CONCLUSION AND SUGGESTIONS FOR FURTHER WORK

5.1. Conclusion

Fifteen years ago it was estimated that it is necessary to reduce fibre transmission losses below 20 dB/Km in order to produce an economically viable optical fibre transmission system, but this target seemed to be very distant and difficult one. To-day it is relatively common place and has been met by a range of materials and configurations. In fact it is now realistic to assume transmission losses of the order of 1 dB/Km and even less. Complete optical fibre system performance has been studied in the field environment. The valuable experience has been gained of installation in standard duct and with live telephone traffic, large scale applications are foreseen as the cost increases in future when the use of optical fibre system is expanded into distribution networks.

Several significant technological achievements in the development of laser diodes fibres, couplers and splicers have resulted in intensified interest in transmission. This technology will certainly result in achievement of considerably higher transmission bandwidth. Optical fibre systems offer economic and performance
advantage over existing system products, which can be regarded as replacement technology. Types of applications include telephone inter office links, satellite entrance link, military base communication, intracity trunking, railway communication, long haul and under sea system, power and utility communication. The optical fibre systems offer unique characteristics to achieve systems which fulfill demands at affordable cost. This is created due to the performance capability of optical fibre systems. The development in system technology requires its own specific requirements. Fibres and cables should have lower cost consisting with performance in loss and dispersion, to provide a given bit rate repeaterless spacing or repeater spacing to fulfill the given requirement, long operational life and adequate strength for under sea applications. Sources should have long life, high reliability, spectral control, high power, good coupling efficiency and wide temperature ranges. Detectors should have low noise and high speed. Components should have low insertion loss, high stability couplers and optical switching elements.

The wavelength division multiplexing technology is considered as promising method to increase the capacity and flexibility of a fibre link. Main problem on a transmitting side is to produce a beam of high definition and
wavelength of high temporal stability. Another problem is the production of thin layer structures with requisite accuracy. W.D.M. can be widely applied to short haul and long haul transmission applications. W.D.M. also enhances filter system design. It is necessary to improve various performances of sources, multiplexers and demultiplexers (interference filter and defraction rating).

Performance of systems employing W.D.M. and also the developments in W.D.M. multiplexers and demultiplexers have been reported [2], [3], [6], [7], [21], [62], [72], [81], [84], [102], [115], [116], [121], [156], [170], [178], [182].

Fibre optic cable reliability data has been reported for number of practical systems [165]. The reliability is excellent but some failures have been reported. Since the largest numbers of fibre failure are reported in cables cut by back holes, restoration equipment and procedures become necessary to minimise service outage. A procedure has also been described which means the dual requirements of rapid temporary restoration and easy transition to final repair. Empirical formulas are derived for the cost of an optical fibre as the function of attenuation constant, bandwidth and core diameter [37], [55]. These formulas are useful for a system designer to minimize the system cost.
for the components at a given bit rate and link length. A comparison of maintenance cost between copper cable systems equipped for P.C.I. transmission and optical cable system has been reported [162]. The factors compared include man hours and equipment repair cost. Equipment failures are analyzed in terms of frequency of occurrence impact on system operation and the number of units related to the system.

In future systems the possibility of operation at longer wavelength is of great interest. There are two main reasons for this. The first reason concerns the loss of optical fibres. The loss is controlled by absorption from glass materials. Second reason is that the first order material dispersion goes through zero at the wavelength concern, the exact value of which depends upon the actual constituents of the fibre used. There is a possibility of transmitting a number of separate wavelengths through a single fibre, each carrying a separate information channel quite dependent of the other. The principle can be extended to a transmission on a single fibre. The number of channels that can be carried depends on several factors such as line width and line shape of the source, single mode or multi-mode fibre, dispersive properties of multiplexer, insertion
loss, reflection coefficient, cost of component and availability of suitable components. With the freedom of design in the fibre system it is possible to use star or Tee couplers in a wideband data highway communication. Such systems may find application in computer systems, aircrafts and ships, instrumentation systems and in fact in any system in which data has been transferred between a number of processors.

For an on-off keying system the likelihood ratio test consists of evaluating the likelihood ratio for particular realisation of the observed data and then comparing with their threshold. The threshold is given in terms of the intensities \( \lambda_1 \). The receiver circuit is simple to implement. In the case of binary pulse position modulation the strategy involves the counting of the photo electrons in the specified interval of time and the probability of error is also given in terms of signal photo electron and noise photo electron counts. This has been extended to the M-ary case, where the probability of error bound can be easily found in terms of the signal and noise counts and M. In binary phase shift keying the receiver strategy is given in terms of the sub-carrier frequency, incident power, the photo detector parameters and the counting process.
The probability of error bound, in this case also, is given in terms of above parameters. This bound expression has been further simplified by assuming $m \ll 1$ which gives a simplified expression in terms of detector parameters and parameter $\tau$ the value of which satisfies a derived equation.

Signal to noise ratio has been derived in terms of the intensity process, filter response functions and the statistics of the photo detector multiplication process. It has been found that for an unmodulated optical carrier and for detectors without gain the equivalent noise bandwidth of the filter and the statistics of multiplication process are the only deciding factors for the signal to noise ratio. For photo multipliers and Avalanche photo detectors, signal current, background current and dark current also decide the signal to noise ratio performance. An expression for repeater spacing in terms of signal-to-noise ratio for different input pulse shapes is also derived. This shows that the repeater spacing depends on number of factors and can be found for a given value of transmission frequency, signal-to-noise ratio, bit rate and noise figure of the receiver.

The decoding strategy for sub-carrier modulated phase shift keying has been derived. It is found
that the function of the decoder is to observe the counts
during specific interval, to compute the likelihood ratio
and to determine the maximum value. This likelihood ratio
is the discrete correlation of the counts with the log
intensity parameter. The hardware interpretation is also
possible. The decoding strategy for sub-carrier modulated
frequency shift keying has also been derived. The decoder
structure presented is optimum in the sense that it gives
the maximum a posteriori probability. In this case also
the hardware implementation is physically realizable.

5.2. Scope for further work

Much work has not been reported in the wavelength
region of 1.3 µm and beyond. It will be worth while to
study the performance of the optical system in this reg-
ion. Keeping in view the recent developments in the field
of semiconductor injection lasers and photo detectors,
the proposal seems to be feasible there is also growing
trend in fabrication of very low loss optical fibres
which is a further impetus towards the development of
such systems. It has also been noticed that by using wav-
length division multiplexing techniques it is possible
to transmit different types of messages, say voice, video
and data through one single fibre only. Such techniques
may prove to be useful for tele-trafficking and for local
and distributed networks.

Random changes of intensity and phase of the optical signal due to fibre imperfections change the receiver performance and the decoding strategies, which can be looked into by considering appropriate characterization of the random changes. There is also a possibility of an interaction between various modes in multimode fibre which will completely degrade the receiver performance. The type of imperfection caused thereby has to be considered. This may result in complicated analytical treatment, but results will be useful for comparing with the practical results. The interaction may give different results for analog and digital communication systems.

The receiver performance of the optical system with binary keying techniques can be further studied for multilevel techniques. This can give an idea about the number of levels that may result in the optimum performance beyond which it will not be possible to improve the performance irrespective of the number of levels.

It would also be worth while to study the synchronization tracking acquisition and ranging systems with the help of optical digital phase locked loop and digital tan locked loops.

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