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RESEARCH ARTICLE

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TRANSIENT MITIGATION OF MULTICHANNEL LONG-HAUL DWDM OADM RING NETWORK

PREET KANWAL, Dr. JAGJIT MALHOTRA
[1]M.Tech Student,
[2]Associate Professor, ECE
DAVIET, Jalandhar

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PREET KANWAL

ABSTRACT

Wavelength-division multiplexing (WDM) is a method of combining multiple signals. WDM increases the carrying capacity of the physical fiber. But, DWDM carries a greater overall capacity. Such a capacity demand has been driving the service providers to upgrade their network from conventional 10 Gbit/s per wavelength based DWDM systems to more spectrally-efficient 40/100 Gbit/s and beyond based DWDM systems due to the economic advantage of high spectral efficiency. In this paper, it was proved that the cross saturation effects can be minimised with the help of ring laser mitigation technique. OptSim simulation tool was utilised for the simulation of the designed network.

Keywords: *WDM, DWDM, spectral efficiency, PMQPSK, OptSim.*

INTRODUCTION

Huge transmission capacity is provided by numerous installed point-to-point links, making use of wavelength division multiplexing (WDM). In an attempt to improve reliability and efficiency of the transmission, significant efforts are undertaken to integrate these links in optical networks[26]. Although normal channel add/drop can be managed to be relatively slow, accidental channel 'add/drop' such as a fiber cut or in-line component failure can be potentially very fast[13]. Amplification of light-waves by means of erbium doped fiber amplifiers (EDFAs) has become the preferred solution to mitigate reach limitations imposed by fiber attenuation and losses in optical networks based on wavelength division multiplexing (WDM). Network reconfiguration, component failures, fiber breaks or protection switching can cause abrupt changes in optical power of wavelength channels, known as transients. These changes can be transferred to other wavelengths due to the non-ideal dynamic properties of optical amplifiers and stimulated Raman scattering in transmission and dispersion-compensating fibers. Thus, even channels that are not directly affected by the switching operations or failures can suffer from some performance degradation at the receivers. In addition, gain variations can accumulate in a cascade of amplifiers. For this reason, even small gain variations can result in significant power changes at the receivers. But also the speed of the transients increases along the chain. Therefore, efficient amplifier control techniques are required that allow us to keep the gain profile of an amplifier or an amplifier stage relatively constant even if the input power changes[11]. Hybrid amplifiers, composed of erbium doped fiber amplifiers (EDFAs) and distributed fiber raman amplifiers (DFRAs), have emerged as a promising solution in extending the span and transmission capacity of dense wavelength division multiplexed (DWDM) optical networks that already utilize EDFAs [9]. The capacity offered by the today's DWDM networks using 10Gb/s and 40Gb/s modulated wavelengths with 50GHz spacing is considered insufficient to meet the rapidly growing bandwidth requirement. In response to this market demand, WDM systems are being developed for 100Gb/s transmission [23] per wavelength operating on the 50GHz grid, using polarization multiplexed quadrature phase shift keying (PM-QPSK) modulation format. This modulation format has been proven to offer the optimum combination of features: highest bandwidth density with commercially available components [12]. DENSE wavelength-division-multiplexing (DWDM) technologies are being employed widely by network integrators for the next-generation network implementations. The recent trend in the optical transport layer technology migrates from simple point-to-point DWDM links to optical-ring networks with optical add–drop multiplexers (OADMs) located at large traffic aggregation points in the network. The DWDM channels in such topology can be dropped at each OADM node but they can also transparently bypass the node without expensive optoelectronic conversions [7].

System Design and Simulation Set-up

The designed DWDM long haul ring network architecture is based on a single unidirectional fiber ring topology having data rates of 60 Gbps. It consists of six OADM nodes as shown in fig. 1 connected by non linear single mode fiber. Each node is converting the electrical data into the optical signal and transmitting the optical link of DWDM ring. Each node is also equipped with tunable transmitter operating in multiband environment and compound receiver with multiple filters; each receiver takes care of a particular data channel which owns a unique wavelength[29].

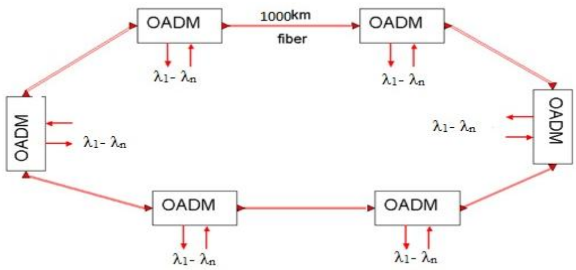

FIg.1 6-Node OADM Ring Network[31]

RESULTS AND DISCUSSIONS

The system model designed to plot the transient response is given below in fig. 4. It consists of the DWDM OADM ring network. Just one node is considered here for observing the result after 1st EDFA. Two wavelengths 1547.2nm and 1553.2nm are used at this node. Here, 1547.2nm is added or dropped in the system but 1553.2nm is the surviving channel. A pump laser of 980nm is also utilised to pump the signal into the system. Fig. 4 shows the system model to plot the transients after one node.

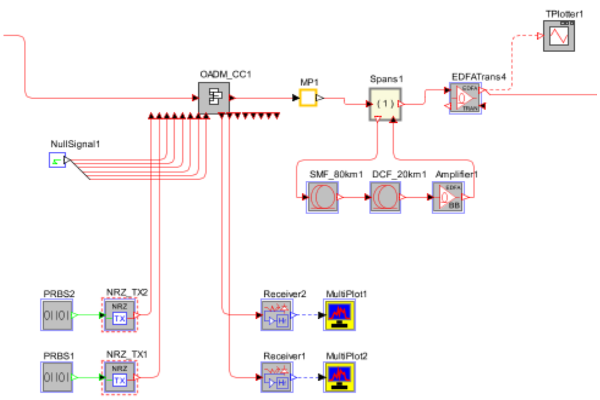

Fig. 2 System model to plot transients after 1st EDFA

The transient response after 1st EDFA is shown in fig. 5. In this case, only two wavelengths are taken into consideration to display the clear results.

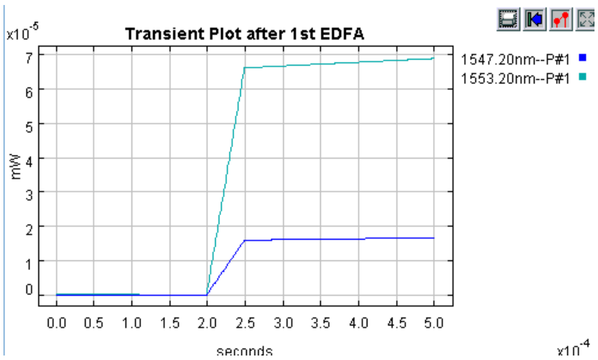

Fig.3 Transient plot after 1st EDFA

The system response is checked after 2nd EDFA also. Here, the transient plot gives a combined response for the 1st as well as 2nd node. An additional wavelength of 1550nm is added in the 2nd system to check the response of the system at different wavelengths. These 3 wavelengths are considered to check the overall system response. The wavelengths are lambda1(1547.2nm), lambda8 (1550nm) and lambda16 (1553.2nm). Fig. 10 shows the system design for two nodes to verify the transient response.

Fig. 6 shows the system model designed to plot the transients after two nodes.

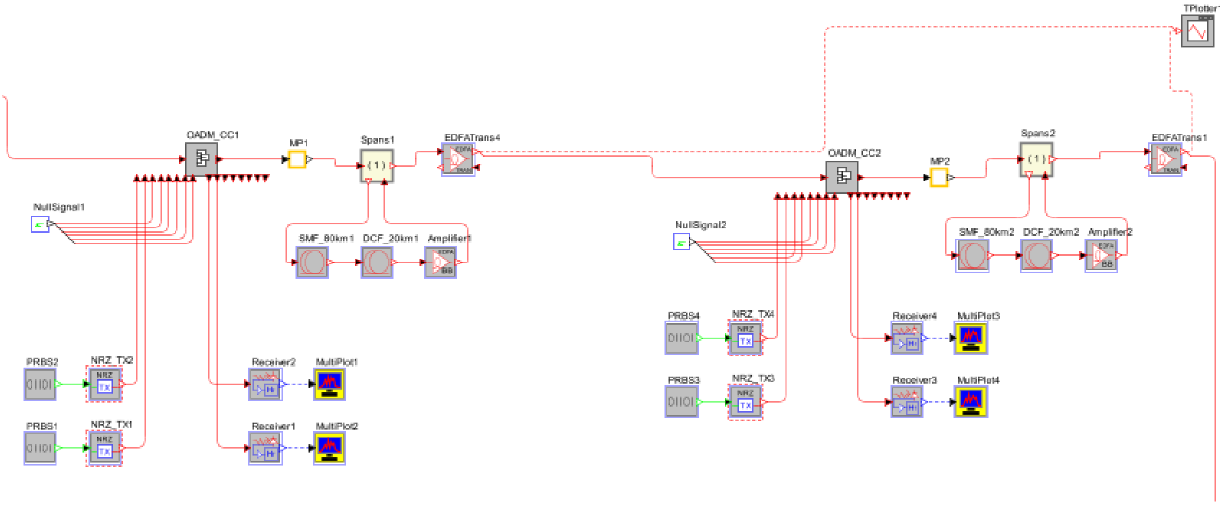

Fig. 4 System model to plot transients after 2nd EDFA

The transient response after 2nd EDFA is shown in fig. 7. In this case, three wavelengths are taken into consideration i.e., lambda1, lambda8 and lambda16.

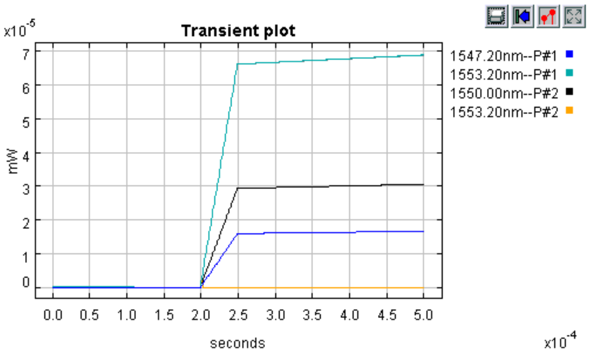

Fig. 5 Transient plot after 2nd EDFA

The transient response of the system is checked and the results are collected. The main objective is to mitigate the cross saturation in the proposed system. For the mitigation of the transients, ring laser technique is utilised. In this technique, an optical filter along with the delay system is implemented and the transients are mitigated. The system is designed to mitigate the cross saturation effect in the system and this is shown in fig. 8.

However, these small power excursions (transients) are much smaller than those that would be realized without the gain control mechanism. The lasing signal evolves from the ASE noise of the EDFA. The lasing wavelength is selected by the filter in the feedback path. By controlling the amount of loss in the feedback path, we can trade gain stability for EDFA gain. Fig. 8 shows the system model designed to mitigate the cross-saturation (transient) effect.

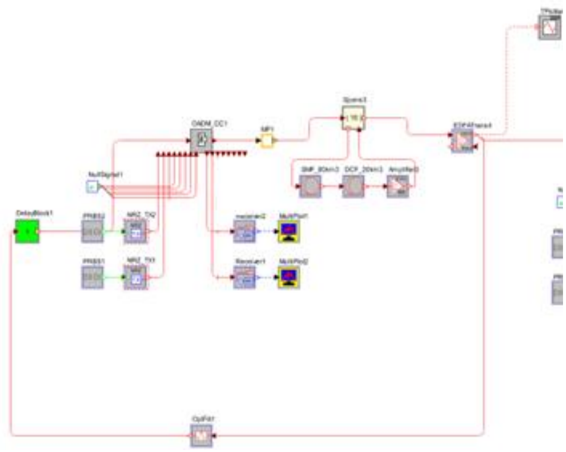

Fig. 6 System model to mitigate the cross saturation effect (Ring Laser Technique)

The ring laser technique is working effectively and the transients are mitigated with the help of this technique. In this method, two wavelengths are utilised i.e., lambda1 and lambda8. The lasing wavelength used here is 1537nm. The response of the transients without using control method was up to $6.6x10^{-5}$ mW and after using the control method, it switched to $7x10^{-5}$ mW. The response of the system is shown in fig. 9.

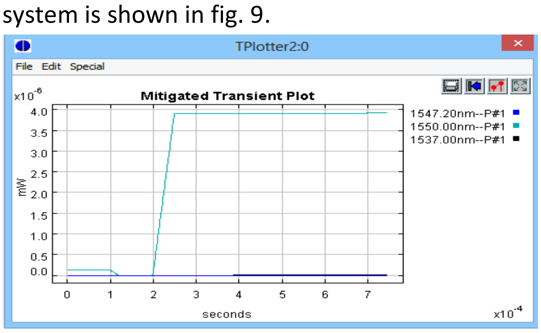

Fig. 7 Mitigated cross saturation effect with transient plot

Table 1 shows the comparison of Transient Response before and after employing the mitigation (ring laser) technique.

Table 1 shows the comparison of transient response before and after the mitigation process.

Time (Sec)	Response of transients after 1st EDFA (mW)		Response of transients after 2nd EDFA (mW)			Response of transients after mitigation (mW)	
	λ 1	λ 16	λ 1	λ 8	λ 16	λ 1	λ 8
2.0	0×10^{-5}	0×10^{-5}	0×10^{-5}	0×10^{-5}	0×10^{-5}	0×10^{-6}	0×10^{-6}
2.5	1.6×10^{-5}	6.6×10^{-5}	1.6×10^{-5}	3.0×10^{-5}	6.6×10^{-5}	0.1×10^{-6}	3.9×10^{-6}
3.0	1.6×10^{-5}	6.6×10^{-5}	1.6×10^{-5}	3.0×10^{-5}	6.6×10^{-5}	0.1×10^{-6}	3.9×10^{-6}
3.5	1.6×10^{-5}	6.6×10^{-5}	1.6×10^{-5}	3.0×10^{-5}	6.6×10^{-5}	0.1×10^{-6}	3.9×10^{-6}

Table 1 Comparison of Transient Response before and after mitigation

CONCLUSION

The DWDM system with OADM, 16 channels, 1000Km fiber. The simulation has been performed and the results are obtained. The cross saturation transients have been successfully reduced with the help of the mitigation technique i.e., the ring laser technique.

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