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Auto Track Receiver using Amplitude and Phase Comparison

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Abstract:

In this Auto Track receiver (ATR) is a passive emitter tracking system which is based on the Mono pulse tracking algorithm. Mono pulse tracker is defined as one in which information concerning the angular location of a target is obtained by comparison of signals received in two or more simultaneous beams. The angle measurement may be made on the basis of a single pulse. Unlike Mono pulse tracking Radar where RF pulse is transmitted and echo is processed using 4 Antennae mono pulse setup, ATR is passive system in the sense it does not transmit any RF energy but it will track any selected emitter signal. ATR is used to align Jammer Antenna towards the Radar. This system ensures maximum Jammer signal to be directed towards the victim Radar. Project involves 4 Horn antennae mounted around the Jammer antenna. RF signal intercepted by each antenna is further down converted and relative amplitude & phase between antennas is measured. Amplitude & phase data from all four antennae is processed within the FPGA based controller. Appropriate information extracted and is send to servo system to position the Jammer antenna in both azimuth and elevation.

Keywords:

Auto Track Receiver, Virtex-4 FPGA, Tracking RADAR.

I.INTRODUCTION:

In any fire control system, target tracking is the means by which target parameters are measured with respect to the tracking station. These parameters, azimuth, elevation, range, and relative target velocity are ultimately employed to predict the collision point between the target and whatever weapon is launched against it. Before any computation or launching can be accomplished, however, the critical targets parameters must be continuously and accurately measured.

This process of continuous measurement is not exact and some error is always present. The line-of-sight (LOS) between the sensor and target, along which radiant energy from the target is received by the sensor, is used to track the target. If the tracking element were at all times pointed directly along this line-of-sight, tracking would be perfect and no error would exist. In reality, however, error is always present, and therefore a second line, the tracking line, is defined as the line that forms the axis of symmetry of the radiated energy, commonly called the antenna boresight axis. When error exists, the line-of-sight and the tracking line are not coincident; usually the tracking line lags the line-of-sight by some small amount, due to the general inability of mechanical tracking systems to anticipate target movements. This error defines the central problem of any tracking system. This problem of minimizing the error between the LOS and the tracking line is further complicated by the fact that weapon platforms are not generally stable. The combined effects of weapon platform roll, pitch, and yaw produce a disturbance in the tracking system that is not related to target motion.

These rotational motions not only affect the tracking element's ability to hold the target, but also generate erroneous output data. Since the basis of relative target velocity computation is an accurate measurement of target Position over time, the uncompensated rotational motions of the weapon platform would result in erroneous target velocities being generated. As will be seen in a later chapter in this text, target velocity data is a major input for the computation of the weapon launch lead angle [1-6]. Tracking radars require separate components for range and angle tracking of a specific target. These functions were performed manually in early radars by operators watching target video, then positioning handwheels to maintain markers over the desired target blip on each scope. The handwheels positioned potentiometers, which adjusted voltages analogous to target azimuth, elevation, or range that were supplied to fire control computers and lead-computing gun sights.

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As target speeds and operator workloads increased, automatic tracking circuitry was developed that maintained tracking efficiency over sustained periods and made possible the later development of unmanned homing weapons.

II.ANGLE SENSING TECHNIQUES:

The 3 main angle-sensing techniques for monopulse radars are:

1. Amplitude Comparison.
2. Phase Comparison.
3. Combination of the above

Requires 4 sequential beams to measure the Target`s angular position. These 4 beams are generated simultaneously rather than sequentially. The 4 feeds (mainly horns), are used to produce the antennae pattern. Amplitude Modulation requires that the 4 signals have the same phase but different amplitudes. The 2 overlapping beams for each of the 2 orthogonal axes are generated from a single reflector illuminated by 4 adjacent feed horns. Σ = Sum pattern of the 4 horns. This used for Range measurement in transmit and receive antenna.

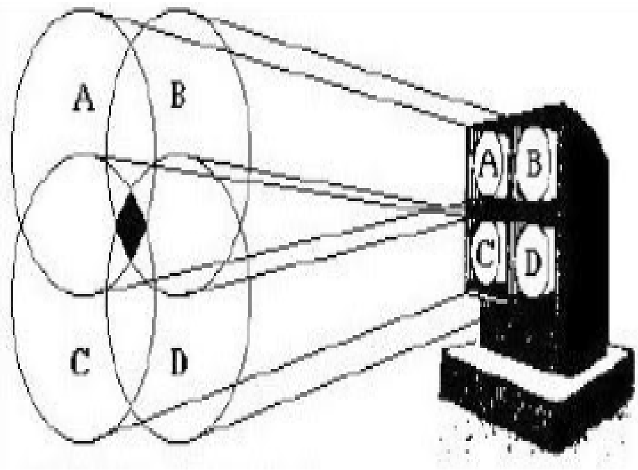

Fig 1 Azimuth and Elevation Error

If A=B=C=D then target is centered. Azimuth error=(A+C)-(B+D),
If (A+C)-(B+D)=0,then no error. Elevation error=(A+B)-(C+D),
If (A+B)-(C+D)=0,then no error.

If the 4 horns receive equal amount of energy, it indicates that the target is located on the antenna`s tracking axis. But when the target is off the tracking axis, an imbalance of energy occurs in different beams. This imbalance is used to generate an error signal that drives servo-central system. The phase of a periodic phenomenon can also be expressed or specified by angular measure, with one period usually encompassing 360o (2π radians). The phase angle of a periodic wave is the number of suitable units of angular measure between a point on the wave and a reference point. The reference point may be a point on another periodic wave. The phase angle between two periodic waves can be specified or expressed by the time of occurrence of the zero crossings of one wave compared to the zero crossings of the other wave. This can simply be expressed by the time delay between the zero crossings of the two waves as shown in Fig. 1. The phase angle can also be expressed by angular measure as mentioned above.[7-8].

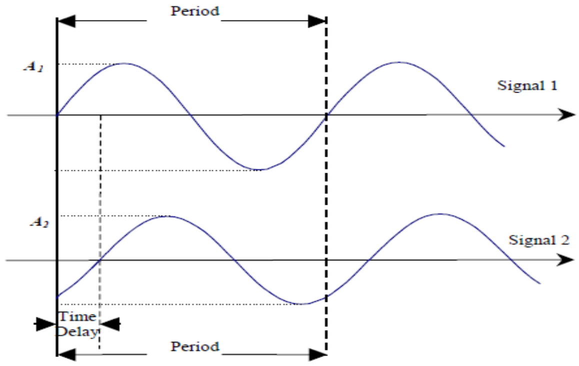

Fig 2 Typical phase angle measurement

The phase angle between two signals can also be measured by using a counter-timer approach. Two repetitive signals having the same period are fed to two channels of the counter-timer, and the device calculates the period of the waveforms and the time delay from one channel relative to the other channel. The problem considered in this manuscript is that of estimating the phase angle between two low-frequency sinusoids The principle of the measurement method is based upon integrating one signal between a zero crossing of this signal and a zero crossing of the other signal. Two different integrals are performed, where each integral is a function of the amplitude and frequency of the integrated signal and the phase angle between the two signals. The two signals do not necessarily have the same amplitudes, but they should have the same frequency (or period). With simple algebraic manipulations, the phase angle is readily evaluated as a function of the two integrals [9-10].

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Consider the following two signals for the purpose of measurement:

$$s_1(t) = A_1 \sin(\omega t) \quad (1)$$

$$s_2(t) = A_2 \sin(\omega t + \theta) \quad (2)$$

where A1 and A2 are the amplitudes of s1(t) and s2(t) respectively, ω =2πf is the radian frequency, f is the frequency in cycles/s, and θ is the phase difference between the signals s1(t) and s2(t).

Let us first integrate the signal s2(t) starting at a zero-crossing of this signal (i.e., s2 (t) = 0 or ωt = -θ), and ending at a zero-crossing of the signal s1(t) (i.e., s1(t) = 0 or ωt=0). It should be noted that the zero-crossings of s1(t) occur at ωt = 0 , π , 2π , 3π , …. , and the zero-crossings of s2(t) occur at ωt = -θ , π-θ , 2π-θ , 3π-θ , ……. Without any loss of generality, we assume that the above integration will be performed in the interval ωt = -θ to ωt = 0, which lies in the positive half of the sinusoidal waveform. In order to visualize the process, the signals are depicted in Fig 3, together with the integrals that are calculated. Therefore,

$$I_1 = \int_{-\theta/\omega}^{0} A_2 \sin(\omega t + \theta)\, dt$$

$$= (A_2 / \omega)(1 - \cos\theta) \quad (3)$$

We next integrate the same signal s2(t) from the zero-crossing of s1(t) where the first integral ended, until the next zero-crossing of s2(t), which occurs at ωt = π - θ .

$$I_2 = \int_{-\theta/\omega}^{(\pi-\theta)/w} A_2 \sin(\omega t + \theta)\, dt$$

$$= (A_2 / \omega)(1 + \cos\theta) \quad (4)$$

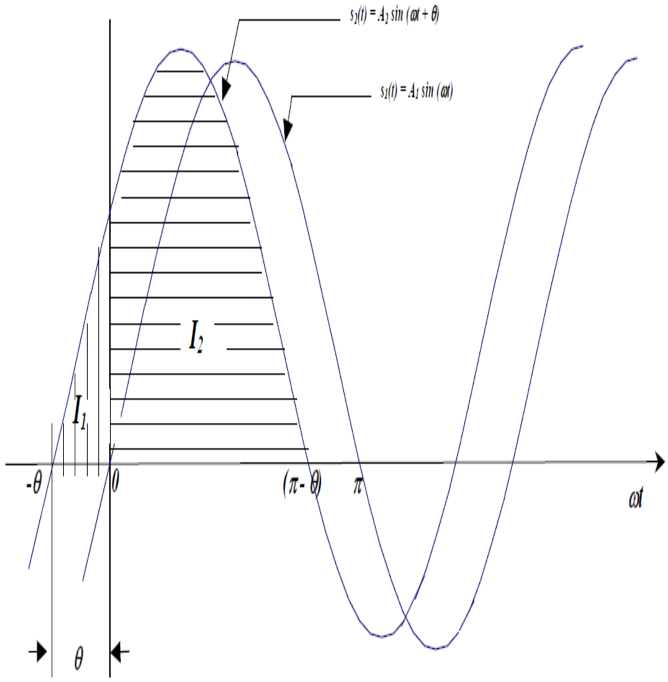

Fig 3 Area under one-half cycle of the sinusoidal signal s2(t)

The two signals s1 (t) and s2 (t) that have a phase difference of θ , which is considered for measurement.In other words, both I1 and I2 were evaluated using only one-half cycle of the signal s2(t). The sum of I1 and I2 must therefore be equal to the area under one-half cycle of the sinusoidal signal s2(t), as shown in Fig. 2. The zero-crossing of s1(t), which is a measure of the phase angle between s1(t) and s2(t), puts the border (i.e., draws the line) which separates the area representing the integral I1 from the area that represents the integral I2. From equations (3) and (4) we obtain:

$$I_2 + I_1 = 2A_2 / \omega \quad (5)$$

$$I_2 - I_1 = (2A_2 / \omega) \cos\theta \quad (6)$$

Dividing Equation (6) over Equation (5),

we obtain a relation between θ and the values of I1 and I2 which is independent of A2 and ω :

$$\cos\theta = (I_2 - I_1) / (I_2 + I_1) \quad (7)$$

Hence the phase angle between the two signals s1(t) and s2(t) can be evaluated as:

$$\theta = \cos^{-1} \{ (I_2 - I_1) / (I_2 + I_1) \} \quad (8)$$

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where I_1 and I_2 are given in Equations (3) and (4) respectively.

III.IMPLEMENTATION DESIGN:

Block diagram for implementing ATR using Amplitude and Phase Comparison method is as shown in fig 4.

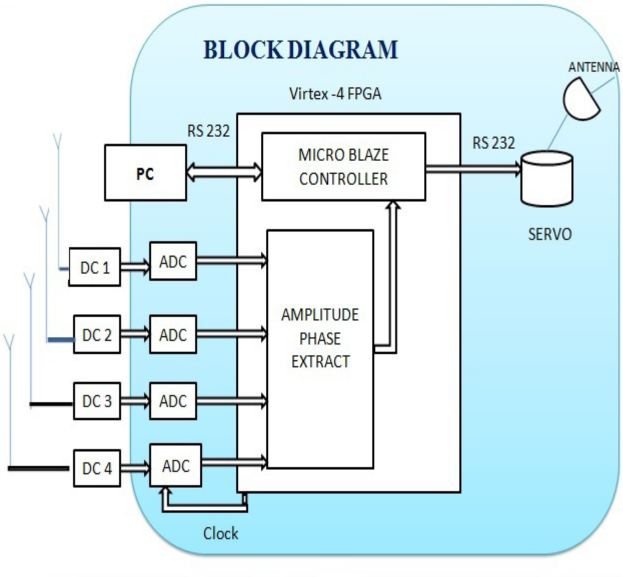

Fig 4 Block diagram

This project will be realized in a Virtex-4 FPGA based board with ADC and associated logic circuits connected externally. Based on the resources available in Virtex-4 FPGA, MicroBlaze processor is configured by using Embedded Development Kit Tool. Using VHDL/VERILOG amplitude or phase comparison technique is implemented in Virtex-4 FPGA. Servo position is based on the result obtained from the applied techniques on the signals given. Another possible choice is to use an FPGA with a soft core. With this method, the FPGA is configured to operate as a reduced instruction set (RISC) processor. Software can then be written for this processor in assembly or even the C programming language.

A Graphical User Interface (GUI):

In order to track the target we need to select the technique to be applied on the signals that are received from target is done through PC. We need to design GUI which acts like an interface between PC and MicroBlaze soft core processor. GUI has to send that data to the MicroBlaze Processor through serial port from the PC.

We used Microsoft Visual Studio Ultimate 2010 version and C# language for programming. After implementing the technique in FPGA obtained result(i.e., target position)is specified here in GUI.

B. MicroBlaze softcore Processor:

The purpose of this processor is to receive the data sent from PC using GUI through serial port RS-232 cable. We have to program the microcontroller such that it has to receive the data send by the pc through RS232 cable and then it has to send that hexadecimal data to the FPGA through serial peripheral Interface (SPI). Received data is stored in the Internal Slave Registers of MicroBlaze Processor[11]. Based on our input commands in GUI, the technique to be implemented in the FPGA is done by collecting required data from the MicroBlaze Processor Internal Slave Registers.

C. Embedded Development Kit Tool:

By using EDK tool [12], we configure and program the MicroBlaze softcore Processor according to our requirements. MicroBlaze is the industry-leader in FPGA-based soft processors, with advanced architecture options like AXI or PLB interface, Memory Management Unit (MMU), instruction and data-side cache, configurable pipeline depth, Floating-Point unit (FPU), and much more. These options can be configured according to our project requirement by using XPS. By using SDK we can program the configured MicroBlaze Processor. So, we can read the data from GUI and save them in the Internal Slave Registers.

D. XtremeDSP Development Kit-IV:

In this kit we use only 2 ADCs for taking the received signals from target and applying their required data in Virtex-4 FPGA. The XtremeDSP Development Kit-IV [13] shown in fig 3 serves as an ideal development platform for the Virtex-4 FPGA technology and provides an entry into the scalable DIME-II systems available from Nallatech. Its dual channel high performance ADCs and DACs, as well as the user programmable Virtex-4 device are ideal to implement high performance signal processing applications such as Software Defined Radio, 3G Wireless, Networking, HDTV or Video Imaging.

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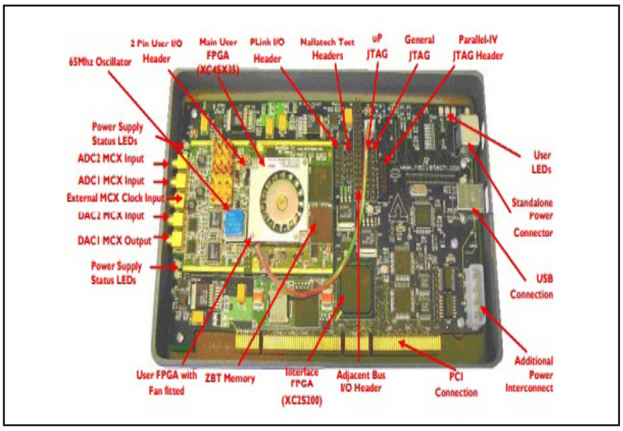

Fig 5 XtremeDSP Development Kit-IV

IV.RESULTS:

Experimental Set up is done as shown below figure 6.In order to generate these, we need GUI which acts like interface between PC and Micro-blaze processor. Technique to be used is mentioned in PC and required data in to processor through GUI using RS-232 cable. These data is read and is stored in internal slave registers of the microprocessor.

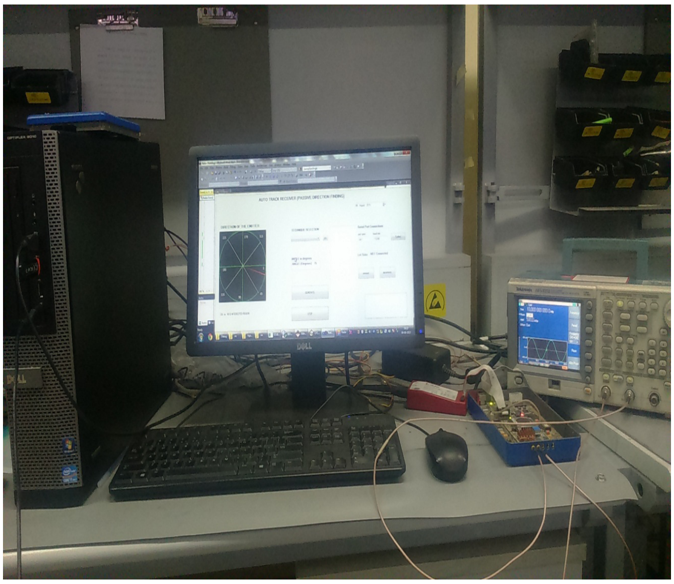

Fig 6 Experimental Set up

Based on our command given in the GUI, amplitude or phase comparison technique is implemented in the FPGA. Through ADC signals on which amplitude or phase comparison is done are fed in to Virtex-4 FPGA. After comparison, results observed in CRO and these results fed back to Graphical User Interface developed by using Microsoft Visual studio is given in below fig 7.

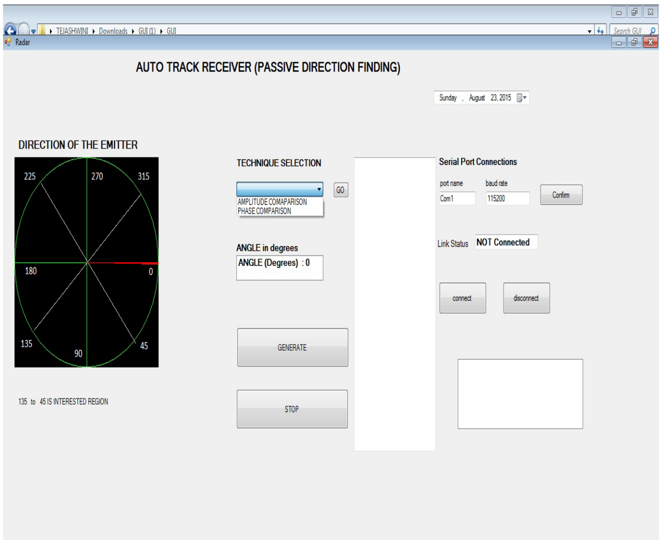

Fig 7 GUI

Servo position will be based on the result obtained from the techniques applied on the signals received from the Target. Servo position will be based on the result obtained from the techniques applied on the signals received from the Target. Using Verilog coding this technique will be implemented in Virtex-4 FPGA .So coding is done based on below concept.

Case 1:Amplitude Comparison:

In this we will be receiving the signals assigned as a,b,c,d from 4 horn antennas .As explained above explained concept i.e.,

•If A=B=C=D then target is centered.

•Azimuth error=(A+C)-(B+D),If (A+C)-(B+D)=0,then no error.

•Elevation error=(A+B)-(C+D),If (A+B)-(C+D)=0,then no error.

So if antenna 1 resultant value is greater than antenna 2 then we will be getting following output in fig 8 below.

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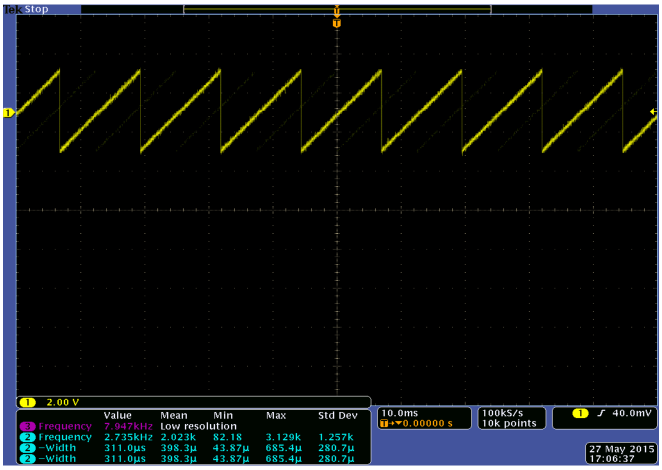

Fig 8Antenna 1>Antenna 2

So if antenna 1 resultant value is less than antenna 2 then we will be getting following output in fig 9 below.

Fig 9 Antenna 1<Antenna 2

Case (ii) Phase Comparison:

In this we will considering again the received signals from target, by using FFT method we will be locating the exact position of target. Using Verilog coding this technique will be implemented in Virtex-4 FPGA .Based on this the servo position is done to target side. For this , In other words, both I1 and I2 were evaluated using only one-half cycle of the received signals. (I1) and (I2) are evaluated based on FFT method .Then (I2-I1) and(I2+I1) is calculated here .By applying the Cos -1 ((I2-I1) /(I2+I1)) we will be getting the angle at which target is located. This angle is observed in GUI window. Based on this result, servo position is changed to track the target desired. This is shown in below fig 10.

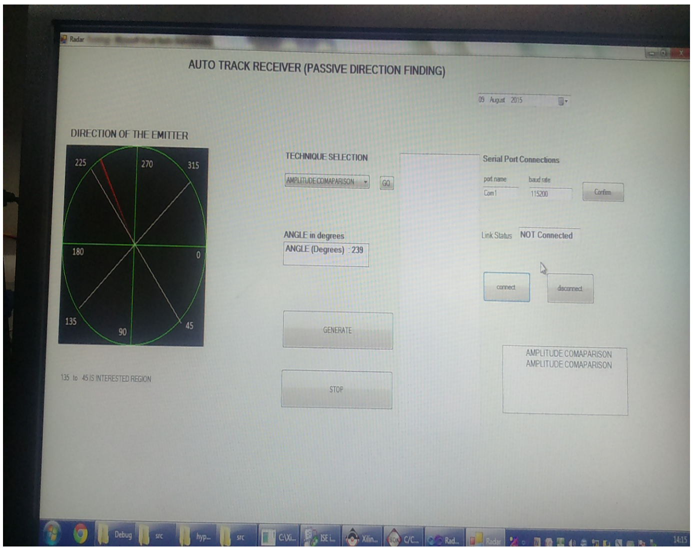

Fig 10 Angle measurement

V.CONCLUSION:

In this thesis, we presented ATR using Amplitude and Phase Comparison method. GUI is designed for interfacing the PC with MicroBlaze processor in Virtex-4 FPGA. Using EDK tool we configured the MicroBlaze processor in Virtex-4 FPGA according to our requirements. The utilization of the customized cores in the design models delivers high level of performance and area efficiency. Thus it resulted in an efficient implementation of the hardware using less percentage of FPGA resources. Thus target is tracked by using above amplitude and phase comparison techniques by FFT method.Servo position is changed accordingly to the result obtained for tracking the target.In the future research, the ambiguity is reduced up to some extent by using four antennae here and it can be further eliminated by using more number of antennae for resolving the ambiguity in direction. Antenna placement and corresponding distance between them are analyzed with different signal to noise values.

REFERENCES:

[1]CH.Vishwanadham, K.Satya Krishna Murthy " Design and Development of Mono-Pulse Auto track Receiver" International Journal of Engineering Trends and Technology (IJETT) – Volume 14 Number 4 – Aug 2014.ccc

[2]Umang Patel, Rahul Petkar, Durvijay Sharma and Sonal Vazirani "Study and Design of Target Tracking and AntiMissile Launching by Amplitude Comparison

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Monopulse Radar Tracking using Matlab", 2012 International Conference on Communication, Information & Computing Technology (ICCICT), Oct. 19-20, Mumbai, India.

[3]Mathew Oommen,Sahaya Lenin,Md. Sohrab Ansari,Shobhit Mishra "An Analysis of Digital Signal Processing in Monopulse Radars", International Journal of Advanced Research in Computer and Communication Engineering Vol. 3, Issue 3, March 2014.

[4]Orduyilmaz, A. Serin, M. Gurbuz, A.C. ; Yildirim, A "Passive direction finding using amplitude and phase comparison techniques", Signal Processing and Communications Applications Conference (SIU), 2014, pg 935 - 938

[5].Ahsan, N, Haider, Z, Sultan,S "Ranging using amplitude comparison of closely spaced time samples", Applied Sciences and Technology (IBCAST), 2013 10th International Bhurban Conference on 15-19 Jan. 2013.

[6]Merril Ivan Scholnik, Radar Handbook, Third Edition, McGraw-Hill Companies, 2008.

[7]Resnick, Halliday and Krane, Physics, Fifth Edition, Volume 1, John Wiley & Sons (Asia) Pte. Ltd., Singapore, 2002.

[8]A. Bourges, R. Guinvarc'h, "Perspectives of the use of high frequency radar on buoys," Oceans 2005 - Europe, pp. 1256-1259, Brest, June. 2005.

[9] Th. Fickenscher, A. Gupta, "Challenges in the Design of a HF Surface Wave Over-The-Horizon Radar Distributed on a Ship Formation," RADCOM 2010, Hamburg, April 2010.

[10]A. I. Abu-El-Haija, "Fast Measurement of Telephone Channel Phase Characteristics - Part 1: Method Description," IEE Proceedings F, Communications, Radar and Signal Processing, Vol. 134, No. 5, pp. 481-486, Aug. 1987.

[11]MicroBlaze softcore processor User Guide.

[12]Embedded Development Kit tool User Guide

[13]XtremeDSP Development Kit-IV User Guide