SMS BASED FLOOD LEVEL MONITORING SYSTEM

Sheikh Izzal Azid

Faculty of Science Technology and Environment,
The University of South Pacific
Suva Fiji

Bibhya Nand Sharma

Faculty of Science Technology and Environment,
The University of South Pacific
Suva Fiji

Abstract: This paper demonstrates the design process, implementation and experimental verification of a Flood Level Monitoring system. The main objective of the proposed system is to be able to read the water level at every second, display it to the supervisor and alert the affected populace and relevant authorities by means of an alarm and short message system (SMS) when the level of water surpasses a user defined threshold. Global System for Mobile Communications (GSM) network has been used for sending the mobile messages. Peripheral Interface Controller (PIC) microprocessor is used to read in the input from the sensor and then display the result. The measuring system is based upon the theory of pressure being applied to liquids. Furthermore, the collated data is useful to the meteorologist for investigating and monitoring the cause of flooding with respect to time and weather patterns. This warning system is deemed to be a faster method of alerting the relevant authorities and the vulnerable residence.

Key words: SMS, pressure sensor, microprocessor, water level

1

1.0 Introduction

The global climatic change during the first half of the twentieth century has brought a tremendous impact on the high mountainous glacial environment. Due to the faster rate of ice and snow melting, possibly caused by the global warming, the sea level is increasing rapidly and resulting in a sudden discharge of large volumes of water and debris causing flooding of the low lying areas. With this ever-increasing regularity of flood damage, a definite need has emerged for an early warning for regions deemed to be 'at high risk' from flooding. Furthermore, the high level of damage to properties and loss of lives are the underlying factor in the development an early warning system - Flood Level Monitoring System.

Currently in the South Pacific the Metrological departments get the weather data from the satellite and then predict the average rainfall in the area. Research has been done on Flood monitoring system using GIS hydrological model in China [1]. Again with the use of satellite this system reads the water level and then subtracts the surface elevation to get the height of flood. Moreover most of Flood level systems depend on on satellite to predict the flood data [2, 3]. However there was a need of a system which automatically reads the data rather than predicting in the threatened area and then alerts the residence instantly.

Mobile Phones have become one of the most popular communication devices amongst the people all over the world. At present with the world population of around 6.7 billion, 60% use mobile phones. This is about 4.1 billion mobile phone users and this assistive technology is used in all facets of our livelihood. Since the GSM network started its operation in 1991, the SMS has become popular as it provides cheap, convenient and a faster method of communication [4].

Recent advances in the automation showed that the billing system for electricity, gas or water uses GSM module based SMS metering service rather than assigning personnel to visit each house and secure the meter readings manually [5], where these SMS are sent only from module to users [6, 7]. Even remote greenhouse measure and control systems are SMS based [8]. Then there is an advert of SMS based intelligent homes which are designed to alert the users via SMS in case of emergencies [9]. The owners of smart homes can inter alia switch on/off their lights and appliances via SMS from work, functions or anywhere away from home [9-11]. Zigbee and Wi-Fi technology is also used for wireless remote controlling; however the distance is very small when compared to GSM control [12].

The Pacific Island countries are scattered over one third of the globe. The region's islands are classified into two groups, high islands and low islands. The since most of the islands are near the equator, the do face tropical cyclones almost every year. The Fiji Islands has a long standing history of tropical cyclones and flash flooding on an annual basis. Frequent severe tropical rainstorms cause major flooding on Fiji's two main islands—Viti Levu and Vanua Levu leaving local authorities struggling to cope with the thousands of people mostly from the low lying areas. Although there are many evacuation centres and authorities on alert, there is severe loss of lives and properties every time there is a flash flooding. This is invariably due to the absence of a proper flood monitoring system that can provide correct and timely information via communication channels that are operational at the time. Radios and TVs, although available in most households, may not be effective due to the power cuts. However, all households have at least a mobile phone. There are three big mobile phone network companies, Vodafone, Inkk and Digicel that provide the service in Fiji, and

competition within the companies has made mobile calls and txt messages very cheap. Therefore, communication using mobiles is much more effective.

1.1 Contribution

This paper presents the idea of alerting flood threatened residence and relevant authorities by means of SMS. Water level of the flood is determined using the pressure sensors. For this system a mobile phone is used rather than GSM module. The advantages of using mobile phone over the GSM module are: the user can easily recharge system mobile during emergencies in case the credit goes low, there is more exposure in using the GSM network if only the mobile is interfaced rather than GSM module and mobile phones can be purchase cheaply in the Fiji Islands. PIC microprocessor is used in this system to read in the sensor value, to carry out the necessary calculations and to programme the phone to send SMS messages. The PIC is also used to check battery level of the system. The whole system can be placed in a remote place and can be powered by 10 volts battery or even a 10 watt solar panel Hence this method would work perfectly in the Fiji Islands and the rest of the Pacific. The overall cost of one unit is below US$80. Therefore, it is still cheaper to install units at all the "pivotal places" and obtain correct information in a timely manner.

2.0 Design Overview

As shown in Figure 1 when a pipe is placed vertically, with one end dipped into a liquid and the other end opened, the level in the pipe will be proportional to the level in the tank. However, if the upper end of the pipe is closed off and some air volume is trapped, the pressure in the pipe will vary proportionally with the liquid level change in the tank. For example, if we assume that the liquid is water and that the water level rises in the tank by 10 mm, then the pressure in the pipe will increase by that same value. Moreover, the gauge pressure sensor measures the pressure difference, which corresponds to the change in the level. We utilize a simple formula: $P = D \times G \times H$, where P = Pressure, D= Density, G = Gravity and H= Height. The overall design is illustrated in Figure 1.
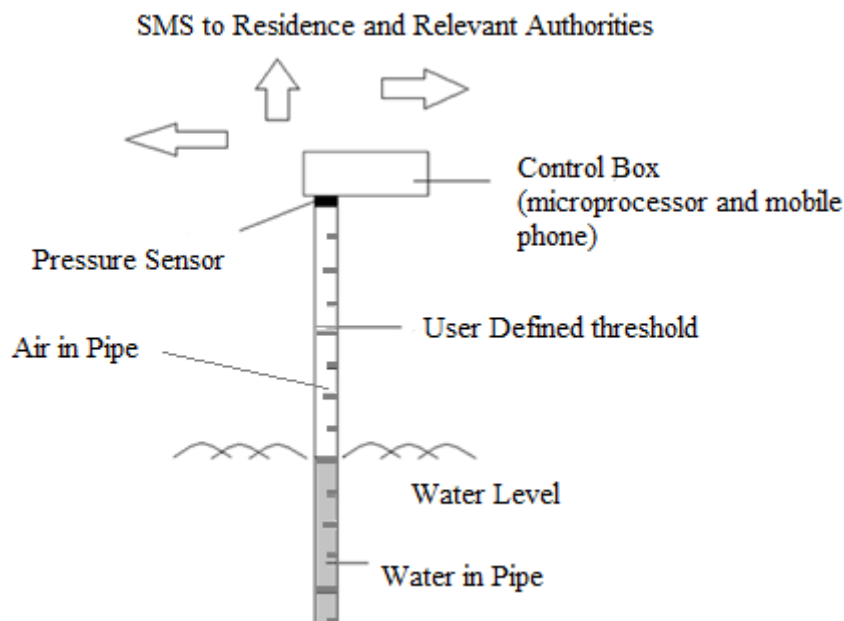
Figure1: The schematic diagram of the new design of the flood level monitoring system.

We note that the thresholds are defined by the user based on prior knowledge and experience with the floods. Different thresholds are defined for units positioned at different places of the flooding area. Now, as the water levels increase the air in the gap compresses resulting in a change in the pressure. The pressure sensor is placed inside facing the trapped air, senses the pressure of the air and converts it into voltage. Since the voltage output of the sensor is in analogue an Analogue to Digital conversion is required for the calculation which is done by the microprocessor. Once the water level rises to the threshold level the system will send emergency SMS to all pre-determined stakeholders and activate the siren. SMS messages in the Fiji Islands will also go to authorities such as the Fiji National Disaster Management Committee (DISMAC). Upon receiving the txt message DISMAC can quickly open up the evacuation centres and carry out the necessary steps to facilitate the evacuation process, alert other authorities (police, military, fire department, etc.) and secure properties. The overall flowchart is given is Figure 2.
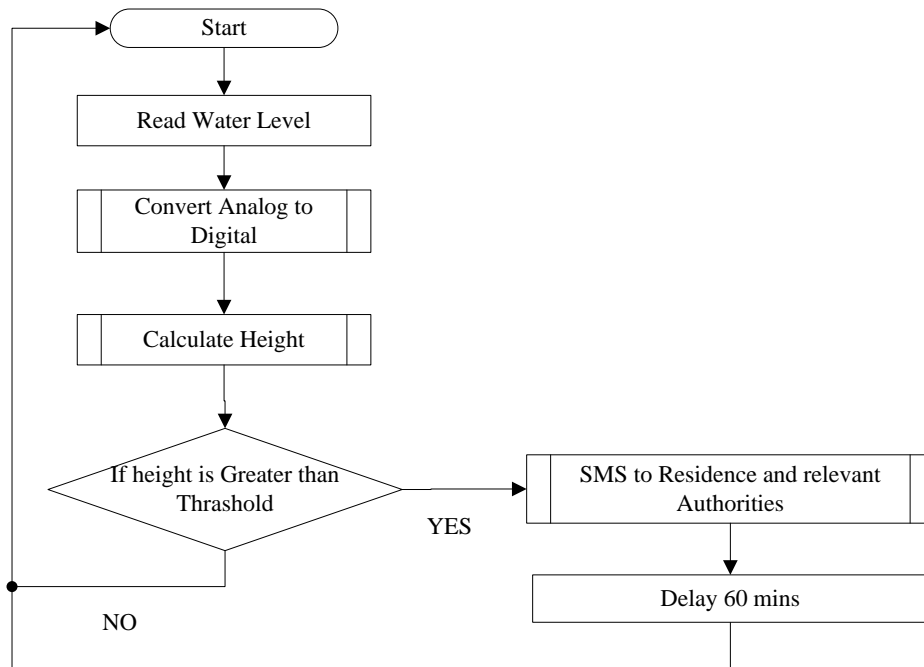

Figure 2: Flowchart of the design of the flood level monitoring system.

3.0 Hardware Model

A. Voltage Regulation

The regulator circuit, shown in Figure 3, is used to provide a stable power supply to all the components of the flood monitoring system. In this case it provides regulated power to the microprocessor and the pressure sensor board which are the essential components of the project design.

This regulator circuit will produce a five-volt output from any input voltage between approximately eight and twenty volts. The design has a 7805-voltage regulator, which is a three terminal IC. It works by actively maintaining a five-volt output independent of the output current. The difference between the output voltage and the input voltage is converted

to heat. With a nine-volt as input powers though, the regulator will not get as hot. Capacitors C1, C2, are the decoupling capacitor used to reduce ringing and ground-bounce on the power supply lines. In other words, they work to clean up any voltage fluctuations of the output voltage.

The connectors are placed to give in nine volts to the microprocessor prototype board. The power supply to the prototype board is not regulated to five-volt, as it has own inbuilt regulating system.
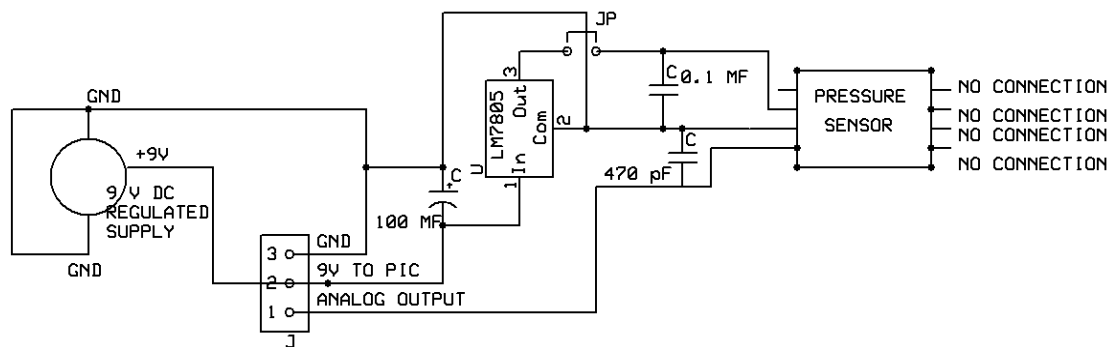
Figure 3: The schematic diagram of the circuit design.

B. *The Pressure Sensor*

As per the design requirement, the pressure sensor (MPVZ5010G7U) needs to be exposed to the air trapped in the pipe. Hence the sensor chip is mounted at the bottom of the printed circuit board, which is in the middle of the pipe diameter. The top board of the pipe is drilled for the sensor chip to fit in. The chip is glued to the board as well as the pipe connector. Note for the pipe a connector is used, as it would be easier to screw any size to pipe to the system depending on the level sensing depth. Figure 4 illustrates this sensing system.
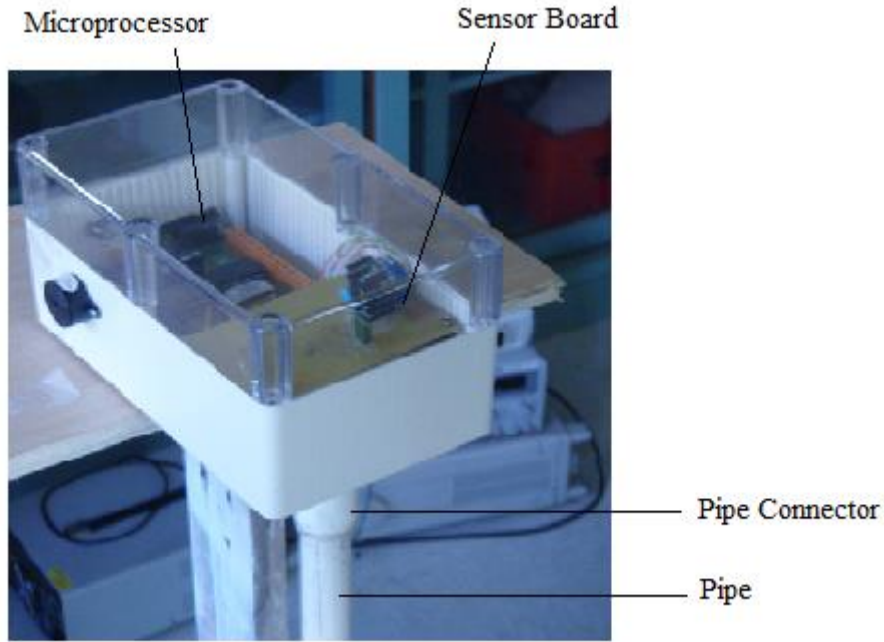
Figure 4: The sensing unit of the flood level monitoring system.

C. The Microprocessor and Mobile Phone

Due to the highly static damage nature of the CMOS PIC16F877 microprocessor, the prototype board has been implemented. The prototype board has a MAX232 chip on board, which is a RS232 transmitter and receiver and this allows the microprocessor to communicate with mobile phone serially. A mobile phone is interfaced with microprocessor to send emergency SMS. The microprocessors as well as the mobile phone are both Data Circuit Equipment (DCE) devices; therefore for serial interface, transmitter pin of microprocessor is connected to receiver pin and receiver pin of microprocessor to transmitter pin of phone [9], as shown in Figure 5.
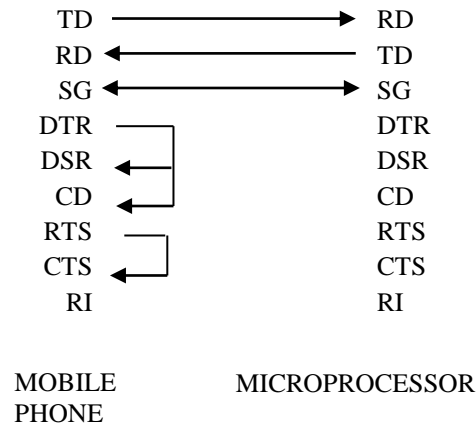

Figure 5: Serial connection between the mobile phone and the microprocessor.

4.0 Software Design

The C Language Compiler Software (Peripheral Interface Controller (PIC C)) is used for programming PIC microprocessor. The output of the pressure sensor gives out analog voltage. PIC 16F877 uses the Analog to Digital (A/D) feature for conversion of an analog

6

input signal to a corresponding 10-bit digital number. The A/D module has high and low-voltage reference input that is software selectable to some combination of Voltage Supplied, Ground, and pin RA2 or pin RA3. The PIC A/D converter has a unique feature of being able to operate even when the device is in the *Sleep* mode.

After conversion of output voltage from analog to digital the voltage is then converted to pressure using the transfer function from the data sheet of the pressure sensor chip (MPVZ5010G7U). The transfer function utilized:

$$V_{out} = V_s \times (0.09 \times P + 0.04) \pm 5\% \qquad (1)$$

where V_s = Voltage Supplied = 5V , hence $V_{out} = (0.45P + 0.2) \pm 5\%$. Therefore, we get $H = \dfrac{P}{9.806}$ taking the gravity as 9.806m/s^2 and the density of water as 1 kg/l.

From the experiment that was designed to find the relationship of the height versus the volume of water immersed. (discussed in section 6), we get

$$Actual\,heigh\,ht = 1.1263H - 0.0007 \qquad (2)$$

Programming was also done to give an alarm as the height surpasses the programmed threshold. Once the threshold height has been detected the microprocessor will set up the mobile phone for sending SMS. As shown in Figure 6 the microprocessor first sends "ATEO" to mobile phone to check if the mobile phone supports AT Command language. The system is designed such that it works with any mobile phone which supports AT Command. All mobile phones have two mode of text message, the first one is Hexadecimal mode and the second is Text mode; "AT+CMGF=1" sets the message to text mode. "AT+CPMS" command sets the SMS message storage to phone [5].

```
//////////////////////////////////////////////// setup the Phone!! ////////
void setupPhone()
{

int i;
delay_ms(1000);
printf("ATE0\r\n");    //Check if phone supports AT Command
    while ((intial[i] = getchar()) !='K')
    {
        lcd_putc(intial[i]);
            i++;
    }
i=0;
delay_ms(1000);
lcd_putc('\f');
lcd_putc("cmgf");    //Sets SMS mode to Text mode
printf("AT+CMGF=1\r\n");

    while ((intial[i] = getchar()) !='K')
    {  lcd_putc(intial[i]);
        i++;
    }
i=0;
delay_ms(1000);
lcd_putc('\f');
lcd_putc("cpms");   //Sets message storage to mobile phone
printf("AT+CPMS=\"ME\"\r\n");
    while ((intial[i] = getchar()) !='K')
    {
        lcd_putc(intial[i]);
        i++;
    }

}
```

Figure 6: The C Language Programming to set up the mobile phone to communicate.

Next the microprocessor uses "AT+CMGS" command to send SMS to all the mobile numbers stored in the phone as shown in Figure 7. The messages to be send are already stored in the microprocessor. The phone will send the message to pre-determined stakeholders simultaneously. The system will pause for 60 minutes and then check the water level again. If the water level is again above the threshold then the system will send the alert SMS again. We note here that the time setting can be reset to ensure timely information flow. Also the SMS can be modified to portray the (declining or accelerating) gravity of the situation.

```
////////////////////////////////////////////////// send SMS to user ////
void feedback()
{
int i;
delay_ms(1000);

arw[0]='\0';

lcd_putc('\f');
lcd_putc("CMGS");
printf("AT+CMGS=\"");
printf("%s",rnumber);   //Sends to all stored number
printf("\"\r\n");

arw=getchar();

delay_ms(1000);
printf(message);
putc(26);
lcd_putc('\f');

i=0;
while((intial[i] = getchar()) != 'K')//reciept that messase is sent
    {
        lcd_putc(intial[i]);
        i++;
    }

lcd_putc('\f');

delay_ms(500);
}
```
Figure 7: The AT+CMGS programming.

6.0 Results

From theory, it is established that as the height increases the pressure increases, and this pressure compresses the air trapped in the pipe as a result water in immersed in the pipe. Note the water level outside the pipe would not be the same as inside because of the air trapped inside the pipe would use the volume space; hence an experiment was performed to observe the relationship between the height of the system and the volume of water immersed in the pipe. Figure 8 shows that the Outside Height = $1.1263 \times$ Inside Height. This proves the water level outside the pipe is higher than is water level inside the pipe. Thus the relationship found is used by the microprocessor to recalculate the actual height (governed by equation (2)) to adjust for the air trapped.
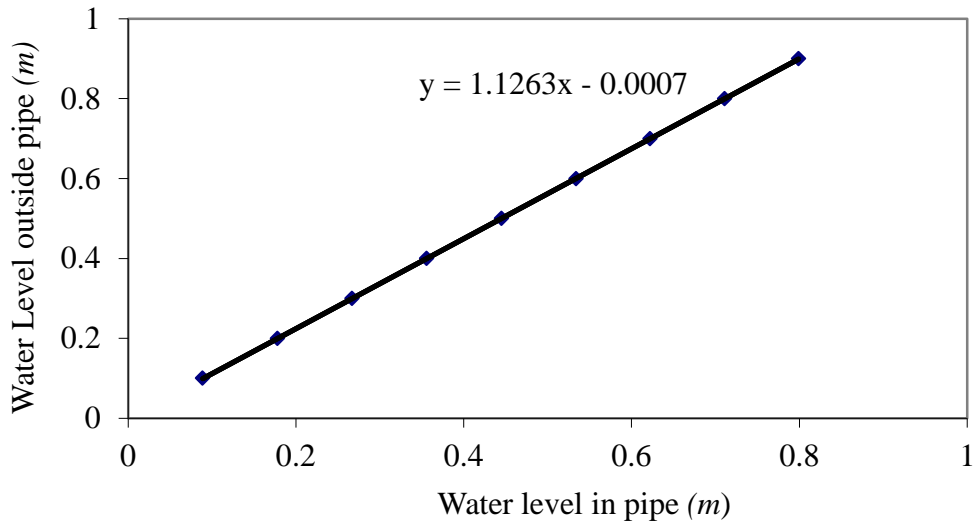
Figure 8: Water level outside the pipe versus water level in the pipe.

After adjusting for the air trapped in the pipe the efficiency of the system was tested. A set of twenty readings was taken for every 0.1m interval as shown in Figure 9.
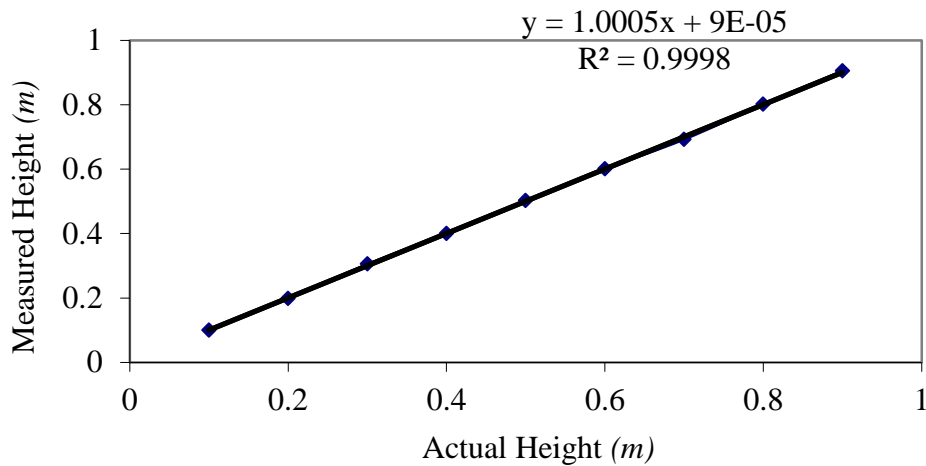

Figure 9: Actual value versus reading value.

According to the experimented data collected the percentage error is less than 1%. This shows that the proposed flood level monitoring system is 99% efficient. The relationship of sensor height versus the actual height (manual) in metres is

$$\text{Sensor height} = 1.0005 \times \text{Actual height} + 5 \times 10^{-9} \qquad (6)$$

7.0 Conclusion

This paper presents the design of a new Flood Level Monitoring System and discusses its implementation. The paper also successfully verifies the reliability of the system with experimental results. The design objectives are fully achieved, the system is 99% efficient and the whole system can be setup with a very low cost. Moreover the alarm system was was dovetailed to the flood level monitoring system in order to further alert the neighbourhood at certain predetermined height. The alarm is activated by switching on a siren. This monitoring system is a faster and cheaper way of alarming the relevant stakeholders and hence help prevent the loss of lives and damage to properties.

8.0 References

1. Shaolong, S., Pengxiao,C (2010) "A real time flood monitoring system based on GIS and Hydrolocical model", IEEE Conference on Environment Science and Information Application technology, 605-608.

2. Liang, G., Mioc, D., Anton, F., Nikerson, B.G. (2007) "Decision Support for Flood Event Prediction and Monitoring" IEEE Xplore, 2439-2442.

3. Bach, H., Appel, F., Fellah, K., Fraipont, P. (2005) "Application of Flood monitoring from Satellite for Insurances" IEEE Xplore, 63-66.

4. Wikipedia: [Online] http://en.wikipedia.org/wiki/Mobile_telephony , September 2011.

5. Ur-Rahman, M.W., Ahmed, M.T., Khan, T.H., Kabir, S.M.L. (2009) "Design of an Intelligent SMS based Remote Metering System", IEEE Conference Information and Automation. 22-24

6. Abdollahi, A.,Dehghani, M., Zamanzadeh, N. (2007) "SMS-Based Reconfigurable Automotic Meter Reading System", IEEE International Conference on Control Applications. 1103-1107.

7. Xuemei, L., Yuan, Q., Wu, W., Peng, X., Hou, L. (2011) "Implementation of GSM SMS Remote Control System Based on FPGA", Information Science and Engineering, 2132-2135.

8. Jin,S., Jingling, S., Qiuyan, H., Shengde, W., Yan, Y. (2007) "A Remote Measurement and Control system for Greenhouse Based on GSM-SMS", International Conference on Electronic Measurement and Instruments, 82-84

9. Azid, I.S., Kumar, S., (2011) "Analysis and Performance of a low cost SMS based Home security system", International Journal of Smart Home. 5(3) 15-24

10. Zhao, Y., Ye, Z., (2008) "A Low Cost GSM/GPRS Based Wireless Home Security System", IEEE Transactions on Consumer Electronics, 54(2) 567-572

11. Ali, A.R., AL-Roshan, A., Mohandas,M. (2004) "GSM-Based Wireless Home Appliances Monitoring and Control System". Information and Communication Technologies. 237-238.

12. Gill,K., Yang.S., Yao,F., Lu, X., (2009) A Zigbee-Based Home Automation System, IEEE Transactions on Consumer Electronics, 55(2) 422-430

13. Bula Internet (2004), Fiji ICT Case Study, International Telecommunication Union.

14. Integrated Silicon Pressure sensor, on chip signal conditioned, Temperature compensated and calibrated, Freescale semiconductor, Motorola Inc 2002.

15. Liquid Level Control Using Motorolla Pressure Sensor, Freescale semiconductor, Motorola Inc, 2002.

16. PIC 16F877, data sheet, Microchip Technology Inc, 2003.