RADAR BASED COST EFFECTIVE VEHICLE SPEED DETECTION USING ZERO CROSS DETECTION

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Abstract: Most of the modern systems use complex analysis and processing of output signals by using expensive digital signal processors (DSP). In the present work, a novel method of zero-crossing detector (ZCD) algorithm for frequency calculation is implemented. The output of the Doppler RADAR which is a sine wave is band-limited, amplified and then fed to a ZCD. The output of the ZCD a Digital signal can be directly fed to the microcontrollers counter (T0 or T1) without the use of an ADC. The microcontroller calculates and displays the speed. The algorithm proposed for vehicular speed detection is a good platform than the other algorithms which are complex and Costly.

Keywords: Doppler Effect, Zero Crossing Detector, RADAR, Microcontroller, Multisim

I.   INTRODUCTION

The Vehicle speed detection is a method having a very important application worldwide. Although there are many systems which have implemented the systems to detect the vehicular speed, But,the present work is done to show that, Using ZCD the system is very cost effective compared to the existing systems. Radio Detection and Ranging (RADAR) is an electromagnetic device for detecting the presence, location and speed of objects. The presence of objects and their speed are determined by the transmission and return of electromagnetic energy. The advantages of the use of microwaves in RADAR are very compact, high gain and highly directional antennas can be used. Speed is measured by distance travelled by an object with respect to time. The existing system measures the distance by knowing where the object was before and the time it took to cover the distance. Earlier grease pencil marks on the radar screen were used to calculate the speed of the moving object by using slide rule. Then came the modern systems which used Doppler shift in the measurement of vehicle speed. In CW Doppler RADARs when a moving target is detected by a continuous wave RADAR signal, frequency shift occurs in the return signal given by Doppler frequency shift, $fd=2f\square/c$, where $f\square$ is the transmitted frequency and c is the velocity of light. When the target is moving toward the RADAR receiver, the signal frequency increases by fd and when it is moving away from the receiver the frequency decreases by fd. Most of the modern systems use complex analysis and processing of output signals by using expensive digital signal processors (DSP).

II.   BACKGROUND

Existing vehicle speed estimation methods
A. Measuring vehicle speeds with on-board Doppler radarUsing FFT

The system for the above said method is based on millimeter wave frontends (61 GHz) and digital processing of aseband signals. The system is implemented on a board Based on FFT techniques a method is used for the estimation of the Doppler frequency sensor model based algorithms are used for post processing. The meaning of post processing here is that the measured Doppler spectra are correlated with theoretically calculated spectra. Two DSPs of Motorola's DSP 56001 with 24 bit fixed point arithmetic have the signal processing algorithm implemented on it. The first only serves as an interface to a 14 Bit A/D-converter running at 540 kHz conversion rate. The disadvantage is the use of expensive DSP's and complex FFT techniques.

B. Vehicle speed measurement using an imaging method

After understanding the disadvantage of the first method mentioned above, the feasibility of a simple imaging technique for measuring vehicle speed was studied. In the imaging method, the axis of the camera was perpendicular to the road and a single interlaced frame was captured by a frame store. Speed is measured on the basis of comparing two consecutive half frames by using matching technique to determine the displacement of the vehicle between consecutive half frames. Using a conventional video camera, these images were significantly blurred, although this did not hinder the procedure for determining the pixel displacement. From the displacement, the vehicle speed was determined from known vehicle dimensions. Reasonable agreement was obtained between speed observed on the speedometer and speed calculated from the speed and scale data. This system needs very expensive high resolution cameras, highly complex image processing and also the use of DSP's. Hence the disadvantage is,the system is complex and costly.

C.An FPGA-based vehicle speed measurement system using an un-calibrated camera

Measuring a vehicle's speed using a video image is an important technique in an intelligent transportation system. This method presents a hardware implemented vehicle speed measurement (VSM) system. The operation of the system consists of three steps. First, this method removes vehicles from a series of captured images to create a background. To do this, the system introduces a simplified exclusion algorithm optimized to the hardware. Second, it subtracts the background from the incoming image and concurrently and applies affine rectification. Finally, based on the rectified image, it tracks the vehicles and measures the velocity. The system uses two SRAMs and one FIFO to store images. The system obtained ± 7.5% velocity error using an experiment comparing the vehicle's speedometer and the vision-based measured velocity. The disadvantage again is the use of very expensive high resolution cameras, highly complex image processing and also the use of DSP's.

D.Vehicle speed measurement using LASER

The working of the LASER is different from RADAR. The laser gun sends out a beam of laser light that is so narrow and precise it must be aimed with an optical sight. The operator looks through the sight, aims at a specific vehicle, and pulls the trigger, sending out a beam of light. When this beam is reflected back to the laser unit, the unit provides a speed reading. Because of the narrow beams, laser units are hand-held, and can only be used from a stationary position. The disadvantages are: Laser can only be used at a large distance of a thousand feet. This does not give much time for aiming or vehicle identification. Laser is affected by Environmental conditions like Rain, fog, and snow can lead to false readings, scan reflections of laser light from highway structures and other vehicles. It's even possible for the optical sight to be misaligned, so the operator aims at one vehicle, and clocks another. Laser is inherently more difficult to use and sensitive to environmental conditions.

III.   PROPOSED WORK

Present work uses a novel idea for the calculation of frequency without using a Digital Signal Processor and an ADC and just by using a ZCD circuit and a microcontroller. By using ZCD and microcontroller the cost of the vehicle speed measurement is reduced compared to the existing methods which uses Digital Signal Processors for calculating the frequency. In the present work, we use a miniature Doppler RADAR which has dimensions of only 46 x 40 mm. It operates on a +5v power supply. It emits microwave signals of 10.525 GHz frequencies. The waves can hit any moving object within a distance of 20m. It

reflects back some portion of the transmitted signal with a shift in the frequency. When the target is moving toward the RADAR receiver, the signal frequency increases by fd and when it is moving away from the receiver the frequency decreases by fd, where fd is the Doppler shift. This signal is band-limited and amplified from micro volts to volts with the help of an amplifier circuit. The output of the amplifier is a sine wave which cannot be fed directly to a microcontroller. Therefore it is converted to a square wave by using a ZCD. The output of the ZCD a square wave is fed to the microcontroller counter pins P3.4 or P3.5. The microcontroller performs the tasks of calculation of frequency, calculation of speed and display. Below displayed is the block diagram. And it is devided into Part A and Part B.Part A is HBR 100 RADAR and in Part B Output of RADAR fed to ZCD. (refere Fig1 and Fig 2)
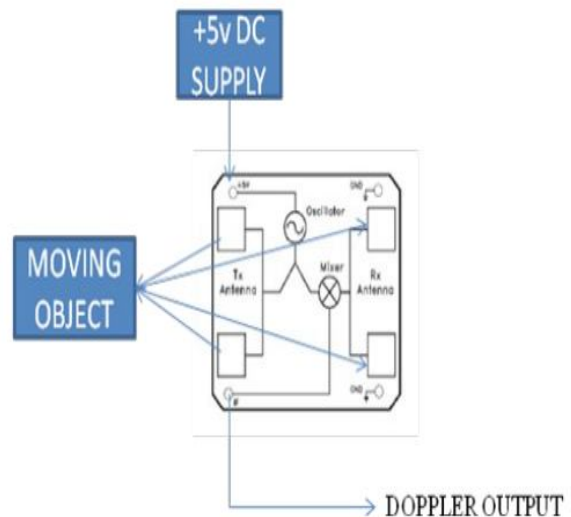

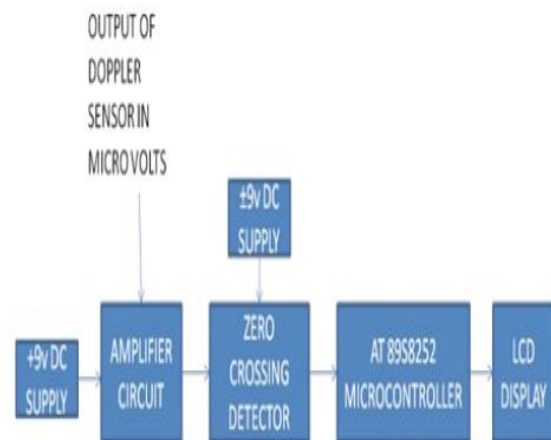**Fig 1. Block diagram Part A: HB100 RADAR**

Fig.2 Block diagramPart B: Output of RADAR fed to ZCD

The figure above is the block diagram and the details are explained in the proposed work.

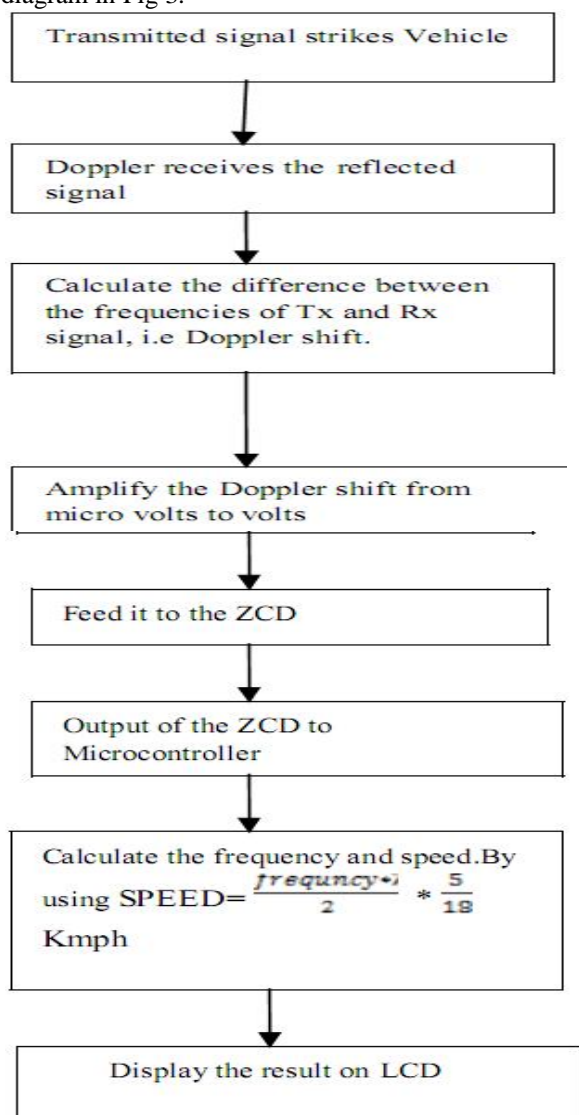The flow of the work done id shown in the flow diagram in Fig 3.

Fig.3.Flow Diagram

IV. EXPERIMENTAL WORK

The complete work is carried out as multiple steps and both simulation and the hardware results are available. The simulation results are carried out in Multisim. And the hardware and softwares used are.

i.Hardware

a. Doppler RADAR-HB100
b.Amplifier Circuit- LM324
c.Zero Crossing Detector (ZCD)- µA741
d.Microcontroller - P89V51RD2
e.LCDDisplay- 16x2 character
f.Power Supply-9v

ii.Software
a.Keil
b.Multisim(Simulating Tool)
c.ISP

V. RESULTS AND ANALYSIS

A.Theoretical results

TABLE 1.Showing resultant speed for different frequencies

FREQUENCY	SPEED
Min. 30 Hz	1.53 Kmph
500 Hz	25.5 Kmph
780 Hz	39.78 Kmph
1000 Hz	51 Kmph
1500 Hz	76.5 Kmph
2000 Hz	102 Kmph
Max. 12850 Hz	655.35 Kmph

Above results are obtained by the following formula

$$SPEED = \frac{frequncy * \lambda}{2} * \frac{5}{18} Kmph$$

$$Where\ \lambda = \frac{c}{f} = \frac{3*10^8 m/s}{10.525*10^9 Hz}$$

$$= Frequency *.051 \quad Kmph$$

$$= Frequency * 51 \quad mph$$
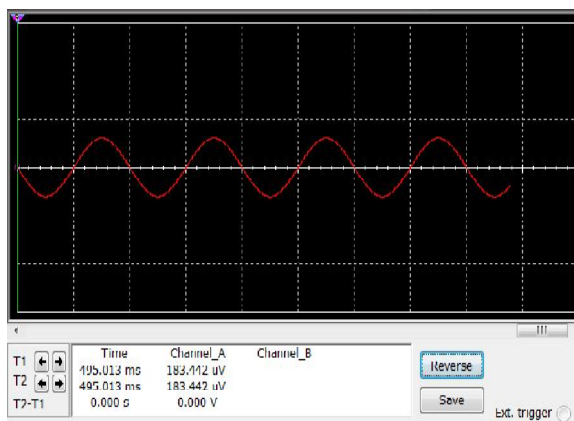
B. Simulation results

Fig 4 Amplifier First Stage Output
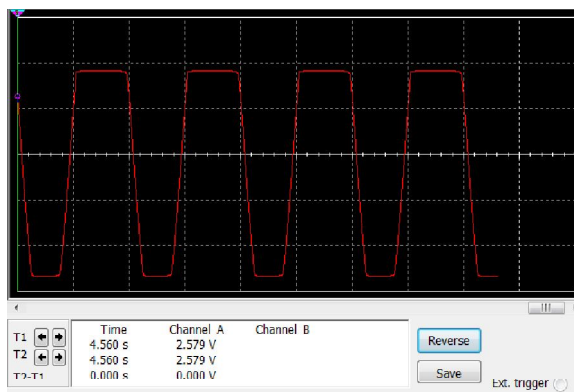

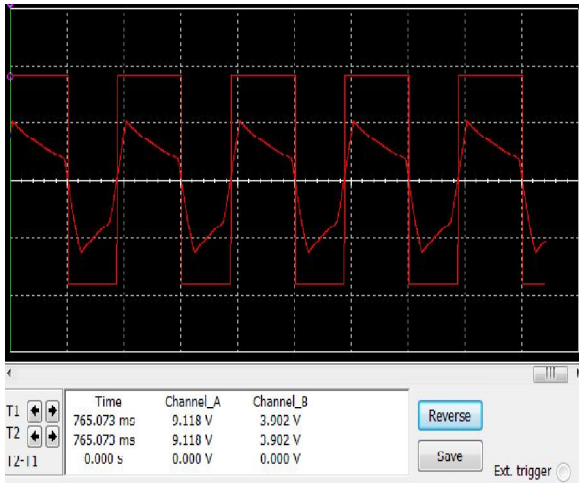**Fig 5. Amplifier Second Stage Output**
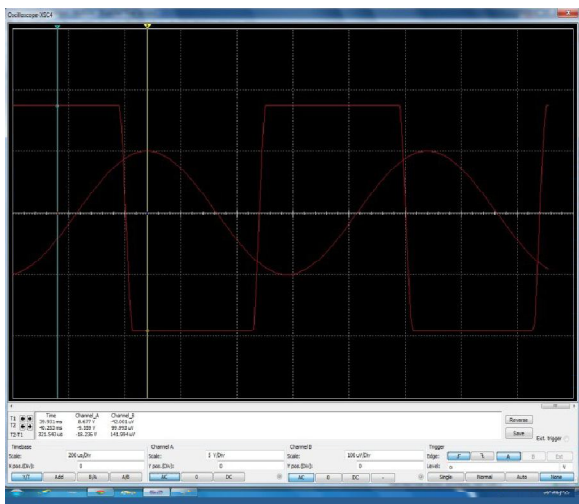
Fig 6. ZCD Output

Fig 7 Amplifier+ ZCD Output

C. Final result on LCD Display

Fig 8 Result display on LCD for an input frequency of 825.88Hz

VI.   APPLICATIONS

A. Voluntary Speed Control:
Radar speed signs by the side of the roads that caution vehicle driver about his speed and the speed limits. An over-speeding vehicle may voluntarily drive at the prescribed speed limits after reading the Radar speed sign.

B. Law-enforcement:
The traffic police can find out the speed of vehicles and over-speeding vehicles can be fined.

C. Intrusion Detection:
The Doppler radar can produce an output signal whenever there is a moving object. This can be used to in intrusion detection.

VII.   FUTURE WORK

There can be several advancements to the present project using the output of the Doppler sensor.
A. Use of DF100 which has a range of 100m as compared to hb100's range of 20m.
B. Over speeding can trigger a camera to capture an image of the over speeding vehicle.
Speed limit can be preset on the device, which when exceeded can trigger a camera to capture the image of the vehicle in question, thus helping in policing.
C. Can be used as traffic counters to count the number of vehicles plying on an highway.

Using the number of disturbances on the sensor, number of vehicles in a particular lane can be estimated.

CONCLUSION

In this paper, a low cost & efficient embedded vehicular speed detecting system is presented.The work aimed at implementing the better results by comparing the existing vehicular methods and also making use of ZCD to calculate the frequency of the moving object,which is required to calculate the accurate speed measurement of vehicle speed. When compared to the existing FFT, DSP and LASER based techniques, the cost of the proposed system has reduced considerably.As a future work, The use of DF100 in place of HB100 can increase the range of detection from 20m to 100m, can be used as traffic counters to count the number of vehicles plying on an highway and also Over speeding can trigger a camera to capture an image of the over speeding vehicle. One of the reasons for road accidents is Speed. Uncontrolled speed of the vehicles are responsible for a high proportion of the mortality and morbidity that result from road crashes. This system can be mounted at potential over speeding stretches, thus alerting the driver when over speeding and eventually help save lives.

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