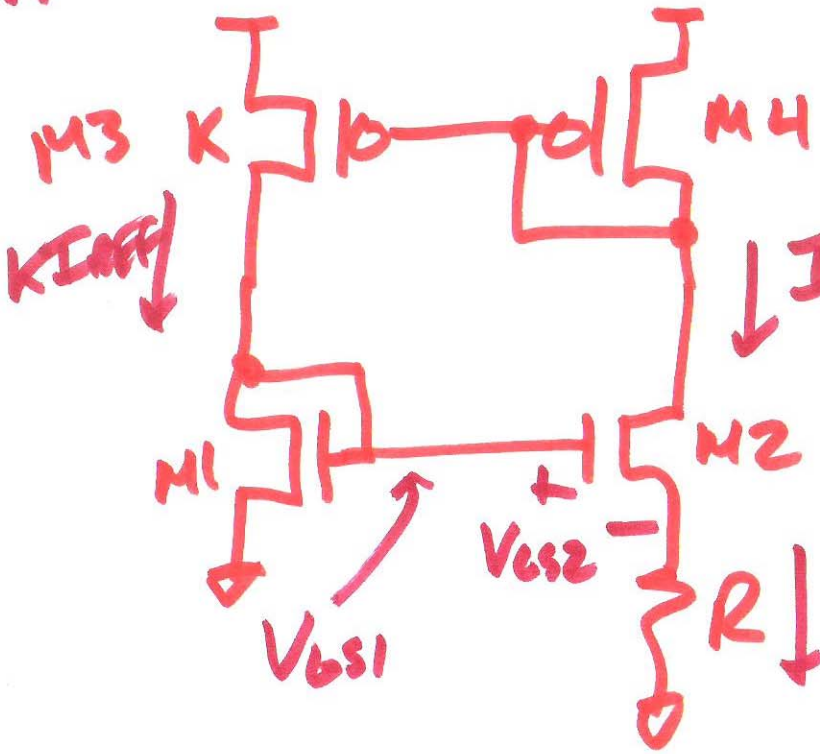
EE 422 / ECG 622
Analog IC Design

3/13/2013 Lecture 13

A20.17



$$V_{GS1} = \sqrt{\frac{2KI_{REF}}{\beta_{1,2}}} + V_{THN}$$

$$V_{GS2} = \sqrt{\frac{2I_{REF}}{\beta_{1,2}}} + V_{THN}$$

$$V_{GS1} = V_{GS2} + I_{REF} \cdot R$$

$$V_{GS1} - V_{GS2} = I_{REF} \cdot R$$

$$\sqrt{\frac{2I_{REF}}{\beta_{1,2}}}\left(\sqrt{K} - 1\right) = I_{REF} R$$

$$\frac{2I_{REF}}{\beta_{1,2}}\left(\sqrt{K}-1\right)^2 = I_{REF}^2 \cdot R^2$$

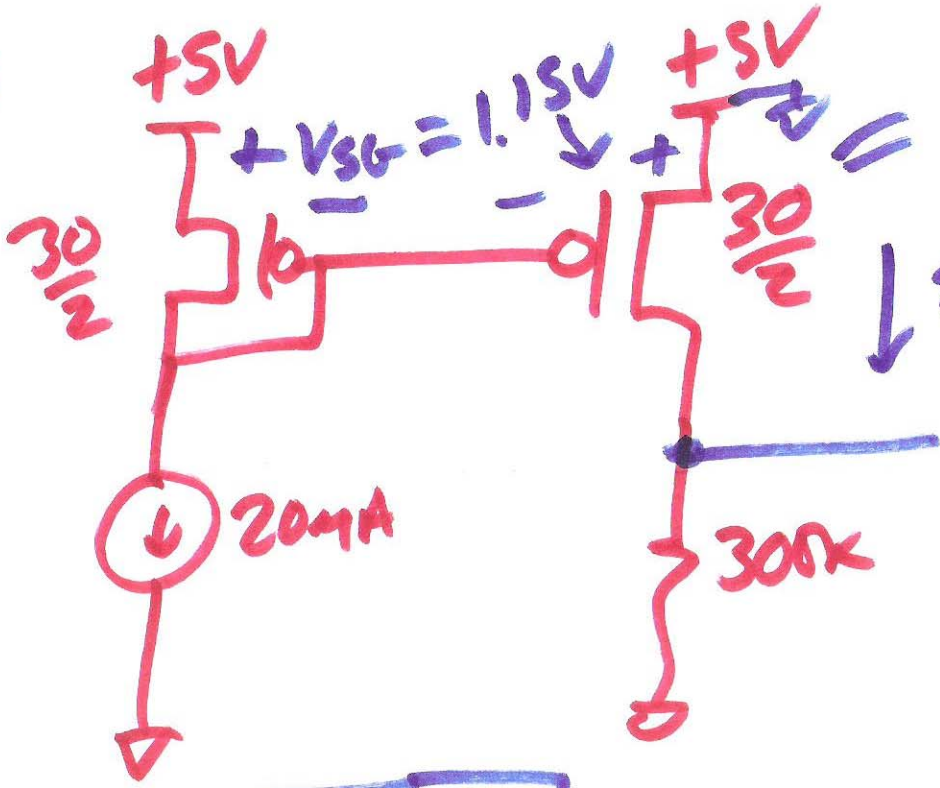
$$\boxed{I_{REF} = \frac{2}{R^2\beta_{1,2}}\left(\sqrt{K}-1\right)^2}$$

$$g_m = \sqrt{2I_{REF}\cdot\beta_{1,2}}$$

$$2I_{REF}\cdot\beta_{1,2} = \frac{4}{R^2}\left(\sqrt{K}-1\right)^2$$

$$g_m = \sqrt{2I_{REF}\cdot\beta_{1,2}} = \frac{2}{R}\cdot\left(\sqrt{K}-1\right)$$

A 20.16)



$$V_{SG} = \sqrt{\frac{2 \cdot 20\mu}{40\mu \cdot \frac{30}{2}}} + .9$$

$$= 1.15V$$

$$R_{CH} = \frac{1}{40\mu \cdot \frac{30}{2}(1.15 - .9)} = 6.5k$$

Assume in sat.

$$V_o = 20\mu \cdot 300k = 6V$$

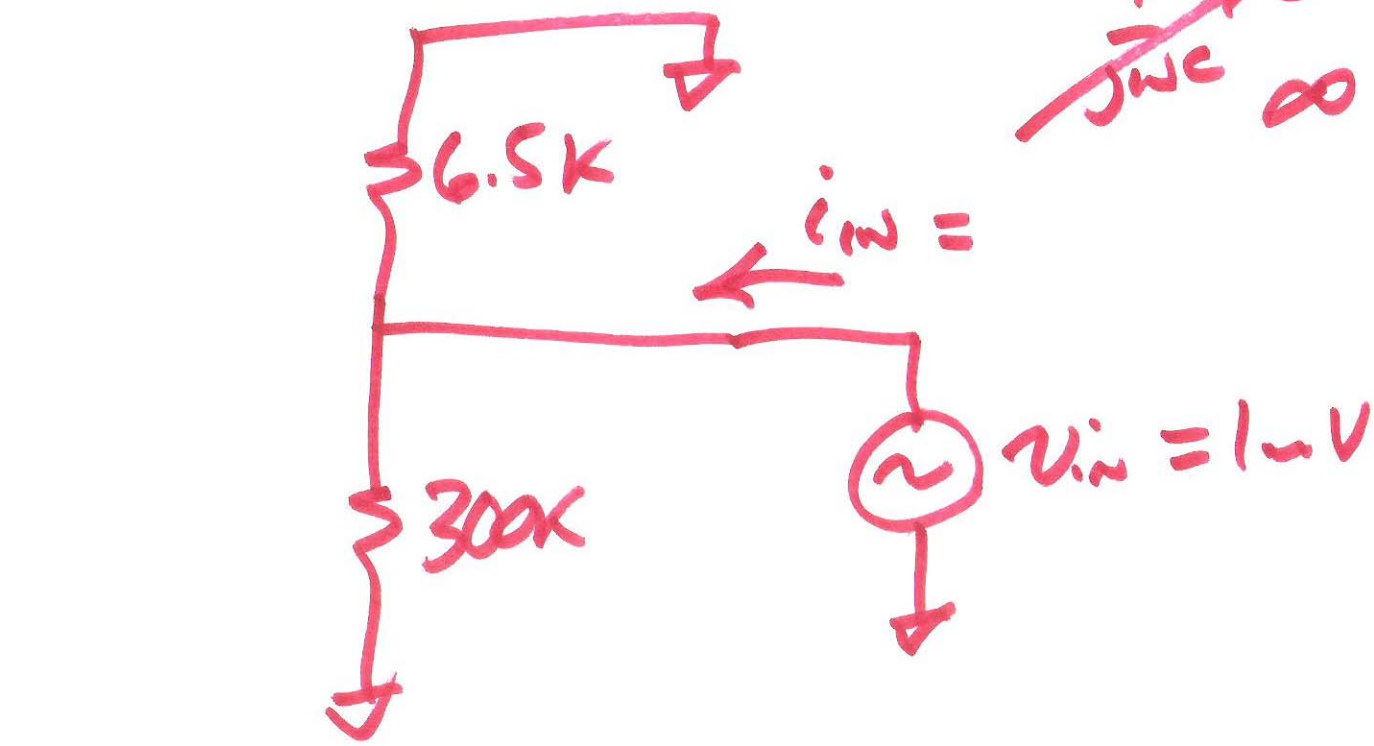
Not in sat! In triode!

R_C

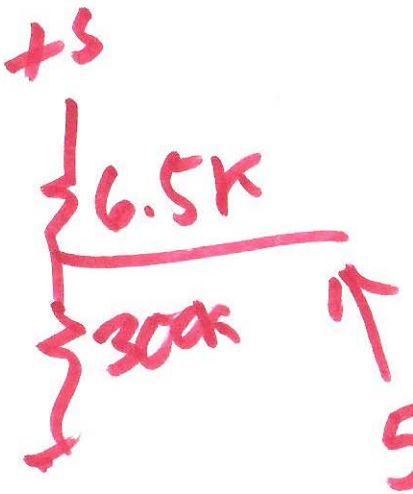
$$\frac{1}{150\mu} = R_{CH}$$

$150\mu \rightarrow 72\mu$

$$R_{CH} = \frac{1}{g_{ds}}$$

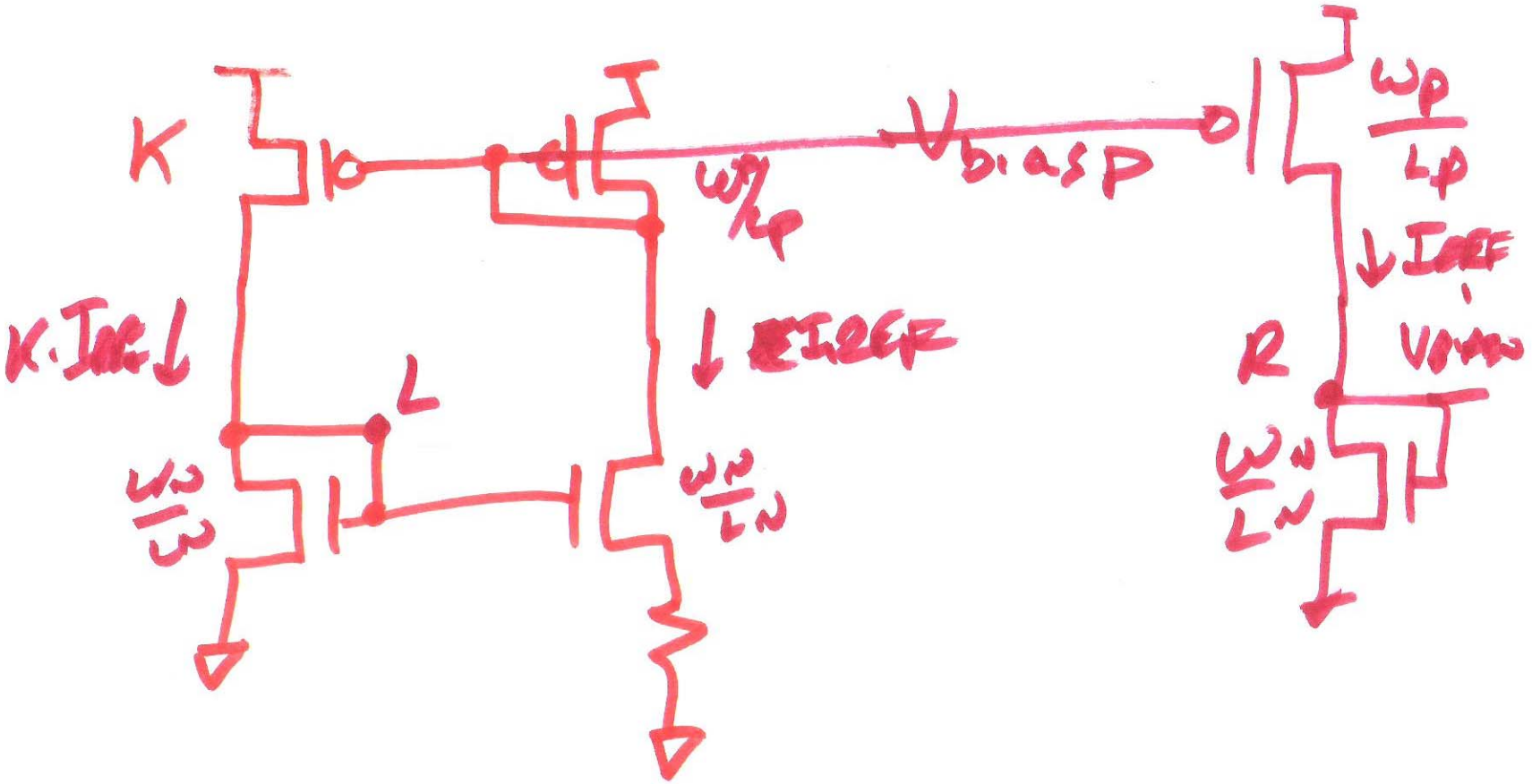


$\frac{1}{j\omega C}$ → 0 for AC, ∞ for DC



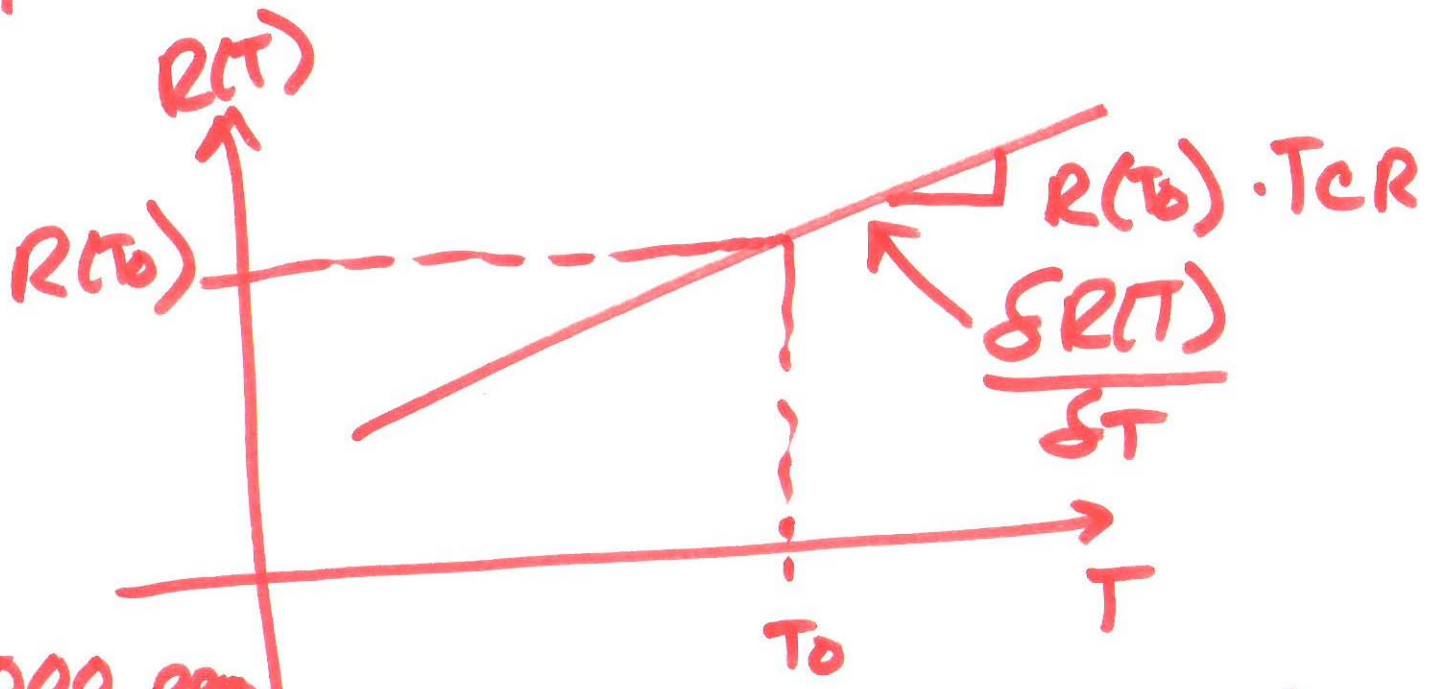
$$i_{in} = \frac{1mV}{6.5K \| 300K} = \frac{1}{65}\,\mu A \simeq 15.3\,nA$$

$5 \cdot \frac{300}{306.5}$



UNLV

$$R(T) = R(T_0)\left(1 + TCR(T - T_0)\right)$$



$$TCR = 2{,}000 \ \frac{ppm}{C^\circ}$$

$$= 0.002$$

$$ppm = 10^{-6}$$

$$R(T_0) \cdot TCR = \frac{\delta R(T)}{\delta T}$$

$$TCR = \frac{1}{R(T_0)} \cdot \frac{\delta R}{\delta T}$$

$$I_{DEF} = \frac{2}{R^2 \beta}\left(1 - \frac{1}{\sqrt{K}}\right)^2 = \frac{X}{R^2 \cdot \beta} = X R^{-2} \beta^{-1}$$

$$= R^{-2} \cdot \beta^{-1} X, \quad X = 2\left(1 - \frac{1}{\sqrt{K}}\right)^2$$

$$\frac{\delta I_{DEF}}{\delta T} = \left(-2 R^{-3} \beta^{-1} \cdot X\right)\frac{\delta R}{\delta T} + \left(-1 R^{-2} \beta^{-2} X\right)\frac{\delta \beta}{\delta T}$$

$$= \underbrace{X R^{-2} \beta^{-1}}_{I_{DEF}}\left(-2 R^{-1} \cdot \frac{\delta R}{\delta T} - \beta^{-1} \cdot \frac{\delta \beta}{\delta T}\right)$$

$$I_{DEF}(T) = I_{DEF}(T_0)\left(1 + TC_{I_{DEF}}(T - T_0)\right)$$

$$\frac{\delta I_{DEF}}{\delta T} = I_{DEF}\left(-2 \underbrace{\frac{1}{R}\frac{\delta R}{\delta T}}_{TCR} - \frac{1}{\beta}\frac{\delta \beta}{\delta T}\right)$$

$$\frac{1}{I_{REF}}\frac{\delta I_{REF}}{\delta T} = -2 \cdot TCR - \frac{1}{\beta}\cdot\frac{\delta \beta}{\delta T}$$

$$\beta_N = KP_N\frac{W}{L} = \mu_N \cdot C_{ox}' \cdot \frac{W}{L}$$

$$\frac{1}{\beta}\frac{\delta \beta}{\delta T} = \frac{1}{\mu}\cdot\frac{\delta \mu}{\delta T} = \frac{1}{KP}\cdot\frac{\delta KP}{\delta T}$$

$$= \frac{-1.5}{T}$$

$-.004$

$$TCI_{REF} = \frac{1}{I_{REF}}\frac{\delta I_{REF}}{dT} = -2TCR + \frac{1.5}{T}$$

0.005

300

$$I_{REF}(T) = I_{REF}(T_0)\left(1 + TCI_{REF}(T - T_0)\right)$$

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