Comprehensive TP2 and TP3 Testing

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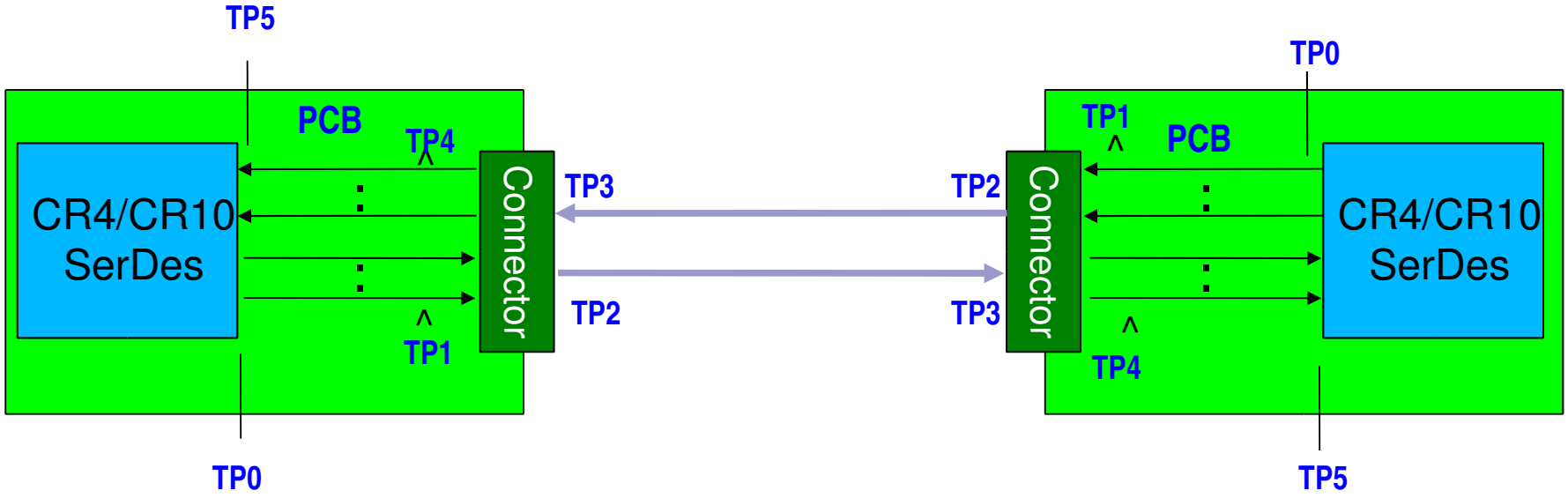
CR4/CR10 Link Block Diagram and Problem Statement

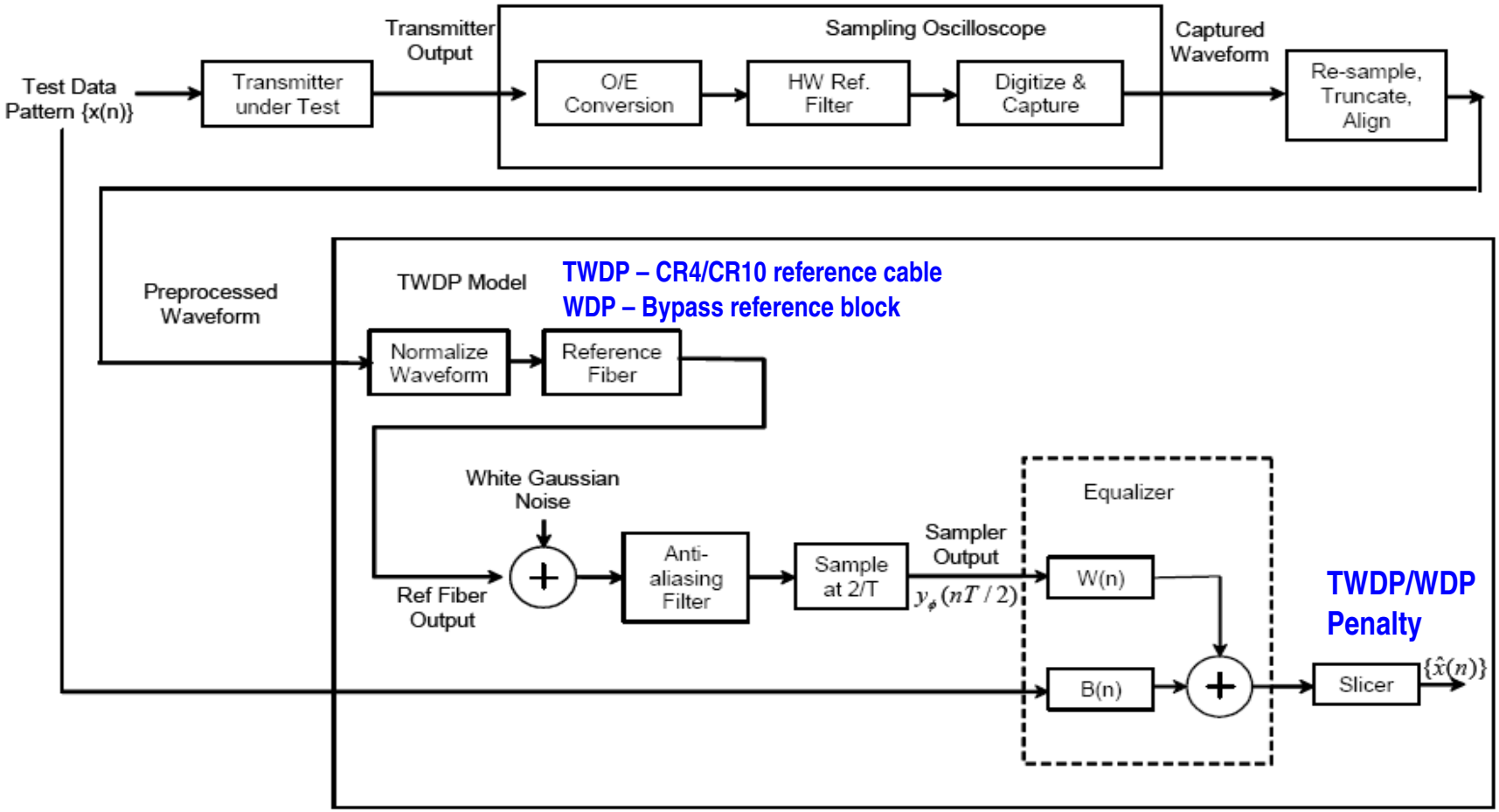
- **CR4/CR10 TP2 points are pluggable through connector and PCB and does the current TP2 specifications confine the distortion sufficiently?**
- **CR4/CR10 TP3 points are pluggable and away from KR TP5 point through a connector and PCB. TP3 specifications must be defined for interoperability**
- **TP0 and TP5 could become informative set of specifications**
- **For detail compliance point definition please see ghiasi_01_0509.**



Using TWDP as Comprehensive Transmitter Test Metric

- **The real receiver care about penalty, what not use the direct method and use the proven TWDP method**
  - **The code already in use in LRM, 8 GFC, and 10GSFP+ Cu**
  - **Paper on the TWDP description http://www.ieee802.org/3/aq/public/tools/TWDP.pdf**
  - **The original LRM TWDP code is available from http://www.ieee802.org/3/aq/public/tools/**
  - **SFF-8431 (SFP+) code which include both LRM and copper cable, see appendix E and G ftp://ftp.seagate.com/sff/SFF-8431.PDF**
  - **The 8GFC code is available with build in timing recovery at http://www.t11.org doc T11/08-077v0.**
  - **TWDP code is also available for SMF application open to the OIF members**
- **Millions of ports are shipping based on proven TWDP method is an excellent tool for transmitter compliance and calibration of the TP3 stressor.**

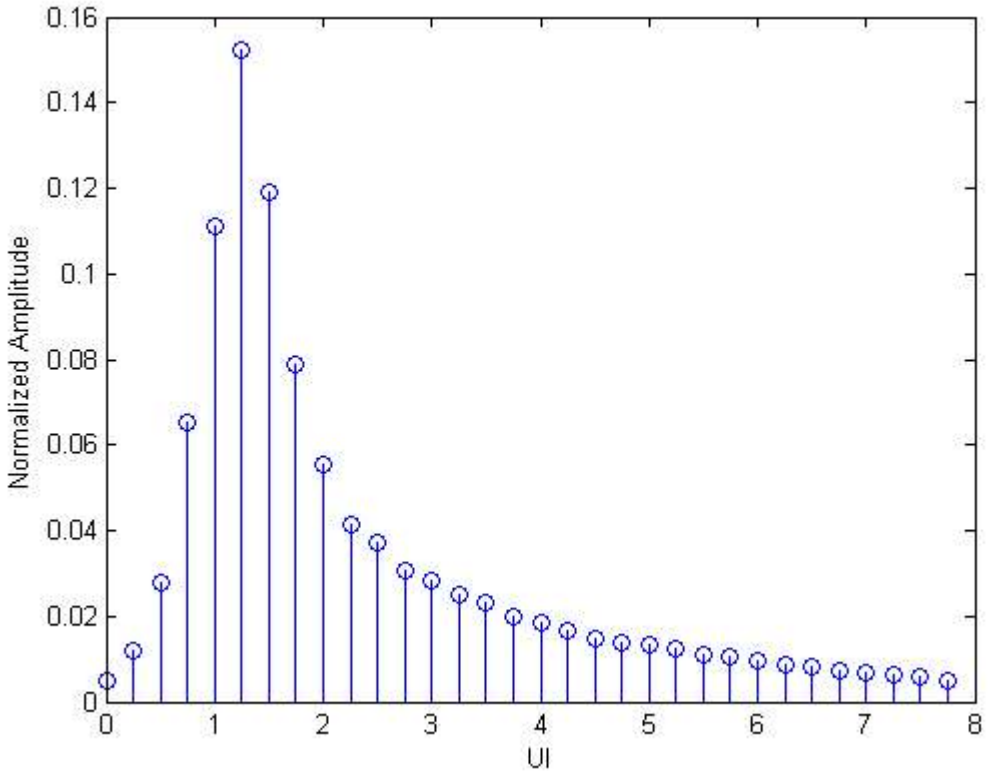
Block Diagram of TWDP/WDP Code



Standards Compliance Testing of Optical Transmitters Using a Software-Based Equalizing Reference ReceiverSwenson, N.L.; Voois, P.; Lindsay, T.; Zeng, S.;
Optical Fiber Communication and the National Fiber Optic Engineers Conference, 2007. OFC/NFOEC 2007. Conference on
25-29 March 2007 Page(s):1 - 10

10 m Cable Impulse Response

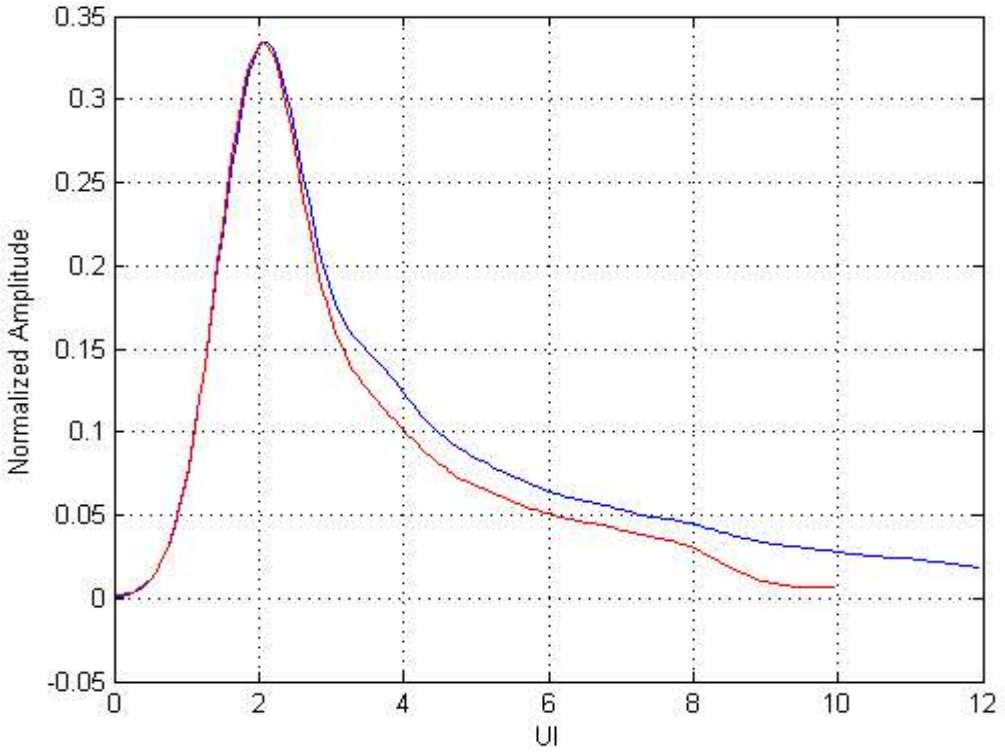
- **Impulse response in TWDP code for transmitter compliance as well as building TP3 tester.**
  - **MCB and connector removed from one end of the cable to eliminate double counting one connector.**



UI	Amp
0	0.0049
0.25	0.0118
0.5	0.0277
0.75	0.0651
1	0.1109
1.25	0.1525
1.5	0.1192
1.75	0.0790
2	0.0554
2.25	0.0416
2.5	0.0374
2.75	0.0305
3	0.0281
3.25	0.0249
3.5	0.0230
3.75	0.0201
4	0.0187
4.25	0.0166
4.5	0.0148
4.75	0.0139
5	0.0132
5.25	0.0125
5.5	0.0109
5.75	0.0103
6	0.0097
6.25	0.0087
6.5	0.0080
6.75	0.0073
7	0.0068
7.25	0.0064
7.5	0.0057
7.75	0.0050

10m 24 AWG Cable Pulse Response

- Blue original 10 m cable response with WDP penalty of 9.34 dBe.
- Red recreated 10 m cable pulse response using the impulse response used for transmitter penalty.
  - If cable end is measured directly then impulse and pulse response match will improve.



How to Update TWDP Code for CR4/CR10

- **The impulse response was 2x oversampled was inserted into the xWDP code.**
- **Starting with SFF-8431 xWDP code page 121 replace line 21-23 with the following**

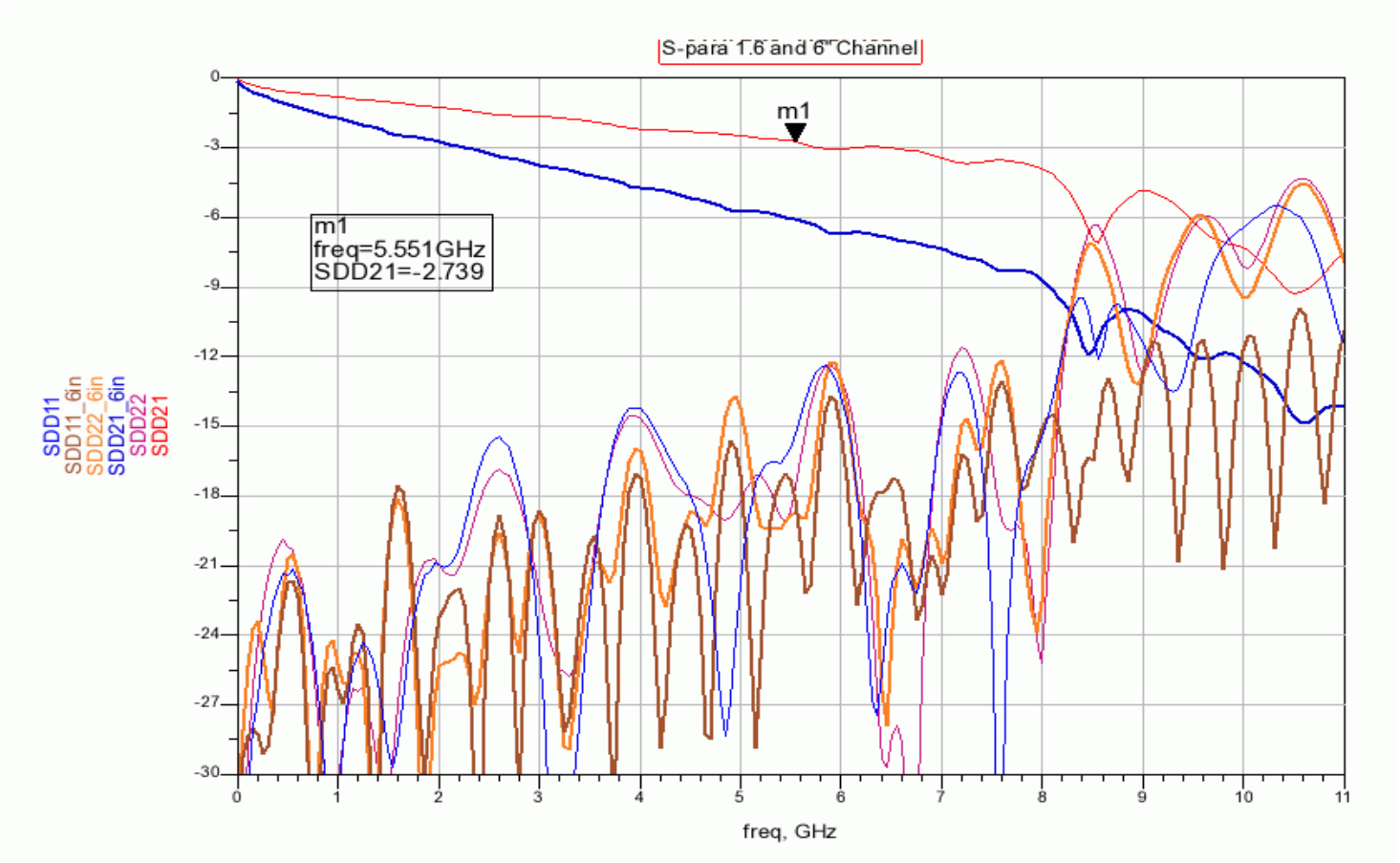
```
ChanResp = [...
              .0 .04849 .09697 .14546 .19394 .24243 .29091 .33940 .38788, ...
              .43637 .48485 .53334 .58182 .63031 .67879 .72728;
              0.0 0.0233 0.1287 0.3015 0.1562 0.0822 0.0603 0.0492 0.0397, ...
              0.0328 0.0275 0.0247 0.0172 0.0144 0.0127 0.0099];
```

TWDP/WDP Evaluation Procedure

- **Capture PRBS9 16x oversampled waveform using sampling or real time scopes.**
- **Run the TWDP/WDP code**
  - `function [xWDP,MeasuredxMA]=SFF8431xWDP(WaveformFile,EqNf,EqNb,SymbolRate,Usage)`
    - `WaveformFile – Input waveform file`
    - `EqNf – Number of feedforward tap`
    - `EqNb – Number of feedback tap`
    - `SymbolRate – 10.3125`
    - `Usage – Switch WDP, TWDP, etc and a code can be provided exactly for CR4/CR10 application and other cases removed.`
- **TWDP code is proven and easy to use for the users**
  - **TWDP code impulse response extraction is the complex part but the use the code is stright forward and does not require.**
  - **An overly complex procedure for the users is unacceptable.**

Channels Used for iFFT, DDPWS, and TWDP Study

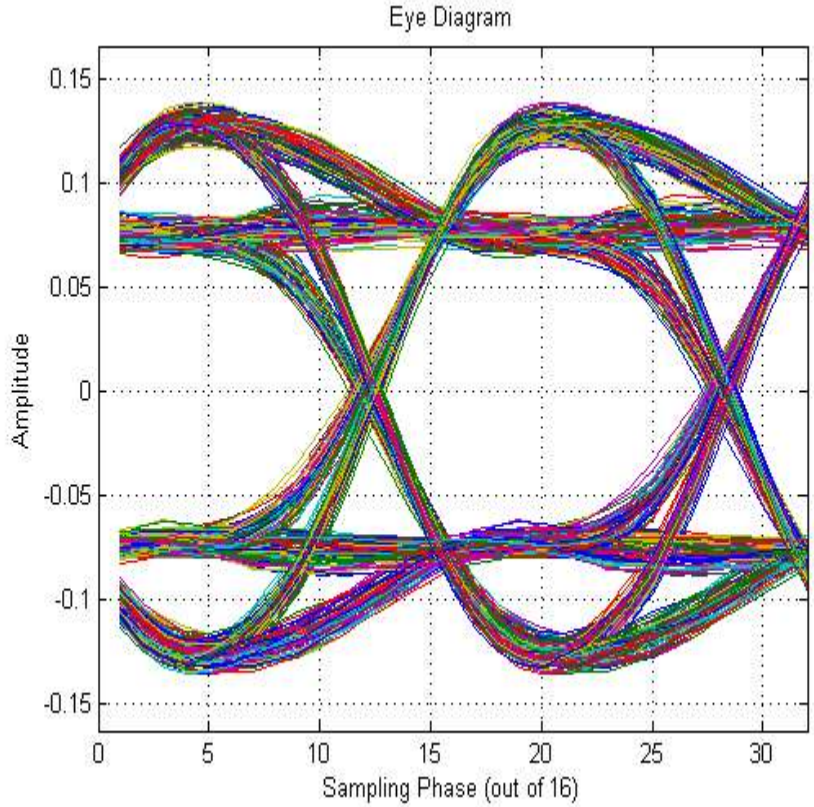
- **Nice 1.6” and 6” SFP+ channel measured with SFP+ HCB with 1 dB loss at Nyquist.**



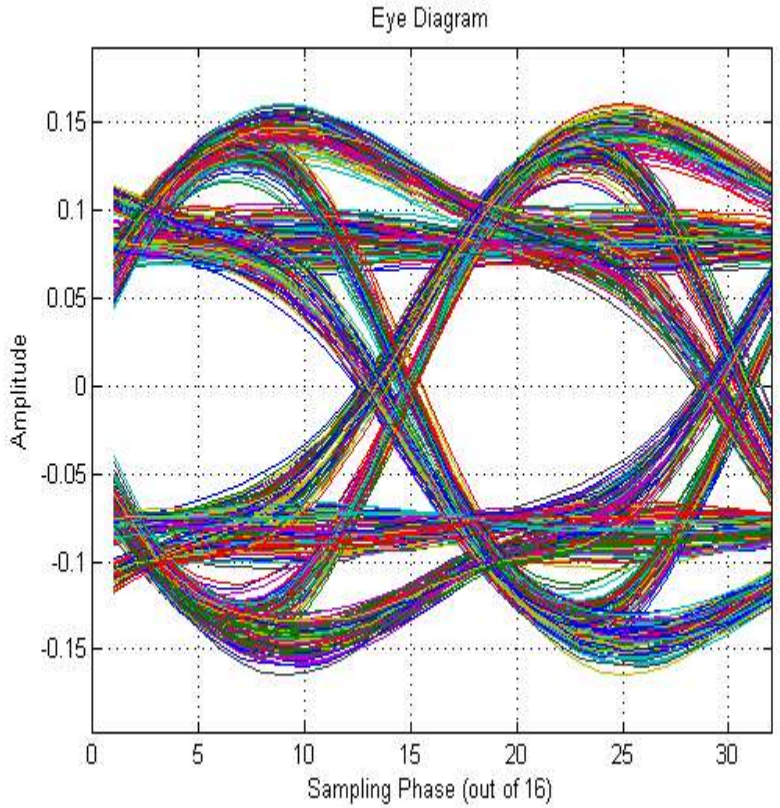
Channel Studied for Analysis

- **SFP+ channel at optimum de-emphasis channel+SerDes meets SFP+ DDJ and DDPWS, eye diagram shown is for ~5.5 dB de-emphasis**

1.6” of FR4-08

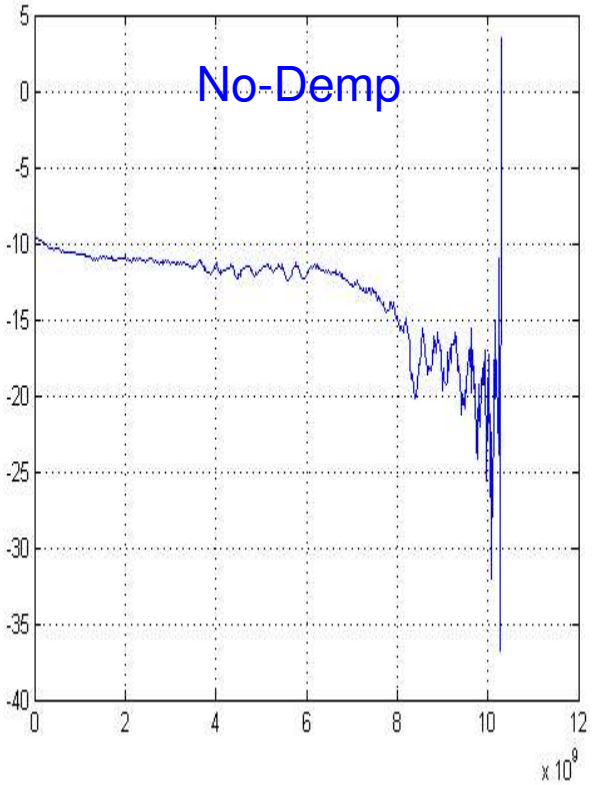


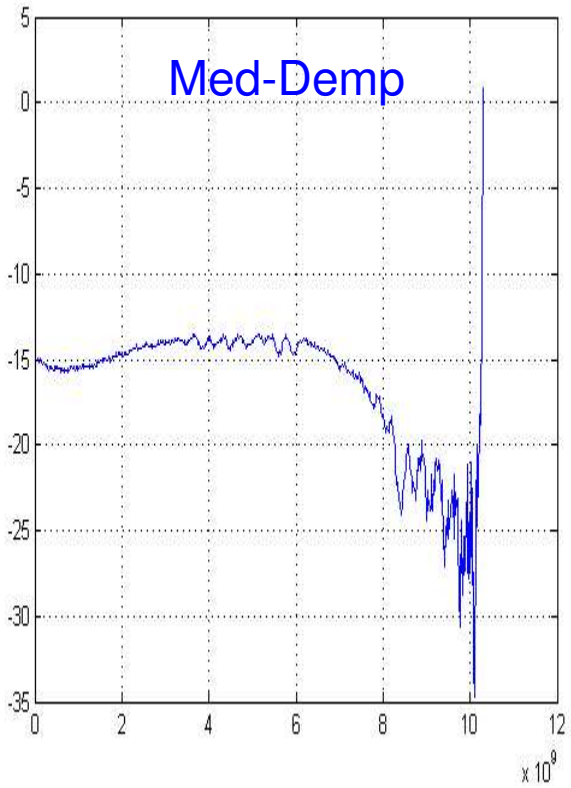
6” of FR4-08

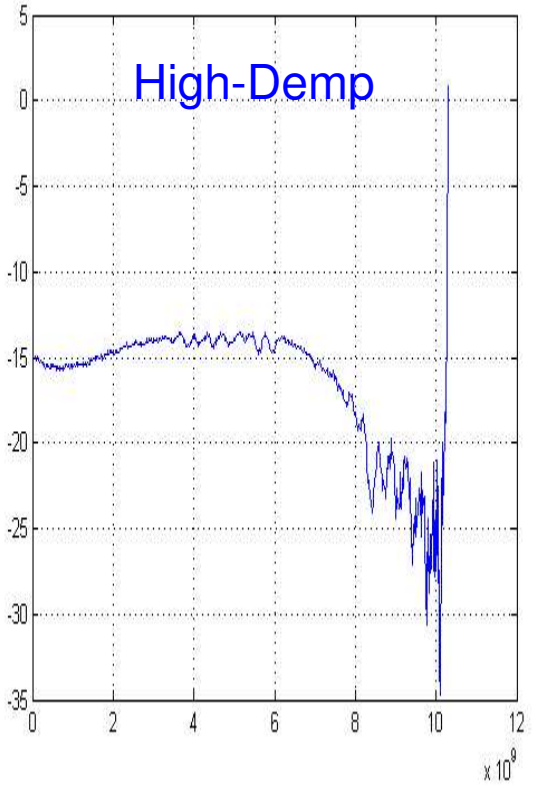


ILTP2 for 1.6” Trace

- **For several de-emphasis**

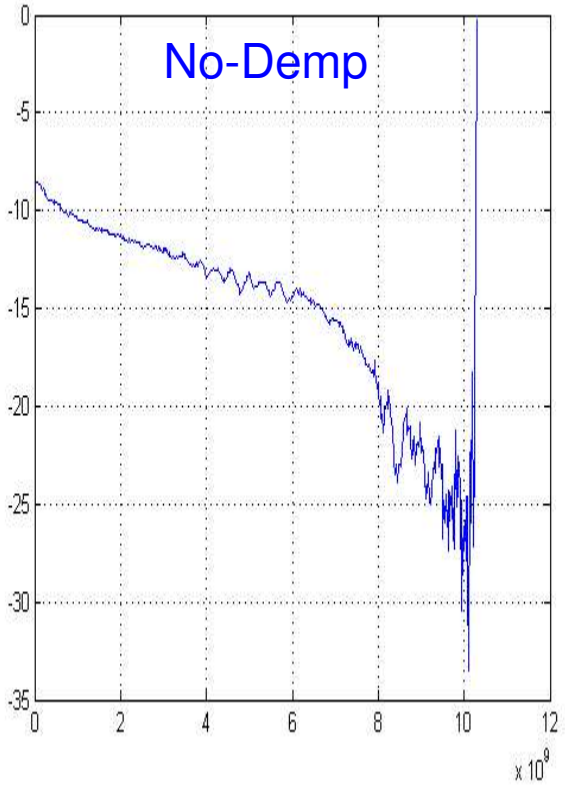


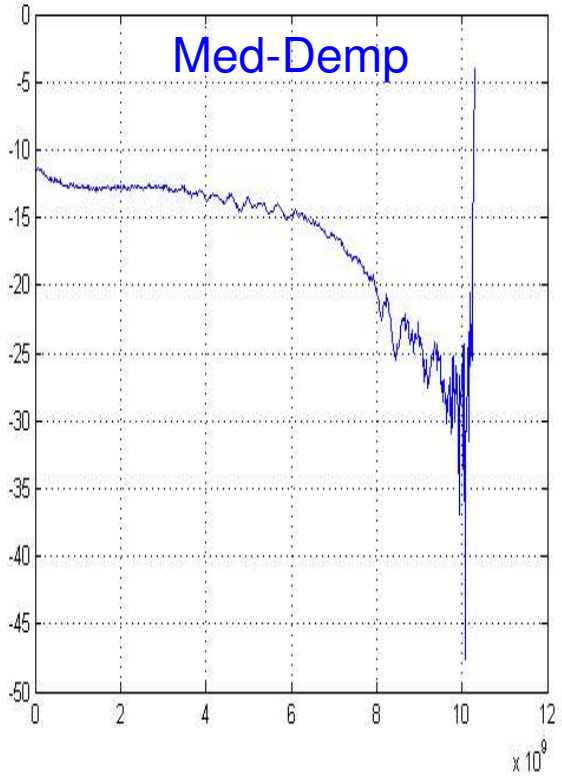


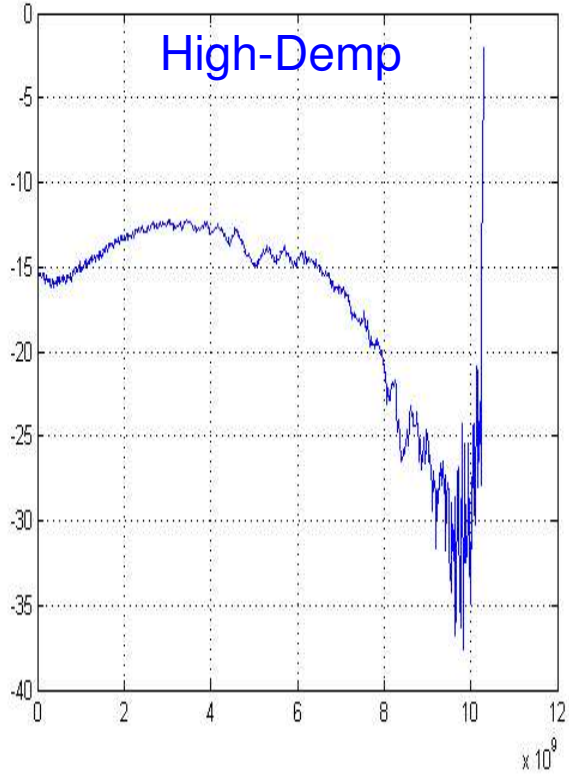


ILTP2 for 6” Trace

- **For several de-emphasis**

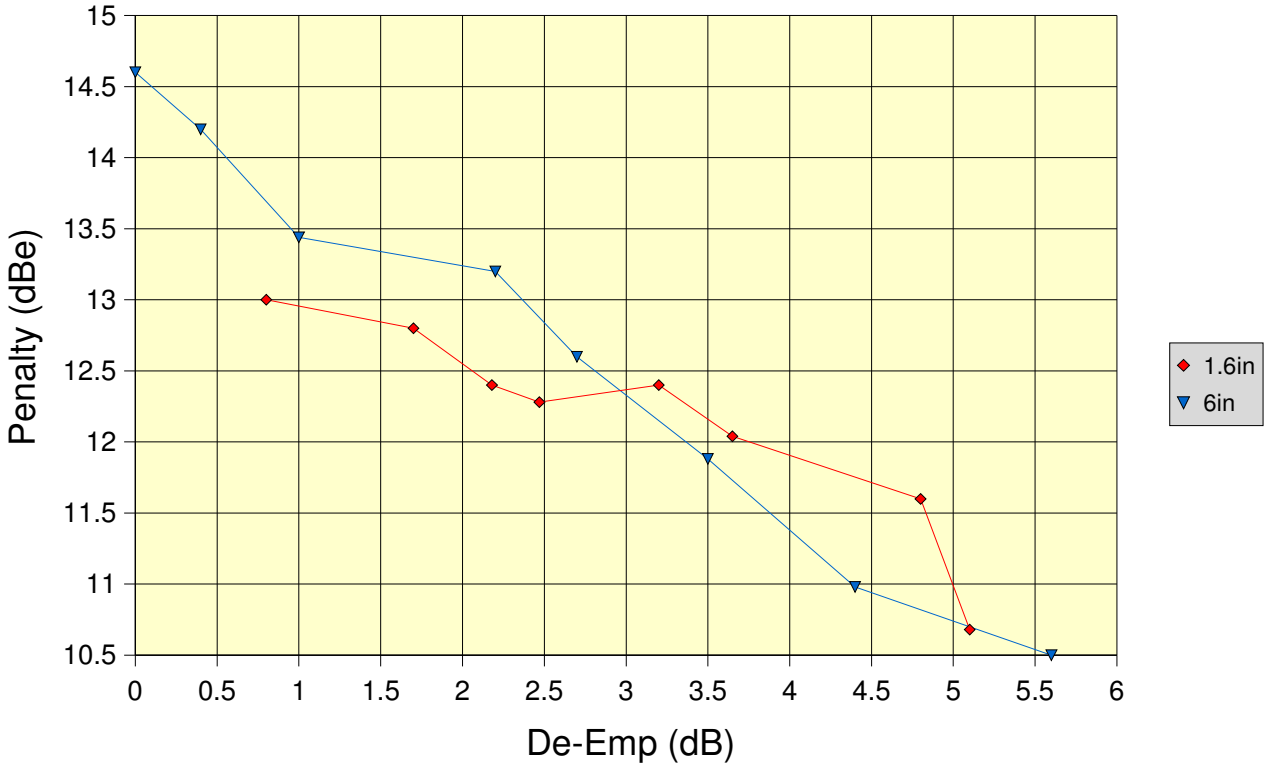






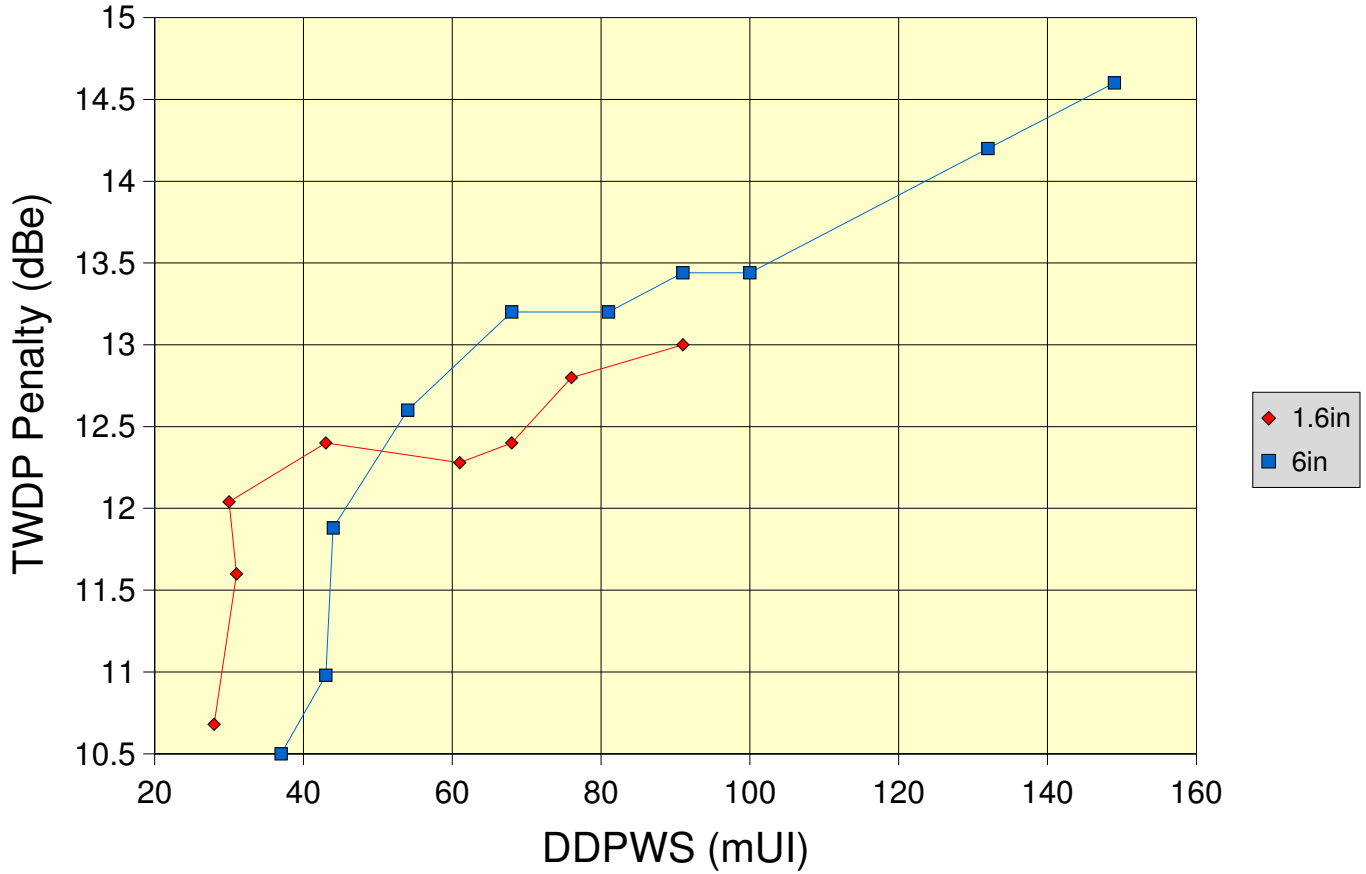
TWDP Penalty for Short and Long Host Channel

- **The 1.6” host channel is sensitive to reflection**



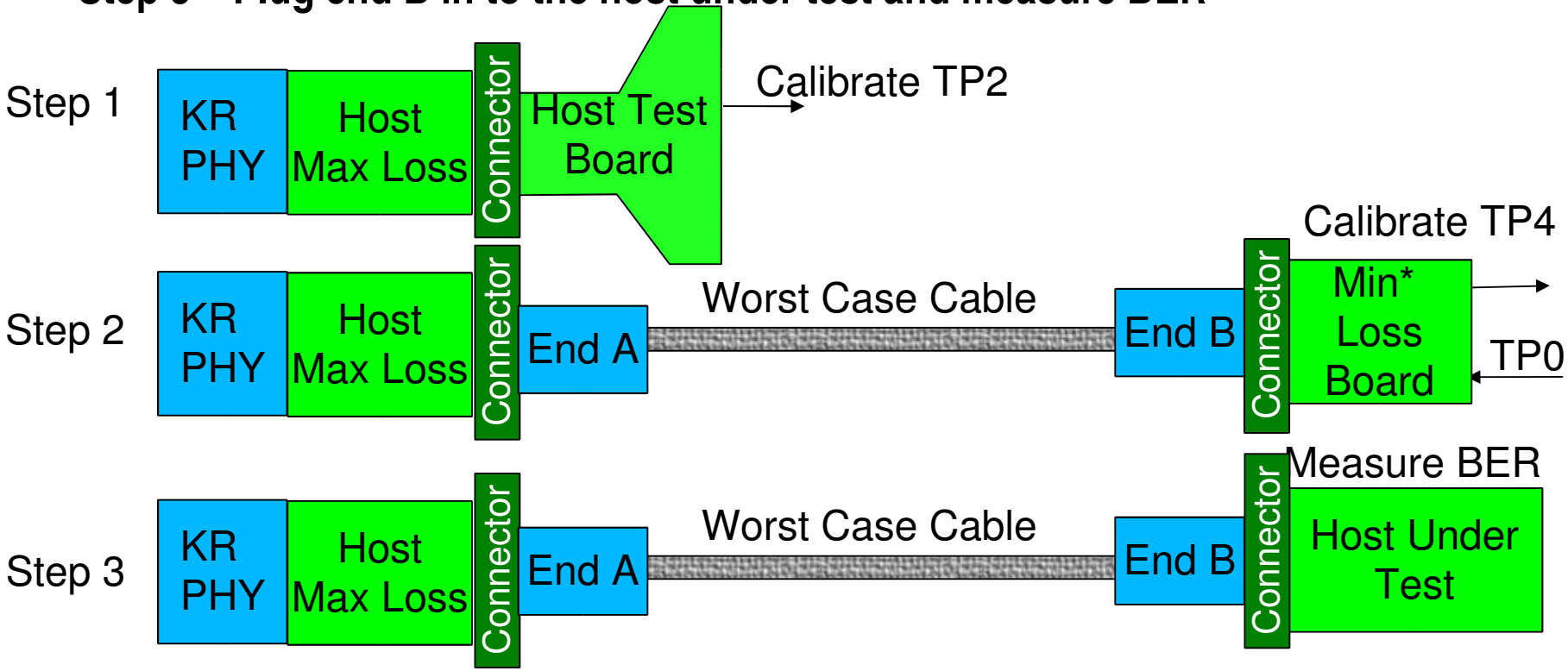
Could DDPWS Provide Sufficient Transmitter Confinement?

- **DDPWS with max value of 0.06 UI will improve current TP2 specification but not to the level of TWDP.**



Block Diagram of TP3 Tester Using Worst Case Cable (Option 1)

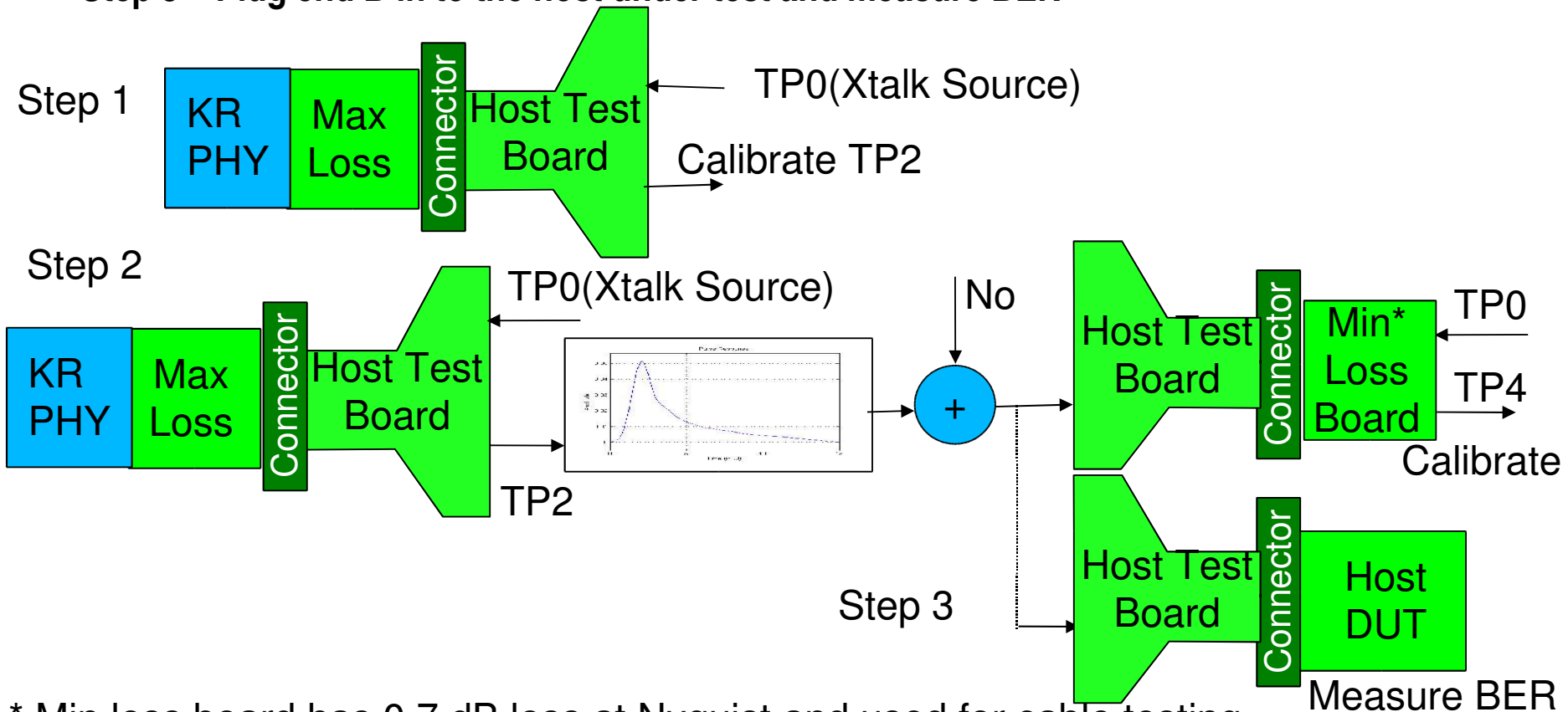
- **Step 1 – Calibrate TP2 for worst case response by measuring TWDP and Qsq**
- **Step 2 – Measure TP4 for compliance to Qsq and Waveform Distortion Penalty (WDP) while a KR transmitter is active at TP0**
- **Step 3 – Plug end B in to the host under test and measure BER**



* Min loss board has 0.7 dB loss at Nyquist and used for cable testing.

Block Diagram of TP3 Tester Using Worst Case Cable Impulse (Option 2)

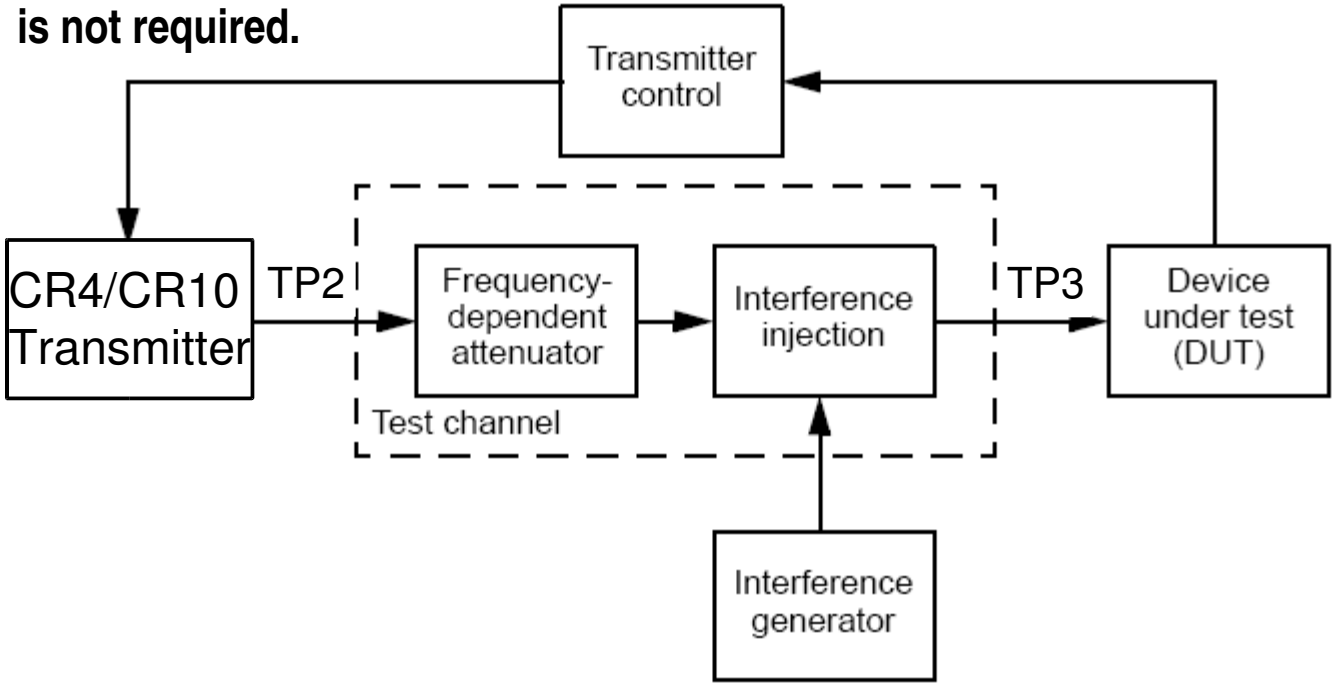
- **Step 1 – Calibrate TP2 for worst case response by measuring TWDP and Qsq**
- **Step 2 – Measure TP4 for compliance to Qsq and Waveform Distortion Penalty (WDP) while a KR transmitter is active at TP0 adjust No to meet the Qsq**
- **Step 3 – Plug end B in to the host under test and measure BER**



* Min loss board has 0.7 dB loss at Nyquist and used for cable testing.

CR4/CR10 Interference Test Setup

- **Just replace KR frequency dependent attenuator with 10 m worst case cable or cable impulse response**
  - **Without the availability of Golden cable a penalty calibration tool like "WDP" is required**
    - **But if the worst case cable impulse response is available then WDP calibration is not required.**



CR4/CR10 **–Interference tolerance test setup**

Transmitter Characteristics at TP2

- **Starting with with table 85-5**
  - **TWDP penalty controlling penalty, random jitter, and DDPWS added**

Table 85–5—Transmitter characteristics'at TP2 summary

Parameter	Value	Units
Maximum total jitter[a]	0.36	UI p-to-p
minimum KR transmit waveform "v_2" [b]	267	mV
QSQ[c]	55.6	
Vertical eye opening[d]	340	mV p-to-p
TWDP (e)	12.5	dBe
Random Jitter	0.18	UI(RMS)
DDPWS (e)	0.06	UI

e. Measured with PRBS9 and xWDP code as defined in SFF-8431 with modification provided here.
f. Measured with PRBS9 pattern based on the procedure in 86.7.4.4.

Receive Characteristics at TP3

- **Starting with KR interference tolerance table**
  - **m_{TC} removed since the impulse response for the frequency dependent attenuator provided or suitable length of cable will be used.**
  - **Minimum KR receive waveform v2 added consistent with TP2 and the cable loss**
  - **Amplitude of broadband noise was calculated for shortest cable and longest cable using 4 NEXT and 3 FEXT.**
  - **WDP penalty will facilitate calibration of the stress generator but would be required if no impulse response is provided for the cable.**

Table 72–10—10GBASE-KR interference tolerance parameters

Parameter	Test 1(0.5 m)	Test 1(10 m)	Units
Target BER	10^{-12}	10^{-12}	
minimum KR receive waveform "v2" b	250	150	mV
Amplitude of broadband noise (min. RMS)	~~5.2~~ 4.0	~~12~~ 2.4	mV
Applied transition time (20%–80%, min.)	47	47	ps
Applied Sinusoidal jitter (min. peak-to-peak)	0.115	0.115	UI
Applied random jitter (min. peak-to-peak)[b]	0.130	0.130	UI
Applied Duty Cycle Distortion (min. peak-to-peak)	0.035	0.035	UI
Waveform Dispersion Penalty (WDP)	4.0	11.0	dBe

Summary

- This presentation investigates 3 options to improve TP2 conformance:
  - iFFT not a good predictive of the TP2 penalty due to driver non-linearly, reflections, and does not predict accurately the penalty for low loss channels.
  - DDPWS better predictive for TP2 penalty
  - TWDP best predictive of TP2 penalty
- Receiver TP3 conformance test also requires better definition and the options are:
  - Provide cable impulse response
  - WDP method
  - Provide cable phase response.
- TP2 and TP3 also requires accurate definition of TP2 and TP3 test points, see ghiasi_01_0509.