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Reduction of FWM in the optical system to improve the performance of optical communication by using DPSK modulation

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***Abstract*— In this paper an analysis of the performance limitation of SMF due to FWM effect is discussed. With the help of optsim simulation software a DCF has been employed with proper length and variation in dispersion and in consecutive pulse is introduced to analyse the behaviour of FWM. Better performance was shown when DPSK modulation is provided. The Q value and BER technique have been used for evaluating the system performance.**

***Keywords*— FWM, Nonlinear effects, Dispersion, DCF, DPSK.**

I. Introduction

The commercial development of optical fibre communication has come in 1980 and the bit rate increases from 45 Mbps to 40Gbps today [1]. In WDM optical system operating beyond ten Gbps (at a very high bit rate) nonlinearity such as FWM, SPM, and XPM could play a role. These nonlinear effects can be reduced through proper system design [2].

Nonlinear effects in optical fibres have become a most prominent area of academic research in the optical fibre based WDM system. The WDM system requires each channel operate relatively at high power level so as to achieve an expected optical signal to noise ratio. When launch power in optical fibre is high then transmission is limited by nonlinear effect present in optical fibre and when launch power in optical fibre is low then transmission in optical fibre is limited by ASE (amplified spontaneous emission) noise.

At high bit rate transmission over SMF with high bit rate at 1550 nm suffer severely from combined effect of Chromatic Dispersion and Nonlinearity.

In this paper, we analyse and compare the performance of an optical communication system by using dpsk modulation technique with bit rate 10 Gbps over 100 Km span on a three different channel.

II. THEORY

The major source of nonlinear crosstalk for WDM light wave system is FWM (Four Wave Mixing).when three wave of frequencies $\omega_i, \omega_j, \omega_k$, co-propagate inside the fibre FWM can generate a new wave at the frequency ω_F.

$$\omega_F = \omega_i + \omega_j - \omega_k \qquad (1)$$

For an N- channel system i, j, k vary from 1 to N, resulting in large combination of new frequency generated by FWM. In FWM, power of main frequency is reduced due to generation of new frequency. System performance is affected by the loss in channel power of new frequency. The FWM depend not only on the loss in channel power of new frequency but also on the bit patterns of channels. The FWM induced noise is quite large for low GVD values because of the quasi matched nature of the FWM process [3-7].

III. SIMULATION MODEL

For almost exact physical realization of the system, optsim simulation software is used. The system is divided into three major section transmitter, channel (optical fibre), and receiver.

A. *Transmitter*

The transmitter consist of a pseudo random bit sequence, Non return to zero(NRZ) coder, continuous wave laser, Mach-zander modulator and for FWM analysis there are three transmitter operated in three different frequency.

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B. Optical fibre (Channel)

The optical signal generated by Tx is carried by the fibre. The 100 kilometre fibre span consists of the two segment SMF of length 85 Kilometre and DCF of length 15 Kilometre.

C. Receiver

A photodiode converts the optical (light) signal into an electrical signal. For measurement optsim provide a visualization tool called scope which is an electrical oscilloscope with numerous data processing options, BER estimation and Q value features.

TABLE I
.Simulation parameter.

Parameter	**value**
Power(dBm)	15

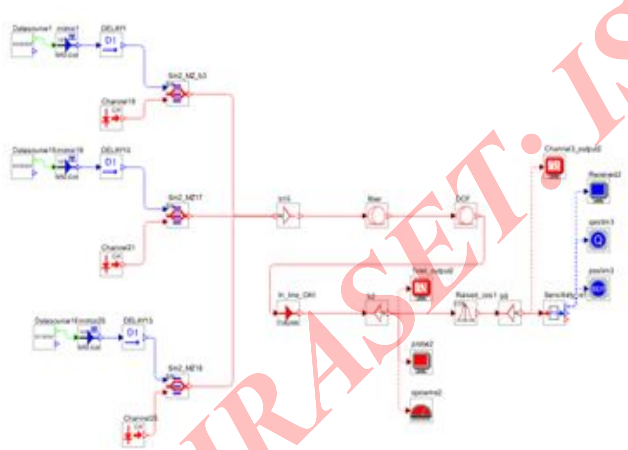

Fig. 1 Simulation Setup of Optical Transmission System by using FWM technique.

IV SIMULATION RESULTS

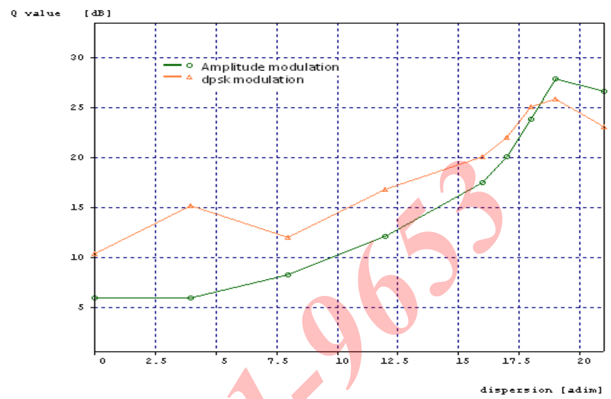

Fig. 2 Q value vs Dispersion for two different type Modulation technique.

TABLE II

Comparison of Q value with two different modulation technique.

dispersion(ps/nm/Km)	**Amplitude modulation**	**DPSK modulation**
00.0	6.02060	10.43671
04.0	6.02060	15.26884
08.0	8.27207	12.07926
12.0	12.13237	16.84101
16.0	17.51096	20.15011
17.0	20.10510	22.08305
18.0	23.89413	25.16732
19.0	27.99104	25.88084
21.0	26.71510	23.13156

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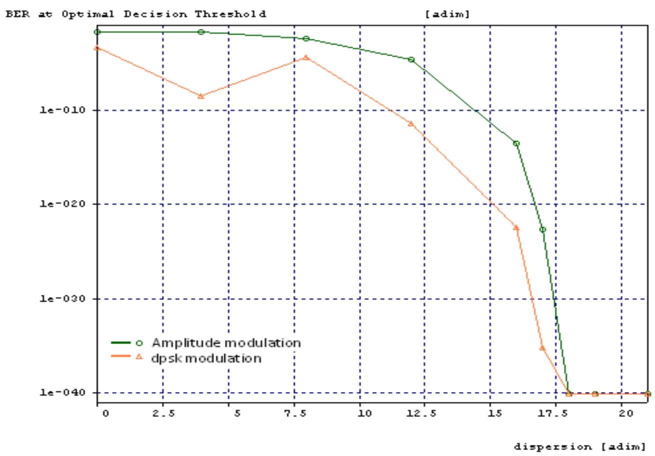

Fig. 3 BER v/s Dispersion for two different type Modulation technique.

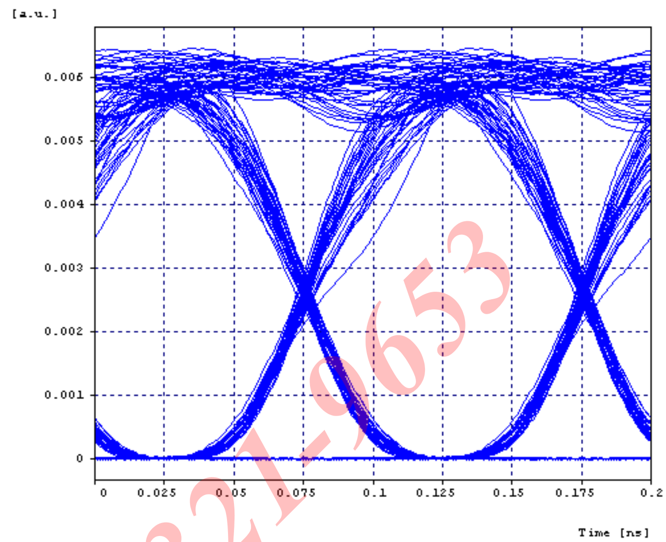

Fig. 4 Eye Diagram at dispersion 17 nm/ps/Km for amplitude modulation

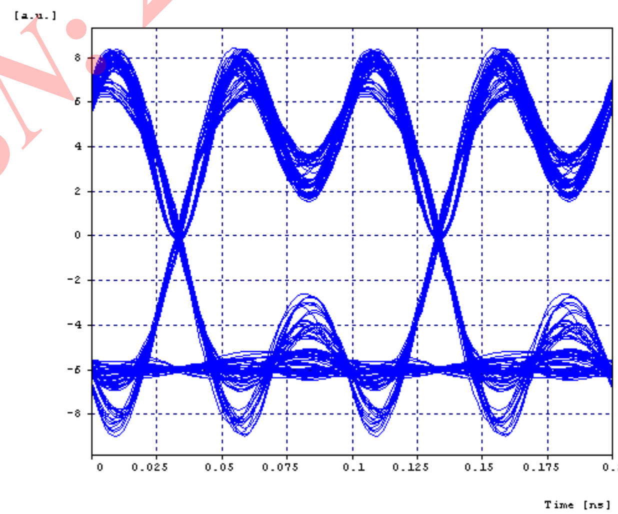

Fig. 5 Eye Diagram at dispersion 17 nm/ps/Km for DPSK

Table III

dispersion(ps /nm/Km)	**Amplitude modulation**	**DPSK modulation**
00.0	0.22750E-01	0.53968E-03
04.0	0.22750E-01	0.42791E-08
08.0	0.47401E-02	0.41737E-04
12.0	0.29072E-04	0.47894E-11
16.0	0.38045E-13	0.47265E-22
17.0	0.29253E-22	0.78956E-35
18.0	0.99999E-40	0.99999E-40
19.0	0.99999E-40	0.99999E-40
21.0	0.99999E-40	0.99999E-40

TABLE IV

Eye Opening at dispersion(ps/nm/ Km)	**Amplitude modulation [a.u.]**	**With DPSK [a.u.]**
17.0	.00551393	10.7176

V. SIMULATION RESULTS AND DISCUSSIONS

The comparison of two different types of modulation techniques (DPSK & Linear modulation) is to analyse the FWM effects on optical transmission system. The two different systems were investigated in terms of Eye diagrams, BER and Q value. The impact of FWM become

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less severe when frequency or phase shift keying (FSK and PSK) is used since channel power become constant in time. In fact, FPM would be harmless if the channel Power is really constant, as constant phase shift does not affect the system performance. Fig. 4.to Fig. 5 shows, eye opening in DPSK modulator is 10000 times better than that of linear modulator. Q value and BER has also verified the same result.

V. CONCLUSIONS

In this paper we have compared and analysed the performance limitation of SMF due to FWM effects.We have employed DPSK modulation with the help of optsim simulation software to handle the nonlinear effects in the transmission system. Better performances has been shown when DPSK modulation technique is used .

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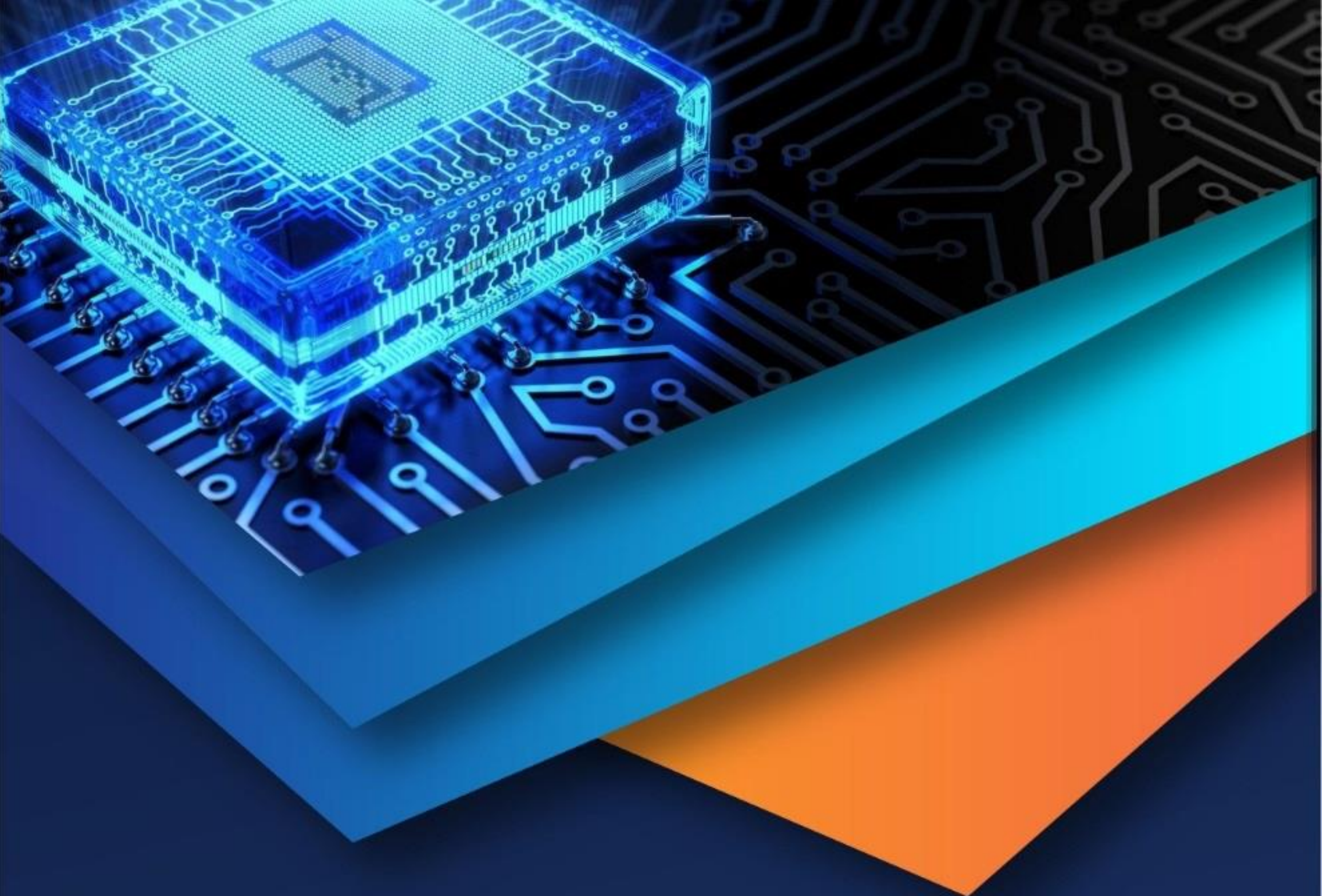

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