BIRZEIT UNIVERSITY

Faculty of Engineering and Technology

Electrical and Computer Engineering Department

DIGITAL INTEGRATED CIRCUITS – ENCS3330

Homework 1

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Problem 1

Watch these video and summarize not more than one page what you learned about Integrated circuit manufacturing process.

The first step in making an integrated circuit is to obtain pure molten silicon, which must be purified because dust or impurities will damage the silicon crystal.

Therefore, there are engineers and supervisors to monitor the complex processes, the automated production takes place in closed production lines in a room of a size of large as two succor pitches, and the room that creates wafers is hundreds of thousands cleaner than the operating room, and each wafer will go through hundreds of production stages to be an IC.

As first step the Photolithography transfers circuit structures onto wafers like a slide projection, then the silicon disk is coated with a photoresist, using UV light, the circuit structure is depicted on a mask on the wafer.

The developer will remove the parts were exposed from the edge of photoconductor and the transferred structures can now be used as templates and the unprotected parts will be etched, and thus the structure of billions of small switching currents is generated per small wafer transistor.

After the photolithography stage, the wafers are transferred to the ion deployment stage where the electrical properties of the transistor will be determined, since silicon is a semiconductor, its conductivity can be varied through the implementation of high precision emplacement of dopant atoms when they are injected into the silicon structure, so that the atoms are randomly distributed in the silicon lattice, at high temperatures, the doping atoms become flexible and occupy a fixed position in the atomic structure.

Wafer cleaning is necessary because particles from each step remain, so clean them to remove these particles to avoid errors Before copper casting, a barrier layer is applied to prevent short circuits and to ensure reliability, the wafers' trenches are then filled with copper, then the excess copper is ground to the edges of the groove, as this insulates each interconnect from the other.

The next step relies heavily on copper, as the finest interconnect wires connect billions of individual transistors to form an integrated circuit.

In two months, the wafer is ready, as the last step is packaging of the chips, a tin silver palette is applied on the wafer as they will connect the chip to the frame, then using finest saw blades the chips got cut off the wafer, then flip chip bond the chip to the frame and it will be sealed with a cover.

Proplem2
Find the output voltage, Vo, for the nFET shown to the right for the following cases. Assume Vg = 2V and Vtn = 0.7V
(a) Vi = 0.5V (b) Vi = 1.4V.

Solution:
Vg > Vtn, 2 > 0.7, the device in both cases is on.

(a) Vi = 0.5V.
Since Vg - Vi
2 - 0.5 = 1.5V is greater than Vtn = 0.7 V, (Here Vi is the "source" then the nFET will pass Vi to Vo) Vo = Vi = 0.5V.

(b) Vi = 1.4V.
Since Vg - Vi
2 - 1.4 = 0.6V Which is less than Vtn = 0.7 V, (Here Vo is the "source" so the nFET output is limited as Vo = Vg-Vtn)
Vo = Vg- Vtn = 2 - 0.7 = 1.3V

Problem3
Find the output voltage, Vo, for the pFET shown to the right for the following cases. Assume Vg = 0V and Vtp = -0.6V
(a) Vi = 0.3V (b) Vi = 1.5V

Solution:

(a) Vi = 0.3V.
Since Vi - Vg
0.3 - 0 = 0.3V which is less than |Vtp|,
(the pFET output is limited as Vo = Vg+|Vtp|) Vo = Vg +|Vtp| = 0.6V.

(b) Vi = 1.5V.
Since Vi - Vg
1.5 - 0 = 1.5V which is greater than |Vtp|, (the pFET will pass Vi to Vo)
Vo =Vi = 1.5V.

Problem4

Find the midpoint voltage, Vx, and output voltage, Vo, for the chain of two nFET pass transistors shown below for the following cases. Assume VDD = 1 V and Vtn = 0.5V.

(a) Vi = 0.4V (b) Vi = 1V

Solution:

(a) Vi = 0.4V.

Since Vdd -Vi =
1 - 0.4 = 0.6V Which is great than Vtn (0.5V), so Vx =Vi = 0.4V

And Vdd -Vx =
1 - 0.4 = 0.6V Which is great than Vtn (0.5), so Vo = Vx = 0.4V.

(b) Vi = 1V.

Since Vdd -Vi =
1 - 1 = 0 V Which is less than Vtn (0.5V), so Vx =Vdd - Vtn = 0.5V

And Vdd -Vx =
1 - 0.5 = 0.5V Which is equal to Vtn (0.5), so Vo = Vx = 0.5V.

Problem5

If VDD=3V, Vtn=0.5Vand |Vtp|=0.4V, find Vg2 and Vo in the 2-transistor circuit shown below for the following cases. Note that Vtn and |Vtp| have different values.

Solution:

There are many cases to find Vg2, and Vo.

Case (1):
VDD - Vi1 > Vtn so Vg2 = Vi1, And Vi2 - Vg2 > |Vtp| so, Vo = Vi2.

Case (2):
VDD - Vi1 < Vtn so Vg2 = Vdd - Vtn, And Vi2 - Vg2 > |Vtp| so, Vo = Vi2.

Case (3):
VDD - Vi1 > Vtn so Vg2 = Vi1, And Vi2 - Vg2 < |Vtp| so, Vo = Vg2 + |Vtp|.

Case (4):
VDD - Vi1 < Vtn so Vg2 = Vdd- Vtn, And Vi2 - Vg2 < |Vtp| so, Vo = Vg2 + |Vtp|.