Subject Name: LINEAR AND DIGITAL IC APPLICATIONS

Prepared by (Faculty (s) Name): Mr. M. SREENIVASULU

Year and Sem, Department: III/I ECE

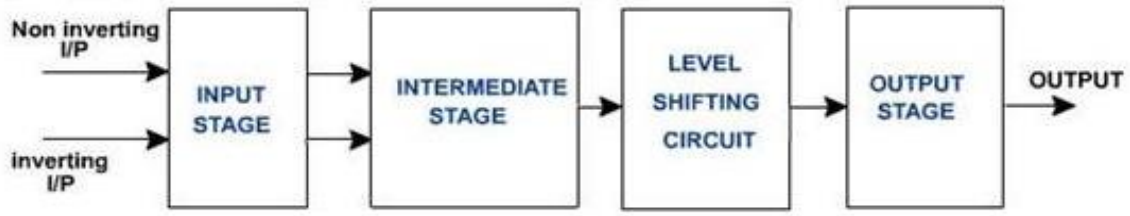
Unit-I: OPERATIONAL AMPLIFIER

IMPORTANT POINTS:

1. An operational amplifier is a direct coupled high gain amplifier usually consisting of one or more differential amplifier and usually followed by a level translator and an output stage.

2. The operational amplifier is versatile device that can be used to amplify DC as well as AC input signals and was originally designed for computing such mathematical functions as addition, subtraction, multiplication and integration. With the addition of suitable external feedback components, the modern day op-amp can be used for a variety of applications such as AC and DC signal amplification, active filters, oscillator, comparators and regulators, and others

3.Block Diafram of an Opamp:



4. An IDEAL op-amp would exhibit the following electrical characteristics.

- Infinite voltage gain, A
- Infinite input resistance R_i
- Zero output resistance R_o
- Zero output voltage when input voltage is zero.
- Infinite bandwidth – any signal can be amplified without attenuation
- Infinite common mode rejection ratio
- Infinite slew rate so that output voltage changes occur simultaneously with input voltage changes.

5. **Input offset voltage (Vio)** is the differential input voltage that exists between two input terminals of an op-amp without any external inputs applied.

6. The output voltage caused by mismatching between two input terminals is called the **output**
offset voltage (Voo).

7.The input offset current Iio is defined as the algebraic difference between two input bias

currents Ib1 and Ib2. In equation form it is Iio = |Ib1 – Ib2|.

8. An input bias current Ib is defined as the average of the two input bias currents, Ib1 and Ib2 as shown.

$$Ib = (Ib1 + Ib2)/2$$

Where, Ib – DC current
Ib1= DC bias current flowing into the noninverting input.
Ib2 = DC bias current flowing into the inverting input.

9.DC Characteristics include

- input bias current,
- input offset current,
- Input offset voltage,
- Output offset voltage and
- Thermal drift.

10.AC characteristics include

- Frequency Response
- Slew Rate

11. The 741 opamp is a high performance monolithic operation amplifier constructed using the planar epitaxial process. The op-amp features are given below:

- High common mode voltage range make the μA741 ideal for use as voltage follower.
- The high gain and wide range of operating voltage provides superior performance in integrator, summing amplifier, and general feedback applications.
- 741 opamp is internally frequency compensated op-amp
- 741 opamp is available in all 3 packages viz 8-pin metal can, 10-pin flat pack, and 8 or 14 pin DIP.
- Offset voltage null capability is available.
- It consumes low power

12. Basically there are 2 modes of op-amp. They are

- Inverting Amplifier
- Non-Inverting Amplifier

13.For Inverting Amplifier the equation for the output voltage is given by

$$V_o = A(V_1 – V_2)$$

where A – large signal voltage gain
V_1 – voltage at non-inverting input terminal
V_2 – voltage at inverting input terminal
here $V_1 = 0$ and $V_2 = V_i$ therefore
$V_o = A (-V_i) = - A V_i$
The negative sign indicates that the output voltage is out of phase with respect to the input by 180° or is of opposite polarity.

14.For non-Inverting Amplifier the equation for the Output voltage is given by

$$Vo = A (V_1 – V_2)$$

here $V_1 = V_i$ and $V_2 = 0$ v

therefore $Vo = A V_i$
This means that the output voltage is larger than the input voltage by gain A and is in phase with the input signal.

15.A differentiator is a circuit in which the output waveform is the derivative of input waveform. By interchanging the resistor and capacitor of the Differentiator, we get the circuit of an
integrator.

16. A comparator is a circuit which compares a signal voltage applied at one input of an op-amp with a known reference voltage at the other input. There are basically two types of comparators.

- Non-inverting comparator
- Inverting comparator

17. Some important applications of comparator are
    - Zero crossing detector
    - Window detector
    - Time marker generator
    - Phase meter.

18 If positive feedback is added to the comparator circuit, gain can be increased greatly. The circuit is also known as Schmitt trigger. The input voltage V_i triggers the output voltage V_o every time it crosses certain voltage levels. These voltage levels are called Upper threshold voltage (V_{UT}) and Lower threshold voltage (V_{LT}).

19. A voltage regulator is a circuit that supplies constant voltage regardless of changes in load currents. Although voltage regulators can be designed using opamps, it is quicker and easier to use IC voltage regulators. Furthermore, IC voltage regulators are versatile and relatively inexpensive and are available with features such as programmable output, current/voltage boosting, internal short-circuit current limiting, thermal shutdown and floating operation for high
voltage applications.

20. **LINE or INPUT regulation:** it is defined as the change in output voltage for a change in the Input voltage and is usually Expressed in milli volts or as a percentage of output voltage Vo.

21.**LOAD Regulation:** It is the change in output voltage for a change in load current and is also expressed in milli volts or as a percentage of Vo.

2-Marks Questions:

1. Significance and definition of upper and lower threshold points of a Schmitt trigger.
2. Mention the reason why open loop is not preferred for linear application.
3. Define unity gain bandwidth of an op-amp.
4. Define slew rate. What causes it?
5. Show the standard representation of IC voltage regulator.
6. Explain the precaution that can be taken to minimize the effect of noise in OPAMP circuit.

7. List AC characteristics of op-amp.
8. What are the different features of IC723.
9. Define input offset voltage.
10. List the features of 741op-amp

5-Marks Questions:

1.a) Explain why emitterfollower circuit is used as level shifter.
b)Design an op-amp differentiator to differentiate an input signal that varies in frequency from 10Hz to about 1KHz.
2.a) What are the disadvantages of using zero crossing detector ? How it can be overcome Schmitt Trigger?
b)Draw the internal architecture of IC723 voltage regulator and explain.
3.a) With neat circuit diagram explain the operation of Schmitt Trigger.
4.a) An IC op-amp 741 used as an inverting amplifier with again of 100.The voltage gain vs frequencycharacteristicsisflatupto12kHz.Findthemaximumpeaktopeakinput signal that can be feed without causing any distortion to the output.
b)Draw and explain the output waveform of ideal inverter circuit when the input is square wave.
5.Design a differentiator circuit that will differentiate input signal with fmax=100Hz.
6.a) What are the differences between the inverting and noninverting terminals? What do you Mean by the term "virtual ground"?
b) Explain the method of boosting the current of a three terminal voltage regulator.
7.a) Explain the working of Non inverting amplifier and derive the equation of its gain.
b)How op-amp is used as differentiator? Explain.
8.How op-amp is used for comparator? Explain its working.
9.Draw the circuit diagram of a two input non inverting type summing amplifier and derive the expression for the output voltage.
10.Explain the working of instrumentation amplifier with suitable diagram.

CHOOSE THE CORRECT ANSWER

1. Which pin is used for the output of the OPAMP in µA 741 IC (B)

   A) 5 B) 6 C) 2 D) 8

2. The gain of the inverting amplifier is--- (A)

   A) R_f/R_1 B) $1+ {}_f/R_1$ C) $- {}_1/R_f$ D) $- {}_f/R_1$

3. Open loop gain of an ideal Op – amp (D)

   A) 0 B) 1 C) -1 D) ∞

4. Inverting amplifier is also known as (A)

(A) Voltage Shunt Feed Back Amplifier (B) Voltage Series Feed Back Amplifier
(C) Current Shunt Feed Back Amplifier (D) Current Series Feed Back Amplifier

5. Operational amplifiers use …….. (B)

(A) Linear ICs (B) Digital ICs (C)Both linear and digital ICs (D) None of the above

6. Which of the following is are instrumentation amplifier (A)
   A) AD620 B) LM337 C) µA741 D) µA723
7. Ideal op-amp has infinite voltage gain because(B)
   a) To control the output voltage
   b) To obtain finite output voltage
   c) To receive zero noise output voltage
   d) None of the mentioned
8. Which factor determine the output voltage of an op-amp? (C)
   a) Positive saturation
   b) Negative saturation
   c) Both positive and negative saturation voltage
   d) Supply voltage
9. The other name for Gain is _____(A)
   a) Scaling factorb) Outputc) Amplifying factord) Scaling level
10. Which circuit converts irregularly shaped waveform to regular shaped waveforms? (A)
a) Schmitt trigger
b) Voltage limiter
c) Comparator
d) None of the mentioned

UNIT-II

OP-AMP, IC-555 & IC-565 APPLICATIONS

1.Based on the components used in the circuit the filters are divided into following categories.

- Active filters
- Passive filters

Active Filters: Active filters employ transistors or op-amps in addition to resistors and capacitors.

Passive Filters: Here the type of element used dictates the operating frequency range of the filter.

Eg:

• RC filters are used for audio or low frequency operation.

• LC or Crystal filters are used at RF or High frequencies.

2. Based on the operating frequency the filters are classified as follows.

- Low pass filter
- High pass filter
- Band pass filter
- Band stop filter
- All pass filter

3. A **band pass filter** has a pass band between two cut-off frequencies f_H and f_L, where $f_H > f_L$
and two stop bands $0 < f < f_L$ and $f > f_H$.
Band width of the band pass filter – f_H-f_L.

4. **The band reject filter** performs exactly opposite to the band pass, i.e it has a band stop between two cut off frequencies f_H and f_L and two pass bands $0 < f < f_L$ and $f > f_H$.
The band reject filter is also called as band stop or band elimination filter.

5. **All pass filter** passes all frequencies equally well i.e input and output voltages are equal in amplitude for all frequencies, with the phase shift between the two a function of frequency.

6. The rate at which the gain of the filter changes in the stop band is determined by the order of the filter.

- For first order low pass filter, gain decreases by 20 dB/decade in the stop band.
- For second order low pass filter, gain decreases by 40 dB/decade in the stop band.

7.**Low pass Filter** allows only low frequency values to pass through the circuit by attenuating the high frequency values.

8. **High pass Filter** allows only high frequency values to pass through the circuit by attenuating the low frequency values.

9.**First Order Low pass Butterworth filter:** A first order low pass Butter worth filter uses an RC network for filtering. Note that the op-amp is used in the non-inverting configuration, hence it does not load down the RC network.

10.There are different types of wave form generators which are given below.

- Square wave generator
- Triangular wave generator
- Saw tooth wave generator

11.Square wave generator is also called a **Free running oscillator**. The principle of generation of square wave output is to force an op-amp to operate in saturation region.

12.Triangular wave generator basically consists of a two level comparator followed by an integrator. The output of the comparator A1 is a square wave of amplitude + or – Vsat and is applied to the –ve input terminal of the integrator A2 producing a triangular wave.

13. The difference between the triangular and sawtooth waveforms is that
rise time and fall time are equal – Triangular
rise time and fall time are unequal – Sawtooth
The triangular wave generator can be converted into a sawtooth wave generator by injecting a
variable DC voltage into the non-inverting terminal of the integrator A2.

14. The 555 timer is a highly stable device for generating accurate time delay or oscillation. A single 555 timer can provide time delay ranging from μ-sec to hours. It is compatible with both TTL and CMOS logics.

15. A **monostable multivibrator** (MMV) often called a one-shot **multivibrator**, is a pulse generator **circuit** in which the duration of the pulse is determined by the R-C network, connected externally to the **555 timer**. In such a vibrator, one state of output is stable while the other is quasi-stable (unstable)

16. **Astable multivibrator** works as a oscillator **circuit**, in which output oscillate at a particular frequency and generate pulses in rectangular wave form.

17.**Using 555 timer IC**, we can generate precise time duration of HIGH and LOW output, from micro seconds to hours, that's why **555** is very popular and versatile **IC.**

18 A PLL is a circuit which is used to lock the frequency value when the output frequency f_o of VCO is identical to Input frequency f_s when compared.

2-Marks Questions:

1. List various applications of IC555 Timer.
2. Differentiate Bessel, Butterworth and Chebyshev filters.
3. What is switched capacitor filter?
4. Draw the circuit diagram of AM detector using PLL.
5. Define stable and quasi stable state.

6. Draw the circuit diagram of Second order high pass filter and give its transfer function.
7. What is the significance of VCO in PLL.
8. Compare active and passive filters.
9. Discuss about all pass filters.
10. List the applications of 565PLL.

5-Marks Questions:

1.a)Draw the block diagram for PLL and explain in detail.
b)Explain two of the following applications for which PLL is used:
i)AM detector ii)FM demodulator
2.a) An local lowpass filter having fh=5kHz is cascaded with highpass filter having fL=4.8 kHz. Sketch the frequency response of the cascaded filter.
b)Explainthemonostableoperationofthe555timerandderivetheexpressionforthe period of a pulse generated by the timer.
3.Explain the operation of monostable multivibrator using 555timers.Derivethe Expression of time delay of monostable multivibrator with 555timers.
4.a)From the given component values find the free running frequency. Control voltage Vc=10.9v, Vcc=12v,R1=4.7k,C1=1.1Nf.
b)Design a narrow bandpass filter using op-amp.Theresonantfrequencyis100HZandQ=2. Assume c=0.1Uf.
5.Design and explain the operation of All pass filter with its characteristics.
6.a)Draw the circuit of Schmitt Trigger using555 timer and explain all the operations.
b)Draw the circuit of a PLL AM detector and explain its operation
7.a)Designanactivehighpassfilterwithcutofffrequencyof4KHz.
b)Howto generate a saw tooth waveform? Explain the working of such a circuit with neat circuit diagram.
8.a)Drawthefunctionalblockdiagramof565ICandexplainitsworking.
b)Explain the working of an Astable multivibrator using IC555 with circuit diagram.
9.Draw the block diagram of 565 PLL and explain abouteach block.Make circuit connections To track the input signal and explain its operation.
10.Design a wideband passfilterwithfL=500HzandfH=2KHzandapassbandagain=5for Both sections of filter.Also determine the value of Q for the filter.

CHOOSE THE CORRECT ANSWER

1. A multivibrator is an electronic circuit used to implement _____(D)
   a) Oscillator
   b) Timer
   c) Flip-flop
   d) All of the Mentioned

2. Astable multivibrator is _____ in any state. (B)
   a) Stable
   b) Unstable

c) Saturated
d) Both Stable & Saturated

3. The second pin in 555 timer (C)

A) Discharge B) Threshold C) Trigger D) output

4. How does a monostable multivibrator used as frequency divider? (A)
   a) Using square wave generator
   b) Using triangular wave generator
   c) Using sawtooth wave generator
   d) Using sine wave generator
5. Monostable multivibrator can also be termed as _____(B)
   a) Full astable multivibrator
   b) Half astable multivibrator
   c) Half bistable multivibrator
   d) Full bistable multivibrator
6. Free running multivibrator is also called as (B)
   a) Stable multivibrator
   b) Voltage control oscillator
   c) Square wave oscillator
   d) Pulse stretcher

7. The VCO is used in---- (A)

A) PLL B) Instrumentation Amplifier C) Multiplier D) Memory

8. How much of Power Supply is used for 555 timer IC practically (C)

A) 15V B) 6V C) 5V D) 12V

9. The pulse width of the OPAMP mono stable multi-vibrator is (C)

A) 0.75 RC B) 0.69 RC C) 1.1 RC D) 0.89 RC

10. How many Pass bands are there in Band pass filter(B)

A) 1 B) 2 C) 3 D) 0

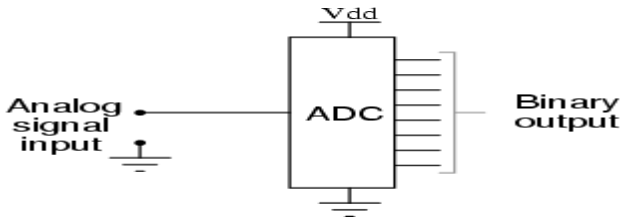
UNIT-III
DATA CONVERTERS

1. Most of the real world physical quantities such as voltage, current, temperature, pressure and time etc are available in analog form. Even though an analog signal represents a real physical
parameter with accuracy, it is difficult to process, store, or transmit the analog signal with out introducing considerable error because of superimposition of noise as in the case of amplitude modulation. Therefore, for processing, transmission and storage purposes, it is often convenient to express these variables in digital form. It gives better accuracy and reduces noise.

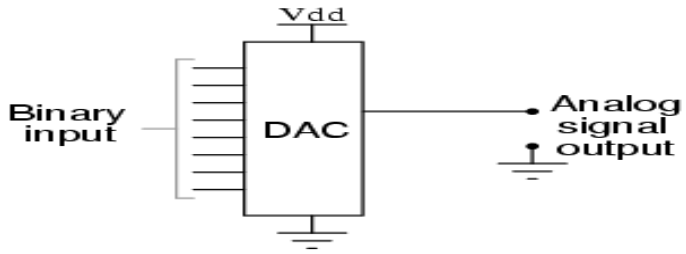
2.A device which converts analog data in to digital data is called an analog to digital converter (ADC) and A device which converts digital data in to analog data is called a digital to analog converter (DAC).

3. The ADC and DAC is used either in full or in part in applications such as digital audio recording and playback, computer, music and video synthesis, pulse code modulation transmission, data acquisition, digital multi meter, direct digital control, digital signal processing, microprocessor based instrumentation.

ADC:



DAC:



4.There are various types of Digital to Analog Converters (DAC's)

- Weighted resistor DAC
- R-2R Ladder DAC
- Inverted R-2R Ladder DAC.

5 There are various types of Digital to Analog Converters (ADC's)

- Flash (comparator) type converter
- Counter type converter
- Tracking or servo conveter

- Successive approximation type converter

6. **Accuracy:**
Absolute accuracy is the maximum deviation between the actual converter output and the ideal converter output. Relative accuracy is the maximum deviation after gain and offset errors have been removed.

7. **Monotonicity:**
A monotonic DAC is the one whose analog output increases for an increase in digital input.
A monotonic characteristic is essential in control applications, otherwise oscillations can result.

8. **Settling time:**
The most important dynamic parameter is the settling time. It represents the time it takes for the output to settle within a specified band + or – ½ LSB of its final value following a code change at the input (usually a full scale change).

9. The performance of converter changes with temperature, age and power supply variations.

2-Marks Questions:

1. Define the following terms as related to DAC; i)Linearity ii)Resolution.
2. Compare R-2R and weight resistor types of ADC.
3. Which type of ADC is the fastest ? Why?
4. An 8bitDAChasaresolutionof20mv/bit. What is an a log output voltage?
5. List out different types of A/D converters.
6. What do you mean by quantization error in an A/D converter.
7. What are the applications of ADC.
8. An8bitD/A converter as a resolution of 8mV/bit. Find the analog output voltage for the input 10111010.
9. List different ADC and DACs.
10. List specifications of DAC.

5-Marks Questions:

1. a) Explain the operation of the fastest analog to digital converter.What is the main draw back of this converter ?Compare this converter with other types.

b) Drawthecircuitofa/laddertypeDACfor4bitsandderiveexpressionforoutput voltage.

2 .a) Draw a schematic diagram of D/A converter. Use resistance values whose ratios are multiples of 2.Explain the operation of the converter.

b) Give the schematic circuit of integrating type A/D converter and explain the operation of this system and derive expression for output voltage Vo.

3. Draw the schematic block diagram of dual slope A/D converter and explain its operation. Derive expression for its output voltage.

4.a) What are the limitations of weighted resistors type D/A converter?
b) What do you mean by quantization error in an A/D converter?

5. Draw the schematic block diagram of Dual-slope A/D converter and explain its operation. Derive expression for its output voltage Vo.

6. a) Whatistheconversiontimeofa10bitsuccessiveapproximationADCifitsinput clock is 5MHz?
b)List the specification of DAC.

7. Explain the working R-2R ladder DAC with neat circuit diagram and write its limitations.

8. Explain the working of dual slope ADC with neat circuit diagram and compare its Performance with other ADC's ?

9. Which is fastest ADC? Explain the operation and discuss its merits and de-merits
.

10. With a neat diagram explain the working principle of R-2R ladder type DAC ?

CHOOSE THE CORRECT ANSWER

1. Which of the following type output is provided by ADC? (C)
(A) Serial type
(B) Parallel type
(C) Both serial and parallel type
(D) None of the mentioned

2. Dynamic range of ADC is depended on _____(D)
(A) Resolution
(B) Linearity
(C) Accuracy
(D) All of the mentioned

3. Pulse width modulator is a type of (B)

(A) ADC
(B) DAC
(C) AAC
(D) DDC

4. A measurement of maximum speed at which DACs circuitry can operate and still produce correct output is called (A)

   (A) maximum sampling rate
   (B) minimum sampling rate
   (C) maximum summation rate
   (D) minimum summation rate

5. The resolution of 0- 5V, 6 bit Digital to Analog converter(DAC) is (A)
   A) 63% B) 64% C) 1.56% D) 15.

6. All the commercially available DAC are (A)
   (A) Monotonic
   (B) Non-monotonic
   (C) Either monotonic or non-monotonic
   (D) None of the mentioned

7. Narrow band pass filterconsistsof no. of feedback paths. (C)
   (A) 0 (B) 1 (C) 2 (D) 3
8. The inverted R-2R ladder can also be operated in (B)
   (A) Inverted mode (B) Current Mode (C) Voltage mode (D) Non inverted mode

9. The practical use of binary-weighted digital-to-analog converters is limited to: (B)

   (A) R/2R ladder D/A converters

   (B) 4-bit D/A converters

   (C) 8-bit D/A converters

   (D) op-amp comparators

10. In DAC, resolution increases with the _____ in number of bits. (A)
(A) Increase (B) Decrease (C) Constant (D) None of the above