212Gb/s Per Lane PAM4 KR Cabled Backplane Channels

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Contributors

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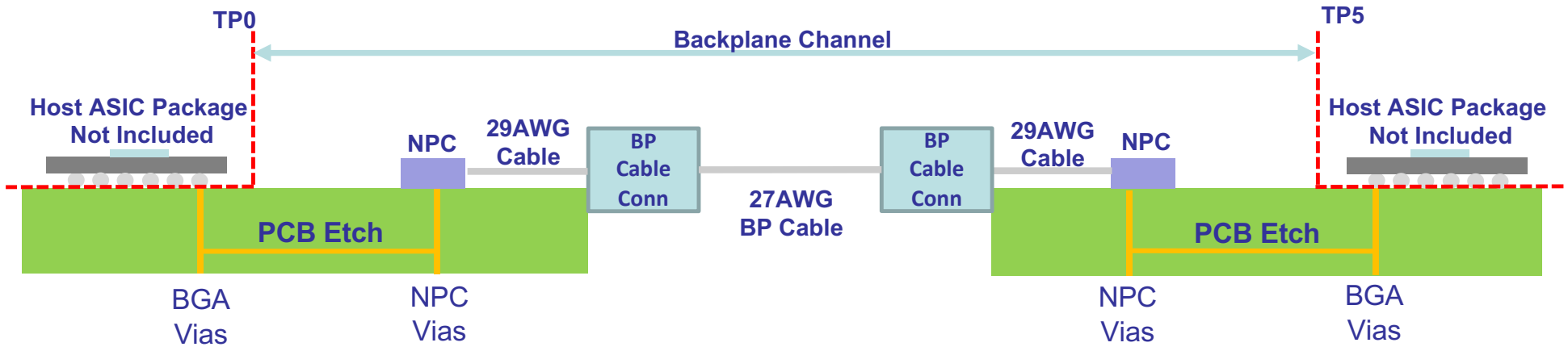
Overview

- 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

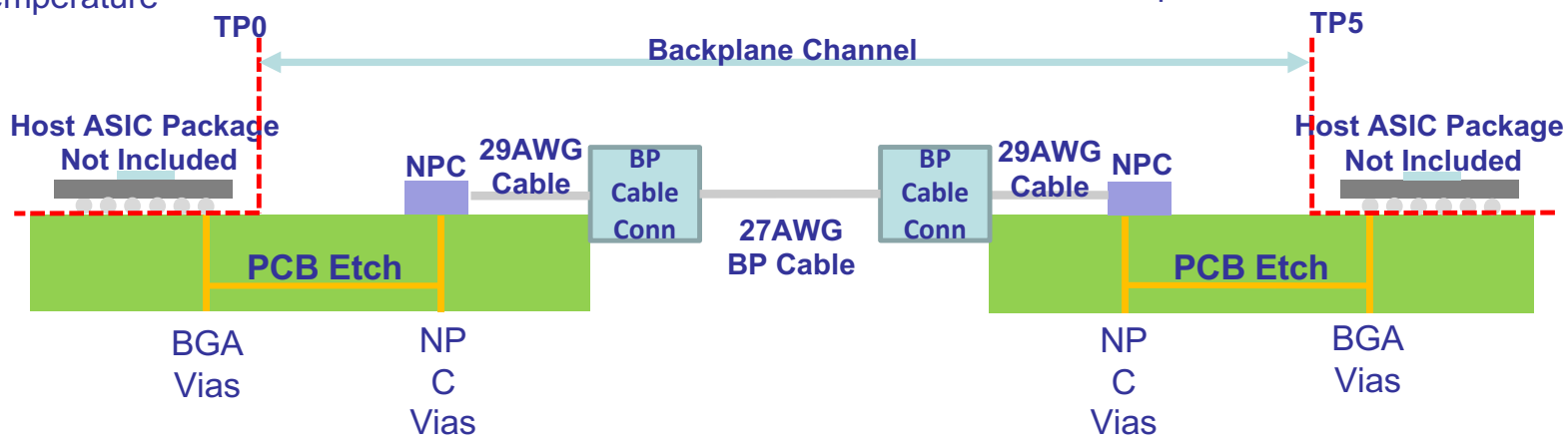
Description

- 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

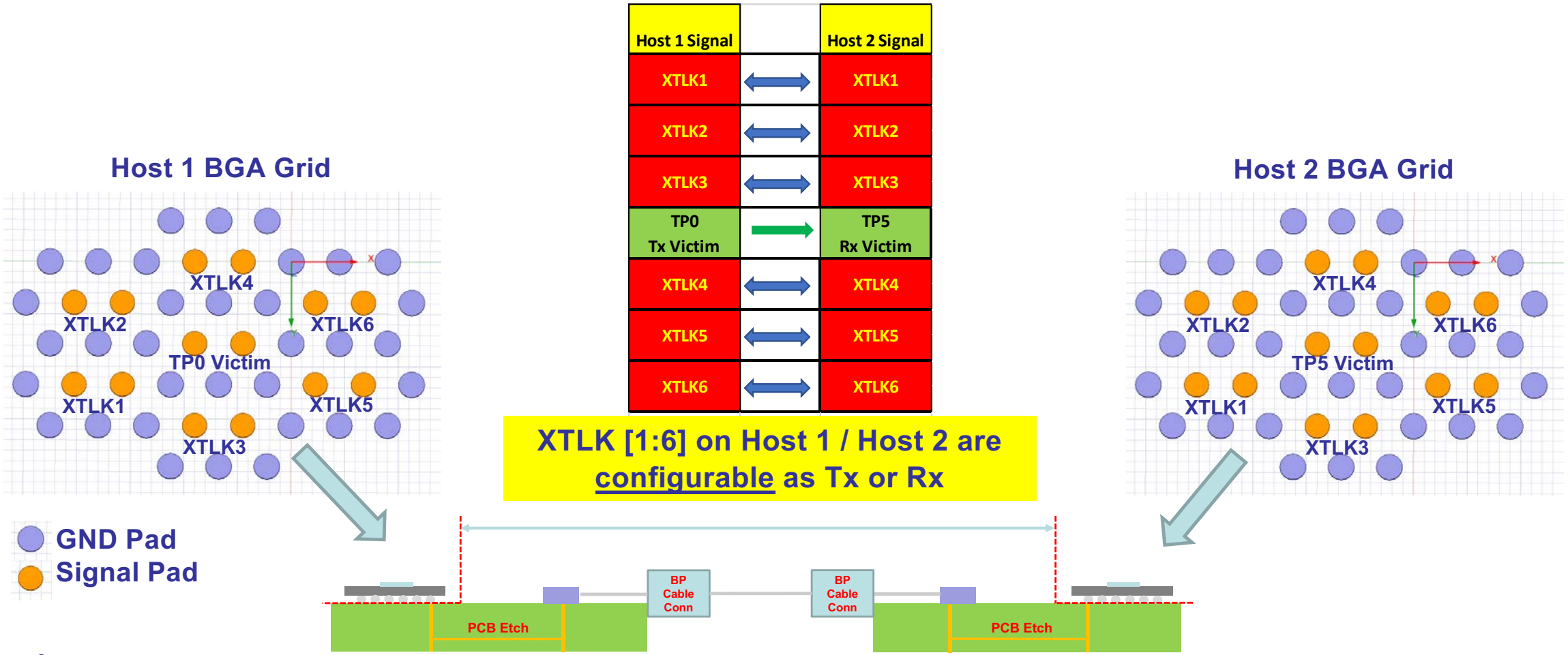


KR Backplane Cable Assembly + Host

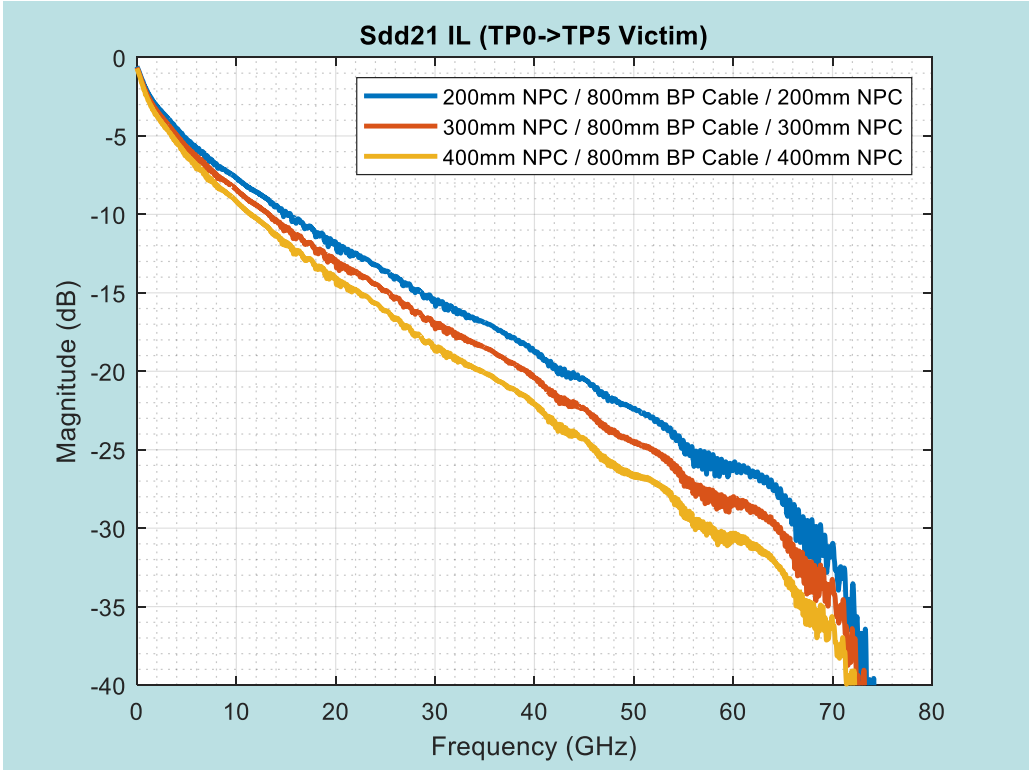
- PCB Composition
  - BGA & NPC Breakout Footprints
    - ~ 3mm PTH breakout depth
    - 8 mil vias with 5 mil stubs
    - Conforms to current PCB fab design rules
    - Nothing exotic: no skip layers, no microvias
  - Host Breakout Trace
    - Fanout length to NPC's: ~ 3 inches
    - Loss: ~ 1.25 dB/in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

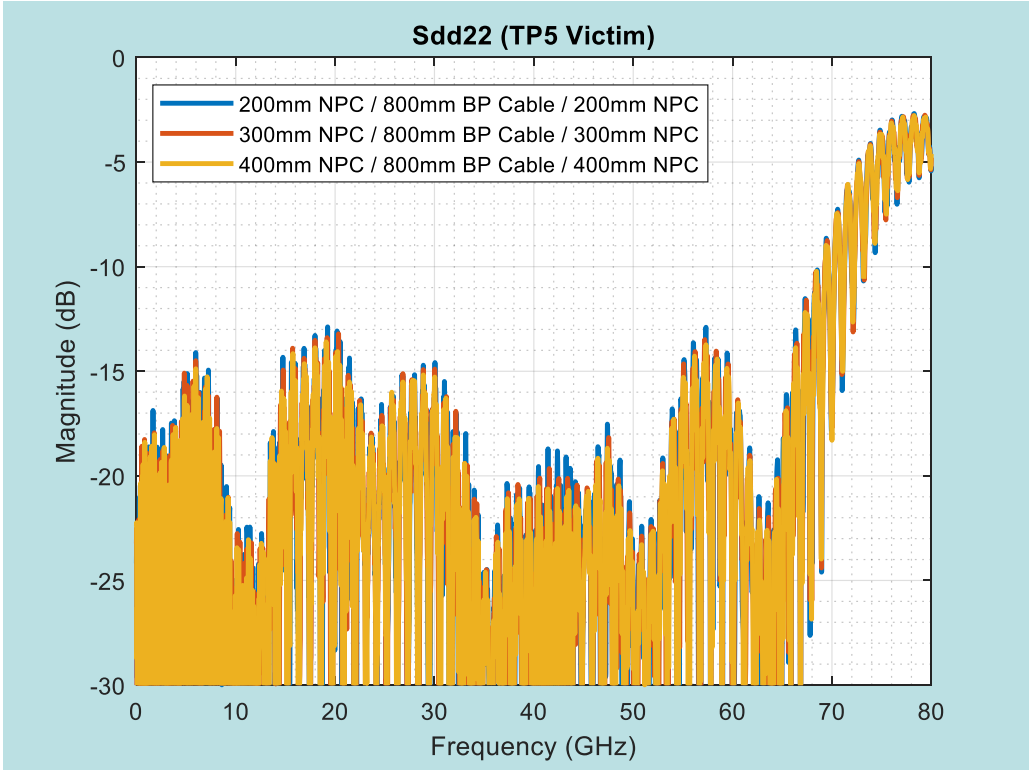


Signaling Topology



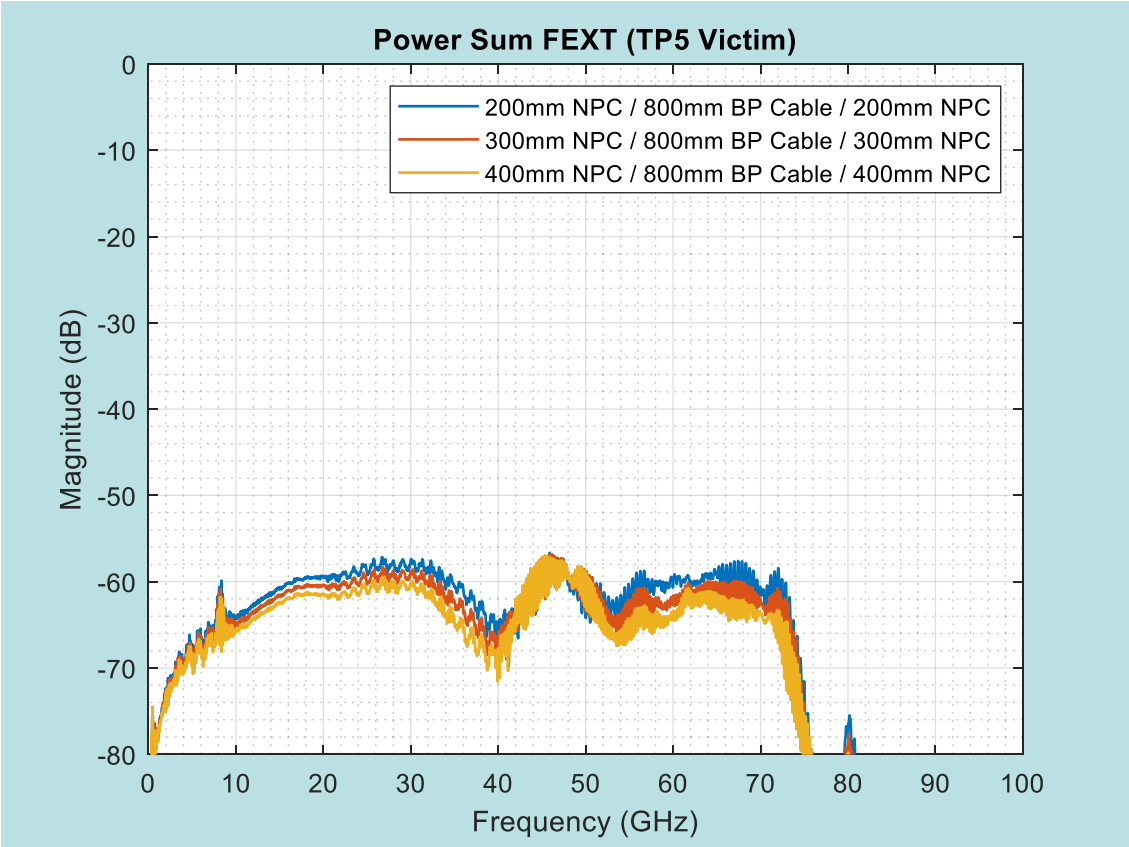
KR BP Cable Channel Model
Sdd21 / Sdd11





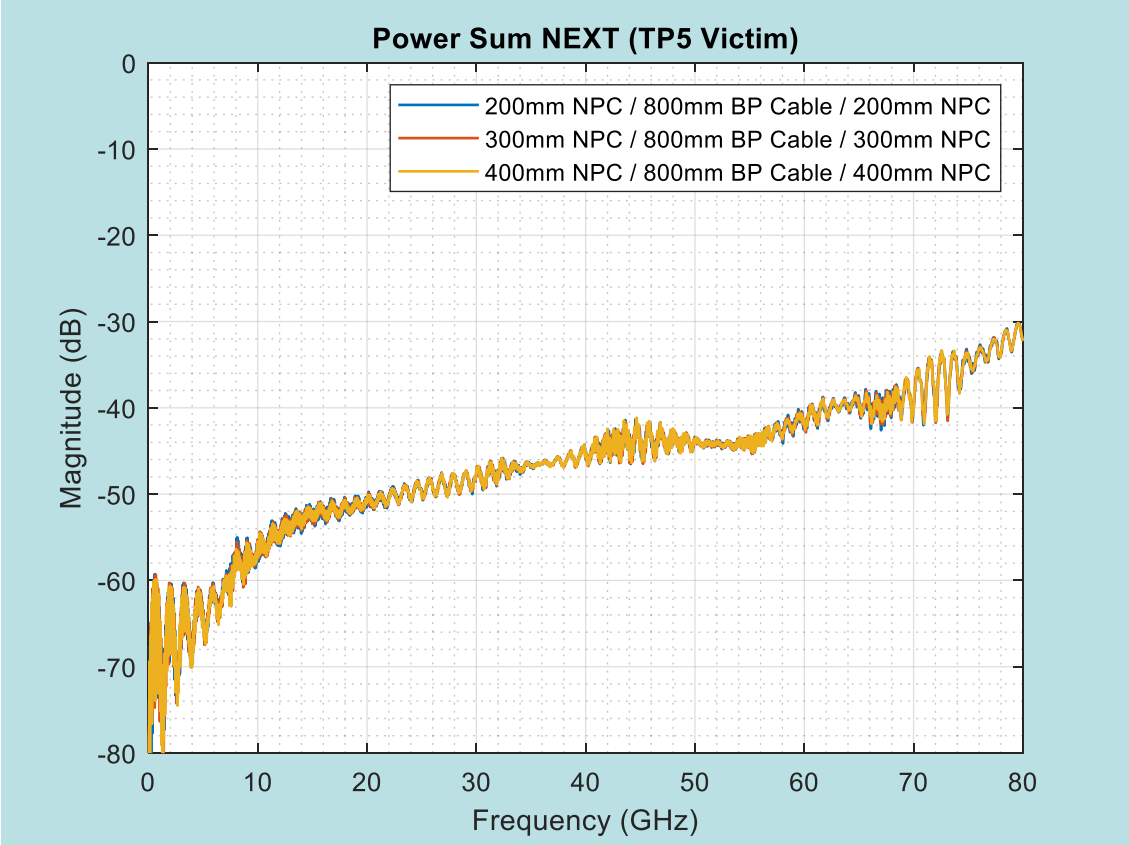
NPC Cable (mm)	BP Cable (mm)	IL @ 53.125 GHz (dB)
200mm	800mm	23.48
300mm	800mm	25.41
400mm	800mm	27.67

KR BP Cable Channel Model
Power Sum FEXT



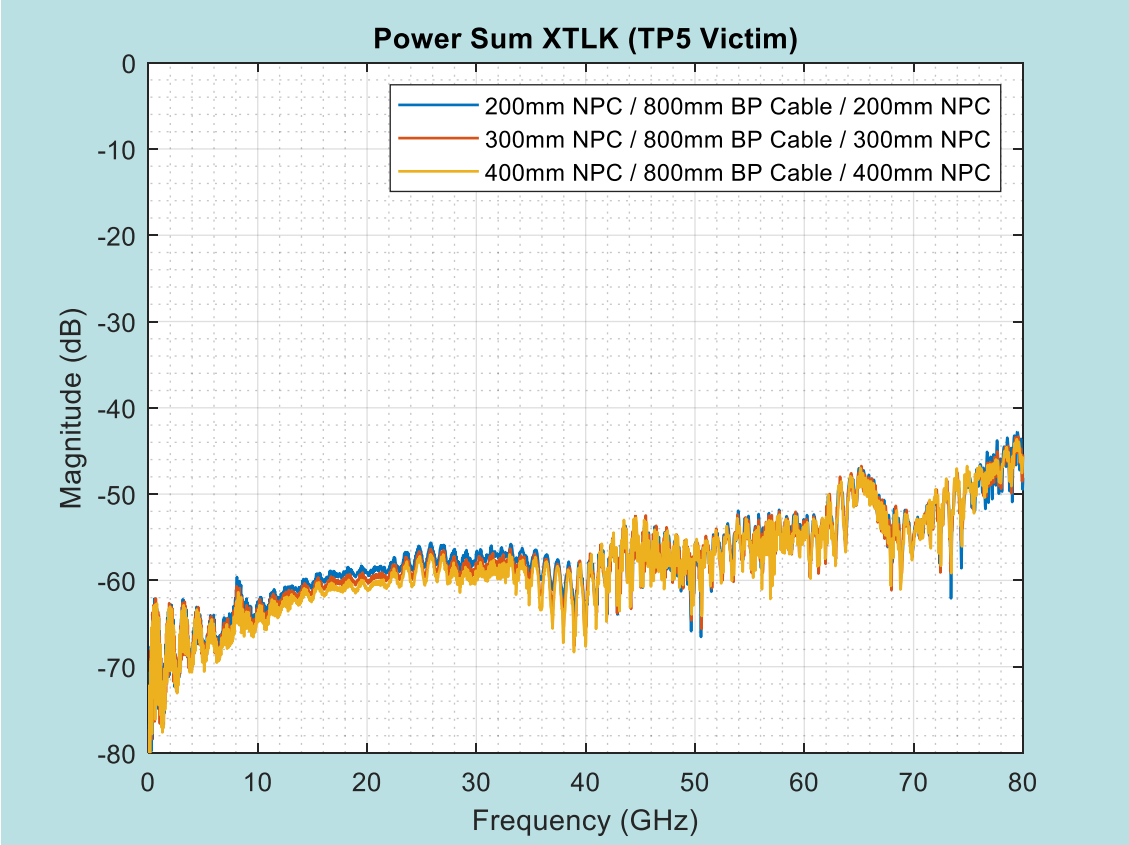
Host 1 Signal		Host 2 Signal	
Tx XTLK1	→	Rx XTLK1	FEXT1
Tx XTLK2	→	Rx XTLK2	FEXT2
Tx XTLK3	→	Rx XTLK3	FEXT3
TP0 Tx Victim	→	TP5 Rx Victim	
Tx XTLK4	→	Rx XTLK4	FEXT4
Tx XTLK5	→	Rx XTLK5	FEXT5
Tx XTLK6	→	Rx XTLK6	FEXT6

KR BP Cable Channel Model
Power Sum NEXT



Host 1 Signal		Host 2 Signal	
Rx XTLK1	←	Rx XTLK1	NEXT1
Rx XTLK2	←	Tx XTLK2	NEXT2
Rx XTLK3	←	Tx XTLK3	NEXT3
TP0 Tx Victim	→	TP5 Rx Victim	
Rx XTLK4	←	Tx XTLK4	NEXT4
Rx XTLK5	←	Tx XTLK5	NEXT5
Rx XTLK6	←	Tx XTLK6	NEXT6

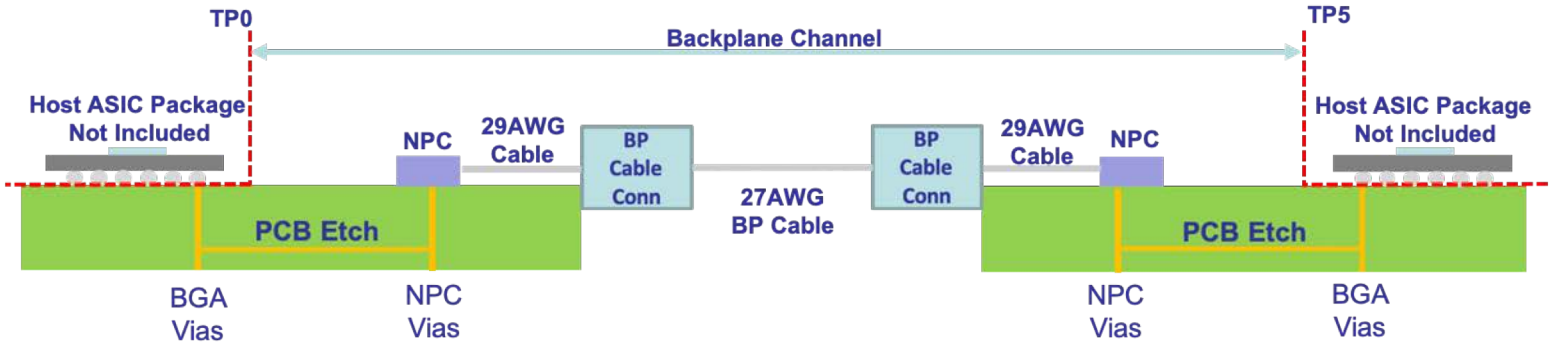
KR BP Cable Channel Model
Power Sum XTLK (Mixed Tx/Rx Example)



Host 1 Signal		Host 2 Signal	
Rx XTLK1	←	Tx XTLK1	NEXT1
Tx XTLK2	→	Rx XTLK2	NEXT2
Rx XTLK3	←	Tx XTLK3	FEXT3
TP0 Tx Victim	→	TP5 Rx Victim	
Tx XTLK4	→	Rx XTLK4	FEXT4
Tx XTLK5	→	Rx XTLK5	FEXT5
Rx XTLK6	←	Tx XTLK6	NEXT6

Summary

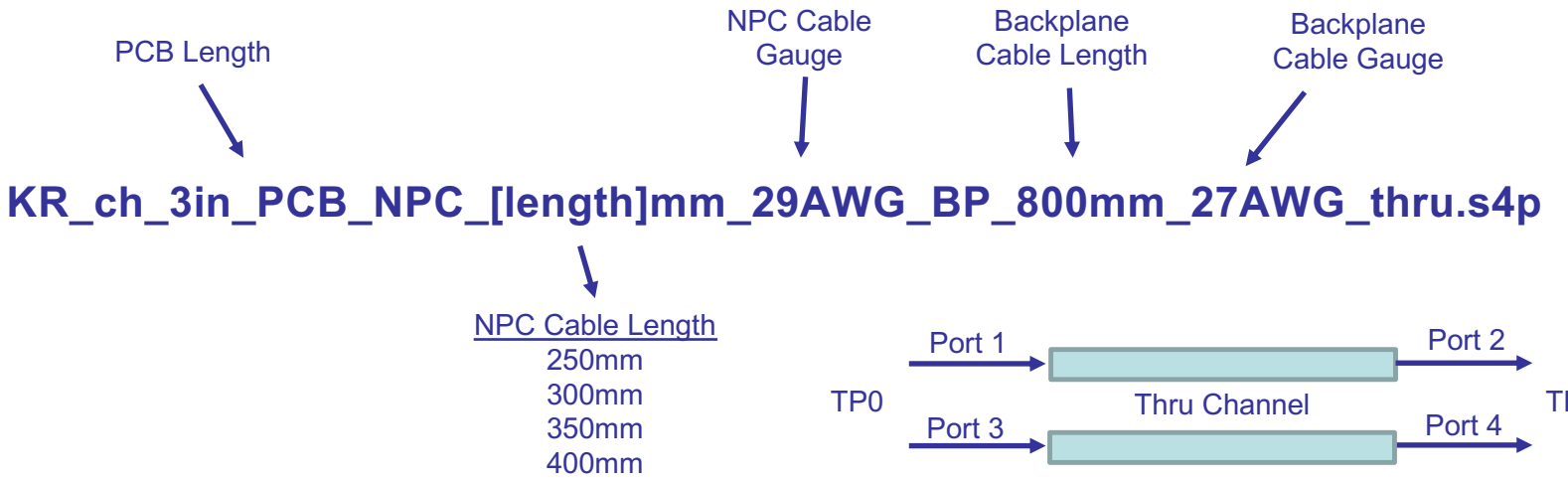
- Contributed channels model a KR link with a cable backplane – daughter cards use near package cabling



  - 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

PCB Length

NPC Cable Gauge

Backplane Cable Length

Backplane Cable Gauge

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

NPC Cable Length
250mm
300mm
350mm
400mm

XTLK Type
FEXT
NEXT

Aggressor #
[1,2,…6]

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
KR_ch_3in_PCB_NPC_200mm_29AWG_BP_800mm_27AWG_NEXT1.s4p
KR_ch_3in_PCB_NPC_200mm_29AWG_BP_800mm_27AWG_NEXT2.s4p
KR_ch_3in_PCB_NPC_200mm_29AWG_BP_800mm_27AWG_NEXT3.s4p
KR_ch_3in_PCB_NPC_200mm_29AWG_BP_800mm_27AWG_NEXT4.s4p
KR_ch_3in_PCB_NPC_200mm_29AWG_BP_800mm_27AWG_NEXT5.s4p
KR_ch_3in_PCB_NPC_200mm_29AWG_BP_800mm_27AWG_NEXT6.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
KR_ch_3in_PCB_NPC_250mm_29AWG_BP_800mm_27AWG_NEXT1.s4p
KR_ch_3in_PCB_NPC_250mm_29AWG_BP_800mm_27AWG_NEXT2.s4p
KR_ch_3in_PCB_NPC_250mm_29AWG_BP_800mm_27AWG_NEXT3.s4p
KR_ch_3in_PCB_NPC_250mm_29AWG_BP_800mm_27AWG_NEXT4.s4p
KR_ch_3in_PCB_NPC_250mm_29AWG_BP_800mm_27AWG_NEXT5.s4p
KR_ch_3in_PCB_NPC_250mm_29AWG_BP_800mm_27AWG_NEXT6.s4p

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