SFF-8470 (CX-4) / Copper Concepts for 802.3ba

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IEEE 802.3ba Objectives

The following are Fujitsu’s commitments to the IEEE 802.3ba Objectives

- Support full-duplex operation only
- Preserve the 802.3 / Ethernet frame format utilizing the 802.3 MAC
- Preserve minimum and maximum Frame Size of current 802.3 standard
- Support a BER better than or equal to $10^{-12}$ at the MAC/PLS service interface
- Provide appropriate support for OTN
- Support a MAC data rate of 40 Gb/s
  - Provide Physical Layer specifications which support 40 Gb/s operation over:
    - at least 100m on OM3 MMF
    - at least 10m over a copper cable assembly
- Support a MAC data rate of 100 Gb/s
  - Provide Physical Layer specifications which support 100 Gb/s operation over:
    - at least 40km on SMF
    - at least 10km on SMF
    - at least 100m on OM3 MMF
    - at least 10m over a copper cable assembly
This presentation will provide information regarding:

- The 10Gbps/lane performance adherence of the SFF-8470 (current IEEE 802.3ak CX-4 I/O interface) connector and 10 meter cable link reach according to the S-Parameter Return Loss, Insertion Loss and Cross-talk criteria as defined by 10GBASE-KR.
- The measurement and HSPICE simulation of the SFF-8470 (current CX-4) connector and 10 meter cable link.
- Demonstrate the performance of the SFF 8470 connector and 10 meter cable assembly with the CX4/IBTA MDI.
- The feasibility of the SFF 8470 connector as a viable connector candidate for IEEE 802.3ba compliant cable system.
IEEE 802.3ba Link Model

100GBASE-CRN or 40GBASE-CR4 Transmit Function

MDI

Signal<\textit{p}>

Lane \textit{n}

Signal<\textit{n}>

Signal shield

Link shield

Cable assembly

MDI

100GBASE-CRN or 40GBASE-CR4 Receive Function
SFF-8470 / CX-4 Connector Structure

Cover, Plug

Sectional View (Connection area)

Ground/Power Contact

Patented Stripline edge coupled structure

Differential pair contacts

Outer shield

0.75mm 1.5mm

1.27mm

Socket

Section X-X (Signal section)

Section Y-Y (Ground section)
SFF-8470 (CX-4) Rack Density

4 Full Duplex Lanes/Connector

2 Lines x 16 connectors = 32 Connectors
4 Lanes/Connector x 32 Connector = 128 Lanes
Return Loss (IL(f)) Measurement

CX4/IB 10 G Test Board

CX4/IB Cable assembly with Amphenol cable 24AWG 10m

CX4/IB 10 G Test Board

Agilent 20 GHz Multi-channel Differential VNA & cabling
SFF-8470 (CX-4) + 10 meter SkewClear EXD Cable Channel Return Loss Compliance

CX4/IB Return Loss Performance vs.802.3ap Limits

<table>
<thead>
<tr>
<th>Frequency (MHz)</th>
<th>Return Loss (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>-60.00</td>
</tr>
<tr>
<td>1,000</td>
<td>-70.00</td>
</tr>
<tr>
<td>100,000</td>
<td>-70.00</td>
</tr>
</tbody>
</table>

- Return Loss Limits
- Measured Return Loss
- HSPICE Channel Simulation
Insertion Loss IL(f) Measurement Set-up

CX4/IB 10 G Test Board

CX4/IB Cable assembly with Amphenol cable 24AWG 10m

CX4/IB 10 G Test Board

Agilent 20 GHz Multi-channel Differential VNA & cabling
### CX4/IB Insertion Loss Compliance with 802.3ap
Annex 68B, Section 4 Channel Parameters

<table>
<thead>
<tr>
<th>Frequency (MHz)</th>
<th>Insertion Loss (dB)</th>
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<tbody>
<tr>
<td>0</td>
<td>-125</td>
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<tr>
<td>2,500</td>
<td>-65</td>
</tr>
<tr>
<td>5,000</td>
<td>-65</td>
</tr>
<tr>
<td>7,500</td>
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<tr>
<td>10,000</td>
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</tr>
<tr>
<td>12,500</td>
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<tr>
<td>15,000</td>
<td>-65</td>
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<tr>
<td>17,500</td>
<td>-65</td>
</tr>
<tr>
<td>20,000</td>
<td>-65</td>
</tr>
</tbody>
</table>

**Channel Parameters**

- **Measured IL(f)**
- **Fitted Attenuation**
- **Channel Attenuation**
- **Max Insertion Loss**

**IL<sub>max</sub>(f) Limit**
- f<sub>min</sub> = 0.05 GHz

**IL<sub>max</sub>(f) Limit**
- f<sub>min</sub> = 0.05 GHz
SFF-8470 (CX-4 CN) + 10 meter SkewClear EXD Cable
Insertion Loss Deviation

CX4/IB Insertion Loss Deviation

- Frequency (MHz)
- Insertion Loss Deviation (dB)
- Upper Limit
- Measured Deviation
- Lower Limit
SFF-8470 (CX4 CN) NEXT/FEXT Measurement Set-ups

**NEXT Set-up**
- CX4/IB Cable assembly
  - With Amphenol cable 24AWG 10m
- Agilent 20 GHz Multi-channel Differential VNA & cabling
- CX4/IB 10 G test Cards
- TP1
- TP4
- 50 Ω terminations

**FEXT Set-up**
- CX4/IB Cable assembly
  - With Amphenol cable 24AWG 10m
- 50 Ω terminations
- TP1
- TP4
802.3 CX-4 Channel Insertion Loss to Crosstalk Ratio

Insertion Loss to Crosstalk Ratio computed from S-Parameter Insertion Loss and Crosstalk Components of the 10 meter CX-4 SkewClear EXD Copper Cable Assembly

4 Near End X-talk (NEXT) Aggressors

3 Far End X-talk (FEXT) Aggressors
SFF-8470 Insertion Loss and Crosstalk Parameters: NEXT, FEXT, PSNEXT, PSFEXT and PSXT(f)

CX4/IB Insertion Loss and NEXT

- Measured Insertion Loss: Pin 6
- NEXT: Pin 6 to Pin 5
- NEXT: Pin 6 to Pin 4
- 4-pin PSNEXT
- 4-pin PSFEXT
- PSXT

Frequency (MHz)

IL and NEXT (dB)
SFF-8470 10 meter Cable Assembly Impulse Response
Channel Model

10 meter CX4/IB Cable Insertion Loss

CX4/IB Return Loss Performance vs. 802.3ap Limits

CX4/IB Insertion Loss and Crosstalk

CX4/IB 10 meter SkewClear Cable Assembly
End-to-End Channel Impulse Response
A circuit element model for the SFF-8470 connector has been developed from TDR measurements. The model includes both the signal and ground paths as well as the receptacle paddle card. Vias and transmission lines are individually accounted for. Model and footprint adjustments are straightforward. Extremely useful for 802.3ba channel studies.

The 10 meter SkewClear EXD RLGC model used is measurement based and optimized to match the Insertion Loss and Return Loss at multiple frequency points.

The 10G test cards have been end-to-end modeled including the high performance SMA differential launches. Channel model easily extracted as well as S-Parameter file. Extremely useful for 802.3ba channel studies.
The measurements, modeling and analyses of the SFF-8470 (CX-4) connector and attached 10 meter cable assembly show the following compliance:

- The Return Loss, both measured and HSPICE end-to-end circuit model meet the 802.3ap Return Loss limits.
- The measured Insertion Loss satisfies the maximum attenuation limit. The fitted data as well as the HSPICE end-to-end circuit model are lower than the 802.3ap maximum attenuation limit.
- The channel model is well behaved and what is to be expected from a dispersive interconnect.
- The current SFF–8470 based cable assemblies will meet the requirements of 802.3ba.
Fujitsu states that the following is possible for SFF-8470 connectorized cable assemblies:

- Incrementally improve the existing SFF–8470 connector receptacle to improve Signal Integrity performance through the introduction of improved ground shields and signal contacts.
- Develop a direct cable attach connector solution for passive cable assemblies that is interface compatible with existing passive or active receptacles to improve SFF–8470 connector crosstalk. Compatible with existing passive receptacles.
- An active cable design\(^{(1)}\) using 10 G or 25 G semiconductor equalizer components mounted on a paddle card behind the connector plug and compatible with existing passive and/or powered receptacles.

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\(^{(1)}\) “Considerations for Active Cables for Higher Speed Ethernet”, Gourgen Oganessyan, Quellan, Inc., Presentation to IEEE802.3 November 2007
Interconnect Options Supporting Active Cable

- A power delivery option to the plug connector
- A twin-ax type cable
- There are two connector candidates for a 4x10G Solution already supporting this

QSFP

InfiniBand/CX4

(1) “Considerations for Active Cables for Higher Speed Ethernet”, Gourgen Oganessyan, Quellan, Inc. , Presentation to IEEE802.3 November 2007
SFF-8470 (CX-4) Active Paddle Card Concept

- Signal contacts (Side 1 and 2)
- Ground contacts (x8)
- x4 Tx/Rx Equalizer
- Alternate Choice of DC-DC regulator
- Local DC-DC regulator
- CX4/IB Connector attach
SFF-8470 (CX-4) cable connector and 10 meters of twinaxial cable be considered for 40GBASE-CR4 cable assembly.