## Experience with10GBASE-T Test Channels and Implications for 40GBASE-T

IEEE P802.3bq 40GBASE-T Task Force

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Channel Modeling Ad Hoc – 5 May 2013

#### One System-Level Context for Various Test Channel Configurations

- 10GBASE-T Physical Layer Link Interoperability Testing
- Characterizes 10GBASE-T physical layer link interoperability, focusing on two primary performance measures, over a range of CAT6/CAT6a/CAT7 channels and channel configurations
  - Time-To-Link (TTL): Evaluates PHY behavior through the 10GBASE-T startup sequence (802.3 Clause 55, Subclause "55.4.2.5.14 Startup sequence")
  - Bit Error Ratio (BER) performance: Evaluates conformance the target FER/BER specification





## Link Interoperability Measurements

- Representative Link Interoperability metrics
  - Time-To-Link (Time to achieve link after link initiation event)
  - # Link Attempts (Number of attempts for each link)
  - # Link Drops (Number of link drops observed after link is established)
  - Clock Recovery (Master/Slave resolution)
  - TTL Distribution (% of links by link time)
  - Speed Downshift/Downgrade (Resolved speed)
  - BER (Calculated BER for each channel endpoint based on received packet error count - typically assume a single bit error/packet error)
    - Typical error counters include CRC and error byte counters (MAC) and a wide range of both standard and manufacturer-specific PHY statistical counters

## **Test Channels**

- Focused channel selection using multiple cable types and lengths
  - 2m, 4m, 7m, 30m, 55m, 90m and 100m are "standard" channels for both TTL and BER
  - Other channel lengths (typically 5m increments) are used to check for consistent link behavior over a range of PHY channel solutions (different PBOs, operating margin, delay/delay skew, etc.)
- Includes point-to-point, 2-connector, and 4connector topologies

## **Typical Test Channel Configurations\***

	+	- <u>[-</u>	]	[	<u> </u>
Patch Cord #1	Permanent Link Patch Cord Perman Segment #1 #2 Segm			rmanent Link egment #2	Patch Cord #3
Channel	Patch Cord #1	Permanent Link Segment #1	Patch Cord #2	Permanent Link Segment #2	Patch Cord #3
2m (S)	2m	х	х	х	х
4m (S)	2m	0m	2m	х	х
7m (S)	2m	1m	2m	0m	2m
30m (M)	2m	4m	2m	20m	2m
55m (M)	2m	9m	2m	40m	2m
90m (L)	2m	4m	2m	80m	2m
100m (L)	2m	4m	2m	90m	2m

\*Many other configurations & channel lengths are possible. Some extreme corner cases are included for specific use cases (back-to-back direct connection for manufacturing test).



### **Representative Channel Characteristics**

- A few selected channels (2m, 4m, 7m, 30m) and PHY performance figure-of-merit response to the channels are included in the following slides
  - Channel characteristics are representative, not comprehensive, and include return loss\* and High Definition Time Domain Crosstalk (HDTDX) to highlight the structural & electrical variation of the test channels
  - PHY F.O.M response is represented by reported SNR operating margin by channel pair (45 link trials in trend and histogram formats)
- Results for a 100m are included as an "insertion loss dominated channel" point of reference

\*Limits are TIA Cat 6A Channel, Draft 8.0; all channel measurements were performed using standard networking test equipment





**Channel Return Loss** 



PHY SNR Operating Margin (45 Trials)



PHY SNR Operating Margin Histogram





**Channel Return Loss** 



PHY SNR Operating Margin (45 Trials)



PHY SNR Operating Margin Histogram

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**Channel Return Loss** 



PHY SNR Operating Margin (45 Trials)



PHY SNR Operating Margin Histogram

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**Channel Return Loss** 



PHY SNR Operating Margin (45 Trials)



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**Channel Return Loss** 



PHY SNR Operating Margin (45 Trials)



PHY SNR Operating Margin Histogram

## **Observations from 10GBASE-T**

- Channel topologies significantly affect the channel solutions realized by PHY DSP systems
  - "Peaky" impairments (return loss, crosstalk) appear to be a factor in link-trial-to-link-trial variability in the system solution
  - May have implications for both system performance and end-user experience
- Mid-length channels shouldn't be ignored potential problem areas may exist
  - Transition region between RL/crosstalk-driven to IL-driven solutions
  - Channel lengths near 10GBASE-T PBO transitions

## **Considerations for 40GBASE-T**

- Specific to the Action Item share some channel configurations and ones that are irrelevant for 40GBASE-T
  - Long channels (>55m)
    - Although in practice longer channels are used to evaluate margin with respect to the specification
  - 4-connector channels (not supported by the objectives)
    - Although the same "how much can it take before it breaks" scenario may also apply
- Channel topologies under consideration (those listed in the Potential Path Forward for Channel Modeling Ad Hoc) include several "short" and "long" configurations that will be useful in both channel modeling and later interoperability-type testing
- Request that the ad hoc consider adding "mid-length" topologies to the list of channel configurations

# Thank You!

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