

Implementation of FPGA for Automatic Reverse Braking System

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ABSTRACT: Automation technology have provided us with various systems that reduces the time and human error. Vehicles, particularly four wheelers are very difficult to drive in the reverse direction. As personally one is very careful about, otherwise damage being caused to the vehicle. In view of this to provide a proper guidance to the vehicle in reverse direction, means are provided. Presently the vehicle has alarm system for maintaining the safe distance between vehicle and object while moving in reverse direction. When the vehicle gets too close to the object, the alarm is triggered this warns the driver about an object. But this feature has many problems and is prone to human error. We have enhanced the facility by using automatic braking when an obstacle is close by. Therefore, in this paper we propose an “Automatic Reverse Braking system” to prevent collision by using sensors to detect obstacles. The “Automatic Reverse Braking system” will process the sensor data and control the vehicle to prevent accidents caused by careless driving or difficulty in detecting objects in reverse path. In this controlling logic is implemented on FPGA using Xilinx software. The system designed by VHDL keeps a distance between the object and vehicle to prevent accidents.

KEYWORDS: FPGA, Control unit, sensors, Automatic braking, sensing circuit.

I. INTRODUCTION

An automobile has been used to move human beings or as a carriers since the automobile was invented. Recently, the automobile is thought as daily necessity because we spend much time with automobiles, such as we require it for emergency services, in factories, to carry loads etc. The use of electronic components in automobiles is set to accelerate and with ongoing efforts to improve safety and comfort, many approaches such as antilock brake systems, traction control systems, and electronic stability programs have been invented to achieve success in collision avoidance. The goal of vehicle safety ultimately is that a vehicle by no means collides, but it induces a large number of problems that we must solve. Collision, particularly for reversing collision due to careless or violent driving, is the most important major cause that leads to traffic accidents. **Fig.1** shows how difficult it is to drive in reverse direction. Unfortunately, because a human driver is never perfect, some minor mistakes by the driver may result in a great deal of losses when the vehicle's driver reverses.



Fig1: Driver moving in reverse direction

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According to the National Highway Traffic Safety Administration, 8% of the accidents occur during driving in reverse [4]. In traffic safety, obstacle detection and recognition play an important role in preventing reversing collision. The earlier an obstacle of a potential reversing collision is detected, the more chances there are available to protect passengers and other road users. Researches have been made on automatic braking systems, but we are introducing automatic brakes in reverse path. Therefore in this paper we propose a system which will help in enhancing the performance of vehicles moving in reverse and thus contributing to the upcoming automobiles technology.

This system includes a novel technology to make vehicles safer and more efficient. The system is probably the most reliable means of detecting human beings and objects and, therefore, invaluable in the prevention of injury or fatal accidents. The aim of this paper is to develop an automatic braking system. Our aim is to design the "Automatic Reverse Braking System" when the vehicle detects an obstacle in its reverse path using FPGA (Field Programmable Gate Array) which can avoid the accident in reversing the heavy loaded vehicles like trucks, buses and all the vehicles consisting of braking system. If there is object in reverse path, the sensor senses the object and the brake is applied automatically. In this, FPGA is used as a control unit to which the devices and sensors are interfaced. This system is suitable for commercial vehicles such as car, emergency services vehicles, trucks and buses.

II. LITERATURE REVIEW

There have been considerable advances in modern vehicle braking systems in recent years. In automation field, designers have proposed several enhancements. A precise short range radar system [1] was developed for anti-collision applications where automatic braking is applied in response to detection of a collision risk where a very high probability of detection is accompanied by a very low level of false alarms. A brake strategy for an automatic parking system [2] of vehicle has proposed brake controller which work with the automatic parking system and make the process of parking smooth and stable. Autonomous antilock braking system (ABS) system [3] which can take over the traction control of the vehicle is developed for a four wheel vehicle. ABS is a braking system that maintains control over the directional stability of the vehicle during emergency braking or braking on slippery roads by preventing wheel lock-up. Auto-Braking System using Sensor [4] was proposed to prevent front-end, rear-end, right-turn and left-turn accidents on roads. This module can detect the distance between front vehicle and driver's vehicle to keep a constant distance using a sensor and operate the brake system.

All the above proposed design models contributed to safety of vehicles and pedestrians. It prevented rear end crashes, provided ABS for sharp turns or slippery roads. But all these are applicable for vehicles running in conventional direction, so we need to develop systems which enhances the performance and safety of vehicles when it moves in reverse direction. A model designed [8] on reversing of vehicles provided detection of obstacle, speed control mechanism based on binocular cameras. The system [9] uses various sensors to reduce the major cause of vehicle reversing collision but drivers overlooks the vital information of rear obstacles. Thus, in this paper we propose an "Automatic Reverse Braking system" to prevent collision by using sensors to detect obstacles. The "Automatic Reverse Braking system" is processing the sensor data and controlling the vehicle to prevent accidents.

III. PROPOSED WORK

The proposed auto-braking system consists of obstacle sensors embedded in vehicle which will detect the obstacles on the reverse path and send signal to FPGA. Fig.2 describes the general block diagram of our proposed system. The output of obstacle sensor is in analog form, but FPGA requires data in digital form and hence we require a circuit called as Sensing circuit. Sensing circuit will convert the analog data into digital form, that is, the analog output of sensor is converted to digital and is given to FPGA. ADC is used as a sensing circuit. The behaviour of FPGA is defined by VHDL which acts as controller logic is designed with the help of FSM, which will sense the object according to the digital input and action will be taken accordingly. The output is provided by switching circuits such as tail lights or LEDs. Practically, the final output is connected to mechanical system which is actually connected to braking system of vehicle, which is responsible for applying brakes thus leading to the concept of automatic braking.

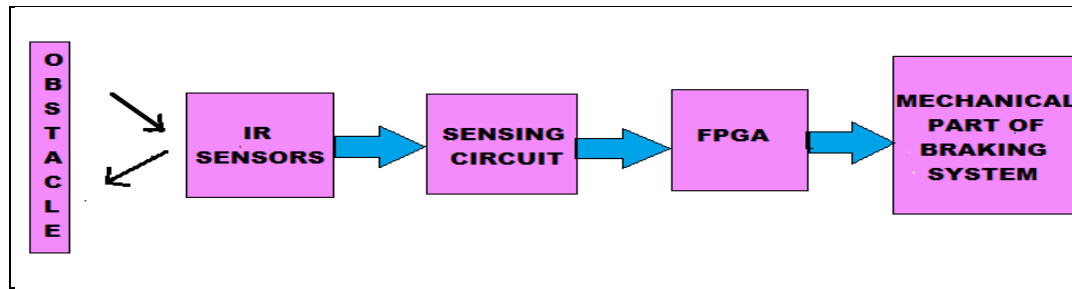


Fig.2. Block Diagram

The IR (Infrared) sensors are used as obstacle sensors in our system which is operated all the time while reversing the vehicle. The IR sensors consists of IR Transmitter and Receiver as shown in Fig.3

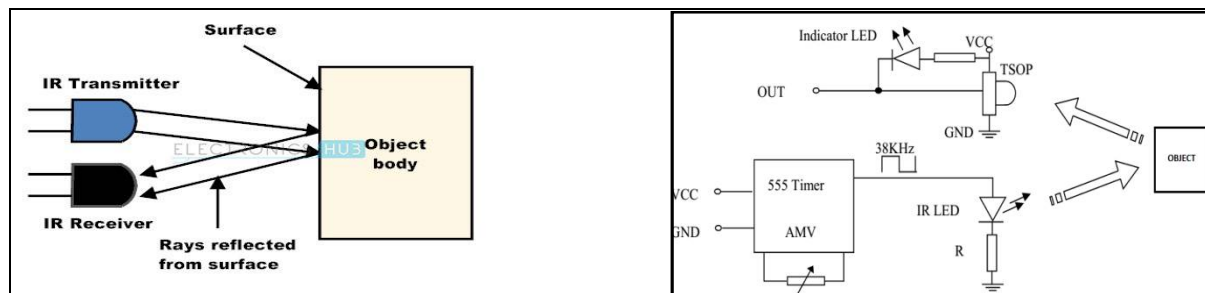


Fig.3: IR(Infrared) Transmitter and Receiver

Fig.4: Schematic Diagram of Sensing circuit

Here as shown in fig.3 ,the object can be anything which has certain shape and size, the IR LED transmits the IR signal on to the object and the signal is reflected back from the surface of the object. The reflected signals is received by an IR receiver.

Fig.4 shows the schematic of sensing circuit. In our system, Sensing circuit consists 555 IC which is used as astable multivibrator. The frequency of the 555 is tuned using the potentiometer as shown in fig.4. The output of 555 is given to the IR transmitter. TSOP detects a frequency of 38 KHz. The output of TSOP goes low when it receives this frequency. Hence the output pin is normally high because, though their LED is continuously transmitting, due to no obstacle, nothing is reflected back to the TSOP. The indication LED is off. When an obstacle is encountered, the output of TSOP goes low, as the required frequency is reflected from the obstacle surface.

The processing part in our system is FPGA (Field Programmable Gate Array) as a controller to which the sensors are interfaced. FPGA accepts the signal from sensors and process the signals and generates the instructions and transfers the generated instruction to control unit of transmission and brakes of vehicle. FPGA can be used to implement any logical functions that an ASIC could perform and has an advantage to update the functionality after shipping reconfiguration of design and low non-recurring engineering cost relative to ASIC design. The behaviour of FPGA is defined by VHDL. It acts as a controller logic designed with the help of FSM logic, which will sense the object according the digital input and action will be taken accordingly The final output is connected to mechanical part of braking system thus leading to the concept of automatic braking. The following procedure is explained with the help of flowchart in **fig.5**.

Fig.6, indicates how our project has been implemented. It gives the design flow of our project. The hardware of our system is defined by VHDL. The program has been compiled and simulated using modelsim software. Further, it is analysed and synthesized by xilinx software tool which generates a bit stream file which is burned into FPGA kit.

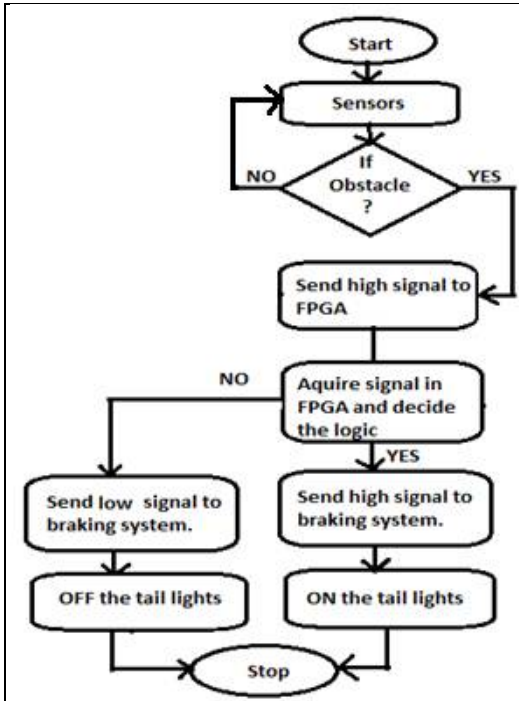


Fig.5: Operating Principle

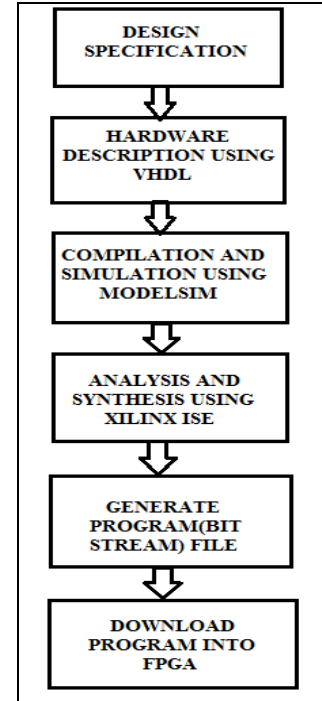


Fig 6: Project Design Flow

III. SIMULATION RESULTS

In our proposed system, controlling logic is implemented on FPGA using Xilinx software. We have used Spartan 3E starter board as a prototype. Its configuration format is

| | |
|---------|------------|
| Family | Spartan 3E |
| Device | XC3S100E |
| Package | VQ100 |
| Speed | -4 |

Xilinx Integrated Software Environment (ISE) is a software tool developed by Xilinx corporation for the synthesis and analysis of Hardware Descriptive Language (HDL) designs. It enables the synthesis of designs, timing analysis , Register Transfer Level(RTL)diagram examinations, simulation as per different environments. The system is designed by VHDL using FSM(Finite State Machine) logic which keeps a distance between the obstacle and vehicle to prevent collision. The VHDL is verified and simulated by a software tool called Modelsim. The design flow of project is illustrated in fig 6.

A. HARDWARE INTERFACING:

In our system , TSOP module is fitted to the back side of vehicles which works when vehicle moves in reverse direction. The TSOP module is shown in **fig.7**. TSOP module is combination of IR sensor and sensing circuit. The TSOP is a general purpose proximity sensor used for collision detection. The module consist of a IR emitter and TSOP receiver pair. The module consists of 555 IC, working in a stable multivibrator configuration. The output of

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TSOP is high whenever it receives a fixed frequency and low otherwise. The on-board LED indicator helps user to check status of the sensor without using any additional hardware. The power consumption of this module is low.

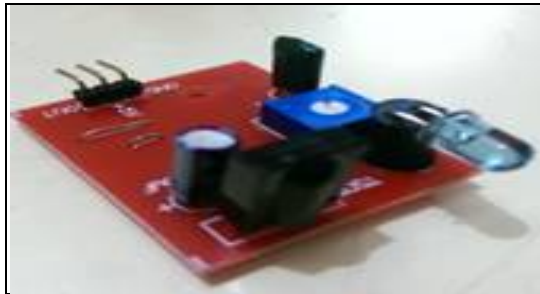


Fig.7: TSOP Module

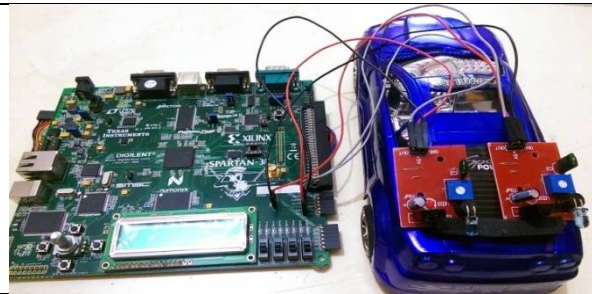


Fig 8: FPGA Board connected to obstacle sensors

The TSOP module is then interfaced with FPGA board in which controlling logic is embedded using Xilinx software. The FPGA then processes the data received from TSOP module and decides the logic. The hardware implementation is shown in **fig.8**. It shows FPGA board connected to the obstacle sensors which is embedded in demo car. When an obstacle is present, the tail lights connected to the demo car are ON, practically leading to the concept of automatic braking.

B. SIMULATION RESULT:

The simulation results of the system are shown in **fig.9**, it shows the outputs of sensor1 and sensor2. The outputs of both sensors are processed by the controller and corresponding outputs (logic) are indicated by the tail lights.

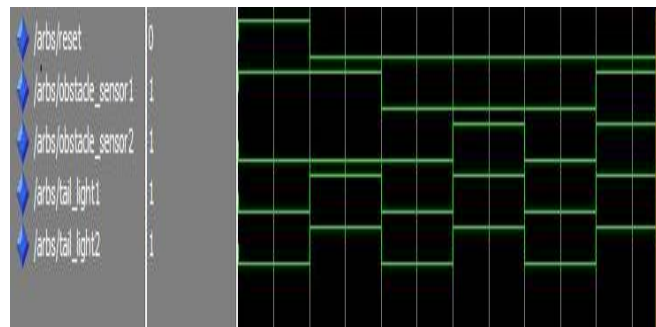


Fig 9: Simulation result

C. HARDWARE ANALYSIS:

a. RTL Schematic

Fig.10 gives us the RTL schematic using Xilinx tool. RTL View is a Register Transfer Level graphical representation of your design. It gives a clear picture of the hardware components present in the system. This representation (.ngr file produced by Xilinx Synthesis Technology (XST)) is generated by the synthesis tool at earlier stages of a synthesis process when technology mapping is not yet completed. The goal of this view is to be as close as possible to the original HDL code. In the RTL view, the design is represented in terms of macro blocks, such as adders, multipliers, and registers. Standard combinatorial logic is mapped onto logic gates, such as AND, NAND, and OR.

b. Technology Schematic:

This schematic is generated after the optimization and technology targeting phase of the synthesis process as shown in **fig.11**. It shows a representation of the design in terms of logic elements optimized to the target Xilinx device or "technology"; for example, in terms of LUTs, carry logic, I/O buffers, and other technology-specific components.

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Viewing this schematic allows you to see a technology-level representation of your HDL optimized for a specific Xilinx architecture, which might help you discover design issues early in the design process.

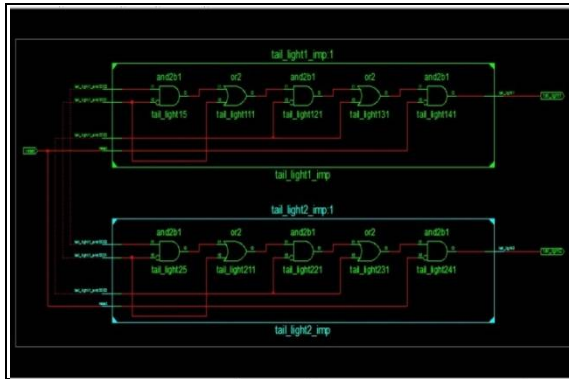


Fig 10: RTL Schematic view

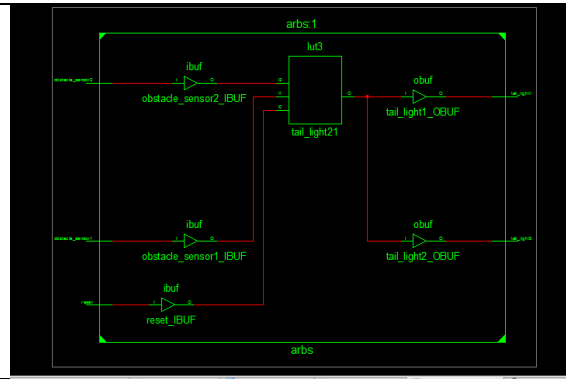


Fig 11: Technology Schematic view

c. Synthesis Report:

| Device Utilization Summary | | | | |
|--|------|-----------|-------------|---------|
| Logic Utilization | Used | Available | Utilization | Note(s) |
| Number of 4 input LUTs | 1 | 1,920 | 1% | |
| Number of occupied Slices | 1 | 960 | 1% | |
| Number of Slices containing only related logic | 1 | 1 | 100% | |
| Number of Slices containing unrelated logic | 0 | 1 | 0% | |
| Total Number of 4 input LUTs | 1 | 1,920 | 1% | |
| Number of bonded IOBs | 5 | 66 | 7% | |
| Average Fanout of Non-Clock Nets | 1.25 | | | |

Fig 12: Device Utilization Summary:

Fig 12. gives the device utilization summary of our system which indicates number of inputs, IOs ,slices utilized. In timing summary fig13. it gives the net propagation delays between the different inputs and outputs in our design. The system is capable to attain maximum frequency of 160MHZ and static power required is 0.034W.

| | | |
|---|-------------------|---------|
| 1 | Propagation Delay | 6.236ns |
| 2 | Maximum frequency | 160MHz |
| 3 | Power Requirement | 0.034W |

Fig13: Timing Summary

IV. CONCLUSION AND FUTURE WORK

The whole system works only while reversing the vehicle. When the sensor senses any obstacle behind the vehicle, it sends signal to the control unit (FPGA). FPGA which act as a controller logic is designed with the help of FSM, which will sense the object according to the digital input and action will be taken accordingly.

For a future development of this project, the Logic Controller designed can be enhanced by applying more rules. By then, it can produce better response. The response should be better and can be applied to a real hardware model to observe the real response and yet can improve the system. The proposed system can be replaced by an ASIC in future.

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