

Design of Photonic Systems & Networks

Optical Transmission System Simulation

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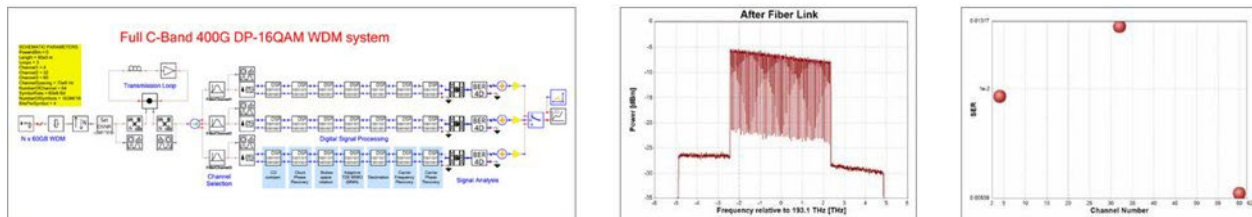
Keysight Optical Transmission System Simulation (VPItransmissionMaker Optical Systems) accelerates the design of new optical transmission systems for short-reach, access, metro and long-haul applications, and allows technology upgrade and component substitution strategies to be developed for existing 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.

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 at different design levels with easy interfacing between these layers, technology benchmarking and stress test definition for higher productivity and shorter 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.

Benefits



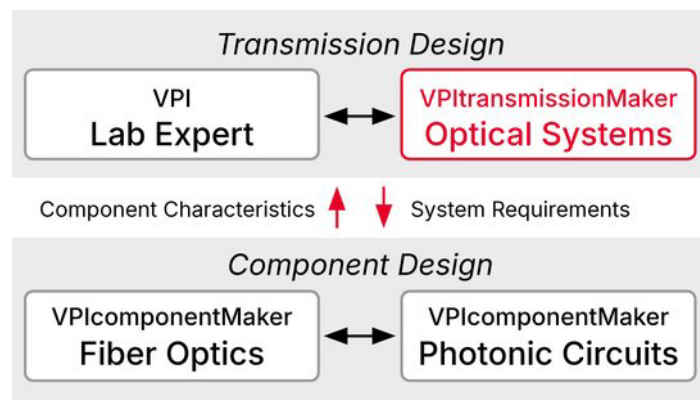
- Design optical transmission systems and subsystems
- Compare upgrade and component substitution strategies
- Evaluate the impact of real-world equipment and new component ideas on systems design
- Virtual prototyping for increased productivity and reduced time-to-market
- Define components requirements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

Photonic Simulation Environment (VPIphotonics Design Suite)

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:

- Photonic Integrated Circuit Simulation (VPIcomponentMaker Photonic Circuits)
- Fiber Amplifier and Laser Simulation (VPIcomponentMaker Fiber Optics)
- Test Signal Generation and Analysis (VPIlabExpert)

VPIphotonics Design Suite



Applications

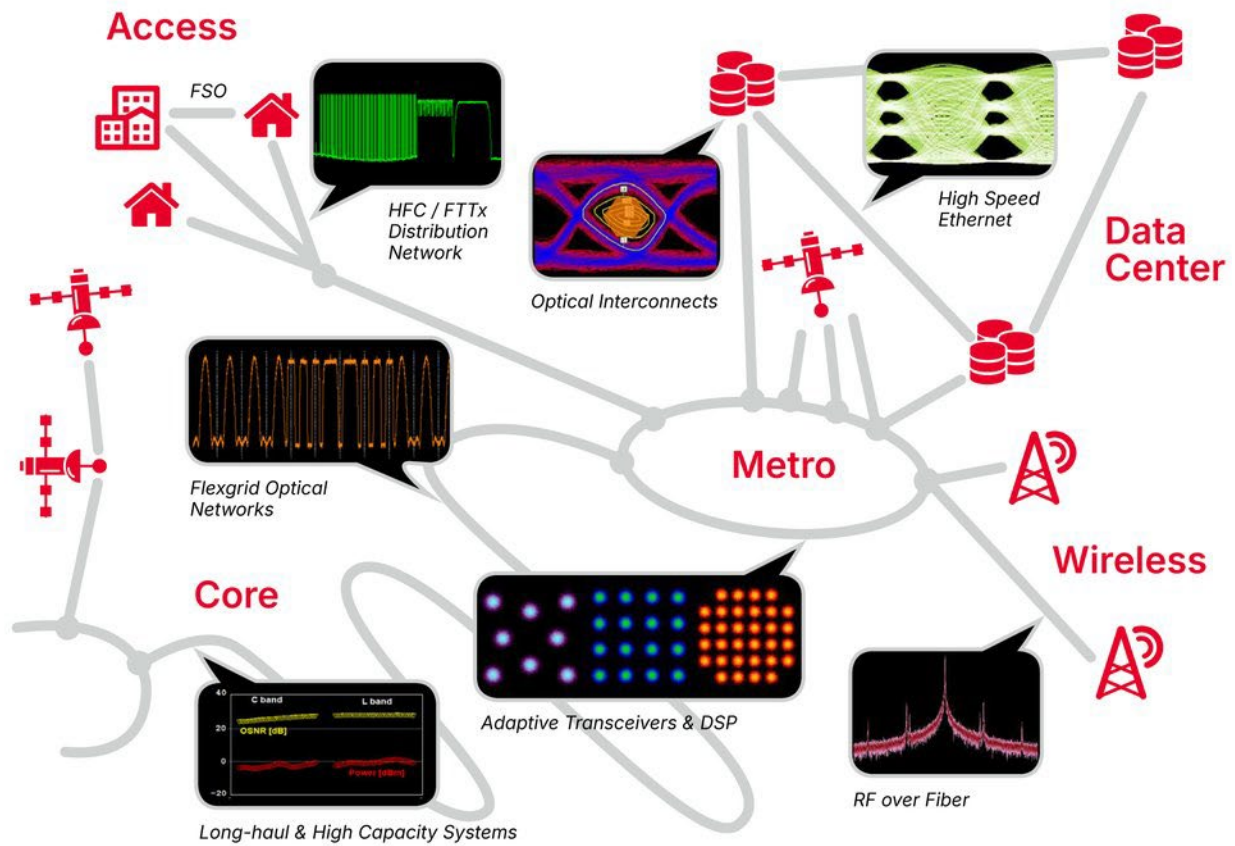
- Design high-performance solutions for 100, 400 Gbps and **1 Tbps transmission** using multilevel modulation, coherent detection and DSP
- Develop effective **DSP** methods for adaptive digital signal processing equalization and precompensation and compare them with state-of-the-art solutions
- Compare 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
- Design **free-space optical communication systems** over terrestrial, ground-to-satellite, and inter-satellite link
- 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
- Evaluate crosstalk and dynamics in **reconfigurable networks** due to power transients and test countermeasures
- Explore new system concepts such as the Kramers–Kronig scheme
- Perform quick WDM system design evaluation using link performance analysis functions and **engineering rules**
- Select technologies (CWDM, PON, ROADM, RSOA) and topologies of access, aggregation and **distribution networks**
- 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 **FSO channel** effects in different weather conditions and evaluate transmission schemes
- 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 automation 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
- **API** (Cosimulation or Simulation Engine Driver) for third-party software connectivity with e.g. Matlab, Python, C++, Keysight ADS
- 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

Custom Level Designs

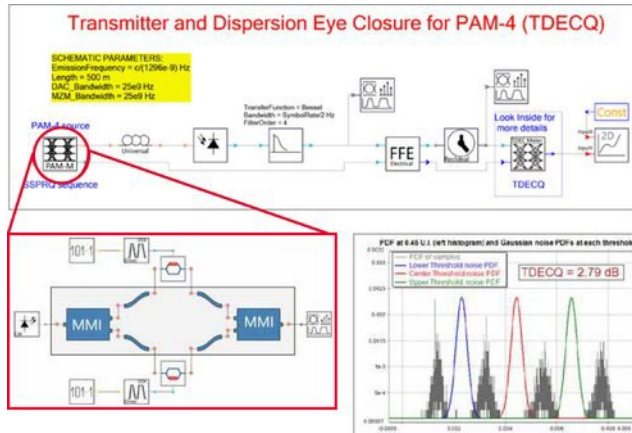
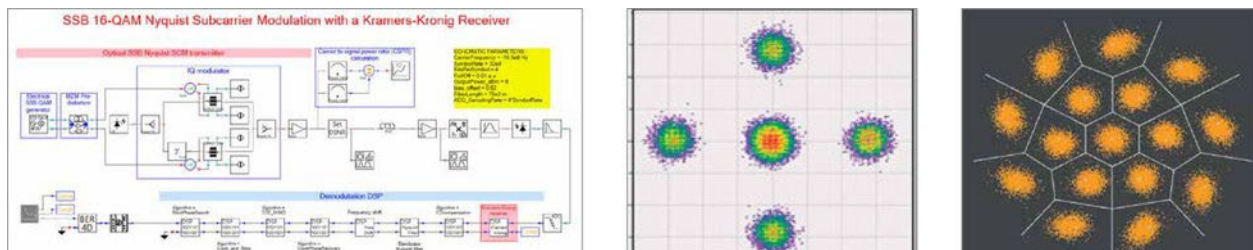


Figure 1. Designed in VPIcomponentMaker Photonic Circuits

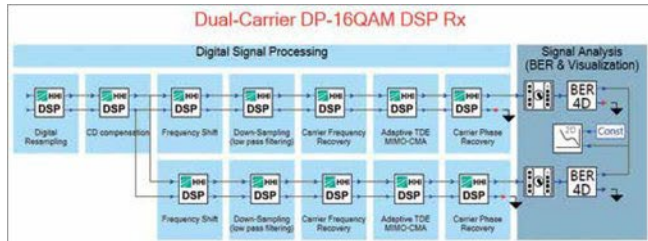
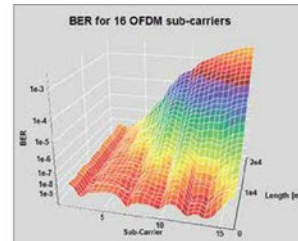
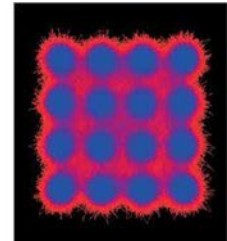
- Hybrid Simulation with VPIcomponentMaker Photonic Circuits and Fiber Optics with flexible integration and customization of various photonic components
- Characterization and evaluation of photonic components and fiber optic designs on system-level (e.g. Transmitter and Dispersion Eye Closure for Quaternary PAM (TDECQ))
- Incorporation of photonic component design results (e.g., S-parameters) into system-level modules

Modulation Formats



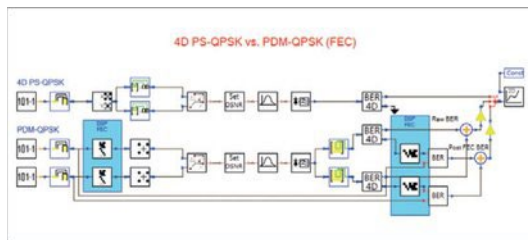
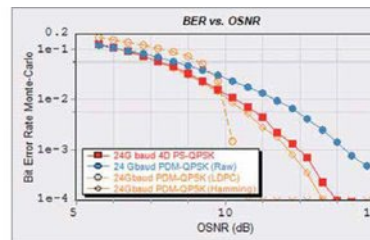
- Development and comparison of a multitude of different modulation formats
- Streamline the development with flexible modulator models, including multiport MZ interferometer and nonlinear EA modulator
- Ready-to-use transmitters and receivers
- Analysis of new modulation formats based on technologies such as multi-dimensional encoding, coherent detection, polarization multiplexing and optical CDMA

High-Speed Electronics



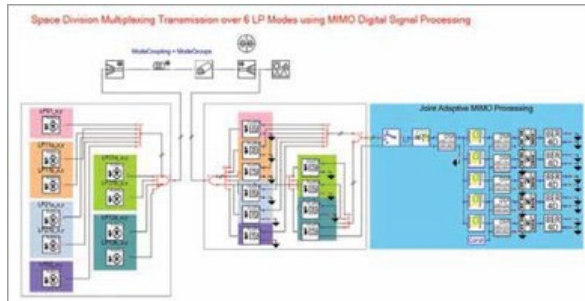
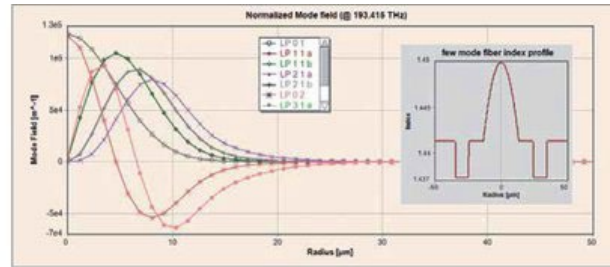
- Explore new prospects offered by high-speed electronics such as the adaptive equalization of binary or multilevel signals
- Generate, detect and equalize multicarrier signals including OFDM
- Realistic limitations of electronic (ADC, DAC) and optoelectronic components such as temperature dependence, PDL, bandwidth limitation, and saturation

Transceiver Design



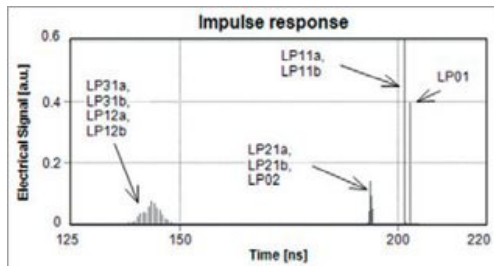
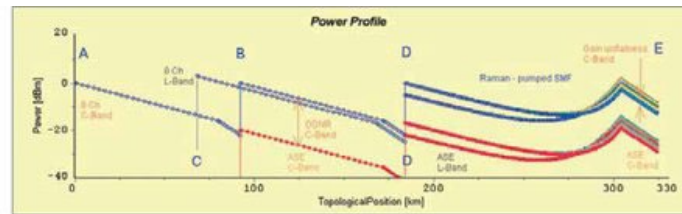
- Multiple modulation formats for varying bandwidth demand and physical characteristics
- Support of state-of-the-art and advanced modulation formats (e.g., DP-BPSK, -QPSK, OFDM, arbitrary n-dim constellation, CAP)
- Rich collection of DSP algorithms for filtering, pre-distortion, equalization and other functions such as demultiplexing and clock recovery
- FEC functionalities (hard & soft decoding) for investigation of different coded modulation

Space Division Multiplexing



- Linear and nonlinear interactions in multicore multimode fiber-based SDM transmission applications
- Evaluation of system performance based on mode coupling induced by mode degeneration or nonideal splices, mode-dependent gain in optical amplifiers or even the Kerr effect
- Design and testing of modern multimode fiber types and advanced equalizer technology

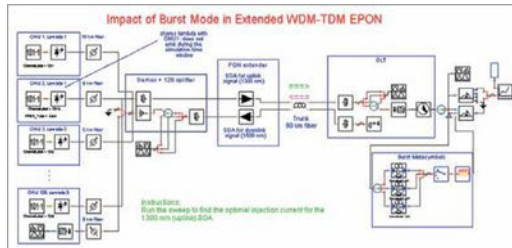
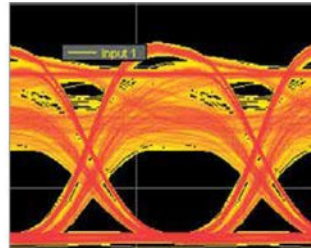
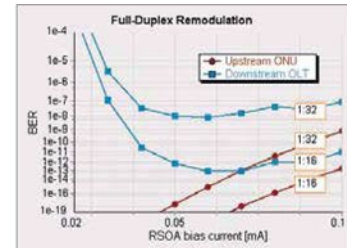
Transmission Impairments



- Design of WDM systems with arbitrary data rates and transmission distances
- Investigate the impact of critical propagation effects such as filtering, chromatic dispersion, nonlinearities, and PMD
- Explore higher-order PMD and the polarization dependence of Raman and Kerr
- Analysis of bidirectional signal transmission including Raman, Brillouin and Rayleigh scattering

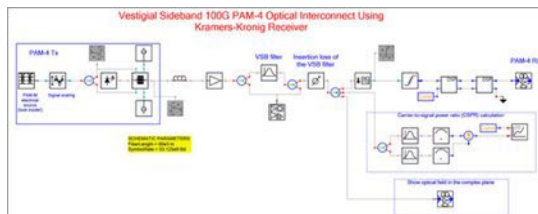
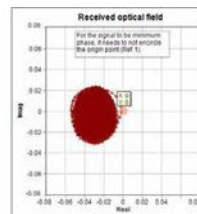
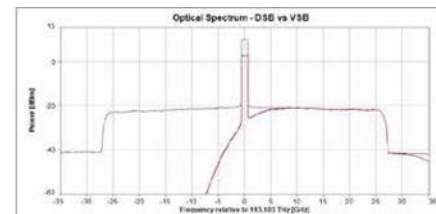
Design Examples

Optical Access



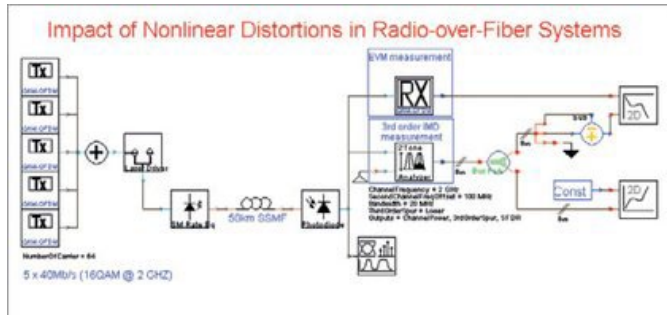
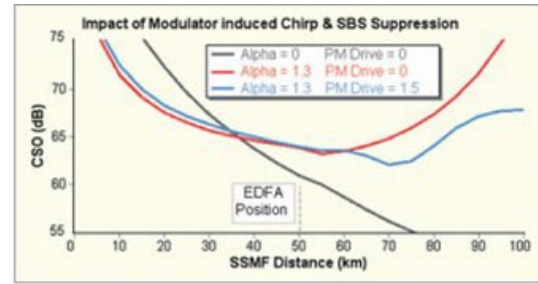
- CWDM, PON, ROADM, RSOA, injection-locked Fabry-Perot laser diodes
- Ring, mesh, branching topologies of aggregation and distribution networks
- Modeling of networks including optical CDMA, PAM, OFDM subcarrier processing, WDM devices such as AWGs and FBGs, SOA operation in burst mode, transient laser and receiver effects, and bidirectional fiber propagation

Short-Reach & Data Center



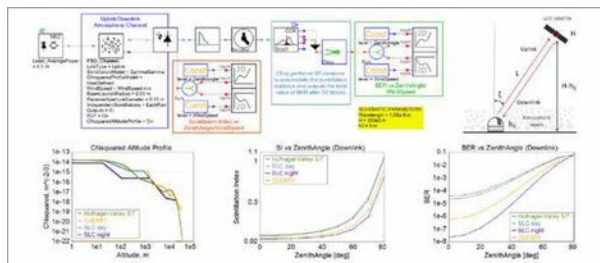
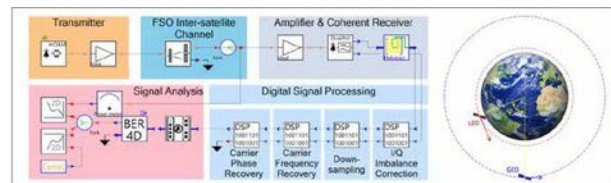
- Benchmarking of technologies for short-reach applications such as building-to-building connections and data center applications (rack-to-rack, chip-to-chip connections)
- Comparison of diverse modulation formats (PAM-M, DMT, multipulse) and transmission media (MMF, SSMF, free-space)
- Investigation of system designs (Kramers-Kronig, Duobinary, Time-Domain Hybrid Modulation)

Microwave Photonics



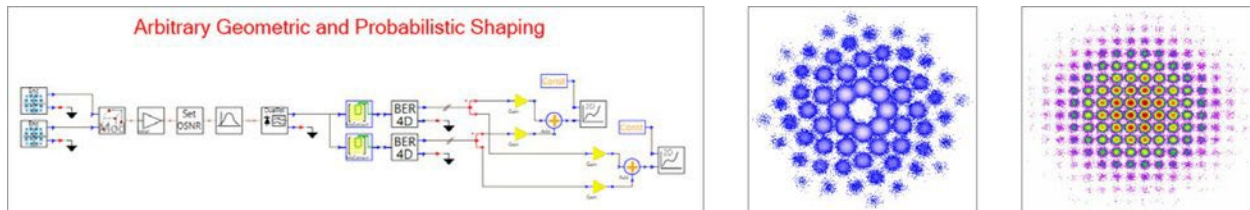
- Format-independent signal transmission, avionics, wireless antenna remoting, radar signal processing and countermeasures, array-antenna beamforming, and broadband EM-field monitoring
- Evaluation of noise, distortion and frequency response characteristics
- Investigation of trade-offs in optical microwave signal processing designs

FSO Communication



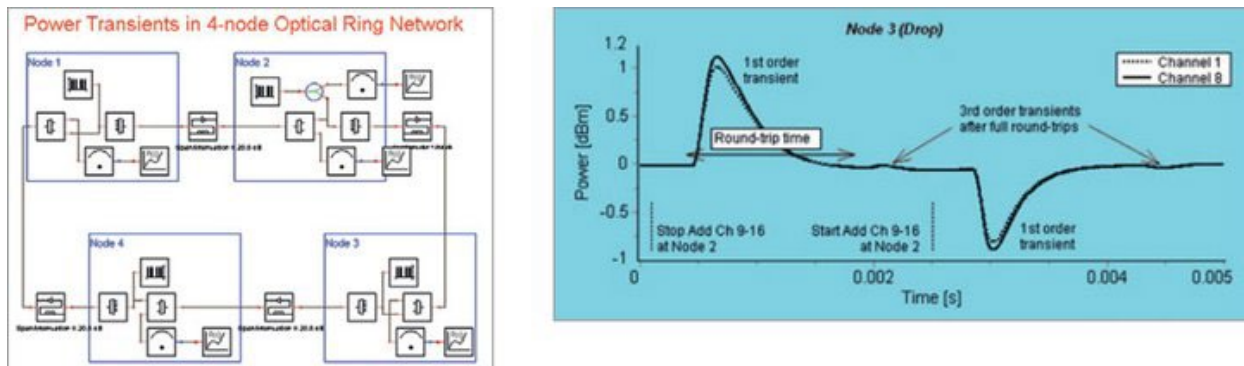
- Statistical atmospheric channel model supporting terrestrial, satellite up- and downlink using log-normal and gamma-gamma PDF
- Predefined models for turbulence altitude profiles
- Inter-satellite channel model considering Doppler effect and pointing jitter using Rician PDF
- Link Budget calculation macro for atmospheric and inter-satellite links

Probabilistic Shaping



- Evaluate flexible optical networks using noninteger bits-per-symbol loading
- Increase the average Euclidean distance between constellation points of the shaped signal
- Compare the performance of probabilistically shaped and uniformly shaped QAM

Dynamic Effects in Networks



- Dynamic SOA, Raman & doped-fiber amplifier models
- Steady-state characteristics of complex networks
- Investigation of network dynamic responses to a series of events (lambda-switching, cable break)
- Extensive comparison of different amplifier control schemes and accurate estimation of dynamic system performances

As a mission-critical design enablement partner, Keysight connects design, emulation, and test so customers can solve the world's most complex engineering challenges. Accelerate innovation at www.keysight.com.