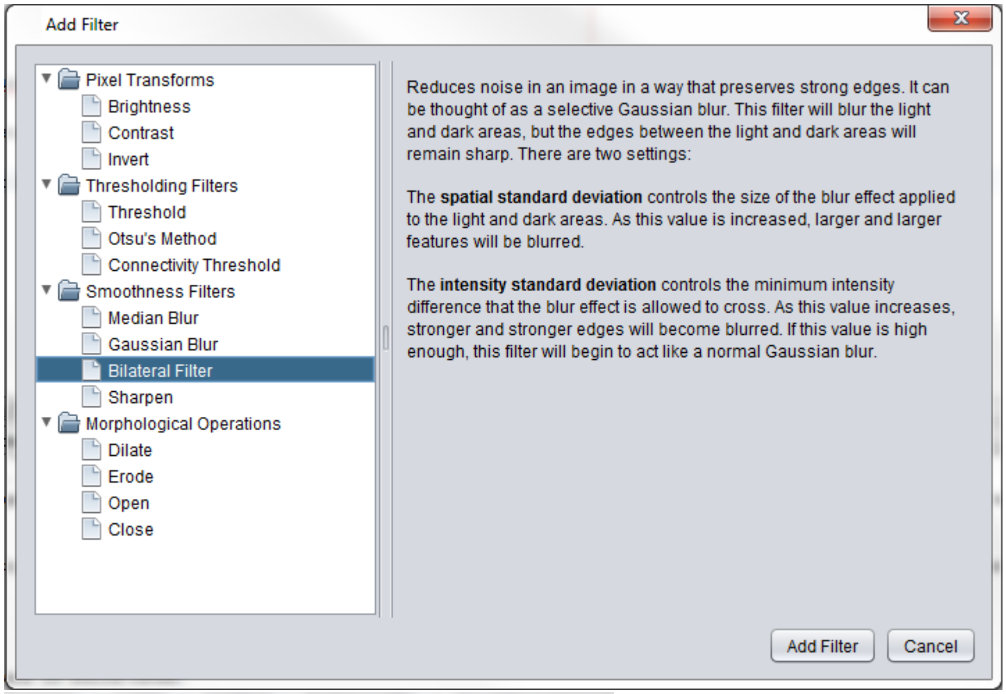


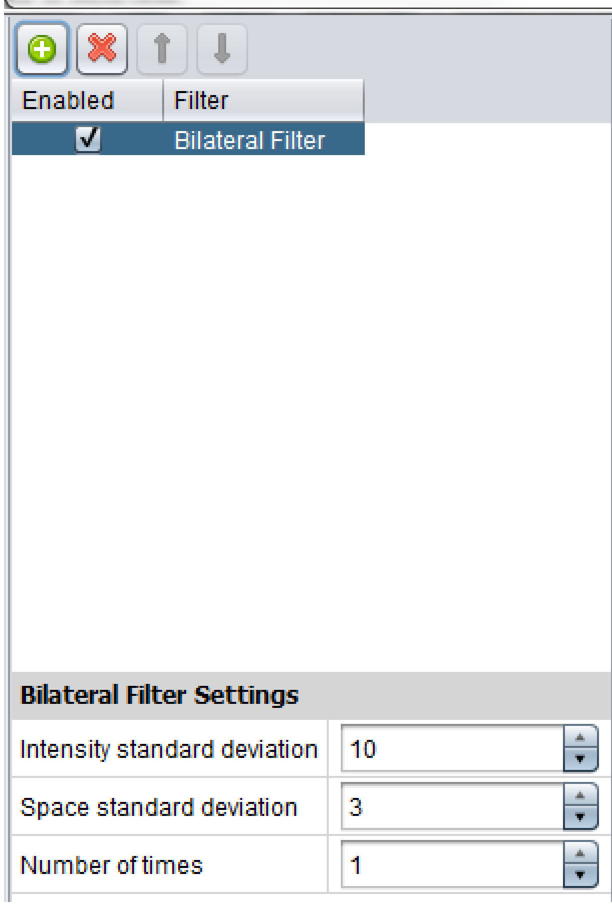
Window size is the number of neighboring pixels considered to calculate the median value. *Number of times* allows the filter to run multiple times.

Gaussian Blur

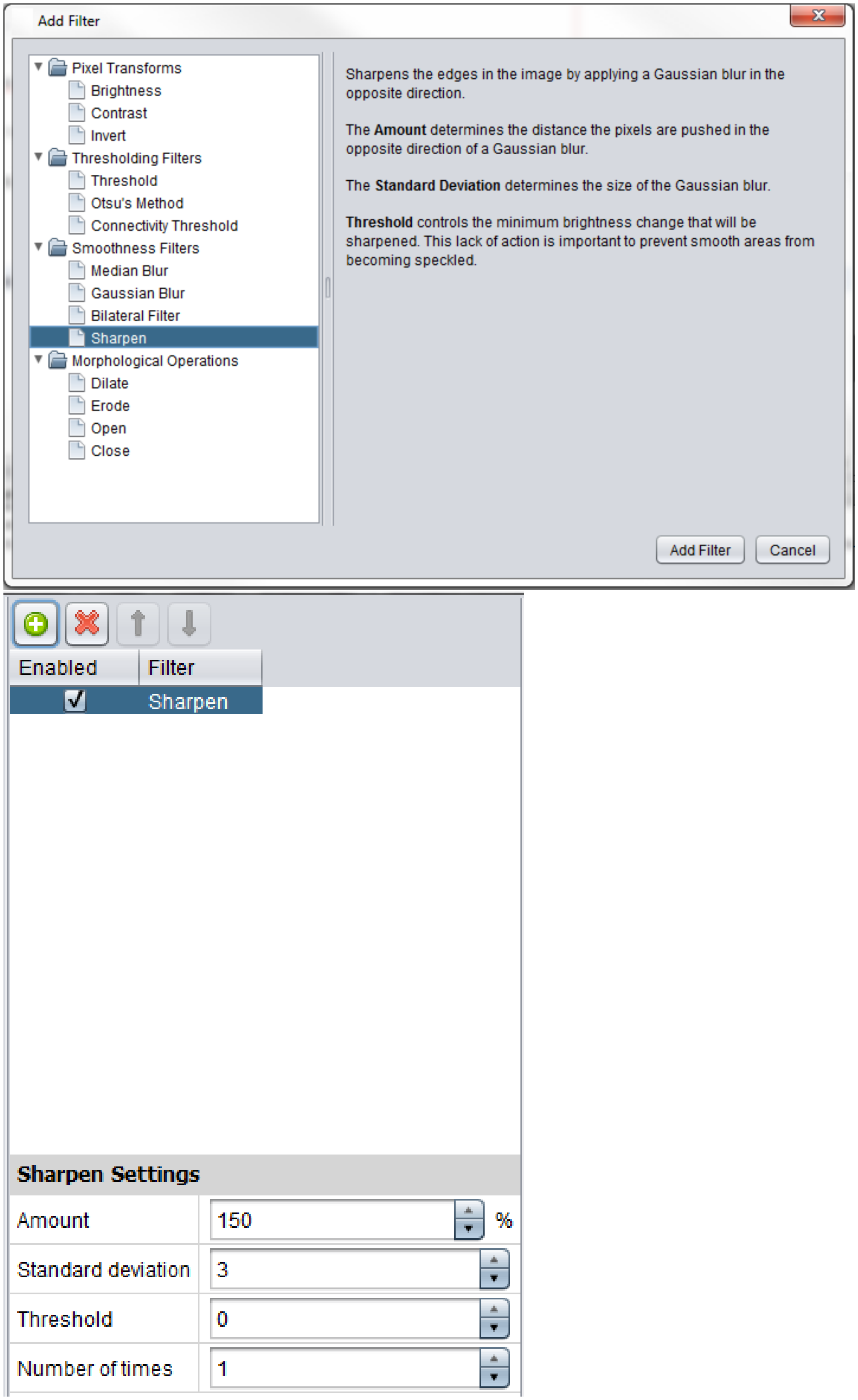


Bilateral Filter


Add Filter
Pixel Transforms
Brightness
Contrast
Invert
Thresholding Filters
Threshold
Otsu's Method
Connectivity Threshold
Smoothness Filters
Median Blur
Gaussian Blur
Bilateral Filter
Sharpen
Morphological Operations
Dilate
Erode
Open
Close
Reduces noise in an image in a way that preserves strong edges. It can be thought of as a selective Gaussian blur. This filter will blur the light and dark areas, but the edges between the light and dark areas will remain sharp. There are two settings:
The spatial standard deviation controls the size of the blur effect applied to the light and dark areas. As this value is increased, larger and larger features will be blurred.
The intensity standard deviation controls the minimum intensity difference that the blur effect is allowed to cross. As this value increases, stronger and stronger edges will become blurred. If this value is high enough, this filter will begin to act like a normal Gaussian blur.
Add Filter
Cancel

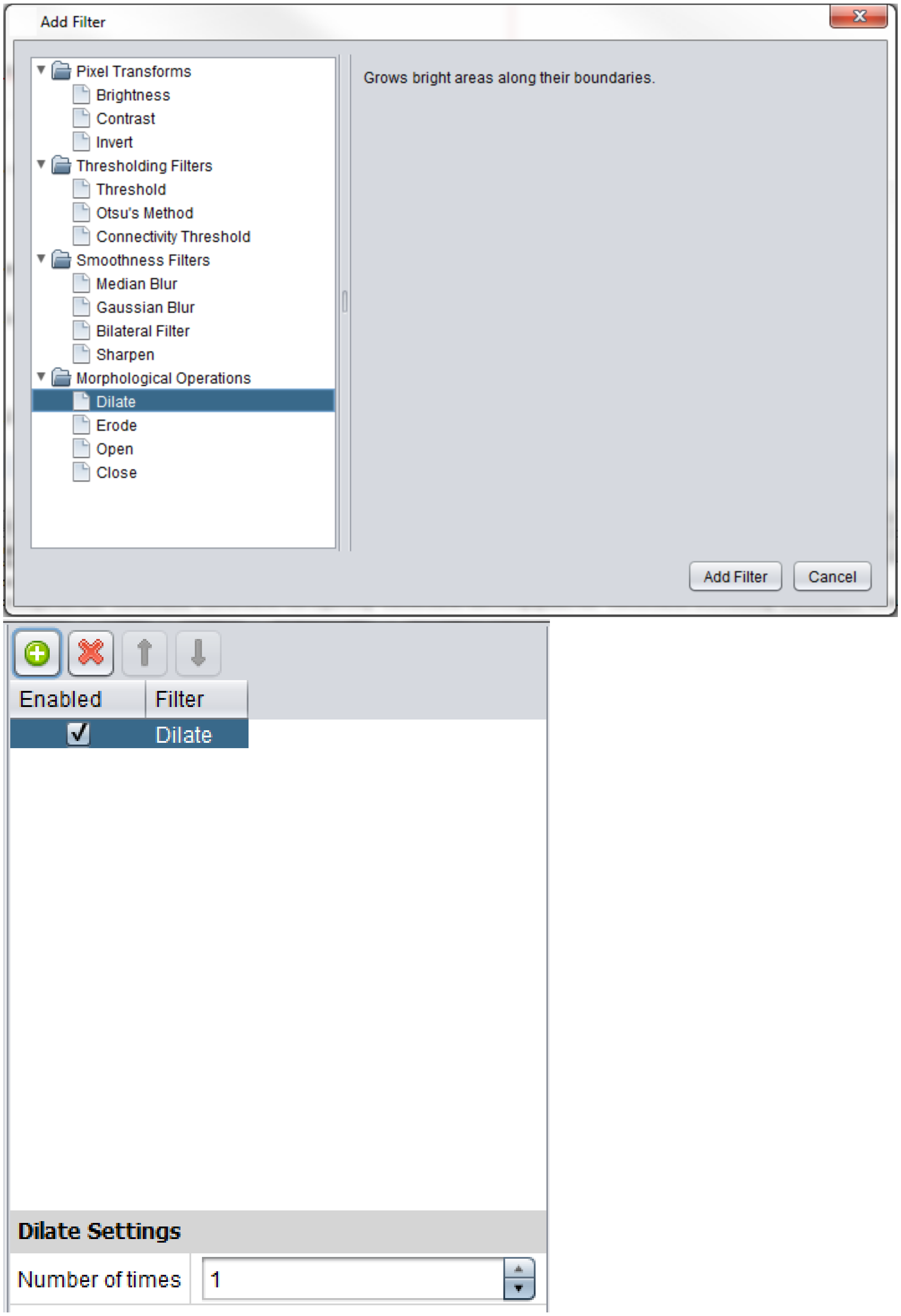

Enabled
Filter
Bilateral Filter
Bilateral Filter Settings
Intensity standard deviation
10
Space standard deviation
3
Number of times
1

Sharpen

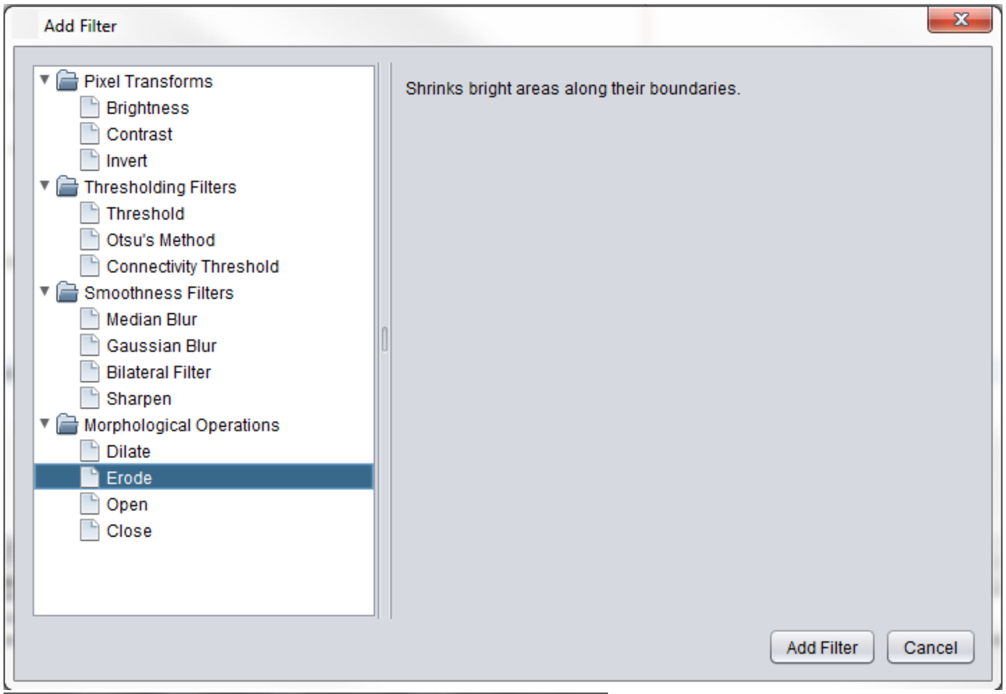


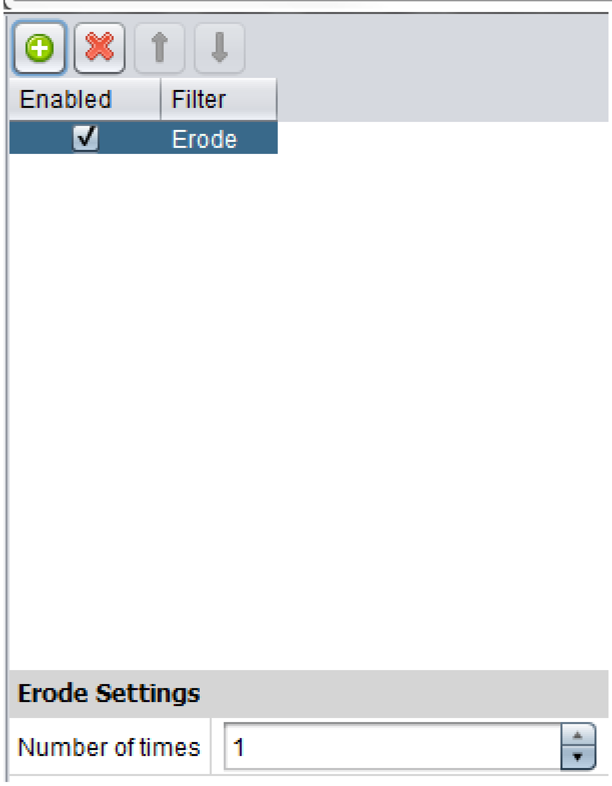
Morphological Operations- morphs the shapes of bright pixels. Works best on binary images.

Dilate

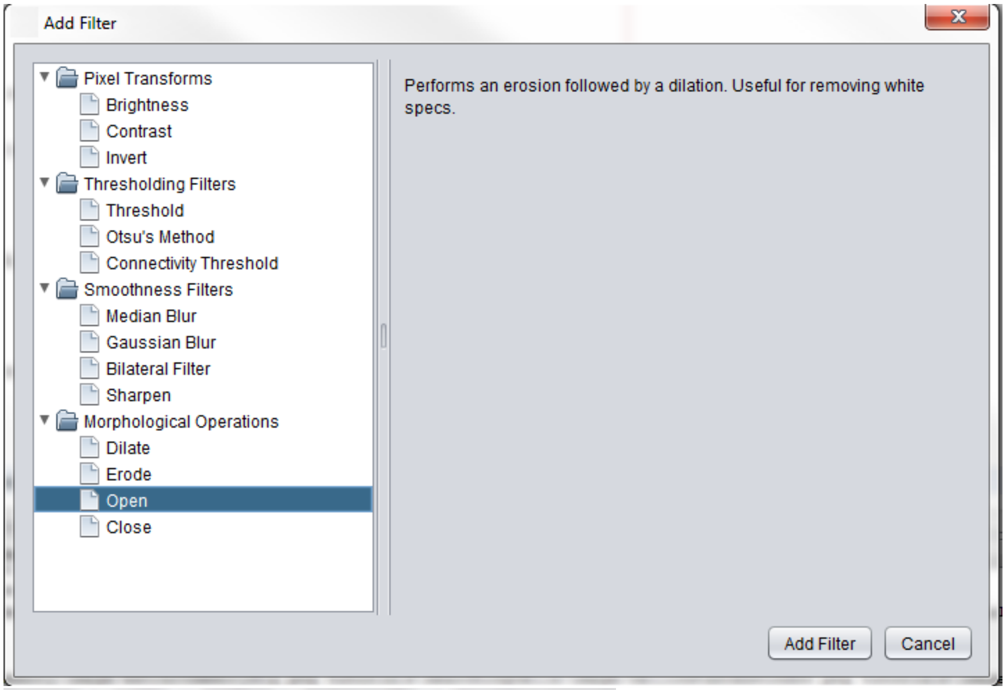


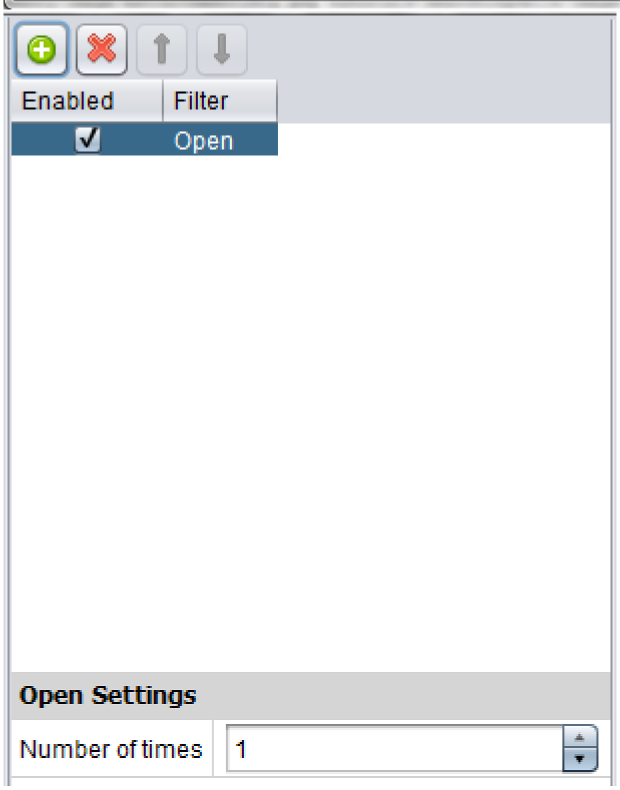
Erode


Add Filter
Pixel Transforms
Brightness
Contrast
Invert
Thresholding Filters
Threshold
Otsu's Method
Connectivity Threshold
Smoothness Filters
Median Blur
Gaussian Blur
Bilateral Filter
Sharpen
Morphological Operations
Dilate
Erode
Open
Close
Shrinks bright areas along their boundaries.
Add Filter
Cancel

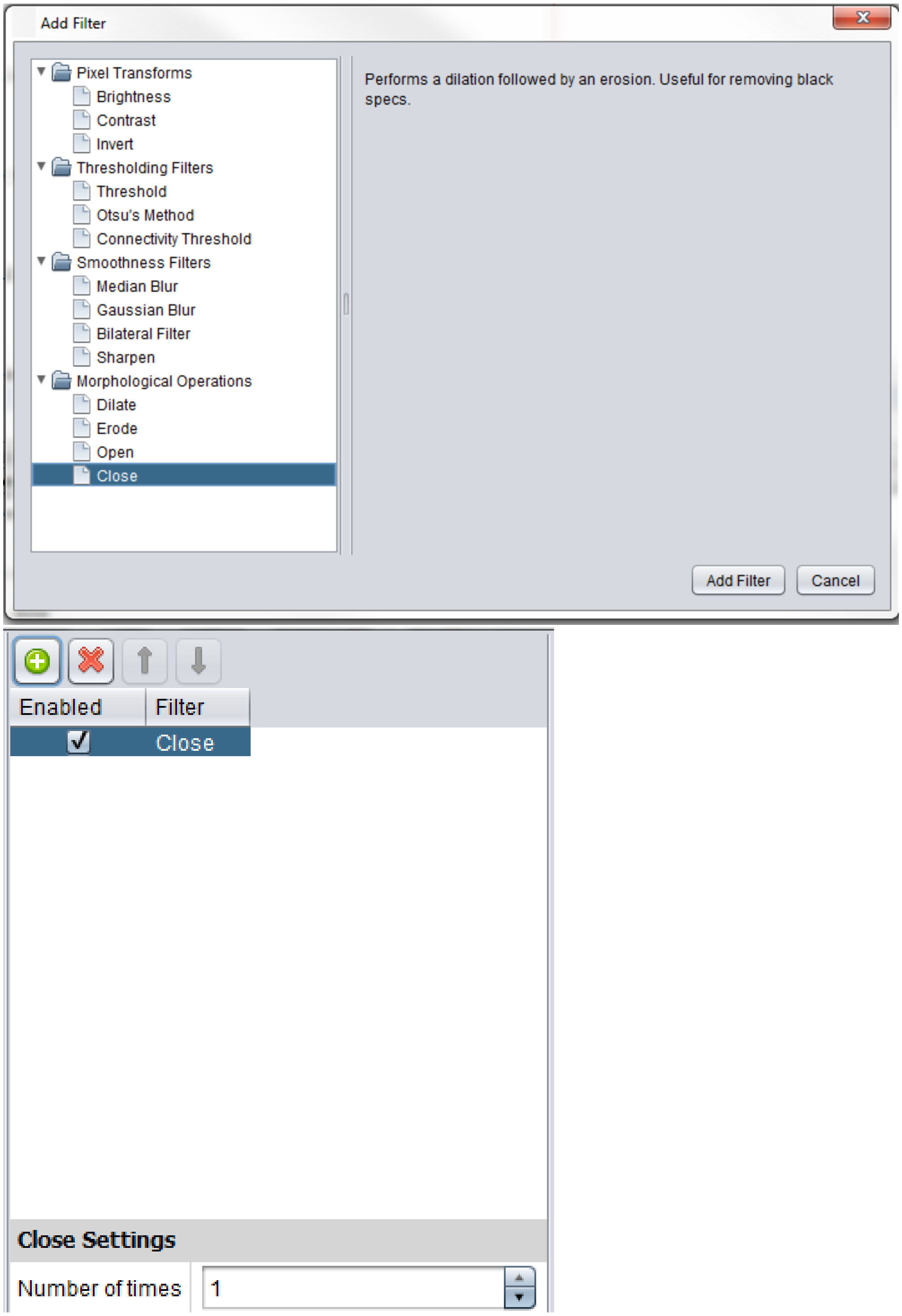

Enabled
Filter
Erode
Erode Settings
Number of times
1

Open


Add Filter
Pixel Transforms
Brightness
Contrast
Invert
Thresholding Filters
Threshold
Otsu's Method
Connectivity Threshold
Smoothness Filters
Median Blur
Gaussian Blur
Bilateral Filter
Sharpen
Morphological Operations
Dilate
Erode
Open
Close
Performs an erosion followed by a dilation. Useful for removing white specs.
Add Filter
Cancel


Enabled
Filter
Open
Open Settings
Number of times
1

Close

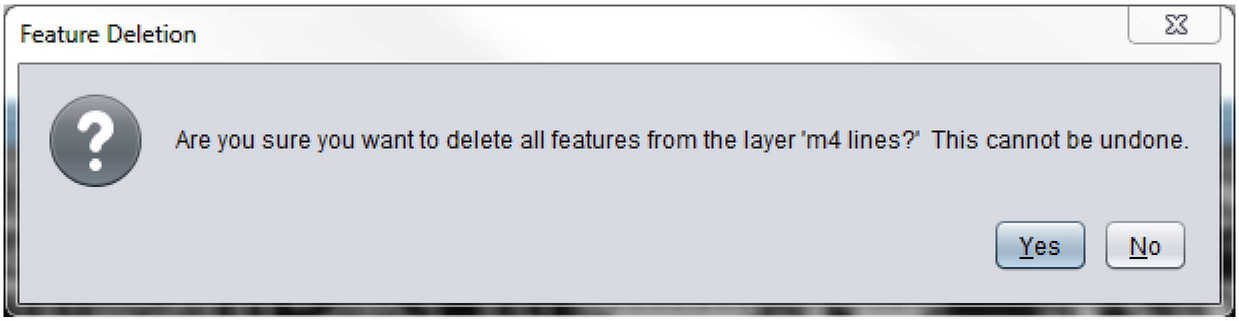


As many filters as desired can be added. Once a filter is created it can be turned on and off by the check mark. Once the desired results are obtained in the *Filtered* pane and the *Polygons* pane, click Extract to extract the polygons.

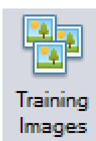
For a tutorial over extracting polygons, please see: *Polygon Extraction*

Clear Polygons

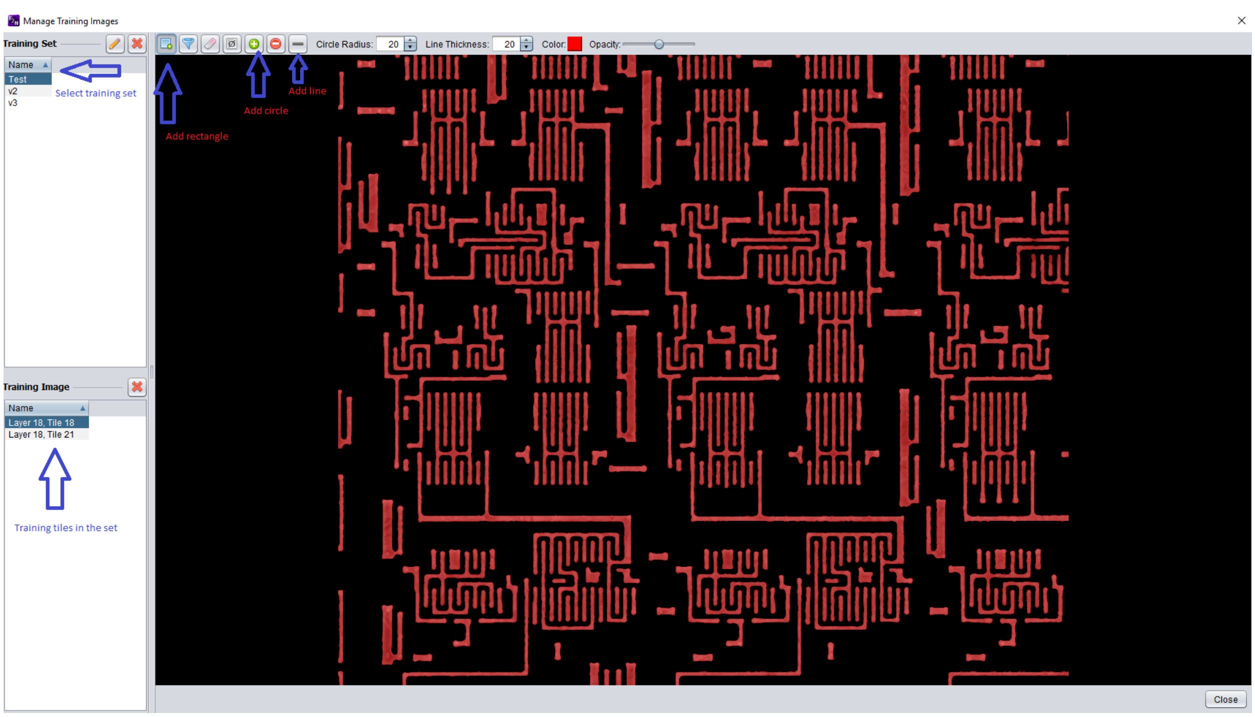
Clears the polygons of the selected layer in the *Layers* window. The following confirmation window will appear:



Training Images

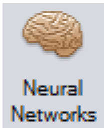


This will open the *Manage Training Images* window that can also be opened from the *Extract Polygons* dialog. Make adjustments to the training set as needed and click close.

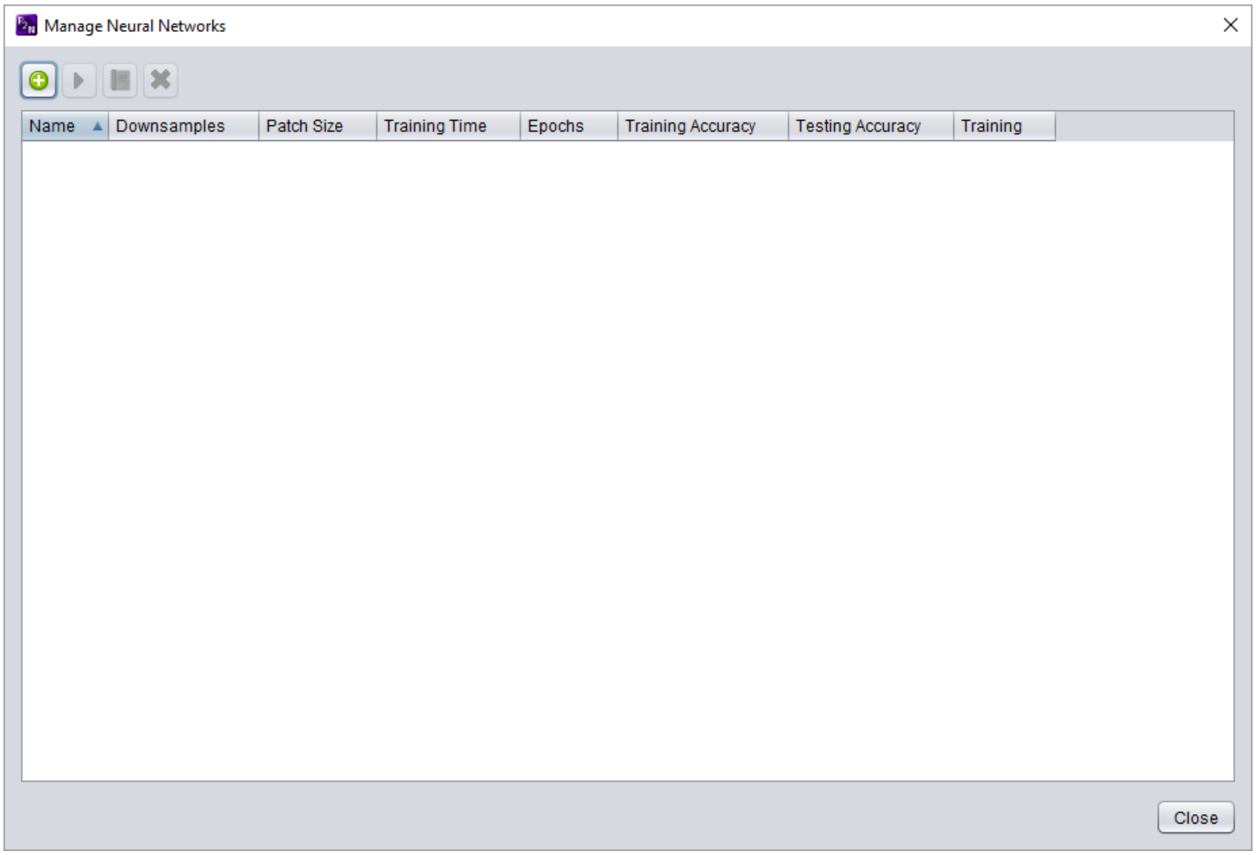


Neural Networks

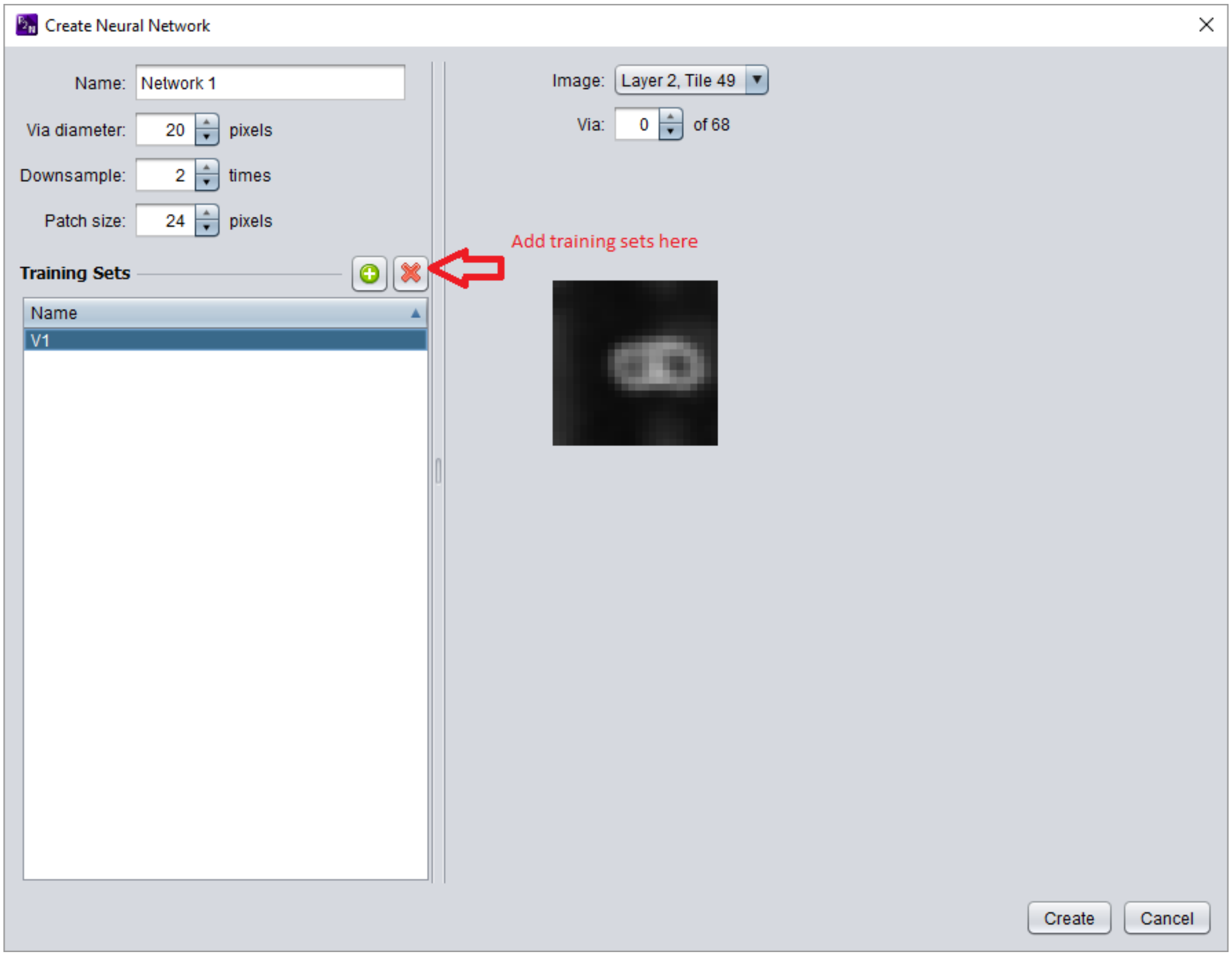
For a tutorial over using the Neural Network, please see: *Neural Network*



This will open the *Manage Neural Networks* window.



The user will need to click the green + sign to add a new neural network. The *Create Neural Network* window will appear:



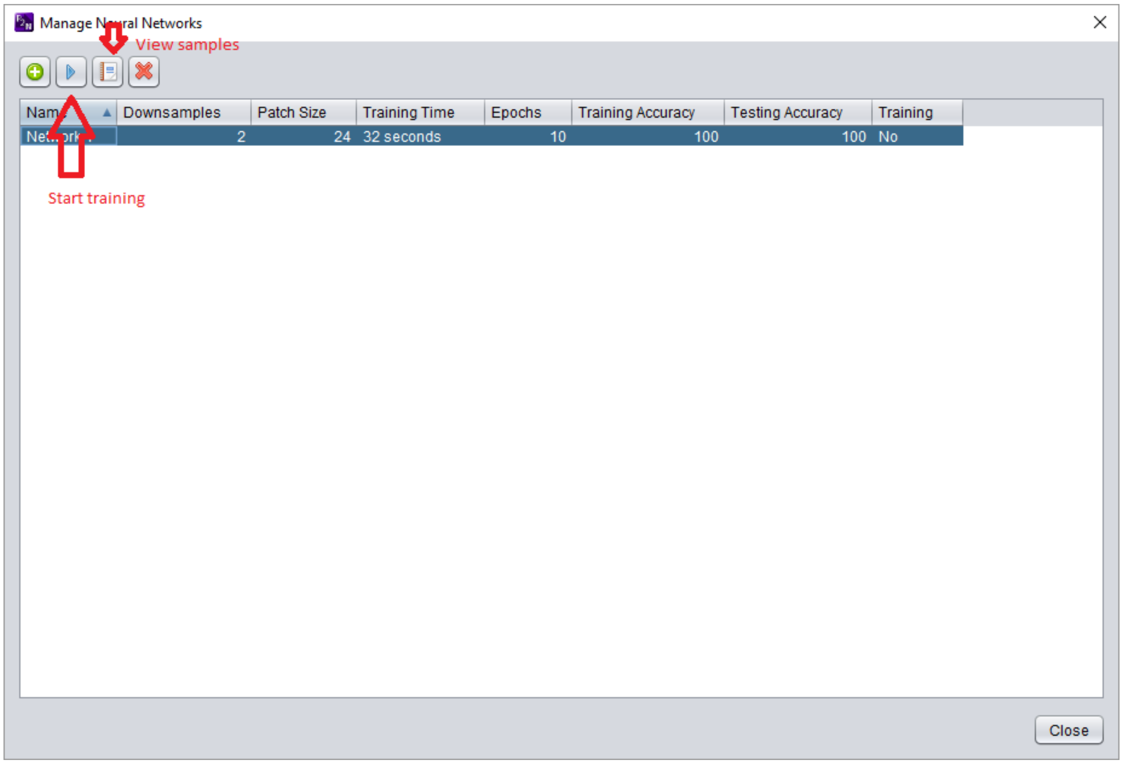
Click the "Neural Networks" button to open the Mange Neural Networks dialog. Click "Add Network".

Set the "Via diameter" to the same value that was used in creating the image set. Click the add button next to "Training Sets" to add the training set that was created. On the right side of the window, cycle through every via in each image of the training set. Adjust the "Downsample" and "Patch size" parameters:

> Downsample is the number of times the image on the right will be zoomed out. Choose the zoom level that makes each via as easily recognizable as possible.
>
> Patch size is the size of the image on the right. Make the patch size as small as possible (so that the neural network runs as quickly as possible), without making the patch size so small that the vias are no longer easily recognizable.

Click "Create".

The network is created, but now it needs to be trained. Select the network and then click the "Start training" button. The neural network will be trained in the background.

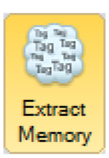


When the network is finished training, click the "View samples" button to visually inspect the results. The following columns are present for each entry:

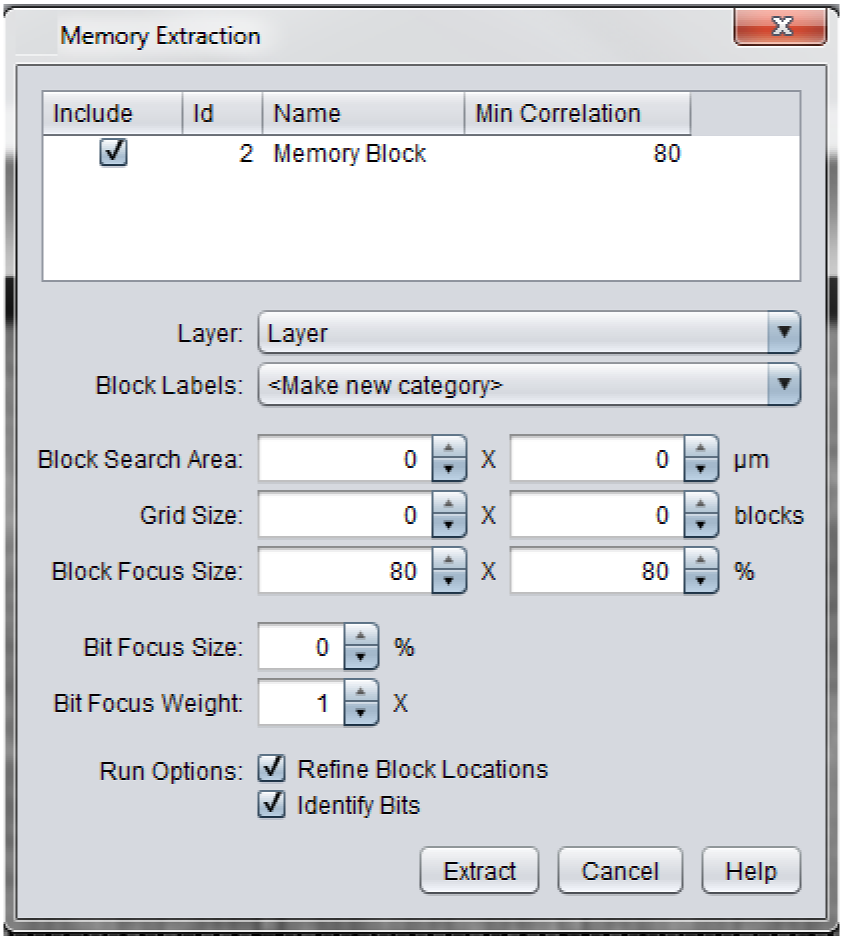
> Sample - A unique number for each entry in the table Type - "Training" if the sample was in the training set, and "Testing" if the sample was in the testing set.
>
> Confidence - A percentage, from 0 to 100, the describes how confident the network is that it labeled the sample correctly.
>
> Correct - This is true if "Network label" matches "User label".
>
> Network label - The label ("via" or "non-via") that the neural network chose for this sample.
>
> User label - The label ("via" or "non-via") that the user specified for this sample in the training image.

Click "Close" to close the dialog.

Extract Memory



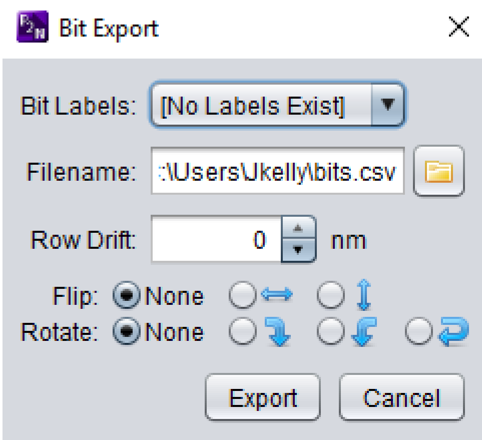
Selecting *Extract Memory* pulls up the extract memory window:



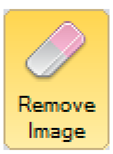
For procedures on ROM extraction see *Extracting Memory from Images*

Export Bits

Select to export a .csv file containing the bits in the ROM.

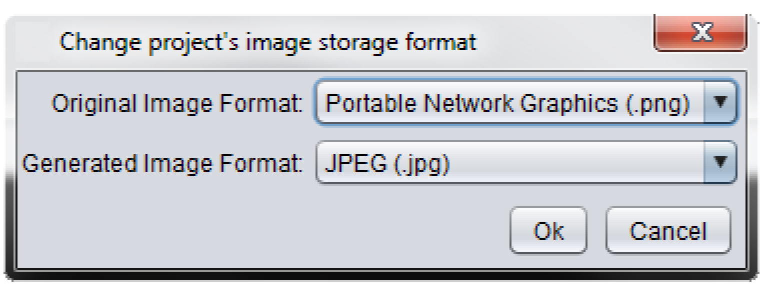


Remove Image



Click and drag over the images/tiles that need to be deleted. Make sure that the tile(s) that will be removed is (are) correct, as it cannot be automatically undone.

Image Settings

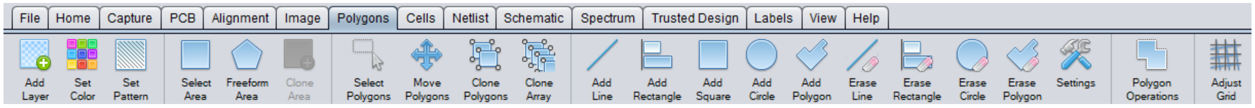


The *Original Image Format* denotes the extension for the original tiles set. This will convert images from .png, .jpg, .bmp to .png, .bmp, .jpg. The .png format is recommended to reduce the size of the dataset.

The *Generated Image Format* denotes the extension for images generated by Pix2Net. These are the images stored in the warped and mulitscale directories. The recommended format is .jpg

Polygon Tab

The *Polygon* tab has features that deal with adding, editing and moving polygons to new layers.

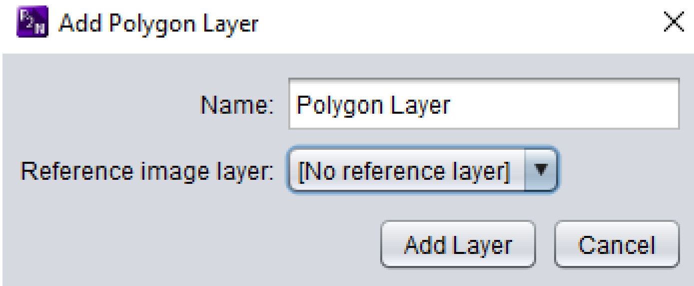


The following tools are available in the *Polygon* tab:

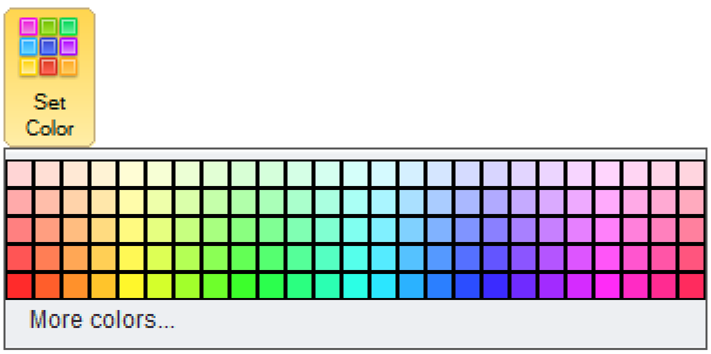
- *Add Layer*
- *Set Color*
- *Set Pattern*
- *Select Area*
- *Freform Area*
- *Clone Area*
- *Select Polygons*
- *Move Polygons*
- *Clone Polygons*
- *Clone Array*
- *Add Line*
- *Add Rectangle*
- *Add Square*
- *Add Circle*
- *Add Polygon*
- *Erase Rectangle*
- *Erase Circle*
- *Erase Polygon*
- *Settings*
- *Polygon Operations*
- *Adjust Grid*

Add Layer

Adds a new polygon layer to the project. A *Create Image Layer Association* window pops up. This allows the new polygon layer to be associated with images and layer warp grid.

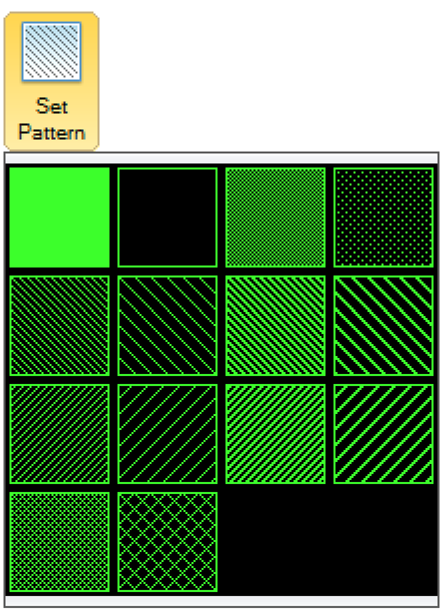


Set Color



Changes the color of the active polygon layer.

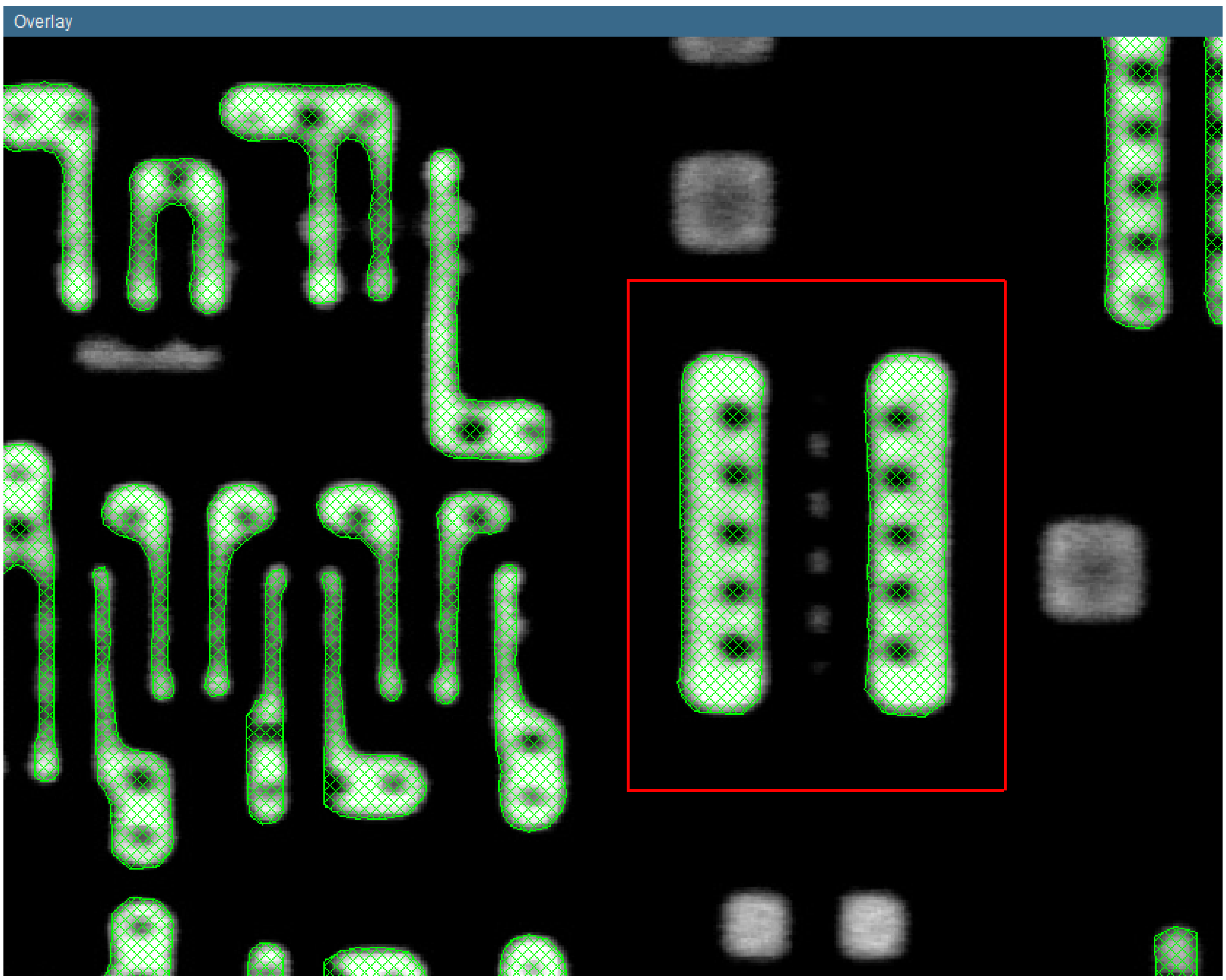
Set Pattern



Sets the pattern for the active polygon layer.

Select Area

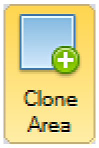
Allows the user to select a rectangular area of polygons that will later be cloned (in clone area). This is different from selecting and cloning polygons because once the selected area is cloned, everything that is selected in the area will be cloned exactly to where the user places it. This includes all polygons and even blank space that will be cloned, so make sure that whatever area that needs to be cloned does not have any unnecessary polygons. At the same time, make sure that there are no necessary polygons within the space that the clone will be placed.



Freform Area

This is the same as Select Area, but the user is able to draw out their own boundaries to choose what area will be cloned.

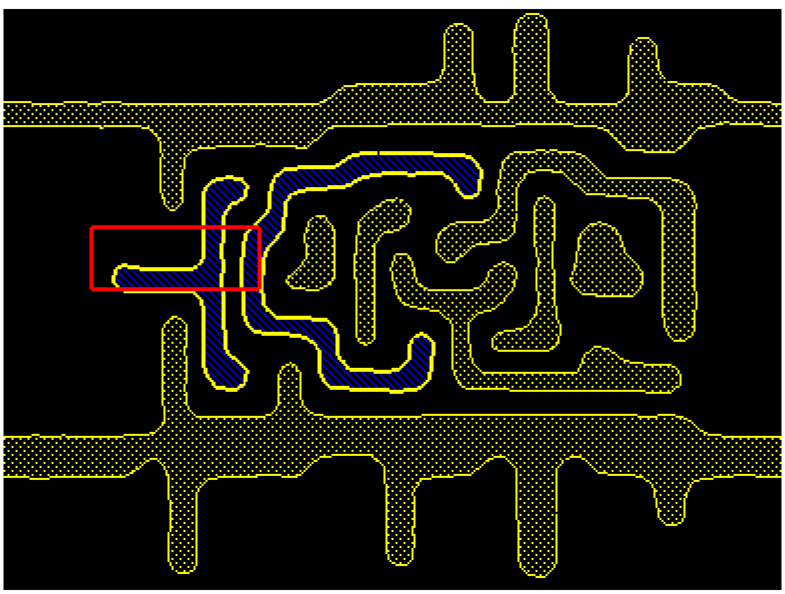
Clone Area



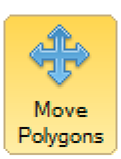
This allows the user to take the selected area or freformed area and clone it anywhere by just clicking and dragging the polygons to the correct spot. This also allows users to clone blank spaces (for when the extraction of polygons is placed incorrectly over areas that should not have polygons) For an example, see *Selecting and Cloning Areas*

Select Polygons

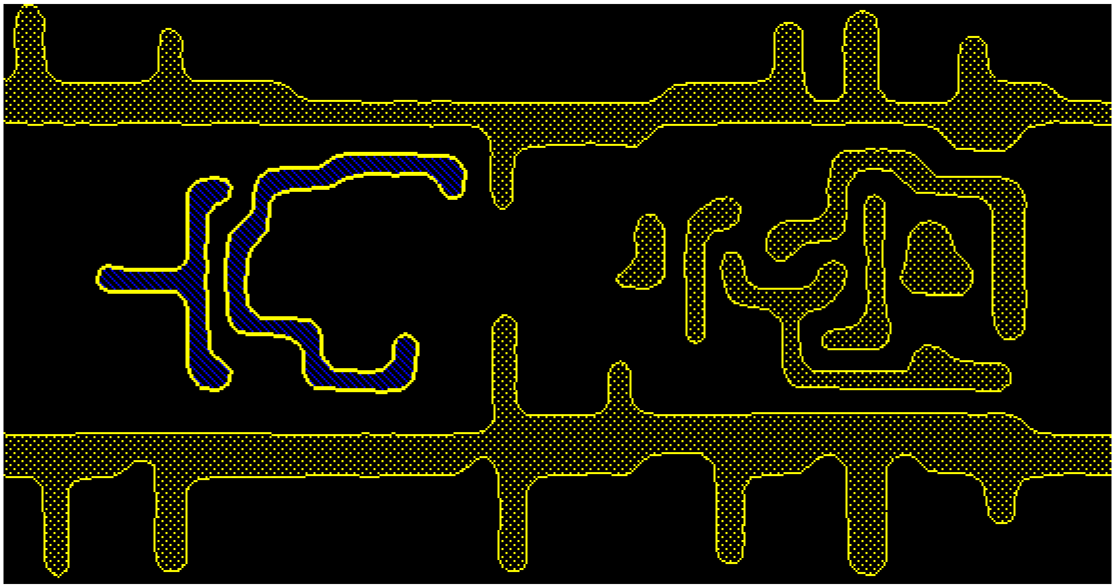
Click and drag to select a single polygon or group of polygons



Move Polygons

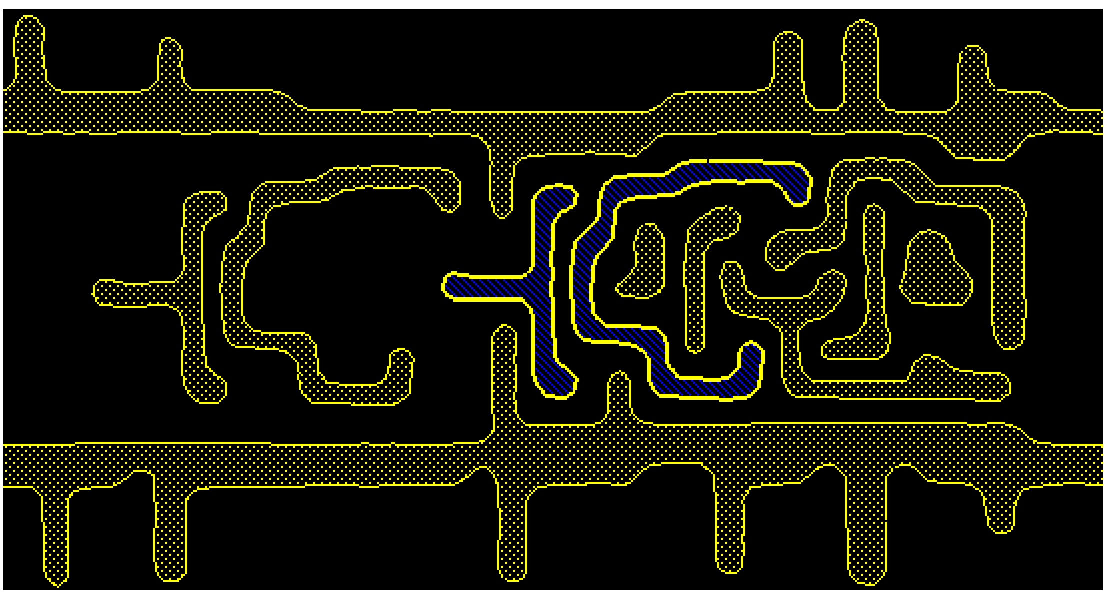


With the selected polygons highlighted, click and drag to move that group to a new location.



Clone Polygons

With the selected polygons highlighted, click and drag to copy that group to a new location.

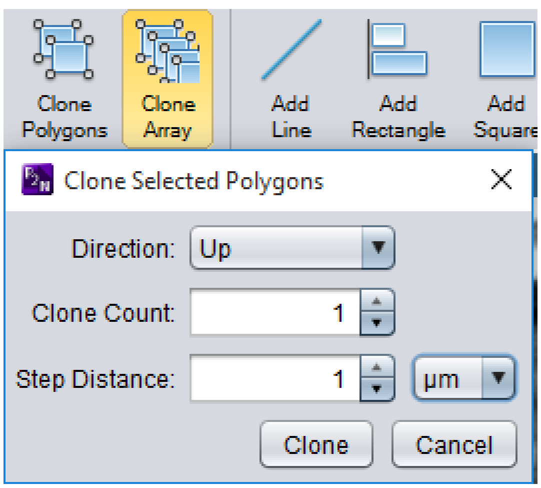


Clone Array

The Clone Array feature allows the user to create multiple copies of one or more polygons, each set placed a fixed distance from the original/previous set in a specific direction. This ability is useful whenever a regular pattern of polygons needs to be created by hand. For example, a grid of 100 squares could be created by creating a square, cloning it 9 times right, then cloning that newly created row 9 times down.

To use the feature:

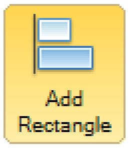
1. Use the select polygons tool to select all polygons which will be cloned. The Clone Array ribbon button will become enabled.
2. Click the Clone Array ribbon button.
3. In the dialog which appears, specify the direction from the original the polygons should be placed, the number of sets of cloned polygons to create, and the distance each set of polygons will be moved away from the previous set. You can specify a unit for the distance value entered.
4. Click "clone," and the polygons will be created.



Add Line

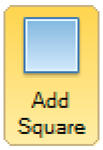
Left click anywhere in the overlay window to add a start point to the line, a second click adds the endpoint. After adding the start point holding shift will force orthogonality. Hold Ctrl when the width of the line is determined to adjust the height. Use Shift to keep the line perfectly horizontal, vertical, or diagonal. The thickness of this line can be defined in the *Polygon Settings* window.

Add Rectangle



Click and drag to outline a box when the left mouse button is released a rectangular polygon will be added to the active layer.

Add Square



Left click in the overlay to add a square to the active polygon layer. The square size can be specified in the *Polygon Settings* window.

Holding Ctrl before clicking allows the user to adjust the size of the square.

Add Circle

Left click in the overlay to add a circle to the active polygon layer. Hold Ctrl before left-clicking, and drag the mouse to increase or decrease circle size, or adjust the size in the Polygon Settings.

Add Polygon

Left click in the overlay window to start adding points, once three or more points are connected, the polygon will be added to the active layer.

Erase Line

The same as `Add Line`, but erases a defined line instead.

Erase Rectangle

Click and drag to outline a box when the left mouse button is released any polygons inside the box will be deleted.

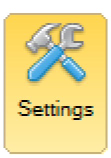
Erase Circle

Click in the overlay to erase a circular area of polygons. The size of the circle is dependant on the size of the last used add circle tool.

Erase Polygon

Left click in the overlay window to start adding points, once three or more points are connected, the polygon will be erased on the active layer.

Settings

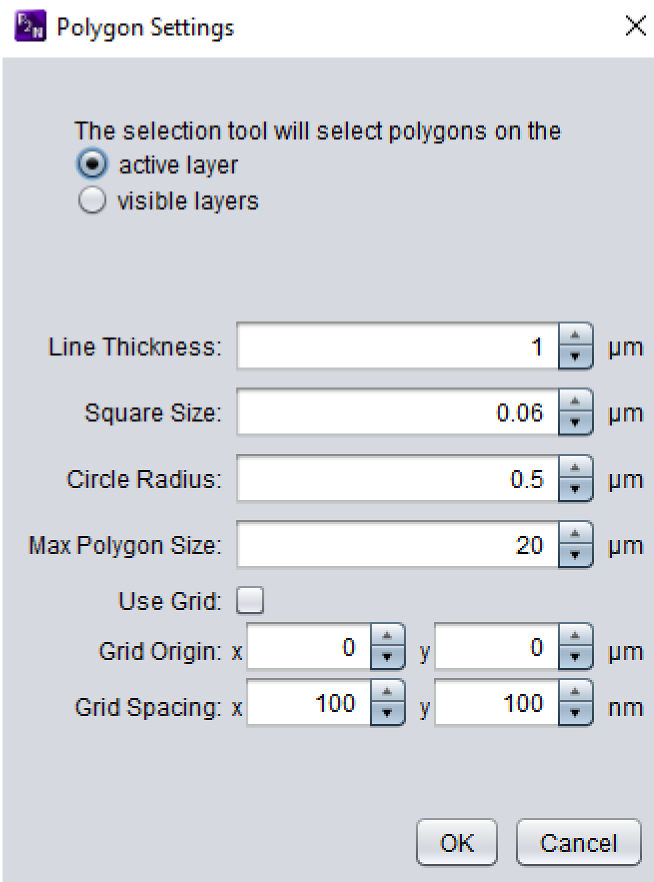


The polygon settings windows allows adjustment to the line thickness, square size, and circle radius in microns. There is also a setting to adjust the maximum polygon size

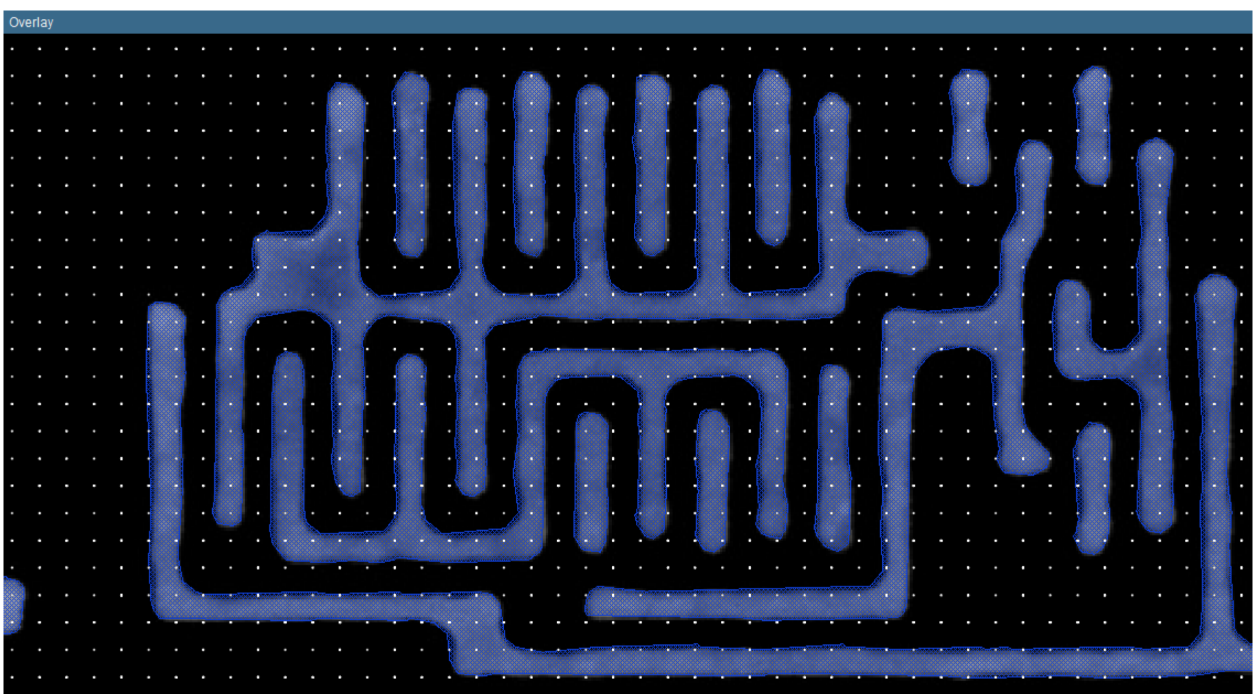
The max polygon size determines the maximum width and height of the polygons in the project. If a tool attempts to create a polygon larger than this size, the polygon will automatically be split until its dimensions no longer exceed the max polygon size. If this value is too high then polygon rendering and netlisting will start to become inefficient.

Select *active layer* to tell Pix2Net that when selecting layers, the user only wants to select the active layer. Select *visible layers* to be able to select all visible layers with polygons. *While using this feature, the user can only move polygons (no cloning). Using the 'Select Area' feature will only select the polygons that are highlighted in the 'Layers' window.*

The user can also click on *Use Grid* to have Pix2Net place a grid on the overlay to help assist with pitch and scale correction of devices. The grid spacing and origin can be adjusted for X and Y coordinates.

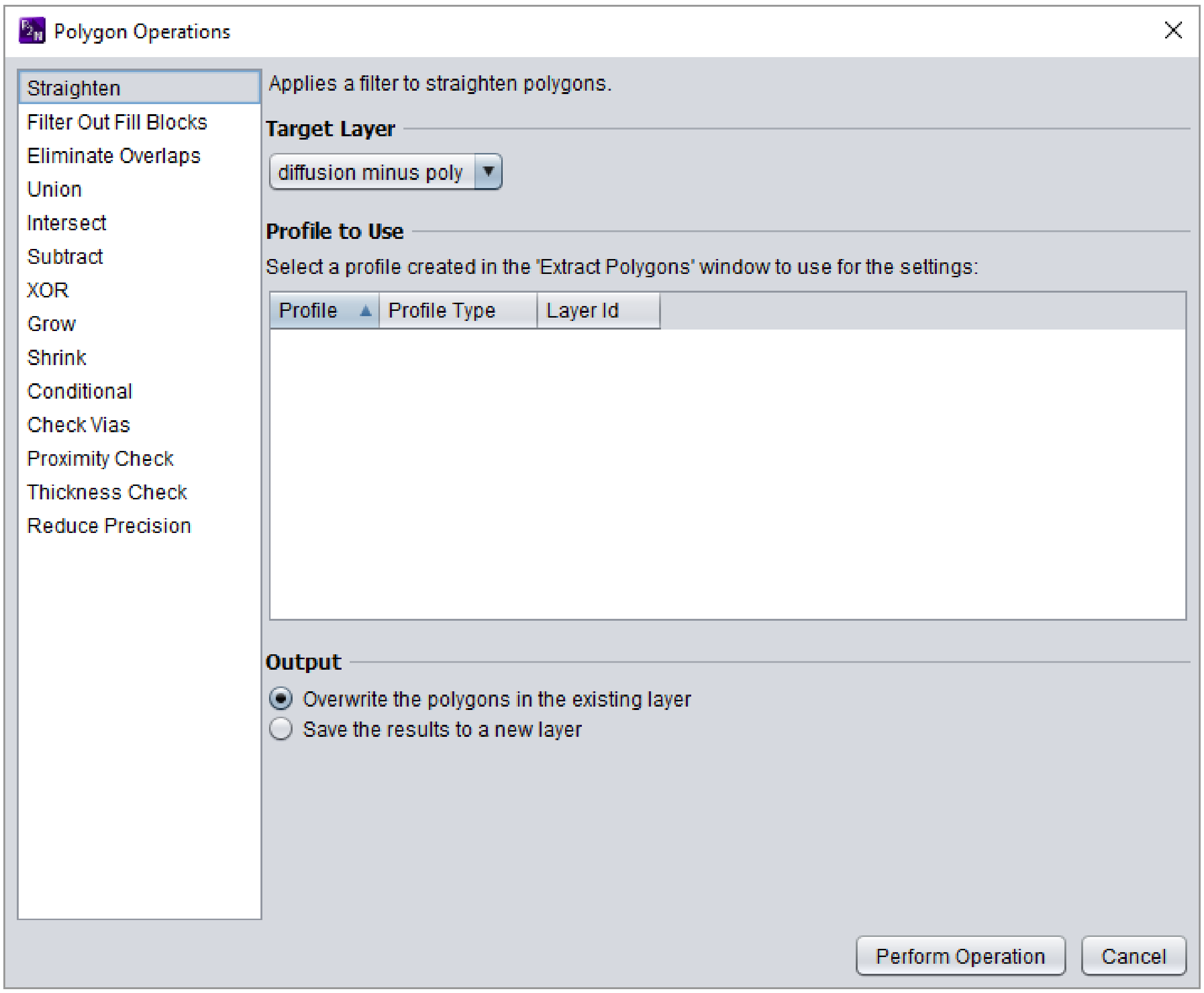


This is what will show on the overlay when *Use Grid* is selected:



Polygon Operations

Clicking this button opens the *Polygon Operations* window. The left column lists the available polygon operations. The right column gives the user options for each operation.

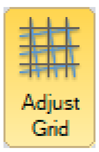


Creates a new polygon layer by performing a transformation on existing polygon layers. The operations are as follows:

- *Straighten:* Applies a filter to straighten polygons.
- *Filter Out Fill Blocks:* Applies a filter to identify.
- *Eliminate Overlaps:* Fixes overlapping polygons by union or elimination.
- *Union:* Generates a new layer by merging all polygons from two selected layers.
- *Intersect:* Generates a new layer by that consists of only the intersection of two selected polygon layers.

- *Subtract:* Generates a new layer by subtracting one polygon layer from another.
- *XOR:* Creates a new layer by exclusive.
- *Grow:* Creates a new layer by expanding all the polygons by a specified amount.
- *Shrink:* Creates a new layer that shrinks all polygons by a specified amount.
- *Conditional:* Performs a conditional operation on the polygons in a layer.
- *Check Vias:* Generates a report for vias not well centered in polygons from a check layer.
- *Proximity Check:* Generates a report for polygons which are placed too closely.
- *Thickness Check:* Generates a report for polygons which are too thin.
- *Reduce Precision:* Reduces the precision of each polygon in a layer.

Adjust Grid



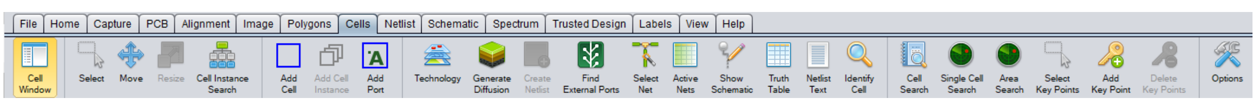
Once *Use Grid* is turned on in the settings, the user may adjust the grid by clicking and dragging the grid along the overlay window. There will be a small white plus sign towards the upper left-hand corner of the image to help the user adjust the grid accordingly.

More Information

For more information on placing polygons and what the user can do with them, click this link: *Polygon Placement*

Cells Tab

The *Cells* tab has features that deal with adding cells, editing cells and ports, creating netlists, adding search plans and scanning areas for matching cells.

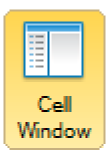


The following tools are available in the *Cells* tab:

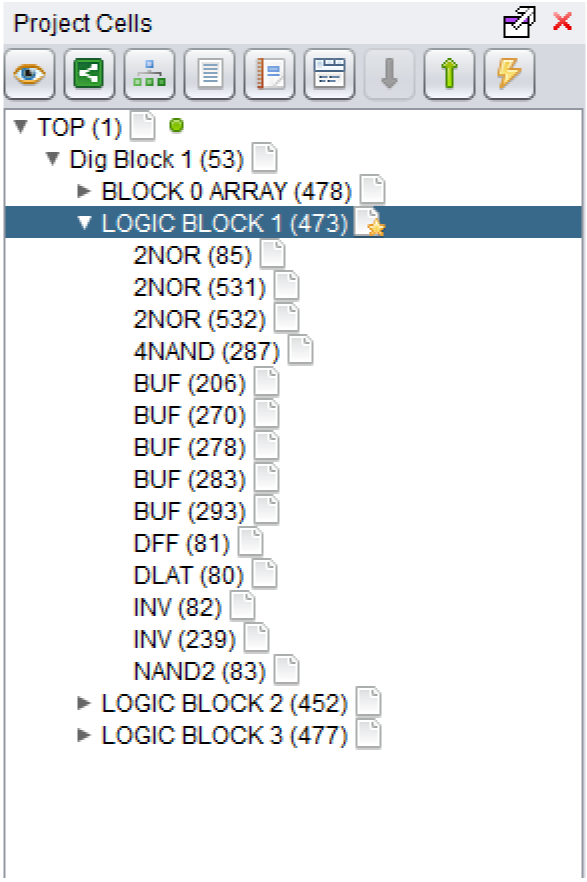
- *Cell Window*
- *Select*
- *Move*
- *Resize*
- *Cell Instance Search*
- *Add Cell*
- *Add Cell Instance*
- *Add Port*
- *Technology*

- *Generate Diffusion*
- *Create Netlist*
- *Find External Ports*
- *Select Net*
- *Active Nets*
- *Show Schematic*
- *Truth Table*
- *Netlist Text*
- *Identify Cell*
- *Cell Search*
- *Single Cell Search*
- *Area Search*
- *Select Key Points*
- *Add Key Point*
- *Delete Key Points*
- *Options*

Cell Window

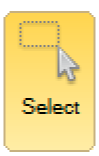


This toggles the *Project Cells* window.



This window shows library cells that have been added to the project as well as the cell hierarchy. Many netlist properties and cell instance information windows can be opened from this panel: *Project Cells Reference*

Select



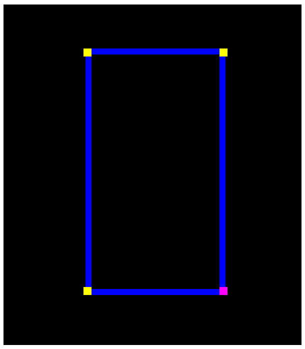
Using the select tool either click inside the desired cell or click and drag around a group of cells to highlight them. With the cell highlighted, tools like move and clone can be used.

Move

With a cell highlighted, select the move tool. Clicking and dragging in the overlay will move the cell.

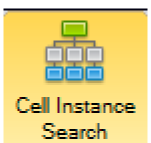
Resize

The resize tool adds a node to each corner of the highlighted cell. Any of these nodes can be clicked and dragged to resize the cell.



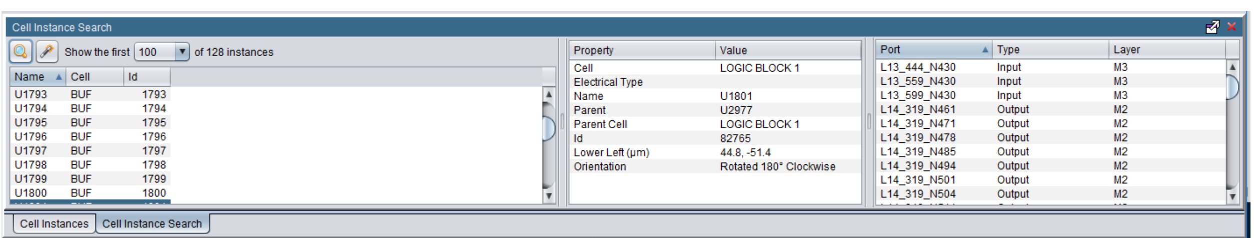
Note: When resizing a cell all instances of the selected cell are also resized.

Cell Instance Search

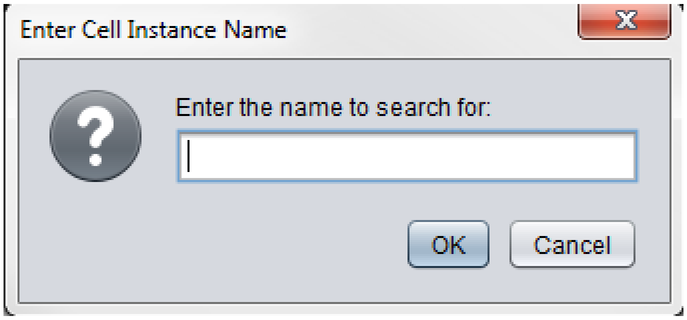


Allows user to view instances of all cells which are children of the active netlist and search for unique cell names.

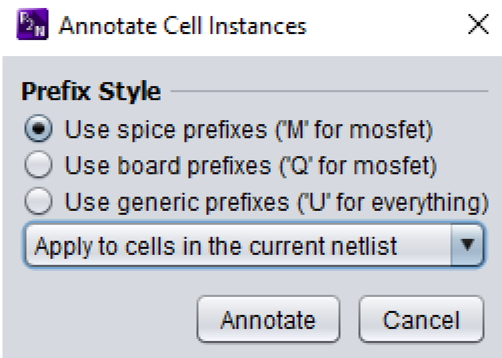
The *Cell Instance Search* window will open in the bottom pane.



Click on the magnifying glass to search for a particular instance in the netlist. The overlay camera will zoom to the instance.

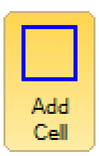


Click on the wand to annotate cell instances using the desired convention.



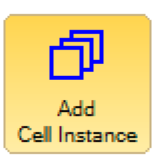
The drop-down option lets the user apply this to the cells in the current netlist or to all cells in the project.

Add Cell



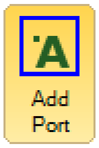
Create a new cell by adding a rectangular boundary for the cell instance. **Recommended** the user should have cell identification knowledge before placing cells.

Add Cell Instance

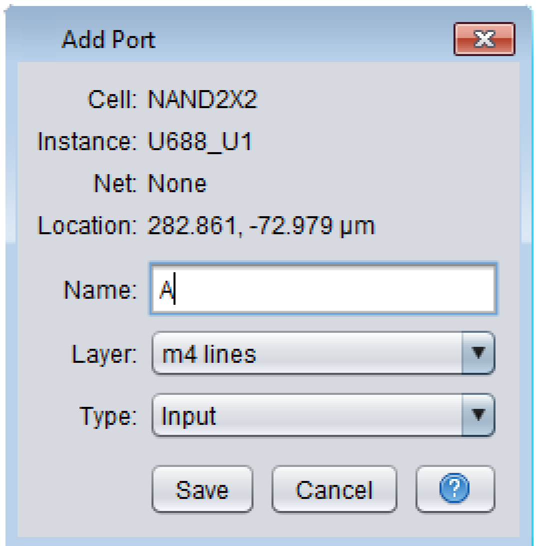


With a cell highlighted, click and drag to add a copy of this cell instance. This new cell will not add a new entry to the *Project Cells* list and all ports and electrical properties are replicated.

Add Port

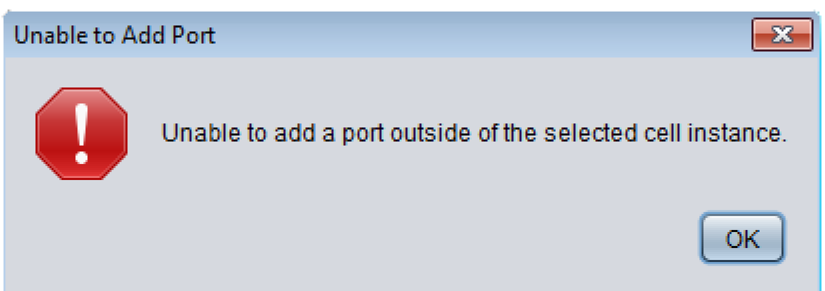


With a cell highlighted and the *Add Port* tool engaged, clicking anywhere in the cell will add a port at that location. A *Add Port* window appears to collect information about this new port.



This window displays the cell name, cell instance name, the net that the port will be added to and the coordinates of the newly added port. Information about the port is included here including, the port name, the polygon layer associated with the port and the type of port (input, output, VSS, VDD, ect.)

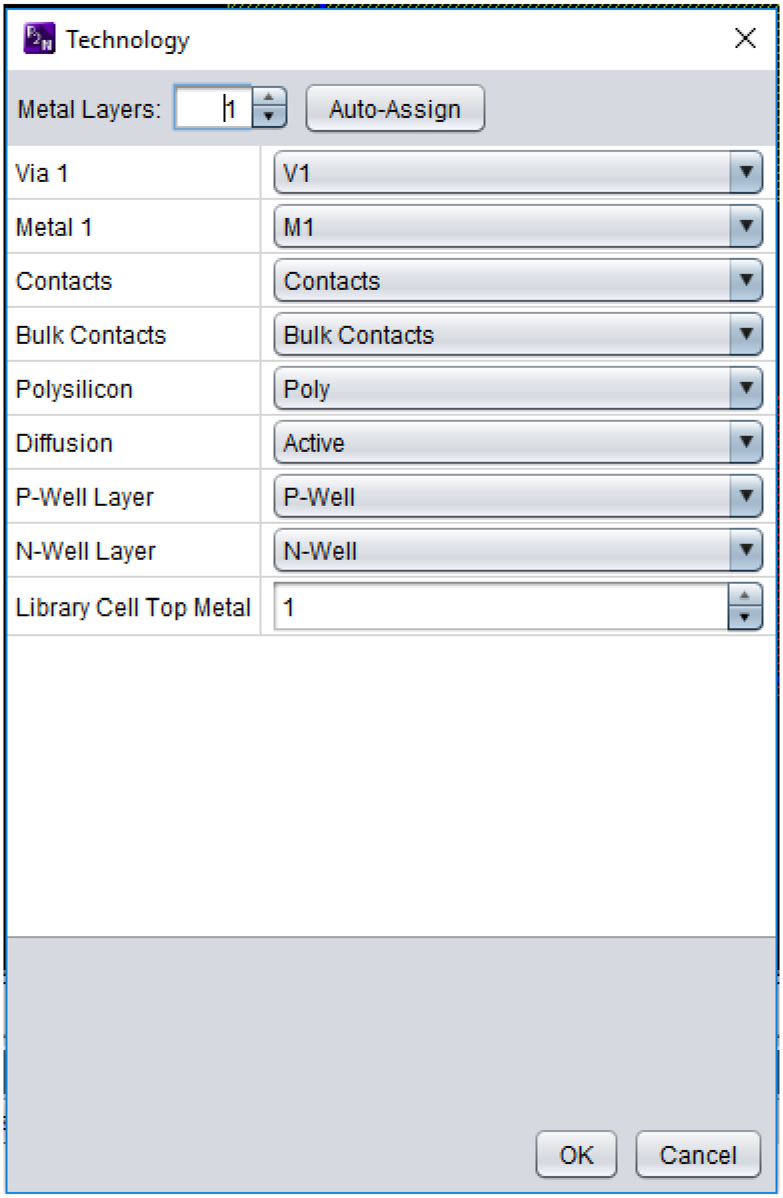
If the port is placed outside the cell boundary an error will appear. Click *OK* and be sure that the port is in the cell boundary.



Technology

User determines the number of metal layers.

Allows the user to define the metal layer (on the left) to the corresponding layer (on the right).



If the layers are correctly in order and defined correctly in the layers window, the user can click on Auto-Assign and Pix2Net will assign the correct layers to their corresponding layer.

Generate Diffusion

Before using this feature, make sure that the Poly and Diffusion layers are defined in `Technology`. This allows the user to easily create generated diffusion and generated transistor layers. When selecting this, the user has the option of either generating diffusion within a cell or the whole layer. *NOTE* Diffusion layers need to be defined before finding

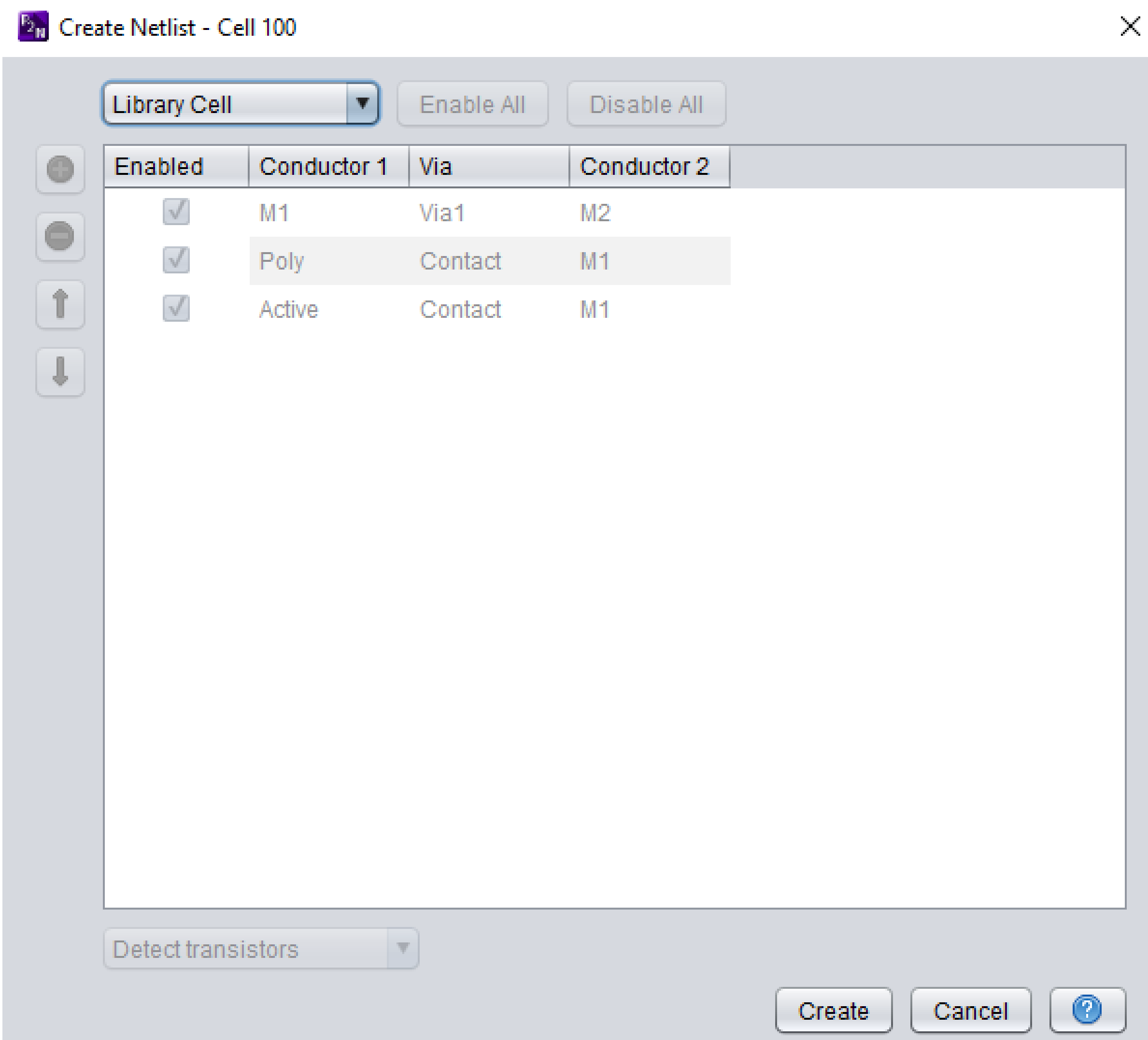
transistors within a cell (which is automatically detected when creating a netlist for a library cell). Generating diffusion tells Pix2Net to find where the diffusion layer intersects with the poly layer. Pix2Net shows the user that the generated diffusion layer will be the diffusion minus the poly, and the generated transistor layer will be where the poly and active overlap. For more information see *Adding a Cell*

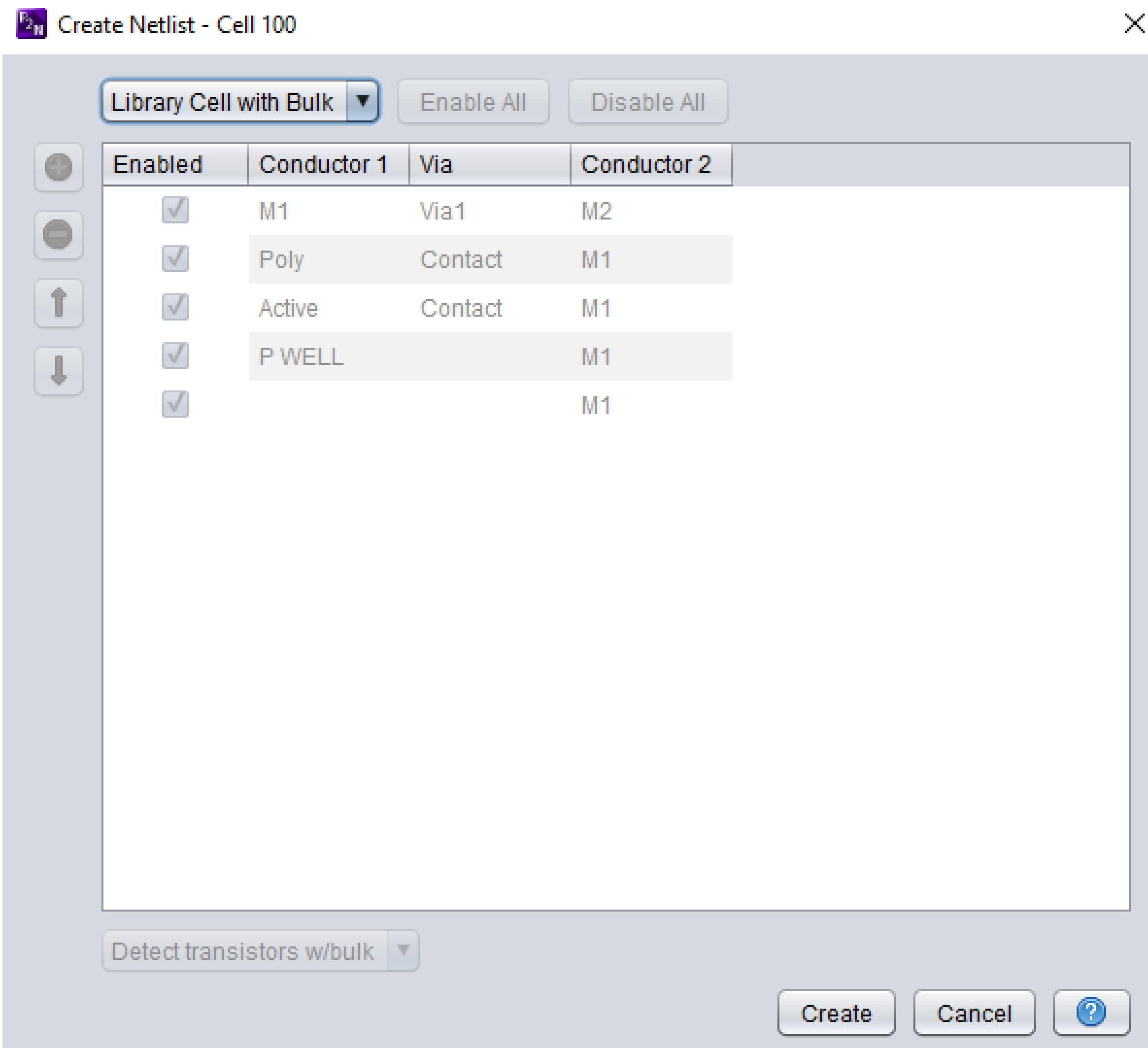
Create Netlist

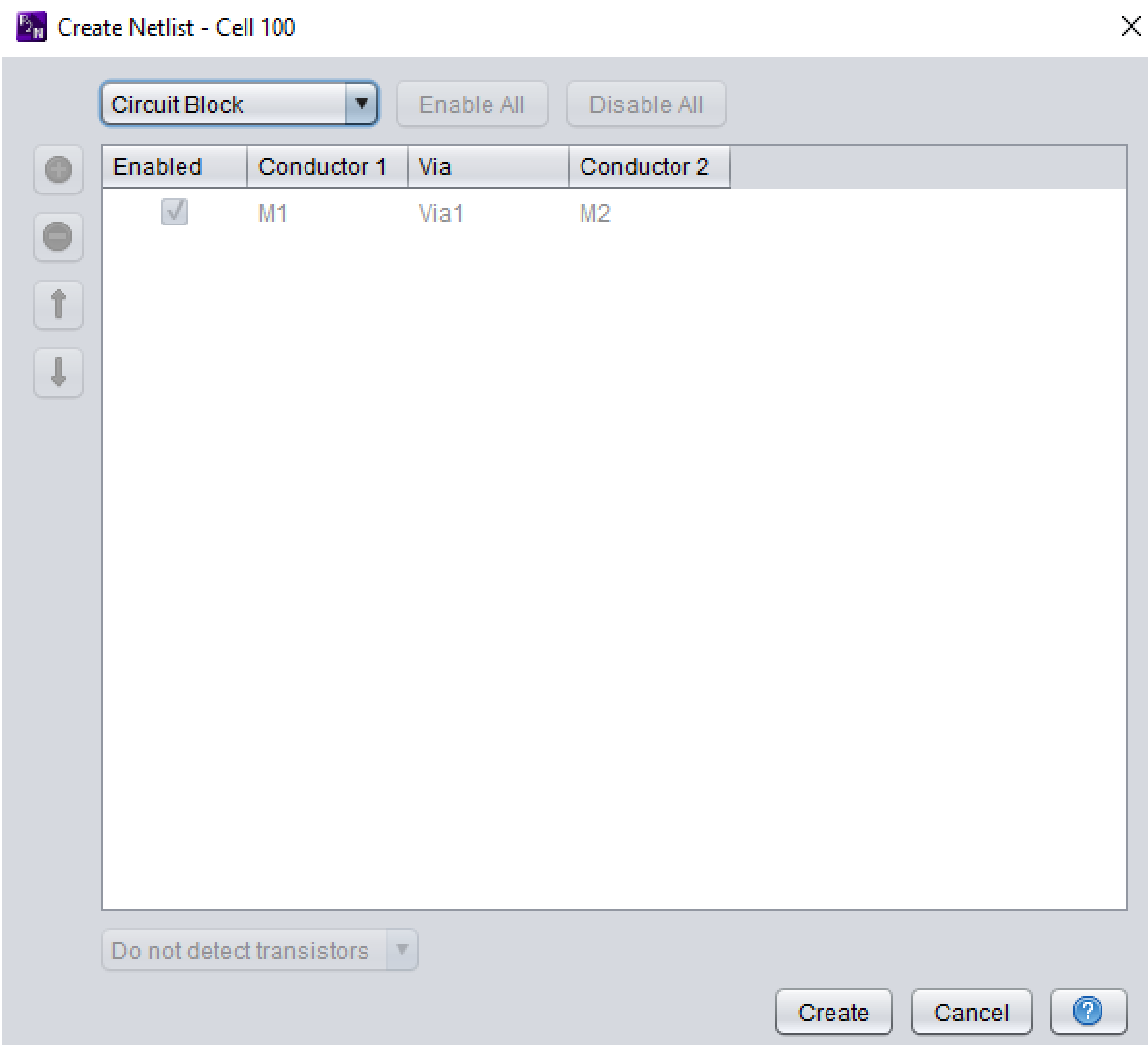
Select the cell to netlist. For selecting a cell see: *Project Cells Window*

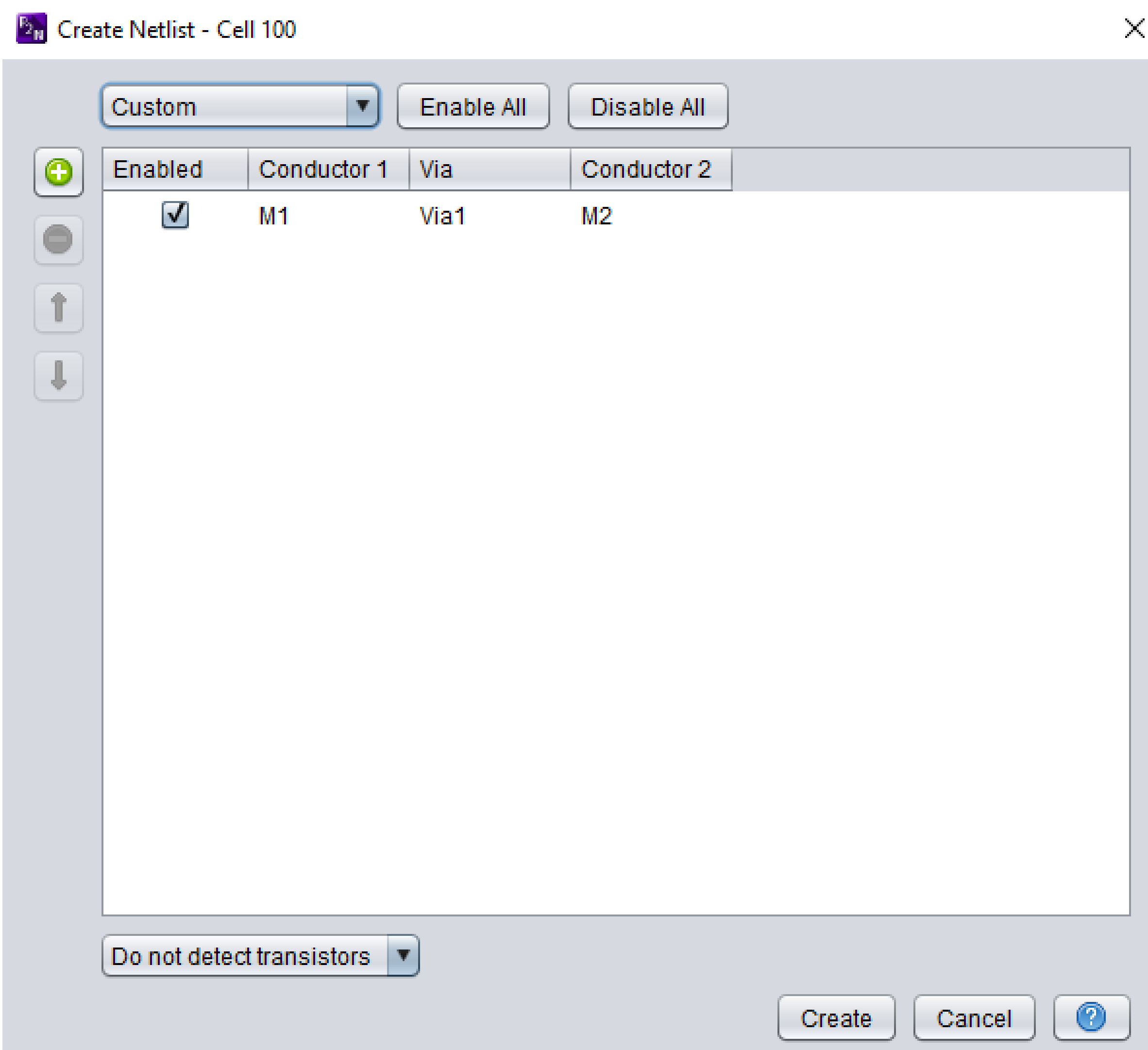
Before creating a netlist, generate the diffusion for the layer.

Click on the *Create Netlist* icon to define a cell as a *Library Cell*, a *Library Cell with Bulk*, a *Circuit Block*, or a *Custom* cell.




Create Netlist - Cell 100
Library Cell with Bulk
Enable All
Disable All
Enabled
Conductor 1
Via
Conductor 2
M1
Via1
M2
Poly
Contact
M1
Active
Contact
M1
P WELL
M1
M1
Detect transistors w/bulk
Create
Cancel


Create Netlist - Cell 100
Circuit Block
Enable All
Disable All
Enabled
Conductor 1
Via
Conductor 2
M1
Via1
M2
Do not detect transistors
Create
Cancel

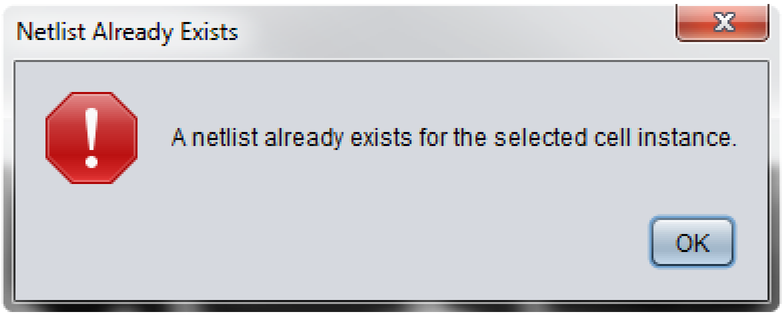


Select the desired type. Typically diffusion and poly layers are only used in library cells and metal1 and above are used in larger cells that contain routing information.

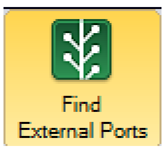
The newest feature, *Library Cell with Bulk* is for users that need to detect four transistors (rather than 3), and needs both the P-Well and N-Well defined in *Technology*. This is used for analog circuits; it will allow the user to create a netlist and view a schematic. Four transistor cells are not able to be simulated in Pix2Net, so the *Netlist Text* and *Identify Cell* will not work for this cell.

Each instance of each cell can have it's own netlist. Once the primary cell instance has been netlisted, the netlist command will run without asking for the layer connections. It will simply use the same layers selected for the primary instance.

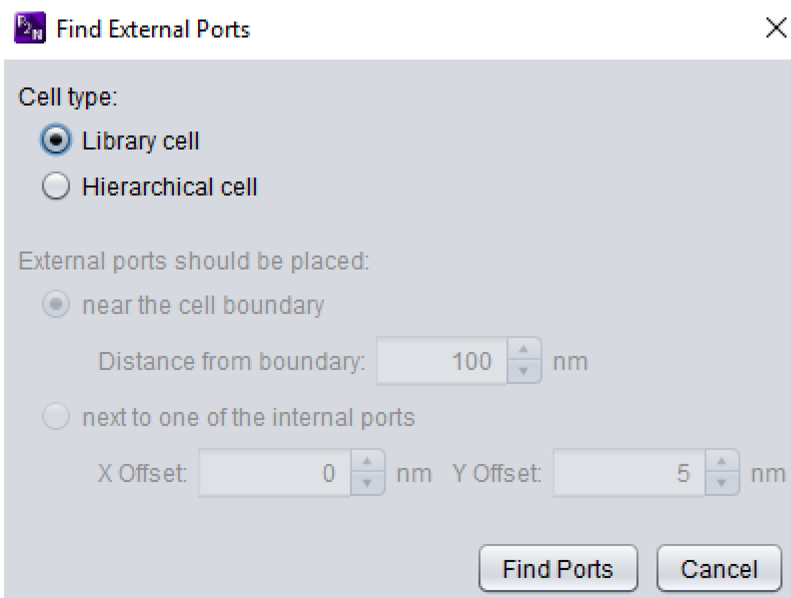
If the cell instance already has a netlist the following message will appear:



Find External Ports



Finding external ports will find all ports that enter or leave the selected cell. with the exception of the top cell.



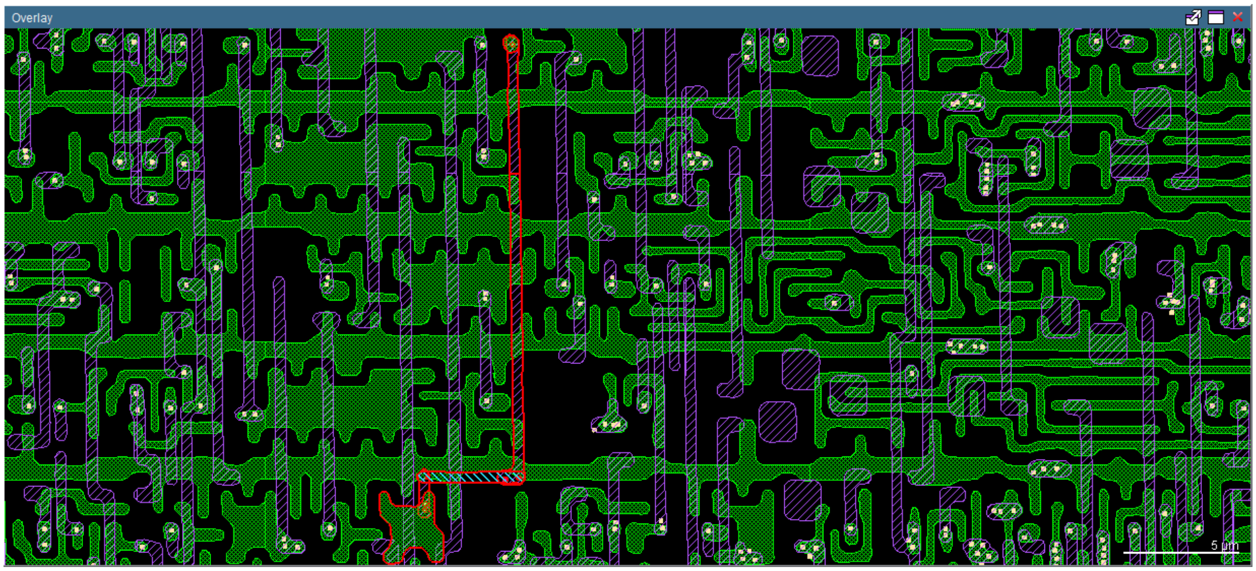
Options for placing the ports are listed in the *Find External Ports* window.

Find External Ports

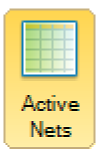
Select Net

When highlighted, the select net tool will highlight a net in the active netlist. Click on the polygon in the overlay window to highlight nets in red.

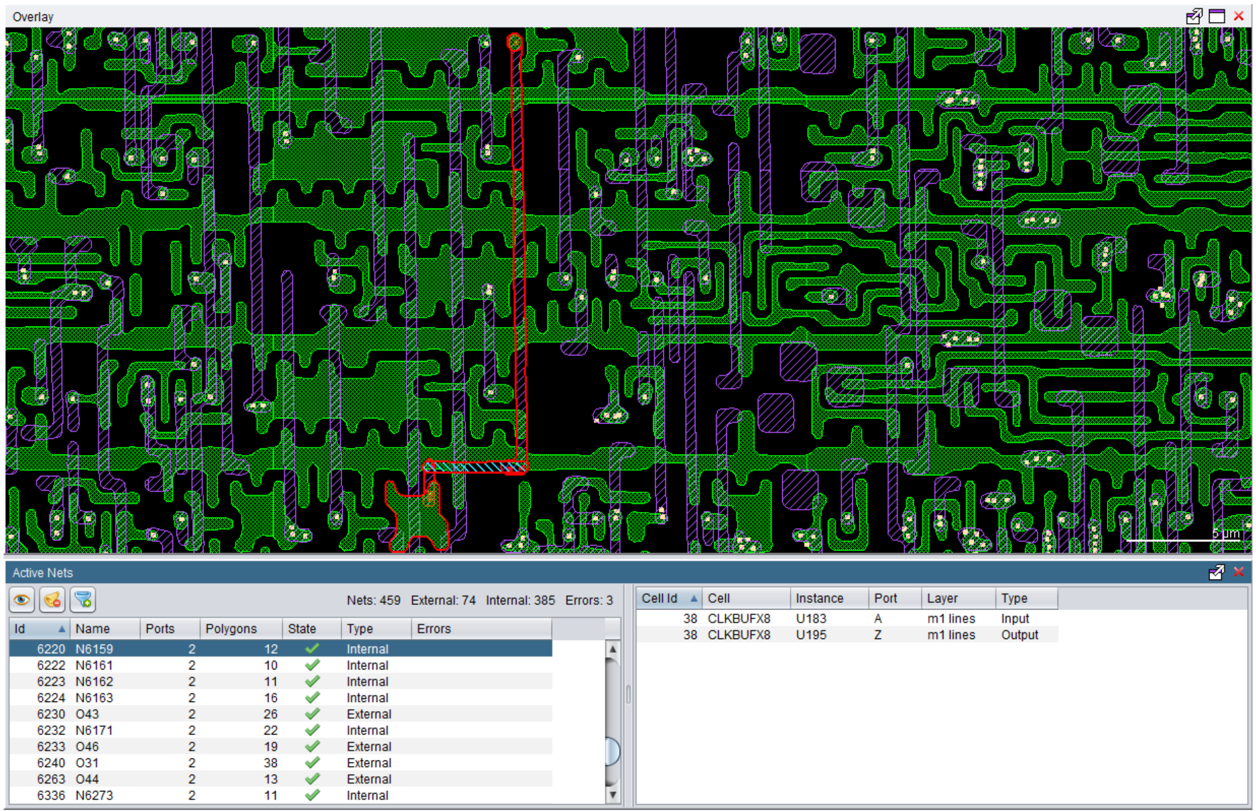
To change the default color see *selected net* in *Preferences*



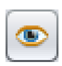
Active Nets

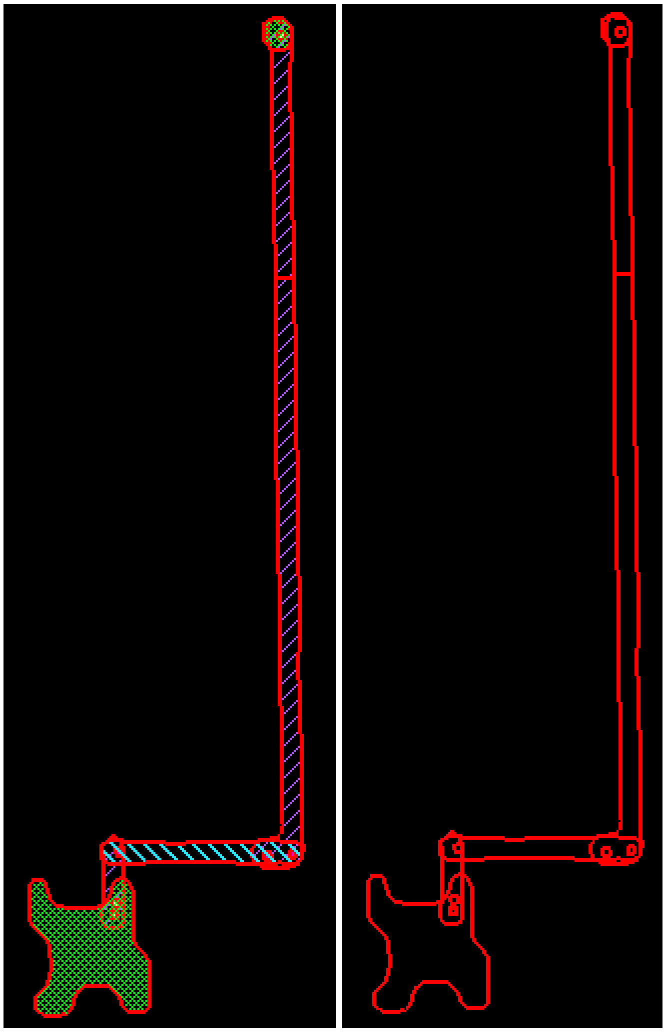


When highlighted, the *Active Nets* window is open. It will be a tab under the overlay.



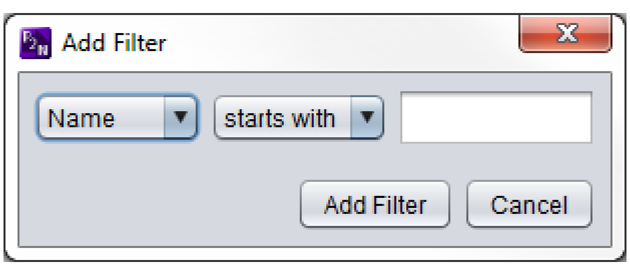
Nets highlighted in the overlay will be selected in the *Active Nets* netlist. The left pane of the *Active Nets* window contains the net id, name, number of ports, number of polygons, error state, net type, and errors. The right pane of the *Active Nets* window lists all of the ports and cell information connected to the highlighted net.

The outline mode icon  controls the selected net outline mode. Default is to show the net with the layers filled in. When depressed, only the selected net outline is shown.



The ignore errors icon  ignores any errors on the selected net. The purpose is to give the user a marker for nets visited that have false errors being reported.

The add filter icon  filters out the nets by column and parameters set in the window:



The left window contains the list of nets. Here are the columns:

- Net: The name of the net.
- Ports: The number of ports in the net.
- Polygons: The number of polygons in the net.
- State: A green checkmark indicates no errors. A red x indicates at least one error.

- Error: A short description of the net's error.

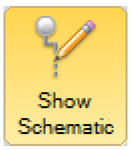
If you click on a row, then the camera will zoom to the net and highlight it, and the right window will show the details of the selected net.

The right window contains the list of ports for the currently selected net. Here are the columns:

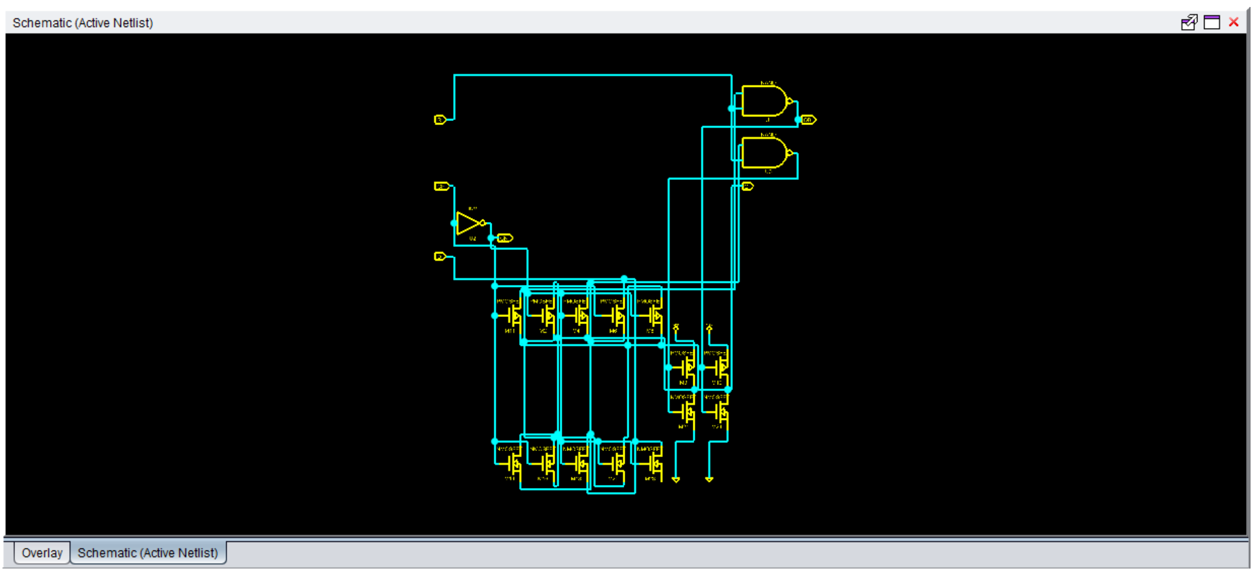
- Cell Number: The number of the port's cell.
- Cell: The name of the port's cell.
- Instance: The name of the port's instance.
- Port: The name of the port.
- Type: The port type: Input, Output, Inout, VSS, or VDD.

If you click on the right column, then the camera will zoom to that particular port.

Show Schematic



Brings up a window that shows the schematic for the active netlist. The window will open as a tab in the overlay.

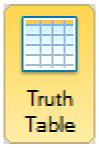


When viewing a schematic in manual layout mode, the user can use the "select" tool in the "schematic" ribbon tab to select some number of schematic cells. The user may then right-click on the schematic window and choose "move components to new block." This will replace the selected schematic cells with a newly created hierarchical block. All of the nets connected to the old schematic cells will route to the new block, and you can double-click on the block to enter it and see the cells that it now contains.

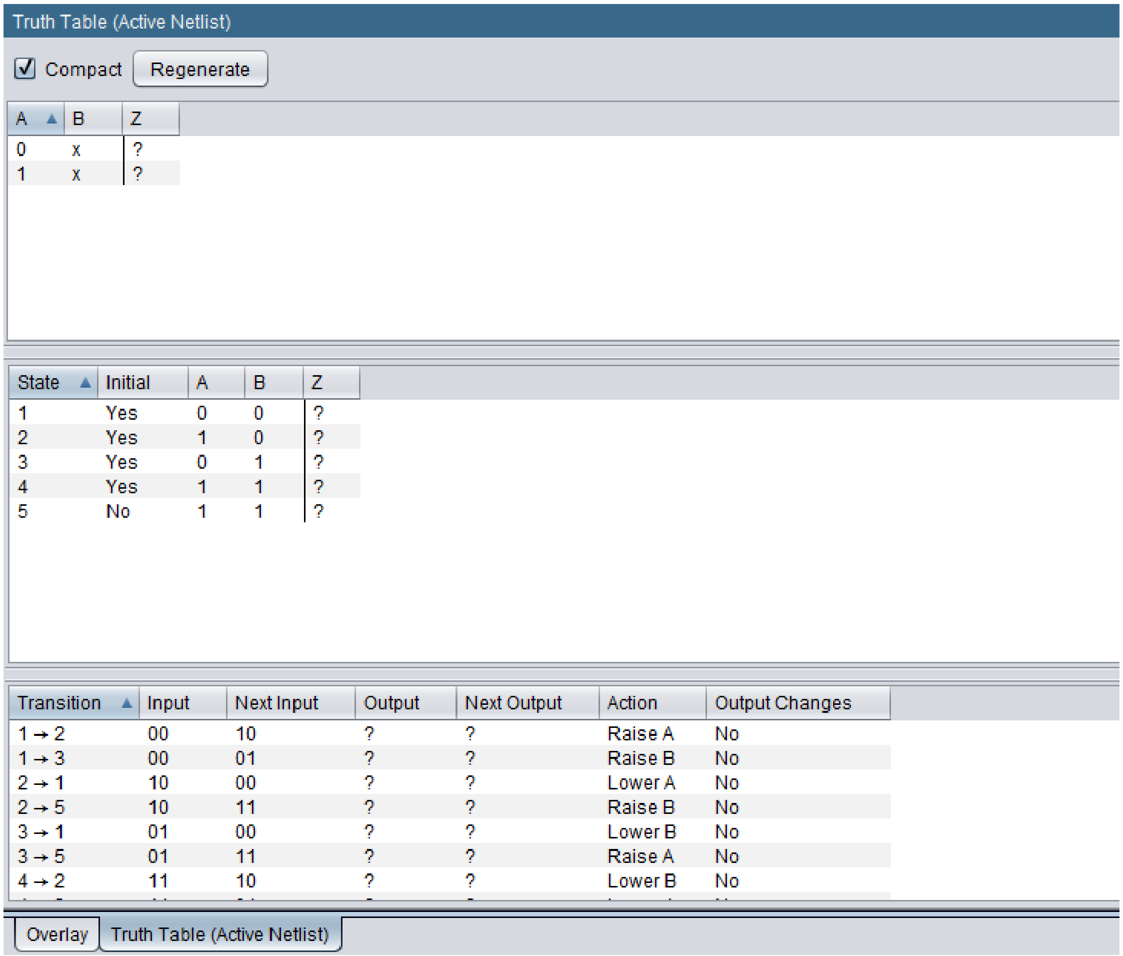
Note

The user can only show the schematic if synchronize mode is off.

Truth Table

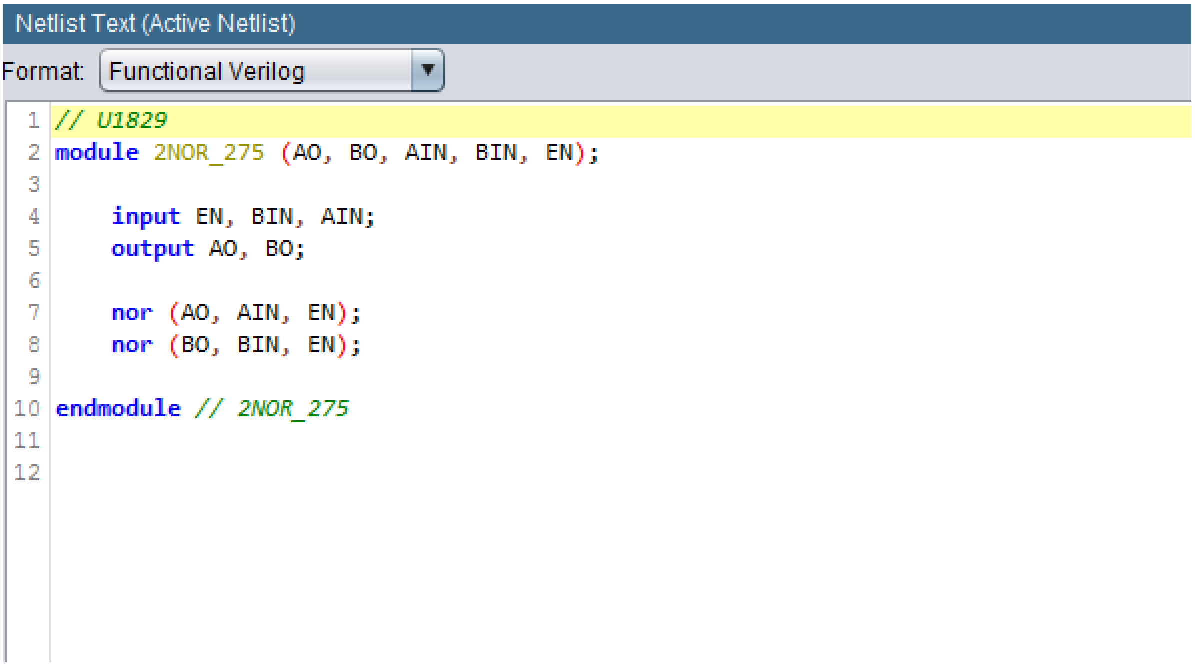


The *Truth Table* is the automatically created truth table of the circuit.



Netlist Text

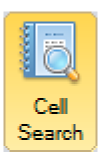
This shows the user the functional verilog, component verilog, H functional verilog, spice, VHDL, and comma-separated values for the active netlist.



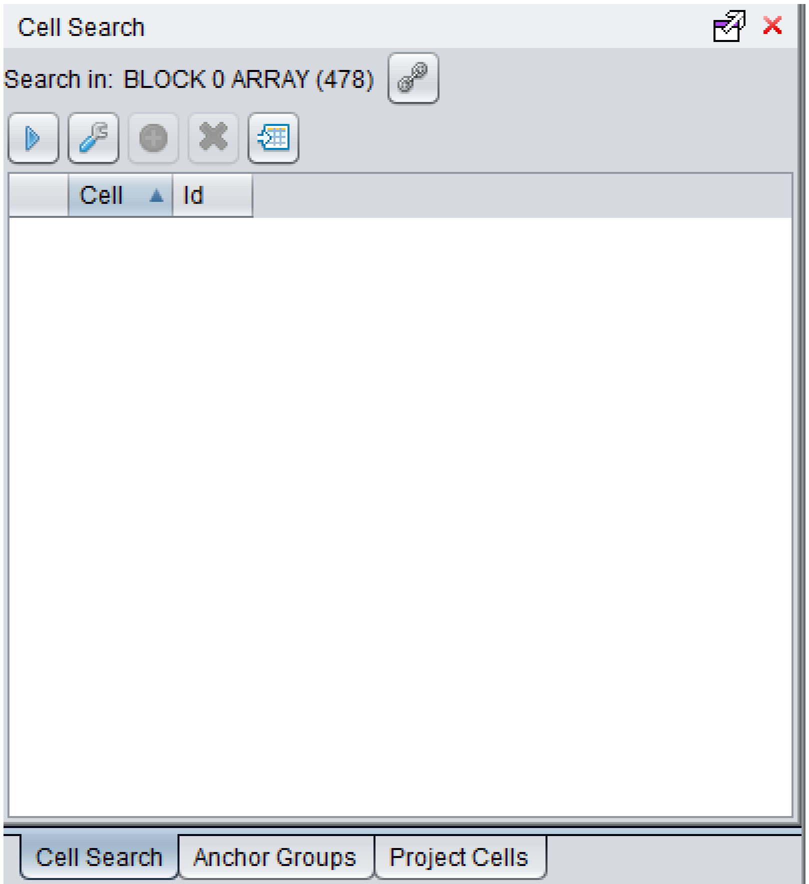
Identify Cell

Once a cell has been placed, its netlist has been created, and its external ports have been found, the user can press `Identify Cell` and Pix2Net will figure out what type of cell it is. For more information on how to add a cell to a netlist and identifying it, please see: *Adding a Cell*

Cell Search

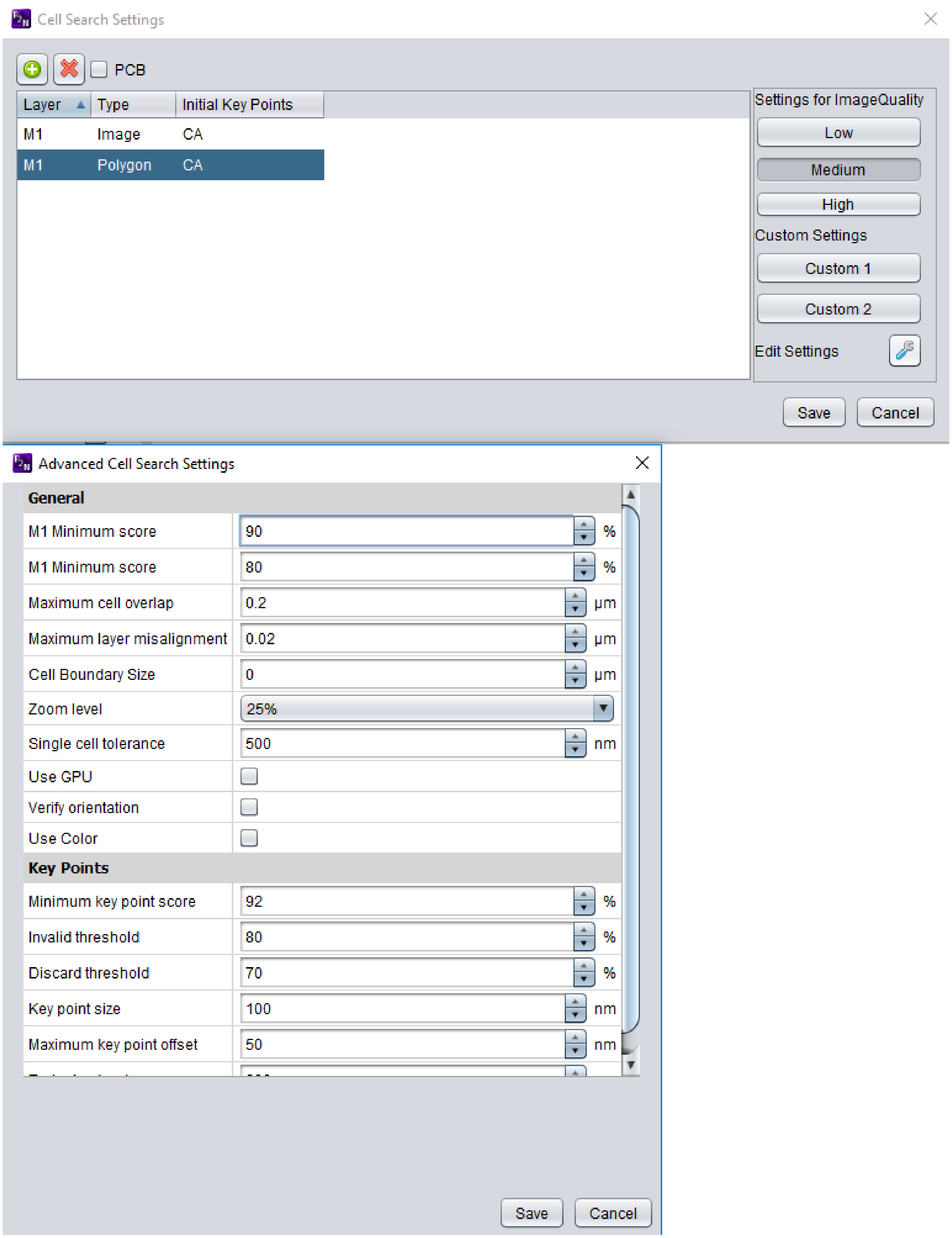


Opens the *Search Plans* tool window:



This window allows search plans to be added, deleted, modified or executed.

Pressing on the settings button will bring up the *Cell Search Settings* window:



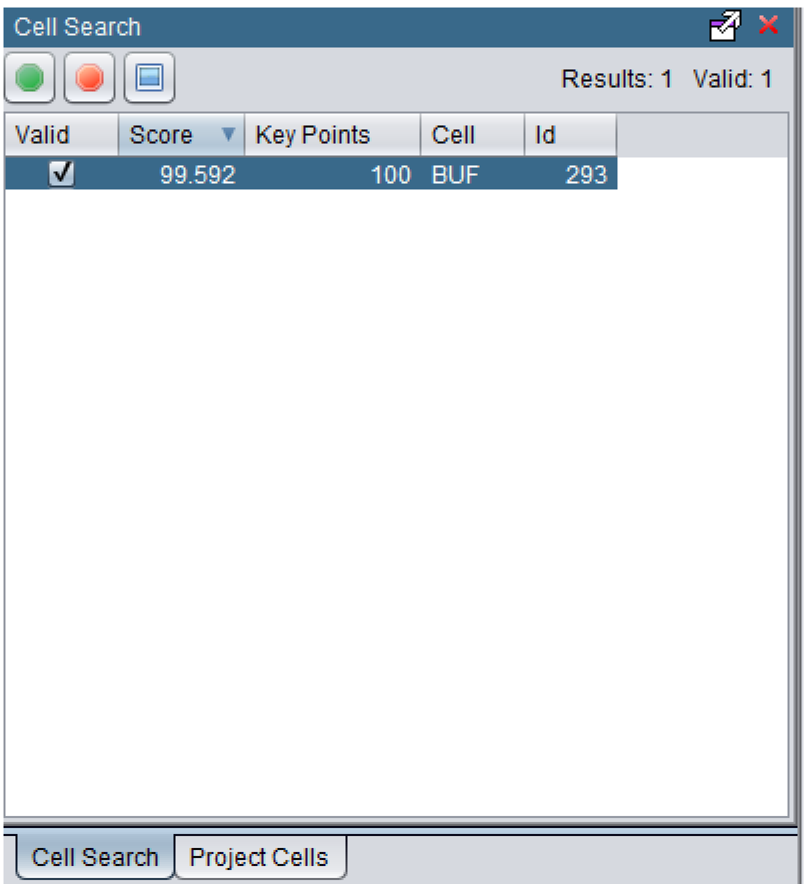
This allows the user to define the layer(s) that should be referenced while searching for similar cells, set settings for key points, as well as defining which layer should be used for setting key points. On the right side, There is an edit

settings button which will bring up the *Advanced Cell Search Settings* window, where the user can set various advanced settings for cell searches. Under settings for image quality, it can be set at low, medium, or high qualities for images (this will change the preset settings in the advanced settings). There is also a custom 1 and 2 setting so the user can customize the advanced settings if the preset settings are not satisfactory.

For more information on search plans see: *Performing a Cell Search* (Scroll to step #8 for more information over key points)

Single Cell Search

Draw a rectangular area that acts as the boundary for the selected search plan.



A pop-up will appear listing all cells in the selected search plan. Please see *Performing a Cell Search* for a detailed tutorial on searching for cells.

Area Search

Area Search searches for potentially multiple placements for each cell in your search plan, all within the area you draw. This is different from Single Cell Searches because it allows the user to look for more than one cell.

Select Key Points

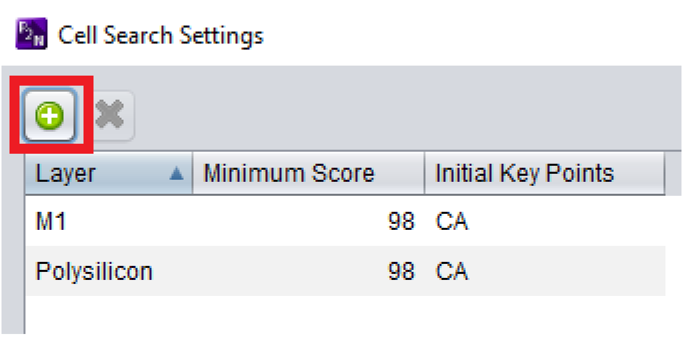
Allows the user to select key points within a search cell to delete incorrectly placed key points.

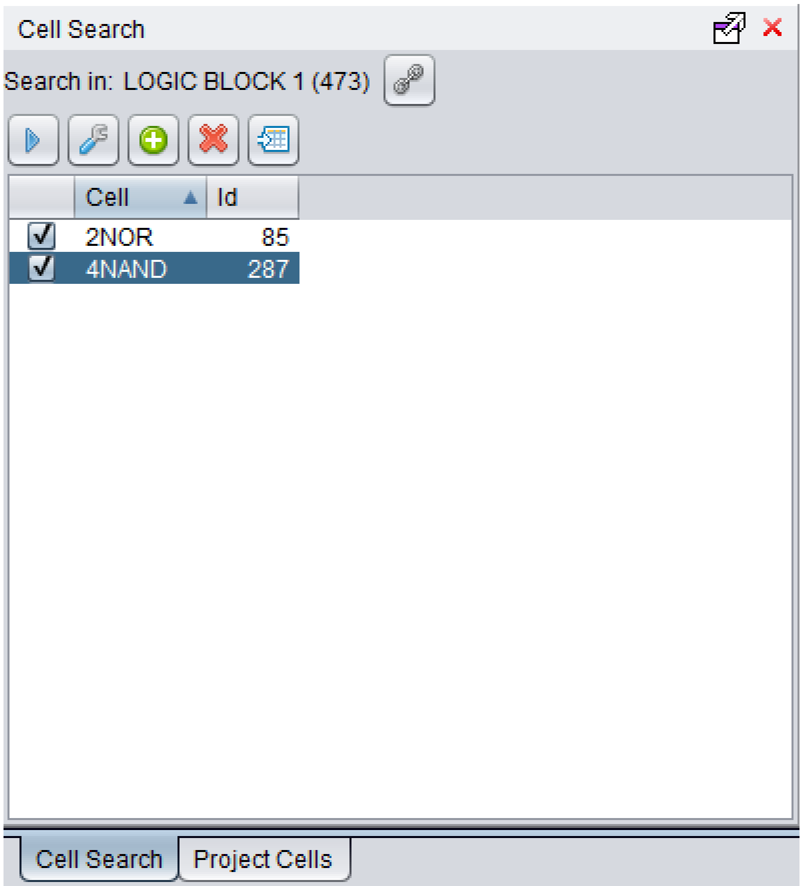
Add Key Point

Before adding key points

When doing a cell search, the user can add Key Points to tell Pix2Net to look for selected specific points when searching for cells. In order to see key points, the user needs to have the "Cell Search" window open, and have one of the cells selected in the list. (Double-clicking on that cell in the `Cell Search` window will take the user to the correct place in the overlay.) Finally, the image layer that the key points were added to must be visible. If the key points are not showing up, then the most likely causes are that the cell is not selected in the "Cell Search" window, or the image layer the key points were added to is not visible.

To see key points, make sure that the cell is highlighted in the ''Cell Search'' window, key points are defined in the settings of the ''Cell Search'', and the image layer is turned on.

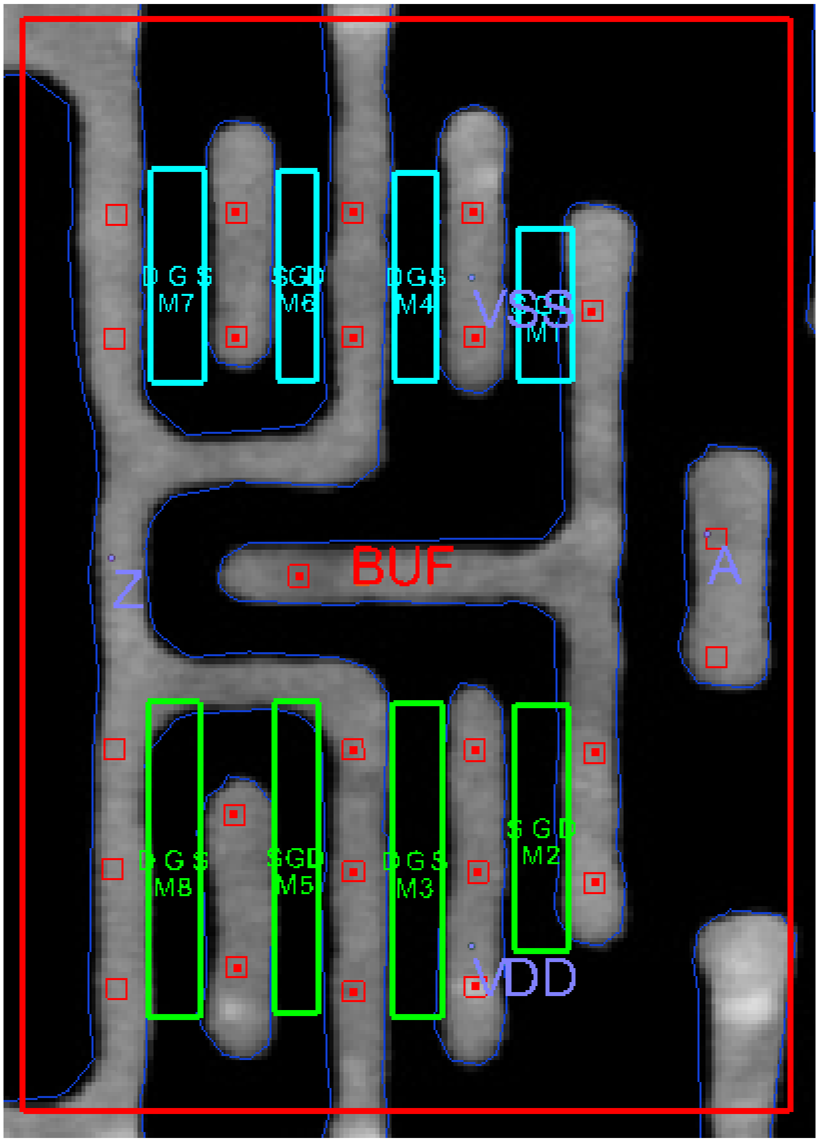




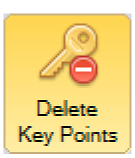
For more information, please reference: *Performing a Cell Search*

Manual Placement – The user can use the "select key points," "add key point," and "delete key points" tools in the "cells" tab of the ribbon interface to manually manage key points within a selected cell which has been placed in a search plan. These tools operate on the main overlay window, and allow you to define the important regions of a cell image. For a tutorial on adding key points manually, please see: *Adding Key Points Manually*

Automatic Placement – If the user finds that placing a key point on every via yields good results, the user can instruct Pix2Net to do this step (we recommend the automatic placement over manually placing key points). When defining the cell search settings, define one or more image layers to use in the comparison. At this time, the user may also specify a polygon layer with the "initial key points" setting. If the user has specified an initial key point layer, then whenever a cell is added to the search plan, that cell will automatically be populated with key points according to the initial key points layer. For each polygon on the initial key point layer which is within the cell bounds, a key point will be placed at that polygon's centroid. For example, if we create a search plan to search on M1 images, and set the initial key point layer to Contact polygons, we will automatically get a key point at the center of each contact. To see the key points, make sure the image layer is on. Here is an example of a cell on the M1 layer using Contacts as key points (the small dots within the red squares are the key points).

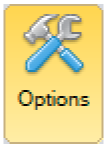


Delete Key Points

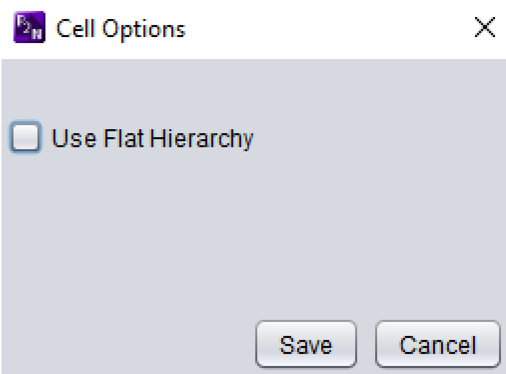


Once a key point or points are selected, clicking this will delete the key point(s) (or press the delete key).

Options



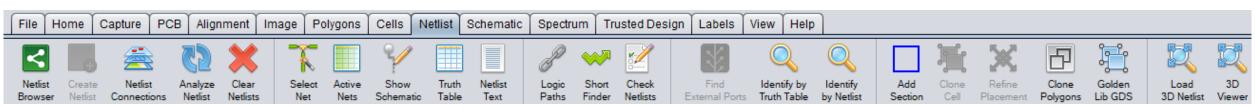
Brings up the Cell Options window.



Allows the user to switch on and off the following options: to show ports in modules, to show cell boundaries in modules, and to tell Pix2net to use a flat hierarchy.

Netlist Tab

The *Netlist* tab creates and manages netlists for all cells.

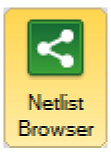


The following tools are available in the *Netlist* tab:

- *Netlist Browser*
- *Create Netlist*
- *Netlist Connections*
- *Analyze Netlist*
- *Clear Netlists*
- *Select Net*
- *Active Nets*
- *Show Schematic*
- *Truth Table*
- *Netlist Text*
- *Logic Paths*
- *Short Finder*
- *Check Netlists*

- *Find External Ports*
- *Identify by Truth Table*
- *Identify by Netlist*
- *Add Section*
- *Clone Cell*
- *Refine Placement*
- *Clone Polygons*
- *Golden Lib GDS*
- *Load 3D Netlist*
- *3D Viewer*

Netlist Browser

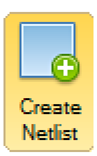


Brings up a window to show the user all the cells within the netlist. If a cell is double-clicked, the user is brought to the cell in the overlay.


Netlist Browser

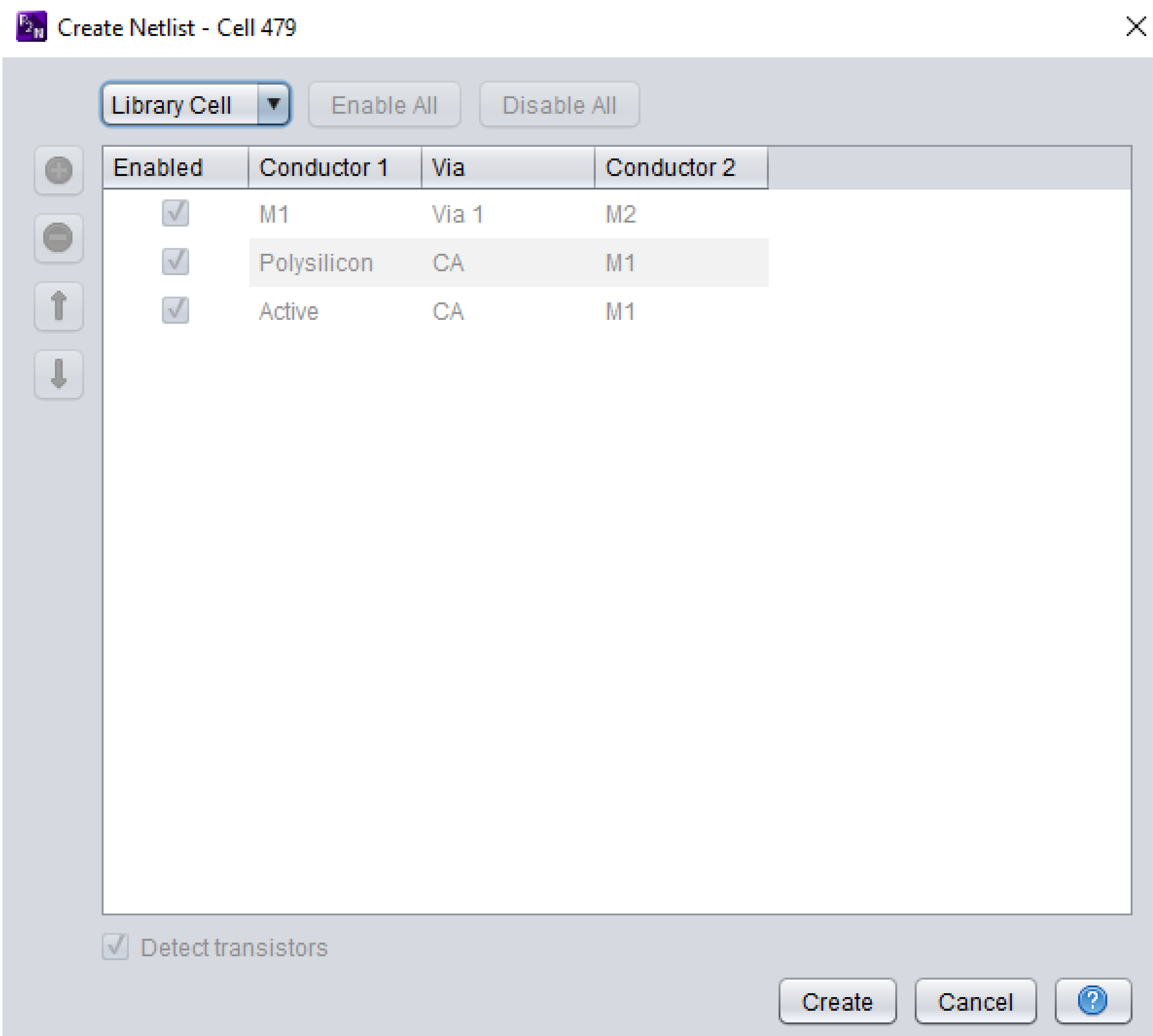
Cell Id	Cell	Primary	Location	Analyzing	Detect Transistors
1	TOP	Yes	0.000, 0.000	No	No
51	NOR2	Yes	45.178, -28.746	Yes	Yes
52	NOR2	Yes	42.435, -28.556	Yes	Yes
53	Dig Block 1	Yes	-0.941, -95.133	Yes	No
54	INV	Yes	47.569, -34.225	Yes	Yes
55	NOR2	Yes	40.264, -28.409	Yes	Yes
56	NAND3	Yes	34.074, -28.580	Yes	Yes
57	AND2	Yes	33.956, -31.583	Yes	Yes
58	NAND2	Yes	39.301, -31.340	Yes	Yes
60	LOGIC1	Yes	33.548, -37.172	Yes	No
61	DFF	Yes	86.620, -65.555	Yes	Yes

Create Netlist



Select the cell to netlist. For selecting a cell see: *Project Cells Window*

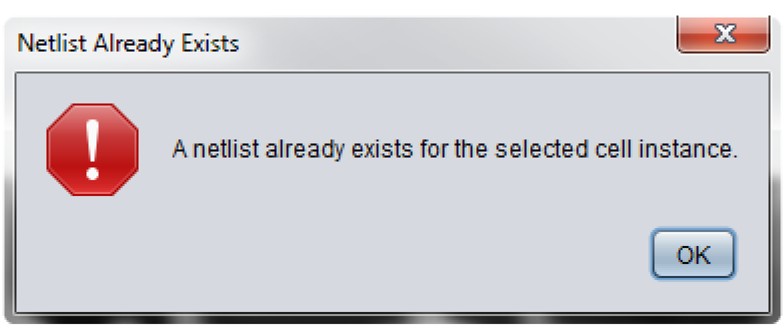
Click on the *Create Netlist* icon to bring up the window:



Select the desired layers. Typically diffusion and poly layers are only used in library cells and metal1 and above are used in larger cells that contain routing information.

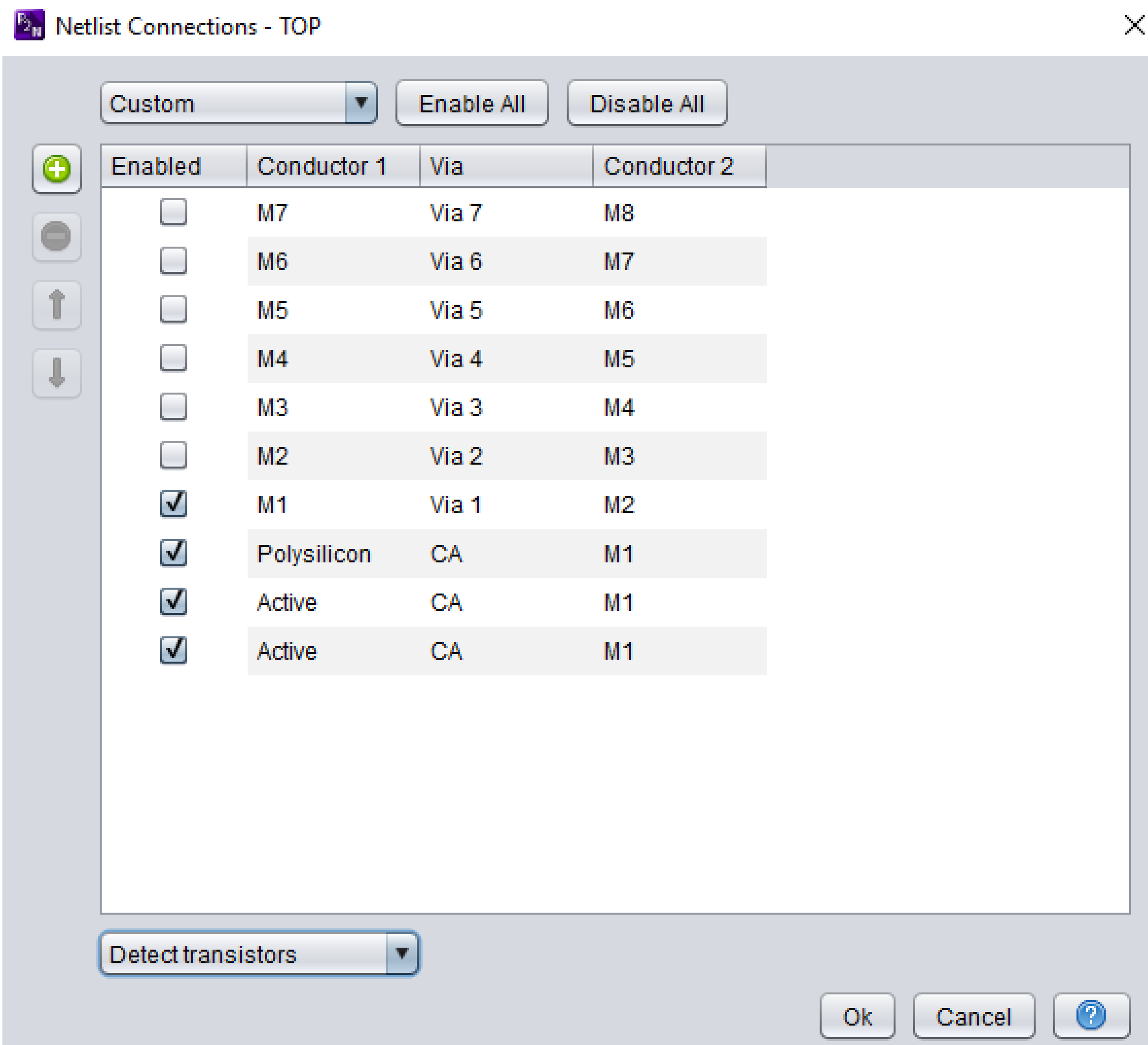
Each instance of each cell can have it's own netlist. Once the primary cell instance has been netlisted, the netlist command will run without asking for the layer connections. It will simply use the same layers selected for the primary instance.

If the cell instance already has a netlist the following message will appear:

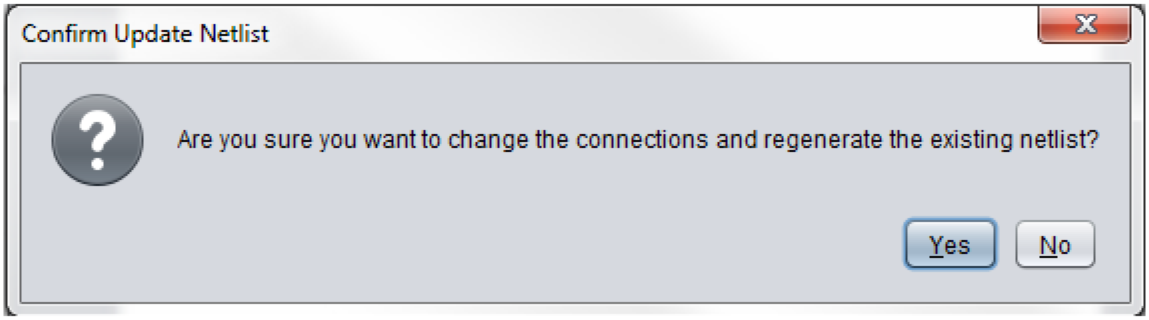


Netlist Connections

Defines the connections in a netlist. The connections can be updated for the active netlist from here. Choose between custom, library cell, or circuit block netlist connections, as well as telling Pix2Net to detect transistors or not.



If updating a connection, a confirmation dialogue will appear.



For a brief description see: *Netlist Connectivity*

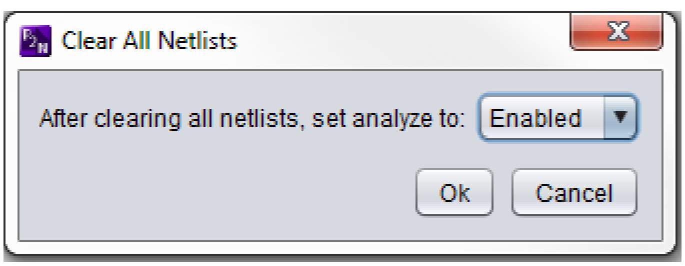
Analyze Netlist

When highlighted, the active netlist will be updated in real time. If the netlist is very large, it is recommended that *Analyze Netlist* is off while editing.

To view the netlist, click the *Active Nets* icon.

Clear Netlists

Clears all netlists in the project.

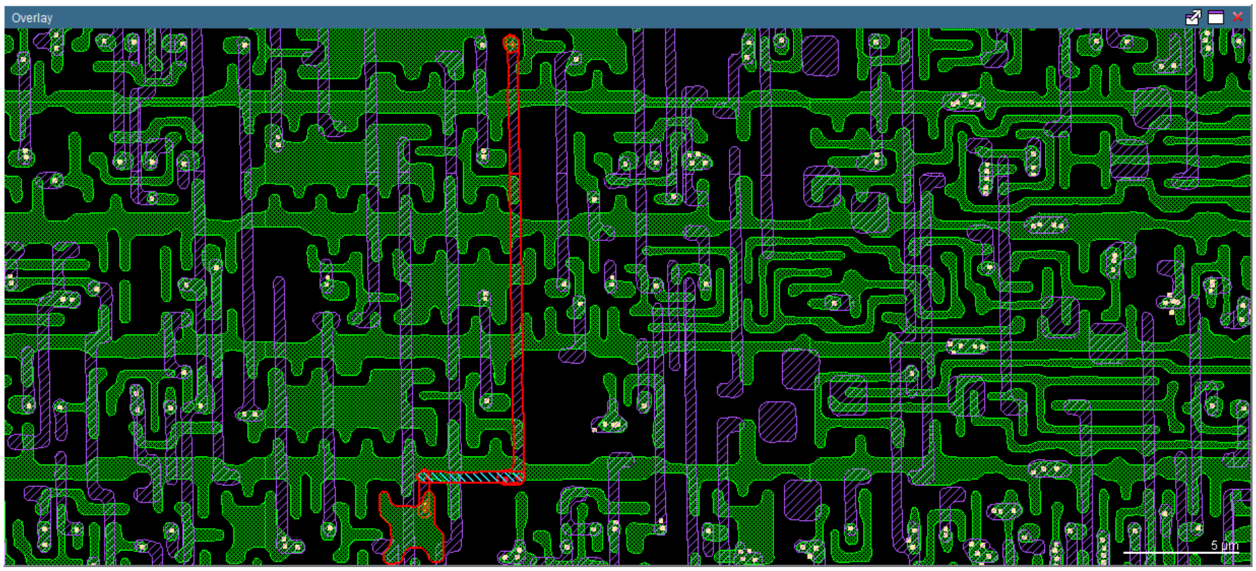


Set analyze to *Enabled* to re create all netlists. Set to *Disabled* to keep all netlists empty.

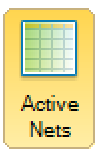
Select Net

When highlighted, the select net tool will highlight a net in the active netlist. Click on the polygon in the overlay window to highlight nets in red.

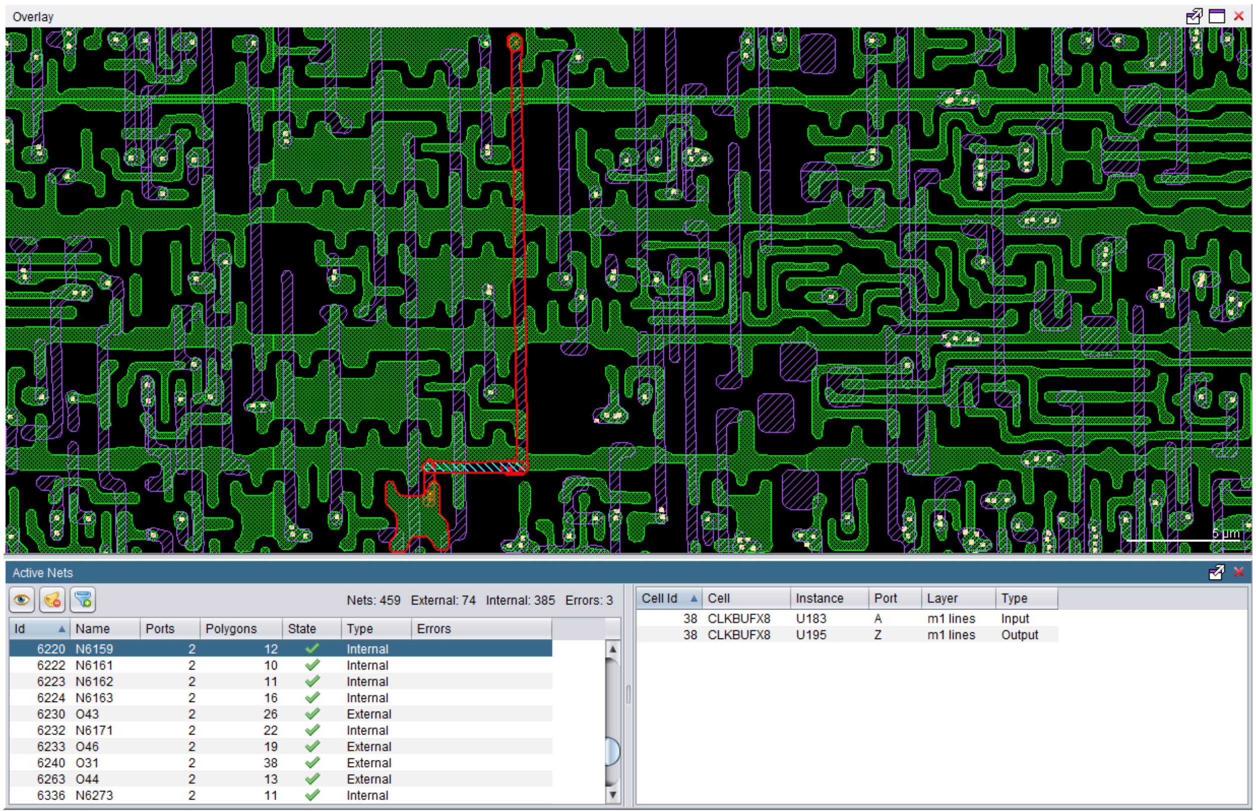
To change the default color see *selected net* in *Preferences*



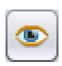
Active Nets

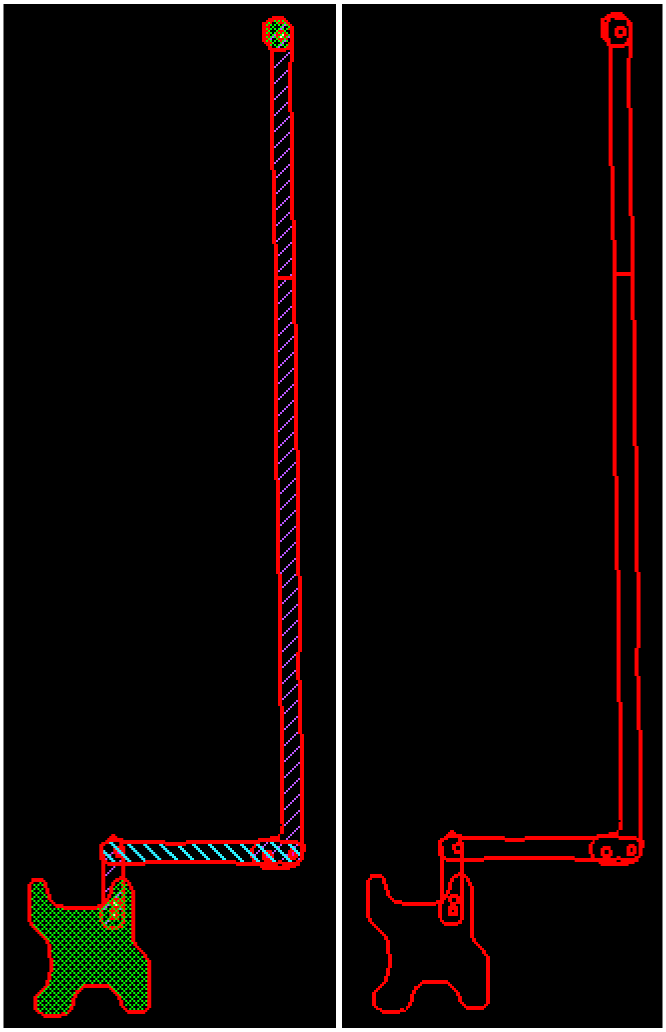


When highlighted, the *Active Nets* window is open. It will be a tab under the overlay.



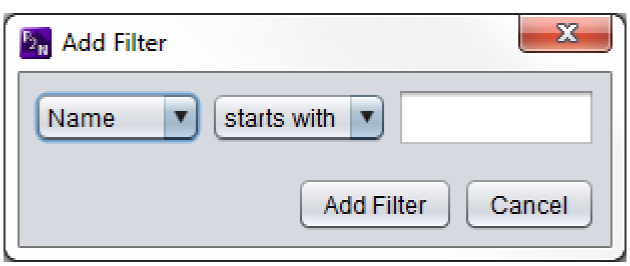
Nets highlighted in the overlay will be selected in the *Active Nets* netlist. The left pane of the *Active Nets* window contains the net id, name, number of ports, number of polygons, error state, net type, and errors. The right pane of the *Active Nets* window lists all of the ports and cell information connected to the highlighted net.

The outline mode icon  controls the selected net outline mode. Default is to show the net with the layers filled in. When depressed, only the selected net outline is shown.



The ignore errors icon  ignores any errors on the selected net. The purpose is to give the user a marker for nets visited that have false errors being reported.

The add filter icon  filters out the nets by column and parameters set in the window:



The left window contains the list of nets. Here are the columns:

- Net: The name of the net.
- Ports: The number of ports in the net.
- Polygons: The number of polygons in the net.
- State: A green checkmark indicates no errors. A red x indicates at least one error.

- Error: A short description of the net's error.

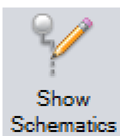
If you click on a row, then the camera will zoom to the net and highlight it, and the right window will show the details of the selected net.

The right window contains the list of ports for the currently selected net. Here are the columns:

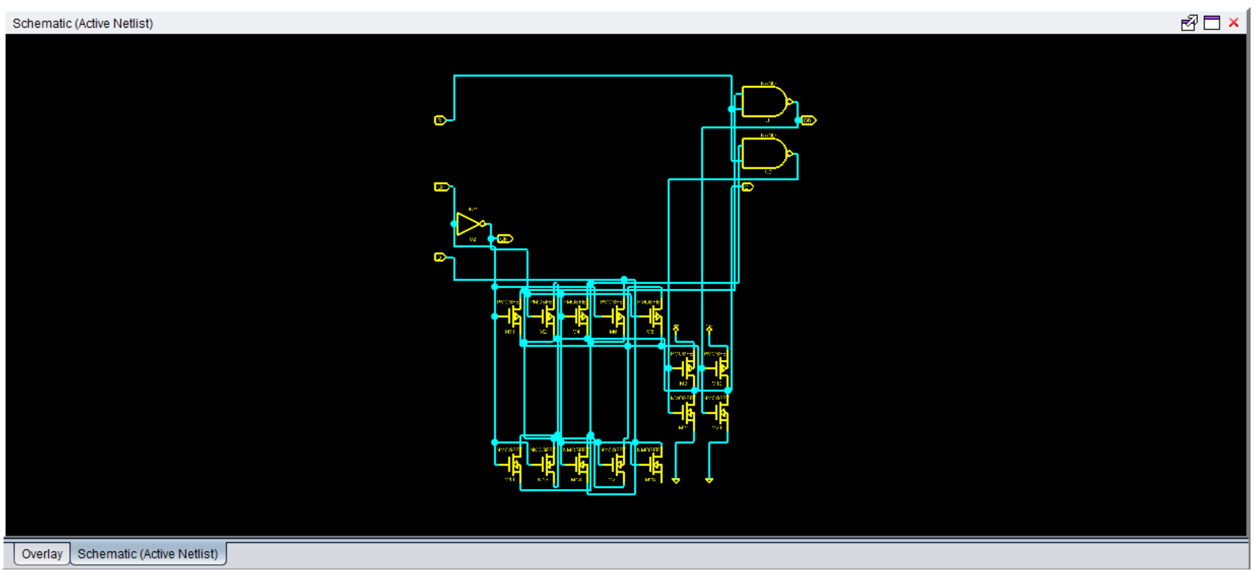
- Cell Number: The number of the port's cell.
- Cell: The name of the port's cell.
- Instance: The name of the port's instance.
- Port: The name of the port.
- Type: The port type: Input, Output, Inout, VSS, or VDD.

If you click on the right column, then the camera will zoom to that particular port.

Show Schematic



Brings up a window that shows the schematic for the active netlist. The window will open as a tab in the overlay.

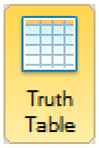


When viewing a schematic in manual layout mode, the user can use the "select" tool in the "schematic" ribbon tab to select some number of schematic cells. The user may then right-click on the schematic window and choose "move components to new block." This will replace the selected schematic cells with a newly created hierarchical block. All of the nets connected to the old schematic cells will route to the new block, and you can double-click on the block to enter it and see the cells that it now contains.

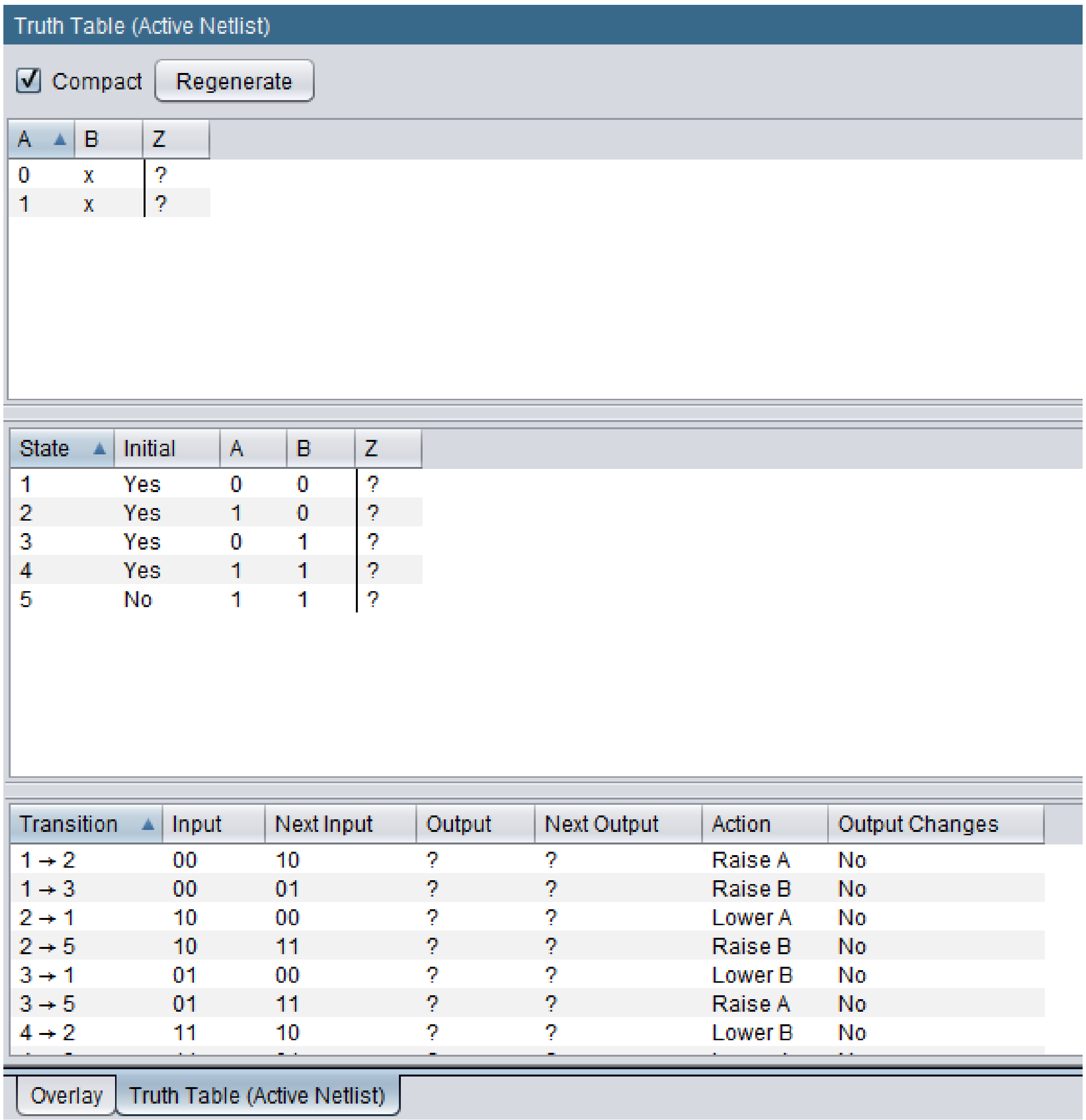
Note

The user can only show the schematic if synchronize mode is off.

Truth Table

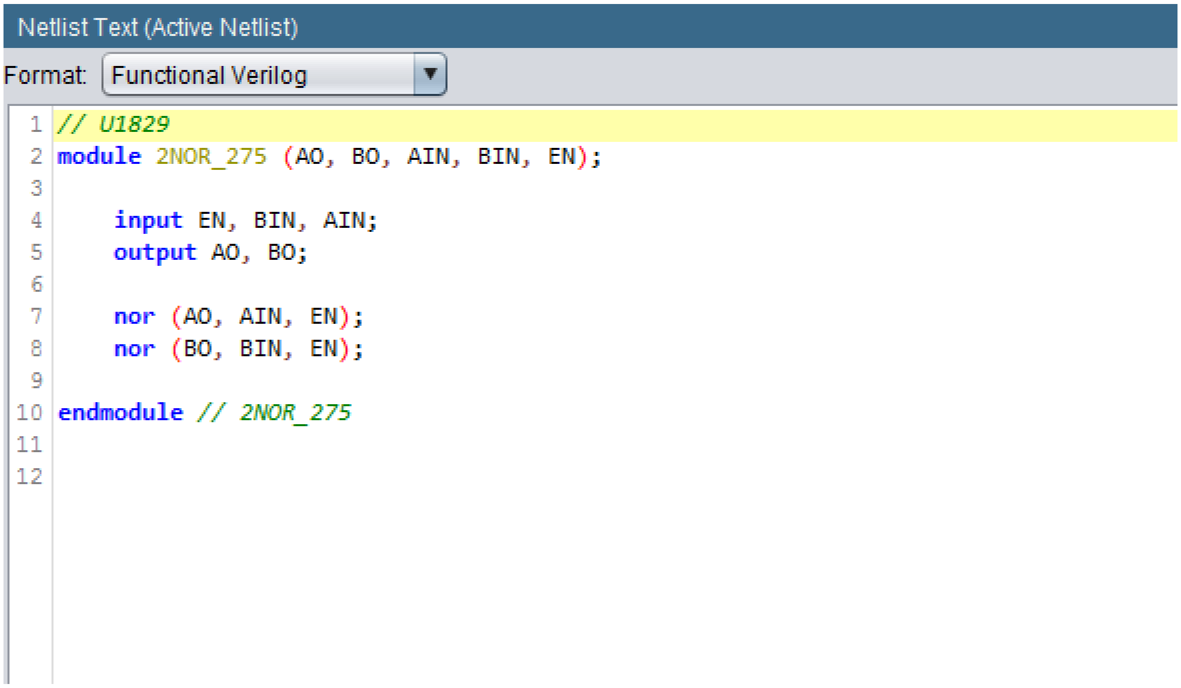


The *Truth Table* is the automatically created truth table of the circuit.



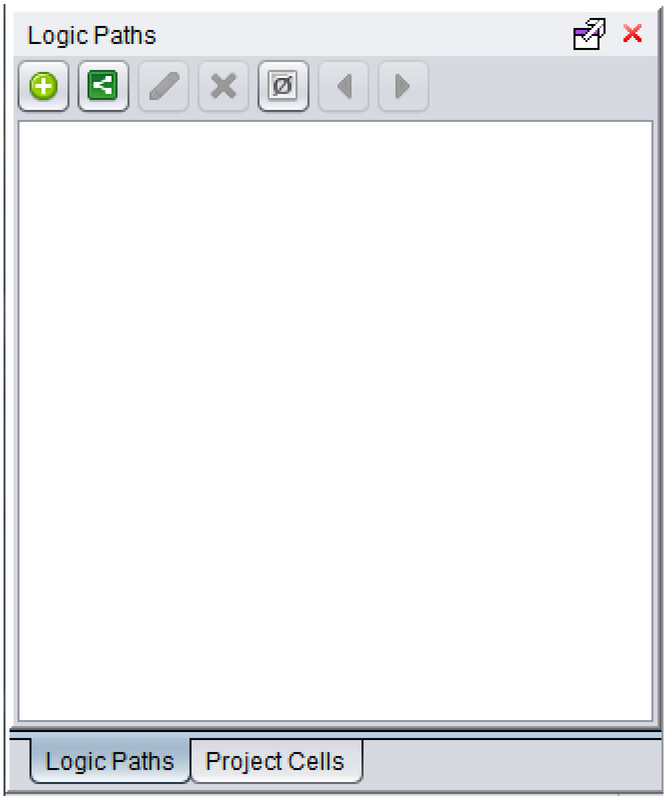
Netlist Text

This shows the user the functional verilog, component verilog, H functional verilog, spice, VHDL, and comma-separated values for the active netlist.

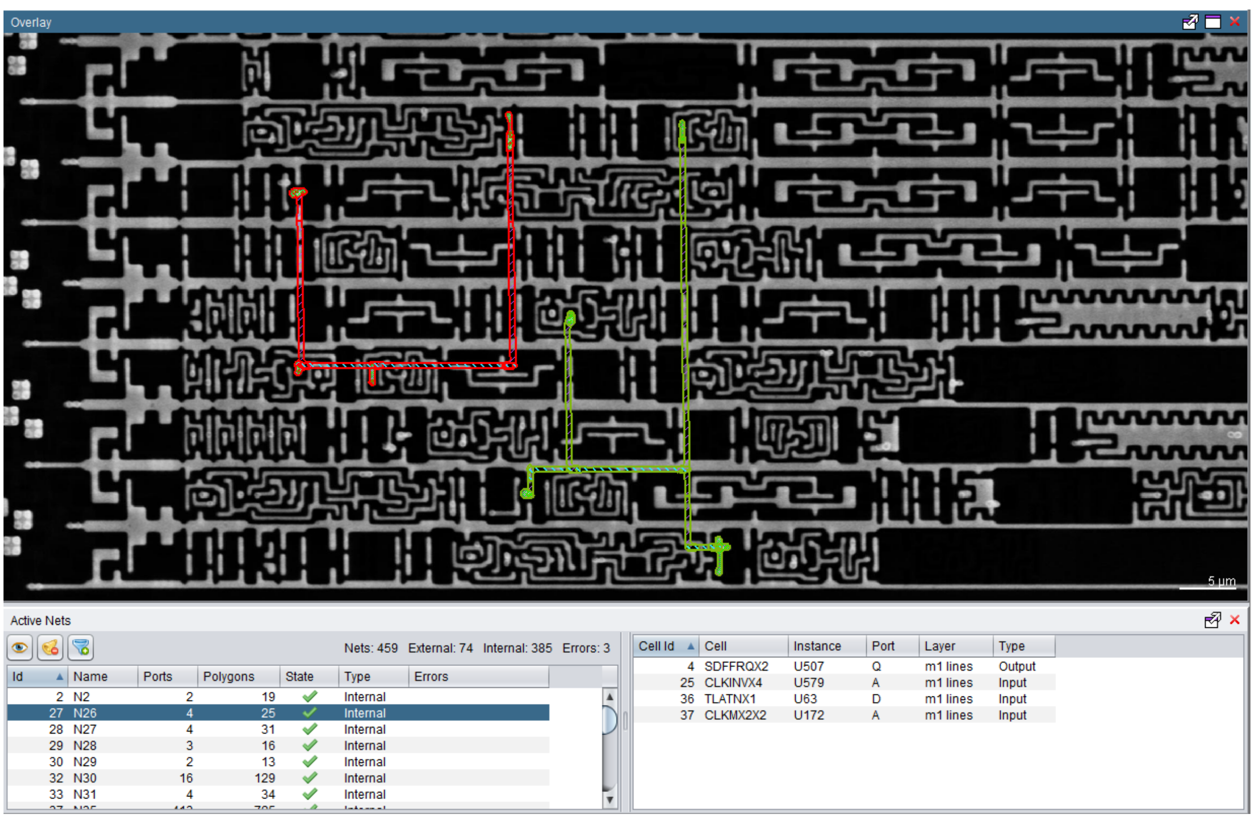


Logic Paths

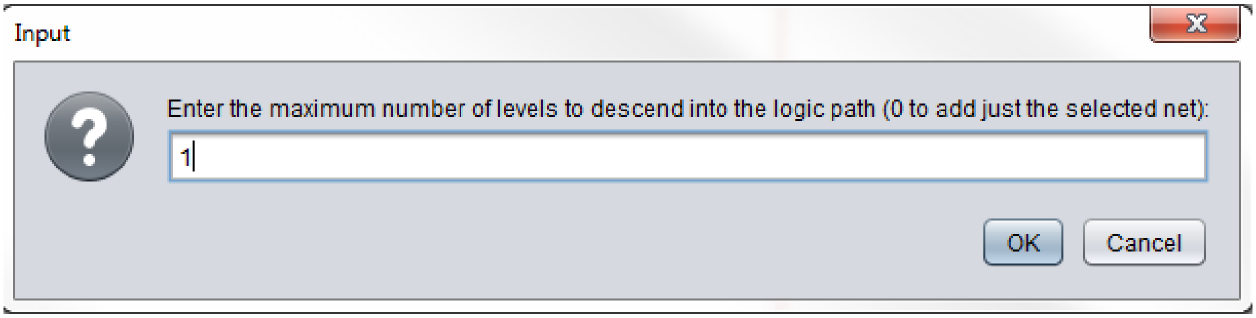
Opens the *Logic Paths* window (tab) in the lower left:



Click the plus sign to add highlighted nets to the *Logic Paths* list. The net will stay highlighted in the overlay in the desired color as long as the net is checked allowing the user to view multiple nets at a time.



click on the  to open the input dialogue. Setting increasing values allows the user to follow a signal through all of the cells it is an input to.

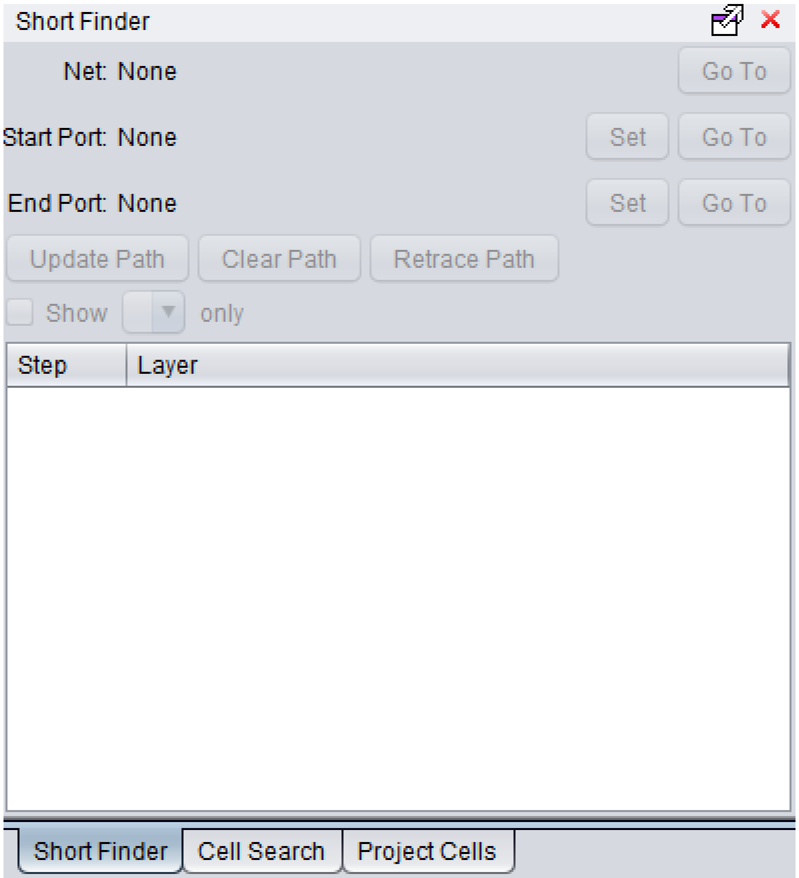


The green net is the original net, and the blue nets are the level 1 descendent nets.

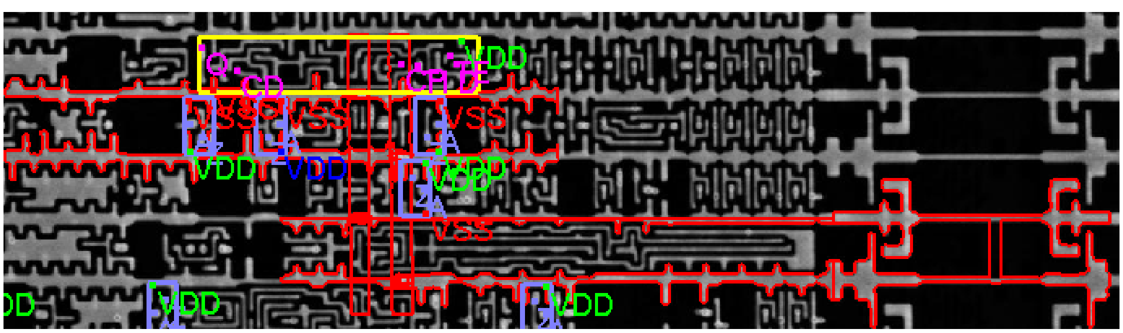
Note: The paths created will not be saved when you close Pix2Net.

Short Finder

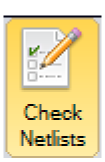
The shortfinder window opens in the lower left corner:



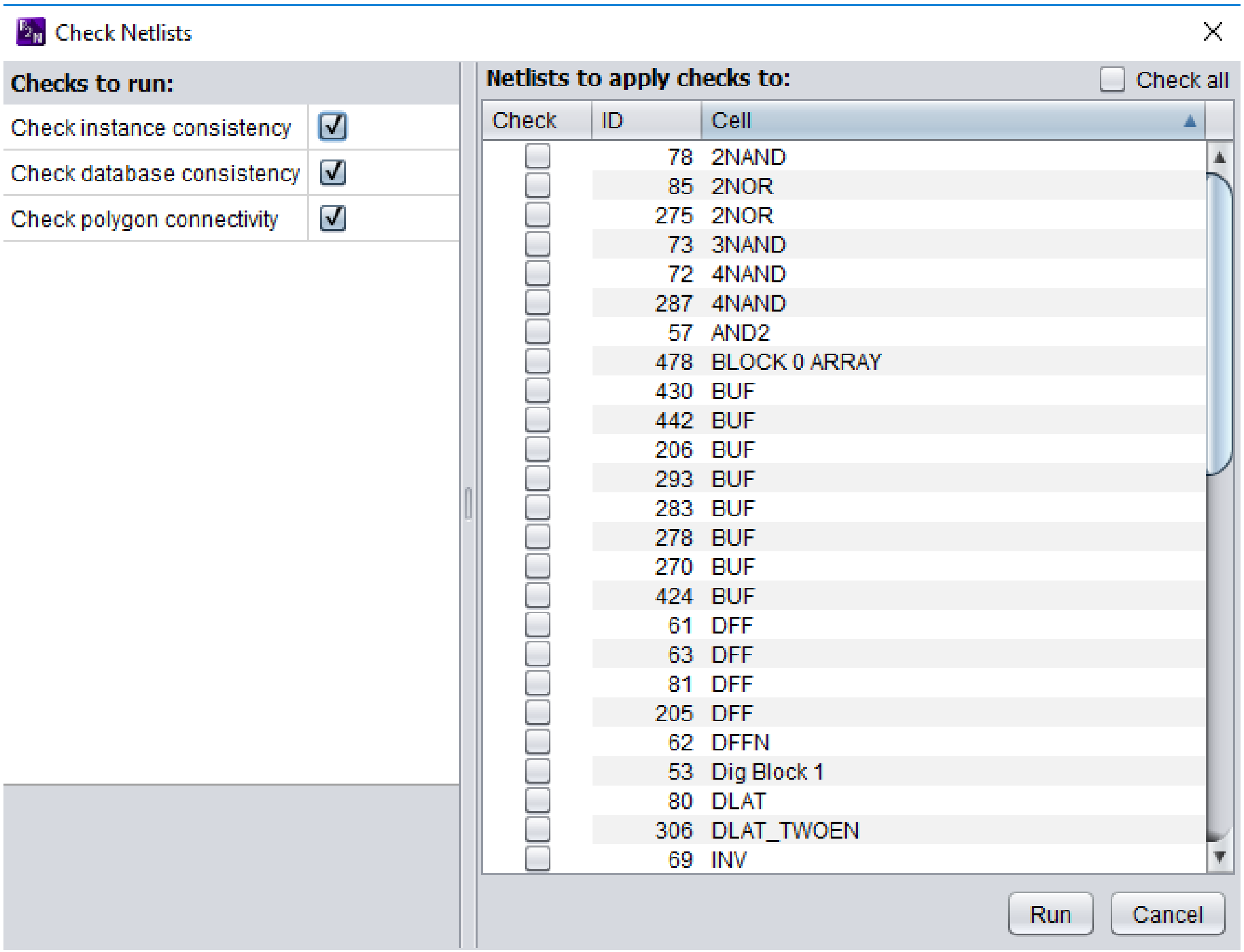
Select a port that is part of the short then click *set*. Select the second port and click *set*. Click *Update Path*. The shortest path between the 2 ports is highlighted.



Check Netlists



The following check netlist options are avaliable:



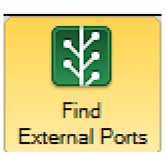
Check instance consistency verifies that the netlist of each instance of a cell matches the primary instance netlist. This will compare the instances of all checked cells in the right hand pane and will report a match to a different, checked cell if there is an inconsistency.

Check database consistency verifies that the netlist doesn't have any missing entries in the database that could cause problems or inconsistencies in the netlist. Run this periodically if database inconsistencies or corruption are suspected.

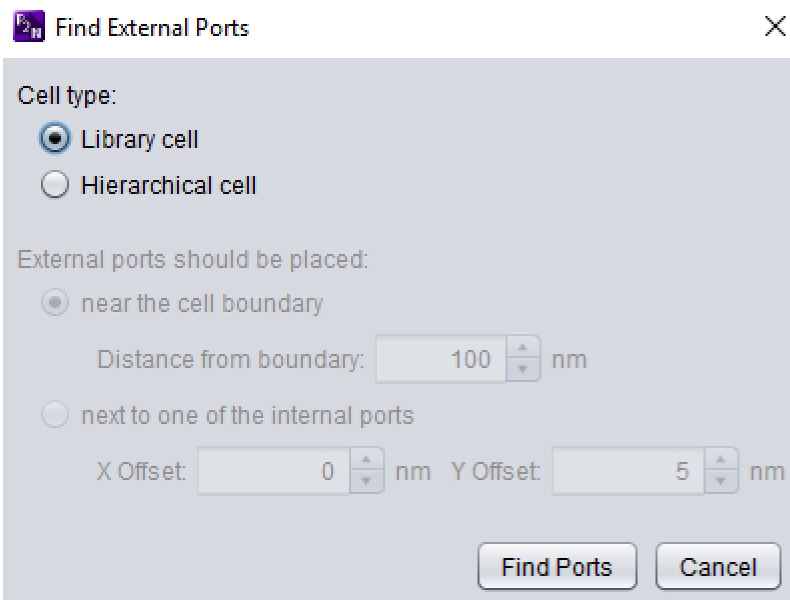
Check polygon connectivity verifies that the polygons are connected and can send energy from one layer to the next.

To access the reports created, got to the *View* tab and click on the *Reports* button. This will open the reports in the bottom of the GUI.

Find External Ports



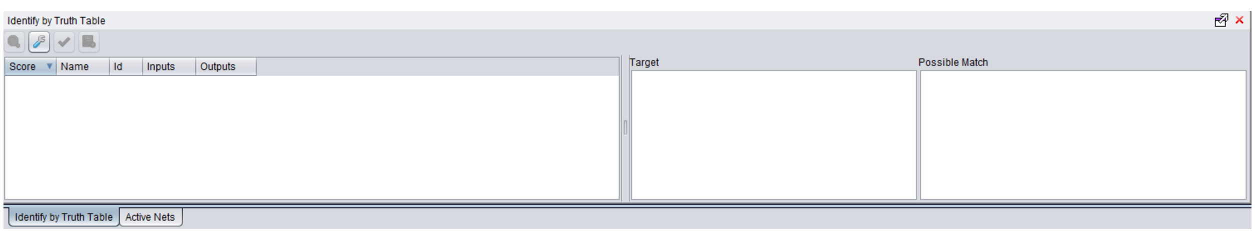
Finding external ports will find all ports that enter or leave the selected cell. with the exception of the top cell.



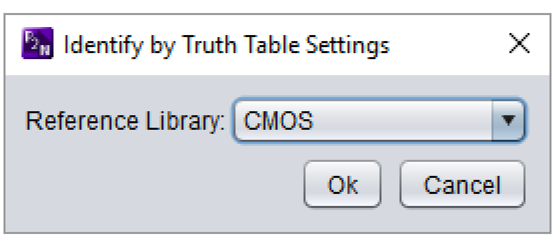
Options for placing the ports are listed in the *Find External Ports* window.

Identify by Truth Table

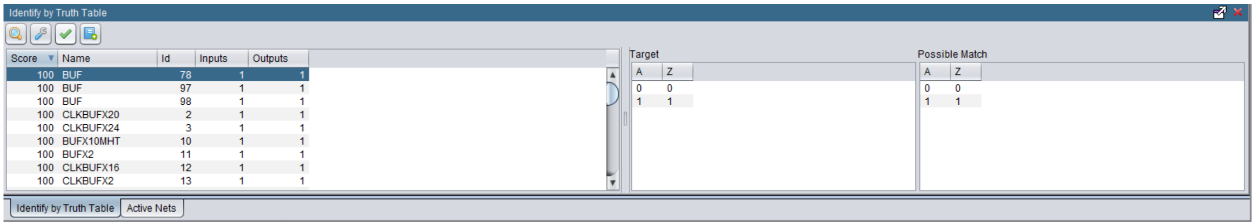
This will open the *Identify By Truth Table* window in the bottom pane.



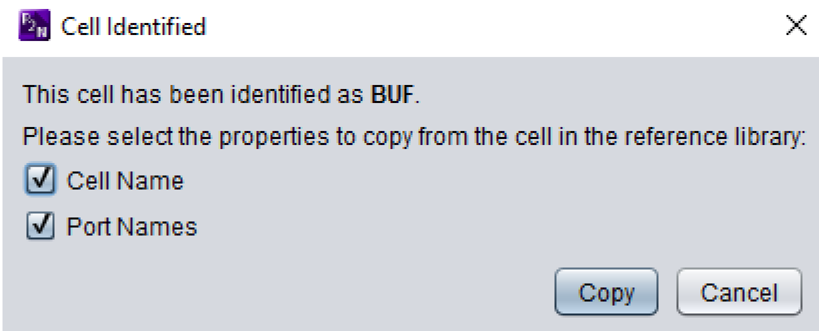
To set the library of comparison, click the wrench. A drop down menu will appear:



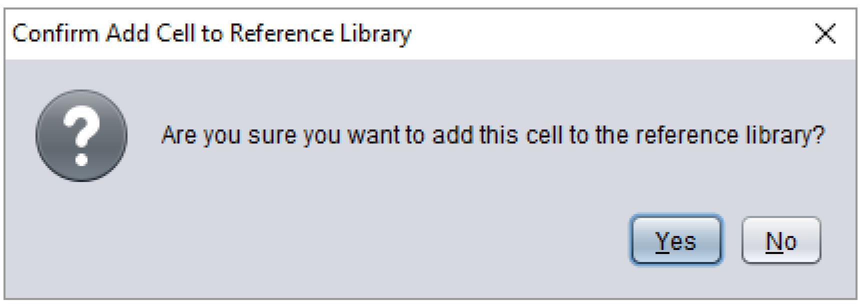
After selecting the desired library, click the magnifying glass to run the comparison to the active netlist. A list of possible matches will appear:



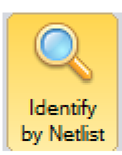
The score shows the percentage of match. A 100% is the best possible. Select one of the 100, and click on the green check mark to check it in. The truth tables show how the signals will map. The *Cell Identified* window will pop up.



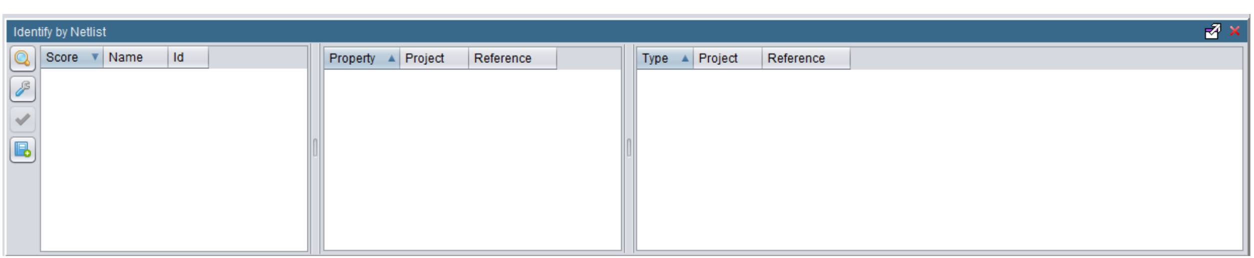
Click copy to transfer the checked properties to the current cell. If the user finds a cell that is not in the library, the cell can be added to the library by clicking on the book icon.A confirmation dialog will pop up:



Identify by Netlist

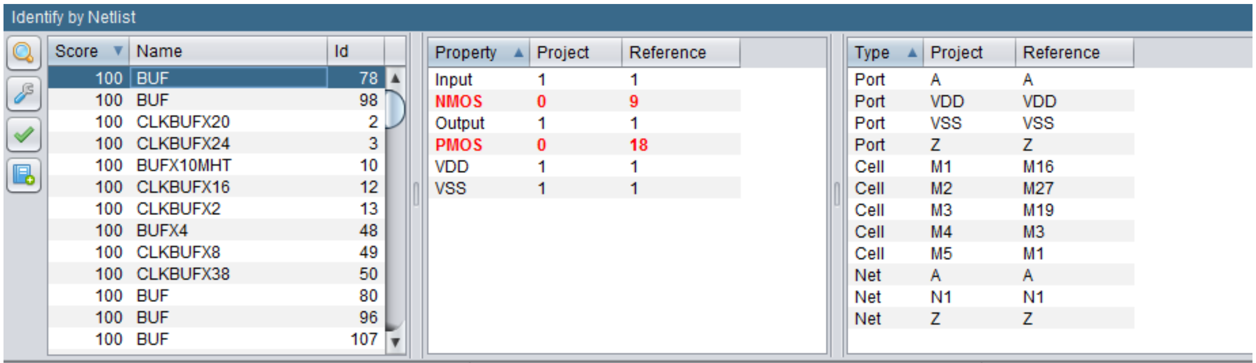


This will open the *Identify by Netlist* window in the bottom pane.

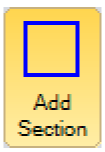


Set the reference library as done in the *Identify by Truth Table*, click on the magnifying glass to run the compare:

The comparison with the highest score is the closest match. If one (or more) has 100, that is a perfect match. Click on the green check mark to check it in, or on the book if you have found a new cell you would like to add to the library.

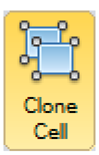


Add Section



Allows the user to add a section. This is used to place netlists into different sections. The sections are marked with green and red dots (next to the cell name). The green dot shows the user what active section they are on, and the red dot shows the user the other sections that were created. If the user right clicks on the sections in the `Project Cells` window, they can set it as the active section or revert it to a normal cell.

Clone Cell



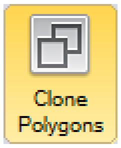
Allows the user to clone a cell. By selecting on a cell and then selecting `Clone Cell` the user can replicate the cell exactly wherever the mouse is clicked.

Refine Placement

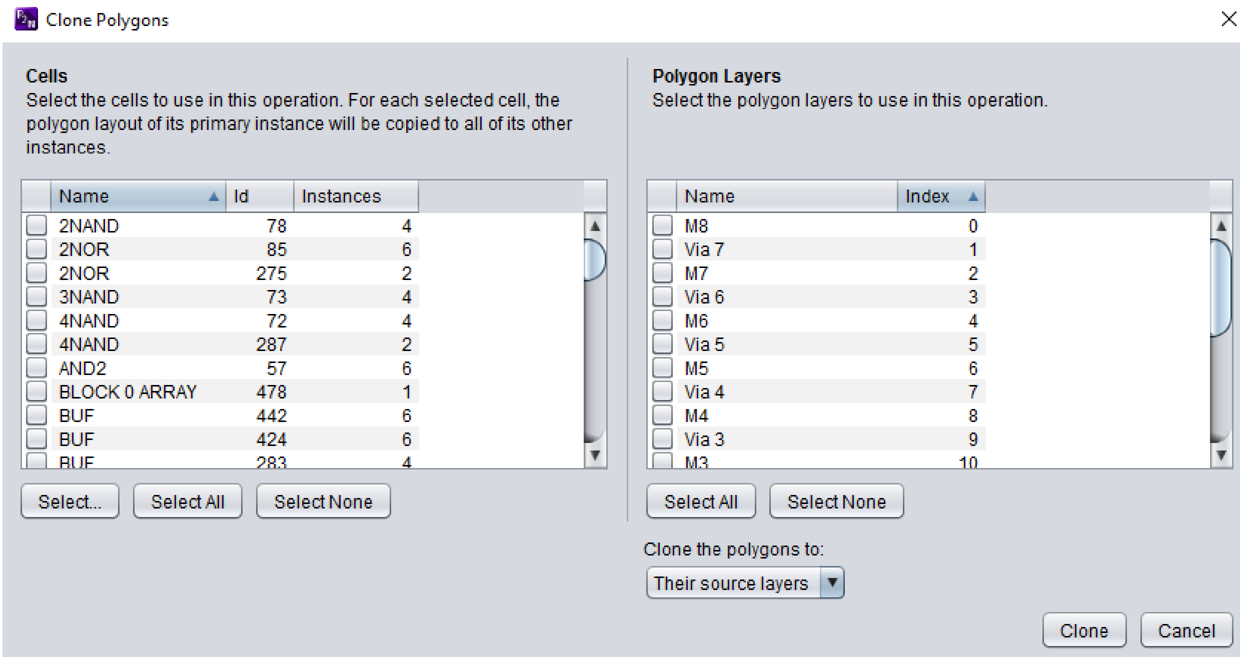
If cell ports are misplaced, refine placement tells Pix2Net to move the ports around to match up with correct polygons.

Clone Polygons

Allows user to clone polygons within selected cell(s).



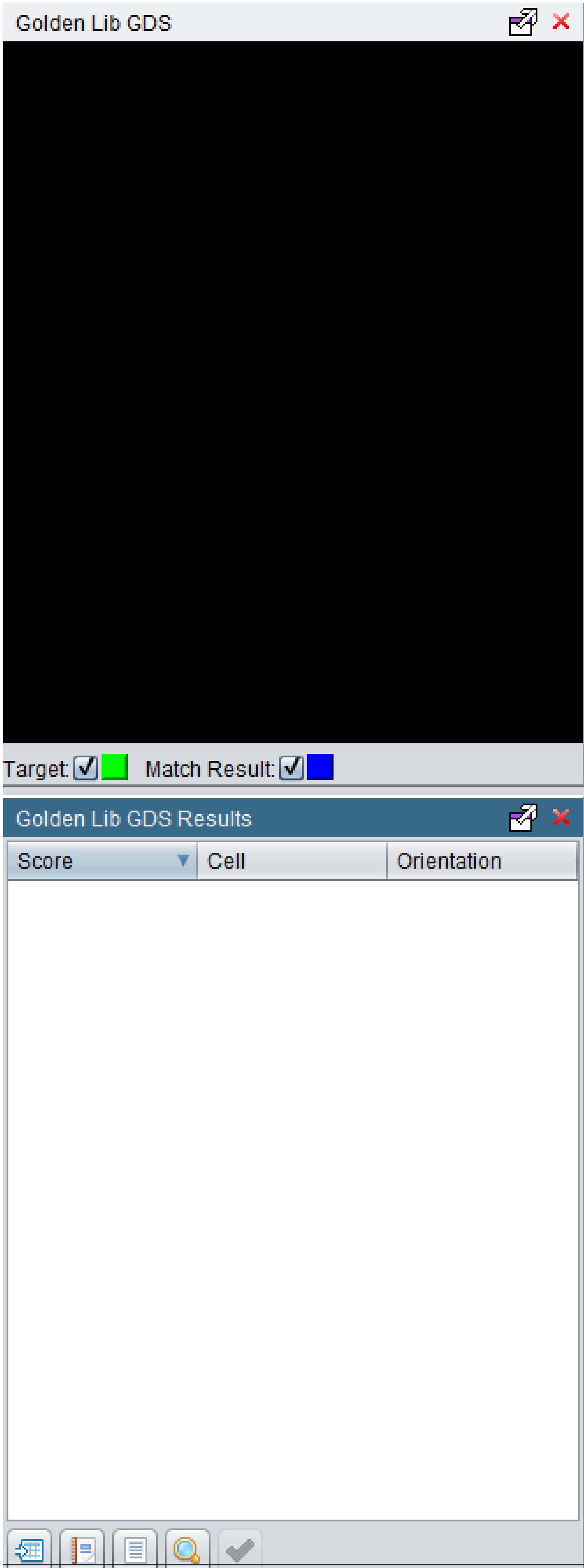
When using `Clone Polygons` in the Netlist tab, the user can tell Pix2Net to the exact polygons in any selected cell. For example, if the user wanted the polygons on Active and Poly to be filled in every BUF cell, simply select the cell in the left hand column and then the layer on the right hand column.



The user can also decide to clone the polygons to their source layers or their new layers.

Golden Lib GDS

Attempts to find the identity of a cell through polygons.


Golden Lib GDS
Target:
Match Result:
Golden Lib GDS Results
Score
Cell
Orientation

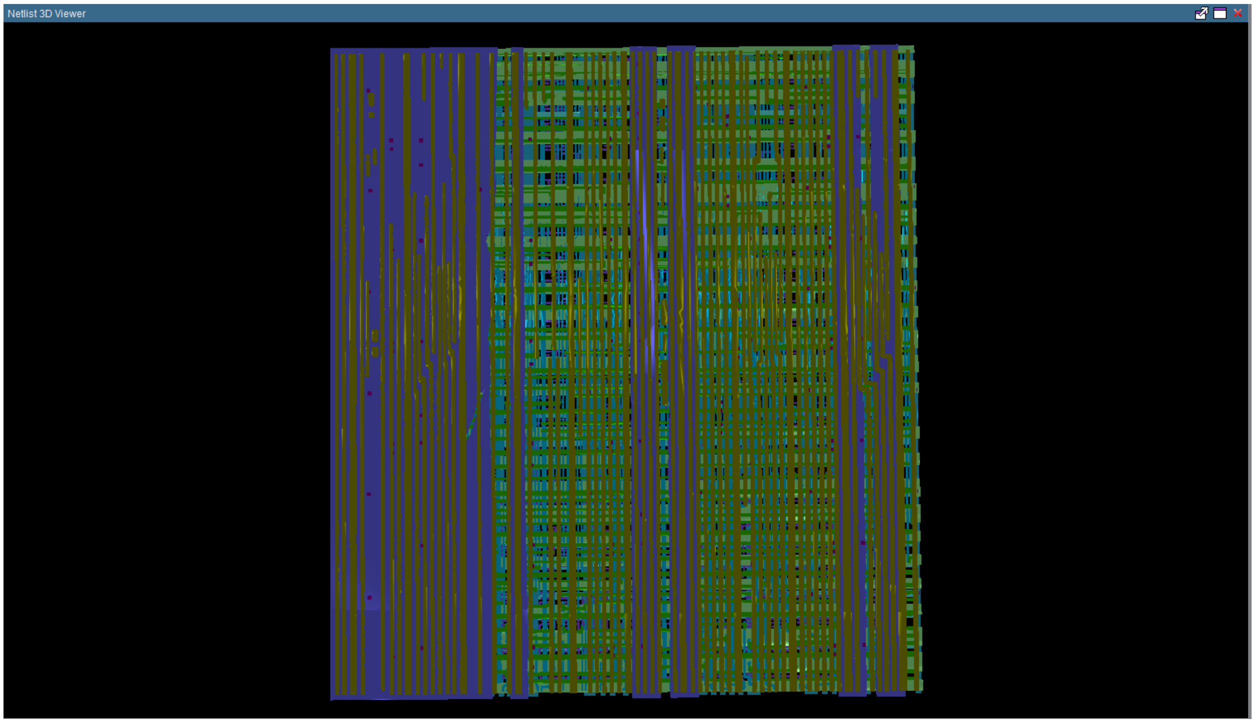
Load 3D Netlist

Loads the selected netlist for 3D viewing.

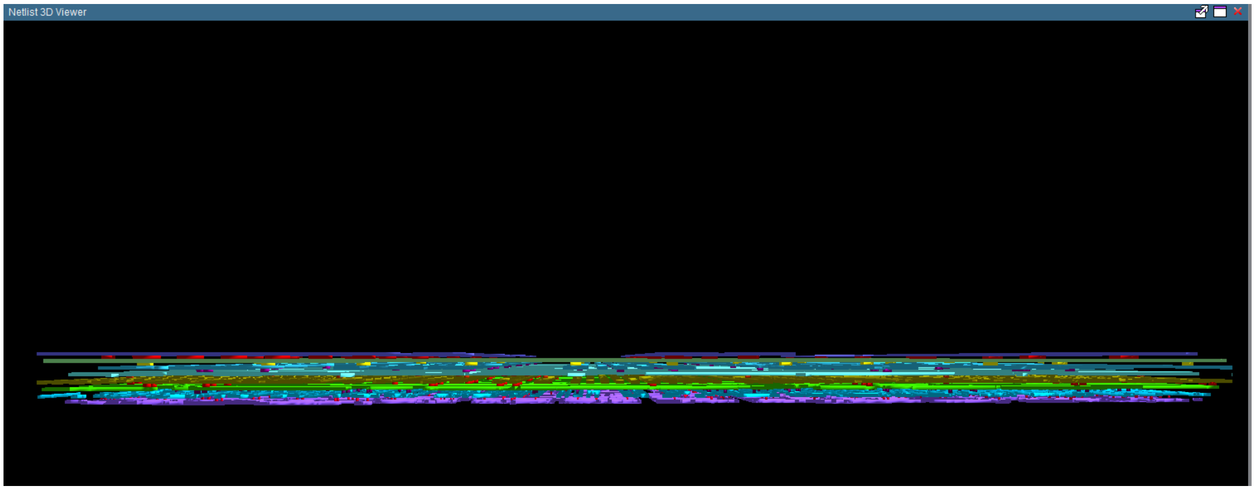
3D Viewer

Once the 3D netlist is loaded, the 3D viwer will show the user the netlist in 3D. Hold the 'W' key to zoom in and the 'S' key to zoom out of the 3D image.

Here is a bird's eye view of what one could expect a netlist to look like in the 3D viewer:

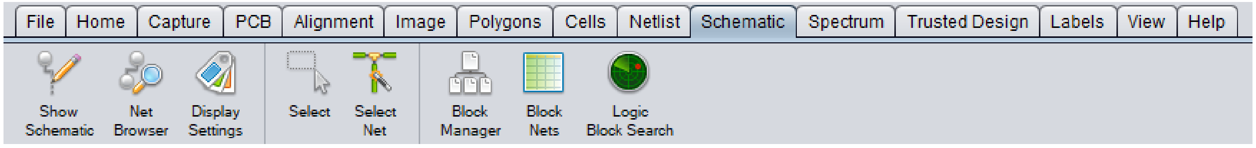


Side view:



Schematic Tab

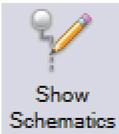
The *Schematic* tab creates and manages schematics for all cells.



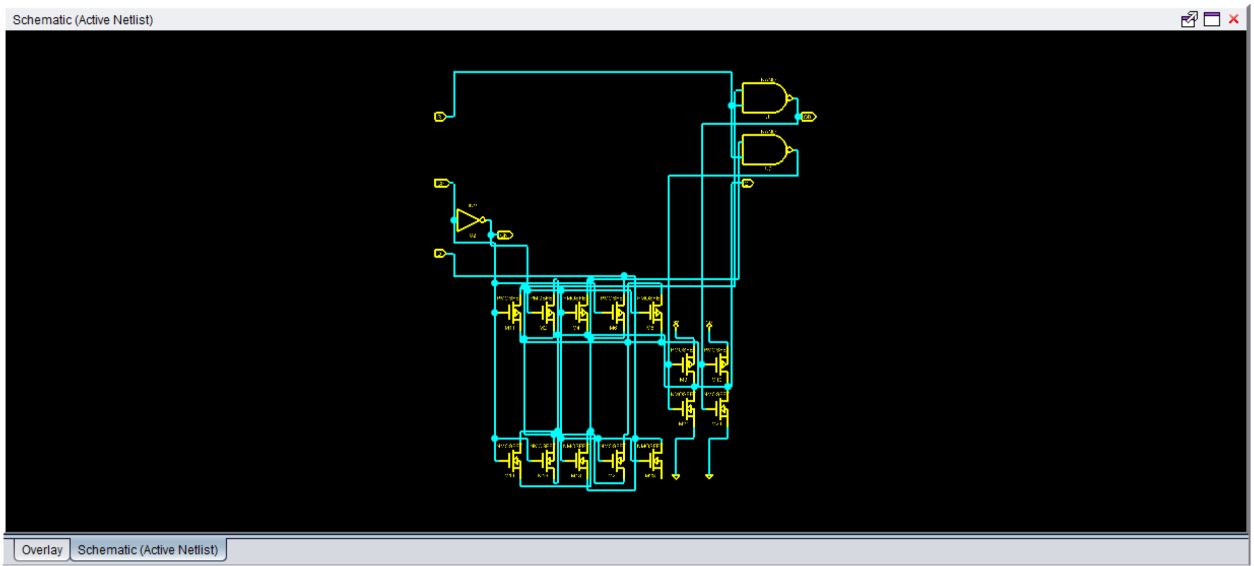
The following tools are available in the *Schematic* tab:

- *Show Schematics*
- *Net Browser*
- *Display Settings*
- *Select*
- *Select Net*
- *Block Manager*
- *Block Nets*
- *Logic Block Search*

Show Schematics

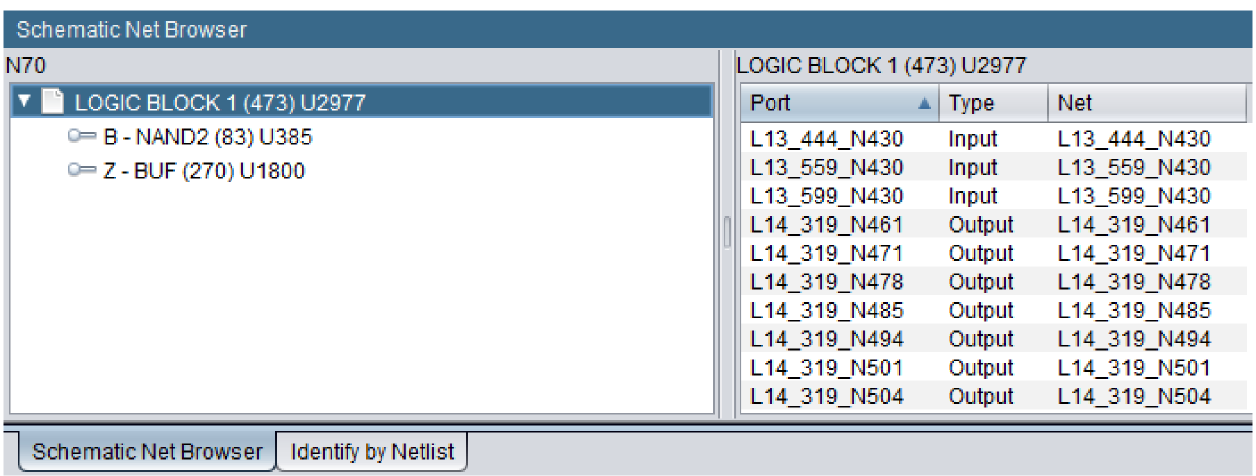


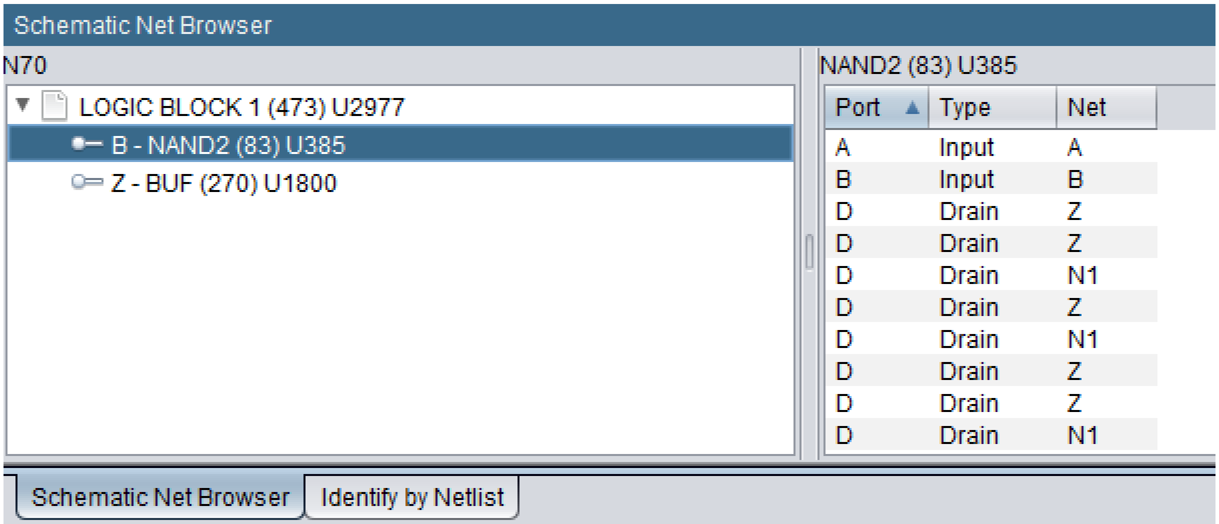
Brings up a window that shows the schematic for the active netlist. The window will open as a tab in the overlay.



Net Browser

Opens a window in the bottom panel that allows for highlighting, and zooming to a particular net in the schematic window.

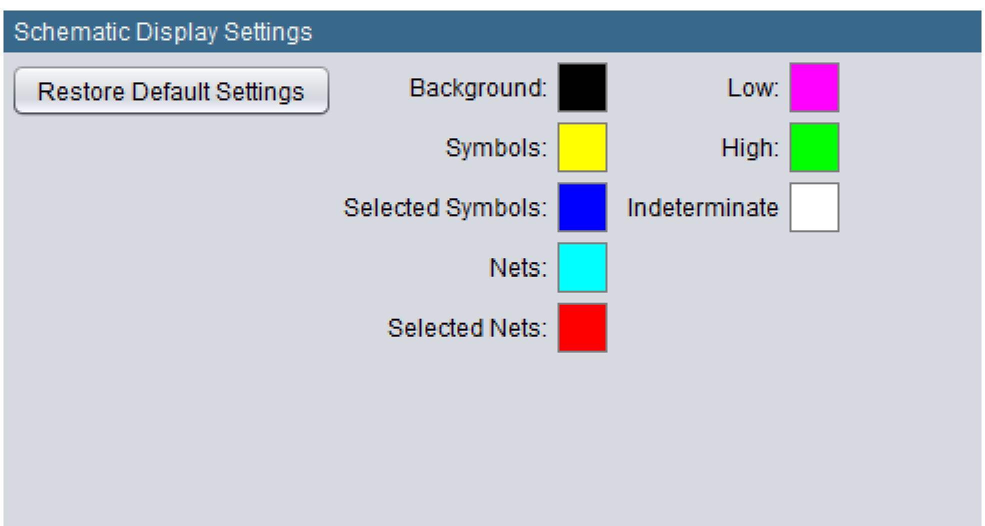




The user can see the ports, types, and nets of each cell or hierarchal block.

Display Settings

Brings up a window for setting the colors used in the schematic window. These settings are saved in the global database. You can restore the default colors at any time by clicking "Restore Default Settings". "Hide Text at this Zoom Level" will hide the text at the current zoom level, however, this is unnecessary in the schematic view.



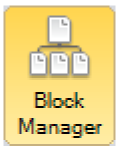
Select

This is the "Select Cell" button, which is in the Schematic tab for convenience. See *Select*.

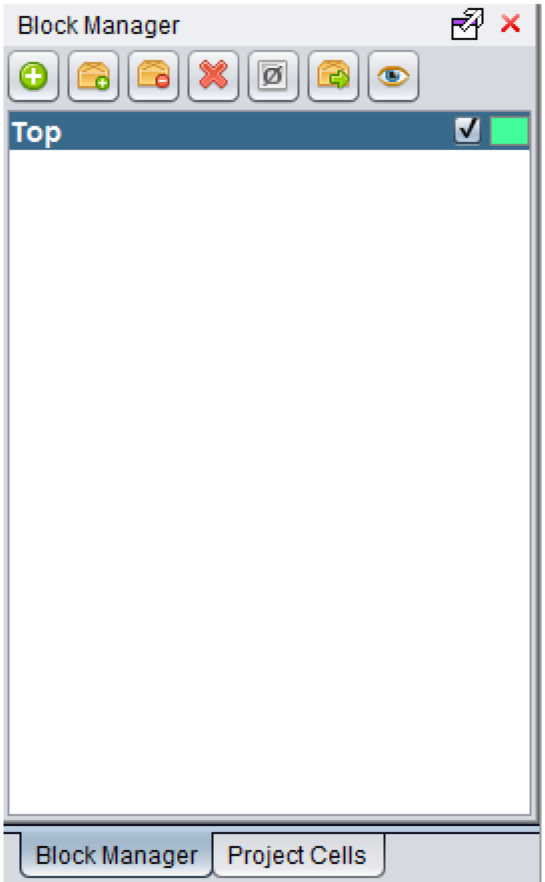
Select Net

This is the "Select Net" button, which is in the Schematic tab for convenience. See *Select Net*.

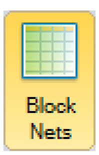
Block Manager



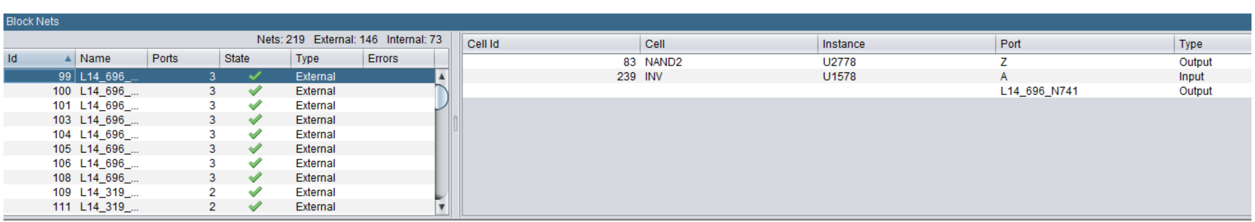
Allows the user to create (and view) hierarchical blocks in the overlay window. This provides more detailed control over schematic blocks, and allows the user to see all of the current blocks



Block Nets



The Block Nets window is similar to the Active Nets window, but it only shows nets which are part of the current hierarchical block. This allows the user to look at selected net ID's to see each port and their state. Once `Block Manager` is open, click on `Block Nets` to bring up a window.

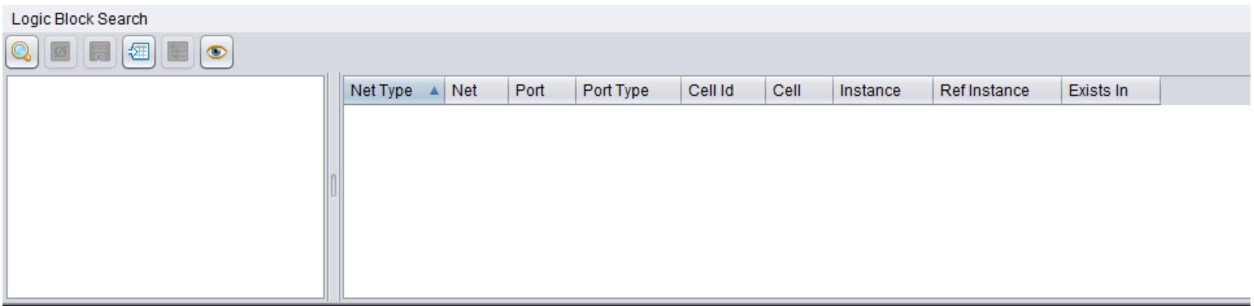


This shows the user each Net and their ID. When clicked on, Pix2Net shows the user the cell ID, the cell, the instance, the ports, and their types.

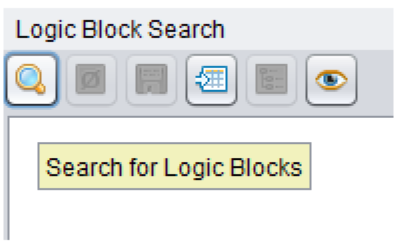
Logic Block Search

NOTE Before searching for logic blocks, make sure that there is a working active netlist.

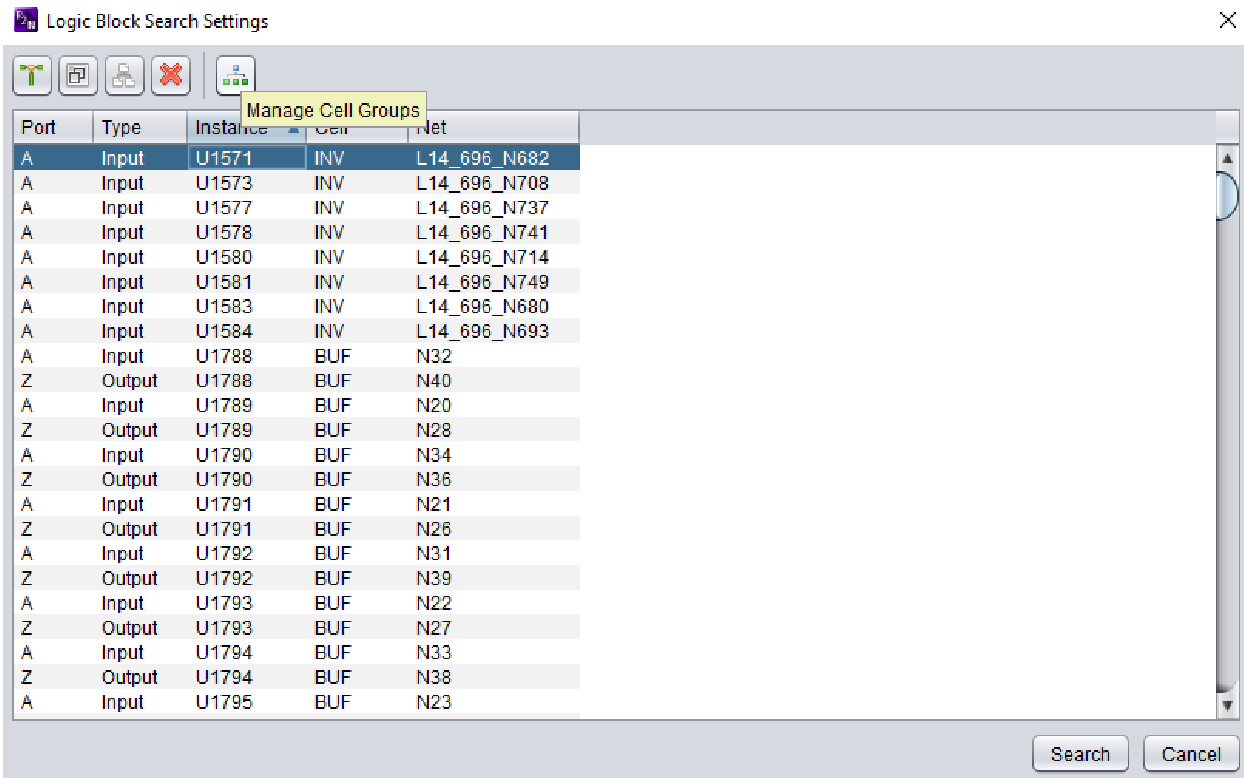
Clicking on *Logic Block Search* opens the following window in the bottom pane:



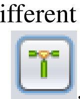
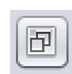
Clicking on the magnifying glass allows the user to search for logic blocks.

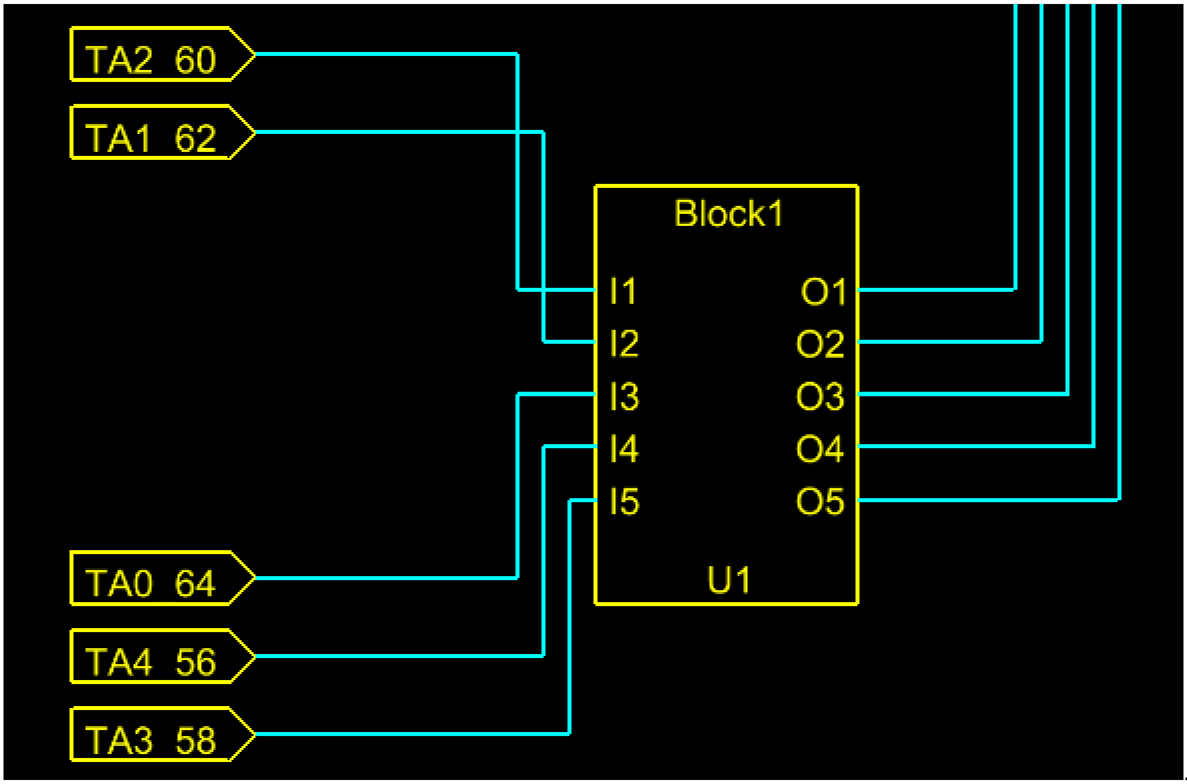


The *Logic Block Search Settings* window pops up:



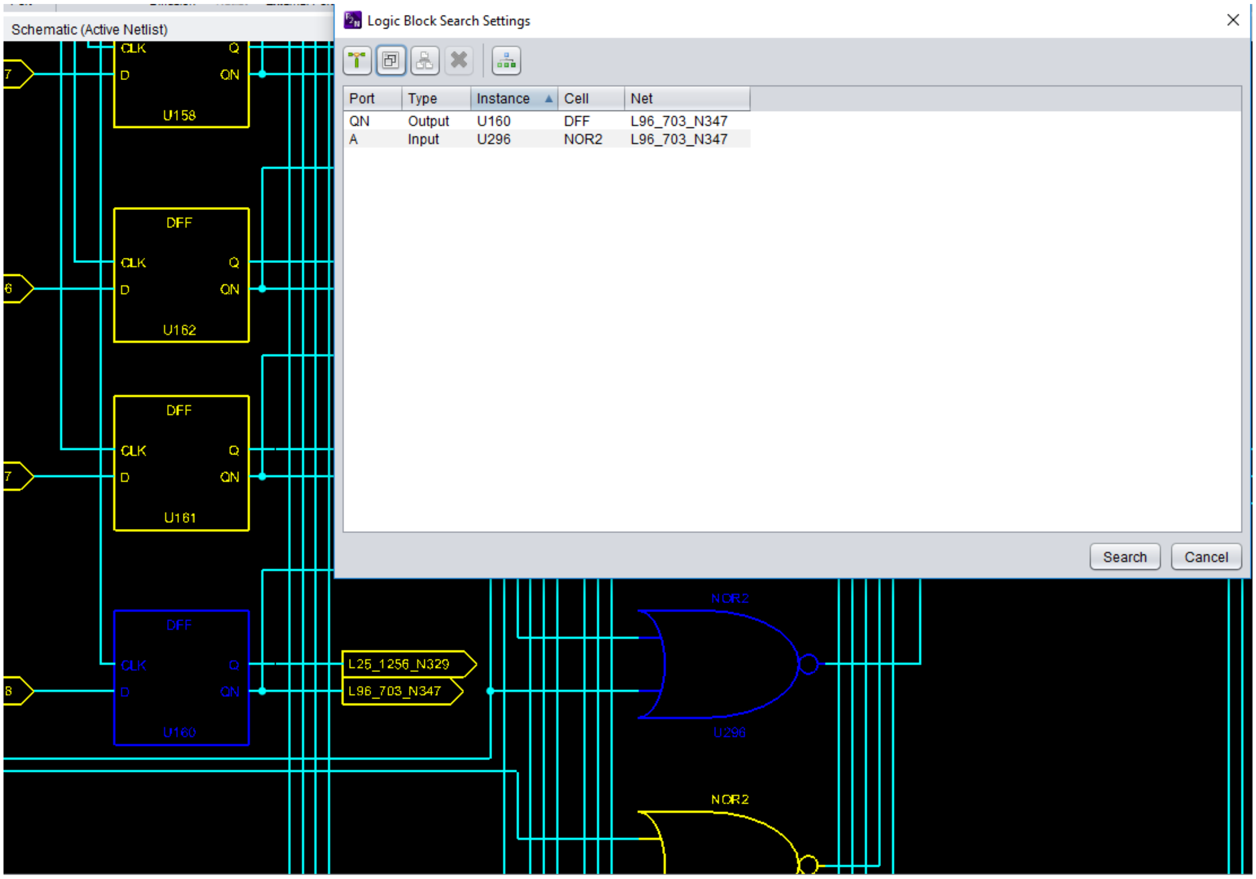
It is pre-populated with the last search performed. To search this again, click *Search*.

The icons in the top of the window allow for different search types. Pix2Net will retrieve the block information from the *Logic Paths* (in the cells tab) window , the current selected cells , or the *Schematic Block*

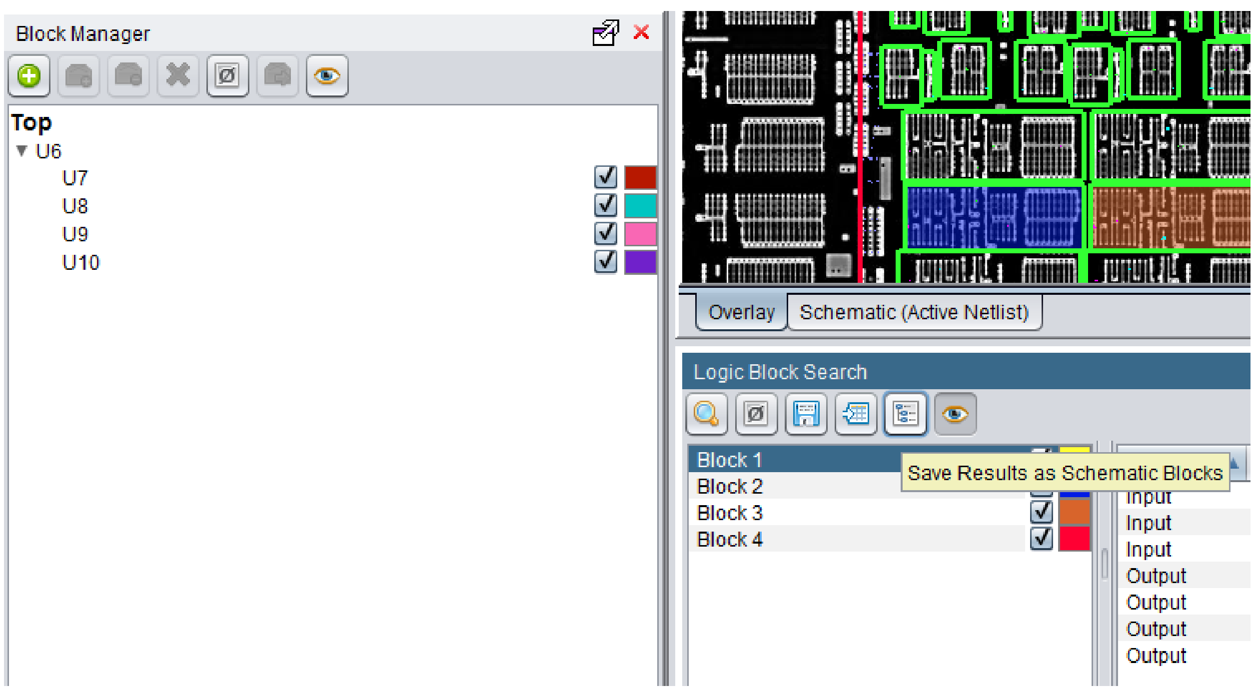


The most common way to retrieve block patterns is through current selected cells, and then to save the results as schematic blocks.

To do this, select a pattern of cells (in the schematic window, or overlay) click on *Search for Logic Blocks*, then *Get Pattern from Selected Cells*, after that click *Search*.



Now, click on *Save Results as Schematic Blocks* to add a hierarchal block and sub-blocks to the block manager.



The search block can be cleared by clicking *clear results* icon. The user can save the current block search by clicking the *save* icon in the *Logic Block Search* Window. This will pop up a dialog that will allow the user to enter a name

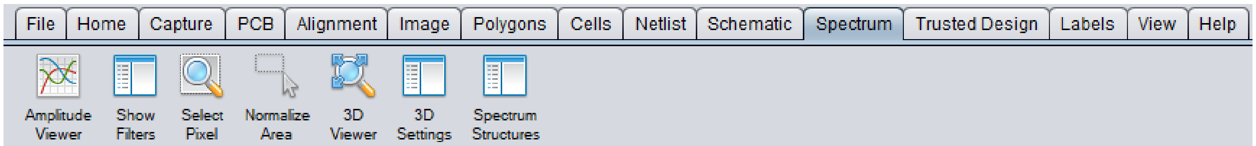
for the block to be saved. *Note that currently Pix2Net allows the user to save blocks with the same name without a warning.* The user can also load a saved pattern by clicking on the *Load Pattern* icon.

Spectrum Tab

Note This tab is only for users with a spectrometer.

The Spectrum tab lets the user take the pixelated information that is gathered from the spectrometer and view its amplitudes and specific pixels.

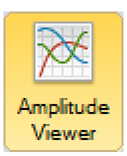
Before proceeding, you will need to have collected a spectrum image from the capture tab. See: *Capture Tab*



The following tools are available in the *Spectrum* Tab:

- *Amplitude Viewer*
- *Show Filters*
- *Select Pixel*
- *Normalize Area*
- *3D Viewer*
- *3D Settings*
- *Spectrum Structures*

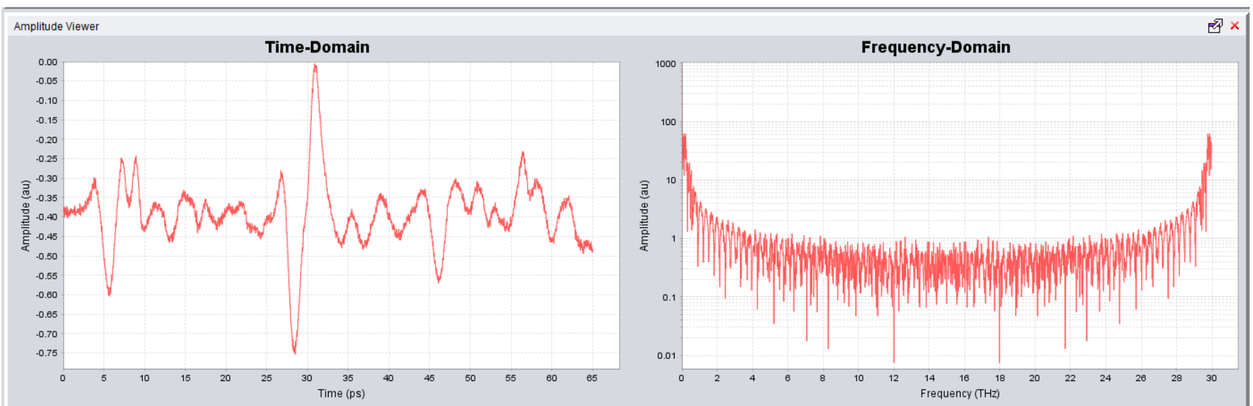
Amplitude Viewer



This shows the user the amplitude of the spectrum that was taken.

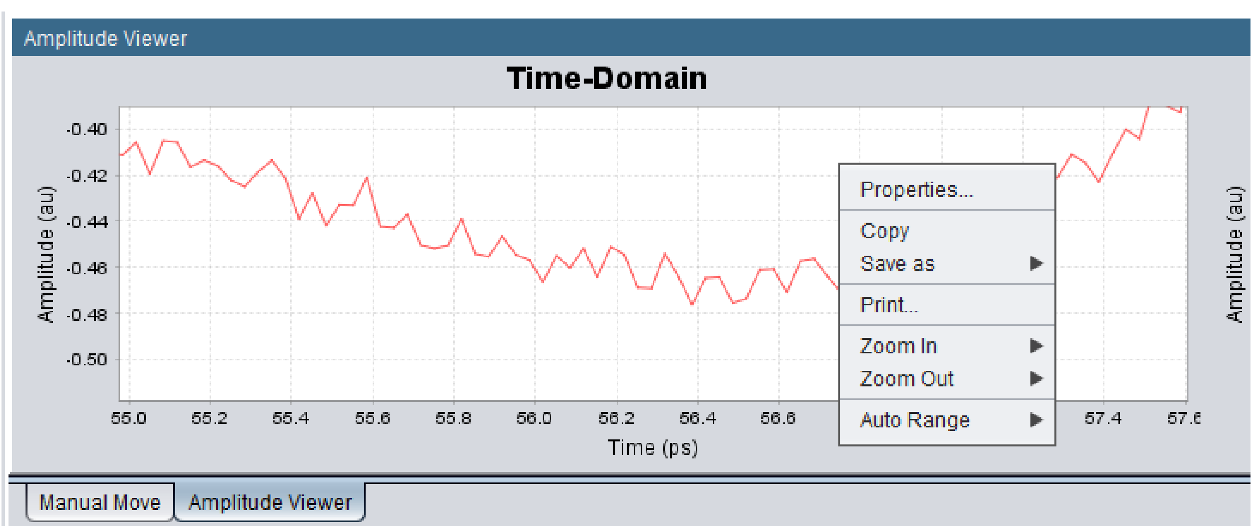
The Amplitude Viewer will be blank until a pixel is selected on the scan.

Use this when there is a sample that is captured by the spectrometer and then Pix2Net will show you the amplitude of the spectra through the time-domain (in ps) and the frequency-domain (in THz).

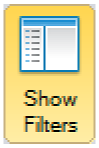


By right-clicking and dragging the mouse, the user can zoom into specific areas of each domain.

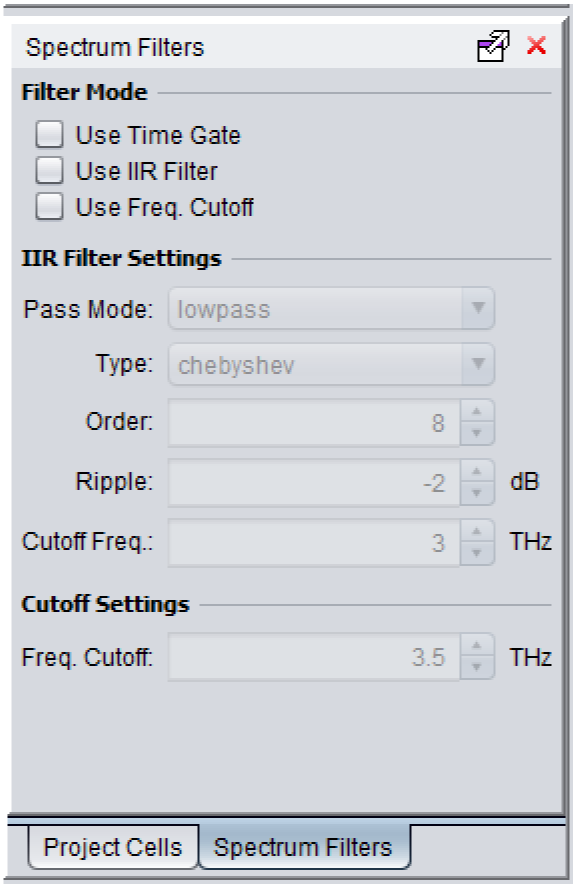
The user may also right-click once inside the viewer window and a small menu of options will pop up to choose from.



Show Filters



Once this is pressed, the `Spectrum Filters` window will pop up.



The user can use this to filter spectrum settings accordingly.

Use Time Gate: allows user to select certain time width of the capture.

Use IIR Filter: sets frequency filters

Pass Mode:

Lowpass - filters out low frequencies

Highpass - (this should be the default) filters out high frequencies

Bandpass - selects range of frequencies

Bandstop -

Type: sets parameters to filter frequency

Butterworth - should be default

Chebyshev

Bessel

Order: number of times filter function is iterated

Ripple:

Use Freq Cutoff:

Cutoff Setting:

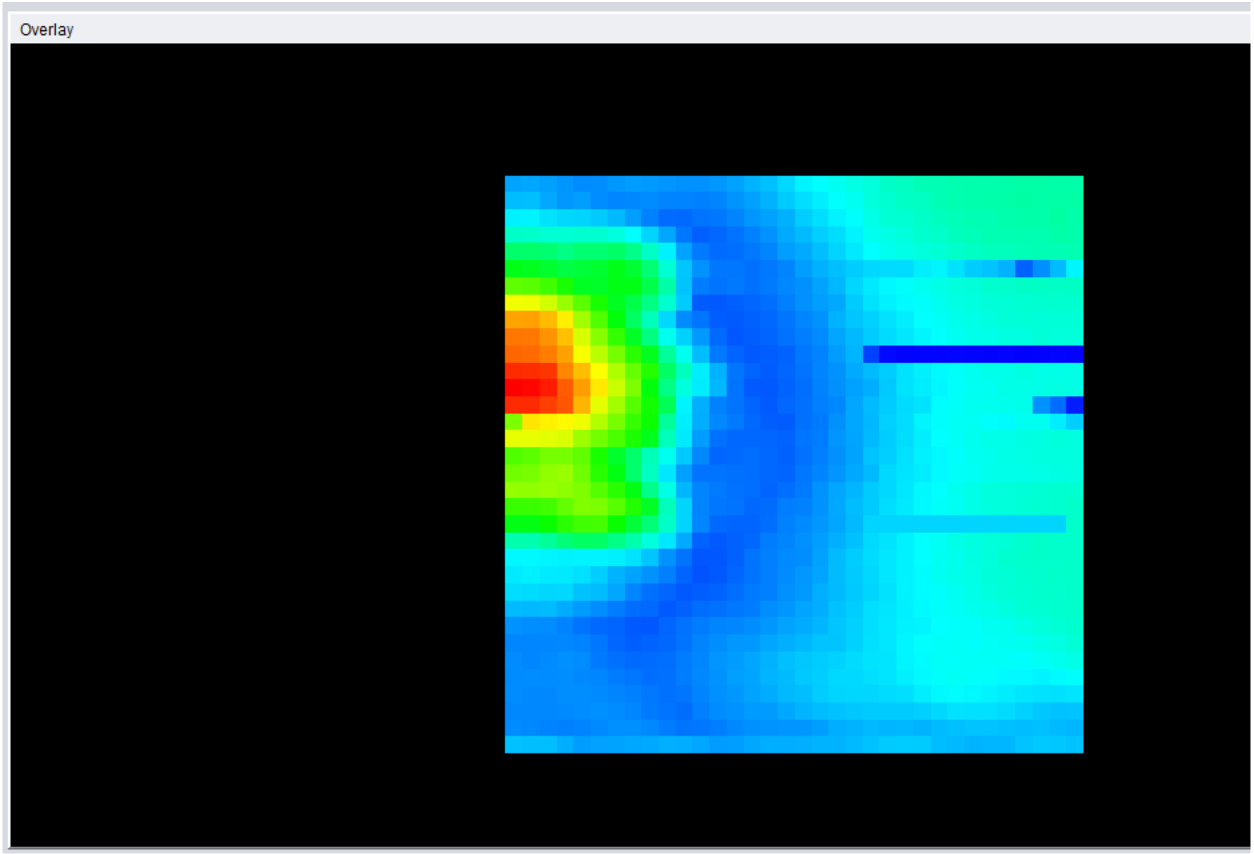
Freq Cutoff - Freq domain = FFT of Time Domain

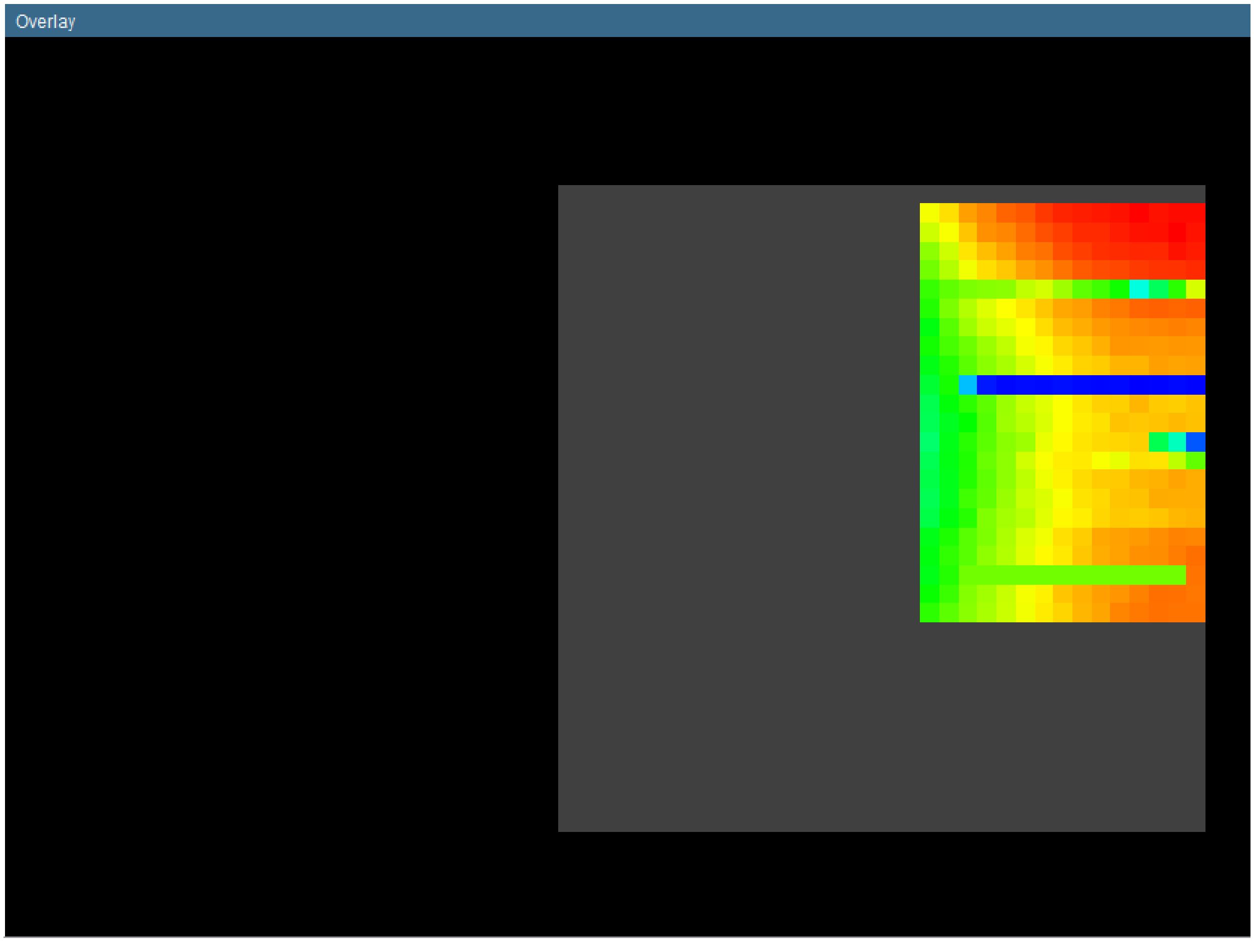
Select Pixel

When using this tool, the user can click on a specific pixel inside the spectrum image and the amplitude viewer will show the time and frequency of just that pixel.

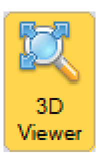
Normalize Area

Use this tool to select a specific portion of the pixels to view more information of that area.


Overlay



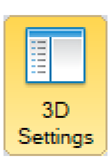
3D Viewer

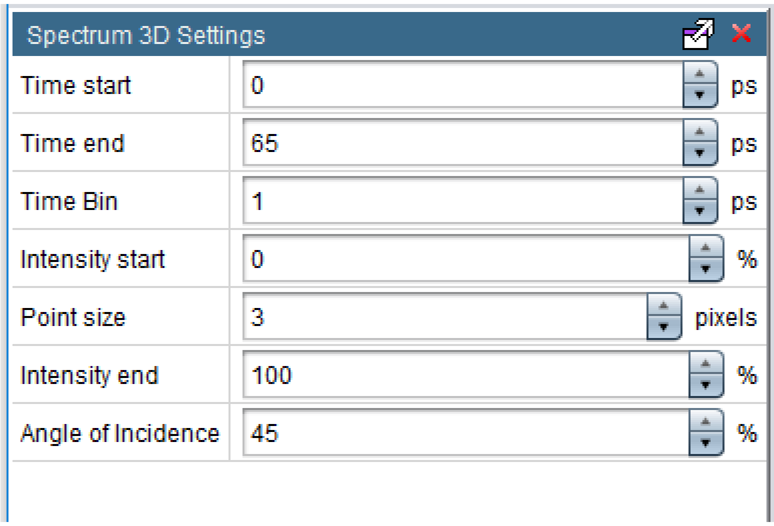


Allows user to see 3D representation of spectrum scan.

Click and drag to move 3D image around.

3D Settings





Time Start: selects starting point in Time Domain

Time End: selects ending point in Time Domain

Time Bin: histogram bin width in Time Domain

Intensity Start: start of the intensity range

Point Size: size of each point

Intensity End: end of the intensity range

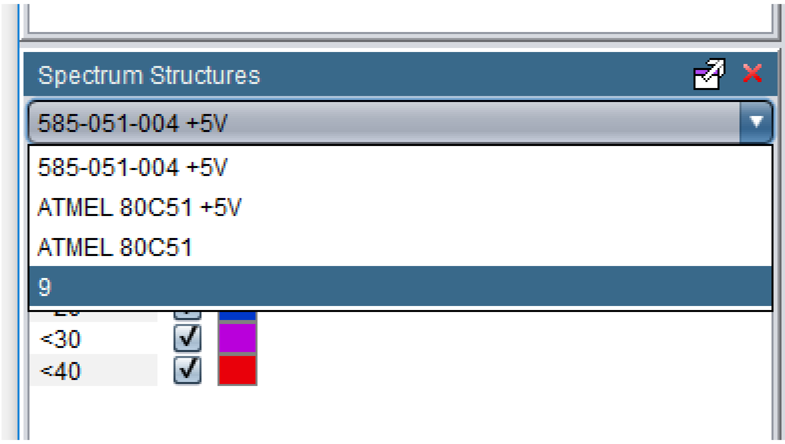
Angle of Incidence: angle of the beam through the sample (45 degrees should be default)

Spectrum Structures

NOTE The user must normalize an area of the spectrum in order to set structures.

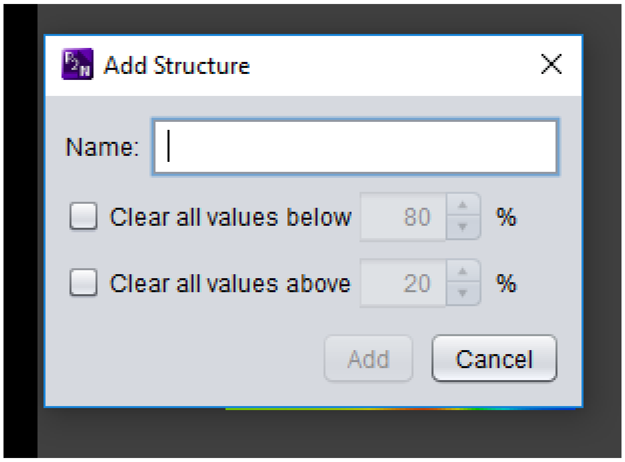
3D Viewer should be activated when setting spectrum structures.

Drop down menu is based on layers in project.



Select layer in drop-down.

Click "Add"



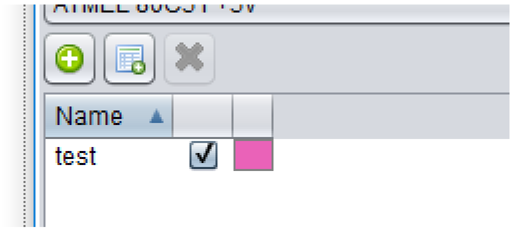
Enter a name for the structure.

Select "Clear all values below".

Enter percentage of measured intensity to be omitted.

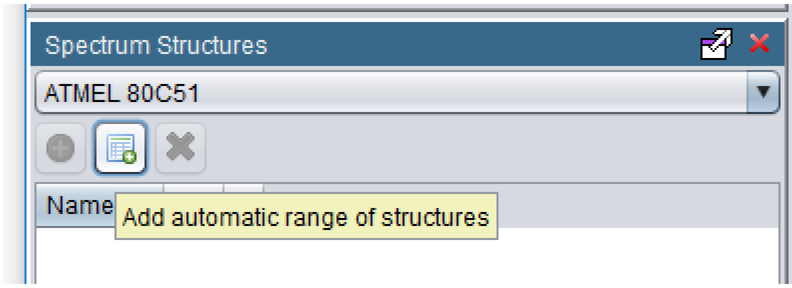
Click "Add".

Select the test structure from the list.

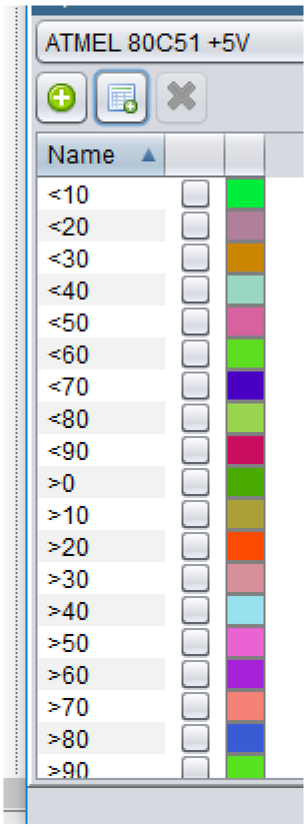


The filtered 3D image is now available in the 3D Viewer.

The user can also generate a range of structures.

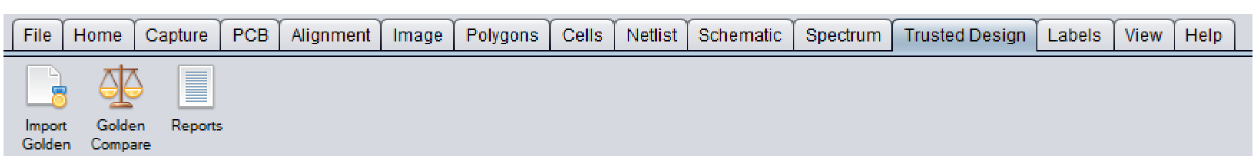


Selecting this function will generate 20 structures to choose from (<10 to >90).



Trusted Design Tab

The *Trusted Design* tab manages comparison to golden gds files.



The following tools are available in the *Trusted Design* tab:

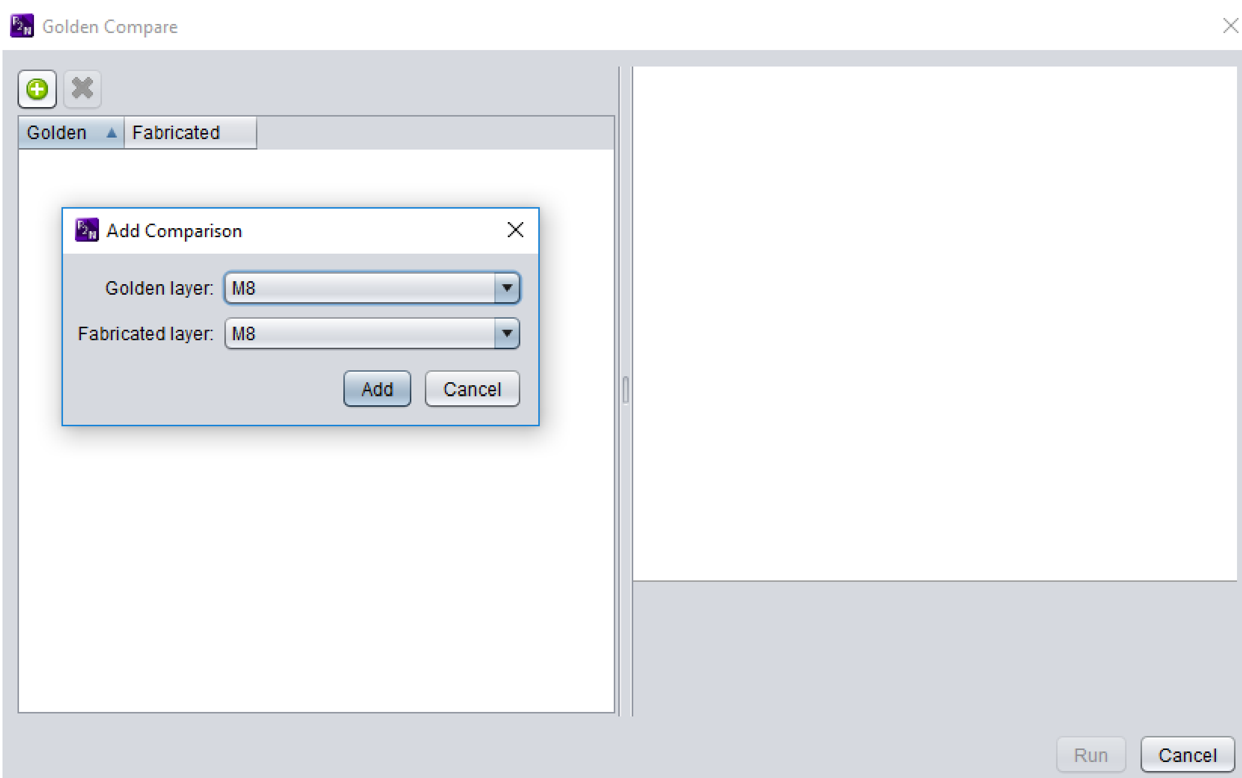
- *Import Golden*
- *Golden Compare*
- *Reports*

Import Golden

Opens a window to import the layer.

Golden Compare

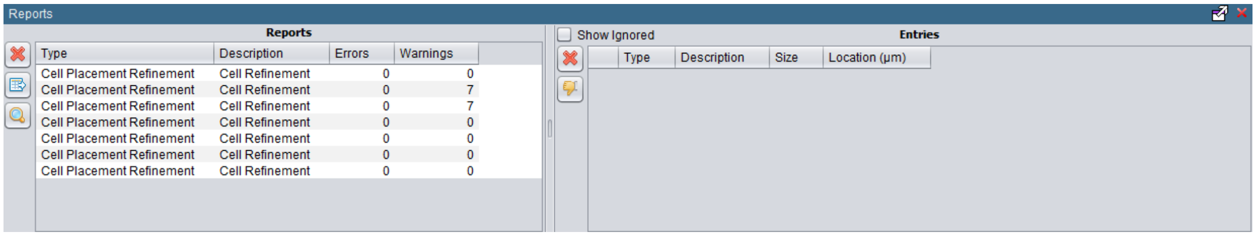
Initiates the golden compare operation



Allows the user to add a comparison between a golden layer and fabricated layer.

Reports

Opens the report in the bottom pane



This lets the user delete, export, and visualize each report.

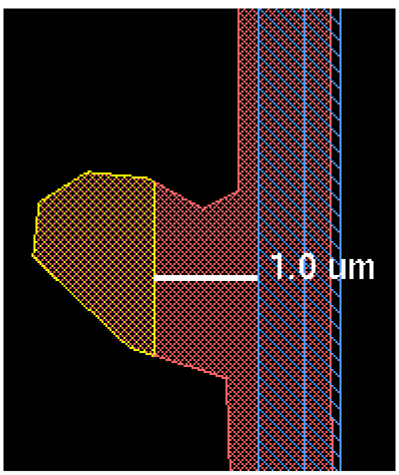
On the right, it shows the user the warnings or errors, that can be deleted or ignored.

See the golden compare tutorial: *Comparing a Layer to a Golden Layer*

Types of Differences

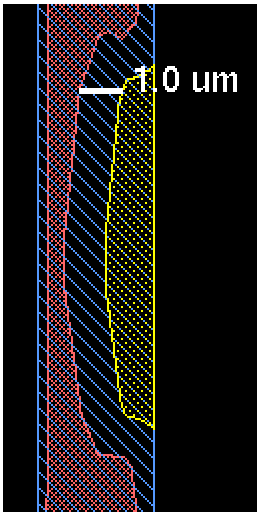
In the following examples, the golden layer is blue, the fabricated layer is red, and the difference is yellow. The tolerance used was 1 micron.

Extra Metal



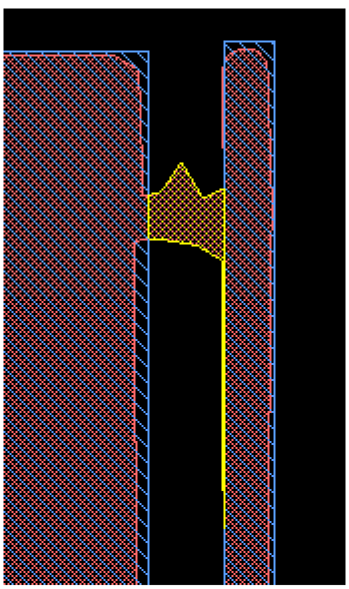
When fabricated metal has no golden metal near it, as defined by the tolerance, then that area will be flagged as an Extra Metal error.

Missing Metal



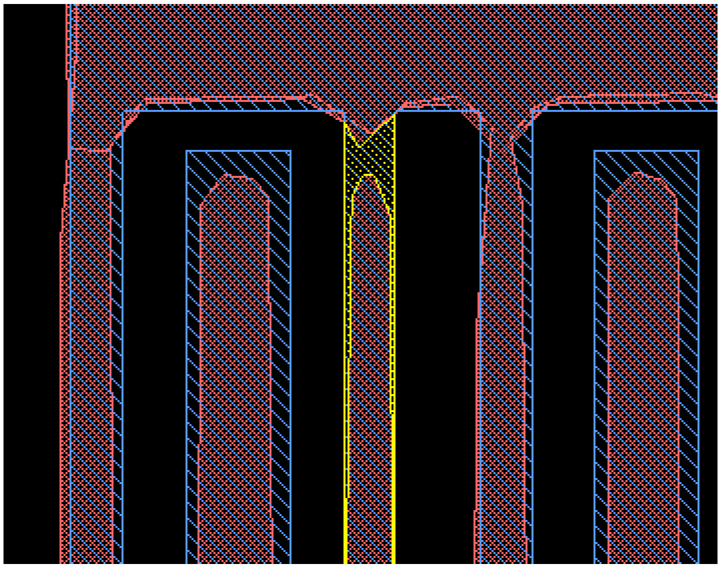
When golden metal has no fabricated metal near it, as defined by the tolerance, then that area will be flagged as a Missing Metal error.

Bridge



A bridge is when one extracted polygon overlaps two or more golden polygons. This error is always detected, regardless of the tolerance setting.

Gap



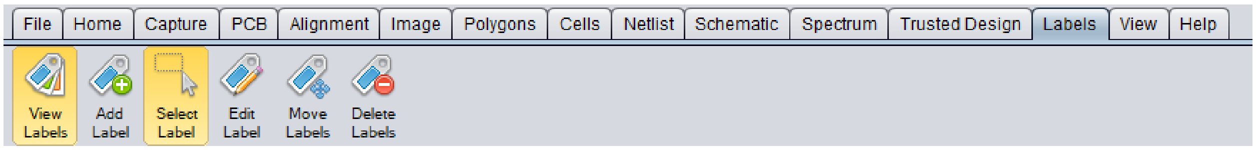
A gap is when one golden polygon overlaps two or more extracted polygons. This error is always detected, regardless of the tolerance setting.

Errors and Warnings

Differences are either considered errors or warnings. In general, differences are flagged as warnings if the highlighted area is smaller than the tolerance.

Labels Tab

The *Labels* tab creates and manages labels for non port type labeling of the design, including memory bits. See *Extract Memory*

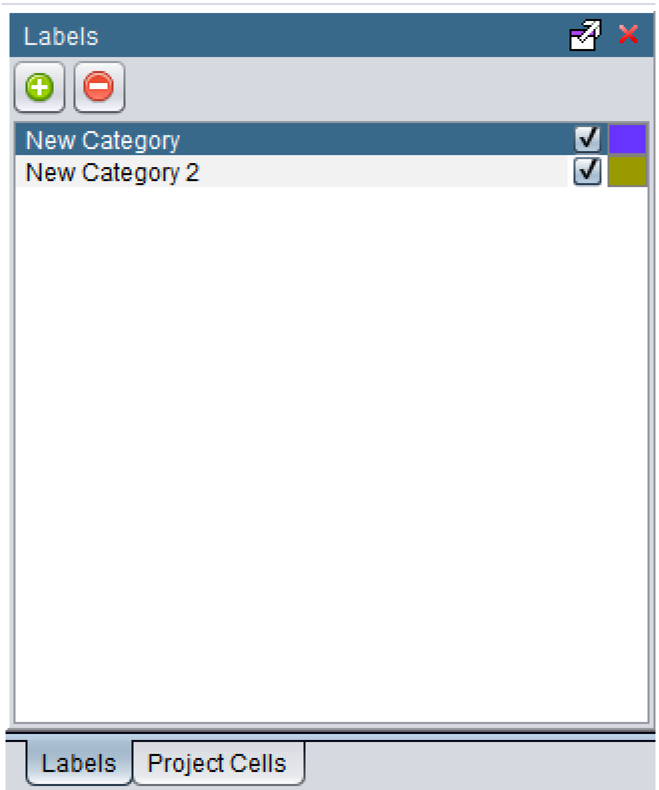


The following tools are available in the *Netlist* tab:

- *View Labels*
- *Add Label*
- *Select Label*
- *Edit Label*
- *Move Labels*
- *Delete Labels*

View Labels

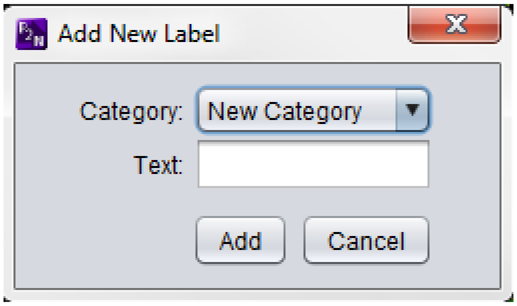
The *View Labels* button opens a tab in the lower left corner of the GUI.



- To add a new label category press the *green plus* button and give the category a name.
- To delete a label category, highlight the category, then press the *red minus* button.
- Show labels in the overlay by having the box checked. Uncheck the box to hide labels in the overlay.
- Change the color of the label by clicking on the colored box and choosing the desired color.

Add Label

To add a label, press the *Add Label* button and click in the overlay in the desired location. The following window will pop up:



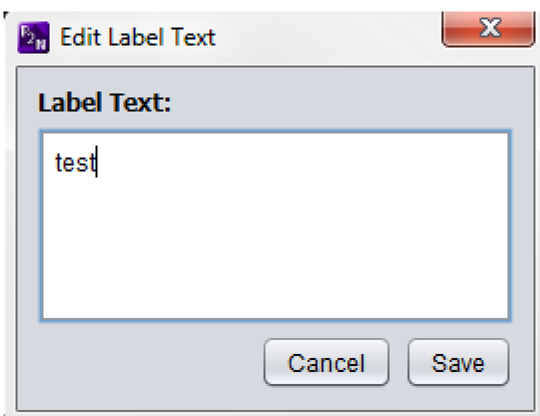
Select the label category in the drop down menu, type in the desired label text, and press *Add*.

Select Label

When highlighted, the *Select Label* function is active. Click and drag around the label of the highlighted category in the overlay. The selected label(s) will turn red.

Edit Label

Select a label, the press the *Edit Label* button. The following window will pop up:



Enter the desired change to the text and press *Save*.

Move Labels

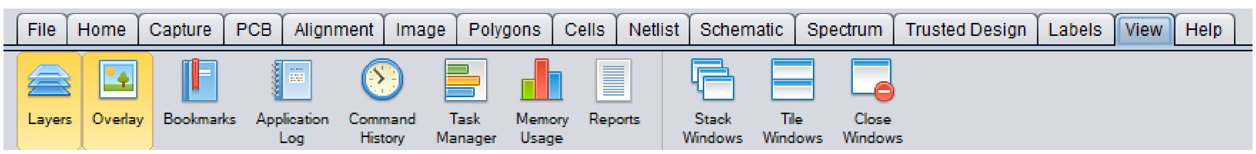
Click and drag to move selected labels.

Delete Labels

Pressing *Delete Labels* will delete all of the currently selected labels. This operation cannot be undone.

View Tab

The *View* tab manages the visibility of panes in the Graphical User Interface.

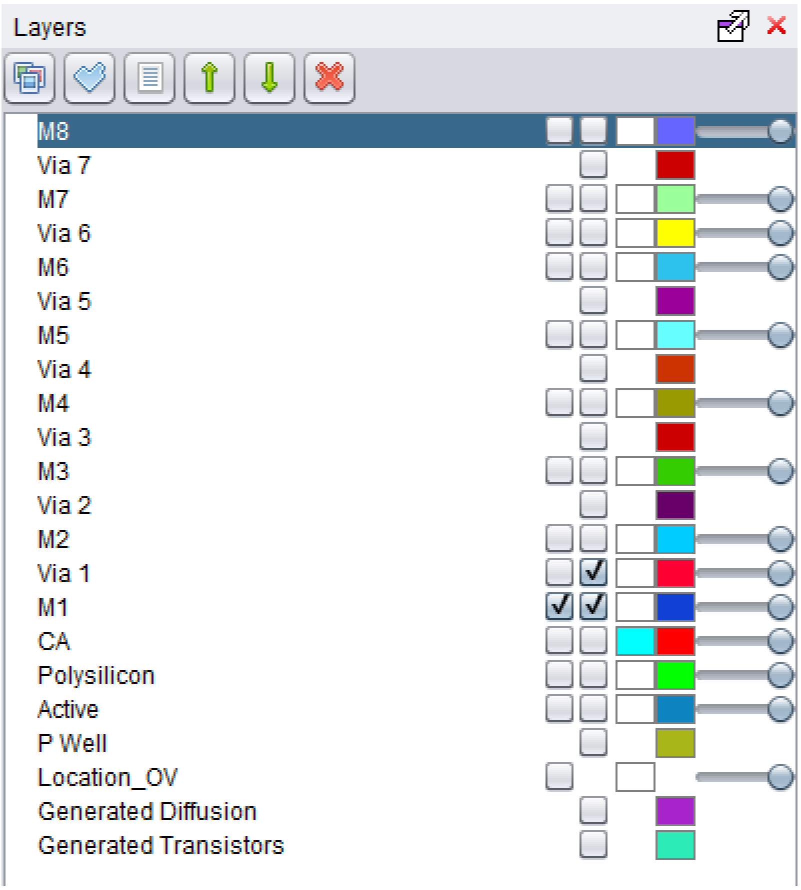


The following tools are available in the *Netlist* tab:

- *Layers*
- *Overlay*
- *Bookmarks*
- *Application Log*
- *Command History*
- *Task Manager*
- *Memory Usage*
- *Reports*
- *Stack Windows*
- *Tile Windows*
- *Close Windows*

Layers

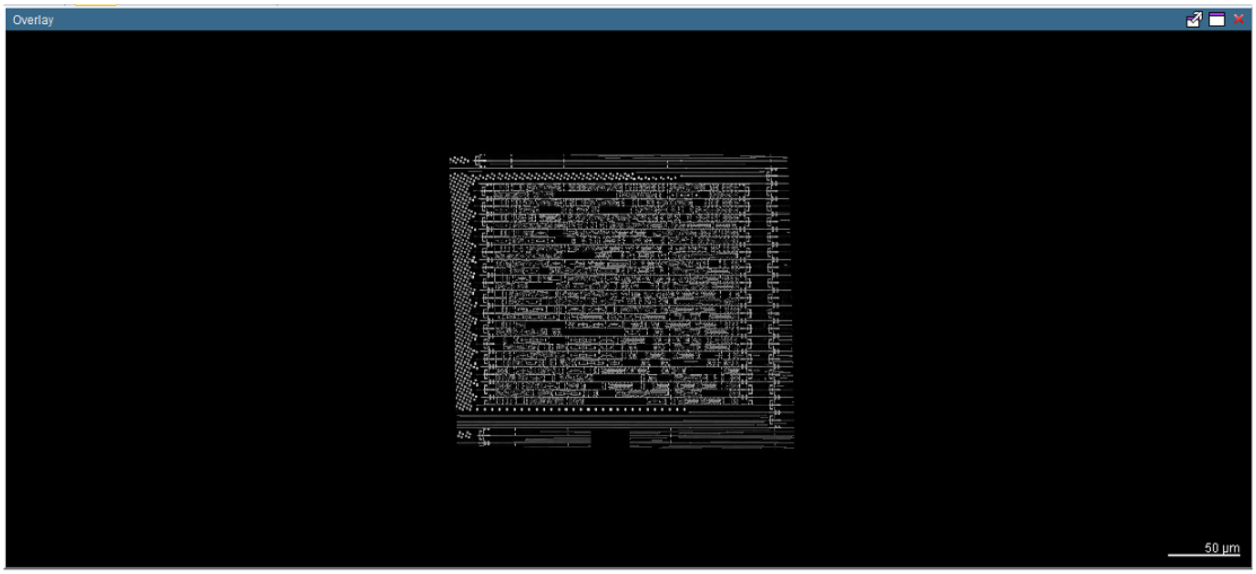
Toggles the layers window. The layers window will open up in the top left of the GUI.



See *Layers Window* for a description.

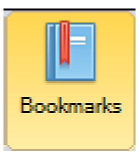
Overlay

Toggles the overlay window. The overlay window will open up in the center of the GUI.

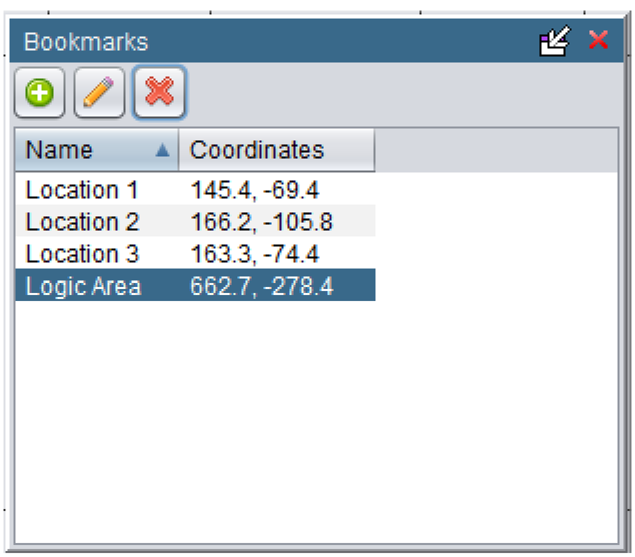


See *Overlay Windows*

Bookmarks

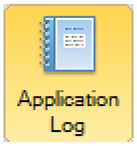


Toggles the bookmarks window. The bookmarks window will open up as a tab in the upper left of the GUI.



The bookmarks window allows you to save your current location by clicking the add button. Your current location is considered to be the micron coordinates the camera is currently focused on. You can also edit the name of the saved location by clicking the pencil button and delete unnecessary ones by clicking the *red x* button.

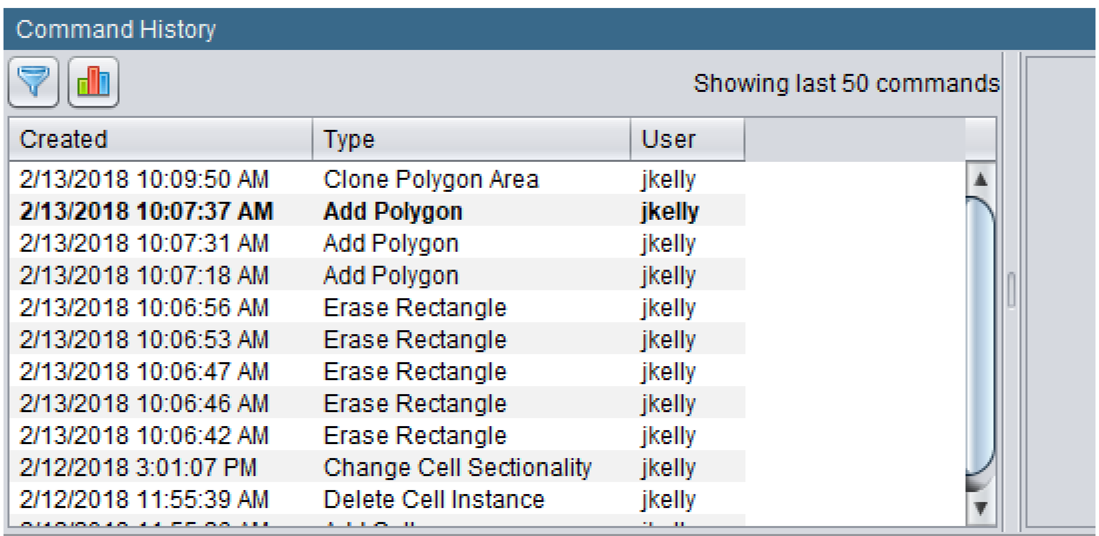
Application Log



Toggles the *Application Log*. The log will open as a tab in the bottom center of the GUI. This log tracks errors in the software.

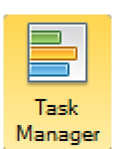
Command History

Toggles the *Command History*. This window will open as a tab in the lower left of the GUI. The history tracks only synchronizable commands.

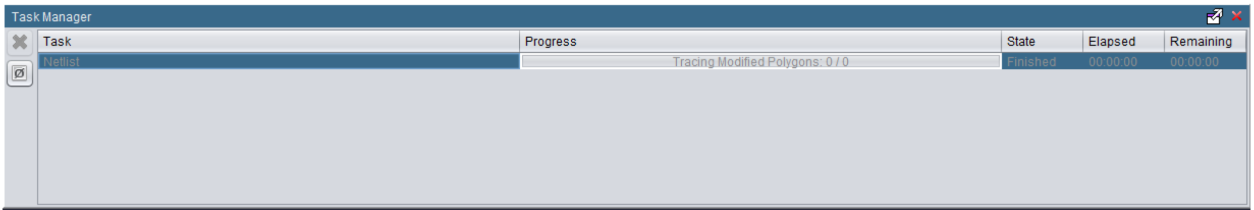


The button on the left allows the user to filter a specific number of commands, or commands at a certain time. The right button shows the statistics of commands - commands by type and by user.

Task Manager



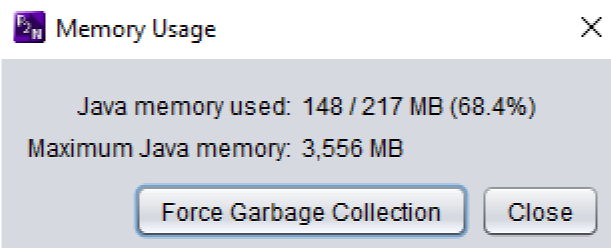
Toggles the *Task Manager*. This window will open as a tab in the bottom center if the GUI. The *Task Manager* tracks the progress of Pix2Net tasks and is especially useful for long running tasks.



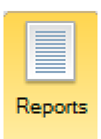
See *Task Manager*

Memory Usage

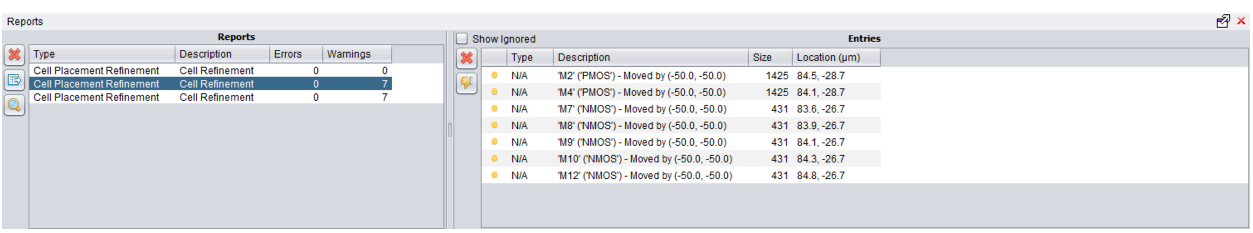
Brings up the *Memory Usage* window. This tells the user how much Java memory has been used and what the maximum java memory is. Also allows the user to force garbage collection.



Reports

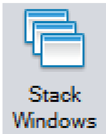


Toggles the *Reports* window. This window will open as a tab in the bottom center.



The left side of the *Reports* window lists all of the available reports, and the right side shows the highlighted report (click on an entry to move to it in the overlay). The user can also click on the magnifying glass on the left side to visualize the selected report as a polygon layer.

Stack Windows

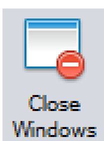


Stacks the windows in the *overlay*. The *netlist-properties* open in the overlay stacked by default.

Tile Windows

Tiles the windows in the *overlay*.

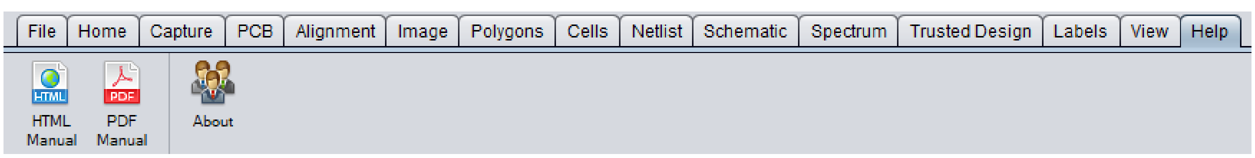
Close Windows



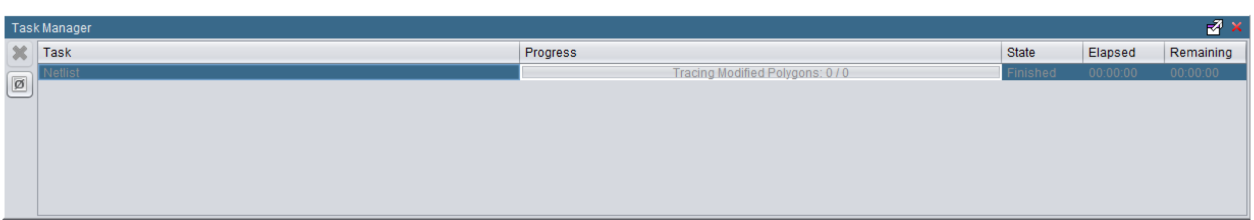
Closes the *overlay* windows.

Help Tab

The *Help* tab contains links to the html and pdf versions of the manual. About shows the current version of the software.



3.1.2 Task Manager



The task manager shows the currently running tasks. You can cancel running tasks. You may also clear finished or canceled tasks.

3.1.3 Status Bar

The status bar is located at the bottom of the application window. It is divided into four areas. From left to right, it displays:

- A progress bar that represents the overall status of the task manager, if at least one task is running. You can click on this area in order to see the task manager.
- The micron coordinates of the area the mouse cursor is currently hovering over.
- The image tile the mouse cursor is currently hovering over.
- The cell instance the mouse cursor is currently hovering over.

3.2 PCB Tab

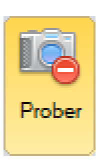
The *PCB* tab controls the printing circuit board prober stage.

NOTE At the moment, the Pix2Net system can only use the PCB prober with a Huntron dual-head probing station. The user also must make sure that the right Capture Mode in the *Capture* tab is on the correct setting according to what is will be captured (image or measurement). The Huntron is compatible with the Semiconductor Characterization System, which applies current to one of the probes while the other reads the voltage. It is also compatible with the Digital Serial Analyzer, where TDR applies voltage and reads it back.

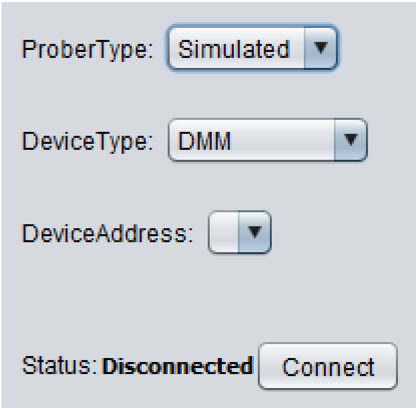
The following tools are available in the PCB tab:

- *Prober*
- *Manual Move*
- *Algin Prober*
- *Move to Point*
- *Grid of Ports*
- *Plot*
- *Capture Config*
- *Start*
- *Stop*

3.2.1 Prober

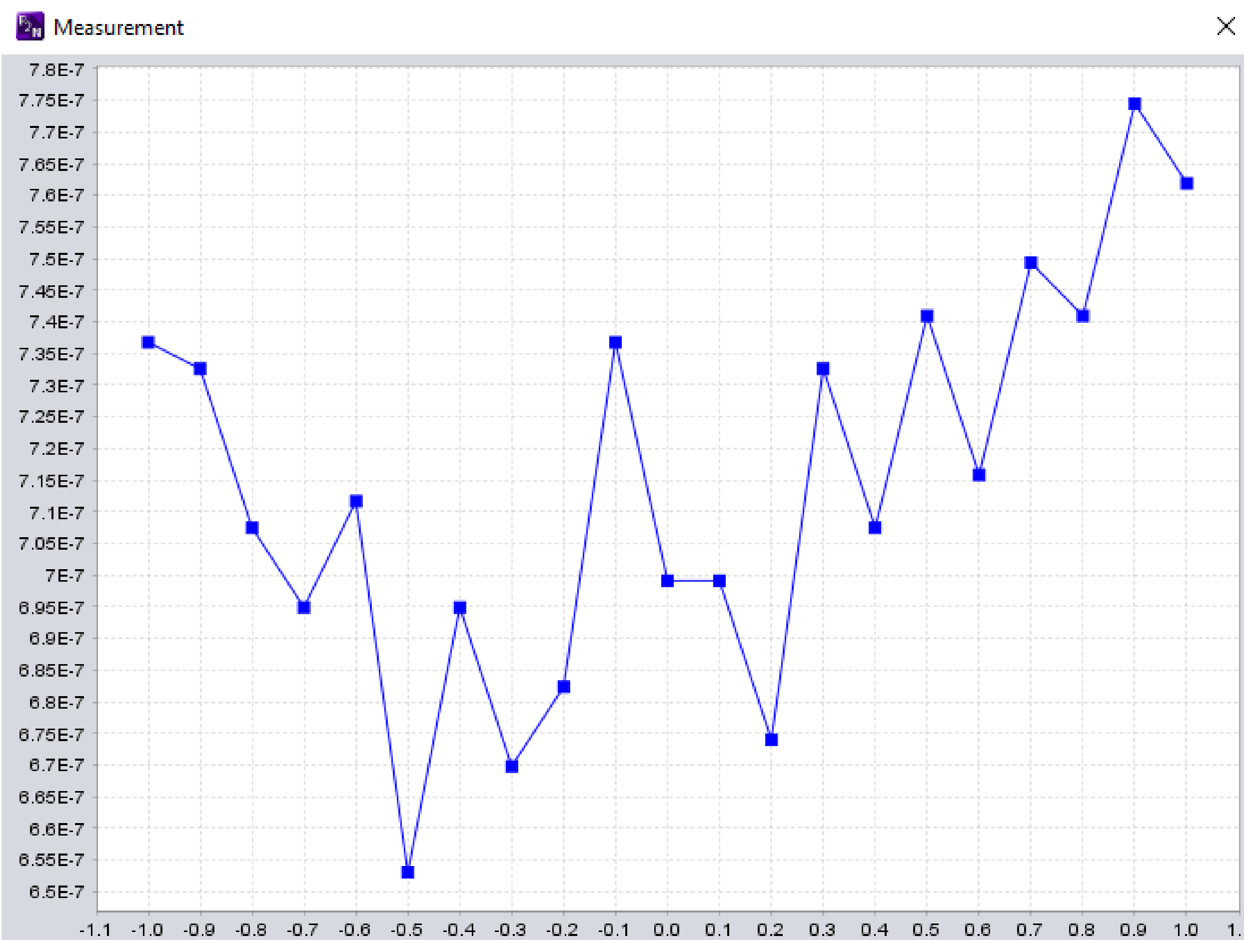


Allows the user to connect to a prober. When the prober is pressed, this menu will pop up:



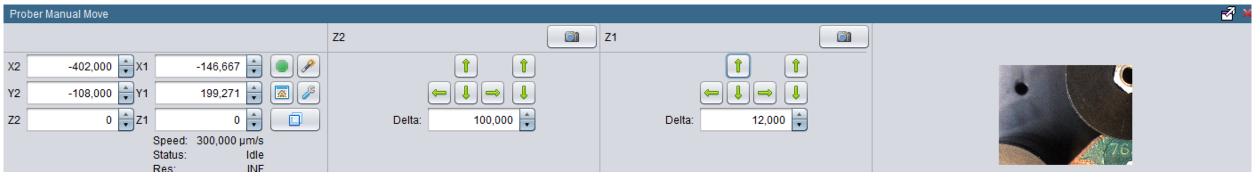
Prober type: Huntron or simulated Device type: DMM, Keithley4200, or DSA8200 Device address: (Addresses of connected devices)

NOTE To take measurements of connectivity through pins, the user must have the Keithley4200 or DSA8200 connected to the Huntron and selected on Pix2Net. Capture the measurement and view in plot, or use manual measurement. This is a similar example of what one might expect to see.



3.2.2 Manual Move

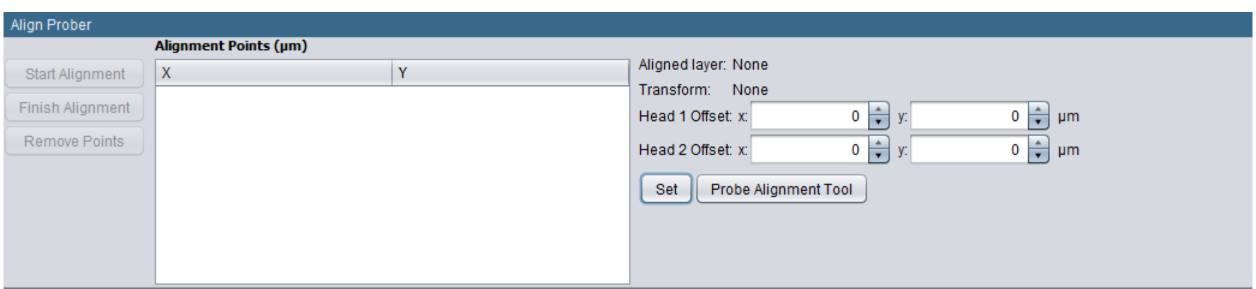
Once the prober is on and hooked up, the user can manually move the prober in units of microns. This window will appear at the bottom of the screen.



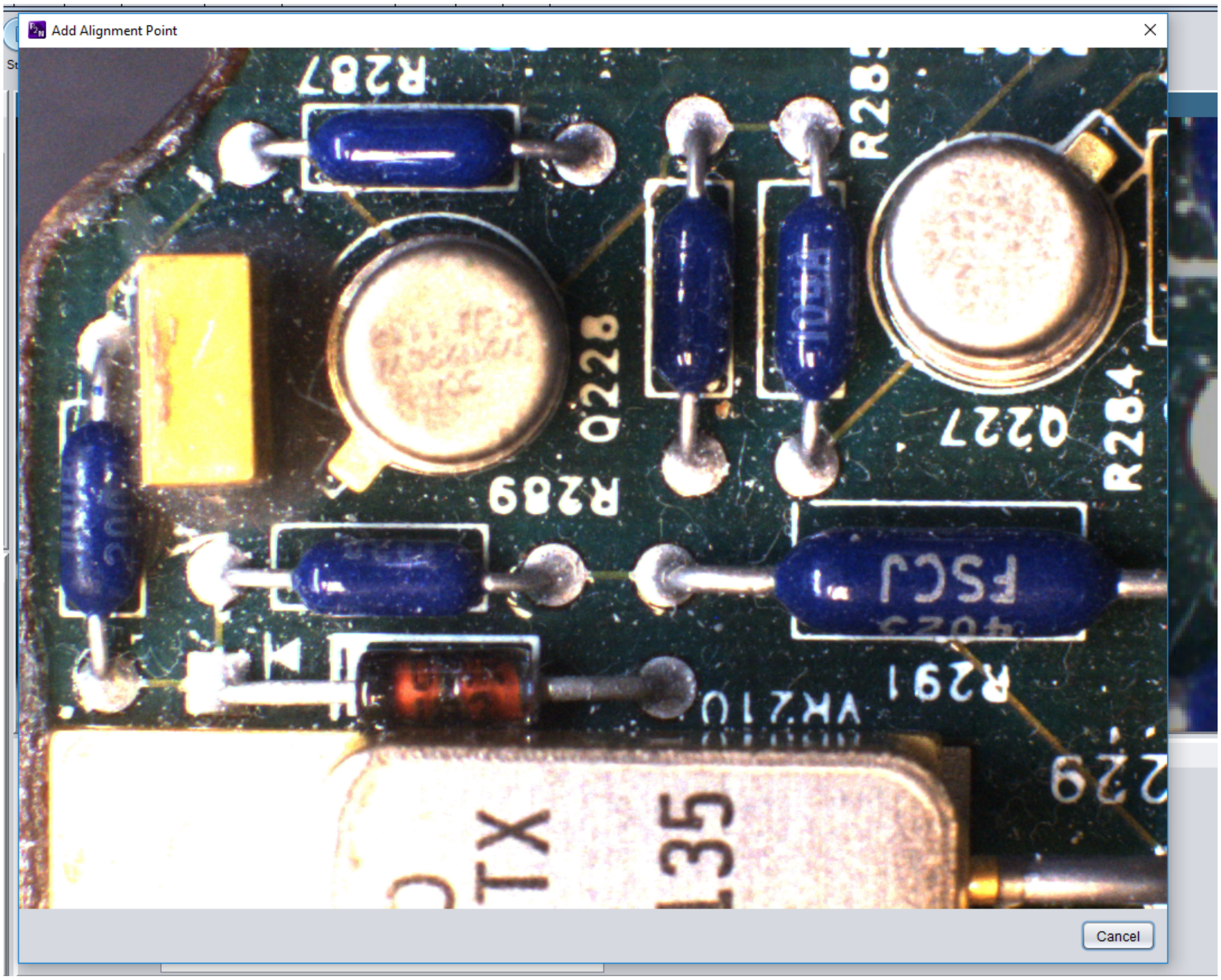
In the first box of numbers and pictures, there are X, Y, and Z (1 and 2) coordinates. These will tell the probers where to be on the board in a 3D axis. The green stop sign tells Pix2Net to send the probers to those coordinates. The wand will allow the user to make a manual measurement. The picture with the home will move the probers back to the home position. The wrench will allow the user to adjust the prober settings. The 2 squares next to each other will create an image capture with the current position as the origin. The Z1 and Z2 boxes control the individual probers. The user can move up, down, left, and right along the board in X, Y coordinates, as well as up and down on the board in Z coordinates. The camera in the top right corners of the boxes will allow the user to capture an image.

3.2.3 Algin Prober

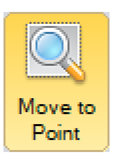
Allows the user to re-align the prober stage. When this is pressed, the Align Prober window will come up at the bottom of the screen.



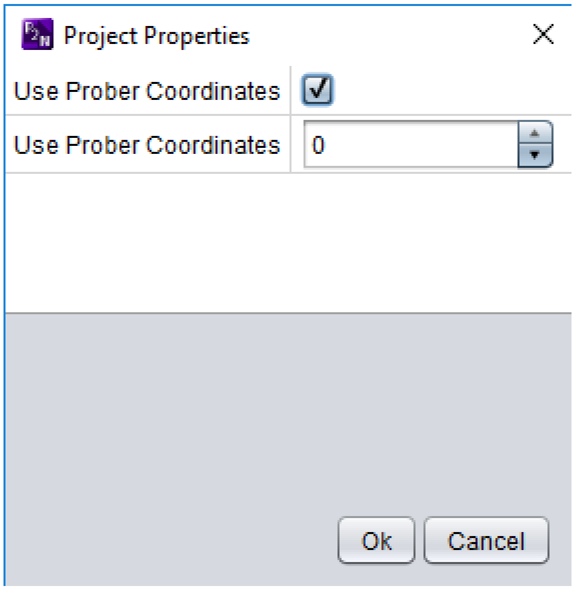
Click on Probe Alignment tool and press in the overlay to set alignment points. When the user left-clicks in the overlay where the alignment point will be, a window with a closer up picture will ask the user to point out exactly where the point will go.



3.2.4 Move to Point

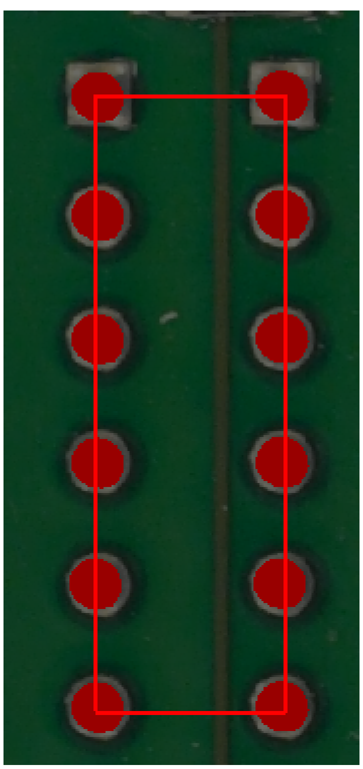


To use this feature, make sure that the alignment process (see above) has been completed. This tells the prober head to move to the position that was clicked in the overlay.

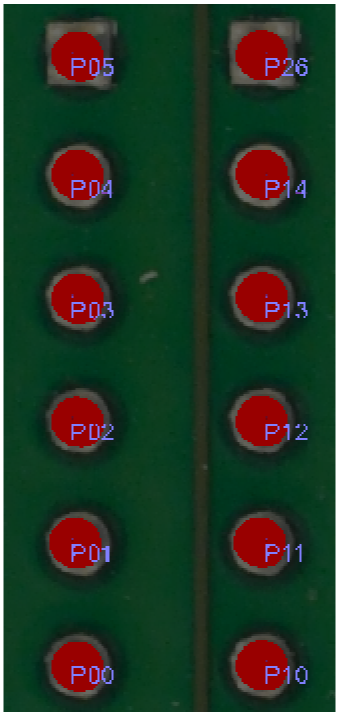


3.2.5 Grid of Ports

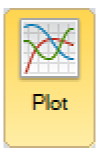
Allows the user to draw a grid of ports. The user must have a Cell Instance selected in the Overlay to activate this tool. When Activated the user can draw a box. Each of the corners of the Box will be the bounds of the port grid.



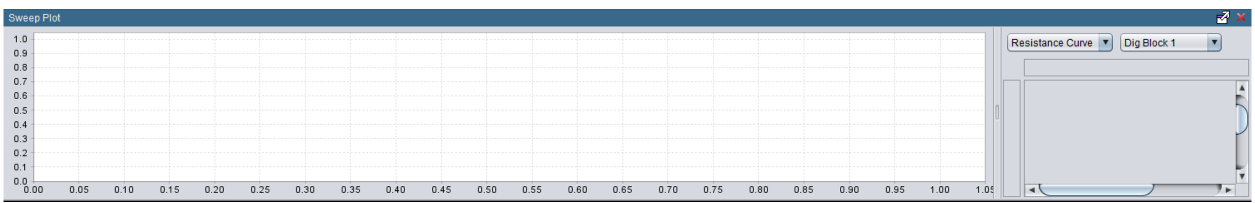
You will be prompted with a dialog that will have two spinners for the number of Columns and Rows. Entering this information and hitting OK will populate all Cell instances will a grid of Cells.



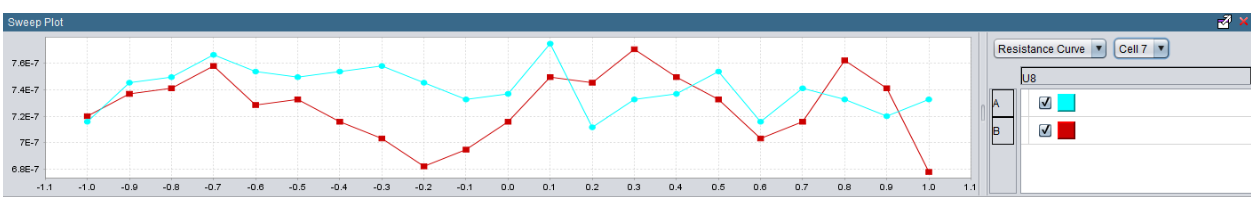
3.2.6 Plot



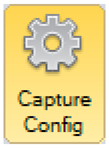
Shows the plot of the resistance curve or TDR curve of cells. Clicking Plot will bring up this window at the bottom of the screen.



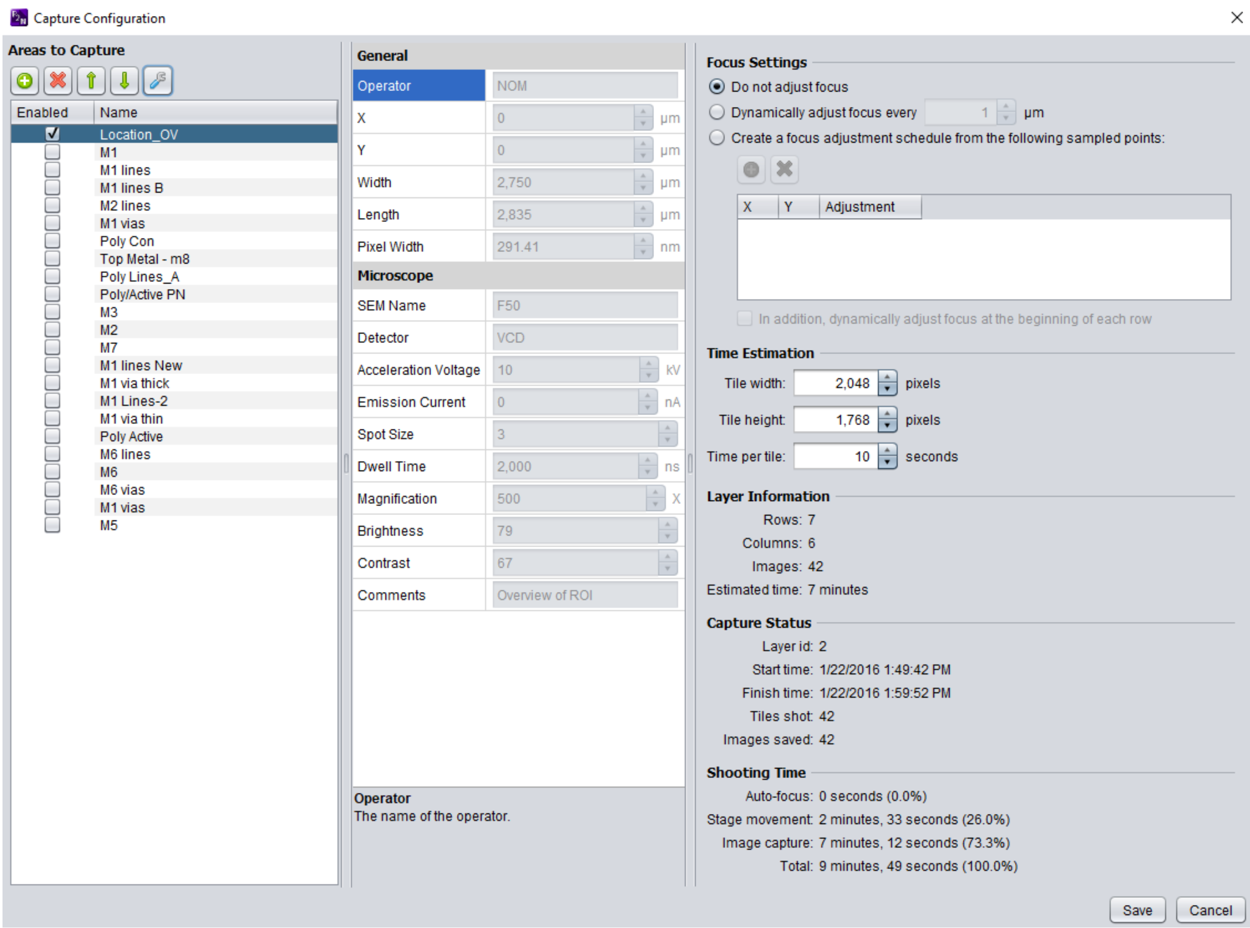
When a cell is selected and ports are placed, Pix2Net and the prober can make a sweep plot of the cell.



3.2.7 Capture Config

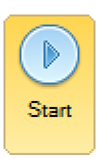


Opens the Capture Config window:



Allows the user to choose which areas to capture, as well as adjust the major and general settings.

3.2.8 Start



Starts the prober

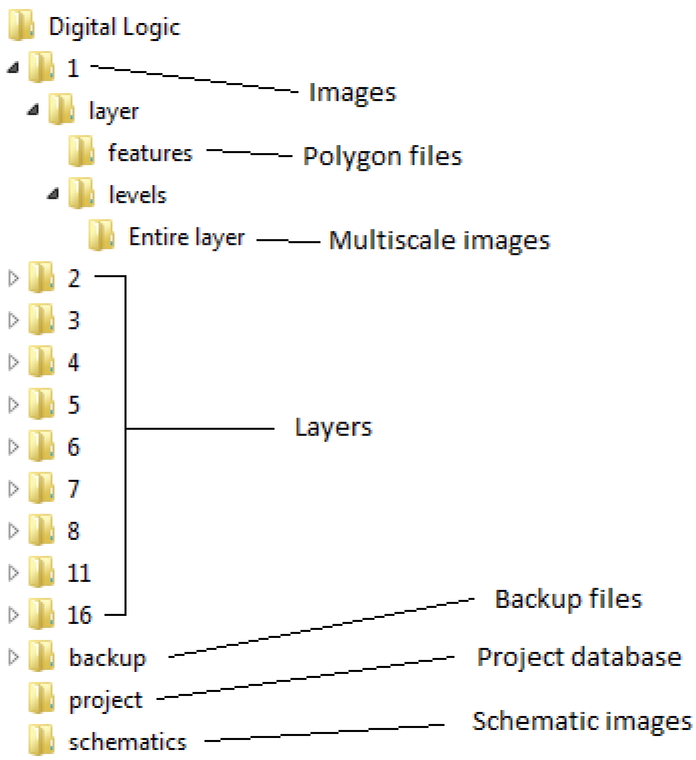
3.2.9 Stop

Stops the prober

3.3 Projects Basics

3.3.1 Project Directories

The directory structure of an example project:



3.3.2 Technology

This dialog is used to configure the properties of the target device. These properties should be filled out before updating the netlist or running cell identification.

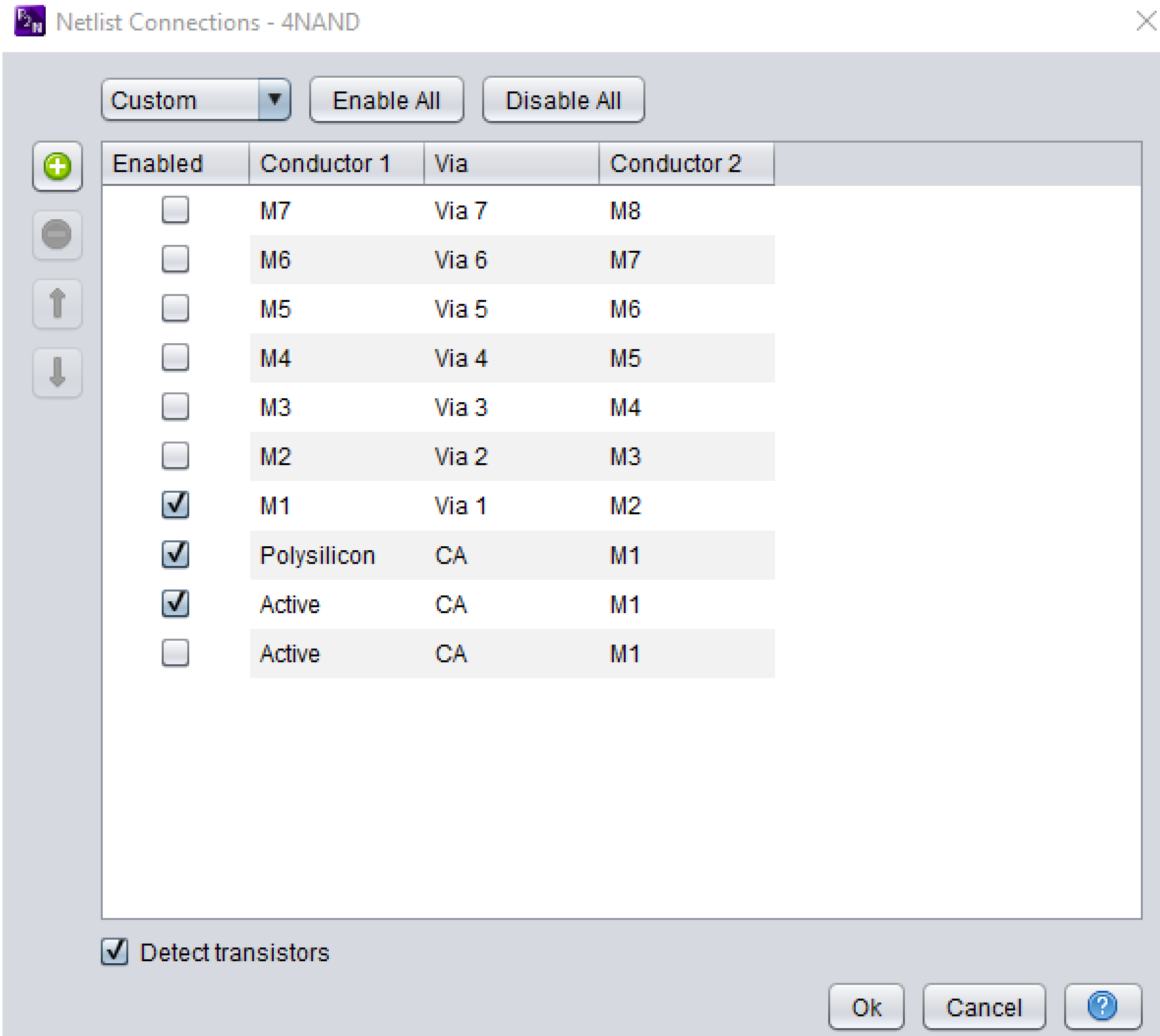
In the Layers section we will identify four special polygon layers: `Metal 1`, `Polysilicon`, `P Diffusion` and `N Diffusion`. The cell identifier will use these layers to search for transistors.

> *Note: Legacy projects will need to regenerate a new diffusion by following these steps:*

Click `Generate Diffusion` to have the software create a new layer. *Generate Diffusion*

The new layer is called `diffusion minus poly`, but it can be renamed to whatever you see fit. Use the `diffusion minus poly` layer under the `Generated Layers` section of the `Technology`

3.3.3 Netlist Connectivity



In the Connections section, the connections between layers are specified. When Pix2Net generates a netlist, it uses the connections to determine if polygons on different layers may touch or not. For example, if you specify `m2`, via `m2 vias`, `m3`, then that means polygons in the `m2` and `m2 vias` layers may touch each other, and polygons in the `m2 vias` and `m3` layers may touch each other. Connections can be disabled for debugging purposes. See also *Netlist Connections*

3.4 Importing and Exporting

3.4.1 Importing Existing Images

In order for Pix2Net to import a set of images, the following requirements must be met:

- The images must be contained in a single directory.
- The images must overlap (ideally by 10%).
- The images must have a number in their name that specifies the order they were captured in.

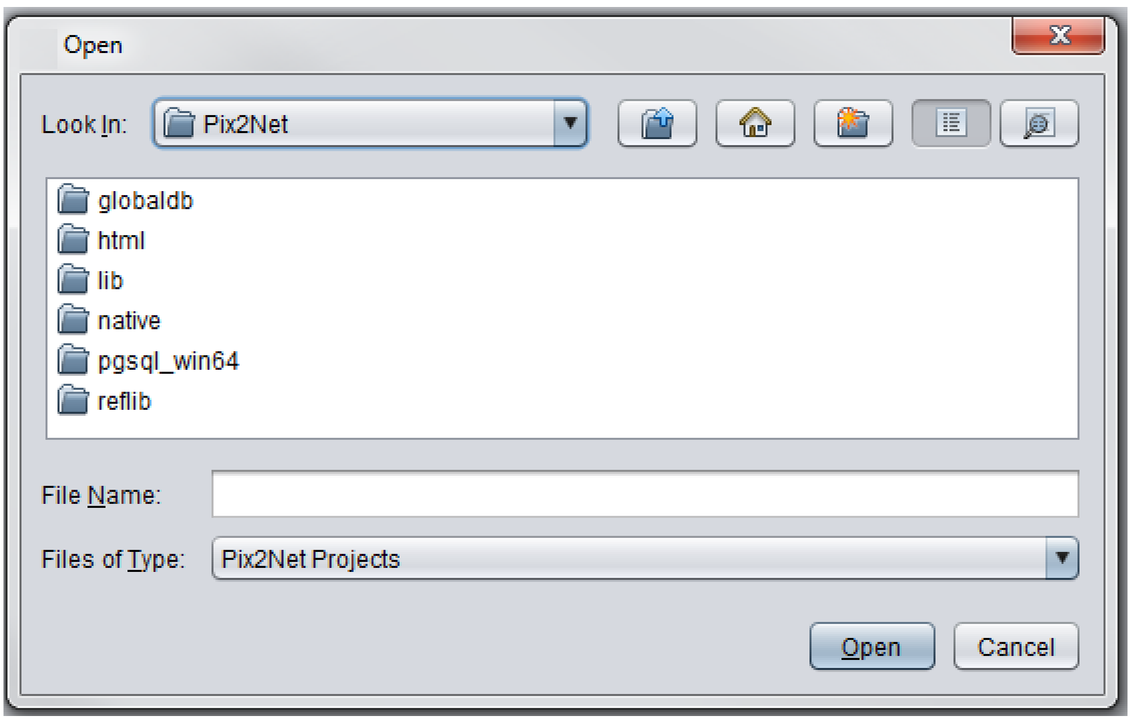
- The images must all be the same size and in the same format (BMP, TIFF, JPEG, or PNG).

You will be asked for the number of columns, the number of rows, the overlap percentage, and the pixels per μm. If you don't know the pixels per μm, you can put in a dummy number, but keep in mind that the ruler will only be as accurate as the pixels per μm is.

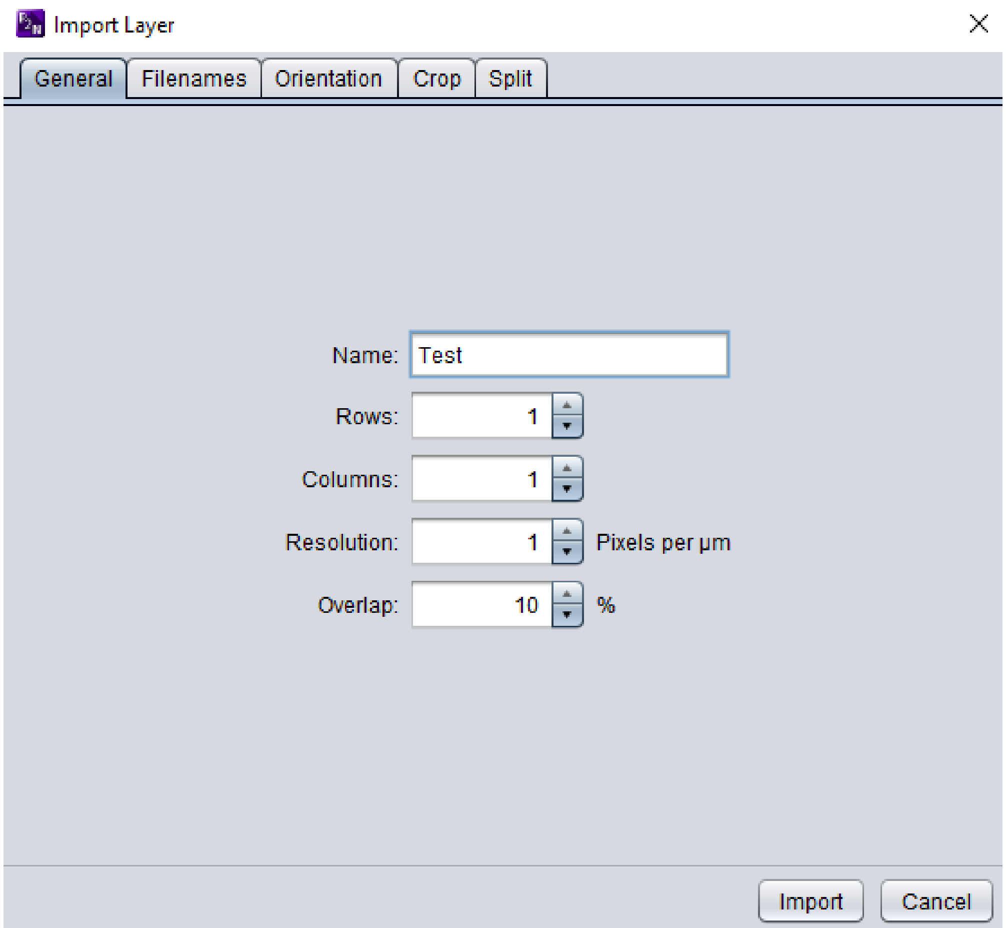
1. Open the desired project or create a new project.
2. On the file tab click `Import`, and select `Multiple images`.
3. Browse to the directory where the images are stored and click the Open button.
4. Fill out the fields in the `Import Layer` dialog and click the Import button.
5. The images will be copied into the project directory (a progress bar is not shown), and then a set of *multiscale images* will be generated (a progress bar is shown).

After the multiscale generation completes, the new image layer is visible. However, the image layer will not look good until the tiles are stitched.

3.4.2 Importing



The *General* tab:



Name: name of the image set (in Pix2Net)

Rows: number of rows

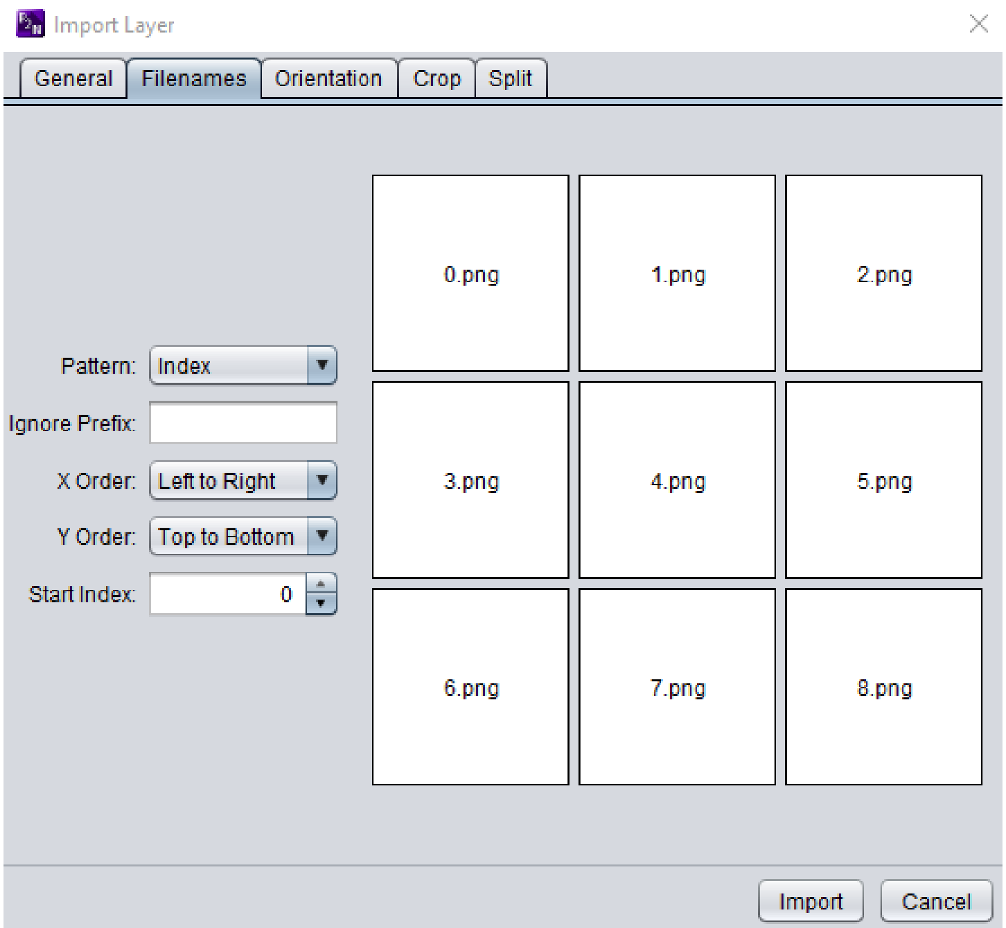
Columns: number of columns

Resolution: image resolution in pixels/um

Overlap: overlap percentage

The *Filenames* tab:

When not using the Pix2Net capture feature, this tab helps the user sort out pictures in the order that is needed.



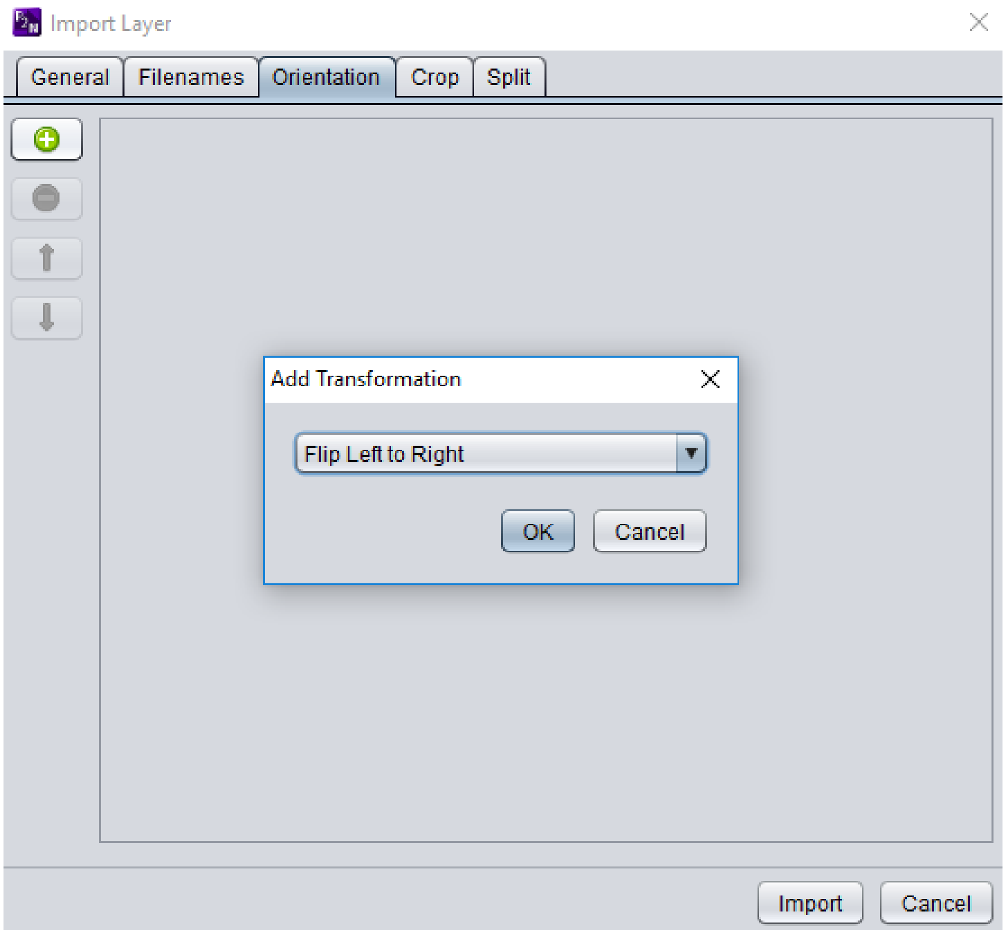
Pattern: Choose between Index, X Y, or Y X.

Ignore Prefix: If the

X and Y Order: When collected, choose how the images are raster Left to Right, or Right to Left (X); Top to Bottom, Bottom to Top (Y).

Start Index: number of first tile

The *Orientation* tab:



Add orientation transformations by clicking the green plus sign.

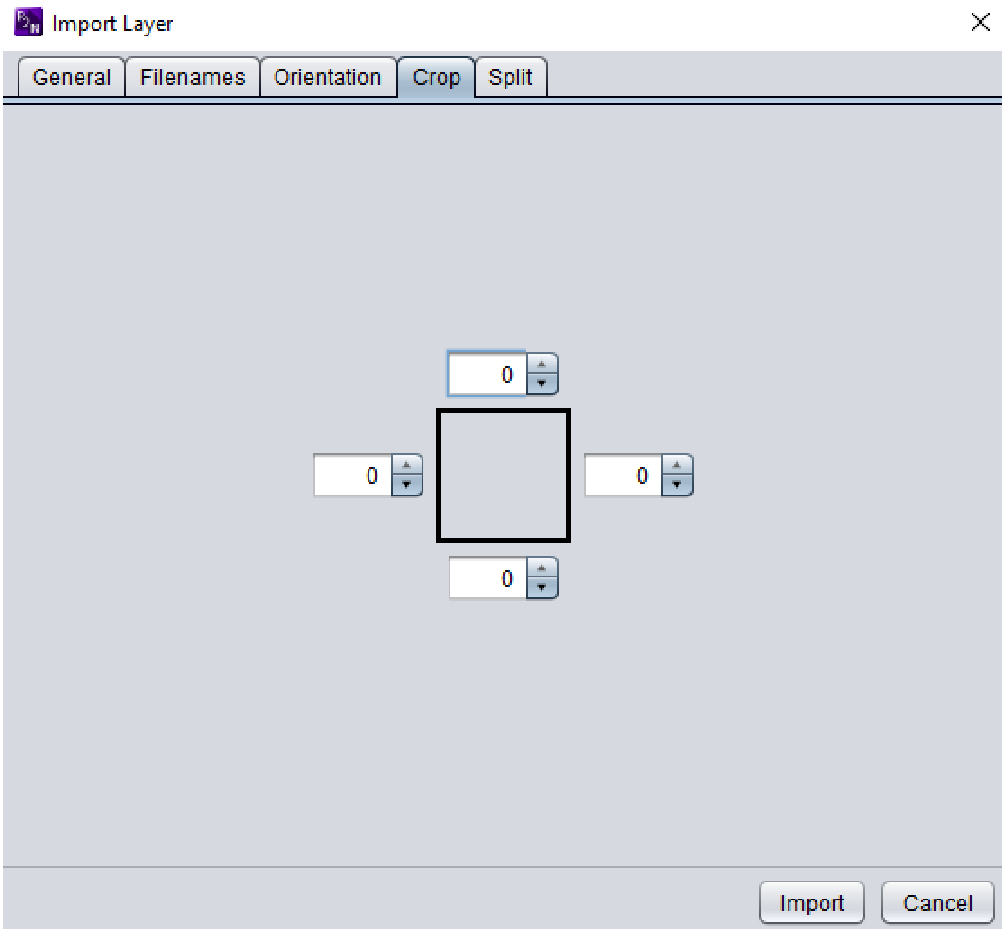
Flip Left to Right

Flip Top to Bottom

Rotate 90 degrees Clockwise

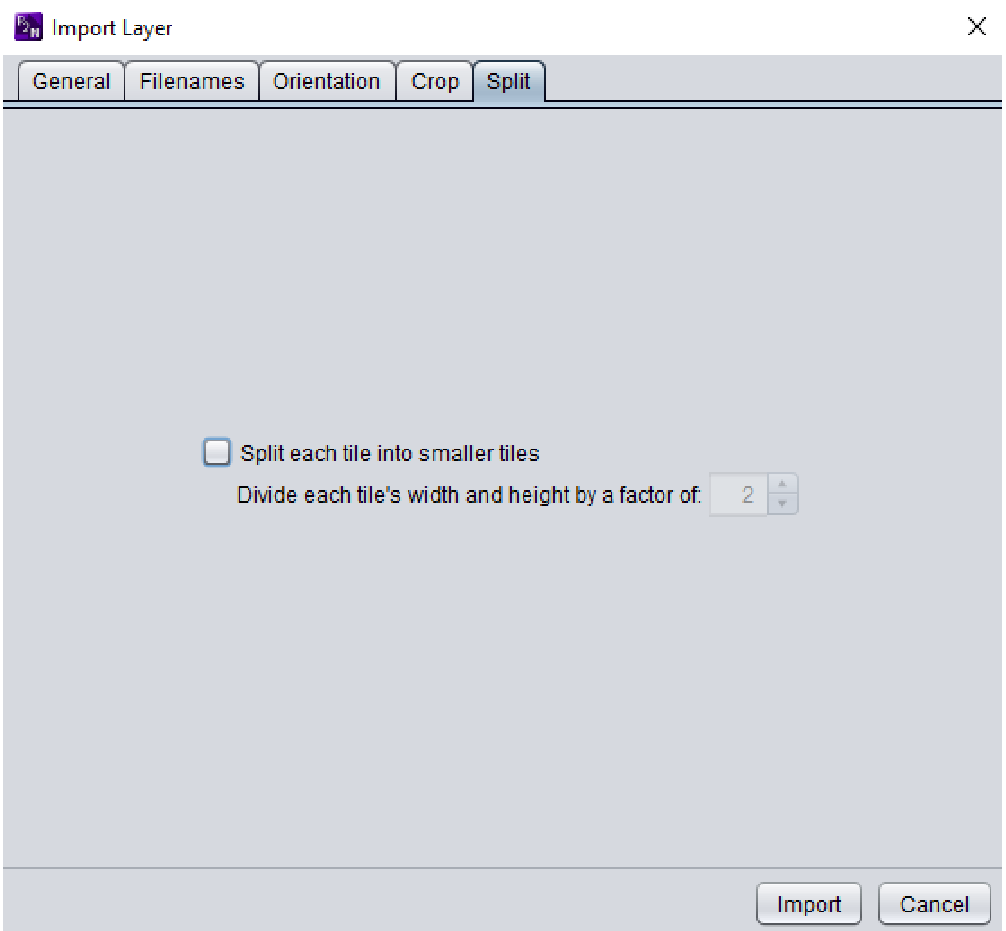
Rotate 90 degrees Counter-Clockwise

The *Crop* tab:



Crops the image as it is imported by the number of pixels specified on each edge.

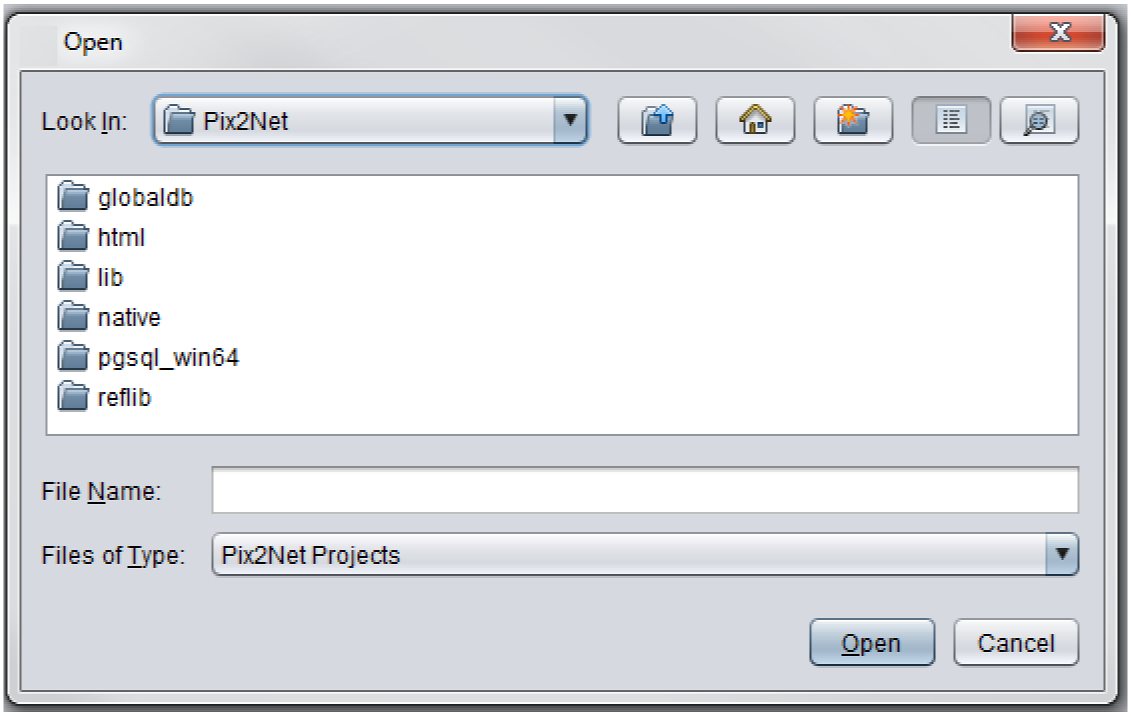
The *Split* tab:



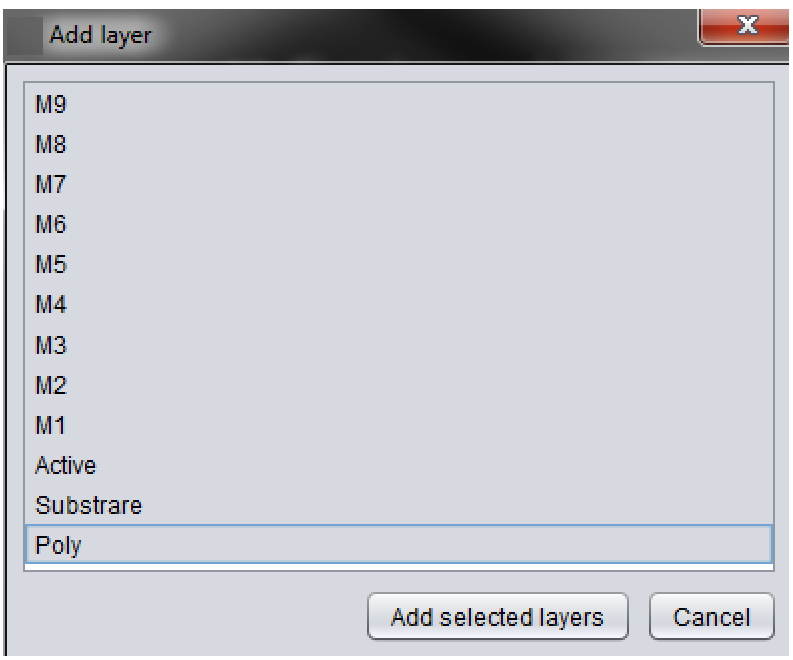
Allows the user to split each tile into smaller tiles and is able to divide the tile's width and height by a certain number.

Pix2Net layer form existing project. . .

Imports a layer from an existing Pix2Net project.



Select the desired layer(s) from the list.



In order to import a multiscale image set into a Pix2Net as a layer, perform the following steps:

1. In a Pix2Net project, use the Import Multiple Images feature. Point it at the directory you saved the images in. Do not select "stitch after import" or "allow gaps."
2. Under the general tab, fill out the settings.

1. Name – The name to use for the new layer
2. Rows – Calculated by dividing the total number of images by the number of columns (see 'c' below).

3. Columns – The number of multiscale images that make up a single row. Determine this number by looking at the first image and counting until the image displays the end of the first row.
4. Resolution – The pixels per micron of the multiscale layer. This value determines the scaling to use for micron rulers and the size legend on the overlay. If you're just using Pix2Net to view the multiscale image, you can ignore this value, but the rulers will be incorrect.
5. Overlap – For importing multiscale images, set the value to 0%.

3. Under the filenames tab, fill out the settings (see attachment for example).

1. Pattern – For multiscale import, set this to "Y X"
2. Ignore Prefix – For multiscale import, set this to the first part of the filename for the images being imported. For example, "IL01". This must be correct, or the import will fail.
3. X Order – For multiscale import, set this to "Left to Right."
4. Y Order – For multiscale import, set this to "Top to Bottom."
5. Start Index – For multiscale import, set this to 0.

4. Click the "Import" button.

Edited images…

Split image into tiles…

Indexed tiles…

GDSII file

Converts a GDSII file into a set of Pix2Net layers, and then adds those layers to the project.

Pix2Net layer from images

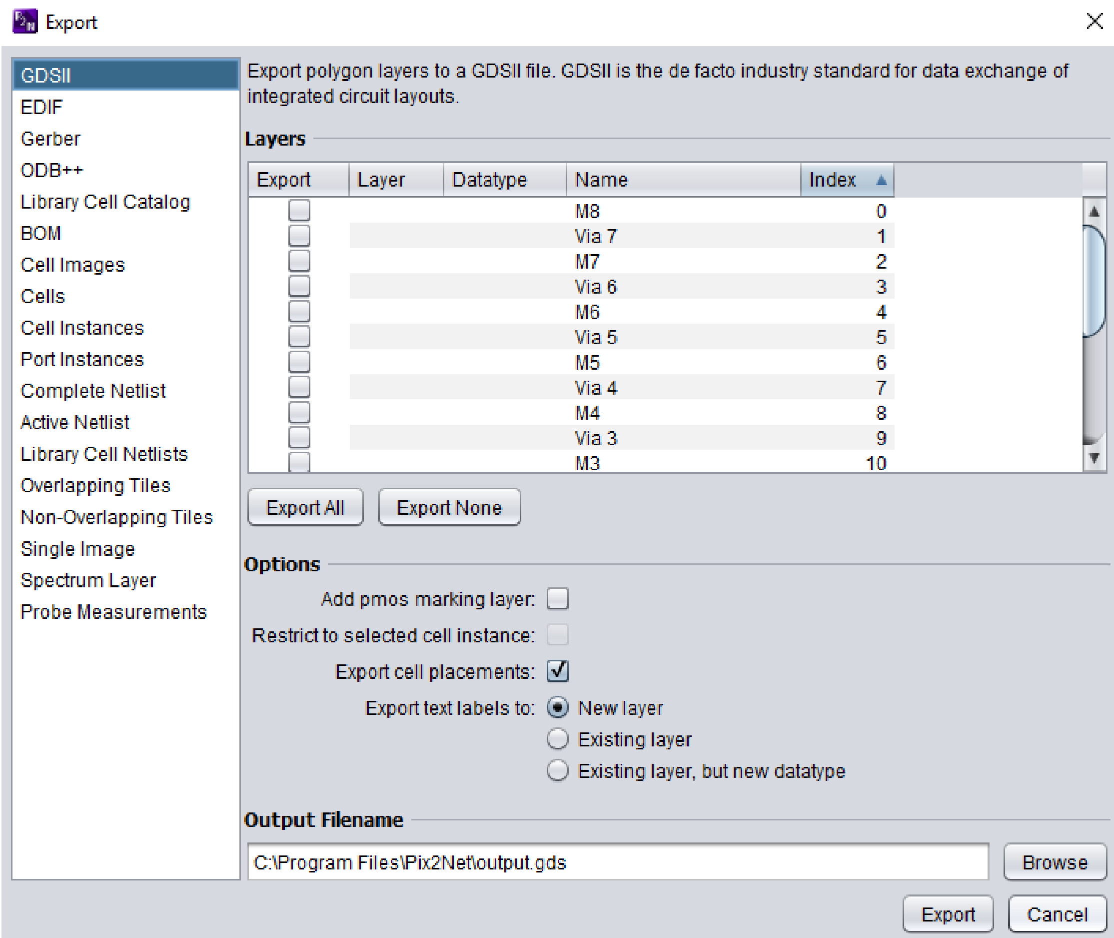
Creates a new image layer from a set of sequentially numbered images on the file system, which have been captures by SEM. A dialog window will appear to allow complex configuration of the import process to match the format of your images.

Pix2Net layer from existing project

Copies one or more Pix2Net layers from an existing project to the currently open project.

3.4.3 Exporting

Exporting GDSII



Check the layer(s) to export. Double click under *Layer* or *Datatype* to add numerical information.

Export All selects all layers. *Export None* deselects all layers.

Add pmos marking layer: Checking this adds a small box of 'pmos' to the active to help distinguish between n-type and p-type diffusion

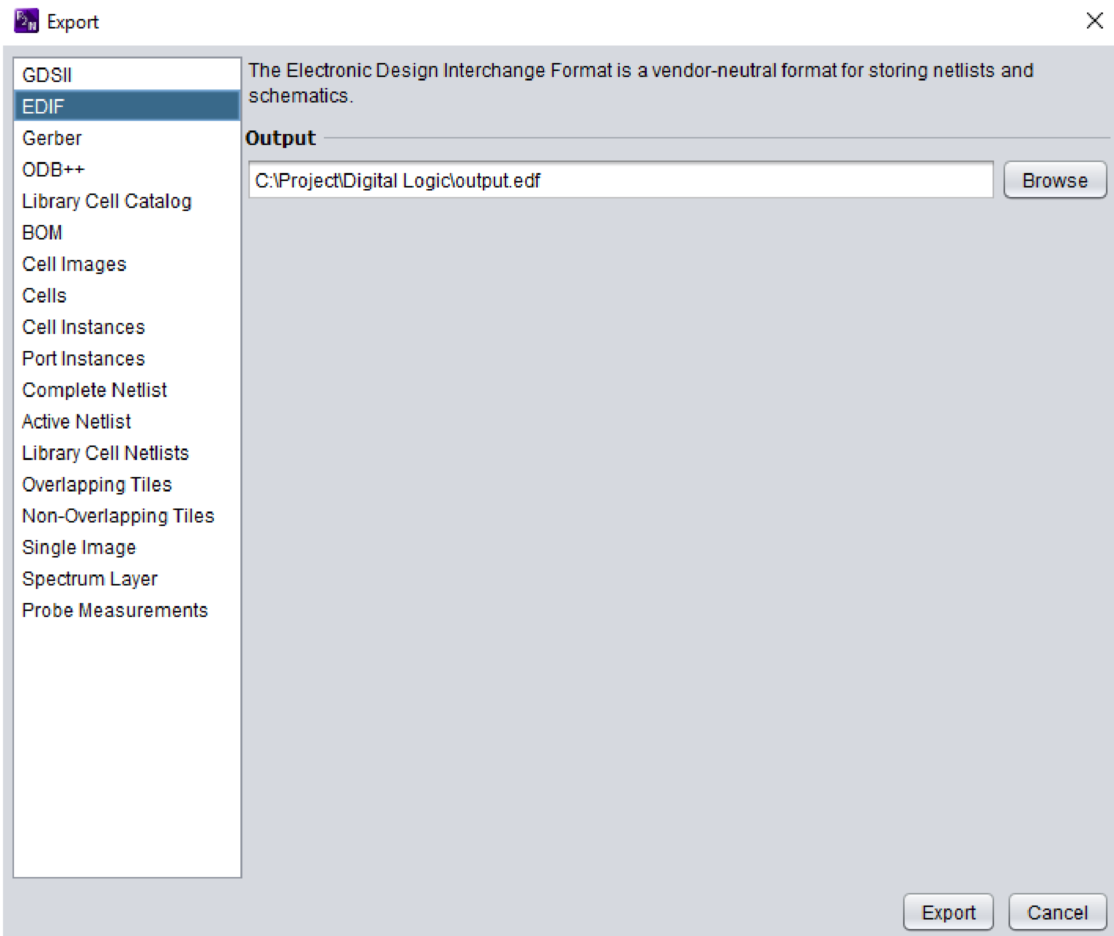
Restrict to selected cell instance: The gdsii layers will be exported within the boundary of the selected cell. When left unchecked, gdsii of the entire area is exported

Export cell placements: Exports cell boundaries as a layer

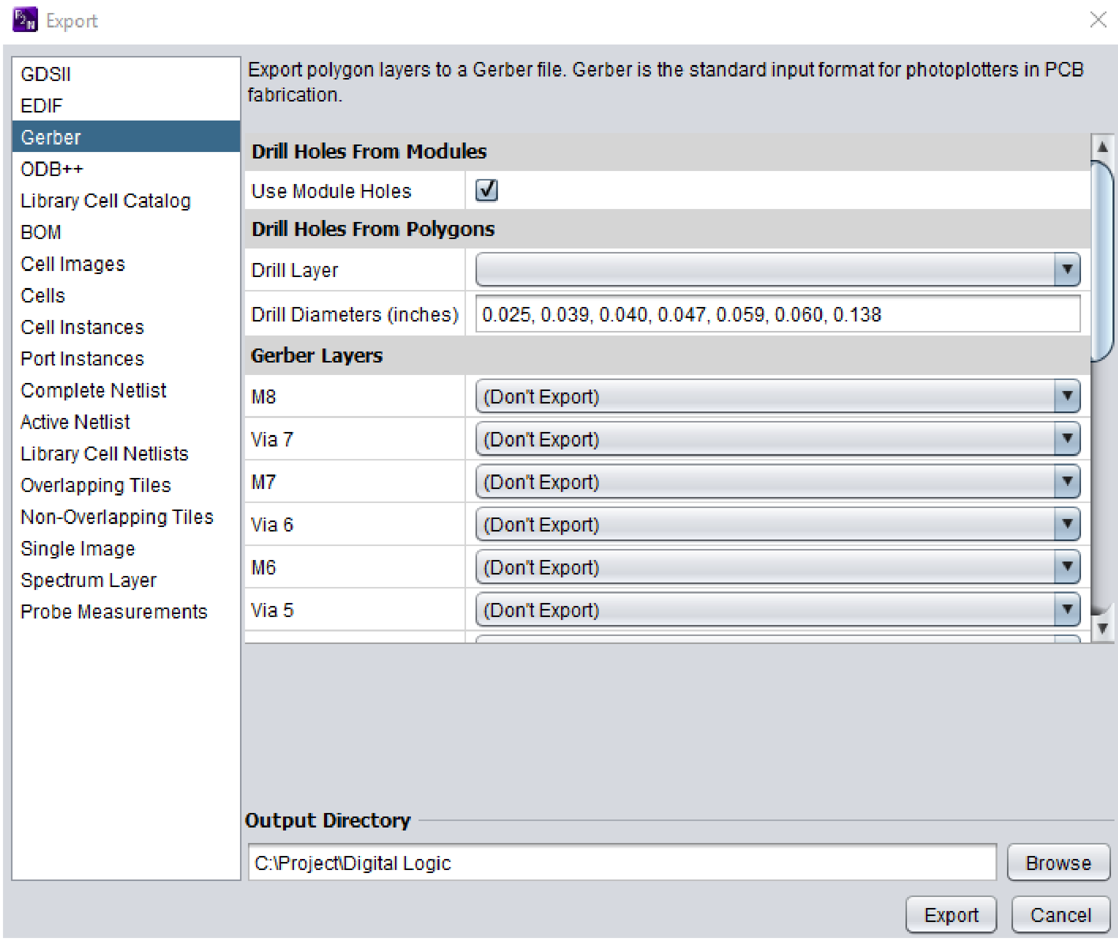
Export text labels: allows selecion between exporting labels on a new layer, an existing layer same datatype, or an existing layer with a new datatype.

Output Filename: Specify where to store the gdsii file, and how to name it.

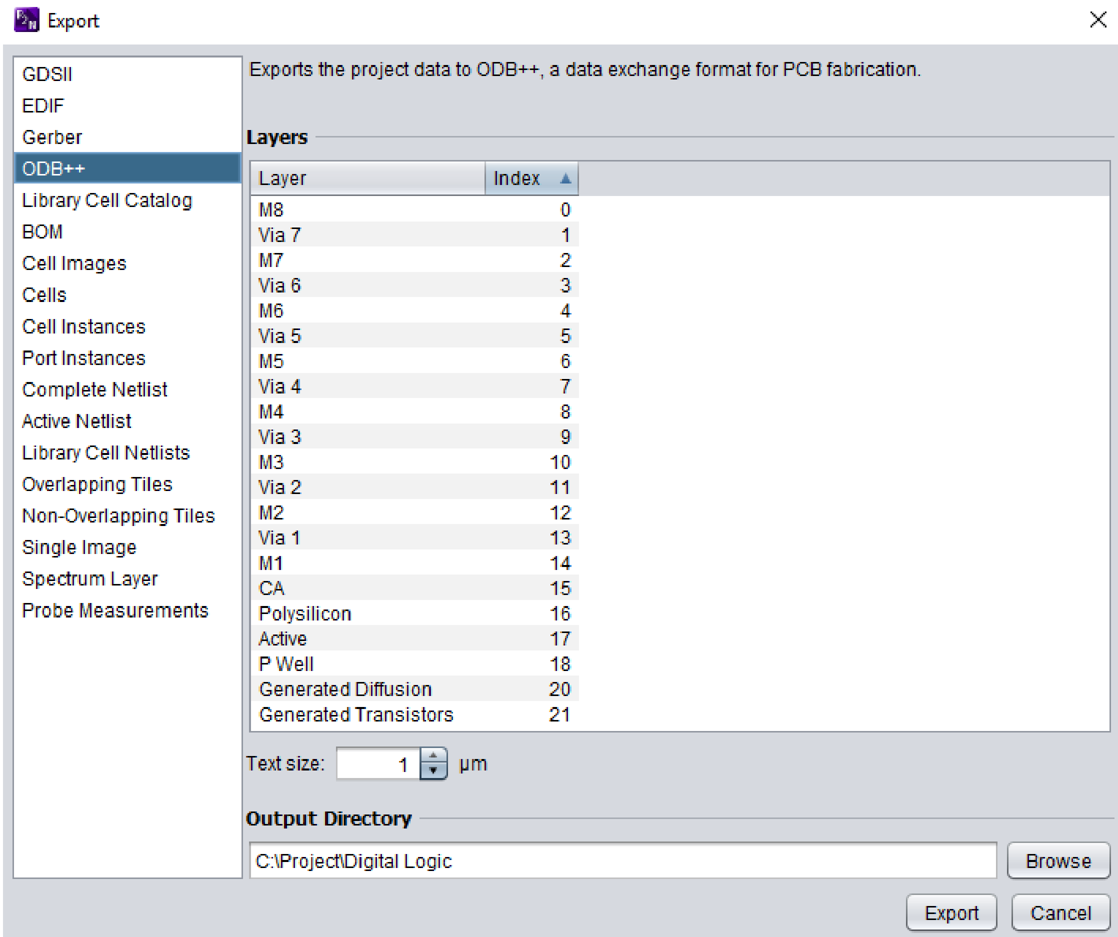
Exporting EDIF



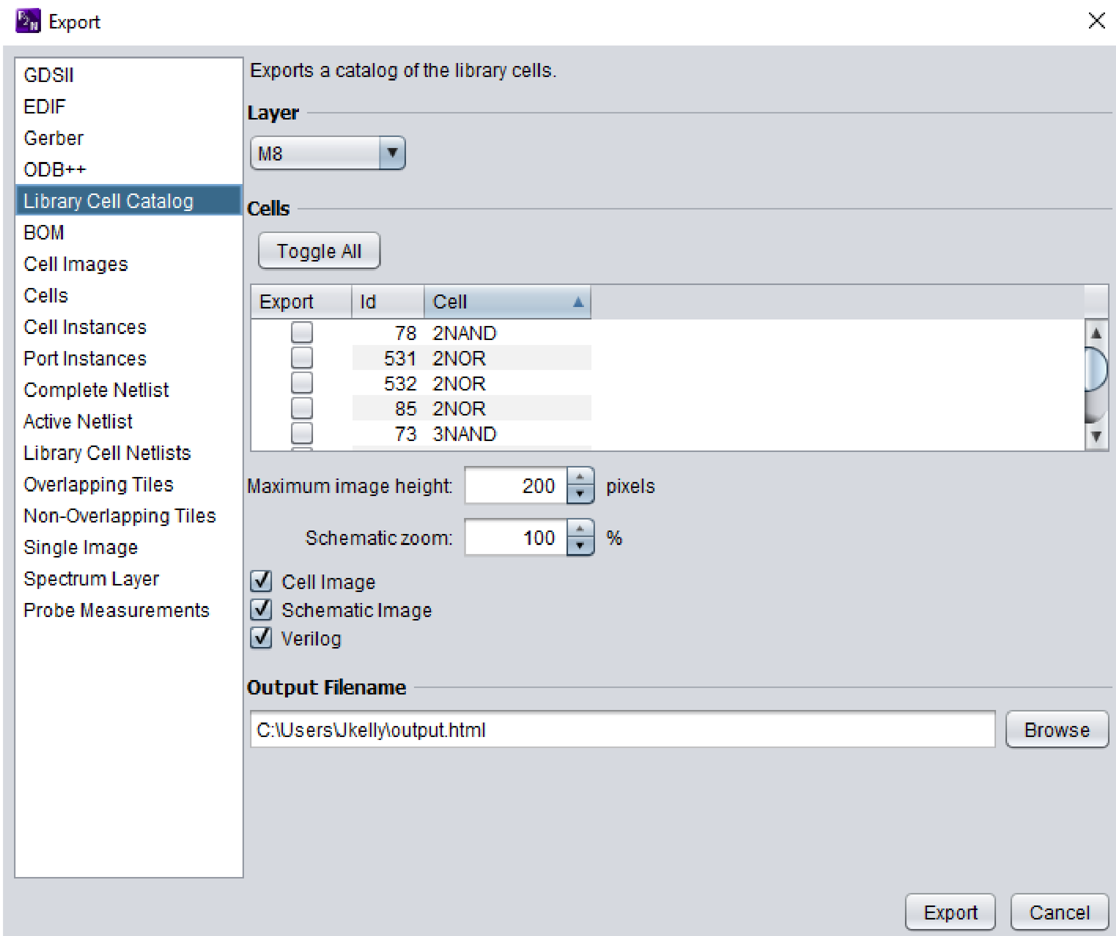
Exporting Gerber



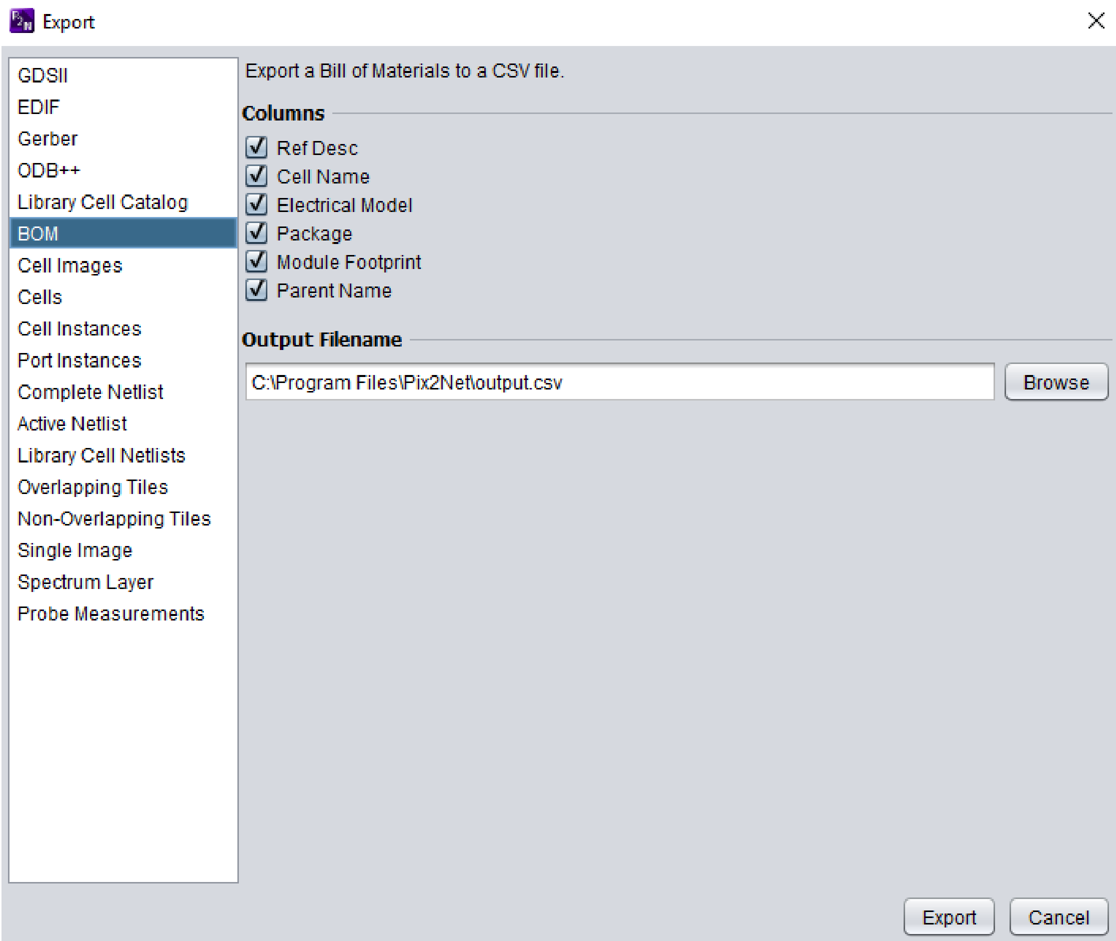
Exporting ODB++



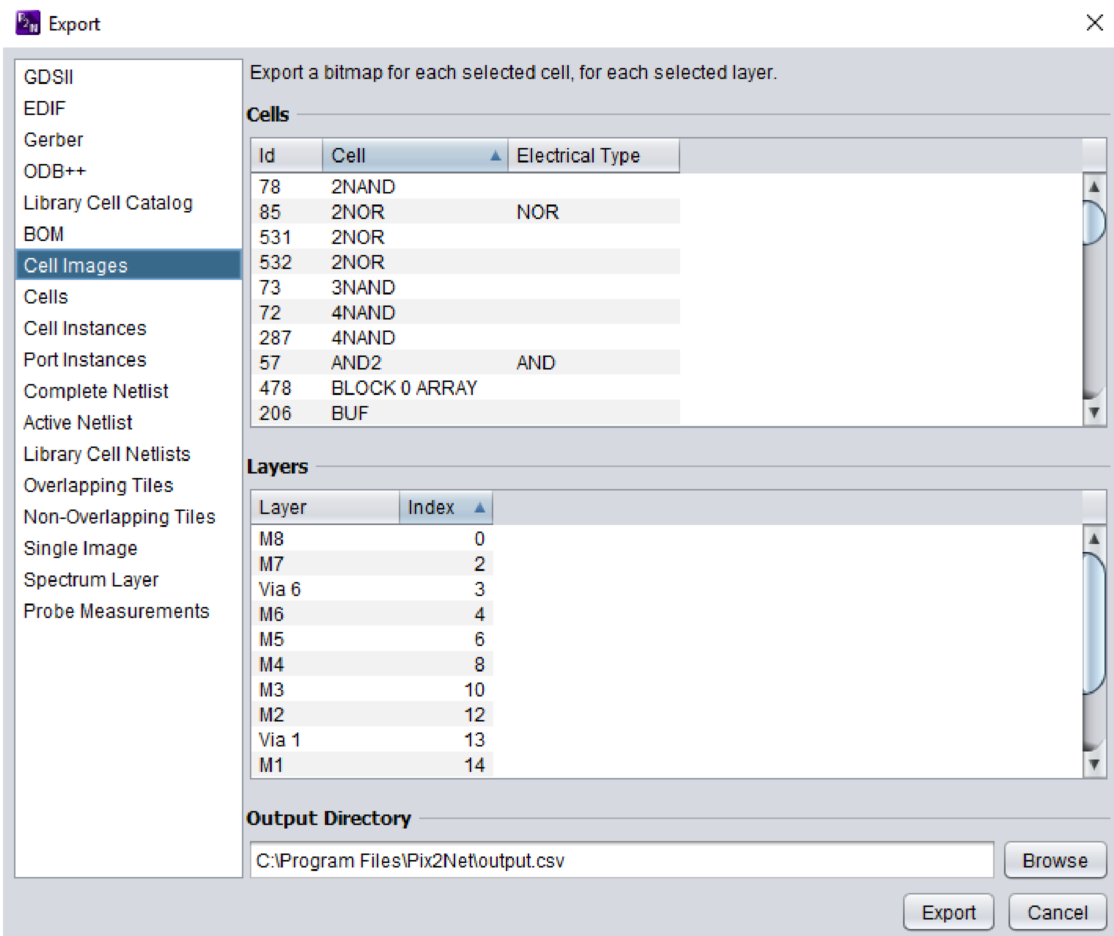
Exporting Library Cell Catalog



Exporting BOM

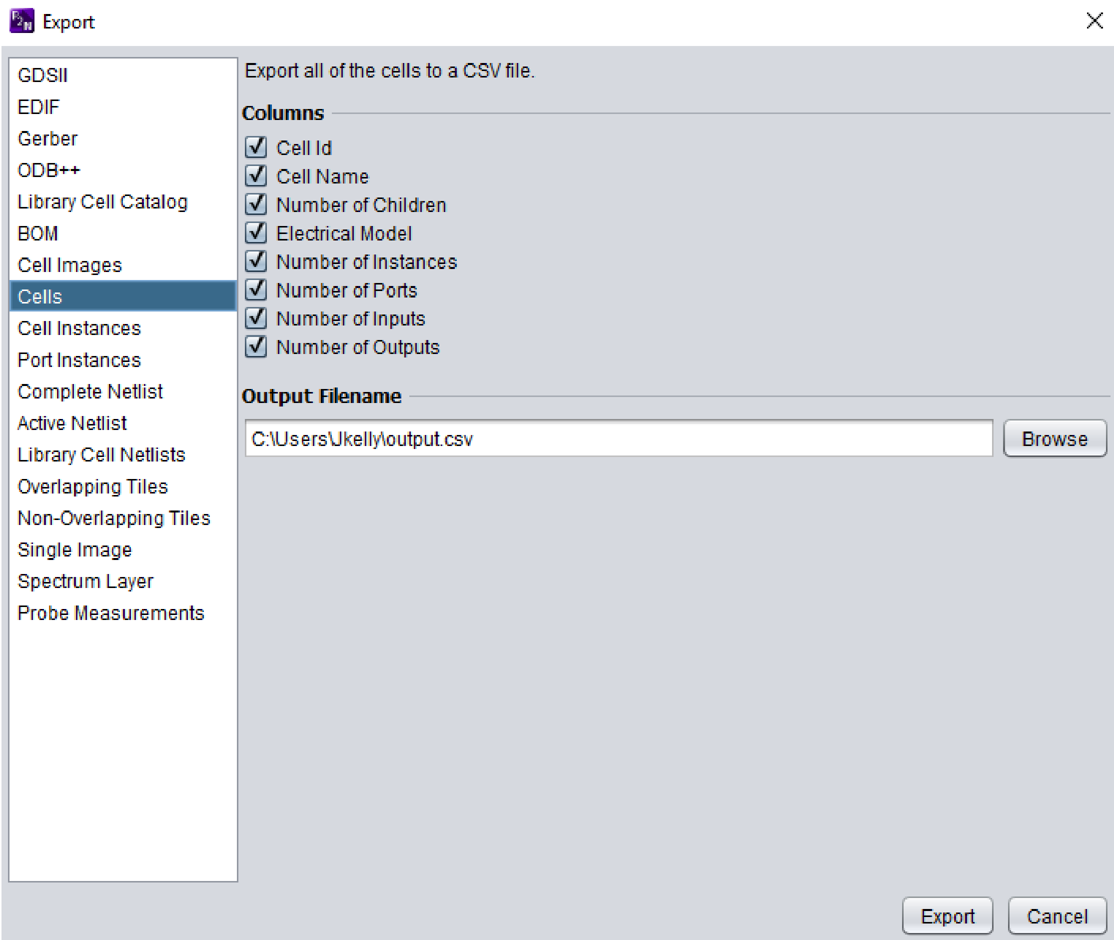


Exporting Cell Images

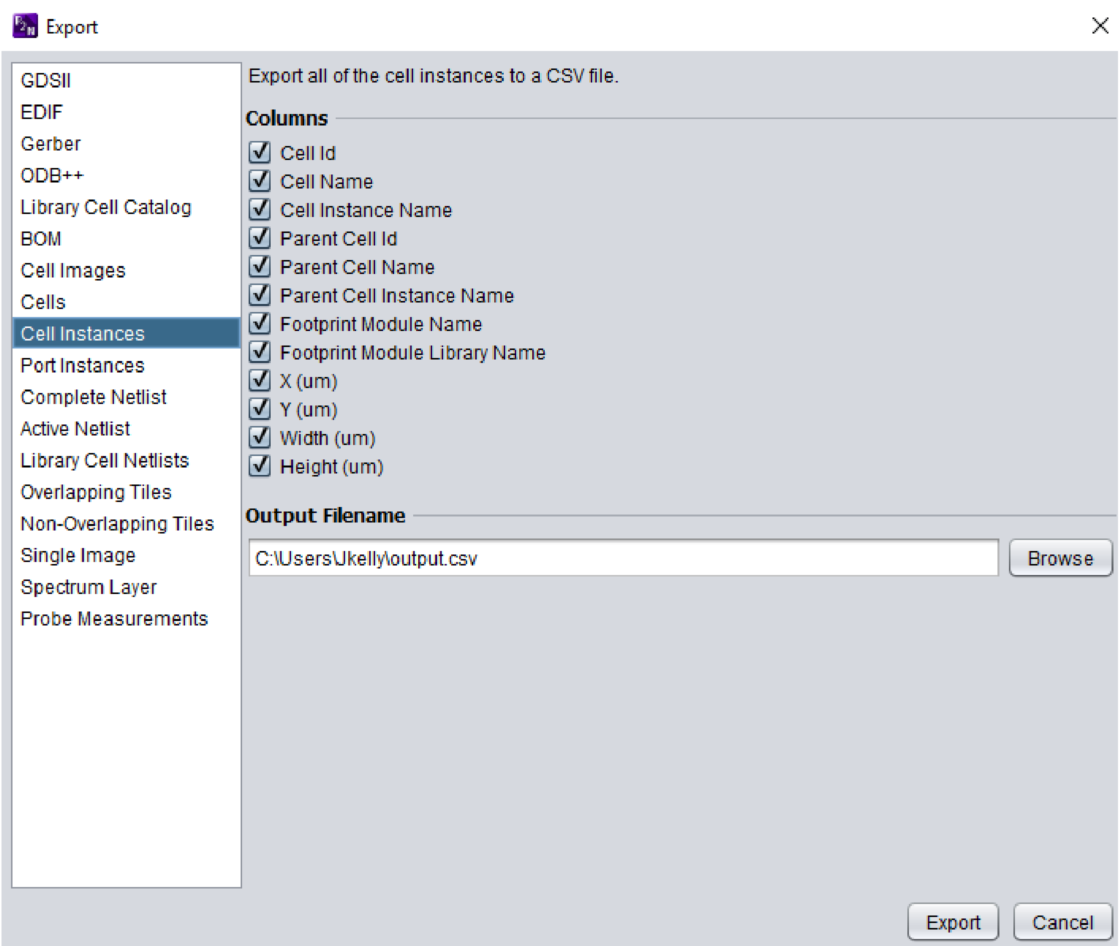


Select the desired cells. Select the desired layer. An image will be exported for each cell/layer combination.

Exporting Cells

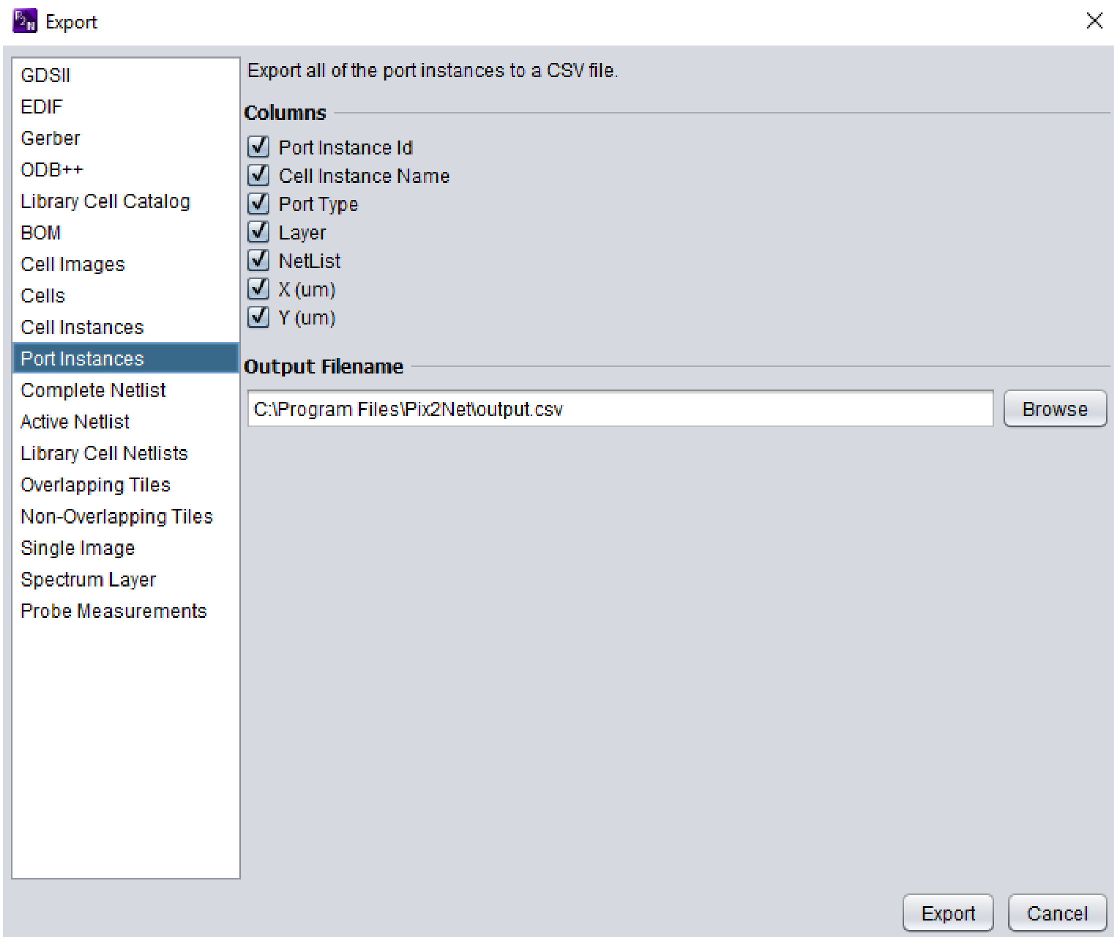


Exporting Cell Instances

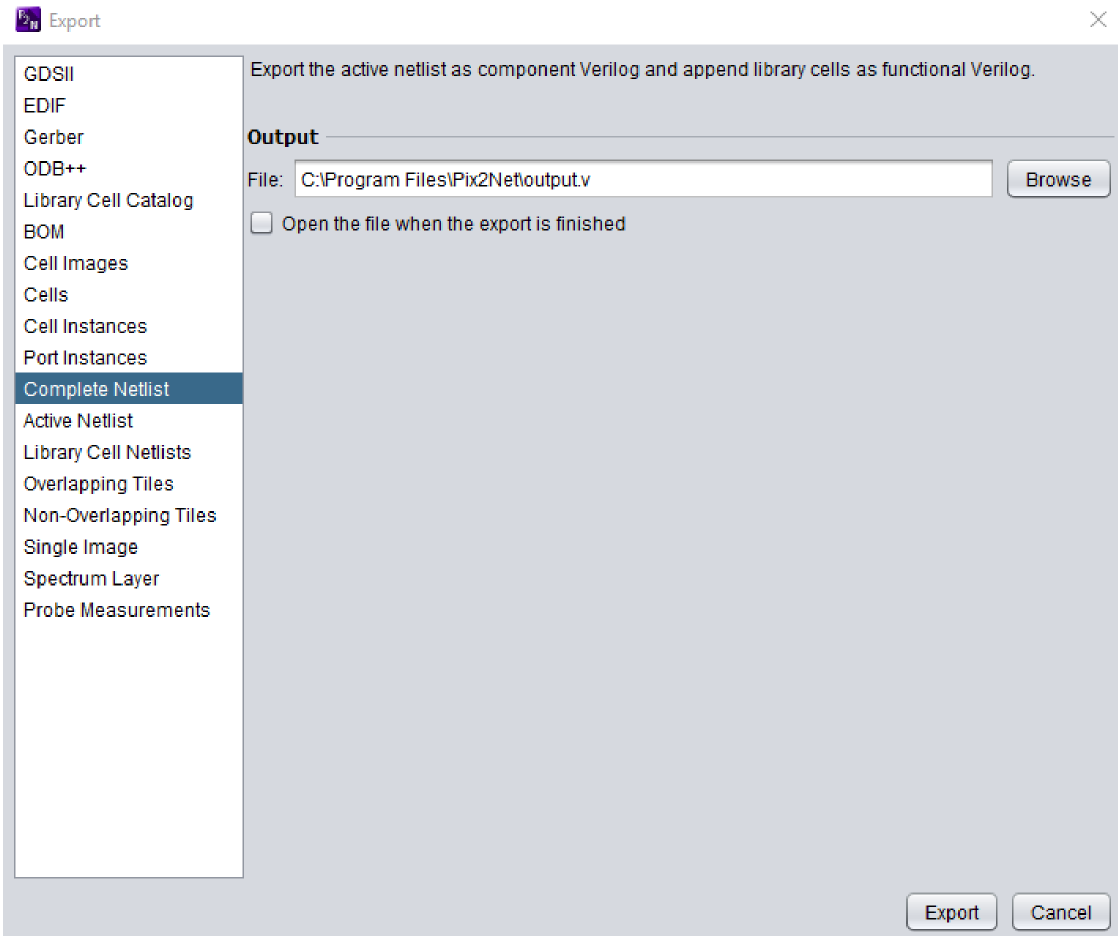


Select the desired column headings. The result is a .csv file of all cell instances in the project.

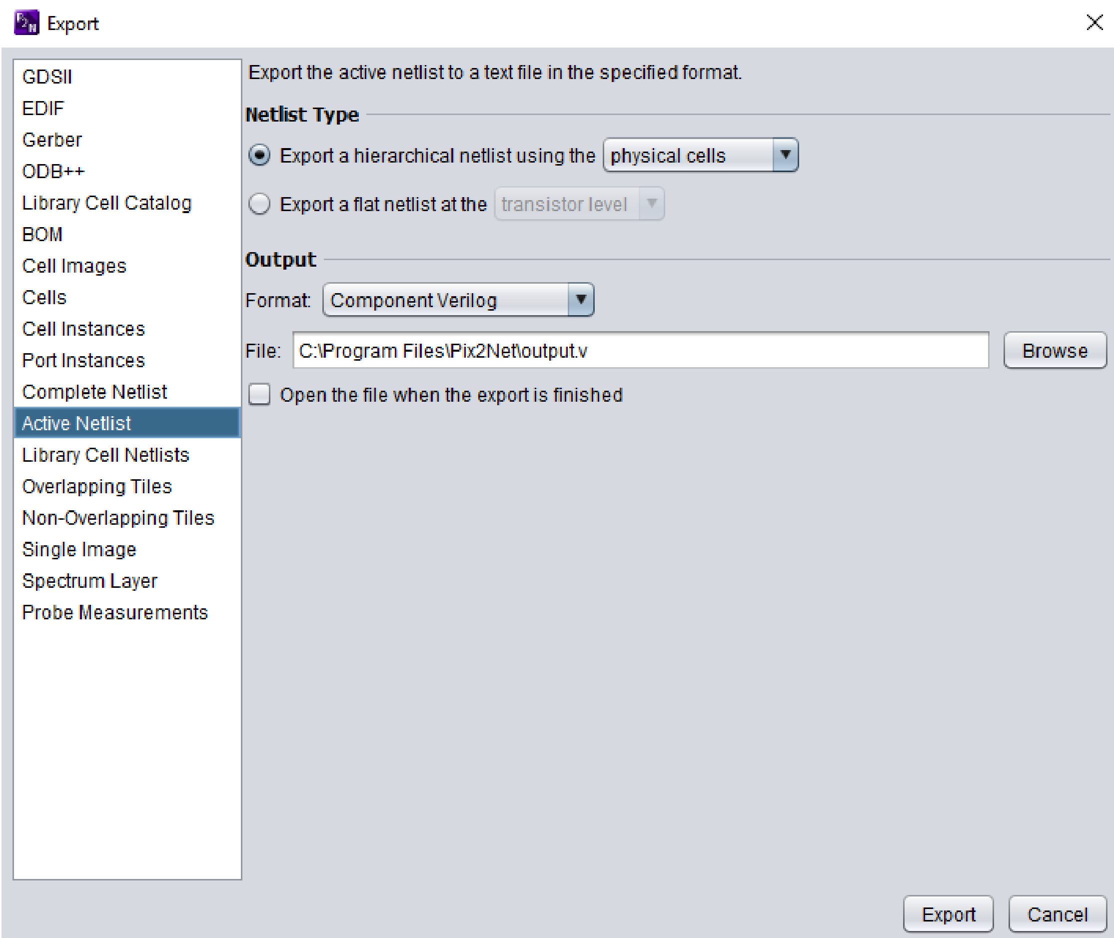
Exporting Port Instances



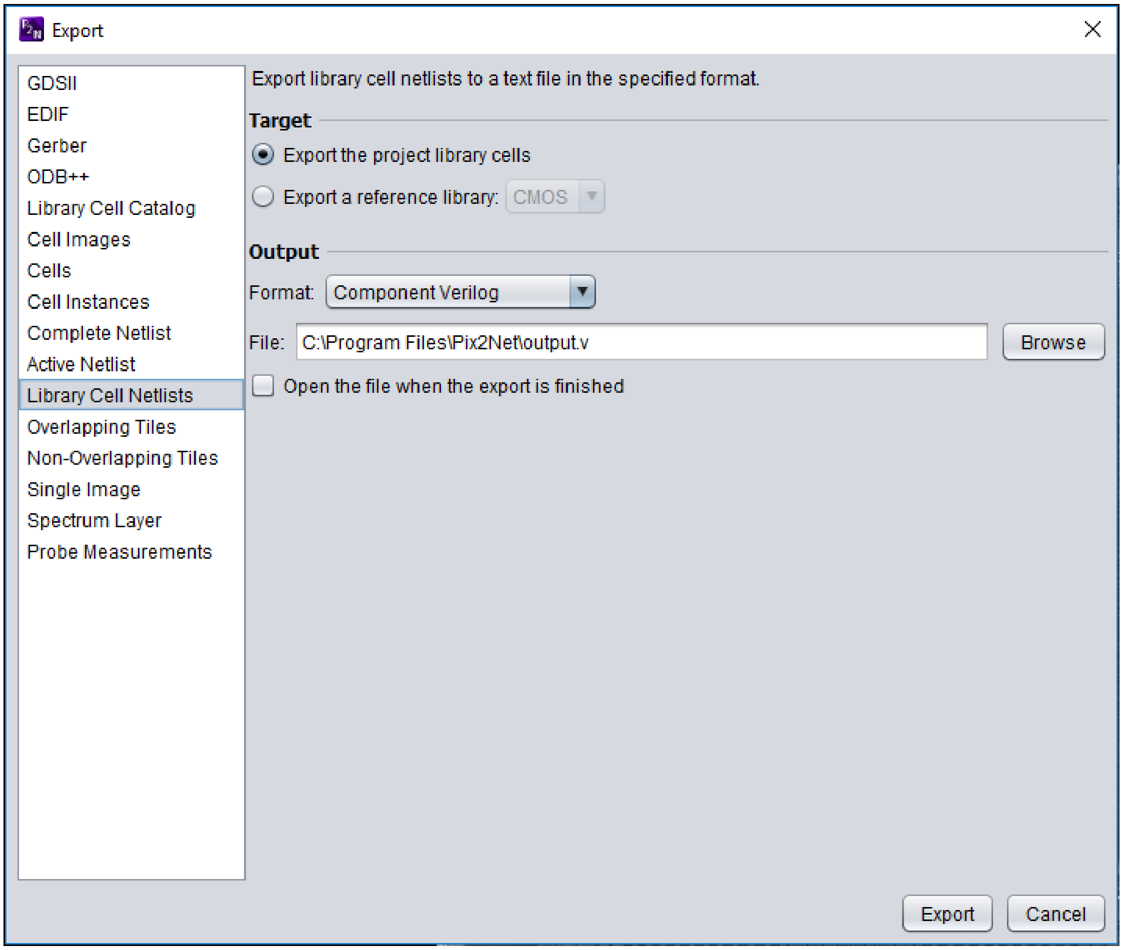
Exporting Complete Netlist



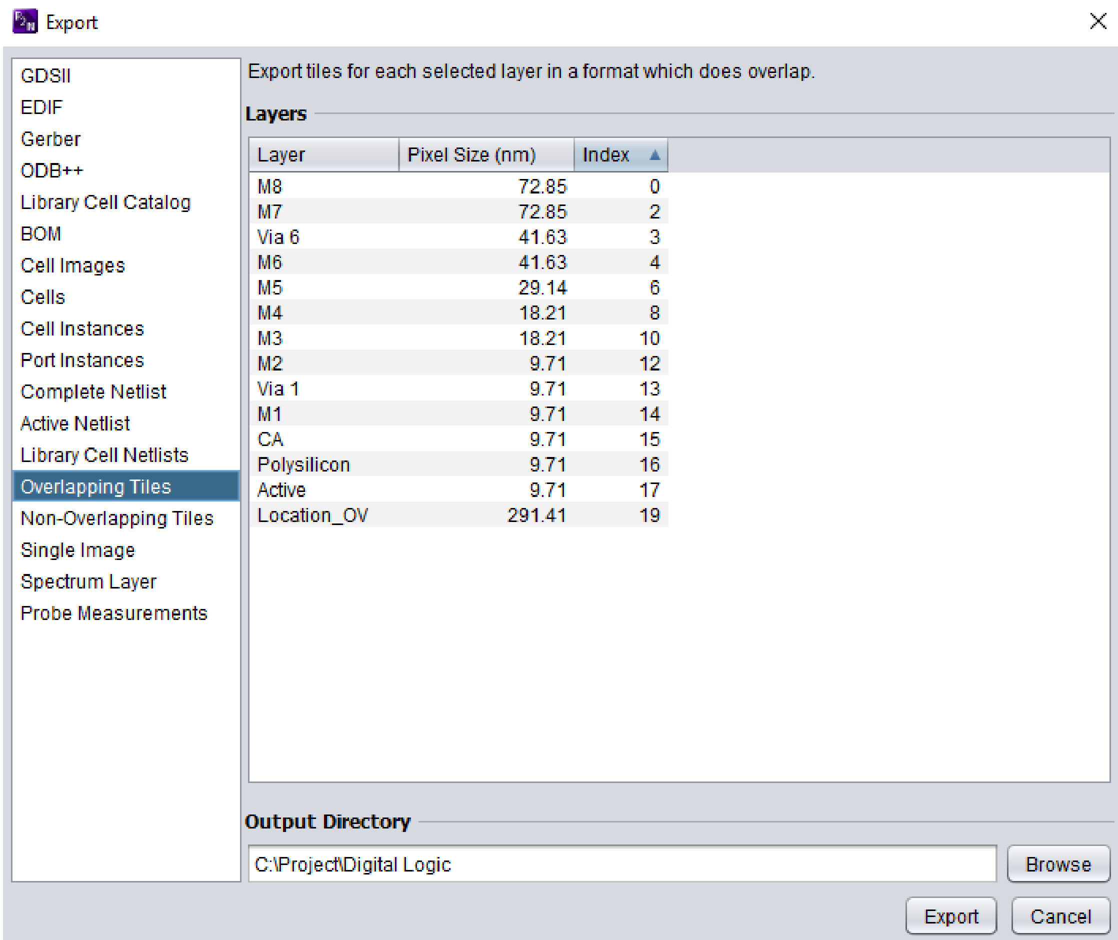
Exporting Active Netlist



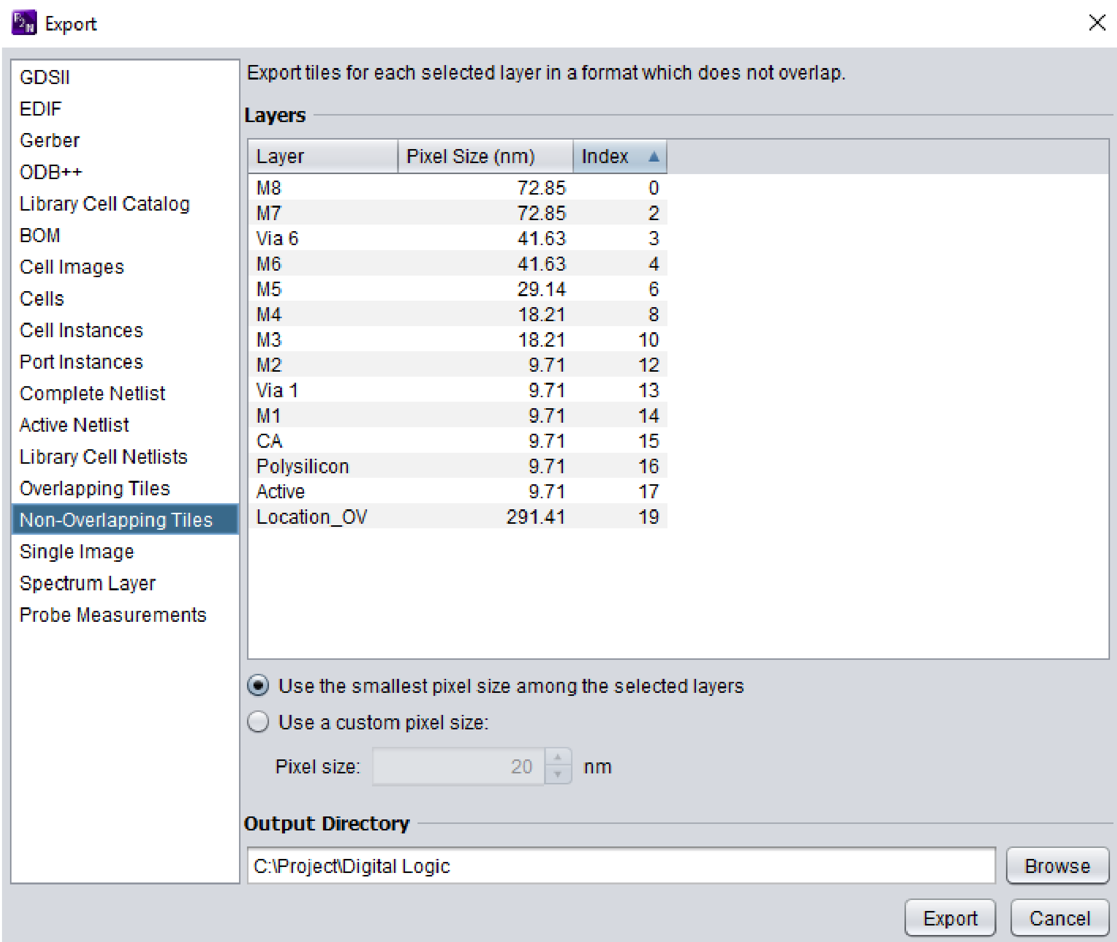
Exporting Library Cell Netlists



Exporting Overlapping Tiles

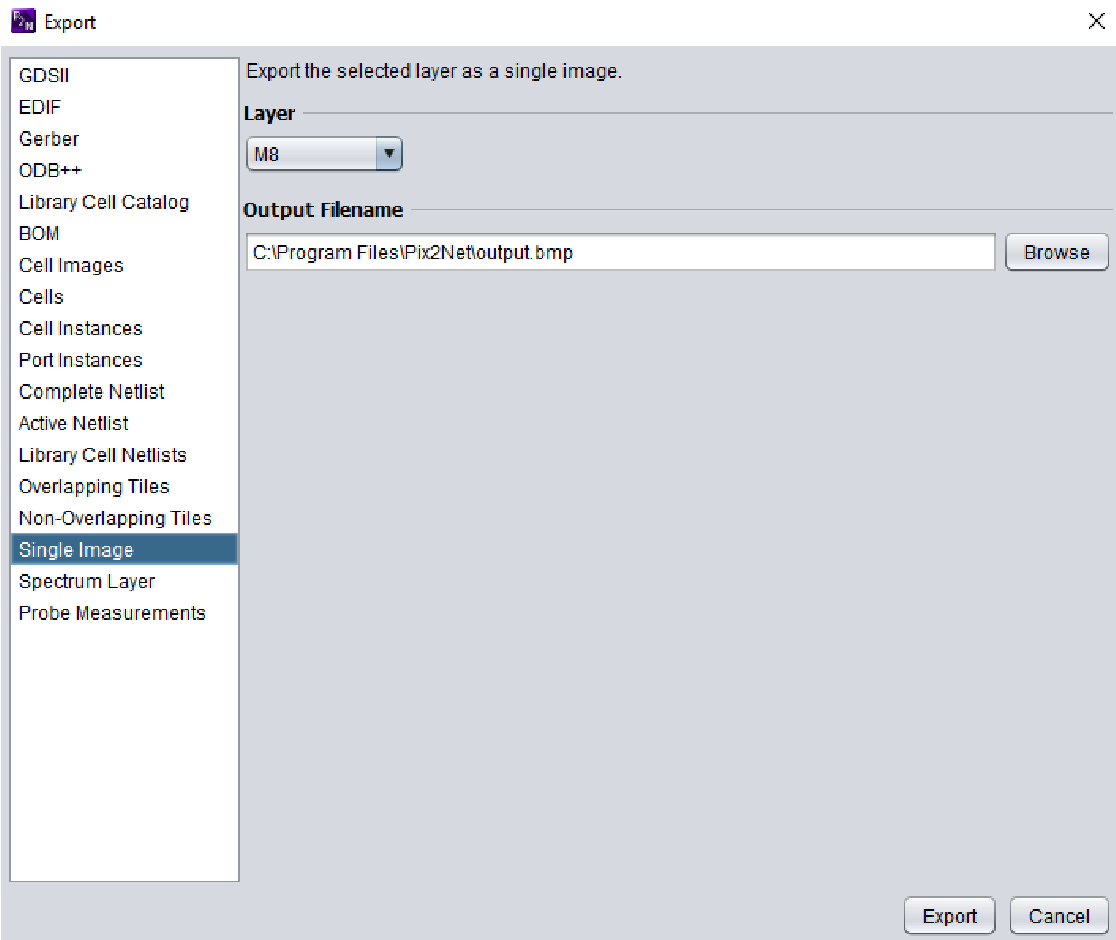


Export Non-Overlapping Tiles



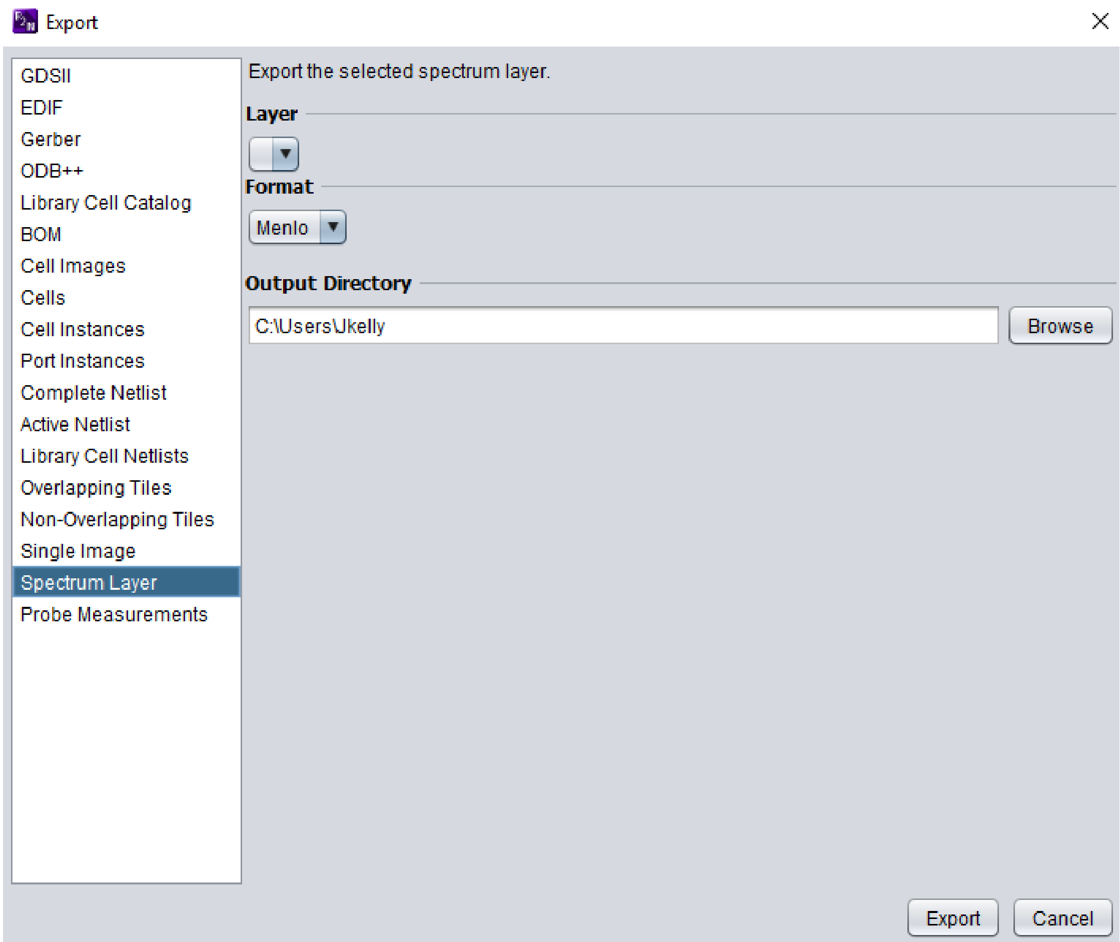
Exports the layers as a data set of non-overlapping images

Export Single Image

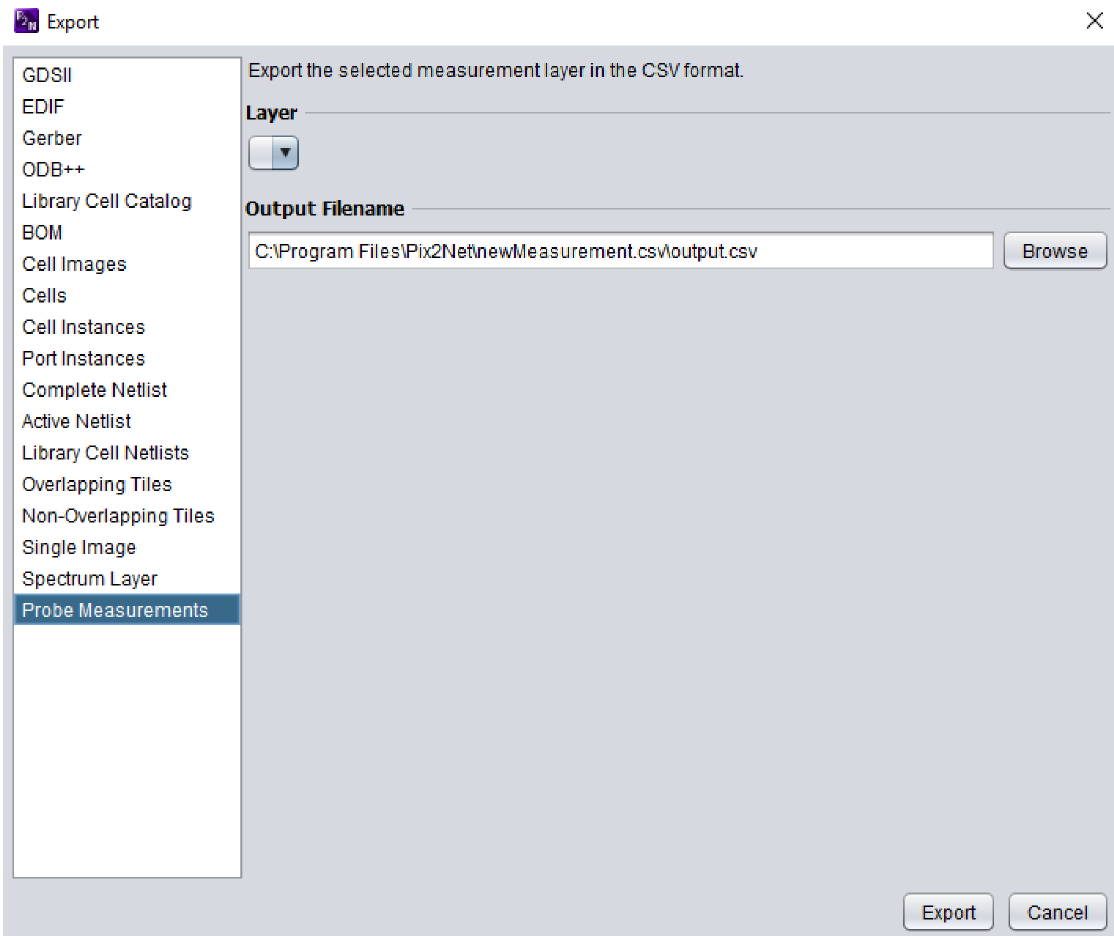


Exports the selected layer as a single .bmp file. Beware that very large layers will result in a .bmp file that is too large to open.

Export Spectrum Layer



Export Probe Measurements

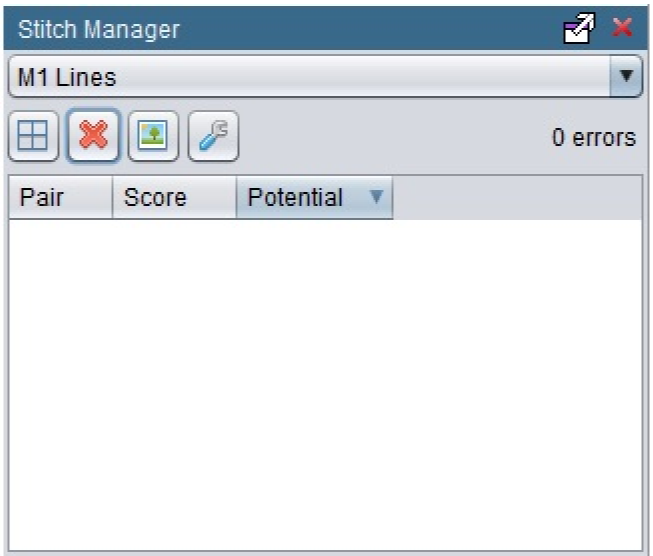


3.5 Stitching

The stitching system is used to stitch a set of tiled images into a single mosaic.

3.5.1 The Stitch Manager

The Stitch Manager is used to control the stitching process. It can be opened by pressing the Stitch Manager button in the Alignment tab.

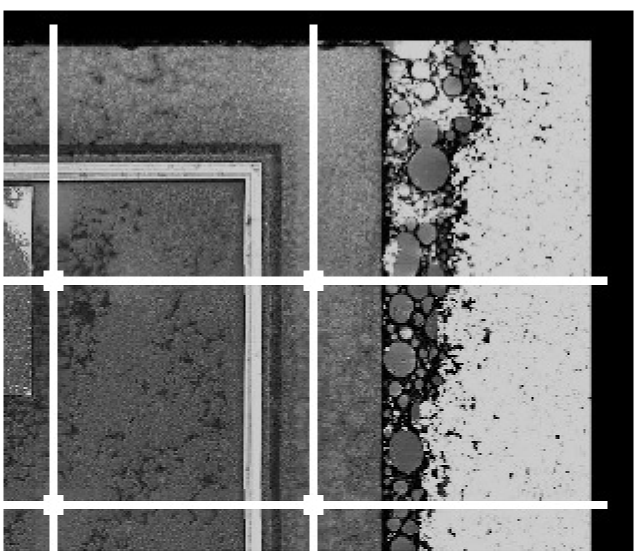


The combo box at the top is used to select the active image layer from the list of visible image layers. There are four buttons under the combo box:

- Stitch - Starts the stitching process for the active layer. During the stitching process, this button turns into a stop button.
- Clear Stitch - Clears the stitching information that is associated with the active layer.
- Open Stitch Viewer - Opens the Stitch Viewer window, which can be used to visualize and edit the selected stitch object.
- Settings - Opens the Settings dialog for the Stitch Manager.

The rest of the window is used to show the list of stitching errors. If the layer has not yet been stitched, then this list will be empty.

Whenever the Stitch Manager window is open, a stitch grid for the active layer will be displayed in the overlay:



The grid will initially be white, but during the stitching process, the lines and dots will turn green or red.

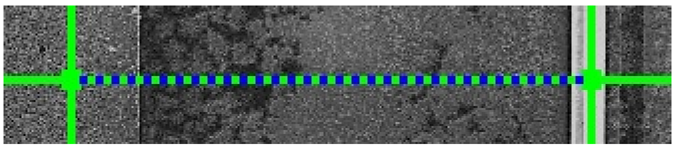
3.5.2 The Stitching Process

To start the stitching process, press the Stitch button in the Stitch Manager. The stitch grid will change colors throughout the stitching process. During the stitching process, it is perfectly fine to change the active layer or close the Stitch Manager window. The stitching process will continue to run in the background, even if the stitch grid is not displayed in the overlay.

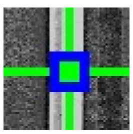
Once the stitching process is complete, the stitch grid can be inspected with the Stitch Viewer. First, a stitch object must be selected. A stitch object can be selected by using the Select Stitch tool:

After activating the Select Stitch tool, click on a line or dot in the stitch grid to select it.

The lines in the stitch grid represent `tile pairs`, which are two tiles that share a common edge:



The dots in the stitch grid represent `tile quads`, which are four tiles that share a common corner:



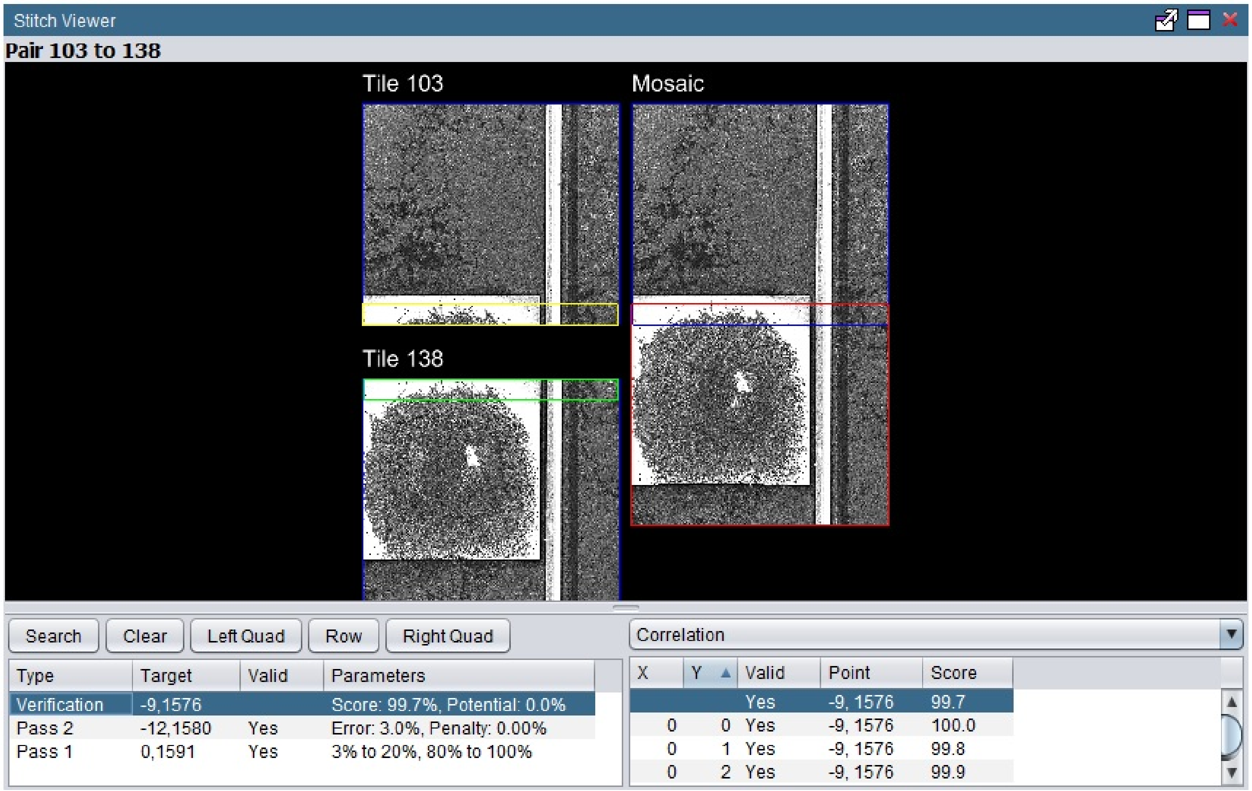
Finally, click on the Open Stitch Viewer button to start viewing the selected tile pair or quad.

3.5.3 The Stitch Viewer

The Stitch Viewer has three modes: Tile Pair mode, Tile Quad mode, and Row/Column mode.

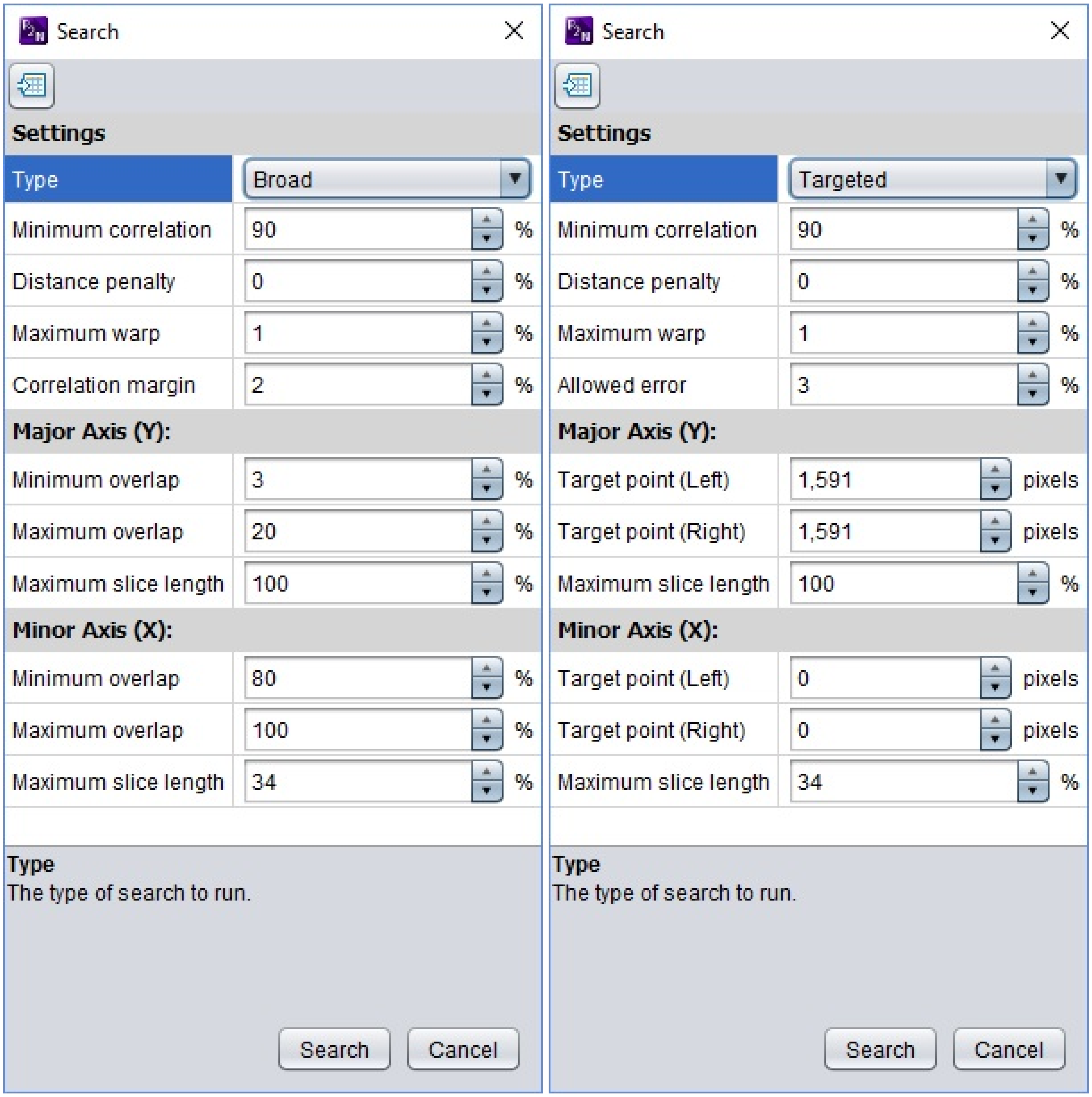
Tile Pairs

If a tile pair is selected, then the Stitch Viewer will start in Tile Pair mode:



The purpose of the Tile Pair viewer is to allow the user to view the results of searches that were run during the stitching process, and to allow the user to run their own searches. What is a "search"? In the stitching system, a "search" is when Pix2Net attempts to find valid stitch points for a pair of tiles.

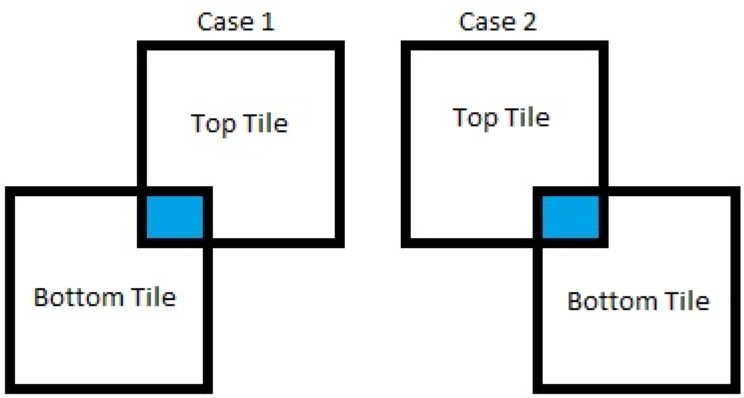
Clicking the Search button will bring up the Search dialog:



There are two types of searches: Broad and Targeted. The purpose of a broad search is to determine if there is only one possible way to stitch a tile pair or not, and if there is, to find that stitch point. The purpose of a targeted search is to find the best stitch point near a target point.

Let's start with the broad search. A search always has a major axis, which points in the direction of stage movement, and a minor axis, which is perpendicular to the major axis. Since we are dealing with a vertical pair of tiles, the major axis is the Y axis and the minor axis is the X axis.

The most important part of the broad search is defining the search boundaries. If we assume that there is some overlap, then there are two possibilities: Either the top tile's lower-left corner is overlapping with the bottom tile's upper-right, or the top tile's lower-right corner is overlapping with the bottom tile's upper-left, as shown in this figure:



In a broad search, the “minimum overlap” and “maximum overlap” determine the worst case scenarios for both cases. A broad search will perform two tests: In the first test, it will take the bottom tile’s image in the “minimum overlap” scenario of case 1 (the “template” image), and it will try to find it in the top tile’s image in the “maximum overlap” scenario of case 1 (the “reference” image). In the second test, it does the same thing, but for case 2. If these two tests produce only a single stitch point, then the broad search has successfully determined that there is only one way to stitch these two tiles. However, if the broad search finds either no stitch points or multiple stitch points, then the broad search’s result will be considered invalid.

The “maximum slice length” in each axis determines how the template image will be sliced up. The reason that a template image is divided into slices during a search is because, if either tile is warped, it may not be possible to find the entire template image in the reference image. The default parameters will divide the template image into three slices along the minor axis.

The “minimum correlation” determines the lowest amount that a template image is allowed to match a reference image and still be considered valid. If there are multiple places where a template image matches a reference image, then “correlation margin” is used to determine if the lower correlations are real matches or not. For example, if the highest stitch point has a correlation of 98%, and the “correlation margin” is 2%, then another stitch point of 97% would also be considered valid (because it is 1% away from 98%), but a stitch point of 95% would not (because it is 3% away from 98%).

The “distance penalty” doesn’t make sense for a broad search, so it should always be zero. The “maximum warp” is the percentage of tile width that the stitch points of the slices are allowed to vary from each other, under the assumption that the tiles can’t possibly be warped enough for both of those slices to be correct. For example, let’s assume a tile width of 2048, a “maximum warp” of 1% (i.e. about 20 pixels), and a slice with a stitch point at 0, 1591. In that case, a second slice point at 0, 1593 would be considered valid (because it is only 2 pixels away), but a third slice point at 0, 1621 would be considered invalid (because it is 30 pixels away).

A targeted search, on the other hand, always returns the best set of stitch points it can find. A targeted search requires the user to specify two target points, at opposite sides along the minor axis. In the case of a vertical tile pair, the first target point is specified on the left side and the second target point is specified on the right side. Pix2Net then chooses a target point for each slice by interpolating between the two extremes. Finally, the “Allowed Error” determines the maximum distance, as a percentage of tile width, that a valid stitch point may be from the interpolated target point.

The targeted search will always return the stitch points with the highest correlation, provided that correlation is higher than the minimum correlation and the slices are within the “maximum warp” constraint. There is just one exception: If the “distance penalty” is greater than 0, then the correlation at each possible stitch point will be adjusted by subtracting the distance penalty times the distance from the target point. The distance penalty is very important for tiles that have many valid stitch points, because the distance penalty will force Pix2Net to lean towards stitch points that are closer to the target point, instead of choosing stitch points solely based on their correlation.

At the top of the Search dialog, there is a “Load settings” button. This button can be used to populate the Search dialog with the standard settings used in each pass during the stitching process. Here are the three passes the occur during the stitching process:

- Pass 1 - In this pass, a broad search is run on each tile pair in order to find a list of known stitch points for each row and column.
- **Pass 2 - In this pass, the list of known points found in pass 1 are used to find a line of best fit for each row and column. Thi** is then used to run a targeted search, with 3% error and 0% distance penalty, on each tile pair.
- **Pass 3 - In this pass, the tile pairs that still have invalid stitch points are fixed by running a targeted search with 1% error** distance penalty. The assumption is that the searches that failed in pass 2 are the searches in which distance needs to be considered, instead of just looking at the correlation.

That covers the search button.

The table on the lower left, beneath the Search button, shows the list of results from the various searches that have been run. It also includes a Verification result, which will be covered in just a little bit. For now, click on a "Pass 2" or "Pass 1" result to see what a search result looks like.

The Clear button can be used to clear the selected search result. The Left Quad and Right Quad buttons are equivalent to selecting the left or right quad in the stitch grid. The Row/Column button will put the Stitch Viewer in Row/Column mode, so that the user can see how this pair's stitch points compare to the other stitch points along the same row or column.

The table on the lower right contains the list of stitch points for each slice in the selected search result. For targeted searches, the combo box above the table will always be "Correlation", but for broad searches, it can be changed to "Test stage moved left" or "Test stage moved right", to specify which of the broad search tests to view.

The table will always contain an entry that does not have an "X" or "Y" coordinate, which is selected by default. This entry is an overview of the slices. It shows the two tiles separately, with a green rectangle around the template image, and a yellow rectangle around the reference image. It also shows a mosaic on the right, which is generated from the stitch points of the valid slices.

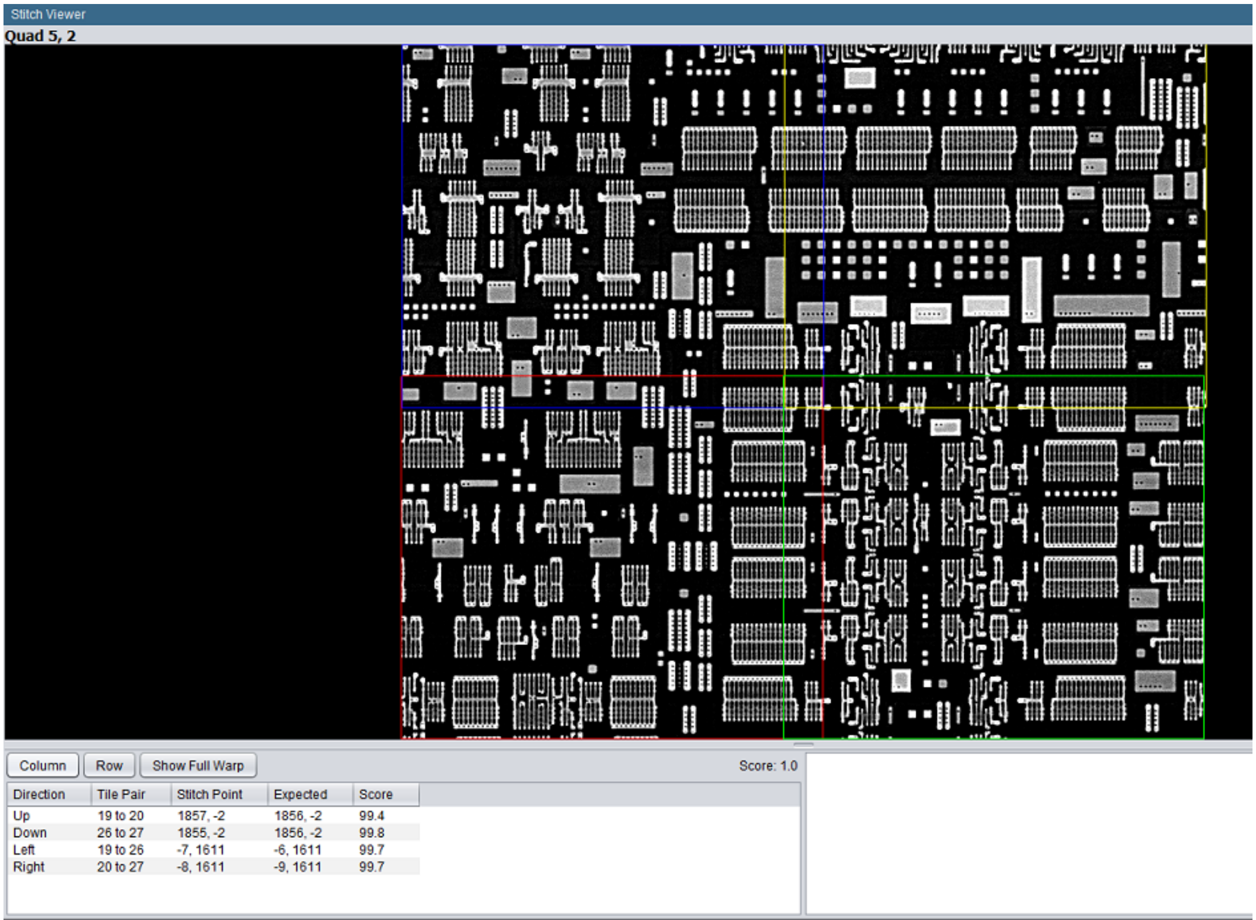
Clicking on the other entries will show the template and reference rectangles for that particular slice. It will also show a correlation image, which has darker pixels for the low correlations and brighter pixels for the high correlations. If the user hovers the mouse over the image, then the corresponding correlation value is displayed in the status bar. For targeted searches, a green dot represents the target point for the slice (for broad searches, the green dot is meaningless). For targeted searches, a red dot represents the best correlation point. For broad searches, a single red dot represents a valid stitch point. The lack of a red dot indicates no valid correlation points were found, and two red dots indicate that there are at least two possible ways to stitch the tiles.

A mosaic shows the template image on top of the reference image at the highest possible correlation point. Finally, a difference image shows the distribution of the differing pixels between the template and reference images. The smallest differences are represented by dark pixels, and the largest differences are represented by white pixels.

Finally, the Verification entry in the lower left table is a special correlation that the stitching process runs on the final, warped tiles. If any new searches are run, the verification entry will immediately vanish, because the final warped images may have changed, so a new verification needs to be run. A verification consists of doing a correlation in which the template image is divided into five slices, and the reference image is 3 pixels bigger than the template. The "score" that the verification reports is the lowest correlation among the five slices. The "potential" is calculated by looking at the worst slice's current correlation score, and the highest score that can be obtained by moving template image around by just 3 pixels. A verification with a low score and a high potential means that at least one of the tile's stitch points is definitely wrong.

Tile Quads

If a tile quad is selected, then the Stitch Viewer will be in Tile Quad mode:



The purpose of the Tile Quad viewer is to show the user what four tiles look like, given the stitch points currently defined. Clicking on the Row or Column button will put the viewer in Row/Column mode.

The score, which is displayed to the right of the Row and Column buttons, is calculated by checking the consistency of the four tile pairs. A lower score is better; a score of zero indicates perfect agreement. A score of 5 or greater indicates that the tile pairs disagree by at least 5 pixels, and the quad will be colored red in the stitch grid.

The stitch points for each tile pair are displayed in the table in the lower left. The user can visit any of these tile pairs by double-clicking on them. The "Expected" column is the stitch point for each tile pair that would be required to give the quad a perfect score of zero. If pass 3 finds a tile quad with 3 valid tile pairs and 1 invalid tile pair, then it will use the expected point when it tries to fix the invalid tile pair.

Rows/Columns

The Stitch Viewer can be placed in Row/Column mode by clicking on the Row or Column buttons in the Tile Pair and Tile Quad modes:

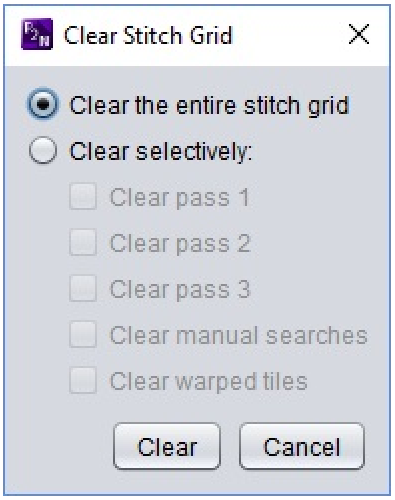
The purpose of the Row/Column viewer is to visualize the trend of stitch points along a column or row. The top graph represents the X values of the stitch points, and the bottom graph represents the Y values of the bottom graph. In both graphs, the tile number is the x axis, and the stitch point's X/Y value in pixels is the y axis. In this view, the tile number is not the usual index of the tile in the layer, but instead, it is the index of the tile along this particular row or column.

In the lower left, the view can be changed from "Active Result" to "Manual", "Pass 3", "Pass 2", or "Pass 1", in order to look at the results of a particular pass. The trend line, which is determined by the results of "Pass 1", can be toggled on and off.

The table in the middle contains all of the stitch objects along this row or column. The user can visit these stitch objects by double-clicking on them.

3.5.4 Clear Stitch Grid

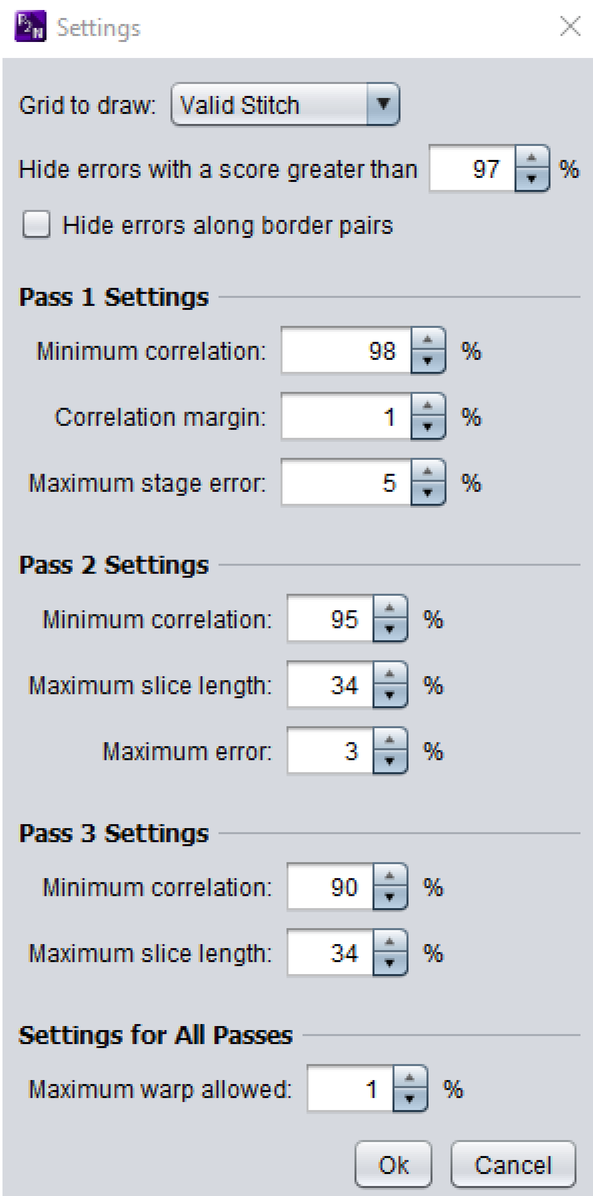
The Clear Stitch Grid dialog can be opened from the Stitch Manager:



This dialog can be used to clear the stitch grid. It can also be used more selectively, so that only certain passes are cleared, or so that only the warped tiles are deleted.

3.5.5 Settings

The Settings dialog can be opened from the Stitch Manager:



The settings dialog controls the verifications that are shown in the Stitch Manager. By default, verifications are only shown if they have a score lower than 97%, and if they are not along the border of the layer.

Another setting that can be changed is the type of stitch grid that is drawn. By default, the stitch grid is white when stitch information is missing, green if stitch objects are valid, and red if stitch objects are invalid. However, if the stitch grid is changed to Degree of Warp, then the colors will represent the extent to which tiles have been warped along their edges. White indicates almost no warp, green indicates a small amount of warp, yellow indicates medium amount of warp, and red indicates a large amount of warp.

The last feature to the Settings are the pass settings. The user can write what is wanted within each pass setting as well as setting the maximum warp allowed for all passes.

3.5.6 Fixing Stitch Errors

During the stitching process, Pix2Net will run three passes. Each pass runs a search that returns a valid result (a green line) or an invalid result (a red line). There are times when pass 1 and pass 2 return a red line, but that does

not necessarily mean something bad happened; there are many times where pass 1 and pass 2 are *supposed* to return invalid results, because it is expected that a later pass will find a valid result. Therefore, search results can be divided into four categories: True positives, true negatives, false positives, and false negatives.

In general, false positives are much worse than false negatives in the stitching process. A false negative is simply a piece of information that could be used, but is ignored by Pix2Net. A false positive, however, represents a bad assumption that may be used by later passes, resulting in more bad assumptions and stitch errors. Therefore, the search parameters for each pass have been chosen with two goals in mind: 1) Eliminate false positives completely and 2) avoid an excessive amount of false negatives.

Pass 1 Errors

If the stitching completes and a row or column has a large amount of red lines, that's a pretty good sign that pass 1 failed on that row or column. In order to verify this, select a tile pair on that row/column, open the Stitch Viewer, and switch to the Row/Column view. If you set the view to 'Pass 1', and you notice that the trend line is tilted due to some outliers, then those outliers are most likely false positives.

In pass 1, a false positive is when pix2net believes there is only one valid way to stitch a tile pair, but there are in fact either multiple ways to stitch the pair, or there is no valid way to stitch the pair. A false negative, on the other hand, is when pix2net believes there is not a single valid way to stitch a tile pair, but there actually is only one valid way to stitch the pair.

False positives are very bad, because it only takes one false positive to throw off a trend line. False negatives aren't nearly as harmful, because a false negative simply means there is one fewer data point to help guide the trend line.

Currently, there's no easy way to simply run pass 1 with different parameters on an entire row or column, so fixing the results of a pass 1 error may be tedious. Pix2Net tries to reduce the chances of a false positive by using a high minimum correlation (98%) and a high correlation margin (.1%). On a side note, if pass 1 does not find any valid stitch points along a row or column, then pass 2 will default to using an ideal trend line.

Pass 2 Errors

Pass 2 will attempt to stitch tile pairs along the trend line from pass 1. Pass 2 will use a distance penalty of zero, so pass 2 will only work if the highest correlation point in each slice is the correct stitch point.

A false positive in pass 2 is when a search result is marked as valid, but the stitch points are actually incorrect. This can happen if the highest correlation point in each slice is wrong, but the points are still within the allowed warping distance, so each slice is consistent with the other slices. A pass 2 false positive is not as bad as a pass 1 false positive, but it can still be pretty bad if a lot of nearby pass 3 stitches rely on it in order to generate their target points.

A false negative in pass 2 is when the highest correlation point in each slice does in fact represent a valid way to stitch the pair, but pass 2 incorrectly marks the search result as invalid. This can happen if the tiles are so warped that the resulting stitch points violate the maximum allowed warping distance. It can also happen if the slices have a low correlation, due to charging effects or excessive tile warp. Pass 2 uses a minimum correlation of 95%, which is lower than pass 1's 98%. However, 95% may still not be low enough to prevent all false negatives.

In contrast to a false negative, a true negative in pass 2 is when a search result correctly identifies a situation where the highest correlation point in each slice does not represent a valid way to stitch a tile pair. A good example of this case is a pair of tiles that have nothing but horizontal white lines, or nothing but vertical white lines. There are many possible, valid stitch points, so pass 2 will not be able to determine the correct way to stitch the pair. A pass 3 search, on the other hand, will work, because pass 3 includes a distance penalty that can be used to sort the valid stitch points by their distance from a target point.

Pass 3 Errors

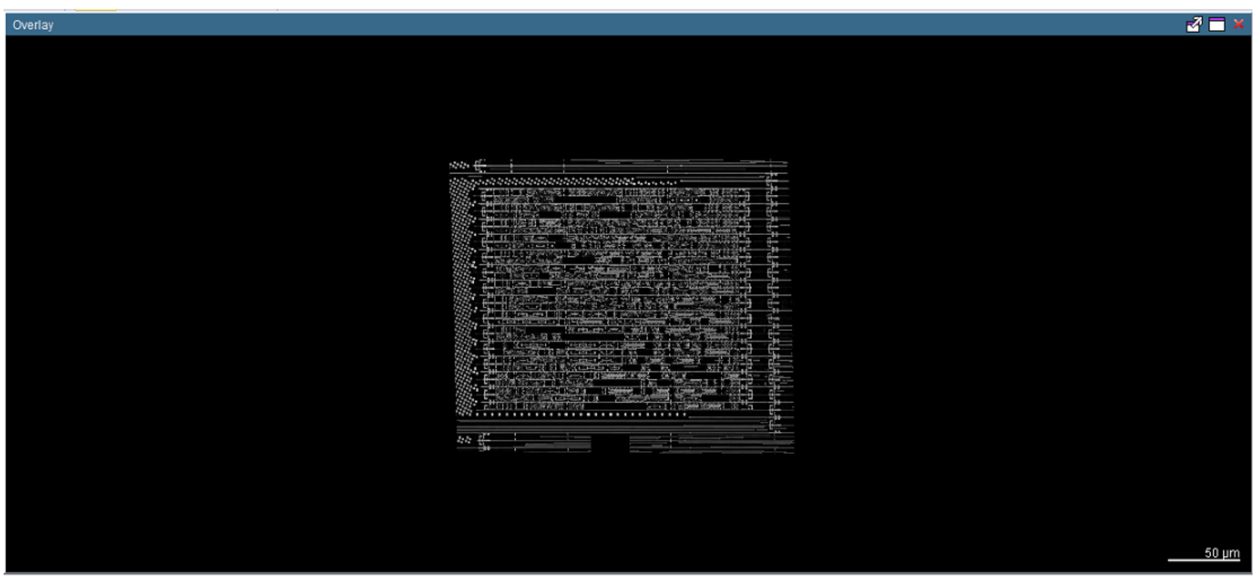
Since pass 3 has a low minimum correlation of 90%, and a distance penalty of 0.1%, it will almost certainly work if valid target points are passed to it. However, the target points used may end up being invalid target points if they were calculated from bad results from pass 2 or pass 1.

Also, pass 3 will only run searches on invalid pass 2 results. Pass 3 will not run on valid pass 2 results, because it does not know which pass 2 results are true positives, and which results are false positives. This means that pass 3 will not fix a red dot that is connected to four green lines, because pass 3 does not know which of those lines is a false positive. However, you as a human may be able to determine this by selecting the red dot, opening the stitch viewer, and looking at the row and column views. Look closely at the stitch points of the pairs that are adjacent to the selected quad. If one or more of those stitch points seems to be out of place in comparison to its neighbors, then that is probably the false positive. You may be able to fix this false positive by simply running a pass 3 search on it.

One final thing to notice is a difference between the way pass 2 and pass 3 choose their targets points. When pass 2 calculates its target points, it uses the trend line from pass 1. When pass 3 calculates its target points, however, it may use the nearby pass 2 and pass 3 search results. Therefore, a pass 3 result may be bad because of other bad pass 3 results, but a pass 2 result will never be bad because of other bad pass 2 results.

3.6 Overlay

3.6.1 Overlay Windows



Overlay windows allow you to view and manipulate the layers in the project. The main layer window is the Overlay window, but each layer also has an image window and/or feature window associated with it. The Overlay window allows you to view multiple layers on top of each other. The Overlay window can be toggled on and off from the View menu. The image windows and feature windows associated with a layer, on the other hand, are useful for viewing two or more layers side by side. These windows can be enabled by the context menu in the Project window.

You can move around in the overlay window with the keyboard by pressing the A (left), D (right), W (up), S (down), Q (zoom in), and E (zoom out) keys. You can also move around with the mouse. Hold down the middle mouse button to move up, down, left, and right, and zoom in and out with the mouse wheel.

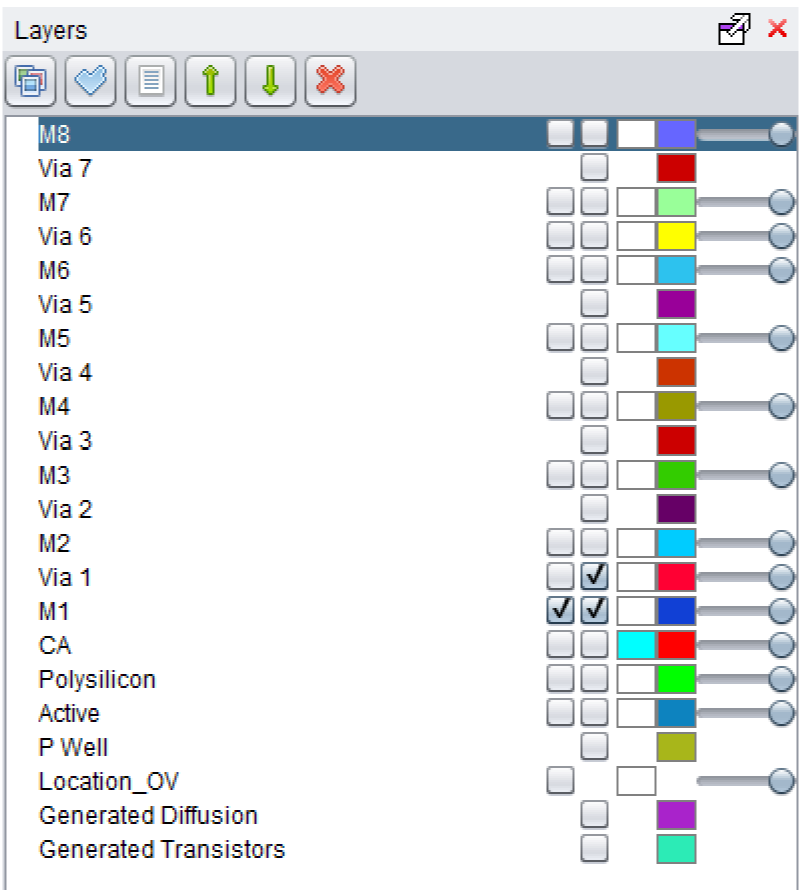
When a layer window has the focus, then you can use the arrow keys to move around. Each layer window has a ruler in the lower-right corner that gives you a sense of scale.

Right-click anywhere in the overlay window, then the following menu will pop up:

- **Count cell instances…**
  - Allows the user to draw a box, and then tell Pix2Net will say how many cell instances are within that box.
- **Go to**
  - Coordinates: Allows you to enter specific micron coordinates to move the camera to.
  - Tile: Allows you to enter an image tile number to move the camera to.
- **Save**
  - Overlay as bitmap: Saves the overlay's contents as an image in a folder specified by the user.
- **Selected cell**
  - Flip left to right: Flips the selected cell left to right
  - Flip top to bottom: Flips the selected cell top to bottom
  - Rotate clockwise: Rotates the cell 90 degrees clockwise.
  - Rotate counter clockwise: Rotates the cell 90 degrees counter-clockwise.
  - Delete cell instance: Removes the selected cell.
  - Delete cell (Exclude Children): Removes the selected cell, but leaves all children cells intact.
  - **Delete pattern: To use this feature, the user must have two cells selected.** Delete pattern will ask which cell to keep. Then, it will search the whole project for places where there exists the "pattern" that the selected cells make together. If there was an 'L' shape of three different cells, it would find all the places where that same 'L' is made of those same cells. Then, in every pattern, it will delete all cells except the "keep" cell.
  - Make port names uppercase: Changes the port names of the selected cells to uppercase.
  - Make port names lowercase: Changes the port names of the selected cells to lowercase.
  - Move to active section: Moves the selected cell to the active section.
  - Identify as 0-bit: Defines the cell as a digital LOW or 0 bit.
  - Identify as 1-bit: Defines the cell as a digital HI or 1 bit.
  - Fill with memory grid…: Creates a memory grid array
- **Selected port**
  - Edit: Edits the selected port.
  - Remove: Removes the selected port.
- **Selected polygon**
  - Flip left to right
  - Flip top to bottom
  - Flip clockwise
  - Flip counter clockwise
  - Remove: Removes the selected polygon(s).
  - Move to layer…: Moves the selected polygon(s) to a different layer.
  - Copy to layer…: Copies the selected polygon(s) to another layer.

- **Selected ruler**
  - Delete: Removes the selected ruler.
- **Origin offset**
  - Clear: Clears the offset
  - Set here: Sets the origin where the mouse was clicked.

3.7 Layers Window



The Layers window lists all of the layers that belong to the project. The selected layer is considered to be the active layer. The active layer is the layer that will be targeted for manipulation whenever a tool is used.

Each layer has a set of controls next to it:

- A check box that can be used to show or hide the images associated with the layer.
- If applicable, a check box that can be used to show or hide the features associated with the layer.
- A color box that can be used to colorize the images associated with the layer.
- If applicable, a color box that can be used to colorize the features associated with the layer.
- A slider that can be used to change the transparency of the images associated with the layer.

The top of the layer window has the following buttons:

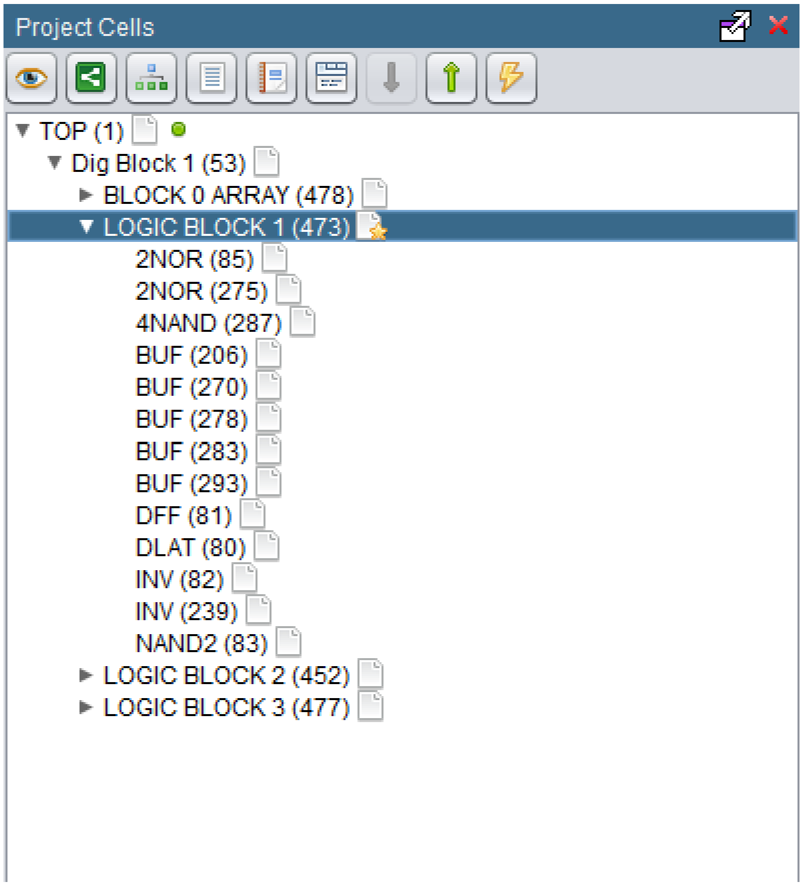
- Show image layer: Opens a new layer window that will only show this layer's image, regardless of what is shown in the overlay window. If you open multiple layer windows, you can view them side by side by going to View -> Tile Windows.
- Show polygon layer: Opens a new layer window that will only show this layer's features, regardless of what is shown in the overlay window.
- Show layer properties: Allows you to edit properties associated with a layer. This feature is not used very much by Pix2Net just yet, but when you import GDS layers, the layer number and data type will be saved as properties.
- Move layer up: Moves a layer one space upwards in the stack.
- Move layer down: Moves a layer one space downwards in the stack.
- Remove layer: Removes a layer from the project, and gives you the option to delete any folders associated with the layer.
- Hide/show all image sublayers: Turns on/off all image layers.
- Hide/show all polygon sublayers: Turns on/off all polygons.

If you right-click on one of the layers, the following menu will pop up:

- Rename: Renames this layer. The layer's directory will be renamed as well.
- New polygon layer: Creates a new, empty feature resource for this layer. This is useful if you intend to draw features by hand.
- Move Ports…: Moves all ports from the highlighted layer to another target layer.
- Move to Top: Moves the highlighted layer to the top of the list.
- Move to Bottom: Moves the highlighted layer to the bottom of the list.
- Display Cells: Displays the cells within the selected layer in the overlay and in the cell visibility window as a quick filter.
- Reset Warp: Resets any warping that has been done to this layer.
- Fix Indexes: If layer indexes are not correct, Fix Indexes renumbers them.
- Lock: Allows you to lock changes to a layer's alignment and polygon layer so they cannot be moved or changed.
- Columns: Allows you to show or hide column options in the Project window.

3.8 Project Cells Window

3.8.1 Project Cells Reference



The project cells window also allows you to toggle the following windows:

- *Cell Visibility*
- *Netlist Browser*
- *Cell Instances*
- *Flat Cell List*
- *Reference Cells*
- *Show Netlist Properties*
- *Move Into Target Netlist*
- *Move Out to Main Netlist*
- *Manage Electrical Models*

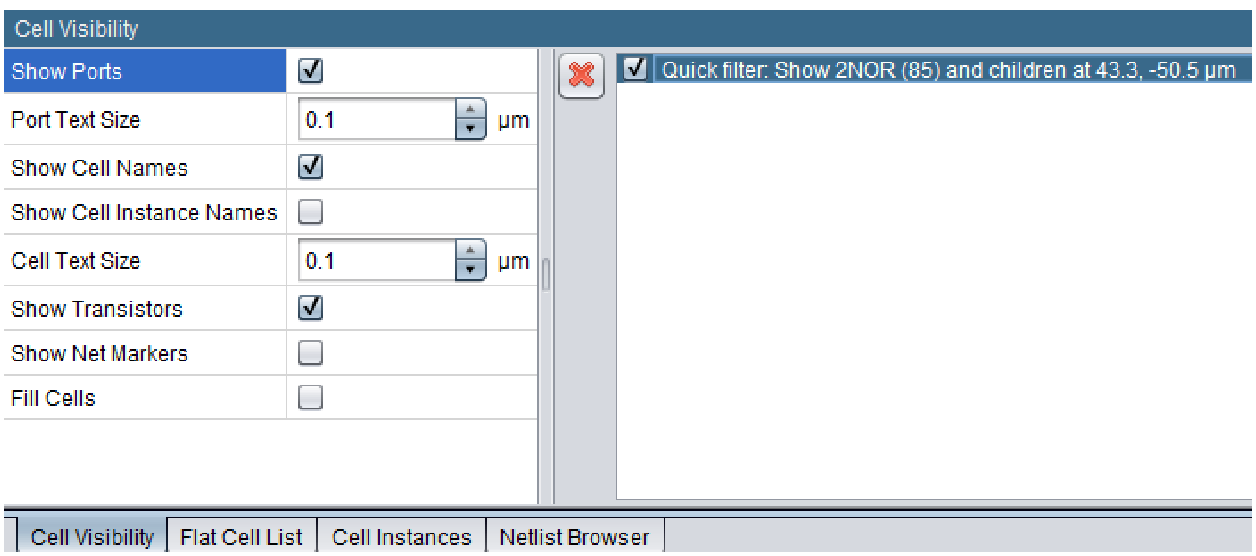
The project cells window shows all of the cells in the project in a tree. You can toggle the visibility of a cell in the tree by clicking on the green down arrow when the cell is highlighted. Right-click a cell to bring up the context menu:

- Show [cell] Only: Equivalent to selecting this cell's check box, and deselecting the check box of every other cell.

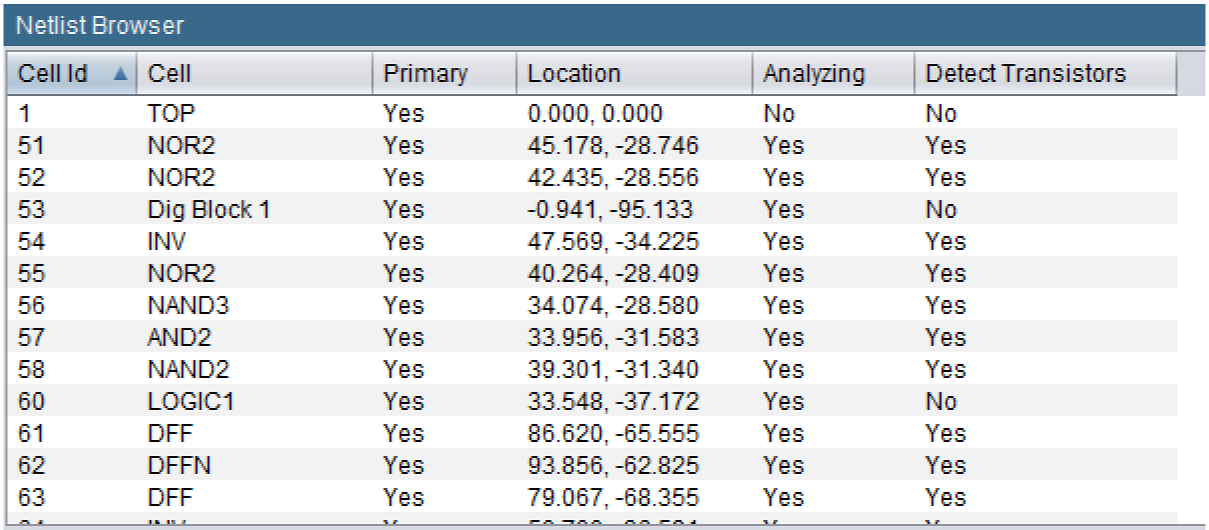
- Show [cell] and Children Only: Shows this cell and is children, and hides the other cells.
- Move Into [cell] Netlist: Moves the user into the targeted netlist (same as pressing the green down arrow).
- Hide All: Hides all cells that are showing.
- Add Persistent Filter (show cell/show children): Shows the cell or both the cell and children.
- Rename [cell]: Renames the cell.
- Delete [cell]: Removes the cell, including its instances and ports.
- Delete Children: Deletes only the child cells of the selected cell.
- Delete Ports: Deletes the ports that were added to a cell.
- Edit Module: Allows the user to edit the module and electrical type of the cell. Modules can be filtered by library, size, or number of ports.
- Pair Inputs: Brings up *Assign input pairs* window. The user can specify relationships between inputs by saying that input A is the inverse or clone of input B. This is necessary if the cell expects there to be a relationship between inputs, such as inversion. This is used for truth tables, state tables, and verilog.
- Edit Invalid States: Lets the user edit and add invalid states to cells. Choose to add an invalid state and if the state should be x, 0, or 1.
- Electrical properties: Opens the electrical properties of a cell. Currently, these properties must be manually entered.
- Section Actions (set as active section/revert to normal cell): Sets the highlighted section as the active one. Only applies to *Sections* not *Cells*.

3.8.2 Cell Visibility

When this (the eye) is pressed, it brings up the *Cell Visibility* window:



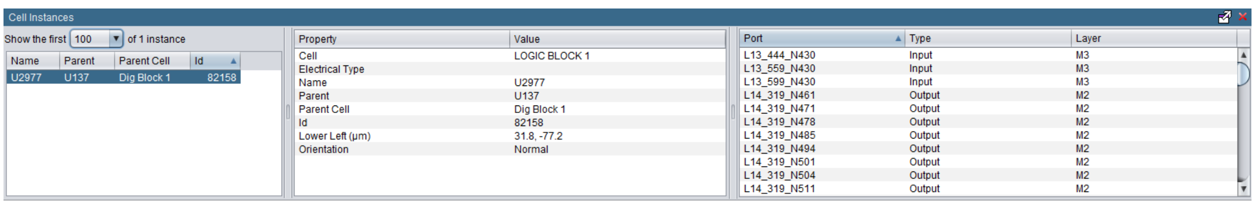
3.8.3 Netlist Browser


Netlist Browser

Cell Id	Cell	Primary	Location	Analyzing	Detect Transistors
1	TOP	Yes	0.000, 0.000	No	No
51	NOR2	Yes	45.178, -28.746	Yes	Yes
52	NOR2	Yes	42.435, -28.556	Yes	Yes
53	Dig Block 1	Yes	-0.941, -95.133	Yes	No
54	INV	Yes	47.569, -34.225	Yes	Yes
55	NOR2	Yes	40.264, -28.409	Yes	Yes
56	NAND3	Yes	34.074, -28.580	Yes	Yes
57	AND2	Yes	33.956, -31.583	Yes	Yes
58	NAND2	Yes	39.301, -31.340	Yes	Yes
60	LOGIC1	Yes	33.548, -37.172	Yes	No
61	DFF	Yes	86.620, -65.555	Yes	Yes
62	DFFN	Yes	93.856, -62.825	Yes	Yes
63	DFF	Yes	79.067, -68.355	Yes	Yes

The cell netlist browser allows you to view the netlist of a selected cell. Generally there is only one netlist per cell instance. If more than one netlist exists for a given cell you can see if any variations exists. Only one active netlist is allowed and all netlist commands will only affect

3.8.4 Cell Instances


Cell Instances

Show the first 100 of 1 instance

Name	Parent	Parent Cell	Id
U2977	U137	Dig Block 1	82158

Property	Value
Cell	LOGIC BLOCK 1
Electrical Type	
Name	U2977
Parent	U137
Parent Cell	Dig Block 1
Id	82158
Lower Left (µm)	31.8, -77.2
Orientation	Normal

Port	Type	Layer
L13_444_N430	Input	M3
L13_559_N430	Input	M3
L13_599_N430	Input	M3
L14_319_N461	Output	M2
L14_319_N471	Output	M2
L14_319_N478	Output	M2
L14_319_N485	Output	M2
L14_319_N494	Output	M2
L14_319_N501	Output	M2
L14_319_N504	Output	M2
L14_319_N511	Output	M2

The cell instances window allows you to see the instances and ports of the cell currently selected in the `Project Cells` window. When you select an instance in the table, the camera in the layer window will center on the instance and highlight it with a blue box.

The instances table has the following columns:

- Name: The instance's name. This field is editable.
- Parent: The instance name of the parent cell.
- Parent Cell: The name of the parent cell instance.
- ID: The instance number.
- Property: Shows the properties of the cell instance.
- Value: Shows the value of the properties.
- Port: Names of the ports.
- Type: Shows type of ports (input, output, VDD, VSS, etc.).
- Layer: Shows which layer the port is on.

The ports table has the following columns:

- Port: The name of the port.

- Type: The port's type: Input, Output, or Inout.
- Layer: The layer the port was placed on.

3.8.5 Flat Cell List

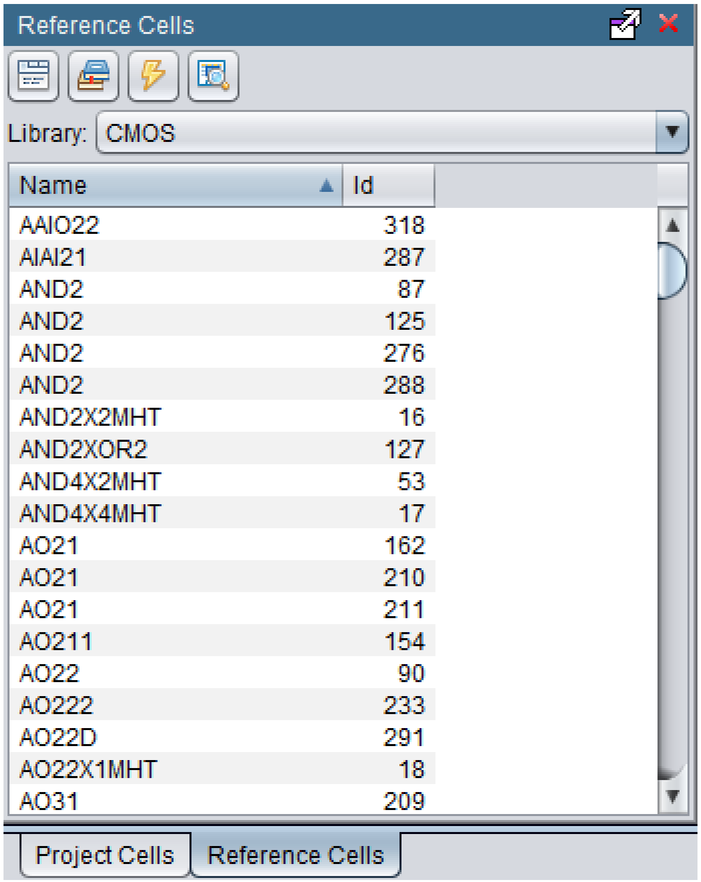
Flat Cell List

Name	Id	Electrical Type	Netlists	Section
2NAND	78		1	No
2NOR	85	NOR	1	No
2NOR	531		1	No
2NOR	532		1	No
3NAND	73		1	No
4NAND	72		1	No
4NAND	287		1	No
AND2	57	AND	1	No
BLOCK 0 ARRAY	478		1	No
BUF	206		1	No
BUF	270	Buffer	1	No

The flat cell list window shows you a flattened list of all of the cells in the project. The following columns are displayed:

- Name: The name of the cell.
- ID: The id associated with the cell.
- Electrical Type: The electrical properties associated with the cell.
- Netlists: The number of nets in the transistor netlist (if the cell has a transistor netlist).
- Section: Indicates whether or not the cell is a section.

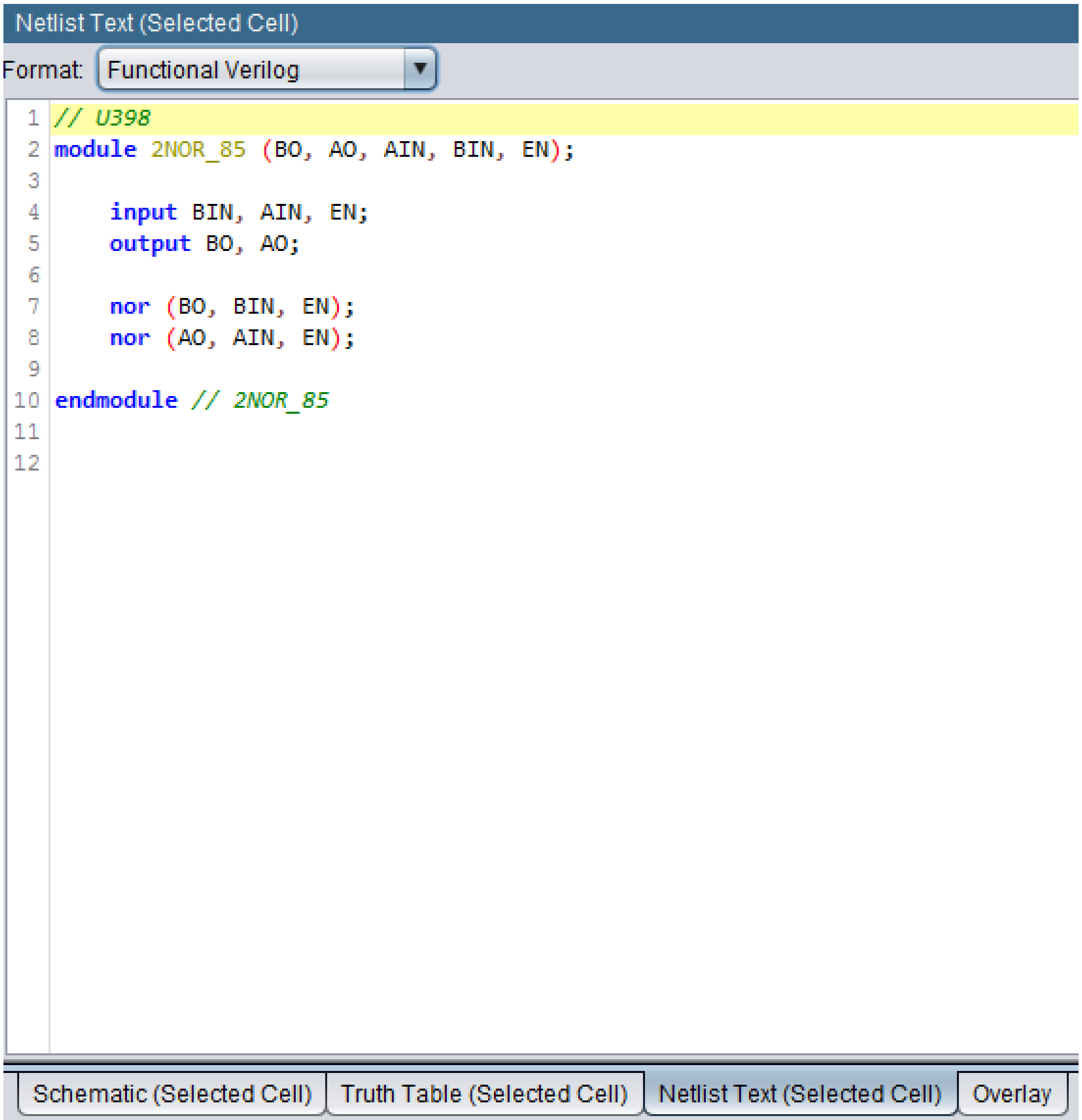
3.8.6 Reference Cells



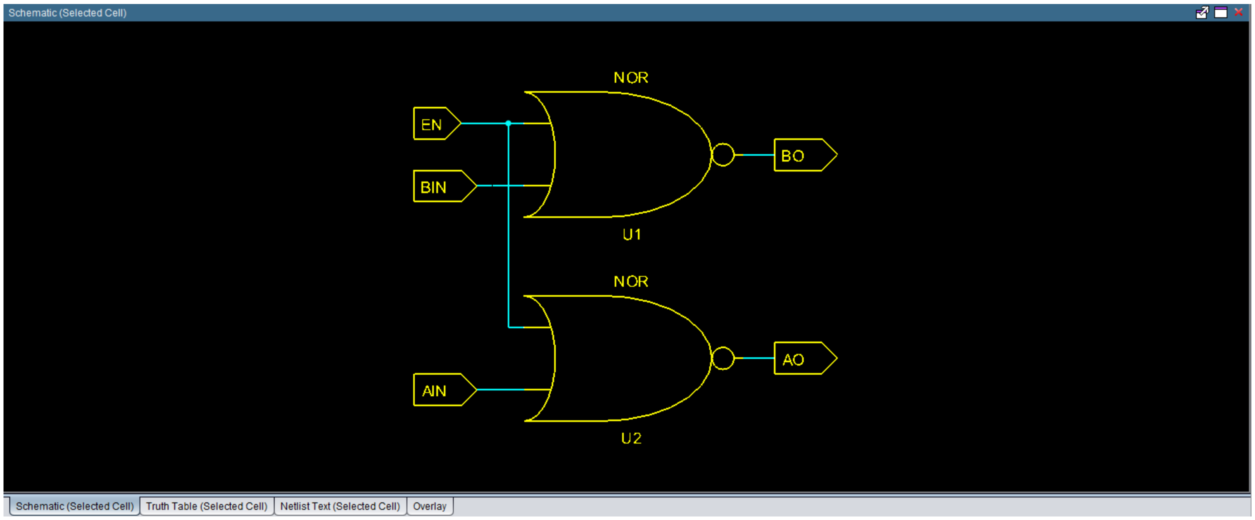
These reference cells can be imported into any project, for usage such as cell identification. It is useful in situations where a series of parts are being reverse engineered, and they have similar, unique cells. You can export the cell you identified to the ref library from one project, and then import it into another project. That way, you only have to do the work once. You can build up a library of common cells for the devices you're using. The reference cell library is in the process of being replaced by the new cell identification feature.

3.8.7 Show Netlist Properties

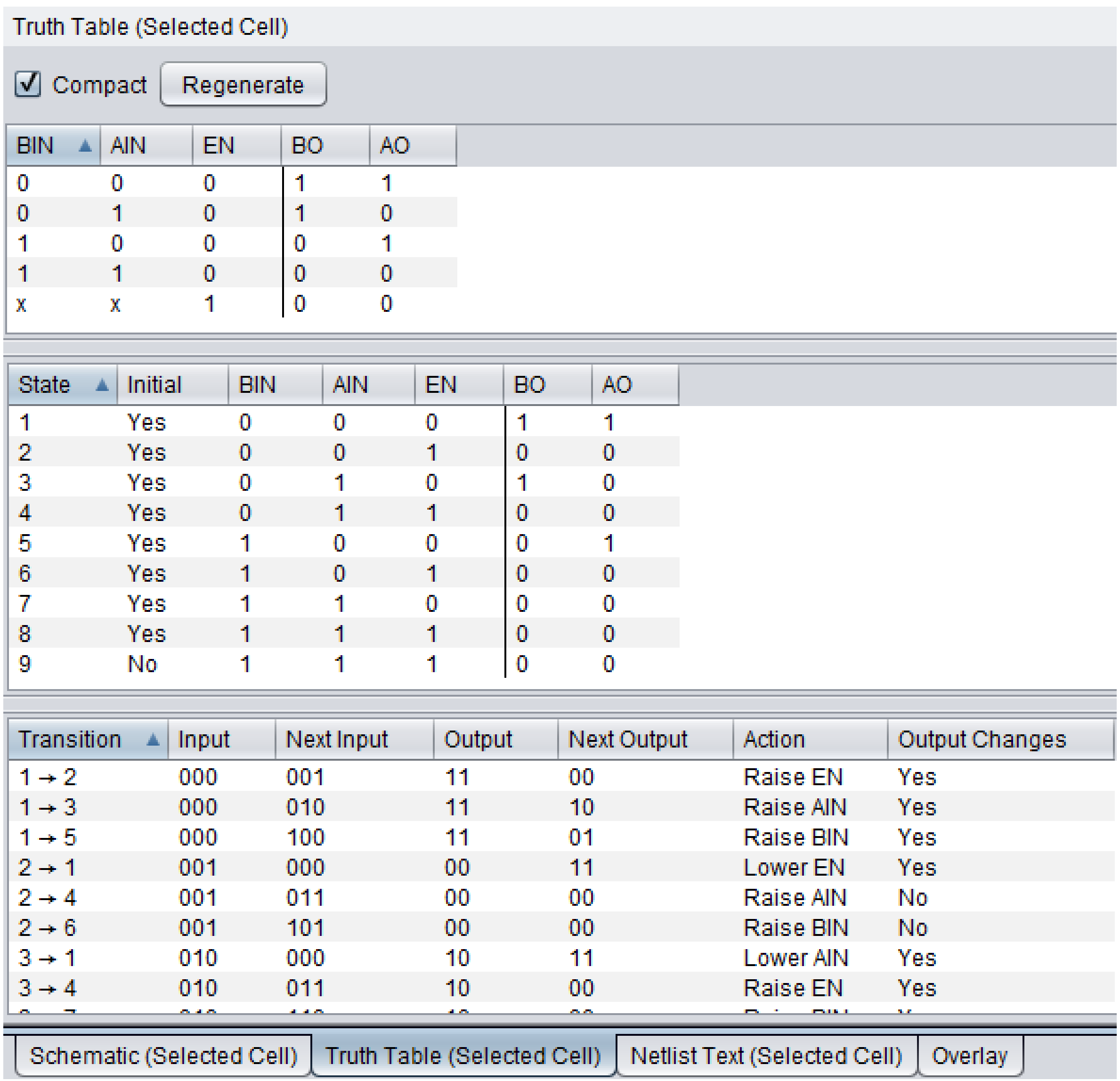
When clicking the `Show Netlist Properties` button, 3 options become available: Netlist Text, Schematic, and Truth Table.



Shows the user the functional verilog, component verilog, H functional verilog, Spice, VHDL, and Comma-seperated values.



Shows the schematic of the cell.



BIN	AIN	EN	BO	AO
0	0	0	1	1
0	1	0	1	0
1	0	0	0	1
1	1	0	0	0
x	x	1	0	0

State	Initial	BIN	AIN	EN	BO	AO
1	Yes	0	0	0	1	1
2	Yes	0	0	1	0	0
3	Yes	0	1	0	1	0
4	Yes	0	1	1	0	0
5	Yes	1	0	0	0	1
6	Yes	1	0	1	0	0
7	Yes	1	1	0	0	0
8	Yes	1	1	1	0	0
9	No	1	1	1	0	0

Transition	Input	Next Input	Output	Next Output	Action	Output Changes
1 → 2	000	001	11	00	Raise EN	Yes
1 → 3	000	010	11	10	Raise AIN	Yes
1 → 5	000	100	11	01	Raise BIN	Yes
2 → 1	001	000	00	11	Lower EN	Yes
2 → 4	001	011	00	00	Raise AIN	No
2 → 6	001	101	00	00	Raise BIN	No
3 → 1	010	000	10	11	Lower AIN	Yes
3 → 4	010	011	10	00	Raise EN	Yes

Shows the truth table of the cell.

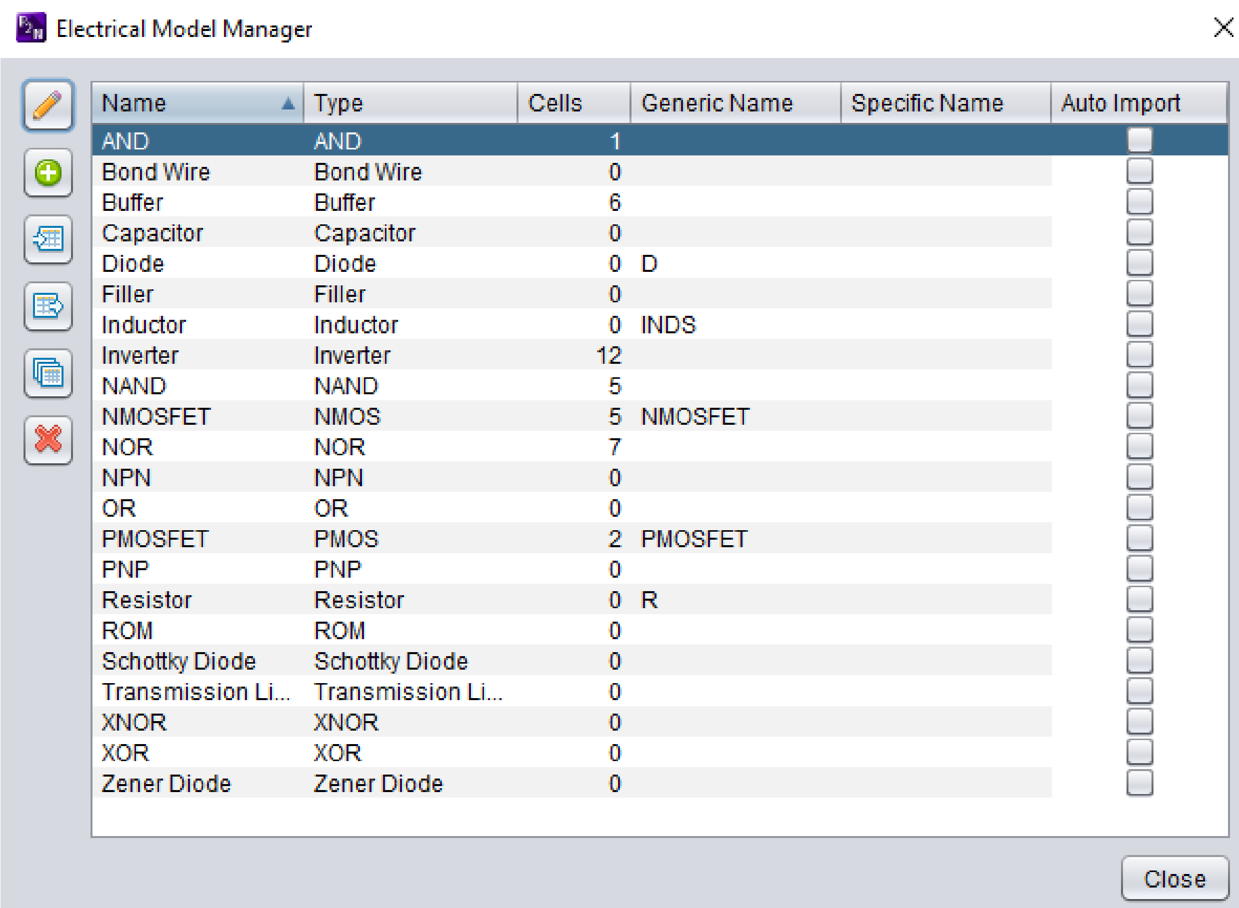
3.8.8 Move Into Target Netlist

When this button (green down arrow) is pressed, it will take the user to the highlighted cell.

3.8.9 Move Out to Main Netlist

When this button (green up arrow) is pressed, it will take the user to the cell that is higher up than the cell that is already targeted.

3.8.10 Manage Electrical Models

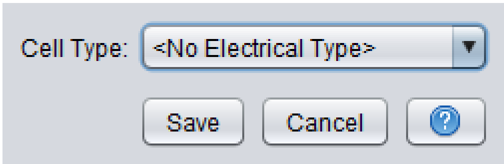


Name	Type	Cells	Generic Name	Specific Name	Auto Import
AND	AND	1			
Bond Wire	Bond Wire	0			
Buffer	Buffer	6			
Capacitor	Capacitor	0			
Diode	Diode	0	D		
Filler	Filler	0			
Inductor	Inductor	0	INDS		
Inverter	Inverter	12			
NAND	NAND	5			
NMOSFET	NMOS	5	NMOSFET		
NOR	NOR	7			
NPN	NPN	0			
OR	OR	0			
PMOSFET	PMOS	2	PMOSFET		
PNP	PNP	0			
Resistor	Resistor	0	R		
ROM	ROM	0			
Schottky Diode	Schottky Diode	0			
Transmission Li...	Transmission Li...	0			
XNOR	XNOR	0			
XOR	XOR	0			
Zener Diode	Zener Diode	0			

3.8.11 Electrical Properties

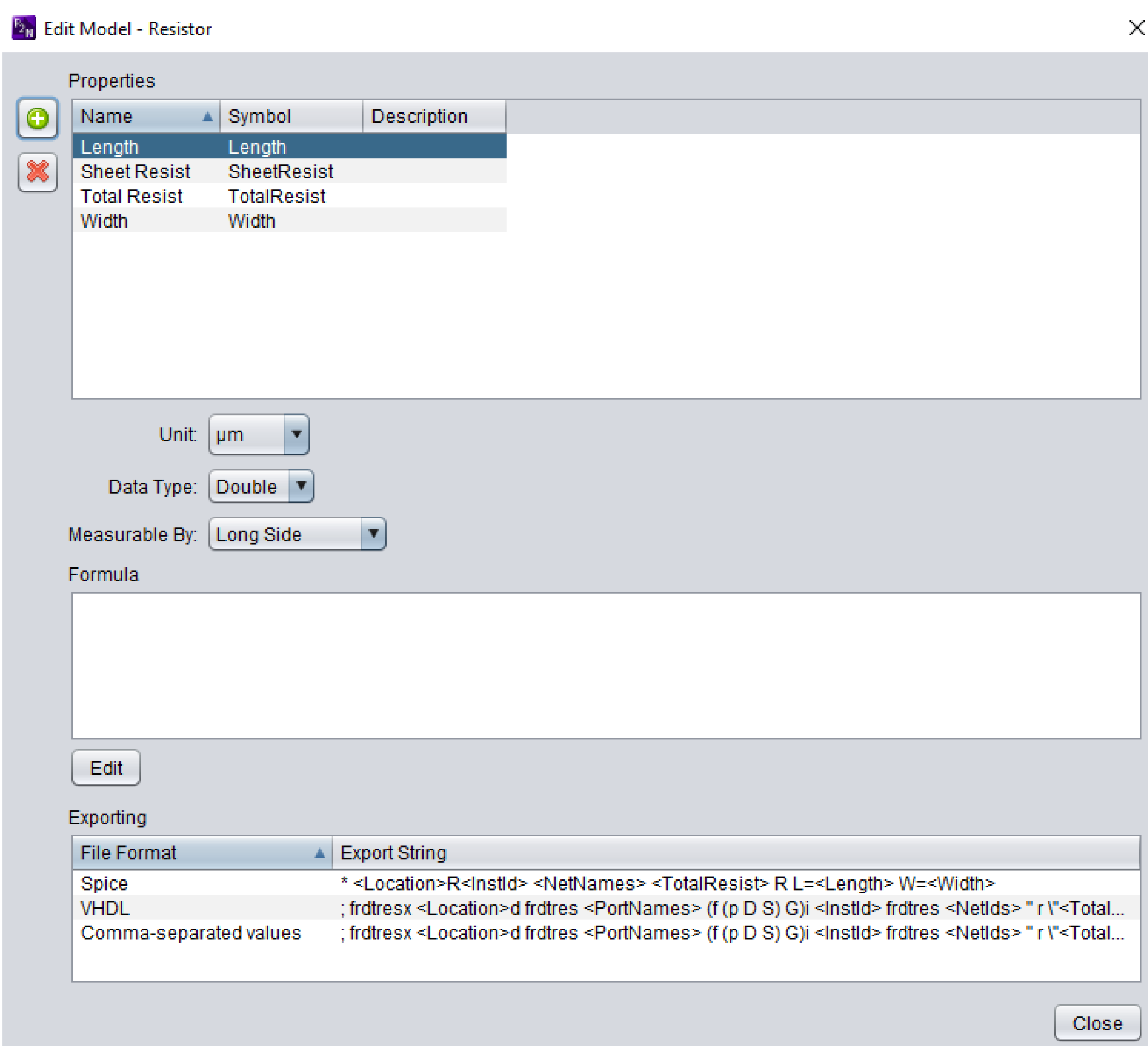
Here's a little bit about electrical properties.

No Type



This is the default state for all new cells. Hierarchical cells that contain other components will have this state. It has no properties.

Resistor



<Add image of a resistor component>

Length: <Add definition>

Width: <Add definition>

Sheet Resist: <Add definition>

(All Types)

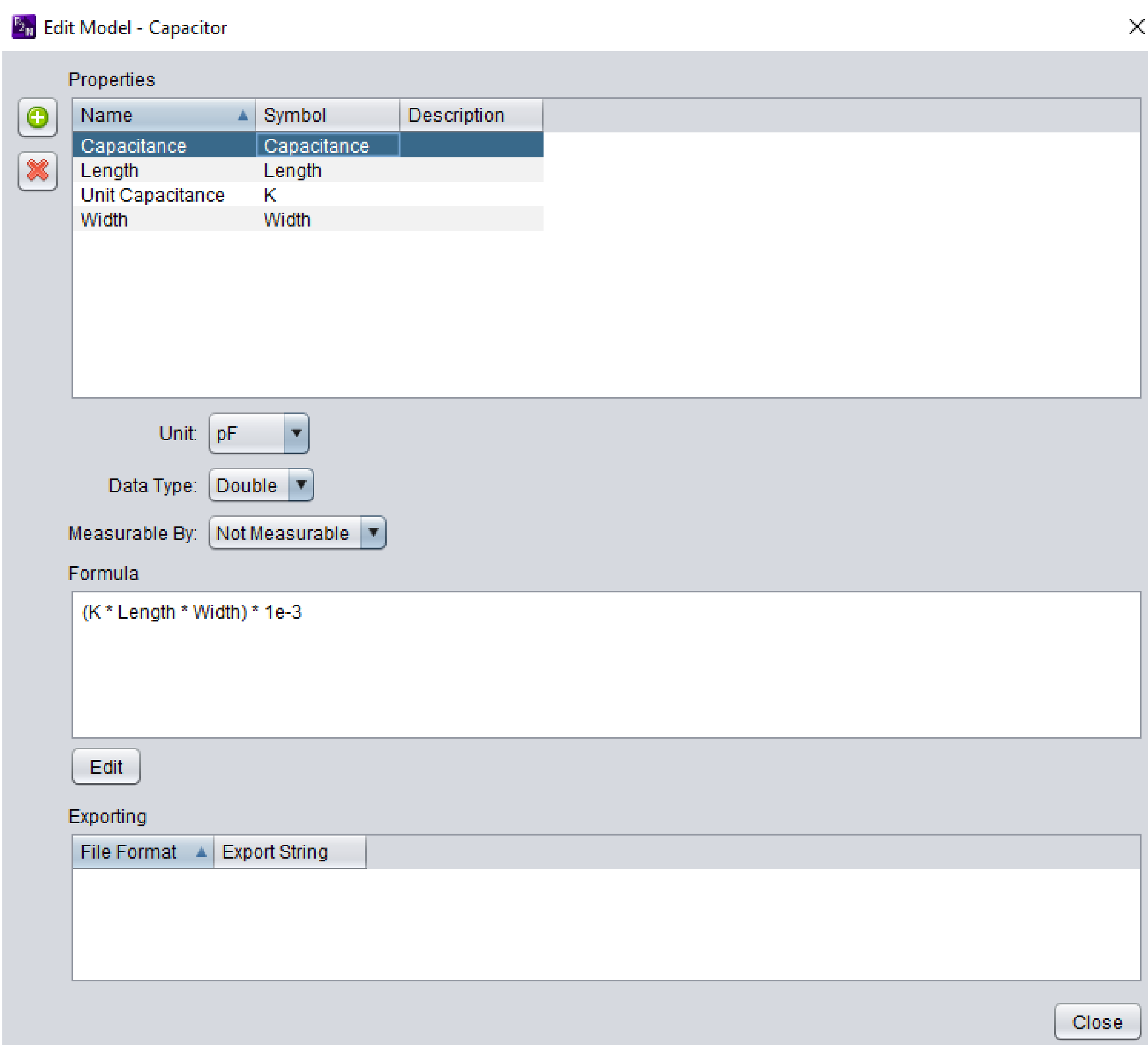
$$sheetResist = \frac{width}{length} \times totalResist$$

Total Resist: <Add definition>

(All Types)

$$totalResist = \frac{length}{width} \times sheetResist$$

Capacitor



<Add image of a capacitor component>

Length: <Add definition>

Width: <Add definition>

Unit Capacitance: <Add definition>

(MIM)

$$unitCapacitance = \frac{totalCapacitance}{length \times width} \times 1.0 \times 10^{-15}$$

(Dual MIM)

$$unitCapacitance = (\frac{totalCapacitance}{length \times width}) + (length \times 2.0) + (width \times 6.0)) \times 1.0 \times 10^{-15}$$

(DCAP)

$$unitCapacitance = \frac{totalCapacitance}{length \times width} \times 1.0 \times 10^{-15}$$

Total Capacitance: <Add definition>

(MIM)

$$totalCapacitance = width \times length \times unitCapacitance \times 1.0 \times 10^{-15}$$

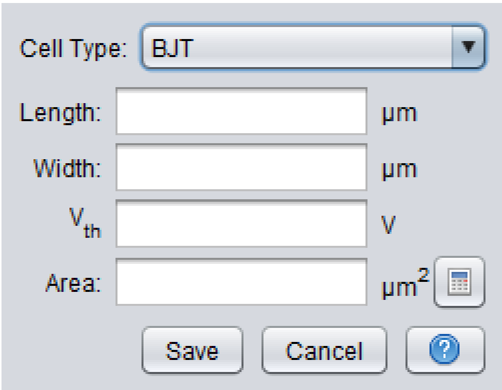
(Dual MIM)

$$totalCapacitance = ((width \times length) + (length \times 2.0) + (width \times 6.0)) \times unitCapacitance \times 1.0 \times 10^{-15}$$

(DCAP)

$$totalCapacitance = width \times length \times unitCapacitance \times 1.0 \times 10^{-15}$$

BJT



<Add image of BJT component>

Length: <Add definition>

Width: <Add definition>

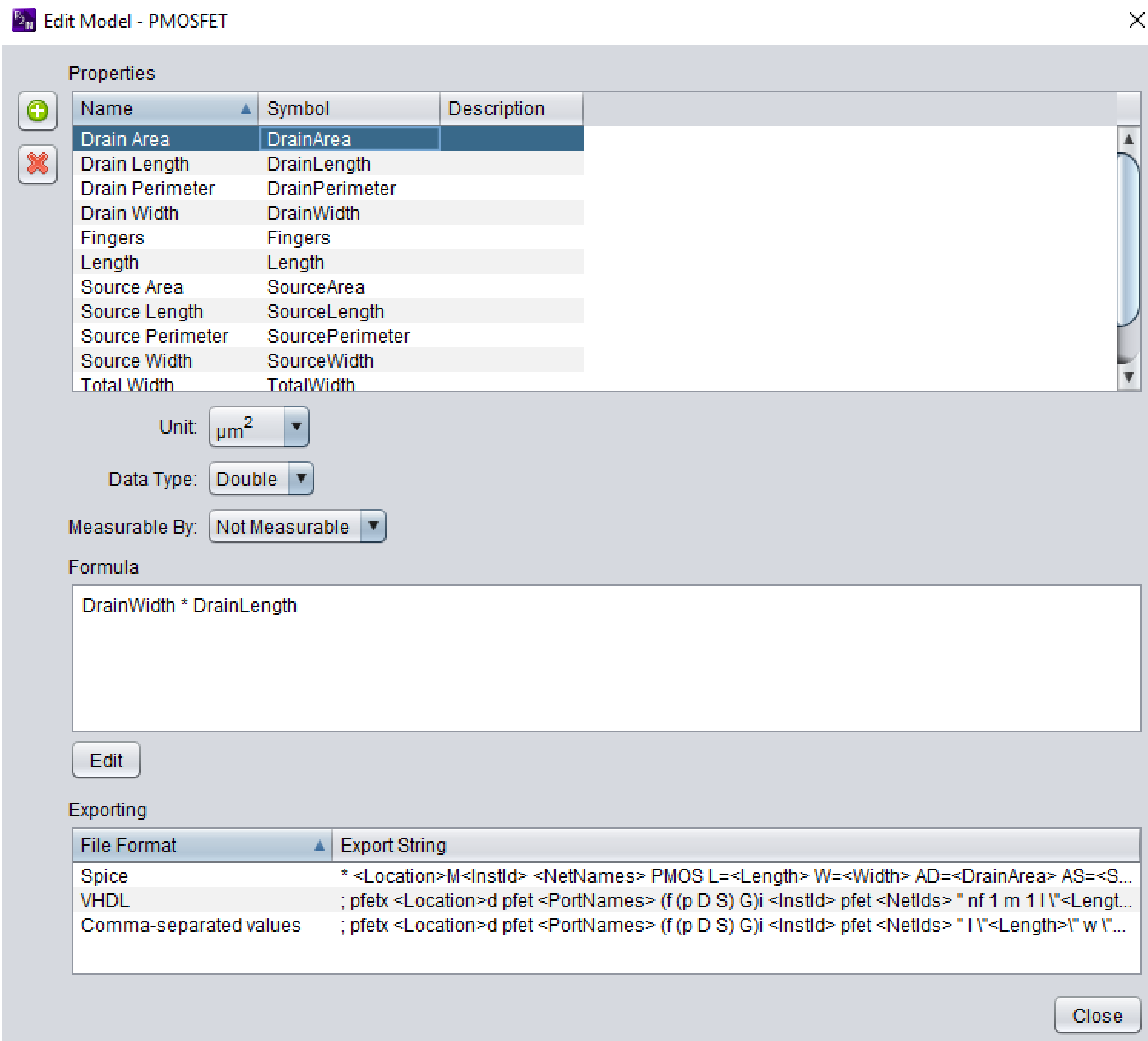
Vth: <Add definition>

Area: <Add definition>

 (All Types)

$$area = length \times width$$

MOSFET



<Add image of MOSFET component>

Length: <Add definition>

Width: <Add definition>

Fingers: <Add definition>

Vth: <Add definition>

Total Width: <Add definition>

 (All Types)

$$totalWidth = width \times fingers$$

Source Length: <Add definition>

Source Width: <Add definition>

Source Area: <Add definition>

(All Types)

$$sourceArea = sourceLength \times sourceWidth$$

Source Perimeter: <Add definition>

(All Types)

$$sourcePerimeter = (sourceLength \times 2.0) + (sourceWidth \times 2.0)$$

Drain Length: <Add definition>

Drain Width: <Add definition>

Drain Area: <Add definition>

(All Types)

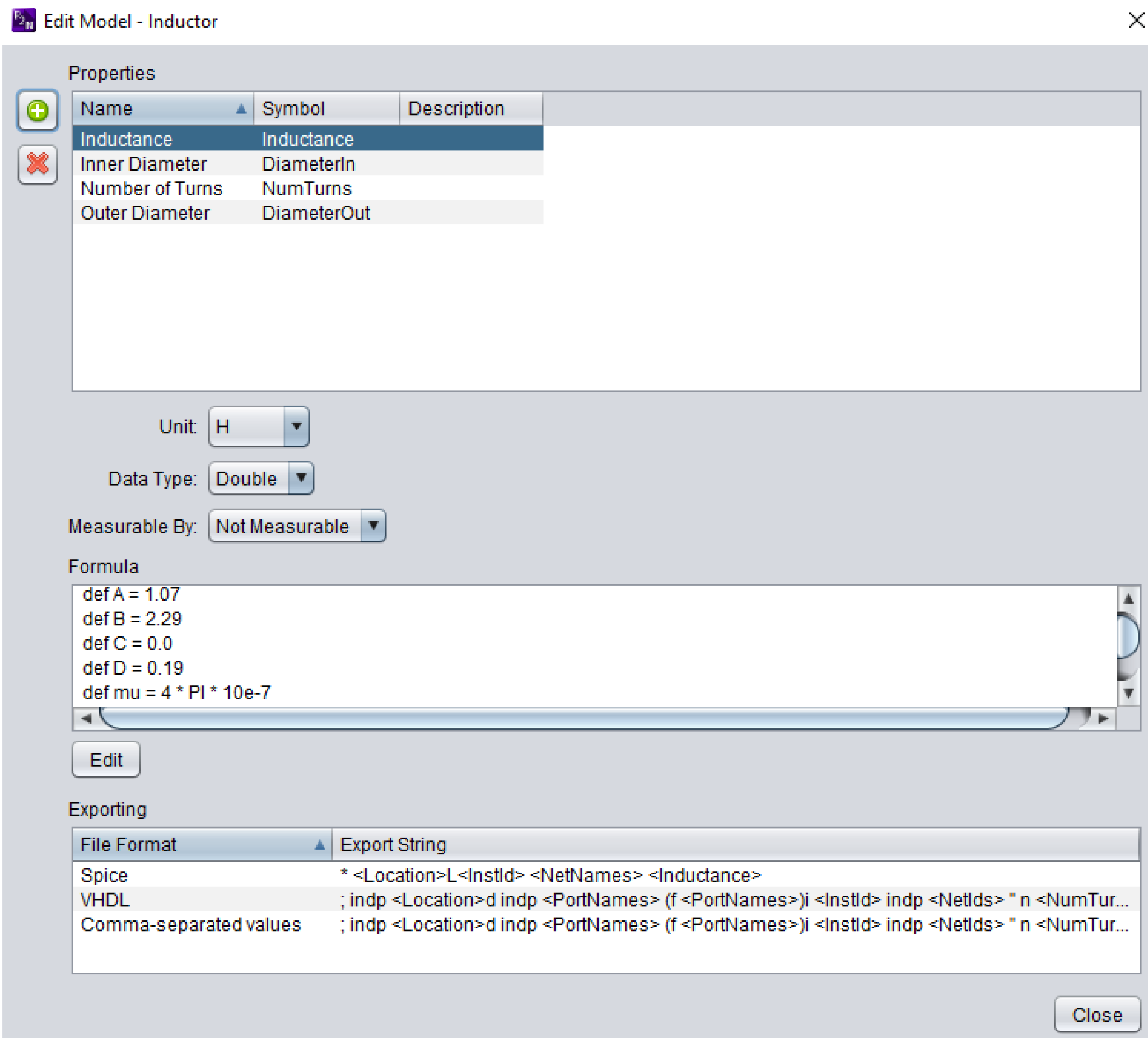
$$drainArea = drainLength \times drainWidth$$

Drain Perimeter: <Add definition>

(All Types)

$$drainPerimeter = (drainLength \times 2.0) + (drainWidth \times 2.0)$$

Inductor



<Add image of inductor component>

Outer Diameter: <Add definition>

Inner Diameter: <Add definition>

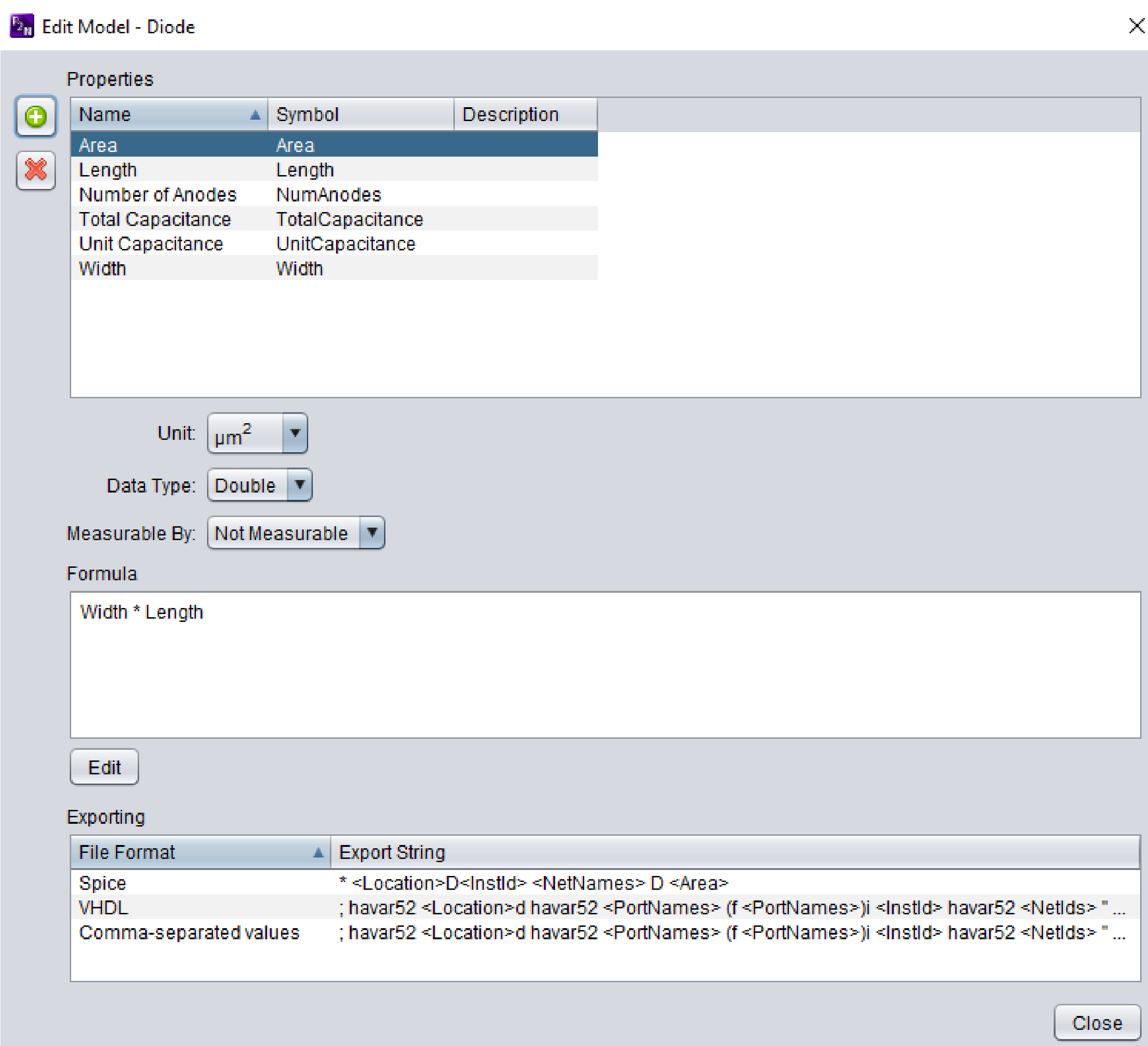
Number of Turns: <Add definition>

Inductance: <Add definition>

 (Octagon)

$$A = 1.07$$
$$B = 2.29$$
$$C = 0.0$$
$$D = 0.19$$
$$\mu = 4\pi \times 1.0 \times 10^{-6}$$
$$d_{avg} = \frac{(outDiameter + inDiameter)}{2.0}$$
$$\rho = \frac{(outDiameter - inDiameter)}{(outDiameter + inDiameter)} \times 1.0$$
$$inductance = \mu \times numTurns^2 \times d_{avg} \times A \times (\log(\frac{B}{\rho}) + (C\rho) + (D\rho^2))$$

Diode



<Add image of diode component>

Length: <Add definition>

Width: <Add definition>

Number of Anodes: <Add definition>

Area: <Add definition>

(All Types)

$$area = length \times width$$

Unit Capacitance: <Add definition>

(All Types)

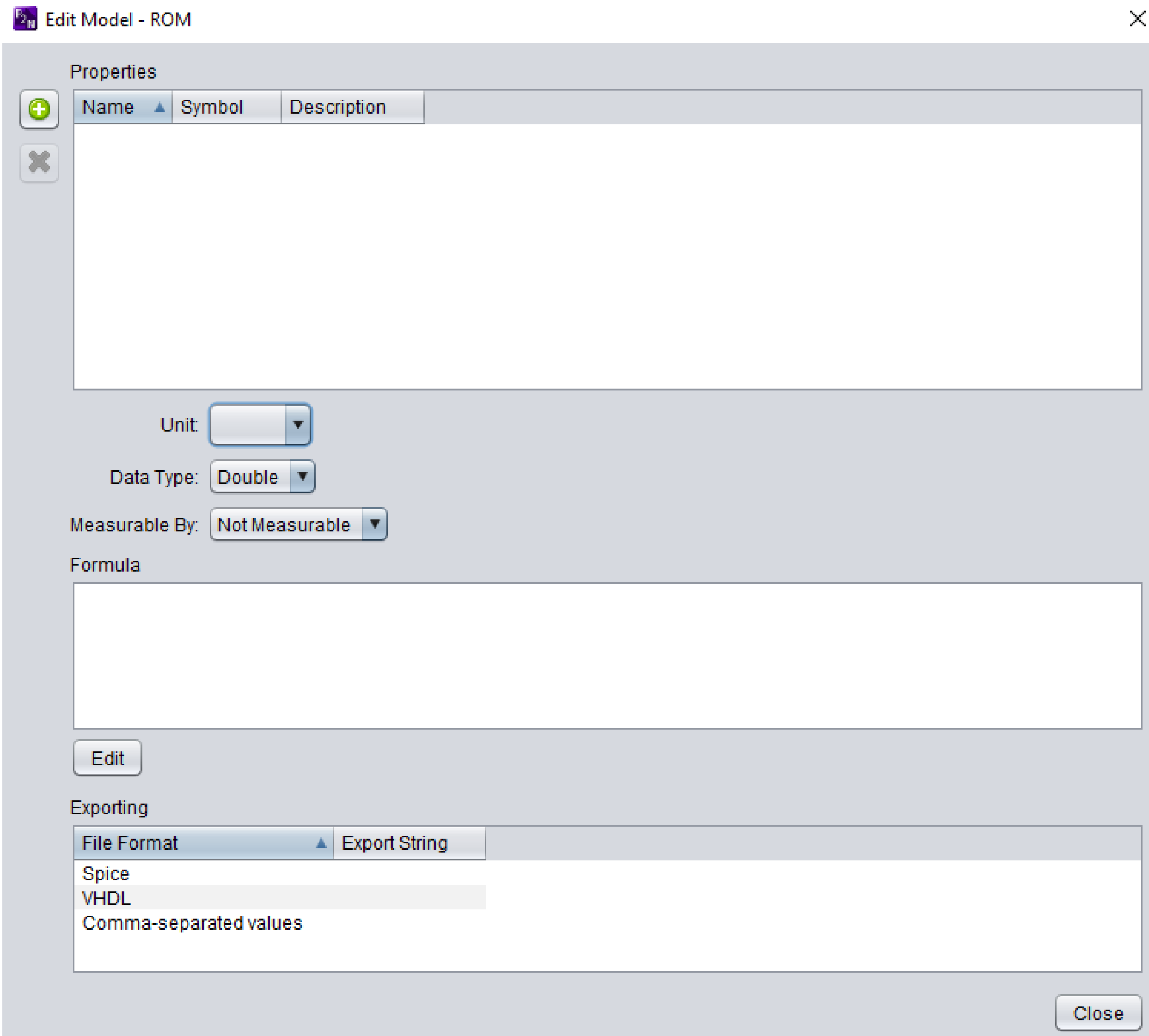
$$unitCapacitance = \frac{totalCapacitance}{length \times width \times numAnodes} \times 1.0 \times 10^{-15}$$

Total Capacitance: <Add definition>

(All Types)

$$totalCapacitance = width \times length \times numAnodes \times unitCapacitance \times 1.0 \times 10^{-15}$$

ROM

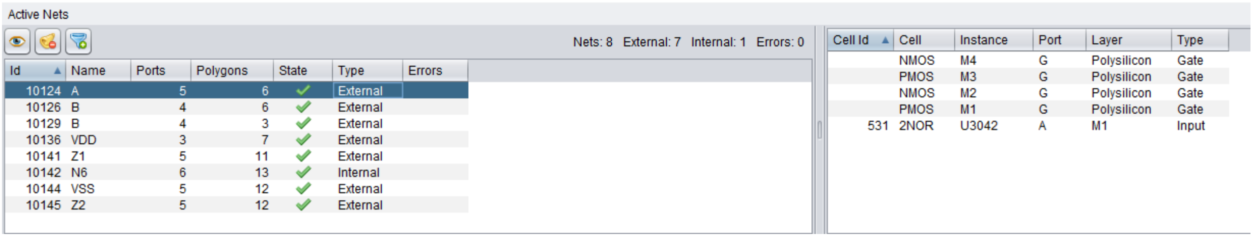


This cell type is used to denote an area that contains bits for memory extraction. It has no properties.

3.9 Netlist

3.9.1 Netlist Window

Before proceeding with netlisting, the technology for the layers needs to be set. see *Technology*



The Netlist window shows all of the nets that have currently been found. Every time that polygons and cells (that are part of a netlist) are updated, Pix2Net automatically updates the `Active Nets`.

The left window contains the list of nets. Here are the columns:

- ID: The ID number of the net.
- Name: The name of the port.
- Ports: The number of ports in the net.
- Polygons: The number of polygons in the net.
- State: A green checkmark indicates no errors. A red x indicates at least one error.
- Type: Shows the type of net, internal or external.
- Error: A short description of the net's error.

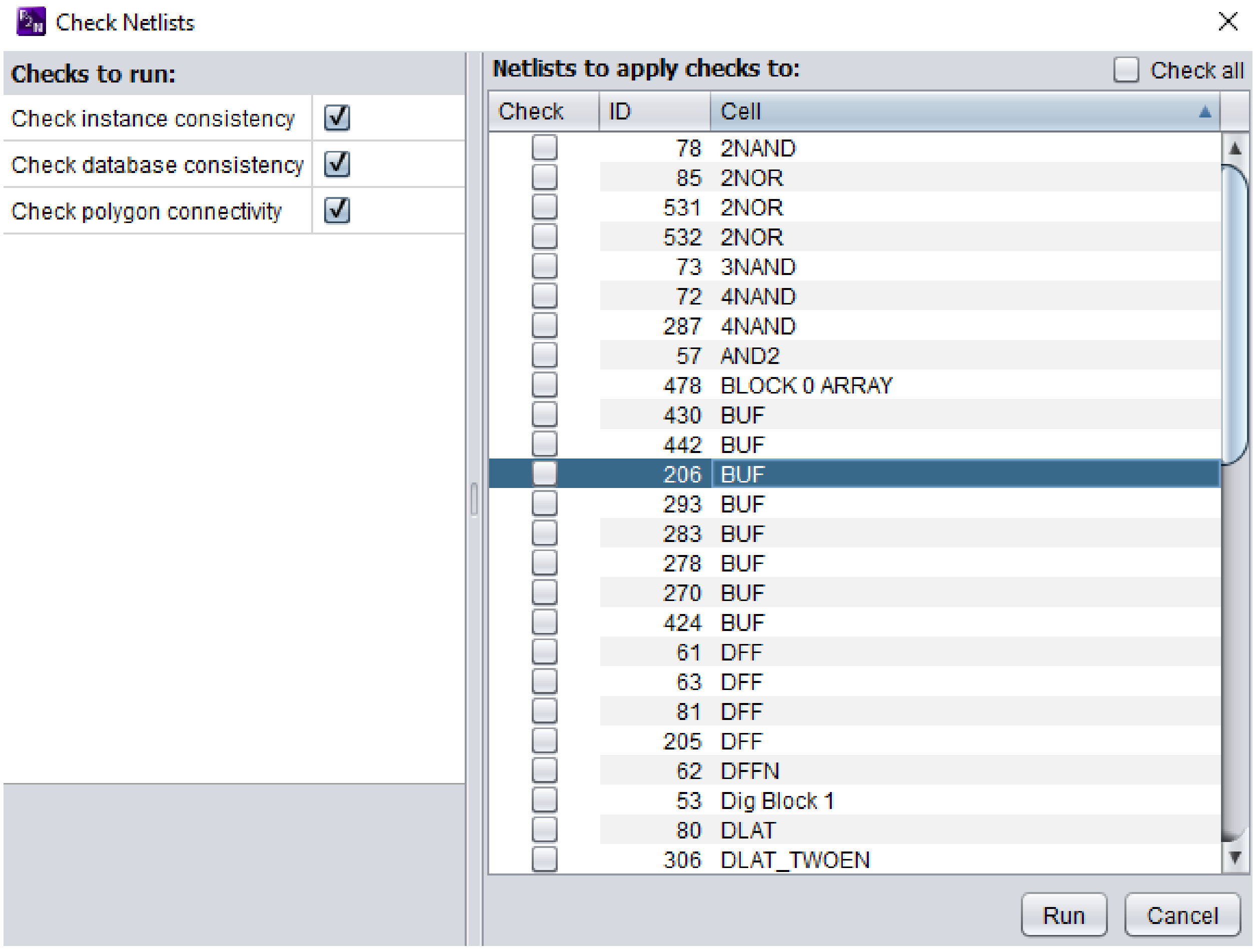
If you click on a row, then the camera will zoom to the net and highlight it, and the right window will show the details of the selected net.

The right window contains the list of ports for the currently selected net. Here are the columns:

- Cell ID: The ID number of the port's cell.
- Cell: The name of the port's cell.
- Instance: The name of the port's instance.
- Port: The name of the port.
- Layer: What layer the port is on.
- Type: The port type: Input, Output, Inout, VSS, VDD, or Gate.

If you click on the right column, then the camera will zoom to that particular port.

3.9.2 Netlist Checker



The Netlist Checker runs a series of sanity checks on the main netlist and makes a report of any errors encountered.

The checker can be configured to run the following tests:

- Check instance consistency: Verifies that the netlist of each instance of a cell matches the primary instance netlist. This will compare the instances of all checked cells in the right hand pane and will report a match to a different, checked cell if there is an inconsistency.
- Check database consistency: Verifies that the netlist does not have any missing entries in the database that could cause problems or inconsistencies in the netlist. Run this periodically if database inconsistencies or corruption are suspected.
- Check polygon connectivity: Verifies that the polygons are connected and can send energy from one layer to the next.

CHAPTER

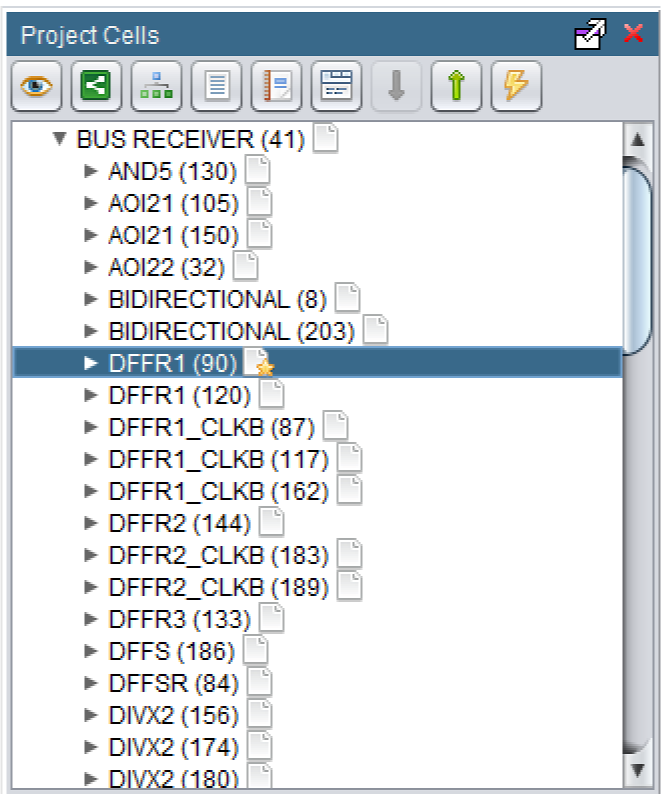
FOUR

STEP-BY-STEP GUIDES

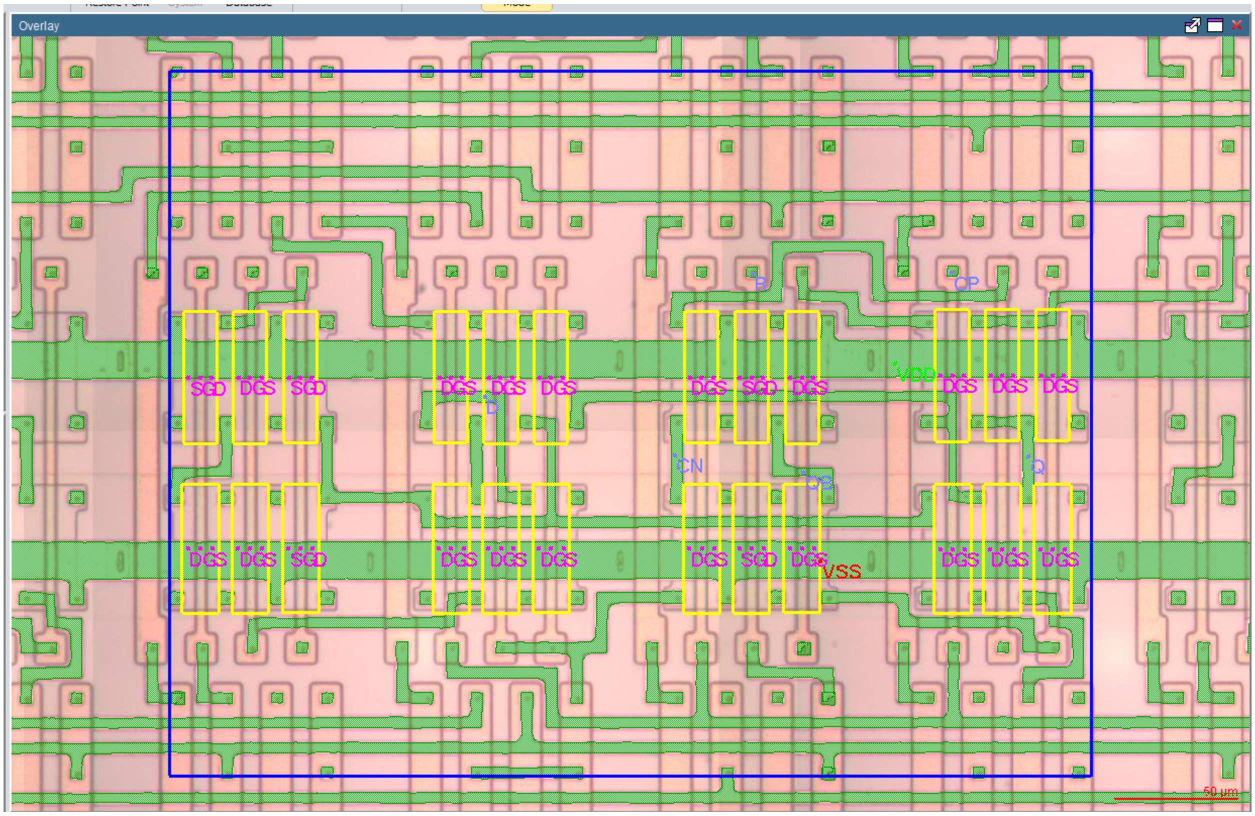
4.1 Schematic Tool Basics

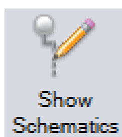
After creating a netlist, the user may create a schematic by following the steps below:

If you have netlisted a library cell, such as a DFFR, you can view the schematic when that netlist is active (has a star by the name in the 'Project Cells' window):



Highlighting the cell in the 'Project Cells' window will take the user to the cell in the overlay:

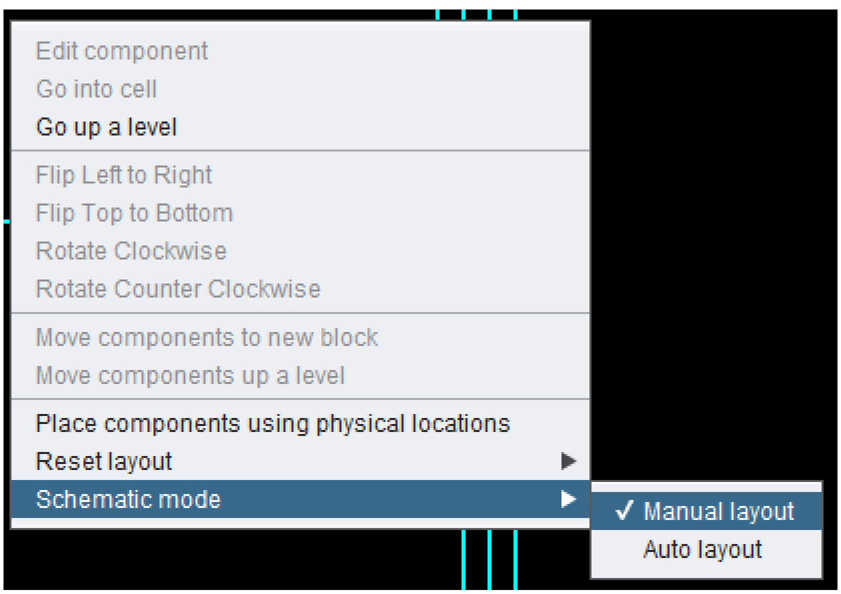


Clicking on the 'Show Schematics' 

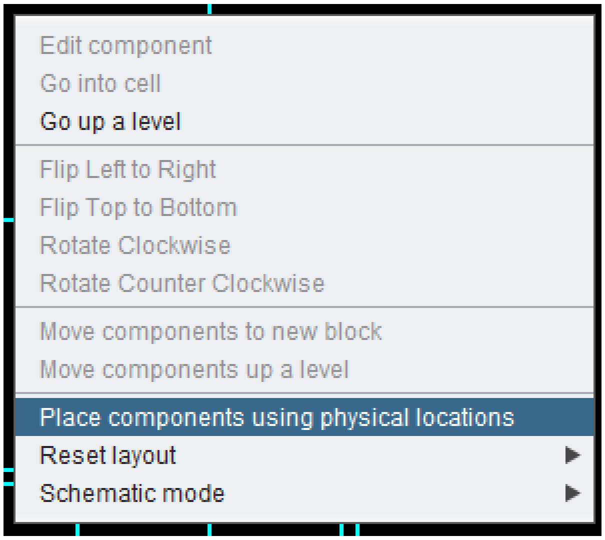
button on the 'Schematic' tab will bring up the schematic in the center pane:

Note:*The schematic is initially rendered in the 'auto layout' mode. The work done in auto layout mode, i.e. rearranging the cells and output ports, is not saved when you close the window.*

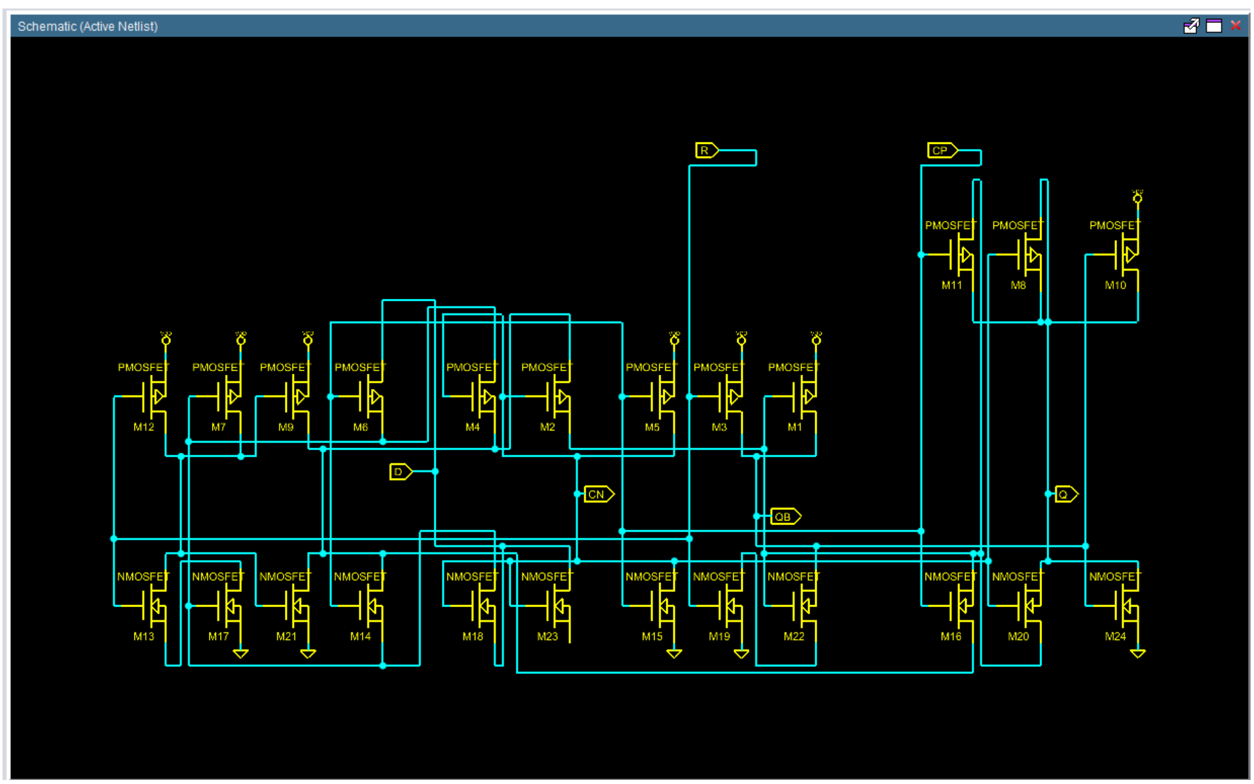
Right click in the Schematic and hover the mouse over 'Schematic mode' and click 'Manual layout'



Right click again in the Schematic to bring up the context menu:

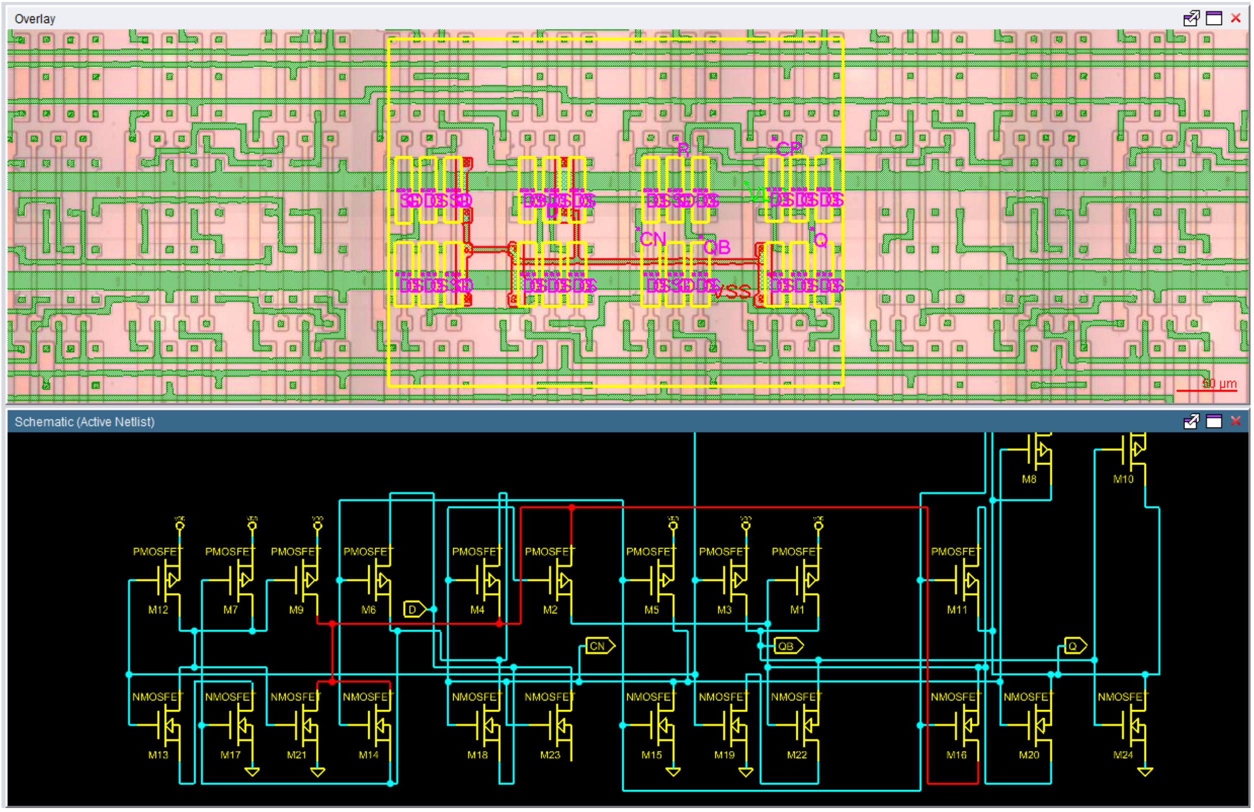


By clicking on ‘Place components using physical locations’ (after the schematic is in manual mode), the schematic will be reorganized to reflect the physical layout. This is especially useful for the library cell level and the analog case:

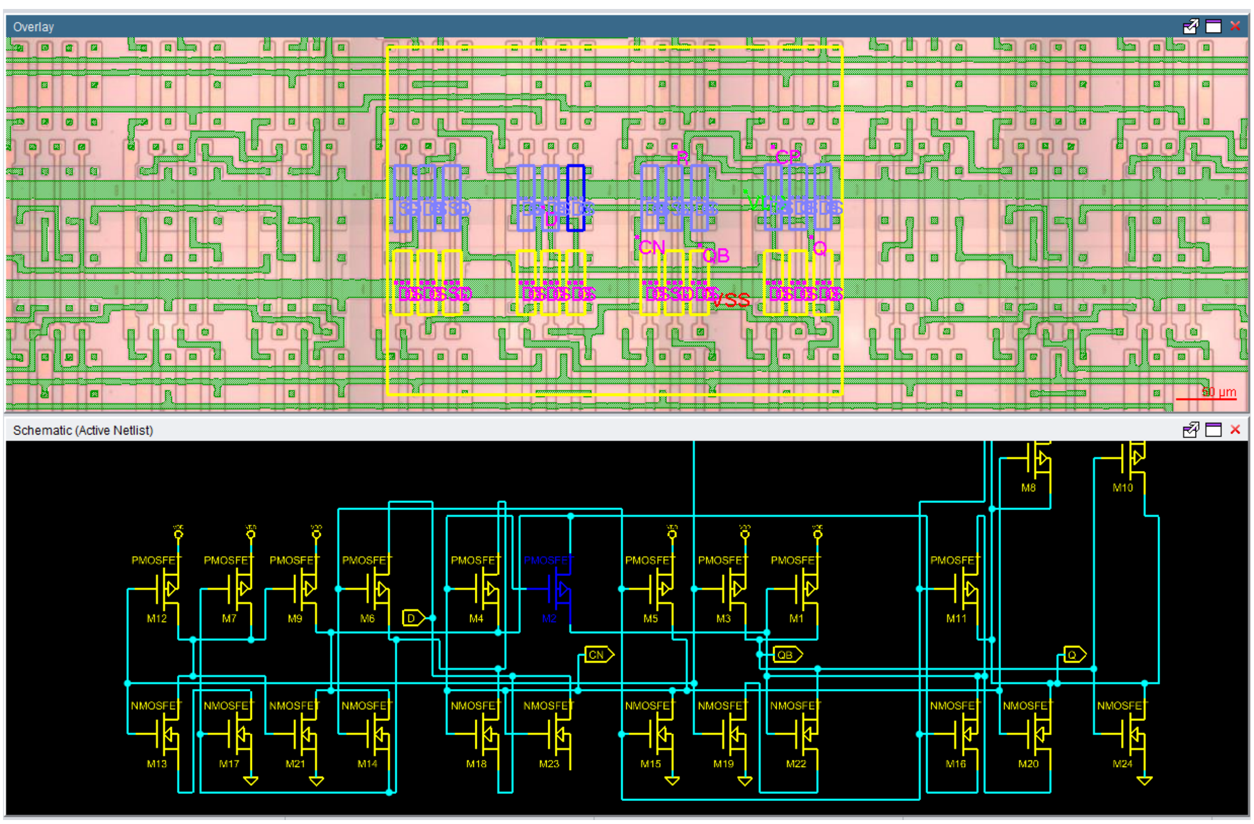


Click on a desired net, cell or port in the schematic window to select it. (Make sure the ‘select’ button is highlighted yellow). You will see the same object highlighted in the overlay.

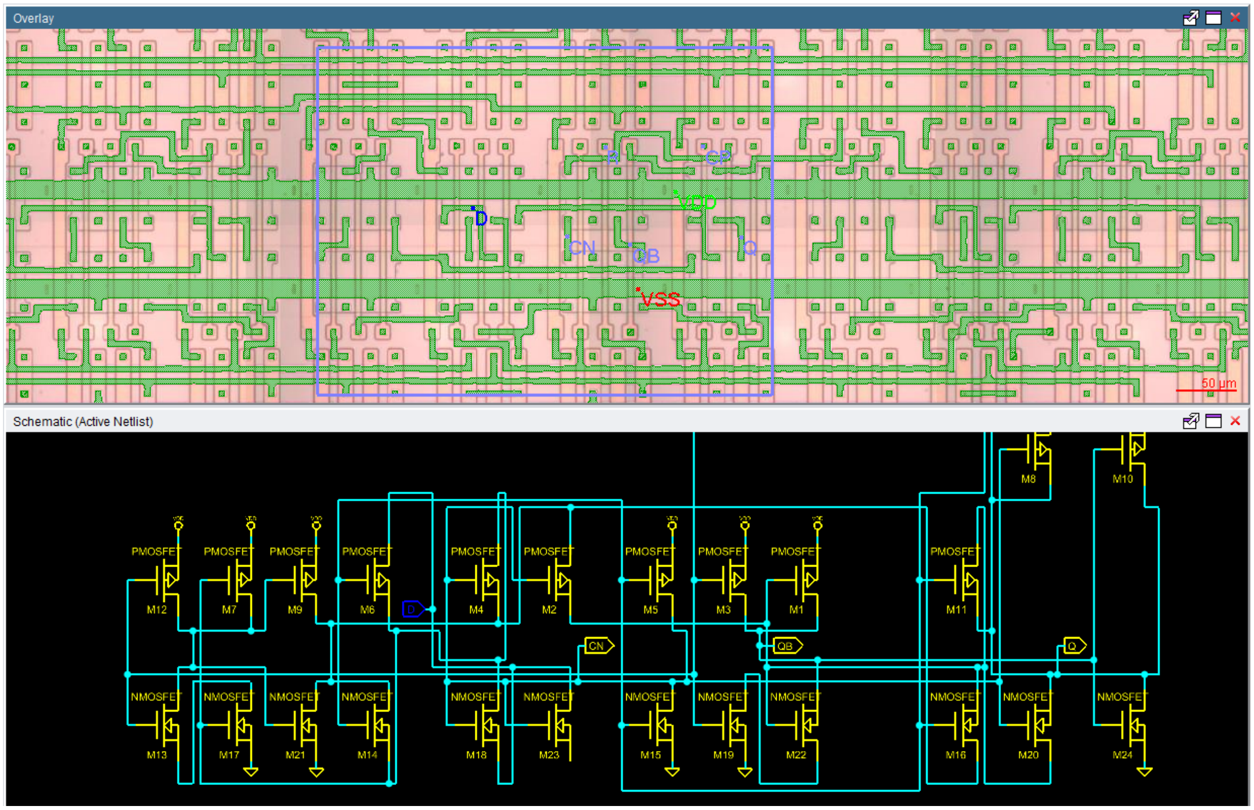
Here is the overlay and schematic with a net highlighted:



Here is the overlay and schematic with a cell highlighted:

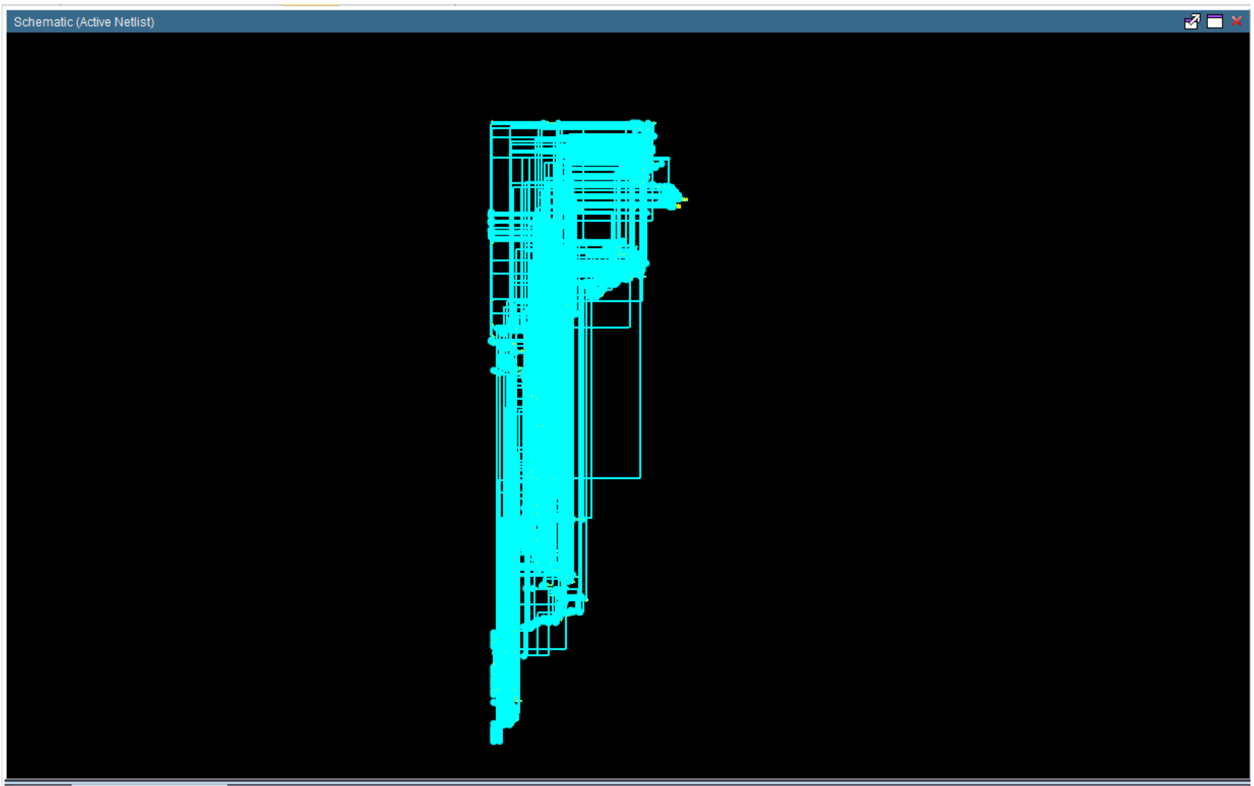


Here is the overlay with the 'D' port highlighted:

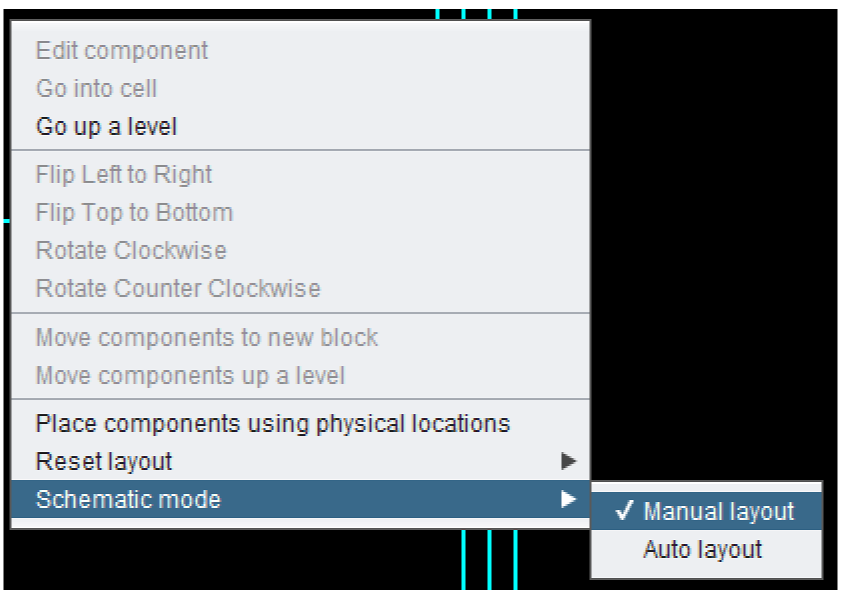


4.1.1 Larger Schematics

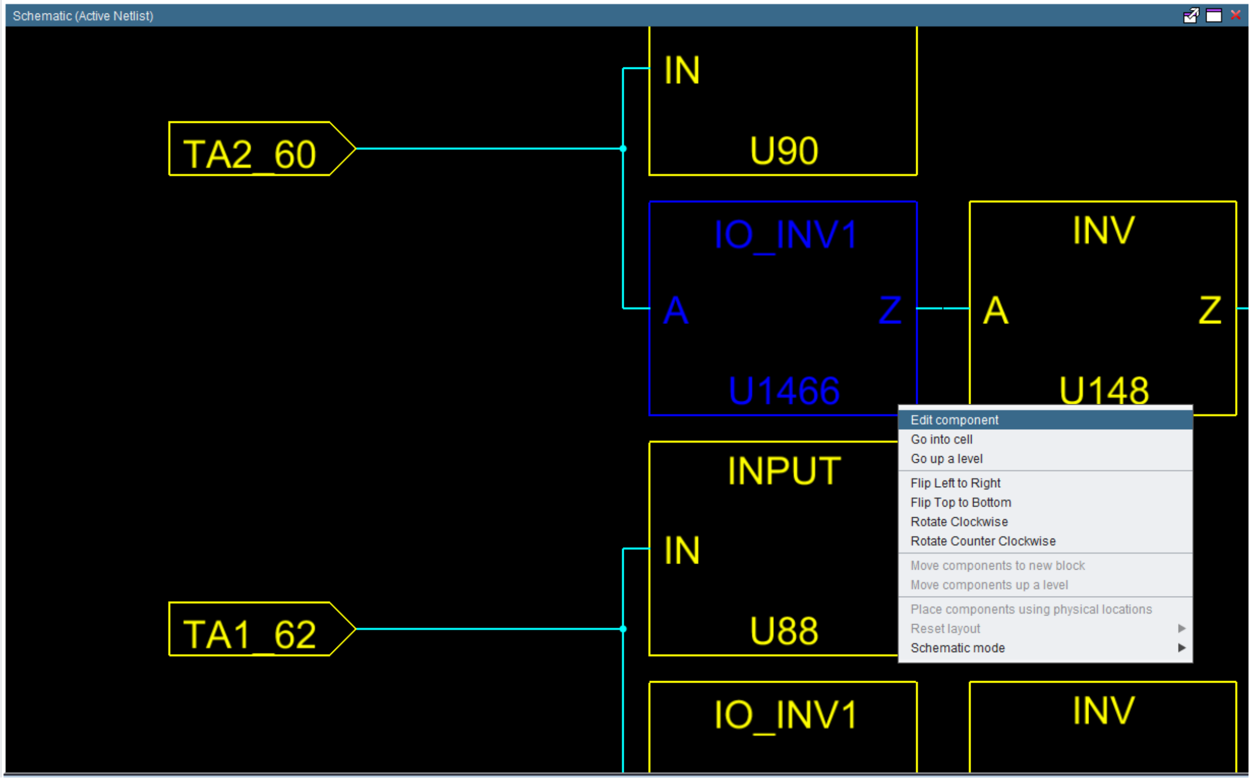
When you open a larger schematic, it will look more like this:



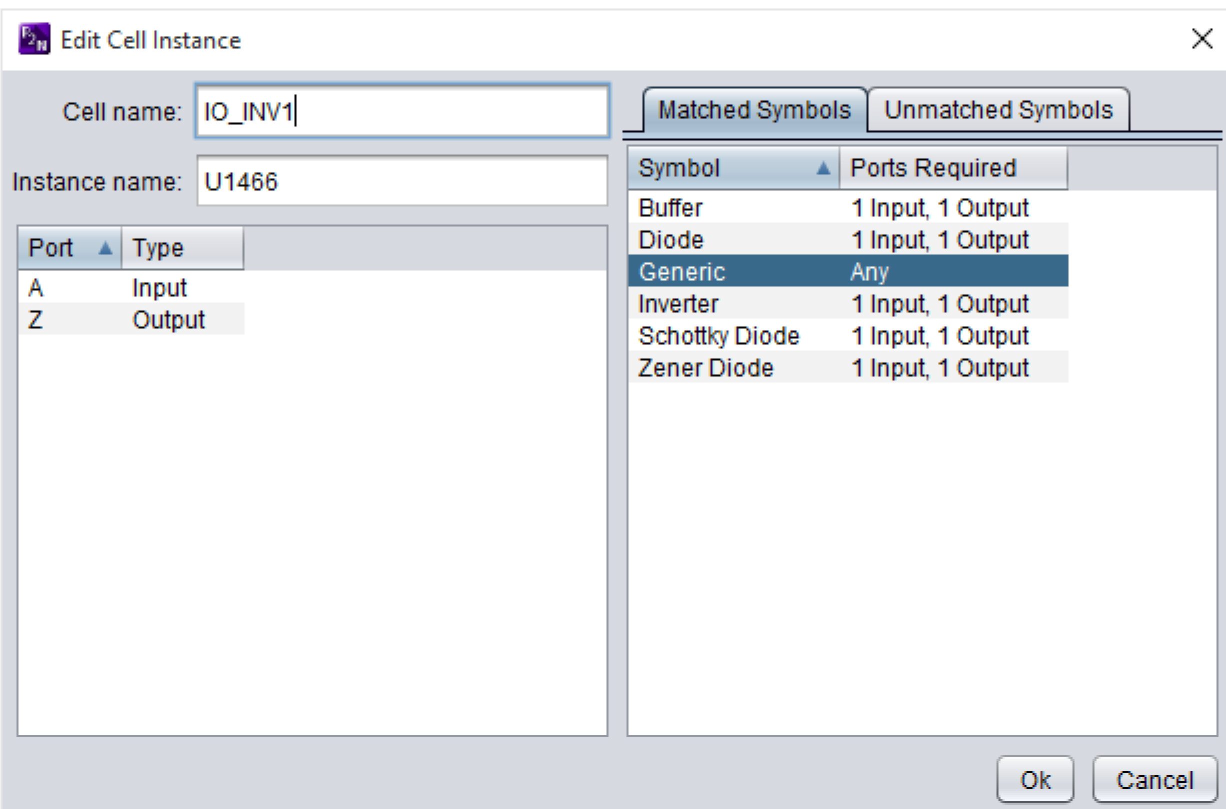
In general, the inputs are in the bottom left edge and the outputs are to the right edge. From here, it is recommended that the user right clicks in the window and sets the schematic mode to 'manual layout'.



Zoom in to a closer view of the components, and select one (so it turns blue). Right click to pull up the context menu. Select *Edit component*.

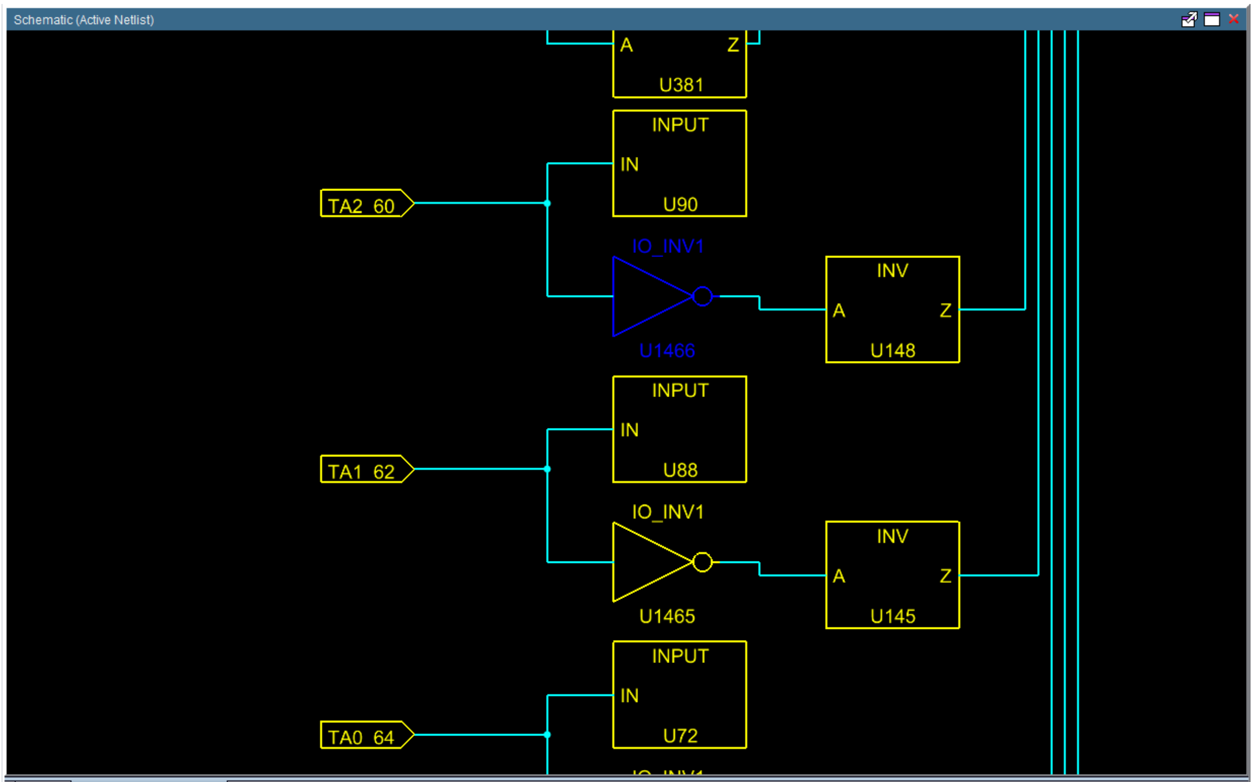


The *Edit Cell Instance* window will appear:

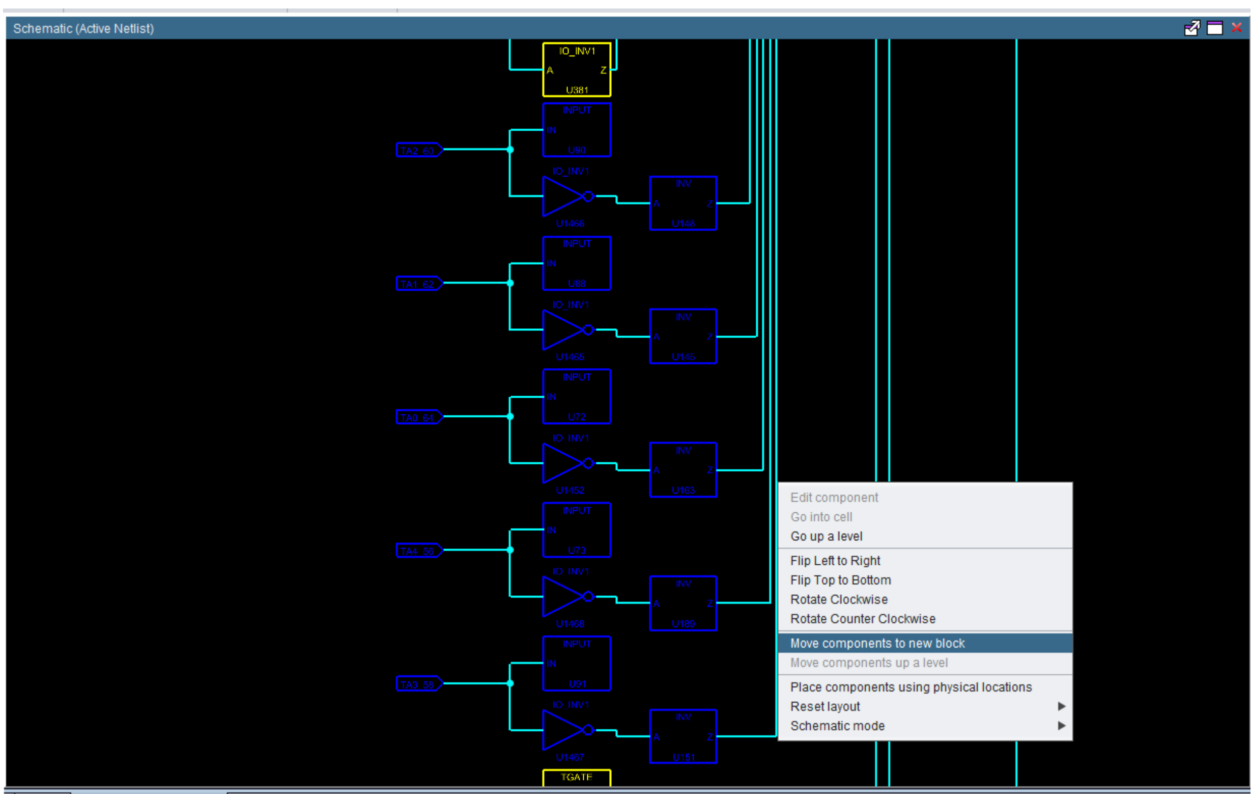


Once you select a desired symbol, all of the cell instances are updated to reflect the change. Here you see the inverter

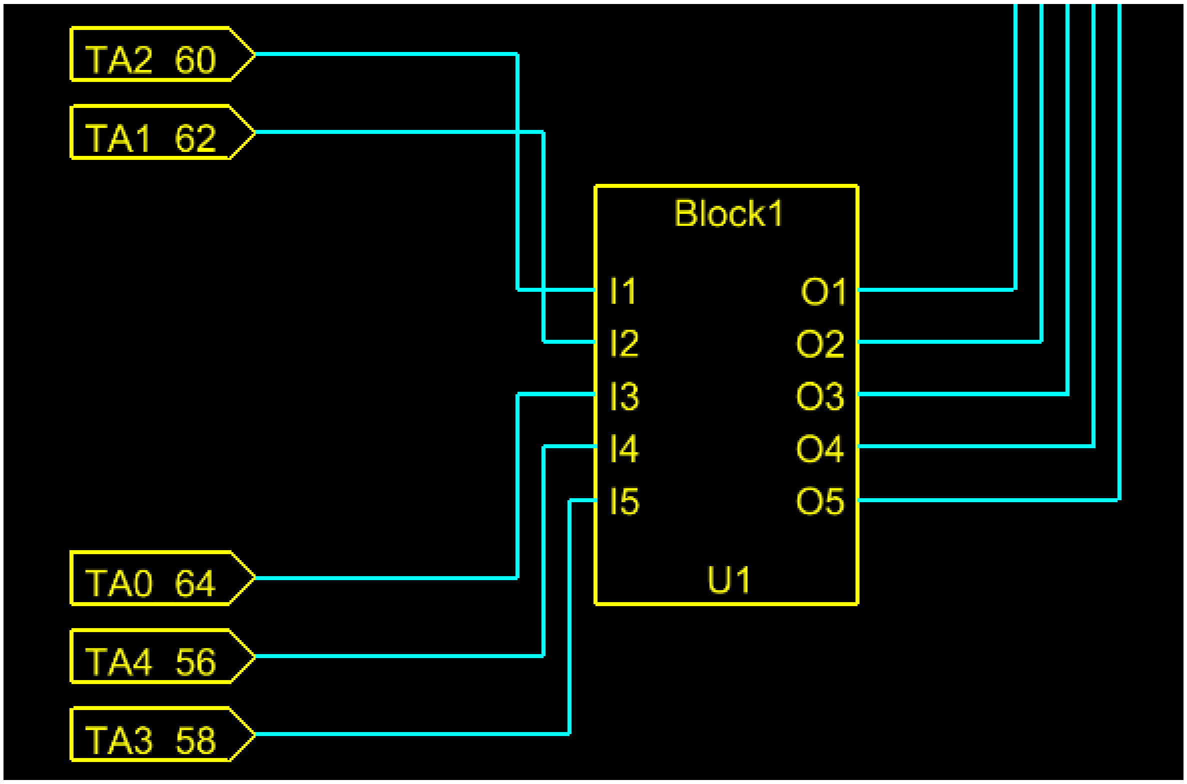
symbol:



Select a group of related cells. They will all highlight in blue. Right click and select *Move components to new block*

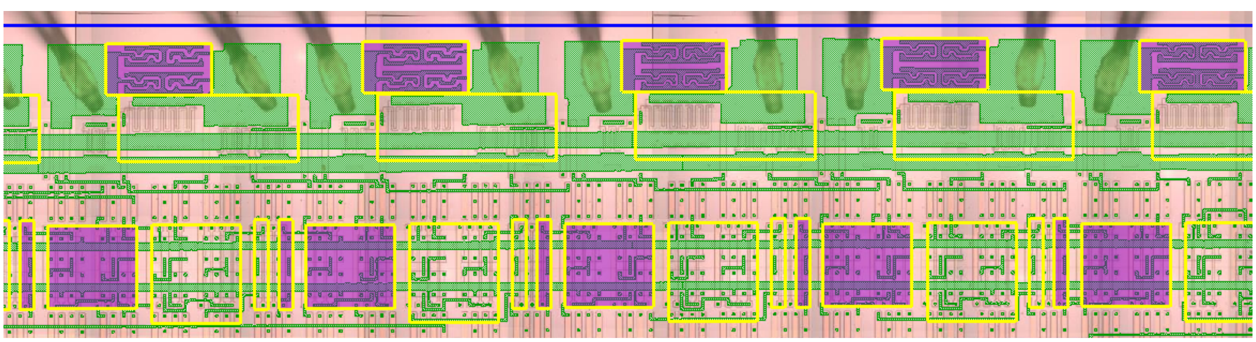


Now the components are in one hierarchical block in the schematic:



Now click on the *Block Creator* 

in the *Schematic Tab*, check only the block that was just created, and switch your view to the overlay.



The corresponding cells are highlighted (in this case in a pink color) so the user can visualize the hierarchy.

CHAPTER

FIVE

RELEASE NOTES

5.1 Change Log

CHAPTER SIX

GLOSSARY

anchor A holding point between two layers to stretch and shrink them in order to stack layer images on top of each other for connectivity. Or, in the layer orthogonal case, an anchor is made to tell Pix2Net how the vertical and horizontal axes should be defined.

cell Pushes the electric current between metals and vias from positive to negative.

feature extraction The process of converting images into polygons.

image layer A set of images that show a device layer.

multiscale images A set of images that show a device layer at multiple zoom levels. Multiscale images are time consuming to generate, but they are essential for rendering image layers efficiently as the user zooms in and out.

netlist Shows the connectivity in the electrical circuit through polygon layer connections (metal layer to via to metal layer).

neural network A network that extracts polygons by looking at images that the user specifies and then looks throughout the layer while learning what should be considered part of the polygon layer, and what should not.

polygon layer A set of polygons that models a device layer.

schematic Shows a diagram of the electrical circuit.

SEM A scanning electron microscope.

stage A nanometer-precision linear or rotation stage that can be used with a SEM.

stitch A feature that is used to connect overlapping images into one image by placing the overlapping portion top of each other and moving them to make sure there is no warp between images.