Data and image transmition over DS-PSK MIMO-UWB system in multipath fading channel using multiple description coding (MDC) and OSTBC

Ali Arshaghi[1] , Mehdi Nooshyar[2]
1- Young Researchers Club,Majlesi Branch, Islamic Azad University, Isfahan, Iran.
Email: .ali.arshaghi@gmail.com (Corresponding author)
2- Assistant Professor Department of Electrical and Computer Engineering, Mohaghegh Ardabili University, Ardebil, Iran.
Email: Nooshyar@ieee.org

Received: September 5, 2012 Revised: September 25, 2012 Accepted: October 5, 2012

ABSTRACT:
UWB communication system is a new high performance technique with low power consumption which has a large application for very high data rates in wireless telecommunications. In this paper, the image transfer techniques using MIMO-UWB wireless environment is introduced in MDC deals. This idea is new and so far that there is no record of it. First, direct sequence ultra wide band performance techniques are analyzed for channels fading. Image transmission is then implemented with multiple description coding and with no multiple descriptions coding of image. The method of multiple description coding ensures that the version that the loss does not need to retransmit the missing version and acceptable quality of image obtain against the channel errors. Send a picture of the proposed system with different number of transmitter and receiver antennas have been numerous experiments confirm the success of the method. Experimental results show that the desired goals are reached.

KEYWORDS: Direct Sequence, UWB, MIMO, MDC

1. INTRODUCTION

Due to the relatively large volume of data in image transmission and non-uniform information bits than data transmission are greater challenges. Image transmission can be more challenging in the wireless environment. In mobile networks, satellite networks, wireless sensor networks and contingency, images (and video) are sent on the wireless channel. Techniques of ultra wide band suitable can be used in image and video transmission. Telecommunication Wireless multimedia plays an important role in recent years; for this reason there is so many applications which used image transmission wirelessly. Ultra Wideband (UWB) technology can be appropriate solutions for telecommunication wireless high-speed whit short-range. The radio technology can be with a bandwidth of 25% of the center frequency. Power UWB system is Low in band frequency, because it can play in a wide frequency band. The immune system in opposite distortion and interference is a high contrast and time resolution in the receiver is very good. Low complexity and low cost are some important advantages of the technology that makes it possible to use mobile application. In these systems, instead of sinusoidal carriers, very narrow pulses are transmitted - and system bandwidth will appear into many GHz [1]. Two basic methods offer for ultra wide band which include Time Hopping UWB (TH-UWB) technique and direct sequence ultra wide band (DS-UWB) technique. So far, most researches in the field image transmission of UWB systems consist of two techniques direct sequence ultra wide band whit modulation antipodal (DS-UWB) and time hopping method by modulation PPM (TH-UWB) [2] and [3]. Further researches are compared in AWGN channel; the performance of the modulation UWB system and method Access different. The results show that the DS-UWB systems with antipodal modulation can be better performance with less complexity than TH-UWB system with Pulse Position Modulation (PPM) modulation [4] , [5].

The multi-transmitter and multi-receiver system or Multiple Input Multiple Output (MIMO) have more bandwidth and are suitable for broadband applications and are more helpful to get more data rates using of technologies such as MIMO antennas. UWB and MIMO system combination technology is a good way to get more data rates of 1 Gb/s in wireless telecommunications [6].

Multiple Description Coding (MDC) technique is a technique that is suited to wireless environments where the risk of losing data. These techniques are used in order to more protect on image transmission and resist data transmitted over wireless channels. MDC In contrast competing methods such as, Multi Layer Coding (MLC) or Joint Source Channel Coding (JSCC) exist that in any case research work for various channel models have been implemented [7].

This paper presents the technique direct sequence ultra wide band in modulation PSK (DS-UWB) and combines MIMO systems that are a new research. Performance of the proposed system survey in fading channel and send image whit method Multiple Description Coding (MDC) have been conducted and the simulation results are compared together with MDC and SDC.

The paper is structured as follows: In Section 2 the model's DS-UWB system with PSK modulation is investigated. In Section 3 multiple descriptions coding of the image and its implementation is discussed. MIMO system is then described in Section 4. In Section 5 the results of several simulations are presented by changing the parameters that influence in the implementation of the ideas which are achieved in this article. Finally, in Section 6 the conclusions and ideas for future work are discussed.

2. DS-UWB SYSTEM MODEL

2.1. Transmit Signal DS-UWB System

We give a direct sequence spread spectrum UWB system with N_u multiple access users. Block diagram DS-PAM UWB system for a user is shown in Fig.1.

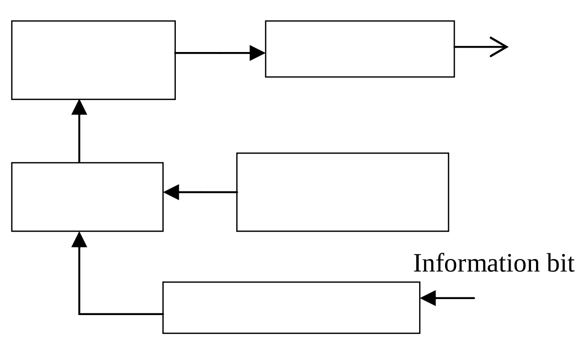


Fig.1 Transmission diagram of the DS-PSK-UWB System

Each user has a pseudo-noise sequence for per data symbol (a period T_f) with N_c the chip so that $N_c T_c = T_f$ and N_c is the spread spectrum processing gain. A typical transmitted signal of the the k[th] user can be expressed as follows [4].

$$s_{tr}^{(k)}(t) = \sum_{j=-\infty}^{+\infty} \sum_{n=0}^{N_c-1} d_j^{(k)} C_n^{(k)} w_{tr}\left(t - jT_f - nT_c\right) \tag{1}$$

where index j is the frame number, t independent parameter time, T_f is period symbol of the message, $\left\{D_j^{(k)}\right\}$ is the binary information bit, $\left\{d_j^{(k)}\right\}$ is the modulated data symbols by user kth in jth frame with $d_j^{(k)} = 2D_{\lfloor j/N_s \rfloor}^{(k)}$, N_s is the pulse repetition time, T_c is the chip time and $C_n^{(k)}$ spread chips and $w_{tr}(t)$ is the transmitted monocycle waveform [4].

2.2. Received Signal

Received signal by K[th] user at the receiver is equal to [4].

$$r(t) = \sum_{k=1}^{N_u} A_k s_{rec}^{(k)}\left(t - \tau_k\right) + n(t) \tag{2}$$

A_k Suggests attenuation received signal $s_{rec}^{(k)}\left(t - \tau_k\right)$ from K[th] transmitter. τ_k is the propagation delay between the transmitter and receiver and $n(t)$ the AWGN noise that modeled as $N\left(0, \sigma_n^2\right)$. Number of transmitters and signal amplitude (A_k) is assumed constant. The main assumption is gotten by ideal channel. Any signal only suffered one weakening and the delay is constant. A system with the ideal channel transmit pulse waveform w_{tr} varies to transferred pulse waveform w_{rec} into the receiver which effects on transmitter and receiver antennas. In Reference [8], [9], the following mathematical model for the received narrow pulse waveform is proposed.

$$w_{rec}\left(t + T_w/2\right) = \left[1 - 4\pi\left(t/\tau_m\right)^2\right] \exp\left(-2\pi\left(t/\tau_m\right)^2\right) \tag{3}$$

T_w The pulse duration and τ_m pulse width parameters. This model is based on empirical measurements obtained and the waveform is shown in Fig. 2.

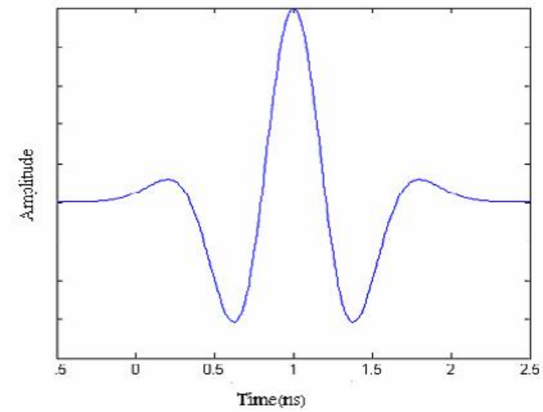


Fig. 2: A narrow pulse waveform received by the relationship (3) Model DS-UWB systems

2.1 Structure of receivers in DS-UWB systems

Received signal of the user 1 in j[th] frame can be presented as [4]:

$$r(t)=A_1\sum_{n=0}^{N_c-1} d_j^{(1)} p_n^{(1)} w_{rec}(t-{}^{2}1-jT_f-nT_c)$$
$$+n_{tot}(t) \qquad (4)$$

Receiver based observation on the received signal $r(t)$ in the time period during $T_f=N_cT_c$ must decision which the bit be $d_j^{(1)}$ is 1 or minus 1. $n_{tot}(t)$ represents the interference and noise.

$$n_{tot}(t)=\sum_{k=2}^{N_u} A_k s_{rec}^{(k)}(t-{}^{2}k)+n(t) \qquad (5)$$

We assume that the receiver is adapted to the transmit signal of the first user, so knows the delay time and pseudo-random sequence of this user. It is assumed that the local oscillator instrument and the pseudo-random sequence in the receiver are synchronized with the transmitter. The receiver block diagram is depicted in Fig. 3.

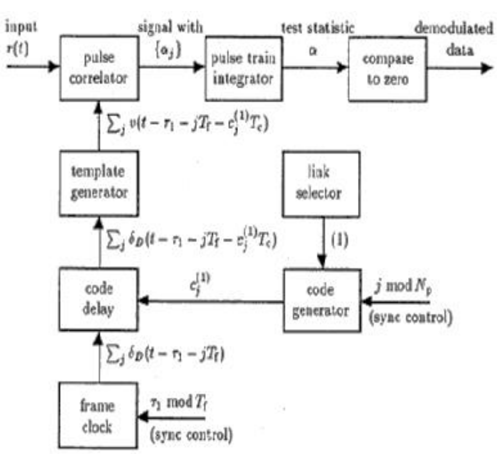


Fig. 3. Structure of receivers in DS-UWB

2.2 signal to noise in the receiver DS-UWB system

Signal to noise ratio at the receiver can be calculated as follows [4].

$$SNR_{out}(N_u)=\left[\begin{array}{l} SNR_{out}^{-1}(1)+\dfrac{N_sN_cE_w^2}{\pm_a^2} \\ *\displaystyle\sum_{k=2}^{N_u}(A_k/A_1)^2 \end{array}\right]^{-1} \qquad (6)$$

When the single use case is considered, the SNR is

$$SNR_{out}(1)=\frac{N_sN_cA_1^2E_w}{\pm_n^2} \qquad (7)$$

The shape of the signal energy is defined

$$E_w=\int_{-\infty}^{+\infty} w_{rec}^2(x)dx \qquad (8)$$

In equation (6), $\pm_a^2$ is the variance of interference in a chip caused of a pulse of interference and equal is:

$$\pm_a^2=T_c^{-1}\int_{-\infty}^{+\infty}\left[\int_{-\infty}^{+\infty} w_{rec}(x-s)\,w_{rec}(x)dx\right]^2 ds \qquad (9)$$

The system probability of error can be shown as

$$p_e(N_u)=Q\left(\left(\left[\frac{N_sN_cA_1^2E_w}{\pm_n^2}\right]^{-1}+\left[\frac{N_sN_cE_w^2}{\pm_a^2}\right]^{-1}\sum_{k=2}^{N_u}\left(\frac{A_k^2}{A_1^2}\right)\right)^{-\frac{1}{2}}\right) \qquad (10)$$

If $N_u=1$ The system probability of error is

$$p_e(N_u=1)=Q\left(\sqrt{\frac{N_sN_cA_1^2E_w}{\pm_n^2}}\right) \qquad (11)$$

3. MULTIPLE DESCRIPTION CODING

Multiple description coding is a source coding techniques that protect the image quality in against the errors of the channel. In Figure 4 a block diagram of the overall four description coding drawn. According to Figure 4 original input image to two or more versions data tht of the so-called version (subimage) will be divided.

Each of versions separate have satisfactory quality of the original image to their. If all copies must be received at the receiver, then the decoder whit quality very good reconstructed image data. But if the number of copies that are lost when crossing the channel decoder with the quality relatively low reconstructed data.

Decoders shows obtained copies, Decoder 1234 for example, indicate that all four versions 1,2,3,4 have been received and rest of decoders express the version numbers. Decode a string of input symbols $\{X_k\}_{k=1}^{N}$ is transmitted through the four channels, $\{\hat{X}_{i.k}\}_{k=1}^{N}$ is string rebuild of the decoder's ith.

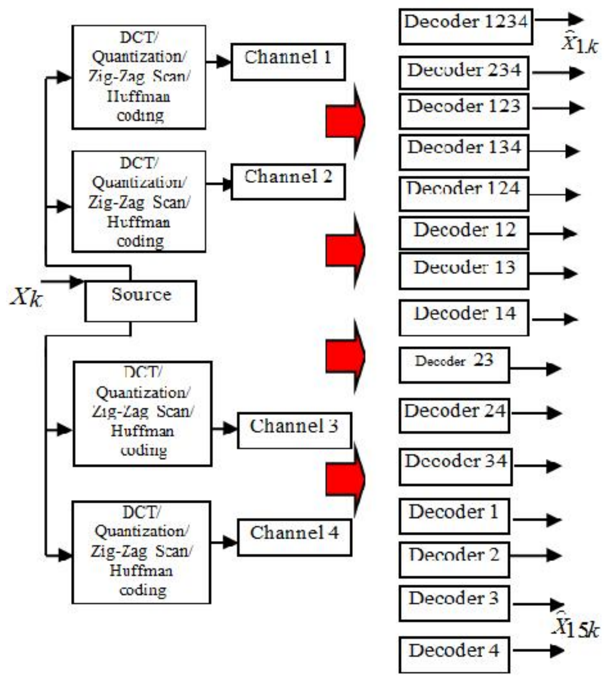


Fig. 4. The structure of four versions coding system based DCT

3.1. Multiple description coding of the image with the DCT transform

In original image make 4 sub-image using MDC and each version is divided to the 4 × 4 block. After that, we calculate the DCT transform of each block After the DC coefficient and the next two ac coefficients of the blocks can be mapped to a vector and done procedures the quantizing, source and channel coding and Spreading and modulate and we'll send signals to the channel, and in the receiver will do the reverse this steps.

Subsampling methods in Figure 5 in this form can assume as circle pixels in Version 1 and square pixels in Version 2 and the rhombus-shaped in version 3 and stars pixels in version 4 are separated of the original image.

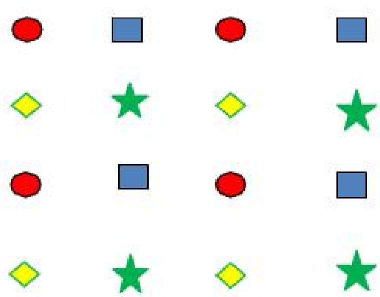


Fig. 5. Polyphase Subsampling in place domain (Image)

4. MIMO

To bring most of the 50 Mb/s data rates, some technologies such as MIMO antennas and OFDM must be used. As recommended in the IEEE802.11n. To reach the target of 1 Gb/s, more advanced techniques should be used. UWB technology combined with MIMO might provide a solution. Fig. 6 shows a MIMO system.

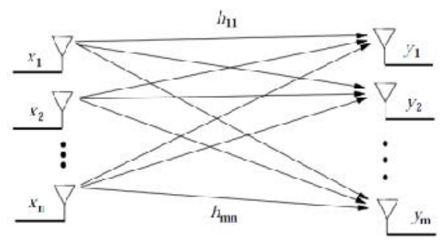


Fig. 6. MIMO system

This system can be expressed as the following equations and discrete-time model:

$$\begin{bmatrix} y_1 \\ \bullet \\ \bullet \\ \bullet \\ y_m \end{bmatrix} = \begin{bmatrix} h_{11} & \bullet & \bullet & \bullet & h_{1n} \\ \bullet & \bullet & & & \bullet \\ \bullet & & \bullet & & \bullet \\ \bullet & & & \bullet & \bullet \\ h_{m1} & \bullet & \bullet & \bullet & h_{mn} \end{bmatrix} \begin{bmatrix} x_1 \\ \bullet \\ \bullet \\ \bullet \\ x_n \end{bmatrix} + \begin{bmatrix} N_1 \\ \bullet \\ \bullet \\ \bullet \\ N_m \end{bmatrix} \quad (12)$$

$$\bar{y} = H\bar{x} + \bar{N} \quad (13)$$

where $\bar{x}$ The transmitted symbols n-dimensional, $\bar{N}$ is the m-dimensional additive white Gaussian noise (AWGN) vector, H contains zero mean complex circular Gaussian random variables h_{ij} that represent the (gain) channel from transmit antenna j to receive antenna i [10].

In wireless communication networks, the performance is improved by using spatial diversity. In a wireless communication system, because there is Fading coefficient error in the mean value of the signal to noise ratio, AWGN channels has increased a lot. The use of spatial diversity (multiple antennas at the transmitter or receiver use), including ways to deal with the effects destructive of the channel is. Composition spatial diversity whit type of diversity of diversity, such as time or frequency, can dramatically improve system performance. Codes, time - space, they simultaneously make the degree of diversity in time and space.

In this study, the MIMO system can be used for diversity. In MIMO system we use in orthogonal space-time block code (OSTBC) encoder for encoding an input symbol sequence. The block maps the input symbols block-wise and concatenates the output codeword matrices in the time domain. This block outputs the input block symbols in the codeword matrix are accession. Also, we use in OSTBC combiner which combines the input signal (from all of the receive antennas) and the channel estimate signal to extract the soft information of the symbols encoded by an OSTBC. A symbol demodulator or decoder would follow the Combiner object in a MIMO communications system.

Often to measure the quality of the reconstructed image (after processing) to measure PSNR (peak signal-to-noise ratio) with the definition of the following equations are used to:

$$MSE = \frac{1}{M*N}\sum_{M,N}\left[I_1(m,n) - I_2(m,n)\right]^2 \quad (14)$$

$$PSNR = 10\log_{10}\frac{255^2}{MSE} \quad (15)$$

256 is the levels of gray, *M*, *N* number of rows and columns entry image, *MSE* represents the cumulative squared error between the reconstruct and the original image, I_1 the original image I_2 is reconstructed image. What the lower the value of MSE, the lower the error and will be higher amount of PSNR.

Defined as SNR (Signal-to-Noise Ratio)

$$SNR = \frac{E_s}{N_0} \quad (16)$$

Where E_s is energy per symbol transmitted by the modulator and N_0 is the noise power spectral density of the actual channel.

5. SIMULATIONS RESULTS

Image received DS-PSK UWB system using the MDC whit four copies received to the dimensions of 128 × 128, and channel Fading and SNR = 15dB, and MIMO 2 × 2 and the signals are Spread. The version shown in Figs. 7, 8, 9, 10. Fig.7-fig.10 show the version of dc coefficient and ac side which two coefficient principal versions has been received. The combinations of these four versions are obtained a image whit size 256 × 256.

Fig. 7. Sub imag 1

Fig. 8. Sub imag 2

Fig. 9. Sub imag 3

Fig. 10. Sub imag 4

Reconstructed images of the 4 versions of 128 × 128 are shown in Fig. 11 to dimension 256 × 256. This version received simulated for different SNR, and the SNR = 15dB showed in here.

Fig. 11. Image after composition of the sub image DS-PSK

Average PSNR values for different versions of the lost using multiple description coding whit DCT transform are shown in Table 1. In cases where a prescription is lost, with versions obtained by averaging the match pixels, are obtained approximations copies of the lost.

Table 1. PSNR to the state of lost prescriptions

Number of copies lost	PSNR SNR=15dB
0	22.2667
1	22.0501
2	21.7961
3	21.3668

Coefficients in Table 2 PSNR Image received for state that only dc coefficient original version have been received, it shows. PSNR image reconstructed in this case based on the number of copies is lost investigate.

Table 2. PSNR DC coefficient images

Number of copies lost	PSNR SNR=15dB
0	19.1936
1	19.2127
2	19.1929
3	19.1416

It is observed from PSNR that image by 3 coefficients in dc and ac copies to be sent above is than image that just a coefficients dc of his version is sent. Fig. 12 shows PSNR values for the number of copies that have been lost.

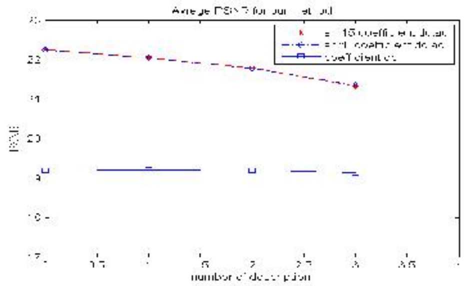


Fig. 12. Mean values of PSNR (dB) for different versions of the lost

Figure 13 and Table 3 show a comparison with and without using MDC (SDC). In this method there is the possibility of loss of image. MDC method give high quality of image in against loss of versions, that in the SDC method so is not. Modulation is DS-PSK and Versions of 128 × 128, Fading channel, SNR = 15dB, MIMO 2 × 2, and signals are Spread. Dc and next two ac coefficients of original versions were sent.

Fig. 13. Image obtained without MDC

Table 3. PSNR image without MDC

image	PSNR
image cameraman without MDC	25.4000

Figure 14 PSNR than SNR with MDC is shown for the four versions and this chart, result of transmit dc and next two ac coefficients of original versions is. MIMO system once 2 × 2 and once 2 × 1 Assume and we show the results.

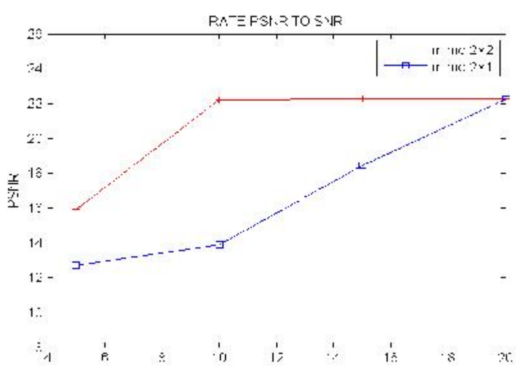


Fig. 14. PSNR than SNR of MDC method with DCT

Table 4 presents the PSNR in the image DS-PSK UWB system using the MDC whit four received copies to the dimensions of 128 × 128, Fading channel and SNR = 5,10,15 dB and MIMO 2 × 1 and Spread signals. In this case, the dc coefficient and ac side two coefficient original copies have been received with combination the received four copies obtains an image whit size 256 × 256.

Table 4. PSNR image MIMO 2*1

image	PSNR
image cameraman	22.2586

Fig. 15 the SNR Fading channel than to BER (error rate) of 12 signals (3 coefficients of four copies that are 12) obtained before modulate and after Demodulate is draw.

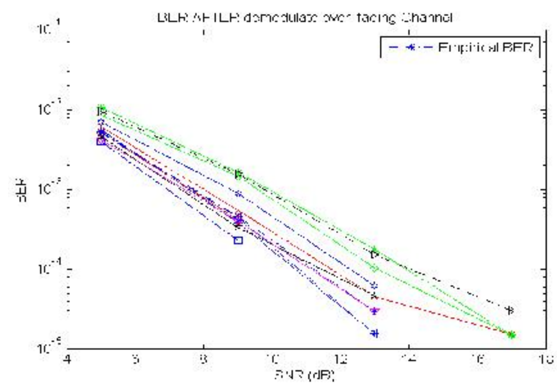


Fig. 15. Error rates after Demodulate

In Figure 16 the error rate before of the channel coding and after the channel decoded shown for 12 signal that all set to zero. Therefore, the channel code is used to correct all errors.

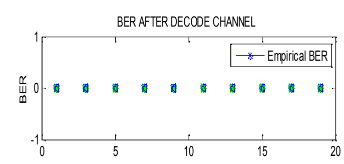
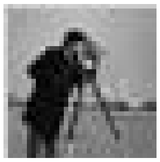


Fig. 16. The error rates after channel decoder

For another state received image DS-PSK UWB system using the MDC to dimensions 32 × 32, Fading channel, SNR = 15dB, MIMO 2 × 2 and raised Spread factor signals. The results can be seen in Fig. 17 and 18. In this state too dc coefficient and ac two side coefficient original copies given and the fusion them image is obtained. Due to the large is image size, image size 32 × 32 we got. In this case, the PSNR is 19.5432.



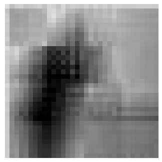


Fig. 17. Origonal image 32 × 32 **Fig. 18**. Image obtained 32 × 32

6. CONCLUSION

In this paper, following the introduction of ultra-broadband systems, the performance of DS-UWB systems with PSK modulation in Fading channel analysis. Multiple description coding of the image, DCT block of the original image, and how to get the pictures were told. MIMO system in the two stste 2 × 2 and 2 × 1 was studied and the results were compared. Image transmission by states Spreading, Snr different, modes MDC, SDC, number selected coefficients of prescriptions survey. It was observed that at low SNR, PSNR not changed much channel code does work better against noise. The number of states that copies are loss, survey. MDC in cases of loss of image, will provide better quality to SDC.

REFERENCES

[1] I.Oppermann and M.Hamalainen,"**UWB Theory and Applications**," John Wiley & Sons, pp. 1-7, 2004.

[2] M. Z. Win and R. A. Scholtz, "**Ultra-wide bandwidth time-hopping spread-spectrum impulse radio for wireless multiple-access communications**," IEEE Trans. Commun., vol. 48, no. 4, pp. 679-690, Apr. 2000.

[3] T.Lv,H.Zhang," **A Selective Approach to Improve the Performance of UWB Image Transmission System over Indoor Fading Channels**," IEEE Conf.,2010

[4] Z.Bai,K.Kwak**." Performance Analysis of Multiuser DS-PAM and TH-PPM UWB Systems in Data and Image Transmission**," IEEE Conf.,2005

[5] Z.Bai,W.Zhang,S.Xu,W.Liu,K.Kwak." **On the Performance of Multiple Access DS-BPAM UWB Systems in Data and Image Transmission**," IEEE Conf.,2005

[6] T.Kaiser,F.Zheng, and E.Dimitrov, "**An Overview of Ultra-Wide-Band Systems With MIMO**," in proc. Of IEEE,vol.97.no.2,pp.285 – 312 ,Feb.2009.

[7] Y. Wang, A.R. Reibman, S. Lin, "**Multiple description coding for video delivery**,", Proceedings of the IEEE, vol. 93, no. 1, pp.57-70, Jan. 2005.

[8] V.S.Somayazulu,"**Multiple access performance in UWB systems using time hopping vs. direct sequence spreading**," in Proc. IEEE Wireless Communications and Networking Conf., vol. 2, pp. 522-525, Mar. 2002.

[9] M. Z. Win and R. A. Scholtz, "**Ultra-wide bandwidth time-hopping spread-spectrum impulse radio for wireless multiple-access communications**," IEEE Trans. Commun., vol. 48, no. 4, pp. 679-690, Apr. 2000.

[10] A.Goldsmith ,"**Wireless Communications**," Stanford University, 2004, pp. 315-320