Multiwavelength optical fibre source

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Abstract: - In this paper we described a structure of an original multiwavelength optical fiber source for DWDM systems. In order to obtain a several dozen of optical carriers with highly stable channel spacing of 4.5GHz a single laser source and acousto optic frequency shifter were used. Results of the analysis of the structure properties were presented.

Key-Words: - DWDM, EDFA, multiwavelength

1 Introduction

Rapid development of optical networks, the WDM systems in particular, has increased the application of systems with more optical channels. The rise in the number of channels, i.e. the number of sources used and narrowing of the channel spacing result in the fact that stabilizing methods are getting more and more complicated and expensive [1]. The multiwavelength sources allowing simplification of transmission systems and reduction of costs [2,3] are currently looked for.

The multiwavelength source is an original and simple structure using a single laser beam to generate a comb signal with numerous frequencies. The distance between the successive frequencies is determined by an acousto-optic frequency shifter (AOFS).

2 Principle of operation and optical source configuration

The source consists of the acousto optic frequency shifter (AOFS), optical amplifier (EDFA), Fabry-Perot filter (FPF), low pass filter (LPF) and optical coupler. Fig. 1 presents a block diagram of the source.

AOFS is the key element of the generating system. The shift of 4.5GHz was obtained by a cascade of three commercially available AOFS. Power losses occurring in the system components are compensated by the optical amplifier (OA). In calculations, we used properties of the EDFA amplifier with flat response. In order to reduce ASE, the Fabry-Perot filter was connected to the output of the amplifier. Its periodic response makes it suitable for applications in the systems with multi-wave signals.A LPF filter whose role is to limit a number of generated frequencies is equally significant.

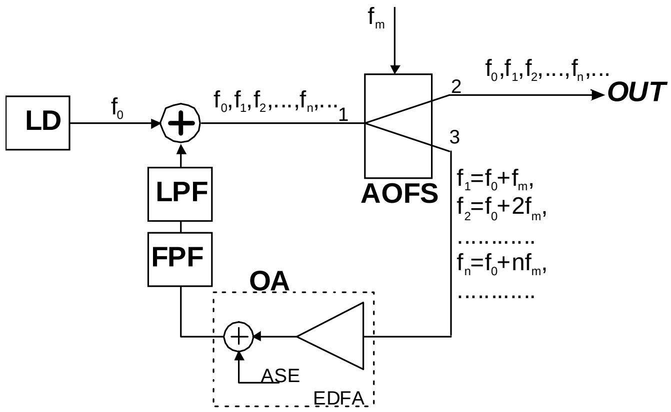


Fig.1. Block diagram of the multiwavelength optical fiber source.

Lasing frequency and amplitude response of LFP filter determine the generating band in which the successive carrier frequencies occur.

The multiwavelength beam is generated in a process of periodic power split, frequency shifting and combining of an output source with a shifted signal. In the AOFS, an incident light wave is split into two beams. The diffracted one is shifted by the amount of the RF frequency which controls the AOFS (in our case 4.5GHz). Therefore, the value of frequency shift does not depend on the properties of the source laser.

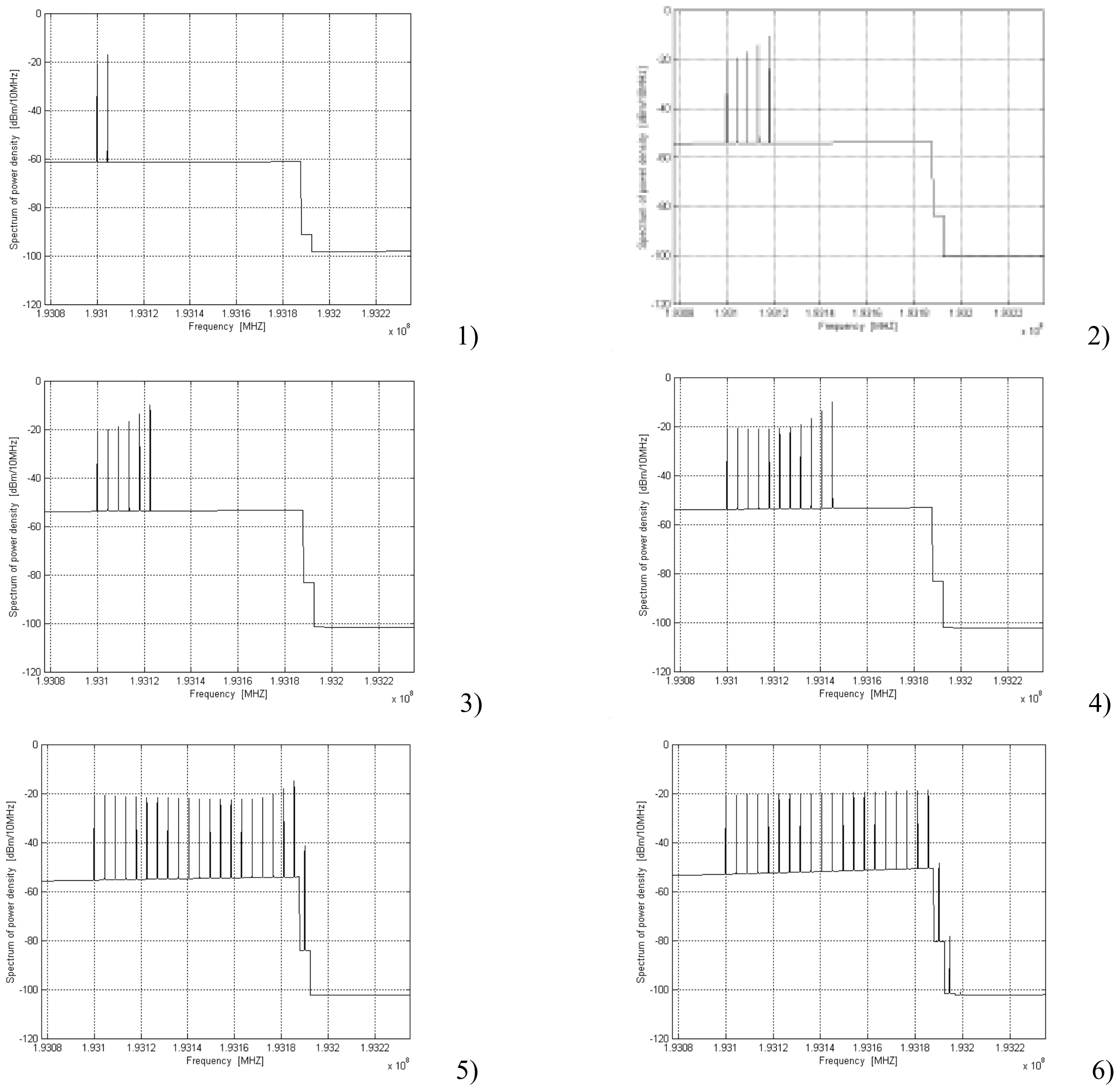


Fig.2. An illustration of the process of channel generation : 1) – 5) and– 6) stabilized operation.

When amplified by the OA, the shifted beam is combined with a source laser beam. In this way, on the no deflected AOFS output the beam consisting of the source laser frequency and the frequency shifted by 4.5GMz originates. Each successive signal circulation results in generating another optical carrier frequency which is 4.5GHz away. During the generation process, a ratio of the amplified signal to ASE is dynamically changing. Fig.2 presents a spectrum of a generated signal limited by LPF to 20 carriers. After a maximum number of channels has been obtained, we can observe the power stabilization phase, and the increase in ASE power may occur degradation SNR of the created carriers.

3 The analysis of the multiwavelength source properties

Computer simulation of the proposed configuration for different arrangements allowed a noise analysis of the generated multi-wave signal and determining an influence of Fabry-Perot filter properties. We assumed a constant optic frequency of a source laser performance equaling 193.1 THz and the LPF stop-band suppression of 30dB. Calculations for different power levels of an optical source laser were carried out. Fig. 3. shows the attainable SNR in particular channels when generating 20, 40, 60, and 80 carrier frequencies.

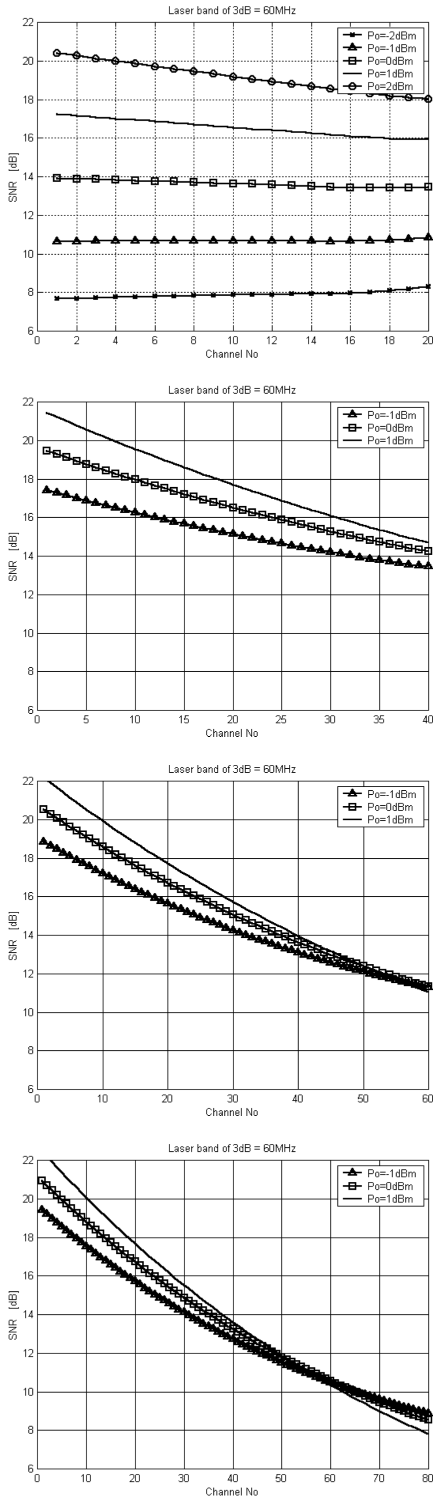


Fig.3. The channels SNR after generating 20, 40, 60 and 80 carriers.

With an increase of the number of generated frequencies the signal's SNR in channels diminished. SNR was improved by substituting the LPF filter by the band pass filter (BPF). Results of calculations are presented in Fig. 4.

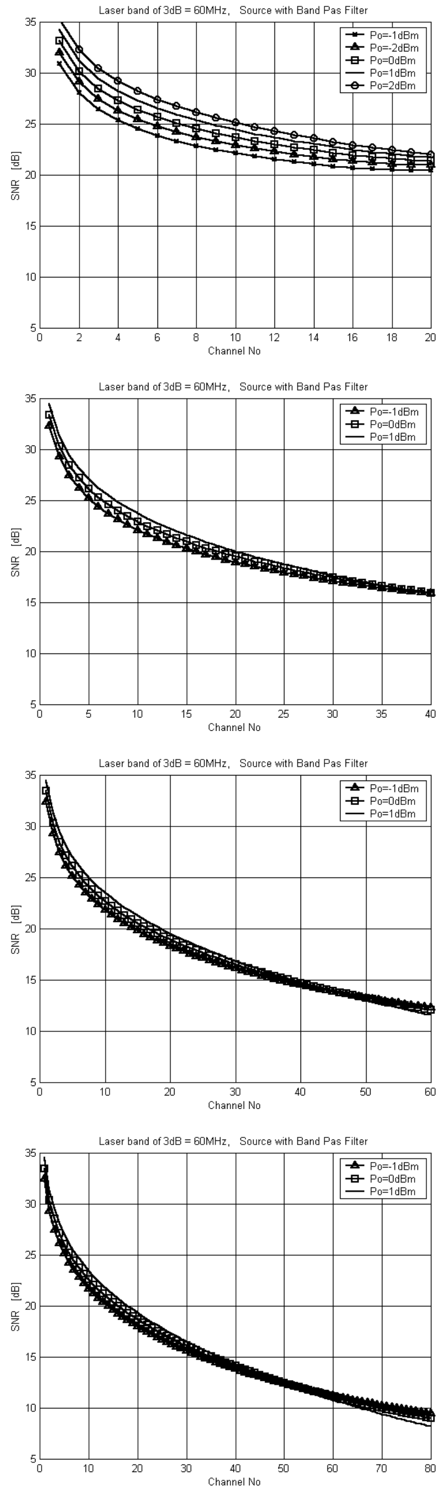


Fig.4. SNR in channels using BPF after generating 20, 40, 60, 80 channels.

Suppression of the amplifier's ASE in the band below the source laser frequency remarkably increases the SNR for several low index carriers. However, this does not improve a larger number of carriers by far, especially those with a higher index.

A significant improvement of SNR was obtained by using the Fabry-Perot filter which suppresses the amplifier ASE over the interchannel space and may lead to narrowing of a generated carrier spectrum. The advantage of applying FP filter is presented in Fig. 5.

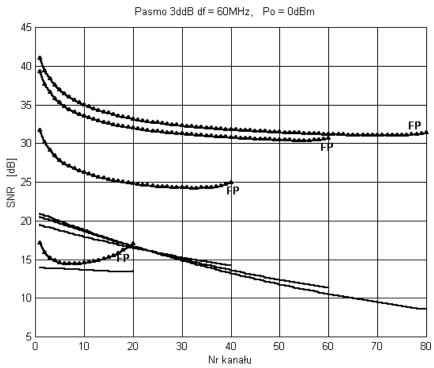
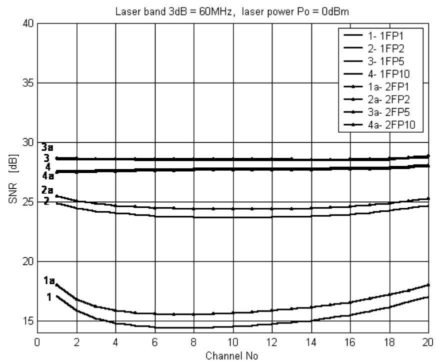


Fig.5. The SNR in the channels with and without FP.

We carried out an analysis of the SNR for a source with the FP filter in two configurations: with a single FP filter and a cascade of two FP filters. The results of calculations are shown in Fig. 6.



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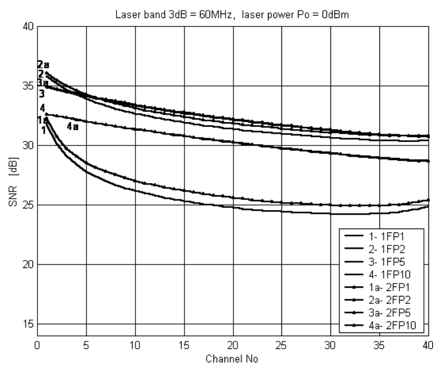

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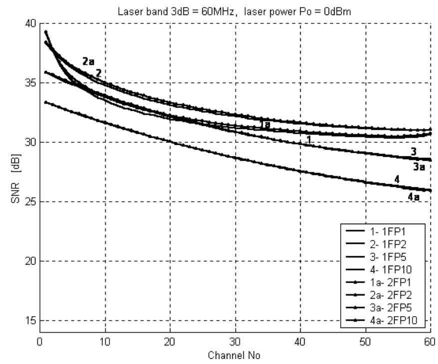

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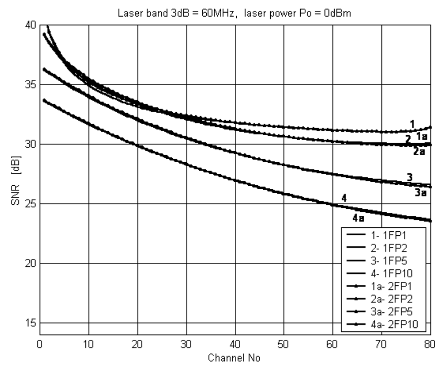

4)

Fig.6. channels SNR after generating 1) 20, 2) 40, 3) 60, 4) 80 carriers by the source with a single 1FP and double 2FP filters whose bands are 1, 2, 5, and 10 times wider than laser FWHM.

The diagrams show a comparison of SNR property of optical channels when a single signal FP filter (1FP) and two cascade filters (2FP) of different pass-band width were applied.

The case of generating 20 carriers proves that the best SNR is obtained when a FP filter with a pass-band 5 times wider than the laser FWHM. The arrangement with a filter with 10 times wider pass-bands is not effective enough in suppressing the amplifier's ASE.

The advantage of applying the cascade filter over a single one is noticeable for the narrowest filters. The difference diminishes for wider filters' bandwidth and also for a significant number of optical carriers. Thus, the set with narrowest filters generates the signal with the highest SNR.

4 Conclusion

The multiwavelength source we presented, is characteristic of its simplicity of construction with a simultaneous high stability of channel distances.

A multi-wave signal of such density (Δf=4.5GHz) is difficult to attain using the independent source method: one laser for one channel.

The possibility to generate scores of carriers having the properties of a source laser provides cheaper substitutes for costly lasers and considerably simplifies stabilizing methods of a transmitting lasers set.

References:

[1] H.Shakouri, Wavelength lockers make fixed and tunable lasers precise, *WDM solutions*, No.1, 2002, pp. 23-32.

[2] M.Kamil Abd-Rahman, Multiwavelength, bi-directional operation of twin-cavity Brillouin / erbium fiber laser, *Optics Communication*, Vol. 181 No. 6, 2000, pp.135-139.

[3] S.K.Kim, M.J.Chu, J.H.Lee, Wideband multiwavelength erbium-doped fiber ring laser with frequency shifted feedback, *Optics Communication*, Vol. 190 No. 4, 2001, pp.291-302.