Batch 1
SET B

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)

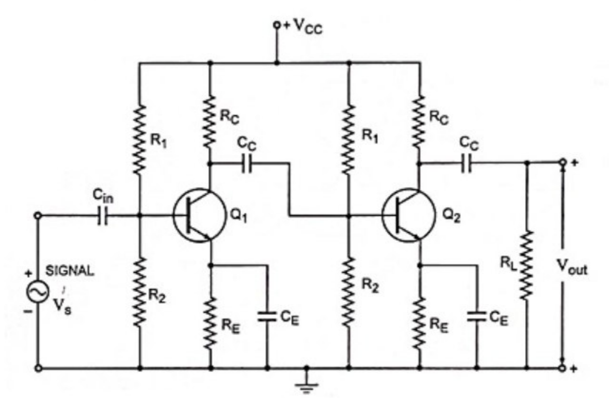
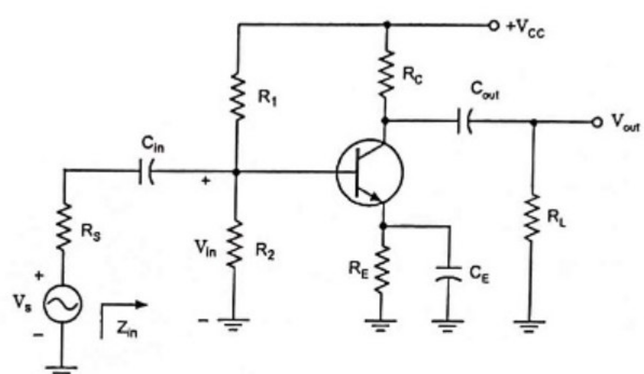
Test: CLAT- 1 **Date: 17.02.23**
Course Code & Title:21ECC202T & ANALOG AND LINEAR ELECTRONIC CIRCUITS **Duration: 1 hour**
Year & Sem: II and IV **Max. Marks: 25**

Course Articulation Matrix:

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	understand the operation and design of transistor amplifier circuits for a given specification
CLR-2:	discuss the elementary concepts and characteristics of an operational amplifier
CLR-3:	introduce the concepts of negative feedback on amplifier circuits, and investigate different feedback topologies to understand their properties, such as transfer gain, input resistances, and output resistances
CLR-4:	analyze and design RC and LC oscillator circuits
CLR-5:	analyze and design linear and non-linear applications of op-amp

		Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	At the end of this course, learners will be able to:	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-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 operational amplifier	2	2	3	-	-	-	-	-	-	-	-	-	-	-	3
CO-3:	classify and identify the suitable feedback topologies and oscillators as per application	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.	The emitter current is always A) greater than the base current B) less than the collector current C) greater than the collector current D) **greater than the base current and greater than the collector current**	**1**	**1**	**CO1**	**1**
2.	The approximate voltage across the forward-biased base-emitter junction of a silicon BJT is A) 0 V B) **0.7 V** C) 0.3 V D) V_{BB}	**1**	**1**	**CO1**	**1**
3.	The bias condition for a transistor to be used as a linear amplifier is called A) **forward-reverse** B) forward-forward C) reverse-reverse D) collector bias	**1**	**1**	**CO1**	**1**
4.	Most small-signal E-MOSFETs are found in (mark1) A) Heavy-current applications B) Discrete circuits C) Disk drives D) **Integrated circuit**	**1**	**1**	**CO1**	**1**
5.	In an Enhancement MOSFET, drain current starts only when VGS (th) is A) Positive B) Negative C) Zero D) **greater than Vgs (th)**	**1**	**1**	**CO1**	**1**
	Part – B (2 x 4 = 8 Marks) **Instructions: Answer any 2 Questions**				
6.	Draw a two stage RC coupled amplifier and explain its working principle.	**4**	**1**	**CO1**	**1**

	Ans: The two transistors used are identical and use a common power supply V_{CC}. The resistors R_1, R_2 and R_E form the biasing and stabilization network. In this arrangement, the signal developed across collector resistor R_C of the first stage is coupled to the base of the second stage through the coupling capacitor C_C. As the coupling from one stage to the next is obtained by a coupling capacitor followed by a connection to a shunt resistor, therefore, such amplifiers are called **Resistance-capacitance coupled** or RC Coupled Transistor Amplifier. The input capacitor C_{in} couples ac signal voltage to the base of transistor Q_1. In the absence of C_{in} the signal source will be in parallel with resistor R_2 and the bias voltage of the base will be affected. Thus the function of C_{in} is to allow only the alternating current from signal source to flow into the input circuit. 				
7.	Write a short note on low frequency response of CE amplifier. Ans:  Fig-1 The total resistance is now (R_s + R_{in}) and the cutoff frequency is $$f_{L_i} = \frac{1}{2\pi(R_s + R_{in})C_{in}} \qquad ...(15.37)$$ At mid or high frequencies, the reactance of the capacitor C_{in} will be considerably small to allow a short-circuit approximation for the element. The relation between V_{in} and V_s is given as	**4**	**1**	**CO1**	**1**

$$V_{in}\big|_{mid} = \frac{R_{in}}{R_{in} + R_s} V_s \qquad ...(15.38)$$

At f_{Li}, input voltage V_{in} will be 0.707 times the value determined by above Eq. (15.38), assuming that C_{in} is the only capacitive element that controls the Low Frequency Response of BJT Amplifier.

For the network given in Fig.1, in analysis of the effects of C_{in}, we must assume that the capacitors C_E and C_{out} are performing their designed function or the analysis becomes too unwieldy, that is, that the magnitudes of the reactances of C_{out} and C_E allow using a short-circuit equivalent as compared to the magnitude of the other series impedances. Using this hypothesis, the ac equivalent network for the input section of the circuit shown in Fig. 1 will become as shown in Fig. 15.16.

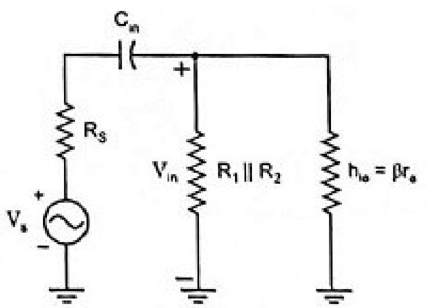


Fig. 15.16

The value of R_{in} is given by the equation

$$R_{in} = R_1 \parallel R_2 \parallel \beta r_e \qquad ...(15.39)$$

The voltage V_{in} applied to the input of device can be determined by using voltage-divider rule and is given as

$$V_{in} = \frac{R_{in} V_s}{R_s + R_{in} - jX_{C_{in}}} \qquad ...(15.40)$$

Thus with the decrease in frequency, the reactance of the capacitor C_{in} increases, some of the signal or source voltage is lost across the input capacitor C_{in} and the voltage V_{in} applied to the input of the device is reduced resulting in decrease in output voltage and hence the gain.

8.	Determine the voltage gain and input impedance of the amplifier shown in Figure . Assume β=150	**4**	**2**	**CO1**	**2**

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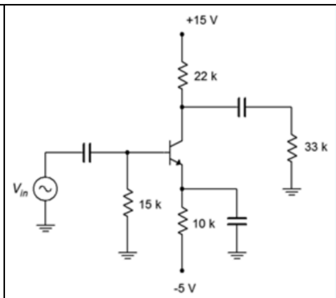
<td>

Ans:

In both cases, the DC emitter resistance is 10 k Ω
. Therefore, I_C
and $r'e$
are unchanged. The bypass capacitor shorts this entire value for the AC equivalent because there is no swamping resistor.

We begin with the input impedance.

$$Z_{in-base} = \beta(r'_e + r_E)$$

$$Z_{in-base} = 150(60.5\Omega + 0)$$

$$Z_{in-base} = 9075\Omega$$

This value is considerably smaller than the value obtained from the swamped circuit. Continuing,

$$Z_{in} = R_B || Z_{in(base)}$$

$$Z_{in} = 15k\Omega \; || \; 9075\Omega$$

$$Z_{in} = 5654\Omega$$

$$A_v = -\frac{r_C}{r'_e + r_E}$$

$$A_v = -\frac{13.2k\Omega}{60.5\Omega + 0}$$

$$A_v = -218.2$$

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<td colspan="6">**Part – C (1 x 12 = 12 Marks)**</td>
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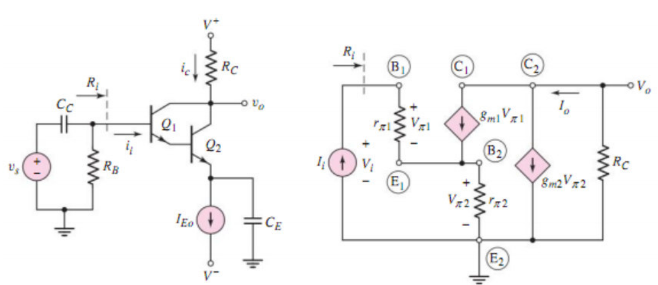
<td>**9.**</td>
<td>Explain with circuit diagram of Darlington connection of BJT amplifier and derive the expression for A_i and Ri .
A Darlington pair consisting of two power transistors has an effective ß of 12500. If the driver BJT has a ß of 200. What is the ß value for main transistor

Ans: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<td>**6+3+3**</td>
<td>**2**</td>
<td>**CO1**</td>
<td>**2**</td>
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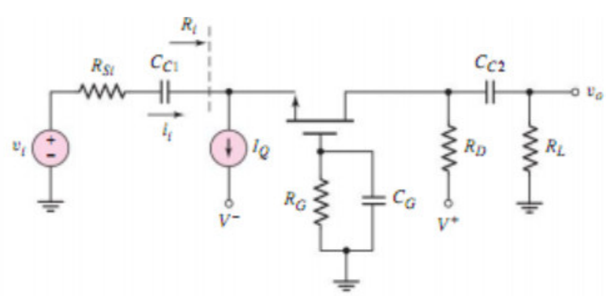
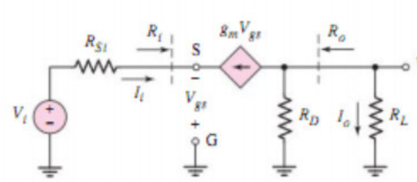
	$g_{m1}V_{\pi 1} = g_{m1}r_{\pi 1}I_i = \beta_1 I_i$ (6.104) Then, $V_{\pi 2} = (I_i + \beta_1 I_i)r_{\pi 2}$ (6.105) The output current is $I_o = g_{m1}V_{\pi 1} + g_{m2}V_{\pi 2} = \beta_1 I_i + \beta_2(1+\beta_1)I_i$ (6.106) where $g_{m2}r_{\pi 2} = \beta_2$. The overall current gain is then $A_i = \frac{I_o}{I_i} = \beta_1 + \beta_2(1+\beta_1) \cong \beta_1\beta_2$ (6.107) From Equation (6.107), we see that the overall small-signal current gain of the Darlington pair is essentially the product of the individual current gains. The input resistance is $R_i = V_i/I_i$. We can write that $V_i = V_{\pi 1} + V_{\pi 2} = I_i r_{\pi 1} + I_i(1+\beta_1)r_{\pi 2}$ (6.108) so that $R_i = r_{\pi 1} + (1+\beta_1)r_{\pi 2}$ (6.109) The base of transistor Q_2 is connected to the emitter of Q_1, which means that the input resistance to Q_2 is multiplied by the factor $(1+\beta_1)$, as we saw in circuits with emitter resistors. We can write $r_{\pi 1} = \frac{\beta_1 V_T}{I_{CQ1}}$ (6.110) and $I_{CQ1} \cong \frac{I_{CQ2}}{\beta_2}$ (6.111) Therefore, $r_{\pi 1} = \beta_1\left(\frac{\beta_2 V_T}{I_{CQ2}}\right) = \beta_1 r_{\pi 2}$ (6.112) From Equation (6.109), the input resistance is then approximately $R_i \cong 2\beta_1 r_{\pi 2}$ $\beta_D = \beta_d \times \beta_M$ $\beta_M = 12500/200 = 62.5$				
	Or				
10.	Explain with circuit diagram of common gate amplifier and derive the expression for Av, Ri &Ro. A MOSFET has a drain resistance R_L of 44 kΩ and operates at 20kHz. Calculate the voltage gain of the device as a single stage amplifier. The MOSFET parameters are g_m= 1.6 mA/V, r_d= 100 kΩ Ans:   **Figure 4.37** Small-signal equivalent circuit of common-gate amplifier	**6+2+2 +2**	**2**	**CO1**	**2**

The small-signal voltage gain is found to be

$$A_v = \frac{V_o}{V_i} = \frac{g_m(R_D \| R_L)}{1 + g_m R_{Si}} \quad (4.41)$$

Also, since the voltage gain is positive, the output and input signals are in phase.

In many cases, the signal input to a common-gate circuit is a current. Figure 4.38 shows the small-signal equivalent common-gate circuit with a Norton equivalent circuit as the signal source. We can calculate a current gain. The output current I_o can be written

$$I_o = \left(\frac{R_D}{R_D + R_L}\right)(-g_m V_{gs}) \quad (4.42)$$

At the input we have

$$I_i + g_m V_{gs} + \frac{V_{gs}}{R_{Si}} = 0 \quad (4.43)$$

or

$$V_{gs} = -I_i\left(\frac{R_{Si}}{1 + g_m R_{Si}}\right) \quad (4.44)$$

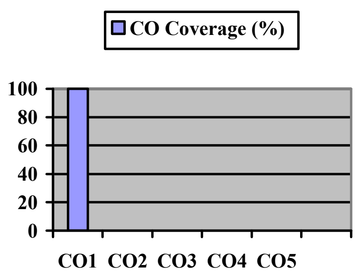
The small-signal current gain is then

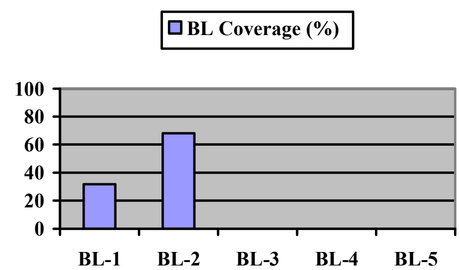
$$A_i = \frac{I_o}{I_i} = \left(\frac{R_D}{R_D + R_L}\right)\cdot\left(\frac{g_m R_{Si}}{1 + g_m R_{Si}}\right) \quad (4.45)$$

We may note that if $R_D \gg R_L$ and $g_m R_{Si} \gg 1$, then the current gain is essentially unity.

$Av = g_m (r_d \| R_L) = 1.6\times10^{-3}(100\times10^3 \| 44\times10^3) = 48.9$

Course Outcome (CO) and Bloom's level (BL) Coverage in Questions





Evaluation Sheet

Name of the Student: **Register No.:**

Part- A (5 x 1= 5 Marks)					
Q. No	**CO**	**PO**	**Maximum Marks**	**Marks Obtained**	**Total**
1	CO1		1		
2	CO1		1		
3	CO1		1		
4	CO1		1		
5	CO1		1		
Part- B (2 x 4= 8 Marks)					
6	CO1		4		
7	CO1		4		
8	CO1		4		
Part- C (1 x 12= 12 Marks)					
9	CO1		12		
10	CO1		12		

Consolidated Marks:

CO	Maximum Marks	Marks Obtained
1	25	
Total		

PO	Maximum Marks	Marks Obtained
Total	25	

Signature of Course Teacher

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