Technology Selection and Deployement Testing for ROADM System based on BER and Optical Spectrum

Deepak Kaushik and Gitanjali Pandove

Abstract: **Optical spectrum and BER are the key parameters for an optical fibre network. These parameters give the performance estimation of the optical communication system. This paper describe an approach to simulate the reconfigurable optical add drop multiplexing system (ROADM). Here the effect of optical signal to noise ratio and other component properties on BER of ROADM system is described. For better understanding of performance the optical spectrum are also taken in consideration. Software used for simulation is OPTSIM. This helps in technology selection and deployment testing of Re-configurable Optical Add-Drop Multiplexers (ROADM) in order to meet dynamic network demands.**

Keywords: ROADM, BER, MONET, EDFA, O-E-O, OXC.

I. INTRODUCTION

In a large, transparent, mesh optical networks, the light paths (wavelength channels) carrying information data potentially With a variety of protocols, modulation formats and bit/line rates travel from source to destination through a path decided by routing (and restoration) algorithms based on traffic congestion, priority assignments and other quality of service (QoS) assurances. An end-to-end path comprises of a number of links and nodes where optical-electrical-optical (O-E-O) conversions take place for switching and sometimes, supervisory purposes. These conversions potentially add to the network costs, latencies, and often signal degradation.
A ROADM, on the other hand, eliminates O-E-O conversions there by eliminating need for expensive high speed switching electronics. Besides, all-optical switches are transparent to protocols, data-rates, modulation formats, etc. and thus are more future-proof than their electronic counterparts. In long run, this provides savings on operating and maintenance costs to the network operators and the service providers.

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In transparent reconfigurable networks the realistic modelling of prolonged physical-level effect in optical fibre network is important for several applications, firstly we have to design and optimize the reconfigurable network. It is necessary to underline, that the simulation of the physical layer impact of long time transients at the network layer is an uncharted area on the map of photonic simulation. Methods exist for fibre, subsystem (e.g. EDFA) and whole point to point link [1]. When we consider the design and operation of a complete mesh network, it is common to address 'logical' network simulation only [2]. The simulation is limited to individual amplifier or amplifier chains. The studies described in the framework of the MONET project served as an exception to this [3]. A different tool for simulation of dynamic fibre network is reported in [4], but neither the signal model, nor the overall organization of simulation framework was published. For detailed analysis of optical signal propagation, an equivalent link model should be employed [5], in other words different network model are necessary for full simulation.
The aim of this paper is to describe how the technology selection and deployment testing for reconfigurable optical add drop multiplexing system are decided based on BER and QBER at different levels.

2. SIMULATION APPROACH

The general workflow for simulating the optical network is summarized in fig. 1. There are basically four steps to setting up a simulation of an optical communication system network. At first create the OPTSIM project and set simulation parameters. In second step draw the schematic diagram, set parameter values of sample models. In second step we can include the definition of topology, selection of model of network element (fibres, nodes, amplifiers etc.). In third step we go for run simulation button and star the single run simulation. In the last we view the result with data display tools.

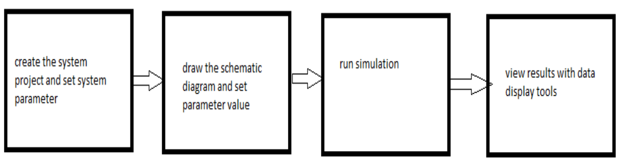

Fig. 1 General workflow for simulation

Before describing our approach, it is necessary to consider the simulation of large fibre network from a different perspective: a complex network can easily contain one or several loops. The calculation on graphs (including the simulation setup described below) normally requires breaking the loops into dependent parts; see for example [8].

3. EXPERIMENTAL SETUP

From network point of view, a ROADM includes transponders, ROADM subsystem, optical service channel, optical power monitoring, pre- and post-amplifiers, and dispersion compensating modules (DCM). The implementation of ROADM subsystem depends upon whether it's a fixed-point ROADM (which uses wavelength blockers (WB) and integrated photonic Light wave circuit (PLC)), or a small witch array (SSA) based ROADM, or a wavelength selective ROADM that uses flexible filters, wavelength selective switches (WSS), and optical cross-connects (OXC). Each of these sub-systems comprise of a number of photonic components. Designing (or choosing) these components with low insertion loss, tunability (filters, lasers), etc. directly affect the network performance. Besides, since a ROADM is expected to undergo fewer upgrade cycles, end-of-life modeling and statistical studies give valuable insights. In addition, modeling also helps find optimum modulation format for the chosen technology. For example, partial DPSK (PDPSK) is shown to perform better [2] with number of ROADM nodes along the path compared to classical DPSK.
The schematic used in this paper is drawn in OPTSIM. This is shown below in fig. 2.

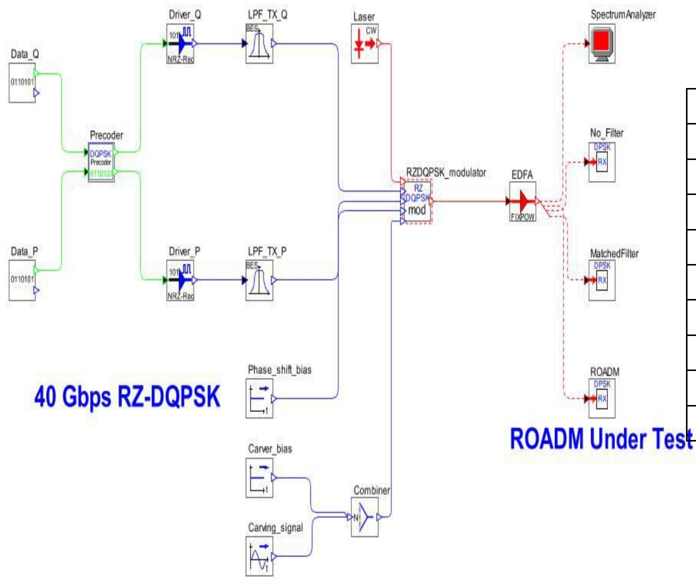

Fig. 2 Schematic of reconfigurable optical add drop multiplexer

A RZ-DQPSK modulator is used in the schematic shown above. This is the heart of the whole schematic. A look inside view of this is shown in fig. 3. This is composed of sin^2 amplitude modulator, ideal splitter and phase modulator. At the output end an optical combiner and sin^2 amplitude demodulator is used.

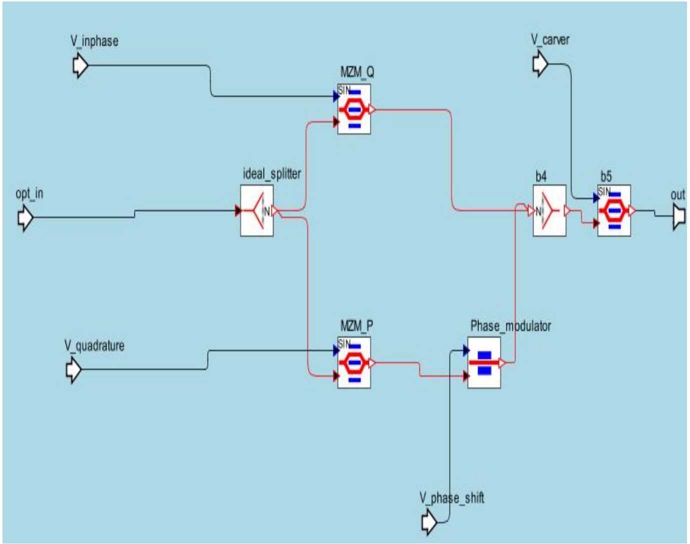

Fig. 3 a RZ-DQPSK modulator schematic

The authors can acknowledge any person/authorities in this section. This is not mandatory.

4. COMPONENT PROPERTIES

Different components are used in the schematic which have their individual properties. Each component properties is shown in the tabular form shown below.

4.1 LASER

Table no. 1

PARAMETER	VALUE
Center emission frequency (THz)	194.10324
Center emission wavelength (nm)	1544.5
Source status	1
CW power (dbm)	-10
CW power (mW)	0.1
FWHM line width (MHz)	0.0
-20 dbm line width (MHz)	0.0
Initial phase	Random
Noise type	Ideal

4.2 EDFA

Table no. 2

PARAMETER	VALUE
Output power (dbm)	0.0
Output power (mW)	1.0
Gain shape	Flat
Maximum small signal gain (db)	35
Noise	No

4.3 SINUSOIDAL WAVE GENERATOR

Table no. 3

PARAMETER	VALUE
Frequency (GHz)	20
Amplitude (AU)	25
Phase (Rad)	0.9

4.4 DATA SOURCE

Table no. 4

PARAMETER	VALUE
Bit rate (Gbps)	20.0
Corresponding simulated bit rate (Gbps)	20.0
Baud rate (G baud/sec.)	20.0
Sample per bit	20.0
Sequence	Random
Pseudo random sequence mode	Manual
Pseudo random sequence degree	8.0
Generating polynomial type	Deterministic

4.5 ELECTRICAL FILTER

Table no. 5

PARAMETER	VALUE
Center frequency (GHz)	60.0
No. of poles	5
-3 db BW (GHz)	20.0
Amplitude plot	No

5. RESULTS

Results of the simulation of the schematics are shown below. First of all bit error rate at optimal threshold value is shown below. Here outputs are taken at no filter, at matched filter and at ROADM. The graph shown below will give the clear idea about the variation of BER with respect to optical signal to noise ratio.

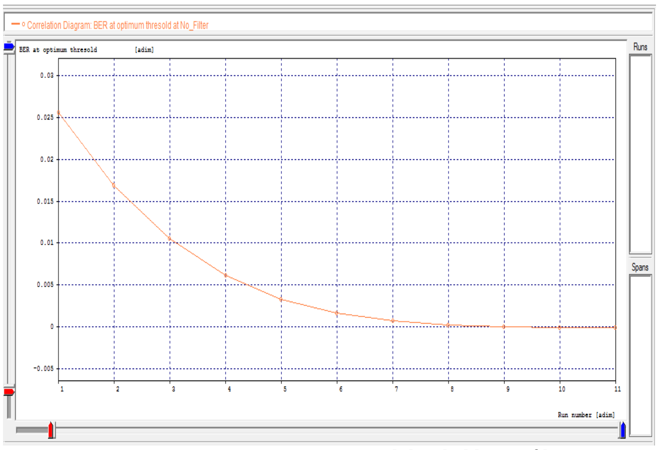

Fig.4 BER versus OSNR at optimal threshold at no filter

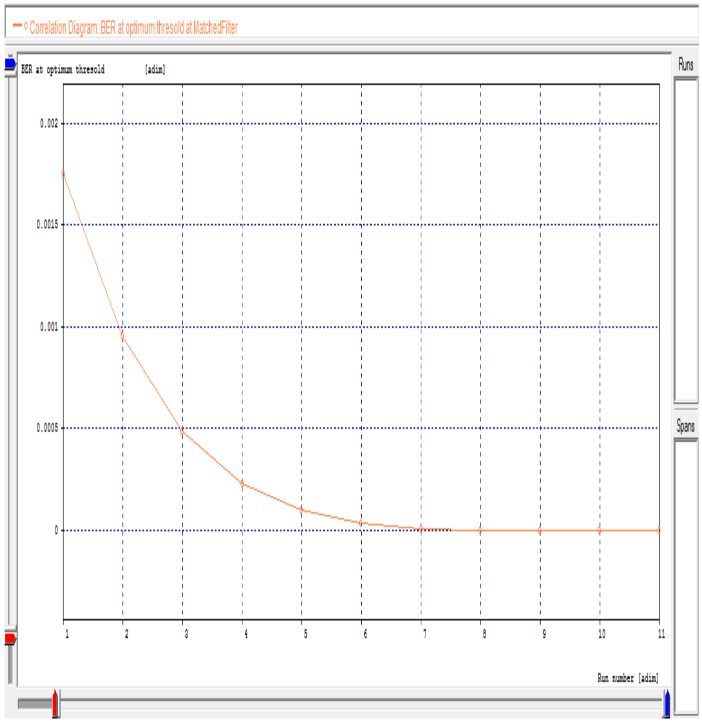

Fig. 5 BER versus OSNR at optimal threshold at matched filter

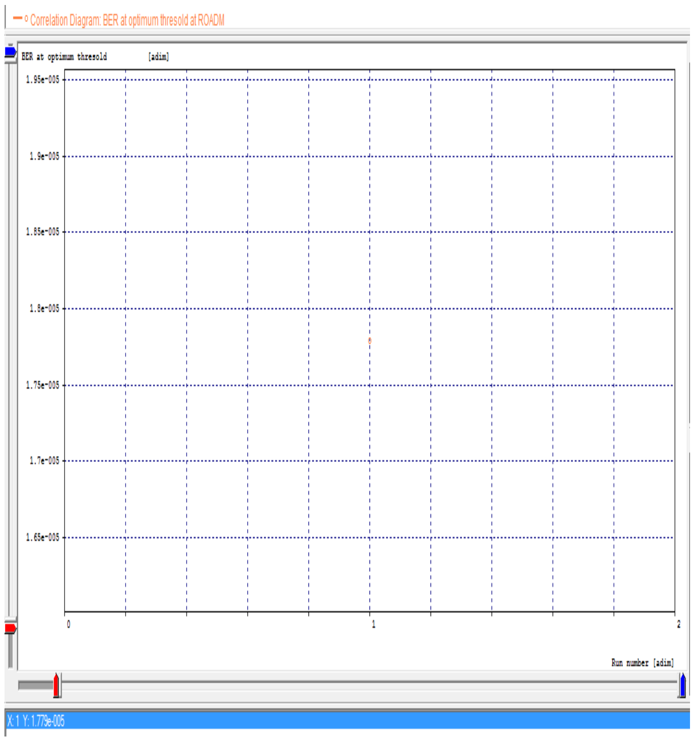

Fig. 6 BER versus OSNR at optimal threshold at ROADM

The graph showing the BER at optimal threshold at all these is shown below which will give the comparative analysis of the system. It will help us in deciding the technology and successful deployment of the ROADM system.

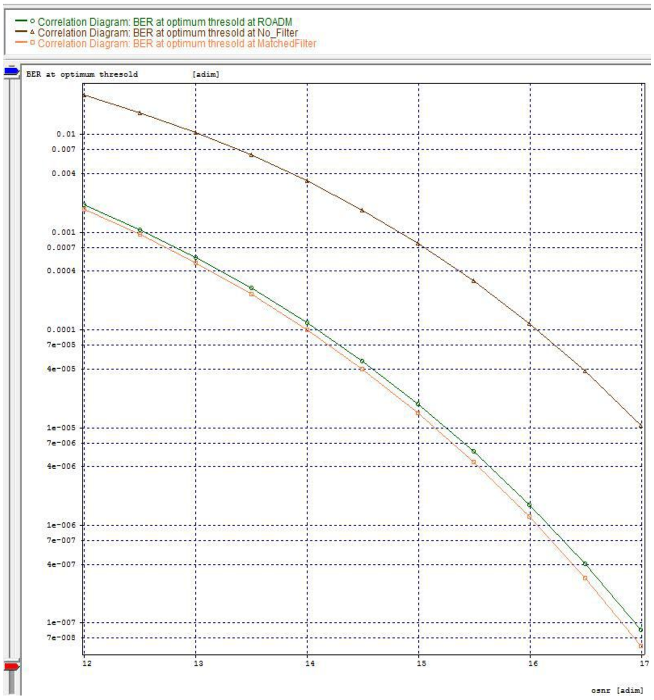

Fig. 7 BER versus OSNR plot for the ROADM under test as compared to matched filter and no filter at the receiver.

Optical spectrum at the input and output of the ROADM system are shown below.

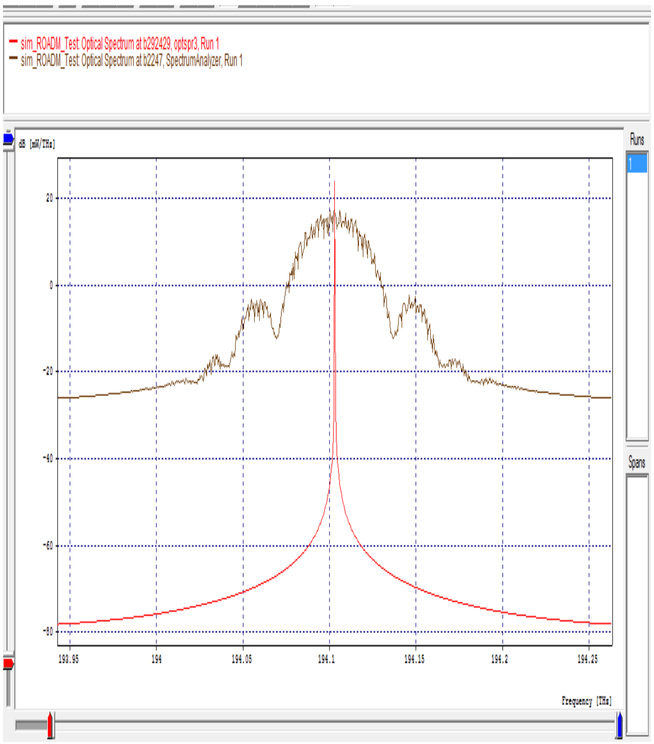

Fig. 8 optical spectrum at input and output of ROADM SYSTEM

7. COMPARATIVE ANALYSIS OF RESULTS

Following table is showing the results at no filter, at matched filter and at ROADM.

Table No. 6

PARAMETER	AT NO FILTER	AT MATCHED FILTER	AT ROADM
BER at optimum threshold	$0.7812e^{-03}$	$0.1433e^{-04}$	$0.1779e^{-04}$
QBER(db) at optimum threshold	10.00220	12.43226	12.32952
Optimum threshold	-0.01007	-0.00100	0.00436
BER at average threshold	$0.7969e^{-03}$	$0.1588e^{-04}$	$0.2104e^{-04}$
QBER(db) at average threshold	9.78559	12.38374	12.24754
Average threshold	-0.01225	-0.00176	0.00194
Sampling instant(ns)	0.02500	0.02500	0.02500

6. CONCLUSION

The results show that the ROADM under test is suitable for 40 Gbps RZ-DQPSK systems and an OSNR of 12.5 dB or better gives pre-FEC BER of 10^{-3} or better. This test can further be extended to study any given ROADM that is characterized by its measured transfer function for different modulation formats and/or bit rates, presence of chromatic dispersion and PMD, random fluctuations in ROADM transfer function bandwidth, crosstalk, etc. Whole work is carried at physical layer. This test can be performed at network layer in future. Which will give more comprehensive idea about the ROADM deployment?

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