

# Closed Loop Control System and Remote Monitoring In Agriculture for Social Modernization

Siva Naga Syam Kumar Periseti, P.Sudhakara Rao

M.Tech,

Department of Electronics & Communication

Nova College of Engineering

Ibrahimpattanam, Vijayawada

[Syam.periseti@gmail.com](mailto:Syam.periseti@gmail.com)

Associate professor,

Department of Electronics & Communication

Nova College of Engineering

Ibrahimpattanam, Vijayawada

Sudhavasi718@gmail.com

**Abstract**—In agriculture field, the current agricultural practices need to intensify the rate of food crop production for the rate of population growth with available resources. This paper describes the automated system to make effective utilization of water resources for agriculture and crop growth monitoring using GSM and Zigbee technology. Firstly, this system utilized rainwater from the harvest rainwater tank for irrigation and then bore well water has been used. The water use efficiency is increased in drip irrigation system by using soil moisture sensor, humidity sensor and temperature sensor. The signals from the sensors are coordinated by the microcontroller and transmitted to irrigation control centre (ICC) through Zigbee wireless radio communication. The optimized water use for an agriculture crops has been achieved in the ICC successfully. The growth status of the crop also monitored using IR transceiver. The device that can report data to the cultivator remotely and the system allow them to effectively control through GSM.

**Keywords**—Agricultural practices; Water resources;

Crop growth monitor; GSM, Zigbee; Drip irrigation; Soil moisture sensor; Water use efficiency; IR transceiver

## I. INTRODUCTION

At present, water use is growing at more than twice the rate of population increases. Due to the shortage of water resources, we need water saving irrigation technology for agriculture. Irrigation is a scientific process to supplying water to the agriculture land that is being cultivated. The dry regions having very little amount of water and that has to be utilized very efficiently. In conventional water irrigation system is wasting the water and drip irrigation systems use 20 - 30% less water than conventional watering methods. Therefore, the conventional method can be replaced by drip irrigation technology [1]. A new idea for saving each drops of water by the way to test the soil conditions before supplying water to the crop fields. This mechanism will reduce the workload of the cultivator and help maintain suitable soil conditions for the better crop production [2]. Hence the technology advancement is possible to design systems that eradicate the direct involvement of the cultivator with respect to irrigation of their fields.

For the sustainable use of water resources, the rainwater is

generally stored in a rainwater tank and it is used for irrigation or directed to recharge groundwater. Firstly the rainwater is used for agriculture in rainy seasons and the well or bore well water is used for other times. The crop growth rate (CGR) can also monitored using the IR transmitter and receiver system. The whole sensor network has analyzed by the microcontroller and sends the sensors information to irrigation control centre (ICC) through Zigbee technology. Zigbee technology has low cost, low power consumption and wireless communication which could replace the wired connections in the traditional system.

In ICC, the entire drip irrigation is controlled by the electromagnetic actuators. The ICC has two technologies one is global system for mobile communication and secondary one is the ARM controller. This GSM facility serves as an important part for controlling the drip irrigation which sending the results to the cultivator using SMS to a mobile device [3,4]. Then the user controls the entire agriculture irrigation system through SMS. The

controller works as a central core for operation of the automated process which is initiated by the sensor networks. Based on the crop field conditions the ARM controller used in ICC is activates the drip irrigation system and their respective valves [2].

## II. SYSTEM ARCHITECTURE

In the automated system, the human factor is reduced by a microcontroller which is specially programmed to monitor any parameter changes in sensors. The function of microcontroller depends on the data of sensors from crop field units and the corrections are made by control devices in the irrigation system until the desired performance to be attained. This automatic system can also be stopped in case of rain, cyclone and crop cutting time, etc by the cultivator through SMS.

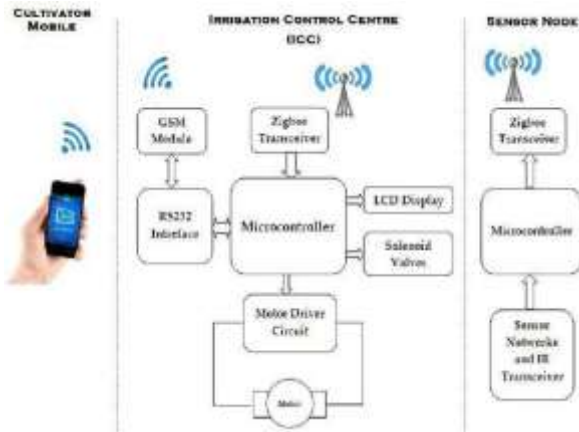


Fig.1. Remote monitoring and closed loop irrigation system

The remote monitoring and closed loop irrigation system is shown in Fig. 1 which consisted of three components: a remote sensor node, a system control module called ICC, and a GSM mobile device. The amount of water required for a crop varies in various growth stages, different in soils and climate changes. The sensor node is placed in each crop field which is continuously collect soil parameters and crop growth. The sensor node consists of soil moisture sensor, humidity sensor, temperature sensor, IR transceiver, Zigbee transceiver and microcontroller. The value of air humidity is important for the correct growth of plants and high air temperature leads to affect the crop yields. High soil moisture will produce high evaporation and reduced the nutrient uptake. The soil parameters and crop growth status are collected by microcontroller and send these data to irrigation control centre through Zigbee wireless serial communication technology.

In irrigation control centre (ICC), the soil parameters, crop growth status, cultivator's control information from GSM are analyzed by the microcontroller. The ICC consists of motor driver unit, solenoid valves with driver, LCD module, Zigbee transceiver, GSM module and

microcontroller. The sensor measurements are transmitted to ICC by sensor node and are received through Zigbee transceiver. The electric solenoid irrigation valves should be installed at the closest point possible to outlet of pump set, that is, the location where you tap in for the irrigation system. ICC turns on the pump according to soil parameters. The valves are operated by 12V driver circuit by the controller which integrates all the environmental information through suitable control algorithms. The gateway allows the activation of automated irrigation when the threshold values of soil moisture, air temperature and humidity are reached. The system provides the details about the agriculture farm to cultivator though SMS by GSM and the same information are display on LCD screen. The cultivator can also sends the control command to ICC through SMS, after processing displayed it on the LCD screen.

## III. SYSTEM COMPONENTS

### A. Software Portion

The choice of a programming language for microcontrollers normally the C language, and most commercially available microcontrollers have C language compilers for the development of their programs. The closed loop irrigation system [5] is developed by the MPLAB compiler and KEIL  $\mu$ VISION4 Compiler. The MPLAB compiler consists of an integrated development environment for the windows operating system and supports the entire line of PIC microcontrollers [6]. The new KEIL  $\mu$ VISION4 by ARM IDE is to enhance developer's productivity, user friendly, faster, flexible window management system, efficient program development and support for multiple monitors. PROTEUS allows designing for circuit simulation. It has a range of simulator models for popular micro -controllers and is possible to simulate complete micro-controller systems.

The first task of the program is to transmit field parameters to ICC via Zigbee protocol. The PIC microcontroller in sensor node has pickup all the sensors information one by one and stored it in memory. This information is send to ICC through Zigbee wireless transmission. Second, the ARM microcontroller in ICC receives the data package transmitted by sensor node. These soil moisture, air humidity and temperature data are processed by the algorithm that compared with the threshold value that already stored in memory. Then it activates the irrigation pumps and respective solenoid valves. Finally, these sensor node data and a crop growth status are transmitted at each predefined time to a user mobile device through SMS via the GSM in real time. Whenever the cultivator needs the information about the crop field, they can give the missed call to ICC's GSM module [7]. The crop fields data are also send to LCD Screen.

## B. Hardware Portion

Smart sensor node is implements four types of measurements via sensors which are soil moisture, air humidity, air temperature and crop growth. The Soil Moisture Sensor is used to measure the volumetric water content of soil [8,9,10]. The SM150 measures volumetric soil moisture content with 3% accuracy. The output dc voltage range of the sensor is 0V to 1.5V. The temperature sensor AD594 is capable of measuring -55 to +125 degrees centigrade. The AD594 has a positive and negative source input. In order to receive 0 to +125 degrees centigrade, the negative input pin has to be grounded. The AD594 gives a linear DC output voltage in the range of 0V to 1.25V.

The soil humidity is measured according to the principle of electric resistance. The humidity sensor module SY-HS-220 converts the relative humidity to the output voltage. The storage humidity is within 95%RH and standard output is 1.9mV at 25 degree and 60%RH. The IR transmitter and receiver pair can be easily made using 555 Timer, IR LED and TSOP1738 IR Receiver. The four set of IR transmitter and receiver are used to measure the four stages of crop growth.

The microcontroller used in sensor node system is PIC18F4550 which is 8-bit microcontroller from PIC18 family. It is based on 16-bit instruction set architecture and it consists of 32 KB flash memory, 2 KB SRAM and 256 Bytes EEPROM. It has five I/O ports (PORTA, PORTB, PORTC, PORTD and PORTE). PORTB and PORTD have 8 pins to transmit/receive 8-bit I/O data. It can work on different internal and external clock sources range of frequency from 31 KHZ to 48 MHZ. The PIC18F4550 has four timers units, ADC, with enhanced communication protocols like USART, SPI, I2C and USB.

The LPC2148 micro-controller is used in ICC which is 32/16 bit ARM7TDMI-S CPU core. They have real-time emulation and micro-controller with embedded high speed flash memory of 512 KB. It has USB 2.0 full speed device, multiple UARTS,

SPI, SSP to I<sup>2</sup>Cs. Various 32-bit timers, dual 10-bit ADC(s), single 10-bit DAC, PWM channels and 45 fast GPIO lines with up to nine edge or level sensitive external interrupt pins, tiny size and low power consumption make these microcontrollers particularly suitable for industrial control and medical systems.

GSM module SIM900 engine works on frequencies EGSM 900 MHZ, DCS 1800 MHZ and PCS 1900 MHZ. This GSM modem is coming with RS232 interface, which allows to directly connecting with microcontroller through only two wires (TX, RX). This modem can be used to sending SMS, data and read SMS through simple AT commands.

CC2500 Zigbee RF Module is a transceiver module which provides easy to use RF communication at 2.4 GHZ. It can be used to transmit

and receive data at 9600 baud rates from any standard CMOS/TTL source and works in half duplex mode [11]. Solenoid valve is an electromechanical valve. The valve can be controlled by an electric current through a solenoid operates at 12V/500mA, in the case of a two-port valve the flow is switched off or on.

## IV. EXPERIMENTAL STUDY

The output of temperature sensor (AD594) is connected with the analog input of PIC microcontroller. The calculation of temperature in degree Celsius is expressed as,

$$T (^{\circ}\text{C}) = ((\text{ADC value} * 5\text{V})/1023) * 100.$$

The predicting growth stage is based on the Development Index Model (DVI), which is used throughout field to estimate the growth stage by means of daily temperature (DT).

$$DVI = \sum_{\text{planting date}}^{\text{cut date}} \frac{100}{A} (1 - e^{-(B(T_i - C)})}$$

Where  $T_i$  is the DT ( $^{\circ}\text{C}$ ) on the  $i^{\text{th}}$  day after cropping, and A, B, C are determined by the plant variety and the region. The solution of equation represents the speed with the crop grows, determined by the DT. In day-by-day to calculate the DVI value which represents the growth stage. The DVI value is 0 at planting, and parameters A, B, C are determined in order to set DVI value = 100 on the day of heading.

The table I shows the air temperature, soil temperature, relative humidity and soil moisture from day-1 to day-12 [12].

Fig.2 shows the relationship between air and soil temperature from day-1 to day-12. It is clear that the soil temperature varies higher than the air temperature [13]. Fig.3 shows the relationship between relative humidity and soil moisture in (%). The upper and lower limits of water storage in the soil reservoir and relative humidity have been determined in the crop field.

TABLE I. OBSERVATION OF PROTOTYPE FOR 12 DAYS

Day	Air Temp. ( $^{\circ}\text{C}$ )	Soil Temp. ( $^{\circ}\text{C}$ )	RH (%)	Soil Moisture (%)
1	30	32	90	25
2	27	30	82	22
3	29	31	95	28
4	26	28	98	36
5	28	29	51	16
6	30	32	78	14
7	31	33	85	18
8	29	30	92	33
9	31	32	83	18
10	27	29	91	32
11	28	32	80	20
12	29	31	78	21

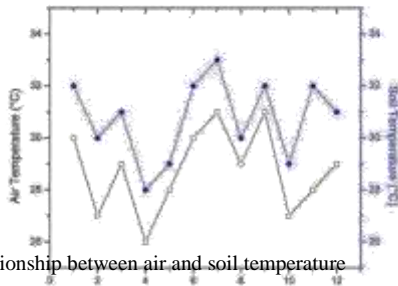


Fig.2. Relationship between air and soil temperature

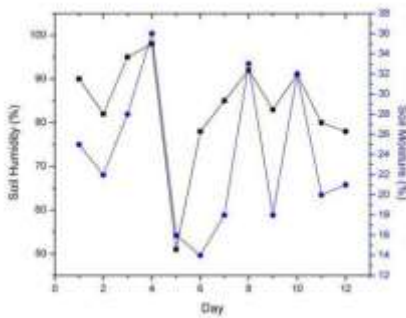


Fig.3. Soil Humidity and Soil Moisture vs day

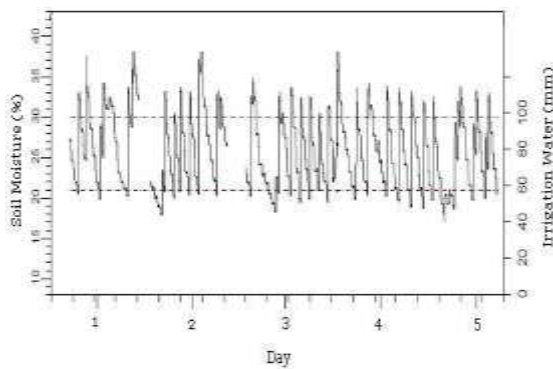


Fig.4. soil-water content, irrigation water during the study period

Fig.4 shows soil-water content, irrigation water during the study period. If the soil water content goes below the level of 21%, the motor is turn-on and respective valve unit is energized. The level of soil water content goes above 30%, the motor will be turned off and respective valve unit is de-energized.

## V. CONCLUSION

The remote monitoring and closed loop irrigation system has been developed and successfully implemented in the agriculture farm. The real time information is gathering from sensor node about the crop field which is transmitted wirelessly through Zigbee. The sensor values are passed into the controller and it controls the water resources utilization effectively. The GSM interface is helpful for the cultivator to receive notifications of the events occurring in the field and growth rate of crop. The

current values of all parameters are also updated on LCD display. Using this system, one can save manpower, water and power consumption is reduced by 20% and 30% when compared to existing method. In future, other important soil parameters namely soil pH, soil electrical conductivity will also be incorporated in the system. The system will investigate leakage in pipe network, filters blockage in head control, and distribution of fertilizer in time. The project will allow for improving the efficiency of the irrigation process.

## ACKNOWLEDGMENT

I would like to thank the P.Sudhakara Rao,HOD, Department of Electronics and Communication Engineering, Nova College of Engineering , Ibrahimpatnam,Vijayawada for providing necessary facilities towards carrying out this work.

## REFERENCES

- [1] Chavez, J. L., Pierce, F. J., Elliott, T. V., Evans, R. G., Kim, Y., & Iversen, W. M. "A remote irrigation monitoring and control system for continuous move systems. Part A: Field testing and results", Precision agriculture Precision Agriculture, 1–10, 2009.
- [2] Mahir Dursun and Semih Ozden., "A wireless application of drip irrigation automation supported by soil moisture sensors", Scientific Research and Essays Vol. 6(7), pp. 1573-1582, 2011.
- [3] Yandong Zhao, Jinfeng Guan, Junfu Zhang and Weilun Yin, "Study on Precision Water-saving Irrigation Automatic Control System by Plant Physiology", IEEE 2009.
- [4] N. P. Jawarkar, Vasif Ahmed and S. A. Ladhake, "Versatile Low Cost Cell Phone Based Monitoring", Proc. 4th IEEE Workshop on Advanced Experimental activities on Wireless networks and systems, Kos, Greece, June 15-19, 2009.
- [5] P. Javadi Kia, A. Tabatabaee Far, M. Omid, R. Alimardani and L. Naderloo. "Intelligent Control Based Fuzzy Logic for Automation of Greenhouse Irrigation System and Evaluation in Relation to Conventional Systems", World Applied Sciences Journal 6 (1): 16-23, ISSN 1818-4952, 2009.
- [6] Akin Cellatoglu and Balasubramanian Karuppanan, "Remote Sensing and Control for Establishing and Maintaining Digital Irrigation ", IJAIT, Vol. 2, No.1, February 2012.
- [7] Jeonghwan Hwang, Changsun Shin and Hyun Yoe. " Study on an Agricultural Environment Monitoring Server System using Wireless Sensor Networks", Sensors, 10, 11189-11211, 2010.
- [8] V.I. Adamchuk, J.W. Hummel, M.T. Morgan and S.K. Upadhyaya, "On the-go soil sensors for precision agriculture", Computers and Electronics in Agriculture, 44, 71–91, 2004.
- [9] Jackson T, Mansfield K, Saafi M, etal. "Measuring soil temperature and moisture using wireless MEMS sensors", Journal of Measurement, 41(4):381-390, 2007.
- [10] Raul Morais, Valente A, Ser dio C. "A wireless sensor network for smart irrigation and environmental monitoring", FITA/WCCA Vila Real Portugal, 845-850, 2005.
- [11] Joaquin Gutierrez, Juan Francisco Villa-Medina, Alejandra Nieto-Garibay, and Miguel Angel Porta-Gandara, "Automated Irrigation System Using a Wireless Sensor Network and GPRS Module" IEEE Transactions on Instrumentation and Measurement , 2013.
- [12] Jaswanti Dhiman, Sukhwinder Singh, Soni Dhiman, "Utilization of Irrigation Water Using Microcontroller," Automatic Control and Information Sciences, Vol. 1, No. 1, 1-5, 2013.
- [13] Bogena H R, Huisman J A, Oberd rster C, etal. "Evaluation of a low-cost soil water content sensor for wireless network applications", Journal of Hydrology, 344(2): 32-42, 2007.