Investigate FWM effect and optical power management by employing the EDFAs.

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Abstract - *FWM effect is the nonlinear effect occurred in fiber during the transmission of two or more signals in same fiber. This unexpected phenomenon should be monitored and controlled for optimizing the optical communication systems. The optical power investigation and management are very important factors for the optical communication systems. The optical power is very much related with the unexpected effects on optical signal. In this paper, the FWM effects and different optical powers are inspected by using the several EDFAs. Here, the EDFAs are not only employed for power boosting but also for power monitoring and controlling. The different optical effects can be handled by the optical power control.*

Key Words: FWM, nonlinear effect, EDFA, power, optical communication, wavelength.

1. INTRODUCTION

Optical communication system receives great attentions owing to its several attractive advantages over other communication technology and very high bandwidth hence high data rate is the most attractive feature of this technology [1,2]. In addition, other benefits like security, resistance to external interferences, etc. make optical signal technology very promising technology. However, there are some problems associated with this technology which try to degrade the optical system performances. There are mainly two types of effects which play vital roles in optical communication and these are linear and nonlinear effects [3]. Linear effects are attenuation, dispersion, polarization mode dispersion. On the other hand, the nonlinear effects are the cause for wasting the energy of the channels [4,5] and the effects are non-elastic and elastic effects. Non-elastic effects are stimulated Brillouin scattering (SBS) and stimulated Raman scattering (SRS). On the other hand, the elastic effects are based on nonlinear refractive index (kerr-effect) and the effects are self phase modulation (SPM), cross phase modulation (XPM) and four wave mixing (FWM). Among these nonlinear effects, the most devastating effect is FWM owing to its new signal generation capacity [6]. However, this nonlinear effect can also be used for optical signal processing like waveform-wavelength change for different networks. Thus, monitoring the nonlinearity of FWM is essential maintaining the signal quality by avoiding the signal degradation and also for nonlinear effect utilization in optical signal processing. With different wavelengths of signal propagate in the same direction through same optical fiber, the scattering process occurred, where three photons are mixed to generate the fourth wave with same interval. That's why, it is named as FWM. FWM is produced by the intensity dependent refractive index of the nonlinear medium. It occurs when a phase matching condition for the maximum power transfer is satisfied by the momentum of the fourth waves. The phase matching in a single mode fiber can be represented as [3]:

$$\beta(\omega_1) + \beta(\omega_2) - \beta(\omega_3) - \beta(\omega_4) = \Delta(\omega), \qquad (1)$$

where,

ω_1, ω_2, ω_3, and ω_4 are the frequencies of the first to the fourth waves.

Δ is the phase mismatching parameter.

When the signal at frequency ω_1 mixes with another signal at frequency ω_2 during propagating through the same fiber, two new signals at the frequencies of $2\omega_1$-ω_2 and $2\omega_2$-ω_1 are generated. This effect is very communal for three or more signals also. These unexpected signals affect the main signals thus, big problem occurred in optical communication systems and hence, the researchers are working to mitigate this nonlinearity [7,8].

Fig -1 shows the output FWM spectra of two signals. When two signals propagate through same fiber with same direction, new signals are produced. These new signals are the "unexpected signals" which plays vital roles for optical system degradation.

On the other hand, the erbium doped fiber amplifier (EDFA) is an optical repeater employed to amplify the optical signals.

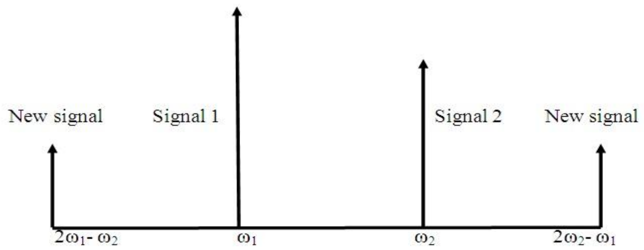

Fig -1: FWM spectra of two signals.

This is a very fundamental component for optical signal transmissions. In this paper, the FWM effects and different optical powers were investigated by using several EDFAs. The role of EDFA is to boost the optical signal. Many research works have been performed with the functions of EDFA [9,10]. In this paper, the EDFA module was employed to monitor and control the optical signals.

2. EXPERIMENTAL SETUP AND DISCUSSIONS

The experimental setup is shown in Fig -2. Two optical signals with different wavelengths are generated from the optical sources. The optical sources are composed of lasers and optical modulators which are not shown in this figure. These two signals are coupled by an optical coupler (OC) before entering into the 1st EDFA. This EDFA is used to compensate the insertion loss and to produce high power for generating the nonlinear effect FWM into the highly nonlinear fiber (HNLF). After that the 2nd EDFA is used to control the output power from the HNLF before input the signal to an EDFA module. The FWM spectra and the power are measured by using the optical spectrum analyzer (OSA) and power meter (PM).

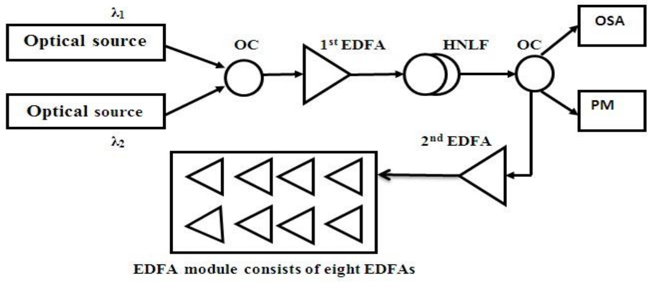

Fig -2: Experimental setup for investigating FWM effect and output powers.

Finally an EDFA module is employed which consists of eight EDFAs. The 2nd EDFA is connected with an input port of an EDFA inside this EDFA module.

3. EXPERIMENTAL RESULTS AND DISCUSSION

Two signals are coupled before entering the 1st EDFA and owing to the gain, the power of the coupled signal was around 15 dBm after the EDFA. Then the coupled signal is inserted into the HNLF for occurring the FWM nonlinearity. Due to the high nonlinear effect: FWM, the newly generated signals are produced and these FWM spectra is depicted in Fig -3. These spectra are captured by optical spectrum analyzer and then MATLAB is used to plot the spectra.

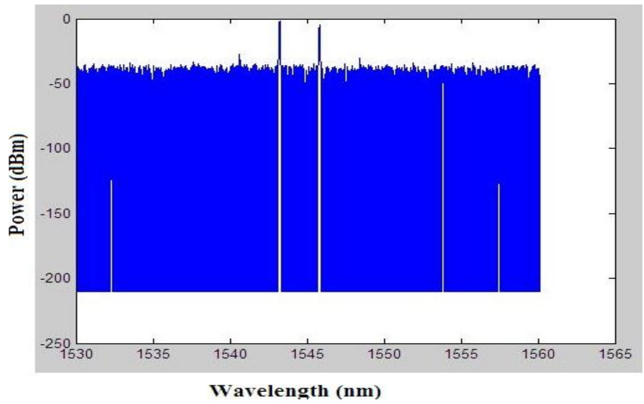

Fig - 3: FWM spectra after HNLF.

The output power after the HNLF is inserted into the 2nd EDFA and by changing the EDFA current, different output powers are achieved after the 2nd EDFA. Finally these changeable powers are inserted into an EDFA module which consists of eight EDFAs. Here the different output powers are the input powers for the EDFA1 of the EDFA module.

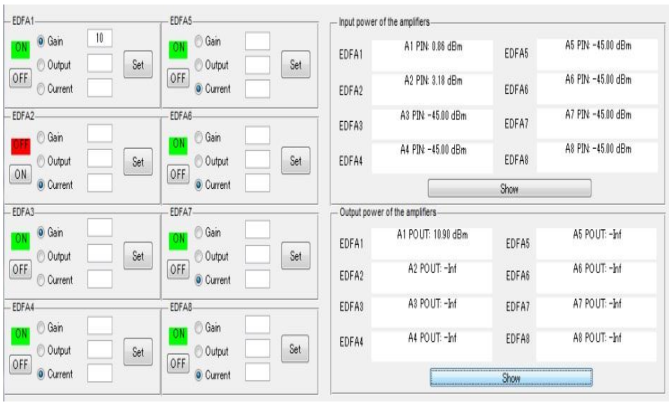

Fig -4: EDFA module consists of eight EDFAs.

Fig -4 shows this EDFA module which consists of eight EDFAs. The output optical power of the EDFA can be determined by fixing gain, output or current.

Here, the input power to the EDFA1of the EDFA module is 0.86 dBm, which is the output power of 2nd EDFA. By fixing the gain of 10, the output of EDFA1 is 10.90 dBm. Thus, the output power after 2nd EDFA is further amplified by the 3rd EDFA (here EDFA1 of EDFA module).

In this way other input powers are also inserted into the EDFA1 one by one and the output powers are obtained after the gain of 10. These input-output powers are shown in Fig - 5.

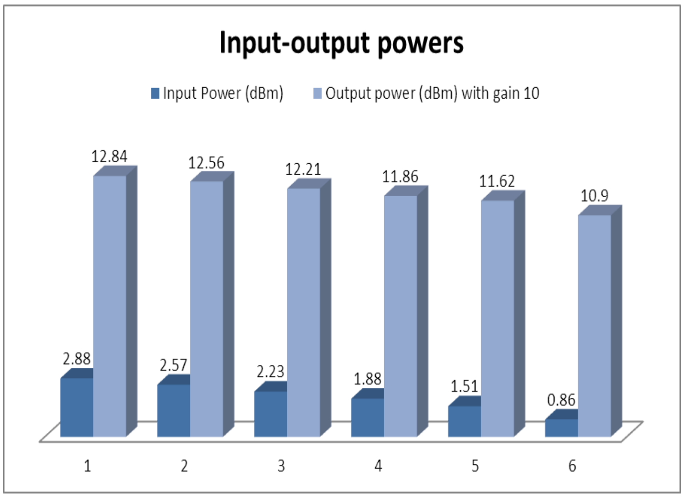

Fig -5: Input and output powers.

The big advantage of this EDFA module is, it consists eight EDFAs which can work simultaneously, though only one EDFA is used of this module.

This EDFA module can be employed not only for amplifying but also for monitoring the powers. As an example, the output power of optical signal may depend on linear and nonlinear effects. Of course this power can be monitored by power meter; however, by using this EDFA module, this power can also be controlled according to different situations and requirements. As examples, if unexpected power is found and the output is connected with any input port of the EDFA module, it can be stopped by operating the module.

3. CONCLUSION

In this paper, the FWM effect is investigated which is generated owing to the high power signals propagation. This effect plays a significant role for signal degradation. However, the newly generated signals from FWM effect can be used for transferring information from one network to another. As the optical power is a very important factor for the optical communications because the effects are related with the optical power, the power management is essential for optimizing the optical communication systems. The power monitoring and controlling is done by using several EDFAs in this scheme. The several powers before and after the EDFAs show that, the power management is performed successfully. With our arrangement, the unnecessary power can easily be stopped by controlling the EDFAs. On the other hand, if the intelligent scheme can be employed with the system, the power management can be monitored and controlled automatically.

4. REFERENCES

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