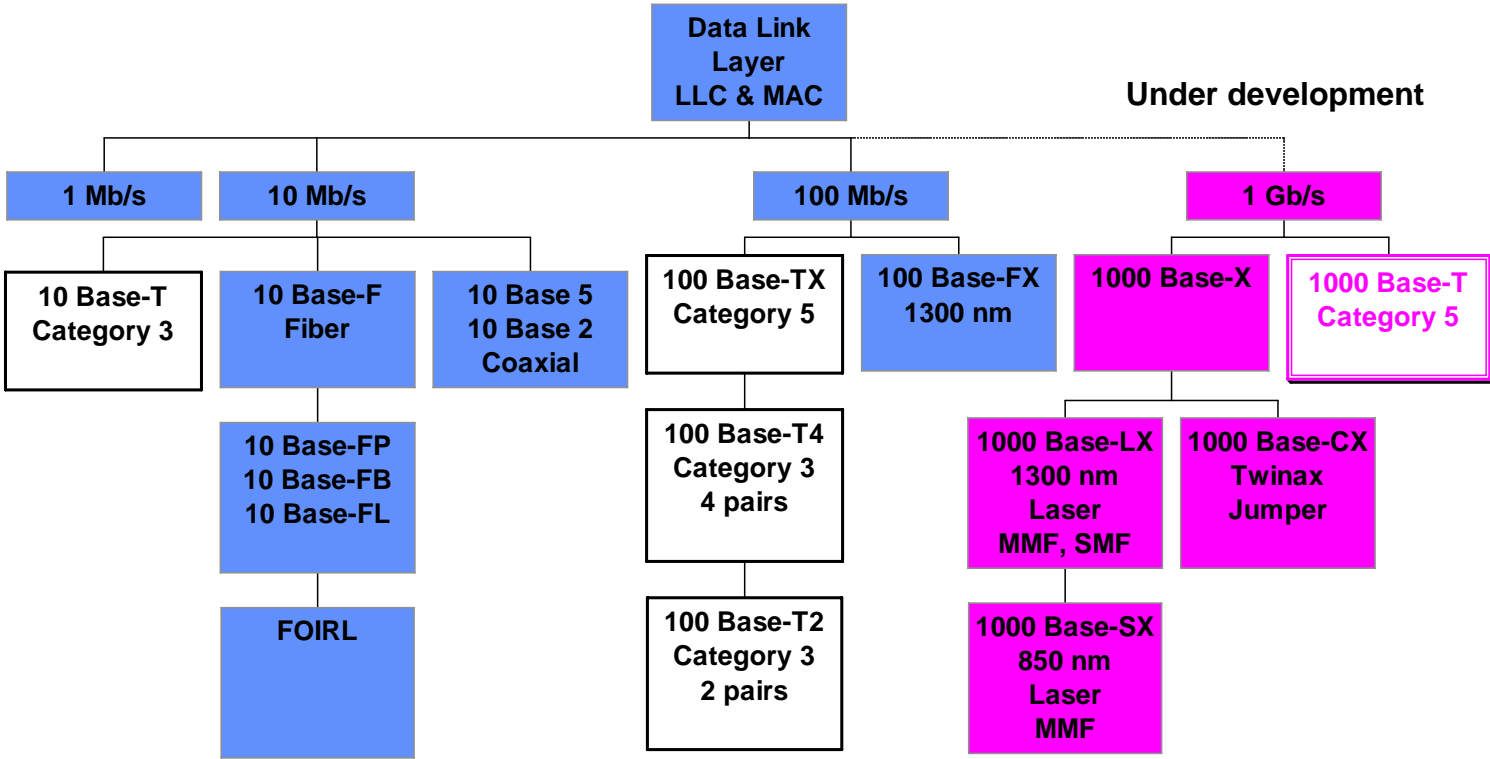


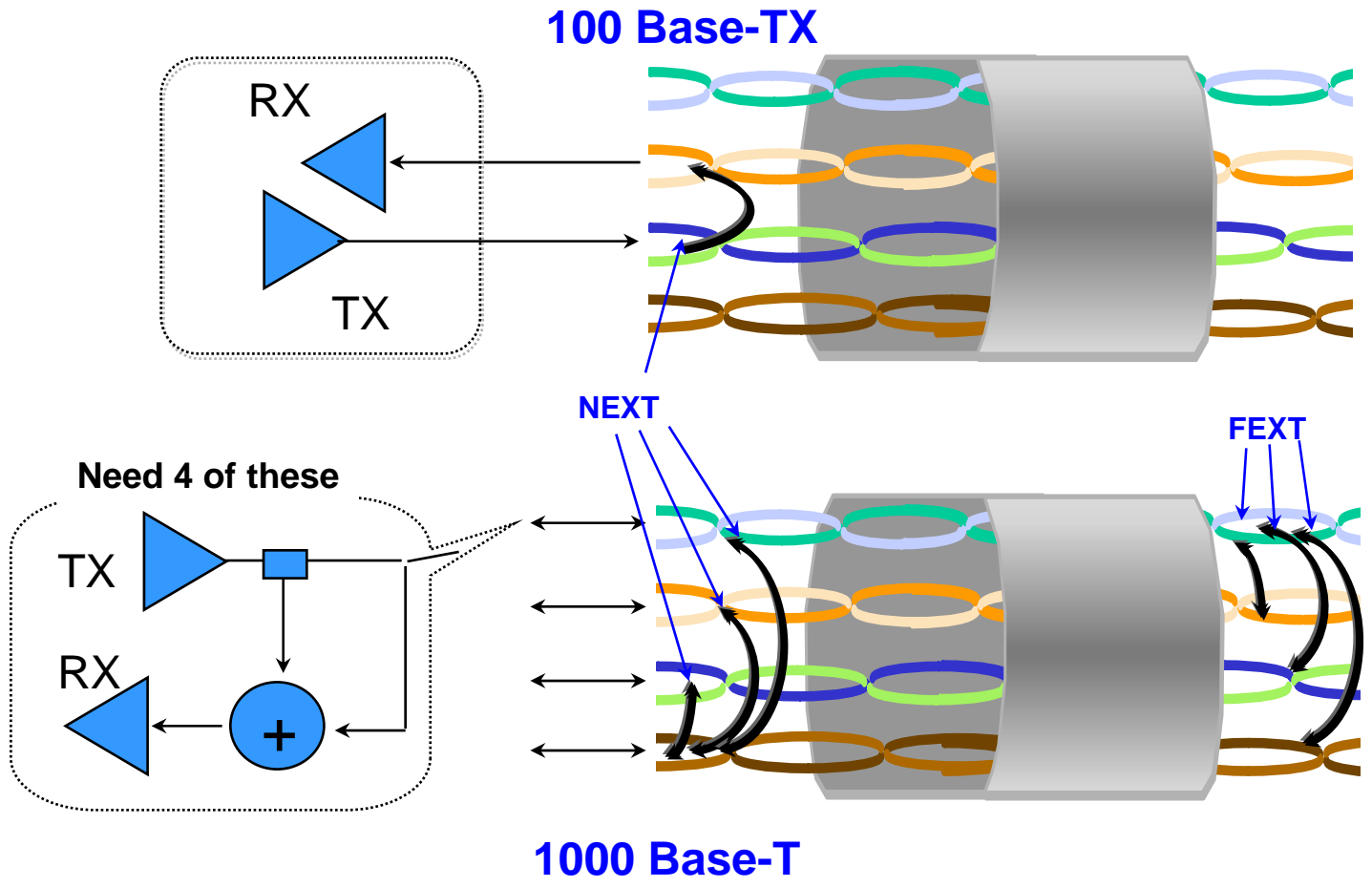
Gigabit Ethernet Over Category 5

Fanny Mlinarsky

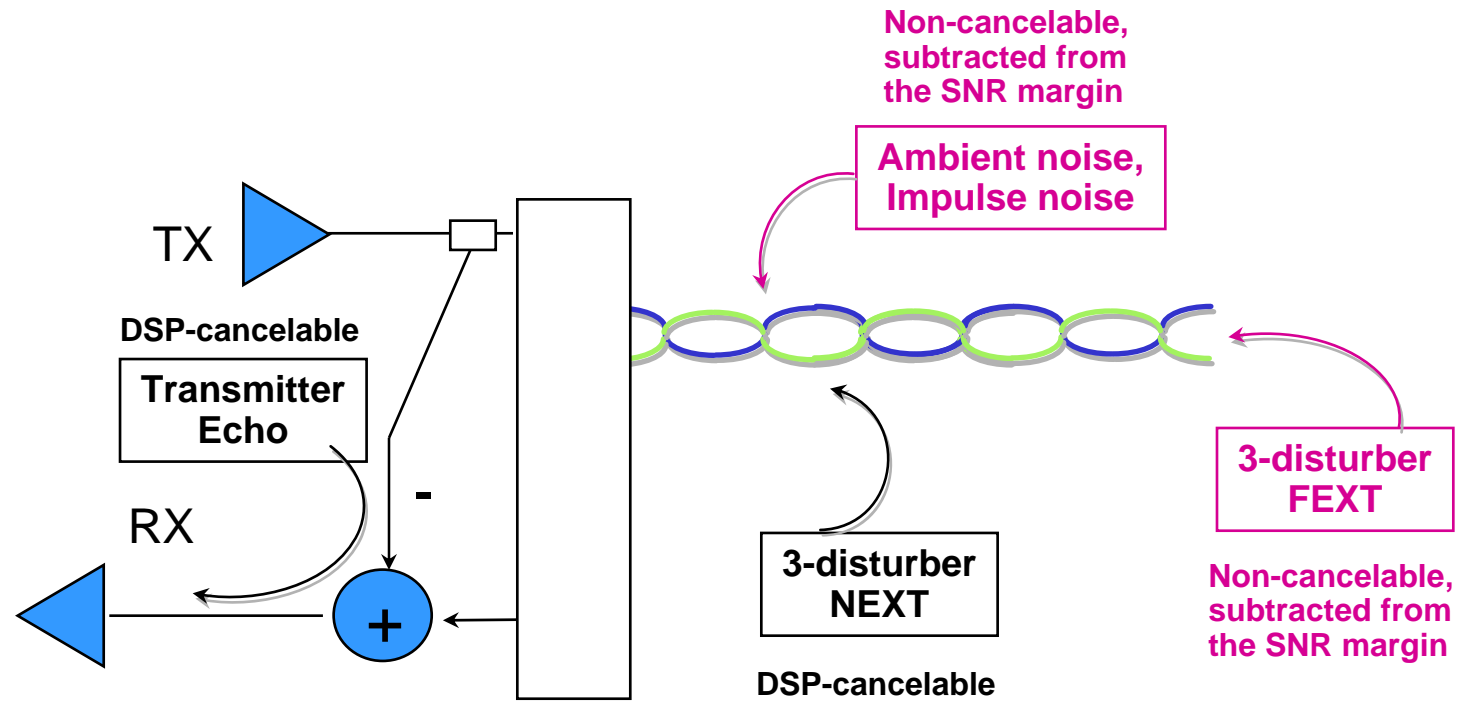
Organization of IEEE 802.3 Standards



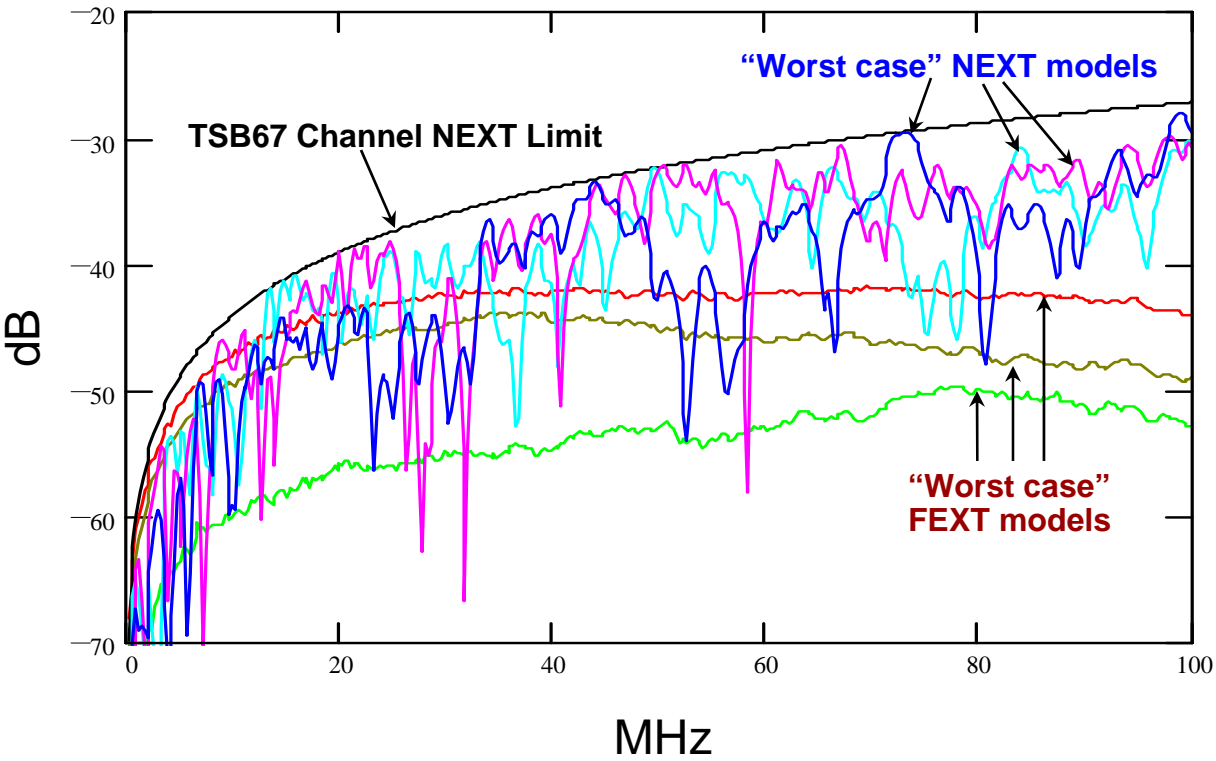
100 Base-T vs. 1000 Base-T



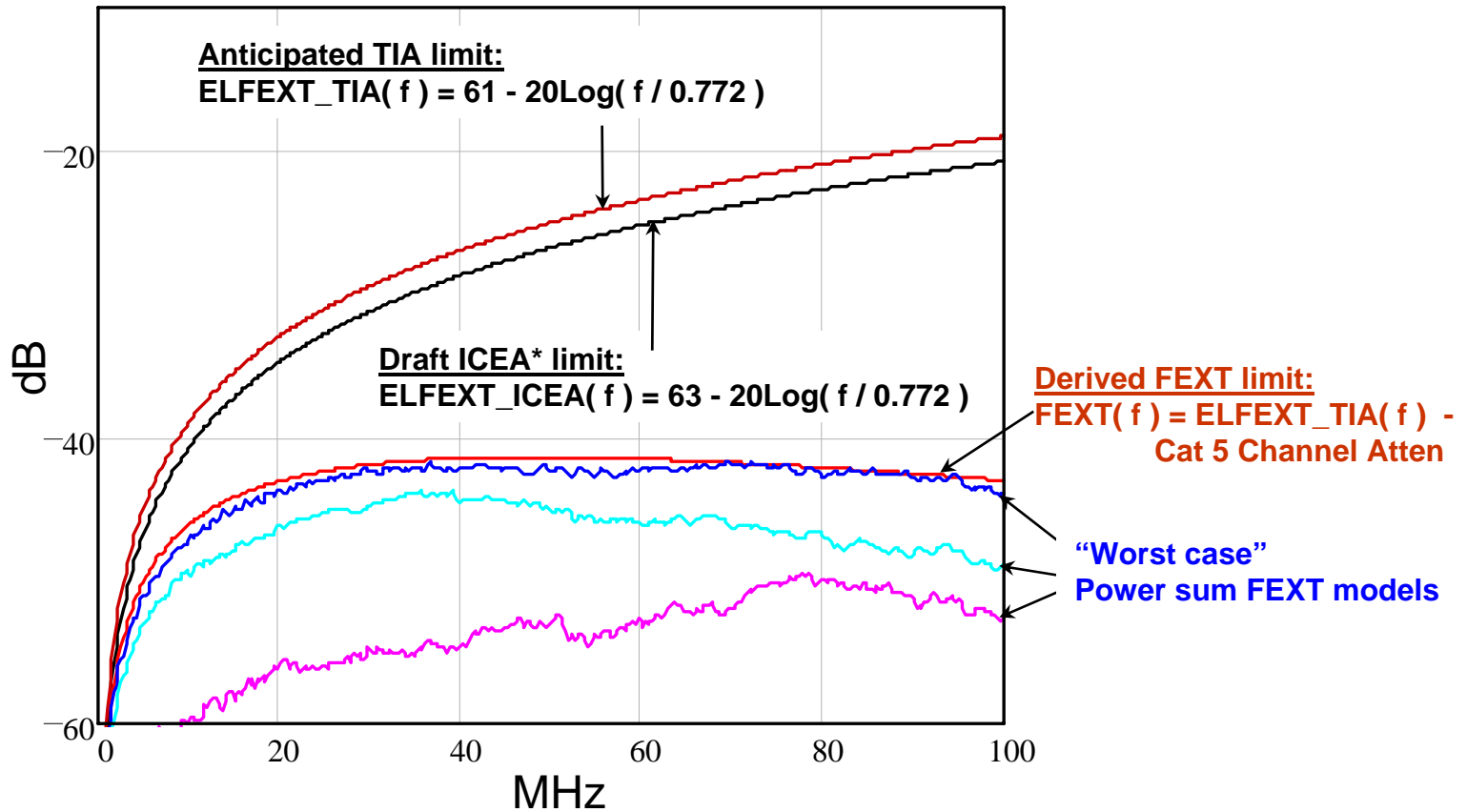
Noise at Each Receiver



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

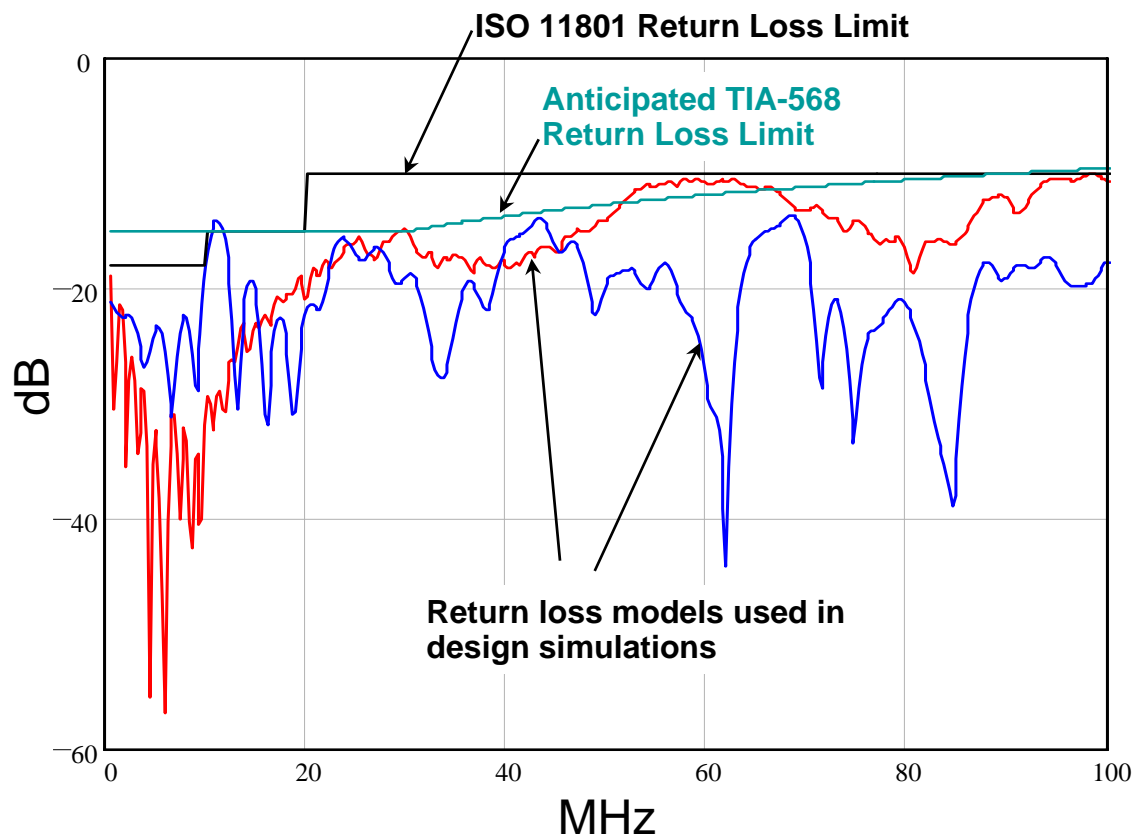


ELFEXT as a Noise Source

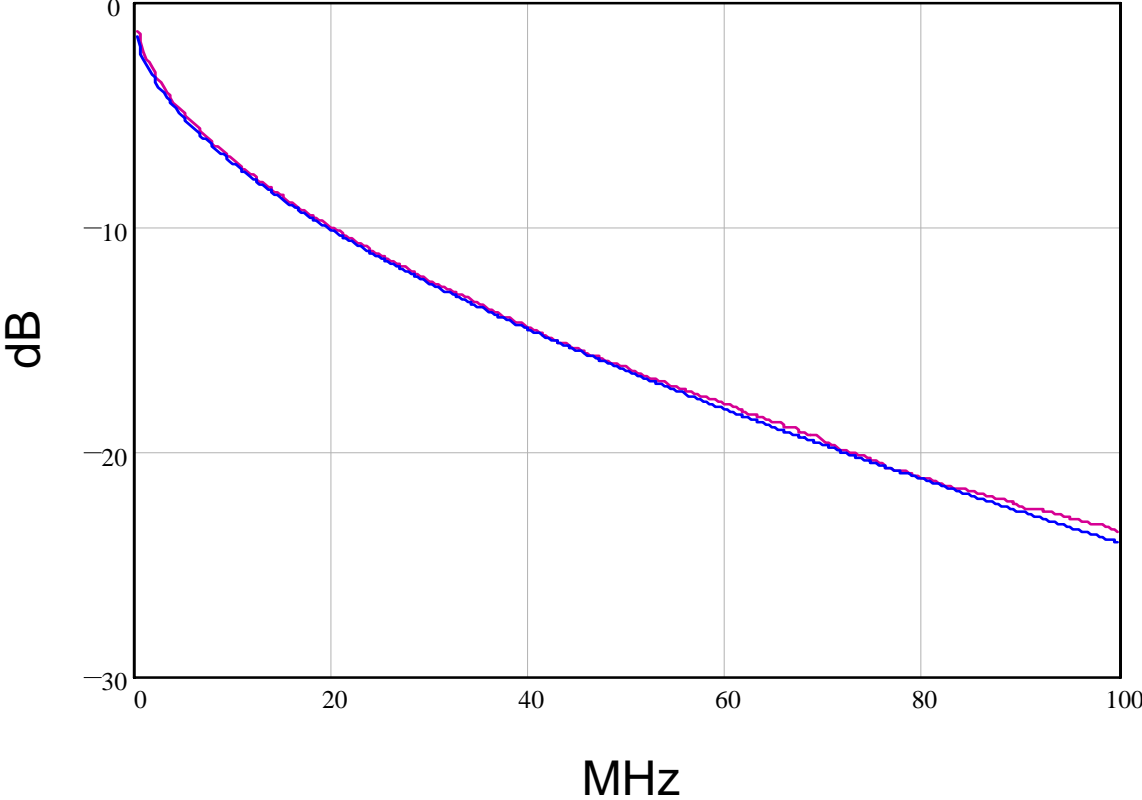


* ICEA = Insulated Cable Engineers Association

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



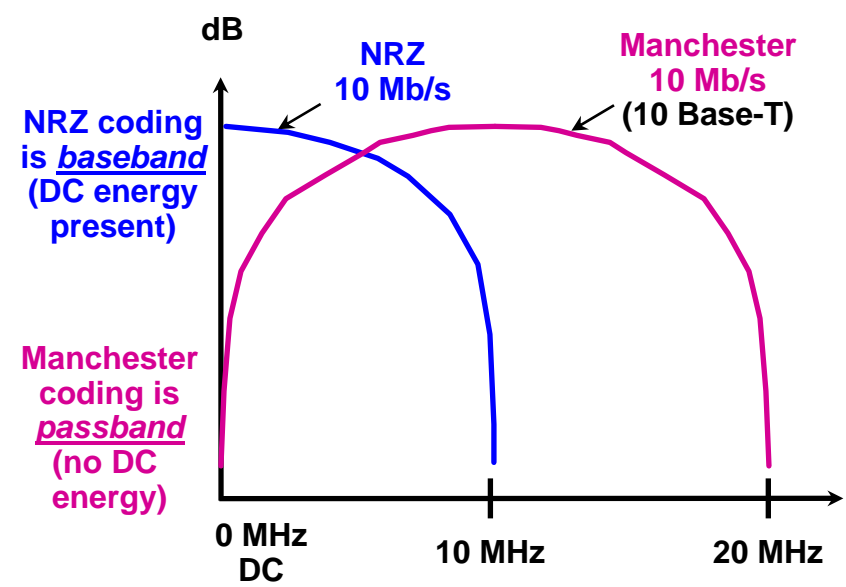
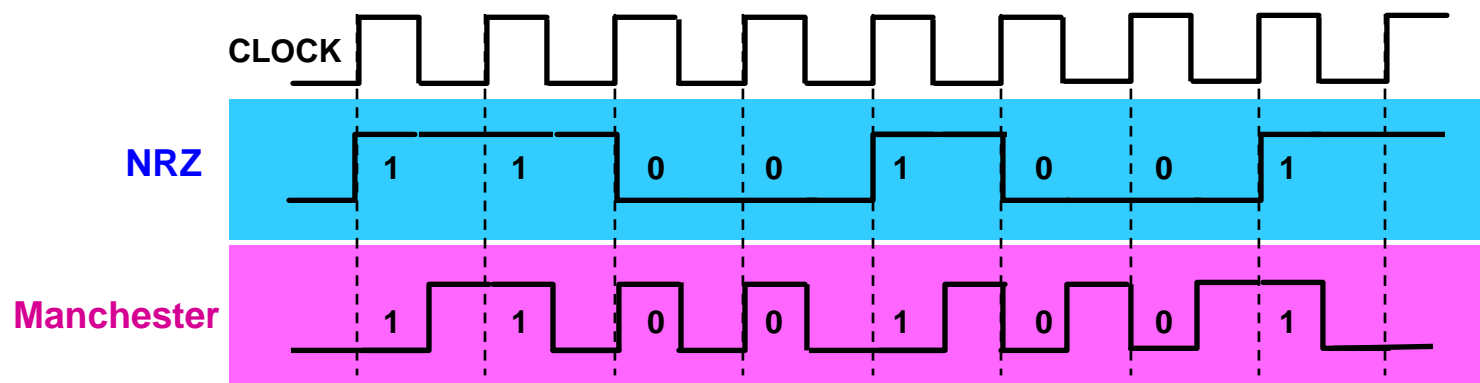
Insertion Loss Model Used In The Proposed 1000 Base-T Designs



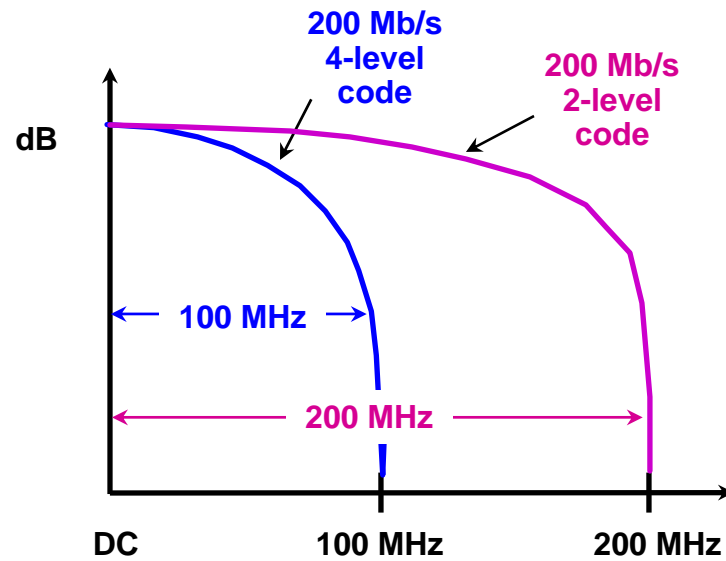
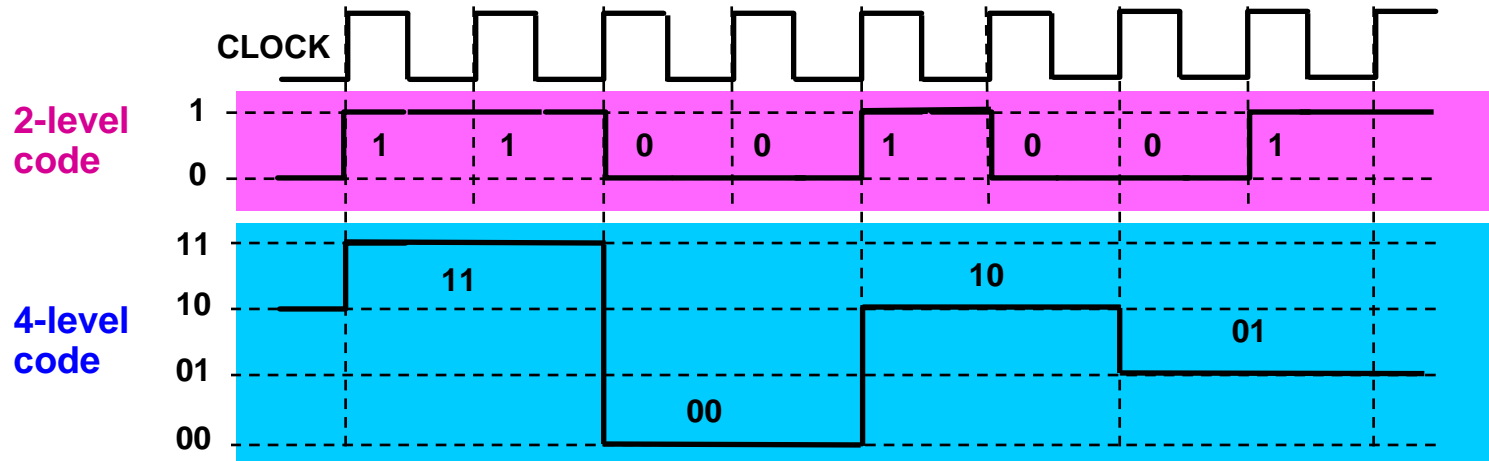
Category 5 Environment

- **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

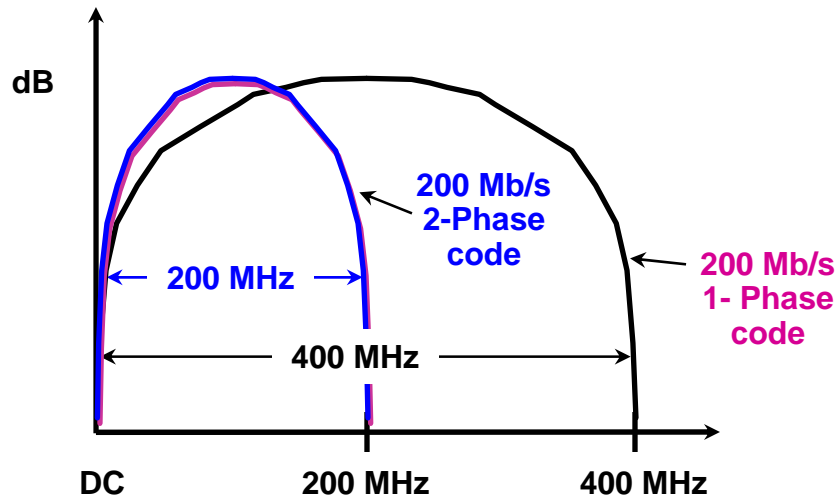
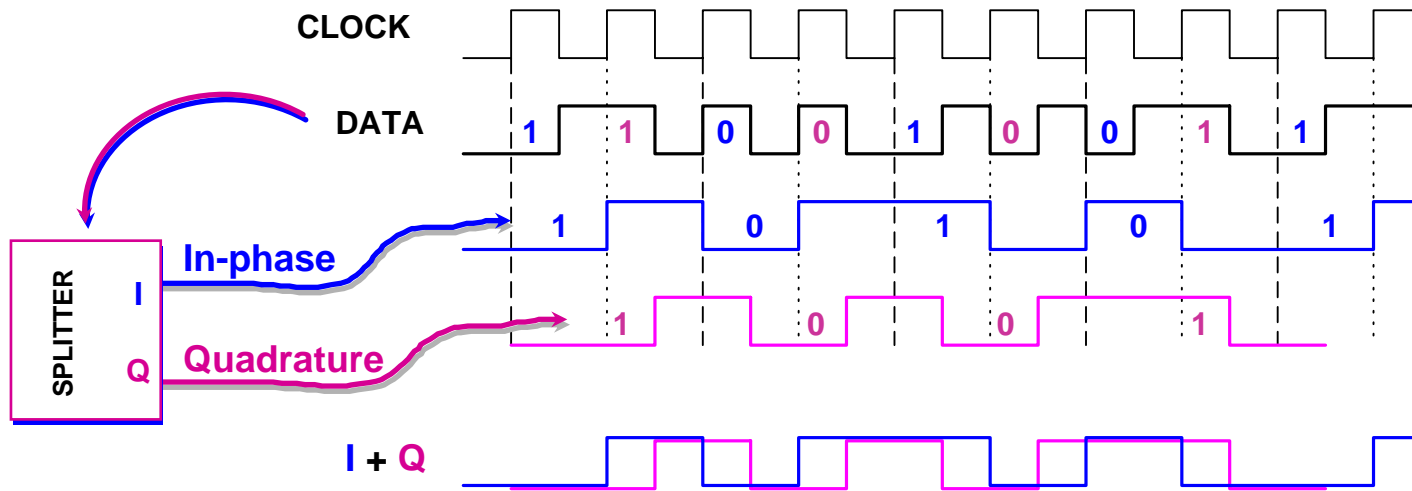
Binary Line Coding



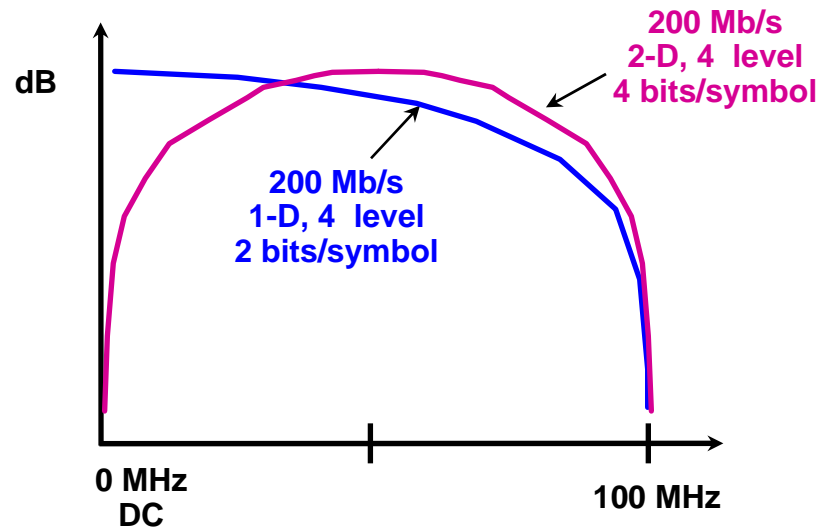
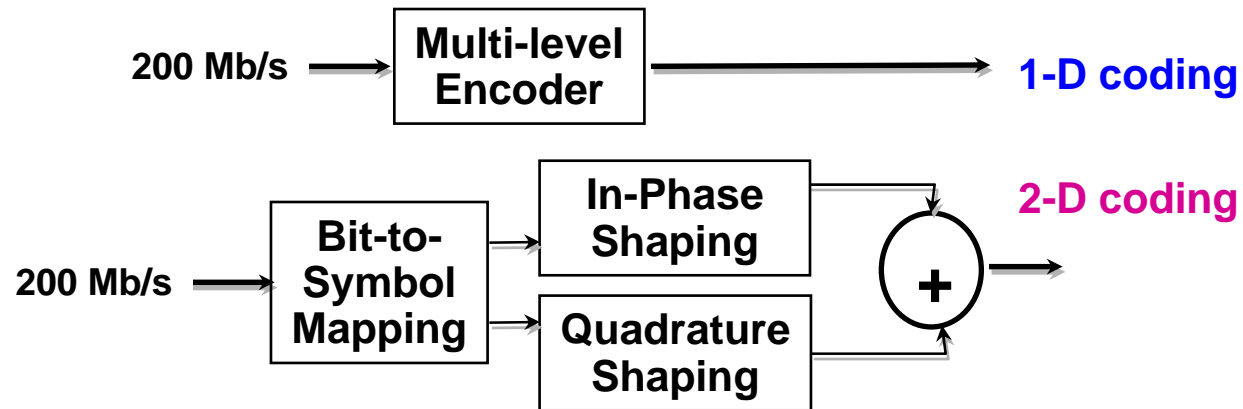
Bandwidth Efficient Multi-Level Coding



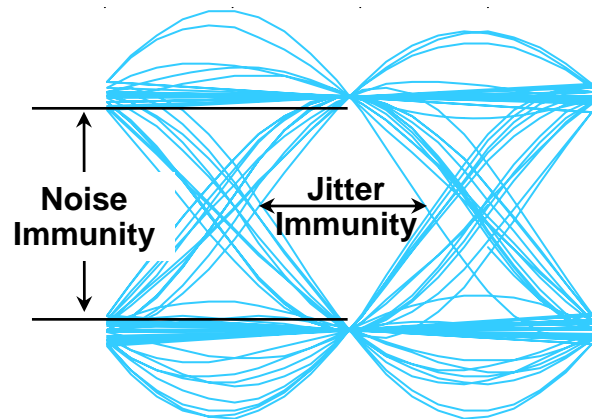
Bandwidth Efficient Two-phase Coding



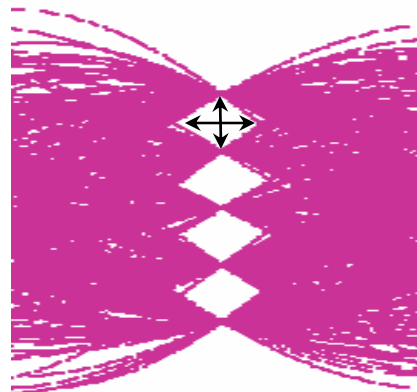
One-dimensional Vs. Two-dimensional Bandwidth Efficient Coding



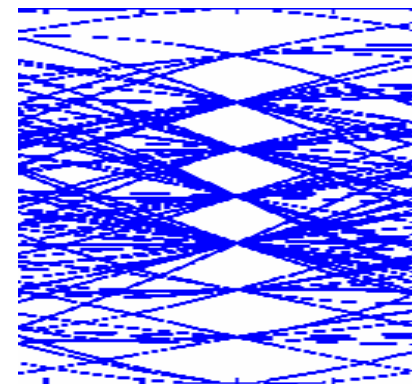
Binary vs. Bandwidth Efficient Coding



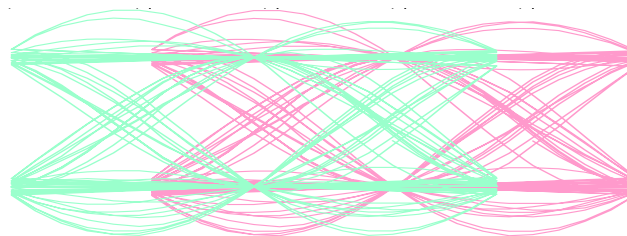
**Eye pattern of
Binary coded data**



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

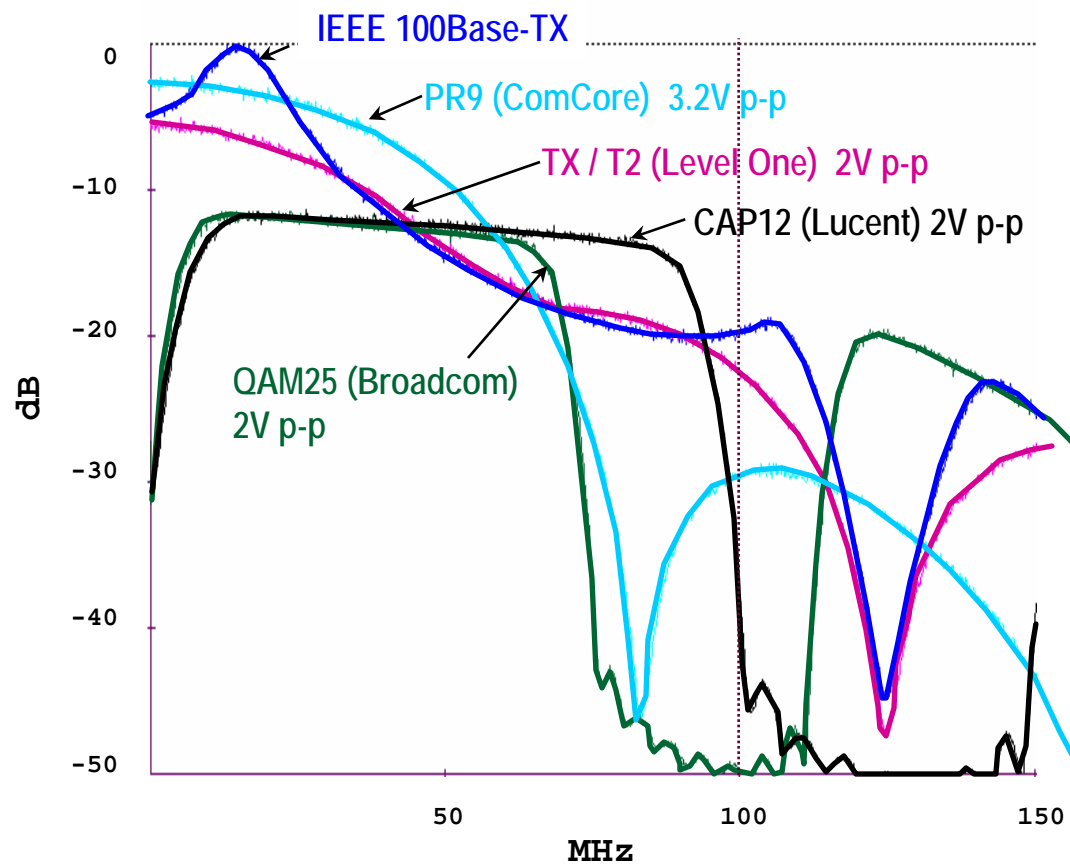


**Eye pattern of
a 9-level PR9 signal**

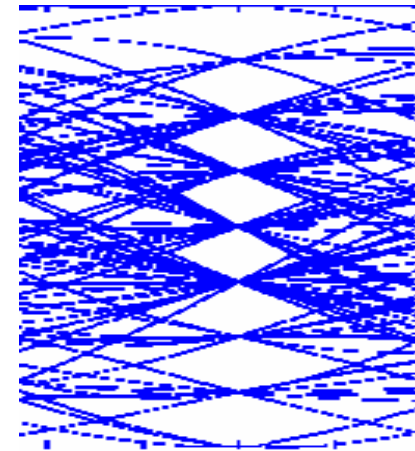
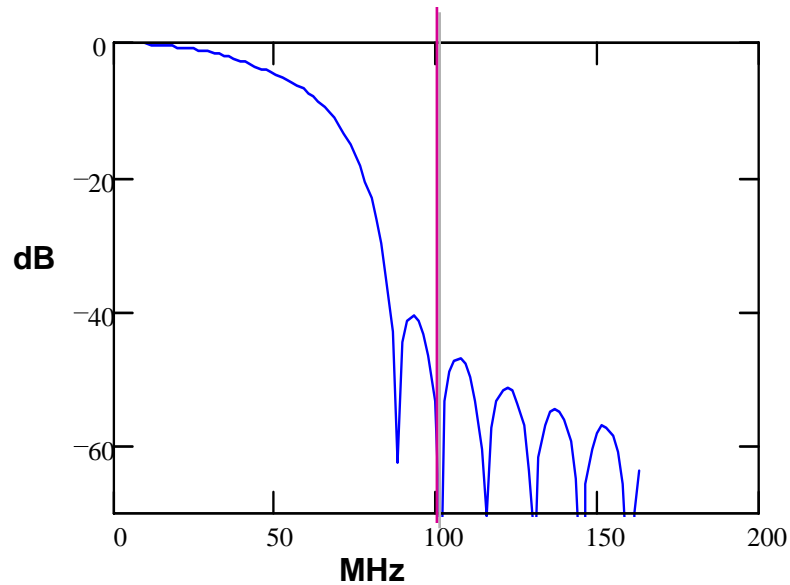


**2-level 2-phase
signal**

Gigabit Ethernet Line Coding Schemes Under Evaluation by IEEE 802.3ab



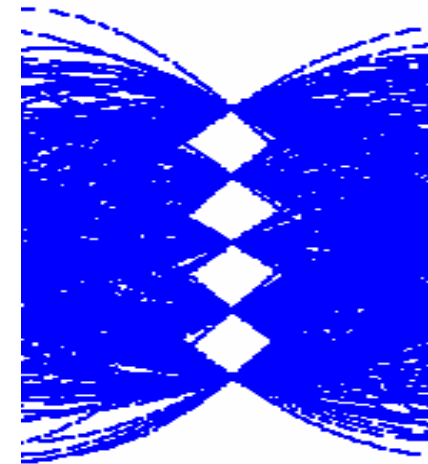
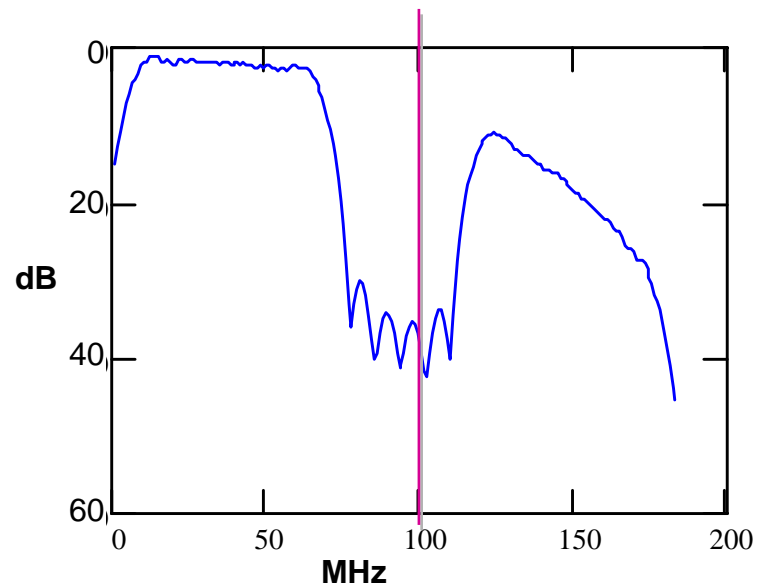
Partial Response 9 (PR9) Coding Scheme Proposed by ComCore



PR9 Eye pattern

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

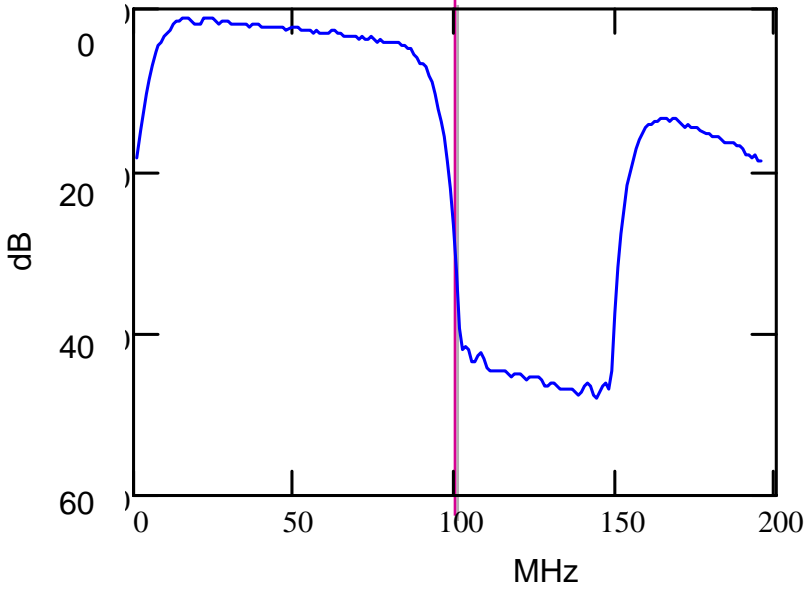
Quadrature Amplitude Modulation (QAM25) Proposed by Broadcom



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

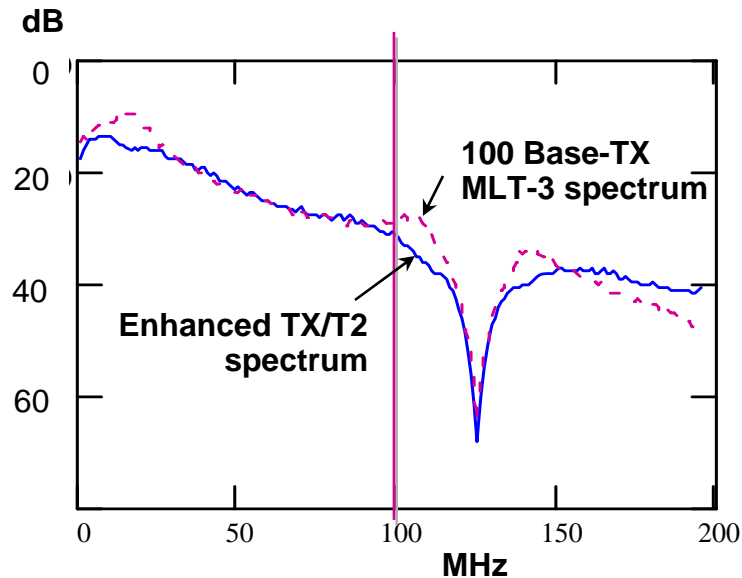
- **Two-dimensional 5 Level AM on two carriers in quadrature**
- **4 bits per symbol**
- **62.5 Mbaud**

Carrierless AM/PM (CAP12) Proposed by Lucent



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

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

