

Design of Embedded Web monitoring System to measure pH of water using Wireless Sensor network for Hydroponics applications

Shashikumar.R^{#1}, Pradeep Karanje^{*2}, Girish L^{*3}, T Eswaran^{*4}, Manjunatha L H^{*5}

1. Professor, School of ECE, REVA University, Bangalore, Karnataka, India, 2. Associate Professor, E&CE department, Gurunank Dev Engineering College, Bidar, Karnataka, 3. Professor and Head, Department of Mechanical Engineering, PESITM, Shivamogga, Karnataka, 4. Principal, TSM Jain College of Technology, 5. Professor, School of Mechanical Engineering, REVA University, Bangalore, Karnataka, India

Abstract

This paper mainly focuses on remote monitoring of pH value of water. Although it is perhaps one of the most important aspects, pH is very important in hydroponic and organic as well as regular soil gardening. We have proposed a low cost solution for measurement of pH using ARM LPC2148 at the base station and ARM9 mini2440 board at the server side. There are many advantages of growing vegetables and fruits hydroponically compared to soil. Our work is to design a Wireless sensor network (WSN) based embedded system for remote monitoring since; hydroponic is one of the emerging methods in agriculture field. The Zigbee has been used for wireless communication

Keywords— pH value, Hydroponics, Web server, Wireless sensor network, mini2440.

I. INTRODUCTION

The Plants are greatest gift for animals including human beings and they are also called as food factories. The growth of animals including human beings mainly depends on plants. These plants produce food and energy by using earth's chemicals with water, gases in the air and sun light. Water is the basis of life for plants and animals. In nature, water acts to recharge the soil with nutrients. Organic wastes in the soil are biologically decomposed into the basic nutrient salts that plants feed on. Soil is mainly used in traditional method of growing vegetable plants. Vegetables grown in soil must be well spaced apart for proper distribution of necessary water and nutrients.

For growing of plants, nutrients must reach properly to the roots of plants and this is possible with hydroponic method. In Hydroponics, this natural process is bypassed by providing these basic nutrient salts in a balanced solution form directly to the plant roots. This method has lot of advantages compared to soil gardens. The space required for hydroponic garden is less compared to soil garden. The plants will grow fast and gives more yields. There is no wastage of water and they are closely placed. It also avoids use of pesticides since there is no contact with soil.

1) *Hydroponics in India*

Hydroponics in India is not that much popular and most of the people have not aware of this. Proper support and guidance is essential to adopt this method for more production of fruits, vegetables, herbs and flowers. Using hydroponics, one can involve with less effort for the grow of most house plants, flowering plants, vegetables, several different kinds of fruits and many different kind of herbs for seasoning or health purposes.

Some of the Vegetables have been easily grown hydroponically in India are carrot, beans, potatoes, tomatoes, radish, cabbages, cucumber, onions etc.

2) *Importance of pH*

pH is very important in hydroponic and organic as well as regular soil gardening. pH is measured on a scale of 1-14 with 7 being neutral. Acids are lower than 7 and alkalis (bases) are above 7. Pure water has a balance of hydrogen (H⁺) and hydroxyl (OH⁻) ions and is therefore pH neutral (pH 7). When the water is less than pure it can have a pH either higher or lower than 7. Some of the pH values are listed in table 1 and pH value for ground water ranges from 6 - 8.5.

TABLE 1

pH VALUE

Sl.no	Plants	pH value
1	Beans	6
2	Cabbage	6.5 - 7
3	Capsicum	6 – 6.5
4	Carrots	6.3
5	Onions	6 -6.7
6	Potato	5 - 6
7	Radish	6- 7
8	Tomato	5 -6

II. IMPLEMENTATION BLOCK DIAGRAM FOR THE pH MEASURMENT AT HYDROPONIC GARDEN

The pH electrodes are used for measuring the pH value. A pH sensor has a battery in which the positive terminal is the measuring electrode (pH electrode) and the negative terminal is the reference electrode. The pH electrode develops a voltage directly related to the hydrogen ion concentration of the solution, which is highly sensitive to hydrogen ion. The voltage signal is directly proportional to the pH level in the water, which is in range of mV. The operational amplifier has been used for amplifying the signal for measurable quantity. The amplifier is constructed by the OP07 operational amplifier. The voltage is given to related circuit in order to find the pH level in the water or solution.

The implementation block diagram at the base station is as shown in figure 1, which mainly consists of pH sensor, Amplifier circuit, LPC2148 microcontroller board, Zigbee wireless module.

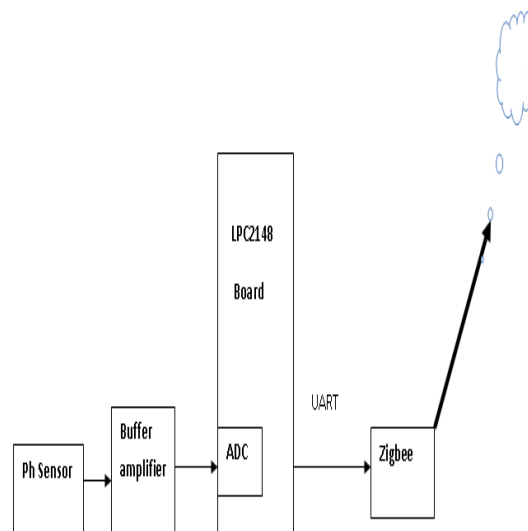


Fig.1 Block diagram of WSN at base station

The voltage produced by pH electrode is in mV; therefore amplifier is needed to boost the signal. The output of the amplifier is analog one converted into digital value by giving signal to the ADC of LPC2148 microcontroller. The processed digital value of pH is transmitted to server side for monitoring in the internet by using Zigbee wireless module.

III. IMPLEMENTATION BLOCK DIAGRAM FOR THE pH MEASURMENT AT SERVER SIDE

The receiver side is as shown in figure 2, consists of Zigbee, mini2440 ARM9 linux board and PC. The pH value transmitted from the transmitter is received by the Zigbee, which is connected to UART of the mini2440 board. The value has read and stored. The CGI program has been written to update the value in web page. The simple web page has been created by using HTML program.

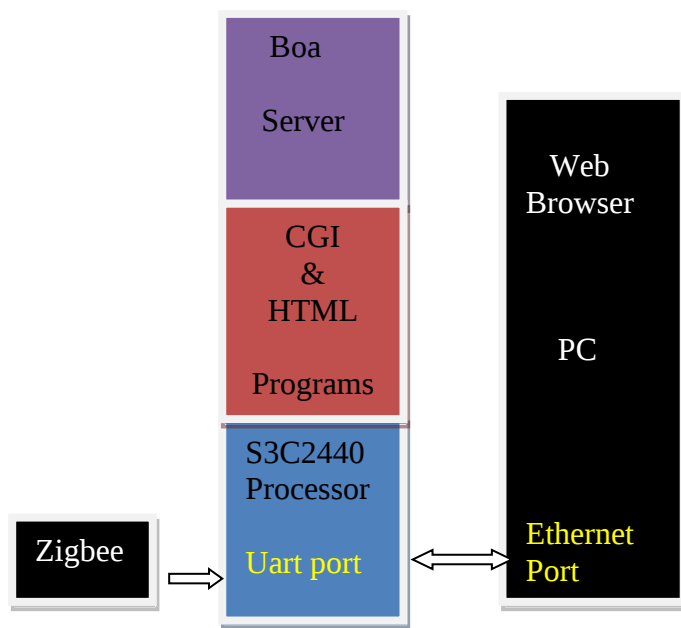


Fig. 2 Server side block diagram

IV. HARDWARE AND SOFTWARE USED

We have been used two different setups for our work, one at the hydroponics garden and other one at the server side. The pH sensor, ARM LPC2148 board and Zigbee used at the transmitter side. The ARM9 mini2440 board and Zigbee wireless module at the server side.

A. ARM LPC2148 board

The LPC2148 is ARM based 32bit ARM7TDMI-S CPU with real-time emulation and embedded trace support. It has embedded high speed flash memory ranging from 32kB to 512 kB and on-chip SRAM of 8 kB up to 40 kB. It has various serial communications interfaces ranging from a USB 2.0 full Speed device, two UARTs, SPI, SSP and I2Cs. This device very well suited for communication gateways and protocol converters, soft modems, voice recognition and automation products. Various 32-bit timers, single or dual 10-bit ADC(s), 10-bit DAC, PWM channels and 45 fast GPIO lines with up to nine edge or level sensitive external interrupt pins make these microcontrollers particularly suitable for agriculture, industrial control and medical systems.

B. ARM9 MINI2440 board

ARM9 mini2440 is a practical low-cost ARM9 development board. It has Samsung S3C2440 processor and On-board 64 MB SDRAM. Some of the board features which includes:

- 100 Mbps Fast Ethernet RJ-45 interface (used network chips DM9000)
- Serial ports
- USB host
- USB slave (B-type interface)
- SD card storage interface
- Channel stereo audio output interface, all the way microphone interface
- 10-pin JTAG interface
- adjustable resistor, analog-to-digital converter for A/D test
- I2C-bus AT24C08 chip for I2C-bus test
- 2.0 mm pitch 20-pin camera interface
- On-board real-time clock battery

Software: To work with mini2440 board, we have to setup tool chain. We need to download two packages:

- ✓ ARM-Linux-gcc <http://www.friendlyarm.net/dl.php?file=arm-linux-gcc-4.3.2.tgz>

This package is used to setup the cross compiler compatible for arm 9

- ✓ Cross compiler tool chain – Download from the site
<http://ftp.arm.linux.org.uk/pub/armlinux/toolchain/cross-2.95.3.tar.bz2>

This package is used to setup the cross compiler compatible for Linux.

The keil4 uVision has been used for compiling the programs and flash magic tool has used to download hex file to the LPC2148. The CGI and HTML programs have been written in C language and boa server has used to display pH value in web page.

V. RESULTS AND DISCUSSIONS

The measurement of pH value requires pH sensor, buffer amplifier, ARM LPC2148 board and Zigbee wireless module. The complete set up for the measurement of pH value is as shown in figure 3.



Fig. 3 Complete set up for pH measurement

The Keil4 uVision software has been used for compilation and generation of hex files. The program has been written in C programming language. The flash magic software has been used for downloading generated hex file into LPC2148. The USB-serial converter has used for connection to the laptop. The UART0 port of ARM LPC2148 is connected to Zigbee module and The ADC Ch0 of ARM LPC2148 is connected to pH sensor. We cannot measure directly from the pH sensor, since the output is in mV. The operational amplifier has used to increase the signal value. The output of the OPAMP is connected to ADC to get the digital value.

The normal value for ground water is in the range from 6 – 8.5 and measured pH value for ground water is 7.6. The figure 4 shows the LCD display of the measure value.



Fig. 4 pH value displayed on LCD

The measured pH value is transmitted by Zigbee wireless module connected from the transmitter side. The Zigbee module connected at the server side receives the data and which is connected to the UART port of ARM9 mini2440 board. The receiver side setup consists of Zigbee and ARM9 mini1440 board is as shown in figure 5. The three different programs have been written for the receiver side.



Fig. 5 Receiver side setup

Before we start to work with the board, the linux OS has been loaded to the board by using DNW software and also we have to set up arm tool chain in our laptop. The connection has been established between board and laptop through Ethernet. The command “**sudo minicom -s**” is used for setup connection between them. This has shown in figure 6.

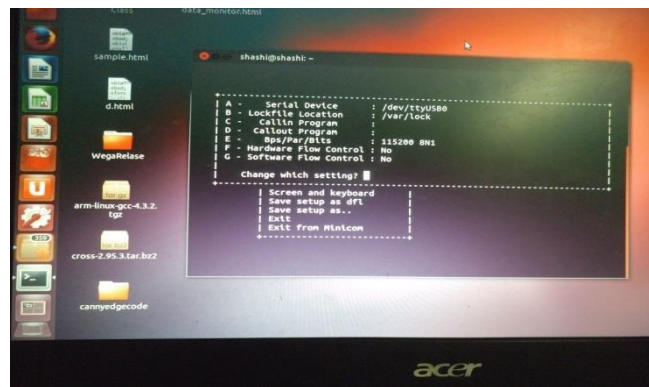


Fig. 6 To establish connection between board and PC

Once the booting has completed, the board is ON with a folder **root@FreindlyARM** as shown in figure7



Fig. 7 board is ON

The program has written for UART communication, which receives the data from the Zigbee module connected to UART port. The CGI and HTML programs are written for displaying the value in web page. The measured value is displayed on web page as shown in figure 8. Now we can monitor the values in internet.

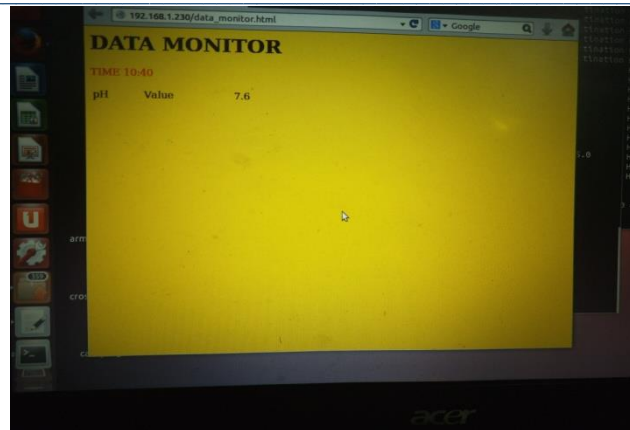


Fig. 8 Value displayed on webpage

The complete set up for the server side is as shown in figure 9.

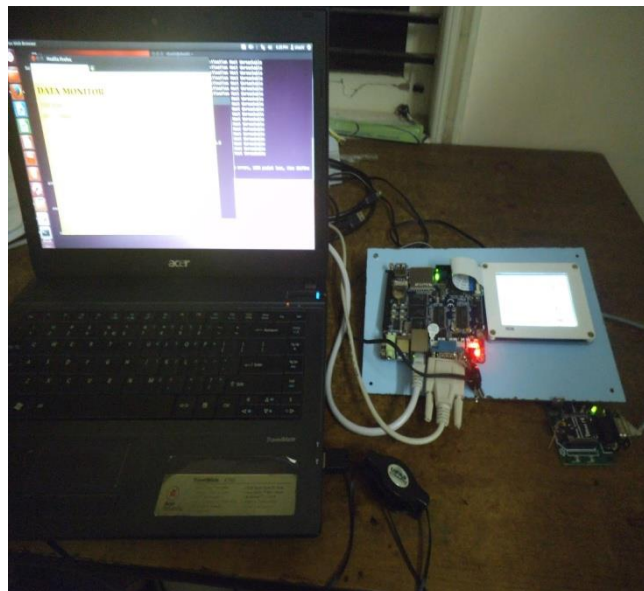


Fig. 9 Server side setup

VI. CONCLUSIONS

The pH value has been measured successfully in remote place and monitored using web browser. This work provides a low cost wireless monitoring system for measurement of pH value using Zigbee. This can be suitable for hydroponics garden in India.

One could write good HTML code for the display of pH value. By monitoring we can also automate the control system for water distribution.

REFERENCES

- [1] I. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, "A survey on sensor networks," IEEE Communications Magazine, Volume: 40 Issue: 8, pp.102-114, August 2002.
- [2] A. Mainwaring, J. Polastre, R. Szewczyk, D. Culler, and J. Anderson. 'Wireless Sensor for Habitat Monitoring'. ACM International Workshop on Wireless Sensor Networks and applications, 2002.
- [3] Kavi K. Khedo, Rajiv Perseedoss and Avinash Mungur "A wireless sensor network air pollution monitoring system" International Journal of wireless and mobile networks (IJWMN) Vol.2, No.2, May 2010.
- [4] ARM LPC2148 keil.com/dd/chip/388www0.htm .
- [5] www.nxp.com/documents/data_sheet/LPC2141_42_44_46_48.pdf
- [6] www.zigbee.org.

- [7] D.D.Chaudhary, S.P.Nayse, L.M.Waghmare “*Application of wireless sensor networks for greenhouse parameter control in precision agriculture*” International Journal of Wireless & Mobile Networks (IJWMN) Vol. 3, No. 1, February 2011.
- [8] <http://www.homehydrosystems.com/links-resources/links-resources.html>.
- [9] “*ARM downloading manual*”
- [10] [10] “ARM mini2440 manual ”