**VPItransmissionMaker™ Optical Systems** accelerates the design of new optical transmission systems for short-reach, access, metro and long-haul applications, and allows technology upgrade and component substitution strategies to be developed for existing network plants. It can fully verify link designs to identify cost savings, investigate novel technologies or perform what-if analyses.

The combination of a powerful user interface, a sophisticated and robust simulation scheduler, together with an unrivaled range of photonic, electronic and supplementary modules and flexible optical signal representations fulfill expert requirements, while enabling an efficient simulation of any transmission system including bidirectional links and complex networks.

**Benefits**

- Design optical transmission systems and subsystems
- Compare upgrade and component substitution strategies
- Evaluate impact of real-world equipment and new component ideas on systems design
- Virtual prototyping for increased productivity and reduced time-to-market
- Define components requirements and evaluate technology alternatives
- Explore systems mixing existing and new transmission techniques

**VPItransmissionMaker Optical Systems** is also perfectly suited to design optical subsystems such as transceivers, amplifiers or ROADMs and to define component specifications. This unique simulation environment enables virtual prototyping, technology benchmarking and stress test definition for increased productivity and reduced time to market.

**VPItransmissionMaker Optical Systems** is used by forward-looking groups around the world including researchers, manufacturers, systems integrators, and service providers to address design challenges ranging from the physics of component design to the business implications of planning wired and wireless networks.

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**Design of Photonic Systems & Networks**

**New Features**

**Improved Capabilities**
Photonic Design Automation

VPIphotonics Design Suite™ embeds expert knowledge in one shared, flexible software environment to support requirements in design, analysis and optimization, providing the most powerful numerical algorithms as a professional solution for Photonic Design Automation (PDA). Beside VPItransmissionMaker™Optical Systems the suite includes:

VPIcomponentMaker™Photonic Circuits is a simulation and design environment for photonic integrated circuits (PICs). It provides advanced device libraries integrated with a scalable time-and-frequency-domain simulation framework for fast and accurate modeling of large-scale PICs with a mix of photonic, electrical and optoelectronic devices.

VPIcomponentMaker™Fiber Optics provides professional means for modeling, optimization and design of fiber-based optical devices such as doped-fiber, Raman and parametric amplifiers, continuous-wave and pulsed optical fiber sources, optical signal processing for telecommunication, high-power and ultrafast applications.

VPIlabExpert™ provides great potential for reducing efforts in the lab, by applying ready-to-use advanced functionalities and virtualizing lab equipment through emulation of optical and electrical components. It addresses the specific requirements of experimentalists for data pre- & postprocessing and signal analysis functions for optical communications.

Applications

- Design high-performance solutions for 100, 400 Gb and 1 Tb transmission using multilevel modulation, coherent detection and DSP
- Develop effective DSP methods for adaptive digital swap order electronic equalization and precompensation and compare them with state-of-the-art solutions
- Compare advantages of diverse modulation formats such as DP/PS-QPSK, geometrically and probabilistically shaped QAM, OFDM, DMT, PAM-M, digital subcarrier multiplexing, etc.
- Quantify fiber-induced degradations due to CD, Kerr, PMD, SRS, SBS, reflections
- Design next generation transmission systems based on space division multiplexing (SDM)
- Design high-capacity WDM systems including novel modulation schemes, CD and PMD compensation, Raman amplification, optical/electrical signal processing, optical channel monitoring and power flattening
- Explore terabit-per-second systems using C-, L-, and S-band windows and alternative amplification techniques
- Upgrade ultralong-haul terrestrial and submarine systems using bandwidth efficient and robust transmission techniques
- Explore crosstalk and dynamics in reconfigurable networks due to power transients and test countermeasures
- Design high-speed & cost-effective transceivers for client-side & data-center applications
- Evaluate new aggregation formats such as optical CDMA and optical SCM-OFDM
- Compare technologies for cost-effective 40 and 100 Gbps access networks
- Develop antenna-remoting and radar systems, using mm-wave signal generation, upconversion, beam-forming and mixing
- Evaluate schemes for RF-over-Fiber systems carrying wireless formats such as WiFi, WiMax, UMTS, LTE
- Investigate the feasibility of upgrading analog HFC networks with digital services
- Investigate transmitter requirements, including electrical bandwidth, laser clipping, memory effects, and external modulation schemes
- Identify critical design parameters including laser chirp, RIN, amplifier gain-tilt and noise, path loss, and filtering performance
- Assess the performance of components in a virtual systems test bed and derive component specifications from that
Modeling Features

- Extensive library of modular building blocks (700+) simulating datasheet and detailed physical models, and providing supplementary simulation functions
- Professional design process supporting Interactive Simulations [sweep, tune, optimize], Design Assistants and Macros, and simulation scripting
- Detailed simulation of the optical field propagation in time and frequency domain
- Time-averaged signal representation for efficient modeling of complex systems
- Cosimulation interfaces for Matlab ©, Python, C++, Keysight’s ADS, and other software via COM interface
- Interfaces with test & measurement equipment

- Tracking, visualization and analysis of signal properties along a link
- Transient Analysis interface to model dynamic effects in reconfigurable networks
- Estimation of performance metrics such as BER, Q, EVM, OSNR, EOP, IP3, SFDR, MI, GMI
- Wide range of modulation formats (DP-M-QAM/C-M-QAM, arbitrary 4D or N-dim constellation, PAM-M, OFDM, probabilistic shaping)
- Ready-to-use DSP functionalities including state-of-the-art DSP algorithms
- GPU-assisted simulations and full support of multicore architectures
- Extensive library of tutorial demo applications (500+)
Design Examples

Modulation Formats

*VPItransmissionMaker Optical Systems* is used extensively to develop and compare a multitude of different optical modulation formats. Flexible modulator models, including multiport MZ interferometer, nonlinear EA modulator and phase / amplitude modulators, together with a range of ready-to-use transmitters and receivers (Duobinary, CRZ, RZ-DIQPSK, DP/PS-QPSK, [C]-M-QAM, OFDM, probabilistically shaped M-QAM, digital SCM, Kramers-Kronig, etc.), as well as application demonstrations speed up the creative process. The extensive module library enables the design and performance analysis of new modulation formats based on technologies such as multi-dimensional encoding, coherent detection, polarization multiplexing and optical CDMA.

400 Gbps & 1 Tbps Superchannel

Besides the design of new 400 Gbps and Terabit equipment, the complex interactions between legacy and new high data-rate channels need to be fully characterized when upgrading transmission systems. The extensive library includes modules for all key technologies to design such systems (polarization multiplexing, coherent detection, multilevel modulation with arbitrary constellation, OFDM, DSP). Realistic optoelectronic equipment modeling helps to characterize system impairments due to component limitations. Using the industry’s most advanced fiber model, one can investigate complex nonlinear interactions such as cross-polarization and cross-phase modulation (XpolM, XPM) in mixed bit-rate systems.

High-Speed Electronics

Libraries of ready-to-use building blocks in *VPItransmissionMaker Optical Systems* enable you to explore new prospects offered by high-speed electronics such as the adaptive equalization of binary or multilevel signals (FFE/DFE, MLSE), ADC and DSP algorithms such as TDE &FDE, DBP, CMA-MIMO, Viterbi& Viterbi, BPS, etc. Besides, the generation, detection, and equalization of multicarrier signals including OFDM are supported. Advanced models account for realistic limitations of electronic (ADC, DAC) and optoelectronic components such as temperature dependence, PDL, bandwidth limitation, and saturation.
Software-Defined Transmission

The need for software-defined transmission raises new challenges for the transceiver design: multiple modulation formats have to be supported to accommodate for varying bandwidth demand and physical characteristics of different optical paths. VPItransmissionMaker Optical Systems is the ideal tool to identify design issues specific to such flexible transceivers. It allows, for instance, to assess requirements of DACs and ADCs in order to support multiple modulation formats (e.g., DP-BPSK, -QPSK, -16QAM or arbitrary n-dim constellations). Equalization schemes developed for this purpose can be tested and benchmarked using state-of-the-art algorithms. Additionally, FEC functionalities (hard & soft decoding) can be used to investigate different strategies for coded modulation.

Space Division Multiplexing (SDM)

Unique signal representations in conjunction with flexible fiber modeling allow taking into account linear and nonlinear interactions in multicore multimode fiber-based SDM transmission applications. For instance, one can investigate how the system performance depends on mode coupling induced by mode degeneration or nonideal splices, mode-dependent gain in optical amplifiers or even the Kerr effect. In addition VPItransmissionMaker Optical Systems supports the design and testing of modern multimode fiber types and advanced equalizer technology (such as time- or frequency-domain MIMO) for SDM systems.

Transmission Impairments

VPItransmissionMaker Optical Systems supports the design of WDM systems with arbitrary data rates and transmission distances. The impact of critical propagation effects such as filtering, chromatic dispersion, nonlinearities, and PMD can be investigated individually or jointly. The Universal Fiber model accounts for all-order PMD and the polarization dependence of Raman and Kerr. It also supports the analysis of bidirectional signal transmission including Raman, Brillouin and Rayleigh scattering. Dedicated models (for multimode fiber, free-space channel) enable the design of short-reach and space division multiplexing systems. Channel performance metrics can be tracked and used in combination with the VPIdesignRules interface for quick and high-level system analysis and validation.
Design Examples

Optical Access & Aggregation

Hundreds of possible technologies (CWDM, PON, ROADM, RSOA, injection-locked Fabry-Perot laser diodes) and topologies (ring, mesh, branching) of aggregation and distribution networks can be evaluated using VPItransmissionMaker Optical Systems. FTTx and NGPON2 applications are rapidly evolving, encompassing a variety of passive optical network approaches, sometimes even combined with video overlay. The development of these systems requires the modeling of whole networks including optical CDMA, PAM, OFDM subcarrier processing, WDM devices such as AWGs and FBGs, SOA operation in burst mode, transient laser and receiver effects, and bidirectional fiber propagation.

Short-Reach & Data Center

VPItransmissionMaker Optical Systems supports the benchmarking of technologies for short-reach applications such as building-to-building connections and data center applications (rack-to-rack, chip-to-chip connections), targeting the requirements of next generation optical Ethernet. Diverse modulation formats (PAM-M, DMT, multipulse) and transmission media (MMF, SSMF, free-space) can be compared. Alternative electrooptic modulators (VCSEL, DML, EML) and requirements of electronic parts (DAC/ADC, driver, amplifier, equalizer) can be jointly investigated. Advanced standardized measurements such as Transmitter and Dispersion Eye Closure for Quaternary PAM (TDECQ) are also possible to perform, ensuring adherence to standards when designing systems. Photonic integrated transmitter and receiver chips can be assessed in conjunction with VPICOMPONENTMaker Photonic Circuits.

Microwave Photonics & RF-over-Fiber

Microwave photonics offers many possibilities for photonic signal processing, format-independent signal transmission, avionics, wireless antenna remoting, radar signal processing and countermeasures, array-antenna beamforming, and broadband EM-field monitoring. Designs can be rapidly evaluated for their noise, distortion and frequency response characteristics. Trade-offs in optical microwave signal processing designs can be examined, such as the effect of laser linewidth on the performance of notch filters using optical interferometers and Bragg gratings.
Equipment Characterization

VPItransmissionMaker Optical Systems supports the virtual characterization of passive and active equipment behavior in realistic system environments. Detailed physical models represent components based on [internal] material and structural parameters. Blackbox and datasheet models are based on the physics of the device with parameters that can be derived from external measurements and datasheets. The different abstraction levels of equipment modeling help to support the specific design needs of component manufacturers and system integrators.

Probabilistic Shaping

Probabilistic shaping is a technique which imposes a nonuniform distribution for the symbol occurrence probability in a given constellation. It enables noninteger bits-per-symbol loading, and thus finer granularity in available throughputs, paving the way for future flexible optical networks. Moreover, the average Euclidean distance between constellation points of the shaped signal is increased, compared with a uniformly distributed signal of the same average signal power: Probabilistically shaped QAM therefore outperforms uniform QAM and can approach the Shannon capacity.

Transients & Network Dynamics

Dynamic SOA, Raman & doped-fiber amplifier models support the investigation of transient effects resulting from dynamic traffic changes in metro networks, or burst operation in access networks. The dedicated Transient Analysis interface enables you to determine the steady-state characteristics of complex networks and to investigate their dynamic responses to a series of events (lambda-switching, cable break). Scenarios can be simulated at different time scales (from bit-level to milliseconds), allowing an extensive comparison of different amplifier control schemes and an accurate estimation of dynamic system performances.
Training & Design Services

Training courses are conducted on site, or at VPIphotonics’ locations in the USA and Germany. A training manual and certificate of completion is awarded to all successful participants. Courses can be tailored to meet individual demands, ranging from beginners to advanced-level participants and addressing general or highly specialized applications.

Additionally, VPIphotonics offers customized modeling and design services in various fields of photonics and optical communications.

Please contact us and tell us about your design challenges and project requirements. Our experts will get back to you.

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