K. K. Wagh Institute of Engineering Education and Research, Nashik

(An Autonomous Institute from A.Y. 2022-23)

Model Answer

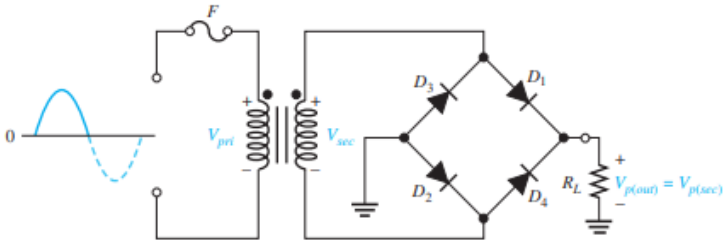
End-Sem Examination, Winter 2025

Academic Year: 2025-2026	Semester: I
Class: FY	Program: B.Tech.
Branch Code:ETC/ADS/CSD	Pattern: 2023
Name of Course:Fundamentals of Electronics Engineering	Course Code: 2300107A

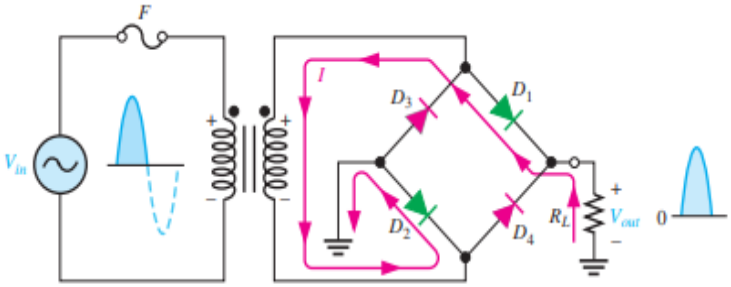
Q. No.	Details
Q.1	With the help of a neat circuit diagram and waveforms, explain the working of a full wave bridge rectifier. (6 marks)

ANSWER:

Circuit Diagram:

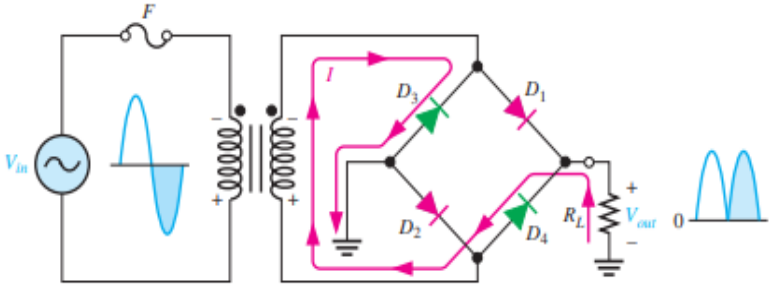


Working:

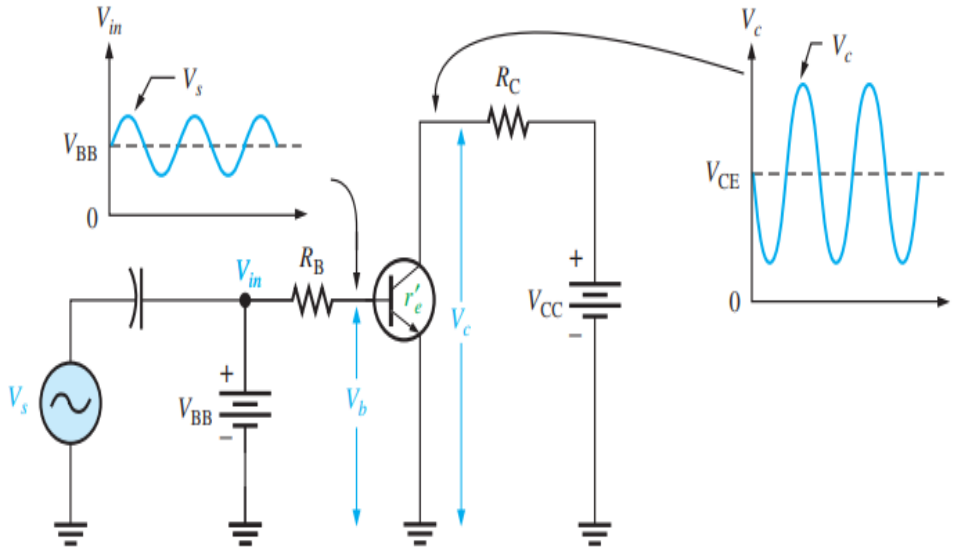


(a) During the positive half-cycle of the input, D_1 and D_2 are forward-biased and conduct current. D_3 and D_4 are reverse-biased.

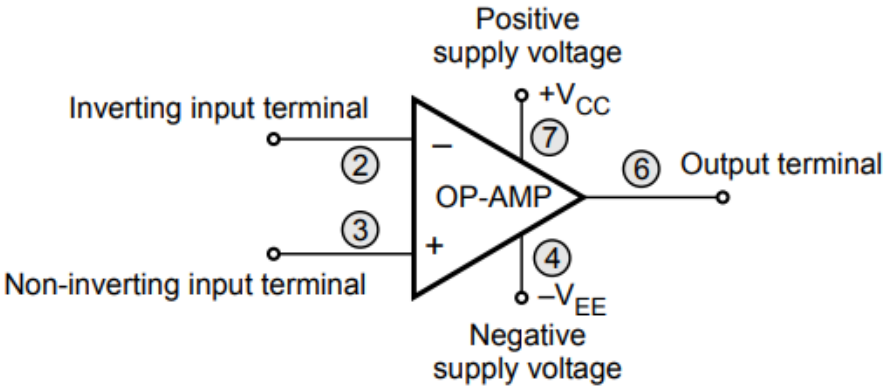
When the input cycle is positive, diodes D1 and D2 are forward-biased and conduct current in the direction shown. A voltage is developed across R_L that looks like the positive half of the input cycle. During this time, diodes D3 and D4 are reverse-biased.



(b) During the negative half-cycle of the input, D_3 and D_4 are forward-biased and conduct current. D_1 and D_2 are reverse-biased.

	When the input cycle is negative, diodes D3 and D4 are forward biased and conduct current in the same direction through R_L as during the positive half-cycle. During the negative half-cycle, D1 and D2 are reverse-biased. A full-wave rectified output voltage appears across R_L as a result of this action. During the positive half-cycle of the total secondary voltage, diodes D1 and D2 are forward-biased. Neglecting the diode drops, the secondary voltage appears across the load resistor. The same is true when D3 and D4 are forward-biased during the negative half-cycle. $V_{p(out)} = V_{p(sec)}$
Q.2	How the BJT can be used as an amplifier? Explain. (6 marks) **ANSWER:** Transistor can be used as an amplifier when it is biased in active region of operation. The Base-Emitter junction should be forward biased and the Collector-Base junction should be reverse biased to operate transistor in the active region. The transistor amplifies current because the Collector current is equal to the Base current multiplied by the current gain, β.  An ac voltage, V_s is superimposed on the dc bias voltage V_{BB} by capacitive coupling as shown in the circuit. The dc bias voltage V_{CC} is connected to the Collector through the Collector resistor, R_C. The ac input voltage produces an ac Base current, which results in a much larger ac Collector current. The ac Collector current produces an ac voltage across R_C, thus producing an amplified, but inverted, reproduction of the ac input voltage in the active region of operation.
Q.3	a) Draw and explain the symbol of an operational amplifier. Also explain the following Op-Amp parameters with their ideal and practical values: i) Slew Rate ii) CMRR (8 marks) **ANSWER:**

OpAmp Symbol:



Non Inverting Input Terminal (+):

- If input is applied at non inverting input terminal, then output will be in phase with input. There will not be phase shift between input and output.

Inverting Input Terminal (-):

- If input is applied at inverting input terminal, then output will be out of phase with input. There will be a phase shift of 180^{o} between input and output.

Output Terminal:

- It provides the output of OpAmp. It is proportional to the difference between non-inverting and inverting inputs.

Positive Supply Terminal ($+V_{CC}$):

- It supplies positive operating voltage to the OpAmp. Its general range is +12 V to +18 V. It determines the maximum positive output swing (+Vsat).

Negative Supply Terminal ($-V_{EE}$):

- It supplies negative operating voltage to the OpAmp. Its general range is -12 V to -18 V. It determines the maximum negative output swing (-Vsat).

Parameters:

i) Slew Rate:

It is the maximum rate of change of the output voltage of an OpAmp with respect to time.

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

Ideal value of slew rate is infinity while its practical value for OpAmp IC 741 is 0.5 V/µs.

ii) CMRR:

It is the ability of an OpAmp to reject the common mode signal.

$$CMRR = \left|\frac{A_d}{A_c}\right|$$

Where Ad is differential gain and Ac is common mode gain.

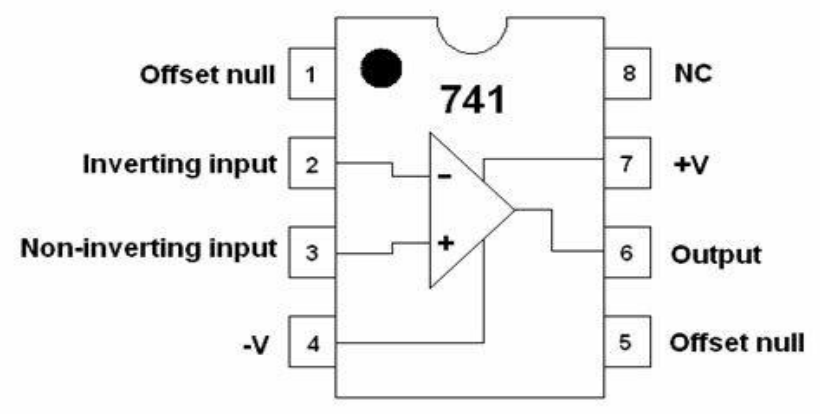
$$CMRR\ (\text{in dB}) = 20 * \log_{10}\left|\frac{A_d}{A_c}\right|$$

Ideal value of CMRR is infinity while its practical value for OpAmp IC 741 is 90 dB.

OR

b) Draw and explain the pin diagram of IC 741. Also explain the following Op-Amp parameters with their ideal and practical values:
i) Input offset current ii) Input impedance (8 marks)

ANSWER:
Pin Diagram of IC 741:



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- It supplies positive operating voltage to the OpAmp. Its general range is +12 V to +18 V. It determines the maximum positive output swing (+Vsat).

Negative Supply Terminal ($-V_{EE}$):
- It supplies negative operating voltage to the OpAmp. Its general range is -12 V to -18 V. It determines the maximum negative output swing (-Vsat).

Offset Null Terminal:
- It is used to eliminate the output offset voltage that appears at the output of OpAmp when both input terminals are grounded.

Parameters:
i) Input Offset Current:
The current flowing into the input terminal of OpAmp is called input bias current. In practice, there are two input bias currents in OpAmp, I_{B1} (for non inverting input) and I_{B2} (for inverting input). The input offset current is the difference between I_{B1} and I_{B2}.

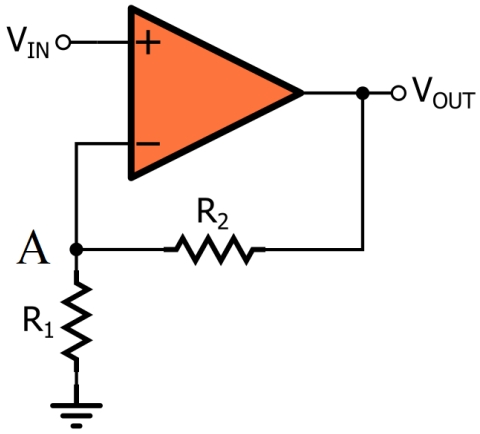
$$Iios = |I_{B1}-I_{B2}|$$

Ideal value of input bias current is zero. Hence the ideal value of the input offset current is also zero while its practical vale for OpAmp IC 741 is 20 nA.

ii) Input Impedance:
It is the impedance observed between two input terminals of an OpAmp. The input impedance of the OpAmp should be infinite to avoid the loading effect. Its practical value is 2 MΩ for OpAmp IC 741.

c) Derive the expression for the voltage gain of an Op-Amp based non inverting amplifier. In an Op-Amp based non inverting amplifier, if Rf = 47 kΩ, R1 = 4.7 kΩ, ±Vcc = ±15V and Vin = 2 Vdc then find output of the circuit and comment on the output. (8 marks)

ANSWER:
Derivation:



According to virtual short concept,

$$V_A = Vin$$

Let us assume that the current flowing through R_1 is I_1 and that though R_2 is I_2.
Here,

$$I_1 = \frac{0 - V_A}{R_1} = -\frac{V_{in}}{R_1}$$

and

$$I_2 = \frac{V_A - V_{out}}{R_2} = \frac{V_{in} - V_{out}}{R_2}$$

As input bias current in OpAmp is ideally zero,

$$I_1 = I_2$$

$$-\frac{V_{in}}{R_1} = \frac{V_{in} - V_{out}}{R_2}$$

$$Voltage\ Gain = \frac{V_{out}}{V_{in}} = 1 + \frac{R_2}{R_1}$$

Numerical:

$$\pm Vsat = \pm\ 0.9 * Vcc = \pm\ 0.9 * 15 = \pm 13.5\ V$$

For non inverting OpAmp amplifier,

$$\text{Voltage Gain} = \frac{Vo}{Vin} = 1 + \frac{Rf}{R1} = 1 + \frac{47\ k\Omega}{4.7\ k\Omega} = 11$$

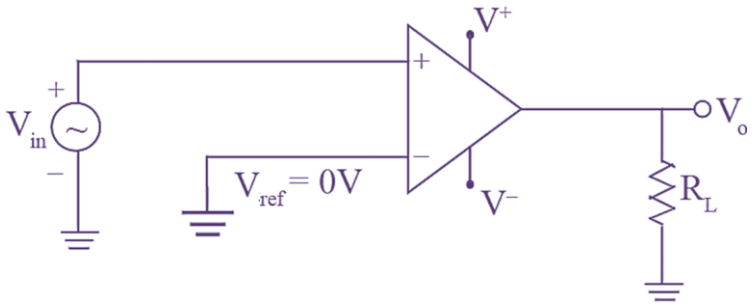
Vo = Vgain * Vin = 11 * 2 Vdc = 22 Vdc

As the output is not within saturation limit, output is not practically possible. Practically the output will be +13.5 V.

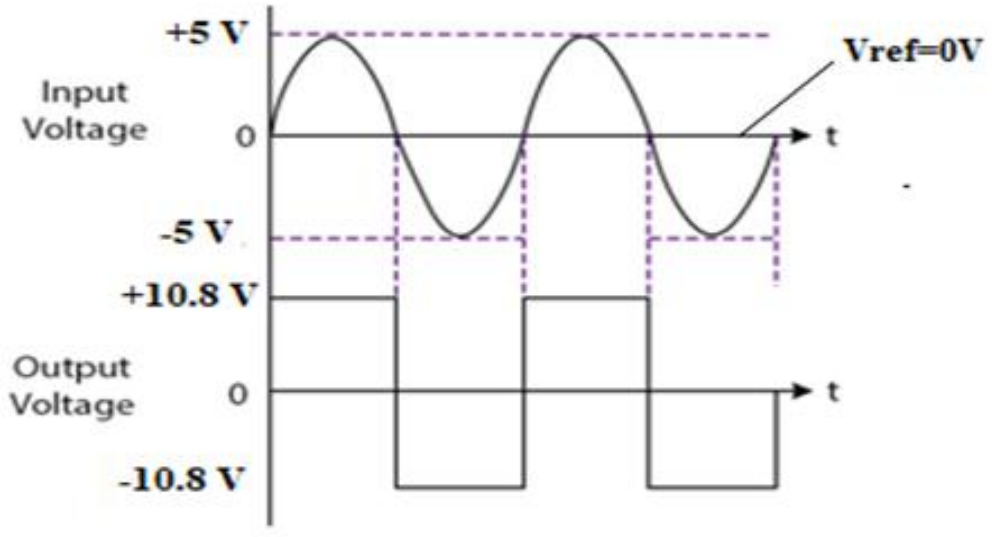
OR

d) Design an Op-Amp based circuit to convert a sine wave to a square wave without phase shift between input and output. Draw the input and output waveforms for the same circuit considering Vin = 10 Vpp sine wave and ±Vcc = ±12 V. (8 marks)

ANSWER:
Proposed circuit to convert a sine wave to a square wave is an OpAmp based comparator in which reference voltage is zero. As there is no phase shift between input and output, it is a non-inverting comparator with zero reference voltage in which variable input is applied at non-inverting input terminal while fixed zero reference voltage is applied at inverting input terminal.

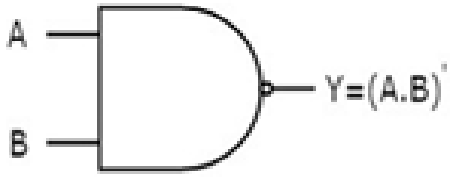


As comparator is an open loop application of the OpAmp, its output is always +Vsat or –Vsat. In a non-inverting comparator, if input is greater than reference then output is +Vsat and if input is less than reference then output is –Vsat.



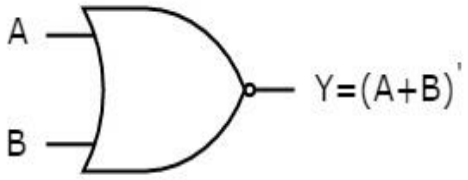
Q.4 a) With the help of the symbol, logic expression and truth table, explain NAND gate and NOR gate. Also convert $(A1B.3)_{16}$ to octal. (8 marks)

ANSWER:
NAND Gate:



A	B	Y = (A.B)'
0	0	1
0	1	1
1	0	1
1	1	0

NOR Gate:



A	B	Y = (A+B)'
0	0	1
0	1	0
1	0	0
1	1	0

Number Conversion:
$(A1B.3)_{16} = (1010\ 0001\ 1011.\ 0011)_2$

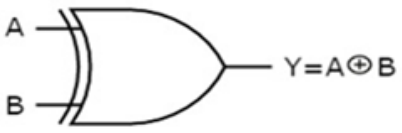
$(101\ \mathbf{000}\ 011\ \mathbf{011}.\ 001\ \mathbf{100})_2 = (5033.14)_8$

OR

b) With the help of the symbol, logic expression and truth table, explain EX-OR gate and EX-NOR gate. Also convert $(126.12)_{10}$ to hexadecimal. (8 marks)

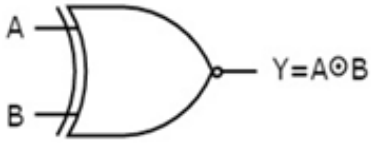
ANSWER:

Ex-OR Gate:



A	B	Y = A⊕B
0	0	0
0	1	1
1	0	1
1	1	0

Ex-Nor Gate:



A	B	Y = A⊙B
0	0	1
0	1	0
1	0	0
1	1	1

Number Conversion:
Step 1: Convert the integer part $(126)_{10}$ to hexadecimal.

Divide by 16 repeatedly:
- $126 \div 16 = 7$, remainder 14 (E)
- $7 \div 16 = 0$, remainder 7

Reading remainders bottom to top: $(126)_{10} = (7E)_{16}$

Step 2: Convert the fractional part $(0.12)_{10}$ to hexadecimal.

Multiply by 16 repeatedly:
- $0.12 \times 16 = 1.92 \rightarrow$ integer 1
- $0.92 \times 16 = 14.72 \rightarrow$ integer E
- $0.72 \times 16 = 11.52 \rightarrow$ integer B
- $0.52 \times 16 = 8.32 \rightarrow$ integer 8

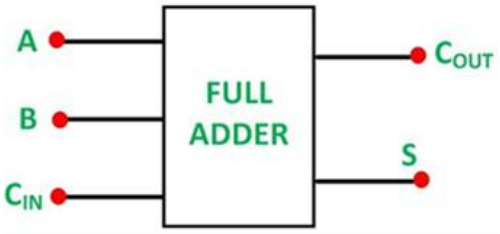
Reading integers top to bottom: $(0.12)_{10} = (0.1EB8)_{16}$

Final Answer: $(126.12)_{10} = (7E.1EB8)_{16}$

c) What is full adder? Derive the expression for its sum and carry outputs using truth table. Also draw its logic diagram. (8 marks)

ANSWER:

Full adder adds two single bit numbers along with a carry from previous position. The schematic representation of a single bit Full Adder is shown below.



The two inputs are A and B, and the third input is a carry input C_{IN}. The output carry is designated as C_{OUT}, and the normal output is designated as S.

Truth table of the Full Adder is shown below.

Inputs			**Outputs**	
A	**B**	**C_{IN}**	**C_{OUT}**	**S**
0	0	0	0	0
0	0	1	0	1
0	1	0	0	1
0	1	1	1	0
1	0	0	0	1
1	0	1	1	0
1	1	0	1	0
1	1	1	1	1

Logic expressions for the outputs of Full Adder are given below.

$$S = \bar{A}.\bar{B}.C_{IN} + \bar{A}.B.\overline{C_{IN}} + A.\bar{B}.\overline{C_{IN}} + A.B.C_{IN}$$
$$S = (\bar{A}.\bar{B} + A.B).C_{IN} + (\bar{A}.B + A.\bar{B}).\overline{C_{IN}}$$
$$S = \left(\overline{A \oplus B}\right).C_{IN} + (A \oplus B).\overline{C_{IN}}$$

Put $A \oplus B = X$

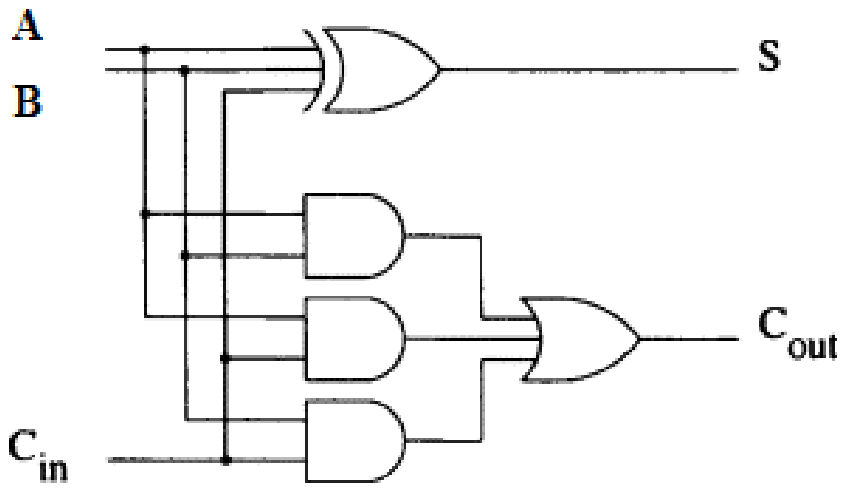
$$S = \bar{X}.C_{IN} + X.\overline{C_{IN}}$$
$$S = X \oplus C_{IN}$$
$$S = A \oplus B \oplus C_{IN}$$

and

$$C_{OUT} = \bar{A}BC_{IN} + A\bar{B}C_{IN} + AB\overline{C_{IN}} + ABC_{IN}$$
$$C_{OUT} = \bar{A}BC_{IN} + A\bar{B}C_{IN} + AB(\overline{C_{IN}} + C_{IN})$$
$$Since\ \overline{C_{IN}} + C_{IN} = 1$$
$$C_{OUT} = \bar{A}BC_{IN} + A\bar{B}C_{IN} + AB$$
$$Since\ C_{IN} + 1 = 1$$

$$C_{OUT} = \bar{A}BC_{IN} + A\bar{B}C_{IN} + AB(C_{IN} + 1)$$
$$C_{OUT} = \bar{A}BC_{IN} + A\bar{B}C_{IN} + ABC_{IN} + AB$$
$$C_{OUT} = \bar{A}BC_{IN} + AC_{IN}(\bar{B} + B) + AB$$
$$Since\ \bar{B} + B = 1$$
$$C_{OUT} = \bar{A}BC_{IN} + AC_{IN} + AB$$
$$Since\ B + 1 = 1$$
$$C_{OUT} = \bar{A}BC_{IN} + AC_{IN}(B + 1) + AB$$
$$C_{OUT} = \bar{A}BC_{IN} + ABC_{IN} + AC_{IN} + AB$$
$$C_{OUT} = BC_{IN}(\bar{A} + A) + AC_{IN} + AB$$
$$Since\ \bar{A} + A = 1$$
$$C_{OUT} = BC_{IN} + AC_{IN} + AB$$
$$C_{OUT} = AB + BC_{IN} + AC_{IN}$$

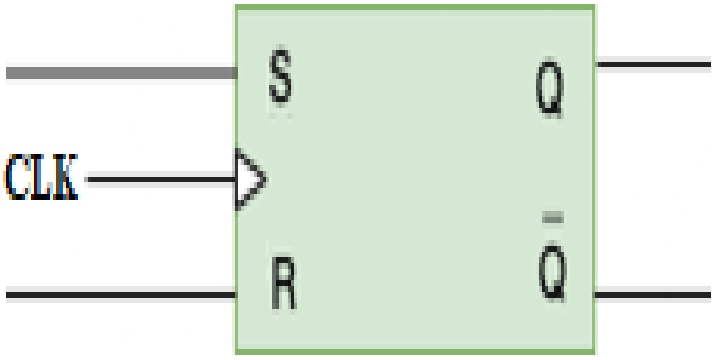
Logic diagram of the Full Adder is shown below.



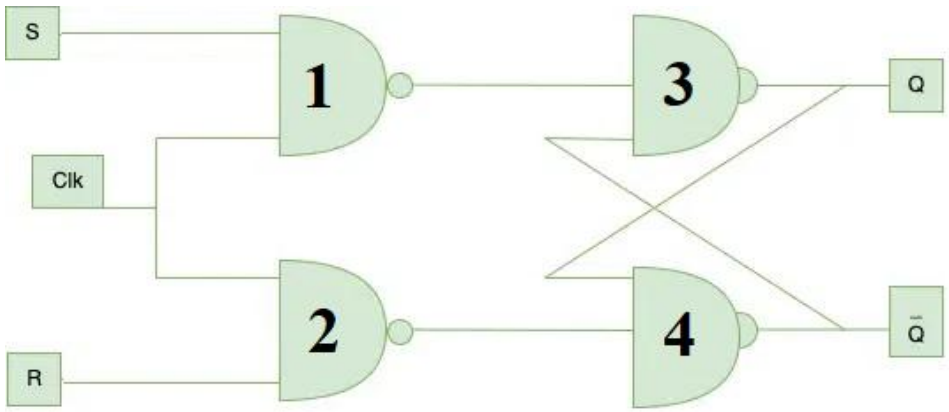
OR

d) Implement SR flipflop using NAND gates and explain its working. (8 marks)

ANSWER:



It is a flip-flop with two inputs; one is S and other is R. Here S stands for Set and R stands for Reset. Set basically indicates setting the flip-flop which means output 1 and reset indicates resetting the flip flop which means output 0. Here clock pulse is supplied to operate this flip flop hence it is clocked flip flop.



Case 1 (Hold state):
If S=0 and R=0, outputs of both gate-1 and gate-2 will be 1. The values of Q and Q' will be same as their previous values.

Case 2 (Reset state):
For S=0 and R=1, if the clock pulse is applied (i.e. CLK=1), the output of gate-1 becomes 1; whereas the output of gate-2 will be 0. The 0 at the input of gate-4 forces the output to be 1 (i.e. Q'=1). This 1 goes to the input of gate-3 to make both the inputs of gate-3 as 1, which forces the output of gate-3 to be 0 (i.e. Q=0).

Case 3 (Set state):
For S=1 and R=0, if the clock pulse is applied (i.e. CLK=1), the output of gate-2 becomes 1; whereas the output of gate-1 will be 0. The 0 at the input of gate-3 forces the output to be 1 (i.e. Q=1). This 1 goes to the input of gate-4 to make both the inputs of gate-4 as 1, which forces the output of gate-4 to be 0 (i.e. Q'=0).

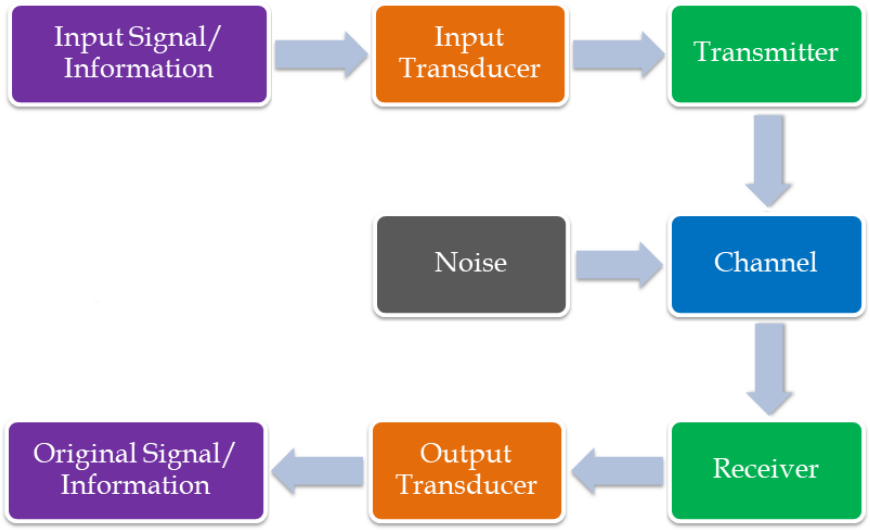
Case 4 (Invalid state)
For S=1 and R=1, if the clock pulse is applied (i.e. CLK=1), the outputs of both gate-1 and gate-2 becomes 0. The 0 at the input of both gate-3 and gate-4 forces the outputs of both the gates to be 1 (i.e. Q=1 and Q'=1) which is invalid.

S	R	Qn+1	State
0	0	Qn	Hold
0	1	0	Reset
1	0	1	Set
1	1	X	Invalid

Q.5 a) Draw and explain the block diagram of electronic communication system. Also write a short note on optical fibre cable. (8 marks)

ANSWER:

Block Diagram of Electronic Communication System:



Input Transducer:

- Coverts message (voice, video, music or text) into its electrical equivalent (Baseband Signal).

Transmitter:

- Signal processing – Amplification, Modulation, Encoding, etc.
- Transmitting antenna at output in case of wireless communication

Channel:

- Medium through which signal is transmitted from Tx. to Rx.
- Wired (Guided): Twisted pair cable/ Coaxial cable/ Optical fiber
- Wireless (Unguided): Radio wave/ Infrared/ Microwave communication

Noise:

- Any unwanted signal which degrades quality of desired information signal

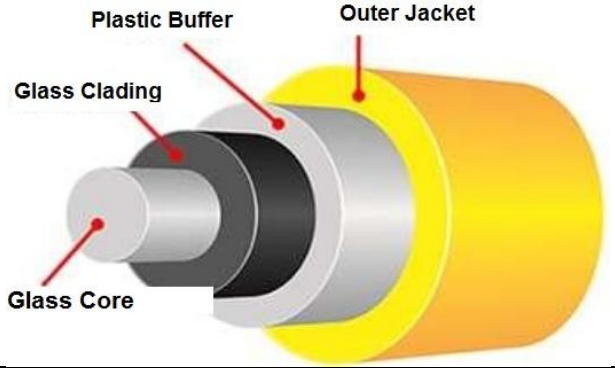
Receiver:

- Signal processing – Amplification, Demodulation, Decoding, etc.
- Receiving antenna at input in case of wireless communication

Output Transducer:

- Coverts Baseband Signal (electrical equivalent) into its original form (voice, video, music or text)

Optical Fibre Cable:



Optical fibre cable is a modern transmission medium that carries information in the form of light pulses through very thin strands of glass or plastic. It is widely used for high-speed and long-distance communication systems.

Structure:

- An optical fibre cable consists of the following layers:
- Core – Central glass or plastic region through which light propagates
- Cladding – Surrounds the core and has a lower refractive index
- Buffer Coating – Protects the fibre from moisture and minor mechanical damage
- Outer Jacket – Provides overall mechanical protection

Operating Principle:

- Optical fibre operates on the principle of Total Internal Reflection (TIR).
- Light signals are guided through the core.
- The refractive index of the core is higher than that of the cladding.
- When light strikes the core–cladding interface at an angle greater than the critical angle, it undergoes total internal reflection.
- Due to repeated total internal reflections, light travels through the fibre with very low attenuation.

Advantages:

- Very high bandwidth and data transmission speed
- Low signal loss, suitable for long-distance communication
- Immune to electromagnetic interference (EMI)
- Lightweight and compact
- High security

Drawbacks:

- High initial installation cost
- Fragile compared to copper cables
- Requires skilled handling and maintenance
- Difficult to repair

Applications:

- Long-distance telecommunication networks
- Internet backbone and FTTH (Fibre to the Home)
- LAN and WAN networking
- Medical instruments (endoscopy)
- Military and aerospace communication

OR

b) Explain simplex and duplex modes of transmission. Also compare wired communication and wireless communication. (8 marks)

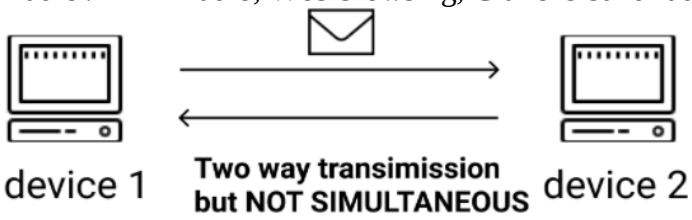
ANSWER:

Simplex Mode:

- Transmission is unidirectional.
- Device can either send signal or it can receive.
- Eg. TV broadcasting, Remote control, Keyboard input to PC

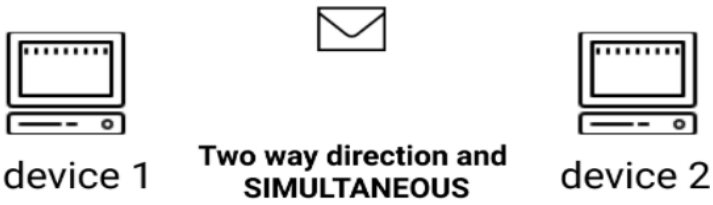
Half Duplex Mode:

- Transmission is bidirectional.
- Both devices can send or receive signal.
- But at a time, a device can either send signal or receive it.
- Eg. Amateur radio / HAM radio, Web browsing, Citizens band radio



Full Duplex Mode:

- Transmission is bidirectional.
- Both devices can send or receive signal.
- Device can send or receive signal simultaneously.
- Eg. Telephone communication, Data transfer over ethernet, Cellular communication



Comparison:

Parameter	**Wired Communication**	**Wireless Communication**
Medium	Physical wire (twisted pair cable, coaxial cable, optical fiber)	Air (radio waves, microwaves, infrared)
Installation	Difficult & requires more time	Easy & requires less time
Distance covered	Less	More
Areas covered	Difficult in hilly & forest area	Easily covers hilly & forest area

Mobility	Limited	High
Environmental interference	Less	More

c) What is modulation? Explain the need of modulation. (8 marks)

ANSWER:

Modulation:

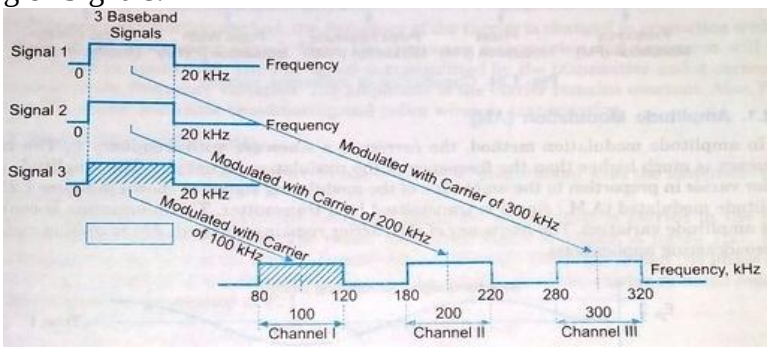
A baseband signal is the original information signal that contains the actual message to be transmitted, such as speech, music, video, or data, before modulation. It is a low-frequency signal and cannot be transmitted over long distances efficiently due to poor radiation and high losses. To transmit the baseband signal over long distances, modulation is required. In the modulation process, a high-frequency carrier signal is used. The carrier signal has fixed amplitude, frequency, and phase. When any one parameter of the carrier signal - amplitude, frequency, or phase - is varied in accordance with the baseband (information) signal, the process is called modulation.

Need of Modulation:

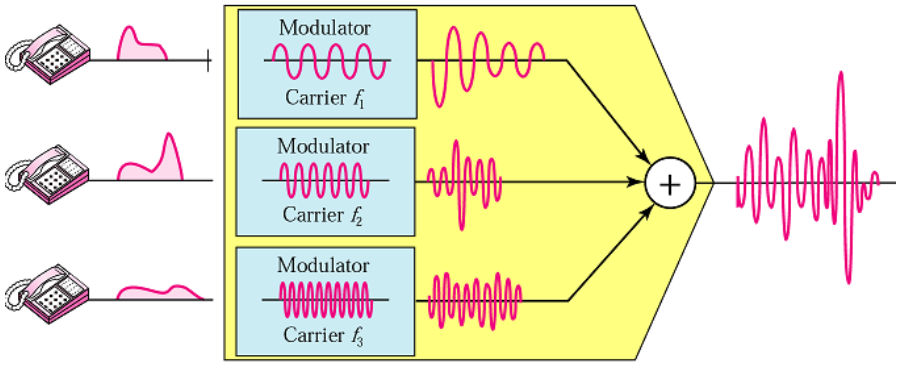
Reduction in Antenna Height:

- Antenna dimensions are always inversely proportional to frequency of operation.
- Simplest antenna is monopole antenna whose height λ/4.
- Monopole antenna height h = λ/4 = c/4*f

Avoids Mixing of Signals:



Multiplexing is Possible:



Allows Long Distance Communication:

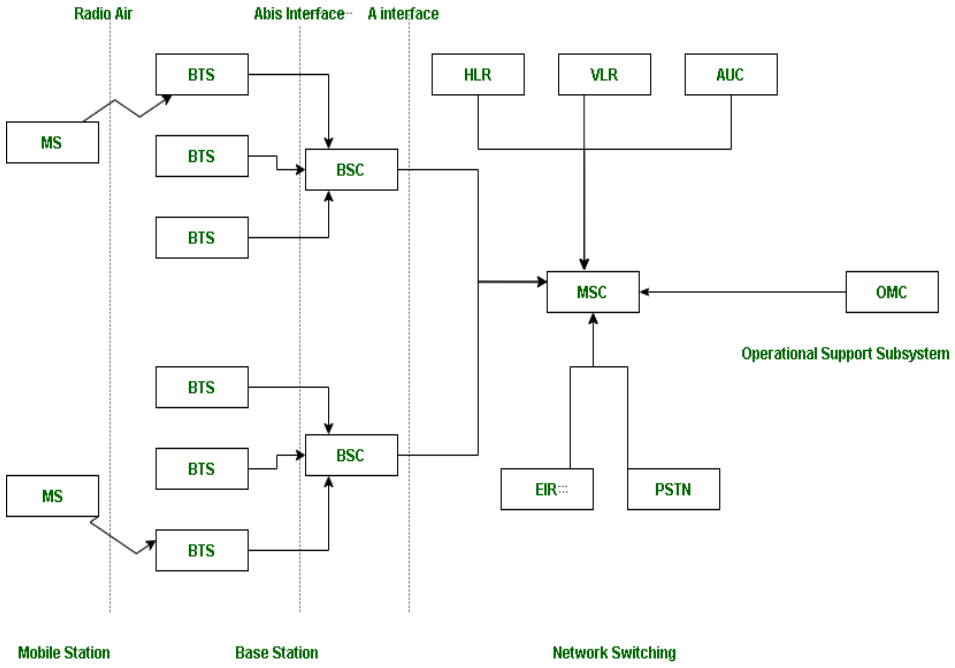
- With increase in frequency, the energy of signal also increases. (i.e. E= h*f)
- Hence signal can travel over long distance.

Improves Quality of Communication:
Modulation avoids mixing of signals; it allows multiplexing of signals and increases energy level of signal. Hence it helps to improve the quality of communication.

OR

d) Explain Electromagnetic Frequency Spectrum. (8 marks)

ANSWER:



GSM is nothing but a larger system which is divided into further 3 subsystems.

1. **BSS:** BSS stands for Base Station Subsystem. BSS handles traffic and signalling between a mobile phone and the network switching subsystem. BSS having two components **BTS** and **BSC.**
2. **NSS:** NSS stands for Network and Switching Subsystem. NSS is the core network of GSM. That carried out call and mobility management functions for mobile phone present in network. NSS have different components like **VLR, HLR** and **EIR.**
3. **OSS:** OSS stands for Operating Subsystem. OSS is a functional entity which the network operator monitors and controls the system. **OMC is** the part of OSS. Purpose of OSS is to offer the customer cost-effective support for all GSM related maintenance services.

Suppose there are 3 Mobile stations which are connected with the tower and that tower is connected to BTS through TRX, and then further connected to BSC and

MSC.

Let's understand the functionality of different components.

1. MS: MS stands for Mobile System. MS comprises user equipment and software needed for communication with a mobile network. Mobile Station (MS) = Mobile Equipment (ME) + Subscriber Identity Module (SIM). Now, these mobile stations are connected to tower and that tower connected with BTS through TRX. TRX is a transceiver which comprises transmitter and receiver. Transceiver has two performances of sending and receiving.

2. BTS: BTS stands for Base Transceiver Station which facilitates wireless communication between user equipment and a network. Every tower has BTS.

3. BSC: BSC stands for Base Station Controller. BSC has multiple BTS. You can consider the BSC as a local exchange of your area which has multiple towers and multiple towers have BTS.

4. MSC: MSC stands for Mobile Switching Center. MSC is associated with communication switching functions such as call setup, call release and routing. Call tracing, call forwarding all functions are performed at the MSC level. MSC is having further components like VLR, HLR, AUC, EIR and PSTN.

- **VLR:** VLR stands for Visitor Location Register. VLR is a database which contains the exact location of all mobile subscribers currently present in the service area of MSC. If you are going from one state to another state then your entry is marked into the database of VLR.
- **HLR:** HLR stands for Home Location Register. HLR is a database containing pertinent data regarding subscribers authorized to use a GSM network. If you purchase SIM card from in the HLR. HLR is like a home which contains all data like your ID proof, which plan you are taking, which caller tune you are using etc.
- **OMC:** OMC stands for Operation Maintenance Center. OMC monitor and maintain the performance of each MS, BSC and MSC within a GSM system.
- **AUC:** AUC stands for Authentication Center. AUC authenticates the mobile subscriber that wants to connect in the network.
- **EIR:** EIR stands for Equipment Identity Register. EIR is a database that keeps the record of all allowed or banned in the network. If you are banned in the network them you can't enter the network, and you can't make the calls.

PSTN: PSTN stands for Public Switched Telephone Network. PSTN connects with MSC. PSTN originally a network of fixed line analog telephone systems. Now almost entirely digital in its core network and includes mobile and other networks as well as fixed telephones. The earlier landline phone which places at our home is nothing but PSTN.