4B6B Coding for Training

Tingting Zhang
Huawei Technologies

Introduction

- Most of the PMA training based on 4B6B PAM2 have achieved consensus.
- Simulation results (Tingting_3dg_01_29_10_2024, Murray_3dg_04a_11132024) have confirmed that 4B6B coding using NND 6-tuples and the random bit Sg_n is well-behaved without significant concern over data correlation.
- Only a small question on the feasibility of replacing (-++++) with a code group with +2 disparity change to further decrease the bounded disparity.
- This presentation shows simulation results of the PAM2 spectrum generated from 4B6B using new coding tables and compares the results with original 4B6B coding and 8B6T.

4B6B Code Groups

- 42 of 64 PAM2 6-tuples have non-negative disparity change. 20 code groups with 0 disparity change have been used in the 4B6B coding. 10 of them are in the table, with the complementary ones (out of the table) for running disparity control.
- There are 15 code groups with +2 disparity change in total. Only five are used. Any one of the redundant 10 code groups can be considered to replace the code group (-++++) in the table.

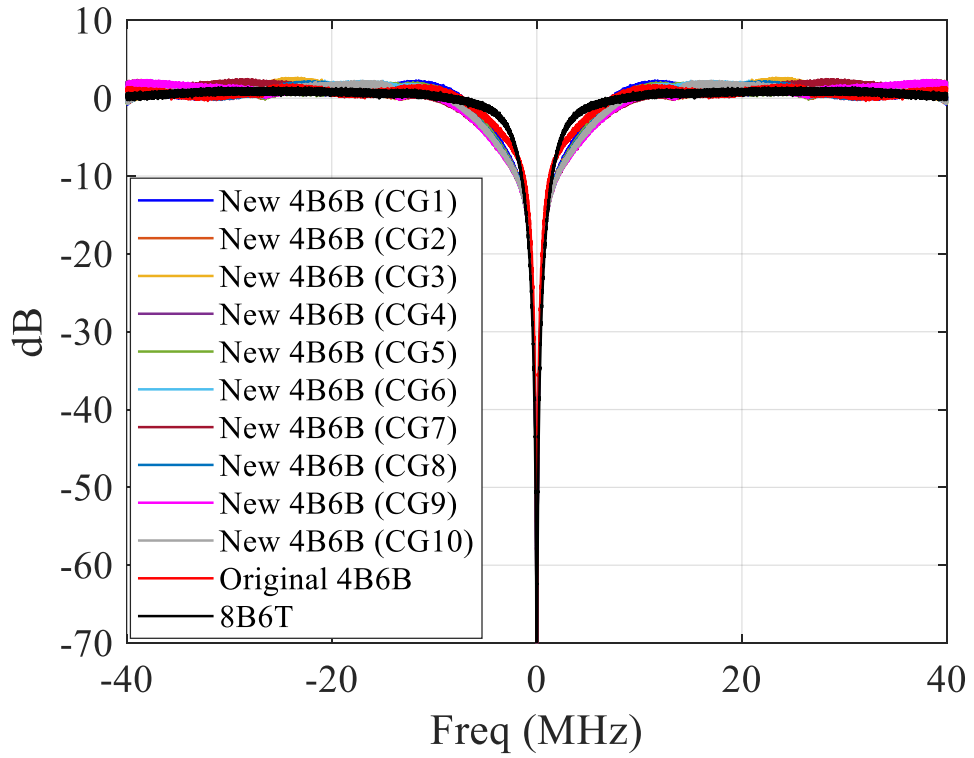
4 bits input	NND Code Groups						Disparity Change
0000	-1	1	-1	1	-1	1	0
0001	-1	-1	1	1	-1	1	0
0010	**-1**	**1**	**1**	**1**	**1**	**1**	**4**
0011	1	-1	1	-1	1	1	2
0100	-1	1	-1	1	1	-1	0
0101	1	1	1	-1	1	-1	2
0110	-1	1	1	-1	-1	1	0
0111	-1	1	-1	-1	1	1	0
1000	1	1	1	1	-1	-1	2
1001	-1	-1	-1	1	1	1	0
1010	-1	-1	1	-1	1	1	0
1011	-1	-1	1	1	1	-1	0
1100	1	1	-1	1	1	-1	2
1101	-1	1	1	-1	1	-1	0
1110	-1	1	1	1	-1	-1	0
1111	1	1	-1	-1	1	1	2

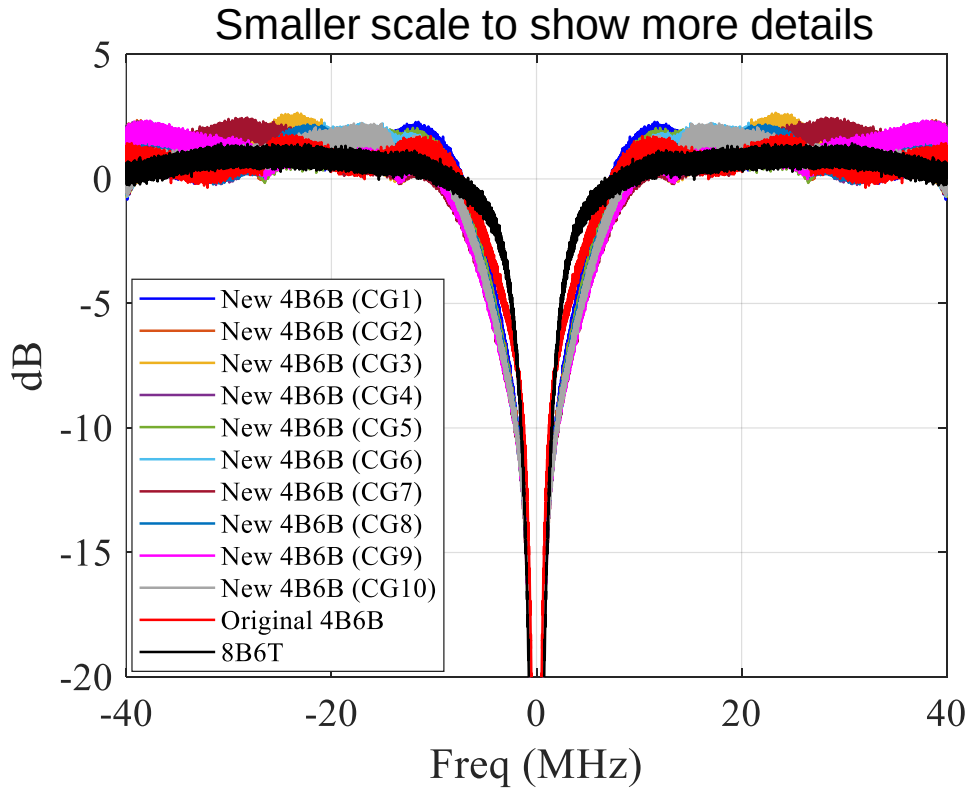
The residual 10 code groups with +2 disparity change

CG1	-1	-1	1	1	1	1
CG2	-1	1	-1	1	1	1
CG3	-1	1	1	-1	1	1
CG4	-1	1	1	1	-1	1
CG5	-1	1	1	1	1	-1
CG6	1	-1	-1	1	1	1
CG7	1	-1	1	1	-1	1
CG8	1	-1	1	1	1	-1
CG9	1	1	-1	1	-1	1
CG10	1	1	1	-1	-1	1

Transmit Spectrum

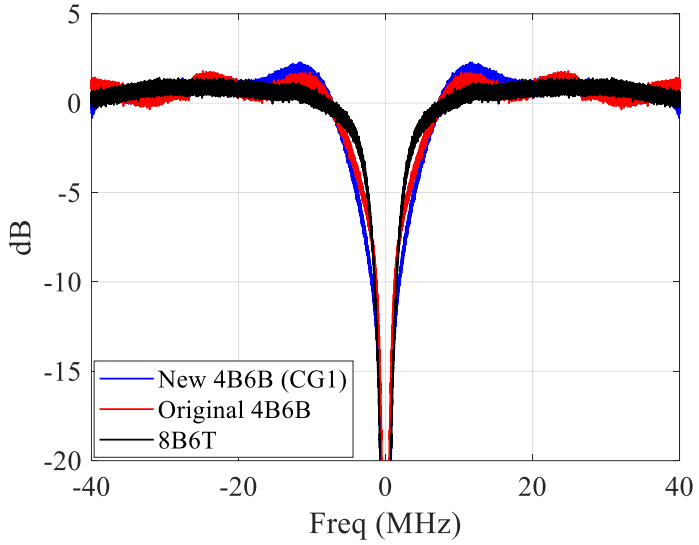
- Replacing the 6-tuple (-,+,+,+,+,+) with one of the residual 10 code groups CG1~CG10 does not result in large spurs in the power spectrum.
- However, the spectrum difference from 8B6T is larger than that using original 4B6B coding with the +4 disparity 6-tuple. A larger MSE change is expected when switching from PAM2 to PAM3.

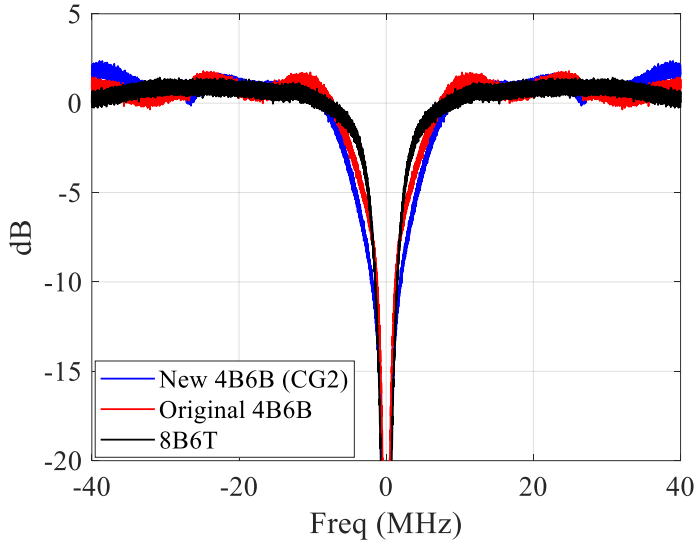


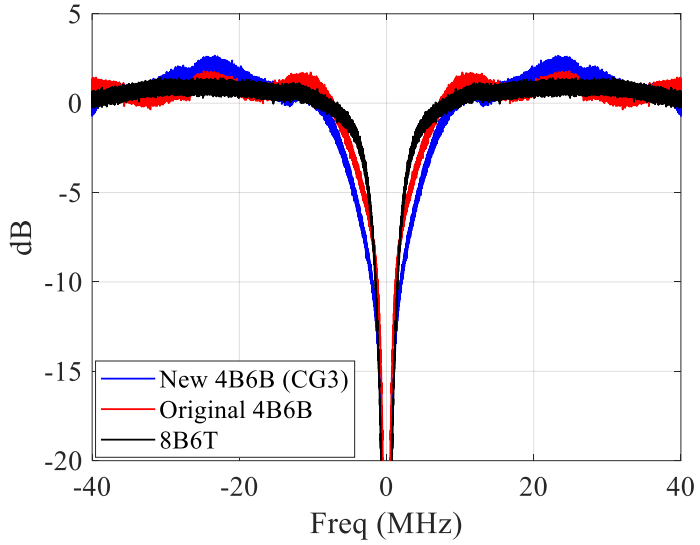


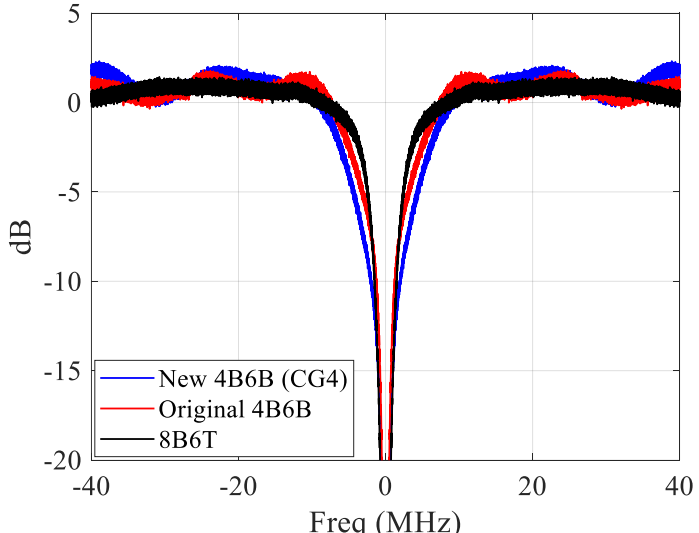
Power Spectrum with smaller scale for each new 4B6B coding

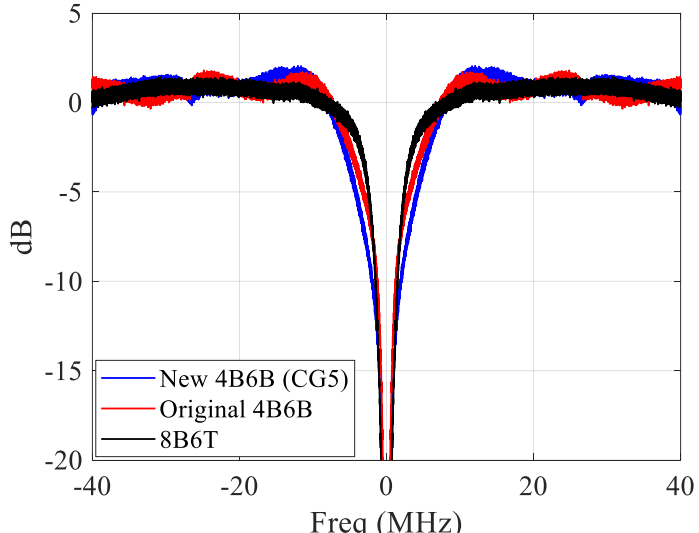
- The new 4B6B coding with the 6-tuple (-,+,+,+,+,+) replaced by CG1, CG2, CG3, CG4, CG5, or CG6 gives larger spectrum difference from 8B6T than original 4B6B coding with (-,+,+,+,+,+).

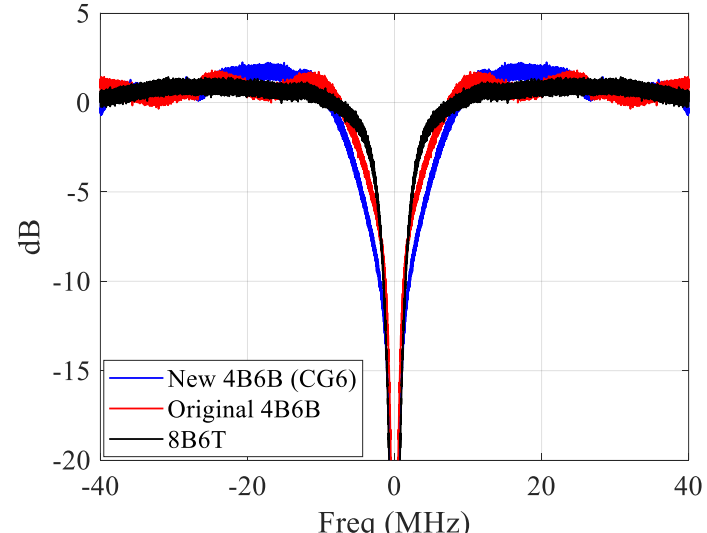






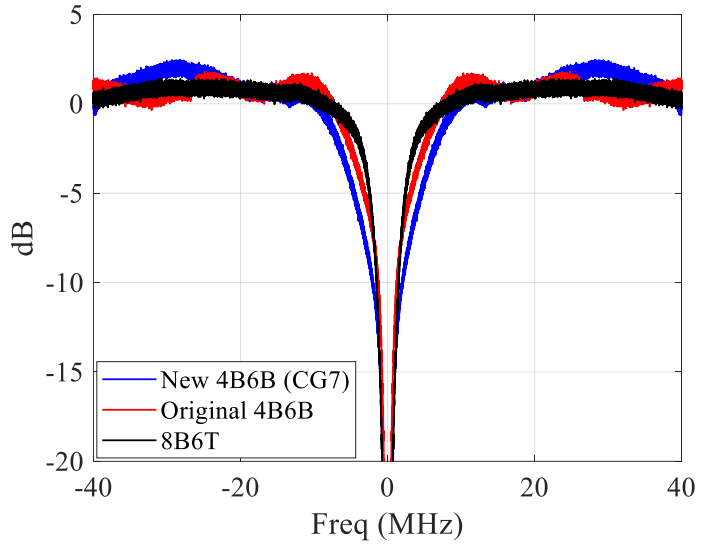


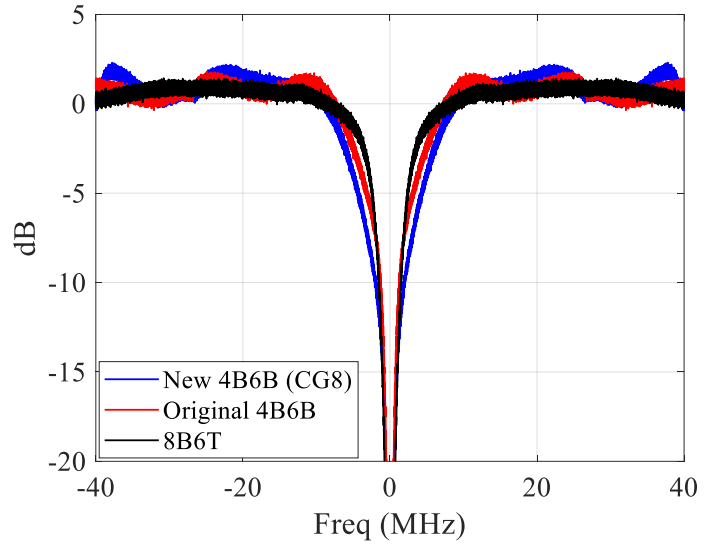


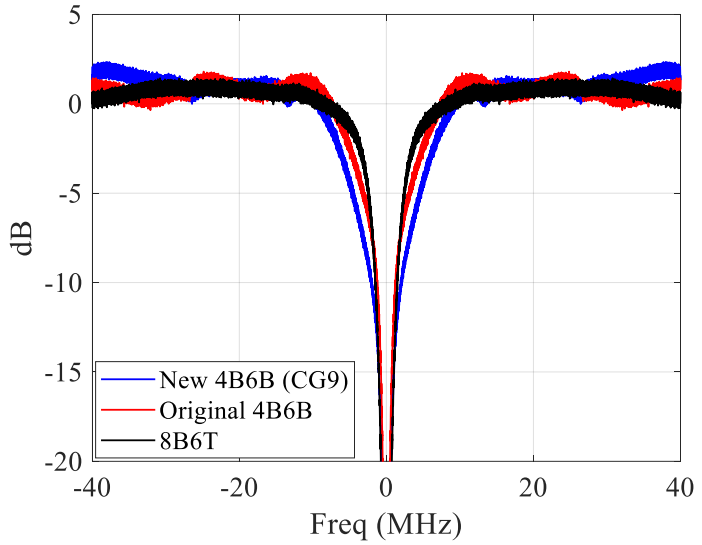


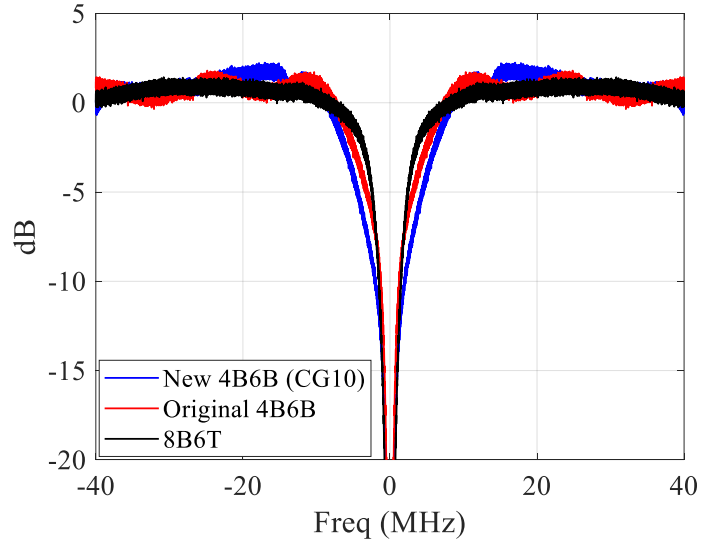
Power Spectrum with smaller scale for each new 4B6B coding (Cont.)

- Replacing the 6-tuple (-,+,+,+,+,+) by CG7, CG8, CG9, or CG10 does not give better results.









Conclusion

- Replacing the PAM2 6-tuple (-,+,+,+,+,+) by any one of the residual 10 code groups with +2 disparity change does not cause large spurs.

- 4B6B using the new coding table results in a larger spectrum difference from 8B6T than utilizing the original coding table. Consequently, a larger MSE change and more coefficient tuning are expected when switching from PAM2 to PAM3.

- We suggest using the original table with the +4 disparity code group for 4B6B coding during training.

Q & A