CodeSScientific

OCSim Modules 2018 version 2.0

Fiber Optic Communication System Simulations Software Modules with Matlab

Use the Existing Modules for Research Papers, Research Projects and Theses
Modify the Modules to the Next Level for Research Papers, Research Projects and Theses
Integrate the Different Modules to Realize Your Own Fiber Optic Communication Systems
Use the Existing Modules for Teaching, Laboratory Simulation Experiments, Exercises and Projects
Modify the Modules for Co-Simulations with the Third Party Commercial Optical Communication System Softwares
**OCSim Modules**

**OCSim** software modules are the most popular products for the design and simulation of modern and advanced level fiber optic communication systems. **OCSim** modules have been proven to provide accurate simulations. The modules which are continuously upgraded are in use for the last fourteen years for simulating fiber optic communication systems, publishing research papers, theses and laboratory simulation experiments.

**Modules (1 to 17) in the Package**

**OCSim (2014-15).a**

- **Module 1**: Electromagnetic Waves
- **Module 2**: Optical Fibers
- **Module 3**: Lasers
- **Module 4**: Modulation Schemes
- **Module 5**: Optical Receivers
- **Module 6**: Optical Amplifiers
- **Module 7**: Fiber Optic Transmission System Design
- **Module 8**: Performance Analysis
- **Module 9**: Channel Multiplexing Techniques
- **Module 10**: Nonlinear Fiber Optics
- **Module 11**: Digital Signal Processing

**OCSim 2016.a**

- **Module 12**: Optical PAM-M Modulators & Transmitters
**Modules in the Package (contd.)**

**OCSim 2016.b**

**Module 13**: Long Haul QPSK Fiber Optic Coherent Communication Systems

**OCSim 2016.c**

**Module 14**: Dual Polarization QAM-M CO-OFDM Systems

**OCSim 2017.a**

**Module 15**: Long Haul QAM-16 Fiber Optic Coherent Communication Systems

**OCSim 2018.a**

**Module 16**: Long Haul Polarization Multiplexed (PM) QAM-M Fiber Optic Coherent Communication Systems

**OCSim 2018.b**

**Module 17**: Long Haul \textit{WDM} Polarization Multiplexed (PM) QAM-M Fiber Optic Coherent Communication Systems
Benefits

- Advanced Level Software Modules with Matlab
- Manuals with Well Explained Related Theory, Formulas and Descriptions
- Use the Existing Modules for Research Papers, Research Projects and Theses
- Modify the Modules to the Next Level for Research Papers, Research Projects and Theses
- Integrate the Different Modules to Realize Your Own Fiber Optic Communication Systems
- Use the Existing Modules for Teaching, Laboratory Simulation Experiments, Exercises and Projects
- Modify the Modules for Co-Simulations with the Third Party Commercial Optical Communication System Softwares
Applications

- Propagation of Rectangular Waves
- Propagation of Cosine Waves
- Simulation of Standing Waves
- Fiber Modes in Optical Fibers
- Fiber Dispersion in Optical Fibers
- Optical Field Envelope / Total Field Propagation in Optical Fibers
- EDFA Gains in Fibers using Nonlinear Differential Equations
- Raman Gains in Fibers using Nonlinear Differential Equations
- Nonlinear Pulse Propagation in Optical Fibers
- Carrier Density and Optical Power of Laser Diodes for DC Currents
- Carrier Density and Optical Power of Laser Diodes for Pulsed Currents
- Shot Noise, Thermal Noise and SNR of PIN and APD Receivers
- Error Probability Calculations of OOK, PSK data for Homodyne Receivers
- Error Probability Calculations of OOK, PSK, FSK data for Heterodyne Receivers
- Error Probability Calculations of OOK, FSK and DPSK data for Direct Detection Receivers
- NRZ-OOK Optical Modulators and Transmitters
- NRZ-PSK Optical Modulators and Transmitters
- NRZ-QPSK Optical Modulators and Transmitters
- QPSK- Nyquist Optical Modulators and Transmitters
Applications (contd.)

- Fiber Optic Long Haul Dispersion Managed Intensity Modulated Direct Detection Systems – Linear & Nonlinear
- Fiber Optic Long Haul WDM Dispersion Managed Direct Detection Systems – Linear & Nonlinear
- Fiber Optic SINGLE Polarization QAM-M CO-OFDM Systems – Linear & Nonlinear
- Fiber Optic DUAL Polarization QAM-M CO-OFDM Systems – Linear & Nonlinear
- Fiber Optic Coherent QPSK Systems with Laser Phase Noise Compensation through Digital Signal Processing (DSP)
- Fiber Optic Coherent QPSK Systems with Chromatic Dispersion Compensation through Digital Signal Processing (DSP)
- Fiber Optic Long Haul Coherent QPSK Systems with Chromatic Dispersion and SPM Compensations through Digital Signal Processing (DSP)
- Fiber Optic Long Haul QAM-16 Coherent Communication Systems
- Fiber Optic Long Haul Polarization Multiplexed (PM) QAM-M Coherent Communication Systems
- Fiber Optic Long Haul WDM Polarization Multiplexed (PM) QAM-M Coherent Communication Systems
- Optical PAM-M Modulators and Transmitters for High Bandwidth Networks and Data Centres
We have been using the Fiber Optic Communication Systems Software Modules for the last 14 years for publishing research papers, theses and laboratory simulation experiments. In these modules, the underlying complex theories and equations of fiber optic communication systems have been converted into Matlab programs giving the insight into the concepts involved and more understanding of the subject. Starting from the first principles, academicians, engineers and researchers in universities and companies can go up to the most modern fiber optic communication systems including the latest analog and digital modulation techniques like BPSK, QPSK, DP-QPSK, DP-QAM-M, PM-QAM-M, QAM-16 and PAM-M.

Professor Shiva Kumar,
Electrical and Computer Engineering Department,
McMaster University, Canada,
and
The author of the book,
"Fiber Optic Communications: Fundamentals and Applications" John Wiley and Sons, 2014
**Module Types**: Software Modules with Matlab (.m files)

- Commercial Perpetual Licenses for Research Labs / Companies
- Academic Perpetual Research Licenses for Universities
- Multiple Perpetual Teaching Licenses for Universities
- Manuals with Well Explained Related Theory, Formulas and Descriptions
- Multiyear Scientific, Theoretical and Programing Support on the Existing OCSim Modules
- Option to Collaborate with CodeSScientific Researchers on the Existing OCSim Modules
- R&D Services for Customization / Integration of Source Code Modules to Your Company’s Products

**With the Purchase of the Modules - Full discount on a reference book for fundamental concepts:**

Selected Simulated Results

Optical Fiber Modes

Optical Fiber Modes

Optical Fiber Dispersion

Optical Fiber Dispersion

Field Envelope Propagation in Optical Fibers

Total Field Propagation in Optical Fibers

EDFA Gains in Optical Fibers

EDFA Gains in Optical Fibers

EDFA Gains in Optical Fibers
Selected Simulated Results

Raman Gains in Optical Fibers

Nonlinear Pulse Propagation in Optical Fibers

Laser Diodes for DC and Pulsed Currents

Optical Receivers
Selected Simulated Results

Optical Homodyne Receivers

Optical Heterodyne Receivers

Optical Direct Detection Receivers

NRZ-OOK Optical Modulators and Transmitters

NRZ-OOK Optical Modulators and Transmitters

NRZ-OOK Optical Modulators and Transmitters

NRZ-PSK Optical Modulators and Transmitters

NRZ-PSK Optical Modulators and Transmitters

NRZ-PSK Optical Modulators and Transmitters
Selected Simulated Results

NRZ-QPSK Optical Modulators and Transmitters

NRZ-QPSK Optical Modulators and Transmitters

NRZ-QPSK Optical Modulators and Transmitters

QPSK Nyquist Optical Modulators and Transmitters

QPSK Nyquist Optical Modulators and Transmitters

QPSK Nyquist Optical Modulators and Transmitters
Selected Simulated Results

Fiber Optic Intensity Modulated Direct Detection Systems
Linear and Nonlinear

Simulation Setup for a long haul fiber optic communication system with a transmitter, a receiver, N fibers (standard and dispersion compensating) and N amplifiers.

Fiber Optic WDM Direct Detection Systems
Linear and Nonlinear

Simulation Setup for a Fiber Optic WDM Direct Detection System

Fiber Optic Intensity Modulated Direct Detection Systems
Linear and Nonlinear

Input Power

Output Power

Eye Diagram

Time Diagram of the Central Channel @ Transmitter

Eye Diagram of the Central Channel @ Transmitter
Selected Simulated Results

Fiber Optic WDM Direct Detection Systems
Linear and Nonlinear

Spectrum of the Central Channel @ Transmitter

WDM Spectrum @ Transmitter

Time Diagram of the Central Channel @ Receiver

Fiber Optic WDM Direct Detection Systems
Linear and Nonlinear

Spectrum of the Central Channel @ Receiver

Eye Diagram of the Central Channel @ Receiver

Receiver Current of the Central Channel

Fiber Optic WDM Direct Detection Systems
Linear and Nonlinear

Eye Diagram of the Receiver Current for the Central Channel
Selected Simulated Results
Selected Simulated Results

Fiber Optic DUAL Polarization QAM-M CO-OFDM Systems
Linear and Nonlinear

Fiber Optic DUAL Polarization QAM-M CO-OFDM Systems
Linear and Nonlinear

Fiber Optic DUAL Polarization QAM-M CO-OFDM Systems
Linear and Nonlinear

Fiber Optic DUAL Polarization QAM-M CO-OFDM Systems
Linear and Nonlinear

Fiber Optic DUAL Polarization QAM-M CO-OFDM Systems
Linear and Nonlinear

Fiber Optic DUAL Polarization QAM-M CO-OFDM Systems
Linear and Nonlinear

Fiber Optic Coherent QPSK Systems with Laser Phase Noise Compensation

Fiber Optic Coherent QPSK Systems with Laser Phase Noise Compensation

Fiber Optic Coherent QPSK Systems with Laser Phase Noise Compensation
**Selected Simulated Results**

**Fiber Optic Coherent QPSK Systems with Chromatic Dispersion Compensation**

Simulation Setup for CD Equalizer using a Digital Dispersion Compensating Filter

**Fiber Optic Coherent QPSK Systems with Chromatic Dispersion Compensation**

Simulation Setup for Finite Impulse Response (FIR) Dispersion Compensator Filter

**Fiber Optic Coherent QPSK Systems with Chromatic Dispersion Compensation**

**Fiber Optic Coherent QPSK Systems with Chromatic Dispersion Compensation**

**Fiber Optic Long Haul Coherent QPSK Systems**

Constellation Diagram After the CD Equalization

**Fiber Optic Long Haul Coherent QPSK Systems**

Constellation Diagram at the Transmitter

**Fiber Optic Long Haul Coherent QPSK Systems**

Constellation Diagram at the End of the Fiber Optic Link

**Fiber Optic Long Haul Coherent QPSK Systems**

Constellation Diagram After the CD Compensation
Selected Simulated Results

Fiber Optic Long Haul Coherent QPSK Systems

Optical PAM-M Transmitters for Data Centres

Eye Diagram After the Bandlimiting Filter

Spectrum Before the Bandlimiting Filter

Spectrum After the Bandlimiting Filter
Selected Simulated Results

Fiber Optic Long Haul QAM-16 Coherent Communication Systems

Fiber Optic Long Haul QAM-16 Coherent Communication Systems

Fiber Optic Long Haul QAM-16 Coherent Communication Systems

Fiber Optic Long Haul Polarization Multiplexed (PM) QAM-M Coherent Communication Systems

Fiber Optic Long Haul Polarization Multiplexed (PM) QAM-M Coherent Communication Systems

Fiber Optic Long Haul Polarization Multiplexed (PM) QAM-M Coherent Communication Systems
Selected Simulated Results

- Fiber Optic Long Haul Polarization Multiplexed (PM) QAM-M Coherent Communication Systems
- Fiber Optic Long Haul Polarization Multiplexed (PM) QAM-M Coherent Communication Systems
- Fiber Optic Long Haul Polarization Multiplexed (PM) QAM-M Coherent Communication Systems
- Fiber Optic Long Haul WDM Polarization Multiplexed (PM) QAM-M Coherent Communication Systems
- Fiber Optic Long Haul WDM Polarization Multiplexed (PM) QAM-M Coherent Communication Systems
- Fiber Optic Long Haul WDM Polarization Multiplexed (PM) QAM-M Coherent Communication Systems
- Fiber Optic Long Haul WDM Polarization Multiplexed (PM) QAM-M Coherent Communication Systems
- Fiber Optic Long Haul WDM Polarization Multiplexed (PM) QAM-M Coherent Communication Systems
- Fiber Optic Long Haul WDM Polarization Multiplexed (PM) QAM-M Coherent Communication Systems
Selected Simulated Results

Fiber Optic Long Haul WDM Polarization Multiplexed (PM) QAM-M Coherent Communication Systems

Normalized Spectrum at Rx before the Demux

Normalized Spectrum at the Rx after Demux
Following Fiber Optic Communication Systems can be designed

- **Long Haul WDM Polarization Multiplexed (PM) QAM-M Fiber Optic Coherent Communication Systems**

- **Long Haul Polarization Multiplexed (PM) QAM-M Fiber Optic Coherent Communication Systems**

- **Long Haul QAM-16 Fiber Optic Coherent Communication Systems**

- **Single Polarization QAM-M CO-OFDM Fiber Optic Communication Systems**
  - 10 Gb/s, 512 subcarrier, 40 span QAM-M CO-OFDM fiber optic systems
  - 25 Gb/s, 1024 subcarrier, 20 span QAM-M CO-OFDM fiber optic systems
  - 40 Gb/s, 2048 subcarrier, 10 span QAM-M CO-OFDM fiber optic systems

  \( n \) Gb/s, \( m \) subcarrier, \( N \) span QAM-M CO-OFDM fiber optic systems

  Choose the desired values of \( n, m \) and \( N \) for simulations.

  **Simulate more:**
  
  Choose the value of \( M \) in QAM-\( M \) to simulate special cases, e.g., \( M = 2 \) for BPSK and \( M = 4 \) for QPSK and \( M = 8, 16 \), and so on for higher order QAM.

  Switch on to nonlinearity to design and simulate nonlinear QAM-\( M \) CO-OFDM fiber optic systems.

- **Dual Polarization QAM-M CO-OFDM Fiber Optic Communication Systems**
  
  This module takes into account (1) Dispersion, (2) Nonlinearity, (3) PMD and (4) Random coupling between polarizations in the fibers.
○ Long Haul QPSK Fiber Optic Coherent Communication Systems with Digital Signal Processing

28 GBaud, 20 span coherent QPSK fiber optic systems
10 GBaud, 60 span coherent QPSK fiber optic systems
28 GBaud, 20 span Nyquist pulse coherent QPSK fiber optic systems
10 GBaud, 60 span Nyquist pulse coherent QPSK fiber optic systems

$n$ GBaud, $N$ span coherent QPSK fiber optic systems

$n$ GBaud, $N$ span Nyquist pulse coherent QPSK fiber optic systems

Choose the desired values of $n$ and $N$ for simulations.

Simulate more:

Compensate Laser Phase Noise, Chromatic Dispersion and SPM through Digital Signal Processing in coherent QPSK fiber optic systems.

Modify to coherent DP-QPSK fiber optic system. Scientific and Programming support is available for modifying to coherent DP-QPSK fiber optic system.

○ Long Haul WDM Dispersion Managed Direct Detection Fiber Optic Communication Systems

28 Gb/s/channel, 50 GHz channel spacing, 8 channel, 20 span WDM fiber optic systems
10 Gb/s/channel, 25 GHz channel spacing, 16 channel, 40 span WDM fiber optic systems
40 Gb/s/channel, 100 GHz channel spacing, 8 channel, 20 span WDM fiber optic systems

$n$ Gb/s/channel, $m$ GHz channel spacing, $M$ channel, $N$ span WDM fiber optic systems

Choose the desired values of $n$, $m$, $M$ and $N$ for simulations.

Simulate more:

Switch on to nonlinearity to design and simulate nonlinear WDM fiber optic systems.
- **Long Haul Dispersion Managed Intensity Modulated Direct Detection (IMDD) Fiber Optic Communication Systems**

  10 Gb/s, 40 span IMDD fiber optic systems
  28 Gb/s, 20 span IMDD fiber optic systems with inline dispersion compensation
  40 Gb/s, 20 span IMDD fiber optic systems with inline dispersion compensation
  40 Gb/s, 20 span IMDD fiber optic systems with dispersion managed fibers

  \( n \) Gb/s, \( N \) span IMDD fiber optic systems
  Choose the desired values of \( n \) and \( N \) for simulations.

**Simulate more:**

Switch on to *nonlinearity* to design and simulate nonlinear IMDD fiber optic systems.
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