HIGH RISE BUILDING ALERT SYSTEM

CHIN XIN YAN

This report is submitted in partial fulfillment of the requirement for the Bachelor Degree of Electronic Engineering (Industrial Electronics) with Honours

Faculty of Electronic and Computer Engineering
Universiti Teknikal Malaysia Melaka

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Tajuk Projek : **HIGH RISE BUILDING ALERT SYSTEM**

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Prof. Madya Tan Kim See
Fakulti Kejuruteraan Elektronik Dan Kejuruteraan Komputer
Universiti Teknikal Malaysia Melaka (UTeM)
Karung Berkunci No 1752
Pejabat Pos Durian Tunggal
76109 Durian Tunggal, Melaka.

Tarikh: 11/6/2013

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Signature : ....

Name : **Associate Professor Tan Kim See**

Date : **11th JUNE 2013**

Dedicated to my father, Chin Xin Yan and my mother, Haw Wai Min.

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ABSTRACT

Every now and then, the world is shocked with news that another building has collapsed causing many innocent people who are occupying the building to lose their lives and bringing untold miseries and sufferings to those who are lucky to survive the tragedy. And, on many occasions, unless being attacked deliberately, a building does not collapse out of the blue. Most of the incidents of buildings tumbling down show evidence the structure or foundation of the buildings have been shifted or disturbed due to earth movement beneath the buildings over a period of time. For a high-rise square or rectangular shaped structure, the possibility of the building leaning to its side due to earth movement is most likely. It will either lean to the east, west, south or north, or that matter, north-east, south-east, south-west or north-west, very much in the cross formation. An automatic detecting system that constantly monitors the stability of the building, if installed in a high-rise building will be most beneficial. Any leaning of the building by any degree to either any of the directions, the system is able to detect immediately. Any such detection, the management of the building will be the first to be informed so that immediate action can be taken to investigate the seriousness of the inclination where remedial work can be undertaken. However, if the management somehow fails to response, the system will send a message via SMS to the occupants when the inclination has reached the danger level so that the occupants have enough time evacuate the building before it collapses.

ABSTRAK

Setiap sekarang dan kemudian, dunia dikejutkan dengan berita bahawa sebuah lagi bangunan telah runtuh menyebabkan ramai orang yang tidak bersalah yang menduduki bangunan yang kehilangan nyawa mereka dan membawa kesengsaraan dan penderitaan orang-orang yang bernasib baik untuk terus hidup tragedi itu. Dan, banyak kali, melainkan jika diserang sengaja, bangunan yang tidak runtuh daripada biru. Kebanyakan kejadian bangunan runtuh menunjukkan bukti struktur atau asas kepada bangunan telah dipindahkan atau terganggu disebabkan oleh pergerakan bumi di bawah bangunan dalam tempoh masa. Bagi struktur berbentuk bertingkat tinggi persegi atau segi empat tepat, kemungkinan bangunan itu bersandar kepada sampingan disebabkan oleh pergerakan bumi adalah yang paling mungkin. Ia sama ada akan bersandar ke timur, barat, selatan atau utara, atau perkara itu, utara-timur, selatan-timur, barat atau utara-barat, sangat banyak dalam pembentukan silang. Satu sistem pengesanan automatik yang sentiasa memantau kestabilan bangunan itu, jika dipasang di bangunan tinggi akan paling bermanfaat. Mana-mana bersandar bangunan itu dengan apa-apa ijazah untuk sama ada apa-apa arahan, sistem ini dapat mengesan dengan segera. Mana-mana pengesanan itu, pengurusan bangunan itu akan menjadi yang pertama untuk dimaklumkan supaya tindakan segera boleh diambil untuk menyiasat seriusnya kecenderungan di mana kerja pemulihan boleh dilaksanakan. Walau bagaimanapun, jika pengurusan entah bagaimana gagal untuk tindak balas, sistem akan menghantar mesej melalui SMS kepada penghuni apabila kecenderungan itu telah mencapai tahap bahaya supaya penghuni mempunyai masa yang cukup mengosongkan bangunan itu sebelum ia runtuh.

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LIST OF ABBREVIATIONS

Acronym	Definition
GSM	Global System for Mobile
MEMS	Micro-electro-mechnical
PC	Personal Computer
PIC	Programmable Integrated Circuit
Rx	Receiver
SNR	Signal to Noise Ratio
SMS	Short Messaging Service
SOS	Structural Orientation System
SIM	Subscriber Identity Module
Tx	Transmitter

CHAPTER 1

INTRODUCTION

1.1 Overview of the project

Building is a structure which is designed to provide convenience and shelter to the people. However, at the same time, the collapse of a building especially with many occupants in it will also bring catastrophic result of sufferings and miseries to the victims. A building does not collapse without any reason. It might be due to some factors like bad design, faulty construction, foundation failure or lack of proper safety standards and unenforced building codes that lead to the building tumbling over. Once the foundation of the building is no longer sustainable, it is unavoidable that the building will collapse without any warning if no proper detection system is installed.

However, with an efficient alert system installed in the building to monitor the stability of the building, the system will be send an alarm to notify the occupants where the occupants could be forewarned of the danger and effort can be taken to do remedial work or to evacuate the building before the building tumbles over. By doing so, lives and properties can be saved. This project researches into the various systems and the final outcome expected is a system that can be installed in all high-rise buildings to safeguard the lives and properties of the public. If the building remains in its original position, the system will remain neutral but once it detects any leaning in the building using its smart sensor, the system will send the necessary warning to the building management and the occupants of the building.

1.2 Project Objectives

The objective of this project is to design a systematic system by using an accelerometer as the smart sensor, to monitor the stability of the building and being able to send message via SMS once there is any indication that the building is slanting to its side. Besides that, the purpose of the project is to provide an early indicator to the occupants or the management of the building instability for any necessary precaution and appropriate action to be taken.

1.3 Problem Statement

On many occasions, building collapsing is unpredictable because most of the time, any slight movement of the building structure is hardly noticeable by the naked eyes more so with people nowadays so busy with their daily routine that the safety of the building they are occupying being taken for granted. By the time the inclination has reached a certain level, the unavoidable will happen, the building will collapse which by then is too late. A very good example that happened in the local front was the Highland Tower which collapsed on 11 December 1993 and caused a total number of 48 people being killed in the tragedy. This tragic incident had brought untold pain and miseries to those who lost their loved ones and till today it still brings painful reminder of one of the nation' worst ecological calamities.

As an engineer, it is one's duty and responsibility to provide solution to engineering problem such as the Highland Towers Disaster from happening and to accord the safety and happiness of the people. Therefore, to design a system to constantly monitor the stability of the building all the time and is able to detect and send messages to the appropriate parties such as to the control room operator and the occupants by using GSM modem will benefit many people. This system will be able to operate throughout the day, and it is more reliable with such a system installed to monitor the stability of the building rather than by manual observation.

1.4 Scope of Work

This project consists of three major parts, which is the detection system, control system and notification system. For the detection system, it comprises of an accelerometer acting as a smart sensor to detect the inclination of the building. The control system consists of a microcontroller with the main role of receiving the signal from the sensor and control the process on the various danger level specified. For notification part, a GSM modem will be used to send message to the control room operator or the occupants of the building. This system is best applied to all high-rise buildings, especially those with high human occupancy and residential building.

1.5 Brief Review of Methodology

The project work started off by first, identifying the objectives and scope of the project in order to achieve the final outcome. This was followed by doing some literature reviews to survey and finding the most appropriate sensor, microcontroller and notification system to be applied. The next move was to study about the function and specification of each component and sensor in order to achieve the objectives of the project. Besides that, a lot of other work related to this project such as reviewing existing systems installed like the leaning Tower of Pisa was done to acquire as much knowledge and ideas to produce a relevant and useful system. After things were in place with the literature review and research, the project proceeded with the design of the hardware and software. Proteus software was used to design the electronic circuitry whereas for the microcontroller C language was used to build the various coding.

After the design of hardware and software was properly done and completed, the system was tested to determine the functionality of each section and troubleshooting and corrective actions were taken part upon any problem being encountered. After everything was thought to be functioning in a proper order, the hardware and software were the integrated and finally the prototype was built. The figure below shows the flowchart of the whole process of this project.

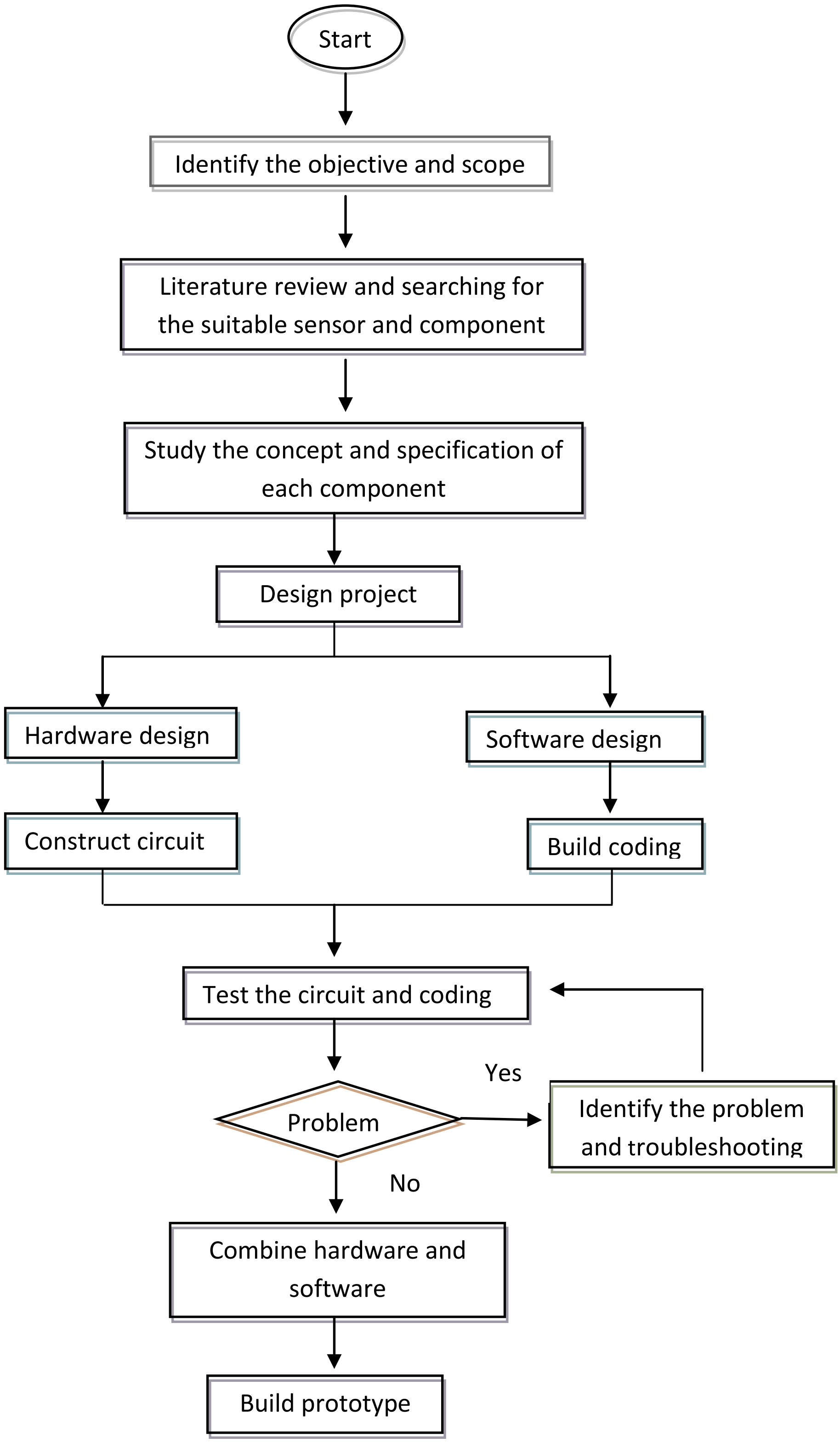

Figure 1.1: Project flow.

1.6 Thesis Outline

This thesis consists of five main chapters, viz., introduction, literature review, methodology, results and conclusion. The first chapter is an introduction in which the chapter will provide a brief description of the project to be implemented such as the background, problem statement project objectives, project scope and methodology.

The second chapter is on literature review, searching and looking up as many journal papers, articles and videos of previous high rise building collapsing, review on the theoretical concept on the various methods and applications currently being used to monitor the stability of high-rise buildings.

The third chapter discusses the project methodology which deliberates on the possible methods and the processes of the project. The various scope of work and the flow of going about executing the whole project are outlined here. The sourcing for the sensors and other components, how they work and how they can be applied in the project are also discussed in the chapter.

The fourth chapter is the chapter that presents all the result, the circuit and data collection and how the project works.

The fifth chapter covers the conclusion and recommendations. The final outcome and success of the project are mentioned. This section will include suggestions and recommendation for future improvement.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This part discusses on the various literature reviews of previous projects or researches done by using sensor to monitor the stability of the structure building. Each published paper works on different types of sensors and principles to monitor the stability of a building. After carefully studying and reviewing the papers, the final decision on the direction of the project was taken, keeping in mind the ideas applied by past researchers.

2.2 Interferometric Sensor

The Leaning Tower of Pisa is one of the world-famous architectural marvels of Italian heritage. The tower was designed to be 'vertical' but it started to incline during its construction. Although, there were much effort had been taken to stop the inclination, it kept on sliding over the centuries. Currently, this tower is tilting about 5.5° toward the south [9]. The people are really concern about the increase in its leaning angle. Therefore, this project is to design a suitable system to provide continuous monitoring system to constantly keep track of the stability of the tower, the critical level of inclination and the disaster level.

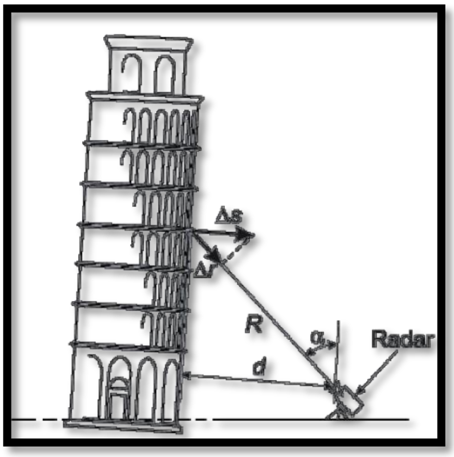

Figure 2.1: Position of the radar and the tower.

Recently, some researchers had developed remote-sensing equipment based on the principle of microwave radar interferometry [1] and had been experimented on the tower in order to measure the stability of the tower without requiring any contact with its structure. The radar is place outside of the tower and is shown in Figure 2.1. Interferometry sensor are basically two types; one is laser interferometry and other one is high speed radar interferometry. Some similar techniques have been carried out to take the measurements by using laser interferometry. However this laser interferometry is impractical because laser is sensitive to dust and environmental changes. Therefore, it is not suitable for long term monitoring whereas the high speed radar interferometry are robust instrument that is suitable for continuous surveying [1].

High speed radar interferometry has been recently developed as a potential sensing technique for remote dynamic surveying of structure such as bridges, viaducts and towers [3][4]. This technique is attractive for surveying the stability of structure of the tower without contact with its structure compared with use of the contact sensor such as accelerometer. High speed radar interferometry's appearance is shown in the Figure 2.2.

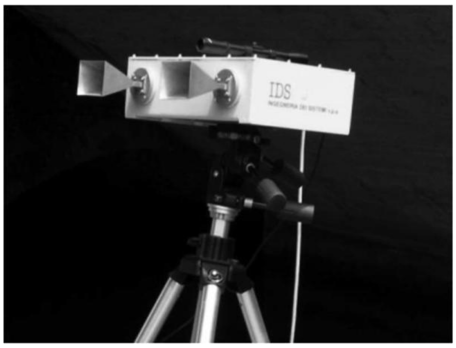

Figure 2.2: Sensor ‘s appearance.

This radar interferometry’s concept is like microwaves, where the radar transmits the light to the structure of the building and then the structure of the building scatters back the energy light back to the radar. The radar concept is shown in the Figure 2.3. The tower movement is able to be determined by measuring the resonant frequencies. The precision of the measurement of the frequencies depends on the signal to noise ratio (SNR) and the distance of the building and its radar cross section. The higher the SNR, the higher is the precision of the measurement. This high speed interferometry is able to detect the object from distances as far as 1 km [5].

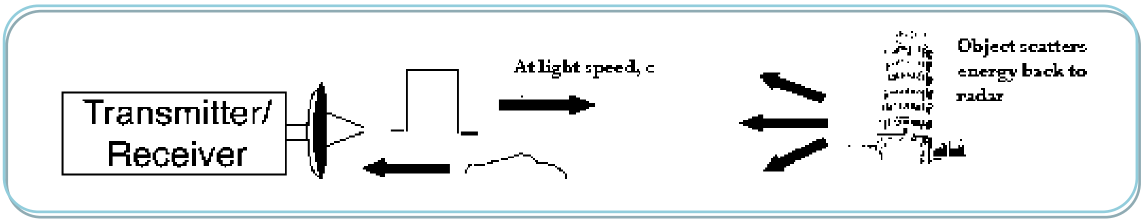

Figure 2.3 Radar Interferometry‘s concept.

2.3 Structural Orientation Sensor (SOS) system

The Structural Orientation Sensor system is another technique applied on the building in order to monitor the stability of the building and provide the emergency response during earthquake or any natural disaster. The goal of this system is to identify the structure that have been partially or totally collapsed, and notification will be sent out to the human emergency responders such as fire station, police station and hospital within a few minutes after the collapse [6]. Besides that, this SOS system is able to monitor the damaged structure and debris piles as well as able to detect the potential slope failures and structure built thereon.

A structural component that has a large tilt such as 3-10° is consider that the structure is certainly badly damaged [6]. For the structural component with smaller tilt may indicates important but not immediately life-threatening damage just like stated in the Uniform Building Code (UBC). This SOS system consists of SOS tilt detection transmitters and SOS receiver.

The size of the SOS tilt detection is small like the size of a smoke detection. The user was able to purchase the SOS tilt detection as many as they want and place it on any part of the structure of the building likes;

a) Soft first structures such as 2-4 storey wood frame apartment building over garage.
b) Decks of bridges and overpasses
c) Roofs and seating decks of high occupancy structure such as stadium, auditoriums, shopping malls
d) Walls of tilt-up building

Any tilt changes on the structure of the building, the SOS tilt detection will detect it and will reporting the response from the structure of the building to the emergency response.

SOS receivers consist of telemetry receiver which receive the signal from the transmitter and broadcast the tilt change status message to the receiver in order to activate some desired response from the emergency responders. The SOS receiver is deployed at all rescue team like fire stations, police station and ambulance in urban area which serves areas about 2 miles radius. When the receiver received the tilt changes status messages, a typical message might be "I'm sensor # 45366 and I have tilt change of 23°. This will let the responder knowledge the location of the sensor in the structure then the responders will able to get to the scene in the fastest time.

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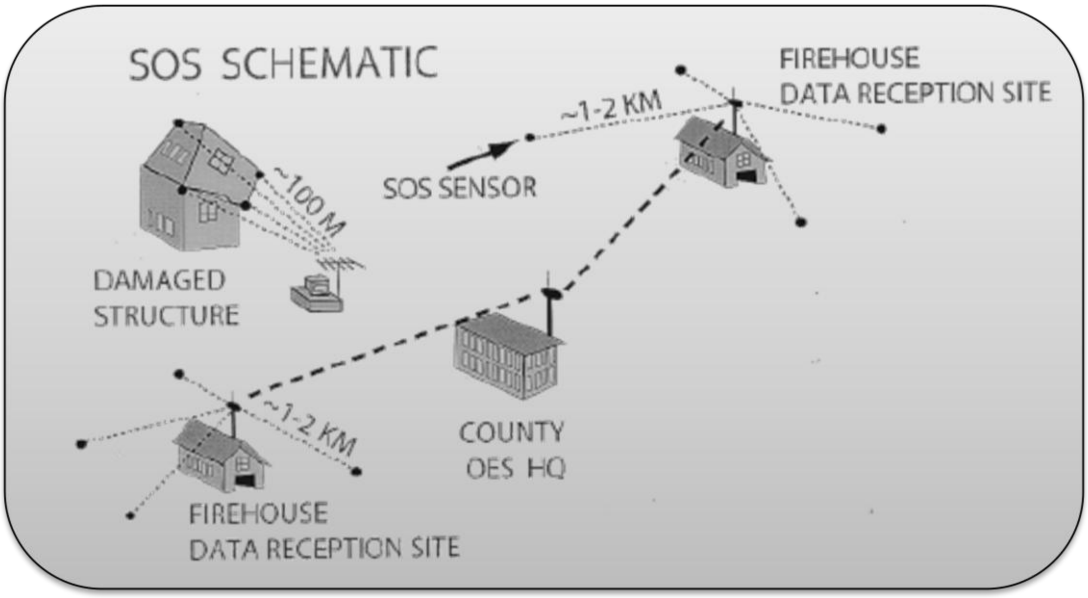

Figure 2.4: Structural Orientation Sensor (SOS) schematic**.**