
# JEPPIAAR
## ENGINEERING COLLEGE

**DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING**

# EC 3451 – LINEAR INTEGRATED CIRCUITS

## (Regulation 2021)

# QUESTION BANK

## Year/ Semester: II/IV

| JEPPIAAR ENGINEERING COLLEGE | | |
|---|---|---|
| **Vision of the Institute** | To build Jeppiaar Engineering College as an institution of academic excellence in technological and management education to become a world class University | |
| **Mission of the Institute** | **M1** | To excel in teaching and learning, research and innovation by promoting the principles of scientific analysis and creative thinking |
| | **M2** | To participate in the production, development and dissemination of knowledge and interact with national and international communities. |
| | **M3** | To equip students with values, ethics and life skills needed to enrich their lives and enable them to meaningfully contribute to the progress of society |
| | **M4** | To prepare students for higher studies and lifelong learning, enrich them with the practical and entrepreneurial skills necessary to excel as future professionals and contribute to Nation's economy |
| **DEPARTMENT: ELECTRONICS AND COMMUNICATION ENGINEERING** | | |
| **Vision of the Department** | To become a centre of excellence to provide quality education and produce creative engineers in the field of Electronics and Communication Engineering to excel at international level. | |
| **Mission of the Department** | **M1** | Inculcate creative thinking and zeal for research to excel in teaching-learning process |
| | **M2** | Create and disseminate technical knowledge in collaboration with industries |
| | **M3** | Provide ethical and value based education by promoting activities for the betterment of the society |
| | **M4** | Encourage higher studies, employability skills, entrepreneurship and research to produce efficient professionals thereby adding value to the nation's economy |

| | | |
|---|---|---|
| **PROGRAM OUTCOMES (PO)** | **PO 1** | **Engineering knowledge**: **Apply** the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems. |
| | **PO 2** | **Problem analysis**: **Identify, formulate, review** research literature, and **analyze** complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| | **PO 3** | **Design/development of solutions**: **Design solutions** for complex engineering problems and **design** system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations |
| | **PO 4** | **Conduct investigations of complex problems**: **Use** research-based knowledge and research methods including **design** of experiments, **analysis** and **interpretation** of data, and **synthesis** of the information to provide valid conclusions. |
| | **PO 5** | **Modern tool usage**: **Create**, **select**, and **apply** appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| | **PO 6** | **The engineer and society**: **Apply** reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| | **PO 7** | **Environment and sustainability**: **Understand** the impact of the professional engineering solutions in societal and environmental contexts, and **demonstrate** the knowledge of, and need for sustainable development. |
| | **PO 8** | **Ethics**: **Apply** ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| | **PO 9** | **Individual and team work**: **Function effectively** as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| | **PO 10** | **Communication**: **Communicate effectively** on complex engineering activities with the engineering community and with society at large, such as, being able **to comprehend** and **write** effective reports and **design** documentation, **make** effective presentations, and **give** and **receive** clear instructions. |
| | **PO 11** | **Project management and finance**: **Demonstrate** knowledge and understanding of the engineering and management principles and **apply** these to one's own work, as a member and leader in a team, to **manage** projects and in multidisciplinary environments. |
| | **PO 12** | **Life-long learning**: **Recognize** the need for, and have the preparation and ability to **engage** in independent and life-long learning in the broadest context of technological change. |

| | | |
|---|---|---|
| **PROGRAM EDUCATIONAL OBJECTIVES (PEOS)** | **PEO I** | Produce technically competent graduates with a solid foundation in the field of Electronics and Communication Engineering with the ability to analyze, design, develop, and implement electronic systems. |
| | **PEO II** | Motivate the students for choosing the successful career choices in both public and private sectors by imparting professional development activities. |
| | **PEO III** | Inculcate the ethical values, effective communication skills and develop the ability to integrate engineering skills to broader social needs to the students. |
| | **PEO IV** | Impart professional competence, desire for lifelong learning and leadership skills in the field of Electronics and Communication Engineering. |
| **PROGRAM SPECIFIC OUTCOMES (PSOs)** | **PSO 1** | Design, develop and analyze electronic systems through application of relevant electronics, mathematics and engineering principles. |
| | **PSO 2** | Design, develop and analyze communication systems through application of fundamentals from communication principles, signal processing, and RF System Design & Electromagnetics. |
| | **PSO 3** | Adapt to emerging electronics and communication technologies and develop innovative solutions for existing and newer problems. |

**EC3451 LINEAR INTEGRATED CIRCUITS L T P C**
**3 0 0 3**

**COURSE OBJECTIVES:**

- To introduce the basic building blocks of linear integrated circuits
- To learn the linear and non-linear applications of operational amplifiers
- To introduce the theory and applications of analog multipliers and PLL
- To learn the theory of ADC and DAC
- To introduce the concepts of waveform generation and introduce some special function ICs

**UNIT I BASICS OF OPERATIONAL AMPLIFIERS 9**

Current mirror and current sources, Current sources as active loads, Voltage sources, Voltage References, BJT Differential amplifier with active loads, Basic information about op-amps – Ideal Operational Amplifier - General operational amplifier stages -and internal circuit diagrams of IC 741, DC and AC performance characteristics, slew rate, Open and closed loop configurations – MOSFET Operational Amplifiers – LF155 and TL082.

**UNIT II APPLICATIONS OF OPERATIONAL AMPLIFIERS 9**

Sign Changer, Scale Changer, Phase Shift Circuits, Voltage Follower, V-to-I and I-to-V converters, adder, subtractor, Instrumentation amplifier, Integrator, Differentiator, Logarithmic amplifier, Antilogarithmic amplifier, Comparators, Schmitt trigger, Precision rectifier, peak detector, clipper and clamper, Low-pass, high-pass and band-pass Butterworth filters.

**UNIT III ANALOG MULTIPLIER AND PLL 9**

Analog Multiplier using Emitter Coupled Transistor Pair - Gilbert Multiplier cell – Variable transconductance technique, analog multiplier ICs and their applications, Operation of the basic PLL, Closed loop analysis, Voltage controlled oscillator, Monolithic PLL IC 565, application of PLL for AM detection, FM detection, FSK modulation and demodulation and Frequency synthesizing and clock synchronization

**UNIT IV ANALOG TO DIGITAL AND DIGITAL TO ANALOG CONVERTERS 9**

Analog and Digital Data Conversions, D/A converter – specifications - weighted resistor type, R-2R Ladder type, Voltage Mode and Current-Mode R - 2R Ladder types - switches for D/A converters, high speed sample-and-hold circuits, A/D Converters – specifications - Flash type - Successive Approximation type - Single Slope type – Dual Slope type - A/D Converter using Voltage-to-Time Conversion - Over-sampling A/D Converters, Sigma – Delta converters.

**UNIT V WAVEFORM GENERATORS AND SPECIAL FUNCTION ICS 9**

Sine-wave generators, Multivibrators and Triangular wave generator, Saw-tooth wave generator, ICL8038 function generator, Timer IC 555, IC Voltage regulators – Three terminal fixed and adjustable voltage regulators - IC 723 general purpose regulator - Monolithic switching regulator, Low Drop – Out(LDO) Regulators - Switched capacitor filter IC MF10, Frequency to Voltage and Voltage to Frequency converters, Audio Power amplifier, Video Amplifier, Isolation Amplifier, Optocouplers and fibre optic IC

**COURSE OUTCOMES:**
At the end of the course the students will be able to

**CO1** : Design linear and nonlinear applications of OP – AMPS
**CO2** : Design applications using analog multiplier and PLL
**CO3** : Design ADC and DAC using OP – AMPS
**CO4** : Generate waveforms using OP – AMP Circuits
**CO5** : Analyze special function ICs

**TOTAL:45 PERIODS**

**TEXT BOOK**

1.D.Roy Choudhry, Shail Jain, "Linear Integrated Circuits", New Age International Pvt. Ltd., 2018, Fifth Edition. (Unit I – V)
2.Sergio Franco, "Design with Operational Amplifiers and Analog Integrated Circuits", 4th Edition, Tata Mc Graw-Hill, 2016 (Unit I – V)

**REFERENCES**

1. Ramakant A. Gayakwad, "OP-AMP and Linear ICs", 4th Edition, Prentice Hall / Pearson Education, 2015
2. Robert F.Coughlin, Frederick F.Driscoll, "Operational Amplifiers and Linear Integrated Circuits", Sixth Edition, PHI, 2001.
3. S.Salivahanan & V.S. Kanchana Bhaskaran, "Linear Integrated Circuits", TMH,2nd Edition, 4th Reprint, 2016.

# UNIT-I BASICS OF OPERATIONAL AMPLIFIERS

## PART-A

**1.** What is the cause for slew rate and how it can be made faster? **[April/May 2021] [April/May 2015]**

There is a capacitor within or outside an op-amp to prevent oscillation. It is this capacitor which prevents the output voltage from responding immediately to a fast changing input .The slew rate can be made faster by having a higher current or a small compensating capacitor

**2.** Write down the characteristics of ideal operational amplifier? **[April/May 2021] [Nov/Dec 2018] [April/May 2017][April/May 16]**

Open loop voltage gain, (AOL) = ∞
Input impedance (Ri) = ∞
Output impedance (Ro) = 0
Bandwidth (BW) = ∞
Zero offset Vo = 0, when V1 = V2 = 0

3. State the significance of current mirror circuit **[April/May 2019]**

A current mirror circuit is designed to copy a current through one active device by controlling the current in another active device of a circuit keeping the output current constant regardless of loading. The current mirrors are used to provide bias currents and active loads to circuits

4. Mention the application of LF155 **[April/May 2019]**

- Precision high speed integrators
- Fast D/A and A/D converters
- High impedance buffers
- Wideband low noise low drift amplifiers

5. Define differential mode gain **[Nov/Dec 2018]**

It is the change in the difference between the two outputs divided by the change in the difference between the two inputs.

6. Enumerate any two blocks associated with op-amp schematic. **[April/May 2018]**

**Differential amplifier**

Differential amplifier is to provide high gain to difference mode signal and cancel the common mode signal**.**

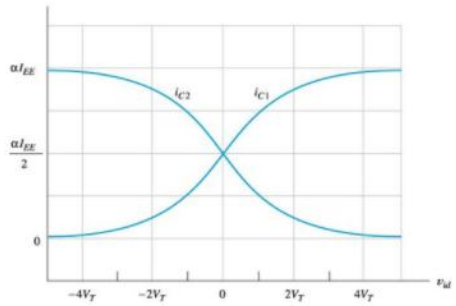
**Level translator**

As the op-amp is used to operate down to d.c no coupling capacitor is used. Because of direct coupling ,the d.c level rises from stage to stage. This increase in d.c level tends to shift the operating point of the next stage. This in turn limits the output swing and may distort the output signal. Therefore it becomes essential that the quiescent voltage of one stage is shifted before it is applied to the next stage.

7. What are the two methods can be used to produce voltage sources? **[April/May 2018]**

- Using temperature compensation
- Using avalanche diode.

8. Draw the dc transfer characteristics of a BJT differential amplifier and define differential mode input voltage **[Nov/Dec 2017]**

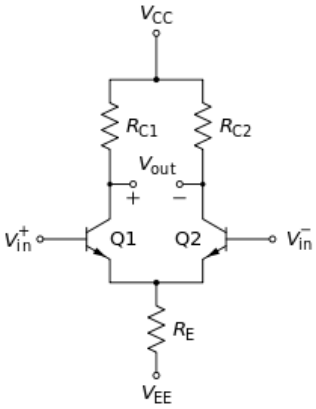



**9.** Why is the current mirror circuit used in differential amplifier stages? **[April/May 2017]**

The current mirror is a special case of constant current bias and the current mirror bias requires of constant current bias and therefore can be used to set up currents in differential amplifier stages

10. Draw the Internal Block diagram of Op – Amp (IC 741) **[Nov/Dec 2016]**


11. Draw the circuit diagram of a symmetrical emitter coupled differential amplifier. **[Nov/Dec 2016]**




12. Differentiate the ideal and practical characteristics of an op-amp**[May/June 2016]**

| Characteristics | Ideal | Practical |
|---|---|---|
| Open loop voltage gain | ∞ | High |
| Input impedance (Ri) | ∞ | High |
| Output impedance (Ro) | 0 | Low |
| Bandwidth (BW) | ∞ | High |
| Zero offset | Vo = 0, when V1 = V2 = 0 | Non zero |

13. An operational amplifier has a slew rate of 4v/μs .Determine the maximum frequency of operation to produce distortion less output swing of 12V **[April/May 16]**

Frequency f = slewrate(SR) / 2ΠVm

= 4 / (2* Π*12)

= 0.013 Hz

14. Define input bias current and input offset current of an operational amplifier **[Nov/Dec 2015]**

Input bias current is the average value of the base current entering in to the i/p terminals of an opamp.Its typical value is 500nA

Input offset current is the algebraic difference between the current into the inverting and non-inverting terminals is referred to as input offset current $I_{io}$. Mathematically it is represented as

$I_{io} = |I_{B+} - I_{B-}|$

Where IB+ is the current into the non-inverting input terminals.

IB- is the current into the inverting input terminals.

15. Mention two advantages of active load over passive load in an operational amplifier **[Nov/Dec 2015]**

- Larger gain
- Larger Bandwidth

16. A differential amplifier has a differential voltage gain of 2000 and a common mode gain of 0.2.Determine the CMRR in dB **[April/May 2015]**

Given common mode gain $A_{cm}=0.2$

Difference mode gain $A_{dm}=2000$

CMRR= $A_{dm}/ A_{cm}$= 2000/0.2 =10000=10log10000=80dB

17. Define Slew rate and what causes slew rate? **[April/May 2015]**

The slew rate of an op amp or any amplifier circuit is the rate of change in the output voltage caused by a step change on the input.

There is usually a capacitor within or outside an op-amp to prevent oscillation. It is this capacitor which prevents the output voltage from responding immediately to a fast changing input

18. Define CMRR of an operational amplifier? **[May/June 2013]**

The common mode rejection ratio (CMRR) can be defined as the ratio of differential gain to common mode gain.

CMRR = |Ad/Ac|

19. Define integrated circuit.

An integrated circuit (IC) is a miniature, low cost electronic circuit consisting of active and passive components fabricated together on a single crystal of silicon. The active components are transistors and diodes and passive components are resistors inductors and capacitors

20. What are the advantages of integrated circuits over discrete components?

i. Miniaturization and hence increased equipment density.
ii. Cost reduction due to batch processing.
iii. Increased system reliability due to the elimination of soldered joints.
iv. Improved functional performance.
v. Matched devices.
vi. Increased operating speeds.
vii. Reduction in power consumption

21. What are the disadvantages of integrated circuits?

- Inductors can't be fabricated
- IC's function at fairly low voltage
- They can handle only limited amount of power.
- It can't withstand for rough handling and excessive heat

22. What is meant by monolithic IC

A monolithic integrated circuit (IC) is an electronic circuit that is built on a single semiconductor base material or single chip

23. What is current mirror?

The circuit in which the output current is forced to equal the input current is called as current mirror circuit. The current mirror makes use of the fact that for a

transistor in the active mode of operation, the collector current is relatively independent of the collector voltage. In this the output current is a reflection or mirror of the reference current.

24. What are the two requirements to be met for a good current source?

A good current source must meet two requirements:

1. Output current $I_O$ should not depend on β;
2. Output Resistance (RO) of the current source should be very high;

25. List the various methods of realizing high input resistance in a differential amplifier.

The various methods of realizing high input resistance in a differential amplifier circuits are

(i) Use of Darlington pair
(ii) Use of FET
(iii) Use of swamping resistors.

26. What is active load? Where it is used and why?

In circuit design, an active load is a circuit component made up of active devices, such as transistors, intended to present a high small-signal impedance yet not requiring a large DC voltage drop, as would occur if a large resistor were used instead. Such large AC load impedances may be desirable, for example, to increase the AC gain of some types of amplifier.

Most commonly the active load is the output part of a current mirror and is represented in an idealized manner as a current source. Usually, it is only a constant-current resistor that is a part of the whole current source including a constant voltage source as well

27. Explain the limitation of current mirror circuits?

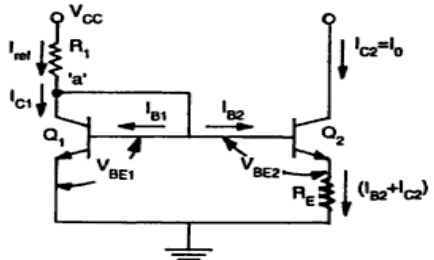
For low value of current source, the value of resistance R should be high which can't be fabricated economically in an Ic circuits.Widlar current source is suitable for low value.

28. Draw the circuit of a Widlar current source and write the exp for its output current. (May 2007)

Ic1 = (β/β+1) Iref

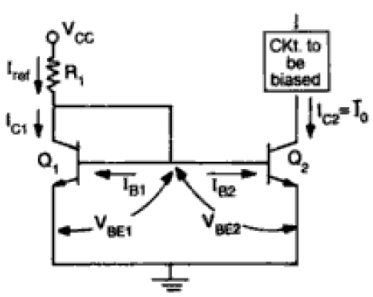
Iref = VCC –VBE / R1 For β>>1,

Ic1 = Iref

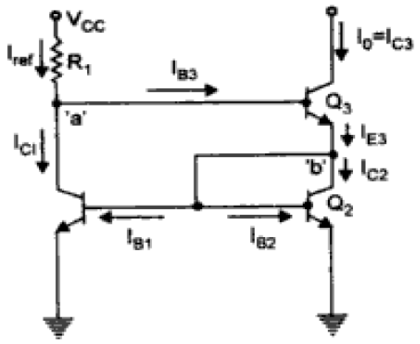



Widlar current source

29. Draw the basic current mirror circuit.



30. Draw the Wilson current source.




31. Define Thermal Drift.

The change in bias current ,offset voltage and offset voltage for each degree Celsius change in temperature .The offset current drift is expressed in A/$^o$c and offset voltage drift in V/ $^o$c

32. What is an operational amplifier?

The operational amplifier is a multi-terminal device, which is quite complex internally. An operational amplifier is a direct coupled high gain amplifier usually consisting of one or more differential amplifiers and usually followed by a level translator and an output stage. An operational amplifier is available as a single integrated circuit package. It is a versatile device that can be used to amplify dc as well as ac input signals and was originally designed for computing such mathematical functions.

33. What are the AC characteristics of an op-amp?

- Frequency response
- Slew rate

34. What are the DC characteristics of an op-amp? Give the typical values for an IC741?

1. Input bias current: 500 nA
2. Input offset current: 200 nA
3. Input offset voltage: 6mV
4. Thermal drift

35. When does the op-amp behave as a switch?

When op-amp is operating in open loop mode it acts as a switch. Consider two signals V1 and V2 applied at both inverting and non-inverting terminal respectively. Since the gain of the op-amp is infinite, the output V0 is either at its positive saturation voltage (+Vsat) or negative saturation voltage (-Vsat) as V1 > V2 or V2 – V1 respectively. Therefore amplifier acts as a switch.

36. In response to square wave input, the output of an op-amp changed from –3V to +3V over a time interval of 0.25μs. Determine the slew rate of the op-amp.

Slew rate = dvc/dt / max
= ΔVo/Δt
= 6V / 0.25μS
= 1.5 V/μS

37. Define supply voltage rejection ratio (SVRR)

The change in OPAMP's input offset voltage due to variations in supply voltage is called the supply voltage rejection ratio. It is also called Power Supply Rejection Ratio (PSRR) or Power Supply Sensitivity (PSS)

38. Define input offset voltage

The input offset voltage is a parameter defining the differential DC voltage required between the inputs of an amplifier, especially an operational amplifier (op-amp), to make the output zero

39. Define Frequency Response

Frequency response is the quantitative measure of the output spectrum of a system or device in response to a stimulus, and is used to characterize the dynamics of the system. It is a measure of magnitude and phase of the output as a function of frequency, in comparison to the input.

40. Define unity gain bandwidth of a Op-Amp

The GBWP (Gain Band Width Product) of an operational amplifier is 1 MHz, it means that the gain of the device falls to unity at 1 MHz. Hence, when the device is wired for unity gain, it will work up to 1 MHz (GBWP = gain × bandwidth, therefore if BW = 1 MHz, then gain = 1) without excessively distorting the signal.

41. Why IC 741 is not used for high frequency applications?

IC741 has a low slew rate because of the predominance of capacitance present in the circuit at higher frequencies. As frequency increases the output gets distorted due to limited slew rate.

42. Why do we use $R_{comp}$ resistor?

$R_{comp}$ is used to compensate for input bias current,which is added between non inverting input terminal of op-amp and ground.

43. What is the gain cross over and phase cross over frequencies?

The gain crossover frequency, wgc, is the frequency where the amplittude ratio is 1, or when log modulus is equal to 0.

The phase crossover frequency, wpc , is the frequency where phase shift is equal to -180o.

44. State loading effect?

Load effect is a power supply specification (also known as load regulation) that describes how well the power supply can maintain its steady-state output setting when the load changes

45. What are the applications of current sources?

The Current sources are used as the emitter resistance in differential amplifier to increase CMRR and as an active load to provide high a.c resistance without disturbing the d.c. conditions.

46. State the various blocks of IC op-amp

- Input stage
- Intermediate stage
- Level shifting stage
- Output stage

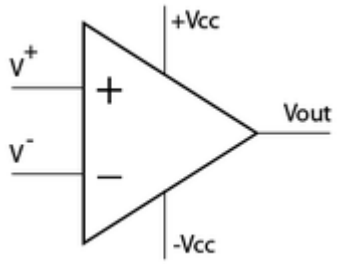
47. Why frequency compensation is required?

The op-amp with single break frequency is inherently stable. Practically op-amp has more than one break frequencies. It is necessary to provide compensation so that only one break over frequency exist duo to which phase shift of op-amp cannot increase beyond $-90^o$ .Hence there is no chance that op-amp phase shift becomes $-135^o$ and phase margin always remains more than $+45^o$.Hence op-amp becomes inherently stable.

48. List the methods used to provide external frequency compensation.

- Dominant pole compensation
- pole zero compensation
- Feed forward compensation

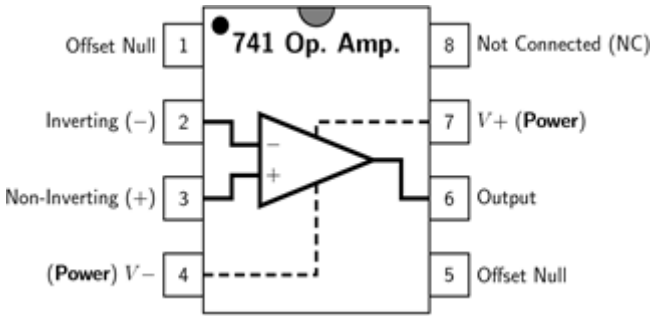
49. Draw the op-amp symbol and state its important terminals.




Important terminals are

- Inverting input
- Non inverting input
- Positive supply
- Negative supply
- output

50. Draw the pin diagram of IC741




51. Why op-amp in open loop is not used for most of the applications?

The open loop gain of op-amp is very large and hence the output saturates at supply voltage which are of the order of few volts. Thus linear operation of op-amp is possible only for very small range of input voltage of the order of few millivolts.This is not sufficient for most of the practical applications. Hence op-amp in open loop is not used for most of the applications

52. Define current mirror with magnification.

A current mirror circuit in which the ratio of the biasing currents in two transistors are fixed , is called current mirror with magnification.

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## PART –B&C

1. (i) Draw the transfer characteristics of an operational amplifier and explain its linear and non linear operations. (8) **[Nov/Dec 2017] [Nov/Dec 2018]**

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 55]

(ii) Discuss the operation of BJT differential amplifier with active loads.(5) **[Nov/Dec 2018]**

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 77]

2. (i) Present the inverting and non inverting amplifier circuits of an op-amp in closed loop configuration. Derive the expressions for the closed loop gain in these circuits. (9) **[Nov/Dec 2018]**

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 43]

(ii) Define slew rate. In what way does it possess impact on the performance of an op-amp circuit (4) **[Nov/Dec 2018]**

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 123]

3. Discuss about the principle of operation of differential amplifier using BJT. **[April/May 2018]**

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 53]

4. Explain about Ideal Op-Amp in detail with suitable diagrams. **[April/May 2018]**

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 41]

5. With a neat diagram Explain the input side of the internal circuit diagram of IC741 **[Nov/Dec2015] [Nov/Dec 2017]**

[Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 96]

6. (i) What is the input and output voltage and current offsets? How are they compensated? **[April/May 2017]**

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 108]

(ii) With neat diagram derive the AC performance close loop characteristics of Op-Amp to discuss on the circuit Bandwidth, Frequency response and slew rate **[April/May 2017]**

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 111]

7. i) With a schematic diagram,explain the effect of $R_E$ on CMRR in differential amplifier **[April/May 2016]**

[Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 63].

ii) Discuss about the methods to improve CMRR **[April/May 2016]**

8. (i) With simple schematic of differential amplifier explain the function of Operational Amplifier (8) **[April/May 2015]**

[Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 63]

(ii) Briefly Explain about constant current source(8) **[April/May2015]**

[Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 73]

9. (i) Briefly explain the techniques used for frequency compensation (12) **[April/May2015]**

[Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 135]

(ii) How do the open loop gain and the closed loop gain of an op-amp differ? (4) **[April/May2015]**

[Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 225]

10. What is the need for frequency compensation in an OPAMP? With a suitable illustration, explain the pole-zero frequency compensation technique. **[Nov/dec 15][April/May 2017]**

[Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 135]

11. Explain different voltage reference circuit in detail

[Ref .S.Salivahanan & V S Kanchana Baskaran, "Linear Integrated Circuits (Second Edition)", Page 60]

12. Explain different voltage sources in detail

[Ref .S.Salivahanan & V S Kanchana Baskaran, "Linear Integrated Circuits (Second Edition)", Page 57]

13. Draw the circuit of basic current mirror and explain its operation. Also discuss about how current ratio can be improved in the basic current mirror.Sketch the improved circuit and explain

[Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 73]

14. (i) Define and explain slew rate. What is full power bandwidth? Also explain the method adopted to improve slew rate

[Ref .Roy Choudhry, Shail B.Jain, “Linear Integrated Circuits (Second Edition)”, Page 140]

(ii) Define output off set voltage. Explain methods to nullify offset voltage

[Ref .Roy Choudhry, Shail B.Jain, “Linear Integrated Circuits (Second Edition)”, Page 123]

[Ref .Roy Choudhry, Shail B.Jain, “Linear Integrated Circuits (Second Edition)”, Page 71]

15. Explain in detail wilson current source and widlar current source and derive necessary equations

[Ref .Roy Choudhry, Shail B.Jain, “Linear Integrated Circuits (Second Edition)”, Page 75]

# UNIT II- APPLICATIONS OF OPERATIONAL AMPLIFIERS

## Part-A

1. Define voltage follower. **[April/May 2021]**

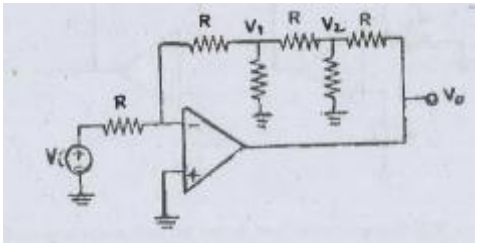
   A voltage follower (also known as a buffer amplifier, unity-gain amplifier, or isolation amplifier) is an op-amp circuit whose output voltage is equal to the input voltage (it "follows" the input voltage). Hence a voltage follower op-amp does not amplify the input signal and has a voltage gain of 1

   In the non-inverting amplifier, if $R_f$=0 and R1=∞ then the modified circuit is called voltage follower or unity gain amplifier.

2. What is the need for an integrator? **[April/May 2021]**

   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. Integration is an important part of many engineering and scientific applications

3. Find the gain $V_o/V_i$ of the circuit **[April/May 2019]**




Applying KCL at inverting terminal

$$\frac{0-V_1}{R}=\frac{V_i-0}{R}$$

$V_1$=-$V_i$

Applying KCL at node 1

$$\frac{0-V_1}{R}=\frac{V_1}{R}+\frac{V_1-V_2}{R}$$

$$V_2=-3v$$

Applying KCL at node 2

$$\frac{V_1-V_2}{R}=\frac{V_2}{R}+\frac{V_2-V_0}{R}$$

$$8V_i=-V_0$$

$$\frac{V_0}{V_i}=-8$$

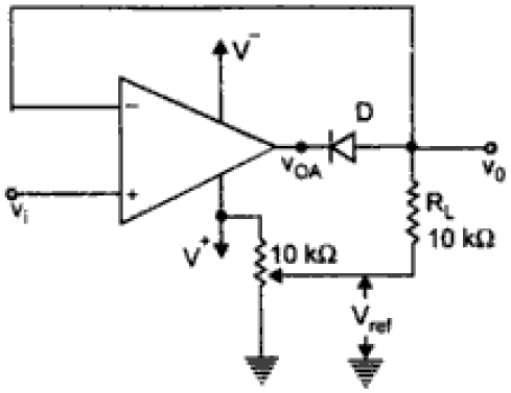
4. How does a zero crossing detector work **[April/May 2019]**

   Zero crossing detector is one type of voltage comparator used to detect a sine waveform transition from positive and negative that coincides when the input crosses the zero voltage condition

5. How does operational amplifier work as an integrator **[Nov/Dec 2018]**

   By replacing this feedback resistance with a capacitor we now have an RC Network connected across the operational amplifiers feedback path producing another type of operational amplifier circuit called an Op-amp Integrator

6. Draw the circuit of clipper using op-amp **[Nov/Dec 2018]**




7. What is the function of a phase shift circuit? **[April/May 2018]**

A phase shifter circuit is one that shifts the relative phase of an input AC signal

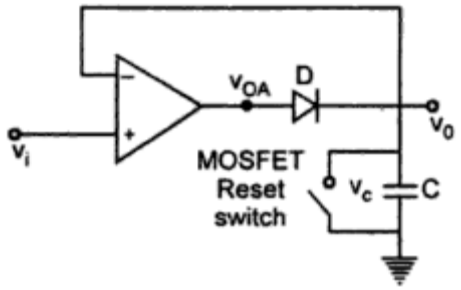
8. Write the other name for clipper circuit. **[April/May 2018]**

Other name of clipper circuit is limiter circuit

9. State the limitations of an ideal integrator. **[Nov/Dec 2017]**

- Bandwidth is very small and used for only small range of input frequencies.
- For dc input (f = 0), reactance of capacitance, Xc is infinite. Because of this op-amp goes into open loop configuration. In open loop configuration the gain is infinite and hence the small input offset voltages are also amplified and appears at output as error

10. How will you realize a peak detector using a precision rectifier? **[Nov/Dec 2017]**



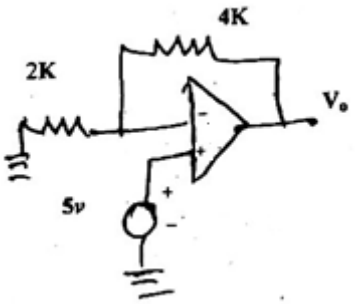

11. What is the need for converting a first order filter into a second order filter? **[April/May 2017]**

A first order active filter has one pole which is defined by a capacitor/resistor pair. A second order filter has two capacitors and resistors. This gives the filters frequency response a steeper slope as it transitions from pass band to stop band

12. How is the current characteristic of a PN junction employed in a Log amplifier? **[April/May 2017]**

The voltage across the diode will be always proportional to the log of the current through it and when a diode is placed in the feedback path of an op-amp in inverting mode, the output voltage will be proportional to the negative log of the input current. Since the input current is proportional to the input voltage, we can say that the output voltage will be proportional to the negative log of the input voltage

13. For the op-amp shown in figure determine the voltage gain **[Nov/Dec 2016]**

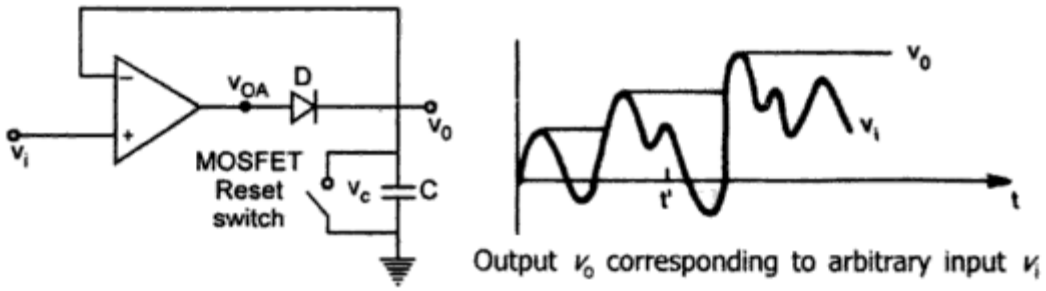



The given circuit is inverting amplifier

For inverting amplifier voltage gain $= -\frac{R_f}{R_i}$

$$= -\frac{4k}{2k} = -2$$

14.Draw the circuit diagram of a peak detector with waveforms. **[Nov/Dec 2016]**




15. Give any four applications of comparators. **[May/June 2016]**

- Zero crossing detector
- Window detector
- Time marker generator
- Phase meter

16.What is hysteresis and mention the purpose of hysteresis in a comparator?

**[April/May 2015]**

Hysteresis is the time-based dependence of a system's output on present and past inputs. The dependence arises because the history affects the value of an internal state. To predict its future outputs, either its internal state or its history must be known.

In comparator hysteresis has the effect of separating the up-going and down-going switching points so that, once a transition has started, the input must undergo a significant reversal before the reverse transition can occur.

17.What is the difference between normal rectifier and precision rectifier?

**[April/May 2015]**

A simple rectifier circuit uses a diode. The input voltage has to exceed the turn-on voltage (0.6V for ordinary Si diode) before rectification is achieved.

A precision rectifier is an active circuit using an opamp and a diode in the feedback loop. This overcomes the turn-on "knee" voltage

18. Plot the transfer characteristics of the circuit shown in figure 2 .The op-amp saturates at +/-12V **[Nov/Dec 2015]**

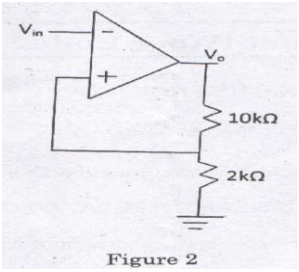
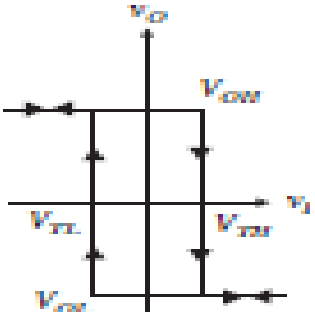


Figure 2



19.determine the output voltage for the circuit shown in figure 1 when

(a) Vin=-2V

(b) Vin=3V **[Nov/Dec 2015]**

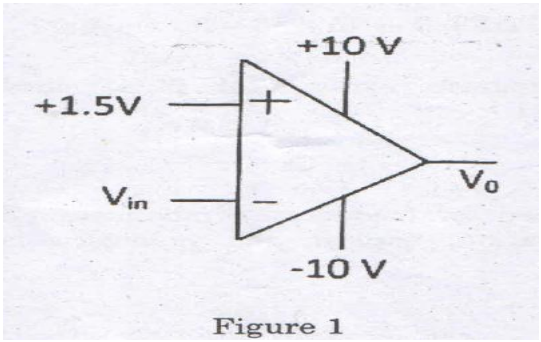


Figure 1

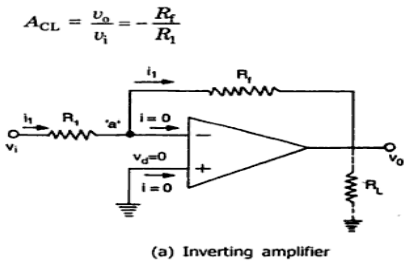
This is basic comparator circuit

when Vin=-2V then Vo=10V

When Vin =3V then Vo=-10V

20.Define inverting amplifier and draw the circuit?

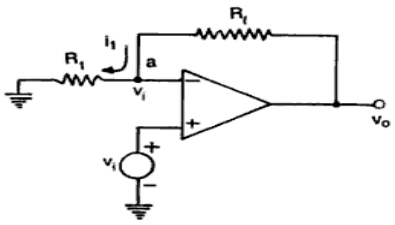
The input $v_{in}$ is given to the second pin of op-amp through the input resistance$R_1$ the feedback resistor $R_f$ connects the output and input pin and the output is always reversed or inverted.



(a) Inverting amplifier

21.Define non-inverting amplifier and draw the circuit?

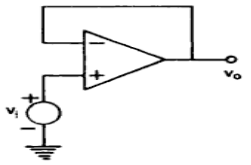
The input $v_{in}$ is given to the non-inverting terminal pin 3 of op-amp.The input resistor R1 & the feedback resistor $R_f$ are connected to the inverting input only ,the input pin and the output is always same phase.




(a) Non-inverting amplifier

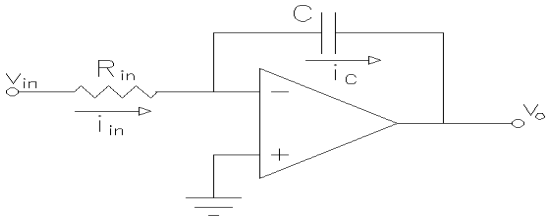
22.What is meant by voltage follower?

In the non-inverting amplifier, if $R_f$=0 and R1=∞ then the modified circuit is called voltage follower or unity gain amplifier.




Voltage follower

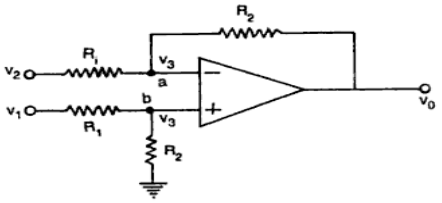
23.Draw the circuit diagram of an op-amp integrator. Mention its applications.




Application:

1. It is generally used in analog computer and analog to digital converter.
2. It also used in wave shaping circuits

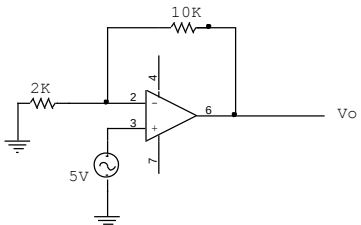
24.Draw the circuit diagram of an op-amp differential amplifier. Mention its o/p equation.




A differential amplifier

$$v_o = \frac{R_2}{R_1}(v_1 - v_2)$$

25.For the op-amp shown in figure, determine the voltage gain.




Vo / Vin = 1+Rf / R1

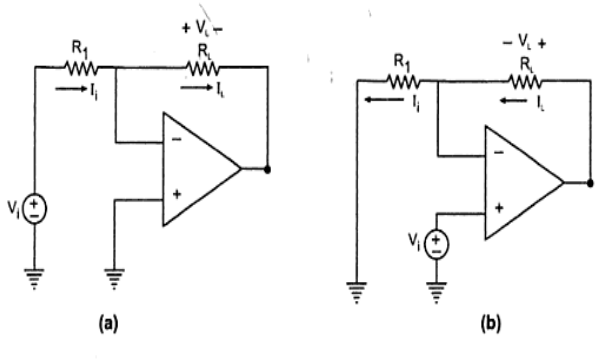
= 1+ 10K / 2K

= 6

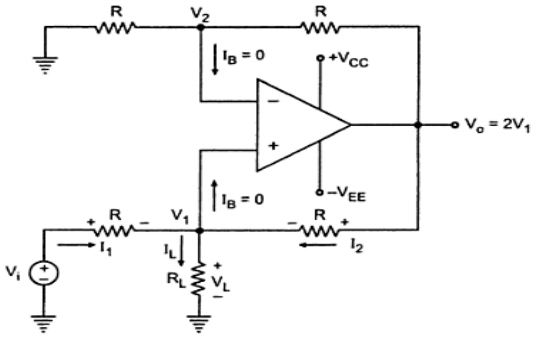
26.Explain the voltage to current convertor

Voltage to current convertor converts an input signal voltage to a proportional output current. According to the connection of load there are two types of voltage to current convertor

1. Floating type
2. Grounded type

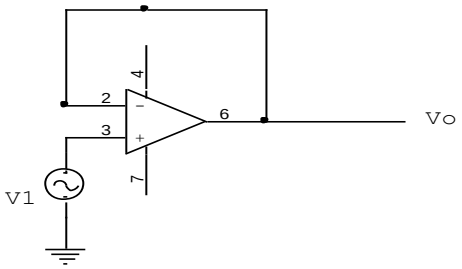



Floating load V-I converters



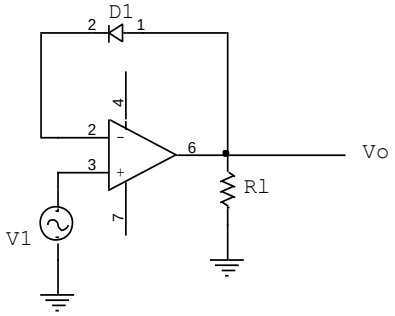

Voltage to current converter with grounded load

27.Draw the circuit of a voltage follower using op-amp and prove that its gain is exactly equal to unity.




Vo / Vin = 1+Rf / R1; Vo / Vin = 1+ 0; Vo / Vin = 1.

28.An ac signal has got a magnitude of 0.1 volt peak to peak. Suggest a suitable half wave rectifier for this signal.




29.Derive the expression for voltage gain of an inverting operational amplifier?

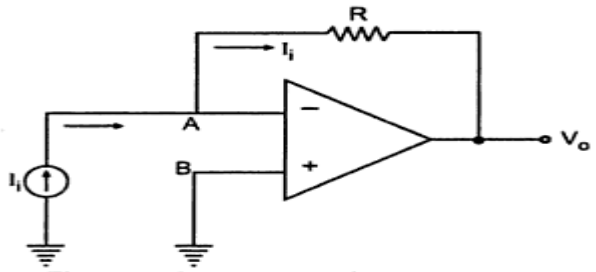
ACL = Vo/Vi = -Rf / R1

30.Mention two linear and two non- linear operations performed by an operational amplifier?

Linear operations: Adder, Subtractor, Voltage to current converter, Current to voltage converter, Instrumentation amplifier, Analog computation, and Power amplifier.

Non-linear operations: Rectifier, Peak detector, Clipper, Clamper, Sample and hold circuits, Log and antilog amplifier and Multiplier.

31.Draw the circuit of current to voltage convertor?




Current to voltage converter

32.Mention two application of Schmitt trigger?

- For eliminating comparator chatter.
- In ON/ OFF controller.
- Square wave generation

33.Mention the characteristics of Instrumentation amplifier?

- High gain
- High CMRR
- High gain stability
- Low dc offset
- Low output impedance
- Low power loss
- High input impedance

34.State the disadvantages of passive filters?

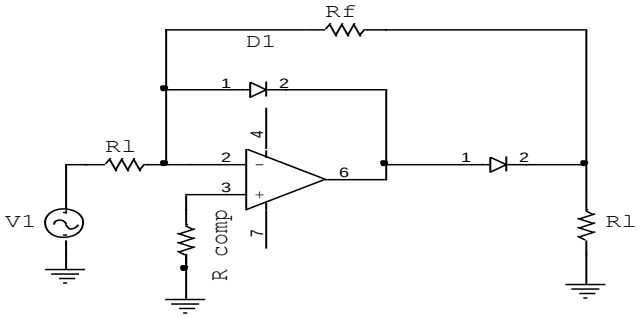
At audio frequencies inductors becomes problematic, as the inductors become large, heavy and expensive. For low frequency application, more number of turns of wire must be used which in turn adds to the series resistance degrading inductors performance.

35.What is Precision rectifier?

It is a rectifier circuit which utilities precision diode instead of usual diodes for rectification purpose in order to operate them for cut-in voltages in the order of microvolt.

36.Define precision half wave rectifier with diagram?

It is defined as a circuit, which utilizes two precision diodes instead of usual diodes for rectification purpose in order to operate them for, cut in voltages in the order of micro volts.




37.What are the main drawbacks of ideal differentiator?

At high frequency, differentiators may become unstable and break into oscillation. The input impedance i.e. (1/ωC1) decreases with increase in frequency, thereby making the circuit sensitive to high frequency noise.

38.What are the steps to be followed while designing a good differentiator?

Choose $f_a$ equal to highest frequency of the input signal. Assume a practical value of C1 (<1μF) and then calculate Rf.

Choose $f_b=10f_a$ (Say). Now calculate the values of R1 and C1.

R1C1 = RfCf.

39.What are the main drawbacks of ideal integrator circuit?

At low frequencies such as dc ($\omega \approx 0$) the gain becomes infinite.

When the op-amp saturates i.e. the capacitor is fully charged it behaves like an open circuit.

40.Give the output voltage when $V_i$ is positive and negative in a precision diode.

When Vi is positive, diode D1 conducts causing V0 to negative by one diode drop (Vr =0.6v). Hence, diode D2 is reverse biased. The output voltage V0 is zero.

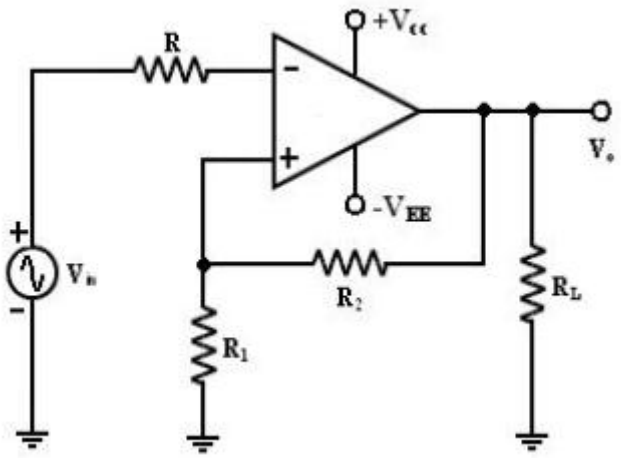
When Vi is negative ie Vi < 0, diode D2 conducts D1 is off. The negative input Vi forces the op-amp circuit VON positive and causes D2 to conduct. Output $V_o$ becomes positive.

41.Give an application of an Inverting Amplifier.

1.Sign Changer

2. Scale changer

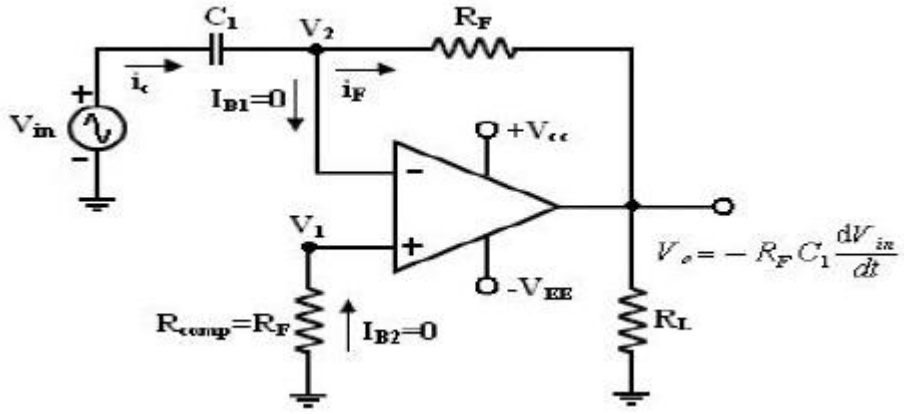
42.Draw the circuit diagram of a schmitt trigger




43. What is a filter?

Filter is a frequency selective circuit that passes signal of specified band of frequencies and attenuates the signals of frequencies outside the band

44.Draw the circuit diagram of differentiators and give its output equation




45. State the applications of V-I converter

- Low voltage d.c voltmeter
- Low voltage a.c voltmeter
- Diode tester
- Zener diode tester

46. State the applications of current to voltage converter

- Photodiode detector
- PhotoFET detector

47. List the applications of differentiator circuit.

- In the wave shaping circuits
- To detect high frequency components in the input.
- As a rate of change detector in the FM demodulator

48. List various applications of comparator.

- Zero crossing detector
- Window detector
- Level detector

49. What is a zero crossing detector?

A circuit which detects the crossing of zero level by the input signal is called a zero crossing detector. An op-amp comparator is used as a zero crossing detector.

50. When inverting amplifier is called phase inverter?

When the gain of inverting amplifier is unity and is used to change the phase of the input to produce the output then it is called phase inverter.

51. State any four applications of instrumentation amplifier,

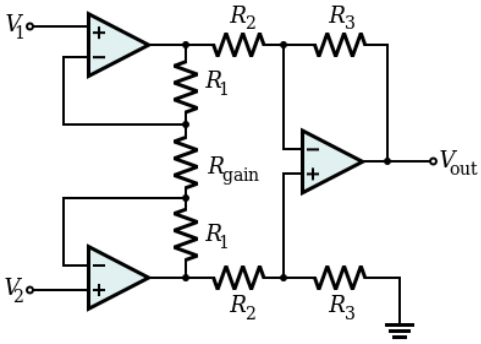
- Temperature controller
- Data acquisition system
- Light intensity meter
- Analog weight scale

52. Why temperature compensation is required for log amplifiers?

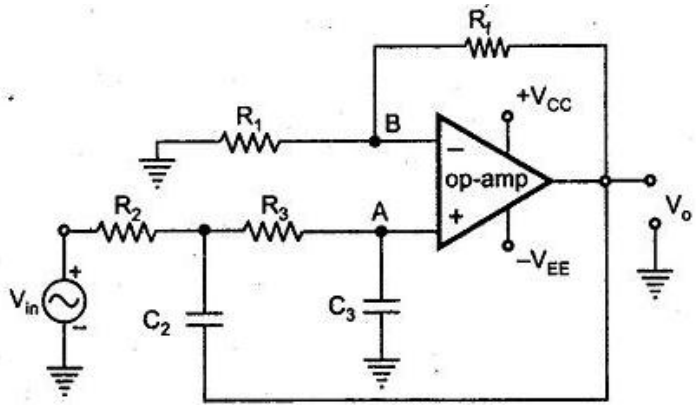
The reverse saturation current $I_o$ for the diode changes with temperature and it doubles for every ten degree celicius rise in the temperature. Similarly the emitter saturation current varies significantly from one transistor to other and also with temperature. Hence it is very difficult to set the term $V_{ref}$ for the circuit. The term $V_T$ which is KT also changes with temperature, which appears in the final equations. Hence temperature affects the performance and accuracy of the basic logarithmic

amplifier circuit. Hence it is must to provide some sort of temperature compensation to reduce the errors.

53. Draw the circuit diagram of 3 op-amp instrumentation amplifier.




54. Draw the circuit diagram of second order active low pass Butterworth filter




## PART –B&C

1. (i) With suitable circuit diagram ,explain the operating principle of an instrumentation amplifier and derive its gain.(7) **[Nov/Dec 2018]**
   [Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 141]
   (ii) Design a second order butterworth low-pass filter having upper cut-off frequency of 2.1961 kHz (6) **[Nov/Dec 2018]**
   [Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 269]
2. (i) Design a clipper circuit for a clipping level of +0.83V,given an input sine wave signal of 0.3V peak. Assume the gain of the amplifier is 9 and it has an input resistance of 2.2k-ohm connected.(5) **[Nov/Dec 2018]**
   [Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 151]
   (ii) Draw the operational diagram and explain the working principle of antilogarithmic amplifier and Schmitt trigger.(8) **[Nov/Dec 2018]**
   [Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 157]
3. i) Describe about voltage follower circuit.(7) **[April/May 2018]**
   [Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 49]
   ii) Write short notes on subtractor circuit(6) **[April/May 2018]**
   [Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 137]
4. With a neat diagram Explain about V-I conveter. **[April/May 2018]**
   [Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 146]
5. (i) For performing differentiation in an operational amplifier, integrator is preferred to differentiator-Explain **[Nov/Dec 2017]**
   [Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 168]

(ii) What is instrumentation amplifier? Draw a system whose gain is controlled by a variable resistance **[Nov/Dec 2017]**

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 141 &142]

6. Explain the operation of differentiator and integrator with relevant waveforms and equations **[April/May 2017]**
7. (i) Design a differentiator to produce an output of 6 V when the input changes by 2V in 40 micro seconds. (5) **[Nov/Dec 2018]**

[Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 170]

(ii) Write short notes on Clipper and clamper circuits(8) **[April /May 2017]**

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 151]

8. With a neat block diagram explain the stages for developing the signal analysis circuits required for an instrumentation module of say a vibration sensor data using instrumentation amplifier, waveshaper, and comparator for ADC using OPAMP and required components

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 141]

[Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 186]

9. i) Draw the circuit of a second order Butterworth active low pass filter and derive its transfer function. **[April/May 2016]**

[Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 293]

ii) Design a second order active low pass filter for a cut-off frequency of 1 KHz. **[April/May 2016]**

[Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 293]

10. Explain the working of 3 op-amp Instrumentation amplifier? **[April/May 2018][ [April/May2016]**

[Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 161]

11. i) Briefly explain the working principle of Schmitt trigger.

[Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 237]

ii) Design a wide band pass filter having $f_L$=400 Hz $f_H$=2kHz and pass band gain of 4.Find the value of Q of the filter **[April/May 2015]**

[Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 306]

12. With a circuit diagram discuss the following applications of op-amp.
    a. Voltage to current converter.
    b. Precision rectifier.

[Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 166 &169]

13. Explain the working of Log amplifier and antilog amplifier? [May/June 14]

[Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 178]

14. (i) Explain the operation of current to voltage converter

[Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 147]

(ii) Differentiate between low pass ,high pass ,band pass and band reject filter.Sketch the frequency plot

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 263]

15. With neat diagram derive the expression for transfer function of a narrow band pass filter and find the resonant frequency factor and Bandwidth

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 272]

# UNIT – III-ANALOG MULTIPLIER AND PLL

## PART-A

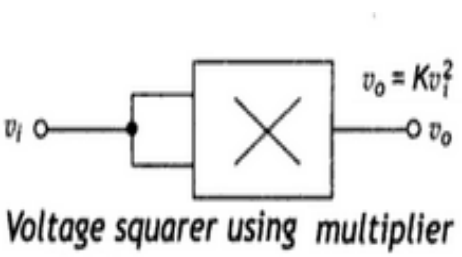
1. List the features of 566 VCO. **[April/May 2021]**
    1. 566 VCO is an 8 pin IC, it can operate between 10 to 24 volts.
    2. High linearity of modulation.
    3. Stable center frequency.
    4. Highly linear triangle wave output.
    5. Frequency programming using a resistor or capacitor voltage or current.
    6. Frequency adjustable over 10-to-1 range with the same capacitor.
2. Define capture range of a PLL? **[April/May 2021]** **[Nov/Dec 2017]**

    The range of frequency over which the PLL can acquire lock with an input signal is called capture range. The PLL cannot acquire a signal outside the capture range, but once captured, it will hold on till the signal frequency goes beyond the lock-in range, larger capture range is required.

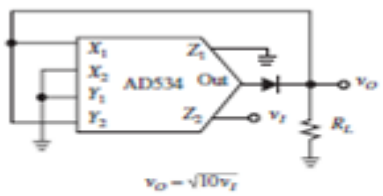
3. What is Gilbert multiplier cell? **[April/May 2018] [April/May 2019]**

    A circuit which uses emitter couples pair in series with cross coupled emitter coupled pairs is called Gilbert Cell.
4. List the basic building blocks of PLL. **[April/May 2019]**
    - Phase detector
    - Low pass filter
    - Error amplifier
    - Voltage controlled Oscillator
5. Mention the significance of Gilbert multiplier Cell. **[Nov/Dec 2018]**

    The Gilbert cell mixer or Gilbert cell multiplier is a form of RF mixer circuit that is widely used in integrated circuits. Not only does the Gilbert cell mixer lend itself to integrated circuit technology, but it is able to provide a high level of performance. Gilbert cells are often referred to as four-quadrant multipliers
6. State various applications of phase locked loop. **[Nov/Dec 2018]**
    - Frequency multiplication and division
    - Frequency translation.
    - AM detection.
    - FM demodulation
7. State any two terminologies associated with multiplier characteristics **[April/May 2018]**
    - Two Quadrant
    - Four Quadrant
8. How are square root and square of a signal obtained with multiplier Circuit ? **[April/May 2015] [April/May 2017]**



Voltage squarer using multiplier



Square root circuit using multiplier

9. How is frequency stability obtained in a PLL by use of a VCO? **[April/May 2017]**

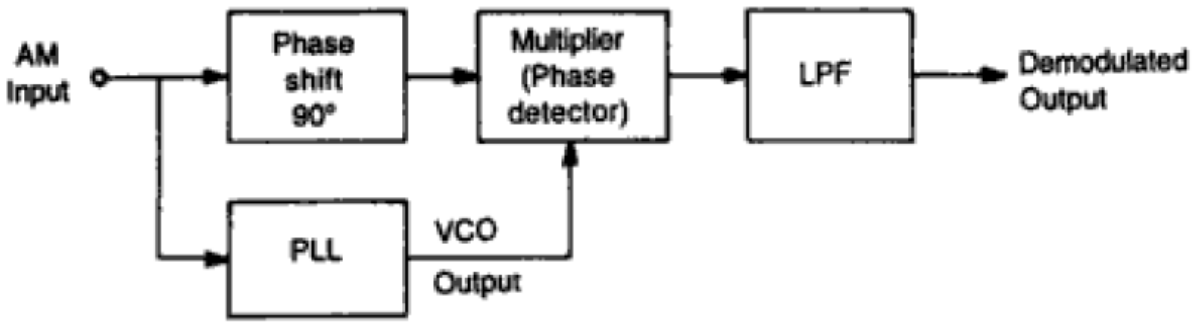
A voltage controlled oscillator is an oscillator circuit in which the frequency of oscillation can be controlled by an externally applied voltage. It provides the linear relationship between the applied voltage and the oscillation frequency.

VCO is a free running multivibrator and operates at a set of frequency fo called free running frequency. This frequency is determined by an external timing capacitor and an external resistor. It can also be shifted to either side by applying a dc control voltage Vc to an appropriate terminal of the IC.The frequency deviation is directly proportional to the dc control voltage and hence it is called a "Voltage Controlled Oscillator

**10.** What is a four-quadrant multiplier? **[Nov/Dec 2016]**

It is a multiplier circuit with two inputs being both positive and both negative, then the multiplier is called as four-quadrant multiplier

11.Draw the block diagram of PLL for AM detection? **[April/May 2016]**




12.Calculate the lock range and the capture range of the PLL.

Lock in range $\Delta f_L$= +/- 7.8 $f_o$/ V

$f_o$is free running frequency

Capture range = +/- = $[\Delta f_L/ (2*\pi*R*C)]^{1/2}$

13.The lock range of a certain general purpose PLL with a free running frequency of 50MHz is specified to be +/- 10% what is its lock range?

Lock in range $\Delta f_L$= +/- 7.8 $f_o$/ V

14.What are the essential building blocks of a PLL?

The essential building blocks of PLL are

- Phase detector
- Low pass filter
- Amplifier
- Voltage Controlled Oscillator

15.What is a two quadrant multiplier?

It is a multiplier one input must be held positive and other can change to positive or negative it is called two quadrant multiplier.

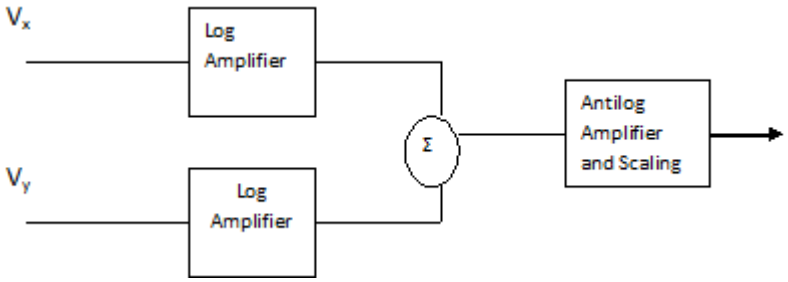
16.What is compander?

The signal is compressed at the transmitter and expanded at the receiver. This is called as companding. The combination of a compressor and expander is called a compander.

17.State why the phase detector output in a PLL should be followed by a low pass filter?

The phase detector is basically a multiplier and produces the sum ($f_s$+$f_o$) and the difference ($f_s$-$f_o$) components at its output. The high frequency component is removed by the low pass filter and the difference frequency component is applied as control voltage $v_c$ to VCO.

18.Draw the block diagram of a multiplier using log and antilog amplifiers.




19.What is frequency synthesizer?

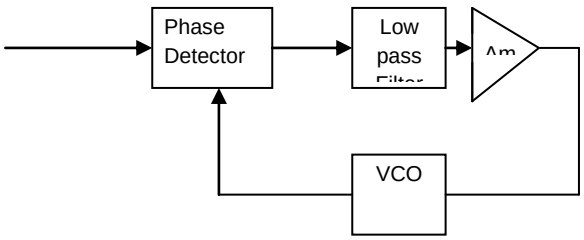
Frequency synthesizer is a circuit here each frequency is selected by closing the desired program switches to program a particular frequency output.

Period = Tsum + T

20.Define PLL

A phase locked loop is a closed loop system designed to lock the output frequency and phase to the frequency and phase of an input signal

21.Draw the basic block diagram of PLL?




22.What is amplitude modulation?

It is the process of amplitude of carrier wave varies in accordance with the instantaneous value of the amplitude of message signal.

23.Define voltage to frequency conversion factor kv?

It is given as

$K_v = \Delta f_o / \Delta v_c$

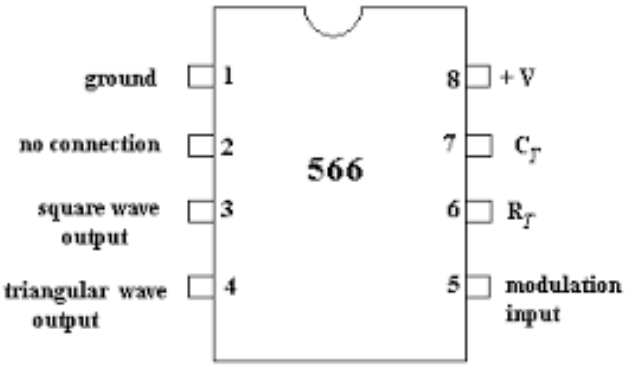
Here $K_{v\ is}$ the modulation voltage required to produce the frequency shift $\Delta f_o$for a VCO.

24.What is a voltage-controlled oscillator?

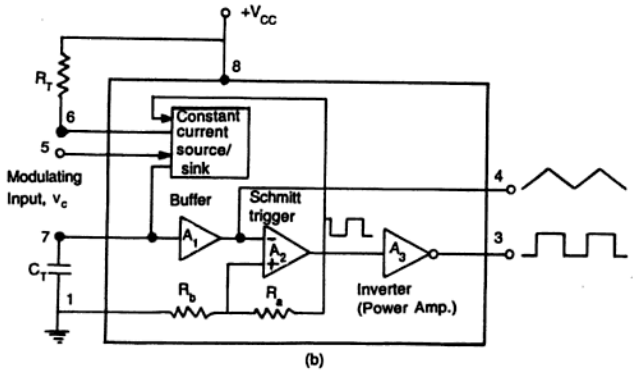
A voltage controlled oscillator is an oscillator circuit in which the frequency of oscillation can be controlled by an externally applied voltage. It provides the linear relationship between the applied voltage and the oscillation frequency.

VCO is a free running multivibrator and operates at a set of frequency fo called free running frequency. This frequency is determined by an external timing capacitor and an external resistor. It can also be shifted to either side by applying a dc control voltage Vc to an appropriate terminal of the IC.The frequency deviation is directly proportional to the dc control voltage and hence it is called a "Voltage Controlled Oscillator".

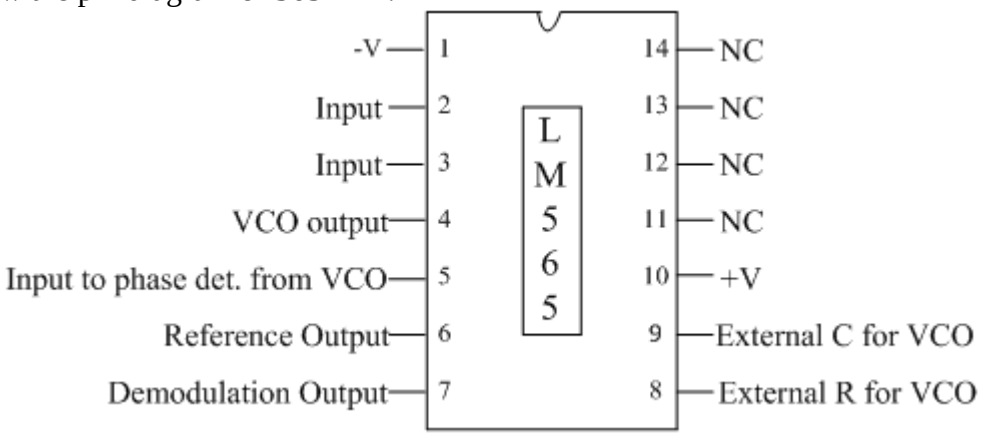
25. Draw the pin diagram of 566 VCO




26. Draw the block diagram of 566 VCO




27. Draw the pin diagram of 565 PLL.




28. How VCO different from oscillators?

An oscillator is a circuit that generates the frequency output of fixed frequency.On the other hand a voltage controlled oscillator (VCO) is an oscillator circuit in which the frequency of oscillations can be controlled by an externally applied voltage.

29.When an amplifier is also called an error amplifier?

An amplifier also called an error amplifier in control theory, which accepts the signal $X_d$ and yields the output signal $X_0$=a.Xd, where a is the forward gain of the amplifier is called the open-loop gain of the circuit.

30.What are the merits of companding?

- The compression process reduces the dynamic range of the signal before it is transmitted.
- Companding preserves the signal to noise ratio of the original signal and avoids non linear distortion of the signal when the input amplitude is large.
- It also reduces buzz, bias and low level audio tones caused by mild interference.

31.List the applications of OTA:

OTA can be used in

- programmable gain voltage amplifier
- sample and hold circuits
- voltage controlled state variable filter
- current controlled relaxation oscillator

32.Mention some areas where PLL is widely used.

Radar synchronization
Satellite communication systems
Air borne navigational systems
FM communication systems

33.Define lock-in range of a PLL.

The range of frequencies over which the PLL can maintain lock with the incoming signal is called the lock-in range or tracking range. It is expressed as a percentage of the VCO free running frequency.

**34.** Define free running mode.

In a PLL if the error control voltage is zero then the PLL is said to be operated in free running mode and its output frequency is called its center frequency $f_0$.

35.What are the advantages of variable transconductance technique?

The advantages of variable transconductance technique are:

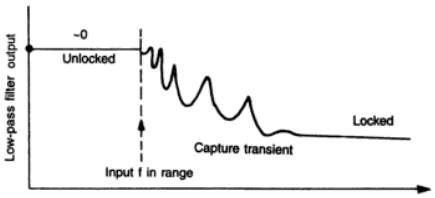
1) Simple to integrate into monolithic chip
2) Provides very good accuracy.
3) Very cheap hence economical.
4) Provides four quadrant operations.
5) It provides high speed of operation which is 2 to 3 times more than the logarithmic method.
6) Reduced error at least by 10 times.

36.With reference to a VCO, define voltage to frequency conversion factor Kv.

Voltage to frequency conversion factor Kv is defind as $Kv=\Delta fo/ \Delta vc$

Here $\Delta vc$ is the modulation voltage required to produce the frequency shift of $\Delta fo$ for a VCO

37.Draw the relation between the capture ranges and lock range in a PLL.




38. Mention two applications of analog multiplier

- Variable-gain amplifier
- Ring modulator
- Product detector
- Frequency mixer

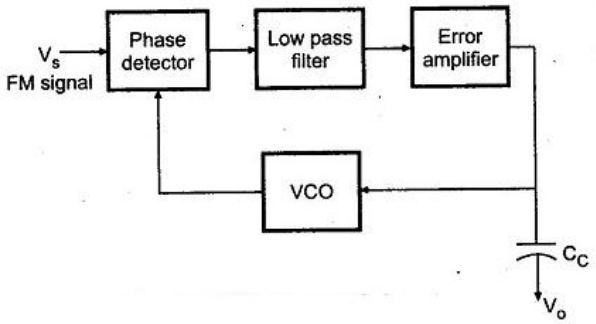
39. VCO is called as V-F converter why?

A voltage-controlled oscillator or VCO is an electronic oscillator whose oscillation frequency is controlled by a voltage input ie the change in input voltage results in change in output frequency hence it is called as V-F converter

40. Define FSK

Frequency shift keying is a digital modulation technique in which the frequency of carrier signal is varied in accordance with the amplitude of digital modulating signal

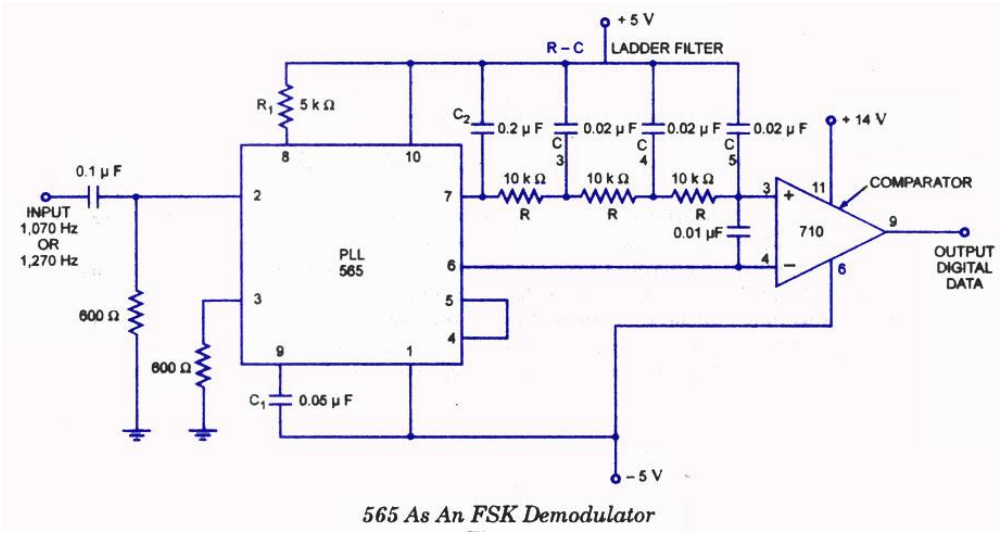
41. Draw the block diagram of PLL for FM detection




42. What is the need for frequency synthesizer

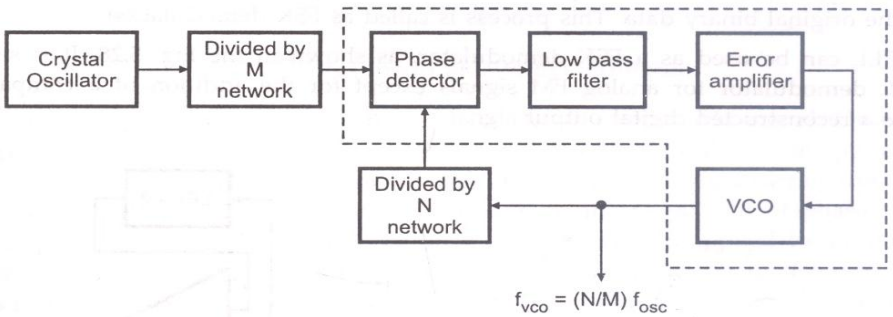
A frequency synthesizer is an electronic system for generating any of a range of frequencies from a single fixed time base or oscillator. They are found in many modern devices, including radio receivers, mobile telephones, radiotelephones, walkie-talkies, CB radios, satellite receivers, GPS systems, etc

43. Draw the block diagram of PLL for FSK demodulation




*565 As An FSK Demodulator*

44. Draw the block diagram of PLL for frequency synthesizing




45. List the performance parameters of multiplier

- Accuracy
- Linearity
- Bandwidth
- Feed through voltage
- Scale factor
- Quadrant

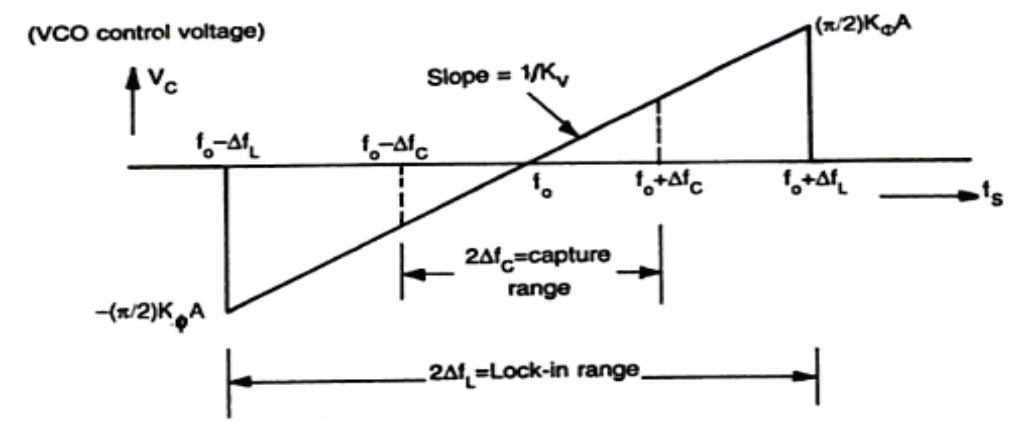
46. State the various techniques used for multiplier.

- Logarithmic summing technique
- Quarter square technique

- Pulse width modulation
- Variable transconductance technique
- Triangle averaging technique

47. What are the limitations of logarithmic summing technique?
    - Poor accuracy
    - One quadrant operation
    - Temperature instability
48. State the two multiplier ICs
    - AD533
    - AD534
49. Mention the applications of AD533
    - Function generator
    - Peak detection
    - RMS computation
    - Phase detection
    - Automatic gain control
    - Square and square root extractor
50. Mention the applications of AD534
    - Multiplier
    - Divider
    - High quality analog signal processing
    - Square and square root extractor
    - Differential ratio and percentage computation
    - Accurate voltage controlled oscillators and filters
51. What is pull in time?

    From the application of the input signal ,the total time taken by the PLL to establish a lock is called pull in time.
52. Which parameter decides the pull in time
    - Initial Frequency and phase difference between two signals
    - Overall loop gain
    - Bandwidth of low pass filter.
53. Draw the relation between the capture range and lock range of PLL




PLL lock-in range and capture range

# PART –B&C

1. (i) Explain in detail the operation of a basic phase locked loop.(5) **[Nov/Dec 2018]**
   [Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 327]
   (ii) How are PLLs applied for frequency synthesizing and FM detection.(8) **[Nov/Dec 2018]**
   Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 343]
2. A PLL has a free running frequency of 400 kHz and the band width of the low pass filter is 8kHz.Will the loop tend to acquire lock for an input signal of 550 kHz? Explain in this case ,assume that the phase detector produces sum and difference frequency components. **[Nov/Dec 2018] [Nov/Dec 2017]**
3. (i) Obtain the expression for free running frequency of voltage controlled oscillator.(6) **[Nov/Dec 2018]**
   [Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 334]
   (ii) Design an analog multiplier employing an emitter coupled transistor pair. (7) **[Nov/Dec 2018]**
   [Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 342]
4. Discuss briefly about analog multiplier ICs **[April/May 2018]**
   [Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 159]
5. Discuss in detail about VCO using suitable diagram. **[April/May 2018]**
   [Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 334]

6. With neat diagram explain the design of (i) Frequency Synthesizer (ii) Frequency Division circuit using PLL IC 565 **[April/May 2017]**
   [Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 342]
7. (i) Discuss the principle of operation of NE 565 PLL circuit **[Nov/Dec 2016]**
   [Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 337]
   (ii) How can PLL be modeled as a frequency multiplier? **[Nov/Dec 2016]**
   [Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 342
8. Explain the Application of PLL as AM detection,FM detection and FSK demodulation **[April/May 2016]**
   [Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 375]
9. Explain the basic blocks of PLL and determine expressions for lock in range and capture range **[April/May 2015]**
   [Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 353& 370]
10. i) With neat simplified internal diagram explain the working principle of Operational Transconductance Amplifier(OTA) **[April/May2015]**
    [Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 210]
    ii) Explain the application of VCO for FM generation **[April /May15]**
    [Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 225]
11. With suitable block diagram explain the operation of 566 voltage controlled oscillator. Also derive an expression for the frequency of the output waveform generated
    [Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 363]
12. Explain the working principle of four quadrant variable form transconductance multiplier **[May/June 2016]**
    [Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 210]
13. Draw the analog multiplier IC and explain its features and Explain the application of analog multiplier IC **[April/May 2015]**
    [Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 183]
14. i)Explain Analog Multiplier using Emitter Coupled Transistor Pair
    [Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 183]

ii)Explain Gilbert Multiplier cell in detail

[Ref .Roy Choudhry, Shail B.Jain, “Linear Integrated Circuits (Second Edition)”, Page 183]

15. Explain the application of PLL for
    i. Frequency synthesizing
    ii. Clock synchronization

[Ref .Roy Choudhry, Shail B.Jain, “Linear Integrated Circuits (Second Edition)”, Page 342]

# UNIT -IV - **ANALOG TO DIGITAL AND DIGITAL TO ANALOG CONVERTERS**

PART A:

1. What is integrating type converter ? **[April/May 2021]**

   Integrating type ADCs perform conversion in an indirect manner by first changing the analog input signal to linear function of time or frequency and then to a digital code.

2. What are the advantages and disadvantages of R-2R ladder DAC ? **[April/May 2021]**

   - Only two resistor values are used in R-2R ladder type.
   - It does not need as precision resistors as Binary weighted DACs.
   - It is cheap and easy to manufacture.

   In R-2R ladder type DAC current flowing in the resistors changes as the input data changes. More power dissipation causes heating which in turn creates non-linearity in DAC

3. Define settling time **[April/May 2019]**

   It is the time the converter takes for the output to settle within a specified band +/-(1/2)LSB

4. What is the largest value of output voltage from an 8 bit DAC that produces 1.0V for a digital input of 00110010 **[April/May 2019]**

   5.10V

5. Differentiate between direct type and integrating type in ADC converters. **[Nov/Dec 2018]**

   Direct type ADCs compare a given analog signal with the internally generated equivalent signal.

   Integrating type ADCs perform conversion in an indirect manner by first changing the analog input signal to linear function of time or frequency and then to a digital code.

6. What is the need of sample and hold circuit. **[Nov/Dec 20178]**

   For accurate analog and digital conversion the analog input voltage should be held constant during the conversion cycle. The input voltage is kept constant during conversion time using sample and hold circuit.

7. Define Sampling. **[April/May 2018]**

   The process of converting analog signals into discrete time signals is called sampling.

8. Write the name of the switches used in MOS transistors. **[April/May 2018]**

   - Totem pole MOSFET switch
   - CMOS inverter switch

9. How is the classification of A/D converters carried out based on their operational features? **[Nov/Dec 2017]**

   A/D converter are classified into two groups according to their conversion

   (i) Direct type ADC
   (ii) Integrating type ADC

   Direct Type ADC

   (i) Flash Type converter
   (ii) Counter type converter
   (iii) Tracking or servo converter
   (iv) Successive approximation type converter

Integrating type ADC

(i) Charge balancing ADC

(ii) Dual slope ADC

10. Find the number of resistors required for an 8 bit weighted resistor D/A converter. Consider the smallest resistance is R and obtain those resistance values. **[Nov/Dec 2017]**

The No of Resistors required =8

The resistance values are $2^1R,2^2R,2^3R,2^4R,2^5R,2^6R,2^7R,2^8R$

11. Why are Scottky diodes used in sample and hold circuits? **[April/May 2017]**

Schottky diodes can be used in diode-bridge based sample and hold circuits. When compared to regular p-n junction based diode bridges, Schottky diodes can offer advantages. A forward-biased Schottky diode does not have any minority carrier charge storage. This allows them to switch more quickly than regular diodes, resulting in lower transition time from the sample to the hold step. The absence of minority carrier charge storage also results in a lower hold step or sampling error, resulting in a more accurate sample at the output

12. What are the advantages of inverted R-2R (current type) ladder D/A converter over R-2R (voltage type) D/A converter? **[Nov/Dec 2016]**

In R-2R ladder type DAC current flowing in the resistors changes as the input data changes. More power dissipation causes heating which in turn creates non-linearity in DAC.This problem can be avoided in inverted R-2R ladder type as the current divides equally at each node.

13. What is the need for electronic switches in D/A converter? **[Nov/Dec 2016]**

The Switches which connects the digital binary input to the nodes of a D/A converter is an electronic switch

14. A 12 bit D/A converter has a resolution of 20mv/LSB.Find the full scale output voltage. **[May/June 2016]**

$$\text{Re}\,solution = \frac{V_{oFS}}{2^n - 1}$$

Where, $V_{oFS}$ is the full scale output voltage

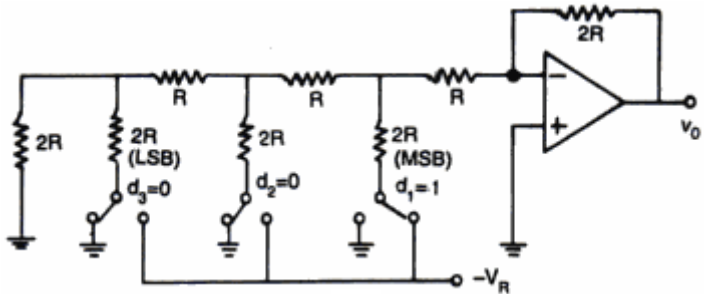
n is the number of bits

$$V_{oFS} = \text{Re}\,solution * (2^n - 1)$$

$$V_{oFS} = 20 * 10^{-3} * (2^{12} - 1)$$

$$V_{oFS} = 81.9V$$

15. Draw the binary ladder network of DAC, If the value of the smaller resistance is 10K.What is the value of other resistance? **[May/June 2016]**




The value of other resistance=2R=20 Kohm

16. Determine the number of comparators and resistors required for 8 bit flash type ADC **[Nov/Dec2015]**

No Of comparators required is $=2^8-1=255$

17. Mention two advantages of R-2R ladder type DAC when compared to weighted resistor type DAC **[Nov/Dec 2015]**

- Only two resistor values are used in R-2R ladder type.
- It does not need as precision resistors as Binary weighted DACs.
- It is cheap and easy to manufacture.

18. What would be produced by a DAC whose output ranges is 0 to 10V and whose input binary number is 10111100(for a 8 bit DAC)? **[April/May 2015]**

$V_o=10V(1x(1/2)+0x(1/2)^2+1x(1/2)^3+1x(1/2)^4+1x(1/2)^5+1x(1/2)^6+0x(1/2)^7+0x(1/2)^8)$

$V_o=7.34V$

**19.** What is over sampling? **[April/May 2015]**

The technique of increasing the apparent sampling frequency of a digital signal by repeating each digit a number of times, in order to facilitate the subsequent filtering of unwanted noise.

In signal processing, oversampling is the process of sampling a signal with a sampling frequency significantly higher than the Nyquist rate. Theoretically a bandwidth-limited signal can be perfectly reconstructed if sampled above the Nyquist rate, which is twice the highest frequency in the signal. Oversampling improves resolution, reduces noise and helps avoid aliasing and phase distortion by relaxing anti-aliasing filter performance requirements.

20. State the reason for keeping the integrating time in the dual slope analog to digital converter equal to that of mains supply period.

The dual slope ADC integrates the input signal for a fixed time, hence it provides excellent noise rejection of ac signals whose periods are integral multiples of the integration time Ti. Thus as noise superimposed on the input signal such as 50Hz power link pick-up will be averaged during the input integration time. So choose clock period T, so that $2^nT$ is an exact integral multiple of the line period (1/50) second = 20 ms.

21. Which is the fastest A/D converter? Give reason.

Parallel comparator A/D is the fastest and most expansive comparator.

Because it consists of a resistive divider network, 8 op-amp comparators and a 8 line to 3 line encoder.

22. A 12 bit D/A converter have resolution of 30 mV/ LSB. Find the full scale output voltage.

Vo = Vfs/2

Vfs = 2xVo

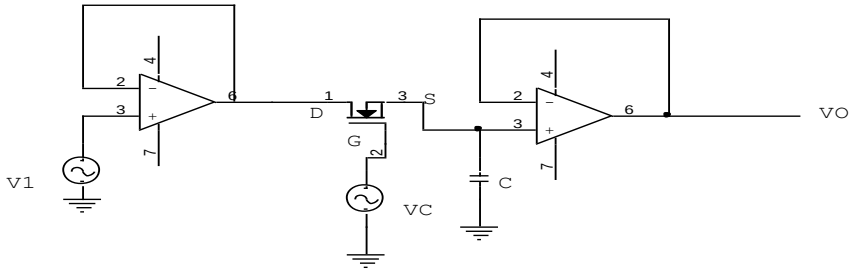
= 2x30 = 60 mv.

23. Calculate the number of comparators required for realizing a 4 bit flash A/D converter.

Numbers of comparators required are $2^n - 1$

$2^4 - 1 = 16 - 1 = 15.$

24. Draw a sample and hold circuit.




25. Define resolution of a D/A converter?

The resolution of a DAC is defined as the smallest change in voltage, which may be produced at the output or input of the converter.

26. How many comparators are required to build n –bit flash type A/D converter?

Comparator required to build n –bit flash type A/D converter is $2^n - 1$

Where n is the desired number of bits.

27. Define monotonicity with respect to D/A converter?

A DAC is said to be monotonic if the analog output increases or remains the same as the digital input increases. This results in the output always being single – valued.

28. Why is R-2R ladder network DAC better than weighted resistor DAC?

Wide ranges of resistors are required in binary weighted resistor type DAC.

This can be avoided by using R-2R ladder type DAC.

i. Easier to build accurately as only two precision metal film resistors are required.
ii. Number of bits can be expanded by adding more sections of same R-2R values.
iii. In inverted R-2R ladder DAC, node voltages remain constant with changing input binary words. This avoids any slowdown effects by stray capacitances.

29. Which type of ADC is used in all digital voltmeter?

Dual slope ADC converters are particularly suitable for accurate measurement of slowly varying signals, such as digital panel meters and multimeters.

30. What do you mean by delta modulation?

Delta modulation is a method of information transmission with the help of pulses. It is one type of digital modulation and it determines the increase or decrease of the signal sample with respect to previous sample. And encodes this rise or fall of amplitude by 1 bit.

31. List the application of sample and Hold circuits?

i. It is used in ADC.
ii. It is used in digital interfacing
iii. It is used in pulse modulation system
iv. It is used in analog demultiplexer

32. Mention the types of DAC techniques?

ii. Weighted resistance
iii. Inverted R-2R ladder
iv. Multiplying.

33. Define the resolution of DAC?

Resolution of DAC is defined as the change in the output voltage corresponding to the change of one bit in the digital input.

34. Explain in brief stability of a converter:

The performance of converter changes with temperature age & power supply variation . So all the relevant parameters such as offset, gain, linearity error& monotonicity must be specified over the full temperature & power supply ranges to have better stability performances.

35. What is meant by linearity?

The linearity of an ADC/DAC is an important measure of its accuracy & tells us how close the converter output is to its ideal transfer characteristics. The linearity error is usually expressed as a fraction of LSB increment or percentage of full-scale voltage. A good converter exhibits a linearity error of less than ±½LSB.

36. What is monotonic DAC?

A monotonic DAC is one whose analog output increases for an increase in digital input.

37. What is multiplying DAC?

A digital to analog converter which uses a varying reference voltage VR is called a multiplying DAC (MDAC). If the reference voltage of a DAC, VR is a sine wave given by:

$$V(t) = V_{in} \text{ Cos } 2\pi ft;$$

Then, $V_o(t) = V_{om} \text{ Cos } (2\pi ft + 180^o)$

38. What is a sample and hold circuit? Where it is used?

A sample and hold circuit is one which samples an input signal and holds on to its last sampled value until the input is sampled again. This circuit is mainly used in digital interfacing, analog to digital systems, and pulse code modulation systems.

39. Define sample period and hold period.

The time during which the voltage across the capacitor in sample and hold circuit is equal to the input voltage is called sample period. The time period during which the voltage across the capacitor is held constant is called hold period.

40. Define accuracy of converter.

Absolute accuracy:

It is the maximum deviation between the actual converter output & the ideal converter output.

Relative accuracy:

It is the maximum deviation after gain & offset errors have been removed. The accuracy of a converter is also specified in form of LSB increments or % of full scale voltage.

41. What output voltage would be produced by a D/A converter whose output range is 0 to 10 V and whose input binary number is 0110 for a 4 bit DAC.

Given $V_{o\,FS} = 10V$

$$Resolution = \frac{10}{10^4 - 1} = 0.6667\ V$$

The output voltage at 0110=0.6667*6=4V

42. What is the main drawback of dual slope ADC?

The conversion time of dual slope ADC is high .This is the main drawback of dual slope ADC.

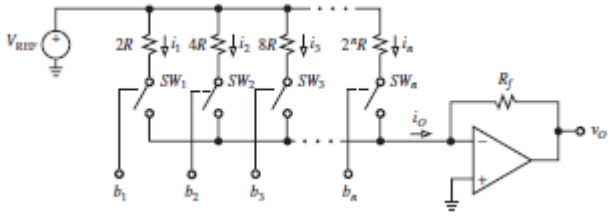
43. Draw the binary ladder network of DAC .If the value of the smaller resistance is 10K what is the value of the other resistance

44. A 12 bit D/A converter has resolution of 20mV/LSB.Find the full scale output voltage **[April/May 16]**

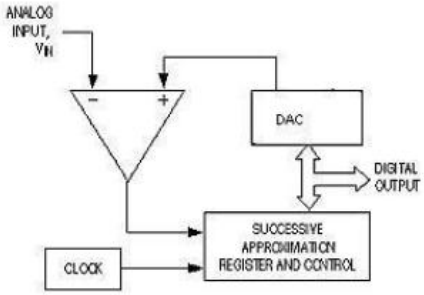
Given resolution = 20mV/LSB

Full scale output voltage =Resolution$(10^{12}-1)=20*10^{-3}\,(10^{12}-1)$

45. Draw the weighted resistor network of DAC[APRIL/MAY 16]



46. Draw the functional diagram of the successive approximation ADC




47. Define voltage droop.

The leakage current causes voltage of the capacitor to drop down.This is referred to as droop.

48. What are current driven DACs?

The DAC in which the problem of radioed emitter is solved by using equal value current sinks and exploiting the current scaling capability of the inverter R-2R ladder to obtain binary weighted contributions to the output is known as current driven DAC

49. What are the specifications of D/A converter?

- Accuracy
- Resolution
- Offset
- Linearity error
- Conversion time
- Monotonicity

50. Define conversion time of DAC

It is the time required for conversion of analog signal into its digital equivalent.

51. What is linear error?

The linear error is defined as the amount by which the actual output differs from ideal straight line output characteristics of DAC

52. Define Offset error.

Offset error is defined as the nonzero level of the output voltage when all inputs are zero.

53. Compare single slope ADC and dual slope ADC

| Sl.No | Single slope ADC | Dual slope ADC |
|---|---|---|
| 1. | Resolution is low | Resolution is high |
| 2. | Does not use integrator | It uses integrator |
| 3. | Accuracy is low | Accuracy is high |
| 4. | Less immune to temperature variations | More immune to temperature variations |
| 5. | More sensitive to input voltage variations | Less sensitive to input voltage variations |

# PART –B&C

1. (i) Describe the operational feature of R-2R ladder type D/A converter.(7) **[Nov/Dec2018]**
   [Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 352]
   (ii) Discuss various switches employed for D/A converters.(6) **[Nov/Dec2018]**
   [Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 351]
2. (i) With a neat block diagram, explain the operation of flash and successive approximation type A/D converter. (10) **[Nov/Dec2018]**
   [Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 358]
   (ii) What is oversampling? Give examples of oversampling converter. (3) **[Nov/Dec2018]**
3. (i) For a 4 bit R-2R ladder D/A converter assume that the full scale voltage is 16V.Calculate the step change in output voltage on input varying from 0111 to 1111(8) **[Nov/Dec2018]**
   [Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 357]
   (ii) Explain sigma delta converters in detail
4. Enumerate the specifications of D/A converter. **[April/May 2018]**
   [Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 366]
5. Describe in detail about the single slope type AC with neat sketch. **[April/May 2018]**
   [Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 363]
6. Describe the operation of dual slope and successive approximation type ADC .What are the advantages of dual slope ADC **[April/May 2017]**
   [Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 358]

7. (i) What is meant by resolution ,offset error in ADC **[April/May 2017]**
   [Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 366]
8. (ii) Discuss on the single slope type ADC **[April/May 2017]**
   [Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 363]
9. (i) Explain the successive approximation type A/D converter **[April/May 2016]**
   [Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 396]
   (ii) Narrate the functions of Analog switches **[April/May 2016]**
   [Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 383]

10. How are A/D converters categorized? **[April/May 2017]**
    [Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 393]
    (ii) Write Short Note on high speed sample and hold circuits(6) **[April/May 2015] [April/May 16]**
    [Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 176]
    [Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 397]
11. (i) Explain voltage mode and current mode operations of R-2R ladder type DAC[Nov/Dec 10]
    [Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 386]
    (ii) Explain over sampling type analog to digital converters
    [Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 176]
12. Draw the block diagram and explain the working of
    (i) Charge Balancing VFCS (8)
    [Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 225]
    (ii) Voltage to Time converter (8)
    [May/June 13]
    [Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 225]
13. Explain the following type DAC with suitable diagrams
    (i) Binary weighted resistor DAC (6)

[Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 382]

(ii) R-2R Ladder DAC (5)

[Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 385]

(iii) Inverted R-2R ladder DAC (5)

[Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 386]

14. (i) Explain the following type of electronic switches used in D/A converter with suitable diagrams

1.Totem pole MOSFET switch (4)

2.CMOS inverter as a switch (4)

[Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 384]

(ii) Compare Flash type ,Dual slope and successive approximation ADC in terms of parameters like speed ,accuracy, resolution ,input hold time(8)

[May/June 12]

[Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 393]

15. With a neat block diagram explain the working of three bit flash type analog to digital converter

[Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 393]

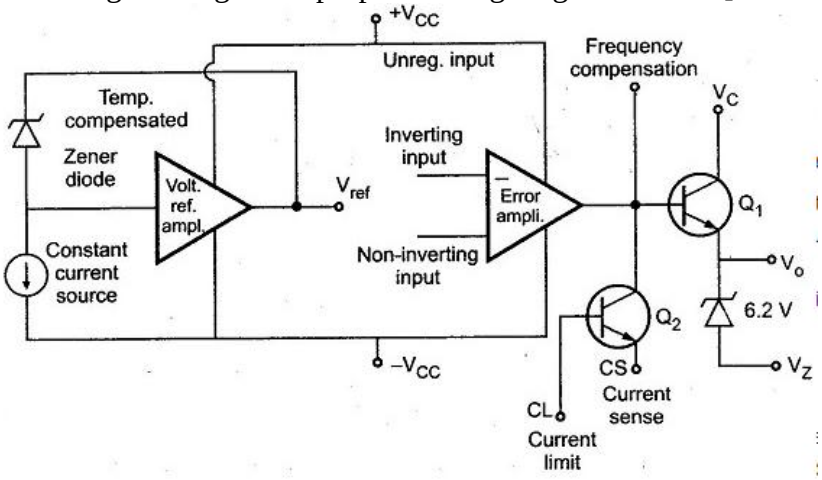
# UNIT-V-WAVEFORM GENERATORS AND SPECIAL FUNCTION ICs

PART A:

1. Mention the advantages of opto-couplers: **[Nov/Dec 2021]**
   - Better isolation between the two stages.
   - Impedance problem between the stages is eliminated.
   - Wide frequency response.
   - Easily interfaced with digital circuit.
   - Compact and light weight.
   - Problems such as noise, transients, contact bounce are eliminated.
2. What is the purpose of connecting a capacitor at the input and the output side of an IC voltage regulator? **[Nov/Dec 2021]** **[Nov/Dec 2015]**

   A capacitor connected between the input terminal and ground cancels the inductive effects due to long distribution leads. The output capacitor improves the transient response.
2. What are the types of multivibrators **[April/May 2019]**
   - Monostable multivibrator
   - Astable multivibrator
   - Bistable multivibrator
3. State the function of Opto coupler **[April/May 2019]**

   An opto-isolator (also called an optocoupler, photocoupler, or optical isolator) is an electronic component that transfers electrical signals between two isolated circuits by using light.Opto-isolators prevent high voltages from affecting the system receiving the signal.
3. List the various applications of multivibrators. **[Nov/Dec 2018]**
   - Pulse width modulation
   - Frequency doublers
   - Linear Ramp generator
   - Missing pulse detector
   - Square wave generator
   - Voltage controlled oscillator
   - FSK generator
4. Draw the circuit diagram of general purpose voltage regulator. **[Nov/Dec 2018]**




5. Name some LC oscillator circuits **[April/May 2018]**
   - Hartley Oscillator
   - Colpitts oscillator
6. Define Line regulation. **[April/May 2018]**

The line regulation is defined as the change in the regulated output load voltage for a specified range of the line voltage .It specifies the effect of changes in the source voltage on the regulator performance.

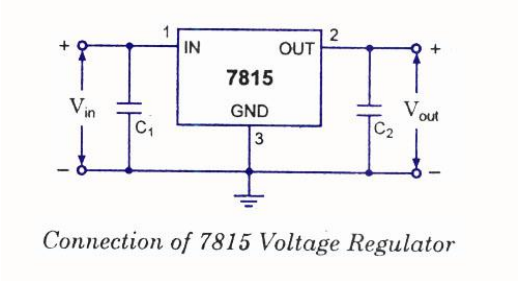
Line regulation is also defined as the percentage change in the output voltage for a change in the input voltage. It is expressed in millivolts or as a percentage of the output voltage.

7. Define current transfer ratio of an opto coupler **[Nov/Dec 2017]**

The current transfer ratio (CTR) is a parameter similar to the DC current amplification ratio of a transistor (hFE) and is expressed as a percentage indicating the ratio of the output current (IC) to the input current (IF).

$$CTR(\%)=(IC/IF) \times 100$$

8. Draw a fixed voltage regulator circuit and state its operation **[Nov/Dec 2017]**




*Connection of 7815 Voltage Regulator*

9. What is a voltage regulator? **[April/May 2017]**

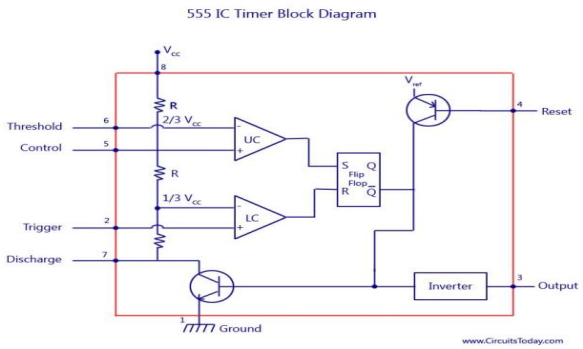
A voltage regulator is an electronic circuit that provides a stable dc voltage independent of the load current, temperature, and ac line voltage variations.

10. Distinguish the principle of linear regulator and a switched mode power supply. **[April/May 2017]**

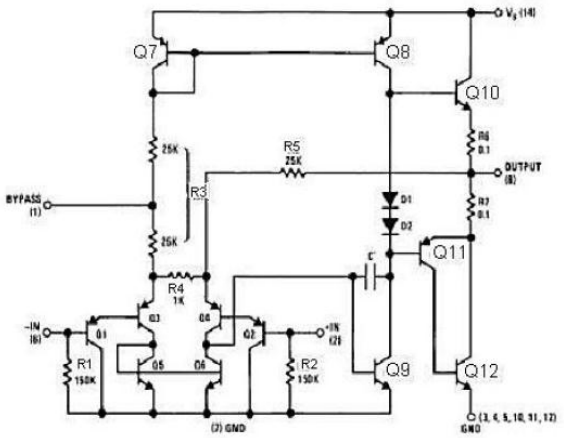
As its name suggests, a linear regulator is one where a linear component (such as a resistive load) is used to regulate the output. It is also sometimes called a series regulator because the control elements are arranged in series between the input and output.

A switching regulator is a voltage regulator that uses a switching element to transform the incoming power supply into a pulsed voltage, which is then smoothed using capacitors, inductors, and other elements.

11. Draw the block schematic of IC 555 timer. **[Nov/Dec 2016]**




12. Draw the internal circuit for audio power amplifier **[April/May 2016]**



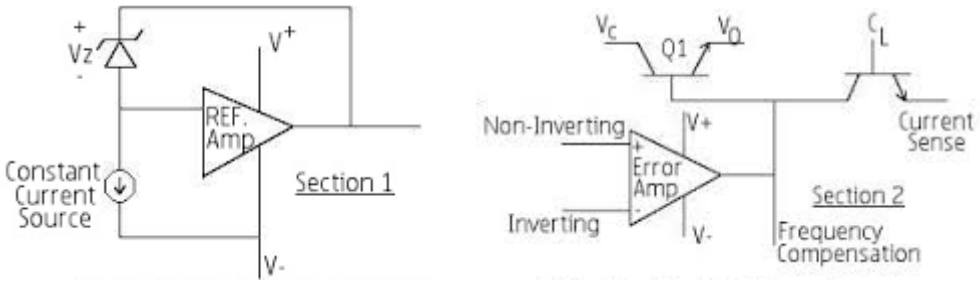

13. What is the function of a voltage regulator? Name few IC voltage regulators.

**[Nov/Dec 2016]**

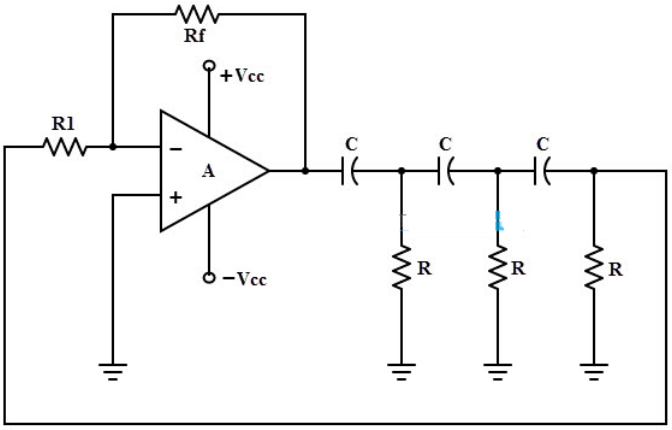
The function of voltage regulator is to provide a stable dc voltage for powering other electronic circuits. A voltage regulator should be capable of providing substantial output current.

Some IC voltage regulator is 78 XX/79 XX series and 723 general purpose regulators

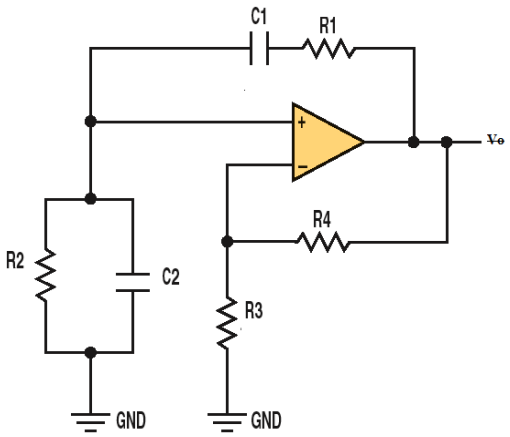
14. Mention two applications of frequency to voltage converter **[Nov/Dec 2015]**
    - Frequency to voltage converter in tachometers.
    - Frequency difference measurement
15. State the two conditions for oscillation. **[April/May 2015]**
    - The loop gain is equal to unity in absolute magnitude, that is, $|\beta A| = 1$ and
    - The phase shift around the loop is zero or an integer multiple of $2\pi$:
16. Draw the functional block diagram of 723 regulator. **[April/May 2015]**



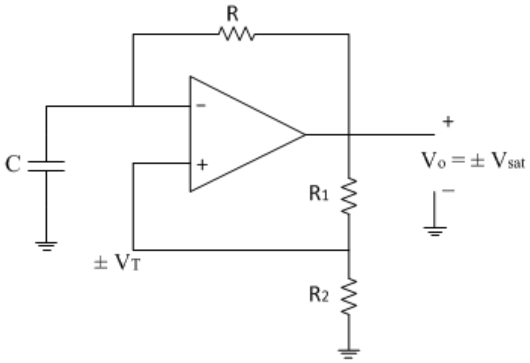

17. Draw the circuit diagram of RC phase shift oscillator



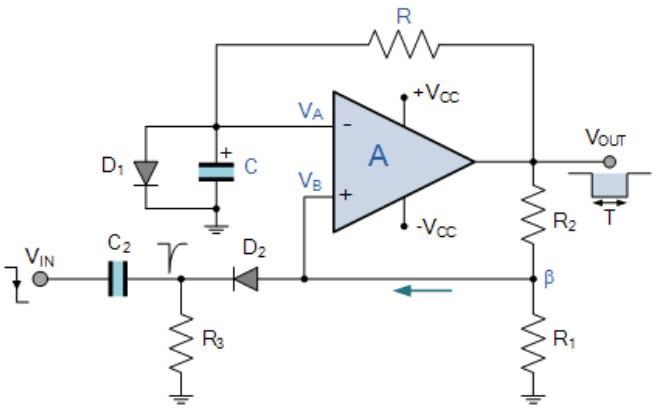

18. Draw the circuit diagram of wien bridge oscillator




19. Draw the circuit diagram of astable multivibrator using op-amp



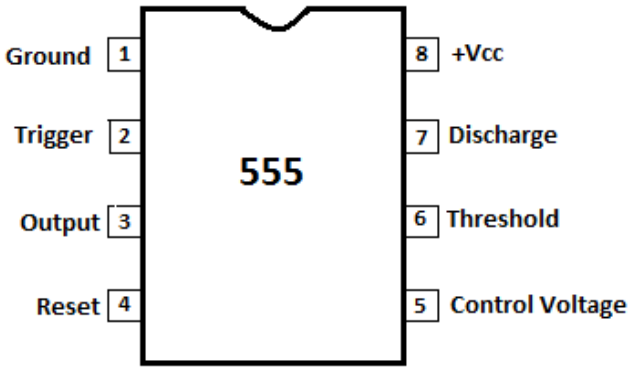

20. Draw the circuit diagram of monostable multivibrator using op-amp



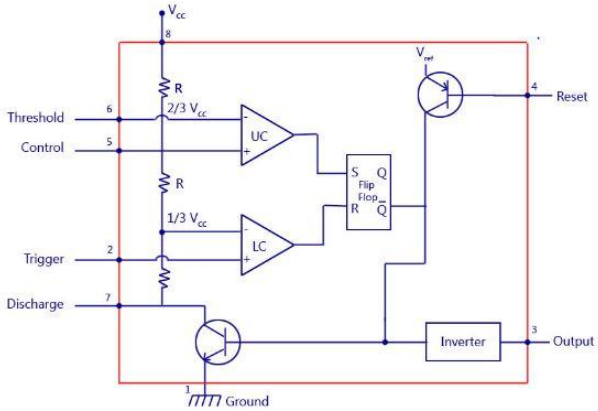

21. Which are the basic elements of IC555 timer

- A relaxation oscillator
- R-S flip-flop
- Two comparators
- discharge transistor

22. Draw the pin diagram of 555 timer




23. Draw the block diagram of 555 timer




24. Mention some applications of 555 timer:
    - Oscillator
    - Pulse generator
    - Ramp and square wave generator
    - Mono-shot multivibrator
    - Burglar alarm
    - Traffic light control.
25. List the applications of 555 timer in monostable mode of operation:
    - Missing pulse detector
    - Linear ramp generator
    - Frequency divider
    - Pulse width modulation.
26. List the applications of 555 timer in Astable mode of operation:
    - FSK generator
    - Pulse-position modulator
27. Give the classification of voltage regulators:
    - Series / Linear regulators
    - Switching regulators.
28. What is a linear voltage regulator?

    Series or linear regulator uses a power transistor connected in series between the unregulated dc input and the load and it conducts in the linear region. The output voltage is controlled by the continuous voltage drop taking place across the series pass transistor.
29. What is a switching regulator?

    Switching regulators are those which operate the power transistor as a high frequency on/off switch, so that the power transistor does not conduct current continuously. This gives improved efficiency over series regulators.
30. What is the purpose of having input and output capacitors in three terminal IC regulators?

A capacitor connected between the input terminal and ground cancels the inductive effects due to long distribution leads. The output capacitor improves the transient response.

31. Define load regulation.

Load regulation is defined as the change in output voltage for a change in load current. It is expressed in millivolts or as a percentage of the output voltage.

32. What is meant by current limiting?

Current limiting refers to the ability of a regulator to prevent the load current from increasing above a preset value.

33. Give the drawbacks of linear regulators:

- The input step down transformer is bulky and expensive because of low line frequency.
- Because of low line frequency, large values of filter capacitors are required to decrease the ripple.
- Efficiency is reduced due to the continuous power dissipation by the transistor as it operates in the linear region.

34. What is the advantage of switching regulators?

- Greater efficiency is achieved as the power transistor is made to operate as low impedance switch. Power transmitted across the transistor is in discrete pulses rather than as a steady current flow.
- By using suitable switching loss reduction technique, the switching frequency can be increased so as to reduce the size and weight of the inductors and capacitors.

35. What is an opto-coupler IC? Give examples.

Opto-coupler IC is a combined package of a photo-emitting device and a photo sensing device.

Examples for opto-coupler circuit : LED and a photo diode,
LED and photo transistor,
LED and Darlington.

Examples for opto-coupler IC : MCT 2F , MCT 2E

36. Mention the advantages of opto-couplers:

- Better isolation between the two stages.
- Impedance problem between the stages is eliminated.
- Wide frequency response.
- Easily interfaced with digital circuit.
- Compact and light weight.
- Problems such as noise, transients, contact bounce are eliminated.

37. What is an isolation amplifier?

An isolation amplifier is an amplifier that offers electrical isolation between its input and output terminals.

38. What is the need for isolation amplifiers?

The isolation amplifier is required when the common mode voltages exist between instrument ground and signal ground. Such voltages allow ground loop cements to circulate in the absence of isolation amplifier. This causes noisy operation, destruction of instrument and measurement errors. To avoid this isolation amplifiers are needed.

39. What is the need for a tuned amplifier?

In radio or TV receivers, it is necessary to select a particular channel among all other available channels. Hence some sort of frequency selective circuit is needed that will allow us to amplify the frequency band required and reject all the other unwanted signals and this function is provided by a tuned amplifier.

40. Give the classification of tuned amplifier:

(i) Small signal tuned amplifier

- Single tuned

- Double tuned
- Stagger tuned

(ii) Large signal tuned amplifier.

41. Why is the monostable multivibrator circuit called time delay circuit and gating circuit?

Monostable multivibrator circuit called time delay circuit because it generates a fast transition at a predetermined time T after the application of input trigger. It is called as a gating circuit because it generates rectangular waveform at a definite time and could be used as gate parts of a system.

42. Why there is no phase shift provided in the feedback network in Wein-Bridge oscillator?

In Wein-bridge oscillator, the feedback signal is connected to the (+) input terminal so that, the op-amp is working as a non-inverting amplifier, which produces 0 degree or 360 degree phase shift.. Therefore the feedback network need not provide any phase shift.

43. Give the formula for period of oscillations in an op-amp astable circuit.

The formula for period of oscillations in an op-amp astable circuit is

$$T = 2RC \ln\left[1 + \frac{2R_2}{R_1}\right]$$

44. Define duty cycle for a periodic pulse waveform.

The duty cycle of the output pulse waveform is given by

$$d\% = \frac{T_C}{T} * 100 = \frac{R_A + R_B}{R_A + 2R_B} * 100$$

45. What is meant by thermal shutdown applied to voltage regulators?

Due to overheating , the series pass element of regulator may get damaged. To avoid this, thermal shutdown is provided. In this protection scheme, the junction temperature of the series pass element is sensed. By sensing this, its power dissipation is reduced by using certain circuit till its temperature drops to a lower safe value.

46. What are the three waveforms generated by ICL8038?

- Sine wave
- Square wave
- triangular Wave

47. List the characteristics of optocoupler

(i) Current Transfer Ratio:
(ii) Isolation voltage between input & output:
(iii) Response Time:
(iv) Common mode Rejection:

48. What is the advantage of switching regulators?

Switching regulators are highly efficient and able to step up (boost), step down (buck), and invert voltages with ease

Switching regulators are efficient because the series element is either fully conducting or switched off because it dissipates almost no power. Switching regulators are able to generate output voltages that are higher than the input voltage or of opposite polarity, unlike linear regulators.

49. What are the basic elements of voltage regulator circuit?

- Voltage reference
- Error amplifier
- Feedback Network
- Active Element

50. Name the various protection circuits used for the voltage regulators.

- Constant current limiting
- Foldback current limiting

- Over voltage protection
- Thermal protection

51. State the applications of IC LM 380
    - Audio amplifier
    - High gain audio amplifier
    - Phone amplifier
    - Intercom systems

## PART B&C:

1. Explain the working principle and salient features of triangular wave generator and saw tooth wave generator. **[April/May 2018] [Nov/Dec 2018]**
   [Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 220]
   [Ref .S.Salivahanan &V S Kanchana Bhaskaram=n, "Linear Integrated Circuits (Second Edition)", Page 335]
2. (i) State the significant difference between fixed and adjustable voltage regulators. **[Nov/Dec 2018]**
   [Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 241]
   (ii) Design a wave generator using 555 timer for a frequency of 110Hz and 80% duty cycle.Assume C=0.16μF. (7) **[Nov/Dec 2018]**
   [Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 322]
3. Discuss briefly about opto-couplers. **[April/May 2018]**
   [Ref .S.Salivahanan &V S Kanchana Bhaskaram=n, "Linear Integrated Circuits (Second Edition)", Page 542]
4. (i) With neat diagram explain the operation of an astable and monostable multivibrators **[Nov/Dec 2017]**
   [Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 216 &318]
   (ii) Draw the functional diagram and connection diagram of a low voltage regulator and explain **[Nov/Dec 2017]**
   [Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 241]
5. Answer any two of the following **[April/May 2017]**
   (iii) Switched capacitor filters
   [Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 288]
   (iv) Audio power amplifier
   [Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 322]
   (v) Opto coupler
   [Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 322]
6. With neat diagram explain IC723 general purpose voltage regulator[May/June 14] **[April/May 16]**
   [Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 272]
7. Explain Sawtooth waveform generator and LM 380Audio amplifier in detail **[April/May 16]**
   [Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 247]
8. Describe the working of a astable multivibrator using 555 timer[Nov/Dec 11] **[April/May 16]**
   [Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 345]
9. Explain in detail Voltage to frequency and frequency to voltage converter [May/June 14]
   . Sergio Franco, "Design with Operational Amplifiers and Analog Integrated Circuits", 3rd Edition page 520
10. (i)Design a phase shift oscillate at 100Hz **(May/June 15)**
    [Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 250]

(ii) Describe monostable multivibrator with necessary diagrams and derive for ON time and recovery time **[May/June 15]**

[Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 337]

11. (i)Briefly describe about monolithic switching regulators **[April/May 15]**

[Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 255]

(ii)Draw the schematic of ICL 8038 function generator and discuss its features (8) **[April/May 15]**

[Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 225]

12. Describe the working of a Astable multivibrator using op-amp [Nov/Dec 14]

[Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 241]

13. Describe the working of a monostable multivibrator using 555 timer[Nov/Dec 13]

[Ref .Roy Choudhry, Shail B.Jain, "Linear Integrated Circuits (Second Edition)", Page 337]

14. Explain Video amplifier and opto-couplers

[Ref .S.Salivahanan &V S Kanchana Bhaskaram=n, "Linear Integrated Circuits (Second Edition)", Page 542]

15. Explain the following in detail
    i. Switched capacitor filter
    ii. Isolation amplifier

[Ref .S.Salivahanan &V S Kanchana Bhaskaram=n, "Linear Integrated Circuits (Second Edition)", Page 547]

# B.E/B.Tech.DEGREE EXAMINATION, APRIL/MAY2015

Fourth Semester

Electronics and Communication Engineering

EC 6404- LINEAR INTEGRATED CIRCUITS

(Regulation 2013)

Time :Three Hours Maximun:100 Marks

Answer ALL questions

PART A(10x2=20 marks)

1. A differential amplifier has a differential voltage gain of 2000 and a common mode gain of 0.2.Determine the CMRR in dB

   Given common mode gain $A_{cm}$=0.2

   Difference mode gain $A_{dm}$=2000

   CMRR= $A_{dm}$/ $A_{cm}$= 2000/0.2 =10000=10log10000=80dB

2. Define Slew rate and what causes slew rate?

   The slew rate of an op amp or any amplifier circuit is the rate of change in the output voltage caused by a step change on the input.

   There is usually a capacitor within or outside an op-amp to prevent oscillation. It is this capacitor which prevents the output voltage from responding immediately to a fast changing input

3. What is hysteresis and mention the purpose of hysteresis in a comparator?

   Hysteresis is the time-based dependence of a system's output on present and past inputs. The dependence arises because the history affects the value of an internal state. To predict its future outputs, either its internal state or its history must be known.

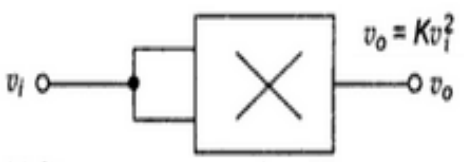
   In comparator hysteresis has the effect of separating the up-going and down-going switching points so that, once a transition has started, the input must undergo a significant reversal before the reverse transition can occur.

4. What is the difference between normal rectifier and precision rectifier?

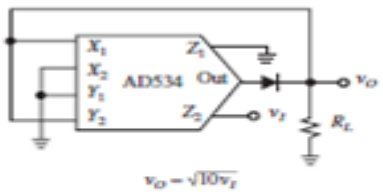
   A simple rectifier circuit uses a diode. The input voltage has to exceed the turn-on voltage (0.6V for ordinary Si diode) before rectification is achieved.

   A precision rectifier is an active circuit using an op-amp and a diode in the feedback loop. This overcomes the turn-on "knee" voltage.

5. How do you convert a basic multiplier to a squaring and square root circuit?

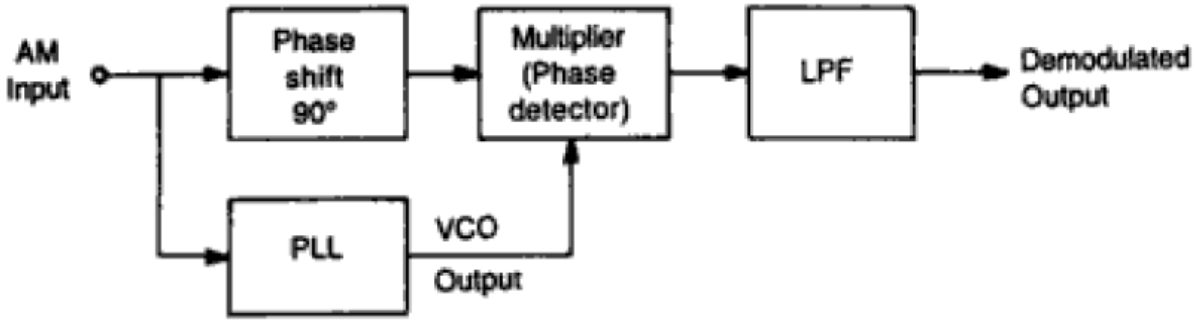



Voltage squarer using multiplier




Square root circuit using multiplier

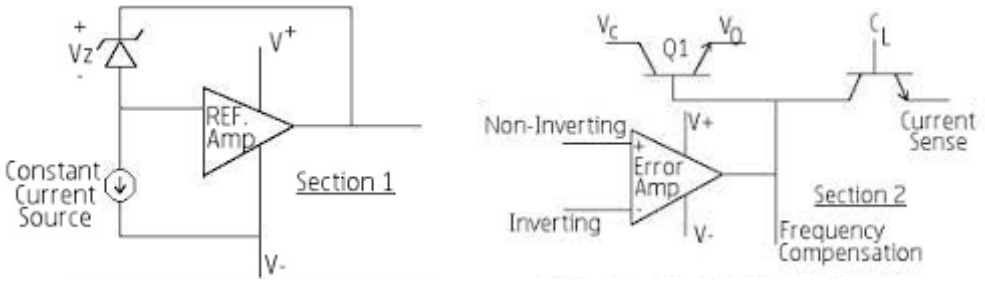
6. What are the applications of PLL for AM detection?




7. What would be produced by a DAC whose output ranges is 0 to 10V and whose input binary number is 10111100(for a 8 bit DAC)?
   $V_o=10V(1x(1/2)+0x(1/2)^2+1x(1/2)^3+1x(1/2)^4+1x(1/2)^5+1x(1/2)^6+0x(1/2)^7+0x(1/2)^8)$
   $V_o=7.34V$
8. What is over sampling?

   The technique of increasing the apparent sampling frequency of a digital signal by repeating each digit a number of times, in order to facilitate the subsequent filtering of unwanted noise.

   In signal processing, oversampling is the process of sampling a signal with a sampling frequency significantly higher than the Nyquist rate. Theoretically a bandwidth-limited signal can be perfectly reconstructed if sampled above the Nyquist rate, which is twice the highest frequency in the signal. Oversampling improves resolution, reduces noise and helps avoid aliasing and phase distortion by relaxing anti-aliasing filter performance requirements.
9. State the two conditions for oscillation.
   - The loop gain is equal to unity in absolute magnitude, that is, $|\beta A| = 1$ and
   - The phase shift around the loop is zero or an integer multiple of $2\pi$:
10. Draw the functional block diagram of 723 regulator.




**PART B-(5x16=80 marks)**

11. (a) (i) With simple schematic of differential amplifier explain the function of Operational Amplifier (8)

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 53]

(ii) Briefly Explain about constant current source (8)

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 65]

Or

(b) (i) Briefly explain the techniques used for frequency compensation (12)

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 119]

(ii) How do the open loop gain and the closed loop gain of an op-amp differ?(4)

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 272]

12. (a) (i) Determine the rate of change of the output voltage in response to the first input pulse as shown below for the integrator. The output voltage is initially zero. Also describe the output after the first pulse. Draw the output waveform

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 168]

(ii) Explain in detail about the V to I and I to V converters (8)

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 146]

Or

(b) (i) With neat diagram explain the operation of schmitt trigger (8)

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 212]

(ii) Design a wide band pass filter having $f_L$=400 Hz $f_H$=2kHz and pass band gain of 4.Find the value of Q of the filter

(8)

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 276]

13. (a) (i) With neat simplified internal diagram explain the working principle of operational transconductance Amplifier(OTA)

(10)

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 181]

(ii) Explain the application of VCO for FM generation (4)

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 344]

Or

(b) Define capture range and lock range .Explain the process of capturing the lock and also derive the capture range and lock range

(16)

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 339]

14. (a) Explain in detail about the following Digital to Analog conversion techniques

(i) R-2R ladder type DAC (8)

(ii) Weighted resistor DAC (8)

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 349]

Or

(b) With neat internal diagram explain the following

(i) Dual slope ADC (8)

(ii) Successive Approximation ADC (8)

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 361]

15. (a) (i) Design a Phase shift oscillate at 100Hz (6)

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 225]

(ii) Describe Monostablemulivibrator with necessary diagrams and derive for ON time and recovery time

(10)

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 312]

Or

(b) (i) Briefly describe about monostable switching regulators

(10)

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 255]

(ii) Write short notes on Voltage to frequency converters (6)

[Ref.Design with Operational Amplifiers and Analog Integrated CircuitsBy Sergio Franco Page No 486]

# B.E/B.Tech.DEGREE EXAMINATION,NOVEMBER/DECEMBER2015

Fourth Semester

Electronics and Communication Engineering

EC 6404- LINEAR INTEGRATED CIRCUITS

(Regulation 2013)

Time :Three Hours Maximun:100 Marks

Answer ALL questions

PART A(10x2=20 marks)

52. Mention two advantages of active load over passive load in an operational amplifier
    - Larger gain
    - Larger Bandwidth

53. Define input bias current and input offset current of an operational amplifier

    Input bias current is the average value of the base current entering in to the i/p terminals of an opamp.Its typical value is 500nA

    Input offset current is the algebraic difference between the current into the inverting and non-inverting terminals is referred to as input offset current $I_{io}$. Mathematically it is represented as

    $$I_{io} = |I_{B+} - I_{B-}|$$

    Where IB+ is the current into the non-inverting input terminals.

    IB- is the current into the inverting input terminals.

54. determine the output voltage for the circuit shown in figure 1 when
    (a) Vin=-2V
    (b) Vin=3V

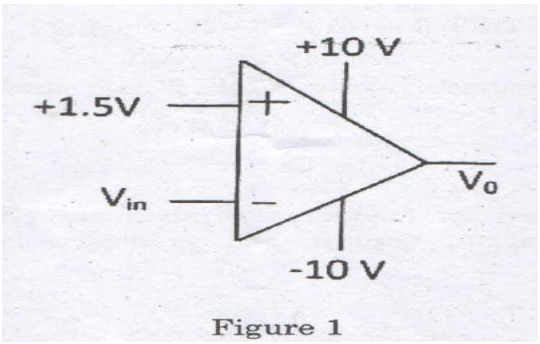


Figure 1

This is basic comparator circuit

when Vin=-2V then Vo=10V

When Vin =3V then Vo=-10V

55. Plot the transfer characteristics of the circuit shown in figure 2 .The opamp saturates at +/-12V

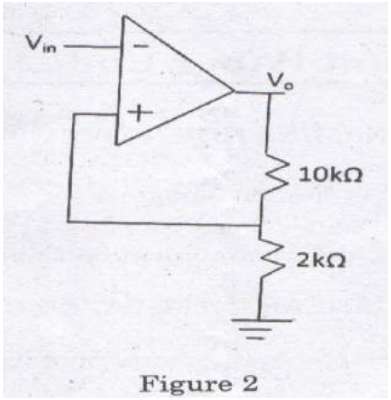
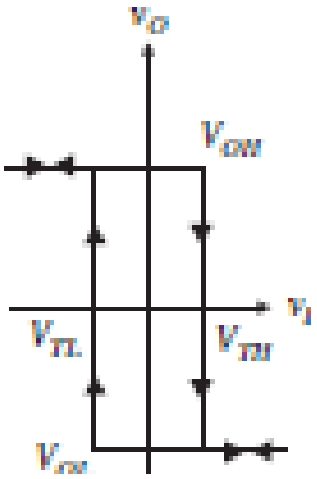


Figure 2




56. Define

(a) Capture range

(b) Lock range Of Phase locked Loop

The range of frequency over which the PLL can acquire lock with an input signal is called capture range. The PLL cannot acquire a signal outside the capture range, but once captured, it will hold on till the signal frequency goes beyond the lock-in range, larger capture range is required

The range of frequencies over which the PLL can maintain lock with the incoming signal is called the lock-in range or tracking range. It is expressed as a percentage of the VCO free running frequency.

57. Mention two applications of analog multiplier

- Variable-gain amplifier
- Ring modulator
- Product detector
- Frequency mixer

58. Determine the number of comparators and resistors required for 8 bit flash type ADC

No Of comparators required is $=2^8-1=255$

59. Mention two advantages of R-2R ladder type DAC when compared to weighted resistor type DAC

- Only two resistor values are used in R-2R ladder type.
- It does not need as precision resistors as Binary weighted DACs.
- It is cheap and easy to manufacture.

60. What is the purpose of connecting a capacitor at the input and the output side of an IC voltage regulator?

A capacitor connected between the input terminal and ground cancels the inductive effects due to long distribution leads. The output capacitor improves the transient response.

61. Mention two applications of frequency to voltage converter

- Frequency to voltage converter in tachometers.
- Frequency difference measurement.

PART B-(5x16=80 marks)

62. (a) With a neat diagram explain the input side of the internal circuit diagram of IC741

[Ref .Roy Choudhry, ShailB.Jain, “Linear Integrated Circuits (Fourth Edition)”, Page 53]

Or

(b) What is the need for frequency compensation in an OPAMP? With a neat suitable illustration explain the pole zero frequency compensation technique

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 119]

63. (a) (i) With neat circuit diagram explain the working of precision rectifier (8)

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 148]

(ii) Explain the application of operational amplifier as differentiator (8)

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 164]

Or

(b) (i) Mention two advantages of active filter over passive filter .Also design a second order low pass filter using operational amplifier for the uppercut off frequency of 2KHz.Assume the value of capacitor to be 0.1μF (8)

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 262&270]

(ii) With a neat circuit diagram explain the working of voltage to current converter

(8)

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 146]

64. (a) Determine the expression for the capture range and lock range of Phase locked Loop

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 339]

Or

(b) Explain the application of Phase Locked Loop as

(i) Frequency synthesizer

(ii) AM demodulator and

(iii) FM demodulator

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 343]

65. (a) With a neat block diagram explain the working of Successive approximation type ADC.Also determine the conversion time of 8 bit and 16 bit successive approximation type ADC if its clock frequency is 50Hz

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 361]

Or

(b) With a neat block diagram explain the working of two bit flash type analog to digital converter

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 359]

66. (a) With a neat functional diagram explain the working of 555 timer as monostable multivibrator ad derive an expression for the frequency of oscillation with relevant waveforms

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 312]

Or

(b) With a neat circuit diagram explain the working of linear voltage regulator using operational amplifier

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 249]

# B.E/B.Tech.DEGREE EXAMINATION, MAY/JUNE 2016

Fourth Semester

Electronics and Communication Engineering

EC 6404- LINEAR INTEGRATED CIRCUITS

(Regulation 2013)

Time :Three Hours Maximun:100 Marks

Answer ALL questions

PART A (10x2=20 marks)

1. Find the maximum frequency for sine wave output voltage 10 V peak with an op-amp whose slew rate is 1 V/μs

$$f_{\max}(Hz) = \frac{SlewRate}{6.28 * V_m} * 10^6$$

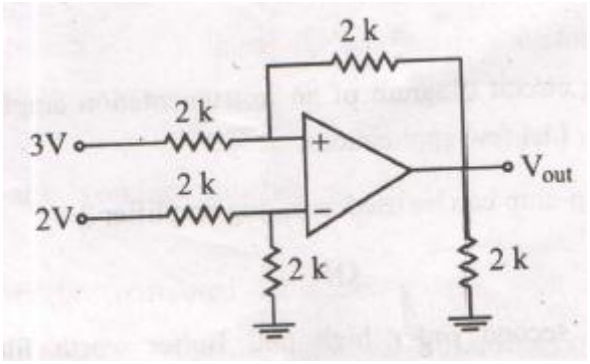
$$f_{\max}(Hz) = \frac{1}{6.28 * 10} * 10^6$$

$$f_{\max}(Hz) = 15.923kHz$$

2. Differentiate the ideal and practical characteristics of an op-amp

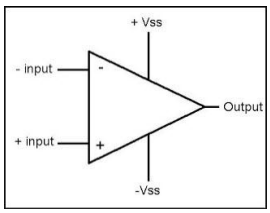
| Characteristics | Ideal | Practical |
|---|---|---|
| Open loop voltage gain | ∞ | High |
| Input impedance (Ri) | ∞ | High |
| Output impedance (Ro) | 0 | Low |
| Bandwidth (BW) | ∞ | High |
| Zero offset | Vo = 0, when V1 = V2 = 0 | Non zero |

3. Calculate the output voltage for the circuit shown below




$V_o$=3-2=1V

4. Draw the circuit diagram of a comparator. Mention its applications.



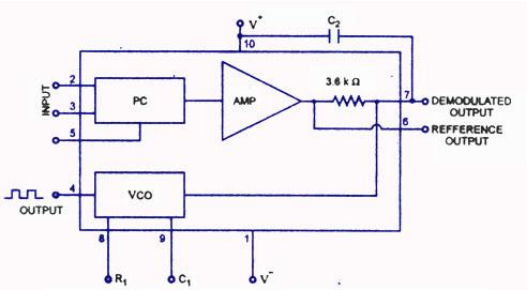

Applications

- Zero crossing detector
- Window detector
- Time marker generator
- Phase meter

5. What is four quadrant multiplier

It is a multiplier circuit with two inputs being both positive and both negative, then the multiplier is called as four-quadrant multiplier

6. Draw the circuit diagram of a PLL circuit using as a FM detector.



*Block Diagram of PLL Unit 565 For Use As FM Detector*

7. A 12 bit D/A converter has a resolution of 20mv/LSB.Find the full scale output voltage.

$$\text{Re}solution = \frac{V_{oFS}}{2^n - 1}$$

Where, $V_{oFS}$ is the full scale output voltage

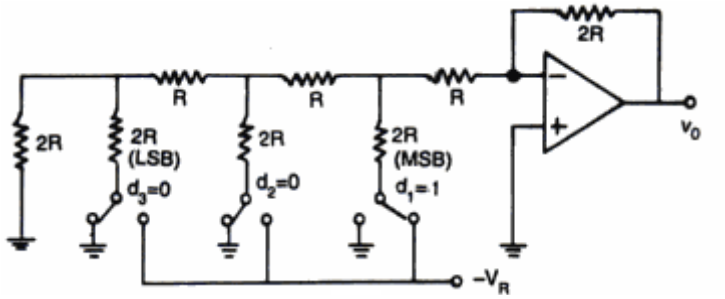
n is the number of bits

$$V_{oFS} = \text{Re}solution * (2^n - 1)$$

$$V_{oFS} = 20 * 10^{-3} * (2^{12} - 1)$$

$$V_{oFS} = 81.9V$$

8. Draw the binary ladder network of DAC, If the value of the smaller resistance is 10K.What is the value of other resistance?




The value of other resistance=2R=20 Kohm

9. A Hartley oscillator has $L_1$=10mH,$L_2$=5mH and C=200 pF.Calculate the frequency of oscillation.

$$f = \frac{1}{2\pi(\sqrt{(L_1 + L_2) * C}}$$

$$f = \frac{1}{2\pi(\sqrt{(10 * 10^{-3} + 5 * 10^{-3}) * 200 * 10^{-12}}}$$

$$f = 91.88KHz$$

10. What is an isolation amplifier? Mention its applications.

An isolation amplifier in an amplifier that offers an ohmic or electrical isolation between its input and output terminals

Isolation amplifiers are a form of differential amplifier that allow measurement of small signals in the presence of a high common mode voltage by providing electrical isolation and an electrical safety barrier

These amplifiers are used for amplifying low-level signals in multi-channel applications

PART B (5x16=80 marks)

11. (a) (i) With a schematic diagram explain the effect of $R_E$ on CMRR in differential amplifier.

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 59]

(ii) Discuss about the methods to improve CMRR

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 64]

Or

(b) (i) Write a note on stability criteria and frequency compensation technique applied in op-amp

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 114]

(ii) A non-inverting amplifier with a gain of 300 having an impact offset voltage of +/-3mV.Find the output voltage when the input is $0.01\sin\omega t$ volt

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 249]

12. (a) (i) Draw the circuit diagram of an instrumentation amplifier and explain its operation. List few applications

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 141]

(ii) How an op-amp can be used as a log amplifier

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 155]

Or

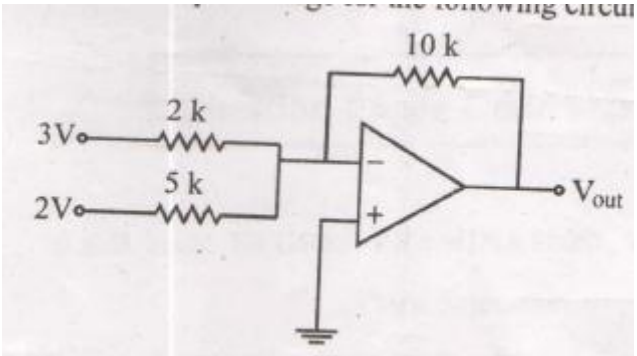
(b) (i) Design a second order high pull Butter worth filter having cut off frequency of 5 kHz

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 272]

(ii) What is a precision rectifier? With circuit schematic explain the working principle of full wave rectifier

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 148-149]

(iii) Determine the output voltage for the following circuit shown in figure




13. (a) Explain the working principle of four quadrant variable form transconductance Multiplier

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 181]

Or

(b) (i) Discuss the principle of operation of NE 565 PLL circuit

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 337]

(ii) How can PLL be modeled as a frequency multiplier?

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 342]

14. (a) (i) Explain the successive approximation type A/D converter.

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 361]

(ii) Narrate the functions of analog switches

[Ref .Roy Choudhry, ShailB.Jain, “Linear Integrated Circuits (Fourth Edition)”, Page 351]

Or

(b) (i) State the significance of using high speed sample and hold circuits. Explain its working principle.

[Ref .Roy Choudhry, ShailB.Jain, “Linear Integrated Circuits (Fourth Edition)”, Page 153]

(ii) Compare the performance of various DACs

[Ref .Roy Choudhry, ShailB.Jain, “Linear Integrated Circuits (Fourth Edition)”, Page 352]

15. (a) (i) Briefly write the working principle and functionalities of LM 380 audio Amplifier

[Ref .Roy Choudhry, ShailB.Jain, “Linear Integrated Circuits (Fourth Edition)”, Page 249]

(ii) Draw the schematic of Linear IC saw tooth waveform generator and explain the circuit operation

[Ref.Design with Operational Amplifiers and Analog Integrated CircuitsBy Sergio Franco Page No 510]

Or

(b) (i) Summarize the working principle of IC 723 general purpose voltage regulator.

[Ref .Roy Choudhry, ShailB.Jain, “Linear Integrated Circuits (Fourth Edition)”, Page 248]

(ii) A 555 timer is configured in astable mode with $R_A$= 2 kohm $R_B$=6kohm and C=0.1µF.Determine the frequency of oscillation

[Ref .Roy Choudhry, ShailB.Jain, “Linear Integrated Circuits (Fourth Edition)”, Page 322]

# B.E/B.Tech.DEGREE EXAMINATION, NOVEMBER/DECEMBER 2016

Fourth Semester

Electronics and Communication Engineering

EC 6404- LINEAR INTEGRATED CIRCUITS

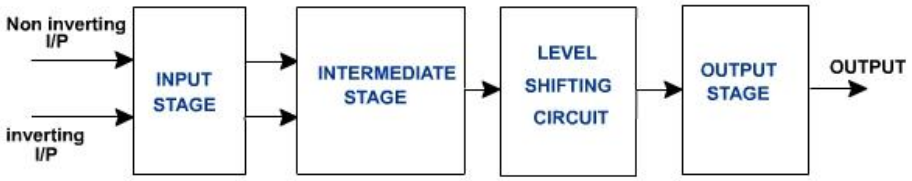
(Regulation 2013)

Time :Three Hours Maximun:100 Marks

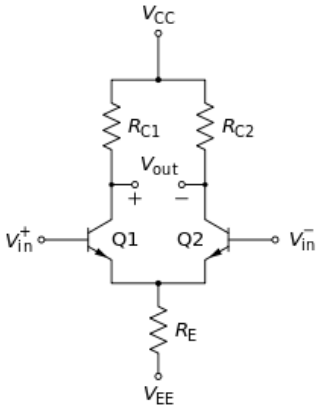
Answer ALL questions

PART A (10x2=20 marks)

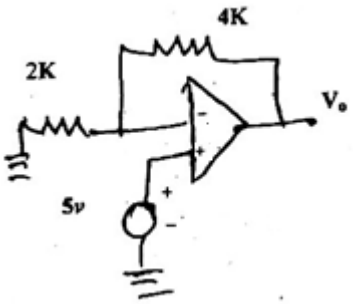
16. Draw the block diagram of a general op-amp.




17. Draw the circuit diagram of a symmetrical emitter coupled differential amplifier.




18. For the op-amp shown in figure determine the voltage gain

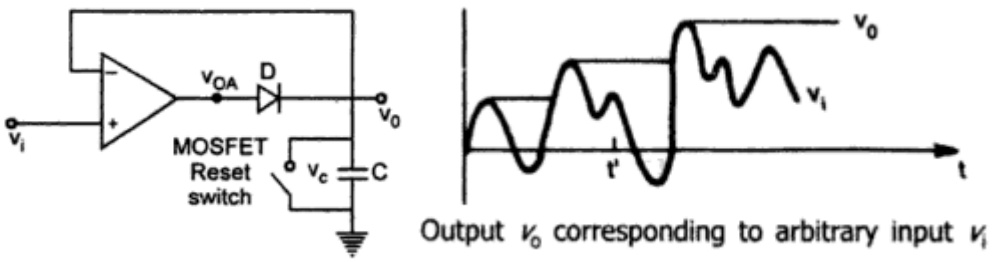



The given circuit is inverting amplifier

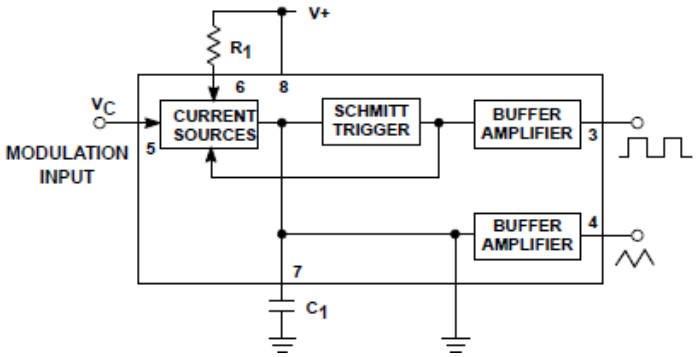
For inverting amplifier voltage gain $= -\frac{R_f}{R_i}$

$$= -\frac{4k}{2k} = -2$$

19. Draw the circuit diagram of a peak detector with waveforms.



20. Draw the block diagram of IC 566 VCO (Voltage controlled Oscillator)




21.Enlist any four applications of NE 565 PLL

i. Frequency multiplication and division
ii. Frequency translation.
iii. AM detection.
iv. FM demodulation

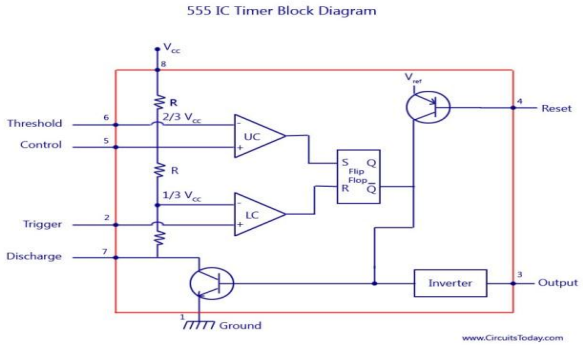
22. What are the advantages of inverted R-2R (current type) ladder D/A converter over R-2R (voltage type) D/A converter?

In R-2R ladder type DAC current flowing in the resistors changes as the input data changes. More power dissipation causes heating which in turn creates non-linearity in DAC.This problem can be avoided in inverted R-2R ladder type as the current divides equally at each node.

23. What is the need for electronic switches in D/A converter?

The Switches which connects the digital binary input to the nodes of a D/A converter is anelectronic switch

24. Draw the block schematic of IC 555 timer.




25. What is the function of a voltage regulator? Name few IC voltage regulators.

The function of voltage regulator is to provide a stable dc voltage for powering other electronic circuits. A voltage regulator should be capable of providing substantial output current.

Some IC voltage regulator is 78 XX/79 XX series and 723 general purpose regulators.

## PART B (5x16=80 marks)

26. (a) (i) Explain the significance of virtual ground in an op-amp

. [Ref .Roy Choudhry, ShailB.Jain, “Linear Integrated Circuits (Fourth Edition)”, Page 43]

(ii) With diagram explain the operation of an inverting amplifier in closed loop configuration. Obtain the expression for closed loop gain

[Ref .Roy Choudhry, ShailB.Jain, “Linear Integrated Circuits (Fourth Edition)”, Page 43]

(iii) Assuming a slew rate for 741 IC is 0.5V/μs. What is the maximum undistorted sine wave that can be obtained for 12 V peak.

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 124]

Or

(b) (i) Explain the operation of a current mirror circuit

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 65]

(ii) Compare the features of ideal and practical op-amp circuit

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 42 ]

(iii) A differential amplifier has CMRR=1000.Differential inputs $V_1$=1100μv and $V_2$=900μv.Calculate the difference in output voltage if the difference gain AD=15000

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 322]

27. (a) (i) Differentiate between low pass ,high pass ,band pass and band reject filter.

Sketch the frequency plot

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 263]

(ii) Design a second order low pass butter worth filter for a cut off frequency of 1KHz

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 269]

Or

(b) Write short notes on

(i) Clipper and clamper circuits

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 151]

(ii) Integrater

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 168]

28. (a) Explain the operation of a variable trans-conductance multiplier

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 181]

Or

(b) (i) With neat schematic explain the working principle of PLL IC NE565

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 337]

(ii) Brief the application of PLL IC for frequency multiplication

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 342]

29. (a) (i) With neat sketch explain the working principle of flash type A/D Converter

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 358]

(ii) An 8 bit A/D converter accepts an input voltage signal of range 0 to 10V

(1) What is the minimum value of the input voltage required to generate a change of 1 LSB?

(2) What input voltage will generate all 1's at A/D converter output?

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 370]

Or

(b) With functional block diagram explain A/D converter using voltage to time converter with input and output waveform

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 364]

30. (a) Write a technical note on :

(i) Isolation amplifier

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 322]

(ii) Opto- coupler

[Ref .Roy Choudhry, ShailB.Jain, “Linear Integrated Circuits (Fourth Edition)”, Page 322]

Or

(b) (i) Discuss the functionalities and working of switched mode power supply

[Ref .Roy Choudhry, ShailB.Jain, “Linear Integrated Circuits (Fourth Edition)”, Page 322]

(ii) Design a monostable multivibrator using 555 timer for a pulse period of 2ms

[Ref .Roy Choudhry, ShailB.Jain, “Linear Integrated Circuits (Fourth Edition)”, Page 322]

# B.E/B.Tech.DEGREE EXAMINATION, APRIL/MAY 2017

Fourth Semester

Electronics and Communication Engineering

EC 6404- LINEAR INTEGRATED CIRCUITS

(Regulation 2013)

Time :Three Hours Maximun:100 Marks

Answer ALL questions

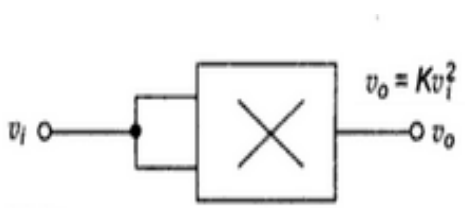
PART A(10x2=20 marks)

9. List the ideal characteristics of Op-Amp
   - Open loop voltage gain, (AOL) = ∞
   - Input impedance (Ri) = ∞
   - Output impedance (Ro) = 0
   - Bandwidth (BW) = ∞
   - Zero offset Vo = 0, when V1 = V2 = 0
10. Why is the current mirror circuit used in differential amplifier stages?

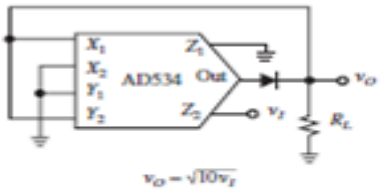
    The current mirror is a special case of constant current bias and the current mirror bias requires of constant current bias and therefore can be used to set up currents in differential amplifier stages
11. What is the need for converting a first order filter into a second order filter?

    A first order active filter has one pole which is defined by a capacitor/resistor pair. A second order filter has two capacitors and resistors. This gives the filters frequency response a steeper slope as it transitions from pass band to stop band
12. How is the current characteristic of a PN junction employed in a Log amplifier?

    The voltage across the diode will be always proportional to the log of the current through it and when a diode is placed in the feedback path of an op-amp in inverting mode, the output voltage will be proportional to the negative log of the input current. Since the input current is proportional to the input voltage, we can say that the output voltage will be proportional to the negative log of the input voltage.
13. How are square root and square of a signal obtained with multiplier



Voltage squarer using multiplier



Square root circuit using multiplier

circuit?
14. How is frequency stability obtained in a PLL by use of a VCO?

    A voltage controlled oscillator is an oscillator circuit in which the frequency of oscillation can be controlled by an externally applied voltage. It provides the linear relationship between the applied voltage and the oscillation frequency.

    VCO is a free running multivibrator and operates at a set of frequency fo called free running frequency. This frequency is determined by an external timing capacitor and an external resistor. It can also be shifted to either side by applying a dc control voltage Vc to an appropriate terminal of the IC.The frequency deviation is directly proportional to the dc control voltage and hence it is called a “Voltage Controlled Oscillator

15. An 8 bit A/D converter accepts an input voltage signal of range 0 to 12 V .What is the digital output for an input voltage of 6V?
16. Why are Scottky diodes used in sample and hold circuits?

    Schottky diodes can be used in diode-bridge based sample and hold circuits. When compared to regular p-n junction based diode bridges, Schottky diodes can offer advantages. A forward-biased Schottky diode does not have any minority carrier charge storage. This allows them to switch more quickly than regular diodes, resulting in lower transition time from the sample to the hold step. The absence of minority carrier charge storage also results in a lower hold step or sampling error, resulting in a more accurate sample at the output
17. What is the need for voltage regulator ICs?

    The function of voltage regulator is to provide a stable dc voltage for powering other electronic circuits. A voltage regulator should be capable of providing substantial output current.
18. Distinguish the principle of linear regulator and a switched mode power supply.

    As its name suggests, a linear regulator is one where a linear component (such as a resistive load) is used to regulate the output. It is also sometimes called a series regulator because the control elements are arranged in series between the input and output.

    A switching regulator is a voltage regulator that uses a switching element to transform the incoming power supply into a pulsed voltage, which is then smoothed using capacitors, inductors, and other elements.

PART-B-(5x13=65 marks)

19. (a) (i) Derive the functional parameters for an inverting mode negative feedback gain circuit with a 741 OpAmp in IC Inverting mode ,with $R_1$=1 Kohm and $R_f$ =40 Kohm and compute $A_f$,$R_{if}$,$R_{of}$,BW ,Offset voltage

    [Ref .Roy Choudhry, ShailB.Jain, “Linear Integrated Circuits (Fourth Edition)”, Page 43]

    (iii) Discuss briefly on the differential mode Instrumentation amplifier

    [Ref .Roy Choudhry, ShailB.Jain, “Linear Integrated Circuits (Fourth Edition)”, Page 141]

    Or

    (b) (i) What is the input and output voltage and current offsets? How are they compensated?

    [Ref .Roy Choudhry, ShailB.Jain, “Linear Integrated Circuits (Fourth Edition)”, Page 108]

    (ii) With neat diagram derive the AC performance close loop characteristics of Op-Amp to discuss on the circuit Bandwidth, Frequency response and slew rate

    [Ref .Roy Choudhry, ShailB.Jain, “Linear Integrated Circuits (Fourth Edition)”, Page 111]
20. (a) With near figures describe the circuit using Op-Amps on the functioning of

    i. Integrator and double integrator circuit

    [Ref .Roy Choudhry, ShailB.Jain, “Linear Integrated Circuits (Fourth Edition)”, Page 168]

    ii. First order high pass filter

    [Ref .Roy Choudhry, ShailB.Jain, “Linear Integrated Circuits (Fourth Edition)”, Page 264]

    Or

    (b) With neat figures describe the circuit using Op-Amps on the operation of

    i. Zero cross Detector, Clipper and clamper circuits

    [Ref .Roy Choudhry, ShailB.Jain, “Linear Integrated Circuits (Fourth Edition)”, Page 151]

ii. Schmitt Trigger

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 212]

21. (a) With neat diagram explain the design of (i) Frequency Synthesizer (ii) Frequency Division circuit using PLL IC 565

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 342]

Or

(b) With neat figures explain the emitter couple circuit based design of (i) Gilbert multiplier cell for four quadrant multiplication (ii) the operation of VCO

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 334]

22. (a) (i) How are A/D converters categorized?

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 357]

(ii) Discuss on the successive approximation type ADC

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 361]

Or

(b) (i) What is meant by resolution ,offset error in ADC

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 366]

(ii) Discuss on the dual slope type ADC

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 363]

23. (a) Describe the 555 timer IC.Design a astable multivibrater circuit to generate output pulses of 25%,50% duty cycle using a 555 timer IC with choice of C=0.01 µF,Frequency as 4.0KHz

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 322]

Or

(b) Answer any two of the following

i. Switched capacitor filters

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 288]

ii. Audio power amplifier

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 322]

iii. Opto coupler

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 322]

PART-B-(5x13=65 marks)

24. (a) With a neat block diagram explain the stages for developing the signal analysis circuits required for an instrumentation module of say a vibration sensor data using instrumentation amplifier, waveshaper, and comparator for ADC using OPAMP and required components

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 141]

Or

(b) With a neat figure design a PLL with free running frequency of 500kHz and the bandwidth of low pass filter is 50kHz.Will the loop acquire lock for an input signal of 600kHz.Justify your answer. Assume that phase detector needs to produce sum and difference frequency components

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 337]

# B.E/B.Tech.DEGREE EXAMINATION, APRIL/MAY 2018

Fourth Semester

Electronics and Communication Engineering

EC 6404- LINEAR INTEGRATED CIRCUITS

(Regulation 2013)

Time :Three Hours Maximun:100 Marks

Answer ALL questions

PART A(10x2=20 marks)

1. Enumerate any two blocks associated with op-amp block schematic

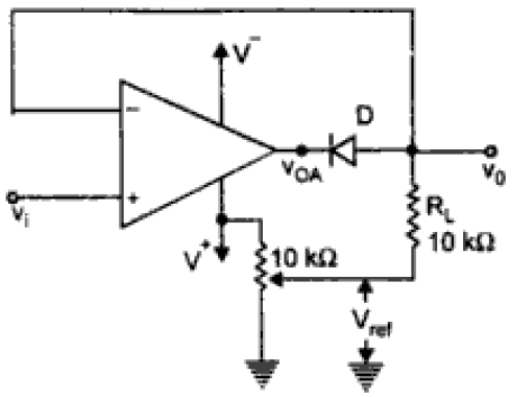
   **Differential amplifier**

   Differential amplifier is to provide high gain to difference mode signal nd cancel the common mode signal**.**

   **Level translator**

   As the op-amp is used to operate down to d.c no coupling capacitor is used. Because of direct coupling ,the d.c level rises from stage to stage. This increase in d.c level tends to shift the operating point of the next stage. This in turn limits the output swing and may distort the output signal. Therefore it becomes essential that the quiescent voltage of one stage is shifted before it is applied to the next stage.
2. What are the two methods can be used to produce voltage sources?
   - Using temperature compensation
   - Using avalanche diode.
3. What is the function of a phase shift circuit?

   A phase shifter circuit is one that shifts the relative phase of an input AC signal
4. Write the other name for clipper circuit.




5. State any two terminologies associated with multiplier characteristics,
   - Two Quadrant
   - Four Quadrant
6. What is Gilbert multiplier cell?

   A circuit which uses emitter couples pair in series with cross coupled emitter coupled pairs is called Gilbert Cell.
7. Define sampling.

   The process of converting analog signals into discrete time signals is called sampling.
8. Write the names of the switches used in MOS transistors.
   - Totem pole MOSFET switch
   - CMOS inverter switch
9. Name some LC oscillator circuits.

- Hartley Oscillator
- Colpitts oscillator

10. Define Line regulation.

The line regulation is defined as the change in the regulated output load voltage for a specified range of the line voltage .It specifies the effect of changes in the source voltage on the regulator performance.

Line regulation is also defined as the percentage change in the output voltage for a change in the input voltage. It is expressed in millivolts or as a percentage of the output voltage.

PART-B-(5x13=65 marks)

11. (a) Discuss about the principle of operation of differential amplifier using BJT.
[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 53]

Or

(b) Explain about Ideal Op-Amp in detail with suitable diagrams.
[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 41]

12. (a) i) Describe about voltage follower circuit.(7)
[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 49]

ii) Write short notes on subtractor circuit(6)
[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 137]

Or

(b) With a neat diagram Explain about V-I conveter.
[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 146]

13. (a) Discuss briefly about analog multiplier ICs
[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 159]

Or

(b) Explain the operation of the basic PLL with a block schematic.
[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 327]

14. (a) Enumerate the specifications of D/A converter.
[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 366]

Or

(b) Describe in detail about the single slope type AC with neat sketch.
[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 363]

15. (a) Explain about sawtooth wave generator with a neat sketch.
[Ref .S.Salivahanan &V S Kanchana Bhaskaram=n, "Linear Integrated Circuits (Second Edition)", Page 335]

Or

(b) Discuss briefly about opto-couplers.
[Ref .S.Salivahanan &V S Kanchana Bhaskaram=n, "Linear Integrated Circuits (Second Edition)", Page 542]

PART-C-(1x15=15 marks)

16. (a) Discuss in detail about instrumentation amplifier with suitable diagrams.
[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 141]

Or

(b) Discuss in detail about VCO using suitable diagram.
[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 334]

# B.E/B.Tech.DEGREE EXAMINATION, NOVEMBER/DECEMBER 2018

Fourth Semester

Electronics and Communication Engineering

EC 6404- LINEAR INTEGRATED CIRCUITS

(Regulation 2013)

Time :Three Hours Maximun:100 Marks

Answer ALL questions

PART A (10x2=20 marks)

**1.** Define differential mode gain.

It is the change in the difference between the two outputs divided by the change in the difference between the two inputs.

2. State the ideal characteristics of an operational amplifier.

Open loop voltage gain, (AOL) = ∞

Input impedance (Ri) = ∞

Output impedance (Ro) = 0

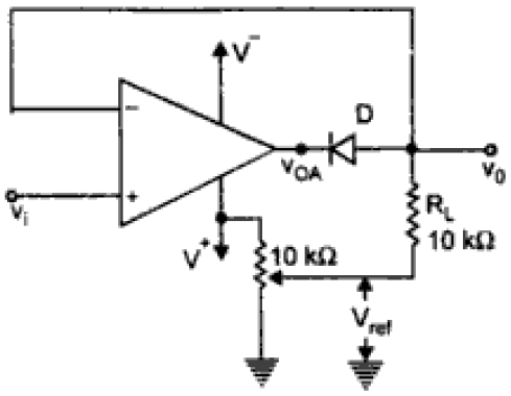
Bandwidth (BW) = ∞

Zero offset Vo = 0, when V1 = V2 = 0

3. How does operational amplifier work as an integrator.

By replacing this feedback resistance with a capacitor we now have an RC Network connected across the operational amplifiers feedback path producing another type of operational amplifier circuit called an Op-amp Integrator

4. Draw the circuit of clipper using op-amp.




5. Mention the significances of Gilbert Multiplier cell

The Gilbert cell mixer or Gilbert cell multiplier is a form of RF mixer circuit that is widely used in integrated circuits. Not only does the Gilbert cell mixer lend itself to integrated circuit technology, but it is able to provide a high level of performance. Gilbert cells are often referred to as four-quadrant multipliers

6. State the various applications of phase locked loop.

1. Frequency multiplication and division
2. Frequency translation.
3. AM detection.
4. FM demodulation

7. Differentiate between direct type and integrating type ADC converters.

Direct type ADCs compare a given analog signal with the internally generated equivalent signal.

Integrating type ADCs perform conversion in an indirect manner by first changing the analog input signal to linear function of time or frequency and then to a digital code.

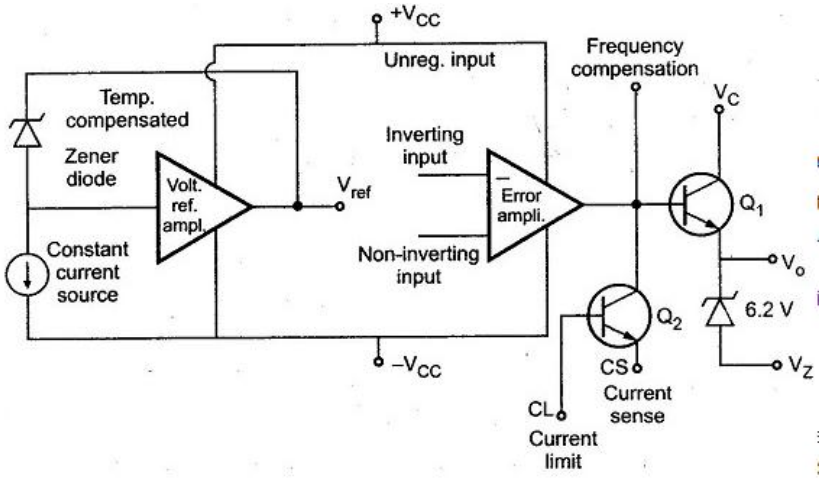
8. What is the need for sample and hold circuit?

For accurate analog and digital conversion the analog input voltage should be held constant during the conversion cycle. The input voltage is kept constant during conversion time using sample and hold circuit.

9. List the various applications of multivibrators,

- Pulse width modulation
- Frequency doublers
- Linear Ramp generator
- Missing pulse detector
- Square wave generator
- Voltage controlled oscillator
- FSK generator

10. Draw the circuit diagram of a general purpose voltage regulator.




**PART B (5x13=65 marks)**

11. (a) (i) Draw the transfer characteristics of an operational amplifier and explain its linear and non linear operations. (8)

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 55]

(ii) Discuss the operation of BJT differential amplifier with active loads.(5)

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 77]

Or

(b) (i) Present the inverting and non inverting amplifier circuits of an op-amp in closed loop configuration. Derive the expressions for the closed loop gain in these circuits. (9)

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 43]

(ii) Define slew rate. In what way does it possess impact on the performance of an op-amp circuit? (4)

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 123]

12. (a) (i) With suitable circuit diagram ,explain the operating principle of an instrumentation amplifier and derive its gain. (7)

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 141]

(ii) Design a second order butterworth low-pass filter having upper cut-off frequency of 2.1961 kHz (6)

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 269]

Or

(b) (i) Design a clipper circuit for a clipping level of +0.83V,given an input sine wave signal of 0.3V peak. Assume the gain of the amplifier is 9 and it has an input resistance of 2.2k-ohm connected. (5)

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 151]

(ii) Draw the operational diagram and explain the working principle of antilogarithmic amplifier and Schmitt trigger. (8)

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 157]

13. (a) (i) Explain in detail the operation of a basic phase locked loop. (5)

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 327]

(ii) How are PLLs applied for frequency synthesizing and FM detection. (8)

Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 343]

Or

(b)(i) Obtain the expression for free running frequency of voltage controlled oscillator. (6)

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 334]

(ii) Design an analog multiplier employing an emitter coupled transistor pair. (7)

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 342]

14. (a) (i) Describe the operational feature of R-2R ladder type D/A converter.(7)

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 352]

(ii) Discuss various switches employed for D/A converters. (6)

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 351]

Or

(b) (i) With a neat block diagram, explain the operation of flash and successive approximation type A/D converter. (10)

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 358]

(ii) What is oversampling? Give examples of oversampling converter. (3)

15. (a) (i) Explain the operation of an astable and monostable multivibrators with necessary diagrams. (10

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 312]

(iv) State the significant difference between fixed and adjustable voltage regulators. (3)

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 241]

Or

(b) Explain the working principle and salient features of triangular wave generator and saw tooth wave generator.

[ Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 220]

**PART-C-(1x15=15 marks)**

16. (a) (i) Design a differentiator to produce an output of 6 V when the input changes by 2V in 40 micro seconds. (5)

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 167]

(ii) A PLL has a free running frequency of 600 kHz and the band width of the low pass filter is 4kHz.Will the loop tend to acquire lock for an input signal of 520 kHz? Explain in this case ,assume that the phase

detector produces sum and difference frequency components.(10)

Or

(b) (i) Design a wave generator using 555 timer for a frequency of 110Hz and 80% duty cycle.Assume C=0.16μF. (7)

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 322]

(ii) For a 4 bit R-2R ladder D/A converter assume that the full scale voltage is 16V.Calculate the step change in output voltage on input varying from 0111 to 1111 (8)

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 357]

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# B.E/B.Tech.DEGREE EXAMINATION, APRIL/MAY 2019

Fourth Semester

Electronics and Communication Engineering

EC 8453- LINEAR INTEGRATED CIRCUITS

(Regulation 2017)

Time :Three Hours Maximun:100 Marks

Answer ALL questions

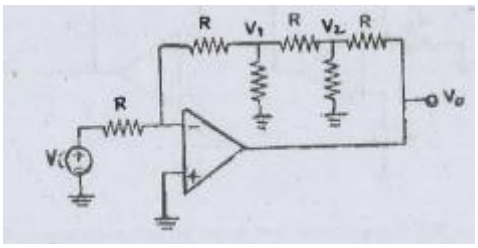
PART A (10x2=20 marks)

1. State the significance of current mirror circuit

   A current mirror circuit is designed to copy a current through one active device by controlling the current in another active device of a circuit keeping the output current constant regardless of loading. The current mirrors are used to provide bias currents and active loads to circuits

2. Mention the application of LF155
   - Precision high speed integrators
   - Fast D/A and A/D converters
   - High impedance buffers
   - Wideband low noise low drift amplifiers

3. Find the gain $V_o/V_i$ of the circuit




Applying KCL at inverting terminal

$$\frac{0-V_1}{R}=\frac{V_i-0}{R}$$

$V_1$=-$V_i$

Applying KCL at node 1

$$\frac{0-V_1}{R}=\frac{V_1}{R}+\frac{V_1-V_2}{R}$$

$$V_2 = -3v$$

Applying KCL at node 2

$$\frac{V_1-V_2}{R}=\frac{V_2}{R}+\frac{V_2-V_0}{R}$$

$$8V_i = -V_0$$

$$\frac{V_0}{V_i}=-8$$

4. How does a zero crossing detector work

   Zero crossing detector is one type of voltage comparator used to detect a sine waveform transition from positive and negative that coincides when the input crosses the zero voltage condition

5. What is Gilbert multiplier cell?

   A circuit which uses emitter couples pair in series with cross coupled emitter coupled pairs is called Gilbert Cell.

6. List the basic building blocks of PLL.
   - Phase detector

- Low pass filter
- Error amplifier
- Voltage controlled Oscillator

7. Define settling time

   It is the time the converter takes for the output to settle within a specified band +/-(1/2)LSB

8. What is the largest value of output voltage from an 8 bit DAC that produces 1.0V for a digital input of 00110010

   5.10V

9. What are the types of multivibrators
   - Monostable multivibrator
   - Astable multivibrator
   - Bistable multivibrator

10. State the function of Opto coupler

    An opto-isolator (also called an optocoupler, photocoupler, or optical isolator) is an electronic component that transfers electrical signals between two isolated circuits by using light.Opto-isolators prevent high voltages from affecting the system receiving the signal.

**PART B (5x13=65 marks)**

11. (a) List and explain the function of all the basic building blocks of an op-amp

    [Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 55]

    Or

    (b) Explain the DC and AC performance characteristics of Op-amp

    [Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 123]

12. (a) Explain the operation of

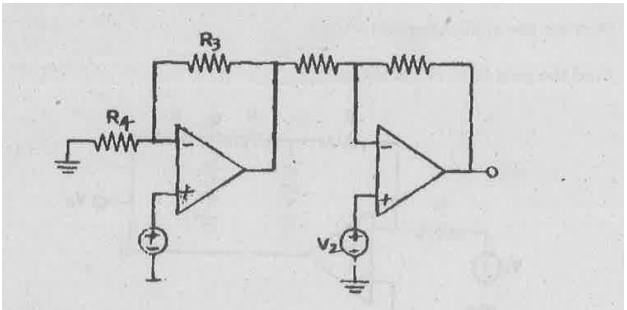
    (i) Schmitt trigger (7)

    (ii) Precision rectifier (6)

    [Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 269]

    Or

    (b) Find Vo,Verify that if R3/R4=R1/R2 the circuit is an instrumentation amplifier with gain A=1+R2/R1




    [Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 157]

13. (a) Explain PLL characteristics and derive the lock range and capture range equations

    Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 343]

    Or

    (b) Explain any two applications of PLL

    [Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 342]

14. (a) (i) Assume the following values for the ADC clock frequency = 1MHz.DAC has F.S output = 10.23V and 10bit input.Determine the following values

    (1) The digital equalent obtained for the input voltage VA=3.728 V

(2) The conversion time

(3) The resolution of this converter in percentage (9)

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 352]

(ii) A 10bit DAC has a step size of 10 mV.Determine the full scale output voltage and the percentage resolution. (4)

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 351]

Or

(b) Explain the working of R-2R ladder type DAC with a circuit schematic.List converter characteristics.

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 351]

15. (a) Explain the working principle of Triangular wave generator circuit using op-amp and mention its applications

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 241]

Or

(b) Explain the following ICs functions and applications:(i)Audio power amplifier (ii) Video amplifier

[Ref .Roy Choudhry, ShailB.Jain, "Linear Integrated Circuits (Fourth Edition)", Page 220]

**PART-C-(1x15=15 marks)**

16. (a) (i) Suppose that an amplifier with input resistance of 500 kΩ or greater is needed and a voltage gain of -10.The feedback resistors are to be implemented in integrated form and have values of 10kΩ or less to conserve chip area. Choose a suitable circuit configuration and specify the resistance value. Finally estimate the resistor tolerance needed so that the gain magnitude maintained within 5% of its nominal value (7)

To attain desired input resistance

$R_1 = 500\ k\Omega$

The formula for the gain is

$$A_v = -\frac{R_2}{R_1}$$

To achieve the desired gain

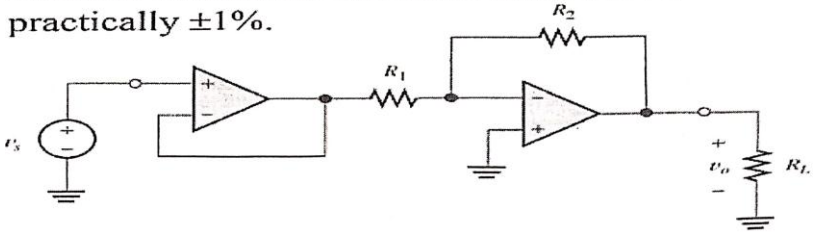
$R_2 = 10R_1 = 10 \times 500 \times 10^3 = 5M\Omega$

These values exceed the maximum values allowed.

A voltage follower at the input must be added as a **buffer amplifier**.

Values for $R_1$ and $R_2$: $R_1 = 1k\Omega$; $R_2 = 10k\Omega$.

Resistor tolerances: not more than ±2.5%; practically ±1%.




∴ To attain large input resistance with moderate resistances for an inverting amplifier, we cascade a voltage follower with an inverter.

(ii) Find the output expression for the figure shown (8)

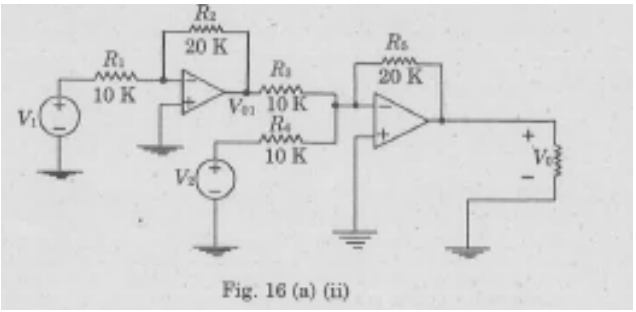



Fig. 16 (a) (ii)

**Solution:**

The first Op Amp is connected as an inverting amplifier. Thus

$$v_{o1} = -\frac{R_2}{R_1} v_1 = -\frac{20000}{10000} v_1 = -2v_1$$

The second Op Amp is connected as summing amplifier

$$v_o = -\left(\frac{R_5}{R_3} v_{o1} + \frac{R_5}{R_4} v_2\right)$$

$$= -\frac{20000}{10000} v_{o1} - \frac{20000}{10000} v_2 = -2v_{o1} - 2v_2$$

$$v_o = 4v_1 - 2v_2$$

Or

(b) (i) Find the issues and challenges in active filter design with example (5)

- **The range of desired frequencies (the passband) together with the shape of the frequency response. This indicates the variety of filter (see above) and the center or corner frequencies.**
- **Input and output impedance requirements. These limit the circuit topologies available; for example, most, but not all active filter topologies provide a buffered (low impedance) output. However, remember that the internal output impedance of operational amplifiers, if used, may rise markedly at high frequencies and reduce the attenuation from that expected. Be aware that some high-pass filter topologies present the input with almost a short circuit to high frequencies.**
- **Dynamic range of the active elements. The amplifier should not saturate (run into the power supply rails) at expected input signals, nor should it be operated at such low amplitudes that noise dominates.**
- **The degree to which unwanted signals should be rejected.**
  - **In the case of narrow-band bandpass filters, the Q determines the -3 dB bandwidth but also the degree of rejection of frequencies far removed from the center frequency; if these two requirements are in conflict then a staggered-tuning bandpass filter may be needed.**
  - **For notch filters, the degree to which unwanted signals at the notch frequency must be rejected determines the accuracy of the components, but not the Q, which is governed by desired steepness of the notch, i.e. the bandwidth around the notch before attenuation becomes small.**
  - **For high-pass and low-pass (as well as band-pass filters far from the center frequency), the required rejection may determine the slope of attenuation needed, and thus the "order" of the filter. A second-order all-pole filter gives an ultimate slope of about 12 dB per octave (40 dB/decade), but the slope close to the corner frequency is much less, sometimes necessitating a notch be added to the filter.**

(ii) the circuit given is inverting amplifier withresistor R3 is addad.The Circuit parameters are R1=5kΩ ,R2=25kΩ , R3=12.5kΩ ,RL=5kΩ

(1) Derive Vout expression

(2) Derive Expression for I3

(3) What happens to I3 is R3 is doubled?(R3=25kΩ) (10)