International Journal of Applied Engineering Research ISSN 0973-4562 Volume 12, Number 24 (2017) pp. 14403-14407

Research on Various Pilot Pattern Design for Channel Estimation in OFDM System

A B Bambhaniya
Assistant Professor, Electronics and Communication Department,
Birla Vishvakarma Mahavidyalaya Engineering College, Vallabh Vidyanagar, Gujarat, India.
Orcid Id: 0000-0003-1508-8837

J M Rathod
Associate Professor, Electronics Engineering Department,
Birla Vishvakarma Mahavidyalaya Engineering College, Vallabh Vidyanagar, Gujarat, India.
Orcid Id: 0000-0001-6474-2386

Abstract

OFDM is a very much important scheme for wireless communication. Various pilot patterns and each pattern have various in effects on Bit Error Rates (BER), efficiency and Symbol Error Rates (SER). Pilot is a reference signal employed by both transmitter side and receiver side**.** Select particular pilot pattern and can be reduced BER, SER, and also increase efficiency. Finding pilot pattern design and how many pilot symbols are required for inserting. Studying and analyzing with different available pilot patterns. Particular applications have required particular types of pilot patterns. With efficient pilot placement can get good result and improve efficiency, reduce BER and SER. Also reduce the computational complexity with particular pilot allocation.

Keywords: OFDM, wireless communication, pilot patterns, channel estimation, Inter-symbol interference.

INTRODUCTION

OFDM is important scheme in wireless channels. It is a parallel transmission technique so increase data levels. Some change makes at receiver and converts a big channel into narrow parallel small channels. It is known sub-channels. The whole bandwidth will be divided into small bandwidth. Here time domain waveforms are orthogonal, so the overlap sub-carriers in frequency domain. Due to overlap, the total bandwidth is used effectively using OFDM systems. Some applications of OFDM are in DAB, HDTV, Wireless LAN, LTE and LTE advanced etc. [1].

In wireless environment, information will be transmitted, reaches at receiver through a channel. Because of channel effect, noise and multipath fading, signal which will be scattered in time domain and frequency domain. So the original signal looks very difference in the frequency and time domain. This can drop using with estimation Different techniques are proposed. The pilot-assisted scheme has been important method in wideband mobile channels. Thus, Pilot-assisted is mostly used today [2]. Now, many channel estimation methods are available. From this only three methods are well-known which are Pilot based, semi blind and blind based. Pilot pattern will be based on the using training data, which is pilot inserted with original data, sent from transmitter and it is known a priori at the receiver [3].

SYSTEM MODEL

Today OFDM is very powerful role in wireless communication. Using OFDM, send more data with good efficiency. OFDM is a parallel modulation technique. Instead of data transmitting serially at a high-speed with a single carrier, using an OFDM modem organize the data into *N* lower rate sub-streams and send the data in the different sub-streams at with different carrier frequencies.

Here figure 1 shows OFDM system with block diagram. In this system, after insertion of pilot between data sequence, it is in frequency domain at the transmitter, the result data will be modulated by IDFT on N parallel subcarrier which converts in time domain. At receiver side it will be transformed back to frequency domain by DFT. Every subcarrier will be formulated as follows [4]:

$$S_b(t)=A_b(t)\, e^{i[wct+\phi c(t)]} \qquad (1)$$

Where, A_b (t) and Φ_c (t) are respectively amplitude and phase. Get different values in different symbols for A_b (t) and Φ_c (t). Signal of OFDM subcarrier will be described as follows:

$$S_b(t)=\frac{1}{N}\sum_{n=0}^{N-1} An(t)\, e^{j[Wn+\varnothing n(t)]} \qquad (2)$$

Where $w_n = w_o + n\Delta w$

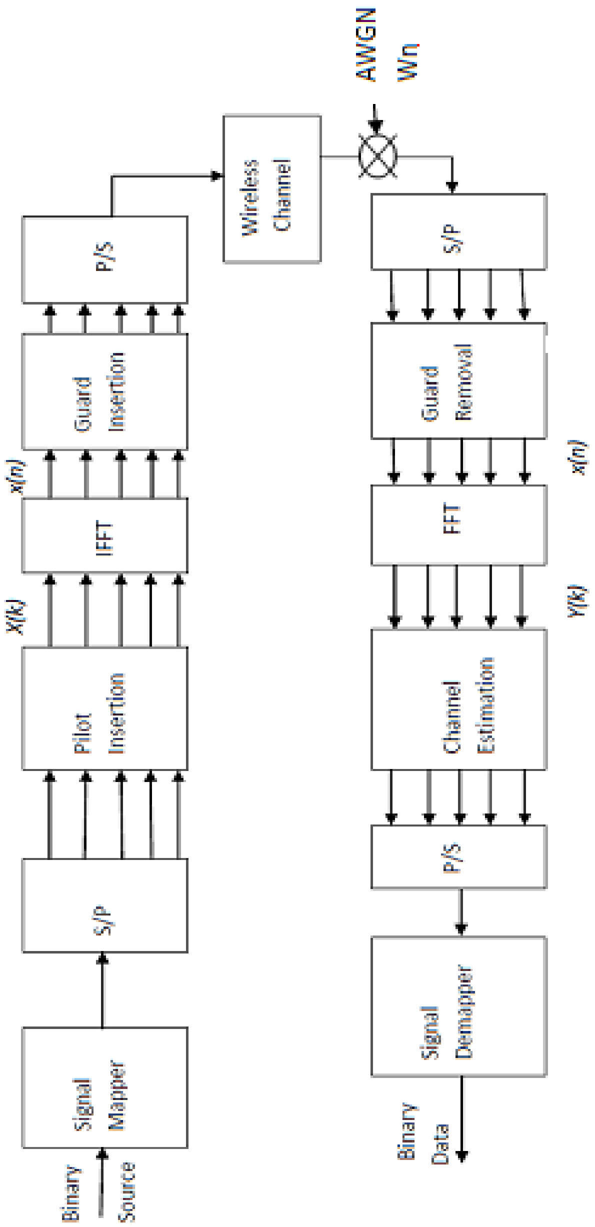

Figure 1: OFDM System [1]

Using cyclic prefix, in OFDM, it can protect from ISI and ICI.

The transmitted data, because of channel and noise, received data is as follows:

$$y_o(n)=x_i(n)\otimes h_i(n)+w_i(n) \quad (3)$$

Where, x_i is the transmitted data, y_o is the received signal, and ω_i is the AWGN. Equation (4) shows after received signal, removing cyclic prefix with applying FFT on it.

$$Y_o(k)=X_i(k)H_i(k)+W_i(k) \quad (4)$$

Here W_i and H_i are the Fourier transform of the w_i and h_i respectively. Pilot subcarrier will be estimated channel and interpolation; data will be detected as follows:

$$X_i(k)=Y_i(k)/H_i(k) \quad (5)$$

Here, Y_i (k) is Fourier transform of y_o (n). X_i (k) is the transmitted data and $H_i(k)$ is the estimated channel respectively.

Here channel estimations are available in various types. Out of many methods, LS and MMSE method are most popular methods. In LS, is very simple but the problem is that it high mean square error (MSE) [4].

Pilot Design

Here the design, where and how many pilot symbols will be inserted in it. Interval of pilot will be adjusted small, so that it can track efficient for the frequency selection and time-varying in channel. From this make decision with using BER [5], [6]. How to design?

The Pilot Interval

Here two important parameters like the first is maximum multipath delay and second is τ_m maximum doppler frequency offset fm. The Nyquist's theory, time and frequency intervals should meet respectively the following formulas.

$$N_f \approx 1/\ 2\Delta f \tau_{max} \quad (6)$$

$$Nt \approx\ 1/2 f_m L_s \quad (7)$$

Here L_s is OFDM symbol length and Δf is the sub-carrier frequency interval.

Practical, equations (6) and (7) will be re-written respectively in modified to

$$N_f \approx \tfrac{1}{2} \bullet 1/\ 2\Delta f \tau_{max} \quad (8)$$

Optimal pilot number

The total pilots numbers in one frame will be calculated

$$Nt \approx \tfrac{1}{2}\ \bullet 1/2 f_m L_s \quad (9)$$

Here also consider the phase noise and oscillating frequency drift [5].

$$N_{grid} = [N_{sc}/Nf] * [N_s/Nt] \qquad (10)$$

Where N_{grid} is the pilot symbols number, Ns is the OFDM signal number and N_{sc} is the number of subcarrier, in one frame, and [.] stands for floor operation. Using equation (10) chooses the optimal pilot symbols to estimate channel [7].

Criterion for performance evaluation

Frequency resource will waste because of pilot insertion. The overhead will be expressed as

$$\wedge = \frac{Ngrid}{N_{sc}*N_s} \qquad (11)$$

The loss of SNR is [6]

$$V_{pilot}=10 \lg \frac{(1)}{1-\wedge} \qquad (12)$$

The BER is [7],

$$BER = \frac{\text{The number of error bit}}{\text{The total number of transmission bit}} \qquad (13)$$

The efficient data transmission rate

We insert the more pilot, the better estimation performance it will be. But the system overhead will be larger. On the contrary, the less pilot we insert, the worse estimation performance it will be. But the system overhead will be smaller. How to counterpoise the both? Besides the BER criteria, it must combine with the other factors (such as the inserted pilot number and the unmistakable data transmission rate). So we define a new parameter DTR, that is, data transmission rate in one frame, just as [7].

$$DTR= \frac{\text{The data symbols number in one frame}}{\text{The total symbols in one frame}} \qquad (14)$$

Or

$$DTR= \frac{\text{The data symbols number in one frame}}{\text{The data symbols number in one frame + pilot symbols number in one frame}} \qquad (15)$$

Based on it, the other new parameter EDTR (efficient data transmission rate) will be defined in one frame as

$$EDTR = DTR *(1-SER) \qquad (16)$$

Where SER=symbol error rate

Present Pilot Pattern

For different channels applications, select different pilot patterns.

Comb-type pilot

By periodical pilots inserting at subcarrier in every OFDM block called a Comb-type shows that figure 2.

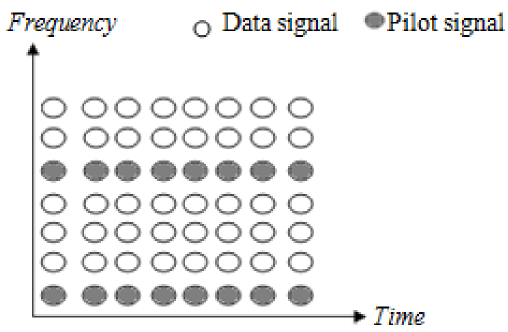

Figure 2: Comb-type arrangement

Comb type pilot is useful in the fast fading. So it is applicable to the fast fading channel application but not for slow fading [3].

Block-type pilot.

In this type, estimation symbols are sending periodically, so all sub-carriers are used as pilots which are shown in figure 3. From the figure, it is used for slow fading channel but not fast fading [3].

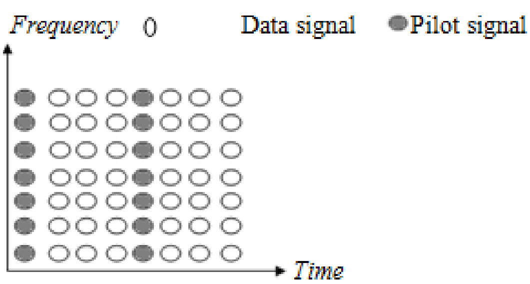

Figure 3: Block-type arrangement

Hybrid-type pilot

Combination of comb and block type pilots which are shown in figure 4. It increases the frequency efficiency capability and channel tracking. But more computer complexity [5], [8].

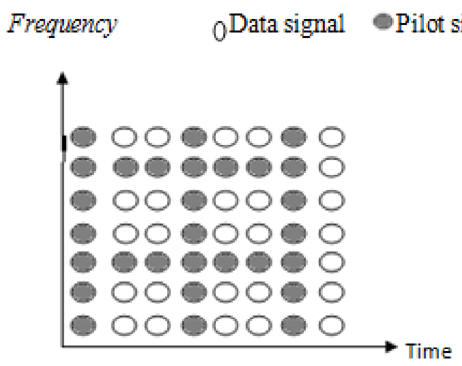

Figure 4: Hybrid pilot structure

During transmitting, OFDM symbols inserted in each sub channel and every frame should have multiple pilot symbols [5].

Scattered-type pilot

With Nyquist, insert pilot from time and frequency domains that is shown in figure 5. It has advantage that it has because of small pilot symbol numbers; spectral use is high but increased computer complexity and difficult to realize it [5].

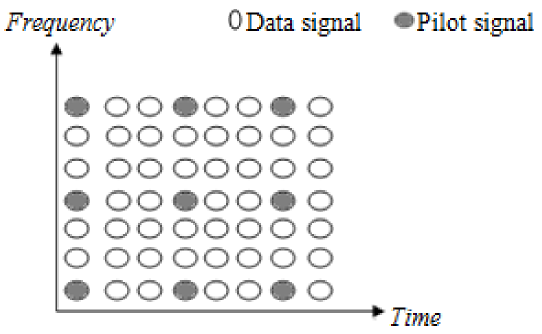

Figure 5: Scattered-type pilot

Diagonal-type pilot

Pilot symbols will be inserted linearly, so full use of information of the frequency and time domains. It reduces computer complexity compared with the Wiener filtering algorithm [3]. Pilot-symbol in doubly selective channel estimation, diamond-shaped pilot is optimal Mean Square Error [9], [10], [11]. It is shown in figure 6.

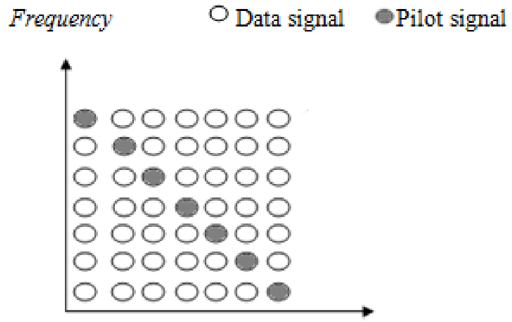

Figure 6: Diagonal-type pilot

Clustered-type pilot

Two neighbouring grouped pilots as one cluster and will be spaced equal [12], [13] as shown in figure 7. Equi powered and spaced pilot symbols will be led to smallest MSE [14]. It advantage is that it decrease half power noise in the pilot sub channel estimation [3].

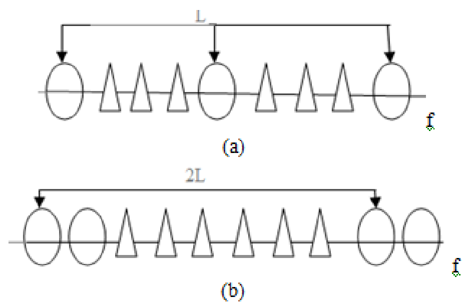

Figure 7: (a) Equi-spaced pilots, (b) clustered pilots

New pilot pattern will be designed with clustered; the pilots can shifts every block [15]. Efficient pilot placement will be possible for compressed sensing based channel estimation [9]. What is the method to select between nearby pilot-symbols distance and data symbol distribute power between same times [14]. Different types of interpolation available likes low pass linear, second order, time domain and spline cubic etc. [16]. The Least Square estimator is easy to implement but it has less complexity but not good performance while the other MMSE estimator has good performance with compare LS but disadvantage is that it has high complexity [17]. Now computational complexity is also problem. Therefore placement of pilot allocation will be reduced computational complexity [18].

CONCLUSION

In this paper, shown the design of different pilot patterns and implementing with channel estimation, improvement is possible to get good efficiency, high precision and less complexity. Particular application has particular pilot design is required. Compressed sensing (CS) is one of a new technology. It is very much useful in pilot pattern design. Using CS, get the same performance with less pilots and so efficiency will increase. It is very much useful in MIMO-OFDM.

REFERENCES

[1] Sinem Coleri, Anuj Puri, Mustafa Ergen and Ahmad Bahai. "Channel Estimation Techniques Based on Pilot Arrangement in OFDM Systems". IEEE Transactions On Broadcasting, 48 (2), pp. 223-229, 2002.

[2] Mehmet Kemal Ozdemir and Huseyin Arslan. "Channel Estimation For Wireless OFDM Systems". IEEE Communications Surveys & Tutorials, 9(2), pp. 18-48, 2007.

[3] R. Hajizadeh, M.R. Tarihi and K Mohamedpor. "Channel Estimation in OFDM System Based on the Linear Interpolation". FFT and Decision Feedback, 18th Telecommunications forum TELFOR 2010 Serbia, Belgrade, pp. 484-488, 2010.

[4] A B Bambhaniya and J M Rathod. **"**Channel Estimation Techniques used in OFDM System for Different Modulation Techniques: an overview". International Journal of Scientific Research, 2(4), pp. 48-51, 2013.

[5] Qun Yu and Ronglin Li. "Research on Pilot Pattern Design of Channel Estimation". Journal of Automation and Control Engineering, 1(2) , 2013.

[6] Rohit Negi and John Cioffi. "Pilot Selection for Channel Estimation in a Mobile OFDM system". IEEE Transactions On Consumer Electronics, 44(3), pp. 1122-1128, 1998.

[7] Qun YU, R.L. LI and Suili FENG Haisheng LIN. " Optimal Pilot Pattern for Channel Estimation by Channel Parameter in OFDM System". Journal of Computational Information Systems , pp. 5083–5092, 2014.

[8] Qun Yu1, Weihai Liu1, Suili Feng1 , Ziyun Shao and Yier Yan. " Channel Estimation Based on Diagonal Pilot in OFDM Systems". International Conference on Information and Automation Lijiang, China, 2015.

[9] V. Nagendra Babu, V. Adinarayana, K. Muralikrishna and P. Rajesh Kumar. "An Improved Compressed Sensing based Sparse Channel Estimation for MIMO-OFDM Systems with an Efficient Pilot Insertion Scheme". Indian Journal of Science and Technology, 9(20), pp. 1-7, 2016.

[10] Michal Simko, Paulo S. R. Diniz, Markus Rupp and Qi Wang, "Adaptive Pilot-Symbol Patterns for MIMO OFDM Systems". IEEE transactions on wireless communications, 12(9), pp. 4705-4715, 2013.

[11] Ji-Woong Choi and Yong-Hwan Lee. "Optimum Pilot Pattern for Channel Estimation in OFDM Systems". IEEE Transactions on Wireless Communications, 4(5), pp. 2083-2088, 2005.

[12] My Abdelkader Youssefi and Jamal El Abbadi. "Optimal Pilot-Symbol Patterns For MIMO OFDM Systems Under Time Varying Channels". Journal of Theoretical and Applied Information Technology , 65 (1) ,pp. 183-191, 2014.

[13] Wei Zhang, Xiang-Gen Xia, and P. C. Ching. "Optimal Training and Pilot Pattern Design for OFDM Systems in Rayleigh Fading". IEEE Transactions On Broadcasting, 52 (4) , pp. 505-514, 2006.

[14] Michal ˇSimko, Qi Wang, Markus Rupp and Paulo S. R. Diniz. "New Insights in Optimal Pilot Symbol Patterns for OFDM Systems". Published in proceeding of WCNC 2013, Shanghai, China, 2013.

[15] Darshan V. Adakane and K. Vasudevan,. "An Efficient Pilot Pattern Design for Channel Estimation in OFDM Systems". IEEE, 2013.

[16] Zhang Zhenchuan and Ma Mingzhuo. "Research on Pilot-Aided Channel Estimation Techniques in OFDM System". IEEE conferenance, 2011.

[17] Jan-Jaap van de Beek, Sarah Kate Wilson, Magnus Sandell, Ove Edfors and Per Ola BÄorjesson. "On Channel Estimation in OFDM Systems". Published in Proc. IEEE Vehicular Technology Conference, 2 ,1995.

[18] Roozbeh Mohammadian., Arash Amini and Babak, Hossein, Khalaj., "Compressive Sensing-Based Pilot Design for Sparse Channel Estimation in OFDM Systems." IEEE Communications Letters, Vol. 21(1), pp. 4-7, 2017.