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Development of Wireless Sensor Network for Water Level Monitoring in Agricultural Land

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Abstract

The Development of wireless sensor network technology allows us to develop a system for real time environmental monitoring. In the current scenario wireless sensor networks participates a lot in precision agriculture. The benefits of using wireless sensor network technology in agriculture are monitor and control of water, distributed data collection and monitoring, irrigation and nutrient supply, improvement in crop health etc. The technology reduce the cost of production and increases the efficiency of production and also improve crop quality. This project presents an automated irrigation system that monitors the water level in the agriculture land and controls the water level to optimize the water use for agricultural crops. In addition to it the system collects sensor information and based on the water status triggers actuators and finally transmits those data to farmer through GSM. The system also automatically activates and deactivates the pump motor. An algorithm was developed with threshold values of water level that was programmed into a microcontroller-based gateway to control water quantity. This project describes the development and deployment of wireless sensor network for water level monitoring in the agriculture land.

Keywords: *Crop Monitoring, Precision Agriculture, Wireless Sensor Networks, Zigbee.*

1. Introduction

South India, the rice bowl is unique among the rice ecologies of the world. Rice is grown by construction of bunds and dewatering the so formed polders mainly during the puncha season from October – November to January – February. The soils in South India are low to medium in fertility. Soil is enriched by annual silt deposition during the monsoon floods. The soils are alluvial with salty clay texture and are acid sulphate in nature with excessive iron content. The major problems faced by South Indian rice are flood and lack of drainage, intrusion of saline water and soil acidity. Rice is the one of the most widely grown crops in the world and is one of the major food crops grown extensively in India. The most important rice producing states of India are West Bengal, Andra Pradesh, Bihar, Tamil Nadu, Assam and Kerala. Regular rinsing of the soil by water can reduce the acidity and increase the production. Rice is a crop which needs enough amount of water for its healthier growth. The main criteria to be taken here is that the water should not be too much or too low. Periodic monitoring and controlling water level is essential for the healthy growth of the rice plant. Due to the socio-economic labor community is getting narrower. The paddy field owners are not able to recruit sufficient labors for these processes. The initial activities like plowing, seeding etc. and the final activities like harvesting are done as a group and hence can be easily coordinated. The periodic monitoring of needs, controlling the pests and water level monitoring is a tedious process. Majority of the paddy field farmers are employed in some other activities and considers this cultivation as a secondary business. Hence their involvement on a daily basis should be greatly reduced. Since the pumping of water to and from the field is the major activity from plowing to harvesting, automating the process can greatly reduce the load on farmers. At the same time there is an urgent need to create strategies based on science and technology for sustainable usage of water, including technical, managerial, and institutional improvements [3]. Automated systems may monitor the water level and regulate the levels by sophisticated systems and can send messages to the farmers.

2. Methodology

2.1 WSN for Monitoring Water Level

Paddy field is a large area and is nearly flat in nature. Normally the water level in a field will be uniform throughout the field. Water wells can be made as per the need and the water level in each well can be monitored. Water level sensors can be used for sensing the levels. Even though electronic sensors are available due to the environmental conditions electro-mechanical devices can be used in the paddy field. The mechanical part in the floating devices that float on water and the electrical part will produce the signals based on the portion of the floating device. These values or signals generated by the sensor needs to be transmitted to the farmers. Due to the issues like transmission media, power consumpt-ion, security etc, conventional communication techniques cannot be used. Low cost communication devices which needs low power and less maintenance, which can operate on a wireless architecture is the solution. Wireless sensor Network (WSN) is a major technology used for real time monitoring of environmental assets [1]. WSN has the advantages of low maintenance, adaptability, scalability, large scale deployment and less power needs with the disadvantages of low memory, low power, low bandwidth etc. They can be employed in hostile environments and the features like use of low power and low maintenance makes them the most suited technology for real-time environmental monitoring [10]. They can be highly useful in monitoring the water level in the paddy fields [11]. ZigBee is the most commonly used wireless networking standard that is aimed at remote control and sensor applications which is suitable for operation in harsh radio environments and in isolated locations. It is built on the IEEE standard 802.15.4(in the year 2003) which defines the physical layer and medium access control sub layer[18]. Above this, ZigBee defines the application and security layer specifications enabling interoperability between products from different manufacturers. There are several different network topologies that a wireless sensor network can form: star, tree, bus, ring, and mesh. All these topologies have their own individual benefits but the mesh network topology is best suited in our case.

2.2 Sensors for Monitoring Water Level in Fields

In our system the sensor network is deployed as a three tier system [7]. The bottom level is the end sensor devices which are in sleepy condition most of the time. The water level sensors are connected to these nodes. They collect the values of water level from the electrical sensors and transmit them. The second tier is the routers or the cluster heads. The end sensor nodes are grouped according to their geographical positions and for a group of end sensors a cluster head is allocated. The end sensor node sends their data to their respective cluster heads periodically. The cluster heads are connected to the sink node or the coordinator node which form the third tier. The overall monitoring and controlling is done by the FCC (Field Control Center). FCC is a software program residing in the user computer. The sink node transmit the data to the FCC and FCC issues the necessary commands for network monitoring and other operations like pumping in and out of water.

2.3 Sensor Column Design

Paddy fields are large in size covering many hectors and are nearly flat. Regular irrigation is done and hence the platform will be like lose clay. Paddy plants are grown very closely with a gap of nearly 10 centimeters. Hence it is a thickly cultivated crop and the plants height is nearly 1 meter. Conventional commercially available sensors do not have water level sensors. They normally have humidity sensors only. The humidity sensors cannot be directly applied here because the area is mostly humid and paddy field have stagnant water always. For measuring the water level of particular area small water wells must be made and sensor columns needs to be installed in those wells. The water well are of the size of 2 inches wide and with a depth of 0.5 meter. Three levels of water were considered for the experiment; high, normal and low. The normal water level was considered as the ground level or the average level of the top of the clay. The low level is 6 inches below the normal level and the high level is 6 inches above the normal level. These levels will be periodically monitored by the sensor column.

Table: 1. Level of water needed by paddy at various climatic zone

Climatic zone	Mean daily temperature		
	low	medium	high
	(less than 15°C)	(15-25°C)	(more than 25°C)
Desert/arid	4-6	7-8	9-10
Semi arid	4-5	6-7	8-9
Sub-humid	3-4	5-6	7-8
Humid	1-2	3-4	5-6

Sensing the water level with electronic circuits and electrical head points were easy but due to the acidic nature of the water of this area they were not producing correct result after a period of time. Hence electro mechanical were used for sensing the level. They consist of a floating device and contact switches. These floating devices will be floating above the water and moves up and down according to the level changes. These electro mechanical devices are placed inside a PVC pipe of 2 inches in diameter. The bottom end of the pipe is closed and holes were drilled on the sides of the pipe for water to enter inside the pipe. A thick covering was given above the holes by wrapping coir. This was for preventing mud and other solid substances entering into the pipe and damaging the mechanical float. The leads from the contact switches were fed to the zigbee sensor boards. Periodically the zigbee module senses these levels and transmits them to the cluster head [16]. When the water level is very low, i.e below the lower sensor all the switches will be in OFF state. When the water level is normal, the low switch will be ON and high will be OFF. When it is high the low and high switches will be ON. When the water is in the normal level, that is, as per our design not below 6 inches or above 6 inches from ground no attention is necessary. In the other two states the water level is too low or too high, hence remedial action should be initiated at the earliest.

If *(both the switches ==OFF)*

then

The water level is ***too low***

ACTION: Switch on the Pump Motor

Send SMS to Farmer

If *(Low Switch ==ON) && (High Switch==OFF)*

then

The water level at ***normal level***

No Action needed

If *(both switch ==ON)*

then

The water level is ***too high***

ACTION: Switch off the pump motor

Send Alert SMS to the Farmer

3. Architecture Diagram

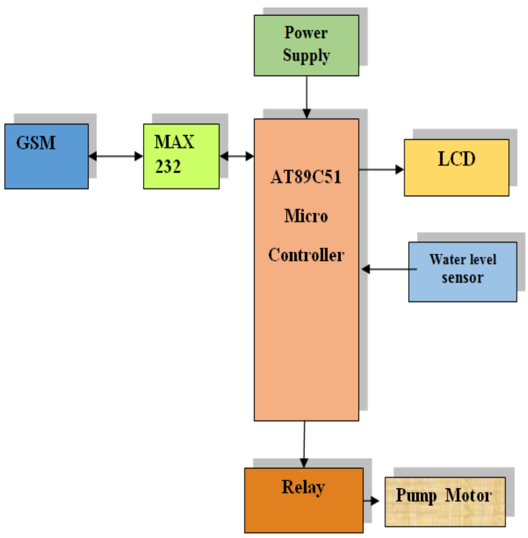

Figure 1: Architecture Diagram

Block Diagram Description

Block 1: Power Supply
Block 2: 8051 Microcontrollers
Block 3: LCD Display
Block 4: Pump Motor
Block 5: GSM module
Block6: Water level sensor

3.1 Power Supply Unit

The 230V AC supply is converted into a supply of 5V DC and given to the system. In order to achieve it the step down transformer is used to convert the 230V Alternating Current into 12V Alternating Current. The microcontroller will support only the Direct Current supply, so the bridge rectifier is used to convert Alternating Current supply into Direct Current. The output of the rectifier contains ripples. A 2200uf capacitor is used for filter those ripples. The ripple free output is given to the 7805 voltage regulator that converts the 12V Direct Current into 5V Direct Current. A 1000uf capacitor is used to filter the output current from the regulator. That produce the pure 5V Direct Current as the output from the power supply unit.

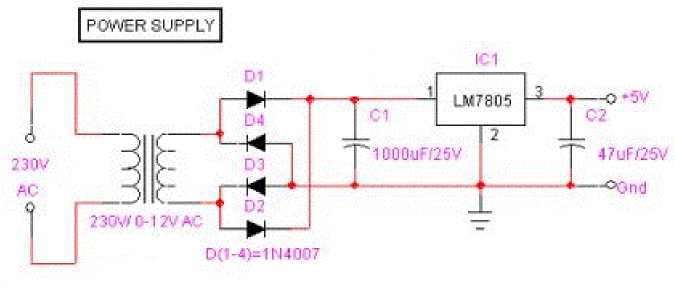

Figure 2: Power supply circuit diagram

3.2 Micro Controller Unit

In the micro controller unit we are going to use microcontroller which is used to sense the value from the water level sensor and will transfer to the farmer regarding the situation. In the sensing part Analog to Digital conversion is done internally in the controller. The controller also converts the data to serial communication for wireless data communication through GSM/GPRS modem.

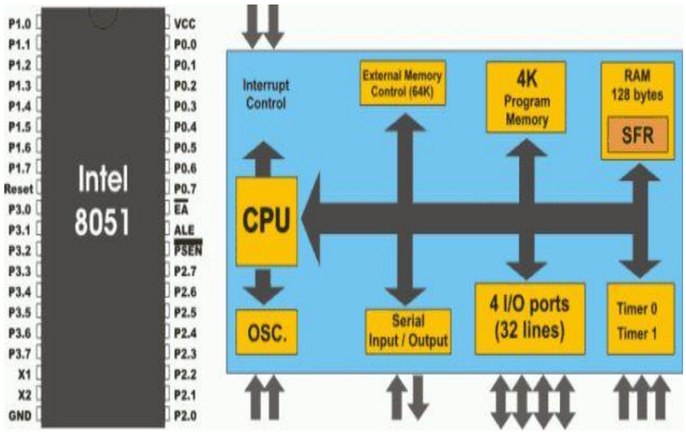

Figure.3: 8051 Microcontroller Pin Configuration

3.3 Sensor Unit

The sensor unit consists of water level sensor. The sensor is placed in the field. The required level has to be set by the farmers for different kind of field. Whenever the water level changes the voltage level to the input of the controller also changes.

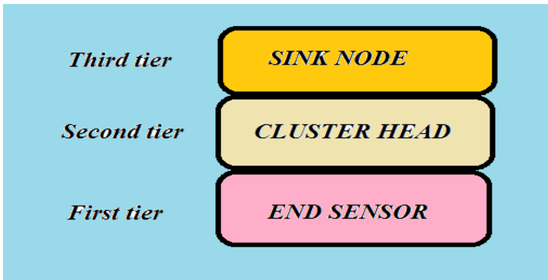

Figure.4: Sensor Three Tier Architecture

3.4 Communication Unit

GSM Modem is a communication technology in which it is used to transmit the message from the monitoring section to the control section. Whenever there are any abnormalities in the sensors or for certain period of time, the microcontroller is used to transmit the data to the monitor section.

3.5 Display Unit (LCD)

The display unit is mainly achieved by the 16X2 LCD. A liquid crystal display (LCD) is a flat electronic visual display that uses the light modulating properties of liquid crystals (LCs). LCs does not emit light directly. The Status of the water level in the field is viewed in the display.

3.6 Software Unit

KEIL µ Vision3 is the software used to compile the coding of the desired application for the corresponding embedded system. This is the embedded C compiler which is compatible for the 8051 microcontroller to compile the code. KEIL µ Vision3 Software makes C compilers, real-time kernels, simulators, debuggers, macro assemblers, integrated environments.

4. Sample Input and Expected Output

4.1 Power Supply Unit

Sample Input

230V, 5A, 50 Hz AC Supply

Expected Output

12V, 500mA- 1A, DC Voltage

4.2 Microcontroller Unit

Sample Input

It receives the input from the water level sensor and control from the GSM modem.

Expected output

It sends the remaining pre-defined value of water level into text message format and sends it to the GSM modem.

4.3 Sensor Unit (Water level sensor)

Sample Input

The water level sensor is provided with moisture or water level in the field.

Expected Output

Change in voltage as per the water level in the field is the output.

4.4 Communication Unit (GSM Modem)

Sample Input

It takes the serial text format data from the microcontroller as an input

Expected Output

Transmits packets to the network is the output.

4.5 Driver Unit (Motor Driver)

Sample Input

The microcontroller gives 5v trigger as an input.

Expected Output

Based on the trigger load gets connected or disconnected.

4.6 Display Unit (LCD)

Sample Input:

The microcontroller gives the text that indicating the device status.

Expected Output:

The received device status is displayed on the LCD screen.

5. Conclusion

Due to urbanization crop fields are getting converted to new forms of the urban world. Also farming community is becoming narrower day by day due to better opportunities. The gap between need and production is increasing at a rapid rate. These problems get elevated when production is decreased. By automating many of the farming procedure and use of advanced machines farming can be made more profitable, thereby attracting more persons into farming and increasing the production. The automated irrigation system would be feasible and cost effective for optimizing water resources. This automated irrigation system allows cultivation in places with water scarcity. This system proves that the use of water can be diminished for a given amount of fresh biomass production. The system can be used for variety of crop and requires low maintenance. The modular configuration of the automated irrigation system allows it to be scaled up for larger greenhouses or open fields.

6. Future Enhancement

The system can be enhanced by using the solar power in this irrigation system is pertinent and significantly important for organic crops and other agricultural products that are geographically isolated, where the investment in electric power supply would be expensive.

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Authors Profile

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