RSOFT Design Group

THE SOURCE FOR PHOTONIC & NETWORK DESIGN SOFTWARE

rsoftdesign.com

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Please contact sales@rsoftdesign.com for further information.

About RSoft Design Group

RSoft Design Group is the worldwide leader in photonic design automation software, and serves several industries including optical communication, optoelectronics, and semiconductor manufacturing. Within optical communications, RSoft is the only company to provide a full range of design, optimization, and planning tools. Within the physical layer, RSoft provides the most extensive collection of award-winning design tools for passive and active optoelectronic components and subsystems.

History

RSoft Design Group, Inc. is a pioneer in the field of photonic design and simulation software. RSoft released its first software package for the integrated optics industry in 1990. In 2001 RSoft merged with NDTI, a spin off from Telcordia Technologies, and two years later, acquired Artis Srl.. In an effort to capitalize on this growth and provide the highest level of customer service, RSoft has anchored offices in the US, Japan, and Europe, as well as established distributors worldwide. RSoft has been committed to meeting the needs for passive and active device design as well as optical communication systems simulation since 1990, and looks forward to providing solutions well into the future.

Government *Contracts*

RSoft has participated in multiple government contracts including a NIST ATP titled PCAD. PCAD was a joint consortium dedicated to Photonics CAD Software and included Telcordia, SAIC, Agilent, Nortel, IBM, JDS Uniphase (SDL), Columbia University, and others. The ambitious five year R&D project created technology included in many of RSoft Design Group's products today.

RSoft has won other government contract awards including multiple SBIRs and STTRs which have resulted in commercialized technology.

Business *Partners*

We have established partnerships with both hardware and software companies to broaden the capabilities of our software. Hardware companies such as Luna Technologies have partnered with us to integrate our software tools into test and measurement applications. MATLAB®, Cadence, and other software manufacturers, have added extended software benefits to the end user. For additional information about these partnerships, please visit www.rsoftdesign.com/aboutus.

Academic Programs

As the global leader in photonic design automation software, RSoft Design Group is committed to support academic research and education. RSoft's academic program provides professors, researchers, and students at several hundred academic institutions all over the world access to its world-class design tools for photonic components, optical communication systems, and optical network design and planning. This creates an infrastructure in which the next generation of optical engineers can be trained, new ideas can be transformed into reality through advanced research, and RSoft's tools are ensured to meet the latest R&D needs through collaborations with leading research groups.

Benefits

- Available single/multi-user license at a discounted price for research and classroom teaching.
- Collaboration with university research groups to develop advanced simulation features and algorithms.
- Partnership in government funded research programs.
- Commercialization of in-house developed models/software and IP licensing.
- Well developed course tutorials with simulation examples.
- Demo software with leading text books.
- Hundreds of application notes and simulation samples.
- Student scholarships to encourage research of novel modeling and simulation techniques.
- Practical training and internship program.
- Joint research publications.
- Hundreds of published articles, white papers and journals for reference.
- Well represented in standard organizations and industry associations.

For more information on our academic program, please contact an RSoft Design Group representative or e-mail: info@rsoftdesign.com.

RSoft's Photonic Component Design Suite

RSoft's Photonic Component Design Suite allows users to design and simulate both passive and active photonic devices for optical communications, optoelectronics, and semiconductor manufacturing.

RSoft currently addresses both passive and active devices through two design suites: a Passive Device Suite and an Active Device Suite. Each suite includes a CAD environment, simulation engines, and an optimization utility.

Key Features

* Highly accurate algorithms allow for rapid virtual prototyping reducing the need for costly and lengthy physical prototyping increasing productivity and decreasing time-to-market.
* Assists in the discovery of new products by creating "what if" product scenarios.
* Each algorithm engine shares a common CAD interface; the software can utilize multiple RSoft packages without having to import designs from one software to the next.
* Scripting can be done with any programming language.
* Includes automated parameter scanning via MOST.
* Each simulation engine is licensed separately, allowing users to choose only those that are relevant to their work.

PASSIVE DEVICE

RSoft CAD Environment
Layout and control program shared by all RSoft's passive device simulators

BeamPROP
Simulates waveguides and fiber applications

FullWAVE
Simulates PBG nanotechnology applications, and biophotonic

BandSOLVE
Computes band structures of photonic bandgap devices

ModePROP
Eigenmode propagation tool

DiffractMOD
Simulates diffractive gratings, semiconductor surface gratings, and metrology applications

GratingMOD
Provides the response of optical gratings and fiber Bragg gratings

FemSIM
Transverse and cavity mode solver for arbitrary structures

ACTIVE DEVICE

LaserMOD
Simulates active device applications

Options & Utilities

RSoft's Options and Utilities extend the capability of RSoft's software tools to provide a complete simulation solution. These tools provide additional simulation options and can be used to combine multiple tools to study advanced application areas.

Key Features

* Provide an easy and simple method to incorporate additional simulation capabilities with RSoft's simulation tools.
* Combine the strengths of multiple simulation tools to meet the needs of specific application areas.
* Each simulation engine is licensed separately, allowing users to choose only those that are relevant to their work.
* Certain options and utilities are included in a limited form with some of RSoft's simulation tools. See product descriptions for complete licensing details.

RSoft CAD ENVIRONMENT

The **RSoft CAD Environment** is the core program of the RSoft Passive Device Suite, and allows researchers and engineers to create systems for the design of waveguide devices, optical circuits, and other photonic devices. It acts as a control program for RSoft's passive device modules, including BeamPROP, FullWAVE, BandSOLVE, ModePROP, DiffractMOD, GratingMOD, and FemSIM, and defines the important input required by these programs: the material properties and structural geometry of the device to be studied.

Benefits

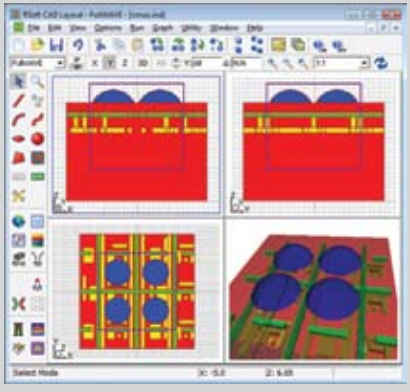
- Highly flexible design environment allows virtually any geometry to be created.
- Included with each of RSoft's passive component simulation tools.
- Provides a unified platform for RSoft's passive component simulation tools; designs do not need to be imported from one software package to another to use different simulation algorithms.
- Easy to use, streamlined user interface that allows fine control over device layout and simulation.

Layout *Capabilities*

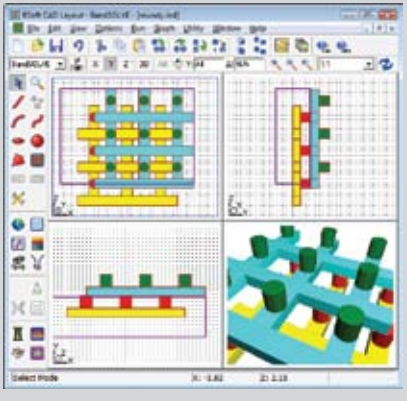
The RSoft CAD Environment has been designed from the ground up to accommodate the special needs of photonic devices and circuits. Fundamental objects such as straight, tapered, and curved components, lenses, and polygons can easily be selected from the toolbar and graphically added to the circuit using the mouse. In addition to standard objects, the CAD allows for the creation of customized components using mathematical equations or data files. Component positions may be specified directly, either absolutely or through relative offsets with respect to any other component. At any time, one or several components may be selected and moved, scaled, deleted, or reinserted. This unique design approach provides an extremely flexible system in which the desired logical arrangement can be maintained.

Object-Oriented *Design*

Each individual component can have its own set of properties that can be accessed with a right click of the mouse. Parameters include shape information and optical properties such as refractive index profile type and value. This unique object-oriented input model is extremely flexible. Furthermore, each parameter of a component (e.g. position coordinates, width, index) can be specified by an arithmetic expression involving user-defined variables, rather than simply being a constant number. This allows an entire design to be easily modified by using formulas to define each component's angle, the entire circuit can be modified by simply changing the value of a single variable without having to edit multiple parts of the structure.



Multi-pane view of 3D CMOS design in CAD showing views along the X, Y, and Z axes as well as 3D view.



Multi-pane view of 3D PBG in CAD.

FEATURES

* 3D editing options allow the structure to be viewed along the X, Y, and Z axis.
* A multi-pane mode where the X, Y, Z, and rotatable 3D views are shown at once.
* Object-oriented design environment *(see previous page)*.
* Hierarchical Layout allows arbitrarily complicated structures to be built from smaller components.
* Mask files in CIF, DXF, and GDS-II formats can be directly imported into the CAD interface. Design files can be exported in both DXF and GDS-II files for mask fabrication.
* Includes layout utilities for common periodic structures, grating structures, and AWG structures.
* Includes WinPLOT, RSoft's technical graphing program.
* Includes DataBROWSWER which allows users to quickly browse and view results.
* Several utilities are included for custom pre- and post-processing capabilities including interfaces with popular ray-tracing software packages.

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BeamPROP

BeamPROP is the industry-leading design tool based on the Beam Propagation Method (BPM) for the design and simulation of integrated and fiber-optic waveguide devices and circuits. The software has been commercially available since 1994, and is in use by leading researchers and development engineers in both university and industrial environments worldwide.

Benefits

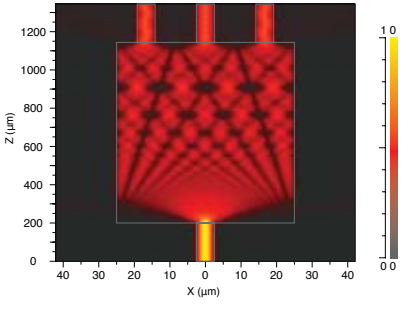
- Industry-proven BPM algorithm for fast and accurate device design.
- Built-in advanced AWG utility for simplifying router and demultiplexer design.
- Advanced capabilities allow for the simulation of complicated devices.
- Fully integrated into the RSoft CAD Environment *(Page 6)*.

Applications

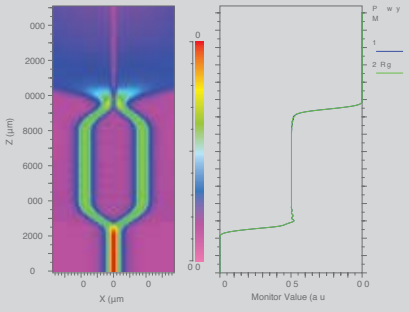
BeamPROP has applications in a wide range of integrated and fiber-optic devices including, but not limited to:

- WDM devices such as arrayed waveguide grating (AWG) routers
- Switches, e.g. directional coupler-based or digital-y type
- Modulators, e.g. Mach-Zehnder type
- Multimode interference devices
- Passive 1 x N or N x N splitters
- Laser structure transverse mode analysis
- Standard and specialty fiber design
- Gratings
- Sensor structures

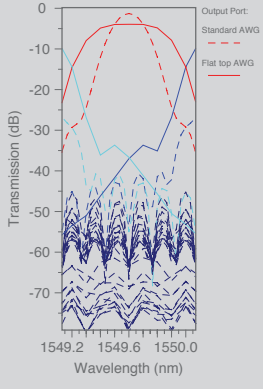
Featured *Application*



BeamPROP simulation of a 1 x 3 MMI device. The length of the MMI was optimized so that the three output waveguides contained equal power.



BeamPROP simulation of a Mach-Zehnder modulator operating completely out of phase. The power in each arm is shown on the right.



BeamPROP simulation of a at-top AWG. The taper on the input port was designed to produce the at-top response shown. The standard AWG output is also shown as reference.

FEATURES

* Superior, robust and efficient results via an implementation of the Beam Propagation Method (BPM) based on an implicit finite-difference scheme.
* 2D and 3D simulation capabilities.
* Non-uniform mesh.
* Anisotropic and non-linear materials.
* Fully intergrated with Multi-Physics Utility *(Page 28)*.
* Polarization effects and coupling via a full-vectorial BPM implementation.
* Wide-angle propagation can be improved by multistep Padé approximation techniques, a variable reference wave number, and conformal index mapping of bends to allow for accurate and efficient off-axis propagation.
* Bidirectional BPM formulation for considering reflection along the propagation direction to be considered.
* Two BPM-based mode-solvers for the computation of modal propagation constants and profiles for both guided and radiation modes for 2D and 3D geometries.
* Comprehensive measurement tools to compute fields, power distribution, loss, etc.
* Automated parametric studies and design optimization using MOST *(Page 24)*.

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FullWAVE

FullWAVE is a highly sophisticated simulation tool for studying the propagation of light in a wide variety of photonic structures including integrated and fiber-optic waveguide devices as well as circuits and nanophotonic devices such as photonic crystals. The software employs the Finite-Difference Time-Domain (FDTD) method for the full-vector simulation of photonic structures. FullWAVE's award winning innovative design and feature set has made it the market leader among optical device simulation tools.

Benefits

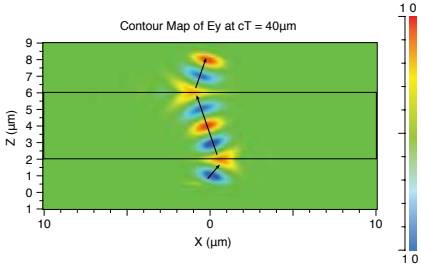
- Cutting edge implementation of mature FDTD algorithm allows for a wide range of simulation and analysis capabilities.
- Advanced capabilities allow for clustered simulation environment for massive computational increases in speed and efficiency.
- Fully integrated into the RSoft CAD Environment *(Page 6)*.

Applications

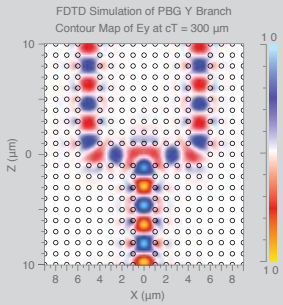
FullWAVE has applications in a wide range of integrated and nano-optic devices including, but not limited to:

- WDM devices such as ring resonators
- Photonic bandgap circuits & applications
- Grating structures, surface normal gratings, and other diffractive structures
- Cavity computations and extractions
- Nano- and micro-lithography
- Biophotonics
- Light scattering
- Metrology
- LED extraction analysis
- Sensor and bio-sensor designs
- Plasmon propagation effects
- Surface plasmons
- Negative refractive index materials

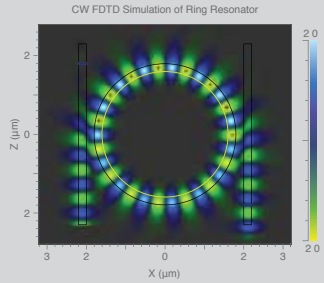
Featured *Application*

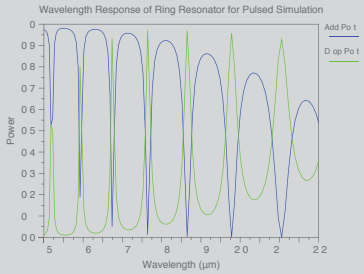


Demonstration of negative index refraction with the propagation of a beam through a left handed material bounded by air.



FullWAVE CW simulation of photonic bandgap y-branch structure.





Top: CW response of ring resonator run at a wavelength resonance of 1.593µm.

Bottom: Wavelength response of a pulsed simulation of the same resonator.

FEATURES

* Advanced and robust FDTD implementation allowing for full-vector field solutions in arbitrary structures and materials.
* 2D, radial, and 3D simulation capabilities.
* Non-uniform mesh.
* Full control of dispersion, non-linear (X^2 and X^3), and anisotropic effects.
* Frequency-dependent saturable gain model.
* Includes Perfectly Matched Layer (PML), periodic, and symmetric/anti-symmetric boundary conditions.
* Advanced excitation options for multiple launch fields, each with different spatial and temporal characteristics such as position, wavelength, direction, polarization, and temporal excitation. Point sources and white light sources are also available.
* Total-field/scattered-field formulation for scattering problems.
* A wide range of analysis and monitoring features to measure common electromagnetic quantities such as power flux, energy densities, overlap integrals, far fields, and the Poynting Vector. Additionally, both FFT and DFT options are included for frequency analysis.
* Includes Q-Finder, a utility that automates the search for cavity modes and *Q*-factors.
* Automated parametric studies and design optimization using MOST *(Page 24)*.
* Increased performance through parallel processing via multi-cpu/core machines and/or clustering across a network of computers. Contact RSoft for licensing policies regarding this feature.
* A native 64-bit version of FullWAVE is available that takes advantage of modern 64-bit CPUs that support additional system memory (RAM).

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BandSOLVE

BandSOLVE is the first commercially available design tool to automate and simplify the modeling and calculation of photonic band structures for all photonic crystal (PC) devices. The BandSOLVE simulation engine employs the Plane Wave Expansion (PWE) algorithm to perform band computations, and also provides a graphical display of the electromagnetic fields and other quantities of interest for further analysis.

Benefits

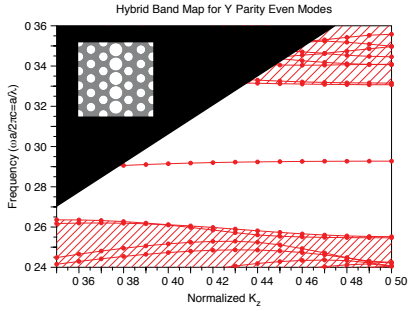
- Advanced implementation of PWE and FDTD (for FullWAVE users only) algorithms allows for a wide range of simulation and analysis capabilities for different types of PBG devices & materials.
- Built-in array layout utility as well as layout hierarchy offers a convenient way to create both standard and custom PBG structures.
- A large number of real application examples.
- Fully integrated into the RSoft CAD Environment *(Page 6)*.

Applications

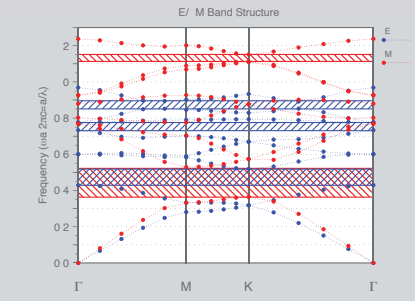
BandSOLVE can be used to optimize the band structure of new photonic crystal geometries before fabricating the device and to determine the performance of existing components. BandSOLVE can be applied to a wide range of PC components, including but not limiting to:

- 2D and 3D PC slab and waveguides
- 2D and 3D cavity problems
- Photonic crystal fibers, both band-gap guiding and conventional guiding
- Defect modes of non-strictly periodic structures
- Metallic and anisotropic structures

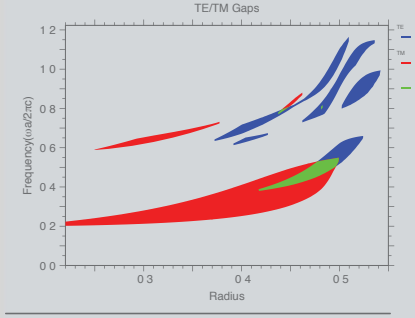
Featured *Application*



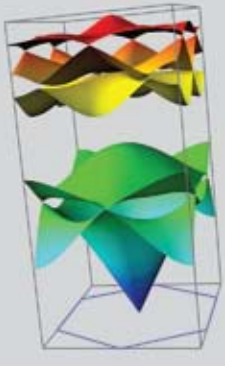
Band diagram for even modes of a waveguide in a lattice of air holes in a photonic crystal slab as computed by a 3D BandSOLVE simulation. The black area represents the leaky mode region, the shaded red regions represent the slab modes, and the red line represents guided modes in the waveguide. The waveguide was formed by enlarging one row of holes as shown.



Band structure for a 2D hexagonal lattice of air holes.



Band gaps for a 2D hexagonal lattice of air holes vs. hole radius.



Band surfaces for a 2D hexagonal lattice of air holes.

FEATURES

* Employs a very efficient and robust Plane Wave Expansion (PWE) algorithm that can solve for the band gaps of most 1D, 2D, and 3D PBG devices.
* Includes several advanced simulation features for more efficient, fast band computations, such as inversion symmetry, mode seeding, and parity for 3D calculations.
* Includes a Finite-Difference Time-Domain (FDTD) engine (for FullWAVE users only) for situations in which the PWE algorithm is not applicable, such as metallic and non-linear systems.
* Employs complete and powerful post-processing tools for the calculation of a wide range of data and graphs. BandSOLVE's analysis features include:
    - Band gaps, band maps, and gap maps
    - Mode computation including Bloch and defect modes
    - Wide range of measurements such as effective and group index, group velocity, and dispersion
    - Equi-frequency plots for analysis of the entire Brillouin zone
    - Light cone filters for photonic crystal slab applications
    - Fixed-frequency analysis to incorporate material dispersion

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ModePROP

ModePROP is an Eigenmode expansion propagation tool that accounts for both forward and backward propagation and radiation modes. It provides a rigorous steady-state solution to Maxwell's equations that is based on the highly-stable Modal Transmission Line Theory. A full array of analysis and simulation features make this tool flexible and easy to use.

Benefits

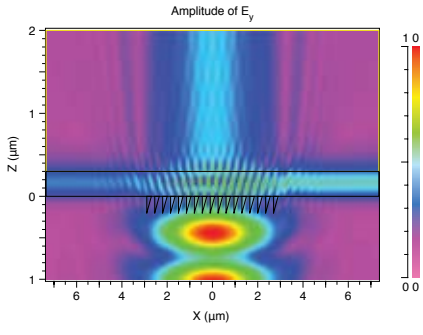
- Rigorous full-vector analysis.
- Solves for both forward and backward traveling modes.
- Fully integrated into the RSoft CAD Environment *(Page 6)*.

Applications

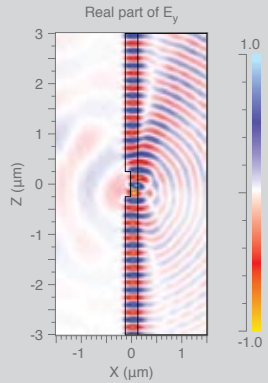
ModePROP has applications including, but not limited to:

- Waveguide/Fiber-based systems
- Surface-normal grating couplers
- Plasmonic devices
- Sensors
- Filters
- Mode converters
- Photonic bandgap
- Computing coupling efficiency

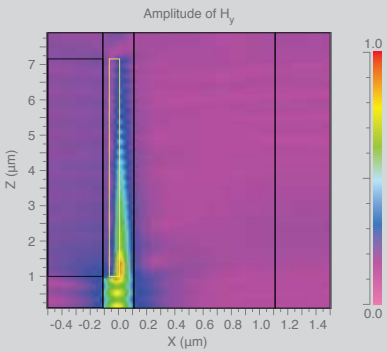
Featured *Application*



ModePROP simulation results of a blazed finite surface grating. An incident Gaussian beam is coupled into a waveguide by a surface grating.



Simulation results that show the field scattered by an air groove.



Simulated field within a surface plasmon based interferometor that is operating out of phase.

FEATURES

* Full-vectorial analysis for both Cartesian and cylindrical (azimuthally symmetric) structures in 2D and 3D.
* Modal Transmission Line (MTL) framework to ensure that the simulation is unconditionally stable.
* Accounts for reflections.
* User-defined initial field.
* Accommodates complex index for lossy materials and high index contrast profiles.
* Robust meshing scheme which conforms to the structure.
* PML boundary conditions.
* Output information includes transmission/reflection of individual modes as well as total values, and the Poynting Vector.
* Sophisticated output options allow user to calculate and display field profiles and other electro-magnetic quantities at any position.
* Automated parametric studies and design optimization using MOST *(Page 24)*.

SEE **PAGE 41** FOR SYSTEM REQUIREMENTS

DiffractMOD

DiffractMOD is a design and simulation tool for diffractive optical structures such as diffractive optical elements, subwavelength periodic structures, and photonic bandgap crystals. It is based on the Rigorous Coupled Wave Analysis (RCWA) technique that has been implemented using advanced algorithms including fast Fourier factorization and generalized transmission line formulation. Already a market leader, the tool has extensive applications in a broad range of areas including semiconductor manufacturing and wave optics.

Benefits

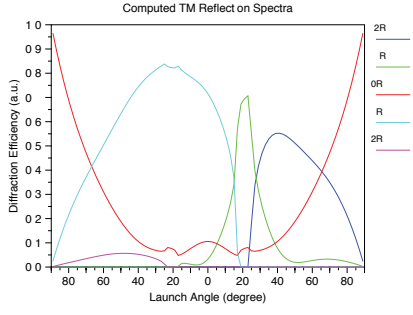
- Incorporates advanced algorithm options that extend the basic RCWA technique to improve its robustness, efficiency, and user-friendliness.
- Fully integrated into the RSoft CAD Environment *(Page 6)*.

Applications

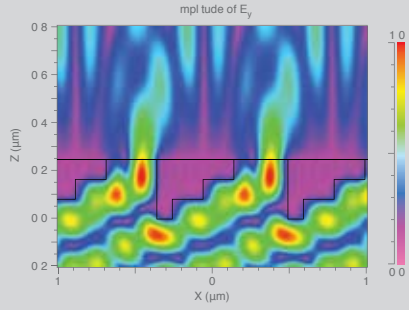
DiffractMOD can handle complicated periodic structures containing both dielectric and metallic components with lossy or dispersive materials. It has application to a wide-range of devices including, but not limited to:

- Waveguide resonance gratings
- Diffractive Optical Elements (DOEs)
- Surface relief and volume index gratings
- Wavelength filters
- Optical metrology
- Nano-lithography
- Polarization sensitive devices
- Artificial dielectric coatings
- Photovoltaic systems
- 3D displays
- Optical interconnections
- Optical data storage
- Spectroscopy

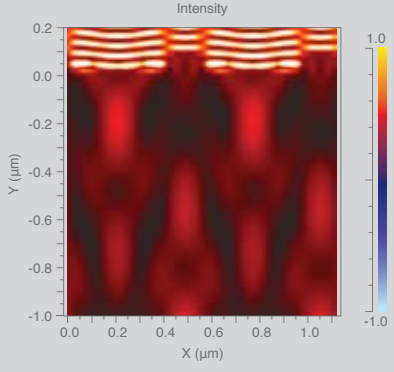
Featured *Application*



Computed spectra for TM reflected diffraction orders for a 2D metallic grating.



Field profile of metallic grating structure.



Simulation of a Phase Shift Mask with DiffractMOD.

FEATURES

* Advanced algorithm options are used to improve convergence.
* Modal Transmission Line (MTL) framework to ensure that the simulation is unconditionally stable.
* Full vector simulations for both 2D and 3D. Additionally, conical incidence is allowed.
* An inverse rule is used to improve the convergence of TM fields. For 3D simulation, DiffractMOD can choose appropriate algorithms depending on structures.
* Account for material dispersion and complex refractive index for metals.
* Calculate, display, and output spectra of diffraction efficiency for any diffraction order.
* Calculate total reflected power, transmitted power, and absorbed power.
* Sophisticated field output options allow the user to calculate and display field profiles at any position.
* Spectrums vs. wavelength, angle and polarization for any diffraction efficiency can easily be computed.
* Output common metrology parameters directly.

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GratingMOD

GratingMOD is a general design tool for analyzing and synthesizing complicated grating profiles in optical fibers and integrated waveguide circuits for a wide variety of photonic applications. The software is based on the Coupled Mode Theory (CMT) algorithm for fast simulation as well as sophisticated multiple mode algorithms for advanced applications. GratingMOD also provides a general platform for simulation of various coupling mechanisms.

Benefits

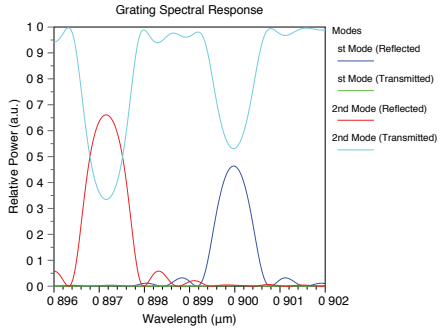
- Incorporates advanced algorithms to improve its robustness, efficiency, and user-friendliness
- Fully integrated into the RSoft CAD Environment *(Page 6)*.

Applications

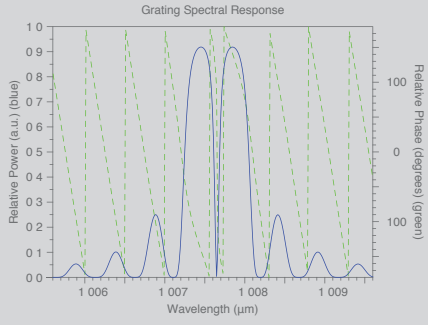
GratingMOD can handle various grating structures for both fiber and integrated waveguides. It has applications to a wide range of integrated and fiber-optic devices including, but not limited to:

- Dispersion compensation Fiber Bragg Grating
- Multiplexing/Demultiplexing
- Add/Drop filtering
- Gain equalization in optical amplifiers
- Grating assisted couplers
- Long period grating sensors

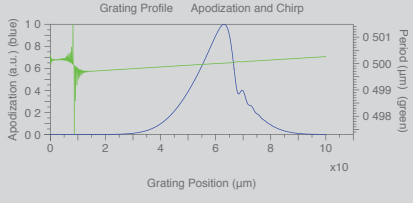
Featured *Application*

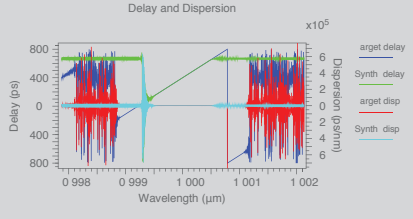


Results for multimode simulation of a grating assisted coupler. Spectra are shown for both forward & backward propagation for both modes in the structure.



Simulation results showing the phase and amplitude.





Synthesis results of a grating with constant dispersion compensation.

FEATURES

* Bragg condition searching to find both the period from the specified modes and the modes from a specified period.
* Sophisticated orthogonality relations for both lossless and lossy waveguide are included.
* Optimal modes are used to reduce error.
* Analytical mode calculations can be used when applicable.
* An arbitrary number of gratings at arbitrary positions in both 2D and 3D structures can be used to study coupling mechanisms. Coupling mechanism includes fiber core coupling, fiber core to cladding coupling, long period fibers, as well as side coupling and vertical coupling for integrated circuits.
* Multi-mode grating systems can be analyzed via a multi-mode CMT implementation.
* An advanced synthesis tool utilizes a state-of-the-art synthesis technique to solve the 'inverse' problem.
* Both waveguide and material dispersion can be included.
* Transmitted and reflected spectra for each mode can be determined.
* Calculation of phase, dispersion, and time delay.
* Generation of mode, apodization, chirp, and grating profiles.
* Automated calculation of band width for primary order reflection.
* Spectrum analysis and Bragg condition analysis.

SEE **PAGE 41** FOR SYSTEM REQUIREMENTS

FemSIM

FemSIM is a generalized mode solver based on the Finite Element Method (FEM) that can calculate any number of transverse or cavity modes of an arbitrary structure on a non-uniform mesh. FemSIM employs a full-vector implementation and has been enhanced with many features to compute complex modes. The tool is flexible and extendable to a wide range of problems such as high index contract, plasmonic, and photonic bandgap based waveguides.

Benefits

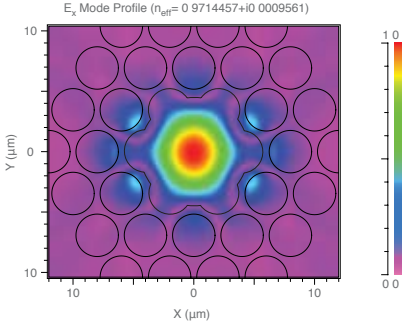
- Advanced implementation of the FEM algorithm allows for a wide range of simulation and analysis capabilities for different types of devices.
- Can be used in conjunction with other RSoft tools to solve for modes and then propagate them through a device.
- Fully integrated into the RSoft CAD Environment *(Page 6)*.

Applications

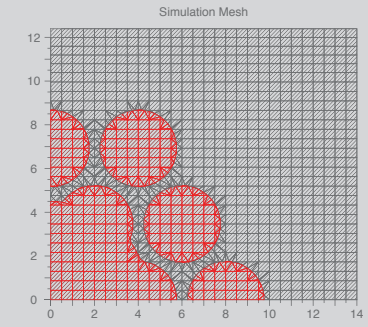
FemSIM has applications for mode solving to a wide range of integrated and nano-optic devices including, but not limited to:

- Structures with arbitrary profiles, including those with curved or uncommon shapes
- Structures with high index contrast and/or small feature sizes
- Air or solid core photonic fibers
- Lossy structures
- Silicon-based devices such as SOIs
- Polarization rotators
- Plasmonic waveguides
- Laser and PBG defect cavities

Featured *Application*

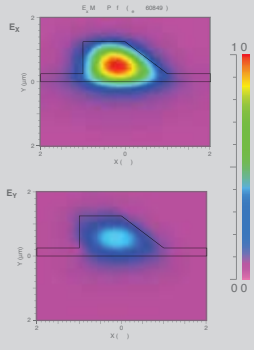


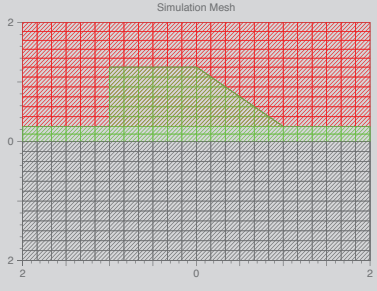
Computed mode profile for an aircore photonic crystal fiber. Symmetric boundary conditions were used in the calculation to provide a speedy solution. The simulation mesh can be seen on the next page.



Simulation mesh for aircore photonic crystal fiber.

Simulation mesh for a rib waveguide with a tilted facet with a highly hybrid polarization; both Ex and Ey components of the mode are shown.





FEATURES

* Full-vector analysis for both Cartesian (1D, 2D) and cylindrical (azimuthally symmetric) structures.
* Accommodates complex index for lossy materials and high index contrast profiles.
* Robust meshing scheme which conforms to the index profile using hybrid triangular and rectangular mesh elements.
* First and second order elements used to avoid spurious modes.
* PML and symmetric/anti-symmetric boundary conditions.
* Determination of propagating, leaky, and cavity modes.
* Higher order modes can be found with minimal additional computational expense.
* Computation of dispersion diagrams.
* Output information includes field profiles, propagation constants, overlap integrals, confinement factors, and diagnostics.
* Automated parametric studies and design optimization using MOST *(Page 24)*.

SEE **PAGE 41** FOR SYSTEM REQUIREMENTS

LaserMOD

LaserMOD is a photonic device design software tool for simulating the optical, electronic, and thermal properties of semiconductor lasers and similar active devices. In these devices, thermal flux and carrier transport can strongly affect overall performance through spatial hole burning and self-heating. LaserMOD accounts for these and other important processes within a self-consistent scheme.

Benefits

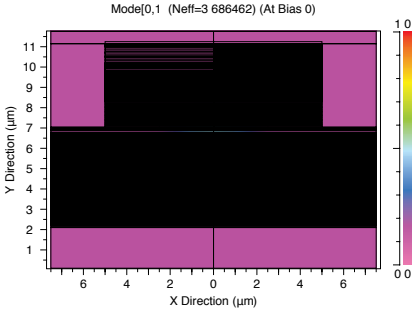
- Versatile, user friendly, parametric CAD interface.
- All simulation modules included in a single package.
- Integrated with both passive device and system tools from RSoft Design Group.

Applications

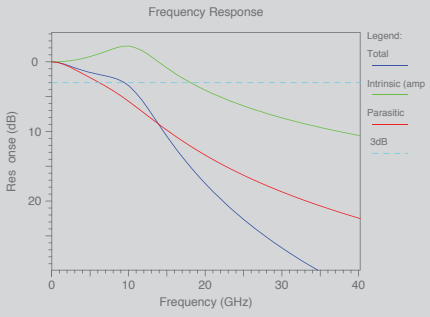
LaserMOD applications include the following device families:

- Edge emitting lasers, such as Fabry-Perot (FP), Distributed Feedback (DFB), and Distributed Bragg Reflector (DBR)
- Cylindrical Vertical Cavity Surface Emitting Lasers (VCSEL)
- Silicon modulators (Electro-absorptive, electro-refractive, and thermo-optic modulators in silicon and other semi-conductor materials)
- Hybrid & Multilevel applications when combined with other tools in the RSoft suite

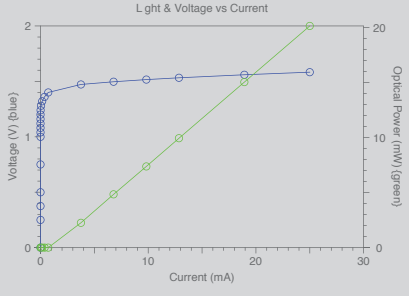
Featured *Application*



Fundamental cavity mode of an oxide-aperture VCSEL calculated via finite-element method (FEM).



Computed light-current and current-voltage (LIV) characteristics indicating the progress of a steady-state simulation.



Frequency response to a small pulse applied at the steady-state operating point. Parasitic effects can be included to account for packaging.

FEATURES

* 1D, 2D and cylindrical (quasi-3D)
* Advanced physics based models
* Self-consistent solution of optics, quartum mechanical gain, and electro-thermal transport
* Steady-state and time dependent simulation
* 8x8 KP band calculation for gain
* Lock up table base gain model
* Integrated BPM and FEM mode solvers
* Integrated mesh generator
* Extensible material libraries
* Numerous tutorial examples
* Standard and custom plot generation
* Scanning of design parameters

SEE **PAGE 41** FOR SYSTEM REQUIREMENTS

MOST

MOST†, RSoft's Multi-varable Optimization and Scanning Tool, is an exciting solution to the critical problem of design optimization for photonic devices. During the research or design cycle, it becomes vital to under stand the full parameter space of the system. Acting as an automated driver for RSoft's physics-based simulators, MOST takes the drudgery out of these important operations by streamlining the definition, calculation and analysis of scans and optimizations. Moreover, if you own multiple copies of RSoft products, MOST can automate the distribution of work across your entire network with virtually a single mouse click.

Benefits

- Automatically scans and optimizes devices with minimal user interaction.
- Automates the design process to take out tedious work.
- A wide range of output and analysis features available through measurement and user-defined metric techniques.
- Fully integrated into the RSoft CAD Environment and with all of the component simulation tools. *(Page 6)*.

Applications

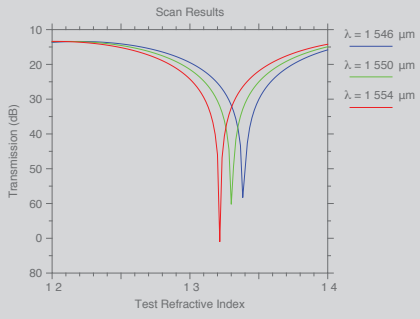
MOST is applicable to any situation where a range of parameters need to be looked at or optimized including, but not limited to:

- Perform parameter scans over any design parameter in any number of dimensions
- Perform single and multiple variable local and global automated optimization
- Perform global optimization by genetic algorithm
- Automated distributed computation of scans and some optimizations

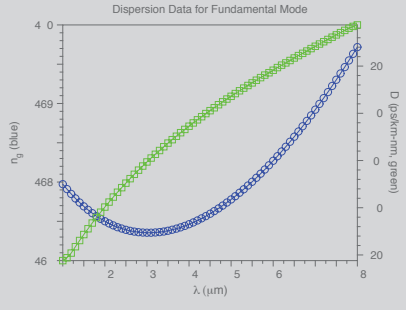
Simulation *Technology*

MOST provides the most flexible scanning/optimization environment available today. Measurements are generalized so that any type of data produced by any simulator can be treated in a uniform fashion. Thus, scanning modal effective indices calculated with BeamPROP is identical to scanning diffraction efficiencies calculated with Diffract-MOD. In addition, vector and matrix quantities such as reflection spectra or modal profiles are scanned just as easily. Literally, any quantity pro-duced by any RSoft tool can be the target of a scan or optimization.

† The scanning portion of MOST is included with all passive device simulation tools; optimization and distribted scanning are licensed seperately.



ModePROP scan results showing surface plasmon resonance locations for different operating wavelengths as a function of the refractive index of the test material.



Computed dispersion parameters for a fiber found using BeamPROP and the scanning/ post-processing capabilities of MOST.

FEATURES

* Any quantity produced by any RSoft tool can be the target of a scan or optimization.
* Scans and optimizations can be performed over an arbitrary number of parameters.
* Automatic generation of line, contour, and 3D volume plots.
* "Data sliced" plots showing behavior in particular planes of the pharameter space.
* Real time convergence plots to track the performance of optimizations.
* Data conveniently accessed and viewed within RSoft's customized DataBROWSER environment.
* Instantly reprocess existing data in different plot styles.
* Complete data dumps to file of any scanned quantity.
* Several optimization algorithms available for different types of convergence.
* Custom post-processing of simulation output to produce scans/optimizations of any parameter.
* Define new optimization algorithms with MOST through custom modules.

SEE **PAGE 41** FOR SYSTEM REQUIREMENTS

SOLAR CELL UTILITY

The **Solar Cell Utility**† provides an optical and electronic simulation solution for solar cell devices. The utility simplifies common tasks associated with solar cell design and aids in the rigorous computation of J-V curves, quantum efficiency spectra, and overall cell-efficiency. The basic version of the Solar Cell Utility uses a simple electronic model and operates with one or more RSoft optical simulation tools††. If a rigorous electronic modeling solution is desired, LaserMOD can be used. The Solar Cell Utilty LaserMOD option provides a limited license of LaserMOD for this purpose.

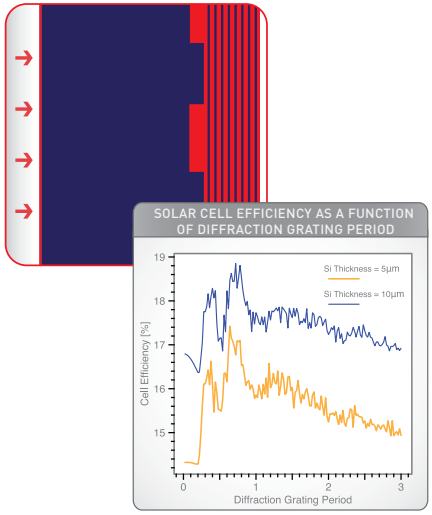
Benefits

- Rigorous optical simulation is performed by one of RSoft's passive optical design tools.
- Can use either a simple electronic model or RSoft's rigorous LaserMOD simulation tool.
- Fully integrated into the RSoft CAD Environment *(Page 6)*.

Applications

- Solar cell design
- Solar cells with diffractive optical elements (DOEs)
- Solar cells with randomly textured material interfaces
- Ideal for investigating the electronic nature of solar cells

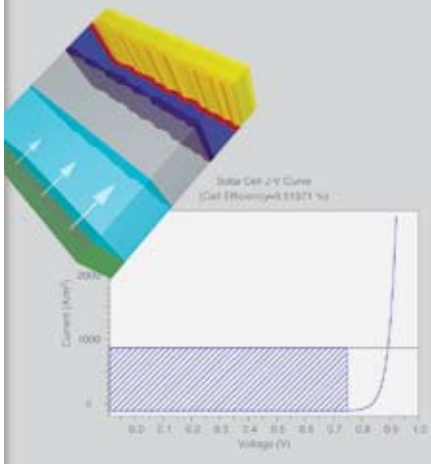
Featured *Application*



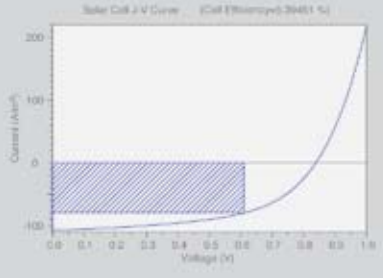
Schematic of solar cell structure along with solar cell efficiency computed by DiffractMOD as a function of the period of a diffractive optical element within the cell.

†The Solar Cell Utility provides owners of some of RSoft's optical simulation tools the functionality described here. All simulation tools are licensed separately.

††Consult an RSoft representive to determine which combinations of products are currently supported.



J-V curve for solar cell with randomly textured interfaces computed using Ideal Diode electrical model and FullWAVE.



J-V curve for the same solar cell above computed with LaserMOD and FullWAVE.

FEATURES

* Arbitrary solar cell geometry can easily be created in the RSoft CAD.
* Important material properties such as frequency-dependent complex refractive indexes can be used to correctly model absorptive materials.
* Simple electronic modeling via modified Ideal Diode equation; rigorous modeling via RSoft's LaserMOD tool.
* Uses the AM1.5 Solar Spectrum as incident spectrum by default; a user-specified spectrum can also be used.
* Direct user control over shadowing, filling-factor, and collection efficiency.
* Accounting of parasitic resistances in both simple and rigorous electronic models.
* Outputs include cell efficiency, J-V curves, and quantum efficiency spectra in addition to the standard output from the simulation tool(s) used (DiffractMOD, FullWAVE, and/or LaserMOD).
* Automated parametric studies and design optimization using MOST *(Page 24)*.

SEE **PAGE 41** FOR SYSTEM REQUIREMENTS

Multi-Physics UTILITY

The **Multi-Physics Utility**† is designed to be used in conjunction with any of RSoft's passive device simulation tools. It provides a convenient interface from which perturbations of the refractive index profile of a structure may be included in the simulation. These perturbations can be due to advanced physical processes in the material, such as electro-optic effects, thermo-optic effects, stress-optic effects (i.e. strain), and carrier-induced effects. All material parameters needed to describe these effects can be defined in RSoft's Material Library.

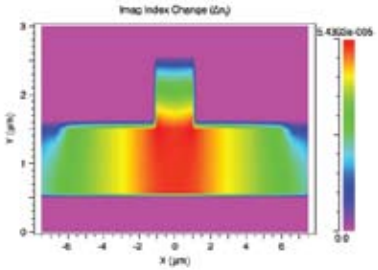
Benefits

- Expands the power of all of RSoft's passive device simulation tools.
- Fully integrated into the RSoft CAD Environment *(Page 6)*.

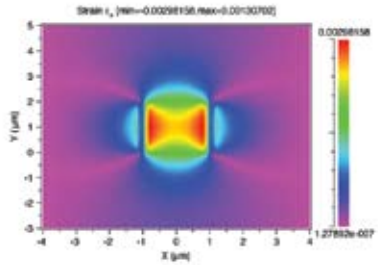
Applications

- Electro-absoptive/electro-refractive modulators
- Thermo-optic switches
- Electrically biased modulators
- Birefringence in waveguides and fibers
- Stress effects caused by cooling during device fabrication.

Featured *Applications*



Change in refractive index, due to carrier effects, in a silicon ridge waveguide buried in SiO_2.



X component of strain in a silicon ridge waveguide buried in SiO_2.

Features

- Fully integrated with all of RSoft's passive device simulation tools.
- Leverages RSoft's material library for all model parameters.
- Computes index perturbation by solving Poisson's equation (electro-optic effect), thermal equation (thermo-optic effect), stress-strain equation (stress effect), and by using LaserMOD to model carrier-based effects.
- Automated parametric studies and design optimization using MOST *(Page 24)*.

† The basic Multi-Physics Utility with electro-optic and thermo-optic effects is included with all passive device tools; the stress and carrier effects are offered as options that are licensed seperately.

Tapered Laser UTILITY

The **Tapered Laser Utility**† provides an efficient and accurate design tool for analyzing and optimizing tapered semiconductor laser diodes. It essentially combines, two of RSoft's most powerful and mature simulation tools BeamPROP and LaserMOD, to provide a full 3D simulation of tapered laser diodes. The quasi-3D electrical, quantum mechanical gain and thermal calculations are performed via LaserMOD, whereas the optical field is propagated via BeamPROP.

Benefits

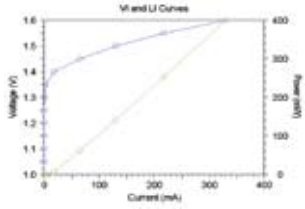
- Leverages the power of RSoft's BeamPROP and LaserMOD simulation tools for use with tapered semiconductor laser diode applications.
- Fully integrated into the RSoft CAD Environment *(Page 6)*.

Applications

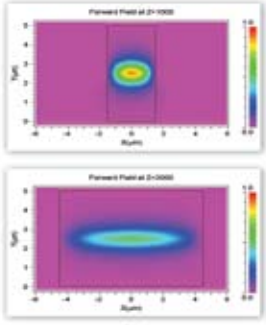
- Tapered laser diode design.

† The Tapered Laser Utility provides owners of BeamPROP and LaserMOD the functionality described here. All simulation tools are licensed seperately.

Featured *Application*



Computed light-current and current-voltage characteristics.



TL Utility computed stabilized field profiles along different sections of the tapered laser. .

Features

- Fully integrated with RSoft's BeamPROP and LaserMOD simulation packages to automatically compute tapered laser characteristics.
- Self-consistent optical, electronic and thermal simulation.
- Extensible material libraries.
- Output information includes L-I curves, I-V curves, spatial field plots, farfields etc.
- Capable of simulating physical effects like spatial hole burning, filamentation, over pumping etc.

RSoft's Optical Communication Design Suite

RSoft's Optical Communication Design Suite allows users to design and simulate current and next generation optical communication systems at the signal-propagation, network-architecture, and packet level. Currently four software packages are part of the suite: OptSim, ModeSYS, MetroWAND, and Artifex. These advanced tools enhance and accelerate user-modeling capabilities and provide real field design scenarios using extensive industry specifications. The customer base includes 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.

OptSim & ModeSYS Key Features

* Enable the user to design and simulate single mode (OptSim) and multimode (ModeSYS) optical communication systems at the signal-propagation level.
* Virtual prototyping reduces the need for costly and lengthy physical prototyping for increased productivity and decreased time-to-market.
* Optimization of the design for enhanced performance and reduced cost.
* Common graphical interface but separate licenses allows users to choose only the simulation engine that is relevant to their work.
* Assist in the discovery and analysis of next generation optical communication systems deploying new modulation formats.
* Interfaces with 3rd party tools such as MATLAB®, Cadence Spectre, Liekki Application Designer, and the Luna Optical Vector Analyzer.
* Advanced electrical modeling with embedded Spice engine.

MetroWAND Key Features

- Plan Ring and Mesh Architectures.
- Highly efficient network design algorithms.
- Design rules incorporate fiber topology, traffic demands and equipment constraints.
- Quick analysis of 'what-if' scenarios.
- Optical link layer performance estimations.
- Failure analysis with rerouting options.
- Customize Vendor equipment library.

Artifex Key Features

- Design and simulate discrete event systems using the Petri Net formalism.
- Graphical object-oriented language and event-driven simulation ensures scalability to high degrees of complexity.
- Integrated platform with tools to create, validate, simulate, measure and deploy the system.
- Dynamic visualization of events and states supports iterative model development.
- Real-time and virtual-time simulation with full user control of model's execution.
- Simulation data analysis and representation.
- Automatic ANSI C and C++ code generation to build custom simulators and control software.
- Networking tool-kit for protocol simulations.

SYSTEM

OptSim
Simulates a broad range of optical communication systems

ModeSYS
Simulates multimode optical communication systems

NETWORK

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

Artifex
Simulates discrete event networks through the Petri Nets formalism applications

OptSim

OPTICAL COMMUNICATION DESIGN
System

OptSim is RSoft's award-winning software tool for the design and simulation of optical communication systems at the signal propagation level. With state-of-the-art simulation techniques, an easy-to-use graphical user interface and lab-like measurement instruments, OptSim provides unmatched accuracy and usability. The software has been commercially available since 1998 and is in use by leading engineers in both academic and industrial organizations worldwide.

Benefits

- Virtual prototyping of the optical communication systems for increased productivity and reduced time-to-market.
- Optimization of the design for enhanced performance and/or reduced cost.
- Interfaces with 3rd party tools such as MATLAB®, Cadence Spectre, Liekki Application Designer, and the Luna Optical Vector Analyzer.
- Advanced electrical modeling with embedded SPICE engine.

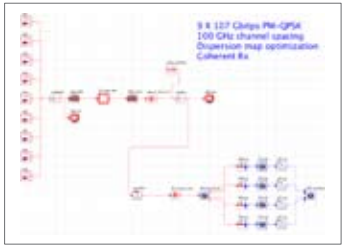
Applications

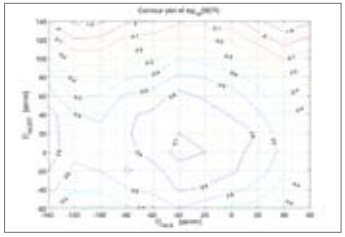
OptSim is ideally suited for computer-aided design of optical communication systems including, but not limited to:

- DWDM / CWDM systems with optical amplification, e.g. EDFA, Raman, SOA, OPA
- Advanced Modulation Formats, e.g. D(Q)PSK, Duobinary, etc.
- FTTx / PON
- Coherent Optical Communication Systems, e.g. PM-QPSK, OFDM
- OCDMA / OTDM
- CATV Digital/Analog
- Optical Interconnects
- EDC
- FSO
- Soliton
- Interferometric Fiber Optic Gyroscope (I-FOG)

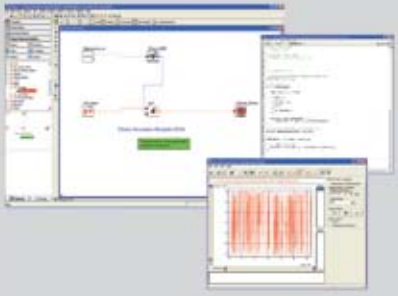
Featured *Application*

- Synchronous PolMUX-QPSK system with 9 channels at 107 Gbit/s, 20x100 Km SMF fiber, and a DSP-based digital coherent receiver.
- Direct error counting on 262,144 simulated bits.
- OptSim's unique capability of simulating arbitrarily long bit sequences makes it the tool of choice to design systems where the direct error counting is required to assess the system performance, such as systems using FEC, MLSE, EDC, and DSP-based digital coherent receivers.





OptSim project layout of a DQPSK system. OptSim includes an advanced BER estimator specific for D(Q)PSK systems based on Karhunen-Loeve series expansion.



OptSim - MATLAB cosimulation project layout. An Electro-Absorption Modulator with Chirp is modeled using the MATLAB m-file programming language. The MATLAB engine is automatically invoked by OptSim at runtime to simulate the EAM model.

FEATURES

* Only design tool with multiple engines implementing both the Time Domain Split Step and the Frequency Domain Split Step for the most accurate and efficient simulation of any optical link architecture.
* MATLAB® interface makes it easy to develop custom user models using the m-file language and/or the Simulink® modeling environment.
* Interfaces with laboratory test equipment such as Agilent and Luna to merge simulation with experiment.
* Interfaces with device-level design tools such as BeamPROP, and LaserMOD provide a powerful mixed-level design flow for optoelectronic circuits and systems.
* Co-simulation with embedded SPICE engine, and interfaces with EDA tools such as Cadence Virtuoso Spectre, and Synopsys HSPICE for a mixed-domain electrical and optical simulation.
* Interfaces with EDA tools such as Berkeley SPICE, Cadence Virtuoso Spectre, and Synopsys HSPICE for a mixed-domain electrical and optical simulation.
* 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 library of predefined manufacturer components makes it easy to model commercially available devices.
* Intuitive and flexible measurement post-processing graphical interface acts like a virtual laboratory instrument.

SEE **PAGE 41** FOR SYSTEM REQUIREMENTS

ModeSYS

ModeSYS supports the design and simulation of multimode fiber optic systems. With a primary focus on data communication applications, ModeSYS allows users to evaluate both temporal and spatial attributes of optical signal propagation. ModeSYS can be used as a standalone tool or combined with OptSim to form a comprehensive single-mode and multimode optical communication system design suite.

Benefits

- Simulates both temporal wave-form and spatial modes of multimode systems combining system-level speed with device-level representation accuracy
- Virtual prototyping of the multimode optical communication system for increased productivity and reduced time-to-market
- Fully supports yield analysis through statistical models of multimode fiber defects such as Cambridge 81 and 108 fiber models
- Interfaces with device-level tools such as RSoft's BeamPROP to simulate at the system level custom components designed at the device level

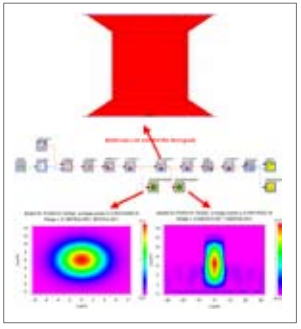
Applications

ModeSYS is ideally suited for computer-aided design of multimode optical communication systems including, but not limited to:

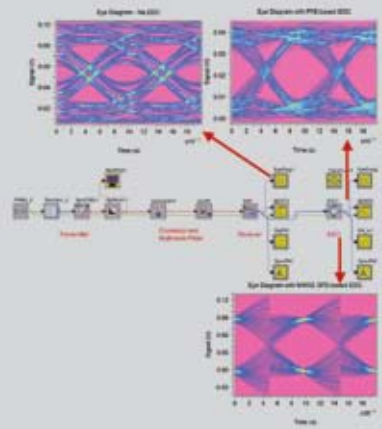
- Gigabit Ethernet, e.g. 1GbE, 10GbE
- 10GBASE- systems, e.g. SX, LX-4 and LRM
- Serial / WDM
- FTTx / PON
- EDC
- Optical Interconnects
- FSO

Featured *Application*

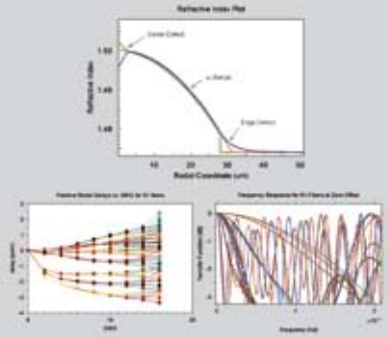
- ModeSYS - BeamPROP co-simulation enables the user to simulate in the context of a ModeSYS multi-mode system simulation a component designed at the device level in BeamPROP
- BeamPROP uses the Beam Propagation Method (BPM) to simulate custom components such as waveguides, lenses, couplers, gratings, etc.
- The figure depicts a 6-mm long waveguide with an input/output width of 14µm that tapers to 8µm within the 4-mm long central region. The substrate, core (index = 3.5) and layer (index = 1.5) materials have different indexes.



Using BeamPROP's SOI-based rib waveguide design in ModeSYS to analyze its system level performance



Modeling of Electronic Dispersion Compensation (EDC) in ModeSYS. ModeSYS and OptSim include FFE- and DFE-based EDC with MMSE-based optimization.



Studying the impact of refractive index profile perturbations using Cambridge-81 and Cambridge-108 models in ModeSYS.

FEATURES

* Multimode fiber model includes Helmholtz equation solver supporting arbitrary index profile and index profile perturbations.
* Extensive set of measurement tools enables the user to analyze key-characteristics of multimode optical communication systems such as:
  - Transverse mode profiles
  - Signal over time
  - Signal spectra
  - Eye diagrams
  - BER
  - Effective modal bandwidth (EMB)
  - Differential Mode Delay (DMD)
  - Encircled Flux (EF)
  - Radial power distributions
* Mode-propagation model supports modal dispersion and Differential Mode Attenuation (DMA).
* Comprehensive spatial model using distinct transverse mode profiles supports launch-condition, optical-coupling, and alignment-tolerances analysis.
* Extensive library of predefined manufacturer components makes it easy to model commercially available devices.
* Deterministic and statistical component parameter sweeping.
* Powerful encryption capabilities make protecting your schematics and model parameters easier than ever.
* Application Programming Interface (API) for programming languages such as C/C++ for the development of custom user models.

SEE **PAGE 41** FOR SYSTEM REQUIREMENTS

MetroWAND

MetroWAND is a network planning/design platform for SONET/SDH and WDM technologies. As a network-modeling tool, MetroWAND is used to simulate various network configuration scenarios, routing methods, failure scenarios, and traffic load analysis. MetroWAND may also be used to obtain various statistics like system utilization, wavelength utilization, throughput rates, and equipment capacity. MetroWAND's optical engineering module simulates the optical channel propagation and calculates the end-to-end link performance of a particular optical channel. End-to-End link performance is validated using the numerical measures of total attenuation, accumulated dispersion, accumulated dispersion slope, optical SNR, BER and Q.

Benefits

- Uses cost-optimization algorithm to locate WDM or SONET ring networks by considering equipment, topology, and traffic.
- Considers any transport rate including gigabit Ethernet, SONET/SDH, and user-defined rates.
- All Optical network design objectives like wavelength routing, wavelenght assignment, and physical layer performance simulation are featured in a single tool.
- Vendor-neutral tool.
- Flexible equipment models enable evaluation of different technologies.
- Mesh Routing and Restoration.
- Intuitive GUI.

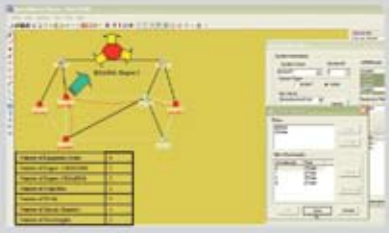
Applications

- Design and optimization of UPSR, 2-fiber BLSR, 4-fiber BLSR, SNCP, and MSSP rings.
- Optical channel performance simulations and placement of amplifiers and regenerators.
- Obtain the minimum network cost by optimizing fiber, structure, cable, amplifier, and regenerator usage along with ring ADMs.
- Model and analyze the existing rings together with planned rings as well as with new rings for the expansion of the network.
- Model multiple equipment types (ADMs, Cross-connects, and MSPPs) and design the network.
- Optical network link engineering and analysis covering both linear effects as well as non-linear effects.

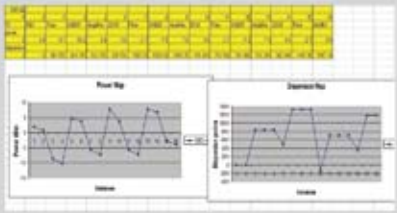
Feature *Application*

A comprehensive network-planning tool that gives flexibility in modeling wavelength routing and wavelength assignments. It accurately simulates the performance of the system under various network conditions. The tool performs analysis on the simulation results and recommends the most suitable hardware components.

Multiple views of the optical network in MetroWAND. Physical layer topology view and traffic demand view.



During the capacity design stage, the software creates an optical ring, it grooms the traffic into optical channels, assigns wavelengths, and places Optical Add Drop Multiplexers (OADMs).



For each wavelength, power, dispersion, OSNR and Q values are plotted and shown for each optical component instances. This will allow the planner to a) adjust amplifier gain b) adjust variable attenuator and c) select a dispersion compensation module. This analysis can be carried out in Terminal-Terminal, Terminal-OADM, or OADM-OADM configurations.

FEATURES

* Design and plan metropolitan mesh and ring networks.
* Capacity planning and optical layer performance simulation in one engine.
* Optical layer optimization by adding amplifiers, dispersion compensators and regenerators based on OSNR and Q values.
* Quick validation of network design scenarios.
* Model next-generation SONET/WDM equipment.
* Model network growth scenarios.
* Determine hub locations and optimum cross-connect locations.
* Partition the network into sub-networks and design core and access rings.
* Analyze disaster recovery under multi-failure scenarios.
* Optical link engineering and Analysis.

SEE **PAGE 41** FOR SYSTEM REQUIREMENTS

Artifex

Artifex is a development platform for discrete event simulation. It uses a graphical modeling and simulation environment to model, design, simulate, and analyze discrete event systems. Artifex is widely used to simulate optical network protocols, control plane architecture, and switching mechanisms.

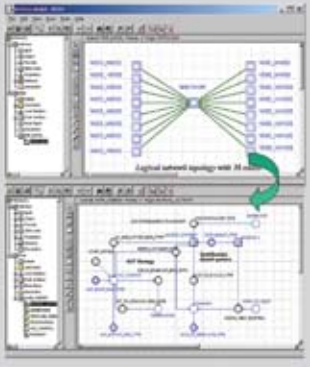
Benefits

- An integrated platform to design, develop, validate, and simulate models and systems
- Quick development of models using the graphical language Petri Net
- C/C++ code integration with the models
- Deploy simulation as a multi-node and/or a multi-threaded application
- Automatic report generation
- Automatic measurements

Applications

Artifex's open and exible modeling approach is utilized in many industries like Transport, Defense, Telecom, and Finance. Listed below are a few applications from the Telecom industry:

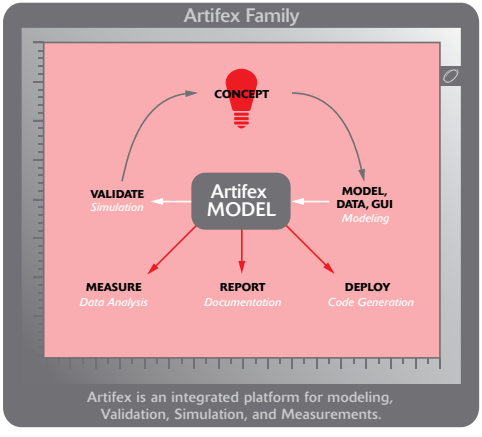
- Model, simulate, and analyze networking protocols like TCP, UDP, IP, Ethernet, OSPF, and MPLS.
- Develop, design, and validate new and emerging protocols.
- Conceptualize a complex system's behavior, prototype, and develop strategies for its implementation.
- Model, simulate, and analyze network elements like routers, switches, optical-Cross Connects (OXCs) and Optical Add/Drop Multiplexers (OADMs) for their logical behavior and protocol implementation.
- Model various traffic generators.
- Design and analyze network performance and quality of services (QoS) using the logical models of traffic generators, protocols, and network elements.
- Design network architectures like rings or meshes, specify network type (optical-access metro or transport), and study the network level behaviors like network through-put, blocking probability, and wavelength assignment.
- Model buffering, memory, and Integrated Circuits (IC).
- Develop, validate, and analyze protection switching or restoration switching protocols.



Shows logical view (mesh) of a WDM Ring and the view of schemes implemented in a ring node. Each node generates packets according to a Poisson process stored in a distinct transmission queue, one associated with each destination/channel. The objective is to study the transmission queue latency time of packets sent to client nodes from client nodes; for example from NODE_2 to NODE_1, NODE_3, NODE_6, NODE_9, NODE_12 and from NODE_9 to NODE_14.

Shows the transmission queue latency times – client to client analysis for the WDM network.

FEATURES



* Graphical modeling and simulation environment to model, design, simulate, and analyze discrete event systems.
* User can draw the system dynamic behavior through an intuitive graphical language based on the Petri Nets formalism.
* Validates the Petri Net model and generates code in C/C++ language.
* Models can be compiled and run in the Artifex environment or compiled and executed as standalone applications.
* Objects can be dragged and dropped from a library to the drawing canvas and connected to create system models.
* Networking tool-kit consists of library of traffic generators, protocols, and optical and non-optical network elements.

SEE **PAGE 41** FOR SYSTEM REQUIREMENTS

Professional Services & Programs

RSoft Design Group provides a variety of professional services and programs that supplement and support our client's need for a total solution. These services include:

Training *Seminars*

RSoft organizes product training seminars every year. Seminars are either hosted at the RSoft offices or by a host sponsor, including many prominent universities. Private seminars are also available at an additional cost.

Customized *Solutions*

In order to address the needs of specialized applications, RSoft offers consulting services to extend the current capabilities of its software tools. Customized solutions accelerate product development and reduce client time to market.

Design *Services*

RSoft offers a range of supplemental consulting services, ranging from application design optimization to full product design. Typical applications include promoting a faster learning curve with the software tools and exploring possible what-if concepts. This can be especially useful if company manpower is limited.

For more information on our professional services and programs, please contact an RSoft Design Group representative or e-mail: info@rsoftdesign.com.

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System Requirements

Most RSoft products have 32-bit and 64-bit versions for both Windows and Linux systems. Please check the 'System Requirements' section of the relevant product on RSoft's website for a list of the specific OS versions we currently support.

Products & Services

For additional information on RSoft's Products & Services, please contact us at ***info@rsoftdesign.com***.

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