IMPLEMENTATION OF BPSK MODULATION FOR GROUND PENETRATING RADAR APPLICATION

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Abstract- The aim of the paper is to design a digital BPSK modulator for Ground Penetrating Radar applications. . The BPSK (Binary Phase Shift Keying) is one of the three basic binary modulation techniques. It has as a result only two phases of the carrier, at the same frequency, but separated by 180º. In this paper we took modulation as a main stream and analyzed about BPSK modulation technique on Xilinx System Generator software on Matlab Simulink Environment and tested it on XILINX ISE using Test Bench.

Index Terms- Binary Phase Shift Keying (BPSK), Ground Penetrating Radar (GPR), Simulink, Xilinx System Generator, Test Bench.

I. INTRODUCTION

Ground penetrating radar (GPR) is a geophysical method that uses radar pulses to image the subsurface. This nondestructive method uses electromagnetic radiation in the microwave band (UHF/VHF frequencies) of the radio spectrum, and detects the reflected signals from subsurface structures as shown in fig.1 [1].

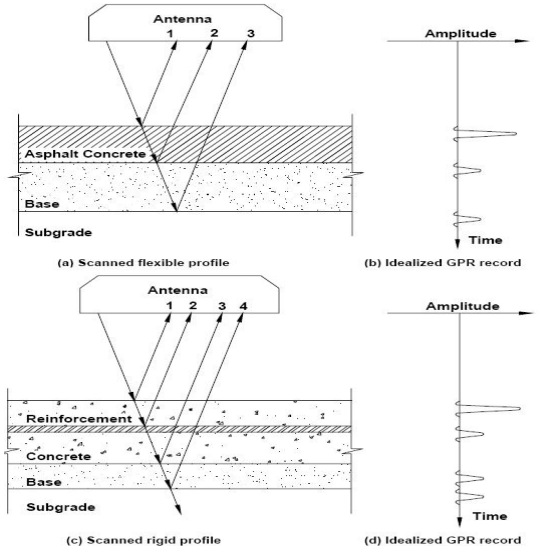


Fig.1 Ground Penetrating Radar

GPR can be used in a variety of media, including rock, soil, ice, fresh water, pavements and structures. It can detect objects, changes in material, and voids and cracks.

GPR Systems are widely used now-a-days in variety of applications including military and security, forensics, mining, archaeology, geology. Various modulation techniques used in GPR are amplitude modulation (A.M.), frequency modulation (F.M.), noise modulation, phase modulation, etc.

In phase modulation BPSK technique has some fine properties which make them an excellent candidate for radar applications. BPSK is chosen as modulation technique because of its advantages like accuracy of ranging, sensitivity, target separation, interference suppression, etc. The block diagram of a phase coded GPR is shown in fig. 2.

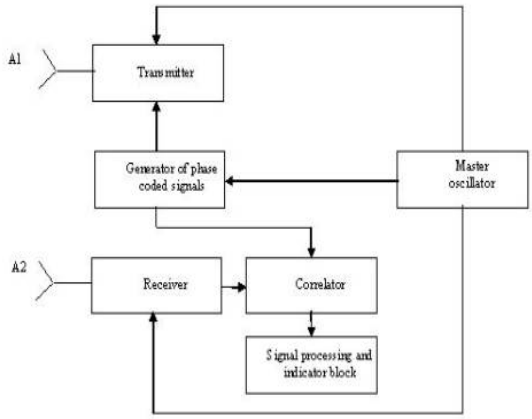


Fig. 2 Ground Penetrating Radar block diagram

The modulation process converts a baseband signal into a band pass signal compatible with available transmission facilities. At the receiver end, demodulation must be accomplished to recognize the signals. The process of deciding which symbol was transmitted is referred to as a detection process. Typically, the receiver generates a signal that is phase-locked to the carrier. Binary phase shift keying (BPSK) does not require but may use a coherent receiver. The coherent receiver is called the correlation receiver because it correlates the received

signal composed of the transmitted signal plus noise with a sinusoidal signal that is phase-locked to the transmitted carrier. The purpose of the correlation receiver is to reduce the received symbol to a single point or statistic that is used by the decision circuit to determine which symbol was transmitted (either 0 or 1). In practice, this single point is a fixed voltage. The decision circuit is a voltage comparator (digital number comparator) that is set so that if the input voltage (number) is above a threshold level, the Comparator indicates a "1" is received; if the input voltage (number) is below that level, a received "0" is indicated [2].

The current project utilizes MATLAB Simulink language as well as system generator block set for simulation and test bench implementation using Xilinx ISE 14.7.

The paper is organized into 6 sections. Section 1 gives an overview of the paper. Section 2 describes the basics of BPSK modulator. In section 3, different implementations of the BPSK modulator are presented. Section 4 is dedicated to the testing of modulator using Xilinx ISE and section 5 to simulation results. Finally, section 6 presents conclusion and future work.

II. BINARY PHASE SHIFT KEYING

BPSK modulation is the process by which the phase of the carrier is varied in accordance with the modulating signal.Fig.3 shows a simplified block diagram of a BPSK modulator.

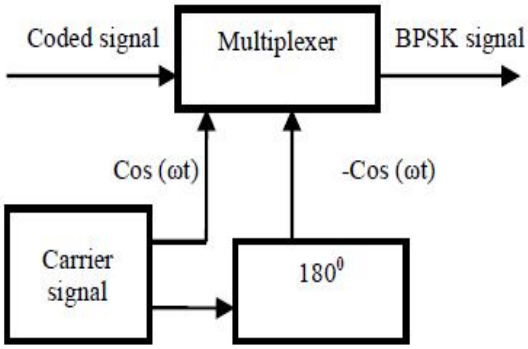


Fig.3 BPSK modulator

The BPSK (Binary Phase Shift Keying) is one of the three basic binary modulation techniques. It has as a result only two phases of the carrier, at the same frequency, but separated by 180º. The general form for the BPSK signals are according to (1), where f_c is the frequency of the carrier.

$$s1(t) = -A\sin(2\pi f_c t), \text{ if } 0_T$$
$$s2(t) = A\sin(2\pi f_c t), \text{ if } 1_T \quad (1)$$

The coded signal (1 or 0) enters to a multiplexer that commutes the phase of the carrier signal. Depending on the logical condition of the digital input, the carrier is transferred to the output, either in phase or at 180° outside of phase, with the reference carrier as shown in fig.4 [2].

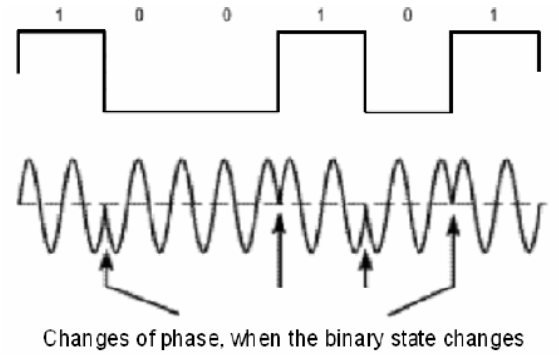


Fig.4 BPSK modulator output

III. BPSK SYSTEM IMPLEMENTATION

A. BPSK Modulator in Simulink

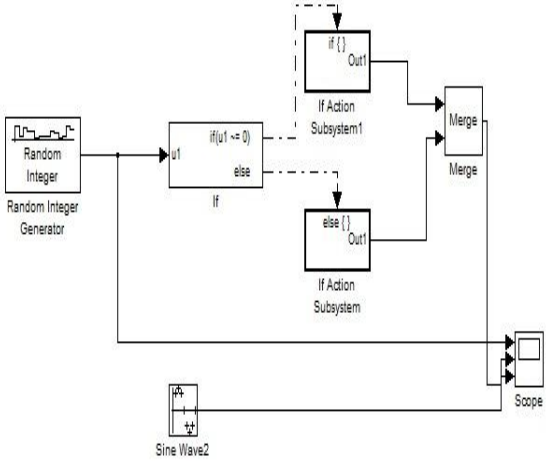


Fig.5 BPSK modulator in Simulink Environment

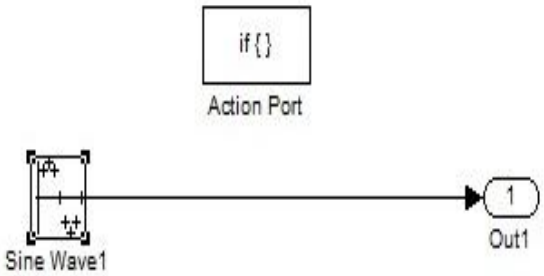


Fig.6 If Action Subsystem Block

Fig.5 shows an implementation of a BPSK modulator in the Simulink environment. The Simulink block set contains: the sine wave block (Fig.5) to generate carrier signal, random integer generator block (Fig. 5) to generate random binary sequence, If block (Fig.5) to choose between sinus for "1" and –sinus for "0". The output is merged in merge block (Fig.5) and can be viewed in scope.

B. BPSK Modulator in System Generator

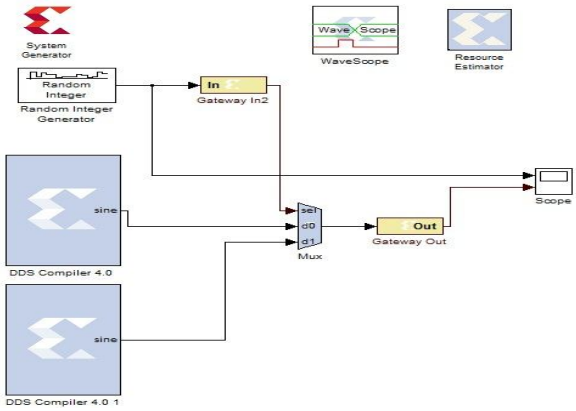


Fig.7 BPSK modulator in system generator

System Generator is a digital signal processing design tool from Xilinx, based on the Simulink environment used for FPGA design. Designs are made in the Simulink environment using a Xilinx specific block set. All implementation steps, including synthesis, place and route are automatically performed to generate an FPGA programming file [5].

Fig. 7 illustrates an implementation of a BPSK Modulator using System Generator tools in Simulink. The carrier is generated internal by DDS blocks from System Generator and the modulating signal is generated external using switches.

The Simulink Block set contains the Random integer generator and the scope.

The System Generator Block set contains: the gateway in blocks which are the inputs into the Xilinx portion of the Simulink design, the mux which implements a multiplexer, the gateway out block which is the output from the Xilinx portion of the Simulink design and two DDS compiler Blocks to generate carrier signals [3].

With the System Generator WaveScope, the user can view the waveforms generated in a design [4].

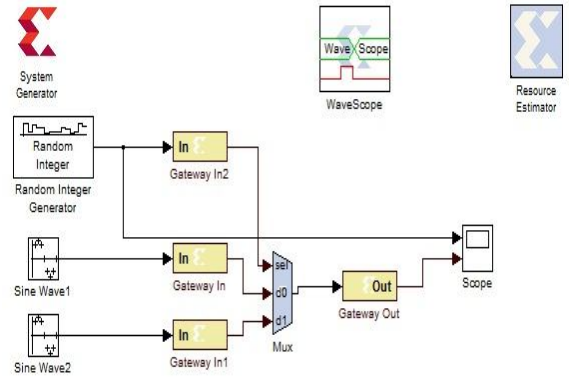


Fig. 8 Second implementation of BPSK modulator in system generator

In fig.8, the carrier as well as the modulating signal is generated external and the modulated signal is generated by Xilinx software package and routed to the scope.

The Simulink Block set contains the sine wave, the random integer generator and the scope.

The System Generator Block set contains: the gateway in blocks which are the inputs into the Xilinx portion of the Simulink design, the mux which implements a multiplexer and the gateway out block which is the output from the Xilinx portion of the Simulink design [3].

IV. TEST BENCH

Of the two implementations in system generator, the first implementation is tested in Xilinx ISE environment using a test bench. The vhdl programming code of the design is generated by the system generator block. The block generates the vhdl code for the hardware kit on which it is to be implemented. Test bench gives the correctness of the design and also tells the closeness of the output between Simulink environment and the Xilinx environment.

V. RESULTS

The following figures demonstrate simulation results for various BPSK modulator implementations and testing.

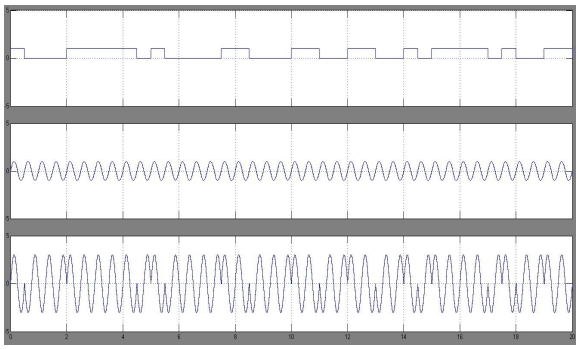


Fig.9 Waveforms of BPSK modulator in Simulink

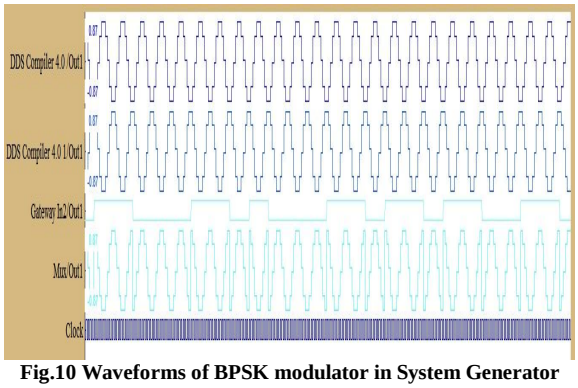


Fig.10 Waveforms of BPSK modulator in System Generator

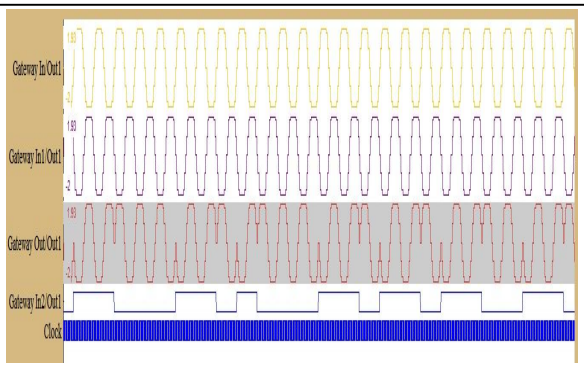


Fig.11 Waveforms of second implementation of BPSK modulator in System Generator

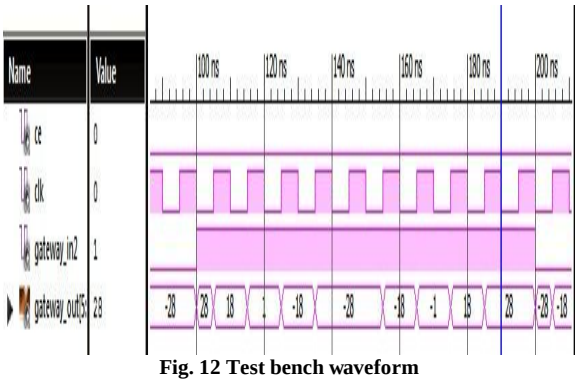


Fig. 12 Test bench waveform

CONCLUSION

We implemented a BPSK modulation technique using Matlab Simulink environment. Then, we made a proposal of two implementations of a BPSK modulator in System Generator. In the first, the three signals: the carrier, the modulating and the modulated signals were generated external. In the second scheme, the carrier is generated internal by DDS, and the modulating signal is generated external.

In the second part of the paper, we tested the BPSK modulator on Xilinx ISE 14.7 using test bench. The results given by the test bench exactly matches with the results obtained from simulation setup.

Our next goal is to implement the two proposals on Spartan 3E board. After implementing the BPSK modulator, we want to realize a BPSK system. The system will consist of a modulator and demodulator and the signal from the modulator to demodulator will pass through a channel affected by AWGN (Additive White Gaussian Noise).

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