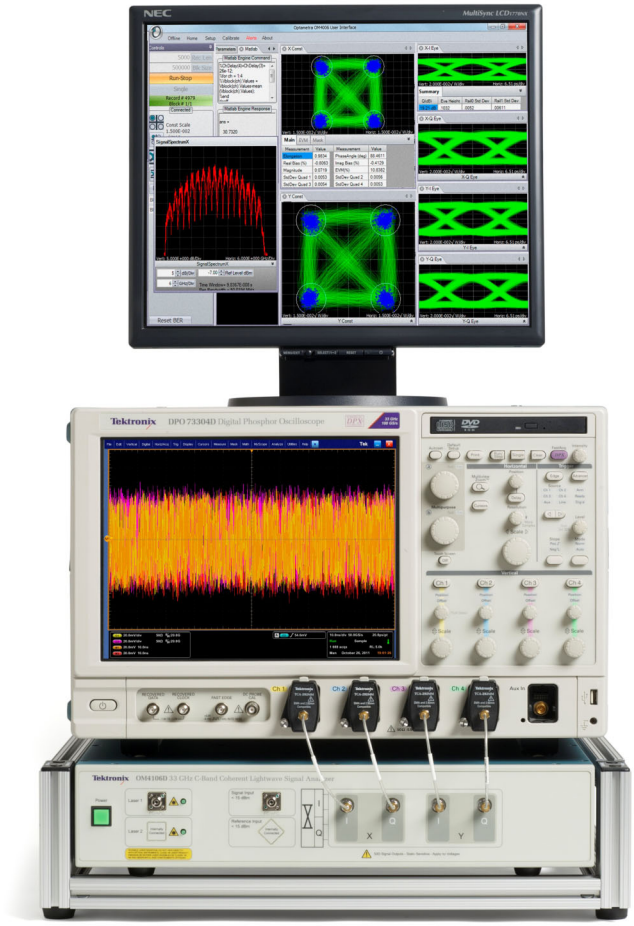
Coherent Lightwave Signal Analyzer

OM4000 Series Data Sheet



OM4000 Series Coherent Lightwave Signal Analyzer (CLSA) and Tektronix*2 DPO70000 Series Oscilloscope.

Features & Benefits

- Superior User Interface offers Comprehensive Visualization for Ease-of-Use Combined with the Power of MATLAB*1
- Coherent Lightwave Signal Analyzer Software included with OM1106 and OM4000 Series Products
- Complete Coherent Signal Analysis System for Polarization-multiplexed QPSK, Offset QPSK, QAM, Differential BPSK/QPSK, and Other Advanced Modulation Formats
- Displays Constellation Diagrams, Phase Eye Diagrams, Q-factor, Q-plot, Spectral Plots, Poincaré Sphere, Laser Phase Characteristics, BER, with Additional Plots and Analyses available through the MATLAB Interface
- User Access to Internal Functions with a Direct MATLAB Interface
- Coherent Lightwave Signal Analyzer Software tolerates >5 MHz Instantaneous Signal Laser Linewidth – Compatible with Standard Network Tunable Sources such as DBR and DFB Lasers
- No Laser Phase or Frequency Locking Required
- Smart Polarization Separation Follows Signal Polarization
- Incorporates a Coherent Receiver for High-stability, Linear, Polarization-diverse, Optical Field Detection
- Includes Signal and Reference Tunable Laser Sources in OM4000 Series Receivers
- Runs with Tektronix and Other Real-time Oscilloscopes*2

*1 MATLAB is a registered trademark of MathWorks.

*2 The OM4106D requires a Tektronix DPO70000 Series Oscilloscope. Other OM4000 models are compatible with many oscilloscopes. Contact sales for details.

Tektronix®

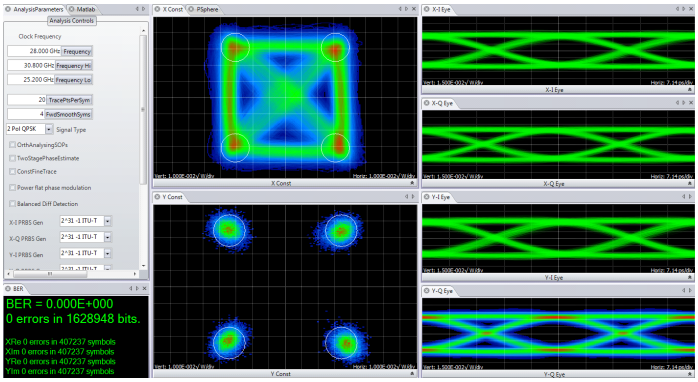


Figure 1 – OM4000 User Interface (OUI) showing some color-grade graphics options. Symbols can also be colored to a key indicating prior state. Data shown is 112 Gb/s PM-QPSK.

Introduction

The OM4000 Coherent Lightwave Signal Analyzer (CLSA) is a 1550 nm (C- and L-band) fiber-optic test system for visualization and measurement of complex modulated signals, offering a complete solution to testing both coherent and direct-detected transmission systems. The CLSA consists of a polarization- and phase-diverse receiver and analysis software enabling simultaneous measurement of modulation formats important to advanced fiber communications, including polarization-multiplexed (PM-) QPSK. The CLSA software performs all calibration and processing functions to enable real-time burst-mode constellation diagram display, eye-diagram display, Poincaré sphere, and bit-error detection. Working with a Tektronix real-time oscilloscope solution of sufficient bandwidth, bit rates exceeding 240 Gb/s can be analyzed.

OM4000 Series User Interface (OUI)

The common thread through the Coherent Lightwave Signal Analyzer product line is the OUI which governs the operation and display of data. Color-grade, persistence, and color-key options are available to help you visualize the data. In Figure 1, the horizontal transitions are more rare than the vertical transitions due to the relative timing of the IQ data sequence (upper middle of Figure 1). The other polarization constellation is shown in color grade with only the symbol points (lower middle). Color grade is also available for the eye diagram (bottom right).

Interaction between OM4000 Series User Interface (OUI) and MATLAB

The OUI takes information about the signal provided by the user together with acquisition data from the oscilloscope and passes them to the MATLAB workspace, shown in Figure 2. A series of MATLAB scripts are then called to process the data and produce the resulting field variables. The OUI then retrieves these variables and plots them. Automatic test is accomplished by connecting to the OUI or by connecting directly to the MATLAB workspace.

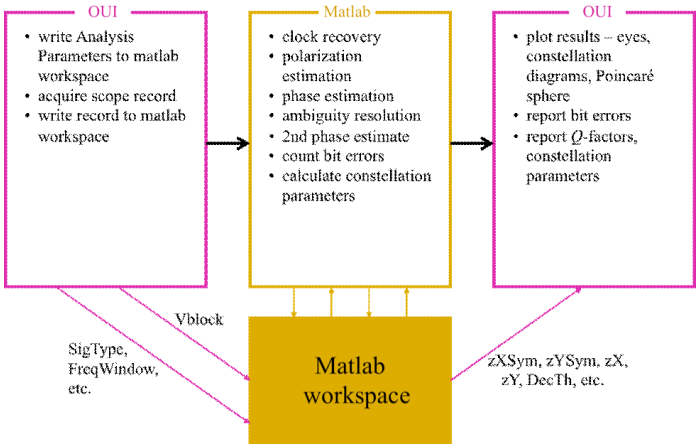


Figure 2 – Illustration of data flow under control of the OUI.

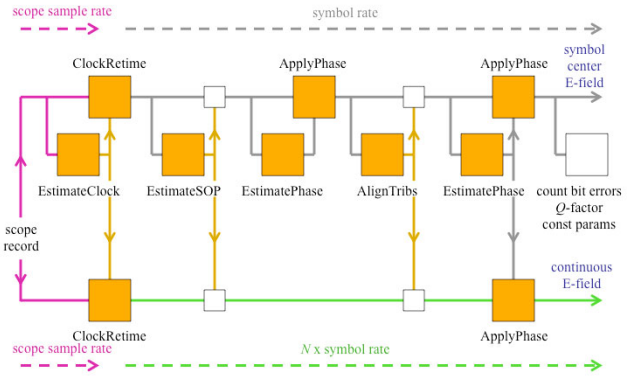


Figure 3 – Data flow through the “Core Processing” engine.

Signal Processing Approach

The first step after data acquisition is to recover the clock and re-time the data at 1 sample per symbol at the symbol center for the polarization separation and following algorithms (shown as upper path in Figure 3). The data is also re-sampled at 10X the baud rate (user settable) to define the traces that interconnect the symbols in the eye diagram or constellation (shown as the lower path). The clock recovery approach depends on the chosen signal type. Laser phase is then recovered based on the symbol-center samples. Once the laser phase is recovered, the modulation portion of the field is available for alignment to the expected data for each tributary. At this point bit errors may be counted by looking for the difference between the actual and expected data after accounting for all possible ambiguities in data polarity. The polarity with the lowest BER is chosen. Once the actual data is known, a second phase estimate may be performed to remove errors that may result from a laser phase jump. Once the field variables are calculated, they are available for retrieval and display by the OUI. At each step the best algorithms are chosen for the specified data type, requiring no user intervention unless desired.

Characteristics

Values stated in the following tables are typical unless stated otherwise (some values are oscilloscope limited).

Coherent Lightwave Signal Analyzer

Characteristic	Description
Maximum Detectable Baud Rate (at Q of 9.5 dB)	60 Gbaud with Tektronix*2 DPO73304D (2-Ch) 46 Gbaud with Tektronix DPO73304D (4-Ch) 40 Gbaud with Tektronix*2 DPO72004
Maximum Detectable Bit Rate for PM-QPSK (at Q of 9.5 dB)	240 Gb/s with Tektronix*2 DPO73304D (×2) 180 Gb/s with Tektronix DPO73304D (×1) 160 Gb/s with Tektronix*2 DPO72004
Sample Rate	100 GS/s with Tektronix*2 DPO73304D 50 GS/s with Tektronix*2 DPO72004
Optical Field Uncertainty (RMS)	2%
O/E Gain Imbalance Between I and Q	0.1 dB
Available Modulation Formats	OOK, 3-state OOK, (PM) BPSK, (PM) QPSK, (PM) 8, 16, 32, 64-QAM, (PM) Offset QPSK, (PM) 8-PSK Any PRBS or user-supplied pattern Contact factory for new modulation formats
Control	Built-in Ethernet interface

*2 The OM4106D requires a Tektronix DPO70000 Series Oscilloscope. Other OM4000 models are compatible with many oscilloscopes. Contact sales for details.

OM4000 Series Coherent Receiver

Characteristic	Description
Optical Input	C-band: 1530 to 1570 nm L-band: 1570 to 1610 nm (Optional) C- and L-band: 1530 to 1610 nm (Optional)
Maximum Input Power	+15 dBm
Maximum Input Power Damage Level	+20 dBm
Polarization Extinction Ratio	>35 dB
Optical Local Oscillator Output	
Optical CW Output Power	+14.5 dBm C-band: 1527.6 to 1565.5 nm L-band: 1570.01 to 1608.76 nm (Optional)
External Local Oscillator Input	
Optical Input Wavelength Range	C-band: 1530 to 1570 nm L-band: 1570 to 1610 nm (Optional)
Suggested External Local Oscillator Input Power Range	+7 to +15 dBm
Maximum Input Peak Power (Damage level)	+20 dBm
Instantaneous Linewidth	<5 MHz
Additional Items	
Electrical Bandwidth	OM4106D: 33 GHz OM4106B: 32 GHz OM4006D: 23 GHz
Optical Phase Angle of IQ Mixer After Correction	90° ±1°
Skew After Correction	±1 ps

Local Oscillator

Characteristic	Description
Wavelength Range	C-band: 1527.6 to 1565.5 nm L-band: 1570.01 to 1608.76 nm
Minimum Wavelength Step	10 GHz
Minimum Frequency Step	100 MHz
Absolute Wavelength Accuracy	10 pm
Linewidth (Short term)	100 kHz
Sidemode Suppression Ratio	55 dB

High-resolution Spectrometer

Characteristic	Description
Maximum Frequency Span	LO frequency ± scope bandwidth
LO Wavelength Range	C-band: 1527.6 to 1565.5 nm L-band: 1570.01 to 1608.76 nm
Number of FFT Points	500k
Minimum RBW	1/max scope time window
Frequency Accuracy	10 pm

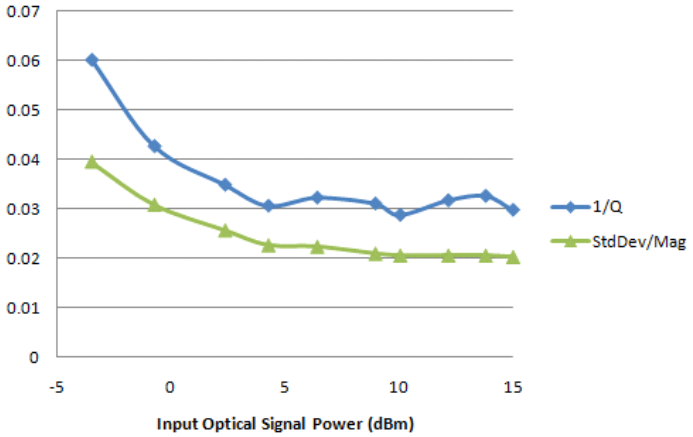


Figure 4 – Constellation diagram accuracy including intradyne and demodulation error can be measured by the RMS error of the constellation points divided by the magnitude of the electric field for each polarization signal. The following data has been measured on a 2.5 Gbaud NRZ 1-pol QPSK transmitter using a Tektronix*2 MSO72004 digitizer.

Measurement Display and Analysis Tools (OM1106 and OM4000 Series)

Characteristic	Description
Constellation Diagram	Constellation diagram accuracy including intradyne and demodulation error can be measured by the RMS error of the constellation points divided by the magnitude of the electric field for each polarization signal; See Figure 4
Constellation Elongation	Ratio of constellation height to width
Constellation Phase Angle	Measure of transmitter IQ phase angle
Constellation I and Q Bias	Measure of average symbol position relative to the origin
Constellation Mask	User-settable allowed EVM level. Symbols violating the mask are counted
Eye Decision Threshold Q-factor	The actual Q achieved will depend on the quality of the data signal, the signal amplitude, and the oscilloscope used for digitization. Using the Tektronix*2 DPO73304D oscilloscope (4-Ch), a Q-factor of 20 dB is achievable at 32 Gbaud
Decision Threshold Q-plot	Displays BER vs. decision threshold for each eye opening. The Q value at optimum decision threshold is the Q-factor
Phase Diagram	Display of signal electric field vs. time in the complex plane
Signal Spectrum and Laser Spectrum	FFT of power signal or laser phase noise
MATLAB Window	Commands may be entered that execute each time signals are acquired and processed
Phase vs. Time Available in MATLAB	Plot any result variable vs. time with MATLAB tools
Frequency Offset Available in MATLAB	All result variables are available through MATLAB even if not displayed in the user interface
Poincarè Sphere	Polarizations of the Pol-muxed signal tributaries are tracked and displayed on the Poincarè sphere. PER is measured
Signal Quality	EVM, Q-factor, and Mask Violations
Tributary Skew	Use the coherent eye diagrams to measure transmitter tributary skew
CD Compensation	No intrinsic limit for offline processing – FFT-based filter to remove CD in frequency domain based on a given dispersion value
DGD Compensation	Open-architecture MATLAB-based system to do first-order compensation
Oscilloscope Delay Compensation	±1 ns
Cable Delay Compensation	±1 ns
Calibration Routines	Receiver Skew, DC Offset, and Path Gain Mismatch Hybrid angle and state of polarization are factory calibrated
Data Export Formats	MATLAB (other formats available through MATLAB or ATE interface); PNG
Raw Data Replay with Different Parameter Setting	Movie mode and reprocessing
Bit Error Ratio Measurements	Number of counted bits/symbols Number or errors detected Bit error ratio Save acquisition on detected error
Offline Processing	Run software on a separate PC or on the oscilloscope

*2 The OM4106D requires a Tektronix DPO70000 Series Oscilloscope. Other OM4000 models are compatible with many oscilloscopes. Contact sales for details.

Physical Characteristics

Dimension	mm	in.
Height	89	3.5
Width	432	17.0
Depth	298.5	11.75
Weight	**kg**	**lb.**
Net	11.8	26
Shipping	15.9	35

Environmental Characteristics – Scope Not Included (OM4106B)

Characteristic	Description
Temperature	
Operating	+10 +35 °C
Storage	–20 to +70 °C, noncondensing humidity
Humidity	15% to 80% relative humidity, noncondensing
Power Requirements	100/115/230 V AC, ~50 to 60 Hz, 1 power cable, max. 100 VA

Calibration and Warranty

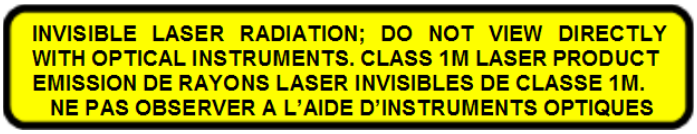
Characteristic	Description
Calibration Interval	1 year

CAUTION

This device is a Class 1M laser product for use only under the recommended operating conditions and ratings specified in the data sheet. Use of controls or adjustments or performance of procedures other than those specified in the data sheet may result in hazardous radiation exposure.

Invisible laser radiation – Do not view the laser output from this device directly with optical instruments.

This device complies with 21CFR1040.10 except for deviations pursuant to Laser Notice No. 50, dated June 24, 2007.



Ordering Information

Models

Model	Option	Description	Receiver Bandwidth	C-band Lasers Included	L-band Lasers Included	Wavelength Band	Oscilloscope Connectivity
OM4006D	CC	23 GHz C-band Coherent Lightwave Signal Analyzer	23 GHz	2	0	1530 to 1570 nm	IVI / Visa
OM4006D	LL	23 GHz L-band Coherent Lightwave Signal Analyzer	23 GHz	0	2	1570 to 1610 nm	IVI / Visa
OM4006D	CL	23 GHz C- and L-band Coherent Lightwave Signal Analyzer	23 GHz	1	1	1530 to 1610 nm	IVI / Visa
OM4106B	CC	32 GHz C-band Coherent Lightwave Signal Analyzer	32 GHz	2	0	1530 to 1570 nm	IVI / Visa
OM4106B	LL	32 GHz L-band Coherent Lightwave Signal Analyzer	32 GHz	0	2	1570 to 1610 nm	IVI / Visa
OM4106B	CL	32 GHz C- and L-band Coherent Lightwave Signal Analyzer	32 GHz	1	1	1530 to 1610 nm	IVI / Visa
OM4106D	CC	33 GHz C-band Coherent Lightwave Signal Analyzer	33 GHz	2	0	1530 to 1570 nm	DataStore
OM4106D	LL	33 GHz L-band Coherent Lightwave Signal Analyzer	33 GHz	0	2	1570 to 1610 nm	DataStore
OM4106D	CL	33 GHz C- and L-band Coherent Lightwave Signal Analyzer	33 GHz	1	1	1530 to 1610 nm	DataStore

Note: DataStore interface is only applicable to Tektronix 70000 Series oscilloscopes.

User Manual Options

Option	Description
Opt. L0	English manual

Power Plug Options

Option	Description
Opt. A0	US plug, 115 V, 60 Hz
Opt. A1	Universal Euro plug, 220 V, 50 Hz
Opt. A2	UK plug, 240 V, 50 Hz
Opt. A3	Australian plug, 240 V, 50 Hz
Opt. A5	Swiss plug, 220 V, 50 Hz
Opt. A6	Japanese plug, 100 V, 110/120 V, 60 Hz
Opt. A10	China plug, 50 Hz
Opt. A11	India plug, 50 Hz
Opt. A12	Brazilian plug, 60 Hz

Service Options

Option	Description
Opt. C3	Calibration Service 3 Years
Opt. C5	Calibration Service 5 Years
Opt. D1	Calibration Data Report
Opt. D3	Calibration Data Report 3 Years (with Opt. C3)
Opt. D5	Calibration Data Report 5 Years (with Opt. C5)
Opt. R3	Repair Service 3 Years
Opt. R5	Repair Service 5 Years

Instrument Models and Options

Order	Description
OM1106	
OM1106 QAM	Adds QAM and other software demodulators
OM1106 SWS0	1-year OM1106 software maintenance agreement from date of purchase (included at no charge)
OM1106 SWS2	2-year OM1106 software maintenance agreement from date of purchase
OM1106 SWS3	3-year OM1106 software maintenance agreement from date of purchase
OM2012	
OM2012	nLaser Tunable Laser Source (requires choice of lasers)
OM2012 CC	C-band nLaser (with 2 C-band lasers)
OM2012 LL	L-band nLaser (with 2 L-band lasers)
OM2012 CL	C- and L-band nLaser (with 1 C-band laser and 1 L-band laser)
OM2210	
OM2210	Coherent Receiver Calibration Source; includes calibration software (requires choice of lasers)
OM2210 C	C-band Coherent Receiver Calibration Source (with 1 C-band laser)
OM2210 L	L-band Coherent Receiver Calibration Source (with 1 L-band laser)
OM2210 CC	C-band Coherent Receiver Calibration Source (with 2 C-band lasers)
OM2210 LL	L-band Coherent Receiver Calibration Source (with 2 L-band lasers)
OM2210 CL	C- and L-band Coherent Receiver Calibration Source (with coupled C- and L-band lasers)
OM2210 NL	Coherent Receiver Calibration Source (no lasers, tested over C- and L-band)
OM4006D	
OM4006D	23 GHz Coherent Lightwave Signal Analyzer (requires choice of lasers)
OM4006D CC	C-band lasers (receiver tested over C-band)
OM4006D LL	L-band lasers (receiver tested over L-band)
OM4006D CL	Coupled C- and L-band lasers (receiver calibrated over C- and L-band)
OM4006D NL	No lasers (receiver calibrated over C- and L-band)
OM4006D EXT	Adds external connections for reference laser
OM4006D QAM	Adds QAM and other software demodulators
OM4006D TSI	Integrate Tektronix oscilloscope with OM4006D Contact sales for integration with other oscilloscopes
OM4006D SWS0	1-year Signal Analyzer software maintenance agreement from date of purchase (included at no charge)
OM4006D SWS2	2-year Signal Analyzer software maintenance agreement from date of purchase
OM4006D SWS3	3-year Signal Analyzer software maintenance agreement from date of purchase
OM4106B	
OM4106B	32 GHz Coherent Lightwave Signal Analyzer (requires choice of lasers)
OM4106B CC	C-band lasers (receiver tested over C-band)
OM4106B LL	L-band lasers (receiver tested over L-band)
OM4106B CL	Coupled C- and L-band lasers (receiver calibrated over C- and L-band)
OM4106B NL	No lasers (receiver calibrated over C- and L-band)
OM4106B EXT	Adds external connections for reference laser
OM4106B QAM	Adds QAM and other software demodulators
OM4106B TSI	Integrate Tektronix oscilloscope with OM4006D Contact sales for integration with other oscilloscopes
OM4106B SWS0	1-year Signal Analyzer software maintenance agreement from date of purchase (included at no charge)
OM4106B SWS2	2-year Signal Analyzer software maintenance agreement from date of purchase
OM4106B SWS3	3-year Signal Analyzer software maintenance agreement from date of purchase
OM4106D	
OM4106D	33 GHz Coherent Lightwave Signal Analyzer (requires choice of lasers)
OM4106D CC	C-band lasers (receiver tested over C-band)
OM4106D LL	L-band lasers (receiver tested over L-band)
OM4106D CL	Coupled C- and L-band lasers (receiver calibrated over C- and L-band)
OM4106D NL	No lasers (receiver calibrated over C- and L-band)
OM4106D EXT	Adds external connections for reference laser
OM4106D QAM	Adds QAM and other software demodulators
OM4106D TSI	Integrate Tektronix oscilloscope with OM4006D
OM4106D SWS0	1-year Signal Analyzer software maintenance agreement from date of purchase (included at no charge)
OM4106D SWS2	2-year Signal Analyzer software maintenance agreement from date of purchase
OM4106D SWS3	3-year Signal Analyzer software maintenance agreement from date of purchase
General	
OMCABLE	Replacement OM cable kit
OMDONGLE	Replacement OM license dongle (requires software license key number)
OMRACK	Tabletop mounting rack for OM4000 Series
OMTRAIN	On-site training and/or installation for OMxxxx products
OMADDLSW	Additional set of Coherent Lightwave Signal Analyzer Software (requires OM4106 instrument serial number)
OMSWS1	1-year Signal Analyzer software maintenance agreement from date of purchase
OMSWS2	2-year Signal Analyzer software maintenance agreement from date of purchase
OMSWS3	3-year Signal Analyzer software maintenance agreement from date of purchase
QAM	Adds QAM and other software demodulators

Upgrade Options

Order	Description
OM1106	
OM11UP QAM	Adds QAM and other software demodulators
OM4006D	
OM40UP QAM	Adds QAM and other software demodulators
OM40UP CC	Replaces OM4006 lasers with 2 C-band lasers
OM40UP LL	Replaces OM4006 lasers with 2 L-band lasers
OM40UP CL	Replaces OM4006 lasers with 1 C-band laser and 1 L-band laser
OM40UP EXT	Adds external connections for reference laser
OM40UP TSI	Adds integration with Tektronix oscilloscope Contact sales for integration with other oscilloscopes
OM40UP 4006D	Upgrades OM4006 (any model) to OM4006D
OM40UP 4106B	Upgrades OM4006 (any model) to OM4106B
OM40UP 4106D	Upgrades OM4006 (any model) to OM4106D
OM4106B	
OM41BUP QAM	Adds QAM and other software demodulators
OM41BUP CC	Replaces OM4006 lasers with 2 C-band lasers
OM41BUP LL	Replaces OM4006 lasers with 2 L-band lasers
OM41BUP CL	Replaces OM4006 lasers with 1 C-band laser and 1 L-band laser
OM41BUP EXT	Adds external connections for reference laser
OM41BUP TSI	Adds integration with Tektronix oscilloscope Contact sales for integration with other oscilloscopes
OM41BUP 4106B	Upgrades OM4106 (any model) to OM4106B
OM41BUP 4106D	Upgrades OM4106 (any model) to OM4106D
OM4106D	
OM41DUP QAM	Adds QAM and other software demodulators
OM41DUP CC	Replaces OM4006 lasers with 2 C-band lasers
OM41DUP LL	Replaces OM4006 lasers with 2 L-band lasers
OM41DUP CL	Replaces OM4006 lasers with 1 C-band laser and 1 L-band laser
OM41DUP EXT	Adds external connections for reference laser
OM41DUP TSI	Adds integration with Tektronix oscilloscope

Additional Requirements for CLSA Software

Customer must provide Mathworks MATLAB 2009a (32-bit) software and computer for it to run on; computer must include an nVidia brand video card for compatibility with some graphics features, and must run Windows XP (32-bit) or Windows 7 (32- or 64-bit). The CLSA software will run on the 70000 Series oscilloscopes, but Windows 7 is preferred. Please check with Tektronix when ordering for the most up-to-date detailed requirements including support for the latest releases of MATLAB software.

Please contact Tektronix for a price quote or to arrange a demonstration. All product descriptions and specifications are subject to change without notice.

CE

Tektronix is registered to ISO 9001 and ISO 14001 by SRI Quality System Registrar.

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For Further Information. Tektronix maintains a comprehensive, constantly expanding collection of application notes, technical briefs and other resources to help engineers working on the cutting edge of technology. Please visit **www.tektronix.com**

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