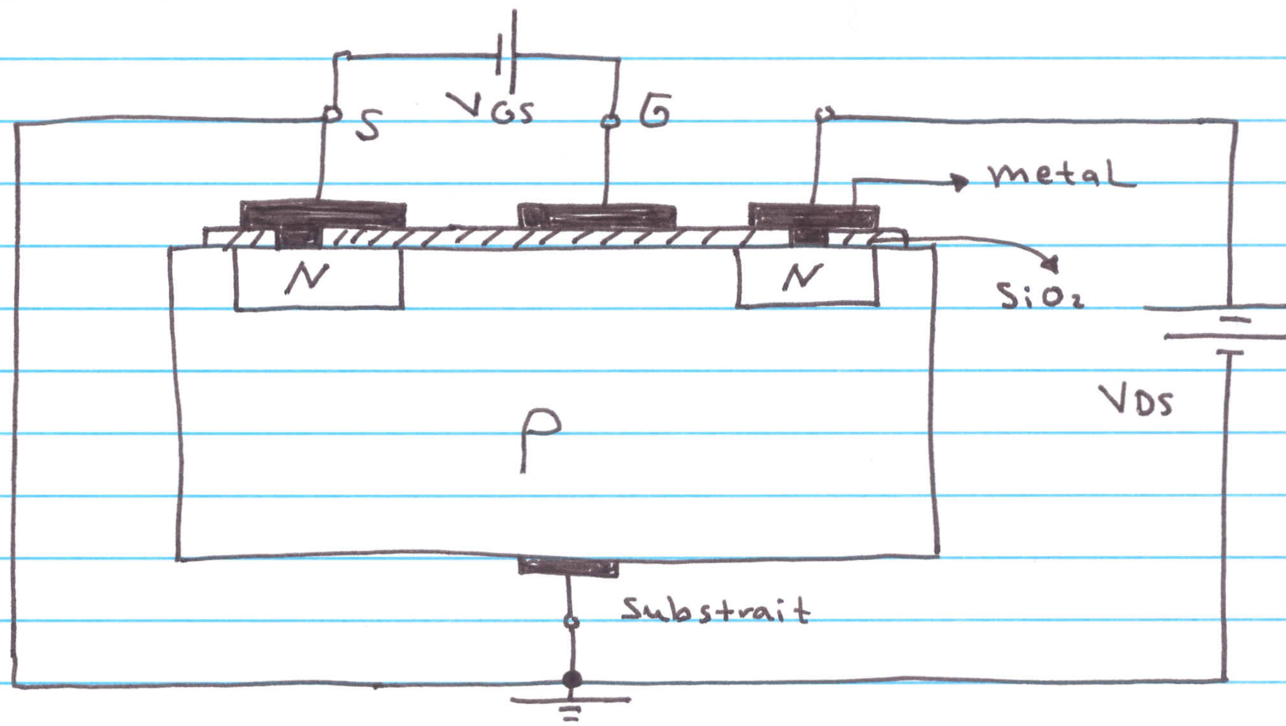
Enhancement type MOSFET

Construction of n-channel EMOSFET :



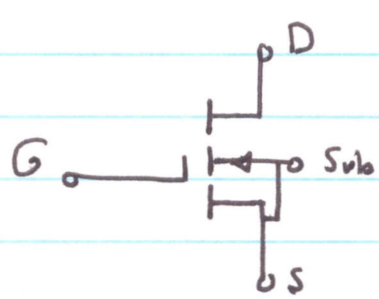
Operation, characteristics and parameters of n-channel EMOSFET

- On the application of VDS and keeping VGS = 0, practically zero current flows
- If we increase VGS in the positive direction, the Concentration of electrons near the SiO2 Surface increases.
- At a particular value of VGS there is

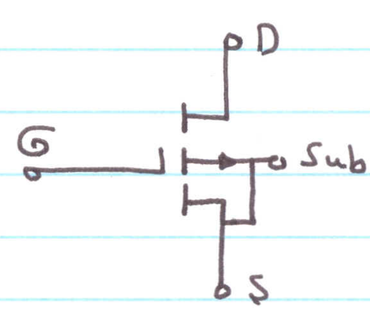
a measurable current flow between drain and source ; I_{DS}

This value of V_{GS} is called Threshold voltage denoted by V_T.

- A positive V_{GS} above V_T induce a channel and hence the drain current (I_{DS}) by creating a thin layer of negative charges (electrons) in the substrait region adjacent to the SiO_2 layer.
- The conductivity of the channel is enhanced by increasing V_{GS} and thus pulling more electrons into the channel.

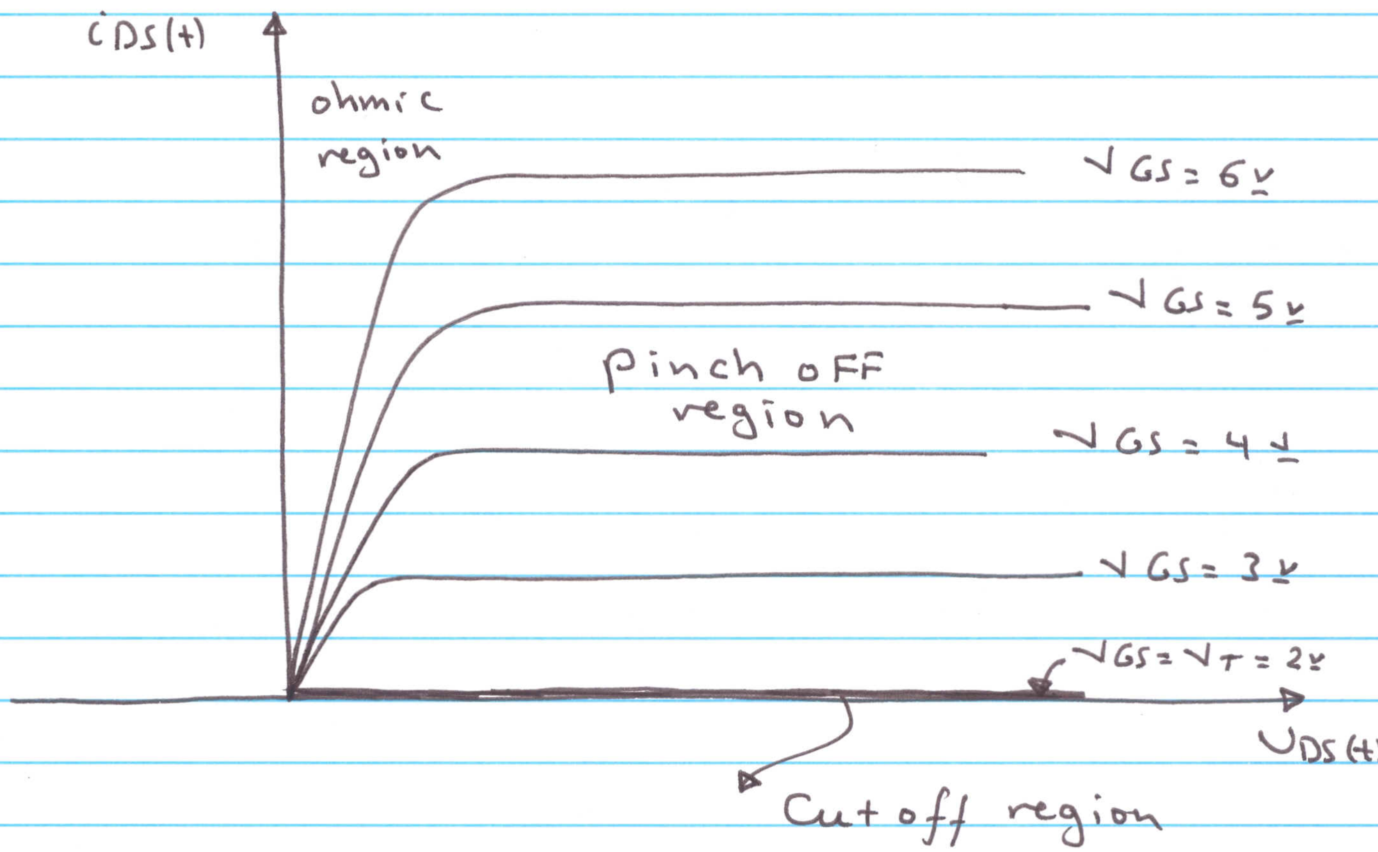


n-channel EMOSFET

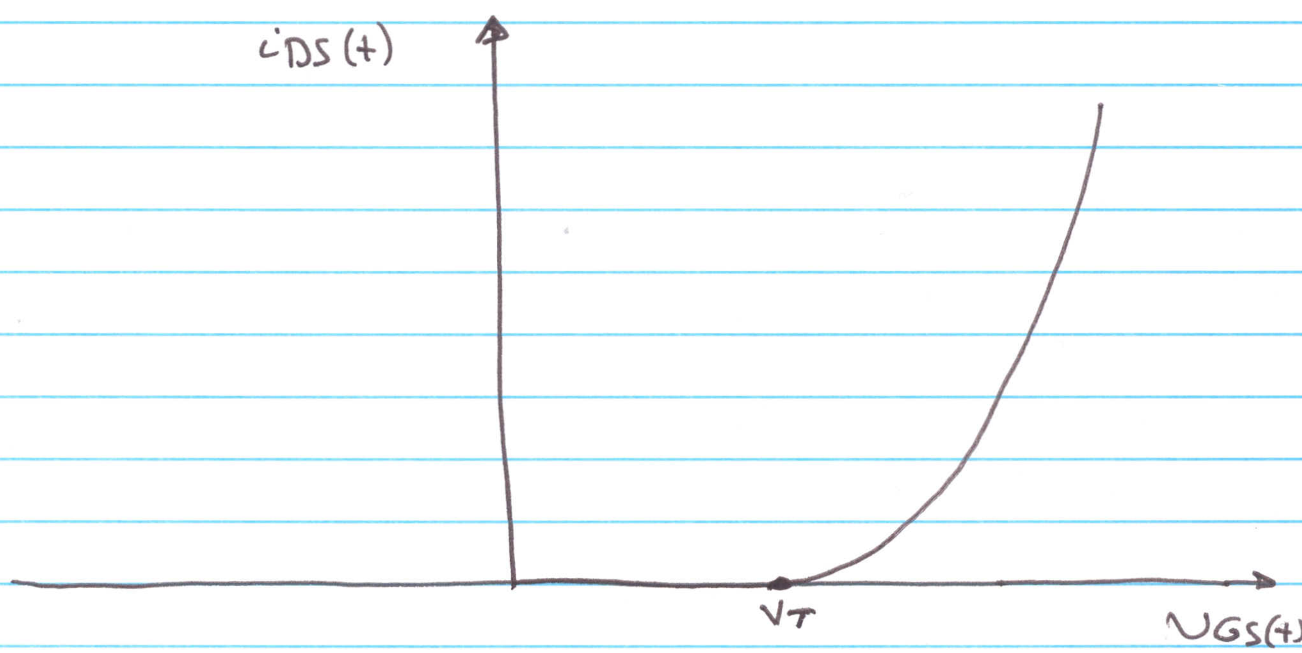


p-channel EMOSFET

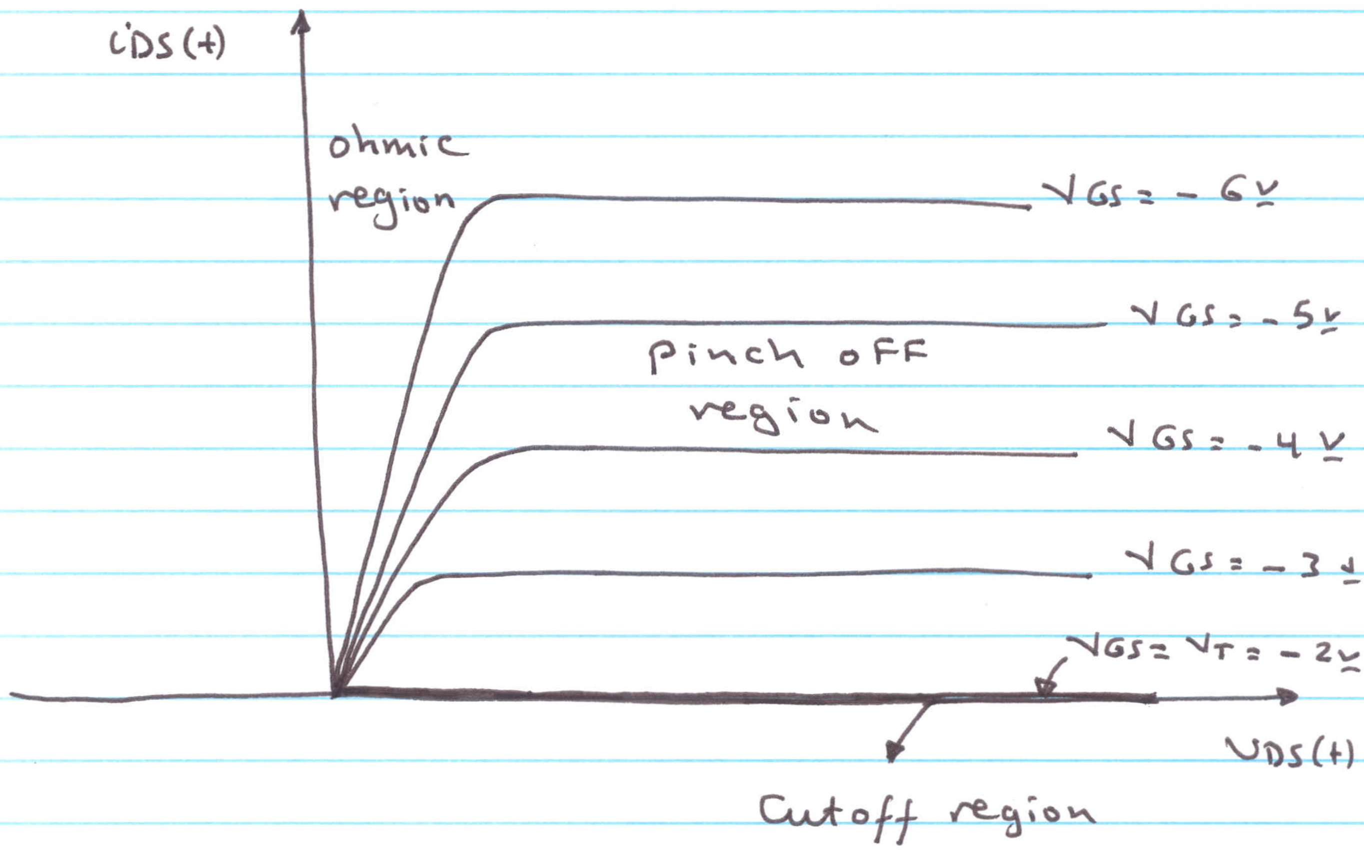
Drain characteristics for an n-channel EMOSFET



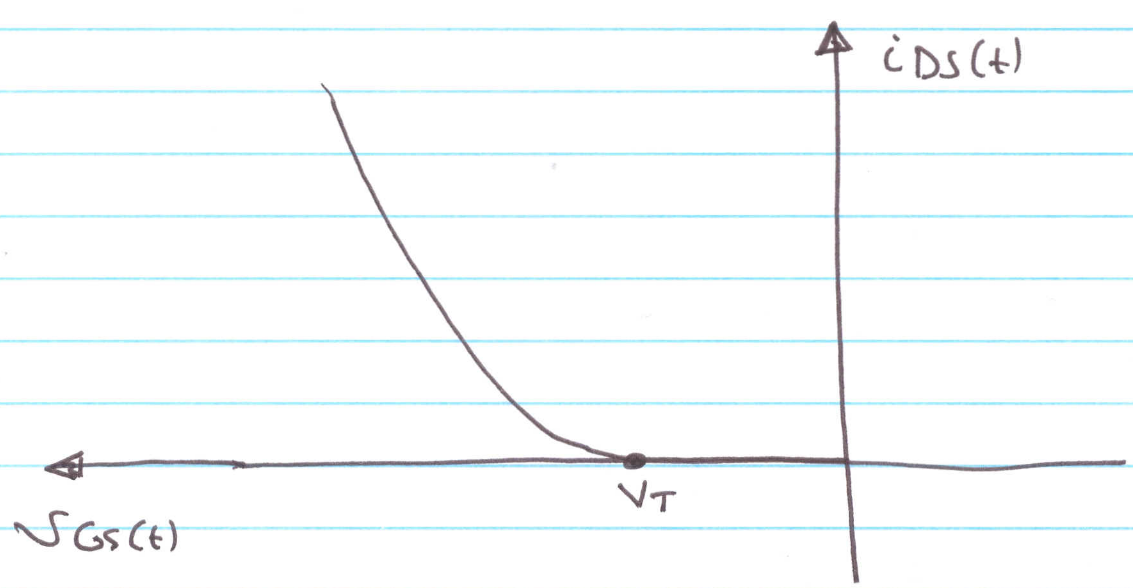
Transfer characteristic for an n-channel EMOSFET



Drain characteristics of p-channel EMOSFET



Transfer characteristic of p-channel EMOSFET



In the pinch off region

$$i_{DS}(t) = K_n \left(V_{GS}(t) - V_T \right)^2$$

$$K_n = \frac{1}{2} \bar{K_n} \frac{W}{L}$$

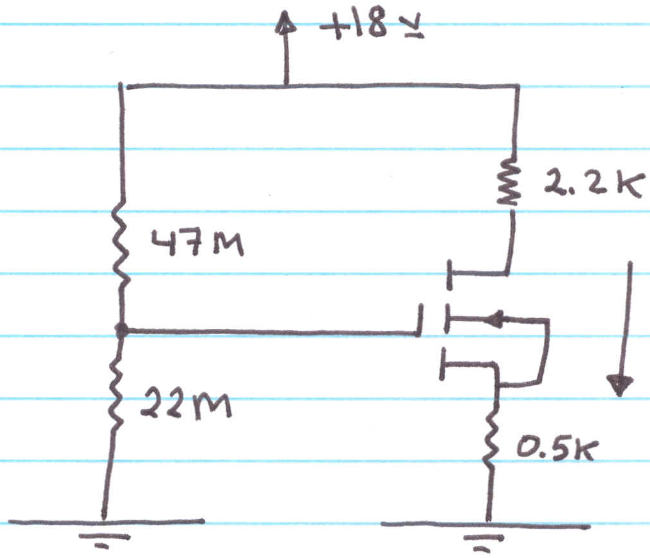
$$\bar{K_n} = \mu_n C_{ox}$$

$$|V_{DS}| > |V_{GS} - V_T|$$

$V_{GS} > V_T$ n-channel

$V_{GS} < V_T$ p-channel

Example



$K_n = 0.25 \times 10^{-3}\ A/V^2$

$V_T = 2\ V$

$$I_{DS} = K_n \left(V_{GS} - V_T\right)^2 \quad \text{--- (1)}$$

$$V_{GS} = V_G - V_S$$

$$V_G = \frac{22M}{22M + 47M} \cdot (18) = 5.74\ V$$

$$V_S = (0.5K)\, I_{DS}$$

$$V_{GS} = 5.74 - 0.5K\, I_{DS} \quad \text{--- (2)}$$

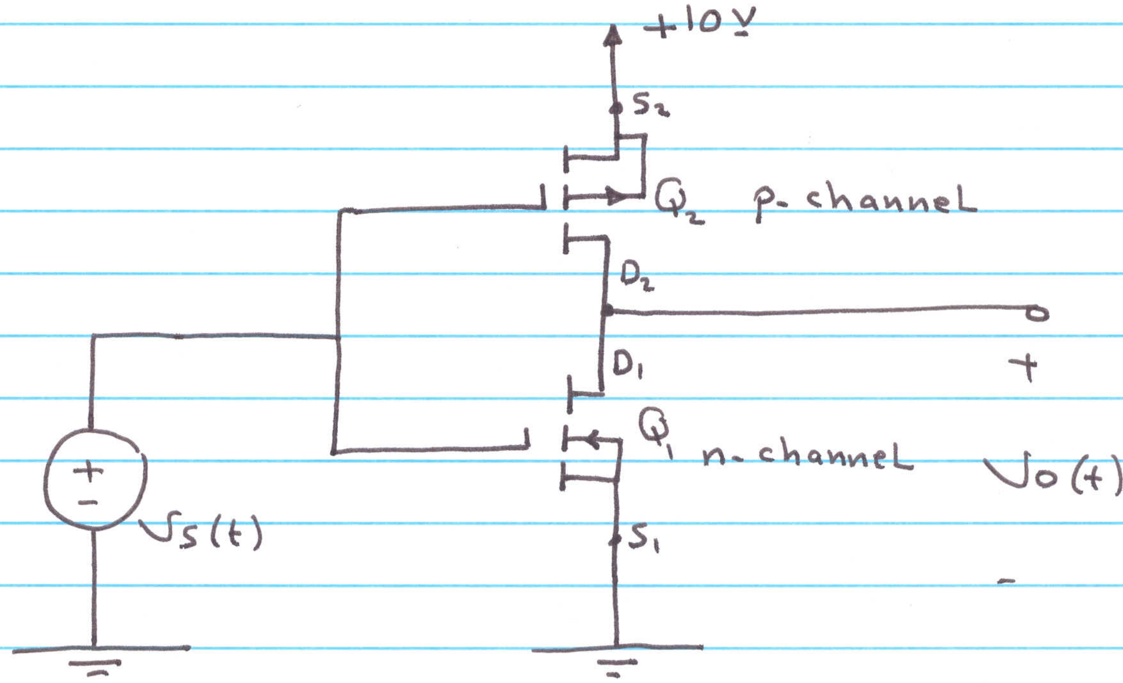
Solving for V_{GS} ;

$$V_{GS} = \begin{cases} 4.78\ V & \checkmark \\ -8.78 & \times \end{cases}$$

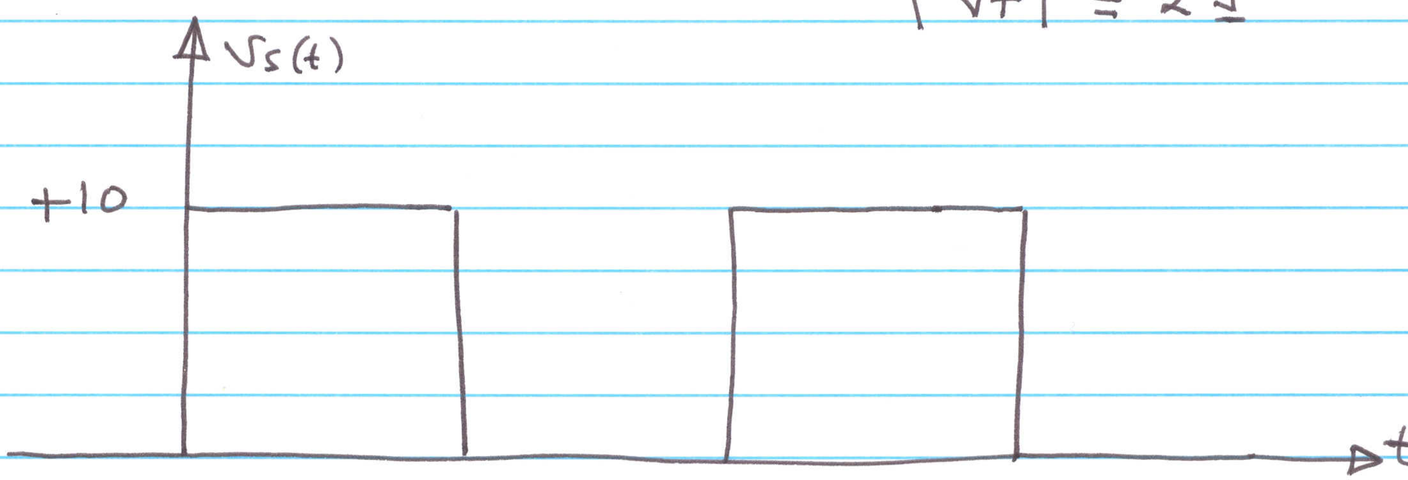
$\therefore\ I_{DS} = 1.92\ mA$

$V_{DS} = 12.82 > |V_{GS} - V_T|$

A Complementary MOS (CMOS) inverter



$|V_T| = 2$ V



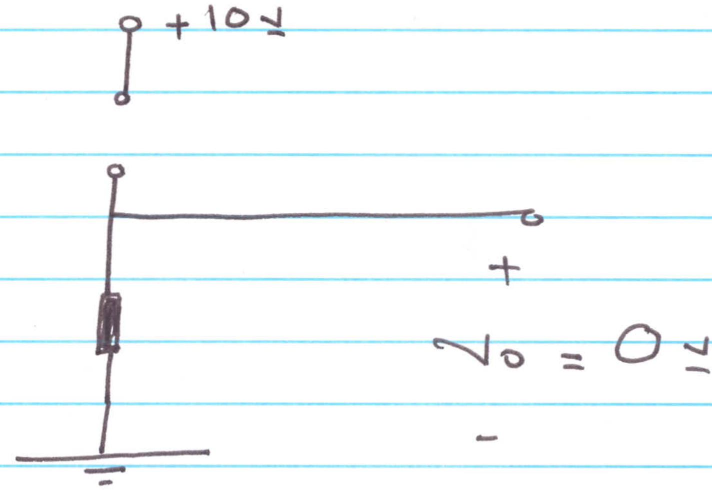
1) Let $v_s(t) = +10$ V

$V_{GS_1} = V_{G_1} - V_{S_1} = 10 - 0 = 10$ V $> V_{T_1}$

∴ Q_1 is on, replaced with short

$V_{GS_2} = V_{G_2} - V_{S_2} = 10 - 10 = 0 > V_{T_2}$

∴ Q_2 is OFF, replaced with open circuit



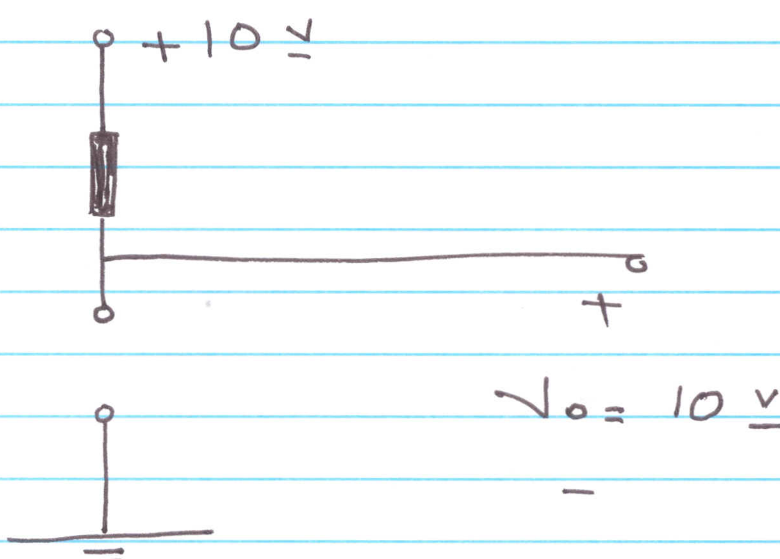
2) Let $V_s(t) = 0$

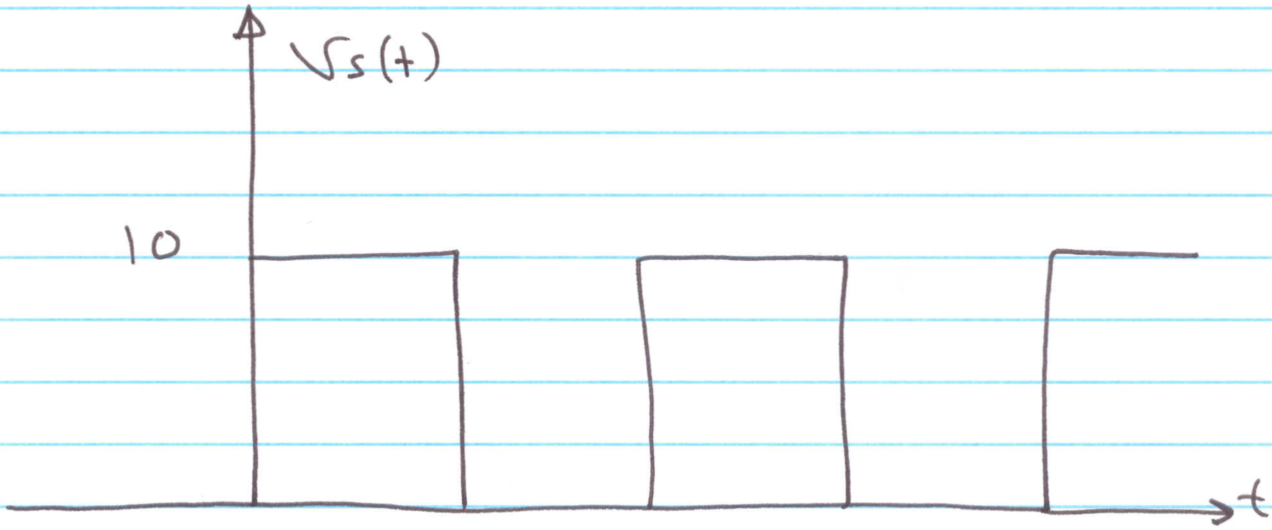
$V_{GS_1} = V_{G_1} - V_{S_1} = 0 < V_{T_1}$

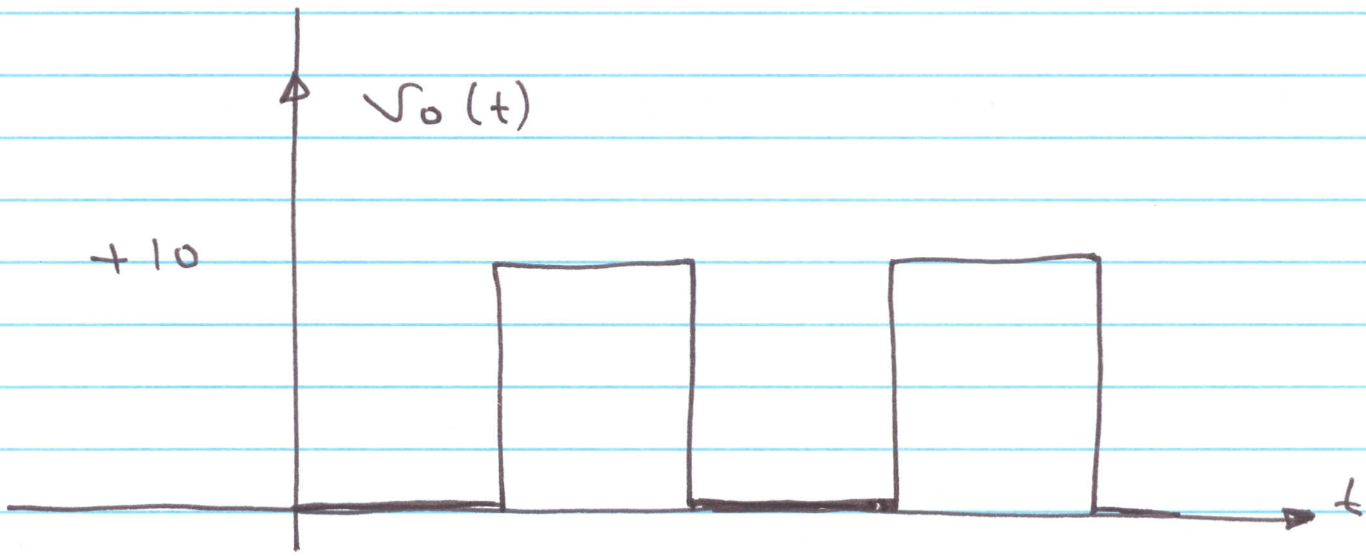
∴ Q_1 is OFF; replaced with open Circuit

$V_{GS_2} = V_{G_2} - V_{S_2} = 0 - 10 = -10 < V_{T_2}$

∴ Q_2 is on; replaced with short Circuit







Inverter ≡ Not gate