Finisar

Fiber Optic Solutions
for High-Speed Networks

Closing the 128GFC optical link budget

May 8, 2014

T11/14-172v0

Roadmap (agenda) …

- **Version 1**: plug 100GBASE-SR4 transceiver into 128GFC slot, no special screening, assumes IEEE uncorrected BER
- **Version 2**: plug special screened version of 100GBASE-SR4 into 128GFC slot, assumes IEEE uncorrected BER

  (caution: Finisar hasn't committed yet to these parameters)

- **Uncorrected bit error** requirements and implications

128GFC link budget – Version 1

- Start with **100GBASE-SR4** spread sheet
- Change signaling rate from **25.78125** Gbd up to **28.050** Gbd (cell C4)
- Assume Ethernet uncorrected bit error tolerance of $5x10^{-5}$
- Assume no other changes in spread sheet parameters
- Result: link is **broken** at any length of fiber!

Version 2 (1 of 2)

- Apply **4** changes to 100GBASE-SR4 spreadsheet:
- Change signaling rate from **25.78125** Gbd up to **28.050** Gbd (cell C4)
- Reduce Tx risetime from **21** ps to **19** ps (cell G2)
- Increase receiver bandwidth from **18.047** GHz to **20** GHz (cell T5)

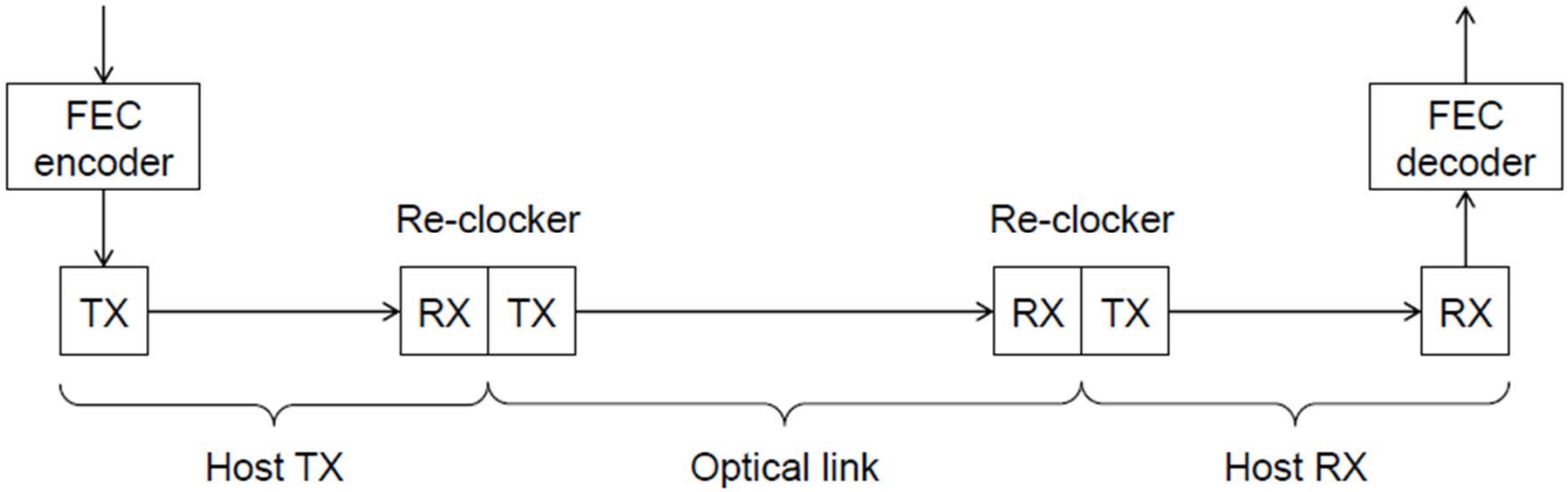
Version 2 (2 of 2)

- Reduce Deterministic Jitter from **21** ps to **19.6** ps (target 0.53 UI at higher signaling rate) (cell G7)
- Result: link can go **95 meters**
- To reach 100 meters, let us also reduce RIN from **-128** dB/Hz to **-129** dB/Hz (cell G4)
- Result: link can go **100 meters**

Disclaimer on Finisar support for Version 2

- The parameters listed on the previous slide were selected solely to achieve a 100 meter link, without regard to whether they are realistic or not
- Finisar R&D is evaluating our performance to determine whether these parameters are achievable with our current generation of product
- Until this evaluation has been completed, do not interpret the parameter list on the previous slide as Finisar commitment
- Furthermore, there are major issues concerning uncorrected bit error requirements that must first be addressed.

Forward Error Correction (FEC)



(from Adam Healey's T11/13-058v0)

IEEE FEC performance

- 100GBASE-SR4 is targeting performance equivalent to a link operating at BER no greater than 10^{-12}, the equivalence is based on the same probability of error for a 64-octet Ethernet frame, and DFE burst errors are explicitly not included. Under these assumptions, you get the $5x10^{-5}$ target and since the electrical links target 10^{-15} each they don't even factor into the calculation.

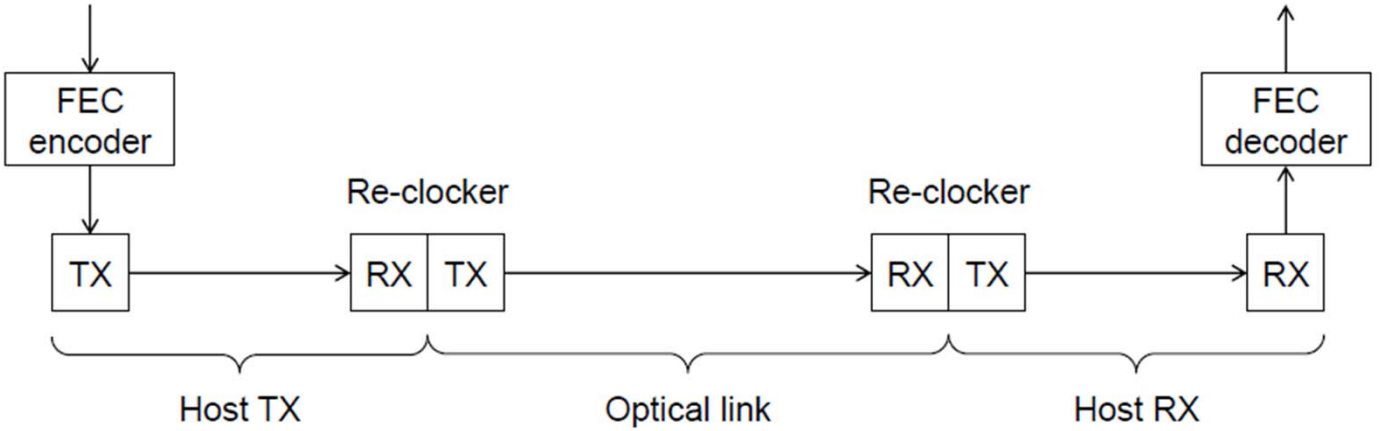
  (from Adam Healey email of April 25)

32GFC FEC performance

- 32GFC defines a maximum BER of 10^{-6} for each "section" of the link and this implies an end-to-end link BER no greater than $3x10^{-6}$. This guarantees a codeword error ratio between 10^{-19} and $3x10^{-14}$ depending on whether or not DFE is used (I don't know how you legislate that DFE is not used in a host receiver).
- Burst errors are considered for 32GFC, implying a lower FEC performance than for non-burst errors.
- We must support breakout options, hence we must support the 32GFC FEC assumptions.

32GFC FEC partition assumptions

Application to 32GFC optical links

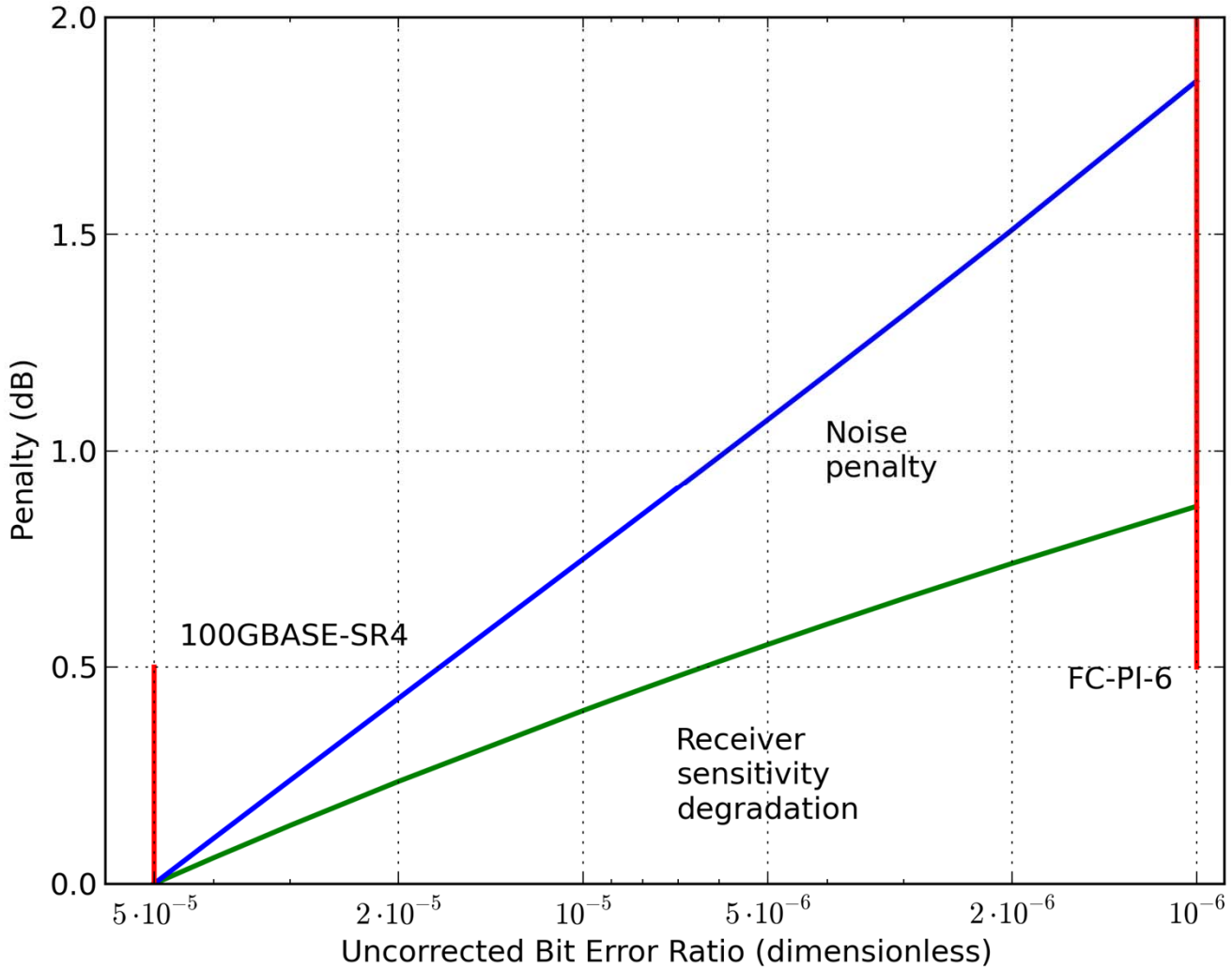


- BER ≤ 2.4E−5 at input to the FEC decoder assuming binary symmetric channel
- For each section (host transmitter, optical link, host receiver), require BER ≤ 8E−6
- If host receiver employs DFE, require BER ≤ 2E−6 for that section to account for the possibility of error propagation

T11/13-058v0

LSI Storage. Networking. Accelerated.

Q power budget degradation



Impact of uncorrected BER on link budget

- Start with Version 2 link budget, established for $5x10^{-5}$ uncorrected BER performance
- Vary Q from 3.89 (= $5x10^{-5}$ BER, per IEEE) to 4.75 (= 10^{-6} BER, per 32GFC)
- Keep fiber link reach fixed at 100 meters of OM4
- Calculate link budget deficit (in dB)
- Deficit is caused by:
  - Degradation in **receiver sensitivity**
  - Greater degradation due to **noise sources**

Laser eye safety risk

- What if we increase Tx min OMA to make up for increased budget loss?
- For 100GBASE-SR4, we're already running very close to the Class 1 limit for laser hazard
- Adding 1.8 dB to the Tx output power runs the risk of going over the Class 1 limit.
- For parallel products, there is no Class 1M option – the next higher class is **3R**
- *(This only applies for parallel products; single channel devices still have a Class 1M option)*
- **This is most likely a non-starter!!!**

128GFC: 3 use cases

- First use case: 4-lane OIF VSR Host Tx, 4-land OIF VSR Host Rx, plus 4-lane optical link
  - Assume uncorrelated error statistics
  - Is $5x10^{-5}$ reasonable for Fibre Channel applications?
- Second use case: 4-lane OIF VSR at one end, fanout to 32GFC single lanes at the other end
  - Assume burst error statistics
- Third use case: 4-lane OIF VSR at one end, fanout to 16GFC single lanes at the other end
  - Assume burst error statistics