Optimizing 10GBASE-CX4 Tx/Rx Implementation

10GBASE-CX4 Study Group
Interim Meeting, 12/02

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Background

- From the 11/02 Plenary presentation:

  “ Potential changes to XAUI specs

  1. *Increased TX amplitude*
  2. *Improved RX sensitivity*
  3. *RX Equalizer*
  4. *Combinations of above techniques ”*

  This proposal attempts to show that #2 and #3 are the key areas to focus on

Agenda

- Tx Signal Considerations
  - Amplitude
- Rx Options
  - Rx Equalization
  - Rx Offset Cancellation
- Measurement Results
  - Channel characteristics
  - Test results

Tx Signal Considerations

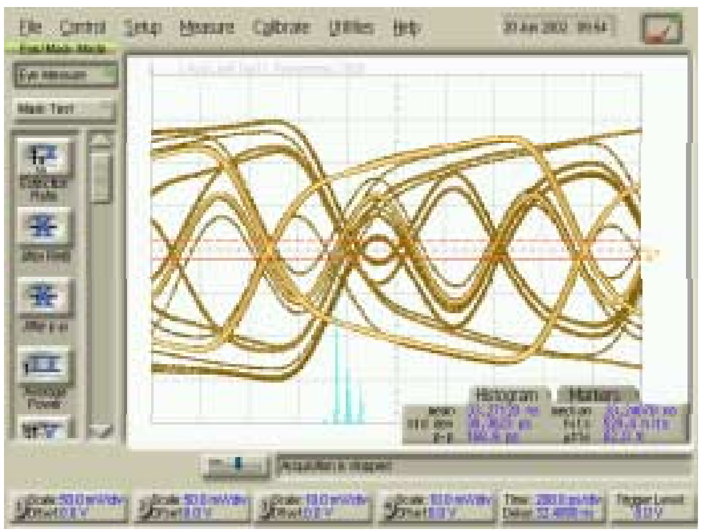
- Tx Signal should be optimized for…
  – Power (amplitude)
  – Noise (amplitude, pre-emphasis)
  – EMI (amplitude, pre-emphasis)
  – Backward compatibility (with XAUI spec)

…while still achieving BER goals

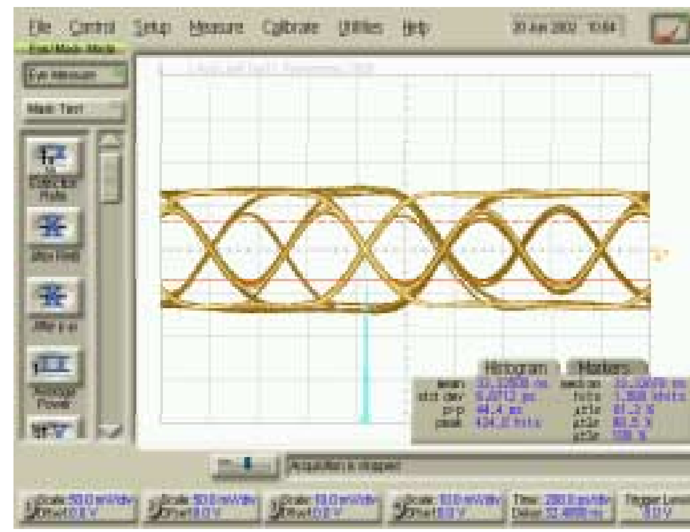
- Increasing Tx amplitude by 25%:
  – From 800mV (XAUI) to 1000mV
  – Tx power consumption scales ~ linearly
    - ~25% increase in Tx power

Rx Equalization (example)

- Reduces amount of eye-opening needed after channel
- Can be integrated
- *Passive* Rx EQ performance is sufficient to open a fairly closed data eye:



Passive
Rx EQ



3.125Gb/s Input (CJPAT)
Jitter pk-pk = 170 ps;
eye opening = 20 mV

3.125Gb/s Output
Jitter pk-pk = 45 ps;
eye opening = 75 mV

Rx Input Offset Cancellation

$$V_{NM} = \frac{1}{2}V_{SW} - K_N V_{SW} - V_{NF}$$

$$V_{SW} = \frac{V_{NM} + V_{NF}}{0.5 - K_N}$$

$$\frac{dV_{SW}}{dV_{NF}} = \frac{1}{0.5 - K_N}$$

- For K_N = 20%, any reduction in fixed noise V_{NF} (such as Rx offset) results in 3x as much reduction in the required swing
- In other words, to achieve the same margin V_{NM}, the swing would have to be increased by 3x as much (inefficient).
- $K_N > 0$ is a result of residual ISI, Xtalk, reflections at Rx slicer input that exist in any link

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Rx Input Offset Cancellation (cont.)

- (from Nov. Plenary): Insertion loss limit for 10GBASE-CX4 allows up to 19dB @1.56GHz of attenuation in the channel

- 19dB attenuation after fully equalized channel:
  – Tx swing of 1000mV, results in 115mV Rx signal
  – Tx swing of 800mV, results in 92mV Rx signal

- Thus, 25% increase in Tx output amplitude only results in 23mV signal improvement at Rx
  =>Very inefficient!

- Improving Rx input sensitivity well below 100mV (e.g. 50mV-80mV) is a more efficient approach:
  – Reduces power consumption
  – Better BER performance than 1000mV Tx / 200mV Rx

Test Setup - Channel Characteristics

- 15 meter cable
  - 24 awg 100 Ohm 4 channel 8 shielded twin axial pair cable assembly
  - Differential impedance 100 ohm +/- 5 ohms
  - Capacitance = 42pF/m nominal
  - Skew (within pair) <= 100ps/7.5m
  - Near end X-Talk (NEXT) = -65dB Typical
  - **Attenuation = 0.81dB/m @1250MHz and/or 1.19dB/m @2500MHz Nominal**

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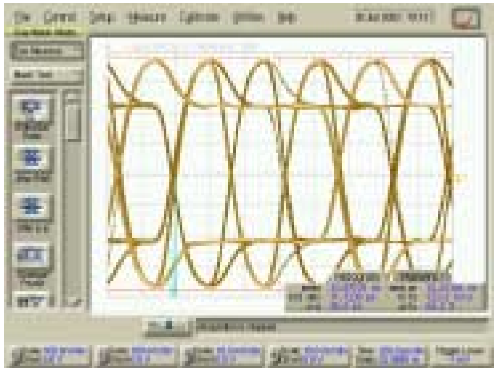
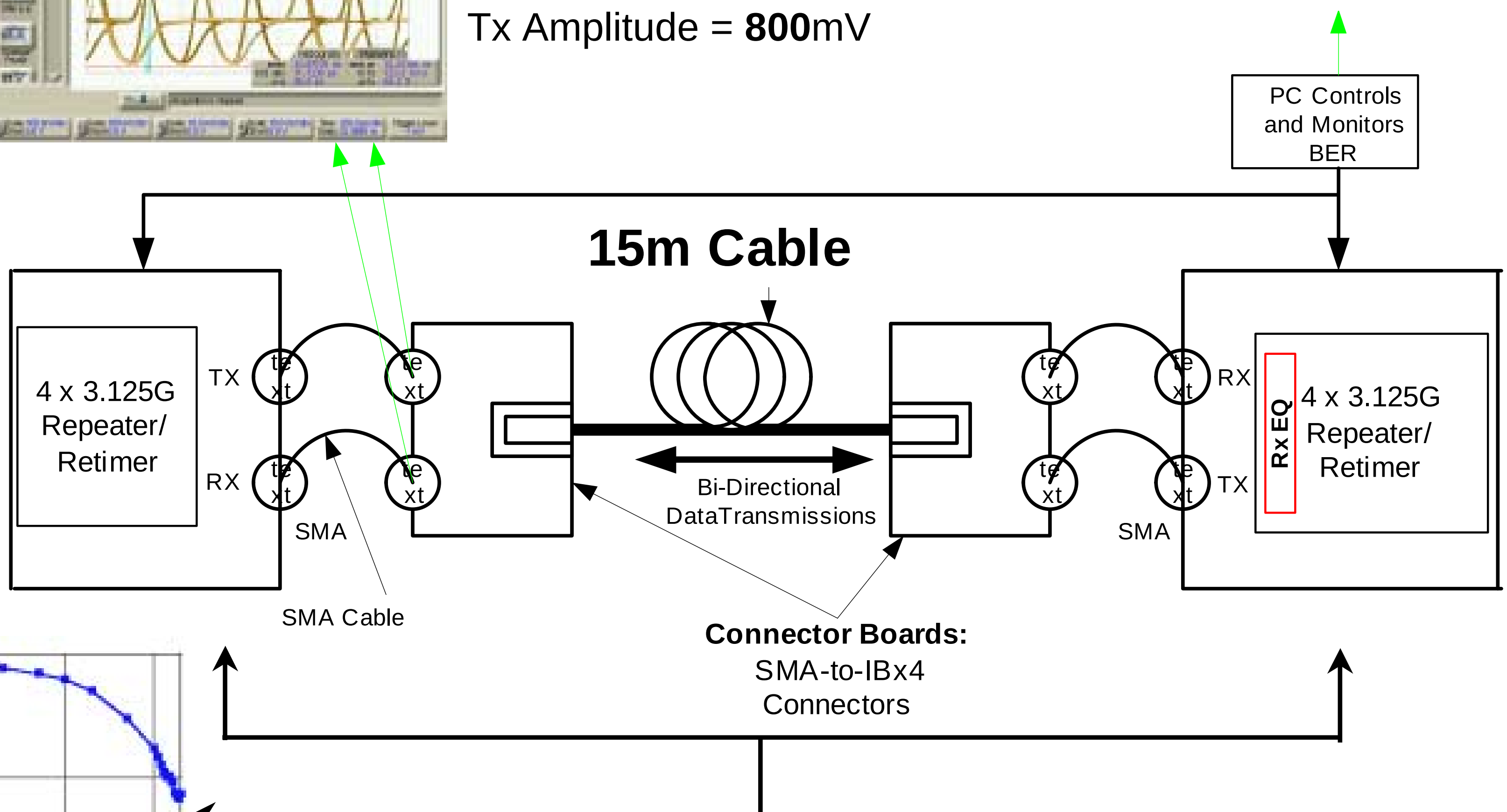
Measurement results, test setup:

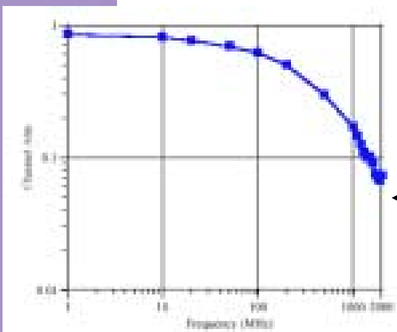


3.125 Gb/s
with pre-emphasis

Tx Amplitude = **800**mV

24hr error free





~21dB total attenuation

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Summary

" Potential changes to XAUI specs

1. *Increased TX amplitude*
2. *Improved RX sensitivity*
3. *RX Equalizer*
4. *Combinations of above techniques "*

#2 and #3 are key areas to focus on

- Tx Amplitude can be kept as specified in XAUI
- Rx Equalization (passive) is sufficient
  - can be integrated
- Rx Sensitivity can be improved
  - Via techniques like offset cancellation