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The effect of attenuation and dispersion on the propagation of a short Gaussian pulse in optical fibers

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Abstract: Fiber optics being the most important in many of applications like medicine and communication. Many factors affect the light propagation through it, like attenuation, dispersion and nonlinear effects. In this paper the effect of attenuation and dispersion on the propagation of a Gaussian pulse in optical fiber was studied by theoretical simulations. Nonlinear Schrödinger equation was solved by split step Fourier method using MATLAB. The study focused on the pulse intensity distribution with time and its distribution along the fiber under the effect of attenuation and dispersion. The pulse propagation is affected strongly with varying these parameters.

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Introduction:

An optical fiber is a very clear glass capable of carrying the light pulses as information in the communication system. The two main elements of an optical fiber are its core and cladding. The core made of silica glass is the light transmission area of the fiber. The cladding is the layer completely surrounding the core. The difference in refractive index between the core and cladding is less than 0.5 percent. Optical fiber played a very important role due to its wide properties like high bandwidth, long distance transmission, and high level of security [1-4]. Dispersion is the main performance limiting factor in optical fiber communication. Dispersion greatly hampers the performance of optical fiber communication. When a pulse travels through an optical fiber it becomes broadened due to dispersion. The dispersion is proportional to the length of the fiber. Dispersion is a consequence of the physical properties of the transmission medium [2,5,8-9].

Attenuation:

Attenuation is one important characteristic of an optical fiber, since it determines the repeater spacing in a fiber transmission system. The lower the attenuation, the greater will be the required repeater spacing and lower will be the cost of that system. Representing by P_0 the power launched at the input of a fiber of length L , the output power is given by [7]:

$$P_L = P_0 \exp(-\alpha L) \quad (1)$$

where α is the attenuation constant (absorption factor), (1/km), and it's a gauge to losses the energy during upload the signal (pulse) in optical fiber [9-10].

Usually, the fiber attenuation is given in dB/km, using the relation [7]:

$$\alpha = \frac{1}{L} \log_{10} \frac{P_0}{P_L} \quad (2)$$

Absorption is the way by which the energy of a photon is taken up by matter, typically the electrons of an atom. Thus, the light energy is transformed to other forms of energy for example, to heat. The absorption of light during wave propagation is often called attenuation [7].

Dispersion:



Figure 1: Distribution of pulse intensity with time at different distance. (a) Initial pulses. (b) pulses start to separate (c) starting to overlap (d) pulses no longer recognizable [3].

Dispersion is defined as pulse spreading in an optical fiber. As a pulse of light propagates through a fiber, elements such as numerical aperture, core diameter, refractive index profile, wavelength, and laser line width cause the pulse to broaden. Dispersion