



The Nonlinear Effects in an Optical Fiber

KEYWORDS

refractive index, modulation and nonlinear effect.

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ABSTRACT Non-linear effects in optical fiber occur due to change in the refractive index of the medium with optical intensity and inelastic- scattering phenomenon.

Change in the refractive index of the medium with optical intensity and inelastic- scattering phenomenon leads to non-linear effects 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-linearity are feared by telecom system designers because they can affect system performance adversely.

Fiber non-linearity's [3] can be managed through 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

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

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.

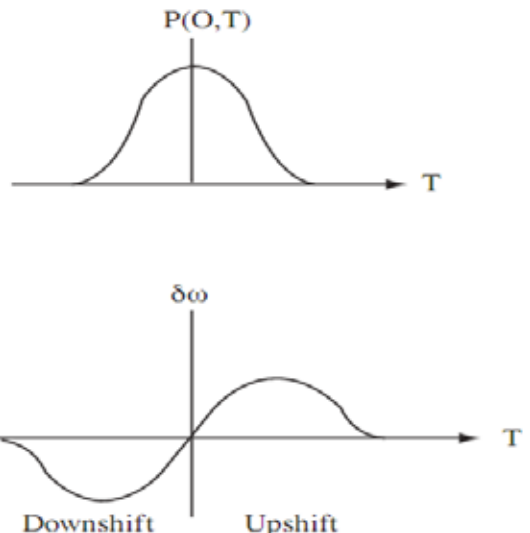


Figure 1: changes in frequency spectrum or broadening of a pulse due to self phase modulation.

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 non-linearity 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-of 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.

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. Non-linear effects leads to interchannel crosstalk in WDM systems and also generates additional noise and degrades system performance. It can produce amplitude and timing jitter.

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