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Characteristics of TE_{01} mode in optical fiber communication link.

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Abstract:- *TE_{01} mode has the largest confinement for all values of R and approaches to 100% at a faster rate than the other modes. This can be compared with other modes. TE_{01} loss smaller than that of the other modes is very important for the transmission properties of optical fiber and is used effectively for low-loss power transport through waveguides over large distances.Hence information carrying capacity of the optical fiber communication link in TE_{01} mode is greater compared to other modes.*

***Keyword**:- Optical fiber, Communication link, Optical frequency, TE_{01} mode.*

Introduction: Since optical waves travels in a fiber are parallel to the axis of the fiber core, so there is variation of E and B fields in transverse direction modes occur in fibers to confine light waves in optical fiber. As micro waves propagate in a wave guide in the same manner optical fiber propagates through optical fiber at a much higher frequency. The TE_{01} mode is the lowest loss mode of the fiber. Its low- loss property is due to the azimuthally polarization which causes the field to be zero at the metal boundary. The TE_{01} mode is different from the other four modes in which its electric field energy density has a mode near the cave mirror interface. This is true in general for all modes of same symmetry and this mode is shown in fig-2

In fact TE_{01} mode is the lowest loss mode in a metal waveguide due to the presence of a mode in the electric field at the metallic wall. This mode was the operating modes for the long distance communication lines. TE_{01} modes have the largest confinement for all values of R. Furthermore, its confinement in the core approaches 100% at a faster rate than the other modes. The penetration of the TE_{01} field into the multilayer configuration is very well approximated by a $1/R^3$ dependence.

Another reason for the low losses of the TE_{01} mode is the fact that this mode is confined in the core only by the TE gap. The fact that the TE_{01} loss is smaller than that of the other mode is very important for the transmission properties of the optical fiber. Even if several modes are excited at the input of a waveguide after a certain distance only the TE_{01} mode will remain in the waveguide. This loss induced modal discrimination results in an effectively single, mode operation in a waveguide that supports many modes. The $1/R^3$ dependence of the TE_{01} dissipation loss is due to the presence of a mode in the electric field of this mode near the interface between the hollow core and the first layer of the dielectric mirror.

Proposed work:- For practical applications, it is of interest to identify the losses associated with the different modes of the waveguide. Metallic waveguides were the subject of intensive research aimed at utilizing them for long-distance optical communications. It was found that the TE_{01} mode is the lowest-loss mode in a metal waveguide due to the presence of a node in the electric field at the metallic wall. This mode was the operating mode for the long-distance communication lines designed by the Bell Laboratories prior to the advent of silica fibers [1].

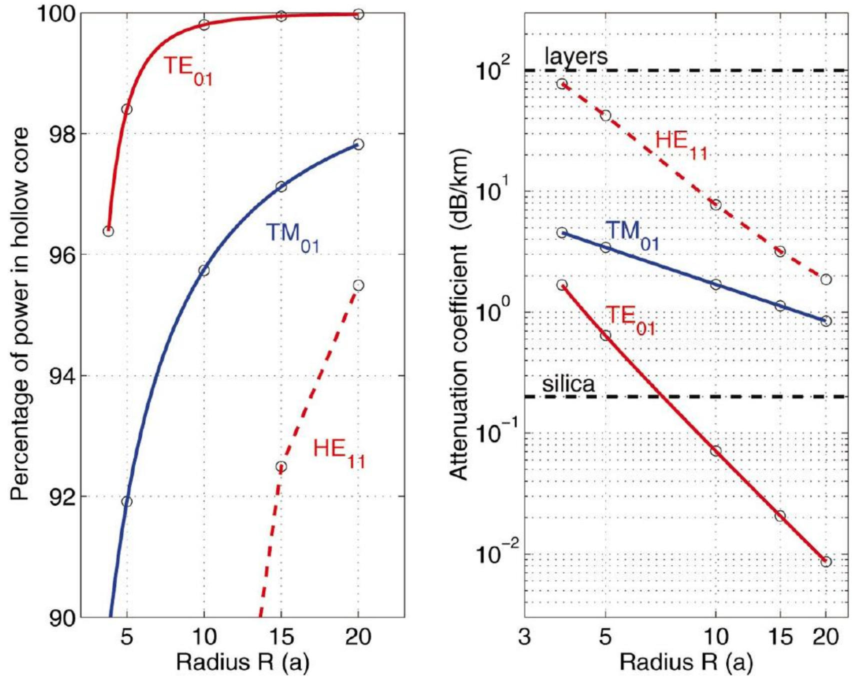

Fig- 1 : The figure shows that TE_{01} mode has the largest confinement for all values of R and approaches to 100% at a faster rate than the other modes that establishes its characteristics.

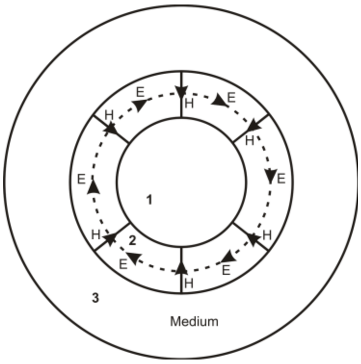

Fig 2 : Co-axial $TE_{01,}$ mode (dotted circles represent optical beam couplings areas)

In the left panel of Fig-1, we plot the confinement in percent of the electromagnetic energy in the core for the TE_{01}, TM_{01}, and HE_{11} modes as a function of the core radius for a fixed frequency ω=0.256($2\pi/a$). As shown, the TE_{01} mode has the largest confinement for all values of *R*. Furthermore, its confinement in the core approaches 100% at a faster rate than the other modes. The penetration of the TE_{01} field into the multilayer structure is very well approximated by $1/R^3$ dependence. A fit to the actual data points (open circles) is shown in Fig- 1 the TM_{01} confinement approaches 100% at a much slower rate. The HE_{11} mode has a mixed polarization and has a more complex variation with the core radius. However, the rate at which its confinement approaches 100% is less than that of the TE_{01} mode.

In the right panel of Fig-1 we plot the attenuation coefficient caused by dissipation losses for the three modes. (We assume that the dielectric mirror has enough layers such that the radiation losses are negligible). We assume the core of the waveguide is lossless, while the materials in the dielectric mirror have a dissipation coefficient of 100 dB/km (chosen to much larger than the loss of silica). Even with such loss materials in the dielectric mirror, the loss of the TE_{01} mode is smaller than the loss of silica fibers (0.2 dB/km) if the core radius *R* is larger than ≈8*a*. This is because the dissipation loss for $TE_{0\ell}$, (ℓ=1,2, . . .) modes decreases as $1/R^3$. This general result is a consequence of the presence of a node in the electric field near the core-mirror interface. Here we note that while the silica fiber has a very low loss only for wavelengths near λ=1.55 µm, the Optical fiber can be designed to have a very low loss in the vicinity of any desired wavelength, from infrared to visible wavelengths.

Result and Discussion:- TE_{01} is the lowest-loss mode within the $TE_{0\ell}$, family of modes. We can show that the loss of a $TE_{0\ell}$, mode is proportional to the square of the transverse wave vector in the core, $k_{T,core}$. This implies a monotonic increase of the loss with the order ℓ. In particular, the loss of TE_{02} is about 3.3 times larger than that of TE_{01} for almost all frequencies and core radii.

For modes other than the $TE_{0\ell}$, modes, the absence of the node in the electric field near the core-layer interface results in more penetration of the field into the cladding, and also different scaling laws for the *R* dependence. In theFig-1, we see that the TM_{01} dissipation loss follows exactly a $1/R$ dependence while the loss of HE_{11} has some intermediate dependence with a slope that approaches $1/R$ for large *R*.

Another reason for the low losses of the TE_{01} mode is the fact that this mode is confined in the core only by the TE gap. TM modes and mixed modes have a component that is confined by the weaker TM gap, and thus they penetrate deeper into the multilayer cladding.

The fact that the TE_{01} loss is smaller than that of the other modes is very important for the transmission properties of Optical fiber. Even if several modes are excited at the input of a waveguide, after a certain distance only the TE_{01} mode will remain in the waveguide. This loss-induced modal discrimination results in an effectively single-mode operation in a waveguide that supports many modes. In our analysis, we assumed that the number of layers in the dielectric mirror is large enough such that radiation losses can be neglected. By choosing the number of layers appropriately, the loss induced modal discrimination can be further enhanced since the radiation losses are also the smallest for TE_{01}. [4,5,8]

While the radiation and absorption losses of the TE_{01} decrease substantially when the core radius is increased, the analysis of attenuation in a practical waveguide necessitates the consideration of other loss mechanisms. In particular, the loss of the TE_{01} mode is increased by coupling to other resonant modes or to cladding modes due to deviations from a straight and perfect waveguide [4]

Conclusion:- We identified the TE_{01} mode as the lowest-loss mode in the dielectric waveguide, as it was the case for the metal waveguide. It is hoped that the analogy developed in this paper has provided an intuitive understanding of the modal configuration of fiber and could be applied to the design of transmission lines or optical devices based on this type of fiber. As the loss is minimum information carrying capacity of the optical fiber communication link will be higher to meet our today's demands.

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