

A Physical Layer for 100 Mbits/s Ethernet over UTP CAT-5 Cable with 800m Range

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True Ethernet PHY

To be compatible with existing
copper Ethernet MAC



Target Installation Base

- PHY with up to 800 meters range can be used
 - From the fiber to the dwelling
 - Within multi-unit buildings
 - Within hospitals
 - Within Hotels
 - Inside home
- Copper is the preferred medium for mid-range data rates due to the lower cost and ease of installation and maintenance



Application Example 1 (LAX)

800m

Los Angeles International Airport

Tom Bradley International Terminal

- Aero California
- Aeroflot
- Air France
- Aer Lingus
- Air Pacific
- Alaska (INTL Flts)
- Alitalia
- ANA (All Nippon)
- AOM French Airlines
- Asiana
- British Airways
- Canada 3000
- Cathay Pacific
- China Airlines
- China Eastern
- Copa Airlines (Arv.)
- COBRAIR*
- EgyptAir
- El Al Israel
- EMA AIR
- Japan Airlines
- Korean Air
- LACSA
- LAN Chile
- Lufthansa
- Malaysia
- Martinair*
- Mexicana
- Oniz
- Philippine Airlines
- QANTAS
- Singapore
- Sun Country*
- TACA
- Thai
- Vang

PARKING LEGEND

- P Ticket Parking
- MP Metered Parking (1st floor/Arrivals)

*Seasonal & Charter Airlines

- ### Terminal 3
- Alaska Airlines
 - Frontier
 - Horizon
 - Midwest Express
 - American Airlines*
 - Spirit
 - TWA
 - *California routes
 - San Francisco/San Jose

- ### Terminal 2
- Air Canada/Canadian Airlines Int'l
 - Air China
 - Air Mobility Command
 - Air New Zealand
 - Allegro-Airlines*
 - American Trans Air
 - Avianca
 - Hawaiian Air
 - KLM
 - Miami Air*
 - Northwest
 - Skyservice* (Ryan Int'l)
 - Virgin Atlantic
 - World* (AMC)

PARKING LEGEND

- A Airline Connections
- B Parking Lot B (111th & La Cienega)
- C Parking Lot C (96th & Sepulveda)

Metro Green Line Train (111th & La Cienega)

- ### Terminal 1
- America West
 - Southwest
 - US Airways

- ### Terminal 4
- American Airlines
 - American Eagle

- ### Terminal 5
- Aeromexico
 - Air Jamaica
 - Air Tahiti Nui
 - China Southern
 - Delta
 - Legend
 - Swissair

- ### Terminal 6
- Continental Airlines
 - Copa Airlines (Dep.)
 - National Airlines
 - Skyswest (United Express)
 - United (Int'l Non-Stop)

- ### Terminal 7
- United
 - United/Shuttle
 - United Express

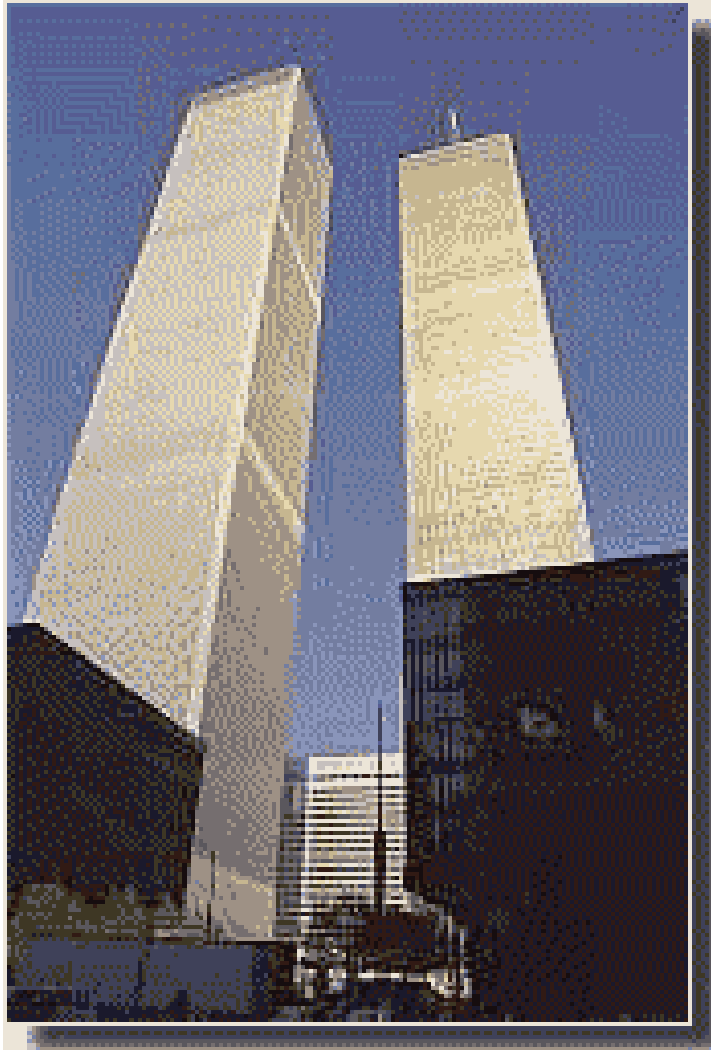
- ### Terminal 8
- United/Shuttle

AUGUST 2000 AIRLINE LOCATIONS

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Application Example 2 (WTC-NYC)



450m



Performance for Proposed PHYs

- 100 Mbits/s is sufficient for many applications (e.g., HDTV, SDTV, digital telephone, internet, etc.) and it is the most widely used Ethernet speed (100BASE-TX)
- Propose a 100 Mbits/s PHY over 4 pairs of CAT-5 cable for range of 800 meters (half a mile)
 - Up to 1000 meters can be demonstrated using existing components
 - Refer to this proposed PHY as 100C5



Modulation Scheme

- Coding/modulation scheme identical to 1000BATE-T
- Throughput at 10 times lower speed
 - Clock rate of 12.5 MHz
- No major implementation problems due to speed or power
- Can be implemented using ASIC methodology
- A proven modulation scheme



Comparison with other Copper Standards

Ethernet Scheme	Data Rate (Mbits/s) /Nyquist Frequency (MHz)	Distance Target (m)	Cabling	Coding / Modulation	Voltage Swing (V)
10BASE-T	10 / 10	≥100	2 pairs CAT-3 or better (simplex)	Manchester Coding	±2.5
100BASE-TX	100 / 62.5	≥100	2 pairs CAT-3 or better (simplex)	4B/5B PAM-3	±1
1000BASE-T	1000 / 62.5	≥100	4 pairs CAT-5 (duplex)	TCM PAM-5	±1
100C5 (CAT-5)	100 / 6.25	≥800 (~1000)	4 pairs CAT-5 (duplex)	TCM PAM-5	±1

**8 dB lower transmission power than 10BASE-T
meets FCC radiation restrictions**



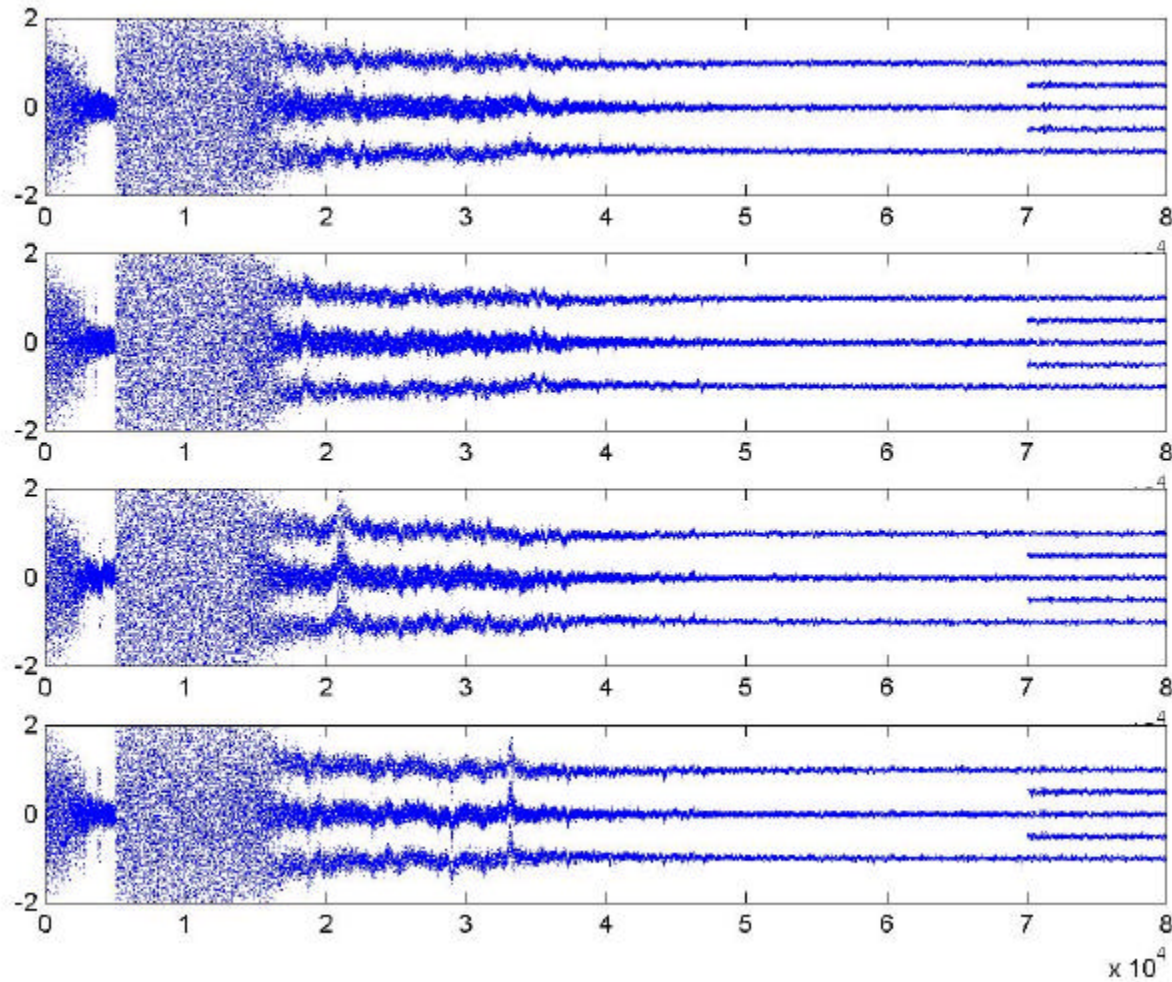
Simulation Models for CAT-5

- ANSI T1.417 CAT-5 cable transfer function model
- TIA/EIA-TSB-95 return loss (echo) model
- TIA/EIA-568-A NEXT model
- TIA/EIA-TSB-95 ELFEXT model
- ANSI T1.417 CAT-5 cable AWGN model



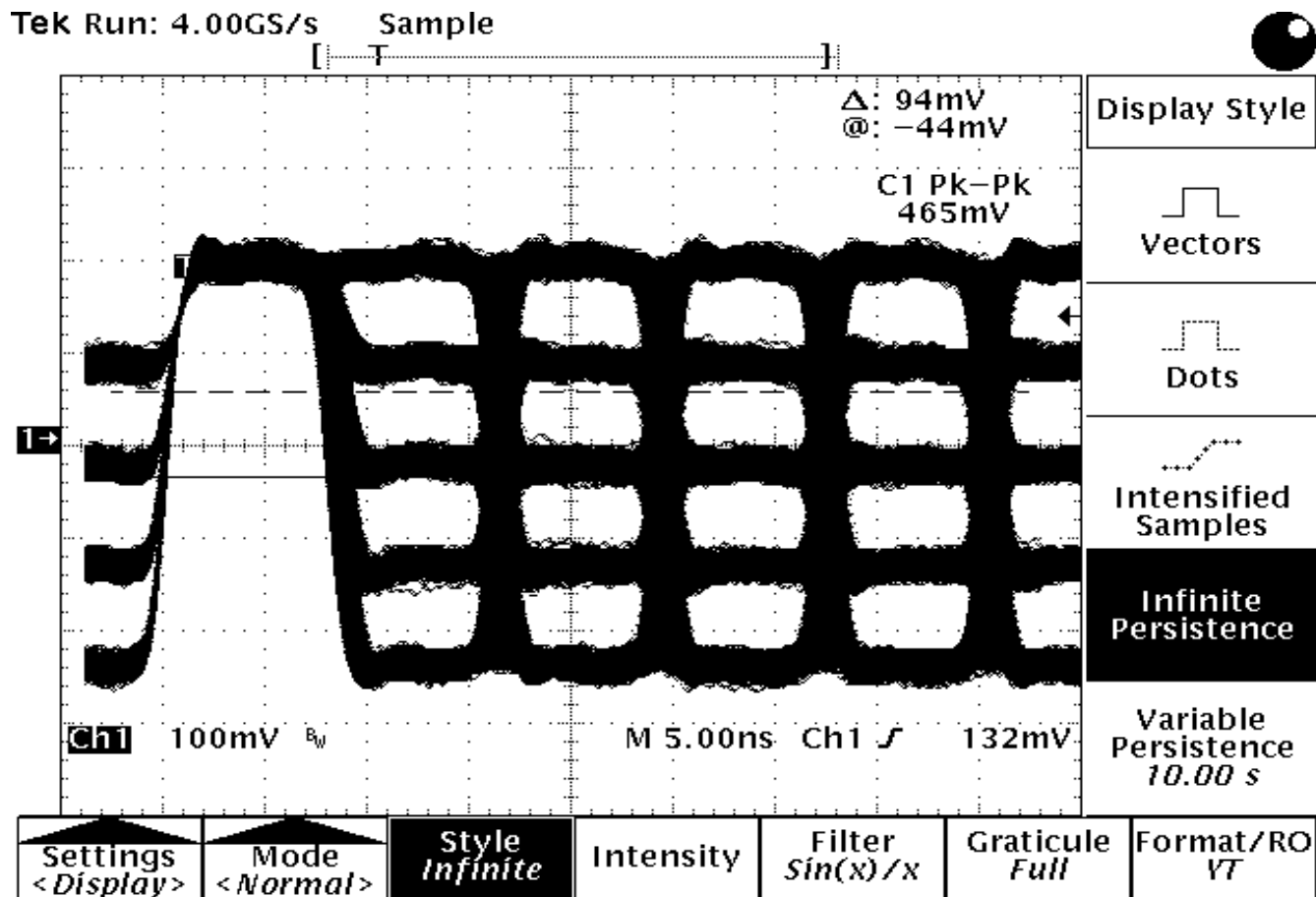
Simulated 1000BASE-T Eye Diagram

100m CAT-5 cable

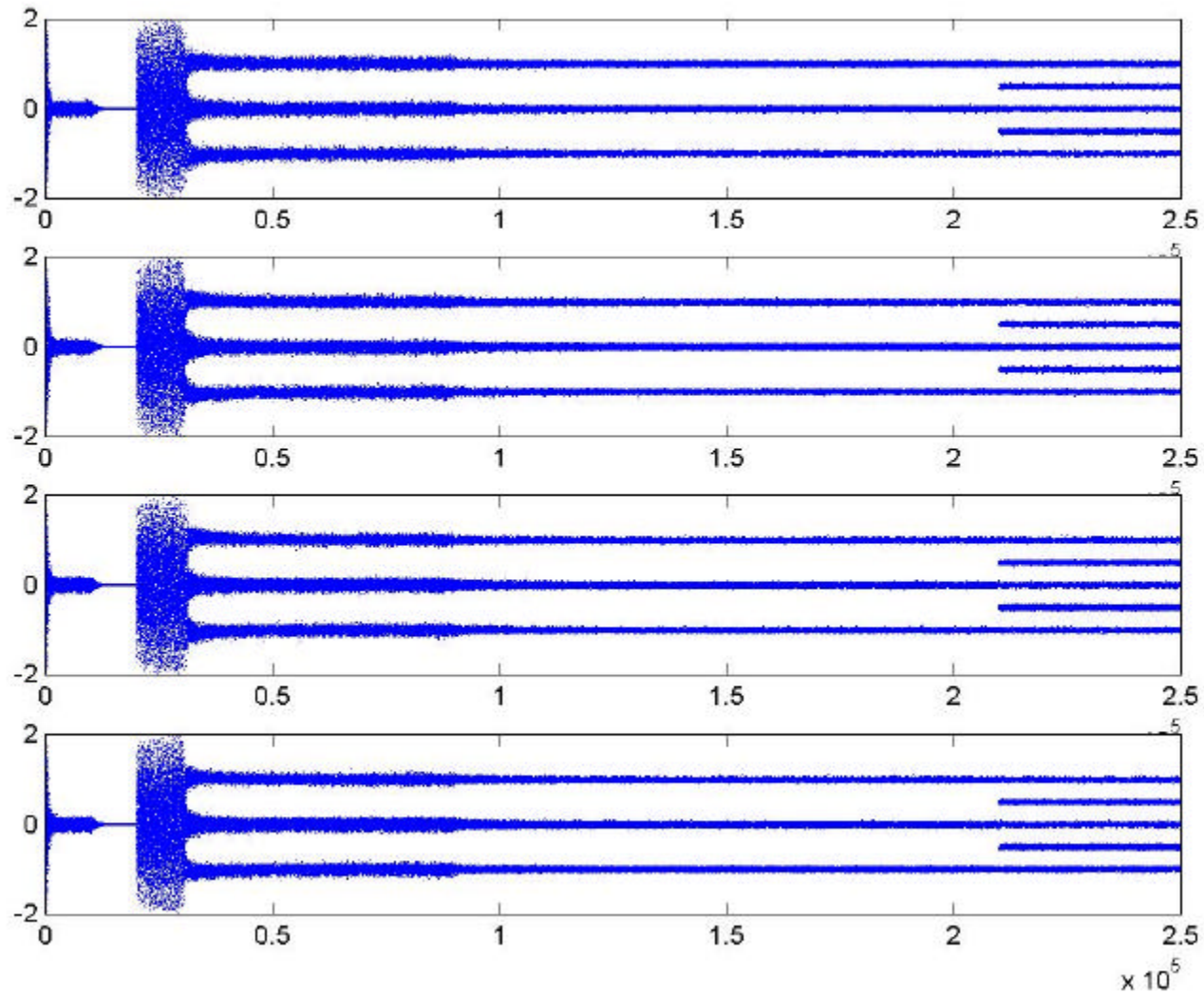


Measured 100BASE-T Eye Diagram

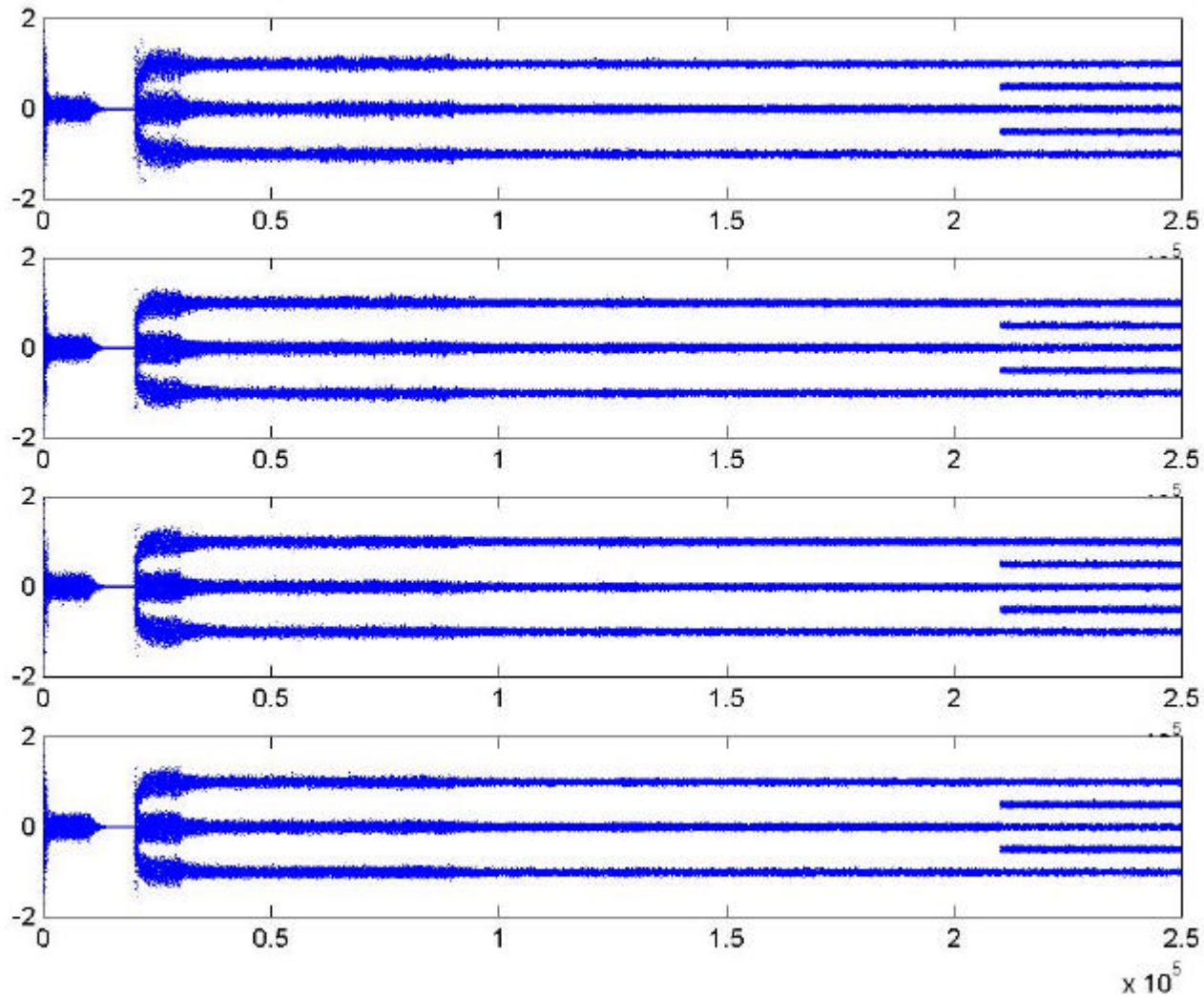
100 m CAT-5 cable



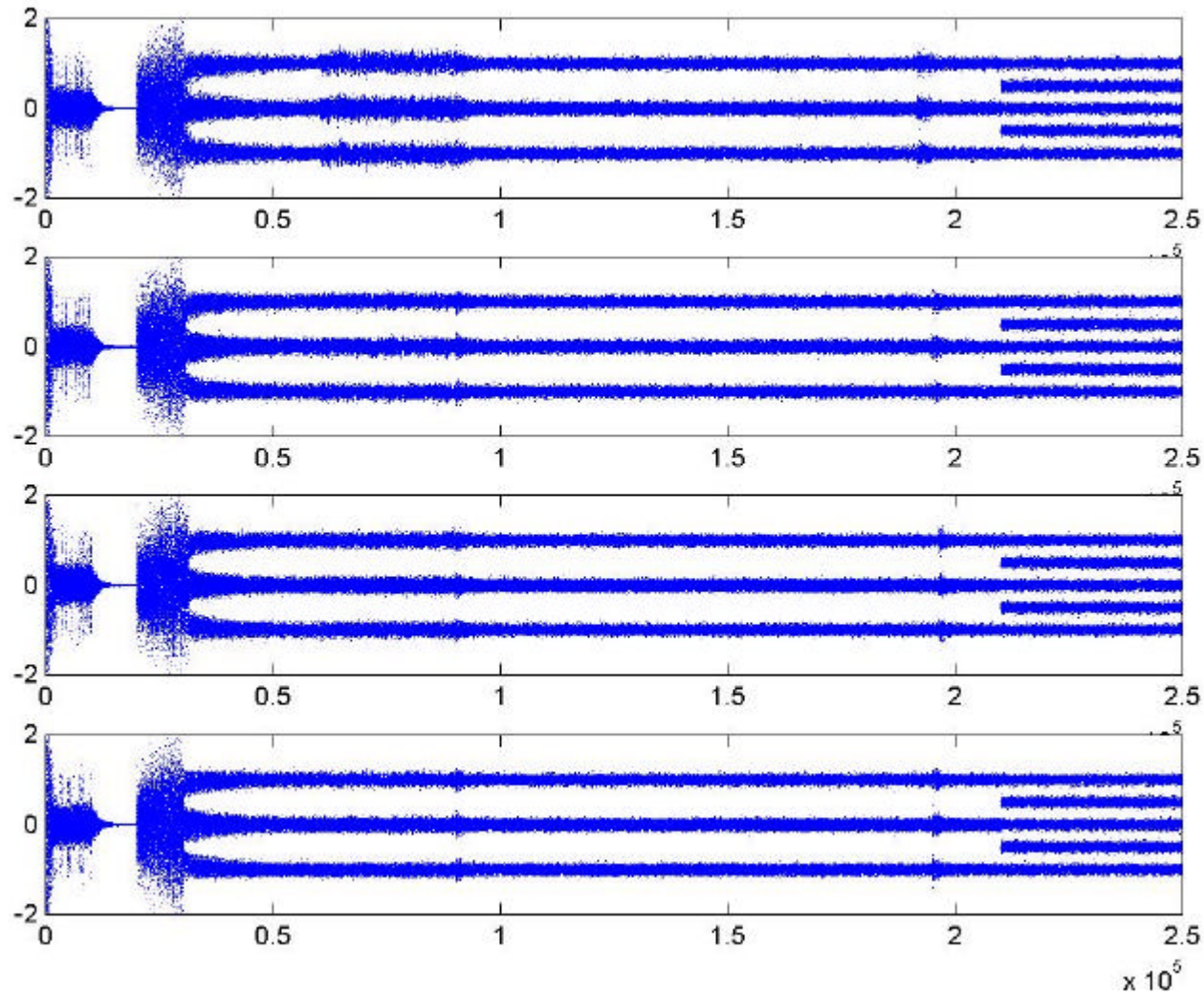
Eye Diagram of 100C5 over 600m CAT-5



Eye Diagram of 100C5 over 800m CAT-5



Eye Diagram of 100C5 over 1km CAT-5



Easy Migration from 100BASE-T to 100C5

- Same CAT-5 cable
- Same TCM scheme (rate 8/9)
- Same transmit power ($\pm 1V$)
- Same receiver architecture
- Same duplex mode
- Ethernet MAC @ 100Mb/s

- Lower data rate (100Mbits/s)
 - Lower circuit speed, better performance
 - Higher ADC resolution (10+ bits)
- Longer transmission distance ($\geq 800m$, $\sim 1km$)
- Lower FEXT
- Lower radiation than 100BASE-TX



Summary of 100C5 Proposal

- Feasibility of 100 Mbit/s over UTP CAT-5 verified by simulation using standardized models
- No change to Ethernet MAC
- Very similar to existing 802.3ab standard
 - Much lower speed (10 times)
 - Low cost and power
- Data rate that supports speed critical applications

