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Fast Self Switching type Frequency Agile RADAR Processing unit Implemented on Xilinx FPGA

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Abstract: RADARs with fixed carrier frequency profile are vulnerable to jamming. Changing the carrier frequency of the RADAR by sensing the channel condition dynamically. Frequency agility is one of the best techniques used for anti jamming. Self adaptive frequency agility analyze jamming spectrum real time so that to control the radar transmission frequency. Frequency agility refers to the radar's ability to rapidly change its operating frequency in a pseudo-random fashion to maintain a narrow instantaneous bandwidth over a wide operating bandwidth. The total architecture was implemented on FPGA board with hardware description language and the results are seen in Chip Scope pro analyzer.

Keywords: RADAR, frequency agility, Self adaptive frequency, bandwidth, FPGA,

I. INTRODUCTION

The term "radar" is generally understood by means of which short electromagnetic waves are used to detect the distant objects and to determine their location and movement of an object. The term RADAR is an acronym from RAdio Detection And Ranging. Jamming is a technique which is usually to make radar non functional. Radar jamming and deception is the intentional emission of radio frequency signals to interfere the operation of a radar by sending to the receiver with noise or false information.

There are different type of technology can be applied to modern pulse radar to meet diversified jamming; The echo signal that comes from the target are to weaken interference signals in order to ensure the radar works properly to the maximum extent. There are so many anti-jamming technologies; frequency selection is one of the best technique .The common frequency selection method includes manual frequency modulation, frequency agility, frequency diversity, spread spectrum technology, etc.

In this paper the anti –jamming [1], [3] technique used is frequency agility. Frequency agility [8] refers to the radar's to rapidly change its operating frequency in a pseudo-random fashion to maintain a narrow instantaneous bandwidth over a wide range operating bandwidth. Frequency agility[7] forces the jamming effort to spread its power over the operating bandwidth of the radar (even through the radar is only using a very narrow instantaneous bandwidth at any one point in time). Frequency agility reduces jammer to signal ratio a, therefore, the effectiveness of the jamming effort. Without agility, the jammer concentrates all of its power into the radar bandwidth. A more advanced form of frequency agility is called look-ahead electronic protection (EP). Rather than using a random approach to changing frequency, look-ahead agility selects the next operating frequency and checks to see that it is clear of jamming. If it is clear, that frequency is used. If not, another selection and check is be made. Look-ahead agility further complicates the jammer's task.

II. FREQUENCY AGILE RADAR

A. Radar Transmission

Radar is a sensor; its purpose is to provide the estimation of certain characteristics of its surroundings area of interest to a user, most commonly the presence, position, and motion of such target as aircraft, ships, or other vehicles in its vicinity.

Radar operates by transmitting electromagnetic wave energy [2], [4] into the surroundings and detecting energy reflected by objects (target). If a narrow beam of energy is transmitted by the radar directive antenna, the direction from which reflections comes and hence the distance of the object may be estimated. The distance of the reflecting object is estimated by measuring the period between the transmission of the radar pulse and reception of the echo pulse. In most the radar applications this period will be very short since electromagnetic energy is same as the velocity of light.

In this paper by using the DDS core, we are generating the radar transmitting signal as cosine signal. Where ever the pulse radar is present for that particular time period only the cosine wave signal is generated.

B. Jammer Section

Radar jamming refers to radio frequency signals originating from sources outside the radar, transmitting in the radar's frequency and thereby masking targets of interest. Jamming may be intentional, as with an electronic warfare (EW) tactic, or unintentional, as with friendly forces operating equipment that transmits using the same frequency range. Jamming is considered an active interference source, since it is initiated by elements outside the radar and in general unrelated to the radar signals

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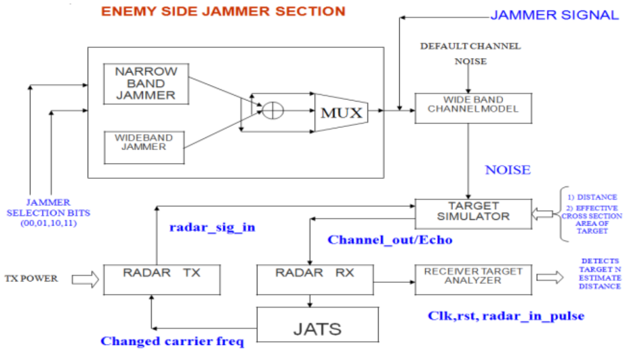

Fig 1: Frequency Agile Radar Blocks Diagram

Jamming is problematic to radar since the jamming signal only needs to travel one-way (from the jammer to the radar receiver) whereas the radar echoes travel two-ways (radar-target-radar) and are therefore significantly reduced in power by the time they return to the radar receiver [2]. Jammers therefore can be much less powerful than their jammed radars and still effectively mask targets along the line of sight from the jammer to the radar. The jammer section will generates of the different types of noises and that noise signal will be added with the radar signal. Here we are generating of the two different noises with different conditions. The two types of noises are the wide band noise and the narrow band noise. Here we take a jamming signal selector with two bit to generate of the four different combinations of noises from the jamming section.

To the jammer noise by default we are adding the additive noise to the radar transmitting signal.

TABLE :1 JAMMER SELECTION LINES

Selection line	output
00	No Jamming
01	Only Narrow band Jamming
10	Only wide band Jamming
11	Both narrow band and wide band jamming

C. Target Simulator

In target simulator the radar signal and jamming signal combined signal will detect the target distance and the cross section area of the target. The echo signal will move to the radar receiver. As the noise is more than that of original signal frequency, the noise over comes the echo signal from the target, so the radar did not detect of the Target. The echo signal will move to the radar receiver. In the radar receiver the JATS will be processed.

So we have to shift frequency of the radar signal instanteously according to the jamming frequency. The frequency agility can be done by the JATS. It can shift the frequency of the radar signal.

D. Jamming Analysis and Transmission Section (JATS)

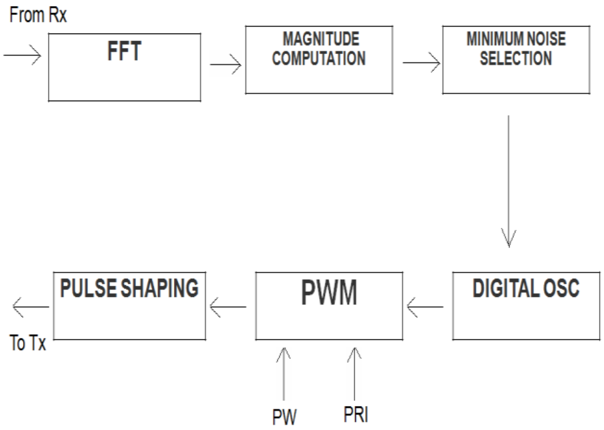

Fig 2: JATS BLOCK DIAGRAM

The echo signal coming from the target is moves to the radar receiver. In the radar receiver we have the JATS. In JATS the echo signal will processed by the FFT algorithm and find the magnitude spectrum from it will select the minimum frequency value and it shifts the radar signal to that minimum frequency. From this the radar signal can overcomes the jamming signal.

Magnitude calculation allows you to view these complex valued signals as either their real and quadrature (also known as imaginary) components separately, or by a magnitude and phase representation. You may switch between these two representations at any point. Mathematically switching between the two representations for a given complex value can be expressed as

$$|X| = \sqrt{X_r^2 + X_i^2} \quad \text{and} \quad \angle X = \tan^{-1}\left(\frac{X_i}{X_r}\right)$$

or equivalently,

$$X_r = |X|\cos(\angle X) \quad \text{and} \quad X_i = |X|\sin(\angle X)$$

where $|X|$ and $\angle X$ are the magnitude and phase of the complex number, and X_r and X_i are the real and quadrature components of the complex number. In this tool, the magnitude is plotted on a dB scale. Select a few signals, such as unit pulses and sine waves, and view them using the two methods to see how they are related.

III. SIMULATION RESULTS

Fig. 3, which contains real data captured on models, in this figure, the radar pulse is the input, whenever the radar pulse is present for that particular time period only the radar_sig is generated. The channel out is the output signal, the radaring is transmitted and hit the target and the echo signal is generated and return to the radar receiver. channel_out is the combination of radar_sig with noise and jammer signal.

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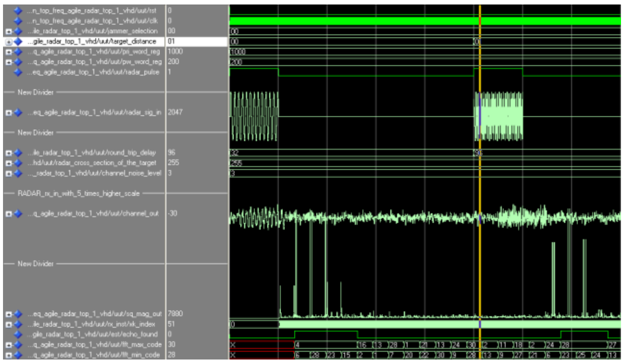

Fig. 3 Simulation Results produced by Models SE 6.2c

IV. CHIPSCOPE PRO ANALYZER

The module is developed on FPGA chip of Spartan -3E by VHDL hardware description language. The results are analyzed by chip scope analyzer. In Spartan -3E kit when we selected the bits as 0011 the channel_out is as

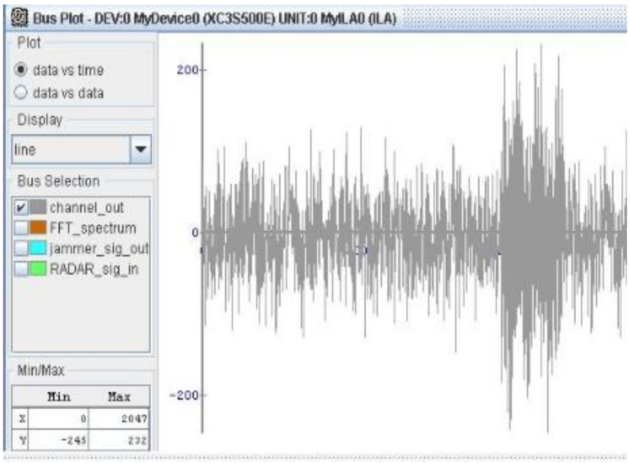

Fig.4 Echo at Both Jamming 0011

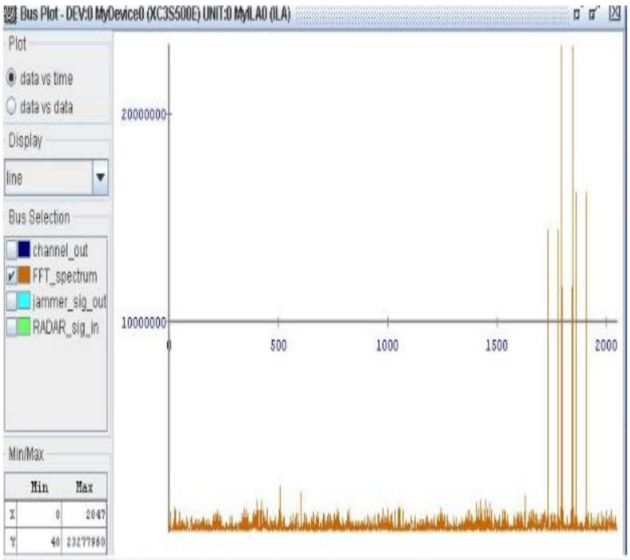

Fig.5 FFT at Both Jamming 0011

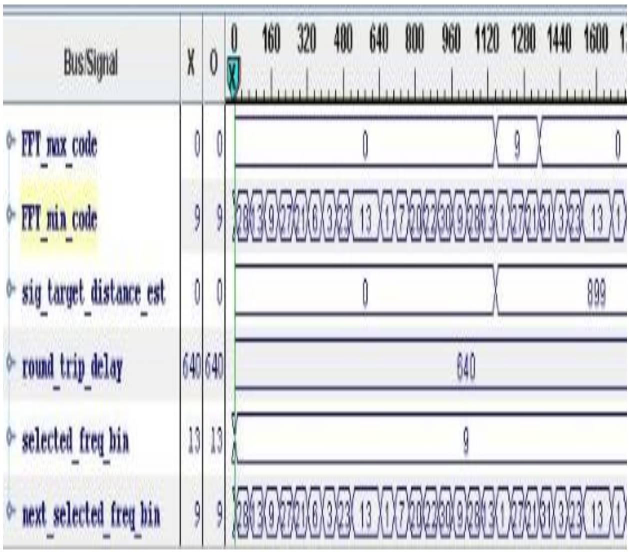

Fig.6 Final Output at Both Jamming

In this final output where **e**ver FFT max code is present next to that we can get the FFT min code. Selected frequency bin is the present radar signal frequency. Suppose the radar sig is jammed so we have to change the selected frequency for that FFT min bin is equal to next selected frequency.

V. SYNTHESIS REPORT

From the above table the device utilization is shown and the number of devices used and the utilization of the devices. Here we are reducing the devices of the available and device utilization using Xilinx Spartan-3E

Table 2. Device Utilization Using Xilinx Spartan-3E

Number of Slices:	2885 out of 4656 61%
Number of Slice Flip Flops:	3557 out of 9312 38%
Number of 4 input LUTs:	4499 out of 9312 48%
Number used as logic:	3343
Number used as Shift registers:	444
Number used as RAMs:	712
Number of IOs:	23
Number of bonded IOBs:	23 out of 232 9%
Number of BRAMs:	9 out of 20 45%
Number of MULT18X18SIOs:	12 out of 20 60%
Number of GCLKs:	3 out of 24 12%

VI. CONCLUSION

Anti-jamming is a major issue that must be resolved on searching radar. In this paper, the jamming analysis and transmission selection module is performed under fixed frequency mode and frequency diversity mode, detailed steps is discussed, the key steps are considered, and the function is applied to Xilinx Spartan 3E board.

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The frequency analysis result displays on the monitor and control terminal, which is clear at a glance. During practical application, this module acquires satisfactory real time anti-jamming effects.

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