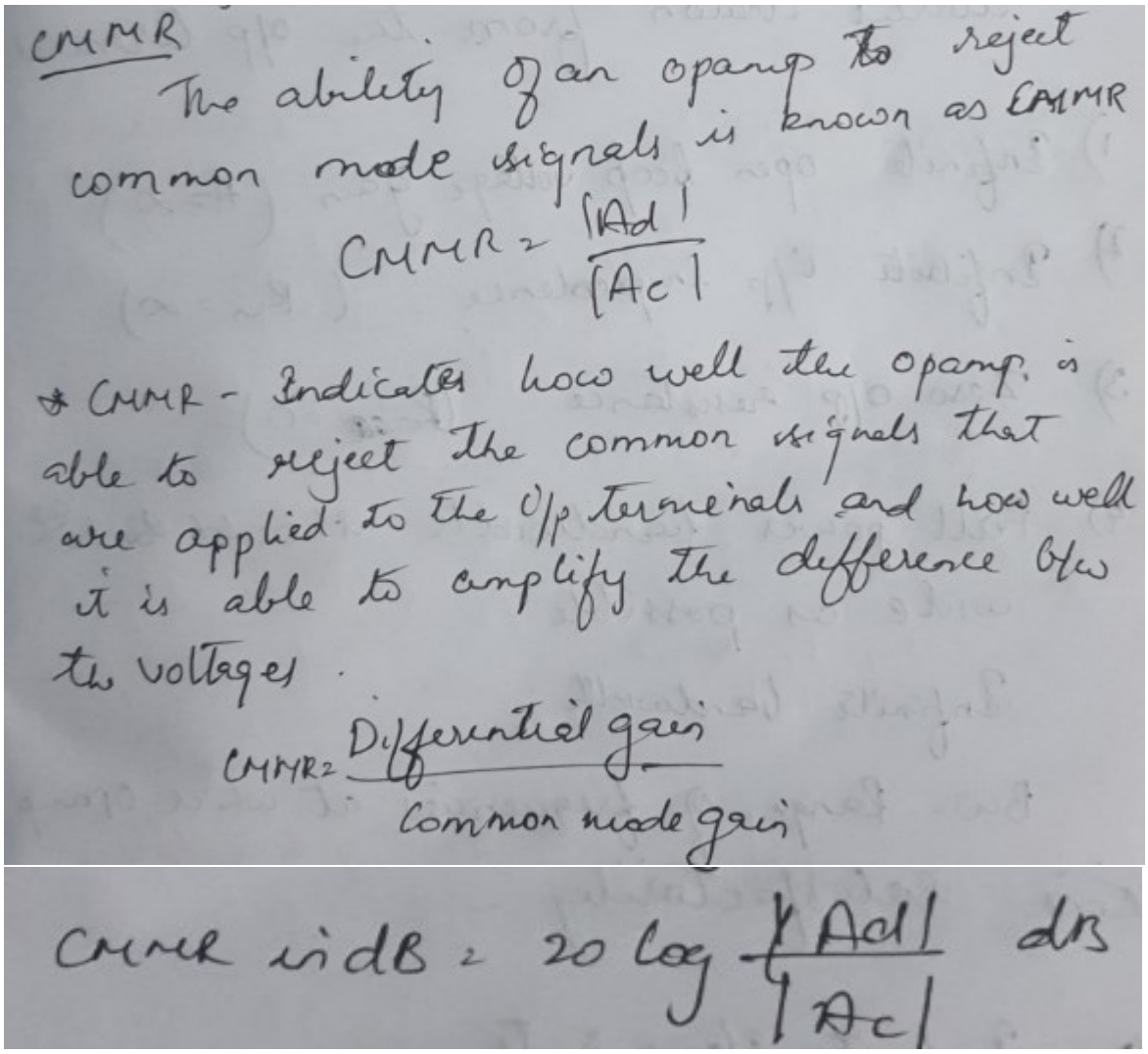
IAT2 Question paper

1a) What is opamp? Define the following opamp parameters: (i)CMRR (ii) Slew Rate (iii) Closed loop Voltage gain b) Explain the Barkhausen criteria for oscillations	[6] [4]	CO1 CO1	L2 L2
2)a) Explain the working of a single stage astable multivibrator with a new circuit diagram. b) Explain the different types of multiple access techniques.	[5] [5]	CO1 CO5	L2 L2
3)Explain the following opamp circuits (i) Non Inverting Amplifier (ii) Integrator	[10]	CO1	L3
4) a) Explain communication channel and its types. b) Write short notes on (i) 7 segment display (ii) Transducer	[5] [5]	CO5 CO2	L2 L2
5) Explain modern communication system with a neat block diagram.	[10]	CO4	L2
6) a)List the difference between General Purpose processor & Embedded system. b) Explain the advantages of digital communication over analog communication.	[5] [5]	CO3 CO5	L2 L2
7) a)With a neat circuit diagram explain the working of a Wein bridge Oscillator. b) Explain the classification of embedded system based on generation.	[5]	CO1	L2
8)a) Explain modulation. What is the need for modulation? b) Explain the concept of Radio wave propagation with a neat diagram.	[6] [4]	CO5	L2

IAT 2 Solutions

1) What is opamp? Define the following opamp parameters:

(i) CMRR


CMMR
The ability of an opamp to reject common mode signals is known as CMMR
CMMR = |Ad| / |Ac|
* CMMR - Indicates how well the opamp is able to reject the common signals that are applied to the i/p terminals and how well it is able to amplify the difference b/w the voltages.
CMMR = Differential gain / Common mode gain
CMMR in dB = 20 log |Ad| / |Ac| dB

(ii) Slew Rate

Slew rate

Slew rate is the rate of change of o/p voltage with time, when a rectangular step input voltage is applied.

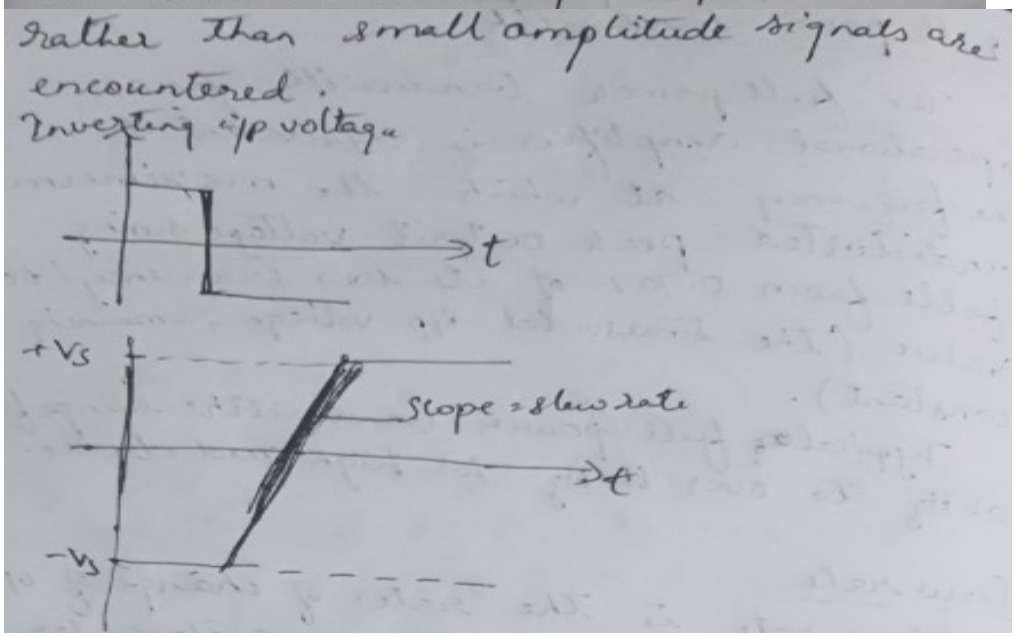
Slew rate of an operational amplifier is the rate of change of o/p voltage with time in response to a perfect step i/p function

$$\text{Slew rate} = \frac{\Delta V_{out}}{\Delta t}$$, where

ΔV_{out} is the change in o/p voltage (in volts)

Δt is the corresponding interval of time (in seconds)

Slew rate is measured in V/s (or V/μs) and Typical values range from 0.2V/μs to over 20V/μs. Slew rate posses limitation on on circuits in which large amplitude pulses rather than small amplitude signals are encountered.



(iii) Closed loop Voltage gain

2) Closed loop voltage gain

It is defined as the ratio of o/p voltage to i/p voltage measured with a small portion of o/p feedback to the i/p (ie with feedback).

The effect of providing negative feedback is to reduce the loop voltage gain to a value that is predictable and manageable.

Practically it ranges from one to several thousands.

It is given by the ratio of o/p voltage to i/p voltage but with negative feedback applied.

$$A_{V(CL)} = \frac{V_{out}}{V_{in}}$$

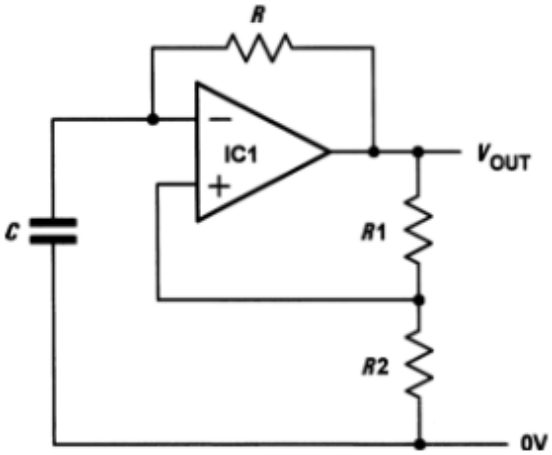
where $A_{V(CL)}$ - closed loop voltage gain

V_{out}, V_{in} - o/p & i/p voltages in closed loop conditions.

Closed loop voltage gain is normally less than open loop voltage gain.

2)a) Explain the working of a single stage astable multivibrator with a new circuit diagram.

- A simple form of astable oscillator that produces a square wave output can be built using just one operational amplifier.
- ***The circuit employs positive feedback*** with the output fed back to the ***non-inverting input via the potential divider formed by R1 and R2.***
- This circuit can make a very simple square wave source with a frequency that can be made adjustable by replacing R with a variable or preset resistor.



- *Assume that C is initially uncharged and the voltage at the inverting input is slightly less than the voltage at the non-inverting input.*
- The output voltage ***will rise rapidly to*** $+V_{CC}$ and the voltage at the inverting input will begin to ***rise exponentially as capacitor C charges through R.***
- Eventually the voltage at the inverting input will have reached a value that causes the voltage at the inverting input to exceed that present at the non-inverting input.
- ***At this point, the output voltage will rapidly fall to*** $-V_{CC}$.
- ***Capacitor C will then start to charge in the other direction and the voltage at the inverting input will begin to fall exponentially.***
- The upper threshold voltage (i.e. ***the maximum positive value for the voltage at the inverting input***) will be given by:

$$V_{UT} = V_{CC} \times \left(\frac{R2}{R1+R2} \right)$$

- The lower threshold voltage (i.e. ***the maximum negative value for the voltage at the inverting input***) will be given by:

$$V_{LT} = -V_{CC} \times \left(\frac{R2}{R1+R2} \right)$$

- Finally, ***the time for one complete cycle of the output waveform produced by the astable oscillator is given by:***

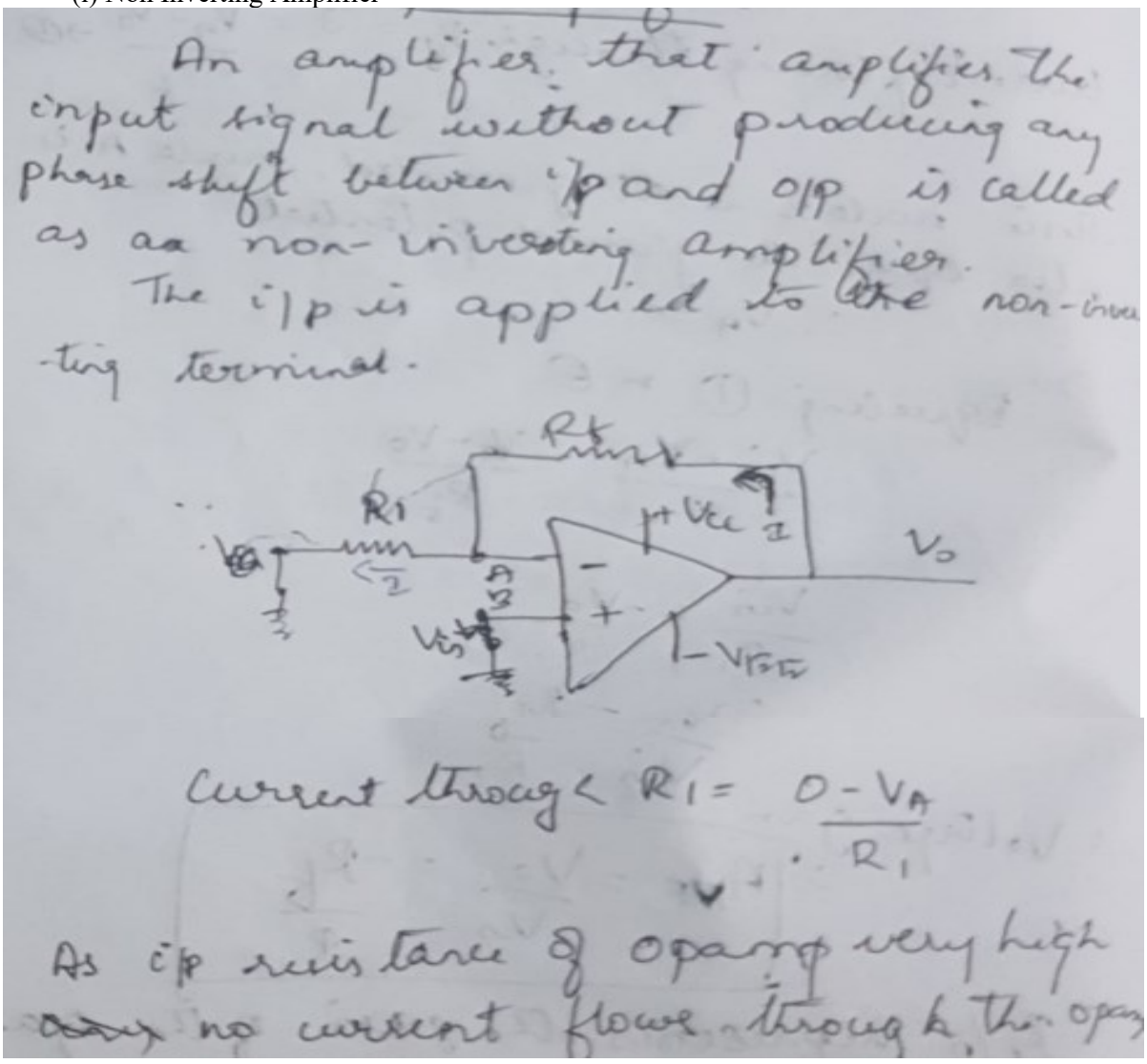
$$T = 2CR \ln\left(1+2\left(\frac{R2}{R1}\right)\right)$$

2)b) Explain the Barkhausen criteria for oscillations.

i)The feedback must be positive (zero degree phase shift) (i.e. the signal fed back must arrive back in-phase with the signal at the input).
Assuming that the amplifier provides 180° phase shift, the frequency of oscillation will be that at which there is 180° phase shift in the feedback network. A number of circuits can be used to provide 180° phase shift
ii)The overall loop voltage gain must be greater than 1 (i.e. the amplifier's gain must be sufficient to overcome the losses associated with any frequency selective feedback network).
To create an oscillator we simply need an amplifier with sufficient gain to overcome the losses of the network that provide positive feedback.

3) Explain the following opamp circuits

(i) Non Inverting Amplifier



current through $R_f = \frac{V_A - V_o}{R_f}$

As node B is connected to V_{in} ($V_B = V_{in}$) and potential at A is same as potential at B.

$\therefore V_A = V_{in}$

Applying KCL at A,

$$\frac{0 - V_A}{R_1} = \frac{V_A - V_o}{R_f}$$

$$\frac{-V_{in}}{R_1} = \frac{V_{in} - V_o}{R_f}$$

$$\frac{V_o}{R_f} = \frac{V_{in}}{R_f} + \frac{V_{in}}{R_1}$$

$$\frac{V_o}{R_f} = V_{in}\left(\frac{1}{R_f} + \frac{1}{R_1}\right)$$

$$\frac{V_o}{R_f} = V_{in}\left(\frac{R_1 + R_f}{R_1 R_f}\right)$$

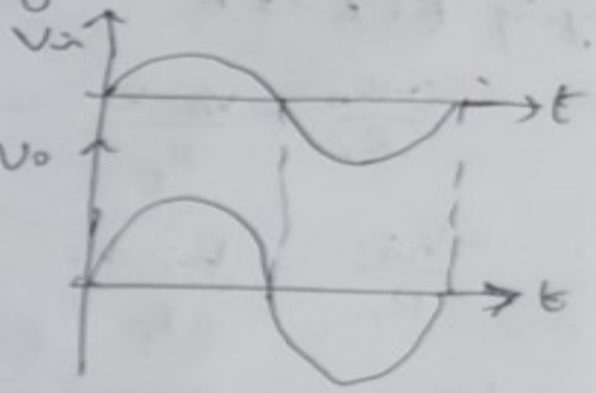
$$\frac{V_o}{V_{in}} = R_f\left(\frac{R_1 + R_f}{R_1 R_f}\right)$$

$$\therefore \frac{V_o}{V_{in}} = \left(1 + \frac{R_f}{R_1}\right)$$

Gain of non-inverting amplifier

$$A = \frac{V_o}{V_{in}} = 1 + \frac{R_f}{R_1}$$

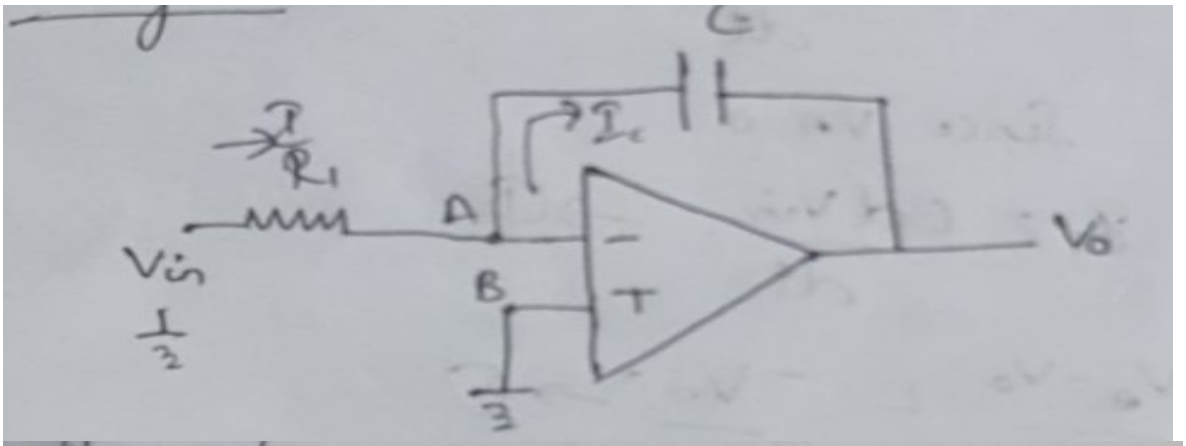
The +ve sign indicates that there is no phase shift between i/p & o/p.



(ii) Integrator

An integrator produces an output that is equivalent to the area under the graph of the input function rather than its rate of change. It performs a function opposite to that of the differentiator.

If the i/p voltage is constant the o/p voltage will ramp up or ramp down



Since B is connected to ground, point A is also at ground potential $\therefore V_A = 0$

Since no current flows into the opamp, the entire current flows into the capacitor.

$$I = \frac{V_{in} - V_A}{R_1} = \frac{V_{in}}{R_1} \rightarrow (1)$$

I_c through capacitor $= I = C\frac{d(V_A - V_o)}{dt}$

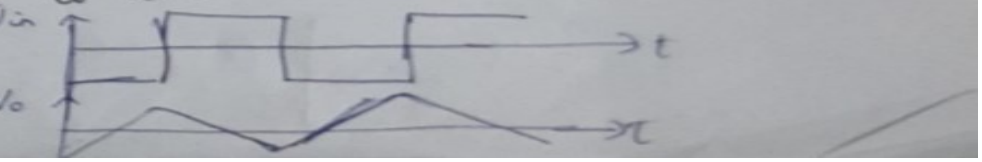
$$I = -C\frac{dV_o}{dt} \rightarrow (2)$$

Equating (1) & (2)

$$\frac{V_{in}}{R_1} = -C\frac{dV_o}{dt}$$

$$\boxed{V_o = -\frac{1}{R_1 C}\int V_{in}\,dt + V_o(0)}$$

where $V_o(0)$ is the constant of integration that is equal to the initial output voltage.



4) a) Explain communication channel and its types.

The transmission medium between the transmitter and the receiver is called a channel.

- Channel is an important part of the Comm. System as its characteristic affect the design of the communication system.
- The transmitted signal should have adequate power to withstand the channel noise.
- The channel characteristics also impose constraints on the bandwidth which is the frequency range that can be transmitted by communication system.
- Transmitting power, signal bandwidth and cost of the communication system are affected by channel characteristics.
- Depending on the physical implementations, one can classify the channels in the following two groups:

  a)Hardwired channels

  b) Softwired channels.

a) Hardwired channels

These are manmade structures which can be used as transmission medium.

There are three possible implementations of the hardware channels.

- Transmission lines
- Waveguides
- Optical Fiber Cables (OFC)
- There is always a physical link between the transmitter and the receiver.
- Transmission lines

  Eg – Twisted pair cables used in landline telephony, coaxial cables used for cable TV transmission.
- Waveguides
  - They are hollow, circular or rectangular metallic structures.
  - The signals enter the waveguide and are reflected by the metallic walls and propagate to the end of the waveguide.
  - They are used to transmit the signal in the Ultra High Frequency (UHF) range
- Optical Fiber Cables (OFC)
  - Highly sophisticated transmission medium
  - Consist of extremely thin circular pipes
  - Signals are transmitted in the form of light energy.
- A physical link is always present in a hardware channel.
- Communication systems that make use of hardware channel are known as **Line communication system**.

Eg- Landline telephony, cable TV network

b) Softwired Channel

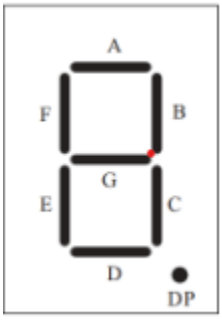
- Natural resources which can be used as the transmission medium for signals. There is no physical link between the transmitter and the receiver.

  Eg. Air or Open space and Sea water.
- The signals are transmitted in the form of electromagnetic (EM) waves also called radio waves.
- Radio waves travel through open space at a speed equal to that of light ($c = 3 \times 10^8$ m/s)
- The transmitter section converts the electrical signals into EM waves by using a transmitting antennae.
- The waves are radiated into the open space by the transmitting antennae.
- At the receiver another antennae called the Receiving antennae receives the signal and converts the EM wave into electrical signal.

- Systems that use radio waves to transmit signal through open space are known as Radio communication systems. Eg- Radio broadcast, television transmission, satellite communication

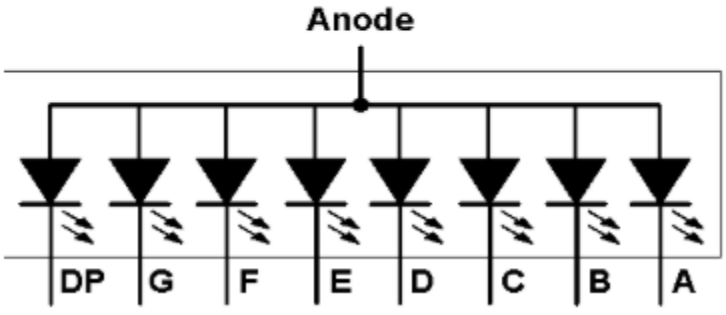
b) Write short notes on (i) 7 segment display (ii) Transducer

- The 7-segment LED display is an output device for displaying alpha numeric characters.
- It contains 8 light-emitting diode (LED) segments arranged in a special form.

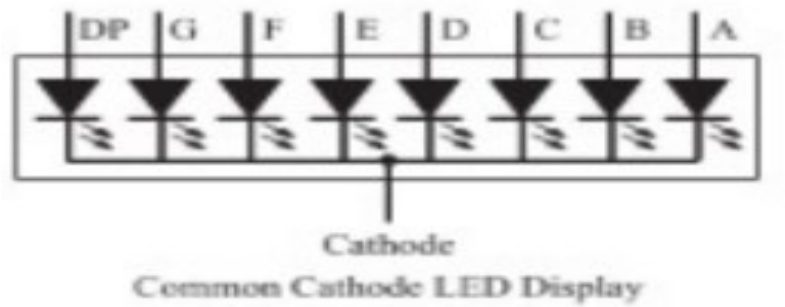


7 segment Display

- The 7 – segment LED display is an output device for displaying alpha numeric characters
- It contains 8 light-emitting diode (LED) segments arranged in a special form.
- Out of the 8 LED segments, 7 are used for displaying alpha numeric characters and 1 is used for representing decimal point.
- The LED segments are named A to G and the decimal point LED segment is named as DP
- The LED Segments A to G and DP should be lit accordingly to display numbers and characters
- The 7 – segment LED displays are available in two different configurations, namely; Common anode and Common cathode
  - In the Common anode configuration, the anodes of the 8 segments are connected commonly.
  - To display '0', the inputs a, b, c, d, e, f should be made low" to forward bias the corresponding LEDs, as the anodes are already connected to Vcc.



Common Anode LED Display



In the Common cathode configuration, the cathodes of the 8 segments are connected commonly and in order to make an led glow, the corresponding pin must be made high.

(ii) Transducer

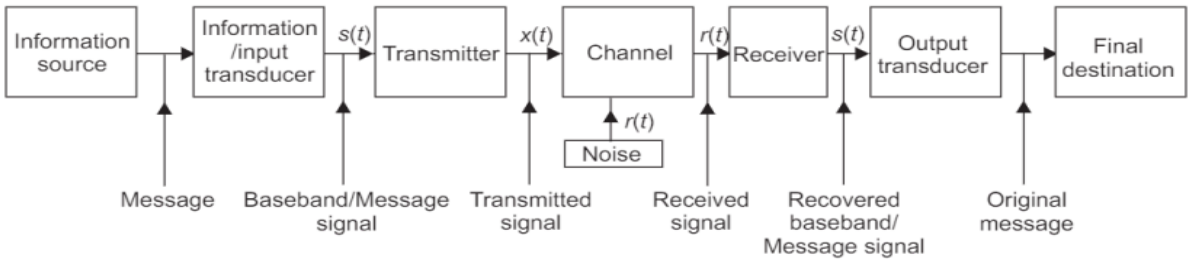
- Transducers are devices that convert energy in the form of sound, light, heat, etc., into an equivalent electrical signal, or vice versa.
- A loudspeaker (output transducer) is a transducer that converts low frequency electric current into audible sounds.
- A microphone(input transducer) will do reverse operation, converting sound pressure variations into voltage or current.

A sensor is also a kind of transducer that is used to generate an input signal to a measurement, instrumentation or control system.

The signal produced by a sensor is an electrical analogy of a physical quantity, such as distance, velocity, acceleration, temperature, pressure, light level, etc.

5) Explain modern communication system with a neat block diagram.

- Communication is the science and practice of transmitting information. It involves sending, processing and receiving information in electrical form.
- Following is the block diagram of Communication system.



Main constituents of communication system are:

- Information source and transducer
- Transmitter
- Channel or medium
- Noise
- Receiver
- Output transducer and final destination

Information source

- A communication system transmits information from an ***information source (message)*** *t*o a ***destination***.
- Examples: Voice, Live scenes(video), music, written text, and e-mail.

Input transducer

- A transducer is a device that **converts a nonelectrical energy** into its corresponding **electrical energy** called **signal** and vice versa. Eg – Loud Speaker, Microphone, camera

Transmitter

There are two types of signals that can be transmitted.
i)Analog Signals
ii) Digital Signals

i) Analog Signals
Analog signals are continuous time signals and have continuous range of values.
Usually represented using sinusoidal waves.
Records the information as it is.
More affected by Noise

Examples: Human voice, data read by analog devices.

ii) Digital Signals
Digital signals are not continuous function of time but defined only at discrete intervals of time. Analog signal that is continuous is converted to discrete time by a process known as sampling. The continuous amplitude is converted to discrete amplitude by amplitude by a process known as Quantization.
Sampling + Quantization – Analog to Digital (ADC) conversion

Baseband signal which is the output of the input transducer is input the transmitter.

- Transmitter processes the signal prior to transmission.
- Nature of processing depends on the type of communication system.
- Two options are available to processing
  i. Baseband signal which lies in low frequency spectrum is translated to the high frequency spectrum by using a high frequency carrier wave. – **Carrier Communication system**
  ii. The baseband signal is transmitted without translating to a higher frequency spectrum – **Baseband communication system**

Channel

- The transmission medium between the transmitter and the receiver is called a **channel.**
- Channel is an important part of the Comm. System as its characteristic affect the design of the communication system.
- The transmitted signal should have adequate power to withstand the **channel noise.**
- The channel characteristics also impose constraints on the **bandwidth which is the frequency range that can be transmitted by communication system.**
- Transmitting power, signal bandwidth and cost of the communication system are affected by channel characteristics.
- Depending on the physical implementations, one can classify the channels in the following two groups:
- **a)Hardwired channels-** These are manmade structures which can be used as transmission medium. Eg – Transmission line, optical fibres
- **b) Softwired channels -** Natural resources which can be used as the transmission medium for signals. There is no physical link between the transmitter and the receiver.

Eg: Air or Open space and Sea water.

Noise

- Noise is defined as unwanted, electrical energy of random and unpredictable nature .
- Noise is an unwanted signal and does not contain any information.
- It is highly undesirable part of a communication system, and has to be minimized.
- Channel is the major source of noise
- When noise is mixed with the transmitted signal, it rides over it and deteriorates its waveform. This results in alteration of the original signal and wrong information is received.
- The signal power should be sufficiently increased so that it can withstand the noise

Receiver

- The task of the receiver is to provide the original information to the user.
- The information is altered due to the processing at the transmitter. The Rx does some processing on the received signal and recovers the original baseband signal.
- The signal received by the receiver is r(t).
- This signal contains both the transmitted signal, x(t), and the noise, n(t), added to it during transmission
- The original baseband signal is recovered by performing an operation opposite to that of the transmitter.
- In carrier communication system, The receiver performs the opposite operation, demodulation which brings the signal from high frequency spectrum to low frequency spectrum.
- In baseband communication as a series of two sinusoidal wave of two different frequencies are used. Hence during reception the sinusoidal signal is replaced by the corresponding original levels.

6) a)List the difference between General Purpose processor & Embedded system.

General Purpose Computing System	Embedded System
A system which is a combination of a generic hardware and a General Purpose Operating System for executing a variety of applications	A system which is a combination of special purpose hardware and embedded OS for executing a specific set of applications
Contains a General Purpose Operating System (GPOS)	May or may not contain an operating system for functioning
Applications are alterable (programmable) by the user (It is possible for the end user to re-install the operating system, and also add or remove user applications)	The firmware of the embedded system is pre-programmed and it is non-alterable by the end-user (There may be exceptions for systems supporting OS kernel image flashing through special hardware settings)
Performance is the key deciding factor in the selection of the system. Always, 'Faster is Better'	Application-specific requirements (like performance, power requirements, memory usage, etc.) are the key deciding factors
Less/not at all tailored towards reduced operating power requirements, options for different levels of power management.	Highly tailored to take advantage of the power saving modes supported by the hardware and the operating system
Response requirements are not time-critical	For certain category of embedded systems like mission critical systems, the response time requirement is highly critical
Need not be deterministic in execution behaviour	Execution behaviour is deterministic for certain types of embedded systems like 'Hard Real Time' systems

6) b) Explain the advantages of digital communication over analog communication.

The following are the advantages of digital Communication over analog communication.

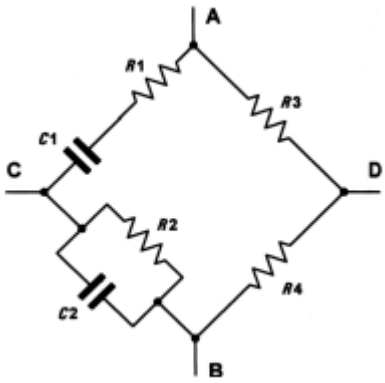
- Less sensitive to noise.
- It is easier to integrate different services
    - video and the accompanying soundtrack, into the same transmission scheme.
- The transmission scheme can be relatively independent of the source.
- Circuitry for handling digital signals is easier to repeat
- Digital circuits are less sensitive to physical effects
    - such as vibration and temperature.
- Digital signals are simpler to characterize ,this makes the associated hardware easier to design.
- Easy to Implement techniques like
    - Multiplexing
    - Channel compensation
    - Equalization
    - Error correction
- There are techniques for removing redundancy from a digital transmission, so as to minimize the amount of information that has to be transmitted.

- Digital techniques make it easier to specify complex standards that may be shared on a worldwide basis.
    - This allows the development of communication components with different features and their interoperation with a different component produced by a different manufacturer.

7) a)With a neat circuit diagram explain the working of a Wein bridge Oscillator.

It is a type of oscillator to generate signals of a particular frequency.

- ***The input signal is applied to A and B*** while the ***output is taken from C and D***.
- ***At one particular frequency, the phase shift produced by the network will be exactly zero (i.e. the input and output signals will be in-phase).***
- If we connect the network to an amplifier producing 0° phase shift which has sufficient gain to overcome the losses of the Wien bridge, oscillation will result.



- The minimum amplifier gain required to sustain oscillation is given by:

$$A_v = 1 + \frac{C1}{C2} + \frac{R2}{R1}$$

- When R1 = R2 = R and C1 = C2 = C the frequency at which the phase shift will be zero will be given by:

$$f = \frac{1}{2\pi \times \sqrt{C1\,C2\,R1\,R2}}$$

$$f = \frac{1}{2\pi \times \sqrt{C^2R^2}} = \frac{1}{2\pi CR}$$

b) Explain the classification of embedded system based on generation.

First Generation

- 8 Bit Microprocessors(8085) and 4 bit Microcontrollers.
- Simple in hardware circuits with firmware developed in assembly code.
- Digital Telephone Keypads, Stepper Motor Control units.

Second Generation

- Built around 16 bit microprocessors.
- 8 bit and 16 bit microcontrollers.
- More complex and powerful.
- Data Acquisition systems, SCADA systems.

Third Generation

- Made use of powerful 32 bit processors and 16 bit microcontrollers.
- Application and domain specific processors/controllers like Digital Signal Processors(DSP) and Application Specific Integrated Circuits(ASICs)
- Instruction set more complex and powerful
- Instruction Pipelining
- Embedded systems were being used in areas such as robotics, media, industrial process control, networking etc.

Fourth Generation

- System on Chip, Reconfigurable processors and multicore processors
- High performance, tight integration and miniaturization.
- Smart phones, mobile internet devices (MIDs)

7) a) Explain modulation. What is the need for modulation?

Modulation – process of translating the low frequency baseband signal to higher frequency spectrum. It is the process of changing the parameters of the carrier signal, in accordance with the instantaneous values of the modulating signal. Based on the parameter of the carrier signal that is varied, there are three types of modulation:

i) Amplitude Modulation
ii) Frequency Modulation
iii) Phase Modulation

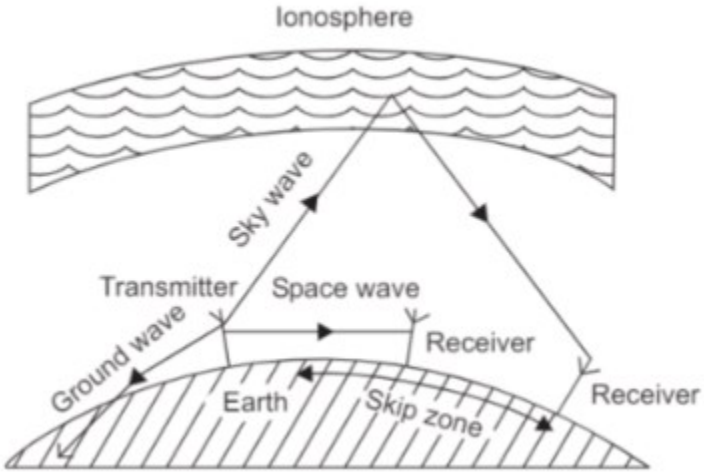
Following are the advantages of modulation

- Improves Quality of reception
- Reduces Height of antenna
- Options for Multiplexing
- Bandwidth Extension
- Increased Range of Communication
- Reduced noise and interference

b) Explain the concept of Radio wave propagation with a neat diagram.

- Depending on the frequency, a radio wave travels from the transmitting to the receiving antenna in several ways.
- On the basis of the Mode Of Propagation, radio waves(10Khz to 300Ghz) can be broadly classified as:

i. Ground or Surface wave
ii. Space or tropospheric wave, and
iii. Sky wave



Different Modes of Radiowave propagation

Ground or Surface wave

- Radio waves are guided by the earth and move along its curved surface from the transmitter to the receiver.
- As waves move around ground they are strongly influenced by the electrical properties of the ground.
- As high frequency waves are strongly absorbed by ground. Ground wave propagation is useful only at only LOW frequencies.
- Below 500 kHz, ground waves can be used for communication within distances of about 1500 km from the transmitter.
- AM radio broadcast in the medium frequency band cover local areas and take place primarily by the ground wave.
- Ground wave transmission is very reliable whatever the atmospheric conditions be.

Space or tropospheric wave

- When a radio wave transmitted from an antenna, travelling in a straight line directly reaches the receiving antenna, it is termed as space or tropospheric wave.
- In space wave or line of sight propagation, radio waves move in the earth's troposphere within about 15 km over the surface of the earth.
- The space wave is made up of two components:
- (a) A direct or line-of-sight wave form the transmitting to the receiving antenna
- (b) Ground-reflected wave traversing form the transmitting antenna to ground and reflected to the receiving antenna.
- Television frequencies in the range 100-220 MHz are transmitted through this mode.

Skywave Propagation

- Radio waves transmitted from the transmitting antenna reach the receiving antenna after reflection from the ionosphere, i.e. the ionized layers lying in the earth’s upper atmosphere.
- Short wave transmission around the globe is possible through sky wave via successive reflections at the ionosphere and the earth’s surface.
- Ionosphere - The ionized region of the earth’s upper atmosphere extending from about 40 km to the height of a few earth radii above the earth.
- The ionosphere is made up of electrons, and positive and negative ions in the background of neutral particles of the atmosphere.
- The propagation of radio wave through the ionosphere is affected by the electrons and ions in the ionosphere.
- The effect of the electrons on the propagation is much greater than that of the ions since the electronic mass is much less than the ionic mass.