Analysis of Optical Code Division Multiple Access Networks and Strategies for Reduction of Optical Multi-user Access Interference

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Certificate

This is to certify that the thesis entitled **"Analysis of Optical Code Division Multiple Access Networks and Strategies for Reduction of Optical Multi-user Access Interference"** being submitted by Mr. Anand Srivastava to the Department of Electrical Engineering, Indian Institute of Technology, Delhi is the record of the bonafide research work carried out by him. He has worked under our supervision and guidance during the period December 1997 to August 2002. He has fulfilled all the requirements for submission of the thesis which has reached the requisite standard.

The results contained in this thesis have not been submitted either in part or in full to any other university or institute for the award of any degree or diploma.

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Abstract

In the research work reported in the thesis, the performance of asynchronous and synchronous OCDMA networks has been analysed in the presence of optical multiple access interference (OMAI), receiver noise and other impairments. Several strategies to reduce OMAI have been suggested. The following types of asynchronous networks are considered:

(i) Single wavelength with optical orthogonal codes (SWOOCs)

(ii) Wavelength code division multiple access with OOC (WaCDMA)

(iii) Multiwavelength optical orthogonal codes (MWOOCs)

(iv) Double hard-limiters single wavelength with OOC (DHLs)

(v) FEC coded with double hard-limiters single wavelength with OOC (FEC-DHLs)

The synchronous OCDMA networks studied are:

(i) With bit-stuffed unipolar m-sequence encoding (BSUME)

(ii) FEC coded with BSUME

In these networks, the receiver is considered to be a PIN-photodiode preceded by an optical amplifier (PIN+OA). However, the APD receiver has also been considered for SWOOCs, WaCDMA and MWOOCs networks. Expressions for the probability of error have been derived after taking into consideration the OMAI, optical amplifier noise and various sources of receiver noise. The numerical results have been computed for practical values of parameters. A comparative study of the various asynchronous networks is presented, followed by the corresponding comparison of synchronous networks. Finally, the best of asynchronous networks is compared with the best of synchronous networks.

Among the asynchronous networks, it is observed that for less number of simultaneous users i.e., N=12, the performance of WaCDMA networks with OOC is better than SWOOCs or MWOOCs based networks. This is due to

the reduced OMAI in the WaCDMA networks as a result of decrease in the number of simultaneous users per wavelength. For large number of users i.e., N=48 or 84, the required error rate of 10^{-9} is not attainable irrespective of any power level in SWOOCs networks and WaCDMA network. However, in MWOOCs based networks, this error rate is achievable but the required power level is quite high. The use of double hard-limiters (DHLs) does not give much advantage for N=12. But level of improvement is more when the number of users are large. This is a very important result from the practical point of view. It is because of the fact that for large number of users, OMAI is high and the optical hard-limiter by virtue of its limiting nature becomes more effective in reducing the effect of OMAI. Consequently, improvement in performance becomes more predominant when the number of users are large. When FEC and DHLs are used together, there is a marginal improvement of 1.3 dB in the performance. It is concluded that among the asynchronous category, OCDMA networks with FEC and DHLs give the best performance. In the two cases considered for synchronous networks, it is seen that the parallel cancellation scheme along with FEC coding provides the best performance.

It is observed that generally the optical synchronous CDMA networks perform better than asynchronous networks. When best of the synchronous networks (FEC coded with bit-stuffed unipolar m-sequence encoding) is compared with best of asynchronous networks (FEC coded with double hard-limiters single wavelength with OOC), the difference in performance is of the order of 10-12 dB.

The overall conclusion of the analysis is that for a given bandwidth expansion, synchronous OCDMA network with FEC coded bit-stuffed unipolar m-sequence code scheme will demand the minimum received power level. In other words, for a given power budget it will support the maximum number of subscribers as compared to other types.

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