ISSN:0975-9646

Tank Water Level Monitoring System using GSM Network

Ayob Johari, Mohd Helmy Abd Wahab, Nur Suryani Abdul Latif, M. Erdi Ayob, M. Izwan Ayob, M. Afif Ayob, Mohd Norzali Haji Mohd
Faculty of Electrical and Electronic Engineering,
Universiti Tun Hussein Onn Malaysia,
86400 Parit Raja, Batu Pahat, Johor, MALAYSIA.

Abstract- **Unexpected shortage of water supply is common phenomena especially in dense population such as in hostels. Water supply at the students' hostels is usually drawn from tank at the roof top of the building. Apparently there is no early warning system to monitor the tank water level when it has reached the critical level. The situation worsened when there is no personnel or technician in-charge to do the maintenance at the time it is needed. It becomes worst especially at the week ends and public holidays. Students have to wait for couples of days for the water supply to resume. This paper presents the development of water level monitoring system with an integration of GSM module to alert the person-in-charge through Short Message Service (SMS). The water level is monitored and its data sent through SMS to the intended technician mobile's phone upon reaching the critical level. The prototype was tested and functioned properly as a mean to reduce the risk of unexpected shortage of water supply.**

Keywords: Water tank, GSM Network, SMS, water supply

INTRODUCTION

Students' hostels are usually provided with water tanks and placed at the roof top of hostel buildings. Water from main inlet is pumped up to the tanks using electrical water pump. Water supplies to most part of the hostels are drawn from the tanks by means of gravity. When there is power failure, no water is pumped up to fill the tanks. As a result the water level in the tank reduces gradually. The situation becomes worse especially at the week ends and public holidays when most of the hostel residences are in. The water level of the tank reduces drastically and within short period of time the water runs out. Unexpected water shortage does occur any time if the tank is not properly monitored. Hence, a monitoring system to monitor the tank water level has to be developed and eventually able to alert the person in-charge or technician on the current status of the tank. The system consists of water level detector circuitry integrated with GSM module. Upon reaching the critical water level in the tank, an SMS is sent through GSM module to the technician in-charge for further action.

RELATED WORK

This section describes some previous works related to the monitoring system using GSM network services.

The work presented by [1] has developed a Prepaid Water Meter System for prepaid billing of water consumption through remote monitoring without any human intervention. This system promises fast and accurate billing of water as well as preventing any misuse of it. However, [2] developed a water meter reading using GSM network that suitable for remote places to monitor the water meter reading before any billing process. This could reduce the use of human resource for reading the meter and issuing a bill. There was also a work on monitoring of electrical meter reading using GSM network done by [3]. The system was capable of monitoring the meter reading and sent an SMS to the authorized center for billing purpose. This could reduce the number of estimated reading when the authorize person unable to reach the meter.

Another work presented by [4] using wireless text messaging system to send early warning SMS messages to users advising them to proactively reduce their power consumption before system capacity is reached and systematic power shutdown takes place. This could increase cost-effective wireless distributed load shedding system for non-emergency scenarios.

In smart home application, the work presented by [5] was a design on a system to control home appliance remotely and provide security when the owner is away from the place. The similar work presented by [6][7] which designed and developed a smart home application system. The system allows the homeowner to be able to monitor and control the house appliances via a mobile phone set by sending commands in the form of SMS messages and receiving the appliances status.

METHODOLOGY

A. *Flow of the system*

This project operates in a condition of low water level. Water detector detects the water level and then sends signal to microcontroller unit. The microcontroller circuit sends signal to GSM modem and then GSM modem sends SMS to the person in-charge mobile phone. The mobile number of the user has been set in AT command of PIC16F877A and sends alert

messages of the status of the current water level. The serial port connects GSM modem for communication (Figure 1).

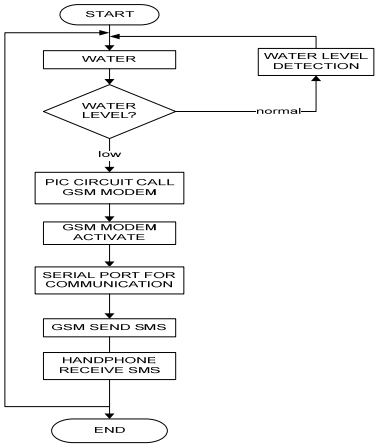

Figure 1. System flow

B. Water Tank

The water level detector is triggered when it touches the water level at specified level (Figure 2)[8].

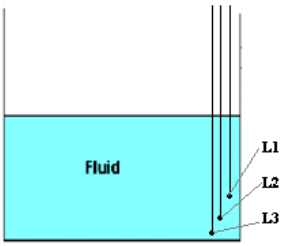

Figure 2. Water level detector

Figure 2 illustrates the three low levels of the water in the tank that to be alerted. The three levels are called as *low level, L1*, *very low level, L2* and *critical level L3*. A signal is sent to each detector circuit and sent notification to microcontroller when it does not detect any water. From the microcontroller, the signal is sent to GSM and to person in-charge in a form of SMS. There are three sequences of SMS sent to the person in-charge to alert the level of the water tank.

C. Microcontroller

PIC16F877A was used in a microcontroller circuit for processing unit. PIC microcontroller is used as a central processor because its capability to operate without other external components due to all necessary peripherals is already built into it. Thus it reduce time and space required to construct the device. This PIC works on a 5V DC power supply, with a 20 MHz crystal oscillator and 2 units of 22pF capacitors (Figure 3)[9][10].

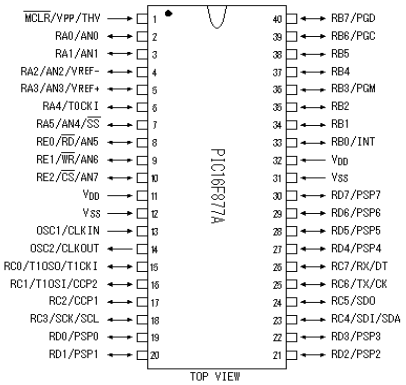

Figure 3: PIC16F877A pin

D. Sony Ericsson

Figure 4. Sony Ericsson K700i

Mobile phone model Sony Ericsson K700i as in Figure 4 was used as a GSM modem [7]. This model has already a built in modem and provides a serial data cable to communicate with microcontroller circuit with IC MAX232. It can be connected through the data cable to the microcontroller unit.

E. PCB Fabrication

There are few steps to implement a printed circuit board (PCB) be it a single layer or double layer PCB. The layout or schematic diagram was designed using Proteus. The image of the artwork is transferred to the circuit board using photolithography process. Then, the etching process took place before assembling and soldering the components on to the board.

F. Power supply for circuit

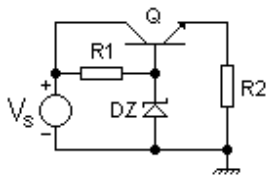

Figure 5. A simple voltage regulator

Adding an emitter follower stage to the simple zener regulator forms a simple series voltage regulator and substantially improves the regulation of the circuit. Here, the load current I_{R2} is supplied by the transistor whose base is now connected to the zener diode. Thus the transistor's base current (I_B) forms the load current for the zener diode and is much smaller than the current through R2. This regulator is classified as "series" because the regulating element, viz., the transistor, appears in series with the load. R1 sets the zener current (I_Z) and is determined as

$$R1 = \frac{V_S - V_Z}{I_Z + K.I_B} \text{----------(1)}$$

where, V_Z is the zener voltage, I_B is the transistor's base current and K = 1.2 to 2 (to ensure that R1 is low enough for adequate I_B).

$$I_B = \frac{I_{R2}}{h_{FE(min)}} \text{----------(2)}$$

where, I_{R2} is the required load current and is also the transistor's emitter current (assumed to be equal to the collector current) and $h_{FE(min)}$ is the minimum acceptable DC current gain for the transistor (Figure 6).

A 9V power supply unit functions as power supply to the circuit and to PIC16F877A. LM7805 regulator is used to provide a stable 5V (VCC) to the microcontroller.

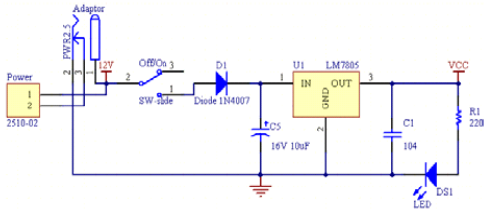

Figure 6. Circuit of 5V power supply

G. Input for PIC microcontroller

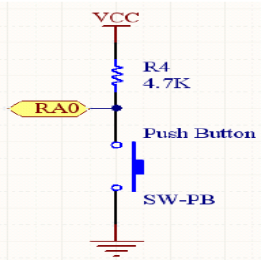

Figure 7. Input for microcontroller

One I/O pin is needed for one push button as input for PIC microcontroller. The connection of the push button to the I/O pin is pulled up to 5V using a 4.7 kΩ resistor. When button is pressed, I/O pin turn to logic 0, while when the button is not pressed, the I/O pin turn to logic 1.

H. LED as Output for PIC microcontroller

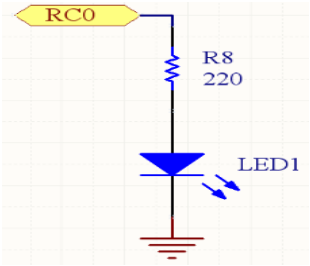

Figure 8. Output for PIC microcontroller

One I/O pin is needed for one LED as output for PIC microcontroller. The connection for a LED to I/O pin is shown in Figure 8. The function of R8 is to protect the LED from over current that will burn the LED. When the output is in logic 1, the LED will ON, while when the output is in logic 0, the LED will OFF.

I. Circuit Operation

i) Microcontroller GSM circuit

PIC 16F877A microcontroller was used for the GSM circuit. It has 40 pins for multipurpose usage.

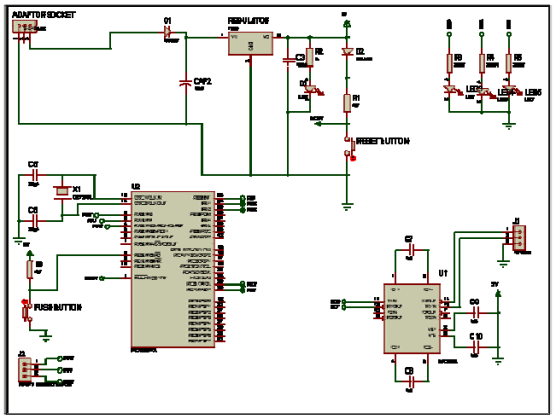

Figure 9. Circuit of a GSM

Three of the pins at port A were used as an input from water level detector. RA0, RA1 and RA2 pins were input from water level detector circuit. Pin 13 and pin 14 were connected to 20 MHz crystal oscillator for delay. Pin no 1 was connected to MCLR (Master Clear) and at pin RE0 there was reset button to reset the activity loop done by the microcontroller. Port B was used as an output for PIC microcontroller and sent signal to GSM phone. Besides, the microcontroller interact with MAX232 at port C; RC6 as transmitter and RC7 as receiver (Figure 9)[7][11].

For the MAX232 IC operation that act as a driver/receiver, the receiver and transmitter pin were used to receive and transmit data from GSM modem interconnected with female 9 pin connector. The signal from the microcontroller was connected to the receiver of MAX232 through pin R1OUT before converting the signal level, sent to the GSM modem through pin R1IN and finally sent SMS to the person in-charge hand phone.

ii) Water Level Detector Circuit

A 9V relay SPDT was used as an input switch for the water level detector to the microcontroller circuit.

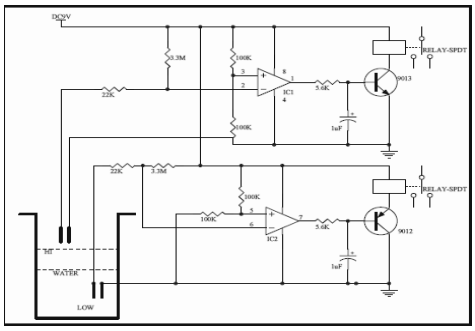

Figure 10. Water Level Detector Circuit

The signal is sent to microcontroller circuit when switch is open. The relay energized when bare wire detect water and closed the relay switch and otherwise. There are three stages of the water level connected to the input Port A of the microcontroller. The circuit used 9V DC as the power supply (Figure 11).

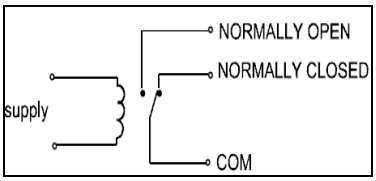

Figure 11. Normally closed relay concept

RESULT AND ANALYSIS

The system consists of three different circuit boards namely the detector relay and circuit boards and microcontroller circuit boards. The three were assembled and connected to the GSM modem. Figure 12 and 13 show the microcontroller and detector circuit boards respectively whereas the complete assembled circuit board is shown in Figure 15. A series of tests were carried out on each of the individual board as well as the final assembled board.

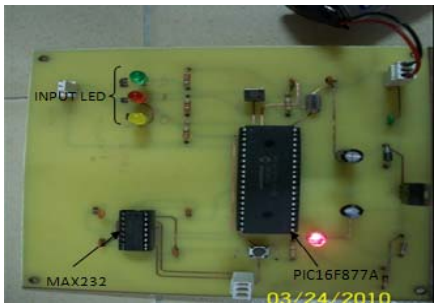

Figure 12. Microcontroller circuit

Three LEDs were used to show whether there are inputs to microcontroller from the detector circuit. Figure 13 shows that there was an input voltage from the detector circuit as indicated by illuminated LED.

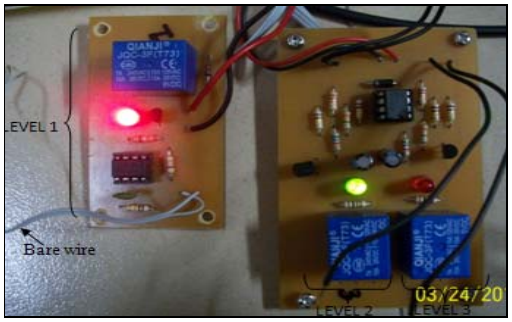

Figure 13. Detector circuit

The LED would turn ON if the bare wire at each level did not detect any water and then sent signal or notification to the microcontroller.

Figure 14. Complete circuit

The assembled circuit is connected to 9V DC supply. Figure 15 shows the voltage level of the 9V supply.

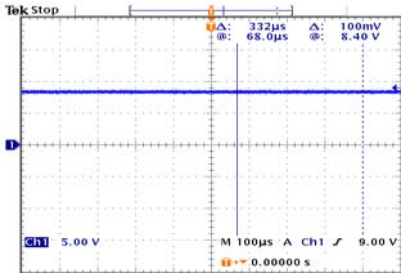

Figure 15. Power supply output graph

The microcontroller operates at 5V. It is obtained from 9V supply with the use of IC regulator LM7805 that reduced to 5V. Figure 16 shows that the waveforms of voltage supply for PIC microcontroller.

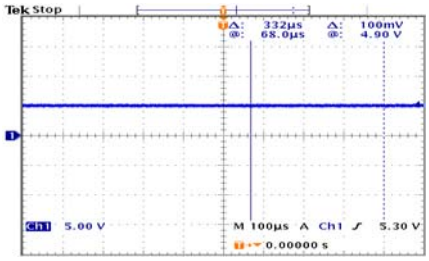

Figure 16. Voltage supply 5V to microcontroller

A 4 MHz crystal oscillator is used for this project. Figure 18 illustrates the crystal oscillator waveform operates at 4.007 MHz. It was used to create an electrical signal with certain frequency value.

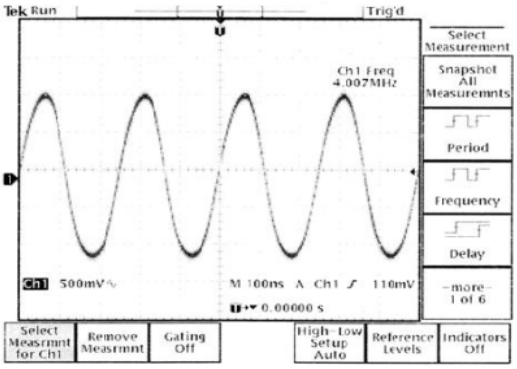

Figure 17. Crystal oscillator waveform

A. PIC16F877A Microcontroller

The microcontroller program was written using MPLAB as illustrated in Figure 18. It can be seen that the program is successfully executed. Test was conducted on the microcontroller and was properly functioned to control the main circuit system after the program has been loaded into the PIC.

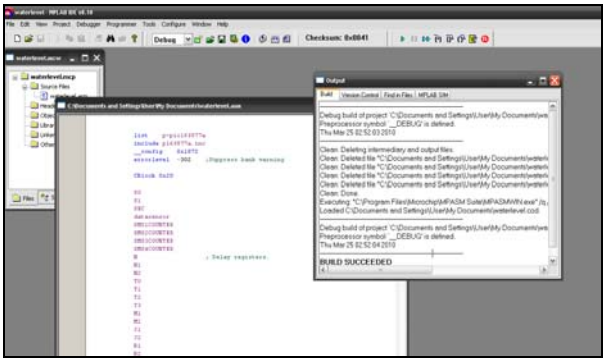

Figure 18. Programming for PIC16F877A

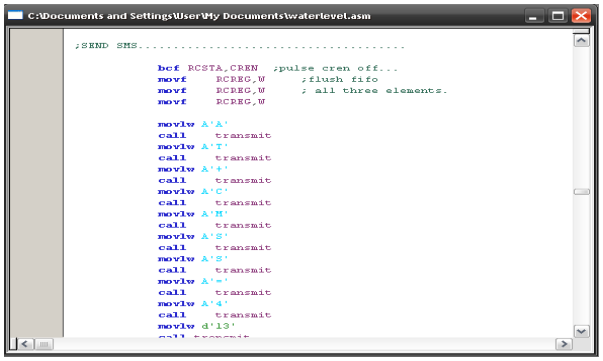

Figure 19. AT Command for Send Message

In the PIC microcontroller, GSM AT command was used to communicate through mobile phone. Since Sony Ericsson K700i hand phone was used as a replacement of GSM modem, the AT commands of the mobile phone were used as GSM communication information node. Table 1 shows the AT command used in microcontroller programming of the project.

Table 1: AT command

No	Command	Possible Response
1.	AT	Initial HyperTerminal
2.	+ CMGR	Read Message
3.	+CMGS	Send Message
4.	+CMSS	Send Message From Storage
5.	+CMGD	Delete Message

The baud rate selected for this program is 9600bps. The baud rate of 9600 bps allow the cable for maximum of 15m long to transfer data trough the serial cable RS232.

B. Calculation of water tank

i) Rectangular tank volume

Formula used:

Tank volume = Width × Length × Height
Width: 14cm = 0.14m
Length: 24.5cm = 0.245m
Height: 21.5cm = 0.215m
Volume: 14×24.5×21.5 = 7374.5cm³ = 73.745m³

Level 1:

Height of water: 6cm = 0.06m

Volume of water = 14×24.5×6= 2058cm³ =20.58m³

Level 2:

Height of water = 4cm= 0.04m
Volume of water = 14×24.5×4 = 1372cm³ = 13.72m³

Level 3:

Height of water = 2cm= 0.02m
Volume of water = 14×24.5×2 = 686cm³ = 6.86m³

CONCLUSION AND RECOMMENDATION

This paper has achieved its objectives and provides a system that could monitor the tank water level and report its level via SMS notification using GSM technology. It is developed with a capability to detect low level of the water in the tank and notify GSM modem to send SMS to the intended user hand phone or person in-charge. The microcontroller as central processor is connected to the modem using MAX232 to interface with HyperTerminal to check the microcontroller operation. A series of tests were conducted and found that the system was functioning well. However at times, delay in receiving SMS had occurred and it could be due to detector circuit, the programming of the PIC, and the soldering of the components connection on the prototype PCB.

REFERENCES

[1]. Islam, N.S. Wasi-ur-Rahman, M. An intelligent SMS-based remote Water Metering System. 12th International Conference on Computers and Information Technology, 2009, 21-23 Dec. 2009, Dhaka, Bangladesh.

[2]. Mohd Helmy Abd Wahab, Siti Zarina Mohd Muji, Fazliza Md. Nazir. Integrated Billing System through GSM Network. In Proceeding of 3rd International Conference on Robotics, Vision, Information and Signal Processing 2007 (ROVISP2007), Penang, 28 – 30 November 2007

[3]. Mohd Helmy Abd Wahab, Azhar Ismail, Ayob Johari and Herdawatie Abdul Kadir. SMS-Based Electrical Meter Reading. In Proceeding of International Conference on Rural Information and Communication Technology 2009 (r-ICT), 17 – 18 June 2009, Bandung, Indonesia

[4]. Taha Landolsi, A. R. Al-Ali, Tarik Ozkul, and Mohammad A. Al-Rousan. Wireless Distributed Load-Shedding Management System for Non-Emergency Cases. International Journal of Electrical and Electronics Engineering 4:7 2010. pp. 453 – 460.

[5]. Malik Sikandar Hayat Khiyal, Aihab Khan, and Erum Shehzadi." SMS Based Wireless Home Appliance Control System (HACS) for Automating Appliances and Security", *Issues in Informing Science and Information Technology*. Vol. 9. pp. 887 – 894. 2009.

[6]. Al-Ali, A.R. Rousan, M.A. Mohandes, M. "GSM-Based Wireless Home Appliances Monitoring & Control System", *Proceedings of International Conference on Information and Communication Technologies: From Theory to Applications*, pp 237-238, 2004.

[7]. Lawrence Harte, Richard Levine and Geoff Livingston, "GSM Superhome", McGraw-Hill, 1999.

[8]. Shao-Quan Lu,"A Circuit for Water Level Detection and Control", HOLTEK, White paper

[9]. Martin Bates, " Interfacing PIC Microcontrollers ; Embedded Design by Interactive Solution", Newnes

[10]. Dogan Ibrahim, " PIC BASIC; Programming and Projects", Newnes, 2001