A Review: Dispersion in Optical Fiber

Himanshu Trivedi and Kiran Rathore
PG student,
Geetanjali Institute of Technical Studies,
Udaipur, Rajasthan
himanshu22693trivedi@gmail.com
kiran28.07@rediffmail.com

Manoj Mali
Asst. Prof.
Shri USB Collage of Engineering and Management,
Abu Road,Rajasthan
manoj3045@gmail.com

Abstract **- In optics, dispersion is the phenomenon in which the phase velocity of a wave depends on its frequency, or alternatively when the group velocity depends on the frequency. Media having such a property are termed *dispersive media*. Dispersion is sometimes called *chromatic* dispersion to emphasize its wavelength-dependent nature, or group-velocity dispersion (GVD) to emphasize the role of the group velocity. Dispersion is most often described for light waves, but it may occur for any kind of wave that interacts with a medium or passes through an inhomogeneous geometry (e.g., a waveguide), such as sound waves. A material's dispersion is measured by its Abbe number, *V*, with low Abbe numbers corresponding to strong dispersion.**

Keywords - GVD, Chromatic Dispersion, Abbe number etc

I. Introduction

The phenomenon that the group velocity of light propagating in a waveguide structure depends on the waveguide mode is define as the intermodal dispersion. Intermodal dispersion (also called *modal dispersion*) is the phenomenon that the group velocity of light propagating in a multimode fiber (or other waveguide) depends not only on the optical frequency (*chromatic dispersion*) but also on the propagation mode involved.

II. Strength of intermodal dispersion

The strength of intermodal dispersion can be quantified as the differential mode delay (DMD). It depends strongly on the refractive index profile of the fiber in and around the fiber core. For example, for a step-index profile the higher-order modes have lower group velocities, and this can lead to differential group delays of the order of 10 ps/m = 10 ns/km. It is then hardly possible to realize data rates of multiple Gbit/s in an fiber-optic link with a kilometer length.

In systems for optical fiber communications based on multimode fibers, intermodal dispersion can severely limit the achievable data transmission rate (bit rate). In order to avoid strong signal distortion, it is usually necessary to keep the pulses long enough to maintain a reasonable temporal overlap of components from different modes, and this unavoidably sets a limit on the data rate.

The natural way of eliminating intermodal dispersion is to use fiber links based on single-mode fibers, but intermodal dispersion can also be minimized by using multimode fibers with a parabolic refractive index profile, where intermodal dispersion is minimized.

III. Chromatic Dispersion

Chromatic dispersion is a phenomenon that is an important factor in fiber optic communications. It is the result of the different colors, or wavelengths, in a light beam arriving at their destination at slightly different times. The result is a spreading, or dispersion, of the on-off light pulses that convey digital information. Special care must be taken to compensate for this dispersion so that the optical fiber delivers its maximum capacity.

Chromatic dispersion is a serious consideration in long-haul optical fibers. Its effect is essentially to stretch or flatten the initially sharply-defined binary pulses of information. This degradation makes the signals (1s and 0s) more difficult to distinguish from each other at the far end of the fiber. The result is that at any given length, the effective information capacity, or bandwidth, of the fiber optic cable can be significantly reduced. Dispersion is added as the modulated beam of light, consisting of a number of closely spaced wavelengths, travels down this nearly transparent waveguide.

The bottom line is that chromatic dispersion becomes a major consideration and must be accounted for when developing or deploying fiber optic equipment for use in telecommunications, cable TV, or other high-speed optical networks.

IV. Dispersion Compensation

Techniques have been developed that help compensate for the negative effects of chromatic dispersion. One method involves pre-compensating the signal for the anticipated dispersion before it's sent down the optical fiber. Another method calls for using dispersion compensating fiber at the end of a length to correct or reverse the dispersion that was realized as the signal traversed the optical fiber. As a result, these techniques are widely used to help solve the problem of chromatic dispersion.

Dispersion compensation essentially means canceling the chromatic dispersion of some optical element(s). However, the term is often used in a more general sense of dispersion management, meaning the control the overall chromatic dispersion of some system. The goal can be, e.g., to avoid excessive temporal broadening of ultrashort pulses and/or the distortion of signals. Dispersion compensation is applied mainly in mode-locked lasers and in telecommunication systems, but also sometimes in optical fibers transporting light e.g. to or from some fiber-optic sensor.

strong dispersive broadening of modulated signals can occur in cases with high data rates. Without dispersion compensation, each symbol would be broadened so much that it would strongly overlap with a number of neighbored symbols. Even for moderate broadening, significant inter-symbol interference can strongly distort the detected signal. Therefore, it is essential to compensate the dispersion before detecting the signal.[4]

For high data rates such as 40 Gbit/s or 160 Gbit/s, pulse broadening becomes much stronger than for 10 Gbit/s, for example. This is essentially because the spectral bandwidth of the signal becomes larger. It is then generally not sufficient to compensate the second-order dispersion only; one also needs to deal with higher-order dispersion. Problems can arise, for example, when dispersion-shifted fibers with a substantial dispersion slope are used, and only dispersion of second order is compensated. Figure 1 show this effect for a single 2-ps pulse at 1550 nm after 10 km and 50 km of such a fiber. Mainly uncompensated third-order dispersion is responsible for the resulting distortions.

CONCLUSIONS

We have discussed about the dispersion which is one of the main factor in optical fibre communication. This paper provides a complete general description about the dispersion, what is intermodal dispersion and chromatic dispersion? , Is it useful or not? , how it can be compensate? Pre-compensating the signal for the anticipated dispersion before it's sent down the optical fiber. Another method is using dispersion compensating fiber at the end of a length to correct or reverse the dispersion.

REFERENCES

[1] R. Paschotta, tutorial on "Passive Fiber Optics", Part 10: Nonlinearities of Fibers and Part 12: Ultrashort Pulses
[2] Chromatic-Dispersion-in-Optical-Fibers by Kevin Miller on Wed, Aug 24, 201
[3] E. B. Treacy, "Optical pulse compression with diffraction gratings", IEEE J. Quantum Electron. QE-5, 454 (1969)
[4] O. E. Martínez *et al.*, "Negative group-velocity dispersion using refraction", J. Opt. Soc. Am. A 1 (10), 1003 (1984)
[5] R. L. Fork *et al.*, "Negative dispersion using pairs of prisms", Opt. Lett. 9 (5), 150 (1984)
[6] D. Garthe *et al.*, "Adjustable dispersion equaliser for 10 and 20 Gbit/s over distances up to 160 km", Electron. Lett. 30 (25), 2159 (1994)
[7] www.rp-photonics.com
[8] www.m2optics.com