



WINTER– 17 EXAMINATION

Subject Name: Linear Integrated Circuits Model Answer Subject Code:

17445

Important Instructions to examiners:

- 1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
- 2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
- 3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills).
- 4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
- 5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
- 6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
- 7) For programming language papers, credit may be given to any other program based on equivalent concept.



Q.1 a) Attempt any SIX of the following : 12 marks

(i) State ideal and typical values of

1) Slew rate

2) CMRR

Ans :-(Each value – ½ mks)

Typical values of

Ideal values

1) Slew rate = 0.5 V/ μ s

Infinite

2) CMRR = 90 dB

Infinite

(ii) State the need of signal conditioning (two points)

Ans :-(Need – 2 mks)

Need of signal conditioning

In an instrumentation system, a transducer is used for sensing various parameters. The output of transducer is an electrical signal proportional to the physical quantity sensed such as pressure, temperature etc.

However the transducer output cannot be used directly as an input to the rest of the instrumentation system.

In many applications, the signal needs to be conditioned and processed. The signal conditioning can be of different types such as rectification, clipping, clamping etc. Sometimes the input signal needs to undergo certain processing such as integration, differentiation, amplification etc.

(iii) List specifications of IC LM 324 .

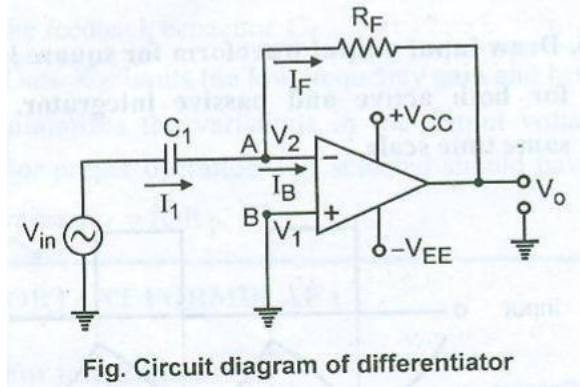
Ans :- (Any four -2 Mks)

Specifications of IC LM 324

- 1) Short Circuited Protected Outputs
- 2) True Differential Input Stage
- 3) Single Supply Operation: 3.0 V to 32 V
- 4) Low Input Bias Currents: 100 nA Maximum
- 5) Four Amplifiers Per Package
- 6) Internally Compensated
- 7) Common Mode Range Extends to Negative Supply

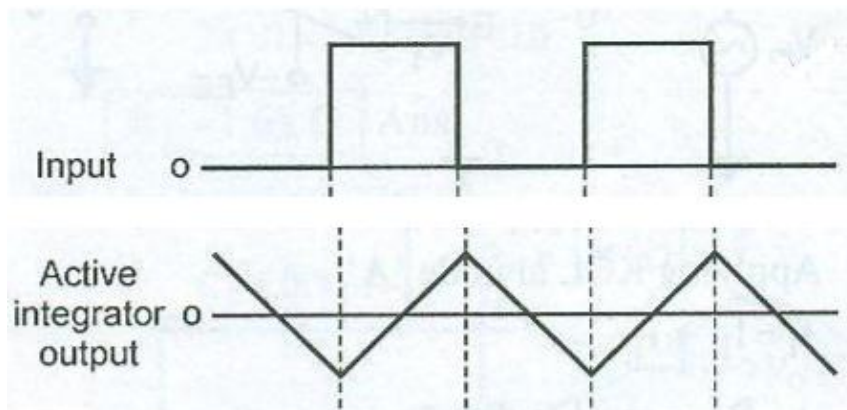
(iv) Draw the circuit of basic differentiator.

Ans:- (Circuit diagram-2 mks)



(v) Draw input and output waveform for active integrator for square wave input.

Ans:- (Correct waveforms -2 mks)



(vi) Define the following w.r.to filter

- 1) Q factor
- 2) Roll off rate

Ans:- (Each Definition – 1 mks)

- 1) Q factor : It is defined as the ratio of center frequency to the bandwidth and it is given as $Q = f_c / BW$
- 2) Roll off rate: The gain falls rapidly in the stop band . The rate at which it falls off is called the Roll off rate.

(vii) State the applications of PLL

Ans:- (Any two – 2 mks)

- 1) FM stereo decoders
- 2) Motor speed controls
- 3) Tracking filters
- 4) FM modulators
- 5) FSK decoders
- 6) FM tuner

7) Generation of local oscillator frequency

(viii) Define :

1) Output voltage swing

2) SVRR

Ans:- (Each Definition -1mks)

1) Output voltage swing : The output voltage swing indicates the value of positive and negative saturation voltages of op-amp.

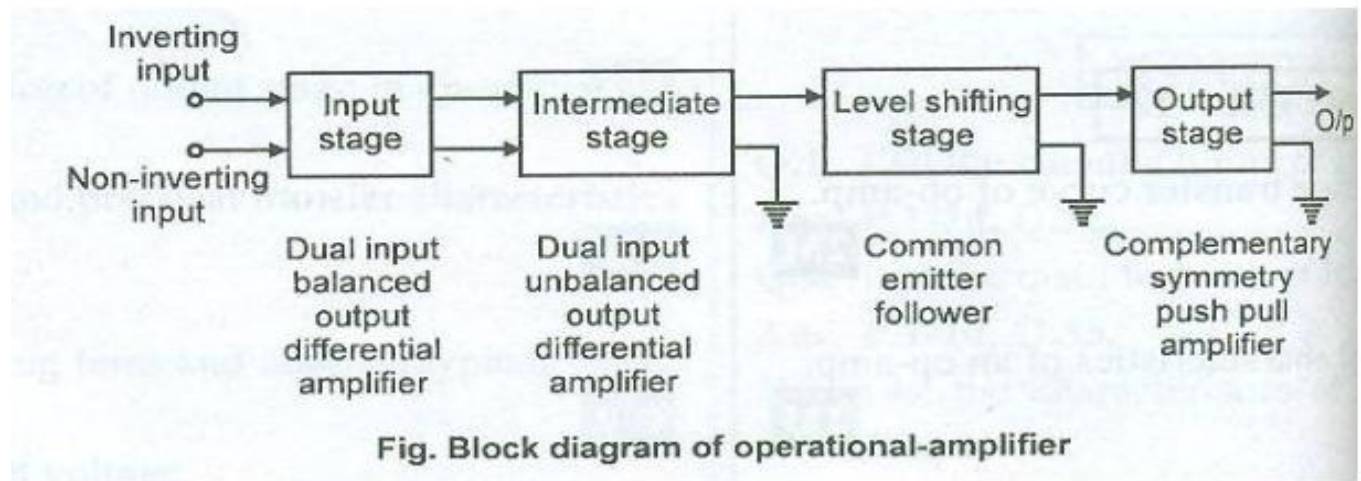
2) SVRR: The change in op-amp's input offset voltage V_{io} , cause by variation in supply voltage is called supply voltage rejection ratio (SVRR).

b) Attempt any TWO of the following:

8

(i) Draw block diagram of OPAMP and state the function of constant current source and Output stage.

Ans:- (Block diagram- 2 mks,, functions- 1 mks each)



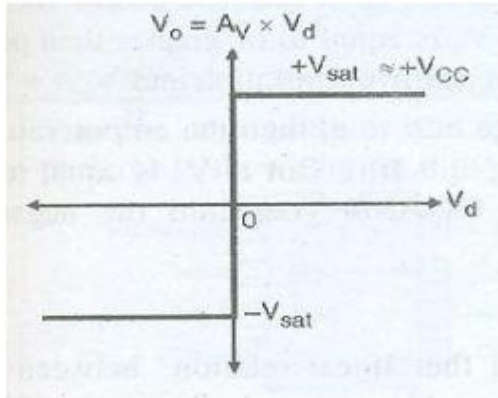
Constant current source stage:

Constant current source provides low output resistance and high CMRR.

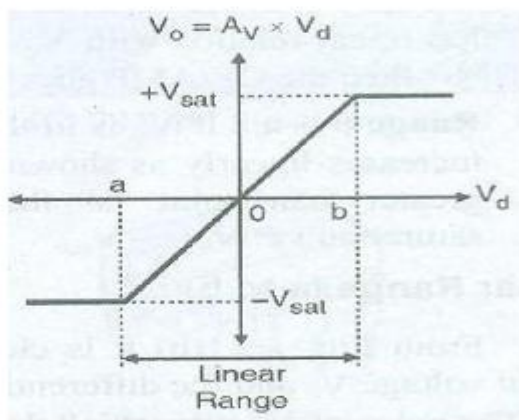
Output Stage: This stage uses complementary symmetry push pull amplifier. This stage provides low output resistance and hence increases the current supplying capability of op-amp and also this stage increases the output voltage swing.

ii) Draw ideal and practical voltage transfer characteristics of OP-AMP.

Ans:- (Each characteristics- 2 mks)



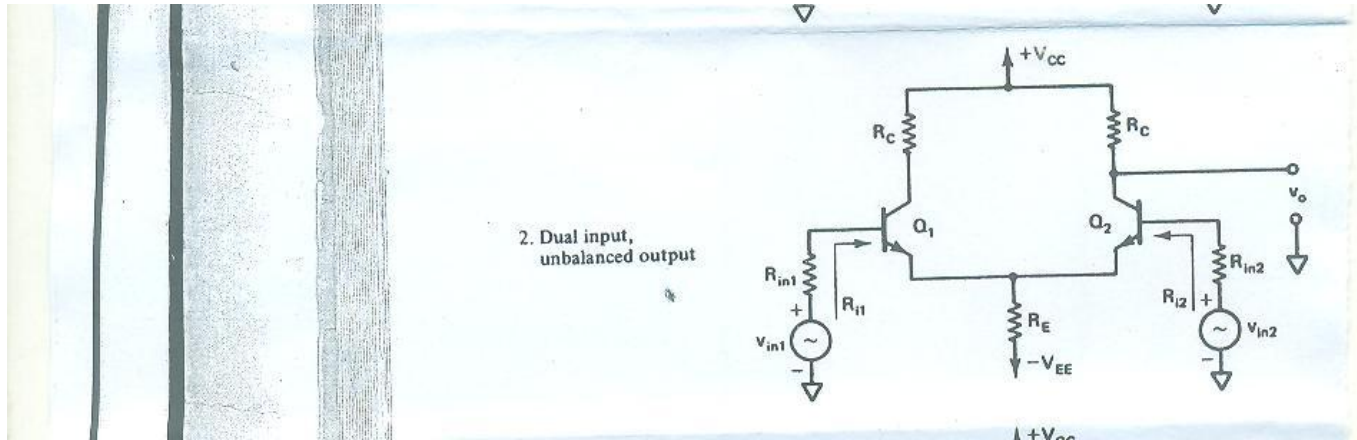
Ideal voltage transfer characteristics of an ideal OP- AMP



Voltage transfer curve of practical OP- AMP

(iii) Draw dual input unbalanced output differential amplifier and state ideal characteristics of op-amp

Ans:- (Diagram- 2 mks, Characteristics- 2 mks- any four points)



Ideal characteristics of opamp are :

- 1) Infinite voltage gain
- 2) Infinite input resistance
- 3) Zero output resistance
- 4) Infinite bandwidth
- 5) Infinite CMRR
- 6) Infinite slew rate

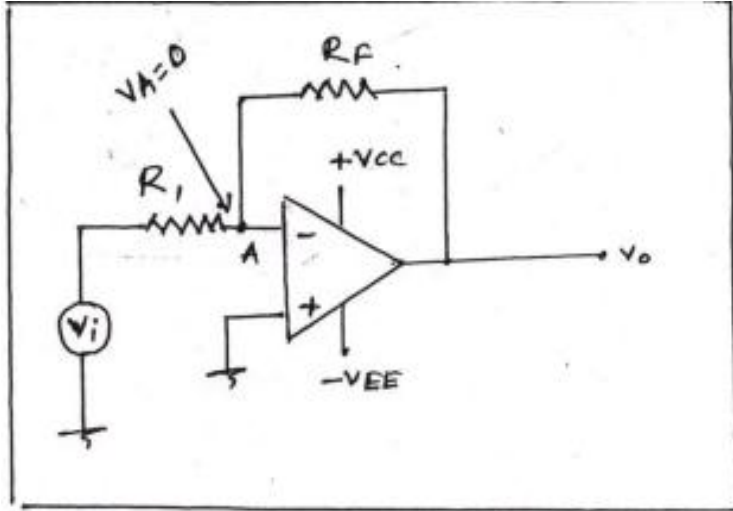
2. Attempt any FOUR of the following:

16

a) Describe virtual ground and virtual short concept with reference to OP-AMP.

Ans:- (Diagram- 1 mks each, description- 1 mks each)

Virtual ground concept-



Description-

In circuit point V_A is virtual ground. Figure shows inverting amplifier using op-amp. In this circuit non-inverting terminal is connected to the actual ground. Due to this potential of inverting terminal become zero. Thus, inverting terminal is not actually connected to the ground. There after its potential is zero. Thus point V_A is known as virtual ground point. This phenomenon of having zero potential without actually grounding is known as virtual ground concept.

Virtual short concept-

A virtual short is a concept that applies to the inputs of an operational amplifier. Like a real short circuit, a virtual short causes the voltage differential (called V_d) between the two inputs to the op amp to drop to 0. Unlike a real short, however, no current is allowed to flow between the inputs-- indeed, an ideal op amp has infinite input impedance.

An ideal op amp has the following characteristics:

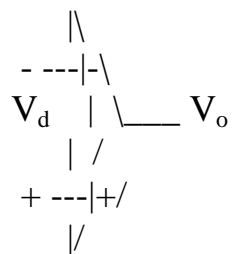
The voltage gain is infinite:

$$A_v = \infty$$

The voltage transfer characteristic equation is:

$$V_o = A_v \cdot V_d$$

Where V_o is the output voltage, and V_d is the input voltage differential, as shown in the figure:



Then, if we express V_d in terms of V_o , we get:

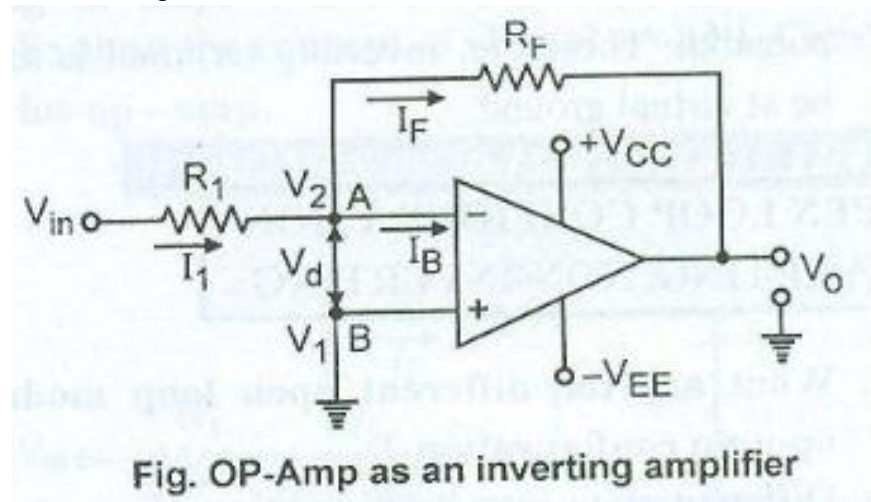
$$V_d = V_o / A_v$$

And, substituting in A_v :

$$V_d = V_o / \infty = 0$$

b) **Draw closed loop inverting amplifier using OPAMP and derive expression for its gain.**

Ans:- (Diagram- 2 mks, derivation- 2 mks)



V_o = output voltage, V_{in} = input voltage, R_F = Feedback resistor, R_1 = Input resistor

1. As input signal V_{in} is applied to inverting input, hence it is called as inverting amplifier and non inverting terminal is grounded.
2. The phase difference between input and output is 180°
3. A negative feedback is provided from output to inverting terminal through R_F (Feedback resistor)

Derivation:

Apply KCL at node 'A', we get,

$$I_1 = I_B + I_F \quad \text{--- (1)}$$

But, $R_{in} = \infty$

$$\therefore I_B = 0$$

$$\therefore I_1 = I_F$$

$$\therefore \frac{V_{in} - V_2}{R_1} = \frac{V_2 - V_o}{R_F}$$

According to virtual ground condition,
 $V_1 = V_2 = 0$

$$\therefore \frac{V_{in}}{R_1} = -\frac{V_o}{R_F}$$

$$\therefore V_o = -\left(\frac{R_F}{R_1}\right) V_{in} \quad \text{--- (2)}$$

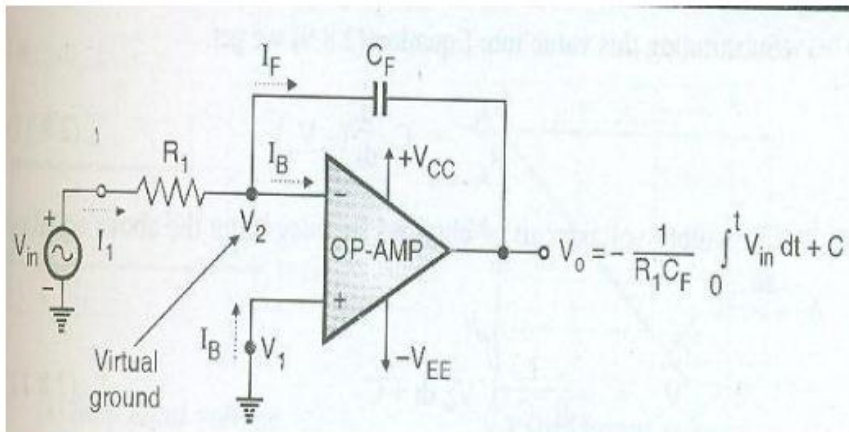
$$\therefore A_v = \frac{V_o}{V_{in}} = -\frac{R_F}{R_1} \quad \text{--- (3)}$$

where, $A_v =$ closed loop voltage gain

c) Draw the circuit diagram and output waveform for sine and square wave input for output voltage .

$$V_o = -\frac{1}{RC} \int_0^t V_{in} dt + C$$

Ans:- (Diagram- 2 mks, Each waveform- 1 mks)



Circuit Diagram

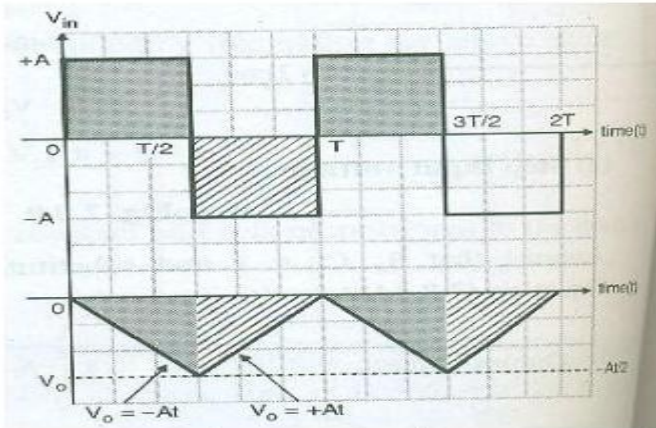


Fig: Input output voltage waveform for a square wave input

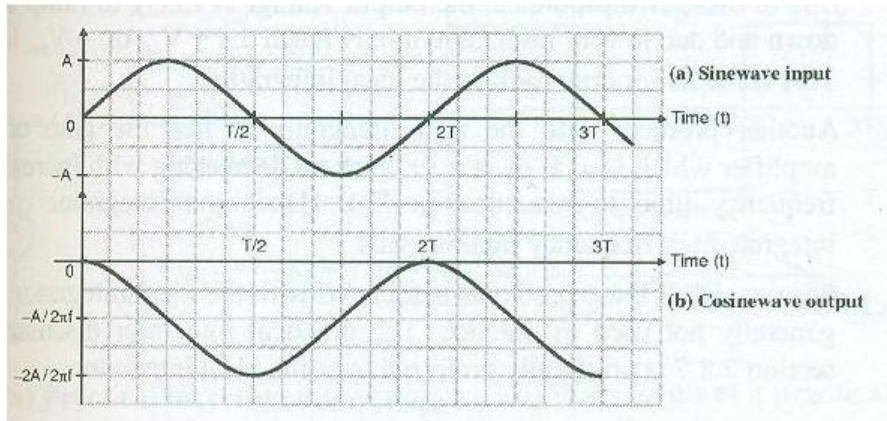


Fig: Input and output voltage waveforms for a sine wave input

d) Using OPAMP, draw the circuit to show the output $V_0 = 5(V_1 - 4V_2)$ Where V_1 and V_2 are input voltages.

Ans:- (Proper design-4 mks)

Sol:-

$$V_0 = 5(V_1 - 4V_2)$$

$$= 5V_1 - 20V_2$$

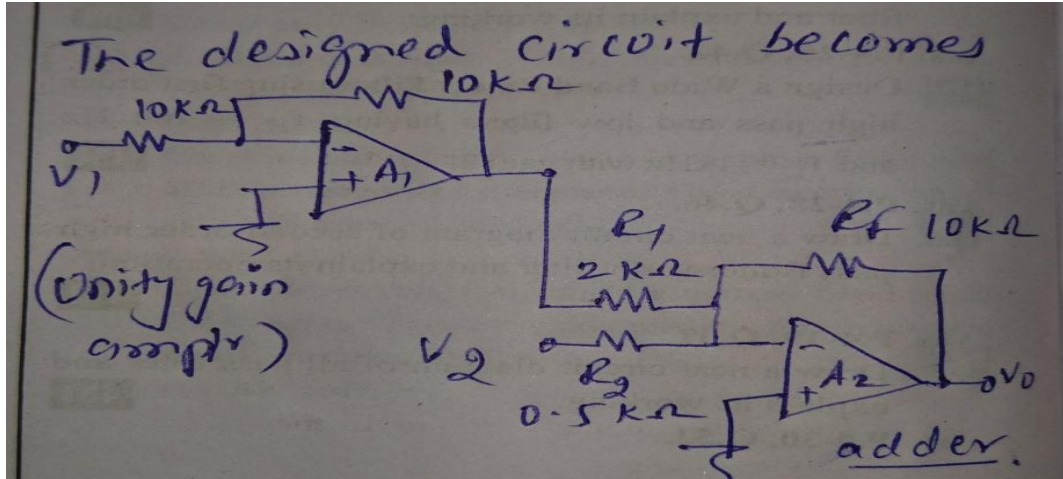
$$= -(-5V_1 + 20V_2)$$

$$= -[5(-V_1) + 20V_2]$$

use unity gain amplifier A_1 to invert V_1 and use inverting adder A_2 to add V_2 with -

$$\frac{R_f}{R_1} = 5 \quad \text{and} \quad \frac{R_f}{R_2} = 20$$

Let $R_f = 10k\Omega$, so $R_1 = 2k\Omega$
and $R_2 = 0.5k\Omega$



e) If $R_1 = 3\text{K}\Omega$, $R_F = 120\text{K}\Omega$, $V_{cc} = \pm 15\text{V}$ and rms input voltage $V_i = 50\text{ mV}$. Calculate output voltage in inverting and non-inverting Amplifier of op-amp.

Ans:- (Both o/p voltage value- 2 mks each)

Given: $R_1 = 3\text{K}\Omega$

$R_F = 120\text{K}\Omega$

$V_{cc} = \pm 15\text{V}$

Input voltage $V_i = 50\text{ mV}$

Find: Output voltage V_o for inverting and noninverting amplifier

1) For Inverting amplifier

$$V_o = - \frac{R_F}{R_1} * V_i$$

$$= - \frac{120}{3} * 50 * 10^{-3}$$

$$= -2\text{ V}$$

2) For non-inverting amplifier

$$V_o = [1 + \frac{R_F}{R_1}] * V_i$$

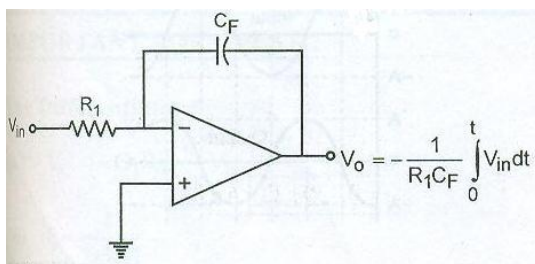
$$= [1 + \frac{120}{3}] * 50 * 10^{-3}$$

$$= 2.05\text{ V}$$

f) Draw and explain basic integrator circuit using op-amp

Ans:- (Diagram -2mks, waveforms -1mks ,explanation -1mks)

Circuit diagram:



Integrator is a circuit in which output is the integral of the input . This integrator circuit using op-amp obtained by with inverting amplifier configuration if resistor R_F s replaced by capacitor C_F .

The equation of above intergator circuit is

$$V_o = - \frac{1}{R_1 C_F} \int_0^t V_{in} dt + C$$

Where C is integration constant and is proportional to the value of the output voltage V_o at time $t=0$ seconds .

From above equation output voltage is directly proportional to negative integral of input voltage and inversely proportional to the time constant $R_1 C_F$. If input is sine wave , the output will be cosine and if input is square then output will be triangular .

Input and Output waveforms:

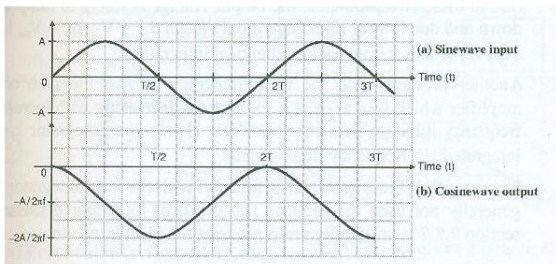


Fig: Input and output voltage waveforms for a sine wave input

OR

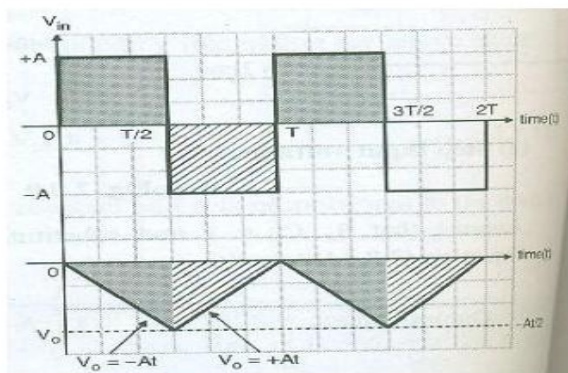


Fig: Input output voltage waveform for a square wave input

3. Attempt any FOUR of the following:

Marks 16

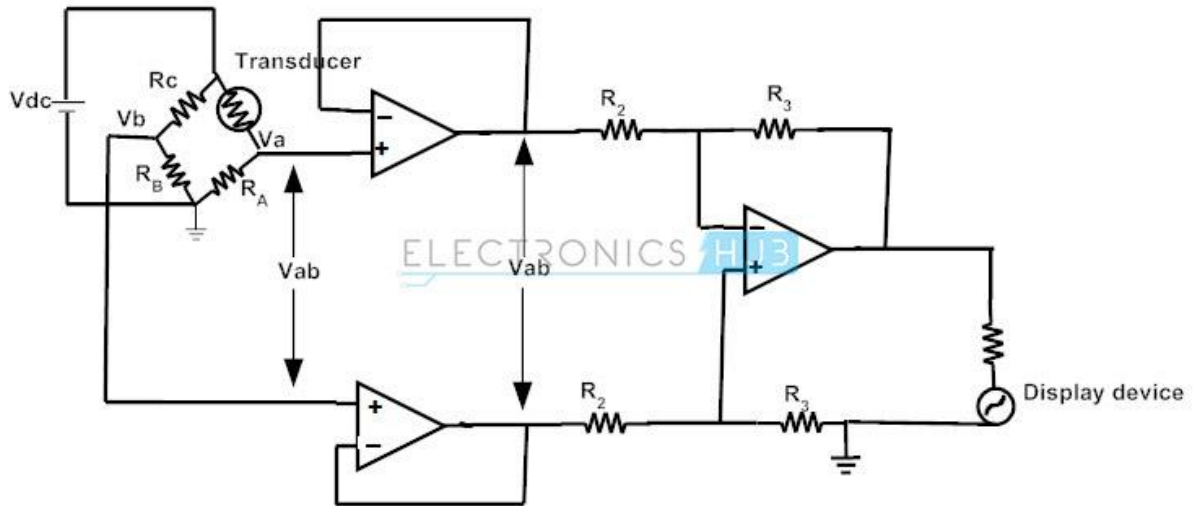
a) Draw the circuit diagram of instrumentation amplifier with transducer bridge and describe the operation of it to obtain output voltage.

Ans:- (Diagram-2 mks, description -1mks,output expression-1 mks)

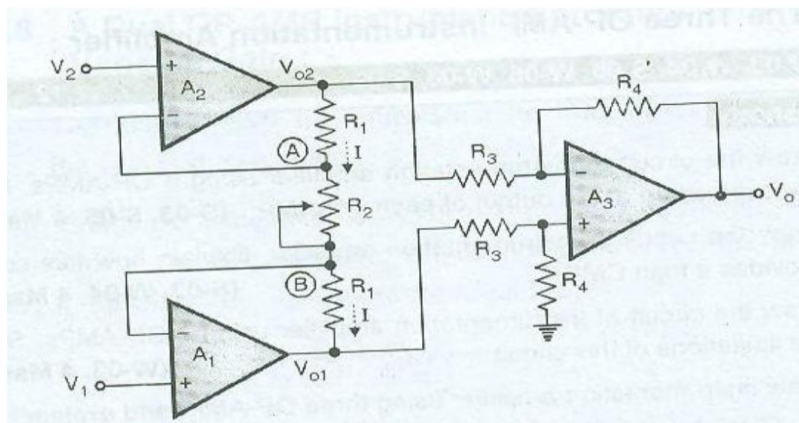
In an instrumentation system, a transducer is used for sensing various parameters. The output of transducer is an electrical signal proportional to the physical quantity sensed such as pressure, temperature etc.

However the transducer output cannot be used directly as an input to the rest of the instrumentation system.

Such **amplifiers**, which are used to amplify signals to measure physical quantities are commonly known as **Instrumentation Amplifiers**. The input to an **instrumentation amplifier** is the output signal from the **transducer**. A **transducer** is a device which converts one form of energy into another.



OR



Output equation-

$$V_{O1} = [1 + R_1/R_2] V_1 - R_1/R_2 V_2$$

$$V_{O2} = [1 + R_1/R_2] V_2 - R_1/R_2 V_1$$

$$V_o = V_{O2} - V_{O1}$$

$$= [1 + 2 R_1/R_2] (V_2 - V_1)$$

b) Draw and explain the circuit of V to I converter with floating load.

Ans:- (circuit-2 mks, explanation-2 mks)

- Figure shows the circuit of voltage to current (V to I) converter with floating load. This is also called as transconductance amplifier.
- The circuit converts the voltage applied to the output current. Figure shows the V to I converter in which load resistor R_L is floating i.e. its neither side is connected to ground since A_V is large.

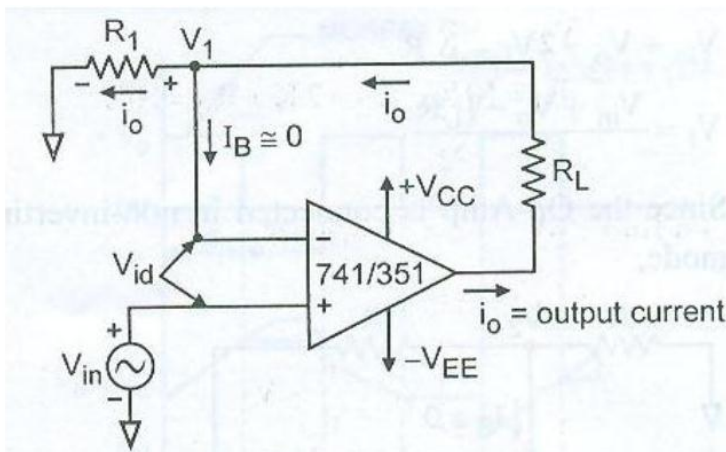


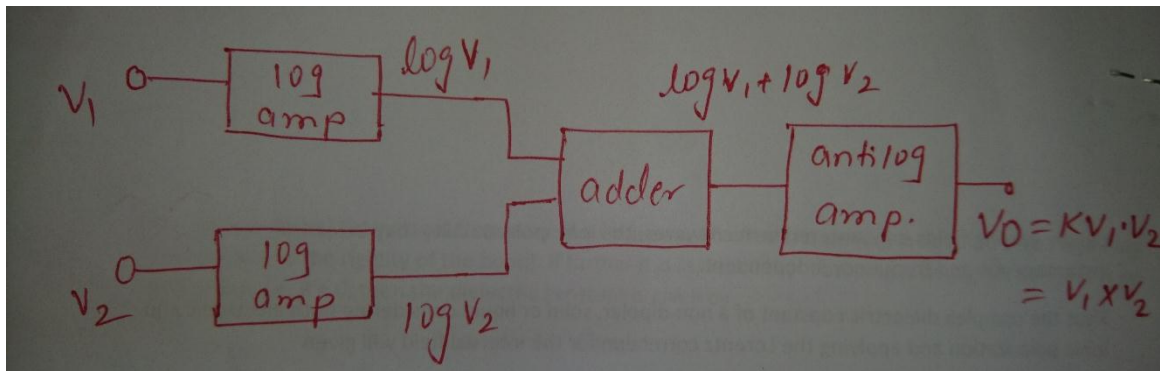
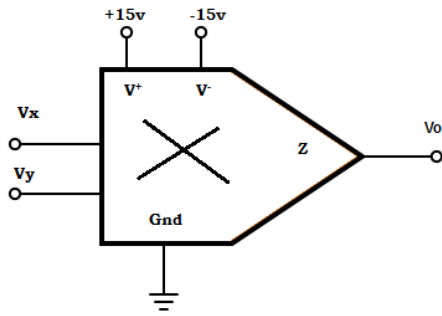
Fig. Voltage to current converter with floating load

- Derivation:
 $V_{id} = 0$ and this means
 $V_{in} = V_1$
 $= R_1 I_L$
 Therefore,
 $I_L = V_{in} / R_1$
 Since I_L is load current through R_L at output, the input V_{in} is converted into an output current V_{in} / R_i

c) Draw and describe following op-amp based operation using log and antilog amplifier. $V_o = V_1 \times V_2$

Ans:- (Diagram- 2 mks, description-2 mks)

Diagram-

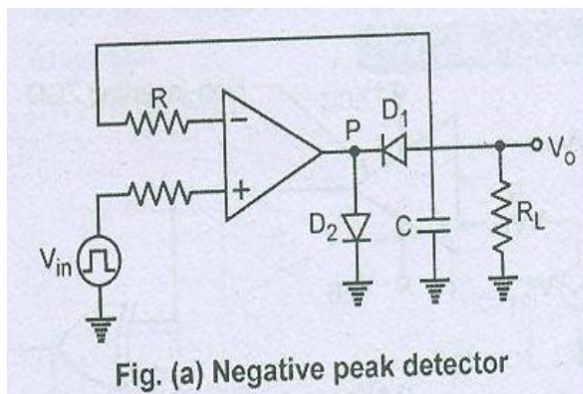


Operation- A multiplier is a circuit in which the output is proportional to the product of two input signals. The two inputs are v_1 and v_2 and output is V_0 .

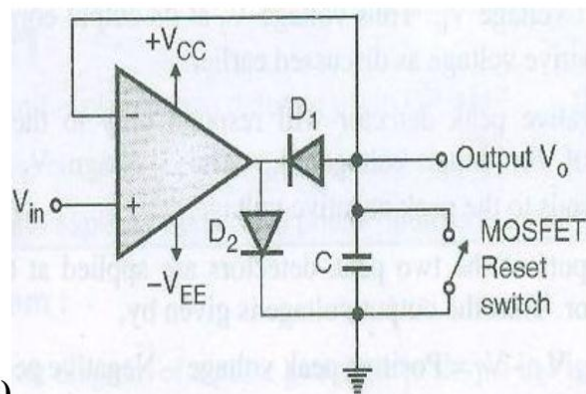
The inputs are passed through log amplifier which gives an output proportional to $\log V_1$ and $\log V_2$. These log voltages are added together and then given to an antilog amplifier to produce an output voltage given by $K \cdot V_1 \cdot V_2$.

d) Explain working of active negative peak detector with neat circuit and waveforms.

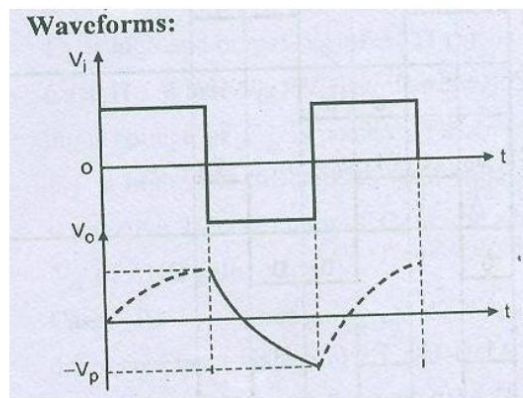
Ans:- (Diagram- 2 mks, description-1 mks ,waveforms- 1 mks)



(OR)



- During the positive half cycle, the potential B at point P is positive.
- Hence, Diode D_1 is reverse biased and D_2 is forward biased.
- Hence D_2 by passes the positive voltage towards ground and capacitor C remains un-charged.
- During negative half cycle, potential P becomes negative, hence D_1 is forward biased.
- Now, capacitor C starts charging for negative half cycle. And it charges up till the negative peak value.
- As, the capacitor charges for the negative half cycle, hence, it is called as negative peak detector.
- The MOSFET switch connected across the capacitor is to reset the circuit. By turning on this switch momentarily, we can discharge the capacitor completely.

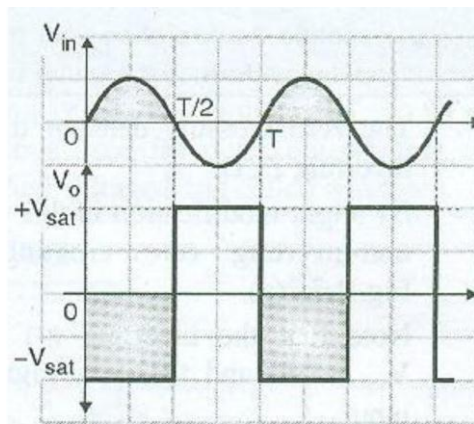
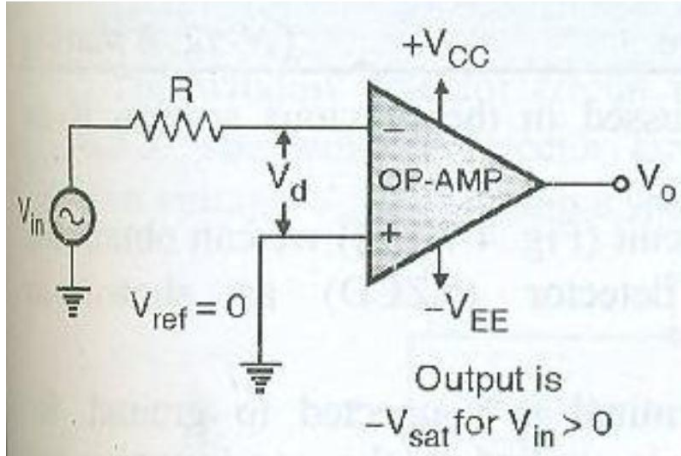


e) Describe the operation of ZCD with neat circuit diagram and waveforms.

Ans:- (Diagram- 2 mks, description-1 mks, waveforms- 1 mks)

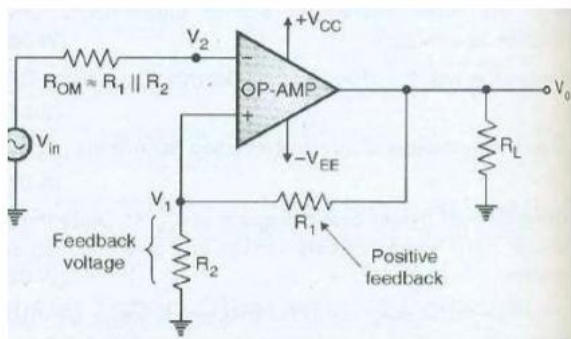
Description- A zero crossing detector or ZCD is a one type of voltage comparator, used to detect a sine waveform transition from positive and negative, that coincides when the i/p crosses the zero voltage condition. In this article, we discuss about zero crossing detector circuit with two different circuits, working principle, theory and applications. The applications of Zero Crossing Detector are phase meter and time marker generator.

Zero crossing detector circuit is used to produce an o/p stage switch whenever the i/p crosses the reference i/p and it is connected to GND terminal. The o/p of the comparator can drive various outputs such as an LED indicator, a relay and a control gate.



f) Draw circuit diagram and input output waveforms of op-amp based Schmitt trigger.

Ans:- (Diagram- 2 mks, description-2 mks)



Description-



Initially, before the application of any input, the output is assumed to be small and positive. This is the output offset voltage. The potential at point B is positive and point A = 0 V. The differential voltage V_{id} is positive. Hence the output is driven to $+V_{sat}$.

At this instant, the potential at point B is

$V_B = \frac{R_2}{R_1 + R_2} \cdot (+V_{sat})$. This is called as the upper trigger point (V_{UTP}). When the input becomes more positive than V_{UTP} , the differential input is negative. Therefore, the output is driven to $-V_{sat}$.

At this instant, the potential at the point B is

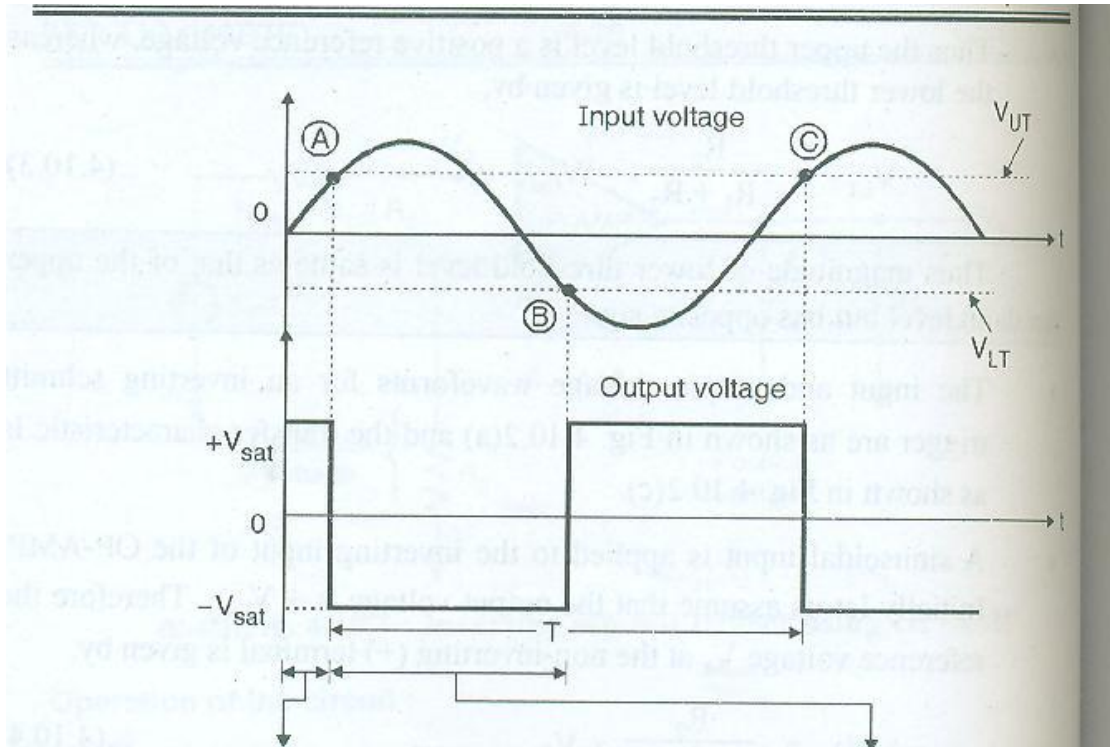
$$V_B = \frac{R_2}{R_1 + R_2} \cdot (-V_{sat})$$

This is the lower trigger point (V_{LTP}). The output remains at $-V_{sat}$ until input voltage becomes more negative than V_{LTP} . When the input crosses and becomes more negative than V_{LTP} , the differential input voltage is again positive and the output becomes $+V_{sat}$.

Thus, if the threshold voltages V_{UTP} and V_{LTP} are made larger than the input noise voltages, the positive feedback will eliminate the false output transitions.

Thus, the Schmitt trigger has two, reference voltages.

Waveforms-

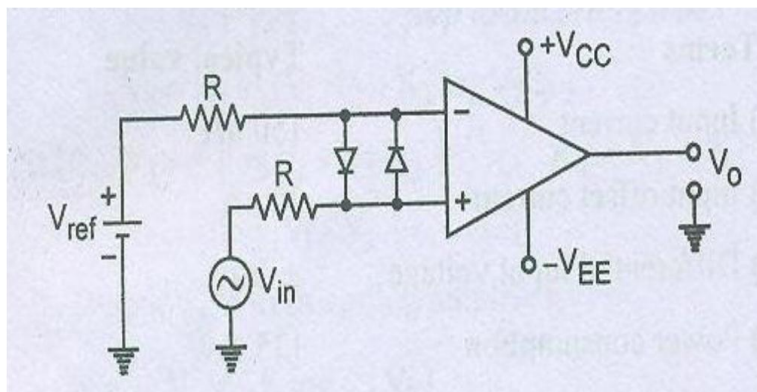


4. Attempt any **FOUR** of the following:

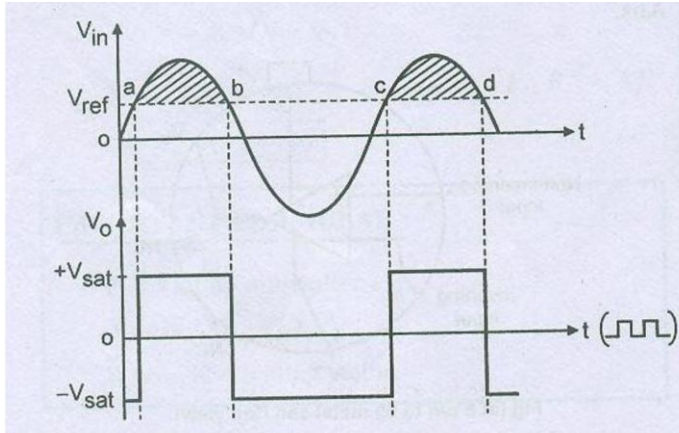
Marks 16

a) Describe the operation of non-inverting comparator using op-amp with waveforms.

Ans:- (Diagram- 2 mks, description-1 mks, waveforms- 1 mks)



Circuit Diagram for non-inverting comparator using OP-AMP



Waveforms for non-inverting comparator using OP-AMP

Description-

When the input is given to the non-inverting terminal and the reference voltage is given to the inverting terminal, the comparator is referred to as non-inverting comparator. When $V_i < V_{ref}$, the differential input voltage is negative and hence the output is driven to negative saturation value.

$V_i < V_{ref}$ makes V_{id} negative and $V_o = -V_{sat}$.

When $V_i > V_{ref}$, the net differential voltage is positive and hence the output is driven to positive saturation ($+V_{sat}$).

When $V_i > V_{ref}$, V_{id} = positive, $V_o = +V_{sat}$.

Thus the transfer characteristics of the non-inverting comparator is shown below for positive, zero and negative, reference voltages.

b) Design a first order low pass filter with 10 kHz cut off frequency and pass band gain 2.

Ans:- (Diagram- 2 mks, description-2 mks)



Given: Pass band gain (A_f) = 2

Cut-off Frequency (f_c) = 10 kHz

Pass band Gain (A_f) is given by the formula

$$A_f = 1 + \frac{R_f}{R_1}$$

Here, $A_f = 2$

$$\text{Therefore, } 2 = 1 + \frac{R_f}{R_1}$$

$$\text{So, } 1 = \frac{R_f}{R_1}$$

Therefore, $R_f = R_1$

Let $R_f = 10\text{k}\Omega$

Therefore, $R_1 = 10\text{k}\Omega$

Assume $C = 0.01\mu\text{F}$

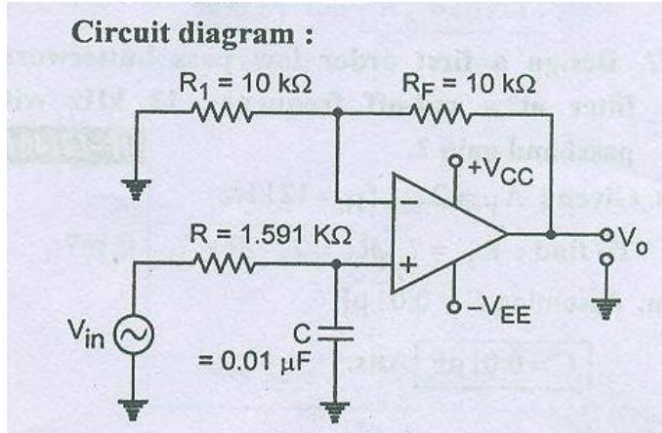
$$\text{But } f_c = \frac{1}{2\pi RC}$$

But $f_c = 10\text{ kHz}$

$$\text{Therefore, } 10\text{ kHz} = \frac{1}{2\pi RC}$$

$$\text{So, } R = \frac{1}{2\pi \times 10 \times 10^3 \times 0.01 \times 10^{-6}}$$

Therefore, $R = 1.59\text{k}\Omega$.



c) State two merits and two demerits of active filters.

Ans:- (Diagram- 2 mks, description-2 mks)

Merits

- 1) Gain and frequency adjustment possible
- 2) No loading problem
- 3) Cost is less

Demerits

- 1) Stability considerations limits the uses of most of the filters below 100kHz
- 2) Selectivity and center frequency are often very sensitive function of gain of op – amp or absolute value of feedback.

d) Classify filters based on

(i) Frequency response

(ii) Components used

(iii) Frequency range

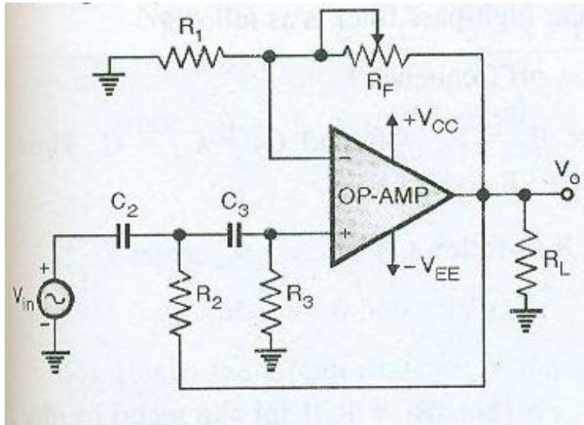
(iv) Nature of pass band and stop band.

Ans:- (Each classification – 1mks)

- i. On the basis of component used, filters can be divided as active and passive filters.
- ii. On the basis of frequency range, can be divided as AF (audio frequency) or RF (radio frequency) filters.
- iii. On the basis of frequency response filters can be divided as high pass, low pass, band pass and band reject filters.
- iv. On the basis of nature of pass band and stop band, they can be divided as narrow band pass, wide band pass, narrow band reject and wide band reject filters.

e) Draw the second order high pass filter and describe its operation.

Ans:- (Diagram- 2 mks, description-2 mks)



Second order high pass filter

The resistors R_1 and R_F will decide the gain of the high pass filter. The gain can be made variable by keeping R_F variable.

The cut-off frequency f_c is determined by R_2, R_3, C_2 and C_3 as follows:

$$f_c = \frac{1}{2\pi \sqrt{R_2 R_3 C_2 C_3}}$$

The voltage gain magnitude is given by,

$$\left| \frac{V_o}{V_{in}} \right| = \frac{A_{VF}}{\sqrt{1 + (f_c / f)^4}}$$

$$A_{VF} = 1 + \frac{R_F}{R_1} = \text{Passband gain of the filter.}$$

- The frequency response of the second order filter. It shows that the gain increases at a rate of 40 db/ decade in the attenuation band. This is doubled the rate of first order filter. This makes the frequency the frequency response sharper.
- The second order filters are important because they can be used for designing the higher order filters.

f) Draw and explain the circuit of notch (narrow band reject) filter.

Ans:- (Diagram- 2 mks, description-2 mks)

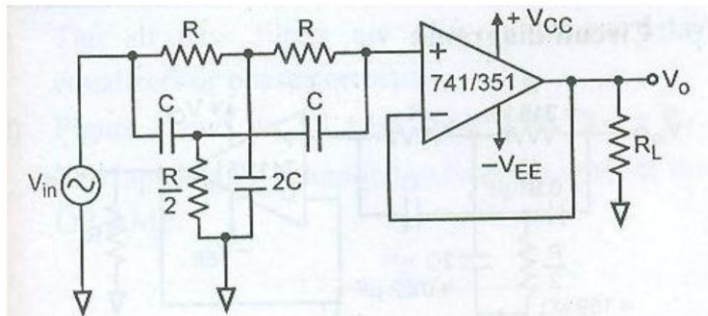


Fig. (a) Narrow band reject filter

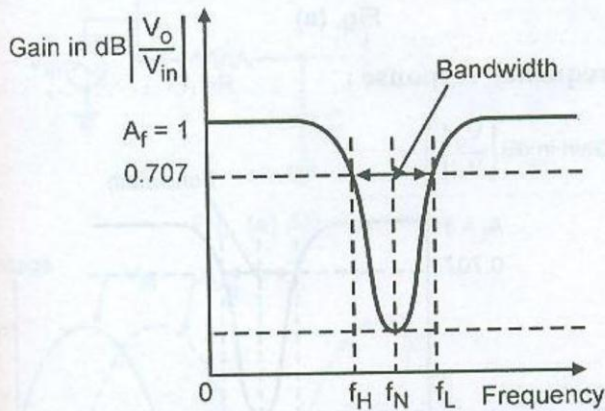


Fig. (b) Frequency response of narrow band reject filter



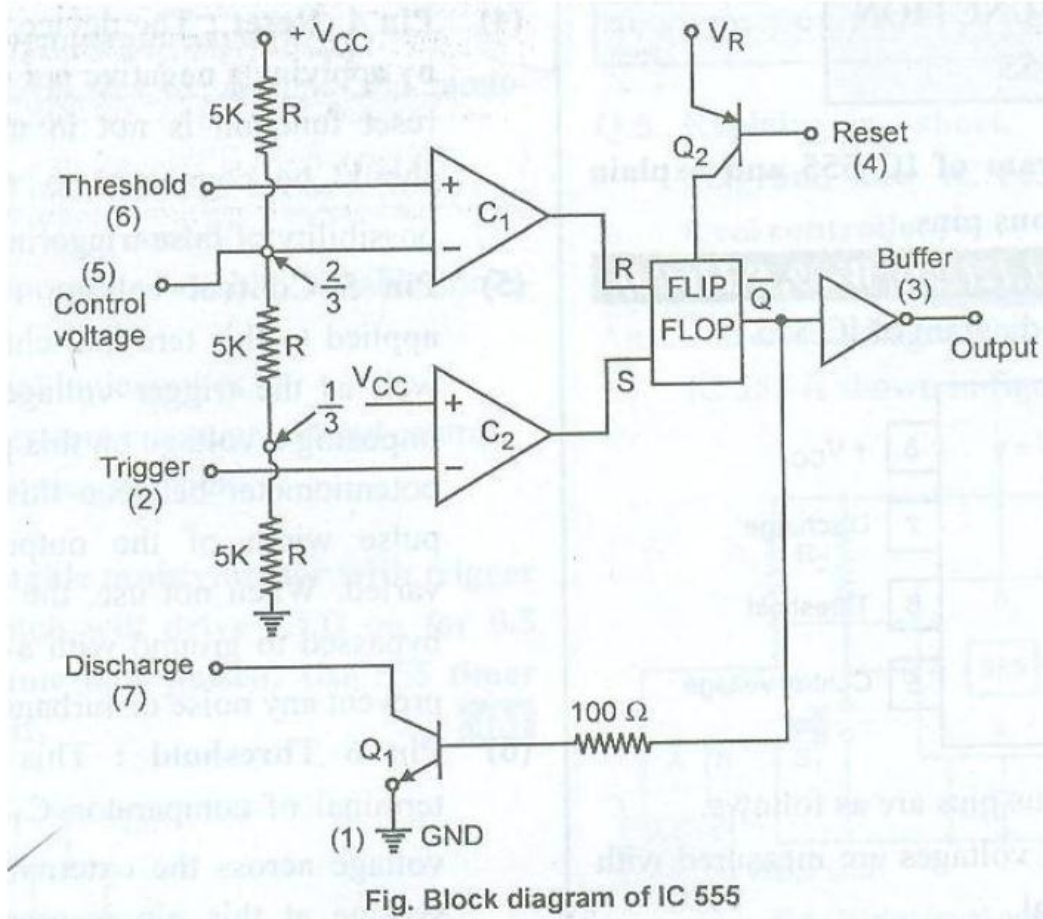
- i. Fig. shows a narrow band rejects active filter often called as Notch filter. It uses a twin T- network.
- ii. The twin T- network is a passive filter composed of two T- shaped networks.
- iii. One T- network is made up of two resistors and capacitors while the other uses two capacitors and a resistor.
- iv. The notch out frequency is the frequency at which maximum attenuation occurs, it is given by
$$f_N = 1 / 2\pi RC \text{ Hz} \text{-----} (1)$$
- v. The twin T- network has very low figure of merit Q. this is increased by using it with a voltage follower as shown in fig. The output of the voltage follower is fed back to the junction of R/2 and C.
- vi. $Q > 10$ for narrow band reject filter.
- vii. One typical application of such filter is for rejection of single frequency, such as 50 Hz power line frequency hum. This notch filter is also used in communication and Bio- medical instruments for eliminating undesired frequencies.
- viii. Frequency in equation (1) is the frequency to be rejected. Choosing $C \leq 1\mu\text{F}$ and then calculate for R, from the equation.

5. Attempt any **FOUR** of the following:

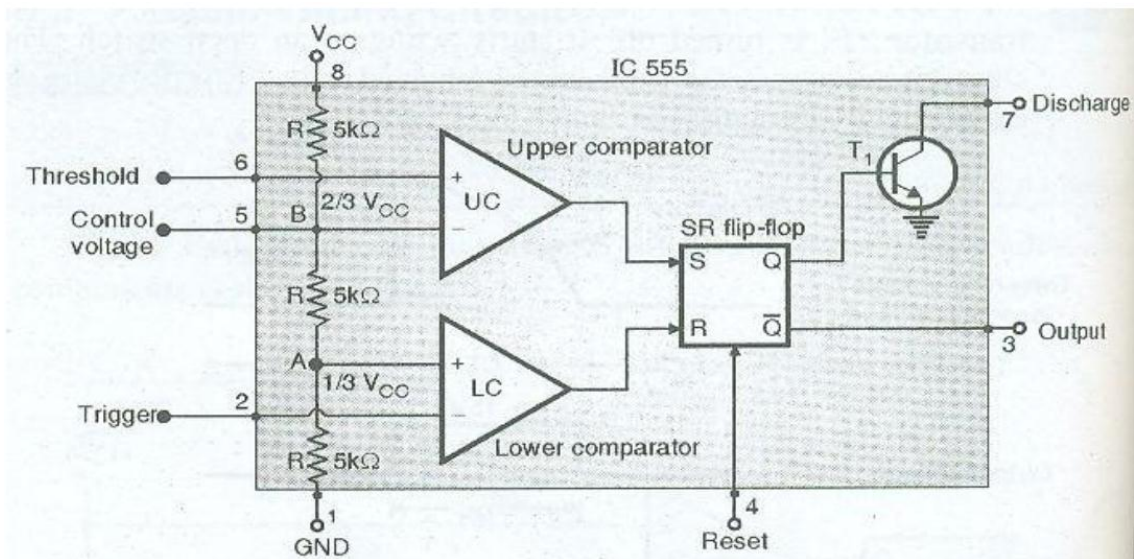
Marks 16

a) Draw the functional block diagram of Timer IC 555 and explain each block.

Ans:- (Diagram- 2 mks, description-2 mks)



OR



Explanation -

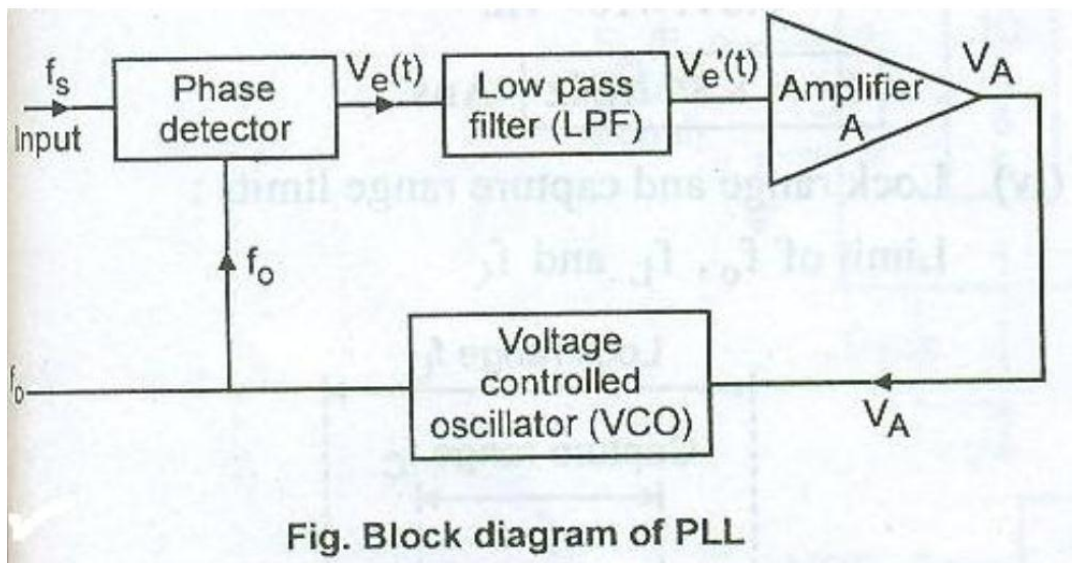
Comparator: The Comparator are the basic electronic component which compares the two input voltages i.e. between the inverting (-) and the non-inverting (+) input and if the non-inverting input is more than the inverting input then the output of the comparator is high. Also the input resistance of an ideal comparator is infinite.

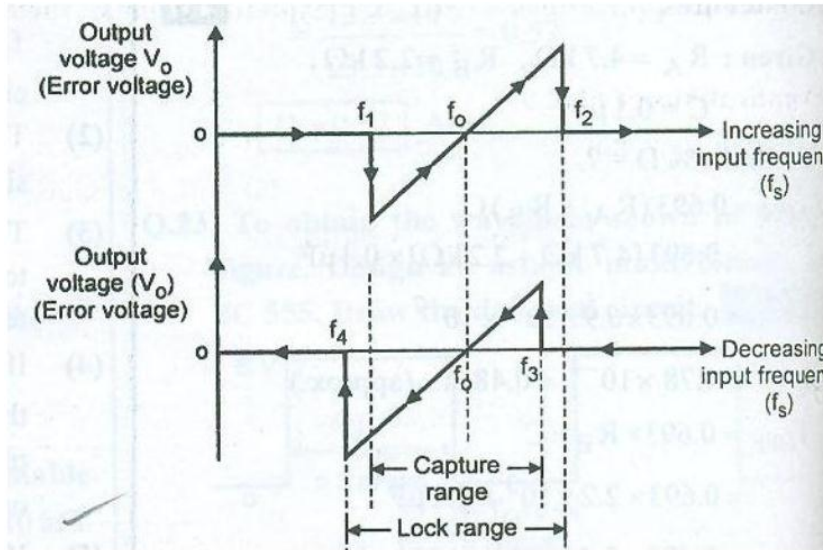
· Voltage Divider: As we know that the input resistance of the comparators is infinite hence the input voltage is divided equally between the three resistors. The value being $V_{in}/3$ across each resistor.

· Flip/Flop: Flip/Flop is a memory element of Digital-electronics. The output (Q) of the flip/flop is 'high' if the input at 'S' terminal is 'high' and 'R' is at 'Low' and the output (Q) is 'low' when the input at 'S' is 'low' and at 'R' is high.

b) Draw block diagram and transfer characteristics of PLL.

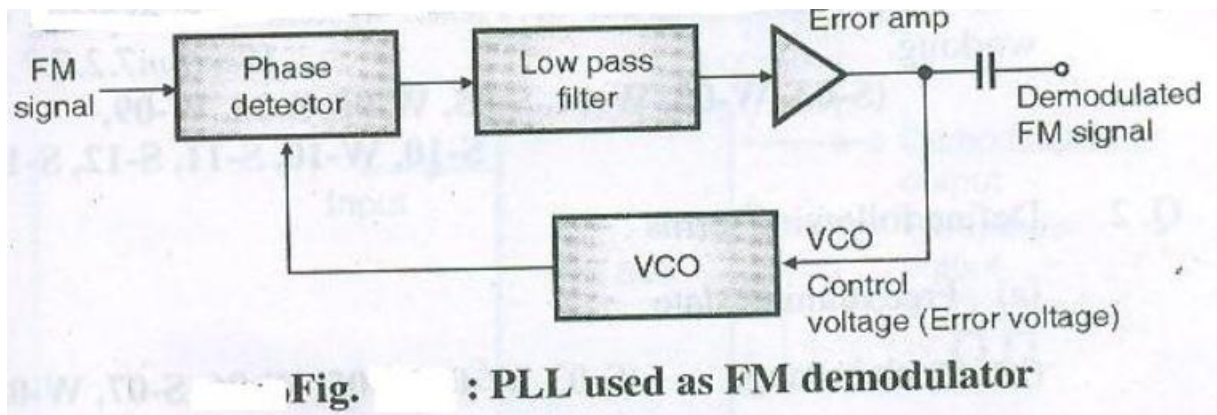
Ans:- (Block diagram- 2 mks, transfer characteristics- 2 mks)





c) Draw and explain the working of FM demodulator using PLL.

Ans:- (Diagram- 2 mks, description-2 mks)



Operation:

- The FM signal which is to be demodulated is applied at the input of the PLL.
- As the PLL is locked to the FM signal, the VCO starts tracking the instantaneous frequency in the FM input signal.
- The error voltage produced at the output of the amplifier is proportional to the deviation of input frequency from the centre frequency of FM. Thus the ac component of the error voltage represents the modulating signal. Thus at the error amplifier output we get demodulated FM output.
- The FM demodulator using PLL ensures a highly linear relationship between the instantaneous input frequency and VCO control voltage (error amplifier output)

d) Describe the operation of phase detector and role VCO in PLL.



Ans:- (Each description-2 mks)

Voltage controlled oscillator (VCO):

- The control voltage V_C is applied at the input of a VCO.
- The output frequency of VCO is directly proportional to the dc control voltage V_C . The VCO frequency f_o is compared with the input frequency f_s by the phase detector and it (VCO frequency) is adjusted continuously until it is equal to the input frequency f_s i.e.
 $f_o = f_s$
- The voltage controlled oscillator (VCO) is a free running multivibrator and operates at a frequency f_o , which is determined by external timing capacitor and external resistor.
- The operating frequency can be shifted on either side by applying a dc control voltage V_C externally.

Phase detector or phase comparator:

- The two points to a phase detector or comparator are the input voltage V_s at frequency f_s and the feedback voltage from a voltage controlled oscillator (VCO) at the frequency f_o .
- The phase detector compares these two signals and produces a dc voltage V_e which is proportional to the phase difference between f_s and f_o . The output voltage V_e of the phase detector is called as error voltage.
- This error voltage is then applied to a low pass filter.

e) Design an Astable multivibrator using IC 555 timer for a frequency of 2 kHz.

Ans:- (Diagram- 2 mks, description-2 mks)

$$f_0 = 2 \text{ kHz}$$

$$T = 0.5 \text{ msec.}$$

$$T_{ON} = 0.693 (R_A + R_B) C$$

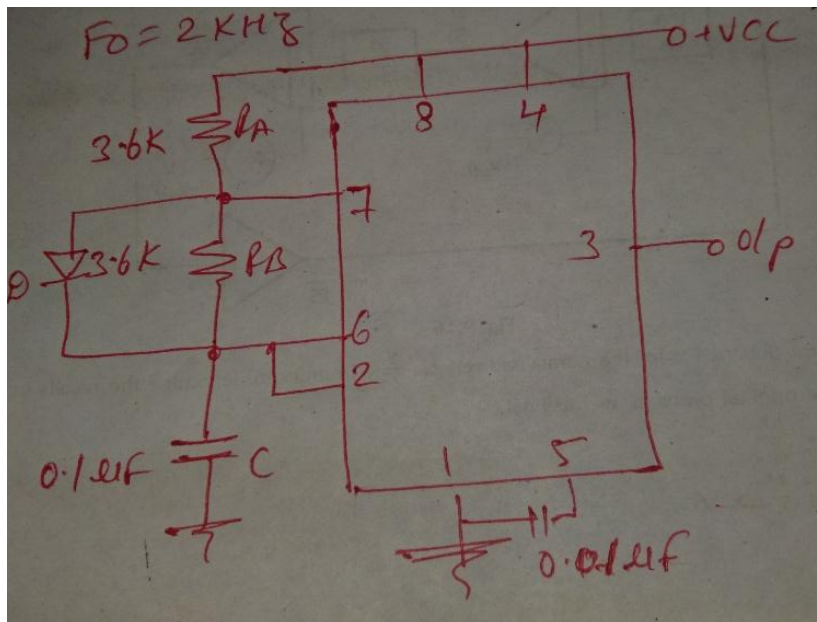
$$T_{OFF} = 0.693 R_B \cdot C$$

Let $T_{ON} = T_{OFF} = 0.25 \text{ msec}$

$$T_{OFF} = 0.25 \times 10^{-3} = 0.693 R_B \cdot C \quad (\text{let } C = 0.1 \mu\text{F})$$

$$\frac{0.25 \times 10^{-3}}{(0.1 \times 10^{-6} \times 0.693)} = R_B$$

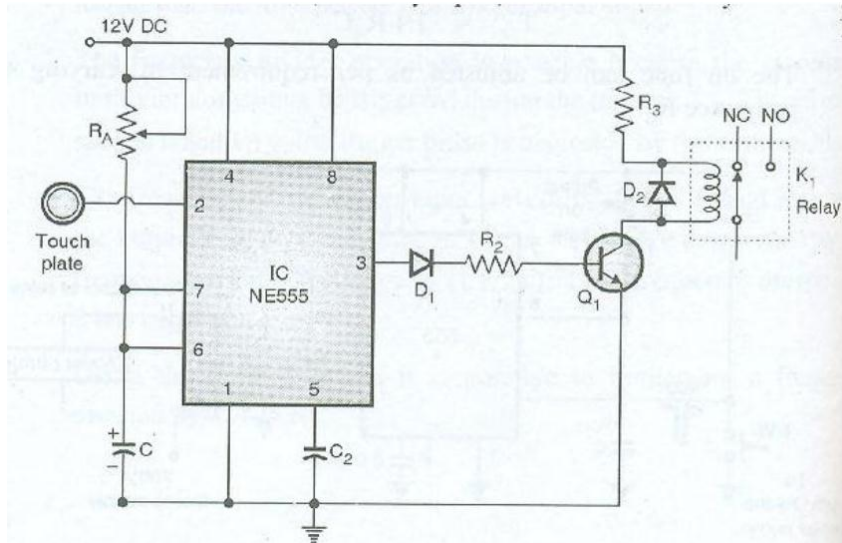
$$\boxed{R_B = 3.6 \text{ K}\Omega} = R_A$$



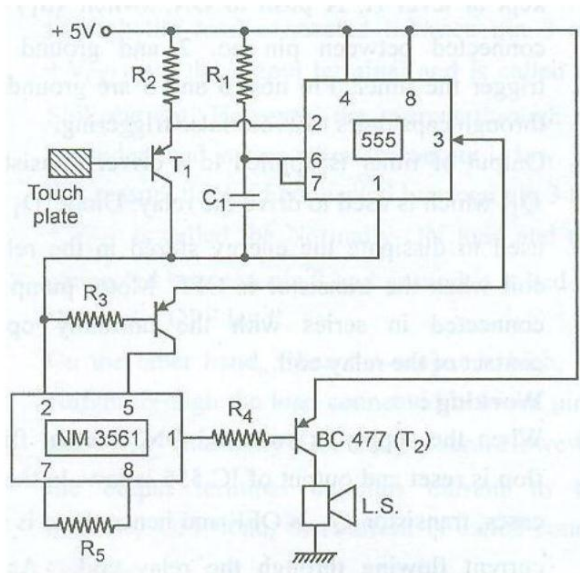
$R_A = R_B = 3.6 \text{ K}\Omega$ for square wave

f) Describe the application of IC 555 as touch plate switch with circuit diagram.

Ans:- (Diagram- 2 mks, description-2 mks)



OR



- When this circuit is connected to a metal locker or cupboard, generates an alarm when touched by an undesirable entity.
- The transistor gets saturated by just touching its base. The 50 Hz hum present in our body is the key to this circuit. The circuit is basically a burglar alarm with timer. Timer circuit is a monostable multivibrator.
- If the sensor, which is base of the transistor T_1 , touched by the finger, transistor T_1 , is saturated. Now the voltage at pin 2 of IC_1 is less than $1/3 V_{CC}$. As a result IC_1 gets a trigger pulse at its trigger input pin 2. Therefore its output goes high for a predetermined time period.
- The period can be adjusted by varying the value of resistor R_1 or capacitor C_1 as $T = 1.1R_1C_1$ sec.

6. Attempt any **FOUR** of the following:

Marks 16

a) Draw a neat circuit diagram of VCO using IC 555 and explain its working.

Ans:- (Diagram- 2 mks, description-2 mks)

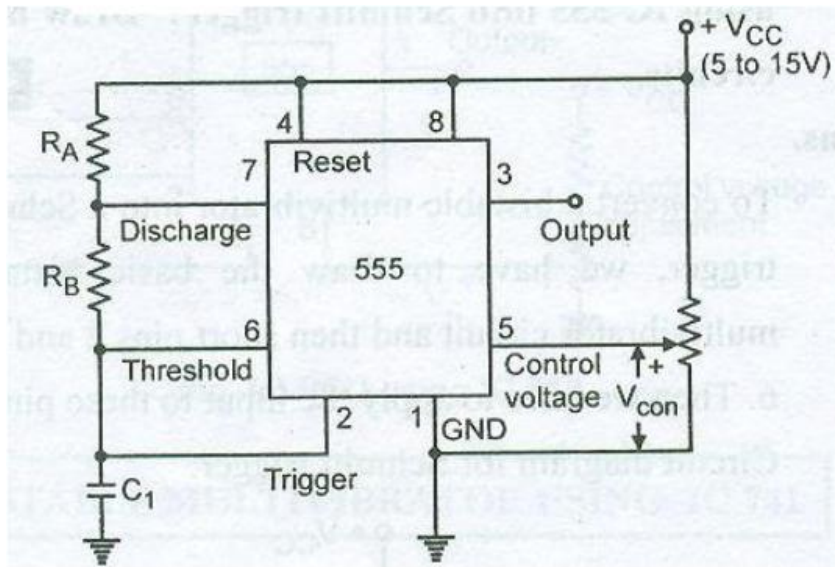
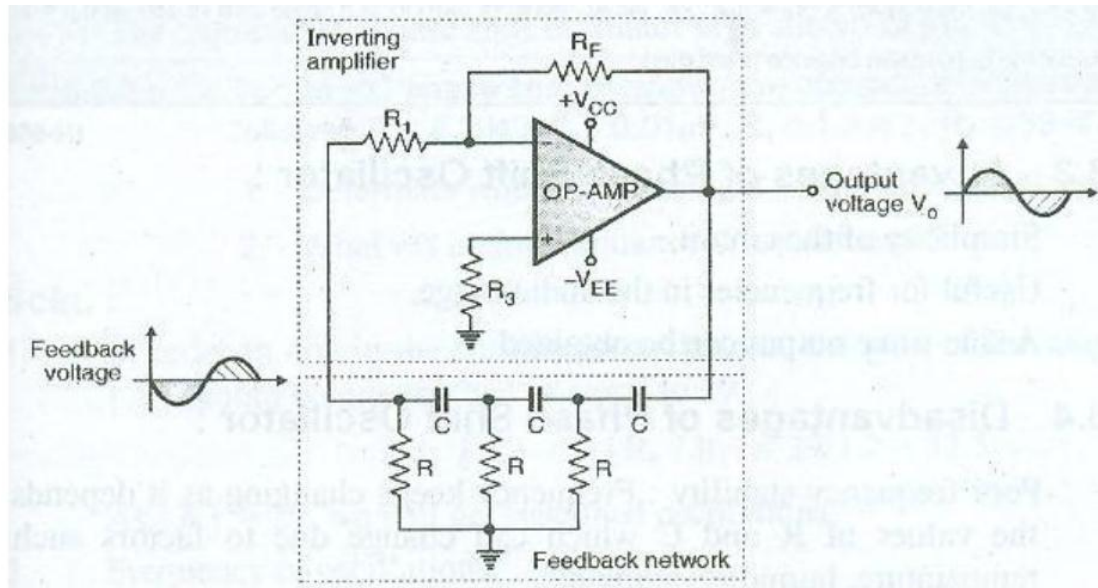


Fig: Circuit diagram of VCO using IC 555

- The constant current source/ sink block is used to charge and discharge the externally connected timing capacitor C_T linearly.
- The value of charging and discharging current is dependent on the control voltage V_C applied at pin number (5) modulating input.
- This current can also be changed by varying the external timing resistor R_T .
- The potential difference between pins (5) and (6) is almost zero. That means these pins are equipotential.
- Therefore if we increase the modulating voltage V_C at pin number (5), the voltage at pin number (6) will increase with the same amount.
- This reduces the voltage drop across R_T and reduces the charging current.
- The voltage across the capacitor is thus triangular wave. This triangular wave is applied to a buffer A_1 .
- The buffer is connected in order to avoid any possible loading of the capacitor. The buffer output is taken out at pin number (4) as triangular wave output.
- The buffer output is also applied to a Schmitt trigger A_2 , which converts the triangular wave into square waveform.
- Resistors R_a and R_b is a potential divider generating the reference levels for the upper and lower trigger voltages. This square wave is inverted by inverter A_3 and made available at pin number (3).

b) Draw and explain the working of phase shift oscillator using IC 741.

Ans:- (Diagram- 2 mks, description-2 mks)



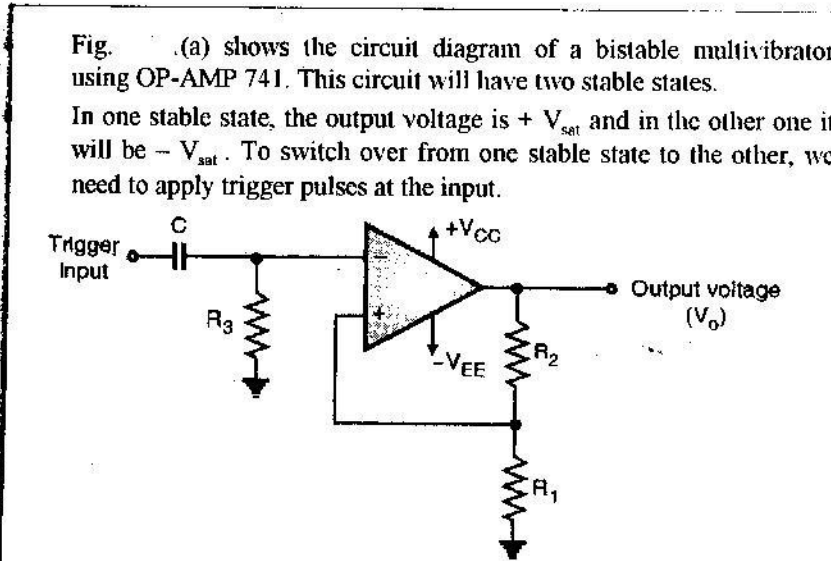
- The OP- AMP is used as an inverting amplifier. Therefore it introduces a phase shift of 180° between its input and output.
- The output of the inverting amplifier is applied at the input of the RC phase shift network. As discussed earlier, this network will introduce a phase shift of 180° . This feedback network attenuates the signal at its input and feeds it to the amplifier input. The level of attenuation is decided by the feedback factor β .
- The gain of the inverting amplifier is decided by the values of R_F and R_1 . This gain is adjusted in such a way that the product $A\beta$ is slightly greater than 1.
- It can be proved that the value of feedback factor β at the frequency of oscillations is $\beta=1/29$. For sustained oscillations, the loop gain $A\beta \geq 1$. Therefore, in order to make the loop gain $A\beta \geq 1$, the gain of the inverting amplifier A should be greater than or equal to 29.
- Gain of the inverting amplifier is given by,

$$A = R_F / R_1$$
Therefore: $R_F / R_1 \geq 29$ or $R_F \geq 29R_1$
- These values of R_F and R_1 will insure sustained oscillations.
- The expression for frequency of oscillations of an RC phase shift oscillation using OP_AMP is given by,

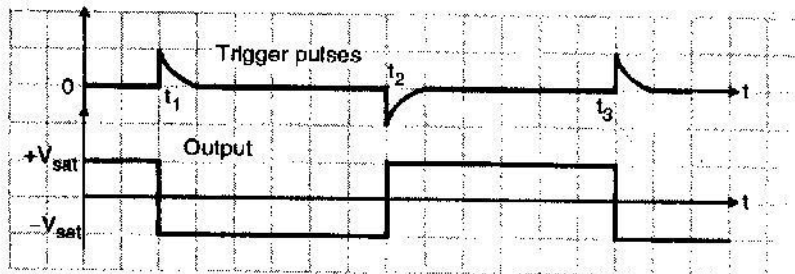
$$f_0 = 1 / 2\pi \sqrt{6} RC$$

c) Draw the circuit diagram of bistable multivibrator using op-amp and describe its working.

Ans:- (Diagram- 2 mks, description-2 mks)



(a) : Bistable multivibrator using OP-AMP



(b) : Waveforms

Operation of the circuit :

- Initially assume that the output voltage is equal to $+V_{sat}$. Therefore voltage at the non-inverting terminal (+) is given by,

$$V_{NON-INV} = \frac{R_1}{(R_1 + R_2)} \times (+V_{sat})$$

- The voltage at the inverting (-) terminal is given by,

$$V_{INV} = 0$$

This is because the inverting terminal is connected to ground through the resistor R_3 . Output voltage $V_o = +V_{sat}$ is one stable state of the circuit.

- In order to change the state of output from $+V_{sat}$ to $-V_{sat}$, it is necessary to have a higher positive voltage at the inverting (-) terminal, than that of the non-inverting (+) terminal. Therefore we apply a positive pulse at instant " t_1 " at the trigger input terminal, as shown in Fig. (b). The amplitude of trigger pulse is given by,

$$V_{TRIGGER} > \frac{R_1}{(R_1 + R_2)} \times (+V_{sat})$$

- As soon as this pulse is applied, the OP-AMP will change its output from $+V_{sat}$ to $-V_{sat}$. This is the second stable state of this circuit.
- In this stable state the voltage at non-inverting (+) terminal will be equal to,

$$V_{NON-INV} = \frac{R_1}{(R_1 + R_2)} \times (-V_{sat})$$

- In order to switch the output from $-V_{sat}$ to $+V_{sat}$, it is necessary to apply a negative trigger pulse at the input. The amplitude of this trigger pulse is given by,

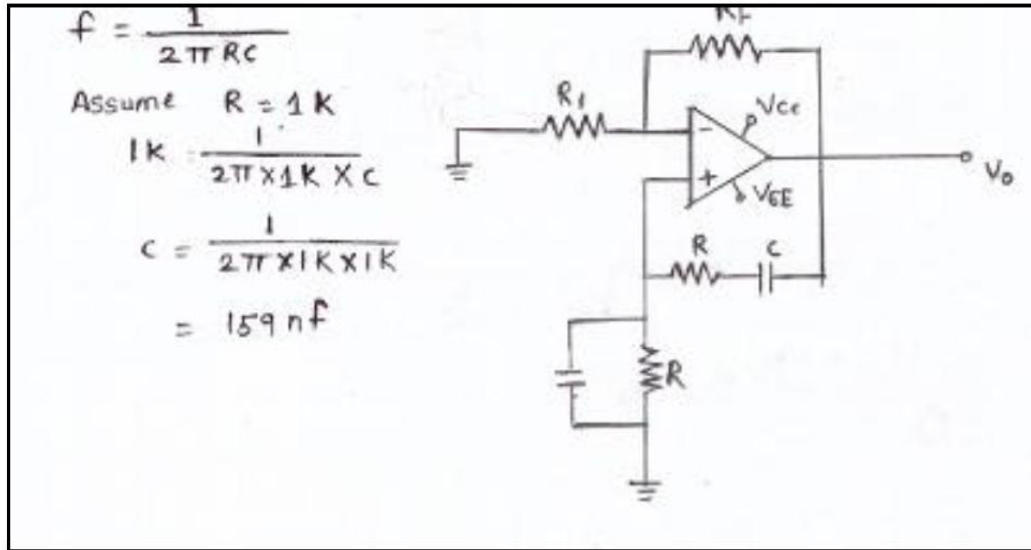
$$V_{TRIGGER} = \frac{R_1}{(R_1 + R_2)} \times (-V_{sat})$$

- At the instant " t_2 " as shown in Fig. (b), a negative trigger pulse of adequate amplitude is applied at the input of the circuit. The output will switch over from $-V_{sat}$ to $+V_{sat}$ at this instant.

d) Design op-amp based Wein Bridge Oscillator for frequency of 1 KHz.

Ans:- (Proper design steps- 2 mks, circuit diagram with component values- 2 mks)

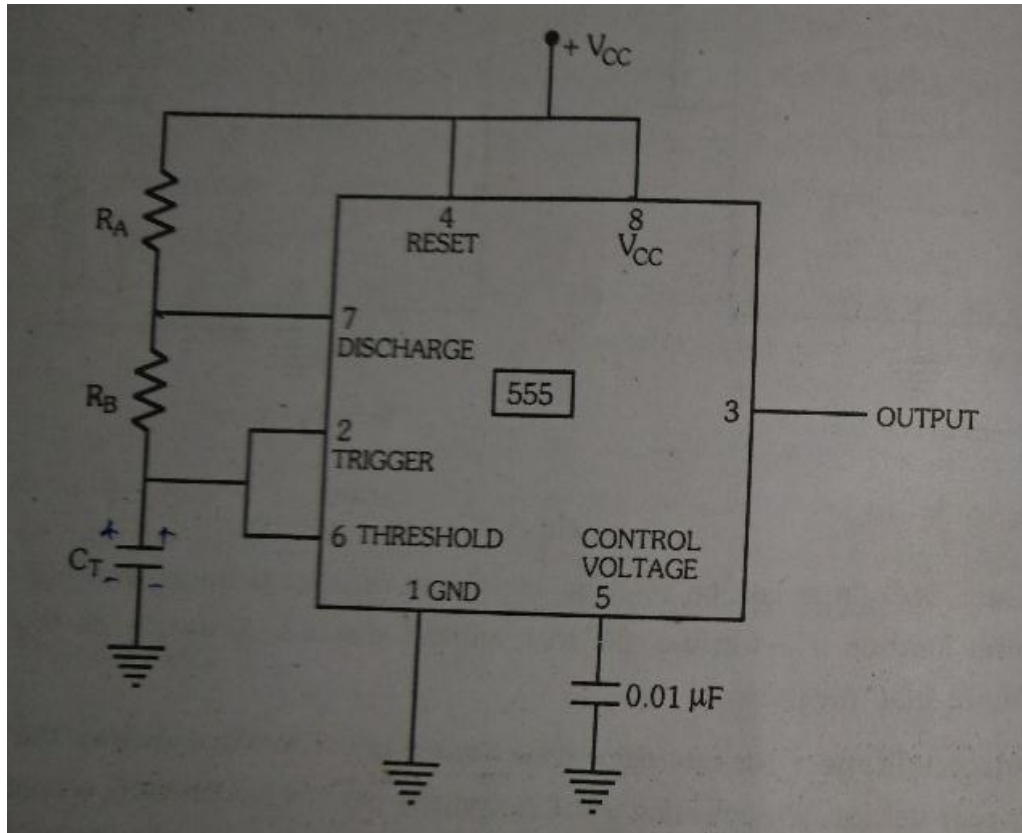
NOTE: students can assume any value of R so accordingly answer for C will change.



e) Draw the circuit of astable multivibrator using IC 555 and describe its working.

Ans:- (Diagram- 2 mks, description-2 mks)

Astable multivibrator is a circuit which will trigger itself and go from one state to another state after a predetermined interval of time. It has two quasi stable state generating rectangular waveforms.



Working : Initially the capacitor is kept uncharged. When V_{CC} is applied, the internal transistor is held OFF and the output goes high. The external capacitor C_T charges through R_A and R_B with a time constant $(R_A + R_B) C_T$. When the voltage across the capacitor reaches $\frac{2}{3} V_{CC}$, [Connected to pin 6] it makes a positive transition near the reference voltage of comparator C_1 , whose output resets the flip flop. The output of the IC goes low. The internal transistor Q_1 is ON and the capacitor discharges through the resistor R_B and the internal transistor Q_1 to ground. When the capacitor discharges to $\frac{1}{3} V_{CC}$ (connected to pin 2), it makes a negative transition near the reference voltage of comparator C_2 , making the output of the comparator set the flip flop. The output goes high. The internal transistor Q_1 becomes OFF and the capacitor again starts charging. The discharging time constant is $R_B C_T$. Subsequently the capacitor charges from $\frac{1}{3} V_{CC}$ to $\frac{2}{3} V_{CC}$ and discharges from $\frac{2}{3} V_{CC}$ to $\frac{1}{3} V_{CC}$. The cycle repeats and generates rectangular pulses at the output.

f) Draw circuit diagram of Schmitt trigger using IC 555.

Ans:- (Proper circuit Diagram- 4 mks)

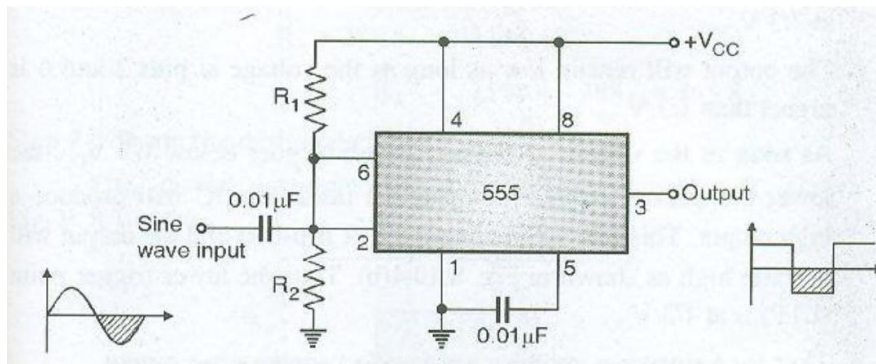


Fig: Schmitt trigger using IC 555.