Q1

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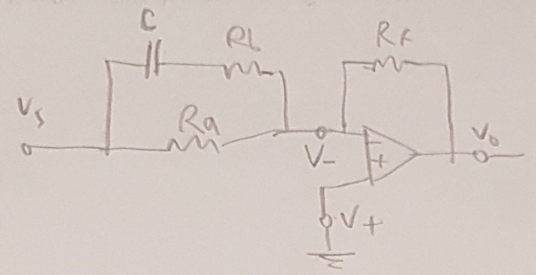
i



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

Total: 82 + 12 = 94

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

Node current rule

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

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

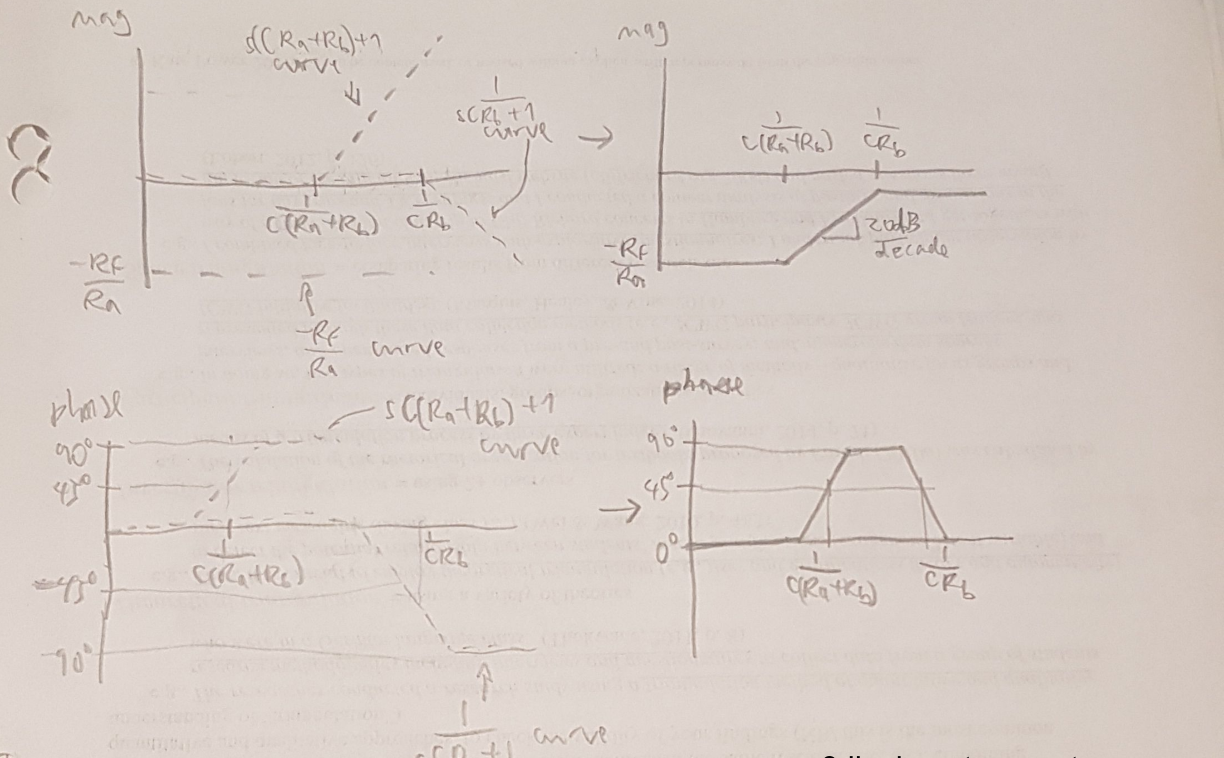
$$\frac{V_o}{R_F} + \frac{V_s}{\left(\frac{1}{R_a} + \frac{1}{Z_c + R_b}\right)^{-1}} = 0 \rightarrow V_o = \frac{-R_F V_s}{\left(\frac{1}{R_a} + \frac{1}{Z_c + R_b}\right)^{-1}}$$

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

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

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

PG1



-3 ii c is not correct

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 $= 0° = 0$ 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

-5 iii a: the result is not correct

1)

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]

$$R_F = -\frac{R_a V_{o\,max}}{V_{s\,max}}\frac{sCR_b+1}{sC(R_a+R_a)+1} \quad \rightarrow s = jw$$

$$= \frac{10K(6)}{12}\frac{(j\,100(2\times10^{-6})2000+1)}{j(100)(2\times10^{-6})(12\times10^3)+1} = j$$

Sensitivity $= \frac{\partial V_o}{\partial V_s}$

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

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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

Q2

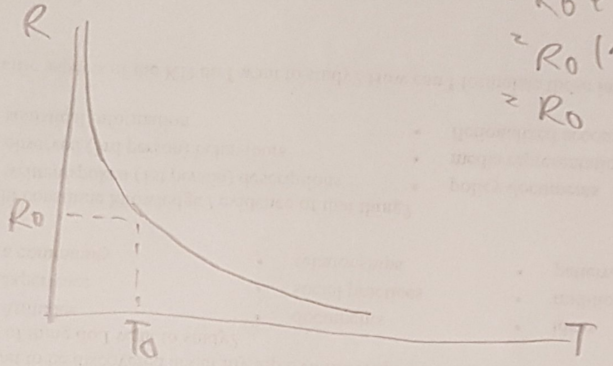
i) $R = R_0 e^{\left(\beta\left(\frac{1}{T} - \frac{1}{T_0}\right)\right)}$

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

$= R_0 e^{\beta 0}$

$= R_0 (1)$

$= R_0$



-5 ii a: the final equation is wrong
-5 ii b: the result is wrong

ii)

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

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

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

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

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

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

2iii b) $e_T = \dfrac{(400K)}{(4200K)} \, (.02 - .01)$

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

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