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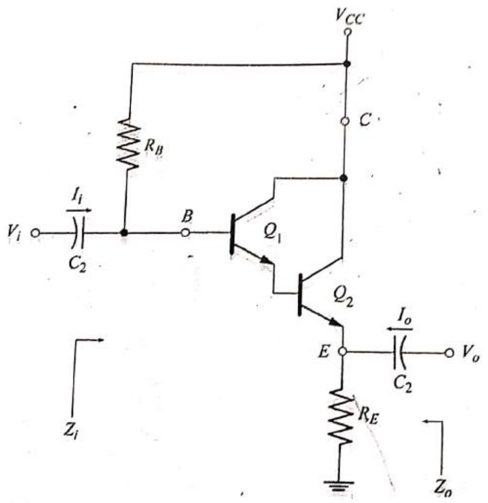
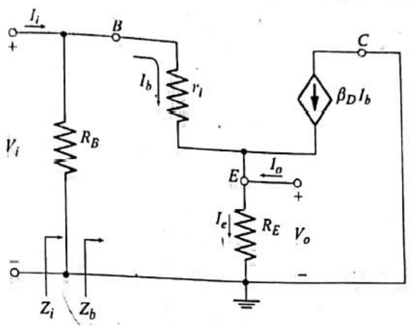
Internal Assessment Test – II – Scheme and Solution

Sub:	**Analog Electronic Circuits and Op-Amps**							Code:	**21EE32**
Date:	26.12.2022 12 – 1.30pm	Duration:	90 mins	Max Marks:	50	Sem:	III	Branch:	EEE

Answer Any FIVE FULL Questions

		Marks	OBE CO	OBE RBT
1	Draw the circuit of Darlington Emitter follower. Derive the expression for A_v, A_I, Z_i and Z_o using its ac equivalent circuit.		CO3	L3

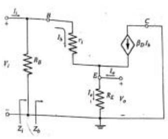




2

Analysis:

Input Impedance:



Applying KVL to the input circuit

$$V_i = I_b r_i + I_e R_E$$

Using $I_e = (1+\beta_D) I_b$, we have

$$V_i = I_b r_i + (1+\beta_D) R_E I_b$$

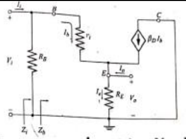
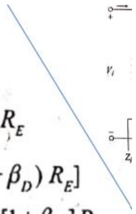
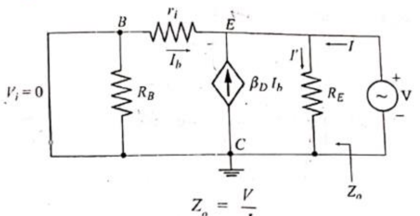
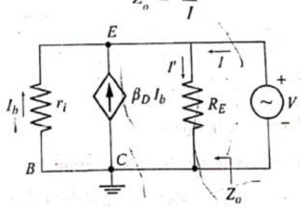
$$Z_b = \frac{V_i}{I_b} = r_i + (1+\beta_D) R_E$$

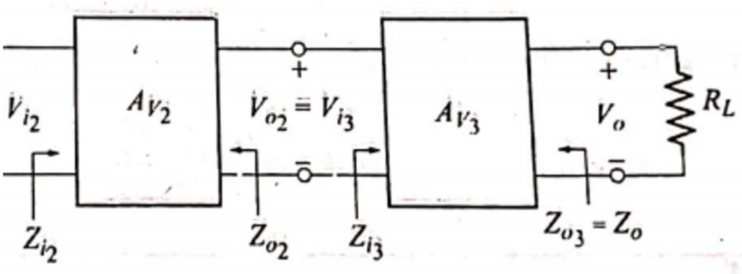
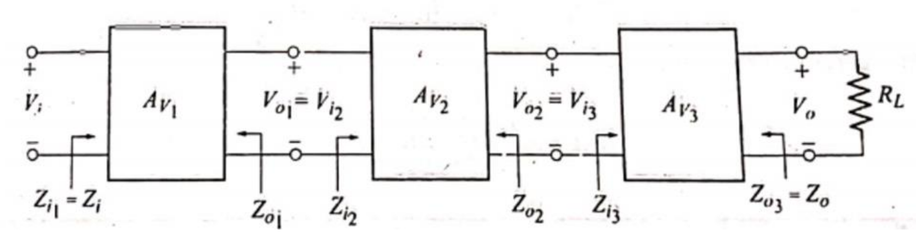
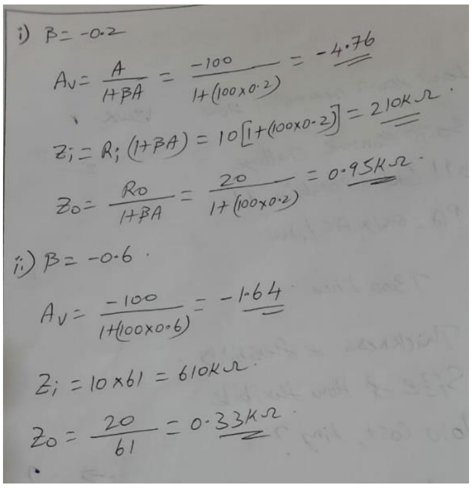
Since β_D is very high,

$$Z_b \approx \beta_D R_E$$

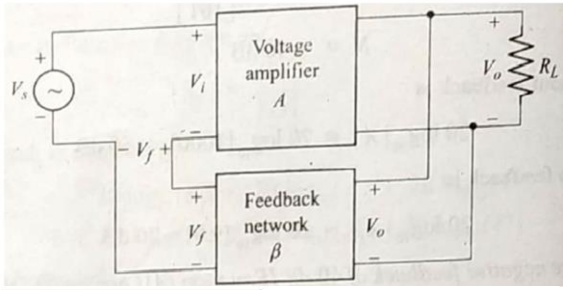
$$\boxed{Z_i = \frac{V_i}{I_i} = R_B \parallel Z_b}$$

2

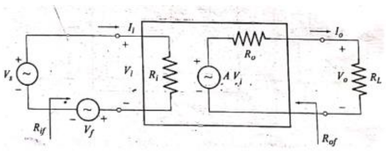
	Current Gain:  $A_I = \frac{I_o}{I_i} = \frac{I_o}{I_b} \cdot \frac{I_b}{I_i}$ But $I_o = I_e$ $\therefore A_I = \frac{I_e}{I_b} \cdot \frac{I_b}{I_i}$ $I_e = (1+\beta_D) I_b \approx \beta_D I_b$ $\Rightarrow \frac{I_e}{I_b} = \beta_D$ Applying KCL to the input circuit we have $I_i = \frac{V_i}{R_B} + I_b$ Using $V_i = I_b Z_b$ we get $I_i = I_b \left[\frac{Z_b}{R_B} + 1\right] = I_b \left[\frac{Z_b + R_B}{R_B}\right]$ $\Rightarrow \frac{I_b}{I_i} = \frac{R_B}{Z_b + R_B}$ $A_I = \beta_D \frac{R_B}{Z_b + R_B}$ Substituting for Z_b $\boxed{A_I = \frac{\beta_D R_B}{R_B + \beta_D R_E}}$	2		
	Voltage Gain:  $V_o = I_e R_E$ $= [1+\beta_D] I_b R_E$ $V_i = I_b [r_i + (1+\beta_D) R_E]$ Now $A_V = \frac{V_o}{V_i} = \frac{I_b[1+\beta_D]R_E}{I_b[r_i + (1+\beta_D)R_E]}$ $A_V = \frac{[1+\beta_D]R_E}{r_i + [1+\beta_D]R_E}$ Since $(1+\beta_D) R_E \gg r_i$ $\boxed{A_V \approx \frac{(1+\beta_D)R_E}{[1+\beta_D]R_E} = 1}$	2		
	Output Impedance:  $Z_o = \frac{V}{I}$  Applying KCL at the emitter node we have $I_b + \beta_D I_b - I' + I = 0$ But $I_b = \frac{-V}{r_i}$ and $I' = \frac{V}{R_E}$ $-\frac{V}{r_i} + \beta_D\left(-\frac{V}{r_i}\right) - \frac{V}{R_E} + I = 0$ $\left[\frac{1}{r_i} + \frac{1}{R_E} + \frac{\beta_D}{r_i}\right] V = I$ $Z_o = \frac{V}{I} = \frac{1}{\frac{1}{r_i} + \frac{1}{R_E} + \frac{\beta_D}{r_i}}$ $\therefore \boxed{Z_o = r_i \parallel R_E \parallel \frac{r_i}{\beta_D}}$	2		
2	Explain the need of cascading amplifier. Draw and explain the block diagram of two stage cascade amplifier. • Cascading amplifiers are used to increase signal strength in Television receiver. • In cascading amplifier output of first stage is connected to input of second stage. A single stage amplifier is not sufficient to build a practical electronic system. • Although the gain of amplifier depends on device parameters and circuit components, there exists upper limit for gain to be obtained from single stage amplifier. Hence, the gain of single stage amplifier is not sufficient in practical application.	3	CO3	L2

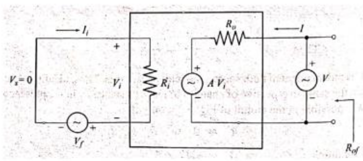
	• To overcome this problem, we need to cascade two or more stage of amplifier to increase overall voltage gain of amplifier. When more than one stages used in succession it is known as multi-stage amplifier. • The overall reason for **cascading amplifiers** is the **need** for an increase in **amplifier** output to meet a specific requirement.  $$A_{V_T} = A_{V_1} \cdot A_{V_2}$$ $$A_{I_T} = -A_{V_T} \frac{Z_{i_1}}{R_L}$$	3 2 2		
3	A given amplifier arrangement has the following voltage gains. $A_{v1} = 10$, $A_{v2} = 20$, $A_{v3} = 30$. Calculate overall voltage gain and determine the total voltage gain in dB. Also draw the block diagram of three stage cascade amplifier AVT = Av1 * Av2 * Av3 = 6000 In dB = 75.56dB  	3 3 4	CO3	L3
4	Determine A_v, Z_i and Z_o with feedback for voltage series feedback amplifier having A = -100, R_i = 10KΩ, R_o = 20KΩ for feedback of (i) β = -0.2 and (ii) β = -0.6  i) β = -0.2 $A_v = \frac{A}{1+\beta A} = \frac{-100}{1+(100\times0.2)} = -4.76$ $Z_i = R_i(1+\beta A) = 10[1+(100\times0.2)] = 210K\Omega$ $Z_o = \frac{R_o}{1+\beta A} = \frac{20}{1+(100\times0.2)} = 0.95K\Omega$ ii) β = -0.6 $A_v = \frac{-100}{1+(100\times0.6)} = -1.64$ $Z_i = 10\times61 = 610K\Omega$ $Z_o = \frac{20}{61} = 0.33K\Omega$	5 5	CO3	L3

<table>
<tr><td>5</td><td>Derive an expression for transfer gain, input resistance and output resistance with feedback for voltage series feedback amplifier.

Transfer gain


$V_o = A V_i$
$V_i = V_s - V_f$
$V_o = A[V_s - V_f]$
$= AV_s - AV_f$
But $V_f = \beta V_o$
Now $V_o = AV_s - A\beta V_o$
$V_o[1 + A\beta] = AV_s$
$A_f = \frac{V_o}{V_s} = \frac{A}{1+\beta A}$

For voltage series feedback amplifier
$A = A_v$ and $A_f = A_{vf}$
$A_{vf} = \frac{A_v}{1+\beta A_v}$</td><td>4</td><td>CO3</td><td>L3</td></tr>
<tr><td></td><td>Input impedance

$R_i = \frac{V_i}{I_i}$ = Input resistance without feedback
$R_{if} = \frac{V_s}{I_i}$ = Input resistance with feedback.
Applying KVL to the input circuit
$V_s - V_i - V_f = 0$
But $V_i = I_i R_i$ and $V_f = \beta V_o$
Substituting these relations we have
$V_s - I_i R_i - \beta V_o = 0$

But $V_o = A V_i = A I_i R_i$
$V_s - I_i R_i - \beta A I_i R_i = 0$
$V_s = I_i R_i [1+\beta A]$
Now $R_{if} = \frac{V_s}{I_i} = R_i[1+\beta A]$
Since $[1+\beta A] > 1$
$R_{if} > R_i$</td><td>3</td><td></td><td></td></tr>
<tr><td></td><td>Output Impedance

Applying KVL to the input circuit we have
$V_s - V_i - V_f = 0$
Since $V_s = 0$,
we get $V_i = -V_f$
$V_f = \beta V_o$
But $V_o = V$
$\therefore V_f = \beta V$
$V_i = -\beta V$

Applying KVL to the output circuit, we have
$V - I R_o - A V_i = 0$
$V - I R_o - A[-\beta V] = 0$
$V[1+\beta A] = I R_o$
Now $R_{of} = \frac{V}{I} = \frac{R_o}{1+\beta A}$</td><td>3</td><td></td><td></td></tr>
<tr><td>6</td><td>Explain the operation of class A Transformer coupled power amplifier with neat circuit diagram and prove that the maximum efficiency is 50%</td><td></td><td>CO4</td><td>L3</td></tr>
</table>

- A transformer can increase or decrease voltage or current levels according to its turns ratio a=N 1 :N 2
- The impedance connected to one side of a transformer can be made to appear either larger or smaller (step up or step down) at the other side of the transformer.

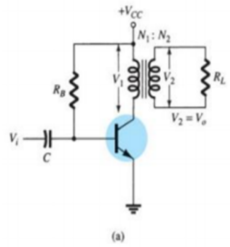


FIG.
Transformer-coupled

4

The dc power drawn by the circuit is given by

$$P_{i(dc)} = V_{CC} I_{CQ}$$

ac power developed across

$$P_{o(ac)} = \frac{V_{CE(p)} I_{C(p)}}{2}$$

$$V_{CE(max)} = V_{CC} + V_{CE(p)}$$

and $V_{CE(min)} = V_{CC} - V_{CE(p)}$

Adding Equations

$$V_{CE(max)} + V_{CE(min)} = 2\,V_{CC}$$

or $$V_{CC} = \frac{V_{CE(max)} + V_{CE(min)}}{2}$$

Subtracting Equations

$$V_{CE(max)} - V_{CE(min)} = 2\,V_{CE(p)} = V_{CE(p-p)}$$

or $$V_{CE(p)} = \frac{V_{CE(max)} - V_{CE(min)}}{2} = \frac{V_{CE(p-p)}}{2}$$

similarly $$I_{C(p)} = \frac{I_{C(max)} - I_{C(min)}}{2} = \frac{I_{C(p-p)}}{2}$$

$$P_{o(ac)} = \frac{[V_{CE(max)} - V_{CE(min)}][I_{C(max)} - I_{C(min)}]}{8}$$

or $$P_{o(ac)} = \frac{V_{CE(p-p)} I_{C(p-p)}}{8}$$

But $I_{C(p-p)} = \frac{V_{CE(p-p)}}{R'_L} \Rightarrow V_{CE(p-p)} = I_{C(p-p)} R'_L$

$$P_{o(ac)} = \frac{V^2_{CE(p-p)}}{8R'_L} = \frac{V^2_{CE(p)}}{2R'_L}$$

or $$P_{o(ac)} = \frac{I^2_{C(p-p)}}{8} R'_L = \frac{I^2_{C(p)}}{2} R'_L$$

AC Power Delivered to the Load

The ac power delivered to the load on the secondary side is

$$P_L = V_{L(rms)} I_{L(rms)}$$

Using $$I_{L(rms)} = \frac{V_{L(rms)}}{R_L}$$

$$P_L = \frac{V^2_{L(rms)}}{R_L} \quad \text{or} \quad P_L = I^2_{L(rms)} R_L$$

Maximum ac Output Power

Thus, $$P_{o(ac)\,max} = \frac{V_{CE(max)} I_{C(max)}}{8}$$

Using $$I_{C(max)} = \frac{V_{CE(max)}}{R'_L},$$

$$P_{o(ac)\,max} = \frac{V^2_{CE(max)}}{8R'_L}$$

with $V_{CE(min)} = 0$, we get

$$V_{CE(max)} = 2\,V_{CC}$$

$$P_{o(ac)max} = \frac{V^2_{CC}}{2R'_L}$$

3

$$\%\,\eta = \frac{50\,V_{CE(p)} I_{C(p)}}{V_{CC} I_{CQ}}\,\%$$

$$= 50 \times \frac{\left[\frac{V_{CE(max)} - V_{CE(min)}}{2}\right]}{\left[\frac{V_{CE(max)} + V_{CE(min)}}{2}\right]}\,\%$$

$$\%\,\eta = 50 \times \frac{V_{CE(max)} - V_{CE(min)}}{V_{CE(max)} + V_{CE(min)}}\,\%$$

if $V_{CE(min)} = 0$

$$\%\,\eta_{max} = 50\,\%$$

3