Batch 1
SET A

SRM Institute of Science and Technology
College of Engineering and Technology
DEPARTMENT OF ECE

SRM Nagar, Kattankulathur – 603203, Chengalpattu District, Tamilnadu

Academic Year: 2023-2024 (EVEN)

Test: CLAT- 1 | **Date: 17.02.2024**
Course Code & Title: 21ECC202T & Analog and Linear Electronic Circuits | **Duration: 4 PM-4:50 PM**
Year & Sem: II & IV | **Max. Marks: 25**

Course Articulation Matrix:

Course Articulation Matrix		Program Outcomes (POs)														
		Graduate Attributes												PSOs		
COs	*At the end of this course, learners will be able to:*	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO-1:	Apply the small-signal equivalent circuit in the analysis of single and multistage transistor amplifier circuits	*2*	*2*	*3*		-	-	-	-	-	-	-	-	-	-	*3*
CO-2:	Infer the DC and AC characteristics of the operational amplifier	*2*	*2*	*3*		-	-	-	-	-	-	-	-	-	-	*3*
CO-3:	Classify and identify the suitable feedback topologies and oscillators	*2*	*2*	*3*		-	-	-	-	-	-	-	-	-	-	*3*
CO-4:	Elucidate and design linear and non-linear applications of op-amp	*2*	*2*	*3*		-	-	-	-	-	-	-	-	-	-	*3*
CO-5:	Illustrate the function of application-specific ICs	*2*	*2*	*3*		-	-	-	-	-	-	-	-	-	-	*3*

Part – A (5x1 = 5 Marks) Answer all the questions					
Q. No	**Question**	**Marks**	**BL**	**CO**	**PO**
1.	c) Linear	**1**	**1**	**1**	**1**
2.	d) increase in overall gain and reduction in overall bandwidth	**1**	**1**	**1**	**1**
3.	c) MOSFET	**1**	**1**	**1**	**1**
4.	b) All Capacitor	**1**	**1**	**1**	**1**
5.	a) Darlington pair	**1**	**1**	**1**	**1**
Part – B (2 x 4 = 8 Marks) **Instructions: Answer any 2 Questions**					

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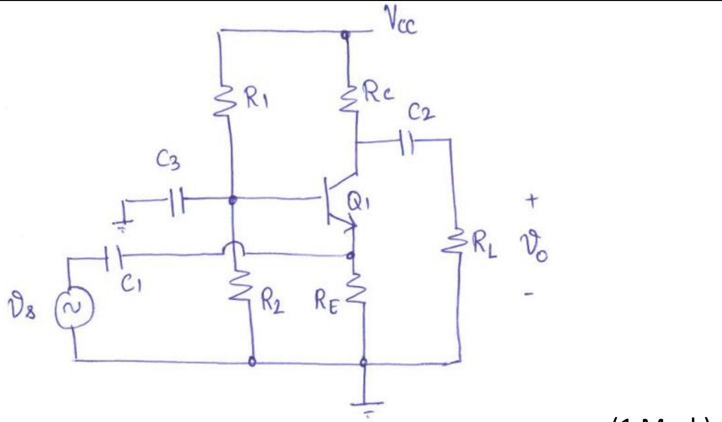
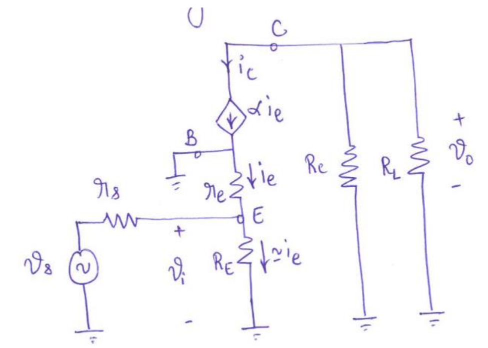


(1 Mark)



(1 Mark)

Voltage Gain

Open-Circuit Voltage gain, $A_{vo} = \frac{v_o}{v_i}\Big|_{R_L=\infty} = \frac{-i_o R_o}{-i_e(r_e \| R_E)}$

$$= \frac{\alpha i_e R_c}{i_e(r_e\|R_E)} \simeq \frac{R_c}{r_e\|R_E} \quad \text{as } \alpha \simeq 1$$

$$\simeq \frac{R_c}{r_e} \quad \text{if } r_e \ll R_E$$

$$= g_m R_c$$

By taking into account the effect of R_L, the voltage gain of the ampr. can be expressed as

$$A_v = A_{vo} \times \frac{R_L}{R_o + R_L} = g_m R_c \times \frac{R_L}{R_c + R_L} = g_m (R_c \| R_L)$$

By taking into account the effect of r_s, the Voltage gain of the CB ampr. can be expressed as

$$A_{vs} = A_v \times \frac{R_{in}}{r_s + R_{in}} \simeq g_m (R_c\|R_L) \times \frac{r_e}{r_s + r_e}$$

$$\simeq \frac{R_c\|R_L}{r_s + r_e} \quad \text{since } g_m \simeq \frac{1}{r_e}$$

(2 Marks)

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<td>4</td>
<td>2</td>
<td>1</td>
<td>2</td>
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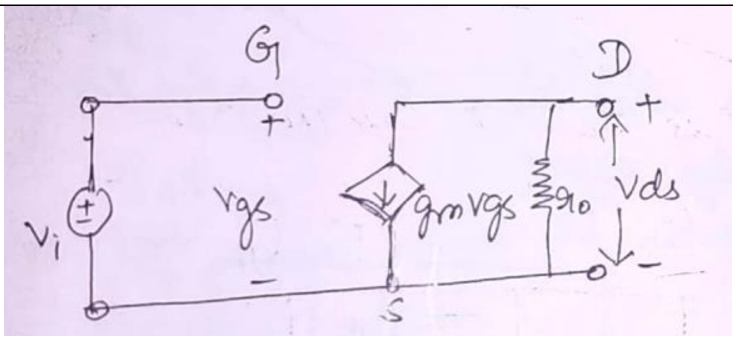
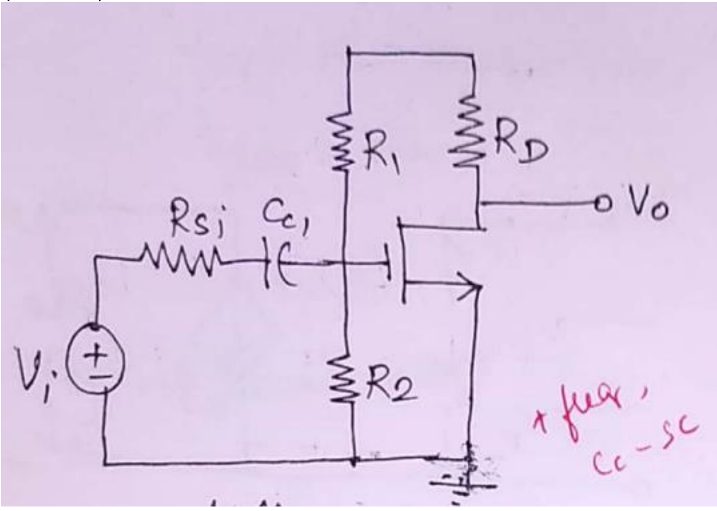
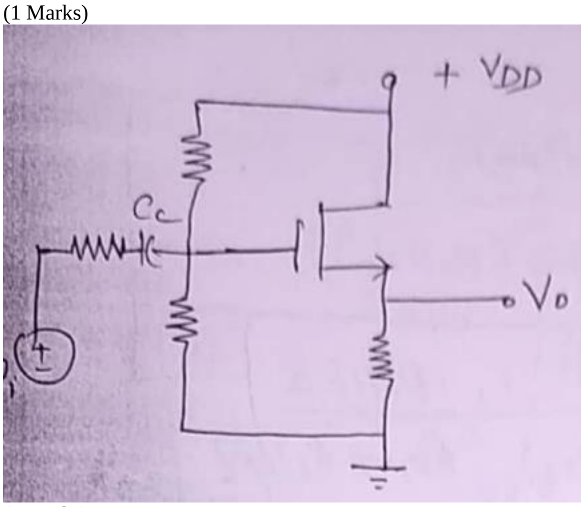
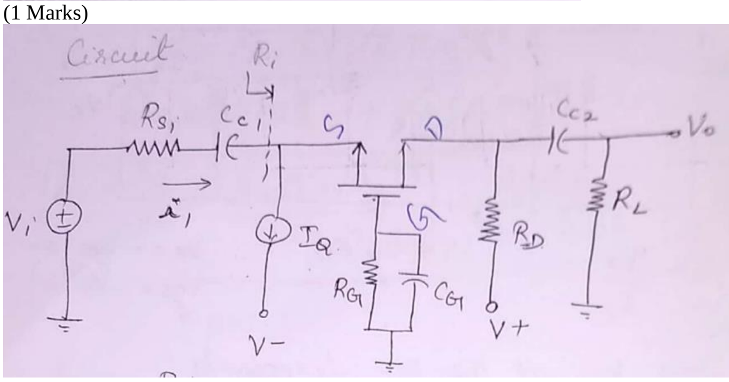
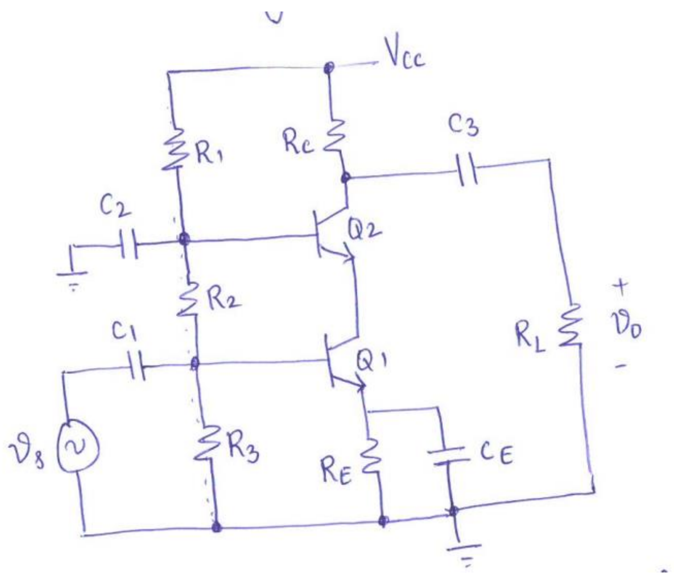
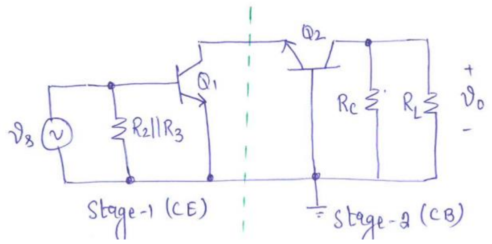
7.	 (1 Marks)  (1 Marks)  (1 Marks)  (1 Marks)	**4**	**2**	**1**	**2**
8.	The Miller effect and Miller capacitance are factors in the high-frequency characteristics of MOSFET circuits $C_M = C_{gd} (1 + g_m R_L)$	**4**	**2**	**1**	**2**

	* Using Millers Theorem, equivalent capacitance is $C_{eq} = (1 + A_v) C = (1 + A_v) C_{gd}$ (2 marks) When the MOSFET is biased in the saturation region, as in an amplifier circuit, the major contribution to the total gate-to-drain capacitance Cgd is the overlap capacitance. This overlap capacitance is multiplied because of the Miller effect and may become a significant factor in the bandwidth of an amplifier. (2 Marks)				
	Part – C (1 x 12 = 12 Marks)				
9.	 (2 Marks) Ac analysis The Ac equivalent ckt of the cascode amps. can be drawn as  (2 Marks) Input Resistance, Rin $R_{in1} = R_2 \| R_3 \| R_{ib1}$ where $R_{ib1} = r_\pi$ $R_{in2} \simeq r_e$	**12**	**3**	**1**	**3**

(1 Marks)

Output Resistance, Rout

$$R_{out1} = R_{in2}$$

$$R_{out2} = R_c \| R_L$$

(1 Marks)

Voltage gain, Av

$$A_{v1} = -g_m \times \text{eff. resis. @ collector of stage-1}$$
$$= -g_m r_e \simeq 1$$

$$A_{v2} = g_m \times \text{eff. resis. @ collector of stage-2}$$
$$= g_m (R_c \| R_L)$$

∴ The overall voltage gain of the amps. is given by

$$A_v = A_{v1} \times A_{v2}$$
$$= g_m (R_c \| R_L)$$

(2 Marks)

Current Gain, Ai

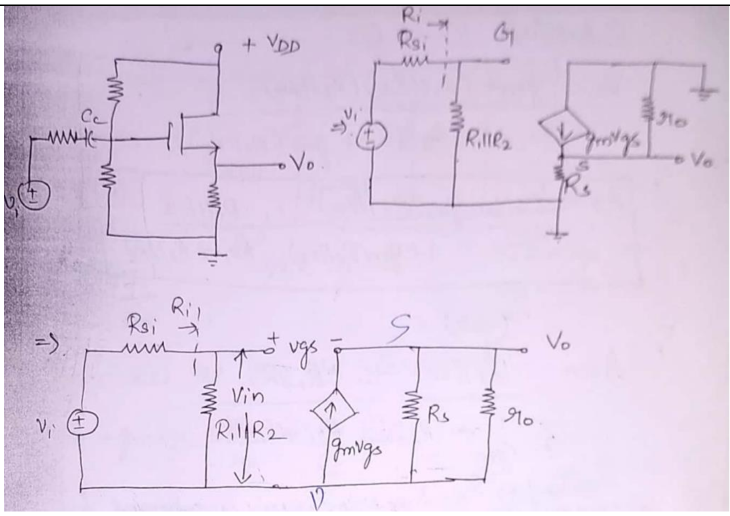
$$A_i = A_v \times \frac{R_{in}}{R_{out}} = \frac{g_m \cancel{(R_c \| R_L)} \times (R_2 \| R_3 \| R_{ib1})}{\cancel{(R_c \| R_L)}}$$

$$= g_m (R_2 \| R_3 \| R_{ib1})$$

(2 Marks)

$A_v = g_m(R_c \| R_L)$ = 20 mA/V *(1.5 kΩ || 10 kΩ) = 26 (2 Marks)

Or

10.	 (6 Marks) $A_v = \frac{V_o}{V_i}$ $V_o = g_m v_{gs} (R_s \| r_o)$ $V_{in} = \frac{V_i \times R_1 \| R_2}{R_{si} + R_1 \| R_2} \rightarrow (1)$ But $V_{in} = V_{gs} + (g_m V_{gs})(R_s \| r_o)$ $V_{in} = V_{gs} [1 + g_m (R_s \| r_o)$ $V_{gs} = \frac{V_{in}}{1 + g_m (R_s \| r_o)}$ Sub in Vo. $V_o = \frac{g_m V_{in} (R_s \| r_o)}{1 + g_m (R_s \| r_o)} \rightarrow (2)$	**12**	**3**	**1**	**3**

Substitute (1) in (2)

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

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

(Or)

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

(2 Marks)

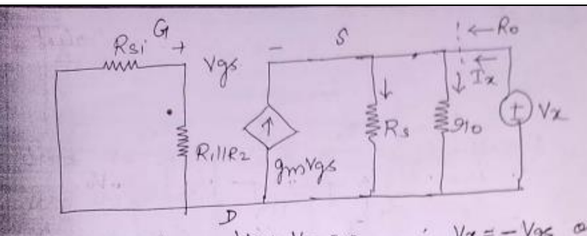
<u>Input Impedance</u>

$R_i = R_1 || R_2$

<u>Output Impedance</u>

A small O/P resistance is desirable when the circuit is to act as ideal voltage source & drive load circuit without suffering loading effects.

To find the O/P resistance let $V_i = 0$ & test voltage is applied to the O/P.



$$R_o = \frac{V_x}{I_x} \qquad V_x + V_{gs} = 0 \qquad \therefore V_x = -V_{gs} \text{ or } V_{gs} = -V_x.$$

Apply KCL at the o/p terminal

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

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

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

$$I_x = V_x\left[\frac{1}{r_o} + \frac{1}{R_s} + g_m\right]$$

$$V_x = I_x\left(r_o \,\|\, R_s \,\|\, \frac{1}{g_m}\right)$$

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

(2 Marks)

Voltage gain A_v

$$A_v = \frac{g_m(R_s \| r_o)}{1 + g_m(R_s \| r_o)} \cdot \frac{R_i}{R_i + R_{si}}$$

$$= \frac{(11.3)(0.75 \| 12.5)}{1 + (11.3)(0.75 \| 12.5)} \cdot \frac{120}{120+4} = 0.860$$

$$R_i = R_1 \| R_2 = 120k\Omega.$$

(2 Marks)

Signature of Course Teacher

Approved by the Course Coordinator **Approved by the Academic Advisor**