Overview: The System and Network Software for Telecommunication Engineering

RSoft Design Group produces design software for the telecommunication industry, specifically for optical system simulation and network planning. These advanced tools to enhance and accelerate user modeling capabilities and provide real field design scenarios using extensive industry specifications. Our users include optical component and equipment manufacturers, system integrators, service providers, as well as government labs and academic institutions.

Whether you are interested in maximizing performance, minimizing costs, reducing time-to-market, fast-prototyping, or analyzing multiple what-if scenarios for optical communication networks, these tools will become an inseparable partner and the secret of your success.

RSoft Design Group currently markets four software packages for the simulation, analysis, and planning of telecom systems and networks:

***OptSim** – Simulates a broad range of optical communication systems*

***ModeSYS** – Simulates multimode optical communication systems*

***MetroWAND** – Models network design, network engineering and network-planning*

***Artifex** – Simulates discrete event networks through the Petri Nets formalism*

Key Features of OptSim

OptSim provides the unique capability of simulating optical systems in both the time and frequency domains. Infinitely long bit sequences as well as Course WDM systems can be simulated with the highest efficiency. More than 600 models are readily available to setup a wide range of optical communication systems, including Nonlinear Fiber, VCSEL laser, SOA, EDFA and Raman amplifier models. New models can be created incorporating, among others, MATLAB, C/C++, Fortran and Java code, allowing legacy code to be reused with minimal effort. An impressive set of validations and an extensive customer base demonstrate the accuracy of OptSim results. OptSim can also be integrated with the RSoft Component Design Suites for a total application solution.

Key Features of ModeSYS

ModeSYS fully simulates multimode optical systems by taking into account the transverse mode profile propagating through the system. This unique capability ensures a correct signal shape and eye diagram and allows accurate performance estimates to be obtained. The inclusion of spatial effects into multimode models within a system-level simulation framework combines the accuracy of a device level simulation and the efficiency of a system-level simulation. ModeSYS provides, among others, the following key analyses: system bandwidth, launching condition, offset launch, arbitrary index profile, coupling, chromatic and modal dispersion, differential mode delay, and encircled flux.

Key Features of MetroWAND

MetroWAND uses high-level models to determine where ring and mesh topologies are most economic, given the network connectivity, traffic demands, and optical equipment constraints. MetroWAND's automated design approach is useful during both the planning and maintenance aspects of network design. Before a network is physically realized, an optical equipment manufacturer can use MetroWAND to reduce the time needed to create many 'what-if' scenarios as a part of a proposed network design solution for RFP and RFQ responses. Vendor's equipment libraries and design rules can be built into the tool so that the creation and demonstration of viable design scenarios is possible even by a non-specialist. Once a network is in place, MetroWAND can be used by service providers to accomplish their day-to-day network planning activities including network growth studies and network optimization.

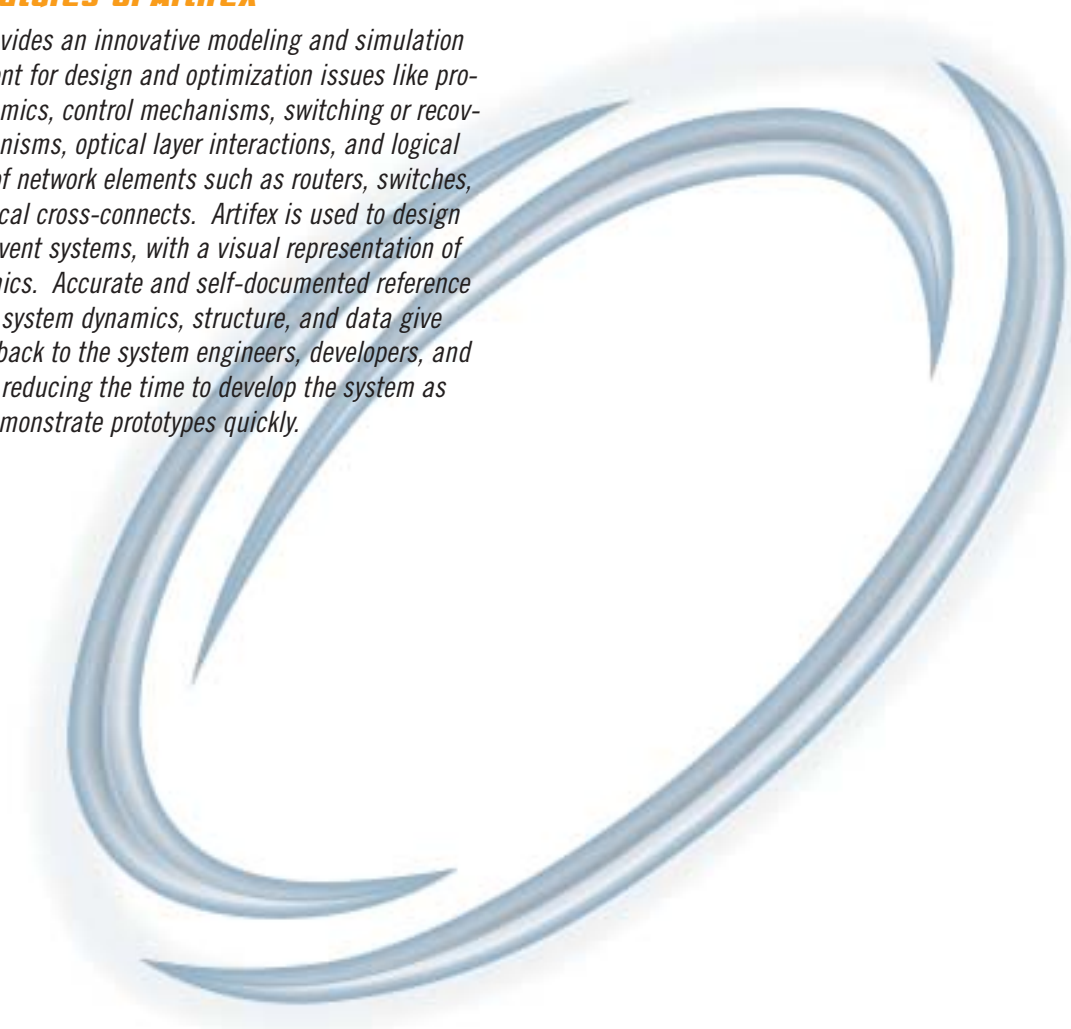
Key Features of Artifex

Artifex provides an innovative modeling and simulation environment for design and optimization issues like protocol dynamics, control mechanisms, switching or recovery mechanisms, optical layer interactions, and logical behavior of network elements such as routers, switches, WDM, optical cross-connects. Artifex is used to design discrete-event systems, with a visual representation of the dynamics. Accurate and self-documented reference models of system dynamics, structure, and data give early feedback to the system engineers, developers, and end users reducing the time to develop the system as well as demonstrate prototypes quickly.

Computer Platforms and System Requirements

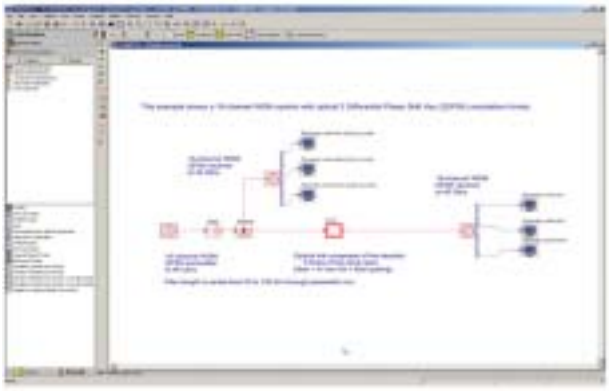
Currently the above System and Network tools are available on a variety of platforms including Windows, Linux and Unix (Sun Solaris) systems. Minimum system requirements for running the software vary depending on the application, but simple, low memory applications can run on a typical desktop computer. For further information on both software and hardware requirements, please contact RSoft Design Group.

For more information beyond this overview, please refer to the individual product sections. Please note that all products are licensed and sold as separate packages.



OptSim™

OptSim is an intuitive modeling and simulation environment supporting the design and the performance evaluation of the transmission level of optical communication systems. With an easy-to-use graphical user interface and lab-like simulation results analysis instruments, OptSim provides a fast learning curve for high usability. The large library of flexible component models and simulation algorithms provide the best trade-off between accuracy and speed to reduce time-to-market and provide cost savings on complex projects and designs. OptSim has been thoroughly validated, demonstrated reliability with a large number of WDM channels, and has a large installed base in research and industrial organizations.

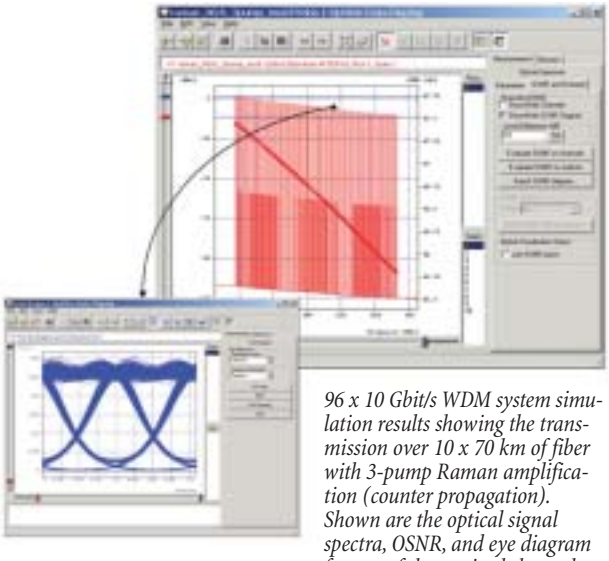


A 16 channel 40 Gbps DPSK modulated system is simulated. The eye diagram and the histogram of the eye diagram are shown for channel 8 at the receiver after 125 km of fiber.

Applications

OptSim is ideally suited for computer-aided design of:

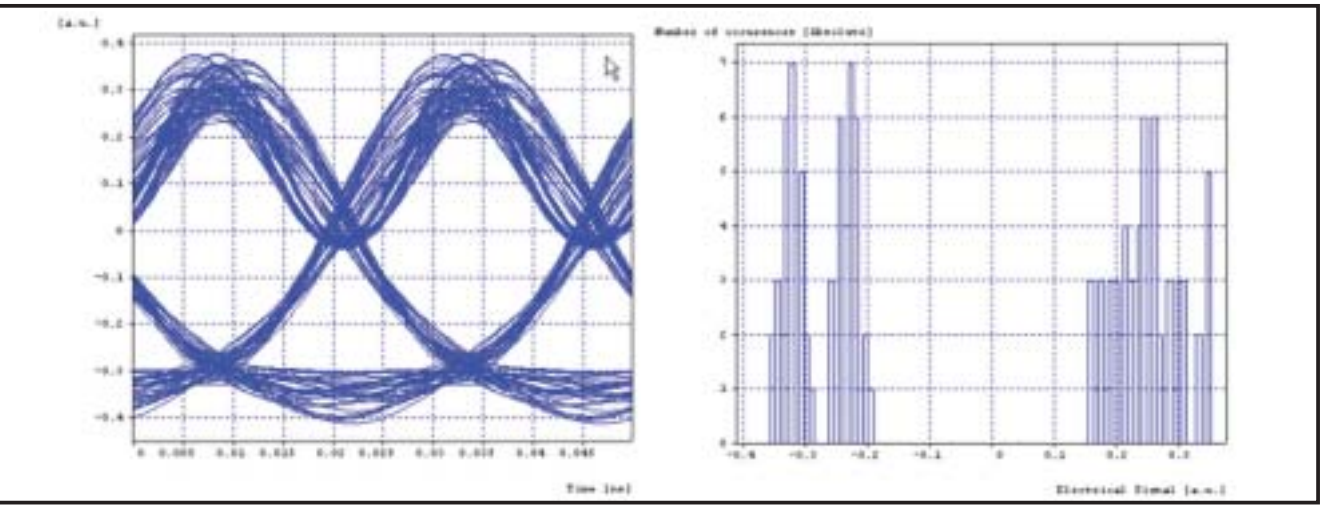
- *DWDM/CWDM amplified (e.g. EDFA, Multipump Raman, SOA, Hybrid amplifier) systems*
- *FTTx/PON systems*
- *OTDM/OCDMA systems*
- *CATV Digital/Analog systems*
- *All-optical networks*
- *Ultra long-haul terrestrial and submarine systems*
- *Soliton systems*
- *Optical LANs*
- *Optical interconnects*
- *Free-space optics (FSO) systems*



96 x 10 Gbit/s WDM system simulation results showing the transmission over 10 x 70 km of fiber with 3-pump Raman amplification (counter propagation). Shown are the optical signal spectra, OSNR, and eye diagram for one of the received channels.

OptSim can be used for a wide range of applications including the following:

- *Link optimization: power budget, dispersion map, gain balancing, tailoring of pulse shape and chirp, transmitter pre-emphasis, amplifier positioning.*
- *Spectral occupancy and gain optimization through Multipump Raman Amplification.*
- *Transmission impairment analysis and assessment of countermeasures (e.g. All-order PMD, SPM, XPM, FWM, PG, MI, Stimulated Raman Scattering effect).*
- *Edge design and validation: channel spacing, number of supported channels, transmission rate, enhancement of modulation techniques, coherent systems.*
- *Monte-Carlo simulation to evaluate system sensitivity to stochastic phenomena (e.g. PMD, pattern effects, dispersion statistical variation, ASE noise).*
- *Research novel modulation schemes.*
- *System sensitivity evaluation.*
- *Laser driver design optimization.*
- *Analysis of power transients due to adding and dropping of channels in optical amplifier chains.*
- *All-optical gain control design for amplifier chains.*



RSoft System Simulation Framework Features

OptSim is built on a powerful framework for system simulation that includes a flexible user-friendly graphical user interface (GUI), multiple simulation engines, powerful data post-processing utilities, and hundreds of sophisticated component models. The framework enables OptSim and ModeSYS to be fully integrated for the simulation and design of mixed single-mode and multimode communication systems.

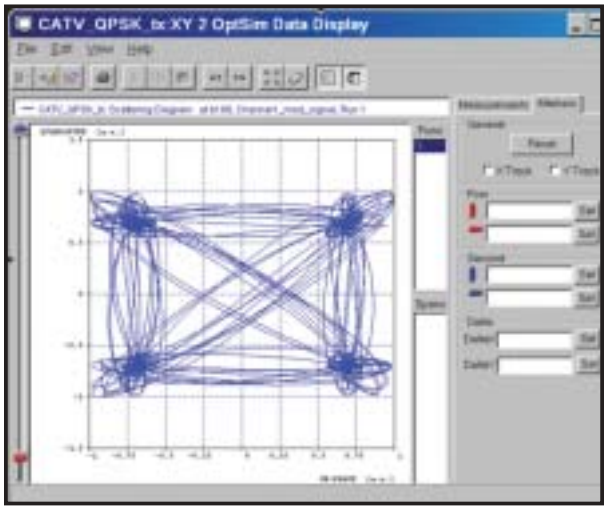


Fig. 3. The scatter diagram of the received signal in one channel of a QPSK CATV system.

OptSim is rich with features, including the following:

- *MATLAB® interface makes it easy to develop custom user models and customize and extend the simulation and analysis capabilities.*
- *Interfaces with laboratory test equipment merge simulation with experiment to maximize the value of each in an efficient design and development environment.*
- *Interfaces with device-level simulation tools such as BeamPROP, GratingMOD, and LaserMOD provide a powerful mixed-level design flow for optoelectronic circuits and systems.*
- *Interfaces with EDA tools such as Berkeley SPICE, Cadence Virtuoso Spectre, and Synopsys HSPICE combine electronic circuit simulation with optical communication system simulation. This provides for the most accurate end-to-end simulation and design optimization of laser driver circuits and mixed-domain electrical and optical communication systems.*
- *Application Programming Interface (API) for programming languages such as C/C++ for the development of custom user models.*
- *Best Fit Laser Toolkit™ makes customizing powerful rate-equation laser model parameters to fit desired performance characteristics easy.*
- *Extensive predefined manufacturer component database makes it easy to model commercially available components.*
- *Intuitive and flexible measurement post-processing graphical interface acts like a virtual laboratory instrument.*
- *Powerful encryption capabilities make protecting your schematics and model parameters easier than ever.*

OptSim™

Simulation Techniques

OptSim provides multiple simulation engines that provide complementary simulation techniques. This enables the greatest flexibility in modeling and simulating systems ranging from short-distance data communication links, to ultra long-haul DWDM telecom systems, to large metro networks with feedback paths and EDFA transients due to adding and dropping of channels.

An all-optical gain control scheme simulated using OptSim's wavelength-domain simulation technique. This demonstrates the use of feedback, EDFA transient behavior modeling, and fast simulation over a 2 ms time window.

Analysis

Data Post-Processing and Display

OptSim's data post-processing and display facilities provide an intuitive and flexible measurement graphical interface that acts as a lab-like set of virtual instruments. Interactive and post-processing functionality (e.g. graph superimposition, correlation graphs, interactive cursor read-out data, peak search, eye-diagram measurements, BER/Q evaluation) allow one to simulate the project once and perform further analysis of results later (saving time during the design process). Simulation results can be plotted in a number of forms including signal waveforms, eye diagrams, signal spectra, OSNR, Poincare sphere, dispersion maps, and more. A wide and complete choice of measurements is available including jitter, eye opening/closure, electrical/optical spectra, chirp, optical instantaneous phase/frequency and power.

Flexible Tuning for Design Optimization

All component parameters can be expressed as a deterministic or stochastic function of one or more variables. Variables can assume different values in order to allow a fast optimization process, and Monte-Carlo analysis.

OptSim Library

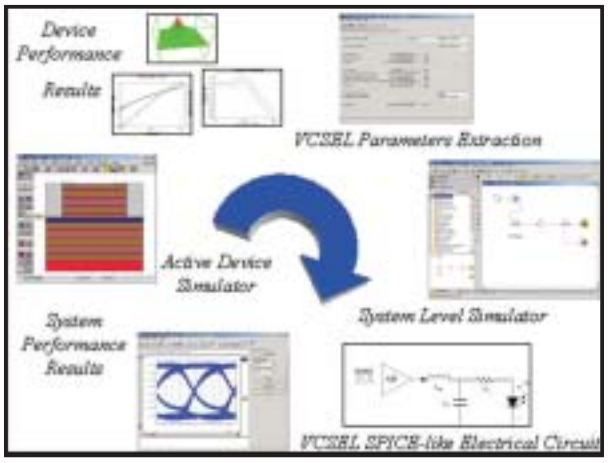
A comprehensive library of arithmetic models and simulation algorithms for the most widely used optical, optoelectronic and electronic components is distributed with OptSim. These include components such as:

- *Pattern and signal generators*
- *Lasers*
- *LEDs*
- *Modulators*
- *Optical and electrical amplifiers*
- *Optical and electrical filters*
- *Optical fiber*
- *Optical receivers*
- *Mux and Demuxes, etc.*

Some of the wide range of components included are highlighted below.

Nonlinear Fiber Models:

Flexible fiber models allow user-defined wavelength dependencies for attenuation, dispersion, Raman gain profile, and Raman pumps spectra. Models provide full-featured simulation of linear, non-linear and polarization-related phenomena. The different effects including FWM, SPM, XPM, PMD, Raman scattering, dispersion and attenuation can be individually turned on and off. OptSim is the only tool that provides both the Time Domain Split Step and the Split Step Fourier methods for solving modified forms of the nonlinear Schrödinger equation for the simulation of optical fiber.



The VCSEL-based System Mixed-level Simulation Flow Diagram featuring LaserMOD, OptSim, Best Fit Laser Toolkit, Electrical Circuit Model Generator, and SPICE.

Raman Multipump Amplifier Models:

- *Multiple pump waves at different wavelength and power*
- *Co- and counter- propagating and bi-directional pumping scheme*
- *Pump regeneration*
- *Pump spectra specified by a grid of frequency-power or by power*
- *Spectra measurement file*
- *Full spectral and bi-directional resolved analysis for a variety of effects, including cross-talk among pumps, pump depletion/saturation effects, and noise generation*
- *Rayleigh scattering with infinite multiple reflections of noise*
- *Interference due to double Rayleigh backscattering of signal*
- *Terminal reflectivities*

EDFA Models:

Models include parameterized "black-box" models as well as custom-defined measurement-based models and detailed physics-based models. Gain saturation, wavelenth-dependent gain, and amplified spontaneous emission (ASE) noise are all included.

SOA Models:

Physics-based SOA models support wavelength conversion and optical switching applications as well as optical amplification.

Laser Models:

Models are provided for CW lasers, mode-locked lasers, Fabry-Perot lasers, DFB lasers, and VCSELs. The rate equations are used for the direct modulated lasers to produce accurate optical waveform results including the AM response, FM response, relative intensity noise, self-phase modulation, cavity dispersion, timing jitter, L-I curve, and small signal frequency response. The VCSEL model also includes spatial and thermal effects including secondary pulse and thermal rollover of the L-I curve. The Best Fit Laser Toolkit enables easy parameter extraction of rate equation model parameters for accurate modeling of lasers based on data sheets or measurements.

Modulators:

Modulators including Mach-Zehnder and electroabsorption modulators can be modeled with a variety of parasitic frequency response fitting forms and modulation responses, or with data sheet or measurement data. The amplitude and phase modulation response, electrical response, frequency chirping, extinction ratio, and modulator losses are all included as well as nonlinear modulator responses and dc chirp.

Optical Receivers:

Optical receiver models are provided that include PIN and APD photodetectors, transimpedance amplifiers, and electrical filters to model the receiver's signal and noise properties. A number of options are provided to specify their properties including photodetector intensity response and responsivity, quantum efficiency, noise, and sensitivity.

OptSim also includes a library of pre-built, customizeable network components such as:

- *OXC*
- *OADM*
- *AWG/Mux/Demux*
- *Switch, etc.*

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MATLAB Enabled

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