# Performance analysis of wavelength converter using XPM technique having 3R regenerator circuit in WDM system

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***Abstract*** - The innovations in semiconductor fabrication techniques used in wavelength conversion have improved the phase of optical communication. This paper represents a simulation and analysis of wavelength converter using cross phase modulation (XPM) technique in desired manner of bit rate, quality of signal and BER in a WDM system. Wavelength conversion and its performance analysis is an important part of optical communication having 3R regenerator circuit at altered bitrates while performing wavelength conversion using inferometeric XPM (two SOA) technique. However this paper demonstrates maximum quality of signal and minimum bitt error rate (BER) at variable input bit rate, input power and frequency having fixed fiber length of 100 km .Maximum Q factor and minimum BER response calculated in this wavelength conversion is 31.3323 and $8.07034\times10^{-216}$ respectively. Likewise complete explanation of Q-factor and BER is presented by EYE diagram in optisystem.

***Keywords*** - *Bit error rate (BER), eye diagram, inferometric cross phase modulation (XPM), 3R-regenerator, optical fiber communication, WDM system.*

## I. INTRODUCTION

A WDM based optical fiber communication system suggests wavelength division multiplexing technique which leads to multiplexing of altered optical carrier signals onto a single optical fiber. It is bidirectional communications system in which different wavelengths are assigned by using multiplexer and then pass through a desirable capacity holder channel. Different transponders have different wavelengths which are multiplexed by using a multiplexer and then the different wavelengths are extracted by using demultiplexer at output as shown in fig.1.

A WDM system uses a multiplexer at the transmitter to join the signals together, and a demultiplexer at the receiver to split them apart by selecting a particular fiber, a device can be made which will work both as an optical add-drop multiplexer simultaneously. However, an efficient optical space switches might be fabricated using tunable wavelength converters together with an array of fixed output filters [1].

Fiber optic technology can be considered our savior for meeting our above-mentioned need because of its potentially limitless capabilities [2, 3] huge bandwidth [nearly 50 terabits per second] (Tb/s)] and low signal attenuation (as low as 0.2 dB/km), low signal distortion, low power necessity, low material usage, lesser space requirement and low cost.

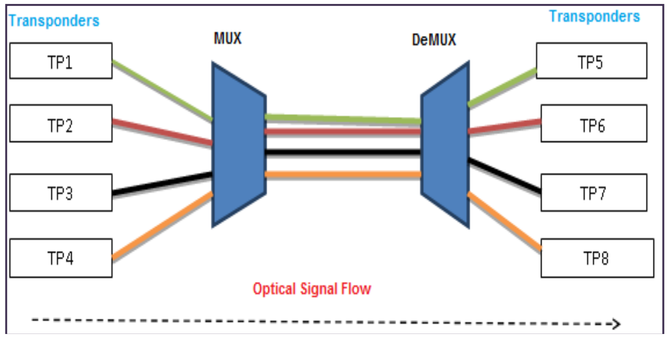

Fig.1: WDM system

However, higher bit-rate systems at 10 Gb/s are alternatively available, despite the dispersion and nonlinearities in the fiber strictly limit the transmission distance [4]. Our challenge is to turn the ability of fiber optics to realism to meet our information networking demands of the next decade (and well into the 21st century)[5]. A formal optical filtering device has been used as etalons (stable solid-state single-frequency Fabry-Pérot interferometers in the form of thin-film-coated optical glass).This concept was first shown in 1978, and then realized in laboratories by 1980 in WDM systems. A modern system was designed which associates two signals and can tolerate up to 160 signals and can thus spread a basic 10 Gbit/s system over a single fiber pair to over 1.6 Tbit/s. WDM systems are popular with telecommunications systems because they permit them to spread the maximum capacity of the network without placing more fiber. By exploiting WDM and optical amplifiers, they can accommodate several generations of technology development in their optical infrastructure without renovation of desired backbone network. Also Link Capacity can be spread out by elevating and upgrading the multiplexers and demultiplexers at all optical ends. By using optical-to-electrical-to-optical translation, optical interfaces can be equipped at every edge of the transport network. Most WDM systems work on single-mode fiber optical cables, which have a core radius of 18 µm. Also, different forms of WDM can also be used in multi-mode fiber cables which have core diameters of 50 or 62.5 µm. Wavelength conversion is very important key feature in advancement of optical communication. The need of converters will be system dependent and these following parameters have to be enlightened while doing operations [6].

- Q-factor
- BER
- Eye diagram

## II. CROSS-PHASE MODULATION (XPM)

Cross-phase modulation is a nonlinear optical effect where one wavelength is affected due to phase variation of another wavelength by optical Kerr effect. Cross-phase modulation can be used as a modulation technique for adding information to a light stream by modifying the phase of a coherent optical beam with another beam through fundamental variations in an appropriate non-linear medium as shown in Fig.2[7].This technique is realistic for optical fiber communications. Intensity modulation and direct detection are two step processes which show XPM effects in DWDM application. Initially the signal is phase modulated by the co-propagating second signal. Secondly power will show variations due to transformation in phase modulation which exhibits dispersion. Likewise the dispersion leads to walk-off between the channels and thereby reduces the XPM-effect. In wavelength conversion procedures the light is switched or split into two individual path containing SOAs and induced relative phase shift by optical switching technique enters in one of the SOA, which saturates the gain as shown in Fig.2. Moreover the phase difference between two paths leads to destructive, constructive and recombination of light [8].

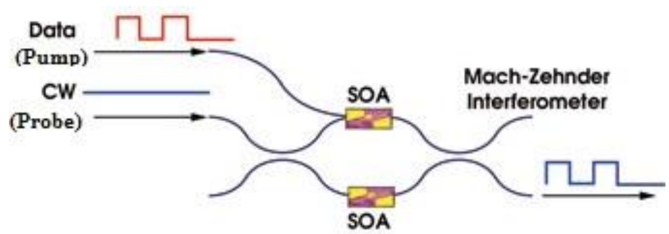


Fig. 2: Basic diagram of cross phase modulation

Furthermore, an analysis is conceded out of an all-optical wavelength converter based on cross phase modulation (XPM) in a SMF and DSF [9]. Despite this, a new, simple, and robust wavelength converter is proposed and experimentally demonstrated at 40 Gb/s [10] [11]. If a fiber with high nonlinearity [12] is exploited together with a high-power erbium-doped fiber amplifier in a polarization independent confirmation, the structure has the potential to appreciate a compact polarization independent broad-band wavelength converter.

## III. 3R-REGENRATOR IN SOA

Re-shaping, re-timing, and re-amplification (3R regeneration) of optical signals is measured as an important capability for spreading the range of long-haul transmission and also for restoring the impairments enforced by a compound optical network. Also the speed of optoelectronic 3R regeneration can be raised up to 40 Gb/s using electronic flip- flop circuits [13]. Furthermost all-optical 3R regenerators, the input and output optical waves are varied in accordance to non-linear medium at high power levels. Meanwhile some problems occur for all optical approaches [14].

- The non-linear medium may be sensitive to the polarization and wavelength of the input signal.
- High power optical amplifiers may be required and tunable optical filters are needed to suppress amplified spontaneous emission (ASE) noise.
- Regeneration at the same wavelength would require cascading two stages of regenerator with an intermediate wavelength.

Recent developments of all-optical 3R regenerators have made progress to relax some of these limitations; especially those based on semiconductor optical amplifiers [15].Henceforth, a development in 100 GB/s optical 3R regeneration technology that can be applied to both OOK and BPSK modulation schemes [16].

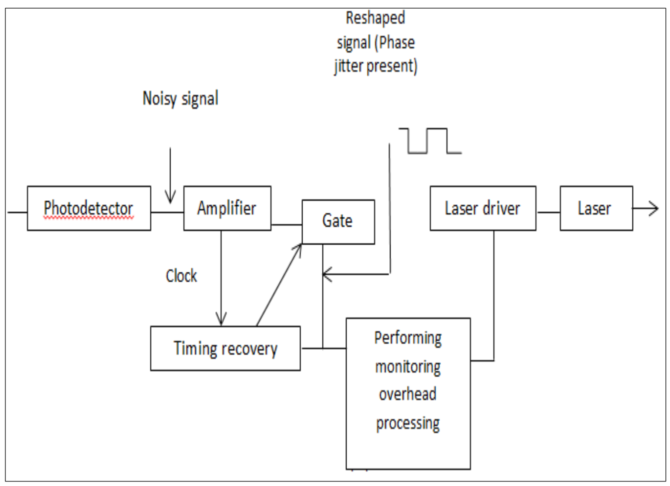


Fig.3: block explanation of 3R regenerator circuit

- With the usage of receiver, the polarization and wavelength dependence can be minimized.
- High power optical amplifiers and tunable optical filters are not essential since electrical amplifiers are used.

- Regeneration at the same wavelength without cascade is inherently viable because the input and output signals are not mixed optically.

These advantages make optoelectronic 3R regeneration very competitive when the bit-rate can be handled by electronics.

## IV. RESULTS AND DISCUSSION

Fig.4 demonstrates the experimental setup of wavelength converter in WDM system using cross phase modulation (XPM) technique taking 100 Km of fixed fiber length at bitrate of 1Gb/s. In this setup 1 Gb/s bit sequence or bit rate of 1Gb/s is provided to optical Gaussian pulse generator having input frequency of 1550 nm and power of 0.000316 W is provided to WDM MUX. Simultaneously, an optical pump signal in the form of Laser having parameters frequency of 1540 nm and laser power of -10db W is provided to WDM MUX. Further, input optical signal from 2:1 WDM MUX passes through a fixed optical fiber length of 100 Km. Furthermore, as per cross phase modulation technique, the desired signal is provided to two different semiconductor optical amplifiers(SOA's) by using a splitter. Moreover the optical signal is demultiplexed by WDM DEMUX and changes to electrical form. Afterward, a photo detector, a low pass Bessel filter of cut of frequency 0.8 Hz are used to evaluate different parameters like Q- factor and BER (bit error rate). Experimentation process leads to variation in different component parameters in accordance to frequency, power, bit rate and optical length. Fig.5 shows that as the input power varies from -40 dbm to 40dbm,maximum quality of response or Q factor obeseverd at power -10 dbm. Simultanoesly, minimum bit error is calculated when input power get varied near to -10dbm as shown in Fig6. It is calculated that Q-Factor and Bit Error Rate came nearly 31.33 and $8.07034\times10^{-216}$.

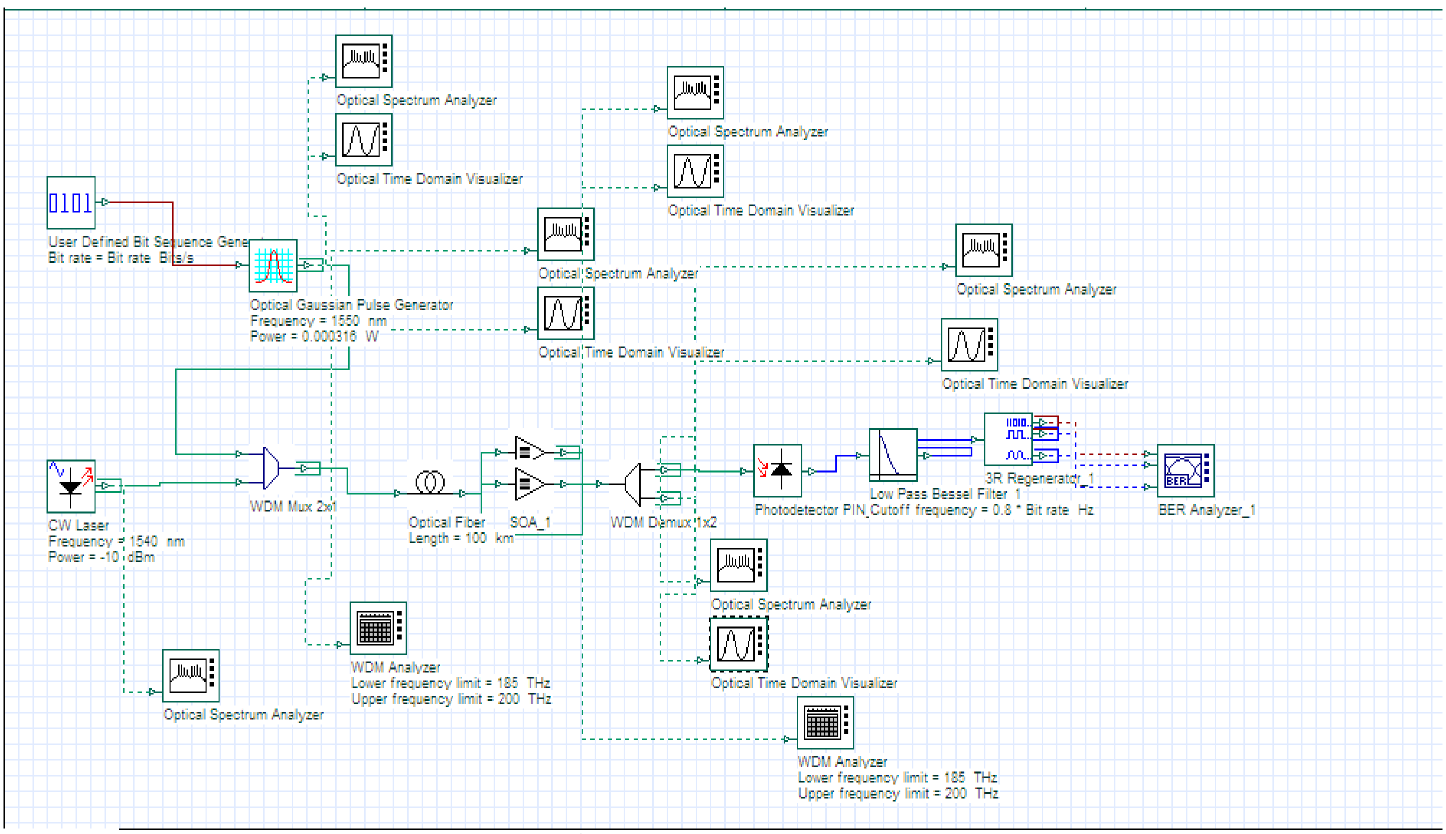


Fig.4: Simulated setup of wavelength converter using XPM having 3R Regenerator

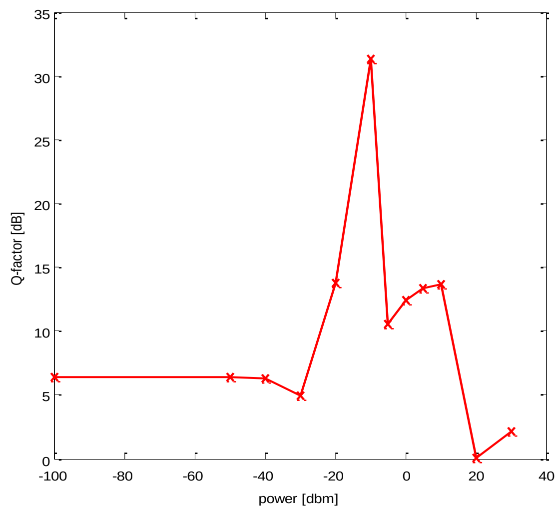


Fig.5: Graphical representation of Q factor with respect to power (dbm)

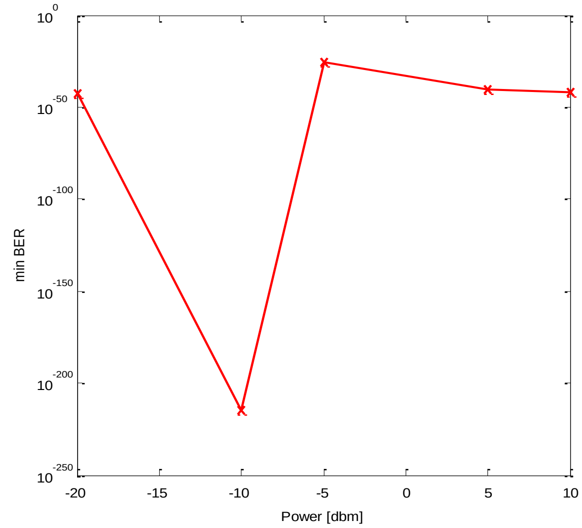


Fig.6: Graphical representation of BER with respect to power (dbm)

Similarly same dilemma is calculated with variation in input frequency.Fig.7 and Fig.8 illustrates that maximum Q-factor and minimum BER is observed when input frequency is 1540nm.

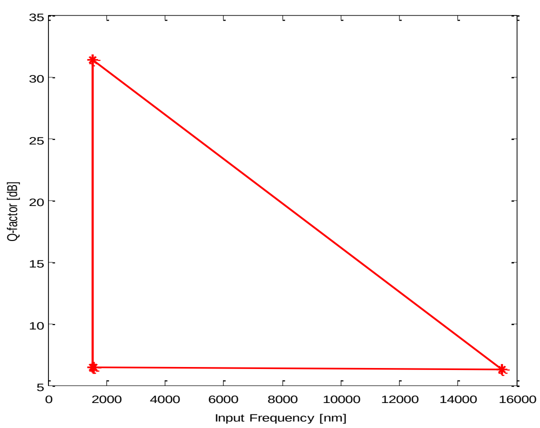


Fig.7: Graphical representation of Q factor with respect to input frequency (nm)

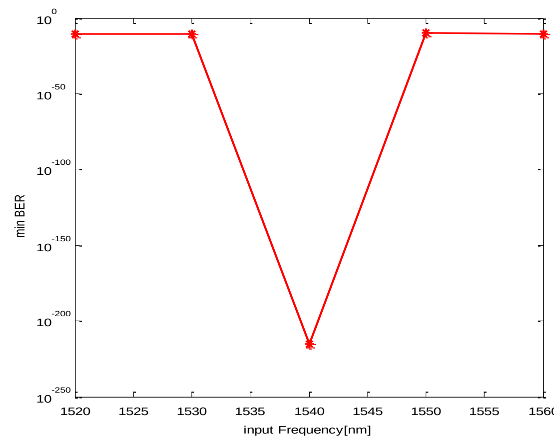


Fig.8: Graphical representation of BER with respect to input frequency (nm)

Furthermore, at desired bit rate 10 Gb/s, input frequency of 1540nm, laser power -10dbm and fixed optical fiber length of 100Km maximum Q-factor of 31.33 and minimum BER of $8.07034\times10^{-216}$ is calculated while performing wavelength conversion using cross phase modulation technique having 3R regenerative circuit. The graphical representation of Q-factor and BER using is shown in Fig.9 and Fig.10.

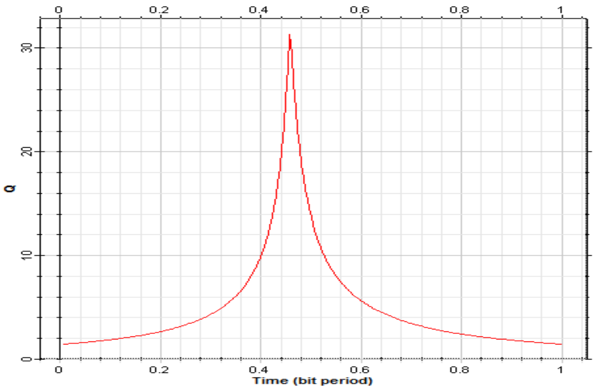

Fig.9: Graphical representation of Q factor with respect to time

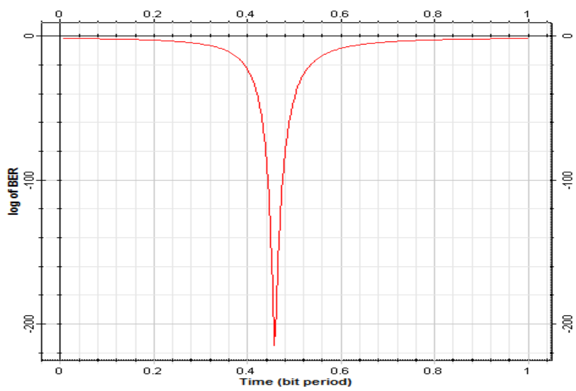

Fig.10: Graphical representation of BER with respect to time

In Optisystem, the Eye Pattern of wavelength converted output optical signal by usage of low pass Bessel filter and 3R Regenerators are shown in Fig. 11 and Fig. 12.

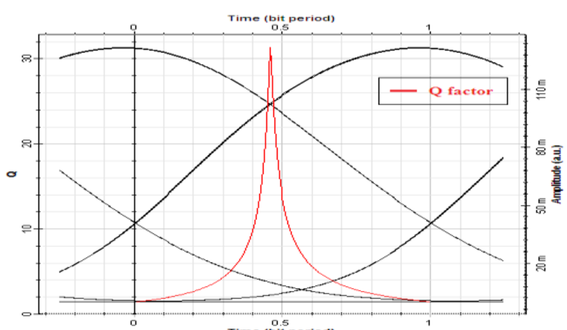

Fig.11: Eye diagram of Q factor

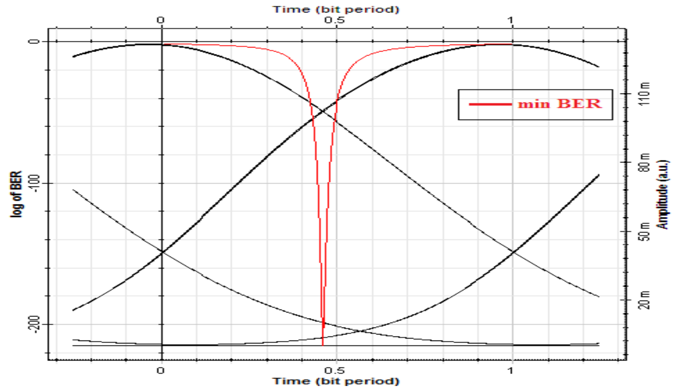

Fig.12: Eye diagram of BER

## V. CONCLUSION AND FUTURE SCOPE

In nutshell, wavelength conversion using interferometer cross phase modulation technique having 3R regenerative circuit can be realized. This paper illustrates that at 10Gb/s bit rate, pump signal input frequency 1540nm, power -10dbm and at optical fiber length of 100 Km the maximum quality factor of 31.3323 and minimum bit error rate of $8.07034\times10^{-216}$ is evaluated while analysis wavelength conversion using XPM technique having 3R regenerative circuit. Further in future, signal to noise ratio and threshold can be determined easily by using this schematic technique.

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