Smart System Sensor Network for Building Monitoring

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Abstract

Analysing the stability of the building is needed in measurement process for all buildings in the cities. Earthquake damage & structural behavior of the building can be monitoring using low power sensor network. This paper describes an applications of wireless sensor network in monitoring and controlling of energy in residential and commercial buildings. In addition to that we are developing fire sensor, gas sensor network to detect and to alert the people who were inside the buildings, alert message to nearby hospitals, ambulances, police stations at the time of emergency cases like earthquake, firing, gas leakage occurring in the building. Accelerometer, vibration sensors are used to monitor and detect the damages occurred in the building. Communication is established between transmitter and receiver base station is through GSM protocol. In this project the receiving base station which consists of mobile phone. Inside the mobile phone the GSM SIM300 is inserted.

Keywords: *Accelerometer sensor, GSM SIM300, Micro electro mechanical system (MEMS), strain sensor.*

I. INTRODUCTION

Now a days due to environmental disorders and man-made hazards building can be subjected to damage during their operational life time due to seismic events, unforeseen foundation settlements. At the same time due to material aging, design error are occurred in tall buildings and high cost buildings and more human lives are lost[1]. This can be avoided by monitoring the buildings periodically and update to the people who wants is the key step to guarantee an adequate level of safety and service ability.

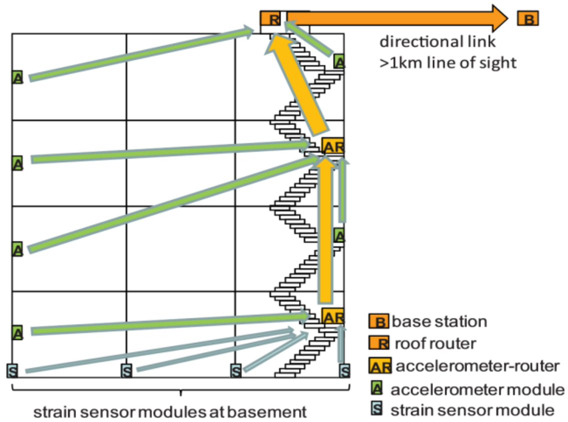

Fig. 1.Network Architecture of the Monitoring System.

To get detailed information about the change in the seismic events [2] possibilities out breaking of fire, gas leakage a separate equipments are essentially needed and they must be installed to the buildings.

Here to detect the earthquake accelerometer and vibration sensor modules are used, to detect the possibilities out breaking of fire and gas leakage, fireand gas sensor modules are installed respectively. To measure settlement and plastic hinge activation after an earthquake the vibration sensors are used at lowest level of the building. 3D accelerometer sensor is placed at each floor of the building to measure horizontal acceleration during an earthquake as shown in fig1. Fire and gas sensors which are placed in each level of the building to detect the smoke and fire that affect the building[3]. LCD module can be placed at the top of the building to show warning messages when smoke and fire rises.

The data from sensor networks is transmit to receiving base station (mobile station) through GSM wirelessly. Inside the mobile station GSM SIM300 is inserted. Main advantage of using SIM300 is more detailed information could be conveyed from the structural behavior as well as the actual condition of the building structure.

II. PROPOSED SYSTEM

Fig2 shows the complete structure of the proposed system. It consists of

- Proposed system
- Sensor architecture
- Wireless system.

A. *Processing System*

A data processing system is a combination of machines, processes and people that for a set of input produces defined set of outputs. The inputs and outputs are interpreted as data, facts, information depending on the interpreter's relation to the system. Here we are make use P89V51RD2 micro-controller to process the information coming from the sensor networks and to produce the output. This output will transmit to mobile station through GSM.

B. *Sensor Architecture*

There are two types of MEMS sensor modules are used to monitor the building structure. Strain (vibration) sensing module and acceleration sensing module. The vibration and accelerometer sensor are combinely called as MEMS sensor[4]. MEMS sensor based specification are as shown in table1.

Accelerometers are available that can measure acceleration in one, two or three orthogonal axes .The main operation principle of accelerometer sensor is the displacements of a small proof mass etched into the silicon surface of the integrated circuit and suspended by small beams consists with Newton's second law of motion (F=ma), as an acceleration is applied to the device, a force develops which displaces the mass. The support beams act as a spring and the fluid (air)trapped inside the IC acts as a damper andresulting in a second order lumped physical system.

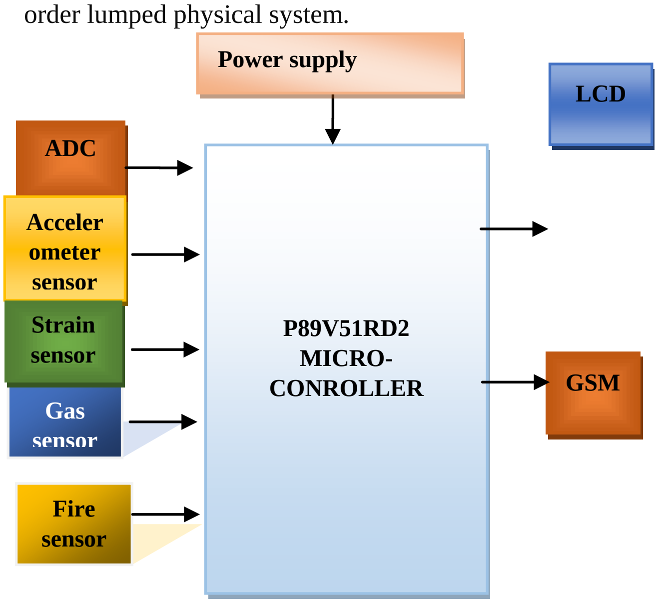

Fig2. Block Diagram of Proposed System.

The accelerometer sensor was fabricated with a surface micro machined process from a SOI wafer system 85µm thick. It has a total sensitivity of 2.02pF/g with 78 fingers. The Z sensor has an area of 2.17mm² per plate. A mainchallenge for the designing of given accelerometer is the sensitivity-bandwidth linearity in all three axes. The data coming out from this sensor is analog in nature, by using ADC the output of accelerometer is converted into digital and converted output is passed to microcontroller.

Parameter	Accelerometer	Strain sensor
Basic Capacitance	20pF (X,Y) 20pF (Z)	5.3pF
Proof mass weight	0.34mgrams (X,Y) 0.5mgrams (Z)	N.A.
Mechanical Sensitivity	0.4-0.06µm/g	3nm/ µε
Electrical Sensitivity	0.23-2.02pF/g (X,Y) 0.38-0.94pF/g (Z)	0.133fF/µε
Resonant Frequency	785-2080Hz (X,Y) 780-1015 (Z)	56 kHz
Pull-in voltage	2.3-5.4V (X,Y) 0.95-1.3V (Z)	N.A.
Finger gap	3µm	4µm

Table 1. Accelerometer and Strain Sensor Specifications.

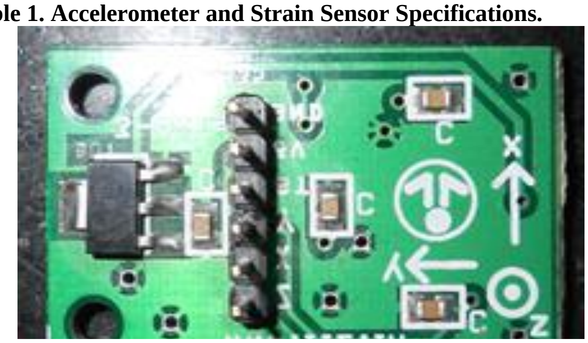

Fig. 3 Accelerometer Sensor.

The strain sensor is a longitudinal combination finger capacitor. It operate on the principle that as the foil is subjected to stress, the resistance of the foil changes in a defined way. The fabrication of strain sensor proceed use of SOI water with a 25µm thick oxide layer with 400 fingersin sensor,50µm thick fingers and500µm thickhand and it has sensitivity of 0.133fF/µC and it can be depicted in fig4.Fire sensor is used to detect fire flames. The module make use of fire sensor and comparator to detect fire up to a range of 1 meters that can be shown in fig5.

Gas sensor can be placed at the each level of the building to measure gas leakage. They are used in gas leakage detecting equipments in family and industry, are suitable for detecting of LPG, natural gas avoid the noise of alcohol and cooking fumes and cigarette smoke. Structure and configuration of MQ-5 gas sensor is shown as Fig6.

Fig4 Stain sensor.

Fig5. Fire sensor

Fig6. Gas sensor.

C. Wireless System

An efficient and greater awareness of the commercial buildings like hotels, schools, hospitals, industries etc… is needed for the people. The sensor network which can sense the natural calamities occurring in the environment and transmits the data wirelessly to nearby base station (Mobile Station) through GSM. A multi-hop network architecture is used in order to form a rebust (forceful) wireless communication link from all sensor modules including strain sensor, fire and gas sensor[5]. A router module can be placed at the roof of the building to forward the data between the sensor networks and the receiver base station. To improve the vertical floor-to-floor propagation it is necessary to place router close to stairwell of the building.

III. HARDWARE DESIGN

Hardware designed kit of building monitoring system is as shown in fig6. Transmitting unit mainly consists of MEMS sensor, fire sensor, gas sensor. Here the accelerometer sensor's data is in analog in nature. Analog signal is converted into digital before the data is loaded to microcontroller with the help of ADC. It is not in-build in P89V51RD2 IC. The GSM and microcontroller are of different logic levels, so we can't directly interface both the devices. In order to interface GSM with microcontroller to establish wireless communication UART is used. Here in our microcontroller the UART is in-build. UART operates in all standard modes, also LCD module is used to display the warning messages.

IV. SOFTWARE REQUIREMENTS

To implement the building monitoring system KeilµVision3, Flash magic softwares are used. The µVision3 IDE is a Windows-based software development platform that combines a robust editor, project manager, and make facility. µVision3 window can be shown in fig7. It integrates all tools including the C compiler, macro µVision3 IDE offers numerous features and advantages that help you quickly and successfully develop embedded applications. They are easy to use and are guaranteed to help you achieve your design goals.

Flash Magic is Windows software that allows easy access to all the ISP features provided by the devices.

Embedded C:When designing software for a smaller embedded system with the 8051, it is very common place to develop the entire product using assembly code. With many projects, this is a feasible approach since the amount of code that must be generated is typically less than 8 kilobytes and is relatively simple in nature. If a hardware engineer is tasked with designing both the hardware and the software, he or she will frequently be tempted to write the software in assembly language.

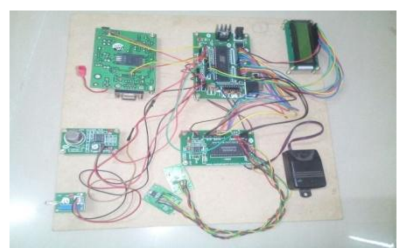

Fig6. Hardware Design Kit.

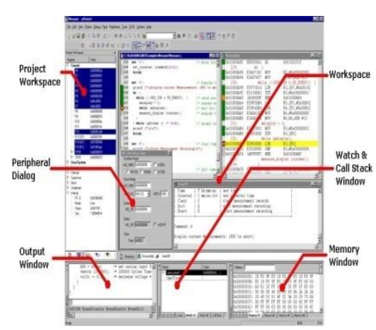

Fig7. KeilµVision3 Window

V. POWER SUPPLY

The input to the circuit is applied from the regulated power supply. The a.c. input i.e., 230V from the mains supply is step down by the transformer to 12V and is fed to a rectifier. The output obtained from the rectifier is a pulsating d.c voltage. So in order to get a pure d.c voltage, the output voltage from the rectifier is fed to a filter to remove any a.c components present even after rectification. Now, this voltage is given to a voltage regulator to obtain a pure constant dc voltage.

VI. RESULTS

To save large number of human lives greater awareness is needed for the people inside the building. So that knowing of actual condition of the building is necessary parameter. This can be achieved by sending text message and voice announcement to the base station through GSM during an emergency cases .Here three parameter can be observed

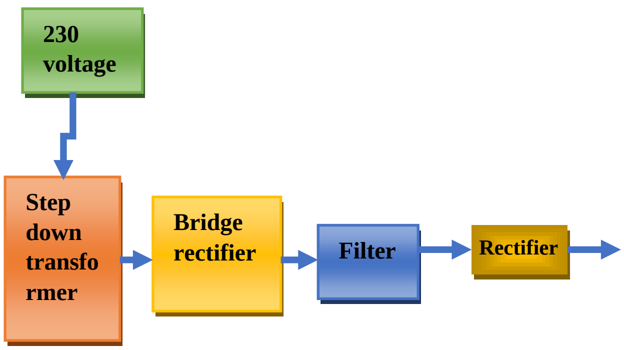

Fig8. Power Supply System.

A. *Earthquake*

Acceleration can be measured by accelerometer sensor, if sensing value is greater than threshold value text message (example " *X=162, *Y=174, $X=170, $Y=164 ") will sent to base station as shown in fig.9a., where *X, *Y be the axes of first accelerometer, $X, $Y be the axes of second accelerometer sensor.

B. *Vibration*

During an earthquake vibrations are measured by strain (vibration) sensor. If the value of vibration is greater than the threshold value text message " VIB" will sent to base station as shown in fig9b.

C. *Fire*

Fire sensor can be placed at each level of the building to detect the fire. When building can subjected to fire the text message "FIRE" is sent to base station as shown in fig9b.

D. *GAS*

Gas sensor can also mounted at each level of the building to detect the gas leakage in the building. Gas sensor sensing value is greater than the threshold valuethe text message "SMOKE " is sent to base station as shown in fig9b.

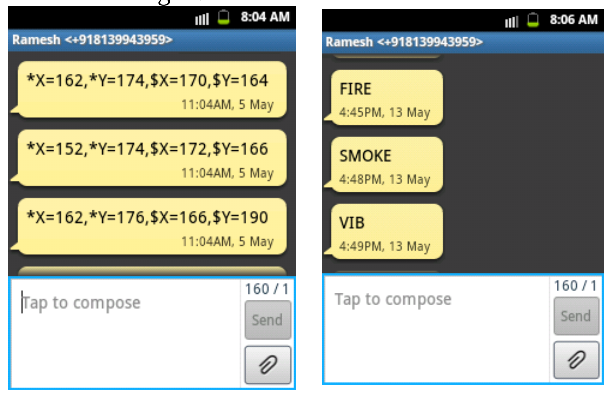

Fig9a. During acceleration, Fig9b. During fire, smoke, vibrations respectively.

VII. CONCLUSION

Building monitoring takes advantage of low power enhanced reconfigurability, more secure data, to realize a solution which offers long battery lifetime and potentially low cost in manufacturing, installation and maintenance, while providing high-quality sensor data at the right time and large number of human lives are saved.

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