

PAM-2 Training in 100BASE-T1L

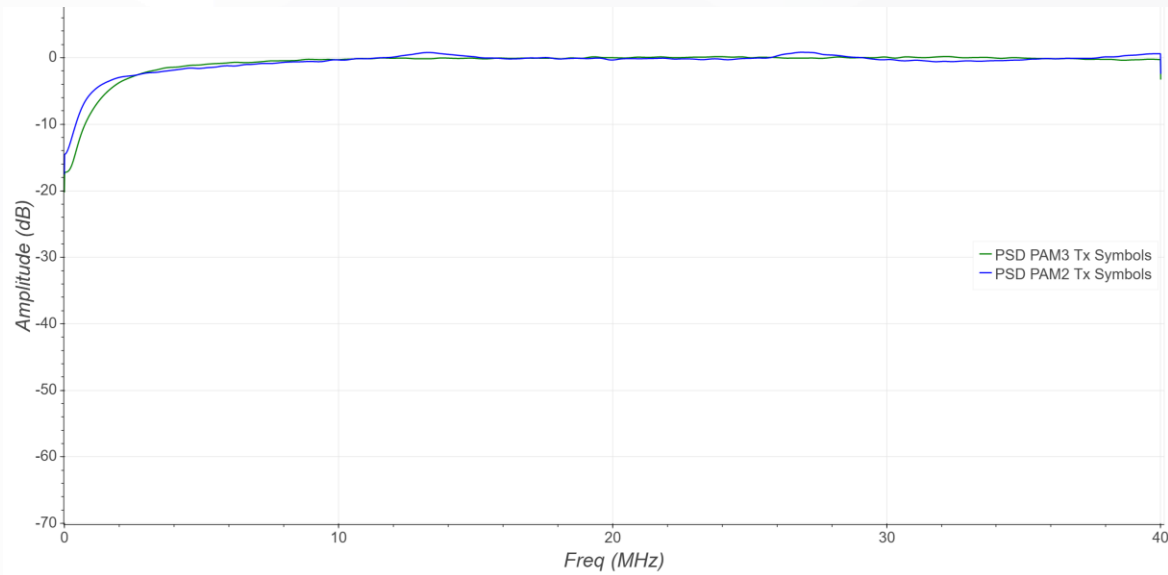
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- ▶ Using PAM-2 during training has been discussed in some recent presentations
 - At the October Interim meeting a PAM-2 line coding table of NND PAM2 6-tuples with a running disparity scheme to ensure randomization and control of running disparity was presented
 - See [Tingting_3dg_01_29_10_2024](#) for the most recent presentation
- ▶ PAM-2 has a greater SNR than PAM-3 and thus an advantage during start-up and blind acquisition as it is easier to open the eye
 - It is not clear that there is a problem to be solved here as we appear to be always able to open the eye with PAM-3 for channels that we can operate on with a reasonable SNR
- ▶ There is a concern over data correlation as the number of 6-tuples in PAM-2 is greatly reduced
 - This may result in spurs in the spectrum of the transmitted signal
 - This may result in a different set of DFE and echo canceller coefficient in training compared to data, which then have to be adjusted before entering data
 - However, the results presented to date appear to show that neither of the above is a significant problem
- ▶ As there are advantages to PAM-2 this suggest further investigation is warranted to confirm there are no other downsides to including PAM-2 during training
 - With a view to including PAM-2 during start-up and training

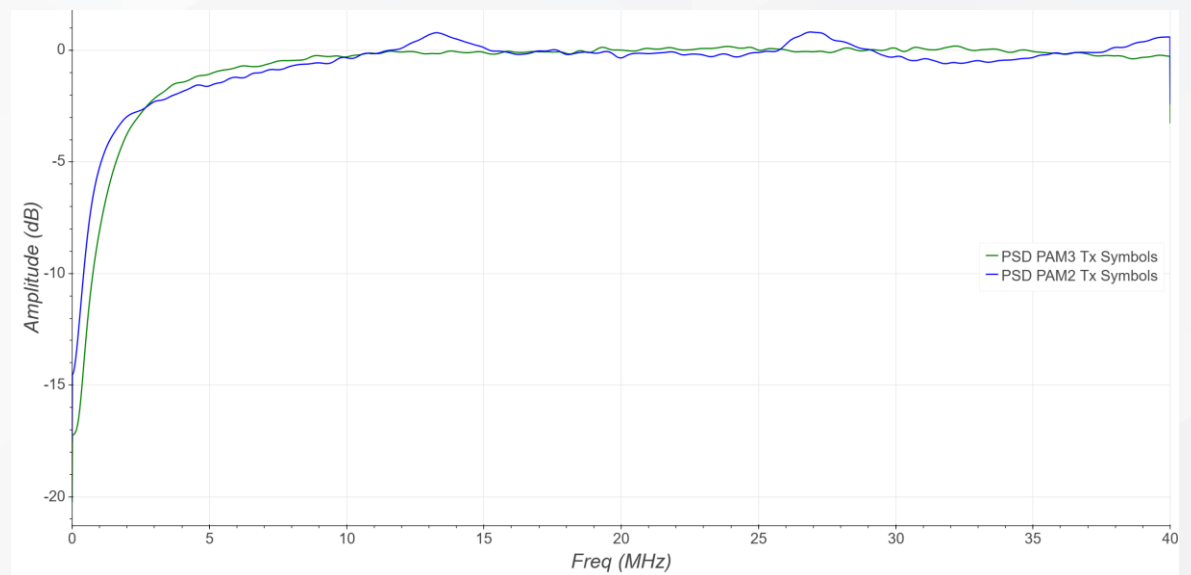
Parameters to Calculate the Amplitude Spectrum

- ▶ [Tingting_3dg_01_29_10_2024](#) has already presented results of the amplitude spectrum of the PAM-2 4B6T symbols
 - This presentation also calculates the amplitude spectrum and shows similar results
- ▶ The amplitude spectrum of the PAM-3 8B6T and PAM-2 4B6T symbols are calculated using the Welch method with overlapping segments
 - Using 131072 6-tuples
 - This is 786432 symbols, ~10 ms time duration
 - Using an 8192 point FFT and Hann window
 - Identical data set used for PAM-3 and PAM-2
 - Select the PAM-3 6-tuple using the scrambled data octet $Sd_n[7:0]$ where the input to the scrambler $TB_n[7:0]$ is set to zero
 - Select the PAM-2 6-tuple using 4 LSBs, $Sd_n[3:0]$
- ▶ Do not average multiple spectrum
 - Spectrum result presented is for this set of 786432 scrambled data octets
 - This result does not include the delimiters

Spectrum of PAM-2 4B6T Symbols

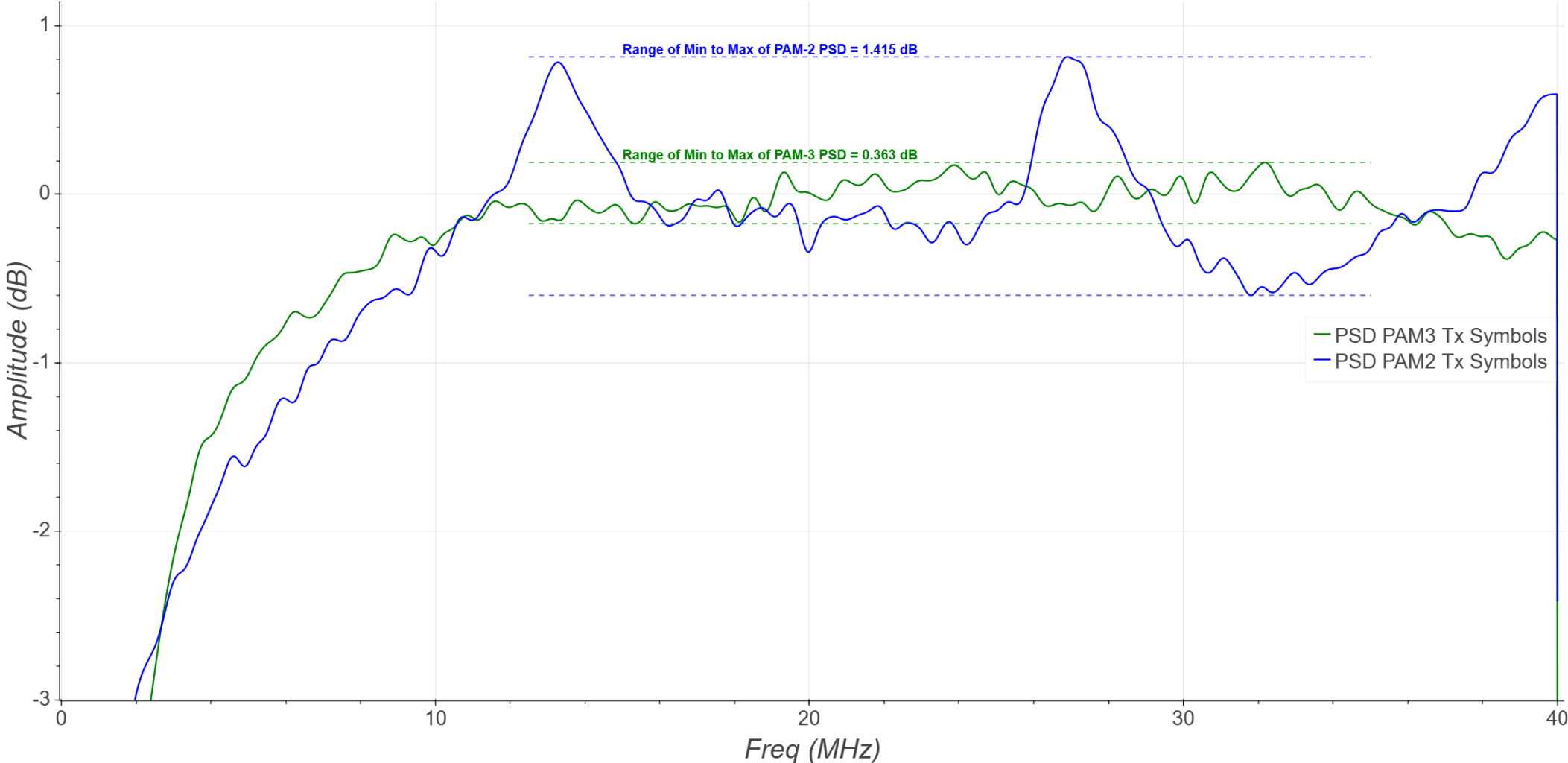


Same scale as presented in [Tingting_3dg_01_29_10_2024](#)



Smaller scale to show more detail

Spectrum of PAM-2 4B6T Symbols – Min / Max Range



Amplitude Spectrum Results

- ▶ Result confirm the result already presented in [Tingting_3dg_01_29_10_2024](#)
 - No large spurs in the power spectrum
 - Similar positive deviation of about 0.8 dB around 14 MHz and 28 MHz and negative deviation of about 0.6 dB near 34 MHz
 - The PAM-3 spectrum shows a difference between the min and max amplitude spectrum in the mid-range of about 0.4 dB, increasing to 1.4 dB with PAM-2
 - No real concern here with respect to ESD requirements of behaviour of the transmit spectrum
- ▶ With the smaller data set of PAM-2 we would expect to see some data correlation
 - This is evident in the PAM-2 amplitude spectrum
 - The optimal coefficients of the adaptive filters depend on the autocorrelation characteristics of the data and the spectrum shows there is some correlation in the data
 - Hence, we expect to require some adjustment of coefficients when we switch to PAM-3

- ▶ Do not see any issue with the amplitude spectrum of the proposed PAM-2 set of symbols used in 4B6T
 - Have not looked at 5B6T but expect a similar result
 - The 4B6T would be a simpler map to 8B6T, so would appear to be a better choice
- ▶ Expect to require some tuning of the coefficients when we switch from PAM-2 to PAM-3
 - Don't expect to see any issues here, but would like to confirm with further investigation
 - Is there any advantage to using a different selection of 6-tuples?
- ▶ Running Disparity
 - The range of running disparity for the PAM-2 training is ± 7 , compared to ± 5 during 8B6T data
 - For 8B6T data the bound at the 6-tuple boundary is ± 3 and have 0 disparity codes starting with 2 +1, e.g. (++----), and thus, the instantaneous disparity can be ± 5
 - PAM-2 training has one 6-tuple with disparity +4 and a 0 disparity code starting with 3 +1(+++---), so ± 7
 - Ideally, we would have the same disparity bound during training and data
 - Is there a selection of 6-tuples of only disparity 0 and disparity 2?

Questions ?