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Simulation and Design of Transceiver System of Zigbee Using Matlab

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ABSTRACT

ZigBee technology was developed for special wireless networks where Bluetooth & wi-fi technologies are not showing better results. In wireless personal area networks (PAN) where we need to transmit low data rate information in comparatively large area (10-100 m). We can use Zigbee transceiver system instead of other technologies. As the functionality of Simplicity and Zigbee Technology is similar still we prefer Zigbee system. So this paper will show that how Zigbee technology is different from Simplicity and other wireless networking technologies and what are basic advantages of Zigbee technology over other systems. To design the Zigbee transceiver system different modulation techniques can be used. In this paper, the design methodology and simulation results of ZigBee transceiver at physical layer are presented using MSK modulation technique.

1. INTRODUCTION

ZigBee is a home-area network designed specifically to replace the proliferation of individual remote controls. ZigBee was created to satisfy the market need for a cost-efficient, standards-based wireless network that supports low data rates, low power consumption, security, and reliability. To address this need, the ZigBee Alliance, an industry working group is developing standardized application software on top of the IEEE 802.15.4 wireless standard. Zigbee standard is basically design for low cost, low power consuming & low data rate required system. Zigbee standard is placed in Physical and Medium Access Layer (MAC). As Zigbee is an standard of Zigbee Alliance. Higher layer specified in the Zigbee standard is for industry alliance. The application of Zigbee Technology can be seen in home monitoring system, climate sensors communication, collection of data in small area in research field & industrial control etc. The major application of Zigbee transceiver is shown in wireless sensor networking and automatic control system such as home controlling, biotelemetry, personal caring (for senior citizens) etc. Home, industry and other organization automation is the major application of Zigbee transmission. Light (Power) control, Light machinery control, SCADA networking etc are some more important application areas of Zigbee technology. Here a comparatively analysis of Zigbee, Bluetooth and Wi-Fi technology is also present that will help us that how Zigbee is different than other wireless networking technologies.

Table 1: Comparison of Other Wireless Technology

System	Zigbee	Bluetooth	Wi-fi
Application	Monitoring & Control	Cable Replacement	Internet
System Resources	4-32 KB	250KB	1 MB+
Battery Life (Days)	100-1000	1-7	Hours
Nodes in Network	255/65K	7	32
Baseband(Kb/s)	20-250	720	11 Mbps
Distance	1-100 m	1-10m	100 m
Key Characteristics	Stability, low consumption , low cost	Price, Easy use, High Data Rate	Very High Speed. Large network

2. DESIGN OF TRANSCEIVER

This section describes the implementation of ZIGBEE transmitter system. The implementation was built on Matlab/Simulink using fundamental components in Simulink to demonstrate how reliably complex modulation schemes can be built, cost effectively and efficiently. The design of ZigBee transmitter using OQPSK modulation with half sine pulse shaping is shown. Here the input bit stream is having a data rate of 250Kbps. Now we are mapping 4 input data bits to a symbol having a symbol rate of 62.5Kilo symbols per second. The symbol is then used to select one of 16 nearly orthogonal 32-chip PN sequences to be transmitted and results in a chip rate of two mega chips per second. After that, resultant chip sequence is send to the serial to parallel converter. It is used here to separate the even indexed chips and odd indexed chips. Following this half sine pulse shaping is performed and signal modulated with a 2.4 GHz carrier on the I and Q data stream and add it to get the required transmitter output signal. Step by step procedure to implement ZigBee transmitter using simulink is presented below.

After obtaining the inphase and Quadrature signals after half sine pulse shaping, we need to do modulation for the transmission of the signal. Generally we do this with the help of high frequency(2.4GHz) sinusoidal carrier. By using sine wave block in Signal Processing Tool Box, sine wave can be generated by adjusting the parameters like amplitude, frequency, sample time, phase and sine type. Now the inphase signal after half sine pulse shaping is multiplied by a sine wave and Quadrature signal after half sine pulse shaping is multiplied by its orthogonal carrier i.e., cosine signal which is nothing but 900 phase shift of original sinusoidal carrier.

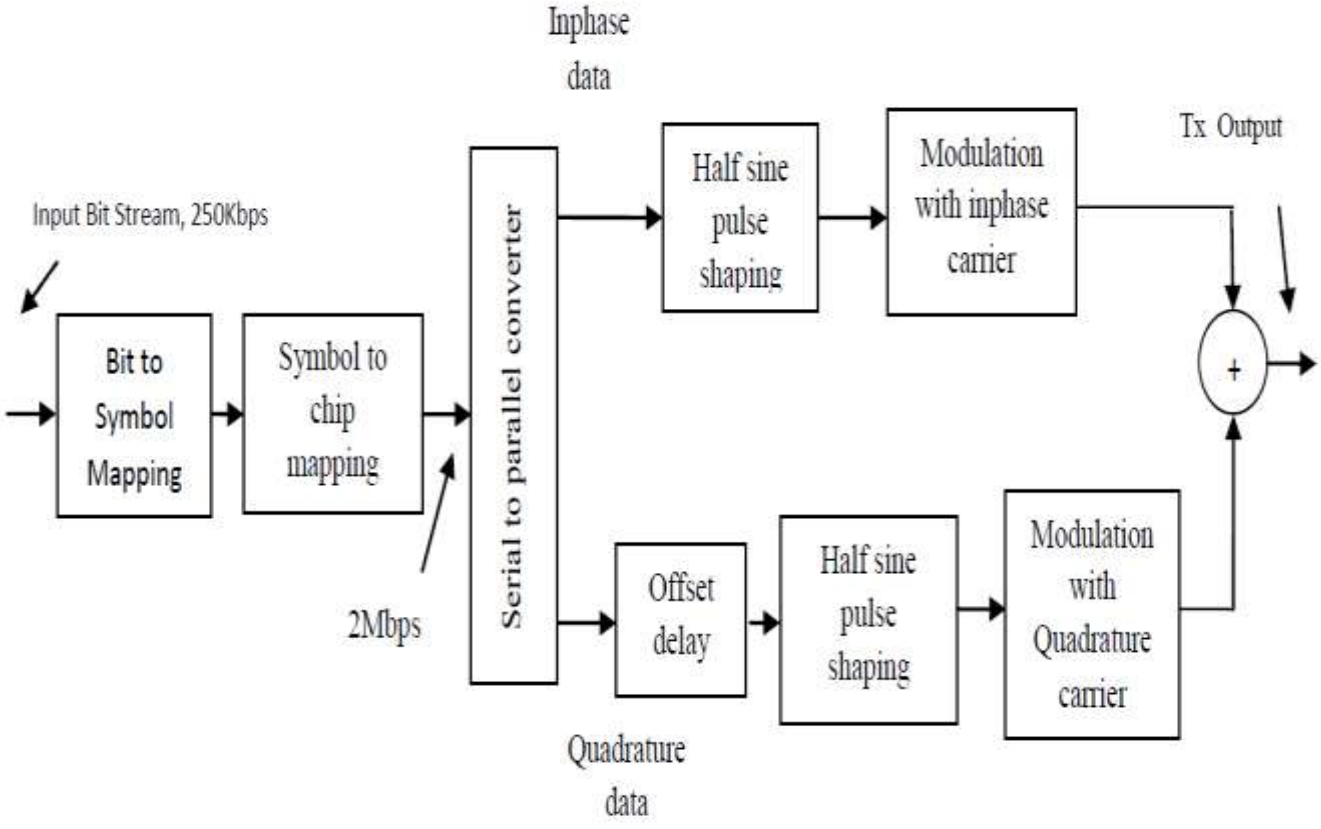

Figure 1: Zigbee Transmitter

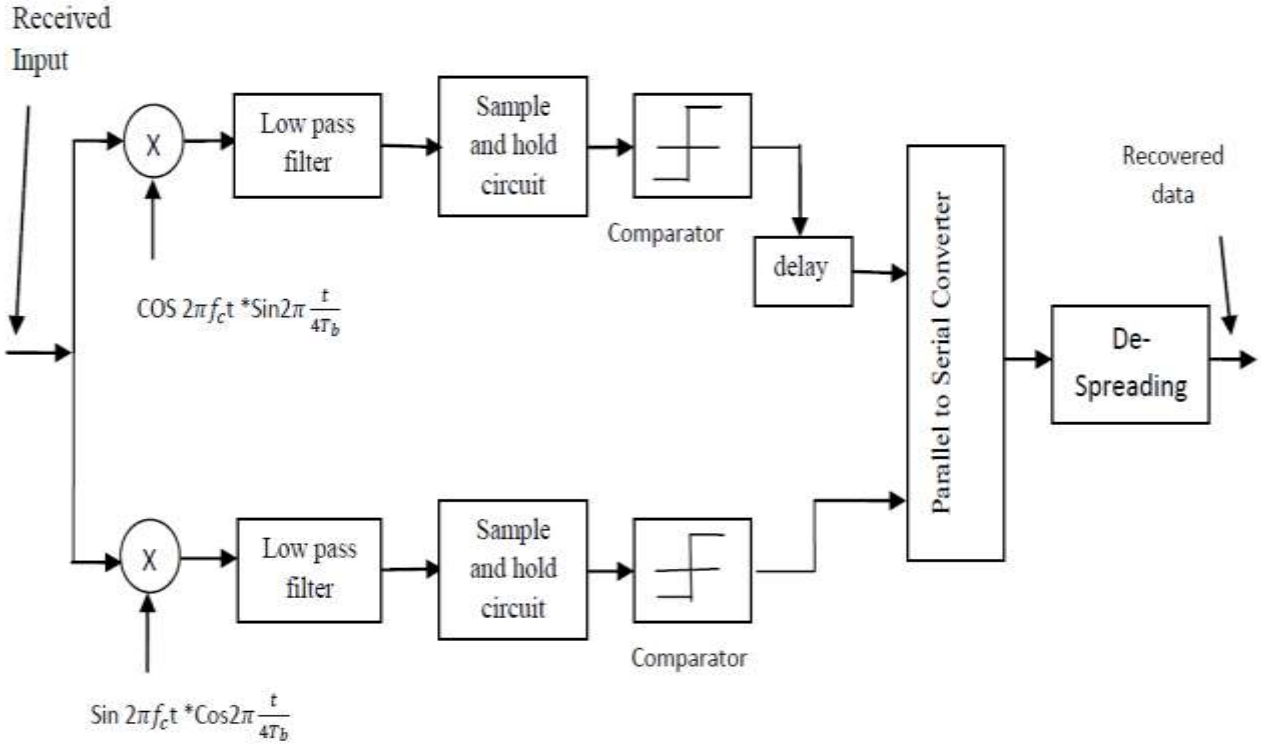

Figure 2: Zigbee Receiver

There are two type detection schemes available for the detection of original baseband data. They are coherent detection and non-coherent detection. In coherent detection, the phase of carrier that we used in the transmitter and phase of recovered carrier must be same. So proper carrier synchronization is necessary in the coherent demodulation. In case of non-coherent demodulation, there is no need of carrier synchronization. Coherent detection is costlier to implement, that is, the receiver must be equipped with a carrier recovery circuitry, which in turn increases system complexity, and can increase size and power consumption. Additionally, there is no ideal carrier recovery circuit. So, no practical digital communication system works under perfect phase coherence. While Non coherent detection uses previous bit information for extracting the original data and there is no need of using the carrier recovery circuit.

Non-coherent detection is simpler, but it suffers from performance degradation as compared to coherent detection, but this difference can be small in practice for some modulation schemes due to the specifics of the modulation and also due to the penalty caused by imperfections in the carrier recovering process. In the receiver configuration of ZigBee, we are using a MSK demodulator and a multiplier for dispreading. This multiplier is supplied by a PN sequence data that is an exact replica that used in the transmitter. The data coming from the MSK demodulator (i.e. at the parallel to serial converter) is having a data rate of 2Mbps. From this data, the original data is extracted by multiplying with the PN sequence data. But the 2Mbps data obtained at the output of parallel to serial converter contains some offset delay. This offset delay must introduced in the PN sequence data while multiplying with 2Mbps data, So that output contains original bit stream without any errors.

Step by step procedure to implement ZigBee receiver using Simulink is presented below.

A. RF to Baseband conversion

B. Sampling and thresholding.

C. Parallel to serial conversion.

D. Despreading.

3. SIMULATION RESULTS

AT TRANSMITTER END

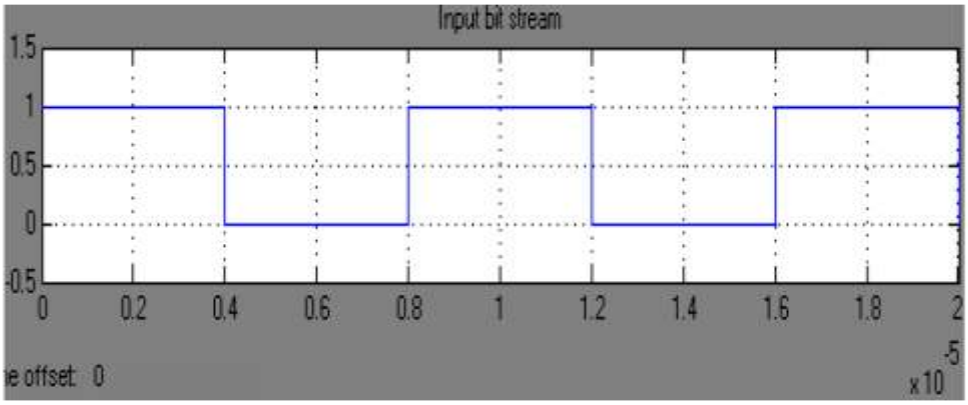

Figure 3: Input Bit Stream

The input stream is generated from a random integer generator. It has a data rate of 250Kbps. i.e., it generates a bit for every 4μs as shown in the time axis. Each division for the time axis is taken as 10μs. The 250Kbps input data is mapped into a symbol, making the symbol rate 62.5Kilo symbols per second. The Pseudo Noise code is generated from a PN sequence generator. It has a data rate of 2Mbps. That means each bit in the PN sequence is having a time period of 0.5 μs. Clearly the chip rate is equal to eight times the bit rate or it is equal to 32 times of symbol rate. Direct Sequence Spread signal is generated by converting the input bit stream and PN bit sequence into NRZ form and multiply the resultant data. The clock signal used for the flip-flops. From this clock, two clocks are generated using T flip-flop. These two clocks are

complement to each other. The period is double to that of original clock signal. These are called as inphase clock and Quadrature clock. Clearly ,the results shows that there is no phase transitions in the output by using OQPSK with half sine pulse shaping. By taking this as advantage, an efficient power amplifier design is possible in the realization of hardware.

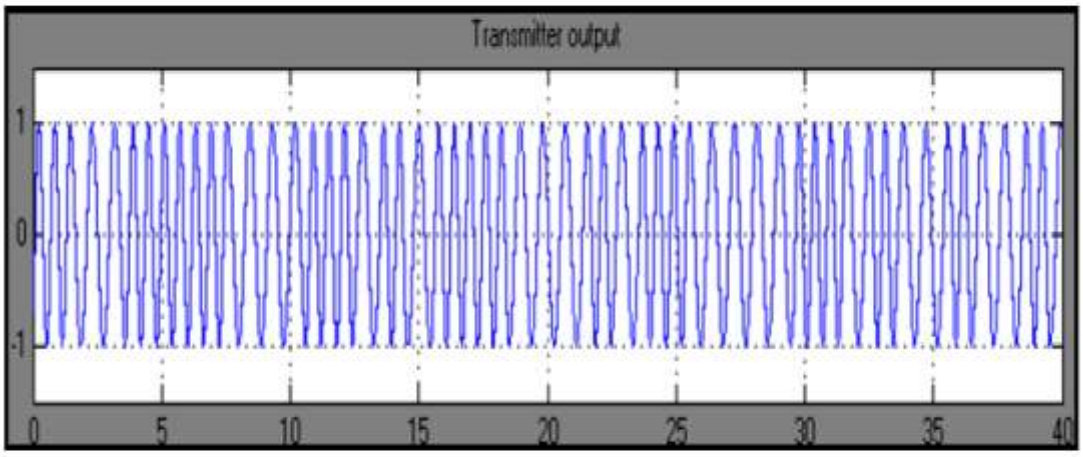

Figure 4: Outout Of Transmitter

AT RECEIVER END

By observing these figures, we can know easily what happens exactly inside the ZigBee Receiver. The transmitted signal is passed through a AWGN channel. The noisy version of the transmitted signal at the input of receiver is shown in Figure. The resultant signals containing both the high frequency harmonics and baseband signal components. Separate the baseband signal components form high frequency harmonics by passing through a low pass filter. These signals are passed through a 3rd order Butterworth low pass filter having cutoff frequency of 500 KHz for extracting only baseband data. Outputs after low pass filtering. Next this baseband output is passed through a sample and hold circuit for sampling of base band signal. The sample period used for sampling is 2µs. This sampled data is passed through a comparator, for deciding whether the transmitted bit is „1" or „0". Set the threshold for comparator as „0". Next, introduce a delay of one bit period at the Quadrature demodulator output. If the delay introduced in the transmitter at Quadrature side, then introduce the same amount of delay in the receiver in phase stage and vice versa.

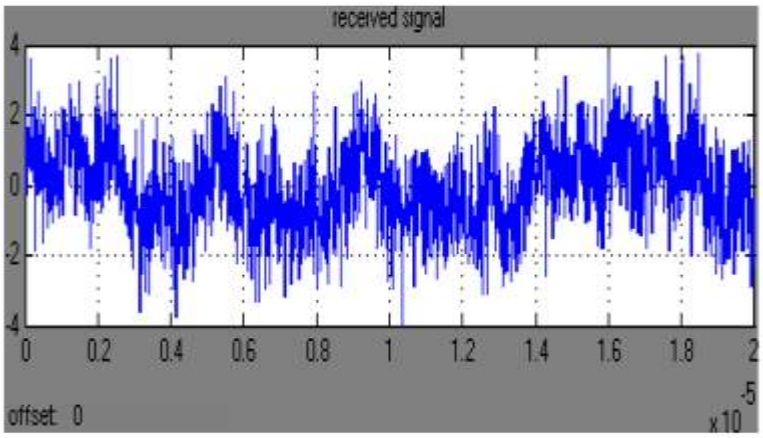

Figure 5: RECEIVED SIGNAL THROUGH CHANNEL

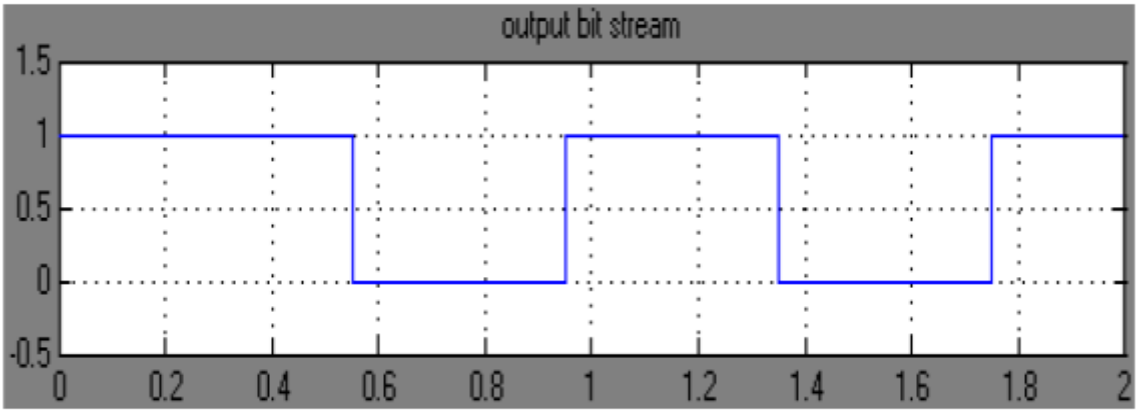

Figure 6: OUTPUT BIT STREAM

CONCLUSION

Design and simulation of Zigbee transceiver using QPSK modulation technique in Simulink is presented here. This shows that this is most promising technology which provide low data rate with low BER & large acquired area. So, this technology can be used for future Personal Area Network in general purpose. This paper also presents the comparative analysis of Zigbee transceiver system with other networking technologies like Wi-fi, Bluetooth, IEEE 802.11b.

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