BHARAT INSTITUTE OF ENGINEERING & TECHNOLOGY
MANGANPALLY 501510
IBRAHIMPATNAM RR DISTRICT
ECE DEPARTMENT

AS PER : R18 B.TECH. ECE SYLLABUS
EC 407 PC : LINEAR IC APPLICATIONS LAB B.Tech. II YEAR II SEM
ANSWERS TO VIVA VOCE QUESTIONS IN ICA LAB

PREPARED BY
Prof. G.KUMARASWAMY RAO
ECE DEPARTMENT
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(FORMER DIRECTOR DLRL DRDO MINISTRY OF DEFENCE)

LIST OF EXPERIMENTS

1. Inverting and Non Inverting Amplifiers using Op-Amps
2. Adders and Subtractors using Op-Amps
3. Comparators using Op-Amps
4. Integrator circuit using IC 741
5. Differentiator circuit using O-Amp
6. Active Filter Applications LPF , HPF (First Order)
7. IC 741 waveform generators- Sine, Square wave, and Triangular waves
8. Monostable Multivibrator using IC 555
9. Astable Multivibrator using IC 555
10. Schmitt Trigger circuits using IC 741
11. IC 565 PLL Applications
12. Voltage Regulator using IC 723
13. Three terminal voltage regulator 7805, 7809, 7912

ANSWERS TO VIVA-VOCE QUESTIONS IN ICA LAB

LESSON NOS. 1 A ,1B , & 1C: (Inverting & Noninverting)

1. What is an Operational Amplifier?

An operational amplifier is a DC coupled very high gain electronic voltage amplifier with a differential input and usually a single ended output

2. What are the ideal characteristics of an Operational amplifier?

IDEAL CHARACTERISTICS OF OP-AMP:

1. Infinite voltage gain
2. Infinite high input impedance
3. Zero output impedance
4. Zero input voltage offset
5. Positive and negative voltage swings to the supply rails

3. What is meant by CMRR?

CMRR Common Mode Rejection Ratio indicates the ability of Op-amp to supress signal common to the two inputs.

CMRR =20 log $\left[\frac{DIFFERENTIAL\ GAIN\ Av_d}{COMMON\ MODE\ GAIN\ Av_{cm}}\right]$

The op-amp provides a very high gain for single ended or differential signals and zero gain for common mode signals

High CMRR is better for op-amp

4. What is meant by Slew rate?

Slew rate is defined as the maximum rate of change of the output voltage per unit time. It is generally specified at unity (+1) gain condition

$$S = \frac{dV_0}{dt}\Big|_{\max}$$

5. What is meant by maximum output swing?

The op-amp swings to positive and negative voltages of the supplies used. In real op-amps the swing will be less than the DC supplies used.

6. What is meant by Inverting operational amplifier?

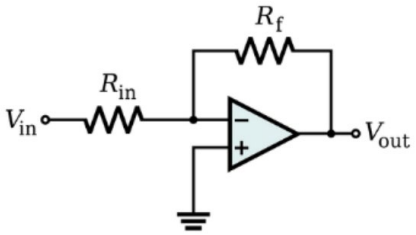
An inverting operational amplifier is a type of operational amplifier circuit which produces an output which is out of phase with respect to its input by 180^0. If the input voltage is positive, then the output voltage will be negative and vice versa.

7. What is the gain of Inverting operational amplifier?

Voltage gain of the inverting amplifier is decided by the ratio of the feedback resistor to the input resistor with the minus sign indicating the phase-reversal

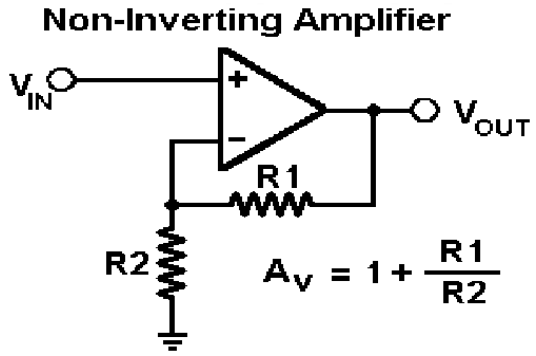
$$A_v = -\frac{R_f}{R_i}$$

where A_v is the voltage gain, R_f is the feedback resistor and R_i is the input resistor.



8. What is meant by Non-Inverting operational amplifier?

When the signal is applied at the non-inverting input, the resulting circuit is known as Non-Inverting Op-Amp. In this amplifier the output is exactly in phase with the input i.e. when a positive voltage is applied to the circuit, the output will also be positive.



9. What is the gain of Non-Inverting operational amplifier?

$$A_v = \left(1 + \frac{R_f}{R_i}\right)$$

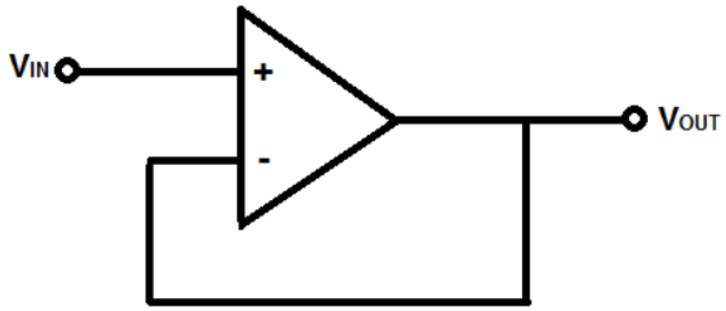
where A_v is the close loop gain of Non-inverting amplifier, R_f and R_i are the resistors as given in the figure.

10. What is meant by voltage follower with op-amp?

A voltage follower (also known as a buffer amplifier, unity-gain amplifier, or isolation amplifier) is an op-amp circuit whose output voltage is equal to the input voltage (it "follows" the input voltage). Hence a voltage follower op-amp does not amplify the input signal and has a voltage gain of 1.

11. What is the gain of voltage follower with op-amp?

The voltage follower with op-amp does not provide any amplification thus, its voltage gain is unity.



$$A_v = \frac{V_{out}}{V_{in}} = 1$$

12. List the applications of voltage follower with op-amp

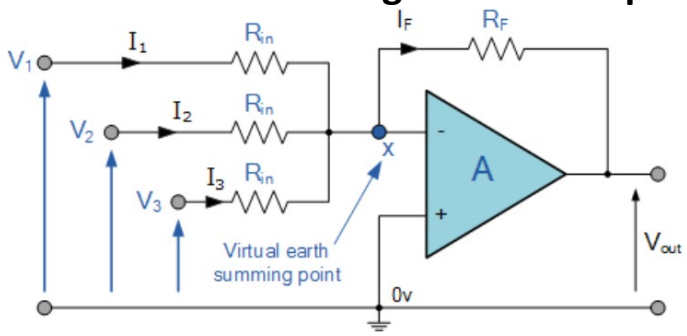
1. The voltage follower takes zero current from the input since it has very high impedance. The loading effect can be avoided
2. It provides low output impedance to circuits which use the voltage follower

Voltage follower Applications.

1. used in bridge circuits using transducers.
2. used in active filters.
3. used in sample and hold circuits.
4. as a buffer for logic circuits

LESSON NOS. 2 A & 2B: (Adder & Subtractor)

1. Draw the circuit diagram of a 3 input Adder



$$\boldsymbol{I_F = I_1 + I_2 + I_3 = -\left[\frac{V_1}{R_{in}} + \frac{V_2}{R_{in}} + \frac{V_3}{R_{in}}\right]}$$

Inverting equation

$$V_{out} = - I_F R_f$$

$$V_{out} = -\left[\frac{R_f}{R_{in}} V_1 + \frac{R_f}{R_{in}} V_2 + \frac{R_f}{R_{in}} V_3\right]$$

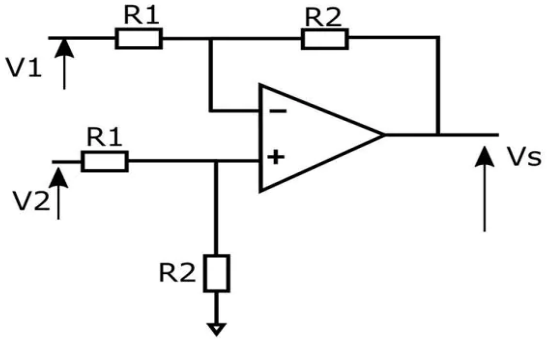
$$Let \ \frac{R_f}{R_{in}} = 1$$

$$V_{out} = -[V_1 + V_2 + V_3]$$

2. What is the other name for adder?

Summing Amplifier

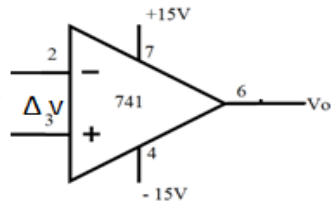
3. Draw the circuit diagram for subtractor



$$V_S = \frac{R_2}{R_1}(V_2 - V_1)$$

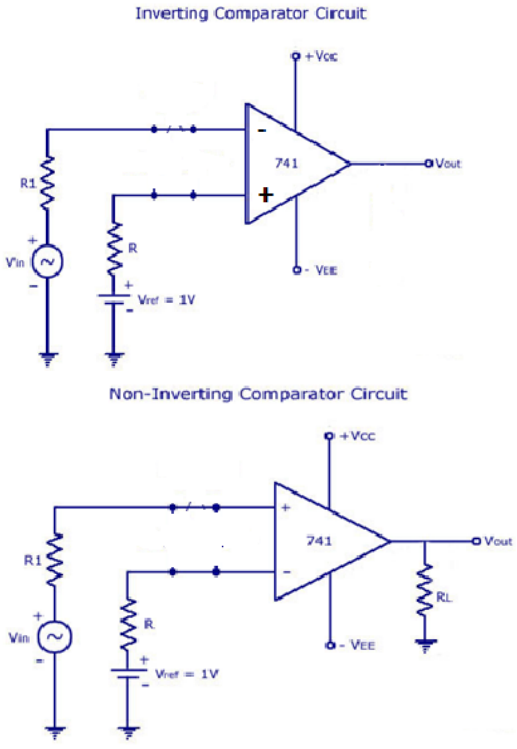
LESSON NO 3 : (Comparators)

1. How many basic input parameters are required for the comparator?



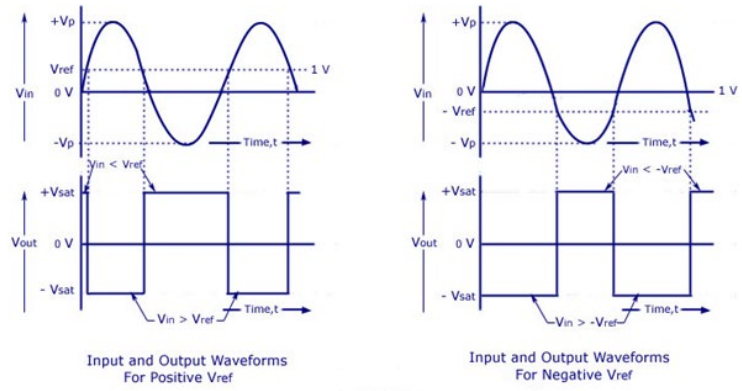
Two inputs are required, one at Inverting terminal and the other at noninverting terminal

2. Draw the circuit diagram of inverting and noninverting comparator



3. What is the output of a inverting and noninverting comparator if the input is sinusoidal

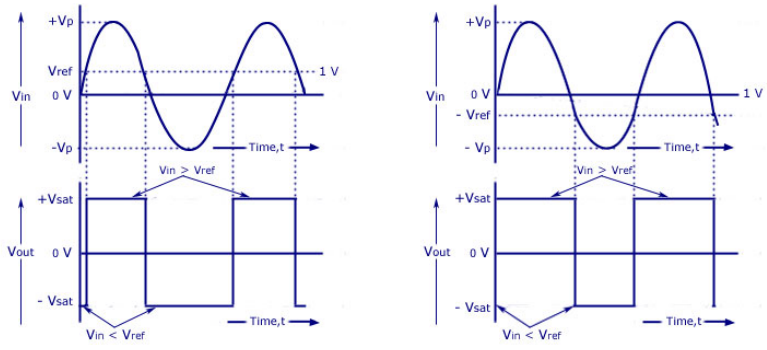
Inverting comparator:



Input and Output Waveforms For Positive Vref

Input and Output Waveforms For Negative Vref

Noninverting comparator



Input and Output Waveforms For Positive Vref

www.CircuitsToday.com

Input and Output Waveforms For Negative Vref

4. What are the differences between the inverting and noninverting comparators ?

An inverting comparator is an op-amp based comparator for which a reference voltage is applied to its non-inverting terminal and the input voltage is applied to its inverting terminal. This comparator is called as inverting comparator because the input voltage, which has to be compared is applied to the inverting terminal of op-amp.

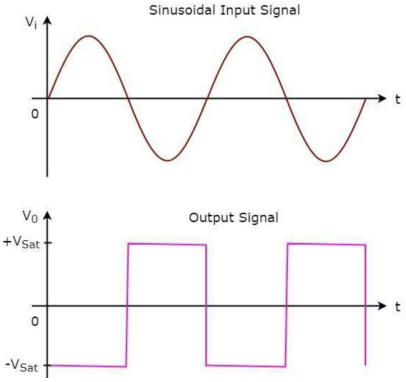
A non-inverting comparator is an op-amp based comparator for which a reference voltage is applied to its inverting terminal and the input voltage is applied to its non-inverting terminal. This op-amp based comparator is called as non-inverting comparator because the input voltage, which has to be compared is applied to the non-inverting terminal of the op-amp.

5. What is the name of the comparator if the reference voltage is zero ?

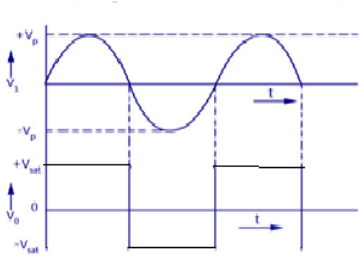
The Comparator is called Zero crossing detector

6.Draw the circuit diagram and output wave form of inverting and noninverting zero crossing detectors

Inverting Zero crossing detector:



Noninverting Zero crossing detector:



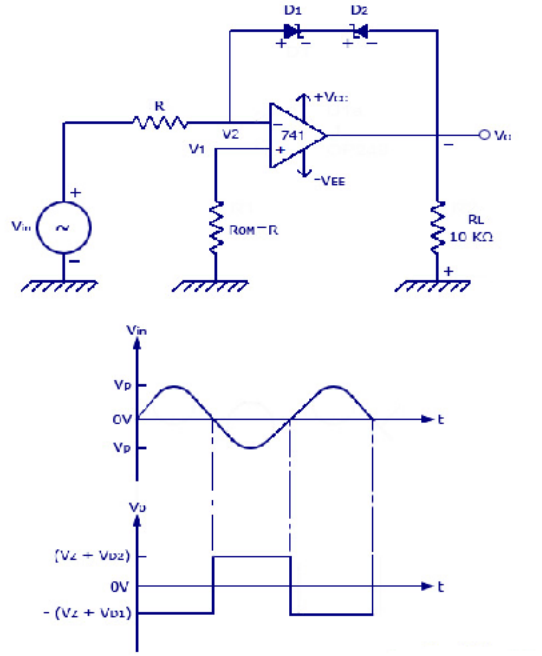
7. Discuss the characteristics of an ideal comparator.

Analog **comparators** are amplifiers that compare the magnitude of voltages at two inputs. An analog **comparator** is an operational amplifier with negative feedback removed, and with no feedback and very high gain, the output voltage goes to one extreme to the other

8. List the different types of comparators.

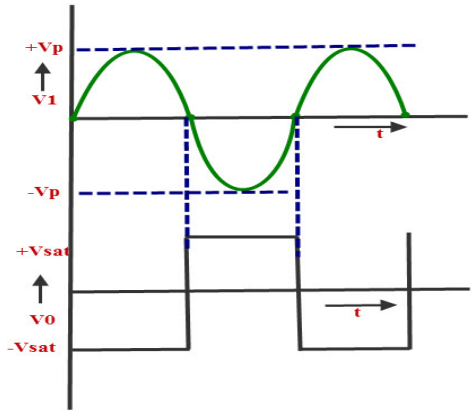
A. Inverting comparator
B. Non inverting comparator
C, Zero crossing comparator
D. Regenerative Comparator
4. What is zero crossing detector?
5. What are the applications of comparator

9. What is the meaning of voltage limiting?



10. What is zero crossing detector?

A zero-crossing detector or ZCD is 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.



11. What are the applications of comparator

Digital Interfacing
Schmitt Trigger
Discriminator
Voltage level detector and oscillators

9. In which mode the operational amplifier is connected in the comparator

It can be connected in both Inverting and Noninverting mode

LESSON NO:4 (Integrator)

1. What is an integrator?

An integrator in measurement and control applications is an element whose output signal is the time integral of its input signal. It accumulates the input quantity over a defined time to produce a representative output.

2. What are the applications of integrator

a. To find the area under a curve
b. To Find Centre of mass of an object
c. To Find speed of a moving missile from the acceleration or position from speed
d. In function generator, the integrator circuit is used to produce the triangular wave.
e. It is used in analog computers, where integration is needed to be done using the analog
circuit.
f. Integrator circuit is also widely used in analog to the digital converters.

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3. Write down the expression for output Vo of an integrator

$$v_o = -\frac{1}{R_1\ C}\int_0^t v_{in}\ dt$$

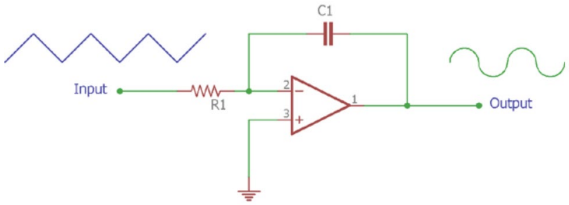
4. For an op-amp. integrator circuit, sine wave input of 4 Sin 1000t is given. In the circuit, R = 200 MΩ and C = 0.1 µF. Determine the value of output voltage

For an input A Sin (ω t) we get the output as $\frac{1}{\mathrm{R\,C}} \times \frac{\mathrm{A}}{\omega}\ \mathrm{Cos}\ (\omega\ \mathrm{t})$

Output =

$$\frac{1}{200 \times 10^6\ \times 0.1 \times 10^{-6}} \times \frac{4}{1000}\ \mathrm{Cos}\ (1000\ \mathrm{t}) = 0.2 \times 10^{-3}\ Cos\ (1000t)$$

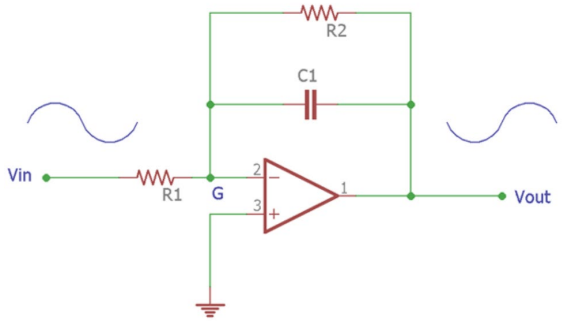
5. What type of output waveform is obtained when a triangular wave is applied to integrator circuit



If triangular wave is the input to the op-amp integrator it produces a **sinusoidal wave**.(we should have got t 2 as the output) As the amplifier act as a low pass filter, the high-frequency harmonics are greatly reduced. The output sine wave only consists of low-frequency harmonics and the output will be of low amplitude.

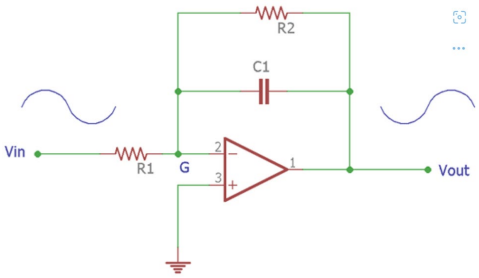
6. What is the purpose behind the connection of Rf in the feedback path of integrator?

In low frequency or in DC, the capacitor impedance $\frac{1}{2\,\pi\,f\,C} \rightarrow \infty$ since f → 0. This produces open circuit in the feedback circuit. The output voltage saturates. To overcome this, a resistor is connected in parallel with capacitor. This added resistor provides a feedback path.

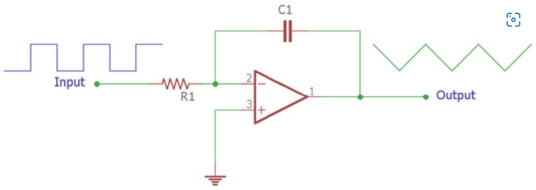


7. Draw the output waveform of the integrator for different waveforms

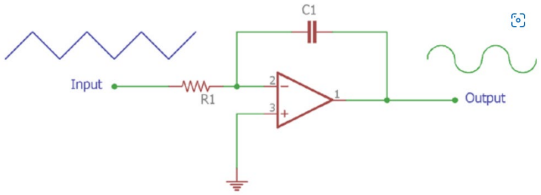
Input = Sine wave
output =Cosine wave



Input = Square wave
output = Triangular wave



Input = triangular
output = Sine wave

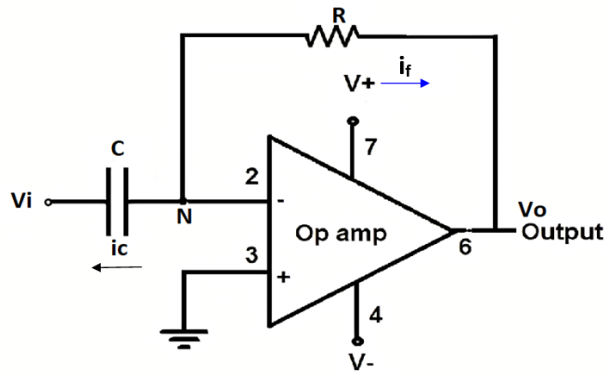


LESSON NO:5 (Differentiator)

1. What is a differentiator?

Differentiator, a device or set of components for performing the mathematical operation of differentiation —i.e., supplying an output proportional to the derivative of the input with respect to one or more variables**.**

2. Draw the circuit of the differentiator using OP-AMP IC741.



3. Write down the expression for Vo of a differentiator.

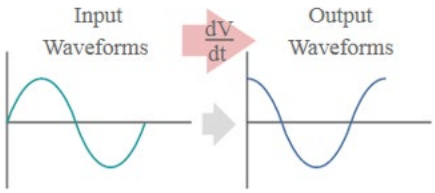
$v_0 = -R\,C\frac{d\,v_i}{dt}$

output v_o = derivative of v_i input voltage multiplied by – (RC)

— ve sign indicates 180 ^{0} phase shift

4. Draw the output waveform of the differentiator when the input is a sine wave

Sine wave passed through a Differentiator becomes Cosine wave



LESSON 6: (Active Filter)

1. List the advantages of active filters over passive filter

ADVANTAGES OF ACTIVE FILTERS.

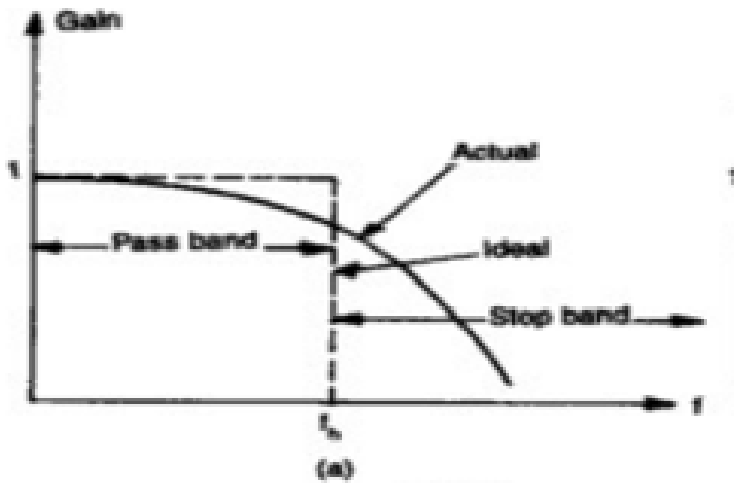
i) No inductors
ii) op-amps , resistors and capacitors used
iii) provides required gain
iv) easier to design
v) high input impedance prevents excessive loading of the driving source
vi) low output impedance prevents the filter from being affected by the load
vii) easy to adjust over a wide frequency range without altering the desired response
viii) reduced size and weight
ix) increased reliability and improved performance
x) in larger quantities its cost is less compared to passive filter

DISADVANTAGES OF ACTIVE FILTERS:

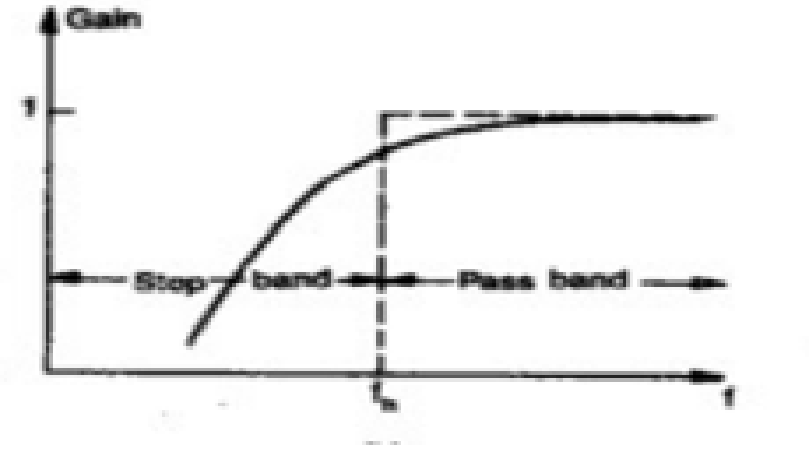
i) Limited bandwidth of active devices limits the operation at highest frequency around
100 KHz (passive filters can go upto 500KHz
ii) require power supply unlike passive filters
iii) increased sensitivity to variations in circuit parameters caused by environmental
changes compared to passive filters

2. Draw the frequency response for ideal and practical of all types of filters

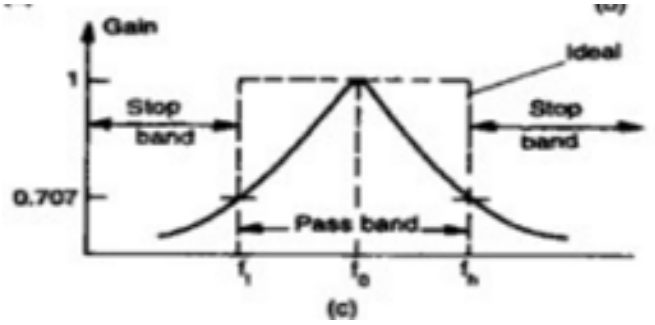
LOW PASS FILTER:



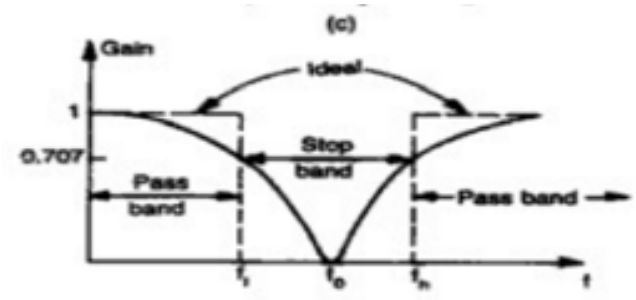
HIGH PASS FILTER:



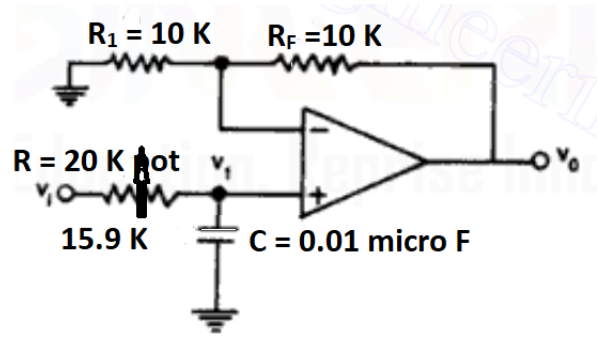
BAND PASS FILTER:



BAND REJECT FILTER:



3. Design a first order low pass filter for 2 kHz frequency with a pass band gain of 2



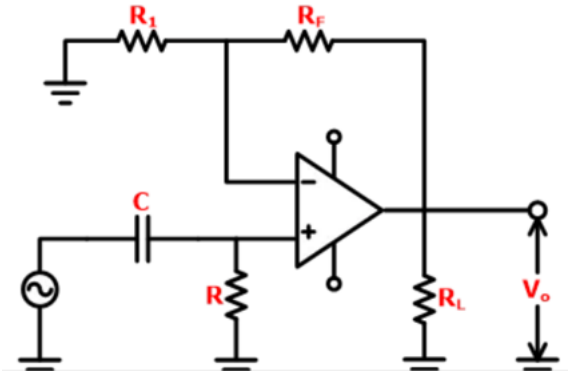
A). f_H = 1 KHz. B). Let C = 0.01 µF

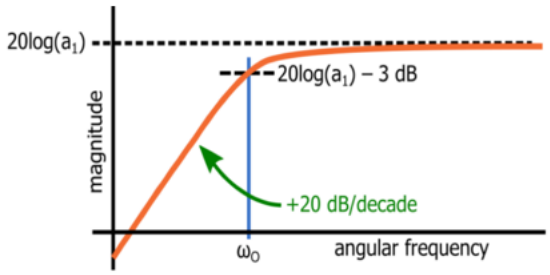
C). Then R = $\frac{1}{2\pi f_H C} = \frac{1}{2\,\pi\, 10^3 \times 0.01 \times 10^{-6}} = 15.9\ K\ ohms$.

Use a 20 K ohms potentiometer and adjust it to get required value

D). Pass band gain is 2 = $1+\frac{R_F}{R_1}$. So $R_F = R_1$ let the value be 10K

4. Draw the ideal and practical frequency response characteristics of high pass filter





5. What are the applications of LPF and HPF

APPLICATIONS OF LPF:

- LPF are used in telephone systems for converting the frequencies of audio in the speaker to a band-limited voice band signal.
- LPFs are used to filter high-frequency signals which are unwanted and 'noise' from a circuit, as the signal is passed through this filter. Then the most of the high-frequency signal is eliminated along with the noise
- LPF is used as an integrator
- In multi-rate DSP, while executing an Interpolator, LPF is used as an Anti – Imaging Filter. Similarly, when executing a decimator this filter is used as an anti-aliasing filter.
- LPFs are used in receivers like Super heterodyne for an efficient response of the baseband signals.
- LPf is used in the medical devices for the signals coming from the human body . So these signals can flow through the LPF for removing some unwanted ambient sound.
- These filters are used in the conversion of duty cycle amplitude as well as phase detection in the phase locked loop.

- LPF is used in AM radio for the diode detector to change the AM modulated intermediate frequency signal to the audio signal.

APPLICATIONS OF HPF:

- These are used in the loud speakers to reduce the low level noise.
- Eliminates rumble distortions in audio applications so these are also called are treble boost filters.
- These are used in audio amplifiers to amplify the higher frequency signals.
- These are also used in equalizers.
- Used in AC coupling

LESSON 7 (Waveform Generator)

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LESSON 8 (Monostable Multivibrator)

1. List the important features of the 555 Timer.

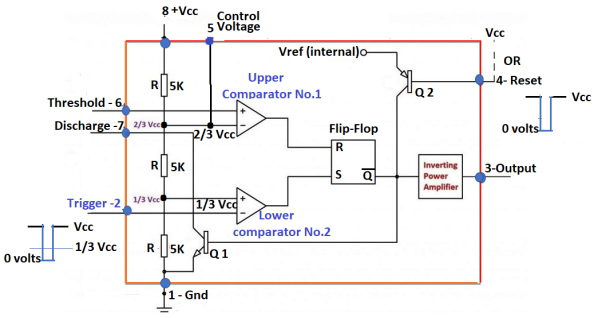
- **MAIN FEATURES OF IC 555:**
- 1. It operates from + 5 Volts to + 18 Volts supply voltage.
- 2. Sink or source 200 mA of load current.
- 3. Timing intervals can be made into several minutes along with the frequencies exceeding several hundred kilohertz.
- 4. The output drives a transistor-transistor logic (TTL) due to its high current output.
- 5. It has a temperature stability of 50 parts per million (ppm) per degree Celsius change in temperature, or equivalently 0.005 %/ °C.
- 6. The duty cycle of the timer is adjustable.
- 7. Maximum power dissipation per package is 600 mW
- 8. Its trigger and reset inputs has logic compatibility.

2. What is the function of control input (pin5) of 555 timers?

This is directly connected to the inverting terminal of the first comparator. 2/3 Vcc is internally connected at this pin. Through this pin external voltage is connected if required.

This pin controls the timing of the 555 by overriding the 2/3Vcc level of the voltage divider network.

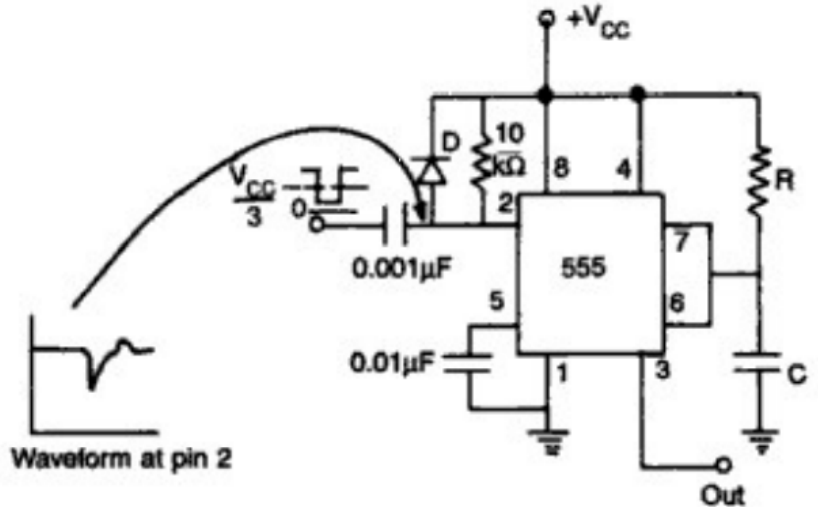
By applying a voltage to this pin the width of the output signal can be varied independently of the RC timing network. When not used it is connected to ground via a 10nF capacitor to eliminate any noise.



3. List the applications of 555 timers in Monostable mode.

- 1. Missing pulse detector
- 2. PWM: Pulse Width Modulations
- 3. Frequency Divider
- 4. Linear Ramp generator

5. Explain the trigger circuit used for Monostable multivibrator?



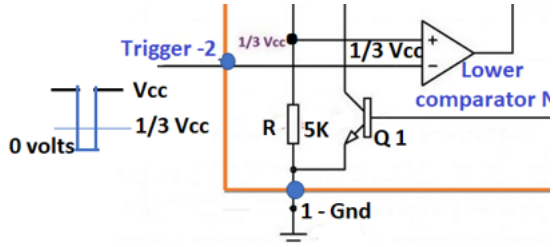
6. Why do we use negative trigger for Monostable operation?

TRIGGER

It is responsible for SET transition of the flip-flop. With this the timing pulse starts. The non-inverting terminal of the second comparator is connected to the **1/3 Vcc** point . So if we decrease the voltage of the trigger pin below the **1/3 Vcc** then the output of the comparator will be **HIGH** (Set) and the FF is SET. Q =1 and $\overline{Q}$ = 0 (LOW)

This trigger is an active low trigger.

The output at the **pin 3** goes **HIGH** when the 555 timer is triggered through **pin 2**



7. What are the applications of Monostable multivibrator?

Application of Monostable:

1. The monostable multivibrator is used as delay and timing circuits.
2. It is also used for temporary memories.
3. It is often used to trigger another pulse generator.
4. It is used for regenerating old and worn out pulses.

LESSON 9 (Astable Multivibrator)

1. Define Duty cycle

Duty cycle is the ratio of ON time (duration of HIGH state or pulse width) to the total time period of a cycle. The duty cycle of an Astable multivibrator = $\frac{Ton}{Ton+Toff}$

2. Consider the Astable multivibrator with R1 = 200 KΩ and C = 0.1 µF . Determine a) High state interval b) Low state interval c) period d) Frequency e) Duty cycle

t_{HIGH} = 0.69 (R_1 + R_2) C = 0.69 (10 + 200) $10^3 \times 0.1 \times 10^{-6} = 14.5$ millisecs

t_{LOW} = 0.69 R_2 C = 0.69× 200 × 10^3 × 0.1 × 10^{-6} = 13.8 millsecs
T = t_{HIGH} + t_{LOW} = 0.69 (R_1 + 2 R_2)C = 0.69 × (10 + 2×200) 10^3 × 0.1 × 10^{-6} =28.3millisecs
Frequency = 1 / T = $\frac{1}{0.69\,(\,R_1+2\,R_2)C} = \frac{1.45}{(R_1+2\,R_2)C}$ =
$=\frac{1.45}{(10+2\times200)\times10^3\times0.1\times10^{-6}} = 35.4$ HZ
Duty cycle = $\frac{t_{HIGH}}{T} \times 100 = \frac{R_1+R_2}{(\,R_1+2\,R_2)} = \frac{10+200}{(\,10+2\times200)} = 0.51 = 51\%$

3. Why do we connect pin 4 of IC 555 timer to supply pin when it is not used ?

PIN NO.4 : RESET

The pin no.4 is used to reset the flip-flop circuit. The negative pulse is applied to this pin to disable or reset. If not used it is connected to Vcc to avoid false triggering due to noise. This
provides a mechanism to reset the FF . This overrides the effect of any instruction
coming from Lower comparator

4. What is the function of control input (pin5) of 555 timer?

PIN NO.5 CONTROL VOLTAGE:

This is directly connected to the inverting terminal of the first comparator. 2/3 Vcc is internally connected at this pin. Through this pin external voltage is connected if required.
This pin controls the timing of the 555 by overriding the 2/3Vcc level of the voltage divider network. By applying a voltage to this pin the width of the output signal can be varied independently of the RC timing network. When not used it is connected to ground via a 10nF capacitor to eliminate any noise.

5. Design an Astable 555 timer circuit to produce a 2kHz square wave with a duty cycle of 70%.

Duty cycle = $\frac{t_{HIGH}}{T} \times 100 = \frac{R_1+R_2}{(\,R_1+2\,R_2)}$ **= 0.7**
Frequency = 1 / T = $\frac{1}{0.69\,(\,R_1+2\,R_2)C} = \frac{1.45}{(R_1+2\,R_2)C} = 2000$
Let C= 0.1 micro farad and R1and R2 can be found out

6. What is the other name for Astable multivibrator (AMV)?
Wave form generator

7. What is the formula for the time period of the waveform of AMV?
$T = t_{HIGH} + t_{LOW} = 0.69 (R_1 + 2 R_2)C$

8. What is the formula for the % of duty cycle?
Duty cycle = $\frac{t_{HIGH}}{T} \times 100 = \frac{R_1+R_2}{(R_1+2 R_2)} \times 100$

9. List out the applications of Astable multivibrator
1. The astable multivibrator is used as the wave generator.
2. It is used as voltage-frequency converter.
3. It is used in pulse synchronization.
4. Since it produces square waves, it is a source of production of a harmonic frequency of higher order.
5. It is used in the construction of voltmeter and SMPS.
6. It can be operated as an oscillator over a wide range of audio and radio frequencie

LESSON 10 (SCHMITT TRIGGER)

1. Which type of comparator is called as Schmitt Trigger?
It is called Regenerative comparator

2. What is the output of Schmitt Trigger if the input is sine wave?
Square wave

3. What type of waveform is obtained when triangular or ramp waveforms are applied to Schmitt Trigger?
Square wave

4. What is the threshold voltage?

Input voltage V_i triggers the output V_o whenever V_i exceeds certain voltage levels. These voltages are Upper threshold voltage V_{UT} and Lower threshold voltage $V_{LT.}$

5. What is the hysteresis

The hysteresis width is difference between upper and lower thresholds

LESSON 11 (PLL)

1. List the basic building blocks of a PLL.

The PLL consists of i) a phase detector ii) a low pass filter and iii) a voltage controlled oscillator

2. Define capture range.

It is the frequency range $\pm \Delta \omega_C$ centered about ω_O , over which the PLL can acquire lock with an input signal. The capture range is affected by filter characteristics

3. Define lock range.

When PLL is in lock, the frequency range $\pm \omega_L$, centered about ω_o , over which the loop can track the input is called Lock range. It is affected by the operating range of the phase detector and the VCO

4. Define pull in time.

The Capture of an input signal does not take place as soon as the signal is applied, but it takes finite time. The total time taken by the PLL to establish a lock is called pull in time

5. Which is greater capture range or lock range?

Capture range is greater than lock range

6. List the applications of PLL

1. Frequency Modulation (FM) stereo decoders, FM Demodulation networks for FM operation.
2. Frequency synthesis that provides multiple of a reference signal frequency.
3. Used in motor speed controls, tracking filters.
4. Used in frequency shift keying (FSK) decodes for demodulation carrier frequencies.

LESSON 12 (723 VOLTAGE REGULATOR)

1. What is the function of a voltage regulator?

The purpose of a voltage regulator is to keep the voltage in a circuit relatively close to a desired value. Voltage regulators are one of the most common electronic components, since a power supply frequently produces raw current that would otherwise damage one of the components in the circuit.

2. Define line and load regulation of a regulator.

In practice change in input voltage to a voltage regulator will cause a change in its output or load voltage.

The line regulation (source regulation) indicates the change in output that will occur due to change in input voltage.

It is defined as the change in regulated load voltage due to change in line voltage (input voltage) in specified range

Line regulation = $\frac{\Delta Vout}{\Delta Vin} \times 100$

Load regulation can be defined as the percentage change in output voltage for a given change in load current

Load regulation can also be explained as a percentage change in output voltage from no load (NL) to full load (FL)

Load regulation = $\frac{VNL - VFL}{VFL} \times 100$

4. List the features of a voltage regulator IC 723.

1. It has wide variety of applications such as series, shunt, switching and floating regulators.

2. Relative simplicity with power supply can be designed.
3. It has small in size and lower in cost.
4. Input voltage is maximum 40 V.
5. Output voltage adjustable from 2 V to 37 V.
6. Output current up to 150 mA without external pass transistor.
7. Load and line regulations of 0.03%.
8. It operates in positive or negative supply operation.
9. It has choice of supply voltage.
10. Low standby current gain.

5. List the different types of IC voltage regulators.

Basically, there are two types of Voltage regulators: Linear voltage regulator and Switching voltage regulator.
There are two types of Linear voltage regulators: Series and Shunt.
There are three types of Switching voltage regulators: Step up, Step down and Inverter voltage regulators.

6. What are the applications of voltage regulator

Wherever the power-supply must be kept at a fixed value, regardless of variations in load current or input voltage
1. Use in all power supplies to electronic gadgets to regulate voltage and save the device from damage
2 . Used with the alternator of internal combustion engines to regulate the alternator output.
3. Used in electronics circuits to supply a precise amount of voltage

LESSON 13 (THREE TERMINAL VOLTAGE REGULATOR)

1. List various positive voltage regulator ICs.

78XX series:

This is a positive regulator. The first two digits i.e.78 indicates that the output voltage is positive. The second two digits 'XX' indicates output voltage of the regulator. The available ICs of this series are 7805(+5V), 7812 (+12V), 7815(+15V) etc. The output voltages are shown in brackets.

2. List various negative voltage regulators

79XX series:

This is a negative voltage regulator. The first two digits i.e.79 indicates that the output voltage is negative. The second two digits 'XX' indicates output voltage of the regulator. The available ICs of this series are 7905(-5V), 7912 (-12V), 7915(-15V) etc. The output voltages are shown in brackets

CONCLUDED