OCSim Modules
(Optical Fibers: Dispersion in an Optical Fiber)

MODULE 5: OPTICAL FIBERS: DISPERSION IN AN OPTICAL FIBER

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OCSim Advanced Level Software Modules

Softwares for Fiber Optic Communication Systems

Module 5: Optical Fibers: Dispersion in an Optical Fiber

Scientific Manual

Background Theory and Formulation of the Module

CodeSScientific

sales@codesscientific.com / www.codesscientific.com

Trademarks

Disclaimer

Optical Fibers

Fiber Dispersion

Background Theory and Formulation of the Module

In an optical fiber, different frequency components of the signal undergo different amounts of delays (or phase-shifts) and arrive at different times at the receiver, leading to pulse broadening. The pulse broadening is described by fiber transfer function defined as,

$$H_f(\Omega, L) = \exp(-\alpha L/2 + i\beta_1 \Omega L + i\beta_2 \Omega^2 L/2) \quad (1)$$

Where α is the fiber loss coefficient, L is the fiber length, and β_1 and β_2 are the first constant propagation delay of the signal to reach the receiver from the transmitter and typically, this term can be ignored.

The signal propagation in a fiber is summarized as follows:

Step 1: Input field envelope $s_i(t)$ is known. Take its Fourier transform to obtain $\tilde{s}_i(\Omega)$.

Step 2: Multiply $\tilde{s}_i(\Omega)$ by $H_f(\Omega, L)$ to get the output spectrum, $\tilde{s}_0(\Omega)$.

Step 3: Take the inverse Fourier transform of $\tilde{s}_0(\Omega)$ to obtain the output field envelope $s_0(t)$.

Step 4: Total field distribution at the output is obtained by,

$$\psi(x, y, L, t) = \Phi(x, y) \exp[-i(\omega_0 t - \beta_0 L)\, s_0(t)] \tag{2}$$

Where $\Phi(x; y)$ is the transverse distribution, ω_0 is the angular frequency of the laser output, and β_0 is the propagation constant at ω_0.

Company Researchers & Developers

Integrate the Modules with your in-house and Commercial Software & Hardware Products

(1) **Use the Existing Modules** / Components for Your Research & Development.

(2) **Modify** the Modules / Components to the Next Level for Your Research & Development.

(3) **Integrate** Different Modules / Components in the OCSim Package to Realize Your Own Fiber Optic Communication Systems.

(4) **Modify** the Modules for Co-Simulations with the Third-Party Commercial Optical Communication Systems Softwares.

Optical Fibers

Fiber Dispersion

Source Code File

Main File : fiber_dispersion.m

The signal propagation in a fiber is simulated using this source code. Fiber nonlinear effects are ignored. The Fourier transform of the input signal field is taken to obtain the input spectrum. It is multiplied by the fiber transfer function and then the inverse Fourier transform leads to the output pulse.

Explore Further this Module:

1. **Simulation 1:** Let $\beta_2 = 0$ s^2/m, $\beta_1 = (1.5e^{-6})/3e^8$ s/m and $\alpha = 0$ m^{-1}. **Plot** fiber input and output field envelopes and electric field distributions. Is the pulse width at the fiber output different from that at the input? **Explain.**

2. **Simulation 2:** Let $\beta_2 = -21$ ps^2/km, $\beta_1 = 0$ s/m and $\alpha = 0$ m^{-1}. Does the pulse undergo a time-shift? **Explain.**

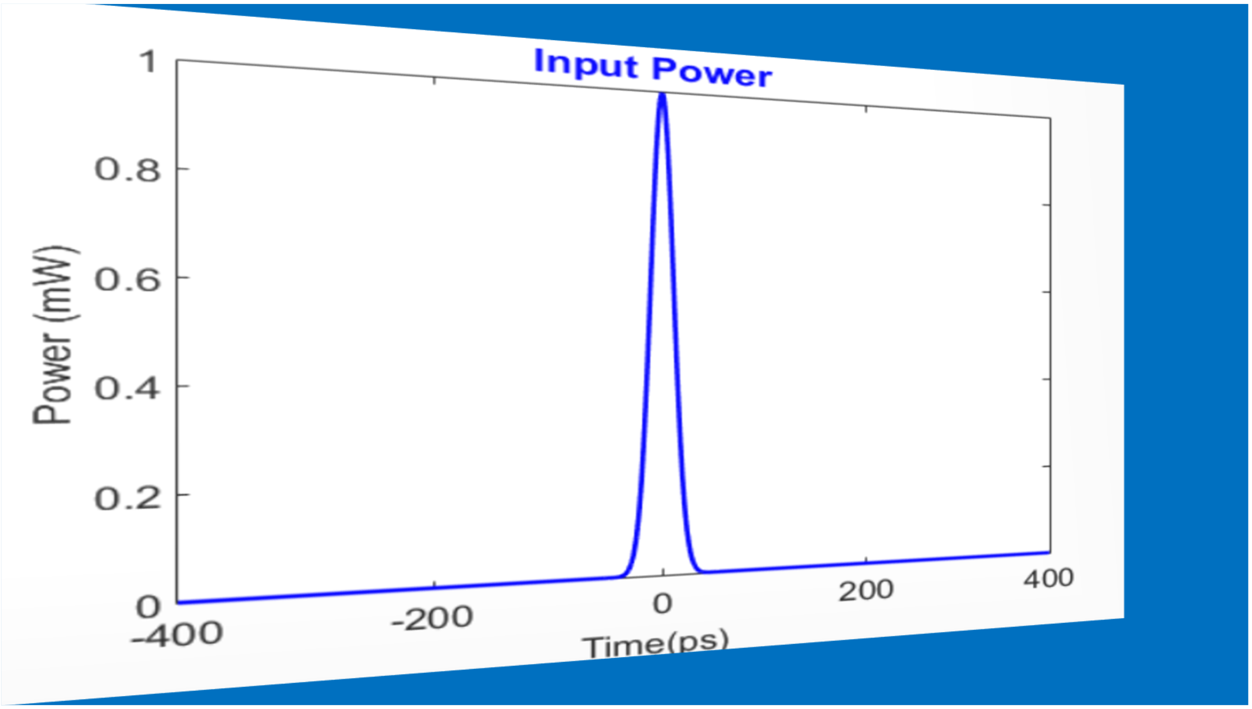
3. **Simulation 3:** Let $\beta_2 = -21$ ps^2/km, $\beta_1 =$ (1.5e^{-6})/3e^8 s/m and $\alpha = 0$ m^{-1}. **Plot** fiber input and output field envelopes and electric field distributions.

4. **Simulation 4: Repeat** simulation 3 with loss coefficient = 0.2 dB/km. Does the fiber loss affect the pulse broadening? **Compare** the pulse widths and peak amplitudes corresponding to simulation 3 and simulation 4.

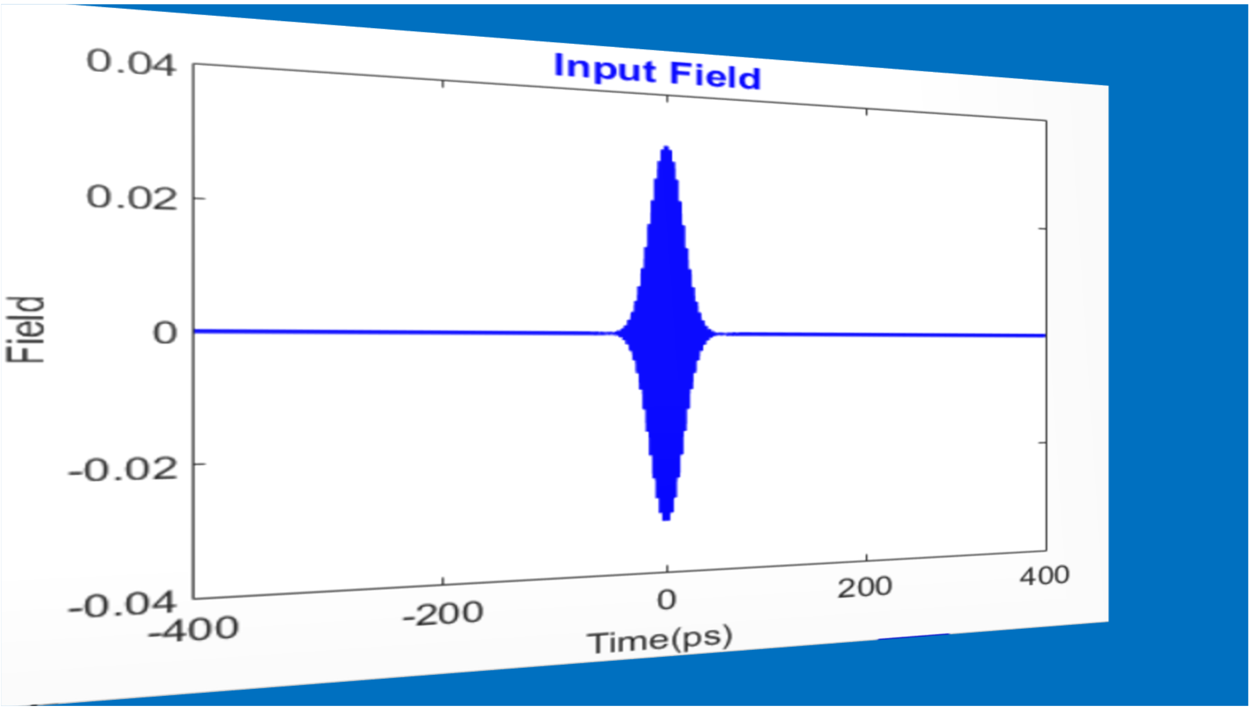
5. **Simulation 5: Repeat** simulations 2 to Simulation 4 with a rectangular pulse.

Selected Simulated Results Using this Module

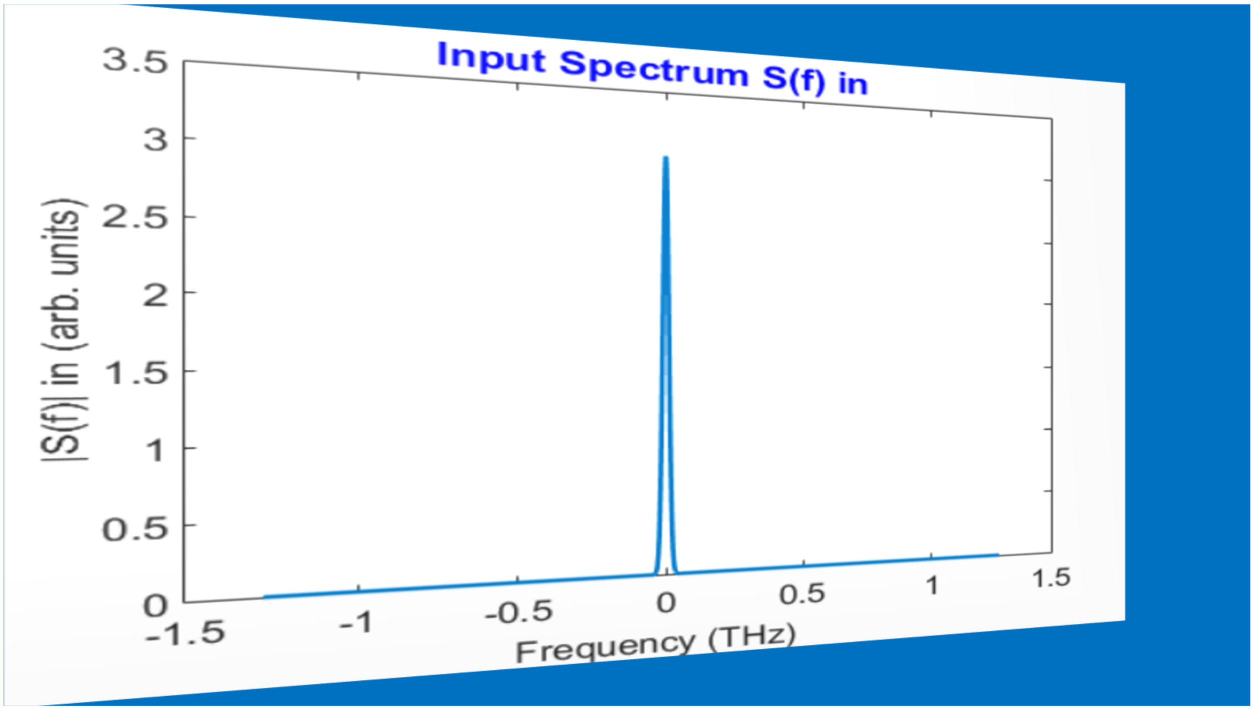
Input Power in Time Domain



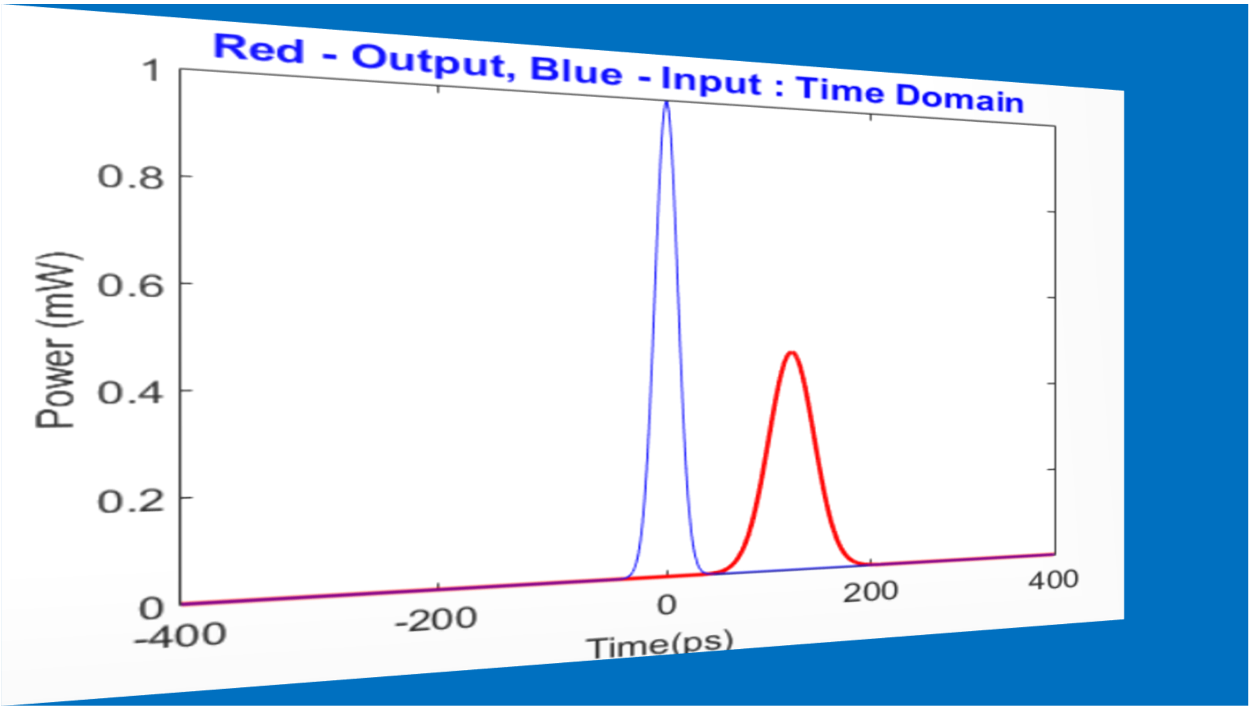
Input Field in Time Domain



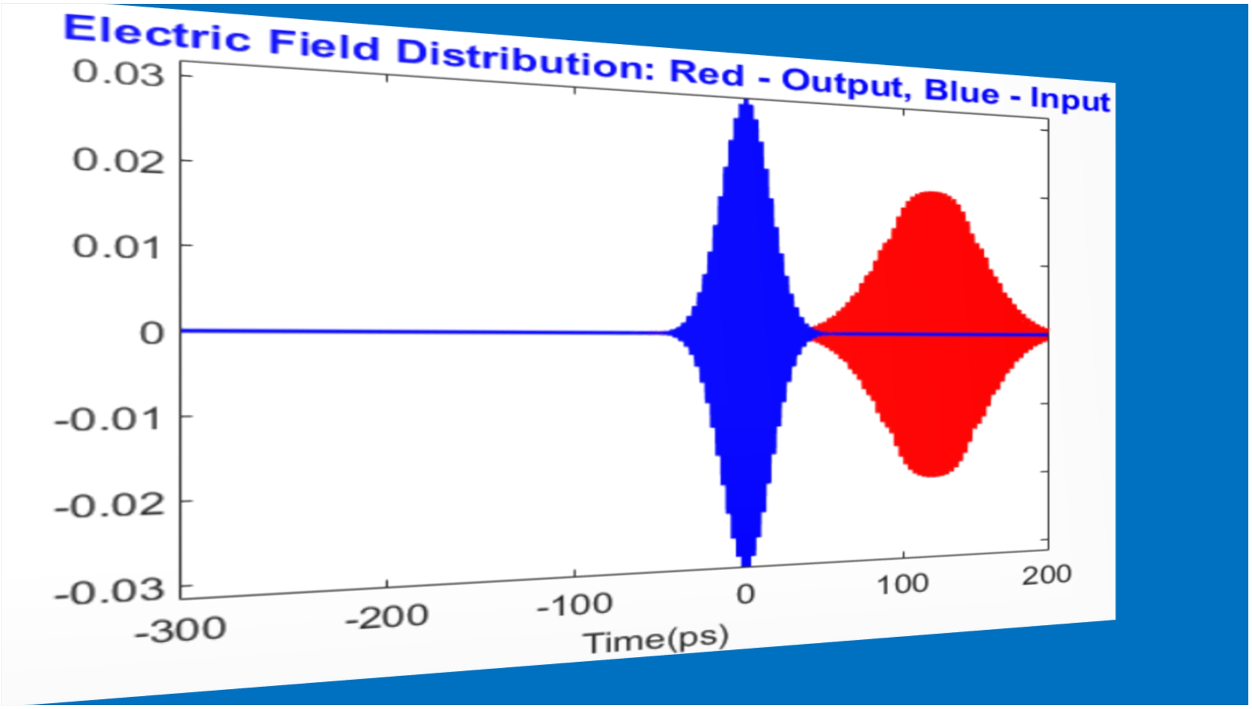
Input Spectrum



Input and Output Powers in Time Domain



Input and Output Electric Field Distributions in Time Domain



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CodeSScientific Photonics

sales@codesscientific.com / www.codesscientific.com