Design of Flyover QSFP (FQSFP) for 56+ Gbps applications

Presented by Jim Nadolny, Samtec

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SPEAKER

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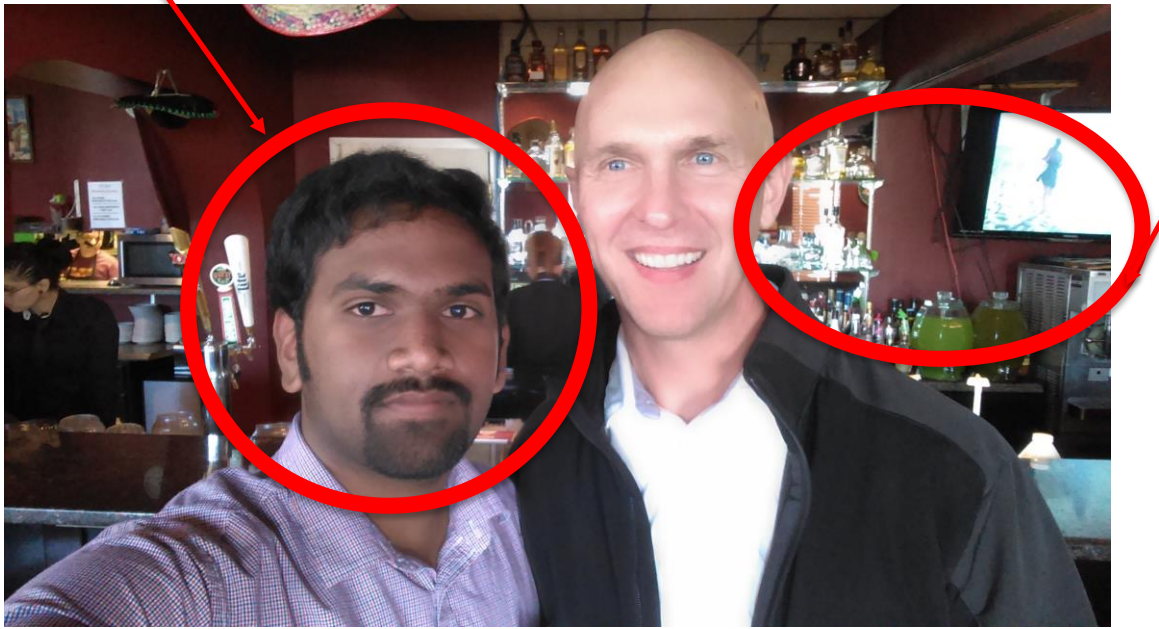
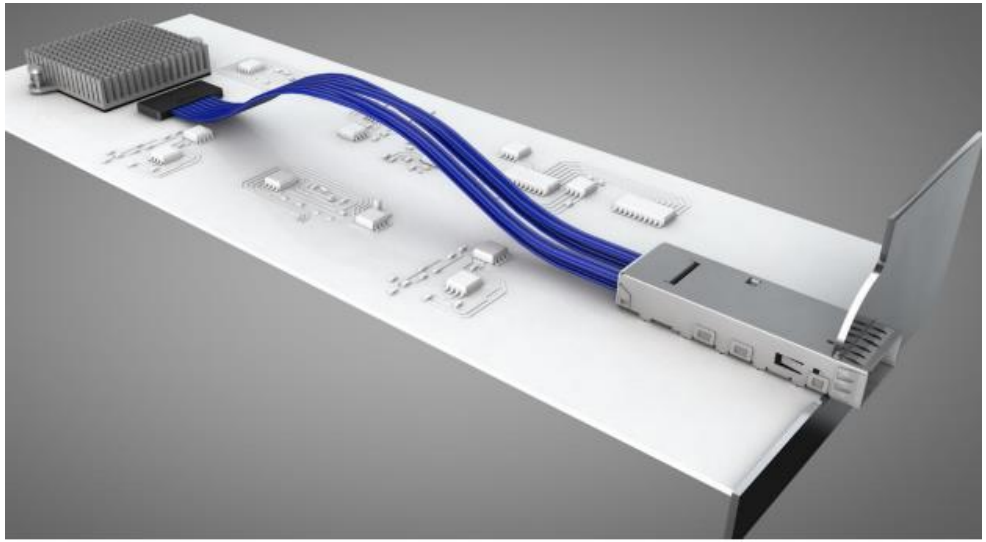
Worker

Necessary Lubricant



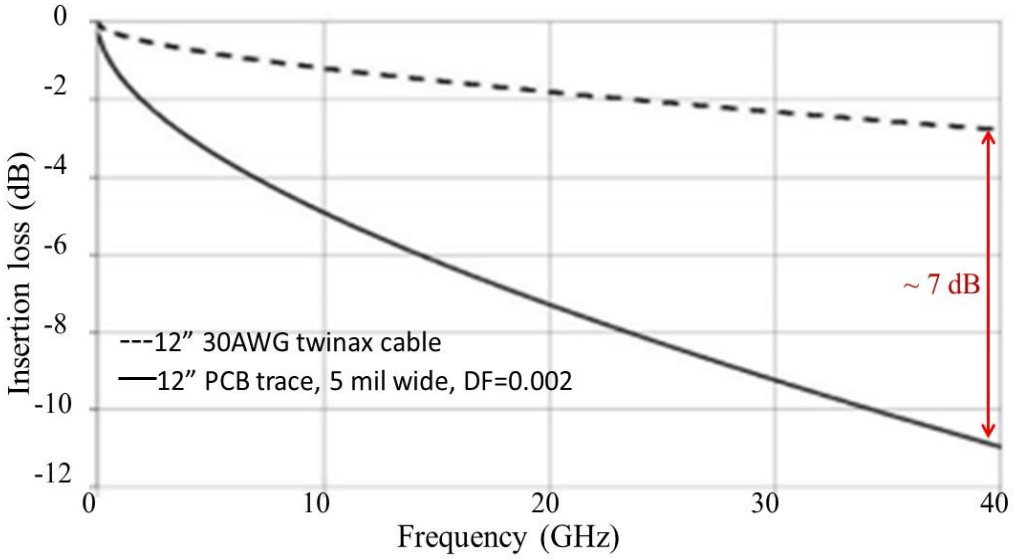
Outline

- **Introduction**
  - Twinax vs PCB traces
  - Flyover Technology and FQSFP
  - Ethernet Interconnect requirements
- **EMI Characterization of FQSFP**
  - Design of Test Vehicle
  - Computational approach
  - Correlation Efforts
- **Next Steps**



Introduction

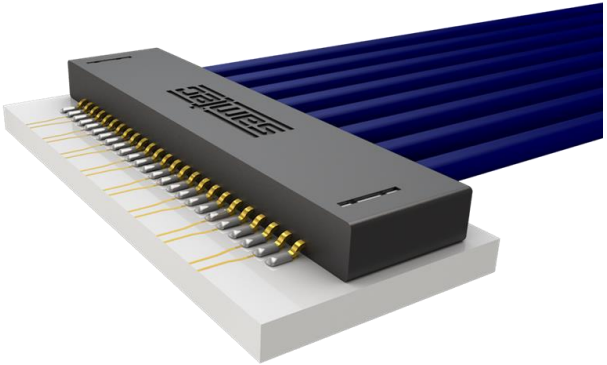
- Twinax vs PCB traces
  - Compare the insertion loss of 30 AWG twinax with a 5 mil trace on Meg6

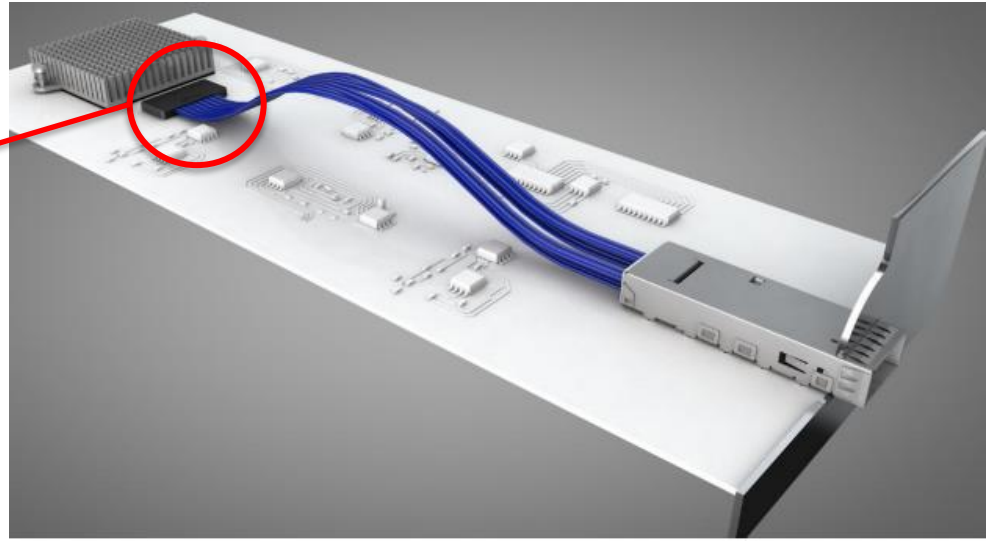


The motivation is to take advantage of the reduced attenuation that twinax cable provides

Introduction

- Flyover Technology and FQSFP

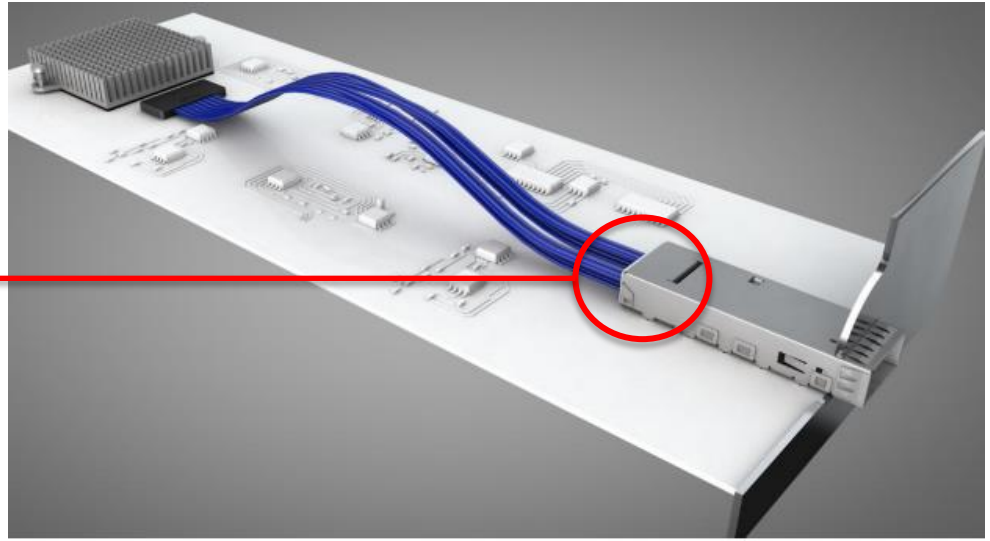




A short, high performance connector near the switch chip…

Introduction

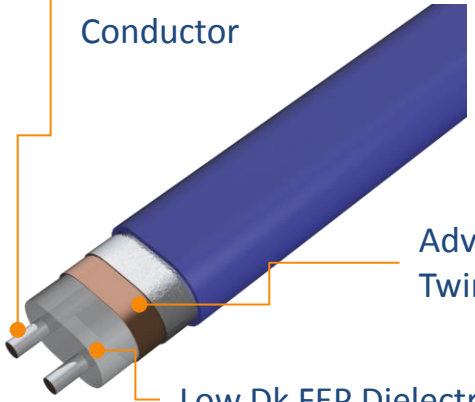
- Flyover Technology and FQSFP

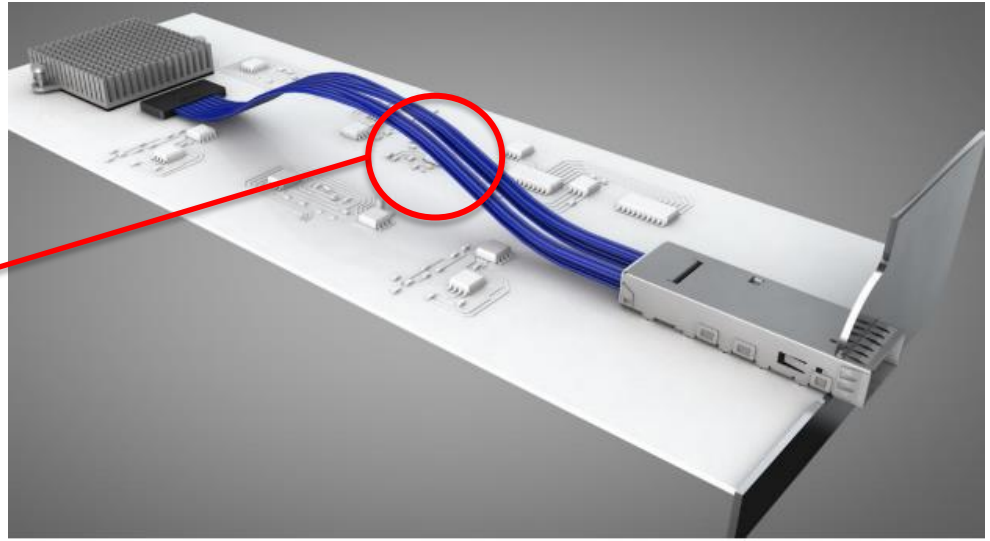


A QSFP connector with direct attach twinax…

Introduction

- Flyover Technology and FQSFP





Twinax cable designed for "suckout free" performance

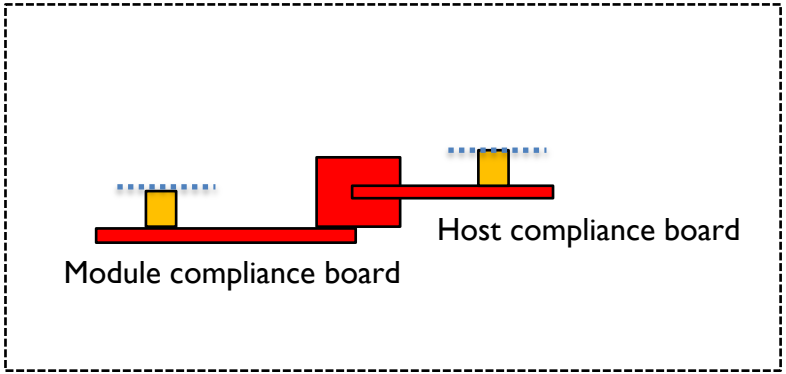
Introduction

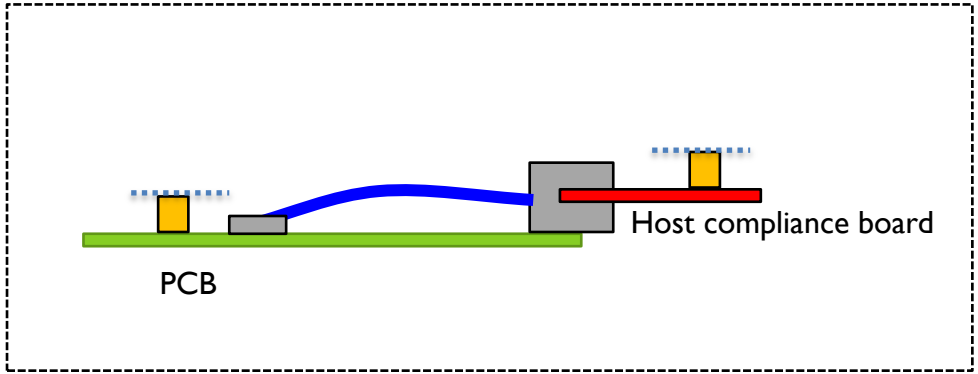
- IEEE 802.3bs interconnect requirements
  - Front panel pluggable solutions (QSFP) are qualified using compliance boards
    - Host compliance board tests the module
    - Module compliance board test the host
  - Compliance boards for 100 GbE are defined in IEEE 802.3bj (4 channels at 28 Gbps NRZ)
  - Compliance boards for 400 GbE are the same as IEEE 802.3bj (8 channels at 56 Gbps PAM4)
    - This may evolve as PAM4 implementations mature

To show 56 Gbps PAM4 compliance, we take a mated host-module compliance board approach

Introduction

- IEEE 802.3bs interconnect requirements





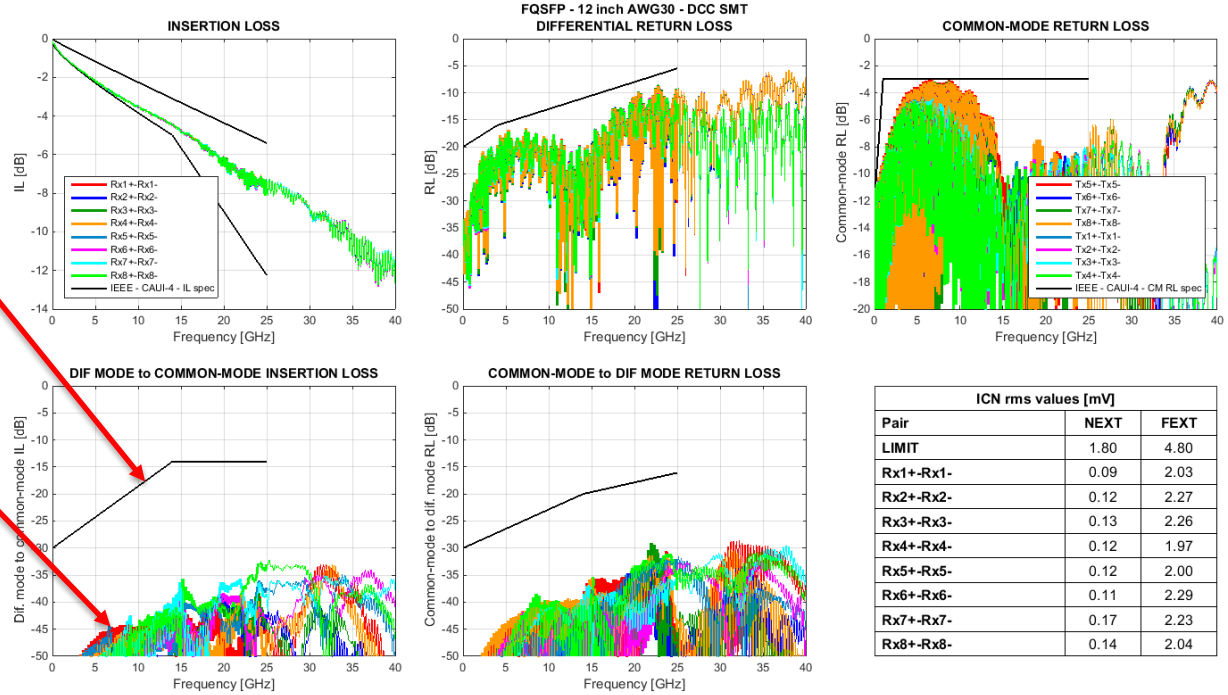
Reference plane location

To show 56 Gbps PAM4 compliance, we take a mated host-module compliance board approach

Introduction

Mated compliance board limits

FQSFP simulated data



ICN rms values [mV]		
Pair	NEXT	FEXT
LIMIT	1.80	4.80
Rx1+-Rx1-	0.09	2.03
Rx2+-Rx2-	0.12	2.27
Rx3+-Rx3-	0.13	2.26
Rx4+-Rx4-	0.12	1.97
Rx5+-Rx5-	0.12	2.00
Rx6+-Rx6-	0.11	2.29
Rx7+-Rx7-	0.17	2.23
Rx8+-Rx8-	0.14	2.04

To show 56 Gbps PAM4 compliance, we take a mated host-module compliance board approach

EMI Characterization of FQSFP

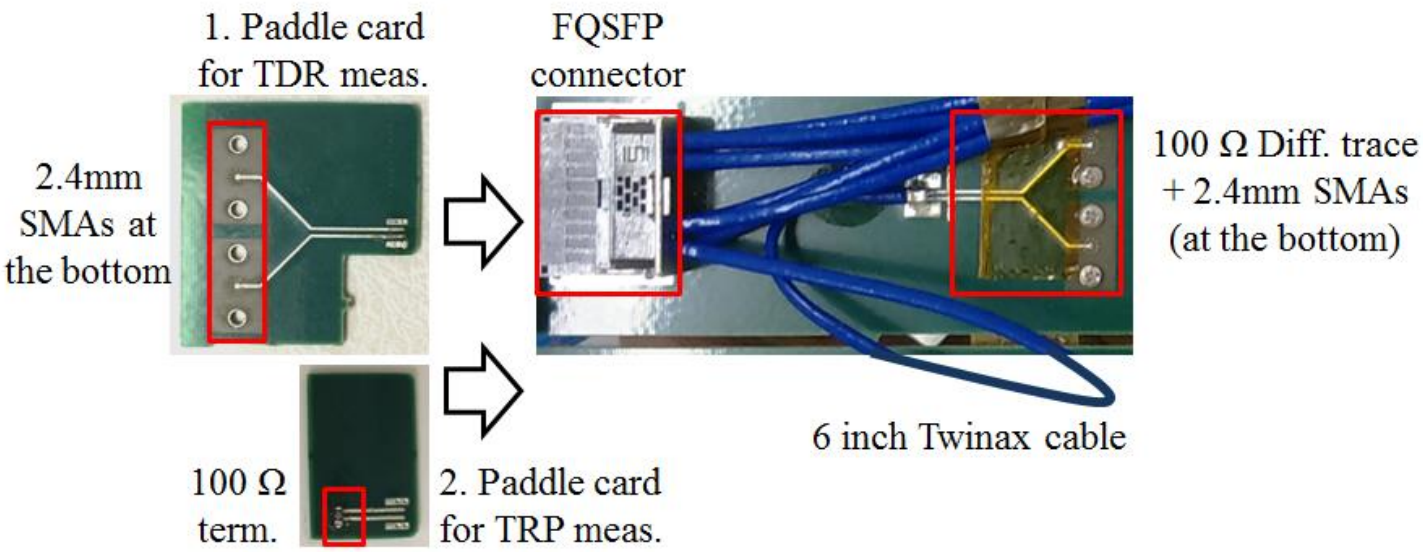
Approach:

- Full wave simulations of small, simple structures
  - Quick(er) computational time
  - Validate with measurements
  - Build confidence that future steps are built on solid ground
- Start with the QSFP connector
- Incrementally build the model and validation vehicles

Avoid the rookie mistake of putting the entire cable assembly, EMI cage, chassis model and PCBs into CST/HFSS and simulating the total radiated power (TRP)

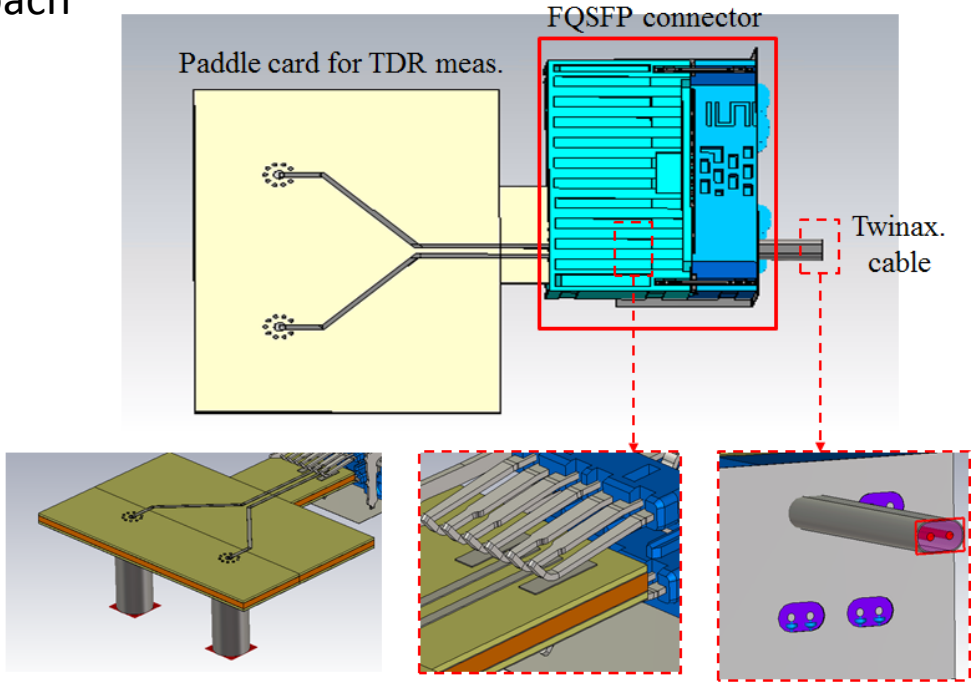
EMI Characterization of FQSFP

Design of test vehicle



EMI Characterization of FQSFP

Computational Approach

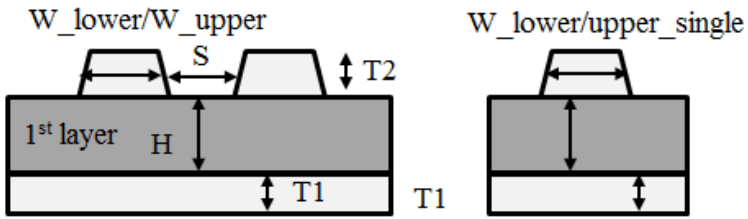


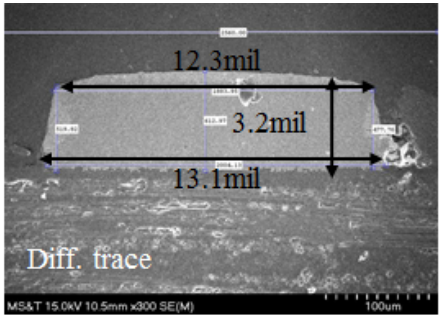
SMA port at the bottom of paddle card

Traces to FQSFP conn. transition

EMI Characterization of FQSFP

Tweaking the model to reflect the test vehicle

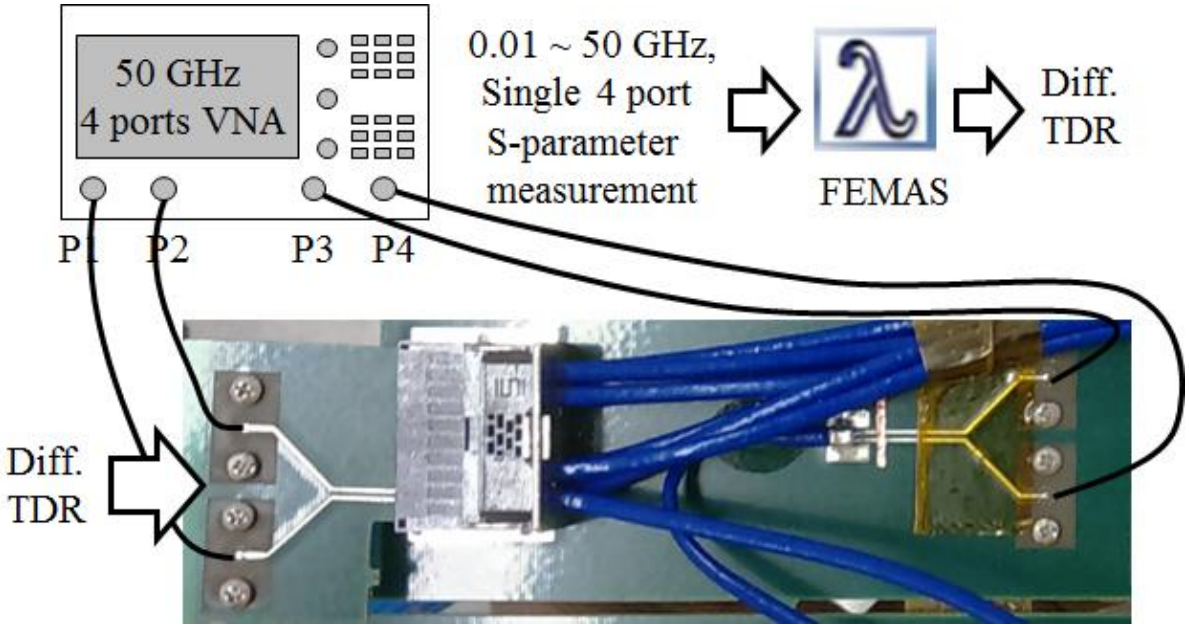




	W_lower	W_upper	S	H	T1	T2	W_lower _single	W_upper _single
Designed dimensions	12.5 mil	-	18	7.6	1.2	1.4	13.6	-
Fabricated dimensions	13.1	12.3	20	7.5	1.3	**3.2**	14.2	13.8

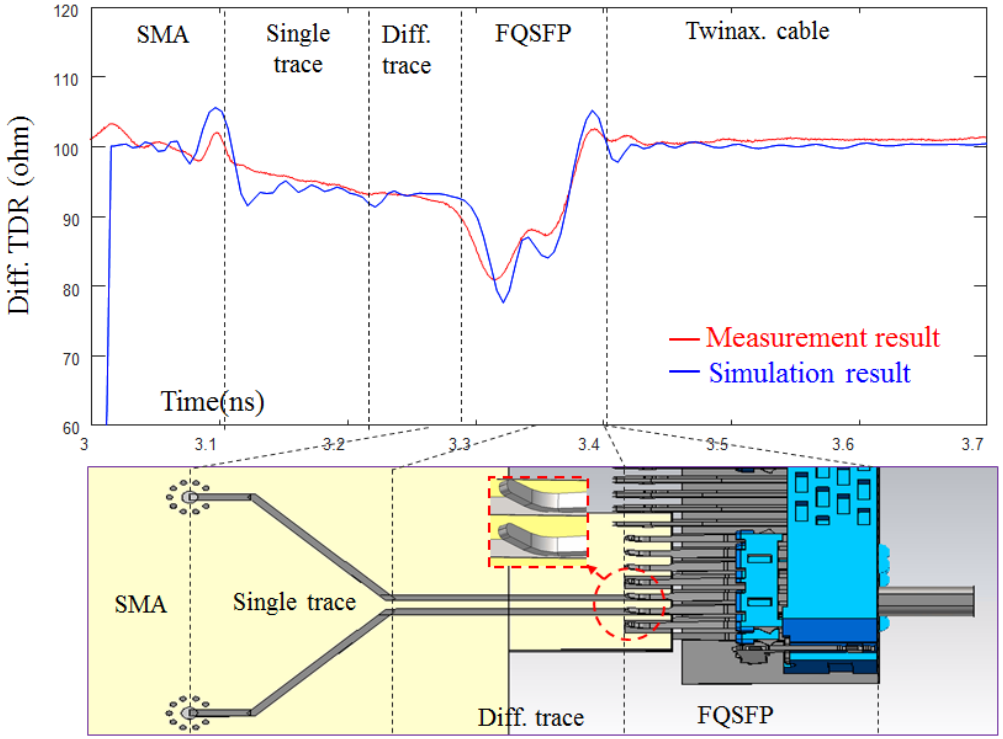
EMI Characterization of FQSFP

S-Parameter Measurements



EMI Characterization of FQSFP

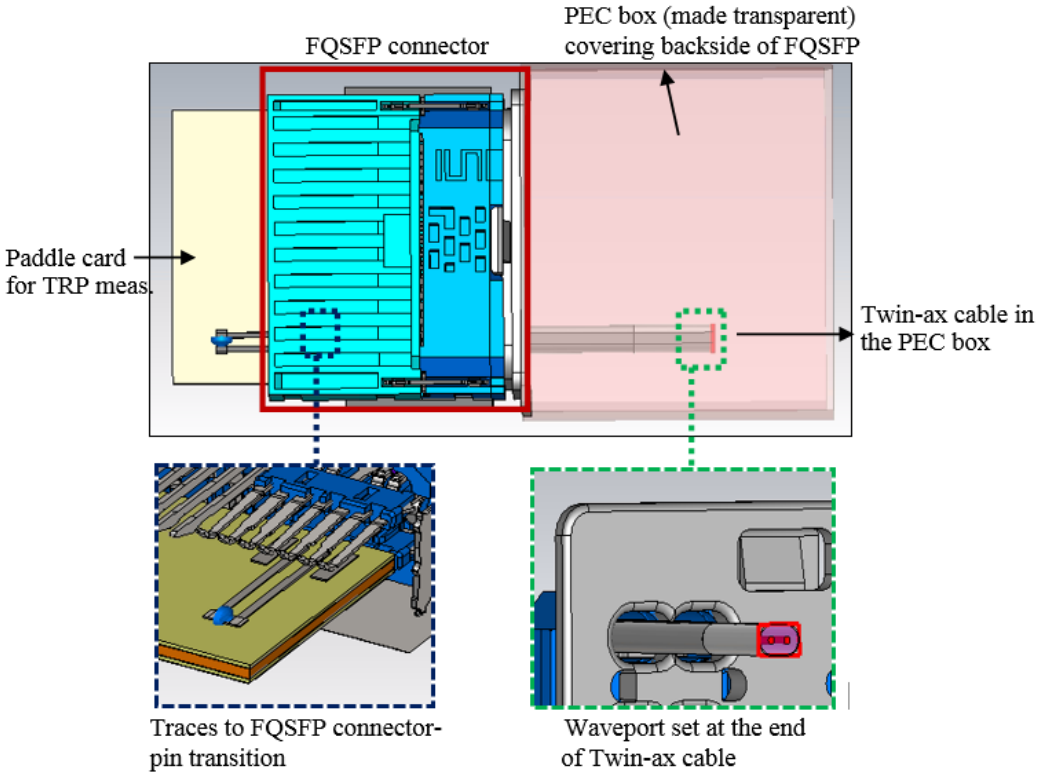
Time Domain Correlation



EMI Characterization of FQSFP

Full Wave Simulation

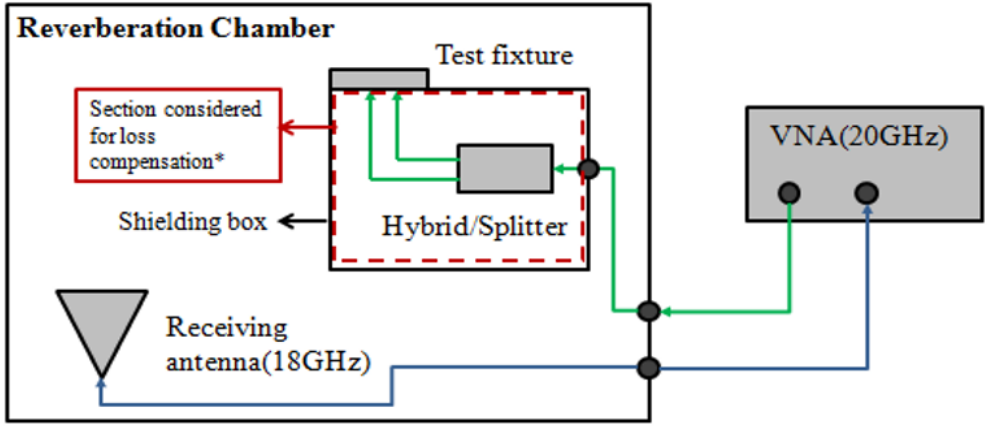
- Energize the twinax cable
- Energy excites the connector, PCB, etc.
- Total radiated power computed by integrating over the computational domain
- Sim time – 3-4 hours with CST MS and GPU acceleration



EMI Characterization of FQSFP

TRP Measurements

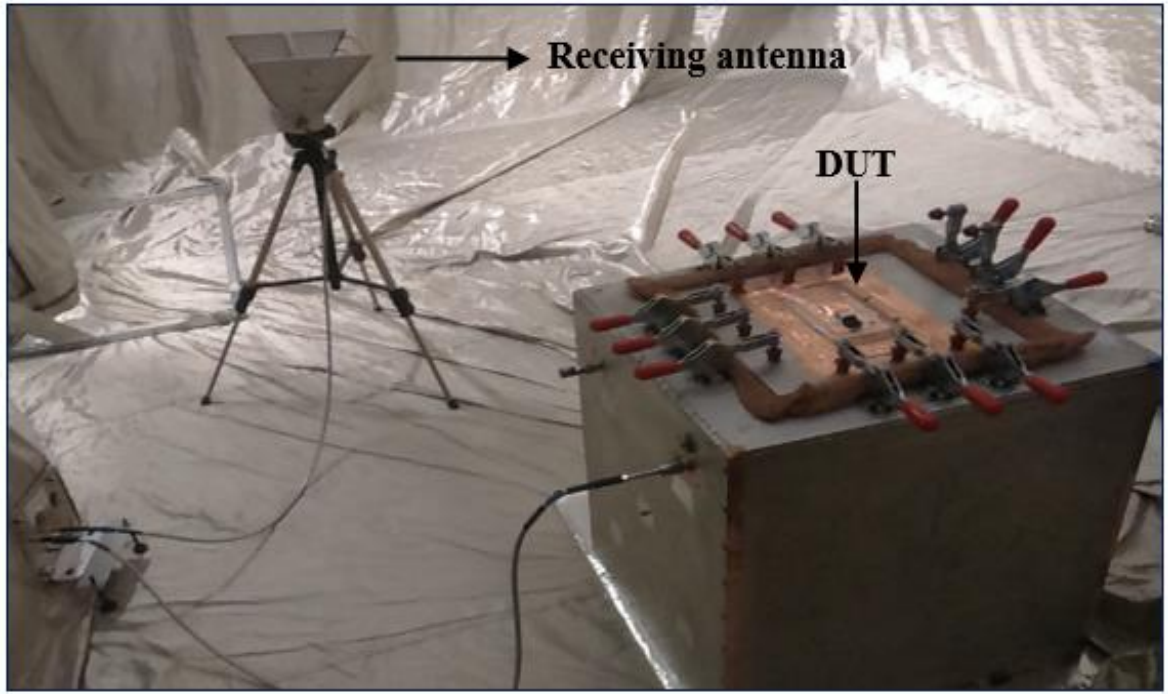
- As with S-parameter measurements, calibration is required to compensate for reflections and attenuation.
- Methodology is NIST traceable



EMI Characterization of FQSFP

TRP Measurements

We measured the radiation from just the connector



EMI Characterization of FQSFP

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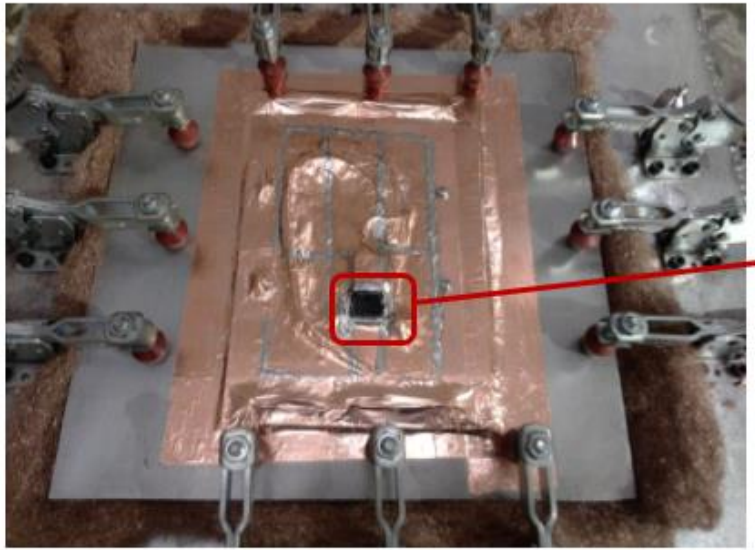
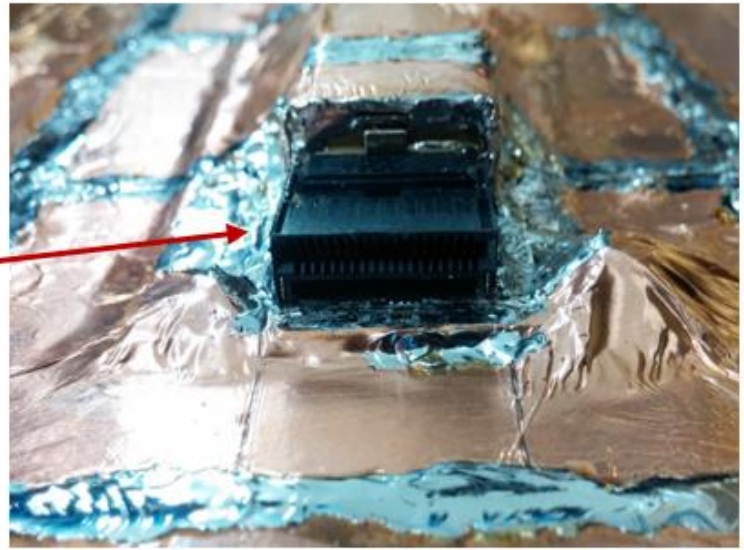
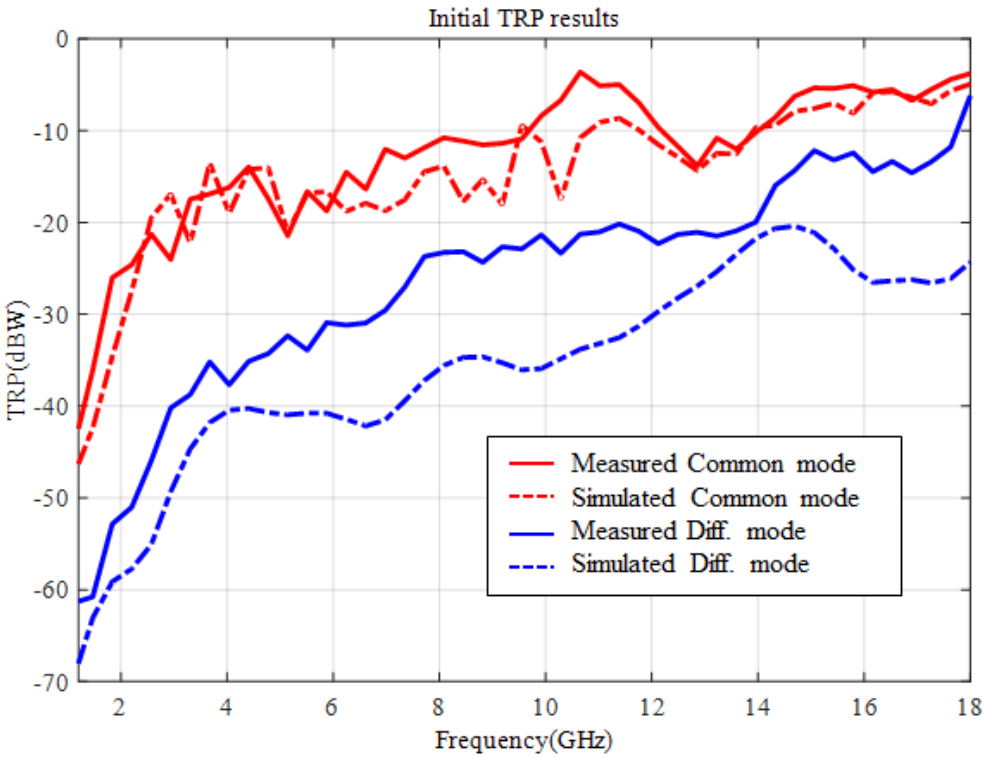




EMI Characterization of FQSFP

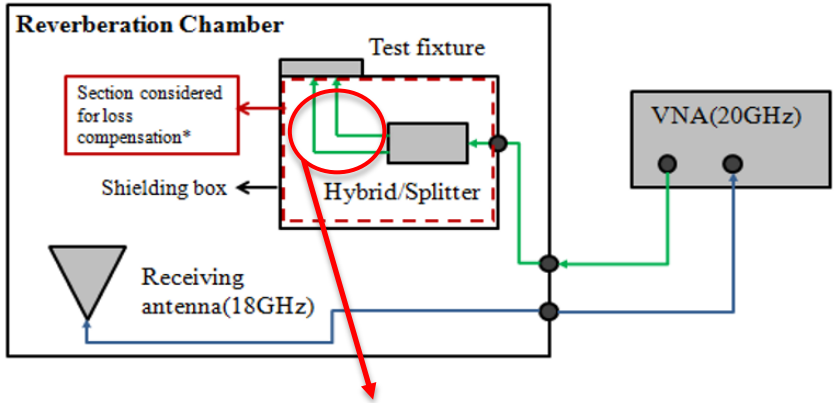
TRP Measurements

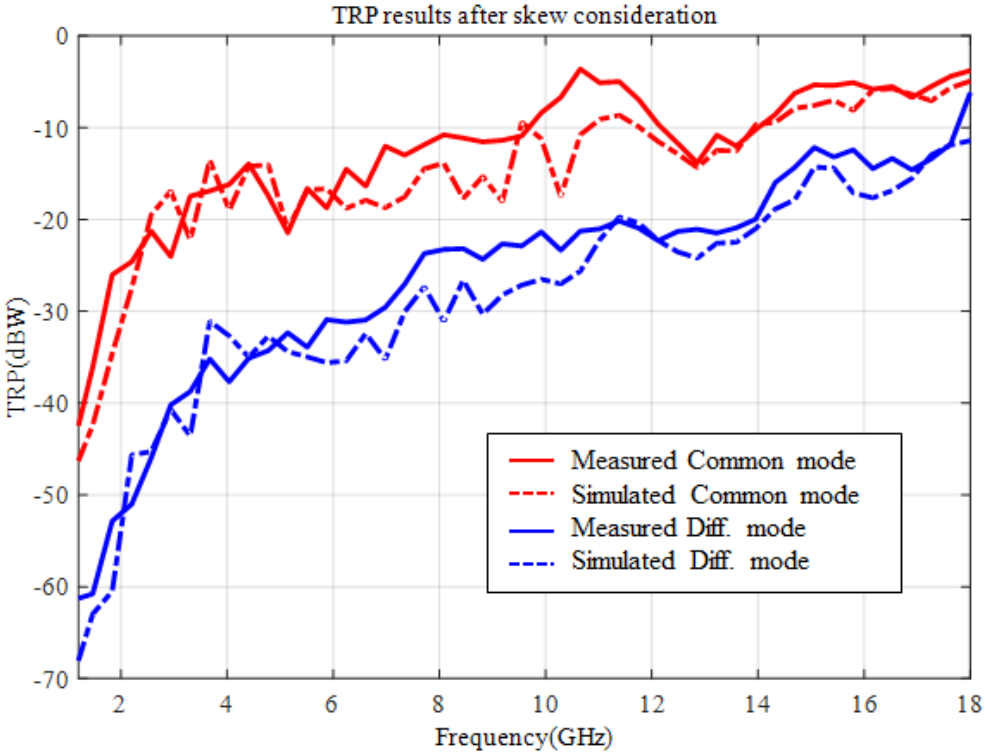
- Differential results show poor correlation



EMI Characterization of FOSFP

Correlation efforts

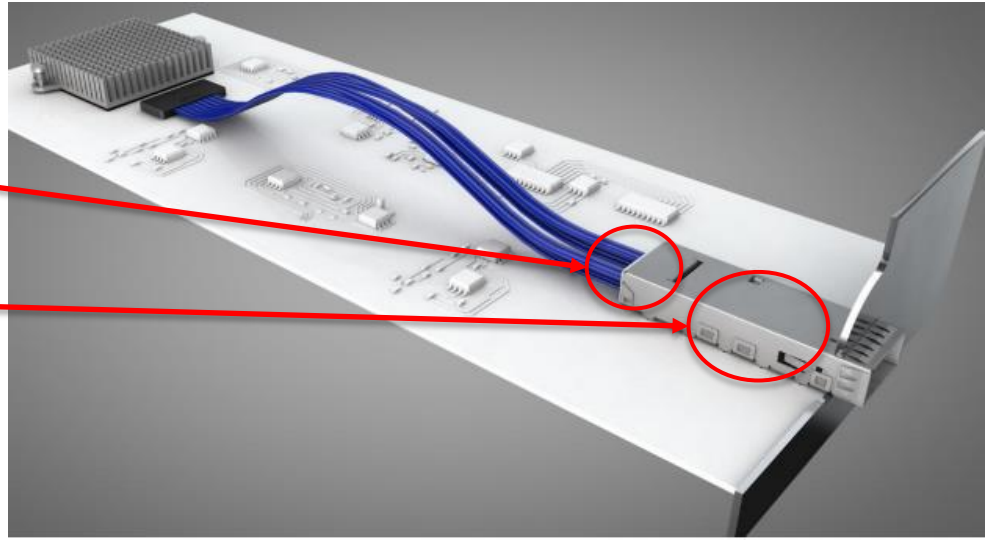




Differential correlation improvement when instrumentation skew is compensated

Next Steps

- More fully explore the twinax to EMI cage termination
- Add the card cage
- Add optical modules
  - Optical ferrule radiation
- Expand frequency range to 40 GHz



MORE INFORMATION

- **Websites**
  - **emclab.mst.edu**
  - **Samtec.com**
- **Contact info**
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Thank you!

QUESTIONS?