Implementation of Correlation Radar using VHDL for Automotive Application

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Abstract:

The RADAR is the basic requirement of anti-collision system hence many type of RADAR has been already proposed according to its property and requirement of system .Anti-collision system use RADAR detection to measure distance to obstacles and obstacles relative speed. Many RADAR antennas were developed but correlation radar is the most recent radar used in Anti-collision system. It's a bad and erroneous estimation of the safety distance from the driver that cause car accidents on the road. The safety distance is the minimum distance required to stop a braking vehicle. This paper proposed an approach to making the device simpler cheaper which can be used in automotive application and can also be used for automated vehicle derive system to avoide accident ,we can also add many other features like vehicle signature reading can be used to come across out the type of vehicle such as life saving or emergency vehicle. The proposed paper shows the achievement of a FPGA based mean to calculate the distance of extra vehicle as bright speed & it can also tell between the signals from other large quantity of radars transmitting at equivalent happening in same road which not barely finished this radar constructive for large travel area by dropping false constructive & false negative detection but also reduces the direct width mandatory for these applications even though the dissertation illustrate the total construction of anticipated radar except we concentrate on our correlation code corresponding algorithm & it realization on FPGA using VHDL.

Keywords- Radar, Correlation,FPGA, VHDL.

1. Introduction

Development in electronic systems continuously increases its application on all other engineering fields to increase their performance, flexibility & safety. As several collision warning radar systems will come on the automotive market this year, and as some manufacturers plans to avoid radar on board, research is still carried out for a radar system that could avoid most longitudinal collision. Anti-collision systems are the part of electronic devices used to build an intelligent car with a maximum safety. Car anti-collision systems are becoming popular in automotive industry as well as in research. The principle of system is to avoid collision between the equipped vehicle and the one in front, or other kind of obstacles (animals , etc) , this will reduce accidents and enhance road safety. Also the interest of customer towards safety facial manifestation pressuring the company to employ these of diplomacy in their vehicle, hence the present design of radars do not considers about very crowed & noisy state of affairs because only a not many vehicles having such facility, but with the time at what time it will be positioned to all the vehicles some new concepts must be required to cope up with such condition, for the reason that when large numeral of radars operated close to each other at the same time, the nosiness of the signals resolve be too large which causes the complicatedness in recognition of correct signal as a result the radar could be totally useless, also it could create the confusion by screening the false or specter targets. Targeting to these conditions in this paper we consider some significant concepts of interference between different radar signals we also evaluate the presentation of association radar for automotive application, emphasizing on the type on PN-sequences & their performances.

2. Previous Work

The notion of automotive radar is not original it is planned from the development of radar but unavailability of technology it was never taken seriously but past two decades technology made it practicable so lots of people planned their concept for manufacture enhanced radar. Some of the applicable papers intentional by us for inscription this paper are discussed . Firstly FPGA based soft radar with FIR filters is proposed by R.L.Walke, J.Dudley & D. Sadler[1] their proposal is to implement a receiver with FIR filters to detect the transmitted signals but this method can work with multiple

radar operating simultaneously because there is no method proposed except different frequencies to differentiate the signals from different radars hence we need a large number of frequency bands which is not practically feasible but a good approach for simple, cheap & reprogrammable radar implementable on FPGA.Chika[2] Sugimoto, Yasuhisa Nakamura, and Takuya Hashimoto propose a prototype pedestrian-to-vehicle communication system which uses a cellular phone and wireless communication to improve the safety of pedestrians. A pedestrian-to-vehicle communication system was developed by using a cellular phone and a car navigation system equipped. with GPS and wireless communication function basically the give the idea about it the exchange of information between a cellular phone and a car navigation system and make each of a pedestrian and a driver find the other from out of sight.Yuki NAKANISHI, Ryohta YAMAGUCHI [3] et all developed Vehicular Collision Avoidance Support System(VCASS) based on Inter –Vehicle Communications (IVC) inorder to prevent a vehicular collision before hand. The system grasps the relative locations of vehicles by exchanging the GPS information in each vehicle. Then the system warns drivers if it detects a danger of collision. VCASS can drastically reduce the potential accidents of vehicular collisions,VCASS can not avoid collisions between vehicles and pedestrians, but avoid collisions just between vehicles. we propose a new collision judgment algorithm for Pedestrian-Vehicular Collision Avoidance System (P-VCASS) which extends VCASS which avoid collision . L.sakkila,c.tatkeu[4] et all proposed a new technique for improving road safety and to allow a better transport management.The concept behind an system consist of number of sensor,in order to perceive the environment and the tool used for this objective is embedded radar and ultra wide band communication system to transmit low power ,carrier less signal occupying a very board spectrum,good resolution and increased precision for detection and localization of obstacles.Ken Teo, Kai Wei Ong and Hoe Chee Lai[5] suggest a new algorithm based on implementation of an obstacle detection, obstacle avoidance and anti-collision system using a COTS multi-beam forward looking sonar. The purpose is to equip our in-house built MEREDITH autonomous underwater vehicle the capability to navigate around obstacles that arise in its programmed path. For a system, the ability to identify unknown obstacles and discards false returns and noise is an important issue and extremely challenging. To remove this problem, image processing technique is employed to extract potential obstacles from the sonar image. This is follow by the employment of a real-time multi-frame filter to confirm the presence of obstacles .One of the complete implementation of correlation radar is proposed by Lounis Douad, Pascal Deloof & Yaseen Elhillali[6] ,the paper proposes a good method concept for single chip implementation of correlation radar with application of PN-sequences although they did not discuss about the utility of different PN-sequences except than maximum length PN-sequence even this is not discussed in much detail because they concentrating on VHDL implementation of the system.

3. Comparison between two sequences

VHDL is a language for describing digital electronics and its is a Very High Speed Integrated Circuits (VHSIC) program. It become clear that there was a need for a standard language foe describing the structure and function of Integrated Circuit(IC).Hence VHSIC Hardware Description Language (VHDL) was developed, and subsequently adopted as a standard by the Institute Of Electronic Engineers (IEEE) in US.VHDL is designed to fill a number of need in the design process. Firstly, it allow description of the structure of a design that is how it is decomposed into sub-designs ,and how those sub-design are interconnect. Secondly, it allows the specification of function of design using familiar programming language forms. Thirdly, as a result, it allows a design to be simulated before being manufactured, so that designer can quickly compare alternatives and test for correctness without the delay and expense of hardware prototyping. PRBS or Pseudo Random Binary succession is fundamentally a random sequence of binary numbers. It is accidental in a sense that the value of an element of the sequence is independent of the values of any of the other elements. It is 'pseudo' because it is deterministic and after N elements it starts to replicate itself, unlike authentic accidental sequences. The accomplishment of PRBS maker is based on the linear feedback shift register, which consists of ‘n’ master slave flip-flops. The PRBS generator produce a predefined sequence of 1's and 0's, with 1 and 0 occurring with the same probability. And the reflected radar signals captured by the receiving antenna are usually very weak, these signals can be strengthened by the electronic amplifiers that all radar sets contain. Radar measurement of range, or distance, is made possible because of the properties of radiated electromagnetic energy.The electromagnetic waves are reflected if they meet an electrically leading surface. If these reflected waves are received again at the place of their origin than that means an obstacle is in the propagation direction. Electromagnetic energy travels through air at a constant speed, at approximately the speed of light,

- 300,000 kilometers per second or
- 186,000 statute miles per second or
- 162,000 nautical miles per second.

This constant speed allows the determination of the distance between the reflecting objects (airplanes, ships or cars) and the radar site by measuring the running time of the transmitted pulse. This energy normally travels through space in a straight line, and will vary only slightly because of atmospheric and weather conditions. By using of special radar antennas this energy can be focused into a desired direction. Thus the direction (in azimuth and elevation) of the reflecting objects can be measured. These principles can basically be implemented in a radar system, and allow the determination of the distance, the direction and the height of the reflecting object.

3.1 PRBS sequence as M-sequences

M-sequence (binary maximal length shift-register sequence) are generated by using linear feedback shift-register and exclusive OR-gate circuits.

Linear generator polynomial g(x) of degree m>0

$$g(x) = g_m x^m + g_{m-1} x^{m-1} + \cdots + g_1 x + g_0$$

Recurrence Equation (gm = $g0$ =1)

$$x^m = g_{m-1} x^{m-1} + g_{m-2} x^{m-2} + \cdots + g_1 x + g_0$$

If g_i = 1, the corresponding circuit switch is closed, otherwise $g_i \neq 1$, it is open.
Output of the shift-register circuit is transformed to 1 if it is 0 and -1 if it is 1.

Correlation Properties of m-sequence
Periodic autocorrelation

1. The m-sequence has the best periodic autocorrelation in terms of minimizing the maximum value of the out-of-phase autocorrelation
2. Best utilized if the synchronization window is longer than one period.

A periodic autocorrelation

1. If the synchronization window is only one period long or less, then the correlation is a periodic.
2. Barker sequences are sequences that have out-of phase

   a periodic autocorrelation magnitude bounded by 1.

we can conclude that the m-sequence codes shows good auto correlation value even in attendance of large sound but it shows some peak with further m-sequences which is not satisfactory for automotive applications.
Some other important conclusions drawn by simulation are:

1. Best possible periodic autocorrelation (Minimizing out of phase autocorrelation).
2. The number of m-sequences is small.

The point 2 & 3 of the above are not acceptable for our case.

3.2 PRBS sequence as Gold sequences

Gold sequences of length N can be constructed from a preferred-pair of m-sequences. A preferred-pair of m-sequences, say $\underline{x}$ and $\underline{y}$, has a three valued Correlation function:

$$\theta_{\underline{x},\underline{y}}(n) = -1, \ -t(m), \ or \ \ t(m) - 2 \ \text{for all n},$$

$$\text{where} \ \ t(m) = 1 + 2^{\lfloor (m+2)/2 \rfloor}$$

The set of Gold sequences includes the preferred-pair of msequences

we can conclude that the gold-sequence codes shows better auto correlation value even in presence of large noise in comparison with m-sequences also it shows no peaks with other gold-sequences which makes it better choise for automotive applications.

Some other important conclusions drawn by simulation are:

1. Greater number of sequences than m-sequences.
2. Good-sequence pairs have no peaks on cross-correlation values.

All the points mentioned above makes it a good choice for our system.

4 Behavior analysis over automotive application circumstances using VHDL

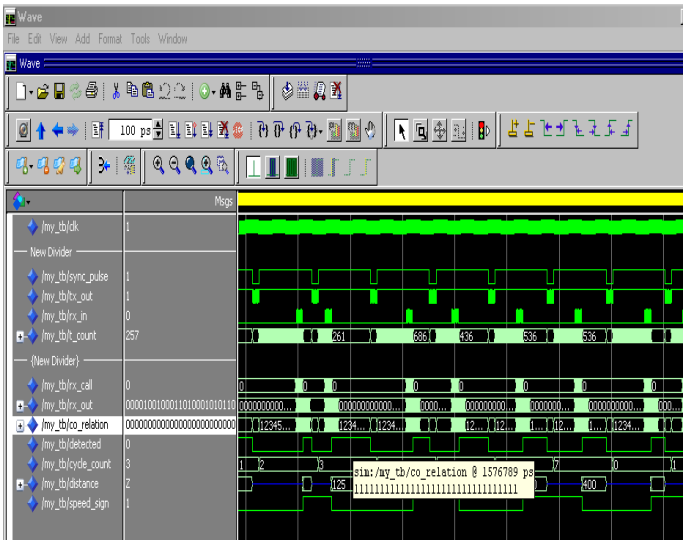

Figure 1 Shows the correlation between transmitted and received signal

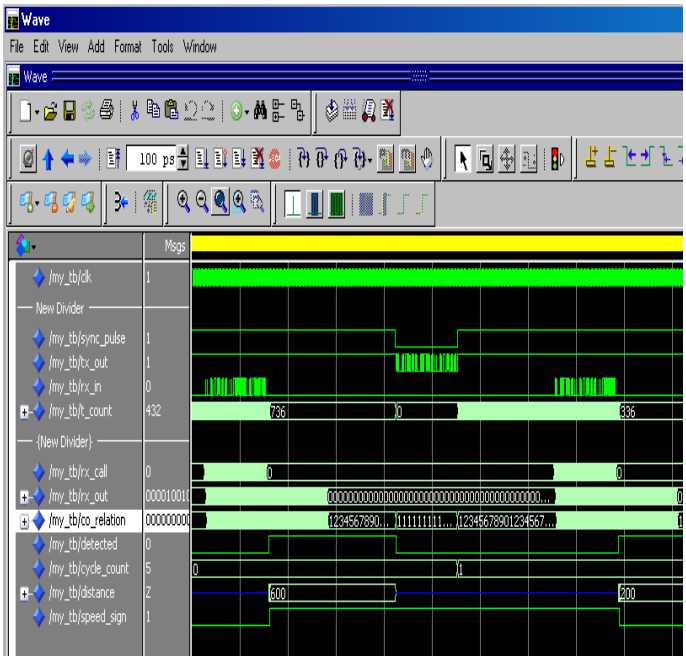

Figure 2 Shows the output at 432 count and correlation between transmitted and received pulse

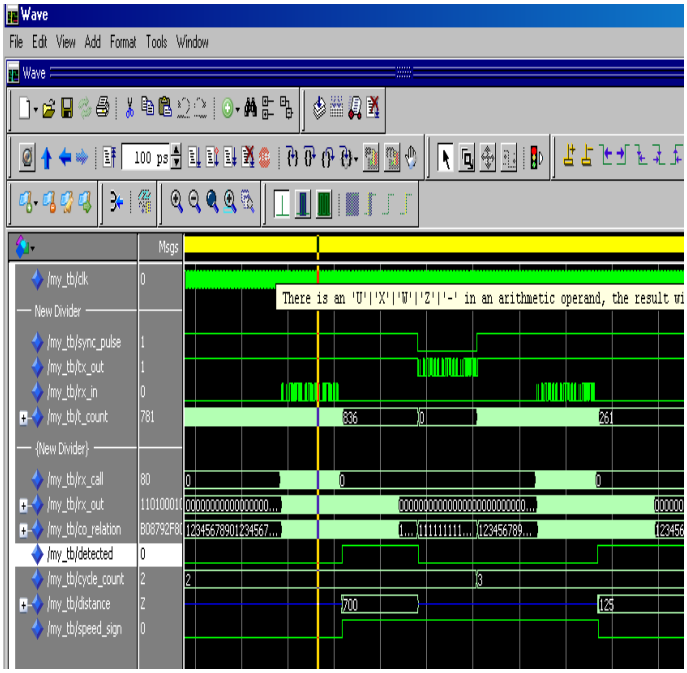

Figure 3 shows the output at 836 and 261 count which shows the obstacles is detected

and its distance is measured.

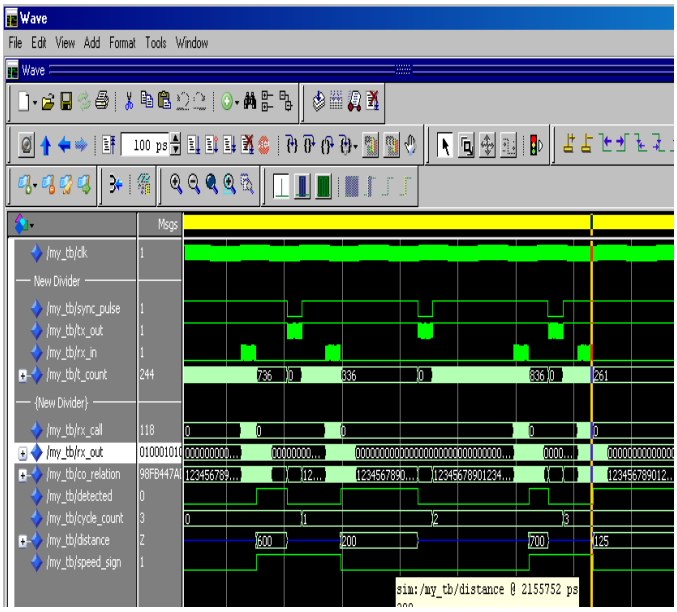

Figure 4 shows the output to determine distance at 2155752 ps to obstacle and its also shows correlation between transmitted and received signal.

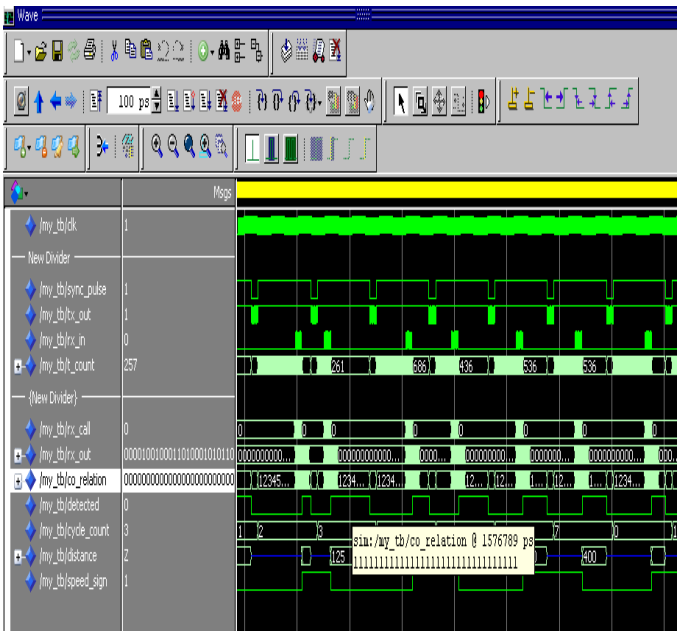

Figure 5 shows the output of correlator when clock =1, sync pulse =1,and correlation between transmitted and received pulse

5. Conclusion

As we discuss in the segment 1 of this document we need a solution for discovery in presence of noise as well in present of other signals & according to analysis of the simulation outcome shows that the gold codes give better presentation in presence of noise & other meddlesome radar signal although it needs larger number of gate for this reason its implementation on FPGA could boost the cost slightly but making an allowance for overall performance its better choice.

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