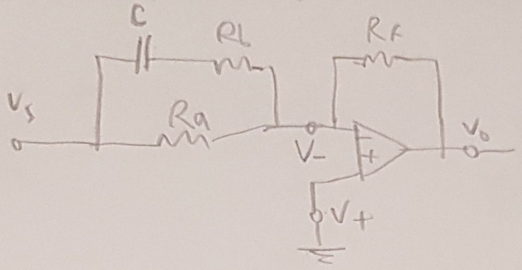
Q1

Ratthamnoon Prakitpong
#63205165

i




$V_+ = V_- = 0\,V$

$$\frac{V_o}{R_F} + \frac{V_s}{R_a} + C\frac{dV_c}{dt} = 0$$

Node current rule

$$V_s = V_c + \frac{dV_c}{dt} C R_b$$

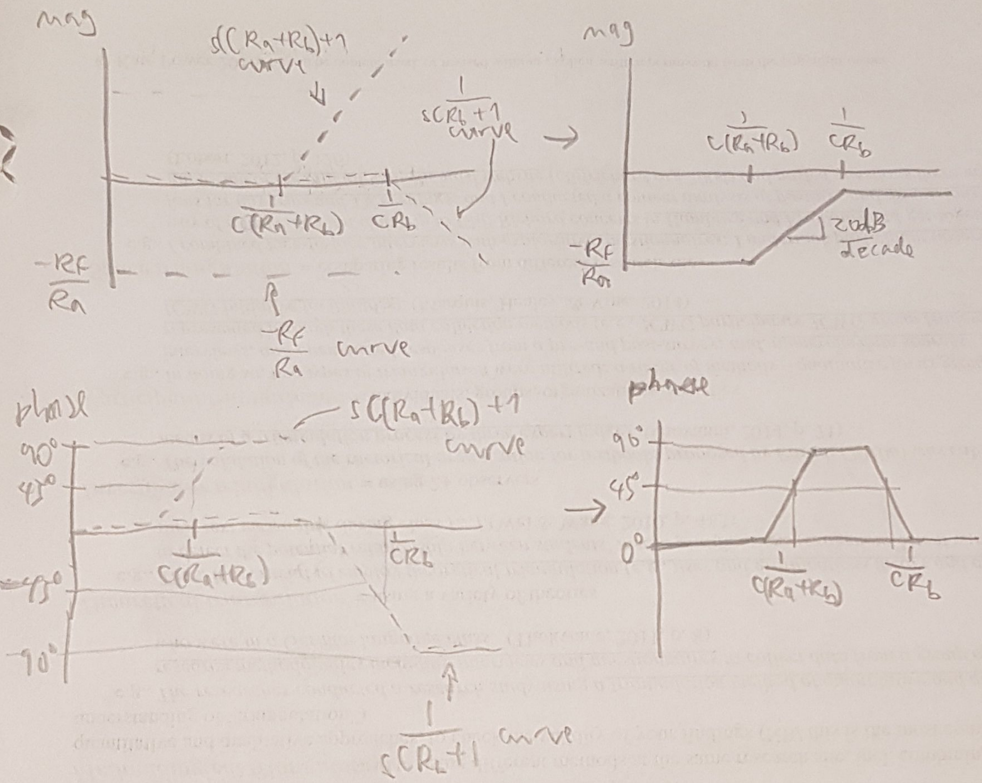
for $G(s) \rightarrow Z_C = \frac{1}{sC}$

$$\frac{V_o}{R_F} + \frac{V_s}{\left(\frac{1}{R_a} + \frac{1}{Z_C + R_b}\right)^{-1}} = 0 \rightarrow V_o = \frac{-R_F V_s}{\left(\frac{1}{R_a} + \frac{1}{Z_C + R_b}\right)^{-1}}$$

$$G(s) = \frac{V_o}{V_s} = -R_F\left(\frac{R_a + Z_c + R_b}{R_a(Z_c + R_b)}\right)\left(\frac{sC}{sC}\right)$$

$$= -R_F\left(\frac{sC(R_a + R_b) + 1}{R_a(sCR_b + 1)}\right)$$

$$= \frac{-R_F}{R_a} \times (sC(R_a + R_b) + 1) \times \frac{1}{sCR_b + 1}$$




ii a) $SS\ gain = \lim_{s \to 0} G(s)$

$$= \frac{-R_f}{R_a}$$

b) $\lim_{s \to \infty} G(s) = \frac{-R_f}{R_a} + 20dB\left(\log\left(\frac{1}{CR_b} - \frac{1}{C(R_a+R_b)}\right)\right)$ [from plot]

c) lead $= 0^\circ = 0$ rad

d) $\frac{1}{C(R_a+R_b)}$ & $\frac{1}{CR_b}$

PG2

At low frequency, acts like inverting amplifier

At mid frequency, acts like measurement tool ($|G|$ proportional to $W$)

At high frequency, acts like inverting amp again

iii)

a) at $W = 100 \frac{cm}{s}$, $V_s = \frac{V_{smax} w}{w_{max}}$, $V_{o_{max}} = 6V$, find $R_F$

$$\frac{V_o}{V_s} = -\frac{R_F}{R_a}\frac{(sC(R_a+R_b)+1)}{(sCR_b+1)}$$

[Use Max values for $V_o$ & $V_s$ to take advantage of full scale output/input]

$$R_F = -\frac{R_a V_{omax}}{V_{S max}} \frac{sCR_b+1}{sC(R_a+R_a)+1} \quad \rightarrow s = jW$$

$$= \frac{10k(6)}{12} \frac{(j100(2\times10^{-6})2000+1)}{j(100)(2\times10^{-6})(12\times10^3)+1} = \frac{j12000+30000}{j2.4+1}$$

$$\text{Sensitivity} = \frac{256 \text{ counts}}{100 \text{ cm/s}} = 2.56 \frac{\text{count}}{\text{cm/s}}$$

b) $0 \sim \frac{1}{C(R_a+R_b)} \rightarrow 0 \sim 41.67 \frac{rad}{s}$ low freq

$\frac{1}{C(R_a+R_b)} \sim \frac{1}{CR_L} \rightarrow 41.67 \frac{rad}{s} \sim 250 \frac{rad}{s}$ mid freq

$\frac{1}{CR_b} \sim \infty \rightarrow 250 \sim \infty \frac{rad}{s}$ high freq

from Nyquist frequency rule, $f_c 2 = f_s$, or sampling rate has to be double of operating frequency

So for low freq → $f_s = 83$ rad/s

mid freq → $f_s = 500$ rad/s

hi freq → $f_s$ = double set frequency at operation

P64

Q2

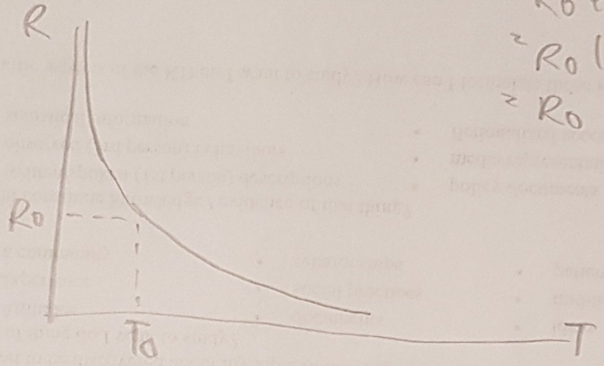
i) $R = R_0 e^{(\beta(\frac{1}{T}-\frac{1}{T_0}))}$

$R(T_0) = R_0 e^{(\beta(\frac{1}{T_0}-\frac{1}{T_0}))}$

$= R_0 e^{\beta 0}$

$= R_0 (1)$

$= R_0$




ii) a)

$$\frac{R}{R_0} = e^{\beta(\frac{1}{T}-\frac{1}{T_0})}$$

$$\ln R - \ln R_0 = \beta\left(\frac{1}{T}-\frac{1}{T_0}\right) = \beta\left(T^{-1}-T_0^{-1}\right)$$

$$\frac{\delta R}{R} - \frac{\delta R_0}{R} = \beta\left(\frac{-\delta T}{T^2}\right)$$

$$e_R - e_{R_0} = -\beta \frac{e_T}{T}$$

$$e_T = \frac{T}{\beta}\left(e_{R_0} - e_R\right)$$

$e_T \propto T$ $\therefore$ larger $T$ result in larger $e_T$

2iii)

$$e_T \approx \frac{(400K)}{(4200K)} (.02 - .01) \approx T_d \quad (7ii2$$

$$= \pm 9.52 \times 10^{-4} =$$

p66