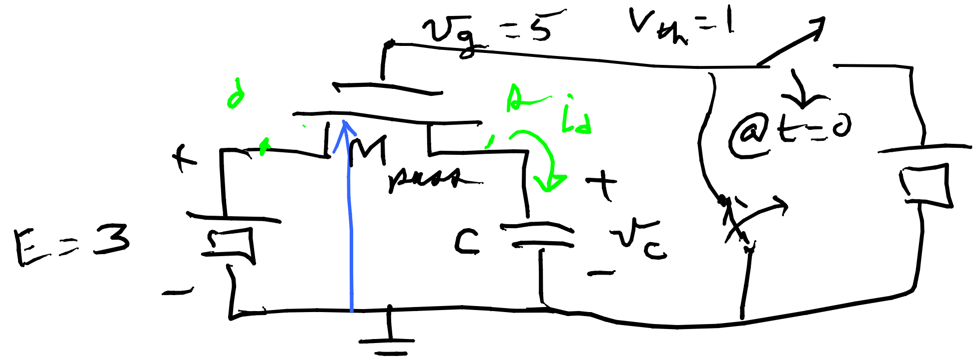
EE 302
03/15/05



$v_c(t)$ desired $t > 0$ $v_c(0)$; $M_{pass} \Rightarrow$ ohmic $t > 0$ at start

$t > 0$

$$C \frac{dv_c}{dt} = i_d$$

$$v_{ds} = E - v_c$$

$$v_{gs} = v_g - v_c$$

$$i_d = \frac{KP}{2}\frac{W}{L}\left\{2(v_{gs} - V_{th})v_{ds} - v_{ds}^2\right\} \quad , \beta = \frac{KP}{2}\frac{W}{L}$$

$$C\frac{dv_c}{dt} = \beta\left(2(v_g - v_c - V_{th})(E - v_c) - (E - v_c)^2\right)$$

$$= \beta\left(2(4 - v_c)(3 - v_c) - (3 - v_c)^2\right)$$

$$\frac{C}{\beta}\frac{dv_c}{dt} = \left(2(1 + [3 - v_c])(3 - v_c) - (3 - v_c)^2\right)$$

$$-\frac{C}{\beta}\left(\frac{d[3 - v_c]}{dt}\right) = \qquad x = 3 - v_c$$

$$-\frac{C}{\beta}\frac{dx}{dt} = \left(2[1 + x]x - x^2\right) = (2 + x)x \; ; \; 0 \le t$$

$$\frac{-\frac{C}{\beta}dx}{(2+x)x\,dt}, dt = dt = \int_0^t d\tau = \frac{-C}{\beta}\int_{\tau=0}^{\tau=t} \frac{1}{(2+x)x}\frac{dx}{d\tau}d\tau$$

$$t = \frac{-c}{\beta} \int_{x(0) = 3 - v_c(0)}^{x(t) = 3 - v_c(t)} \frac{dx}{x(2+x)} \; ; \quad \frac{1}{x(2+x)} = \frac{1/2}{x} + \frac{\frac{1}{-2}}{x+2} = \frac{1}{2}\left(\frac{1}{x} - \frac{1}{x+2}\right)$$

$$= \frac{-c}{2\beta} \int_{3}^{3 - v_c(t)} dx \left[\frac{1}{x} - \frac{1}{x+2}\right]$$

$$= \frac{-c}{2\beta} \left\{ \ln x - \ln(x+2) \right\} \Big|_{3}^{3 - v_c} = \frac{-c}{2\beta} \ln \frac{x}{x+2} \Big|_{3}^{3 - v_c}$$

$$= \frac{c}{2\beta} \ln\left(1 + \frac{2}{x}\right) \Big|_{3}^{3 - v_c} = \frac{c}{2\beta} \left[\ln\left(1 + \frac{2}{3 - v_c}\right) - \ln\left(1 + \frac{2}{3}\right) \right]$$

$$= \frac{c}{2\beta} \ln\left(\frac{1 + \frac{2}{3 - v_c}}{5/3} \right) = t$$

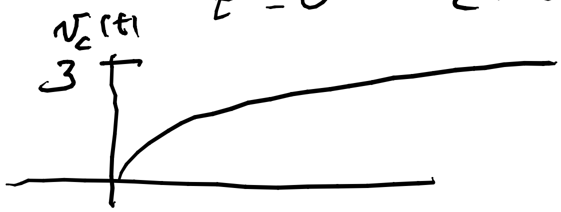
$$\Rightarrow e^{\frac{2\beta}{c} t} = \frac{3}{5}\left(1 + \frac{2}{3 - v_c}\right) = \frac{3}{5} + \frac{6/5}{3 - v_c}$$

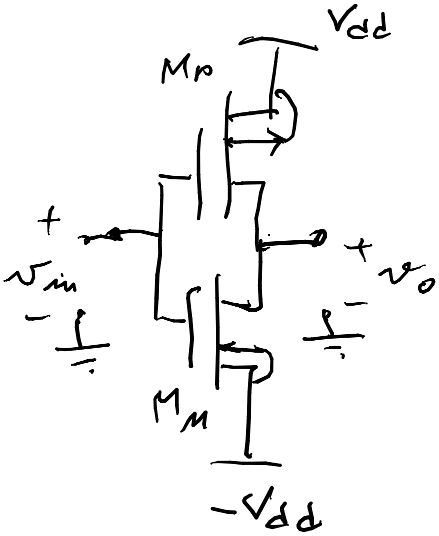
$$-\frac{3}{5} + e^{\frac{2\beta}{c} t} = \frac{6/5}{3 - v_c} \Rightarrow 3 - v_c = \frac{6/5}{-\frac{3}{5} + e^{2\frac{\beta}{c} t}}$$

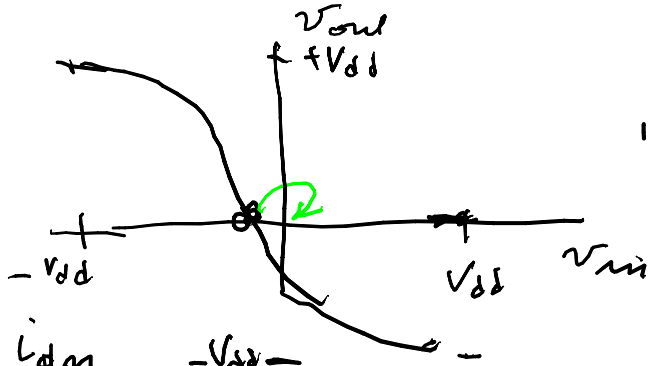
$$v_c = 3 - \frac{6}{-3 + 5 e^{2\frac{\beta}{c} t}}$$

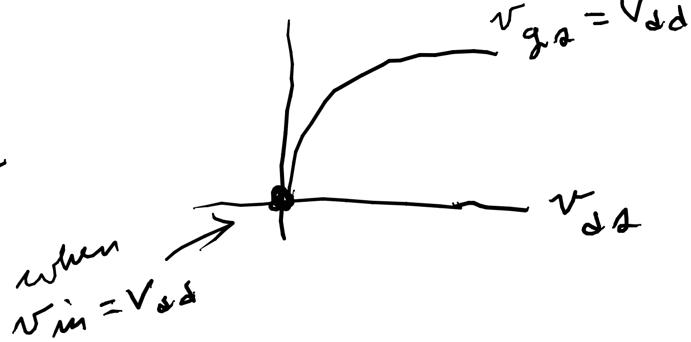
as $t \to \infty$ $v_c \to 3$

$t = 0$ $v_c = 0$









to force transition, when $v_{in} = 0$, to give $v_{out} = 0$

$$v_o = 0 \mid v_{in} = 0 \;;\; M_n,\; v_{gs} = v_{in} - (-V_{dd}) = v_{in} + V_{dd}$$
$$= V_{dd}$$
$$v_{ds} = v_o - (-V_{dd}) = V_{dd}$$

∴ if $V_{th} > 0$ enhancement mode device then at transition $v_{gs} - V_{th} < v_{ds}$

or at transition M_n is in saturation

same for $M_p \Rightarrow$ saturation

$$i_{D_n} = -i_{D_p} = i_{S_p}$$

$$i_{D_n} = \beta_n\left((V_{dd} - V_{th_n})^2\right)(1 + \lambda_n V_{dd}) =$$
$$-i_{D_p} = \beta_p\left((V_{dd} - |V_{th_p}|)^2(1 + |\lambda_p| V_{dd}\right)$$

$W_n = L_n = L_p = 20\mu$

; choose W_p

$$W_p = \frac{\beta_n}{\frac{KP_p}{2}\frac{1}{L_p}}\left(\frac{(V_{dd} - V_{th_n})^2(1 + \lambda_n V_{dd})}{(V_{dd} - |V_{th_p}|)^2(1 + \lambda_p V_{dd})}\right)$$

$\Rightarrow$ implies $v_o = v_{in}$ at $v_{in} = 0$ (the transition pt)

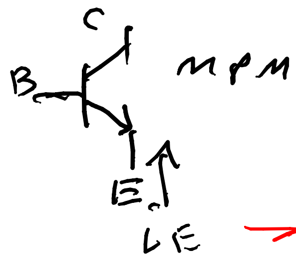
$V_{dd}=3$, $V_{thn}=1/2$, $V_{thp}=-1$; $\lambda_n=0.1$, $\lambda_p=0.2$

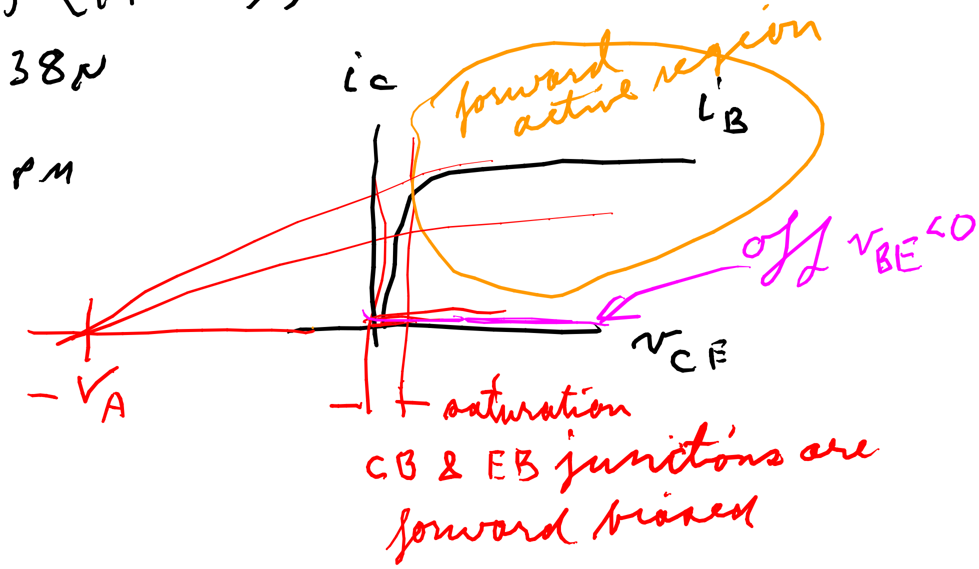
$$KP_n = \frac{3}{2} KP_p$$

$$W_p = L_p \times \frac{3}{2}\left(\frac{(2.5)^2(1+0.3)}{(2)^2(1+0.6)}\right) = \frac{3}{2}\left(\frac{6.25}{4}\times\frac{1.3}{1.6}\right)L_p$$

$$= 1.9\times L_p = 38\mu$$

BJT





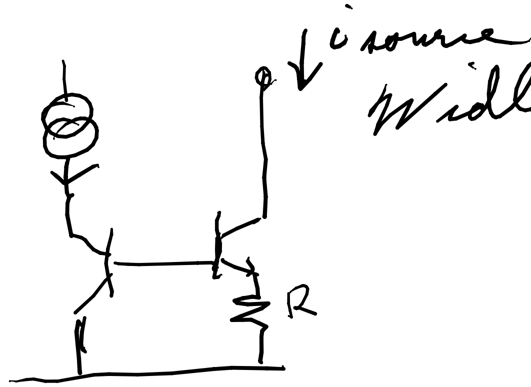
normally $v_{BE} > 0$

$$-i_E = I_A e^{v_{BE}/V_T}$$

if know i_{E_1} & v_{BE_1} then for i_{E_2} can find v_{BE_2}

$$\frac{-i_{E_1}}{-i_{E_2}} = \frac{\cancel{I_A} e^{v_{BE_1}/V_T}}{\cancel{I_A} e^{v_{BE_2}/V_T}} \Rightarrow \ln\left(\frac{-i_{E_1}}{-i_{E_2}}\right) = (v_{BE_1}-v_{BE_2})/V_T$$

$$\Rightarrow v_{BE_2} = v_{BE_1} - V_T \ln\left(i_{E_1}/i_{E_2}\right)$$



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