Ethernet SFF-8431 SFP+ SFF-8635 QSFP+ Compliance and Debug Testing

Tektronix Innovation Forum

Leading Solutions for Today,
Tomorrow and Beyond

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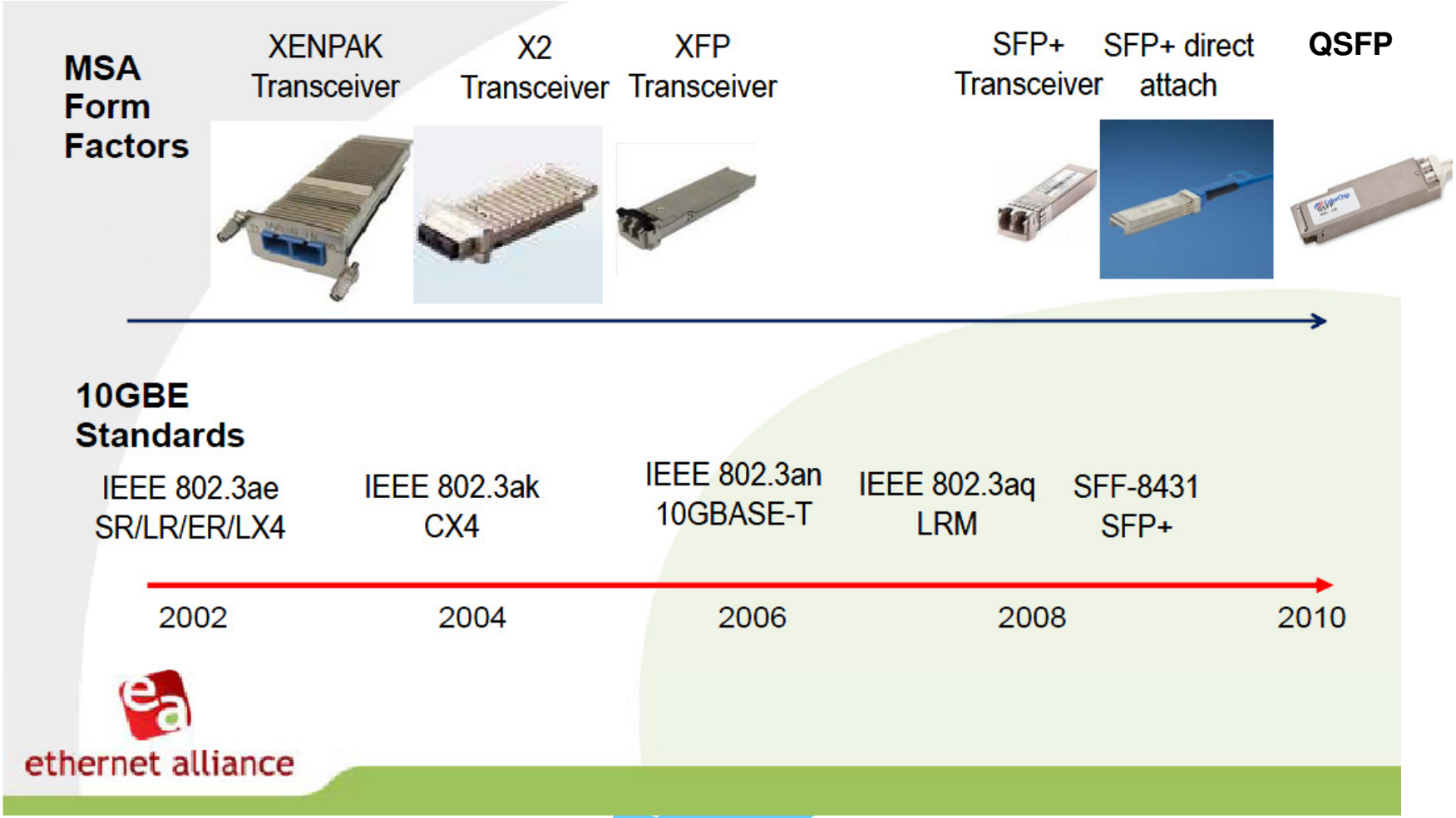
Agenda

- QSFP+ SFP+
  - Technology Overview
  - Testing challenges
    - Performing TWDPc Measurements
- Solution for Debug & Compliance Testing
  - SFP-TX – Automation
  - SFP-WDP – TWDPc Measurements
- SFP+/QSFP+ Fixture
  - Overview of HCB and MCB fixtures
- Features and Benefits

QSFP+ SFP+ Technology and Related Testing Challenges

10Gigabit Ethernet Interface Evolution



Source : Ethernet Alliance

Next Big Thing
SFF-8431
SFP+, QSFP+

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SFF-8431 SFP+/SFF-8635 QSFP+ Technology overview

- SFP+ is a next-generation hot-pluggable, small footprint, serial-to-serial multi-rate optical transceiver for 8.5GbE to 11.1GbE Datacom and Storage Area Networks (SAN) applications.
- SFF-8635 QSFP+ 10 Gb/s 4X Pluggable Transceiver Solution (QSFP10)
- SFP+ technology moved the clock and data recovery units out of the module and onto the line card – Reducing size drastically
- As a result, the modules are smaller, consume less power, allow increased port density, and are less expensive compared to XFP.
- High density capable Up to 48 ports in a rack
- Low power per port - Host Port power < 1 W and Low Latency

SFP+ Test Challenges

- Test Time
  - 48 Port Devices
  - Multiple test points and repetition in setup
- Debug vs. Compliance
  - When and how to make the shift with port replication in the process
  - Difficult to detect low amplitude impact on eye pattern performance
- Connectivity
  - Smaller package with difficulty to access test points
- Ambiguous Test Specification
  - Primary instrument defined for eye pattern measurements is equivalent-time oscilloscope so redefinition needed for real-time oscilloscope
- Test Pattern Setup
  - PRBS31 pattern is treated as an arbitrary waveform

TWDPc Measurement Definitions

- TWDPc
  - **T**ransmitter **W**aveform **D**ispersion **P**enalty for **C**opper
  - *Defined as a measure of the deterministic dispersion penalty due to a particular transmitter with reference to the emulated multi-mode fibers and a well-characterized receiver.*
  - The fiber optics concept has been extended to quantify channel performance of high speed copper links “10GSFP+Cu”
  - Critical for performance
  - Requires a special algorithm
  - ClariPhy has IP rights for this algorithm

- Test Specification Requirements for TWDPc
  - 7 measurement samples per unit interval
  - Causes worst-case 0.24 dB TWDPc over 30 measurements

SFP-TX Host Transmitter Measurements

- 15 Defined Measurements for Host Tx Compliance

SL No.	Measuremnts	Signal Type Recommended	Limit			
			Min	Target	Max	Units
Host Transmitter output electrical Specifications:						
1	Single Ended Output Voltage Range	PRBS31	-0.3		4	V
2	Output AC Common Mode voltage (RMS)	PRBS31			15	mV(RMS)
Host Transmitter Jitter and Eye Mask specifications						
3	Crosstalk source rise/fall time (20%-80%) (Tr, Tf)	8180		34		ps
4	Crosstalk source amplitude (p-p differential)	8180		1000		mV
5	Signal rise/fall time (20%-80%) (Tr, Tf)	8180	34			ps
6	Total Jitter (p-p) (Tj)	PRBS31			0.28	UI(p-p)
7	Data Dependent Jitter (p-p) (DDJ)	PRBS9			0.1	UI(p-p)
8	Data Dependent Pulse Width Shrinkage (p-p) (DDPWS)	PRBS9			0.055	UI(p-p)
9	Uncorrelated Jitter (RMS) (UJ)	PRBS9			0.023	UI(p-p)
10	Transmitter Qsq	8180	50			
11	Eye mask hit ratio(Mask hit ratio of 5×10-5)	PRBS31	X1=0.12UI, X2=0.33UI, Y1=95mV, Y2=350mV			
Host Transmitter output specifications for Cu (SFP+ host supporting direct						
12	Voltage Modulation Amplitude (p-p)	8180	300			mV
13	Transmitter Qsq Output AC Common Mode voltage	8180	63.1			
14	Output AC Common Mode Voltage	PRBS31			12	mV(RMS)
15	Host Output TWDPc *	PRBS9			10.7	dBe

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SFP-TX Module Transmitter Measurements

- 10 Defined Measurements for Tx Module Compliance

SL No.	Measuremnts	Signal Type Recommended	Limit			
			Min	Target	Max	Units
Module Transmitter Input electrical Specifications:						
1	AC common mode voltage tolerance	PRBS31	15			mV
2	Single Ended Input Voltage Tolerance	PRBS31	-0.3		4	V
Module Transmitter Jitter and Eye Mask specifications						
3	Crosstalk source rise/fall time (20%-80%) (Tr, Tf)	8180		34		ps
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SFP-TX & SFP-WDP – SFP+/QSFP+ Automation and Debug Solution

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SFP-TX – SFP+/QSFP+ Compliance and Debug Solution

- Automated Tests
  - One-button selection of critical Host & Module Tests reduces testing time
- Integrated Debugging
  - Popular DPOJET-based interface enables deeper debug of timing root cause analysis without moving to a different instrument/measurement setup
- Integrated support for TWDPc measurements
  - Rely on off-the-shelf products to perform this complex measurement rather than developing custom lab setup reducing testing time and complexity
- Documentation/Reporting
  - Real-time waveform capture and pre-recorded waveform support provides ability to share waveform details with other labs, vendors and customers across multiple locations

Tektronix SFP-TX – Automation Part

- Operates on Tektronix DPO/DSA70000C/D Series Oscilloscopes
- Automate setup & quickly generate reports
- Meets Compliance needs of SFF-8431/SFF-8635
- User defined mode supports PRBS7, PRBS11, PRBS15,PRBS20 & PRBS23 in addition to patterns supported in Compliance mode including PRBS9, PRBS31 and 8180.

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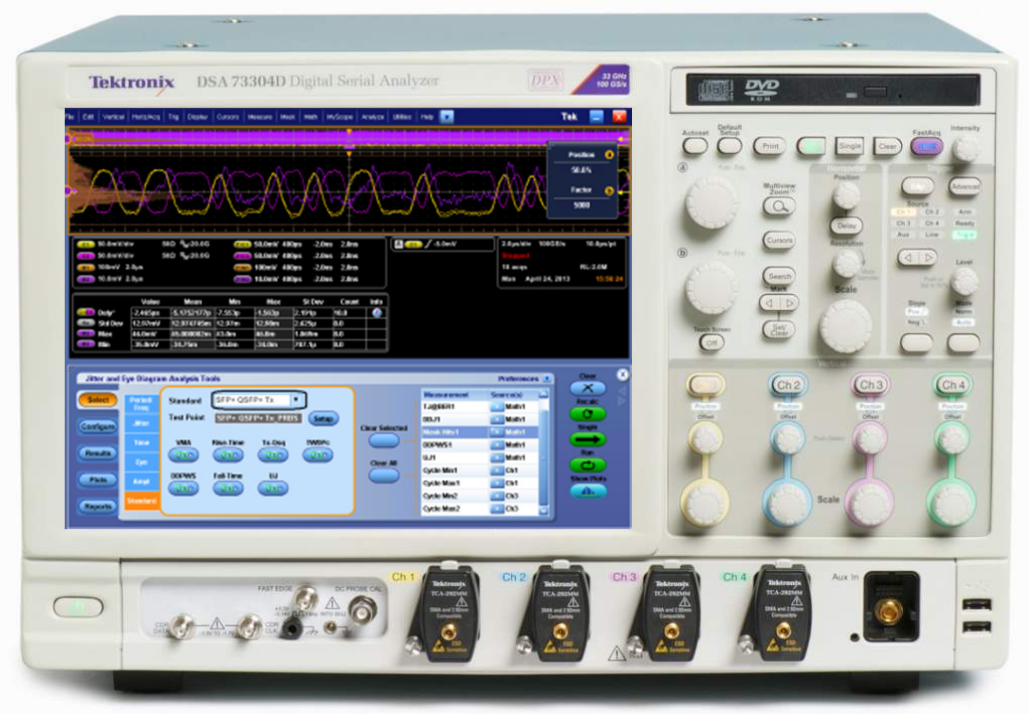
Tektronix SFP-TX – Debug Part



- Operates on Tektronix DPO/DSA70000C/D Series Oscilloscopes
- DPOJET(DJA) Standard Specific Drop down menu item
- Meets Compliance needs of SFF-8431/SFF-8635
- Signal patterns supported include - 8180, PRBS9 & PRBS31

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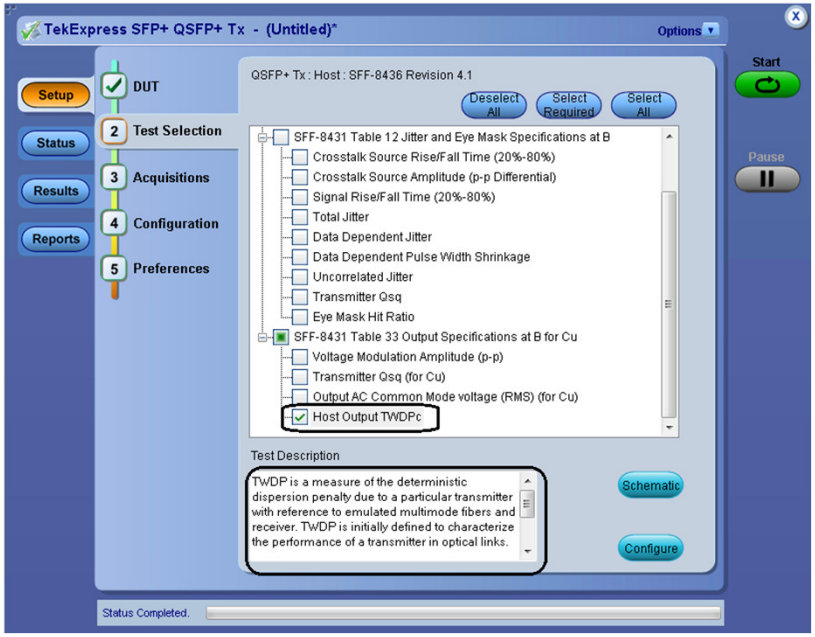
Tektronix SFP-WDP Option – TWDPc Measurement



- Operates on Tektronix DPO/DSA70000C/D Series Oscilloscopes
- Perform Transmitter Waveform Dispersion Penalty measurement with simple setup and test execution
- Ideal for high sample rate acquisition
  - 100GS/sec setting available on DPO/DSA70000C/D

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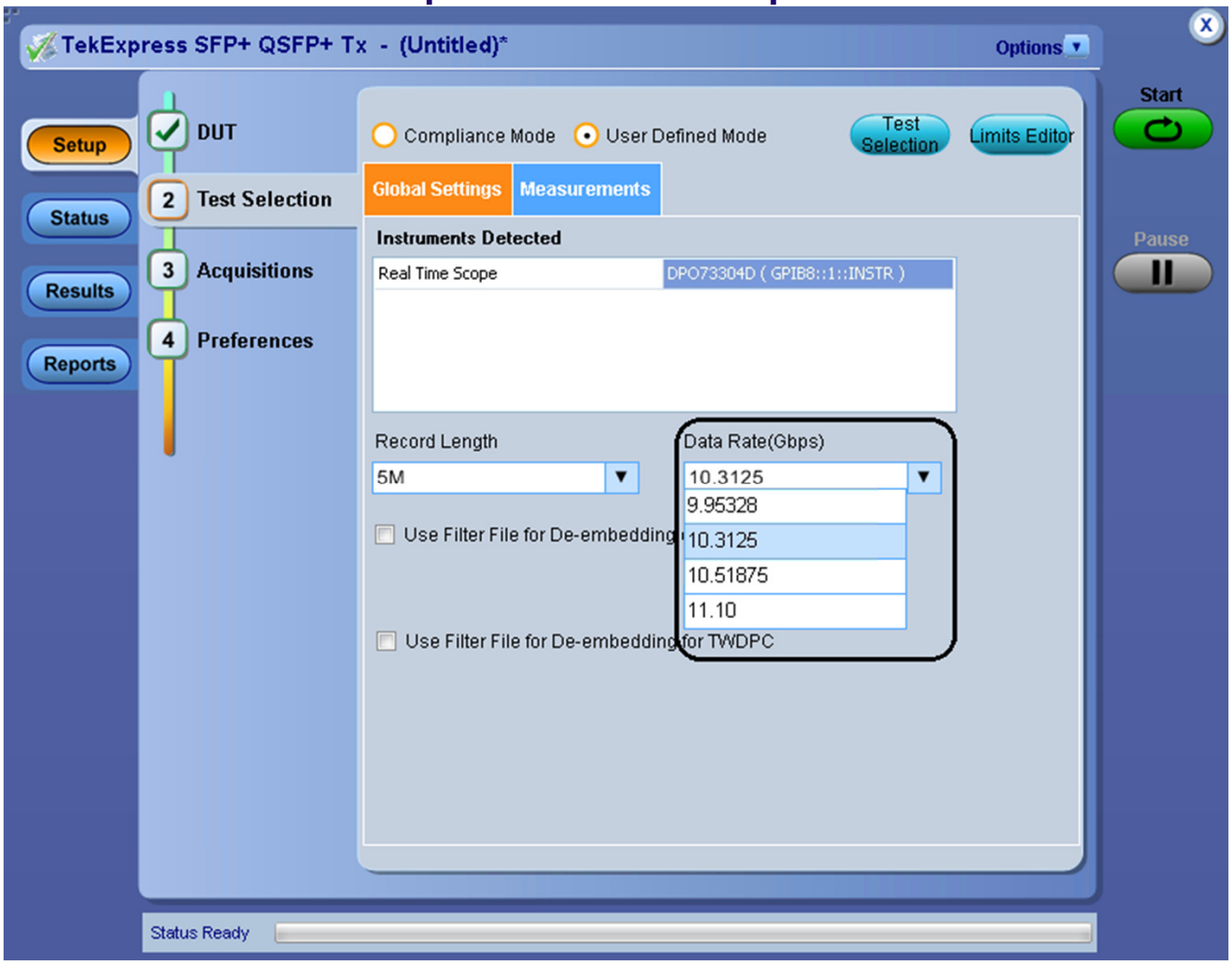
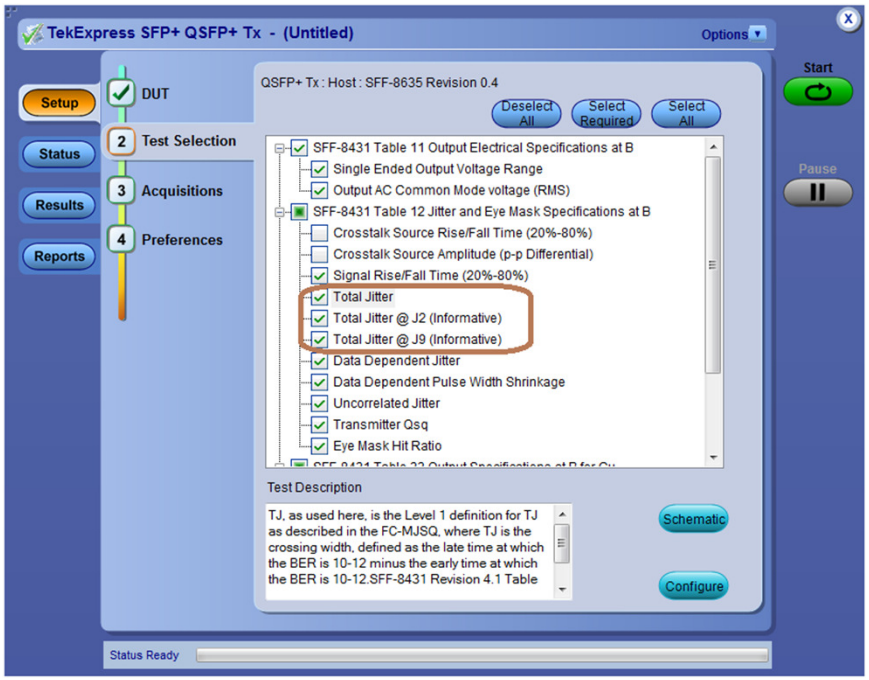
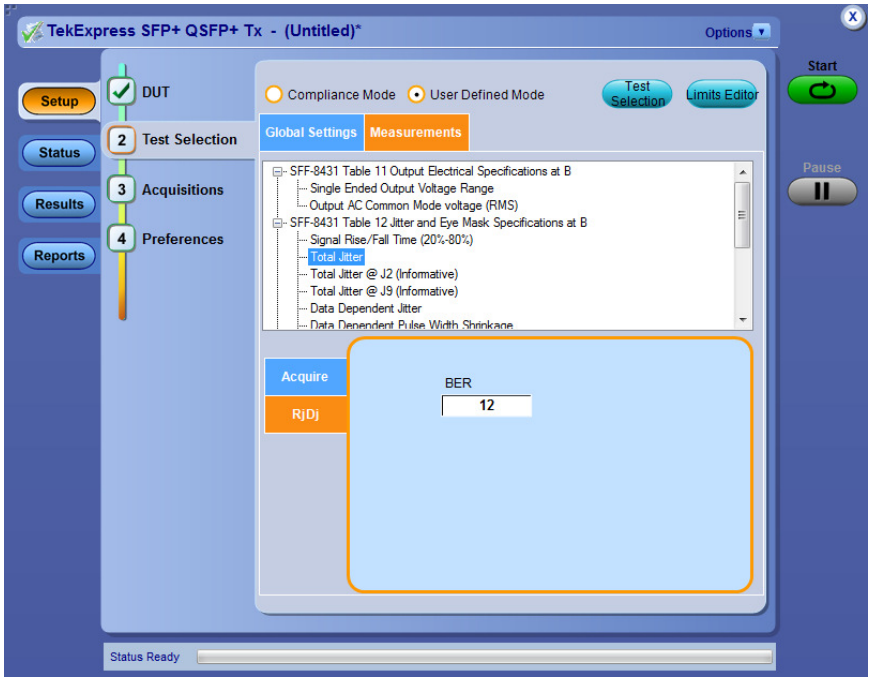
Tektronix SFP-TX Option – Multiple Data Rate Support



- Tektronix application supports multiple data rates including 9.95328Gbps, 10.3125 Gbps,10.51875 Gbps and 11.10 Gbps.

Tektronix SFP-TX Option – J2 & J9 Support





- SFP-TX allows users to enter BER value of in the range of BER e^–2 to –18,providing them the flexibility to calculate Total Jitter at various BER values.
- J2 & J9 measurements are part of other 10G standards like 40GBASE-CR4 and XLPPI.

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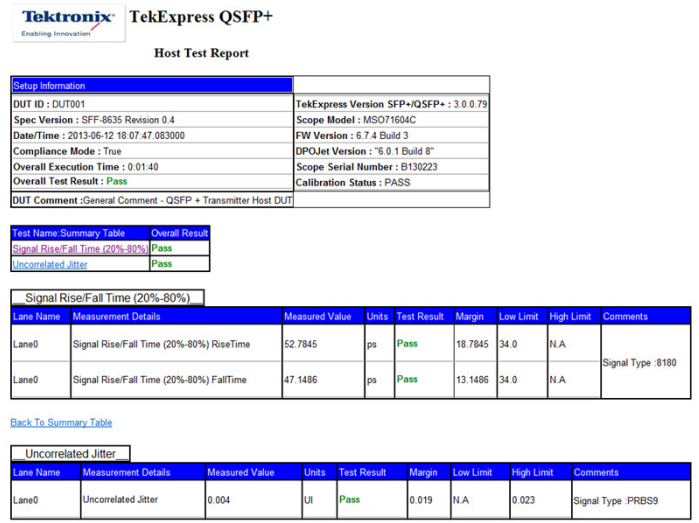
Reporting and Documentation

- Summary-reporting capability in .mht (HTML) format with pass/fail status
- Detailed report includes
  - Measurement results:
    - Test configuration details, waveform plots, and margin analysis
  - Test Setup details:
    - Calibration status, oscilloscope model, probe model, software version, date, execution time etc.
- Flexible report configuration provides options like auto increment, appending etc.



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TekExpress QSFP+

Host Test Report

Setup Information	
DUT ID : DUT001	**TekExpress Version SFP+/QSFP+ :** 3.0.0.79
Spec Version : SFF-8635 Revision 0.4	**Scope Model :** MSO71604C
Date/Time : 2013-06-12 18:07:47.083000	**FW Version :** 6.7.4 Build 3
Compliance Mode : True	**DPOJet Version :** "6.0.1 Build 8"
Overall Execution Time : 0:01:40	**Scope Serial Number :** B130223
Overall Test Result : Pass	**Calibration Status :** PASS
DUT Comment : General Comment - QSFP + Transmitter Host DUT	

Test Name:Summary Table	Overall Result
Signal Rise/Fall Time (20%-80%)	Pass
Uncorrelated Jitter	Pass

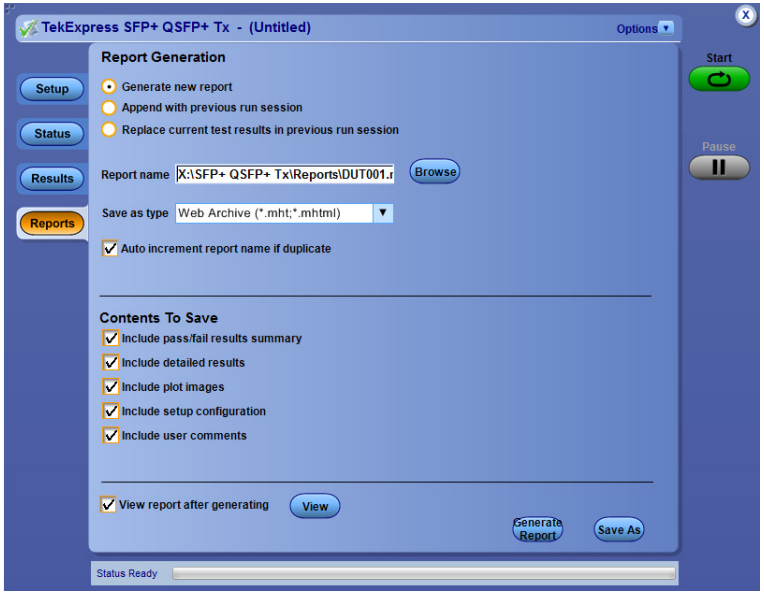
Signal Rise/Fall Time (20%-80%)

Lane Name	Measurement Details	Measured Value	Units	Test Result	Margin	Low Limit	High Limit	Comments
Lane0	Signal Rise/Fall Time (20%-80%) RiseTime	52.7845	ps	Pass	18.7845	34.0	N.A	Signal Type :8180
Lane0	Signal Rise/Fall Time (20%-80%) FallTime	47.1486	ps	Pass	13.1486	34.0	N.A	

Back To Summary Table

Uncorrelated Jitter

Lane Name	Measurement Details	Measured Value	Units	Test Result	Margin	Low Limit	High Limit	Comments
Lane0	Uncorrelated Jitter	0.004	UI	Pass	0.019	N.A	0.023	Signal Type :PRBS9



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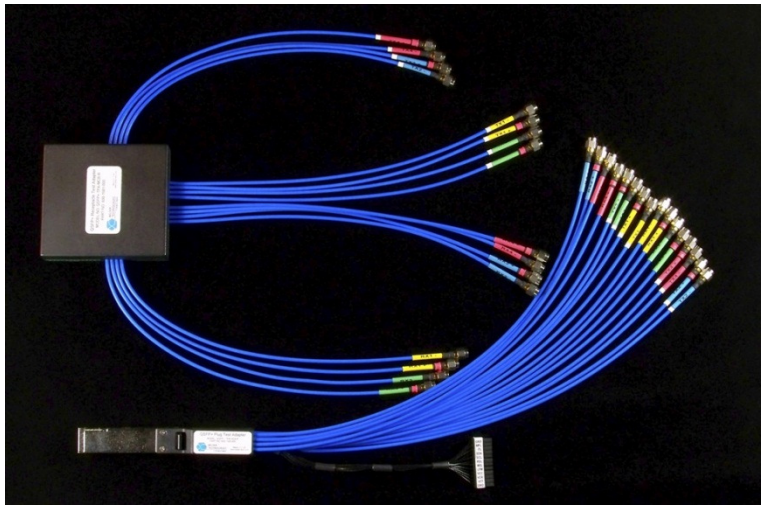

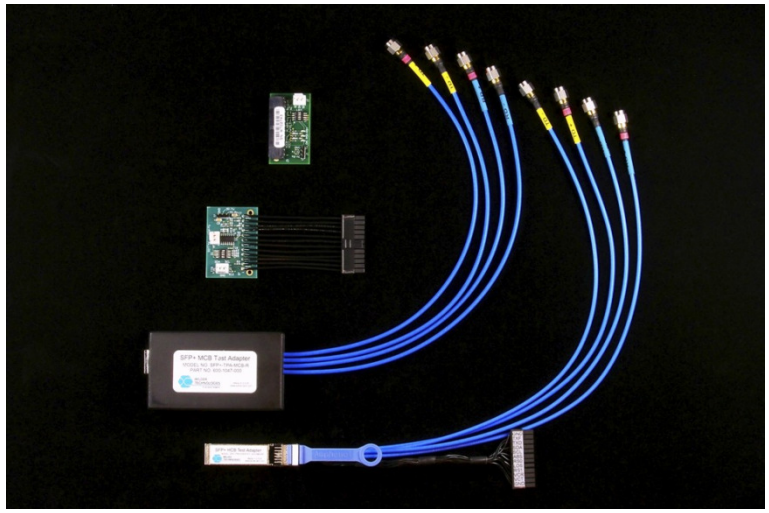

QSFP+ SFP+ Fixture

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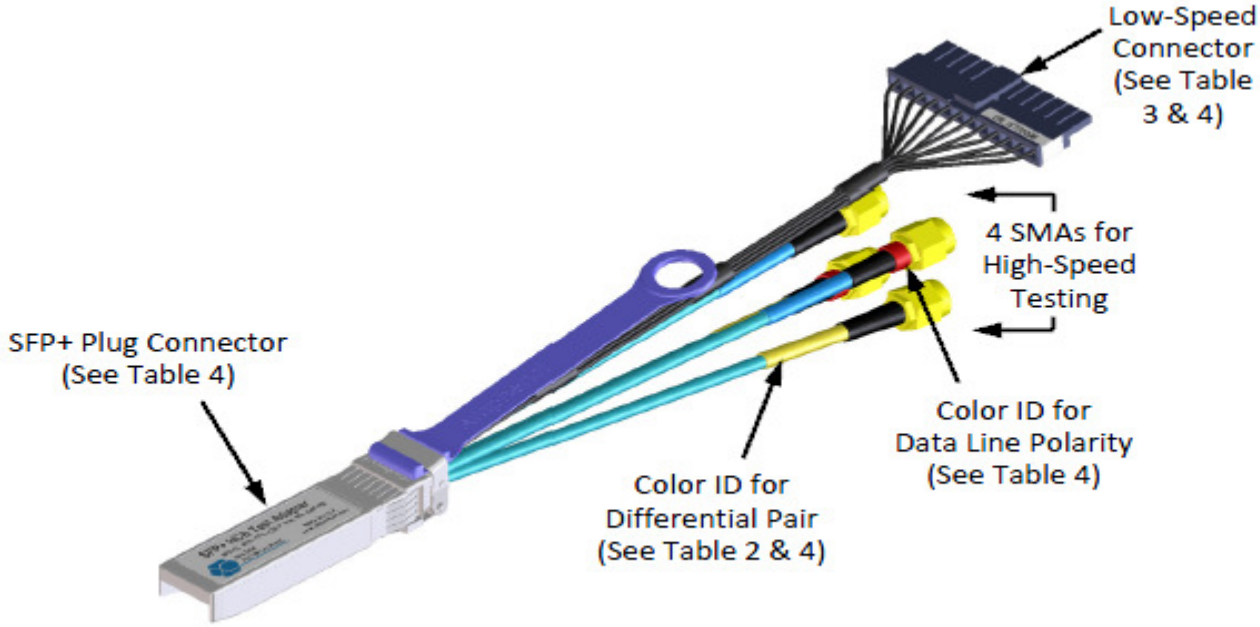
Connectivity for SFP+/QSFP+

- Connectivity Challenges:
  - Fixture required in SFF-8431/SFF-8635 spec is difficult to source
  - Low amplitude signaling so DC offset must be carefully removed
  - Fixture/DUT connections can be difficult to lock/unlock
- Tektronix family of SFP+/QSFP+ Fixtures

Transmitter Test Recommended Accessories – Probes & Fixtures	
Probing	
SMA Cables	Matched-pair SMA cables (TCA-SMA connector)
Fixturing	
TF-SFP-TPA-HCB-P	SFP+ Host Compliance Board Plug
TF-SFP-TPA-MCB-R	SFP+ Module Compliance Board Receptacle
TF-SFP-TPA-PR	SFP+ Host Compliance Board Plug and Module Compliance Board Receptacle
TF-SFP-TPA-HCB-PK	SFP+ Host Compliance Board Plug Kit with DC Blocks
TF-SFP-TPA-MCB-RK	SFP+ Module Compliance Board Receptacle Kit with DC Blocks and Termination
TF-SFP-TPA-PRK	SFP+ Host Module Compliance Board and Module Compliance Board with DC Blocks and Termination
TF-QSFP-TPA-HCB-P	QSFP+ Host Compliance Board Plug
TF-QSFP-TPA-MCB-R	QSFP+ Module Compliance Board Receptacle
TF-QSFP-TPA-PR	QSFP+ Host Compliance Board Plug and Module Compliance Board Receptacle
TF-DC-BLOCK-KIT	DC Block Kit (Quantity 4)

Test Fixture – SFP+ Host Compliance Board (HCB)



- Two variants of the fixture board are available:
  - SFP+ HCB Plug Kit with DC Blocks & Termination
  - SFP+ HCB Plug Kit without DC Blocks & Termination

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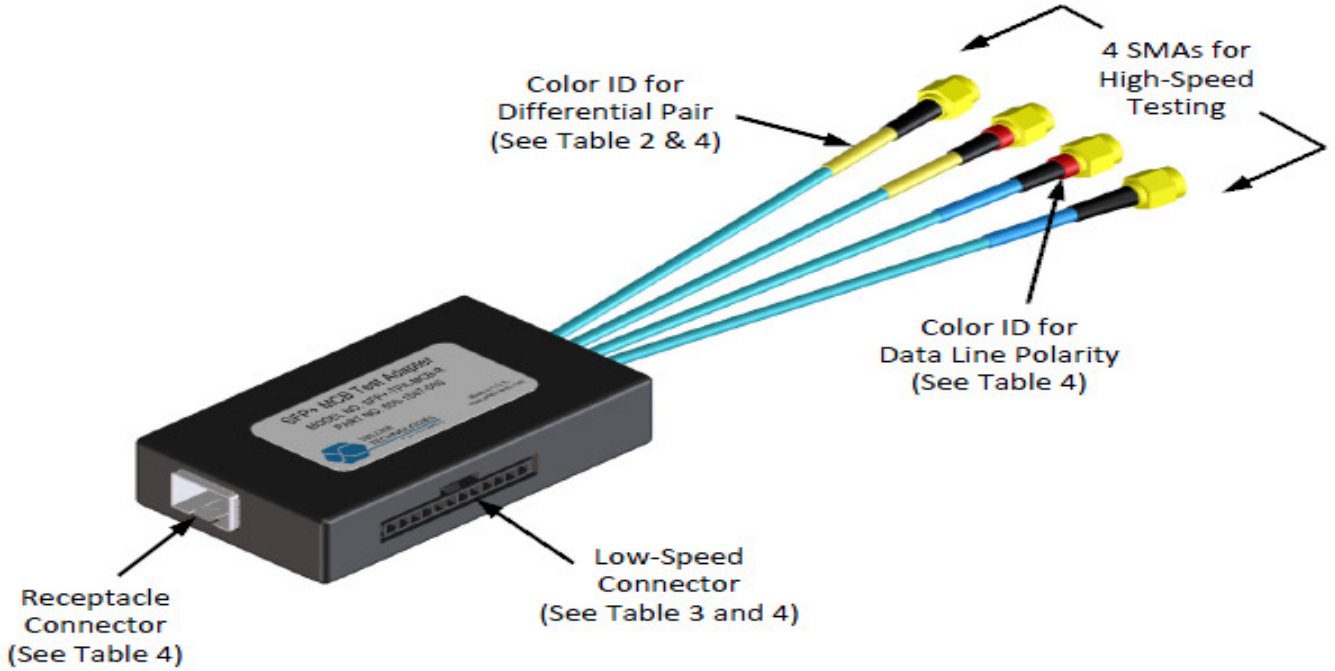
Test Fixture – SFP+ Module Compliance Board (MCB)



- Two variants of the MCB fixture board are available
  - SFP+ MCB Kit with DC Blocks & Termination
  - SFP+ MCB Kit without DC Blocks & Termination.

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Test Fixture – QSFP+ Host Compliance Board (HCB)

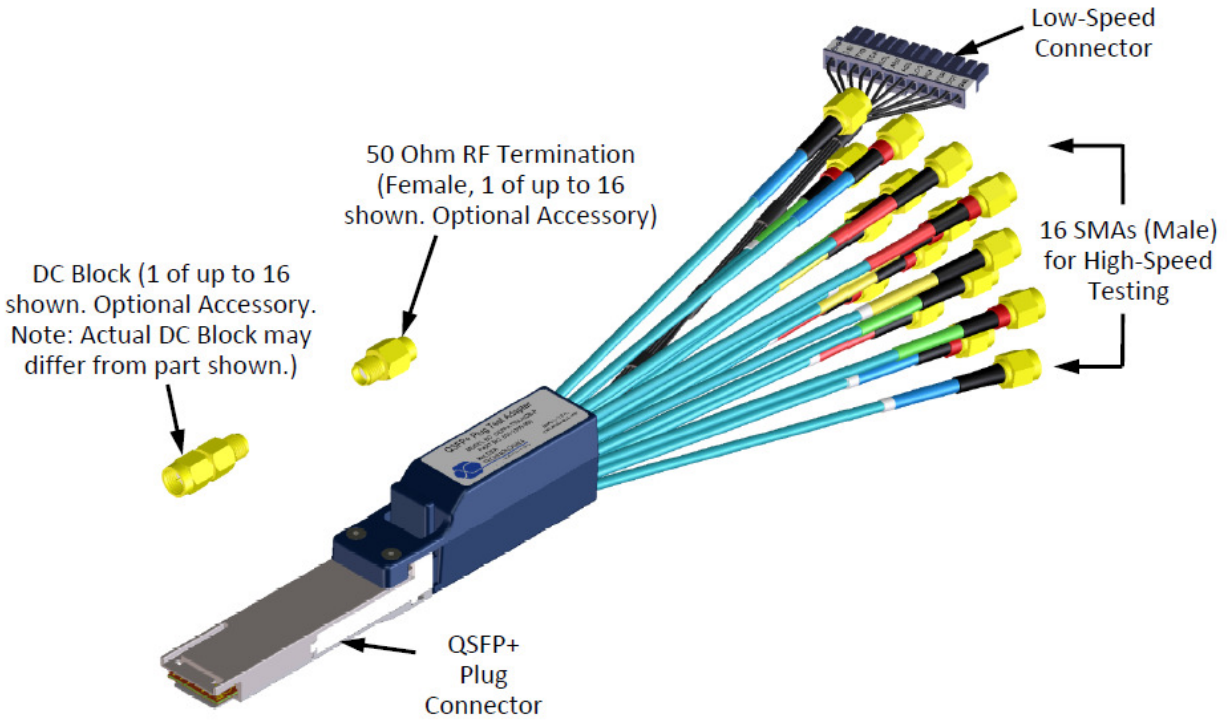

Figure 1. The QSFP+ HCB Test Adapter tests to the requirements of the Host Compliance Board (Plug)
(Note: Coaxial cables shown are illustrated shorter than those used in the test adapter.)

- QSFP+ HCB Test Adapter
- DC Block Kit(Quantity 4) – Available as separate part number

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Test Fixture – QSFP+ Module Compliance Board (MCB)

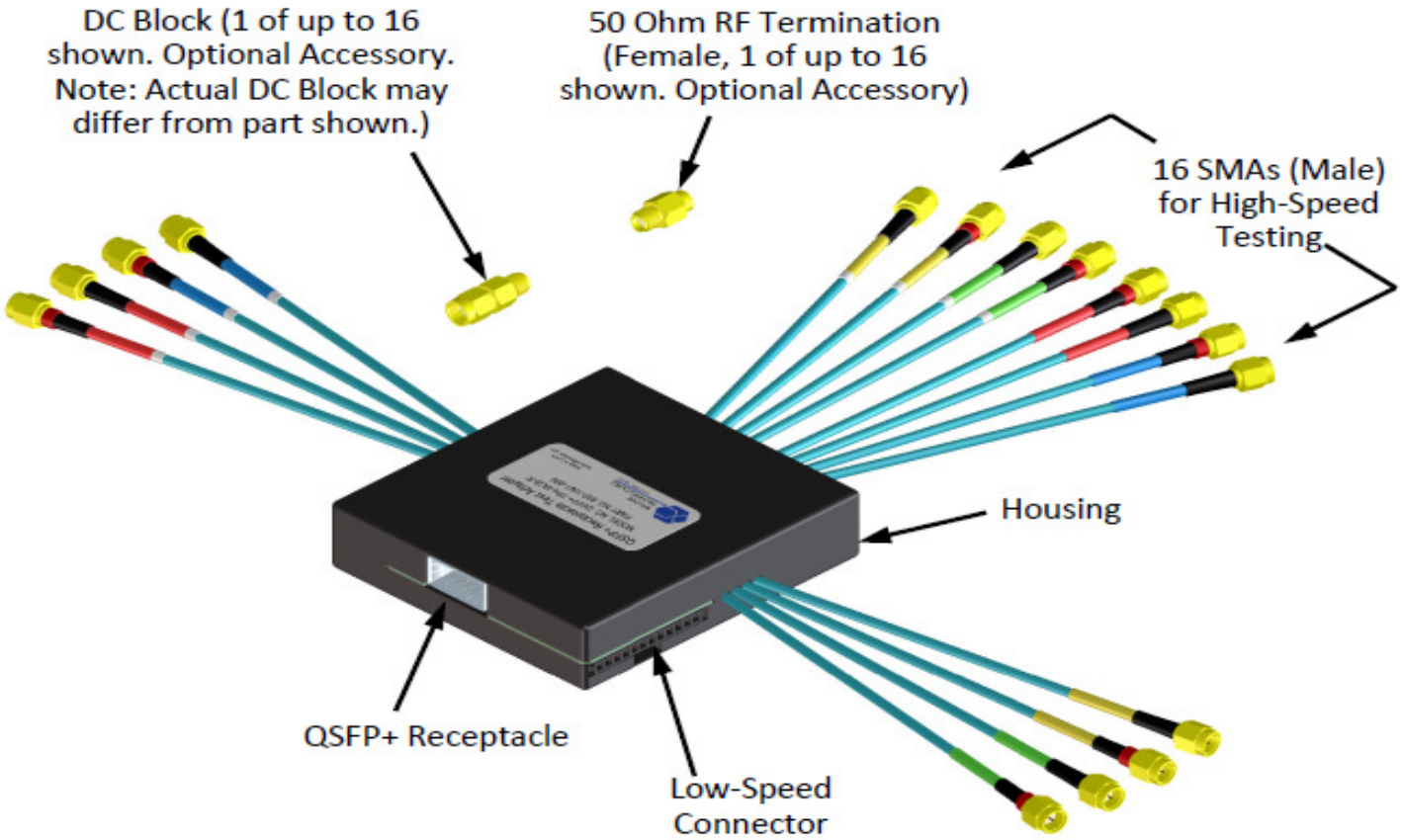

Figure 2. The QSFP+ MCB Test Adapter tests to the requirements of the Module Compliance Board (Receptacle)

(Note: Coaxial cables shown are illustrated shorter than those used in the test adapter.)

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SFP-TX, WDP Recommended Test Equipment

Mapping Technology to Oscilloscope Bandwidth Requirements

- SFF-8431/SFF-8635 SFP+ provides 10.3125 Gb/second connections with the minimum rise time requirement of 34 psec
- DPO/DSA/MSO71604C/D 16GHz Oscilloscope (24.5 psec Rt)
- DPO/DSA/MSO72004C/D 20GHz Oscilloscope (18psec Rt)
  - >16GHz Oscilloscope will meet rise time requirements of SFF-8431/SFF-8635 SFP+ signal
  - Option SFP-WDP requires 100GS/sec Sample Rate

Oscilloscope	Software	Fixture
DPO/DSA/MSO 16-33 GHz scope*	SFP-TX, SFP-WDP & DJA	HCB and MCB

*SFP-WDP requires "C" & "D" series scopes with BW greater than equal to 16GHz

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Tektronix SFP-TX/QSFP+ - Features & Benefit

Features	Benefits
Developed on Platform of choice for Debug and Compliance	Tektronix SFP+ QSFP+ Tx is developed on a Real Time Oscilloscope platform, which is the platform of choice for engineers working on designing their products around SFF-8431 & SFF-8635 technology.
Seamless movement from Compliance to Debug Environment	Customers can seamlessly move from compliance to debug environment and use world-class debug tool from Tektronix i.e. DPOJET.
Integrated TWDPc measurement	SFF-8431 SFP+ TWDPc based Matlab code has been integrated into SFP-WDP option to make sure Engineers can use this measurement in the automated setup
Reduces Testing Time	Tektronix Automated QSFP+/SFP+ Compliance and Debug solution meets compliance needs of SFF-8431& SFF-8635 specifications. Users can save up to 80% on testing time as compared to manual testing.
“One Stop Shop” - Test Fixture Availability	Engineers working on QSFP+/SFP+ can turn to Tektronix for their complete PHY testing solution needs including fixtures and don’t have to design their own fixtures
MOI and Debug Feature	DPOJET setup files for N1N0, PRBS11 and PRBS31 patterns are provided with the SFP-TX which help set scope and load measurements in DPOJET. This helps reduce debug time and set the scope for debug environment.

SFP-TX Demonstration

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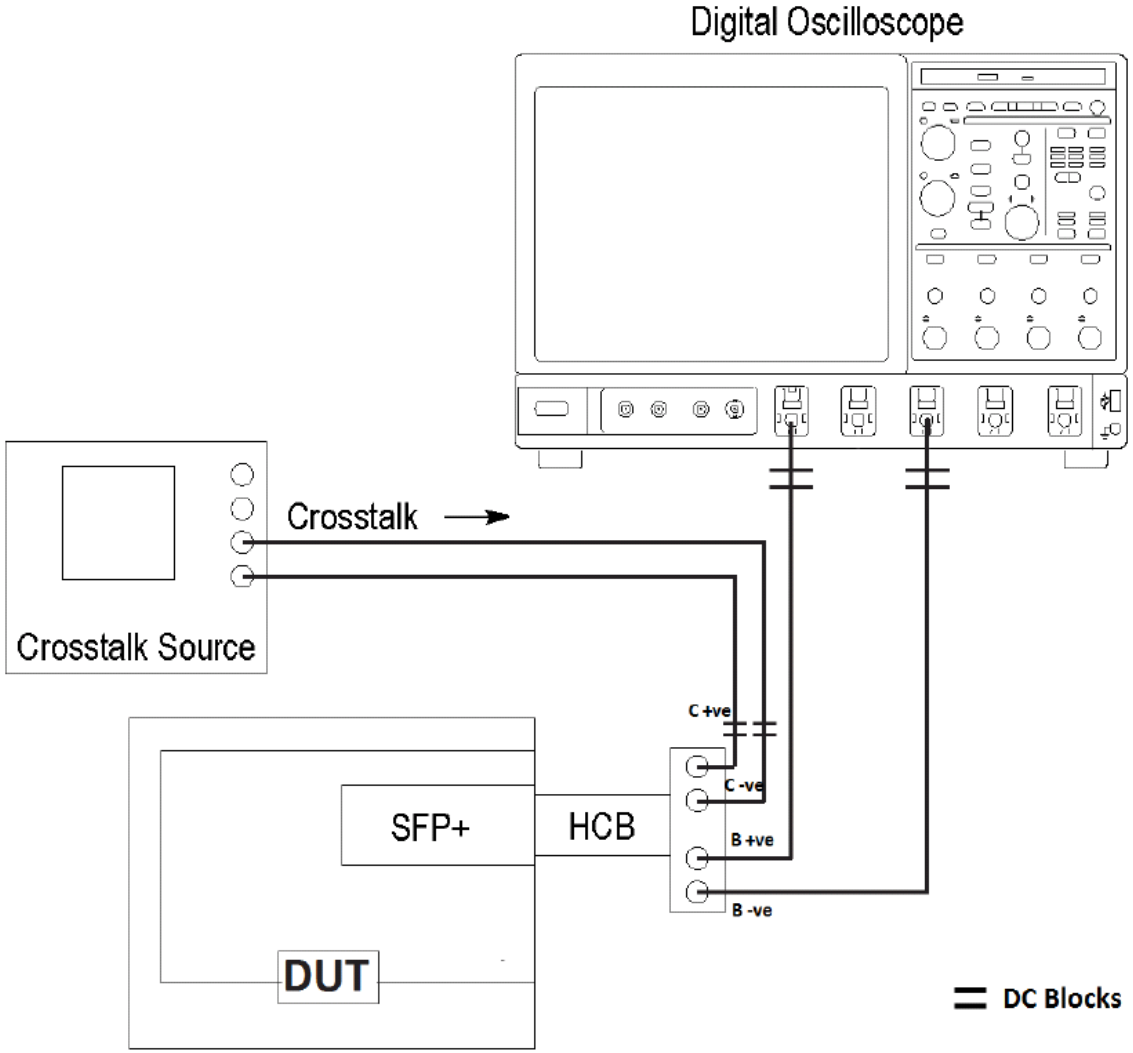
Host Transmitter Test Setup



SFP+ Setup Configuration Diagram

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Tektronix Ethernet Solution – Information

- Tektronix has strong portfolio of products and solution in Ethernet Space – RT Scope, Sampling scope, BERTScope and Optametra products
- TDSET3 – Available since 2003 with, ET3 is widely used solution across industry
- XGbT –10GBASE-T Compliance solution is the only “One Box” solution available in the market
- SFP-TX & SFP-WDP provides comprehensive solution for SFP+ & QSFP+, Tektronix is first to market
- 10GBASE-KR - 802.3ap™-2007 – We now have a Compliance, Debug and Decode Solution
- FC-16G – Fiber Channel 16G Compliance and Debug solution available on RT Scopes
- 802.3az – Energy Efficient Ethernet –Tektronix was the first T&M company to develop a solution in this space
- 10GBASE-KR and SFP+ RX MOI are available on BERT Scope


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Backup

Advantages of SFP+

- SFP + has encapsulation more compact shape dimension which better than the X2 and XFP (the same size as SFP)
- The production cost is lower than XFP, X2, XENPAK.
- The different between SFP+ and SFP
  - SFP and SFP+ have the same appearance and same size
  - SFP protocol specification: IEEE802.3, SFF-8472
- The different between SFP+ and XFP
  - The SFP + and XFP are both 10G optical modules, and can connect other types of 10G modules
  - SFP+ is smaller than XFP
  - Because of the smaller volume, SFP+ transfer signal modulation function, serial / deserializer, the MAC, clock and data recovery (CDR) and electronic dispersion from module to the card