Volume : 4 | Issue : 1 | January 2015 • ISSN No 2277 - 8179

Research Paper

Self-Phase Modulation, Cross-Phase Modulation and Four-Wave Mixing Are the Root Cause of the Nonlinear Effects in Optical Fiber

Engineering

KEYWORDS : self-phase modulation, cross-phase modulation and four-wave mixing.

Dr.Brijesh.N.chawda — Professor, Department of Humanities and sciences, Jayaprakash Narayan college of Engg, Mahaboobnagar, Telangana, India.

A.Swamy — Asst. Professor, Department of Humanities and sciences, Jayaprakash Narayan college of Engg, Mahaboobnagar, Telangana, India.

ABSTRACT

Change in the refractive index of the medium with optical intensity and inelastic- scattering phenomenon leads to non-linear effects like self-phase modulation, cross-phase modulation and four-wave mixing which in turn affect fiber telecom system performance adversely and proper fiber system design reduces these nonlinear effects.

1.1.1: INTRODUCTION:

Optical fibers exhibit a variety of nonlinear effects and fiber non-linearities are feared by telecom system designers because they can affect system performance adversely.

Fiber nonlinearities[3] can be managed thorough proper fiber system design which reduces the nonlinear effects. The three different nonlinear effects are self-phase modulation, cross-phase modulation and four-wave mixing.

The root cause of SPM(self phase modulation)[2] is the change in frequency due to the phase difference introduced (or) developed by the refractive index of fiber which in turn depends on the intensity.

Different parts of travelling pulse have different intensity suffer different phase shift and this results in frequency change (or) also called as frequency chirping. The phase introduced by the fiber after travelling a fiber length L is given by equation

$$\ddot{O} = \frac{2\eth}{\ddot{e}} (n\acute{e} + n_{n\acute{e}} I) L_{eff} \quad (1.1)$$

The first term of above expression gives the linear portion of phase and second term gives the non linear phase constant [3,4].

As phase is varying with time it leads to frequency variation also called as chirping frequency due to SPM.

As phase is varying it leads to change in frequency spectrum or broadening of a pulse due to self phase modulation [7] as shown in figure below.

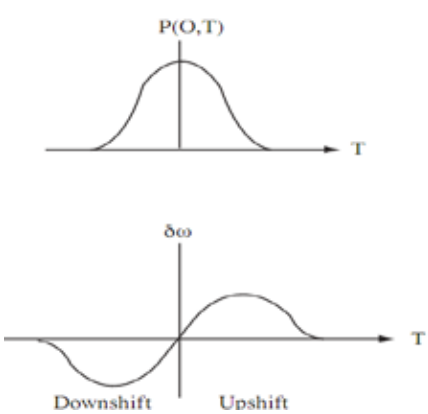

Figure 1: changes in frequency spectrum or broadening of a pulse due to self phase modulation.

SPM-induced spectral broadening can degrade performance of a lightwave system.

Cross-phase modulation (XPM) is a nonlinear optical effect where one wavelength of light can affect the phase of another wavelength of light through the optical Kerr effect. XPM leads to interchannel crosstalk in WDM systems

It can produce amplitude and timing jitter.

FWM stands for Four Wave Mixing is a non-linear property occurring due to optical Kerr effect and occurs when different wave lengths of light are launched into a fiber giving rise to a new wave which will never coincide with any of the other waves.

FWM [6] provides the solution for measuring the non nonlinearity and dispersion (chromatic) of optical fiber.

However, the concept of four Wave Mixing efficiency is used in commutation system which uses WDM (wave length division multiplexing) systems.

FWM leads to interchannel crosstalk in WDM (wave length division multiplexing) systems.

It also generates additional noise and degrades system performance.

1.1.2: Results and Discussion to reduce the non-linear effects:

Impact of SPM[1] can be reduced if power per channel is below 19.6 mW.

FWM has severe effects in WDM systems, which uses dispersion-shifted fiber. If some dispersion exist then effect of FWM is reduced and therefore non-zero dispersion-shifted fibers are normally used in WDM systems.

The effects of CPM can be reduced by increasing the wavelength spacing between individual channels. For increased wavelength spacing, pulse overlaps for such a short time that CPM effects are virtually negligible. In fact, owing to fiber dispersion, the propagation constants of these channels become sufficiently different so that the pulses corresponding to individual channels walk away from each other. Due to this pulse walk-off phenomenon the pulses which were initially temporally coincident, cease to be so after propagating for some distance and cannot interact further. Thus, effect of CPM is reduced.

Volume : 4 | Issue : 1 | January 2015 • ISSN No 2277 - 8179

CONCLUSIONS:

Non-linear effects in optical fibers occur due to change in the refractive index of the medium with optical intensity and inelastic- scattering phenomenon. The power dependence of the refractive index is responsible for the Kerr-effect. Depending upon the type of in- put signal, the Kerr-nonlinearity manifests itself in three different ef fects such as Self-Phase Modulation (SPM), Cross-Phase Modulation (CPM) and Four-Wave Mixing (FWM). Though these effects degrade

the performance of fiber optic systems but are also useful for many applications such as SPM in solitons and pulse compression, CPM in optical switching, and FWM in squeezing and wavelength conversion.

Acknowledgments: We are grateful to the chairman Shri K.S Ravi Kumar Garu, Secretary Sri V.Venkata Rama Rao Garu and principal Dr.R.Ramesh Reddy of JPNCE institution for all the possible support extended to our work.

REFERENCE

1) Biswasand.A and S. Konar (2005) "Soliton-solitons interaction with kerr law non-linearity," Journal of Electromagnetic Waves and Applications, Vol. 19, No. 11, 1443–1453. | 2) A.Biswas.A, S.Konar, and E. Zerrad (2006) "Soliton-soliton interaction with parabolic law nonlinearity," Journal of Electromagnetic Waves and Applications, Vol. 20, No. 7, 927–939. | 3) Biswas.A, Shwetanshumala and S. Konar (2006) "Dynamically stable dispersion-managed optical solitons with parabolic law nonlinearity," Journal of Electromagnetic Waves and Applications, Vol. 20, No. 9, 1249–1258. | 4) Hasegawa.A and Y. Kodma (1995) "Soliton in Optical Communication", Clarendon Press, Oxford.Haus. | 5) H. A (1993) "Optical fiber solitons: Their properties & uses",Proc. IEEE, Vol. 81, 970–983. | 6) Thiel. C.W "Four-wave mixing and its applications". | 7) Haus. H and W. S. Wong (1996) "Soliton in optical communications,"Rev. Mod. Phys., Vol. 68, 432–444.