

A STUDY OF THE PROPAGATION CHARACTERISTICS OF SINGLE  
MODE AND DUAL MODE OPTICAL FIBERS

by

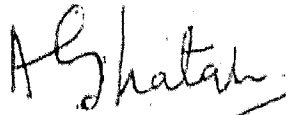
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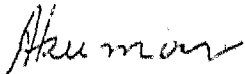
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### ABSTRACT

Due to the absence of intermodal dispersion single mode fibers are considered to be the most suitable transmission media for high bandwidth optical communication systems. Most of these fibers are graded index and therefore extensive research work is going on the propagation characteristics of graded index single mode fibers. Since exact solutions of the wave equation for such fibers do not exist, we have studied their propagation characteristics using scalar variational method. Single and two parameter variational trial fields approximating the fundamental mode propagating in such fibers have been presented. Our single parameter analysis involves computational effort comparable to that involved in the Gaussian approximation and yet gives much better results. The two parameter analysis gives much better estimates of the propagation characteristics as compared to other existing approximations throughout the single mode range.

Next, using these variational approximations for the modal field, we have presented a method for the evaluation of splice loss in single mode graded index fibers. Splice losses for angular and transverse offsets have been expressed in analytical forms which are quite easy to evaluate. A comparison of our results with those obtained using the Gaussian approxi-

mation is also presented which on comparison with exact results shows that our method is much more accurate than the latter. It has been observed that some authors calculate total dispersion in single mode fibers from the solution of vector wave equation, while others solve the scalar wave equation to compute dispersion. We have obtained total dispersion in single mode fibers using these two approaches and have discussed the accuracy of scalar approximation. We have shown that for larger values of relative difference between maximum core index and cladding index, although the fractional difference between the total dispersion obtained by the two approaches differ appreciably in the vicinity of zero dispersion, the optimum core radii and the zero dispersion wavelengths obtained by the two methods differ negligibly for all practical purposes.

Dual mode fibers have emerged as a promising alternative to single mode fibers because they can have a relatively larger core radius which facilitates jointing and splicing and still provide transmission bandwidths comparable to single mode fibers. In the next part of our work we have presented accurate analytical approximations for the modal fields of dual mode optical fibers with power law profiles based on a scalar variational analysis. Single parameter and two parameter trial functions for the  $LP_{11}$  mode have been

presented. Our results show that the relatively simple single parameter field gives a good fit to the field inside the core and estimates the propagation constant fairly well, but is inadequate to calculate the dispersion characteristics. On the other hand, the two parameter field estimates all these characteristics with a high degree of accuracy and enables one to accurately compute the normalised frequency corresponding to zero intermodal dispersion which defines the operating point for such fibers.

Finally, we have developed an exact analysis to find out the complex propagation constants of various guided modes in a weakly guiding lossy optical fiber. We have also developed a first order perturbation theory to see the effect of absorption in such a fiber and the results so obtained are compared with the exact results. Since the photoreceptors behave as lossy optical waveguides, such studies should be of considerable interest in photoreceptor optics also.

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