ISSN : 2231-0711

P.Ramanathan | International Journal of Computer Science Engineering and Technology( IJCSET) | February 2014 | Vol 4, Issue 2,25-28

# Earthquake Evaluation of Concrete Buildings Using Low Power Wireless Sensor Networks

P.Ramanathan
*Assistant Professor,Achariya College of Engineering Technology,*
*Electronics and Communication Engineering,*
*Pondicherry, India.*

***Abstract* - Analysis of the stability of the building is a needed measurement process for all buildings in the cities. Periodic monitoring of the structure for such damage is therefore a key step in rationally planning of safety and serviceability. However, in order for the installation of a permanently installed sensing system in buildings to be economically viable, the sensor modules must be wireless to reduce installation costs, must operate with a low power consumption to reduce servicing costs of replacing batteries, and use low costs sensors that can be mass produced such as MEMS sensors. . The strain sensors are mounted at the base of the building to measure the settlement and plastic hinge activation of the building after an earthquake. They measure periodically or on-demand from the base station. The accelerometers are mounted at every floor of the building to measure the seismic response of the building during an earthquake. They record during an earthquake event using a combination of the local acceleration data and remote triggering from the base station based on the acceleration data from multiple sensors across the building. Low power network architecture was implemented over an 802.15.4 MAC in the 900-MHz band. A custom patch antenna was designed in this frequency band to obtain robust links in real-world conditions. The modules have been validated in a full-scale laboratory setup with simulated earthquakes.**

***Keywords* - 3-D acceleration sensors, Microelectromechanical systems (MEMS), remote monitoring, structural health monitoring, wireless sensor networks.**

## I. INTRODUCTION

Buildings can progressively damage during their operational lifetime, due to seismic events, unforeseen foundation settlement, material aging, design error, etc. Periodic monitoring of the structure for such damage is therefore a key step in rationally planning the maintenance needed to guarantee an adequate level of safety and service-ability. However, in order for the installation of a permanently installed sensing system in buildings to be economically viable [1].

The sensor modules must be wireless to reduce installation costs, must operate with a low power consumption to reduce servicing costs of replacing batteries, and use low cost sensors that can be mass produced such as MEMS sensors. An embedded system is a computer system with a dedicated function within a larger mechanical or electrical system, often with real-time computing constraints. It is embedded as part of a complete device often including hardware and mechanical parts. By contrast, a general-purpose computer, such as a personal computer (PC) is designed to be flexible and to meet a wide range of end-user needs. Embedded systems control many devices in common use today.

Modern embedded systems are often based on microcontrollers (i.e. CPUs with integrated memory and/or peripheral interfaces) but ordinary microprocessors (using external chips for memory and peripheral interface circuits) are also still common, especially in more complex systems. In either case, he processor (s) used may be types ranging from rather general purpose to very specialized in certain class of computations, or even custom designed for the application at hand. A common standard class of dedicated processors is the digital signal processor (DSP).

The key characteristic, however, is being dedicated to handle a particular task. Since the embedded system is dedicated to specific tasks, design engineers can optimize it to reduce the size and cost of the product and increase the reliability and performance. Some embedded systems are mass-produced, benefiting from economics of scale. Physically, embedded systems range from portable devices such as digital watches and MP3 players, to large stationary installations like traffic lights, factory controllers, and largely complex systems like hybrid vehicles, MRI, and avionics. Complexity varies from low, with single microcontroller chips, to very high with multiple units, peripherals and networks mounted inside a large chassis or enclosure.

## II. SYSTEM ARCHITECTURE

*Network Architecture*

The monitoring system consists of two types of sensor modules: strain sensing modules and acceleration sensing modules. The strain sensor modules are mounted at the lowest level of the building, to estimate the vertical column loads and to measure the settlement and plastic hinge activation of the building after an earthquake. Horizontal acceleration is measured by two 3D acceleration sensing modules (where only the two horizontal axes are really required) at each level during an earthquake, allowing analysis of the seismic response of the whole structure.

A typical 7-story, 24-column building requires approx. 72 strain sensors (3 per column) and 14 accelerometer modules (2 per floor). The data obtained by the sensor system is wirelessly transmitted to a nearby base station using a line of sight link with a range of > 1 km. The line of sight link uses directional antennas to improve the link budget, but not so directional that alignment is required, which could pose a problem during seismic events. The receiver base station can store and process the data or forward them, immediately or later, using classical wide area network connection technology.

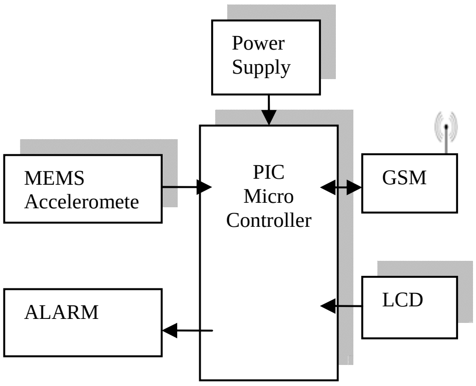
In this way, provided all modules as well as the receiver base station have battery back-up power, the data acquired during seismic events can be properly recorded even in case of outages of the electric power and/or communication networks. In order to form a robust wireless link from all mod- uses, including the strain sensor modules at the basement of the building, towards the receiver base station, a multi- hop network architecture. On the roof of the building a dedicated router module (without sensor) is placed to forward the data between the sensor network and the receiver base station. Some accelerometer modules on intermediate floors can be configured as additional intermediate routers when required to obtain a robust link from all sensor modules in the building towards the roof router module.

It is recommended to place the router modules in or close to the stairwell for improved vertical floor-to-floor propagation through the building. For lowest power consumption in the sensor modules, the network is implemented using indirect data transfer using polling on top of a standard 802.15.4 MAC. In this way, the end nodes' radio is powered down most of the time. Only the routers and base station have their receivers constantly on. To avoid rapid battery depletion, the modules with router functionality are mains-powered through an AC/DC adapter, with the battery serving only for back-up power in case mains power is interrupted. The end nodes (i.e. the large majority of installed sensor modules) are powered exclusively by their battery.

## III. Proposed System

In this project we have MEMS accelerometer to sense the shaking of the building which in sends to the microcontroller which in turn sends to the monitoring section through GSM wireless technology.

*Transmitting Section*:




*Receiving Section:*

Users 1:

Users 2:

Here we have three sections; the floor section has PIC microcontroller, GSM device and MEMS accelerometer. The monitoring section has PC and a GSM wireless device, which will collect the data from the floor sections and analyze the stability of the building.

### *A. PIC 16F877A Microcontroller Unit*

The PIC16F877 is one of the latest products from Microchip. It features all the components which modern microcontrollers normally have. For its low price, wide range of application, high quality and easy availability, it is an ideal solution in applications such as: the control of different processes in industry, machine control devices, measurement of different values etc. As seen in figure the most pins are multi-functional.

For example, designator RA3/AN3/Vref+/C1IN+ for the fifth pin specifies the following functions:

- RA3 Port A third digital input/output
- AN3 Third analog input
- Vref+ Positive voltage reference
- C1IN+ Comparator C1positive input

This small trick is often used because it makes the microcontroller package more compact without affecting its functionality. These various pin functions cannot be used simultaneously, but can be changed at any point during operation. The following tables refer to the PDIP 40 microcontroller.

### *B.MEMS Sensors*

Micro Electro Mechanical Systems or MEMS is a term coined around 1989. However others to describe an emerging research field, where mechanical elements, like cantilevers or membranes, had been manufactured at a scale more akin to microelectronics circuit than to lathe machining. It appears that these devices share the presence of features below

100_m that are not machined using standard machining but using other techniques globally called micro-fabrication Technology. Of course, this simple definition would also include microelectronics, but there is a characteristic that electronic circuits do not share with MEMS. While electronic circuits are inherently solid and compact structures, MEMS have holes, cavity, channels, cantilevers, membranes, etc, and, in some way, imitate 'mechanical' parts.

The emphasis on MEMS based on silicon is clearly a result of the vast knowledge on silicon material and on silicon based micro fabrication gained by decades of research in microelectronics. And again, even when MEMS are based on silicon, microelectronics process needs to be adapted to cater for thicker layer deposition, deeper etching and to introduce special steps to free the mechanical structures. MEMS needs a completely different set of mind, where next to electronics, mechanical and material knowledge plays a fundamental role. Then, many more MEMS are not based on silicon and can be manufactured in polymer, in glass, in quartz or even in metals.

The development of a MEMS component has a cost that should not be misevaluated and the technology has the possibility to bring unique benefits. Packard, but they also include the growing bio MEMS market with micro analysis system like the capillary electrophoresis system from Agilent or the DNA chips. RF (radio frequency) MEMS is also emerging as viable MEMS market.

Next to passive components like high-Q inductors produced on the IC surface to replace the hybridized component as proposed by company MEMSCAP we find RF switches and soon micromechanical filters. But the list does not end here and we can find micro machined relays (MMR) produced for example by Omron, HDD (hard disk drive) read/write head and actuator or even toys, like the autonomous micro-robot EMROS produced by EPSON.

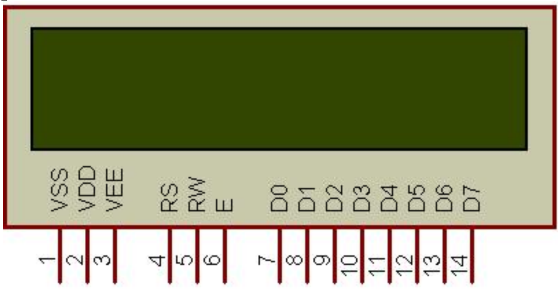
The MEMS accelerometer consists of 2 transverse comb finger structures for the X and Y axis and a pendulating one for the Z axis and was fabricated with a surface micro-machined process from a 85 $\mu$m thick SOI wafer. It has 78 fingers with a total sensitivity of 2.02 pF/g. The Z sensor has an area of 2.17 $mm^2$ per plate. Innovative cap through connections were used. The main tradeoff in the design of the accelerometer is the sensitivity-bandwidth-linearity in all three axes, a challenge for the design given the different used structures.

The XY and Z accelerometers are packaged together with the readout ASIC into a system-in-a-package and then mounted onto the printed circuit board. The MEMS strain sensor is a longitudinal comb finger capacitor. The strain sensor fabrication procedure starts with a SOI wafer with a 500 $\mu$m thick handle, 50 $\mu$m thick fingers and 2 $\mu$m thick oxide layer with 400 fingers in the sensor and it has a sensitivity of 0.133 fF/$\mu\varepsilon$. Two anchors were etched- out of the surface to create the necessary clamps to attach the sensor to the rebar of a pillar.

The fingers are protected with a borosilicate class cap. The use of custom-developed MEMS sensors and read-out ASIC allows to meet the specific requirements of the building monitoring application and differentiates the presented systems.

***C. LCD***

The most commonly used Character based LCDs are based on Hitachi's HD44780 controller or other which are compatible with HD44580.




In this tutorial, we will discuss about character based LCDs, their interfacing with various microcontrollers, various interfaces (8-bit/4-bit), programming, special stuff and tricks you can do with these simple looking LCDs which can give a new look to your application Most LCDs with 1 controller has 14 Pins and LCDs with 2 controller has 16 Pins (two pins are extra in both for back-light LED connections).

Usually these days we will find single controller LCD modules are used more in the market. So we will discuss more about the single controller LCD, the operation and everything else is same for the double controller too. Let's take a look at the basic information which is there in every LCD.

***D. GSM***

GSM stands for Global System for Mobile Communication and is an open, digital cellular technology used for transmitting mobile voice and data services. The GSM emerged from the idea of cell-based mobile radio systems at Bell Laboratories in the early 1970s. The GSM is the name of a standardization group established in 1982 to create a common European mobile telephone standard. The GSM standard is the most widely accepted standard and is implemented globally. The GSM is a circuit-switched system that divides each 200 kHz channel into eight 25 kHz time-slots. GSM operates in the 900MHz and 1.8GHz bands in Europe and the 1.9GHz and 850MHz bands in the US.

GSM owns a market share of more than 70 percent of the world's digital cellular subscribers. The GSM makes use of narrowband Time Division Multiple Access (TDMA) technique for transmitting signals. The GSM was developed using digital technology. It has an ability to carry 64 kbps to 120 Mbps of data rates. Presently GSM support more than one billion mobile subscribers in more than 210 countries throughout of the world.

The GSM provides basic to advanced voice and data services including Roaming service. Roaming is the ability to use your GSM phone number in another GSM network. A GSM digitizes and compresses data, then sends it down through a channel with two other streams of user data, each in its own time slot. It operates at either the 900 MHz or 1,800 MHz frequency band.

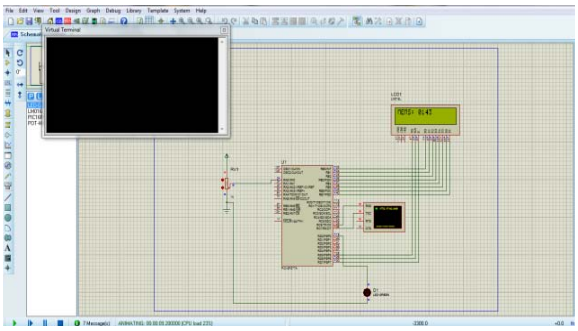
## IV. RESULTS

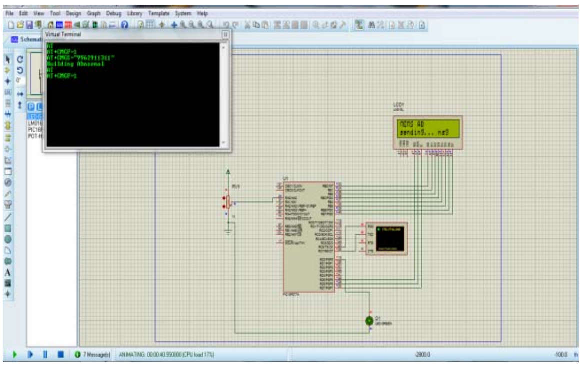
For estimating building condition using GSM and GPS are given below. Using Proteus Design Suite, the simulation results of SMS based physiological parameters Monitoring System is given below:

After getting result in Proteus Design Suite, the execution process is going to done. While executing, we will get the normal values for building condition. It can be displayed in LCD.

*Building Condition Abnormal*

If the building condition is abnormal, LCD display shows that the “MEMS AB sending….. message” i.e., it sends Building abnormal to send the message in phone number or (users) using GSM.





## V. CONCLUSION

The presented wireless system for building monitoring takes advantage of the unique features of custom-developed MEMS sensors and read-out ASIC combined with an optimized network and module architecture, 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.

## REFERENCES

[1] M. Piozzi, D. Zonta, W.Wang, and G. Chen, “A framework for evaluating the impact of structural health monitoring on bridge management,” in *Proc. 5th Int. Conf. Bridge Maintenance, Safety Manage.*, Philadelphia, PA, Jul. 2010, p. 161.

[2] J. P. Lynch and K. J. Loh, “A summary review of wireless sensors and sensor networks for structural health monitoring,” *Shock Vibrat. Dig.*, vol. 38, no. 2, pp. 91–128, 2006.

[3] D. Zonta, M. Pozzi, and P. Zanon, “Managing the historical heritage using distributed technologies,” *Int. J. Arch. Heritage*, vol. 2, no. 3, pp. 200–225, 2008.

[4] M. Kruger, C. U. Grosse, and P. J. Marron, “Wireless structural health monitoring using MEMS,” *Key Eng. Mater.*, vols. 293–294, pp. 625–634, Sep. 2005.

[5] A. Amditis, Y. Stratakos, D. Bairaktaris, M. Bimpas, S. Camarinopolos, and S. Frondistou-Yannas, “Wireless sensor network for seismic evaluation of concrete buildings,” in *Proc. 5th Eur. Workshop Struct. Health Monitor.*, Sorrento, Italy, Jun.–Jul. 2010.

[6] J. Santana, R. van den Hoven, C. van Liempd, M. Colin, N. Saillen, and C. Van Hoof, “A 3-axis accelerometer and strain sensor system for building integrity monitoring,” in *Proc. 16th Int. Conf. Solid-State Sensors, Actuat., Microsyst.*, Beijing, China, Jun. 2011, pp. 36–39.

[7] A. Amditis, Y. Stratakos, D. Bairaktaris, M. Bimpas, S. Camarinopolos, and S. Frondistou-Yannas, “An overview of MEMSCON project: An intelligent wireless sensor network for after-earthquake evaluation of concrete buildings,” in *Proc. 14th Eur. Conf. Earthquake Eng.*, Aug.–Sep. 2010.

[8] D. Trapani, D. Zonta, F. Larcher, A. Amditis, N. Bertsch, M. Bimpas, A. Garetsos, N. Saillen, J. Santana, T. Sterken, Y. Stratakos, T. Torfs, and D. Ulieru, “Laboratory validation of MEMS-based sensors for postearthquake damage assessment,” in *Proc. 8th Int. Workshop Struct. Health Monitor.*, Stanford, CA, Sep. 2011, pp. 2165–2172

.