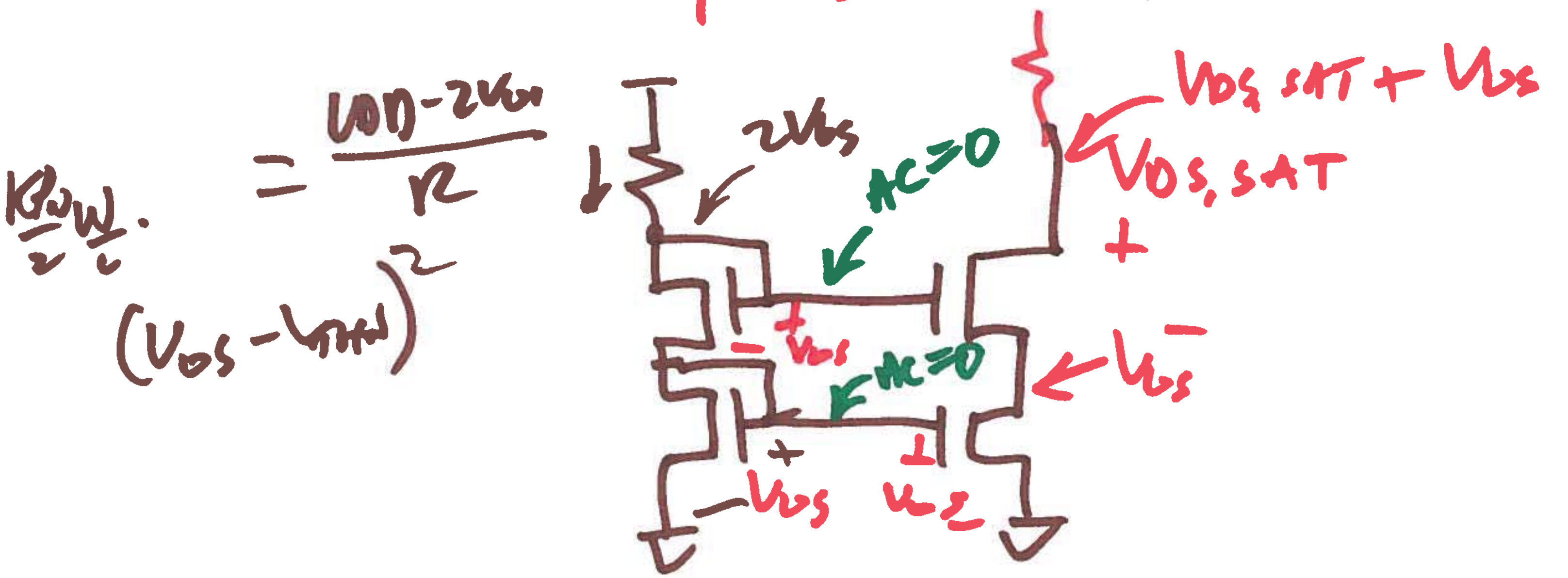
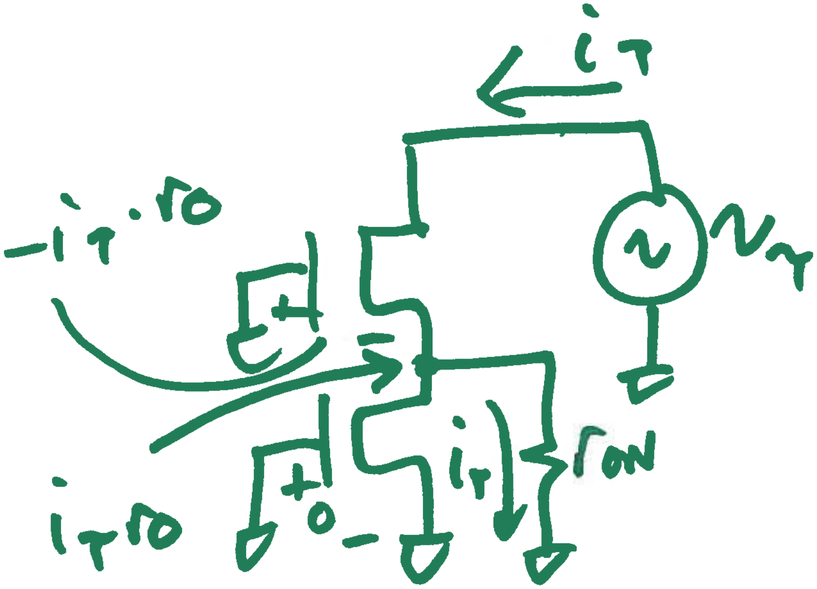
# Lecture 10

# EE 420/ECG 620

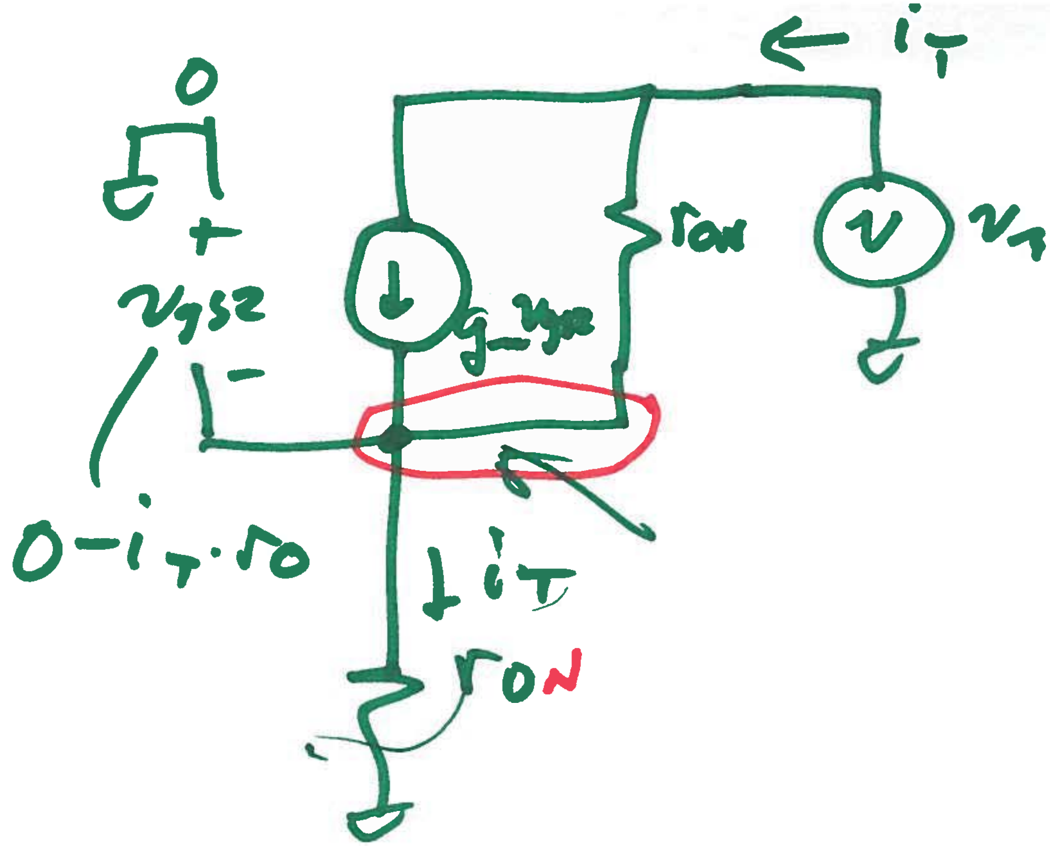
# Analog IC Design

Feb. 22, 2017






AC CKT



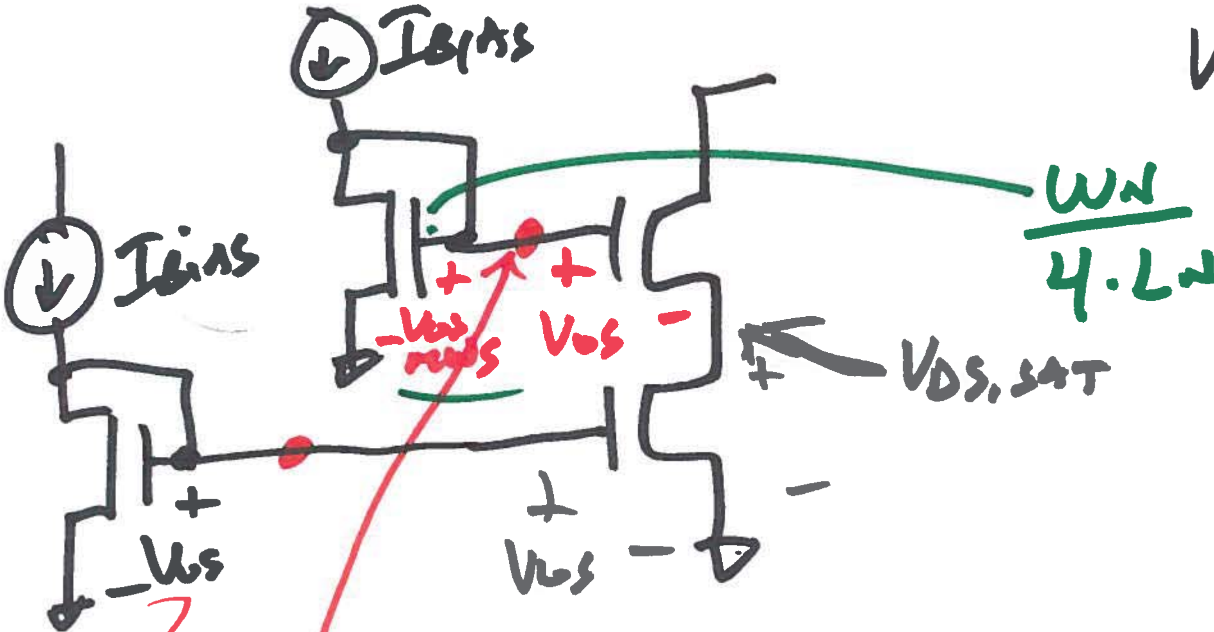

$$\frac{v_T - (i_T r_{oN})}{r_{oN}} + g_{mN}(-i_T r_{oN}) = i_T$$

$$v_T = (g_{mN} r_{oN}^2 + r_{oN} + r_{oN})\, i_T$$

$$R_{ocasN} = \frac{v_T}{i_T} = g_m r_{oN}^2 + r_{oN} \cdot 2 \approx g_m r_{oN}^2$$



2)



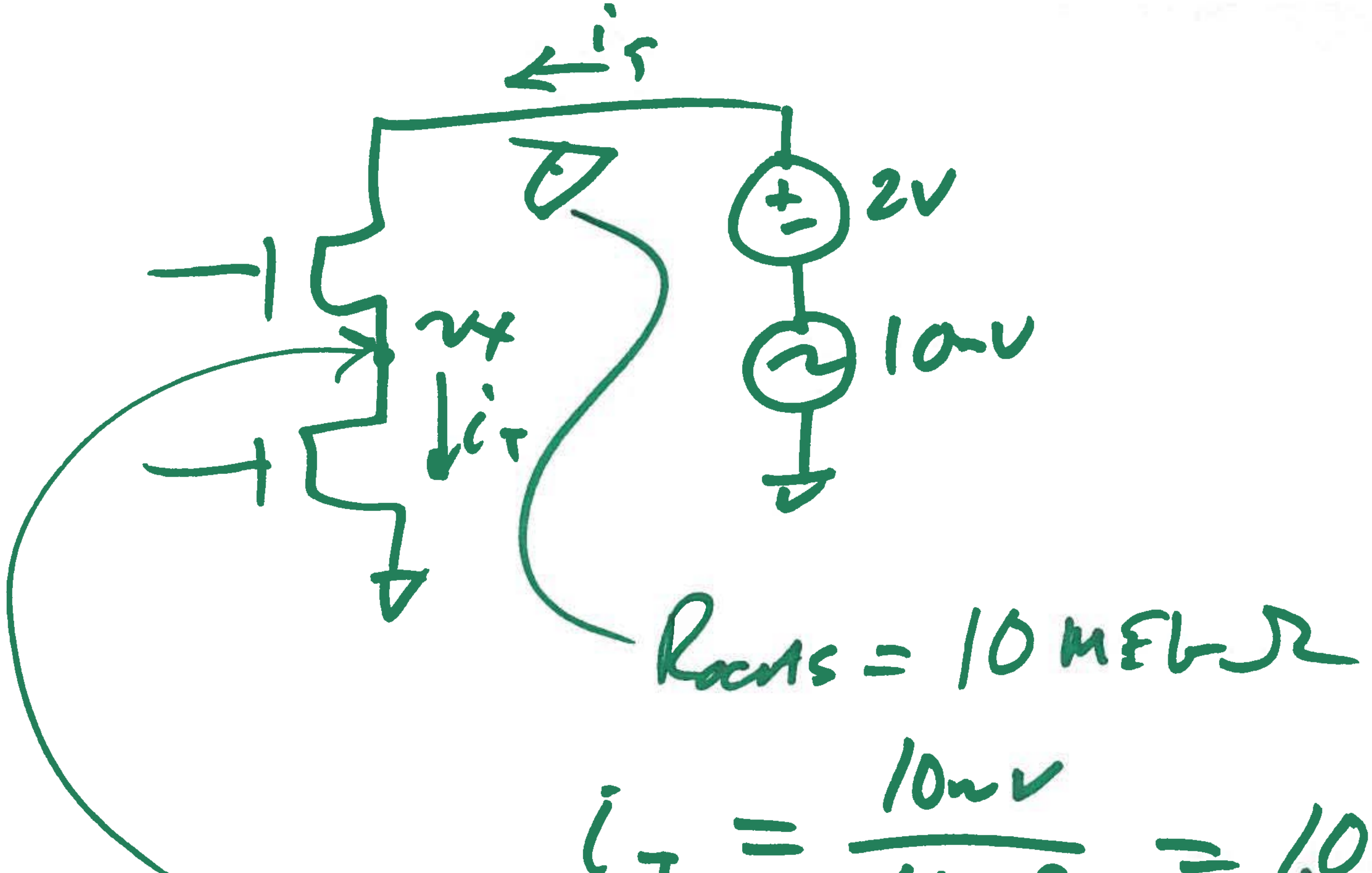

$$V_{GS} = V_{DS,sat} + V_{THN}$$


$$V_{GS} + V_{DS,sat} = \underbrace{2V_{DS,sat} + V_{THN}} = V_{GS,MWS}$$

$$I_{BIAS} = \frac{KP_N}{2}\frac{W_N}{L_N}\Big(\underbrace{V_{GS} - V_{THN}}_{V_{DS,sat}}\Big)^2$$

$$I_{BIAS} = \frac{KP_N}{2}\frac{W_N}{L_{WS}}\Big(\underbrace{V_{GS,MWS} - V_{THN}}_{2V_{DS,sat}}\Big)^2$$

$$L_{WS} = 4\cdot L_N$$

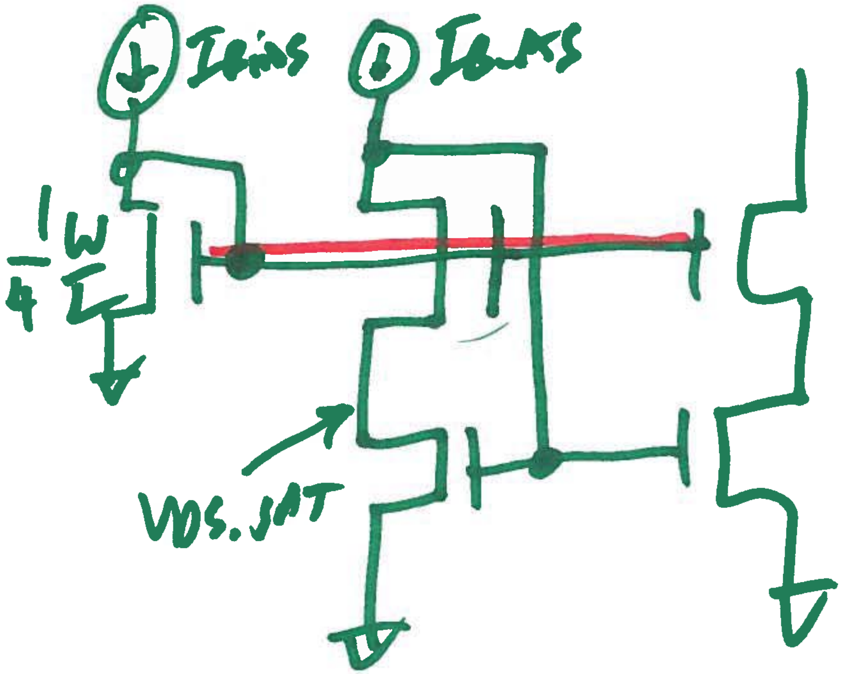


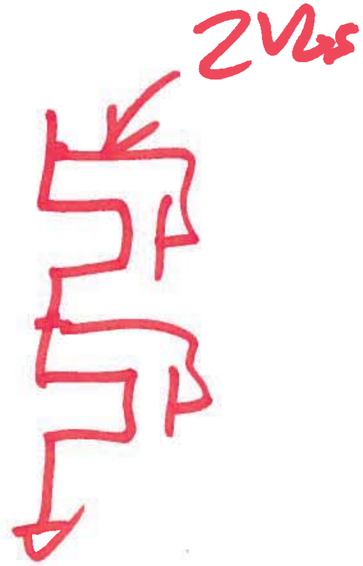

$$i_T = \frac{10\,mV}{10\,MEG} = 1.0\,nA$$

$$v_x = i_T \cdot r_{on}$$

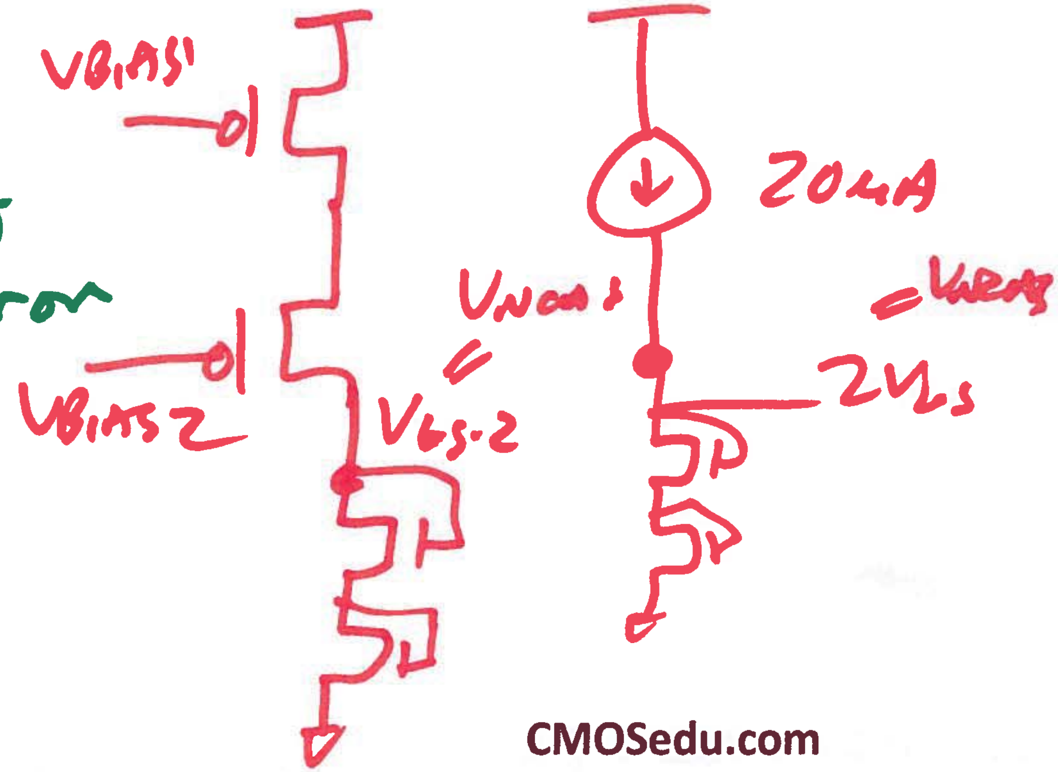
$$\quad 10^{-9} \quad 100K$$

$$v_x = 10^{-9} \cdot 10^{5} = 10^{-4}\,V = 0.1\,mV$$




Low-Voltage wide-swing current mirror

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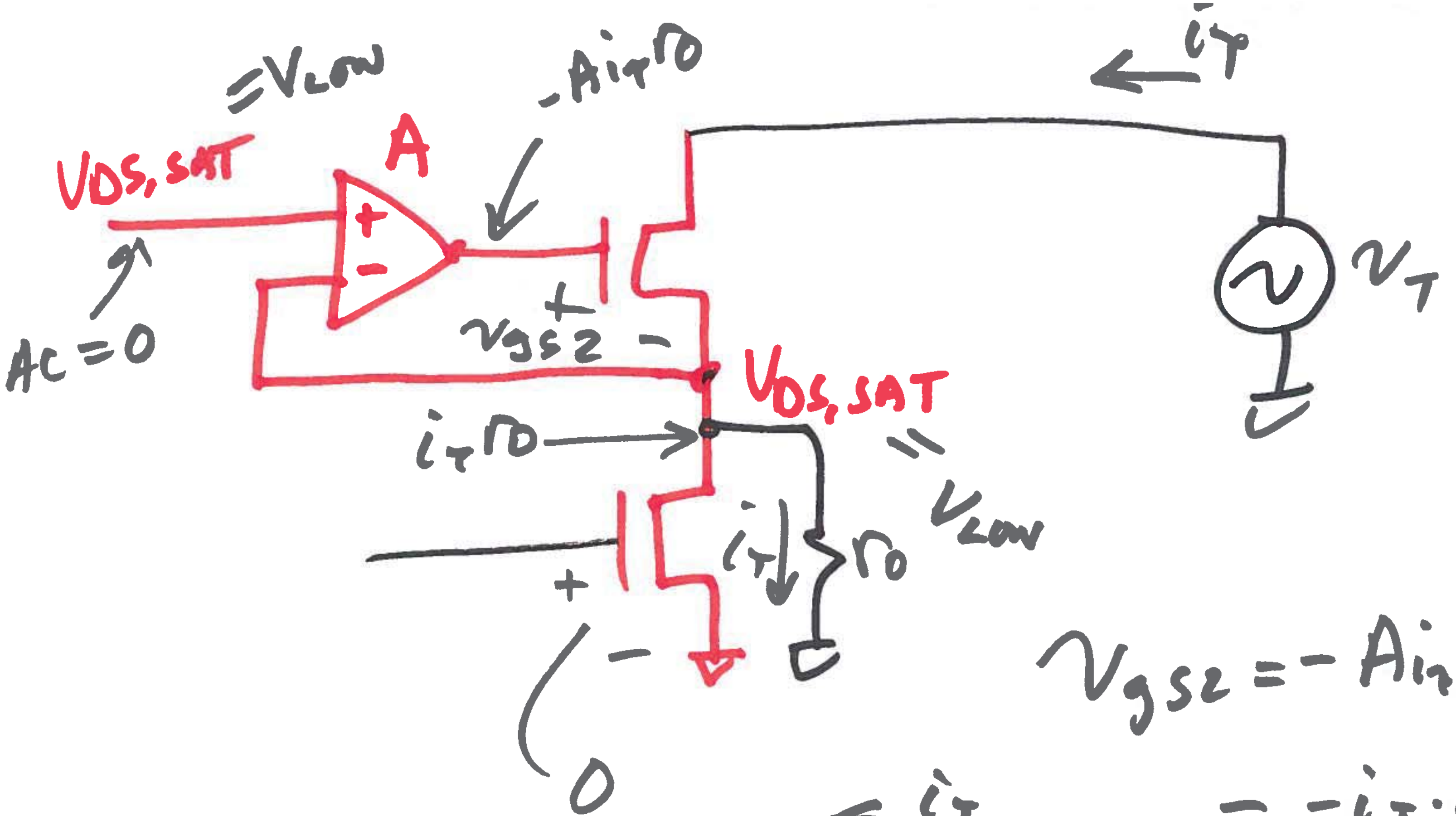
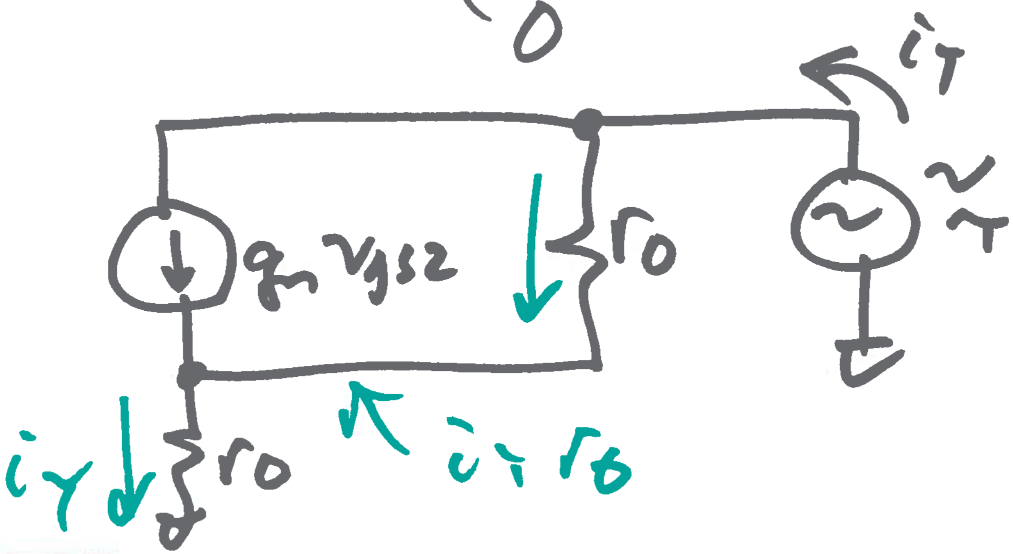



$$v_{gs2} = -Ai_T \cdot r_o - i_T r_o$$

$$= -i_T \cdot r_o (1+A)$$




$$i_T = \frac{v_T - i_T r_o}{r_o} + g_m(-i_T r_o)(1+A)$$

$$i_T\left(r_o + r_o + g_m r_o^2(1+A)\right) = v_T$$

$$R_{ocas}\Big|_{R.G.} = \frac{v_T}{i_T} = 2r_o + g_m r_o^2(1+A)$$

$$\approx g_m r_o^2(1+A)$$