

High Speed Technology at 40G and 100G – New testing required

Technology & Market Update

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BDM
Transport and Datacom



Design

Deployment

Service Assurance

EXFO

EXPERTISE REACHING OUT

I Want Broadband!



YouTube alone uses as much bandwidth today per day as the entire Internet did in 2001.



iPlayer in UK:

- higher quality than YouTube
- 10 x longer viewing
- 30 x more bandwidth



Apple sells 1 million iPhones (all with video) in 74 days



10x more bandwidth as we move from phone to video conversations

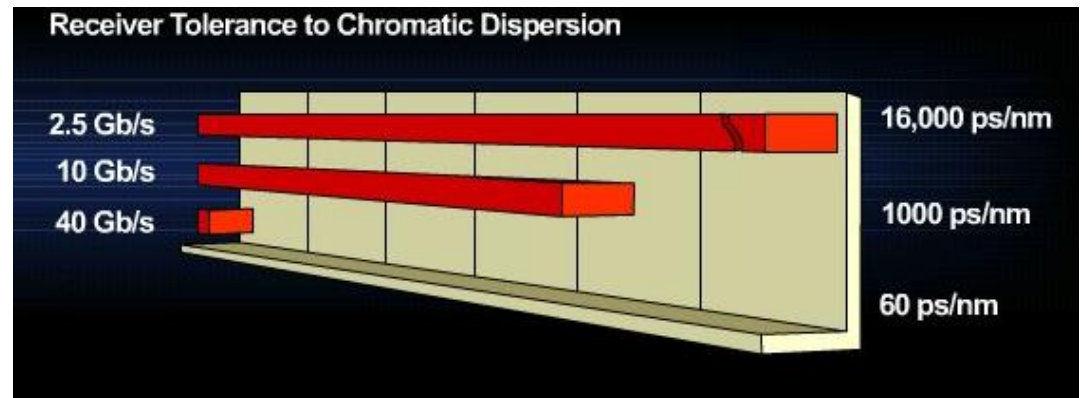
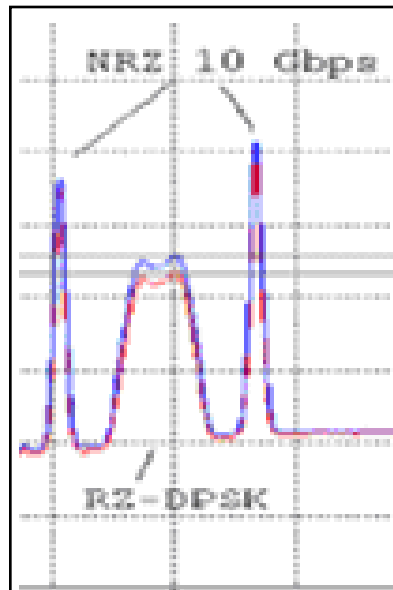


Upgrades from Standard to HDTV will increase bandwidth five-fold
-SA Football will be in 3D

CONFIDENTIAL

Why is 40G - 100G introduction so difficult?

- We are reaching the limits of the physics
 - Limits of the optical fiber
 - Limits of the optic



- Traditional technologies (NRZ, DWDM, EDFAs, etc) have limited use at 100G

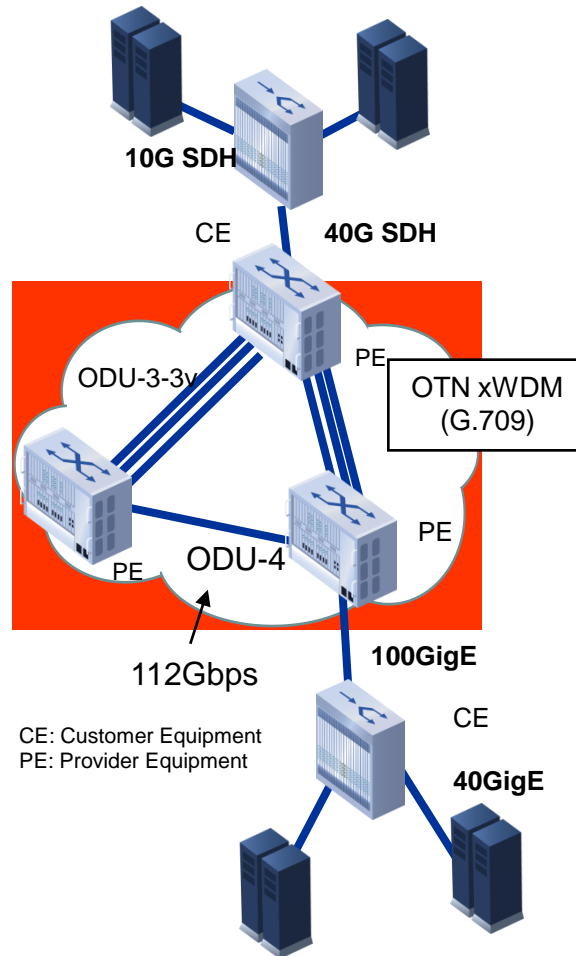
High Speed Interfaces

What is Line Side and Client Side?

And Why is it important to differentiate?

Client Side

- Towards Customer
- Service oriented
- Mostly packet oriented



Line Side

- Towards Network
- Long distance
- Transport oriented

Standard Bodies Involved



- IEEE
 - Working on 802.3ba to define 100Gb and 40Gb Ethernet
 - Draft 2.0 released in March 2009. Ratification target: June 2010
- ITU-T Study Group 15
 - Approved the OTU4 rate of 112G (enough to encapsulate 100GbE)
 - Approved the mechanism to map 40GbE into OTU3
- OIF
 - Recently started the “*Physical and Link Layer*” Working Group to standardize 112G to 128G modulation using Dual-Polarization QPSK (DP-QPSK)
 - Will be the first time a network’s line interface is standardized. This will lower component cost

Updates from ITU-T SG15



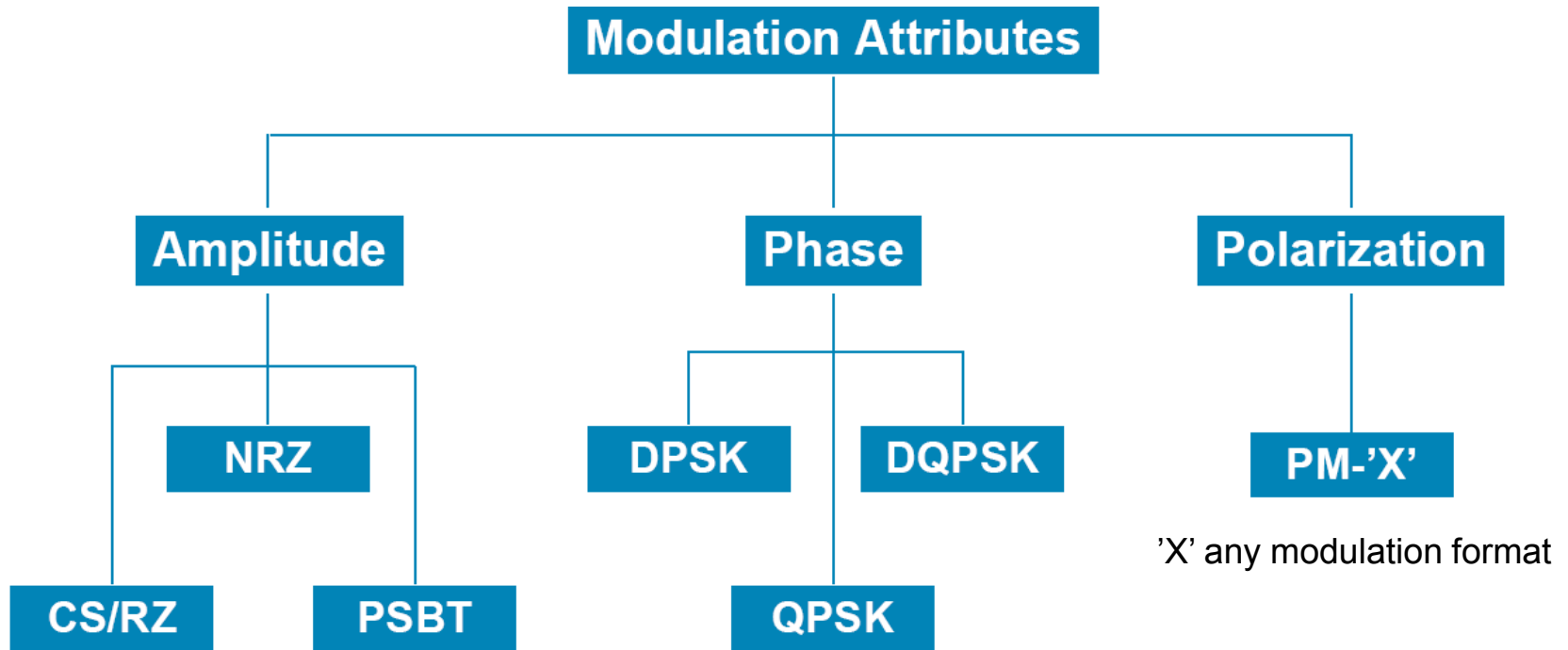
- Consensus is that 40G is the last SDH rate
 - No 160G on the horizon
 - ITU-T SG15 likely to focus solely on OTN from now on
- ITU-T Study Group 15 approved the OTU4 rate of 111.89973Gbps
 - Overclocked rates (128G) to support Ultra-FEC are being discussed
- Support for OTU4 with parallel optics is being discussed
 - Will facilitate the introduction of OTU4 client interface on 100G products
 - OTU4 FEC on client interface still being discussed
 - Mandatory FEC on client interface also being discussed
- Support for OTU3 defined last April
 - 40GbE in OTU3 achieved using 512b/513b transcoding

Key Question

- How to go forward from here?
 - How to overcome the limitations of the Optic and Optical Fiber?
 - By talking to Wireless experienced people they recommend phase modulation instead of Amplitude modulation
 - QPSK
 - DQPSK
 - Nowadays even used in WiFi Routers

Bild					
Preis (aufsteigend sortiert)	30,50 €* 	32,50 €* 	32,50 €* 	39,90 €* 	39,90 €* 
Leitungskodierformat 	DBPSK, DQPSK, CCK, 64 QAM, BPSK, QPSK, 16 QAM	CCK, BPSK, QPSK	DBPSK, DQPSK, CCK, 64 QAM, BPSK, QPSK, 16 QAM, OFDM		DBPSK, DQPSK, CCK, 64 QAM, BPSK, QPSK, 16 QAM, OFDM

Advanced Modulation Schemes Overview



NRZ – non-return to zero

RZ – return to zero

CSRZ – carrier suppressed return to zero

PSBT – phase shaped binary transmission (duobinary)

(D)PSK – (differential) phase shift keying

(D)QPSK – (differential) quaternary phase shift keying

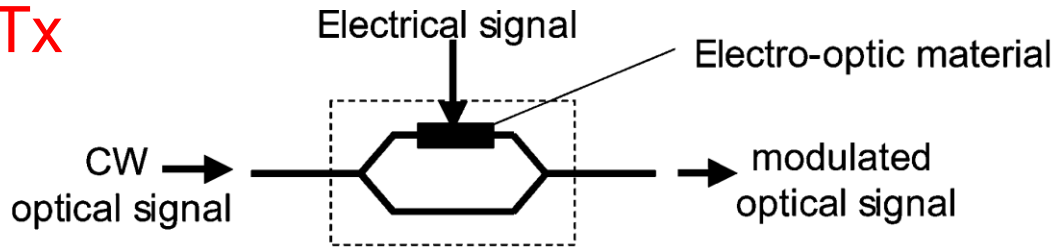
PM – polarization multiplexed

Intensity modulation – NRZ

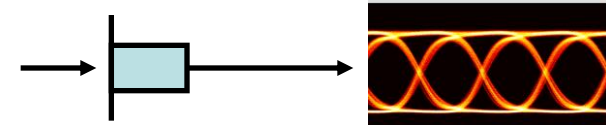


NRZ using a Mach-Zehnder intensity modulator

Tx

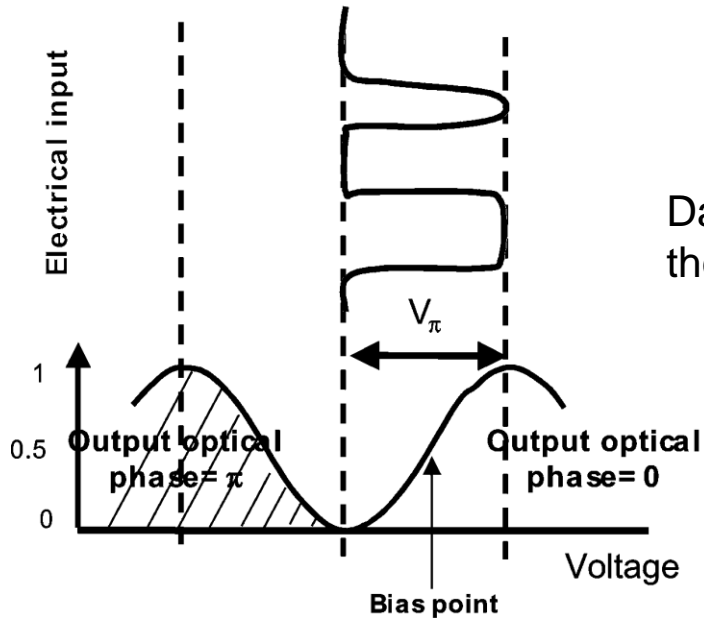


Rx



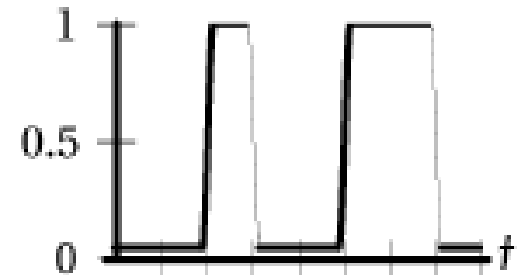
The intensity modulation is easily detected by direct detection with a photo detector

Electro-optic Mach Zehnder modulator



Data is encoded in the intensity

NRZ

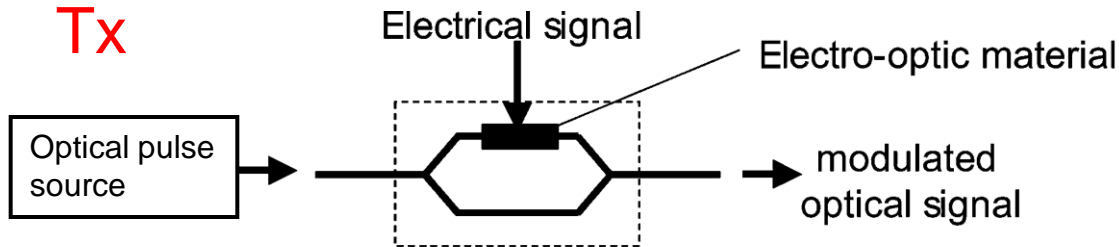


Intensity modulation – RZ



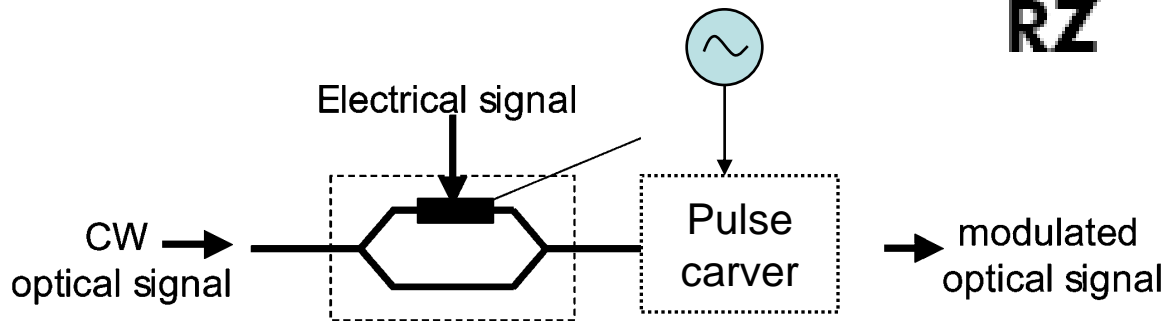
RZ using a pulse source / RZ using pulse carver

Tx

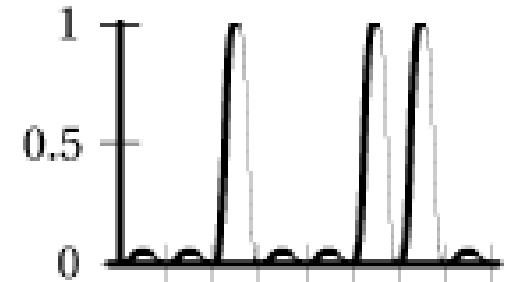


Electro-optic Mach Zehnder modulator

RZ



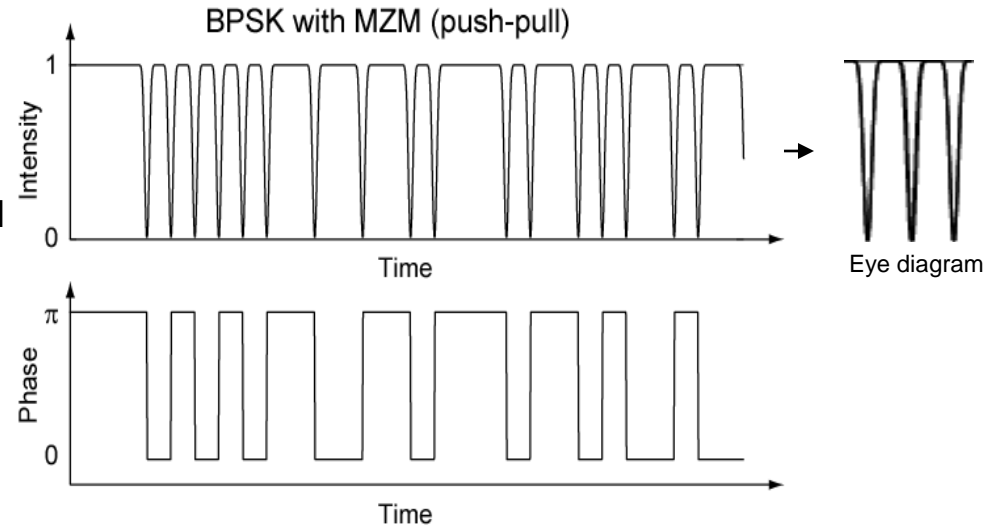
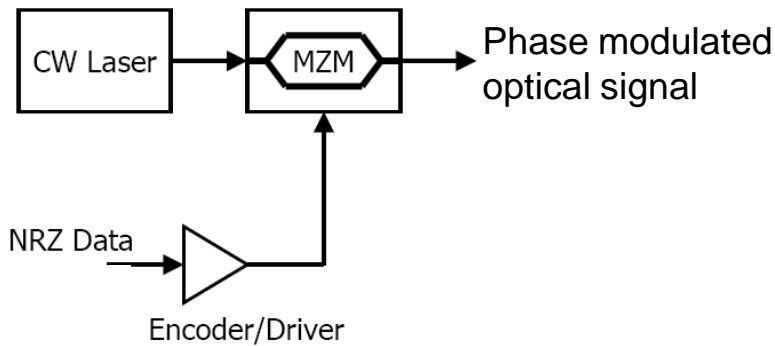
Electro-optic Mach Zehnder modulator



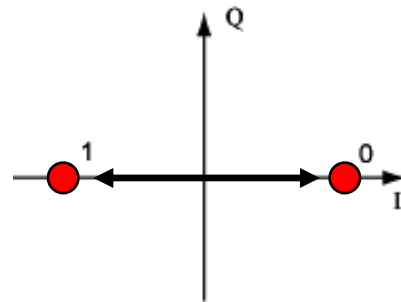
Phase modulation

Binary PSK/DPSK modulation

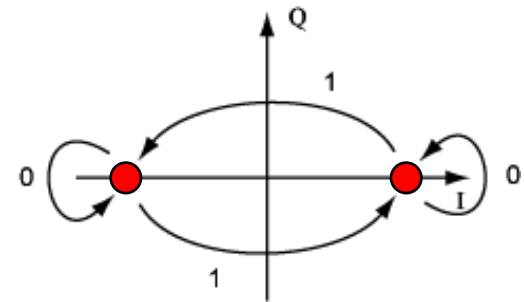
Tx Block Diagram



PSK and DPSK is generated the same way, but the encoding of symbols differ.



PSK - absolute phase encoded

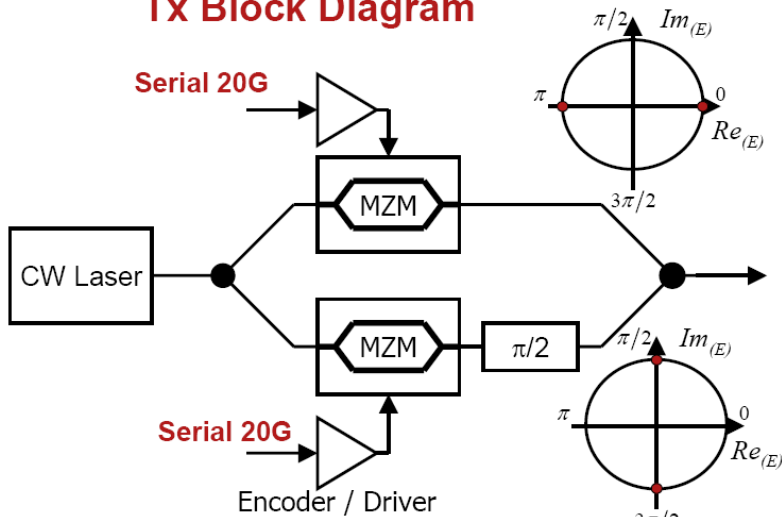


DPSK - data encoded in the phase difference between adjacent symbols

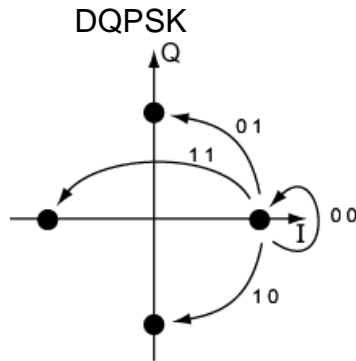
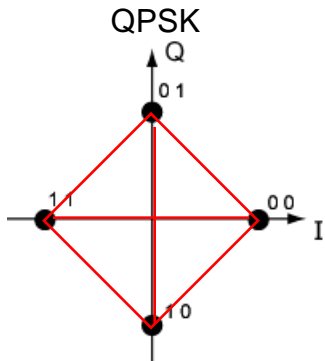
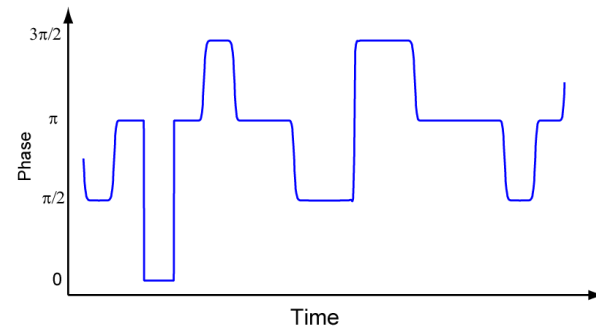
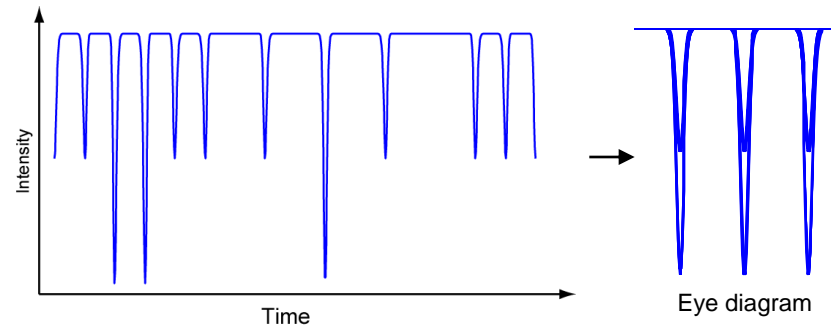
Quaternary phase modulation

QPSK/DQPSK modulation

Tx Block Diagram



QPSK/DQPSK is generated as two parallel binary PSK signals combined at 90 degrees (I/Q modulator)



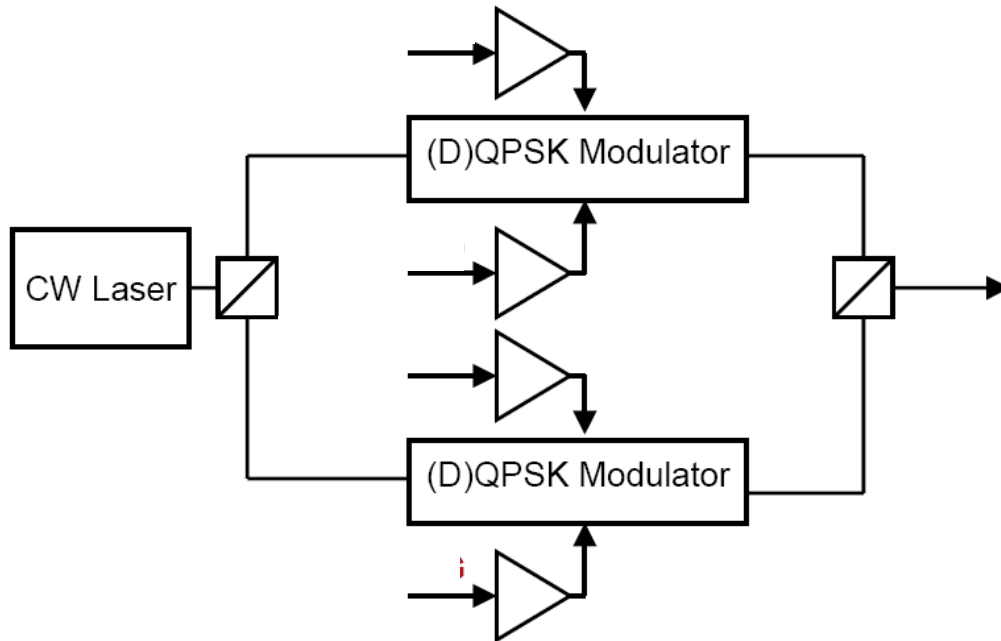
4 phases → 2 bits/symbol

Dual-Polarization



PM-(D)QPSK modulation

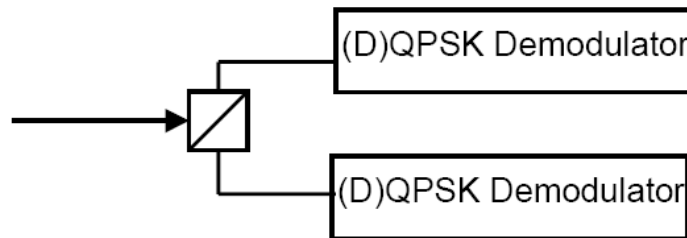
Tx Block Diagram



Polarization multiplexing doubles the capacity (using two sets of Tx and Rx)
PM-(D)QPSK carries 2 x 2 bits/symbol

112 Gbit/s is typically reached by using 28 Gbaud PM-(D)QPSK

Rx Block Diagram



ECOC GUI

EXFO Optical Modulation Analyser (Prototype)

File Measurement Help

Constellation X

Constellation Y

I

Q

Magnitude

Phase angle

Measurements

EVM: 0 dB
IQ Offset: 0 dB
IQ Imbalance: 0 dB
Phase error: 0 dB
Mag error: 0 dB
SNR: 0 dB
BER: 0 dB

Measurements

EVM: 0 dB
IQ Offset: 0 dB
IQ Imbalance: 0 dB
Phase error: 0 dB
Mag error: 0 dB
SNR: 0 dB
BER: 0 dB

Start

Graph Tools

Ready 0.063 s 15.873Hz 46.3506% ??? bits

ECOC Unit



New GUI

Test3.omd - EXFO Optical Modulation Analyzer

File Edit Display Measurement Playback Settings

Constellation X

Constellation Y

I Diagram

Q Diagram

I Diagram

Q Diagram

Polarization X Results

Property	Current	AVG	Min	Max
Constellation Eye X				
BER	0.000	0.000	0.000	0.000
SNR	0.000	0.000	0.000	0.000
Measured Signal Bandwidth	---	---	---	---
IF Offset	0.000	---	---	---
Constellation X				
EVM Peak	0.000	0.000	0.000	0.000
EVM RMS	0.000	0.000	0.000	0.000
EV Phase Peak	0.000	0.000	0.000	0.000
EV Phase Rms	0.000	0.000	0.000	0.000
IQ Imbalance Peak	0.000	0.000	0.000	0.000

Polarization Y Results

Property	Current	AVG	Min	Max
Constellation Eye Y				
BER	0.000	0.000	0.000	0.000
SNR	0.000	0.000	0.000	0.000
Measured Signal Bandwidth	---	---	---	---
IF Offset	0.000	---	---	---
Constellation Y				
EVM Peak	0.000	0.000	0.000	0.000
EVM RMS	0.000	0.000	0.000	0.000
EV Phase Peak	0.000	0.000	0.000	0.000
EV Phase Rms	0.000	0.000	0.000	0.000
IQ Imbalance Peak	0.000	0.000	0.000	0.000

Global Results (X|Y)

	XY Imbalance	Intermediate Frequency	Applied LO Frequency	Phase Slip	CD Unwrapping Found
Current Burst	0.000	0.000	0	0	Yes

Start

File

Playback

Graph Tools

EXFO Ready Burst 1 of 5 Local 12/9/2009 6:05 PM

IEEE 802.3ba Pluggable Modules

- Based on IEEE 802.3ba objectives, MSA (Multi Supplier Agreement) Forums have emerged and agreed on the following form factors:

	40G Ethernet	100G Ethernet
40 km over SMF		CFP
10 km over SMF	CFP	CFP
100 m over OM3 MMF	QSFP optical	CXP optical
10 m over copper cable	QSFP active electrical cable	CXP active electrical cable

- Key differences between 10G and 100G Ethernet
 - Optical interfaces are different; *it's all parallel (WDM or parallel fibers)*
 - Host interface is different; 10x 10G is new
 - Layer 1 is different; PCS Lane, markers and skew are new concepts
- Low cost and simplicity are part of every decision for the specification of IEEE

IEEE 802.3ba Pluggable Modules

- CFP form factor package (86x127x14 mm / 3.4"x5.0"x0.55")

-  ■ 100 GbE, 40 km on SMF (4x 25G LAN WDM, centered at 1305nm)

-  ■ 100 GbE, 10 km on SMF (4x 25G LAN WDM, centered at 1305nm)

-  ■ 40 GbE, 10 km on SMF (4x 10G LAN WDM, centered at 1305nm)

-  ■ **100 GbE, 10 km on SMF (10x 10G CWDM, centered at 1550nm)**

- *From Santur Corporation*

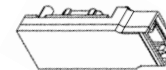


Initial price for 100G CFPs is 10x to 20x the price of 10G XFP

- CXP form factor (approx 20x54x11 mm / 0.78"x2.13"x0.43")

-  ■ 100 GbE, 100 m on OM3 MMF (850 nm parallel optics, 10x 10G)

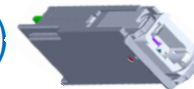
- 100 GbE, 10 m on active cable



- QSFP form factor (18.4x72x8.5 mm / 0.72"x2.8"x0.33")

-  ■ 40 GbE, 100m on OM3 MMF (850 nm parallel optics, 4x 10G)

- 40 GbE, 10 m on active cable



85100G – Interface Specifications

Client Interfaces**

- 100G CFP :
 - 10x 10G SMF
 - 4x 25G SMF
 - 10x 10G MMF
- 100G CXP: 10x 10G MMF
- 40G CFP: 4x 10G SMF
- 40G QSFP: 4x 10G MMF

Clocking

- Stratum-3e clock with +/- 115 ppm user controllable offset
- Support 100G /112G and 40G/43G rates
- High quality reference clock output of up to 3.22G



Pluggable interface controls & monitoring

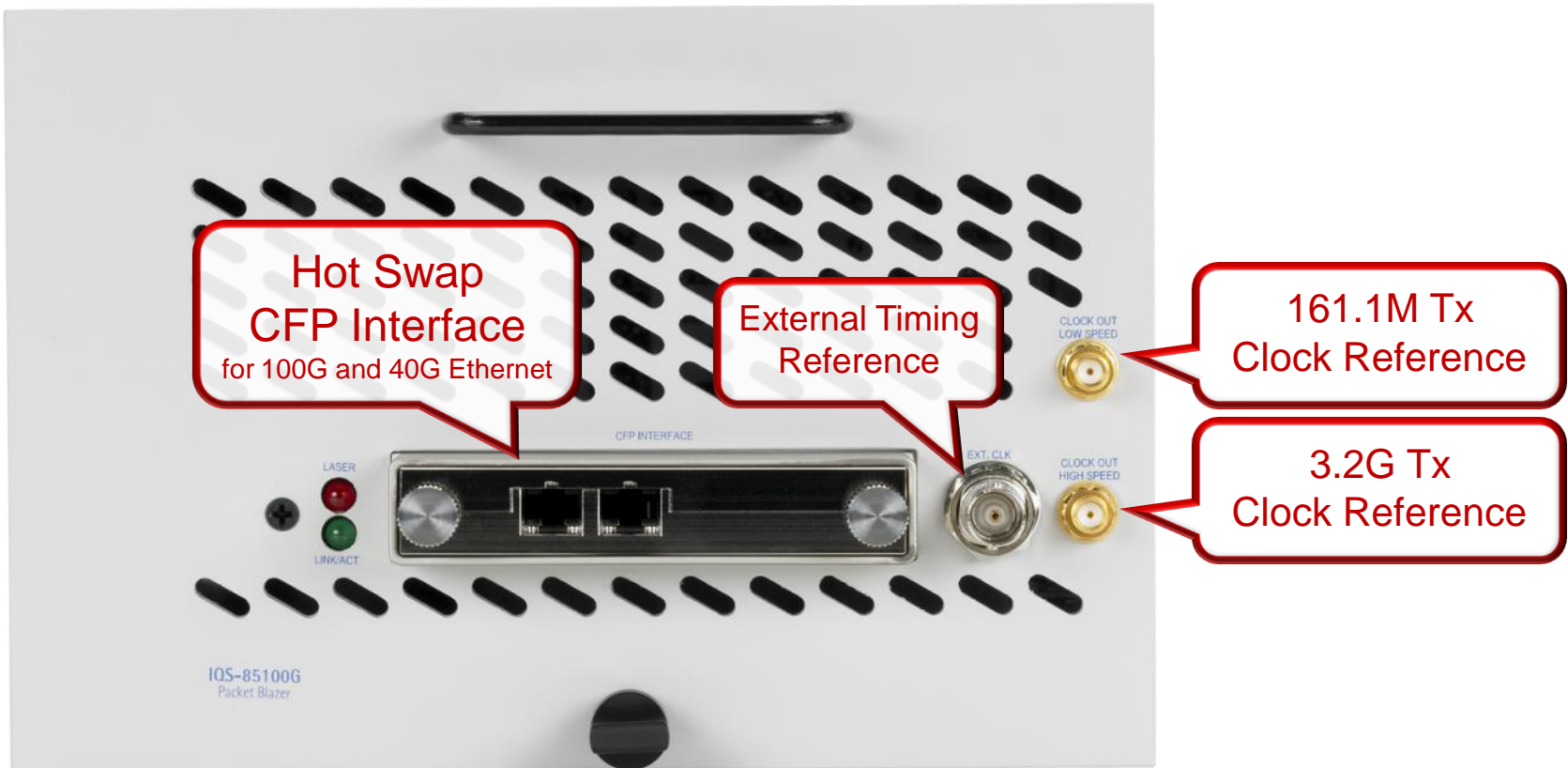
- Control: laser on/off & amplitude (per lane)
- Monitoring: Input level (per lane), Rx frequency
- Read/write any MDIO register

OTU3 and OTU4 hardware ready

- Designed to support OTU3 and OTU4 with parallel or serial data streams
- Unframed BERT (PRBS) at OTN rate

** Availability is dependent on suppliers delivery timeline of pluggable transceivers. Supplier delays could impact EXFO's delivery

85100G Front Panel



Shown is the IQS-85100G. FTB-85100G's front panel includes the same features.

85100G – Layer 1 Specifications

Complete testing of Physical Lanes, PCS Lanes and Skew

- BERT on CAUI/XLAUI Lane, on PCS Lanes or on Trunk (RS Layer)
 - Monitoring includes mismatches on “0”/”1”

Error injection and monitoring

*Injection is on specific or random lane;
Errors are single counts or burst*

- Bit error in Physical Lane
- Bit error in PCS Lane
- Invalid 64b/66b code
- Unsupported PCS code
- Invalid PCS Lane markers
- Duplicate PCS Lane markers

PCS Lanes

- Monitors lane marker period and reports any changes to PCS lane table
- User defined or random mapping supported

Lane Skew

- Dynamically change and measure PCS lane skew

Flow control

85100G – Layer 2/3 Specifications

Ethernet & IP Testing

- Layer 1 error/alarm injection and monitoring are functional at all times while testing Ethernet/IP layer

Packet Definition

- User defined rate utilization (up to 100% with 64 bytes packets)
- User defined MAC and IP address
- User defined packet size up to 16k
- User controlled idle deficit counter
- Random packet sizes

Error injection and monitor

- Payload
- FCS

Ethernet statistics

- Jabber, giant, runt, oversize, FCS, total frames

IP statistics

- Multicast, broadcast, unicast, total

Actual bandwidth usage statistics

What to expect from EXFO



- EXFO is committed at tracking the latest transport technologies
 - We are tracking and attending MEF, IEEE, OIF and ITU SG15 meetings
- Expect more and more EXFO products to be 100G ready:
 - FTB-500 (*New high end portable platform*)
 - FTB-5600 (*New distributed PMD analyzer*)
 - PSO-100 family (*New optical sampling oscilloscopes*)
 - PSO-200 family (*New optical Constellation Analyzer*)
 - FTB-5500/5800 (*CD/PMD analyzer*)
 - IQS-85100G (*New 100GbE tester*)
 -and more to come!!

Questions?



Design

Deployment

Service Assurance

EXFO

EXPERTISE REACHING OUT