

Magic Tutorial

Starting Magic

Magic is started from an Xterm by typing:

```
magic -T <technology file> [<cell name>]
```

where the technology file is specific to the fabrication process you plan to use. We will probably use the technology file 'scmos', which handles processes such as Orbit 2.0u and AMI 1.2u processes.

The cell name is the name of the object you will be editing. If it does not exist, it will be created at startup. Note that while cell files (written from within magic with the 'save' command), contain the suffix '.mag', you do *not* type this suffix when giving the cell name. Magic will add '.mag' to what you type.

Technology Files

The available technology files are found in directory

```
/usr/local/cad/lib/magic/sys
```

Do an 'ls *.tech27' on this directory if you want to see them. Note that you should not type the file suffix '.tech27' when the tech file name is given to magic on startup. Magic adds this to what you type after -T.

The tech file configures magic for the target process(es) by defining the available layers (like poly, ndiffusion, etc.), the design rules, and the extraction and cif/calma output styles. See the MOSIS web page at

```
www.mosis.org
```

for more information on technology files. *Be warned however* - there is a lot of info on this topic. For now, you can stick with using 'scmos.tech27' and not worry about it.

Magic's Windows

Magic will display a graphics window after you start it. You will use the mouse in this window, but commands you type will be echoed in the Xterm from which magic was invoked.

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The Mouse and the Box

In the graphics window, there will be a white outlined box which is used for drawing, selecting, etc. The left mouse button repositions the lower left corner of the box, while the right button repositions the upper right corner.

You can also position the box directly by typing the 'box' command. With the cursor anywhere in the graphics window, type the following command (*be sure to start the command with a colon ':'* !)

```
:box 0 0 10 20
```

This will resize the box with lower left corner at 0,0 and upper right corner at 10,20. (The numbers are "lambda units", which are related to, but not equal to microns. For the AMI process, a single lambda-unit will be equal to 0.6um, whereas for some other process it could be 1.0um, or 0.3um, or ...)

Painting Layers

After issuing the 'box' command above, type the command below (*be sure to start with a colon ':' !!!*)

```
:paint <layer name>
```

This will create 'material' of type <layer name> at location specified by the box. For example, you could paint nwell, or ndiffusion, or poly, or metal, or ...

Composite Layers

An odd (but useful) thing about magic is it's composite layers. For example, if you paint 'polycontact', it shows as a single entity, but when the design is sent to fabrication, it will be decomposed into the layers metall, poly, and contact. Similarly for ndcontact (ndiffusion contact), via, etc. layers. Thus, composite layers save you the trouble of painting all of these individual layers.

Another type of composite layer is created when you paint poly over ndiffusion (or over pdiffusion). In this case, a new layer is magically created (pun intended).

The new layer, where poly overlays ndiffusion, is called ntransistor, and will be output for fabrication in such a way that this region will have thin oxide (as opposed to field oxide) below the poly.

Keystroke Commands

Commands can be entered by single keystrokes as described earlier, or, for some commands, a single keystroke can be used. (This is why you must start the commands above with a colon.) To see a list of keystroke commands, print out the file:

```
/usr/local/lib/magic/sys/.magic
```

Zooming In (or Out)

To zoom in on a region, use the mouse to place the box around the region and hit the 'z' key. To zoom out, type a capital 'Z'.

Displaying the Grid

To toggle the grid on and off, hit the 'g' key. You will only see the grid if you are zoomed into a small enough area. By default, the grid size is one lambda unit. This can be changed using the ':grid <n>' command, where <n> specifies the grid spacing in lambda units.

Snapping to Grid

When the grid size is 1, the resolution for positioning the box is also 1 lambda unit (fractions are not possible). When the grid is set to a larger value, the ':snap on' command can be issued to make sure that the box always lies on a grid coordinate. This is occasionally helpful. Use ':snap off' to disable snapping.

DRC and DRC Why

A great feature of magic is its ability to do design rule checking (DRC) as you enter your layout. If a DRC error is encountered (e.g. you drew an nwell or other feature too narrow), you will see lots of white dots.

If you are unsure what is wrong, place the box around the affected area, and hit the 'y' key (or enter ':drc why'). The rule that is violated will be printed in the Xterm window.

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Stretching

Magic provides the ability to 'stretch' a certain area of your design (e.g. make an nwell region larger on one side). Place the box so that the side is enclosed, select the area by hitting 'a', and then use the command

```
:stretch [up|down|left|right] <n>
```

where <n> is the number of lambda units to stretch it.

Selecting and Deleting

Some commands (like :stretch, described above) require you to specify what layer(s) to operate on (as opposed to just what area of the layout, which can be specified simply by the position of the box). The commands

```
select area <layer>
```

(equivalent to the 'a' keystroke), and

```
select more area <layer>
```

allow you to select only certain layers within the box. Then you can issue a command like ':stretch', or ':delete', which will operate only on the specified layer(s).

A shortcut, in the case of deleting certain layers is the command

```
:erase <layer>
```

Undo

Magic has an excellent undo capability. Use the 'u' key, or type ':undo' to undo the last command. Repeated use undoes many commands!

Saving Your Layout

Before leaving the program, enter the command

```
:save <cell name>
```

to save your current layout under the filename <cell name>.mag, or just ':save' to save it under the name you supplied when you invoked magic. Do not enter the .mag suffix. It will be added to what you type.

Quitting the Program

To exit the program, type

```
:quit
```