Revision :**2015**

Course Title :**Electronic Devices and Circuits**

Course code :**3044**

Question No.	Scoring Indicators	Split Score	Sub total	Total
I 1	The load line is drawn by joining the saturation and cut off points. The region that lies between these two is the **linear region**. A transistor acts as a good amplifier in this linear region. If this load line is drawn only when DC biasing is given to the transistor, but **no input** signal is applied, then such a load line is called as **DC load line**..	2	2	2
I 2	• RC coupled amplifier. • Transformer coupled amplifier • Direct coupled amplifier.	2	2	2
I 3	• Bipolar junction transistors are current controlled and Field effect transistors are voltage controlled. • The input impedance of FET has high compared with bipolar junction transistors • The BJT is responsible for overheating due to a negative temperature co-efficient. • FET has a postive temperature coefficient for stopping over heating	2	2	2
I 4	.The magnitude of the product of open loop gain of the amplifier and the magnitude of the feedback factor is unity, i.e., $\|\beta A\|=1$ where A is the gain of the amplifying element in the circuit and $\beta(j\omega)$ is the transfer function of the feedback path.	2	2	2
I 5	In a Schmitt trigger, the voltages at which the output switches from $+v_{sat}$ to $-v_{sat}$ or vice versa are called upper trigger point (UTP) and lower trigger point (LTP). the difference between the two trip points is called hysteresis.	2	2	2.

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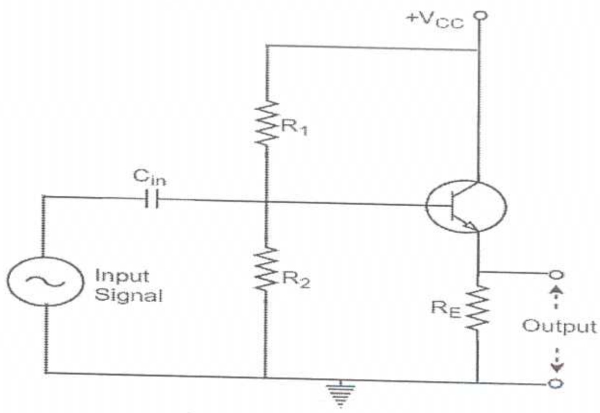
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>II 1</td><td>In the Common Collector transistor configuration, we use the collector terminal as common for both input and output signals. This configuration is also known as emitter follower configuration because the emitter voltage follows the base voltage. The emitter follower configuration is mostly used as a voltage buffer. These configurations are widely used in impedance matching applications because of their high input impedance.



The major characteristics of the emitter follower are as follows –

• No voltage gain. In fact, the voltage gain is nearly 1.
• Relatively high current gain and power gain.
• High input impedance and low output impedance.
• Input and output ac voltages are in phase.</td><td>3

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<tr><td>II 2</td><td>A simple transistor amplifier circuit consisting of a parallel tuned circuit in its collector load makes a single tuned amplifier circuit. The output can be obtained from the coupling capacitor C_C or from a secondary winding placed at L.

The tuned circuit offers high impedance to the signal frequency, which helps to offer high output across the tuned circuit. As high impedance is offered only for the tuned frequency, all the other frequencies which get lower impedance are rejected by the tuned circuit. Hence the tuned amplifier selects and amplifies the desired frequency signal.</td><td>2</td><td></td><td></td></tr>
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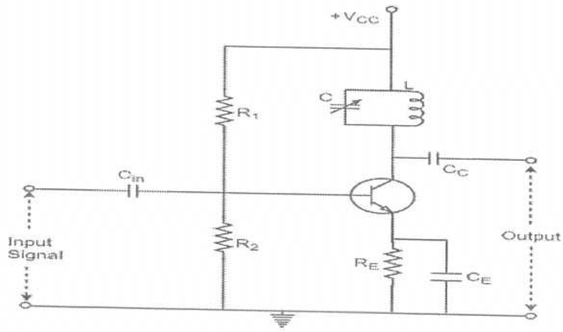
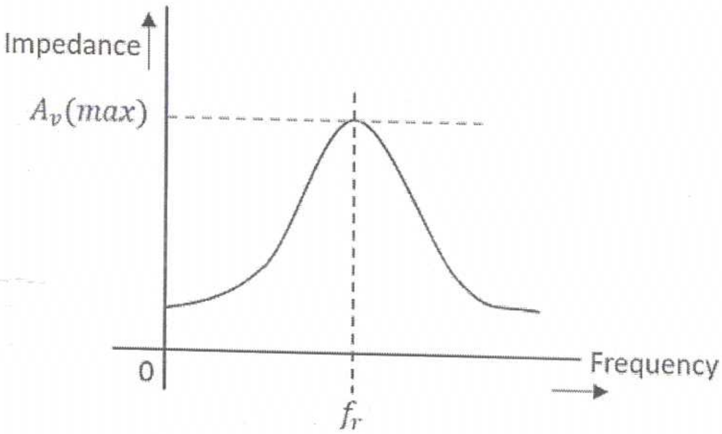


The parallel resonance occurs at resonant frequency f_r when the circuit has a high Q. the resonant frequency f_r is given by

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$



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<tr>
<td>II 3</td>
<td>
□ Class A amplifier – The biasing conditions in class A power amplifier are such that the collector current flows for the entire AC signal applied.

□ Class B amplifier – The biasing conditions in class B power amplifier are such that the collector current flows for half-cycle of input AC signal applied.

□ Class C amplifier – The biasing conditions in class C power amplifier are such that the collector current flows for less than half cycle of input AC signal applied.

□ Class AB amplifier – The class AB power amplifier is one which is created by combining both class A and class B in order to have all the advantages of both the classes and to minimize the problems they have
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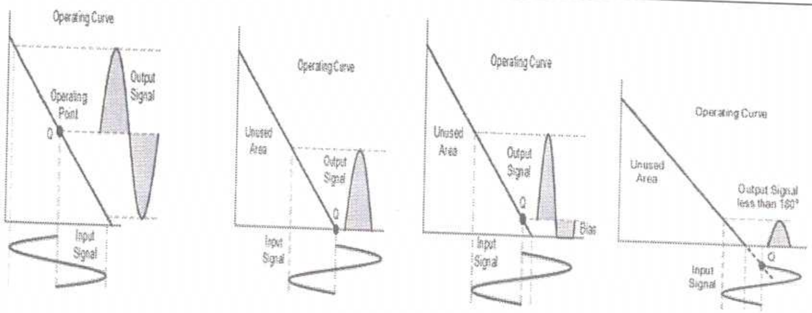
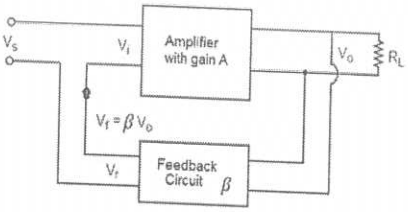
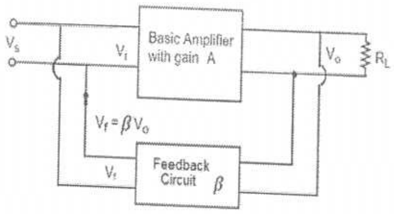
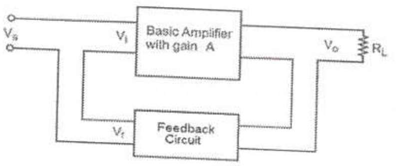
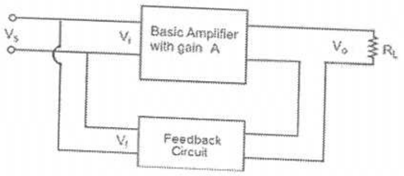
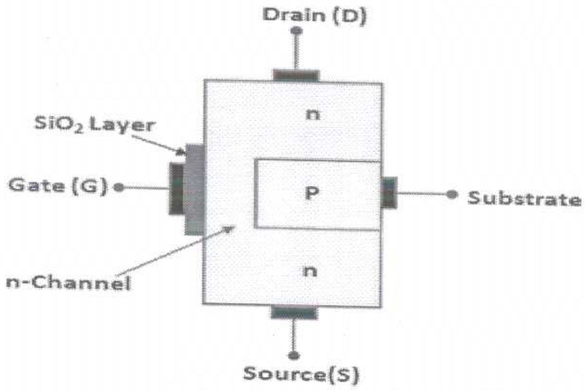
	 Class A Class B Class AB Class C	3	6	6.
II 4	Negative feedback in an amplifier is the method of feeding a portion of the amplified output to the input but in opposite phase. There are four main types of negative feedback circuits. They are – • Voltage-series feedback • Voltage-shunt feedback • Current-series feedback • Current-shunt feedback  Voltage-Series Feedback  Voltage-Shunt Feedback  Current-Series Feedback  Current-Shunt Feedback	2 4	6	6

II 5

(n-Channel D-MOSFET



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The n-channel D-MOSFET is a piece of n-type material with a p-type region called substrate on the right and an insulated gate on the left as shown in fig. The free electrons flowing from source to drain must pass through the narrow channel between the gate and the p-type region (i.e. substrate).

A thin layer of metal oxide, usually silicon dioxide (SiO2) is deposited over a small portion of the channel. A metallic gate is deposited over the oxide layer. As SiO2 is an insulator, therefore, gate is insulated from the channel.

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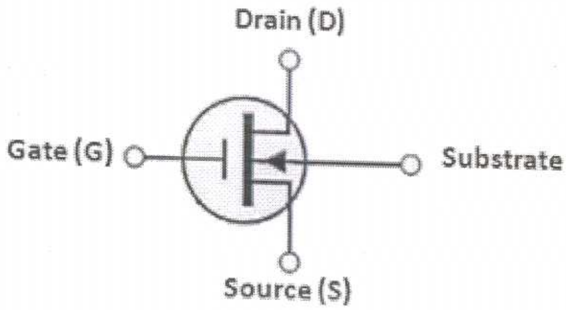
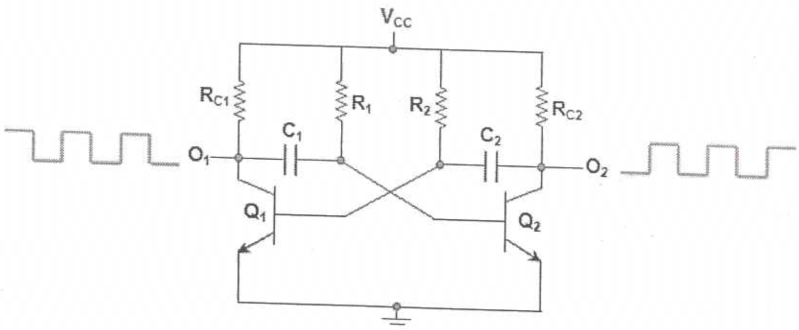
The substrate is connected to the source internally so that a MOSFET has three terminals such as Source (S), Gate (G) and Drain(D). Since the gate is insulated from the channel, we can apply either negative or positive voltage to the gate. Therefore, D-MOSFET can be operated in both depletion-mode and enhancement-mode. The symbol for n-channel D-MOSFET



6 6

II 6	***There are some important advantages of crystal oscillator are given below,*** • The crystal oscillators have very high frequency stability. • The crystal oscillator is possible to obtain very high precise and stable frequency of oscillators. • It has High frequency of operation. • It has very low frequency drift due to change in temperature and other parameters. • The Q is very high. • It has Automatic amplitude control ***There are some important application of crystal oscillator are given below,*** • The crystal oscillators are used in the frequency synthesizers. • It is used in special types of receivers. • It is used in radio and TV transmitters. • It is used as a crystal clock in microprocessors	3 3	6	6
II 7	**Astable multivibrators** are the multivibrators which have no stable state i.e. the multivibrators in which the output continuously oscillates between two permissible states. As a result, they produce square-wave at their output and are regarded to be free-running in-nature. Further, these multivibrators do not require any kind of external triggering, except the DC supply, due to which they fall under the category of relaxation oscillators  	3		

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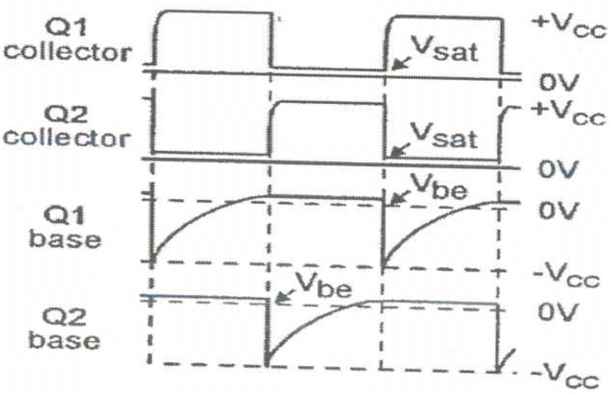
Working

• When the circuit is switched on one transistor will driven to saturation (ON) and other will driven to cutoff (OFF). Consider Q1 is ON and Q2 is OFF.
• During this time Capacitor C2 is charging to Vcc through resistor R.
• Q2 is OFF due to the negative voltage from the discharging capacitor C1 which is charged during the previous cycle. So the OFF time of Q2 is determined by R1C1 time constant.
• After a time period determined by R1C1 time constant the capacitor C1 discharges completely and starts charging in reverse direction through R1.
• When the Capacitor C1 charges to a voltage sufficient provide base emitter voltage of 0.7V to the transistor Q2, it turns ON and capacitor C2 starts dischargeing



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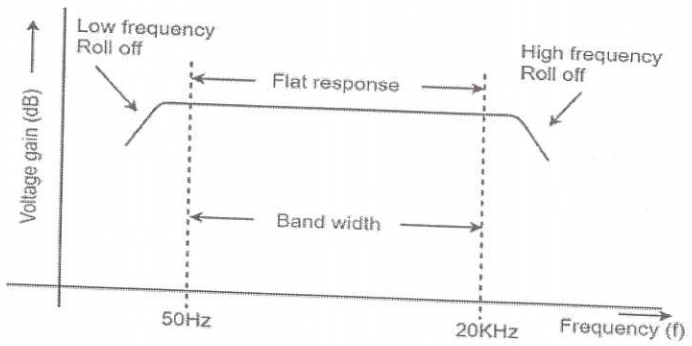
III a

Frequency response curve is a graph that indicates the relationship between voltage gain and function of frequency. The frequency response of a RC coupled amplifier is as shown in the following graph.



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From the above graph, it is understood that the frequency rolls off or decreases for the frequencies below 50Hz and for the frequencies above 20 KHz. whereas the voltage gain for the range of frequencies between 50Hz and 20 KHz is constant.

At Low frequencies (i.e. below 50 Hz)

The capacitive reactance is inversely proportional to the frequency. At low frequencies, the reactance is quite high. The reactance of input capacitor C_{in} and the coupling capacitor C_C are so high that only small part of the input signal is allowed. The reactance of the emitter by pass capacitor C_E is also very high during low frequencies. Hence it cannot shunt the emitter resistance effectively. With all these factors, the voltage gain rolls off at low frequencies.

At High frequencies (i.e. above 20 KHz)

A capacitor behaves as a short circuit, at high frequencies. As a result of this, the loading effect of the next stage increases, which reduces the voltage gain. Along with this, as the capacitance of emitter diode decreases, it increases the base current of the transistor due to which the current gain (β) reduces. Hence the voltage gain rolls off at high frequencies.

At Mid-frequencies (i.e. 50 Hz to 20 KHz)

The voltage gain of the capacitors is maintained constant in this range of frequencies, as shown in figure. If the frequency increases, the reactance of the capacitor C_C decreases which tends to increase the gain. But this lower capacitance reactive increases the loading effect of the next stage by which there is a reduction in gain.

Due to these two factors, the gain is maintained constant.

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Advantages of direct coupled <u>amplifier</u>

The direct coupled amplifier has a excellent frequency response.
The circuit cost is low because the absence of expensive coupling components.
The circuit is very simple because it uses a minimum number of <u>resistors</u>.
It can amplify very low frequency signals down to zero frequency.

Disadvantages of direct coupled amplifier

The direct coupled amplifier cannot amplify high frequency signals.
Its output is not drifting less.
The output changes with the time and change in supply voltage.
It has poor temperature stability, due to this its operating point shifts.
At low frequencies <u>capacitor</u> fail and act like a short circuit.

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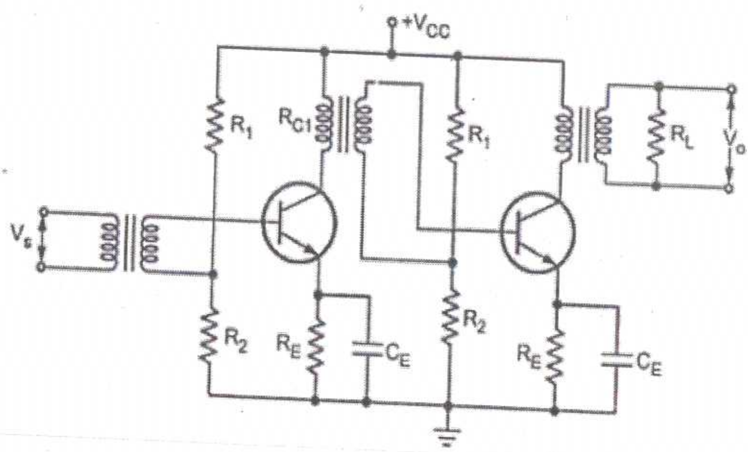

Figure shows transformer coupled amplifier using transistors. The output signal of first stage is coupled to the input of the next stage through an impedance matching transformer
This type of coupling is used to match the impedance between output an input cascaded stage. Usually, it is used to match the larger output resistance of AF power amplifier to a low impedance load like loudspeaker. As we know, transformer blocks d.c, providing d.c.
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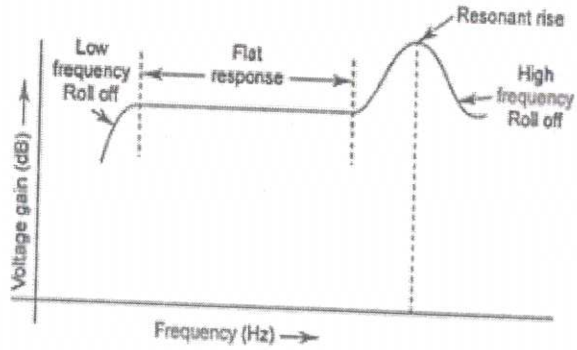
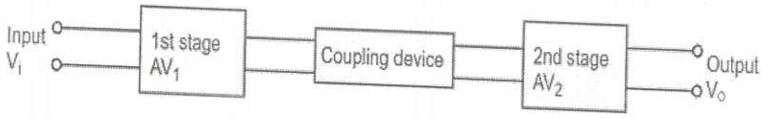
isolation between the two stages. Therefore, transformer coupling does not affect the quiescent point of the next stage



IV b

In Multi-stage amplifiers, the output of first stage is coupled to the input of next stage using a coupling device. These coupling devices can usually be a capacitor or a transformer. This process of joining two amplifier stages using a coupling device can be called as **Cascading.**

The following figure shows a two-stage amplifier connected in cascade.



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The overall gain is the product of voltage gain of individual stages.

$$A_V = A_{V1} \times A_{V2} = \frac{V_2}{V_1} \times \frac{V_0}{V_2} = \frac{V_0}{V_1}$$

Where A_V = Overall gain, A_{V1} = Voltage gain of 1st stage, and A_{V2} = Voltage gain of 2nd stage.

4 7 7

If there is n number of stages, the product of voltage gains of those **n** stages will be the overall gain of that multistage amplifier circuit.

V a

Power Amplifier	Voltage Amplifier
The power amplifier amplifies the power of a signal.	Voltage amplifier amplifies the voltage or increases the voltage level of a signal.
The input signal of the power amplifier must have a high magnitude.	The voltage amplifier can work with low magnitude signal.
The current gain of the power amplifier is very high, it greater than 100	The current gain of the voltage amplifier is very low, it lies between 5 to 20
Transformer coupling is used in Power Amplifier.	RC coupling is used in Voltage amplifier.
The transistor used in the Power Amplifier has a thick base because it handles the very large current.	The transistor used in the voltage amplifier has a thin base because it not handle large current.
The output impedance of the power amplifier is very low, up to 200ohm	The output impedance of the voltage amplifier is very high, about 12 kilo-ohm
The transistor used can dissipate more heat produced as compared to voltage amplifier during its operation	The transistor used can dissipate less heat produced during its operation

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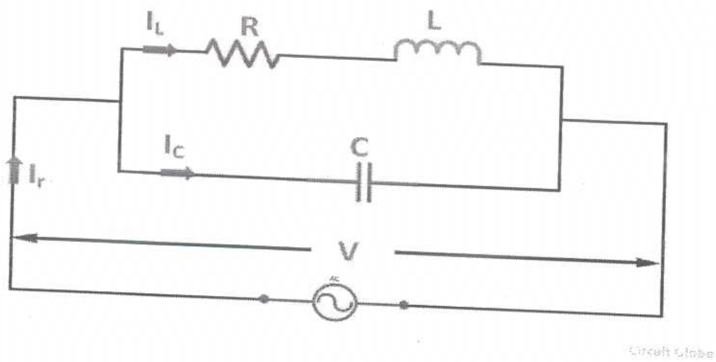
V b

Inductor and capacitor connected in parallel with respect to supply source. Resistance R represents the coil resistance. The capacitor C is assumed to be lossless



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$I_L = \frac{V_s}{X_L}$ Which lags 90 degree with Vs

$I_c = \frac{V_s}{X_c}$ Which leads 90 degree with Vs

If $X_c < X_L$ then $I_c > I_L$ and the circuit act as capacitive

If $X_L < X_c$ then $I_L > I_c$ and the circuit act as inductive

Resonance occurs when $X_L = X_C$

$$X_L = X_C \Rightarrow 2\pi f L = \frac{1}{2\pi f C}$$

$$f^2 = \frac{1}{2\pi L \times 2\pi C} = \frac{1}{4\pi^2 LC}$$

$$f = \sqrt{\frac{1}{4\pi^2 LC}}$$

$$\therefore f_r = \frac{1}{2\pi\sqrt{LC}} \text{ (Hz)} \quad \text{or} \quad \omega_r = \frac{1}{\sqrt{LC}} \text{ (rads)}$$

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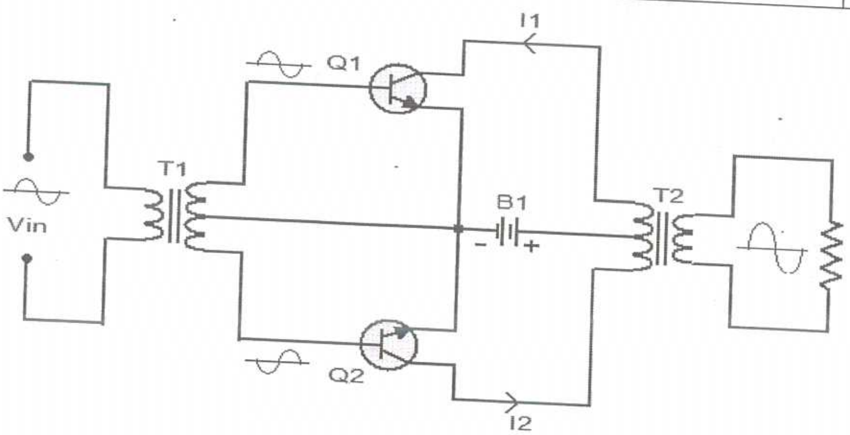
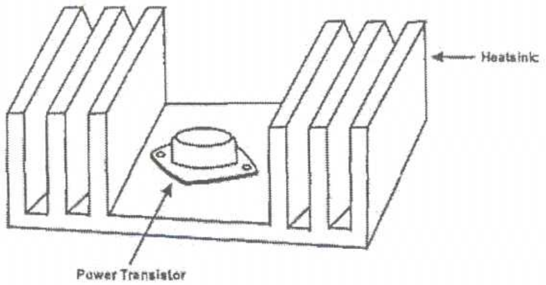
VI a	 The input signal is converted into two similar but phase opposite signals by the input transformer T1. One out of these two signals is applied to the base of the upper transistor while the other one is applied to the base of the other transistor. You can understand this from the circuit diagram. When transistor Q1 is driven to the positive side using the positive half of its input signal, the reverse happens in the transistor Q2. That means when the collector current of Q1 is going in the increasing direction, the collector current of Q2 goes in the decreasing direction. Anyway the current flow through the respective halves of the primary of the T2 will be in same direction. Have a look at the figure for better understanding. This current flow through the T2 primary results in a wave form induced across its secondary. The wave form induced across the secondary is similar to the original input signal but amplified in terms of magnitude	4	4 8	8
VI b	In power transistor or large signal transistors, the power to be dissipated at the collector causes junction temperature to rise to a high level. It is possible to increase the power handling capacity of the transistor if a device that can cause rapid conduction of heat away from the junction is used. Such a device is called a heat sink. A heat sink is a mechanical device. It is connected to the case of the semiconductor device. So it is providing a path for the heat transfer. The heat flows through the heat sink and is radiated to surrounding air.	5		

	If a heat sink is not used then all the heat has to transferred from a transistor case to surrounding air causing case temperature to increase. If the power handled by the transistor is higher, then the case temperatures will be higher. The temperature of the two types of power transistor is Germanium: 100°C to 110°C Silicon : 150°C to 200°C Heat sinks increase the power rating (ie. power handling capacity) of a transistor by getting rid of the heat developed quickly. It is in the form of a sheet of metal. Since the power dissipation within a transistor is mainly due to power dissipated at collector junction, the collector (connected to the case of the transistor) is bolted on to metal sheet for faster radiation of heat.  	2	7	7

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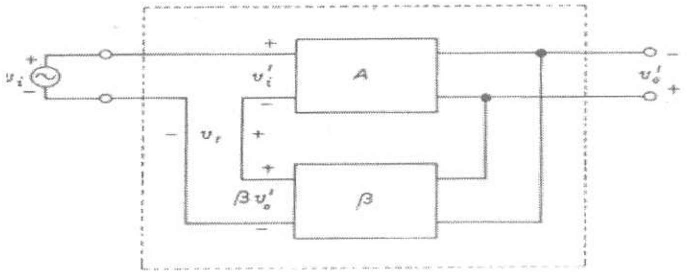

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The input to this feedback amplifier is v_i and the output is v_o'. The voltage gain of this feedback amplifier is then

$$A_f = \frac{v_o'}{v_i}$$

The effective input to the basic amplifier (i.e. the amplifier with no feedback connections) is v_i' and not the external input v_i. In fact, due to negative feedback, the effective input voltage gets modified and becomes

$$v_i' = v_i - v_f$$

Here, the feedback voltage v_f is related to the output voltage v_o' through the β-network.

$$v_f = \beta v_o'$$

The constant β is known as *fedback factor*.
the value of β is

$$\beta = \frac{R_1}{R_1+R_2}$$

For the basic amplifier, the input is v_i' and the output is v_o' Hence, its voltage gain A (called *internal gain*) is given as

$$A = \frac{v_o'}{v_i'}$$

v_i

We shall now derive the expression of the gain A_f in terms of A (internal gain) and β.

$$v_i' = v_i - \beta v_o' \qquad (\text{since } v_f = \beta v_o')$$

or $$(v_o'/A) = v_i - \beta v_o' \qquad (\text{since } v_i' = v_o'/A)$$

or $$v_o = A v_i - A\beta v_o'$$

or $$(1+A\beta)\, v_o' = A v_i$$

or $$\frac{v_o'}{v_i} = \frac{A}{1+A\beta}$$

According to Eq. 12.3, the left hand side of the above equation is A_f.

Hence, $$A_f = \frac{A}{1+A\beta}$$

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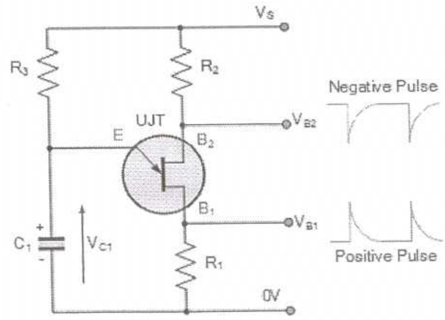
VII b



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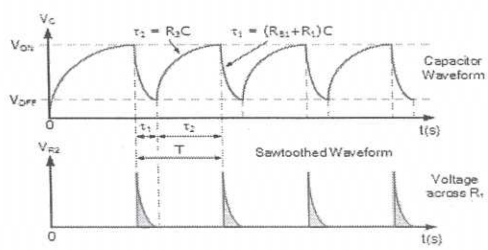
When a voltage (Vs) is firstly applied, the unijunction transistor is "OFF" and the capacitor C1 is fully discharged but begins to charge up exponentially through resistor R3. As the Emitter of the UJT is connected to the capacitor, when the charging voltage Vc across the capacitor becomes greater than the diode volt drop value, the p-n junction behaves as a normal diode and becomes forward biased triggering the UJT into conduction. The unijunction transistor is "ON". At this point the Emitter to B1 impedance collapses as the Emitter goes into a low impedance saturated state with the flow of Emitter current through R1 taking place.

2

As the ohmic value of resistor R1 is very low, the capacitor discharges rapidly through the UJT and a fast rising voltage pulse appears across R1. Also, because the capacitor discharges more quickly through the UJT than it does charging up through resistor R3, the discharging time is a lot less than the charging time as the capacitor discharges through the low resistance UJT.

When the voltage across the capacitor decreases below the holding point of the p-n junction (V_{OFF}), the UJT turns "OFF" and no current flows into the Emitter junction so once again the capacitor charges up through resistor R3 and this charging and discharging process between V_{ON} and V_{OFF} is constantly repeated while there is a supply voltage, Vs applied.

UJT Oscillator Waveforms



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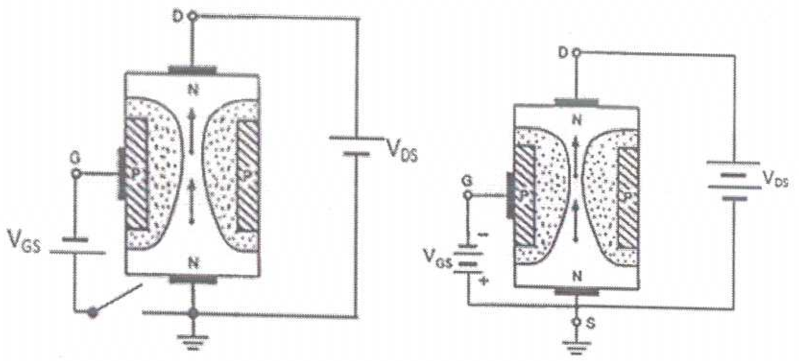
VIII a	A JFET is a three terminal semiconductor device in which current conduction is by one type of carrier i.e. electrons or holes. The current conduction is controlled by means of an electric field between the gate and the conducting channel of the device. The JFET has high input impedance and low noise level  The working of N channel JFET can be explained as follows: When a voltage V_{DS} is applied between drain and source terminals and voltage on the gate is zero as shown in fig.(i), the two pn junctions at the sides of the bar establish depletion layers. The electrons will flow from source to drain through a channel between the depletion layers. The size of the depletion layers determines the width of the channel and hence current conduction through the bar. When a reverse voltage V_{GS} is applied between gate and source terminals, as shown in fig. (ii), the width of depletion layer is increased. This reduces the width of conducting channel, thereby increasing the resistance of n-type bar. Consequently, the current from source to drain is decreased. On the other hand, when the reverse bias on the gate is decreased, the width of the depletion layer also decreases. This increases the width of the conducting channel and hence source to drain current. A p-channel JFET operates in the same manner as an n-channel JFET except that channel current carriers will be the holes instead of electrons and polarities of V_{GS} and V_{DS} are reversed.	4 4	8	8.

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1. Distortion reduction.
2. improvement in linearity of gain.
3. increases input impedance
4. decreases output impedance
5. Reduces noise
6. Improves frequency response

Disadvantage:

1. Reduction in gain
2. fast acting input transients pass uncorrected due to global feedback loop</td><td>5

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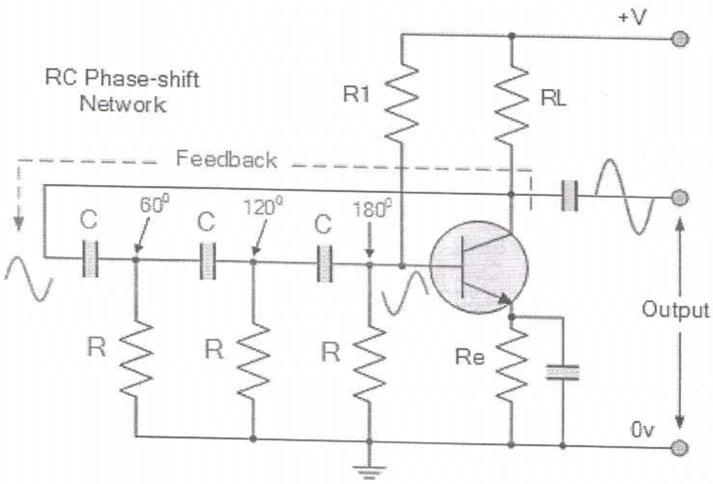
<tr><td>IX a</td><td>

The basic RC Oscillator which is also known as a Phase-shift Oscillator, produces a sine wave output signal using regenerative feedback obtained from the resistor-capacitor combination. This regenerative feedback from the RC network is due to the ability of the capacitor to store an electric charge, (similar to the LC tank circuit).

• If we use a common emitter amplifier with a resistive collector load, there will be a 180° phase shift between the voltages at base and collector. It will also amplify the signal.

• Feedback circuit section must produce another 180° shift to meet the Barkheusan criterion.

• Three sections of phase shift networks are used which is</td><td>4

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constituted by resistive-capacitor combination. In that each section introduces 60° phase shift at resonant frequency.

- The positive feedback from output to input will lead the circuit to operate as an oscillator.
- Phase shift oscillator is a particular type of audio frequency oscillator. Output signal is obtained across 1μF capacitor and ground terminal as shown in circuit schematic.

The frequency of oscillations produced by the RC oscillator is given as:

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

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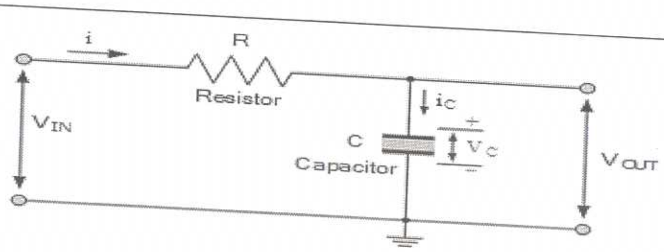
IX b



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RC Integrator. For an RC integrator circuit, the input signal is applied to the resistance with the output taken across the capacitor, then V_{OUT} equals V_C. As the capacitor is a frequency dependant element, the amount of charge that is established across the plates is equal to the time domain integral of the current.

$$i(t) = \frac{V_{IN}}{R} = \frac{V_R}{R} = C\frac{dV}{dt}$$

$$V_{OUT} = V_C = \frac{Q}{C} = \frac{\int i\,dt}{C} = \frac{1}{C}\int i(t)\,dt$$

$$V_{OUT} = \frac{1}{C}\int\left(\frac{V_{IN}}{R}\right)dt = \frac{1}{RC}\int V_{IN}\,dt$$ 3

$$V_{OUT} = \frac{1}{RC}\int_0^t V_{IN(t)}\,dt$$

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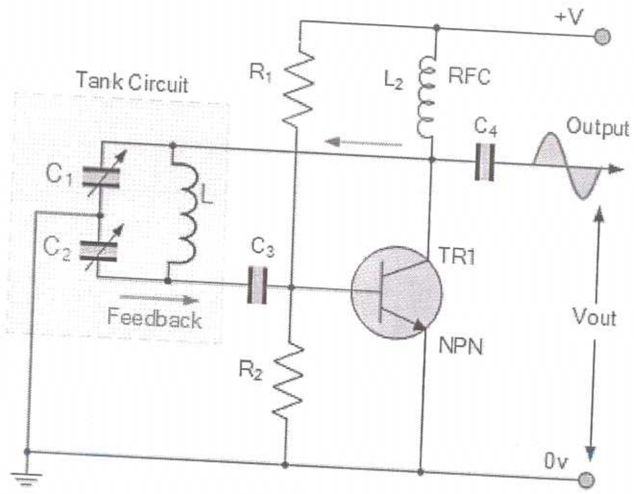
X a The Colpitts oscillator uses a capacitive voltage divider network as its feedback source. The two capacitors, C1 and C2 are placed across a single common inductor, L as shown. Then C1, C2 and L form the tuned tank circuit with the condition for oscillations being: $X_{C1} + X_{C2} = X_L$.



The emitter terminal of the transistor is effectively connected to the junction of the two capacitors, C1 and C2 which are connected in series and act as a simple voltage divider. When the power supply is firstly applied, capacitors C1 and C2 charge up and then discharge through the coil L. The oscillations across the capacitors are applied to the base-emitter junction and appear in the amplified at the collector output.

Resistors, R1 and R2 provide the usual stabilizing DC bias for the transistor in the normal manner while the additional capacitors act as a DC-blocking bypass capacitors. A radio-frequency choke (RFC) is used in the collector circuit to provide a high reactance (ideally open circuit) at the frequency of oscillation, (fr) and a low resistance at DC to help start the oscillations.

The required external phase shift is obtained in a similar manner to that in the Hartley oscillator circuit with the required positive feedback obtained for sustained undamped oscillations. The amount of feedback is determined by the ratio of C1 and C2. These two capacitances are generally "ganged" together to provide a constant amount of feedback so that as one is adjusted the other automatically follows.

The frequency of oscillations for a Colpitts oscillator is determined by the resonant frequency of the LC tank circuit and is given as:

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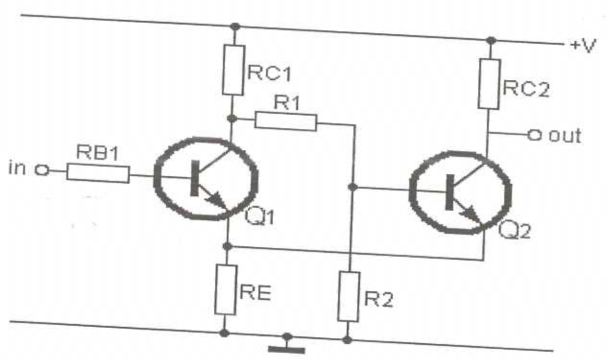
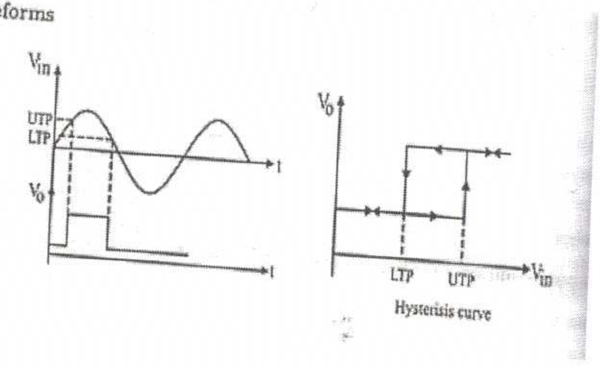
	$$f_r = \frac{1}{2\pi\sqrt{LC_T}}$$ where C_T is the capacitance of C1 and C2 connected in series and is given as: $$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} \quad \text{or} \quad C_T = \frac{C_1 \times C_2}{C_1 + C_2}$$			
X b	The Schmitt trigger is used for wave shaping circuits. It can be used for generation of a square wave from a sine wave input. Basically, the circuit has two opposite operating states like in all other multivibrator circuits. The Schmitt trigger is level sensitive and switches the output state at two distinct trigger levels. One of the triggering levels is called a lower trigger level (abbreviated as L.T.L) and the other as upper trigger level (abbreviated as U.T.L).			
	 **Figure 1: Schmitt Trigger Transistor Circuit** **Waveforms**  	3 2		

	Now suppose an A.C. signal is applied at the input of the Schmitt trigger (i.e. at the base of the transistor Q_1). As the input voltage increases above zero, nothing will happen till it crosses the upper trigger level (U.L.T). As the input voltage increases, above the upper trigger level, the transistor Q_1 conducts. The point, at which it starts conducting, is known as upper trigger point (U.T.P). As the transistor Q_1 conducts, its collector voltage falls below V_{CC}. This fall is coupled through resistor R_1 to the base of transistor Q_2 which reduces its forward bias. This in turn reduces the current of transistor Q_2 and hence the voltage drop across the resistor R_E. As a result of this, the reverse bias of transistor Q_1 is reduced and it conducts more. As the transistor Q_1 conducts more heavily, its collector further reduces due to which the transistor Q_1 conducts near cut-off. This process continues till the transistor Q_1 is driven into saturation and Q_2 into cut-off. At this instant, the collector voltage levels are $V_{C1} = V_{CE(sat)}$ and $V_{C2} = V_{CC}$ as shown in the figure The transistor Q_1 will continue to conduct till the input voltage falls below the lower trigger level (L.T.L). It will be interesting to know that when the input voltage becomes equal to the lower trigger level, the emitter base junction of transistor Q_1 becomes reverse biased. As a result of this, its collector voltage starts rising toward V_{CC}. This rising voltage increases the forward bias across transistor Q_2 due to which it conducts. The point, at which transistor Q_2 starts conducting, is called lower trigger point (L.T.P). Soon the transistor Q_2 is driven into saturation and Q_1 to cur-off. This completes one cycle. The collector voltage levels at this instant are $V_{C1} = V_{CC}$ and $V_{C2} = V_{CE(sat)}$. No change in state will occur during the negative half cycle of the input voltage.	2	7	7