# Analysis, Design and Performance Evaluation of Optical Fiber Spectrum-Sliced WDM Systems

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ABSTRACT

This dissertation investigates the design and performance issues of a recently demonstrated technique, termed as spectrum-slicing, for implementing wavelength-division-multiplexing (WDM) in optical fiber systems. Conventional WDM systems employ laser diodes operating at discrete wavelengths as carriers for the different data channels that are to be multiplexed. Spectrum-slicing provides an attractive low-cost alternative to the use of multiple coherent lasers for such WDM applications by utilizing spectral slices of a broadband noise source for the different data channels. The principal broadband noise source considered is the amplified spontaneous emission (ASE) noise from an optical amplifier. Each slice of the spectrum is actually a burst of noise that is modulated individually for a high capacity WDM system. The stochastic nature of the broadband source gives rise to excess intensity noise which results in a power penalty at the receiver. One way to minimize this penalty, as proposed and analyzed for the first time in this work, is to use an optical preamplifier receiver.

It is shown that when an optical preamplifier receiver is used, there exists an optimum filter bandwidth which optimizes the detection sensitivity (minimizes the average number of photons/bit) for a given error probability. Moreover the evaluated detection sensitivity represents an order of magnitude ( > 10 dB) improvement over conventional PIN receiver-based detection techniques for such spectrum-sliced communication systems. The optimum is a consequence of signal energy fluctuations dominating at low values of the signal time bandwidth product (*m*), and the preamplifier ASE noise dominating at high values of *m*. Operation at the optimum bandwidth renders the channel error probability to be a strong function of the optical bandwidth, thus providing motivation for the use of forward error correction coding (FEC). System capacity (for BER = $10^{-12}$) is shown to be 23 Gb/s without coding, and 75 Gb/s with a (255,239) Reed Solomon code.

The effect of non-rectangular spectra on receiver sensitivity is investigated for both OOK and FSK transmission, assuming the system (de)multiplexer filters to be $N$'th order Butterworth bandpass. Although narrower filters are recommended for improving power budget, it is shown that system penalty due to filter shape may be kept < 1 dB by employing filters with $N > 2$. Moreover spectrum-sliced FSK systems using optical preamplifier receivers are shown, for the first time, to perform better in a peak optical power limited environment. Performance-optimized spectrum-sliced WDM systems have potential use in both local loop and long-distance fiber communication systems which require low-cost WDM equipment for high data rate applications.