Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Propose for Uplink Pilot Design in IEEE 802.16m**
Date Submitted	**2008-05-05**
Source(s)	Yih-Guang Jan, Yang-Han Lee, Ming-Hsueh Chuang, Hsien-Wei Tseng, Jheng-Yao Lin, Hsi-Chun Tseng, Ting-Chien Wang, Po-Jung Lin **Tamkang University (TKU)** E-mail: yihjan@ee.tku.edu.tw Kanchei (Ken) Loa, Shiann-Tsong Sheu, Yung-Ting Lee, Youn-Tai Lee, Chih-Wei Su **Institute for Information Industry (III)** loa@iii.org.tw Pei-Kai Liao, Paul Cheng **MediaTek Inc.** pk.liao@mediatek.com Yu-Tao Hsieh, Pang-An Ting **ITRI** ythsieh@itri.org.tw
Re:	IEEE 802.16m-08/005: Call for Contributions on Project 802.16m System Description Document (SDD). Target topic: “Pilot Structures as relevant to Uplink MIMO”.
Abstract	This contribution proposes a common pilot structure supporting the enhanced TDM based control structure in a mini-frame.
Purpose	For discussion and approval by TGm
Notice	*This document does not represent the agreed views of the IEEE 802.16 Working Group or any of its subgroups*. It represents only the views of the participants listed in the “Source(s)” field above. It is offered as a basis for discussion. It is not binding on the contributor(s), who reserve(s) the right to add, amend or withdraw material contained herein.
Release	The contributor grants a free, irrevocable license to the IEEE to incorporate material contained in this contribution, and any modifications thereof, in the creation of an IEEE Standards publication; to copyright in the IEEE’s name any IEEE Standards publication even though it may include portions of this contribution; and at the IEEE’s sole discretion to permit others to reproduce in whole or in part the resulting IEEE Standards publication. The contributor also acknowledges and accepts that this contribution may be made public by IEEE 802.16.
Patent Policy	The contributor is familiar with the IEEE-SA Patent Policy and Procedures: <http://standards.ieee.org/guides/bylaws/sect6-7.html#6> and <http://standards.ieee.org/guides/opman/sect6.html#6.3>. Further information is located at <http://standards.ieee.org/board/pat/pat-material.html> and <http://standards.ieee.org/board/pat>.

Introduction

From the contributions [1-7] as listed in the Reference, several pilot patterns were proposed for DL transmission in 802.16m. The uplink pilot pattern could also be derived from these downlink pilot patterns. In this contribution we simulate the system performance by implementing six types of pilot patterns proposed for 802.16m under various MS speeds. It is observed that some pilot patterns are orthogonal each other, we can use this orthogonal characteristic to reduce the interference influence in the data transmission between BS and MS. Also from this simulation result it will provide us a reference in the selection of proper pilot pattern for various sizes of resource block to meet certain system performance in the downlink or uplink transmission. We then introduce and define the concept of pilot correlation weight between two pilot pairs. Then with proper assignment of pilot weight to each pilot pattern we have the result of reducing the overall system interference level comparing with the conventional assignment of assigning equal pilot weight to all pilots.

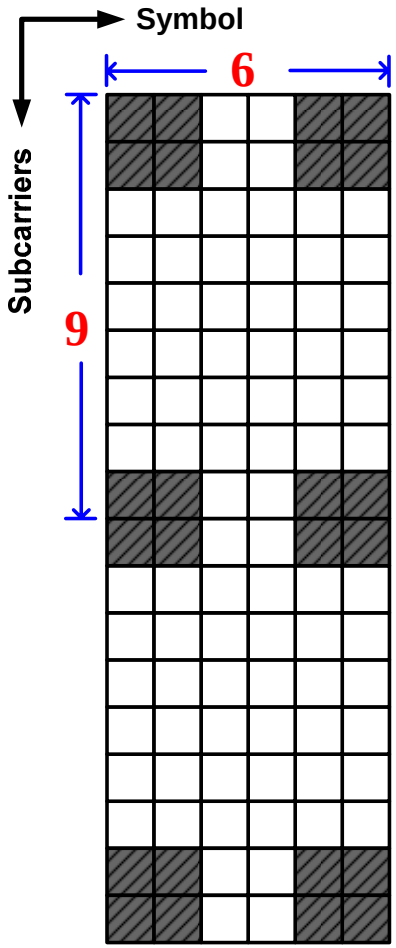
We can further use these resulting pilot patterns as users IDs, i.e. each user is assigned a distinct pilot pattern so that we can manage and distribute the users in a more systematic manner.

Simulation Parameters

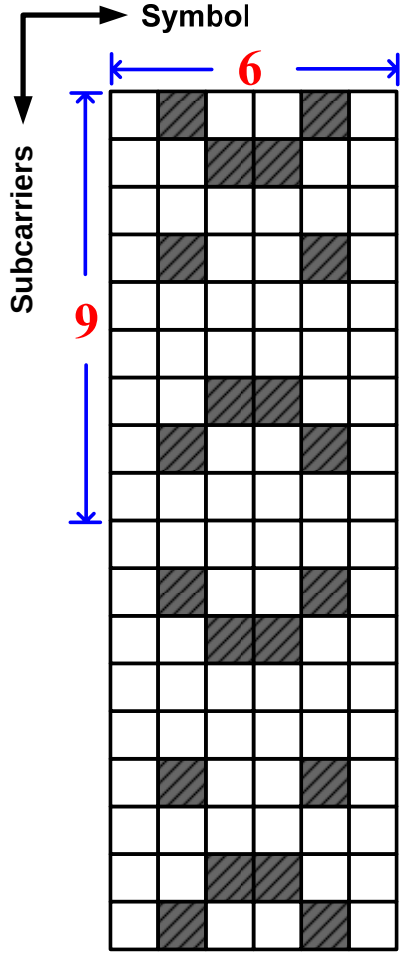
Parameter	Baseline
Carrier Frequency	2.5 GHz
System BW	10 MHz
Channel Model	Veh A. with 3km/hr, 60km/hr and 120km/hr
Channel Coding	Convolutional Code
Antenna Configuration	2x2 MIMO
Modulation and Coding	QPSK
Resource Allocation	1. 6 symbols * 18 subcarriers 2. 6 symbols * 12 subcarriers 3. 6 symbols * 10 subcarriers 4. 4 symbols * 14 subcarriers
Coding Rate	0.5
Pilot Tone Boost	2.5dB over data tone
Channel Estimation	LS

Difference RB Type (1/2)

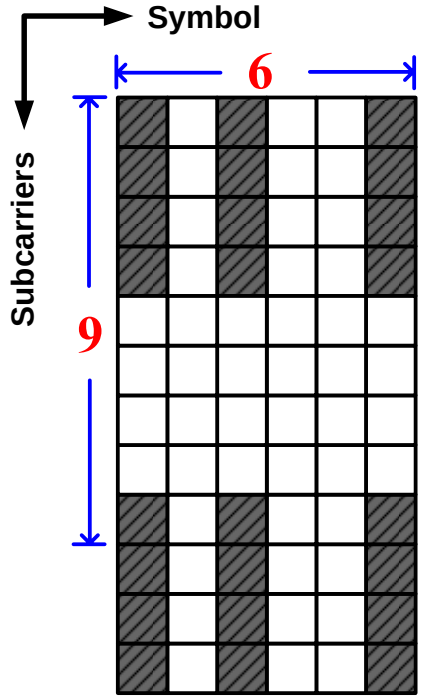
Type A (RB = 18 x 6)



Type B (RB = 18 x 6)

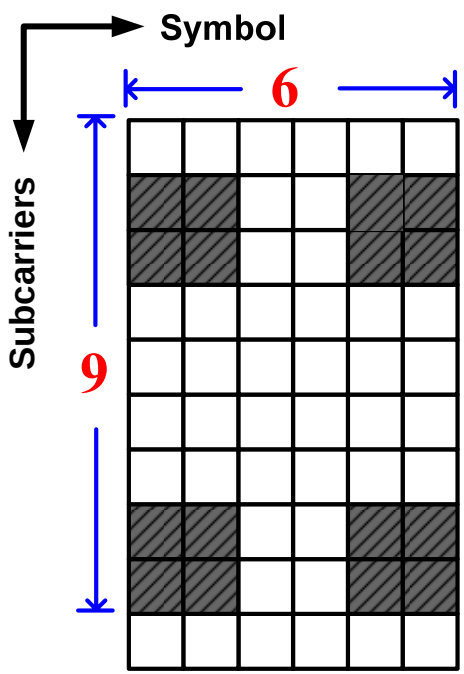


Type C (RB = 12 x 6)

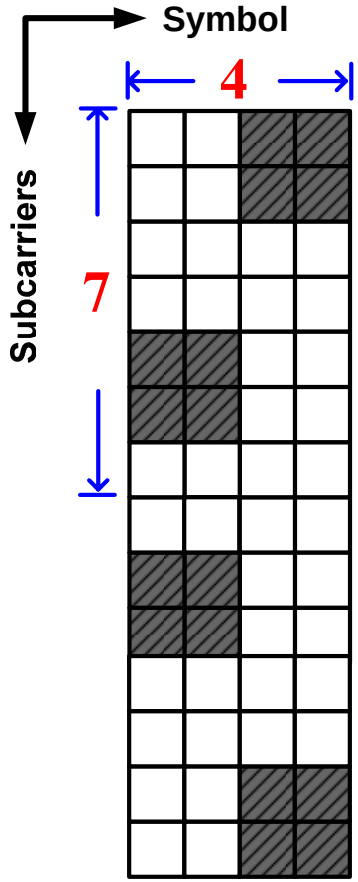


Difference RB Type (2/2)

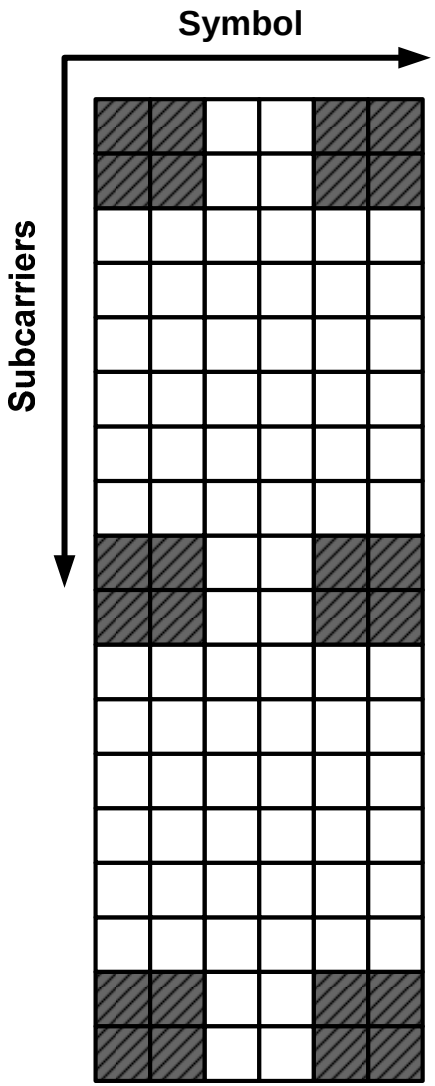
Type D (RB = 10 x 6)

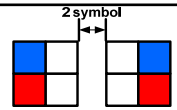
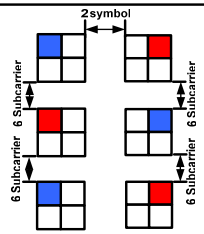
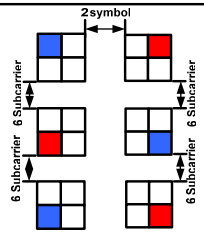


Type E (RB = 14 x 6)

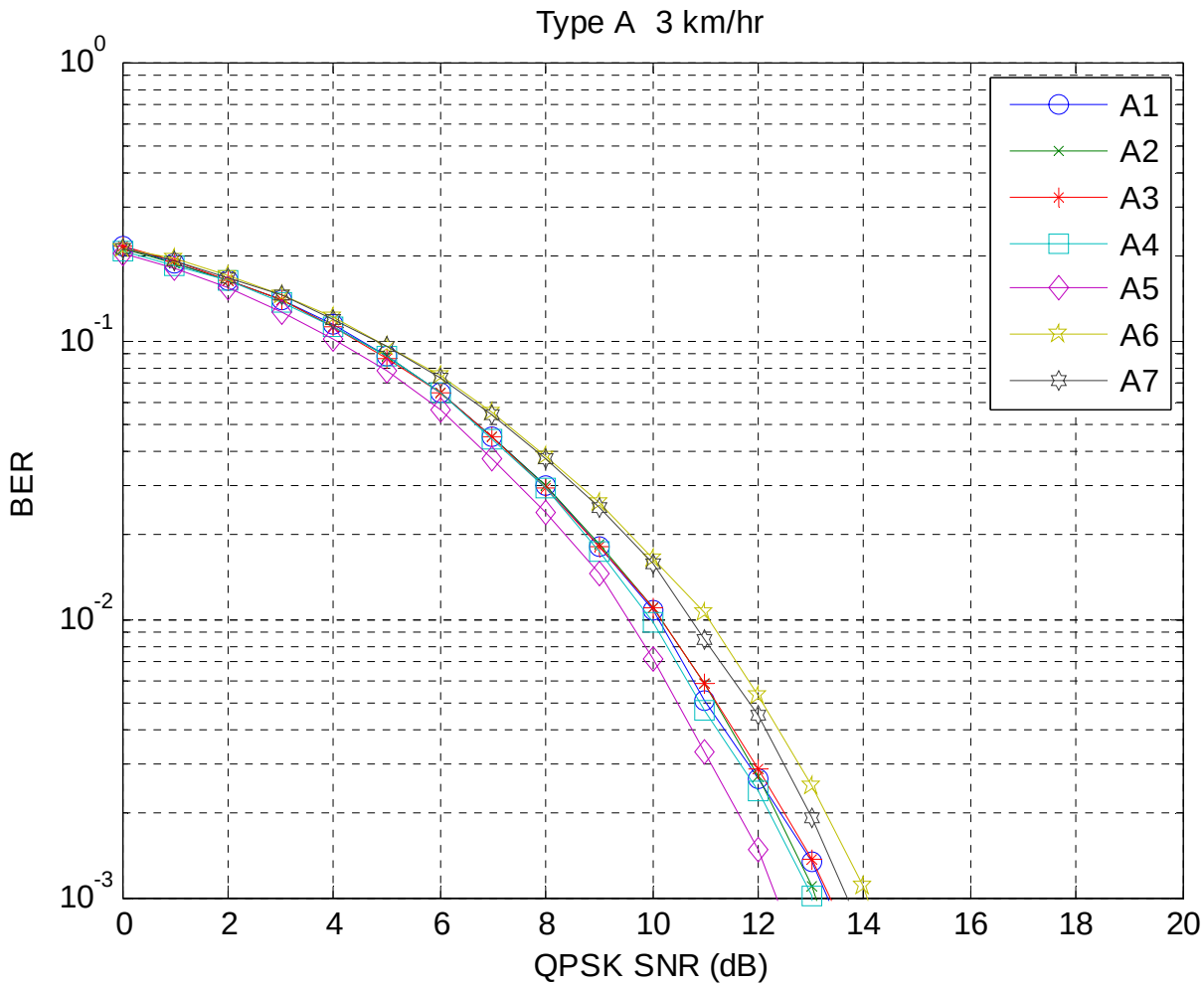


Different Pilot Pattern for Type A RB

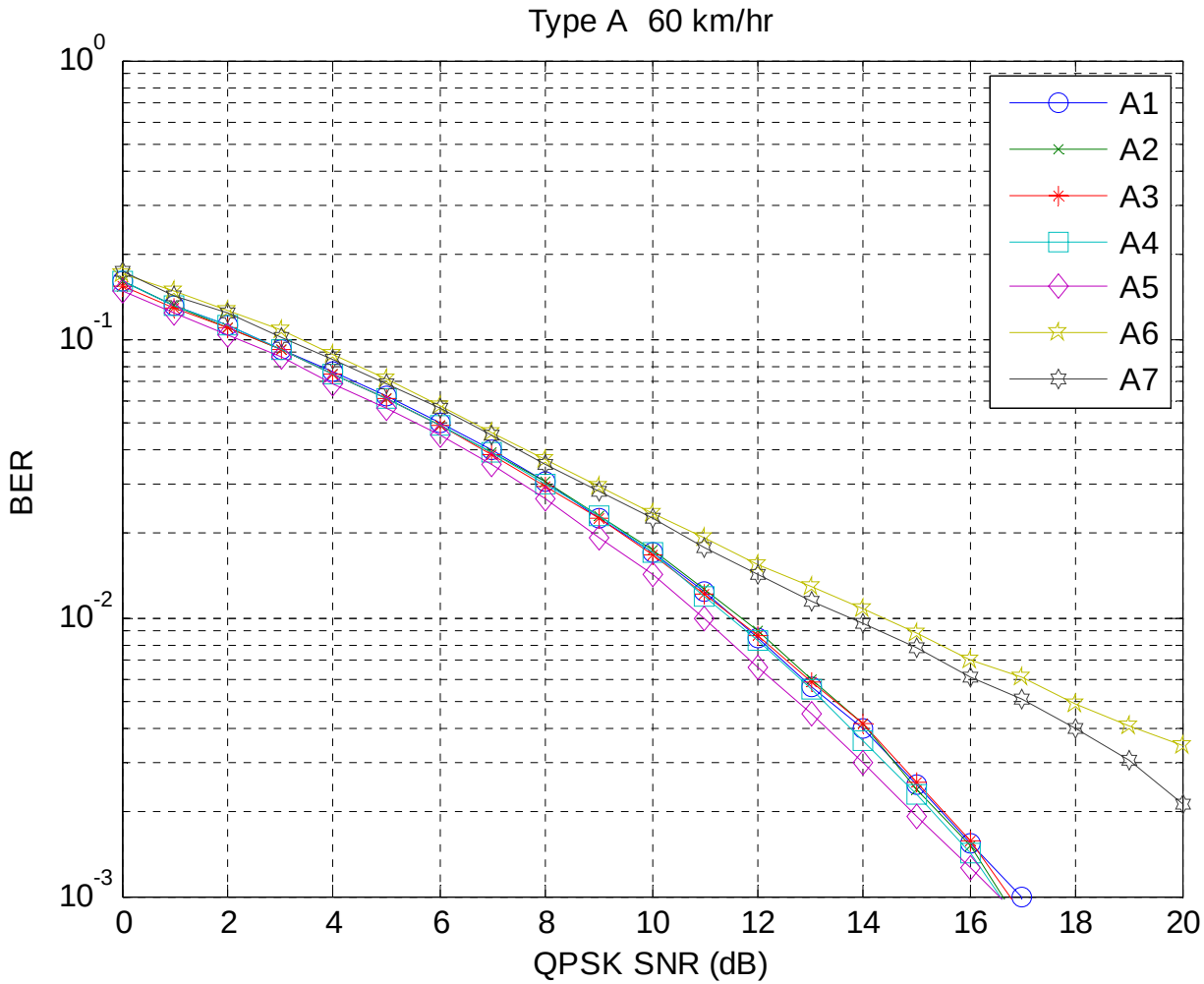


Type	Pilot Structure	Pilot Density
A1		11.11%
A2		
A3		
A4		
A5		
A6		5.56%
A7		

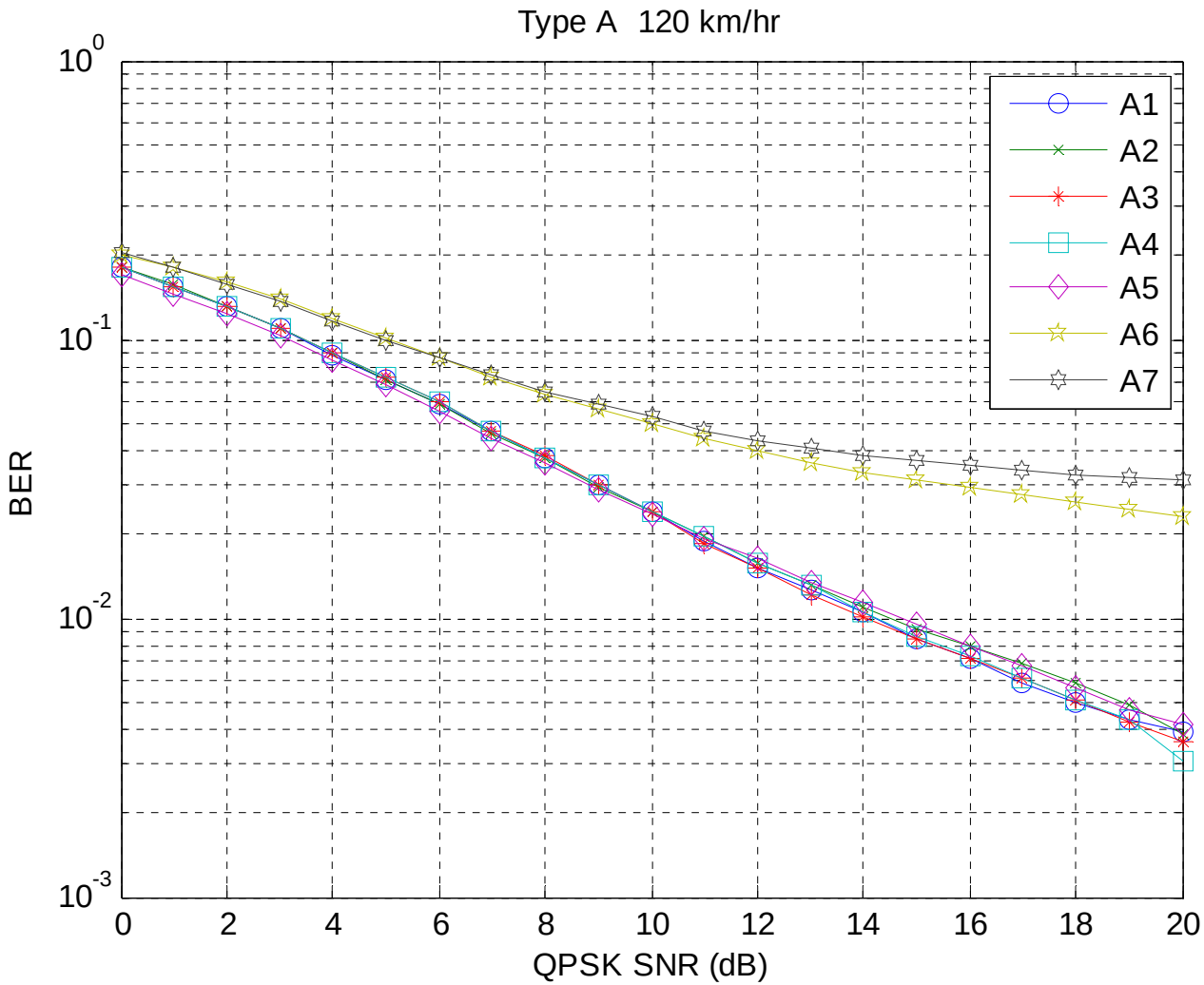
Simulation Result for Type A RB at 3 km/hr



Simulation Result for Type A RB at 60 km/hr



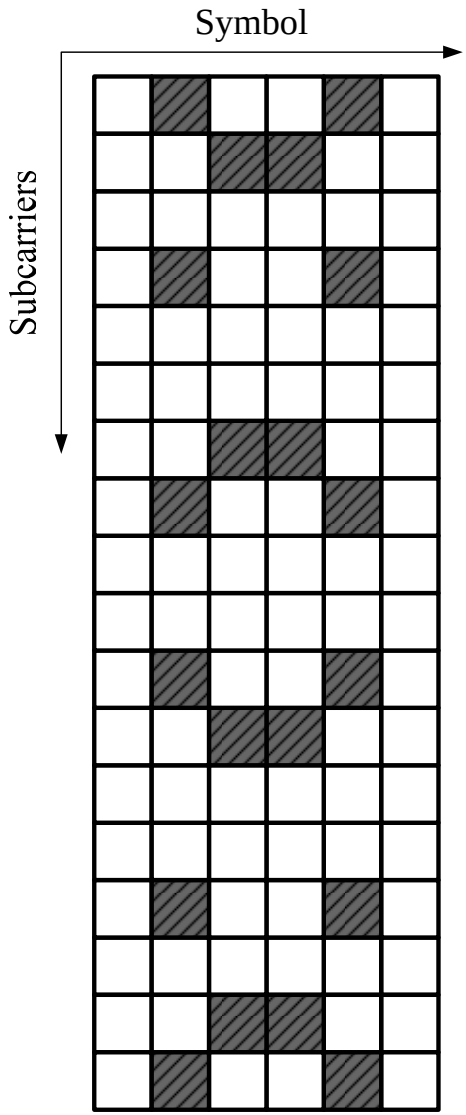
Simulation Result for Type A RB at 120 km/hr

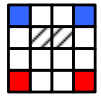
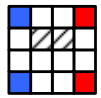
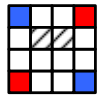
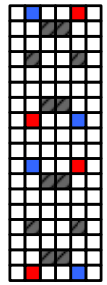
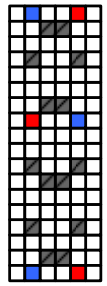


Summary for Type A RB Uplink Pilot Format

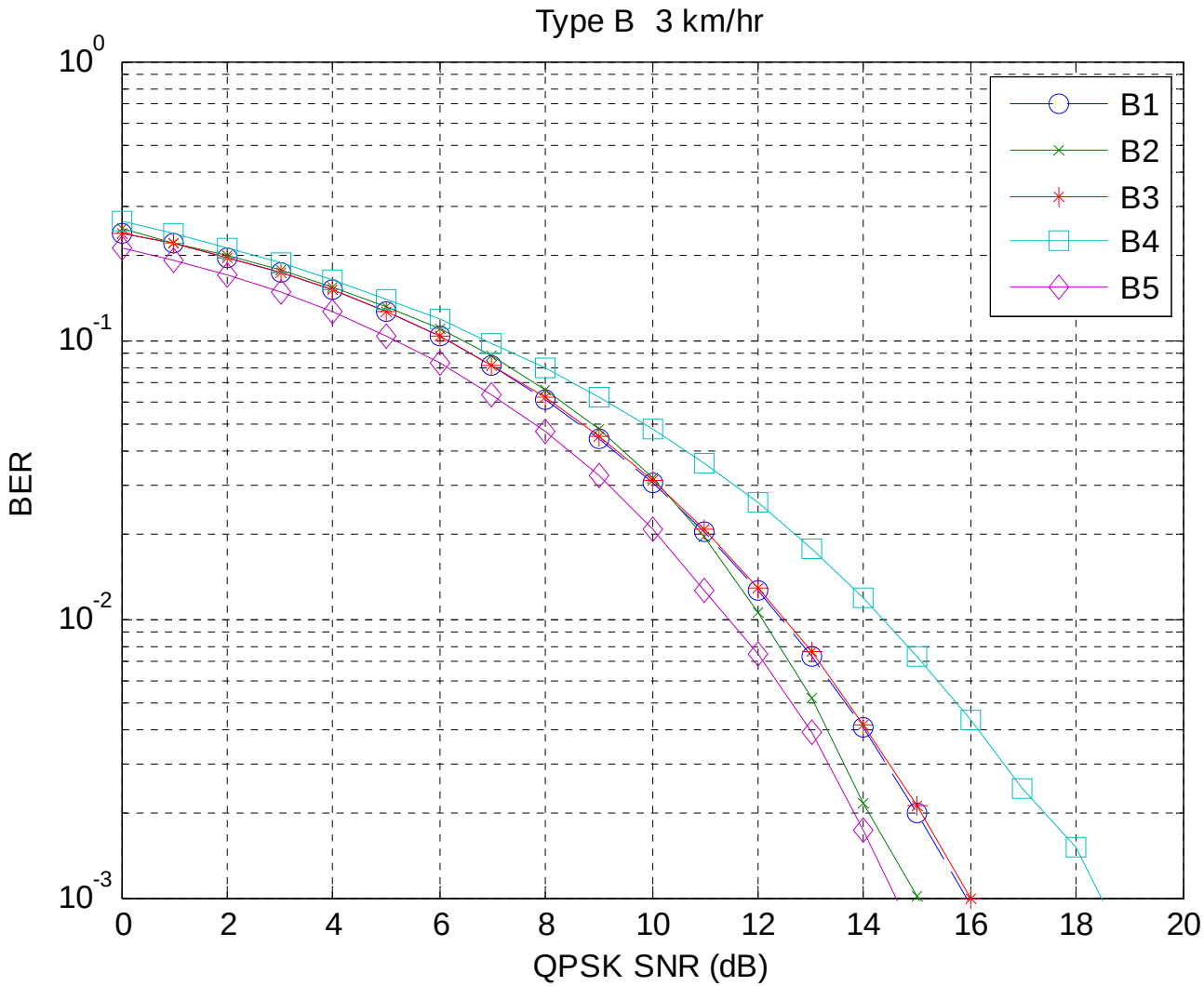
Speed / Type	3 km/hr (Low Mobility)	60 km/hr	120 km/hr (High Mobility)
A1 @BER=10^{-2} Pilot Density=11.11%	SNR= 10 dB	SNR= 11 dB	SNR= 14 dB
A2 @BER=10^{-2} Pilot Density=11.11%	SNR= 10 dB	SNR= 11 dB	SNR= 14 dB
A3 @BER=10^{-2} Pilot Density=11.11%	SNR= 10 dB	SNR= 11 dB	SNR= 14 dB
A4 @BER=10^{-2} Pilot Density=11.11%	SNR= 10 dB	SNR= 11 dB	SNR= 14 dB
A5 @BER=10^{-2} Pilot Density=11.11%	SNR= 10 dB	SNR= 11 dB	SNR= 14 dB
A6 @BER=10^{-2} Pilot Density=5.56%	SNR= 11 dB	SNR= 14 dB	
A7 @BER=10^{-2} Pilot Density=5.56%	SNR= 11 dB	SNR= 14 dB	

Different Pilot Pattern for Type B RB

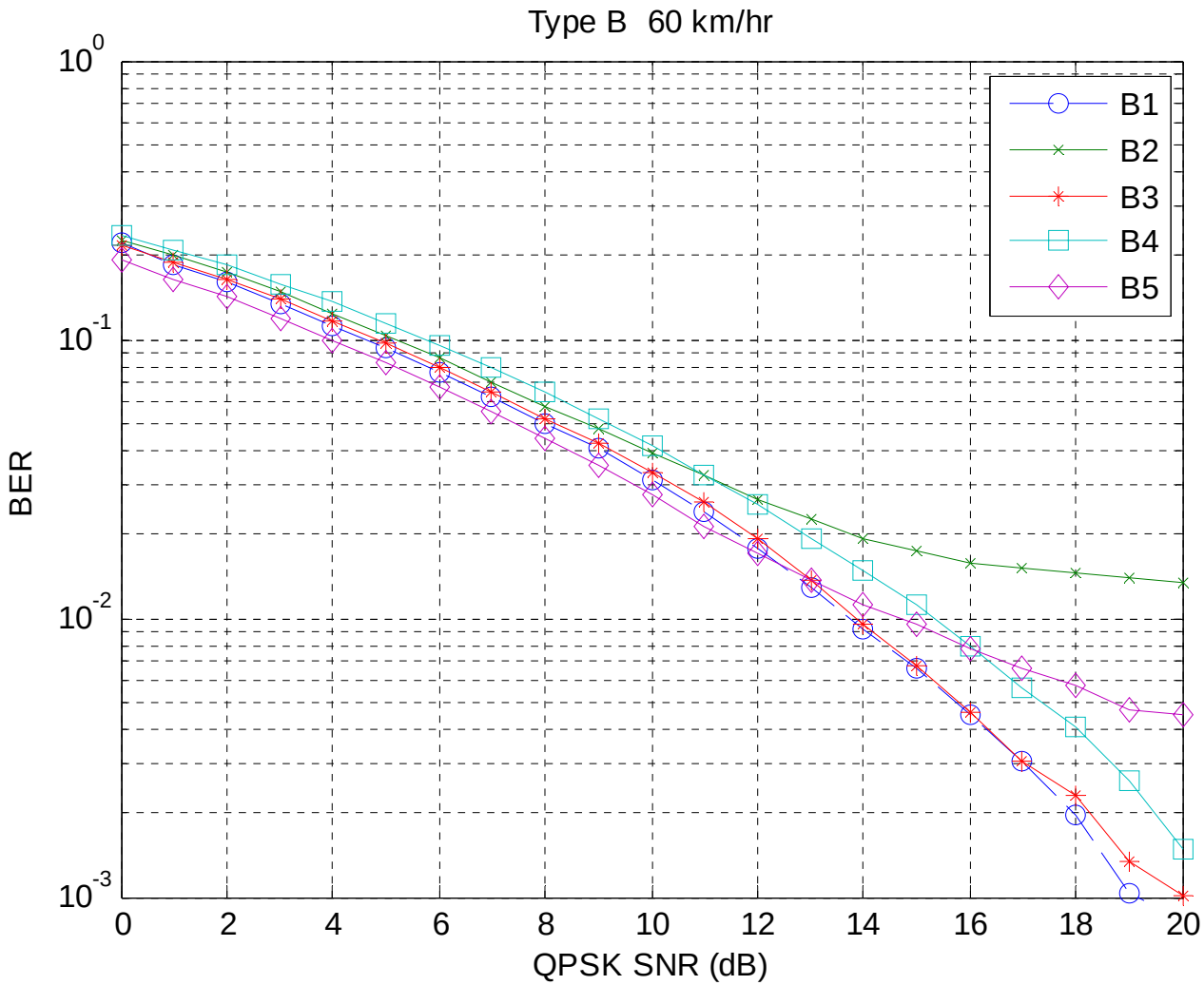


Type	Pilot Structure	Pilot Density
B1		11.11%
B2		
B3		
B4		7.4%
B5		5.56%

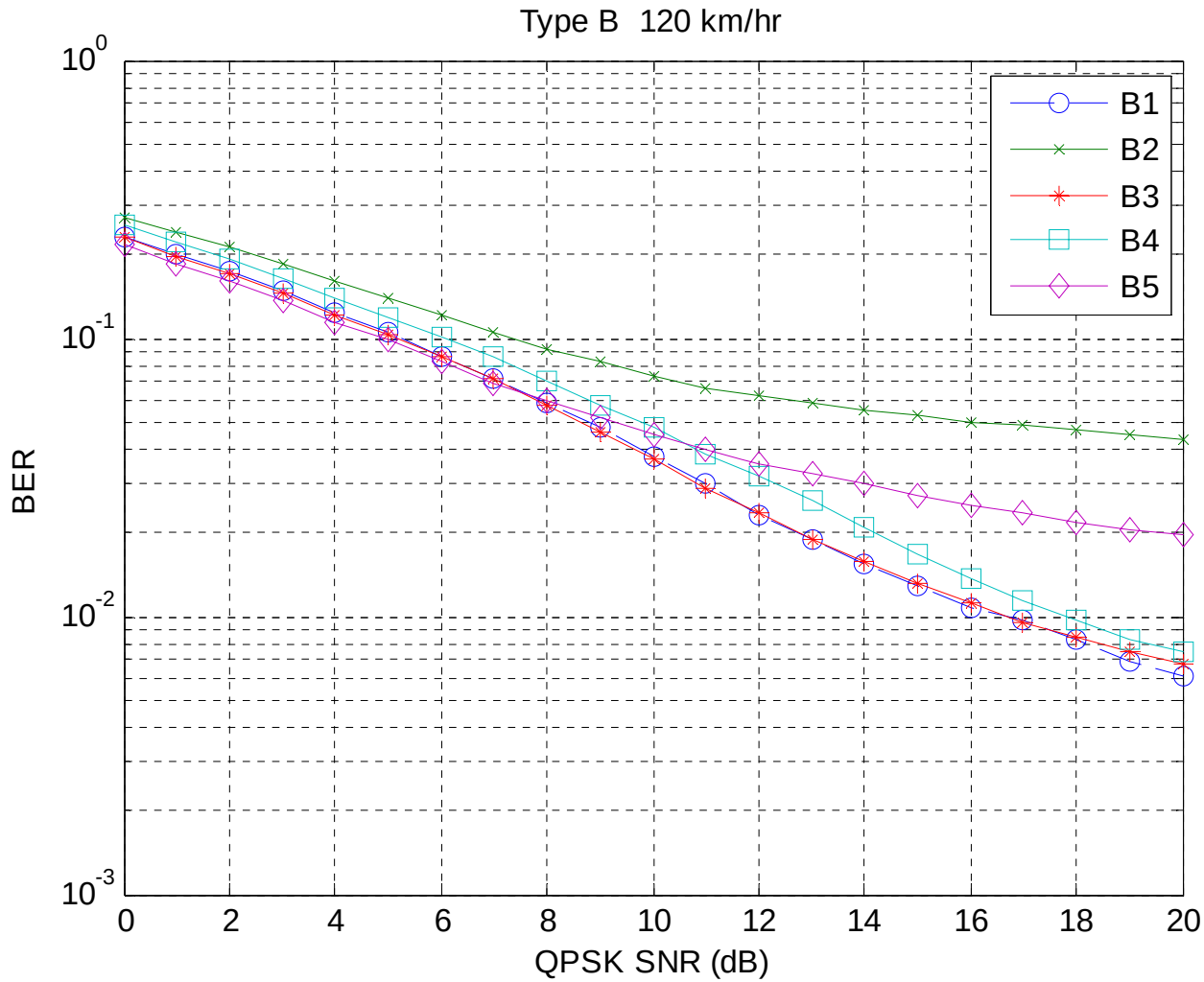
Simulation Result for Type B RB at 3 km/hr



Simulation Result for Type B RB at 60 km/hr



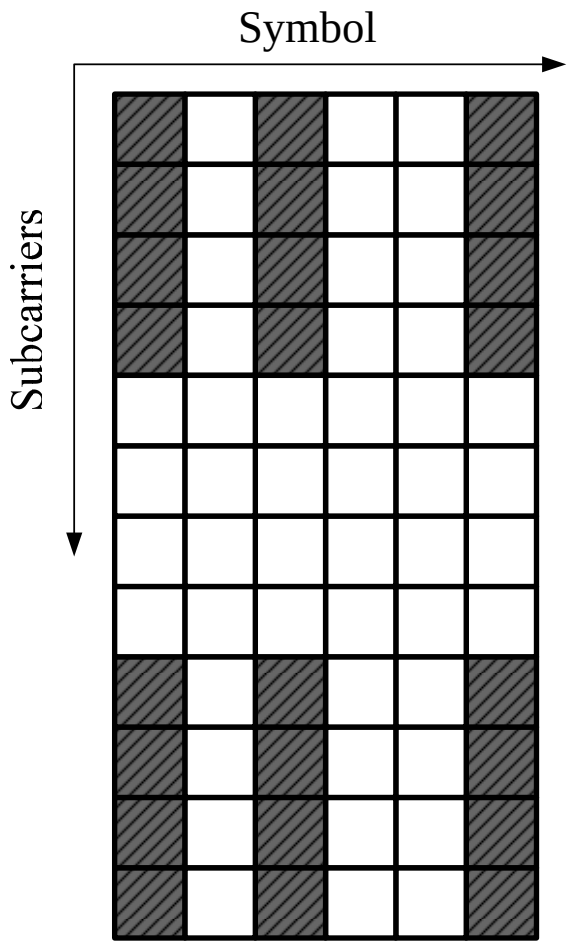
Simulation Result for Type B RB at 120 km/hr

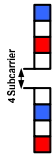
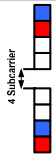
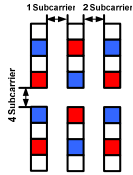
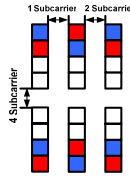
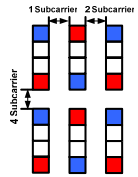
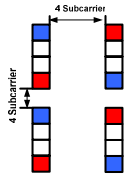


Summary for Type B RB Uplink Pilot Format

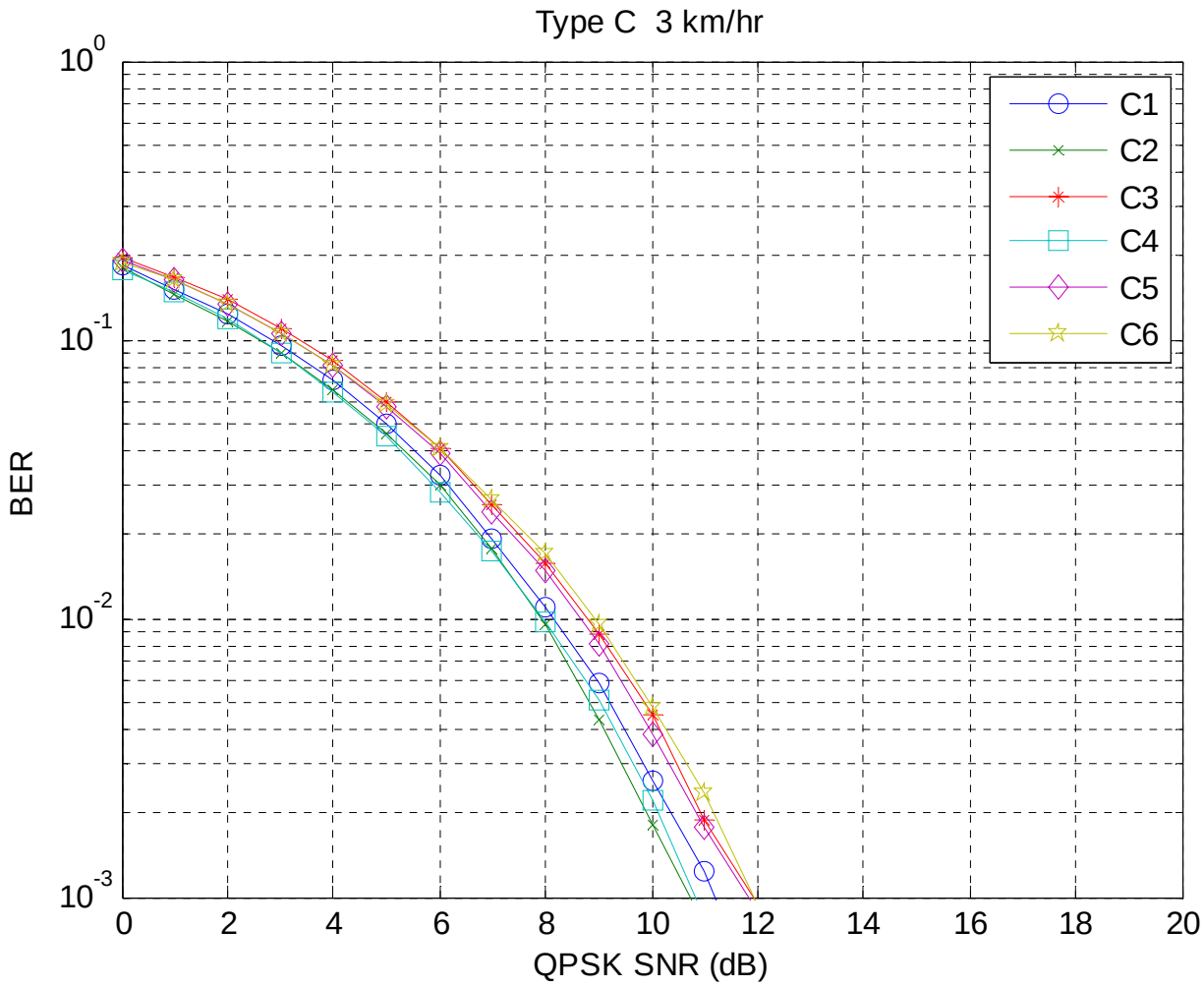
Speed / Type	3 km/hr (Low Mobility)	60 km/hr	120 km/hr (High Mobility)
B1 @BER=10^{-2} Pilot Density=11.11%	SNR= 12 dB	SNR= 14 dB	SNR= 16 dB
B2 @BER=10^{-2} Pilot Density=11.11%	SNR= 12 dB		
B3 @BER=10^{-2} Pilot Density=11.11%	SNR= 12 dB	SNR= 14 dB	SNR= 16 dB
B4 @BER=10^{-2} Pilot Density=7.4%	SNR= 14 dB	SNR= 15 dB	SNR= 18 dB
B5 @BER=10^{-2} Pilot Density=5.56%	SNR= 11 dB	SNR= 15 dB	

Different Pilot Pattern for Type C RB

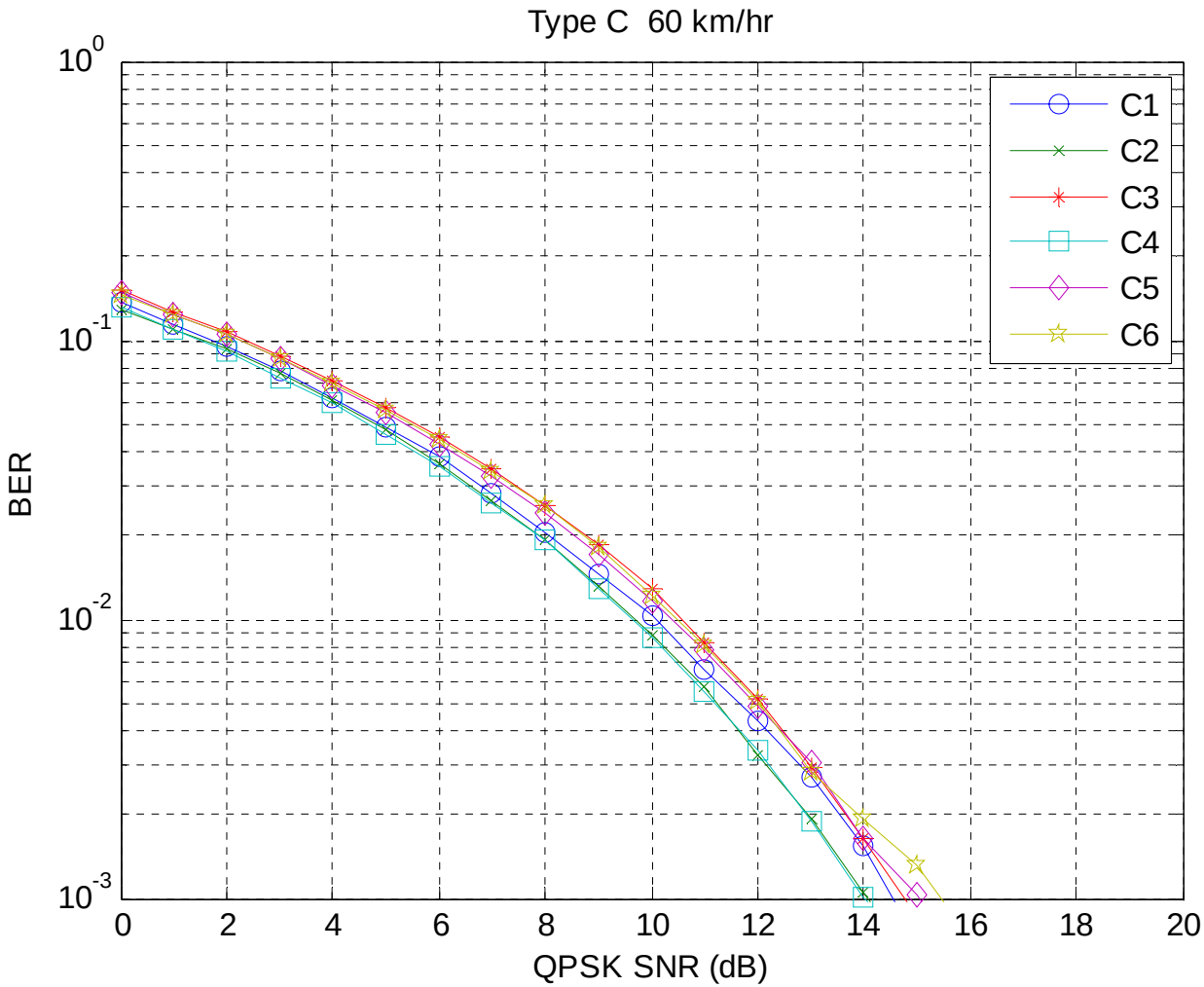


Type	Pilot Structure	Pilot Density
C1		16.67%
C2		
C3		
C4		
C5		
C6		11.11%

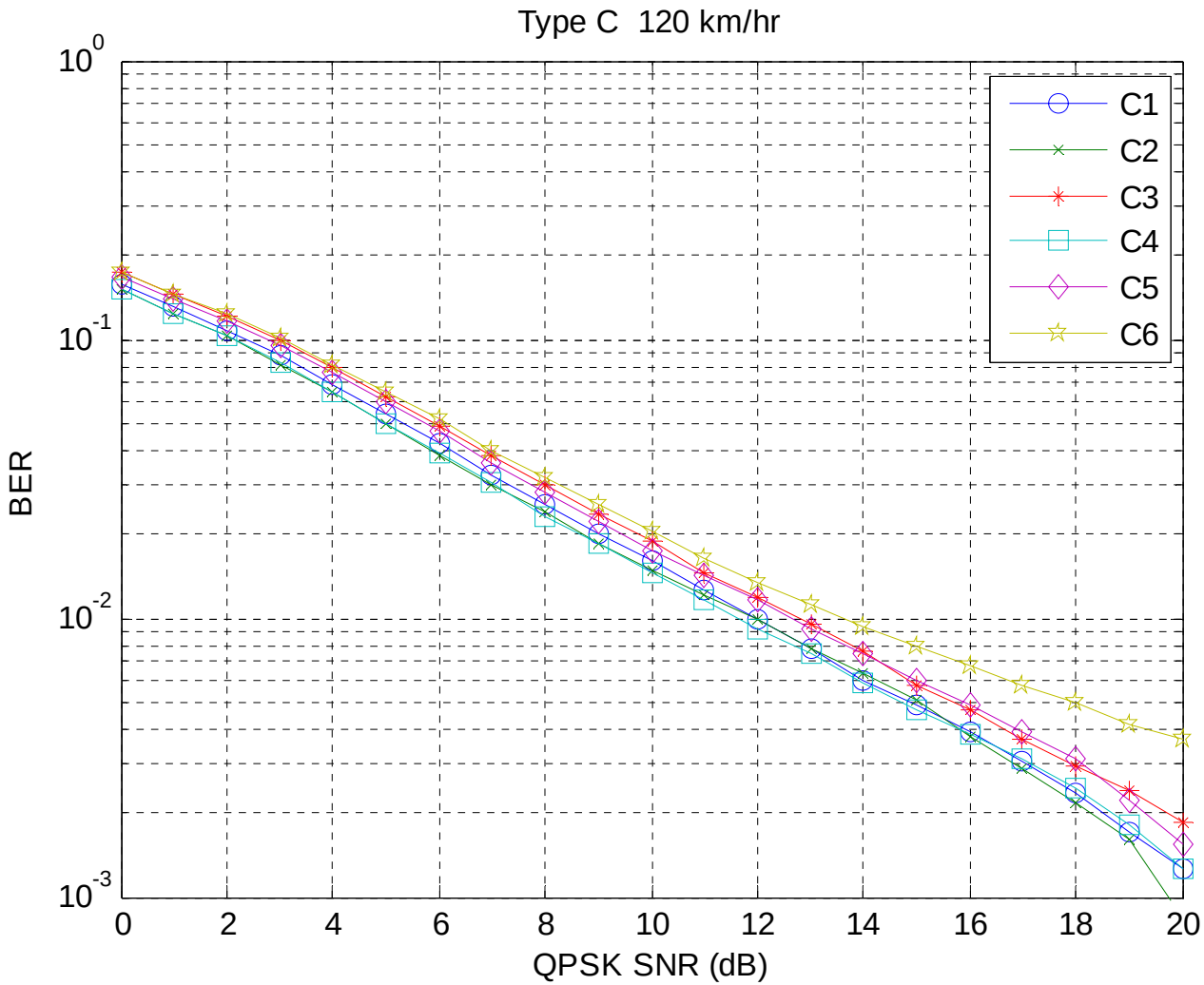
Simulation Result for Type C RB at 3 km/hr



Simulation Result for Type C RB at 60 km/hr



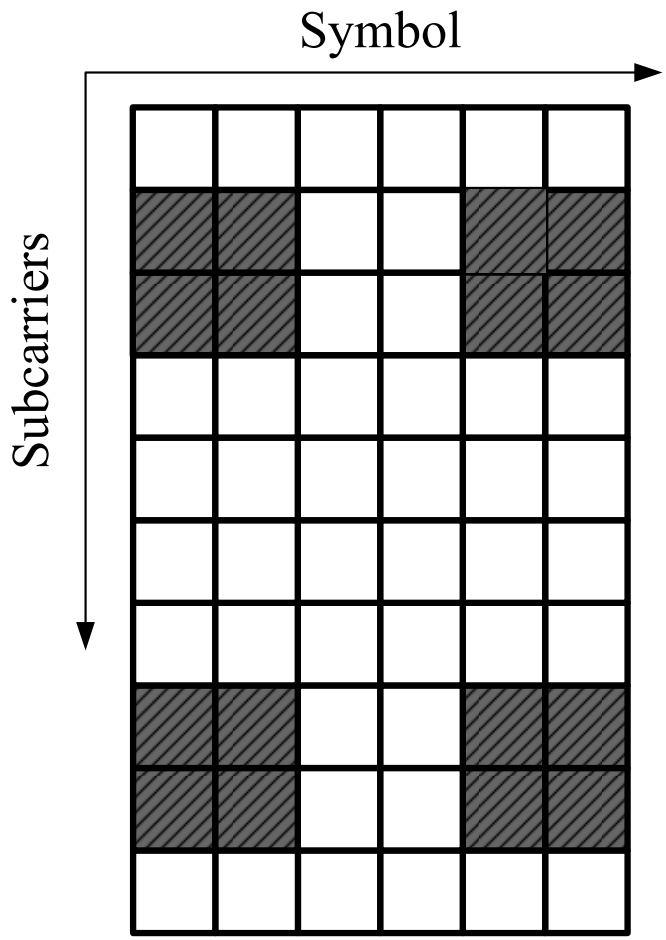
Simulation Result for Type C RB at 120 km/hr

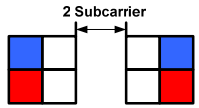
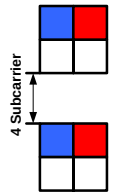
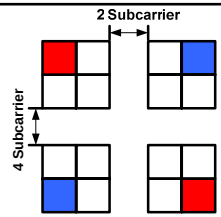


Summary for Type C RB Uplink Pilot Format

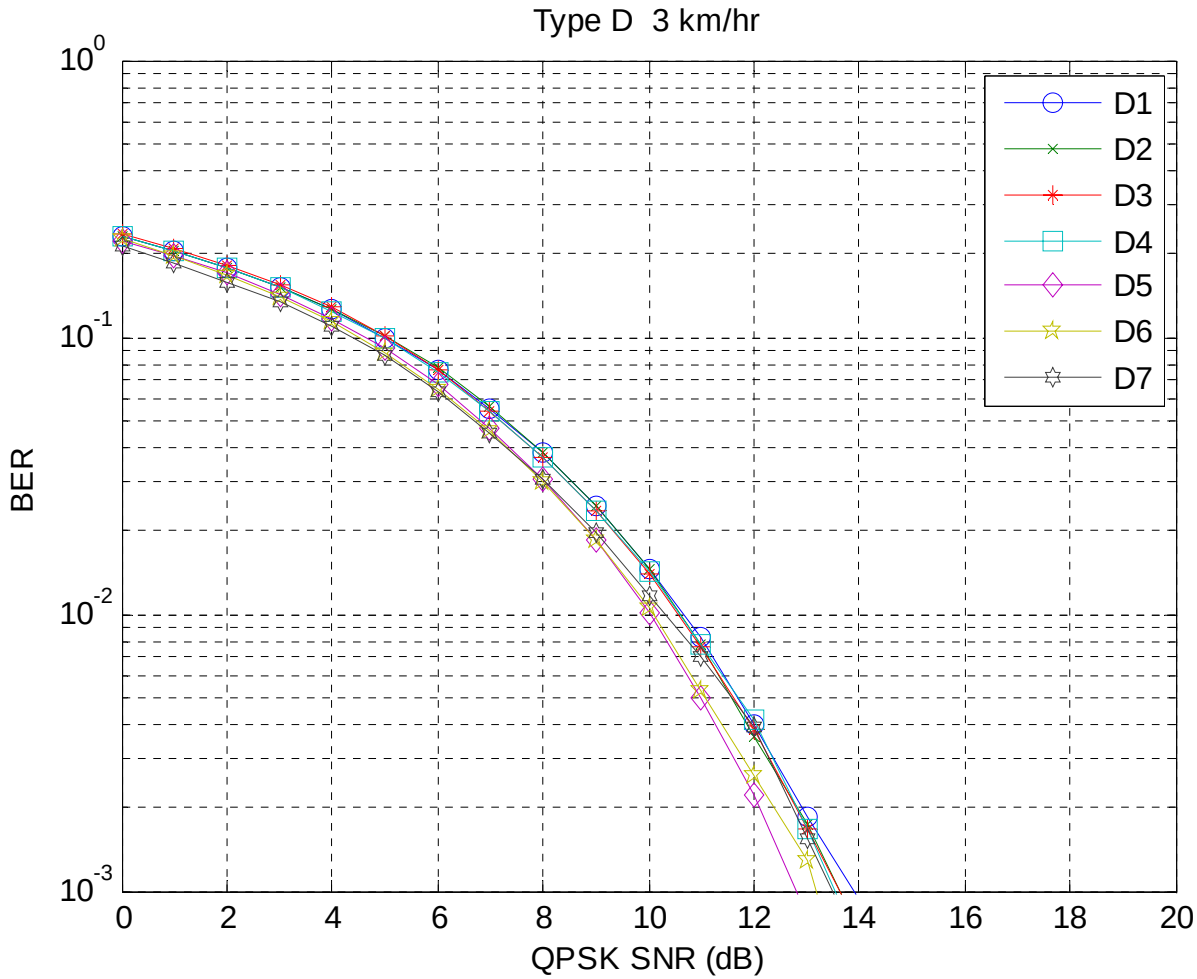
Speed / Type	3 km/hr (Low Mobility)	60 km/hr	120 km/hr (High Mobility)
C1 @BER=10^{-2} Pilot Density=16.67%	SNR= 8 dB	SNR= 10 dB	SNR= 12 dB
C2 @BER=10^{-2} Pilot Density=16.67%	SNR= 8 dB	SNR= 10 dB	SNR= 12 dB
C3 @BER=10^{-2} Pilot Density=16.67%	SNR= 9 dB	SNR= 10 dB	SNR= 13 dB
C4 @BER=10^{-2} Pilot Density=16.67%	SNR= 8 dB	SNR= 10 dB	SNR= 12 dB
C5 @BER=10^{-2} Pilot Density=16.67%	SNR= 9 dB	SNR= 10 dB	SNR= 13 dB
C6 @BER=10^{-2} Pilot Density=11.11%	SNR= 9 dB	SNR= 10 dB	SNR= 14 dB

Different Pilot Pattern for Type D RB

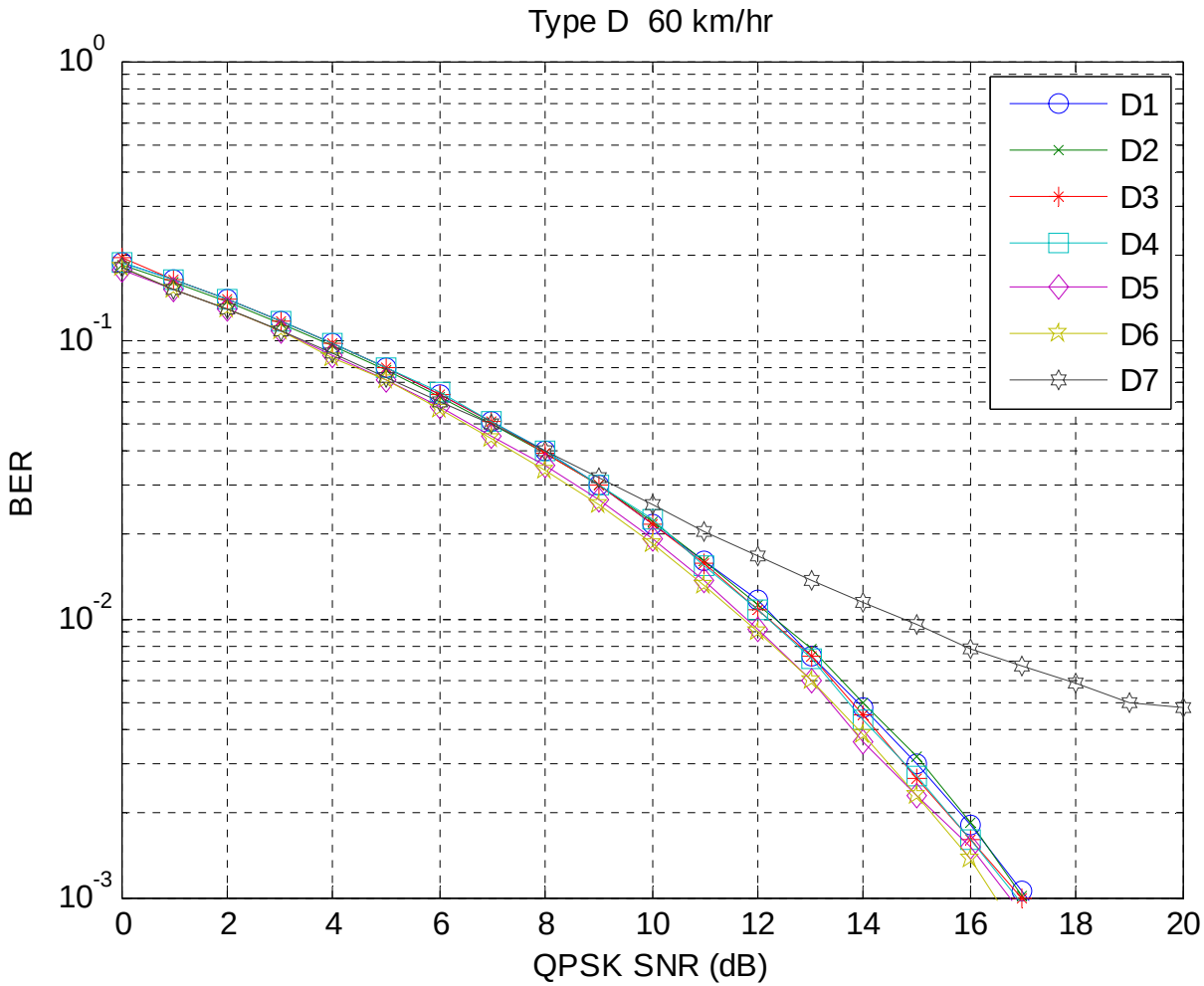


Type	Pilot Structure	Pilot Density
D1		13.33%
D2		
D3		
D4		
D5		
D6		
D7		6.66%

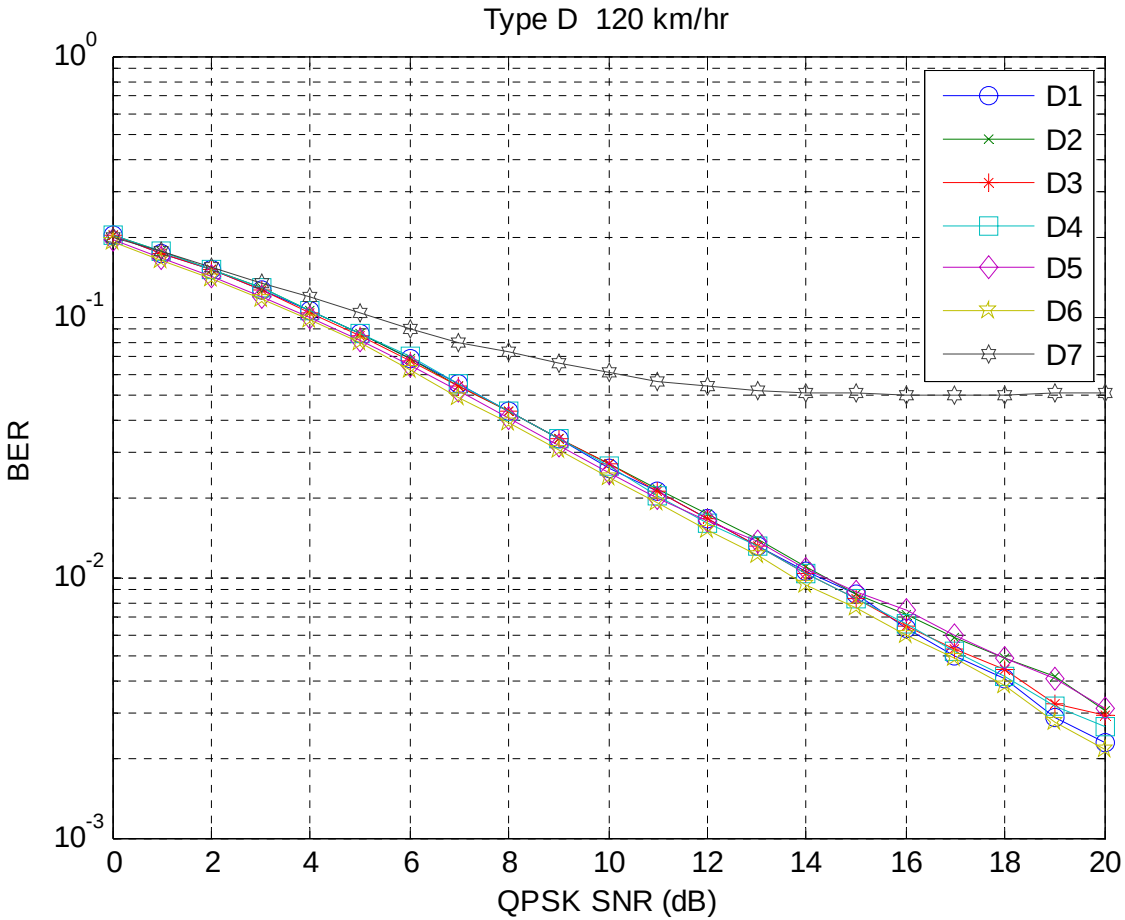
Simulation Result for Type D RB at 3 km/hr



Simulation Result for Type D RB at 60 km/hr



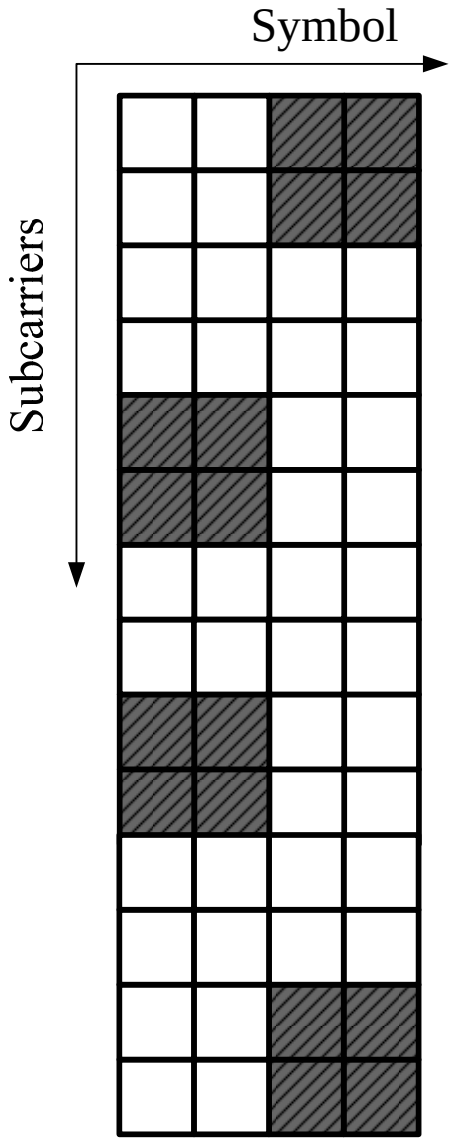
Simulation Result for Type D RB at 120 km/hr

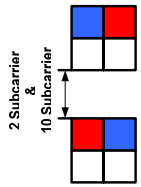
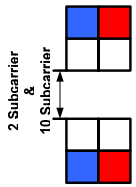
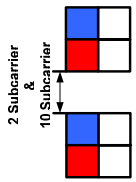


Summary for Type D RB Uplink Pilot Format

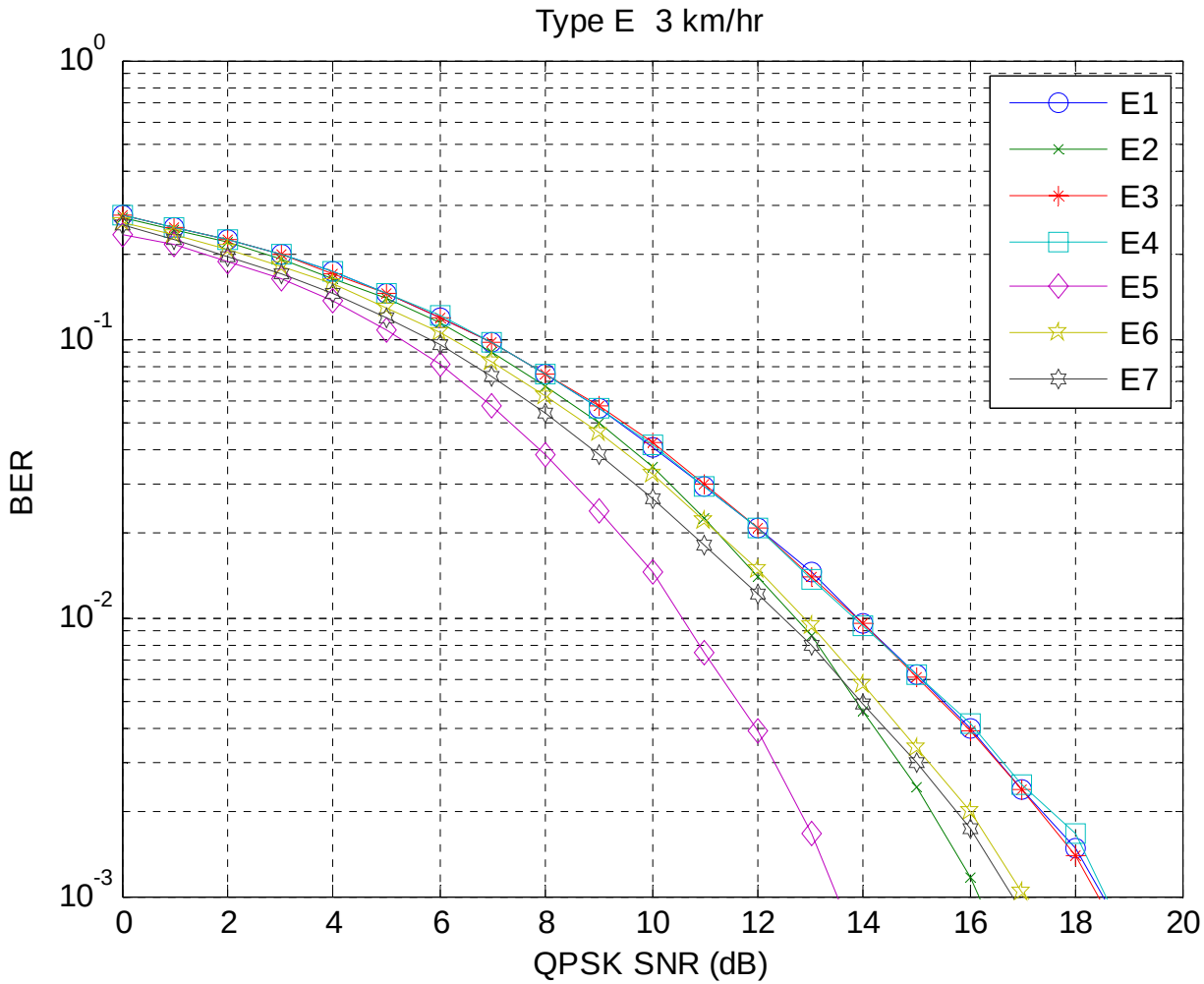
Speed / Type	3 km/hr (Low Mobility)	60 km/hr	120 km/hr (High Mobility)
D1 @BER=10^{-2} Pilot Density=13.33%	SNR= 11 dB	SNR= 12 dB	SNR= 14 dB
D2 @BER=10^{-2} Pilot Density=13.33%	SNR= 11 dB	SNR= 12 dB	SNR= 14 dB
D3 @BER=10^{-2} Pilot Density=13.33%	SNR= 11 dB	SNR= 12 dB	SNR= 14 dB
D4 @BER=10^{-2} Pilot Density=13.33%	SNR= 11 dB	SNR= 12 dB	SNR= 14 dB
D5 @BER=10^{-2} Pilot Density=13.33%	SNR= 10 dB	SNR= 12 dB	SNR= 14 dB
D6 @BER=10^{-2} Pilot Density=13.33%	SNR= 10 dB	SNR= 12 dB	SNR= 14 dB
D7 @BER=10^{-2} Pilot Density=6.66%	SNR= 10 dB	SNR= 15 dB	

Different Pilot Pattern for Type E RB

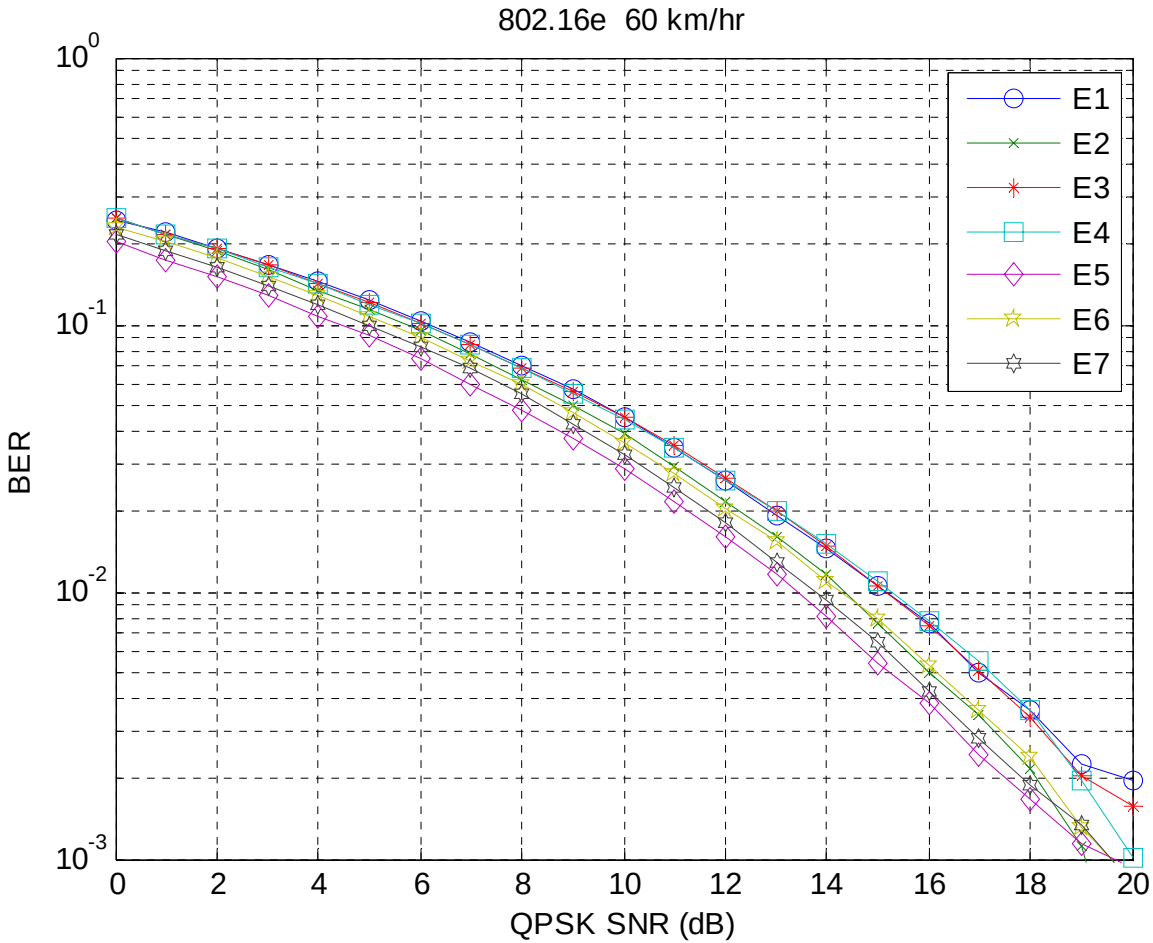


Type	Pilot Structure	Pilot Density
E1		14.28%
E2		
E3		
E4		
E5		
E6		
E7		

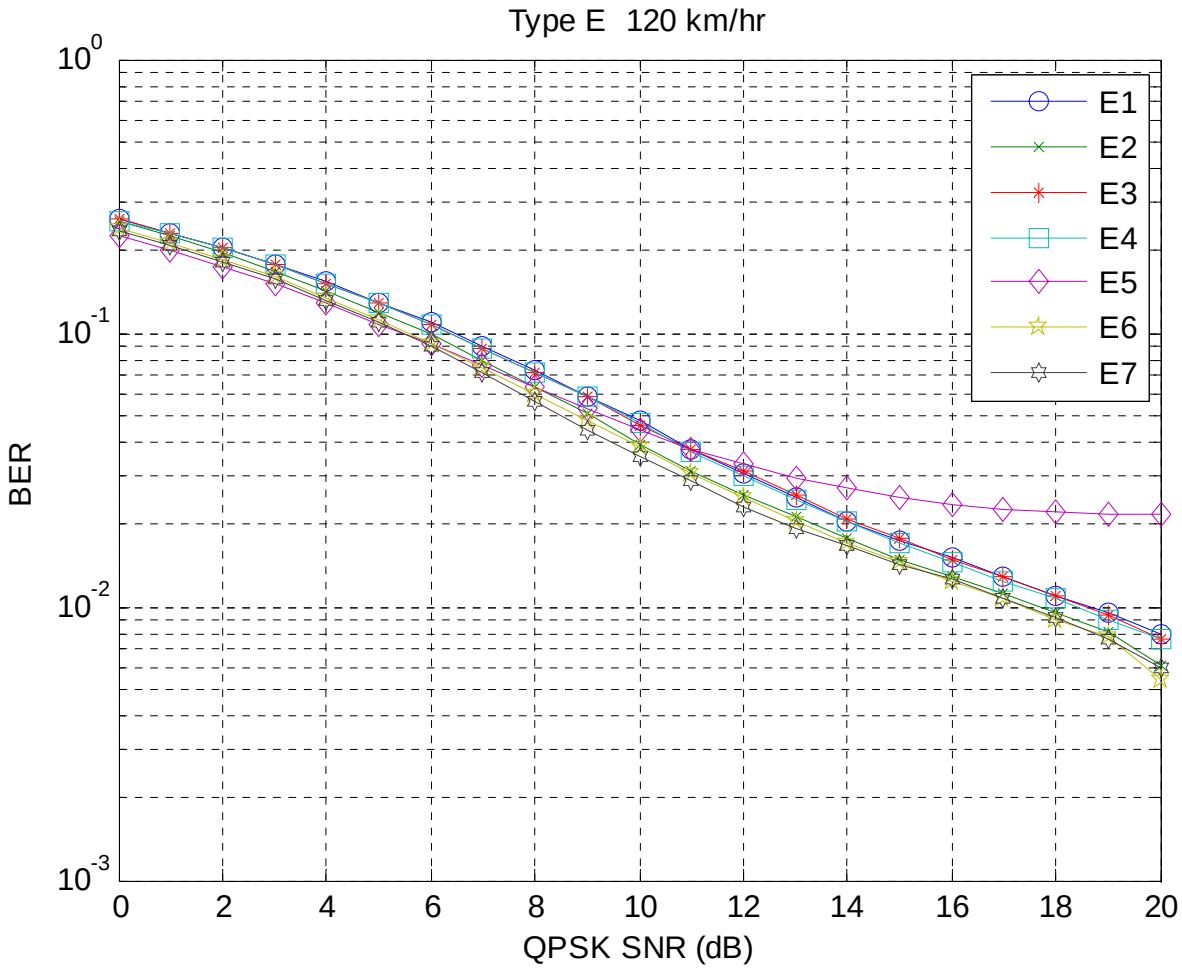
Simulation Result for Type E RB at 3 km/hr



Simulation Result for Type E RB at 60 km/hr



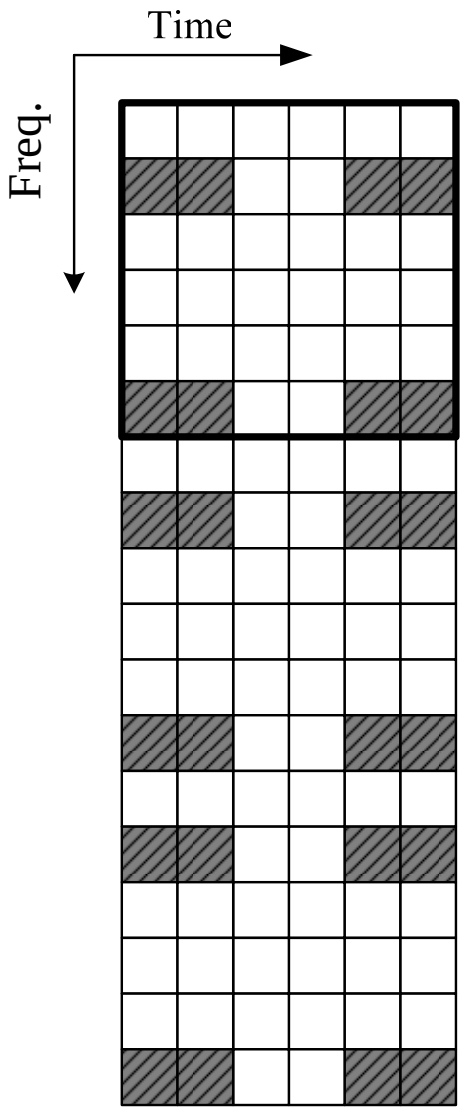
Simulation Result for Type E RB at 120 km/hr

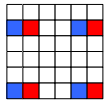
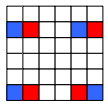
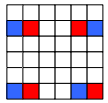
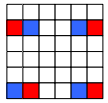
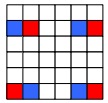
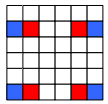
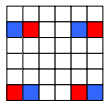
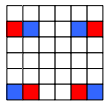


Summary for Type E RB Uplink Pilot Format

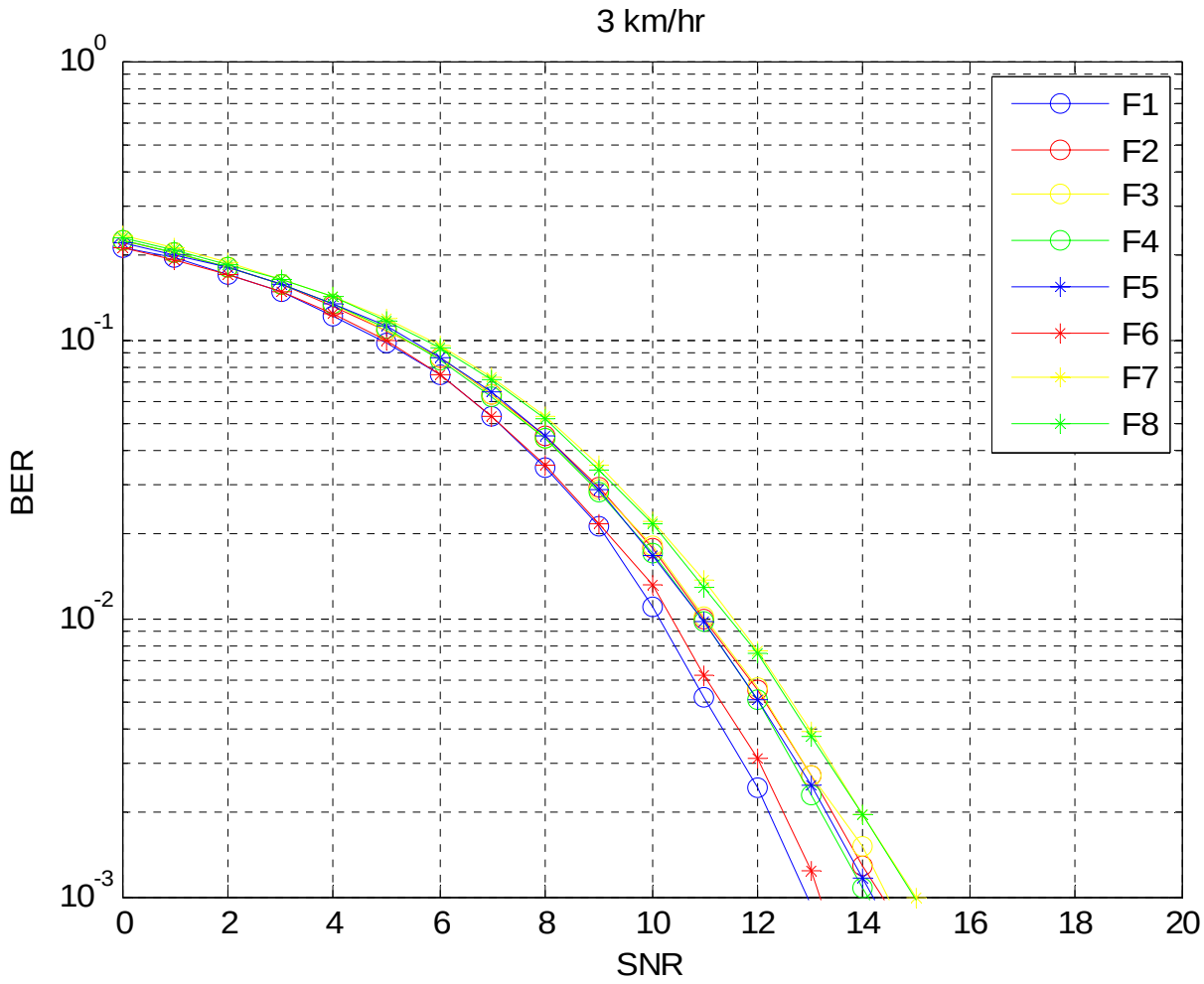
Type \ Speed	3 km/hr (Low Mobility)	60 km/hr	120 km/hr (High Mobility)
E1 @BER=10^{-2} Pilot Density=14.28%	SNR= 14 dB	SNR= 15 dB	SNR= 18 dB
E2 @BER=10^{-2} Pilot Density=14.28%	SNR= 13 dB	SNR= 14 dB	SNR= 18 dB
E3 @BER=10^{-2} Pilot Density=14.28%	SNR= 14 dB	SNR= 15 dB	SNR= 18 dB
E4 @BER=10^{-2} Pilot Density=14.28%	SNR= 14 dB	SNR= 15 dB	SNR= 18 dB
E5 @BER=10^{-2} Pilot Density=13.33%	SNR= 10 dB	SNR= 13 dB	
E6 @BER=10^{-2} Pilot Density=14.28%	SNR= 13 dB	SNR= 14 dB	SNR= 18 dB
E7 @BER=10^{-2} Pilot Density=14.28%	SNR= 13 dB	SNR= 14 dB	SNR= 18 dB

Different Pilot Pattern for Type F RB

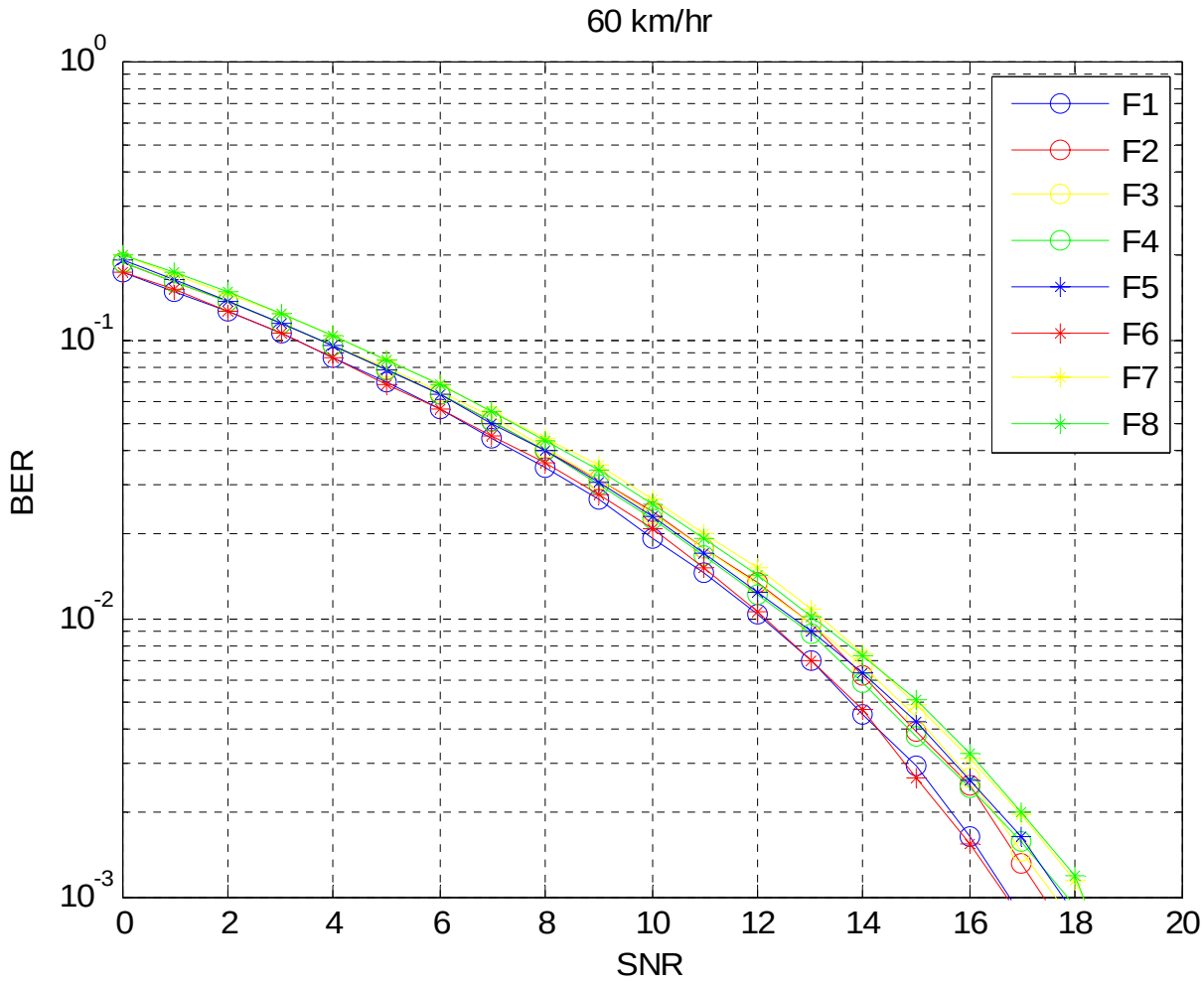


Type	Pilot Structure	Pilot Density
F1		22.22%
F2		
F3		
F4		
F5		
F6		
F7		
F8		

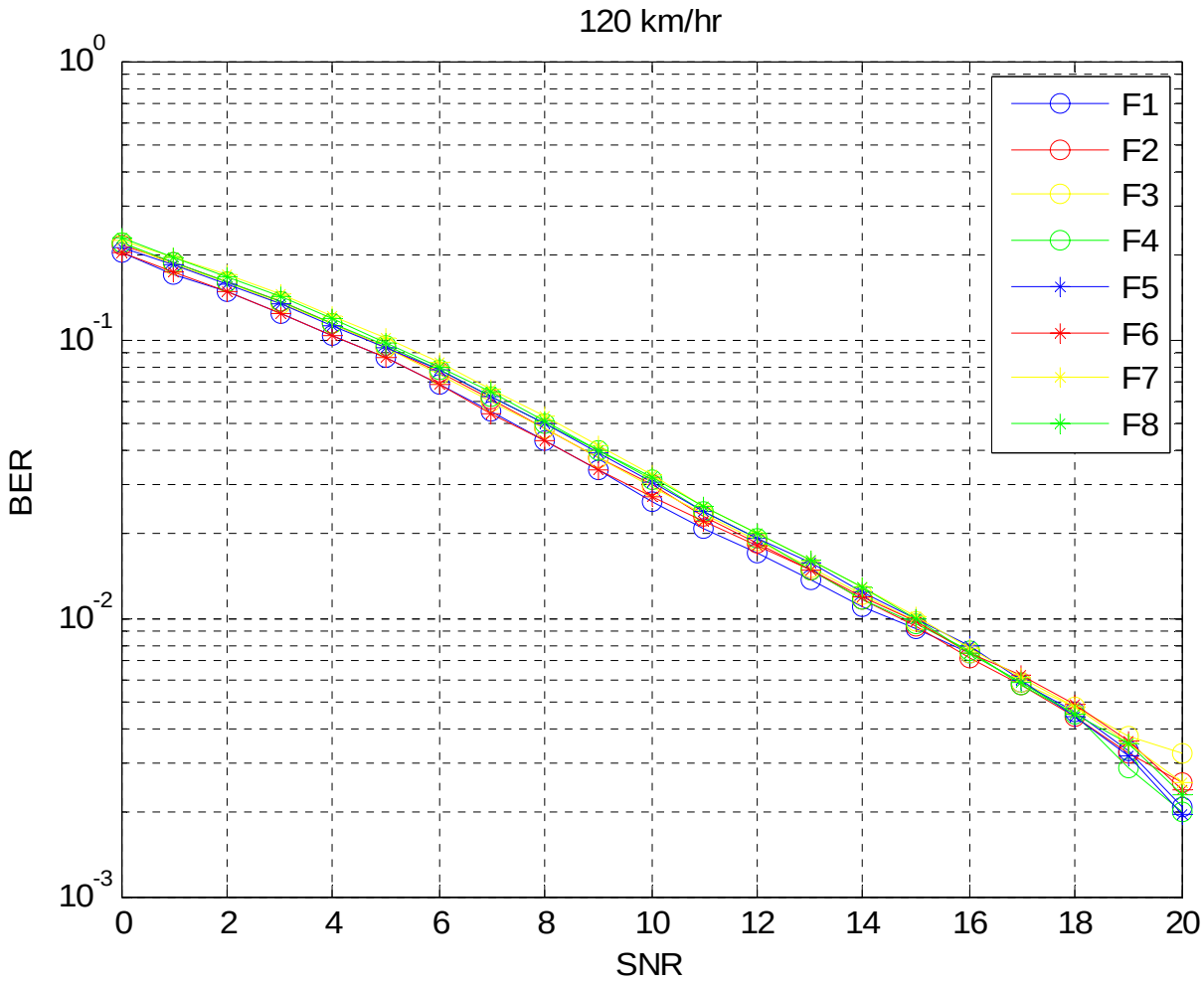
Simulation Result for Type F RB at 3 km/hr



Simulation Result for Type F RB at 60 km/hr



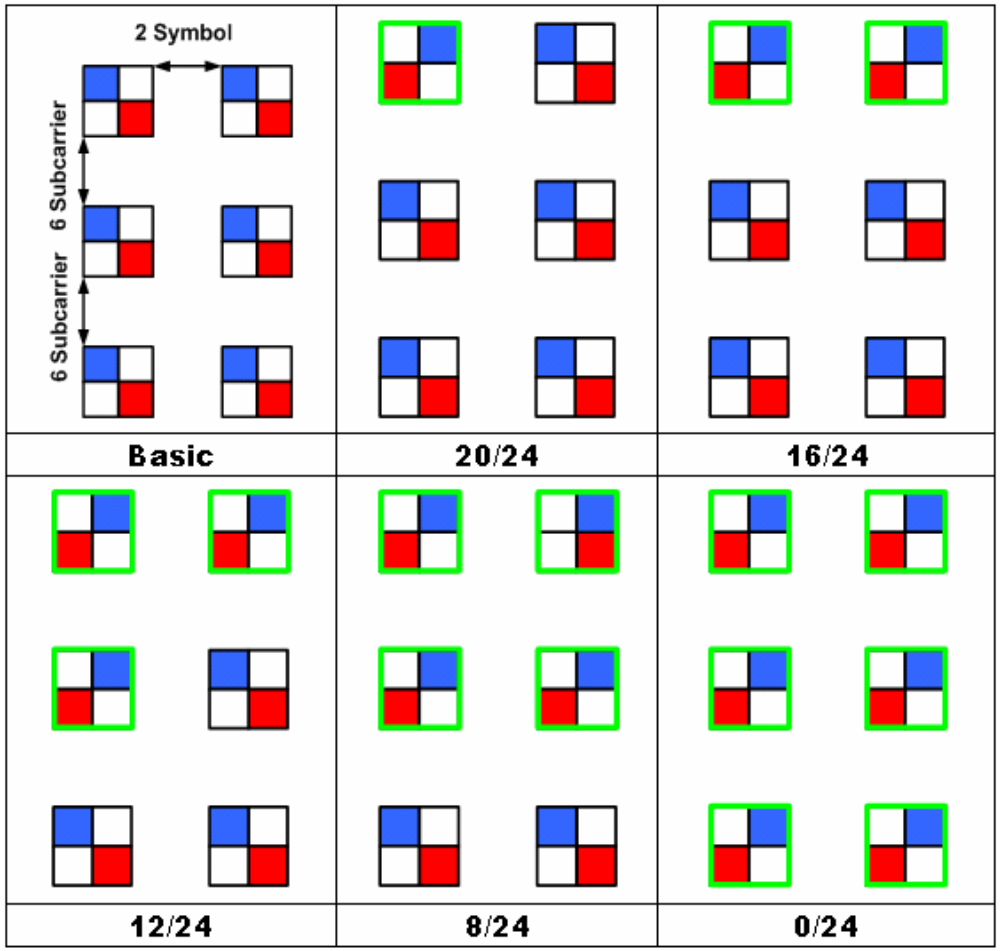
Simulation Result for Type F RB at 120 km/hr



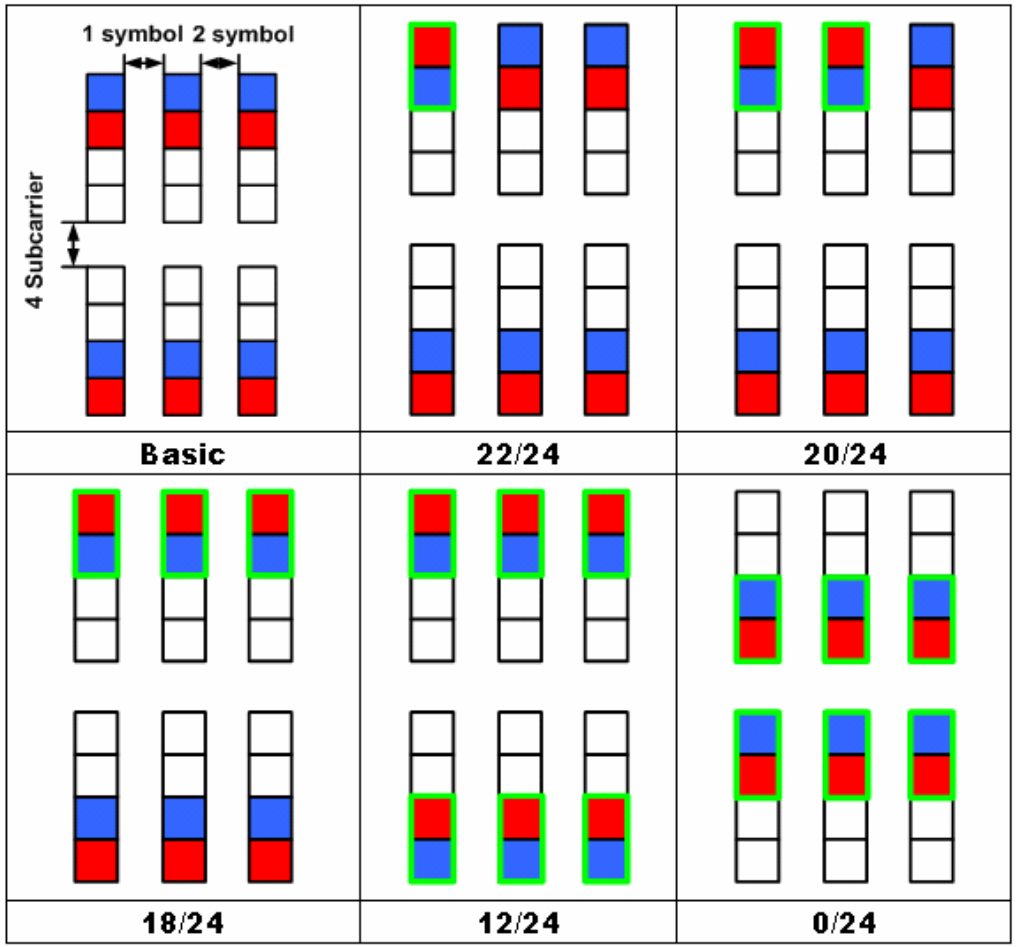
Summary for Type F RB Uplink Pilot Format

Type \ Speed	3 km/hr (Low Mobility)	60 km/hr	120 km/hr (High Mobility)
F1 @BER=10^{-2} Pilot Density=22.22%	SNR= 10.2 dB	SNR= 12 dB	SNR= 14.5 dB
F2 @BER=10^{-2} Pilot Density=22.22%	SNR= 11 dB	SNR= 12.7 dB	SNR= 14.7 dB
F3 @BER=10^{-2} Pilot Density=22.22%	SNR= 11 dB	SNR= 12.7 dB	SNR= 15 dB
F4 @BER=10^{-2} Pilot Density=22.22%	SNR= 10.8 dB	SNR= 12.6 dB	SNR= 14.8 dB
F5 @BER=10^{-2} Pilot Density=22.22%	SNR= 10.8 dB	SNR= 12.6 dB	SNR= 15 dB
F6 @BER=10^{-2} Pilot Density=22.22%	SNR= 10.3 dB	SNR= 12.2 dB	SNR= 14.9 dB
F7 @BER=10^{-2} Pilot Density=22.22%	SNR= 11.5 dB	SNR= 13.2 dB	SNR= 15 dB
F8 @BER=10^{-2} Pilot Density=22.22%	SNR= 11.5 dB	SNR= 13 dB	SNR= 15 dB

Certain pilot structures with different pilot coefficient for square type pilot



Certain pilot structures with different pilot coefficient for line type pilot



Conclusion

In this contribution we simulate the system performance for six types, Type A ~ Type F, of pilot structures. It is observed that some pilot patterns are orthogonal each other, we can use this orthogonal characteristic to reduce the interference influence in the data transmission between BS and MS. We also propose and define the pilot correlation coefficient between a pilot type and a basic pilot type and then when the system interference level is imposed we can select a proper pilot structure with certain pilot correlation coefficient to meet this interference criterion. It can further use pilot patterns as users IDs, i.e. each user is assigned a distinct pilot pattern, and consequently we can not only use various pilot patterns to reduce the communication interference between BS and MS but also by assigning each user with a distinct pilot pattern so that to manage and distribute the users in a more systematic manner.

Proposed Text for SDD (1/2)

11.x Uplink pilots

11.x.1 Uplink pilot structure

11.x.2 Pilot Correlation Coefficient

(1) An example of pilot structures with different pilot correlation coefficient for square type pilot

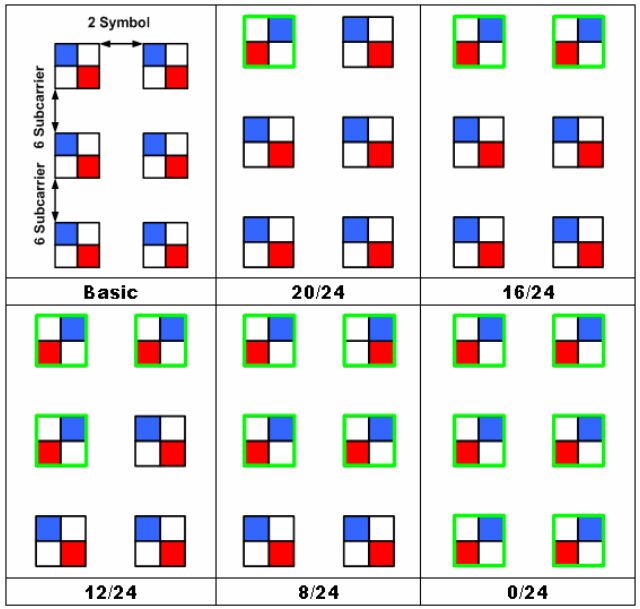


Fig. a An example of pilot structures with different pilot correlation coefficient for square type pilot

Proposed Text for SDD (2/2)

(2) An example of pilot structures with different pilot correlation coefficient for line type pilot

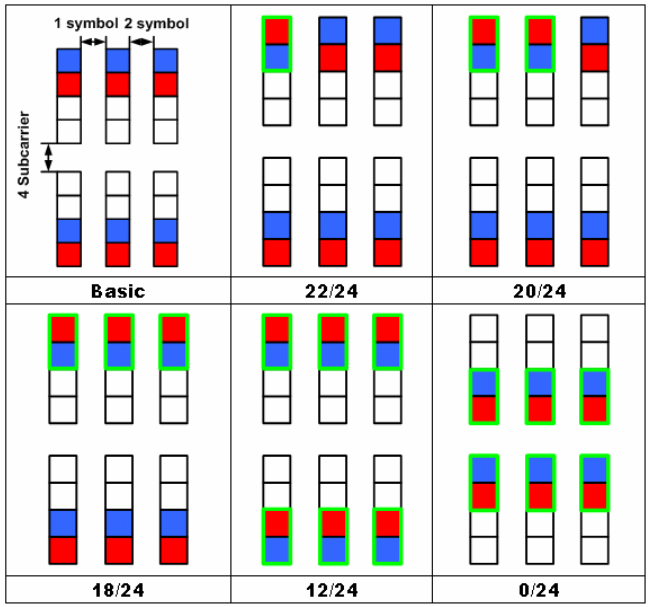


Fig. b An example of pilot structures with different pilot correlation coefficient for line type pilot