In the Consideration of Pilots Design for IEEE802.16m System

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Abstract: In this study, we introduce the concept of correlation weight between pilots in the design of pilots that are utilized by the mobile users in their network entry synchronization and in the channel impulse response estimation. Different set of pilots in various resource block sizes are proposed for mobiles traveling in various speeds. Some pilots are orthogonal to each other so that the resulting system interference will be reduced when this set of pilots are utilized. System performance, evaluated in the system BER vs. SNR, is simulated to reveal the effectiveness of this new design of pilots comparing with the classical pilots design where the same pilot is used by all users.

1 INTRODUCTION

Several pilots design has been proposed in the IEEE 802.16m OFDMA system for users in their network entry synchronization and in the channel impulse response estimation [1-8]. In this paper, the system performance is simulated and compared under various MS speeds when the channel impulse response is estimated from the utilization of six types of pilot with various resource block sizes proposed for IEEE802.16m [9]. It is observed from these simulation results that some pilots are orthogonal to each other and when these pilots are utilized in the system the resulting system interference level will be reduced and consequently the system performance is improved [10-14]. We then from the consideration of interference between two pilots to introduce and define the pilot weight for each pilot and consequently from each pilot's weight it will reveal how interference level will be affected when this pilot is introduced in the system. Finally the system performance in bit error rate (BER) vs. SNR is simulated and compared when the system is implemented with the new pilot design that is embedded with the correlation weight concept with that when the system is implemented with the classical pilot design where the same pilot is utilized in the system.

The organization of this paper is as follows. In Section II the system simulation parameters are introduced, these same system parameters will be used in the whole paper when various system performances are simulated. The six types of pilot with various resource block sizes considered in IEEE 802.16m are introduced in Section III. The concept of pilot correlation coefficient is introduced in Section IV. In Section V it conducts simulations to evaluate and compare the system performance when the new designed pilots are implemented and when the conventional pilot design where the same pilot is used for all users. A conclusion is drawn in Section VI.

2 SIMULATION ENVIRONMENT

In Table I we list the overall system parameters that will be used in the simulations; it includes four types of resource blocks (RB), namely 6 symbols * 18 subcarriers or 18 * 6, 4 symbols * 14 subcarriers or 14 * 4, 6 symbols * 12 subcarriers or 12 * 6 and 6 symbols * 10 subcarriers or 10 * 6.

TABLE I SIMULATION PARAMETERS

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

3 SIMULATION WITH VARIOUS RESOURCE BLOCK TYPES

3.1 Type A Resource Block

As shown in Fig. 1 is an 18 x 6 Type A resource block consisting of 18 subcarriers and 6 symbols in a resource block with pilot patterns exhibited in shaded square block. Only seven pilots, A1 ~ A7, are selected and considered from Type A resource block.

3.2 Type B Resource Block

As shown in Fig. 2 is an 18 x 6 Type B resource block consisting of 18 subcarriers and 6 symbols in a resource block with pilot patterns exhibited in shaded square block. Six pilots, B1 ~ B6, are selected and considered from Type B resource block.

3.3 Type C Resource Block

As shown in Fig. 3 is a 12 x 6 Type C resource block consisting of 12 subcarriers and 6 symbols in a resource block with pilot patterns exhibited in shaded square block. Six pilots, C1 ~ C6, are selected and considered from Type C resource block.

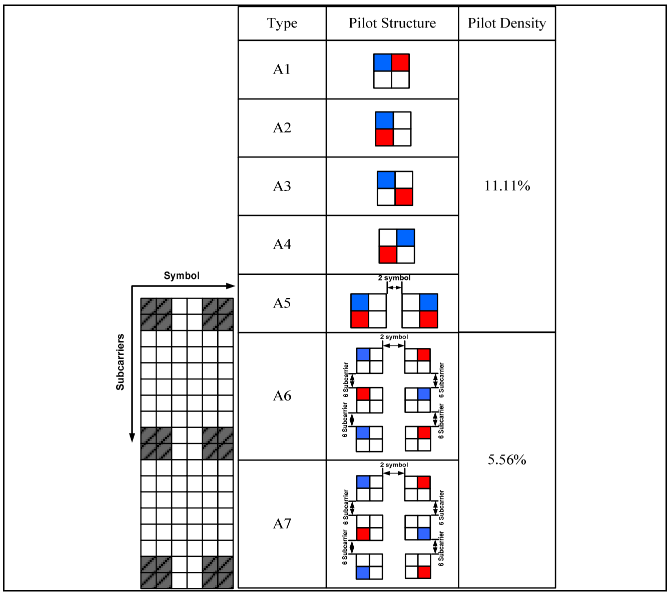


Figure 1 SEVEN PILOTS ARE SELECTED FROM TYPE A RB

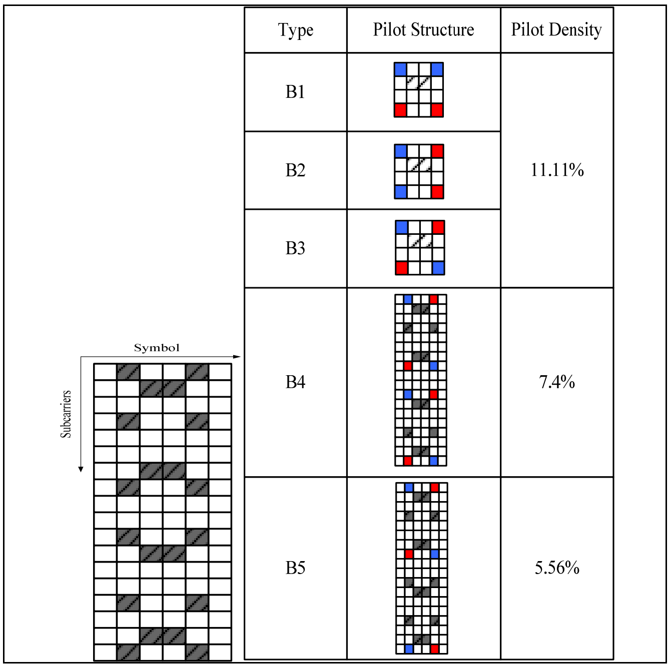


Figure 2 FIVE PILOTS ARE SELECTED FROM TYPE B RB

3.4 Type D Resource Block

As shown in Fig. 4 is a 10 x 6 Type D resource block consisting of 10 subcarriers and 6 symbols in a resource block with pilot patterns exhibited in shaded square block. Seven pilots, D1 ~ D7, are selected from Type D resource block.

3.5 Type E Resource Block

As shown in Fig. 5 is a 14 x 4 Type E resource block consisting of 14 subcarriers and 4 symbols in a resource block with pilot patterns exhibited in shaded square block. Seven pilots, E1 ~ E7, are selected from Type E resource block.

3.6 Type F Resource Block

As shown in Fig. 6 is an 18 x 6 Type F resource block consisting of 18 subcarriers and 6 symbols in a resource block with pilot patterns exhibited in shaded square block. Eight pilots, F1 ~ F8, are selected from Type F resource block.

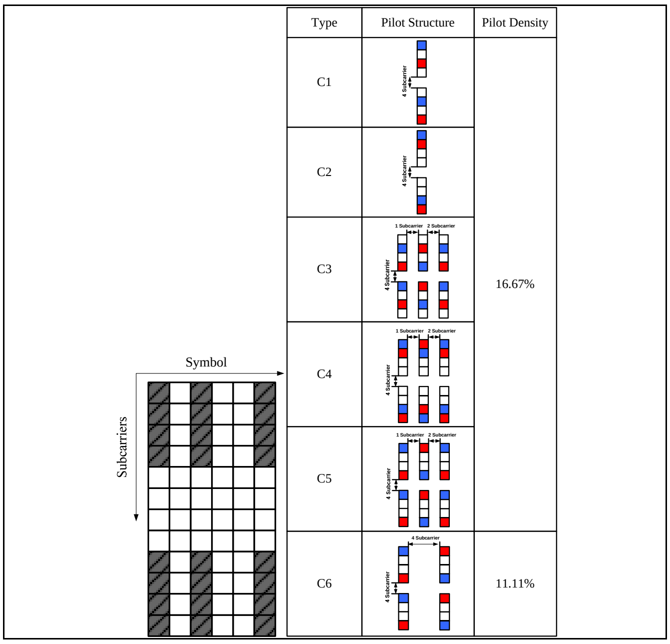


Figure 3 SIX PILOTS ARE SELECTED FROM TYPE C RB

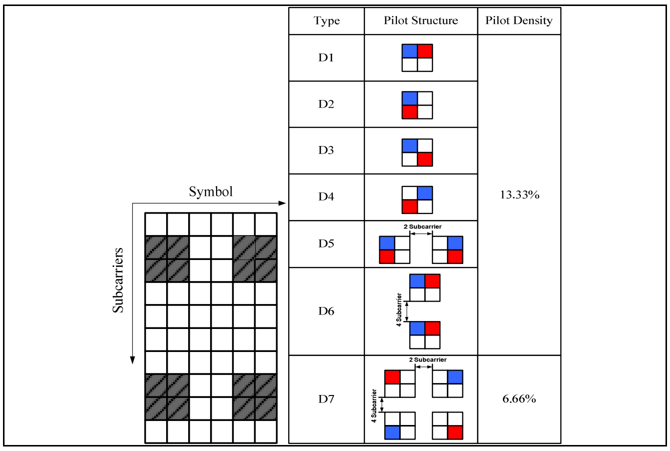


Figure 4 SEVEN PILOTS ARE SELECTED FROM TYPE D RB

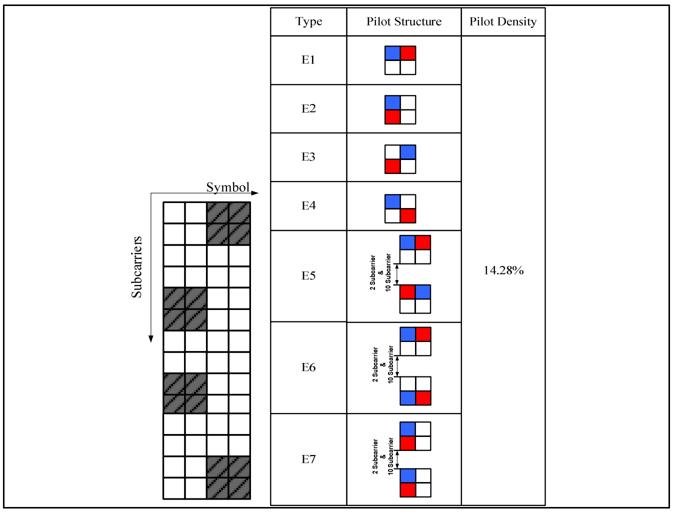


Figure 5 SEVEN PILOTS ARE SELECTED FROM TYPE E RB

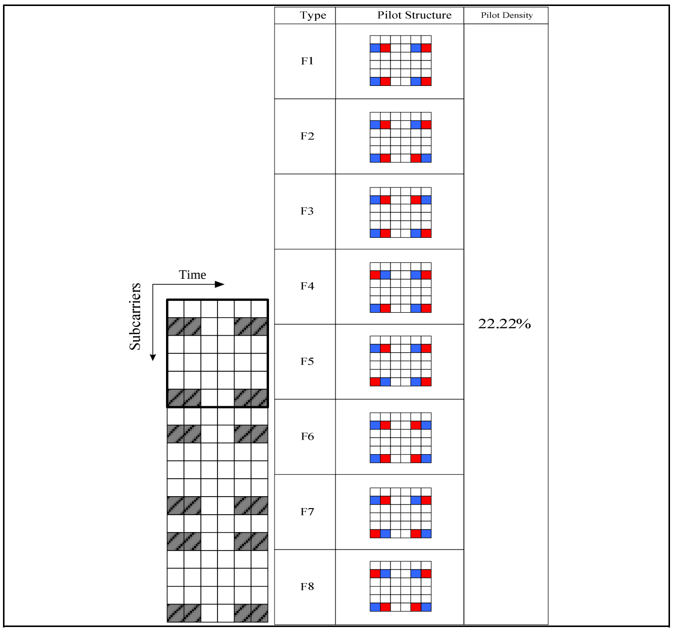


Figure 6 EIGHT PILOTS ARE SELECTED FROM TYPE F RB

4 PILOT CORRELATION COEFFICIENT

As shown in Fig. 7 and Fig. 8, we use Type A and Type C pilot patterns as examples to illustrate the variations of 'pilot correlation coefficient' between two pilots in each resource type. In Fig. 7 we consider six square pilot blocks with each square block consisting of four pilots. The 'reference' pilot structure is defined as that in the six square pilot blocks each block contains the same pilot pattern. If we change one of the six square pilot blocks to its corresponding orthogonal square block then the resulting overall pilots have only 20 pilot patterns that have the same patterns as the reference pilot structure and then we define the pilot correlation coefficient is 20/24 which is designated as 20/24 pilot structure in the figure. By continuously inverting the pilot patterns in each subsequent six pilot blocks to its orthogonal part we can get the pilot structures with pilot correlation coefficients of 16/24 till 0/24, i.e. it has 16 pilots and zero pilots are in the same pilot patterns as the reference pilot structure respectively. Consequently when we designate a pilot structure with M/24 where 0<=M<=24 it means it has M pilots out of 24 pilots that have the same pilot patterns as the reference pilot structure. Similarly we can define the pilot correlation coefficient for line type pilots as shown in Fig. 8.

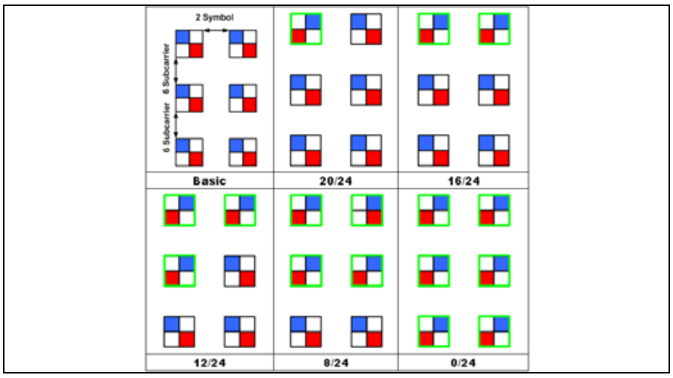


Figure 7 PILOT STRUCTURES WITH VARIOUS PILOT CORRELATION COEFFICIENTS FOR SQUARE TYPE PILOT STRUCTURE

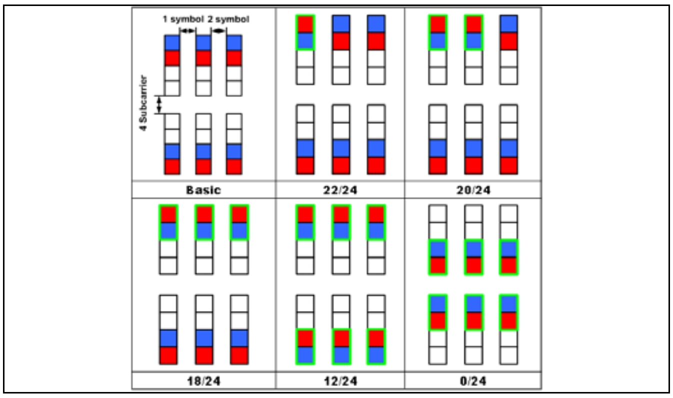


Figure 8 PILOT STRUCTURES WITH VARIOUS PILOT CORRELATION COEFFICIENTS FOR LINE TYPE PILOT STRUCTURE

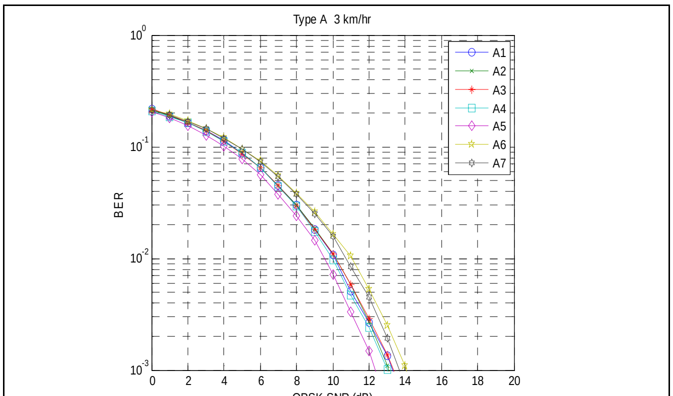
5 SIMULATION

From the pilot patterns as described in the above section we select Types A, B and C pilot patterns to simulate the system performance in this section. The system performance in terms of bit error rate (BER) is simulated when the mobile is moving in various speeds and when the system parameters defined in Table 1 are used with various pilot structures derived from Type A, B and C resource blocks are considered.

5.1 Type A Resource Block

For Type A resource block, the system performance, in terms of BER vs. Signal to Noise ratio in QPSK modulation, has the results as shown in Fig. 9(a) ~ Fig. 9(c) when the mobile is moving at 3 km,/hr, 60 km/hr and 120 km/hr respectively. From Fig. 9 results it lists in Table II the required Signal to Noise ratio for Type A1 ~ A7 pilots to meet the 10^{-2} BER requirement, it reveals that it requires almost the same Signal to Noise ratio for A1 ~ A7 pilots to attain the same BER.

Specifically it is noted, from Fig. 1, that pilot Type A3 and pilot Type A4 are orthogonal to each other then the resulting system interference level will be the least comparing with other pilot pairs are used if two pilots are needed and utilized in the data transmission.



(a)

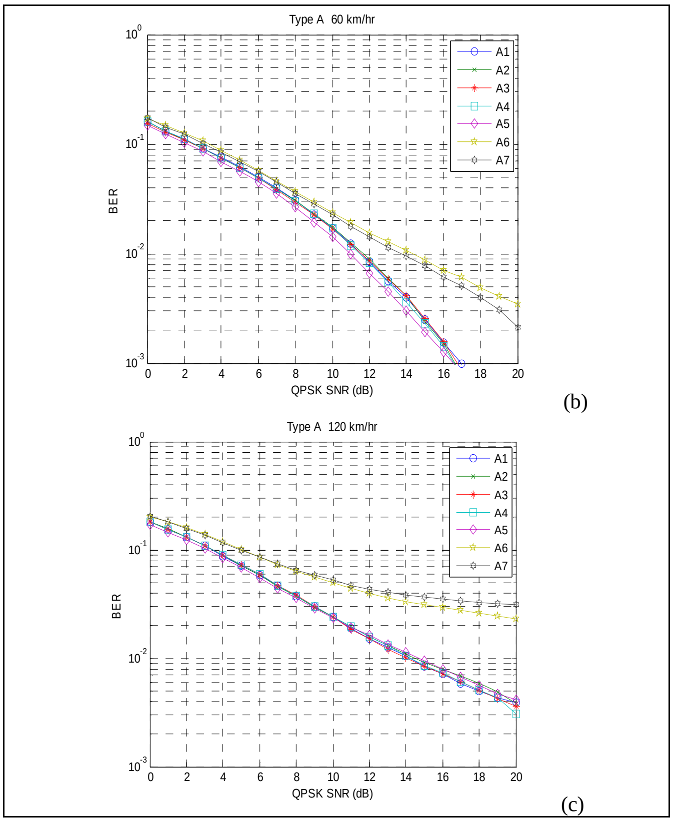
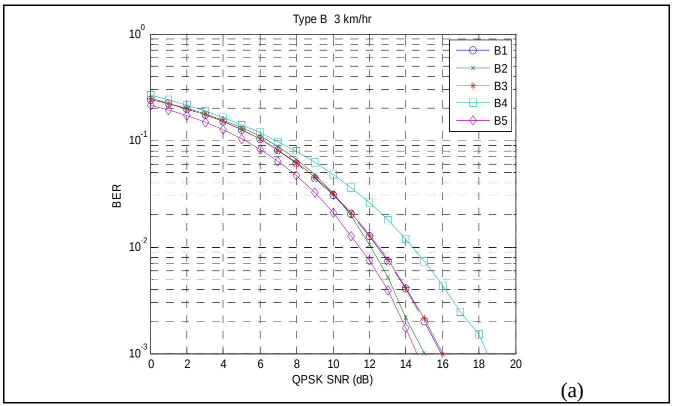


Figure 9 SIMULATION RESULT FOR TYPE A PILOTS AT (A) 3 KM/HR (B) 60 KM/HR (C) 120 KM/HR

TABLE II SUMMARY OF REQUIRED SNR TO MEET BER= 10^{-2} FOR TYPE A1 ~ A7 PILOTS FOR TYPE A RESOURCE BLOCK

	3 km/hr	60 km/hr	120 km/hr
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	

5.2 Type B Resource Block



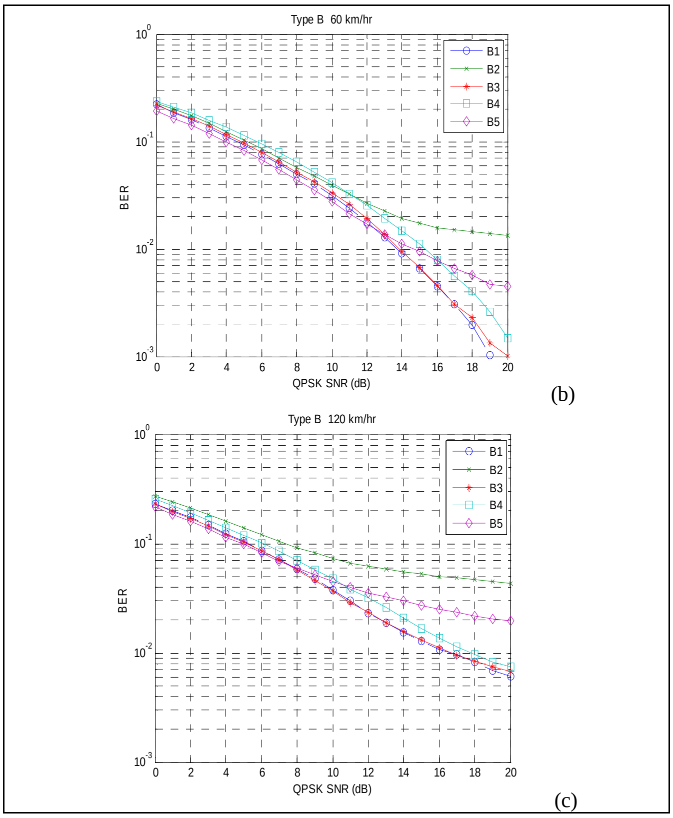


Figure 10 SIMULATION RESULT FOR TYPE B PILOTS AT (A) 3 KM/HR (B) 60 KM/HR (C) 120 KM/HR

For Type B resource block, the system performance, in terms of BER vs. Signal to Noise ratio in QPSK modulation, has the results as shown in Fig. 10 (a) – Fig. 10 (c) when the mobile is moving at 3 km/hr, 60 km/hr and 120 km/hr respectively. From Fig. 10 results it lists in Table III the required Signal to Noise ratio for Type B1 ~ B5 pilots to meet the 10^{-2} BER requirement, it reveals that it requires almost the same Signal to Noise ratio for B1 ~ B5 pilots to attain the same BER.

TABLE III SUMMARY OF REQUIRED SNR TO MEET BER= 10^{-2} FOR TYPE B1 ~ B5 PILOTS FOR TYPE B RESOURCE BLOCK

	3 km/hr	60 km/hr	120 km/hr
B1, BER=10-2 Pilot Density =11.11%	SNR=12dB	SNR=14dB	SNR=16dB
B2, BER=10-2 Pilot Density =11.11%	SNR=12dB		
B3, BER=10-2 Pilot Density =11.11%	SNR=12dB	SNR=14dB	SNR=16dB
B4, BER=10-2 Pilot Density =7.4%	SNR=14dB	SNR=15dB	SNR=18dB
B5, BER=10-2 Pilot Density =5.56%	SNR=11dB	SNR=15dB	

5.3 Type C Resource Block

For Type C resource block, the system performance, in terms of BER vs. Signal to Noise ratio in QPSK modulation, has the results as shown in Fig. 11 (a) – Fig. 11 (c) when the mobile is moving at 3 km/hr, 60 km/hr and 120 km/hr respectively. From Fig. 11 results it lists in Table IV the required Signal to Noise ratio for Type C1 ~ C6 pilots to meet the 10-2 BER requirement, it reveals that it requires almost the same Signal to Noise ratio for C1 ~ C6 pilots to attain the same BER.

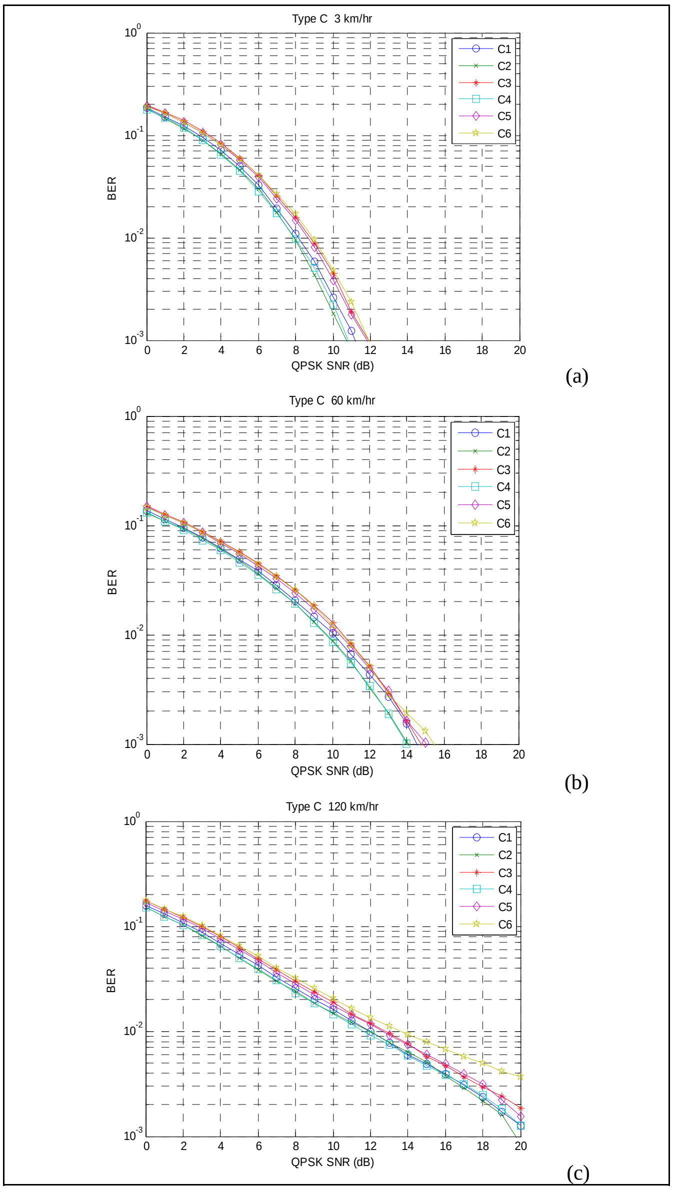


Figure 11 SIMULATION RESULT FOR TYPE C PILOTS AT (A) 3 KM/HR (B) 60 KM/HR (C) 120 KM/HR

TABLE IV SUMMARY OF REQUIRED SNR TO MEET BER= 10^{-2} FOR TYPE C1 ~ C6 PILOTS FOR TYPE C RESOURCE BLOCK

	3 km/hr	60 km/hr	120 km/hr
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

6 CONCLUSION

In this paper, we simulated the system performance in terms of BER when six types of pilot structures, Type A ~ Type F, were implemented in the system. It is observed that some pilots are orthogonal to each other so that when these pilots are selected in the data transmission the resulting system interference would be at its minimum level. We also proposed and defined the pilot correlation coefficient between a pilot and a reference pilot; it is then imposed the pilots selection rule to minimize the system interference level when pilots are selected as the synchronization control signals for users in their network entry operations and in the estimation of channel impulse response.

ACKNOWLEDGMENT

This work is supported in part by the National Science Council, Taiwan, Republic of China, under Grant No. NSC 97-2219-E-002-017, NSC97-2221-E-032-027-MY3, NSC 97-2221-E-032-002-MY2 and this study is conducted under the "A plan to actively participate in international standard organizations for wireless communications" of the Institute for Information Industry which is subsidized by the Ministry of Economy Affairs of the Republic of China.

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