Chapter 19
Understanding the Numerical Resolution of Perturbed Soliton Propagation in Single Mode Optical Fiber

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ABSTRACT
The authors solve the propagation soliton perturbation problem in a nonlinear optical system based on a single mode optical fiber by introducing Rayleigh’s dissipation function in the framework of variational approach. The adopted methodology has facilitated the variational approach to be applied on a dissipative system where the Lagrangian and Hamiltonian are difficult to solve. The authors model the propagation in a nonlinear medium by using a nonlinear Schrödinger equation (NLSE). This is a mathematical model used to describe the optical fiber. The chapter is focused on the propagation of perturbed solitary waves in single mode fiber.

INTRODUCTION
Optical fiber devices communications are now an essential value to human life progress. The number of system users canceled and the amount of information conveyed is increasing (Calvez, 2001). The invention and development of amplifiers/regenerator’s erbium-doped fiber (Agrawal, 2007), and optical directional couplers has been the revolution in telecommunications fiber technology (Svalgaard, 1997; Chiang, 1995). This new all-optical technology, which combines the principle of issue stimulated in erbium with the guiding properties of the fiber, allows, without the
conversion steps optical-electronic and electronic-optical increase rates of transmission (Romagnoli, 1992). The fiber can be an optical amplifier, an optical switch converter wavelength, solitons in a source, a compressor noise, a filter, an optical memory,..., where the total internal reflection is the basic phenomenon responsible for guiding of light. Although most applications of fiber only use their linear characteristics, nonlinear effects have been studied since 1982 and can lead to all-optical switching among other applications (Chu, 1993, Akhmediev, 1993). The characteristics of soliton propagation in a nonlinear guided medium have evoked immense interest when subject to perturbation or to various forms of pulse degradation evolving through nonconservative and conservative perturbing processes.

As with any occupational hazardous phenomena, in telecommunication, the control technology is targeting the reduction of the noise to acceptable levels by action on the devices parameters. Such action involves the implementation of any measure that will reduce noise generated, by reducing the noise transmission through the air or through the structure of the fiber device. In fact, the best approach for noise hazard control in the optical fiber is to eliminate or reduce the hazard at its source of generation, either by direct action on the source or by its confinement. In certain cases, the solution may be found in a combination of the cited measures which by themselves would not be enough to avoid the noise effects. To achieve a part of the required reduction through environmental measures, it is possible to complement them with protection measures such as adding protection cladding for only few hours. The characteristics of soliton propagation in a nonlinear guided medium have evoked immense interest when subject to perturbation or to various forms of pulse degradation evolving through nonconservative and conservative perturbing propagation processes. In real physical systems, two-photon absorption, gain dispersion, higher order group velocity dispersion, noise control filtering and modulation, two-soliton interaction, higher order nonlinearity, intrapulse Raman scattering (IPRS), and self-steepening are considered to be the prime perturbing effects on a propagating optical pulse. The dissipative effects on the pulse are expected due to the influence of TPA, GD, and filtering, whereas in case of other perturbations, the pulse energy is likely to be conserved mathematically in [8], the generalized Kantorovitch method has been introduced in order to solve the extended nonlinear Schrödinger equation (NLSE) which describes the nonlinear loss and/or gain. Currently, the concept of this technique is frequently being associated with different perturbation problems (Akhmediev, 1993, Chu, 1995). In all the described techniques, the prime objective is to evaluate the differential equations that predict the evolution dynamics of different pulse parameters under various perturbations. The perturbing effects which are associated with a nonlinear pulse evolution have been solved mostly through variational formalism. In an attempt, we try to evaluate the perturbing effects on soliton pulse parameters by introducing Rayleigh’s dissipation function (RDF) with a similarity to a mechanical system where the frictional dissipative problems are solved by using RDF (Wang, 2006-Marcuse, 1982). Several Numerical simulations based on the Split-Step Fourier (SSF) were used to simulate the evolution of solitons in single mode optical fiber. Before presenting the detailed resolution of NLSE, we recall here some basics on how to calculate the number of modes in optical fibers.

**MODAL ANALYSIS: HOW TO CALCULATE THE NUMBER OF MODES IN AN OPTICAL FIBER**

The optical fiber is very thin transparent thread that has the ability to conduct light and is used in terrestrial broadcasting and oceanic data. Cylindrical, it is composed of a core refractive index