

On Symbol Mapping For 1000BASE-T1

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Supporters

Agenda

- Considerations of Mapping
- Mapping Schemes
- FEC Requirements
- Clock Content
- Baseline Wander
- Discussions

Considerations of Mapping

- Bandwidth efficiency
 - Power \sim Baud Rate².
 - BW needs to be smaller than 500MHz to avoid potential RFI in the future.
- Clock Content
 - Clock can only be recovered with sufficient signal transitions. Lack of clock content leads to larger clock jitter.
 - Clock jitter affects error performance: echo cancellation and signal equalization.
- Baseline Wander
 - Larger baseline wander requires longer DFE feedback.
 - The difficulties of implementing DFE with large number of taps are often under estimated.
 - Cause more error propagation.
 - Increased signal dynamic range and increased power consumption.

Mapping Schemes

| Mapping Schemes | Bandwidth Efficiency | Error Propagation Control | Run Length | Decision Distance | Complexity |
|-----------------|----------------------|---------------------------|--------------------------|-------------------|---------------------|
| 7B11T | 99% | No | 12 | 0 dB | LUT of 2048 entries |
| 2B3T | 94.6% | No | Infinity | -0.5dB | LUT of 8 entries |
| 7B10T | 90.1% | 6dB | 4 for “+-1” 6 for “0” | 0.07dB | 2 LUT of 8 entries |

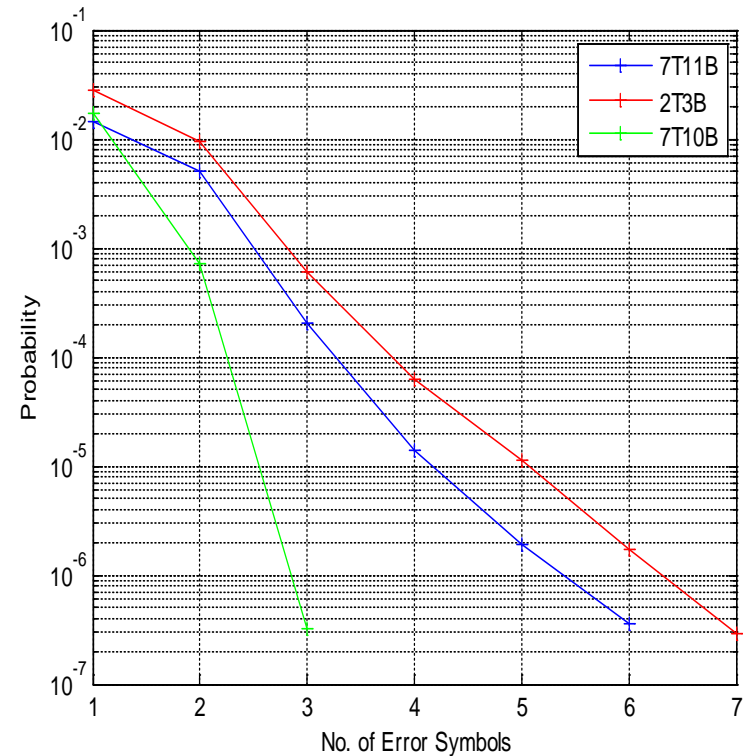
FEC Requirements

- RS codes.
- If connector interruption ($>7\Omega$ impedance) is not an issue, consider codeword length <300 ns.
- A single error correction is sufficient for ISO 7637-3 transient noise [xiaofeng_3bp_02_0514].
- RFI dictates coding requirements.
 - Determine the required correction capability t as the maximal burst error length within a codeword at probability $< \text{Number_of_bits_per_codeword} * 1e-10$.

Error Performance Under RFI

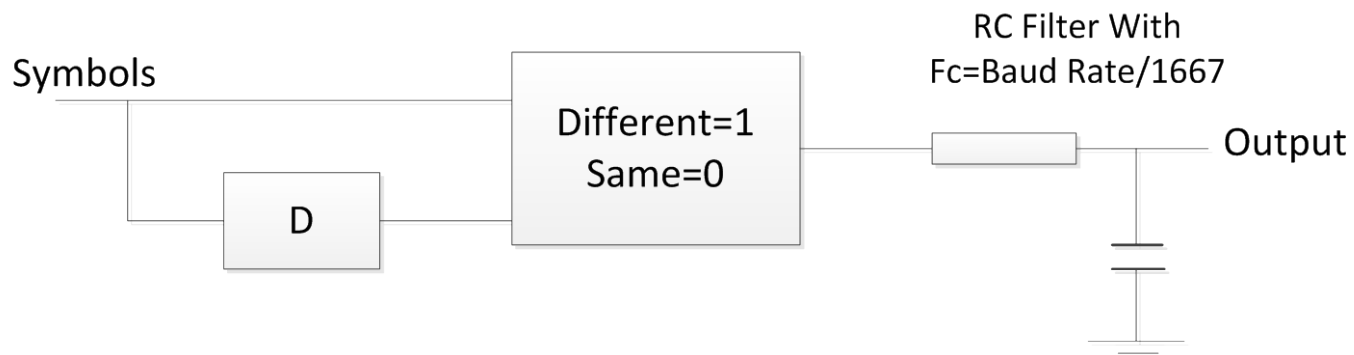
- DFE Tap $B(n) = [0.6484 \quad 0.0978 \quad -0.0452 \quad -0.1192 \quad -0.1232 \quad -0.1309 \quad -0.1196 \quad -0.1166 \quad -0.1050 \quad -0.1000 \quad -0.0898 \quad -0.0845 \quad -0.0758 \quad -0.0708 \quad -0.0634]$ for 2m channel at room temperature.
- RFI peak to peak amplitude = 0.70 vs. eye height = 1.
- RFI frequency at 0.47fb with fb as symbol rate.
- Codeword length 255.

| Mapping Scheme | Required t | Coding Efficiency |
|----------------|------------|-------------------|
| 7T11B | 7 | 0.94 |
| 2T3B | 8 | 0.933 |
| 7T10B | 4 | 0.965 |

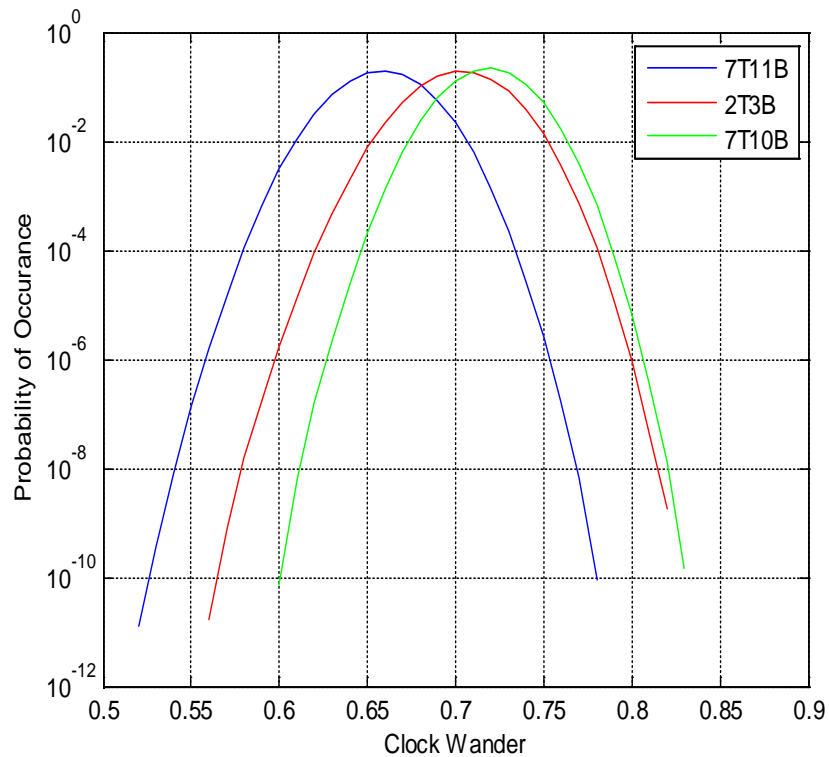


Clock Content

- Use OIF definition of “clock wander” as a metric of clock content, see [http://www.oiforum.com/public/documents/OIF_WP_CEI_Short Stress Patterns.pdf](http://www.oiforum.com/public/documents/OIF_WP_CEI_Short_Stress_Patterns.pdf)
 - The Golden PLL with $f_c = \text{Baud rate}/1667$ is appropriate for the purpose here (clock around 100ppm).
 - For PAM-3, make no difference between signal levels in evaluating clock wander.

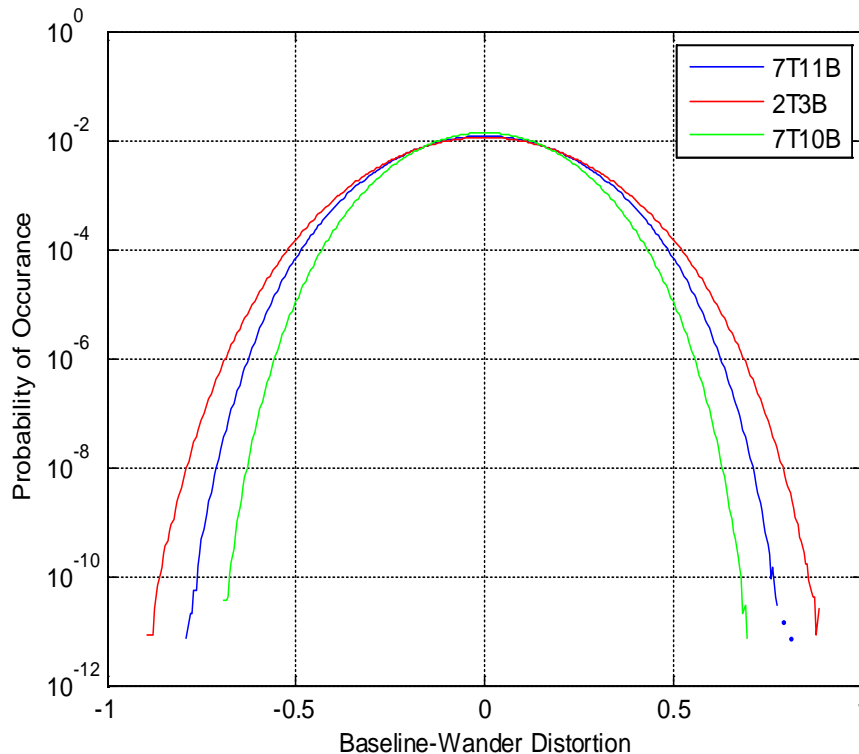


Clock Content II



- 7T10B provides the most clock content and 7T11B has the poorest clock content.
- At $1e-10$, 7T10B has a 0.6 dB gain over 2T3B and 1.1 dB over 7T11B.

Baseline Wander



- Consider the instantaneous offset caused by an HPF with cutoff frequency at 10MHz.
 - Symbols take values $\{-1, 0, 1\}$.
- At $1e-10$, 7T10B has 1dB less baseline wander distortion than 7T11B and 2.1dB less baseline wander distortion than 2T3B.
 - If allow truncation at $1e-12$, the dynamic range of 7T10B is 0.5dB less than that of 7T11B and 1dB less than that of 2T3B.

Summary

| Mapping Schemes | Bandwidth Efficiency With Coding | Clock Content @1e-10 | Baseline Wander Distortion @1e-10 |
|-----------------|----------------------------------|----------------------|-----------------------------------|
| 7B11T | 93.2% | 0.525 | 0.76 |
| 2B3T | 88.3% | 0.565 | 0.86 |
| 7B10T | 87.0% | 0.602 | 0.68 |

Discussions

- Symbol mapping affects bandwidth efficiency, clock, and baseline wander.
- 7T10B has the least bandwidth efficiency, 6.2% loss over 7T11B 1.3% over 2T3B, but provides the most signal transitions and less baseline wander distortion.
- Projected increase of power consumption of 7T10B due to bandwidth efficiency may well be made up by reduced implementation complexity due to desired signaling properties.
- At current stage, it is undesirable to emphasize bandwidth efficiency over other implementation difficulties.