RSOFT Design Group

REVIEW

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New RSoft CAD 8.0 with 3D Viewing Options

Version 8.0 of the RSoft CAD includes many additions and improvements to further streamline RSoft's highly flexible and user-friendly CAD interface. New 3D visualization options have been added which greatly simplifies the design of any 3D structure and new toolbars and buttons provide easy access to both new and existing features. Several new primitive components have been added to better realize complicated structures, and the entire visual appearance of the CAD has been updated. This new release will affect virtually any passive device application area since the CAD is shared by RSoft's passive device simulation suite, including the BeamPROP, FullWAVE, BandSOLVE, GratingMOD, DiffractMOD, FemSIM and ModePROP*(see page 3)* products.

The new version of the CAD introduces new ways to visualize 3D structures: views along all three axes are now possible, allowing complicated designs to easily be seen. Furthermore, a new cut mode allows a particular cut plane along any axis to be displayed. A new multi-pane mode has also been added in which all three axis views as well as a 3D rendered view of the structure are displayed simultaneously. Each axis view can be controlled separately, and the 3D view can be rotated by the user. These viewing options

FIGURE 1: **CAD 8.0 WITH 3D VIEWING OPTIONS.**

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100 Gbit/s DQPSK System Design and Simulation in OptSim 4.7

The increase in popularity of services such as IPTV, VOIP, video and music download is saturating the carrier providers' core bandwidth at a quick pace. The need for faster communication channels is driving the industry towards the evaluation of network upgrades. In November 2006 an IEEE study group ratified 100 Gbit/s Ethernet as the next evolution of the technology.

Intensity Modulation Direct Detection systems currently cap at 40 Gbit/s but are often limited to 10 Gbit/s. With such a data rate the adoption of WDM transceivers is mandatory to reach 100 Gbit/s operation, and 10 x 10 Gbit/s, 5 x 20 Gbit/s and 4 x 25 Gbit/s solutions have already been suggested. Looking at what happened with the parallel 10GBASE-LX4 and the serial 10GBASE-LRM standards for 10 Gbit/s Ethernet, the WDM configuration is likely to be a transitional technology enabler, until there is an advanced serial solution that can provide advantages in areas such as thermal, size, complexity, and, ultimately, cost.

Among the most promising next-generation technologies, the Differential Quadrature Phase Shift Keying modulation format is likely to become the solution for serial 100 Gbit/s links. The Quadrature configuration enables the reach of 100 Gbit/s data rate by merging two distinct 50 Gbit/s data streams. Thanks to this characteristic the bandwidth required for the electronics and the Mach-Zehnder modulator is limited to 50 GHz, halving the IMDD requirements. The design and simulation of DQPSK systems however poses unprecedented challenges to the system engineer. At the transmitter the binary information is encoded in the amplitude and phase of the optical signal and sent over fiber spans of tenths of Kilometers. The serial data rate can reach an all time high of 100 Gbit/s, and at these frequencies the fiber chromatic dispersion and non-linearities impair the signal very heavily. Finally, the noise distribution at the receiver is not Gaussian, making it very problematic to calculate the system performance during the design process.

OptSim, RSoft's award winning optical communication system simulator, provides an ideal framework for the design and simulation of serial 100 Gbit/s systems. OptSim 4.7 includes several new models of D(Q)PSK transmitters and receivers and an innovative BER and Q meter specific to phase shift keying systems. Figure 1 depicts an OptSim layout of a 100 Gbit/s CSRZ-DQPSK system. The system includes a pre-coder model that takes as input two Pseudo Random Bit Sequences at 50 Gbit/s and elaborates them at the logical level so that the same sequences can be received after the CSRZ-DQPSK modulation. A sine generator at 25 GHz drives a Mach-Zehnder modulator around zero Volts to carve the optical

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New RSoft CAD 8.0 with 3D Viewing Options continued from page 1

not only simplify the process of creating 3D structures by allowing a design to be easily visually inspected, but also make it easier to perform editing tasks such as selecting overlapping components. This is especially important for complicated 3D structures such as CMOS pixels, user-defined 3D PBGs, PCFs, and LEDs.

In addition to better visualization of the structure, several simulation parameters are now displayed as well: the simulation domain as well as the launch plane, if any, are now displayed in the CAD, allowing users to quickly determine if the correct settings are made. New buttons provide easy access to RSoft's Material Editor and User Tapers and Profiles. A new 'view' toolbar provides easy access to the new 3D visualization options described above as well as common settings such as the aspect ratio. In addition to the new viewing and editing features, the CAD has received a complete visual refresh.

Figure 1 shows an example of a CMOS image sensing circuit in the new CAD. It contains lenses and several metallization layers in a silicon substrate which can easily be seen in the semi-transparent 3D display. Each layer can be imported from a layout mask and positioned independently via a hierarchy feature. The lenses, which can have an arbitrary shape, focus light into the sensing region of the substrate. The circuitry is designed to not interfere with the light; this is easy to verify by looking at various cross-sections of the structure along any axis. Once the structure has been verified in the CAD, a simulation can be performed using one of RSoft's device simulation programs to determine the viability of the design. MOST, RSoft's scanning and optimization tool, can also be used to further optimize the design to meet any design requirements.

Version 8.0 provides optical designers with a streamlined platform to create novel designs using RSoft's passive device simulation suite.

100 Gbit/s DQPSK System Design and Simulation in OptSim 4.7 continued from page 1

source signal and suppress the carrier. At the receiver section the signal first goes through an optical bandpass filter centered at the laser frequency, then it's split and reaches two separate DPSK receivers that have an interferometer structure for converting the signal phase information into amplitude. Finally the electrical signal is filtered with a 5th order Bessel low-pass filter at 50 GHz and the resulting eye diagram is visible in Figure 1. The BER is calculated using the advanced Karhunen-Loeve Technique and Figure 2 depicts the BER versus OSNR curve at the receiver.

In conclusion the core network bandwidth requirement is surging and faster solutions such as 100 Gbit/s DQPSK links are needed. The design and simulation of such advanced systems poses unprecedented challenges to the system engineer. OptSim 4.7 includes several advanced models for DQPSK modulation and helps answer questions such as what the performance of the system will be, what the filter shape and bandwidth should be, what transmitter should be chosen between NRZ, RZ, and CSRZ types, what the gain and bandwidth of the amplifier should be, etc. For this reason OptSim is the ideal framework for the design and simulation of state-of-the-art DQPSK 100 Gbit/s links. OptSim is available for a 1-month free evaluation. For more information please contact RSoft at *info@rsoftdesign.com* .

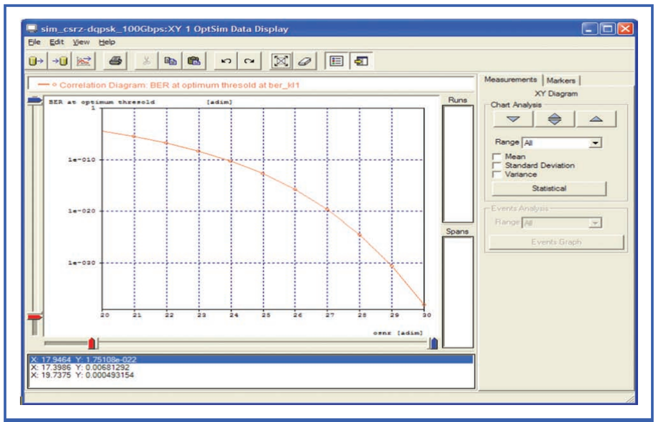

FIGURE 2: **BER VS. OSNR CURVE FOR A 100 GBIT/S CSRZ-DQPSK SYSTEM.**

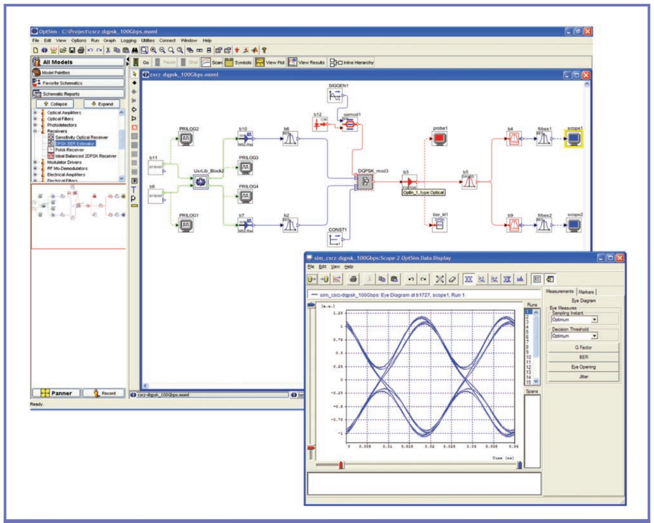

FIGURE 1: **OPTSIM LAYOUT AND EYE DIAGRAM OF A 100 GBIT/S CSRZ-DQPSK SYSTEM.**

Introducting ModePROP 1.0 with Simulation Capabilities for 2D and 3D Omni-Directional Propagation and Scattering in Optical Waveguide Devices

Frequently, optical waveguide circuit design requires the simulation of omni-directional propagation and scattering; capabilities typically necessitating the use of Finite-Difference Time-Domain (FDTD). While there are efficient commercial FDTD tools on the market, such as RSoft Design Group's FullWAVE, long 2D waveguide structures, and most 3D problems, can quickly expend the available memory in a typical PC. An alternate approach, which can be faster and less memory intensive in many circumstances, is based on the modal expansion method. This method combines the speed and memory efficiency associated with the Beam Propagation Method (BPM) with the accuracy and rigor of FDTD.

RSoft Design Group's new ModePROP provides an advanced Eigenmode expansion that includes both propagating and radiation basis in 2D and 3D. Additionally, the mode matching is based on the unconditionally stable Modal Transmission Line method (MTL). Furthermore, Perfectly Matched Layer (PML) boundary conditions allow for the analysis of aperiodic structures, leaky waveguides, and evanescent coupling. This offers a rigorous steady-state solution to Maxwell's Equations, taking into account all the reflections at waveguide junctions and propagation of modes in all directions. Additionally, by the concept of divide and conquer, an extremely long structure can be mapped into cascading modal transmission lines, extending the application scope of this tool to a wide variety of problems, including MMI's, ring resonators, PBG structures, and many others.

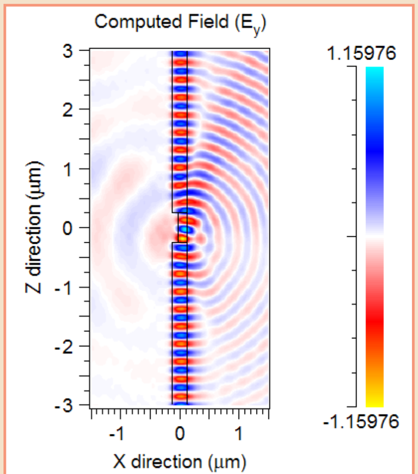

FIGURE 1: **SCATTERING FROM A NOTCH IN A SURFACE WAVEGUIDE.**

Shown in the enclosed figures are the simulation results from some typical applications. Figure 1 describes the scattering of a propagating field as it encounters a notch (thinner section) in surface layer waveguide. The radiation can be seen emanating in all directions, though predominantly into the substrate. Also, it can be seen that there are several preferred directions for the scattering. Figure 2 depicts the coupling of a surface normal beam into a waveguide due to a blazed finite surface grating (shown inset). The power is coupled preferentially to the right and propagates at 90 degrees from the incident direction. The radiation that is transmitted into the substrate can easily be reduced by extending the length (number of periods) of grating.

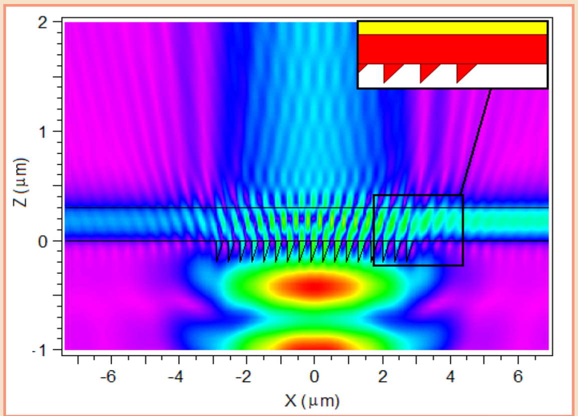

FIGURE 2: **SURFACE NORMAL COUPLING INTO A WAVEGUIDE DUE TO BLAZED FINITE SURFACE GRATING.**

While these structures may be solved using FDTD, ModePROP makes short work of them. Additionally, ModePROP can be used to analyze much longer structures that are out of reach of FDTD, due to efficiencies permitted in the mode propagation method within homogeneous sections of the problem.

ModePROP is complementary to other RSoft tools such as FullWAVE, BeamPROP, and DiffractMOD. Similar to DiffractMOD, which is ideally suited to efficiently solving all manner of large and small periodic structures, ModePROP extends this capability to non-periodic applications. Together, they offer a complete solution to meet the various simulation needs at different stages of the product design cycle. Moreover, the cross-checking of results between tools, which are based on different theories, will allow the designer to have a high level of confidence in the simulation results.

As with all tools in RSoft Design Group's passive device suite, ModePROP employs the versatile, user-friendly, and parametric RSoft CAD Layout, allowing the same problem definition to be simulated by any of the available engines. Together, these design products are well positioned to meet the future design needs of the photonic integrated circuit industry.

ROADM Capabilities with MetroWAND 3.5

Today's backbone optical networks are mainly driven by on-demand traffic patterns generated by HDTV, high speed Internet, VoIP, content on demand by YouTube and iTunes, as well as new content providers like Google, Yahoo, Virgin and MSN. In order to accommodate this rapidly changing business model, service providers need flexible, dynamic bandwidth-provisionable optical networks. Re-configurable Optical Add Drop multiplexer (ROADM) is a new generation optical multiplexer gaining popularity due to its simple architecture and manageable control plane. However the ROADM's dynamic wavelength allocation also calls for physical layer performance validation as well as properly sized ROADM placements during the network planning process.

RSoft Design Group's popular network design software, MetroWAND 3.5, has powerful capabilities that integrate both capacity planning and performance design validation. In a ROADM network design three major steps are involved: capacity allocation, end-to-end physical layer performance validation and ROADM placement. In the first step, the planner needs to plan for the bandwidth allocation considering various routing methods, configuration options and failure scenarios.

Let's consider a simple optical network design with ROADMs using

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MetroWAND software. Drawing nodes and fiber links on the canvas using the drawing tools of the software creates the fiber connectivity of the network. Users have the option to select standard fiber types or a custom fiber type. User can see many 'what if' scenarios using various built-in routing algorithms like shortest path, minimum number of nodes, minimum cost or maximum availability.

Wavelengths between two nodes can also be categorized as protected or shared protected or un-protected. In the capacity design stage, the software created an optical ring with four optical equipment nodes and a point to point system with two optical equipment modes as shown in figure 1. The equipment placements at node4 and node1 call for special attention. The equipment at node4 and node1 needs three fiber connections. This node can be configured as a ROADM with three arms or a ROADM with degree 3. A ROADM consists of one or more arms (multiplexer/de-multiplexer) and a switch fabric. In a ROADM , optical fibers will be connected to muliplexers/demultiplexers, and the pass-through wavelengths will be cross-connected using the switch fabric.

In an operational network, this routing is software controlled. When designing the network, the cost of the network depends upon the number of ROADMs used as well as the number of arms of the ROADMs along with various other factors like fiber cost, transponder cost and amplifier cost. MetroWAND's node sizing algorithm finds the minimum number of ROADMs that can satisfy the network demands.

After optimizing the optical channel layer (OCH) and optical multiplexer (OMS) layer, it is necessary to simulate various impairments that affect optical channels, in order to test the viability of the optical transmission section (OTS).

The MetroWAND optical engineering module simulates the optical channel propagation while designing the network. In the physical performance design process, fiber parameters such as distance, attenuation,

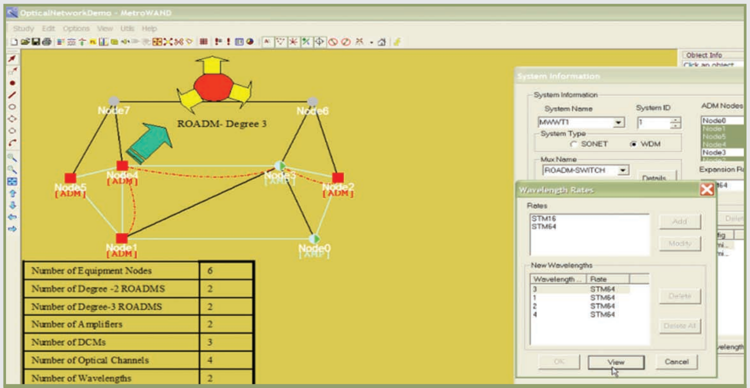

FIGURE 1: **METROWAND LAYOUT OF AN OPTICAL NETWORK WITH A DEGREE 3 ROADM.**

dispersion and PMD, and ROADM parameters such as insertion loss, power, noise figure, wavelength and channel bandwidth are considered as input. The analytical link performance engine simulates the end-to-end link performance of a particular optical channel. In our project, for simplicity we assumed two fiber types: Corning SMF-28 and Lucent AllWave single mode optical fibers. During the physical layer performance simulation the software found that the total loss and the accumulated dispersion exceeds the allowed maximum for two wavelengths in the ring. The software then place amplifiers and dispersion compensation modules in node3 and node0. The performance of each channel is characterized by numerical measures like total attenuation, accumulated dispersion, accumulated dispersion slope, optical SNR, BER and Q. A performance report is provided for all channels.

With the integration of capacity design rules, performance validation and ROADM placements in a single network-planning software package, MetroWAND provides a very powerful tool for planning ROADM networks.

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ICTON 2007	Rome, Italy	1-5 July	
InterOpto 2007	Chiba, Japan	9-13 July	61
ECOC 2007	Berlin, Germany	17-19 September	12074
Optics East 2007	Boston, MA	9-12 September	233
IEEE Leos Annual Meeting	Lake Buena Vista, FL	21-25 October	
Nature Photonics Technology Conference	Tokyo, Japan	24-26 October	
FPD International	Yokohoma, Japan	24-26 October	
APOC 2007	Wuhan, China	1-5 November	(Exhibited by LuY)

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