II/IV B.Tech (Regular) Degree Examination, July 2023
Department of ECE
Scheme of Evaluation
Subject code: - 20EC402 (Electronic Circuit Analysis)

Time: Three Hours — **Maximum:** 70 Marks

Answer Question No.1 compulsorily. (14X1 = 14 Marks)

Answer ONE question from each unit. (4X14=56 Marks)

1. Answer all questions

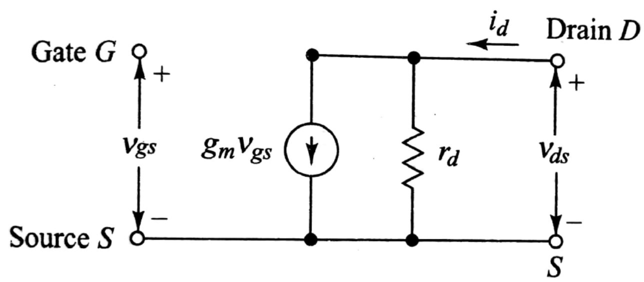
a) List the typical h-parameter values of a transistor in different configurations. 1M

Ans

Parameter	CE	CC	CB
$h_{11} = h_i$	1100 Ω	1100 Ω	21.6 Ω
$h_{12} = h_r$	2.5×10^{-4}	~1	2.9×10^{-4}
$h_{21} = h_f$	50	-51	-0.98
$h_{22} = h_o$	24 µA/V	25 µA/V	0.49 µA/V
$1/h_o$	40K	40K	2.04M

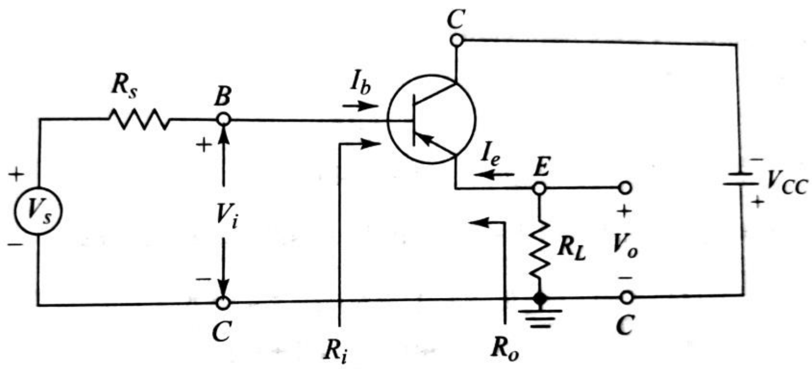
b) Draw the small signal model of FET. 1M

Ans



c) Draw the circuit of single stage CC transistor amplifier. 1M

Ans Any CC amplifier circuit diagram-1M



d) Why is biasing not required in push-pull amplifier? 1M

Ans Power transistors do not require biasing. Because power amplifiers are large-signal amplifiers.

e) Why are multistage amplifiers preferred? 1M

Ans Write any of the following reason -1M

i. To Improve the gain

ii. To Improve the Impedance Matching

f) The turns ratio of transformer is 20:1. If a load of 10 ohms is connected across the primary, what will be effective resistance seen looking into secondary? 1M

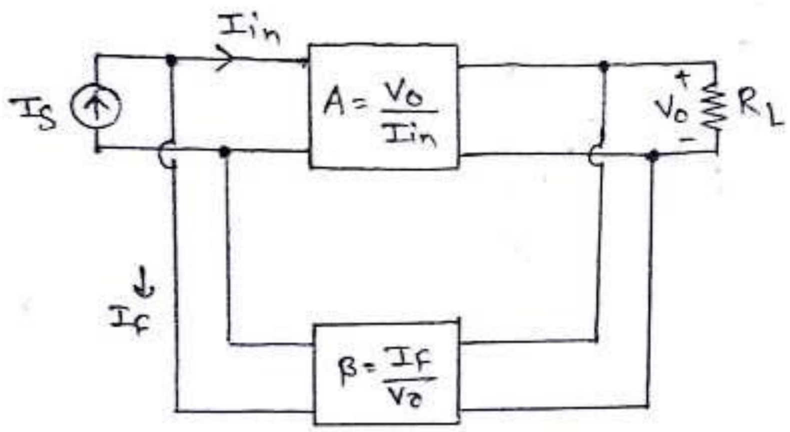
Ans $R_{L\,(Secondary)} = R_L / n^2$

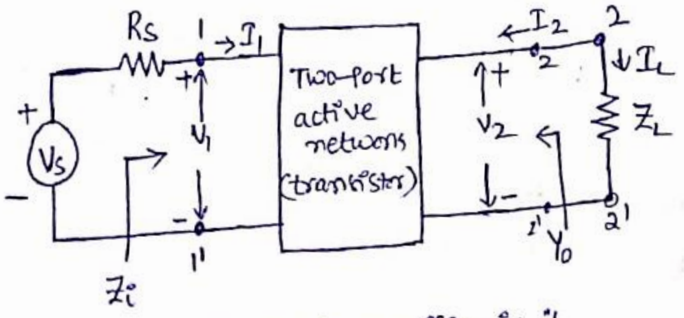
n= Turns ratio

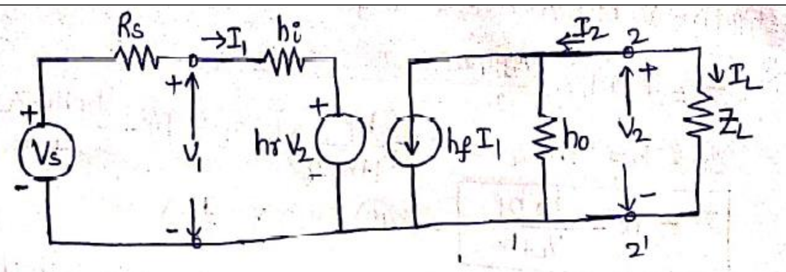
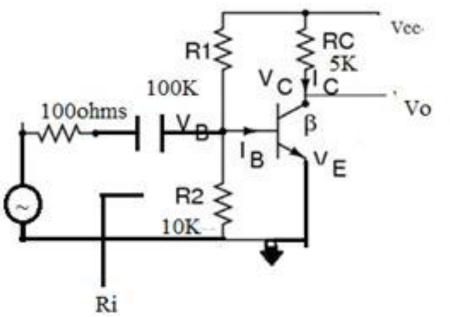
$n = N_{Primary} / N_{Secondary}$

g) State any two advantages of negative feedback? 1M

Ans Any two advantages- 1M

	i. The input and output impedances can be modified as desired. ii. Stabilized gain iii. Increases the bandwidth. iv. Provides more linearity. v. Reduced Noise and Distortion.	
h)	**Draw the block diagram of a Voltage-Shunt Feedback amplifier.**	1M
Ans		
i)	**Why oscillators exhibit positive feedback?**	1M
Ans	For oscillations to exist, system should satisfy Barkhuasen's Criterion i.e. Feedback Signal and Input Signal should have phase difference in integral multiple of 2π i.e. Phase difference between input and feedback signal should be 2πn.. Positive Feedback is preferred in oscillators as it provides higher Gain to the system.	
j)	**In Colpitts oscillator, C1= 0.16μH, L= 15.8mH and its frequency of oscillations is 10KHz, calculate the value of capacitor C2.**	1M
Ans	Formulas -1M $f_r = \frac{1}{2\pi\sqrt{LC_T}}$ $\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2}$ or $C_T = \frac{C_1 \times C_2}{C_1 + C_2}$ Find C2 based on the above formula.	
k)	**Give the classification of amplifiers.**	1M
Ans	Any one classification-1M Based on number of stages i. Single-stage Amplifiers ii. Multi-stage Amplifiers Based on the input signals i. Small signal Amplifiers ii. Large signal amplifiers Based on the frequency range i. Audio Amplifiers ii. IF Amplifiers iii. Video Amplifiers Based on the Coupling Method i. RC Coupled ii. Transformer Coupled iii. Direct Coupled Based on the transistor configuration i. CE Amplifier ii. CB Amplifier iii. CC Amplifier	

l)		**For a JFET amplifier, g_m=2.5mA/V and r_d=500kohms. The load resistance is 10Kohms. Find the voltage gain.**	1M
Ans		Voltage gain expression-1M Voltage gain= Vo/Vi = $g_m (r_d \|\| R_L)$	
m)		**What is the main component that is responsible for the fall of gain of an RC Coupled amplifier in low frequency range?**	1M
Ans		Any one capacitance is mentioned-1M. Coupling capacitor and Emitter Bypass capacitor.	
n)		**What is an Oscillator?**	1M
Ans		Oscillator is an electronic circuit which produces the output signal without any external input.	
		UNIT-I	
2.	a)	**A common collector amplifier with R_S=1K ohm and R_L=5 K ohm, h_{ie}=1.1kohms, h_{fe}=50, h_{oe}=25*10^{-6}, h_{re}=2.5*10^{-4}. Evaluate voltage gain, current gain, input and output resistance using exact analysis of h-parameter model.**	
	Ans	Formulas Calculation $A_I = \frac{-I_e}{I_b} = \frac{-h_{fc}}{1+h_{oc}R_L} = \frac{1+h_{fe}}{1+h_{oc}R_L}$ $R_i = \frac{V_i}{I_b} = h_{ic} + h_{rc}A_I R_L = h_{ie} + A_I R_L$ $A_V = \frac{V_o}{V_i} = \frac{A_I R_L}{R_i} = \frac{R_i - h_{ie}}{R_i} = 1 - \frac{h_{ie}}{R_i}$ $Y_o = h_{oc} - \frac{h_{fc}h_{rc}}{h_{ic} + R_s} = h_{oc} + \frac{1+h_{fe}}{h_{ie} + R_s}$	4M 3M
	b)	**Analyze transistor Amplifier using h-parameters and find various gains and various impedances.**	
	Ans	h-parameter equivalent circuit calculation of current gain and input impedance Voltage and voltage gain with source Output impedance Analysis of a transistor amplifier using h-parameter model: A transistor amplified is formed by connecting an external load and signal source as shown in below figure and to bias the transistor properly.  Fig: Basic amplifier circuit.	2M 2M 2M 1M

		 (a) The current Gain or current Amplification (A_I): For a transistor amplifier stage, A_I is defined as the ratio of output to input current. $A_I = \frac{I_L}{I_1} = -\frac{I_2}{I_1}$ — (1) where $I_2 = h_f I_1 + h_o V_2$ — (2) and $V_2 = I_L \cdot Z_L = -I_2 Z_L$ — (3) Substitute V_2 in eq (2), we get: $I_2 = h_f I_1 - I_2 Z_L h_o$; $I_2 + I_2 Z_L h_o = h_f I_1 \Rightarrow I_2(1+h_o Z_L) = h_f I_1$ $I_2 = \frac{h_f I_1}{1+h_o Z_L}$ — (4) $A_I = -\frac{I_2}{I_1} =$ $A_I = \frac{-\frac{h_f I_1}{(1+h_o Z_L)}}{I_1} = -\frac{h_f}{1+h_o Z_L}$ $A_I = -\frac{h_f}{1+h_o Z_L}$ — (5) (C) Voltage gain, or Voltage Amplification (A_V): The ratio of output voltage V_2 to the input voltage V_1 is called the voltage gain of the transistor. $A_V = \frac{V_2}{V_1} = \frac{(-I_2 Z_L)}{V_1} = \frac{A_I I_1 Z_L}{I_1 Z_i}$ ($\because -I_2 = A_I I_1$, $V_1 = I_1 Z_i$) $A_V = \frac{A_I Z_L}{Z_i}$ — (11) $Y_0 = h_{oe} - \frac{h_{fe}h_{re}}{R_S + h_{ie}}$ $R_o = \frac{1}{Y_0}$	
	(OR)		
3.	a)	**The transistor amplifier shown in the figure uses a transistor with h- parameter values. Calculate A_i, A_V, A_{Vs}, R_o and R_i. h_{ie}=1kohms, h_{fe}=50, hoe=25*10^{-6}, h_{re}=2.5*10^{-4} and R_S=2K.**  	4M 3M
	Ans	**Formulas-4M**	

Calculation-3M

$$A_I = \frac{-h_{fe}}{1 + h_{oe}R_L}$$

$$R_i = h_i + h_{re}A_I R_L$$

$$A_v = \frac{A_I R_L}{R_i}$$

$$Y_0 = h_{oe} - \frac{h_{fe}h_{re}}{R_S + h_{ie}}$$

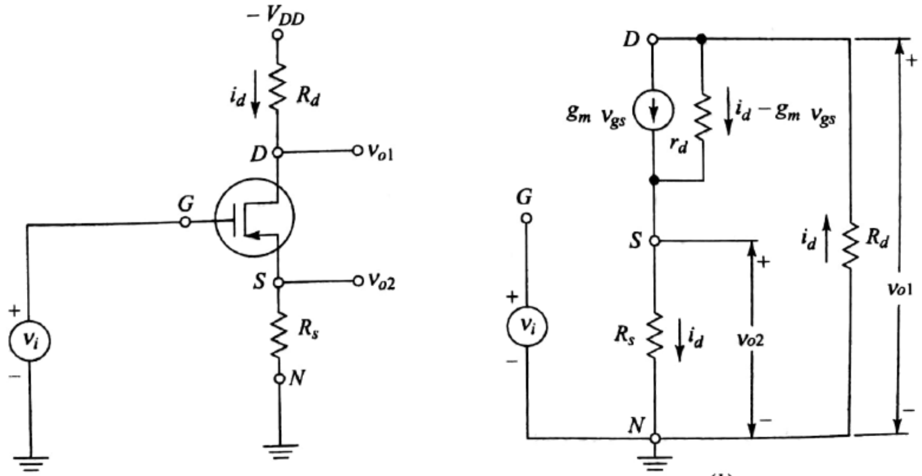
$$R_o = \frac{1}{Y_0}$$

$$A_{vs} = Av\, Rs/\,(Rs+Ri)$$

b) **Analyze CS amplifier along with circuit diagram using small signal model.**

Ans

Circuit Diagram	2M
Small signal Equivalent	1M
Finding of Av	4M



(a) (b)

From the above figure (a), for the CS stage the output V_{o1} is taken at the drain and R_s=0.

Applying KVL to the output circuit of figure (b) yields:

$$i_d R_d + (i_d - g_m v_{gs})r_d + i_d R_s = 0$$

From the figure (b), the voltage from G to S is given by:

$$v_{gs} = v_i - i_d R_s$$

Combining above two equations and substitution of $\mu = g_m . r_D,$ we get

$$i_d = \frac{\mu v_i}{r_d + R_d + (\mu + 1)R_s}$$

Since $V_{o1} = -i_d . R_d$, then

$$v_{o1} = \frac{-\mu v_i R_d}{r_d + R_d + (\mu + 1)R_s}$$

The output resistance is given by:

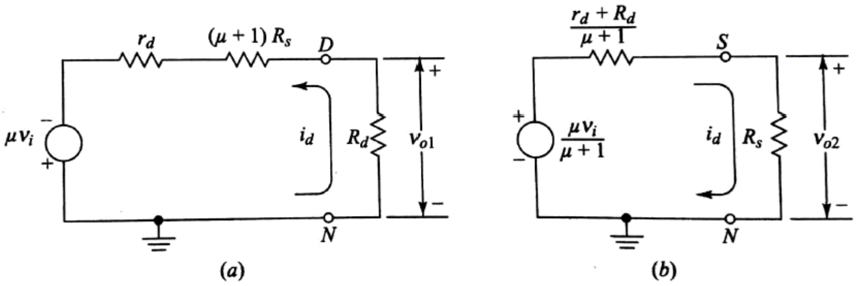
$$R_o = r_d + (\mu + 1)R_s.$$

The voltage gain for CS amplifier with Rs=0 is defined as:

$$A_V = v_{o1}/v_i.$$

$$A_V = \frac{v_{o1}}{v_i} = \frac{-\mu R_d}{r_d + R_d} = -g_m R'_d$$

$$R'_d = R_d \,||\, r_d.$$



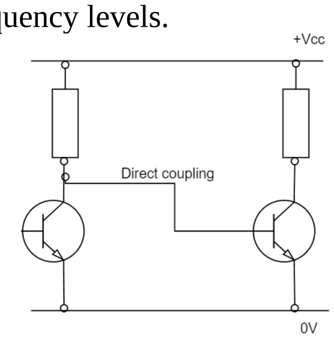
	UNIT II		
4.	a)	**Explain the different types of coupling schemes used in multistage amplifiers.**	
	Ans	Types of coupling names Circuit diagrams explanation	2M 3M 2M

The type of coupling decides the classification of the multistage amplifier and those are as follows:

- Direct coupling
- Transformer coupling and
- Capacitor coupling

Direct Coupling (DC)

In a few of the amplifiers, both AC and DC are connected between the amplifier stages. Whereas in the direct coupling, the collector stage output has a direct connection (or through resistance) with the base stage and this does not show any blockage to DC. The direct coupling type permits the amplification of extremely minimal frequency values along with 0Hz. Mostly, wideband amplifiers employ this type so as to remove the usage of capacitors, because capacitors may cause increased frequency instability conditions. With this, there might have changes in the output gain at few frequency levels.



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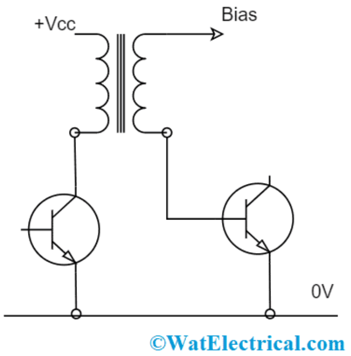
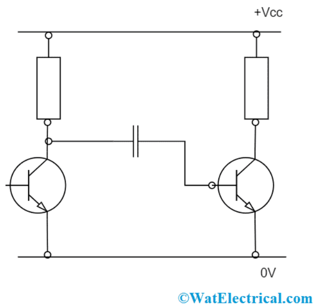
Transformer Coupling

In this type of coupling, the current flow at the collector of one stage will stream via the primary winding of the transformer. This stimulates signal voltage to the secondary winding which is connected at the input of the following stage. This signal is connected to the DC biasing at the base end of the following stage.



Capacitor Coupling

This type of coupling method offers electrical separation (which means blockage of DC) between the cascaded stages and permits the AC signals. This scenario permits for a various base and the collector voltages on the cascaded stages and minimizes any kind of DC stability complications. Through this approach, the capacitor reactance should be so minimal at the low signal frequency range where this not extensively minimize signal in between the stages.



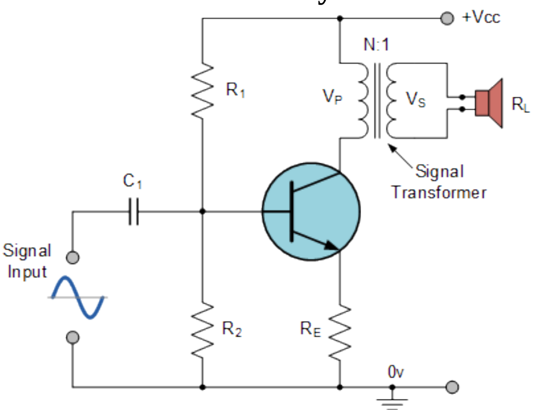
b) **Draw the circuit of transformer coupled Class A power Amplifier and derive the expression for efficiency.**

Ans

Transformer coupled class A power amplifier circuit diagram. 3M

Explanation 2M

Calculation of efficiency 2M



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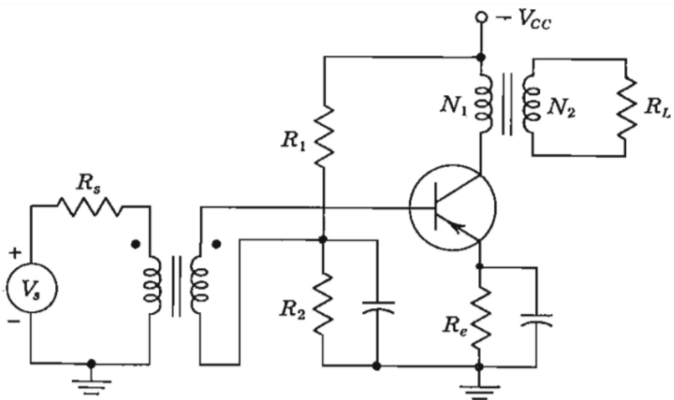


$$\eta = \frac{AC\ power\ delivered\ to\ load}{DC\ power\ supplied} X\ 100$$

$$= \frac{V_{rms}\, I_{rms}}{V_{CC} I_C}\ X100$$

$$= \frac{\frac{V_m}{\sqrt{2}}\frac{I_m}{\sqrt{2}}}{V_{CC} I_C}\ X100$$

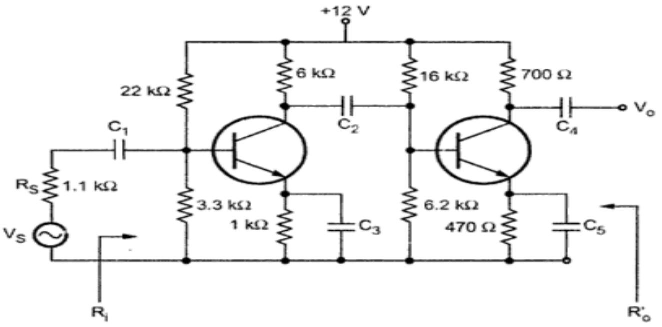
$$= \frac{V_m I_m}{2V_{CC} I_C}\ X100$$

$$= \frac{V_{CC} I_C}{2V_{CC} I_C}\ X100$$

$$= 50\%$$

(OR)

5. a) **For a two-stage amplifier shown in figure 1 calculate (a)A_v (b) A_{vs}, (c) R_i (d) R_o. Neglect the effect of all capacitances, assume that both the transistors are identical with following parameters. h_{fe}=50, h_{ie}=1.1KΩ, h_{re}= 2.5 ×10^{-4} h_{oe}=24×10^{-6} A/V**



Ans

Calculation of Input impedance, Voltage gain and current gain from output stage to input stage — 2M

Individual stages and overall amplifier — 3M

Output impedance form input stage to output stage — 2M

$$A_I = \frac{-h_{fe}}{1 + h_{oe}R_L}$$

$$R_i = h_i + h_{re}A_I R_L$$

$$A_v = \frac{A_I R_L}{R_i}$$

$$Y_0 = h_{oe} - \frac{h_{fe}h_{re}}{R_S + h_{ie}}$$

$$R_o = \frac{1}{Y_0}$$

$$A_{vs} = Av\, Rs/\,(Rs+Ri)$$

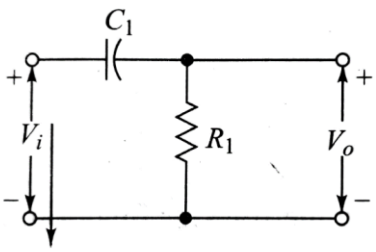
b) **Discuss about the frequency response of an amplifier.**

Frequency response curve with explanation — 3M

Low frequency analysis with the help of HPF (Circuit diagram +Analysis) — 2M

High frequency analysis with the help of LPF (Circuit diagram +Analysis) — 2M

i. Low-frequency response: The low-frequency response of an amplifier is computed using high-pass RC circuit.



Applying Laplace transform on the circuit, we get the relationship between the output and input voltage as:

$$V_o(s) = \frac{V_i(s)R_1}{R_1 + 1/sC_1}$$

$$= V_i(s)\frac{s}{s + 1/R_1C_1}$$

Thus, the voltage transfer function at low frequencies, $A_L(s)=V_o(s)/V_i(s)$, has one zero at s=o and one pole at $s=-1/R_1C_1$. For real frequencies ($s=jw=j2\pi$), the $A_L(s)$ becomes

$$A_L(jf) = \frac{1}{1 - j(f_L/f)}$$

where

$$f_L = \frac{1}{2\pi R_1C_1}$$

The magnitude $|A(jf)|$ and phase θ_L of the gain are given by

$$|A_L(jf)| = \frac{1}{\sqrt{1 + (f_L/f)^2}}$$

$$\theta_L = \arctan\frac{f_L}{f}$$

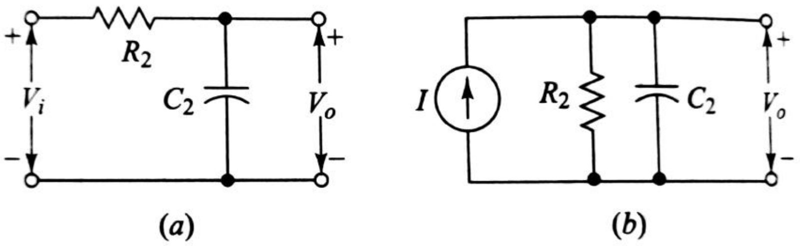
At $f=f_L$, $|A_L(jf)|=0.707$

At $f>>f_L$, $|A_L(jf)|$ approaches 1

At $f<f_L$, $|A_L(jf)|$ is proportional to the frequency

The frequency f_L at which the gain has fallen to 0.707 times its midband value of *Ao*. This is same as a decibel reduction of *20log(0.707)* or *3-dB*. Hence, the frequency f_L referred to as *lower 3-dB frequency*.

ii. High-frequency response: The high-frequency response of an amplifier is computed using low-pass RC circuit.



Applying Laplace transform on the circuit, we get the relationship between the output and input voltage as:

$$V_o(s) = \frac{1/sC_2}{R_2 + 1/sC_2}V_i(s)$$

$$= \frac{1}{1 + sR_2C_2}V_i(s)$$

Thus, the voltage transfer function at low frequencies, $A_H(s)=V_o(s)/V_i(s)$, has one pole at $s=-1/R_2C_2$. For real frequencies ($s=jw=j2\pi$), The magnitude $|A_H(jf)|$ and phase θ_H of the gain are given by

$$|A_H(jf)| = |V_o(s)/V_i(s)|_{s=j2\pi f}$$

$$|A_H(jf)| = \frac{1}{\sqrt{1+(f/f_H)^2}}$$

$$\theta_H = -\arctan\frac{f}{f_H}$$

Where

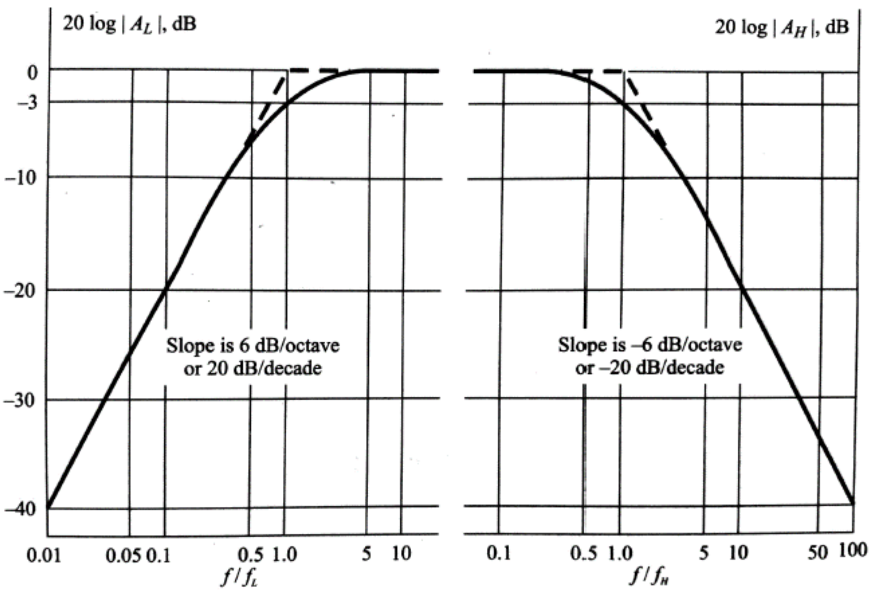
$$f_H = \frac{1}{2\pi R_2 C_2}$$

At $f=f_H$, $|A_H(jf)|=0.707$

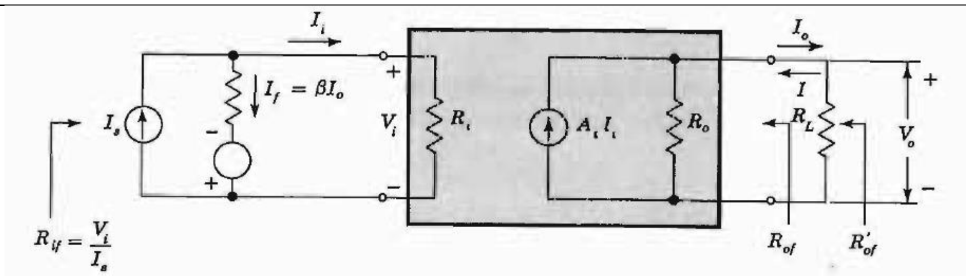
At $f<<f_H$, $|A_H(jf)|$ approaches 1

At $f>f_H$, $|A_H(jf)|$ is indirectly proportional to the frequency.

The frequency f_H at which the gain has fallen to 0.707 times its midband value of *Ao*. This is same as a decibel reduction of *20log(0.707)* or *3-dB*. Hence, the frequency f_H referred to as *upper 3-dB frequency*.



	UNIT III		
6.	a)	**Draw the circuit diagram of current shunt feedback and derive expressions for input and output resistance**	
	Ans	**h-Parameter equivalent circuit and identifying of input impedance decreases and output impedance increases.** **Input Impedance Calculation** **Output Impedance Calculation**	3M 2M 2M



$$I_s = I_i + I_f = I_i + \beta I_o$$

and

$$I_o = \frac{A_i R_o I_i}{R_o + R_L} = A_I I_i$$

where

$$A_I \equiv \frac{I_o}{I_i} = \frac{A_i R_o}{R_o + R_L}$$

$$I_s = (1 + \beta A_I) I_i$$

$$R_{if} = V_i / I_s \text{ and } R_i = V_i / I_i.$$

$$R_{if} = \frac{V_i}{(1 + \beta A_I) I_i} = \frac{R_i}{1 + \beta A_I}$$

Output Impedance:

$$I = \frac{V}{R_o} - A_i I_i$$

With $I_s = 0$, $I_i = -I_f = -\beta I_o = +\beta I$. Hence

$$I = \frac{V}{R_o} - \beta A_i I \qquad \text{or} \qquad I(1 + \beta A_i) = \frac{V}{R_o}$$

$$R_{of} = \frac{V}{I} = R_o(1 + \beta A_i)$$

Note that R_o is multiplied by the desensitivity factor $1 + \beta A_i$ which c the short-circuit current gain A_i (*not* A_I).

The output resistance R'_{of} which includes R_L as part of the amplifie given by $R'_o(1 + \beta A_I)$, as one might thoughtlessly expect. We shall n the correct expression for R'_{of}.

$$R'_{of} = \frac{R_{of} R_L}{R_{of} + R_L} = \frac{R_o(1 + \beta A_i) R_L}{R_o(1 + \beta A_i) + R_L}$$

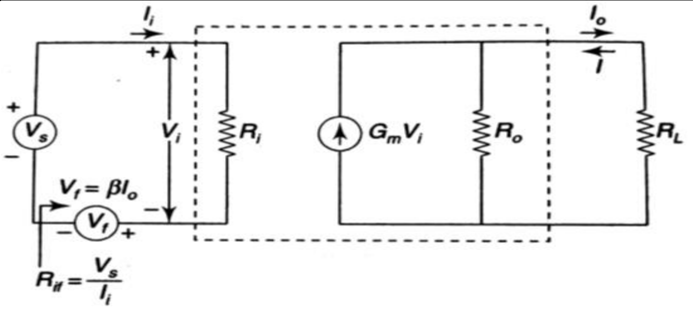
$$= \frac{R_o R_L}{R_o + R_L} \frac{1 + \beta A_i}{1 + \beta A_i R_o/(R_o + R_L)}$$

$$R'_{of} = R'_o \frac{1 + \beta A_i}{1 + \beta A_I}$$

For $R_L = \infty$, $A_I = 0$ and $R'_o = R_o$,

$$R'_{of} = R_o(1 + \beta A_i)$$

	b)	**An RC coupled amplifier has a voltage gain of 1000, f_1=50Hz, f_2=200KHz and a distortion of 5% without feedback. Find the amplifier voltage gain, f_{1f}, f_{2f} and distortion when a negative feedback is applied with the feedback ratio of 0.01.**	
		Formulas **Calculations** $D_f = \frac{D}{1 + A_v\beta}$ $A_f = \frac{A}{1 + A\beta}$ $f_{1f} = \frac{f1}{1 + A\beta}$ $f_{2f} = f2\ (1 + A\beta)$ $BW_f = BW(1 + A\beta)$	4M 3M
	(OR)		
7.	a)	**Enumerate the effects of negative feedback on the various characteristics of the amplifier?**	
	Ans	• Input impedance and output impedance can be modified as desired (increases or decreases) • Improves the frequency response. • Provides more linearity. (High Fidelity) • Decrease in Gain $A_f = \frac{A}{1 + A\beta}$ • Stabilized gain $\frac{dA_f}{A_f} = \frac{dA}{A} \frac{1}{(1 + A\beta)}$ • Increase of Bandwidth $BW_f = BW(1 + A\beta)$ • Decrease in amplitude and phase Distortion. $D_f = \frac{D}{1 + A_v\beta}$ • Decrease in Noise $N_f = \frac{N}{1 + A_v\beta}$	1M 1M 1M 1M 1M 1M
	b)	**Derive the expression for R_{if} and R_{of} in current series feedback amplifier?**	
	Ans	**h-Parameter equivalent circuit and identifying of input impedance increases and output impedance increases.** **Input Impedance Calculation** **Output Impedance Calculation** The input circuit is represented by Thevenins model and output circuit is represented by Nortons model.	3M 2M 2M



By applying KVL at the input side, we get

$$V_s = I_i R_i + V_f = I_i R_i + \beta I_o$$

And the output current is given by

$$I_o = \frac{G_m V_i R_o}{R_o + R_L} = G_M V_i$$

Where

$$G_M = \frac{I_o}{V_i} = \frac{G_m R_o}{R_o + R_L}$$

By substituting G_M in V_s, we get

$$V_s = I_i R_i + \beta G_M I_i R_i$$

Therefore then input resistance with feedback is

$$R_{if} = \frac{V_s}{I_i} = R_i (1 + \beta G_M)$$

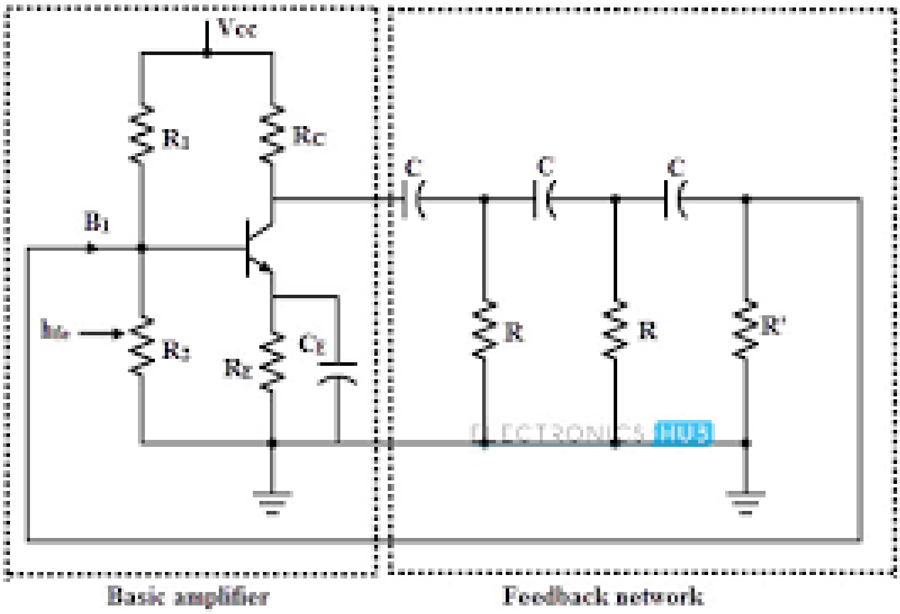
The relationship between short-circuit transconductance G_m and transconductance without feedback G_M by taking R_L into account is given by

$$G_m = \lim_{R_L \to 0} G_M$$

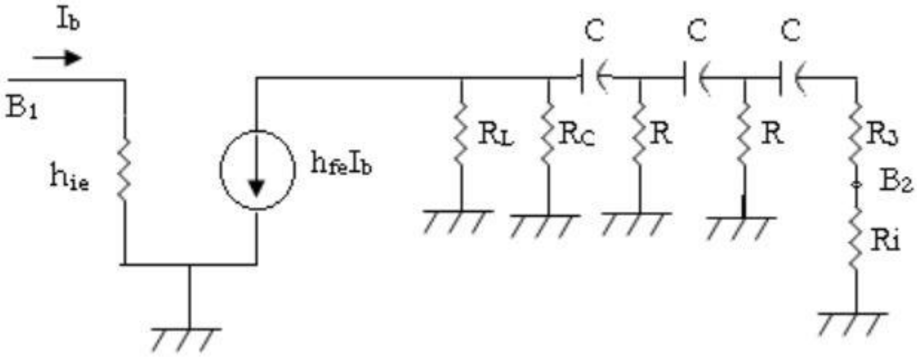
$$R_{of} = R_o(1+\beta G_m)$$

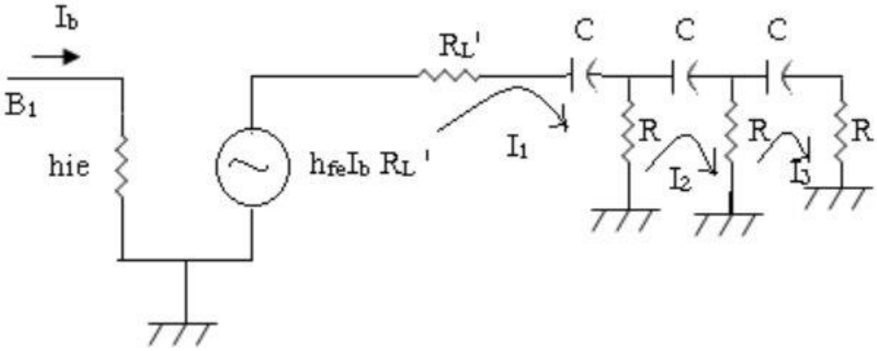
$$R_{of}' = R_o' \frac{(1+\beta G_m)}{(1+\beta G_m)}$$

	UNIT IV		
8.	a)	**State the Bark Hausen criteria. And explain about the operation of RC-Phase shift Oscillators.**	
	Ans	**Barkhausen Criteria.** **RC-Phase Shift Oscillator Circuit diagram** **h-Parameter equivalent circuit** **Operation** Oscillator is a positive feedback amplifier which is going generate a periodic output waveform without giving any external input signal.	2M 2M 1M 2M



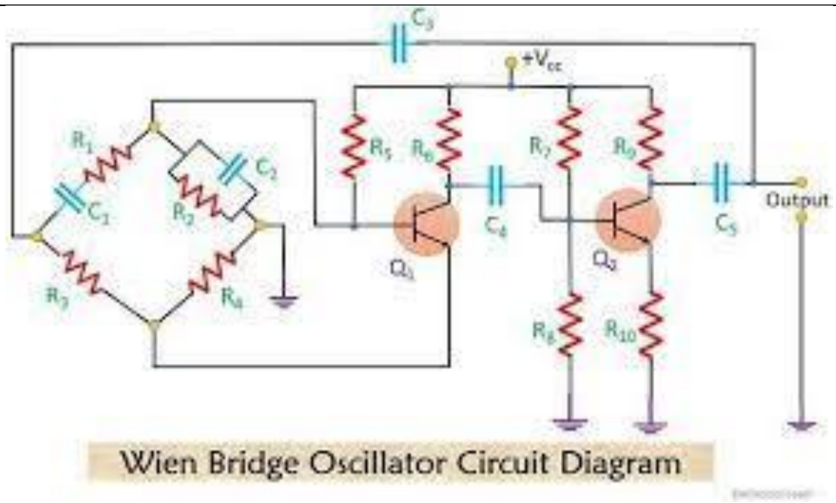
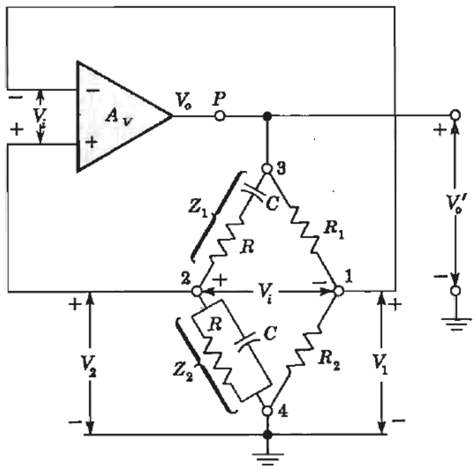
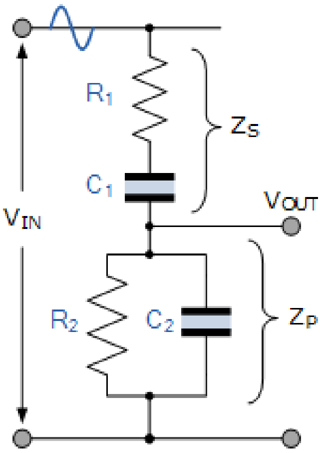
$R = R_i + R_3$

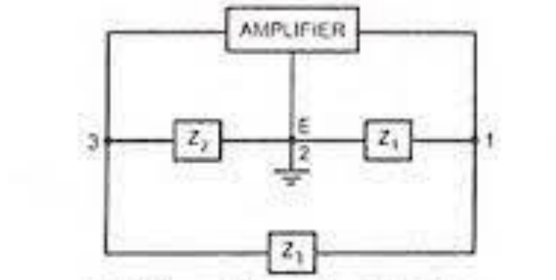
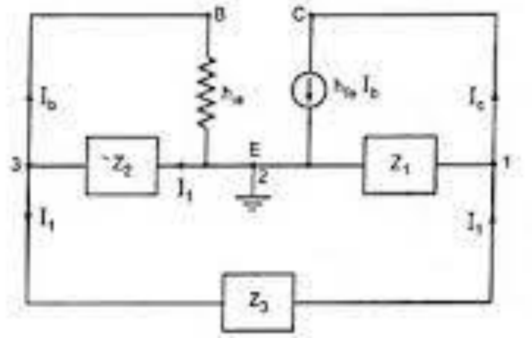




$$f = \frac{1}{2\pi RC\sqrt{6 + 4\frac{R_C}{R}}}$$

	b)	**Draw the circuit of Wein bridge oscillator and derive the expression for frequency of oscillations.**	
	Ans	**Circuit diagram using BJT or Op-amp.** **Operation** **Frequency of oscillation calculation** **Frequency expression**	2M 2M 2M 1M

		 **(or)**  Fig. 14-34 Wien bridge oscillator using an operational amplifier as the active element.  $f_r = \frac{1}{2\pi RC}$	
	(OR)		
9.	a)	**List advantages and applications of crystal oscillator. A crystal oscillator has L=2H, C=0.01PF and R=2KΩ. Its mounting capacitance is 2PF. Calculate its series and parallel frequency?**	
	Ans	Advantages of crystal oscillator Applications of crystal oscillator Series resonant frequency calculation Parallel resonant frequency calculation $f_s = \frac{1}{2\pi\sqrt{LC}}$ $f_p = \frac{1}{2\pi\sqrt{LC_T}}$ $C_T = \frac{CC_m}{C + C_m}$ Where $C_m$is mounting capacitance	1M 2M 2M 2M

	b)	**Derive an expression for general form of LC Oscillators.**	
	Ans	**Circuit Diagram** **h-Parameter equivalent Circuit** **Derivation for general form** **Final General form of LC oscillators expression**  *(a) General Form of an Oscillator*  *(b) Equivalent Circuit* Fig. 21.6 $\mathbf{h_{ie}(Z_1+Z_2+Z_3) +(1+h_{fe})Z_1Z_2+Z_1Z_3=0}$	2M 1M 3M 1M