Electronic Complements Exam
9/01/2014

1 See lecture notes p. 12

$$V_1 = -\frac{V_X R_{33}}{2r_e}, \quad V_2 = +\frac{V_X R_{34}}{2r_e}$$

fed into dif. amp. 100x

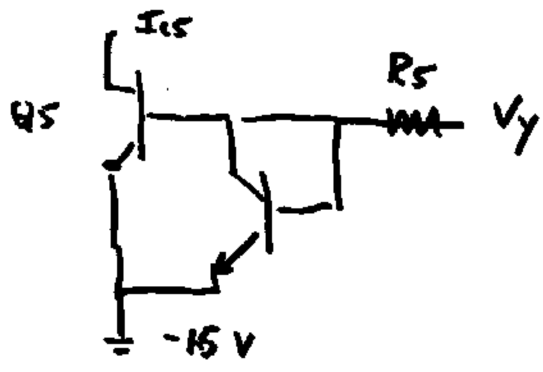
$$V_o = 100 \times \frac{R_{34} + R_{33}}{2r_e} V_X$$

r_e is (polarization current of transistors)

$$\frac{V_T}{I_E}.$$

$$I_E = \frac{1}{2} I_{c5}$$

How much is I_{c5} ?!



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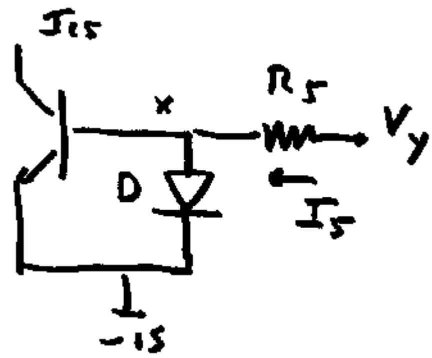


At x $V = -15V + 0.7$

$$I_5 = \frac{V_y - (0.7V - 15V)}{R_5}.$$

$\beta = \infty \Rightarrow I_5$ goes through D.

I_{c5} is copying this ((current mirror)

$$I_{c5} = \frac{V_y + 15V - 0.7V}{R_5}$$

The circuit does not work very nice linear, but Vx on Vy both modulate V_0

$$V_0 = 100 \cdot \frac{R_{34} + R_{33}}{2 R_5} \cdot \frac{V_X \cdot (V_Y + 15 - 0.7)}{V_T}$$

a) It is a two-quadrant amplifier

V_X can be positive and negative (like in any dif. pair. amp.)

V_Y can have only current going down in current source, thus $V_Y + 15 - 0.7 > 0$

2] A1 is an amplifier with the gain depending on the value of the resistance of T1

Simplified: voltage divider $R_2 : R_1 \approx \frac{1}{100}$ at entrance. Then if $R_{T1} = \infty$ a 10 times amp (R_4 / R_3)

If T1 conducting R_3 reduces to 5V / 20 mA = 250 Ω (derivative of Fig.). A1 gain = 60.

IC2 is a final amplifier of 10 x. Thus, the overall gain varies between $\frac{1}{100} \times 10 \times 10 = 1$ to $\frac{1}{100} \times 60 \times 10 = 6$.

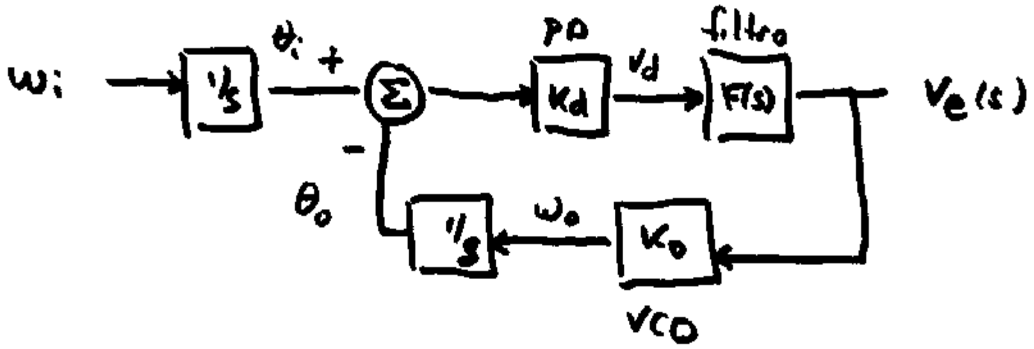
A2 takes care of the feedback. HPF at entrance (C_4, R_9). Gain equal to P1 potenciometer, between 0 and 1

The exit of A2 can discharge C1 through D1

R7, R8 and C1 form a 'filter' (LPF), charging C1 through R7 ($\tau = 10^6\,\Omega \times 10\,\mu F = 10s$) and discharging basically through R8 ($\tau = 1500\,\Omega \times 10\,\mu F = 15$ ms).

This changes voltage at gate of T1 and regulating gain of A1.

3] a) See lecture notes



$$\theta_o = (\theta_i(s) - \theta_o(s))\,K_d\,F(s)\,K_o \cdot \frac{1}{s} \Rightarrow$$

$$H(s) \equiv \frac{\theta_o(s)}{\theta_i(s)} = \frac{K_v F(s)}{s + K_v F(s)} \quad \text{with } K_v = K_d K_o$$

b) without LPF

$$H(s) = \frac{K_v}{K_v + s} = \frac{1}{1 + s/K_v} \qquad (s = j\omega)$$

is like LPF $\frac{1}{1 + j\omega/\omega_c}$ with cut-off frequency

$$\omega_c = K_v = K_d K_o = 1\,V \cdot \frac{4\pi \text{ krad/s}}{V}$$

$w_c = 4000\pi$ rad/s , $f_c = 2000$ Hz

c) At 110 kHz , at lock $\omega_o = \omega_i = 2\pi\ 110$ kHz

$f_o = 100\text{ kHz} + V_e \cdot 2\text{ kHz/V} = 110\text{ kHz} \Rightarrow$

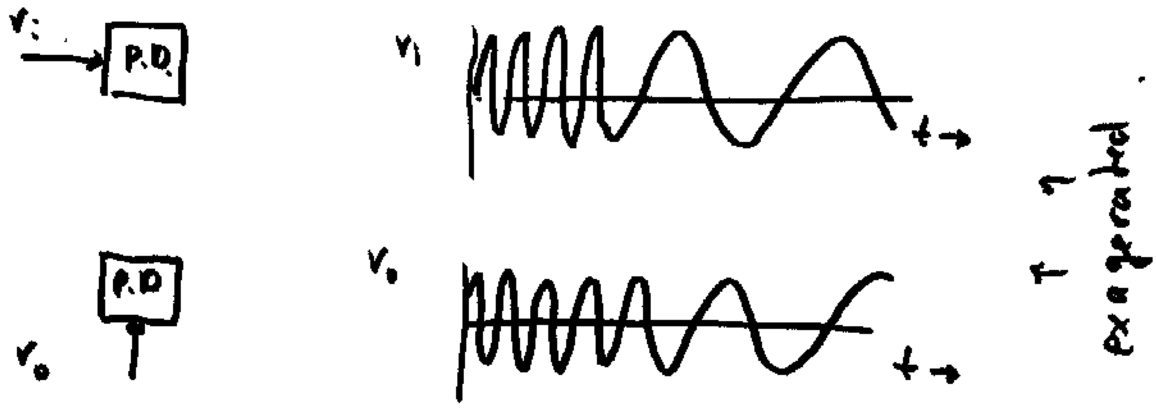
$V_e = 5$ volt.

At 100 kHz , at lock $\omega_o = \omega_i = 2\pi\ 100$ kHz

$f_o = 100\text{ kHz} + V_e \cdot 2\text{ kHz/V} = 100\text{ kHz} \Rightarrow$

$V_e = 0$ volt

The relaxation time going from 5 volt to 0 is given by K_v , $\tau = \frac{1}{\omega_c} = \frac{1}{K_v} = \frac{1}{4000\pi}$ s



d) From electronics II we know about stability

The transfer function was (negative feedback, '+' sign !)

$$\frac{v_o}{v_i} = \frac{A}{1 + A\beta}$$

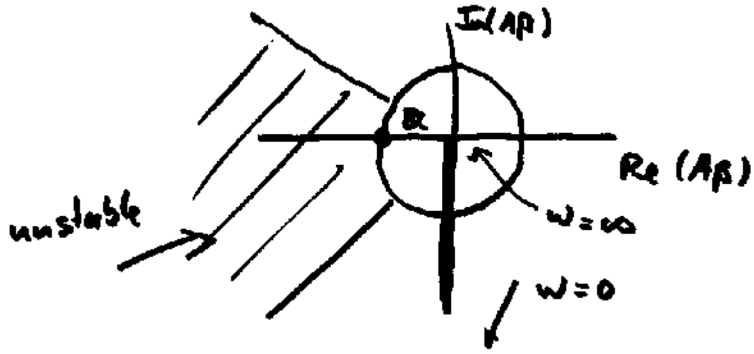
and we analyzed $A\beta$. If it hit Barkhausen

Criterion it was not stable

$A\beta$ in our case is

$$A\beta = k_d\, F(s)\, K_o \cdot \frac{1}{s}$$

without filter $(F(s) = 1)$, $A\beta = K_d K_o / s = -j\, K_d K_o / \omega$



Stable!

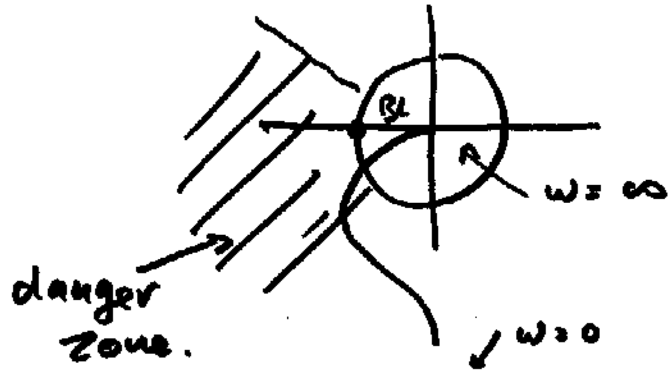
with filter

$$A\beta = \frac{K_v}{s\,(1 + s/\omega_c)} \qquad \omega_c = \frac{1}{RC} = \frac{1}{\tau}$$

$$= \frac{K_v}{j\omega + (j\omega)^2/\omega_c} = \frac{K_v}{j\omega - \omega^2/\omega_c}$$

$\omega = \infty$: $A\beta = -0$ $\quad \phi = 180^\circ$

$\omega = 0$: $A\beta = -j0$ $\quad \phi = -90^\circ$



can be unstable!

4] See lecture notes.