Microcontroller 8051 Based Accident Alert System Using MEMS Accelerometer, GPS and GSM Technology

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Abstract: **the largest cause of unnatural deaths in the world today (apart from diseases) is road accidents. With increase in population and thus in the number of vehicles, accidents are only going to increase. Most of these deaths are due to delay in medical attention to the injured. The major cause of this delay is lack of intimation or delayed intimation of the accident to emergency medical response authorities. This can be addressed by the system proposed. This system uses an accelerometer, GSM modem and a GPS device along with a microcontroller to report an accident. The system also incorporates a "panic switch" which when depressed will send a text message for help to stored numbers. This facility provides assistance in the case of some chronic medical condition like heart attack or robberies that are increasing on highways.**

Keywords: MEMS accelerometer, detecting collision as high G force, GPS, GSM, panic switch

I. INTRODUCTION

The detection of accident of the vehicle equipped with this system is done by sensing the G force that the vehicle suffers. This is sensed by the MEMS based accelerometer module. A GPS module is also contained in the system which continuously obtains the position of the vehicle. When the acceleration (or deceleration) as measured by the MEMS sensor and reported to the microcontroller goes above the threshold value, the controller fetches the co ordinates from the GPS and sends them to the stored number(s) in the form of a text message indicating that an accident has occurred. This message would be sent to some relative of the occupant of the vehicle but it might also be sent to emergency response call center or the police. The "panic switch" feature of the system is to get immediate help which might be required to the vehicle occupants, say, in the case of a medical condition like heart attack or an epilepsy attack or in other dangerous situations like an attempted burglary wherein it might not be possible to make a call physically without getting harmed by the culprit. There is also a Liquid Crystal Display that shows the status of the system in terms of message sent or not. If there is a minor accident and the message has been sent, the occupant can call back and acknowledge that he or she is all right and no medical attention is required.

II. SYSTEM DESCRIPTION

The block diagram of the system is given in Fig.: 1. The main component of the system is the accelerometer. Accident is detected from the fact that it creates a massive g forces to be developed. The accelerometer detects this force producing an output corresponding to the amount of force developed. To quantify this g force, the output of the accelerometer is fed to an ADC via a unity gain amplifier which actually works as an impedance matching unit so that the sensor is not loaded by the ADC. The ADC is an 8 bit unit and provides a digital parallel out corresponding to the sensor analog reading. This is given to the microcontroller which compares the same with stored threshold for an accident. If the value read is greater than the threshold stored, the microcontroller immediately sends the location of the vehicle obtained from the GPS to the programmed numbers in the form of a text message or SMS. This is done through the GSM modem that has been interfaced with the microcontroller. An LCD display has also been interfaced with the controller that shows the status of the system. The entire system is powered by vehicle battery and onboard arrangement of obtaining dc 5V has been also made. Thus the system can be powered by 12V or 24 V battery system of any vehicle.
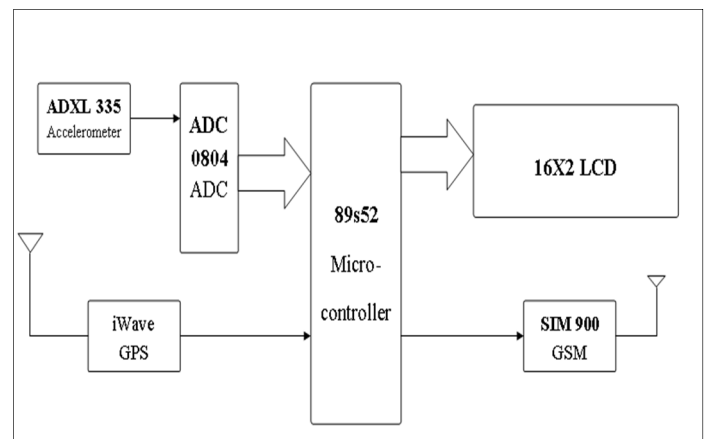

Fig. 1: Block Diagram of the System

III. METHODS AND MATERIALS

A. ADXL 335 ACCELEROMETER

ADXL 335 is a three axis accelerometer module from Analog Devices. The device is capable of measuring acceleration or deceleration along all three X, Y and Z axes. The maximum range of the sensor is ±3g which is enough for the small scale prototype. The actual system would need to have a sensor with much higher maximum range. The sensor is capable of measuring dynamic acceleration resulting due to shock, vibration or sudden motion. It also provides static acceleration output resulting from earth's gravitational pull. The main component of the sensor is a micromachined polysilicon surface built on a silicon wafer. Resistance to acceleration is provided by polysilicon springs that suspend the structure on the surface of the wafer. Deflection occurring due to acceleration is measured by differential capacitor which has stationary plates and moving plates attached to a mass. The differential capacitor is unbalanced by the moving mass as a result of acceleration. This produces an output proportional to the acceleration as the stationary plates are driven by square waves which are 180 degrees out of phase. The MEMS sensor on the module is capable of producing outputs corresponding to vibrations ranging from 0.5 Hz to 1500 Hz. The lower limit has been set to 50 Hz by the on module filter capacitors of 0.1 uF. The operating power supply range of the module is 1.8V dc to 3.6V which is provided on board with a zener diode. Of the three axes, only one, here x axis output has been utilized for accident detection.

B. ADC 0804 ANALOG TO DIGITAL CONVERTER AND 89S52 MICROCONTROLLER

The ADC used is ADC0804 also from National Semiconductors. This device is a CMOS successive approximation 8 bit analog to digital converter which uses a modified potentiometric ladder and has three state gates in its output. This converter has a conversion time less than 100 micro seconds. The converter has an input analog range of 0 to 5V which can be externally set for maximum accuracy at any given range. No zero adjustment is required for the chip. This converter also presents an option of running it without applying any external clock signal as it has its internal clock generator based on an externally connected RC network. The ADC is also controlled by the microcontroller by the start conversion and write signals. The free running frequency of the ADC is set by the RC network on 10k and 100pF connected to its 4 and 19 pins. The ADC gives an 8 bit output

corresponding to the analog voltage that it receives from the Accelerometer. The output of the accelerometer module is applied to the pin 9 of the ADC. As the single ended capability of the ADC is used, the second differential (inverting) terminal of the chip is grounded. The analog ground and digital ground of the chip are also grounded.

The controller used is the 89s52 which has a standard 8051 core of the very popular series of microcontroller series from Intel. This controller has 8kB of internal ROM and 256 bytes of RAM. The memory type is flash and thus is easily programmable. The onboard flash memory guarantees an endurance of 1000 erase/program cycles. The version s52 is different from the c52 by the fact that it has a programming voltage of 5V as compared to 12V of that of the c51/52 devices. This controller is also in-system programmable. The chip has three 16 bit timers/ counters and 8 interrupt sources. The microcontroller has 32 programmable I/O lines and a full duplex UART serial channel. There are also two software selectable power saving modes. The maximum frequency supported by the chip is 33MHz. The clock crystal of 11.0592MHz has been used in this application as it is necessary for generating standard baud rates which would be necessary for communication with the GPS module and GSM modem.

C. THE GPS MODULE AND NMEA STANDARD

The GPS module used is from iWave. The module has a 20 channel receiver with a tracking sensitivity of -159dBm and an accuracy of 10m. This module has a startup first acquisition time of 2 seconds during normal temperatures and up to about 40 seconds under extreme cold conditions. Maximum working altitude for the module is 18000m and max. linear working speed is 514 m/sec. The output protocol is NMEA (National Marine Electronics Association) at data speeds of 4800 or 9600 bauds. The module works on 3.3Vdc which is provided from a regulator on board.

NMEA means National Marine Electronics Association. The NMEA 0183 protocol presently used is a combined data and electrical specification for marine electronics equipments like echo sounders, GPS receivers, gyrocompass etc. It uses standard ASCII serial communications protocol to transmit data from one transmitter to many receivers. GPS data available from the receiver module mentioned above is in NMEA 0183 protocol from which position co ordinates has to be separated by the microcontroller. As per NMEA 0183, each data sentence must begin with $ sign and end in <CR><LF> (carriage return and line feed). If the signal is from a GPS- technically a "talker", the message would begin

as $GPGGA. Typical NMEA data format from GPS receiver would be:

*$GPGGA,hhmmss.sss,ddmm.mmmm,a,dddmm.mmmm,a,x,xx, x.x,x.x,M,,,,xxxx*hh<CR><LF>*

Here, hhmmss.sss = GPS time in hours minutes and seconds

Ddmm.mmmm = date in day month and year

a = N or S depending on latitude North or South

ddmm.mmmm = latitude in degrees and minutes

a= E or W depending on longitude East of West

dddmm.mmmm = longitudes in degrees and minutes

remaining are details such as GPS quality indicator, no. of satellites in use horizontal dilution of precession, altitude etc.

D.   THE SIM 900 GSM MODEM

The SIM 900 is a quad band GSM/ GPRS modem supporting 850/900/1800/1900 MHz. The modem sports an RS-232 port so that it can be directly interfaced with a computer. Although in this particular application the modem has been directly connected via its TxD RxD pins (TTL level) to the microcontroller. The modem can be controlled by standard AT command set. This method is used here and the controller communicates with it using AT commands.

IV.   THE PROGRAM FLOW

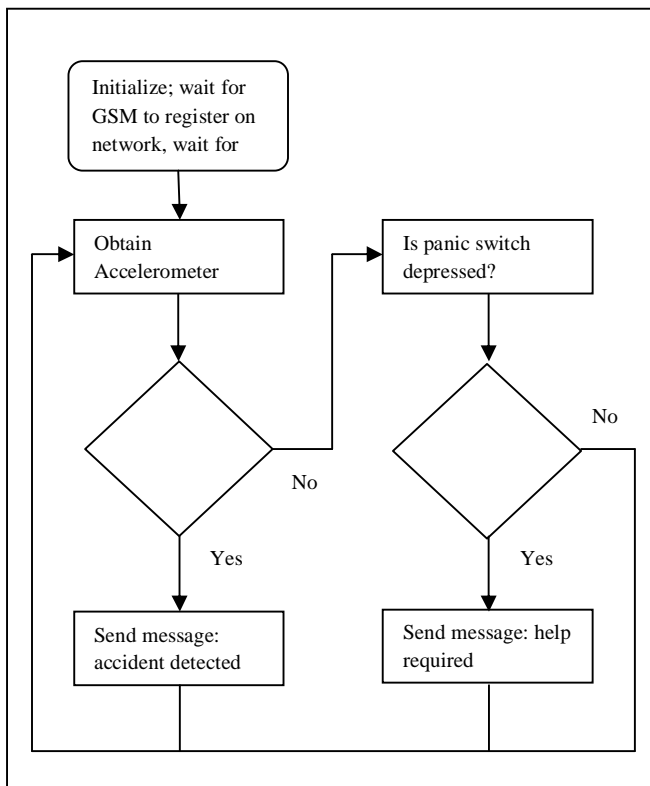The program for the system has been developed using

Fig. 2: program flow chart

assembly language for the 8051 microcontroller. The program flow chart is shown in brief form in *fig.2*.

V.   RESULTS

The results of the system were up to mark. The snap shots of the hardware and various messages shown on the hardware LCD has been shown in *fig3*. This system provides immediate response to those who have been injured during an accident and thus can be used to reduce the fatalities occurring due to delay in medical attention. The system was able to detect collision effectively when tested on a miniature level. As single axis of accelerometer had been used, it failed to detect a side on collision. The panic switch concept worked perfect.

VI.   CONCLUSION AND FUTURE EXPANSION

With GSM connectivity now available almost everywhere in the country (about 7,50,000 cell sites approx in 2012) this system can be used without any infrastructure investment to be made in availing its usefulness. The system can be more effective if legislation is made wherein the system can be allowed to send messages directly to the emergency services rather than the friends or relatives of the occupants, it would be possible to reduce the delay in treatment further. The problem of detecting collision in one axis only is solely due to usage of a single axis of the accelerometer. Monitoring all three axes would lend a definite edge to the system allowing it to detect collision from any direction. Moreover the size of the system has to be reduced as vehicles do have a serious issue of place where they could be securely mounted to the main chassis.
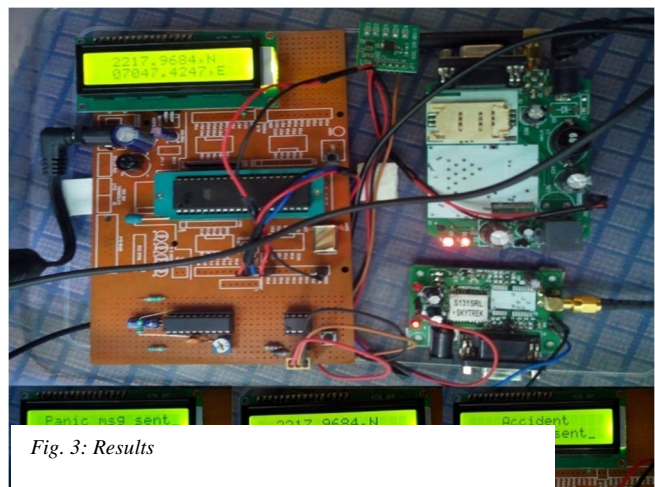

Fig. 3: Results

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