21/05/22

Test - CIAT2 - Answer Key

Course code: MECC2013 - Analog Electronic Circuits

Year/Sem: II/IV

Max marks: 50

SET-A

Part-A: (10×1 = 10) Marks

1. b) 1.43V/V
2. a) mobility decreases
3. c) $-g_m R_D/(1+g_m R_s)$
4. c) Common gate
5. a) coupling Capacitor short Circuit and Load Capacitor Open Circuit
6. b) Error signal
7. b) increases
8. a) Distortion.
9. c) High, high
10. b) Oscillator

23/05/2022

Part-B: (4×10 = 40) Marks.

11. Common Gate Configuration

Sol:

$I_Q = I_{DQ} = K_n(V_{GSQ} - V_{TN})^2$

$1 = 1(V_{GSQ} - 1)^2$

$\boxed{V_{GSQ} = 2V}$ $\rightarrow$ (2m)

$g_m = 2K_n(V_{GS} - V_{TN})$

$= 2(1)(2-1)$

$= 2 mA/V$ $\rightarrow$ (2m)

from A_i, we can write

$$I_o = I_i\left(\frac{R_D}{R_D+R_L}\right)\left(\frac{g_m R_{si}}{1+g_m R_{si}}\right)$$

$$V_o = I_o R_L$$

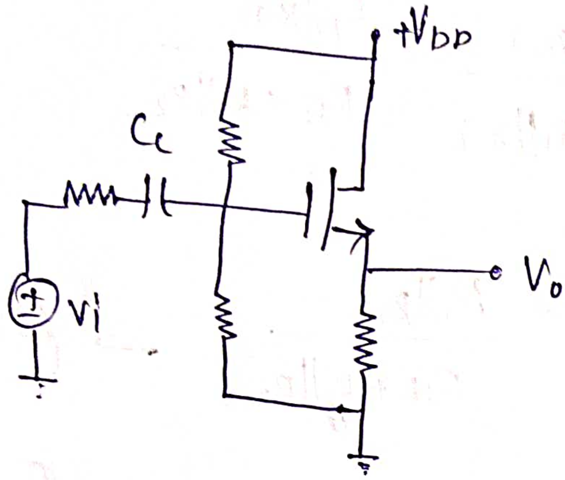
$$V_o = I_i\left(\frac{R_D}{R_D+R_L}\right)\left(\frac{g_m R_{si}}{1+g_m R_{si}}\right) \times R_L$$

$$= \left[\frac{(10)(5)}{5+10}\right]\left[\frac{2(50)}{1+(2)(50)}\right] \times R_L \;(0.1)\sin\omega t$$

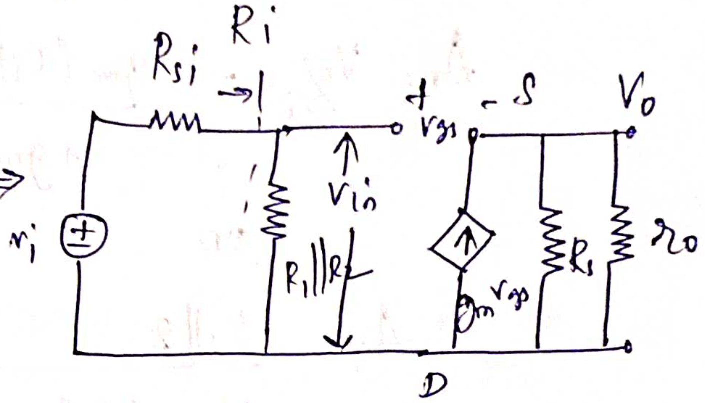
$\boxed{V_o = 0.\cancel{22} \sin\omega t}$ $\rightarrow$ (6m)

12) N-channel ckt & derive the expression for i/p, o/p & voltage gain.

Common Drain Amplifier



$\Rightarrow$



$$A_v = V_o / V_i$$

$$V_o = g_m V_{gs} (R_s \| r_o)$$

$$V_{in} = \frac{V_i \times R_1 \| R_2}{R_{si} + R_1 \| R_2} \rightarrow ①$$

but

$$V_{in} = V_{gs} + (g_m V_{gs})(R_s \| r_o)$$

$$V_{in} = V_{gs}\left[1 + g_m (R_s \| r_o)\right]$$

$$V_{gs} = \frac{V_{in}}{1 + g_m (R_s \| r_o)}$$

Sub in V_o $\rightarrow$ (3m)

$$V_o = \frac{g_m V_{in} (R_s \| r_o)}{1 + g_m (R_s \| r_o)} \rightarrow ②$$

Sub ① in ②

$$V_o = \frac{g_m v_i (R_1 \| R_2)(R_s \| r_o)}{(R_{si} + R_1 \| R_2)(1 + g_m (R_s \| r_o))}$$

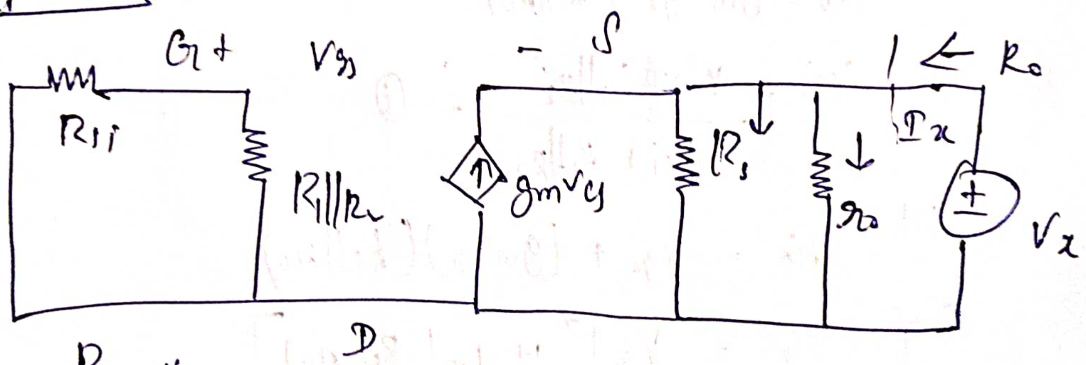
$$A_v = V_o / V_i = \frac{g_m (R_s \| r_o)}{1 + g_m (R_s \| r_o)} \cdot \frac{R_1 \| R_2}{R_{si} + R_1 \| R_2}$$

(or)

$$A_v = \frac{R_s \| r_o}{1/g_m + (R_s \| r_o)} \cdot \frac{R_1 \| R_2}{R_{si} + R_1 \| R_2} \rightarrow (2m)$$

I/p imp: $R_i = R_1 \| R_2$ → (1m)

O/p imp:



$R_o = V_x / I_x$

Apply KCL at the o/p terminal → (4m)

$$I_x + g_m V_{gs} = \frac{V_x}{r_o} + \frac{V_x}{R_s}$$

Sub $V_{gs} = -V_x$ in the above eq

$$R_o = \frac{V_x}{I_x} = (r_o \| R_s \| 1/g_m)$$

13) a) Bypass Capacitor in frequency response.

Explanation $\rightarrow$ (2m)

Circuit & Equivalent circuit $\rightarrow$ (2m)

Voltage gain $A_v = V_o/V_i$

$= -g_m R_D$ $\rightarrow$ (1m)

b) Small Signal Voltage gain of Common Source with Source bypass capacitor.

Sol:

$I_{DQ} = I_Q = K_n(V_{GSQ} - V_{TN})^2$

$0.5 = (1)(V_{GSQ} - 0.8)^2 = 1.51V$

$g_m = 2K_n(V_{GS} - V_{TN}) = 1.4$ $\rightarrow$ (3m)

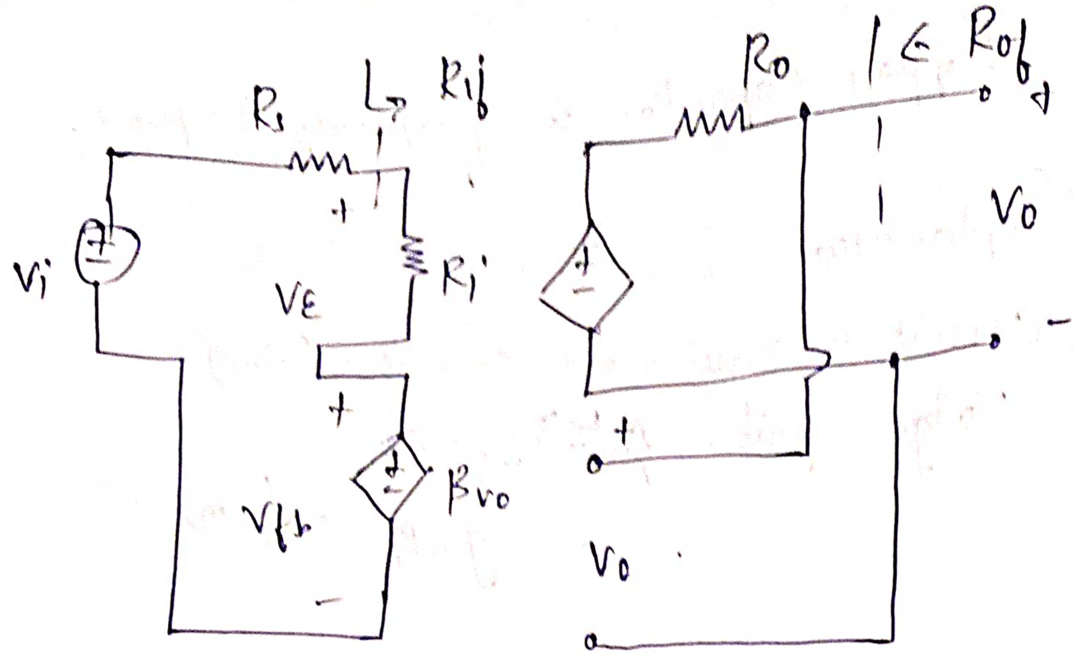
$A_v = V_o/V_i$ $\rightarrow$ (2m)

$= -g_m R_D = -(1.4)(7) = -9.8$

Section - B2:

14) Series Shunt feedback Topology.

a) I/p res, O/p res + gain with feedback.



1m

I/p → Series Connection

O/p ⇒ Shunt Connection

V_E ⇒ error Voltage = difference between I/p + feedback.

O/p of feedback n/w is open Circuit

$$A_{vf} = V_o / v_i$$

$$V_o = A_v V_E \Rightarrow V_E = \frac{V_o}{A_v}$$

$$V_i = V_E + V_{fb} = V_E + \beta_v V_o$$

2m

$$\therefore V_i = \frac{V_o}{A_v} + \beta_v V_o$$

$$\boxed{A_{vf} = V_o / v_i = \frac{A_v}{1 + \beta_v A_v}}$$

R_{if} :

$$R_{if} = \frac{V_i}{I_i}$$

$$V_i = V_E + V_{fb}$$

O/P side:

$$V_o = A_V V_E$$

$$V_{fb} = \beta_V V_o = \beta_V A_V V_E$$

Sub in V_i

$$V_i = V_E + \beta_V A_V V_E$$

$$V_i = V_E (1 + \beta_V A_V)$$

from I/P side → (2m)

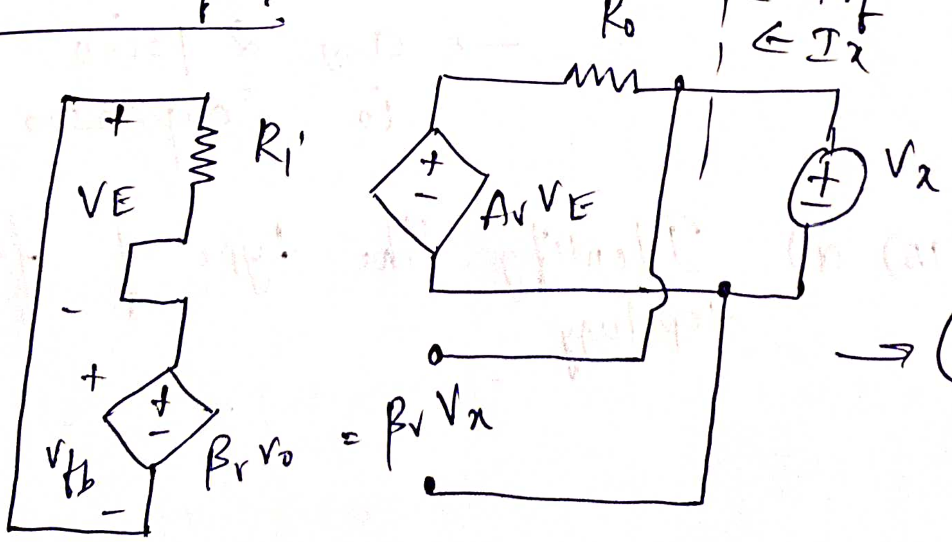
$$V_E = I_i R_i'$$

Sub in the above eq

$$V_i = I_i R_i (1 + \beta_V A_V)$$

$$\boxed{V_i / I_i = R_{if} = R_i (1 + \beta_V A_V)}$$

O/P Res: R_{of} :



→ (1m)

$$R_{of} = \frac{V_x}{I_x}$$

$$I_x = \frac{V_x - A_v V_E}{R_o}$$

from i/p since $V_i = 0$

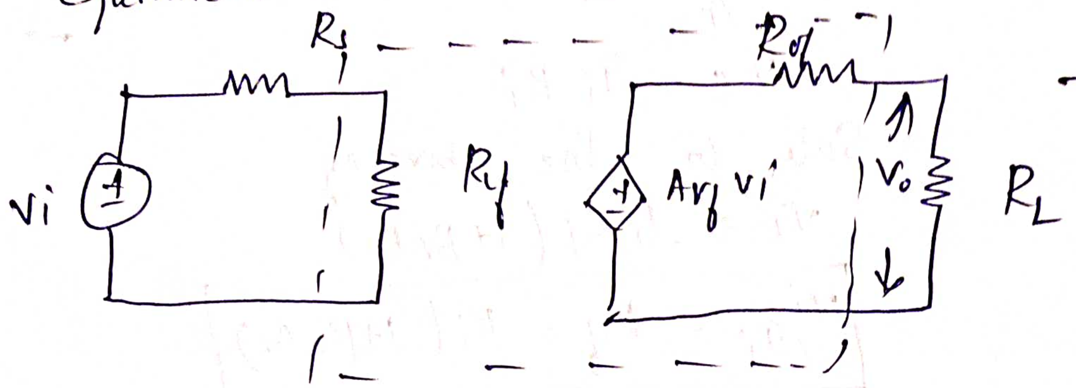
$V_E + V_{fb} = 0 \Rightarrow V_E = -V_{fb} = -\beta_v V_o = -\beta_v V_x$

Sub in I_x

$$I_x = \frac{V_x + \beta_v V_x A_v}{R_o} = \frac{V_x(1+\beta_v A_v)}{R_o}$$

$$\boxed{R_{of} = \frac{V_x}{I_x} = \frac{R_o}{1+\beta_v A_v}}$$

Equivalent Circuit



→ (2m)

14) b) Compare RC + LC Oscillator

→ any 2 points in comparison → (2m)

15) a) Identify the type of feedback topology

Shunt Series Configuration

→ $I_E = I_i - I_{fb}$

→ Current amplifier

→ i/p → Shunt ; o/p → Series

A_{if}: I_o / I_i

$I_i = I_E + I_{fb}$

$I_o = A_i I_E \Rightarrow I_E = \frac{I_o}{A_i}$

Sub in I_i

$I_i = \frac{I_o}{A_i} + I_{fb}$ → 2m

$$\boxed{I_o / I_i = A_{if} = \frac{A_i}{1 + A_i \beta_i}}$$

I/p resistance with feedback A_{if}:

$R_{if} = \frac{V_i}{I_i}$.

$I_i = I_E + I_{fb}$

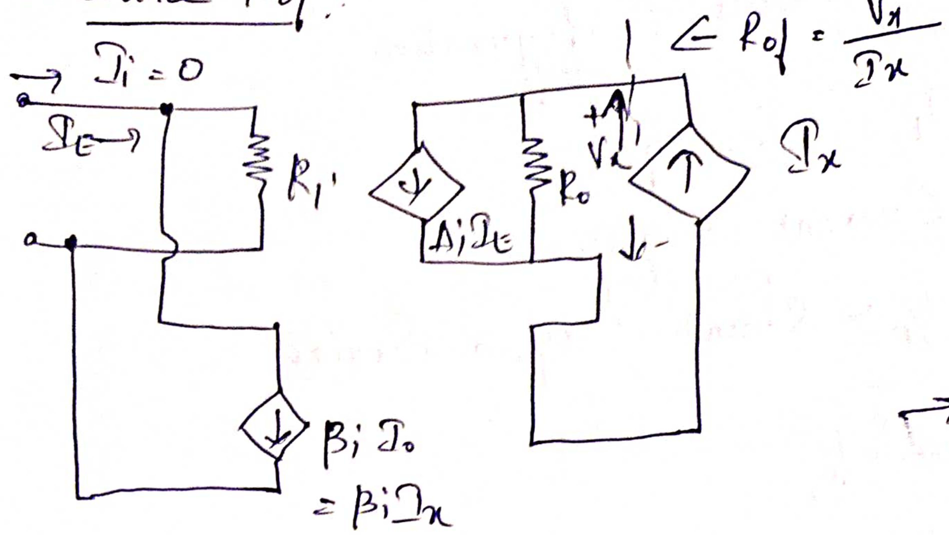
$I_f = \beta_i I_o = \beta_i A_i I_E$

$I_i = I_E (1 + \beta_i A_i)$

$\therefore I_i = V_i / R_i (1 + \beta_i A_i)$ → 2m

$$\boxed{R_{if} = V_i / I_i = \frac{R_i}{1 + \beta_i A_i}}$$

o/p resistance R_{of}:



→ 1m

$$R_{of} = \frac{V_x}{I_x} \; ; \quad I_x = \frac{V_x}{R_o} + A_i I_E$$

from i/p

$$I_E = -I_{fb} = -\beta_i I_x$$

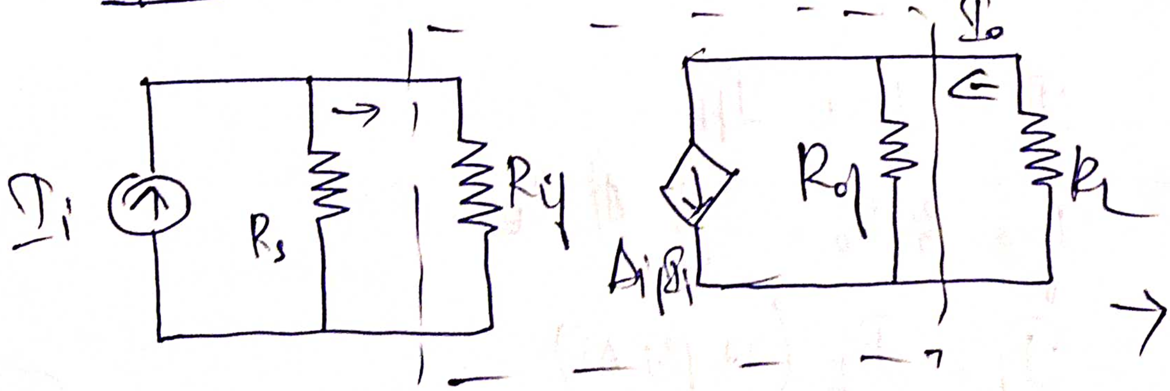
Sub in I_x

$$I_x (1 + A_i \beta_i) = \frac{V_x}{R_o}$$

→ 1m

$$\boxed{R_{of} = \frac{V_x}{I_x} = R_o (1 + A_i \beta_i)}$$

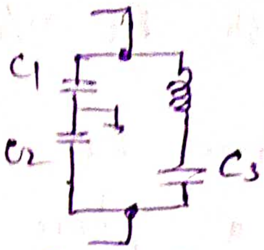
Eq ckt:



→ 1m

6

15) b) Clapp Osc:

Diagram → (2m) 

Frequency expression → (1m) → $f = \frac{1}{2\pi\sqrt{LC_{eq}}}$

$C_{eq} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$

16) a)

$L_1 = 1000\,\mu H$

$L_2 = 500\,\mu H$

$C = 50\,pF$

$M = 20\,\mu H$

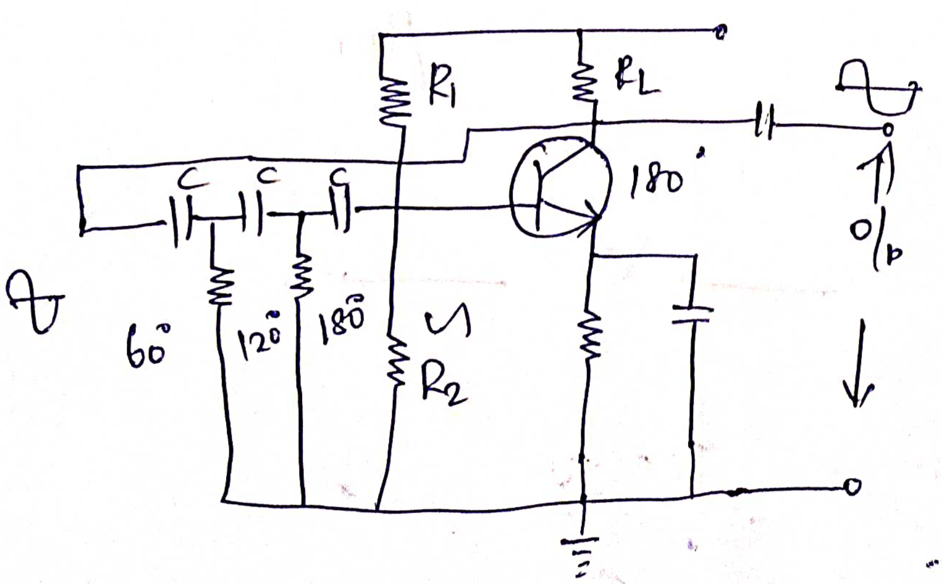
Sol:

$L_T = L_1 + L_2 + 2M = 1000 + 500 + 2(20) = 1540\,\mu H$

$f = \frac{1}{2\pi\sqrt{L_T C}} = \frac{1}{2\pi\sqrt{1540 \times 50}} = 57.4\,MHz$

(2m) (2m)

16) b) RC phase shift Osc



→ (2m)

→ Each RC n/w provides a phase shift of 60

→ Three RC stages are cascaded to provide a phase shift of 180°.

→ Value of RC components determine the frequency of Oscillation → (2m)

$$f_c = \frac{1}{2\pi RC\sqrt{2N}}$$

N → no. of stages

$$\therefore f = \frac{1}{2\pi RC\sqrt{6}}$$

The amplifier gain $A \geq 29$; $\beta = 1/29$.

Advantages: → Simple to design
→ produces Sine wave → (2m)

Disadvantage → frequency stability poor

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