INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact factor: 4.295
(Volume 4, Issue 2)
Available online at: www.ijariit.com

Channel estimation in MIMO-OFDM using the blind adaptive technique

Chandaka Yuva Lalitha
chandakalalitha25@gmail.com
Gayatri Vidya Parishad School of Engineering, Visakhapatnam, Andhra Pradesh

Moyyi Padmalatha
mpaddu717@gmail.com
Gayatri Vidya Parishad School of Engineering, Visakhapatnam, Andhra Pradesh

Pabbisetty Mukesh Sai
mukeshsai96@gmail.com
Gayatri Vidya Parishad School of Engineering, Visakhapatnam, Andhra Pradesh

Sigatapu Vamsi Krishna
vamsikrishnasigatapu@gmail.com
Gayatri Vidya Parishad School of Engineering, Visakhapatnam, Andhra Pradesh

Myla Sai Sandesh
sandesh3112@gmail.com
Gayatri Vidya Parishad School of Engineering, Visakhapatnam, Andhra Pradesh

G. S. B. Raghavendra
raghavendra@gvptc.edu.in
Gayatri Vidya Parishad School of Engineering, Visakhapatnam, Andhra Pradesh

ABSTRACT

A new blind channel estimation scheme for orthogonal frequency division multiplexing systems is proposed based on the maximum likelihood principle. In the Blind channel estimation scheme, the blind channel estimator is proposed based on the noise subspace method and establishes conditions for blind channel estimation in spatially multiplexed MIMO-OFDM systems. A novel approach is also proposed for resolving the phase ambiguity of the blind channel estimate without the need for any reference symbols. Simulations were performed for mobile radio environments with high Doppler frequencies and short-to-medium delay spreads. The achieved performance is comparable to that of pilot-based channel estimation for the case of QPSK-modulation.

Keywords: *Channel estimation, Blind channel estimation, MIMO-OFDM systems, Doppler frequencies, QPSK- modulation.*

1. INTRODUCTION

Recently, increasing interest has been concentrated on modulation techniques that provide high data rates over broadband wireless channels for applications, including wireless multimedia, wireless Internet access, and future-generation mobile communication systems. Orthogonal frequency division multiplexing (OFDM) is a promising digital modulation scheme to simplify the equalization in frequency-selective channels. The main benefit is that it simplexes implementation, and it is robust against the frequency-selective fading channels. Multiple-input multiple-output (MIMO) communication, enabled by multiple transmits and receives antennas, can increase the channel capacity. Thus, MIMO-OFDM systems which combine the OFDM with MIMO communication can provide a high-performance transmission.

In a MIMO-OFDM system, coherent signal detection requires a reliable estimate of the channel impulse responses between the transmitter and receiver antennas.These channels can be estimated by sending training sequences or channel is estimated using Blind estimation method.

2. ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING (OFDM)

OFDM, as a multi-carrier modulation technique, overcomes the main problem arising from high-data-rate communications, known as time dispersion. In OFDM systems, the subcarrier frequencies are chosen in such a way that there is no impact on other subcarriers in the detection of the information in a subcarrier when the orthogonality of the subcarriers is maintained. The data-bearing symbol stream is split into several lower-rate streams and these streams are transmitted on different subcarriers. Since this increases the symbol period by the number of overlapping subcarriers, multipath echoes will affect only a small portion of the neighboring symbols. Remaining ISI can be removed by cyclically extending the OFDM symbol. The length of the cyclic extension should be at least if the maximum delay spread of the channel. In this way, OFDM reduces the effect of multipath propagation encountered with high data rates and avoids the need for complex equalizers.

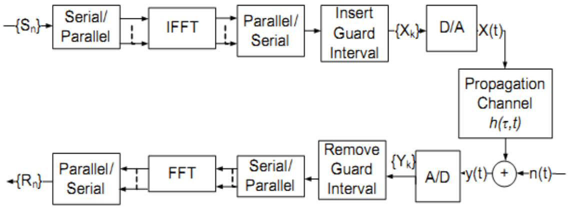

Fig -1: MIMO-OFDM Block Diagram

3. MIMO-OFDM

The quality of a wireless link can be described by three parameters, namely the transmission rate, the transmission range and the transmission reliability. Conventionally, the transmission rate may be increased by reducing the transmission range and reliability. By contrast, the transmission range may be extended at the cost of a lower transmission rate and reliability, while the transmission reliability may be improved by reducing the transmission rate and range. However, with the advent of MIMO assisted OFDM systems, the above mentioned three parameters may be simultaneously improved. Initial field tests of broadband wireless MIMO OFDM communication systems have shown that an increased capacity, coverage and reliability are achievable with the aid of MIMO techniques. Furthermore, although MIMOs can potentially be combined with any modulation or multiple access techniques, recent research suggests that the implementation of MIMO-aided OFDM is more efficient, as a benefit of the straightforward matrix algebra invoked for processing the MIMO OFDM signals.

4. MIMO CHANNEL MODELS

Insufficiently rich multipath environments, the channel capacity can be significantly increased by using multiple antennas at both the transmitter and the receiver sides of the link. MIMO technique brings a relevant increase not only in capacity but also in coverage, reliability, and spectral efficiency. In a MIMO system, the transmission channel is described by means of a matrix instead of a vector, and the spatial correlation properties of the channel matrix define the number of available parallel channels for data transmission. Depending on the channel gains of the parallel channels, the MIMO channel can have much higher channel capacity as compared to a single-input-single-output (SISO) channel in the same frequency range and with the same total transmit power. The performance of such a system is largely determined by the MIMO channel characteristics. Hence it is critical to study channel models that accurately reflect realistic behaviors.

5. TIME-INVARIANT FADING CHANNELS

Because of the multiplicity of factors involved in propagation in a cellular mobile environment, it is convenient to apply statistical techniques to describe signal variations. In a narrowband system, the transmitted signals usually occupy a bandwidth smaller than the channel's coherence bandwidth, which is denied as the frequency range over which the channel fading process is correlated. That is, all spectral components of the transmitted signal are subject to the same fading attenuation. This type of fading is referred to as frequency non-selective. There is the scope for involving the various type of fading channels likeRayleigh fading channel, spatial channel fading but, in this thesis, we use Rayleigh fading channel because it deals with multipath fading.

6. RAYLEIGH FADING

We consider the transmission of a single tone with constant amplitude. In a typical land mobile radio channel, we may assume that the direct wave is obstructed, and the mobile unit receives only reflected waves. When the number of reflected waves is large, according to the central limit theorem, two quadrature components of the received signal are uncorrelated Gaussian random processes with a zero mean and varianceσ_s^2. As a result, the envelope of the received signal at any time instant undergoes a Rayleigh probability distribution and its phase obeys a uniform distribution between -π and π. The probability density function (pdf) of the Rayleigh distribution is given by

$$p(a) = \begin{cases} \frac{\boldsymbol{a}}{\sigma_s^2}\boldsymbol{e}^{-\boldsymbol{a}^2/2\sigma_s^2} & a \geq 0 \\ 0 & a < 0 \end{cases}$$

In fading channels with a maximum Doppler shift of $f_{d_{max}}$the received signal experiences a form of frequency spreading and is band-limited between $f_c \pm f_{d_{max}}$

Assuming an Omnidirectional antenna with waves arriving in the horizontal plane, many reflected waves and a uniform received power over incident angles, the power spectral density of the faded amplitude, denoted by$|P(f)|$, is given by

$$|P(f)| = \begin{cases} \dfrac{1}{2\pi\sqrt{{f_{d_{max}}}^2 - f^2}} & if\ |P(f)| < |f_{d_{max}}| \end{cases}$$

7. CHANNEL ESTIMATION IN MIMO-OFDM

The principle of synchronized (coherent) detection is mainly used in the existing wireless communication systems. In other words, the channel state is estimated, and the estimate is used in the detection and decoding as if it was the true channel state. Channel estimation can be avoided by using different modulation techniques. However, this would limit the data rate and cause a drop in the performance. Another possibility, especially in systems with time division duplex (TDD) but also with frequency division duplex (FDD), is to perform channel estimation at the base station and send a pre-distorted signal to the mobile. However, in fast fading channels, the pre-distortion would be uncorrelated with the channel, causing degradation in the performance. Channel estimation for wireless systems is a challenging problem and the literature treating channel estimation in wireless systems is vast. Channel estimation methods for OFDM systems could be grouped into two main categories: blind and non-blind methods. The blind methods require a large amount of data since they use the statistical behavior of the received signal to estimate the channel. The non-blind channel estimation schemes can be further categorized into data-aided (DA) and decision directed (DD) channel estimation methods.

8. BLIND CHANNEL ESTIMATION TECHNIQUES

Transmitting the training sequences is undesirable for certain communication systems. Thus, blind channel estimation for MIMO-OFDM systems has been an active area of research in recent years. Zhou et al. proposed a sub-space based blind channel estimation method for space-time coded MIMO-OFDM systems using properly designed redundant linear precoding and the noise subspace methods. A variety of second-order statistics (SOS)-based blind estimators have been presented since Tong et al. Introduced an SOS-based technique for the blind identification of single-input multiple-output systems. Among those methods, the noise sub-space method is believed to be one of the most promising due to its simple structure and superior performance. Thus, by exploiting the fundamental structure of the noise subspace method, sub-space methods for single-input-single-output (SISO) OFDM systems have been proposed and achieved good estimation performance. Muquetetal Developed a sub-space method for SISO-OFDM systems by utilizing the redundancy introduced by the cyclic prefix (CP) insertion and derived a condition for channel identifiability.

9. CHANNEL ESTIMATION IN MIMO-OFDM USING TRAINING BASED SEQUENCE

Here Training-based channel estimation scheme is used, which is based on the training data sent the transmitter and known *a* priority the receiver and the overall channel from source to destination are estimated at the destination only. A non-statistical Least Square (LS) estimation technique is used in obtaining the Channel State information (CSI). But it is seen that several antennas used in the system increase the performances of LS estimation deteriorates and this will degrade the performance of the system.

10. MIMO-OFDM SYSTEM MODEL

A discrete MIMO-OFDM system is considered with *N* transmitting antennas, *M* receiving antennas and *L* subcarriers as shown in Fig. 2

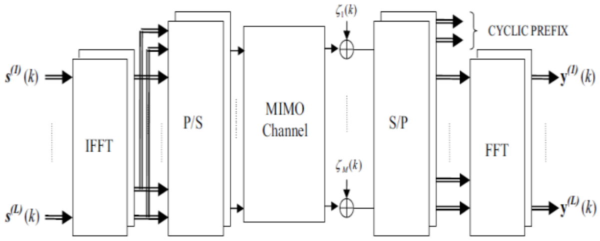

Fig. 2: A discrete MIMO-OFDM system with N transmitting and M receiving antennas

The *l*th subcarrier received vector at time *k* is given by

$$\boldsymbol{y}^{(l)}(k) = \boldsymbol{H}^{(l)}\boldsymbol{s}^{(l)}(k) + \boldsymbol{n}^{(l)}(k)$$

Where,$\boldsymbol{y}^{(l)}(k) = [\boldsymbol{y}_1^{(l)}(k), \boldsymbol{y}_2^{(l)}(k), \ldots\ldots, \boldsymbol{y}_m^{(l)}(k)]^T$ is a*M*×1 output vector, $(.)^T$ stands for transposed operation. $\boldsymbol{s}^{(l)}(k) = [s_1^{(l)}(k), s_2^{(l)}(k), \ldots\ldots, s_N^{(l)}(k)]^T$is the *N*×1 transmitted signal vector and $\boldsymbol{H}^{(l)}$ is the *M* × *Nl*th sub-channel matrix whose *ij*th element is $\boldsymbol{H}_{ij}^{l}(k)$. It is assumed that the observation data is corrupted by a zero-mean AWGN (additive white Gaussian noise) with zero mean and autocorrelation matrix $\boldsymbol{R}_{nl}$= $N_0\boldsymbol{I}_m$for *l*= 1, 2, . . ., L while $\boldsymbol{I}_M$is the *M* × *M*identity matrix.
Each element of the received signal at *i*th receiver antenna is given by equation

$\boldsymbol{y}_i^l(k) = \boldsymbol{H}_i^{(l)}\boldsymbol{s}^{(l)}(k) + \boldsymbol{n}_i^l(k)$*i*= 1, 2…, *M* *l*= 1, 2…, *L*

Where $\boldsymbol{H}_i^l = [\boldsymbol{H}_{i1}^l, \boldsymbol{H}_{i2}^l, \ldots\ldots, \boldsymbol{H}_{iN}^l]$ is the ith row of the $\boldsymbol{H}^{(l)}$ matrix to expand the Eq for *l* =1, 2... L, the observation matrix is defined as $\boldsymbol{y}_i(k) = [\boldsymbol{y}_i^{(1)}(k), \boldsymbol{y}_i^{(2)}(k), \ldots\ldots, \boldsymbol{y}_i^{(L)}(k)]^T$ and can be given as

$$\boldsymbol{y}_i(k) =$$

$$\begin{bmatrix} \boldsymbol{H}_i^{(l)} & 0_{1\times N} & 0_{1\times N} & 0_{1\times N} \\ 0_{1\times N} & \boldsymbol{H}_i^{(l)} & \vdots & \vdots \\ \vdots & \vdots & \ddots & \vdots \\ 0_{1\times N} & 0_{1\times N} & 0_{1\times N} & \boldsymbol{H}_i^{(l)} \end{bmatrix} \begin{bmatrix} \boldsymbol{s}^{(1)}(k) \\ \boldsymbol{s}^{(2)}(k) \\ \vdots \\ \boldsymbol{s}^{(L)}(k) \end{bmatrix} + \boldsymbol{n}_i(k)$$

Where $\boldsymbol{n}_i(k) = [n_i^1(k), n_i^2(k), \dots\dots.., n_i^L(k)]$ is the AWGN noise vector By defining the signal vector$\boldsymbol{S}_j(k) = diag\left(s_j^{(1)}(k), s_j^{(2)}(k), \dots\dots, s_j^{(L)}(k)\right)$ and the channel matrix from *i*th receiving antenna to *j*th transmitting antenna is given as $\boldsymbol{H}_{ij} = [H_{ij}^{(1)}, H_{ij}^{(2)}, \dots.., H_{ij}^{(L)}]^T$ for *i*=1,2,…*M* and *j*=1,2,….*N* and the above equation can be written in the following form

$$\boldsymbol{y}_i(k) = \boldsymbol{X}(k)\boldsymbol{H}_i + \boldsymbol{n}_i(k)$$

Where $X(k) = [S_1(k), S_2(k), \dots., S_n(k)]$ is $L \times LN$ matrix the training sequence which is assumed to be known at the receiver side. The matrix$\boldsymbol{H}_i = [\boldsymbol{H}_{i1}^T, \boldsymbol{H}_{i2}^T, \dots.., \boldsymbol{H}_{iN}^T]^T$ is a $LN \times 1$ column matrix. To estimate the $\boldsymbol{H}_i$ vector uniquely, receiving a vector with N successive $y_i(k)$ signal is needed. By definithe teng the receiving vector $\mathbf{Y}_\mathrm{i}(k)$ as

$\mathbf{Y}_\mathrm{i}(k) = \boldsymbol{X}(k)H_i + \boldsymbol{z}_i(k)$(3.5) *i*=1, 2……, *M*

Where

$$\boldsymbol{Y}_i(k) = [\boldsymbol{y}_i(k)^T, \boldsymbol{y}_i(k-1)^T, .., \boldsymbol{y}_i(k-N+1)^T]^T$$
$$\boldsymbol{X}(k) = [X(k)^T, X(k-1)^T, \dots\dots., X(k-N+1)^T]^T$$
$$\boldsymbol{z_i}(k) = [\boldsymbol{n_i}(k)^T, \boldsymbol{n_i}(k-1)^T, \dots\dots., \boldsymbol{n}_i(k-N+1)^T)]^T$$

11. LEAST SQUARE (LS) CHANNEL ESTIMATION

Least Square (LS) criteria are often for channel estimation since it leads to a low complexity simple architecture while maintaining reasonable performance even with short training symbols. The method of least squares is about estimating parameters by minimizing the squared discrepancies between observed data, on the one hand, and their expected values on the other.

With help of the training sequence $\mathbf{X}$(k) which is known at the receiver the overall channel is estimated at the each receiving antenna. The LS estimation of $\mathbf{H}_\mathrm{i}$ at time k is given by

$$\widehat{\boldsymbol{H}_\iota} = (\boldsymbol{X}(k)^H\boldsymbol{X}(\boldsymbol{k}))^{-\mathbf{1}}\boldsymbol{X}(k)^H\boldsymbol{Y}_i(k)$$

Where $\mathbf{Y}_\mathrm{i}$(k) is the received vector at *ith*antenna. Now channel state information is obtained by LS estimation technique. The LS estimation algorithm is applied to all receiving antennas for i=1, 2… *M* and channel state information is obtained at each receiving antenna.

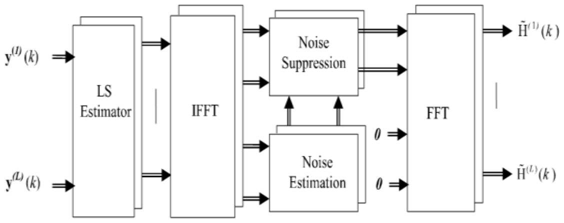

Fig -3: The structure of the improved LS channel estimation algorithm

12. MMSE ESTIMATION ALGORITHM

The Minimum Mean Square Error (MMSE) detection minimizes the mean square error (MSE) between the transmitted symbols and the soft estimates of the transmitted symbols. The MMSE estimator uses a priori knowledge of noise autocorrelation function and is optimal when these statistics of the channel are known. If sub-channel impulse responses are modeled as random processes and when the statistical parameters of the channel and noise are known Based on the covariance matrix of h and the noise autocorrelation function the MMSE estimation of the channel becomes

$\overbrace{\boldsymbol{h}}(k)=\boldsymbol{C}_h\ddot{\boldsymbol{I}}_{L_c}\boldsymbol{x}(k)^H(\boldsymbol{x}(k)\ddot{\boldsymbol{I}}_{L_c}{}^T\boldsymbol{C}_h\ddot{I}_{L_c}\boldsymbol{x}(k)^H + N_0\boldsymbol{I}_{NL})^{-1}\boldsymbol{y}(k)$ (3.23)

Where $\boldsymbol{C}_h$ is the covariance matrix of h which is assumed to be known at rthe th receiver end

13. SIMULATION

We have observed the variation of bit error rate in different channels using mat labstimulant

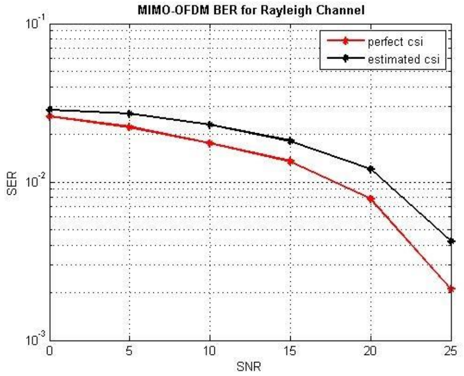

Fig -4: MIMO-OFDM BER for Rayleigh Channel

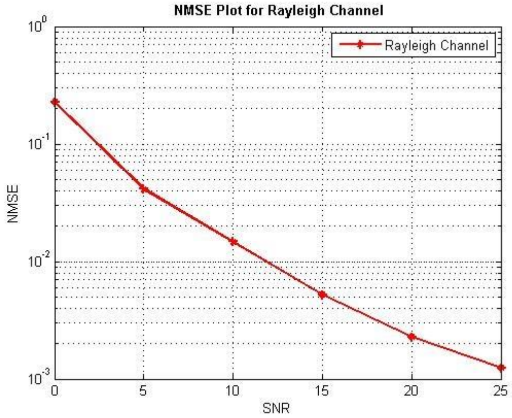

Fig -5: NMSE Plot for Rayleigh Channel

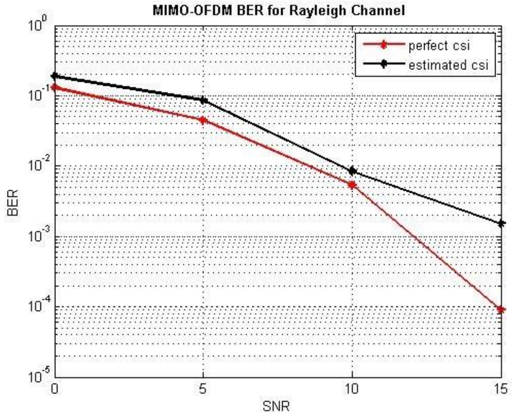

Fig -6: MIMO-OFDM BER for Rayleigh Channel

14. FUTURE SCOPE

Although the algorithm is a training-based channel estimation method, since the algorithm has not been developed based on a specific training sequence, it can also be extended and applied in the tracking mode with a decision-aided method. The Sub-Space based blind estimation method discussed can be extended to a MIMO-OFDM system with no or insufficient Cyclic Prefixes, thereby potentially increasing channel utilization.

15. CONCLUSION

In this thesis, channel estimation algorithms, which are based on the training sequence and noise sub-space method for MIMO-OFDM systems are discussed. In the training-based estimation method, least square (LS) is used to obtain the Channel State Information of the MIMO-OFDM systems.

The blind channel estimation scheme for MIMO-OFDM systems is presented based on the noise sub-space method. The method used achieves accurate channel estimation and bandwidth efficient one. This method also demonstrates insensitivity to the exact knowledge of a true MIMO channel order, which implies that it only requires an upper bound on the MIMO channel order. The approaches perform better in a time-invariant environment, i.e.., if several time samples are averaged, the better the estimation performance will be. So, a new scheme is applied to overcome some fundamental limitation of the subspace-based approach when applied to MIMO-OFDM transmission over time-varying channels. When considering the time invariance requirement of a practical

MIMO-OFDM system with many OFDM subcarriers. Through numerical results, it is shown that the proposed method achieves a better estimation accuracy with reasonable time averaging.

16. REFERENCES

[1] H. Zamiri-Jafarian, S.Pasupathy,” Robust and Improved Channel Estimation Algorithm for MIMO-OFDM Systems”, *IEEE Trans ON Wireless Communication*, Vol. 6, no. 6, Jun. 2007
2] C. Shin, R. W. Heath, Jr., E J. Powers, “Blind Channel Estimation for MIMO-OFDM Systems” *IEEE transfer. Technol*, Vol. 56, no 2, Mar 2007
[3] C. Cheng Tu, B. Champagne, “Subspace-Based Blind Channel Estimation for MIMO-OFDM Systems with Reduced Time Averaging” *IEEE Trans Veh. Techno, Vol*. 59, no. 3, Mar2010.
[4] G. L. Stuber, J. R. Barry, S. W. McLaughlin, Y. Li, M. A. Ingram, and T. G. Pratt, “Broadband MIMO-OFDM wireless communications,” *Proceedings of the IEEE*, vol. 92, no. 2, pp. 271–294, Feb. 2004.
[5] H. Sampath, S. Talwar, J. Tell ado, V. Erceg, and A. Paul raj, “A fourth-generation MIMO-OFDM broadband wireless system design, performance, and field trial results,” *IEEE Commune. Mag.*, pp. 143–149, Sept.2005.
[6] A.J.Paulraj, D.A.Gore, R.U.Nabar, and H.Bolcskei,“ An overview of MIMO communications - a key to gigabit wireless,” *Proceedings of the IEEE,* vol. 92, no. 2, pp. 198–218, Feb. 2004.
[7] Y. Hongwei, “A road to future broadband wireless access: MIMO-OFDM based air interface,” *IEEE Commune. Mag.* vol. 43, no. 1, pp.53–60, Jan.2005.
[8]Li and Z. Ding, “Blind channel identification based on second-order cycle stationary statistics,” in *Proc. I EEE Int. Conf. Acoustic., Speech, Signal Process*, Apr. 1993, vol. 4, pp. 81–84.
[9] L. Tong, G. Xu, B. Hassibi, and T. Kailas, “Blind channel identification based on second-order statistics: A frequency-domain approach,” *IEEE Trans. Inf. Theory*, vol. 41, no. 1, pp. 329–334, Jan. 1995.
[10] J. H Kotecha and A. M. Sayeed, “Transmit signal design for optimal estimation of correlated MIMO channels,” *IEEE Trans. Signal Processing*, vol. 52, no. 2, pp. 546–557, Feb. 2004.
[11] G. Foschini and M. J. Gans, “On limits of wireless communications in a fading environment when using multiple antennas,” Wireless Personal Communications, vol. 6, pp. 311 – 355, Mar. 1998.
[12] L. Hanzo, J Ming, “Multi-*user MIMO-OFDM for Next-Generation Wireless systems” Proc. IEEE*, Volume, 95, No.7, pp. 1430-1469, July 2007.
[13] Zest, A.V., Schenk, T.C.W, "Implementation of a MIMO OFDM–Based Wireless LAN System", *IEEE Translations on Signal Processing,* vol. 52, No. 2, pp. 483-493, February 2004.
[14] Why, E.U, "MIMO – OFDM Systems for High Data Rate Wireless Networks", EE360 Advanced Wireless Networks, Stanford University, 2003.