ISSN 1870-4069

Diffraction Effect in a Pulse Propagation

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Abstract. In this work, we present the simulation of propagation of a pulse and the effect of distanceattenuation in the pulse, based on MATLAB. Specifically present the results in the propagation of a Gaussian pulse and its effect on the diffraction spread in the different distances, the pulse corresponding to a HeNe laser. The results show the effect of diffraction on the propagation of the pulse; this informationis useful for example for teaching purposes.

Keywords: Diffraction effect, propagation, pulse.

1 Introduction

Some problems in optical communications are the losses of pulse energy, and that limit the propagation distance. The mechanisms for loss of greater importance that affect the pulsed electromagnetic propagation are: scattering, absorption, diffusion and diffraction, which show different behaviors depending on the intensity of the pulse.

The beam propagation method is a numerical way of determining the fields inside a waveguide. With this method, the mode profile of an unusual waveguides such as couplers can be determined with ease. The dynamic mode profile can be accurately estimated as the wave propagates through the wave guide [2]. The theory is based on a special class of solutions of the Maxwell's equation for beam of electro- magnetic radiation that is reasonably well collimated and having relatively small dimensions, measured in wavelengths, transverse to the axis of propagation.

The solution of the wave equation, in a cylindrical coordinate system is obtained from Helmholtz wave equation:

$$(\nabla^2 + k^2)\Psi = 0. \tag{1}$$

In this equation we assumed that the beam has well defined direction of propagation and some transverse variation. The distribution of the intensity of the electric field at a given distance$z$ along the axis of propagation and at a given perpendicular distance r from the axis.

The parameter w_0 denotes as the beam radius at z=0, which is called *the beam waist radius,* andthe variable w is called the beam radius:

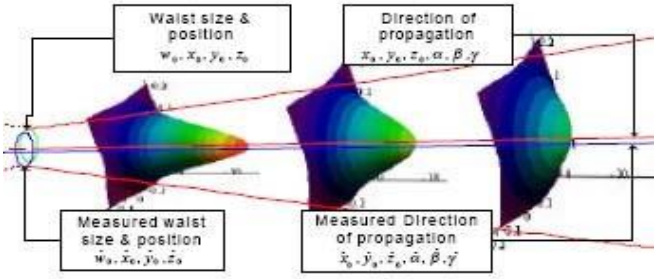

Fig. 1. Propagation scheme.

$$w(z) = w_0\sqrt{1 + (\lambda z/\pi w_0)^2}. \quad (2)$$

Based in the last two equations, we canconclude that the frequency, the beam waist andthe coordinates of the beam waist with its orientation (beam axis direction) are the complete set of the parameters to define Gaussian beam.

To align the HIFI receivers with the antenna beam we need to measure the receiver Gaussianbeams via obtaining their parameters as above with a high degree of accuracy. The proposed measuring technique for the Beam MeasurementRange is to perform a set of power measurements in several parallel cross sections along the direction of beam propagation.

2 Beam Propagation

The beam propagation method essentially decomposes a mode into a superposition of plane waves, each traveling in a different direction. These individual plane waves are propagated through a finite predetermined distance through the wave guide until the point where the field needs to be determined has arrived.

At this point, all the individual plane waves are numerically added in order to get back the spatial mode.

3 Experimental Results

In the following pictures we can appreciate the diffraction effect in a propagation pulse.

In Fig. 1 we show the original pulse.

In Fig. 2, in the next five subpictures the pulse has been propagate a distance of 1000 mm each one. In the seventh subpicture the propagation distance is 8000 mm, meanwhile the last subpicture it is 20000 mm.

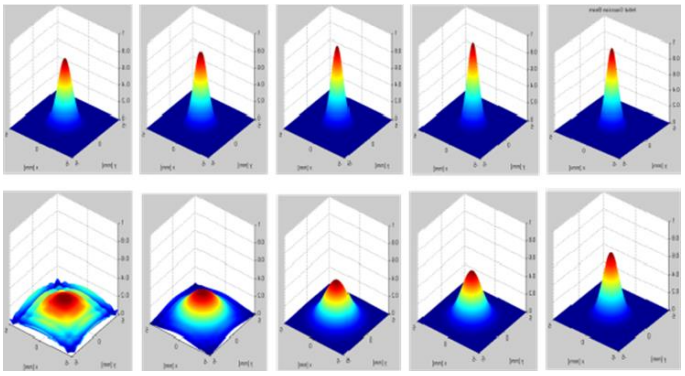

Fig. 2. Propagation with difraction.

4 Conclusions

We successfully used MATLAB for modeling the scalar Gaussian beam. The simulation program was employed for:

- optimization of the measurement procedures, the raw data reduction and investigation of the measurement error components.
- with the optimized procedures and data handling the simulation was used to evaluate ultimate performance of the proposed system and for the measurement error analysis

References

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