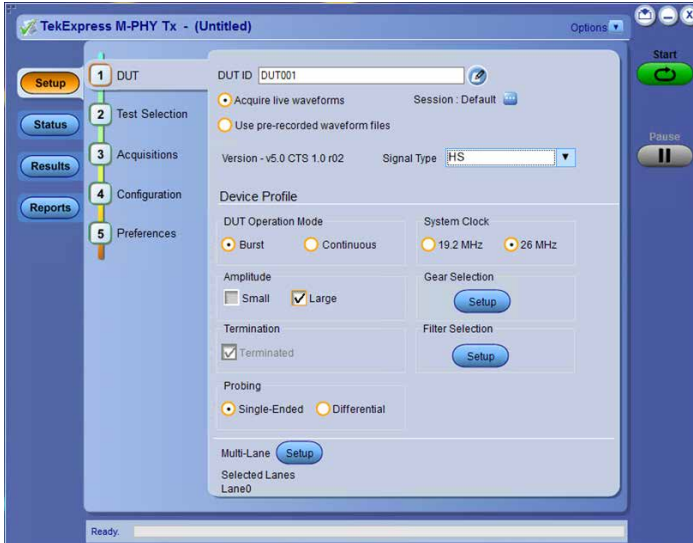
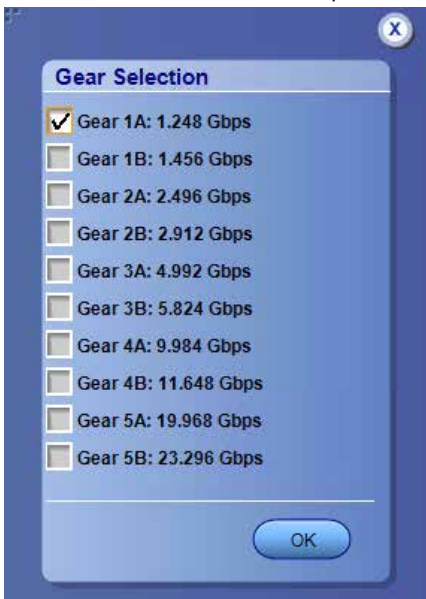


MIPI M-PHY Transmitter Test Solutions

TekExpress M-PHY Tx with MPHY50 and MPHY40 Automated



The Tektronix TekExpress M-PHY TX Automated test software for MPHY40 and MPHY50 product runs on Tektronix real-time oscilloscopes that are based on Windows 10 computer operating system. MPHY50 and MPHY40 Automated solution provide support for 100% of tests as per Spec 5.0 and CTS 1.0 at revision 02 using TekExpress 5.0 framework. It's state-of-the-art tool designed for automation. This solution is designed for engineers doing verification and validation as per the CTS for High Speed (HS)-Gear1, Gear2, Gear3, Gear4, and Gear5 for MPHY50 and HS-Gear1, Gear2, Gear3, and Gear4 for MPHY40. It also supports UFS4.0 Reference Clock measurements for both MPHY50 and MPHY40 products.



Key Features for M-PHY Transmitter testing

- 100% test coverage for all modes and data rates for HS-Gear1, Gear2, Gear3, Gear4, and Gear5 for MPHY50 and HS-Gear1, Gear2, Gear3, and Gear4 for MPHY40 products
- The Application covers PWM and SYS modes. Supports UFS4.0 Reference Clock measurements for both MPHY50 and MPHY40 products
- M-PHY TX Automated User-defined mode allows modifying every parameter of different HS, UFS4.0 Reference Clock, PWM, and SYS tests for comprehensive debug analysis and characterization
- Automated testing reduces the complexity of executing transmitter tests and enables you to test devices faster
- Improved HS measurement execution performance
- Selection of different Gears and Subgears of HS, PWM, and SYS signals, large/small amplitudes, impedance terminated/Non terminated
- Full Contour Extrapolated eye diagram for BER analysis in steps at E-6 to E-12
- HS Gear1 Mask Dynamic Movement to provide optimum eye opening as per specification
- Accumulation of 3 M UIs in a single acquisition reducing test times for analysis
- Ability to embed/de-embed using filter files to enable mid bus probing
- Support for tri mode probes for single-ended and differential signaling probing using Industry lowest noise probe P76xx series
- Manual mode testing for multiple lanes
- Highly optimized setup performs Power Spectral Density (PSD) tests using oscilloscope-integrated algorithms uniquely, and does not require an external spectral analyzer or extra hardware to perform PSD measurements
- Single printable report for all tests across different combinations, provides pass/fail summary table, along with margin details, optional waveform captures, and eye diagrams. Available in (.mht and pdf)

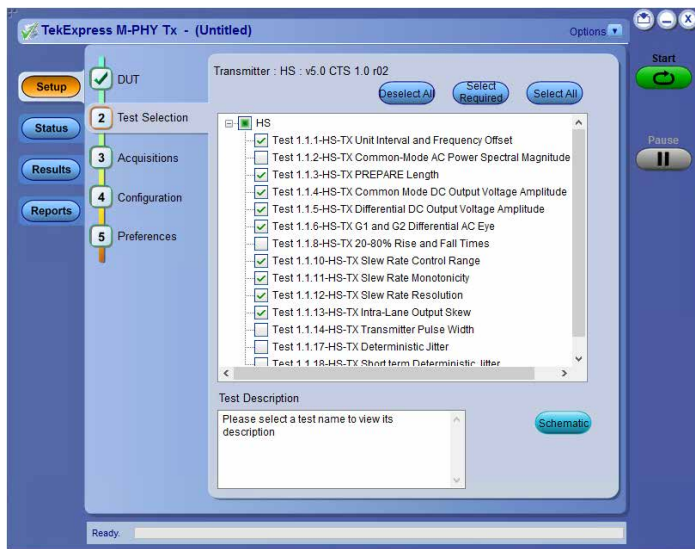
Applications

The Physical layer is implemented for various high-speed serial interfaces (chip to chip communication) inside mobile devices. The common interfaces which utilize the M-PHY solution are:

- RFIC and modem interfaces in mobile devices
- Companion chip interface with application processor over UniPro/SSIC
- Storage over UniPro/UFS

M-PHY transmitter testing with TekExpress M-PHY TX Single-button automated M-PHY transmitter testing

Once the test bench is set up and the DUT is properly connected, simply press the Run button to perform the selected test suite.



Single-button Automated M-PHY Transmitter testing

Automated transmitter testing saves time and resources

You do not need to be an expert on testing procedures. Remembering the exact steps to take each measurement is time consuming and often requires going back to the M-PHY specifications. M-PHY TX takes the guesswork out of conducting M-PHY Transmitter testing.

Even if you remember how to use the test equipment, it is common for even the most experienced operators to forget steps in the procedure or to set up the correct parameters, such as applying the correct signal impairments for a given test. M-PHY TX allows engineers to simply select the desired tests to run, and then work on other tasks while the tests are being executed.

Simple setup, test execution, and reporting

Test setup and test execution is very simple with the M-PHY TX Automated software. The test setup connections are very minimal, as it involves only one-piece of equipment for M-PHY TX. The TekExpress

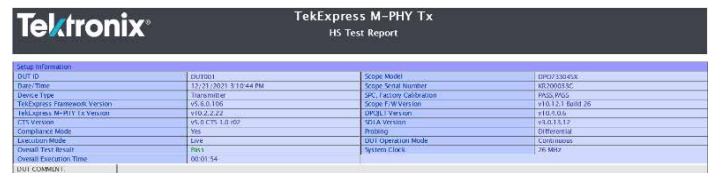
software provides a Graphical User Interface (GUI) and an intuitive workflow through setup and testing.

Setting up the bench

When setting up a test, nothing can be simpler than hooking up the test system by looking at a schematic. View the schematic of the selected test with a click of a button.

Pass/fail report

The M-PHY TX Report tab provides a single printable report of all the tests along with a Pass/Fail summary table, margins, and optionally waveform screen captures, eye diagrams, histograms, bathtub charts, etc.



Test Report

Probe Information	Probe Connector Type	Probe Connector Serial Number
CH1	TCAD200	N/A
CH2	PF6CA-290C	P7922
CH3	TCAD200	N/A
CH4	PF6CA-290C	P7921

Test Name Summary Table	Pass
Test 1.1.1-HS-TX Unit Interval and Frequency Offset	Pass
Test 1.1.1.1-HS-TX, Setup the Data Rate	Informative
Test 1.1.1.3-HS-TX, Test Jitter	Informative
Test 1.1.1.4-HS-TX, Short Term Jitter	Informative
Test 1.1.1.7-HS-TX, Deterministic Jitter	Informative
Test 1.1.1.8-HS-TX, Short Term Deterministic Jitter	Informative
BER Eye Capture	Informative

Test 1.1.3-HS-TX Unit Interval and Frequency Offset	Measurement Details	Cur	Amplitude	Termination	Low Limit	Measured Value	High Limit	Margin	Units	Test Result
Limit0	Frequency Offset Min	Cur1A	Large (L)	Terminated (RT)	-2000	-0.627	2000	Low: 1999.373, High: 2000.627	ppm	Pass
Limit0	Frequency Offset Max	Cur1A	Large (L)	Terminated (RT)	-2000	6.29	2000	Low: 2000.29, High: 1999.71	ppm	Pass
Limit0	Frequency Offset Mean	Cur1A	Large (L)	Terminated (RT)	-2000	14.499	2000	Low: 2014.499, High: 1985.501	ppm	Pass
Limit0	Frequency Offset Skew	Cur1A	Large (L)	Terminated (RT)	NA	801.277	NA	Low: NA, High: NA	ps	Informative

Test 1.1.4-HS-TX Transmitter Pulse Width	Measurement Details	Cur	Amplitude	Termination	Low Limit	Measured Value	High Limit	Margin	Units	Test Result
Limit0	Tx Pulse Width	Cur1A	Large (L)	Terminated (RT)	0.9	0.992	NA	Low: 0.992, High: NA	UI	Informative

Test 1.1.5-HS-TX Total Jitter	Measurement Details	Cur	Amplitude	Termination	Low Limit	Measured Value	High Limit	Margin	Units	Test Result
Limit0	TJ050	Cur1A	Large (L)	Terminated (RT)	NA	0.017	0.22	Low: NA, High: 0.22	UI	Informative
Limit0	TJ4	Cur1A	Large (L)	Terminated (RT)	NA	0.006	NA	Low: NA, High: NA	UI	Informative

Test 1.1.6-HS-TX Short-Term Jitter	Measurement Details	Cur	Amplitude	Termination	Low Limit	Measured Value	High Limit	Margin	Units	Test Result
Limit0	TJ050	Cur1A	Large (L)	Terminated (RT)	NA	0.015	0.2	Low: NA, High: 0.19	UI	Informative
Limit0	TJ4	Cur1A	Large (L)	Terminated (RT)	NA	0.004	NA	Low: NA, High: NA	UI	Informative

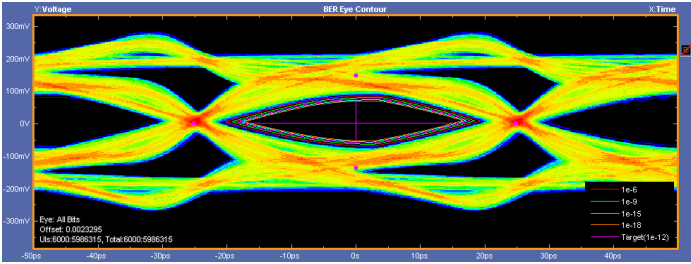
Test 1.1.7-HS-TX Deterministic Jitter	Measurement Details	Cur	Amplitude	Termination	Low Limit	Measured Value	High Limit	Margin	Units	Test Result
Limit0	Deterministic Jitter	Cur1A	Large (L)	Terminated (RT)	NA	0.007	0.15	Low: NA, High: 0.14	UI	Informative

Test 1.1.8-HS-TX Short-Term Deterministic Jitter	Measurement Details	Cur	Amplitude	Termination	Low Limit	Measured Value	High Limit	Margin	Units	Test Result
Limit0	Deterministic Jitter	Cur1A	Large (L)	Terminated (RT)	NA	0.007	0.1	Low: NA, High: 0.09	UI	Informative

BER Eye Capture	Measurement Details	Cur	Amplitude	Termination	Low Limit	Measured Value	High Limit	Margin	Units	Test Result
Limit0	BER Eye Capture	Cur1A	Large (L)	Terminated (RT)	NA	399.865	NA	Low: NA, High: NA	mV	Informative

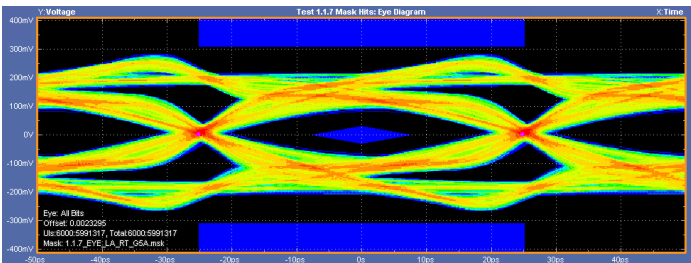
Transmitter Eye Diagram measurement

For M-PHY eye diagram, prorated parameter values are for a BER of 1E-12.

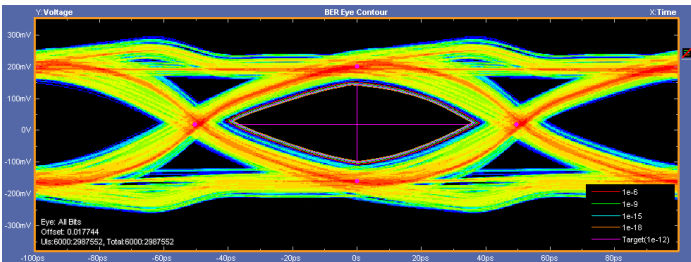


Transmitter Eye diagram measurement for HS G5 with BER contour

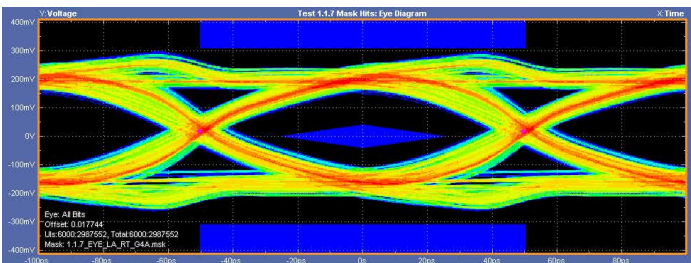
For HS G4 and G5, the eye diagram shows the accumulated eye at BER E-6 and extrapolated eye at various values in contour format. The extrapolated eye is at BER of 1E-12. Tektronix provides the unique ability for extrapolation using contours. This provide designers the level of confidence in their design, a good perspective on margin for their designs, and allows them to accomplish this task in less time without having to accumulate the eye at BER-12.



Transmitter Eye Diagram measurement for HS G5A



Transmitter Eye Diagram measurement for HS G4 with BER contour



Transmitter Eye diagram measurement for HS G4A

Embed/De-embedding for Mid-bus probing

For M-PHY TX testing, measurements are specified at the TX pins. Many a times, the users measure signals at the end of the channel to view the effect at the RX pins or some test point in the middle of

the channel (Mid-bus probing). For conformance testing, to ensure that the values meet the CTS, there would have a need to embed and/or de-embed channel to make measurements at the pin.

TekExpress Automated software allows you to do mid-bus probing via embedding/de-embedding signal path using filter files. You can use the 'Filter Setup' option in DUT panel to add the filters. This setting is applied globally to all the measurements during acquisition.



Filter Selection

Probing needs for M-PHY

The requirements for measurement equipment used to test conformance of an M-PHY transmitter running in High Speed mode is summarized below.

Summary of oscilloscope and probe requirements for M-PHY transmitter measurements

Requirement	Performance
Return Loss	Per specification limits
Differential termination	100 Ω across input
Common mode termination	Infinite or consistent value
Rise Time	3X fastest signal rise time
Sensitivity	200-300 mV _{FS} capability
Noise	Minimal added noise, (<1 or 2 mV _{rms} desirable)
Attenuation	Smallest attenuation possible (1X desirable)

The MIPI M-PHY standard presents significant challenges for oscilloscopes and probing. These challenges result in stringent requirements for HS-MODE measurements. SMA style probes with 50 Ω inputs have been shown to yield superior results compared to

high impedance probe approaches, particularly for HS-GEAR5 speeds. M-PHY CTS has been updated to list support for “SMA probe” type probing solutions. Tektronix SMA probes like the P7633 are unique and they can meet the requirements of M-PHY testing and introduce lower noise than the other oscilloscope probes.



Tektronix P7633 SMA probe

For more details on probe specifications, refer to the probe's datasheet:

<http://www.tek.com/datasheet/p7600-series-trimode-probes>

Required equipment for MIPI® transmitter testing

For a complete list of required equipment, visit www.tek.com/MIPI.

Specifications

M-PHY TX characteristics

Specification	M-PHY Base Specification Revision 5.0 and Conformance Test Specification Version 1.0, Release 02.
Probing configuration	Both Differential and Single-ended Acquisition supported
Reports	.MHT format and PDF format, with pass/fail tables and waveform screenshots
Data rates	All HS, UFS4 Reference Clock, PWM, and SYS
HS (High Speed) measurements	<ul style="list-style-type: none"> 1.1.1 – HS-TX Unit Interval and Frequency Offset 1.1.2 – HS-TX Common-Mode AC Power Spectral Magnitude Limit 1.1.3 – HS-TX PREPARE Length 1.1.4 – HS-TX Common-Mode DC Output Voltage Amplitude 1.1.5 – HS-TX Differential DC Output Voltage Amplitude 1.1.6 – HS-TX G1 and G2 Differential AC Eye 1.1.7 – HS-TX G3, G4, and Differential AC Eye 1.1.8 – HS-TX 20/80% Rise and Fall Times 1.1.9 – HS-TX Lane-to-Lane Skew 1.1.10 – HS-TX Slew Rate Control Range 1.1.11 – HS-TX Slew Rate State Monotonicity 1.1.12 – HS-TX Slew Rate State Resolution 1.1.13 – HS-TX Intra-Lane Output Skew 1.1.14 – HS-TX Transmitter Pulse Width 1.1.15 – HS-TX Total Jitter 1.1.16 – HS-TX Short-Term Total Jitter 1.1.17 – HS-TX Deterministic Jitter 1.1.18 – HS-TX Short-Term Deterministic Jitter <p>BER Contour for extrapolated eye capability available for Test 1.1.6 and Test 1.1.7 with oscilloscope Option DJAN</p>
PWM (Pulse Width Modulation) measurements	<ul style="list-style-type: none"> 1.2.1 – PWM-TX Transmit Bit Duration 1.2.2 – PWM-TX Transmit Ratio 1.2.3 – PWM-TX PREPARE Length 1.2.4 – PWM-TX Common Mode DC Output Voltage Amplitude 1.2.5 – PWM-TX Differential DC Output Voltage Amplitude 1.2.7 – PWM-TX Maximum Differential AC Output Voltage Amplitude 1.2.8 – PWM-TX 20/80% Rise and Fall Times 1.2.9 – PWM-TX Lane-to-Lane Skew 1.2.10 – PWM-TX G1 Transmit Bit Duration Tolerance

1.2.11 – PWM-TX G0 Minor Duration

SYS (System clock) measurements

- 1.3.1 – SYS-TX Unit Interval and Frequency Offset
- 1.3.2 – SYS-TX Ref Clock Frequency
- 1.3.3 – SYS-TX PREPARE Length
- 1.3.4 – SYS-TX Common Mode DC Output Voltage Amplitude
- 1.3.5 – SYS-TX-Differential DC Output Voltage Amplitude test
- 1.3.7 – SYS-TX Maximum Differential AC Output Voltage Amplitude
- 1.3.8 – SYS-TX 20/80% Rise and Fall Times
- 1.3.9 – SYS-TX Lane-to-Lane Skew

UFS4 Ref Clock measurements

1. Frequency
 2. Frequency Error
 3. Input High Voltage
 4. Input Low Voltage
 5. Input Clock Rise Time
 6. Input Clock Fall Time
 7. Duty Cycle
 8. Random Jitter
 9. Deterministic Jitter
-

Ordering information

TekExpress M-PHY TX [MPHY50 and MPHY40]

Model	Description
DPO/MSO70000/DX/SX	DPO (Digital Phosphor Oscilloscope), or MSO (Mixed Signal Oscilloscope) Oscilloscopes with Option DJA and Option DJAN (for BER Contours). Option DJA is mandatory. Option DJAN is optional but required for BER Contours. Option SDLA64 is mandatory for Gear4 and Gear5 Differential AC Eye measurements. The following bandwidths are needed: <ul style="list-style-type: none"> • 6 GHz and above is recommended for HS-Gear1 • 12.5 GHz and above is recommended for up to HS-Gear2 • 23 GHz and above is recommended for up to HS-Gear3 • 25 GHz and above is recommended for up to HS-Gear4 • 33 GHz and above is recommended for up to HS-Gear5
DPO/MSO70000/DX/SX Option MPHY40 DPO-UP Option MPHY40	TekExpress MIPI M-PHY Gear4 Tx Compliance Solution (Requires Opt. DJA and Opt. SDLA64) includes HS-Gear1, Gear2, Gear3, and Gear4; PWM, SYS, and UFS4 Reference Clock.
DPOFL-MPHY40	TekExpress MIPI M-PHY Gear4 Tx Compliance Solution (Requires Opt. DJA and Opt. SDLA64) includes HS-Gear1, Gear2, Gear3, and Gear4; PWM, SYS, and UFS4 Reference Clock (Floating License version)
DPO/MSO70000/DX/SX Option MPHY50 DPO-UP Option MPHY50	TekExpress MIPI M-PHY Gear5 Tx Compliance Solution (Requires Opt. DJA and Opt. SDLA64) includes HS-Gear1, Gear2, Gear3, Gear 4, and Gear5; PWM, SYS, and UFS4 Reference Clock.
DPOFL-MPHY50	TekExpress MIPI M-PHY Gear5 Tx Compliance Solution (Requires Opt. DJA and Opt. SDLA64) includes HS-Gear1, Gear2, Gear3, Gear4, and Gear5; PWM, SYS, and UFS4 Reference Clock (Floating License version)

Recommended probes for TekExpress M-PHY TX

Gear type	Maximum Data rate	Fixtured / RF connection
HS-Gear1 ¹	1.46 Gb/s	P76xx
HS-Gear2	2.92 Gb/s	P76xx
HS-Gear3	5.824 Gb/s	P76xx
HS-Gear4	11.648 Gb/s	P76xx
HS-Gear5	23.296 Gb/s	P76xx
PWM Gears (G0 to G7) ²	10 Kbps to 576 Mbps	P7313

Table continued...

¹ RT (Resistively Terminated).

² NT (Not Terminated).

Gear type	Maximum Data rate	Fixtured / RF connection
SYS Gears	26 MHz 38.4 MHz 52 MHz	P7313

ASEAN / Australasia (65) 6356 3900
Belgium 00800 2255 4835*
Central East Europe and the Baltics +41 52 675 3777
Finland +41 52 675 3777
Hong Kong 400 820 5835
Japan 81 (120) 441 046
Middle East, Asia, and North Africa +41 52 675 3777
People's Republic of China 400 820 5835
Republic of Korea +822 6917 5084, 822 6917 5080
Spain 00800 2255 4835*
Taiwan 886 (2) 2656 6688

Austria 00800 2255 4835*
Brazil +55 (11) 3759 7627
Central Europe & Greece +41 52 675 3777
France 00800 2255 4835*
India 000 800 650 1835
Luxembourg +41 52 675 3777
The Netherlands 00800 2255 4835*
Poland +41 52 675 3777
Russia & CIS +7 (495) 6647564
Sweden 00800 2255 4835*
United Kingdom & Ireland 00800 2255 4835*

Balkans, Israel, South Africa and other ISE Countries +41 52 675 3777
Canada 1 800 833 9200
Denmark +45 80 88 1401
Germany 00800 2255 4835*
Italy 00800 2255 4835*
Mexico, Central/South America & Caribbean 52 (55) 56 04 50 90
Norway 800 16098
Portugal 80 08 12370
South Africa +41 52 675 3777
Switzerland 00800 2255 4835*
USA 1 800 833 9200

* European toll-free number. If not accessible, call: +41 52 675 3777

For Further Information. Tektronix maintains a comprehensive, constantly expanding collection of application notes, technical briefs and other resources to help engineers working on the cutting edge of technology. Please visit www.tek.com.
 Copyright © Tektronix, Inc. All rights reserved. Tektronix products are covered by U.S. and foreign patents, issued and pending. Information in this publication supersedes that in all previously published material. Specification and price change privileges reserved. TEKTRONIX and TEK are registered trademarks of Tektronix, Inc. All other trade names referenced are the service marks, trademarks, or registered trademarks of their respective companies.