212Gb/s Per Lane PAM4 KR Cabled Backplane Channels

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Overview

- This is a preliminary investigation into a typical host-to-host cabled backplane architecture
- These are high-loss KR channels, as are found in large switches and routers.
- The intent is to facilitate early discussion among participants using realizable channels
  - PCB trace s-parameter data measurement procedure similar to Delta-L but using AFR
  - Cable models vetted with measured data by Merrick Moeller, affiliated with Amphenol
  - Connector simulation models provided by Vysakh Sivarajan, affiliated with Amphenol
  - All PCB footprints designed using HFSS and conform to the DFM rules of major fabricators
- These models are ball-to-ball to allow use with different package models
  - Bump-to-bump channel specification is still critical, owing to large package losses
- Development is continuing, so all models are subject to continuous refinement.
  - New channels will be contributed as refinements are made
Simulation of a typical KR cabled backplane architecture over various cable lengths

Contributions:
- BGA / PCB trace / NPC via escapes simulated with HFSS
- NPC + BP cable assemblies: provided by Michael Rowlands, affiliated with Amphenol

Ball-to-Ball topology: does not include package effects

This presentation does NOT propose the following:
- Specific aggregate or cable losses
- Specific host architecture implementations
KR Backplane Cable Assembly + Host

PCB Composition
- BGA & NPC Breakout Footprints
  - ~3mm PTH breakout depth
  - 8 mil vias with 5 mil stubs
  - Conforms to current PCB fab design rules
  - Nothing exotic: no skip layers, no microvias
- Host Breakout Trace
  - Fanout length to NPC’s: ~3 inches
  - Loss: ~1.25 dB/in @ 53.125 GHz
  - 90 ohm @ 6 mil line width
  - Room Temperature

Cable Assembly Composition
- Near Packaged Copper (NPC)
  - 95 ohm 29 AWG Twinax lengths
    - 200mm, 250mm, 300mm, 350mm, 400mm
  - Room Temperature
  - Assumes symmetric lengths on both sides of channel
- BP Cable Connector + Twinax
  - 95 ohm 27 AWG
  - Twinax length: 800mm
  - Room Temperature
Signaling Topology

XTLK [1:6] on Host 1 / Host 2 are configurable as Tx or Rx
KR BP Cable Channel Model
Sdd21 / Sdd11

<table>
<thead>
<tr>
<th>NPC Cable (mm)</th>
<th>BP Cable (mm)</th>
<th>IL @ 53.125 GHz (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>200mm</td>
<td>800mm</td>
<td>23.48</td>
</tr>
<tr>
<td>300mm</td>
<td>800mm</td>
<td>25.41</td>
</tr>
<tr>
<td>400mm</td>
<td>800mm</td>
<td>27.67</td>
</tr>
</tbody>
</table>
KR BP Cable Channel Model
Power Sum FEXT

Power Sum FEXT (TP5 Victim)

Host 1 Signal | Host 2 Signal
---|---
Tx XTLK1 | Rx XTLK1
Tx XTLK2 | Rx XTLK2
Tx XTLK3 | Rx XTLK3
TP0 | TP5
Tx Victim | Rx Victim
Tx XTLK4 | Rx XTLK4
Tx XTLK5 | Rx XTLK5
Tx XTLK6 | Rx XTLK6

FEXT1
FEXT2
FEXT3
FEXT4
FEXT5
FEXT6
KR BP Cable Channel Model
Power Sum NEXT

![Power Sum NEXT (TP5 Victim)](image_url)

- Host 1 Signal:
  - Rx XTLK1
  - Rx XTLK2
  - Rx XTLK3
  - Rx XTLK4
  - Rx XTLK5
  - Rx XTLK6

- Host 2 Signal:
  - Tx XTLK2
  - Tx XTLK3
  - Tx XTLK4
  - Tx XTLK5
  - Tx XTLK6

- NEXT:
  - NEXT1
  - NEXT2
  - NEXT3
  - NEXT4
  - NEXT5
  - NEXT6

Frequency (GHz)
Magnitude (dB)
KR BP Cable Channel Model
Power Sum XTLK (Mixed Tx/Rx Example)
Summary

• Contributed channels model a KR link with a cable backplane – daughter cards use near package cabling

• TP0 to TP5 insertion losses range from 23.5dB to 27.7dB in five different model variants

• Each variant contains 7 signal lanes: 1 victim and 6 aggressors

• Return losses less than –10dB to 70GHz

• Power summed FEXT less than –50dB to ~80GHz

• Power summed NEXT less than –40dB to ~65GHz
KR Backplane Cable Channels

File Naming Convention: TP0→TP5 Thru Channels

**Thru Channel Files:**
- KR_ch_3in_PCB_NPC_200mm_29AWG_BP_800mm_27AWG_thru.s4p
- KR_ch_3in_PCB_NPC_250mm_29AWG_BP_800mm_27AWG_thru.s4p
- KR_ch_3in_PCB_NPC_300mm_29AWG_BP_800mm_27AWG_thru.s4p
- KR_ch_3in_PCB_NPC_350mm_29AWG_BP_800mm_27AWG_thru.s4p
- KR_ch_3in_PCB_NPC_400mm_29AWG_BP_800mm_27AWG_thru.s4p
KR Backplane Cable Channels

File Naming Convention: XTLK Channels

KR_ch_3in_PCB_NPC_[length]mm_29AWG_BP_800mm_27AWG_[xtlk][#].s4p

PCB Length

NPC Cable Length
250mm
300mm
350mm
400mm

NPC Cable Gauge

Backplane Cable Length

Backplane Cable Gauge

XTLK Type
FEXT
NEXT

Aggressor #
[1,2,…6]

Port 1 Port 2
Thru Channel
Port 3
Source
Aggressor

TP5
Port 4
KR Backplane Cable Channels

**XTLK Channel Files:**

### 200mm NPC Cables
- KR_ch_3in_PCB_NPC_200mm_29AWG_BP_800mm_27AWG_FEXT1.s4p
- KR_ch_3in_PCB_NPC_200mm_29AWG_BP_800mm_27AWG_FEXT2.s4p
- KR_ch_3in_PCB_NPC_200mm_29AWG_BP_800mm_27AWG_FEXT3.s4p
- KR_ch_3in_PCB_NPC_200mm_29AWG_BP_800mm_27AWG_FEXT4.s4p
- KR_ch_3in_PCB_NPC_200mm_29AWG_BP_800mm_27AWG_FEXT5.s4p
- KR_ch_3in_PCB_NPC_200mm_29AWG_BP_800mm_27AWG_FEXT6.s4p

### 250mm NPC Cables
- KR_ch_3in_PCB_NPC_250mm_29AWG_BP_800mm_27AWG_FEXT1.s4p
- KR_ch_3in_PCB_NPC_250mm_29AWG_BP_800mm_27AWG_FEXT2.s4p
- KR_ch_3in_PCB_NPC_250mm_29AWG_BP_800mm_27AWG_FEXT3.s4p
- KR_ch_3in_PCB_NPC_250mm_29AWG_BP_800mm_27AWG_FEXT4.s4p
- KR_ch_3in_PCB_NPC_250mm_29AWG_BP_800mm_27AWG_FEXT5.s4p
- KR_ch_3in_PCB_NPC_250mm_29AWG_BP_800mm_27AWG_FEXT6.s4p

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KR Backplane Cable Channels

**XTLK Channel Files:**

### 300mm NPC Cables

- KR_ch_3in_PCB_NPC_300mm_29AWG_BP_800mm_27AWG_FEXT1.s4p
- KR_ch_3in_PCB_NPC_300mm_29AWG_BP_800mm_27AWG_FEXT2.s4p
- KR_ch_3in_PCB_NPC_300mm_29AWG_BP_800mm_27AWG_FEXT3.s4p
- KR_ch_3in_PCB_NPC_300mm_29AWG_BP_800mm_27AWG_FEXT4.s4p
- KR_ch_3in_PCB_NPC_300mm_29AWG_BP_800mm_27AWG_FEXT5.s4p
- KR_ch_3in_PCB_NPC_300mm_29AWG_BP_800mm_27AWG_FEXT6.s4p
- KR_ch_3in_PCB_NPC_300mm_29AWG_BP_800mm_27AWG_NEXT1.s4p
- KR_ch_3in_PCB_NPC_300mm_29AWG_BP_800mm_27AWG_NEXT2.s4p
- KR_ch_3in_PCB_NPC_300mm_29AWG_BP_800mm_27AWG_NEXT3.s4p
- KR_ch_3in_PCB_NPC_300mm_29AWG_BP_800mm_27AWG_NEXT4.s4p
- KR_ch_3in_PCB_NPC_300mm_29AWG_BP_800mm_27AWG_NEXT5.s4p
- KR_ch_3in_PCB_NPC_300mm_29AWG_BP_800mm_27AWG_NEXT6.s4p

### 350mm NPC Cables

- KR_ch_3in_PCB_NPC_350mm_29AWG_BP_800mm_27AWG_FEXT1.s4p
- KR_ch_3in_PCB_NPC_350mm_29AWG_BP_800mm_27AWG_FEXT2.s4p
- KR_ch_3in_PCB_NPC_350mm_29AWG_BP_800mm_27AWG_FEXT3.s4p
- KR_ch_3in_PCB_NPC_350mm_29AWG_BP_800mm_27AWG_FEXT4.s4p
- KR_ch_3in_PCB_NPC_350mm_29AWG_BP_800mm_27AWG_FEXT5.s4p
- KR_ch_3in_PCB_NPC_350mm_29AWG_BP_800mm_27AWG_FEXT6.s4p
- KR_ch_3in_PCB_NPC_350mm_29AWG_BP_800mm_27AWG_NEXT1.s4p
- KR_ch_3in_PCB_NPC_350mm_29AWG_BP_800mm_27AWG_NEXT2.s4p
- KR_ch_3in_PCB_NPC_350mm_29AWG_BP_800mm_27AWG_NEXT3.s4p
- KR_ch_3in_PCB_NPC_350mm_29AWG_BP_800mm_27AWG_NEXT4.s4p
- KR_ch_3in_PCB_NPC_350mm_29AWG_BP_800mm_27AWG_NEXT5.s4p
- KR_ch_3in_PCB_NPC_350mm_29AWG_BP_800mm_27AWG_NEXT6.s4p
KR Backplane Cable Channels

**XTLK Channel Files:**

**400mm NPC Cables**

- KR_ch_3in_PCB_NPC_400mm_29AWG_BP_800mm_27AWG_FEXT1.s4p
- KR_ch_3in_PCB_NPC_400mm_29AWG_BP_800mm_27AWG_FEXT2.s4p
- KR_ch_3in_PCB_NPC_400mm_29AWG_BP_800mm_27AWG_FEXT3.s4p
- KR_ch_3in_PCB_NPC_400mm_29AWG_BP_800mm_27AWG_FEXT4.s4p
- KR_ch_3in_PCB_NPC_400mm_29AWG_BP_800mm_27AWG_FEXT5.s4p
- KR_ch_3in_PCB_NPC_400mm_29AWG_BP_800mm_27AWG_FEXT6.s4p
- KR_ch_3in_PCB_NPC_400mm_29AWG_BP_800mm_27AWG_NEXT1.s4p
- KR_ch_3in_PCB_NPC_400mm_29AWG_BP_800mm_27AWG_NEXT2.s4p
- KR_ch_3in_PCB_NPC_400mm_29AWG_BP_800mm_27AWG_NEXT3.s4p
- KR_ch_3in_PCB_NPC_400mm_29AWG_BP_800mm_27AWG_NEXT4.s4p
- KR_ch_3in_PCB_NPC_400mm_29AWG_BP_800mm_27AWG_NEXT5.s4p
- KR_ch_3in_PCB_NPC_400mm_29AWG_BP_800mm_27AWG_NEXT6.s4p