3GPP TSG RAN WG1 Meeting #48bis **R1-071272**
St. Julian, Malta. 26 March – 30 March, 2007

Source: **Agere Systems**

Title: **Performance Comparison of Downlink Tx Diversity schemes with 4 Tx antennas for the Shared Data Channel**

Agenda Item: **7.9.3**

Document for: **Discussion and Decision**

Introduction

In [1], we presented a quasi-orthogonal SFBC technique (QO-SFBC-pi/4) for 4 transmit antennas that achieves full diversity (i.e. diversity order = 4) at full rate (i.e. no loss in transmission rate). The simulation results we presented in [1] indicated that QO-SFBC-pi/4 performs better than SFBC-FSTD and SFBC-CDD. In this contribution, we present more simulation results to compare the performance of the three TxD schemes for various scenarios of interest.

Simulation Assumptions

Our focus in this contribution is only for the case with 4 transmit antennas. We focus on three TxD schemes: QO-SFBC-pi/4, SFBC-FSTD, and SFBC-CDD. Detailed descriptions of each of these techniques can be found in [1]. Our simulation assumptions are shown in Table 1.

Bandwidth	5MHz
FFT Size	512 points
Modulation	QPSK
Encoder	Turbo encoder without HARQ
Coding Rates	1/3, 2/3, 4/5
Channel Estimation	Non-ideal (Time Averaging with Freq interpolation)
Tx, Rx antennas	4x1 and 4x2
Channel model	Flat fading and SCM-C
Doppler	3 km/hr and 30 km/hr
Block	1 RB (12 subcarriers) x 14 OFDM symbols (1ms)
TxD schemes	QO-SFBC-pi/4, SFBC-CDD, SFBC-FSTD

Table 1

Simulation Results

Table 2 provides a summary of the simulation results we are presenting in this contribution.

			Coding Rate	Antenna Configuration	Channel	Doppler
Fig 1	(a)	BER	4/5	4x2	SCM-C	3 km/hr
Fig 2	(a)	BER	4/5	4x2	SCM-C	30 km/hr
	(b)	FER				
Fig 3	(a)	BER	4/5	4x1	SCM-C	3 km/hr
	(b)		2/3			
	(c)		1/3			
Fig 4	(a)	BER	4/5	4x1	SCM-C	30 km/hr
	(b)		2/3			
	(c)		1/3			
Fig 5	(a)	BER	4/5	4x2	Flat	3 km/hr
	(b)		2/3			
	(c)		1/3			
Fig 6	(a)	BER	4/5	4x2	Flat	30 km/hr
	(b)		2/3			
	(c)		1/3			
Fig 7	(a)	BER	4/5	4x1	Flat	3 km/hr
	(b)		2/3			
	(c)		1/3			
Fig 8	(a)	BER	4/5	4x1	Flat	30 km/hr
	(b)		2/3			
	(c)		1/3			

Table 2

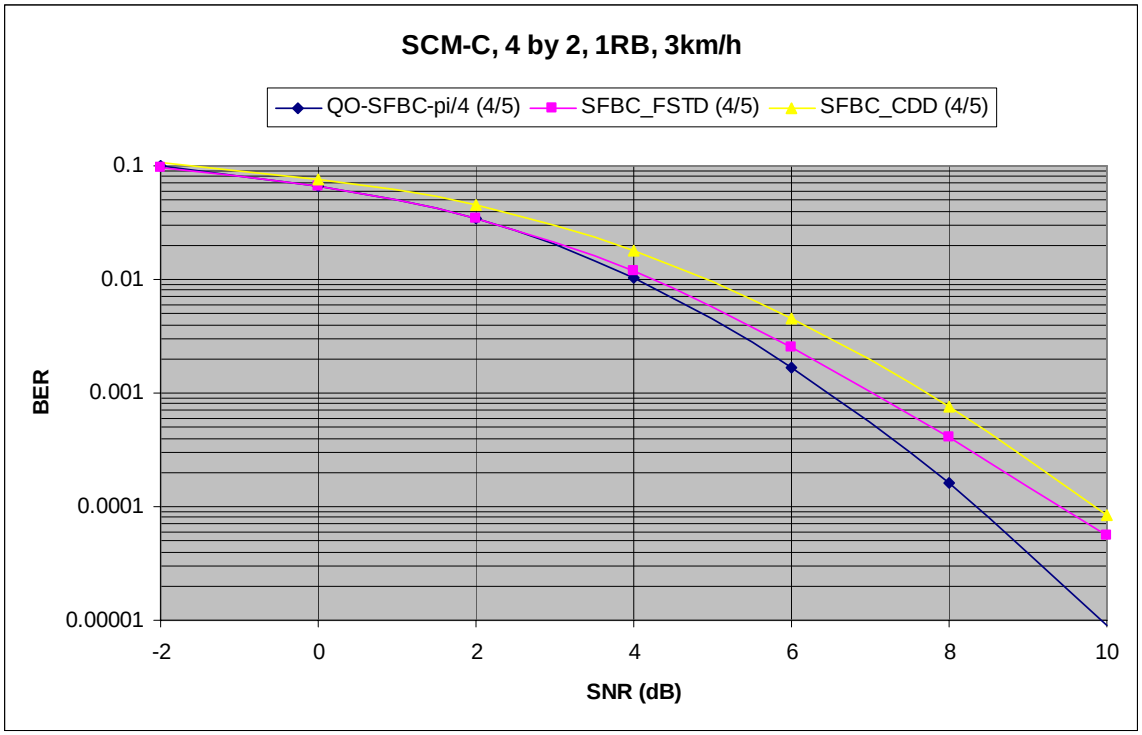
SCM-C, 4 by 2, 1RB, 3km/h
QO-SFBC-pi/4 (4/5)
SFBC_FSTD (4/5)
SFBC_CDD (4/5)
BER
0.1
0.01
0.001
0.0001
0.00001
-2
0
2
4
6
8
10
SNR (dB)

Fig 1(a)

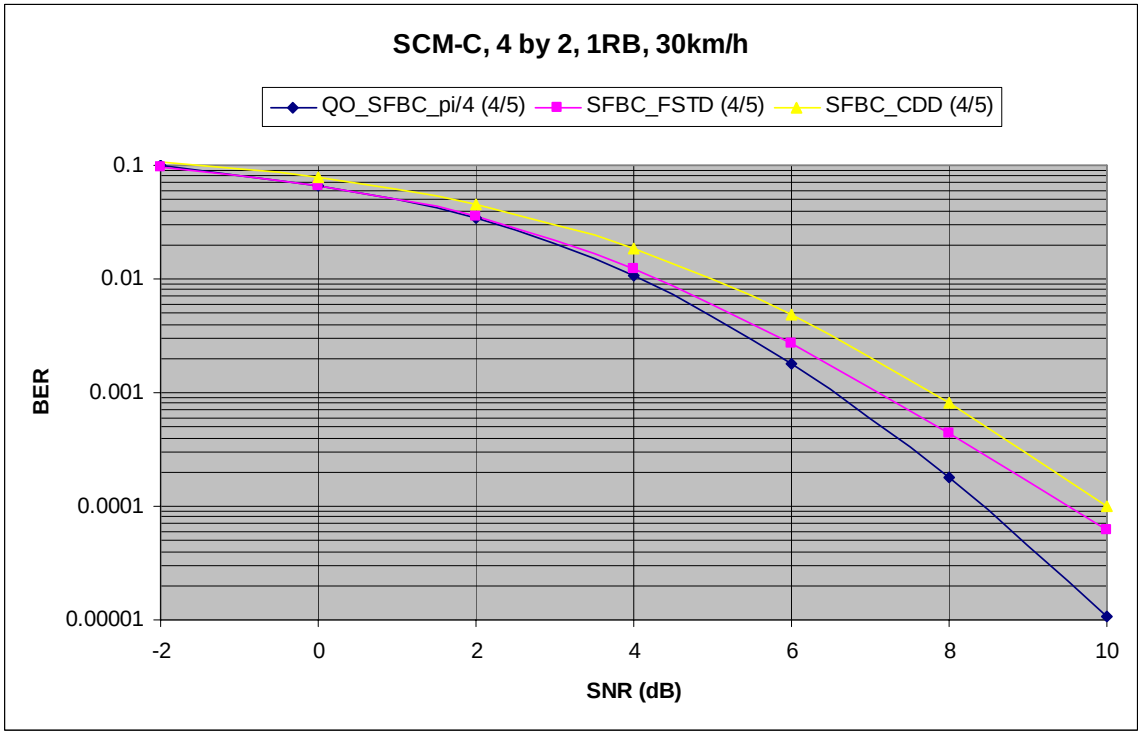
SCM-C, 4 by 2, 1RB, 30km/h
QO_SFBC_pi/4 (4/5)
SFBC_FSTD (4/5)
SFBC_CDD (4/5)
BER
0.1
0.01
0.001
0.0001
0.00001
-2
0
2
4
6
8
10
SNR (dB)

Fig 2(a)

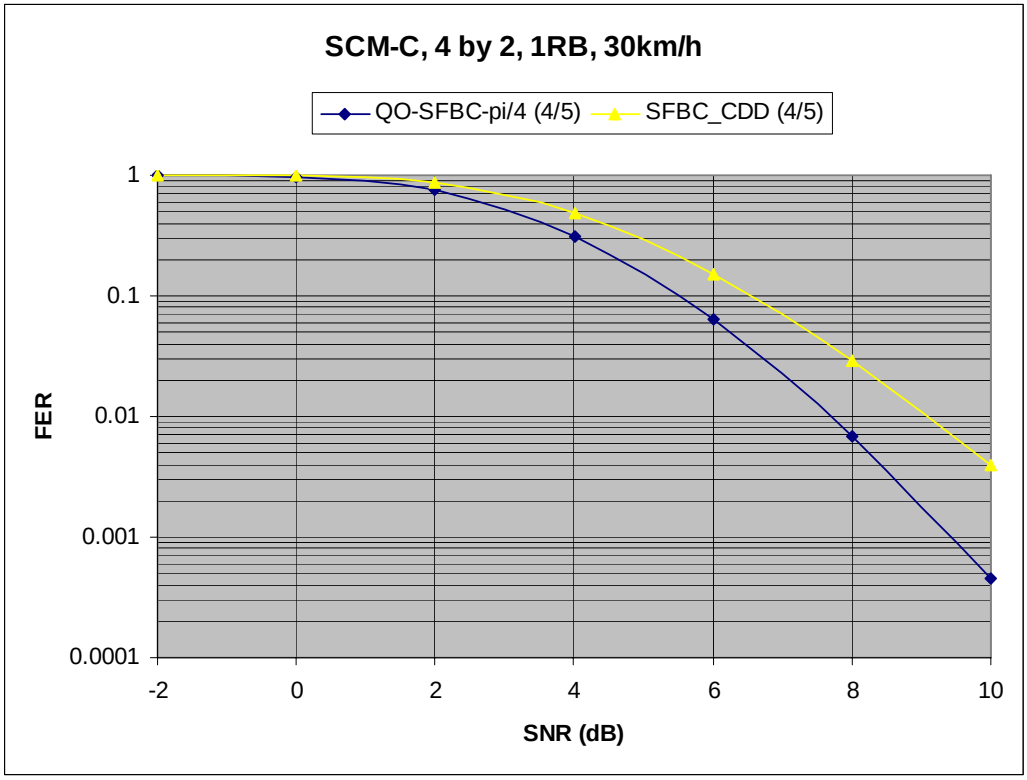
SCM-C, 4 by 2, 1RB, 30km/h
QO-SFBC-pi/4 (4/5)
SFBC_CDD (4/5)
FER
1
0.1
0.01
0.001
0.0001
-2
0
2
4
6
8
10
SNR (dB)

Fig 2(b)

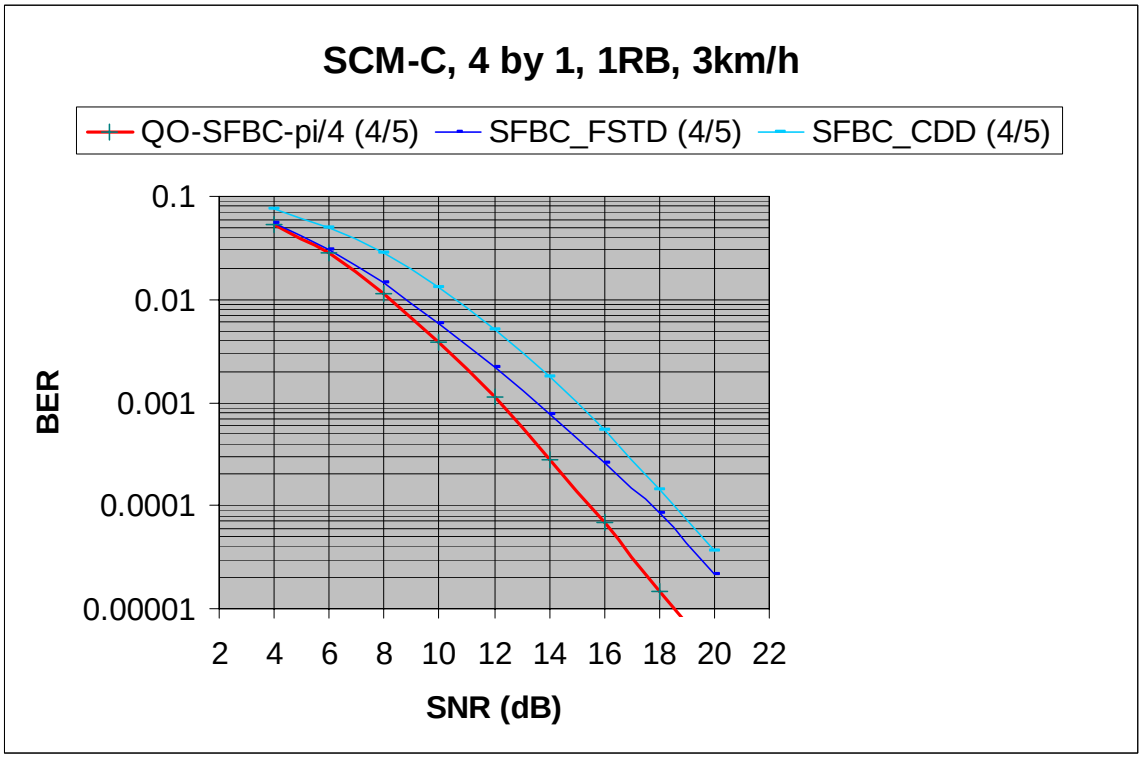
SCM-C, 4 by 1, 1RB, 3km/h
QO-SFBC-pi/4 (4/5)
SFBC_FSTD (4/5)
SFBC_CDD (4/5)
BER
0.1
0.01
0.001
0.0001
0.00001
2
4
6
8
10
12
14
16
18
20
22
SNR (dB)

Fig 3(a)

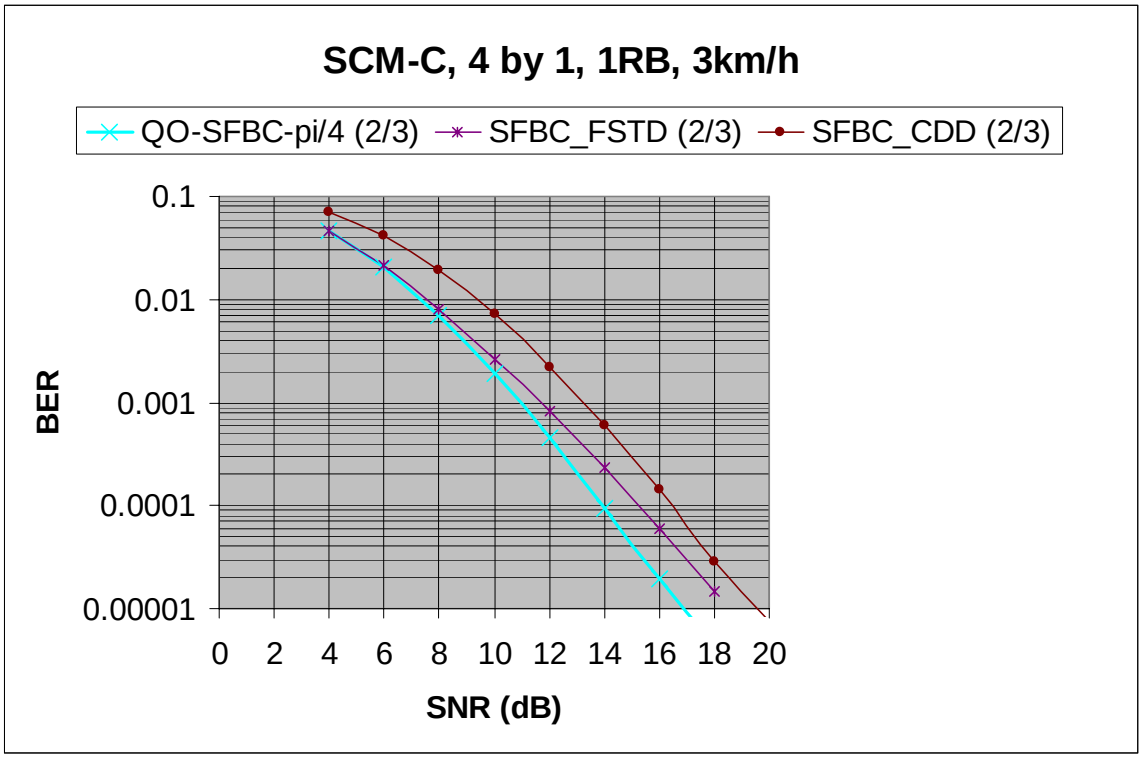
SCM-C, 4 by 1, 1RB, 3km/h
QO-SFBC-pi/4 (2/3)
SFBC_FSTD (2/3)
SFBC_CDD (2/3)
BER
0.1
0.01
0.001
0.0001
0.00001
0
2
4
6
8
10
12
14
16
18
20
SNR (dB)

Fig 3(b)

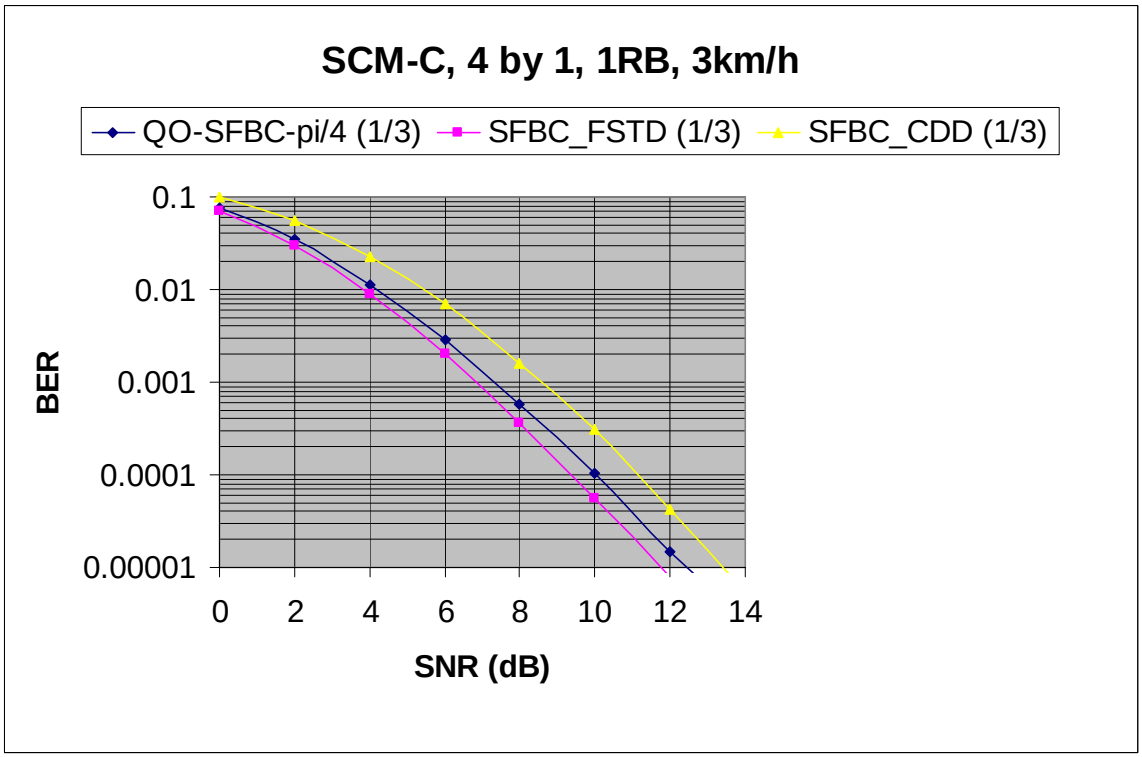
SCM-C, 4 by 1, 1RB, 3km/h
QO-SFBC-pi/4 (1/3)
SFBC_FSTD (1/3)
SFBC_CDD (1/3)
BER
0.1
0.01
0.001
0.0001
0.00001
0
2
4
6
8
10
12
14
SNR (dB)

Fig 3(c)

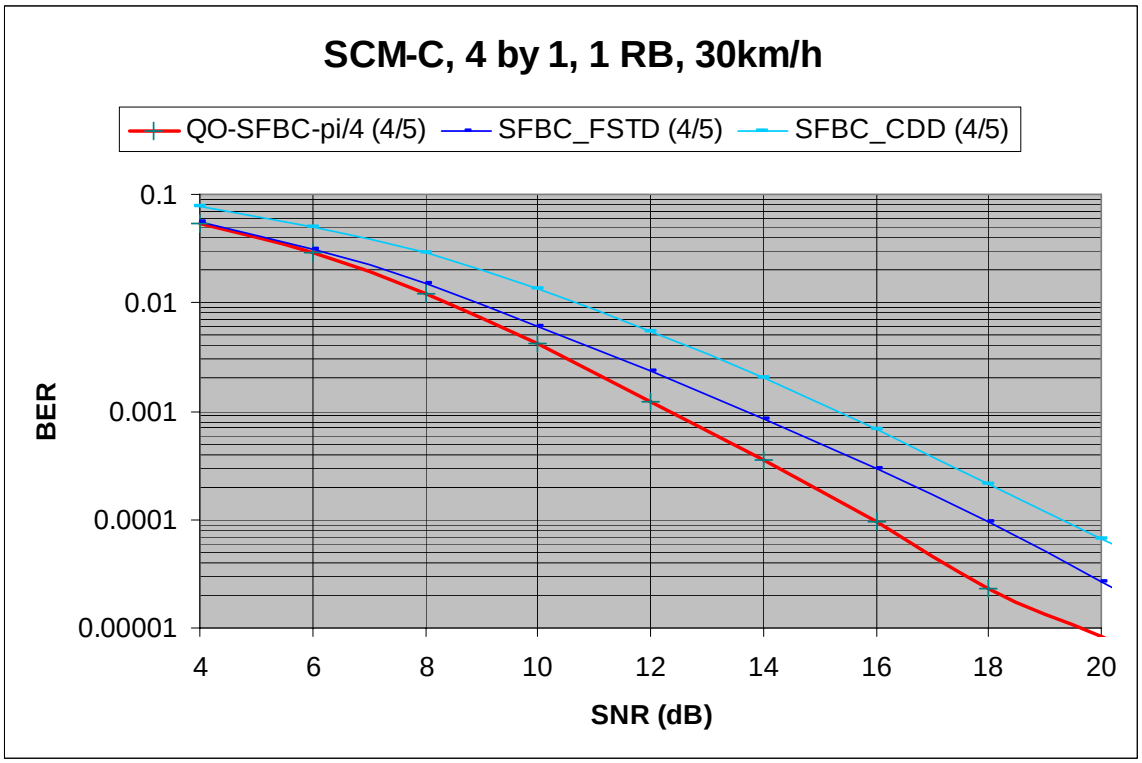
SCM-C, 4 by 1, 1 RB, 30km/h
QO-SFBC-pi/4 (4/5)
SFBC_FSTD (4/5)
SFBC_CDD (4/5)
BER
0.1
0.01
0.001
0.0001
0.00001
4
6
8
10
12
14
16
18
20
SNR (dB)

Fig 4(a)

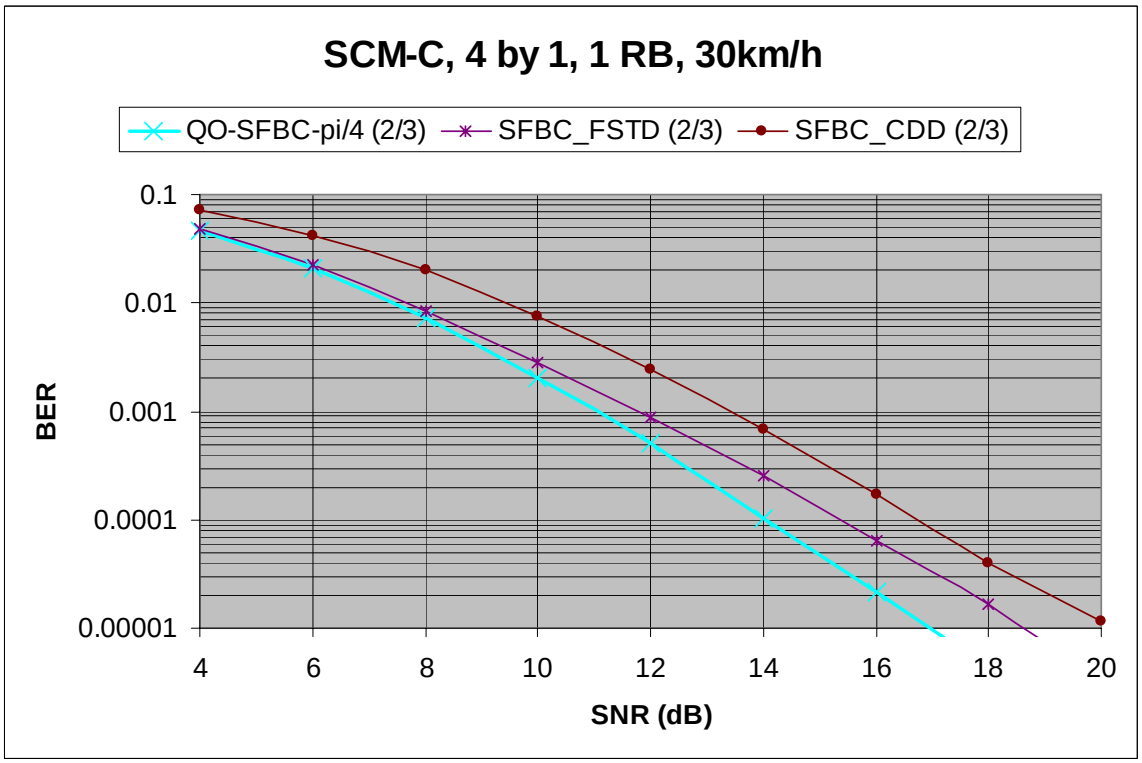
SCM-C, 4 by 1, 1 RB, 30km/h
QO-SFBC-pi/4 (2/3)
SFBC_FSTD (2/3)
SFBC_CDD (2/3)
BER
0.1
0.01
0.001
0.0001
0.00001
4
6
8
10
12
14
16
18
20
SNR (dB)

Fig 4(b)

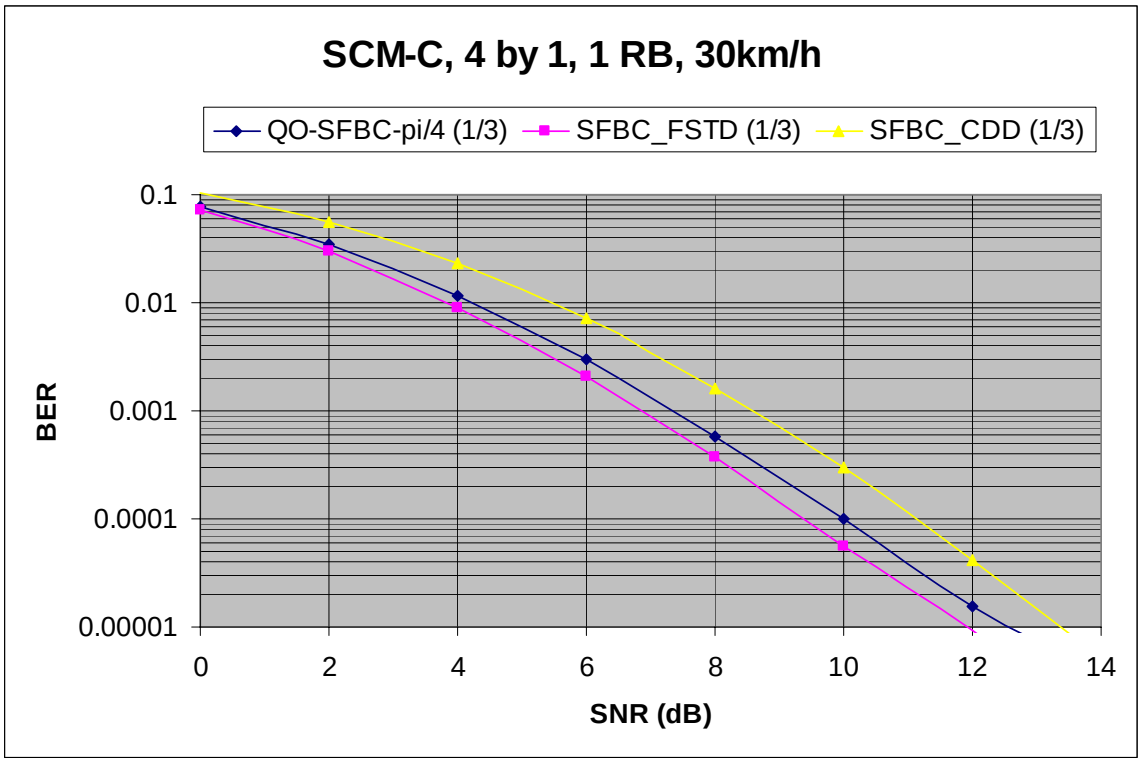
SCM-C, 4 by 1, 1 RB, 30km/h
QO-SFBC-pi/4 (1/3)
SFBC_FSTD (1/3)
SFBC_CDD (1/3)
BER
0.1
0.01
0.001
0.0001
0.00001
0
2
4
6
8
10
12
14
SNR (dB)

Fig 4(c)

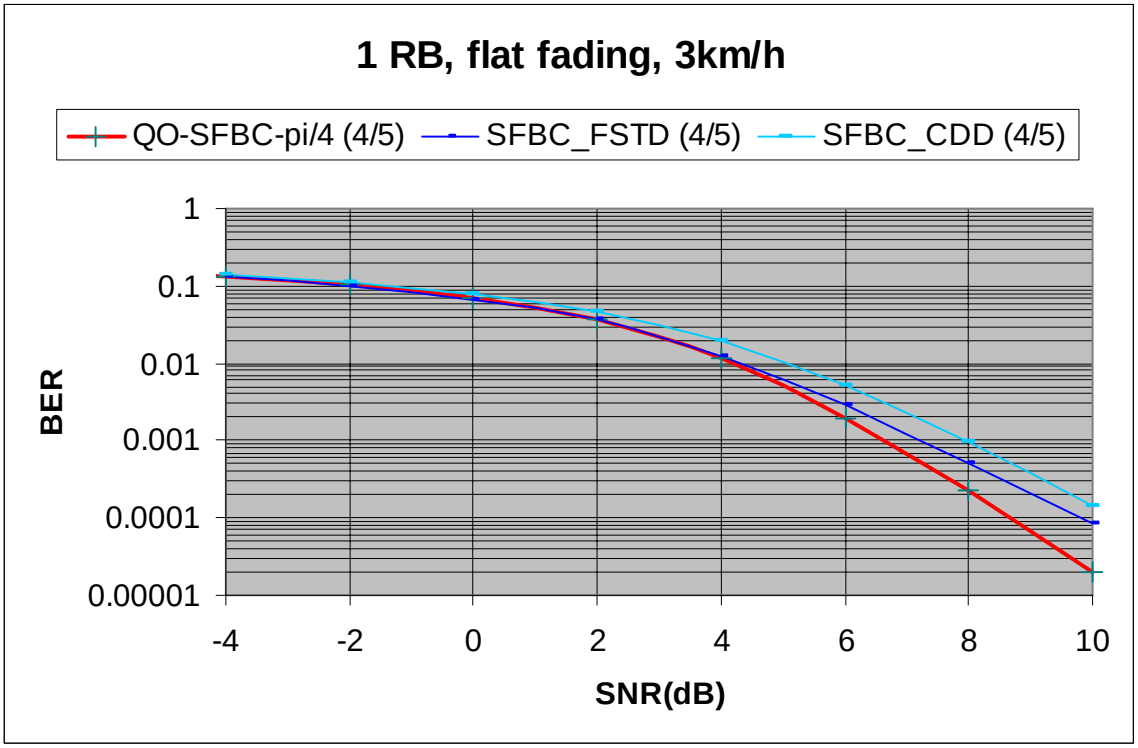
1 RB, flat fading, 3km/h
QO-SFBC-pi/4 (4/5)
SFBC_FSTD (4/5)
SFBC_CDD (4/5)
BER
1
0.1
0.01
0.001
0.0001
0.00001
-4
-2
0
2
4
6
8
10
SNR(dB)

Fig 5(a)

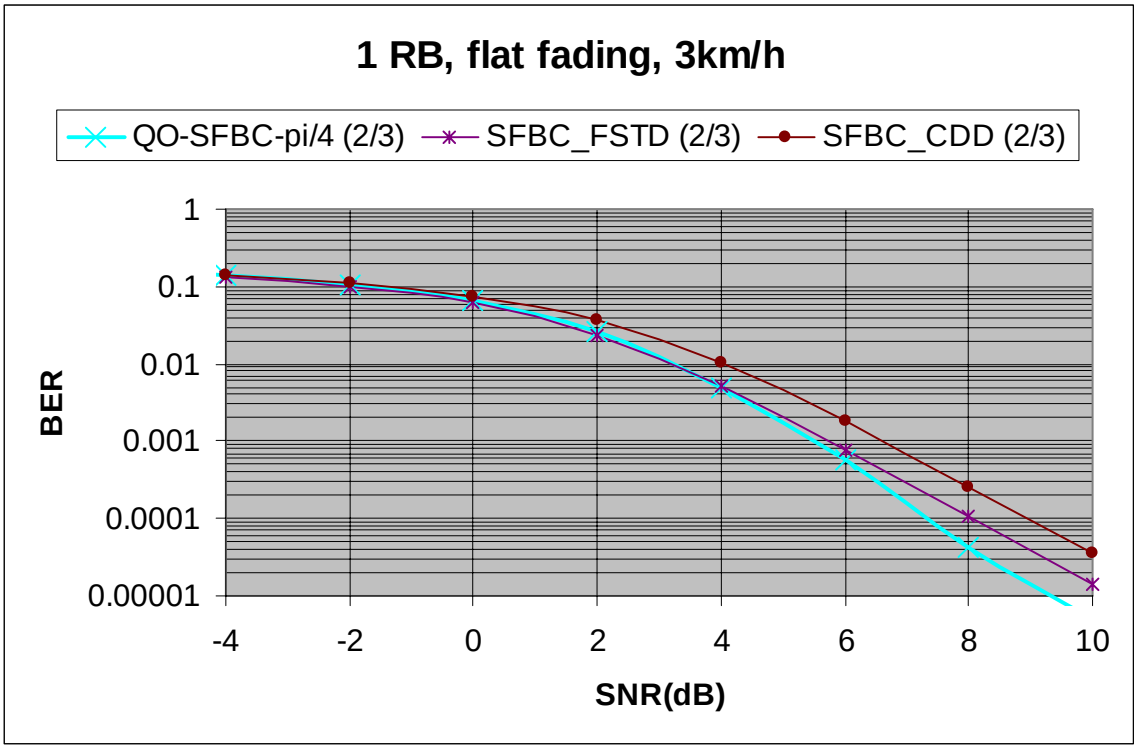
1 RB, flat fading, 3km/h
QO-SFBC-pi/4 (2/3)
SFBC_FSTD (2/3)
SFBC_CDD (2/3)
BER
1
0.1
0.01
0.001
0.0001
0.00001
-4
-2
0
2
4
6
8
10
SNR(dB)

Fig 5(b)

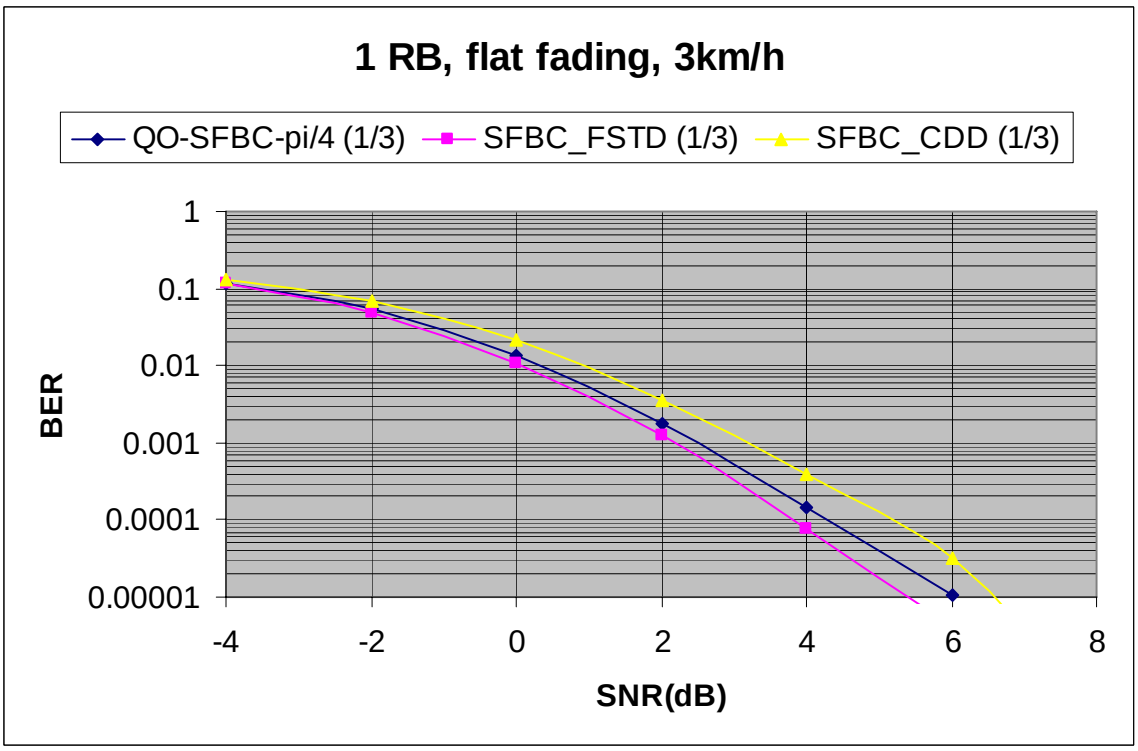
1 RB, flat fading, 3km/h
QO-SFBC-pi/4 (1/3)
SFBC_FSTD (1/3)
SFBC_CDD (1/3)
BER
1
0.1
0.01
0.001
0.0001
0.00001
-4
-2
0
2
4
6
8
SNR(dB)

Fig 5(c)

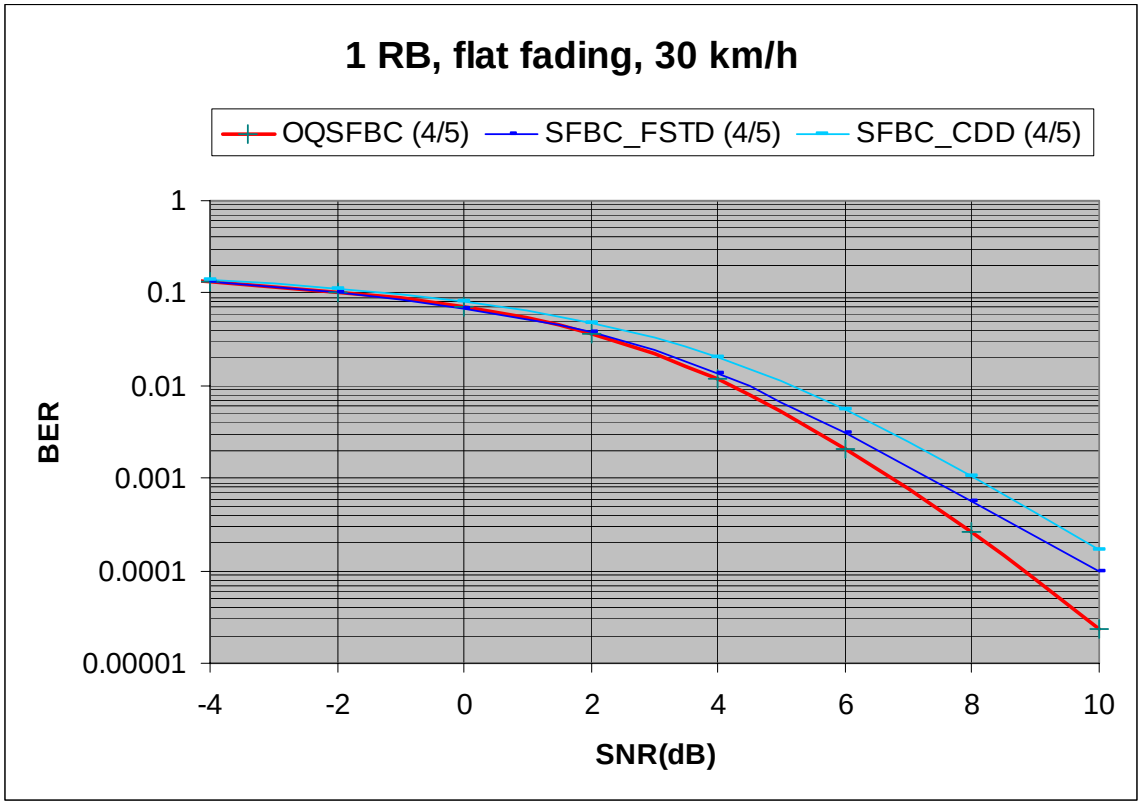
1 RB, flat fading, 30 km/h
OQSFBC (4/5)
SFBC_FSTD (4/5)
SFBC_CDD (4/5)
BER
1
0.1
0.01
0.001
0.0001
0.00001
-4
-2
0
2
4
6
8
10
SNR(dB)

Fig 6(a)

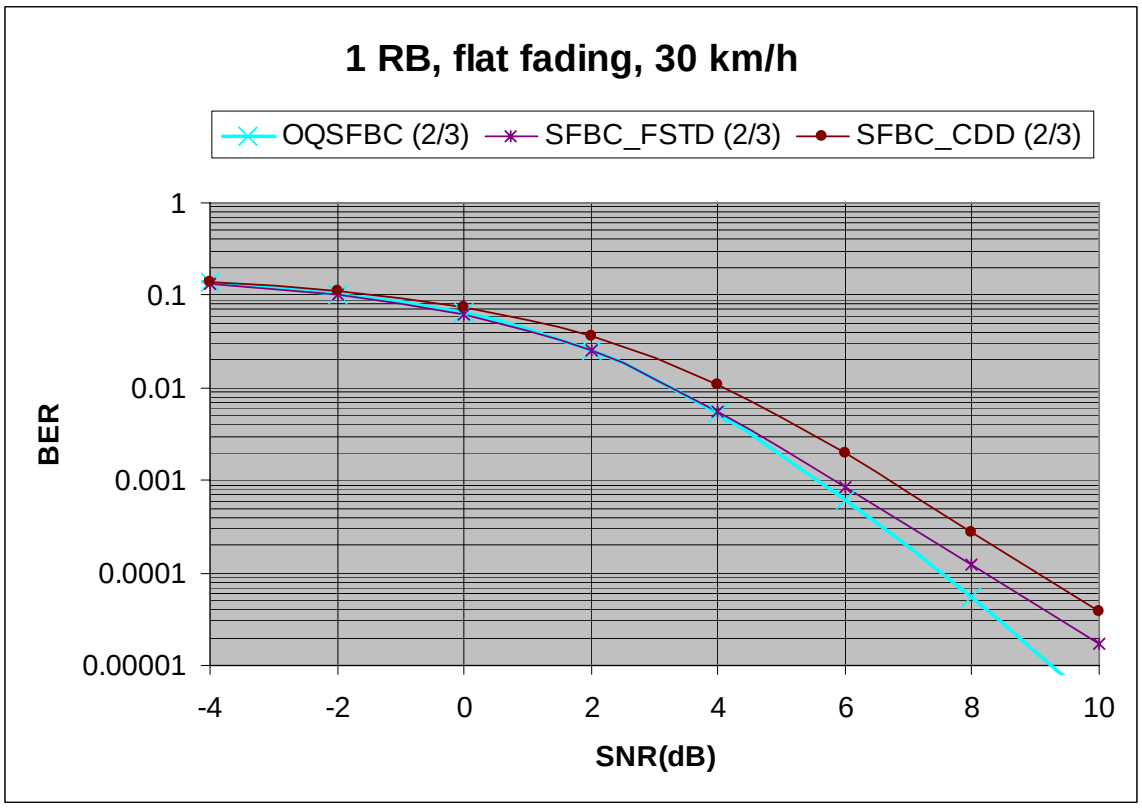
1 RB, flat fading, 30 km/h
OQSFBC (2/3)
SFBC_FSTD (2/3)
SFBC_CDD (2/3)
BER
1
0.1
0.01
0.001
0.0001
0.00001
-4
-2
0
2
4
6
8
10
SNR(dB)

Fig 6(b)

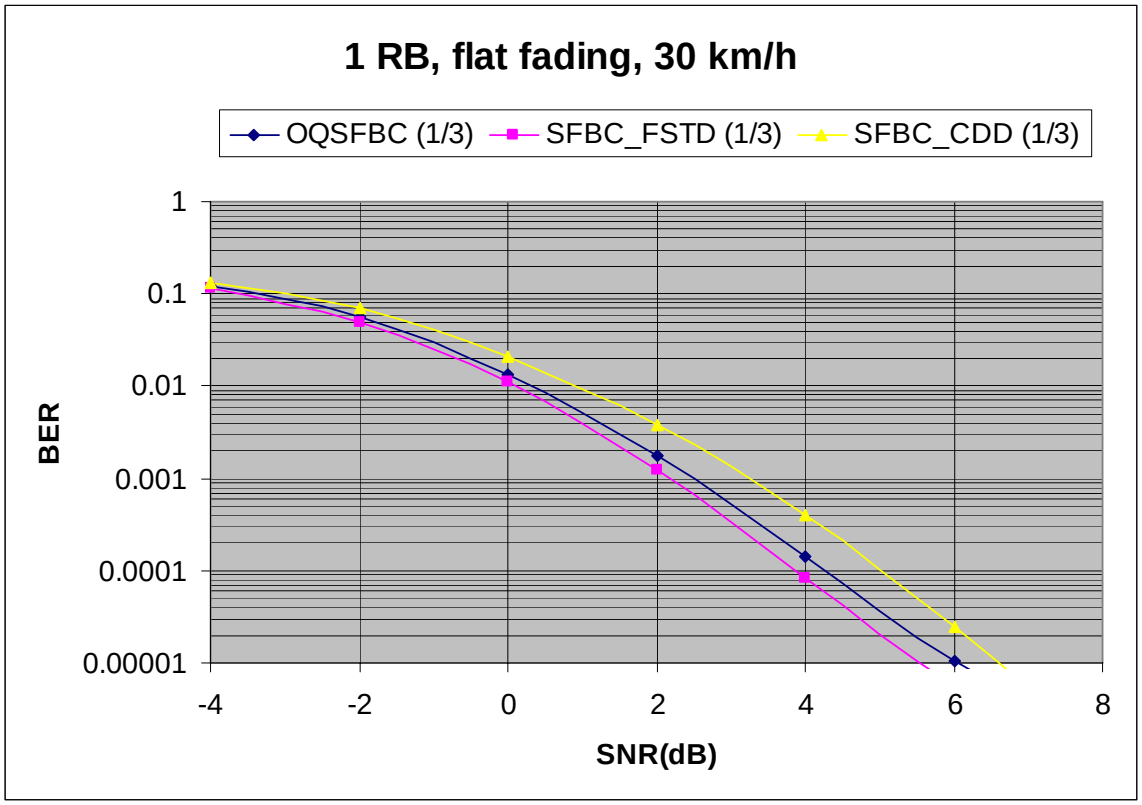
1 RB, flat fading, 30 km/h
OQSFBC (1/3)
SFBC_FSTD (1/3)
SFBC_CDD (1/3)
BER
1
0.1
0.01
0.001
0.0001
0.00001
-4
-2
0
2
4
6
8
SNR(dB)

Fig 6(c)

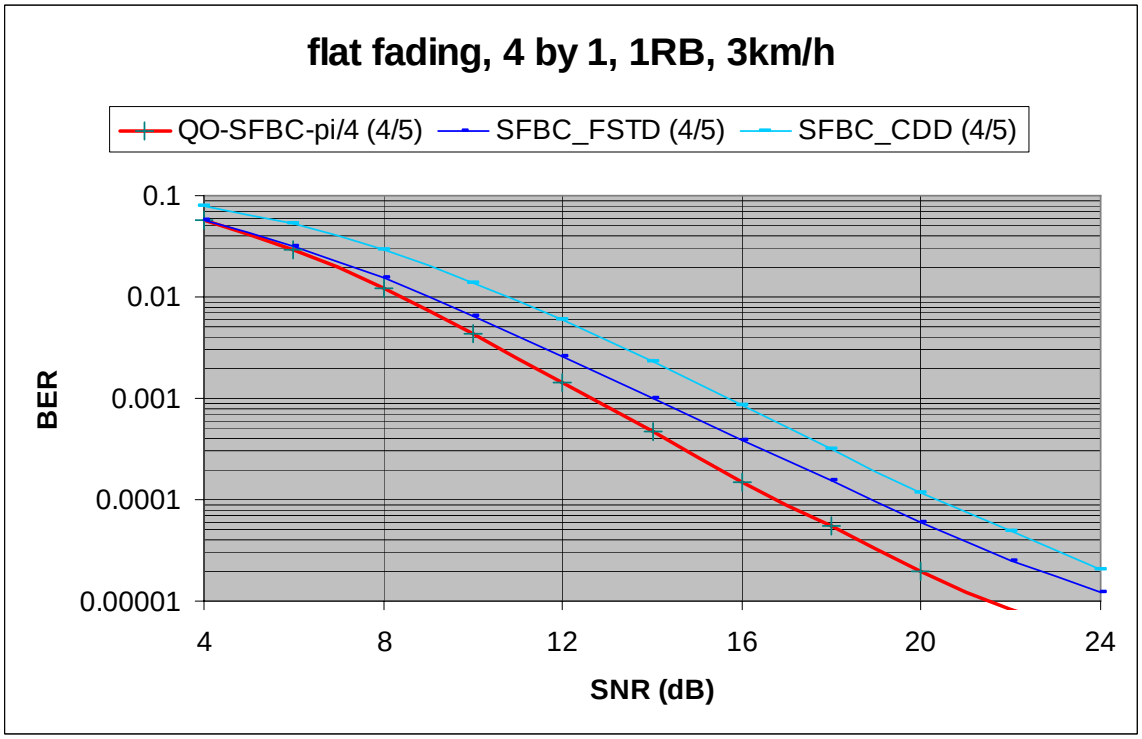
flat fading, 4 by 1, 1RB, 3km/h
QO-SFBC-pi/4 (4/5)
SFBC_FSTD (4/5)
SFBC_CDD (4/5)
BER
0.1
0.01
0.001
0.0001
0.00001
4
8
12
16
20
24
SNR (dB)

Fig 7(a)

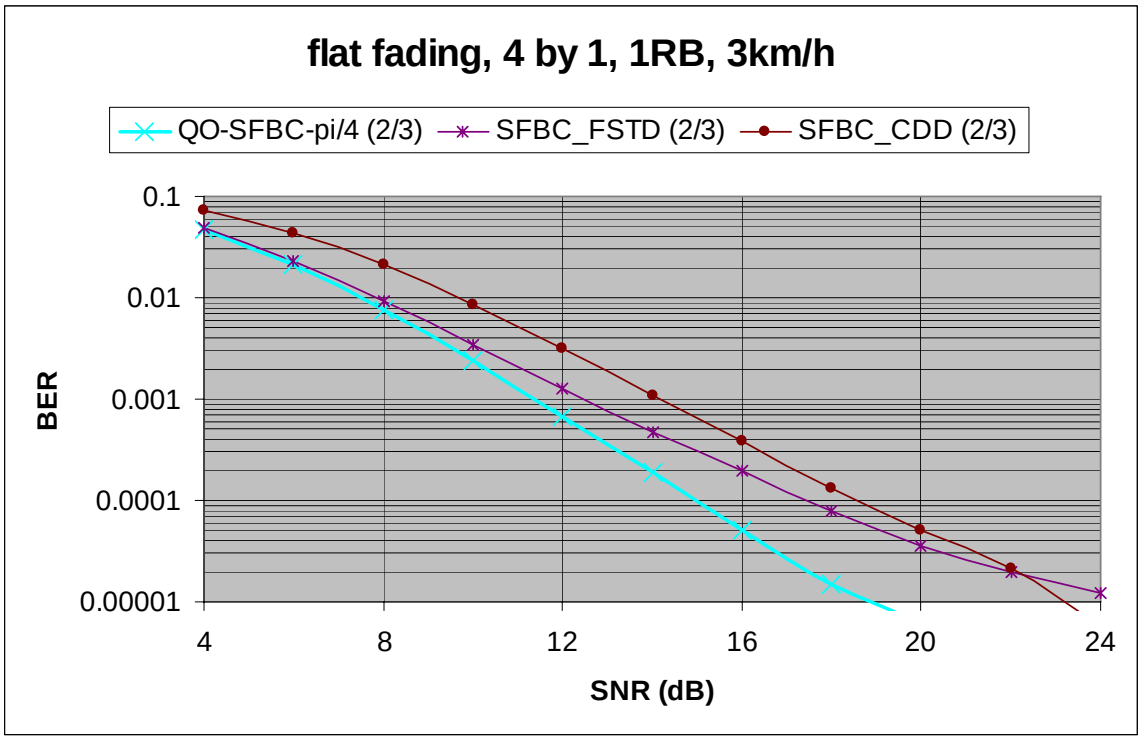
flat fading, 4 by 1, 1RB, 3km/h
QO-SFBC-pi/4 (2/3)
SFBC_FSTD (2/3)
SFBC_CDD (2/3)
BER
0.1
0.01
0.001
0.0001
0.00001
4
8
12
16
20
24
SNR (dB)

Fig 7(b)

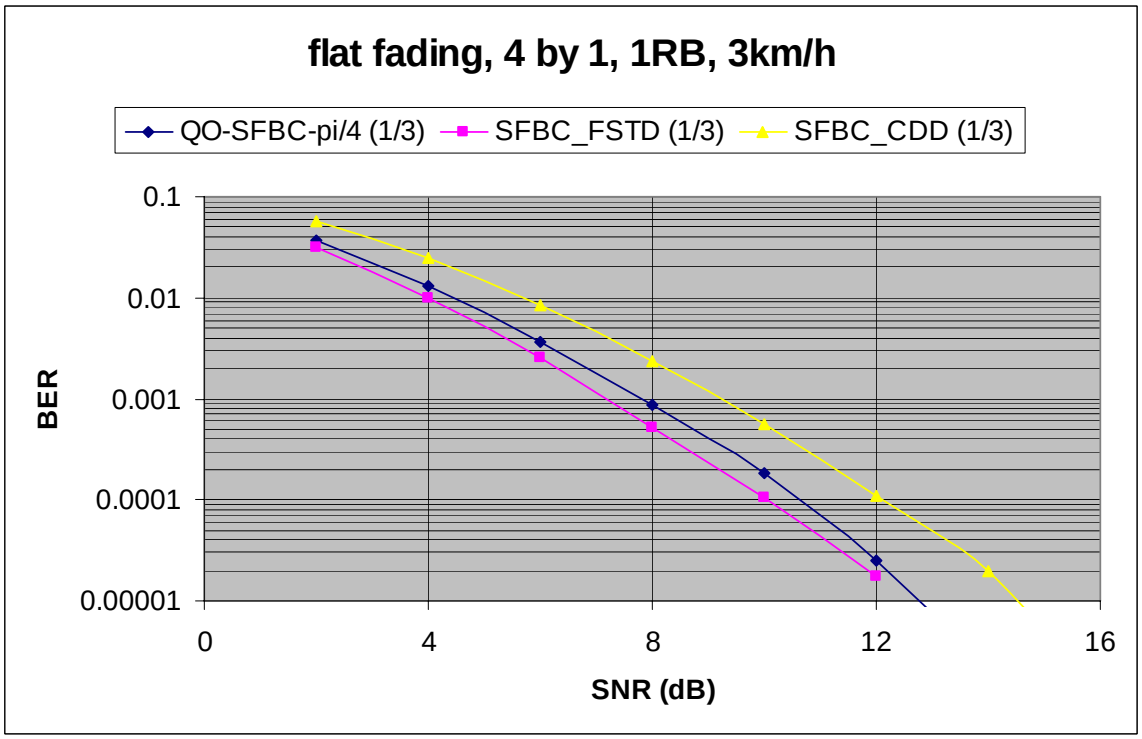
flat fading, 4 by 1, 1RB, 3km/h
QO-SFBC-pi/4 (1/3)
SFBC_FSTD (1/3)
SFBC_CDD (1/3)
BER
0.1
0.01
0.001
0.0001
0.00001
0
4
8
12
16
SNR (dB)

Fig 7(c)

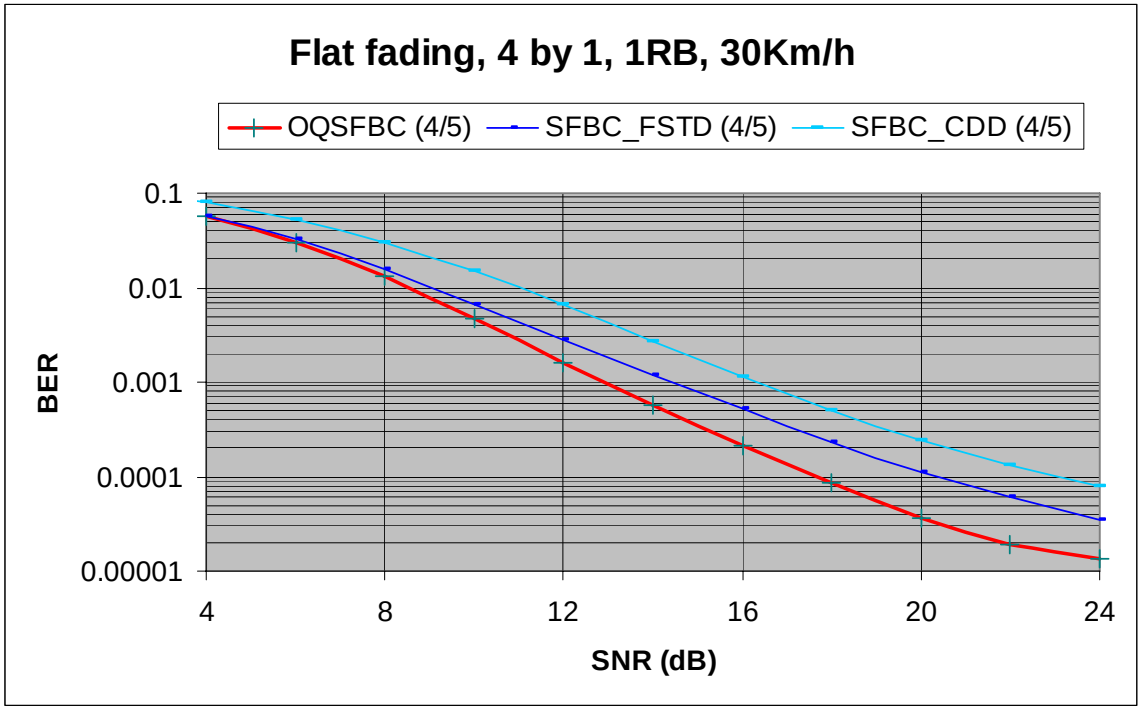
Flat fading, 4 by 1, 1RB, 30Km/h
OQSFBC (4/5)
SFBC_FSTD (4/5)
SFBC_CDD (4/5)
BER
0.1
0.01
0.001
0.0001
0.00001
4
8
12
16
20
24
SNR (dB)

Fig 8(a)

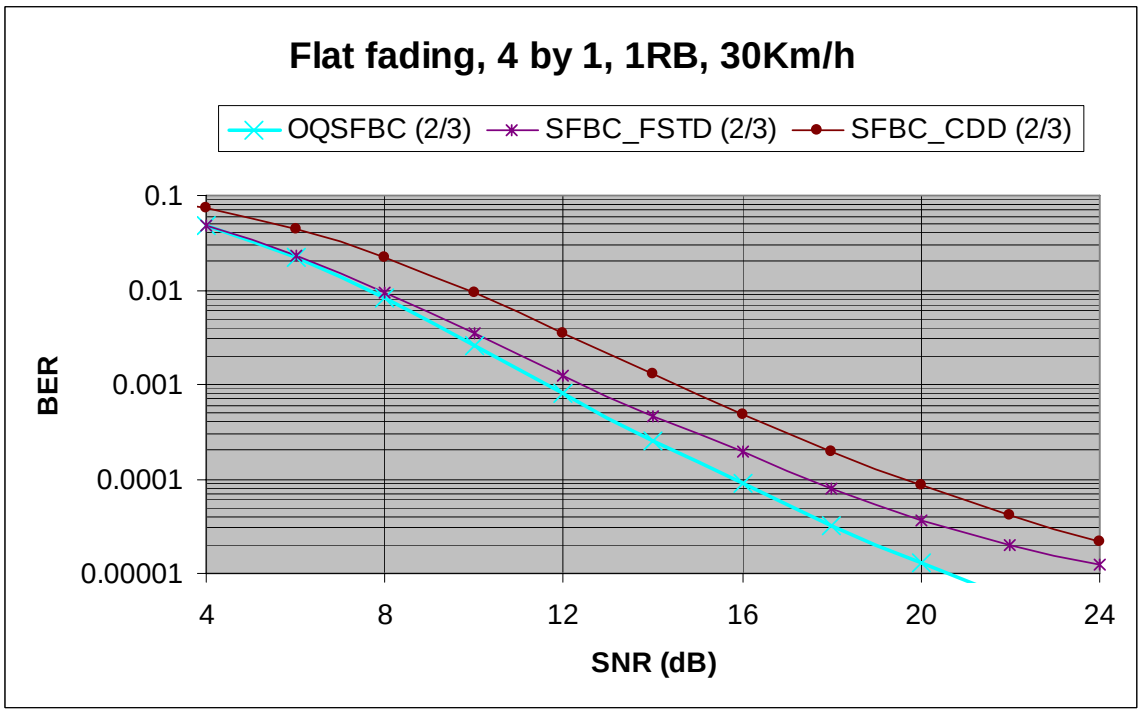
Flat fading, 4 by 1, 1RB, 30Km/h
OQSFBC (2/3)
SFBC_FSTD (2/3)
SFBC_CDD (2/3)
BER
0.1
0.01
0.001
0.0001
0.00001
4
8
12
16
20
24
SNR (dB)

Fig 8(b)

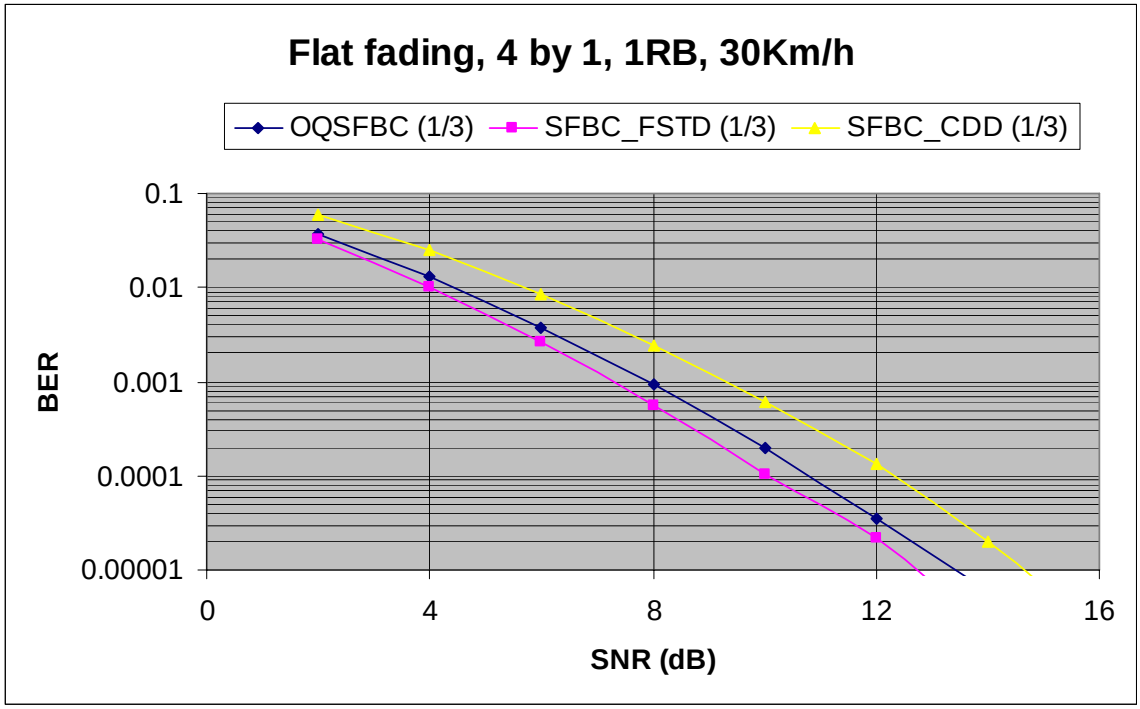

Fig 8(c)

Discussion of results

From our simulation results, we observe that for channel coding rates of 2/3 and 4/5, irrespective of the other simulation parameters (such as Doppler, channel type, single or dual Rx antennas), QO-SFBC-pi/4 outperforms both SFBC-FSTD and SFBC-CDD. At these coding rates, we observe that QO-SFBC-pi.4 has the steepest BER-SNR curve, indicating that it is achieving the highest diversity advantage.

We also show in Fig 2 that for R=4/5, QO-SFBC-pi/4 performs the best in terms of both BER and FER metrics (where one frame is defined as 1RBx14symbols).

However, for channel code rate of 1/3, we find that SFBC-FSTD offers a slight coding advantage over QO-SFBC-pi./4, but no diversity advantage (i.e. there is no difference in the slope of the BER-SNR curves).

Finally, we note that SFBC-CDD consistently performs the worst in all our simulation scenarios.

Conclusion

In scenarios where frequency diversity can not be effectively exploited by the turbo decoder (such as at higher coding rates of 2/3 and 4/5), we find that QO-SFBC-pi/4 offers the best performance, since it achieves the highest spatial diversity advantage. And since QO-SFBC is a quasi-orthogonal code, it can be implemented with a simple decoder that achieves ML performance. Hence, we would recommend adopting QO-SFBC-pi/4 for the case of 4 transmit antennas.

References

[1] R1-070015, Agere Systems, “Open Loop Transmit Diversity for Downlink Channels with 4 Transmit Antennas in E-UTRA,” Sorrento, Italy, Jan 2007.