Frequency Agile Radar Processing Unit Realized With FPGA

Ankam Ranjit Kumar, B. Nagarjun Singh, J Manasa, Y.Sravani, B.Saraswathi

ABSTRACT-- Frequency Agility in RADARs works good even when there is jamming. Jamming is a technique which is usually adopted to make a RADAR non functional. Many kinds of Technology can be applied to modern pulse radar to meet diversified jamming. Frequency Agility refers to the radars ability to change its frequency rapidly over a wide operating range. By dynamically changing the frequency and sensing the channel at regular intervals yields better results. The practical application on a searching radar shows that the module has a good real time and anti jamming capacity. The total architecture is implemented on FPGA board with Hardware Description Language and the results are observed in chip scope pro analyzer.

INDEX TERMS:- FREQUENCY AGILITY, RADAR, FREQUENCY DIVERSITY, JAMMING, FPGA.

I. INTRODUCTION

Today RADARs are used both in military and civilian applications. In military applications RADARs play vital role in detecting the enemy aircrafts at larger distances. Jamming is a technique which is usually adopted to make a RADAR non functional. Hence a robust RADAR must be able to work even when there is jamming attach from enemy side. Many kinds of technology can be applied to modern pulse radar to meet diversified jamming; in a word, they all enhance useful echo signals and avoid or weaken interference signals in order to ensure the radar works properly to the maximum extent[1]. Among so many anti-jamming technologies, frequency selection is widely used and also very effective. The common frequency selection method includes manual frequency modulation, frequency agility, frequency diversity, spread spectrum technology, etc. Frequency agility can be divided into random frequency agility and self-adaptive frequency changing, which are effective methods to resist jamming. Self-adaptive frequency agility can adapt the changing of the jamming environment to a certain extent. It analyzes jamming spectrum real time so that to control the radar transmission frequency, it make the radar signal spectrum center locate at the weak part of the jam spectrum all the time, so as to improve the signal-interference ratio[2]. Self adaptive frequency agility can not only deal with narrow band aiming jam, but also control wide band block jam to a certain extent. In this paper Frequency Agility is the anti jamming technique, which uses the change of frequency at greater speeds. Frequency agility forces the jamming signal to concentrate over all frequencies available in RADAR frequency bandwidth. By this we can reduce the jamming power. There by it increases the signal to jamming ratio. It deals with narrow band as well as wide band block jamming. In this paper Self adaptive frequency agility is implemented using Jamming Analysis and Transmission Selection (JATS)[3]. This is realized on a DSP chip of TMS320C25 and on a micro control unit (MCU) and is developed with FPGA. The JATS module using FPGA is applied to PSR.

- Ankam Ranjit Kumar - Pursuing Masters degree inVLSI System Design in Sarada Institute of Technology and Science, Khammam.
- B.Nagarjun Singh – Assistant Prof. in SITS, Khammam.

II. JAMMER MODULE

Anti jamming ability is the key feature for any searching radar. In this paper this searching radar will work effectively with fixed frequency as well as frequency diversity. The mutual interference between wide transmission pulse and narrow transmission pulse is avoided by working mode of frequency diversity [4]. These in turn reduces the signal loss because of the target signal fluctuation and thus reduce the probability of losing targets. The receiver will produce 16 frequencies, unlike 25 frequencies which were discussed in the earlier editions. The radar system will select 4 transmission frequencies that jump during successive time periods to achieve frequency diversity. There is a 10 MHz frequency offset between two groups of transmission signal. The relationship between the jamming analysis module and other sub-systems is shown in fig.1.

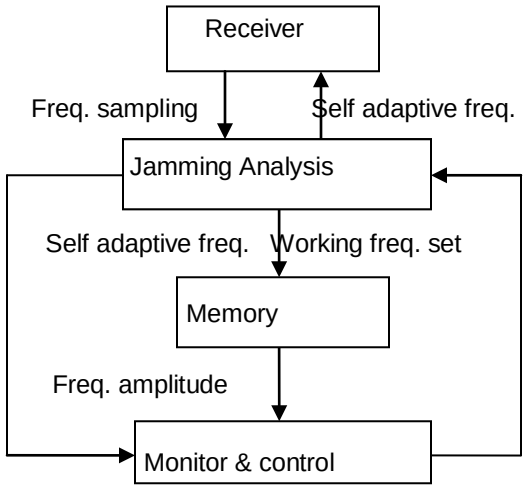

Fig.1 Jammer module schematic chart

The frequencies obtained at the receiver are sampled and sent to jamming analysis which delivers the amplitudes of frequency and are stored in memory[5]. Each stored frequency amplitude is monitored and controlled in the respective unit. If the working frequency has jamming another frequency is selected from the frequency group. This process is repeated until a new frequency which is free from jamming is obtained. This process is made very fast by using the FPGA module which is discussed in the next section.

III. FPGA IMPLEMENTATION

The time assignment for sampling is denoted as t1, t2, t3…t16. When the local oscillator changes its frequency one by one, the receiver can obtain the jamming amplitude at each frequency point. The following flow chart shows the assignment of a working frequency to Jammer Module. The transmitter in Jammer module works with fixed frequency and also with frequency diversity. In each of the above cases 4 data are sampled at one frequency and processed together to obtain average amplitude. The Average amplitude equation is as follows:

Aavg = ¼ ∑ log √[Ji2 + Qi2] , where i = 1,2,3,4

In the above equation J and Q are Quadrature components. For 16 frequency points, we can get 16 average amplitudes which will judge the Jamming sign as follows:

J sign = { 1, if Aavg ≥ Jamming threshold
{ 0, if Aavg < Jamming threshold

After Jamming signs are obtained two logic operations are implemented as follows:

All Jamming = Js1AND Js2 AND…AND Js16

Is Jamming = Js1OR Js2 OR…OR Js16

If All Jamming equals 1, which means that radar is jammed on all 16 frequencies; then pseudorandom frequency changing is used, and if All Jamming equals 0, it means that radar is not jammed on all frequencies. If Is Jamming equals 1, it means there is Jamming among 16 frequencies; If Is Jamming is 0, it means that there is no Jamming among 16 frequencies. For frequency Diversity mode flow chart is shown below in fig 2.

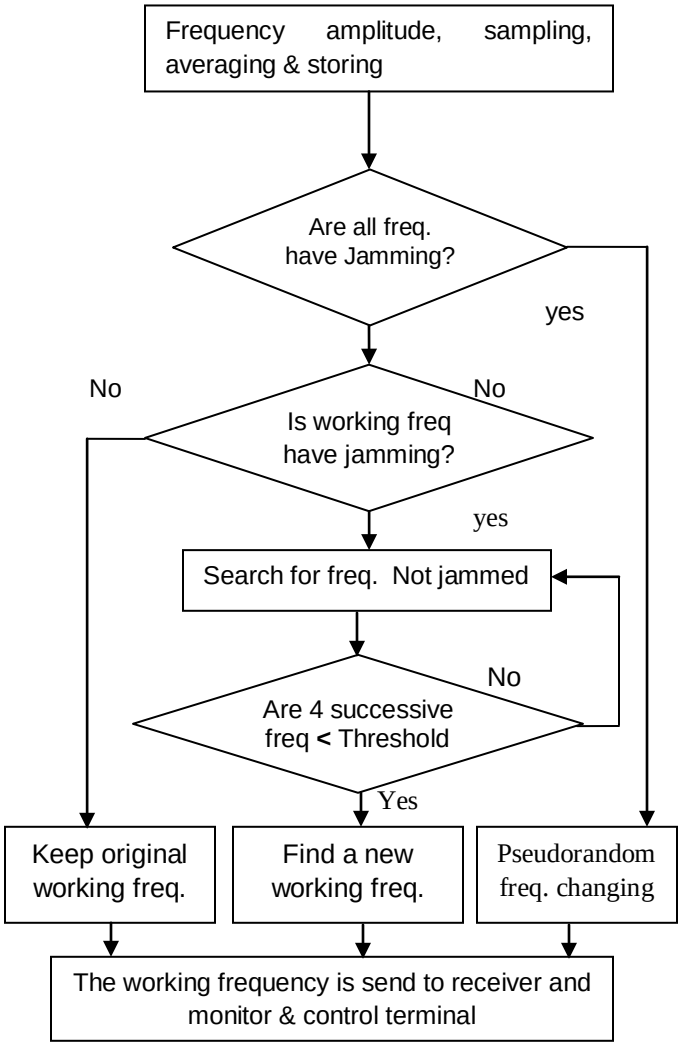

Fig.2.Jamming Analysis with frequency Diversity

If there is Jamming among 16 frequencies, the amplitudes of four successive frequencies will compare with a threshold one after another until a frequency group including four frequencies is found with all the four members less than the threshold. This frequency group then becomes the working frequency diversity[6]. And this frequency will be sent to receiver and monitor and control terminal[7]. When the transmitter works at a fixed frequency, the frequency which has the least interference can be found and chosen as the working frequency. First, amplitudes of 16 frequencies are obtained.

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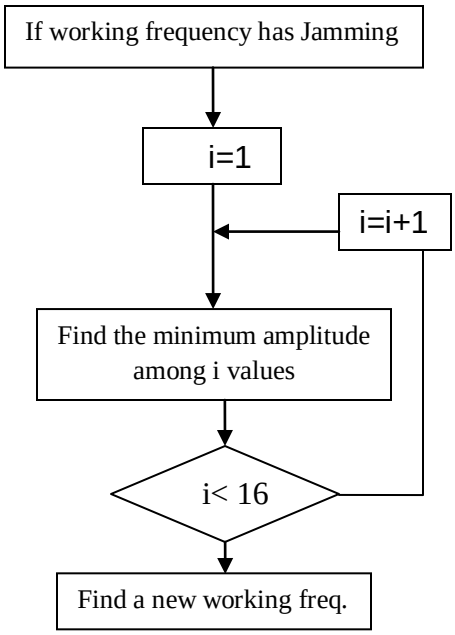

Fig.3.Jamming Analysis with fixed frequency

From the above flow chart we can say that if the first frequency amplitude is minimum, then the second frequency amplitude comes in to action. It will compare with the minimum, if it less than the minimum then the second frequency becomes the new minimum. Otherwise the minimum is unchanged. This is repeated until the 16th frequency amplitude is performed. The frequency with least interference is reached at last.

IV. SIMULATION RESULTS

The following results show the real data which is performed on MODELSIM6.2C simulator. After going through the Jamming analysis and self adaptive frequency module, the frequency that has least interference or the frequency diversity and frequency which has not been interfered with can be given. If there is jamming through all working frequency areas, the radar will work under pseudorandom frequency changing mode.

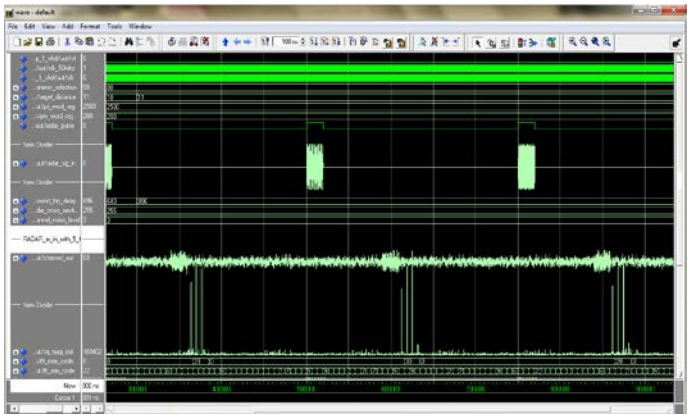

Fig 4.Simulation picture for radar pulses at regular intervals

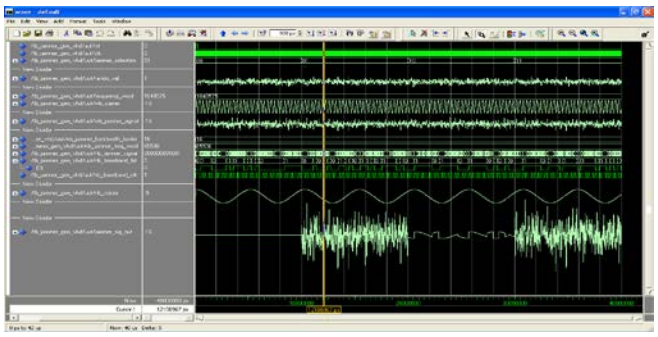

Fig 5.Simulation picture for Jammer signal generator.

V. CONCLUSION

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