10GBASE-T Task Force
July 2004, Portland, Oregon

PHY based cable diagnostics definitions

For inclusion in the standard

* What is PHY cable diagnostics?
* Why in 10GBASE-T?
* How should it be added?

* Agreement?

What does “cable diagnostics” mean?

In this context:

Analysis of cable characteristics by the PHY

Find if there’s a fault on the cable…

Shorts, opens etc.
Bad connectors

… or if the cable isn’t good enough to run 10GBT

Category (7, 6E, enhanced)
Out of specification (crosstalk, attenuation, noise)

Avoid bad links!

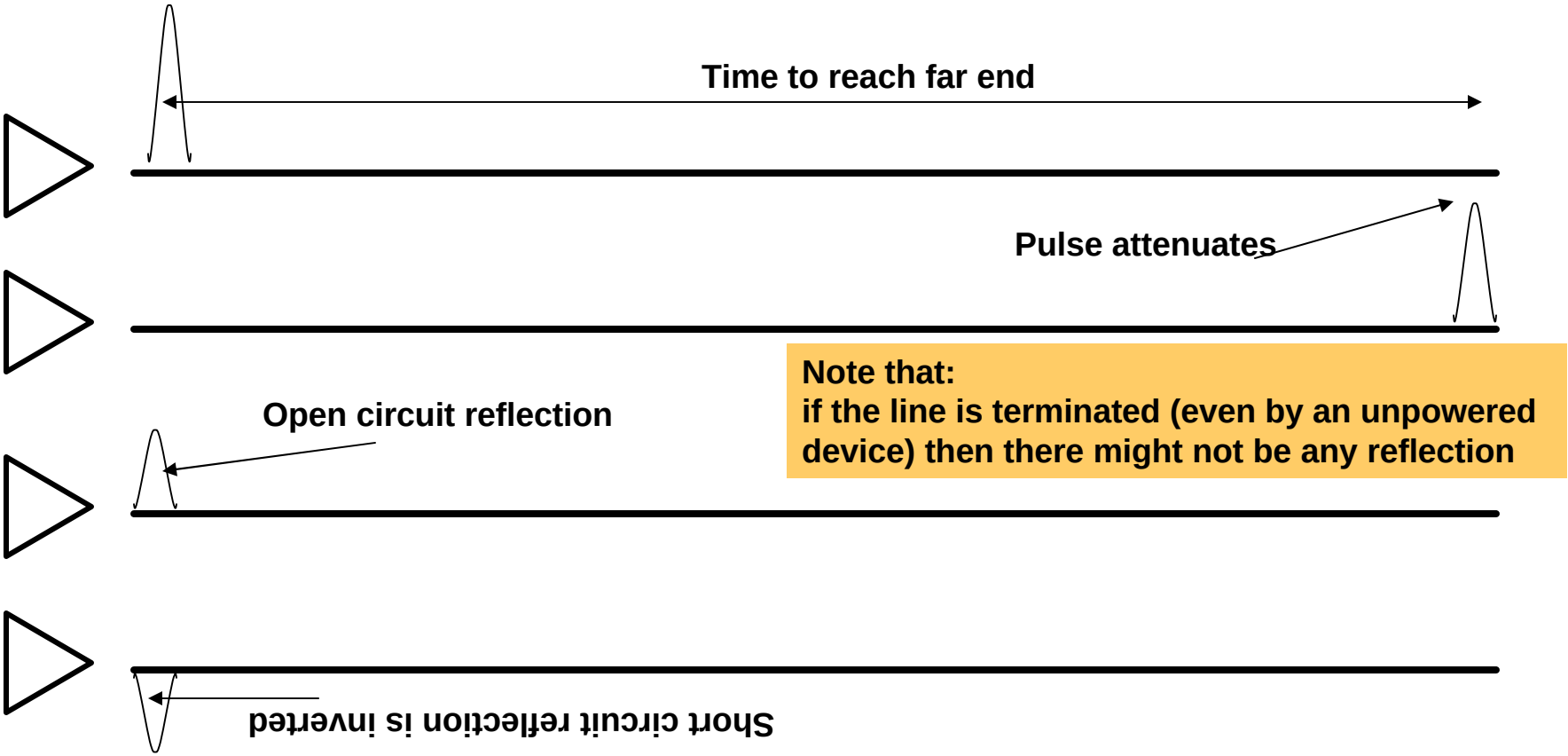
How does it work

- **Two modes**
  - **Stand alone (without link partner)**
  - **Dual-ended (with link partner)**
- **Stand alone performed before other end installed**
  - **Uses Time Domain Reflectometry (TDR)**
  - **Might not work if other device connected (terminated line)**
  - **Not specific to 10GBT**
- **Dual ended needs an operational device at far end**
  - **Uses PHY's own equalizers**
  - **All parameters that require equalization may be verified**

What on earth does “reflectometry” mean?

- **Measuring reflections**

Send out a pulse, see what comes back…

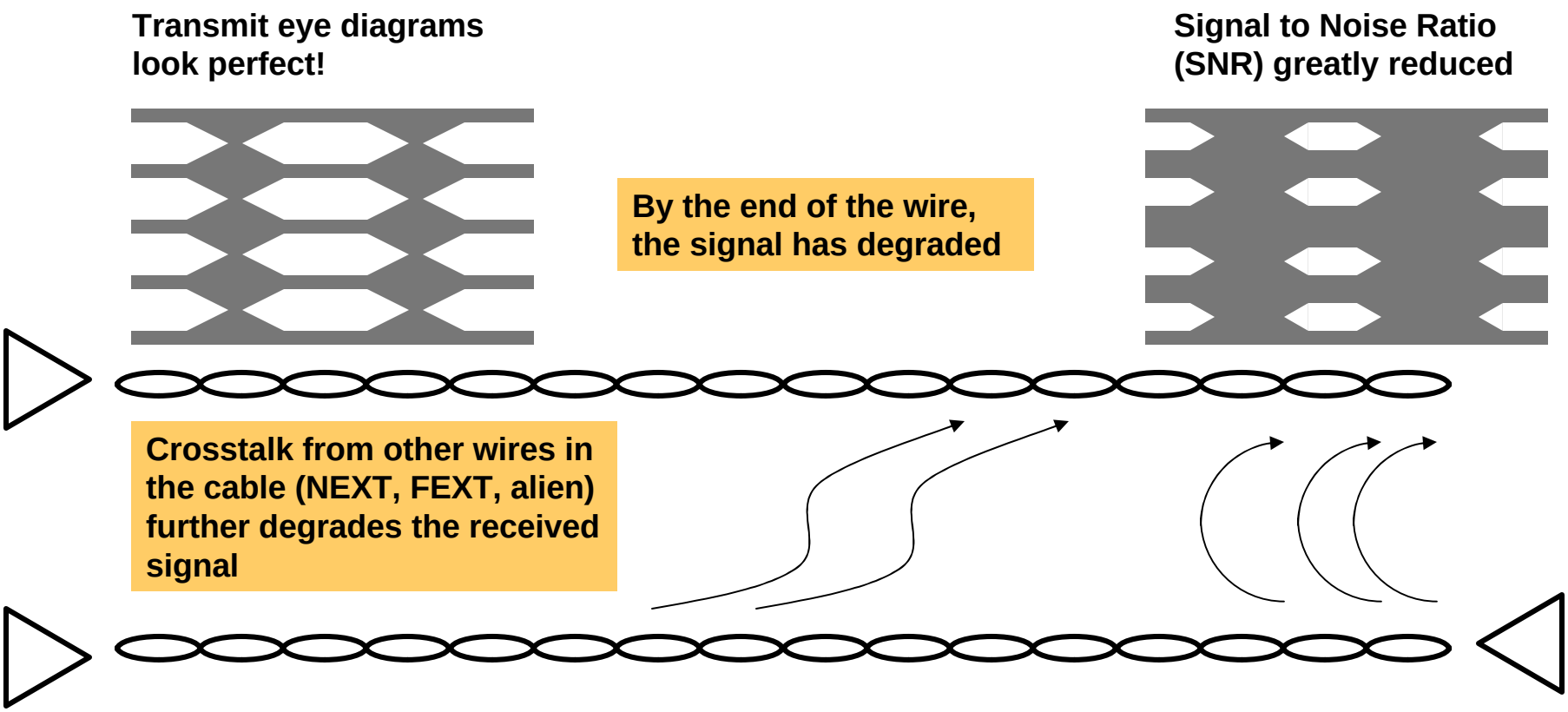


Note that:
if the line is terminated (even by an unpowered device) then there might not be any reflection

Gigabit signals

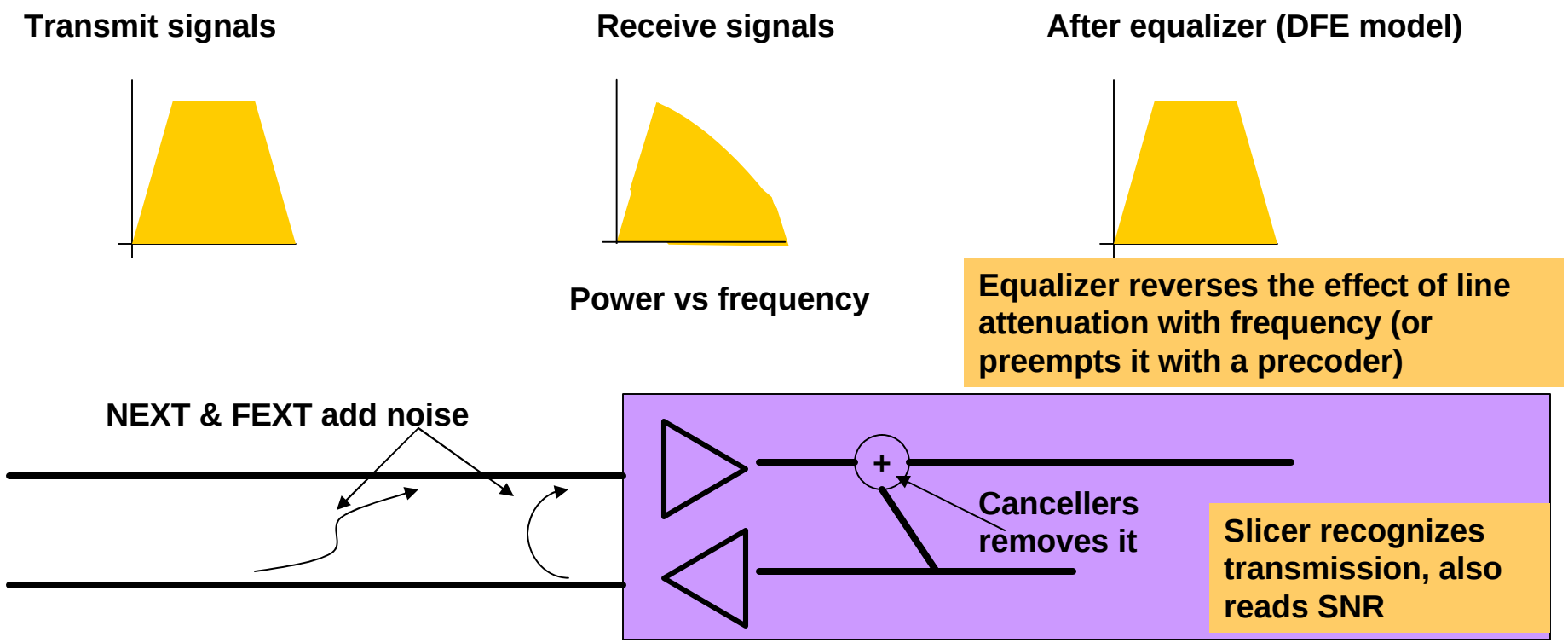
- **10GBT signals being transmitted**

  During initialization and operation



How the PHY works

- **PHY must cope with these problems**
  - **Equalizer compensates for signal degradation**
  - **Cancellation removes the effect of crosstalk**



In-system measurements

- **Normal operation yields cable characteristics**
- **Equalizer parameters for attenuation**
  - **Attenuation vs frequency**
  - **Linearity (non-linearity due to faults)**
- **Canceller parameters for crosstalk & reflection**
  - **High XT indicates wrong cable or connector type, installation problem etc.**
  - **Reflection due to impedance mismatch**
- **SNR indicates that overall system is in range**
  - **Possibly due to other factors:**
  - **Alien noise**

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When would this be used?

- **Both for first installation and during operation**
- **Detect bad wiring when switch is installed**
  - **Too long, broken, shorted, bad connector, etc.**
  - **Find fault before link is needed**
- **Marginal faults (even though link is achieved)**
  - **Bad crosstalk, noise**
  - **Parameters out of envelope (indicative of other fault)**
  - **Error rate (BER) will be too high**
    - **Packet loss = degraded operation**

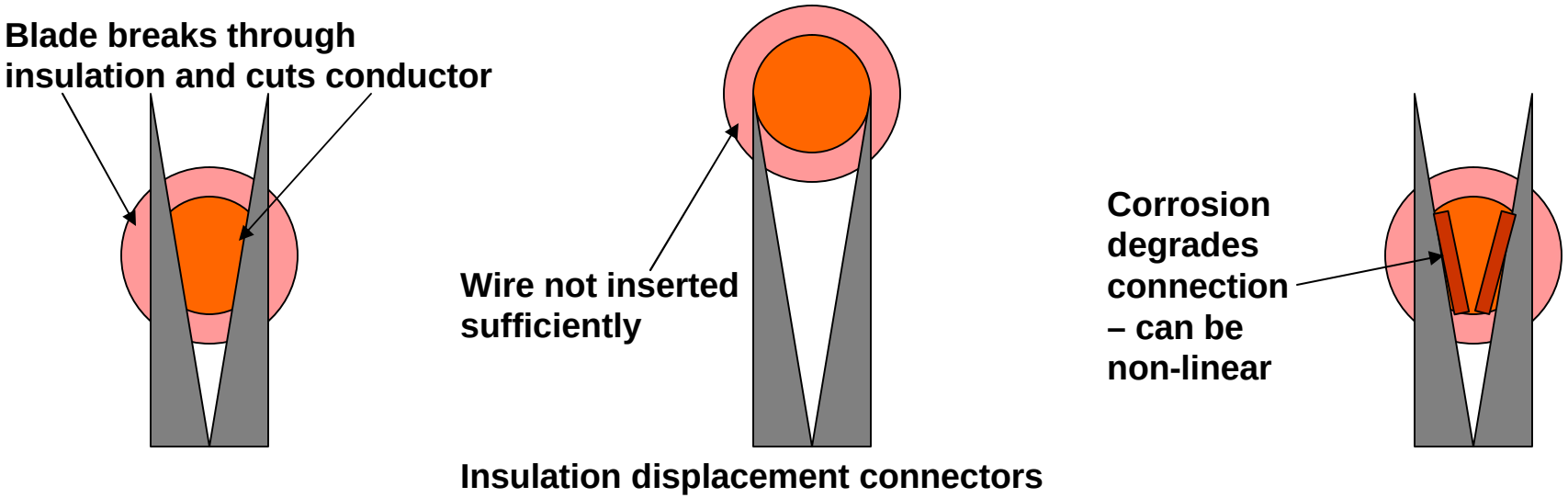
Early warning

- **Some errors develop over time**
- **Seen as deterioration in PHY parameters**

  Either parameters out of envelope, or…

  …change beyond expectation (for constant link)

  Parameters change before BER increase (early warning)



So why should this be in 10GBT?

- **10GBT is using (some) cable not designed for 10Gbit**
  - **Parameters not tested at installation**
  - **Length shorter than installation guideline**
  - **Alien crosstalk notoriously difficult to measure**
- **QOS needs stable links**
  - **Packet errors don't respect COS/TOS**
  - **Layer 1 errors notoriously difficult to diagnose**
  - **Especially critical at 10Gbps**
- **But most of all – because we can!**
  - **10GBT PHY has all the necessary components**
  - **Already ubiquitous for Gig (& we must be better that that!)**
  - **If everybody will have it – better to make it standard**

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How to add 10GBT

- **Editing in clauses**
  - **Clause 30 - MIB**
  - **Clause 45 – (MDIO) register view**
  - **Clause 55**
- **MIB (& register) view most important**
  - **Interoperable function – not implementation restriction**
  - **Ranges and granularity (accuracy) for parameters**
- **So what is needed in Clause 55?**
  - **Restrictions of transmitters (PSD etc.)**
  - **Dual-ended operation – test tones etc.**
  - **Part of start up sequence?**

Proposal (i) – TDR parameters

- **Cable length (electrical length)**
  - **Based on a specific Vpp**
  - **Range up to 150m, granularity 1m (accuracy +/- 1m)**
  - **Single reading for each of the 4 pairs**
- **Other TDR**
  - **(very coarse) amplitude**
  - **Short / open**
- **Error conditions (derived – no MIB required)**
  - **Differential length too great**
  - **Amplitude out of range (compared to length)**
- **Run on demand, only when link is inactive**

Proposal (ii) – Single ended tests

- **NEXT**
  - **Either single ended or during start-up**
  - **Based on a test carrier**
  - **Uses NEXT canceller taps**
- **Pair-to-pair or PowerSum?**
  - **Pair-to-pair probably redundant, PowerSum for each pair sufficient**
  - **(assuming no error condition requires the detailed information)**
- **Coupling vs frequency**
  - **Measure at key frequencies (f_{max}, $3*f_{max}/4$, $f_{max}/2$, $f_{max}/4$)**
  - **Gives piecewise approximation of spectral shape**
- **In total, 16 numbers:**
  - **PSNEXT (dB), at 4 frequencies for each pair**
  - **Range (say) 51.1dB, resolution 0.1dB**

Proposal (iii) – Dual ended tests (i)

- **FEXT**
  - **During start-up**
  - **Based on a test carrier sequence (from far end)**
  - **Uses FEXT canceller taps**
- **Pair-to-pair or PowerSum?**
  - **As per NEXT**
- **Coupling vs frequency**
  - **As per NEXT**
- **In total, 16 numbers:**
  - **PSFEXT (dB), at 4 frequencies for each pair**
  - **Range (say) 51.1dB, resolution 0.1dB**

Proposal (iv) – Dual ended tests (ii)

- **Attenuation**
  - **During start-up**
  - **Based on a test carrier (from far end) could be same as FEXT**
  - **Uses DFE or THP taps**
- **Coupling vs frequency**
  - **As per NEXT**
  - **(does it need more frequencies?)**
- **In total, 16 numbers:**
  - **Loss (dB), at 4 frequencies for each pair**
  - **Range (say) 102.3dB, resolution 0.1dB**

Proposal (v) – Dual ended tests (iii)

- **Alien crosstalk**
  - **During start-up**
  - **Based on a test carrier**
  - **Use SNR in slicer?**
- **Requires lowering Tx power**
  - **Either reduce by a fixed amount – to give go/no-go**
  - **Or reduce in steps to give measurement**
- **One number – gross alien crosstalk …**
  - **Relative to Rx power**
  - **Range -63dB, resolution 1dB**
- **… or reduce margin & record symbol errors**

Proposal (vi) – Other issues

- **Definition must include test carrier sequencing**
  - **Need to consider accuracy (reasonably) expected of Tx**
  - **May require 2-way communication**
- **Other things to measure…**
  - **Electrical length (based on propagation delay)**
  - **May be useful to evaluate other parameters**
  - **Requires signal & response mechanism**
- **Testing during operation**
  - **Update parameters during operation or not?**
  - **Possibly use IPG for test sequences**

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Support in principle

- **The following individuals have indicated support for the inclusion of cable diagnostic functions in the 10GBASE-T standard:**

Hugh Barrass, Wael Diab : Cisco Systems

Albert Molina, Adam Healy : Agere Systems; Scott Powell, Kevin Brown : Broadcom; Mike McConnell : KeyEye Communications

Your name : could be here…

Agreement in principle

- **The baseline shall include a definition of cable diagnostics (details TBD).**

P: Hugh Barrass S:

10GBT TF Y: nn N: nn A: nn

802.3 Y: nn N: nn A: nn

Baseline adoption

- **Adopt presentation barrass_1_0704 as the baseline for PHY cable diagnostics.**

P: Hugh Barrass S:

10GBT TF Y: nn N: nn A: nn

802.3 Y: nn N: nn A: nn


Cisco Systems