# Design & Simulation of Zigbee Transceiver System Based on MSK and QPSK Using Matlab

***Kapil Dev Jha and Mohit Kumar Srivastava***

**Abstract: ZigBee technology was developed for special wireless networks where Bluetooth & wi-fi technologies are not showing where we need to transmit low data rate information in comparatively large area (10-100 m) [1]. We can use Zigbee transceiver system instead of other technologies. As the functionality of SimpliciTI and Zigbee Technology is similar still we are preferring Zigbee system. So this paper will show that how Zigbee technology is different from SimpliciTI 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 [6].**

**Keywords- IEEE 802.15.4, SimpliciTI, MSK, Zigbee.**

## I. 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.

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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 [3]:

**TABLE 1: COMPARISON OF ZIGBEE WITH OTHER NETWORKING SYSTEMS**

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

## II. COMPARISON WITH SIMPLICITI

SimpliciTI is Texas Instruments proprietary network protocol for low-power radio frequency wireless communication. Main properties of SimpliciTI are, Low cost which means that SimpliciTI network protocol can be implemented in systems with small memory capacity. Flexibility is achieved by multiple network topologies namely star and peer-to-peer. The basic Application Programmers Interface (API) makes SimpliciTI simple to be used. Wide selection of transceiver chips made to work with SimpliciTI operating in sub-1GHz frequencies and in 2.4 GHz band makes this protocol versatile. Finally very low current consumption in sleep state makes SimpliciTI very well suited for battery powered applications. SimpliciTI and ZigBee modules have slightly different characteristics. ZigBee has greater range but power consumption in sleep state is higher than SimpliciTI module. Both modules can be battery powered and both are small in size. However ZigBee has more peripherals, so in complicated personal area network zigbee module is more preferable than any other technology [4].

## III. CONSTRUCTION OF TRANSCEIVER

The implementation was built on Matlab/Simulink usingfundamental components in Simulink to demonstrate how reliably complex modulation schemes can be built, cost effectively and efficiently [5]. The design of ZigBee transmitter using MSK modulation is shown in the Figure 1. Here we map input data bits to 8-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 odd and even bit indexed chips. Following this bipolar data formatting is performed and signal modulated with a 2.4 GHz carrier on the In Phase and QuadraturePhase data stream and adds it to get the required transmitter output signal.

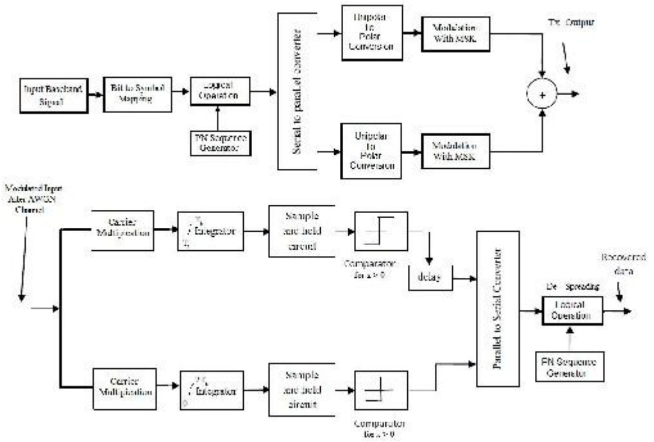


Fig 2: Block Diagram of Zigbee transmitter and receiver system

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 for the coherent detection. 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 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 [7], [8]. As Here we are using coherent detection, first In-pahse and Quadrature-Phase carrier is multiplied with received signal and then integrated with their respective time limits. Sample & hold circuit makes the samples by which we can find out the spreaded data signal with the help of comparator. Up to this we have In- Phase and Quadrature-Phase spreaded data which passes through the parallel to serial convertor to be a serial spreaded baseband signal can be obtained.

## IV. RESULTS

After simulation of the Zigbee transceiver system as shown in figure 1, the following results have been obtained. As the input bit stream generated by Bernoulli binary generator of 250Kbps is shown here in figure 2.

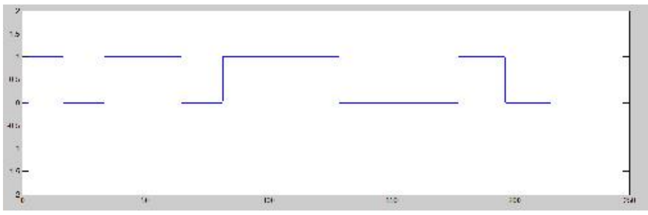

Fig.2: Input bit stream generated by Bernoulli random generator

The DSSS signal has a data rate of 2Mbps. So PN Sequence is chosen with 32chips /s, So chip rate is achieved of 2Mbps. PN Sequence and spreaded input signal is shown in figure 3 and 4.

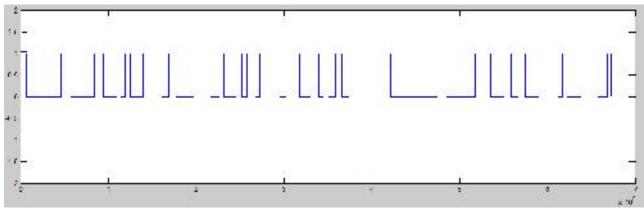

FIG 3: PN SEQUENCE

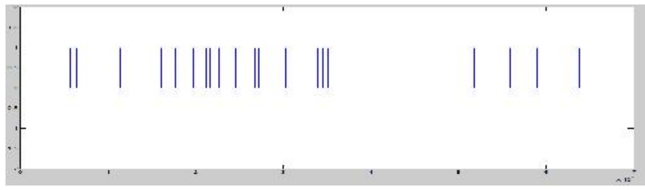

Fig 4: Spreaded Input Data

Using serial to parallel data converter, odd bits and even bits are achieved. To generate it we need clock pulse as shown in figure 5.

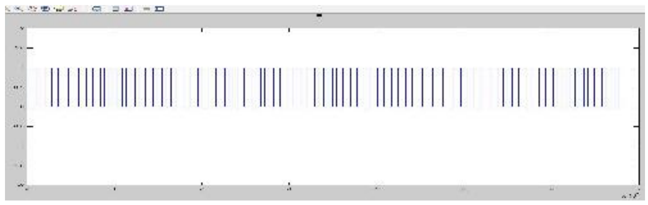

Fig 5: Clock Pulse

The In-phase data and Quadrature-Phase data after serial to parallel conversion are shown in figure 6.

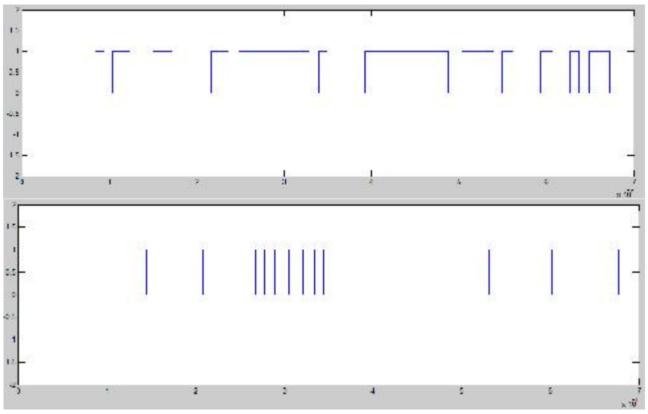

Fig 6: In-phase and Quadrature-Phase data stream

In MSK modulation technique we need bipolar signal in place of unipolar data sequence. So using bipolar converter we got bipolar in-phase and quadrature-phase data sequence is obtained as shown in figure 7.

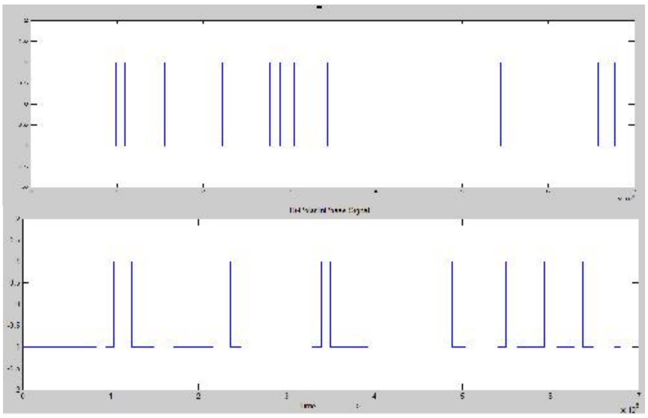

Fig 7: Bipolar Form of In-Phase and Quadrature-Phase Data Stream

After multiplying with carrier of center frequency 2.4 GHz MSK modulation of in-phase and quadrature-phase data signal is obtained.

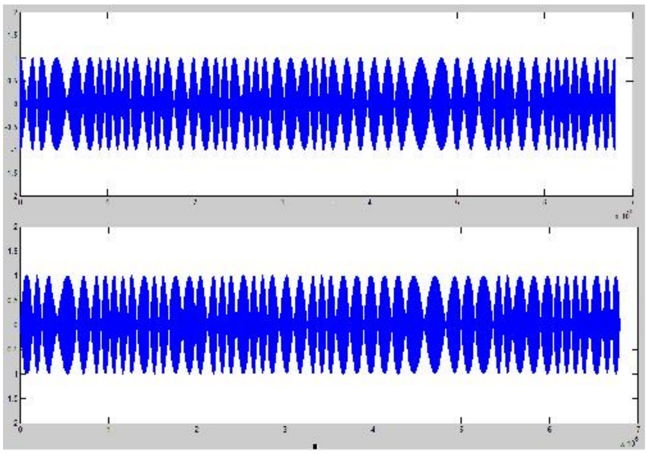

Fig 8: In-Phase and Quadrature-Phase Modulated Signal

Addition of both data will generated the final MSK modulated Zigbee transmitter signal (Figure 9).

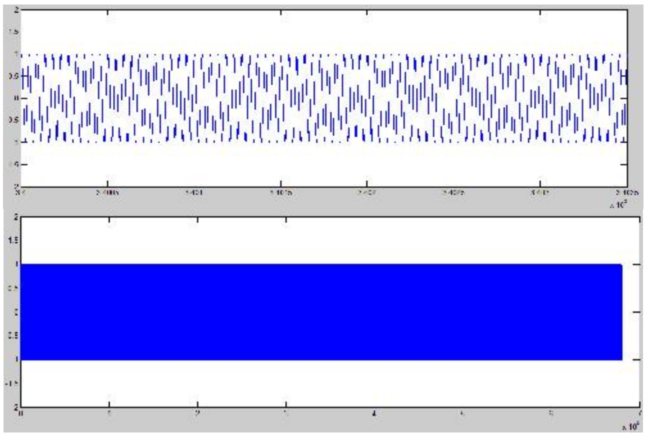

Fig 9: Transmitted Signal

As human eyes are not able to see the high frequency transmitted signal so here the zoomed signal is presented in figure 10.

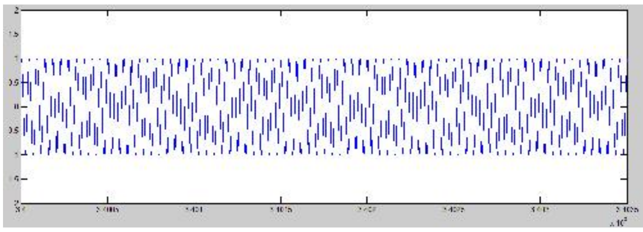

Fig 10: Zoomed Transmitted Signal

After passing through AWGN Channel, white Gaussian noise is added to the transmitted signal. So the changes in signal and zoomed signal are shown in figure 11 and 12 respectively.

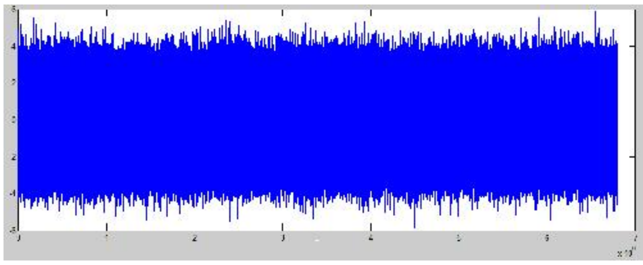

Fig 11: Received Signal at Receiver

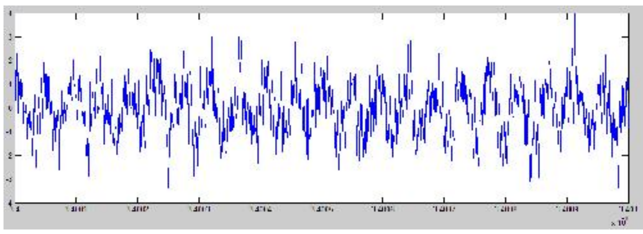

Fig 12: Zoomed View of Received Signal

To recover signal carrier signal of center frequency 2.4GHz is multiplied with received signal. Which create in-phase and quadrature-phase signal as shown in figure 13.

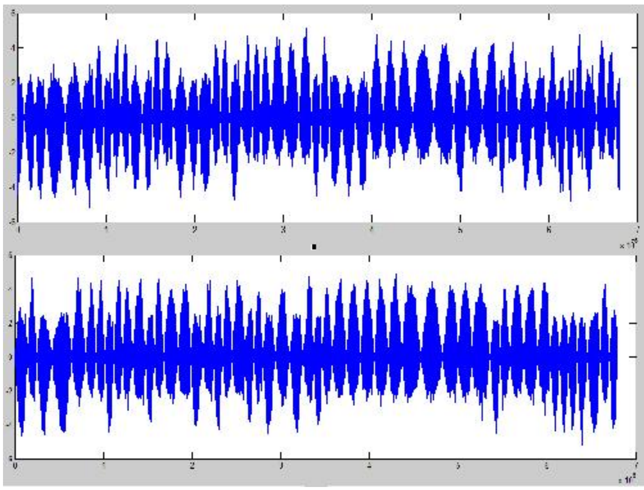

Fig 13: In Phase and Quadrature Phase Data after Carrier Multiplication

Sample & hold circuit & comparator provide us the original inphase & quadrature phase data. Then after providing one bit delay in quadrature phase data & find out the parallel to serial data.

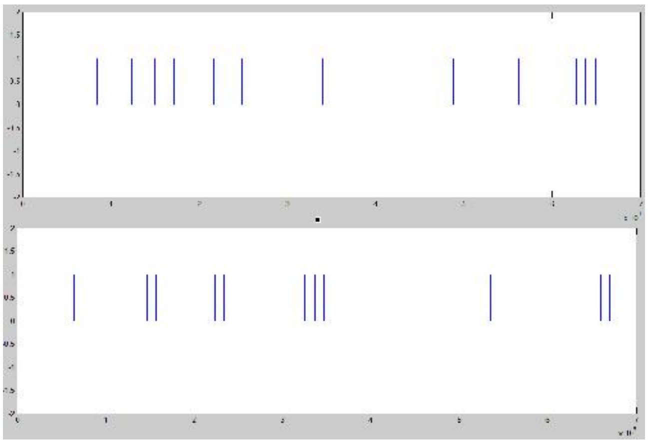

Fig 14: In Phase and Quadrature Phase Data after Comparision

Now signal can be serially received after using parallel to serial converter as shown in figure 15.

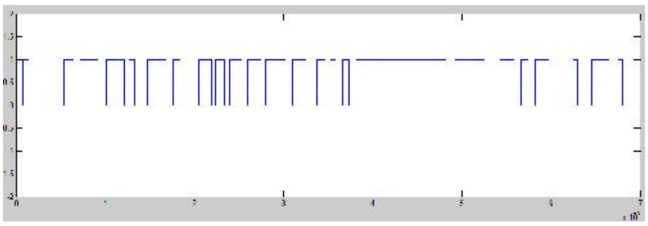

Fig 15: Spreaded Output Signal

Here we recovered the original data after use of shifted version of PN sequence at the receiver end as shown in figure 16.

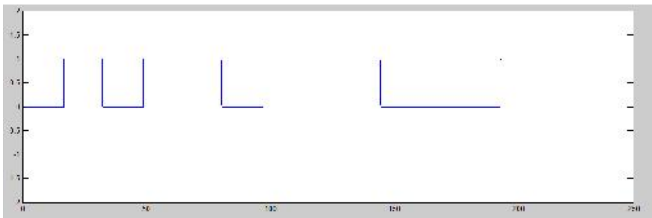

Fig 16: Delayed Baseband Digital Signal at Receiver

## V. CONCLUSIONs

Design and simulation of Zigbee transceiver using MSK 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, SimpiliciTI.

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