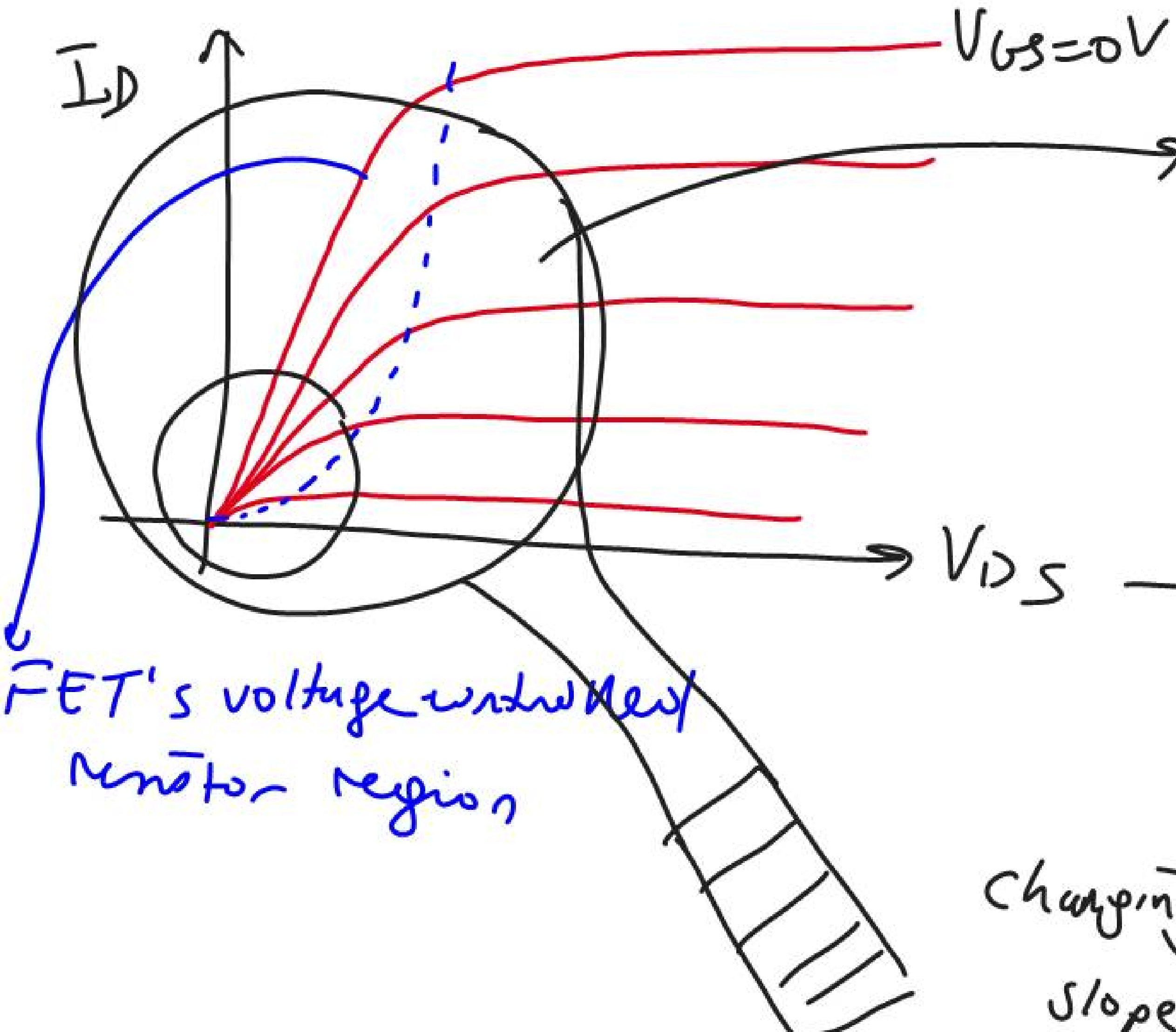
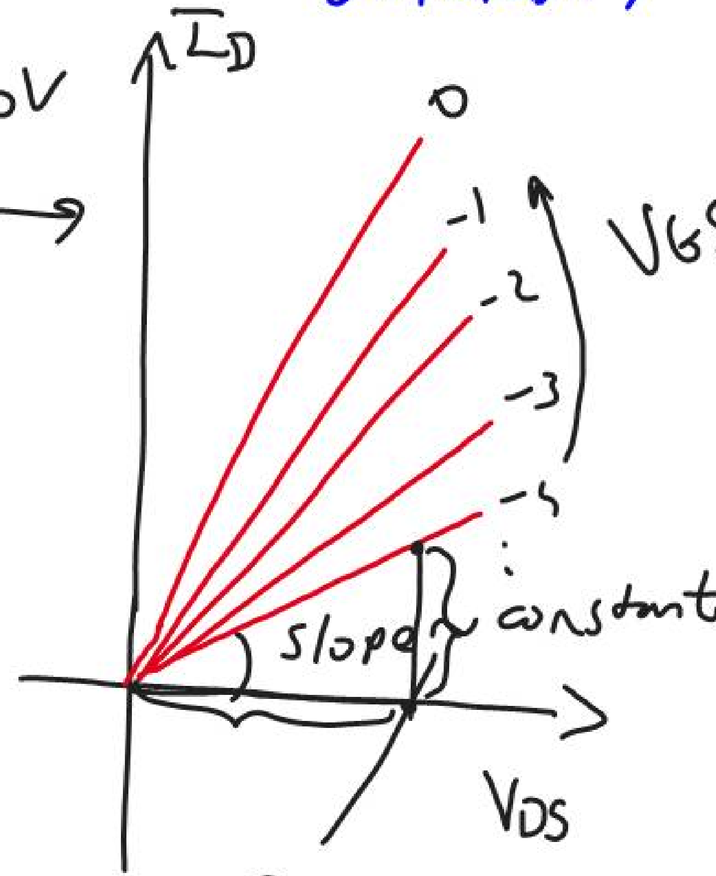
30.04.2011
©
SATURDAY

FET as a voltage-controlled Resistor



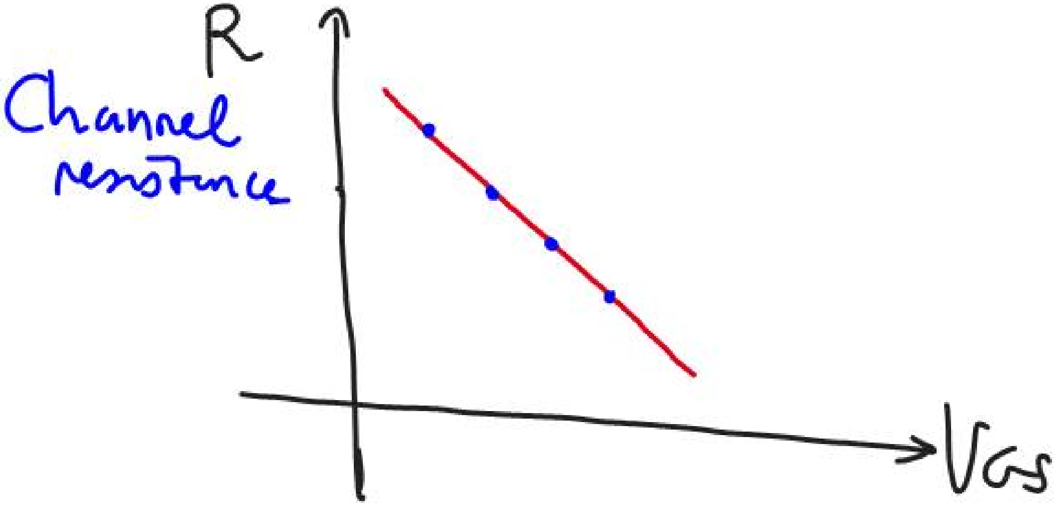


Changing V_{GS} → Changing slope

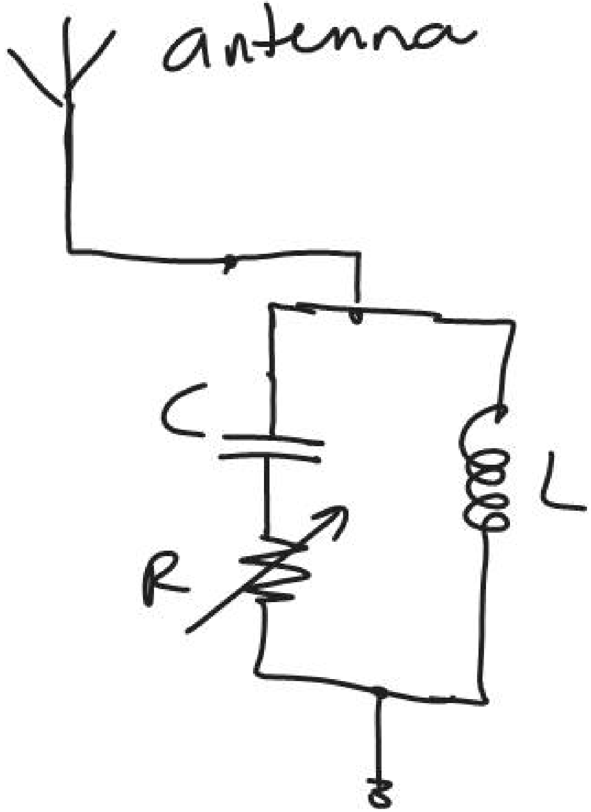
$$\text{slope } \alpha = \frac{\Delta I_D}{\Delta V_{DS}} \cong \frac{I_D}{V_{DS}} \quad \text{constant for each } V_{GS}$$

$$R = \frac{V}{I} \rightarrow \frac{1}{R} = \frac{I}{V}$$

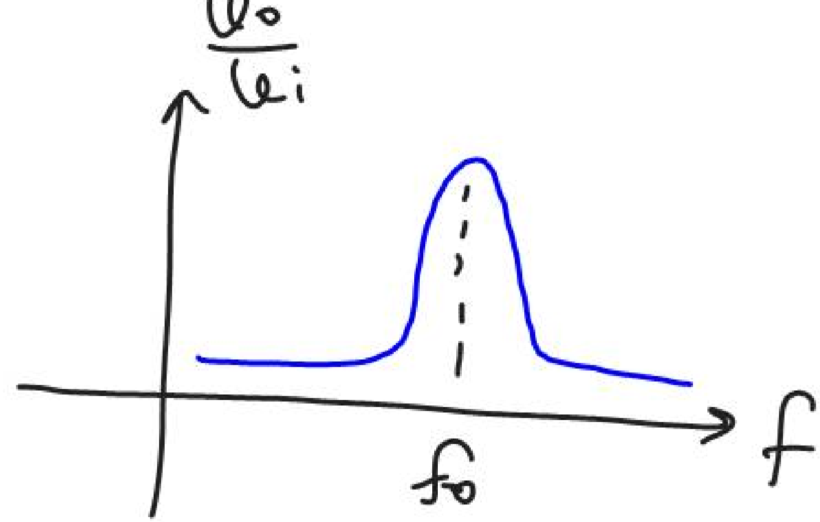
as slope gets higher the channel resistance gets lower:



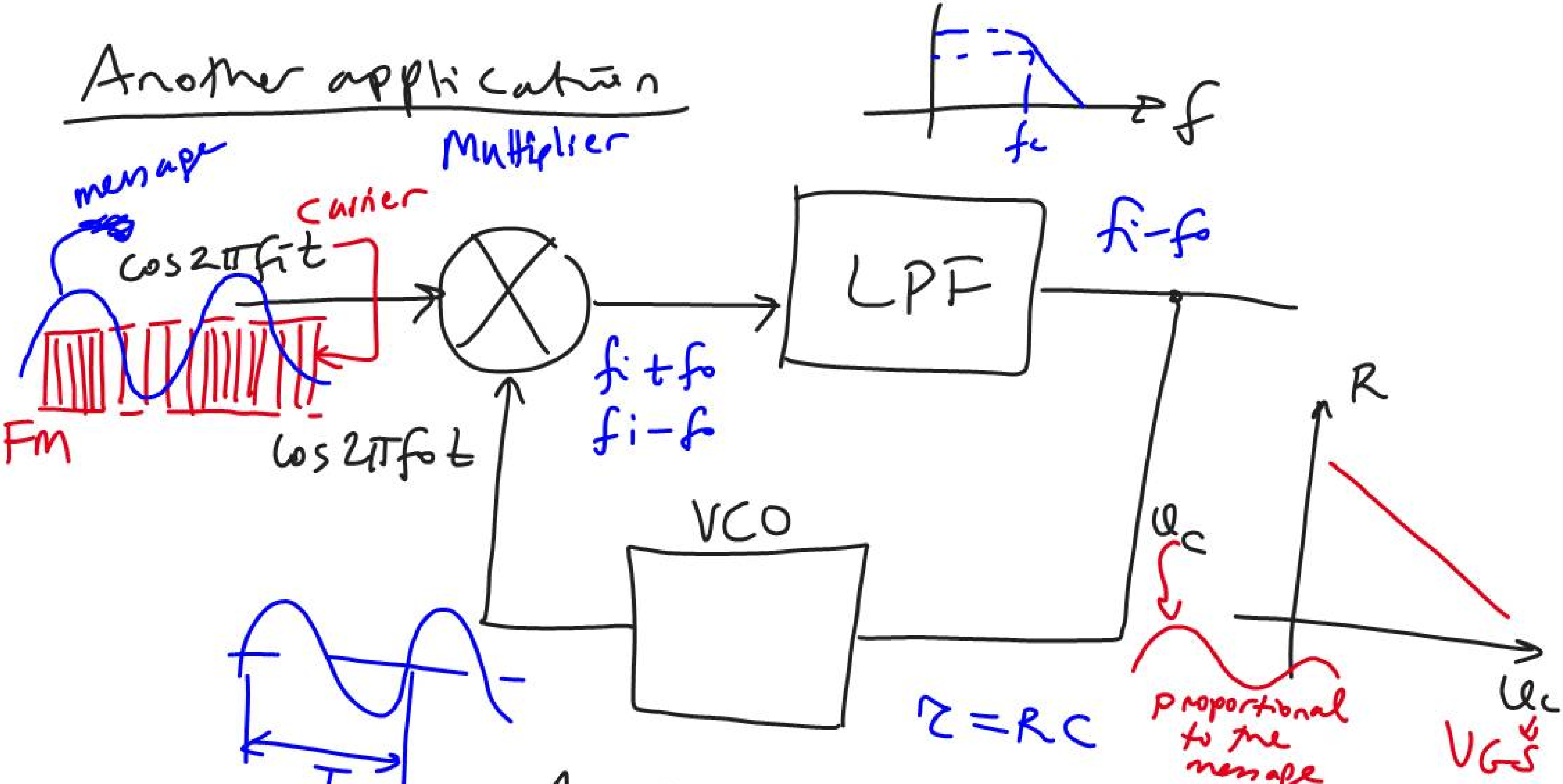
<u>ex</u> of application



Filter.



Another application

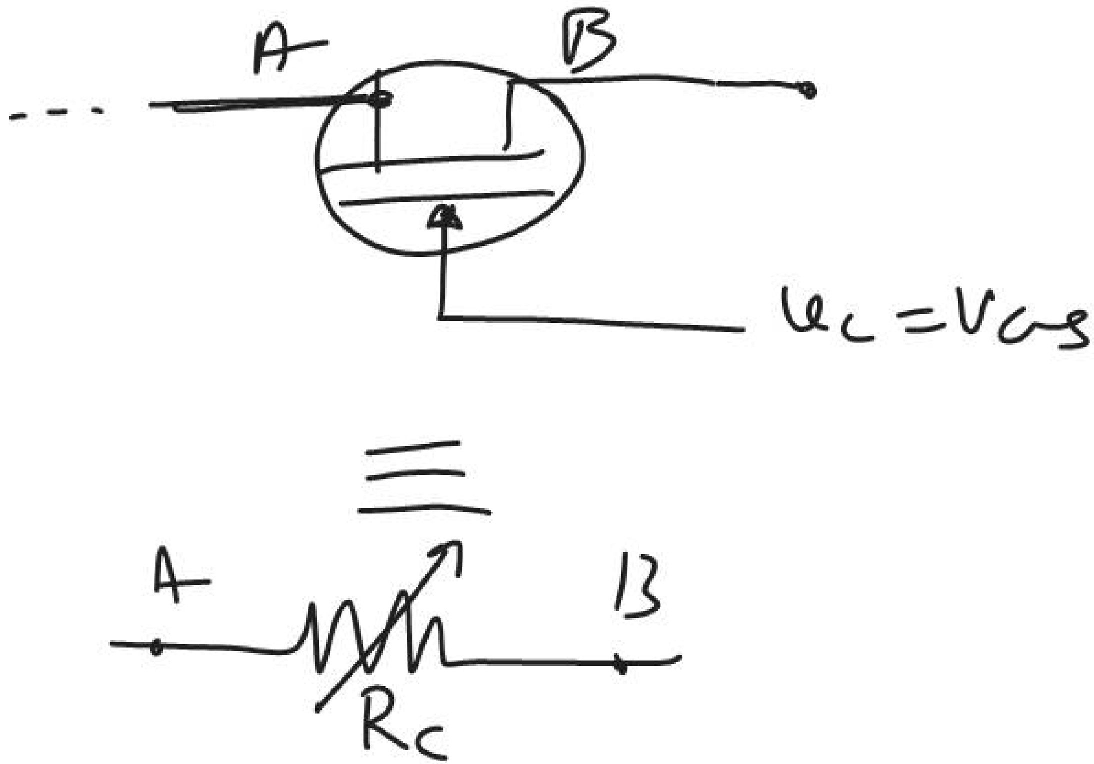


A voltage-controlled oscillator

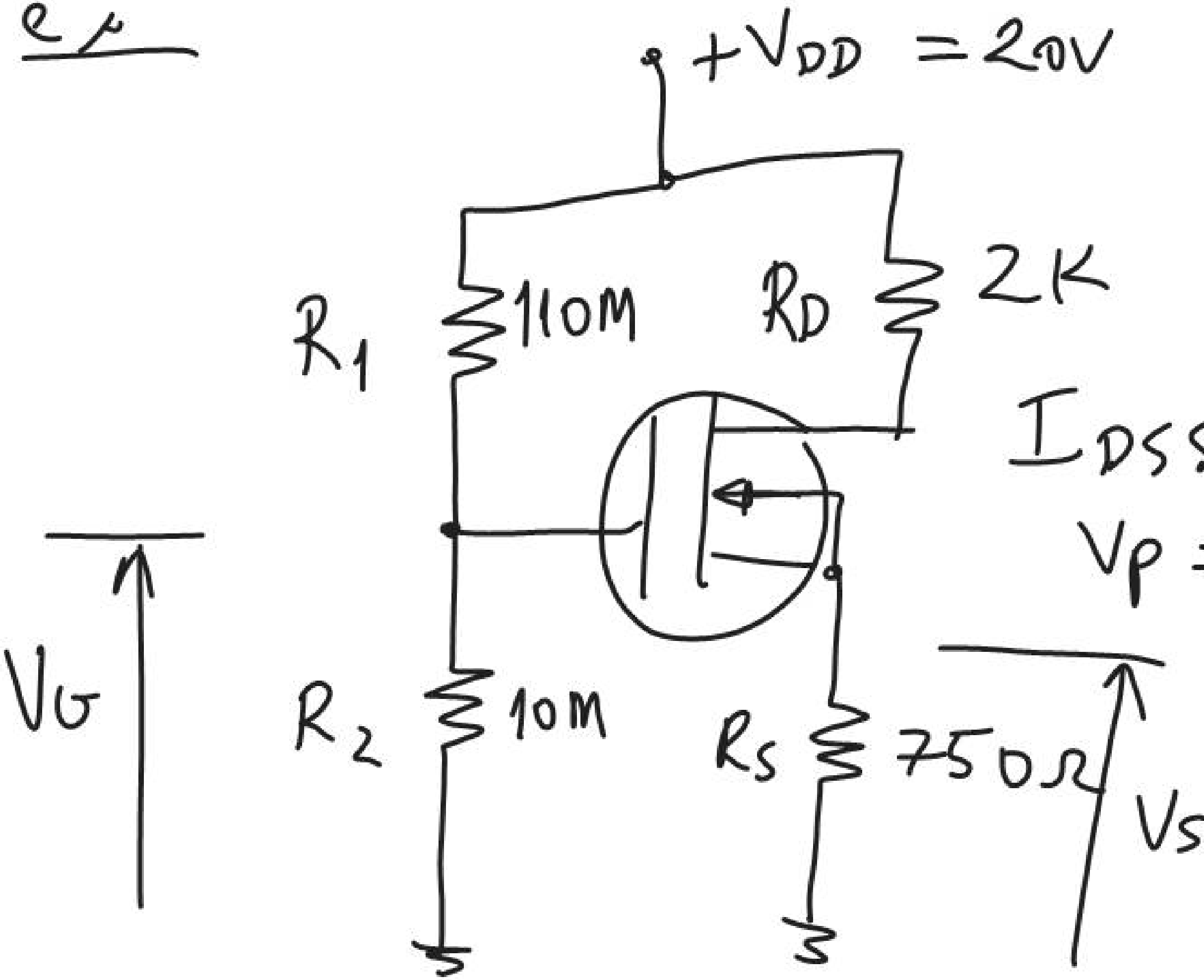
v_c = control voltage

f_0 = output frequency controlled by v_c

Phase Locked Loop (PLL)


A
B
$u_c = V_{GS}$
≡
A
B
R_c

ex



$I_{DSS} = 6mA$

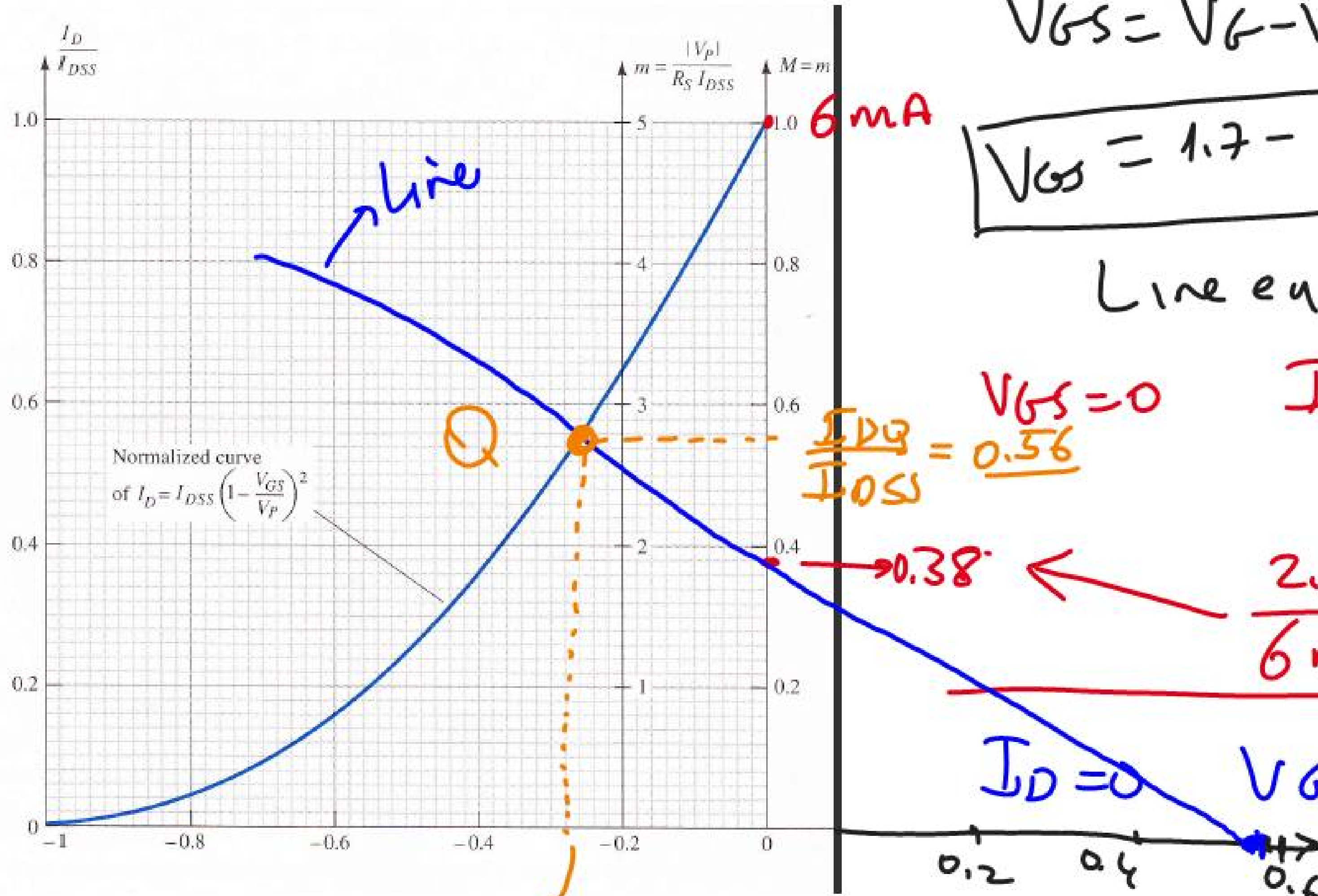
$V_P = V_{GSoff} = -3V$

$$V_G = \frac{V_{DD}}{R_1+R_2} \cdot R_2$$

$$V_G = \frac{20}{120 \times \cancel{10^6}} \times 10 \times \cancel{10^6}$$

Determine the quiescent point (Q) $V_G \doteq 1.7V.$

$V_S = I_D \cdot R_S = 750 I_D$



$V_{GS} = V_G - V_S$

$$\boxed{V_{GS} = 1.7 - I_D \cdot 750}$$

Line eqn.

$V_{GS} = 0$

$I_D = \frac{1.7}{750} = \sim 2.3\,mA$

$\frac{2.3\,mA}{6\,mA} \doteq 0,38$

$I_D = 0 \qquad V_{GS} = 1.7$

$\frac{1.7}{3.0} \doteq 0,57$

$V_P = -3V$

$\frac{V_{GSQ}}{|V_P|} = -0.28$

$I_{DQ} = 0.56 \times I_{DSS} = 0.56 \times 6mA = 3.4mA$

$V_{GSQ} = 0.28 \times |V_P| = -0.28 \times 3 = -0.84\,V$

$$\boxed{\begin{aligned} I_{DQ} &= 3.4\ mA \\ V_{GSQ} &= -0.84\ V \\ V_{DS_Q} &\cong 14\ V \end{aligned}}$$

Q point

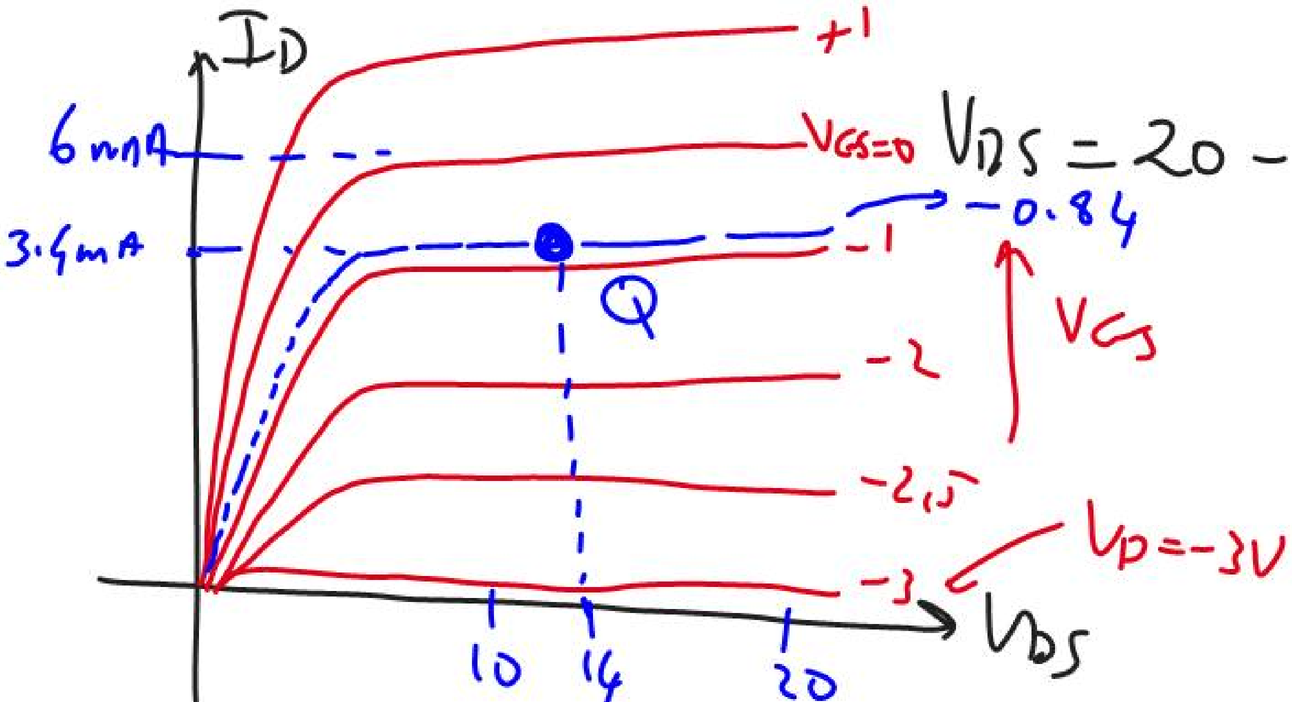
Output KVL

$$V_{DD} - I_D \cdot (R_D + R_S) - V_{DS} = 0$$

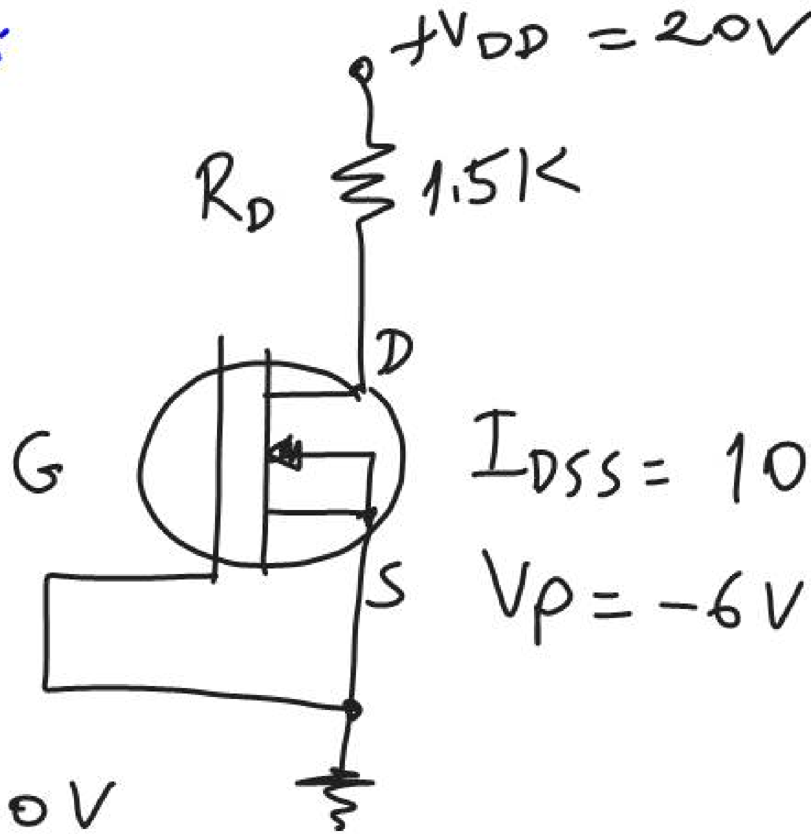
$$V_{DS} = V_{DD} - I_D (R_D + R_S)$$

$$V_{DS} = 20 - 3.4 \times \cancel{10^{-3}} (1 + 0.75) \times \cancel{10^{3}}$$

$$V_{DS} = 20 - 5.95 \approx \underline{14\,V}$$



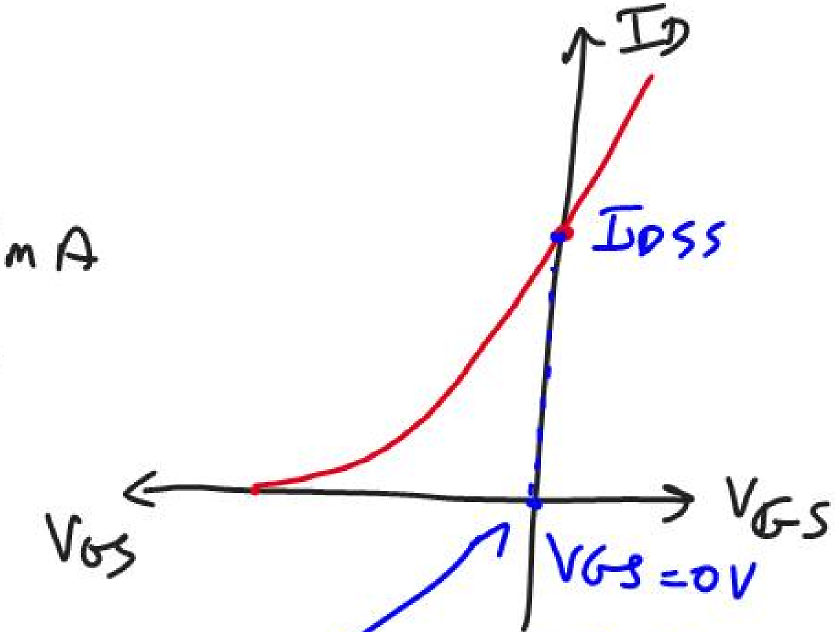
ex:



$I_{DSS} = 10mA$

$V_P = -6V$

Determine Q



$V_G = 0V$

$V_S = 0V$

$V_{GS} = 0 - 0 = 0$

$\Rightarrow I_D = I_{DSS}$

Q

$I_{DQ} = 10mA$

$V_{GSQ} = 0V$

$V_{DSQ} = 5V$

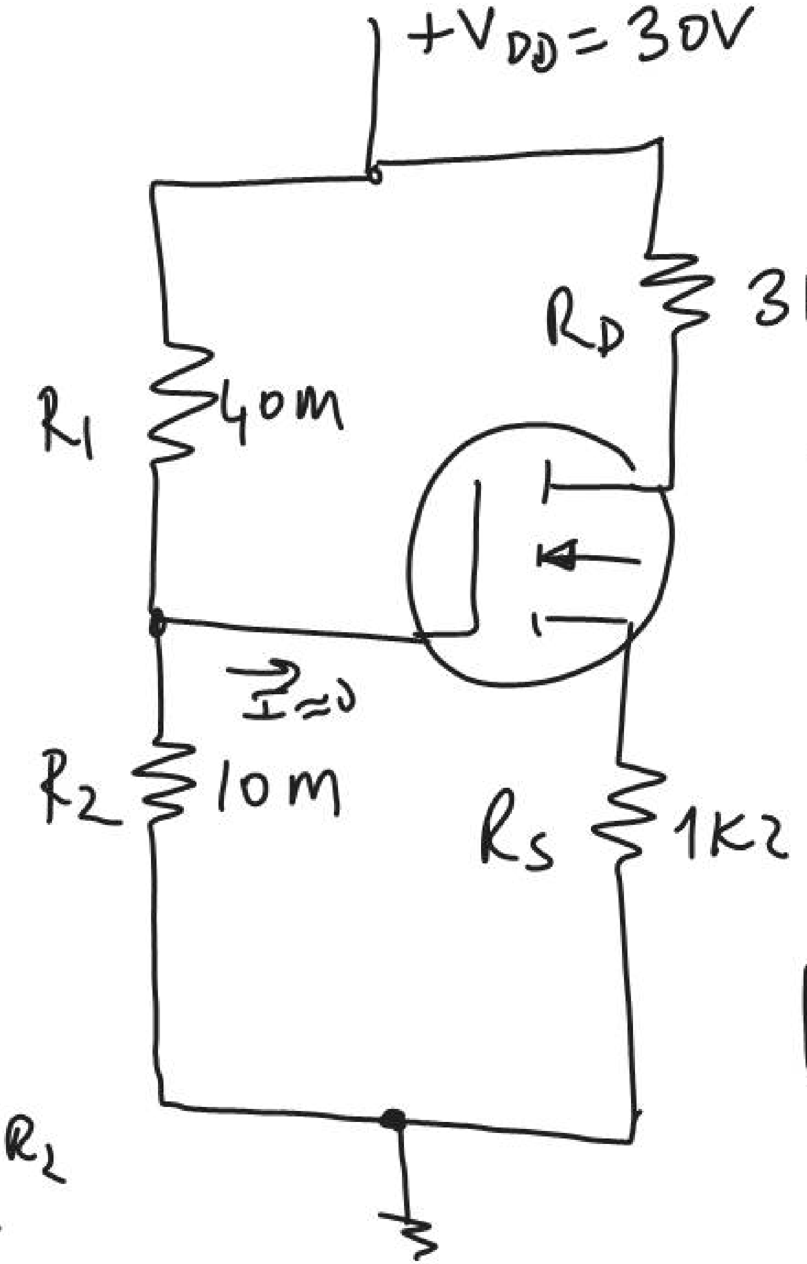
$V_{DD} - I_D R_D - V_{DS} = 0$

$V_{DS} = V_{DD} - I_D R_D$

$V_{DS} = 20 - 10 \times \cancel{10^{-3}} \times 1.5 \times \cancel{10^{3}}$

$\boxed{V_{DS} = 5V}$

ex



V_G

$V_T = 3V$

$k = 0.4 \times 10^{-3}\ A/V^2$

$V_{GS} = V_G - V_S$

$V_{GS} = 6 - I_D \times 1.2 \times 10^3$

$\boxed{V_{GS} = 6 - 1200\, I_D}$ Line

1st eqn.

$V_G = \frac{V_{DD}}{R_1 + R_2} \cdot R_2$

$V_G = \frac{30}{5\cancel{0} \times \cancel{10^6}} \times 1\cancel{0} \times \cancel{10^6} = \underline{6V}$

2nd Eqn: $I_D = k(V_{GS} - V_T)^2$

$$I_D = 0.4\times10^{-3}(V_{GS} - 3)^2$$

From the first Eqn:

$$V_{GS} = 6 - 1200 I_D$$

$$I_D = 0.4\times10^{-3}(6 - 1200 I_D - 3)^2$$

$$\boxed{I_D = 0.4\times10^{-3}(3 - 1200 I_D)^2}$$

$\longrightarrow$ The roots can be calculated and I_{DQ}, V_{GSQ} are obtained.

$$ax^2 + bx + c = 0$$

where $x = I_D$

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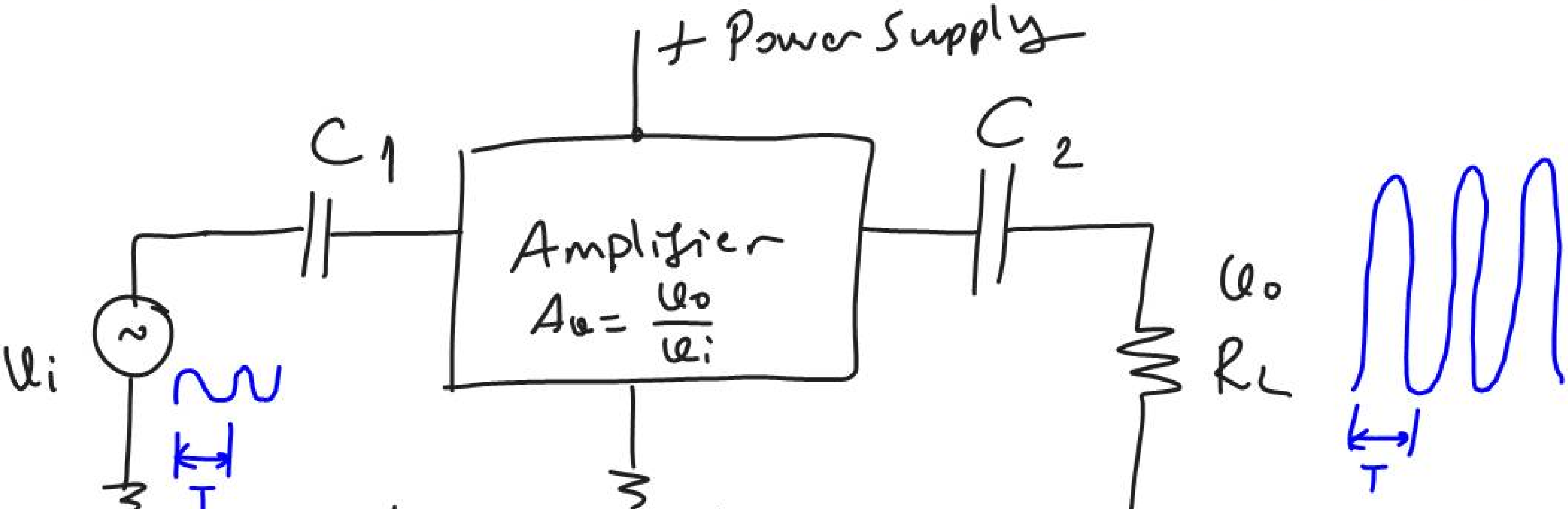
and $V_{DD} - I_D R_D - V_{DS} - I_D R_S = 0$

$$V_{DS} = V_{DD} - I_D(R_D + R_S)$$

SMALL SIGNAL AMPLIFICATION



LINEAR AMPLIFIERS

C_1, C_2 are blocking capacitors. They separate the stages in terms of DC

$y = ax + b$ linear

$u_o = A_u \cdot u_i + b \rightarrow$ a DC voltage

if $A_u > 0 \rightarrow$ zero phase shift

if $A_u < 0 \rightarrow 180°$ phase shift

If not linear, and only power amplification is the concern, then POWER AMPLIFIERS are used