PERFORMANCE ENHANCEMENT OF WDM SYSTEMS WITH DIFFERENTIAL DETECTION
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ABSTRACT
Wavelength Division Multiplexing (WDM) is a technique of transmitting a large number of channels with different wavelengths over the same fiber. The conventional WDM systems use direct detection receivers to decide for the transmitted bit whereas the differential detection utilizes subtraction of two streams for complimentary bits to decide on the transmitted bit in the receiver. In this paper, the performance of 4-channel WDM system is studied and is compared with that of 4-channel direct detection system. The analysis is carried out through simulation of an optical WDM system.

I. INTRODUCTION
The innumerable advances in all the building blocks of optical WDM systems such as optical sources, modulators, filters, amplifiers, receivers etc. have resulted in enormous increase in system capacity. However, the high-data rate systems are limited by the physical layer impairments most troublesome being the optical fiber non-linearities such as Four Wave Mixing (FWM), Cross Phase Modulation (XPM), Stimulated Raman Scattering (SRS) etc. These optical medium effects increase with the increase in the transmission distance, number of channels, number of amplifiers etc. A number of authors have also proposed different line formats to improve the system capacity of WDM systems [1-2]. One such technique is differential detection that is useful in reducing the channel interference as well as beat noise. It reduces the noise by cancellation of the common noise in the two bits in the receiver. The principle of differential detection is further elaborated in the next section. In this paper, we apply differential detection to WDM systems to study the resulting performance improvement. For this, a 4-channel WDM optical link communication system is designed using OptSim, an optical system simulator from RSoft’s. The BER performance is studied with the increase in the transmission distance simulated by using repeated fiber spans.

II. PRINCIPLE OF DIFFERENTIAL DETECTION
Differential detection in the receiver is used for the suppression of multiple access interference (MAI) [3-4]. The principle of differential detection is shown in fig. 1. The incoming signal is divided into two streams each carrying a polarizer detector corresponding to the polarization applied in the transmitter. The signal is then separately the two photo-detectors. The detected electrical signals are then combined and the decision is made in the threshold circuit on whether the transmitted bit is a ‘1’ or ‘0’. For the purpose of transmitting, ‘1’ bits and ‘0’ bits are transmitted with orthogonal polarizations.

Polarization Detectors

PD: Photo-detector   Th: Threshold in threshold detector

Fig. 1: Principle of differential detection.
III. SYSTEM SIMULATION
Figure 2 shows the snapshot of a four-channel WDM system. The four signals are combined in a multiplexer and their power levels are assumed to be the same. This is assured by an optical normalize that will have the same output power for each channel. Two systems have been simulated; the first uses conventional direct detection whereas the second uses differential detection. The important system parameters have been listed in Table I.

![Schematic snapshot of a 4-channel WDM system using OptSim.](image)

**TABLE I: Important System Parameter values**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Channel Wavelength</td>
<td>1544 nm</td>
</tr>
<tr>
<td>Uniform Channel Spacing</td>
<td>0.4 nm</td>
</tr>
<tr>
<td>Bit Rate</td>
<td>2.5 Gbps</td>
</tr>
<tr>
<td>User Transmitted Powers</td>
<td>0.1 mW</td>
</tr>
<tr>
<td>Filter Band Width</td>
<td>0.1 nm</td>
</tr>
<tr>
<td>Zero-dispersion wavelength</td>
<td>1.55 nm</td>
</tr>
<tr>
<td>Uniform Amplifier spacing</td>
<td>50 Km</td>
</tr>
</tbody>
</table>

IV. RESULTS AND DISCUSSION
The figures 3 & 4 show the results obtained for channels 1 & 4 respectively. This is shown that with differential detection, the BER performance is better than that of the system using conventional direct detection both for channel 1 and channel 4. This also shows that there is a significant improvement in the channel BER. The improvement in channel 4 is much more pronounced than channel 1 as channel 4 was closer to the zero-dispersion wavelength and this resulted in better dispersion-compensation than channel 1.

![BER vs. Link Length for Channel 1.](image)

![BER vs. Link Length for Channel 4.](image)

V. CONCLUSION
In this paper, two optical WDM systems have been simulated; one using conventional direct detection and the other using differential detection. A comparative analysis has been carried out between conventional direct detection and differential detection by measuring the system BER performance. This has been observed that differential detection results in significant improvement in system BER over the conventional direct detection systems.

REFERENCES
