INFLUENCE OF PHASE OPTIC SENSOR TO THE DWDM NETWORK

Milan Čučka

Doctoral Degree Teleinformatics (I.), FEEC BUT

E-mail: xcucka00@stud.feec.vutbr.cz

Supervised by: Miloslav Filka

E-mail: filka@feec.vutbr.cz

Abstract: This article deals with influence of phase optic sensor to the DWDM transmission. In DWDM network we use four lasers sources for data transmission on one optical fiber. Next one DFB laser is used for phase optical sensor on the same optical fiber. This article is focused on influence of power DFB laser to the DWDM network. We changed the power of the DFB laser from-2 dBm to 35 dBm and watching the bit error rate and eye of the decision of the DWDM system. This model is simulated in RSoft Optsim.

Keywords: WDM, DWDM, Optical fiber, Optical sensor, Phase OTDR, Optsim

1. INTRODUCTION

In recent years, board the forefront of optical sensors, their usage is growing stronger thanks to its properties. For example, are used for temperature sensing transformers due to their ability to withstand high temperatures. Another example might be the determination of detection of vibration, which are put on already existing routes and are used to track your movement around these trails and eventual elimination of theft. This article explains the influence of phase optic sensor and their laser to the Bit error rate of the DWDM system. DWDM system use standard wavelength which start at 1550 nm. Optic sensor use wavelength at 1600 nm. [1]

2. DENSE WAWELENGTH DIVISION MULTIPLEX – DWDM

Wavelength division multiplex WDM is association of optical channels, which have previously been transmitted by one each fiber into a single thread on the basis of wavelength, or frequency separation. On each of the carrier frequency is modulated transmitter which transmitted information. Multiplexor multiplexed each of optical channels to the one optical fiber. For n-channel connection is needed one multiplexer and demultiplexer, and also n modulators, demodulators and the light sources. [1]

The technology uses lasers especially DFB (Distributed Feedback) laser with extremely narrow spectral line and highly selective spectral filters. These devices are very sensitive to frequency and thermal stability. This is one reason why the technology is costly. ITU-T G.694.1 specifies the individual transmission channels in the wavelength lengths in the range from 1490 nm (200.95 THz) to 1620 nm (186.00 THz) (called S, and C L-band). DWDM grid based on the normalized pilot frequency 193.1 THz. From this rate is based on the grid with a spacing of individual channels in the range of 100 GHz, 50 GHz, 25 GHz in the ultra DWDM in development is already 12.5 GHz. For proper function and transmission quality it is necessary that the wavelength deviate from the prescribed wavelengths of more than 0,2 for supporting spaced 100 GHz grid. [2], [4]

The spacing between transmitting channels is 0,8 nm and 0,1 nm theoretically up with ultra DWDM. Consequently, it allows transfer one optical fiber tens of channels. Channels are transmitted by the optical fiber in parallel and independently. It highly increases the transmission capacity of optical fiber. Today's DWDM systems can transmit 2.5-10 Gbit/s in one meter optic channel and operate normally these 96 channels on a single physical circuit. [3]

3. DISTRIBUTED FIBER-OPTIC SENSORS

Fiber optics sensors are very useful type of sensors which have many positives as optical fibers. Such as dielectricity or temperature resistance or radiation resistance. Distributed optical sensors can be described just like hundreds of sensors spread along optical fiber. Resolution of this measurement can be micrometers or many kilometers. It is two types of sensors short type or long type sensors. Optical fiber can sense temperature, vibrations, pressure, or mechanical tense and next. Distributed optical sensors must send information about measured but also about created response location. This principles uses reflectometry technology. [5], [6]

Source of optical radiation send beam to the fiber, it is short time and high powered pulse which can travel throw optical fiber and then is scattered because of elastic or inelastic effects. This beam is measured by processing the scattered signal. This scattered signal is captured by the fiber and then spread farther. Capturing and processing of this signal is the most uses technique. This technique uses Rayleigh scattering. [8], [9]

This signal is sensed by the optical time domain reflectometry. This technology is very useful for detection vibrations and their localization. Many distributed sensors use phase-sensitivity. It is big advantages of this types of sensors. It can be used to monitoring of more than one vibration source along optical fiber. [8], [10]

Our sensor system need at least power 150 mW and pulse duration 200 ns, because reflected power of this pulse is 230 nW. Received signal power is an order of magnitude less level thaht means the back-scatter signal is about 58 dB lower compared to the input. [8]

4. SYSTEM DESCRIPTION AND EXPERIMENTAL MEASUREMENT

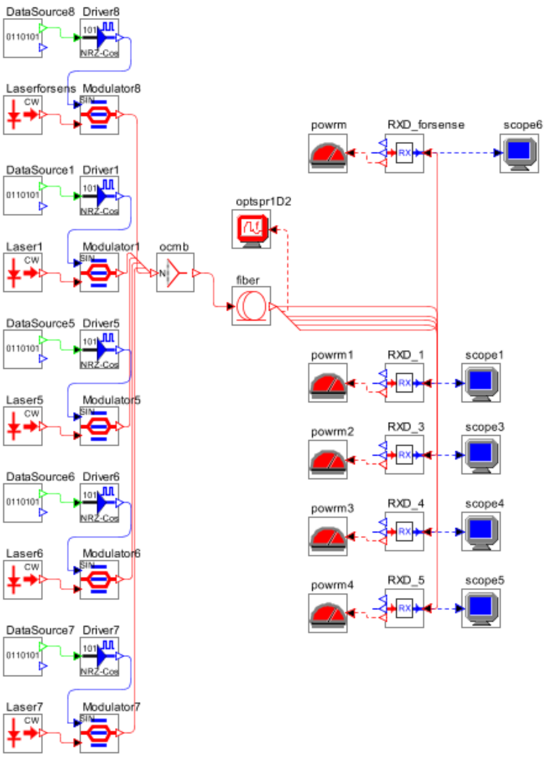

Figure 4.1: DWDM and Laser system configuration

In our system [Figure 4.1 DWDM and Laser system configuration] we use four DFB (distributed feedback) lasers for DWDM system and one DFB laser for fiber optics sensor. Lasers for DWDM have wavelength 1550 nm, 1550,8 nm, 1551,6 nm, 1552,4 nm and power 3 dBm. This system transmit data 10 Gbit/s with BER (Bit error rate) about 4,91e-13. Our testing optical path consist of 50 km optical fiber without amplifiers. But in this system have totaly clear eye of the decision. We have random sequence to transmit and for edit data sequence we use non return to zero cosine filter. Next is in transmitter modulator and combiner for combine signal from lasers. We use standard optical fiber, it is G.652.D.

Receiving part of this system consist of two types of filters, optical lorentzian and electrical Bessel. This types of filters is configured by receiving wavelength. Our simulation is focused on function of DWDM system, we don´t need to watch the BER of sensor system.

Laser for optics sensor have wavelength 1600nm and performance is various. We start at -2 dBm and watching the BER of the DWDM system. In this case the BER is about 1e-40 and eye of the decision is clear. Other wavelength is clear too. When we gradually increasing power of the sensoric laser we can see that Bit rate error is slowly increasing and eye of the decision is not so clear. It becomes with laser power 29 dBm. With high power of the sensoric laser the DWDM transmit have BER about 1,65e-10 that means data transmit is unsucessfull. Dependency of BER on laser power can be see on graph. [Figure 4.2 Dependency of Bit error rate on laser power]

Another important part of the measurements are differences between eyes of the decision, that can be seen on the pictures. [Figure 4.3 Eyes of the decision on 1550 n]

Eyes of the decision is from DWDM system which working on 1550 nm. Blue eye is sensoric laser power -2 dBm and green one is sensoric laser power 35 dBm. These results confirm that the DWDM system is capable of transmitting data when the sensor laser performance of the laser greater than 29 dBm. Final part of our simulation is the table of all bit rate errors. Which consist of wavelength 1550 nm, 1550,8 nm, 1551,6 nm, 1552,4 nm. Results for each wavelength are similar.

The route that is used for simulation simulates the actual effects that may arise on the optical fiber, it is mainly the dispersion and the Raman scattering.

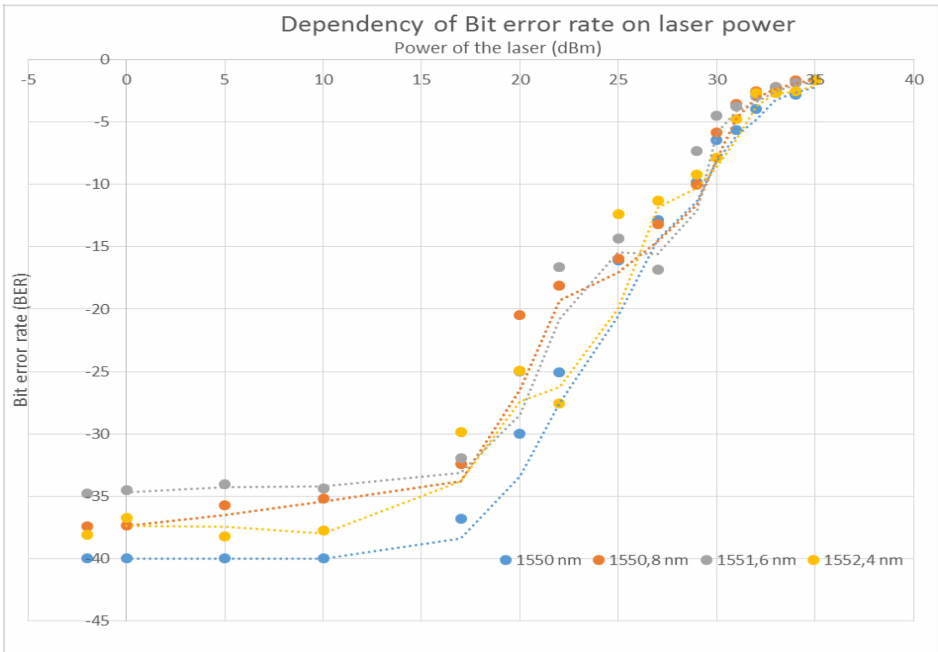

Figure 4.2: Dependency of Bit error rate on laser power

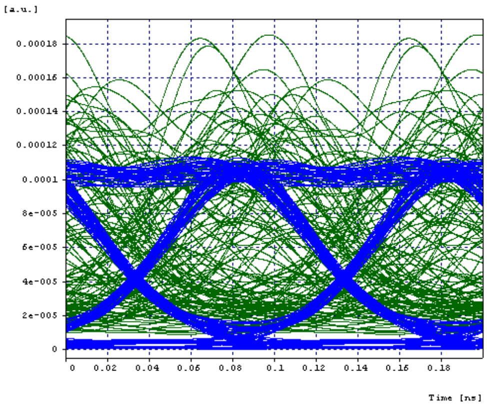

Figure 4.3: Eyes of the decision on 1550 nm

5. CONCLUSION

Our simulation system from Optsim showed that it is possible to use an optical fiber for DWDM transmit and it can be used as an optical sensor simultaneously. This system is limited by the power of the used laser sensor systems. At first one random sequence for both DWDM and for sensor system. However, simulation results showed that better performance can be achieved when a signal sequence is used for DWDM system and a different signal for the sensor system.

REFERENCES

[1] FILKA, Miloslav. *Optoelektronika pro telekomunikace a informatiku*. Vyd. 1. Brno: Miloslav Filka, 2009, 369 s. ISBN 978-80-86785-14-1.

[2] ITU-T Recommendation G.697 - Optical monitoring for DWDM systems. 2004.

[3] Träger, F.: Springer Handbook of Lasers and Optics. Springer, 2012, ISBN 9783642194092

[4] Kaminov, I.: Optical Fiber Telecommunications (Sixth Edition). Berkeley, California, USA: Academic Press, 6 vydání, 2013, doi:0.1016/B978-0-12-396960-6.00031-6.

[5] *Fiber optic sensors: an introduction for engineers and scientists*. 2nd ed. Editor Eric Udd, William B Spillman. Hoboken: Wiley, c2011, xiii, 498 s. ISBN 978-0-470-12684-4.

[6] RAJAN, Ginu. Optical fiber sensors: advanced techniques and applications. pages cm. ISBN 978-148-2228-250.

[7] HANÁČEK, F., J. LÁTAL a P. KOUDELKA. Nový způsob měření pomocí vláknově optických senzorů s frekvenční změnou na výstupu. *Elektrorevue* [online]. 2009, roč. 2009, č. 19 [cit. 2015-02-25]. Dostupné z: http://www.elektrorevue.cz/file.php?id=200000301-6ddca6ed6a.

[8] ŠIFTA, Radim, Petr MÜNSTER, Petr SYSEL, Tomáš HORVÁTH, Vít NOVOTNÝ, Ondřej KRAJSA a Miloslav FILKA. Distributed fiber-optic sensor for detection and localization acoustic vibrations. *Metrologia i Systemy Pomiarowe / [Polska Akademia Nauk Komitet Metrologii i Aparatury Naukowej]* [online]. 2015, roč. 22, č. 1, 111 - 118 [cit. 2015-03-22]. Dostupné z: http://www.degruyter.com/view/j/mms.2015.22.issue-1/mms-2015-0009/mms-2015-0009.xml?format=INT

[9] ŠIFTA, Radim, Petr MÜNSTER, Ondřej KRAJSA a Miloslav FILKA. Simulation of bidirectional traffic in WDM- PON networks. *Przegląd elektrotechniczny* [online]. 2014, roč. 90, č. 1, 95 - 100 [cit. 2015-03-22]. Dostupné z: http://pe.org.pl/articles/2014/1/23.pdf

[10] NOVOTNÝ, Vít, Petr SYSEL, Radim ŠIFTA, Petr MÜNSTER, Tomáš HORVÁTH a Miloslav FILKA. Distributed fiber-optic sensor system based on phase- sensitive OTDR. In: *Optical Communications 2014*. Praha: Agentura Action M, 2014, 20 - 23. ISBN 978-80-86742-39- 7