Title:

8-DPSK vs. 8-PSK.

Source:

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Abstract:

This contribution provides performance results of simulations for 8-DPSK with a new channel encoding scheme and for 8-PSK with the channel encoding scheme described in [1]. Simulation results presented in this contribution show that, in terms of uncoded BER at low speed, practical differential detection of 8-DPSK is about 0.5 dB worse than practical coherent detection of 8-PSK. In terms of FER differential detection is within 0.5 dB for class 1A and within 1 dB for class 1B of practical coherent detection of 8-PSK. At higher Doppler rates (50 and 184 Hz), the results demonstrate that the proposed coding scheme with 8-DPSK matches or significantly betters the performance of the scheme in [1]. Based on the results presented in this contribution, it is recommended that a differential encoding scheme with the proposed channel coding scheme, be adopted for 136+.

Recommendation:

Review and adopt.

Notices:

Introduction

This contribution presents performance results for differential detection and coherent differential detection of differentially encoded 8-PSK using a new channel coding and interleaving scheme for US1 codec. For clarity, the new channel coding scheme will be referred to as US1+. All results for US1+ were obtained by Lucent. The channel coding proposed in [1] with 8-PSK will be referred to as US1. All results for US1 were obtained by Ericsson. The results in [1] for ideal coherent performance were verified by Lucent's own simulations.

Simulation Details

Modulation
The data bits following Gray mapping are mapped in 8-PSK symbols for coherent modulation, and in 8-DPSK symbols for differential modulation.

Time Slot Format for 8-PSK
The timeslot format for coherent 8-PSK is described in [2].

Time Slot Format for 8-DPSK
The timeslot format used for the 8-DPSK simulations is as in fig.2. Note that no pilots and no reference symbols are necessary in a practical implementation of a 8-DPSK receiver.

SYNC 14 symbols	PC 1	DATA 434	RAMP 9

Fig.1: Slot format for 8-DPSK.

Channel Coding for 8-PSK
Channel coding for 8-PSK is described in [1]. For clarity we report the partition of bits in classes in figure 2.

Number of pre-cod bits	Code rate	Number of coded bits
class 1A+CRC : 89	1/2	178
class 1B : 74	~3/5	125
class 2 : 89		89
total: 252		392

Fig.2: Bit partitioning as in [1].

The code is with tail-biting and has a constraint length equal to 6 (32 states).

Channel Coding for 8-DPSK
For 8-DPSK new channel coding the partition of bits in classes is as follow:

Number of pre-cod bits	Code rate	Number of coded bits
class 1A+CRC : 88	2/5	220
class 1B : 76	3/5	126
class 2 : 88		88
total: 252		434

Fig.3: Bit partitioning in the new channel coding (as in UWCC)

The convolutional codes use tail-biting and have constraint length equal to 6 (32 states) or to 7 (64 states). Bit chain interleaving across 2 consecutive slots is used.

Performance Results

Simulations on 10,000 frames of data were performed to collect class 1A FER, class 1B FER, class 1A BER, class 1B BER, and class 2 BER statistics for the coding and channel estimation schemes discussed above at Doppler frequencies of 10 Hz, 50 Hz, and 184 Hz. The figures report error statistics as in the following described:

Fig. 4 : class 2 BER and modem BER at 10 Hz Doppler.
Fig. 5 : class 1A and class 1B FER at 10 Hz Doppler.
Fig. 6 : class 1A BER and class 1B BER at 10 Hz Doppler.
Fig. 7 : class 2 BER and modem BER at 50 Hz Doppler.
Fig. 8 : class 1A and class 1B FER at 50 Hz Doppler.
Fig. 9 : class 1A BER and class 1B BER at 50 Hz Doppler.
Fig. 10 : class 2 BER and modem BER at 184 Hz Doppler.
Fig. 11 : class 1A and class 1B FER at 184 Hz Doppler.
Fig. 12 : class 1A BER and class 1B BER at 184 Hz Doppler.

Each plot contains results for the following :

US1 Ideal Coherent Detection (ICD-US1) – Ideal coherent detection using known CSI, channel coding scheme in [1], timeslot format in [1]. Curves taken from [1].

US1 Practical Coherent Detection (PCD-US1) – Practical coherent detection , channel coding scheme in [1], timeslot format in [1]. Curves taken from [1].

US1+ Ideal Coherent Detection (ICD-US1+) – Ideal coherent detection using known CSI, new proposed channel coding scheme, new timeslot format (with no pilots).

US1+ Differential Detection (DD-US1+) - Differential detection using the new channel coding scheme and the new timeslot format.

US1+ Coherent Differential Detection (CDD-US1+) - Coherent Differential detection using the new channel coding scheme and the new timeslot format.

First consider the performance of US1 at 10 Hz Doppler. Refer to figures 4, 5 and 6. Since the ideal coherent performance curves in [1] were reproducible, we use the curves reported in [1] for coherent detection of 8-PSK (figures 16-30 in [1]) as reference. We will use 10^{-2} error rate as the point of reference. According to [1], the practical coherent receiver is about 0.5 dB worse than the ideal one in class 2 BER, about 1.5 dB worse in class 1A FER, about 1 dB in class 1B FER, and about 1 dB in class 1B BER.

Now consider the performance of US1+ at 10 Hz Doppler in the same figures. In terms of class 2 BER, it is seen that the ICD-US1+ and ICD-US1 ideal modem BER performance curves are very close as expected. However, due to the way the class 2 bits are mapped onto the 8-PSK constellation, the class 2 BER for US1 is about 1.5 dB worse than for US1+. On top of this, there is a small degradation seen by going to a practical coherent detection scheme. Considering both of these degradations, it is seen that the class 2 BER performance for practical coherent US1 (PCD-US1) is only .5 dB better than the class 2 BER for US1+ using differential detection (DD-US1+). A coherent differential decoding scheme will improve upon the differential detection performance further and thus it is seen that the CDD-US1+ and PCD-US1 curves are nearly identical. Thus, there is no advantage in class 2 BER with coherent detection.

Now consider class 1A FER and class 1B FER at 10 Hz Doppler and for FER=10^{-2} (fig.5). the performance of DD-US1+ is about 1 dB worse than PCD-US1 in both class 1A FER and class 1B FER when using a K=6 convolutional code. A coherent differential decoding scheme (CDD-US1+) will get to within .5 dB of the PCD-US1 performance. However if the constraint length is increased to K=7, DD-US1+ is only about 0.5 dB worse than PCD-US1 and CDD-US1+ is almost identical to the PCD-US1 curve. Thus, there is less than 1 dB to be gained by going to coherent detection over differential detection and less than .5 dB is gained over a coherent differential decoding scheme.

It should be noted that the performance improvements with coherent detection are even less at higher SNRs and that CDD-US1+ actually outperforms PCD-US1 under these conditions. Since the main application for the US1 vocoder is the indoor environment, it is likely that the operating point may more likely be at these higher SNRs where CDD-US1+ shows an advantage over PCD-US1.

Now consider class 1B BER at 10 Hz Doppler at 10^{-2} BER (fig. 6). It is seen that the PCD-US1 curve is about 1 dB better than the DD-US1+ curve, but only about .5 dB better than the CDD-US1+ curve for K=6.
Going to K=7 shows that the CDD-US1+ performance is nearly identical to the PCD-US1 performance curve. In addition, at higher SNRs, it is seen that the performance of PCD-US1 is actually slightly worse than the performance of DD-US1+ and about 1 dB worse than the performance of CDD-US1+. Thus, it is again seen that under good channel environments, which are more likely for indoor applications, the CDD-US1+ scheme can outperform PCD-US1.

Considering higher speeds, (50 and 184 Hz Dopplers) (figures 7-12) it is seen that the differences in performance between PCD-US1 and DD-US1+ are smaller than for 10 Hz Doppler. Actually, at 184 Hz the class 1A FER performance of PCD-US1 is 0.5 dB worse than DD-US1+ and significantly degraded compared to the performance of CDD-US1+. Since there has recently been some consideration for using 8-level modulation with six full-rate users per carrier (TDMA-6) which would be intended for mobile environments, it seems that a differential encoding scheme would be more beneficial and provide coverage improvements. This is further emphasized by the fact that to use coherent 8-PSK with TDMA6, the codes would have to be significantly punctured to obtain pilot symbols. Thus TDMA6 may be unfeasible with coherent 8-PSK.

Based on the above discussion, it is recommended that 8-DPSK modulation with the slot format and channel encoding proposed in this contribution be adopted for 136+ US1 vocoder.

References

[1] “Performance results for 8-PSK”, Ericsson, TR45.3.5/98.04.06.09

[2] “Slot Format for 8-PSK voice”, Ericsson, TR45.3.5/98.04.06.10

[3] “Details of coding used in UWC US1 evaluation”, TIA 45.3.5/98.03.17.05

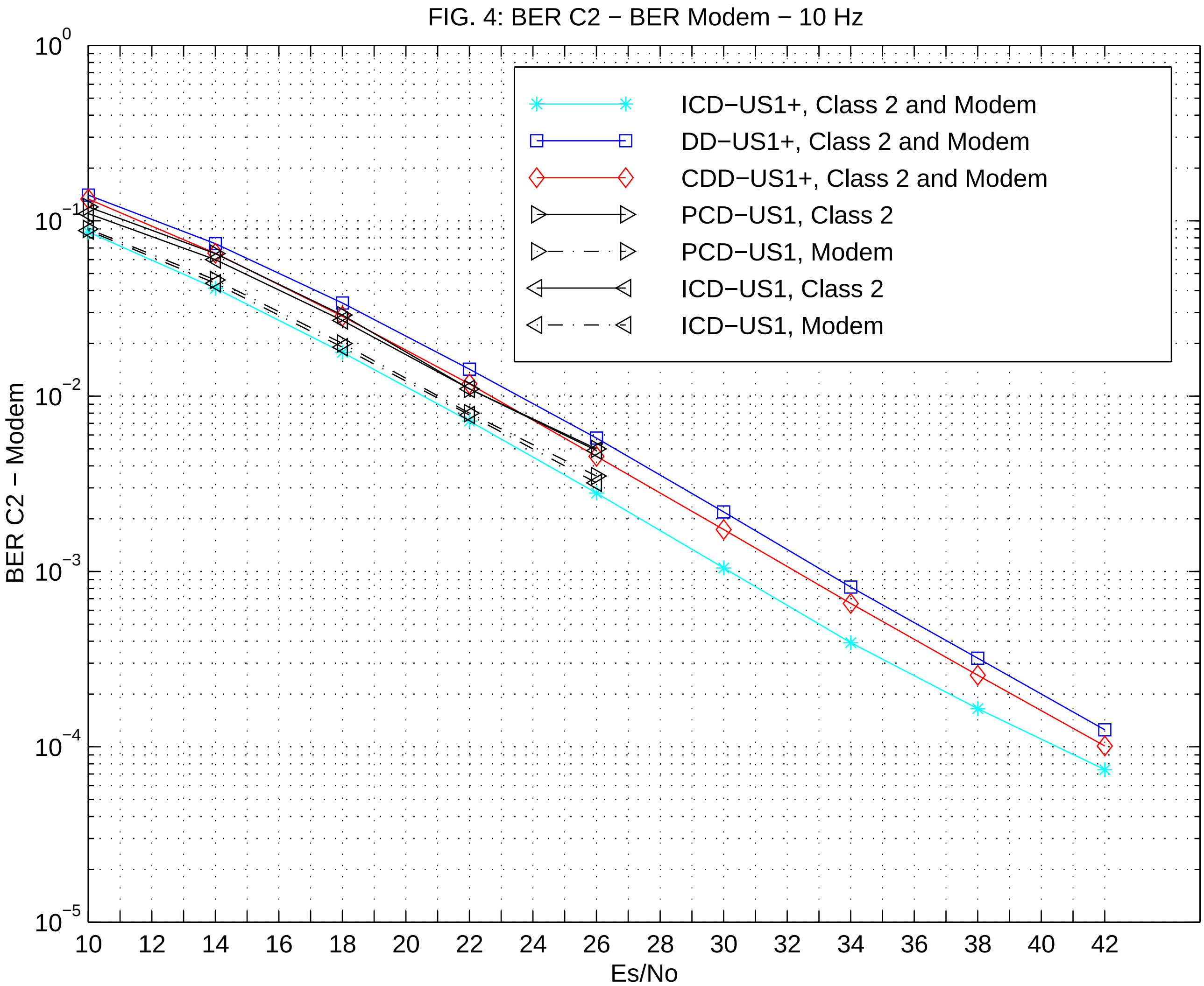


FIG. 4: BER C2 − BER Modem − 10 Hz
BER C2 − Modem
Es/No
ICD−US1+, Class 2 and Modem
DD−US1+, Class 2 and Modem
CDD−US1+, Class 2 and Modem
PCD−US1, Class 2
PCD−US1, Modem
ICD−US1, Class 2
ICD−US1, Modem
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42

FIG. 5: FER C1A − FER C1B − 10 Hz

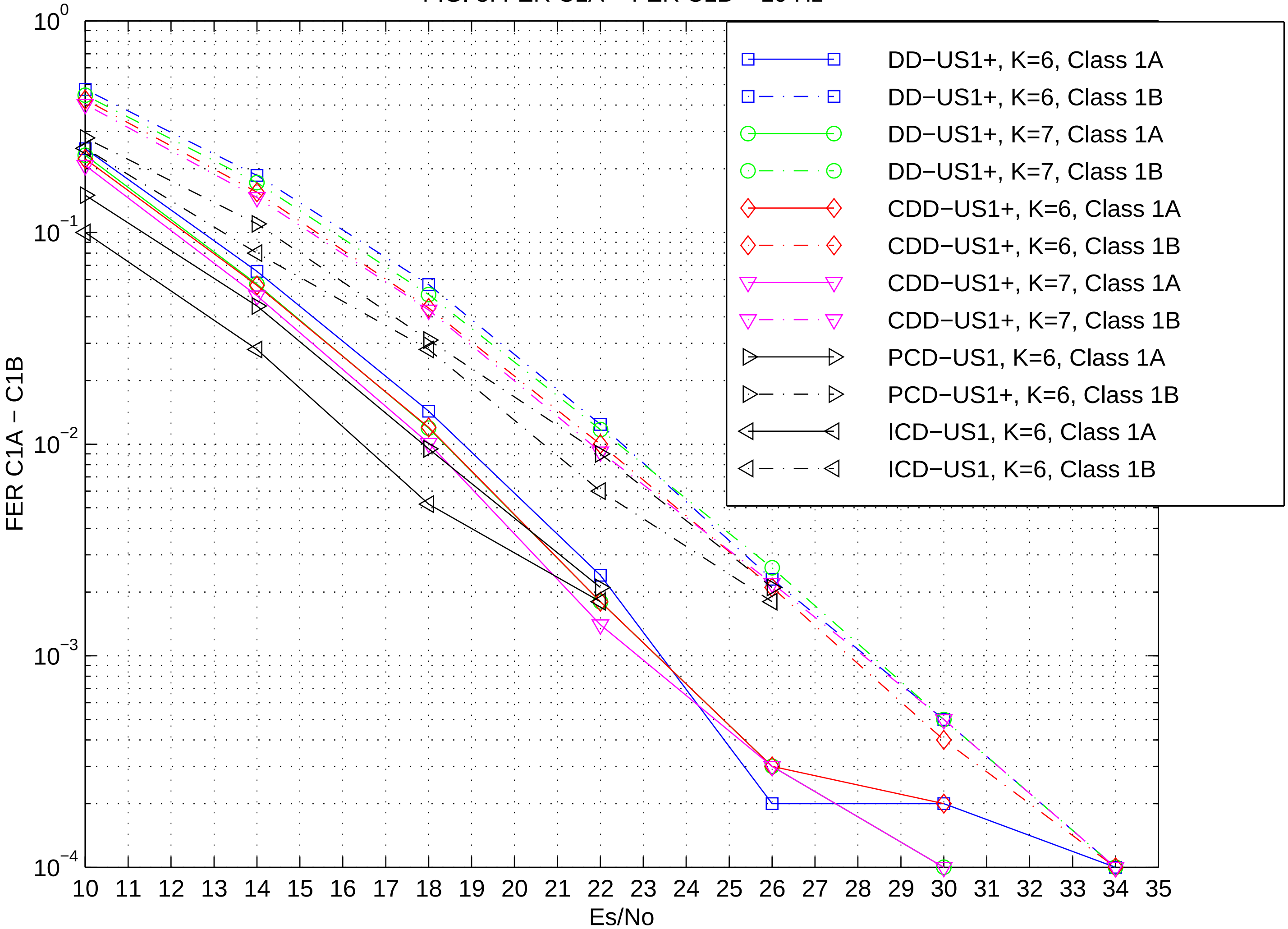


FIG. 6: BER C1A − BER C1B − 10 Hz

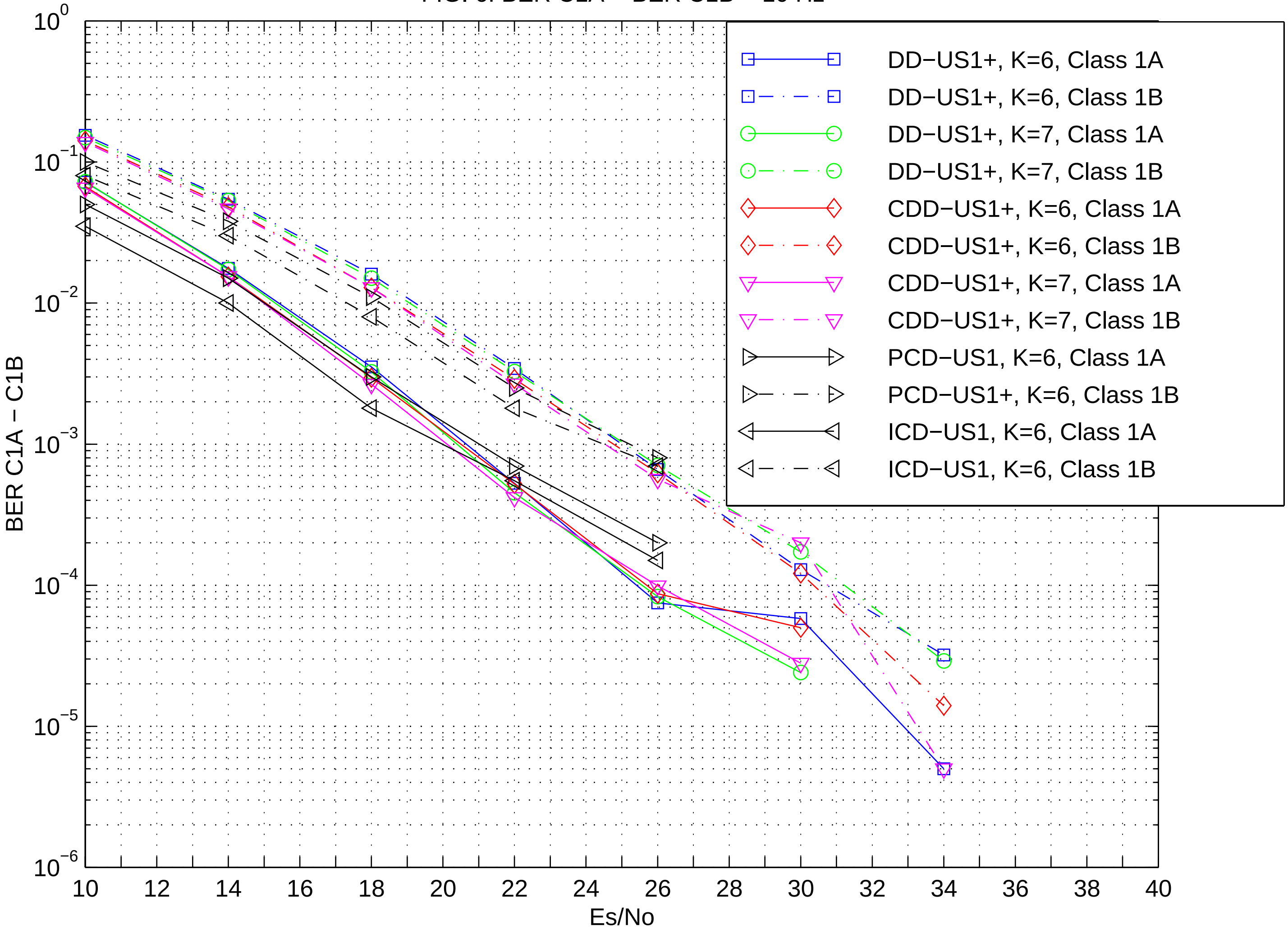


FIG. 7: BER C2 − BER Modem − 50 Hz

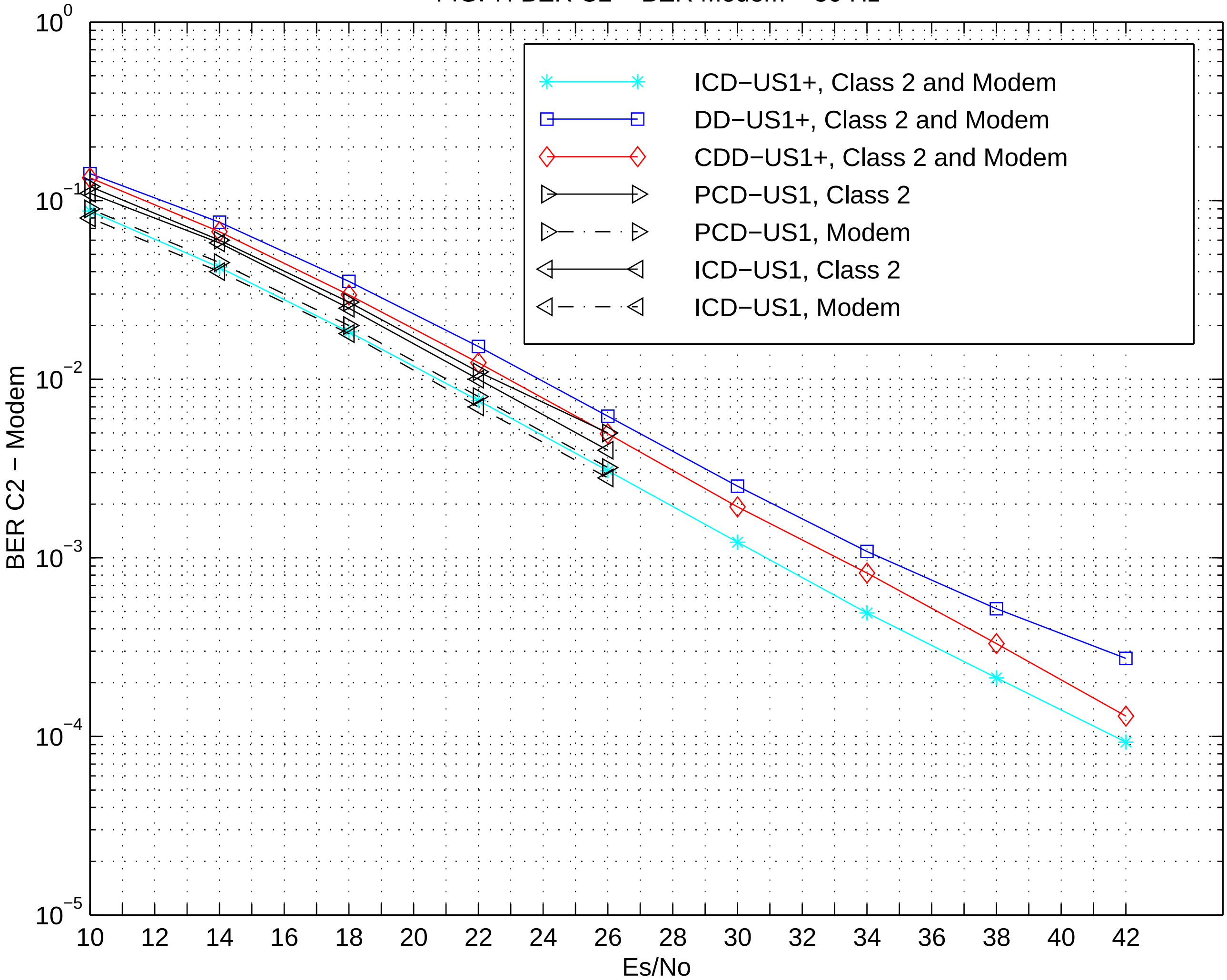
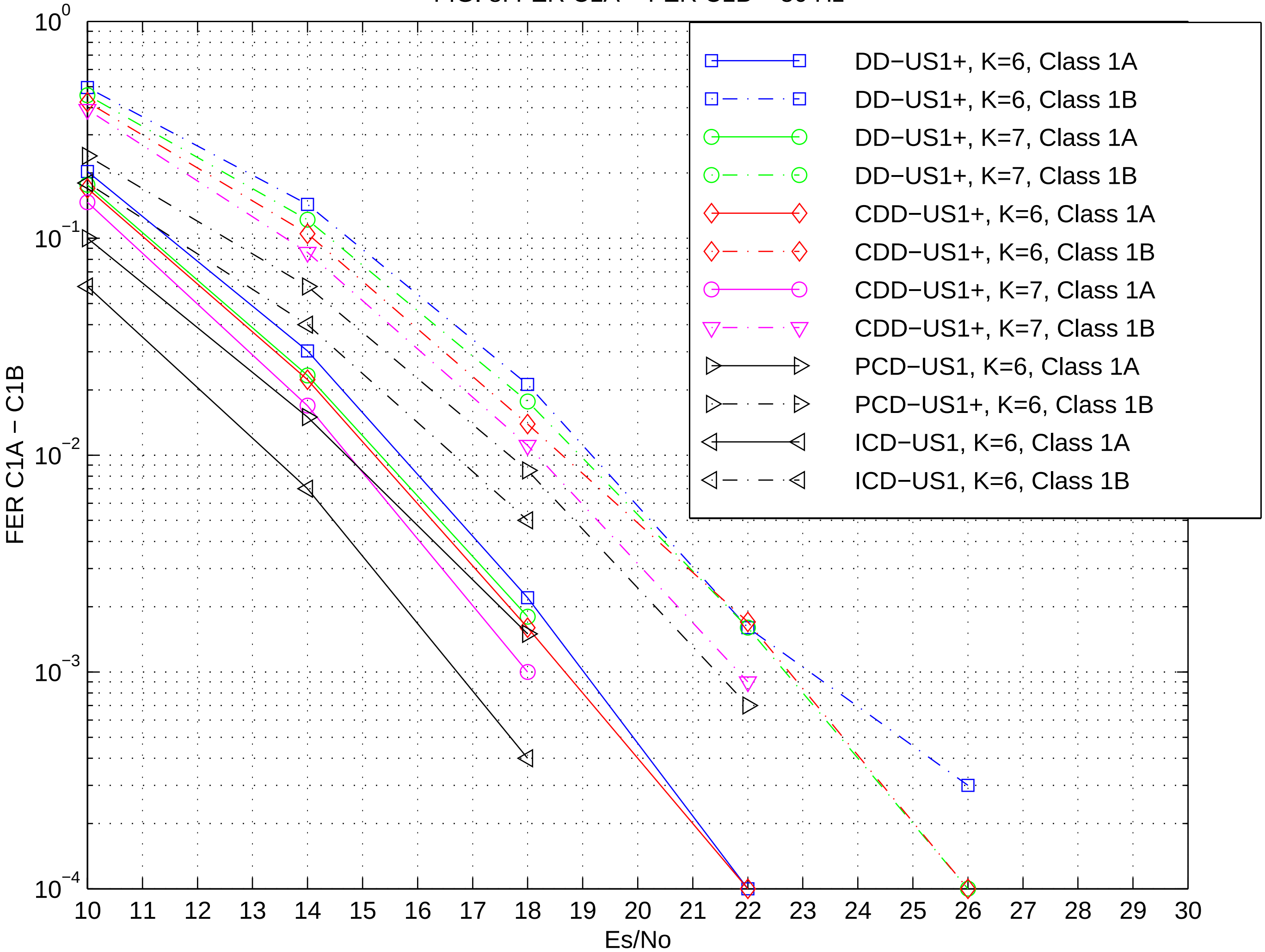


FIG. 8: FER C1A − FER C1B − 50 Hz



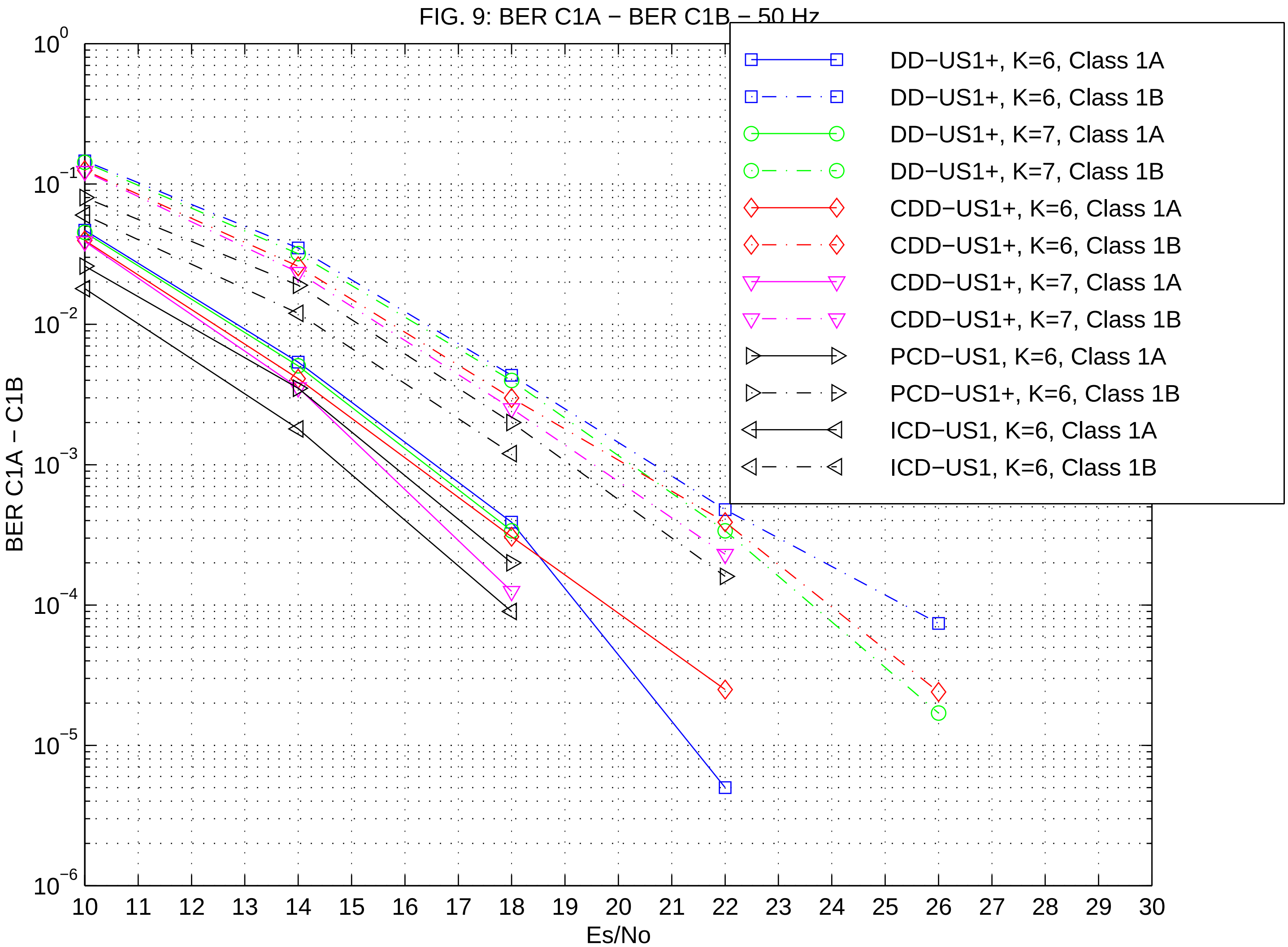


FIG. 9: BER C1A − BER C1B − 50 Hz
BER C1A − C1B
Es/No
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
DD−US1+, K=6, Class 1A
DD−US1+, K=6, Class 1B
DD−US1+, K=7, Class 1A
DD−US1+, K=7, Class 1B
CDD−US1+, K=6, Class 1A
CDD−US1+, K=6, Class 1B
CDD−US1+, K=7, Class 1A
CDD−US1+, K=7, Class 1B
PCD−US1, K=6, Class 1A
PCD−US1+, K=6, Class 1B
ICD−US1, K=6, Class 1A
ICD−US1, K=6, Class 1B

FIG. 10: BER C2 − BER Modem − 184 Hz

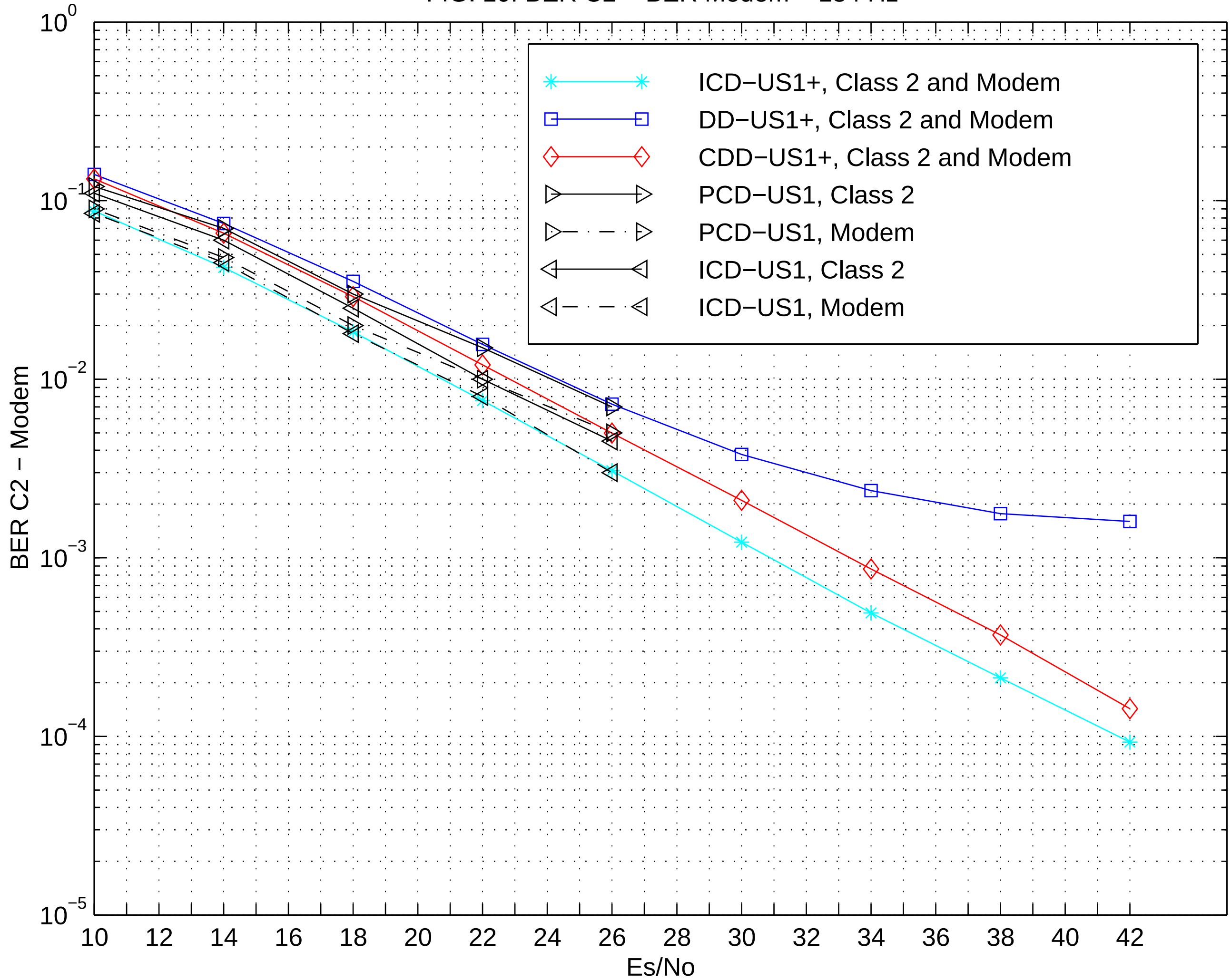
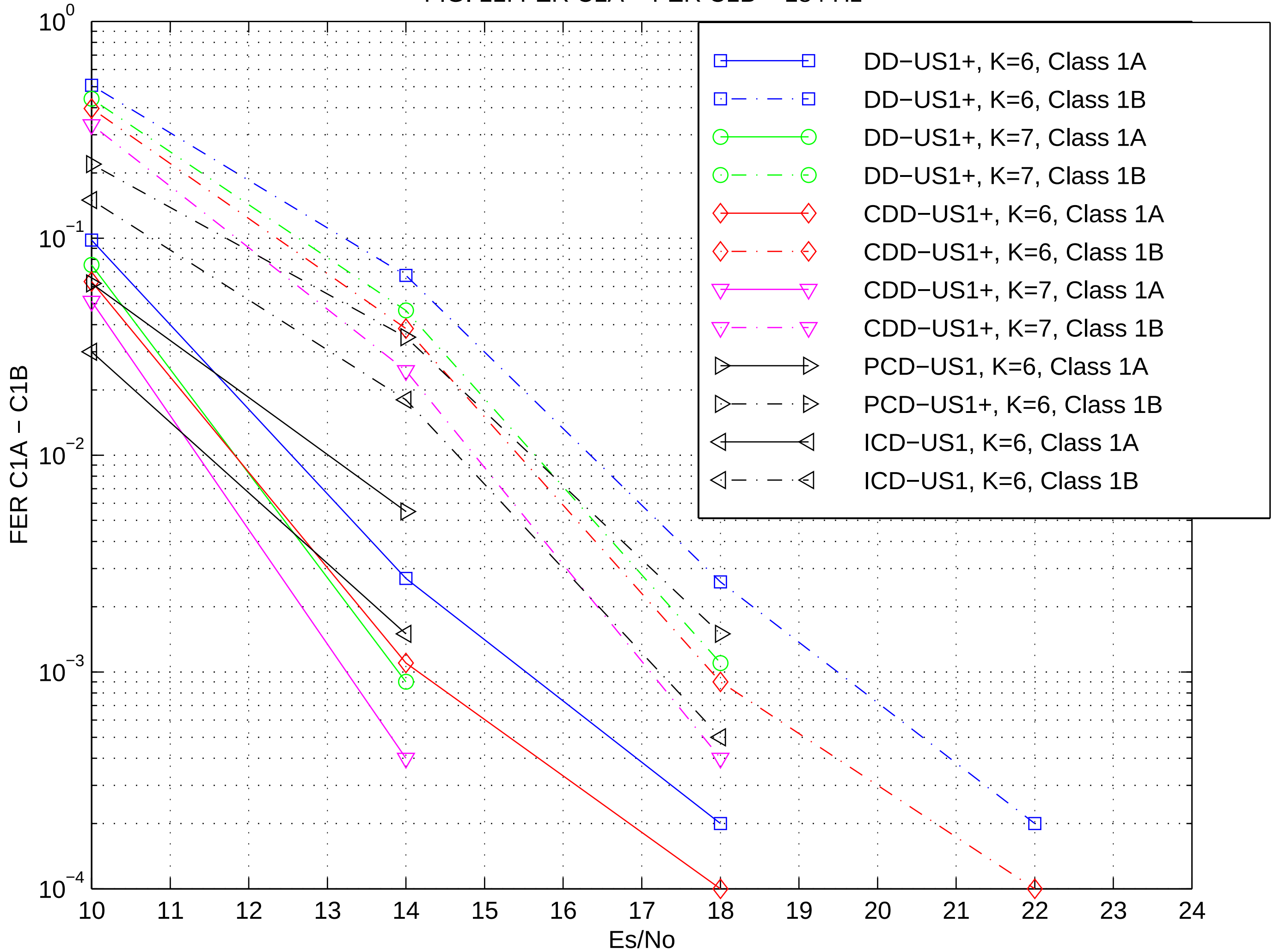


FIG. 11: FER C1A − FER C1B − 184 Hz



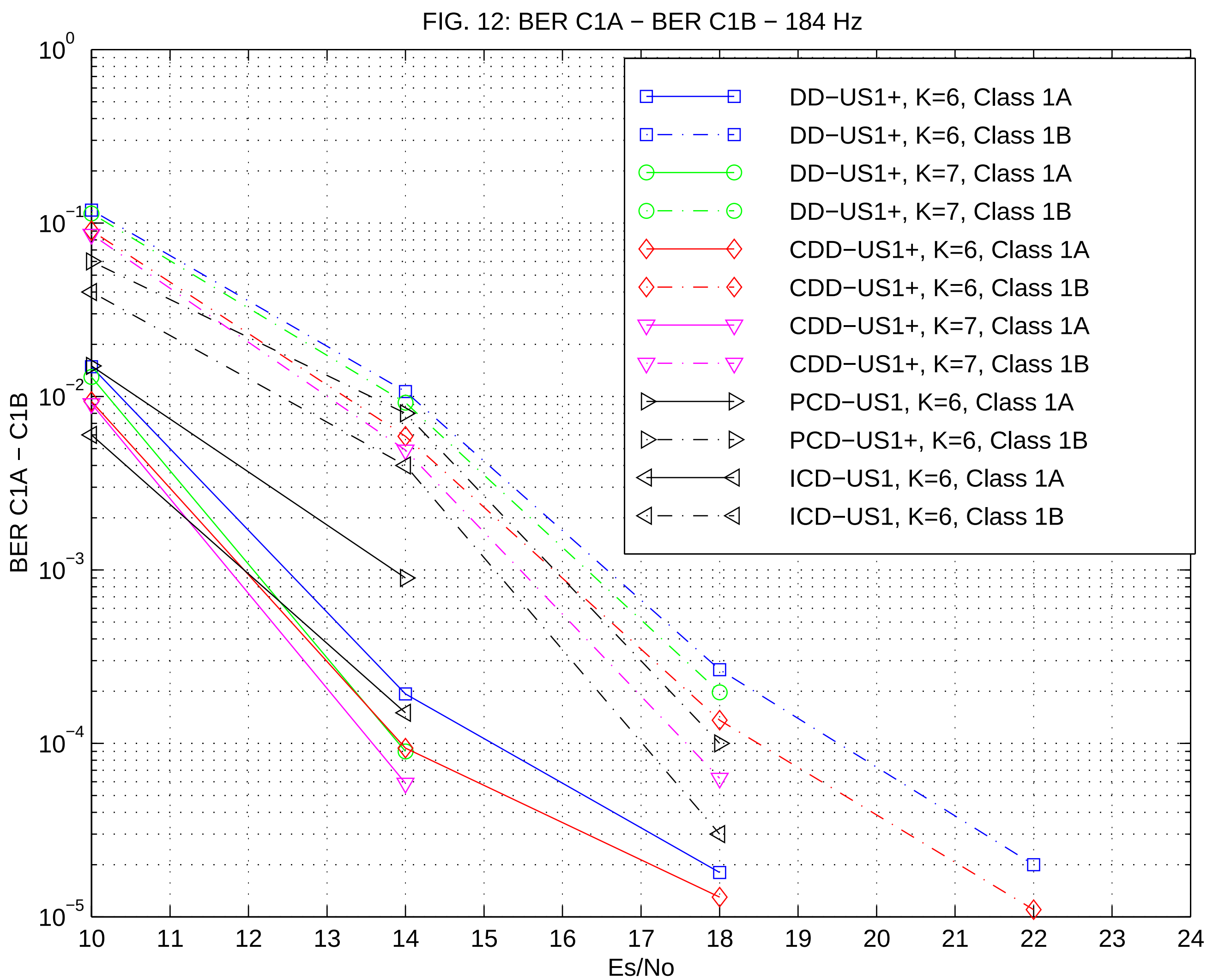


FIG. 12: BER C1A − BER C1B − 184 Hz
BER C1A − C1B
Es/No
DD−US1+, K=6, Class 1A
DD−US1+, K=6, Class 1B
DD−US1+, K=7, Class 1A
DD−US1+, K=7, Class 1B
CDD−US1+, K=6, Class 1A
CDD−US1+, K=6, Class 1B
CDD−US1+, K=7, Class 1A
CDD−US1+, K=7, Class 1B
PCD−US1, K=6, Class 1A
PCD−US1+, K=6, Class 1B
ICD−US1, K=6, Class 1A
ICD−US1, K=6, Class 1B