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Re:	IEEE P802.16-2004/Cor1-D3	
Abstract	Correct the misfortunate combination of interleaver and permutation	
Purpose	Adopt changes	
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Problem in Interleaver and Permutation Combination in OFDMA

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Assi Jakoby, Tzahi Weisman, Alexei Davydov

1. Motivation

The interleaver definition with d=16 might cause a performance degradation in some cases, due to a disastrous combination of interleaving and permutation. This is because, in OFDMA, the permutation actually performs an “interleaving like” operation, which partially reverse the current interleaver operation. This performance degradation occurs with burst allocations having low frequency diversity, for example bursts allocated to a single sub-channel. In these cases, adjacent coded bits might be transmitted on the same sub-carrier. Thus the interleaver operation becomes useless.

Simulation results show, in a worst case scenario, a DL degradation of about 4-5 dB at FER of 10^-2, with the current interleaver compared to the proposed interleaver scheme. In UL degradation is about 1-2dB in most cases. It is unreasonable to use an interleaver which might cause severe performance degradation in some cases, whereas it is supposed to improve the performance.

Thus, we propose to add an optional interleaving scheme to the CC- TB to allow equal (better) performance to all burst allocations.

2. Contents

3. Details

For an interleaver with dimension d, a pair of adjacent coded bits before the interleaver is separated after the interleaver by distance Ncbps/d bits. If a FEC block spans more than one slot duration, then several bits from the same FEC block are transmitted on each sub-carrier. These bits are distributed in the FEC block periodically, where the period equals the number of bits in a single symbol divided by the distance.

With the current interleaver dimension d = 16, for a worst case scenario (DL PUSC, burst allocation of 1 sub-channel, 4 slots in a FEC block, QPSK constellation) this period can be as small as 2 bits!! This example is depicted in Figure 1 where the numbers in brackets are the indices of the coded bits before the interleaver.

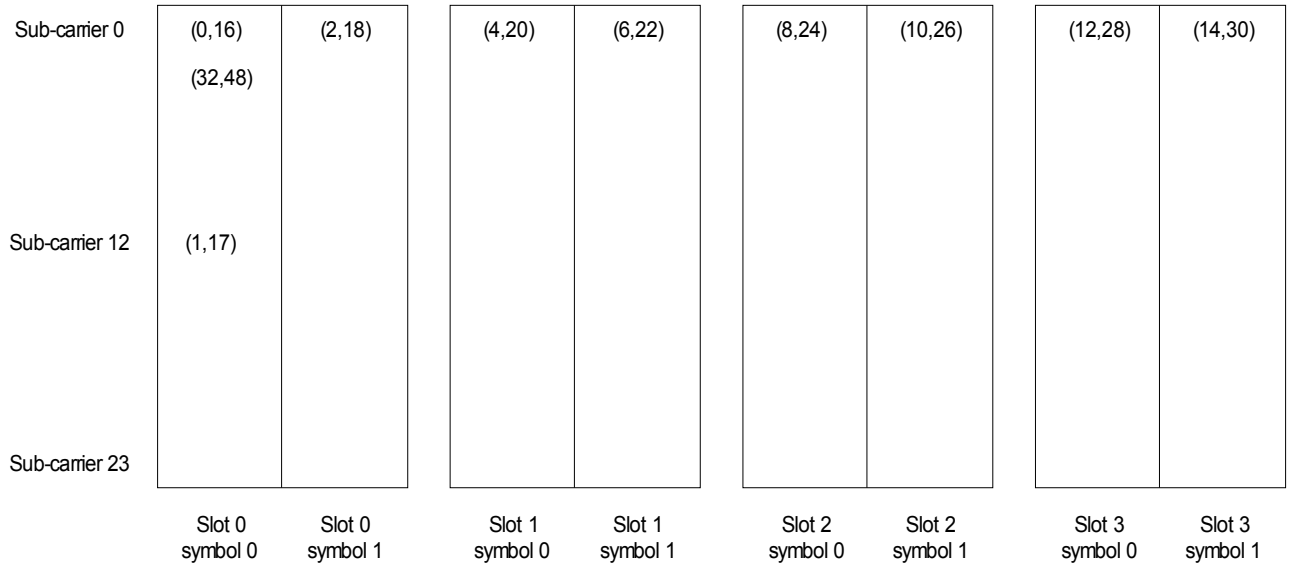


Figure 1: Worst case scenario of permutation-interleaver combination

The reason for this is that the order of subcarriers passed to the de-interleaver (in the receive side) is not a linear frequency-domain order (which the interleaver was designed for), but an arbitrary order. This order depends on the permutation, on the way the 48 logical subcarriers are mapped to physical subcarriers, on the in-slot rotation between subchannels, and on the way the slots are aggregated. The following figure shows the correlation structure in a FEC block on which the de-interleaver works (and of which the interleaver is unaware):

Similar colors mean high correlation (of fading):

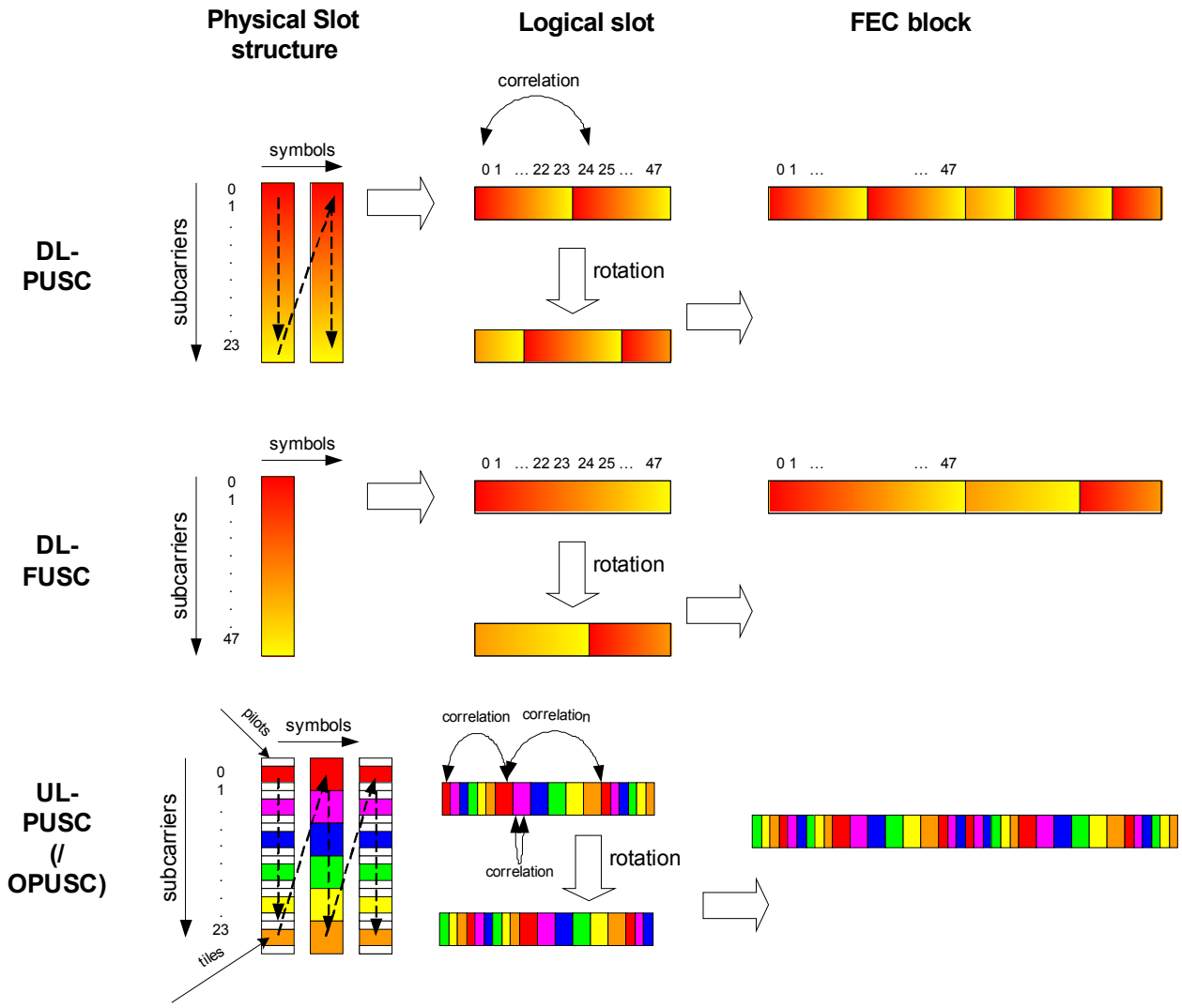


Figure 2: Example of correlation in slot and FEC block

The seemingly "random" structures of correlations in the FEC block are processed by the de-interleaver and create another "seemingly random" correlation structure at the input to the decoder. However, since these sequences are repetitive and not random, there are misfortunate choices of FEC block size for each permutation that create high correlations and reduce the performance significantly.

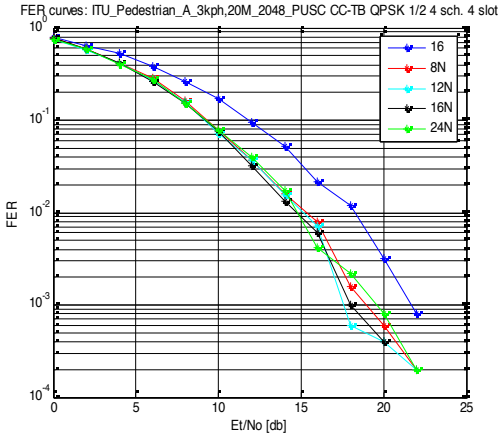
4. Simulation results

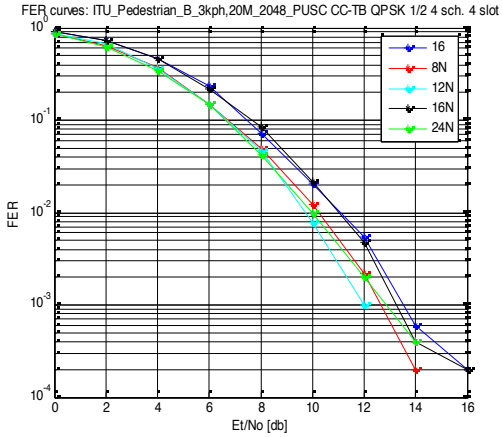
A subset of the simulation results is given here; more results are in the appendices.
The legend specifies the interleaver dimension (existing interleaver is d=16).

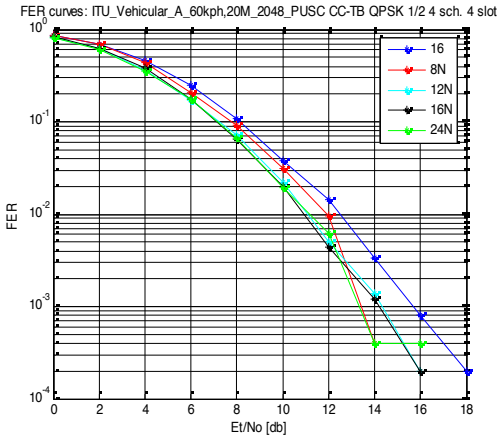
4.1. Downlink

In the simulations below we simulated two cases:

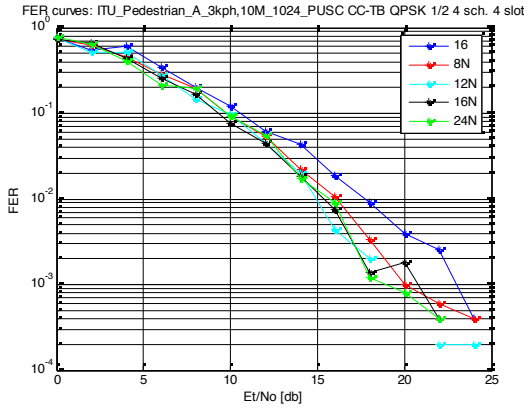
1. DL MAP emulator case – FEC blocks with 4 slots mapped over 4 sub-channels
ITU PED A 3Km/h ITU PED B 3Km/h and ITU VEH A 60Km/h.
20MHz, FFT Size – 2048:

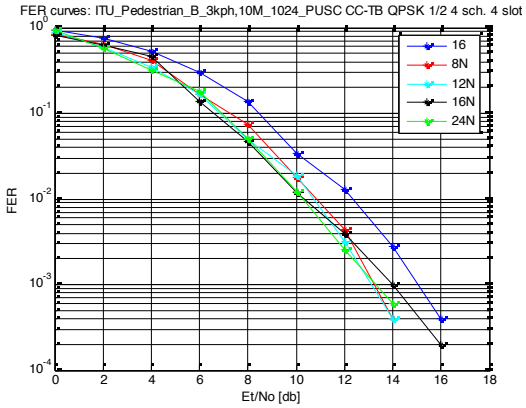

FER curves: ITU_Pedestrian_A_3kph,20M_2048_PUSC CC-TB QPSK 1/2 4 sch. 4 slot
FER
Et/No [db]
16
8N
12N
16N
24N

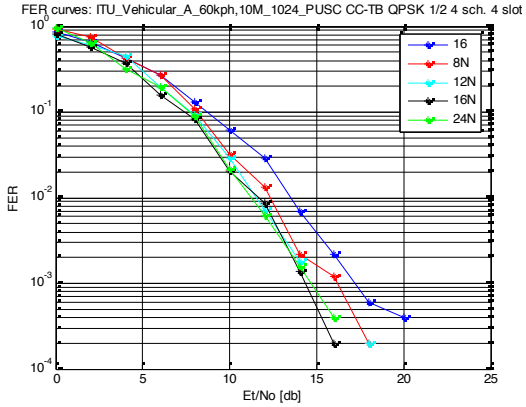

FER curves: ITU_Pedestrian_B_3kph,20M_2048_PUSC CC-TB QPSK 1/2 4 sch. 4 slot
FER
Et/No [db]
16
8N
12N
16N
24N


FER curves: ITU_Vehicular_A_60kph,20M_2048_PUSC CC-TB QPSK 1/2 4 sch. 4 slot
FER
Et/No [db]
16
8N
12N
16N
24N

10MHz, FFT Size – 1024:





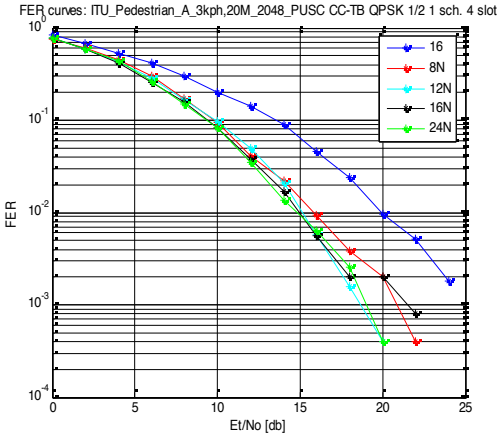


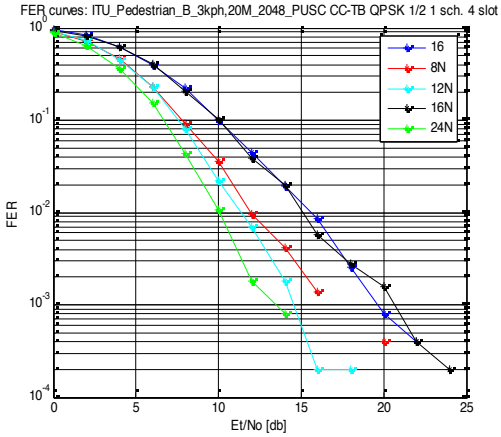
A 2 dB gain is evident for d =16N in comparison to d=16 for ITU- PED A 3Km/h and ITU VEH A 60Km/h.

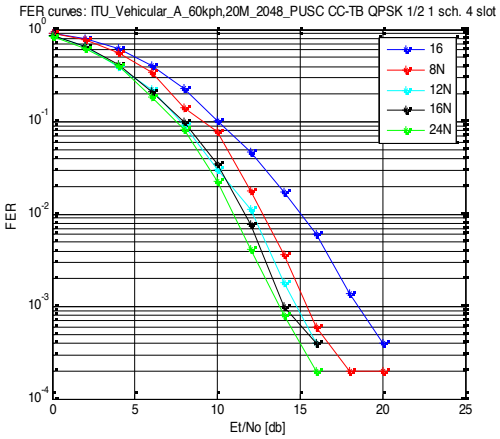
2. worst case – FEC blocks with 4 slots mapped over 1 sub-channel in PUSC

The worst case is in terms of distance between bits after interleaving and permutation. In worst case, each other bit at encoder output is mapped to a sub carrier with the same frequency.

20MHz, FFT Size – 2048:

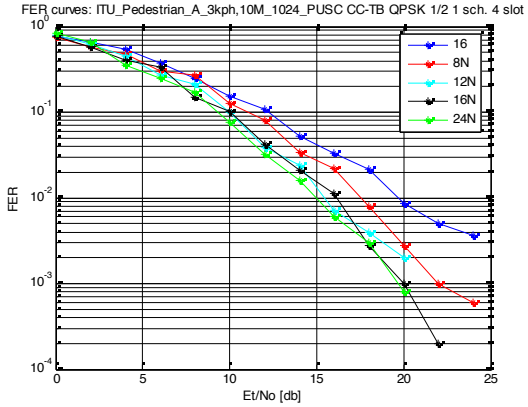


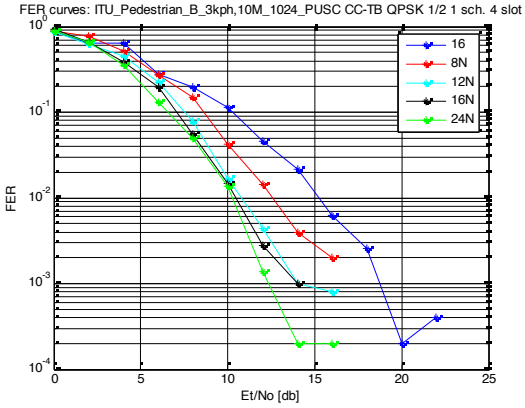


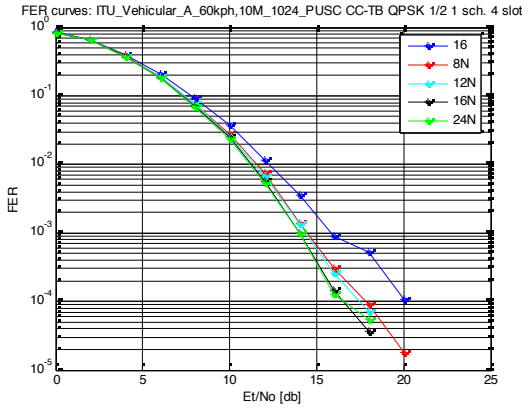


The performance gain is 5dB in ITU PED A channels and around 3dB for ITU VEH A 60Km/h when comparing d= 16N and d=16.

10MHz, FFT Size – 1024





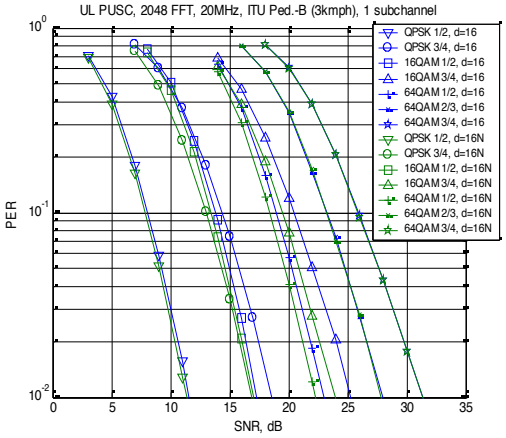


The performance gain is 5dB in ITU PED A/B channels and around 1-2dB for fast channels as ITU VEH A 60Km/h when comparing d = 16N and d =16.

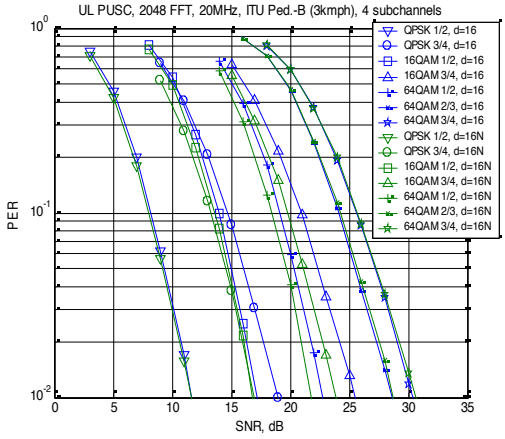
4.2. Uplink

20MHz, FFT Size – 2048:

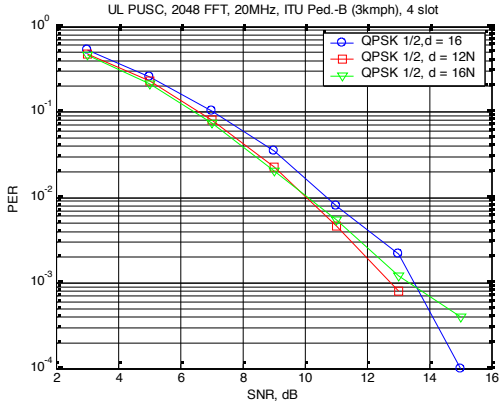
1. 1 sub channel ~108 bytes bursts, all MCS.



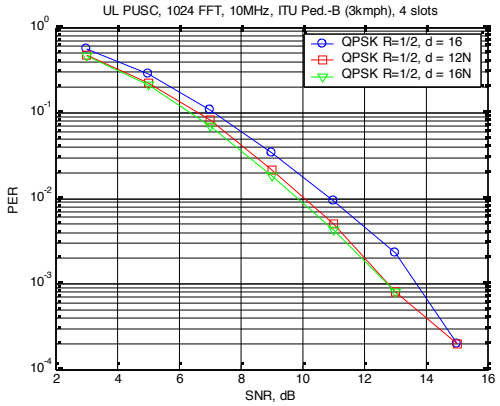
2. 4 sub channels ~144bytes bursts, all MSC



3. 1 sub channel 4 slots, QPSK ½.

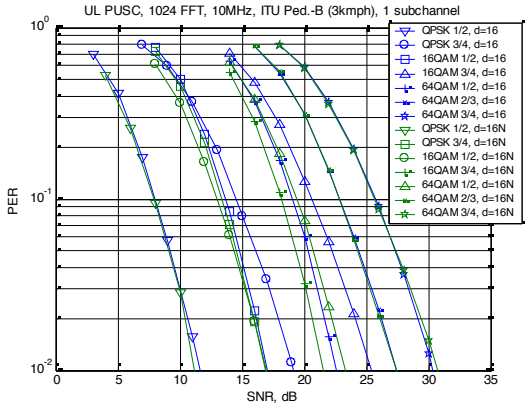


4. 4 sub channels 4 slots QPSK ½.

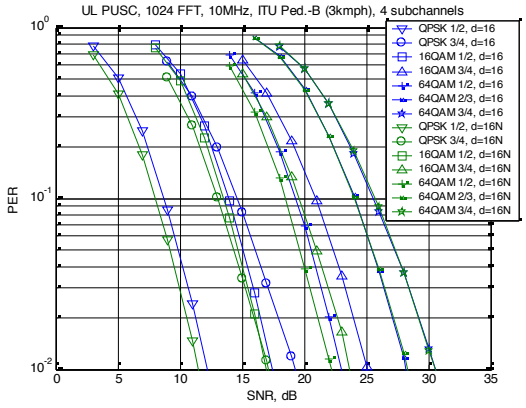


10MHz, FFT Size – 1024:

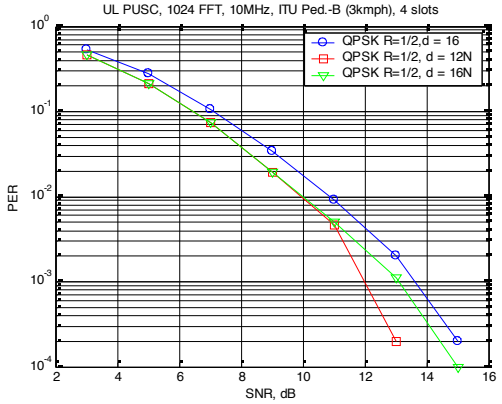
5. 1 sub channel ~108 bytes bursts, all MCS.



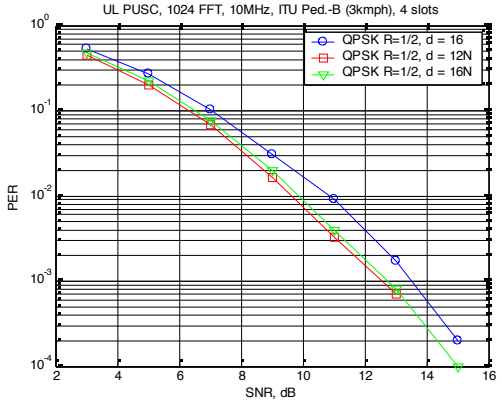
6. 4 sub channels ~144bytes bursts, all MCS.



7. 1 sub channel 4 slots, QPSK ½.



8. 4 sub channels 4 slots, QPSK ½.



The simulations show 2dB performance improvement over when comparing d=16N and current interleaver d=16.

5. Interleaver distance design (d)

5.1. DL

In DL PUSC permutation selecting d = 24N (where N is the number of slots) results in adjacent bits sub carriers spread of 2 logical sub carrier ~ (spread > 8-12) physical sub carriers , if we select 16N then the logical sub carrier spread is 3 ~ (spread > 12-18)) physical sub carrier spread . The sub carrier spacing assumed is 10 KHz.

12-18 physical sub carriers is around 120-180 KHz which assumes channel coherence time of = 6- 8 us.

Although simulation results show slightly better performance of d = 24N over d =16N, we chose d = 16N because of its advantage for channels with large coherence bandwidths. In these channels frequency diversity is important and d = 16N will give improved performance due to its higher frequency diversity.

5.2. UL

A UL PUSC slot is composed of three time symbols and one sub channel. The sub channel is constructed from six uplink tiles. Each tile has three pilots and 8 data sub carrier symbols. For first and third time intervals 12 sub carriers (2 per tile) are allocated for data transmission and 24 sub carriers (4 per tile) for central symbol. UL PUSC permutation consists from two steps

Outer permutation – tile permutation
Inner permutation – sub channel-dependent sub carrier shift within slot

During outer permutation the tiles that come from single slot are spread over whole frequency band. So, it can be assumed for further analysis that channel gains on sub carriers *within tile are correlated* and sub carriers *from different tiles are uncorrelated*.

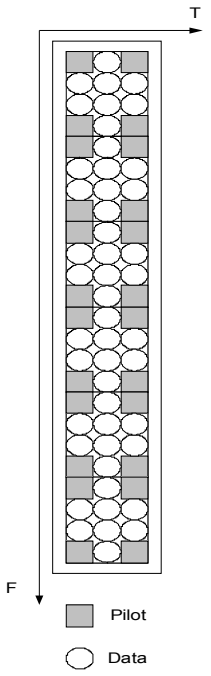


Figure 3. UL PUSC slot structure

Based on this assumption, we can formulate the criteria for interleaving parameters selection: *The adjacent bits after interleaving shall be placed on sub carriers of different tiles.*

This results in selecting d = 12N or 16N. Simulation results showed that 16N gives better performance.

Also simulation results were performed for AMC permutation in order to check that the change does not degrades performance in AMC. This is evident in the AMC simulation results which show similar performance for d=16 and d=16N.

6. Changes summary

We present an additional optional interleaver distance, which is summarized in the following table:

	Optional interleaver
Interleaver dimension UL	16N
Interleaver dimension DL	16N
Sub-channel reordering	k+48*n (Stays the same)
In-slot rotation (n+13*s)	Stays the same
Repetition	Stays the same

where

N – number of allocated slots per FEC block

k – sub-carrier index

n – slot index

6.1. Propsed Interleaver change

Add an optional interleaver option which changes the interleaver dimension to be dependent on the number of slots in FEC block (N). Specifically, the interleaver dimension in the UL is 16N, and in the

DL is 16N.

7. Text changes

7.1. Change FCH data structure

8.4.4.3 DL Frame Prefix

Change the text in coding indication in Table 266—OFDMA downlink Frame Prefix format. as follows:

Syntax	Size	Notes
Coding_Indication	3 bits	0b000 - CC encoding used on DL-MAP 0b001 - BTC encoding used on DL-MAP 0b010 - CTC encding used on DL-MAP 0b011 = ZT CC used on DL-MAP 0b100 = CC TB using optional Interleaver. 0b101 to 0b111 -*Reserved*

7.2. Change capability negotiation

11.8.3.7.3 OFDMA SS modulator

Remove and change the following in OFDMA SS modulator TLV.

Type	Length	Value	Scope
152	1	Bit# 0: 64-QAM Bit# 1: BTC Bit# 2: CTC ~~Bit #3: AAS Diversity Map Scan*Reserved*;~~ shall be set to zero Bit# 4: AAS Direct Signaling*Reserved*; shall be set to zero Bit# 5: H-ARQ Bits# 6 CC TB optional interleaver support. Bit# 7: *Reserved*; shall be set to zero	SBC-REQ (see 6.3.2.3.23) SBC-RSP (see 6.3.2.3.24)

11.8.3.7.2 OFDMA SS demodulator

Remove and change the following in OFDMA SS demodulator TLV.

Type	Length	Value	Scope
152	1	Bit# 0: 64-QAM Bit# 1: BTC Bit# 2: CTC ~~Bit #3: AAS Diversity Map Scan*Reserved*;~~ Bit#3 CC TB optional interleaver support shall be set to zero Bit# 4: AAS Direct Signaling*Reserved*; shall be set to zero Bit# 5: H-ARQ Bits# 6–7: *Reserved*; shall be set to zero	SBC-REQ (see 6.3.2.3.23) SBC-RSP (see 6.3.2.3.24)

Note that Bit#3 in 802.16e is redundant since it is defined in 11.8.3.7.5 OFDMA SS Demodulator for MIMO support of Cor1D3 of 802.16d.

7.3. Change UCD

Change the text FEC Code type and modulation type in Table 357—UCD burst profile encodings WirelessMAN-OFDMA.

Name	Type	Length	Value
FEC Code type and modulation type	150	1	0 = QPSK (CC) 1/2 1 = QPSK (CC) 3/4 2 = 16-QAM (CC) 1/2 3 = 16-QAM (CC) 3/4 4 = 64-QAM (CC) 1/2 5 = 64-QAM (CC) 2/3 6 = 64-QAM (CC) 3/4 7 = QPSK (BTC) 1/2 8 = QPSK (BTC) 3/4 or 2/3 9 = 16-QAM (BTC) 3/5 10 = 16-QAM (BTC) 4/5 11 = 64-QAM (BTC) 2/3 or 5/8 12 = 64-QAM (BTC) 5/6 or 4/5 13 = QPSK (CTC) 1/2 14 = Reserved 15 = QPSK (CTC) ¾ 16 = 16-QAM (CTC) 1/2 17 = 16-QAM (CTC) 3/4 18 = 64-QAM (CTC) 1/2 19 = 64-QAM (CTC) 2/3 20 = 64-QAM (CTC) 3/4 21 = 64-QAM (CTC) 5/6 22 = QPSK (ZT CC) 1/2 23 = QPSK (ZT CC) 3/4 24= 16-QAM (ZT CC) 1/2 25= 16-QAM (ZT CC) 3/4 26= 64-QAM (ZT CC) 1/2 27= 64-QAM (ZT CC) 2/3 28= 64-QAM (ZT CC) 3/4 29..43 = *Reserved* [1] 44 = QPSK (CC with optional interleaver) 1/2 45 = QPSK (CC with optional interleaver) 3/4 46 = 16-QAM (CC with optional interleaver) 1/2 47 = 16-QAM (CC with optional interleaver) ¾ 48 = 64-QAM (CC with optional interleaver) 2/3 49= 64-QAM (CC with optional interleaver) 3/4 50..255 = *Reserved*

Note that in 802.16e the code 5 = 64-QAM (CC) 2/3 was added.

7.4. Change DCD

Change the text FEC Code type and modulation type in Table 361—DCD burst profile encodings WirelessMAN-OFDMA.

Name	Type	Length	Value

[1] Reserved for 802.16e

FEC Code type and modulation type	150	1	0 = QPSK (CC) 1/2 1 = QPSK (CC) 3/4 2 = 16-QAM (CC) 1/2 3 = 16-QAM (CC) 3/4 4 = 64-QAM (CC) 1/2 5 = 64-QAM (CC) 2/3 6 = 64-QAM (CC) 3/4 7 = QPSK (BTC) 1/2 8 = QPSK (BTC) 3/4 or 2/3 9 = 16-QAM (BTC) 3/5 10 = 16-QAM (BTC) 4/5 11 = 64-QAM (BTC) 2/3 or 5/8 12 = 64-QAM (BTC) 5/6 or 4/5 13 = QPSK (CTC) 1/2 14 = Reserved 15 = QPSK (CTC) ¾ 16 = 16-QAM (CTC) 1/2 17 = 16-QAM (CTC) 3/4 18 = 64-QAM (CTC) 1/2 19 = 64-QAM (CTC) 2/3 20 = 64-QAM (CTC) 3/4 21 = 64-QAM (CTC) 5/6 22 = QPSK (ZT CC) 1/2 23 = QPSK (ZT CC) 3/4 24= 16-QAM (ZT CC) 1/2 25= 16-QAM (ZT CC) 3/4 26= 64-QAM (ZT CC) 1/2 27= 64-QAM (ZT CC) 2/3 28= 64-QAM (ZT CC) 3/4 29..43 = *Reserved*[2] 44 = QPSK (CC with optional interleaver) 1/2 45 = QPSK (CC with optional interleaver) 3/4 46 = 16-QAM (CC with optional interleaver) 1/2 47 = 16-QAM (CC with optional interleaver) ¾ 48 = 64-QAM (CC with optional interleaver) 2/3 49= 64-QAM (CC with optional interleaver) 3/4 50..255 = *Reserved*

Note that in 802.16e the code 5 = 64-QAM (CC) 2/3 was added.

7.5. Addition of an optional interleaver with change of interleaver dimension

[Add a section with optional Interleaver for CC]

8.4.9.3.1 Optional interleaver for CC

[Add the following sentence]

For the CC optional interleaver, the interleaver structure is as defined in 8.4.9.3. The value of d in equations 126-129 shall be set to 16n for the DL and 16n for the UL, where n is the number of allocated slots per FEC block.

[2] Reserved for 802.16e

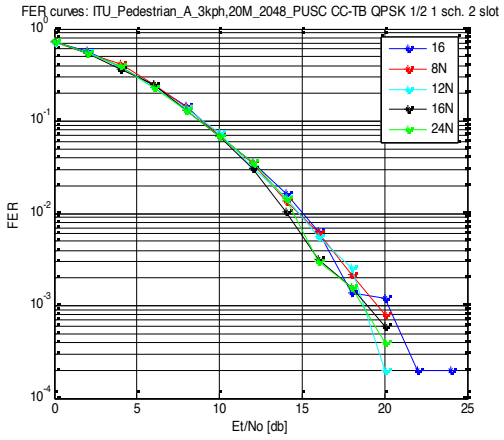
Appendix A - Downlink simulation results

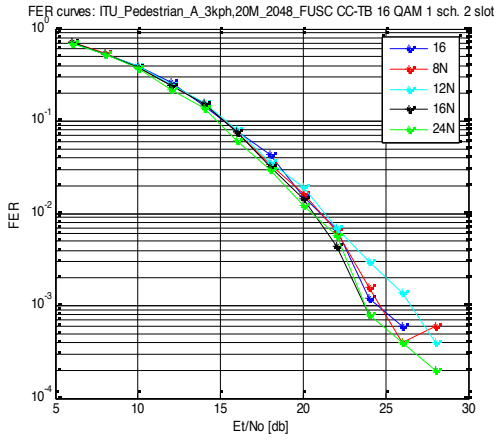
Appendix B DL PUSC/ FUSC simulation parameters – FFT Size - 2048

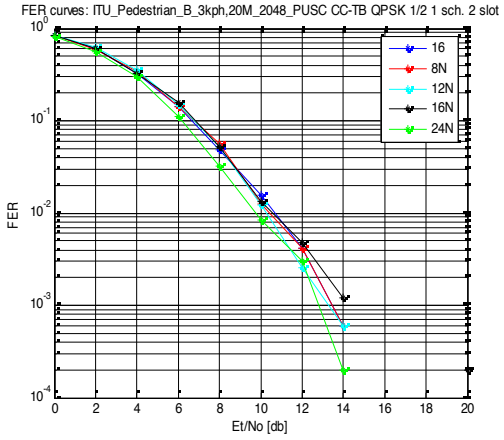
Permutation	DL-PUSC
FFT size	2048
BW	20MHz
Modulation	QPSK ½, 16QAM ½, 64QAM ½
Code	CC-TB
Frame	
Bursts allocation	worst case – 1 sub-channel DL MAP Emulator 4 sub-channels
FEC block size	best case - 6 slots / worst case – 4 slots
Channel	random channel, normalized to unity power over signal band ITU PED A 3 kmh / ITU PED B 3 kmh / ITU vec A 60 kmh /

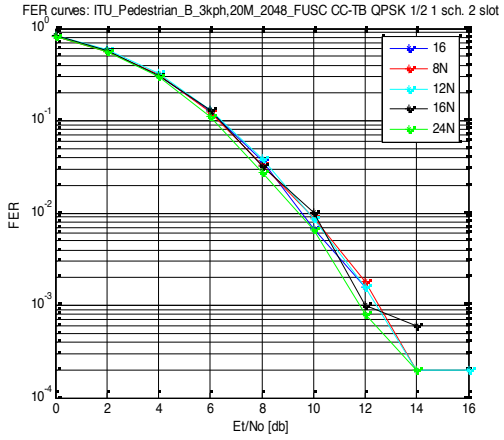
Appendix C QPSK R= ½ Simulation results

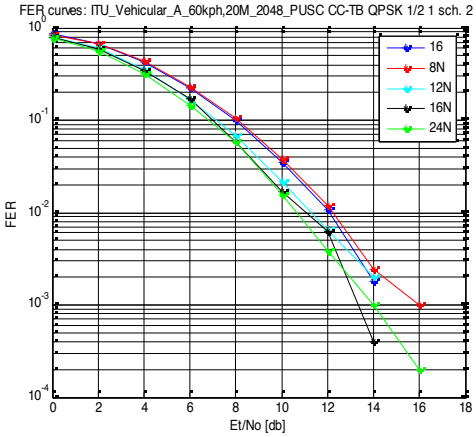
Appendix D 1 sub channel 2 slots PUSC / FUSC

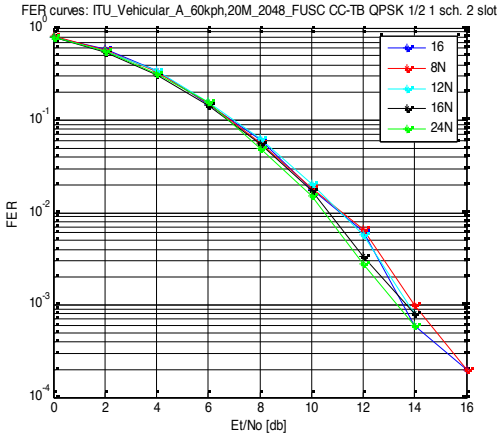




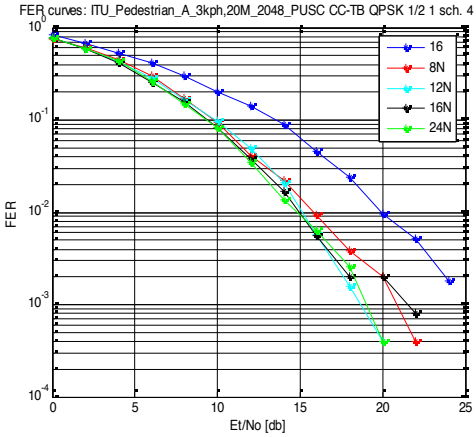


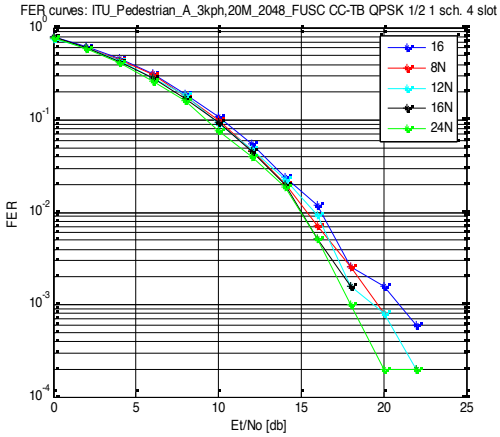


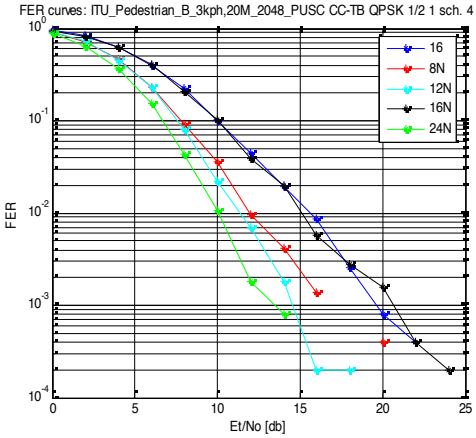


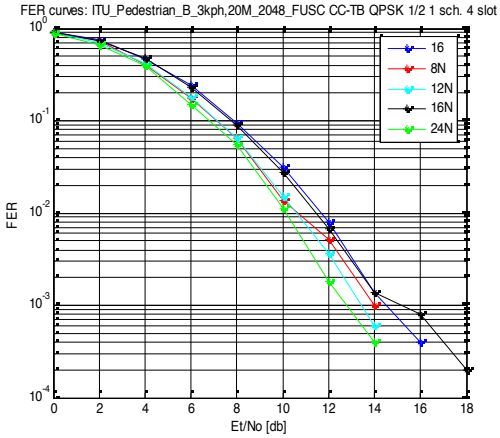


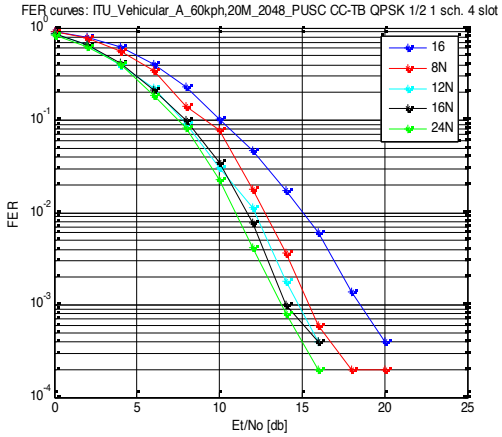
Appendix E 1 sub channel 4 slots PUSC / FUSC

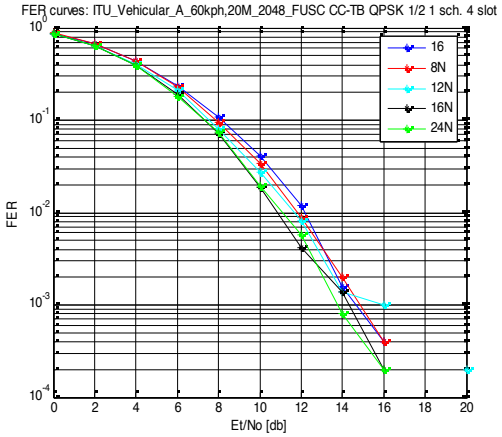




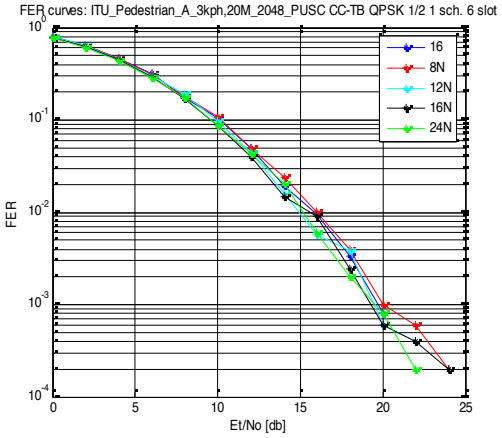


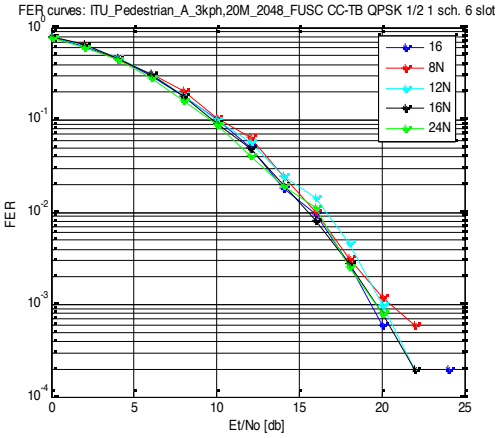


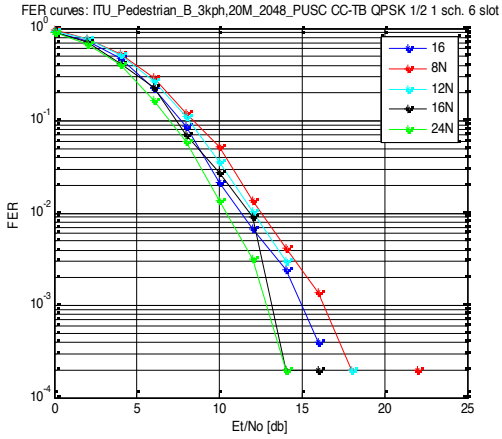


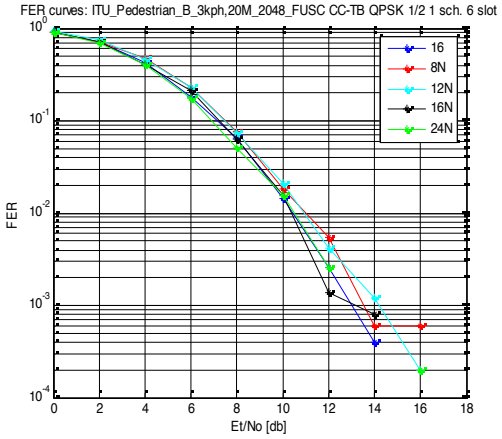


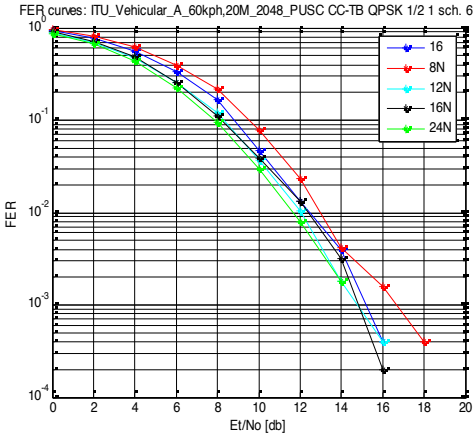
Appendix F 1 sub channel 6 slots PUSC / FUSC

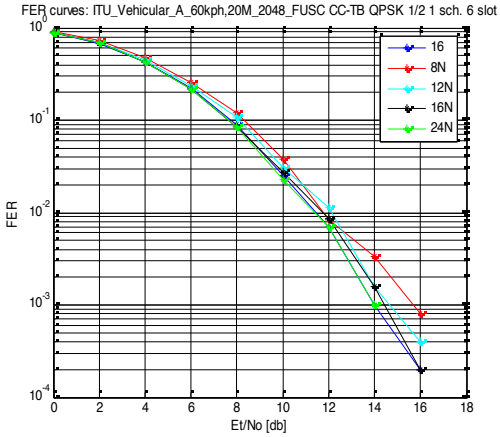




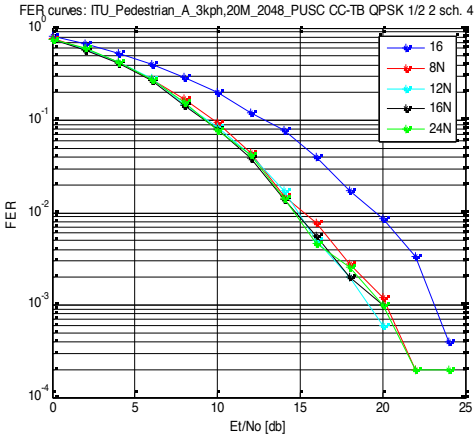


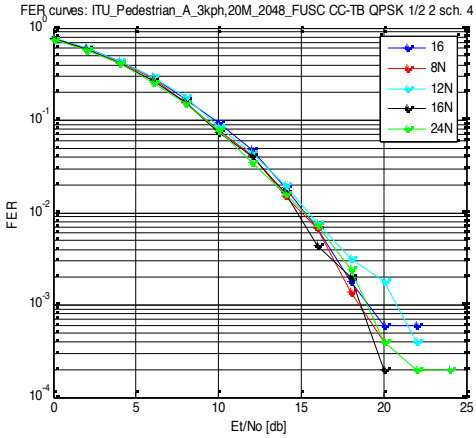


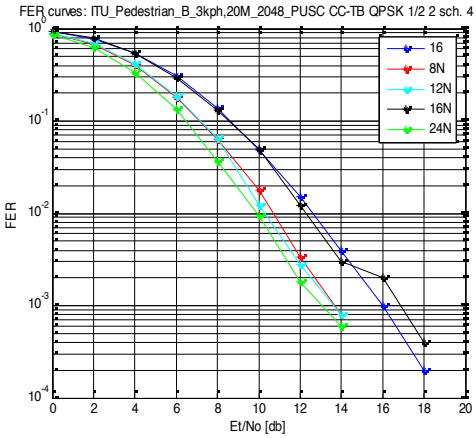

FER curves: ITU_Vehicular_A_60kph,20M_2048_PUSC CC-TB QPSK 1/2 1 sch. 6 slot
FER
Et/No [db]
16
8N
12N
16N
24N

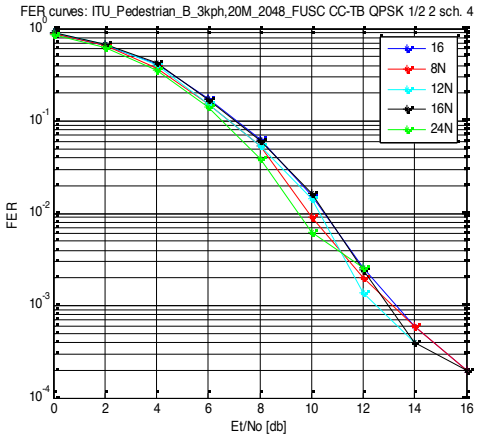

FER curves: ITU_Vehicular_A_60kph,20M_2048_FUSC CC-TB QPSK 1/2 1 sch. 6 slot
FER
Et/No [db]
16
8N
12N
16N
24N

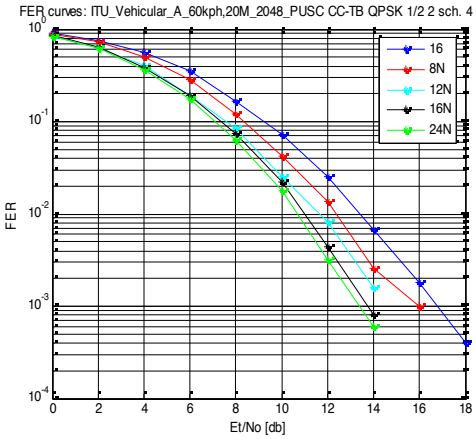
Appendix G 2 sub channel 4 slots PUSC / FUSC

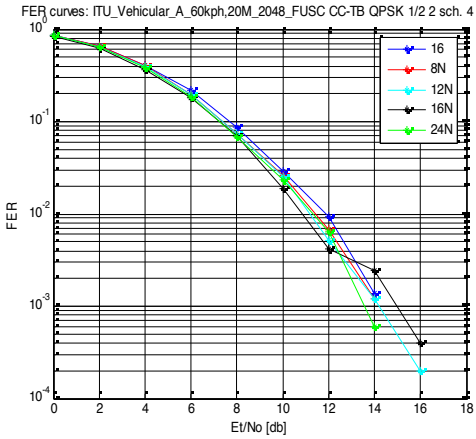




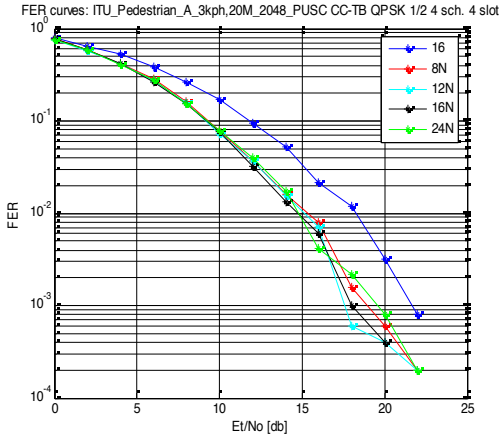


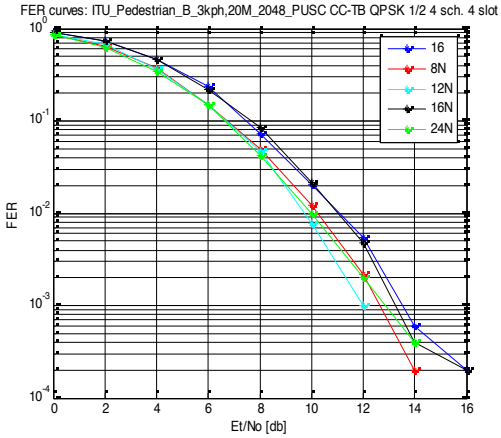


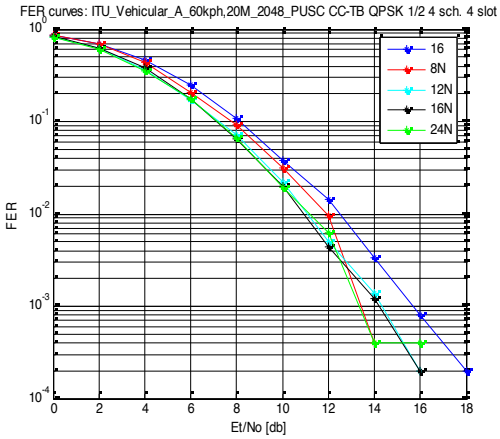




Appendix H 4 sub channel 4 slots PUSC (DL MAP emulation)

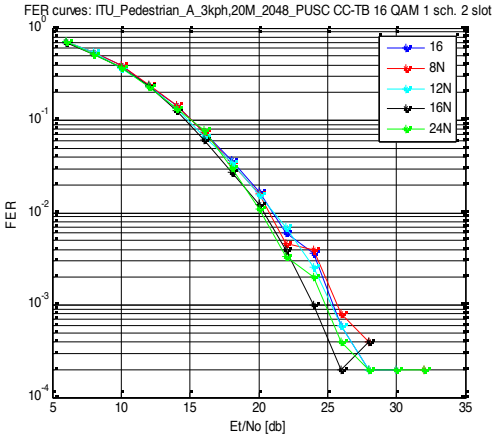


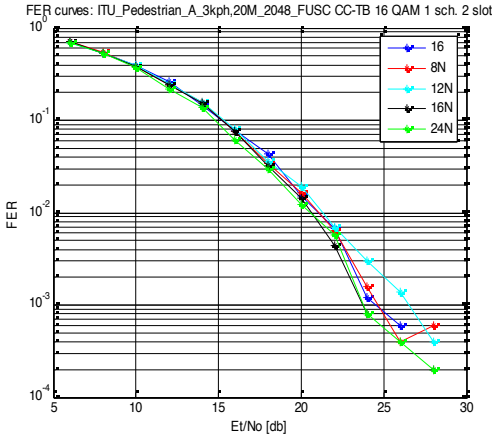


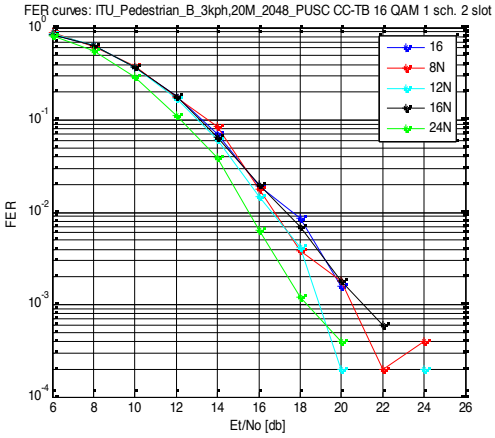


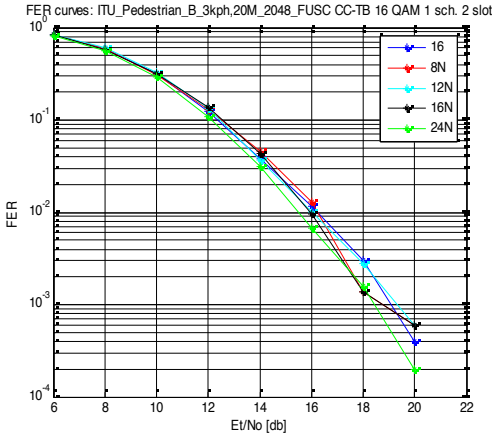
Appendix I 16QAM R= ½ Simulation results

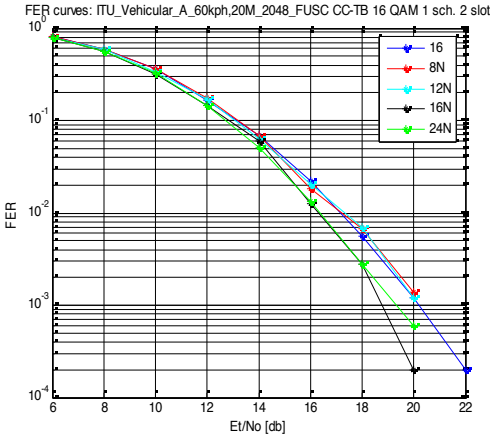
Appendix J 1 sub channel 2 slots PUSC / FUSC

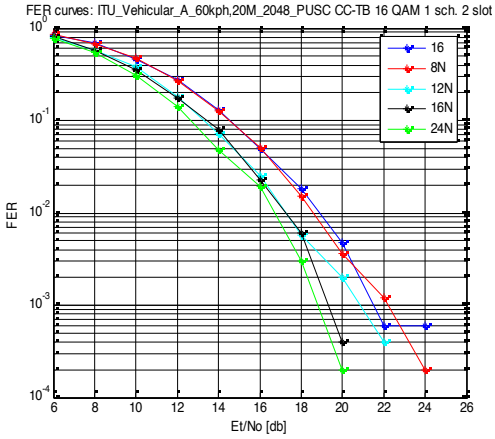






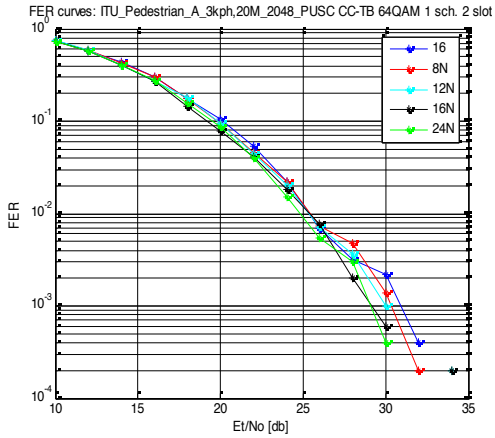


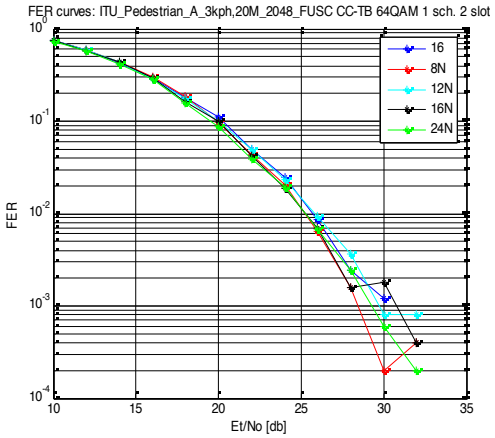


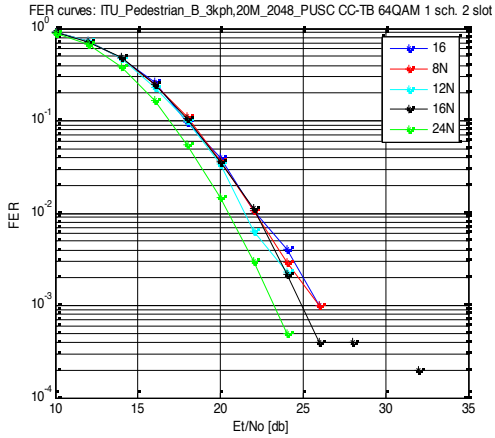


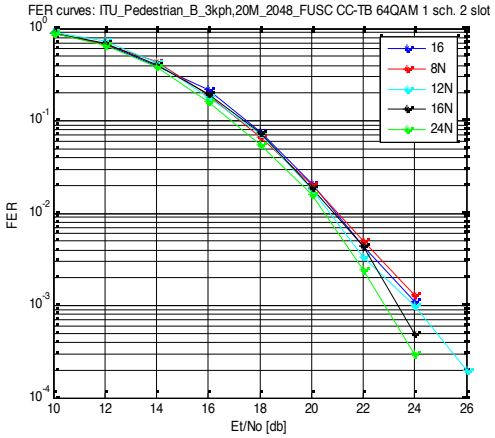
Appendix K 64QAM R= ½ Simulation results

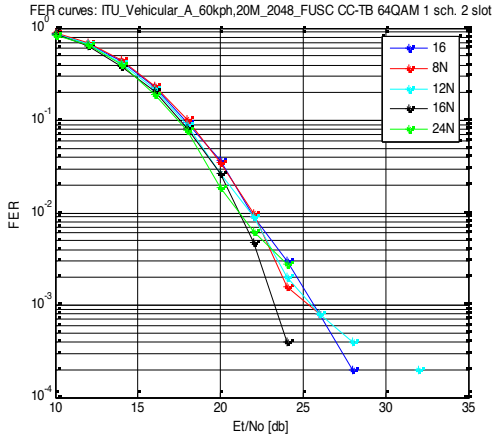
Appendix L 1 sub channel 2 slots PUSC / FUSC

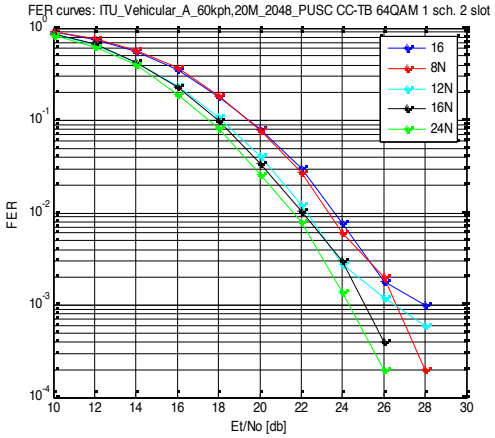












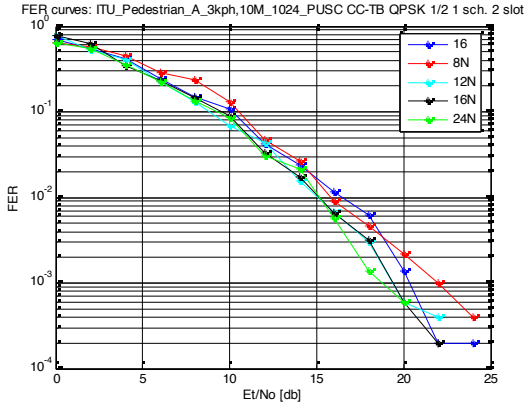
Appendix M DL PUSC/ FUSC simulation parameters – FFT Size 1024

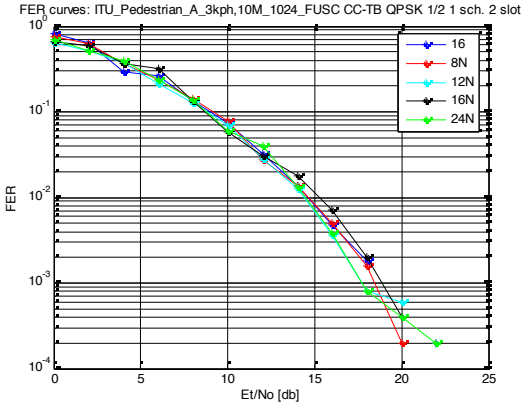
Permutation	DL-PUSC
FFT size	1024
BW	10 MHz
Modulation	QPSK ½, 16QAM ½, 64QAM ½
Code	CC-TB

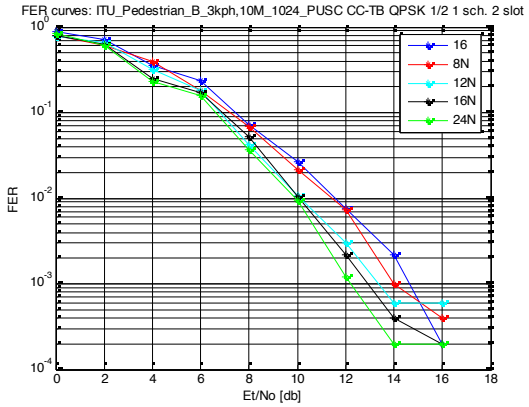
Frame
Bursts allocation worst case – 1 sub-channel
DL MAP Emulator 4 sub-channels
FEC block size best case - 6 slots / worst case – 4 slots
Channel random channel, normalized to unity power over signal band
ITU PED A 3 kmh / ITU PED B 3 kmh / ITU vec A 60 kmh /

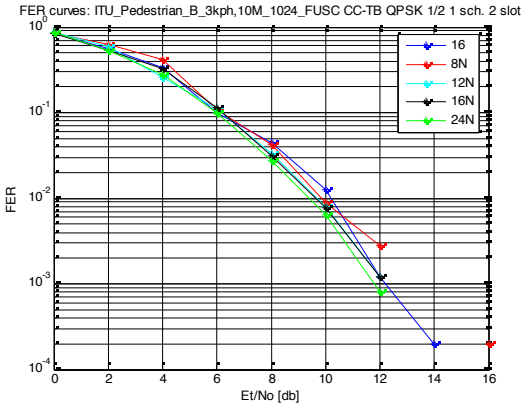
Appendix N QPSK R= ½ Simulation results

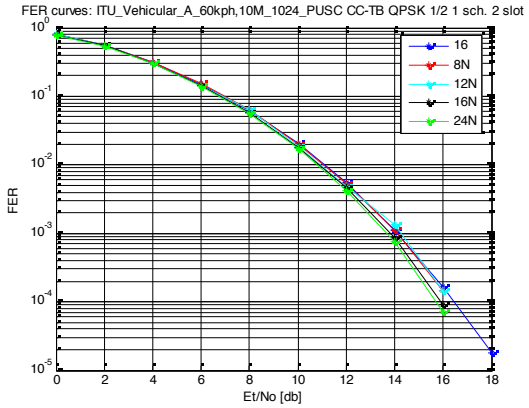
Appendix O 1 sub channel 2 slots PUSC / FUSC

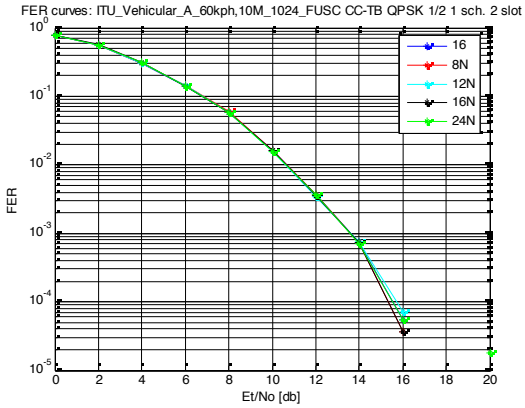




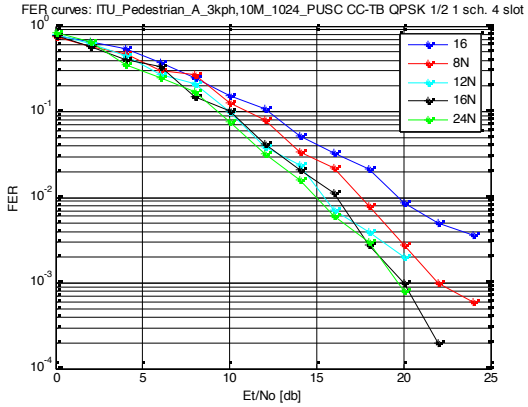


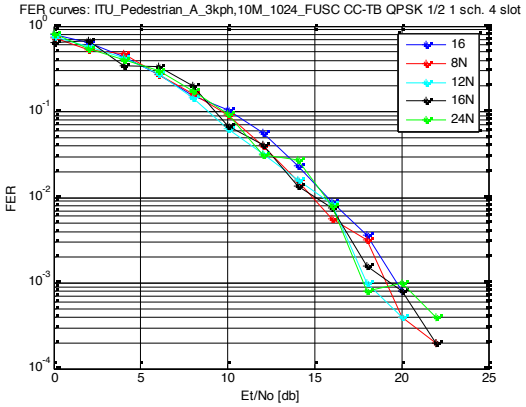


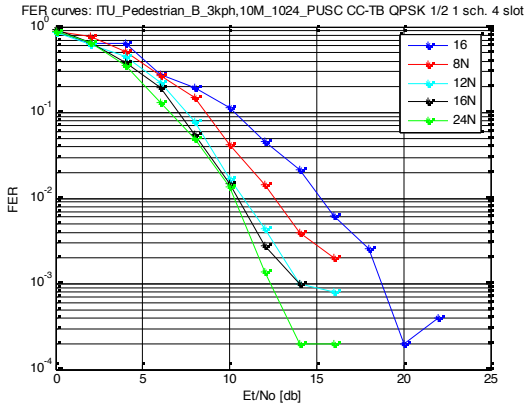


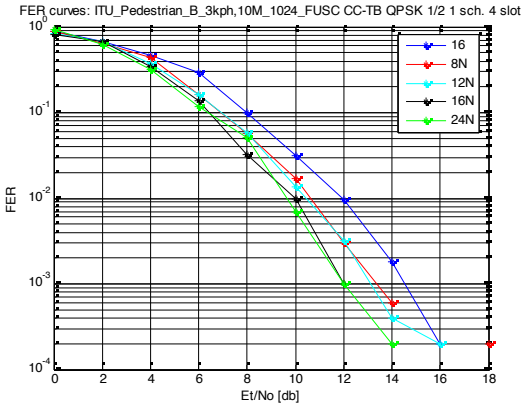


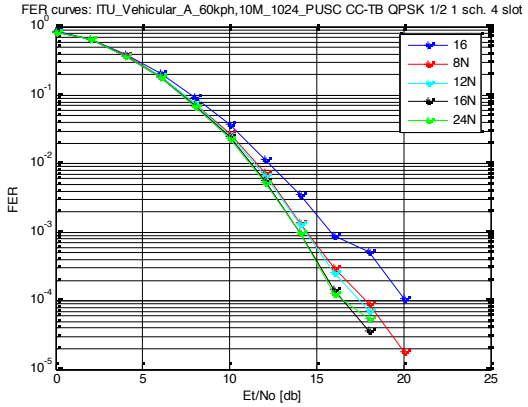
Appendix P 1 sub channel 4 slots PUSC / FUSC

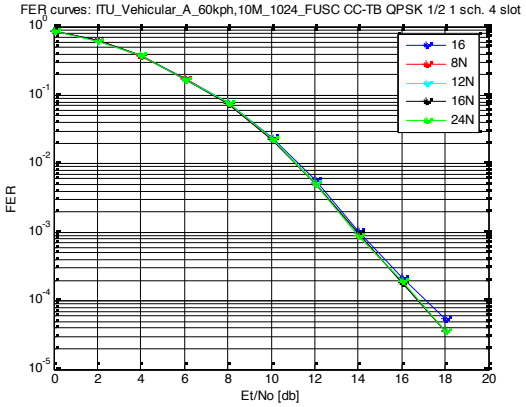




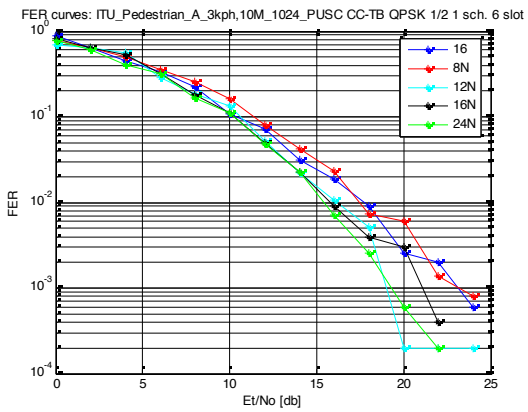


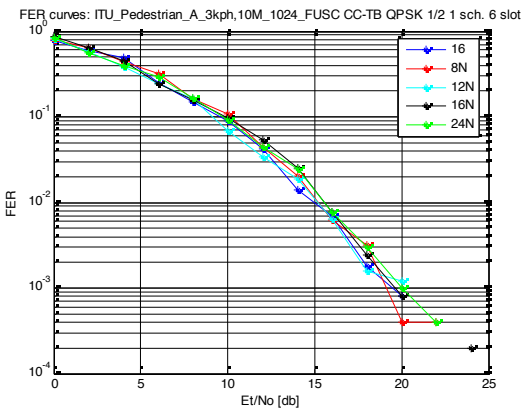


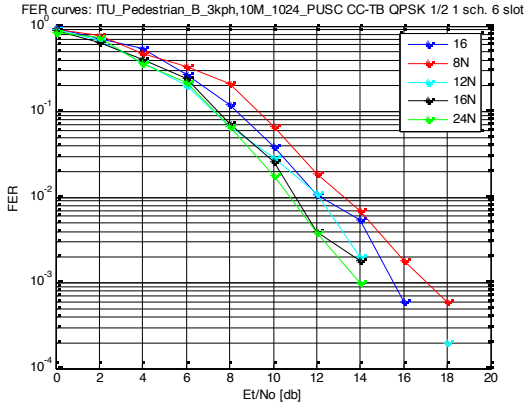


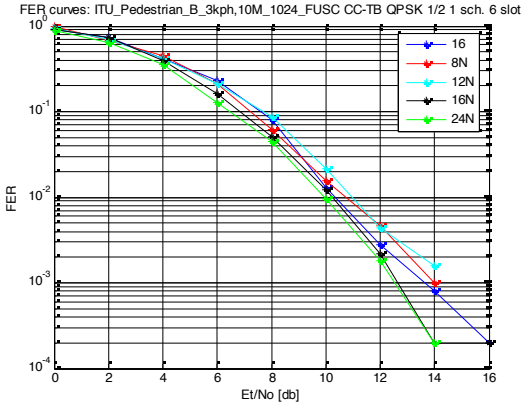


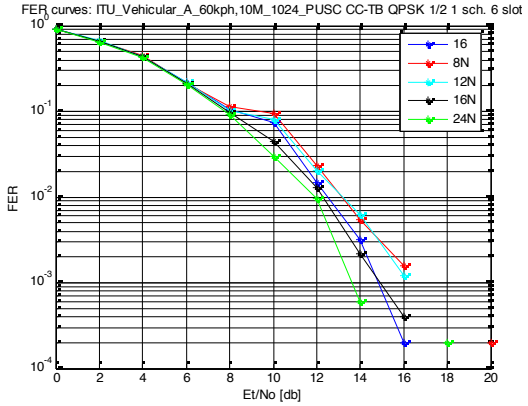
Appendix Q 1 sub channel 6 slots PUSC / FUSC

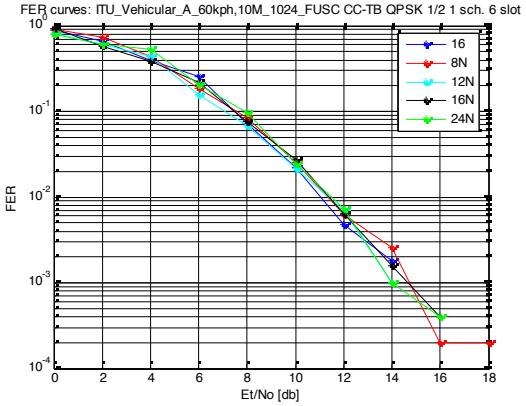




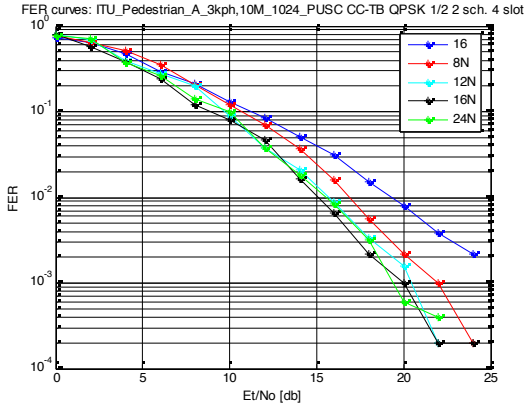

FER curves: ITU_Pedestrian_B_3kph,10M_1024_PUSC CC-TB QPSK 1/2 1 sch. 6 slot
FER
Et/No [db]
16
8N
12N
16N
24N

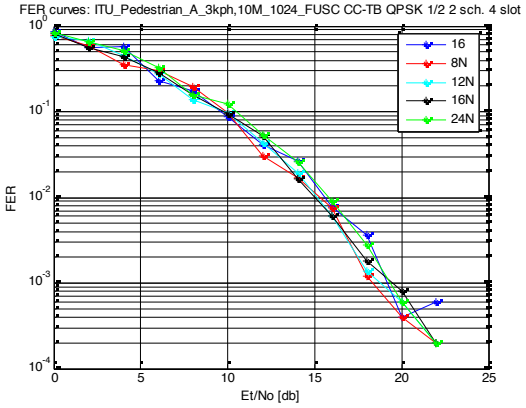

FER curves: ITU_Pedestrian_B_3kph,10M_1024_FUSC CC-TB QPSK 1/2 1 sch. 6 slot
FER
Et/No [db]
16
8N
12N
16N
24N

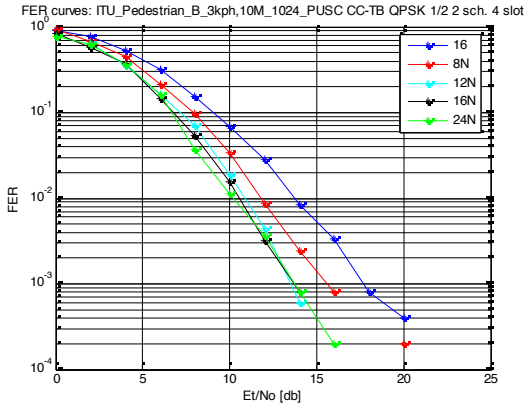

FER curves: ITU_Vehicular_A_60kph,10M_1024_PUSC CC-TB QPSK 1/2 1 sch. 6 slot
FER
Et/No [db]
16
8N
12N
16N
24N

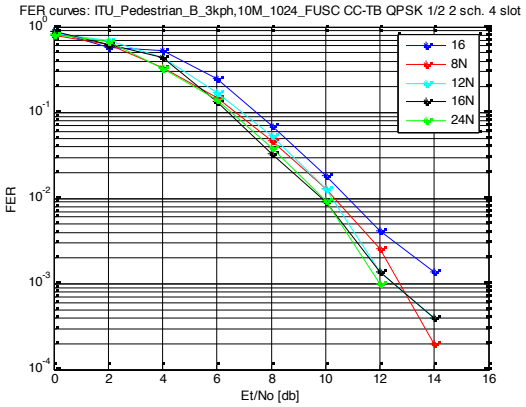

FER curves: ITU_Vehicular_A_60kph,10M_1024_FUSC CC-TB QPSK 1/2 1 sch. 6 slot
FER
Et/No [db]
16
8N
12N
16N
24N

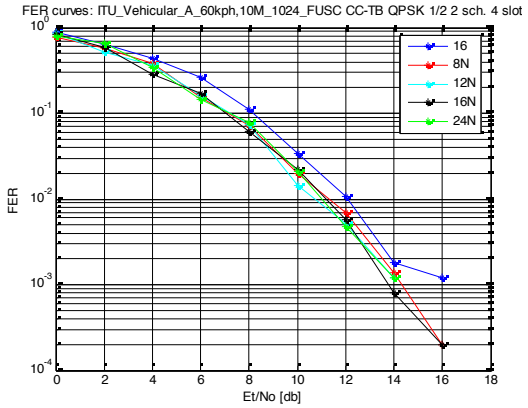
Appendix R 2 sub channel 4 slots PUSC / FUSC

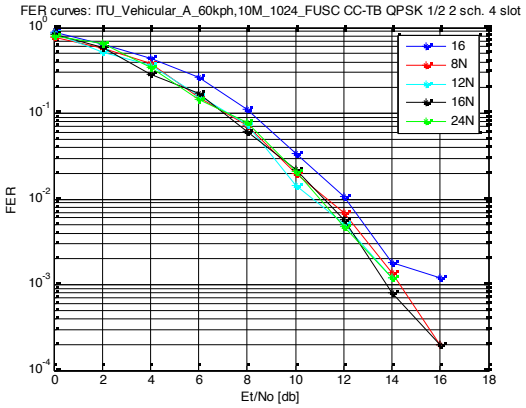




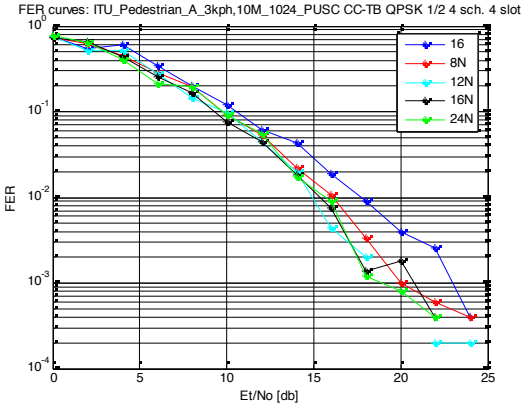


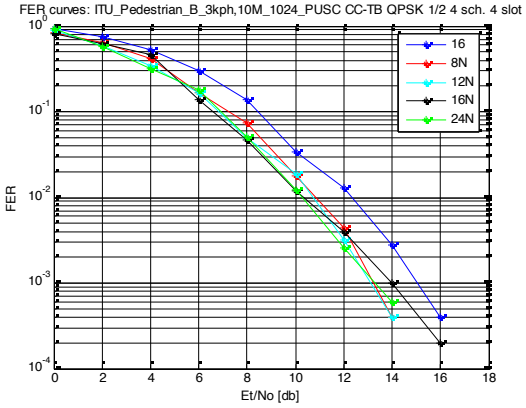


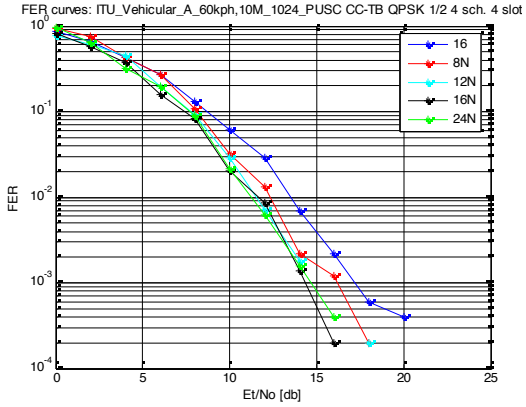




Appendix S 4 sub channel 4 slots PUSC (DL MAP emulation)

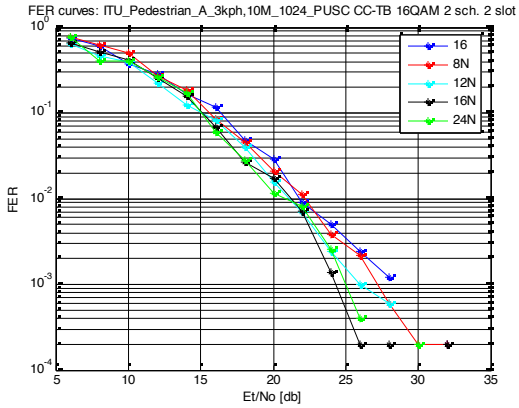


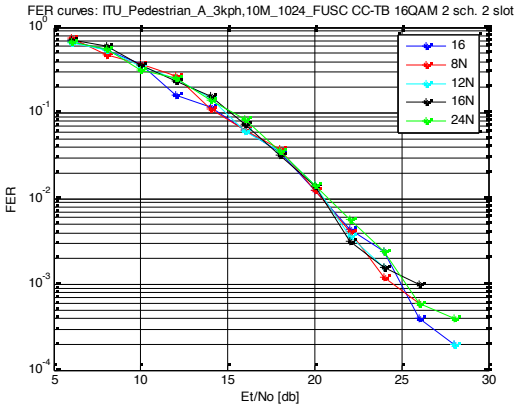


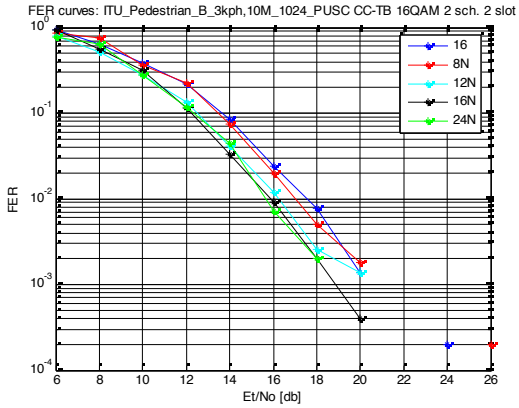


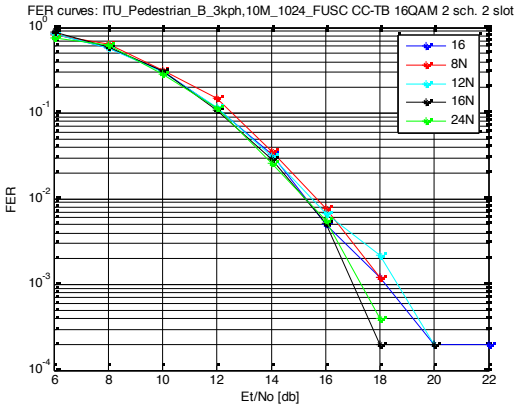
Appendix T 16QAM R= ½ Simulation results

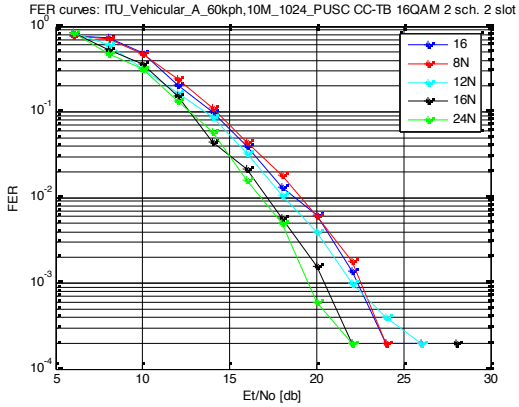
Appendix U 1 sub channel 2 slots PUSC / FUSC

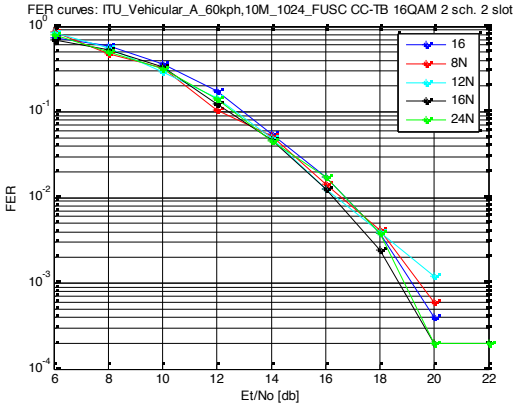






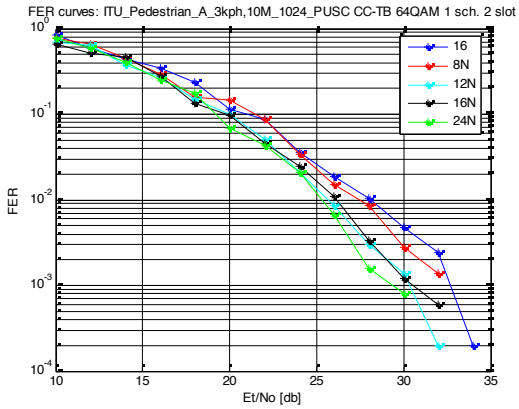


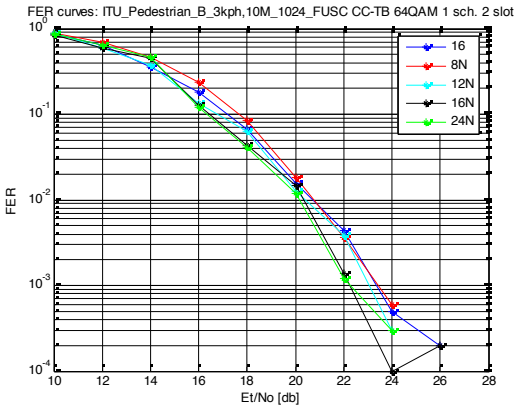


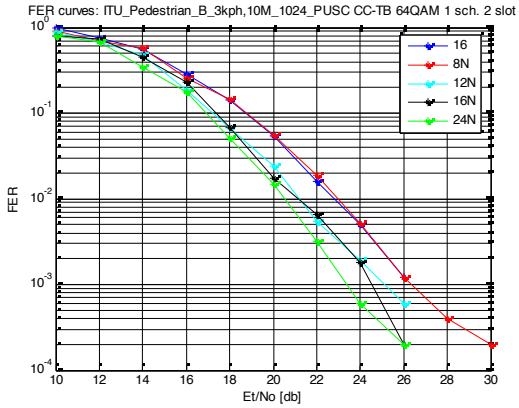


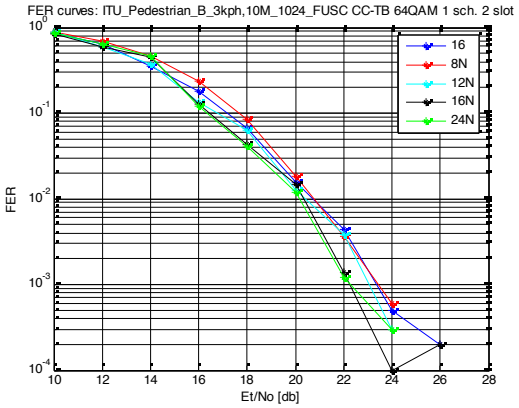
Appendix V 64QAM R= ½ Simulation results

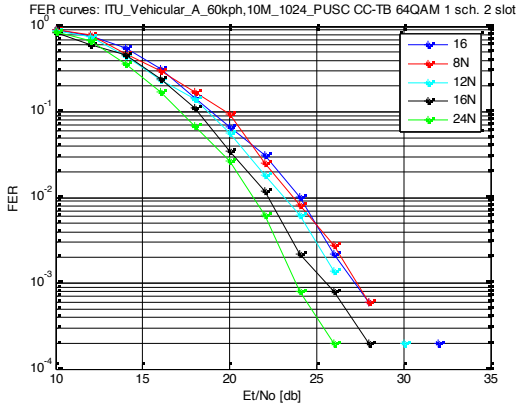
Appendix W 1 sub channel 2 slots PUSC / FUSC

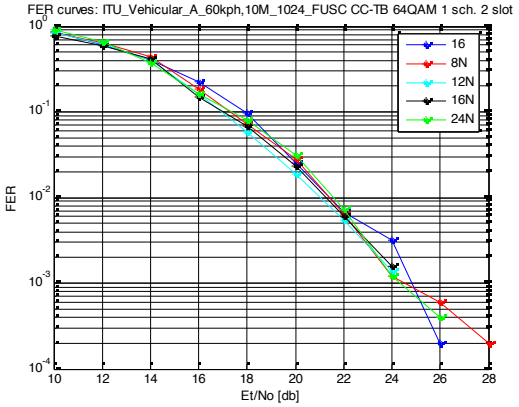





FER curves: ITU_Pedestrian_B_3kph,10M_1024_PUSC CC-TB 64QAM 1 sch. 2 slot
FER
Et/No [db]
16
8N
12N
16N
24N


FER curves: ITU_Pedestrian_B_3kph,10M_1024_FUSC CC-TB 64QAM 1 sch. 2 slot
FER
Et/No [db]
16
8N
12N
16N
24N


FER curves: ITU_Vehicular_A_60kph,10M_1024_PUSC CC-TB 64QAM 1 sch. 2 slot
FER
Et/No [db]
16
8N
12N
16N
24N


FER curves: ITU_Vehicular_A_60kph,10M_1024_FUSC CC-TB 64QAM 1 sch. 2 slot
FER
Et/No [db]
16
8N
12N
16N
24N

Appendix X - Uplink simulation results

Appendix Y UL PUSC simulation parameters – FFT Size 1024

Permutation	UL-PUSC
FFT size	1024
BW	10 MHz
Modulation	QPSK ½, QPSK 3/4 , 16QAM ½,16QAM ¾ , 64QAM ½, 64QAM ¾
Code	CC-TB
Frame	
Bursts allocation	worst case – 1/2/4 sub-channels (see below for exact allocations)
FEC block size	
Channel	random channel, normalized to unity power over signal band ITU PED B 3 kmh / ITU vec A 60 kmh /

1 Sub channel allocation

MCS	QPSK R=1/2	QPSK R=3/4	16QAM R=1/2	16QAM R=3/4	64QAM R=1/2	64QAM R=2/3	64QAM R=3/4
Number of subchannels	1	1	1	1	1	1	1
Number of slots	18	12	9	6	6	4	4
Packet length	108	108	108	108	108	96	108

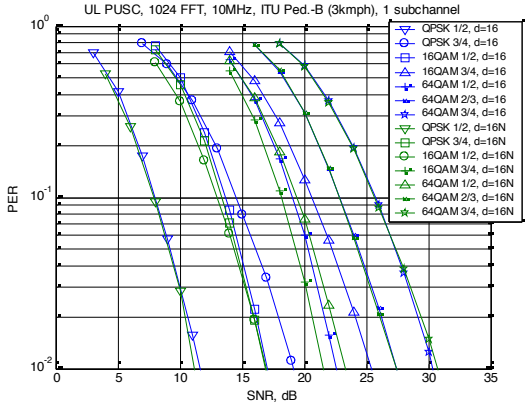
2 Sub channel allocation

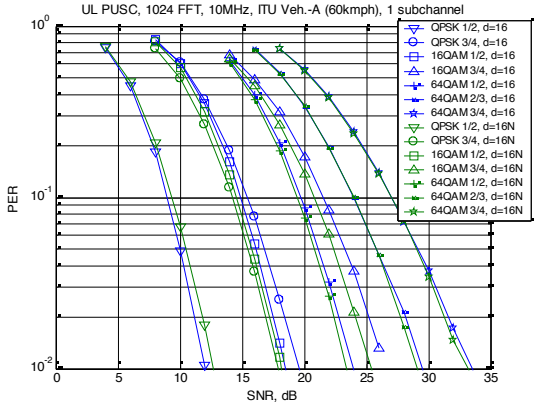
MCS	QPSK R=1/2	QPSK R=3/4	16QAM R=1/2	16QAM R=3/4	64QAM R=1/2	64QAM R=2/3	64QAM R=3/4
Number of subchannels	2	2	2	2	2	2	2
Number of slots	18	12	12	6	6	4	4
Packet length	108	108	144	108	108	96	108

4 Sub channel allocation

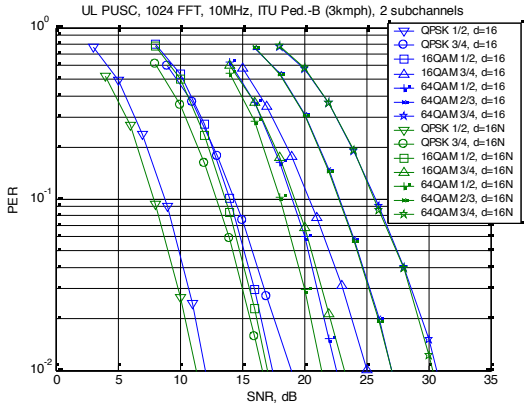
MCS	QPSK R=1/2	QPSK R=3/4	16QAM R=1/2	16QAM R=3/4	64QAM R=1/2	64QAM R=2/3	64QAM R=3/4
Number of subchannels	4	4	4	4	4	4	4
Number of slots	24	16	12	8	8	8	4
Packet length	144	144	144	144	144	192	108

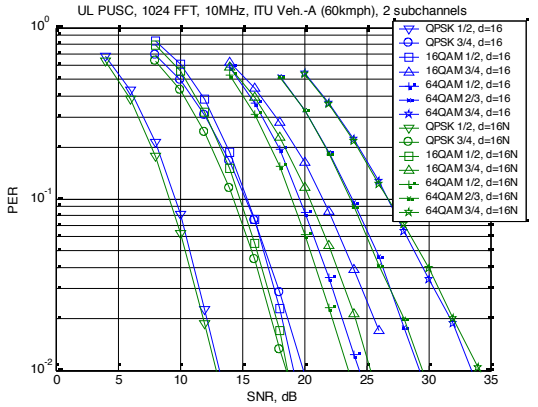
Appendix Z 1 sub channel ITU PED B 3Km/h ITU VEH A 60Km/h



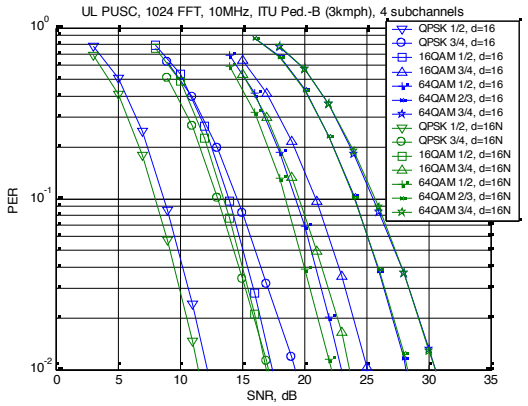


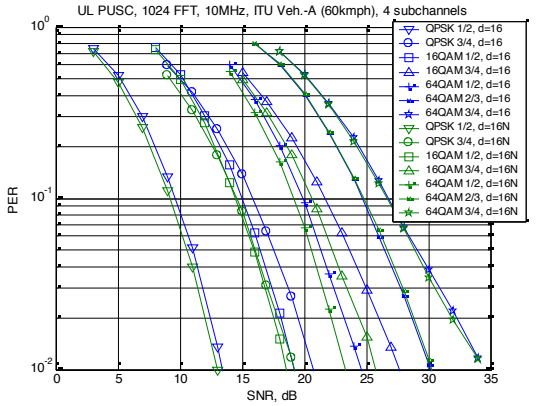
Appendix AA 2 sub channels





Appendix BB 4 sub channel





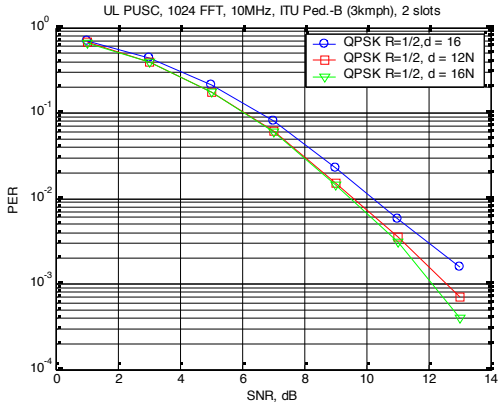
Appendix CC UL PUSC simulation parameters

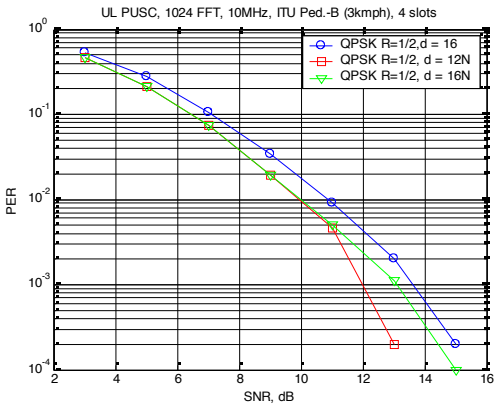
Permutation	UL-PUSC
FFT size	1024
BW	10 MHz
Modulation	QPSK ½, 16QAM ½, 64QAM ½
Code	CC-TB
Frame	
Bursts allocation	see burs allocation description in tables below.

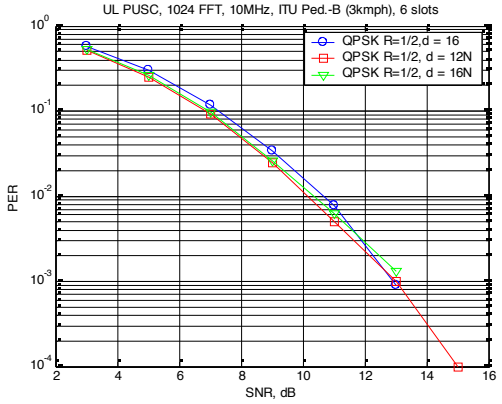
FEC block size	2, 4, 6 slots
Channel	random channel, normalized to unity power over signal band ITU PED B 3 kmh / ITU vec A 60 kmh /

Appendix DD ITU Pedestrian -B channel 3Km/h d=16, 12N, 16N

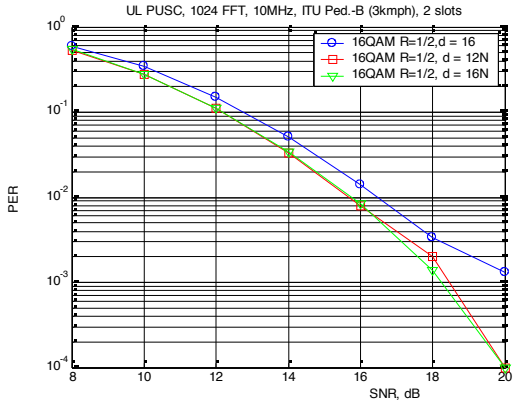
Appendix EE 1 sub channel QPSK R = 1/2

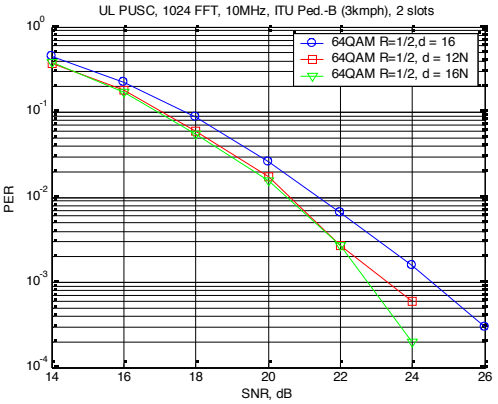




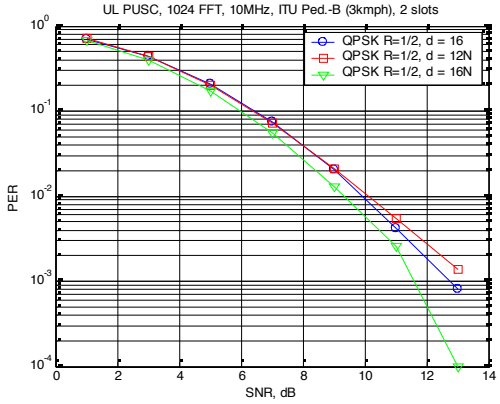


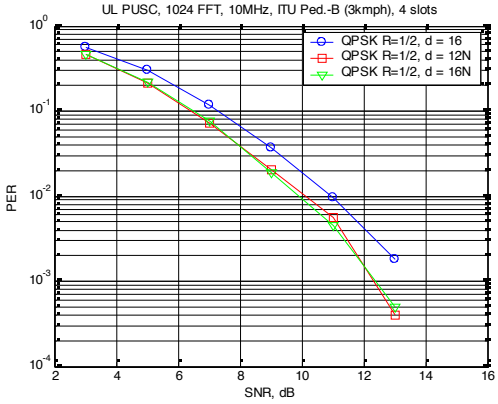
Appendix FF 1 sub channel 2 slots 16QAM/ 64QAM R = 1/2

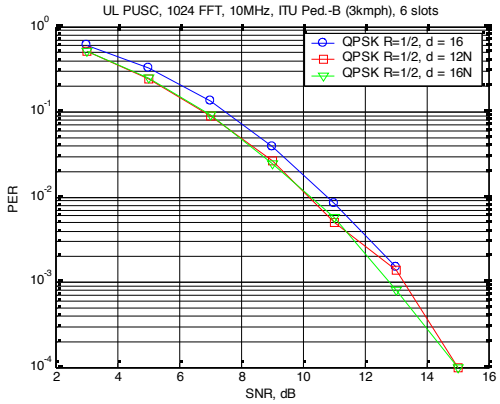




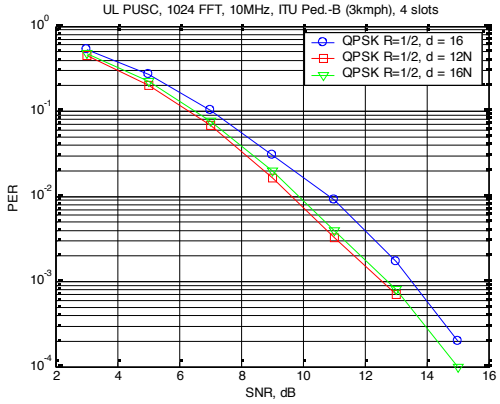
Appendix GG 2 sub channel QPSK/ 16QAM/ 64QAM R = 1/2





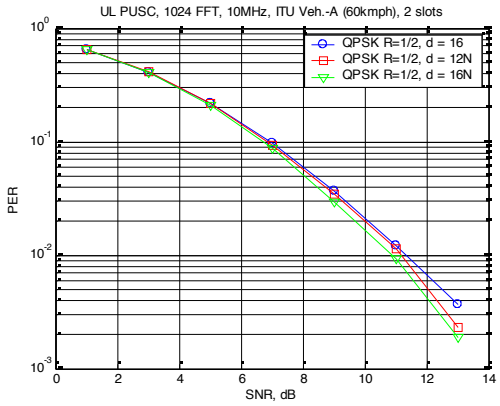


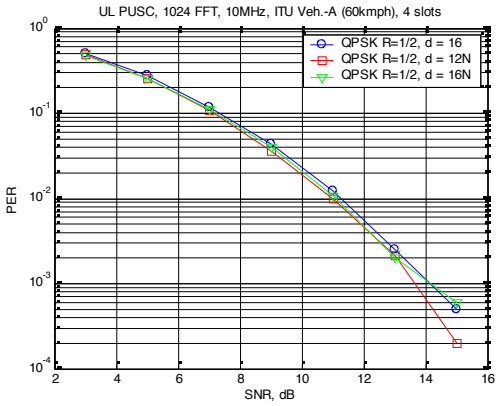
Appendix HH 4 sub channel QPSK R=1/2

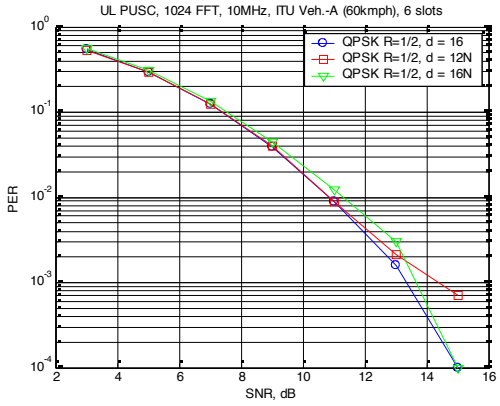


Appendix II ITU Vehicular -A channel 60Km/h d=16, 12N, 16N

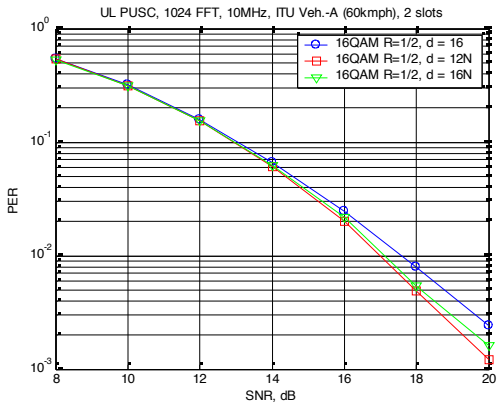
Appendix JJ 1 sub channel QPSK R = 1/2

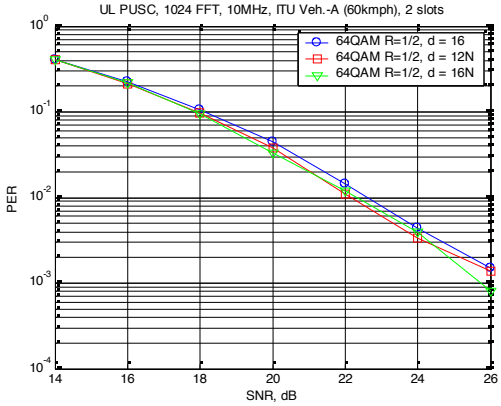




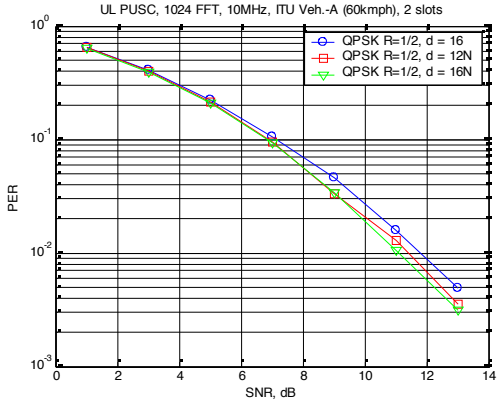


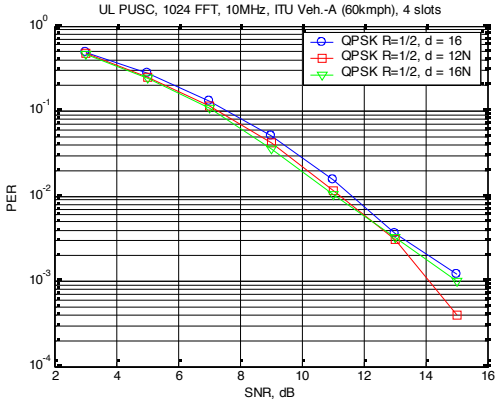
Appendix KK 1 sub channel 2 slots 16QAM/ 64QAM R = 1/2

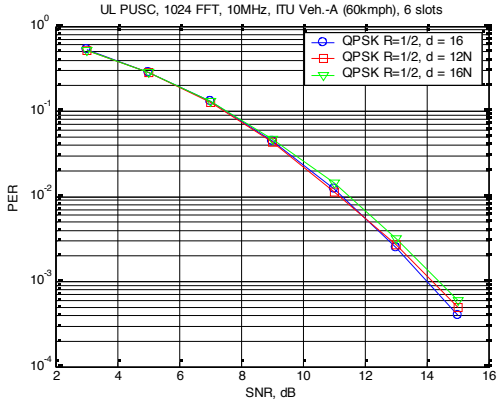


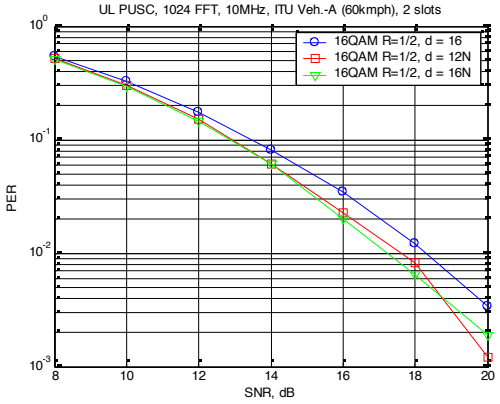


Appendix LL 2 sub channel QPSK/ 16QAM/ 64QAM R = 1/2

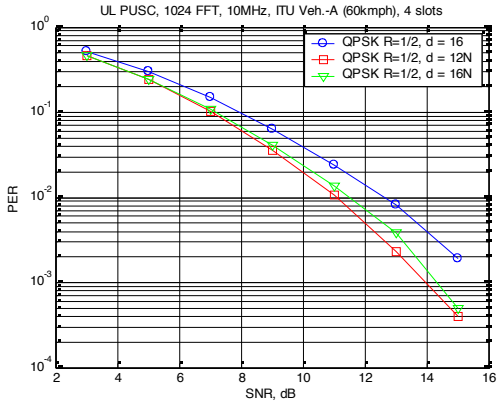








Appendix MM 4 sub channel QPSK R = 1/2



Appendix NN UL PUSC simulation parameters – FFT Size 2048

Permutation	UL-PUSC
FFT size	2048
BW	20 MHz
Modulation	QPSK ½, QPSK 3/4 , 16QAM ½,16QAM ¾ , 64QAM ½, 64QAM ¾
Code	CC-TB
Bursts allocation	worst case – 1/2/4 sub-channels (see below for exact allocations)
FEC block size	
Channel	random channel, normalized to unity power over signal band ITU PED B 3 kmh / ITU vec A 60 kmh /

1 Sub channel allocation

MCS	QPSK R=1/2	QPSK R=3/4	16QAM R=1/2	16QAM R=3/4	64QAM R=1/2	64QAM R=2/3	64QAM R=3/4
Number of subchannels	1	1	1	1	1	1	1
Number of slots	18	12	9	6	6	4	4
Packet length	108	108	108	108	108	96	108

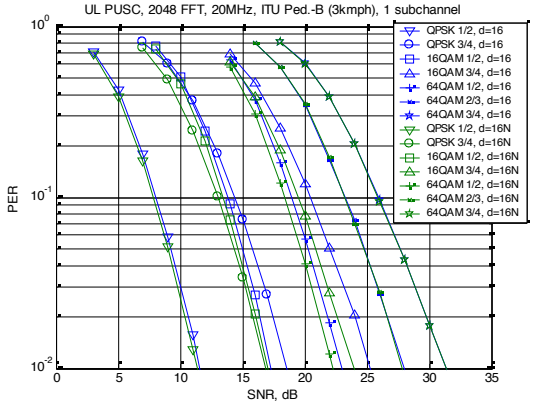
2 Sub channel allocation

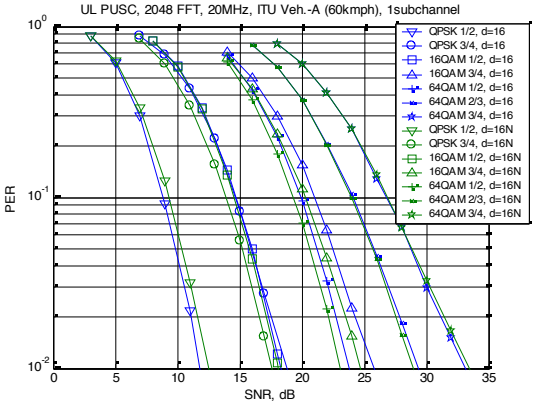
MCS	QPSK R=1/2	QPSK R=3/4	16QAM R=1/2	16QAM R=3/4	64QAM R=1/2	64QAM R=2/3	64QAM R=3/4
Number of subchannels	2	2	2	2	2	2	2
Number of slots	18	12	12	6	6	4	4
Packet length	108	108	144	108	108	96	108

4 Sub channel allocation

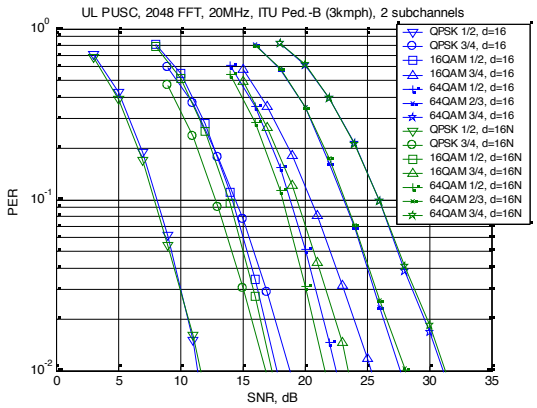
MCS	QPSK R=1/2	QPSK R=3/4	16QAM R=1/2	16QAM R=3/4	64QAM R=1/2	64QAM R=2/3	64QAM R=3/4
Number of subchannels	4	4	4	4	4	4	4
Number of slots	24	16	12	8	8	8	4
Packet length	144	144	144	144	144	192	108

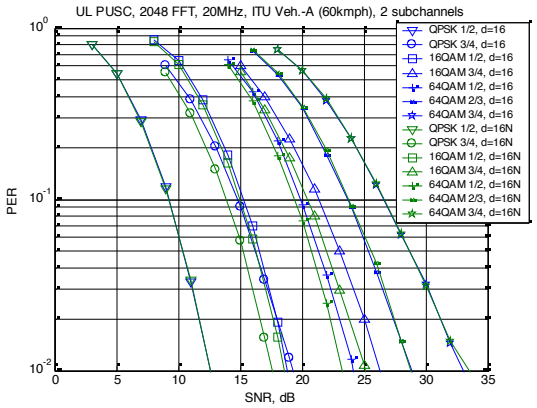
Appendix OO 1 sub channel ITU PED B 3Km/h ITU VEH A 60Km/h



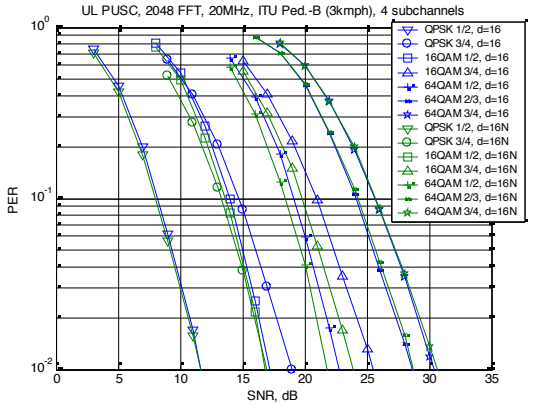


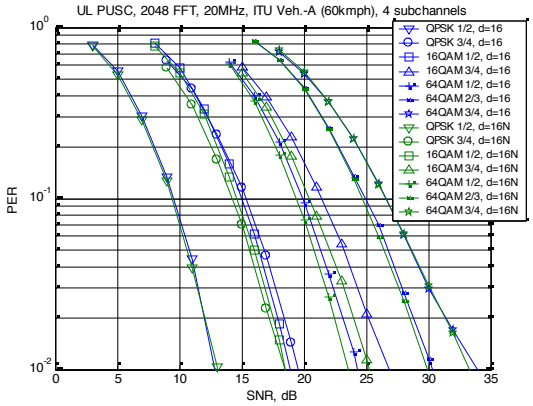
Appendix PP 2 sub channels





Appendix QQ 4 sub channel



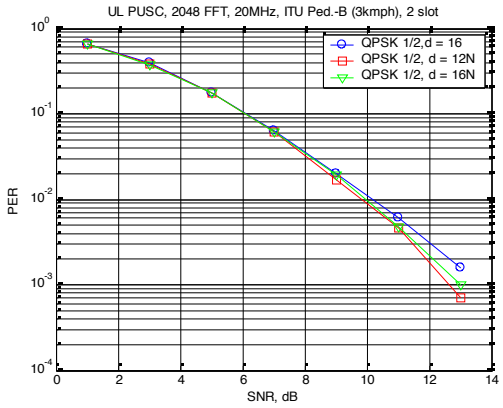


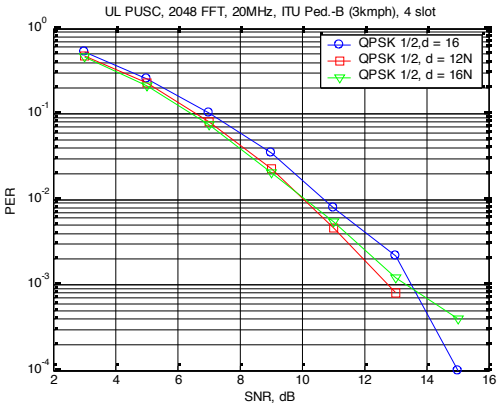
Appendix RR UL PUSC simulation parameters

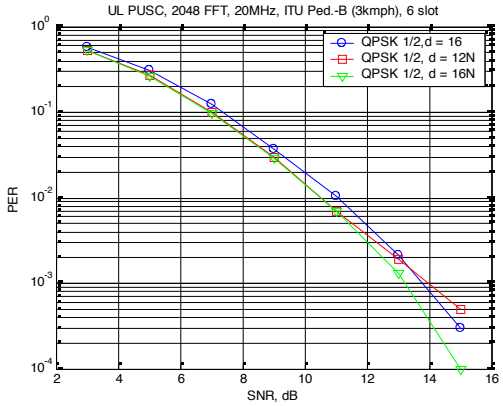
Permutation	UL-PUSC
FFT size	2048
BW	20 MHz
Modulation	QPSK ½, 16QAM ½, 64QAM ½
Code	CC-TB
Bursts allocation	see burs allocation description in tables below.
FEC block size	2,4,6 slots
Channel	random channel, normalized to unity power over signal band ITU PED B 3 kmh / ITU vec A 60 kmh /

Appendix SS ITU Pedestrian -B channel 3Km/h d=16, 12N, 16N

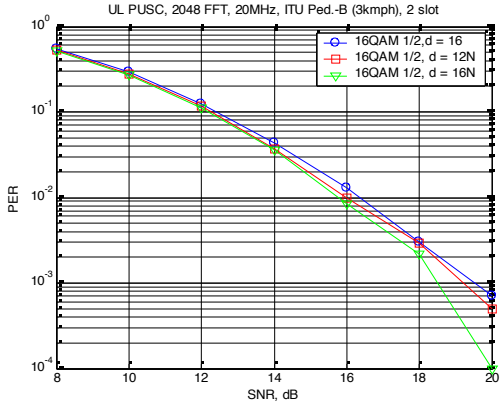
Appendix TT 1 sub channel QPSK R = 1/2

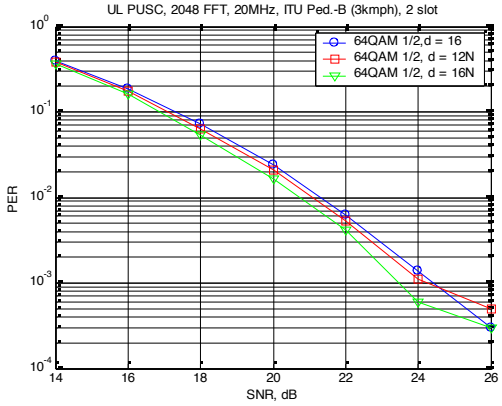




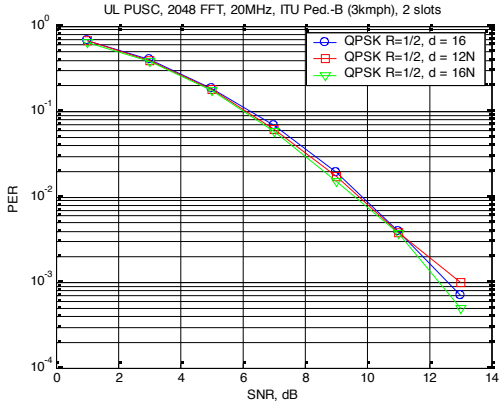


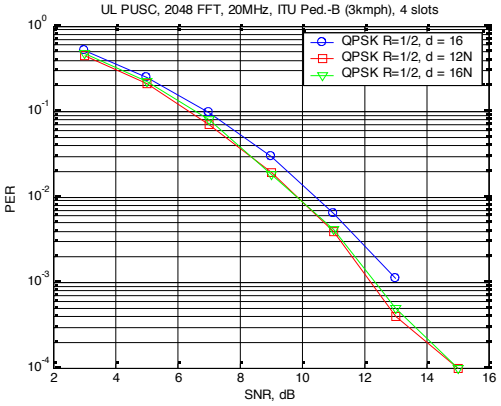
Appendix UU 1 sub channel 2 slots 16QAM/ 64QAM R = 1/2

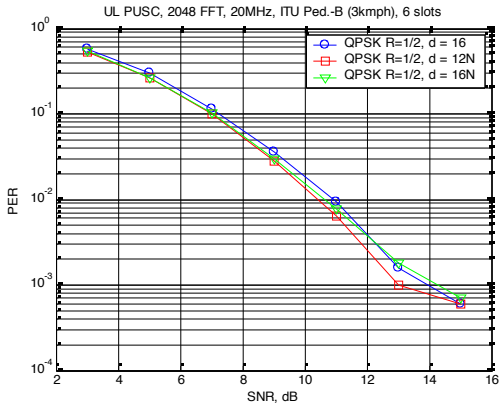




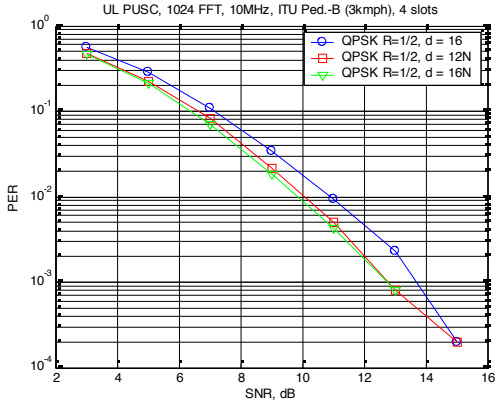
Appendix VV 2 sub channel QPSK/ 16QAM/ 64QAM R = 1/2





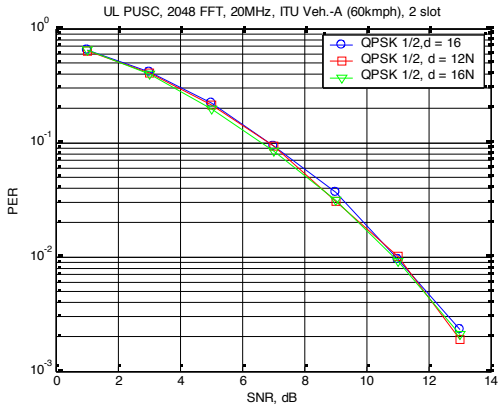


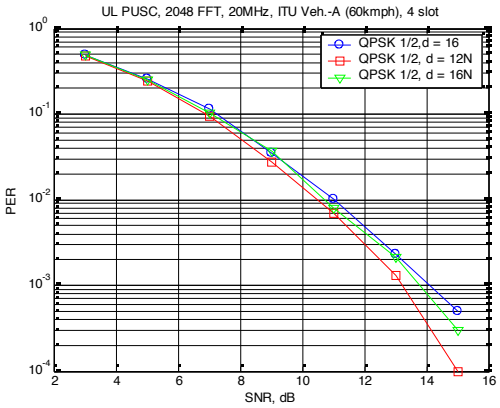
Appendix WW 4 sub channel QPSK R=1/2

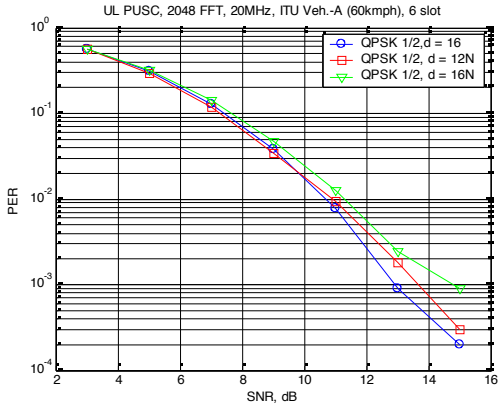


Appendix XX ITU Vehicular -A channel 60Km/h d=16, 12N, 16N

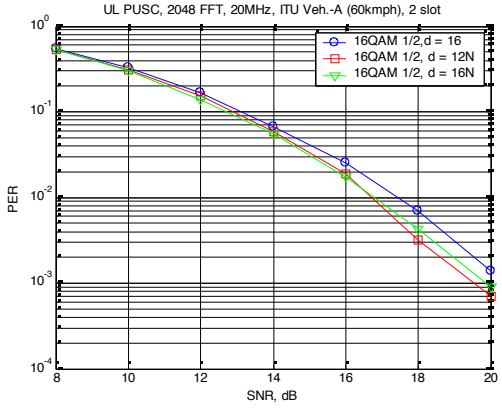
Appendix YY 1 sub channel QPSK R = 1/2

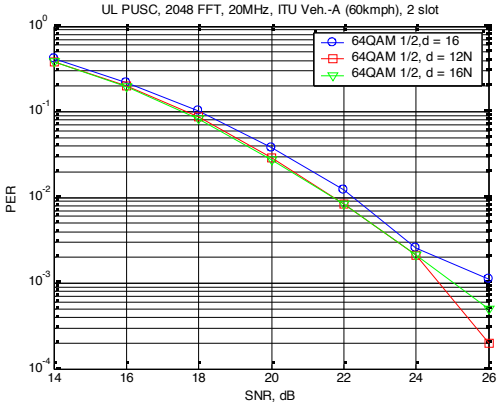




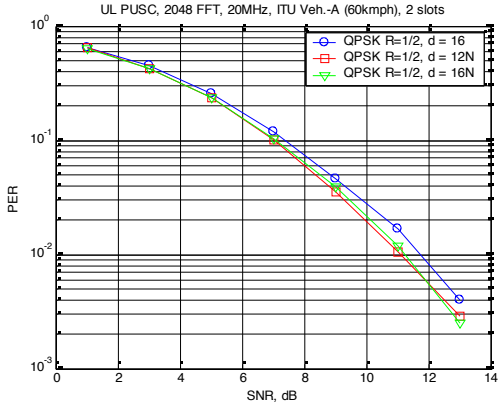


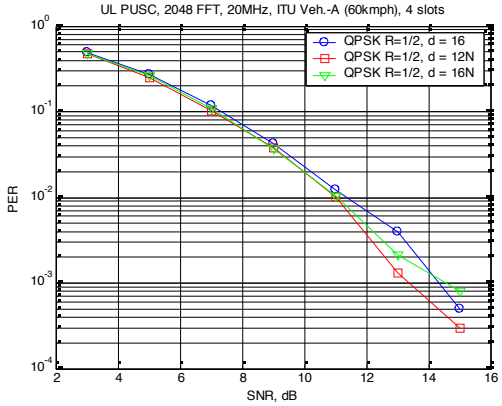
Appendix ZZ 1 sub channel 2 slots 16QAM/ 64QAM R = 1/2

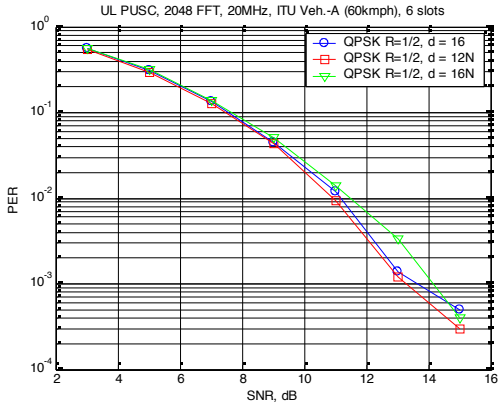


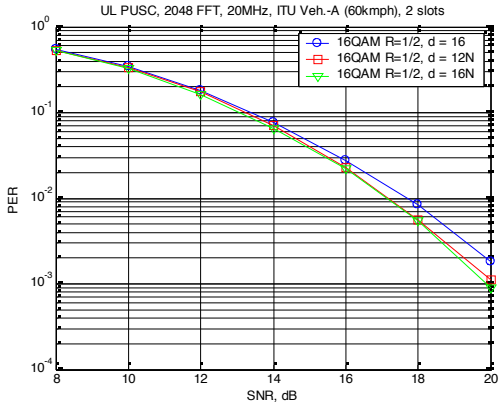


Appendix AAA 2 sub channel QPSK/ 16QAM/ 64QAM R = 1/2









Appendix BBB UL 2x3 AMC simulation parameter

Permutation	UL-AMC
FFT size	1024
BW	10 MHz
Modulation	QPSK ½, QPSK 3/4 , 16QAM ½,16QAM ¾ , 64QAM ½, 64QAM ¾
Code	CC-TB
Bursts allocation	1/2/4 sub-channels (see below for exact allocations)
FEC block size	1-6 slots
Channel	random channel, normalized to unity power over signal band SUI-2 /

1 Sub channel allocation

MCS	QPSK R=1/2	QPSK R=1/2	QPSK R=1/2	QPSK R=1/2	QPSK R=1/2	QPSK R=1/2	16QAM R=1/2	16QAM R=1/2	16QAM R=1/2	64QAM R=1/2	64QAM R=1/2
Number of subchannels	1	1	1	1	1	1	1	1	1	1	1
Number of slots	1	2	3	4	5	6	1	2	3	1	2
Packet length	6	12	18	24	30	36	12	24	36	18	36

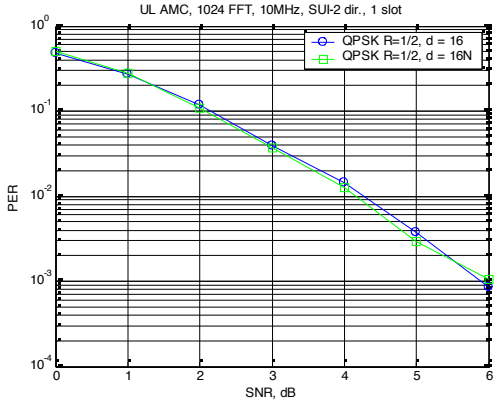
2 Sub channel allocation

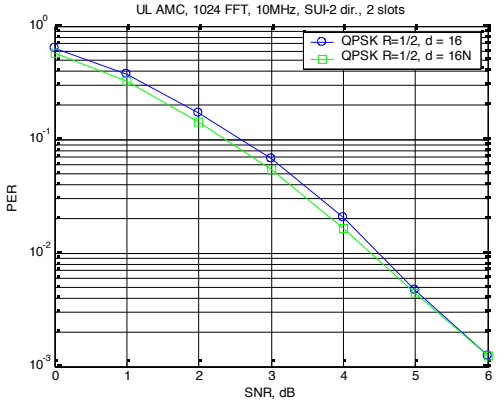
MCS	QPSK R=1/2	QPSK R=1/2	QPSK R=1/2	16QAM R=1/2	64QAM R=1/2
Number of subchannels	2	2	2	2	2
Number of slots	2	4	6	2	2
Packet length	12	24	36	24	36

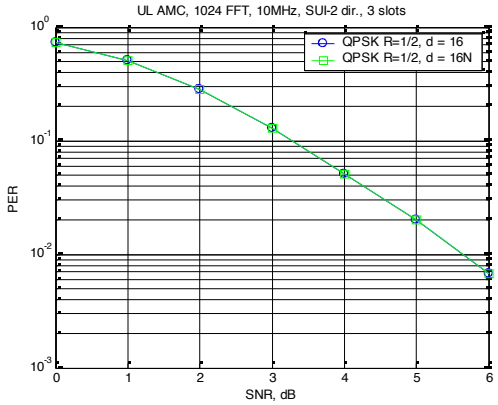
4 Sub channel allocation

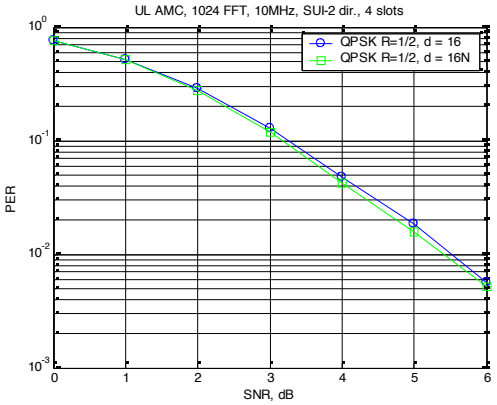
MCS	QPSK R=1/2
Number of subchannels	4
Number of slots	4
Packet length	24

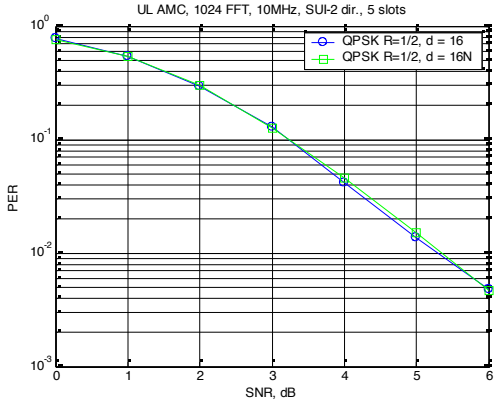
Appendix CCC 1 sub channel

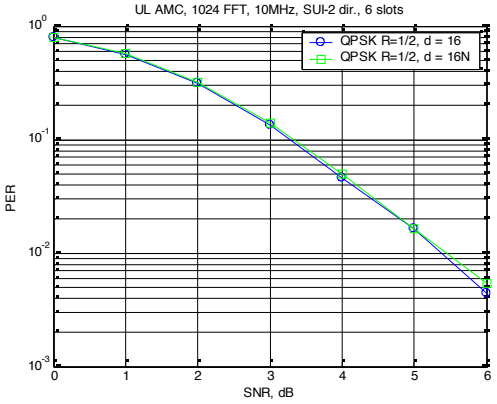


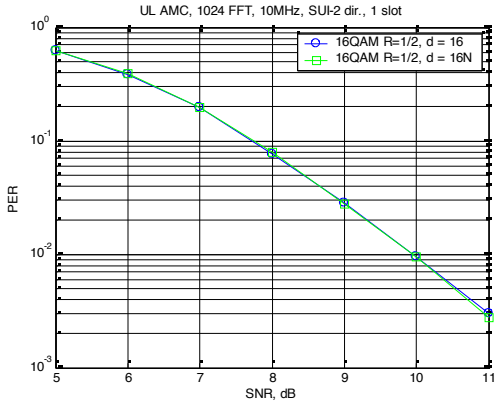


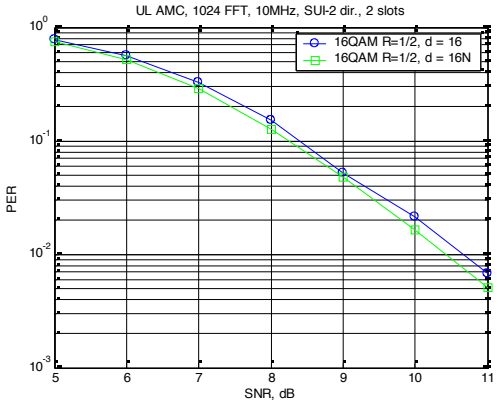


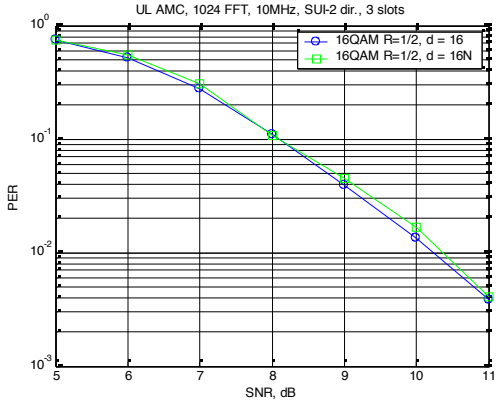


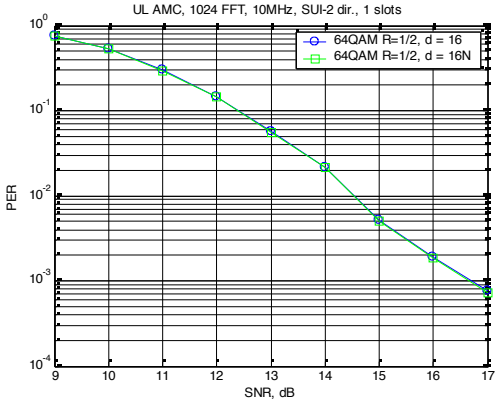


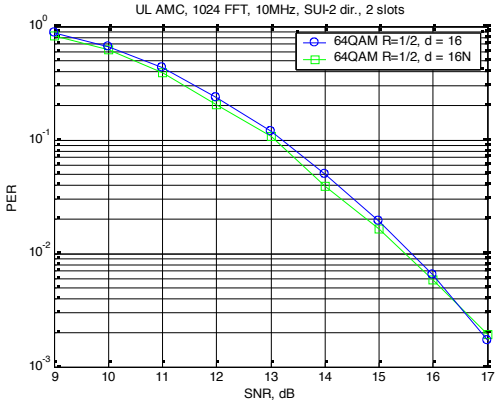



UL AMC, 1024 FFT, 10MHz, SUI-2 dir., 1 slot
16QAM R=1/2, d = 16
16QAM R=1/2, d = 16N
PER
SNR, dB

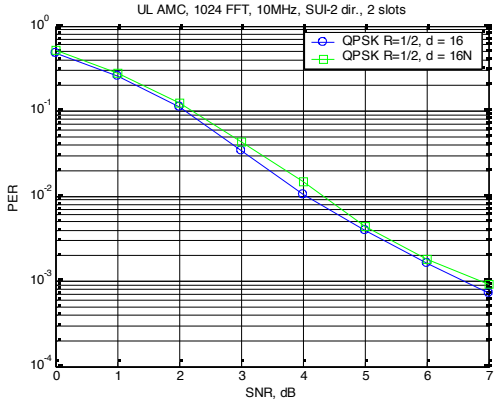

UL AMC, 1024 FFT, 10MHz, SUI-2 dir., 2 slots
16QAM R=1/2, d = 16
16QAM R=1/2, d = 16N
PER
SNR, dB

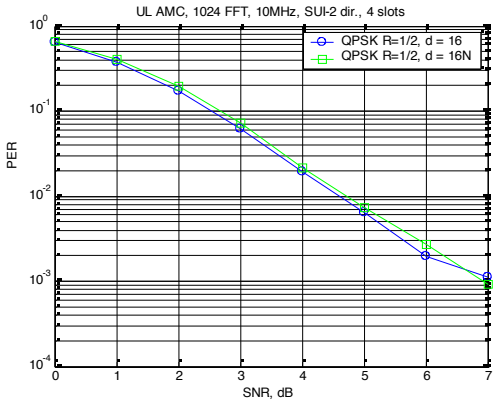

UL AMC, 1024 FFT, 10MHz, SUI-2 dir., 3 slots
16QAM R=1/2, d = 16
16QAM R=1/2, d = 16N
PER
SNR, dB

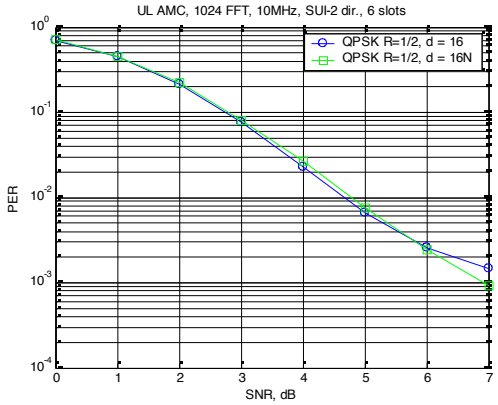

UL AMC, 1024 FFT, 10MHz, SUI-2 dir., 1 slots
64QAM R=1/2, d = 16
64QAM R=1/2, d = 16N
PER
SNR, dB

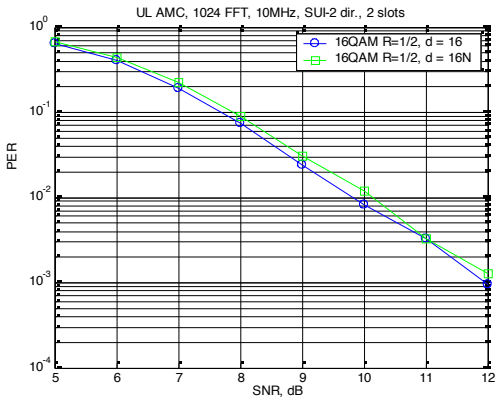

UL AMC, 1024 FFT, 10MHz, SUI-2 dir., 2 slots
64QAM R=1/2, d = 16
64QAM R=1/2, d = 16N
PER
SNR, dB

Appendix DDD 2 sub channels









Appendix EEE 4 sub channel