PHASE-TO-INTENSITY MODULATION FORMAT CONVERSION IN OPTICAL BAND-PASS FILTERS

Oskars Ozoliņš[1], Ģirts Ivanovs[1]

[1]*Institute of Telecommunications, Riga Technical University, LV 1048 Riga, Latvia*

e-mail: oskars.ozolins@rtu.lv

Travelling through a multiple optical band-pass filters the optical signal experiences spectral narrowing due to pass-band narrowing of filtering devices and instability of central frequency of light sources due to temperature changes in dense wavelength division multiplexing (DWDM) systems. This could be the main factor of degradation in long haul transmission systems. The pass-band narrowing of optical band-pass filter depends on the shape of the amplitude square transfer function. The fastest pass-band narrowing at several cascaded optical band-pass filters is observed for the Lorenzian filter, whereas the slowest – for flat-top filters (Raised-Cosine) [1]. From other point of view, narrowing of pass-band in band-pass filters could be used for realization of novel applications like all-optical modulation format conversion. In this paper we propose a linear phase-to-intensity modulation format conversion with a Raised-Cosine band-pass filter. The main advantage of this approach is to use simplified receiver configuration which could decrease the complexity of the overall system. Also could give advance because of better transmission properties and resistance to nonlinear optical effects for phase modulation format.

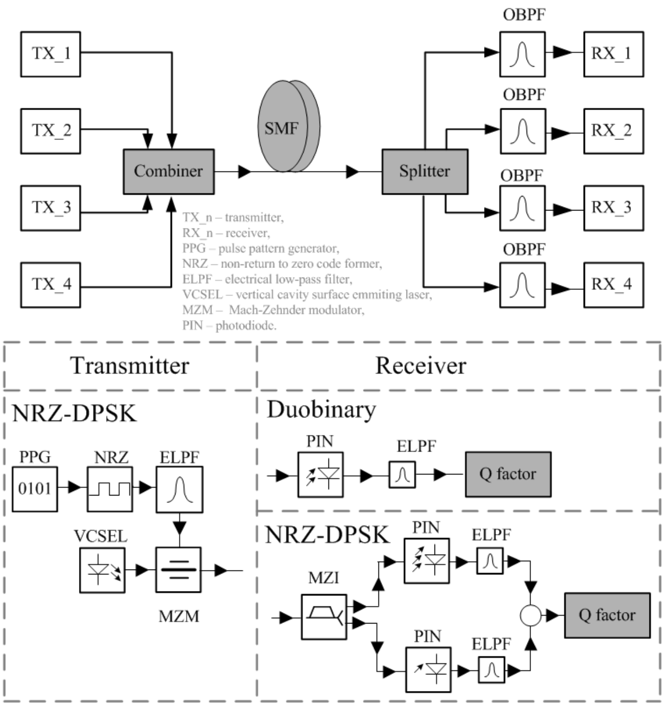

Fig. 1. Four-channel 2.5/10/40 Gbit/s DWDM system for phase-to-intensity modulation format conversion with different optical band-pass filters, direct and coherent receivers.

For the research the OptSim simulation software was chosen. Three different transfer functions of the optical band-pass filters for realization of non-return to zero-differential phase shift keying (NRZ-DPSK) to Duobinary modulation format conversion were employed. These functions were chosen because with the Lorentzian optical filter's transfer function we can approximate different wavelength filters [1].

In this research the dependences of Q-factor on the full width half maximum (FWHM) bandwidth of optical band-pass filters with different amplitude transfer functions (Lorentzian, Raised-Cosine and Supergaussian) were calculated for various simulation setups: with channel spacing 100 GHZ, four channel's, data transmission speeds 2.5/10/40 Gbit/s and NRZ-DPSK modulation format (see Fig.1.). The main idea is to find an efficient FWHM bandwidth for realization of phase-to-intensity modulation format conversion. As distinguished from the previous results [1], a more sophisticated design of receiver is used for NRZ-DPSK (see Fig.1.), which is connected with modulation format realization since all the information is recorded in a signal's phase. It is not always possible to create an especially sophisticated receiver. Therefore, in the work a method is proposed which allows – using narrow-band (Raised-Cosine) filtering and a square-law detector – to perform the conversion of NRZ-DPSK to Duobinary modulation format and use the direct detection.

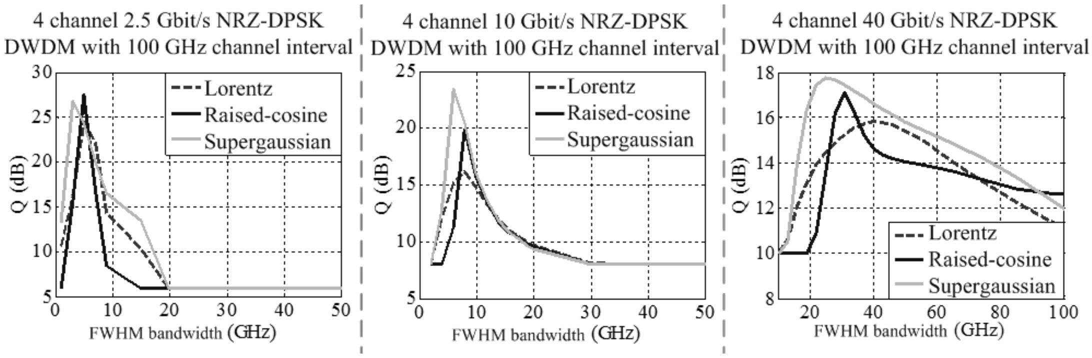

Fig. 2. Q-factor vs. bandwidth for different OBPFs (shown in the inset) of the NRZ-DPSK four-channel 2.5/10/40 Gbit/s DWDM system with 100 GHz channel spacing and direct detection.

The results are seen in Fig. 2, where the Q-factor is shown in dependence on the FWHM bandwidth for different wavelength filters of a four-channel 2.5/10/40 Gbit/s DWDM system with a 100 GHz interval between channels, which is realized with a square-law detector. In this case, the NRZ-DPSK to Duobinary (phase-to-intensity) modulation format conversion takes place at decreasing the FWHM bandwidth. The NRZ-DPSK all-optical modulation format conversion is a possible because of lower FWHM bandwidth values – the best signal quality in a 40 Gbit/s DWDM system with a 100 GHz inter-channel spacing is at the 24 GHz FWHM bandwidth for Supergaussian filter in the case with square-law detector [2]. Similar results have been obtained (also experimentally) by other authors in whose investigations both Supergaussian and Lorenzian filters were used [3, 4, 5]. In the case of Supergaussian filter the data transmission speed should be multiplied by coefficient 0.6 in order to obtain an appropriate FWHM bandwidth for a DSPK signal's demodulation. The main contribution of the present work is the NRZ-DPSK demodulation with a Raised-Cosine filter followed by successful detection using a square-law detector. For all-optical phase-to-intensity modulation format conversion different optical band-pass filters have been used, but the Raised-Cosine optical band-pass filter is the closest to the amplitude transfer function of an ideal optical band-pass filter.

References

1. O.Ozolins, V.Bobrovs, G.Ivanovs Efficient Wavelength Filters for DWDM Systems *Latv. J.Phys.Techn.Sci*., 2010, No.6, 47-58.pp.
2. N.Calabretta, M.Presi, G.Contestabile, P.Ghiggino, E.Ciaramella, F.Cavaliere, R. Proiettii Optical PON Network Using Passive DPSK Demodulation *US Patent Application Publication*. - 09/23/2010. - US 2010/0239258 A1. – 1.-9.p.
3. Y.Ding, J.Xu, C.Peucheret, M.Pu, L.Liu, J.Seoane, H.Ou, X.Zhang, D.Huang Multi-Channel 40 Gbit/s NRZ-DPSK Demodulation Using a Single Silicon Microring Resonator *J. Lightwave Technol.*, 2011, Vol.29, 677-684.pp.
4. I.Lyubomirsky, C.C.Chien DPSK Demodulator Based on Optical Discriminator Filter *Photonics Technology Letters*, 2005, Vol.17(2), 492–494.pp.
5. L.Zhang, J.Y.Yang, M.Song, Y.Li, B.Zhang, R.G.Beausoleil, A.E.Willner Microring-based modulation and demodulation of DPSK signal *Opt. Express*, 2007, Vol.15, 11564.-11569.pp.