

Signal Constellation Options to achieve Multiple Signaling Objectives in 1000BASE-T1

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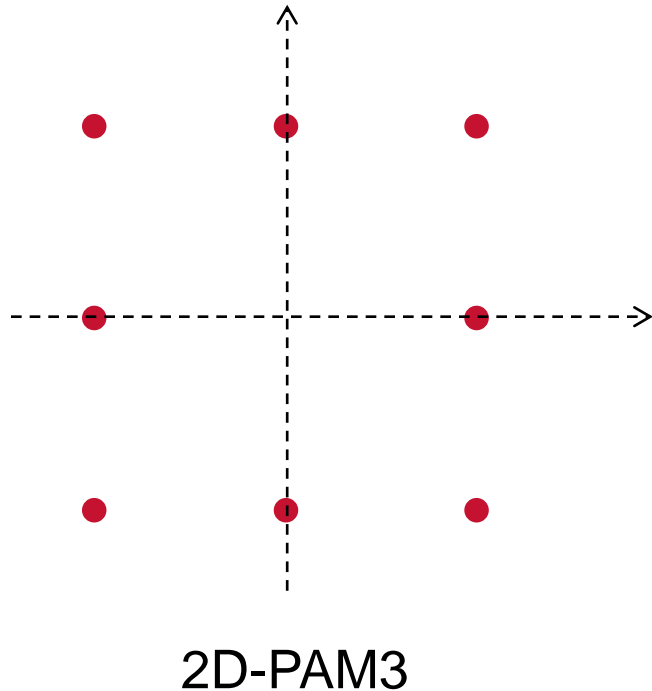
Outline

- Review signaling objectives in 1000BASE-T (IEEE802.3) as it may relate to 1000BASE-T1
- Propose a signal constellation for coded data in line with signaling objectives
- Propose a signal constellation for training during link-up process
- Example choices for signal constellation during Idle mode and LPI and for data stream markers .
- Example clock structure from GMII to MDI

Signaling objectives for 1000BASE-T1 adopted from 1000BASE-T (IEEE802.3 clause 40.1.4)

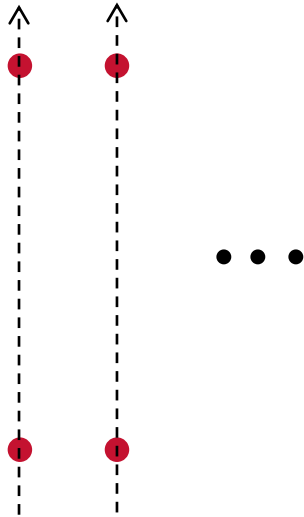
- **1000BASE-T1 signaling is performed by the PCS generating continuous code-group sequences that the PMA transmits over each wire pair. The signaling scheme achieves a number of objectives including**
 - a) Forward Error Correction (FEC) coded symbol mapping for data.
 - b) Algorithmic mapping and inverse mapping from data to PAM3 symbols and back.
 - c) Uncorrelated symbols in the transmitted symbol stream.
 - d) No correlation between symbol streams traveling both directions.
 - e) Idle mode uses a subset of code-groups to ease synchronization, start-up, and retraining.
 - f) Ability to rapidly or immediately determine if a symbol stream represents data or idle.
 - g) Robust delimiters for Start-of-Stream delimiter (SSD), End-of-Stream delimiter (ESD), and other control signals.
 - h) Ability to signal the status of the local receiver to the remote PHY to indicate that the local receiver is not operating reliably and requires retraining.
 - i) Optionally, ability to signal to the remote PHY a request to enter the LPI mode and to exit the LPI mode and return to normal operation.
 - j) Optionally, ability to signal to the remote PHY that the update of the local receiver state (e.g., timing recovery, adaptive filter coefficients) has completed.
 - k) Ability to automatically detect and correct for incorrect polarity in the connections.

Constellation for coded data



- 3 bits assigned to 2 symbols in 2D-PAM3 constellation.
- 00 point is left for SSD/ESD, LPI etc.
- Short mapping sequence for data encoding and decoding.
- Balance assignment with no DC component
- Low PAR (1.26dB before PSD shaping)
- Increased Euclidean distance between some constellation points improves immunity for some 2D noise vectors.

Constellation for training



PAM2

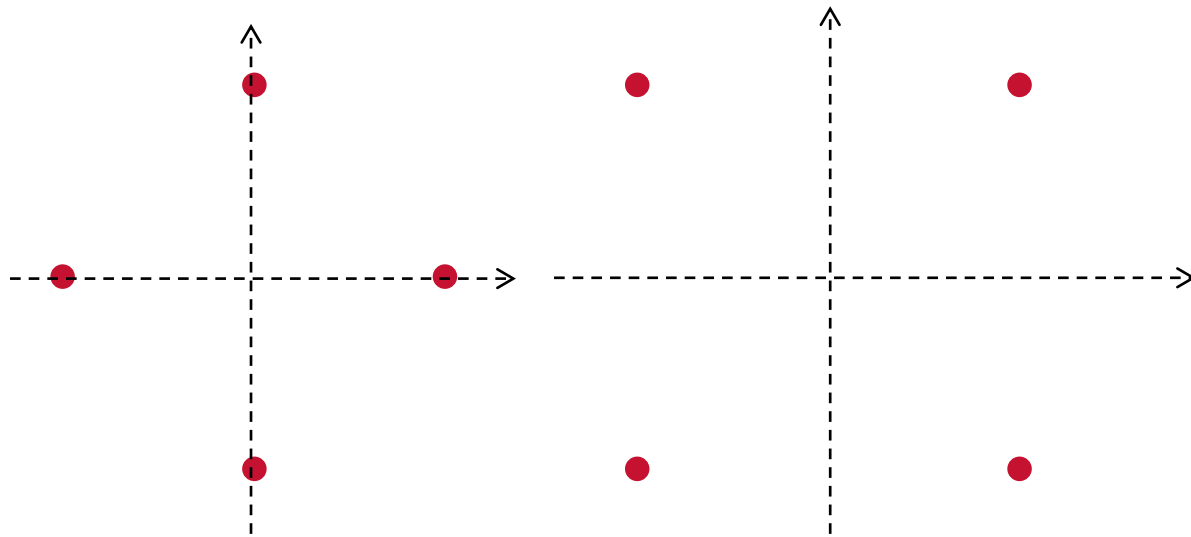
- Largest minimum distance allows robust link up on strong noise presence
- Single dimensional mapping, no symbol synchronization is needed with blind equalization.
- Balance assignment with no DC component
- Same DAC levels and PSD shaping as in data mode.



Appendix

Example choices for Idle mode, LPI and stream markers (SSD/ESD)

Example of Idle mode constellation when the Link is up

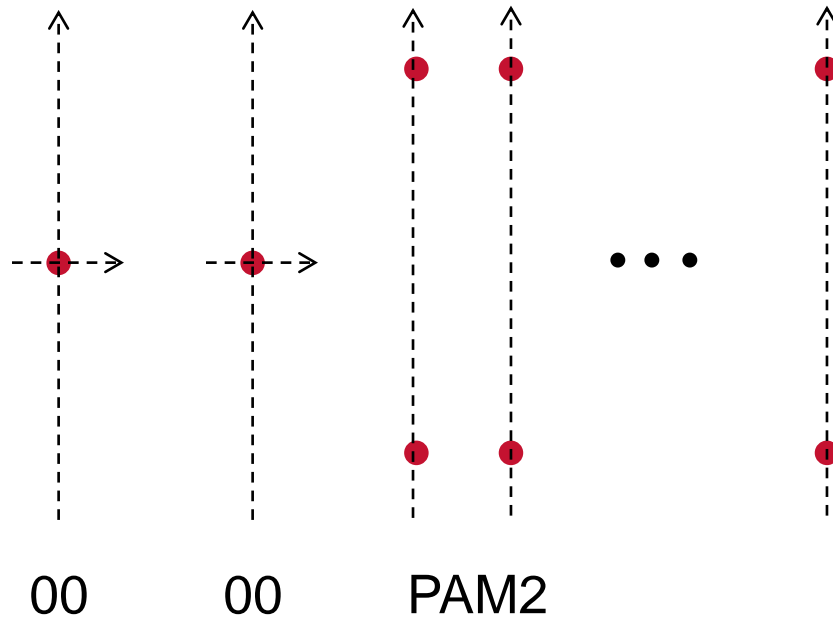


2D-PAM3

2D-PAM2

- Idle symbols are transmitted over 4 PAM3 symbols
- Short mapping sequence.
- Balance assignment with no DC component
- Increased Euclidean distance compared to data constellation
- 00 point is left for SSD/ESD, LPI, etc.
- Same average and same peak power as data to maintain PSD limit and emission requirements

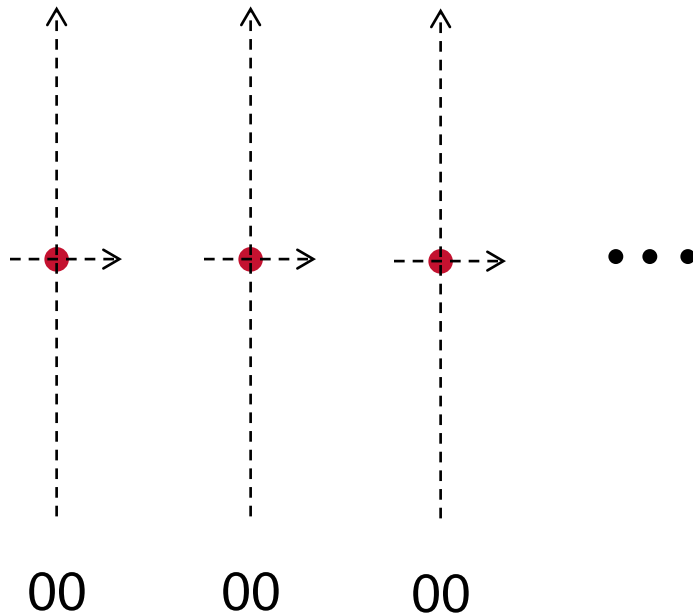
Example of Start and end of stream Markers



- SSD/ESD markers are shown for 100BASE-T in clause 32.3.3 and for 1000BASE-T in clause 40.3.2 of IEEE802.3
- Table 40-1 in IEEE802.3 specification shows constellation points assigned for SSD/ESD in 1000BASE-T

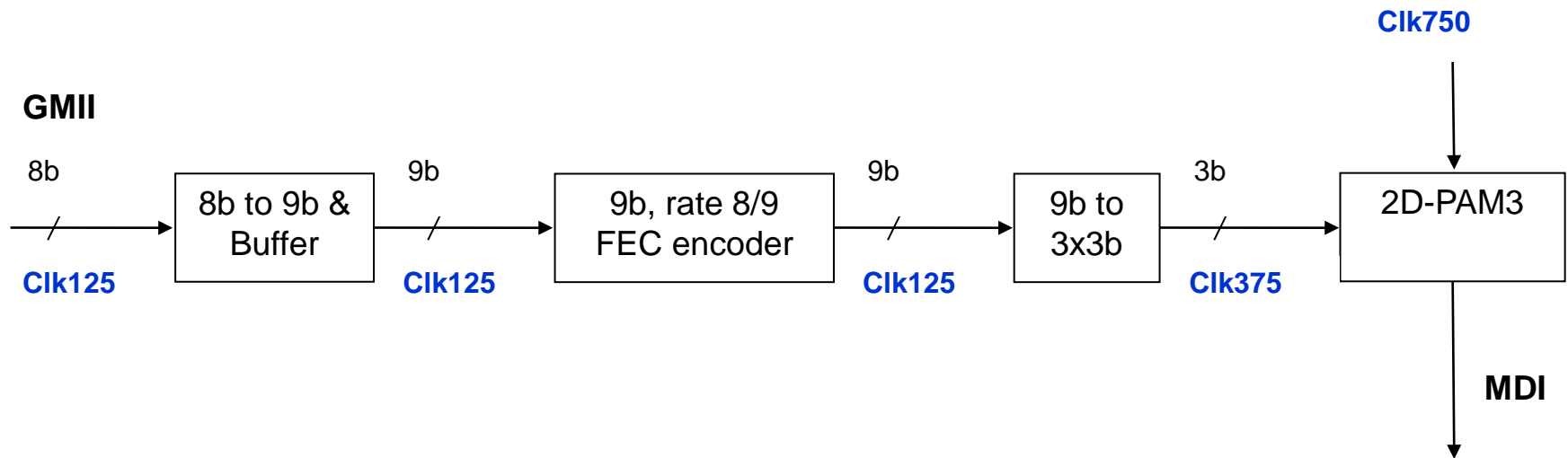
- 00 point is used as marker indication.
- In order to reduce false detection, 00 is repeated (four or six PAM symbols)
- Subsequent PAM2 symbols carry the message (SSD/ESD, etc.)
- Redundant PAM2 symbols are added to improve detection in noise.
- SSD/ESD markers allow going in/out of Idle mode without additional latency.

Example of Idle mode constellation when the Link is up



- Fast recognition of LPI mode without requiring additional handshaking between two sides of a link (Note 00 is not used in data mode).
- This allows fast refresh periods for improved tracking as well as low emission idle (refresh duration less than 1uS). Note that emission is measured on 100KHz BW.
- Options to go In/Out of LPI with little or no latency.

Example clocking from GMII to MDI



- Major clocks are multiples of 25MHz.