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Improved fault tolerance for air bag release in automobiles

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Abstract. In order to increase the reliability of the airbag system in automobiles which in turn increase the safety of the automobile we require improved airbag release system, our project deals with Triple Modular Redundancy (TMR) Technique where we use either three Sensors interfaced with three Microcontrollers which given as input to the software voter which produces majority output which is feed to the air compressor for releasing airbag. This concept was being used, in this project we are increasing reliability and safety of the entire system.

1. Introduction

Air bag is a vehicle safety module .The airbag module consists of flexible bag made up of fabric which is inflated at collision [1]. Present days air bags are employed in various parts of car to provide more safety .Normally these are present at steering, passenger seats. This air bags are blown with help of air compressor [2]. Air compressor is device which converts electrical energy to potential energy which absorbs air rapidly in to storage tank. The fault tolerant technique we used is Triple Modular Redundancy which is denoted as TMR, where three systems do same operation and the obtained result will be majority input which is produced by voting system to give single output [3]. Here we use 2 is to 3 redundancy technique so for the three inputs at least 2 must give the same result which is considered as the output.

A microcontroller is manufactured in a single integrated circuit. This contains a memory, programmable in/out peripherals and processor core. Memory can sub divided in to Program memory which generally called as ROM/FLASH memory, and small amount memory which is used to store temporary values called as RAM .Microcontrollers can programmed for applications related to embedded systems.

Microcontrollers are employed in various automatically controlled applications, such as automobile engine which is used in control systems, medical devices which are used in implantations, wireless remote controls, in various appliances [4]. By rapid changes in manufacturing of micro controllers in terms of reducing size and cost compared to that of a design which uses a different microprocessor unit, separate memory, and various in/out devices [5]. These microcontrollers are more reliable. 8051 Microcontroller which we used here is a Basic Microcontroller.



Vibration sensor which is used here is used to detect vibrations. When an vibration occurs which blocks the flow of current which in turn acts as high resistance device.

2. Methodology

Here we are using Triple Modular Redundancy (TMR) method which is derived from N Modular Redundancy, where three sensors with same type of input are given to the voter which uses majority concept that is where when at least two sensors gives the same input that will be given as the output. Voter does bit-wise comparison to generate majority output. If even one module fails, output is still correct. Here we are using software TMR.

This use 3 times the hardware that is actually required and a majority voter, if one system becomes faulty and the two other correct, one will get masked so that the faults are reduced thereby increasing reliability. Voter does bit-wise comparison on the given inputs. If one of the three module fails, output will be still correct. The main problem if the voter fails that is failure occurs in complete system, but voter is simple circuit and unlikely to get failure. Reliability of TMR less than or equal to reliability of voter “Single-point-of-failure”. This Model is not directly applicable to “standard computerized system”, works only on bit-level ,required of bit-wise synchronization.

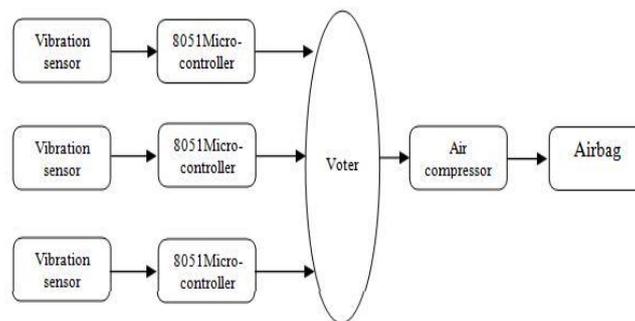


Figure 1. Block Diagram.

The Vibration Sensor that we are using is SW-420. It consists of a Single roller which is of full induction type trigger switch. When there is no vibration or tilt, it is in 'ON' condition, when there is a vibration or tilt, the switch will be delivered. This sensor is waterproof and dustproof. This sensor acts as a switch usually in the conduction state on resistance, Sensor has high sensitive settings by Integrated circuit, can be adjusted according to their requirements of sensitivity.

The Voter is software TMR which discussed above. The Microcontroller which we use is 8051 which is a 40 pin DIP chip. It is the basic Microcontroller. We use Air Compressor to blow the air into airbag when the crash of automobile happens. The air compressor is connected with airbag. So upon collision the airbag will be released. Here we use relay as switches.

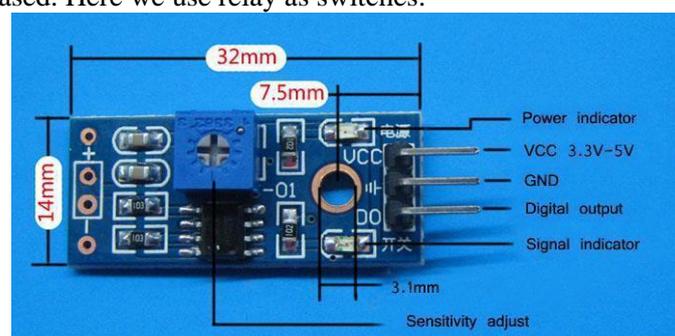


Figure 2. Pin diagram

3. Working module

In this we have shown each module separately and then the final module.

Module 1:

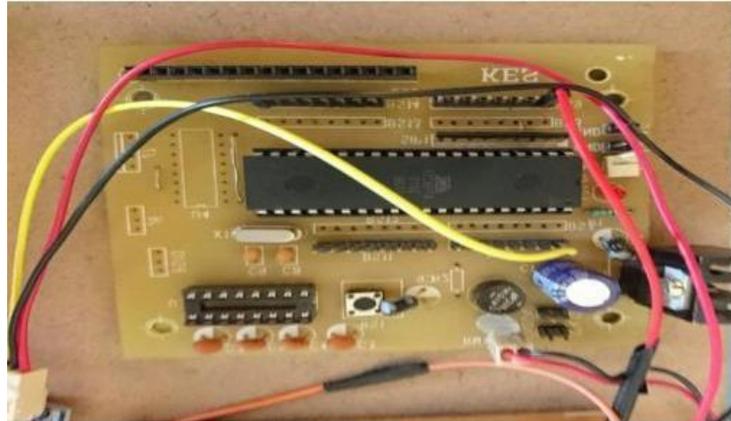


Figure 3. Vibration Sensor SW-420.

Previously, they used to use either three Impact sensors and one Microcontroller or one sensor and three Microcontrollers along with TMR voter for releasing of the airbag in automobiles.

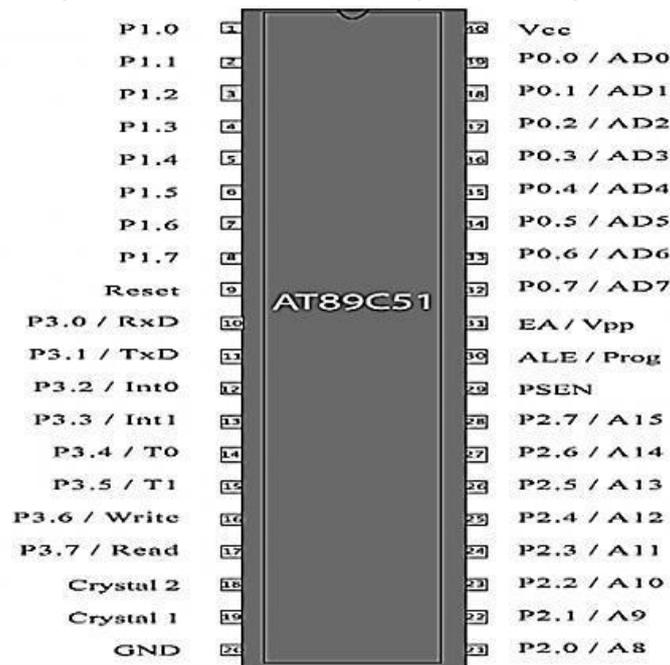


Figure 4. 8051 Microcontroller.

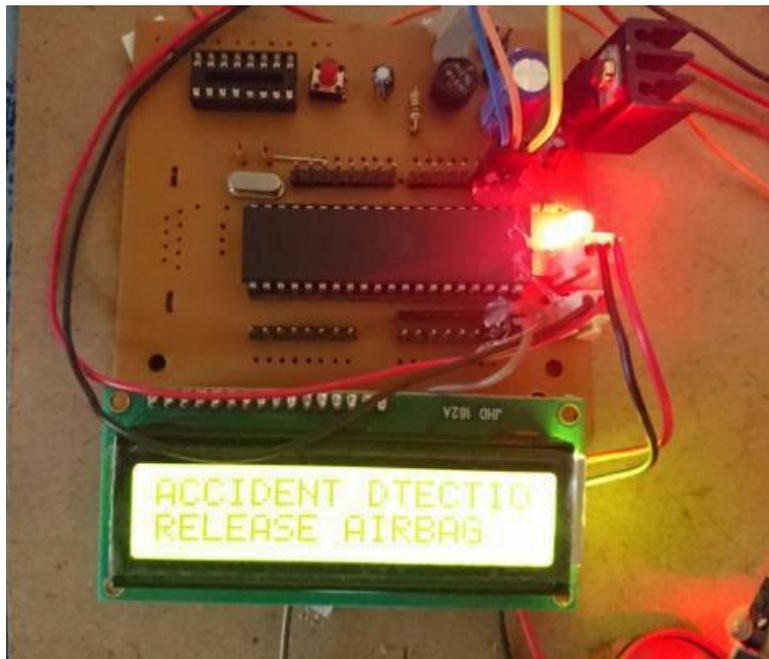


Figure 5. Interfacing Vibration Sensor with 8051.

This microcontroller is interfaced with vibration sensor .When the output of vibration sensor is set this microcontroller is programmed such that output pin of microcontroller is set that it is High.

Module 2:

In this paper, we modifying the concept so that the reliability is improved of the existing system and safety is also improved. Here three vibration (Impact) sensors are given to three Microcontrollers each so fault occurrence will reduce. The results from Microcontrollers are to a TMR voter (Software voting) where we get one output. This output is given to an air

This module acts as a software voter circuit in this airbag release system where, when the output of the at least two microcontrollers is set then it is programmed such that it generates high signal at its output.

Module 3:



Figure 6. Interfacing Motor and Air bag with 8051

This module is motor attached to balloon to resemble the air compressor that we use in the ordinary cars. This motor is set to run when the output of the software voter circuit is set.

Module 4:

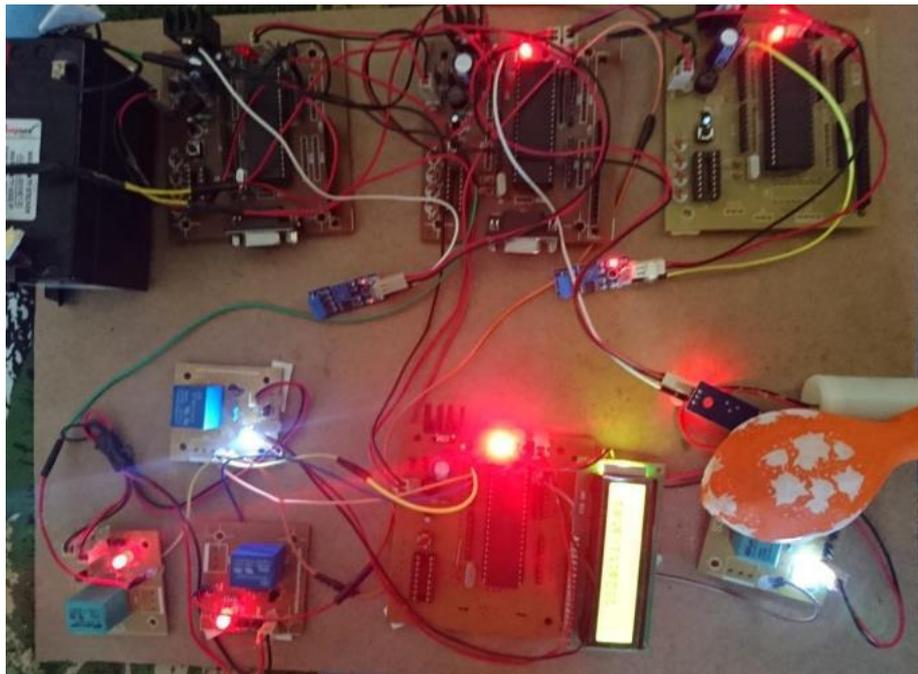


Figure 7. Airbag release system using fault tolerance concepts.

This is the final working module which consist of three Vibration sensors (Impact sensors in cars) interfaced to three microcontrollers which are then connected to the voter circuit which when activated will run the motor which in turn pumps the balloon.

Table 1 Logical Table for Air Bag Release

Microcontroller A	Microcontroller B	Microcontroller C	Voter
0	0	0	0

0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

According to Logic Table if at least two Micro-controllers are in high then Voter output will be high otherwise low.

We can express Voter output in form of Boolean equation as

$$\mathbf{Voter = AB + BC + CA}$$

4. Conclusion

Using TMR voter along with three sensors given to three Microcontrollers each in order to increase reliability of the system which in turn increase safety of automobile. We use three Sensors which are given to three Microcontrollers each. The outputs of this are given to voter. In this voting we use Triple modular redundancy (TMR) where we give same input to three systems (Microcontrollers) to voter in which at least two must give same result and should give one output. This output is given to air compressor in order to release airbag. Thus implementing the concept discussed in this paper we can increase the Reliability and safety of the Airbag Release System.

Implementing two level voting where we use CAN for third level voting. Here we connect one PIC or ARM7 Microcontroller to the three existing Microcontrollers using CAN bus. In this PIC or ARM7 Microcontroller we use software voting redundancy so that the reliability and safety will be further more increase.

References

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