

Analysis of MEMS-based sensors for building integrity monitoring

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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 the maintenance needed to guarantee an adequate level 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 cost sensors that can be mass produced such as MEMS sensors. In this work MEMS accelerometer is used to sense the shaking of the building which in sends message signal to the microcontroller which in turn sends to the receiver section through RF wireless technology. Here there are three sections, the two floor sections has PIC microcontroller, RF device and MEMS accelerometer. The monitoring section has PC and GSM module, which collect the data from the floor sections and analyze the stability of the building. RF receiver collect the data from the floor sections and transfer the information to the PIC 16F877A microcontroller which is used to analyze the stability of the building by comparing it with the normal stable readings. USB Controller displays the security sounds and provide the

storage capacity and offers both asynchronous and isochronous (real-time) data transmission over a simple and inexpensive 4-wire cable. The receiver section immediately sends the warning message to the respective numbers already stored in the microcontroller by means of GSM technique.

Keywords: Analog to Digital converters (ADCs), Micro electromechanical systems (MEMS), inertial measurement unit (IMU).

INTRODUCTION

A wireless sensor network is a collection of nodes organized in a network. Each node consists of one or more microcontrollers, CPUs or DSP chips, a memory and a RF transceiver, a power source such as batteries and accommodates various sensors and actuators. The nodes communicate wirelessly and often self-organize after being deployed in an ad hoc fashion. Sensing units are usually composed of two subunits: sensors and analog to digital converters (ADCs). The analog signals produced by the sensors are converted to digital signals by the ADC, and then fed into the processing unit. The processing unit which is generally associated with a small storage unit manages the procedures that make the sensor nodes collaborate with the

other nodes to carry out the assigned sensing tasks. A transceiver unit connects the nodes to the networks. One of the most important components of a sensor node is the power unit. Power units may be supported by a power scanning unit such as solar cells. Sensor nodes can be imagined as small computers, extremely basic in terms of their interfaces and their components. They usually consist of a processing unit with limited computational power and limited memory, sensors (including specific conditioning circuitry), a communication device (usually radio transceivers or alternatively optical), and a power source usually in the form of a battery. Other possible inclusions are energy harvesting modules, secondary ASICs, and possibly secondary communication devices (e.g. RS-232 or USB). The base stations are one or more distinguished components of the WSN with much more computational, energy and communication resources. They act as a gateway between sensor nodes and the end user.

LITERATURE SURVEY

A. Amditis et al (2010) proposed wireless sensor network technology has enabled the wide spread adoption of structural health monitoring techniques for integration into bridge management systems. Definitive in-service diagnostics and prognostics from distributed vibration measurements have remained elusive largely to the lack of a large-scale database of real-world case studies encompassing the many design types and details of the nation's extensive highway network. Enabling technologies with immediate benefit, such as strain-based sensor networks for periodic load rating, could transition the infrastructure to a state of quantitative condition-based assessment while delivering the database history necessary to facilitate continuous diagnostic and prognostic routines. The WSSS provides an adaptive,

field demonstrated approach for in-service monitoring of highway infrastructure through offering a concurrent platform for strain-based as well as vibration-based real-time wireless monitoring. A. Amditis et al (2010) proposed the use of PEM and COB technology, for recent military applications has been and shall remain application specific, until military specifications and standards can fully address reliability and manufacturing concerns. The requirement for environmental testing (including HAST) is and will remain critical to the successful development, screening and implementation of PEM and COB technologies into military electronic equipment and systems. M. Pozzi et al (2010) proposed an Onboard computer which is commonly termed as microcontroller. This onboard computer can efficiently communicate with the different sensors being used. The controller is provided with some internal memory to hold the code. This memory is used to dump some set of assembly instructions into the controller. Antobennet et al., proposed an important aspect of the design was miniaturization, so that the system was as nonintrusive as possible to the wearer. This was achieved by the use of surface-mounted devices on the PCBs designed. Low-power operational amplifiers were used to minimize battery consumption. The major cost comes from the use of ZigBee modules in the current design. With some modification, the system can be made available commercially. Future improvements will focus on the use of flexible PCBs to replace the stiff cards, so that it could be molded around the wrist unit, making it more comfortable for the wearer. The inertial measurement unit (IMU), which senses the acceleration and angular velocity, is traditionally applied in the inertial navigation system for aircraft and automobile. In those applications, the kinetic parameters are measured and then

computed to obtain the positions and angles of the vehicle.

PROPOSED METHOD

In this work MEMS Accelerometers are acceleration sensors. An inertial mass suspended by springs is acted upon by acceleration forces that cause the mass to be deflected from its initial position. This deflection is converted to an electrical signal, which appears at the sensor output. The variation that occurs in the 3D MEMS sensor is collected by means of RF transmitter and send it to the receiver section. RF receiver collect the data from the floor sections and transfer the information to the PIC 16F877A microcontroller which is used to analyze the stability of the building by comparing it with the normal stable readings. The PIC architecture was among the first scalar CPU designs, and is still among the simplest and cheapest. The PIC instruction set is suited to implementation of fastlookup tables in the program space. The MEMS and RF circuits are controlled remotely using a 40-pin MicroChip 16F877A microcontroller at the receiver station that receives commands via RS232 and translates them into hardware control logic. The microcontroller connections to the modules that it controls in the switching center. It customize the building security such as closing and opening the doors. USB Controller allow circuit to interface with a PC for downloading files to the Compact Flash card at slow speeds. It uses RX/TX pins from serial interface on PIC. USB Controller displays the security sounds and provide the storage capacity and offers both asynchronous and isochronous (real-time) data transmission over a simple and inexpensive 4-wire cable. The variation in the MEMS sensor is identified by using LCD with 2 lines and 16 characters per line, this

gets data from the microcontroller and displays the same. It has 8 data lines, 3 control line, a supply voltage V_{cc} (+5v and a GND). GSM digitizes and compresses data, then sends it down a channel with two other streams of user data, each in its own time slot. It operates at either the 900 or 1800 MHz frequency band. GSM also pioneered a low-cost alternative to voice calls, by sending short message service. The SIM is a detachable smart card containing the user's subscription information. The receiver section immediately sends the warning message to the respective numbers already stored in the microcontroller by means of GSM technique.

Working of RF Communication

Consider an RF transmitter that is wiggling an electron in one location. This wiggling electron causes a ripple effect, somewhat akin to dropping a pebble in a pond. The effect is an electromagnetic (EM) wave that travels out from the initial location resulting in electrons wiggling in remote locations. An RF receiver can detect this remote electron wiggling. The RF communication system then utilizes this phenomenon by wiggling electrons in a specific pattern to represent information. The receiver can make this same information available at a remote location; communicating with no wires. In most wireless systems, a designer has two overriding constraints: it must operate over a certain distance (range) and transfer a certain amount of information within a time frame (data rate). Then the economics of the system must work out (price) along with acquiring government agency approvals (regulations and licensing) shown in figure 1&2.

Regulations and Licensing

The Federal Communications Commission (FCC) and other regulatory bodies around the world have set up a series of regulations defining the emission levels and usage for all the different frequencies. Digi radios operate within the Industrial, Scientific and Medical (ISM) bands that offer license free operation within certain frequencies. Within the United States, the most popular ISM band are at 902-928 MHz and 2.4 – 2.4835 GHz. Portions of the 902-928 MHz band are also available in Canada, Mexico, Australia and Israel. The 2.4 GHz band is generally more accepted worldwide. certain power levels some regulatory agencies require some form of spread spectrum. Spread spectrum can either be done by frequency hopping or by direct sequence. Frequency hopping consists of rapidly moving from one channel to the next while maintaining synchronization with the receiver. Direct Sequence is more complex, but works by slicing the carrier up with a code that can be decoded at the other end. Digi radios use frequency hopping as its method of spread spectrum.

RF Communications And Data Rate

Data rates are usually dictated by the system - how much data must be transferred and how often does the transfer need to take place. Lower data rates, allow the radio module to have better receive sensitivity and thus more range. In the XStream modules the 9600 baud module has 3dB more sensitivity than the 19200 baud module. This means about 30% more distance in line-of-sight conditions. Higher data rates allow the communication to take place in less time, potentially using more power to transmit.

TRANSMITTER SECTION

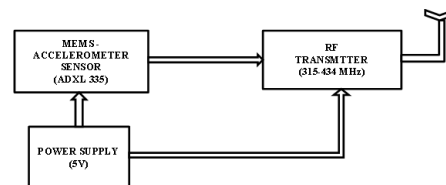


Fig 1 :Transmitter Section

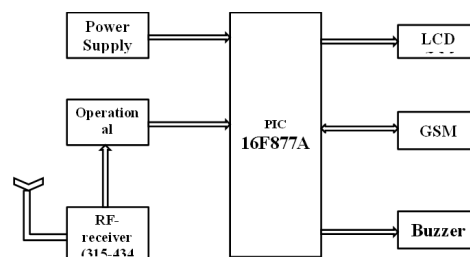


Fig 2. Receiver Section

Operational Amplifier is probably the most versatile Integrated Circuit available. It is very cheap since it contains several hundred components. The most common Op-Amp is the 741 and it is used in many circuits. Its main purpose is to amplify (increase) a weak signal - a little like a Darlington Pair. The OP-AMP has two inputs, inverting (-) and non-inverting (+), and one output at pin 6 shown in Fig 3.



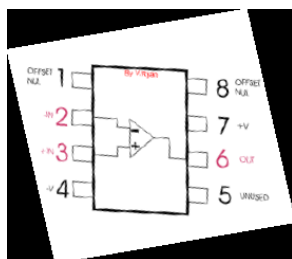


Fig 3. IC 741 Operational Amplifier

The chip can be used in a circuit in two ways. If the voltage goes into pin two then it is known as an inverting amplifier. If the voltage goes into pin three then the circuit becomes a non-inverting amplifier. The 741 integrated circuit looks like any other 'chip'. However, it is a general purpose OP-AMP. The diagram opposite shows the pins of the 741 OP-AMP. The important pins are 2, 3 and 6 because these represent inverting, non-inverting and voltage out.

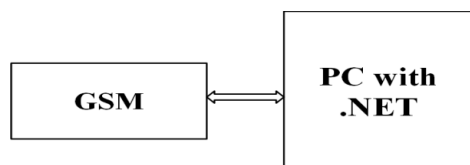


Fig 4. Monitoring Section

Global System for Mobile communications (GSM: originally from Group Spécial Mobile) is the most popular standard for mobile phones in the world. Its promoter, the GSM Association, estimates that 82% of the global mobile market uses the standard GSM is used by over 2 billion people across more than 212 countries and territories. It makes international roaming very common between mobile phone operators, enabling subscribers to use their phones in many parts of the world. GSM differs from its predecessors in that both signaling and speech channels are digital call quality, and thus is considered a second generation (2G) mobile phone system. This has also meant that data communication was built into the

system using the 3rd Generation Partnership Project (3GPP) shown in fig 4.

MEMS-Based Sensor

Micro electromechanical systems (MEMS) are Freescale's enabling technology for acceleration and pressure sensors. MEMSbased sensor products provide an interface that can sense, process and/or control the surrounding environment. Freescale's MEMS-based sensors are a class of devices that builds very small electrical and mechanical components on a single chip. MEMS-based sensors are a crucial component in automotive electronics, medical equipment, hard disk drives, computer peripherals, wireless devices and smart portable electronics such as cell phones and PDAs shown in fig 5.

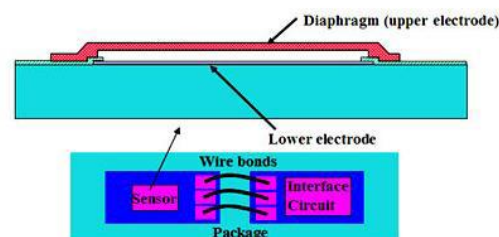


Fig 5. MEMS Fabrication

EXPERIMENTAL RESULTS

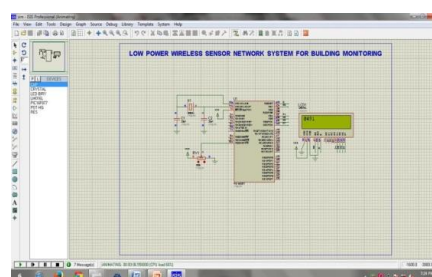


Fig:6.Low power wireless

Sensor networking for Building Monitoring

The Simulation output is shown in Fig 6. describes that there is any variation made in the potentiometer it will reflects on the LCD. In real time embedded systems, potentiometer can be replaced by means of 3D MEMS sensors.

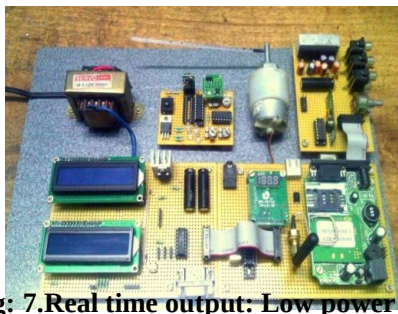


Fig: 7. Real time output: Low power wireless Sensor networking for Building Monitoring

The mismatching takes place in 3D MEMS sensor means, immediately the LCD displays the warning message as shown in Fig 4. With the help of DTMF decoder the doors in that particular buildings automatically gets opened. The Buzzer produces the warning sound which is fitted in the building. Thus by means of GSM the warning message and call is sending to the owner of the building, fire station and ambulance shown in fig 7.

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. It is checked by

means of stimulation software and will implement by using MEMS sensors. The system provides the immediate response gets checked by means of Proteus 7 Professional software as shown in the Fig 4.1 using potentiometer instead of 3D MEMS sensor. The coding process is done by using MPLAB IDE v8.76 and compilation by using HITECH C compiler. The variation sensed by means of MEMS sensor is given to the microcontroller, it compares with the idle values, if there is mismatching occurs means immediately the LCD displays the warning message. With the help of DTMF decoder the doors in that particular buildings automatically gets opened. The Buzzer produces the warning sound which is fitted in the building. Thus by means of GSM the warning message and call is send to the owner of the building, fire station and ambulance. The future scope of the project is to install the fire sensor with automatic water sprayer, if any fire accidents takes place in the buildings due to change in the dimension of the buildings, material damaging and material aging, the Carbon Tetra Chloride gas in the cylinder is automatically discharged. Therefore the fire accidents can be controlled in the initial stage itself. And implementing in the buildings of hill stations, because large amount of earth quakes and soil erosion are occur. Hope this additional feature will prevent the loss of death and reduce the loss of resource happens during both natural and artificial type of disasters.

REFERENCES

- 1 Amditis, A. Stratakis, Y. Bairaktaris, M. Bimpas, D. Camarinopoulos, S. and Frondistou-Yannas, S. (2010) 'Wireless sensor network for seismic evaluation of concrete buildings', in Proc. 5th Eur. Workshop Struct. Health Monitor, Sorrento, Italy., Vol.

- 2, No. 3, pp. 85–108.
- 2 Amditis, A. Stratakis, Y. Bairaktaris, D. Bimpas, M. Camarinopoulos, S. and Frondistou-Yannas, S. (2010) ‘An overview of MEMSCON project: An intelligent wireless sensor network for after-earthquake evaluation of concrete buildings’, in Proc. 14th Eur. Conf. Earthquake Eng., vol. 7, no. 1, pp. 36–39.
 - 3 Pozzi, M. Zonta, D. Wang, W. and Chen, G. (2010) ‘A framework for evaluating the impact of structural health monitoring on bridge management,’ in Proc. 5th Int. Conf. Bridge Maintenance, Safety Manage., Philadelphia, PA, Vol. 3, No. 1, pp. 161.
 - 4 Dr. Anto Bennet, M, Sankaranarayanan S, Ashokram S, Dinesh Kumar T R, “Testing of Error Containment Capability in can Network”, International Journal of Applied Engineering Research, Volume 9, Number 19 (2014) pp. 6045-6054.
 - 5 Dr. Anto Bennet, M, Sankar Babu G, Natarajan S, “Reverse Room Techniques for Irreversible Data Hiding”, Journal of Chemical and Pharmaceutical Sciences 08(03): 469-475, September 2015.
 - 6 Dr. Anto Bennet, M, Sankaranarayanan S, Sankar Babu G, “ Performance & Analysis of Effective Iris Recognition System Using Independent Component Analysis”, Journal of Chemical and Pharmaceutical Sciences 08(03): 571-576, August 2015.

