Optical fibers and dispersion in optical fibers

Types of dispersion

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***Abstract* - In this paper ensue to be characterized all types of optical fibers and their features, also the phenomenon of dispersion and the reasons of its appearance or occurance. By means of all pictures shown below in the paper, the reader gets easier into essence of exposed theoretical material.**

Index terms: optical fiber, telecommunications, attenuation, dispersion, refractive indices

Introduction

The field of fibre optics communications has exploded over the past two decades. Fibre is an integral part of modern day communication infrastucture and can be found along roads, in buildings, hospitals and machinary. The fibre itself is a strand of silica based glass, it's dimensions similar to those of a human hair, surrounded by a transparent cladding. Light can be transmitted along the fibre over great distances at very high data rates providing an ideal medium for the transport of information. This section will provide explainations for *some* of the terms associated with the field of fibre optic engineering for telecommunications. Once conveyed through optical fibers, optical radiation meets in its way different barriers, and as result appears losses, attenuation and dispersion. Subsequently, the final signal, received, has a different amplitude-frequency characteristic than initial one, thus the quality of transmission is not so high.

In this paper is approached the topic about dispersion, and therefore in optics, **dispersion** is the phenomenon in which the phase velocity of a wave depends on its frequency. Sometimes the term ***chromatic* dispersion** is used for specificity. Although the term is used in the field of optics to describe light and other electromagnetic waves, dispersion in the same sense can apply to any sort of wave motion such as acoustic dispersion in the case of sound and seismic waves, in gravity waves (ocean waves), and for telecommunication signals along transmission lines (such as coaxial cable) or optical fiber.

1. WHAT IS OPTICAL FIBER ?

An **optical fiber** is a flexible, transparent fiber made by drawing glass (silica) or plastic to a diameter slightly thicker than that of a human hair.[1] Optical fibers are used most often as a means to transmit light between the two ends of the fiber and find wide usage in fiber-optic communications, where they permit transmission over longer distances and at higher bandwidths (data rates) than wire cables. Fibers are used instead of metal wires because signals travel along them with less loss.

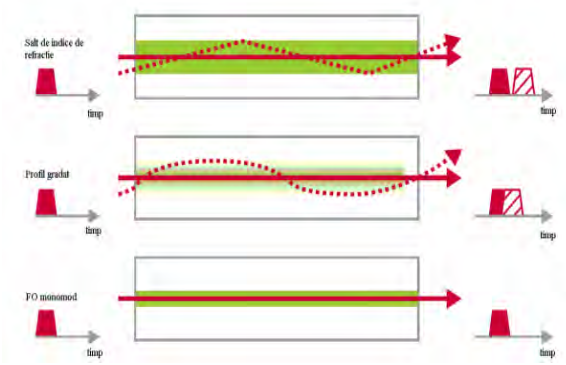

Fig.1 Types of Optical Fibers

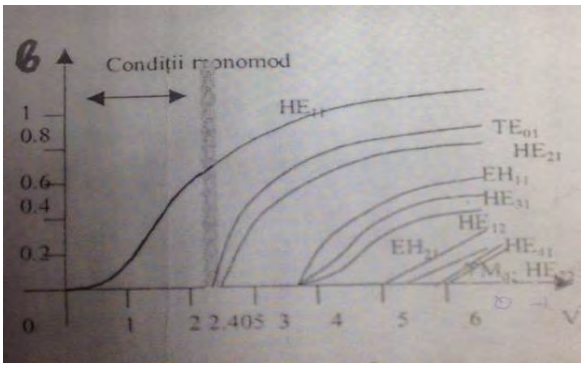

Fig.2 Ways of conveying optical radiation via OF

2. WHAT IS OPTICAL FIBER DISPERSION?

Dispersion is the spreading out of a light pulse in time as it propagates down the fiber. Dispersion in optical fiber includes model dispersion, material dispersion and waveguide dispersion. Each type is discussed in detail below.

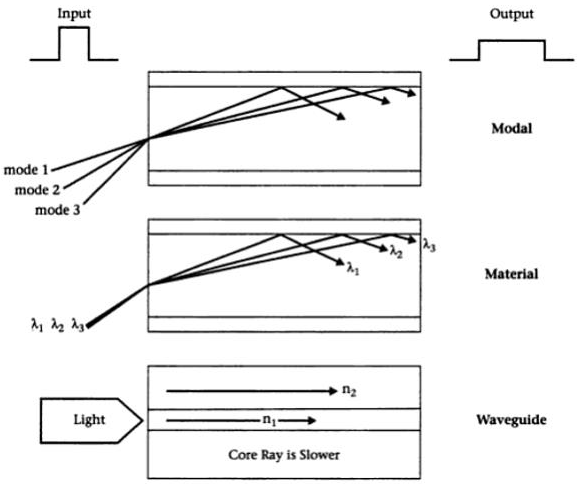

Fig.3 Types of dispersion

3. MODAL DISPERSION IN MULTIMODE FIBERS

Multimode fibers can guide many different light modes since they have much larger core size. This is shown as the 1st illustration in the picture above. Each mode enters the fiber at a different angle and thus travels at different paths in the fiber.

Since each mode ray travels a different distance as it propagates, the ray arrive at different times at the fiber output. So the light pulse spreads out in time which can cause signal overlapping so seriously that you cannot distinguish them any more.

Model dispersion is not a problem in single mode fibers since there is only one mode that can travel in the fiber.

4. MATERIAL DISPERSION

Material dispersion is the result of the finite linewidth of the light source and the dependence of refractive index of the material on wavelength. It is shown as the 2nd illustration in the first picture.

Material dispersion is a type of chromatic dispersion. Chromatic dispersion is the pulse spreading that arises because the velocity of light through a fiber depends on its wavelength.

The following picture shows the refractive index versus wavelength for a typical fused silica glass.

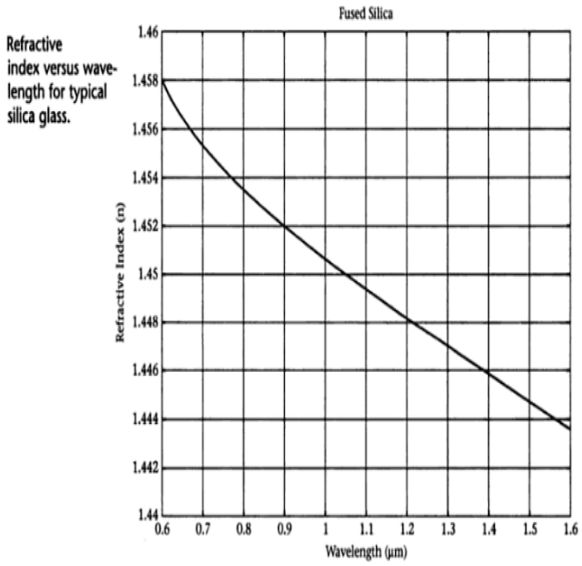

Fig.4 The refractive index versus wavelength for a typical fused silica glass

5. WAVEGUIDE DISPERSION

Waveguide dispersion is only important in single mode fibers. It is caused by the fact that some light travels in the fiber cladding compared to most light travels in the fiber core. It is shown as the 3rd illustration in the first picture.

Since fiber cladding has lower refractive index than fiber core, light ray that travels in the cladding travels faster than that in the core. Waveguide dispersion is also a type of chromatic dispersion. It is a function of fiber core size, V-number, wavelength and light source linewidth.

While the difference in refractive indices of single mode fiber core and cladding are minuscule, they can still become a factor over greater distances. It can also combine with material dispersion to create a nightmare in single mode chromatic dispersion.

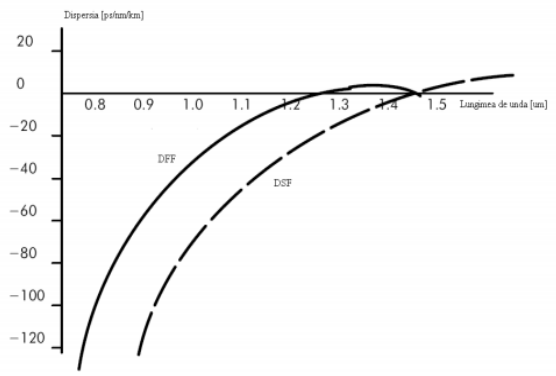

Fig.5 Dispersion for different types of OF

Various tweaks in the design of single mode fiber can be used to overcome waveguide dispersion, and manufacturers are constantly refining their processes to reduce its effects.

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