FPGA Implementation of Digital Modulators

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Abstract -- **This paper presents an overview of the Implementation of Digital Modulator BASK, BFSK, and BPSK on FPGA and presents a new approach for its implementation. The simulation of a Digital Modulator using Matlab environment and a tool from Xilinx is used for FPGA design as well as the implementation of the modulator on FPGA using a Spartan 3E starter kit. The modulator algorithm has been implemented on FPGA using the VHDL language on Xilinx ISE 12.3. Based on recent development of software tools and FPGA circuits, the technique used in this paper improves a solution for implementing the Digital Modulator on FPGA. The modulated signal obtained from simulations h a s b e e n compared with the signal obtained after implementation. The modulator design has been simulated and theirs performances has evaluated by measurements.**

Keywords: BASK, BFSK, BPSK, Digital Modulator,FPGA.

I. INTRODUCTION

FIELD-PROGRAMMABLE gate arrays (FPGAs) are semiconductor devices containing programmable logic elements (LEs) and a hierarchy of reconfigurable interconnects to realize any complex combinational or sequential logic functions. Hardware implemented in an FPGA can be reconfigured by programming the logic elements and interconnections for specific applications, even after the product has been installed in the field. Today's FPGAs consist of configurable embedded static random-access memories (SRAMs), high speed transceivers, high-speed input/output (I/O) elements, network interfaces, and even hard-embedded processors

A literature survey shows that FPGAs are widely used in different applications, such as motor controllers, neural network fuzzy-logic controllers etc. On the other hand implementation of digital modulation and demodulation using FPGAs has received considerable attention. Signal-processing systems such as software-defined radios (SDRs) can receive various kinds of modulated signals via software programming using digital signal processors (DSPs).

Since digital modulation is less complex, more secure, and more efficient in long-distance transmission and noise detection/ correction than its analog counterpart, it has an important place in modern communications.

As we know it is very costly to buy real network devices and tools required to establish or deploy a complete system for building any simple or complex communication network systems. In addition, it is difficult to deploy tested systems without having the real equipment such as computers, switches, routers, oscilloscopes and also the different software required for the systems. To overcome these problems many researchers and software engineers developed different network simulation tools that can help in designing the complete network system. This work compares the performance and tradeoffs of popular digital modulation systems. The work presents combination of high-level modelling environments and automatic code generation with hardware/software co-design which elaborates the simulation to synthesis of digital modulation schemes using the MATLAB program and its implementation in a XILINX's Spartan-III kit using system generator. The specific digital design from analysis over creating the simulation model to mapping the modulator to the FPGA is discussed. Test benches created for both traditional and block diagram oriented Simulink system generator combination approaches. The results indicate that synthesis on FPGA hardware can be generated automatically reducing the design time from days to minutes.

II. THEORY OF DIGITAL MODULATIONS

BASK Modulation : The BASK is obtained by the alteration of the amplitude of the carrier wave. It has a very poor bandwidth efficiency. The basic merit of this technique is its simple implementations, but is highly prone to noise and the performance is well established only in the linear region, which does not make it a viable digital modulation technique for wireless or mobile application in the present scenario.

In a BASK (binary amplitude-shift keying) modulation process, the amplitude of the sinusoidal carrier signal is changed according to the message level ("0" or"1"), while keeping the frequency and phase constant.

A BASK signal can be expressed as:

$$S(t) = m(t)\,A\sin(2\pi f_c t + \Phi_0),\ 0 \le t \le T$$

where $m(t)$=0 or 1 (the binary message), T is the bit duration,

and A and fc, and Φ_0 are the amplitude and frequency of the sinusoidal carrier signal.
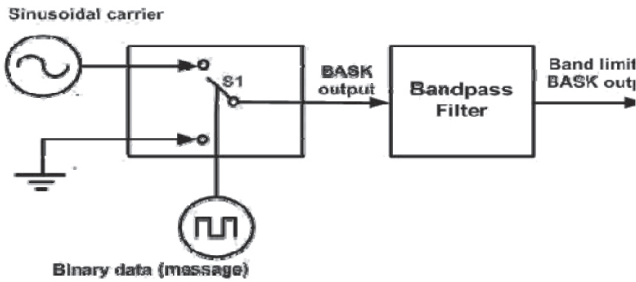
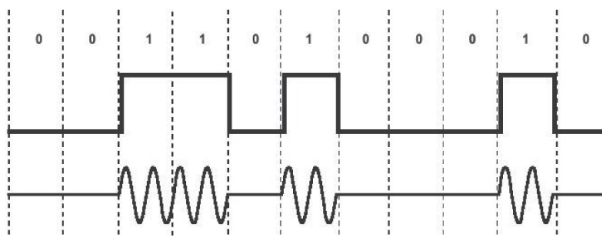

Figure 1. A block diagram of BASK modulation.

Figure 2. The modulating-signal (message) and BASK signal waveforms.

BFSK Modulation: In a BFSK (binary frequency-shift keying) modulation process, the frequency of the sinusoidal carrier signal is changed according to the message level ("0" or "1") while keeping the amplitude and phase constant.

A BFSK signal can be expressed as:

$$S_{BFSK}(t) = A \sin\{2\pi[fc + m(t)fm]t + \Phi_0\}, 0 \leq t \leq T$$

where $m(t) = 0$ or $m(t) = 1$ (the binary message), T is the bit duration, and A, fc, and Φ_0 are the amplitude, frequency, and phase of the sinusoidal carrier signal.
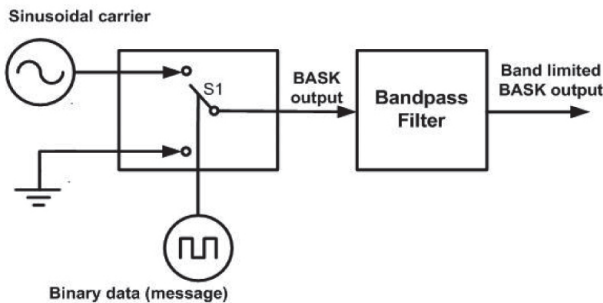

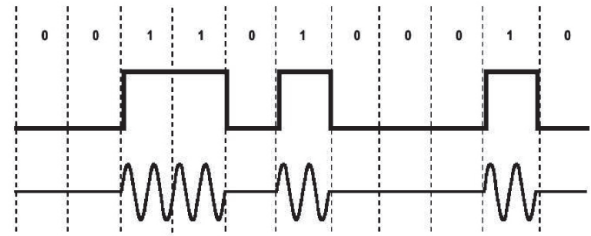Figure 3. A block diagram of BFSK modulation.

Figure 4. The modulating-signal (message) and BFSK signal waveforms.

BPSK Modulation: In a BPSK (binary phase-shift keying) modulation process, the phase of the sinusoidal carrier signal is changed according to the message level ("0" or "1") while keeping the amplitude and frequency constant.

A BPSK signal can be expressed as:

$$S^{BPSK}(t) = A \sin[2\pi f_c t + m(t)\pi], \qquad 0 \leq t \leq T$$

where $m(t)=0$ or 1 (the binary message), T is the bit duration, and A and fc are the amplitude and frequency of the sinusoidal carrier signal.
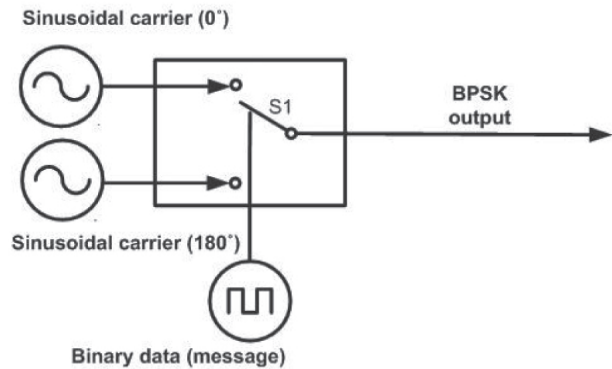

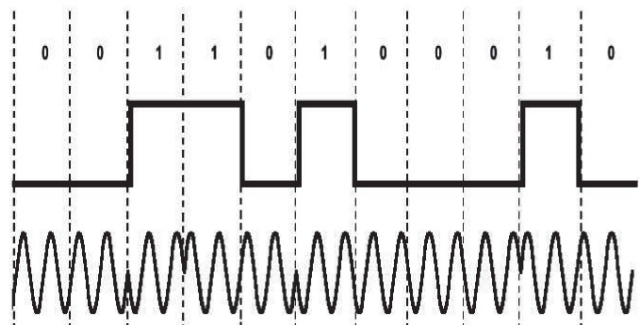Figure 5. A block diagram of BPSK modulation.

Figure 6. The modulating-signal (message) and BPSK signal waveform.

III. MATLAB MODEL FOR DIGITAL MODULATORS

Before solving a problem, one needs to first define and formulate the problem one intends to solve. Implementation of Digital modulator through Matlab creates the virtual environment to reduce the hardware cost and area overheads by increasing the frequency as a major parameter. To implement the above design we have used MATLAB to simulate and XILINX Spartan III to implement design on the FPGA Kit.

Implementation of Digital Modulator on FPGA: The setup Lab measurement used for realizing the Digital Modulator is illustrated in figure 7 below. Some of the resources used are Spartan 3E starter kit board. Spartan 3E FPGA starter kit is development platform based on Spartan 3E FPGA, it provides a development platform for Embedded processing application. The Spartan 3E family of FPGAs is designed to be well suited for wide range of electronics applications.
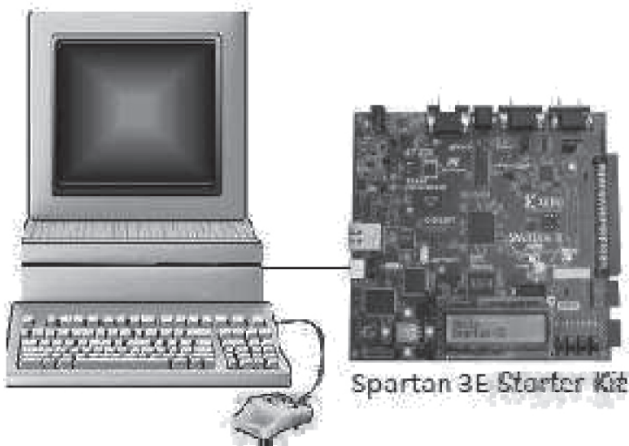

Figure 7. Spartan Kit.

IV. SIMULATION AND EXPERIMENTAL RESULT

Prior to the FPGA hardware implementation, the designed BASK, BFSK, and BPSK digital modulators were verified through simulations using the Matlab/Simulink environment. There are two parameters used in designing of Digital Modulator i.e. carrier frequency and modulating frequency.

BASK Simulation Result: For generating the modulating signal of BASK the value of carrier frequency is 1000 Hz and Modulating frequency is 500 Hz. Simulation result of BASK modulator shown in figure 8.
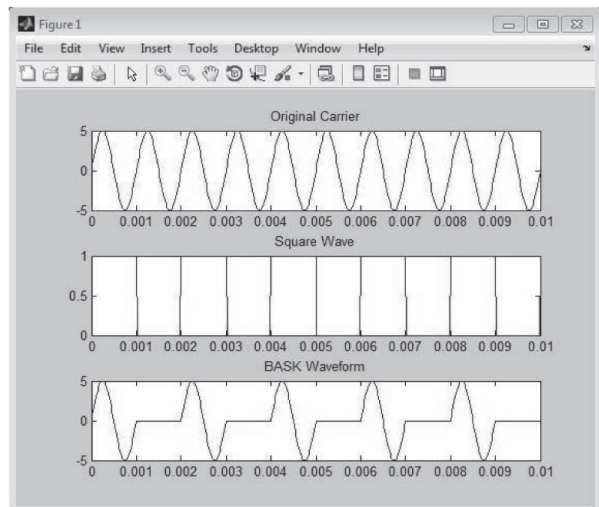

Figure 8. BASK Result.

BFSK Simulation Result: For generating the modulating signal of BASK the value of first carrier frequency is 1000 Hz, second carrier frequency is 2000 Hz and Modulating Frequency is 125 Hz. Simulation result of BFSK modulator shown in figure 9.
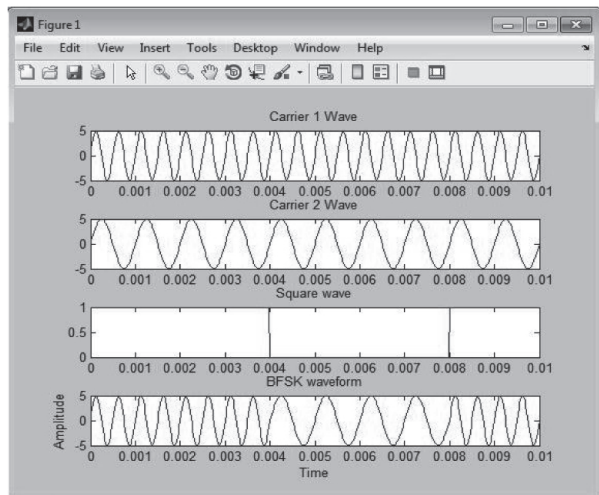

Figure 9. BFSK Result.

BPSK Simulation Result: For generating the modulating signal of BASK the value of carrier frequency is 1000 Hz and Modulating Frequency is 250 Hz. Simulation result of BPSK modulator shown in figure 10.
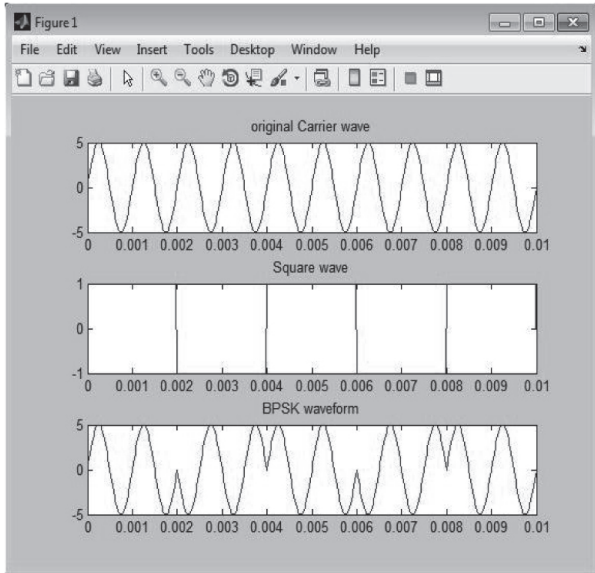
Figure 10. BPSK Result.

V. CONCLUSION

The choice of digital modulation scheme significantly affects the characteristics and resulting physical realization of communication system. This work describes the Concepts and simulations to Methods of hardware implementations of all the main digital modulation schemes used such as BASK, BFSK, and BPSK. It elaborates the simulation to synthesis of digital modulation schemes using the MATLAB/Simulink program and its implementation in a XILINX's Spartan- III kit.

VI. ACKNOWLEDGEMENT

VII. REFERENCES

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Dr. K.K. Tripathi possesses in-depth experience of 48 years in field of technical education, in teaching, guiding research and administration. He was founder Professor and HoD of Electronics Engineering Department of H.B.T.I. Kanpur. After completing 36 years of distinguished service at H.B.T.I. Kanpur, he joined premier technical institutions AKGEC, RKGIT, IMS and HRIT, Ghaziabad.

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