Amendment and Supplement to brown_01_0312

IEEE P802.3bj

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Introduction

- Amendment to brown_01_0312 “100G backplane PAM4 PHY encoding (revised)”
  - Corrections to slides 4 and 26.
- Supplement brown_01_0312 with electrical test methodology and parameters based on
  - moore_02_0312
  - bliss_01a_0911

- **AMENDMENTS ←**
- ELECTRICAL TEST METHODOLOGY AND PARAMETERS

Amendment to brown_01?_0312
delete slide 4 and replace with the following

Transmitter process

- Transcoding: 256B/257B (was 512B/514B)
  - Aligns with NRZ (gustlin_01_0312)
- FEC: RS(444,412,T=16,M=10)
- PAM4 Symbols: Gray mapping,
  - {+1,+1/3,-1/3,-1} map to {10,11,01,00}
- Precoding: 1/(1+D) MOD 4
- PAM4 block termination: 1 PAM4 termination symbol per 32 PAM4 symbols
  - 63 data bits per 32 PAM4 symbols
- PAM4 symbol rate: 88 * 156.25 MHz = 13.75 Gbaud
- Tx pre-emphasis: 3 taps, one pre, one post
  - same structure as for 10GBASE-KR
- ~~PAM4 test methodology and parameters addressed in bliss_01a_0911.~~

PAM4 electrical test methodology and parameters are provided in brown_02_0312.

Amendment to brown_01?_0312
Delete slide 26 and replace with the following…

PAM4 encoding

- ~~Gray mapping~~
  - ~~pre-coder output {10, 11, 01, 00} maps to {+1,+1/3,-1/3,-1}~~
  - based on 2B1Q coding used in HDSL and ISDN

Gray mapping
- {10,11,01,00} map to {3,2,1,0} at input to pre-coder
- pre-coder output {3,2,1,0} map to {+1,+1/3,-1/3,-1}

- AMENDMENTS
- ELECTRICAL TEST METHODOLOGY AND PARAMETERS ←

Introduction

This is a proposed baseline for signal integrity specifications in IEEE802.3bj. It is either complete or nearly complete in general form and outline but many specific specs and values need refinement. I intend to ask the task force to accept it as a baseline for writing the initial draft spec.

This proposal is heavily leveraged from IEEE802.3ap and IEEE802.3ba and some slides are specifically based on tables or equations from these prior specs. Some values have been changed to take into account the increased data rate and some have been marked TBD. New tests have been added to the receiver to take into account operation relying on FEC.

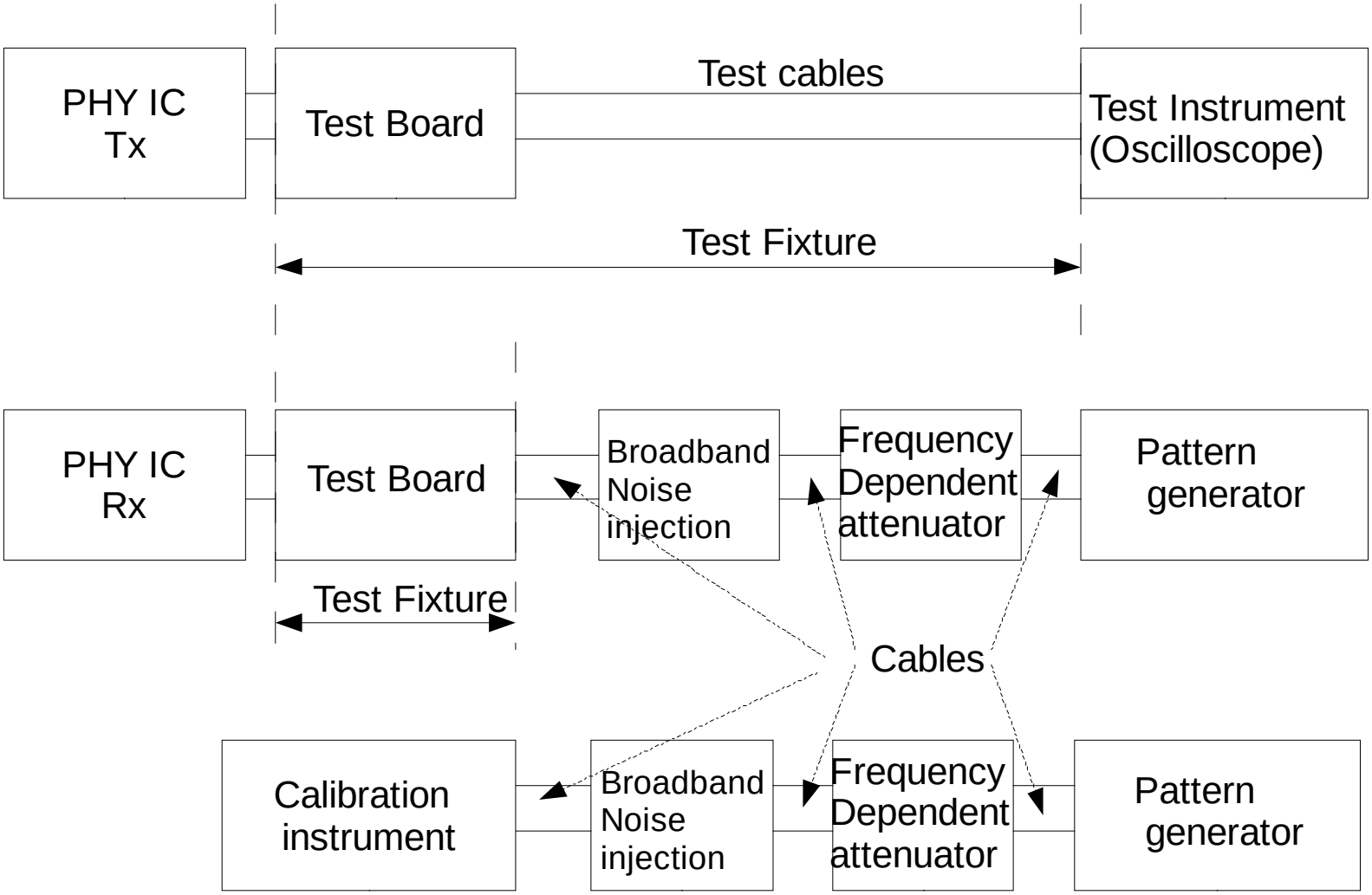
Many values are not marked as TBD but are intended only as examples of what could be done. These are highlighted in green and if this presentation is used as a baseline for an initial draft standard, they will be changed to TBD in the draft.

Fixtures for testing receiver and transmitter

We can no longer test as though the tester is connected directly to the part, the effects of losses in the channel connecting the part under test and the tester must be taken into account. This was done in IEEE802.3ba, Clause 85 for both the receiver and the transmitter but the channel, the host trace, was part of what was measured. For IEEE802.3bj we will need to specify the PHY IC by itself so to test the Rx and Tx we will need a specified test fixture and a spec which takes the fixture loss into account. The test fixture is described in another presentation given by Pavel Zivny (zivny_01a_0312). The spec given below apply at the points called TP0A and TP5A.

Expected test fixture characteristics

Test channel	Insertion loss at PAM4 Nyquist
Transmitter test board plus cable	1.5 dB- 1.7 dB
Receiver test board only	0.8 dB 1.0 dB



Tx and Rx test fixtures

Tx PHY IC Specification in test fixture Normative for PAM4 backplane

Use method used in Clause 85.8.3 “Transmitter characteristics” except

1 Change Table 85.5 as shown in slide 12 for PAM4

2 Change Table 85.6 as shown in slide 15 for PAM4

3 Change equation 85.1 (return loss) as shown in slides 13 and 14for PAM4.

Note: equation 85.1 will be used in finding re-reflection noise so we will have some rational basis for choice.

4. Additional linearity as shown on slides 16 and 17.

PAM4 Transmitter characteristics at Test interface summary

Parameter	Subclause reference	Value	Units
Signaling rate, per lane	85.8.3.8	13.75 ±100ppm	GBd
Differential peak-to-peak output voltage (max) with Tx disabled	85.8.3.3	30	mV
Common-mode voltage limits	72.7.1.4	0-1.9	V
Differential output return loss (min)	85.8.3.1	See Modified equation	dB
Common-mode output return loss (min)		See Modified equation	dB
Common-mode AC output voltage (max., RMS)		30	mV
Amplitude peak-to-peak (max)	72.7.1.4	1200	mV
Transmitter Steady State Amplitude	85.8.3.3	TBD min 600 max	mV
Linear fit pulse (min)	85.8.3.3	TBD x Transmitter DC amplitude	mV
Transmitted waveform PAM4 DAC linearity max normalized error(linear fit) abs coefficient step size minimum precursor fullscale range minimum post cursor fullscale range	 (new clause) 85.8.3.3 85.8.3.3.2 85.8.3.3.2 85.8.3.3.2	 0.06 0.025 0.0083 min, 0.05 max 1.54 4	
Far-end transmit output noise (max) Low insertion loss channel High insertion loss channel	85.8.3.2	 2 See Equation (85–2) 1 See Equation (85–3)	mV
Max output jitter (peak-to-peak) Random jitter Duty Cycle Distortion Total jitter excluding data dependent jitter		 0.075 0.01 0.13	 UI UI UI

PAM4 Transmitter characteristics at Test interface

Differential output return loss (min)

$$\text{Return\_loss(f)} = 10 \cdot \log_{10}\left(\frac{\Gamma_{01}^2 + (f/f_1)^2}{1 + (f/f_1)^2}\right) \qquad f < 8\text{GHz}$$

f in Hz

$f_1 = 1.6 \cdot 10^{10}$

$\Gamma_{01} = 0.161$

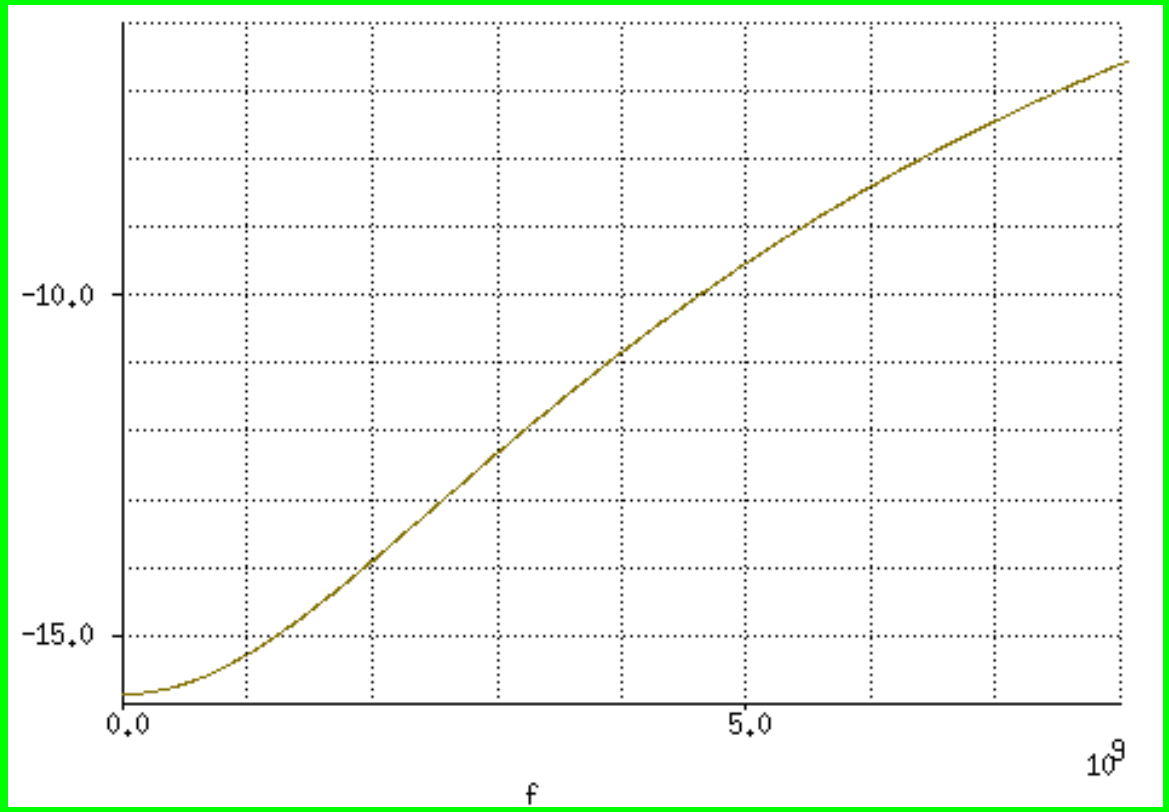
Common-mode output return loss (min)

$$\text{Return\_loss} = TBD \qquad f < 8\text{GHz}$$

PAM4 Transmitter characteristics at Test interface

Differential output return loss (min) -

-

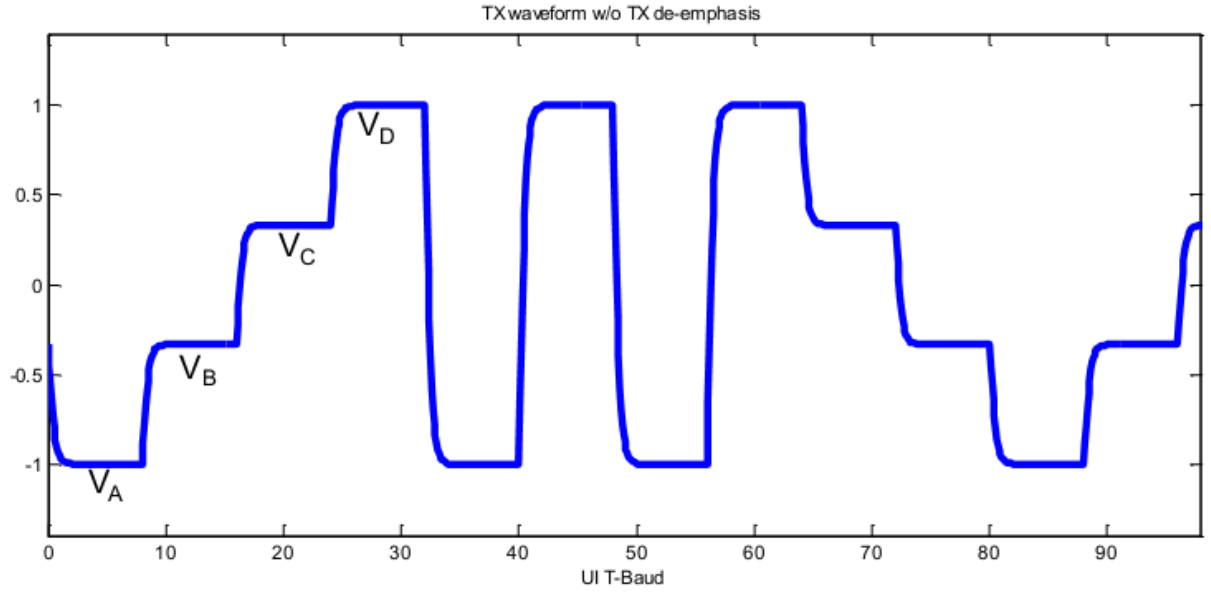


PAM4 Transmitter characteristics at test interface:
Normalized transmit pulse template

Description	Symbol	Value	Units
Linear fit pulse length	N_p	8	UI
Linear fit pulse delay	D_p	2	UI
Equalizer length	N_w	8	UI
Equalizer delay	D_w	2	UI

Slide 4 from bliss_01a_0911

A Proposed TX Stairstep Test Waveform for PAM-4



- PAM-4 test waveform is period 80T with stair steps up, stair steps down, and full swing transitions
- Each transmitted level is of duration 8 Baud periods
- Each transmitted level is measured after 3-7 Baud periods of settling

Slide 5 from bliss_01a_0911

TX Specification for PAM-4 Levels

- The most important specification for PAM-4 is that the four levels (w/o TX de-emphasis) are approximately equally spaced, else low frequency Signal to Distortion Ratio (SDR) suffers
  - Define $V_{LOW} = (V_C - V_B)/2$
  - Define $V_{HIGH} = (V_D - V_A)/6$
  - Define $V_{AVG} = (V_{HIGH} + V_{LOW})/2$
  - Spec $|V_{HIGH} - V_D/3| < 0.06\ V_{AVG}$
  - Spec $|V_{HIGH} + V_A/3| < 0.06\ V_{AVG}$
  - Spec $|V_{LOW} - V_C| < 0.06\ V_{AVG}$
  - Spec $|V_{LOW} + V_B| < 0.06\ V_{AVG}$
- More specifications can be tested with the single proposed waveform and capture
  - Symmetry between 'up' and 'down' steps
    - Rise and fall times
    - Duty cycle
  - Symmetry between steps of magnitude 2 and steps of magnitude 6
    - Rise and fall times the same

V_{AVG} is the ~amount of noise voltage at the slicer that will cause an error

Rx PHY IC Specification in test fixture

Use method described in Annex 69A “Interference tolerance testing” except:

1.Test channels defined in terms channel loss at Nyquist and limits on fitting parameters.
2. Signal and noise defined at test interface rather than IC
3. Two tests: one for short, low-loss channel, one for long, high-loss channel.
4.Normative tests for PAM4 receivers used in back planes are given in slide 19.
5. Specify differential return loss in a manner similar to the Tx.
6. Also specify differential to common mode return loss.

Conditions for normative interference tolerance test of PAM4 backplane PHY

Parameter	Test 1 values	Test 2 values	Units
Type of test	Short	Long	
Bit error ratio before ECC max (BER < 10^{-12} after ECC)	3E-4	3E-4	
Loss at 6.88 GHz Real part of a0 min Real part of a1 min Real part of a2 min Real part of a4 min	15 -0.100 -1.2×10^{-5} No min -2.5×10^{-21}	32 -0.100 -1.5×10^{-5} No min -5.0×10^{-21}	dB $Hz^{-1/2}$ Hz^{-1} Hz^{-2}
Channel Noise minus Tx-Rx re-reflection noise	0.0	0.0	mV
Applied SJ (peak-to-peak) at > 50 MHz	0.058	0.058	UI
Applied RJ (peak-to-peak at BER=10^{-12})	0.075	0.075	UI
Applied DCD (peak-to-peak)	0.01	0.01	UI
Broad band Noise (RMS)	10.2	4.6	mV

For all test channels: maximum a0=0.1, maximum for a1, a2, a4 is 0

Thanks!