January - June 2006

RSOFT Design Group REVIEW

Volume 5, Number 1

Advanced Electromagnetic Modeling of High Extraction Efficiency LEDs

Light Emitting Diodes (LEDs) are already ubiquitous in today's society, appearing in everything from display technologies such as flat-panel computer displays to light sources such as traffic lights and flash-lights, and have great future potential. Future demands for applications such as the displacement of incandescent bulbs will require devices capable of producing more light at a lower power and manufacturing cost. These new LEDs will not only function as brighter light sources, but also promise to be cheaper to operate and generate less heat, making them easier to package and therefore smaller.

One of the largest barriers to achieving a higher efficiency LED is that the majority of photons generated cannot be emitted from the device due to total internal reflection at the interface between the high-index semi-conductor regions of the device and the lower index regions that surround it. One method to circumvent this inefficiency is to alter the geometry of this interface using surface gratings such as 2D photonic crystal (PC) patterns so that more photons can be successfully extracted out of the device.

The need to accurately model PC patterns at material interfaces translates to a need for different simulation algorithms: standard interfaces can be modeled by ray-tracing techniques, whereas nano-structured interfaces require advanced electromagnetic modeling capabilities that accurately account for physical effects at the wave optics level such as diffraction. RSoft's *DiffractMOD™* and *FullWAVE™* software products are well-suited for this task and provide a much needed way to design efficient LED geometries. Also, when used in conjunction with RSoft's scanning and optimization package *MOST™*, these products can be used to intelligently search over multiple parameters for new optimized LED designs.

In order to determine how effective a particular PC geometry will be at improving an LED's extraction efficiency, an understanding of the geometry's ability to transmit light over a wide range of incident angles is required. RSoft's *DiffractMOD* package, which is based on Rigorous-Coupled Wave Analysis (RCWA), is best suited for this type of analysis for periodic structures. A sample structure was created in the RSoft CAD Environment. It con-

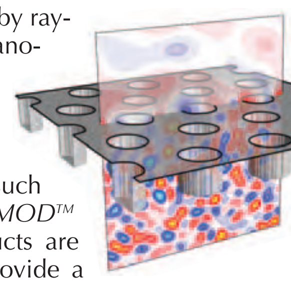

Figure 1
Schematic of LED structure used with one slice of 3D simulation data shown.

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DPSK Systems Simulated in OptSim 4.5 with New BER Estimation Technique

Recent advances in optical communication systems demonstrated that new modulation techniques can allow higher capacities and longer distances compared to traditional on-off-keyed (OOK) signals. Particular improvements were observed using phase-shift keying (PSK) techniques where information is carried in the optical phase itself - DPSK, RZ-DPSK, DQPSK, RZ-DQPSK, etc. Detection of DPSK signals requires a more complex receiver implementation using a delay interferometer (DI) with an asymmetric Mach-Zehnder (AMZ) filter and a balanced photodetector (see Figure 1). As a result the noise statistics and the noise-signal interactions are different from those in the conventional IM/DD receivers, and the Gaussian approximation does not provide sufficiently accurate BER estimation. Recently a new exact semi-analytical BER estimation technique was developed in *OptSim™* for direct-detection systems, including DPSK/DQPSK systems with balanced receivers [1].

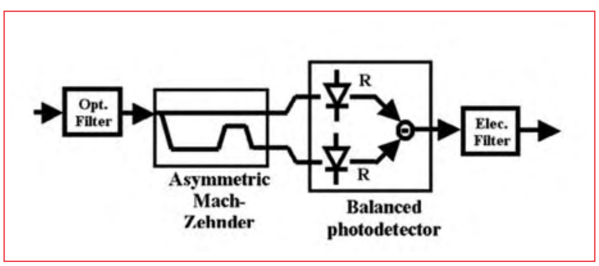

Figure 1
DPSK receiver schematic

In general, when dealing with a DPSK receiver with imperfections and arbitrary optical and electrical post-detection filters, it is not possible to obtain an exact analytical expression for the BER. In the conventional semi-analytical BER

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(Advanced Electromagnetic Modeling continued from page i)

sists of an interface between a high-index material (n=3.17), and air with a hexagonal PC of air holes with period 2.0 µm. Figure 1 shows a schematic of the structure used (along with FDTD results to be discussed later), and Fig. 2a shows the transmission as a function of incident angle through the PC for structures with and without the PC layer. The PC does allow light at angles larger than the critical angle (~20 degrees) to be transmitted, but in order to determine exactly how much more, a more rigorous 3D analysis is required.

In order to study this structure in more detail, a more realistic model is required. *FullWAVE*, RSoft's Finite-Difference Time-Domain (FDTD) tool is a general purpose electromagnetic solver, and is perfect for this type of 3D computation. *FullWAVE* also has a clustering option which can distribute the simulation workload over several computers in a network to result in faster and larger simulations. In order to simulate the incoherent nature of light from the active region, over 100 dipole sources were evenly distributed beneath the PC surface, each continuously driven in time

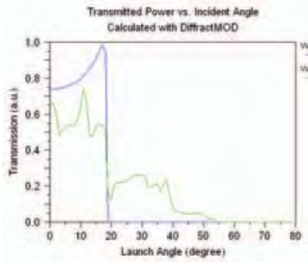


Figure 2a
Total transmission through an infinite grating for the interface with and without the PC layer calculated with *DiffractMOD*. The presence of the PC layer allows light incident at angles larger than the critical angle to be transmitted.

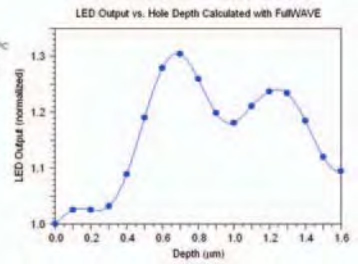


Figure 2b
Increase in LED output power for various grating depths calculated with *FullWAVE*. These results are normalized to the output power without a PC layer.

at a same wavelength (1.55 µm) with a random phase and dipole orientation. Perfectly Matched Layer (PML) was used at the domain edges, and since only several periods of the structure were used for simulation, periodic boundary conditions were employed on the lateral directions. During simulation, the power flux outside the surface was measured. Figure 1 shows the PC structure used with a data slice from the 3D simulation, and Fig. 2b shows the increase in power extraction at various hole depths.

The use of a PC pattern at material interfaces can have a dramatic effect on LED performance. This simple example saw a modest increase in output power; a finely tuned lattice can produce even better results. Also, the inclusion of a metallic reflector behind the active region will increase the efficiency as well. Furthermore, though not examined here, the use of a PC layer can modify the radiation pattern of the LED and assist in creating better directional sources of light. The search for more efficient LED devices requires simulation tools capable of accurately modeling physical field effects such as diffraction. RSoft's *DiffractMOD* and *FullWAVE* packages are perfect for modeling a variety of structures, including PC-based nano-structured interfaces and cavities in LEDs.

(DPSK Systems Simulated in OptSim continued from page i)

estimation method, the ASE noise is kept separate from the signal. As a result, the simulation does not account for signal-noise beating along the link but instead at receiver after detection. Since DPSK systems are often signal-noise beat limited, a more accurate treatment of noise statistics is required. To compute the BER we used a semi-analytical technique based on the expansion of optical signal and noise into a Karhunen-Loève (KL) series, modified in order to be applicable to the DPSK modulation format. It can be shown that by applying the KL series method it is possible to write the expression of the moment-generating function (MGF) of the decision variable in a closed form. The exact probability density function and the BER can now be obtained from the numerical integration of the MGF.

The model is validated against direct error counting (Monte-Carlo) simulations and experimental results reported in the literature, and excellent agreement was achieved. This technique accurately estimates the DPSK receiver impairments due to various imperfections such as AMZ detuning, photodetector responsivity imbalance, phase error, etc. It can be applied to DQPSK and other PSK-based systems as well. In addition, this technique applied to the conventional OOK IM/DD systems can produce more accurate results than the one based on Gaussian or chi-squared statistics in the systems where, for example, there are significant contributions from nonlinear phase noise due to EDFA/Raman amplification or noise polarization due to PMD and PDL.

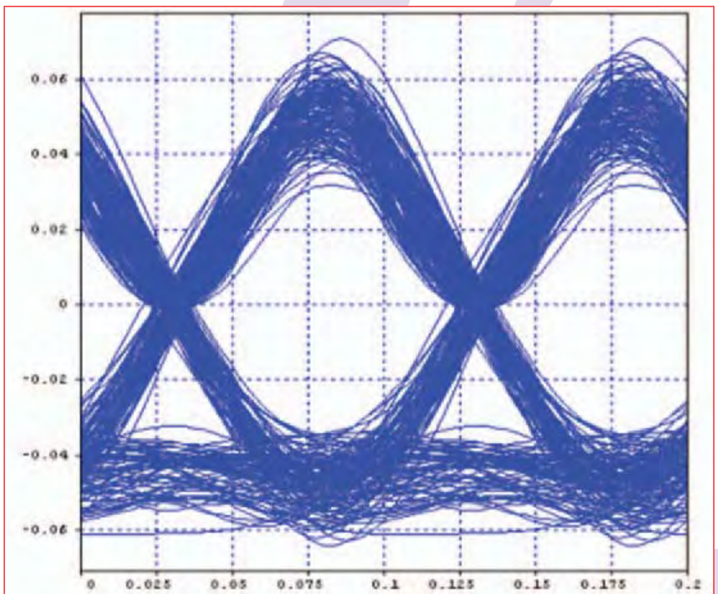


Figure 2
Eye diagram for DPSK modulated signal at the balanced receiver.

Reference:

[1]. G. Bosco and P. Poggiolini, Journal of Lightwave Technology, vol. 23, p. 842-848, 2005.

Advanced VCSEL Modeling with LaserMOD 2.2 and FemSIM 1.0

Vertical cavity surface emitting lasers (VCSELs) with oxide apertures provide a unique challenge to simulation tools. Since approximate techniques may fail to accurately predict the cavity loss of the modes of such structures, rigorous full-vector solution methods are required. To this end, *LaserMOD* 2.2 now includes a Finite-Element Method (FEM) mode solver, via integration with RSoft's *FemSIM*™, to better solve the optical problem in VCSELs, leaky waveguides, and other complex structures. Hybrid edge/node elements have been implemented in both 1st and 2nd order for both rectangles and triangles. This helps eliminate unphysical numerical solutions (spurious modes) from the simulation results. FEM is a full vector method and runs faster than FDTD (finite-difference time-domain) mode-solving techniques. Furthermore, it is not sensitive to launch conditions, so that modes are not skipped or missed. The new FEM mode solver, coupled with *LaserMOD's* existing feature set that includes a versatile, user-friendly, and easy to learn GUI, a powerful simulation engine which provides for the self-consistent solution of electro-thermal transport, quantum mechanical gain, and the optical field, enables *LaserMOD* to offer a comprehensive simulation solution for VCSELs and other active photonic devices.

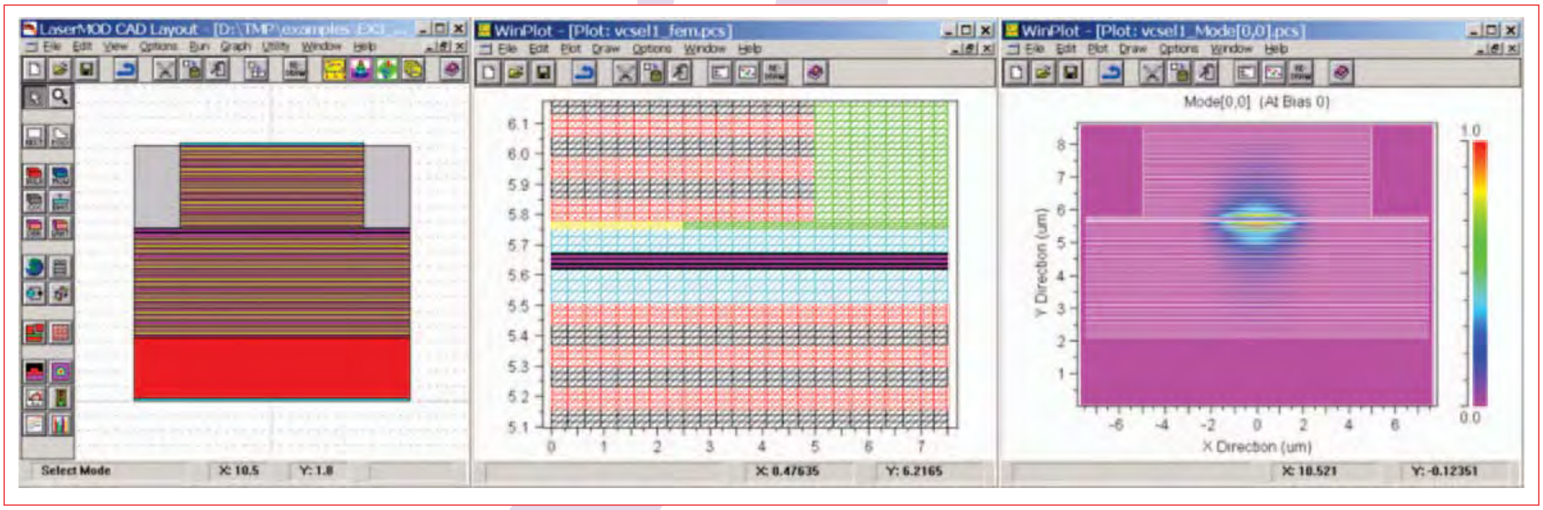


Figure 1
CAD layout (left) FEM mesh (middle) and diametric cross-section of the cavity mode (right) in an oxide-aperture VCSEL with cylindrical mesa.

(Mission Ready Defense Industry Applications in OptSim continued from page iv)

Radio-over-Fiber (RoF)

For battlefield, airborne, and shipboard electronic warfare and RF platforms, the dimensions and weight of cable size and equipment are very important. In addition, the protection path features of optical networks offer the potential for rapid deployment, as well as flexibility for fast re-routing in case of any intrusion in mission-critical fiber-based RF systems, thereby providing added resilience compared to legacy RF solutions. Since RoF moves the system complexity away from the remote base station antenna towards a centralized radio signal processing installation, the equipment can thus be stationed in a controlled and safer environment.

The basic scheme for an RoF network design is implemented as shown in Fig. 2. The central station (CS) transmits optical intermediate (IF) and local oscillator (LO) signals to the remote node where amplification and optional wavelength conversion take place. The demodulated channels are transmitted to remote antenna stations (RAS) covering each cell, which can also be a microcell or picocell, depending upon the architecture.

IF1 and IF2 are WDM data channels with DPSK-encoded data that are modulated using electro-absorption modulators (EAM). Each data channel transmits 1 Gbps data streams that are DPSK-encoded over a 2.5-GHz carrier. The WDM architecture is preferred due to its potential to support a large number of RAS's.

To discuss your specific applications or to know more about simulations of FSO and robust designs in hostile environment, please contact RSoft.

RSoft on Campus

Micro-ring Research at Optical Communications Laboratory, Department of Informatics and Telecommunications, University of Athens

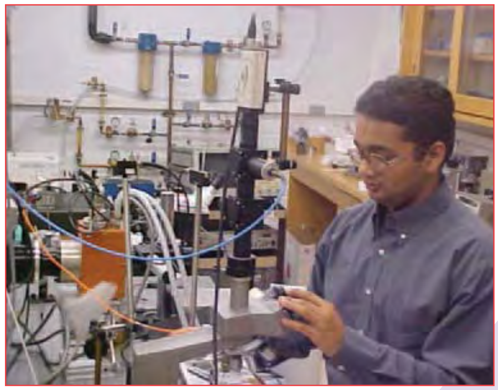
The activities of the Optical Communications Laboratory at the Department of Informatics and Telecommunications, University of Athens, span a number of research topics related to optical communications. These range from fundamental physical description of semiconductor material to devices, transmission techniques, and networks. The theoretical and experimental study of semiconductor micro-ring structures, which are recognized as a viable candidate for photonic VLSI devices, has become a major activity of the group, and honored as part of the EU IST "WAPITI" project.

Dr. Dimitris Alexandropoulos in the Lab says that: "The micro-ring structures we study have an additional 'awkward' geometrical characteristic of a vertical coupling ring with the bus

waveguide. While this characteristic facilitates tailoring of the optical properties of the structures, it significantly complicates the study. To make it successful, a detailed design is required for guiding fabrication and safeguarding it from unnecessary costly runs. In our approach, we choose the rigorous numerical FDTD simulation tool *FullWAVE* to realize these purposes. *FullWAVE* has proven itself as a very efficient FDTD code while the CAD interface is user friendly. Additionally, the clustering option is a very attractive feature that expands the operational range of *FullWAVE*. The recently developed optimization tool *MOST* will also provide a self consistent way to analyze the material and waveguiding properties of an optoelectronic device."

Supporting Cutting-edge Research on FTTx at University of North Carolina Charlotte

The Optical Communications and Networks (OCN) Lab at the University of North Carolina Charlotte (UNCC) is actively engaged in the research of optical network architecture design and studies in optical signal transport, including EPON optical access networks. When creating



test-beds for OC-48 and OC-192 links, the OCN Lab turned to RSoft for their modeling needs. RSoft's optical communication system design tool, *OptSim*, provides choice of time-, frequency- and wavelength-domain simulation approaches, and comes with pre-designed examples and a rich library of components and models to simulate various up- and downstream triple-play FTTx and access network architectures (BPON, GPON, EPON, etc.) at the physical-layer level. *OptSim's* accurate estimation of quasi-analytical and Monte Carlo BER for a variety of modulation schemes (including DPSK) helps compare performance metrics for various design approaches for handling data, VoIP and video traffic. Prof. Yasin Raja, who leads the OCN Lab states "We have two different research groups currently using software solutions from RSoft. One group uses *OptSim* for access network modeling, and the other uses *LaserMOD* for VCSEL modeling. These tools go hand-in-hand with our experimental facilities, and the technical support from RSoft represents an important added value. We are glad that RSoft is responsive to our needs and feedback, and we look ahead to continued interactions and to broaden our collaborations with them." The OCN Lab at UNCC is also collaborating with the Microelectronics Center of North Carolina/North Carolina Research and Education Network (MCNC/NCREN) at Research Triangle Park, North Carolina as well as with National University of Science and Technology (NUST), Islamabad, Pakistan.

Photonic Integrated Circuit and All-Optical Signal Processing Research at Tokyo Institute of Technology

Professor Mizumoto's Group in the E&E Engineering Department at Tokyo Institute of Technology is extensively involved in both photonic integrated circuit and all-optical signal processing research areas. All-optical controlled optical devices, which are based on intensity dependent nonlinearity effects of III-V semiconductor materials, can be used to create a variety of fiber optical communication devices such as optically switched directional couplers and bistable switches. Recently, they have developed unique technology to integrate an optical isolator with a laser diode through wafer direct bonding of a magneto-optical crystal and III-V compound semiconductor materials. In the past decade, they have published over 150 papers on these effects and devices. Their research is a part of the CREST projects supported by the Japan Science and Technology Agency (JST) and the photonic network projects which Optoelectronic Industry and Technology Development Association (OITDA) has contracted with the New Energy and Industrial Technology Development Organization (NEDO). The group uses RSoft's *BeamPROP* and *FullWAVE* software packages to compute waveguide modes, to design interference waveguides and couplers, and to compute coupling efficiencies at waveguide intersections. According to Professor Mizumoto, "Our group chose RSoft tools because they meet our design needs. They are very easy to use and offer very useful analysis simulation results, and has many features that help us find optimal values for structural parameters. We look forward to future collaboration with RSoft."

Laser Fiber Accelerator Research at Stanford University

The Accelerator Research Department B at the Stanford Linear Accelerator Center and the Applied Physics Department of Stanford University, Stanford, California, have expanded their joint research program in the field of photonic band gap fibers for use as miniature particle accelerators. With funding from the Department of Energy, the Stanford team is actively pursuing the design, fabrication, and testing of optical-scale fiber accelerators powered by lasers to accelerate electrons to high energy for applications in science, applied technology, and medicine. The identification and characterization of confined, accelerating modes in central fiber defects as well as mode optimization with respect to fiber geometry are essential to this cutting-edge design effort, and the RSoft tools *BandSolve*™ and *MOST* were recently added to the team's suite of calculating programs. Professors Robert H. Siemann and Robert L. Byer jointly lead the research group, which is remarkable for the large proportion of graduate students involved in both the design and experimental testing of fiber structures. RSoft recently assisted the Stanford educational effort by providing complimentary tutorial use of the *BandSolve/MOST* software to introduce graduate students to the field of photonic fiber design.

RSoft Interview with Gregory Miller, Collinear, Inc.

Dr. Gregory D. Miller is the CTO for the Collinear Corporation located in Santa Clara, California, USA. After earning his PhD at Stanford University in 1998 in the field of nonlinear optics,

Dr. Miller worked on laser-based displays at Silicon Light Machines, and then helped to found Collinear in 2002. Collinear is developing the next generation of solid state RGB light sources. Utilizing semiconductor lasers and non-linear optics, the Company's illumination module replaces the last remaining analog components of projection systems and will enable consumer electronics manufacturers to offer fully digital projection products.

RSoft: Dr. Miller, please tell us a little bit about your position and some of the products that Collinear is developing.

I am Chief Technology Officer and a Founder of Phaseon Corporation which became Collinear in January 2005. We are commercializing inventions that have come as a result of many years of research in photonics, non-linear optics, display technology and human vision.

We are creating visible light sources from infrared photonic devices with a focus on display applications.

RSoft: How would some of these devices assist in the development of the next generation of projection products and systems?

There are severe limitations created by the use of lamps in both projection displays and flat-panel technology. Primary limitations exist around lamp lifetime, etendue, color space, luminous efficiency, and volatility. These are all things that can be significantly improved when developing laser-based illumination where we have a diffraction-limited light source with very low etendue and a highly tuned color spectrum. Combine that with the high conversion efficiency of solid-state semiconductor laser diodes and the unique wavelength conversion technologies that we have recently patented and you have the perfect light source for many applications – especially display applications.

RSoft: What made you chose RSoft Design Group as the vendor of choice for design and simulation software?

After comparing products from multiple vendors, I found that RSoft's products were best suited to our needs. Not only was simulation faster and more accurate, it also allowed us to design and model novel high-contrast waveguide structures. In addition, the technical and sales support provided by the RSoft team proved exceptional and they have supported us from the earliest days of the company. Finally, RSoft provides a continuous stream of updates through their maintenance program keeping us up to the minute with the latest enhancements.

RSoft: In what way has RSoft's line of component design and simulation software aided in Collinear's efforts?

We have been able to model and simulate some fairly sophisticated photonic devices and helped us generate manufacturable designs. Many times a new waveguide engineer comes on board with a set of assumptions about the limitations of commercial design and simulation software, but after just a few days of learning and operating the RSoft products, they become convinced that they no longer need to write their own code.

RSoft: What types of research have you been pursuing with LaserMOD?

Our research with LaserMOD™ has been focused on learning how semiconductor lasers and nonlinear planar lightwave circuits interact and how best to design the circuits to extract the maximum efficiency from the diodes.

RSoft: How do you see the need and demand for photonic software in future applications?

The ongoing trend as photonics-based products enter and grow in the consumer market is to decrease device size, which means that index contrast must be increased. Photonic software will be called upon to give highly accurate and fast results in increasingly sophisticated optical circuits. At Collinear, we are using the latest 64-bit version of the RSoft Component Suite on a Quad Opteron system with 32GB of RAM, and our team has been keeping the system busy with multiple projects. As Collinear grows, I'm sure we'll be coming back to RSoft to add to our capacity to generate new products at a high rate.

RSoft: Thank you for your time and we wish you good luck in your research and business!

Mission-Ready Defense Industry Applications in OptSim 4.5

OptSim has been a tool of choice by researchers, project managers, and independent contractors in the defense industry. The design objectives and constraints in defense applications are quite different than those in legacy optical communication systems. Robust security, rapid deployment capabilities, minimal needs for monitoring, operational abilities in extreme environment, etc. are some of the "must meet" requirements. Through various SBIR awards, participation in R&D consortia, and interactions with leading defense industry customers, RSoft has worked hand-in-hand in developing mission-ready defense applications and modeling capabilities in *OptSim*.

Free space optics (FSO), optical code division multiple access (OCDMA), radio-over-fiber (RoF), and robust optical communication system designs in hostile environments are several of the challenging defense applications of recent interest where *OptSim* can play a crucial role in achieving secure, flexible, scalable and survivable designs. Two of these applications, OCDMA and RoF are discussed here.

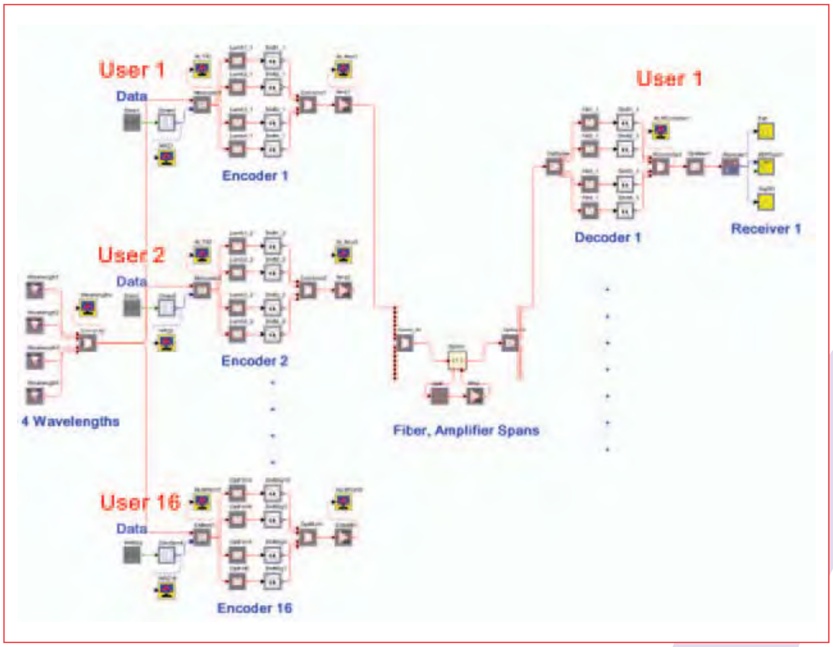


Figure 1
Topology of an OCDMA system.

Optical Code Division Multiple Access (OCDMA)

Data access security and the ability to support asynchronous, bursty data transmission are two of the main driving forces behind much of the interest in optical CDMA techniques. On the other hand, the poor spectral efficiency of OCDMA systems demands an appropriate choice of coding techniques. Furthermore, multi-access interference (MAI) is often a limiting factor. OCDMA techniques have been studied for various networking applications including LAN, access networks and all-optical GMPLS-based packet switching. Unlike RF-CDMA, the OCDMA codes need to have minimal cross-correlation properties due to the IM/DD nature of the data links.

The basic scheme for an OCDMA network design with a commonly used tree-network topology is implemented as shown in Fig. 1. Four mode-locked lasers are used to create a dense WDM multi-frequency light source. There are sixteen OC-48 users requiring sixteen distinct signature codes. Some of the wavelength/time (W/T) matrix codes can permit extensive wavelength reuse and some can allow extensive time-slot reuse. In this article, an extensive time-slot reuse sequence is used for User 1 $(\lambda_1\lambda_3; 0; \lambda_2\lambda_4; 0)$. There are four time slots used without any guard-band, giving a chip period of 100 ps.

The encoders and decoders, respectively, use delay and inverse delay line arrays to provide delays in terms of integer multiples of the chip times. The placement of the delay-line arrays and the amount of each delay are dictated by the specifics of the user signatures. A number of studies can be carried out to test data security and penalties due to multiple access interference (MAI).

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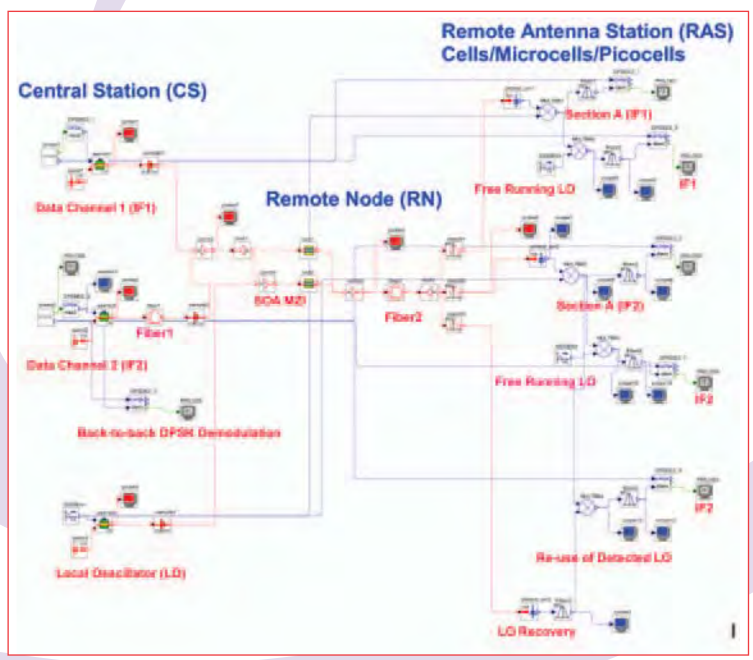

Figure 2
Topology of an RoF system.

Optical Network Engineering Module Added to MetroWAND

RSoft Design Group's network planning software, *MetroWAND™*, will include an Optical Network Engineering module that enables the inclusion of optical layer performance characteristics into network planning in the upcoming release. Optical performance characteristics such as dispersion, Optical Signal to Noise Ratio (OSNR) and estimated BER can now be taken into account while designing an optical network. The simulated values are then fed in to the design process to find the best locations for (Dispersion Compensation Module) DCM and amplifiers/regenerators in the network. The optimization algorithms also minimize the total number of DCM and amplifier/regenerator requirements in the network.

An optical network layer provides more bandwidth and additional flexibility for routing traffic in a network. However, the physical fiber network connectivity as well as end-to-end wavelength connectivity is limited due to the fact that power loss and waveform distortion occur as optical signals travel in the network. Apart from bandwidth allocation and routing, the objective of optical network design is to determine cost-effective compensation schemes for power loss and waveform distortion in the network. The modeling of an optical network architecture and simulation of optical signal performance are complex tasks since there are so many physical topologies, logical topologies, fiber types, and routing mechanisms to consider, as well as many choices for compensation (DCM/Amplifier/Regenerator) locations. In metropolitan networks, optical network planning is even more complicated because of the dynamically changing traffic pattern, random connection requests, and the continuous addition of add/drops nodes to existing ring or mesh networks. This warrants that the optical network needs to be fully transparent to loss and waveform distortion. Often these network design tasks require the coordination of many design engineers, as well as weeks of design time. RSoft has launched a set of solutions to automate the optical network planning process that reduces the resources required and shrinks the design time to days.

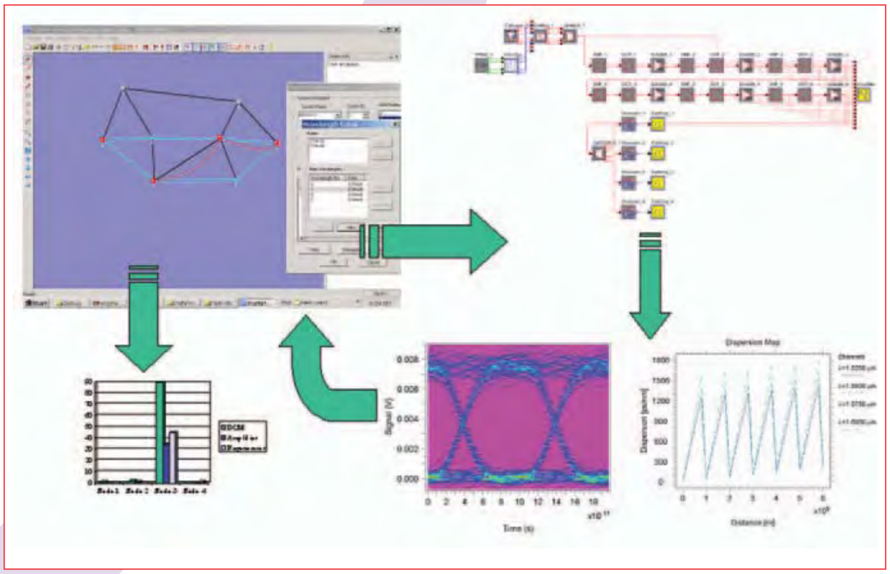

Figure 1
Optical Network Engineering Process.

RSoft is firmly focused on the development of robust commercial and technical solutions for service providers and optical network equipment vendors. *MetroWAND's* new Optical Network Engineering Module is based on the widely accepted ITU-T OTN (Optical Transport Network), and provides the required accurate and detailed modeling needed to consider optical performance when studying complex network architectures. In the OTN framework, an optical network layer has three components: optical channel (OCH), optical multiplexer section (OMS) and Optical Transmission section (OTS). OCH is the end-to-end wavelength channel, OMS is a section where multiplexed optical channels are available, and OTS is a section where compensation (e.g., dispersion compensation), amplification, and regeneration are implemented. For a network to operate properly, the optical channel performance should be viable for the life of the optical channel while considering the performance of the OMS and OTS. Also it is necessary to minimize the number of OMS and OTS sections in a network to minimize the network cost. *MetroWAND* will take these requirements into consideration when simulating the performance of a network.

As part of *MetroWAND*'s network design process, OSNR and dispersion compensation budgets are created at the optical channel layer based upon the span loss and fiber types. These results are used by the the planning tool to select the best locations for Dispersion Compensation Modules and amplifiers/regenerators in the network.

MetroWAND's integration of an optical layer performance simulation into the network-planning process further automates the optical network engineering and life-cycle transport network processes. Since the time required to design a DWDM network is reduced significantly, different network scenarios can be created for a comparison evaluation. This comprehensive type of planning helps make sales–resource utilization more effective, and allows a faster sales response.

RSoft Sponsors APOC Best Student Paper Awards

For the second straight year, RSoft proudly sponsored the Best Student Paper Awards at APOC on November 6-10th in Shanghai, China. The Best Student Awards were created to encourage participation and motivate active involvement of young engineers and scientists in APOC. The finalists presented their talks at special sessions on Tuesday afternoon and four Best Student Paper Awards were presented at the APOC 2005 conference banquet on Wednesday evening.

RSoft Awarded STTR by NAVAIR and ONR

RSoft has been awarded a Small Business Technology Transfer (STTR) Phase I contract by NAVAIR and the Office of Naval Research for "Advanced WDM Fiber Optic Network Architecture Analysis, Modeling, Optimization and Demonstration for Aerospace Platforms." RSoft has partnered with Professor Daniel Blumenthal of the University of California, Santa Barbara to combine his group's expertise in optical network architectures with RSoft's expertise in modeling and simulation. As part of this effort, RSoft is collaborating with leaders in the field and taking a leadership role in the SAE Aerospace WDM LAN Standard Committee, with RSoft's Brent Whitlock chairing the modeling and simulation task group. For more information, please contact RSoft Design Group.

RSoft Software Interfaces with Macro Optics Ray Tracing tools

As the field of integrated photonics expands beyond telecom applications - especially toward image sensors and detectors - it is even more important to combine traditional optical simulation techniques such as ray tracing with other advanced numerical methods like BPM, FDTD and RCWA.

RSoft, the market leader in integrated photonic simulation tools, provides a comprehensive package to import and export data from most of the sophisticated ray tracing simulation tools available on the market. As an example, by using the RSoft conversion tools, it is possible to import the field computed by a Ray Tracing simulation—a bulk lens system, for example—and use it to perform a sub-wavelength diffraction simulation with *BeamPROP*, *FullWAVE* or *DiffractMOD*.

The ability to exchange data between different simulation tools expands RSoft's simulation capability, allowing for unparalleled versatility and easiness of use. For more information on specific ray tracing software interfaces, please contact RSoft Design Group at info@rsoftdesign.com.

AT OFC/NFOEC 2006

RSoft will present a talk at the OFC Workshop on Design and Planning Tools for WDM Systems and Networks. Please check the workshop schedule at www.ofcnfoec.org for additional information or contact RSoft Design Group.

Application Papers on our Website

RSoft Design Group has compiled a collection of technical papers authored by both our technical staff and customers which describes a variety of design applications for our software. Please visit our website, www.rsoftdesign.com, for further information and downloads.

RSoft Training Seminars

RSoft offers training seminars worldwide. Location specific training and on-line training are also available. Email us at info@rsoftdesign.com for quotes and additional information.

RSoft will be exhibiting at the following conferences in the first half of 2006:

FOE, Booth 53-001
Photonics West, Booth 6384
Microlithography, Booth 213
Integrated Photonics Research (IPR)
OFC/NFOEC, Booth 2631
Photonics Europe, Booth 516
CLEO, Booth 1315
Neofunctional Materials, Booth M-63

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