C-PHY Essentials Transmitter Test Solution
TekExpress C-PHY Essentials Tx

Tektronix C-PHY TX Essentials
The Tektronix C-PHY TX Essentials Test software runs on Tektronix real-time oscilloscopes that are based on Windows 7 computer operating systems. C-PHY Tx Essentials improves time to market by automating the characterization, debugging, and margin testing processes of C-PHY Tx signals in your new product development environment.

Key features
- Supports de-embed and embed feature for three-port on either side (6-port parameter support for de-embedding).
- Measures the rise time and fall time of the DUT C-PHY signals.
- Performs both eye height and eye width measurements, and also verifies the eye diagram on C-PHY signals.
- Verifies that the static point common mode voltage VCPTX of the Trio signal is within the transmitter limit.
- Verifies that the common-mode voltage mismatch (ΔVCMTPX) of the DUT Data Lane HS transmitter is less than the maximum conformance limit.
- Verifies that the common mode level variation is between 50 MHz to 450 MHz.
- Measures the Intra pair skew of the trio signal.

Applications
- Camera CMOS Image sensors
- Display Driver ICs
- Application processor for Mobile devices
MIPI C-PHY 1.0 provides high throughput performance over bandwidth limited channels for connecting to peripherals, including displays and cameras. The interface allows system designers to easily scale the existing MIPI® Alliance Camera Serial Interface (CSI-2) ecosystem to support higher resolution image sensors while keeping power consumption low.

MIPI® C-PHY and MIPI® D-PHY are pin compatible, allowing connections to the companion device with either technology. C-PHY was designed to coexist on the same IC pins as D-PHY so that dual-mode devices can be developed.

MIPI C-PHY introduces 3-phase symbol encoding offering about 2.28 bits per symbol to transmit data symbols on 3-wire lanes, or trios, where each trio includes an embedded clock.

These signals have three levels, do not use the standard NRZ format of signaling, and are single ended. They are represented as LineA, LineB and LineC. At any given point in time, no signals are at the same voltage levels. The receive side is differential and sees 4 different voltage levels; Strong 1, Weak 1, Strong 0, Weak 0. The receiver however sees either logic 1 or logic 0.

C-PHY clock recovery

C-PHY uses a unique mechanism for clock recovery. C-PHY 1.0 implements a custom clock recovery algorithm referred to as triggered eye. In this model, the first zero crossing of the four differential signals is used as a trigger point for clock recovery and rendering the eye diagram.

The eye mask is optimally placed for maximum eye opening where the eye height is measured. Because of the triggered eye mechanism, all the jitter at the trigger point (zero crossing) is swallowed and reflected on the other side. See the image above.
C-PHY transmitter test measurements

For characterization, debugging and margin testing some of the key measurements needed in the High Speed Mode include:

- Rise time
- Fall time
- Eye diagram
- AC common mode measurement
- DC Common mode mismatch measurement
- AC Common mode level variation from 50 MHz to 450 MHz
- AC Common mode level variation above 450 MHz
- Intra-pair skew

Eye diagram analysis for 3M UI

Jitter and eye diagram rendering performed over the entire record length helps designers better characterize devices by displaying anomalies of the device over an extended period. The software allows you to run the eye diagram analysis for 3M UI and overnight runs for a detailed characterization.

Custom triggered eye diagram

The screen shot depicts the C-PHY Tx Essentials Test software being configured for a custom triggered eye diagram with auto mask position for optimal mask placement.
**Rise time/Fall time transition details**

Each differential waveform has four transitions of interest when characterizing the device.

- Strong to weak transition (S-W)
- Weak to strong transition (W-S)
- Weak to weak transition (W-W)
- Strong to strong transition (S-S)

The image below shows details for measuring these transitions.

**Insertion loss and crosstalk**

As a part of characterizing the device, designers need to embed or de-embed insertion loss and crosstalk. This is supported using filter files generated using the s4p/s6p, S-parameter files, as shown in the following image.

**Measuring intra pair skew**

The skew between trios, referred to as the Intra pair skew, is an informative test of interest to many design engineers. The following image shows a report generated by the Tektronix C-PHY Tx Essentials Test software that includes details and status of the intra pair skew for twelve combinations of wire states.

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Datasheet

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Signaling and termination

C-PHY signaling is similar in ways to D-PHY. For instance, it dynamically switches from LP mode to HS Mode, and many of the timing measurements defined for C-PHY are similar to D-PHY.

The following image, from the MIPI Alliance C-PHY specification 1.0, shows the structure of a C-PHY signal (HS data transmission in burst).

To make measurements during this switchable termination mode, load boards or termination boards are needed. The physical setup for making these measurements requires an oscilloscope, probes and a termination board.

The following diagram shows the physical setup for high-speed measurements. For HS measurements only, a termination board and probes are not needed, and you can connect SMA cables directly.
C-PHY Rx calibration

While the primary purpose of the C-PHY TX software is for transmitter characterization, the core measurements supported by this software are designed to be used for receiver calibration. The C-PHY receiver calibration, according to CTS, recommends calibrating to the eye diagram with the predefined rise time/fall time. The calibration includes support for DCD (Duty Cycle Distortion) as an important stress parameter which drives closure of the eye. The next steps include calibrating the C-PHY signal with impairment of the DC common mode and AC common mode noise. The generation of these stresses is supported using the Tektronix AWG 70000 Series Arbitrary Waveform Generators.

C-PHY oscilloscope-based decoder

The Moving Pixel Company CPhy Scope Decoder software is a single-lane CPhy and CSI2 protocol decoder from CPhy signal acquisitions from an oscilloscope.

The software runs on any WinXP or Win7 host that is connected to the oscilloscope through a LAN, using the remote-control capability of the oscilloscope to control real-time acquisition.

The main functions of this software include:

- Provide real-time oscilloscope acquisition and control of one CPhy lane using three channels. Alternatively, saved binary waveform files can be loaded and disassembled.
- Post-process the acquisition data to provide DPhy/DSI/CSI2 protocol disassembly views of communication on the link.
- The views provided are similar in look-and-feel to a logic analyzer type display.
- Provide extensive functions and manipulations for viewing, filtering, and searching captured data.
- Build video frames from decoded packets, including a frame summary listing that provides statistics, navigation, viewing and saving of images.

- Check and report many types of errors, including illegal state transitions, invalid symbol sequences, packet header and payload CRC errors, among others.
- Correlate any event in the disassembly back to acquired waveforms on the oscilloscope using the zoom window and cursors.
Specifications

All specifications apply to all models unless noted otherwise.

Test parameters

<table>
<thead>
<tr>
<th>Parameter group</th>
<th>Parameter name</th>
<th>Range</th>
<th>Default</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ref levels</td>
<td>Reference levels</td>
<td>Absolute, Percentage</td>
<td>Percentage</td>
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<tr>
<td></td>
<td>Reference level-High (%)</td>
<td>70 to 90 (in %) 40 to 60 (in Absolute)</td>
<td>80 (in %) 58 (in Absolute)</td>
<td>% or V</td>
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<td></td>
<td>Reference level-Low (%)</td>
<td>10 to 30 (in %) -60 to -40 (in Absolute)</td>
<td>20 (in %) -58 (in Absolute)</td>
<td>% or V</td>
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<td></td>
<td>Reference level-Hysteresis (%)</td>
<td>5 to15 (in %) 5 to 25 (in Absolute)</td>
<td>10 (in %) 10 (in Absolute)</td>
<td>%</td>
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<tr>
<td>Clock Settings</td>
<td>Clock recovery method</td>
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<td>Signal Type</td>
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<td>CLOCK</td>
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<td>Clock Edge</td>
<td>RISE FALL BOTH</td>
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</tr>
<tr>
<td></td>
<td>Loop bandwidth (MHz)</td>
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<td>4</td>
<td>MHz</td>
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<td>MaskHitType</td>
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<td>Others</td>
<td>Accumulation</td>
<td>True False</td>
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<td></td>
<td>Eye Height Percentage</td>
<td>10 to 90</td>
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</tr>
<tr>
<td></td>
<td>Hysteresis</td>
<td>5 to 15</td>
<td>10</td>
<td>%</td>
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</table>

Minimum system requirements

Operating system

Windows 7, 64-bit

Software requirements

Microsoft .NET 4.0 Framework
Microsoft Excel 2002 or above
Microsoft Internet Explorer 6.0 SP1 or later
Adobe Reader 7.0 or equivalent software for viewing portable document format (PDF) files
Ordering information

C-PHY Essentials Transmitter Test licensing

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
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<tbody>
<tr>
<td>DPO-UP C-PHY</td>
<td>C-PHY Essentials Transmitter Solution</td>
</tr>
<tr>
<td>DPO-FL-C-PHY</td>
<td>C-PHY Essentials Transmitter Solution (Floating)</td>
</tr>
<tr>
<td>Opt. C-PHY</td>
<td>C-PHY Essentials Transmitter Solution (Node Locked)</td>
</tr>
<tr>
<td>TMPC-CPHYVIEW</td>
<td>C-PHY Scope based Single Lane Decoder</td>
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Required instruments and accessories

<table>
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<tr>
<th>Nomenclature</th>
<th>Description</th>
<th>Number</th>
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<tbody>
<tr>
<td>DPO/DSA/MSO70000C, Option DJA</td>
<td>6 GHz and above real-time oscilloscope</td>
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</tr>
<tr>
<td>P7313</td>
<td>Differential active probes</td>
<td>3</td>
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<tr>
<td>TMPC-CTB</td>
<td>C-PHY termination board (supports up to 4 lanes)</td>
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CE Marking Not Applicable.

Tektronix is registered to ISO 9001 and ISO 14001 by SRI Quality System Registrar.


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.tektronix.com.