iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 Issue: VI Month of publication: June 2021

DOI: https://doi.org/10.22214/ijraset.2021.35106

Transmission of BPSK in UWB using MATLAB

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Abstract: Ultra Wide Band (UWB) is a promising technology for sensor networks, broadband wireless data accessing, positioning and location finding applications. This project outlines the development and validation of a single transmitter and receiver system across the multipath channel. We have designed and tested a UWB simulator using MATLAB to operate for a continuous wave. After a brief survey BPSK was chosen to be the modulation technique. This paper outlines the basic design and simulation of a BPSK signal through the UWB. The system parameters and the simulation runs are shown and described along with the BER calculations. The time domain and frequency domain study is shown and analyzed of a IR-UWB channel with the transmitter, channel and the receiver blocks. This model compares and analyses the bit efficiency of a channel, for a BPSK modulation technique for various bit powers. The example simulation uses rudimental inputs to visualize the response of the channel.
***Keywords*: Ultra Wide Band, multipath fading, BER, IR-UWB.**

I. INTRODUCTION

In usual words, a communication system is called a UWB-communication system if the instantaneous bandwidth of the system is greater than the minimum bandwidth required to deliver a, certain information in the band of 3.1 to 10.6 GHz. The evolution of UWB communication systems are marked by the performance of the Federal Communications Commission (FCC). FCC is a regulatory body, established by the Communications Act of 1934, as a successor to Federal Radio Commission (FRC). It has been charged with regulating all the non-federal government usage of the radio spectrum including radio and television broadcast, and all the inter-state telecommunications all wired, satellite and cabled as well as all the international communications that are originated or terminated in the United State. The FCC is also responsible for carving the spectrum into thin slices, which are then assigned to the various users. This carving of the spectrum into thin slices became the biggest problem of UWB communications and became a main reason for experimental work for a very long period [4] & [14]. The UWB channel allows up-to 20% of its spectral range, for the transmission of a modulated signal. The BPSK signal is a continuous signal modulation technique used mostly for its simplicity and less BER.

II. LITERATURE SURVEY

An In this chapter we explain in detail about the literature survey we have done to attain a base for the project and collect all material, formulas and methods required to implement our solution.

In 2005, from the paper "An Ultra Wideband Simulator Using MATLAB/Simulink", according to Vial, Peter; Wysocki, Beata; Wysocki, Tad et.al the matlab simulation of a UWB channel can be generated by assuming a 28dB noise floor in the transmission channel. The simulated channel is a Saleh-Valenzula channel using the same parameters, we used the same model and noise parameters to configure the matlab filters [1].

In 2004 the author Benedetto, Giancola et.al defined about the UWB channel and radio fundamentals necessary to understand the parameters of the channel, in his paper. The authors stated the definitions of Energy Bandwidth, time-bandwidth product, effective SNR etc. the paper provides the calculations needed fot the analysis of UWB [2].

In 2000, the author Rooyen, Lotter, Wyk et.al, mentioned in their paper, the features of UWB-IR using a binary PPM scheme was presented, as an estimate of the multi-access capability of a communication system employing this under ideal propagation conditions were given, and the design issues were described [3].

In 2000, from paper "UWB: Theory and applications", written by Oppermann; Hamalainen; linatti et.al studied the performance of the same system in [2], including the estimate of the multiple access capability for both analog modulation format and digital format. They also expanded their studies by presenting time-hopping sequence design and by estimating the system's performance in terms of achievable transmission rate [7].

We have developed a UWB simulation using MATLAB which shows comparable results to those reported in [1]. We did simulations for a Saleh-Valenzula channel using the same parameters as [1]. This thesis compares the BER performances of BPSK modulation scheme simulated and theoritical using pulse shapes: Gaussian first derivative, Gaussian second derivative. Following, the effects of UWB-IR factors including pulse duration, pulse repetition rate, modulation scheme, and pseudorandom codes on the PSD of the transmitted signals are analyzed. In this study, both BER and PSD comparisons are demonstrated in detail with explanations and figures.

III.PROPOSED SYSTEM

The system we proposed transmits the continuous wave –BPSK signal in the bandwidth of 3Ghz – 10Ghz which covers the Ultra Wide Band range. There are three classes of UWB signals. They are Carrier less IR-UWB (Impulse Radio-UWB), Carrier IR-UWB and MB-UW (Multiple Band-UWB). The difference between Impulse radio and multiple-band is the IR-UWB transmits very short pulses with a very low duty cycle.

We have used Carrier less IR-UWB method to generate signal for the channel. We can use variety of pulses to generate the IR-UWB there are several pulse shapes found in literature for UWB communication, ranging from spectrally inefficient [7, 35-37], to precisely controlled frequency tolerance [24, 38]. The optimal choice of the pulse shape doesn't depend just on the pulse time and frequency response, but also on the application. However, for linear receivers, the performance is completely characterized by SNR and interference ratios. Therefore, the three metrics used in this thesis to quantify a pulse shape are: spectral efficiency, out-of-band emissions, and time-bandwidth product [6].

The data which is to be modulated is generated through a random bit generator, but for our convenience we have considered small no. of bits and then multiply with the gaussian pulses to make them BPSK modulated. The logic 1 sends the gaussian pulse unchanged and logic 0 would invert the pulse by 180° which is equal to -1.

We have modelled the process into various steps to achieve the required observation, to simulate a ultra wide band signal we considered a Gaussian triplet pulse of less time period and bandwidth around 10GHz. To check the characteristics of the channel a BPSK signal is transmitted into the channel and recreated using the same oscillator frequency. The input is generated from the rand function of matlab and assigned with signs -/+ to make the signal in-phase and out-of-phase modulated [1]. The created signal is a continuous signal modulated in BPSK the signal is converted into symbols. Using matrix transpose methods and the hence created symbols is matrix multiplied with channel carrier frequency.FFT is performed on the hence created signal to obtain the frequency domain parameters of the output and compare the input and output spectrum. The receiver is assumed to be in synchronization with the transmitter and the signal is recreated using simple multiplication of output and un-modulated pulses. Then use comparator to identify the level of output and pass it through low pass filter. The system is checked further for BER evaluation and system efficiency. BER rates for the AWGN channel in the input range for various Eb/No values is given in the Table II[8]. The noise generator is calibrated to determine the value of Eb/No and SNR in dB scale allowing the system to operate error free in a noisy environment. The Eb/No value is a number in dB scale which is used in link calculations. Formula used - theoryBer = 0.5*erfc(sqrt(10. ^(Eb_N0_dB/10))). The table I, shows the comparison between the simulated and theoretical values of BER for various values of Eb/No, which are calculated by using the above formula and simulated results are generated from the BER plot.

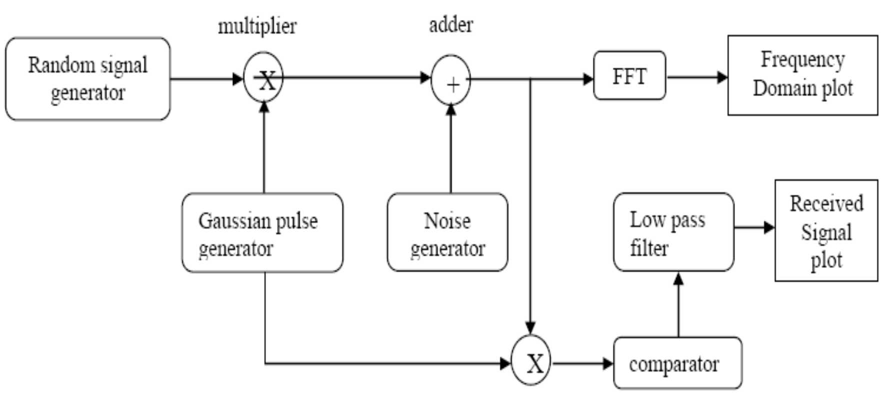


Figure 1. Block Diagram.

Figure 1 shows the block diagram of the proposed model and contains the whole system, transmitter, channel and receiver. From the figure, we can understand the step by step process of signal execution and modulation.

IV. SIMULATION RESULTS

The proposed model is implemented in the Matlab 2016b software in windows operating system containing 4Gb RAM. The matlab code for the model is given in the Appendix. We have simulated a virtual UWB channel with the help of Binary data and gaussian pulses, the channel is analyzed by considering several blocks of code which manipulates the data to create a simulation of functions such as transmitter, receiver, correlator, LPF, Comparator etc,. the BER evaluation of the modulation technique is done by assuming the E_b / n_o for various values which are compared to the simulated data.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue VI Jun 2021- Available at www.ijraset.com

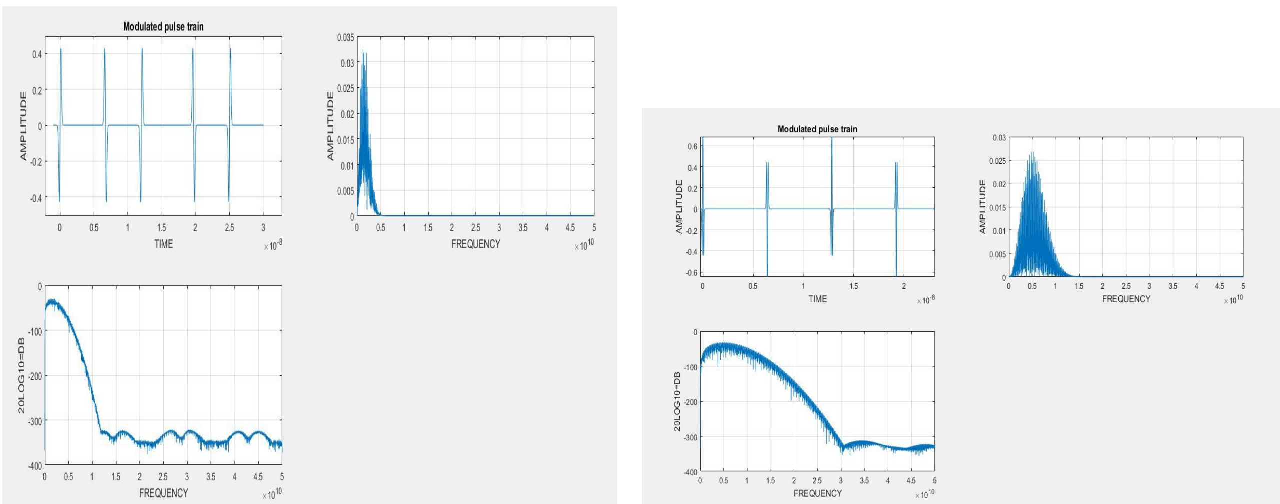
1) The input data taken in the model for evaluation is a 5 bit binary data 10101.
2) Input data is modulated using BPSK technique as it is considered to be the method having the least BER and high SNR for a single path model.
3) The channel is created and verified using two pulses Gaussian mono-pulse and doublet.
4) The signal is then added with a noise (AWGN) to simulate the noise present in a chanel.
5) The data is then correlated and send to a comparator to reconstruct the signal back.
6) The BER is then calculated and simulated.

Here are the detailed results of the individual blocks of the data

A. *Modulated Signal:*

The binary data is BPSK modulated before entering into the UWB transmitter module, the logic 0's are considered as –ve 1 and logic 1's are considered as +ve 1, then multiplied with the gaussian pulses to generate the modulated UWB signal.

1) *Mono-Pulse Modulated:*



(a) (b)

Figure 4.1 (a) modulated gaussian mono pulse train with frequency domain plot of the signal in normal and log scale (b) modulated gaussian doublet pulse train with frequency domain plot of the signal in normal and log scale

The BPSK is first modulated with a Gaussian mono-pulse and the figure 4.1 a given below contains three subplots having three graphs of the modulated signal.The gaussian pulse train is a short duration mono-pulse, they are multiplied accordingly with the data and the frequency representation of the gaussian pulse is a low pass, base band signal, this generates the signal in the lower UWB range. To obtain the result above the input taken is binary bits 1s and 0s, which are modulated by Gaussian pulses to create a BPSK representation of the signal the 1s are multiplied directly and the 0s are multiplied inversely. The frequency domain plots are obtained by performing FFT on the signal thus generated. The PSD is generated by converting the amplitude from the normal scale to the log scale.

2) *Doublet Modulated:* Then the BPSK is now modulated with a Gaussian doublet, and the figure 4.1 b given below contains three sub plots having three graphs of the modulated signal. The gaussian pulse train is a short duration gaussian doublets, the pulses are multiplied with the data accordingly and the frequency representation of the modulated gaussian pulse is a low pass, base band signal, this generates the signal in the medium UWB range. The input is binary bits 1s and 0s, which are modulated by Gaussian pulses to create a BPSK representation of the signal the 1s are multiplied directly and the 0s are multiplied inversely. The frequency domain plots are obtained by performing FFT on the signal thus generated. The PSD is obtained in the log scale.

B. *Unmodulated Pulse Train:*

The unmodulated pulse train is also generated along with the modulated signal to help compare with the modulated signal and generate a correlated signal.

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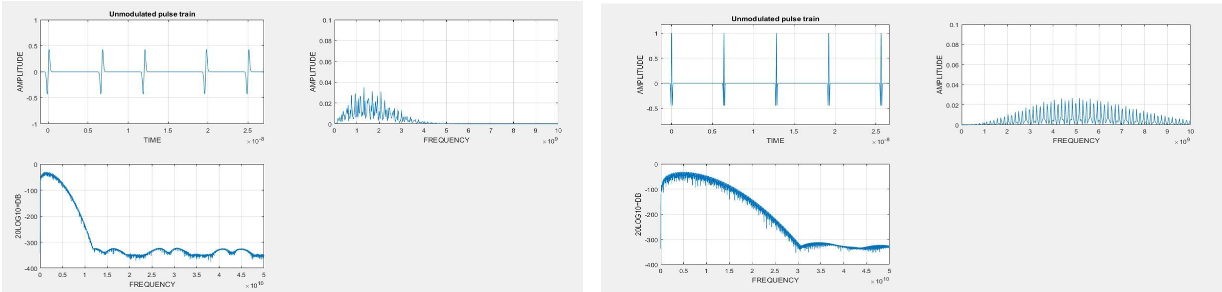
1) *Mono-Pulse Train:* The unmoulated mono-pulse train is generated by using a formula mentioned in the code available at appendix and figure 4.2 a shows the result that contains three sub plots having three graphs of the mono-pulse unmodulated signal. into frequency domain by applying the FFT. The frequency signal is very weak and is not constructive.



(a) (b)

Figure 4.2 (a) unmodulated carrier mono-pulse pulse train and its frequency domain representation in normal and log scale (b) unmodulated carrier doublet pulse train and its frequency domain representation in normal and log scale

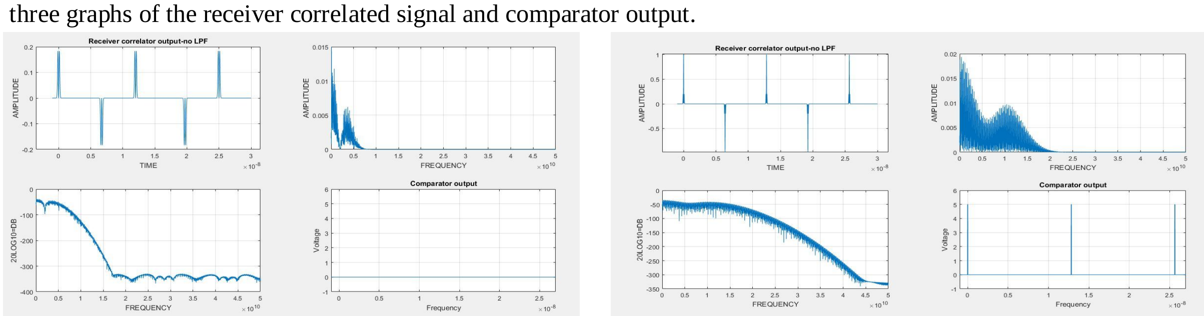
The obtained PSD of the signal has low power and spreads over a small range of frequencies. The time domain signal contains the Gaussian pulses which are unmodulated and repeat after a certain duration or period. The pulses may occur at equal intervals or at different intervals. The frequency domain plot shows the response which is similar to the noise. The mono pulse is easy to generate in a hardware but contains a large amount of noise.

2) *Doublet Pulse Train:* The unmoulated doublet pulse train is generated by using a formula mentioned in the code available at appendix and figure 4.2.b contains three sub plots having three graphs of the doublet unmodulated signal. As we can see the doublet in the time domain is converted into frequency domain by applying the FFT. The frequency signal is evenly distributed over the range of frequencies 3Ghz – 10Ghz. The obtained PSD of the signal has high power and spreads over a wide range of frequencies. The time domain signal contains the Gaussian pulses which are unmodulated and repeat after a certain duration or period. The pulses may occur at equal intervals or at different intervals. The frequency domain plot shows the wide band spread spectrum depicting the ultra wide band spectrum over a effective bandwidth of 3Ghz to 10Ghz. The obtained PSD covers over a large area i.e. more power.

C. Receiver Correlator Output

The receiver block in the code is generated by having the modulated and unmodulated pulses correlated and added with a noise (AWGN) then compared with the reference voltage (+5v).

1) *Mono-Pulse Receiver Output:* The mono-pulse receiver output is shown in the figure 4.3 a. contains four sub plots having three graphs of the receiver correlated signal and comparator output.



(a) (b)

Figure 4.3 (a) Correlator output and its frequency domain representation and the comparator output-mono-pulse b: correlator output and its frequency domain representation and the comparator output-doublet

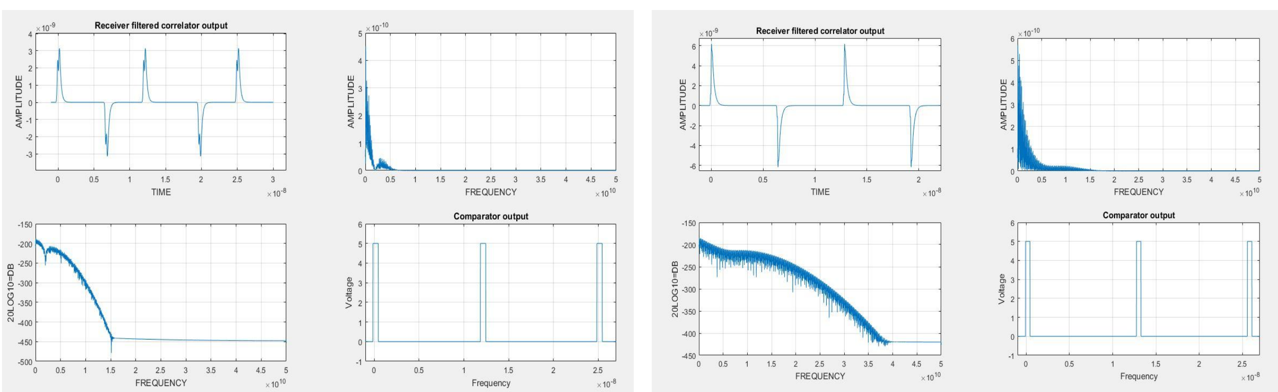
The received mono pulse signal from a correlator contains the part that is left after the CCF of the modulated signal with the unmodulated signal. For a logic 1 or +ve voltage the signal is retained and –ve part is removed in the calculations. For a logic 0 or –ve voltage the signal < 0 is retained and +ve part is removed in the calculations. The time domain signal contains the modulated Gaussian pulses which are converted into frequency domain using FFT. The spectrum of a mono-pulse modulated signal has less bandwidth and difficult to analyze. The Comparator output shows the voltage value of the received signal comparing with the reference voltage. Here the expected signal at the comparator must be showing the pulses at the logic 1. But, the received signal is a DC line, which means signal reconstruction is difficult.

2) *Doublet Receiver Output:* The doublet receiver output is shown in the figure 4.3 b contains four sub plots having three graphs of the receiver correlated signal and comparator output. The received mono pulse signal from a correlator contains the part that is left after the CCF of the modulated signal with the unmodulated signal. For a logic 1 or +ve voltage the signal is retained and –ve part is removed in the calculations. For a logic 0 or –ve voltage the signal < 0 is retained and +ve part is removed in the calculations. The time domain signal contains the modulated Gaussian pulses which are converted into frequency domain using FFT. The spectrum of a doublet modulated signal has good bandwidth range and is perfect to reconstruct and analyze. The Comparator output shows the voltage value of the received signal comparing with the reference voltage. Here the expected signal at the comparator must be showing the pulses at the logic 1. But, the received signal is a DC line, that means signal reconstruction is difficult. The correlator output is generated by multiplying the generated BPSK signal with added noise to the unmodulated carrier pulse train. The frequency domain plot clearly shows the noise in the spectrum. To remove the noise we pass the comparator signal through the LPF as the comparator output generates the pulses with higher energy.

D. Filtered Correlator Output

The correlated output contains noise in the frequency components and need to be low pass filtered. The signal passed through LPF contains limited frequency response but the pulse width of the comparator output increases.

1) *Mono-Pulse Filtered Correlator Output:* The mono-pulse filtered output in the figure 4.4 a contains four sub plots having three graphs of the filtered received signal and the comparator output signal.The received signal is now passed through a LPF consisting (LPF)(RC=.2e-9) the LPF removes the extra spread in the frequency and cuts off to the required base band signal, the signal generated using a mono pulse after passing through the LPF contains around ~1Ghz bandwidth. The PSD of the signal doesn't contain higher frequencies, which makes it suitable for short range communication. The comparator output shows pulses with some delay as the frequency spectrum is trimmed the time delay in the pulses increases. The pulses appear at the logic 1and no pulse at logic 0. The signal is reconstructed using a coherent detector to identify the presence of data at particular intervals.



(a) (b)

Figure 4.4 (a) receiver mono-pulse filtered output with frequency spectrum representation and comparator output after passing through LPF (b) receiver doublet filtered output with frequency spectrum representation and comparator output after passing through LPF.

2) *Doublet Filtered Correlator Output:* The doublet filtered output in the figure 4.4 b contains four sub plots having three graphs of the filtered received signal and the comparator output signal.The received signal is now passed through a LPF consisting (LPF)(RC=.2e-9) the LPF removes the extra spread in the frequency and cuts off to the required base band signal, the signal generated using a mono pulse after passing through the LPF contains around ~1Ghz bandwidth. The PSD of the signal doesn't contain higher frequencies, which makes it suitable for short range communication. The comparator output shows pulses with some delay as the frequency spectrum is trimmed the time delay in the pulses increases. The pulses appear at the logic 1and no pulse at logic 0. The signal is reconstructed using a coherent detector to identify the presence of data at particular intervals. The spectrum of the signal reduces by passing through LPF and time domain signal gets expanded as the frequency domain signal is being filtered. The time period of the pulse increases slightly so as the comparator output.

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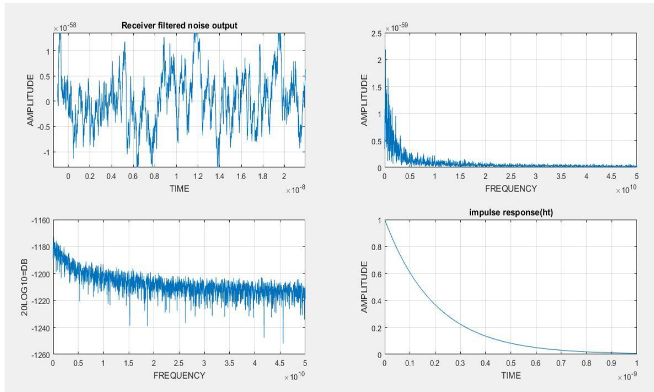
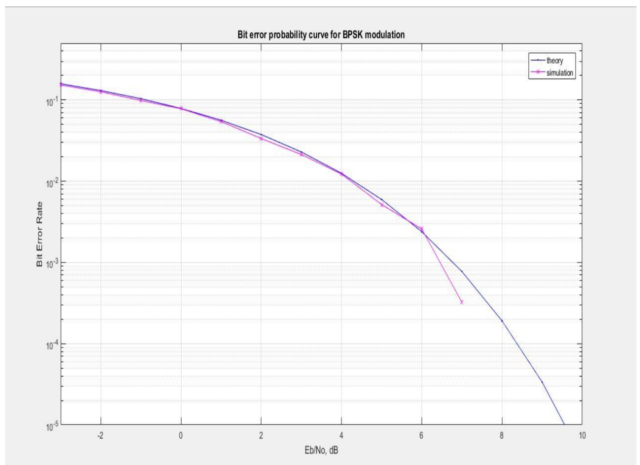
E. Filtered Noise Output and Impulse Response

The noise is filtered by using a LPF, the noise is same for both the pulse modulations, the removed noise is plotted in the graph below and used for the SNR calculations in finding the noise power in the channel which is used in plotting the BER graph.



(a)



(b)

Figure 4.5: (a) filtered noise output and impulse response of the filter (b) BER curve theoretical vs simulated

The Impulse response of the LPF is also plotted just for a reference to check the noise frequency response. The figure 4.5 contains four sub plots having three graphs of the filtered noise output signal and impulse response. The signal filtered through LPF is the noise present in the transmitted signal, the frequency spectrum shows the noise, the noise is a base band noise and high at lower frequencies and can completely nullify the transmitted signal and PSD of the noise is almost same over all the frequencies as we have considered the AWGN and has a constant power spectrum. The noise is eliminated through the low pass filter and the noise output can be clearly seen through the plot. Since, it is a AWGN noise it has a constant PSD over the range of frequencies and is zero mean signal. The impulse response of the filter is also shown in the window. The noise here shown is removed noise from the received signal.

F. BER Calculations

The BER calculations are made based on the transmission of BPSK modulated signal in the AWGN channel we used in the project. The BER is first evaluated and plotted for bit values and E_b / n_o values respectively, later the values are also plotted by simulation in the same graph to compare the simulated Vs theoretical values. The table for the below result is given in Table I. The Figure 4.6 consists of BER graph estimated Vs stimulated [x-axis:SNR dB, y-axis: BER]. The BER (bit error rate) curve is plotted for various values of Eb/No to generate various SNR values and for the noise in the range of time period of the input signal. The BER is same as the estimated till 7dB SNR value for the chosen BPSK signal modulated with Gaussian doublet.

Table I: Theoretical Vs Simulated BER values.

Theoritical	0.1583683	0.1306445	0.1037591	0.0786496	0.056282	0.0375061	0.0228784
Simulated	0.151564	0.1270558	0.1025476	0.0799742	0.0538536	0.0341825	0.020961
eb/no(dB)	-3	-2	-1	0	1	2	3
Theoritical	0.0125008	0.0059539	0.0023883	0.0007727	0.0001909	3.36E-05	3.87E-06
Simulated	0.0138665	0.0054821	0.0019349	0.0009674	0.0003225	0	0
eb/no(dB)	4	5	6	7	8	9	10

V. CONCLUSION

We have developed a UWB simulation using Matlab which shows comparable results to those reported. We did this for an IR-UWB channel using the same parameters as mentioned. We also found that for our randomly generated data set with the channel changing every symbol sent an error floor became evident at about 28dB expected SNR. The developed model is flexible in that we can also use its framework to model other channel models by generating the channel state information separately and importing these. The Gaussian doublet is used to show better results in a UWB channel. The BER is calculated and link budget can be calculated using the values calculated and assuming some values of the antenna. The results are simulated for both Gaussian mono-pulse and also Gaussian doublet and when compared doublet shows clearer results in the spectrum and while reconstructing at the comparator. IR-UWB without a carrier using Gaussian doublet can have generated and can be used in a closed room and short-range object positioning, because the PSD of the signal is frequency limited and has high power in that range. The receiver needs to be in synchronization with the transmitter to obtain accurate results, when the distance of communication increases the signal attenuates because of the multi-path and delay propagation.

REFERENCES

[1] Vial, Peter; Wysocki, Beata; Wysocki, Tad (2005) "An Ultra Wideband Simulator Using MATLAB/Simulink", Noosa Heads, Queensland, 18- 21st Dec. 2005, DSPCS05' & WITSP'05.
[2] Benedetto, Di; Giancola (2004) "Understanding Ultra Wide Band: Radio Fundamentals", Prentice Hall Communications Engineering and Emerging Technologies Series, ISBN 0-13-148003-0.
[3] Oppermann; Hamalainen; linatti (2004) "UWB: Theory and applications", Wiley, ISBN 0-470-86917- 8.
[4] Vial, Peter; Wysocki, Beata; Wysocki, Tad (2006) "Direct Sequence Modified Time Hopping PPM over Ultra Wideband S-V Channel", Hobart, Tasmania, 11-13th Dec. 2006, WITSP'06.
[5] Proakis (2001) "Digital Communications", fourth edition, McGraw-Hill, ISBN 0-07-118183-0.
[6] Liberti & Rappaport (1999) "Smart Antennas for wireless communications: IS-95 and Third Generation CDMA Applications", Prentice Hall Communications Engineering and Emerging Technologies Series, ISBN 0-13-719287-8.
[7] Rooyen, Lotter, Wyk (2000) "Space Time Processing for CDMA Mobile Communications", Kluwer International Series in Engineering and computer science, Kluwer Academic Publishers, ISBN 0-7923-7759-1.
[8] Golub ;Loan (1996)"Matrix Computations", Johns Hopkins University Press, ISBN 0-8018-5414- 8.
[9] M. Z. Win and Robert A. Scholtz, “On the robustness of ultra-wide bandwidth signals in dense multi-path environments,” IEEE Comm. Lett., vol. 2, pp. 51-53, Feb. 1998.
[10] R. J.-M. Cramer, M. Z. Win, and R. A. Scholtz, “Spatio-temporal diversity in ultra-wideband radio,” IEEE Wireless Comm. And Networking Conf., vol. 2, pp. 888-892, Sep. 1999.
[11] L. Zhao and A. Haimovic, “Performance of ultra-wideband communications in the presence of interference,” IEEE Journal on Selected Areas in Communications, vol. 20, pp. 1684-1692, Dec. 2002.
[12] J. R. Foerster, “Interference modeling of pulse-based UWB waveforms on narrowband systems,” IEEE 55th Vehicular Technology Conference, vol. 4, pp. 1931-1935, May 2002.
[13] A. Muqaibel, B. Woerner, and S. Riad, “Application of multi-user detection techniques to impulse radio time hopping multiple access systems,” IEEE Conference on Ultra Wideband Systems and Technology, May 2002.
[14] J. D. Choi and W. E. Stark, “Performance of Ultra-Wideband Communications With Suboptimal Receivers in Multipath Channels,” IEEE Journal on Selected Areas in Communications, vol. 20, no. 9, Dec. 2002.
[15] X. Chen and S. Kiaei, “Monocycle shapes for ultra wideband system,” IEEE International Symposium on Circuits and Systems, vol. 1, pp. 597 –600, May 2002.