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FWM Suppression on Wavelength Converters Using Modulation Techniques

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Abstract: *Wavelength converters plays an important role for increasing the capacity and flexibility of WDM network. This paper investigates the FWM suppression on wavelength converters using modulation techniques in semiconductor optical amplifier (SOA). FWM is a type of nonlinear effect, and occurs when an optical signal of two or more different wavelengths is launched into medium. The modulation techniques covered are NRZ and RZ. All performances are analyzed in terms of its FWM power and converted signal power. The result assured that the RZ format yields better performance corresponding to less FWM power at different probe power, channel spacing and bit rate. The system was simulated using OptiSystem software version 7.*
Keywords: *FWM, Wavelength converters, modulators, NRZ, RZ, SOA, OptiSystem*

I. Introduction

Wavelength conversion plays a major role to reduce wavelength blocking, provide high flexibility and utilization of wavelength allocation in network management, which has been investigated extensively in the past several years. Ultra-high data rate all-optical wavelength conversion is an enabling technology for providing wavelength flexibility, increasing the capacity of photonics networks and enhancing optimized all-optical routing and switching. Several all-optical wavelength conversion approaches have been demonstrated, which are based on nonlinearities in semiconductor optical amplifiers, in optical fibers, in crystals and so on. Among these approaches, wavelength conversion based on the nonlinearity of Soa is inherently featured of femtosecond response time, low insertion loss, non-degraded extinction ratio of the signal and low-noise characteristics, which shows the promising potential of achieving terabit-per-second performance. Nonlinear effects mainly applied in Soa-based wavelength conversion are XPM, FWM and SPM, all of which originate from the Kerr effect. Among the various nonlinear phenomena exploited for Soa-based wavelength conversion, FWM is regarded as advantageous due to its transparency both in terms of modulation format and bit rate. However to make use of this nonlinear phenomenon in optical signal processing requires that a suitable fiber be available.

II. Four Wave Mixing (Fwm)

The four wave mixing (FWM) is a parametric process, which is at the origin of the production of new frequencies. It can be explained by the two or several optical signals having different wavelengths propagating in the SOA, structure, which generates signals having new optical frequencies. The FWM effect in SOA can be used for wavelength conversion. It is independent of modulation format.so wavelength conversion based on FWM effect offers strict transparency, including modulation format and bit rate transparency and it is capable of multi wavelength conversions. In general for N wavelengths launched into medium, the number of generated mixed products M is

$M=N^2(N-1)/2$

For wavelength conversion, two optical signals namely the pump and probe signal are used to generate four signals. The additional two signals generated are the converted signal and satellite signal. The intensity of the new generated signals are proportional to the product of the interacting wave intensities.

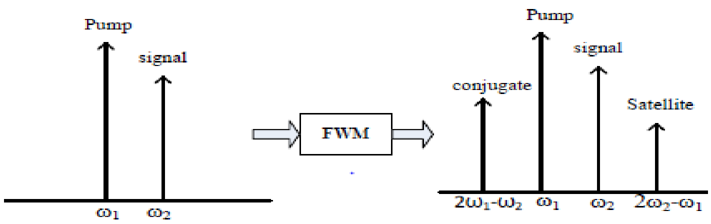

Fig 1: Concept of four wave mixing

III. Fwm Suppression Using Modulation Formats

For the suppression of four wave mixing (FWM) different modulation formats are used. Such as RZ and NRZ modulation formats. The NRZ has been the most leading modulation format in intensity modulated-direct detection fiber-optical communication systems for the previous years. The reasons for using non return-to-zero in the early days of fiber-optical communication as it is not perceptive to laser phase noise, needs a moderately low electrical bandwidth for transmitter and receivers in comparison of RZ and the simplest configuration of transmitter and receiver. NRZ pulses have a narrow optical spectrum. This reduced spectrum width improves the dispersion tolerance but it has the effect of ISI between the pulses. This modulation format is not suitable when high bit rates and distance are considered. The narrow spectrum of NRZ pulses yields an improved realization of dense channel spacing in Dense Wavelength Division Multiplexing systems [1]. In RZ modulation format, power is transmitted only for a fraction of the bit period. A return-to-zero signal with the same average power of a non-return-to-zero signal has a spectrum peak-power twice larger than the NRZ pulse. The most important feature of RZ modulated signals is a moderately broad optical spectrum. The large spectral width results in a reduced spectral efficiency and reduced dispersion tolerance of RZ-based Wavelength Division Multiplexing systems. The return-to-zero pulse shape enables an increased robustness to fiber nonlinear effects.[2] The RZ system implementation improves the system receiver sensitivity up to 3 dB. Due to its broader spectrum, RZ pulse has a reduced dispersion tolerance and spectral efficiency. The duty cycle of RZ pulse is less than unity. The reduced pulse width implies a broader signal spectrum making this technique less interesting for the implementation in DWDM systems. Higher optical powers per channel can be tolerated in a RZ-based WDM system, resulting in an improved maximum transmission length. The RZ modulation format is used for long haul optical communication systems working at higher bit rates [3].

IV. system design

The proposed block diagram of FWM on WDM system for wavelength conversion is shown in figure 2. The data is transmitted to SOA with the help of WDM mux. The probe signal is modulated with non- return to zero (NRZ) or return to zero (RZ) format. The pump and probe signals (1550nm and 1552nm) are transmitted through SOA, two new signals are obtained at output of an SOA due to nonlinear effect. The set up consists of transmitter section, receiver section and medium SOA. In the transmitter section the generated data signals from pseudo random sequence generator is transmitted to an electrical driver that converts logical inputs into electrical signal. The signals from laser source and data source are fed to Mach-zender modulator, where intensity modulation occurs. That means information signals is modulated with the help of light signal. The pump signal, i.e. normal light signal and probe signal, i.e. data signal are given to a WDM multiplexer. The output of multiplexer is applied to a SOA, due to nonlinear effect (FWM) at the output of SOA two new signals are produced at different wavelengths. In the receiver fabry perot filter is to select the wideband of signals and reject remaining signals. The photo detector is used to convert optical signals into electrical signal. The BER analyser is used to display quality factor and bit error rate of signal. Optical spectrum analyser and optical power meter is used to measure the converted signal power. This can be simulated and modelled using OptiSystem.

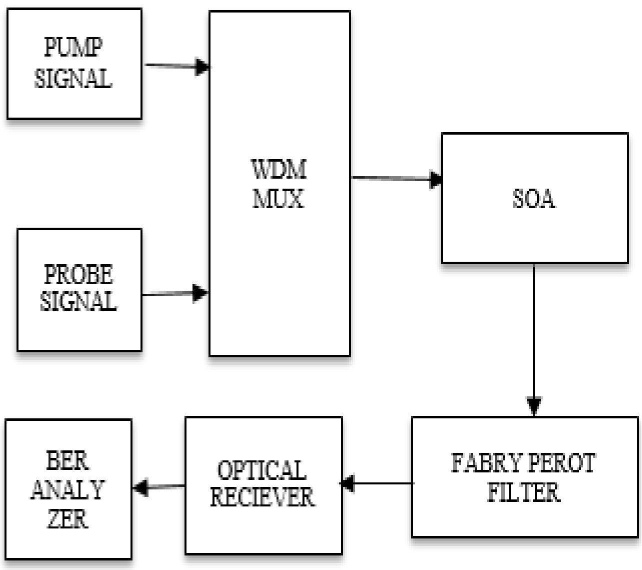

Fig 2: Basic block diagram

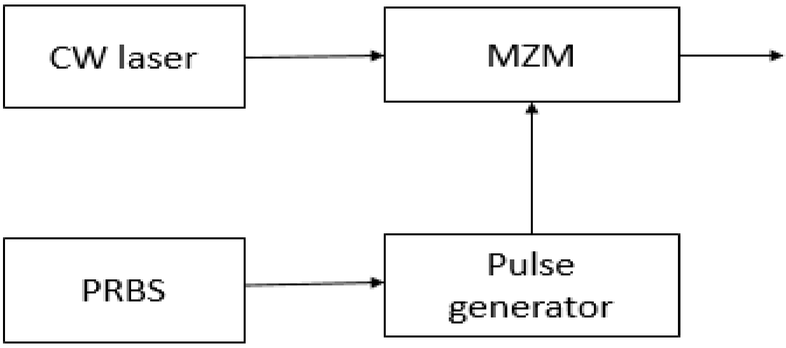

Fig 3: probe signal generator

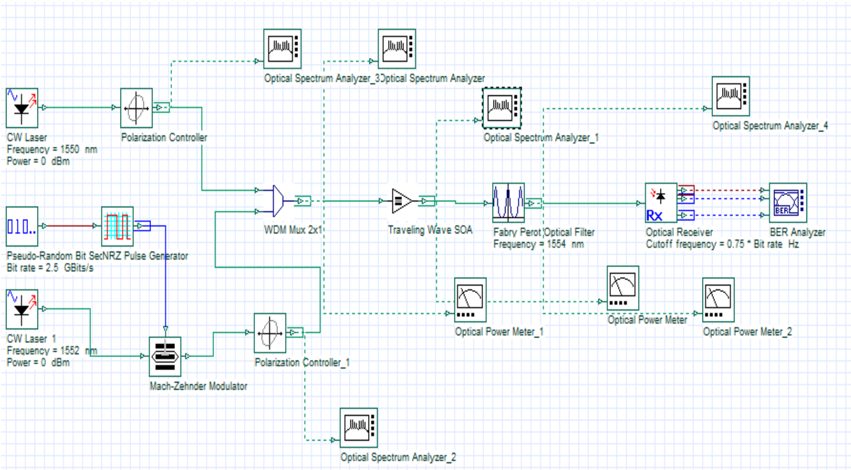

Fig 4: Simulation layout

V. Results And Discussion

Effect of probe power: The pump power of the input source is fixed at 0dBm and vary the probe power of wavelength converters from -10dBm to 10dBm.When the probe power level of the signal sources is decreases the FWM effect also decreases that increases the conversion efficiency.

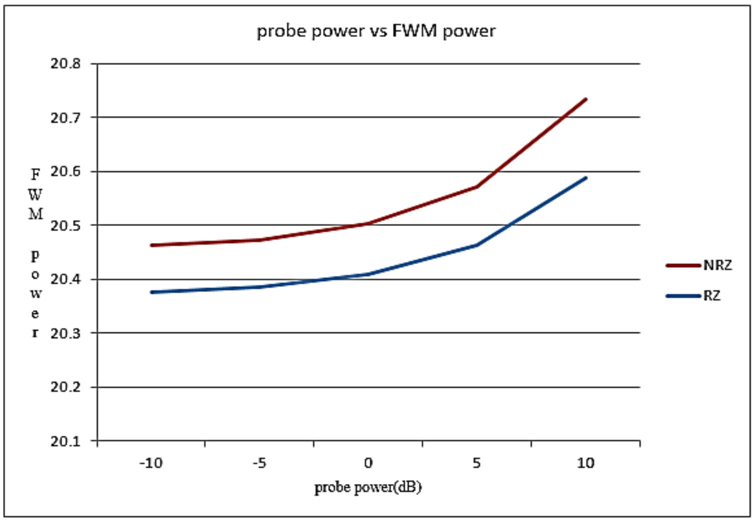

Fig 5: effect of probe power

Effect of bit rate: The bit rate of the up and down converter is varied at 2.5Gbps, 5Gbps and 10Gbps. When the bit rate increases the FWM power decreases by this the FWM effect also reduces.

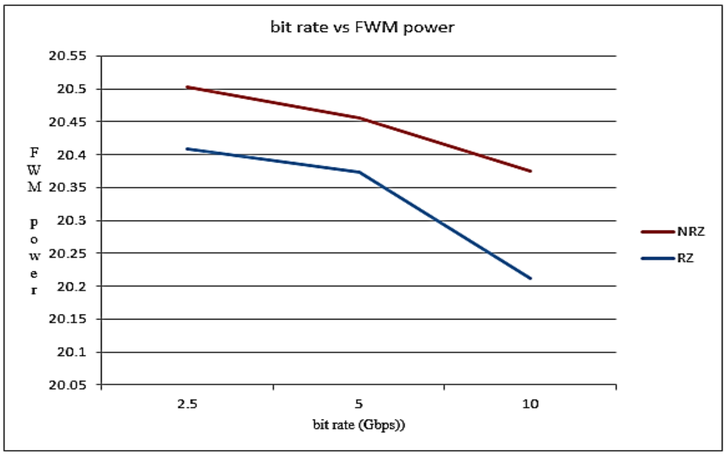

Fig 6: effect of bit rate

Effect of channel spacing: The channel spacing is varied at three different values of 0.2nm, 2nm and 4nm.when the spacing increases the FWM effect on system decreases. But at low channel spacing the FWM power is low.

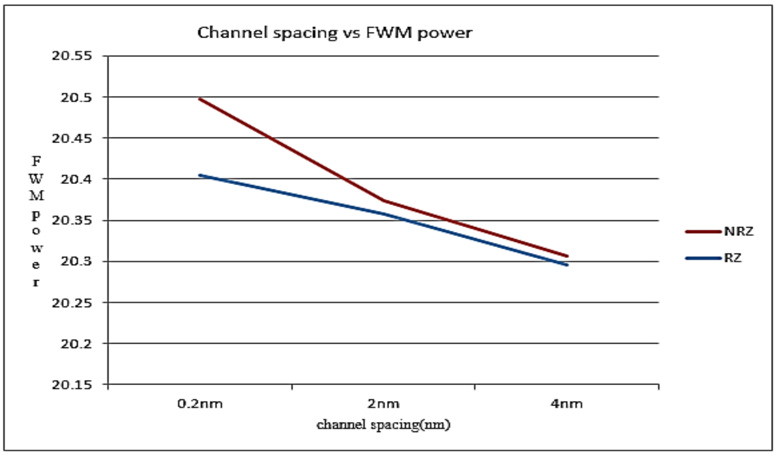

Fig 7: effect of channel spacing

VI. Conclusion

The FWM process occurred within an SOA medium which provides numerous advantages over fiber optic cable such as transparency to bit rates and modulation formats. In addition to this, various parameters are analyzed such as probe power, channel spacing and bit rates. By this there is a large difference between the power of RZ and NRZ modulation at low value of input signal power. When channel spacing increases, the FWM power decreases. When bit rate increases the FWM effect decreases. By analyzing all the parameter, the RZ provides better performance compared with NRZ modulator for the FWM suppression.

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