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Two Long Range PHYs for 100 Mbits/s Ethernet over CAT-5 and CAT-3 Cables

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True Ethernet PHY

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To be compatible with existing
Copper Ethernet MAC

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Target Installation Base

- PHY with several hundreds of 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 due to lower cost and ease of installation and maintenance

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Performance for Proposed PHYs

- 100 Mbits/s is sufficient for many applications and it is also a true Ethernet speed (100BASE-TX)

- Propose a 100 Mbits/s PHY over 4 pairs of CAT-5 cable for range of 400+ meters (refer to 100C5 for the rest of this document)
  - 600 meters can be demonstrated using existing components

- Propose a 100 Mbits/s PHY over one pair of CAT-3 cable for range of 150+ meters(refer to 100C3 from this point on)
  - 200 meters can be demonstrated using existing components

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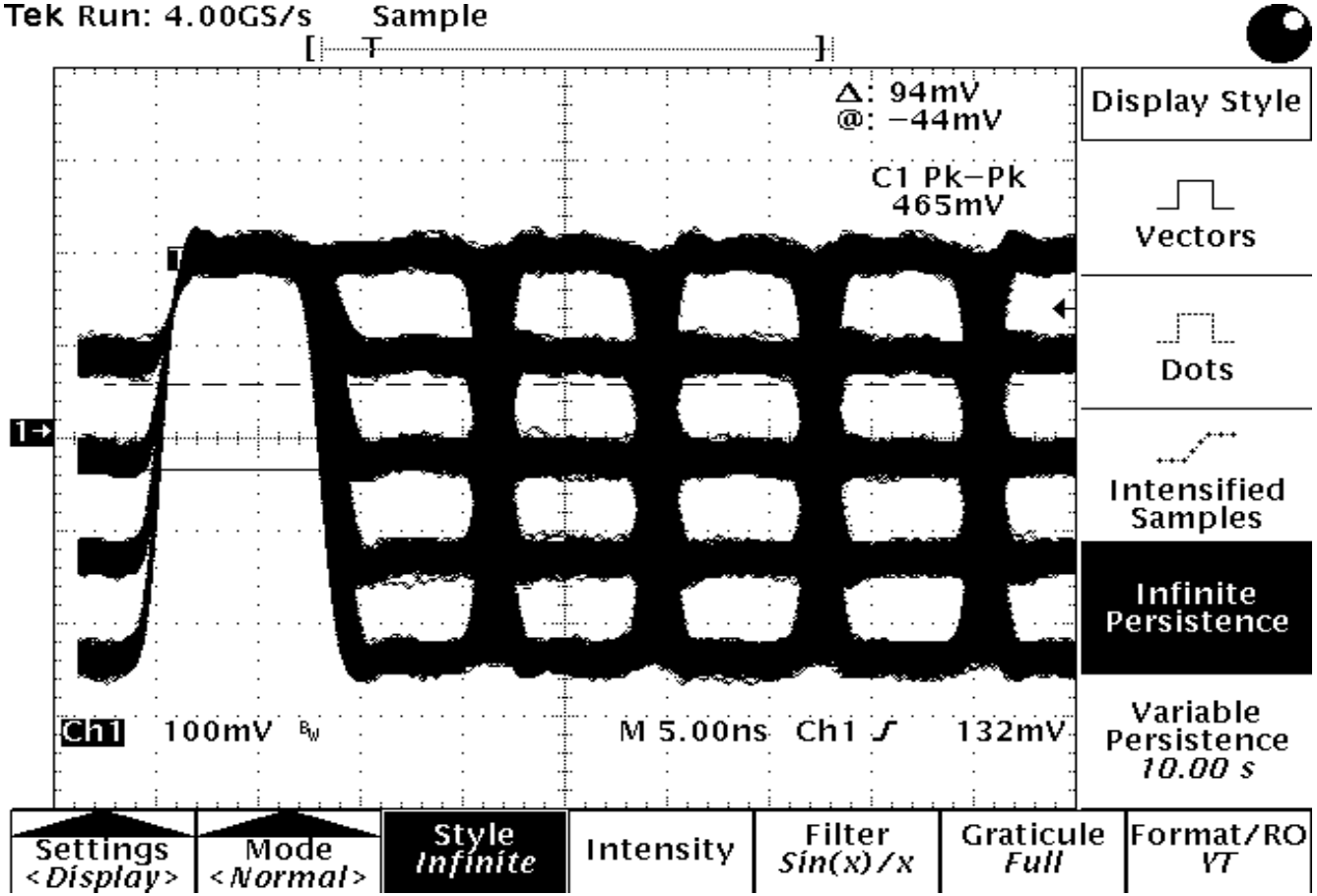
Modulation Scheme

- Modulation scheme identical to 1000BATE-T
- Throughput at 10 times lower speed
  - Clock rate of 12.5 MHz for 100C5
  - Clock rate of 50 MHz for 100C3
- No major implementation problems due to speed or power
- Can be implemented using ASIC methodology
- A proven modulation scheme

Measured 1000BASE-T Eye Diagram

100 m CAT-5 cable



Measured 1000BASE-T Eye Diagram

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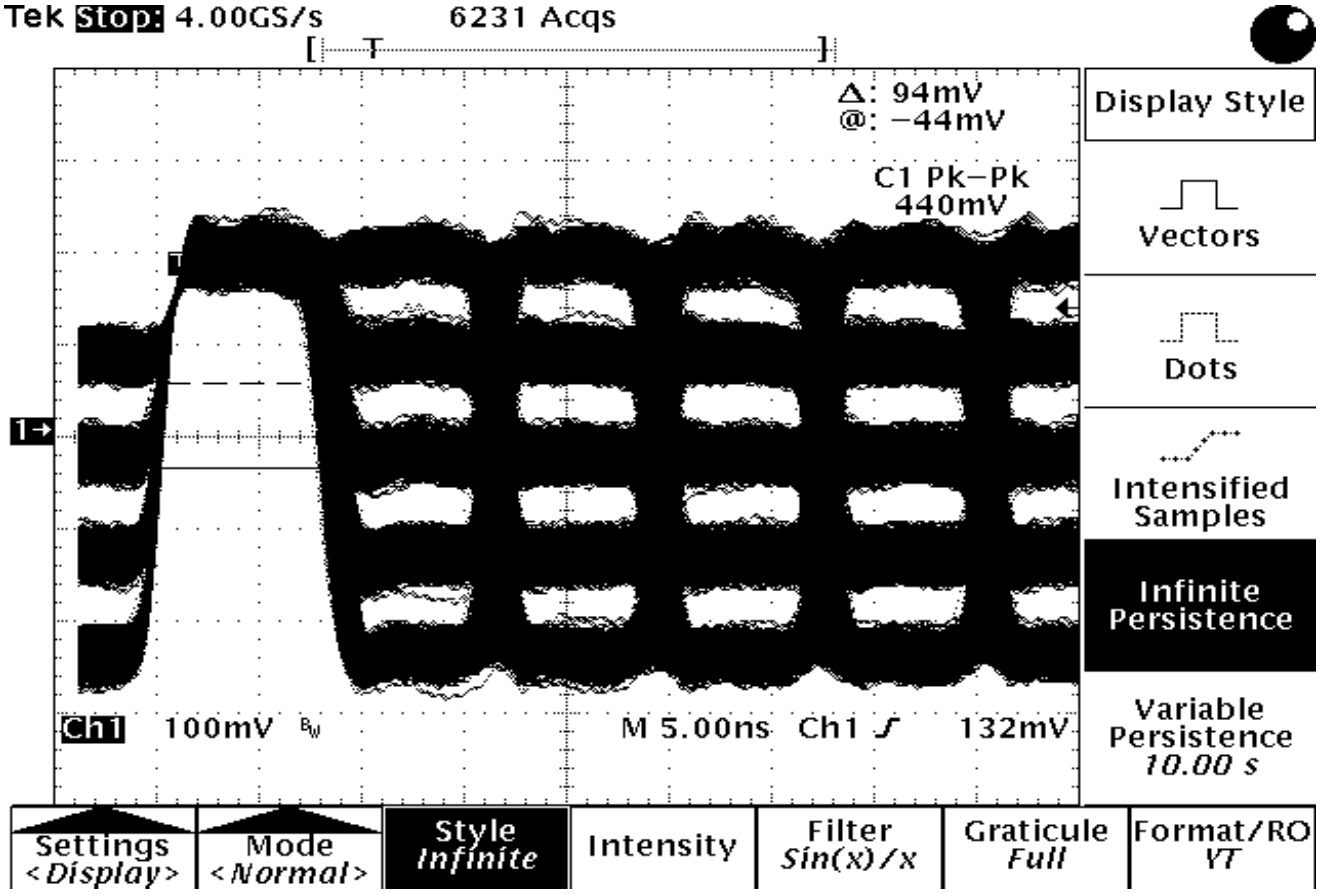
170 m CAT-5 cable



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Comparison with other Copper Standards

Ethernet Scheme	Data Rate (Mbits/s) /Nyquest 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)	8B10B PAM-3	±1
1000BASE-T	1000 / 62.5	>=100	4 pairs CAT-5 (duplex)	TCM PAM-5	±1
100C5 (CAT-5)	**100 / 6.25**	**>=400 (>=600)**	**4 pairs CAT-5 (duplex)**	**TCM PAM-5**	**±1**
100C3 (CAT-3)	**100 / 25**	**>=150 (>=200)**	**1 pair 26AWG (duplex)**	**TCM PAM-5**	**±1**

No issue with FCC radiation restrictions

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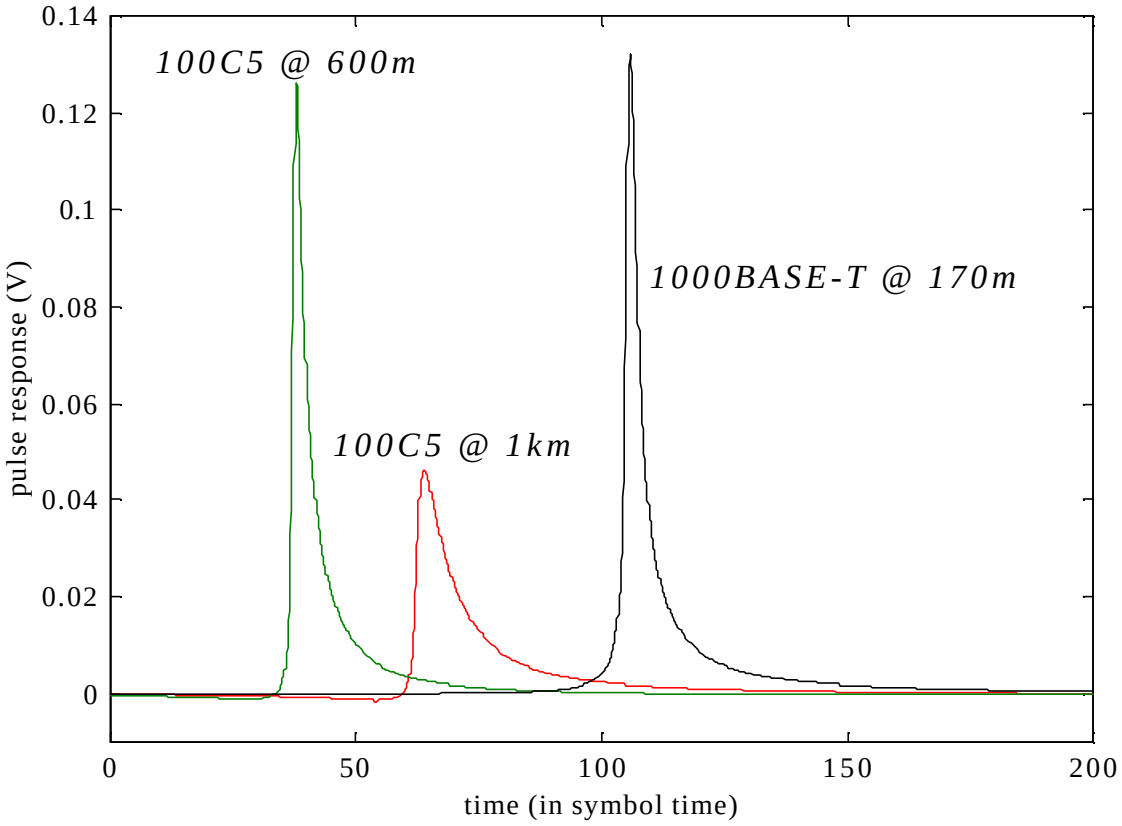
Pulse Response of CAT-5 Cable



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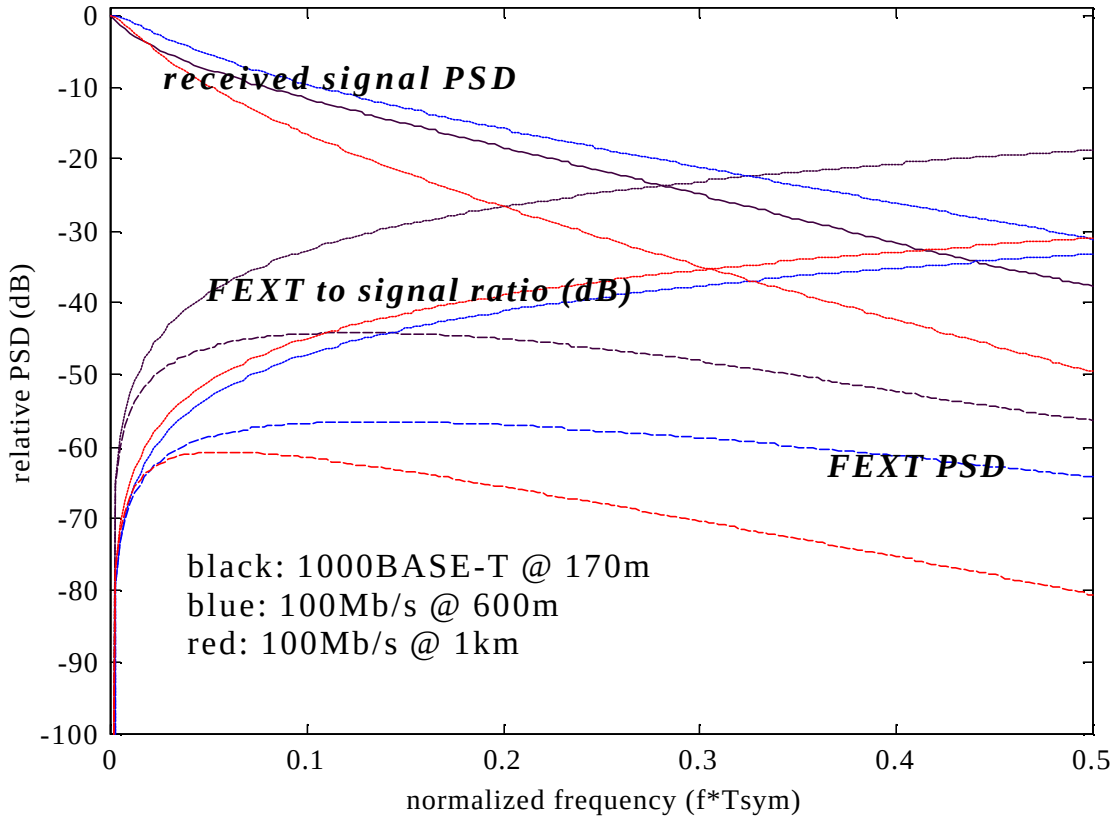
Comparison of PSDs (CAT-5)



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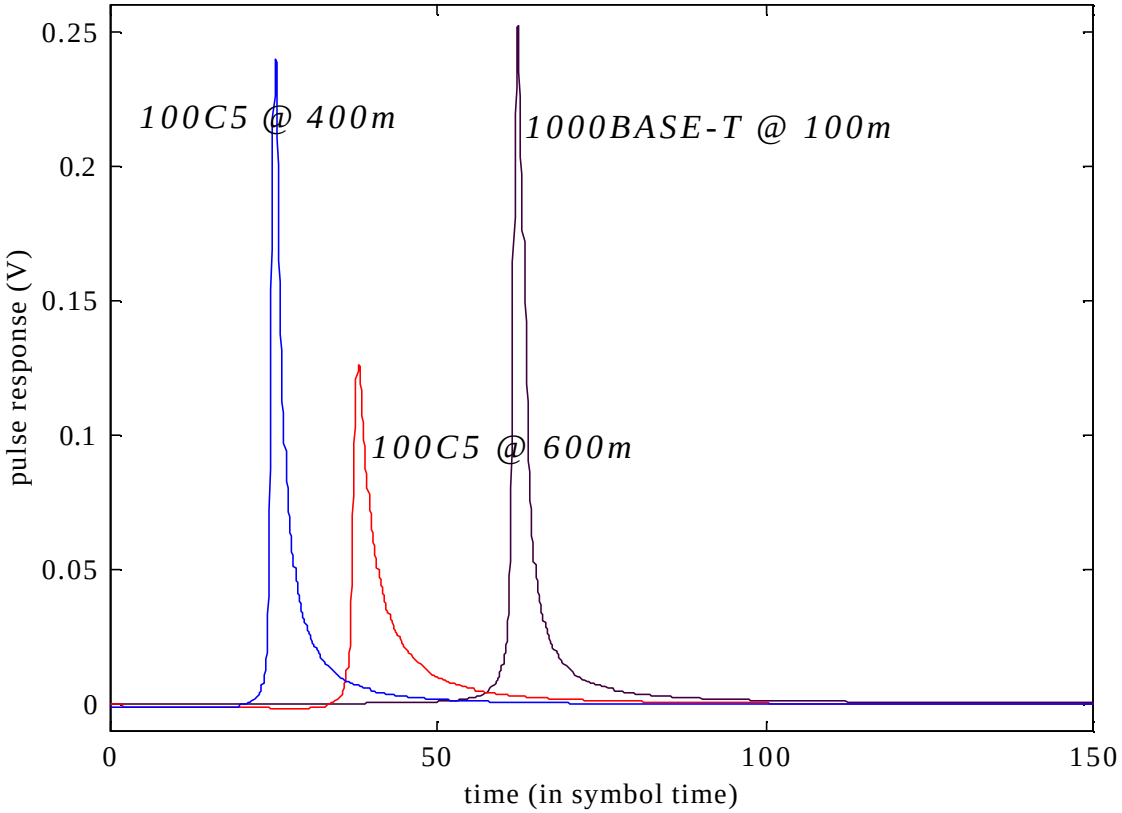
Pulse Response of CAT-5 Cable



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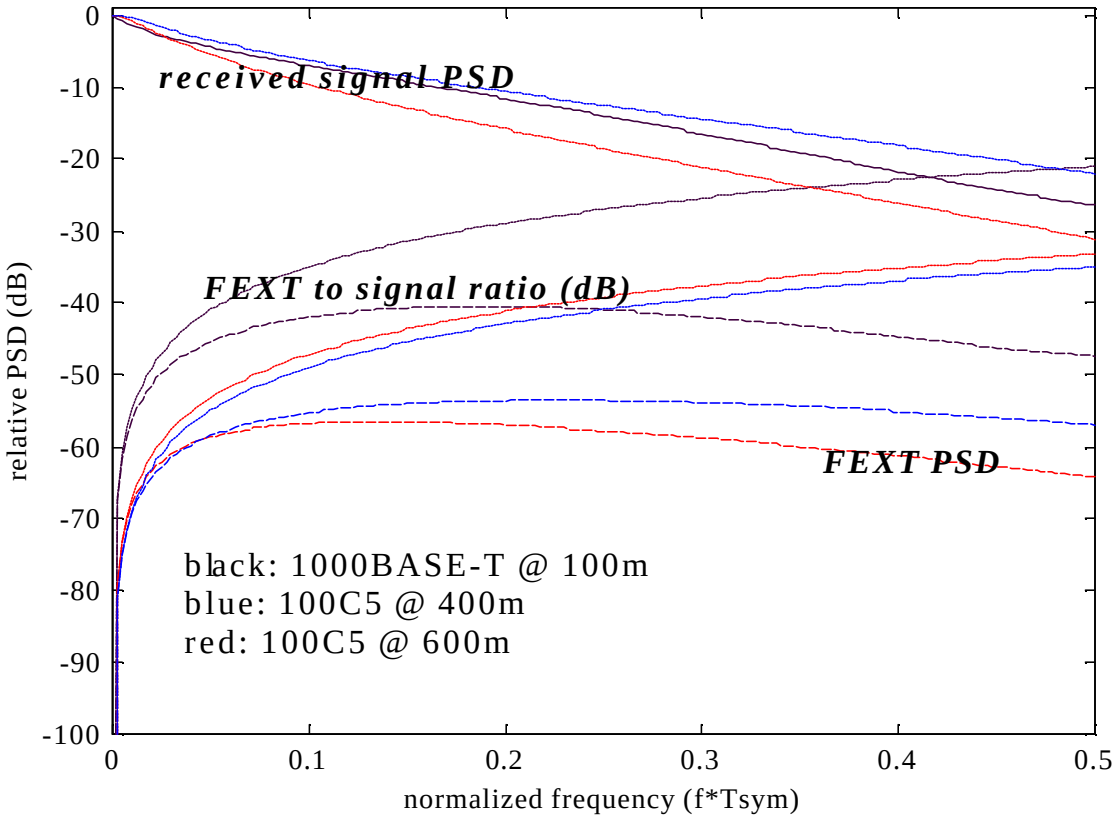
Comparison of PSDs (CAT-5)



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From 1000BASE-T to 100 Mb/s over CAT-5

- Same CAT-5 cable
- Same TCM scheme
- Same transmit power (± 1V)
- Same receiver architecture
- Same duplex mode
- 100BASE-TX MAC

- Lower data rate (100Mbits/s)
  - Lower circuit speed, better performance
  - Higher ADC resolution (10+ bits)
- Longer transmission distance (>400m, ~600m ?)
- Lower FEXT
- Lower radiation than 100BASE-TX

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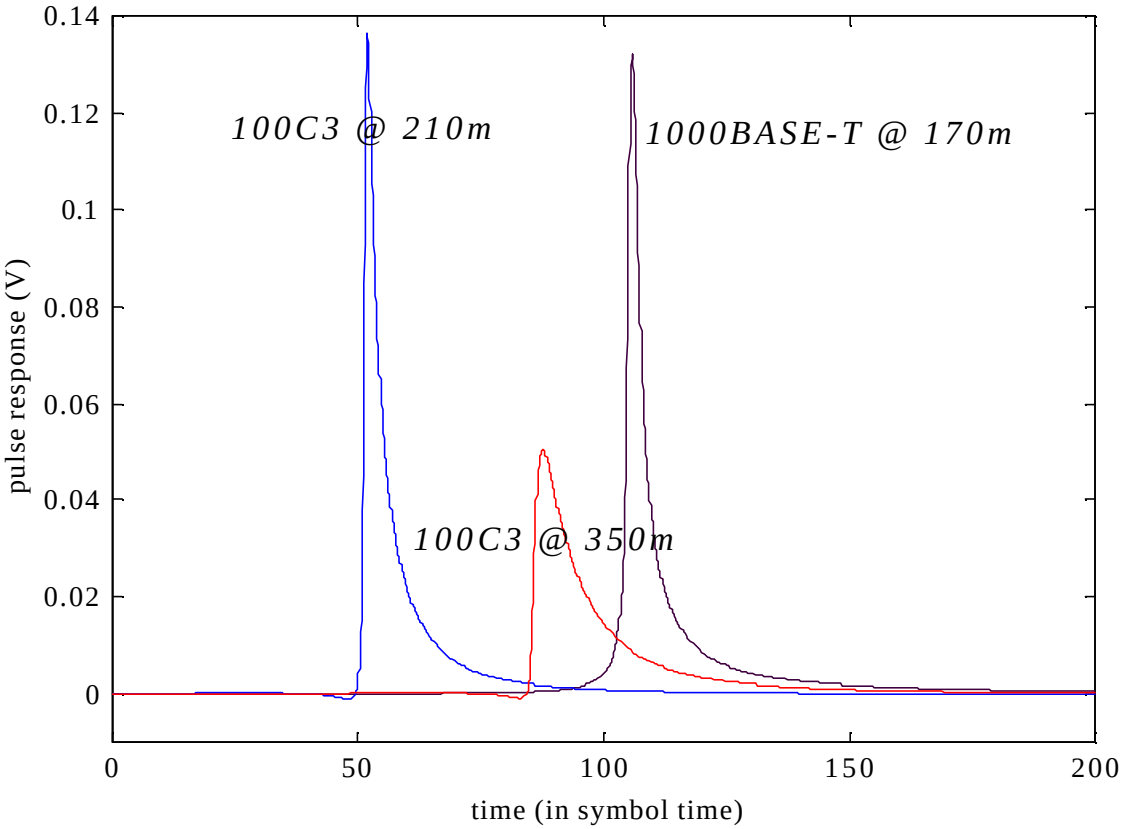
Pulse Response of CAT-3 (26AWG) Cable



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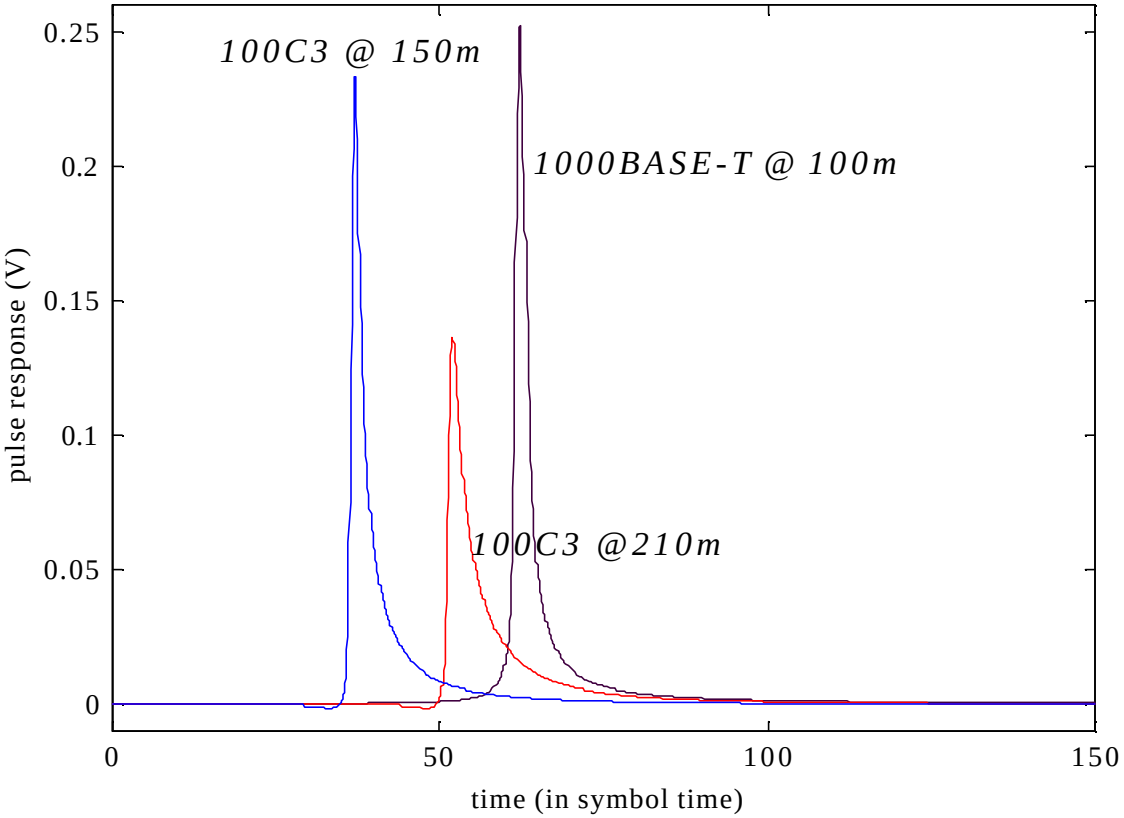
Pulse Response of CAT-3 (26AWG) Cable



From 1000BASE-T to 100Mbits/s over CAT-3

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- Similar TCM scheme (with 6dB coding gain)
- Same transmit power (± 1V)
- Similar receiver architecture
- Same duplex mode
- 100BASE-TX MAC
- Same PHY except of the TCM scheme

- Only one CAT-3 cable
- Lower data rate (100Mbits/s)
  - Lower circuit speed, better performance
  - Higher ADC resolution (10+ bits)
- Longer transmission distance (> 150m, ~200m ?)
- Lower radiation than 100BASE-TX