MAGIC INTRO AND CHEAT

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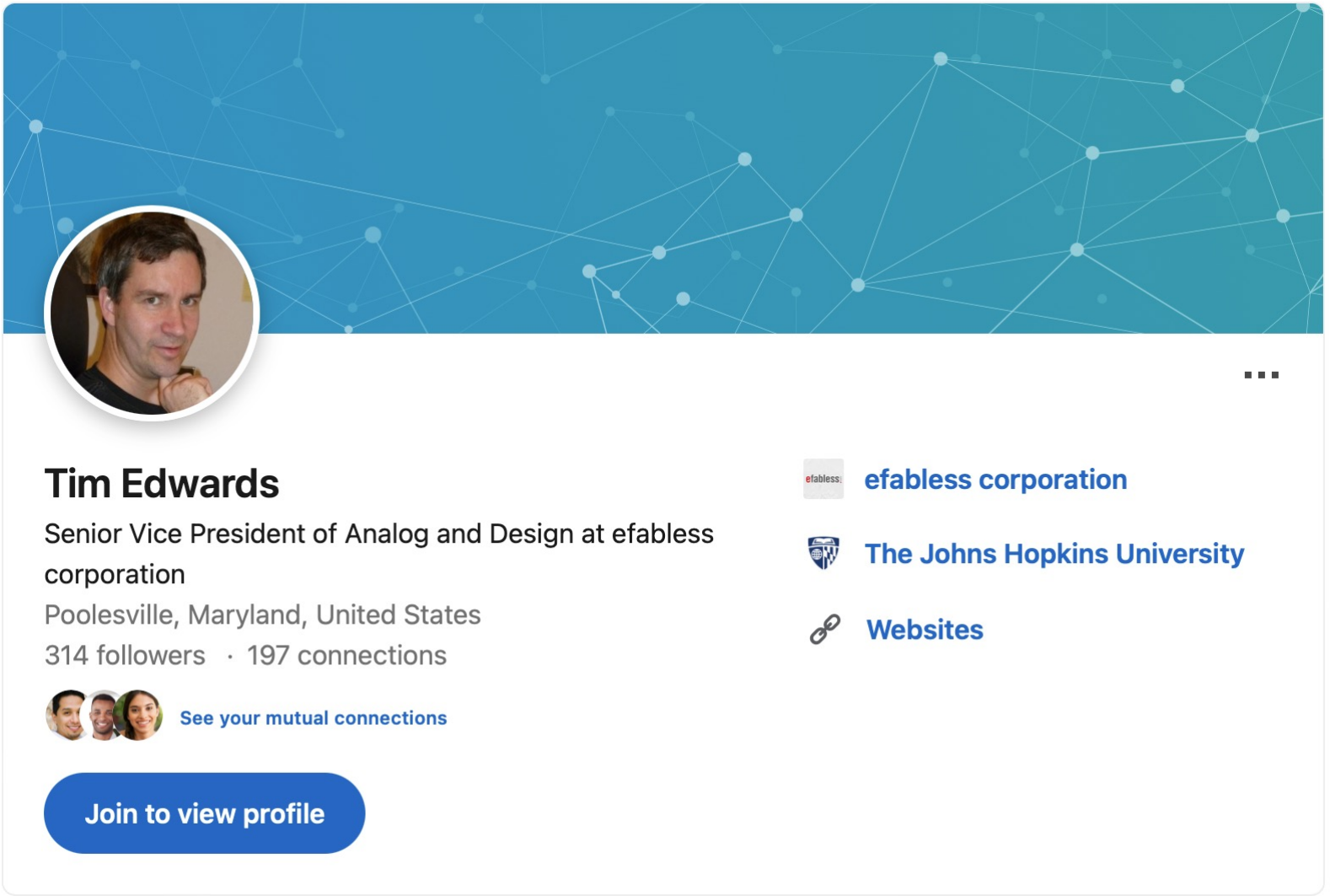
Tim Edwards → designing magic

Announcements

- HW 2 is due soon, so make sure you get started.
- If you have questions, please post them to Canvas or see me.
  - Other people can learn from your problems.
- If you do not want to post to Canvas, because your name will appear, you can always post anonymously.
  - Posting privately allows only the other person to see what you are chatting about (i.e., so your name does not appear).
- Please remember – only try to make 1-2 `vncserver` connection(s).
  - You are welcome to have 2 sessions for at home and school for different display resolutions.
  - There are methods to switch resolutions, but I am not sure how to do this (I can get you in contact with someone who knows, if interested).

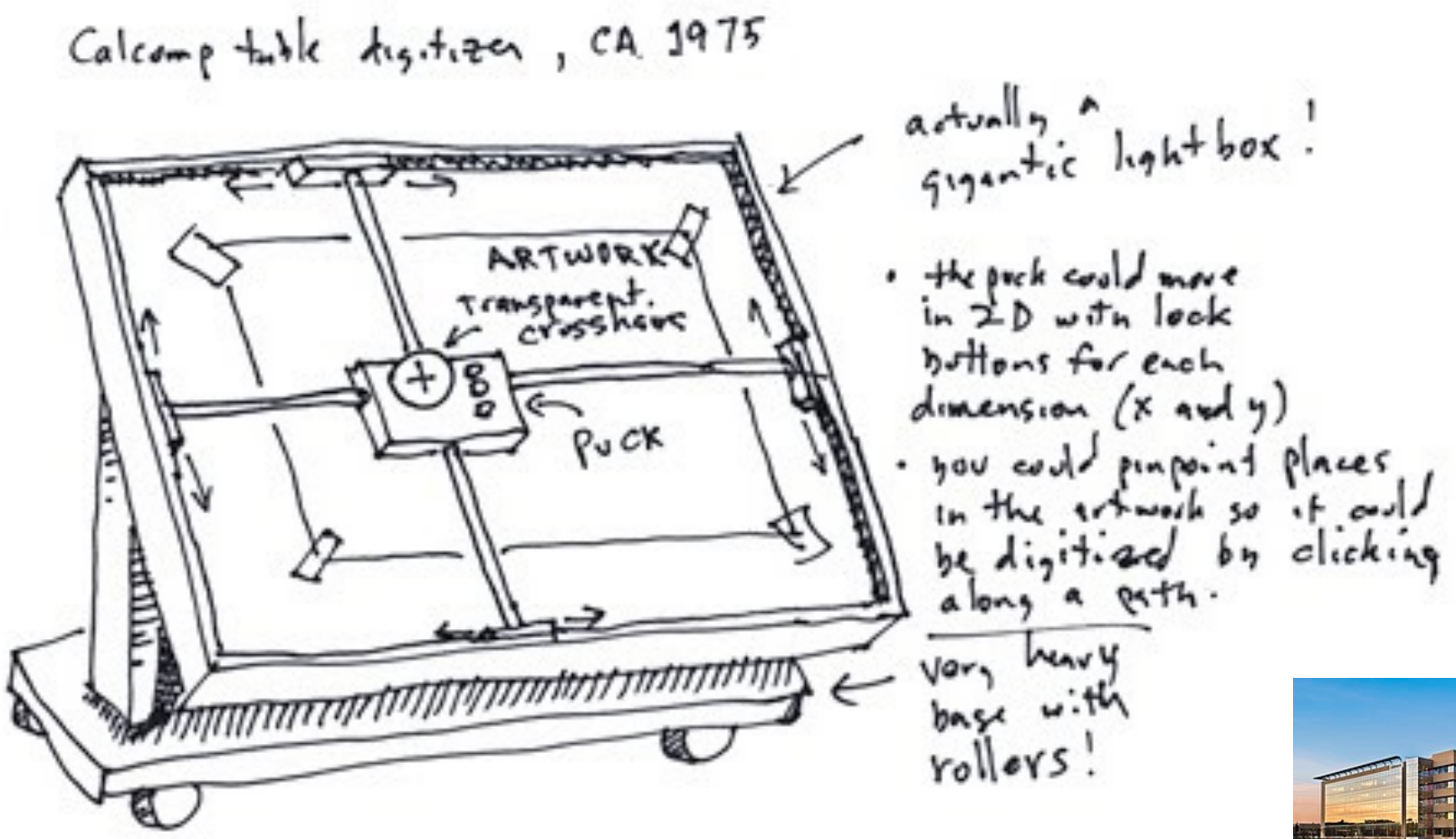
Google Skywater open PDK 90nm and up!

Guest Lecture



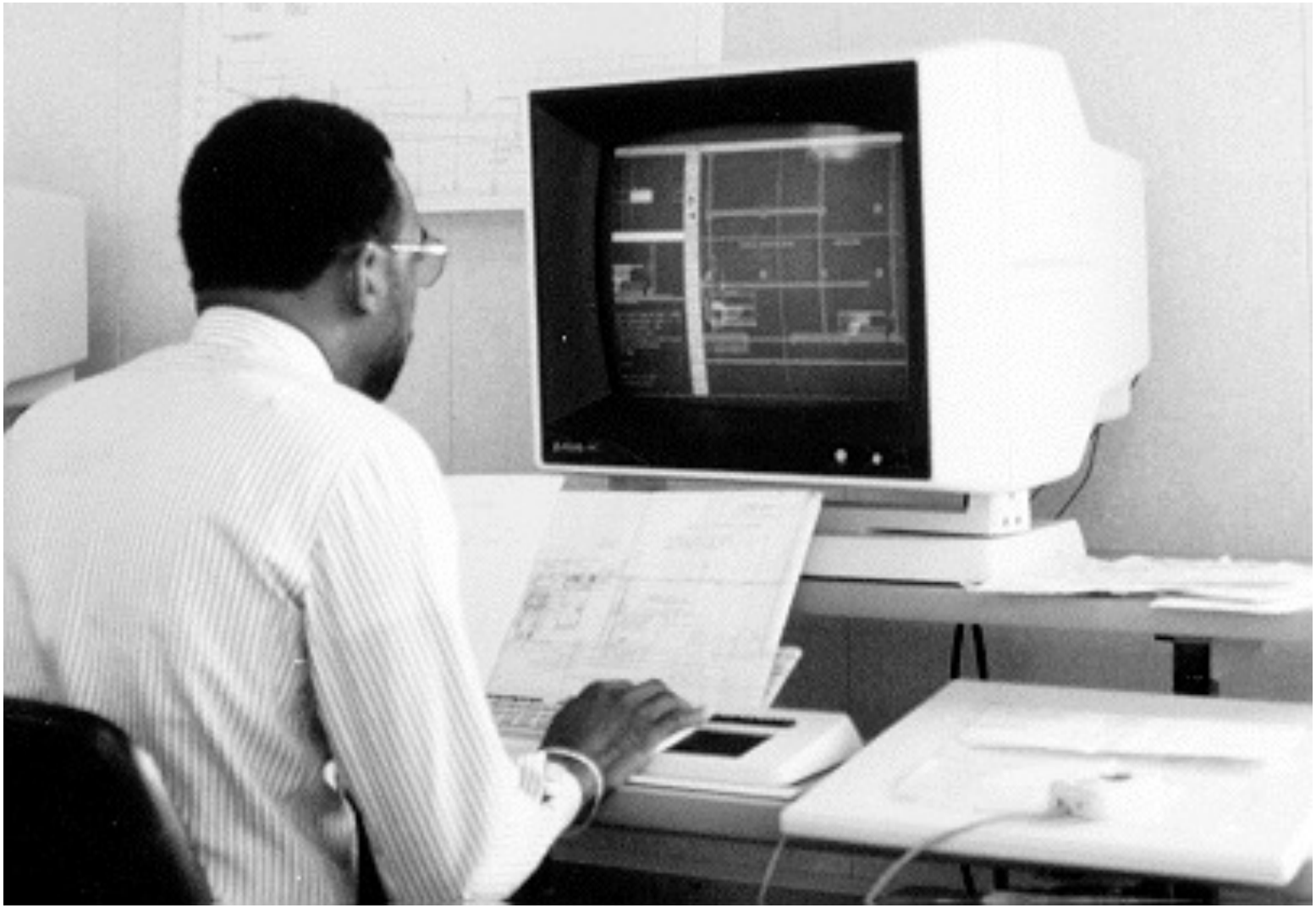
Early VLSI system

https://en.wikipedia.org/wiki/Calma



Calma → Valid → Cadence Design Systems

Another Early VLSI System



Early VLSI System

Using Early CAD Systems

https://en.wikipedia.org/wiki/Computervision

Check it out!!!

SKY130A

- We are using SKY130A FOSS 130nm Production PDK through Skywater Technology fabrication facility (formerly Cypress Semiconductor)
- https://www.skywatertechnology.com
- PDK
  - Masks: https://skywater-pdk.readthedocs.io/en/main/rules/masks.html
  - Layers: https://skywater-pdk.readthedocs.io/en/main/rules/layers.html#layers-definitions
  - GDS (more later) info: https://skywater-pdk.readthedocs.io/en/main/rules/layers.html#gds-layers-information
  - Summary of Key Periphery Rules: https://skywater-pdk.readthedocs.io/en/main/rules/summary.html
  -

What changed?

- What changed was the invention of the PC.
  - Thank Ed Roberts!
  - It made it much easier and cheaper to run software for VLSI.
- Open-source
  - Open-source software (i.e., software developed by a community of developers) helped to really develop debugged software.
  - It also allowed others to flush out problems.
- Magic
  - Magic was originally written by John Ousterhout from UCB.
  - It languished around until probably mid 1980s when my friend Tim Edwards decided to take on revitalizing the software.
  - It goes through lots of revisions daily and is open-source.
  - http://www.opencircuitdesign.com
- Linux
  - Linux also changed things by having a reliable Operating System (OS) that all can use (and that's free and open-source!).

Setup

- **Do this only once!!!!**

1. Log into your account either on VNC or SSH
2. `/classes/ecen4303F23/copy_csh.sh`
3. If you are in a VNC session, kill your terminal, and start a new one; otherwise, in ssh, just logout and log back in.

- Don't forget to type `eda-tools` on each new terminal before working on something.

- **Anytime you want to use magic with SKY130A**

magic –rcfile $PDK_ROOT/`sky130A/libs.tech/magic/sky130A.magicrc`

- **You can also just type `magicsky`**

Caveat Emptor

- Layout is essential in any fabrication process, but you should have a game plan starting out.
- For Integrated Circuits and layout, a stick diagram to start out is essential.
  - Its even better if you have some idea of the sizes involved.
- Always remember that layout is a time sink so having an idea where to go is important.
- Scripts are essential in any EDA tool and using them really saves you time.
  - If you are not sure this is the way to do something, please ask.
  - Post on Canvas!
  - Show a screen shot of your problem and issues!

Mouse

- Your mouse or puck is the key to any layout tool.
  - Get used to handling and using your mouse within magic.
- Left Click
  - Lower left-hand corner of rectangle
- Right Click
  - Upper right-hand corner of rectangle
- Middle Click
  - Will paint inside the box what layer your mouse is over (trick and perhaps best understood later when you understanding more commands).
  - For example, if you move your mouse over poly and click the middle mouse button, it will paint poly in that box!

Commands

- All error messages pertaining to the design are also displayed in this text window.
  - Always make sure you see the text window!
- Commands can be done several ways
  - By pressing buttons on the mouse in either the graphics or text window.
  - By typing long commands on the keyboard, where **long commands** are preceded by a colon "**:**".
  - By typing single-character macros on the keyboard.

Box

- Grid is key and always make sure you are in BOX mode!
  - The BOX tool is the default tool and is indicated by a crosshair cursor. It is used to position a graphical outline box that layers can be painted and erased in. This is the tool used for all basic drawing tasks and is your layout workhorse. Use of the BOX tool is described below in the Basic drawing section and in more detail in the MAGIC Tutorial #1: *Getting Started* and MAGIC Tutorial #2: *Basic Painting and Selection*.
- :tool box
- The SPACE bar is also enabled to cycle through each tool set (e.g., box).
  - Wiring
  - Netlist
  - Pick
  - Box

Useful Global Commands

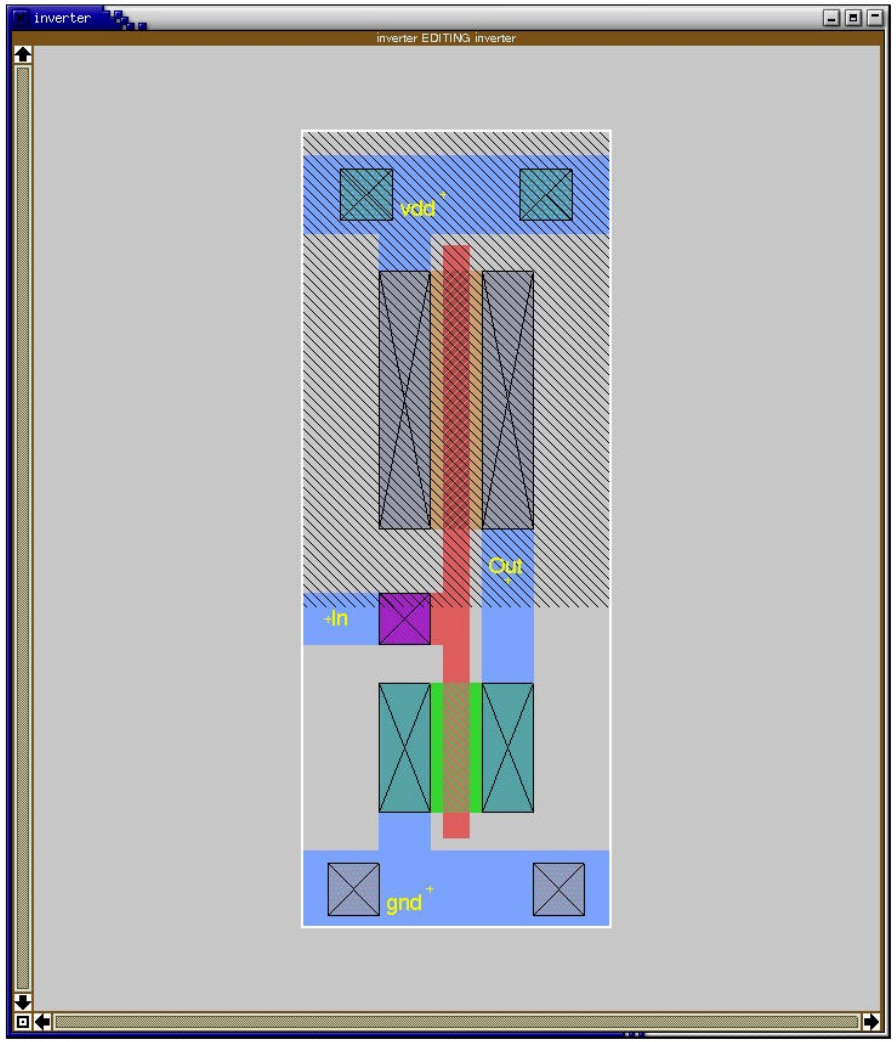
- **:quit** quits MAGIC and exits to the shell.
- **:help** command prints out a brief description of all the commands or the specified command.
- **:load** circuit-name loads circuit-name into the window; if circuit-name doesn't exist, MAGIC creates a new empty circuit.
- **:save** circuit-name saves all the changes to the circuit.
- **:view** or **v** fills the active drawing window with everything painted thus far in the current design.
- **:f** or Select Cell highlights the whole area of your layout with a box.
- **:grid** or **g** toggles a visible screen grid in the layout area on or off. The grid is useful for lining up various cells, wires, and sections of a schematic. A grid of ***n*** lambda by ***n*** lambda can be displayed by entering the **:grid n** command. The **g** macro is useful shorthand.
  - If you do this by mistake, type **:grid off**
- **:zoom *amount*** zooms in and out of the active window by a factor of amount, i.e. **:zoom 2** zooms in twice as much, and **:zoom 0.5** zooms out twice as much. The **z** (small z) macro zooms out to fit the box on the paint window. The **Z** (uppercase **Z**) macro zooms in the same as the "**:zoom 2**" command.
- **:macro** displays all current macros (not useful)

Paint

- The two basic layout operations are painting and erasing. They can be invoked using the **:paint** and **:erase** commands, or by using the mouse buttons.
  - **:paint *layers*** paints rectangular regions as specified by the box region in the graphical window.
  - **:erase *layers*** deletes the specified layers from the region within the box.
- The easiest way to paint and erase is with the mouse buttons!

Main colors (stineje.github.io)

- Polysilicon
  - :paint poly
- n+/p+
  - :paint ndiff/pdiff
- n/p-contact
  - :paint ndc/pdc
- Metal (according to layer!)
  - :paint li
- Contact to substrate (n/p)
  - :paint nsd/nsc
  - :paint psd/nsc



Super Editing commands

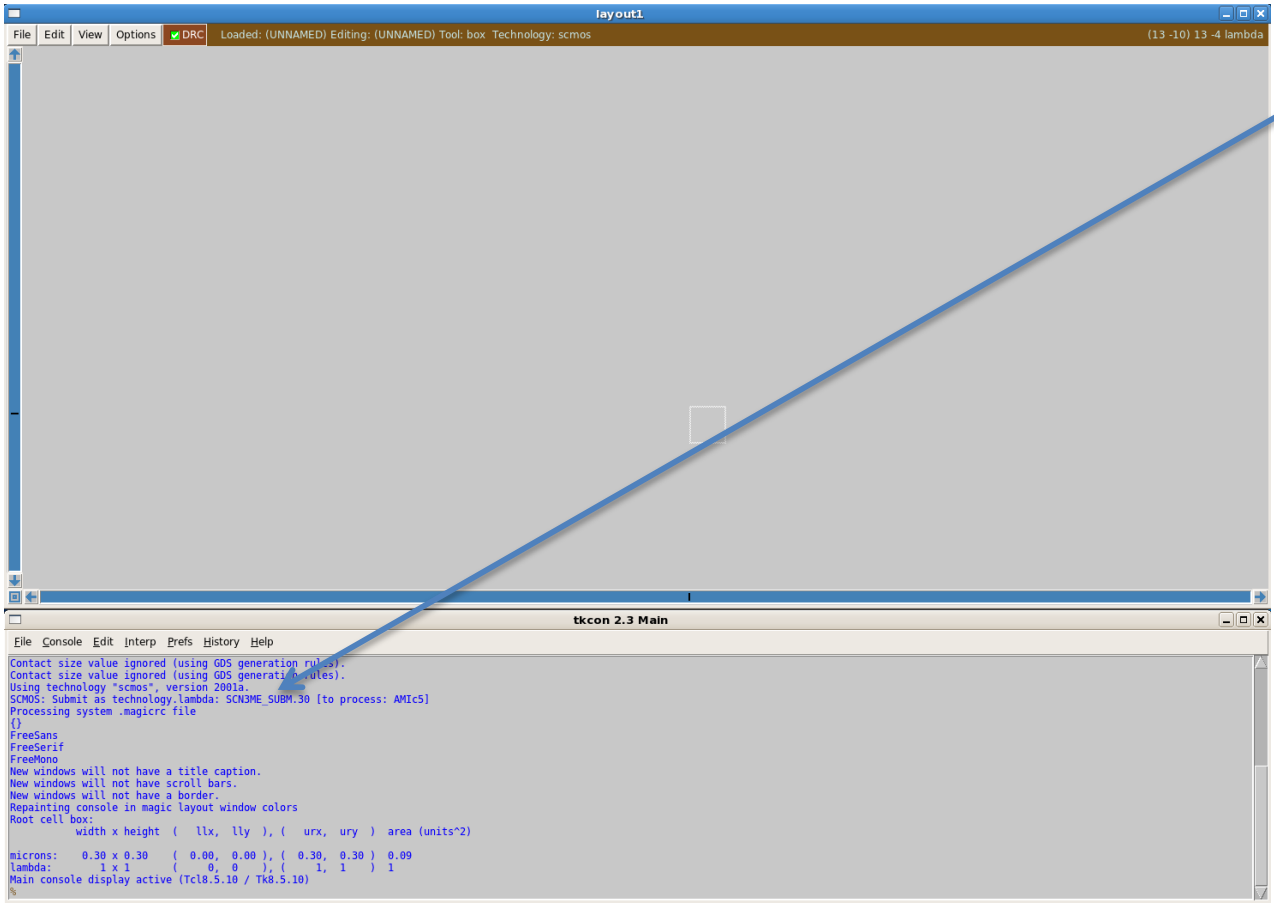
- This one will take time, but its so cool its worth mentioning over and over!
  - Place box over the area you want selected.
  - :select or “a” (macro)
  - QWER move by 1 lambda in different directions.
    - You need to get feel of movements
- You can also copy and stretch stuff, but this is more difficult.
- Don’t forget
  - :sideways
  - :clockwise
  - :upsidedown
  - :delete (macro “d”)
  - :copy (macro “c”)
  - :erase
  - :undo (macro “u”)
  - :redo (macro “U”)
- You can also use the “.” (dot) macro to repeat the last command

Labels

- Don’t forget to label your items (:label labelname)
- where labelname can be any valid UNIX designation, but a good convention is to use labels that will correspond to circuit signals and make the layout more readable in a printout.
  - It is necessary to label the supply wires (nodes) as vdd and gnd typed exactly as indicated.
  - The ! mark (optional) - commonly known to programmers as "bang" - indicates that the node is global and spans the entire drawing.
  - Why some labels are all caps and the other not is a matter of constant debate and dates to some obscure historical origin that not even the finest of long-hair Internet hackers can agree on.

DRC

- :drc why
- Design Rule Checking is performed automatically in MAGIC and is one of its most powerful features.



Technology stated when starting magic!

Summary

- Magic takes time to learn, but its easy to learn.
- Magic is also, unfortunately, a TIME SINK!
  - Don't give into it – always have a stick diagram and use it to create your design!
  - Keep them in your lab notebook or some other place of storage.
- Ask questions!
  - Piazza seems to be a great place for this!
- Magic tutorial
  - http://stineje.github.io
- YouTube channel
  - https://www.youtube.com/user/jlstine/