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Optical Fibers-Principles and Applications

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Abstract: **The optical fiber Sagnac interferometer was first demonstrated over 25 years ago. Immediately its potential for gyroscopic measurements became apparent and since the first demonstration substantial research and development investment has evolved a diversity of rotation measuring instruments. The fiber Sagnac interferometer has, however, also ventured into unexpected domains. The fiber loop mirror has become the ubiquitous reflector. Sagnac-based intruder alarms, hydrophones, geophones and current measuring systems have emerged. The Sagnac interferometer has expanded from the rotation measuring instrument into a very versatile sensing tool. Indeed, it is arguably the most successful of optical fiber sensing technologies. In this paper, we review both the principles and applications of the fiber Sagnac interferometer. The background theory highlights the need to understand the conditions for reciprocity within the interferometer network. The applications range from the expected gyroscopes into novel hydrophone arrays and intruder detection systems. The basic interferometer is now well understood and the engineering required to realize useful and effective instruments has been carefully defined. Its versatility though continues to amaze even the most experienced practitioner and doubtless its applications potential will continue to expand.**

Keywords: **Sagnac, ubiquitous.**

4. INTRODUCTION

An optical fiber is a flexible,fiber made of high quality extruded glass or plastic ,slightly thicker than a human hair.It can function transparent as a wavelength,or light pipe to transmit light between the two

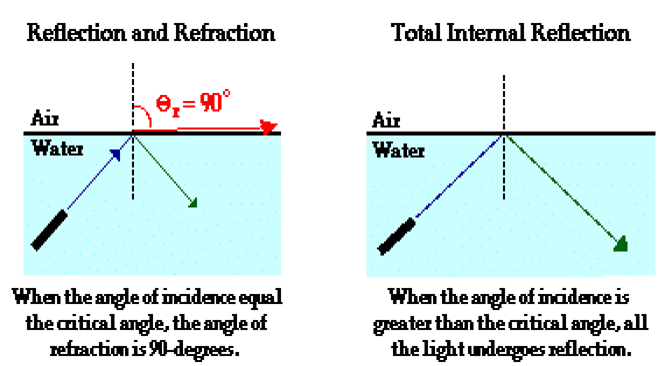
Ends of the fiber.The field of applied science and engineering concerned with the optic design and application of optical fibers is known as fiber optics.optical fibers are widely used in fiber-communications,which permits transmission over longer distance and at the higher bandwidths than other forms of communication.Fibers are used instead of metal wires because signals travel along them with less loss and are also immune to electromagnetic interference.Fibers are also used for illumination,and are wrapped in bundles so that they may for variety of other applications,including sensors and fiber lasers.They are used as light guides in medical and other applications where bright light needs to be shone on a target without a clear line-of-sight path.many microscopes use fiber-optic light sources to provide intense illumination of samples being studied.

1.1PRINCIPLES OF OPTICAL FIBER COMMUNICATION:-

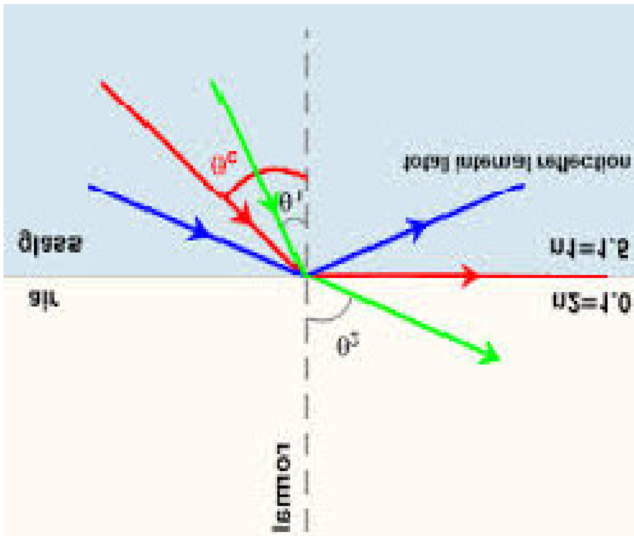
An optical fiber is a cylindrical dielectric wave guide that transmits light along its axis,by the process of total internal reflection.the fiber consists of core surrounded by a cladding layer,both of which are made of dielectric materials.to confine the optical signal in the core,the refractive index of the core must be greater than that of the cladding.The boundary between the core and cladding may either be abrupt,in step-index fiber,or gradual,in graded-index fiber.

1.2TOTAL INTERNAL REFLECTION:-

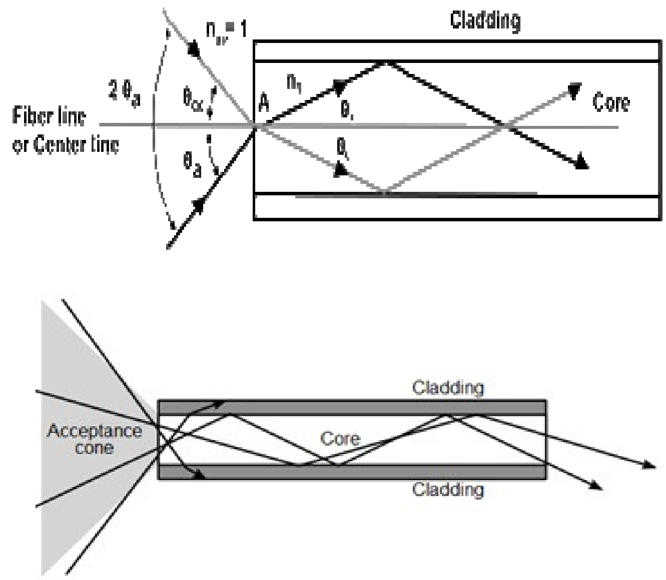
Total internal reflection is a phenomenon that happens when a propagating wave strikes a medium boundary at an angle larger than a particular critical angle with respect to the normal to the surface.if the refractive index is lower on the other on the other side of the boundary and the incident angle is greater than the critical angle,the wave cannot pass through and is entirely reflected.The critical angle is the angle of incidence above which the total internal reflection occurs.This is particularly common as an optical phenomenon,where light waves are involved,but it occurs with many types of waves are involved,but it occurs with many types of waves,such as electromagnetic waves in general or sound waves.



(Fig.1.1-Diagram for the total internal reflection)



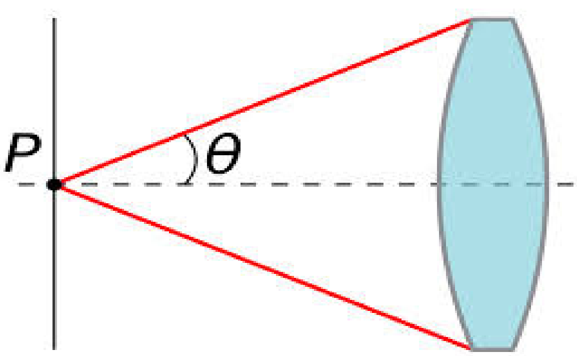
Total (Fig.1.2-Principle of internal Reflection)



(Fig.1.3 Acceptance angle and acceptance cone of fiber)

1.3ACCEPTANCE CONE AND NUMERICAL APERTURE:

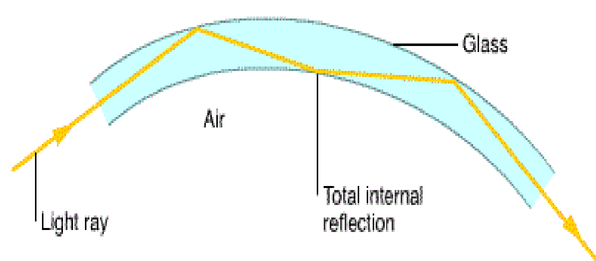
When light traveling in an optically dense medium hits a boundary at a steep angle(larger than the critical angle for the boundary),the light is completely reflected.this is called total internal reflection.This effect is used in optical fibers to confine light in the core.Light travels through the fiber core,bouncing back and forth off the the boundary between the core and cladding.Because the must strike the boundary with an angle greater than the critical angle,only light that enters the fiber within a certain range of angles can travel down the fiber without leaking out.This range of angles is called the acceptance cone of the fiber.The size of this acceptance cone is a function of the refractive index difference between the fiber's core and cladding.In simpler terms,there is a maximum angle from the fiber axis which light may enter the fiber so that it will propagate,or travel,in the core of the fiber.the sine of the maximum angle is the numerical aperture(NA)of the fiber.Fiber with a larger NA requires less precision to splice and work with than fiber with a smaller NA.Single-mode fiber has a small NA.



A multi-mode optical fiber will only propagate light that enters the fiber within a certain cone,known as the acceptance cone of the fiber.The half-angle of this cone is called the acceptance angle.For step index fiber multi mode fiber,the acceptance angle is determined only by the indices of refraction of the core and the cladding.

1.4 FIBER OPTIC CABLE

Fiber optics uses this property of light beams focused Fig(1.4) without significant loss.The light enters the glass cable,and as long as the bending is not too sudden,will be totally internally reflected when it hits the sides,and thus is guided along the cable.Fig(1.4)This is used in telephone and cable TV cables to carry the signals.Light as an information carrier is much faster and more efficient than electronics in an electric current.Also,since light rays don't interact with each other,it is possible to pack a large number of different light signals in to the same fiber optics cable without distortion.



(Fig:-1.4 Fiber optic cable)

1.5 STRUCTURE OF FIBER OPTIC CABLE

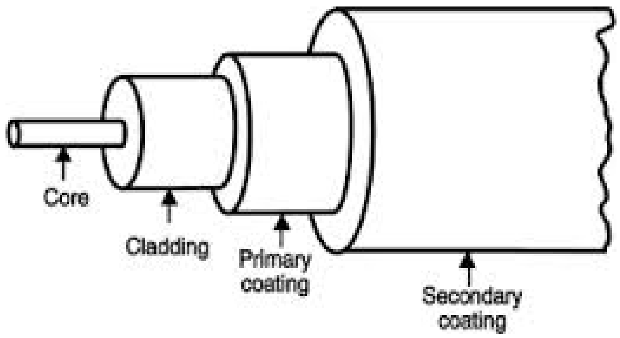


Fig:1.5 Structure of fiber optic cable

This cylinder is known as core of the fiber.The core is surrounded by a solid dielectric called cladding.Although,cladding is not necessary for light to propagate along the core of the fiber, it serves several purposes.(a)The cladding reduces scattering loss that results from dielectric discontinuities at the core surfaces,(b)it adds mechanical strength to the fiber,and,(c)it protects the core from absorbing surface contaminants with which it could come in contact.The fiber must be cabled-enclosed within a protective structure.This usually includes strength members and an outer jacket.The most common strength member is Kevlar aramid yarn,which adds mechanical strength.During and after installation,strength members provide crush resistance and handle the tensile stresses applied to the cable so that the fiber is not damaged.Steel and fiber glass rods are also used as strength members in multifiber bundles. consists of a dielectric core(usually doped silica) of high refractive index surrounded by a lower refractive index cladding.

Two types of rays can propagate along an optical fiber.The first type is called meridional rays.Meridional rays are rays that passes through the axis of the optical fiber.Meridional rays are used to illustrate the basic transmission properties of optical fibers.The second type is skew rays.Skew rays are rays that travel through an optical fiber without passing through it axis.Meridional rays can be classified as bound or unbound rays.Bound rays remain in the core and propagate along the axis of the fiber.Bound rays propagate through the fiber by total internal reflection.Unbound rays are refracted out of the fiber core.Skew rays are not confined to a single plane ,but instead tend to follow a helical-type path along the fiber.These rays are more difficult to track as they travel along the fiber,since they do not lie in a single plane.

Light injected into the core and striking the core-to-cladding interface at an angle greater than the critical angle will be reflected back into the core.Since angles of incidence and reflection are equal,the light ray continues to zig-zag down the length of the fiber.The light is trapped with in the core.Light striking the interface is less than the critical angle passes into the cladding and is lost.

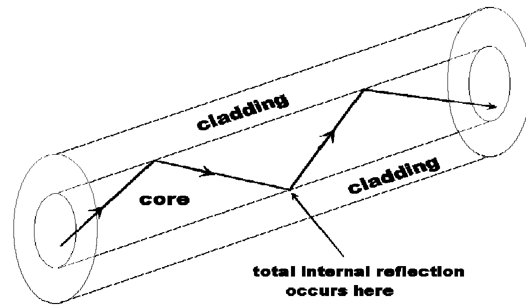


Fig:1.6

1.6 CLASSIFICATIONS OF OPTICAL FIBERS:

i).CLASSIFICATION OF FIBER ON THE BASIS OF MATERIAL:

1. Glass fiber(e.g:silicon dioxide)
2. Plastic fiber (e.g:PMMA-Co-polymer,polystyrene-PMMA)

ii).CLASSIFICATION BASED ON NUMBER OF MODES:

1. Single-Mode Fiber Optic
2. Multi-Mode Fiber Optic

iii).CLASSIFICATION BASED ON REFRACTIVE INDEX:

1. Step index fiber
2. Graded index fiber

1.7 ENGINEERING APPLICATIONS OF OPTICAL FIBER:

Optical fiber is used by many telecommunications companies to transmit telephone signals,Internet communication,and cable television signals.Due to much lower attenuation and interference,optical fiber has large advantages over existing copper wire in long-distance and high-demand applications.However,infrastructure development within cities was relatively difficult and time consuming,and fiber-optic systems were complex and expensive to install and operate.

Due to these difficulties, fiber-optic communication systems have primarily been installed in long-distance applications, where they can be used to their full transmission capacity, offsetting the increased cost.Since 2000, the prices for fiber-optic communications have dropped considerably.

These price for rolling out fiber to the home has currently become more cost-effective than that of rolling out a copper based network.

i)TELECOMMUNICATION:

Telecommunication applications are widespread,ranging from global networks to desktop computers.These involve the transmission of voice,data,or video over distances of less than a meter to hundreds of kilometers,using one of a few standard fiber design in one of several cable designs.

ii)NETWORK:

Carriers use optical fiber to carry plain old telephone service (POTS)across their nationwide networks.Local exchange carriers(LECS) use fiber to carry this same service between central office switches at locals levels,and sometimes as far as the neighborhood or individual home.

iii)TRANSMISSION:

Optical fiber is also used effectively for transmission of data.Multinational firms need secure,reliable systems to transfer data and financial information between buildings to the desktop terminals or computer and to transfer data around the world.Cable television companies also use fiber for delivery of digital video and data services.The high bandwidth provided by fiber makes it perfect choice for transmitting broadband signals,such as high-definition television(HDTV) telecasts.

Intelligent transport systems,such as smart highways with intelligent traffic lights,automated tollbooths,and changeable message signs,also use fiber-optic-based telemetry systems.

REFERANCE

[1] Dr.Ravichandran,Professor,Sathyabama university,chennai,Tamilnadu