Improvements on DME-based Autoneg Signaling

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Outline of presentation

- ## Previous Results
  - T3=8nsec
  - Comparator based detector
  - Preamble is 8 T6 symbols
  - Poor performance with PoDL HPF (see "tu_3bp_01a_0914")
  - Not compatible with 100BASE-T1 ADC
- ## Proposed Improvements for DME autonegotiation signaling
  - Optimizing T3 for 100BASE-T1 and 1000BASE-T1
  - Better preamble
  - Improved detector
- ## Performance Results
- ## Conclusion

# IMPROVEMENT #1: OPTIMIZING T3 FOR 100BASE-T1 AND 1000BASE-T1

Choosing T3

T3	100BASE-T1 max Fs=66.67MHz	1000BASE-T1 Max Fs=750MHz
8nsec	Not compatible	6x oversample, Fs=750MHz
15nsec	Fs=66.67MHz	3x oversample, Fs=200MHz
30nsec	2x oversample, Fs=66.67MHz	6x oversample, Fs=200MHz
45nsec	**3x oversample, Fs=66.67MHz**	**9x oversample, Fs=200MHz**
60nsec	4x oversample, Fs=66.67MHz	Severe droop with PoDL

BEST

45nsec T3 offers 3x oversampling with 66.67MHz sampling rate for 100BASE-T1 receiver

IMPROVEMENT #2: BETTER PREAMBLE

Received Waveform: Preamble = 8 T6

Received Start Delimiter, 15m Channel, 11MHz HPF, 45ns T3
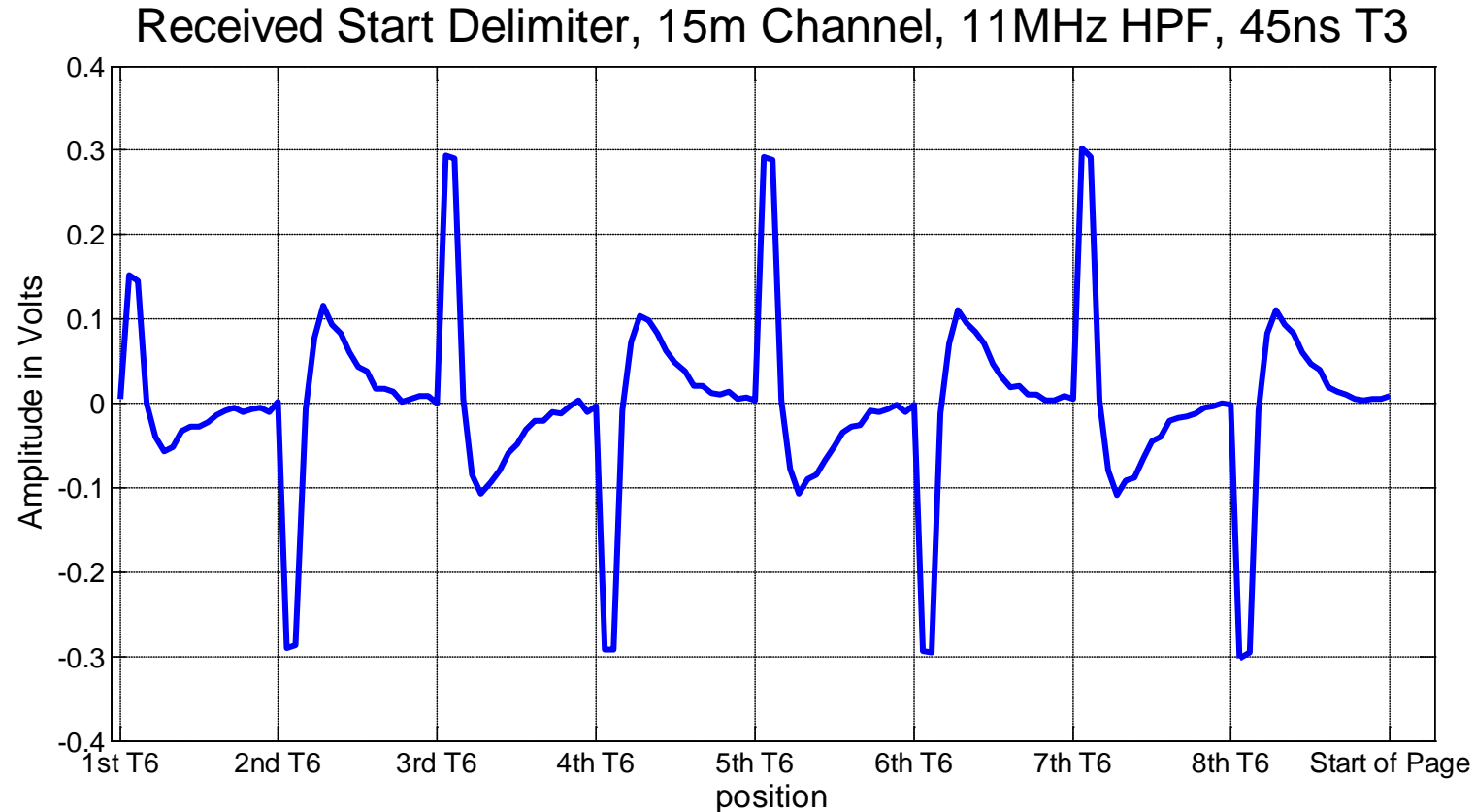
- How to Synchronize with this?
- Too much signal droop due to PoDL HPF
- Clearly, an improved preamble is required

Golay Sequences

- Golay sequences were proposed in 1961 [1] and have a number of interesting properties
  - Golay sequences have good aperiodic autocorrelation properties
  - Golay-26 is only 2 T3 longer than current 24xT3 preamble.

1. M. J. E. Golay, "Complementary Series", *IRE Transactions on Information Theory*, Vol 7, No. 2 (1961)

Proposed Preamble Sequence

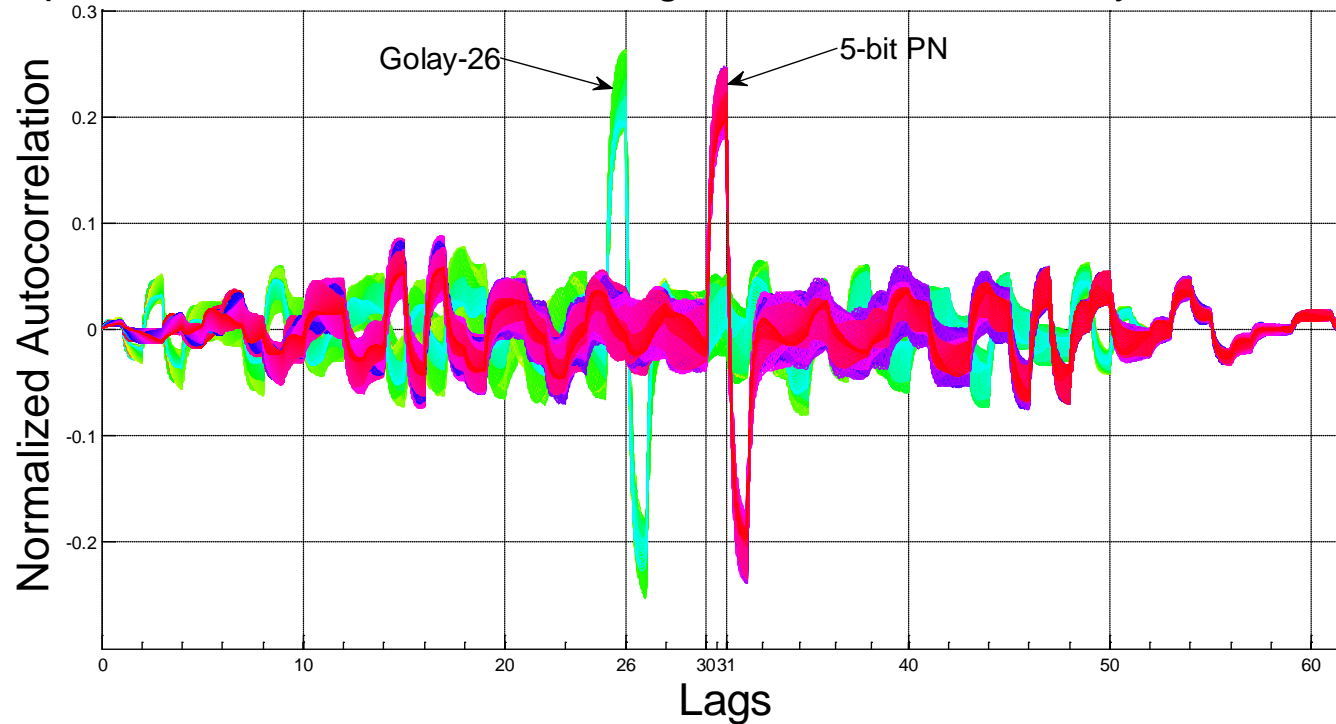Golay-26 Sequence For 1000BASE-T1 Preamble
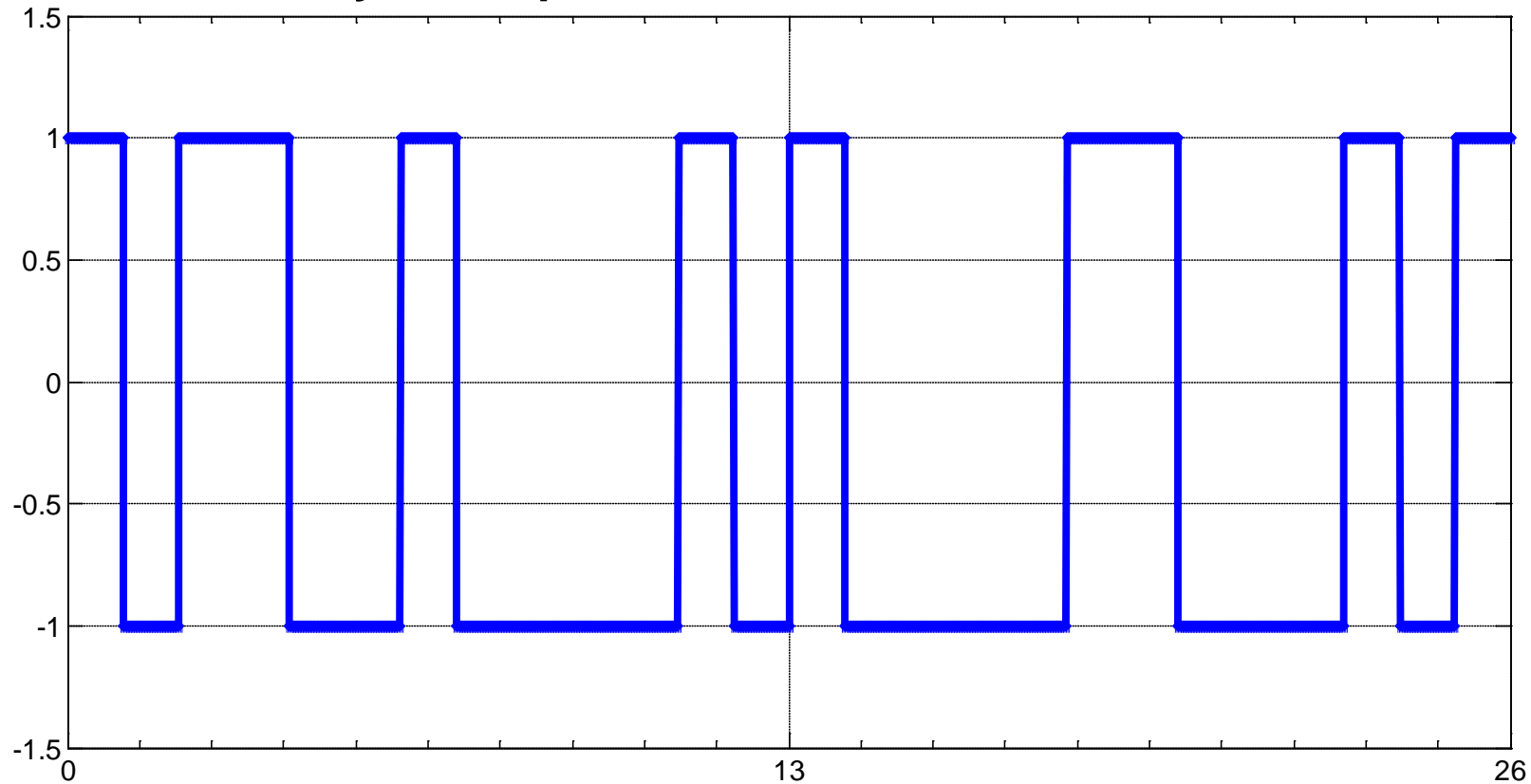
Golay-26 = [1 -1 1 1 -1 -1 1 -1 -1 -1 -1 1 -1 1 -1 -1 -1 -1 1 1 -1 -1 -1 1 -1 1]

Note: maximum sub-run length is 4
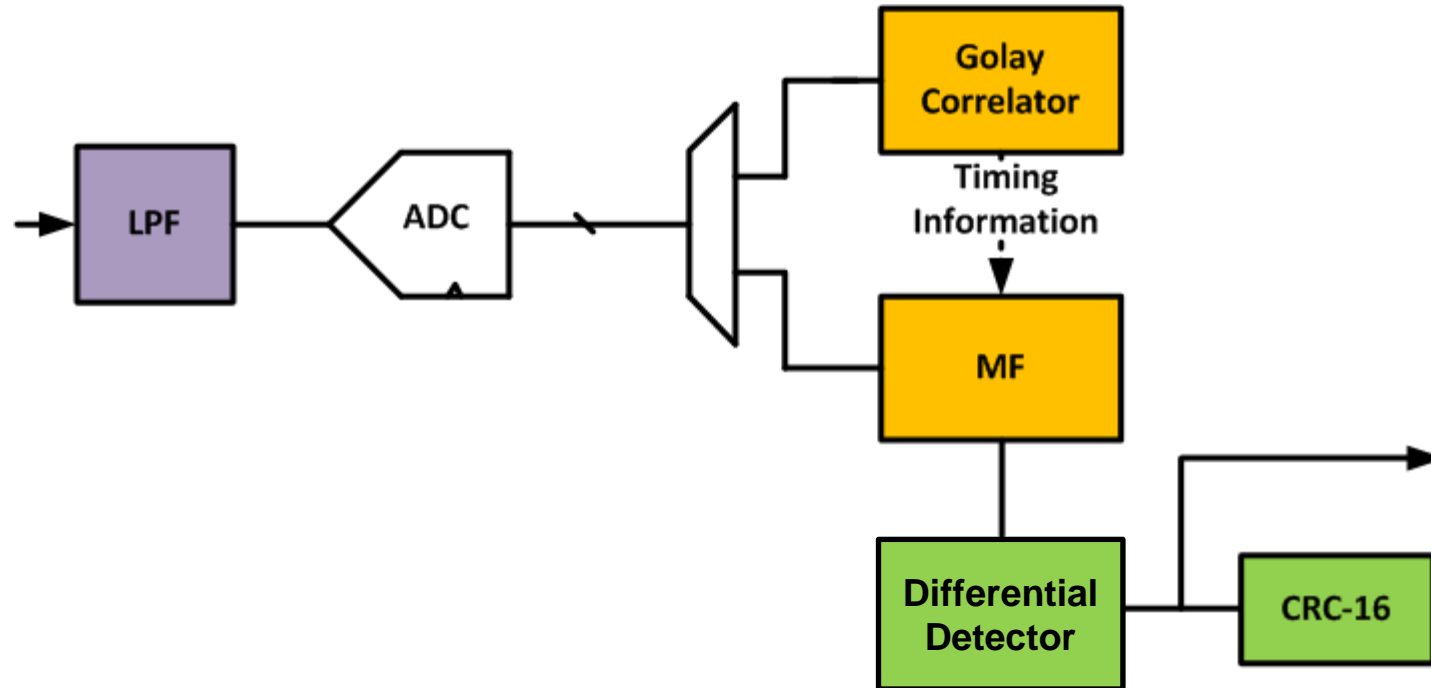
Autocorrelation: Golay-26 vs. PN-31

Aperiodic Autocorrelation With High Pass Distortion Golay-26 vs. 5-bit PN

- Simulation setup: HPF=11MHz, 400mVpp CW, random CW phase
  ➔ Golay-26 has better performance than PN-31.

# IMPROVEMENT #3: IMPROVED DETECTOR

Receiver Block Diagram

SIMULATION RESULTS

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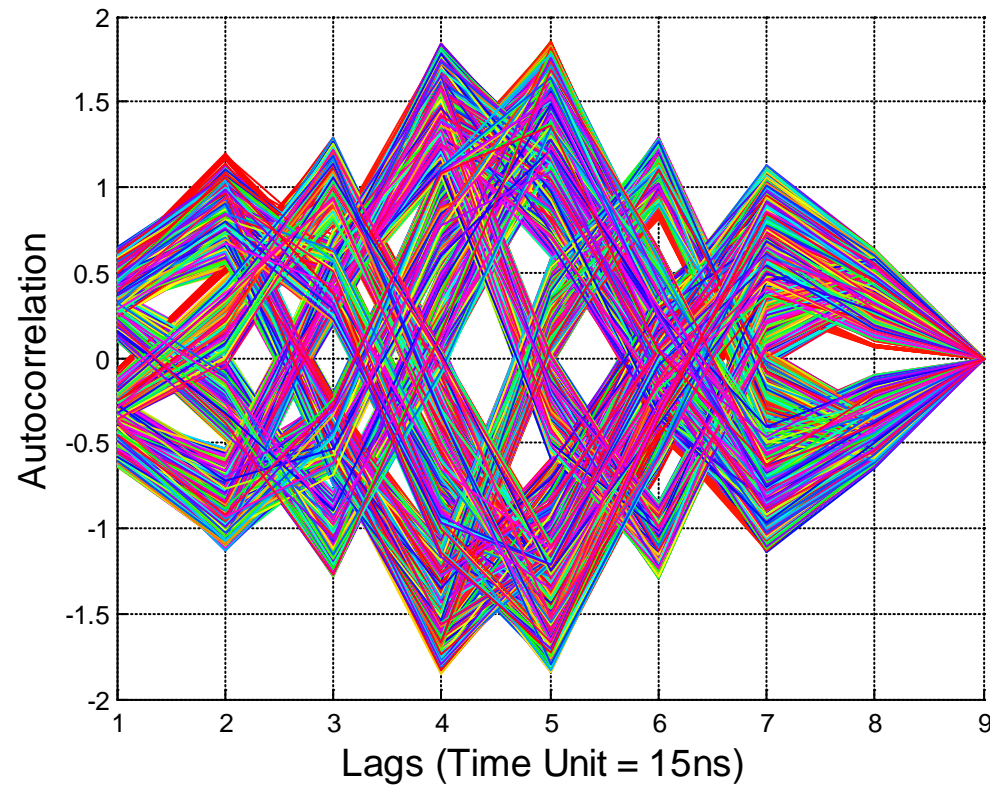
Simulation Setup

- 15m Channel model
- 1Vpp TX Amplitude
- 24dB SNR AWGN at RX
- T3 = 30 vs. 45nsec
- Packet:
  - Golay-26 Preamble
  - Random Payload
  - CRC-16
  - T6
- 1st order HPF
- PoDL HPF corner frequencies
  - 1MHz HPF
  - 11MHz HPF

- Random phase offset for DME
- Sweep CW Frequency
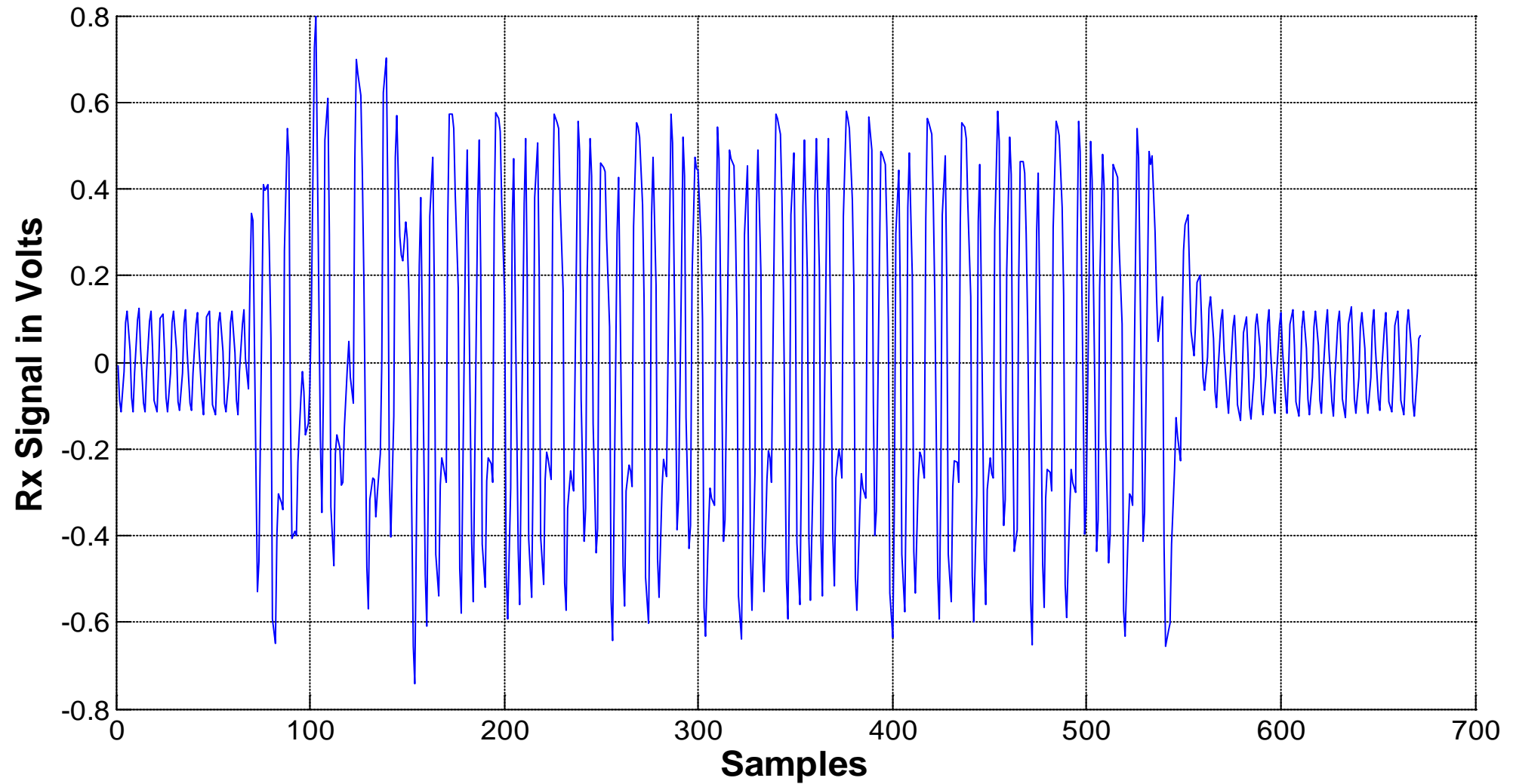- Random CW phases
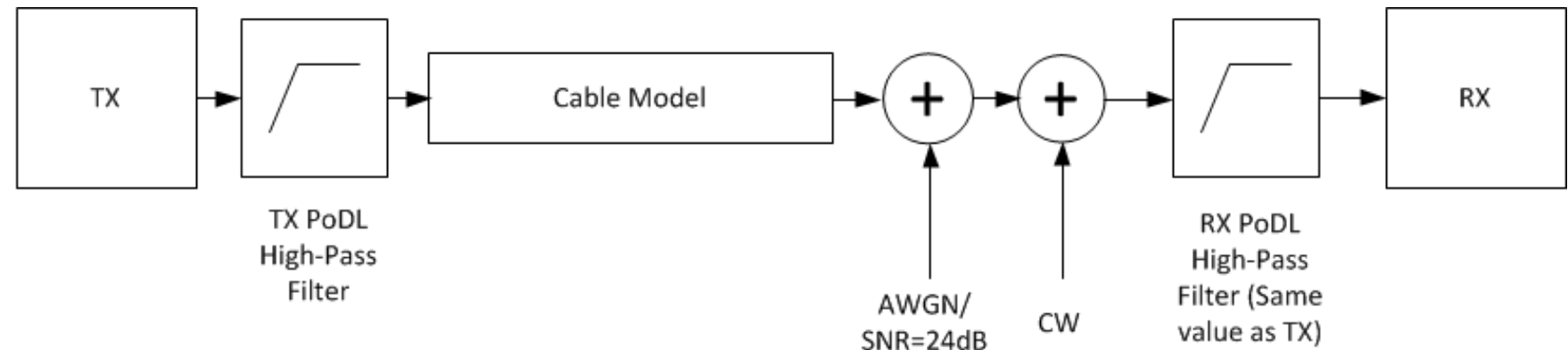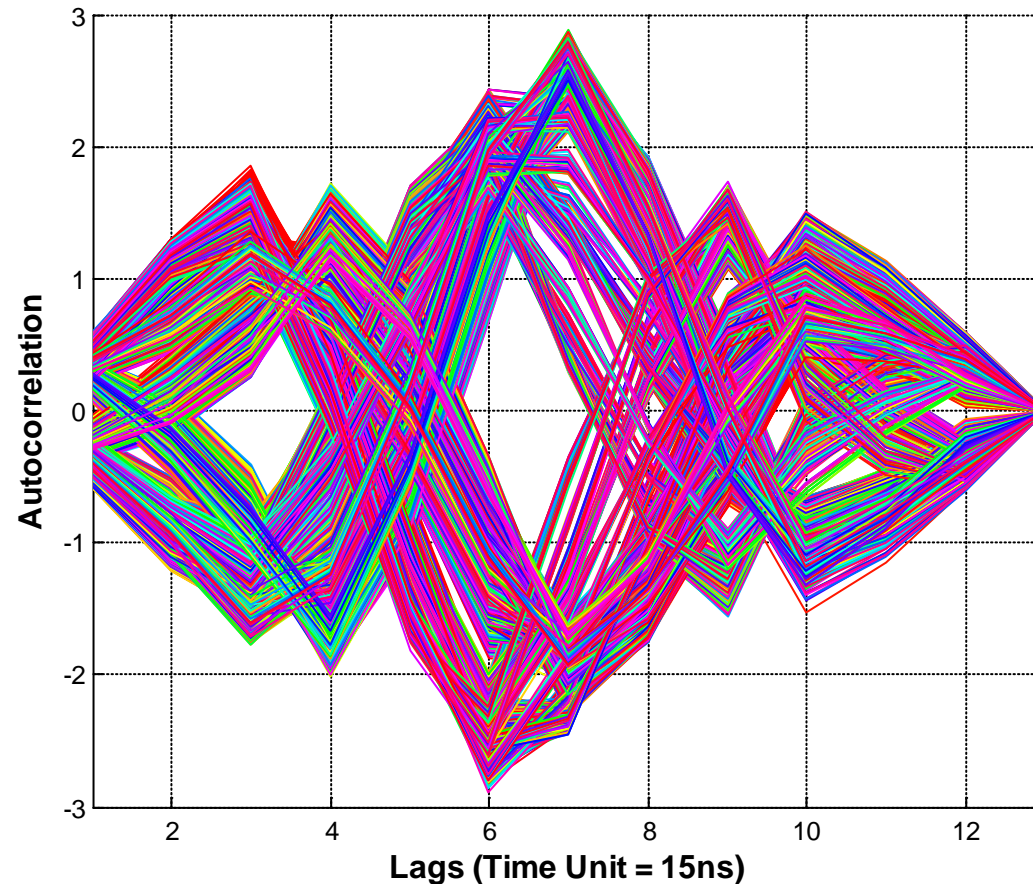
RX Signal: T3=30nsec
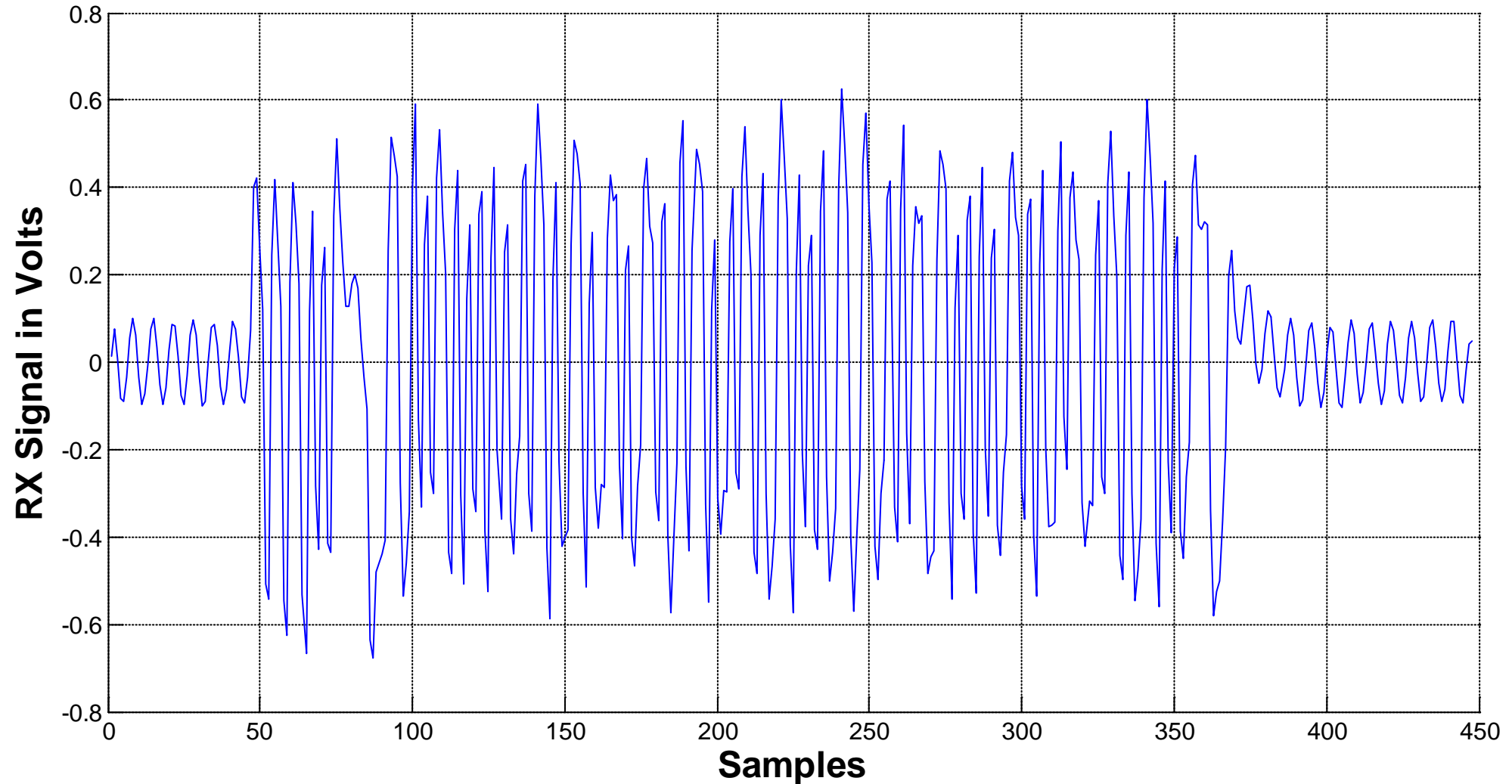
RX Eye Diagram: T3=30nsec

- Eye is narrower due to only 2x oversampling, unable to sample at optimal phase.
- Noise shown = 10MHz CW NBI @ 180mVpp + 24dB SNR AWGN

RX Signal: T3=45nsec

RX Eye Diagram: T3=45nsec

- Wider eye opening due to 3x oversampling.
- Noise shown = 11.11MHz CW NBI @ 250mVpp + 24dB SNR AWGN

Simulation Results with T3=30nsec

	1MHz HPF	11MHz HPF
NBI Sweep Range	1-66MHz	11-200MHz
NBI Tolerance	180mVpp	250mVpp

Simulation Results with T3=45nsec

	1MHz HPF	11MHz HPF
NBI Sweep Range	1-66MHz	11-200MHz
NBI Tolerance	250mVpp	300mVpp

- Over 200mVpp CW NBI tolerance

Conclusion

- Change T3 from 8nsec to 45nsec to allow interoperability and speed negotiation between 100BASE-T1 and 1000BASE-T1.

- Replace preamble from 8 T6 to Golay-26 preamble.

- NOTE: Increasing T3 from 8nsec to 45nsec will increase the expected auto-negotiation time by 5.6x which will take away from 100ms start-up time.