



Tradeoffs and Benefits of Equalization in CX4

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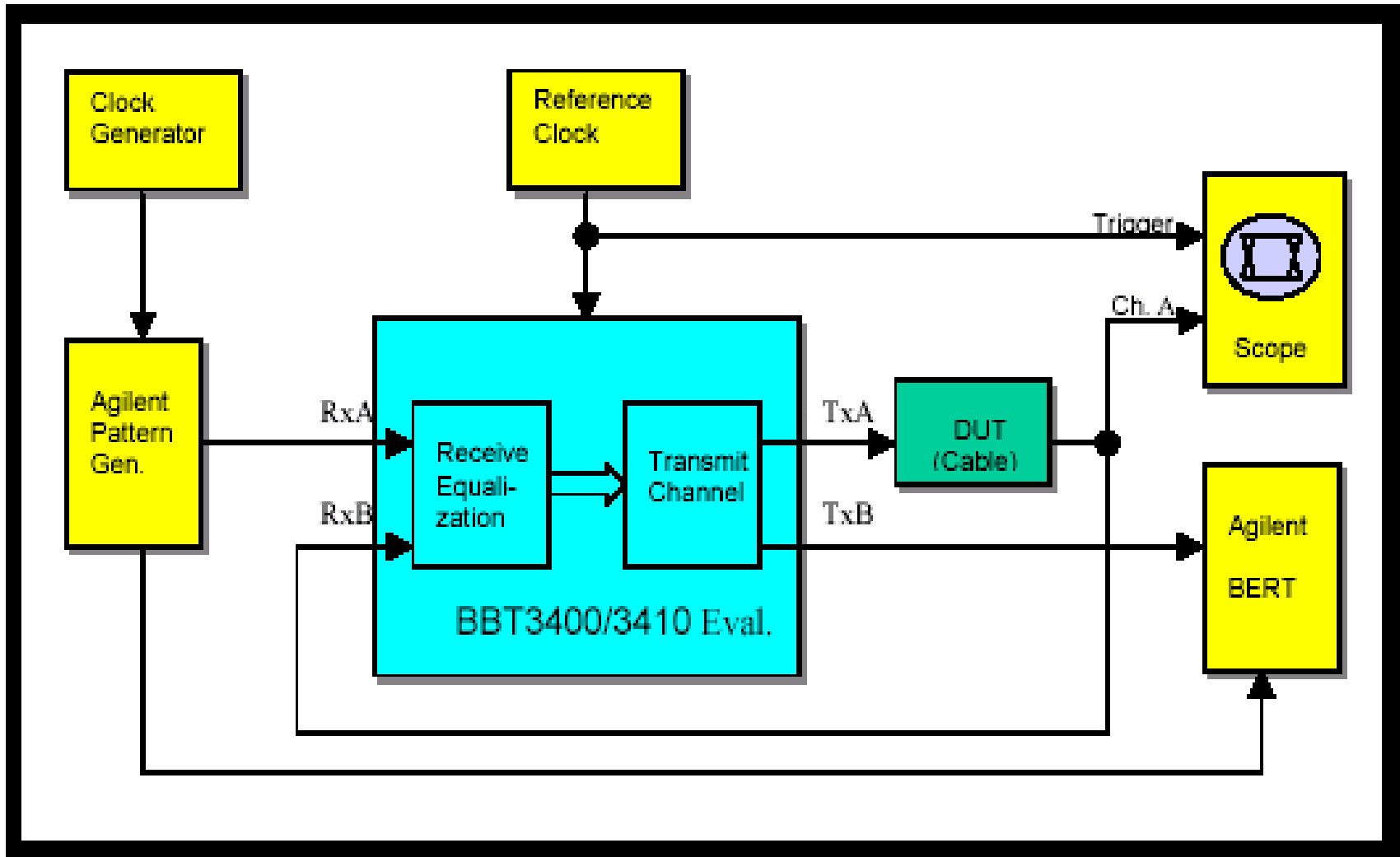
IEEE 10GBASE-CX4 Dec 16/17 2002

Outline



- Some measurements on pre-emphasis and equalization
 - Using SMA connectors and a breakout box
 - Using the IBx4 connector
- Recommendations
 - Equalization allows longer reach with less EMI & power consumption
 - Longest reach achievable combined with pre-emphasis

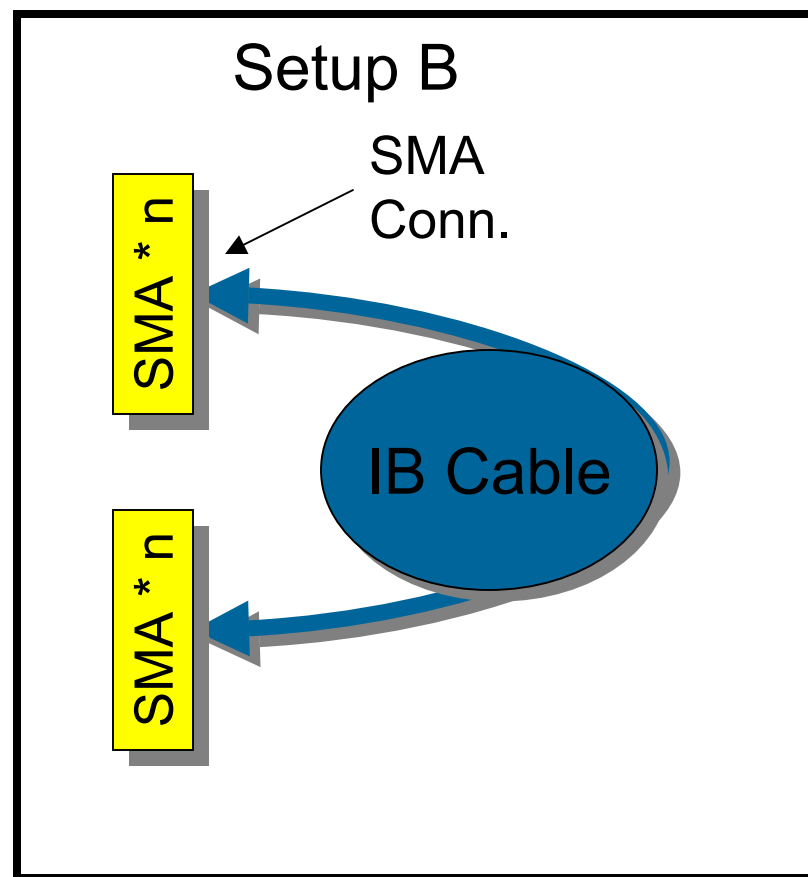
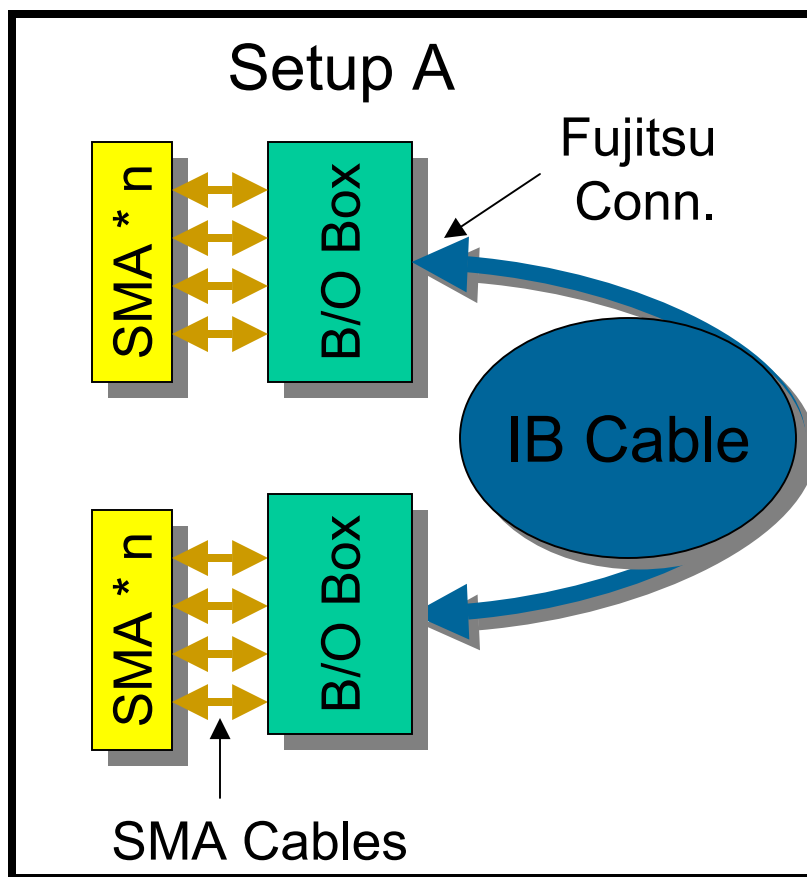
Test Setups A, B



BitBlitz BBT3410 and CX4 test using IB Cable, SMA connectors

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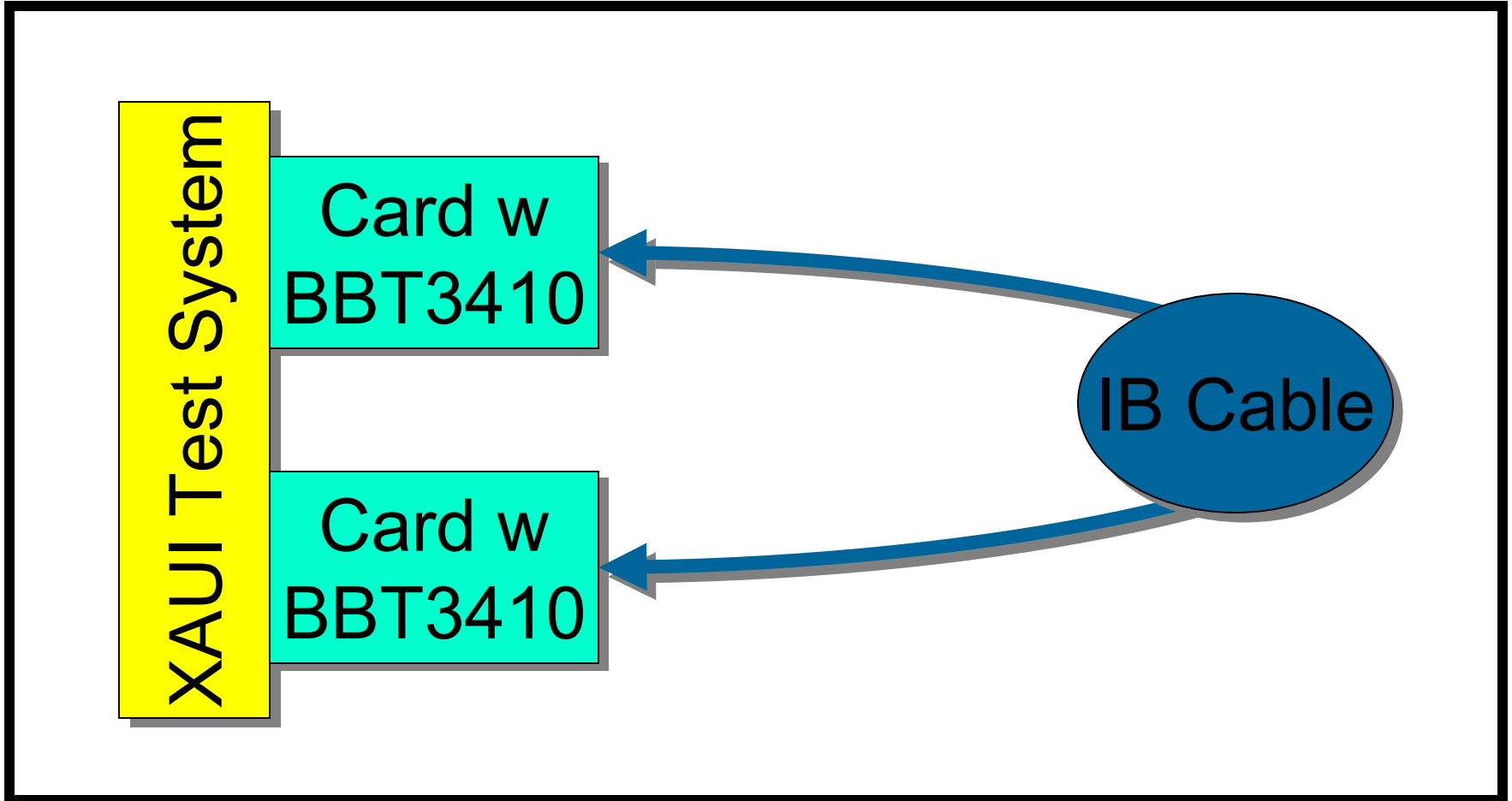
Cables for A,B



Setup Issues (A & B)

- A: Breakout Boxes have impedance mismatch, discontinuities, reflections.
 - All channels available
 - Extra cables; ~32 cm FR-4, ~60 cm SMA
- B: Does not use IBx4 Connector
 - Only one channel implemented (mechanical limitations)

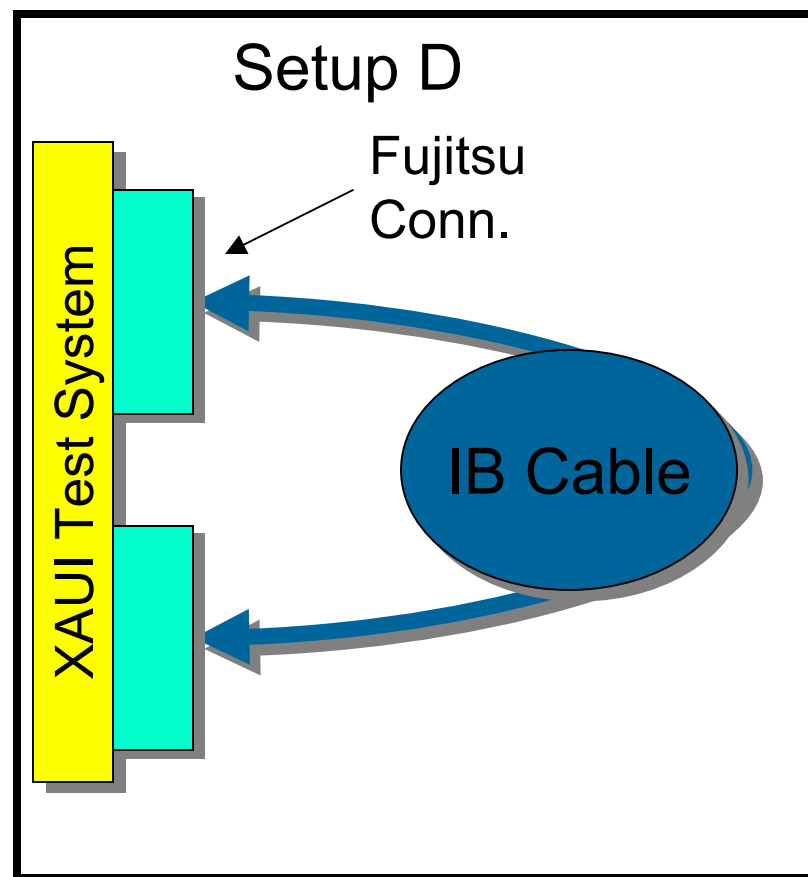
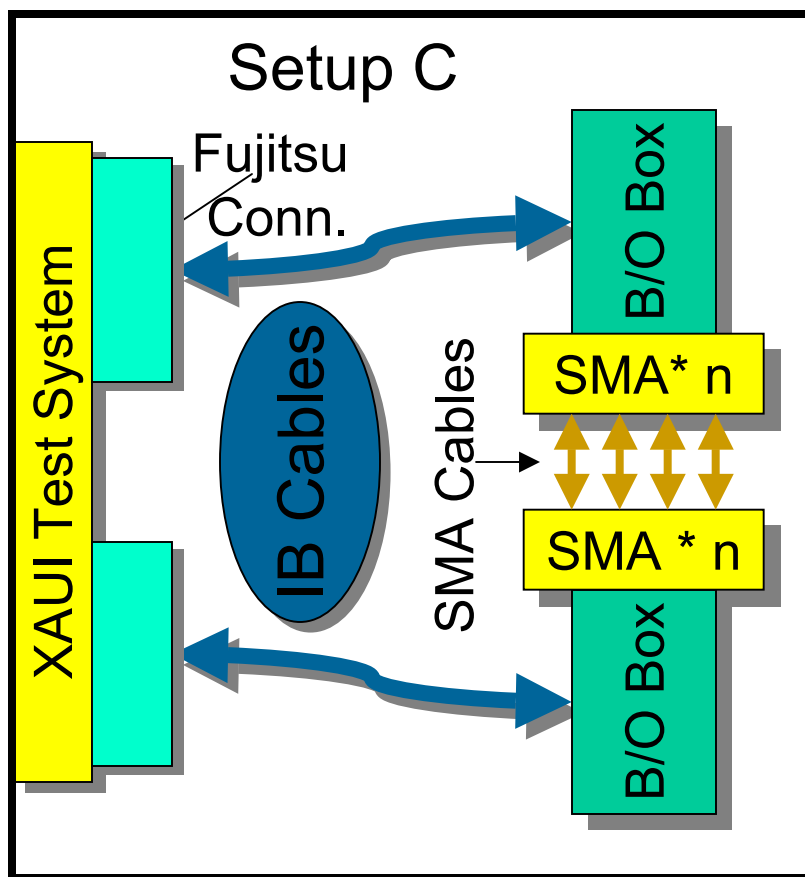
Test Setups C,D



BitBlitz BBT3410 and CX4 test using IB Cable and Connectors

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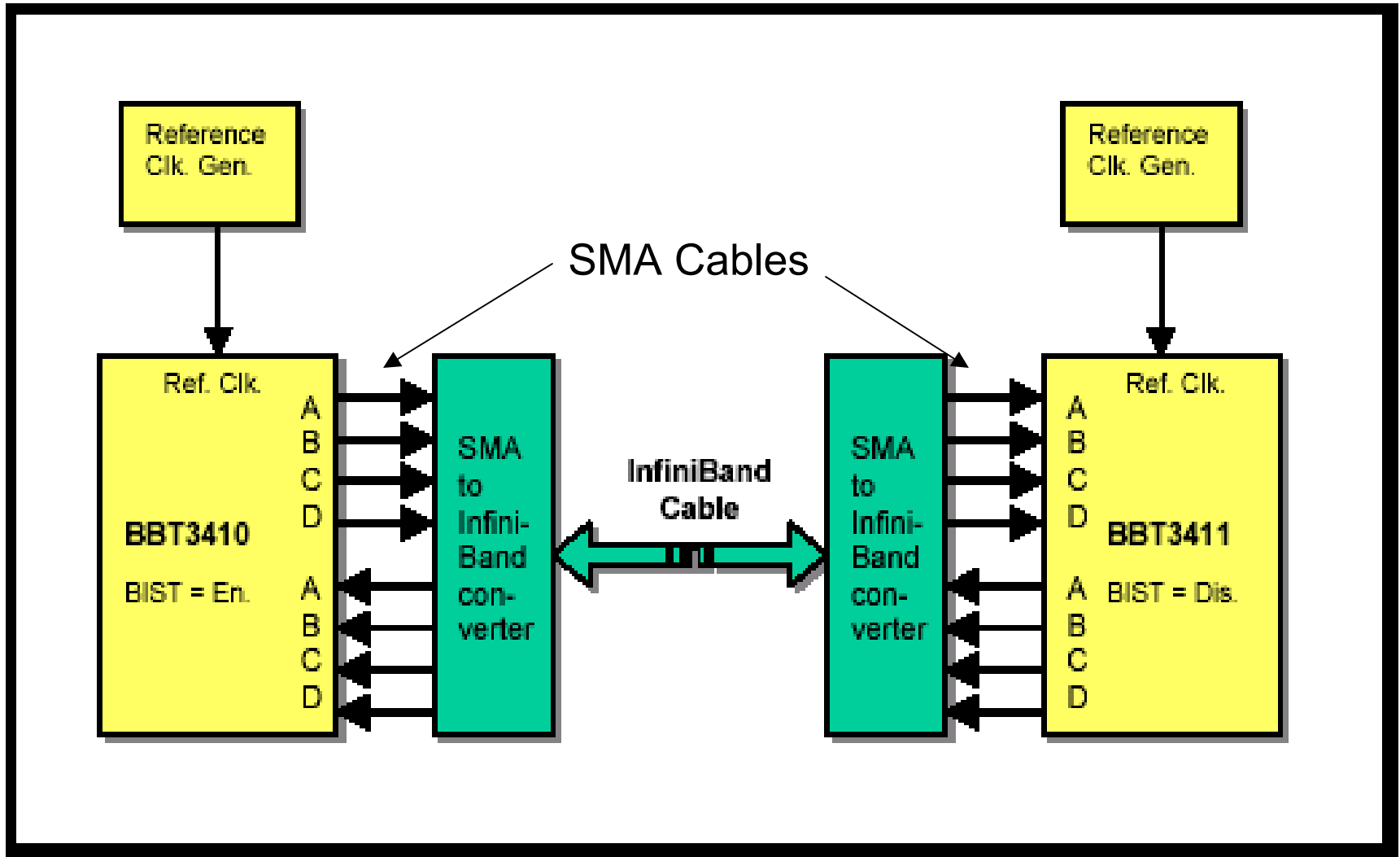
Cables for C,D



Setup Issues (C & D)

- C: Breakout Boxes have impedance mismatch, discontinuities, reflections.
 - All channels available
 - Extra cables, etc.; ~15 cm FR-4, ~30 cm SMA, 2 extra IBx4 connectors
- D: Pinout Problems cause inversion and rotation of Lanes
 - Limited patterns available

Test Setup E



BBT3410/11 and CX4 test using IB Cable, SMA connectors

Setup Issues E

- E: Breakout Boxes have impedance mismatch, discontinuities, reflections.
 - All channels available
 - More 'realistic' configuration
 - Extra cables, etc.; ~15 cm FR-4, ~30 cm SMA, 2 extra IBx4 connectors

Test Patterns

- A number of different test patterns were used. All were run for $>10E12$ bits without errors, some for much longer

Test Patterns

| Pattern | Defined by. | Characteristics |
|-----------|-------------|--|
| CJPAT | 802.3ae | See Annex 48A |
| PRBS-7 | Test Equip. | Not 8b/10b coded |
| BIST | BBT3410 | $10^{23}-1$ PRBS 8b-10b with /K/ characters |
| Alt 1 & 0 | Test Box | Polarity Invariant |

ICs Used for Tests

- Three parts tested with IB Cables:-
 - BBT3400: XGXS, No pre-emphasis
 - BBT3410: XGXS, Adjustable Pre-emphasis
 - Four levels; 0.0, 0.15, 0.38, 0.75
 - BBT3411: XAUI Retimer, Adj. pre-emphasis (=)
- All have equalization boost at 1.5 GHz settable from 0dB (setting 0'h) to ~7dB (setting F'h)

Results

- Several different Cable lengths and wire gauges were used.
- All results were taken at 3.125 Gbps.
- Where possible, multiple channels were tested simultaneously

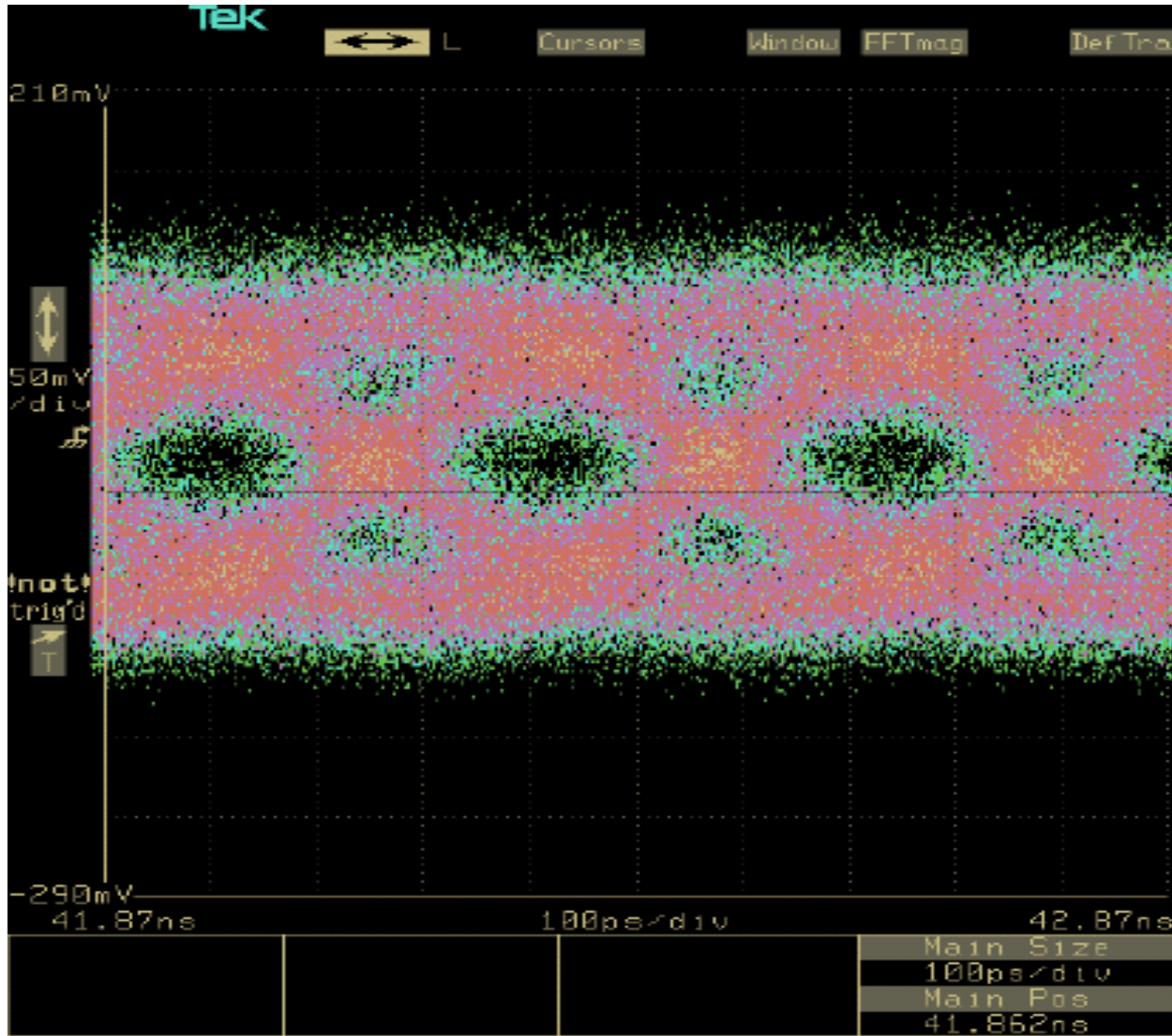
20 meter 24 AWG

| Setup | SERDES | Pre-emph | Equalization | Pattern | BER |
|-------|---------|----------|--------------|---------|---------|
| D | BBT3410 | 0.75 | 5'h | Alt 1&0 | <10E-12 |
| D | BBT3410 | 0.38 | 7'h | Alt 1&0 | <10E-12 |
| D | BBT3410 | 0.18 | 9'h | Alt 1&0 | <10E-12 |
| D | BBT3410 | 0.0 | D'h | Alt 1&0 | <10E-12 |

15 meter 24 AWG

| Setup | SERDES | Pre-emph | Equalization | Pattern | BER |
|-------|------------|----------|--------------|---------|----------|
| E | BBT3410/11 | 0.75 | F'h | BIST | <3*10E13 |
| C | BBT3410 | 0.75 | 5'h | CJPAT | <10E-12 |
| C | BBT3410 | 0.38 | E'h | CJPAT | <10E-12 |
| D | BBT3410 | 0.75 | 4'h | Alt 1&0 | <10E-12 |
| D | BBT3410 | 0.38 | 5'h | Alt 1&0 | <10E-12 |
| D | BBT3410 | 0.18 | 7'h | Alt 1&0 | <10E-12 |
| D | BBT3410 | 0.0 | B'h | Alt 1&0 | <10E-12 |

RX Data Eye $pe=0.75$



Setup E

15 m

24 AWG

BIST

0.75 pre-emph.

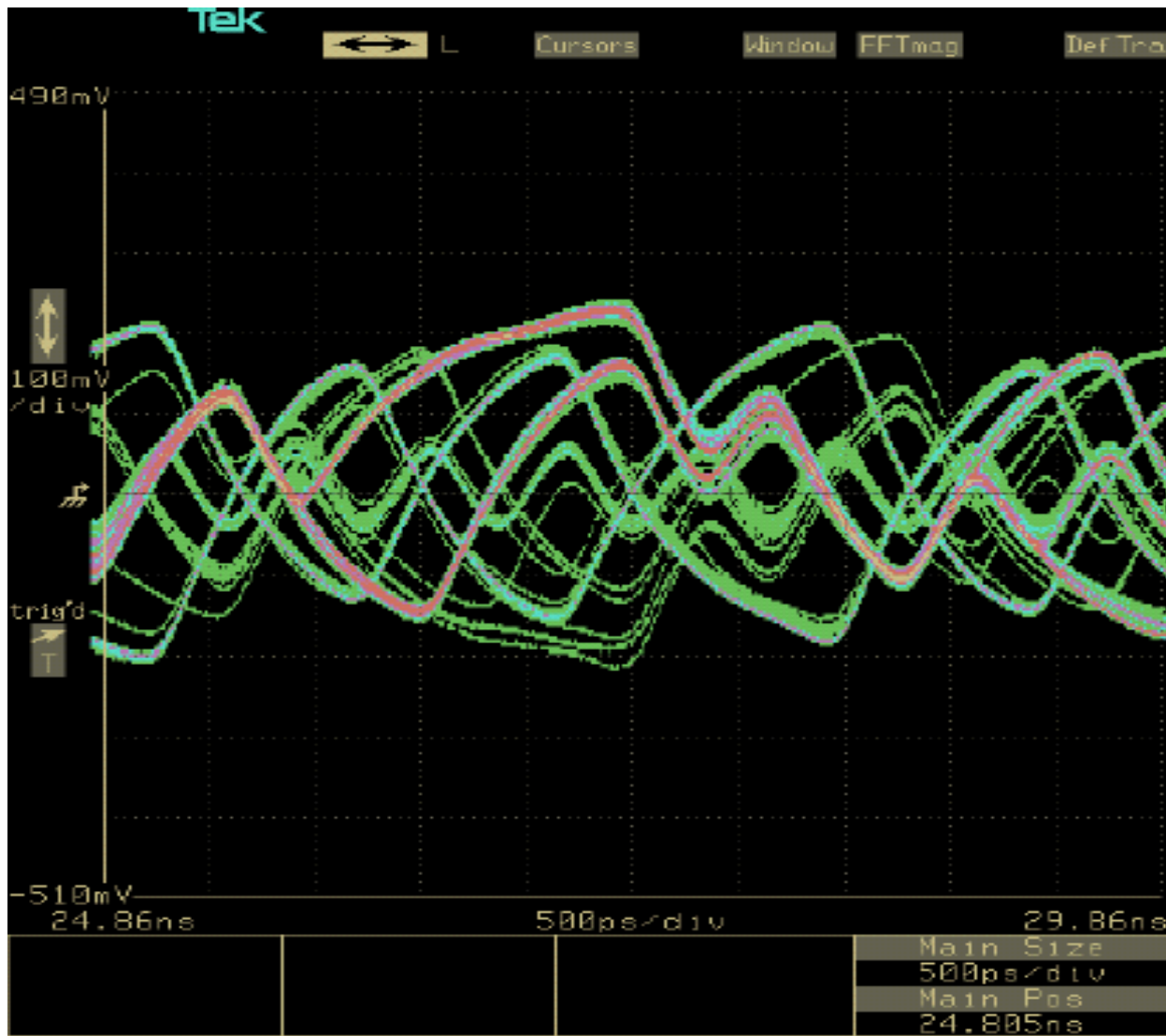
15 meter 26 AWG

| Setup | SERDES | Pre-emph | Equalization | Pattern | BER |
|-------|---------|----------|--------------|---------|---------|
| C | BBT3410 | 0.75 | Ah | CJPAT | <10E-12 |
| D | BBT3410 | 0.75 | 4h | Alt 1&0 | <10E-12 |
| D | BBT3410 | 0.38 | 6h | Alt 1&0 | <10E-12 |
| D | BBT3410 | 0.18 | 8h | Alt 1&0 | <10E-12 |
| D | BBT3410 | 0.0 | Bh | Alt 1&0 | <10E-12 |

10 meter 26 AWG

| Setup | SERDES | Pre-emph | Equalization | Pattern | BER |
|-------|---------|----------|--------------|---------|-----------|
| A | BBT3400 | None | Ah | CJPAT | <10E-12 |
| A | BBT3400 | None | Bh | PRBS7 | <10E-12 |
| A | BBT3400 | None | Ch | BIST | <7*10E-14 |
| C | BBT3410 | 0.75 | 4h | CJPAT | <10E-12 |
| C | BBT3410 | 0.38 | 7h | CJPAT | <10E-12 |
| C | BBT3410 | 0.18 | 8h | CJPAT | <10E-12 |
| C | BBT3410 | 0.0 | Dh | CJPAT | <10E-12 |

RX Data Eye $pe=0.0$



Setup A

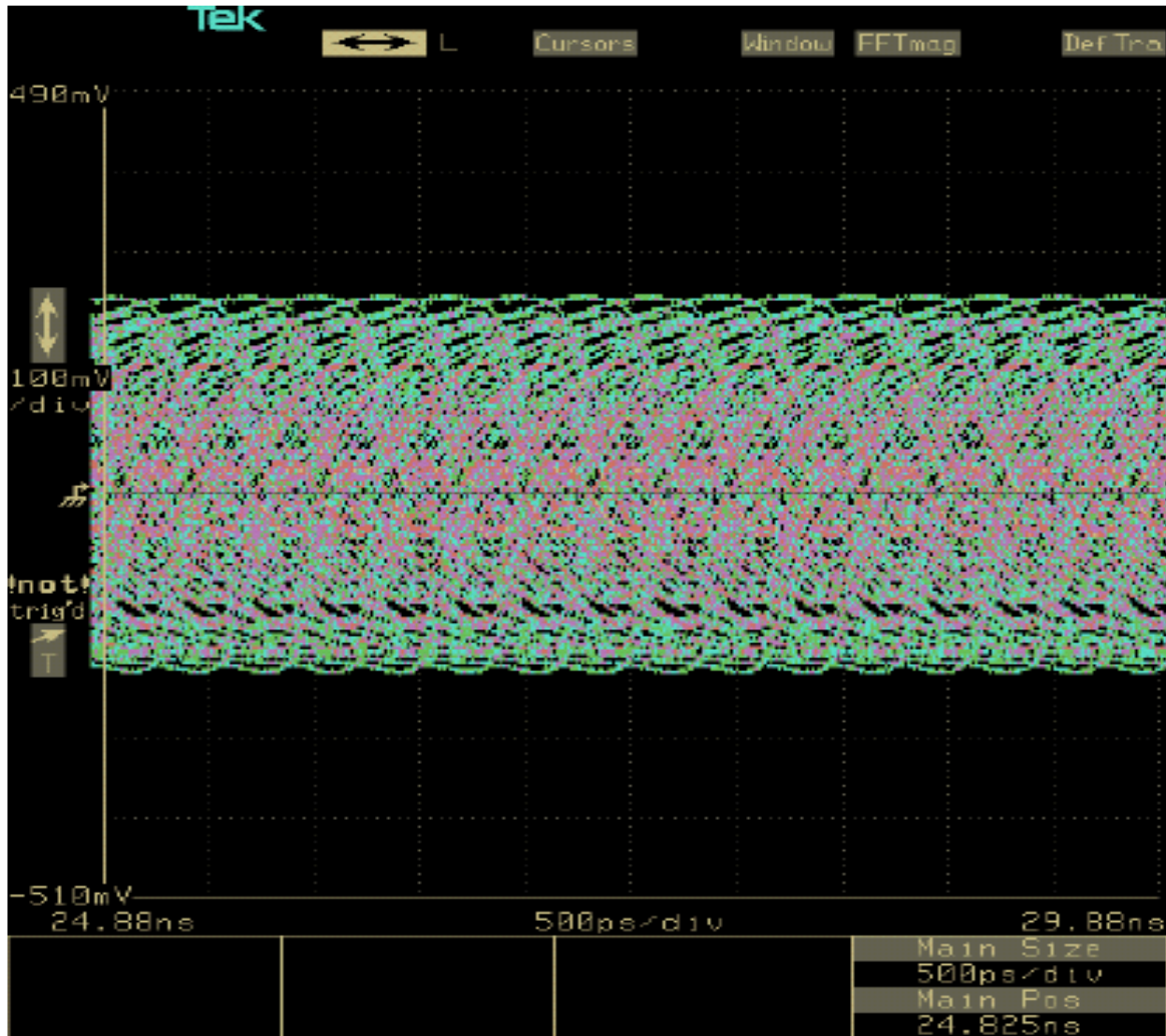
10 m

26 AWG

CJPAT

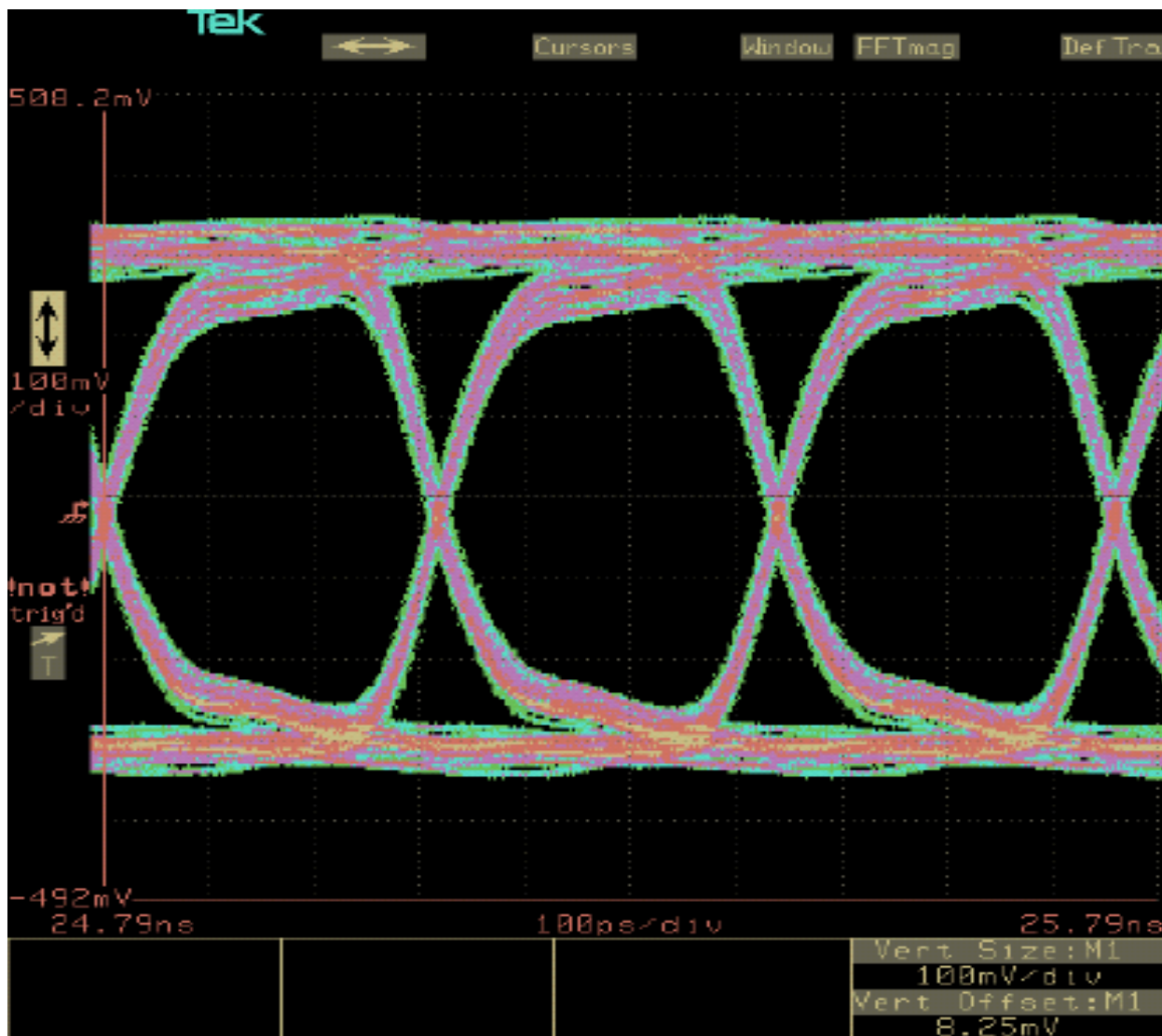
No pre-emph.

RX Data Eye $pe=0.75$



Setup A
10 m
26 AWG
PRBS-7
0.0 pre-emph.

Retransmitted Eye



Setup A

10 m

26 AWG

PRBS-7

12 meter 26 AWG

| Setup | SERDES | Pre-emph | Equalization | Pattern | BER |
|-------|---------|----------|--------------|---------|---------|
| B | BBT3400 | None | Ch | CJPAT | <10E-12 |
| B | BBT3410 | 0.75 | 0h | CJPAT | <10E-12 |
| B | BBT3410 | 0.75 | 0h | PRBS7 | <10E-12 |

RX Data Eye $pe=0.0$

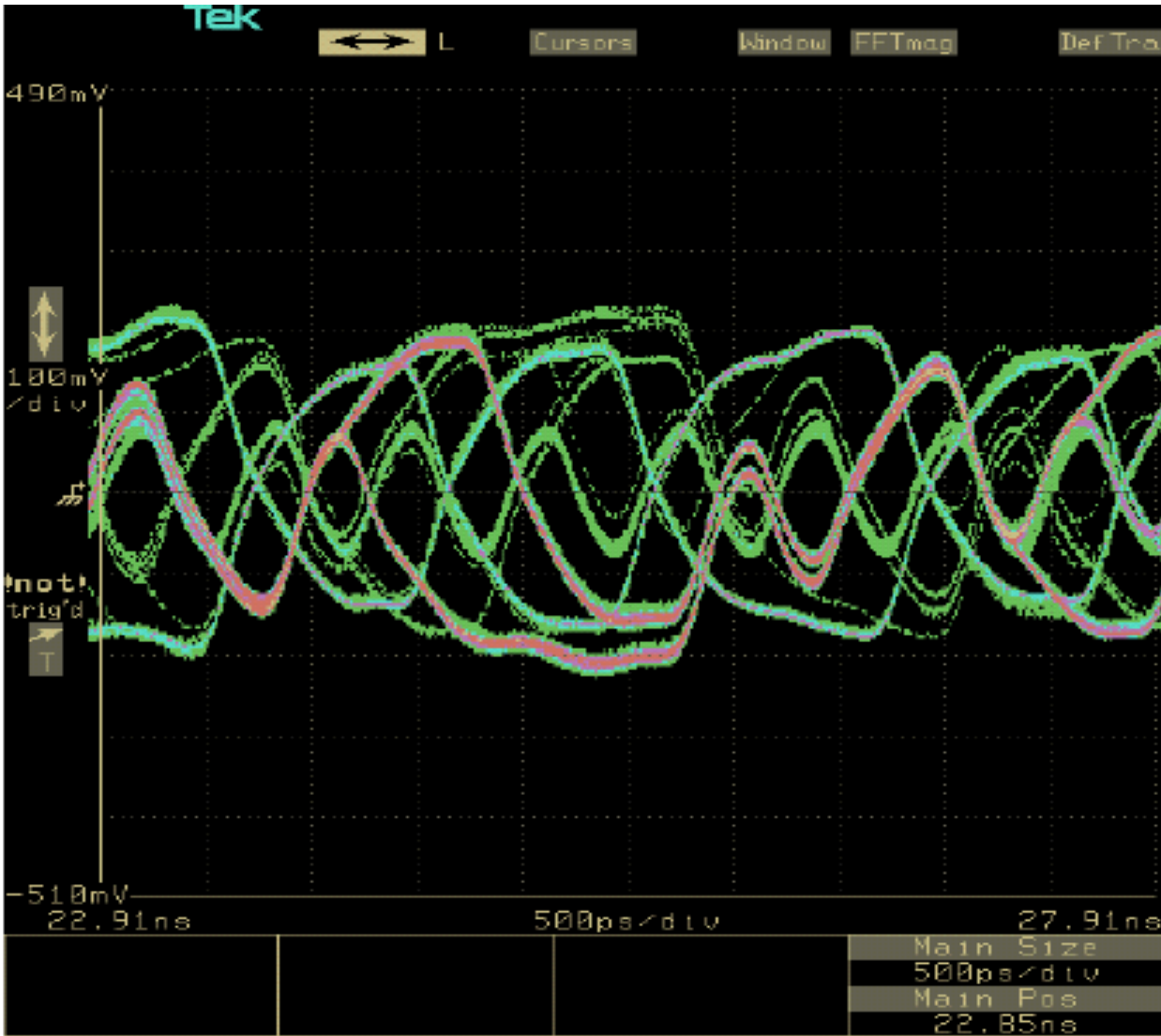
Setup B

12 m

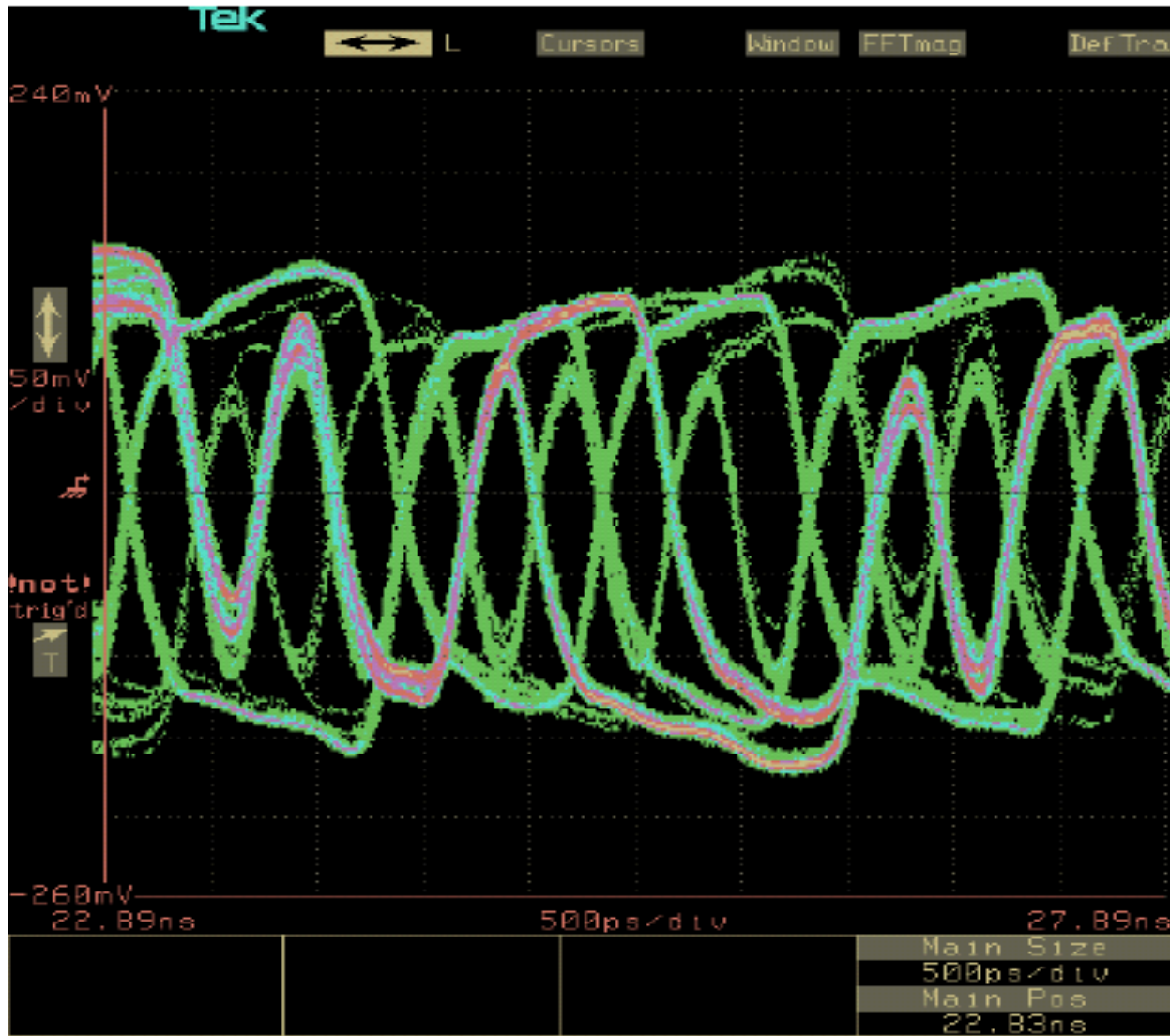
26 AWG

CJPAT

No pre-emph.



RX Data Eye $pe=0.75$



Setup B

12 m

26 AWG

CJPAT

0.75 pre-emph.

RX Data Eye $pe=0.75$

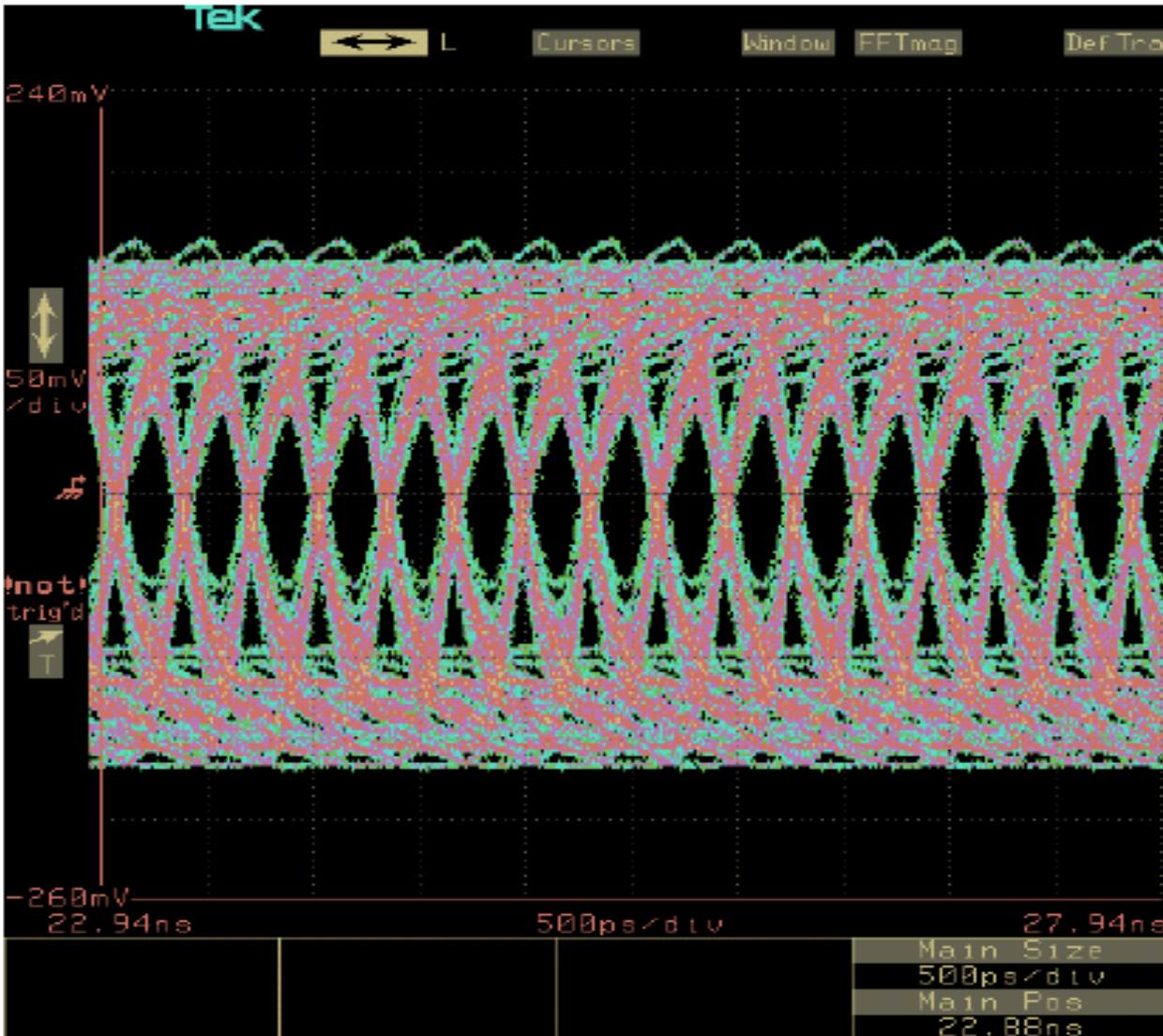
Setup B

12 m

26 AWG

PRBS-7

0.75 pre-emph.



Crosstalk Test

- Done using Configuration D
- One channel running Alt 1&0 pattern
- Other three channels running different PRBS patterns
- Tested Equalization needed for error-free operation with that in single channel test

Typical Crosstalk Result

Test Conditions:-

Alt 1 & 0 on test channels, all other with differing PRBS

15 m 26 AWG Cable, BBT3410

| Setup | Pre-emph | Equalization for:- | | BER |
|-------|----------|--------------------|-----------|---------|
| | | One Channel | Crosstalk | |
| D | 0.75 | 4h | 4h | <10E-12 |
| D | 0.0 | Bh | Bh | <10E-12 |

Conclusions

- Tests show that 20 meters of IB cable can operate without error using ONLY Equalization.
- From a system perspective, adaptive Equalization can be handled easily.