Keysight N7700A
Photonic Application Suite

KEYSIGHT TECHNOLOGIES

N7700A Photonic Application Suite

The N7700A Photonic Application Suite is a collection of advanced and basic software tools for making optical measurements, controlling fiberoptic instruments, and analyzing measurement results.

Key elements:

- N7700A Package Manager:
  Select, install and maintain N7700A software packages
- Main Package:
  Analyze results in a powerful Viewer, save and export to common file formats and tools
- IL Engine:
  Measure IL vs. wavelength with a tunable laser and power meters
- Fast Spectral Loss Engine: Calibrate and adjust devices with the fast spectral loss engine at repetition rates up to 10x faster than the IL engine
- IL&PDL Engine:
  Measure IL and PDL vs. wavelength with the advanced single-sweep Mueller method; results now including responsivity for receiver devices with integrated photodiodes, polarization extinction ratio and return loss
- Polarization Navigator:
  Use N778x instruments for polarization analysis and control, including PMD measurements
- Drivers, firmware, documents, N77xx Viewer: Keep equipment and guides up to date
- COM Automation Interface:
  This allows easy integration of the test station into the production work flow. External control of the system from software platforms like VEE, LabView, Matlab, etc. is easily realized. Programming examples are included in the installation.

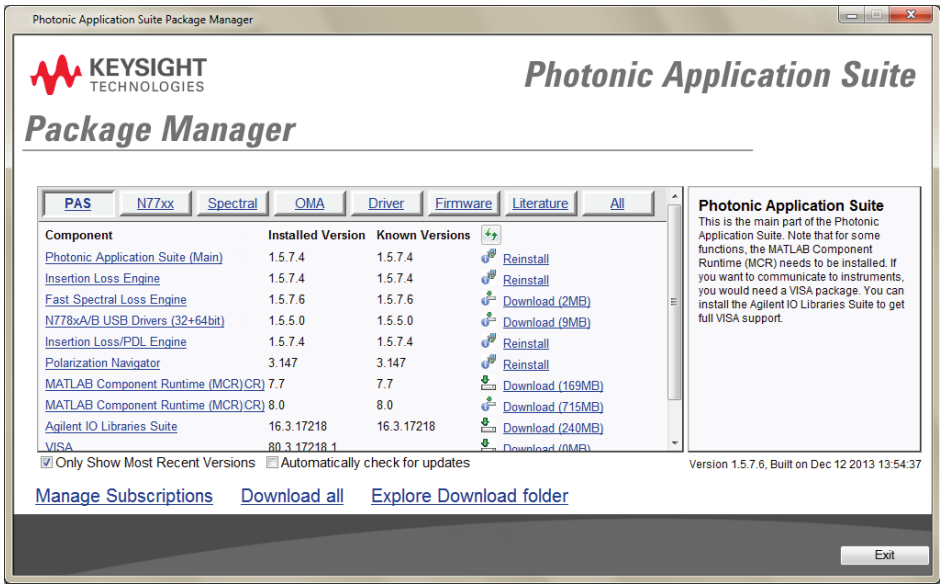


Figure 1. The N7700A Package Manager simplifies software installation and maintenance.

The N7700A Package Manager

The N7700A Photonic Application Suite is available for download from the following link: **www.keysight.com/find/N7700.**

The setup installation provides the N7700A Package Manager. This shows any packages and necessary software prerequisites installed or downloaded on the computer and the packages and updates available from the download site. Use this to install and maintain your desired configuration.

Many elements can be permanently installed and used without charge. Packages requiring a license can be used immediately for up to 14 days and a free 60-day evaluation license can be quickly requested and downloaded for extended testing before purchasing a license.

The N7700A Main Package

is distributed free and provides the basis for the measurement engines and a powerful File Viewer program for analyzing measurement data. It has been designed for sharing measurement results throughout entire development teams or manufacturing groups. The library functions in this package also allow your programs to read and save data in the .omr file format for analysis with the File Viewer.

Features include:

- Display and overlay of traces from multiple channels and multiple measurement files
- Scale switching between wavelength and frequency
- Display of tabular analysis
- Markers, zooming and analysis features of associated measurement engines
- File loading, saving and data export
- Direct launching of Excel and Matlab with data

N7700A Photonic Application Suite (continued)

The N7700A IL/PDL Engine package

measures passive optical components and optical-to-electrical devices like integrated receivers with an advanced routine to determine the dependence on wavelength and polarization for one or multiple ports. The unique single-sweep Mueller Matrix method reduces measurement time and is very robust against environmental disturbance like fiber movement and temperature drift, while maintaining high dynamic range, wavelength accuracy and freedom from bandwidth-limited distortions.

In addition to the measured IL and PDL traces, the Mueller Matrix 1st-row data can be exported and analyzed to provide the polarization resolved IL traces for the device axes (TE/TM). The same applies to measuring the responsivity of receiver devices with photocurrent output.

Required instruments:

- One or more continuous-sweep tunable lasers and mainframe: 81600B or earlier similar modules, 81960A, 81940A, 81980A
- N7786B fast switching polarization synthesizer (including N7786-61601 trigger adapter cable)
- One or more N7744A or N7745A multiport optical power meters or 81636B power sensor module

Optional instruments *(see page 7)*:

- 81595B switch for multi-band
- 81610A return loss module
- N7745A-E02 photocurrent meter
- One or more B2900A Series source/measure unit (and an N1294A Opt 031 GPIO-BNC trigger adapter and BNC T-adapter for each SMU)

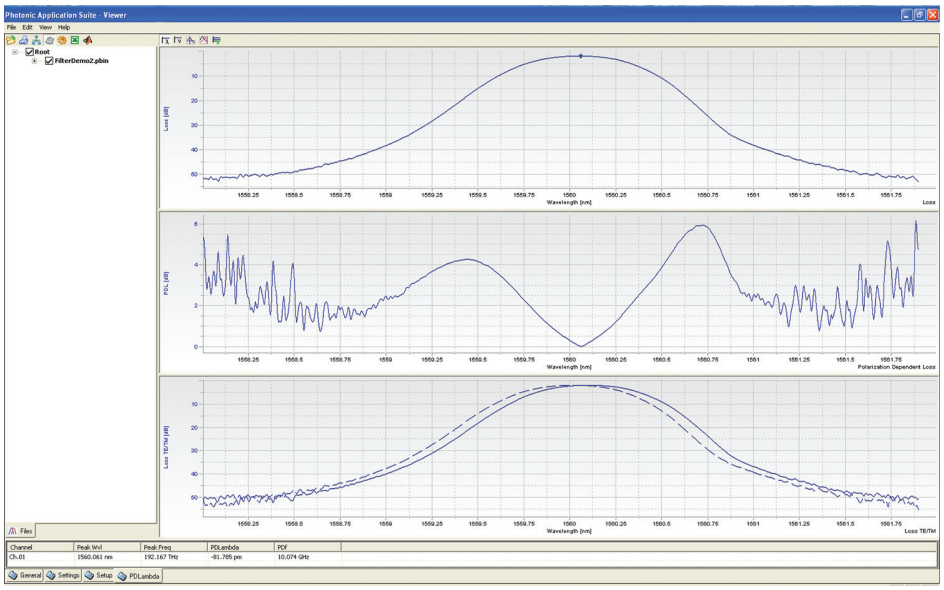


Figure 2. Sample AWG passband measurement showing IL, PDL and the polarization-resolved IL traces for TE & TM.

- The IL/PDL Engine also supports automated switching of multiple lasers for extended wavelength range.
- Polarization averaged return loss can be measured at the same time.
- Reference measurements from one power meter port for multiple ports, normalized for individual detector responsivity or reference from each port directly.
- Measurements can be easily automated with the engine's COM interface.
- Devices with integrated photodiodes, like coherent receivers (ICR) can also be measured with Keysight Technologies, Inc. special N7745A-E02 with photocurrent inputs or B2900A Series source/measure unit in the same setup. The software engine will determine spectra of photocurrent and wavelength responsivity as well as TE vs. TM resolution. A bias voltage can also be applied to the photodiodes.
- For devices with high polarization dependence like polarization beamsplitters and ICR for polarization-multiplexed signals, an additional routine for accurately measuring PER beyond 20 dB is included.
- IL/PDL License available for purchase as N7700A-100.

For more details, see the application note, "IL and PDL spectra with the N7786B Polarization Synthesizer and the N7700A Photonic Application Suite", from the Library tab of the web page **www.keysight.com/find/N7700**.

The N7700A Photonic Application Suite can easily be downloaded from the following link: **www.keysight.com/find/N7700**.

N7700A Photonic Application Suite (continued)

The IL Engine package

provides a measurement engine for very accurate swept- wavelength insertion loss measurements. This is a convenient GUI implementation of the widely used 816x Plug&Play MFlambdascan functionality. This can be used with all Keysight continuously swept tunable lasers, 816-series power sensor modules and heads as well as the N7744A, N7745A and highest sensitivity N7747A and N7748A power meters. No license required.

The Filter/Multiplexer Analysis package

provides extended post-processing of measurements from the IL/PDL and IL engines for analysis of narrow-band components like filters and multiplexers. Analysis parameters include peak and center wavelength, wavelength offset from ITU grid, IL at ITU wavelength and center wavelength, IL ripple, bandwidth, channel isolation from adjacent and non-adjacent channels, total crosstalk, and channel PDL.

From the TE & TM traces of the IL/PDL engine, the polarization dependent frequency shift (PDf or PDλ) of channels in filters, interleavers or phase demodulators can also be determined.

A convenient peak search function is also included.

License available for purchase as N7700A-101. Installed with main N7700A package.

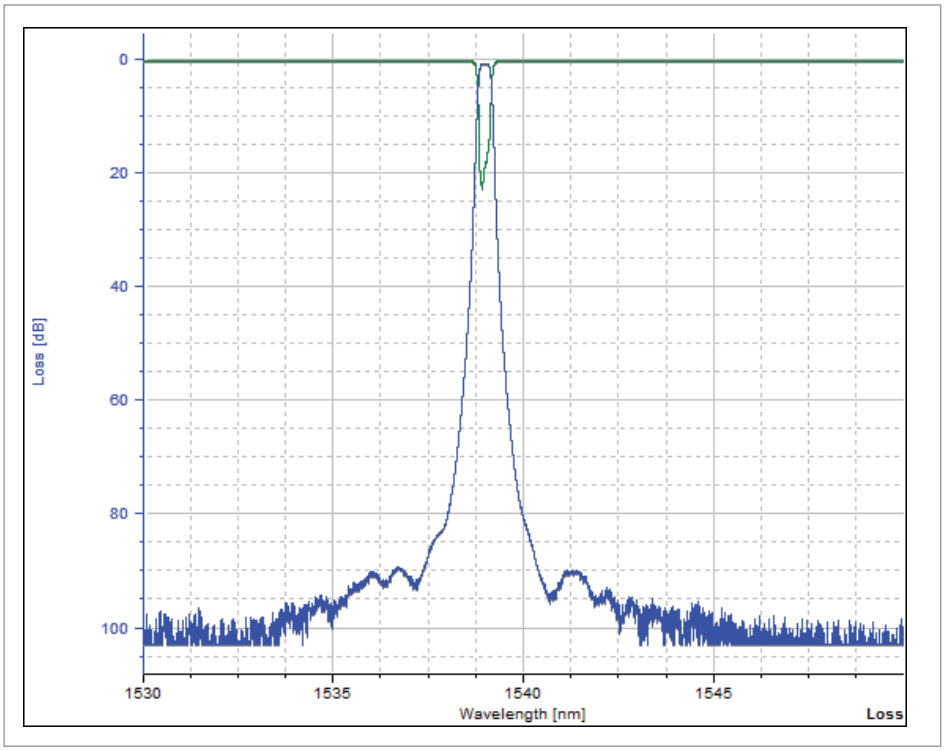


Figure 3. Measurement of an add/drop filter. The combination of the 81600B tunable laser with low SSE, N7747A with high sensitivity and the IL Engine with power range stitching provide the extremely high dynamic range.

The Fast Spectral Loss Engine package

provides insertion loss and power spectra at enhanced repetition rate compared to the basic IL Engine and is a valuable tool for tuning and calibrating devices with near real-time feedback. By making optimal use of the instrument features, repetition rates can be improved by as much as a factor 10. This engine is especially powerful in combination with the 81960A tunable laser which provides bidirectional sweeps and speeds up to 200 nm/s as well. Repetition rates of 1 to 3 scans per second can be attained, depending on the sweep range.

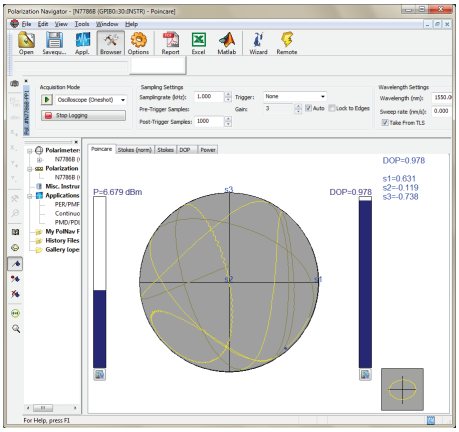
Required instruments:

- Continuous-sweep tunable laser and mainframe: 81960A, 81940A, 81980A, 81600B or earlier similar modules
- N7744A or N7745A multiport optical power meter

Such repetitive measurements have often been made with the combination of an OSA and broadband source. Use of the tunable laser and power meter combination can offer improved wavelength resolution and dynamic range as well as the possibility of simultaneous multiport measurements.

License available for purchase as N7700A-102.

N7700A Photonic Application Suite (continued)

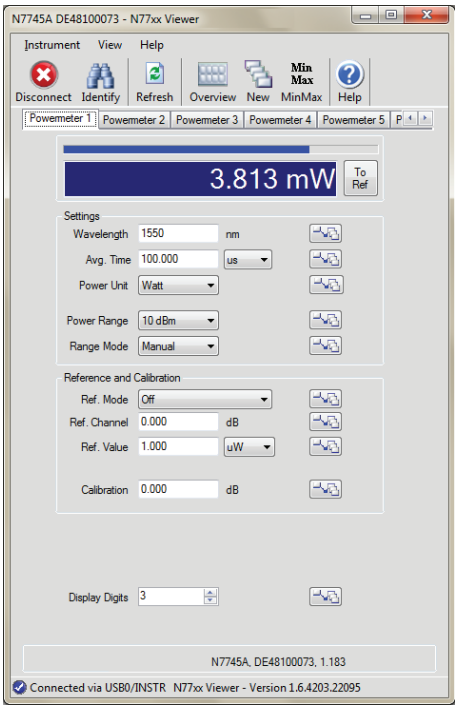


The Polarization Navigator package

provides all the tools needed for your work with N778x polarization analysis and control instruments: measurement of Stokes parameters and degree of polarization (DOP), representation on the Poincaré sphere, PER measurement, long-term monitoring, spike analysis, etc. Various functions for control, switching and scrambling the polarization of optical signals are also provided.

The Polarization Navigator also makes robust single-sweep PMD, PDL and IL measurements with the N7788B and a tunable laser.

Installation of the N7700A main package will also be required. No license required.



The N77xx Viewer

provides a convenient user interface program for the N77-Series products including the N771xA tunable laser sources, the N775xA and N776xA optical attenuator instruments and the N773x optical switches. The program is easy to use and only requires a VISA installation on the computer, which can be obtained by installing the Keysight IO Library Suite from the Package Manager. The N77xx Viewer is free for use with the instruments.

The N4150A Keysight Photonic Foundation Library

is well known for optimizing the speed of repeated-sweep tunable laser routines and for multichannel IL and PDL measurements including use of the 8169A polarization controller. This library has been updated to support the N7744A and N7745A power meters. License available for purchase as N7700A-200.

Configuring the N7700A-100 IL/PDL Measurement Engine

A typical setup for measuring with the IL/PDL engine is shown in Figure 4. Details to the method are described in the application note "IL and PDL spectra with the N7786B Polarization Synthesizer and the N7700A Photonic Application Suite" 5990-3779EN, available at **www.keysight.com/find/n7700.**

This setup combines a continuously-swept tunable laser with the fast-switching N7786B polarization synthesizer and one or more multiport power meter instruments. With multiple power meter instruments, devices with many output ports can be measured with a single wavelength sweep. Similarly, by splitting the signal from the N7786B, multiple devices can also be measured in parallel. For each power meter port, the fast measurement produces wavelength traces of insertion loss and polarization dependent loss with respect to a reference measurement that is usually made by connecting the fiber from the N7786B directly to the optical power meter.

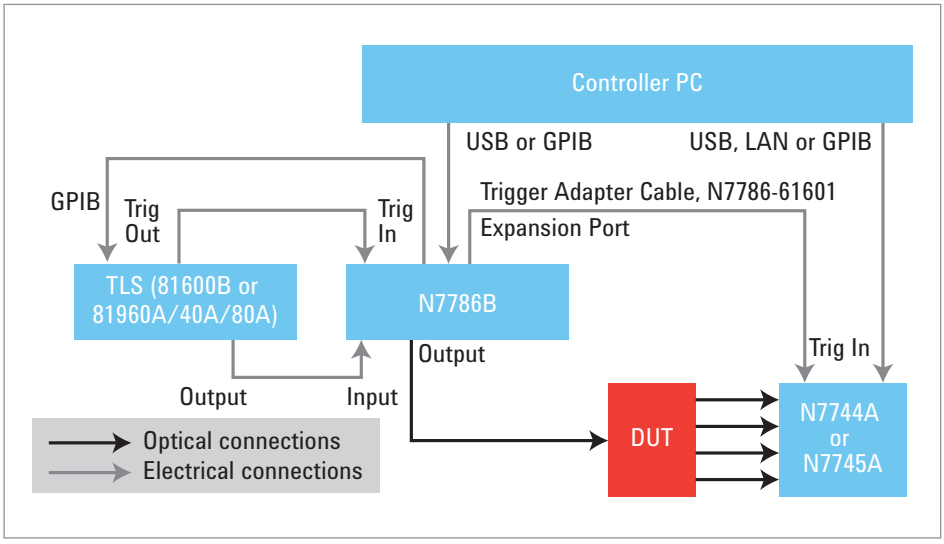


Figure 4. Schematic Setup for Single-Sweep IL and PDL Measurements.

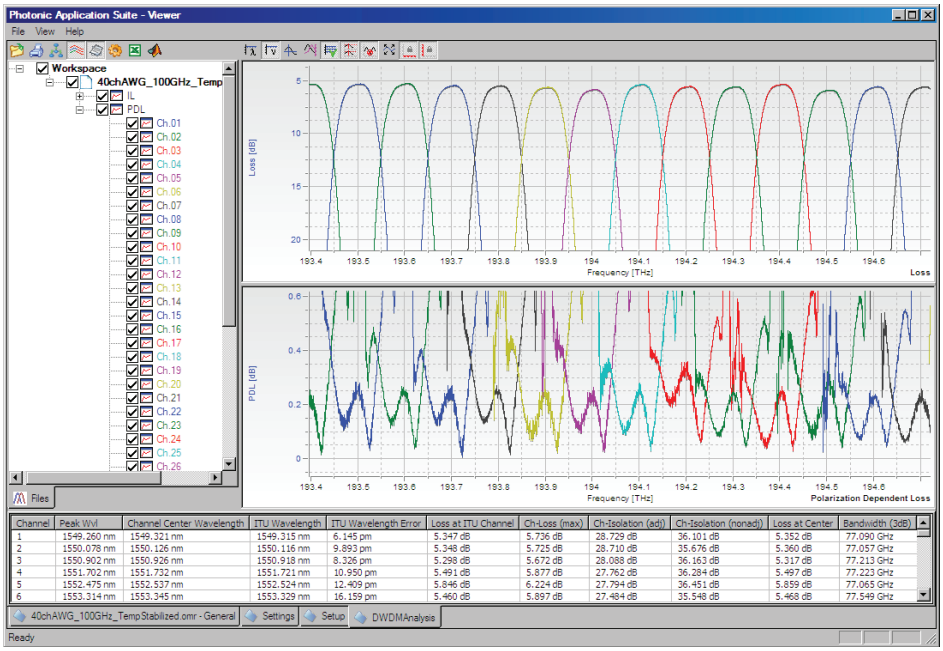


Figure 5. Measurement of 40-channel AWG multiplexer, zoomed to show PDL and channel analysis tab.

Advanced multiport referencing

The reference measurement can be made for each optical port individually. Or to speed the process, the reference can also be made on any single power meter port and then applied to the measurements at all ports. To improve the accuracy in this case, the IL/PDL engine uses the wavelength responsivity data calibrated into the power meters to normalize the measurement results to the responsivity of the detector used for the reference. This corrects for variation in wavelength dependence among the individual detectors.

More complex channel reference schemes can also be configured, for example when a splitter is used to distribute the optical signal to multiple DUTs. Then the reference can be measured at each branch of the splitter on a separate port and these references can then be assigned to the proper ports for the outputs of each device.

These features also apply to the measurement of optoelectric components with photocurrent output, where the optical input signal is measured on an optical channel and the photocurrent is measured on electrical ports of the N7745A-E02 or the B2900A series source/measure units. The N7745A-E02 has 4 optical and 4 electrical ports for this purpose. When using the B2900A series instruments, the optical reference can also be made using an 81636B power sensor module.

Configuring the N7700A-100 IL/PDL Measurement Engine (continued)

Additional functionality with add-on instruments

The measurement capability can be expanded in several ways.

- The wavelength range can be extended by using 2 or 3 tunable lasers, which can be chosen for the desired wavelength range. For example a configuration like in Figure 6 can be used for tests in the O-band, C-band and L-band. The 81600B with option 132 or 130 tunes from 1260 to 1375 nm and the 81960A tunes from 1505 to 1630 nm. Wider ranges and higher spectral dynamics can be obtained by combining 2 or 3 81600B low-SSE lasers, even over the full 1260 to 1640 nm single-mode fiber wavelength range. The measurement runs automatically, like with a single laser, using the 81595B switch. Results are shown as a single graph, possibly with a gap or overlap between the measured wavelength ranges.
- Polarization-averaged return loss can be measured by including the 81610A (or other model) return loss module, as shown in Figure 6. An example including two tunable lasers is shown in Figure 7, where the insertion loss was progressively increased to increase the return loss from an open FC/PC connector. Here the RL range extends beyond 55 dB. In the diagram, the two laser wavelength ranges meet at 1495 nm. The 3 colored traces represent measurements with different insertion loss, adjusted by wrapping the fiber.
- Instruments to detect photocurrent output from the DUT can also be used in the setup to measure optoelectrical devices, as described next.

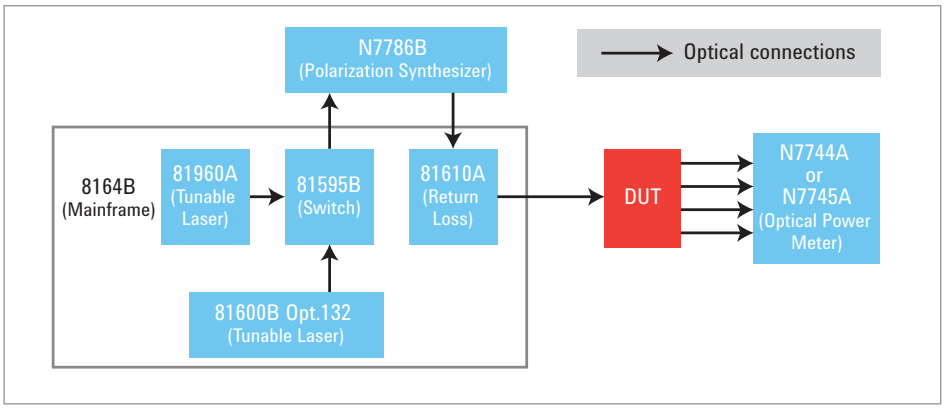


Figure 6. Example IL/PDL configuration using 2 switched lasers and the return loss module.

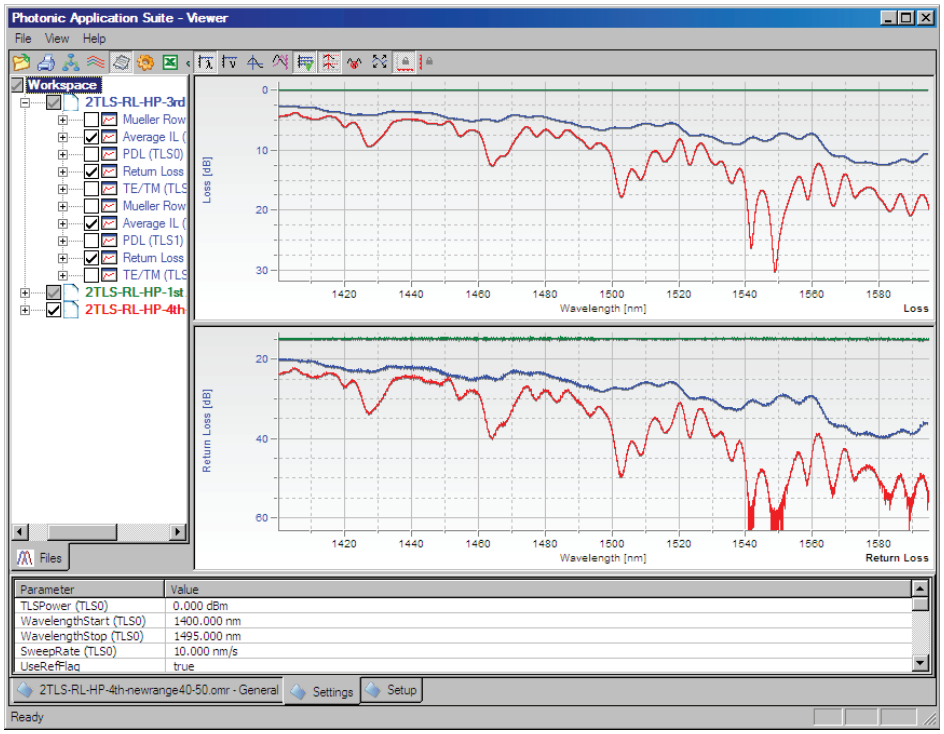


Figure 7. Sample measurements using two lasers to measure from 1400 to 1600 nm, including return loss.

Spectral Measurement of Devices with Integrated Photodiodes

ICR Measurements

With Version 1.5, the Option 100 IL/PDL Engine adds several features that support measurement of ICR and other integrated detector devices.

- The B2900A series source/measure units can also be used to measure the photocurrent, which adds the flexibility of applying positive or negative bias to the anodes. The device can be isolated from chassis ground as well.
- There is a mode with reduced sampling rate to accommodate devices with high capacitance and thus lower bandwidth at the photodiode ports.
- The 81636B fast power sensor can be used for the optical measurements, as an alternative to the multiport power meters. This can be particularly convenient when only one optical port is needed, as for referencing the B2900A photocurrent measurements.
- An additional all-states polarization dependence routine is included for accurate measurement of polarizing devices like ICRs for polarization multiplexed signals. This allows PER measurements beyond 30 dB.
- Photodiode dark current measurement is also available.
- The measurement results can now be shown as maximum and minimum responsivity (A/W) with respect to polarization and the common mode rejection ratio (CMRR) of detector pairs can also be determined.

The system can also be configured to measure devices with integrated photodiodes, for which the output signal is not optical but is instead a photocurrent, which is generally accessible from the bias-voltage pins of the device. Examples include photodiodes and integrated coherent receivers (ICR). One way uses the N7745A in a special configuration with 4 photocurrent inputs and 4 optical power meter inputs. This can be requested as the special N7745A-E02 option and is integrated into the IL/PDL setup in the same way. The software then also provides photocurrent and wavelength responsivity traces. The instrument can also provide a bias voltage to the photodiodes.

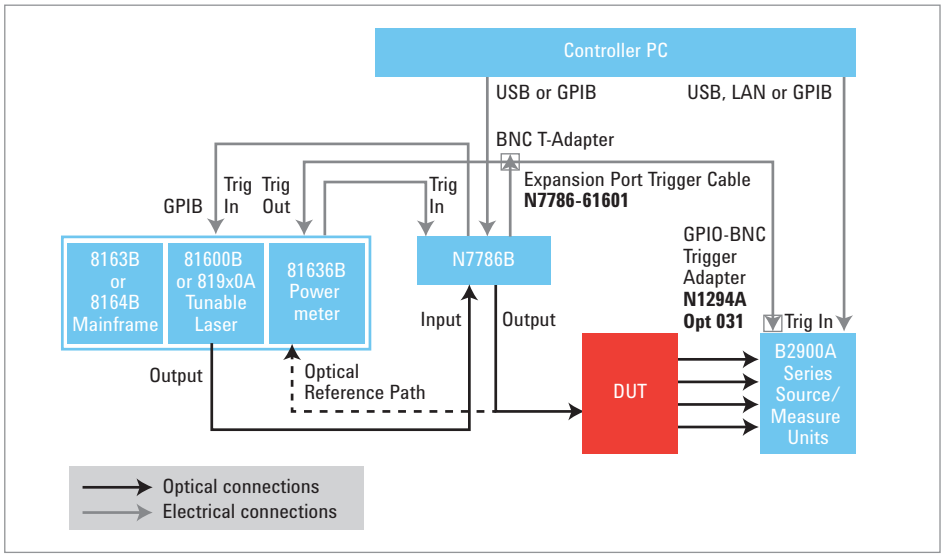


Figure 8. Setup example for ICR measurements.

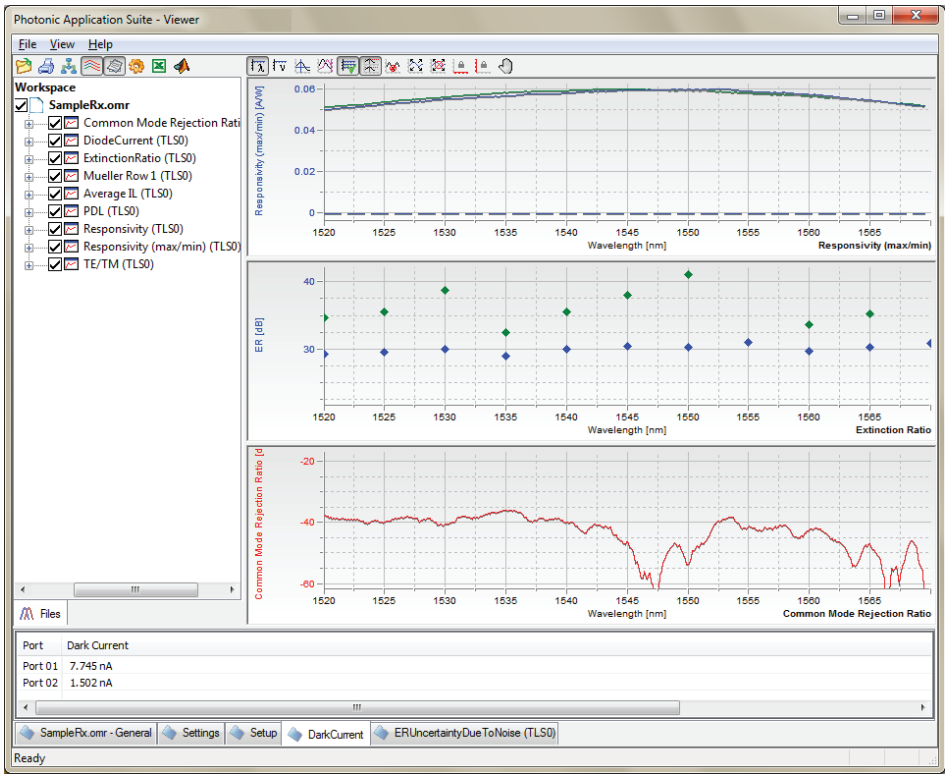


Figure 9. Example measurement for an ICR with high extinction ratio.

Details for Other Applications

Details for the N7700A-101 filter/multiplexer analysis

The N7700A-101 license can be purchased to provide additional analysis of results from the IL/PDL and the IL engines for devices with passbands, like filters, multiplexers, interleavers and delay-line interferometers. The functionality begins with a convenient peak-search routine that can locate multiple channels in a trace. For add-drop filters and multiplexers with a single-wavelength channel on each port, the analysis of the IL trace based on the standard IEC 61300-3-29 gives: peak wavelength, center wavelength, ITU wavelength, ITU wavelength error, loss at ITU wavelength, maximum channel loss, channel ripple, adjacent channel isolation, nonadjacent channel isolation, total crosstalk, loss at center wavelength, and ndB bandwidth. From the PDL trace, the PDL at the ITU wavelength and the maximum channel PDL are also determined.

From the Mueller Matrix results of the IL/PDL measurement, the wavelength or optical frequency offset, PDλ or PDf, between the TE and TM peaks is also determined. This is also used for traces with multiple channels like for interleavers and demodulators. This is also a valuable method for DPSK receivers with integrated delay-line interferometers.

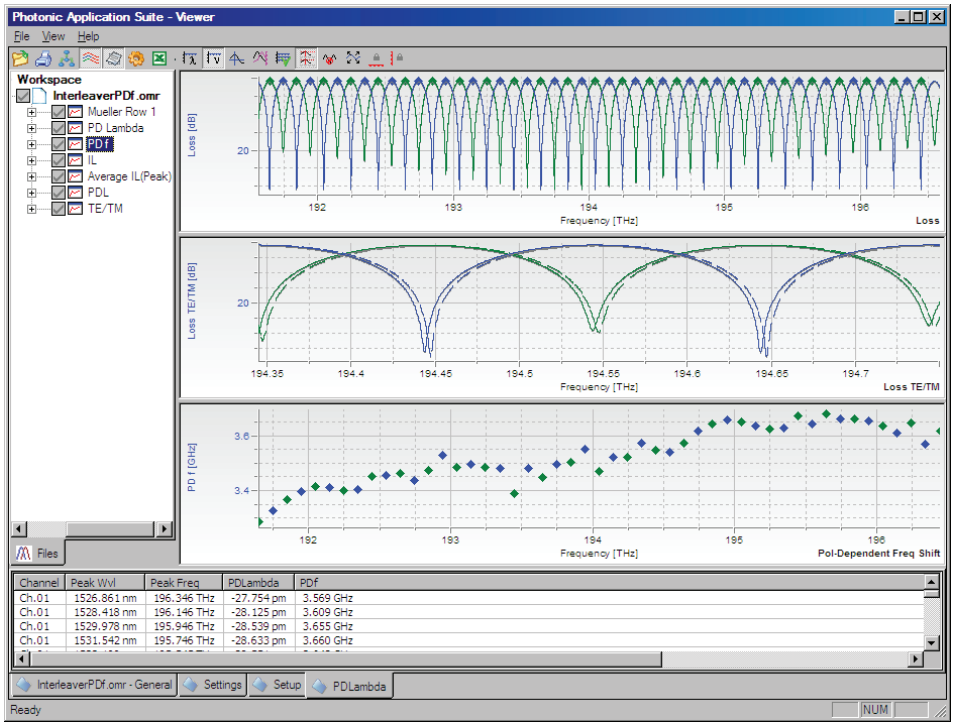


Figure 10. Measurement of an interleaver, analyzed for polarization dependent frequency, PDf.

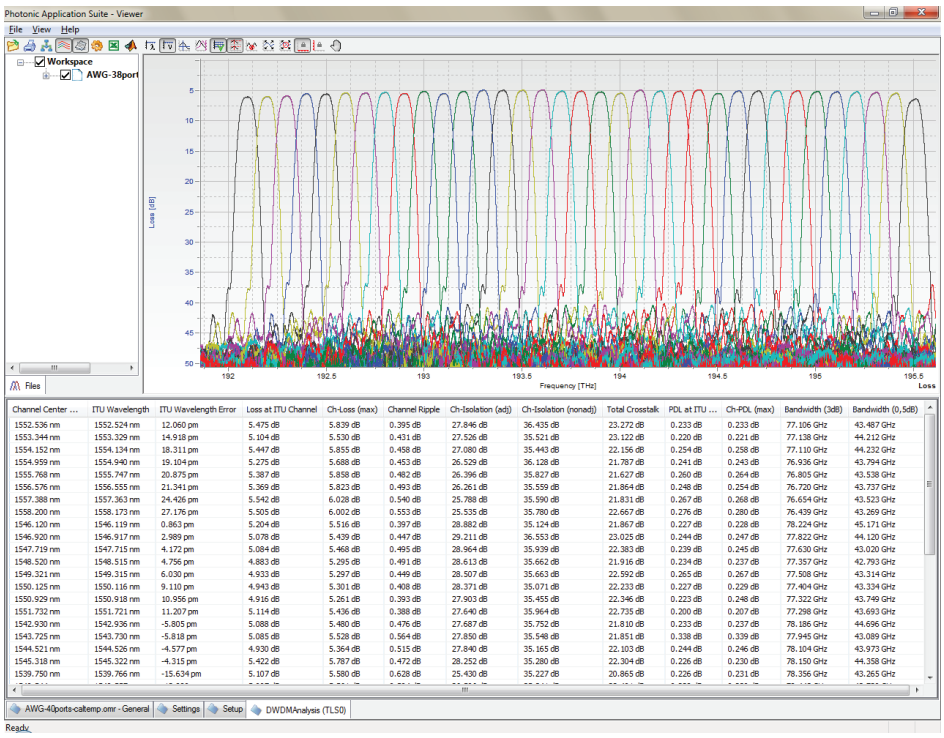


Figure 11. Example of DWDM channel analysis for a 100 GHz AWG multiplexer.

Details for Other Applications (continued)

Configuring the fast spectral loss measurement engine

This engine is used to synchronize one of the Keysight swept-wavelength tunable lasers with an N7744A or N7745A multiport power meter for spectral measurements with high repetition rate and high dynamic range. The setup is illustrated in Figure 10. When used with the 81600B, 81940A or 81980A, this rapidly repeats sweeps from short to long wavelength. With the 81960A, the repetition rate is further increased by using bidirectional sweeps, also measuring while the laser returns to short wavelength.

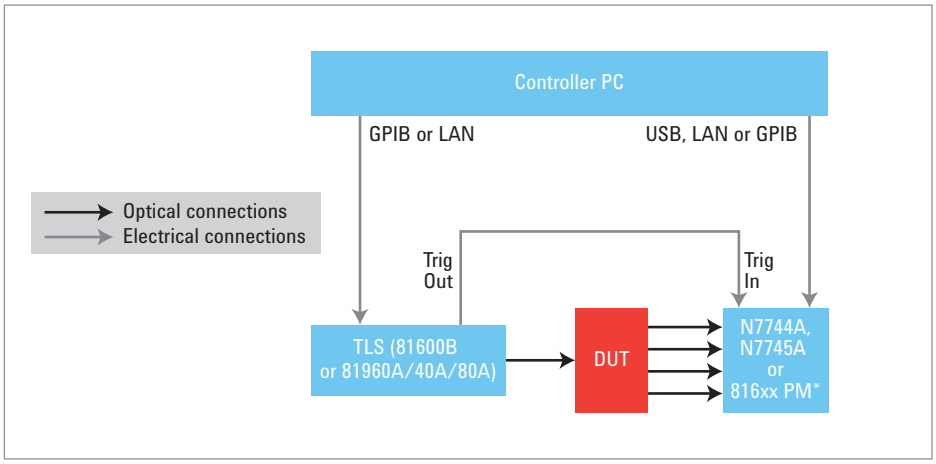


Figure 12. Schematic instrument configuration for Fast Spectral Loss Engine and IL Engine measurements.
* 816xx power meters not supported by Fast Spectral Loss engine.

Configuring the N7700A IL measurement engine

This engine provides a user-interface program for combining a continuously-swept tunable laser with one or more Keysight optical power meters for spectral IL measurements. The program uses the established MFlambdascan routine from the 816x VXI Plug&Play driver, which can also be installed by the N7700A Package Manager. The simple equipment setup is shown in Figure 12. If all power meters are modules in the same mainframe as the tunable laser, then no external trigger cable is needed. No software license is required.

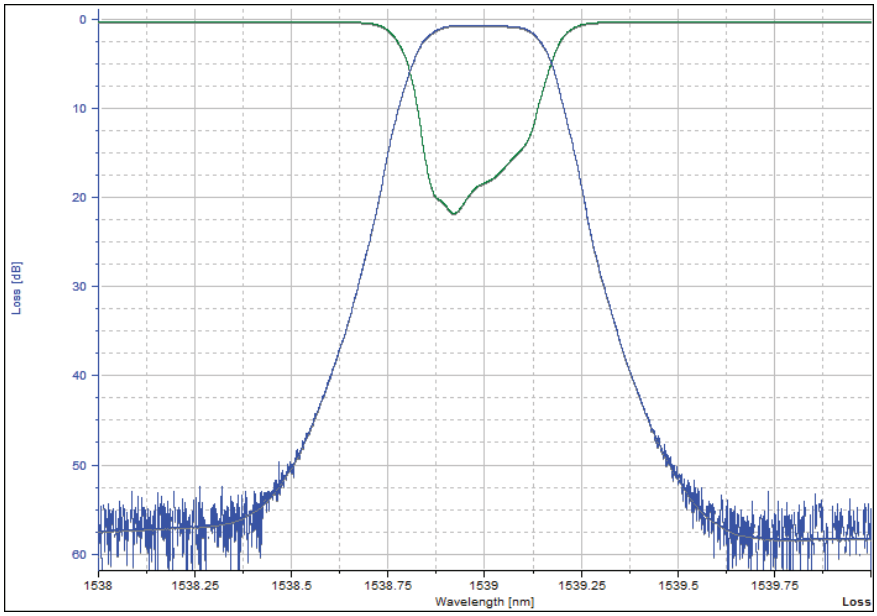


Figure 13. Sample measurement of a 50 GHz add-drop filter showing the dynamic range reached with an 81960A laser.

Details for Other Applications (continued)

Details for the Polarization Navigator

The Polarization Navigator is the user interface for the N778x-series polarization instruments. This has now been integrated into the N7700A suite and is free. Installation requires the N7700A Main package and the Polarization Navigator package.

For instruments that include a polarization analyzer, including the N7781B, N7788B, and more limited to special uses the N7782B and N7786B, the software provides the polarization analyzer functions. The signal can be displayed and traced on the Poincaré sphere or as Stokes vector traces. The degree of polarization and optical power are measured and can be logged. The polarization extinction ratio, PER, of signals in polarization maintaining fiber or the splice angle between two such fibers can be measured, especially when extending the N7782B with one or two N7783B thermal cycling units.

The polarization controlling instruments, the N7784B, N7785B, N7786B, and N7788B are supported in their specific uses for stabilizing, scrambling and determinately setting the state of polarization, with manual and automatic routines. The two instruments with both controller and analyzer, the N7786B and N7788B can display and measure the SOP while it is changed with the controller.

The N7788B is configured so that a polarized source like a tunable laser can be input and the polarization controlled signal is the output to the front panel. It can then be applied to a DUT and the DUT output signal is then returned to the polarization analyzer input of the instrument.

Internal switching for automatic referencing is also included. This setup is especially used for measuring wavelength dependent differential group delay, DGD and PMD, together with PDL and IL. This is also achieved with a single wavelength sweep as with the IL/PDL Engine. So this setup contrasts to the IL/PDL engine in that it also provides DGD and PMD results, but can only measure with one output channel.

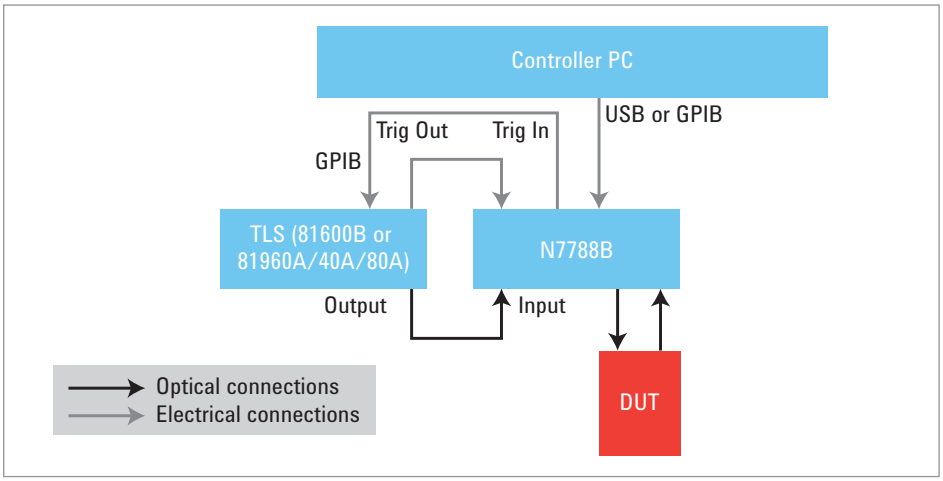


Figure 14. Schematic instrument configuration for swept-wavelength DGD/PMD, PDL and IL measurements using the N7788B.

License ordering information

Model	Description
N7700A-100	IL/PDL (Insertion Loss/Polarization Dependent Loss measurement engine
N7700A-101	Filter/Multiplexer analysis
N7700A-102	Fast spectral loss measurement engine
N7700A-200	Photonic Foundation Library - single user license

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