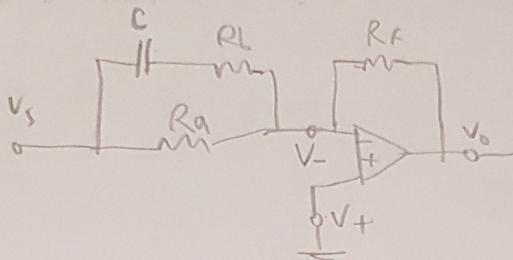


Q1

Rathnayake Pratip
#63205165

$$V_+ = V_- = 0 \text{ V}$$

$$\frac{V_o}{R_f} + \frac{V_s}{R_a} + C \frac{dV_c}{dt} = 0 \quad \text{Node current rule}$$

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

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

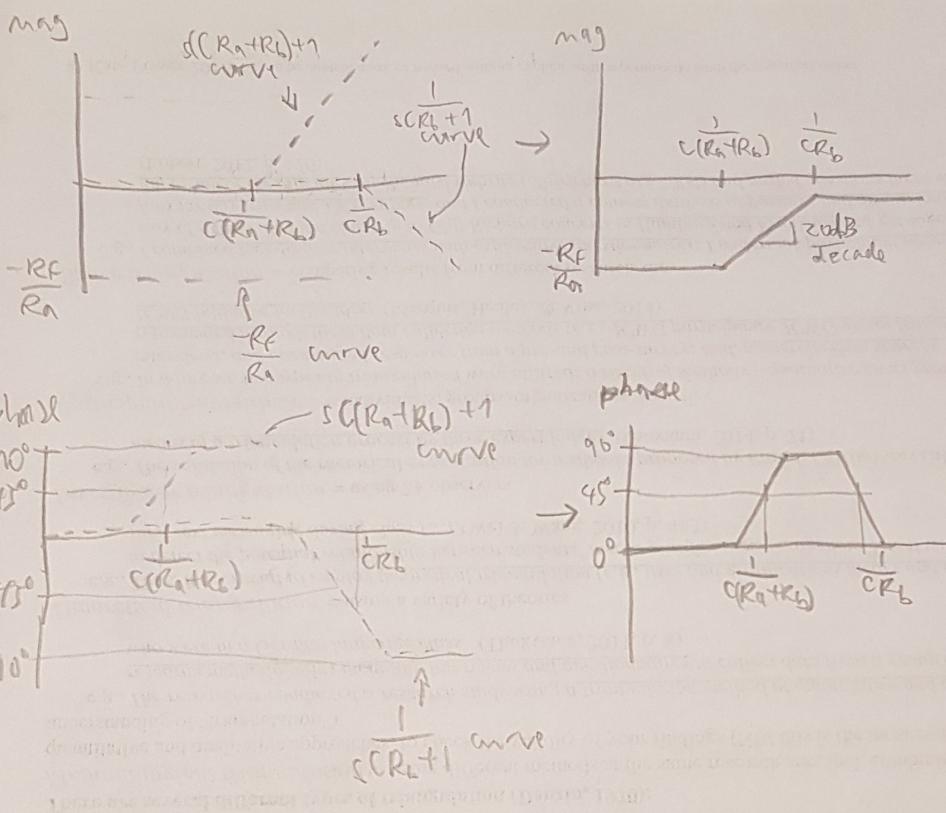
$$\frac{V_o}{R_f} + \frac{V_s}{\left(\frac{1}{R_a} + \frac{1}{Z_C + R_b}\right)} = 0 \rightarrow V_o = \frac{-R_f V_s}{\left(\frac{1}{R_a} + \frac{1}{Z_C + R_b}\right)}$$

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

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

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

P67



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

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

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

c) lead = 0° $\Rightarrow 0$ rad

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

PG 2

At low frequency, acts like inverting amplifier

At mid frequency, acts like measurement tool (16) proportional to W)

At high frequency, acts like inverting amp again

(iii)

a) $V_{gt} = W \cdot 10.0 \frac{\text{cm}}{\text{s}}$, $V_s = \frac{V_{sm}}{w_{\max}}$, $V_o = 6V$, find R_f

$$\frac{V_o}{V_s} = -R_f \left(\frac{1}{C(R_a + R_b)} \right) \quad \left[\begin{array}{l} \text{use Max values for} \\ V_o \text{ & } V_s \text{ to take advantage of} \\ \text{full scale output/input} \end{array} \right]$$

$$R_f = \frac{R_a V_{sm}}{V_s \max} \frac{1}{C(R_a + R_b)} \rightarrow s = j\omega$$

$$= 10k \left(\frac{1}{2} \right) \left(\frac{j100(2 \times 10^{-6})}{j(100)(2 \times 10^{-6})} \right) \left(\frac{2000 + 1}{12 \times 10^3 + 1} \right) \approx j(2000 + 3000) = j24 + 1$$

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

b)

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

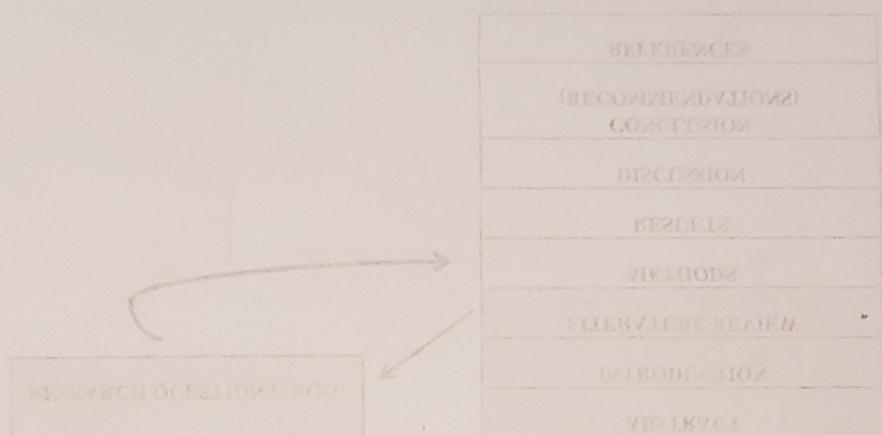
$$\frac{1}{C(R_a + R_b)} \sim \frac{1}{C_R L} \rightarrow 41.67 \frac{\text{rad}}{\text{s}} \approx 250 \frac{\text{rad}}{\text{s}} \quad \text{mid freq}$$

c)

$$\frac{1}{C R_b} \sim \infty \rightarrow 250 \sim 0 \frac{\text{rad}}{\text{s}} \quad \text{high freq}$$

From Nyquist frequency rule, $f_{c2} = f_s$, or
sampling rate has to be double of operating frequency

- So for low freq $\rightarrow f_s = 83 \text{ rad/s}$
 mid freq $\rightarrow f_s = 500 \text{ rad/s}$
 hi freq $\rightarrow f_s = \text{double set frequency at operation}$



- design approach that is not only about a design but also about a solution
- more focused on how to evaluate a system rather than what to do (e.g. "good design" - see Chapter 4)
- more about the process than the outcome
- more about what to do than how to do it (e.g. "good design" means "design that follows standards")
- design approach is to start with "what needs to be done" (a "problem statement") and then move to "how to do it" (a "solution")

Introduction to the design process

(February 2011, pp. 121-128)

The design process can be described as follows:
 1. Problem Statement
 2. Requirements Gathering
 3. Design
 4. Prototyping
 5. Testing
 6. Iteration

(February 2011, p. 122)

Example: Designing a car
 Requirements:
 • Fast
 • Safe
 • Reliable
 • Stylish
 • Cheap
 • Environmentally friendly
 • Low maintenance costs

(February 2011, p. 129)

Design process:
 1. Problem Statement
 2. Requirements Gathering
 3. Design
 4. Prototyping
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 6. Iteration

(February 2011, p. 129)

Example: Designing a car
 Requirements:
 • Fast
 • Safe
 • Reliable
 • Stylish
 • Cheap
 • Environmentally friendly
 • Low maintenance costs
 • Low cost

Q2

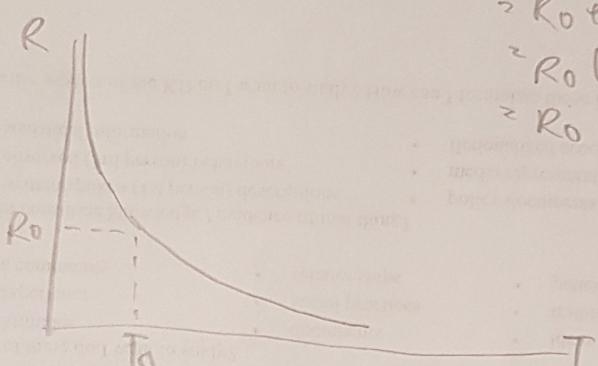
$$i) R \propto R_0 e^{(\beta(\frac{1}{T} - \frac{1}{T_0}))}$$

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

$$\Rightarrow R_0 e^{\beta 0}$$

$$\Rightarrow R_0 (1)$$

$$\Rightarrow R_0$$



A) Find the equivalent resistance between nodes 1 and 2 in the circuit shown below.

R = $\frac{V}{I}$ where V is the voltage across the resistor and I is the current flowing through it.

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

$$a) R_0$$

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

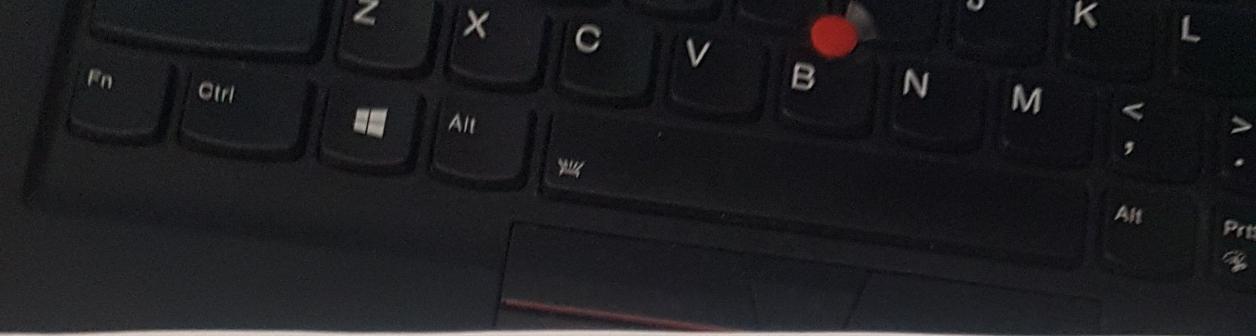
$$\frac{\partial R}{R} = \frac{8R_0}{R} = \beta \left(-\frac{8T}{T^2} \right)$$

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

$$e_T = \frac{1}{\beta} (e_{R_0} - e_R)$$

for large T , small e_T and e_R

$\frac{dR}{dT} = -\frac{8R_0}{T^2}$ \Rightarrow negative slope \Rightarrow decreasing R with increasing T



9.11.2)

$$e_T = \frac{(400\text{K})}{(4200\text{K})} (0.02 - 0.01)$$

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