Elec 422: VLSI Design I

Notes on Substrate Contacts and Layout Style

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Notation

In stick diagrams, the nsubstratecontact can be drawn as a green "X" contact on the Vdd line. The psubstratecontact can be drawn as a brown "X" contact on the GND line. In *magic* layout, it is best to leave about 4 λ of space between diffusion contacts and the appropriate substrate contact. This simplifies the creation of the final CIF file for fabrication.

Transmission Gates

For transmission gates, try to follow the approach that I mentioned in class of running the Vdd line above the pchannel transistor and the GND line below the nchannel transistor. Usually, the TGate is near or left of an inverter or NAND.

```
Vdd  -----X-------X------------------


           P     P
         TGate  TGate   Inverter or NAND
           N     N


GND -------X-------X-----------------
```

Compound Gates

For a more complicated gate, like a 3 input NAND. Usually, one nsubstratecontact near the P trans and one psubstratecontact near the N trans will be fine.

```
Vdd    _____________X_______________________


             P    P     P



                  N


                  N


                  N
 GND    _____________X________________________
```

Arrays of Transmission Gates

For an array of TGates, like the barrel shifter, things can get more complicated. Substrate contacts are not that essential since the devices are not directly connected to Vdd or GND. However, it is good practice to make sure that each well has a substrate contact.

There is no direct need for Vdd and GND in such a circuit and so there are usually no convenient Vdd and GND lines to place substrate contacts. This may require you to run additional Vdd and GND lines to place the substrate contacts.

```
GND -------X------------X------------

       N      N       N       N
     TGate  TGate   TGate   TGate
       P      P       P       P

Vdd -------X------------X------------

       P      P       P       P
     TGate  TGate   TGate   TGate
       N      N       N       N

GND -------X------------X------------

       N      N       N       N
     TGate  TGate   TGate   TGate
       P      P       P       P

Vdd -------X------------X------------

       P      P       P       P
     TGate  TGate   TGate   TGate
       N      N       N       N

GND -------X------------X------------
```

As an alternative Vdd and GND lines may be run vertically. Obviously, the extra lines will reduce your circuit density.

A Word of Caution

The design rule checker in *magic* is very good at most spacing rules. However, it does not check electrical connections carefully. You can short Vdd and GND together through the substrate and cause problems in your circuit.