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Building Stability Monitoring System using WSN

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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. 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.***

Keywords— WSN (Wireless Sensor Network), Microelectromechanical System (MEMS), Remote Monitoring

I. INTRODUCTION

The MEMS accelerometer to sense the shaking of the building which in sends to the microcontroller which in turn sends to the monitoring section through ZigBee wireless technology. Here we have three sections, the two floor sections has PIC microcontroller, ZigBee device and MEMS accelerometer. The monitoring section has PC and a ZigBee wireless device, which will collect the data from the floor sections and analyse the stability of the building. If the earthquake level is high, buzzer will make sound for alerting.

II. SYSTEM ARCHITECTURE

The monitoring system consists of two types of sensor modules: strain sensing modules and acceleration sensing modules. They are placed in the building. 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).

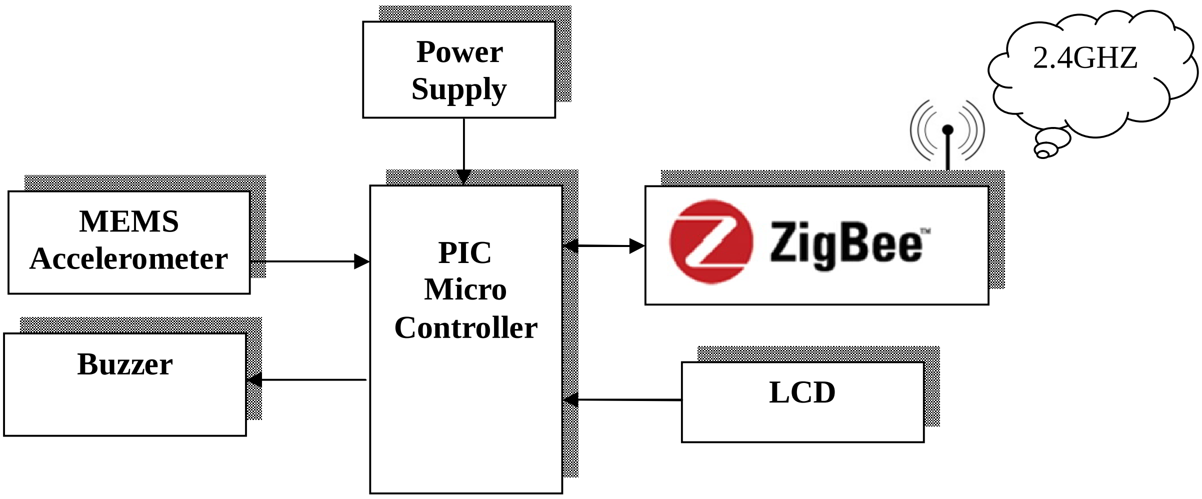

Fig.1 System Architecture

A. MEMS Accelerometer

An accelerometer is a device that measures proper acceleration. The proper acceleration measured by an accelerometer is not necessarily the coordinate acceleration (rate of change of velocity). Instead, the accelerometer sees the acceleration associated with the phenomenon of weight experienced by any test mass at rest in the frame of reference of the accelerometer device. For example, an accelerometer at rest on the surface of the earth will measure an acceleration g= 9.81 m/s2 straight upwards, due to its weight. By contrast, accelerometers in free fall or at rest in outer space will measure zero. Another term for the type of acceleration that accelerometers can measure is g-force acceleration.

Accelerometers have multiple applications in industry and science. Highly sensitive accelerometers are components of inertial navigation systems for aircraft and missiles. Accelerometers are used to detect and monitor vibration in rotating machinery. Accelerometers are used in tablet computers and digital cameras so that images on screens are always displayed upright. Single- and multi-axis models of accelerometer are available to detect magnitude and direction of the proper acceleration (or g-force), as a vector quantity, and can be used to sense orientation (because direction of weight changes), coordinate acceleration (so long as it produces g-force or a change in g-force), vibration, shock, and falling in a resistive medium (a case where the proper acceleration changes, since it starts at zero, then increases). Micro machined accelerometers are increasingly present in portable electronic devices and video game controllers, to detect the position of the device or provide for game input.

Pairs of accelerometers extended over a region of space can be used to detect differences (gradients) in the proper accelerations of frames of references associated with those points. These devices are called gravity gradiometers, as they measure gradients in the gravitational field. Such pairs of accelerometers in theory may also be able to detect gravitational waves.

An accelerometer measures proper acceleration, which is the acceleration it experiences relative to freefall and is the acceleration felt by people and objects. Put another way, at any point in space time the equivalence principle guarantees the existence of a local inertial frame, and an accelerometer measures the acceleration relative to that frame. Such accelerations are popularly measured in terms of g-force.

An accelerometer at rest relative to the Earth's surface will indicate approximately 1 g upwards, because any point on the Earth's surface is accelerating upwards relative to the local inertial frame (the frame of a freely falling object near the surface). To obtain the acceleration due to motion with respect to the Earth, this "gravity offset" must be subtracted and corrections for effects caused by the Earth's rotation relative to the inertial frame.

B. Strain Sensing Module

The MEMS strain sensor is packaged together with the readout ASIC into a special front-end strain sensing module which is embedded inside the reinforced concrete onto the reinforcing bar, preferably prior to the pouring of the concrete. the sensor is mounted on a polyimide carrier which in turn is glued onto the reinforcing bar. A variant of this package exists in which the carrier is thin steel, which offers the additional possibility for welding the carrier to the reinforcing bar. The module is moulded in PDMS silicone to protect the components from the environment during installation and pouring of concrete, while remaining a mechanically compliant package to avoid distorting the strain

C. Measurement Initiation in Accelerometer

The main trigger for the recording of an acceleration measurement is the detection of the start of an earthquake. The detection is done using a distributed earthquake detection mechanism. When the output of the built-in accelerometer in a selected number of monitoring nodes exceeds a certain minimum threshold, during a certain minimum time, these monitoring nodes provide alerts to the base station. The base station software will decide based on the number of monitoring nodes providing alerts whether to wake up the entire network of acceleration sensing nodes over the radio the monitoring nodes are selected based on their location and amount of environmental noise. Ground level nodes may be suitable candidates, provided they are sufficiently far removed from disturbance sources such as heavy traffic. The selection of monitoring nodes can be done dynamically from the base station. This allows for example to disable the monitoring function on nodes that report unusually high numbers of false alarms. To that purpose, the hardware and software of the monitoring nodes are identical to that of the non-monitoring nodes. The monitoring function is an optional function which can be enabled or disabled during operation by the base station. After the nodes have been woken up the recorded data is read out by the base station which sequentially requests the data of each sensor module.

D. Measurement Initiation in Strain sensing module

The main measurement scenario for the strain sensor is a periodic readout. Samples are taken at a configurable sample rate between 10 seconds and 18 hours. The strain sensor modules use a radio polling interval of 60 seconds. This also allows manual wake-up functionality from the base station, again useful for monitoring and testability reasons. Unlike for the accelerometers, in the case of the strain sensors the sensor and read-out ASIC can be entirely shut down between measurements. This results in a lower power consumption and longer battery life. Since a typical building requires many more strain sensors than accelerometer modules, it is useful for the strain sensors to have the longest battery service life.

E. Buzzer

A buzzer device or system of alarm devices gives an audible or visual alarm signal about a problem or condition.

Fig.2. Buzzer Alarm

Alarm devices include:

Burglar alarms, designed to warn of burglaries; this is often a silent alarm: the police or guards are warned without indication to the burglar, which increases the chances of catching him or her. alarm clocks can produce an alarm at a given time distributed control manufacturing systems or DCSs, found in nuclear power plants, refineries and chemical facilities also generate alarms to direct the operator's attention to an important event that he or she needs to address. Alarm in an operation and maintenance (O&M) monitoring system, which informs the bad working state of (a particular part of) the system under monitoring. First-out alarm safety alarms, which go off if a dangerous condition occurs. Common public safety alarms include: tornado sirens fire alarms "Multiple-alarm fire", a locally-specific measure of the severity of a fire and the fire-department reaction required. car alarms community Alarm or auto dialer alarm (medical alarms) air raid sirens personal alarm tocsins — a historical method of raising an alarm Alarms have the capability of causing a fight-or-flight response in humans; a person under this mindset will panic and either flee the perceived danger or attempt to eliminate it, often ignoring rational thought in either case. We can characterise a person in such a state as "alarmed". With any kind of alarm, the need exists to balance between on the one hand the danger of false alarms (called "false positives") — the signal going off in the absence of a problem — and on the other hand failing to signal an actual problem (called a "false negative"). False alarms can waste resources expensively and can even be dangerous. For example, false alarms of a fire can waste firefighter manpower, making them unavailable for a real fire, and risk injury to firefighters and others as the fire engines race to the alleged fire's location. In addition, false alarms may acclimatise people to ignore alarm signals, and thus possibly to ignore an actual emergency

III. RESULTS

A. Power Consumption

Fig. 3(a) and (b) shows the measured power consumption in the sensor modules for strain sensor and accelerometer modules and how it is broken down according to the different components of the system. The total average power consumption is 0.274 mW for the strain sensor modules and 1.73 mW for the accelerometer modules. With the above mentioned C-cell size battery this implies a battery life of 12 years for the strain sensor modules application. Otherwise the signals correlate well. However, the most interesting result for the monitoring application and 2 years for the accelerometer modules.

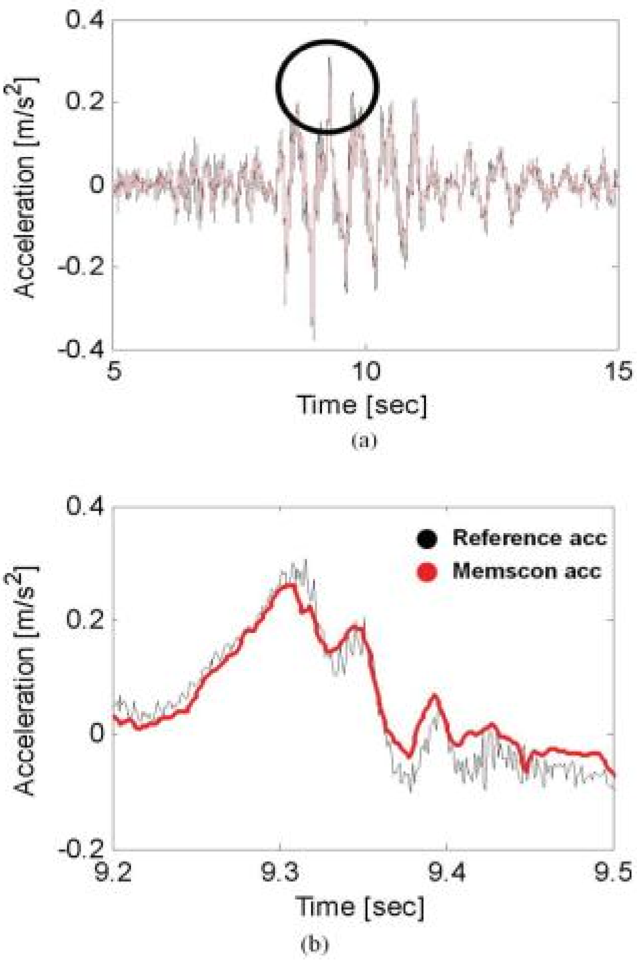

Fig 3(a) Wireless sensor module acceleration signal output. (b) Enlargement of the peak

Compared to the reference signal, the signal from the wireless accelerometer modules is smoother due to the low pass filtering post-processing at 25 Hz that has been performed in the data acquisition software in this case, as required by the building monitoring application. Otherwise the signals correlate well. However, the most interesting result for the monitoring application is the comparison of the calculated displacement through double integration of the acceleration signals to the actual displacement applied from the actuator. As can be seen in Fig.3 (a), the calculated displacements from the measurements of the wireless acceleration sensor modules correspond very well to the actual displacement. The strain sensor front-end modules have been validated in the laboratory in a specially constructed calibration setup in which a known strain is applied to the module and its output is recorded.

IV. 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.

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