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| Re: | 802.16m-08/016r1 Call for contributions on project 802.16m system description document (SDD).<br><br>Specific topic : Uplink Pilot Structures |
| Abstract | This contribution proposes the pilot structure for 802.16m |
| Purpose | For discussion and approval by TGm |
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# Propose for Pilot Design in IEEE 802.16m

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## *1. 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.

## *2. Simulation environment*

In Table 1 we list the overall system parameters used in the simulation and consider three types of resource blocks (RB), namely 6 symbols * 18 subcarriers, 18 * 6, 6 symbols * 12 subcarriers, 12 * 6 and 6 symbols * 10 subcarriers, 10 * 6 in the simulation. The detailed 1024 subcarriers allocations for 18*6, 12*6 and 10*6 resource blocks are tabulated in Table 2.

Table 1 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<br>2. 6 symbols * 12 subcarriers<br>3. 6 symbols * 10 subcarriers |
| Coding Rate | 0.5 |
| Pilot Tone Boost | 2.5dB over data tone |
| Channel Estimation | LS |

Table 2 1024 FFT OFMDA Subcarrier Allocation

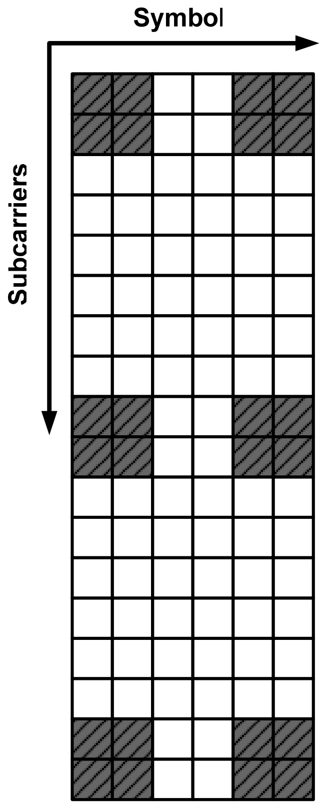
| Type | Parameters | Value |
|---|---|---|
| Type A (18x6) | Number of DC Subcarriers | 1 |
| | Number of Guard Subcarriers: left, right | 80, 79 |
| | Number of Used Subcarriers ($N_{used}$) (including all possible allocated pilots and the DC subcarrier) | 865 |
| | Number of Subchannels ($N_{Subchannels}$) | 48 |
| | Number of Tiles ($N_{tiles}$) | 288 |
| | Number of Subcarriers per Tile | 18 |
| | Tile per Subchannel | 6 |
| Type B (18x6) | Number of DC Subcarriers | 1 |
| | Number of Guard Subcarriers: left, right | 80, 79 |
| | Number of Used Subcarriers ($N_{used}$) (including all possible allocated pilots and the DC subcarrier) | 865 |
| | Number of Subchannels ($N_{Subchannels}$) | 48 |
| | Number of Tiles ($N_{tiles}$) | 288 |
| | Number of Subcarriers per Tile | 18 |
| | Tile per Subchannel | 6 |
| Type C (12x6) | Number of DC Subcarriers | 1 |
| | Number of Guard Subcarriers: left, right | 80, 79 |
| | Number of Used Subcarriers ($N_{used}$) (including all possible allocated pilots and the DC subcarrier) | 865 |
| | Number of Subchannels ($N_{Subchannels}$) | 72 |
| | Number of Tiles ($N_{tiles}$) | 432 |
| | Number of Subcarriers per Tile | 12 |
| | Tile per Subchannel | 6 |

| Type | Parameters | Value |
|---|---|---|
| Type D (10x6) | Number of DC Subcarriers | 1 |
| | Number of Guard Subcarriers: left, right | 92, 91 |
| | Number of Used Subcarriers ($N_{used}$) (including all possible allocated pilots and the DC subcarrier) | 841 |
| | Number of Subchannels ($N_{Subchannels}$) | 84 |
| | Number of Tiles ($N_{tiles}$) | 504 |
| | Number of Subcarriers per Tile | 10 |
| | Tile per Subchannel | 6 |
| Type E (12x6) | Number of DC Subcarriers | 1 |
| | Number of Guard Subcarriers: left, right | 80, 79 |
| | Number of Used Subcarriers ($N_{used}$) (including all possible allocated pilots and the DC subcarrier) | 865 |
| | Number of Subchannels ($N_{Subchannels}$) | 72 |
| | Number of Tiles ($N_{tiles}$) | 432 |
| | Number of Subcarriers per Tile | 12 |
| | Tile per Subchannel | 6 |
| Type F (18x6) | Number of DC Subcarriers | 1 |
| | Number of Guard Subcarriers: left, right | 80, 79 |
| | Number of Used Subcarriers ($N_{used}$) (including all possible allocated pilots and the DC subcarrier) | 865 |
| | Number of Subchannels ($N_{Subchannels}$) | 48 |
| | Number of Tiles ($N_{tiles}$) | 288 |
| | Number of Subcarriers per Tile | 18 |
| | Tile per Subchannel | 6 |

## 3. *Simulation of using various types of resource block*

### *1) Type A RB*

As shown in Fig. 1 it is an 18x 6 resource block with 18 subcarriers and 6 symbols in a resource block with pilot patterns as depicted in the square block in gray. From these pilot patterns we select and consider only seven possible types of pilot pattern, types A1 ~ A7. The system performance, expressed by BER vs. QPSK signal to noise ratio, has the results as shown in Fig. 2(a) - Fig.2(c) for the mobile speed at 3 km,/hr, 60 km/hr and 120 km/hr respectively. For a fixed BER it lists in Table 3, from the results of Fig. 2, the required signal vs. noise ratio to meet the required BER for pilot types A1 ~ A7. By observing this table it finds that with the same pilot pattern density various types of pilot pattern have very close results. Specifically we can use the orthogonal characteristic of Type A3 and Type A4 pilot patterns and select them in the BS communication links so as to reduce the interference influence.



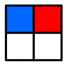
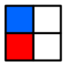
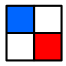
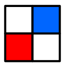
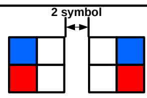
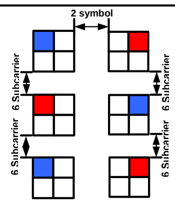
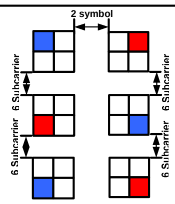
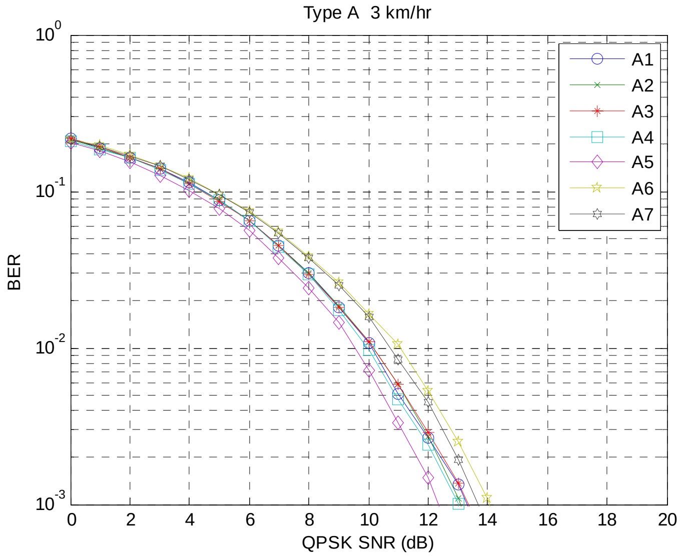
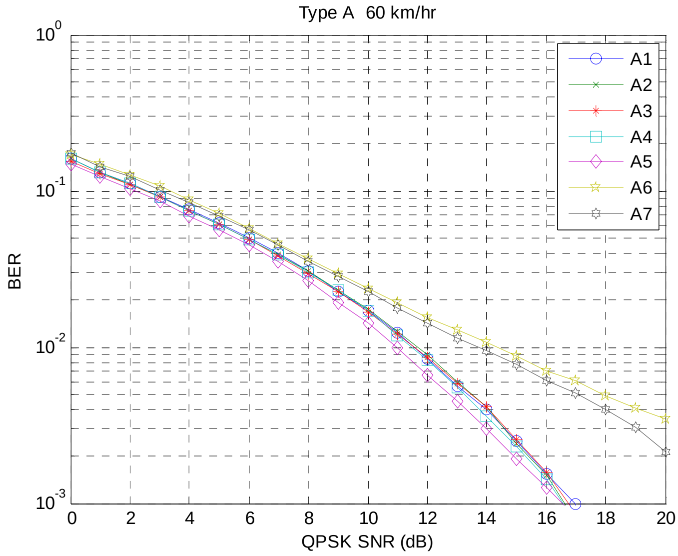

| Type | Pilot Structure | Pilot Density |
|---|---|---|
| A1 |  | 11.11% |
| A2 |  | |
| A3 |  | |
| A4 |  | |
| A5 |   | |
| A6 |   | 5.56% |
| A7 |   | |

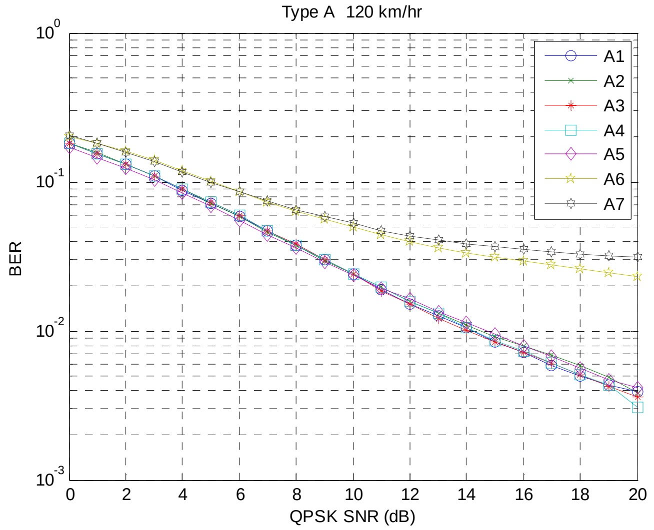
Fig. 1 Different pilot pattern for Type A RB


Type A 3 km/hr
BER
QPSK SNR (dB)
A1
A2
A3
A4
A5
A6
A7

*(a)*


Type A 60 km/hr
BER
QPSK SNR (dB)
A1
A2
A3
A4
A5
A6
A7

*(b)*




*(c)*

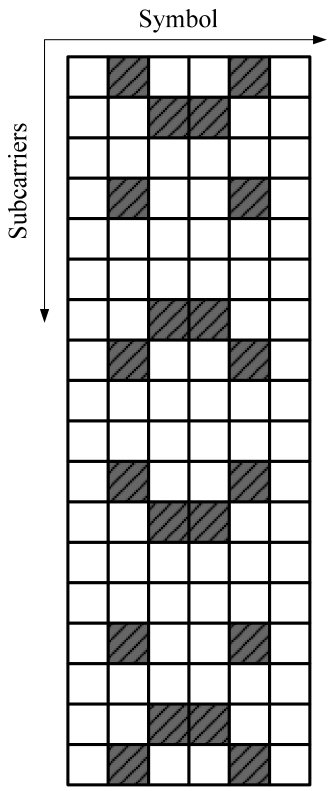
Fig. 2 Simulation Result for Type A RB at (a) 3 km/hr (b) 60 km/hr (c) 120 km/hr

Table 3 Summary of system performance for Type A1~ A7 pilot patterns for Type A resource block

| 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 | |

***2) Type B RB***

As shown in Fig.3, it is an 18x 6 resource block Type B with 18 subcarriers and 6 symbols in a resource block with pilot patterns as depicted in the square block in gray. From these pilot patterns we select and consider only five possible types of pilot pattern, types B1 ~ B5. The system performance, expressed by BER vs. QPSK signal to noise ratio, has the results as shown in Fig. 4(a) – Fig. 4(c) for the mobile speed at 3 km,/hr, 60 km/hr and 120 km/hr respectively. For a fixed BER it lists in Table 4, from the results of Fig.4, the required signal vs. noise ratio to meet the required BER for pilot types B1 ~ B5. By observing this table it finds that with the same pilot pattern density various types of pilot patterns have very close results.



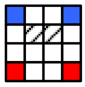
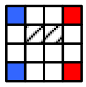
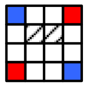
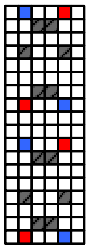
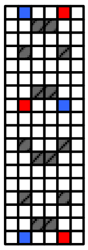
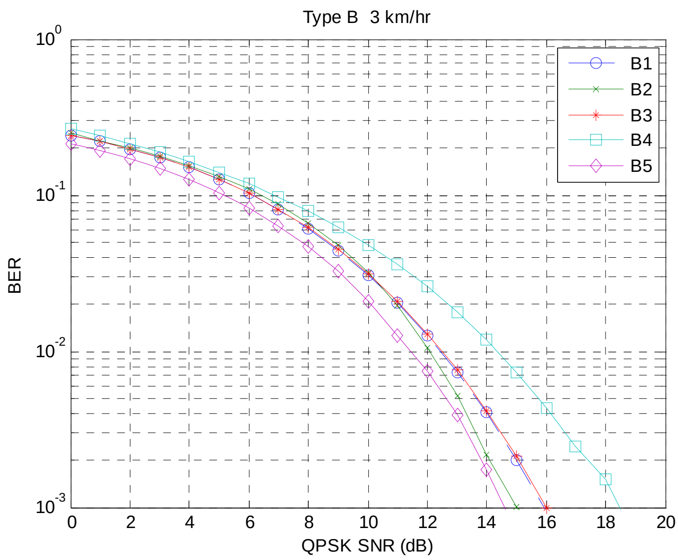
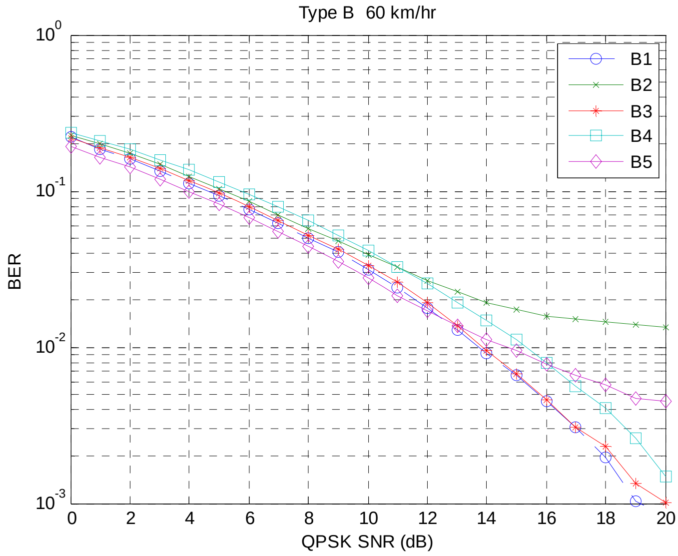

| Type | Pilot Structure | Pilot Density |
|---|---|---|
| B1 |  | 11.11% |
| B2 |  | |
| B3 |  | |
| B4 |  | 7.4% |
| B5 |  | 5.56% |

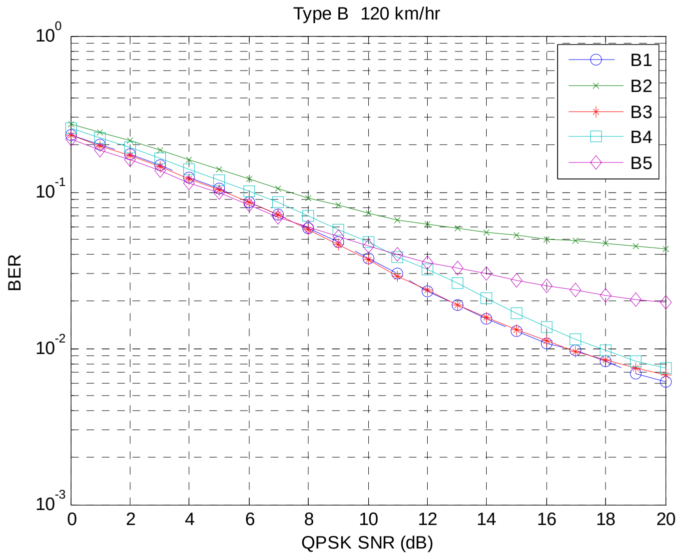
Fig. 3 Different pilot pattern for Type B RB




*(a)*




*(b)*




*(c)*

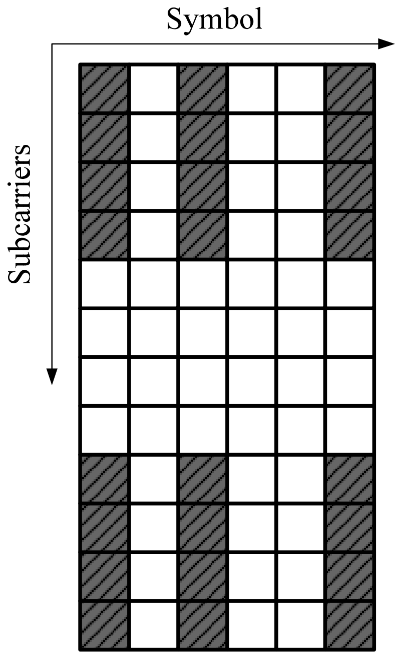
Fig. 4 Simulation Result for Type B RB at (a) 3 km/hr (b) 60 km/hr (c) 120 km/hr

Table 4 Summary of system performance for Type B1~ B5 pilot patterns for Type B resource block

| Type \ Speed | 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 | |

***3) Type C RB***

As shown in Fig.5, it is a 12x 6 resource block Type C with 12 subcarriers and 6 symbols in a resource block with pilot patterns as depicted in the line block in gray. From these pilot patterns we select and consider only six possible types of pilot pattern, types C1 ~ C6. The system performance, expressed by BER vs. QPSK signal to noise ratio, has the results as shown in Fig.6(a)- Fig. 6(c) for the mobile speed at 3 km,/hr, 60 km/hr and 120 km/hr respectively. For a fixed BER it lists in Table 5, from the results of Fig. 6, the required signal vs. noise ratio to meet the required BER for pilot types C1 ~ C6. By observing this table it finds that with the same pilot pattern density various types of pilot patterns have very close results.



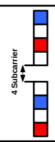
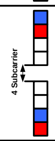
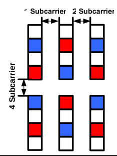
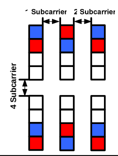
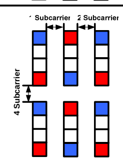
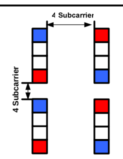
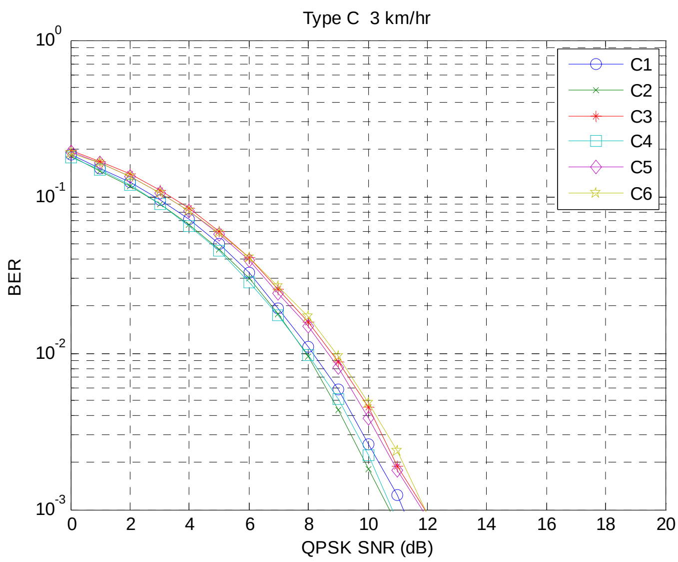
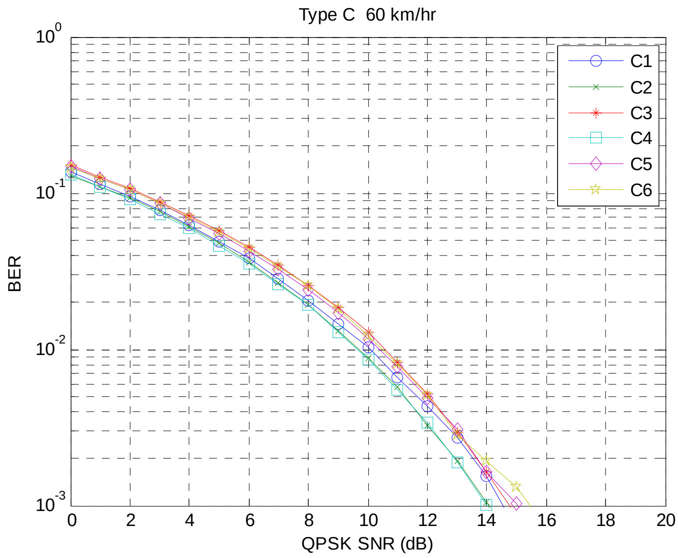

| Type | Pilot Structure | Pilot Density |
|---|---|---|
| C1 |  | 16.67% |
| C2 |  | |
| C3 |  | |
| C4 |  | |
| C5 |  | |
| C6 |  | 11.11% |

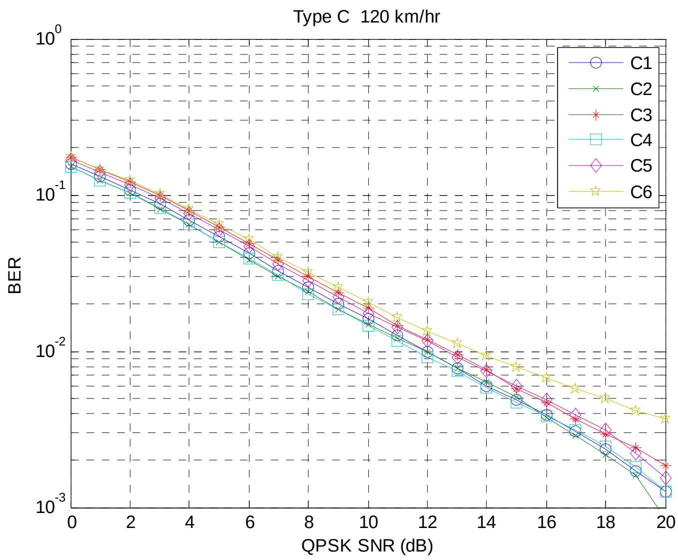
Fig. 5 Different pilot pattern for Type C RB




*(a)*




*(b)*




*(c)*

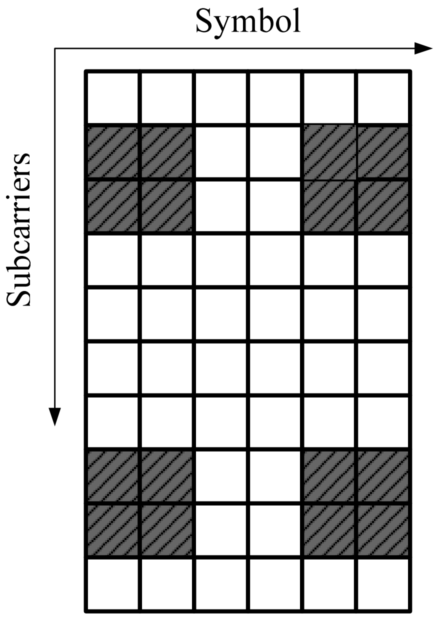
Fig. 6 Simulation Result for Type C RB at (a) 3 km/hr (b) 60 km/hr (c) 120 km/hr

Table 5 Summary of system performance for Type C1~ C6 pilot patterns for Type C resource block

| 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 |

***4) Type D RB***

As shown in Fig.7, it is a 10 x 6 resource block Type D with 10 subcarriers and 6 symbols in a resource block with pilot patterns as depicted in the square block in gray. From these pilot patterns we select and consider only seven possible types of pilot pattern, types D1 ~ D7. The system performance, expressed by BER vs. QPSK signal to noise ratio, has the results as shown in Fig. 8(a) – Fig. 8(c) for the mobile speed at 3 km/hr, 60 km/hr and 120 km/hr respectively. For a fixed BER it lists in Table 6, from the results of Fig. 6, the required signal vs. noise ratio to meet the required BER for pilot types D1 ~D7. By observing this table it finds that with the same pilot pattern density various types of pilot patterns have very close results. Specifically we can use the orthogonal characteristic of Type D3 and Type D4 pilot patterns and select them in the BS communication links so as to reduce the interference influence.



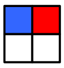
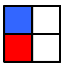
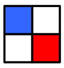
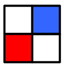
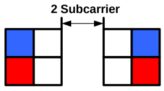
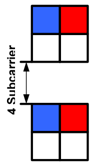
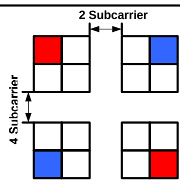
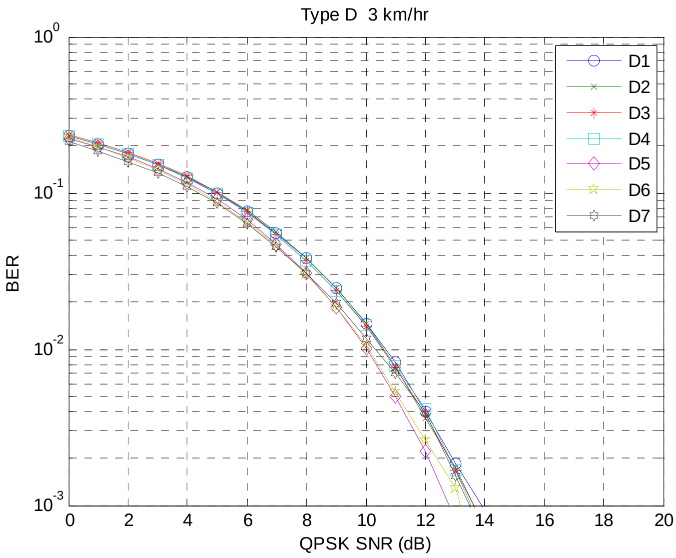
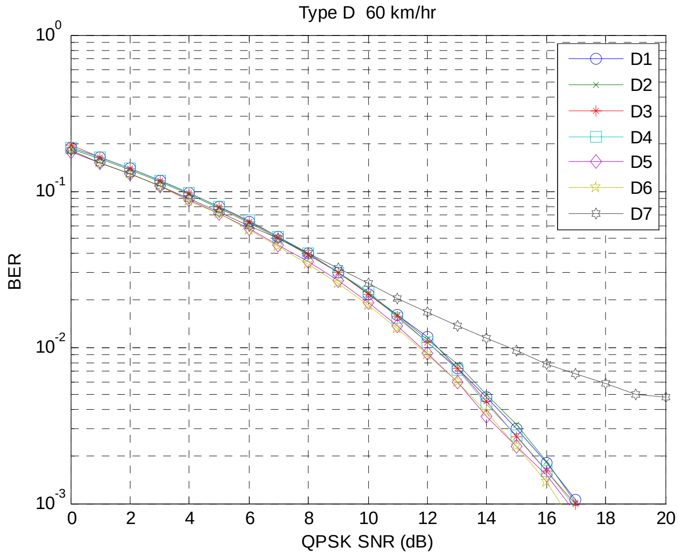

| Type | Pilot Structure | Pilot Density |
|---|---|---|
| D1 |  | 13.33% |
| D2 |  | |
| D3 |  | |
| D4 |  | |
| D5 |   | |
| D6 |   | |
| D7 |   | 6.66% |

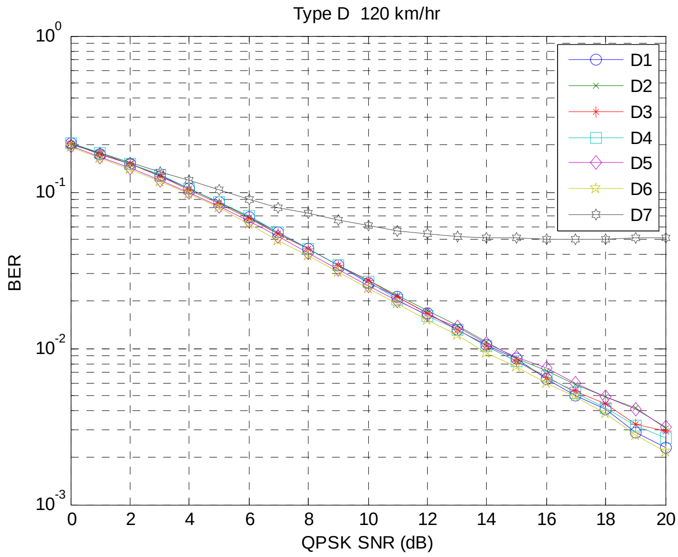
Fig. 7 Different pilot pattern for Type D RB




*(a)*




*(b)*




*(c)*

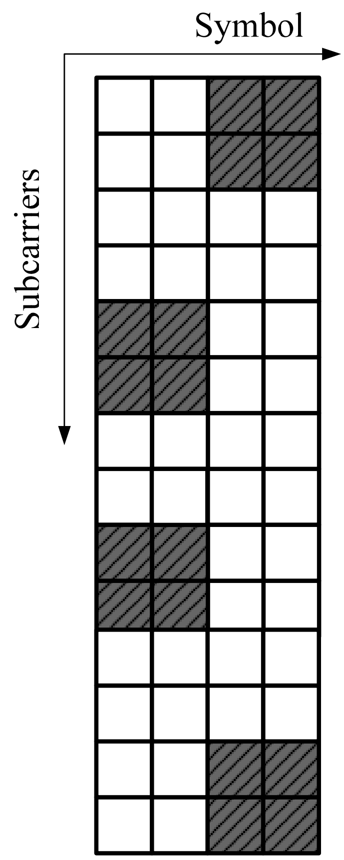
Fig. 8 Simulation Result for Type D RB at (a) 3 km/hr (b) 60 km/hr (c) 120 km/hr

Table 6 Summary of system performance for Type D1~ D7 pilot patterns for Type D resource block

| 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 | |

***5) Type E RB***

As shown in Fig.9, it is a 14 x 2 resource block Type E with 14 subcarriers and 2 symbols in a resource block with pilot patterns as depicted in the square block in gray. From these pilot patterns we select and consider only seven possible types of pilot pattern, types E1 ~ E7. The system performance, expressed by BER vs. QPSK signal to noise ratio, has the results as shown in Fig.10(a)- Fig. 10(c) for the mobile speed at 3 km,/hr, 60 km/hr and 120 km/hr respectively. For a fixed BER it lists in Table 7, from the results of Fig. 10, the required signal vs. noise ratio to meet the required BER for pilot types E1 ~ E7. By observing this table it finds that with the same pilot pattern density various types of pilot patterns have very close results. Specifically we can use the orthogonal characteristic of Type E3 and Type E4 pilot patterns and select them in the BS communication links so as to reduce the interference influence.



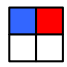
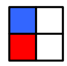
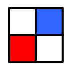
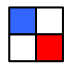
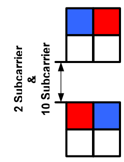
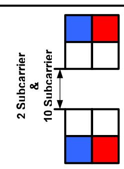
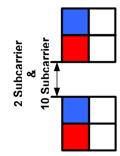
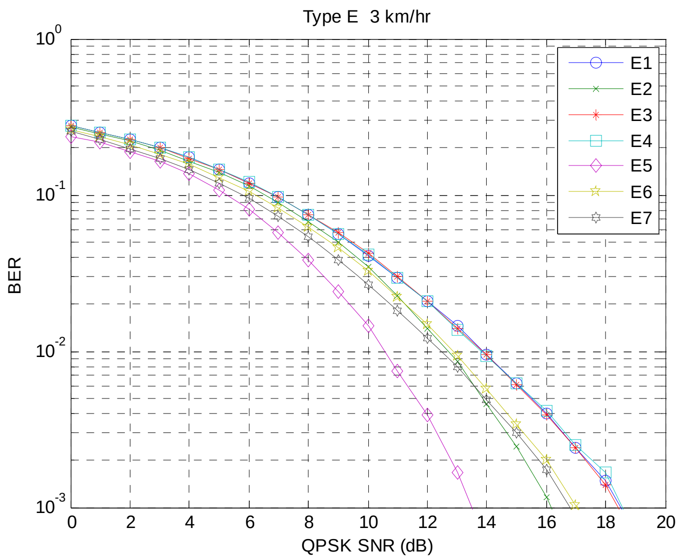
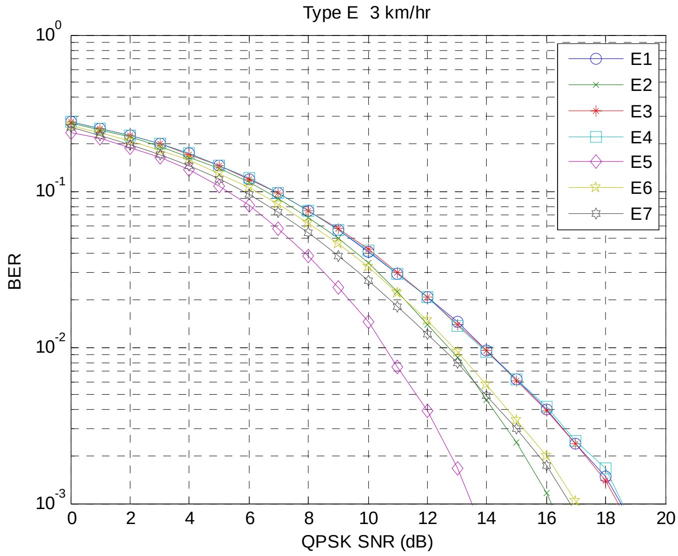

| Type | Pilot Structure | Pilot Density |
|---|---|---|
| E1 |  | |
| E2 |  | |
| E3 |  | |
| E4 |  | |
| E5 |   | 14.28% |
| E6 |   | |
| E7 |   | |

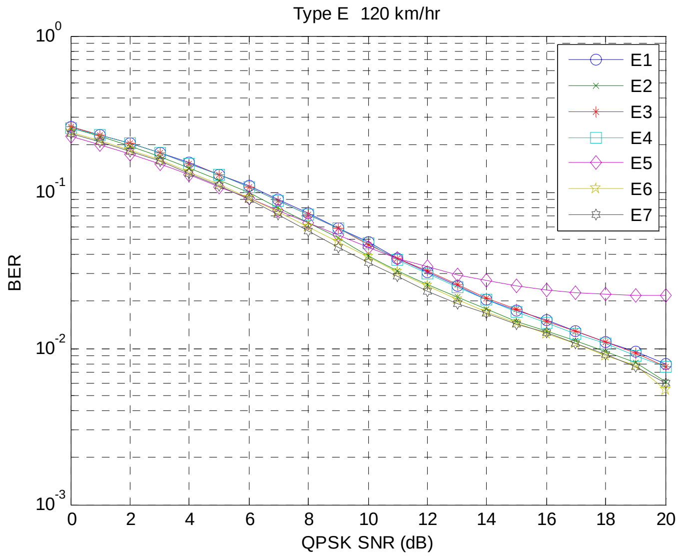
Fig. 9 Different pilot pattern for Type E RB




*(a)*




*(b)*




*(c)*

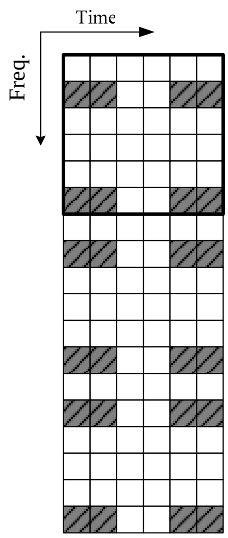
Fig. 10 Simulation Result for Type E RB at (a) 3 km/hr (b) 60 km/hr (c) 120 km/hr

Table 7 Summary of system performance for Type E1~ E7 pilot patterns for Type E resource block

| 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 |

***6) Type F RB***

As shown in Fig.11, it is an 18x 6 resource block Type F with 18 subcarriers and 6 symbols in a resource block with pilot patterns as depicted in the line block in gray. From these pilot patterns we select and consider only sixteen possible types of pilot pattern, types F1 ~ F8. The system performance, expressed by BER vs. QPSK signal to noise ratio, has the results as shown in Fig.12(a)- Fig. 12(c) for the mobile speed at 3 km,/hr, 60 km/hr and 120 km/hr respectively. For a fixed BER it lists in Table 8, from the results of Fig. 6, the required signal vs. noise ratio to meet the required BER for pilot types F1 ~ F8. By observing this table it finds that with the same pilot pattern density various types of pilot patterns have very close results.



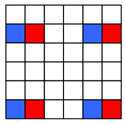
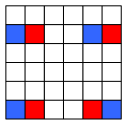
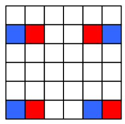
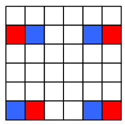
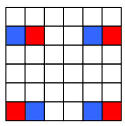
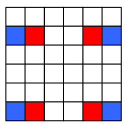
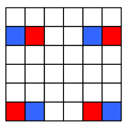
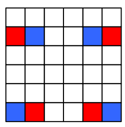
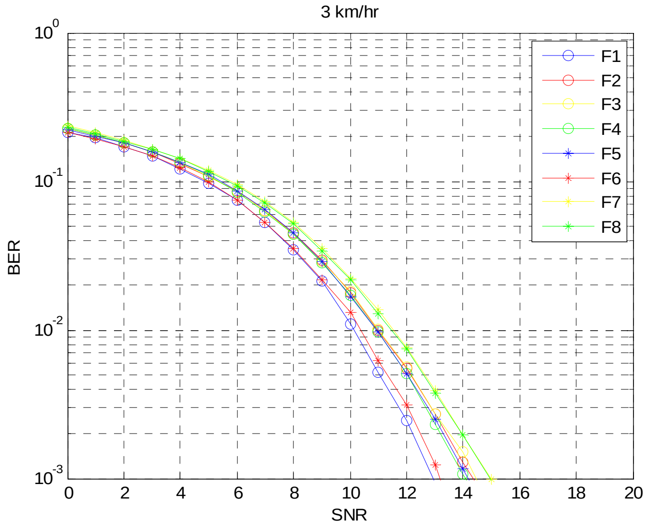
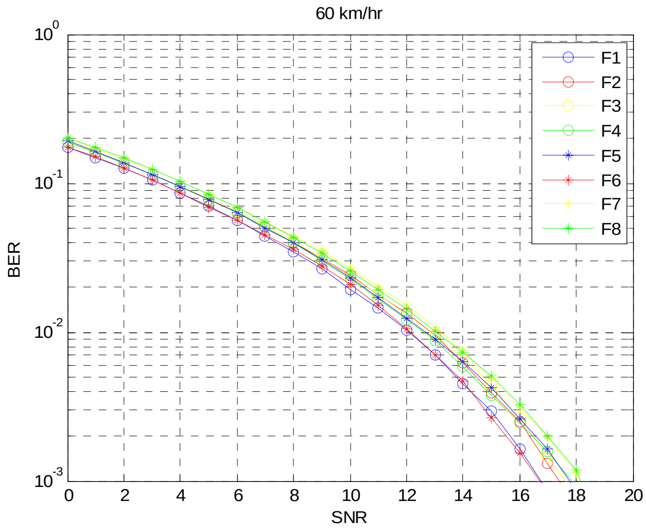

| Type | Pilot Structure | Pilot Density |
|---|---|---|
| F1 |  | 22.22% |
| F2 |  | |
| F3 |  | |
| F4 |  | |
| F5 |  | |
| F6 |  | |
| F7 |  | |
| F8 |  | |

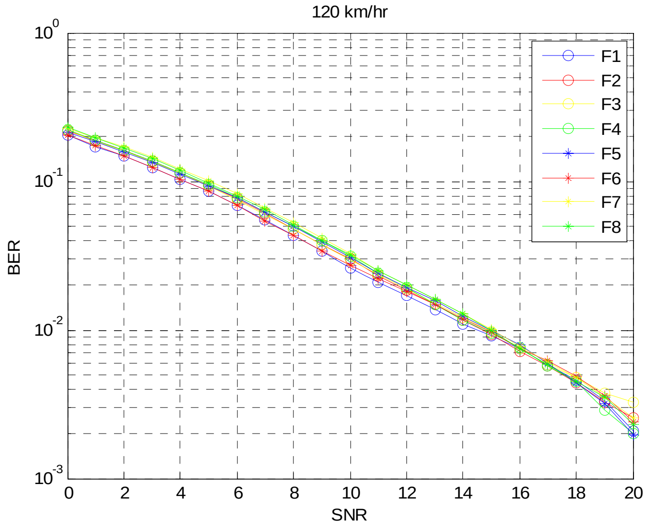
Fig. 11 Different pilot pattern for Type F RB


3 km/hr
BER
SNR
F1
F2
F3
F4
F5
F6
F7
F8

*(a)*


60 km/hr
BER
SNR
F1
F2
F3
F4
F5
F6
F7
F8

*(b)*




*(c)*

Fig. 12 Simulation Result for Type F RB at (a) 3 km/hr (b) 60 km/hr (c) 120 km/hr

Table 8 Summary of system performance for Type F1~ F8 pilot patterns for Type E resource block

| Speed / Type | 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 |

## 4. *Pilot Correlation Coefficient*

As shown in Fig. 17 and Fig. 18, we use the Type A and Type C pilot patterns as examples to illustrate the variations of ‘pilot correlation coefficient’. In Fig. 17 we consider six square pilot blocks with each square block consisting of four pilots. The ‘Basic’ pilot structure is defined as that in the six square pilot blocks each block contains the same pilot patterns. If we change a square pilot block to its corresponding orthogonal square block then the resulting overall pilots have only 20 pilots that have the same patterns as the basic pilot structure and the pilot correlation coefficient is defined as 20/24, designated as the 20/24 pilot structure in the figure. By continuingly invert the pilot patterns in each subsequently four pilots block we can get the pilot structures with pilot correlation coefficients of 16/24 till 0/24, i.e. in the designation of 16/24 it has with 16 pilots having the same pilot patterns with the basic pilot structure and does not have the same pilot patterns with the basic pilot structure in the 0/24 structure. Consequently for a pilot structure denoted as M/24 with 0<=M<=24 it has M pilots in 24 pilots with the same pilot patterns with the basic pilot structure. Similarly in line type pilot structure as in Fig. 18 we can also define a pilot structure that has certain pilot correlation coefficient comparing with the basic pilot structure. Consequently if we use the Type A pilot structure in Fig. 17 as an example it has a total possible pilot permutations of $6^6$(46656) and if we assign each pilot combination as an user ID, i.e. each pilot structure is an user ID then we can not only select certain pilot structures to guarantee low level of interference in the data transmission between MS and BS but also to have a systematic management and distribution of the users.

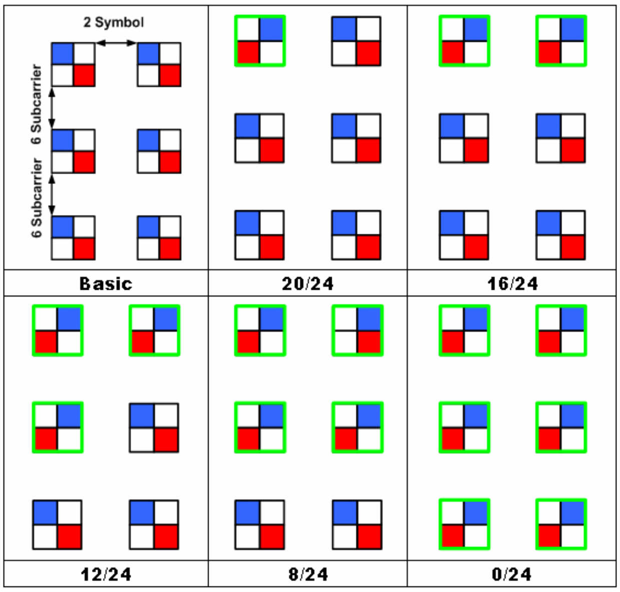



Fig. 17 Certain pilot structures with different pilot correlation coefficient for square type pilot

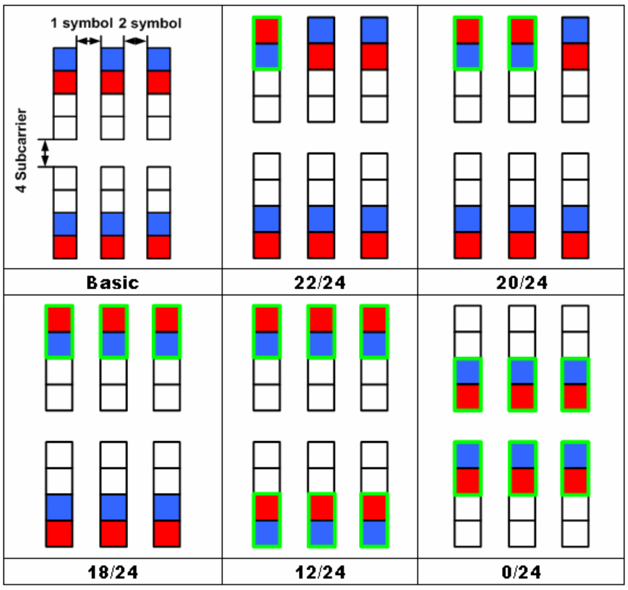



Fig. 18 Certain pilot structures with different pilot correlation coefficient for line type pilot

## 5. *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.

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