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Investigation of Wave length converter using four wave mixing in an optical fiber

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Abstract
Wavelength conversion at 10 Gb/s based on four wave mixing in an optical fiber is investigated with simulation in this paper. The power of converted signal increases with increase of signal power. The converted signal power is investigated as a function of input signal power and pump power is fixed at 0 dBm. This technique is energy efficient as required pump power is very low. On comparison of converted signal power at different value of input signal power, we observe that best converted signal power is obtained at -2 dbm input signal power for both up conversion as well as for down conversion.

Keywords: ***Four wave mixing, an optical fiber, wavelength conversion***

1. Introduction

When a high power optical signal passes through an optical fiber, it changes the refractive index of an optical fiber .This is a nonlinear effect, in which optical signal power changes the properties of medium through which it passes. Four wave mixing is a type of nonlinear effect, this effect occurs when light of two or more wavelengths is launched in to an optical fiber.[1,3] The launch of light of different wavelengths produce a signal at new wavelength. On basis of parameters of optical fiber one, two or more signals can be obtained, which can be called as up converted signal or down converted signal. Four wave mixing is commonly avoided but it can be useful for some applications Four wave mixing has been used to be give the transmission of data at new wavelength, which is obtained as a result of interaction of given set of wavelengths. The problem is created if equal channel spacing is used between given set of wavelengths. Rajneesh Kaler et al.[1] investigated that on increasing the spacing between input channels, their interference with each other decreases and thus, the four wave mixing effect also decreases. Arisma Cerqueira et al.[2] demonstrated a three pump technique for efficient generation of frequency combs spaced by hundreds of GHz. K.P. Lor et al.3] described that frequency shift is insensitive to the pump frequency difference makes possible the generation of a distinct frequency-shifted beam by mixing a distinct pump beam with a spectrum of light. Nahyan Al Mahmud et al.[4] proposed use of Low chromatic dispersion fiber causes high FWM efficiency An optical amplifier is used to increase the transmission distance, which an optical signal can cover with sufficient value of power. This will require an increase of power of signal. The power of converted signal increases with increase of input signal power

2. Simulation set up and parameters

FWM is a third order nonlinearity in silica fibers, which causes three optical waves of frequencies f_i, f_j and f_k

($k \neq i, j$) to interact in a multichannel WDM system to generate a fourth wave of frequency given by

$$f_{ijk} = f_i + f_j - f_k \quad (1)$$

Four wave mixing is also achievable in an optical fiber. This technique provides modulation format independence and high bit rate capabilities. If channel spacing is small FWM process can still occur and transfer power from each channel to its nearest neighbors. Such a power transfer not only results in the power loss for the channel but also induces interchannel crosstalk that degrades the system performance. FWM can also be useful in designing light wave systems. It is often used for demultiplexing individual channels when time division multiplexing is used in the optical domain. It can also be used for wavelength conversion.

In this model data is transmitted at 10 Gb/s through an optical fiber. Input signal is modulated in NRZ format. The modulated signal and pump signal are transmitted through an optical fiber. Two new signals are obtained at output of an optical fiber due to interaction of signals with fiber nonlinearities.

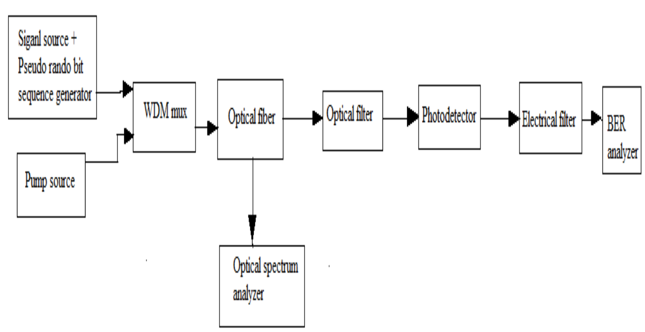

Fig.1: 10 Gb/s optical wavelength conversion set up

As shown in fig.1 set up consist of transmitter section, receiver section and channel. The transmitter section consist of electrical driver, data source, laser and external Mach Zehnder modulator. The function of data source is to generate signal of 10 Gb/s with pseudo random sequence. The electrical driver converts logical input signal in to electrical signal. The CW laser sources generate laser beams at 1550nm and 1552nm.The signals from laser source and data source are fed to Mach Zahnder modulator, where signal from laser source is modulated by the information signal. The simulation set up of an optical fiber is shown in fig.1 for different dispersion parameters and signal powers. The modulated signal and laser signal are given to a WDM mux. The output of mux is applied to an optical fiber, then due to nonlinear effects at the output of fiber two new signals are produced at different wavelengths. These signals are amplified by using an optical amplifier, so that signals can be properly received at the receiver section. The receiver section consist of an optical filter, photodetector, low pas filter and BER analyzer. The function of an optical filter is to select the desired band of signals and reject remaining signals. The photodetector is used to convert an optical signal into electrical signal. Low pass filter is used to pass only low frequency of electrical signals and reject high frequency signals. BER analyzer is used to display quality factor and bit error rate of signal. An optical signal is transmitted and its performance is evaluated for different values of dispersion parameters and signal powers. The set up is repeated by varying parameters of an optical fiber and signal strength is measured for different iterations. Different results like eye diagram, quality factor and BER is obtained, which calculate best parameters of an optical fiber. Optical spectrum analyzer and BER analyzer are used to measure power of signal and quality factor, bit error rate of signal respectively.

The various parameters and their values are shown in tabular form. The parameters for Mach Zehnder modulator are shown in table number1

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Table1: Parameters of mach zehnder are:

Extinction ratio	30dB
Symmetry factor	-1

WDM mux is used to combine optical signals, its various parameters are shown in table number number 2

Table 2: Parameters of WDM mux are:

Bandwidth	20 Ghz
Depth	100 dB
Filter type	Bessel
Order	3

An optical fiber is used to transmit the optical signal, its various parameters are shown in table number 3

Table 3 Parameters of an optical fiber are:

Reference wavelength	1550 nm
Length	7 Km
Dispersion	-50 ps/nm/km
Dispersion slope	-0.01 ps/nm^2/k
Differential group delay	0.5 ps/km
Effective area	50 μm^2
Attenuation	0.2 dB

3. Results and discussion

As shown in fig.2 two optical signals are applied at 1550 nm and 1552 nm. Due to effect of four wave mixing two new signals are obtained at 1554nm and 1548 nm, called as up converted signal and down converted signal respectively. An optical filter of gain 29 dB is used, so that signals can be properly received. Two optical filters of 20 ghz tuned at different frequencies are used to get the converted signals.

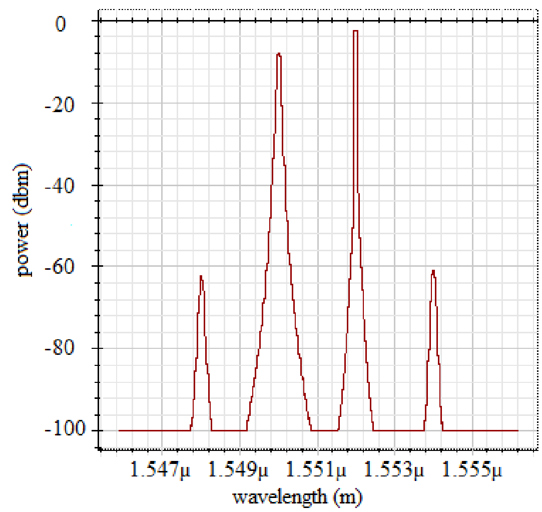

Fig.2 Variation of power of siganls with wavelength

In fig.3Graph is plotted between converted signal power and input signal power. The converted signal varies as we changes the input signal power. For this comparison input signal is applied at 1550 nm wavelength with a variation of power from -20 dbm to -2 dbm . The pump signal of power 0 dbm is applied at 1552 nm wavelength. An optical fiber of length 8 km, dispersion -50ps/nm/km is used in simulation set up. The number of converted signals obtained depend on the parameters of an optical fiber.

Both up converted signal and down converted signal power increases with increase in input signal power as shown in figure 3. The highest value of power for converted signal is obtained at -2 dbm .

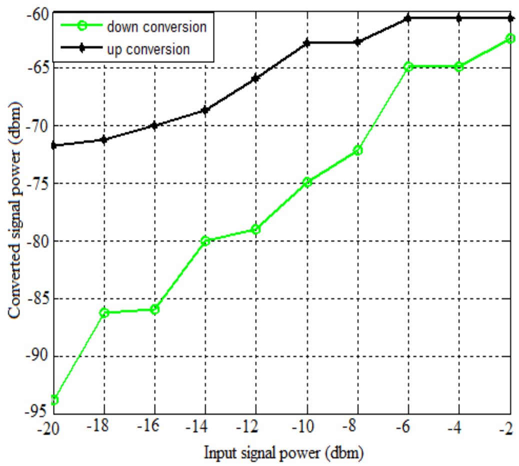

Fig.3: Converted signal power versus input signal power

4. Conclusion

We demonstrate the optical fiber that can be used to convert the data to another wavelength using an optical fiber. Converted signals are obtained for both upward conversion as well as for downward conversion. There is large difference between the power of up converted signal and down converted signal at low value of input signal power. As we increase the power of input signal, the difference between the power of up converted signal and down converted start to decrease. At -2dbm down converted signal power comes close to up converted signal power. The highest value of converted signal is also obtained at -2 dbm for both signals. This conversion technique is power efficient since value of pump power is very small. We believe that this scheme for wavelength conversion will find suitable application in optical packet routers.

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