multiLane

PRELIMINARY DATASHEET

Innovation for the next generation

ML4015E

Optical and Electrical Sampling Oscilloscope

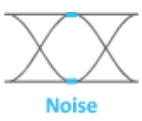
Ideal for 53.125 GBaud PAM4 and NRZ transceiver testing | Supports 802.3 TDECQ measurements via SSPRQ patterns | Open Eye MSA support | 100G per wavelength and channel characterization

Summary

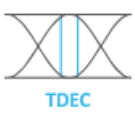
Currently the Data Center Interconnect market is rapidly transitioning to 100G per channel for both optical, as well electrical interfaces, with the introduction of 800G Ethernet. Cost-effective characterization tools are required to enable this technology transition and to accelerate the deployment of 800G Data Center Interconnects, such as optical transceivers.

The characterization of Ethernet transceivers introduces a myriad of test and measurement challenges. For instance, precise validation of 53.125 GBaud PAM4 optical transmitters requires prohibitively expensive instrumentation setups for production applications. MultiLane introduces the ML4015E Optical and Electrical Sampling Oscilloscopes as a well-correlated alternative to incumbent solutions at a high-value price point.

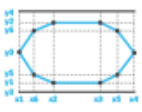
Key Features



Extremely low noise



Fast TDECQ

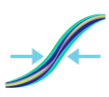


Comprehensive eye mask library

Extensive library of built-in DSP filters

Brand new user interface

Precision TimeBase



Extremely low jitter

ML4015E

Optical and Electrical DSO

Introduction

The ML4015E is a fully featured, cost effective single channel sampling oscilloscope. It can be configured to have an optical bandwidth of either 25 or 40 GHz. The supported wavelengths range from 1260 to 1650 nm single mode or 700 to 870 nm multimode. The ML4015E can also be configured with either a 35 or 70 GHz differential electrical sampler.

Key Features

The ML4015E family of optical DSOs boasts an extensive set of features and functions that are unique in the industry. These include:

- A noise floor of 5 µW at an analog bandwidth of 25 GHz, and 6-7 µW at 42 GHz bandwidth.
- Sensitivity level of -11 dBm for a 25.78 Gbps NRZ signal.
- Up to 50 - 70 MHz sampling rate.
- Less than 10 seconds TDECQ on an SSPRQ pattern.
- FPGA-based architecture enabling TDECQ measurements via capture of SSPRQ and PRBS16 patterns.
- An extensive library of built-in DSP filters such as Bessel-Thomson, CTLE, DFE, FFE, de-embedding, and component emulation, all available free of charge in the standard GUI.
- Comprehensive eye mask library.
- Individual impulse response calibration performed at factory.
- Compact instrument footprint with a ruggedized enclosure and handle.
- Comprehensive set of APIs and associated sample scripts to accelerate automation development under Linux and Windows, supporting Python, LabView, Matlab, and C#.

Typical Optical Applications

- Production/manufacturing testing of 1G to 800G optical transceivers.
- Benchtop characterization of optical circuits.
- Qualification of PAM-N and NRZ optical modulators and drivers.
- Sensitivity testing of optical receivers.
- System testing with ML1016E-CR clock

Typical Electrical Applications

- TP1a stress calibration.
- SERDES characterization.
- Receiver electrical output characterization.
- Benchtop characterization of electrical circuits.

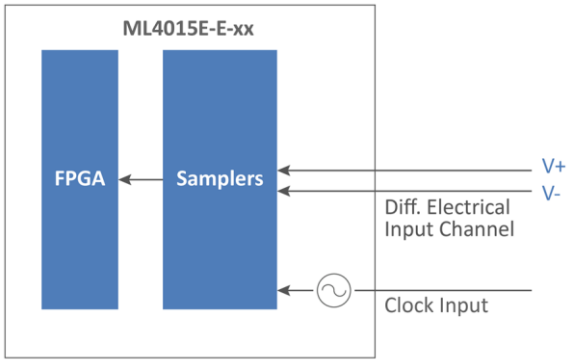


Figure 1: Schematics of the ML4015E-E-35 (or 70)

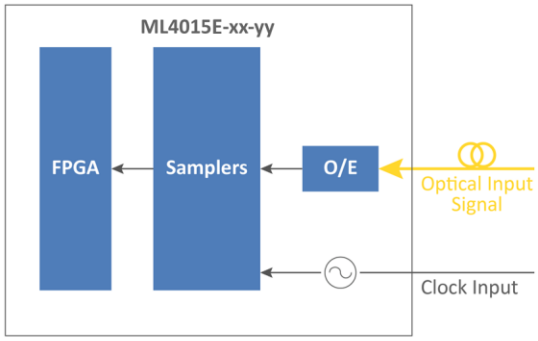


Figure 2: Schematics of the ML4015E-OPT

Optical Specifications

Parameter	Specifications
SM Wavelength	1260 - 1650 nm
MM Wavelength	700 - 870 nm
Calibrated wavelengths	1310 and 850 nm
Optical bandwidth	25 or 42 GHz
Noise RMS at 1310 nm	5 µW at 25 GHz 6 - 7 µW at 40 GHz
Sensitivity at 1310 nm at 25.78 G NRZ	< -11 dBm
Intrinsic jitter	220 fs rms (PTB Enabled) 300 fs rms (no PTB)
Input Power damage level	10 dBm
Fiber Input SM	9 / 125 µm
Fiber Input MM	50 / 125 µm
Connector	FC-UPC
Analog Sampling Hardware Resolution	14 bits
Clock input bandwidth	0.1 - 20 GHz
Clock input swing	225-1800 mVpp
Clock input connector	SMA (f), 50 Ω
Pattern capture	> 8 M Samples
Sampling frequency	50 - 70 MHz
Memory	8 MSa
Pattern Lock	Up to PRBS16, SSPRQ
Temperature range	0 - 75 °C
Line Power	100 - 240 V AC, 50 / 60 Hz

Electrical Specifications

Parameter	Specifications
Electrical amplitude	< 600 mV SE and < 1200 mV Diff
Electrical bandwidth	35 or 70 GHz
Intrinsic jitter	250 fs rms
Electrical channel Connectors	1.85mm or SMPS
Analog Sampling Hardware Resolution	14 bits
Clock input bandwidth	0.1 - 20 GHz
Clock input swing	225 - 1800 mVpp
Clock input connector	SMA (f), 50 Ω
Pattern capture	> 8 M Samples
Sampling frequency	50 - 70 MHz
Memory	8 MSa
Pattern Lock	Up to PRBS16, SSPRQ
Temperature range	0 - 75 °C
Line Power	100 - 240 V AC, 50 / 60 Hz

Minimum PC Specifications	
OS	Windows 7 64-bit
Processor	Core i5 / Ryzen 5
Memory	8 ot 16 GB
Storage	2 GB

Recommended PC Specifications	
OS	Windows 10 64-bit
Processor	Core i7 / Ryzen 7
Memory	8 GB
Storage	10 GB

Supported DSP Functions

- Frequency response correction of O/E & analog front end.
- N^{th}-Order Bessel-Thomson.
- CTLE adaptive or manual.
- FFE adaptive or manual.
- DFE adaptive or manual.
- De-embedding or embedding of four-ports (.s4p) and two-ports (.s2p) files.
- Moving average.

Supported Measurements

Coding	Measurement
PAM4	TDECQ
	SNDR
	Open Eye MSA
	RLM
	OMA_{outer}
	Eye Height by BER
	Eye Width by BER
NRZ	Top & Base
	Min & Max
	One & Zero
	Transition Time
	Crossing %
	AOP
	OMA
	Mask
	Peak to Peak
	Eye Amplitude
	Eye Height
	Eye Width
	Jitter
	SNR
	ER
	VEC
	Vrms
	DJ & RJ
	Noise

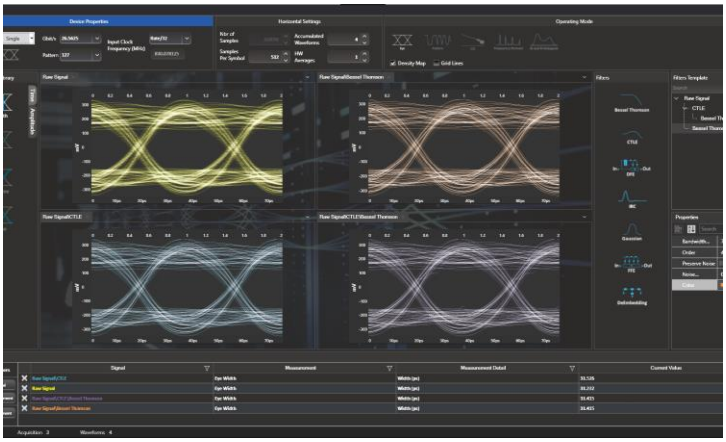


Figure 3: Multi-Signal Display Feature

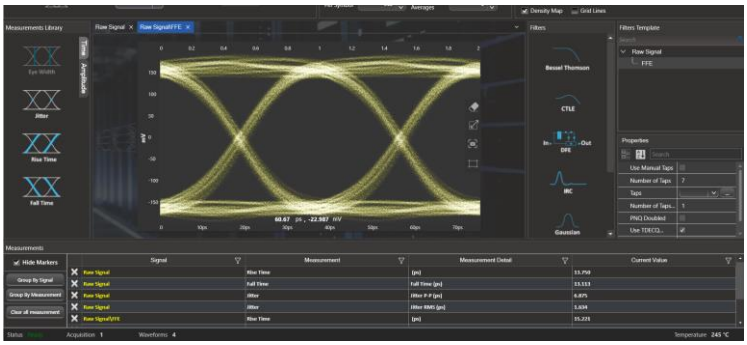
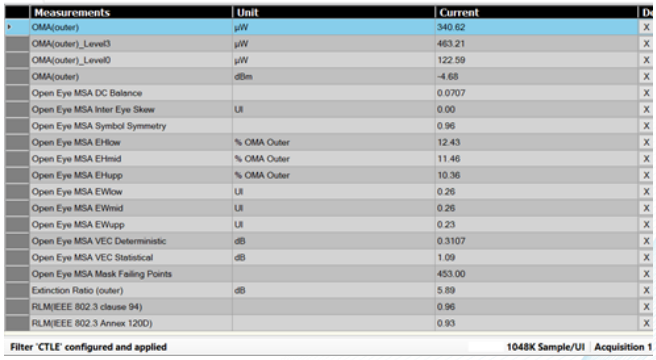


Figure 4: 26.5625 GBaud Optical Eye Diagram



Measurements	Unit	Current
OMA(outer)	µW	340.62
OMA(outer)_Level3	µW	463.21
OMA(outer)_Level0	µW	122.59
OMA(outer)	dBm	-4.68
Open Eye MSA DC Balance		0.0707
Open Eye MSA Inter Eye Skew	UI	0.00
Open Eye MSA Symbol Symmetry		0.96
Open Eye MSA EHlow	% OMA Outer	12.43
Open Eye MSA EHmid	% OMA Outer	11.46
Open Eye MSA EHupp	% OMA Outer	10.36
Open Eye MSA EWlow	UI	0.26
Open Eye MSA EWmid	UI	0.26
Open Eye MSA EWupp	UI	0.23
Open Eye MSA VEC Deterministic	dB	0.3107
Open Eye MSA VEC Statistical	dB	1.09
Open Eye MSA Mask Failing Points		453.00
Extinction Ratio (outer)	dB	5.89
RLM(IEEE 802.3 clause 94)		0.96
RLM(IEEE 802.3 Annex 120D)		0.93

Filter 'CTLE' configured and applied | 1048K Sample/UI | Acquisition 1

Figure 5: Supported Open Eye MSA measurements

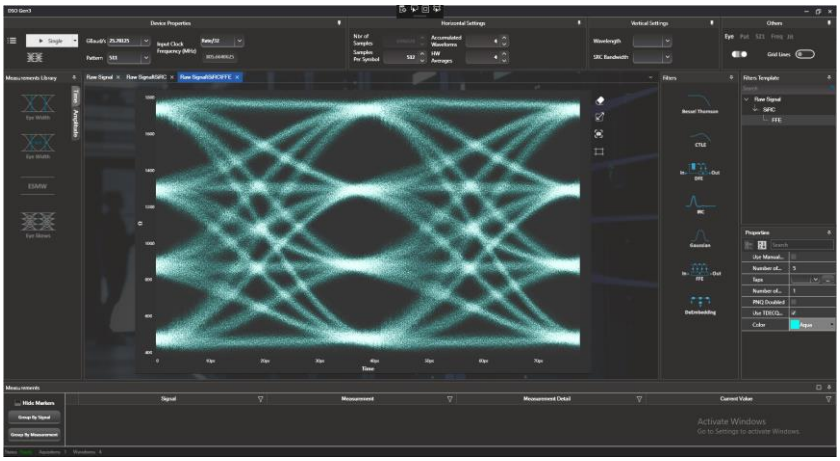


Figure 6: 25.78125 GBaud Optical Eye Diagram – SRC+FFE

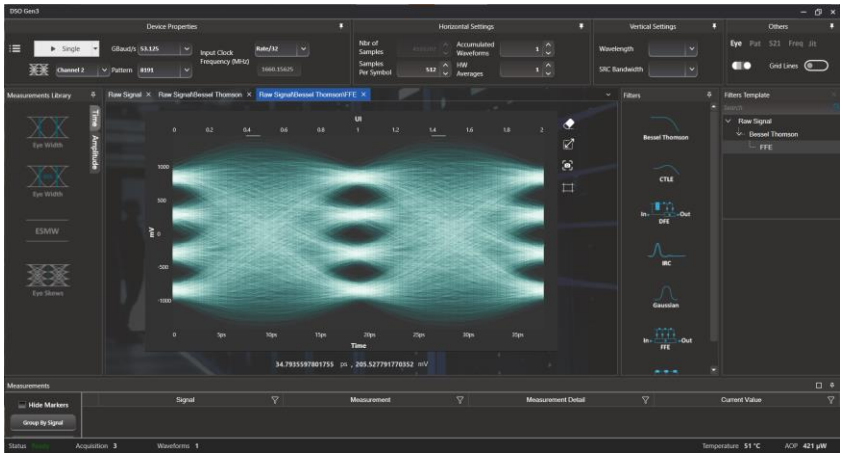


Figure 7: 53.125 GBaud Electrical Eye Diagram – Bessel Thomson + FFE

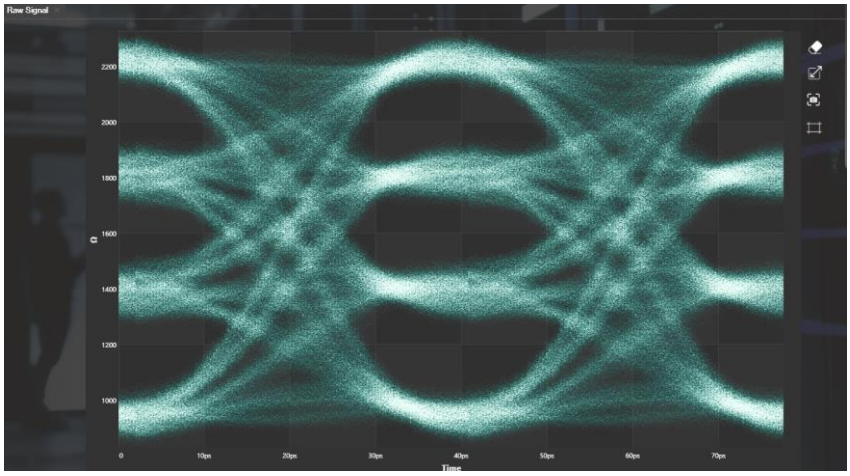


Figure 8: 53.125 GBaud Optical Eye Diagram – Raw Diagram

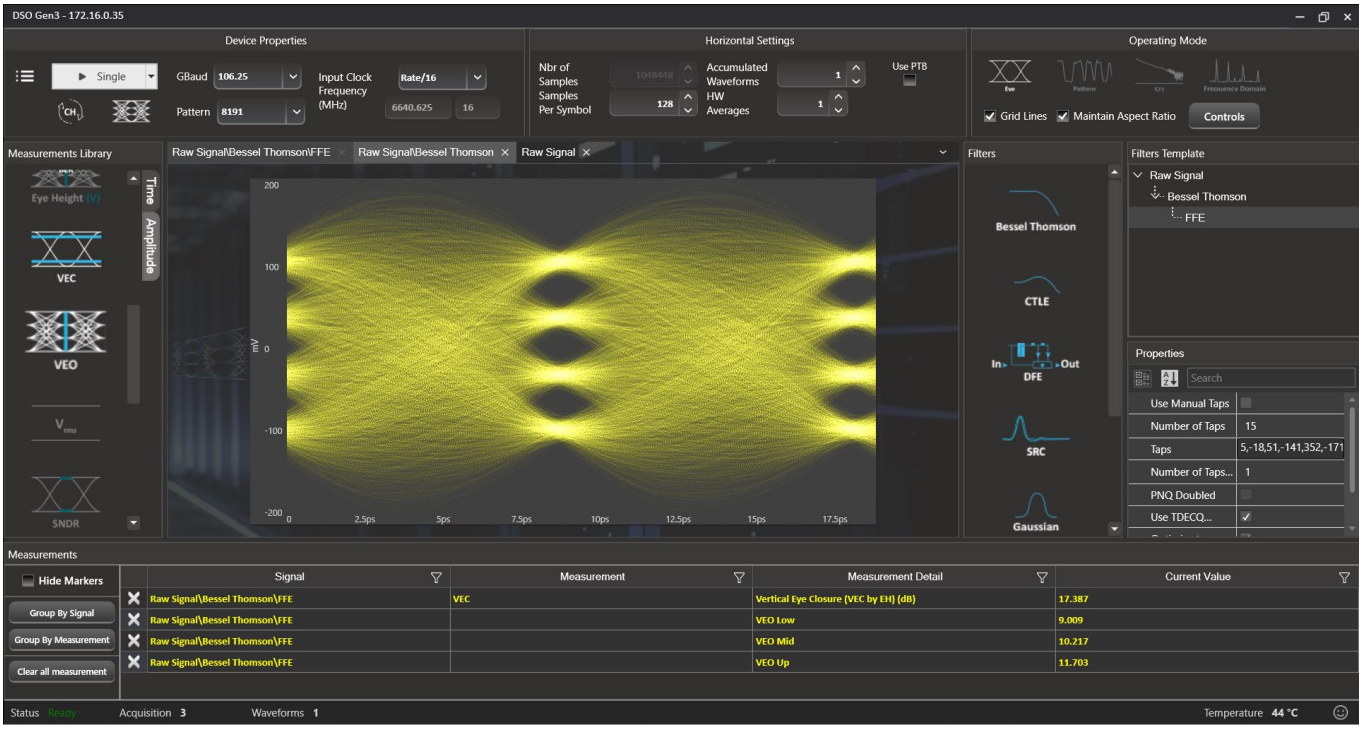


Figure 9: 112 GBaud (or 224Gbps) Electrical Eye Diagram with BT4 and FFE

Triggering ML4015E using ML1016E-CR Optical Clock Recovery Module

The ML1016E-CR is a 26.5625/53.125 GBd PAM4 Optical Clock Recovery Module ideally suited for 50G and 100G per wavelength optical measurements. The recovered clock can trigger the ML4015E Optical Scope to perform 26.5625/53.125 GBd PAM4 optical measurements such as TDECQ, OMA, and ER.

Test Setup Using ML4015E

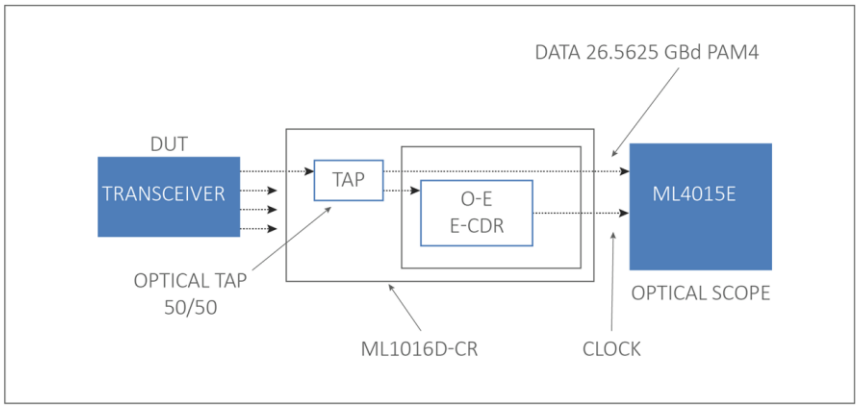


Figure 9: Functional block diagram of the ML1016E-CR + ML4015E-SM

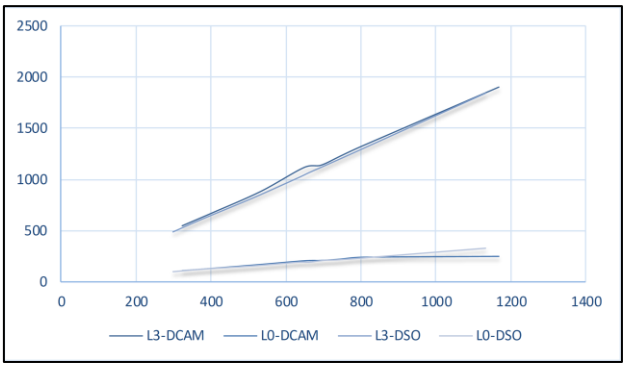


Figure 10: L1 and L3 comparison

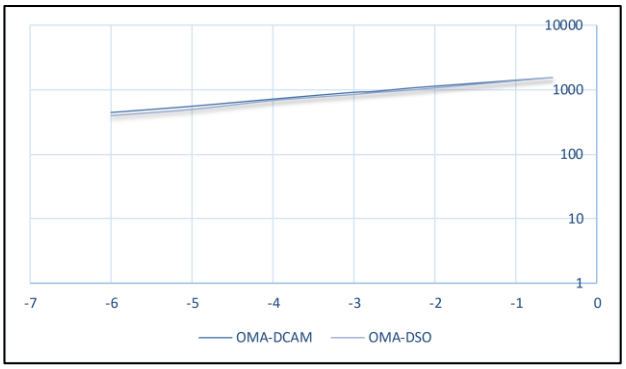


Figure 12: OMA-DCAM and OMA-DSO comparison

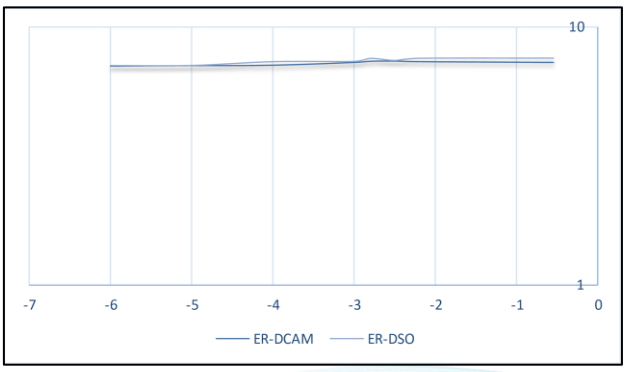


Figure 11: ER-DCAM and ER-DSO comparison

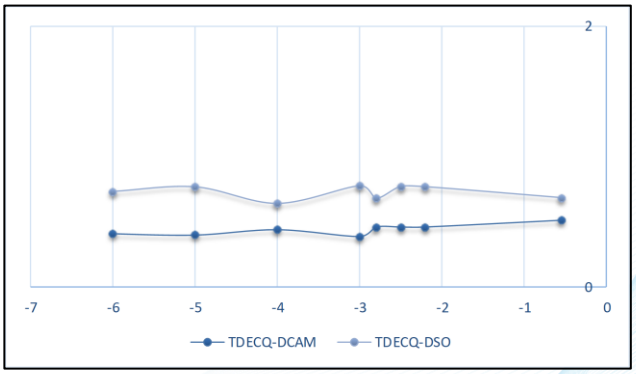
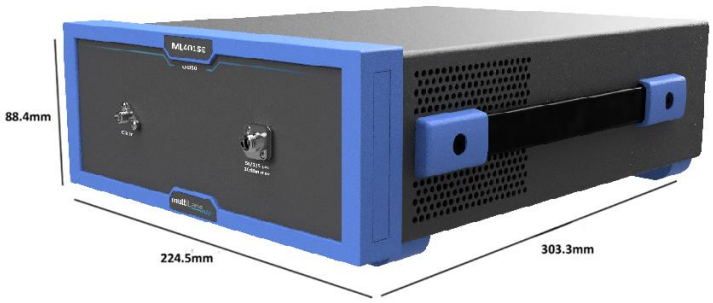


Figure 13: TDECQ-DCAM and TDECQ-DSO comparison

Mechanical Dimensions

The ML4015E is a benchtop instrument that also fits in a 19-inch 2U rack. It has a ruggedized Enigma enclosure with improved mechanical rigidity. Two ML4015Es arranged side by side comprise one 2U slot in the rack. MultiLane also supplies the needed bracket.



Ordering Information

Name	ML Part number	Description
ML4015E-OPT	ML4015E-OPT	Optical DSO with 25Ghz either SM or MM O.E For 26Gbaud Applications
	SM42	42Ghz Receiver for 53Gbaud SM Applications
	BBR25G	Swap with a Broad Band Receiver
	BIC26	Built in CDR 25/26G
	BIC53	Built in CDR 53/56G this will cover 25/26G as well
	3YW	3 years warranty
	5YW	5 years warranty
	EXP1	Extended Warranty Plan-1 year
ML4015E-E	35	Electrical 35Ghz BW
	70	Electrical70Ghz BW
	BIC53	Built in CDR for Electrical Scope 53
	BIC26	Built in CDR for Electrical Scope 26
	3YW	3 years warranty
	5YW	5 years warranty
	EXP1	Extended Warranty Plan-1 year
ML4015E-2X	35	Dual Electrical 35Ghz BW
	70	Dual Electrical70Ghz BW
	35-OPT25	One Electrical 35Ghz and 1 Optical (MM or SM 25Ghz)
	35-OPT42	One Electrical 35Ghz and 1 Optical (SM42)
	70-OPT25	One Electrical 70Ghz and 1 Optical (MM or SM 25Ghz)
	70-OPT42	One Electrical 70Ghz and 1 Optical (SM 42Ghz)
	35-BBR25	One Electrical 35Ghz and 1 Optical BroadBand Receiver
	70-BBR25	One Electrical 70Ghz and 1 Optical BroadBand Receiver
	BIC26	Built in CDR 25/26G
	BIC53	Built in CDR 53/56G this will cover 25/26G as well
	3YW	3 years warranty
	5YW	5 years warranty
	EXP1	Extended Warranty Plan-1 year

Recommended Accessories

Instrument	Recommended Cables	Comments
ML4015E-25-SM	1x MLCBPS-2.92-30/60	2.92 mm connector, Clock Input Cable, 30 or 60 cm
ML4015E-25-MM	1x MLCBPS-2.92-30/60	2.92 mm connector, Clock Input Cable, 30 or 60 cm
ML4015E-40-SM	1x MLCBPS-2.92-30/60	2.92 mm connector, Clock Input Cable, 30 or 60 cm
ML4015E-E-32	1x MLCBPM-2.92-30/60, 1x MLCBPS-2.92-30/60	2.92 mm connector 2x1 channel, 30 or 60 cm, and 2.92 mm connector for Clock Input, 30 or 60 cm
ML4015E-E-50	1x MLCBPM-2.92-30/60, 1x MLCBPS-2.92-30/60	2.92 mm connector 2x1 channel, 30 or 60 cm, and 2.92 mm connector for Clock Input, 30 or 60 cm
ML4015E-E-50-24	1x MLCBPM-2.4-30/60, 1x MLCBPS-2.92-30/60	2.4 mm connector 2x1 channel, 30 or 60 cm, and 2.92 mm connector for Clock Input, 30 or 60 cm

Please contact us at sales@multilaneinc.com.