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Gigabit Ethernet
Over Category 5

Fanny Mlinarsky

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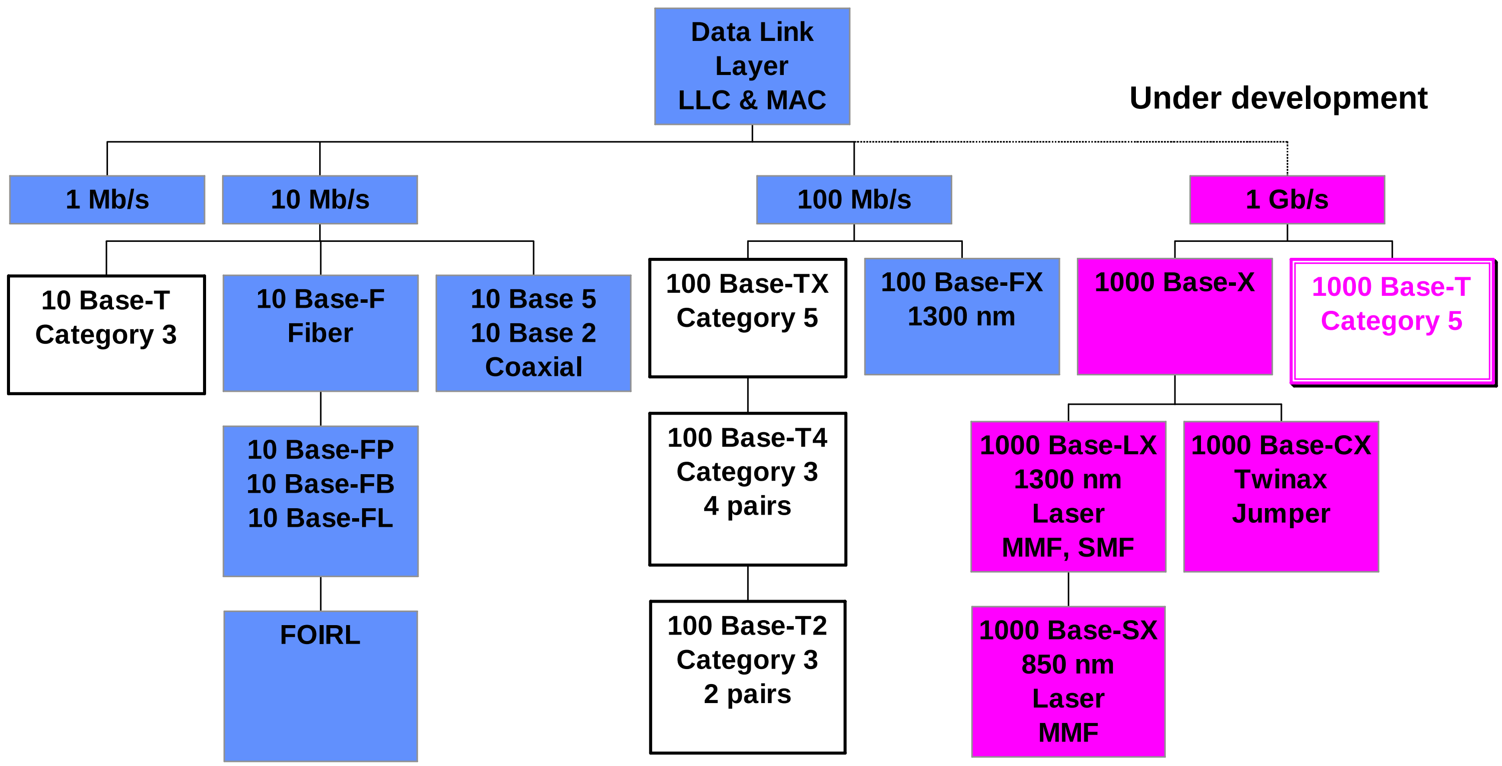
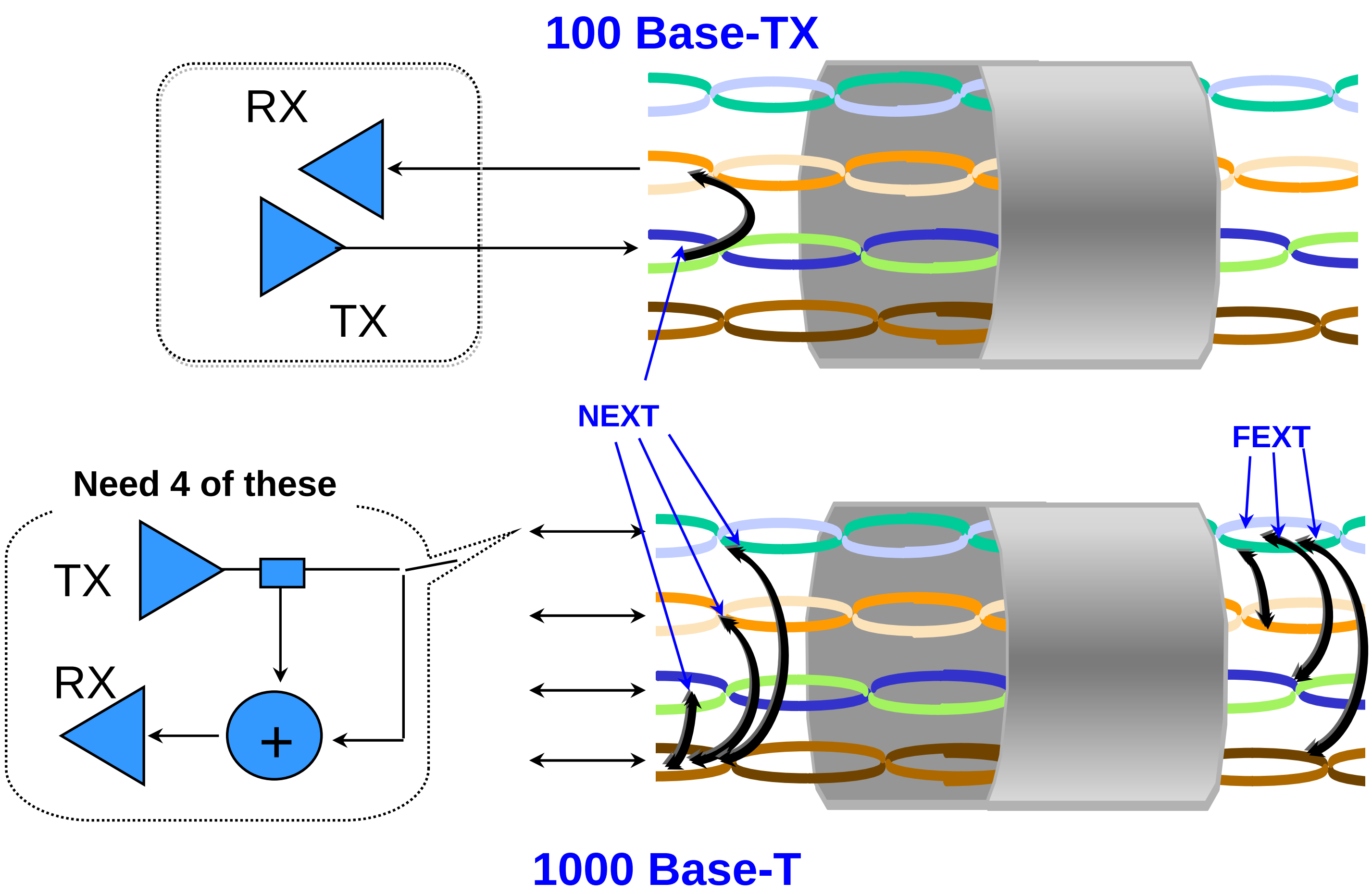
Organization of IEEE 802.3 Standards



100 Base-T vs. 1000 Base-T



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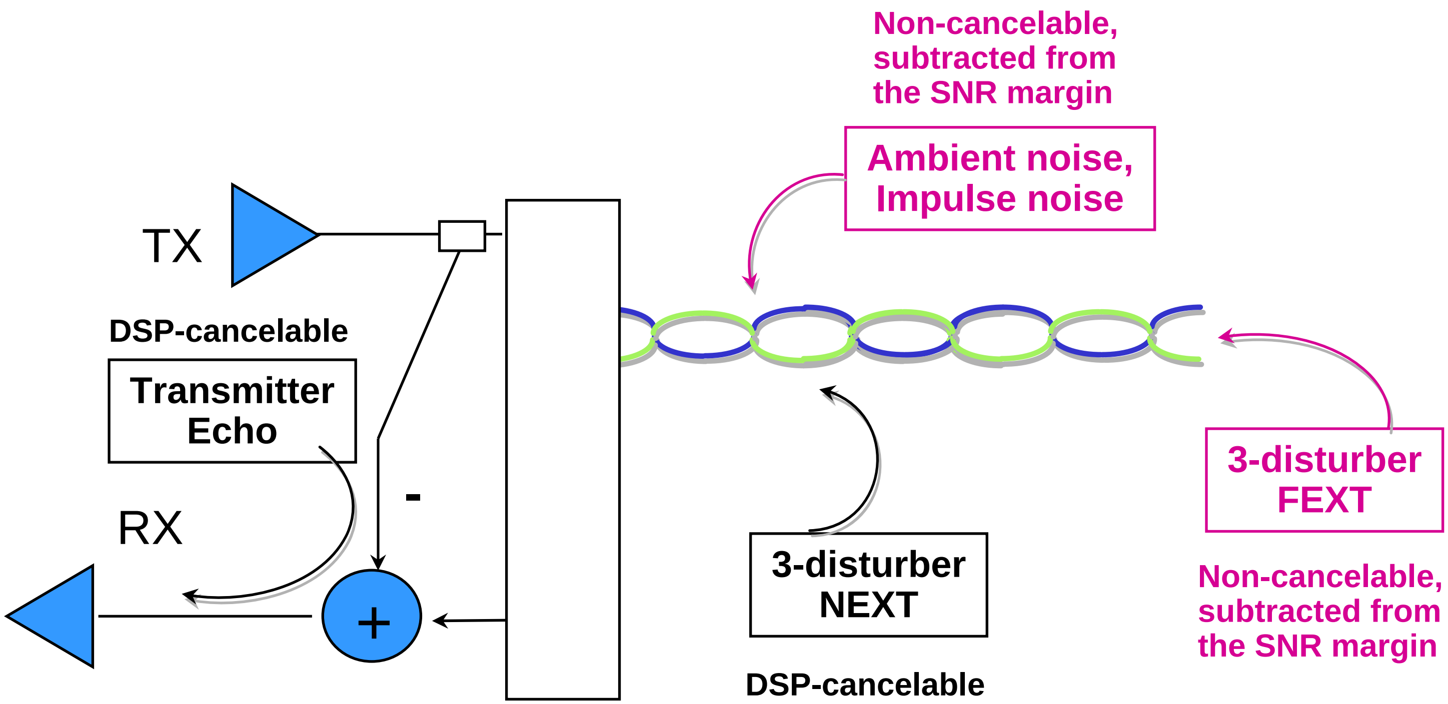
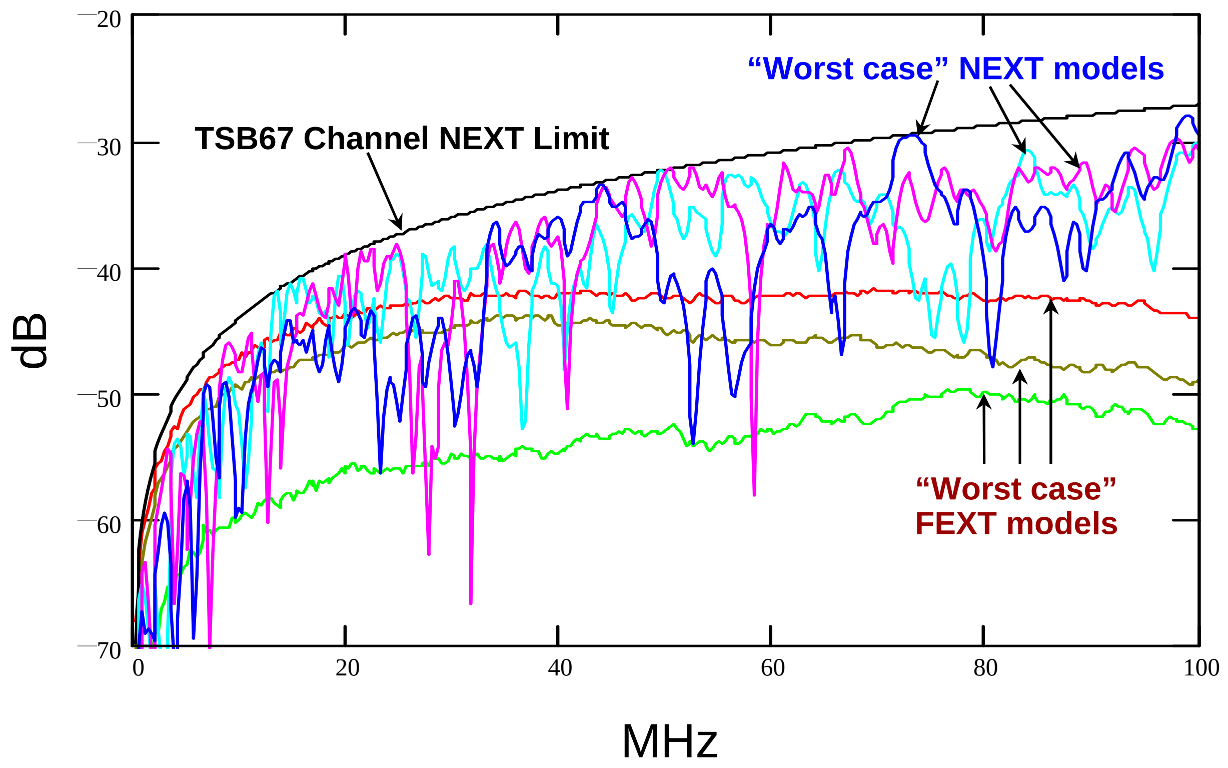
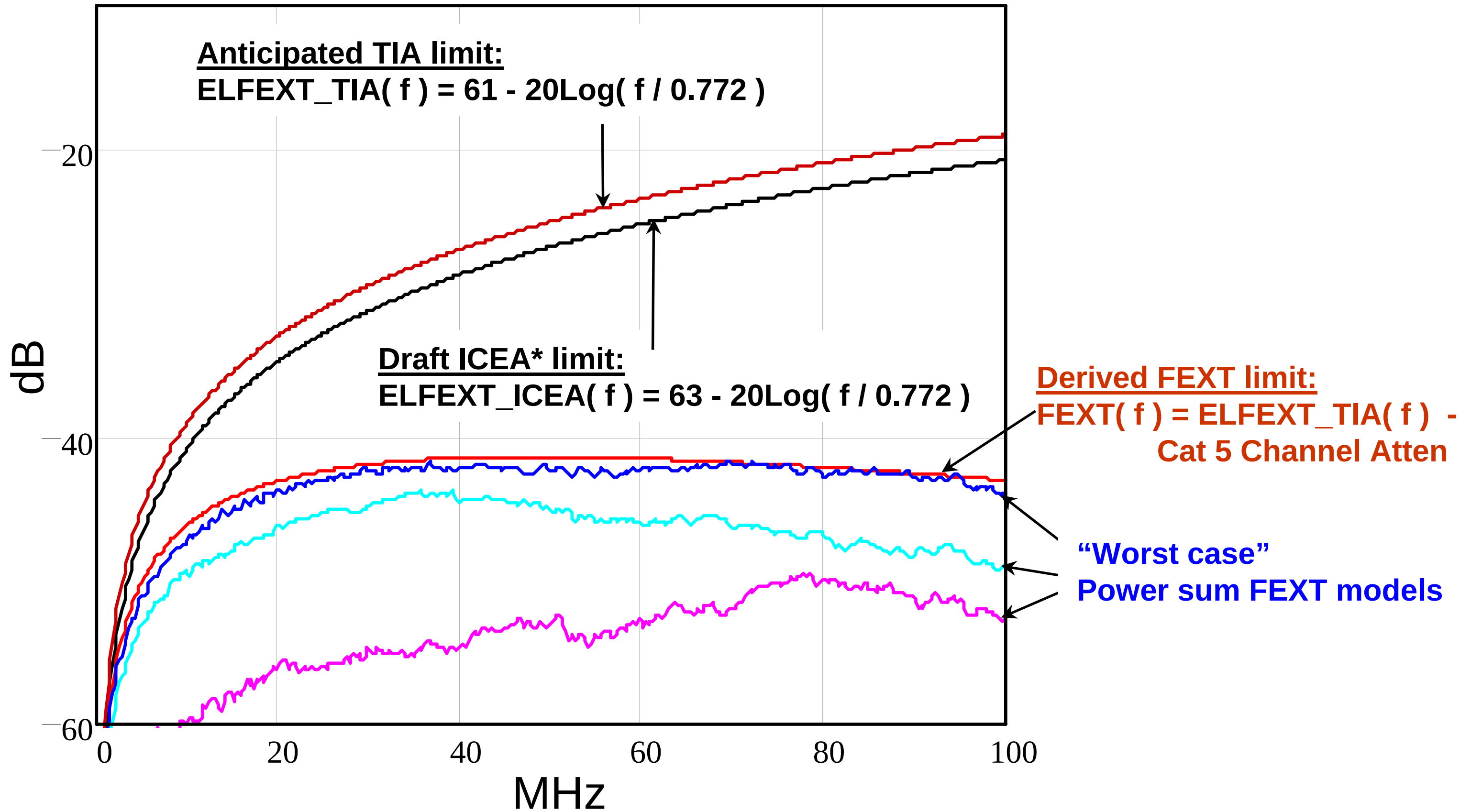
Noise at Each Receiver



NEXT and FEXT Models Used In The Proposed 1000 Base-T Designs

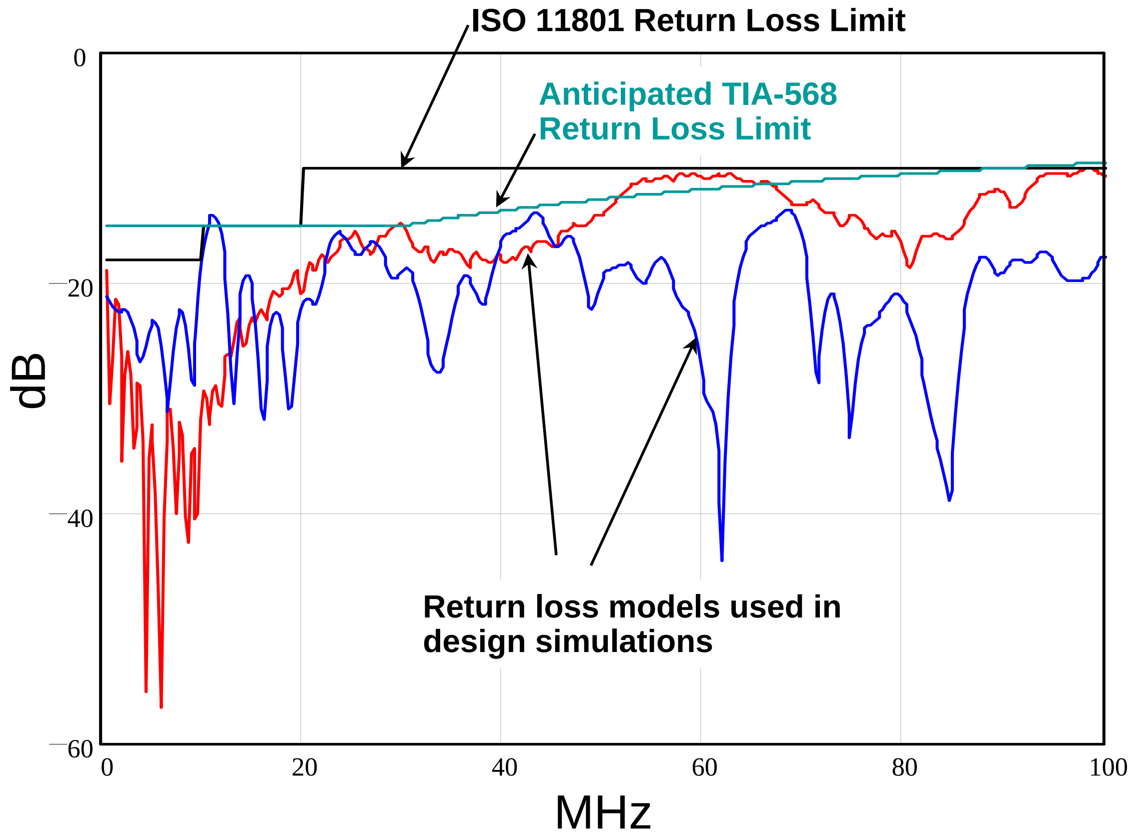


ELFEXT as a Noise Source

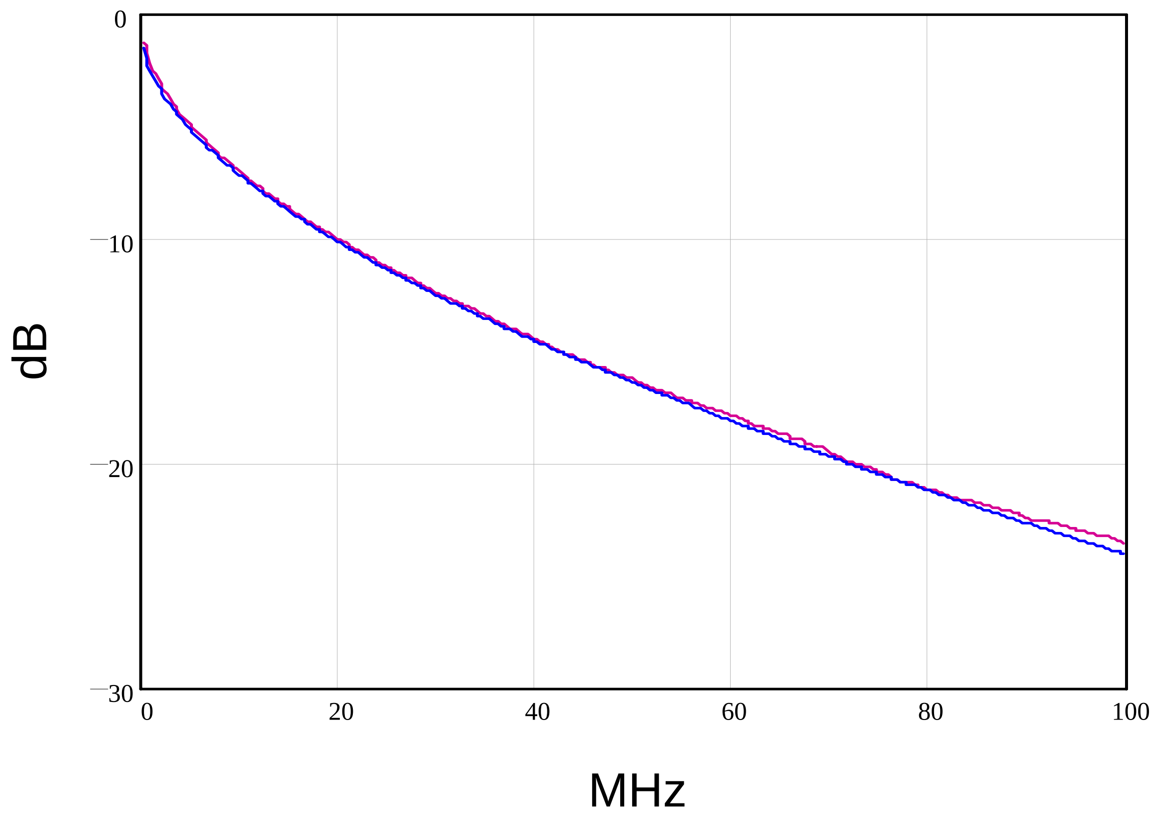


* ICEA = Insulated Cable Engineers Association

Return Loss Models Used In The Proposed 1000 Base-T Designs



Insertion Loss Model Used In The Proposed 1000 Base-T Designs



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Category 5 Environment

- **Two of the four sources of noise are unspecified in the cabling standards**
  - **Channel Return Loss**
  - **Far End Crosstalk (FEXT)**
- **Design simulations use empirical models of a "worst case" category 5 channel**
- **Minimally compliant category 5 may have little SNR margin**
  - **The design margin for the SNR performance can be consumed by FEXT and ambient noise**

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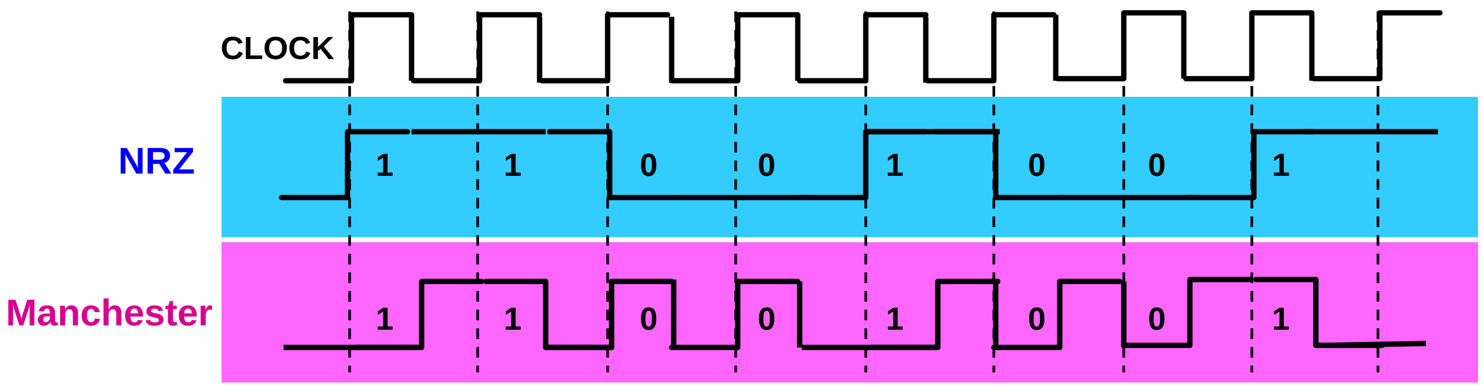
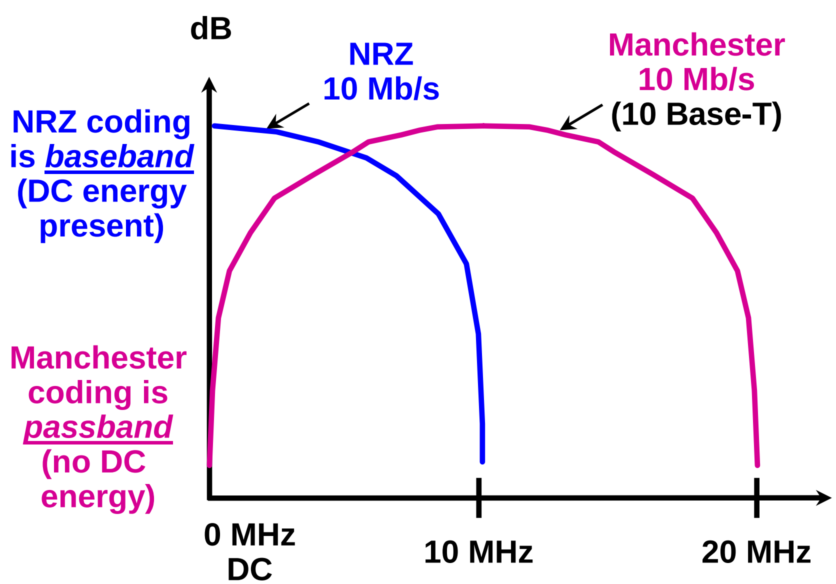
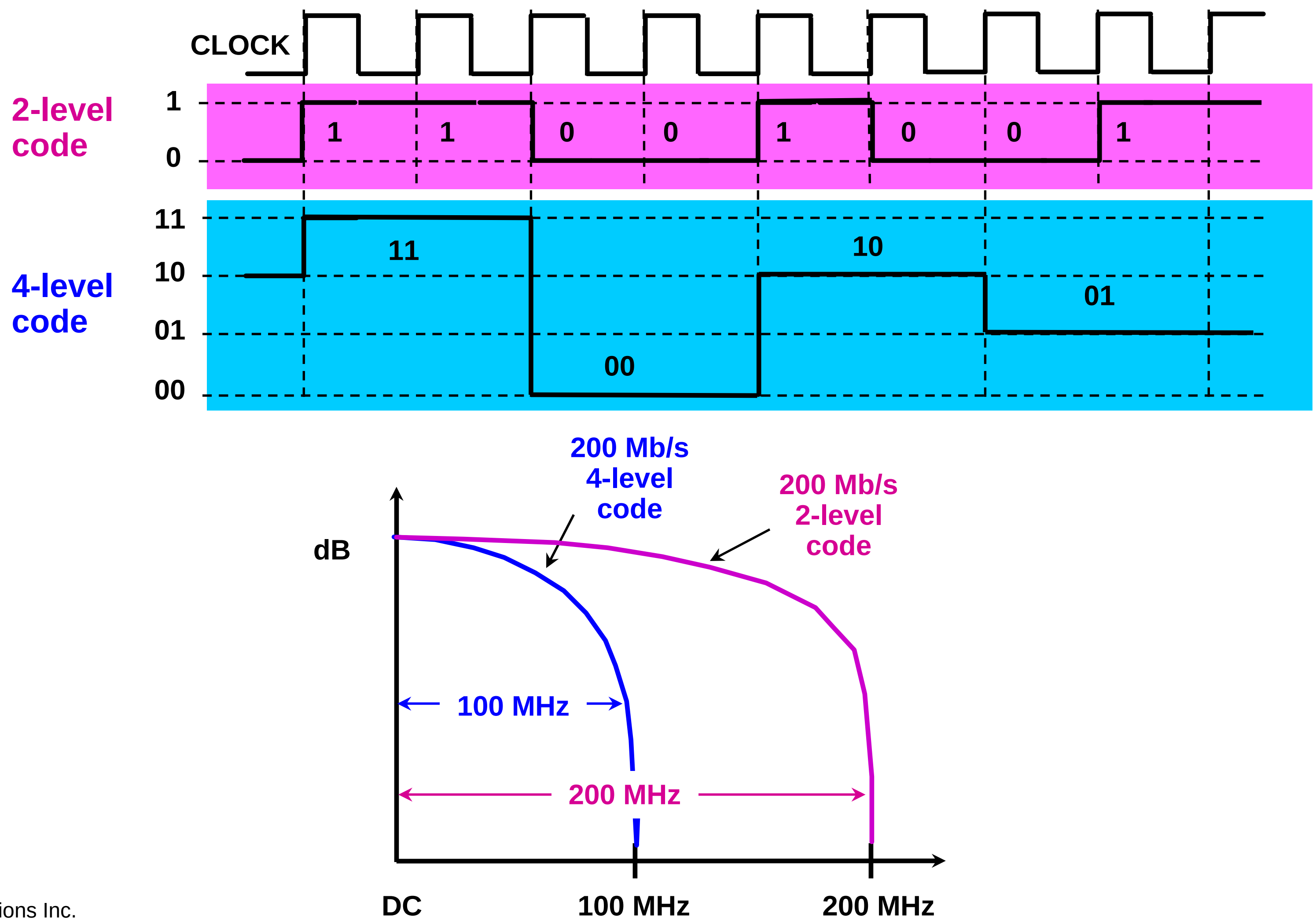
Binary Line Coding

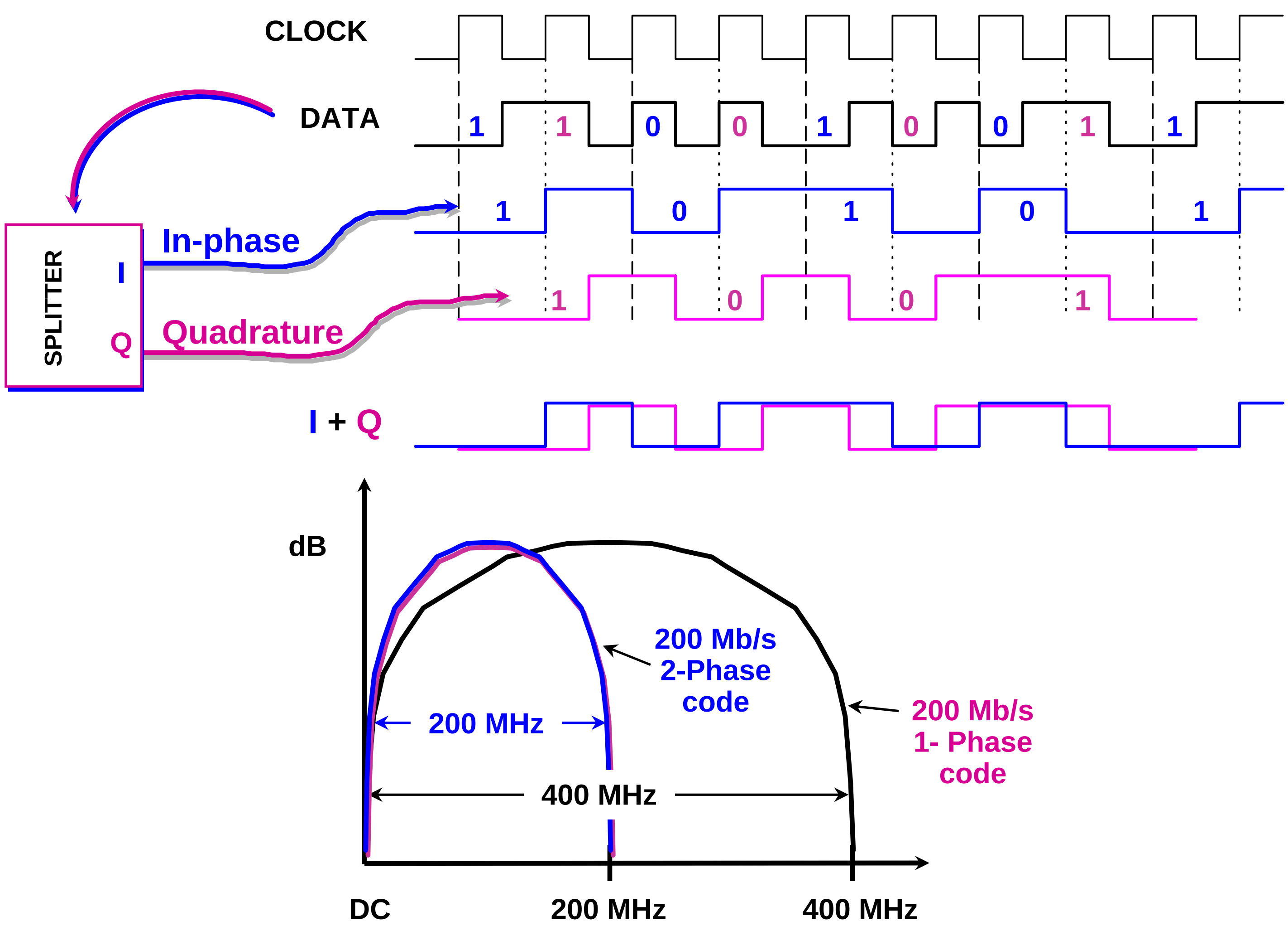




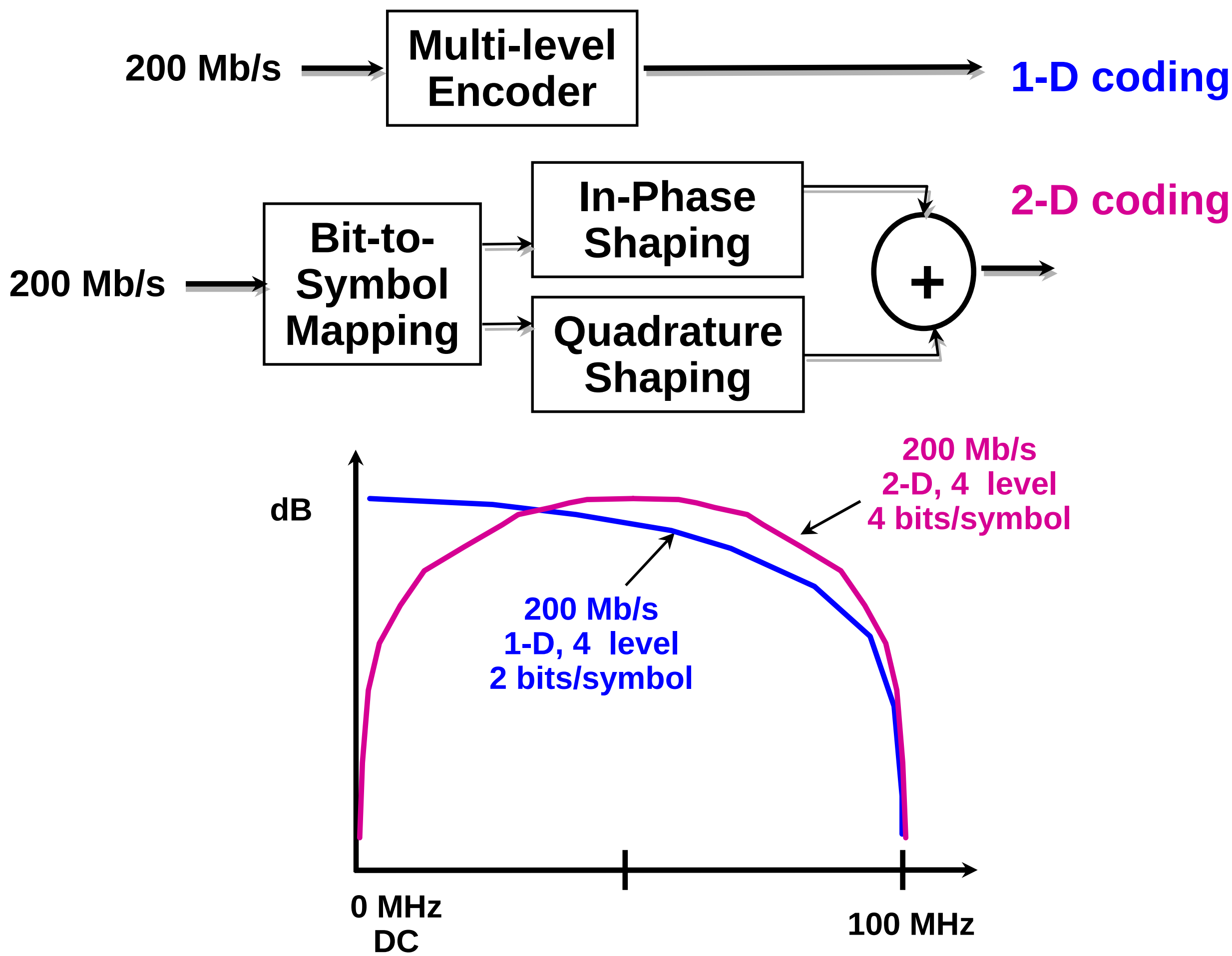
Bandwidth Efficient Multi-Level Coding



Bandwidth Efficient Two-phase Coding



One-dimensional Vs. Two-dimensional Bandwidth Efficient Coding



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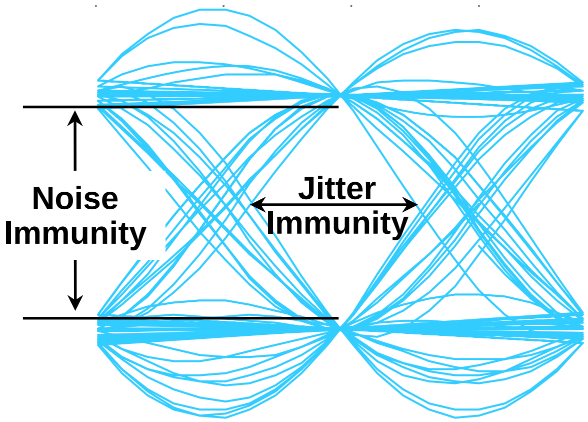
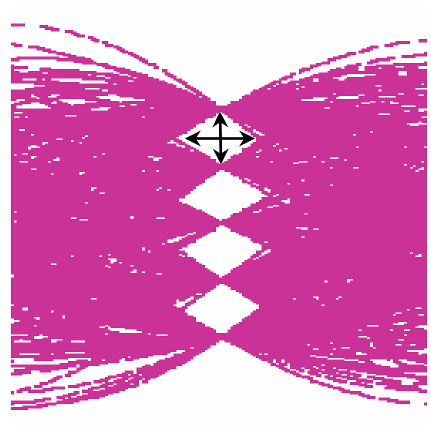
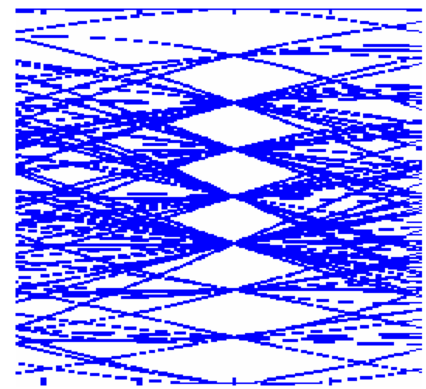
Binary vs. Bandwidth Efficient Coding



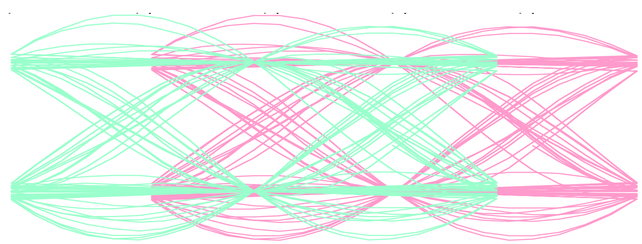
**Eye pattern of
Binary coded data**



**Eye pattern of
the in-phase component
of a QAM 25 signal**

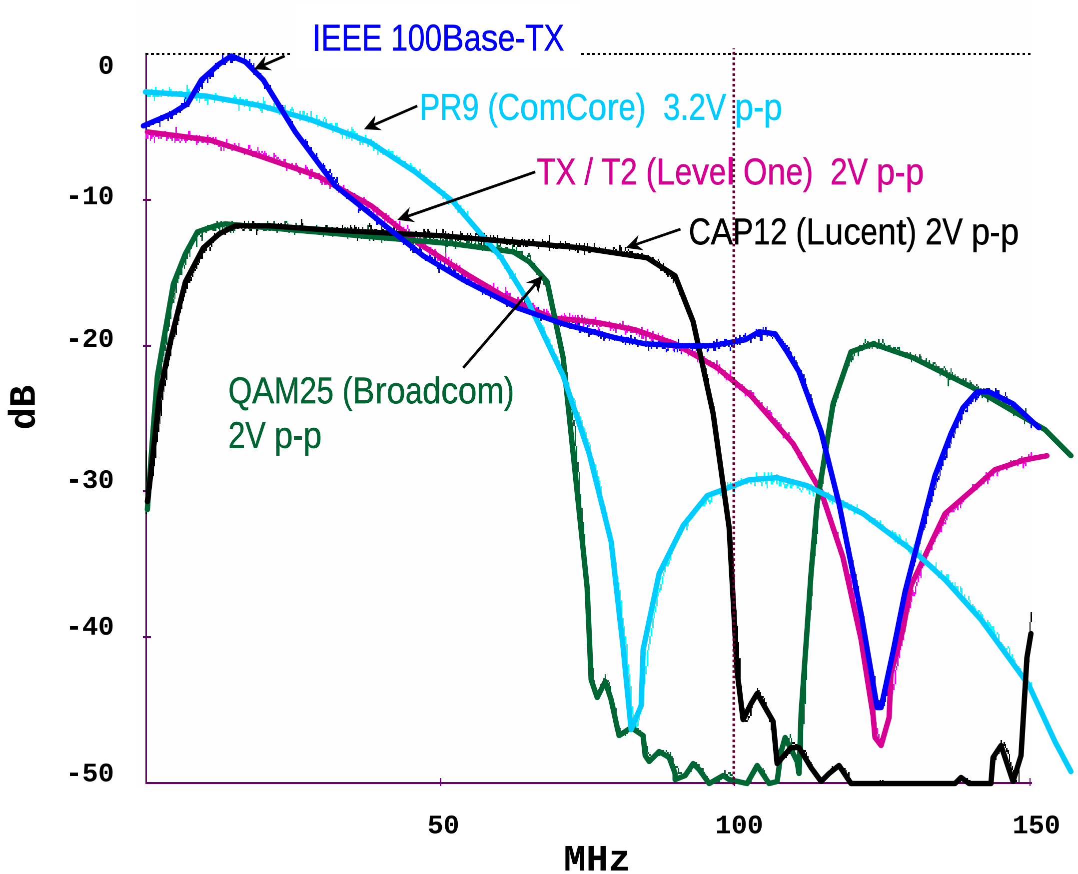


**Eye pattern of
a 9-level PR9 signal**

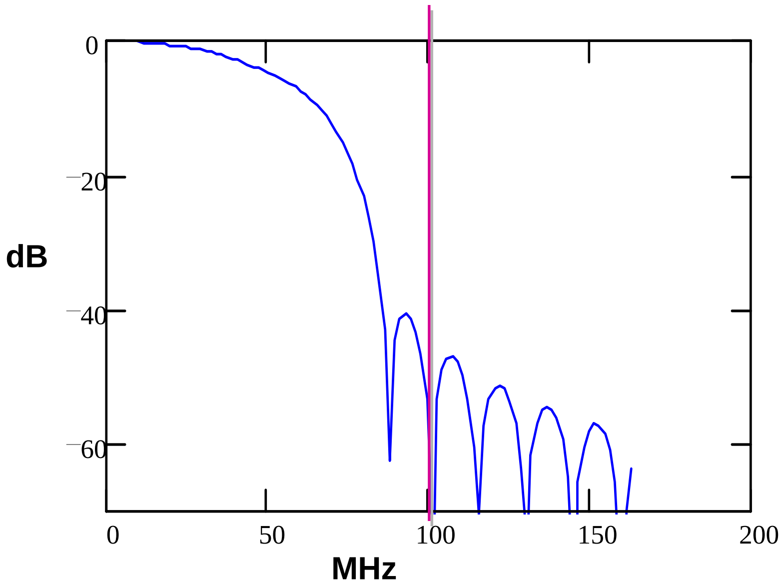


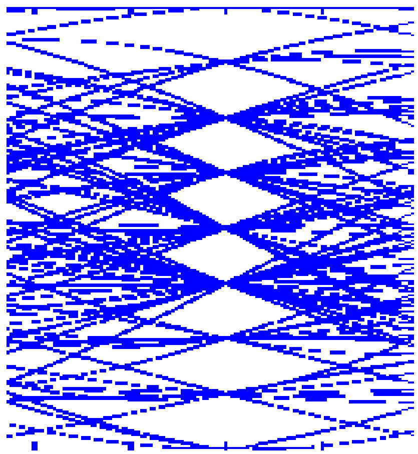
**2-level 2-phase
signal**

Gigabit Ethernet Line Coding Schemes Under Evaluation by IEEE 802.3ab



Partial Response 9 (PR9) Coding Scheme Proposed by ComCore

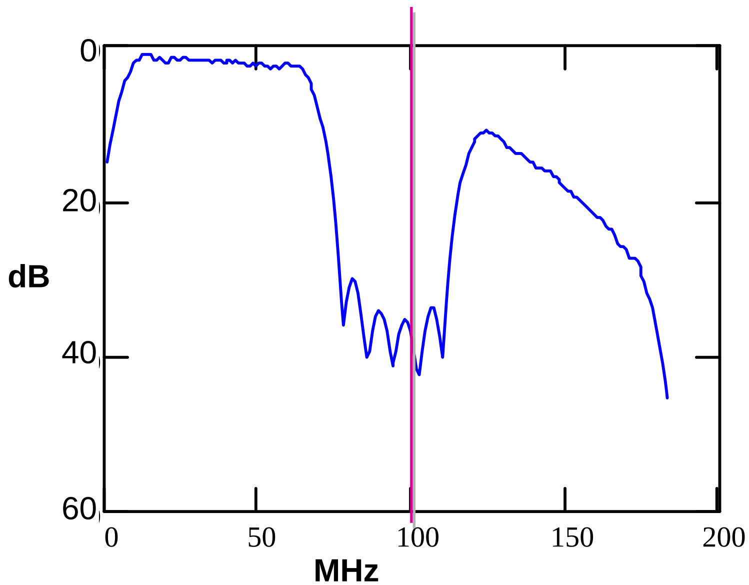


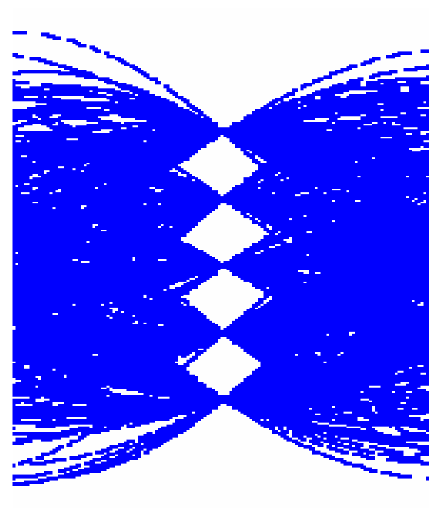


PR9 Eye pattern

- One-dimensional 9 level coding
- 3 bits per symbol
- 83 Mbaud

Quadrature Amplitude Modulation (QAM25) Proposed by Broadcom





Eye pattern of
the in-phase component
of a QAM 25 signal

- Two-dimensional 5 Level AM on two carriers in quadrature
- 4 bits per symbol
- 62.5 Mbaud

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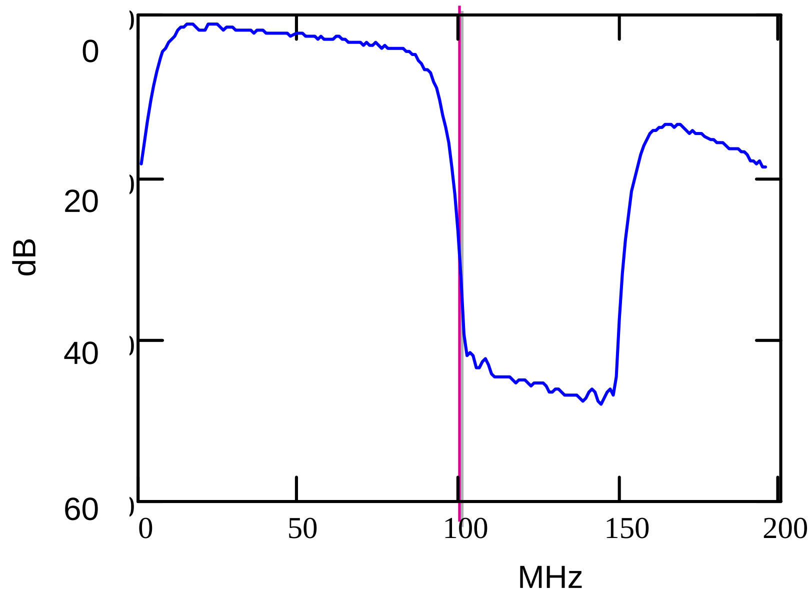
Carrierless AM/PM (CAP12) Proposed by Lucent



- **Two-dimensional CAP coding**
  - **4 levels on two different phases**
- **3 bits per symbol**
- **83 Mbaud**

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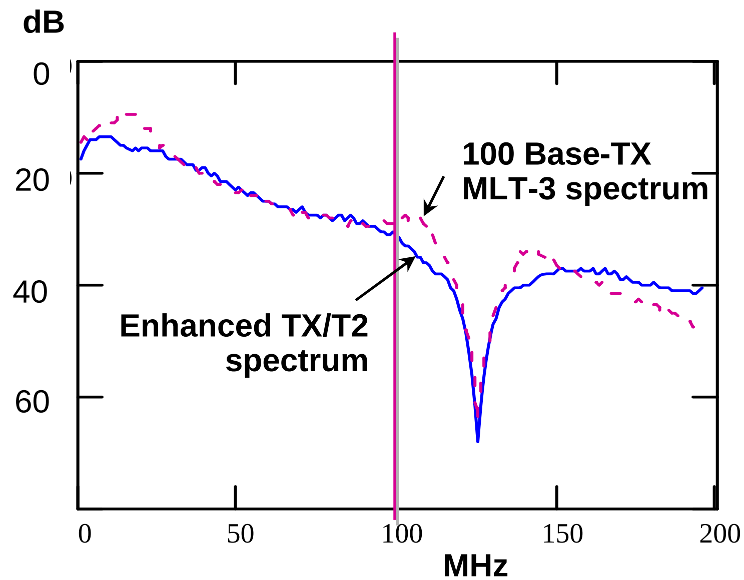
Enhanced TX/T2 Coding Proposed by Level One



- One-dimensional 5 level coding
- 2 bits per symbol
- 125 Mbaud
- Spectrum shaped to resemble that of 100 Base-T
  - facilitates 100/1000 Base-T implementations

Signal and FEXT Noise - 100 m Cat 5 Link TX/T2 Scheme