QUANTIFI PHOTONICS™

Optical Test and Measurement Products
to support highly parallel production testing

D. McCormick 17MAY2022

Parallel Optics: both in fibers and muxed-wavelengths

- Transceivers designed for Data Center Interconnect (DCI) have been using parallel fibers and some parallel wavelengths (CWDM) to increase bandwidth: this trend continued with 100G, 400G, and will continue with 800G+ and beyind t a greater extent.

Application Code	form factor	# CH	Gbps/CH	modulation	wavelengths	connector	fiber	dist
100G-SR10	CXP,CFP,CFP2/4,CPAK	10	10G	10G NRZ	850nm	MPO-24	OM3	100m
100G-SR4	QSFP28, CFP2/4,CPAK	4	25G	25G NRZ	850nm	MPO-12	OM3	70m
100G-SR2 BiDi	QSFP28	2	50G	25Gbaud PAM-?	850nm, 900nm	dual LC	OM3	70m
100G-DR	SFP112	1	100G	50Gbaud-PAM4	1311nm	dual LC	SM	500m
100G-LR4	QSFP28, CFP2/4,CPAK	4	25G	25G NRZ	1296, 1300, 1305, 1309nm	dual LC	SM	10km
100G-ER4	QSFP28, CFP, CFP2	4	25G	25G NRZ	1296, 1300, 1305, 1309nm	dual LC	SM	40km
100G-ZR	CFP	2	25G	DP-QPSK	1546.119nm coherent	dual LC	SM	80km
100G-FSM4	QSFP28, CFP4	4	25G	25G NRZ	1295-1325nm	MPO-12	SM	500m
100G-CWDM4	QSFP28, CFP2/4	4	25G	25G NRZ	1271, 1291, 1311, 1331nm	dual LC	SM	2km

Application Code	form factor	optical channels	speed per lane	modulation	wavelengths	connector	fiber	distance
400G-SR8	QSFP56-DD, OSFP	8	50G	25GBaud-PAM4	850nm	MPO-24 w/16 fibers	MM OM-4	100m
400G-SR4	QSFP56-DD, OSFP	4	100G	50GBaud-PAM4	850nm	MPO-16 w/8 fibers	MM OM-4	100m
400G-SR4 2xBidi	QSFP56-DD, OSFP	8	50G	25GBaud-PAM4	850nm/910nm	MPO	MM OM-4	100m
400G-DR4	QSFP56-DD, OSFP	4	100G	50GBaud-PAM4	1310nm	MPO-12 w/8 fibers	SM	500m
400G-FR4	QSFP56-DD, OSFP	4	100G	50GBaud-PAM4	1270, 1290, 1310, 1330nm	dual LC w/2 fibers	SM	2km
400G-FR8	QSFP56-DD, OSFP	8	50G	25GBaud-PAM4	1273, 1277, 1282, 1286, 1295, 1300, 1304, 1309nm	dual LC w/2 fibers	SM	2km
400G-LR4	QSFP56-DD, OSFP	4	100G	50GBaud-PAM4	1295, 1300, 1305, 1310nm	dual LC w/2 fibers	SM	10km
400G-LR8	QSFP56-DD, OSFP	8	50G	25GBaud-PAM4	1273, 1277, 1282, 1286, 1295, 1300, 1304, 1309nm	dual LC w/2 fibers	SM	10km
400G-ER8	QSFP56-DD, OSFP	8	50G	25GBaud-PAM4	1273, 1277, 1282, 1286, 1295, 1300, 1304, 1309nm	dual LC w/2 fibers	SM	40km
400G-ZR8					1550nm coherent			

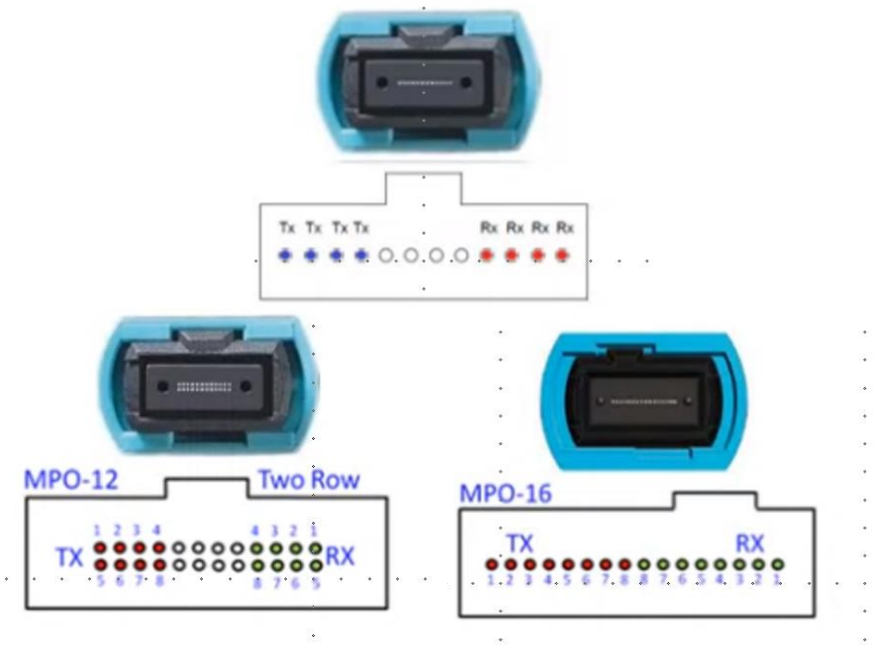
Multiple wavelengths are being muxed into single fibers for DCI using CWDM, and in future DWDM; breaking these individual wavelengths out for testing requires additional special fiberoptic test equipment

Optical interfaces to transceivers are increasingly using more and more parallel fiber connectors (such as MPO/MPT) to increase density on the front panel

Parallel Optics: MPO/MPT interfaces on test equipment emerges

- In 2020 QP introduced an MPO-input-interface for the traditional Optical Power Meter POWER-1400/1500 series: this allows capturing the sum of all optical power emitted from an MPO/MPT interface (up to MPO-24)

The MPO/MPT option for the POWER-1400/1500 QP Power Meters allows capturing all the optical power emitted from an MPO interface up to MPO-24



POWER-1405-2-MP-PXIE

POWER-1401-4-FC-PXIE

POWER-1401-4-FC-MTRQ

Parallel Optics: HPC parallel laser sources are emerging

- The move to more parallel optics not only affects transceivers for DCI, but also the emerging massive parallel photonics integrated circuits (PICs) being developed for high performance computing (HPC) and other massive parallel switching/routing developments using co-packaged optics

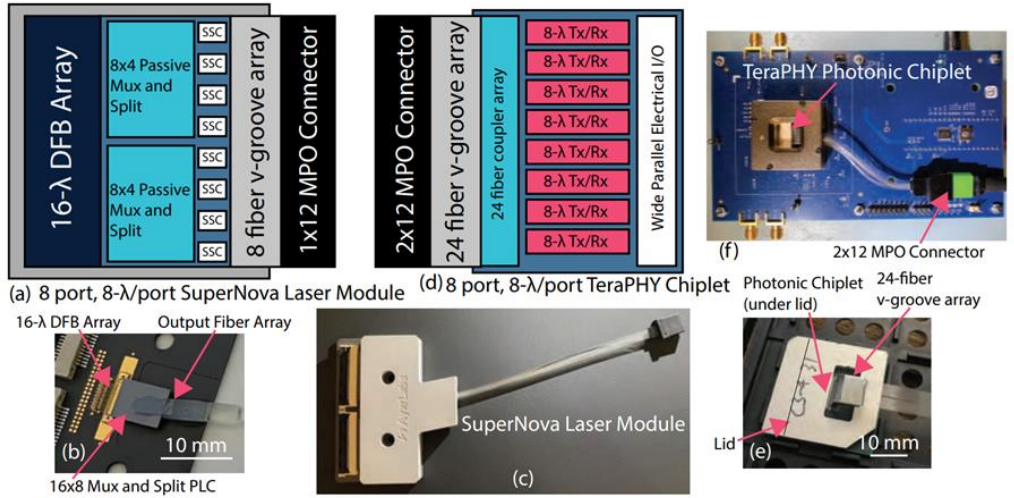


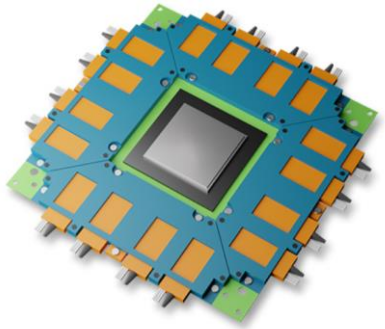
Fig. 1: (a) Block diagram of the multi-port, multi-wavelength laser module. (b) Picture of the assembled laser module without lid and (c) with lid. (d) Block diagram of the optical I/O CMOS chiplet. (e) Picture of the assembled optical I/O chiplet package. (f) Picture of the optical chiplet test board.

An Error-free 1 Tbps WDM Optical I/O Chiplet and Multi-wavelength Multi-port Laser

M. Wade[†], E. Anderson, S. Ardalan, W. Bae, B. Beheshtian, S. Buchbinder, K. Chang, P. Chao, H. Eachempatti, J. Frey, E. Jan, A. Katzin, A. Khilo, D. Kita, U. Krishnamoorthy, C. Li, H. Lu, F. Luna, C. Madden, L. Okada, M. Patel, C. Ramamurthy, M. Raval, R. Roucka, K. Robberson, M. Rust, D. Van Orden, R. Zeng, M. Zhang, V. Stojanovic, F. Sedgwick, R. Meade, N. Chan, J. Fini, B. Kim, S. Liu, C. Zhang, D. Jeong, P. Bhargava, M. Sysak, C. Sun

From: https://cw-wdm.org/?wpdmdl=2203

Standards are emerging for parallel stand-off optical sources to support massively parallel optical I/O for High Performance Computing (HPC). Highly dense co-packaged optics for future data-center switches and routers utilize parallel optics to deliver multi-wavelength laser sources for the highly parallel photonics integrated circuits utilized in these developments.



Example of a co-packaged switch ASIC, adapted from OIF (oiforum.com)

CW WDM MSA

Promoter Members

ARISTA, AyarLabs, II-VI, imec, intel, LUMENTUM, LUMINOUS, MACOM, QUINTESSENT, sivers PHOTONICS, SUMITOMO ELECTRIC

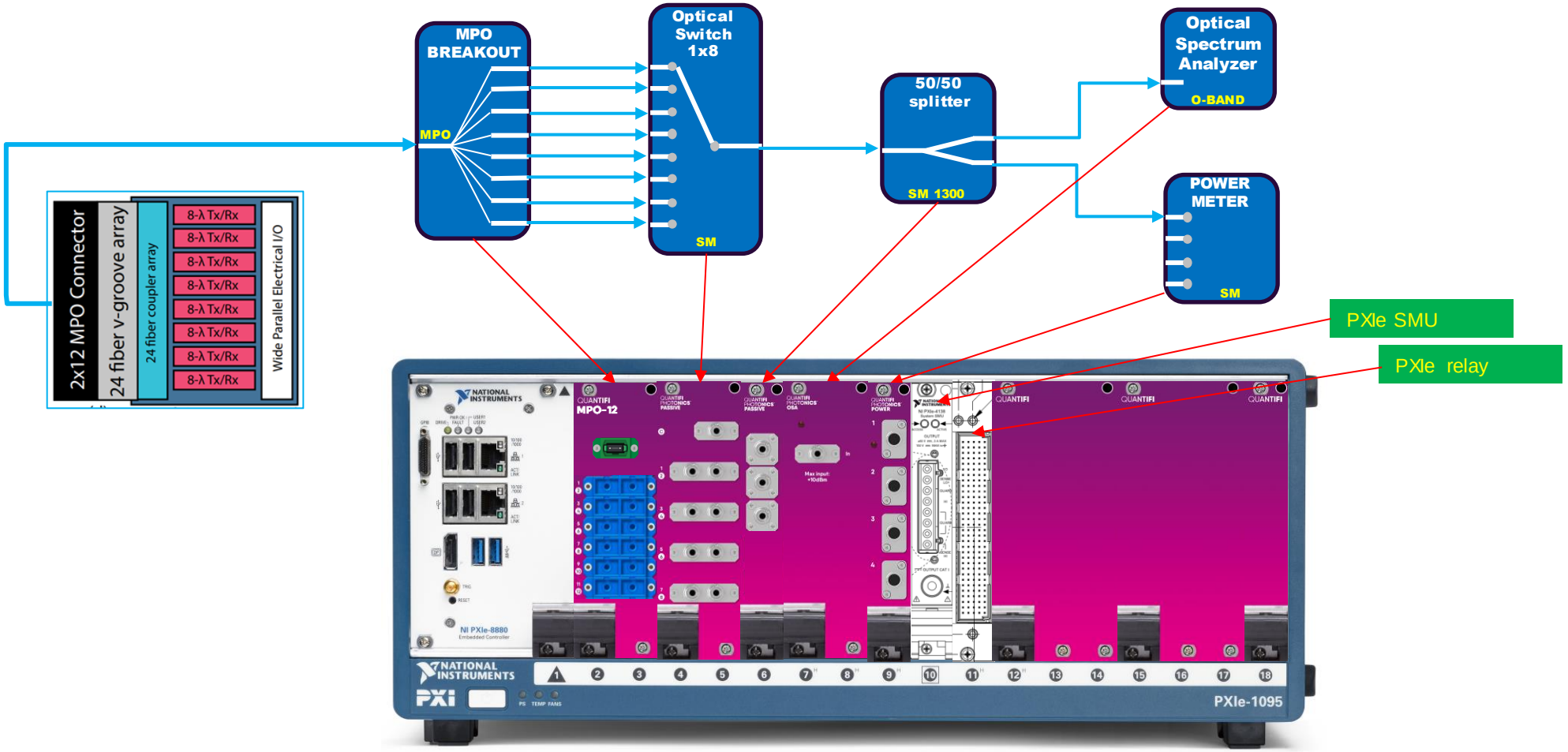
Observer Members

ACACIA, Alibaba Group, AMD, amf, AXALUME, BROADCOM, cadence, ePIXfab, Hisense Broadband, FREEDOM PHOTONICS, FURUKAWA ELECTRIC GROUP, GlobalFoundries, Hewlett Packard Enterprise, HITACHI Inspire the Next, INNOLUME, Inphi, KEYSIGHT TECHNOLOGIES, LIGHTELLIGENCE, LITUREX, MicroR systems, NeoPhotonics, NVIDIA, Octave Photonics, PHONONIC, POET, QUANTIFI PHOTONICS, samtec, SCINTIL PHOTONICS, SEMTECH, SENKO Advanced Components, SiFotonics, SKORPIOS TECHNOLOGIES, SP SOURCE PHOTONICS, Tektronix, THORLABS, XY TECH

https://cw-wdm.org

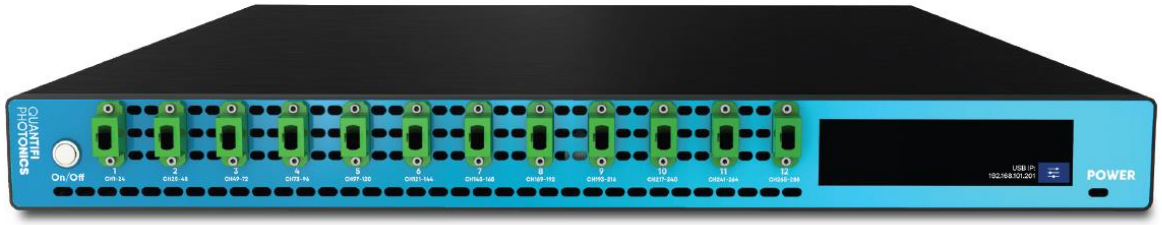
Parallel Optics: optical and electrical switching

- Existing test and measurement equipment in PXIe allows for testing parallel optics using breakouts, optical switches, and parallel and/or relay-matrix Source Measurement Units (SMUs).
- The diagram below shows a minimal test-equipment setup to test a total of 64-lasers from an 8-fibers x 8-wavelength muxed laser sources across its LIV curve.
- For faster testing, the equipment needs to support simultaneous parallel testing in addition to switching.



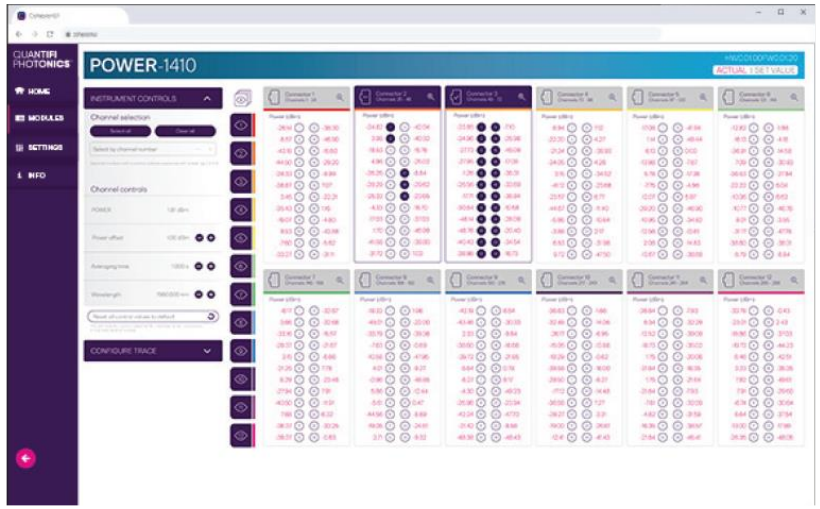
Parallel Optics: high density optical parallel testing

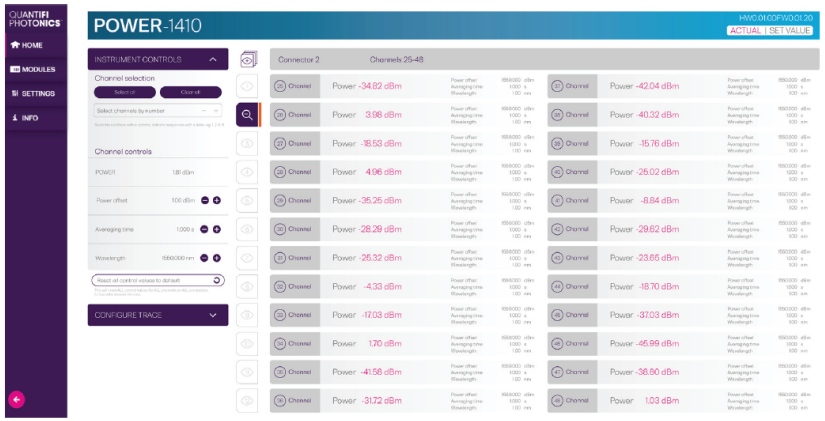
- In 2022 QP introduced the MPO/MPT-input parallel Optical Power Meter POWER-1410
- This can be configured with 1 to 12 MPO inputs
- Each MPO input can have up to 24 individual fibers: the POWER-1410 measures the individual power on each fiber on each input: with twelve MPO inputs, this is 288 channels of simultaneous optical power monitoring in a highly dense 1U high programmable instrument
- The POWER-1410 uses the same Ethernet and/or USB interface with SCPI programming commands as the other QP PXIe and Matriq instruments.



Power-1410-288-MTP-EPIQ

QP's cohesionUI software allows for benchtop use of all QP instruments without needing to use a programming interface or VI; this eases the transition from R&D benchtop testing to production ATE testing under full programmability (SCPI commands can also be READ/WRITE directly from the cohesion GUI).





Parallel Optics: extending the parallel capability of PXIe

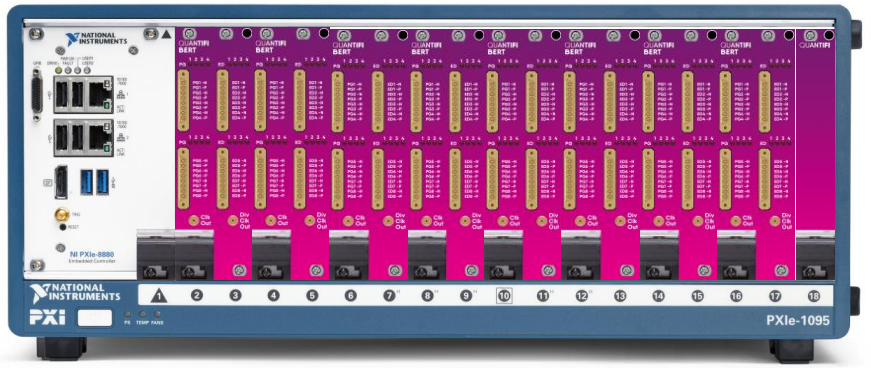
- PXIe instruments with simplex optical inputs & outputs already offer an existing path for increase density in production optical testing.
- The POWER-1600 series of IN-LINE optical power meters allows the user to measure the power in fibers without interrupting the signal (the inline power meters only have ~0.15dB of through-pass insertion loss of the signal)

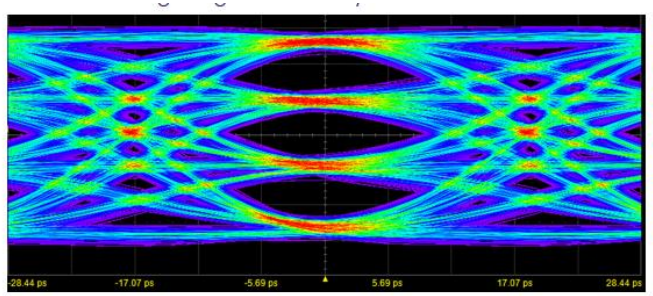
At OFC2022 QP demonstrated the POWER-1410, but also the natural-density of PXIe with even simplex fibers: the PXIe chassis shown here contains 68 channels of IN-LINE optical power monitors: this allows for live-measurement of optical power in each fiber without interrupting the signal like a terminating power meter would: this is easily scalable to implement MPO connectors instead of simplex, thus multiplying the parallel testing capability massively

Parallel Optics: …driving the need for high density parallel electrical testing

- The **BERT-1102-8** brings unprecedented density to electrical BERT testing.
- Customers can now do parallel PAM-4 BERT testing with up to 64-channels per chassis (and this can be extended to multiple chassis for hundreds of channels, all synchronous without clock distribution being necessary)

BERT-1102-8-PXIE



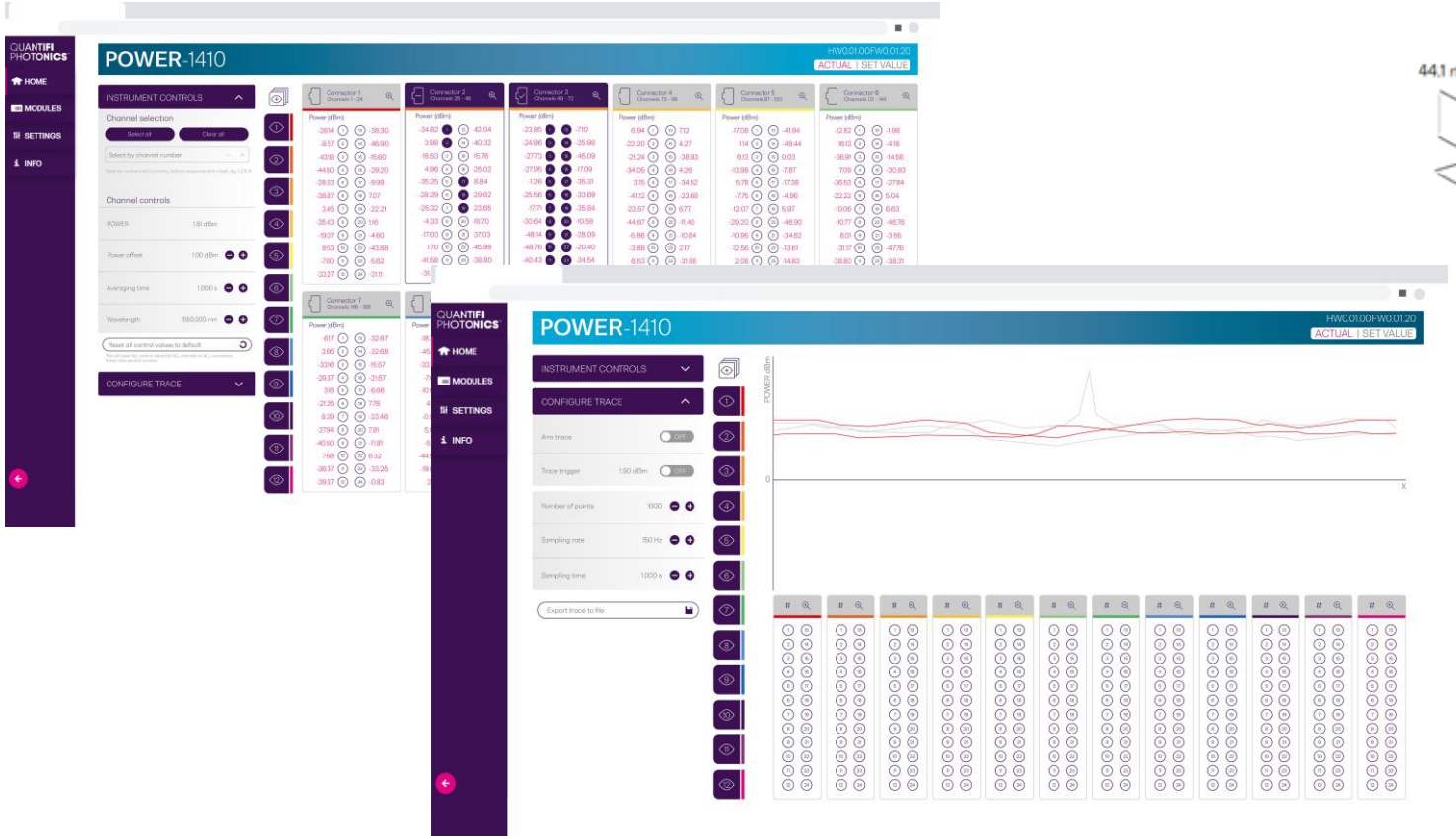


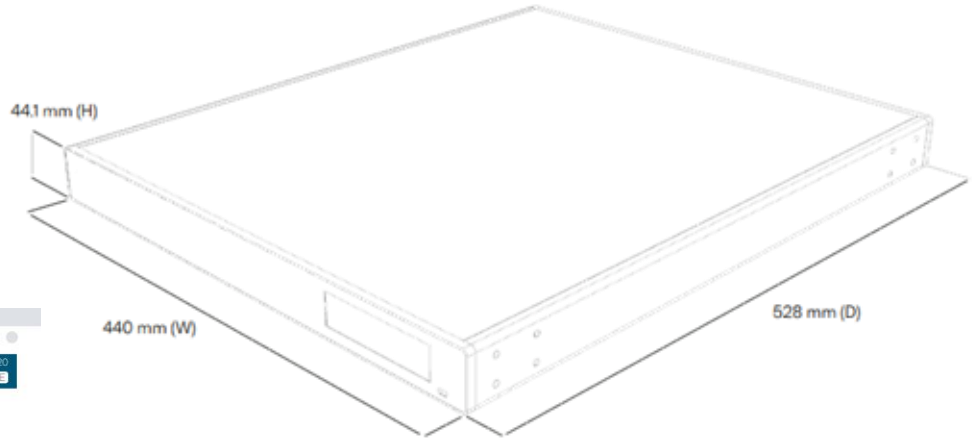
BERT-1102-8-MTRQ

QP also performs system integration (example of massive parallel BERT testing system with 272 channels)

New product releases – Power-1410

- Monitoring of signal power from -60 to +10 dBm
- Wavelength range of 1250 to 1650 nm.
- Configurable up to 288 parallel channels
- Hardware triggering capability





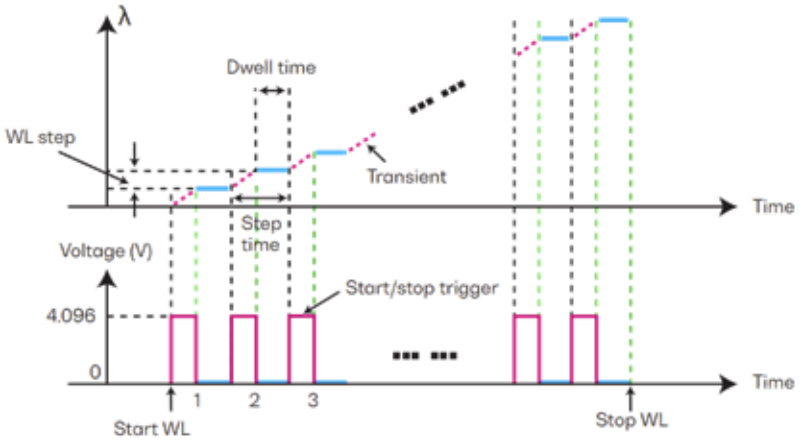
New product releases – LASER-2000 Series

- Swept and tunable laser source in the O-band or C-band
- Wavelength range of 1250 to 1650 nm.
- Built-in synchronization trigger inputs and outputs
- 0.01 dB power stability and 400 nm/s scan rate

LASER-2001-1-FC-PXIE

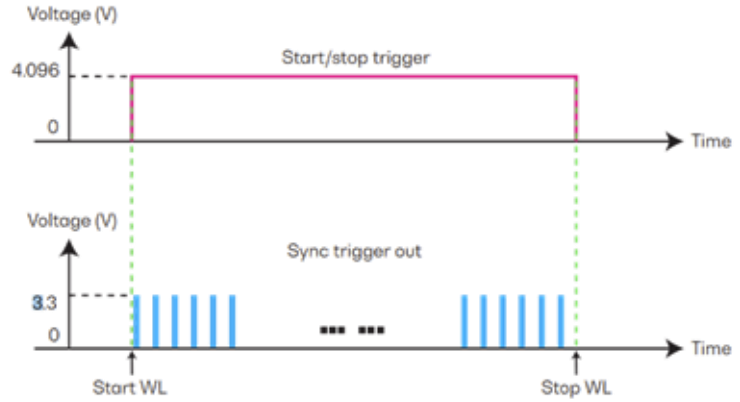
Step Tuning

Laser jumps from set point to set point or stays at the set point.



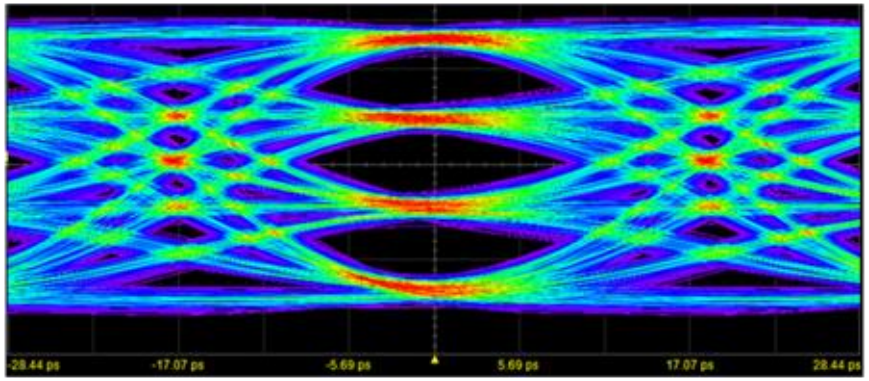
Swept Tuning

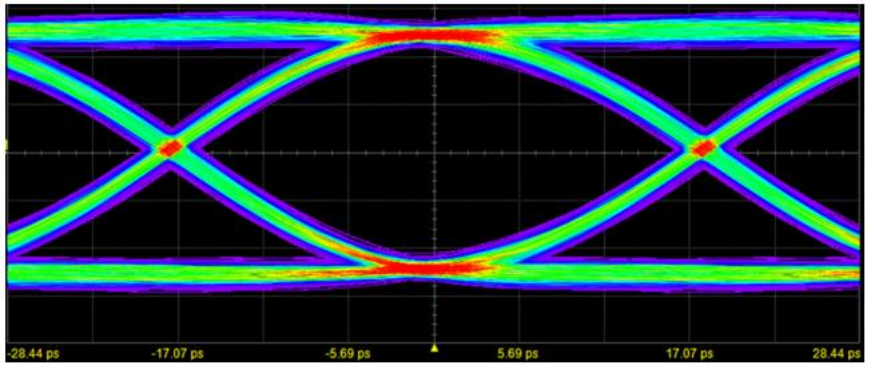
Laser performs a continuous sweep over selected wavelength range.

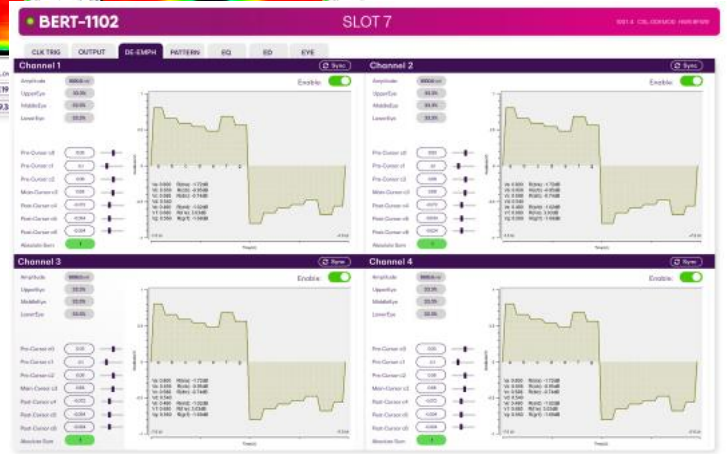


New product releases – nrz/pam4 bert

- 4 or 8-ch 28Gbaud NRZ/PAM4 BERT
  - NRZ: 28Gb/s
  - PAM4 56Gb/s
- Programmable 7-tab PPG Tx de-emphasis
- Error detection equalization, BERT bathtub and eye histogram
- 3D BER eye contour







BERT Roadmap

BERT-1005-4

- 14.5 Gbaud
  - NRZ: 14.5Gb/s
- 4 channel differential PPG

+

- 4 channel differential ED

BERT-1102-4 or -8

- 28Gbaud
  - NRZ: 28Gb/s
  - PAM4 56Gb/s
- 4 or 8 channel differential PPG

+

- 4 or 8 channel differential ED

BERT-1103-4 or -8

- 56Gbaud
  - NRZ: 56Gb/s
  - PAM4: 112Gb/s
- 4 or 8 channel differential PPG

+

- 4 or 8 channel differential ED

Thank You

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