Vehicle Speed Detection and Collision Avoider RADAR (VSDCAR)

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Abstract - *The most unwanted thing to happen to a road user is road accident. One serious road accident in the country occurs every minute and 16 die on Indian roads every hour. Most of the fatal accidents occur due to over speeding. Faster vehicles are more prone to accident than the slower one. Among the various methods for detecting speed of the vehicle, object detection systems based on Radar have been replaced for about a century for various purposes like detection of aircrafts, spacecraft, ships, navigation, reading weather formations and terrain mapping. The essential feature in adaptive vehicle activated sign systems is the accurate measurement of a vehicle's velocity; this measured velocity is used to take the necessary remedies to avoid accidents.*

Key Words: *VSDCAR, Doppler frequency Shift, Doppler Effect, Radar module, RF signal.*

1. INTRODUCTION

This project major focus will be on the making the vehicle driving safer. The radar used in vehicle Speed detection is called a Doppler radar. It is specialized radar that uses the Doppler Effect to produce velocity data about objects at a distance. It does this by bouncing a microwave signal off a desired target and analyzing how the object's motion has altered the frequency of the returned signal. This variation gives direct and highly accurate measurements of the radial component of a target's velocity relative to the radar. Doppler radars are also used for aviation, sounding Satellites, meteorology, radar guns, radiology and healthcare.

In the conventional Doppler radars the source is stationary only the target is in the motion. But in the Vehicle Speed detection and Collision Avoider radar both source and target are in motion. We know that the Doppler Effect is the same as that for reflection of light by a moving mirror. The Doppler Effect causes the received frequency of a source to differ from the sent frequency if there is motion that is change in the distance between the source and the target.

The Doppler Effect is also known as Doppler Frequency Shift which is given by the equation in the case of source and the target both are in motion:

$$fs = fo\ \left(\frac{c+v}{c-v}\right)$$

Where 'c' as the speed of light, 'v' is the velocity of the target, 'fs' is the shifted frequency and 'fo' is the original frequency. Doppler frequency 'fd' is given by the equation:

$$fd = fs - fo = 2v\ \frac{fo}{(c-v)}$$

Since most practical applications $v << c$, then the value of $(c - v) \rightarrow c$ then

$$fd \cong 2v\ \frac{fo}{c}$$

2. VEHICLE SPEED DETECTION AND COLLISION AVOIDER RADAR

Vehicle Speed Detection and Collision Avoider Radar System is capable to perform the task of primary radar which is a long range radar (40 – 60 m) and secondary radar which is a short range radar (6 – 10 m) and a Microwave Radar Human Body Induction Switch Module (5 – 10 m).These two radars are Doppler radars function based on Doppler Effect. These are placed at front and rear ends of the vehicle, the data from radar is collected and displayed. Then it is analyzed, if the degree of closeness between the vehicles is increased then the necessary action of applying the brakes to reduce the speed is imitated automatically to avoid collision.

The design of the radar deal with HB100 Doppler Speed Sensor of 10.525GHz frequency and RCWL-0516 Microwave Radar Sensor Module Human Body Induction Switch Module Intelligent Sensor for the development of the short range (5 – 10 m) prototype of Vehicle Speed Detection and Collision Avoider Radar.

The design of the Vehicle Speed Detection and Collision Avoider Radar with the primary and secondary radar and Human body induction switch module is developed with the operating frequency of 23.5 GHz range the antenna used in this radar module is the rectangular patch micro strip patch antenna simulated in ANSYS HFSS 15.0. The function of the radar modules is developed in NI LAB View 2014 by the

simulation process the radar system operation is tested and verified. The model of Vehicle Speed Detection and Collision Avoider Radar is simulated and tested and its working prototype is in process. The VSDCAR short range prototype is designed and it is functional. The detail description of the radar short range prototype and also the simulation results of the Vehicle Speed Detection and Collision Avoider Radar with 23.5 GHz frequency are mentioned in this research paper.
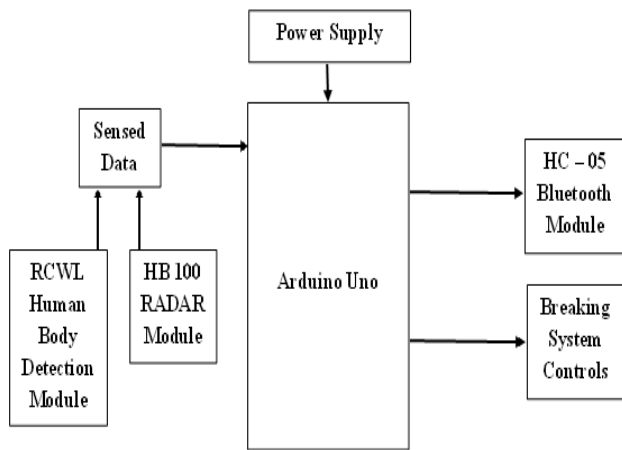
2.1. BLOCK DIAGRAM

Figure 1: Internal Block Diagram of the Vehicle Speed Detection and Collision Avoider Radar

The block diagram of the Vehicle Speed Detection and Collision Avoider Radar consist of two main sensors HB 100 Radar module and RCWL – 0516 Human body induction switch module. The data sensed from these modules is provided to the digital data inputs of the Arduino Uno Controller board.

Sensor data is then analyzed if the vehicle is over speeding and degree of closeness between the two vehicles is increased the automatically the vehicle speed is reduced by providing the data to the breaking system controls which are connected to the digital output ports of the Arduino Uno.

In this prototype of radar we are using a Bluetooth Controlled Vehicle its operation is based on the clockwise and anti-clockwise movement of the motor which is connected to the Arduino Uno and data is transferred to the controlling device using the HC – 05 Bluetooth Module and the controlling device used is a mobile phone

Mobile application has been developed which is used to communicate with the Arduino Uno with the help of Bluetooth module. By using this application we can control the vehicle and this application also displays the speed of the vehicle.

3.1. HB 100 RADAR MODULE:

HB100 radar module can detect the distance within 20m and its transmitted frequency is 10.525GHz.

It consists of Dielectric Resonator Oscillator (DRO), microwave mixer and path antenna. The oscillator is used to produce a sinusoidal wave of frequency 10.525GHz, patch antenna connected to the oscillator radiates the wave towards the target and the reflected wave is received by another set of patch antenna.

The mixer mixes these two signals to generate a sinusoidal wave with frequency equal to the difference between the two signals. Figure 2 below shows the internal structure of HB100.
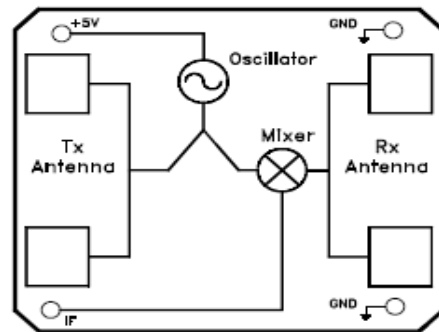

Figure 2: Internal Structure of the HB 100

Power supply:

HB100 powered continuous DC power supply (CW) mode, and pulsation power supply (PW) mode of the two: HB100 adapt to the voltage range of 5V ± 5 %. Continuous DC power supply (CW) mode with a typical current of 35mA. Low duty cycle pulse power supply (PW) mode, 3 to 10 % duty cycle pulse supply an average current of 1.2mA to 4mA.

RF output:

In any of the two recommended operating mode, HB100 is very low, both in constitute any hazard to the human body within the safe range. Continuous DC power supply (CW) mode, with a total output power of less than 15mW. Output power density in the 5mm at 1mW/cm2, 1m at 0.72 W / cm2. When the at a 5 % duty cycle of the pulse powered mode, the power density were reduced to the level of 50 W / cm2, and 0.036 W / cm2.

IF Output:

When the object in HB1001 m/s with respect HB100 antenna surface, HB100 72Hz / s IF pulsation of the output frequency with the object relative radial movement speed is approximately linear relationship.
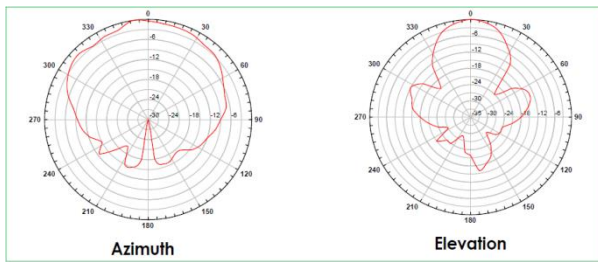
Chart - 1: The Radiation Pattern of HB 100

The module is to be mounted with the antenna patches facing to the desired detection zone. The radiation patterns of the antenna and their half power beam width (HPBW) are in Chart - 1.

HB 100 module output voltage is very less it is need to be amplified in order to be detectable by the Arduino Uno. The figure 3 shows the amplifier circuit of the HB 100 radar module and its connection with the Arduino Uno.

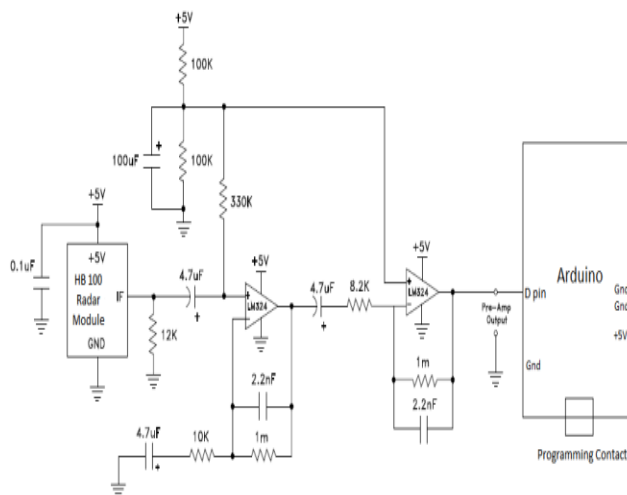This amplifier circuit consists of LM 324 amplifier to amplify the signal of the HB 100 module.

Figure 3: Amplifier Circuit for the HB 100

3.2. RCWL HUMAN BODY INDUCTION SWITCH MODULE

RCWL-0516 microwave radar sensor module Human body induction switch module intelligent sensor.

RCWL-0516 is a Doppler radar technology, specialized in the detection of moving objects in the microwave induction module. The module has the characteristics of high sensitivity, high induction distance, high reliability, large induction angle, wide power supply voltage range, etc. it is widely used in various kinds of human body induction lighting and alarm and so on. RCWL-0516 microwave radar sensor switch module human body induction module intelligent induction detector has sensing distance of about

5-10 meters and the detection is not affected by the surroundings and it has better performance than the IR sensor.
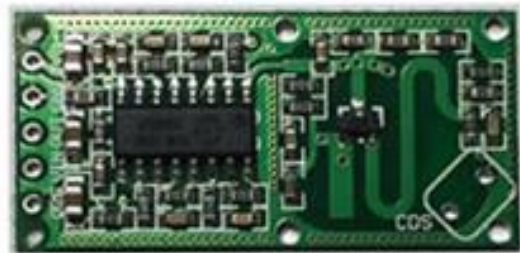

Figure 4: RCWL-0516 Human body Induction Switch Module design

The pin details of RCWL-0516 are as below:

- **3V3:** 3.3V regulated output
- **GND:** Ground
- **OUT Trigger:** 3.3V if motion detected
- **VIN:** 4 - 28V supply voltage
- **CDS:** Enable control chip

4.1. ARDUINO UNO

Arduino Uno is a microcontroller board based on the ATmega328. It has 20 digital input/output pins (of which 6 can be used as PWM outputs and 6 analog inputs), a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with AC-to-DC adapter or battery to get started.

The sensed data form RCWL-0516 and HB100 is given to Arduino. The instructions to the microcontroller are in such a way that if any movement of the human is detected in the range of the radar RCWL - 0156 immediately the breaks are being applied to reduce the speed or else if any other vehicle is being detected by the radar HB 100 if the vehicle is very close about a distance of few meters the brakes are being applied to reduce the vehicle speed. This operation of the vehicle is controlled by using a mobile application which communicates with the Arduino Uno with the help of a Bluetooth module HC – 05 and the controls

Pin details of Arduino Uno:

- **Operating Voltage:** 5 V +
- **Digital I/O Pins:** 14
- **Analog Input Pins:** 6 DC
- **Current per I/O Pin:** 40 mA DC
- **Current for 3.3V Pin:** 50 mA
- **Flash Memory:** 32 KB
- **SRAM:** 2 KB
- **EEPROM:** 1 KB

Figure 5: Arduino Uno

4.2. POWER SUPPLY

VIN the input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). To power up Arduino USB cable connected to a battery or power it with AC-to-DC adapter. Supplying voltage via the 5V or 3.3V pins bypasses the regulator, and can damage the Arduino Uno.

4.3. BREAKING CONTROL SYSTEM

A motor driver IC is connected in order to control vehicle and for controlling the breaking system. Motor driver act as an interface between Arduino and the motor's. The motor driver IC used in the vehicle design is L293D.

The L293D is a 16 pin IC, with eight pins, on each side, dedicated to the controlling of a motor. There are 2 INPUT pins, 2 OUTPUT pins and 1 ENABLE pin for each motor. L293D consist of two H-bridge. H-bridge is the simplest circuit for controlling a low current rated motor.
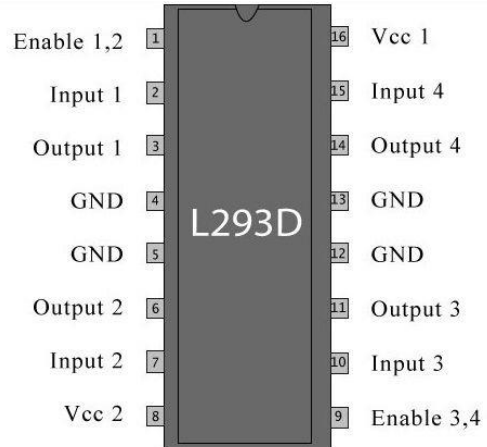

Figure 6: L293D Motor Driver IC

5.1. PATCH ANTENNA DESIGN

Using the ANSYS HFSS 15.0 we designed micro strip patch antenna. Patch Antenna is designed for resonant frequency of 23.5 GHz with the dielectric constant of Rogers RO4350 material is €r is 3.48.

Rectangular patch antenna is developed for the transmission of RF signal of frequency 23.5 GHz is used for the Vehicle Radar. This antenna is used for the transmitting the signal to the target and the reflected signal is collected by the antenna from the target.
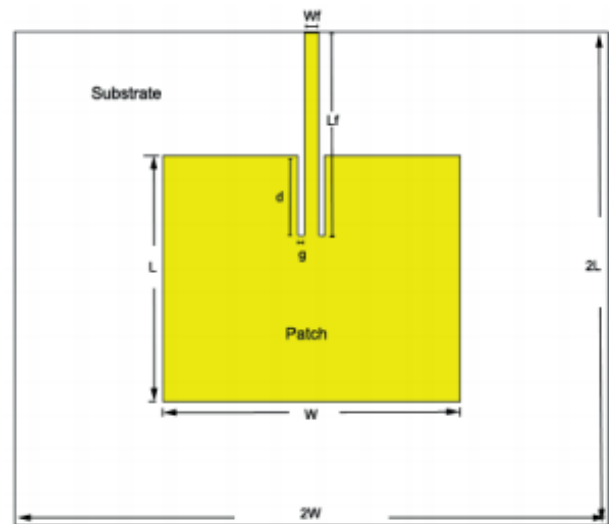

Figure 7: Micro strip patch antenna of resonant frequency of 23.5 GHz

The dimensions of the rectangular patch antenna are given by

- Width of the patch (W) = 4.5 mm
- Length of the patch (L) = 3.13 mm

- Width of the micro strip line (Wf) = 0.1 mm

- Length of the micro strip line (Lf) = 1.81 mm

- Distance of gap (g) = 0.1 mm

- Inset feed distance (d) = 0.75 mm

- Height of substrate (h) = 0.25 mm

- Thickness of patch (t) = 12 μm

5.1.1. Micro strip patch antenna parameters are

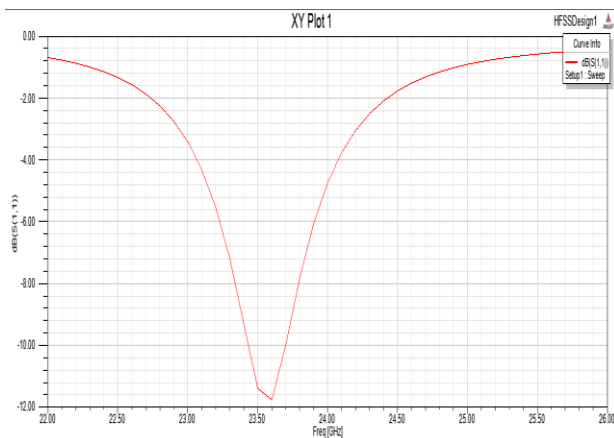### 5.1.1.1. S – Parameter plot

Chart - 2: S – parameter plot of the rectangular micro strip patch antenna

From this S - parameter plot in the Chart – 2 we can infer that resonant frequency of the antenna is occurred at the frequency of 23.5 GHz. This micro strip patch antenna radiates the RF signal at this frequency range.
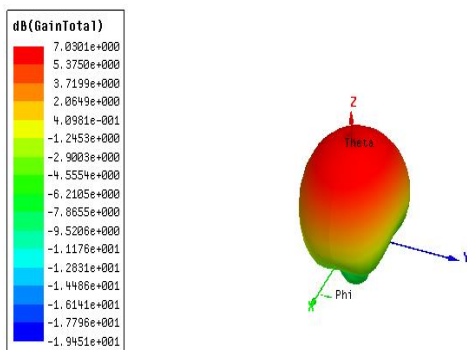
5.1.1.2 Gain of the Micro strip Antenna

Chart - 3: Gain of the rectangular micro strip patch antenna

There are no side lobes and the antenna is highly directional from the radiation pattern in the above chart - 3.

5.2. SIMULATION OF THE VSDCAR

Using LAB View 2014 we have developed a Vehicle Speed Detection and Collision Avoider Radar which works on the principle of the Doppler frequency shift.

Doppler Equation that we have considered is

$$fr = fs \, [(c - VT) / (c - VS)]$$

Where,

- fr = Received frequency
- fs = Source frequency
- c = Velocity of the EM wave (or) Light
- VT = Target Velocity
- VS= Source Velocity

Equation of Velocity (VT) = c - (c – VS) fr / fs

We know that distance between the target and source is given by (D) = (VT – VS) t

Where, t = time in sec

Using this equation we have designed the Lab VIEW based Simulation of our Project the front panel and block diagram is designed. In this process we have developed a simulation to launch Anti-Lock Braking System if the distance gap is less than or equal to 1m.The breaking system is automatically disabled once the gap is being increased. This system operation is simulated and the results were analyzed by providing different frequencies and by using the simulation result we have come to the conclusion that 23.5 GHz frequency is most suitable for the application of the Vehicle Speed Detection and Collision Avoider Radar.
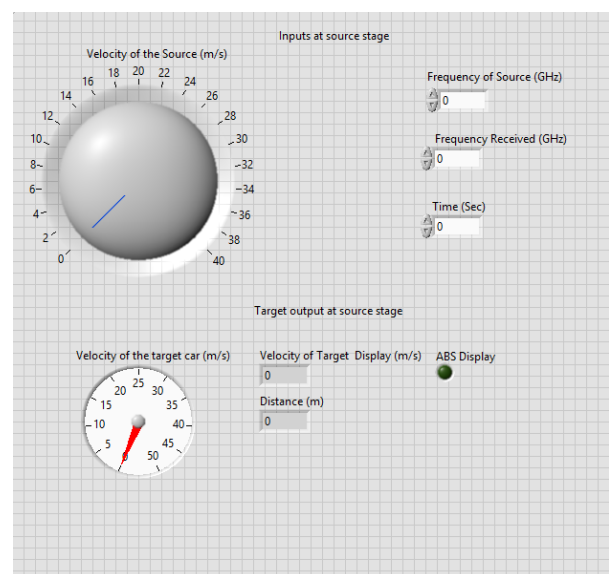

Figure 8: Front Panel of Vehicle Speed Detection and Collision Avoider Radar
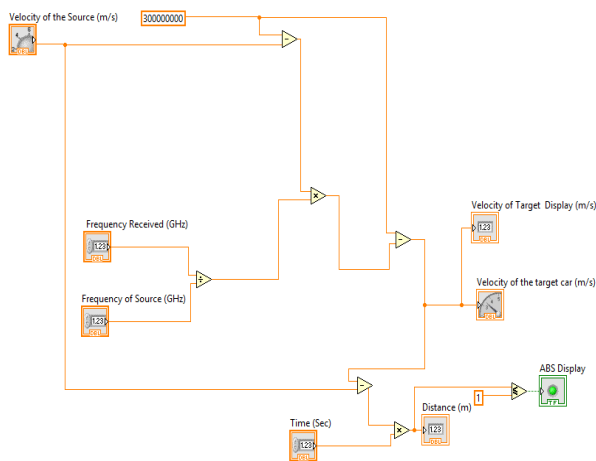
Figure 9: Block Diagram of Vehicle Speed Detection and Collision Avoider Radar

6. APPLICATIONS

The major application of this VSDCAR is the Vehicle Safety Equipment. It can detect the speed and exact distance of the car ahead or behind. It can provide the speed to be maintained so that you can prevent collision with other vehicles. Anti - lock braking system can be linked to it to avoid collision when the degree of closeness is increased. It helps to detect the vehicles presence in the blind spot region of the driver. It can detect any obstacle coming toward the vehicle i.e. humans and animals while crossing the road. It can be used by the Police for the speed detection of the vehicle while travelling in the care without using the conventional Doppler radar for the detection.

7. CONCLUSION

From the results of the design of the antenna design and the simulation of the Vehicle Speed Detection and Collision Avoider Radar in Lab View we have found that the radar can operate in the frequency range of the 23.5 GHz and we have tested the prototype of the radar using the HB 100 and RCWL – 0156 modules and it is found to be operational and results from the short distance prototype testing is satisfactory and we are planning to develop the prototype of the 23.5 GHz frequency range Vehicle Speed Detection and Collision Avoider Radar.

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