Novel Strategies for Optimizing Optical WDM Network Performance

by

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Certificate

This is to certify that the thesis entitled **"Novel Strategies for Optimizing Optical WDM Network Performance"** being submitted by Mr. Shree Prakash Singh 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 January 2001 to December 2006. He has fulfilled all the requirements for submission of the thesis which has reached the requisite standard.

The results contained in the 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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SHREE PRAKASH SINGH

TO MAA SHARDA
WHO ENLIGHTENS HER DISCIPLES

Abstract

In this thesis, the effect of physical layer impairments (i.e., non-linear effect in optical fiber, amplified spontaneous emission (ASE) noise of amplifier and wavelength converter noise) on the performance of all-optical wavelength division multiplexed (WDM) network has been analyzed.

Four-wave mixing (FWM) is a dominant non-linear effect present in optical WDM networks using dispersion-shifted fiber when the channels are equally spaced. To reduce the FWM effect, the channels are made unequally spaced and this is called unequally spaced channel allocation scheme. However, this increases the bandwidth. To reduce the increase in bandwidth, periodically unequally spaced channel allocation scheme can be used. The modified PUSCA scheme has been proposed which results in fewer FWM components and a more efficient bandwidth utilization. To further reduce the number of FWM components, the paired PUSCA scheme has also been proposed. A figure of merit, defined as the ratio of decrease in number of FWM components generated to increase in bandwidth, has been used as a metric of performance.

This analysis is extended by considering the signal to FWM noise ratio for all frequency allocation schemes. This makes the analysis more realistic and relevant to practical systems. We have compared both the proposed methods by considering the ratio of increase in weighted average signal to FWM noise ratio to increase in bandwidth as a new figure-of-merit. Further, the performance of paired PUSCA scheme on G.653 fiber has been compared with equally spaced channel allocation (ESCA) scheme on G.652 fiber in which FWM is not a dominant non-linear effect.

Optical amplifiers are used in optical networks to amplify the attenuated optical signal. This increases the effective fiber span between the source

and the receiver. All optical amplifiers generate ASE noise which degrades the signal to noise ratio (SNR) and affects the performance of all-optical WDM networks. A detailed analysis on the effect of FWM and ASE noise on a WDM optical star network has been carried out. Erbium-doped fiber amplifier (EDFA) has been considered in the analysis. It has been used either as a booster amplifier, or in-line amplifier or as a preamplifier. Analysis for the evaluation of probability of error has been carried out (a) when only FWM is present and (b) when both FWM and ASE noise are present. Numerical results are presented in the graphical and tabular forms for the practical values of parameters. Finally, the optimal location of the amplifier in the network has been identified.

The effect of FWM and ASE noise in a WDM star network has been further extended by taking into account the effect of wavelength converter noise on the performance of an all-optical WDM tree network. Wavelength converters are placed at switching nodes to improve the blocking performance of network. The converter considered for analysis is based on FWM in semiconductor optical amplifier. This converter preserves amplitude, frequency and phase information, and is thus generally format independent. However, this converter has a drawback - the power of the converted signal depends on translation range. This means that, in these converters, for a particular input frequency, conversion to some output frequency results in an output signal which is significantly reduced. As wavelength conversion is achieved by means of optical amplifiers, each converter generates ASE noise also. The above mentioned effects further degrade SNR. Effect of wavelength converter on the performance on all-optical WDM tree networks has been analyzed. Analysis for the evaluation of probability of error has been carried out when (a) only thermal and shot noises are present, (b) thermal, shot, FWM and ASE noises are present and (c) thermal, shot, FWM, ASE and wavelength converter noises are present. Numerical results are presented for the practical values of parameters.

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