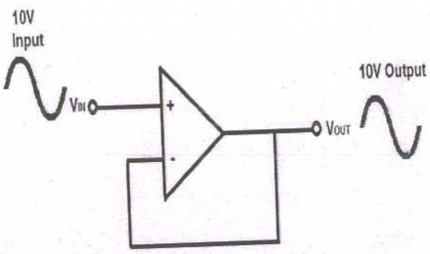
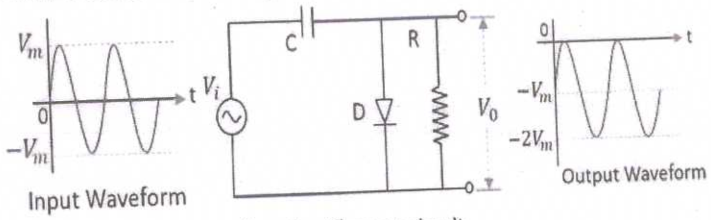
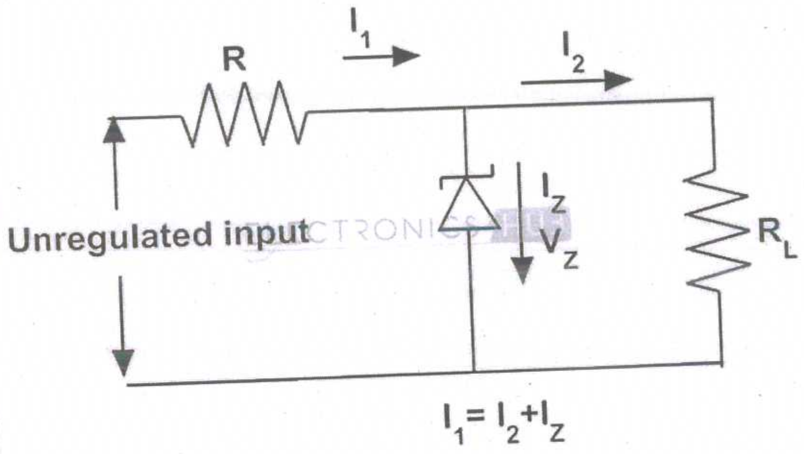
SCHEME OF EVALUATION

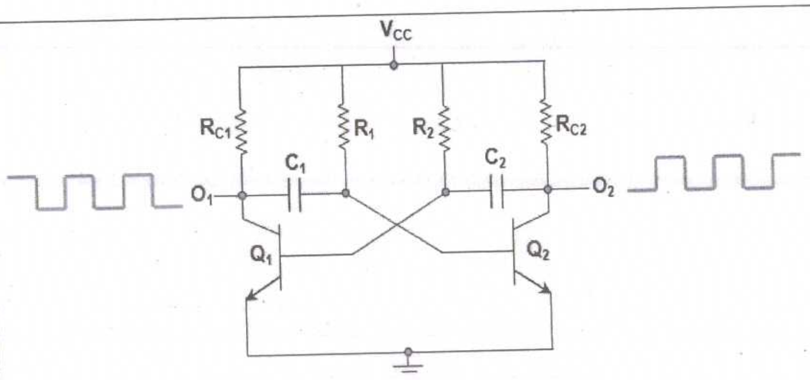
(Scoring Indicators)

Revision: 2015 Corse Title: Analog Devices and Circuits		Course Code: 3031		
Qn No.	Scoring Indicator	Split Score	Sub Total	Total
	Part A			
I 1	Using a filter or smoothing circuits can reduce ripples or ac components in the rectifier output and allow only dc to reach the load.	2	2	
2	• Negative feedback reduces noise and distortion • It improves stability of amplifier gain • It increases bandwidth • It increases input impedance ** Any two of the above	1 x 2	2	10
3	i) The magnitude of loop gain must be equal to one. ie $\mid A\beta \mid = 1$ ii) The total phase shift around closed loop is zero or 360 degrees	1 x 2	2	
4	• Used as square wave generators • Used in construction of digital voltmeter and SMPS	1 x 2	2	
5		2		

II 1	**Part B** A Negative Clamper circuit is one that consists of a diode, a resistor and a capacitor and that shifts the output signal to the negative portion of the input signal. The figure below explains the construction of a negative clamper circuit.  Negative Clamper circuit **During positive half cycle:** During the positive half cycle of the input AC signal, the diode is forward biased and hence no signal appears at the output. In forward biased condition, the diode allows electric current through it. This current will flows to the capacitor and charges it to the peak value of input voltage in inverse polarity $-V_m$. As input current or voltage decreases after attaining its maximum value V_m, the capacitor holds the charge until the diode remains forward biased. **During negative half cycle:** During the negative half cycle of the input AC signal, the diode is reverse biased and hence the signal appears at the output. In reverse biased condition, the diode does not allow electric current through it. So the input current directly flows towards the output. When the negative half cycle begins, the diode is in the non-conducting state and the charge stored in the capacitor is discharged (released). Therefore, the voltage appeared at the output is equal to the sum of the voltage stored in the capacitor ($-V_m$) and the input voltage ($-V_m$) {I.e. $V_o = -V_m - V_m = -2V_m$} which have the same polarity with each other. As a result, the signal shifted downwards.	Circuit diagram – 2 waveform – 2 Description - 2	6	42
2	Zener Diode is a general purpose diode, which behaves like a normal diode when forward biased. But when it is reverse biased above a certain voltage known as zener breakdown voltage **or** zener voltage **or** avalanche point **or** zener knee voltage the voltage remains constant for a wide range of current.			

	 Whenever a load is connected in parallel with zener diode, voltage across the load is same as the zener diode voltage. However the source voltage must be greater than the zener voltage. As the input voltage increases, current through the zener diode increases, but the drop in voltage remains constant which is the necessary feature required for zener diodes. Therefore, reverse current in the circuit has increased, voltage drop across the resistor increases by an amount equal to the difference between the applied input voltage and the zener knee voltage of the zener diode.	Circuit diagram – 3 Explanation - 3	6	
3	Classes of the amplifier represent the input cycle proportion when the current is passed through amplifier. Three important classifications of amplifier are :- • Class A Ampliier • Class B Ampliier • Class C Ampliier	2 marks each for specifying the type and its description 2 x 3	6	

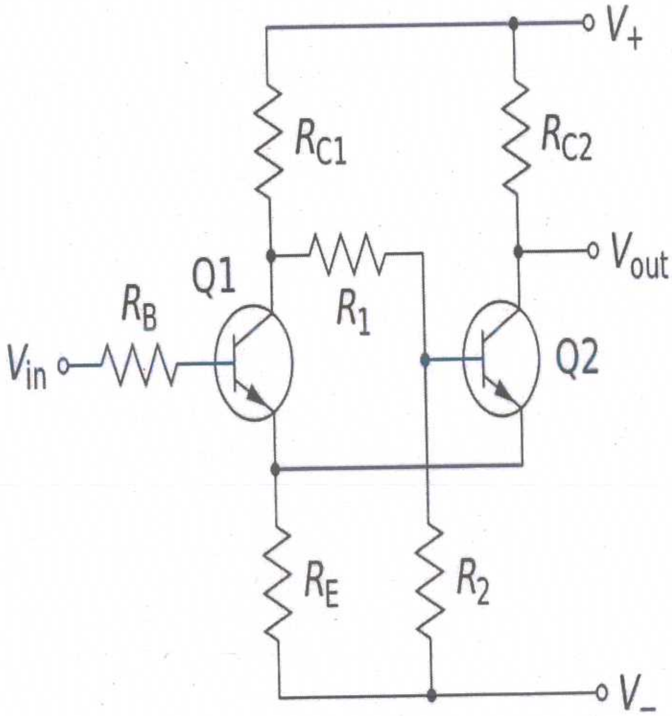
	Class A Amplifier Class A amplifier is a high gain amplifier with high linearity. In case of Class A amplifier, the conduction angle is 360 degree. As we stated above, a 360-degree conduction angle means the amplifier device remains active for the entire time and use complete input signal. **Class B Amplifier** The Class B amplifier is a bit different from the Class A. It is created using two active devices which conduct half of the actual cycle, ie 180 degrees of the cycle. Two devices provide combined current drive for the load. **Class C Amplifier** Apart from the Class A, B, and AB amplifier, there is another amplifier Class C. It's a traditional amplifier which works differently than the other amplifiers classes. Class C amplifier uses less than 180-degree conduction angle. Class C amplifier also gives huge distortion across the output.			
4	For many applications, the performance obtainable from a single-stage amplifier is often insufficient; hence several stages may be combined forming a multistage amplifier. These stages are connected in cascade, i.e. output of the first stage is connected to the input of second stage, whose output becomes input of third stage, and so on. The basic purposes of a coupling device are • To transfer the AC from the output of one stage to the input of next stage. • To block the DC to pass from the output of one stage to the input of next stage, which means to isolate the DC conditions. The three couplings generally used are. 1.RC coupling 2. Transformer coupling 3. direct coupling	Need for coupling – 3 For writing names of 3 coupling schemes 1 x 3	6	

5	 **Figure 1 Astable Multivibrator Using BJTs** It is free running oscillator which switches continuously between its two unstable states. With no external signal applied, the transistors alternately switch from cutoff to saturation state at a frequency determined by the RC time constants of the coupling circuits. • When the circuit is switched on one transistor will drive to saturation (ON) and other will drive 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 -ve 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 discharging. • The negative voltage from the capacitor C2 turns off the transistor Q1 and the capacitor C1 starts charging from Vcc through resistor R and base emitter of transistor Q2. Thus the transistor Q2 remains in ON state. • As in the previous state, when the capacitor C2 discharges completely it starts charging towards opposite direction through R2.	Circuit diagram – 3 Explanation - 3	6 6	

- When the voltage across the capacitor C2 is sufficient to turn ON transistor Q1, Q1 will turn ON and capacitor C1 starts discharging.
- These processes continue and produce rectangular waves at the collector of each transistor.

6

Circuit diagram – 3



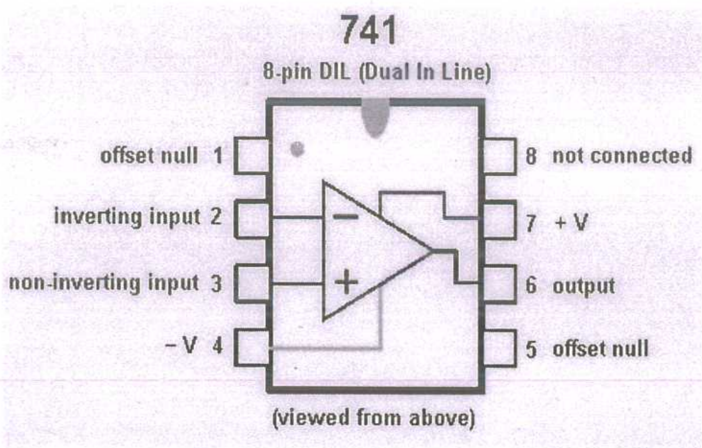
Explanation - 3

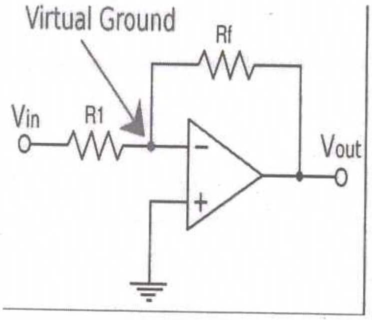
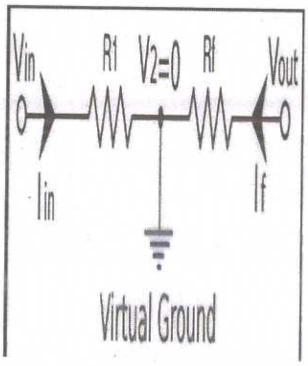
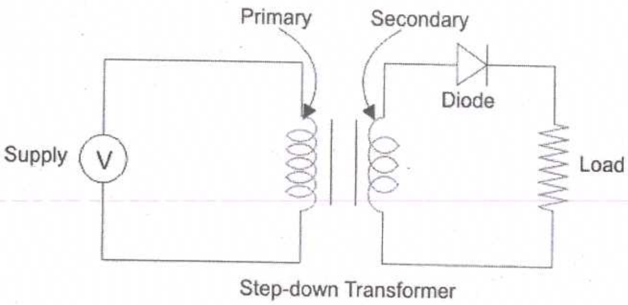
6

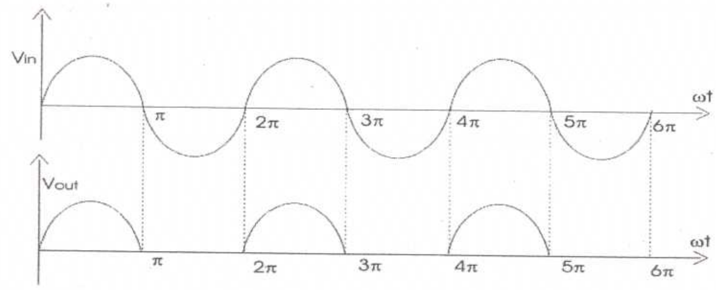
Schmitt trigger is a wave shaping circuit used for generation of a square waveform from a sine wave input.

It is special form of emitter coupled bistable multivibrator. It is used as comparator circuit. It is also used as a pulse squaring circuit. The stable state of the Schmitt trigger is determined by the amplitude of the voltage.

As the input voltage Vin rises to V1 or falls to V2 the circuit makes a fast regenerative transfer to its other state. When the supply is switched ON, with no input voltage applied to the circuit, transistor T1 is OFF and transistor T2 is in ON condition. If T2 conducts at saturation, the voltage across resistor RE is

	V_{E2}.In this case, the output voltage Vo is $V_o = V_{E2} + V_{CEsat}$ The voltage V_{E2} provides a reverse bias across the E-B unction o T1 and it is driven into cut off state. So, the transistor T1 conducts when the input voltage must be greater than V_{E2}. The amplitude of the input voltage required for the transistor T1 to conduct is called Upper trigger potential (UTP). Similarly hen the input voltage falls below V_{E1}, again transistor T2 begins to conduct. This causes the transistor T2 driven into saturation and T1 is cut off. The amplitude of the input voltage required for the transistor T2 to conduct is called lower trigger potential (LTP).			
7	 As the name indicates it is virtual, not real ground. For some purposes we can consider it as equivalent to ground. In op amps the term virtual ground means that the voltage at that particular node is almost equal to ground voltage (0V). It is not physically connected to ground. This concept is very useful in analysis of opamp circuits and it will make a lot of calculations very simple. This means that the differential input voltage v1dv1d between the non-inverting and inverting input terminals is essentially zero. This is obvious because even if output voltage is few volts, due to	Drawing symbol and correct marking – 3 Virtual ground concept - 3	6	

	large open loop gain of op-amp, the difference voltage at the input terminals is almost zero.  			
III a)	**Part C** A half wave rectifier is the simplest form of rectifier available. When a standard AC waveform is passed through a half-wave rectifier, only half of the AC waveform remains. Half-wave rectifiers only allow one half-cycle (positive or negative half-cycle) of the AC voltage through and will block the other half-cycle on the DC side. A complete half-wave rectifier circuit consists of 3 main parts: 1. A transformer 2. A resistive load 3. A diode  Figure - 2 The low AC voltage produced by the step-down transformer is directly applied to the diode. When low AC voltage is applied to the diode (D), during the positive half cycle of the signal, the diode is forward biased and allows electric current whereas, during the negative half cycle, the diode is reverse biased and blocks electric current. In simple words, the diode allows the positive half-cycle of the input AC signal and blocks the negative half-cycle of the input AC signal.	Circuit diagram – 2 waveform – 2 Description - 2 Ripple factor and rectification efficiency - 1 mark each 1 x 2	8	120



The **ripple factor value is 1.21** for a half wave rectifier.
The **rectification efficiency** of a half wave rectifier is **40.6%**

b) All voltage sources cannot able to give fixed output due to fluctuations in the circuit. For getting constant and steady output, the voltage regulators are implemented. The integrated circuits which are used for the regulation of voltage are termed as voltage regulator ICs.

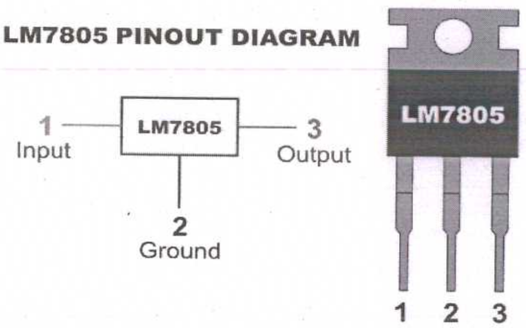
The voltage regulator IC 7805 is actually a member of the 78xx series of voltage regulator ICs. It is a fixed linear voltage regulator. The xx present in 78xx represents the value of the fixed output voltage that the particular IC provides. For 7805 IC, it is +5V DC regulated power supply. This regulator IC also adds a provision for a heat sink. The input voltage to this voltage regulator can be up to 35V, and this IC can give a constant 5V for any value of input less than or equal to 35V which is the threshold limit.

Connection diagram -2

Explanation – 3

Applications – 2

7



PIN1-INPUT

The function of this pin is to give the input voltage. It should be in the range of 7V to 35V. We apply an unregulated voltage to this pin for regulation. For 7.2V input, the PIN achieves its maximum efficiency.

PIN 2-GROUND
We connect the ground to this pin. For output and input, this pin is equally neutral (0V).
PIN 3-OUTPUT
This pin is used to take the regulated output. It will be 5 V.

Applications of Voltage Regulator 7805 IC

- Current regulator
- Regulated dual supply
- Building circuits for Phone charger, UPS power supply circuits, portable CD player etc.
- Fixed output regulator

IV a)

Parameters	Half wave rectifier	Full wave rectifier
No. of diodes	1	2 or 4
Rectification efficiency	40.6%	81.2%
Ripple frequency	f	2f
Ripple factor	More	Less
Voltage regulation	Good	Better than HWR
Transformer utilization factor	0.287	0.693
Transformer core saturation	Possible	Not possible

1 mark for each comparison 1 x 8

8

b)

The filter is a device that allows passing the dc component of the load and blocks the ac component of the rectifier output. Thus the output of the filter circuit will be a steady dc voltage. The filter circuit can be constructed by the combination of components like capacitors, resistors, and inductors.

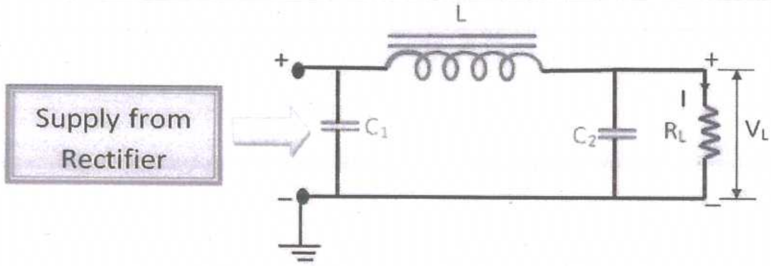
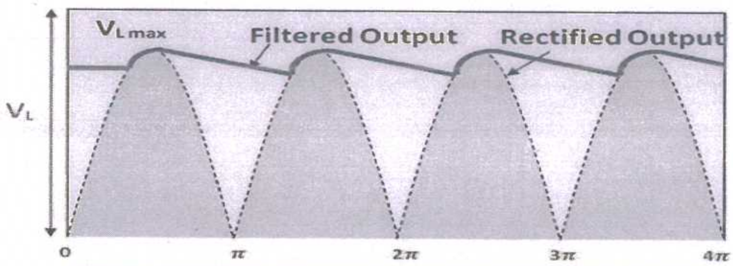
The name pi – Filter implies to the resemblance of the circuit to a Π shape with two shunt capacitances (C1 and C2) and an inductance filter 'L'. As the rectifier output is provided directly into the capacitor it also called a capacitor input filter.

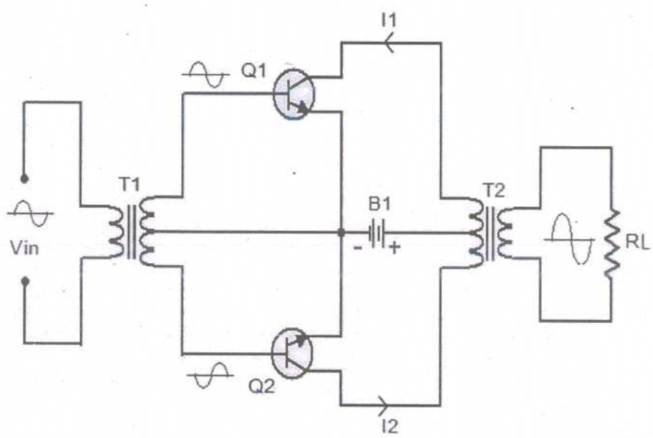
Circuit diagram – 2

waveform – 2

Description - 3

7

	 Capacitor Input Filter or Pi Filter Electronics Coach The output from the rectifier is directly applied to the input capacitor. The capacitor provides low impedance to AC ripples present in the output voltage and high resistance to DC voltage. Therefore, most of the AC ripples get bypassed through the capacitor in input stage only. The residual AC components which are still present in filtered DC signal gets filtered when they pass through the inductor coil and through the capacitor connected parallel across the load.  Output Voltage Waveform Electronics Coach			
V a)	A Power amplifier is meant to raise the power level of the input signal. Push Pull amplifier is categorized under class B type of power amplifiers. It consists of two transistors T1 and T2 with the emitter terminals connected each other. The circuit has two transformers- one at the input and the other at the output. The input transformer has a center tapped secondary winding. It provides equal and opposite voltages to the base circuits of two transistors. Similarly the collector terminals of two transistors are connected to the supply Vcc through the center tapped primary of output transformer.	Circuit diagram – 4 Description - 4	8	

	Working Polarity of end terminals of input transformer varies in correspondence to the input signal. Hence transistor T1 will be in forward biasing mode during positive half cycles of input signal while T2 remain in reverse biased condition. Hence T1 conducts and an amplified half cycle is obtained at the upper half of primary of output transformer. Similarly, when negative half cycle appear at the input side, T2 will not conduct as it is reverse biased while T2 conducts developing another amplified half wave at the output transformer. The center tapped primary of output transformer combines two collector currents to form a complete sine wave in the secondary. Since collector current flow in opposite directions net dc in the primary is zero. 			
b)	1) Bandwidth The bandwidth of an amplifier is defined as the range of frequencies over which the gain is equal to or greater than 0.707 or 1/sqrt(2) of the maximum gain. From frequency response curve it is calculated as the difference between two cut off frequencies. Bandwidth = (f2 – f1) Hz. 2) Lower and uppercut off frequencies The frequencies at which the voltage gain reduces to 0.707 or 1/sqrt(2) of the maximum gain are known as the cot off frequencies of the amplifier. As per the frequency curve f1 is	Definition of bandwidth and cut off frequencies – 4 marks		

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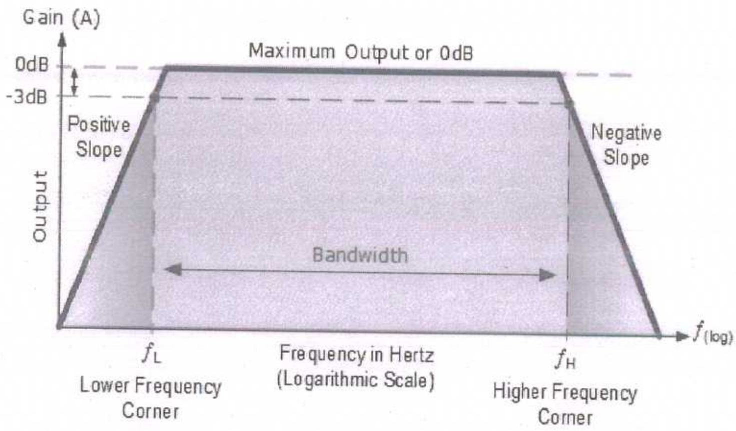
the lower cut off frequency and the frequency f2 represents the upper cut off frequency.



Cut-off points corresponds to a fall in gain of 3dB (0.7071) relative to its maximum dB value. These cut-off or corner frequency points also indicate the frequencies at which the power associated with the output falls to half its maximum value. Hence they are also known as half power frequencies.

</td>
<td>Frequency response curve - 2

Definition of half power frequencies - 1</td>
<td>7</td>
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<tr>
<td><u>VI a)</u></td>
<td>

Direct coupling basically means interconnecting each stage directly with a cable. Typically, it is used for interconnecting common-emitter stages with other emitter-follower stages. In the following diagram showing a two-stage amplifying circuit, the output of **T1** is directly connected to the input (base) of **T2**. The network of resistors is a voltage divider used to provide the bias and operating voltages for **T1** and **T2**. The DC collector voltage of the first stage provides the base-bias voltage for the second stage and there are no coupling or by-pass capacitors.

Direct coupling provides good response at low frequency, since no frequency-sensitive components such as capacitors or coils are used. The frequency response of the circuit is only affected by the amplifying component itself. Increased reactance of coupling and by-pass capacitors at very low frequencies becomes excessive for practical capacitor values and produces signal loss and gain reduction.

</td>
<td>Circuit diagram – 3

Description – 3

Applications - 2</td>
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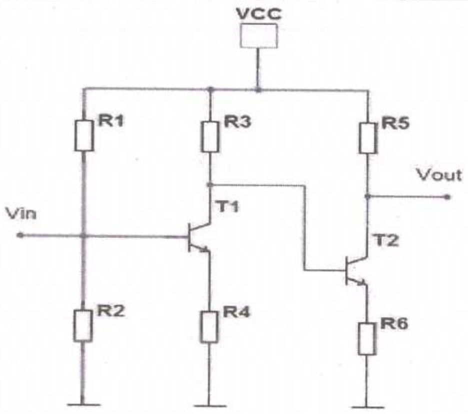


Directly coupled amplifying circuit

Applications of direct coupled amplifier

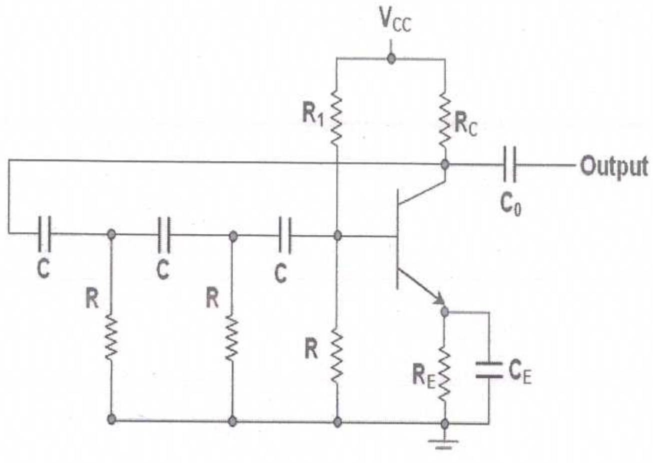
- Pulse amplifier
- Differential amplifier
- Computer circuitry
- Jet engine control

b)

Negative feedback	Positive feedback
• In negative feedback the feedback signal is in phase opposition or 180 deg out of phase with input signal • It reduces the net input to the amplifier • It reduces the gain of the amplifier • IT reduces the noise and distortion • It improves the stability of amplifier operation • Improves the bandwidth of the amplifier • Frequently used in amplifier circuits	• In positive feedback the feedback signal is in phase with the input signal • It increases the net input to the amplifier • It increases the gain of the amplifier • It increases the noise and distortion • Does not improve the bandwidth of the amplifier • Employed in oscillator circuits

1 mark for each comparison 1 x 7

7

VII **a)**	 Figure 2 RC Phase-Shift Oscillator Using BJT 1) RC phase shift oscillator consists of a transistor amplifier and RC phase shift network having three identical RC sections. Each RC section provides a phase shift of 60 deg. Thus a total of 60 x 3 = 180 phase shift is provided by the RC phase shift feedback network. Since transistor CE amplifier produces a phase shift of 180 deg and further phase shift of 180 is produced by the RC phase shift network. Thus the total phase shift around the entire loop is 360 deg. **Circuit operation** When the circuit is switched on, it is set into oscillations by any random motion of electrons in elements or the transistor. This voltage is very small in amplitude. It gets amplified and appears at the output terminals. The amplified noise drives the feedback network. At some particular frequency of output voltage the RC phase shift network provides the The frequency of oscillation is given by $$f = \frac{1}{2\pi RC\sqrt{2N}}$$ Where, N is the number of RC stages formed by the resistors R and the capacitors C.	Circuit diagram – 4 Description - 4	8	

b)

Amplifier	Oscillator
Amplifier is an electronic circuit which gives output as amplified form of input	Oscillator is an electronic circuit which gives output without application of input.
The amplifier does not generate any periodic signal	The oscillator is generating of the periodic electronic signal.
Amplifier uses negative feedback.	Oscillator uses positive feedback
The Amplifier provides amplified signal.	Oscillator is gives oscillatory signal.
Amplifiers do nothing till input signal is fed to the input	Oscillators produce signals from the moment of powered

1 mark for each comparison 1 x 7

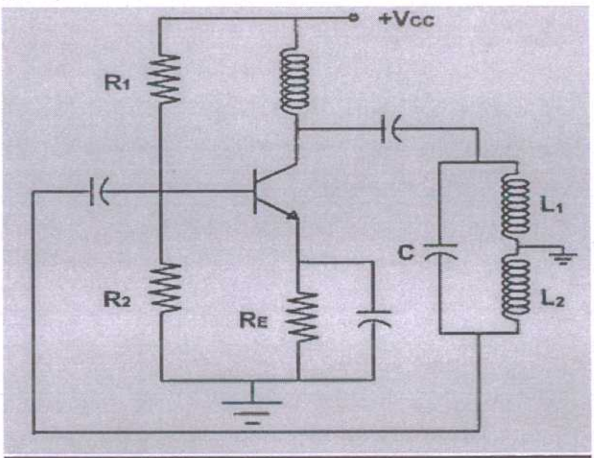
7

VIII a)

Hartley oscillator is inductively coupled, variable frequency oscillators where the oscillator may be a series or shunt fed. Hartley oscillators has the advantage of having one tuning capacitor and one center tapped inductor.

The circuit diagram of a Hartley oscillator is shown in the below figure. An NPN transistor connected in a common emitter configuration works as the active device in amplifier stage. R1 and R2 are biasing resistors and RFC is the radio frequency choke, which provides the isolation between AC and DC operation.

At high frequencies, the reactance value of this choke is very high, hence it can be treated as an open circuit. The reactance is zero for DC condition, hence causes no problem for DC capacitors. The C_E is the emitter bypass capacitor and R_E is also be a biasing resistor. The C_{C1} and C_{C2} are the coupling capacitors.



Circuit diagram – 4

Description - 4

8

	When the DC supply (Vcc) is given to the circuit, the collector current starts rising and begins with the charging of the capacitor C. Once capacitor C is fully charged, it starts discharging through L1 and L2 and again starts charging. This back-and-fourth voltage waveform is a sine wave which is a small and leads with its negative alteration. It will eventually die out unless it is amplified. Now the transistor comes into the picture. The sine wave generated by the tank circuit is coupled to the base of the transistor through the capacitor C_{C1}. Since the transistor is configured as common-emitter, it takes the input from tank circuit and inverts it to a standard sine wave with a leading positive alteration. The frequency of oscillations in this circuit is $f_o = 1/(2\pi\sqrt{(L_{eq} C)})$ Where Leq is the total inductance of coils in the tank circuit is given as $L_{eq} = L1 + L2 + 2M$			
b)	In the standby state. Flip flop with Q =0 holds transistor T1 ON, thus clamping external timimg capacitor to ground. At t = 0, an external trigger pulse is applied at pin no. 2 of 555 timer IC. When this trigger pulse amplitude drops below Vcc/3, the filp flop is set with Q' = 0. This makes the transistor T1 off and short circuit across timing capacitor C is released. When Q' is LOW, output goes HIGH. Timing cycle now begins with the charging of capacitor C exponentially through R towards Vcc. After time period T, when capacitor voltage raises above 2/3 Vcc, flip flop resets to make Q' =1 resulting in the discharging of timing capacitor to ground potential. The duration of quasi stable state of the system is determined by the charging of capacitor through resistor R which is determined by the following equation. $T = RC \ln(3) = 1.1\, RC$	Circuit diagram – 4 Description - 3	7	

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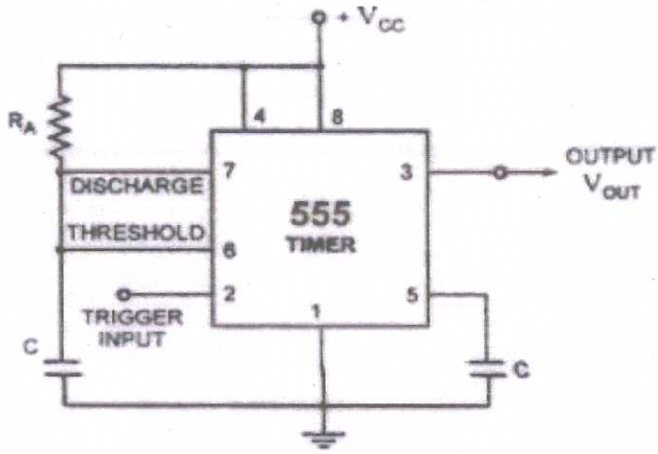
<tr><td></td><td>

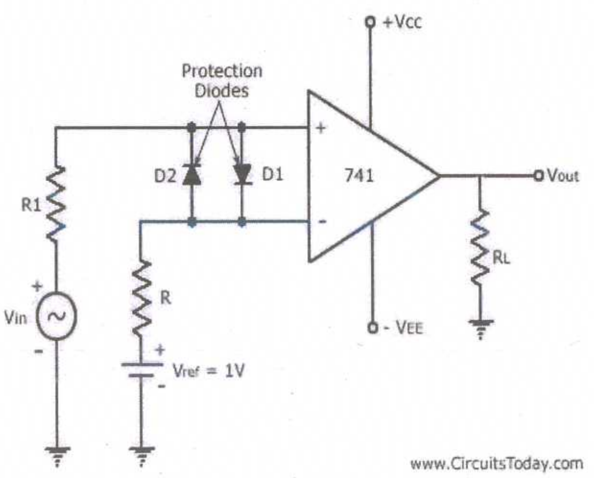
Circuit of The Timer 555
as a Monostable Multivibrator</td><td></td><td></td><td></td></tr>
<tr><td><u>IX</u>
<u>a)</u></td><td>a. <u>Input resistance</u>
It is defines as the differential input resistance as seen at either of the input terminals with the other terminal connected to ground.
For IC 741, input resistance is 2 M ohm.
b. <u>CMRR</u> (Common mode rejection ratio)
It is defined as the ration of differential mode voltage gain to the common mode voltage gain.
CMRR = Ad/Ac,
Higher the CMRR is better is the op-amp. Typical value is 90 dB.
c. <u>Slew Rate</u>
The slew rate is defined as the maximum rate of change of the closed loop amplifier output voltage caused by a step input voltage.
Slew rate = dVo/dt
Typical value = 0.5 V/micro second
d. <u>Input bias current</u>
The average of the currents entering into the input</td><td>1 mark for definition and one mark for magnitude each
2 x 4</td><td>8</td><td></td></tr>
</table>

<table>
<tr><td></td><td>terminals of an op- amp is called input bias current.

Typical value is 500 nA for 741 IC op-amp.</td><td></td><td></td><td></td></tr>
<tr><td>b)</td><td>

A comparator is a circuit which compares a signal voltage applied to one input of an op- amp with a known reference voltage at the other input. It is also called non-inverting comparator.

Non-Inverting Comparator Circuit



A fixed reference voltage V ref is applied to inverting input and a time varying signal Vi is applied to non-inverting input. The output voltage is at –Vsat for Vi < Vref and it transfers to +Vsat for Vi > Vref. Thus, output voltage Vo changes from positive saturation point to negative saturation point whenever the difference between Vin and Vref changes. This is shown in the waveform below.

</td><td>Circuit diagram of comparator – 2

waveform – 2

Description – 2

Circuit diagram of zero crossing detector – 1</td><td>7</td><td></td></tr>
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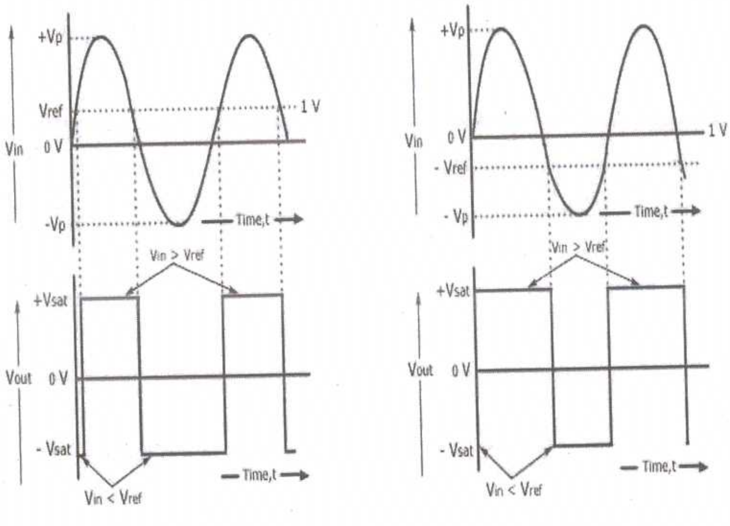
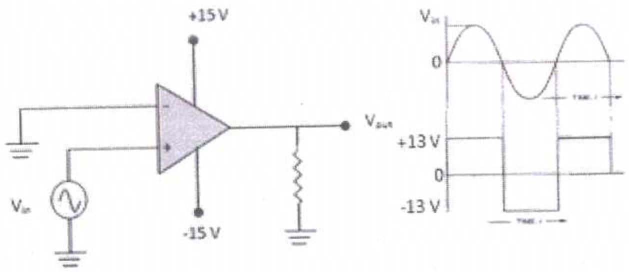


Input and Output Waveforms For Positive Vref

www.CircuitsToday.com

Input and Output Waveforms For Negative Vref

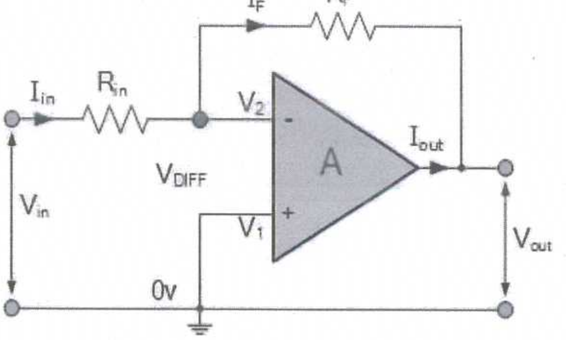
Above circuit can be modified into zero crossing detector by shorting the reference voltage source as shown below:-



X a)

The input signal Vin is applied to the inverting input terminal through R1 and non-inverting input terminal of op- amp is connected to the ground.

The output voltage Vo is fed back to the inverting input terminal through the resistor Rf. The signal fed back is proportional to the output voltage, determined by the feedback resistor Rf. Phase inversion through the amplifier ensures that the feedback is negative. The output obtained from the inverting amplifier configuration will be an inverted form of input signal fed to the inverting input terminal.



Voltage gain

Due to high input resistance op-amp draws no current. Hence all current flowing through R1 will flow through the feedback path.

i.e. Iin = If

Or

We have $\frac{Vin - V2}{R1} = \frac{V2 - V0}{Rf}$

As per the concept of virtual ground, V1 = V2 = 0

Hence $\frac{Vin}{R1} = \frac{-V0}{Rf}$

Therefore **Voltage gain** = $\frac{\mathbf{V0}}{\mathbf{Vin}} = \frac{\mathbf{-Rf}}{\mathbf{R1}}$

Negative sign indicates an output phase shift of 180 deg with respect to input.

Circuit diagram – 3

Description – 2

Derivation - 3

8

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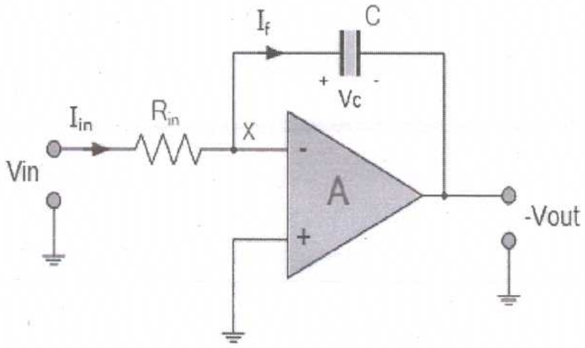
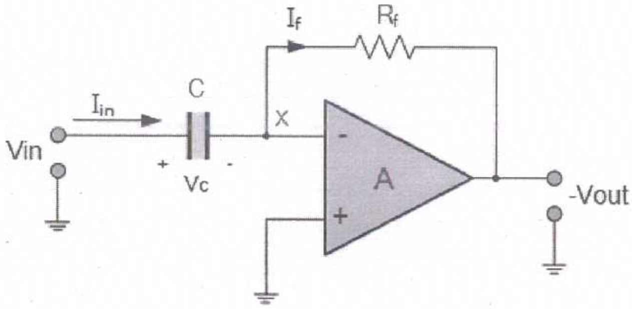
Op-amp Integrator Circuit



As its name implies, the **Op-amp Integrator** is an operational amplifier circuit that performs the mathematical operation of Integration, that is we can cause the output to respond to changes in the input voltage over time as the op-amp integrator produces an output voltage which is proportional to the integral of the input voltage.

Op-amp Differentiator Circuit



Here, the position of the capacitor and resistor have been reversed and now the reactance, X_C is connected to the input terminal of the inverting amplifier while the resistor, Rf forms the negative feedback element across the operational amplifier as normal.

This operational amplifier circuit performs the mathematical operation of **Differentiation,** that is it "produces a voltage output which is directly proportional to the input voltage's rate-of-change with respect to time".

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<td>Circuit diagram of integrator circuit– 2

Circuit diagram of differentiator – 2

Description – 3</td>
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