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Development of Tsunami early warning embedded system with GSM alert

Nirmal Patel[(1)*], Kiresh Gohil[(2)], Dhairya Kothlikar[(3)], Mayur Solanki[(4)],Mr. Bhavik Prajapati[(5)]

1Nirmal Patel, Electrical Engineering, Sigma Institute of Engineering Bakrol, Vadodara, Gujarat, India
2Kiresh Gohil, Electrical Engineering, Sigma Institute of Engineering Bakrol, Vadodara, Gujarat, India
3Dhairya Kothlikar, Electrical Engineering, Sigma Institute of Engineering Bakrol, Vadodara, Gujarat, India
4Mayur Solanki, Electrical Engineering, Sigma Institute of Engineering Bakrol, Vadodara, Gujarat, India
5Assi. Professor Bhavik R Prajapati, Electrical Engineering, Sigma Institute of Engineering Bakrol,

ABSTRACT

A tsunami is a series of ocean waves caused by an underwater earthquake, landslide or volcanic eruption with a height that reaches over 100 feet. On the advent of a tsunami, timely measures need to be taken in order to prevent loss of life and property. Current tsunami warning system proves to be ineffective because of time taken in processing and analyzing the signal when the tsunami is triggered in shallow waters. This paper proposes an automated system that detects the occurrence of tsunami and notifies the warning in the form of a text message broadcasted over the offshore area.

Keywords: Disaster Management , GSM , Alert System , Wireless Communication , Safety

1. INTRODUCTION

A Tsunami is a very long-wavelength wave of water that is generated by earthquakes that causes displacement of the seafloor, but Tsunami can also be generated by volcanic eruptions, landslides and underwater explosions. Earthquakes of M > 6.5 are critical for tsunami generation. On the average, there are two tsunamis per year somewhere in the world. Approximately every 15 years a destructive, Pacific wide tsunami occurs. Tsunami velocity is dependent on the depth of water through which it travels Tsunamis travel approximately 700 kmph in 4000 m depth of sea water. The velocity drops to about 36 kmph at 10 m of water depth which cause damage near the shore. Tsunami often occurs suddenly without warning and they are extremely dangerous to the coastal communities. To protect ourselves from such disaster some automated warning systems should be made. The proposed Tsunami warning system is basically an Embedded Systems. An embedded System is a microcontroller based system that is incorporated into a device to monitor and control the functions of the components of the device. Embedded systems are designed to perform specific tasks. An Embedded system is designed to perform a specific function, in which the software rules the entire hardware. The end user cannot alter the software. Reliability, responsiveness, specialized hardware, low cost, robustness are some of the important features of an embedded system. To make such embedded applications, microcontrollers are needed. In this

work microcontroller is programmed to send and receive the signals.

2. SYSTEM ARCHITECTURE

2.1. Introduction

This design consists of three sensor, and GSM module. The sensors used are tilt sensor, rain gauge sensor and temperature sensor. Output of sensor will send to the controller for further process. Using RF transmitter, signal is transmitted to receiver. These all nodes of sensors are connected to the controller for collection of data. It obtains the information at the receiver side by LCD display at receiver station or by SMS.

2.2. BLOCK DIAGRAM

Below is the block diagram showing the transmitter section of the system architecture.

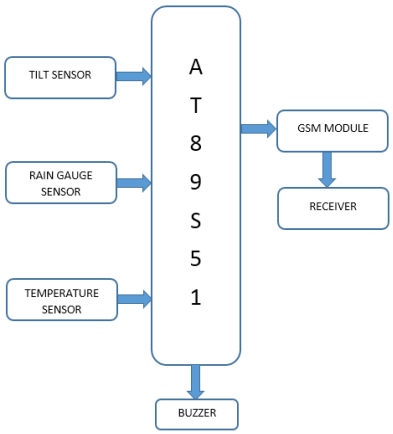


Fig1. *Block diagram of system*

Tilt Sensor: Tilt sensor which senses slope angle if there is any movement in landslide and it is also used for tsunami purpose. This Tilt sensor acts as a switch, switches employ a mercury bead which connects its terminals whenever it is tilted. Then mercury is being a liquid metal can flow down and establish contact between the leads of the switch in this way sensor is activated.

Rain Gauge Sensor: When transistor base comes in contact with the water, the 5V is passes through the water and base will be triggered. The base triggering current will be 5mA and voltage is 2.5V. This is sufficient to trigger the transistor base. In this way the sensor is activated.

Temperature Sensor: LM35 series are precision integration-circuit temperature sensors whose output voltage is linearly proportional to the Celsius temperature. The LM35 does not require any external calibration or trimming to provide typical accuracies. This is three legs IC that directly gives analog output. This unit requires +5VDC for it proper operation

GSM: GSM wireless communication technology used to send the alert message to the responsible authority if the sensor is activated.

RECEIVER: Mobile phone is used as a receiver.

3. HARDWARE DISCRIPTION

In this design a system that can alert before these disasters occur. This design uses three sensors. The LM35 temperature sensor is used for collecting the temperature. Angle or tilt sensor which gives the readings of slope angle if there is any movement in landslide and it is also used for tsunami purpose. Rain gauge sensor is used to collect the depth of water at the mountains. If any drift or variation occurs, output of sensor will send to the Microcontroller for further process. These all nodes of sensors are connected to the Microcontroller for collection of data. As it obtained the information at the receiver side by SMS, it can alert the people, save lives and property. This project is very important as it is used in real time purpose for saving lives and property. This design combines of GSM wireless communication technology and able to inform quickly to the user or to the responsible authority if the sensor is activated.

3.1. AT89S51 microcontroller

The AT89S51 is a low-power, high-performance CMOS 8-bit microcontroller with 4K bytes of In-System Programmable Flash memory. The device is manufactured using Atmel's high-density nonvolatile memory technology and is compatible with the indus-try-standard 80C51 instruction set and pin out. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory pro-grammer. By combining a versatile 8-bit CPU with In-System Programmable Flash on a monolithic chip, the Atmel AT89S51 is a powerful microcontroller which provides a highly-flexible and cost-effective solution to many embedded control applications.

The AT89S51 provides the following standard features: 4K bytes of Flash, 128 bytes of RAM, 32 I/O lines, Watchdog timer, two data pointers, two 16-bit timer/counters, a five-vector two-level interrupt architecture, a full duplex serial port, on-chip oscillator, and clock circuitry. In addition, the AT89S51 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. The Idle Mode stops the CPU while allowing the RAM, timer/counters, serial port, and interrupt system to continue functioning. The Power-down mode saves the RAM con-tents but freezes the oscillator, disabling all other chip functions until the next external interrupt or hardware reset.

Pin Configurations:

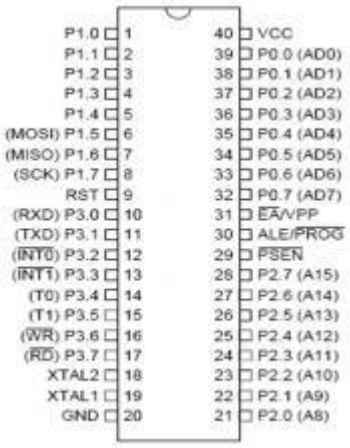
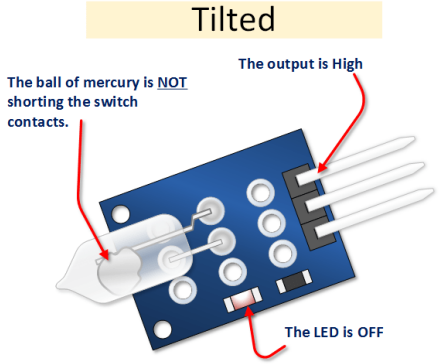


Fig2. *AT89S51 pin configuration*

3.2. Sensors

3.2.1. Tilt Sensor

These switches employ a mercury bead which connects its terminals whenever it is tilted. Then mercury is being a liquid metal can flow down and establish contact between the leads of the switch. The blob of mercury is able to provide resistance to vibrations as mercury is a dense liquid metal [3]. Using mercury is discouraged as it is a toxic metal and poses a potential hazard to the user when the glass casing breaks and metal spillage take place. This sensor is connected to pin number 5 of the PIC controller.



3.2.2. Rain Gauge Sensor

When transistor base comes in contact with the water, the 5V is passes through the water and base will be triggered. The base triggering current will be 5mA and voltage is 2.5V. This is sufficient to trigger the

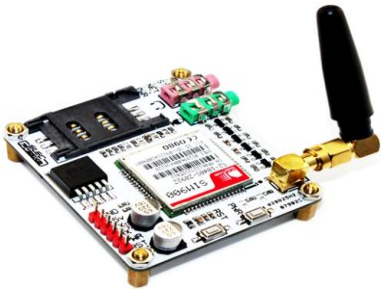
transistor base. When transistor is triggered, then collector terminal of the transistor goes low. This will be applied to the microcontroller. This sensor is operating in digital mode. The power consumption of the circuit is 5mA to 6mA. This sensor is connected to pin number 3 of the PIC controller.

3.2.3. Temperature Sensor

The LM35 series are precision integrated-circuit temperature devices with an output voltage linearly-proportional to the Centigrade temperature. The LM35 device has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from the output to obtain convenient Centigrade scaling. The LM35 device does not require any external calibration or trimming to provide typical accuracies of ±¼°C at room temperature and ±¾°C over a full –55°C to 150°C temperature range. Lower cost is assured by trimming and calibration at the wafer level.

3.3. GSM SIM900

The baud rate can be configurable from 9600-115200 through AT command. Initially Modem is in Auto baud mode. This GSM -RS232 Modem is having internal TCP/IP stack to enable you to connect with internet via GPRS. It is suitable for SMS as well as DATA transfer application in M2M interface. The modem needed only 3 wires (Tx, Rx and GND) except Power supply to interface with microcontroller/Host PC. The built in Low Dropout Linear voltage regulator allows you to connect wide range of unregulated power supply (4.2V -13V) and 5V is in between them. Using this modem, you will be able to send SMS.GSM modem, works on frequencies 850 MHz, 900 MHz, 1800 MHz and 1900MHz. It is very compact in size and easy to use as plug in GSM Modem. The Modem is designed with RS232 Level converter circuitry, which allows you to directly interface PC Serial port.



3.4. Power Supply Regulation Stage

All digital circuits require regulated power supply. Fig. shows the basic block diagram of a fixed regulated power supply. Let us go through each block.

Step down Transformer: Step down transformer is used to reduce the voltage according to the required voltage of the circuit. Most of the circuit needs 5V to 12V only. Here it used 12V transformer to get 12V as output by giving 230V as input.

Bridge Rectifier: The output from the transformer is in AC, but the supply for circuit in DC. So it needs to rectify the AC output to DC output. So the diodes are used to build a Bridge rectifier circuit to convert the 12VAC to 12VDC. A smoothing capacitor can be used at the output side of the rectifier to get a constant voltage. Bridge Rectifier consists of four diodes namely D1, D2, D3 and D4. During the positive half cycle diodes D1 & D4 conduct whereas in the negative half cycle diodes D2 & D3 conduct.

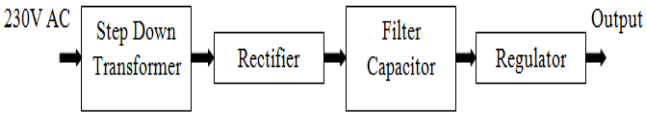


Fig3. *Block diagram of power supply*

Voltage Regulator 7805: The output DC voltage now available is 12V but it has to be converted into 5V since the transistor base voltage should be in the range of 5V-6V. Voltage regulators are used in the circuits to provide a constant required voltage and to avoid major

fluctuations in the voltage to the circuit. It has 3 pins. The input pin, ground pin and output pin. The input voltage must be within the range of 5V to 30V. So the voltage regulator regulates the voltage to 5V.

4. SOFTWARE DESCRIPTION

4.1. Keil u vision 4

Compilers are programs used to convert a High Level Language to object code. Desktop compilers produce an output object code for the underlying microprocessor, but not for other microprocessors. I.E the programs written in one of the HLL like 'C' will compile the code to run on the system for a particular processor

5. DETECTION OF TSUNAMI

Deep-ocean tsunami detection buoys are one of two types of instrument used by the Bureau of Meteorology (Bureau) to confirm the existence of tsunami waves generated by undersea earthquakes. These buoys observe and record changes in sea level out in the deep ocean. This enhances the capability for early detection and real-time reporting of tsunamis before they reach land.

6. HOW SYSTEM WORKS

The tsunamis are generated by earthquakes, volcanic eruptions, landslides, underwater explosions, and meteorite impacts. The tsunamis generated by landslides tend to be relatively localized and do less damage than the Tsunami generated by earthquakes.

When a sudden earthquake or landslide occur in the ocean, large amount of water creates waves depending upon the depth of the sea.

This waves are sense by surface Buoy which consist power circuit, controlling circuit, tilt sensor. This sensor gives output signals to the microcontroller and this microcontroller takes necessary action. All the data of tsunami are collected in the AT89S51 MICROCONTROLLER. This will give signal to GSM module for generating a warning massage which is feed already.

This massage will pass to the weather department, fire-fighters, costal area safety officer, corporation, news channels etc.

7. APPLICATION, WEAKNESS, SOLUTION

7.1. Application

Tsunmi monitoring is an important topic related to tsunami. Big high tides are mainly generated in the ocean. To get alerted of tsunami, this monitoring system is useful.

Tsunami warning system is used to detect tsunamis in advance and issue warnings to prevent loss of life and damage.

7.2. Weakness

Current system is based on GSM alert. It needs to be a strong network to pass on the safety massages to everyone. Some time network may clash because of bulk massages send by a GSM module.

Power consumption also an issue for this system.

7.2. Solution

It need to be a trusted network provider which has a strong network to fulfil service.

Solar energy is the solution for power consumption problem.

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