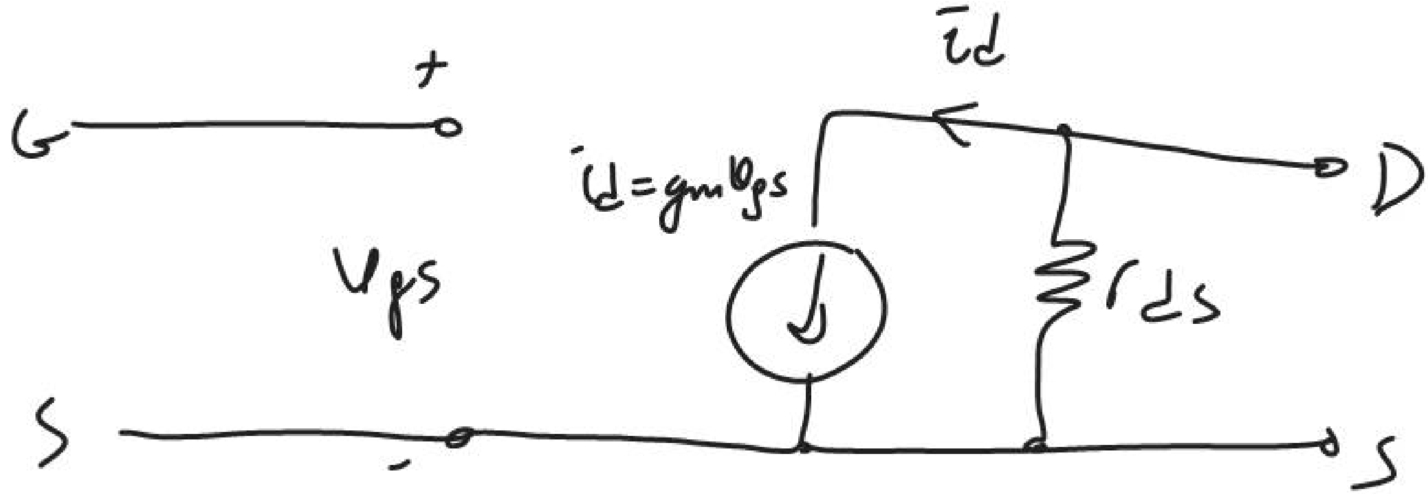
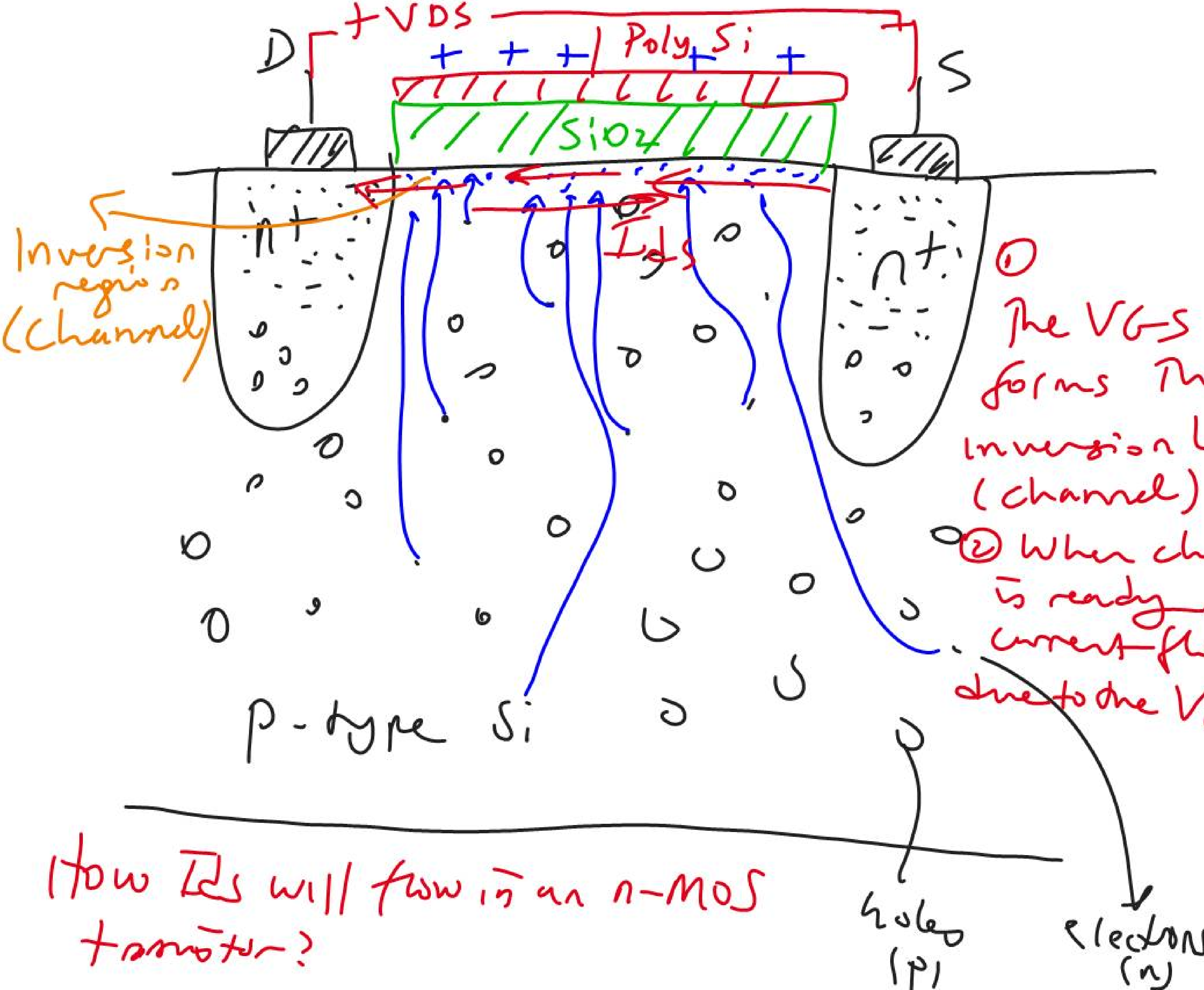
22.10.2010



Small signal equivalent of the MOS transistor.
It is used when the MOS transistor is used as an amplifier (in linear applications, at medium frequency regions for the particular device).

<u>In Inverters</u> we use the device as a SWITCH. So we apply BIG voltage changes. Operate the MOS in NONLINEAR REGIONS.



① The VGS forms the inversion layer (channel)

② When channel is ready current flows due to the VDS.

How I_{DS} will flow in an n-MOS transistor?

Homework #1

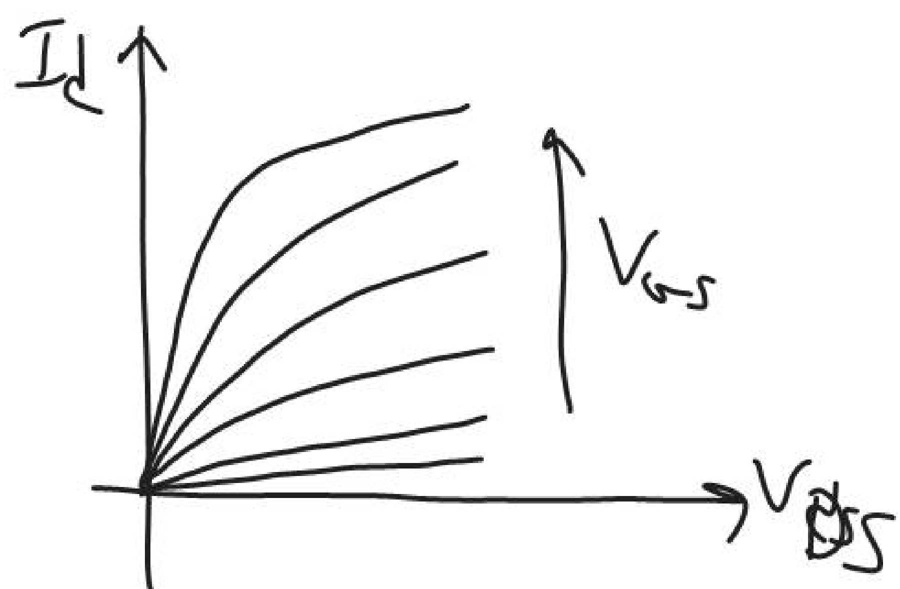
Obtain the output characteristics and plot them for an n-channel transistor of

$L = 200nm$ $\quad \mu = 3600\, cm^2/V\text{-}s$

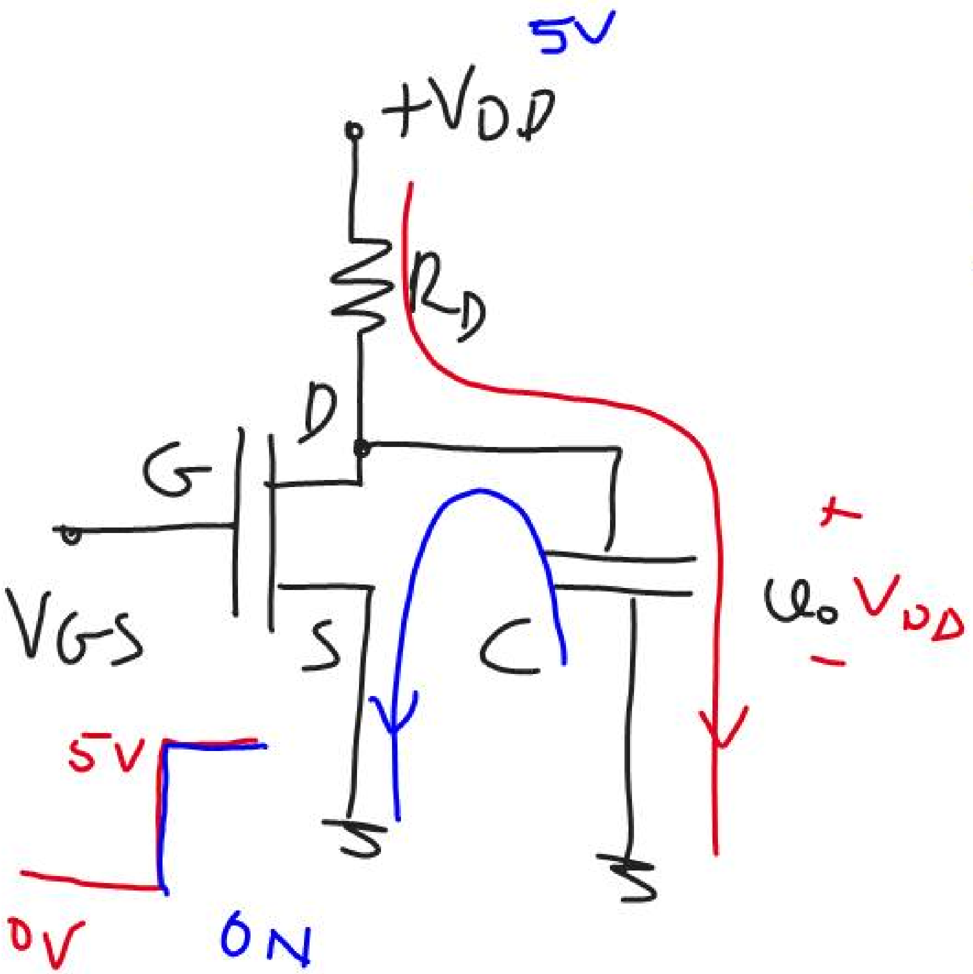
$W = 600nm$ $\quad \epsilon_r = 12 \quad (\epsilon = \epsilon_r \cdot \epsilon_0)$

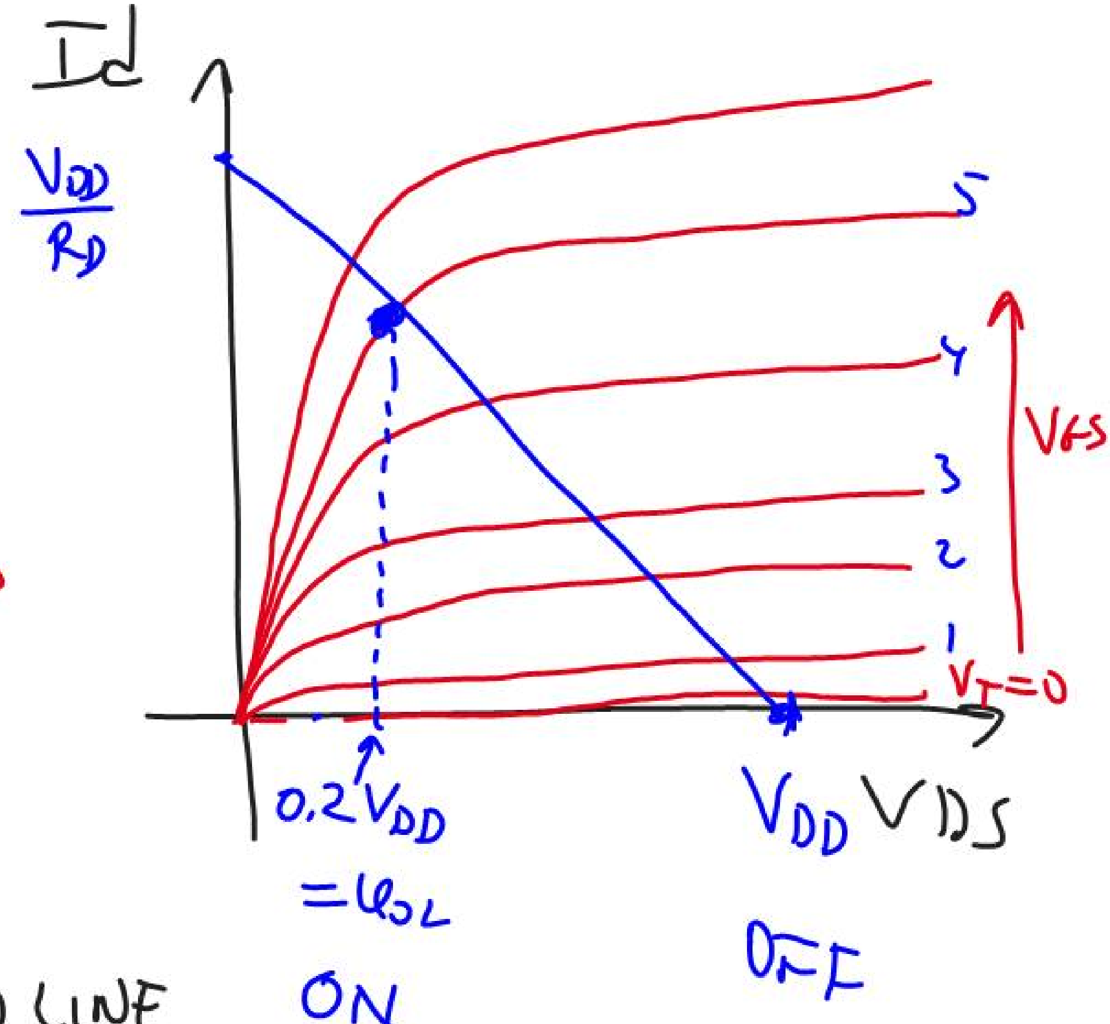
$t_{ox} = 150 A^\circ$

USING MATLAB



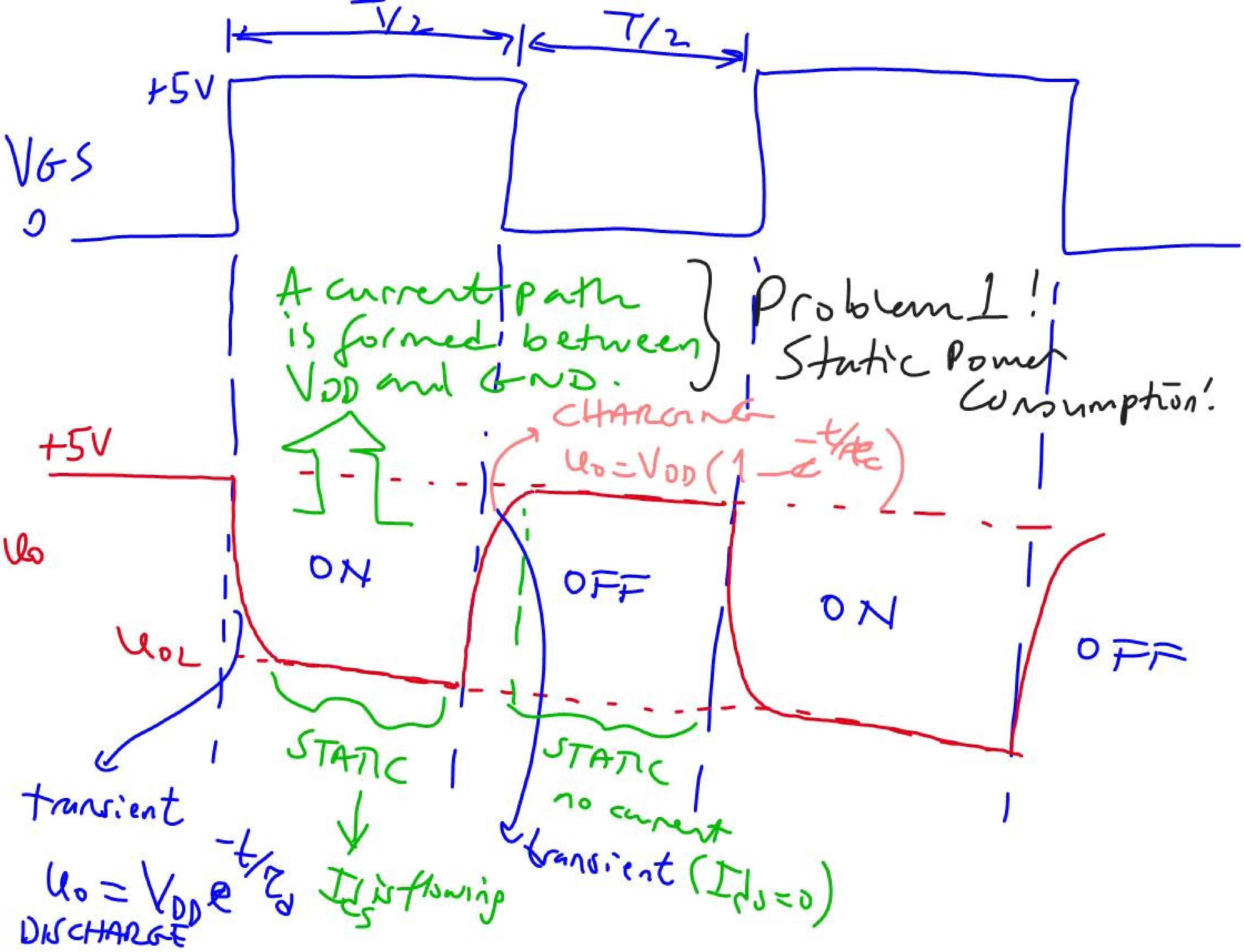
THE BASIC INVERTER





Static $V_{DD} - I_D R_D - V_{DS} = 0$ LOAD LINE

$I_D = 0 \quad V_{DS} = V_{DD}$ / when $V_{DS} = 0 \quad I_D = \frac{V_{DD}}{R_D}$


T/2
T/2
+5V
VGS
0
A current path is formed between VDD and GND.
Problem 1! Static Power consumption!
CHARGING
u0 = VDD (1 − e^(−t/RC))
+5V
u0
ON
OFF
ON
OFF
u0L
STATIC
STATIC no current
transient
u0 = VDD e^(−t/τd)
DISCHARGE
IDS is flowing
transient (IDS = 0)

$$\tau_c = R_d \cdot C$$

$$\tau_d = R_{ch} \cdot C$$

$\downarrow$

Channel resistance of the MOS transistor when i_2 is turned-ON

When $v_{OL} \leq 0.2 V_{DD}$

$$v_O = V_{DD}\, e^{-t/\tau_d}$$

$$0.2 \cancel{V_{DD}} = \cancel{V_{DD}}\, e^{-t/\tau_d}$$

$$0.2 = e^{-t/\tau_d}$$

$$-\frac{t}{\tau_d} = \ln(0.2)$$

$$-t = \tau_d(-1.6)$$

$$t = 1.6\,\tau_d$$

$$\boxed{t = 1.6 \cdot R_{ch} \cdot C}$$

Capacitor charging:

$$v_o = V_{DD}\left(1 - e^{-t/\tau_c}\right)$$

$$v_o = 0.9\,V_{DD}$$

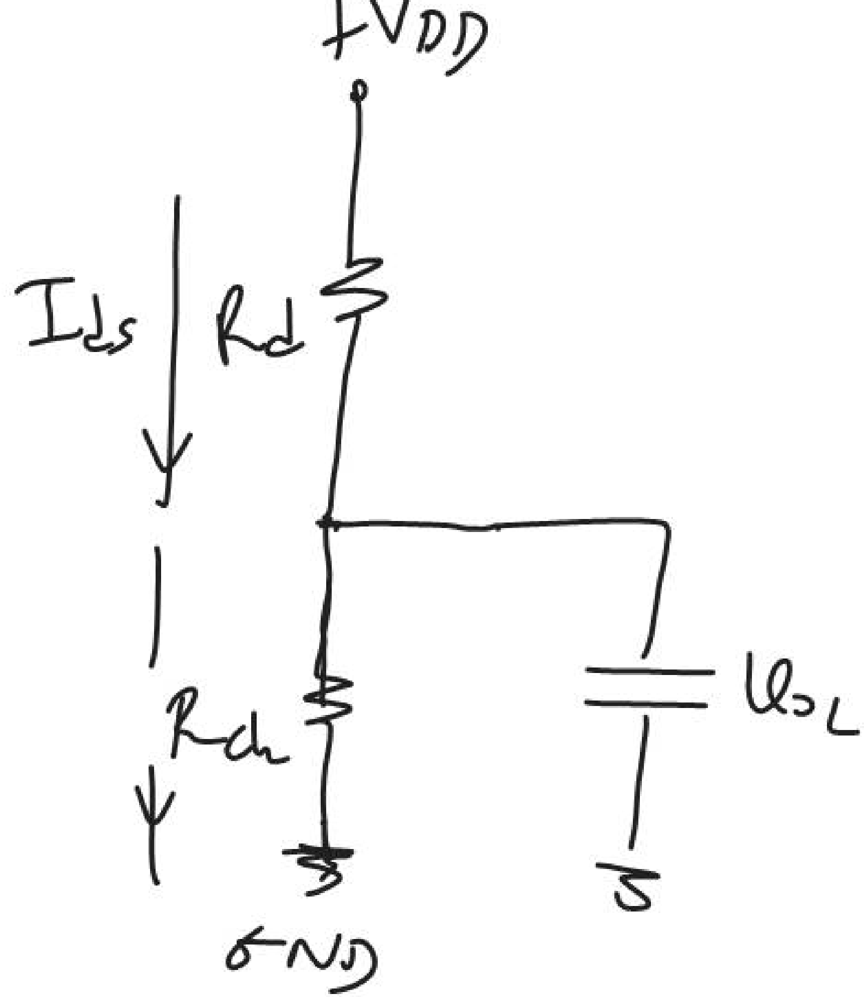
$$0.9\,\cancel{V_{DD}} = \cancel{V_{DD}}\left(1 - e^{-t/\tau_c}\right)$$

$$0.1 = -e^{-t/\tau_c}$$

$$t = \tau_c \cdot \ln 0.1$$

$$\boxed{t = 2.3\,R_d \cdot C}$$

STATIC



$$v_{OL} \cong \frac{V_{DD}}{R_d + R_{ch}} \cdot R_{ch}$$

When $v_{oL} = 0.2 V_{DD}$

$$0.2 \cancel{V}_{DD} = \frac{\cancel{V}_{DD}}{R_d + R_{ch}} \cdot R_{ch}$$

$$0.2 R_d + 0.2 R_{ch} = R_{ch}$$

$$0.2 R_d = 0.8 R_{ch}$$

$$R_d = \frac{0.8 R_{ch}}{0.2}$$

$$\boxed{R_d = 4 \cdot R_{ch}}$$

$v_{oL} = 0.1 V_{DD}$

$$\Rightarrow$$

$$R_d = \frac{0.9 R_{ch}}{0.1}$$

$$\boxed{R_d = 9 R_{ch}}$$

* Problem 2!