Super-PON
Chromatic Dispersion Considerations

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IEEE P802.3cs - March 12, 2019
Overview

- VPI simulations were used to quantify the tolerance to chromatic dispersion of transmitters with different alpha parameters
- Downstream: APD receiver, -0.5 to +0.5 alpha, high ER
  - DCM not needed for downstream
- Upstream: optical preamp, 0-3 alpha, low ER
  - DCM will greatly increase ONU transmitter options for upstream
• A high extinction ratio is needed since the signal is boosted by amplifier
  • External modulation will offer higher extinction ratios at 10 Gb/s
• A low or negatively chirped EA modulators are possible because of the lower required transmit power
• ONU receiver will be an APD
Modulation depth = 0.9 (ER = 10 dB), alpha = 0

- 1000 ps/nm of chromatic dispersion results in around 0.6 dB penalty at BER=10^{-3}
- 1000 ps/nm is around:
  - 58 km in the C-band
  - 53 km in the L-band
- No DCM needed if OLT transmitters are chirpless EMLs
Modulation depth = 0.9 (ER = 10 dB), alpha = -0.5

- Sensitivity gain for all residual dispersion >0
- Peak gain at 600 ps/nm
- No DCM needed if OLT transmitters are specified to be negative chirp
- Potentially made possible by the lower output power required (boosted by EDFA)
Upstream assumptions

- ONU transmitter is required to be relatively high power >2 dBm @ 10 Gbps
  - No booster amplifier on the ONU side
- DML lasers are preferred for low cost and higher launch power
- OLT receiver will contain an optical preamplifier

Transmitter with 10 dB ER

\[ P_{out} = +4 \text{ dBm} \]

No noise

17 ps/nm/km

Attenuator sets link loss

Swept

16 dB gain

NF = 5.5 dB

100 GHz Gaussian

APD receiver
Modulation depth = 0.9 (ER = 10 dB), DCM = 0 km

- Can see that higher chirp DML lasers cannot pass a 50 km link without a DCM
- Chirpless EML still has ~1.5 dB penalty from CD
Modulation depth = 0.9 (ER = 10 dB), DCM = 25 km

- Chirpless transmitter has similar performance at 0 or 50 km
- +ve chirped transmitters have gain at 0 km and penalty at 50 km
- Penalty is ~2 dB even for the alpha=1 case, which is a low-chirp DML
Modulation depth = 0.9 (ER = 10 dB), DCM = 50 km

- Chirpless transmitter
  - ~1 dB penalty at 0 km, from the DCM
  - No penalty for 25 km or 50 km
- +ve chirped transmitters
  - No penalty at 50 km (dispersion neutral)
  - Improvement in sensitivity for 25 km and 0 km
- Both chirpless EMLs and +ve chirped DMLs can be supported if a DCM is used
- DCM comp >= max length of ODN
Modulation depth = 0.8 (ER = 7 dB), DCM = 50 km

- Similar story for relative performance of different lengths of propagation
- ~2 dB penalty from reduced ER compared to ER = 10 dB
Modulation depth = 0.7 (ER = 5.2 dB), DCM = 50 km

- Similar story for relative performance of different lengths of propagation
- ~2 dB penalty from reduced ER compared to ER = 7 dB or ~4 dB penalty from ER = 10 dB
- Larger penalty from reducing ER than expected
- Reduced performance likely from the increase of noise on the zeros
Placement of DCM

Can be avoided if 0 or -ve chirp Tx used for OLT
Will increase the amplified link budget and make the link for both directions harder to close

Needed to have zero CD penalty for chirpless Tx
Definitely needed to support DMLs at ONU
Conclusions

• For Super-PON upstream at the speed of 10Gb/s, a single dispersion compensation module (DCM) placed between the optical preamplifier and the demultiplexer is able to resolve the chromatic dispersion issues for any link length within the 50 km limit.
• The DCM enables the use of multiple ONU transmitter types to all cover the 50 km range.
• The upstream DCM should compensate for at least the maximum link distance of the desired ODN length, so for at least 50 km.
• For Super-PON upstream at the speed of 2.5Gb/s, dispersion compensation is likely to not be an issue, with or without DCMs.
Super-PON Architecture
Thank you