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De-Interleaving and Identification of Pulsed Radar Signals Using ESM Receiver System

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ABSTRACT: An ESM sensor composed of either a single channel or multi channel superhetrodyne receiver followed by Digital receiver and ELINT processor to identify radar emitters in a particular frequency band of interest. In real life, such systems may encounter with a continuous stream of pulses accompanied by many imperfections, and it should work on real-time basis. In order to handle such circumstances and to develop better De-interleaving algorithms, a simulation environment is needed. In this project the design of a scenario-based mixed pulse generator (simulator) and De-interleaving of various pulse characteristics of radar such Stagger PRI, Jitter PRI, Sliding PRI, Dwell and switch PRIs. During this project the algorithms are implemented in Matlab environment and implementation of hardware in Xilinx FPGA using ISE environment. Apart from this the commands to front end system is implemented in Ethernet interface and interleaved pulse data is received in through fibre optic interface.

KEYWORDS: Electronic warfare (EW), Interleaving, De-interleaving, FPGA, Fibre optic interface.

I.INTRODUCTION

In order to fit for the Electronic Warfare environment of today and future, Electronic Support Measure and Electronic Intelligence systems must have the ability to analyze rapidly and dispose all kinds of radar signals in real time or near real time. The previous work introduces several advanced de-interleaving algorithms, too. One is the de-interleaving method for radar signals with dithering PRI and another one is the de-interleaving method based on pulse repetition frequency. All of these algorithms depend on advanced signal processing methods, and they provide new ways for de-interleaving of radar signals. Furthermore, the thesis researches the problems of synthetic analysis in de-interleaving field, too, and brings forward an effective method to pick up pulses. This new algorithm for the de-interleaving of radar signals based on the direction of arrival (DOA), carrier frequency (RF), and time of arrival (TOA). The algorithm is applied to classic (constant), jitter, staggered, and dwell switch pulse repetition interval (PRI) signals. These signals can be sent using fibre optic interface. The fibre optic interfacing uses Aurora. The commands to the front end system which is implemented by Ethernet interface. . Electronic Support (ES) is the subdivision of EW involving actions tasked by, or under direct control of, an operational commander to search for, intercepts, identify, and locate or localize sources of intentional and unintentional radiated electromagnetic (EM) energy for the purpose of immediate threat recognition, targeting, planning, and conduct of future operations. Now days, the emitters in the environment are increasing vastly. Along with the increase in the emitters, these also started emitting dissimilar, distinct, unique pulse trains of different characteristics. Hence a proposed method called Sequential search based on time of arrival to characterize and recognize the emitter pattern which is new de-interleaving technique has been carried out.

II.EW AND CLASSIFICATION

Electronic warfare (EW) is any action involving the use of the electromagnetic spectrum or directed energy to control the spectrum, attack an enemy, or impede enemy assaults via the spectrum. Any military action involving the use of electro-magnetic and directed energy can be used to control the electro-magnetic spectrum or to attack the enemy. It can also be represented as EW. The three major sub divisions within electronic warfare are: electronic attack, electronic protection and electronic support.

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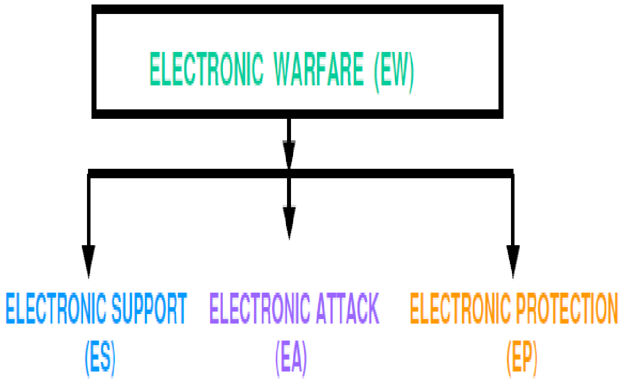

Fig Electronic warfare classification

A.ELECTRONIC SUPPORT (ES): ES also is known by ESM (Electronic Support Measure) ES involves search, intercept, locate, record and analyze radiated EM energy for the purpose of exploiting 'the radiation information either for formulating EOB (Electronic Order of Battle) or to provide the real time information to EA system. ES provides surveillance and warning information derived from intercepted EM environment emission. ES also known by ESM involve actions taken to search, intercept, locate, record and analyze radiated EM energy.

B.ELECTRONIC ATTACK(EA) That division of electronic warfare involving the use of electromagnetic energy, directed energy facilities or equipment with the intention of degrading, neutralizing or destroying enemy combat capability and is considered a form of fires.

ElectronicAttack include

1)Actions taken to prevent or reduce an enemy's effective use of theelectromagnetic spectrum, such as jamming and electromagnetic deception, and

2) Employment of weapons that use either electromagneticor directed energy as their primary destructive mechanism (lasers, radio frequency weapons, particle beams).

C.ELECTRONIC SELF PROTECTION (EP): EP also is known by old name ECCM (Electronic Counter Counter Measures). EP involves actions taken to ensure friendly use of EM spectrum despite the use of ECM. EP protects own platform against EA by the adversary.

ELECTRONIC SUPPORT MEASURES PURPOSE:

The purpose of ESM is to search, intercept, locate and identify source, of enemy radiation. The information acquired by ESM is used for threat recognition and deployment of countermeasures.

III. SPECIAL TOOLS

There are different types of RADAR signals in electronic warfare environment. All the signals are exist in environment with different frequency structures and all these signal structures are operated by the RADAR to escape from enemy's battle plan. In the present project work involves four types of signals; Constant PRI, Jittered PRI, Dwell and Switch PRI, Staggered PRI.

AURORA PROTOCAL With advances in communication technology, you can achieve gigahertz data-transfer rates in serial links without having to make trade-offs in data integrity. The proliferation of serial connectivity can be attributed to its advantages over parallel communication. The Xilinx Aurora protocol and its associated designs address these challenges by managing the multi-gigabit transceivers (MGT's) control interface. Aurora is free, small, scalable, and customizable. The Aurora protocol defines the structure of data packets and procedures for flow control, data striping, error handling, and initialization to validate MGT links. Aurora shrink-wraps MGTs by providing a transparent interface to them, allowing the upper layers of proprietary or industry-standard protocols such as Ethernet

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and TCP/IP to ride on top of it and provide easily access. This easy-to-use pre-defined protocol needs very little time to integrate with existing user designs. Being lightweight, Aurora does not have an addressing scheme and cannot support switching. It does not define correction within data payloads.
By using fibre optic cable when the data is sent aurora protocol is used here.

CHIPSCOPE As the density of FPGA devices increases, so does the impracticality of attaching test equipment probes to these devices under test. The Chip Scope ILA tools integrate key logic analyzer hardware components with the target design inside the Virtex device. The Chip Scope ILA tools communicate with these components and provide the designer with a complete logic analyzer, without the need for cumbersome probes or expensive test equipment.

TOOL NAME	DESCRIPTION
Chip Scope Core Generator	Provides net lists and instantiation templates for the Integrated Controller (ICON) core and Integrated Logic Analyzer (ILA) cores.
Chip Scope Core Inserter	Automatically inserts the ICON core and one or more ILA cores into the user's synthesized design.
Chip Scope Analyzer	Provides capability for trigger setup and trace display for the ILA core(s) in the user's Instrumented design. Also provides JTAG Boundary Scan configuration and communication capability.

IV. INTERLEAVING AND DE-INTERLEAVING

By using these signals and their specific characteristics we may search enemy radars to save our self's and to destroy adversaries battle plan. If these types of all emitters coming from the enemy as a group, we should take care about the signals and we have to de-interleave and identify those clustering signals by using ESM Receiver.

DE-INTERLEAVING De-interleaving is the process of isolating the pulses. The Main aim of the de-interleaving process is to identify enemy radars based upon their signal unique characteristics. Every Radar emitter has their unique characteristic for Identify. (Or) De-interleaving is the process of isolating the pulses of a single or multiple emitters from a pulse stream containing pulses from two or more signals. Enabling users and to focus on data from a single emitter at a time, rather than a mixture of data from several emitters.

NEED OF DE-INTERLEAVING The ultimate goal of passive Electronic Warfare (EW) systems is to classify radar signals. Once the characteristics of radars signals are determined they can be identified. Usually derivation of parameters is not easy because pulse trains from a number of different sources are received on the same communication channel.

DE-INTERLEAVING PROBLEM For the purpose of detecting and identifying radar emitters in the environment, the pulse sequences received from radars are used. The problem of determining the presence of a specific emitter in the environment is a problem of detecting a consistent pulse sequence in the incoming stream of interleaved pulses. The structure of received signals from the enemy emitters is a combination of constant pri, staggers pri, dwell and switch pri, and jitter pri etc...., all these signals having different PRIs, different pulse widths, frequencies and amplitudes. But each pulse train have same frequency, Pulse width and pulse amplitude.

V. IMPLEMENTATION OF ALGORITHM

Sequential search is an improvement to the all differences histogram algorithm, cumulative differences histogram algorithm and sequential differences histogram algorithm. The distinction is that processing a time. This algorithm allows many improvements in speed, reliability and efficiency to be achieved. As the algorithm required to dumping the code into FPGA

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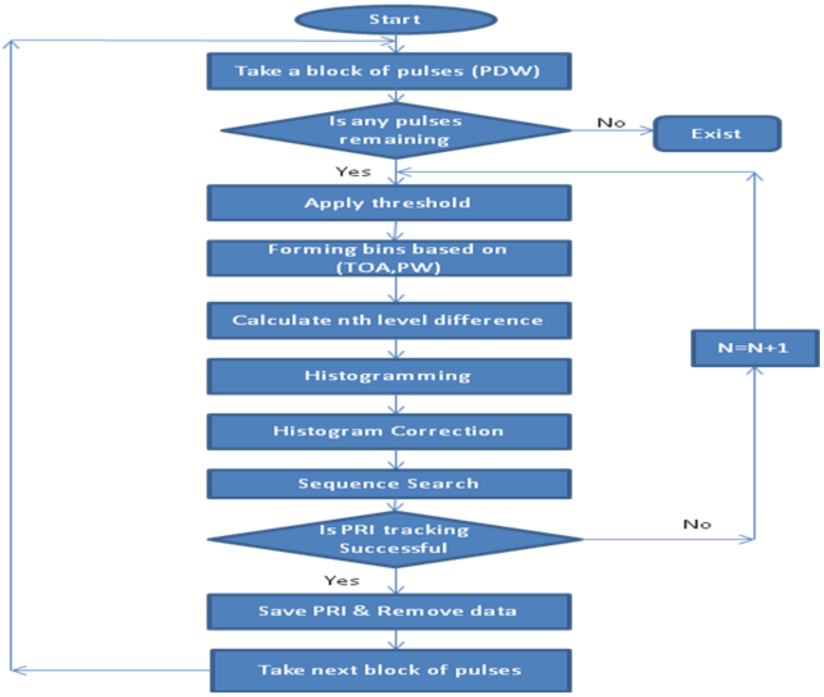

Fig: Sequential Search Algorithm

VI. RESULTS

Generation of different radar signals with different PRIs and having different pulse characteristics are generated by using MATLAB and XILINX simulation is shown below.

CONSTANT PRI

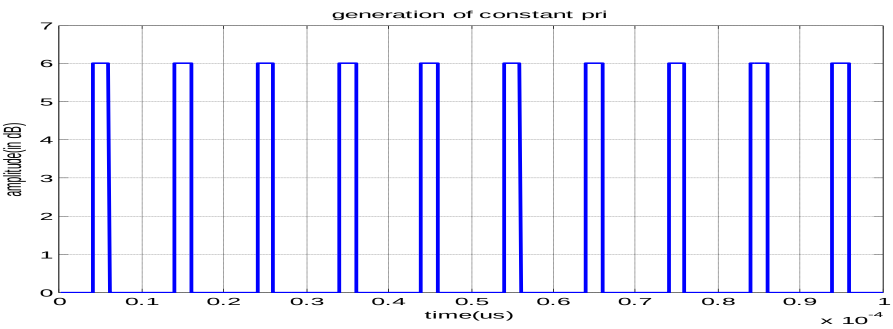

Fig: Simulated Waveform of Constant PRI by MAT LAB

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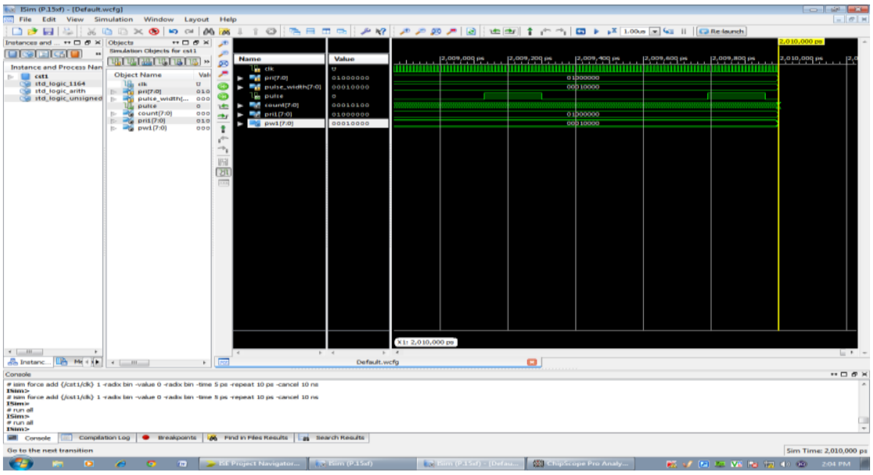

Fig: Simulated Waveform of Constant PRI by VHDL

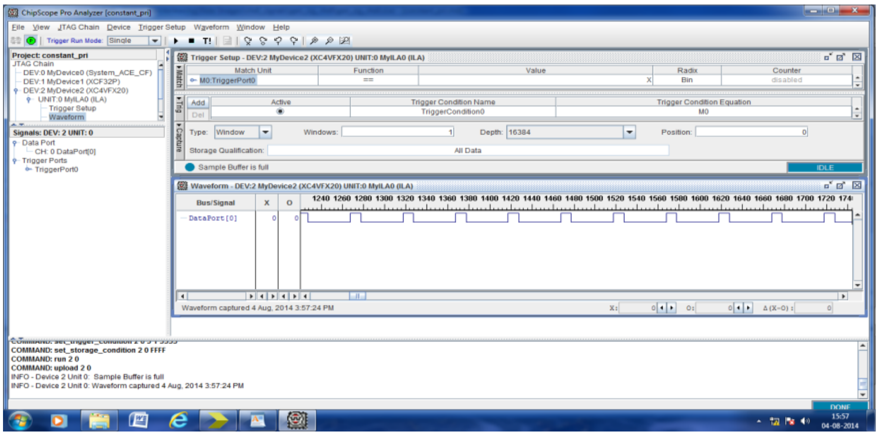

Fig: Waveform of Constant PRI by Chip Scope Pro Analyser

STAGGERED PRI

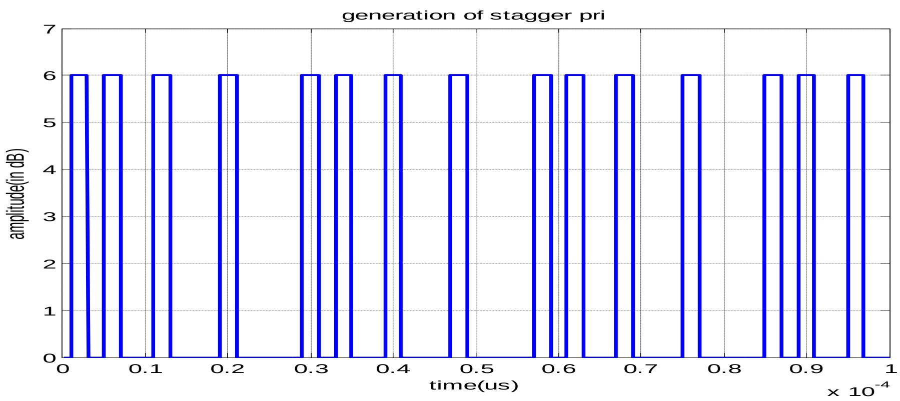

Fig: Simulated Waveform of Stagger PRI by MATLAB

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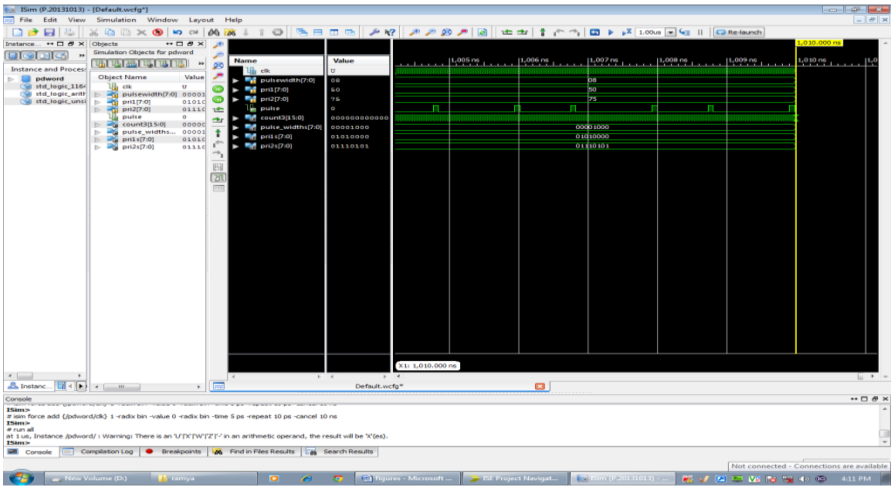

Fig: Simulated Waveform of Staggered PRI by VHDL

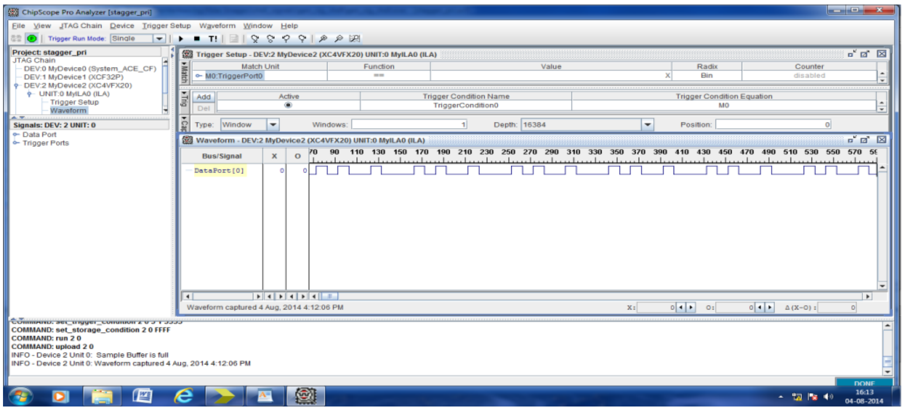

Fig: Waveform of STAGGERED PRI by Chip Scope Pro Analyser

DWELL AND SWITCH PRI

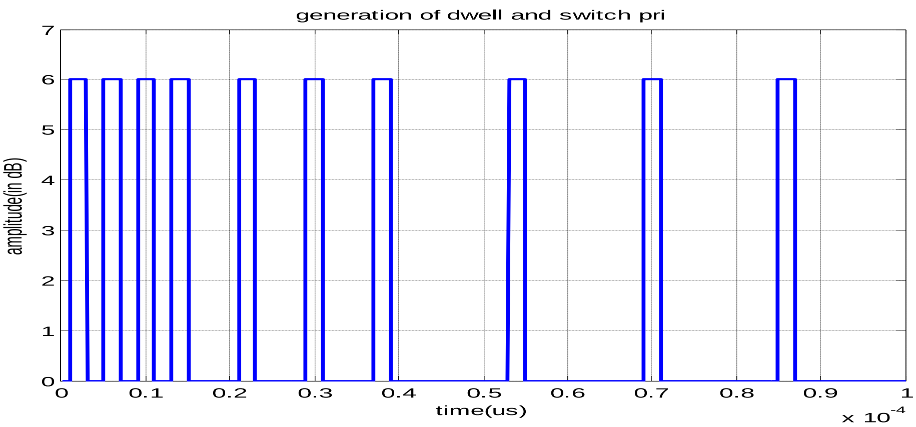

Fig:Simulated Waveform of Dwell and Switch PRI by MAT LAB

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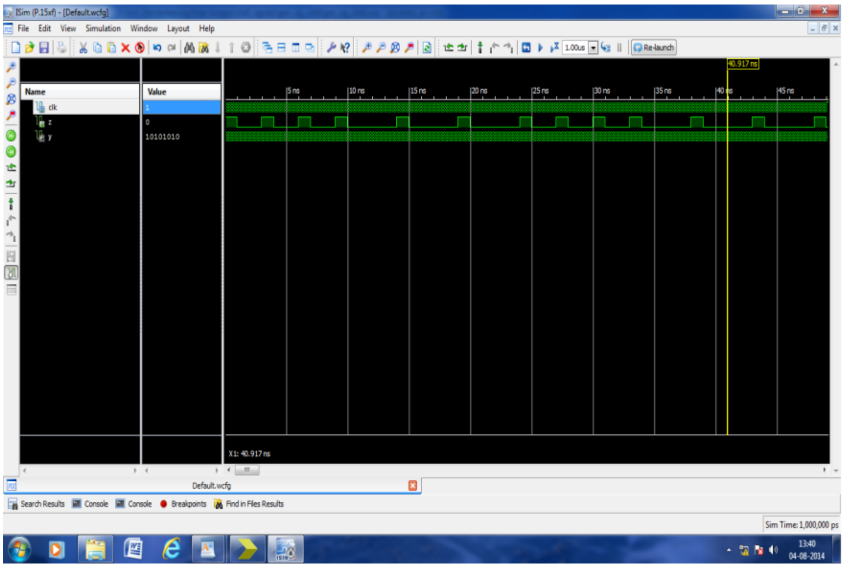

Fig: Simulated Waveform of Dwell and Switch PRI by VHDL

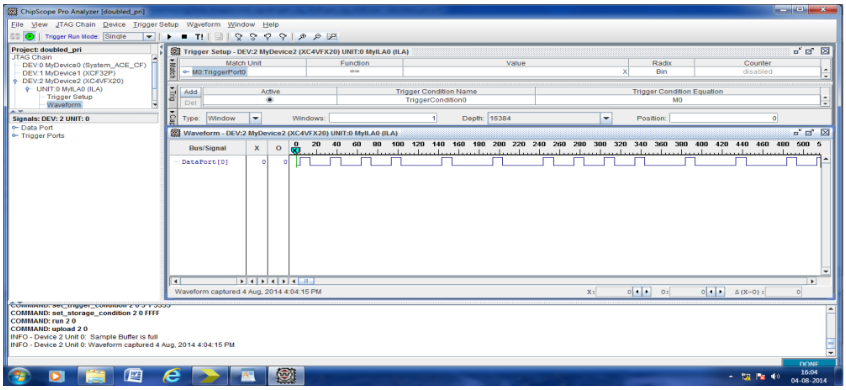

Fig: Waveform of Dwell and Switch PRI by Chip Scope Analyser

JITTER PRI

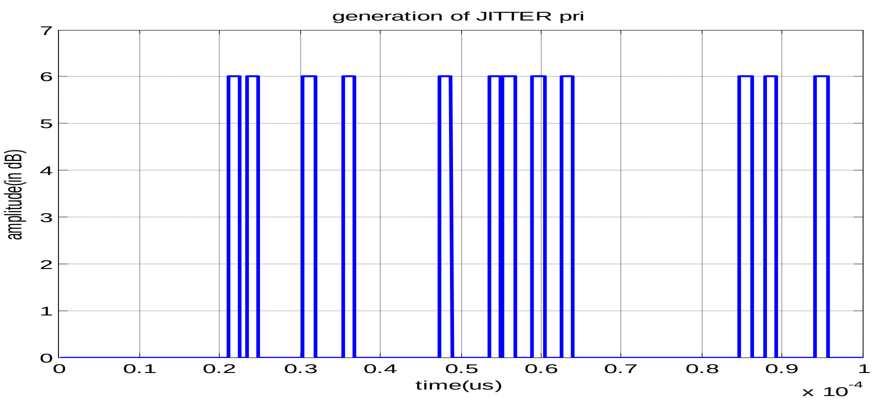

Fig: Simulated Waveform of Jitter PRI by MATLAB

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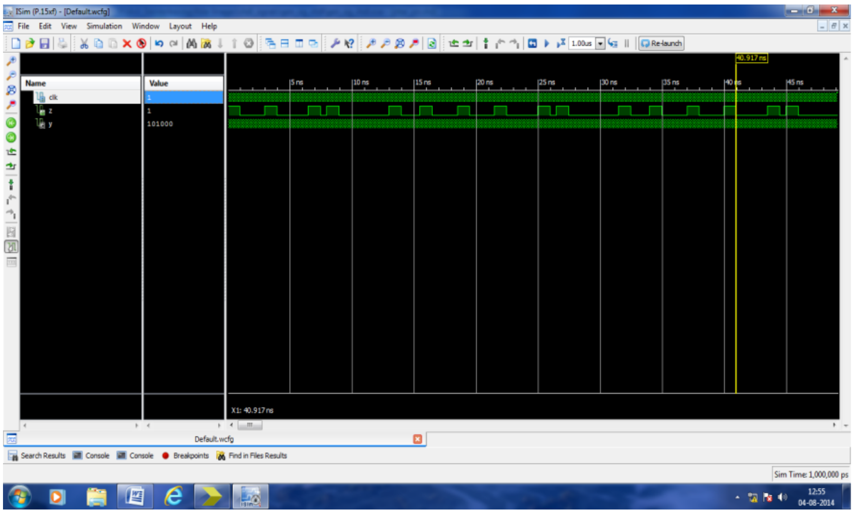

Fig: Simulated Waveform of Jitter PRI by VHDL

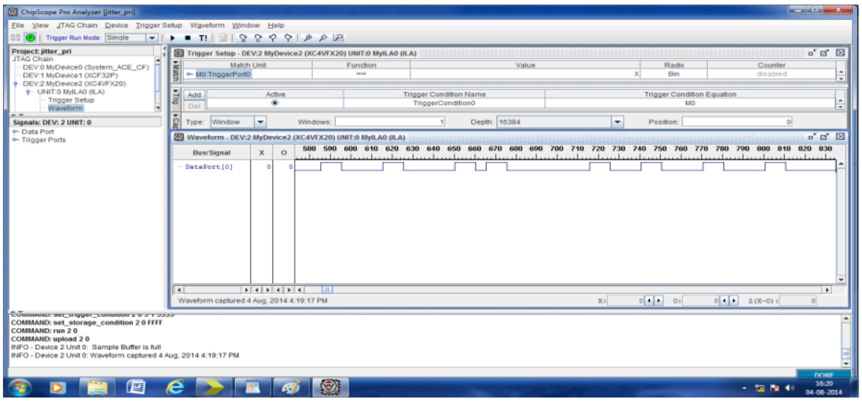

Fig: Waveform of Jitter PRI by Chip Scope Analyser

INTERLEAVED PRI

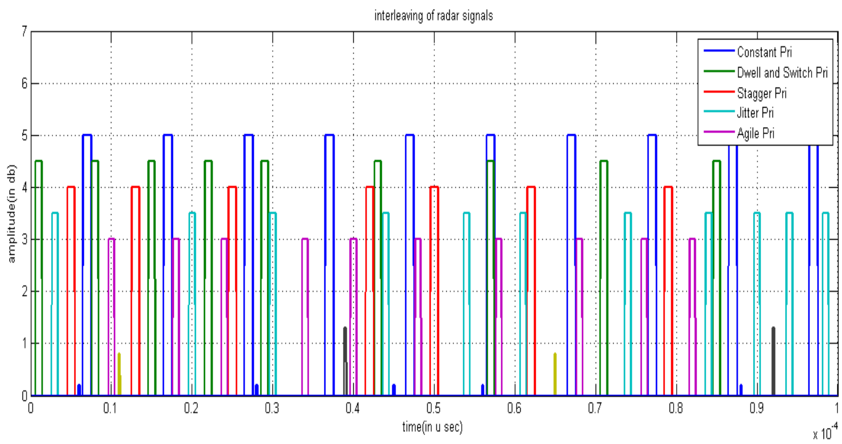

Fig:Simulated Waveform of Interleaved PRI by MAT LAB

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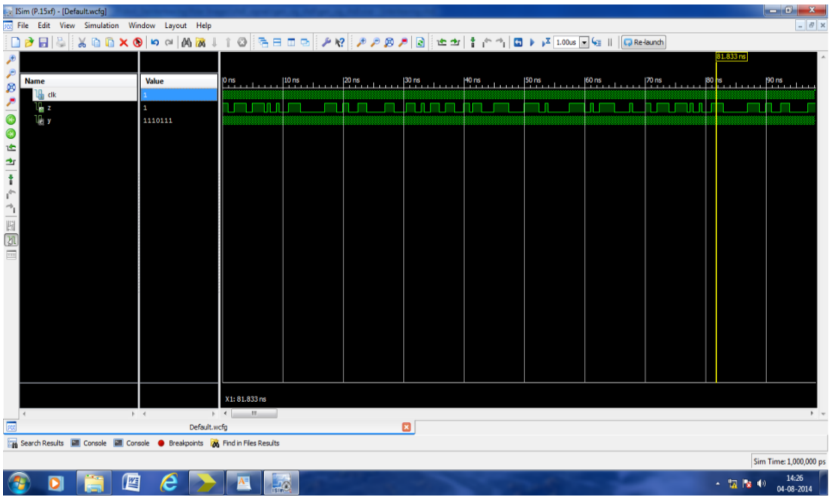

Fig:Simulated Waveform of Interleaved PRI by VHDL

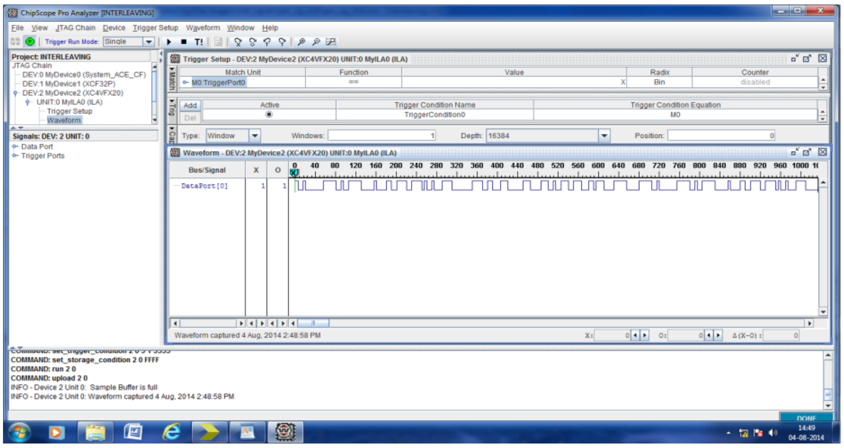

Fig: Waveform of Interleaved PRI by Chip Scope Analyser

VII.CONCLUSION

The PRI based Generation, Interleaving and de-interleaving is successfully implemented in ESM systems, while in the ES systems. This project presents aspects of PRI analysis of different radar signals Generation, interleaving and de-interleaving with simulated signals. The {Sequential search algorithm} using TDOA (Time Difference Of Arrival) allows for more efficient analysis of long pulse sequences of periodic changes in PRI such as (Constant, stagger, dwell and switch, and Jittered). The Data is sent through fiber optic cable and the commands are given using Ethernet The parameters like time of arrival (TOA) in µs, pulse width (PW) in µs and pulse repetition interval (PRI) in µs for different emitters are calculated. If Radar uses frequency hopping then this algorithm is combined with frequency of arrival to provide efficient identification of radar emitter.

VIII. ACKNOWLEDGEMENTS

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BIOGRAPHIY

V.Dhananjayulu received his B.Tech degree in Electronics and Communication Engineering from Sri Venkateswara University in 2001, M.E. degree in Digital systems from Osmania University in 2006. He worked as VLSI designer (2001-2002) in Qualcore logic Ltd and IFF radar group in HAL (2002-2003) Hyderabad. He has joined DRDO in 2003 as Scientist 'B' and posted to Defence Electronics Research Lab (DLRL). He is currently working as Scientist-D and engaged in design and development of ELINT receiver systems

P.Rakesh Kumar was born in India in 1986. He did his B.Tech From CR Reddy Engineering College, M.Tech from Koneru lakshmiah college of Engineering,and pursuing Ph.d from jntu-kakinada university. Presently he is working as Assistant professor in the department of ECE of LBR college of Engineering, Mylavaram. He is having Five years of teaching experience and he is having 16 International Journal papers in his credit. His field of interest includes antennas and VLSI design.

N.Ramya received her B.Tech degree in Electronics and Communication Engineering from Dhanekula institute of technology and engineering in 2013, pursuing M.tech degree in Systems and Signal Processing from in Lakireddy Balireddy college of Engineering (2013 -2015).