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

Presented by Jim Nadolny, Samtec

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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

  - Ag Plated Cu Solid Center Conductor
  - Advanced Cu Alloy Twinax Shield
  - Low Dk FEP Dielectric co-extruded Technology

*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

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<table>
<thead>
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<th>Pair</th>
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<th>FEXT</th>
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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

1. Paddle card for TDR meas.
   - 2.4mm SMAs at the bottom

2. Paddle card for TRP meas.
   - 100 Ω term.

FQSFP connector

100 Ω Diff. trace + 2.4mm SMAs (at the bottom)

6 inch Twinax cable
EMI Characterization of FQSFP

Computational Approach
EMI Characterization of FQSFP

Tweaking the model to reflect the test vehicle

<table>
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<th>W_lower</th>
<th>W_upper</th>
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<th>H</th>
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<th>T2</th>
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</tbody>
</table>
EMI Characterization of FQSFP
S-Parameter Measurements
EMI Characterization of FQSFP

Time Domain Correlation

- Measurement result
- Simulation result
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

TRP Measurements

We measured the radiation from just the connector
EMI Characterization of FQSFP

TRP Measurements

- Differential results show poor correlation
EMI Characterization of FQSFP

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

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Thank you!

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QUESTIONS?