OptiSystem

Optical Communication System and Amplifier Design Suite

14.2

New Features

Created to address the needs of research scientists, photonic engineers, professors and students; OptiSystem satisfies the demand of users who are searching for a powerful yet easy to use photonics system design tool.

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Key Features for OptiSystem 14.2

OptiSystem 14.2 includes several new components and component enhancements including new **Uniform FBG Sensor** and **WDM FBG Sensor Interrogator** components, major updates to our ***Doped Fiber models***, and enhancements to the functionality of several of our ***Electrical pulse generators***. Key new features include:

- New **Uniform FBG Sensor** and **WDM FBG Sensor Interrogator** components have been added to our new ***Sensors*** folder. These new components allow for the characterization of fiber-based grating sensor systems.
- Functionality updates and enhancements to our steady state doped fiber models, including the **Er Doped Fiber**, **Er-Yb Codoped Fiber**, **Yb Doped Fiber**, **Tm Doped Fiber**, **Pr Doped Fiber**, and **Ho Doped Fiber** components (the last item is a new model addition to our doped fiber library)
- Functionality updates and enhancements to our dynamic doped fiber models, including the **Er Doped Fiber Dynamic**, **Er-Yb Codoped Fiber Dynamic**, **Yb Doped Fiber Dynamic**, **Tm Doped Fiber Dynamic**, and **Ho Doped Fiber Dynamic** (the last two items are new model additions to our fiber library)
- Several of our electrical pulse generator components have been updated to allow for more flexibility in defining pulse sequences (components include the **Hyperbolic-Secant Pulse Generator**, **Gaussian Pulse Generator**, **Triangle Pulse Generator**, **Saw-Up Pulse Generator**, **Saw-Down Pulse Generator**, **Impulse Generator**, **Raised Cosine Pulse Generator**, **Sine Pulse Generator**, **Measured Pulse**, and **Impulse Generator**)

New library components and major enhancements

<u>Optical amplifier and fiber design (Steady state models)</u>: Er Doped Fiber, Er-Yb Codoped Fiber, Yb Doped Fiber, Tm Doped Fiber, Pr Doped Fiber, and Ho Doped Fiber

The steady state optical doped fiber models have undergone a significant update. All steady state fiber models now include the modeling of Double-cladding pumping, Rayleigh scattering, Raman and Brillouin inelastic scattering, dispersion and self-phase modulation. In addition, the component parameters tabs have been overhauled to provide better consistency and logic between all doped fiber models.

Also a new steady state model has been added for the characterization of Holmium-doped fibers

For further information on these important updates please see the technical background section for each doped fiber model (see *OptiSystem_Component_Library.pdf*)

<u>Optical amplifier and fiber design (Dynamic models)</u>: Er Doped Fiber Dynamic, Er-Yb Codoped Fiber Dynamic, Yb Doped Fiber Dynamic, Tm Doped Fiber Dynamic, and Ho Doped Fiber Dynamic

The dynamic optical doped fiber models have undergone a significant update. All dynamic fiber models now include the modeling of Double-cladding pumping, Rayleigh scattering, Raman inelastic scattering, and dispersion effects. In addition, the component parameters tabs have been overhauled to provide better consistency and logic between all doped fiber models.

Also, new dynamic models have been added for the characterization of Thulium-doped and Holmium-doped fibers.

For further information on these important updates please see the technical background section for each doped fiber model (see *OptiSystem_Component_Library.pdf*)

<u>Optical fiber sensor design</u>: Uniform FBG Sensor, WDM FBG Sensor Interrogator

New **Uniform FBG Sensor** and **WDM FBG Sensor Interrogator** components have been created to allow for the characterization of fiber-based grating sensor systems (to model both temperature and stress/strain events). The **Uniform FBG sensor** is a uniform fiber Bragg grating which includes analytical models that link temperature and/or stress/strain events to changes in the grating optical properties (reflection and transmission spectrum). The **WDM FBG Sensor Interrogator** combines the **Optical Spectrum Analyzer** with analysis tools for locating the maxima or minima of reflection spectra.

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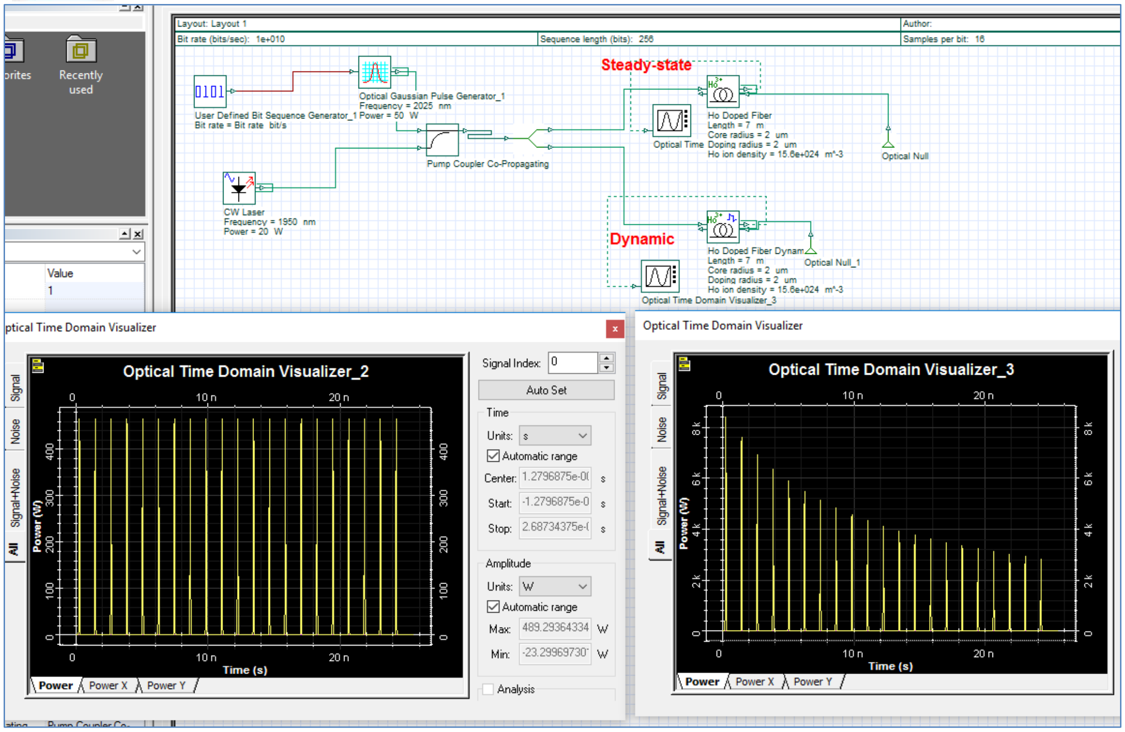

Fig 1: New Holmium Doped Steady State and Dynamic models *– This example shows results for the Ho Doped fiber (steady state - left and dynamic - right) amplifier models subject to an input stream of pulses. For the dynamic model, carrier densities will vary with time; for the steady state model, a constant gain regime is assumed over the entire simulation time window (for this reason the dynamic model should be used if modeling fast transitions in time)*

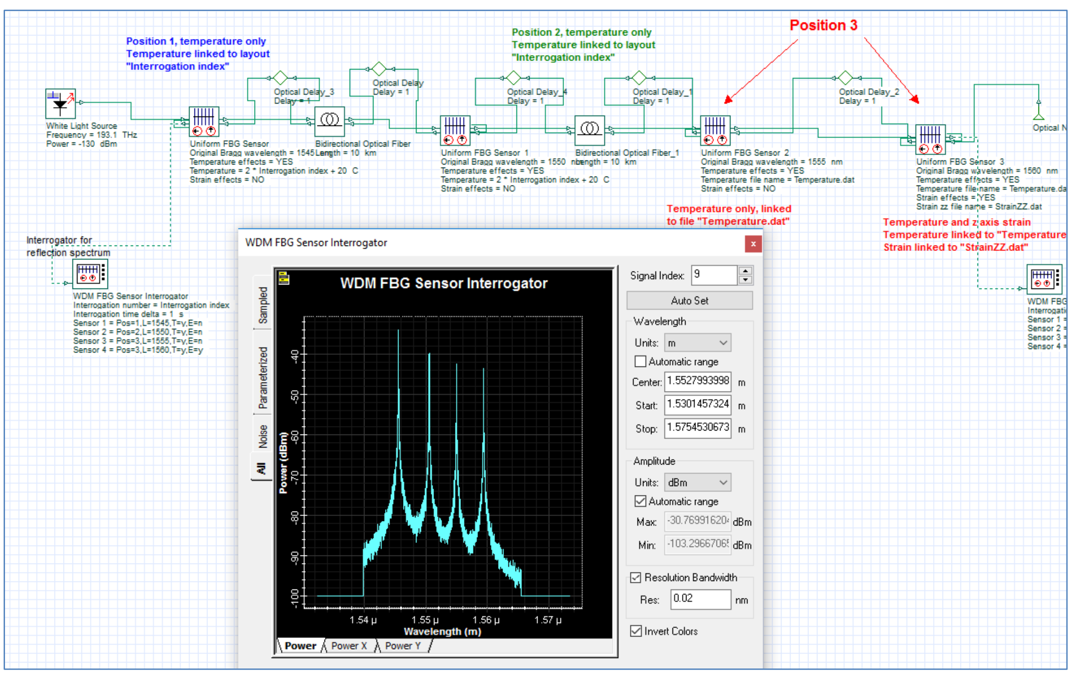

Fig 2: Example FBG sensor system with four positions *– The sensors are created from the* ***Uniform FBG Sensor*** *component and can be used to model temperature and strain effects simultaneously or independently. The* ***WDM FBG Sensor Interrogator*** *combines the Optical Spectrum Analyzer with analysis tools for locating the maxima or minima of reflection spectra.*

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<u>Transmitter library (Electrical pulse generators)</u>: Hyperbolic-Secant Pulse Generator, Gaussian Pulse Generator, Triangle Pulse Generator, Saw-Up Pulse Generator, Saw-Down Pulse Generator, Impulse Generator, Raised Cosine Pulse Generator, Sine Pulse Generator, Measured Pulse, Impulse Generator

Several of our electrical pulse generator components have been updated to allow for more flexibility in defining pulse sequences, including:

- The ability to define whether to define the pulse sequence based on an external bit sequence generator (default) or to use internal parameters.
- When using internal parameters, the option to define the specific points in time where to introduce pulses and the repetition rate (in time) of these pulse groupings.
- When applicable, the option to define the pulse width and truncation length.

In addition, the **Impulse Generator** component now includes support for M-ary input signals and the ability to match the output amplitude directly to the input amplitude

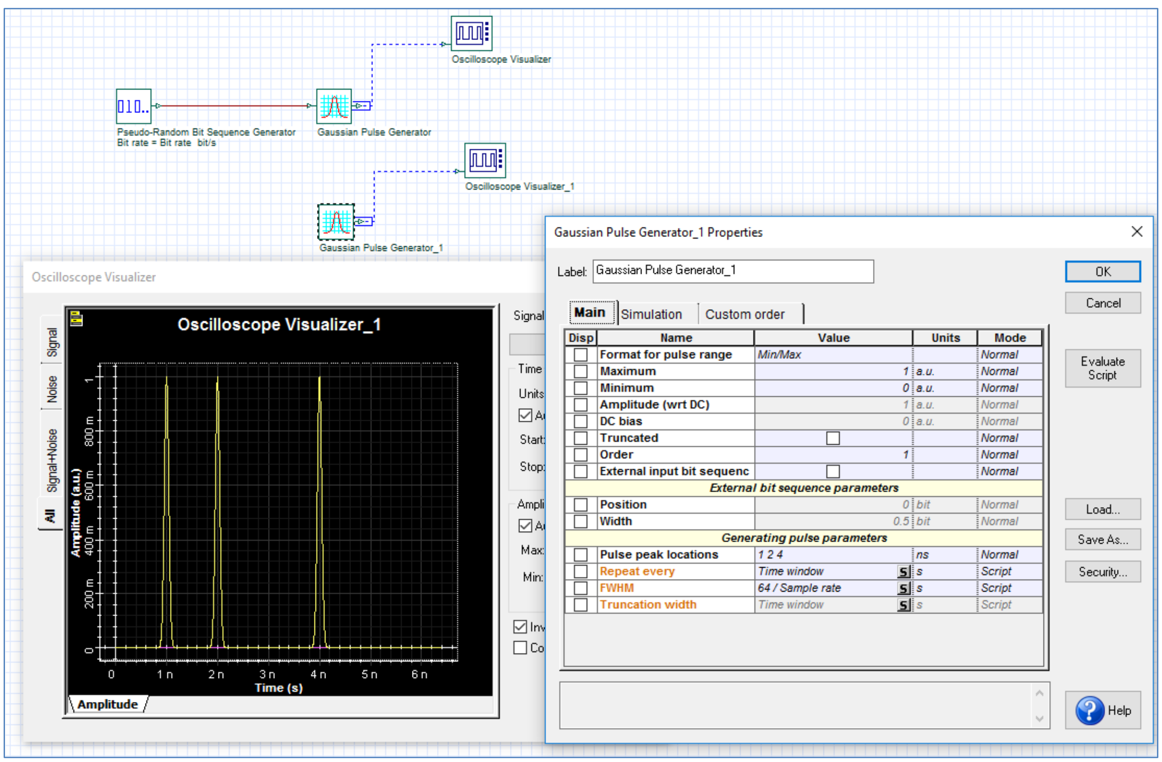

__Fig 3: New pulse definition features for electrical pulse generators__ – Several of our electrical pulse generators now include the ability to define pulse sequences based on external bit sequence generator (existing feature) or internally by defining the specific time points where pulses will appear. The example above shows an internally defined pulse sequence with peak pulse locations defined for time positions of 1, 2 and 4 nano-seconds.

Other product improvements and fixes

Filters library

The transfer functions for the **Low Pass Raised Cosine Filter** and **Band Pass Raised Cosine Filter** components have been updated. For further information on the new formulas, please see the technical background for these components.

Transmitters library

The pulse definitions for the **Raised Cosine Pulse Generator** and **Mary Raised Cosine Pulse Generator** components have been updated. For further information on the new definitions and formulas, please see the technical background for these components.

The **User Defined Bit Sequence Generator** component now includes support for ***Non-zero bit locations***. When selected, users will be able to define the exact locations where the bits will be placed (all other locations for the sequence will be filled with zero bits).

The **FEC Encoder** component now includes an option for *Trim to sequence length*. In some applications (such as for higher order modulation systems) it is desirable for the bit sequence length exiting the encoder to be the same as that entering.

Passives library

The Power Combiner components (**Power Combiner 2x1**, **Power Combiner 4x1**, **Power Combiner 8x1** and **Power Combiner**) now include options to force the power conservation condition and include phase dependence at the input. For further information on these new features, please see the technical background for these components.

Receivers library

The **Universal DSP** component now includes the option to perform the adaptive equalization (AE) routine before or after the frequency offset (FOE) routine. For the BPSK modulation format (when stochastic PMD is present) it can be beneficial to perform FOE first.

The **FEC Decoder** component now includes the options for *Zero pad to sequence length* (to compensate for the removal of overhead symbols used in the coding/decoding process)

Amplifiers library

The **Transimpedance Amplifier** has been updated to fix a bug that was found in the *Load Transfer Function* option of the parameter ***Transfer function model*** (the central frequency of the filter profile was not being set correctly)

Applications updates

The Samples folder (OptiSystem 14.2 Samples) has been updated as follows:

- A new set of models and scripts has been created to allow for the performance analysis of higher order modulation systems under Gaussian noise conditions; including PSK, QAM and PAM. These examples, and the associated Excel output analysis curves, can be found under “Advanced modulation systems\SER and BER Analysis of QAM-PSK-PAM systems”.
- New examples have been created for Holmium steady-state and dynamic models and Tm dynamic models (see “Optical amplifiers\Ho doped fiber models” and “Optical amplifiers\Tm doped fiber models”)
- The BPSK optical coherent systems examples have been updated to fix an issue found with phase recovery when stochastic PMD impairments are applied to the transmission model. The updated examples are located under “Advanced modulation systems\PSK systems\BPSK”
- A new “Sensor systems” folder has been added to the OS 14.2 samples. New examples have been added for LIDAR and FBG sensor systems.
- A new receiver sensitivity design project (PIN and APD Receiver Sensitivity Analysis.osd) has been added to the folder “Optical receiver design and analysis\Photodetector noise and sensitivity analysis”. These new examples provide theoretical matched simulation models for quantum-limited, shot, thermal and optical pre-amplifier PIN/APD detection systems.

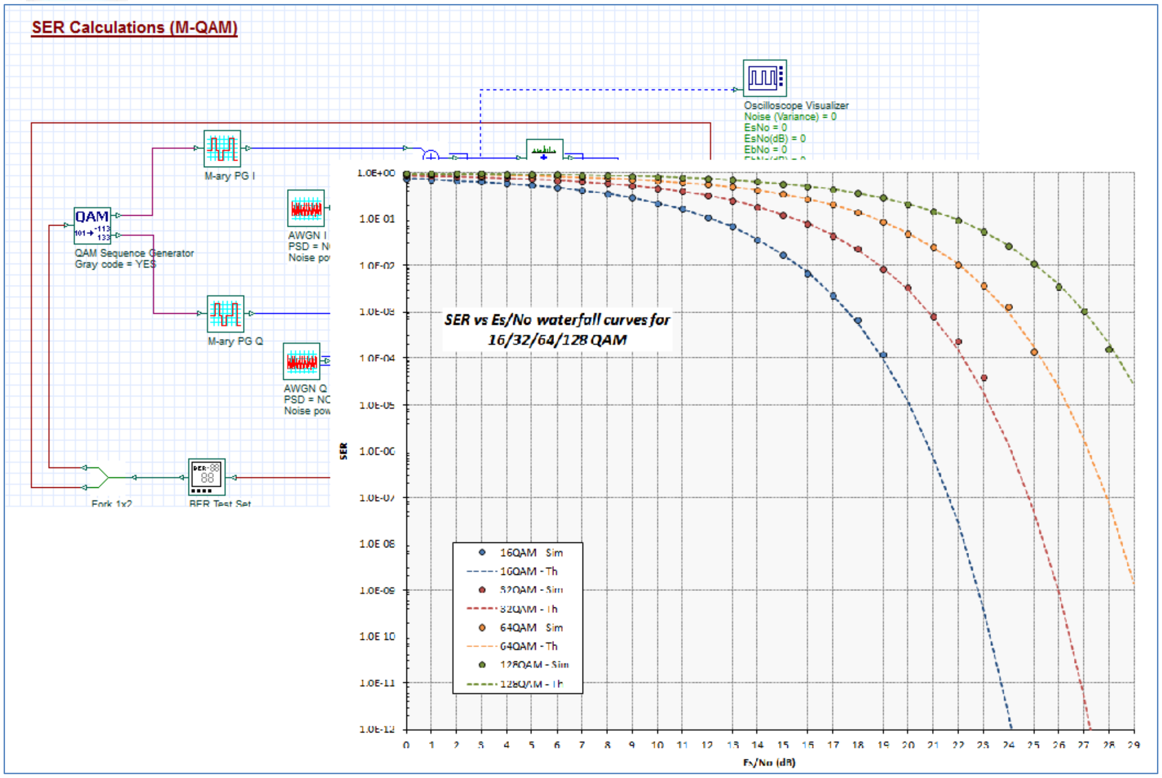

***Fig 4: System performance analysis tool kits for QAM, PSK and PAM systems** – New OptiSystem project and scripts have been added to the OptiSystem 14.2 Samples to allow users to quickly setup SER and BER waterfall analysis curves based on EbNo/EsNo (Energy per bit/symbol to noise power spectral density ratio) Gaussian noise impairment sweep models. The scripts are designed to automatically export data for post-processing and graphing in Excel (the Excel templates have been included in the OptiSystem 14.2 samples)*

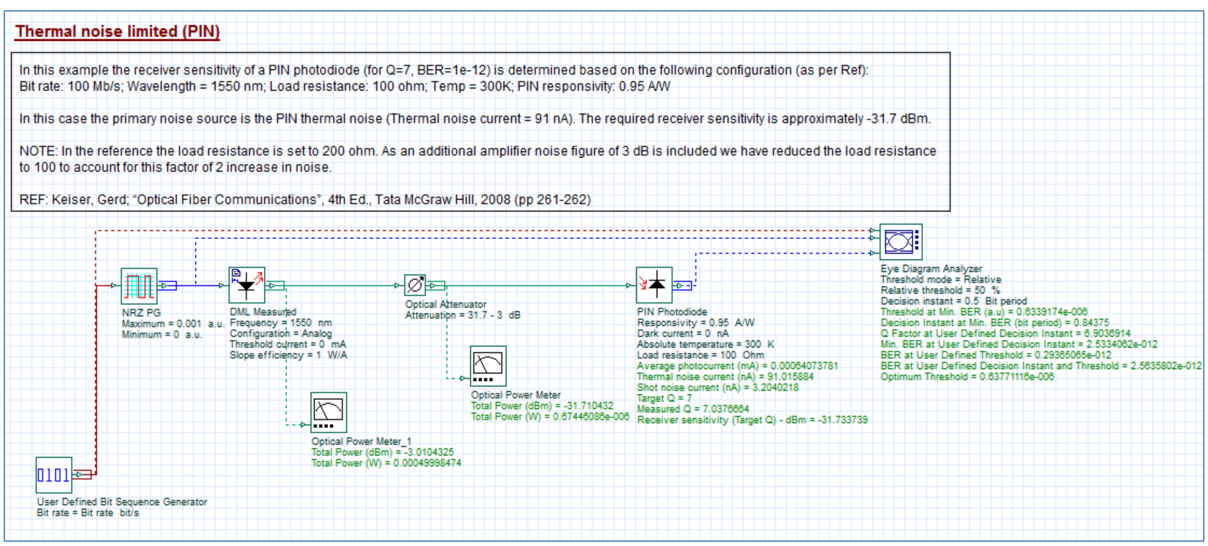

***Fig 5: Receiver sensitivity analysis tool kit** – A new OptiSystem receiver analysis tool kit project (PIN and APD Receiver Sensitivity Analysis.osd) has been added to the "Optical receiver design and analysis" folder. This new tool kit includes customized component scripts for calculating theoretical receiver performance metrics (Q, Receiver sensitivity) for quantum-limited, shot, thermal and optical pre-amplifier PIN/APD detection systems. These models can be used as reference templates for the creation of manufacturer-based IM-DD receiver subsystem designs.*

Documentation updates

OptiSystem Component Library

The parameter tables and/or technical description sections of the following components have been updated (or created):

- Er Doped Fiber, Er-Yb Codoped Fiber, Yb Doped Fiber, Tm Doped Fiber, Pr Doped Fiber, Ho Doped Fiber (new)
- Er Doped Fiber Dynamic, Er-Yb Codoped Fiber Dynamic, Yb Doped Fiber Dynamic, Tm Doped Fiber Dynamic (new), Ho Doped Fiber Dynamic (new)
- Uniform FBG Sensor (new), WDM FBG Sensor Interrogator (new)
- Hyperbolic-Secant Pulse Generator, Gaussian Pulse Generator, Triangle Pulse Generator, Saw-Up Pulse Generator, Saw-Down Pulse Generator, Impulse Generator, Raised Cosine Pulse Generator, Sine Pulse Generator, Measured Pulse
- User defined bit sequence generator
- Low Pass Raised Cosine Filter & Band Pass Raised Cosine Filter
- Raised Cosine Pulse Generator & M-ary Raised Cosine Pulse Generator
- Power Combiner 2x1, Power Combiner 4x1, Power Combiner 8x1, Power Combiner
- Universal DSP
- FEC Encoder, FEC Decoder
- Constellation Visualizer

Optiwave
7 Capella Court
Ottawa, Ontario, K2E 7X1, Canada
www.optiwave.com