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TO STUDY LASER DIODE PARAMETERS IN FIBER OPTIC COMMUNICATION SYSTEM

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***Abstract*- In this paper we study laser diode parameters in fiber optic communication system and we study the relationship between them. The capacity of optical communication systems is rising exponentially in order to follow the rapidly increasing demand for data traffic. Limitations due to dispersion and non-linearity in the optical fiber become more stringent for higher bit rates.. In optical communication transmitters are light sources, receivers are light detectors and the channels are optical fibers. In optical communication the channel i.e., optical fiber plays an important role because it carries the data from transmitter to the receiver. Laser is a powerful source of light having extraordinary properties which are not found in the normal light sources like tungsten lamps, mercury lamps, etc..Laser surgery has also provided itself to be a preferred tool of operation over standard tools in a lot of the cases.**

Key Words: optical fiber, fiber optic communication, laser diode.

I. INTRODUCTION

Optical Fiber is a glass or plastic fiber that has the ability to guide light along its axis. Fibers are used instead of metal wires because signals travel along them with less loss and are also immune to electromagnetic interference Within the last 30 years, the transmission capacity of optical fibers has been increased enormously. The rise in available transmission bandwidth per fiber is even significantly faster than e.g. the increase in storage capacity of electronic memory chips, or in the increase in computation power of microprocessors. The transmission capacity of a fiber depends on the fiber length. The longer a fiber is, the more detrimental certain effects such intermodal or chromatic dispersion are, and the lower is the achievable transmission rate..[1]

A laser gets its name from how it works, Light Amplification by Stimulated Emission of Radiation. All lasers, including semiconductor based laser diodes, start with a small amount of light that is sent in to an optical cavity where it bounces around and stimulates more light. Once amplified, the light then leaves the optical cavity in a tight, coherent beam. In a laser diode, the initial light that starts the light amplification process comes from what is essentially an LED and the optical cavity is typically formed by either cleaving the crystal to form mirror like ends or by optically grinding, polishing and coating the sides of the optical cavity. Laser diodes require a certain amount of current to turn on and actively lase. The turn on current is usually very close to the maximum current the laser diode can handle which makes precisely controlling the current very important.[3]

II. OPTICAL FIBER

An optical fiber is a flexible, transparent fiber which is made of a pure glass silica. It functions like a waveguide to transmit light between the two ends of the fiber. Optical fibers are widely used in fiber-optic communications. Optical fiber transmits light over longer distances and at higher bandwidths. Optical fiber consists of a transparent core which is surrounded by a transparent cladding material. Refractive index of cladding is lower than the refractive index of core. Optical fibers are good for communication because they are inexpensive to produce, they do not conduct electricity, they do not corrode and also they are small in size. Optical fibers are of two types- single-mode fibers and multi-mode fibers. Optical Fibers that supports many propagation paths are known as multi-mode fibers while the optical fibers that supports only a single mode are known as single-mode fibers .Single-mode fibers are used mostly for communication links longer than 1,050 meters.[1]

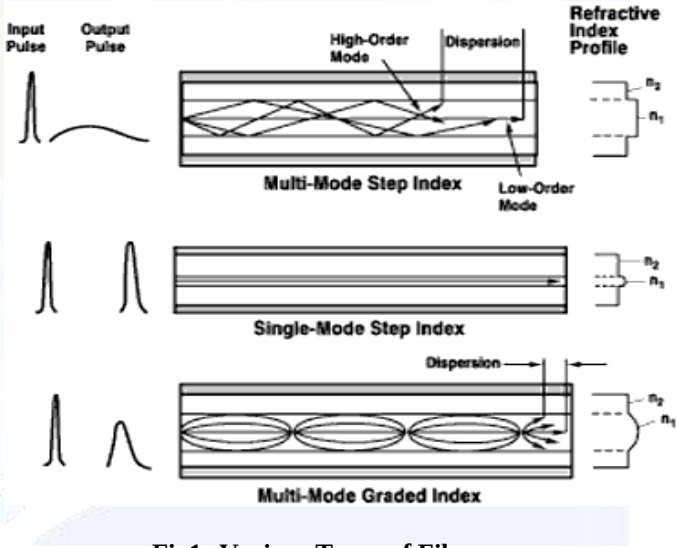

Fig1:-Various Types of Fibers

III. FIBER OPTIC COMMUNICATION

Fiber-optic communication is a method of transmitting information from one place to another by sending pulses of light through an optical fiber. In Fiber optic communication, the light forms an electromagnetic carrier wave which is modulated to carry information.

The process of communication using fiber-optics involves the following basic steps:

1. Creating the optical signal involving the use of a transmitter.,

2. Relaying the signal along the fiber.
3. Ensuring that the signal does not become too distorted or weak.
4. Receiving the optical signal, and
5. Converting it to an electrical signal.[2]

IV. LASER DIODE

LASER: Light Amplification by Stimulated Emission of Radiation

A laser is a device that produces optical radiation by the process of stimulated emission. Laser beam produces a coherent light and is highly monochromatic while the intensity of ordinary light sources decreases rapidly with distance. Also laser beam is extremely intense and does not diverge. Laser beams can be focused to very tiny spots, achieving a very high irradiance. Three major components of laser are: energy source, active medium, optical resonator[3]

A laser diode is formed by doping a very thin layer on the surface of a crystal wafer. The crystal is doped to produce an n-type region and a p-type region, one above the other, resulting in a p-n junction, or diode. Forward electrical bias across the laser diode causes the two species of charge carrier – holes and electrons – to be "injected" from opposite sides of the p-n junction into the depletion region. Holes are injected from the p-doped, and electrons from the n-doped, semiconductor. A depletion region, devoid of any charge carriers, forms as a result of the difference in electrical potential between n- and p-type semiconductors wherever they are in physical contact. Due to the use of charge injection in powering most diode lasers, this class of lasers is sometimes termed "injection lasers," or "injection laser diode" (ILD).

As diode lasers are semiconductor devices, they may also be classified as semiconductor lasers. Either designation distinguishes diode lasers from solid-state lasers.

Fig 2: Structure Of Laser Diode

V. WORKING OF LASER DIODE

A. PRINCIPLE OF LASER ACTION

Every atom, according to the quantum theory, can have energies only in certain discrete states or energy levels. Normally, the atoms are in the lowest energy state or ground state. When light from a powerful source like a flash lamp or a mercury arc falls on a substance, the atoms in the ground state can be excited to go to one of the higher levels. This process is called absorption. After staying in that level for a very short duration (of the order of 10-8 second), the atom returns to its initial ground state, emitting a photon in the process, This process is called spontaneous or a emission. The two processes, namely, absorption and , spontaneous emission, take place in a conventional light source, In case the atom, still in Its urns to excited state, is struck by an outside photon having precisely the energy necessary for spontaneous emission, the outside photon is augmented by the one given up by the excited atom, Moreover, both the photons are released from the same excited state in the same phase, This process, called stimulated emission, is fundamental for laser action .Thus, the atom is stimulated or induced to give up its photon earlier than it would have done ordinarily under spontaneous emission, The laser is thus analogous to a spring that is wound up and cocked, It needs a key to release it, In this process, the key is the photon having exactly the same wavelength as that of the light to be emitted.

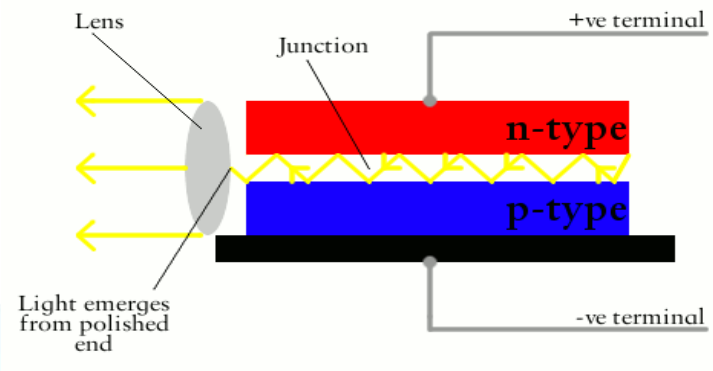

Fig.2 Working of laser diode.

VI. LASER DIODE PARAMETERS

1 .DISTANCE:

Distance is defined as the space between two objects.i.e. how far the objects are from each other.

$$d=\sqrt{(\Delta x)^2}$$

$$d=\sqrt{(x2-x1)2}$$

2. FIBER LENGTH:

Fiber length is the length of the fiber which is spread out at a particular distance. fiber length is the length which is spread out for transmitting the signal from transmitter end to the receiver end so that communication between two devices takes place.

RELATION BETWEEN DISTANCE AND FIBER LENGTH:.

As distance increases fiber length also increases
.i.e. if distance becomes longer and longer then length of the fiber will also increases.
i.e. distance is directly proportional to the fiber length.

$$D \alpha FL$$

3. POWER:

Power is the rate at which energy is transferred from one object to another object.

As we know,

$$P=V I$$

Where

P is the power
V is the voltage
I is the current

As we know,

$$V= IR$$

Where

R is the resistance from where current is passed

So,

P=R

4. POWER CONSUMPTION:

It is the power or energy consumed by the object to do its operation. as an object goes far away then it will use more power i.e. it will consume more power to do its operation.

So it means distance increases power utilization also increases.

i.e fiber length increases so power penalty increases so power consumption also increases.

RELATION BETWEEN FIBER LENGTH AND POWER CONSUMPTION:

If fiber length increases then power utilization also increases

i.e. if length of fiber is more then power consumed will be more.

FLα PC

VII. ADVANTAGES OF LASERS

1. Small size and weight: A typical laser diode measures less than one millimeter across and weighs a fraction of a gram, making it ideal for use in portable electronic equipment.

2. Low current, voltage, and power requirements: Most laser diodes require only a few mill watts of power at 3 to 12 volts DC and several mill amperes. Therefore, they can operate using small battery power supplies.

3 .Low intensity: A laser diode cannot be used for spectacular purposes such as burning holes in metal, bringing down satellites, or blinding aircraft pilots. Nevertheless, its coherent output results in high efficiency and ease of modulation for communications and control applications.

4. Wide-angle beam: A laser diode produces a "cone" rather than a "pencil" of visible light or IR, although this "cone" can be collimated using convex lenses[3].

VIII. TOOLS USED

MATLAB® is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. MATLAB is an interactive system whose basic data element is an array that does not require dimensioning. This allows you to solve many technical computing problems, especially those with matrix and vector formulations, in a fraction of the time it would take to write a program in a scalar noninteractive language such as C or Fortran. The name MATLAB stands for matrix laboratory. MATLAB was originally written to provide easy access to matrix software developed by the LINPACK and EISPACK projects.

IX. SIMULATION RESULTS

If fiber length increases then power utilisation also increases.

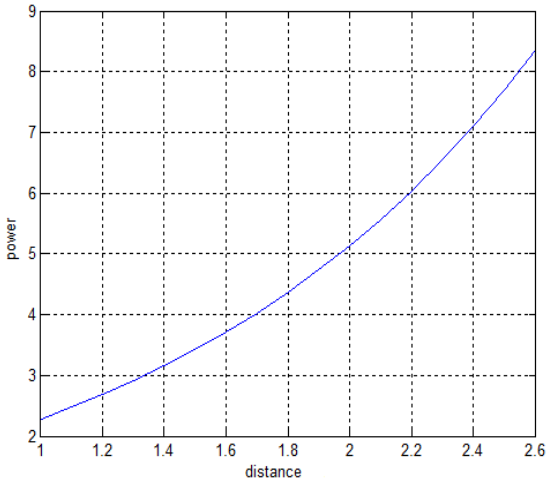

Fig:3 Shows the relation between power and distance.

As fiber length goes on increasing i.e. when communication takes place at longer distances then the energy or power used as input gets utilized more and more. As shown in figure that as distance increases power utilization also gets increased which is not beneficial for the system. to make it beneficial or to make it as power conservative we should first decrease the dispersion between the optical fiber.

X CONCLUSION

In this paper we studied various laser diode parameters like distance, fiber length, power and power consumption and we have studied the relationship between them.

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