



## Testing 100G Transport Networks and Services

Peter Winterling, JDSU Germany  
SSO Organization EMEA



### Agenda



#### ► Technology for 100 Gbps

Optical Modulation Formats  
Coherent Receiver  
Optical Measurement Line Side

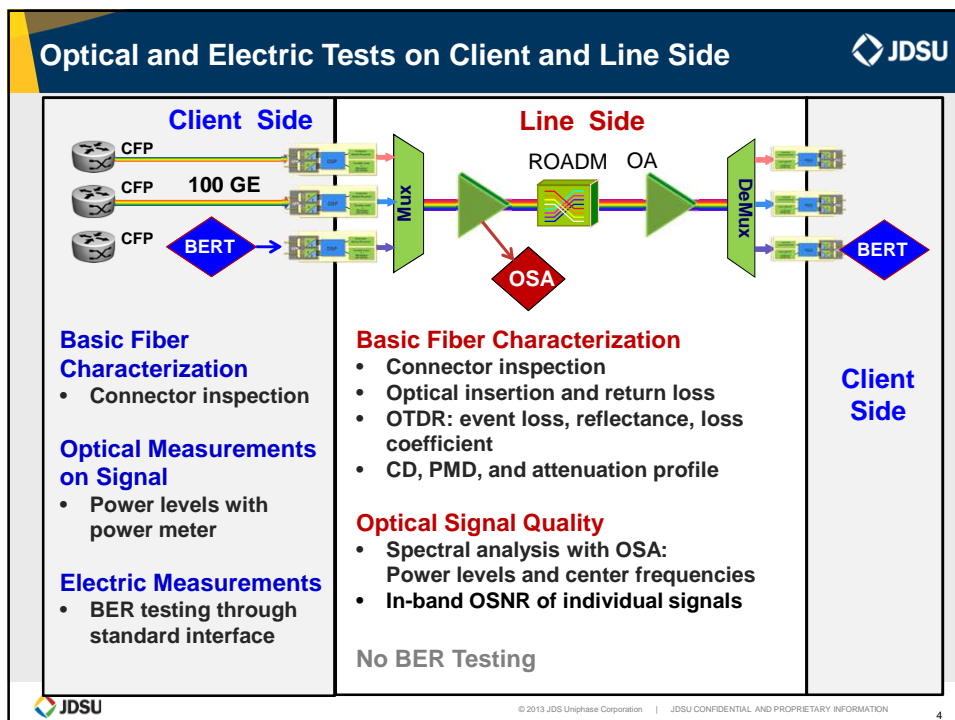
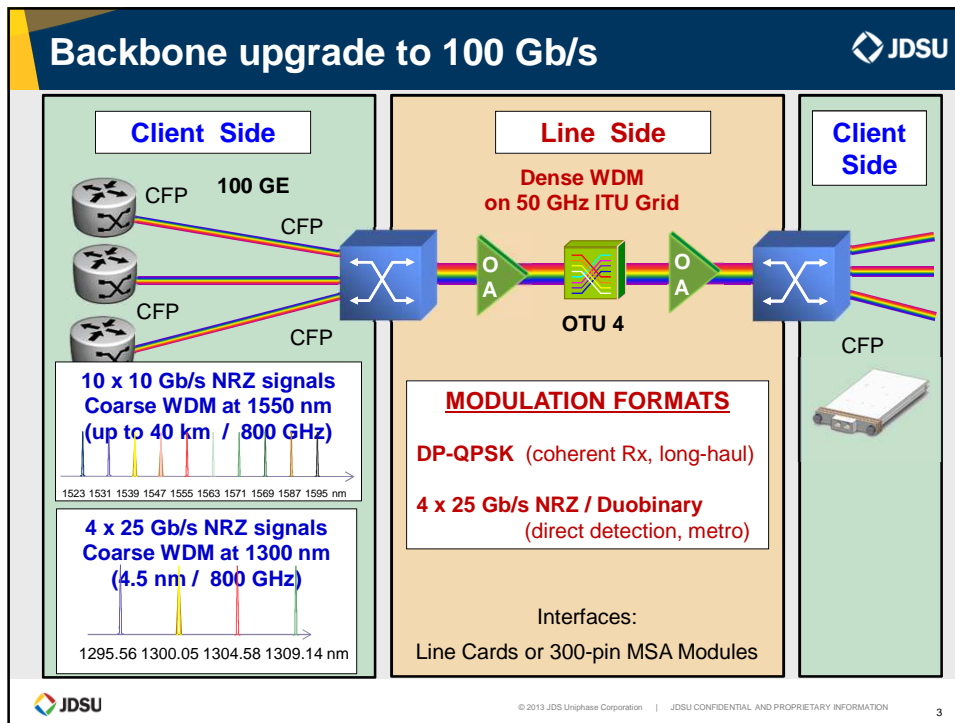
#### ► System Verification for 100G (SVT & Lab)

CFP & CFP2, CFP4 and QSFP28  
Physical Layer evaluation  
OTN acc. G.709

#### ► Turn up Tests for 100G (Field applications)

J-Proof  
RFC2544 / Y.1564  
Tester overview





## Evolution of Line Side Transmission Formats (DWDM) JDSU

- Binary modulation formats: 1 bit/symbol
  - OOK (On-Off Keying): **10 Gb/s** (10 GBaud)
  - BPSK (Binary Phase-Shift Keying): **40 Gb/s** (40 GBaud)
- Quaternary formats: 2 bits/symbol
  - QPSK (Quaternary Phase-Shift Keying): **40 Gb/s** (20 GBaud)
- Polarization-multiplexed QPSK: (4 bits/symbol)
  - PM-QPSK: **40 Gb/s** (10 GBaud)  
**100 Gb/s** (25 GBaud)

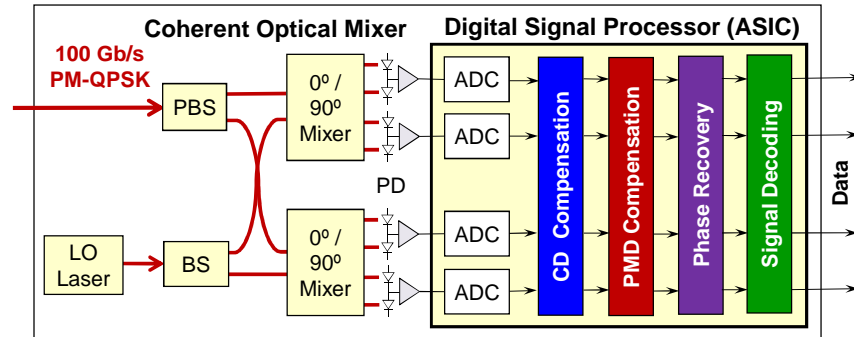
© 2013 JDS Uniphase Corporation | JDSU CONFIDENTIAL AND PROPRIETARY INFORMATION

## Principle of Polarization Multiplexing JDSU

- Polarization multiplexing or polarization-division multiplexing (PDM) doubles the spectral efficiency of signal transmission by combining **two orthogonally polarized signals** of the same bit rate into the same wavelength channel.
- Using PDM enables the reduction of the symbol rate by a factor of 2, thus enabling the use of digital signal processing for PMD and CD compensation
- PDM is widely used for long-haul 100 GB/s DWDM transmission (usually in combination with **coherent detection**).

© 2013 JDS Uniphase Corporation | JDSU CONFIDENTIAL AND PROPRIETARY INFORMATION

## Coherent Receiver with High-Speed Digital Signal Processing JDSU



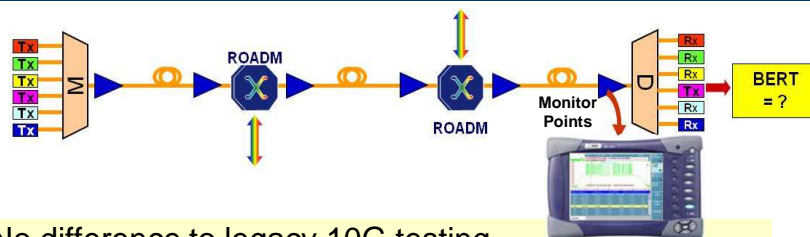
- **Electronic compensation of chromatic dispersion (CD)**
  - More than 50,000 ps/nm (~3000 km of uncompensated G.652 fiber)
- **Electronic compensation of polarization-mode dispersion (PMD)**
  - At least 25 ps mean DGD (>2.5 x the tolerance of 10 Gb/s NRZ signals)
- **Electronic polarization de-multiplexing and signal decoding**
  - Versatile decoder: adaptable to BPSK, QPSK and 16-QAM



© 2013 JDS Uniphase Corporation | JDSU CONFIDENTIAL AND PROPRIETARY INFORMATION

8

## Testing 40/100G with an OSA (line side) JDSU



### No difference to legacy 10G testing

- Final acceptance tests during I&M and trouble shooting
- Use system monitor points (Mon) at amplifiers
- Measure power, wavelength and OSNR of each DWDM-channel

### Challenges for spectral testing

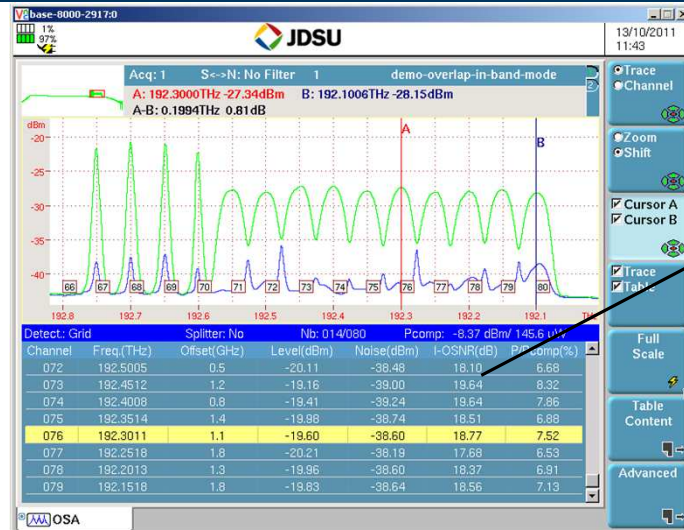
- New modulation formats create different optical spectra and require new analysis for accurate measurements
- Need for in-band OSNR testing in ROADM networks



© 2013 JDS Uniphase Corporation | JDSU CONFIDENTIAL AND PROPRIETARY INFORMATION

9

## In-Band OSNR measurement at single Polarized Signals



I-OSNR values in the table



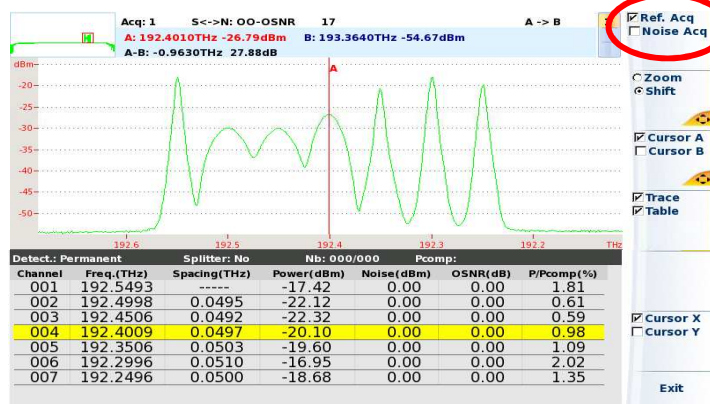
© 2013 JDS Uniphase Corporation | JDSU CONFIDENTIAL AND PROPRIETARY INFORMATION

10

## JDSU's On/Off-OSNR Method

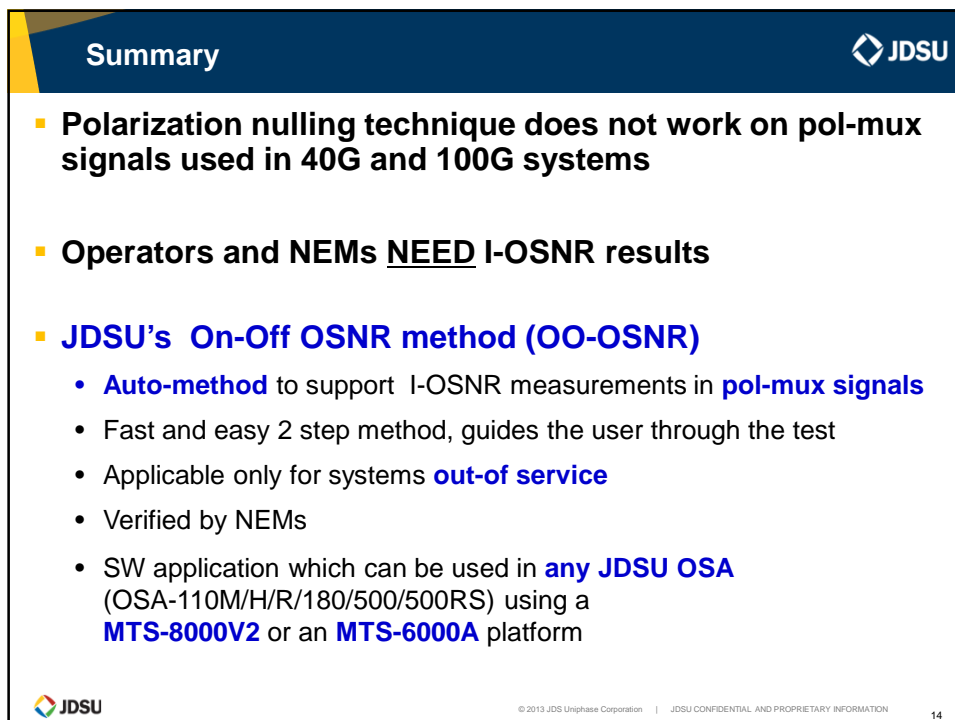
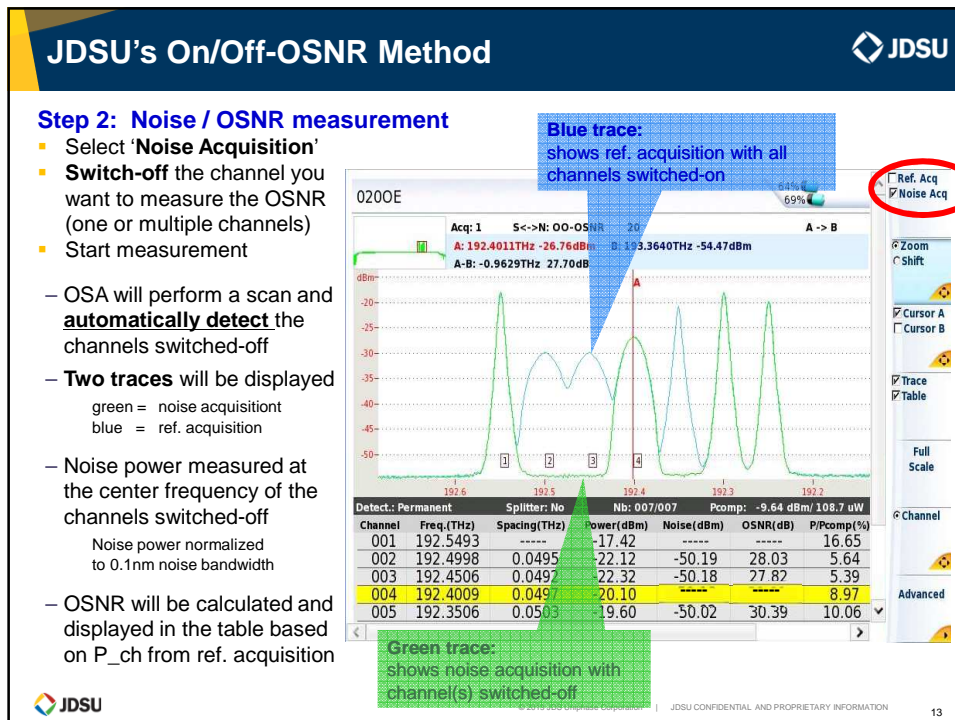
### Step 1: Reference measurement

- Select 'Ref. Acquisition' and perform OSA measurement (all channels ON)
- All channels will be detected and the total channel power (=integrated ch-power) of each channel will be shown / stored in the table = P\_ch (Power [dBm])
- OSNR and Noise will not yet be displayed



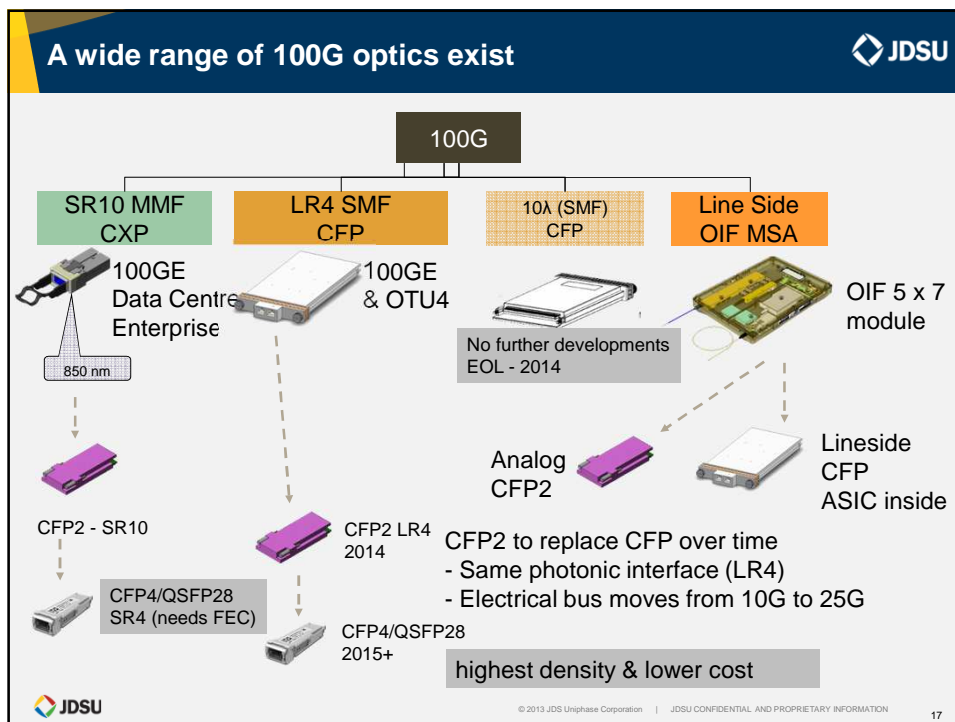
© 2013 JDS Uniphase Corporation | JDSU CONFIDENTIAL AND PROPRIETARY INFORMATION

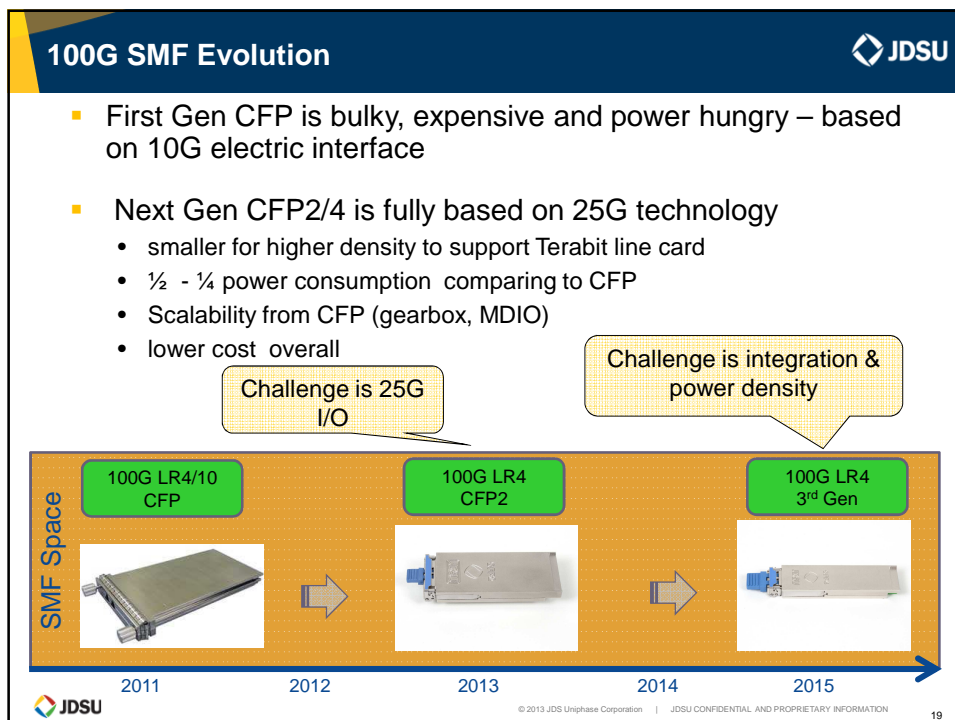
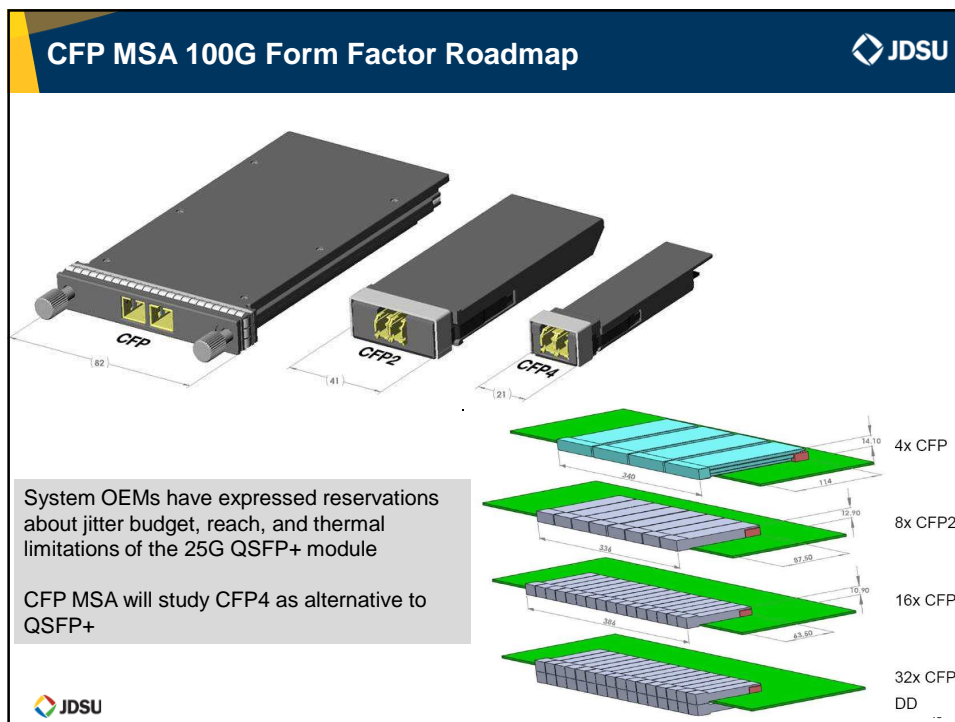
12





## Client Side Interfaces







**CFP2, CFP4 & QSFP28**

All of these represent 'next generation' 100G

They all offer increased density (and lower power & cost) than CFP

All have a part to play in the future 100G ecosystem

CFP => very flexible slot that can support 40G (parallel & serial), 100G (10x10 & 4x25) and line side applications

CFP2 => native support for 10x10 and 4x25G, good thermal density

CFP4/QSFP28 => ultra high density – ideal for datacenter applications

CFP2, CFP4 & QSFP28 all require a stable 25G I/O to work



© 2013 JDS Uniphase Corporation | JDSU CONFIDENTIAL AND PROPRIETARY INFORMATION

20



**System Verification / Lab  
Test and Measurement for 100G**

## The ONT 603 with 100G CFP2



The only completely integrated 2<sup>nd</sup> generation 100G CFP2 test solution

Delivers in all the critical areas of 100G development, validation and test

Shares the ONT 100G CFP pedigree

Unique accessories and applications to accelerate product development and validation

Less than half the cost (and x3 quicker test time) than anything else!



© 2013 JDS Uniphase Corporation | JDSU CONFIDENTIAL AND PROPRIETARY INFORMATION

22

## Product Overview



### 2 Independent Ports

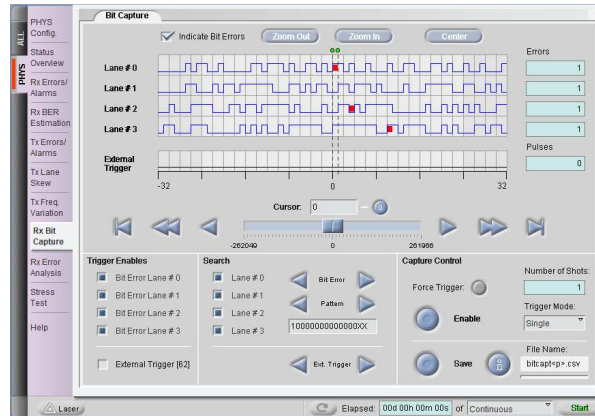
- Each port (1 & 2) can be configured to be either 40G or 100G.
- Each port can independently run basic physical layer through Ethernet & OTN at either 40G or 100G.
- Perfect for the needs of mainstream 40G & 100G in SVT & Production



© 2013 JDS Uniphase Corporation | JDSU CONFIDENTIAL AND PROPRIETARY INFORMATION

23

## Testing 100G Systems - Unique Bit Capture



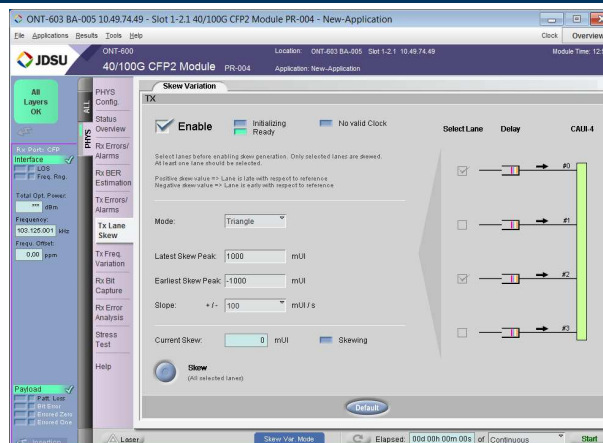
- Trigger on wide range of events
- Reconcile & correlate errors with cause
- Rich interconnect trigger options with external equipment



© 2013 JDS Uniphase Corporation | JDSU CONFIDENTIAL AND PROPRIETARY INFORMATION

25

## Testing 100G Systems - Unique Dynamic Skew




- Self contained – no external clock source required
- Large range (+/-512 UI)
- Skew rate range from 10 mUI/sec => 10 UI/sec



© 2013 JDS Uniphase Corporation | JDSU CONFIDENTIAL AND PROPRIETARY INFORMATION



26

## CFP is the Past – CFP2 is now!



▶ According IEEE next CFP generation already deployed in serial production now.

▶ How to protect your Invest?

CFP2

CFP-CFP2 adapter


▶ CFP-CFP2 adapter for SR10 (10x10G) is available now

▶ CFP-CFP2 LR4 (4x25G) adapter available now

- Have been working on active LR4 CFP-CFP2 adapter for some time

▶ Important facts to note:


- CFP and CFP2 support the same 100G optical interfaces




© 2013 JDS Uniphase Corporation | JDSU CONFIDENTIAL AND PROPRIETARY INFORMATION

27

## Adapting next Generation: CFP2 to QSFP28 adapter






sampling  
now

This is the adapter for CFP2 to QSFP28 and can support LR4, SR4 & potential future PMDs like PSM4 & CWDM4

The adapter takes care of all the I<sup>2</sup>C to MDIO and allows all the deep applications like OTN, PTP and Ethernet to run over QSFP28




© 2013 JDS Uniphase Corporation | JDSU CONFIDENTIAL AND PROPRIETARY INFORMATION


28

## Testing Core/Edge Router

▶ Port Density  
 ▶ Route Speed  
 ▶ Cross Talk



Core Router / Switch board 1960!

 JDSU
 © 2013 JDS Uniphase Corporation | JDSU CONFIDENTIAL AND PROPRIETARY INFORMATION 29

## Why The ONT 100G is successful?

▶ Physical Layer
 

- Compressed
- Unique
- Dynamic

▶ Ethernet
 


- Service condition


▶ OTN
 

- ODU0s
- ODUflex
- Multi-channel

▶ SONET
 

- SDH/SONET
- FR optical



 JDSU
 © 2013 JDS Uniphase Corporation

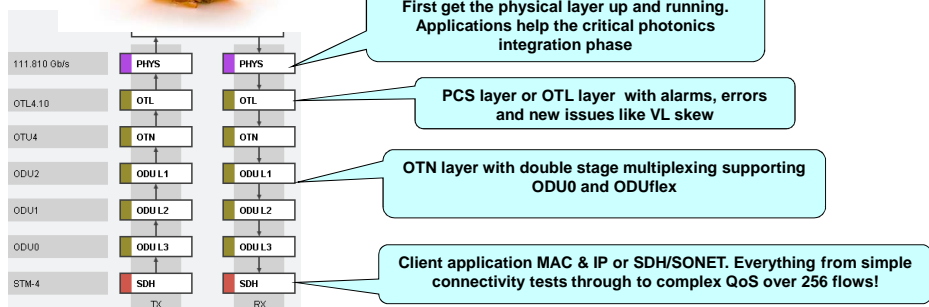


## New OTN acc. ITU-T G.709


### Simple Structure on ONT





- Simple Menu structure helps 'peel the onion' without tears!




## Our Pedigree




*October 2009*

- ▶ JDSU releases world's first 100GE & OTU4 test set.
- ▶ Unique (patented) features include Lambda mapping, dynamic skew & MDIO debug.
- ▶ Product now includes comprehensive OTN mapping from ODUflex upwards.



*December 2011*


- ▶ JDSU releases most compact and comprehensive 100G field solution, includes native support for CFP & QSFP+





© 2013 JDS Uniphase Corporation | JDSU CONFIDENTIAL AND PROPRIETARY INFORMATION

34

## Our Pedigree




*February 2013.*


**Comprehensive validation test for CFP2**

- ▶ integrated solution for full CFP2 coverage
- ▶ from unframed BERT through Ethernet & OTN
- ▶ Member of "Industry Reference ONT 100G family"
- ▶ Intelligent applications focused on end needs



*March 2014*

- ▶ JDSU released smallest 100G Analyser with CFP2, QSFP+ and SFP
- ▶ Same feature set as 100G analyser (CFP)



© 2013 JDS Uniphase Corporation | JDSU CONFIDENTIAL AND PROPRIETARY INFORMATION

35





## Test and Measurement for 100G / Field



## 100G Installation and Trouble Shooting



### Service Activation testing

- J-QuickCheck Perform quick end-to-end connectivity and config test
- RFC 2544: Throughput, Latency, Packet jitter, Frame Loss, Bursting
- Y.1564 SAMComplete
- Easy far-end loop up/down operation
- BERT burn-in tests





## J-QuickCheck

### Issues

- Takes too long to get right test set-up to start
- Users mis-configure settings: loopback ; auto-neg
- It's a waste of time to run the full test if throughput is way off from expected

### The Solution

- Perform quick end-to-end connectivity and config test
- Verifies test settings (like auto-neg) and connectivity to far end with loopback
- Quickly verifies end-to-end throughput

© 2013 JDS Uniphase Corporation | JDSU CONFIDENTIAL AND PROPRIETARY INFORMATION

## Time-Saving Activation Procedures

### J-QuickCheck Integration

- Time-saving pre-test checker
  - Loopback Detect
  - Summary throughput test

### Enhanced RFC2544


- The quickest RFC test
  - Run throughput, latency & packet jitter simultaneously
  - Integrate high-accuracy latency
  - Will integrate CBS test

### Y.1564 at 40GE/100GE

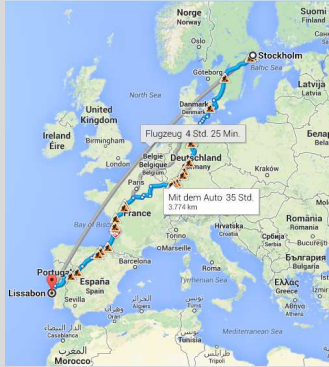
- Only 100G solution with Y.1564
  - SAMComplete available for multi-stream test
  - Integration of high-accuracy latency & CBS test


© 2013 JDS Uniphase Corporation | JDSU CONFIDENTIAL AND PROPRIETARY INFORMATION

## High-Accuracy Latency



- ▶ **Importance of highly accurate latency:**
  - Financial sector (HFT) tough requirements at nsec level
  - Wireless (4G)
- ▶ **High precision ATPv3 supports distances up to 37,000km (18,500km RTD)**
  - 100 nsec accuracy
  - Stockholm to Lisbon is 4000 km one way → can always be measured with high precision!






© 2013 JDS Uniphase Corporation | JDSU CONFIDENTIAL AND PROPRIETARY INFORMATION

41

## Anatomy of Optics Self-Test

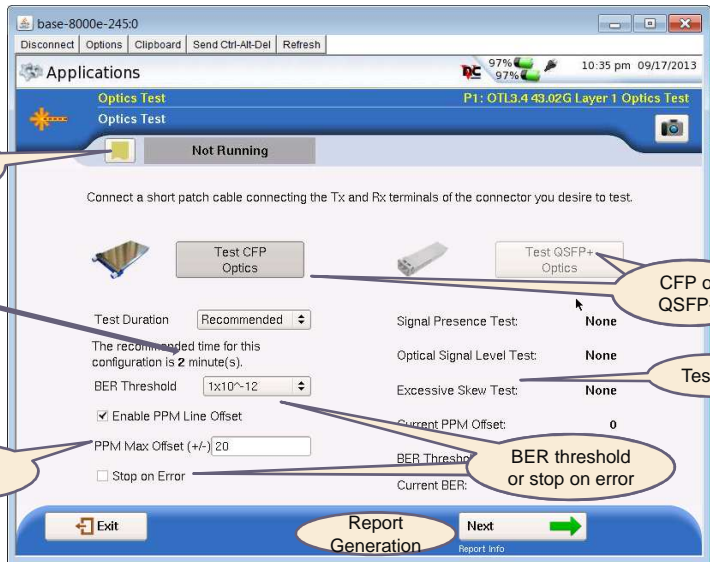


Straightforward workflow script with report generation

**Error Log**

**Test duration calculated based on BER objective**


**Clock offset with range**



**CFP or QSFP+**

**Test list**

**BER threshold or stop on error**



© 2013 JDS Uniphase Corporation | JDSU CONFIDENTIAL AND PROPRIETARY INFORMATION

42

## Deploy the Right Solution for the Application

**JDSU**

**MTS-8000v2**  
Modular and Expandable



**MTS-6000Av2**  
Compact and Modular



**MTS-5800**  
Integrated and Handheld





**40/100G Module**  
40/100G Ethernet  
OTU3 & OTU4  
OC-768 & STM-256



**New: CSAM**  
40/100G Ethernet  
OTU3 & OTU4  
OC-768 & STM-256



**MSAM**  
10M-10G Ethernet  
OTN, SONET/SDH,  
PDH, FC, CPRI, & OBSAI



**StrataSync®**  
Empower your assets

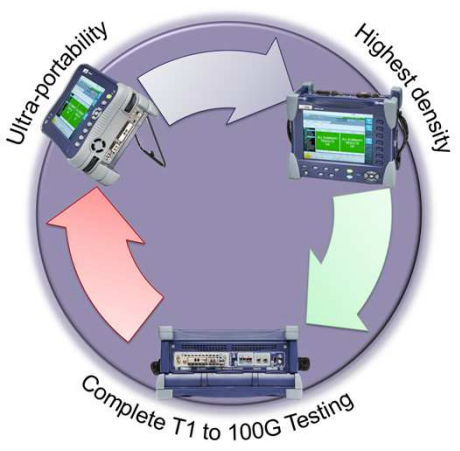
© 2013 JDS Uniphase Corporation | JDSU CONFIDENTIAL AND PROPRIETARY INFORMATION 43

## CSAM: 100G Services Application Module

**JDSU**

### Enabling Versatile 100G Testing


- ▶ Test 100G with the ultra portable MTS-6000A
- ▶ Enable 2 port 100G testing or T1 to 100G with the MTS-8000
- ▶ Key Features:
  - **Supported Optics:** CFP2, QSFP+, and SFP+ with field optimized optics self test
  - **OTN:** OTU4 & OTU3 with ODU muxing (ODU1, ODU0, & ODU2/2e) including GCC transparency and G.709 latency testing
  - **Ethernet:** 100GE & 40GE with advanced test features such as Y.1564, J-Proof L2CP transparency & high-accuracy latency
  - **Advanced Connectivity:** wifi, Bluetooth, StrataSync, SSH



© 2013 JDS Uniphase Corporation | JDSU CONFIDENTIAL AND PROPRIETARY INFORMATION 44

JDSU
Technology for 100 Gbps and towards 400 Gbps

## Questions?




**JDSU**


**Peter Winterling**  
Senior Technology and Application Specialist  
Optical Transport EMEA


**Communications Test  
and Measurement**


**JDSU Deutschland GmbH**  
Mühlweg 5  
D-72800 Eningen u.A.

Tel +49(0)7121-86-2024  
Mobil +49(0)172-6091690  
FAX +49(0)7121-86-1888  
Email peter.winterling@jdsu.com  
www.jdsu.com/de









## JDSU enables new ways