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Reconfigurable MIMO Based Cognitive Radio on FPGA

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ABSTRACT: The sign of the cognitive Radio is to utilize the natural resources efficiently including frequency, time, and transmitted energy. The Cognitive Radio mainly involves radio sense analysis and channel identification performed by the receiver and transmits power control carried through the transmitter. The objective of the paper is to detect the ideal channel which means free of data and making the ideal channel available for allocation of data. In this paper we offer a way out for some problems like determining the location and reducing the interference and changing transmission parameter and characteristics with the help of MIMO. A Multiple Input, Multiple Output systems (MIMO) system typically consists of *x* transmit and *y* receive antennas. MIMO technology can also be used to increase the data rate instead of increasing errors. The paper combines the technique called reconfigurable to adapt all types of traffic signals. Another technique used here is the FSK modulation which generally gives eight bit data but we incorporate with the reconfigure system, we configure the data in to sixteen bit or to thirty two bit. The Scheduled result is to solve the high traffic user adapting with the help of reconfigurable MIMO FSK transmitter and CR.

KEYWORDS*:* Cognitive radio, MIMO, FPGA, Reconfigurable.

I. INTRODUCTION

Nowadays, radio frequency spectrum is considered as national resource which is reusable. However, recent studies highlight that many spectrum bands are not fully utilized because those spectrum bands are allocated through static assignment policies but only used in bounded regions or over limited period of time. To deal with such bandwidth scarcity and inefficient bandwidth usage, the concept of *Cognitive Radio* has been recognized in as an effective method. Types of Cognitive Radio: Full Cognitive Radio and Spectrum Sensing Cognitive Radio. Full cognitive radio is taken every possible parameter into account.

Spectrum Sensing Cognitive Radio is considering only radio frequency spectrum. The key idea that enables the underlay mode in a CR network is that with multiple antennae. MIMO technology has passionate interest because of its possible applications in digital television (DTV), wireless local area networks (WLANs), metropolitan area networks (MANs), and mobile communications. The antennas at each end of the communications circuit are combined to minimize errors and optimize data speed. The use of two or more antennas, along with the transmission of multiple signals at the source and the destination. The multiple antennae refers to a MIMO system typically consists of *m* transmit and *n* receive antennas. By using the same channel, every antenna receives not only the direct components intended for it, but also the indirect components intended for the other antennas. The direct connection from antenna 1 to 1 is specified with h11, etc., while the indirect connection from antenna 1 to 2 is identified as cross component h21, etc. From this is obtained transmission matrix **H** with the dimensions ***n x m.***

Reconfiguration is defined as the ability to modify or change the functional configuration of the device during operation, through either hardware or software changes. This is an FPGA feature that is important to communications, military, and consumer applications as an approach to reducing component count and power consumption, by reusing the same FPGA for several functions shown in Fig 1. The primary advantages of run-time reconfiguration in devices

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are reduced power consumption, hardware reuse, obsolescence avoidance, and flexibility. The costs of run-time Reconfigurability are in design and implementation complexity-both in architecture definition and in coding and test.

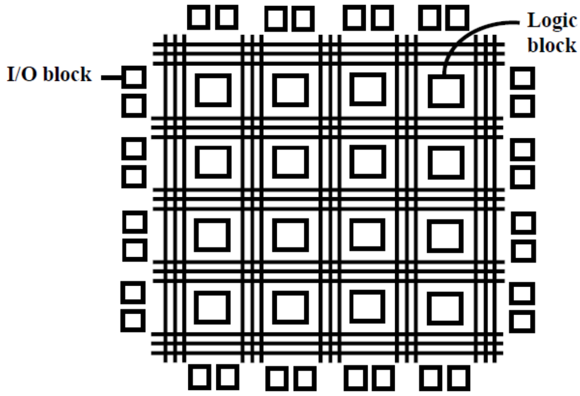

Fig. 1. Simplified Internal Structure of FPGA

II. COGNITIVE RADIO

A cognitive radio is an intelligent radio that can be programmed and configured dynamically. Its transceiver is designed to use the best wireless channels in its vicinity. Such a radio automatically detects available channels in wireless spectrum, then accordingly changes its transmission or reception parameters to allow more concurrent wireless communications in a given spectrum band at one location. This process is a form of dynamic spectrum management. The main functions of cognitive radios are:

A. *Power Control*: Power control is usually used for spectrum sharing CR systems to maximize the capacity of secondary users with interference power constraints to protect the primary users.

B. *Spectrum sensing*: Detecting unused spectrum and sharing it, without harmful interference to other users.

C. *Spectrum sensing:* Techniques may be grouped into three categories:
- Transmitter detection
- Matched filter detection
- Energy detection

Spectrum management: Capturing the best available spectrum to meet user communication requirements, while not creating undue interference to other(primary) users. Cognitive radios should decide on the best spectrum band (of all bands available) to meet quality of service requirements; Therefore, spectrum management functions are required for cognitive radios.

Function cycles of cognitive radio shown in Fig 2:
1. CR Sensing: It will sense in transmitter side such as radio environment and number of users waiting and number of channels we want to adapt.
2. CR Analysis: Get the acknowledgement from the receiver about the availability to transmitter. The Feedback from the receiver is send to transmitter (i.e.) Handshake.
3. CR Decide: It will decide for the feedback (i.e.) Final decision to allocate users to the appropriate channels.
4. CR Adapt: Users to the channels (i.e.) multi users in one channels. Ideal channels can adapt the data from the transmitter and busy channels cannot able to adapt the data from the transmitter.

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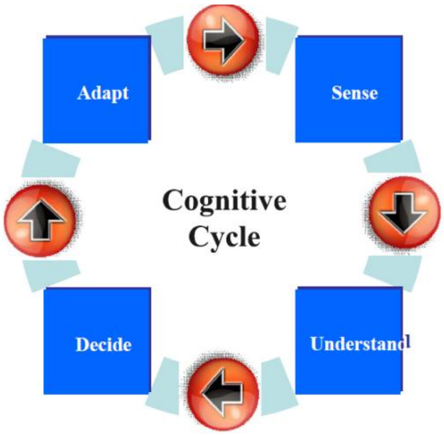

Fig. 2. Function Cycles Of Cognitive Radio

The concept of Cognitive Networks means that cognitive resource management will be applied throughout the wireless networks in order to more efficiently exploit both radio and network resources. The overall goal is to enhance communication capabilities throughout the networks. Principles of flexible spectrum use, including spectrum sensing methods, policies, sensing and utilization algorithms and spatial frequency reuse in cooperative and non-cooperative scenarios. Dynamic system management, radio resource management and multi-channel medium access control methods shown in Fig 3.

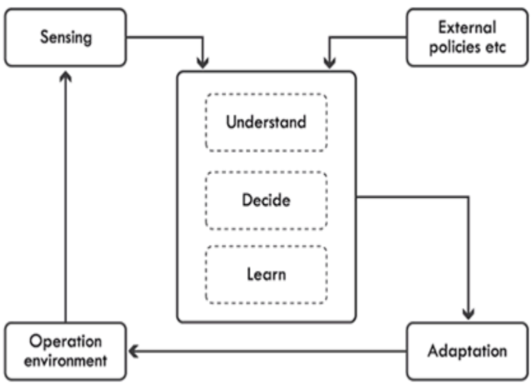

Fig. 3. Schematic view of the cognition cycle

III. RECONFIGURATION

Reconfiguration is defined as the ability to modify or change the functional configuration of the device during operation, through either hardware or software changes. This is an FPGA feature that is important to communications, military, and consumer applications as an approach to reducing component count and power consumption, by reusing the same FPGA for several functions. The primary advantages of run-time reconfiguration in devices are reduced power consumption, hardware reuse, obsolescence avoidance, and flexibility. The costs of run-time reconfigurability are in design and implementation complexity-both in architecture definition and in coding and test.

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A. MIMO:

A complete reconfigurable antenna system composed of multi element reconfigurable antennas and a control unit capable of efficiently driving the antennas is proposed to deliver unprecedented system performance. The key idea of this work is to show that reconfigurable antennas, through their capability to dynamically change their electrical and radiation properties, can be used to change the propagation characteristics of the wireless channel existing between the transmitting and receiving antennas.In MIMO systems, a transmitter sends multiple streams by multiple transmit antennas. The transmit streams go through a matrix channel which consists of all *M*x *N* paths between the *M* transmit antennas at the transmitter and *N* receive antennas at the receiver. Then, the receiver gets the received signal vectors by the multiple receive antennas and decodes the received signal vectors into the original information. The core idea under the MIMO systems is the ability to turn multi-path propagation, which is typically an obstacle in conventional wireless communication, into a benefit for users shown in Fig 4.

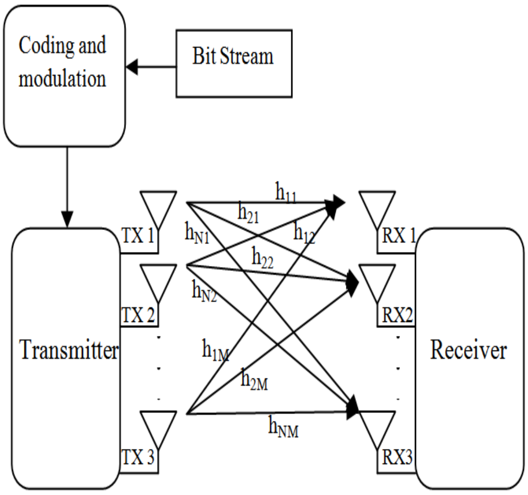

Fig. 4. MIMO System

B. FREQUENCY SHIFT KEYING:

In frequency-shift keying, the signals transmitted for marks (binary ones) and spaces (binary zeros) are respectively. This is called a discontinuous phase FSK system, because the phase of the signal is discontinuous at the switching times. A signal of this form can be generated by the following system is shown in Fig 5:

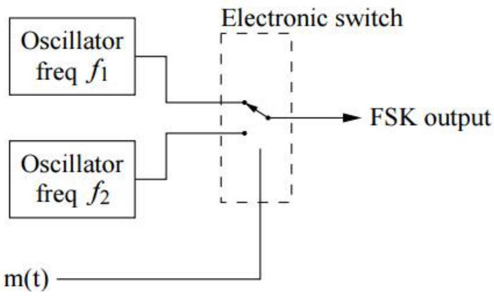

Fig. 5. FSK Signal

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A more practical alternative to discontinuous-phase FSK systems are continuous-phase FSK systems, where a polar binary baseband signal is provided as the input to a voltage-controlled oscillator (VCO). Overly sharp transitions in the phase of the output signal can be restricted by band-limiting the input to the VCO shown in Fig 6.

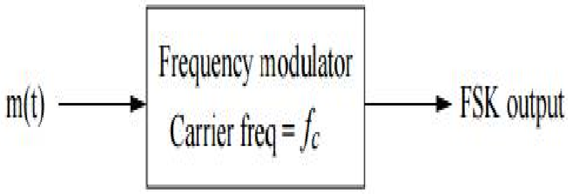

Fig. 6. FSK Modulation

IV. SYNTHESIS

Synthesis is the process of translating a design description to another level of abstraction, i.e, from behaviour to structure. We achieved synthesis by using a Synthesis tool like Foundation Express which outputs a netlist. It is similar to the compilation of a high level programming language like C into assembly code.
The synthesizer converts HDL (VHDL/Verilog) code into a gate-level netlist (represented in the terms of Xilinx library containing basic primitives). By default Xilinx ISE uses built-in synthesizer XST (Xilinx Synthesis Technology). Other synthesizers can also be used. Synthesis report contains many useful information. There is a maximum frequency estimate in the "timing summary" chapter. One should also pay attention to warnings since they can indicate hidden problems.

A. FPGA HARDWARE:

An FPGA is a device that contains a matrix of reconfigurable gate array logic circuitry. When a FPGA is configured, the internal circuitry is connected in a way that creates a hardware implementation of the software application. Unlike processors, FPGAs use dedicated hardware for processing logic and do not have an operating system. FPGAs are truly parallel in nature so different processing operations do not have to compete for the same resources. As a result, the performance of one part of the application is not affected when additional processing is added in Fig 7.

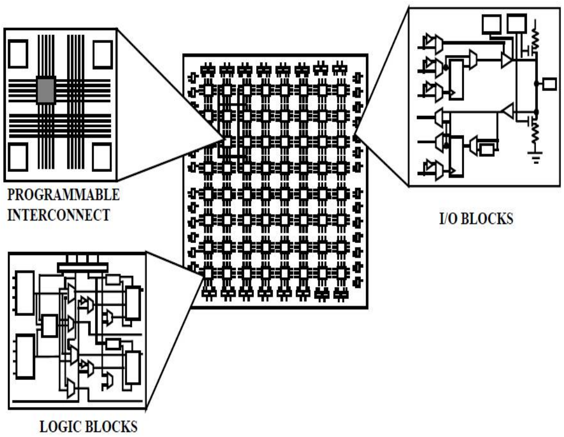

Fig. 7. Internal Structure of FPGA

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V. RESULTS

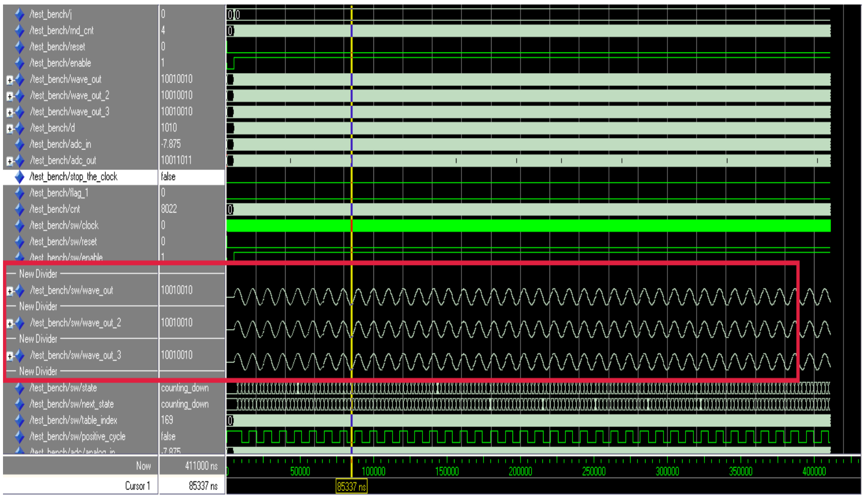

Fig.8. Sine Wave

A. DESCRIPTION FOR SINE WAVE:

The wave out signal was comes out from the test bench program where the inputs and outputs were already given. The modulated wave out was the FSK signal (i.e.) Sine wave. The table value index length changing accordingly shown in Fig 8.

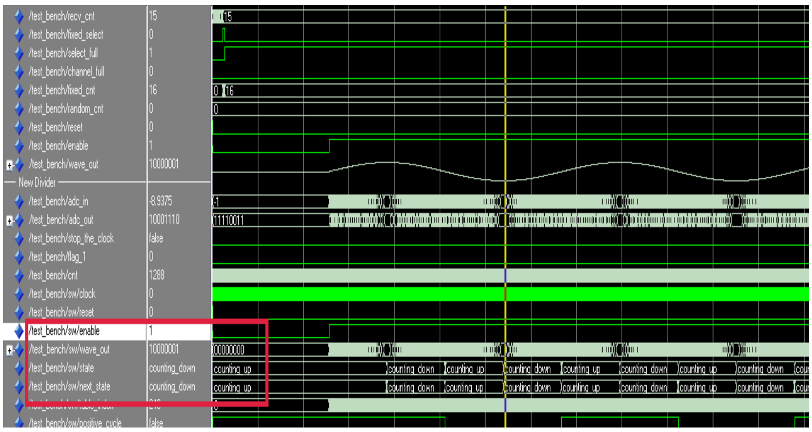

Fig.9. Table Index

B. DESCRIPTION FOR TABLE INDEX:

The state and next state were comes under the table index value for counting up and down the values for sine wave. The table index value was counting up till 255 counts and down after reaching the table index value 255 and that was called as counting down shown in Fig 9.

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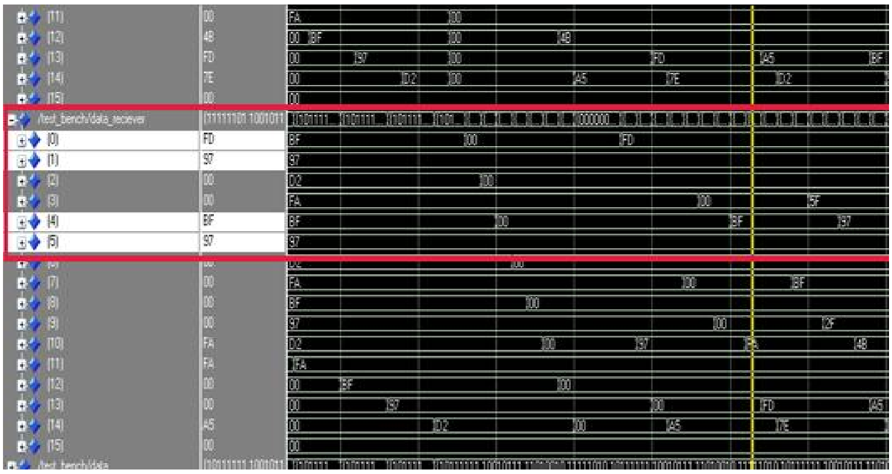

Fig.10. LED Output

C. DESCRIPTION FOR LED OUTPUT

The above waveform describes the LED output and indicates the 0^{th} ,1^{st} ,4^{th} and 5^{th} channels output in hexadecimal format. This showed the synthesis result in Hardware device shown in Fig 10.

IV. CONCLUSION

Cognitive radio has the capability of sensing the spectrum environment without the intervention of the user or hardware parts, CR will adapt to the user's data traffic (communication) needs while conforming their data transmission. In theory, the number of spectrum in nature is infinite; But practically, for signal navigation in certain environment and other aspects of CR is finite because of the desirability of certain spectrum portions, this desirability is depends upon the number of users in the coverage area. Allocated spectrum has lot of space from being fully occupied, and efficient spectrum use is a growing context; CR offers lot of solutions to this problem. We designed efficient MIMO based cognitive radio that prevent spectrum not to be wasted.

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