Name

Reg.No:

COMBINED FIRST AND SECOND SEMESTER B.TECH. (ENGINEERING)

DEGREE EXAMINATION- MODEL QUESTION PAPER 1

EN14 107-BASICS OF ELECTRICAL, ELECTRONICS AND COMMUNICATION ENGINEERING

(2014 admissions) Time:1 ½ hours

Section 2 (Basics of Electronics and Communication Engineering)

Part A

Answer all questions.

1. What are advantages of CMOS logic?

2. Explain in brief about differential amplifiers.

3. Describe about advantages and disadvantages of microwave communication.

4. What are the advantages of optical communication systems?

5. State any 5 boolean algebra laws. (4X5=20 Marks)

PART B

6. Describe in detail about Working and block diagram of CRO.

OR

7. Explain about operational amplifiers and its characteristics.

8. Describe in detail about principle of super heterodyne receiver with block diagram.

OR

9. Describe in detail about optical communication systems with neat diagram.

Answers: Part A

1.

CMOS is the abbreviation for Complementary Metal Oxide Semiconductor. It is basically a class of integrated circuits, and is used in a range of applications with digital logic circuits, such as microprocessors, microcontrollers, static RAM, etc. It is also used in applications with analogue circuits, such as in data converters, image sensors, etc. There are quite a few advantages that the CMOS technology has to offer.

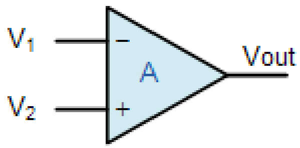
One of the main advantages that CMOS technology, which makes it the most commonly-used technology for digital circuits today is the fact that it enables chips that are small in size to have features like high operating speeds and efficient usage of energy. Besides, they have very low static power supply drain (or very low power consumption) most of the time. Devices using CMOS technology also have a high degree of noise immunity.

2.

A **differential amplifier** is a type of electronic amplifier that amplifies the difference between two input voltages but suppresses any voltage common to the two inputs.It is an analog circuit with two inputs V_{in}^{-} and V_{in}^{+} and one output V_{out} in which the output is ideally proportional to the difference between the two voltages

$$V_{out} = A(V_{in}^{+} - V_{in}^{-})$$

where A is the gain of the amplifier.



3.

Microwaves are electromagnetic waves with a frequency greater than 1 GHz (1,000,000 Hz). Microwave signal due to their inherently high frequencies, have relatively short wavelengths, hence the name "micro" waves.

Advantages:

- No cables needed
- Multiple channels available
- Wide bandwidth

Disadvantages:

- Line-of-sight will be disrupted if any obstacle, such as new buildings, are in the way
- Signal absorption by the atmosphere. Microwaves suffer from attenuation due to atmospheric conditions.
- Towers are expensive to build
- Need of repeaters- Microwave Repeaters: Microwave communications requires the line-of-sight or space wave propagation method. There are some instances where barriers are inevitable which cause obstructions between the transmitter and receiver. This kind of problem is best resolved by repeaters

4.

BENEFITS OF OPTICAL FIBER COMMUNICATION SYSTEM :

Some of the innumerable benefits of optical fiber communication system are:

- Immense bandwidth to utilize
- Total electrical isolation in the transmission medium
  - Very low transmission loss,
  - Small size and light weight,
  - High signal security,
  - Immunity to interference and crosstalk,
  - Very low power consumption and wide scope of system expansion etc.

5.

1.	Law of Identity	$A = A$ $\overline{A} = \overline{A}$
2.	Commutative Law	$A \cdot B = B \cdot A$ $A + B = B + A$
3.	Associative Law	$A \cdot (B \cdot C) = A \cdot B \cdot C$ $A + (B + C) = A + B + C$
4.	Idempotent Law	$A \cdot A = A$ $A + A = A$
5.	Double Negative Law	$\overline{\overline{A}} = A$
6.	Complementary Law	$A \cdot \overline{A} = 0$ $A + \overline{A} = 1$
7.	Law of Intersection	$A \cdot 1 = A$ $A \cdot 0 = 0$
8.	Law of Union	$A + 1 = 1$ $A + 0 = A$
9.	DeMorgan's Theorem	$\overline{AB} = \overline{A} + \overline{B}$ $\overline{A + B} = \overline{A}\,\overline{B}$
10.	Distributive Law	$A \cdot (B + C) = (A \cdot B) + (A \cdot C)$ $A + (BC) = (A + B) \cdot (A + C)$
11.	Law of Absorption	$A \cdot (A + B) = A$ $A + (AB) = A$
12.	Law of Common Identities	$A \cdot (\overline{A} + B) = AB$ $A + (\overline{A}B) = A + B$

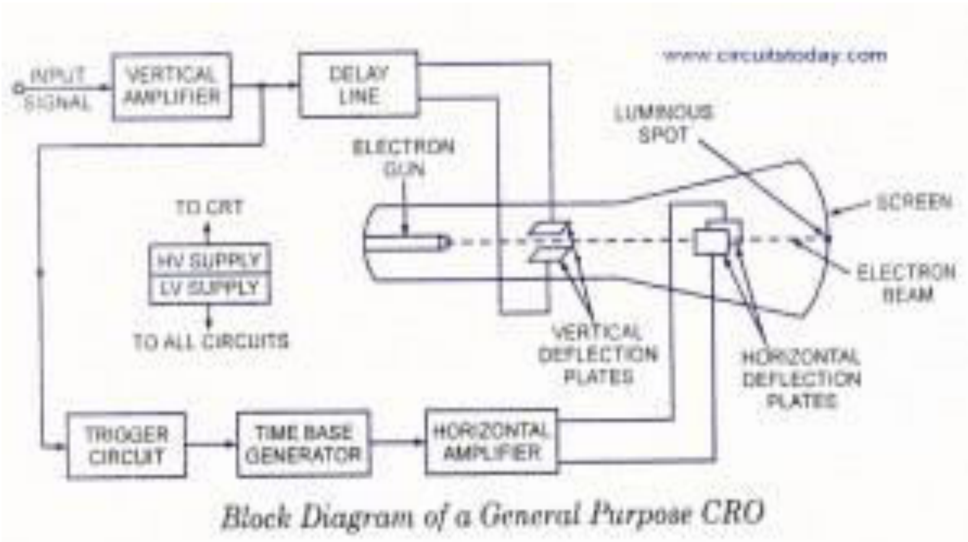
Part B

6.

The cathode ray oscilloscope is a versatile laboratory instrument. With it we can measure, AC/DC voltage, AC/DC current, resistance, phase and phase difference between two or more waveforms, relative frequency of a waveform, observe the amount of noise present on a signal, etc.

In addition, CRO is also useful to observe the shape of waveform or signal and observe its real time progression on time axis. The waveform displayed on it, is observed with respect to x-y axes or co-ordinate system. The screen of CRO is plotted in terms of a measuring scale, known as graticule. Using this scale, the amplitude and wavelength of waveform can be accurately measured in centimetres and then converted into required unit.

Block Diagram of a CRO



CRO Block Diagram

The instrument employs a **cathode ray tube** (CRT), which is the heart of the oscilloscope. It generates the electron beam, accelerates the beam to a high velocity, deflects the beam to create the image, and contains a phosphor screen where the electron beam eventually becomes visible. For accomplishing these tasks various electrical signals and voltages are required, which are provided by the power supply circuit of the oscilloscope. Low voltage supply is required for the heater of the electron gun for generation of electron beam and high voltage, of the order of few thousand volts, is required for cathode ray tube to accelerate the beam. Normal voltage supply, say a few hundred volts, is required for other control circuits of the oscilloscope.

Horizontal and vertical deflection plates are fitted between electron gun and screen to deflect the beam according to input signal. Electron beam strikes the screen and creates a visible spot. This spot is deflected on the screen in horizontal direction (X-axis) with constant time dependent rate. This is accomplished by a time base circuit provided in the oscilloscope. The signal to be viewed is supplied to the vertical deflection plates through the vertical amplifier, which raises the potential of the input signal to a level that will provide usable deflection of the electron beam. Now electron beam deflects in two directions, horizontal on X-axis and vertical on Y-axis. A triggering circuit is provided for synchronizing two types of deflections so that horizontal deflection starts at the same point of the input vertical signal each time it sweeps. A basic block diagram of a general purpose oscilloscope is shown in above figure.

Vertical amplifier: It is a set of preamplifier and main vertical amplifier. The input attenuator sets up the gain of vertical amplifier.

Delay line: The delay line delays the striking of electron beam on the screen. It synchronizes the arrival of the beam on screen when time base generator signal starts sweeping the beam horizontally. The propagation delay2 produced is about 0.25msec.

Trigger circuit: It takes the sample of input voltage connected at y-input of CRO and feeds it to the input of time base generator. So the TBG(Time Base Generator) starts only when input signal is present at input.

Time base generator: It produces a saw tooth wave. The waveform is used to sweep (move) the electron beam horizontally on the screen. The rate of rise of positive going edge of saw tooth waveform is controlled by Time/div control knob. Thus, the saw tooth wave controls the horizontal deflection of electron beam along x-axis.

Horizontal amplifier: It amplifies the saw tooth waveform coming from TBG. It contains phase inverter circuit also. Due to this circuit, two outputs are produced. One output produces positive going saw tooth and other output produces negative going saw tooth. The first output is connected to right side H-plate and the second output is connected to left side H-plate. So the electron beam moves properly from left to right of the screen.

The high voltage section is used to power the electrodes of CRT and the low voltage section is used to power the electronic circuits of the CRO.

7.

An **Operational Amplifier**, or op-amp for short, is fundamentally a voltage amplifying device designed to be used with external feedback components such as resistors and capacitors between its output and input terminals. These feedback components determine the resulting function or “operation” of the amplifier and by virtue of the different feedback configurations whether resistive, capacitive or both, the amplifier can perform a variety of different operations, giving rise to its name of “Operational Amplifier”.

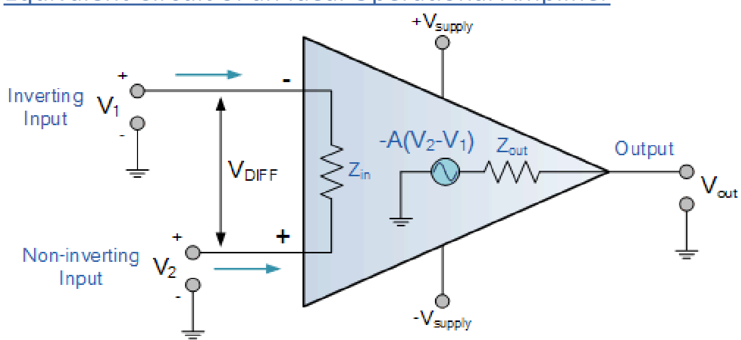
An *Operational Amplifier* is basically a five-terminal device which consists of two high impedance inputs, one called the **Inverting Input**, marked with a negative or "minus" sign, (-) and the other one called the **Non-inverting Input**, marked with a positive or "plus" sign (+).

The third terminal represents the Operational Amplifiers output port which can both sink and source either a voltage or a current. The other two terminals are for applying + and – power supplies. In a linear operational amplifier, the output signal is the amplification factor, known as the amplifiers gain (A) multiplied by the value of the input signal and depending on the nature of these input and output signals, there can be four different classifications of operational amplifier gain.

- Voltage – Voltage "in" and Voltage "out"
- Current – Current "in" and Current "out"
- Transconductance – Voltage "in" and Current "out"
- Transresistance – Current "in" and Voltage "out"

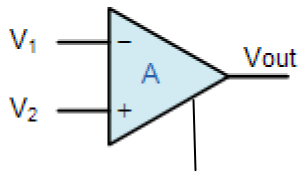
The output voltage signal from an Operational Amplifier in simple open loop condition is the difference between the signals being applied to its two individual inputs.

Equivalent Circuit of an Ideal Operational Amplifier



An **Operational amplifiers** is a very high gain DC differential amplifier that uses one or more external feedback networks to control its response and characteristics. We can connect external resistors or capacitors to the op-amp in a number of different ways to form basic "building Block" circuits such as, Inverting, Non-Inverting, Voltage Follower, Summing, Differential, Integrator and Differentiator type amplifiers. These are all closed loop configurations of opamp.

+ve supply



-ve supply

An “ideal” or perfect Operational Amplifier is a device with certain special characteristics such as infinite open-loop gain Ao, infinite input resistance Rin, zero output resistance Rout, infinite bandwidth 0 to ∞and zero offset (the output is exactly zero when the input is zero).

Op-amp Parameter and Idealised Characteristic

Open Loop Gain, (Avo)

Infinite – The main function of an operational amplifier is to amplify the input signal and the more open loop gain it has the better. Open-loop gain is the gain of the op-amp without positive or negative feedback and for such an amplifier the gain will be infinite but typical real values range from about 20,000 to 200,000.

Input impedance, (Zin)

Infinite – Input impedance is the ratio of input voltage to input current and is assumed to be infinite to prevent any current flowing from the source supply into the amplifiers input circuitry (Iin = 0). Real op-amps have input leakage currents from a few pico-amps to a few milli-amps.

Output impedance, (Zout)

Zero – The output impedance of the ideal operational amplifier is assumed to be zero acting as a perfect internal voltage source with no internal resistance so that it can supply as much current as necessary to the load. This internal resistance is effectively in series with the load thereby reducing the output voltage available to the load. Real op-amps have output impedances in the 100-20kΩ range.

Bandwidth, (BW)

Infinite – An ideal operational amplifier has an infinite frequency response and can amplify any frequency signal from DC to the highest AC frequencies so it is therefore assumed to have an infinite bandwidth. With real op-amps, the bandwidth is limited by the Gain-Bandwidth product (GB), which is equal to the frequency where the amplifiers gain becomes unity.

Offset Voltage, (Vio)

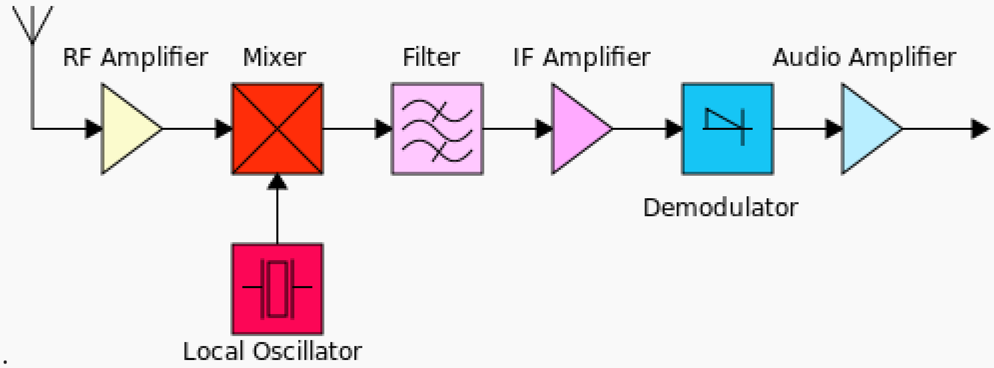
Zero – The amplifiers output will be zero when the voltage difference between the inverting and the non-inverting inputs is zero, the same or when both inputs are grounded. Real op-amps have some amount of output offset voltage.

8.

A super-heterodyne receiver (often shortened to super-het) uses frequency mixing to convert a received signal to a fixed intermediate frequency (IF) which can be more conveniently processed than the original radio carrier frequency. Virtually all modern radio receivers use the superheterodyne principle. At the cost of an extra frequency converter stage, the superheterodyne receiver provides superior selectivity and sensitivity compared with simpler designs.

Design and principle of operation

The principle of operation of the super heterodyne receiver depends on the use of heterodyning or frequency mixing. The signal from the antenna is filtered sufficiently at least to reject the image frequency and possibly amplified. A local oscillator in the receiver produces a sine wave, which mixes with that signal, shifting it to a specific intermediate frequency (IF), usually a lower frequency. The IF signal is itself filtered and amplified and possibly processed in additional ways. The demodulator uses the IF signal rather than the original radio frequency to recreate a copy of the original information (such as audio).



Block diagram of a typical superheterodyne receiver

The diagram at right shows the minimum requirements for a single-conversion superheterodyne receiver design. The following essential elements are common to all superheterodyne circuits: a receiving antenna; a tuned stage, which may optionally contain amplification (RF amplifier); a variable frequency local oscillator; a frequency mixer; a band pass filter and intermediate frequency (IF) amplifier; and a demodulator plus additional circuitry to amplify or process the original audio signal (or other transmitted information).

9.

GENERAL OVERVIEW OF OPTICAL FIBER COMMUNICATION SYSTEM :

Like all other communication system, the primary objective of optical fiber communication system also is to transfer the signal containing information (voice, data, video) from the source to the destination. The general block diagram of optical fiber communication system is shown in the figure9.

The source provides information in the form of electrical signal to the transmitter. The electrical stage of the transmitter drives an optical source to produce modulated light wave carrier. Semiconductor LASERs or LEDs are usually used as optical source here. The information carrying light wave then passes through the transmission medium i.e. optical fiber cables in this system. Now it reaches to the receiver stage where the optical detector demodulates the optical carrier and gives an electrical output signal to the electrical stage. The common types of optical detectors used are photodiodes (p-i-n, avalanche), phototransistors, photoconductors etc. Finally the electrical stage gets the real information back and gives it to the concerned destination.

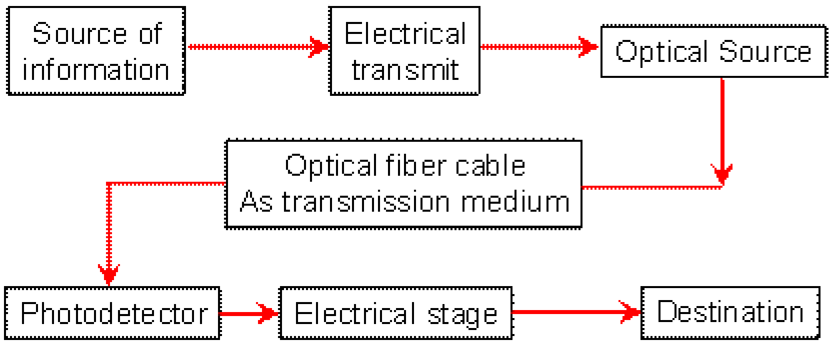


FIGURE 9.

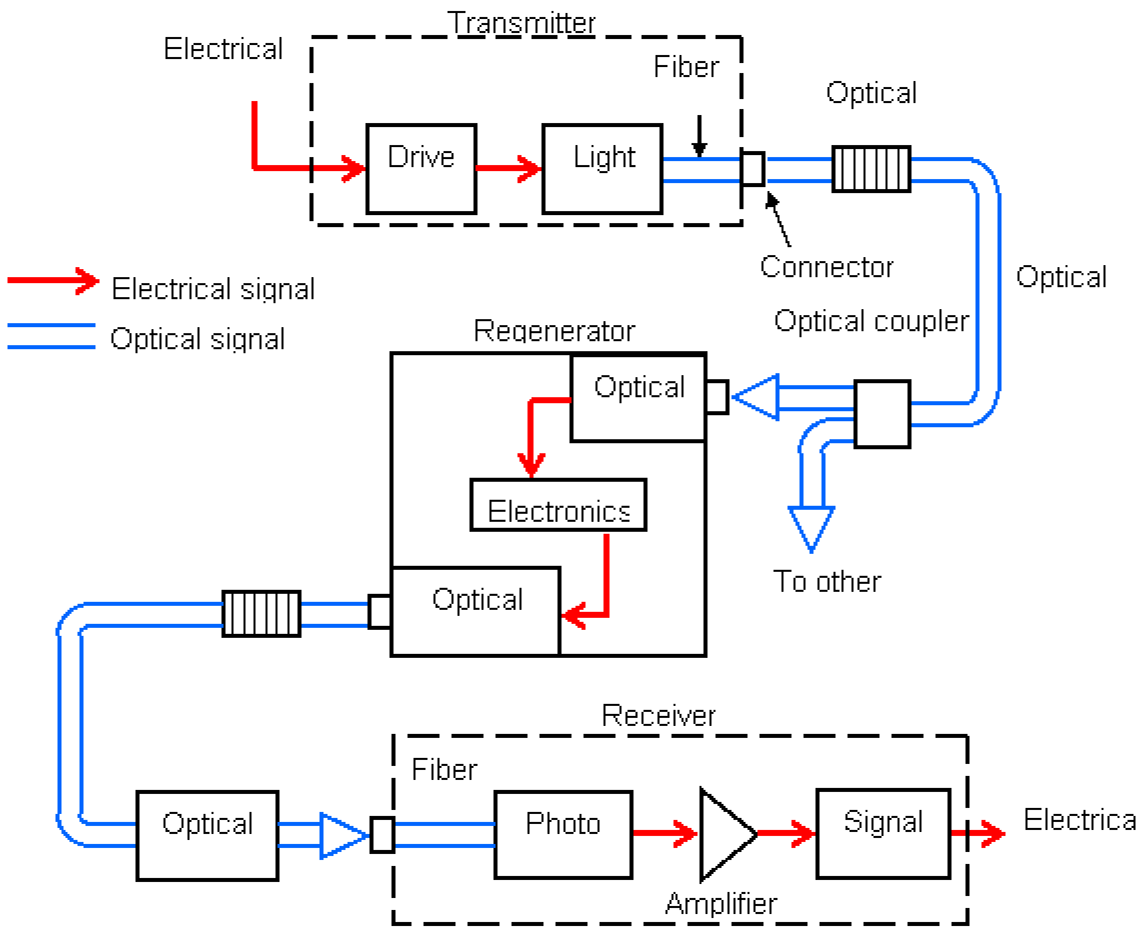
It is notable that the optical carrier may be modulated by either analog or digital information signal. In digital optical fiber communication system the information is suitably encoded prior to the drive circuit stage of optical source. Similarly at the receiver end a decoder is used after amplifier and equalizer stage.

PRIMARY ELEMENTS OF OPTICAL FIBER COMMUNICATION SYSTEM :

Figure10 shows the major elements used in an optical fiber communication system. As we can see the transmitter stage consists of a light source and associated drive circuitry. Again, the receiver section includes photodetector, signal amplifier and signal restorer.

Additional components like optical amplifier, connectors, splices and couplers are also there. The regenerator section is a key part of the system as it amplifies and reshapes the distorted signals for long distance links.

Figure 10.



Transmitter section :

The main parts of the transmitter section are a source (either a **LED** or a **LASER**), efficient coupling means to couple the output power to the fiber, a modulation circuit and a level controller for LASERs. In present days, for longer repeater spacing, the use of single mode fibers and LASERs are seeming to be essential whereas the earlier transmitters operated within 0.8µm to 0.9µm wavelength range, used double hetero structure LASER or LED as optical sources. High coupling losses result from direct coupling of the source to optical fibers. For LASERs, there are two types of lenses being used for this purpose namely **discrete lenses** and **integral lenses**.

LED vs LASER as optical source :

A larger fraction of the output power can be coupled into the optical fibers in case of LASERs as they emit more directional light beam than LEDs. That is why LASERs are more suitable for high bit rate systems. LASER is more temperature dependent than LED. LASERs have narrow spectral width as well as faster response time. Consequently, LASER based systems are capable of operating at much higher modulation frequencies than LED based systems. Typical LEDs have lifetimes in excess of 10^7 hours, whereas LASERs have only 10^5 hours of lifetime. Another thing is that LEDs can start working at much lower input currents which is not possible for LASERs. So, according to the situation and requirements either LED or LASER can be utilized as an optical source.

Now there are a number of factors that pose some limitations in transmitter design such as electrical power requirement, speed of response, linearity, thermal behavior, spectral width etc.

Drive circuitry :

These are the circuits used in the transmitters to switch a current in the range of ten to several hundred miliamperes required for proper functioning of optical source. For LEDs there are drive circuits like common emitter saturating switch, low impedance, emitter coupled, transconductance drive circuits etc. On the other hand for LASERs, shunt drive circuits, bias control drive circuits, ECL compatible LASER drive etc are noticeable.

Receiver section :

Receiver section includes Photodetector, low noise front end amplifier, voltage amplifier and a decision making circuit to get the exact information signal back. High impedance amplifier and Trans impedance amplifier are the two popular configurations of front end amplifier, the design of which is very critical for sensible performance of the receiver. The two most common photodetectors are **p-i-n diodes** and**avalanche photodiodes**. Quantum efficiency , responsivity and speed of response are the key parameters behind the decision of photodetectors. The most important requirements of an optical receiver are **sensitivity**, **bit rate transparency**, **bit pattern independence**, **dynamic range**,**acquisition time** etc. As the noise contributed by receiver is higher than other elements in the system so, we must put a keen check on it.

BENEFITS OF OPTICAL FIBER COMMUNICATION SYSTEM :

- Immense bandwidth to utilize
- Total electrical isolation in the transmission medium
    - Very low transmission loss,

- Small size and light weight,
- High signal security,
- Immunity to interference and crosstalk,
- Very low power consumption and wide scope of system expansion etc.

FIELDS OF APPLICATION :

Due to its variety of advantages optical fiber communication system has a wide range of application in different fields namely :

a. **Public network field** which includes trunk networks, junction networks, local access networks, submerged systems, synchronous systems etc.

b. **Field of military applications** ,

c. **Civil, consumer and industrial applications,**

d. **Field of computers** which is the center of research right now.