Practical Experiences in MIPI D-PHY\textsuperscript{SM} and C-PHY\textsuperscript{SM} Receiver Testing
In Theory...

[Diagram showing a Test Instrument connected to a DUT]
In Real Life...

Test Requirements Through Product Lifecycle Stages

<table>
<thead>
<tr>
<th>IP Bring-Up</th>
<th>Component Bring-Up</th>
<th>Application Module Bring-Up</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Test IP in isolation</td>
<td>• Focus on entire chip functionality including interface</td>
<td>• Where is the receiver?</td>
</tr>
<tr>
<td>• Theoretical case (perhaps!)</td>
<td>• Other effects start to appear</td>
<td>• Where is the channel?</td>
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<td>• What stimulus to use?</td>
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Agenda

• Overview of receiver test
• Illustration of practical module implementations and evaluation platforms
• Recommendations and best practices
Physics of Signal Transmission

Transmitter

Channel (cable, connector, flex PCB, package)

Receiver

Large Signal
Small Noise

Small Signal
Large Noise
Objective of Receiver Test

Generate a stressed signal as if it went through a channel

- Model ISI
- Model DCD
- Model Jitter
MIPI D-PHY\textsuperscript{SM} Receiver Specification

MIPI D-PHY\textsuperscript{SM} Generator

Reference Channel

Data Rx

Clock Rx

Reference Channel

Figure 67 Receiver Eye Diagram Specification
MIPI C-PHY<sup>SM</sup> Receiver Specification
The Linear Channel Model

- $|S_{21}|$
- $\Phi_{S21}$
- Group Delay $S_{21}$
- Frequency
The Linear Channel Model

Timing Edges Largely Unaffected in a Linear Channel
The Linear Channel Model

Timing Edges Largely Unaffected in a Linear Channel

Results in almost non-realistic jitter injection requirements
Practical Evaluation Board... Nonlinear!
Linear Channel Versus Non-Linear Channel

Tx Eye Diagram

Linear Channel Eye Diagram (~0.3 UI Closure)
Linear Channel Versus Non-Linear Channel

Tx Eye Diagram

Non-Linear Channel Eye Diagram (~0.4 UI Closure)
Channel is 25% Shorter
Practical Experiences: Skew

Test Instrument

Bend or Via

Flex

Flex

IC
Practical Experiences: Skew

Skew introduces common-mode noise (not good for receiver!)

**Difficult** to detect on differential scope eye diagram
Practical Experiences: Reflections

Discontinuity (Connector)

Test Instrument

Flex

IC
Practical Experiences: Reflections

Worst-case example of a channel non-linearity

Signal rise time is sharp, but reflections can cause bit flips
Practical Experiences: Reflections

Stub Causing Complete Eye Closure

Slowing Data Rate Reveals Stub Waveform
Practical Experiences: Grounding
Practical Experiences: Grounding

HS eye diagram affected by CM and Diff effects
LP waveforms affected by crossing levels and reflections
Practical Experiences: Inductance

Discontinuity (Test Point)
Practical Experiences: Inductance

Often due to test points

Makes correlation with specifications difficult
Adopt a **system-level approach to test** if your evaluation board looks like a system.

Identify stress parameters **suitable for characterizing your device** in its environment.

Characterize receiver performance **across system constraints** as well as through ideal “linear” channel.