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DESIGN OF SENSOR NETWORK FOR REAL TIME DATA ACQUISITION OF WATER LEVEL IN THE AGRICULTURAL FIELD

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ABSTRACT

Crop loss due to water logging and floods in the agricultural fields is one of biggest challenges faced by the farmers and a cause of concern for the scientists and researchers working for the innovations in agricultural technologies. Crop loss due to water logging take toll of heavy economic loss to the farmers and indirectly affect country's economy by enhancing the fiscal deficit. To counteract this problem, this paper proposes a system wherein the crop loss is reduced by controlling the water level in the field. In this system, capacitive plate based liquid level sensors are used in the sensor network. The main focus of this paper is on the design of a novel sensor network which is capable of sensing 96 sensor values which is obvious in the case of large commercial farms, using few ADC pins of a micro controller. This paper makes use of the proposed sensor network for agricultural application to prevent crop loss due to water logging.

Keywords: sensor design, real time data acquisition, LPC 1343, GSM, schmitt trigger oscillator.

1. INTRODUCTION

In India, out of 1.2 billion populations, 65% are farmers whose livelihood depends primarily on agriculture [1]. As per the report by National Crime Records Bureau (NCRB), at least 17,368 farmers have committed suicide in India during 2009 due to various reasons [2]. This huge figure infers that on an average 1 farmer kills himself every 30 minutes. One of the main causes of these mishappening includes huge debts incurred by the farmers due to non-repayment of their crop loans. The farmers are unable to clear their crop loans because of crop failures. Now a day’s crop loss due to water logging and lack of proper water supply to the crops are challenging problems every farmer could face seasonally. Water logging in crop fields can seriously affect various ongoing metabolic processes inside a plant cell. Plants need oxygen for various biological processes like cell division, growth, transportation of nutrients, etc. [3]. Water logging condition affects the proper diffusion of oxygen with the plants. Water logging can severely affect the root growth and may also lead to rotting of roots leading to crop loss.
A system in combination with Liquid level sensors can be effectively utilized to monitor and control the amount of water present in the fields [5-8]. But if the land size is high, then we need to design large array of sensor network to cover large area [4], [9-10]. This necessitates the use of multiple microcontrollers. Use of multiple microcontrollers, not only increase the cost by several manifolds, it also increases stress on size of the system and ultimately leads to high power consumption due to mass wastage of microcontroller power resources. This prevailing problem can be counteracted by utilizing a novel sensor network capable of interfacing several sensors to just 1 microcontroller thus saving power and equipment cost.

This paper makes use of capacitive liquid level sensors which is interfaced to proposed sensor network. This can prevent crop loss due to water logging conditions in large commercial fields. Rest of the paper is organized as follows. Section II describes the system, sensor and the innovative design of the sensor network. Section III describes the system and sensor network working procedure. Section IV discusses the results and finally the paper is concluded.

2. DESIGN METHODOLOGY

A. Design of the system

Figure-1 illustrates various components of the proposed system. The heart of this system is the novel sensor network interfaced with LPC1343 microcontroller based on ARM Cortex M3 processor. The sensor network proposed in this system can be used to interface 96 sensors in it and it is capable of sending all the monitored values using just 6 output which can be fed to 6 ADC pins of the microcontroller. The data from the microcontroller is sent to the display device of the HMI (Human Machine Interface). The water level is continuously monitored and in case of alarming levels of water, SMS notifications are sent to the farm supervisor, prompting him to take necessary actions.

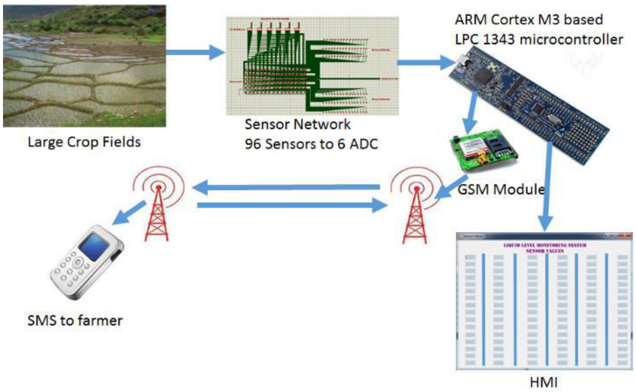

Figure-1. Various components of the system.

B. Design of capacitive plate based liquid level sensor

Measurement of water levels in the field is achieved using capacitive plate based liquid level sensor. "Capacitance of a capacitor changes with change in the dielectric medium present between both the plates", is the principle used in the design of the capacitive plate based liquid level sensor.

Capacitance of a capacitor is given by

$$C = \frac{A\epsilon}{d}$$

Where $\epsilon = \epsilon_r \times \epsilon_o$
A is the area of cross section of the capacitor,
ϵ is the permittivity of the medium,
ϵ_r is the relative permittivity of the medium,
ϵ_o is the permittivity of free space,
d is the distance between the 2 plates.

The diagrammatic representation of the proposed liquid level sensor is shown in Figure-2.

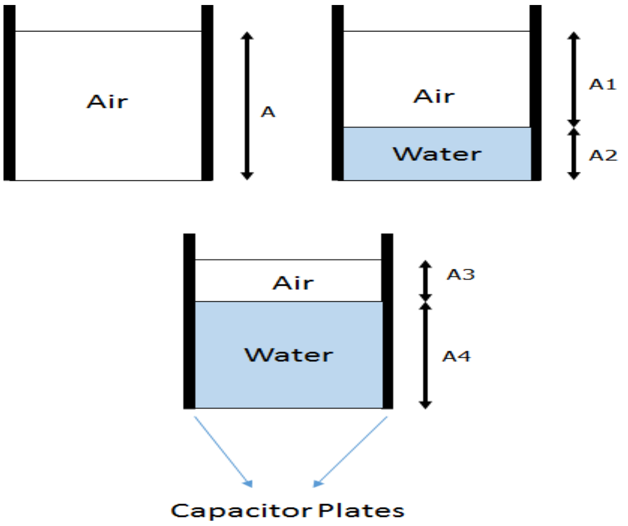

Figure-2. Capacitive plate based liquid level sensor demonstrating change in area of cross section with change in water level.

The sensor presented here initially possesses air as the dielectric medium. When the sensor is exposed to water, then it acts as a two parallel capacitor, one consisting of air as the medium with relative permittivity k_1 and other consisting of water as the medium with relative permittivity k_2. With increase in water level the area of cross section for each type of capacitor changes and hence the effective capacitance also changes.

The change in capacitance is calculated by measuring the frequency of the square waves produced by the Schmitt trigger circuit shown in Figure-3. Frequency measurement of the Schmitt trigger is achieved with the help of LPC1343 microcontroller. With change in the effective capacitance of the capacitor plates, the charging and discharging time of the RC circuit changes and hence the frequency of the generated square wave changes. The change in capacitance thus calculated is calibrated using microcontroller to estimate the liquid level in the field.

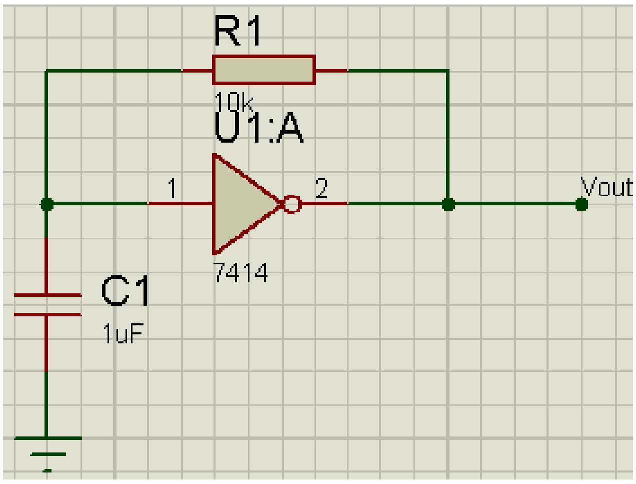

Figure-3. Schmitt trigger where C1 is capacitive sensor.

C. Design of sensor network

The proposed sensor network is capable of sensing 96 sensor values using just 6 ADC pins of any microcontroller. This system uses ARM Cortex M3 (LPC 1343) microcontroller because of its low power requirement and its ability to work for deterministic real time applications. To control the sensor network, 24 GPIO pins are required, which can be taken from LPC1343.

This sensor network makes use of six 4x16 decoders which get input from the microcontroller and gives the output to 96 relays. Figure-4 shows decoders for sensor network.

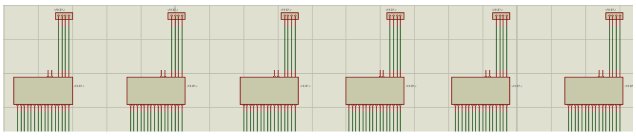

Figure-4. Decoders used for controlling relays.

The microcontroller is programmed in such a way that at a time, only one column of the decoder is set to HIGH. The output from the decoders is used to control 96 relays present in the system. The relay layout used in this system is shown in Figure-5.

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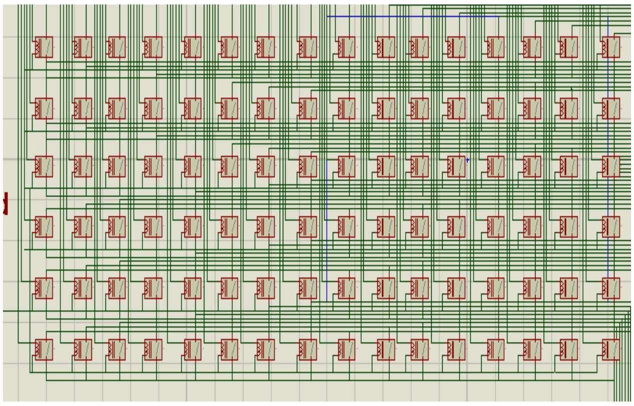

Figure-5. Controlling relay network in 6x16 matrix form.

The relays in Figure-4 are arranged in 6x16 matrix format. The specialty of this arrangement is the key element behind the working of sensor network. All relays in a particular row are connected only to a single decoder. The pin connections sequence from relays to their corresponding decoder follows the same sequence in every relay row. Every column of this matrix contains 6 relays. The Input to all the relays is given from the sensors. The output terminals of the relays are given to ADC in a different fashion. The output terminals of every relay in a particular row are shorted together and connected to a single ADC pin. Similarly all relays in other rows are shorted together and connected to corresponding ADC pins.

The sensors are placed in the form of 6x16 layouts. All the 96 sensors are individually connected to their corresponding relays. Figure-6 shows the complete sensor network.

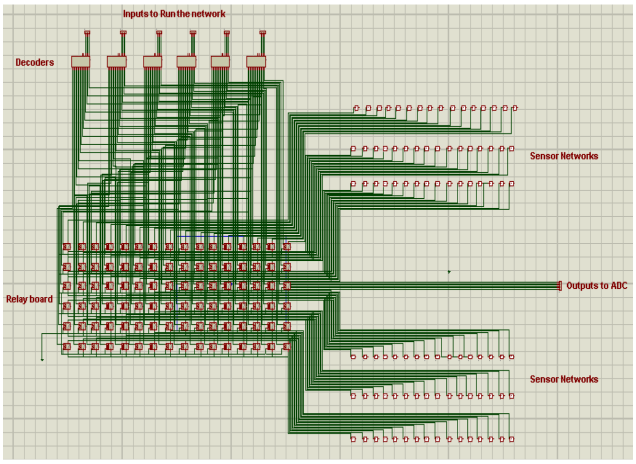

Figure-6. Complete sensor network.

The shown sensor network is simulated in Proteus 7.7 Professional simulation software. The complete working procedure along with its flowchart is given in the next section.

3. SYSTEM WORKING PROCEDURE

A. Working of sensor network

Figure-7 shows working of the sensor network with the help of flow chart.

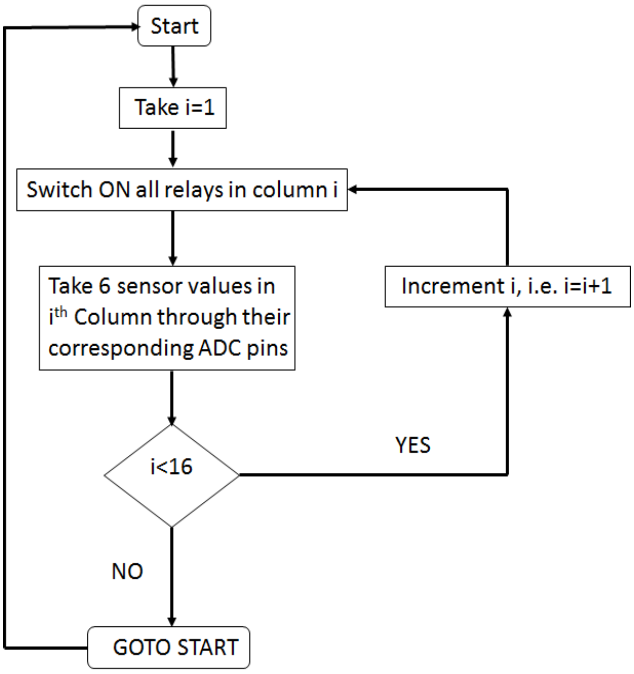

Figure-7. Flowchart describing the working of sensor network.

In the sensor network, output of relays in every rows are shorted together and further connected to a single ADC pin. In Figures 8 and 9, the working of the sensor network is illustrated using a 6x2 matrix.

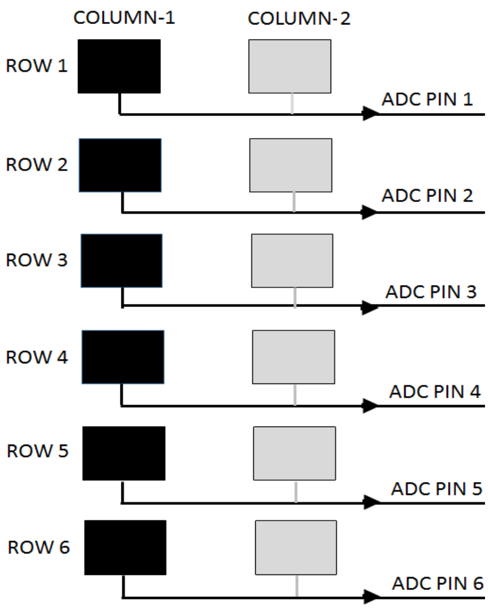

Figure-8. Step 1 illustrating column 1 relays as switched ON.

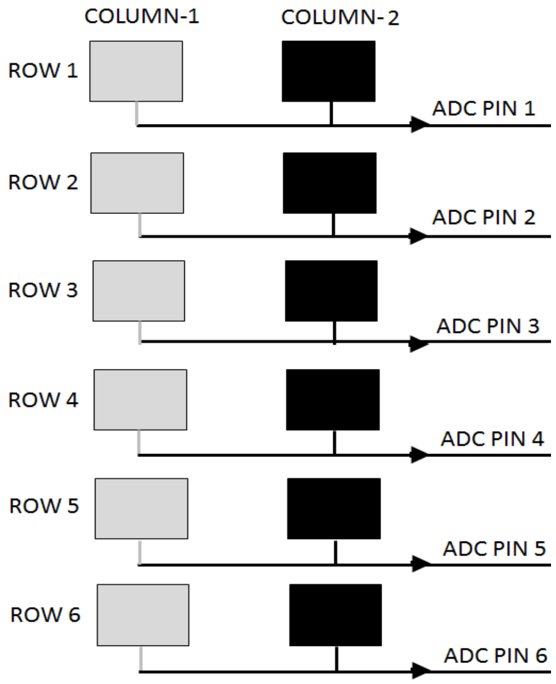

Figure-9. Step 2 illustrating column 2 relays as switched ON.

In the first step, all the relays in the first column are given HIGH pulse and all other columns are LOW. This results in a condition wherein, the ADC pins will receive the values of all the 6 sensors present in the first Column. In the next step, the all the relays in the second column are made HIGH and others as LOW, due to which the ADC pins of microcontroller is able to sense values for the sensors present in the second column. This process is repeated till the 16^{th} column is reached. After this step the whole procedure is repeated in an infinite loop. Since the microcontroller's clock frequency is 16MHz, each iteration takes a minimal of few microseconds time.

B. Process flow

Figure-10 is describing the process flow of the proposed system. In this system, the liquid level sensors send the data to the microcontroller using the sensor network. These data are continuously monitored and checked that the water level in the field are not above a certain pre-defined level. If the water level in the field increases beyond a certain level, then an instant SMS notification is sent to the farm supervisor mentioning the increase in water level and region where the level has increased. This SMS intimation will enable the supervisor to take necessary steps to prevent water logging. The SMS are sent using the SIM900 GSM module interfaced with the microcontroller.

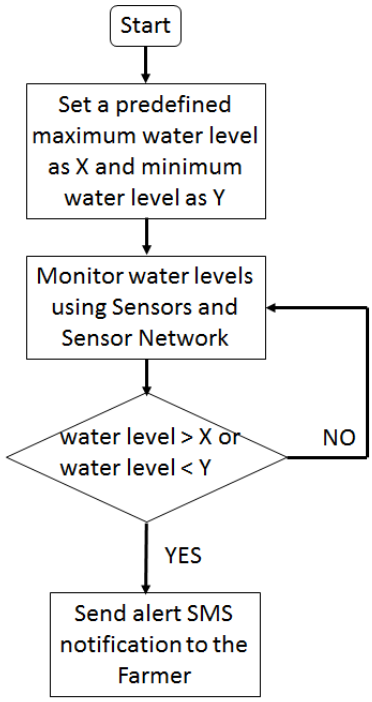

Figure-10. System process flowchart.

The same principle can be used to prevent crop loss due to lack of water, for e.g. in Paddy fields; where in large amount of water is required. The system can be utilized to send SMS notifications to the supervisor in case the water level decreases below the required level in the farmland.

4. RESULT AND DISCUSSIONS

Figure-11 shows the implementation of the system with the proposed sensor network.

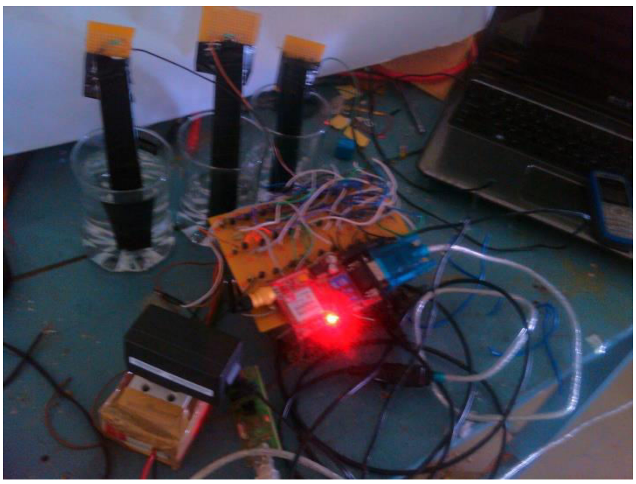

Figure-11. System prototype interfaced with sensor network.

Figure-12 shows the response of sensor network through GSM communication.

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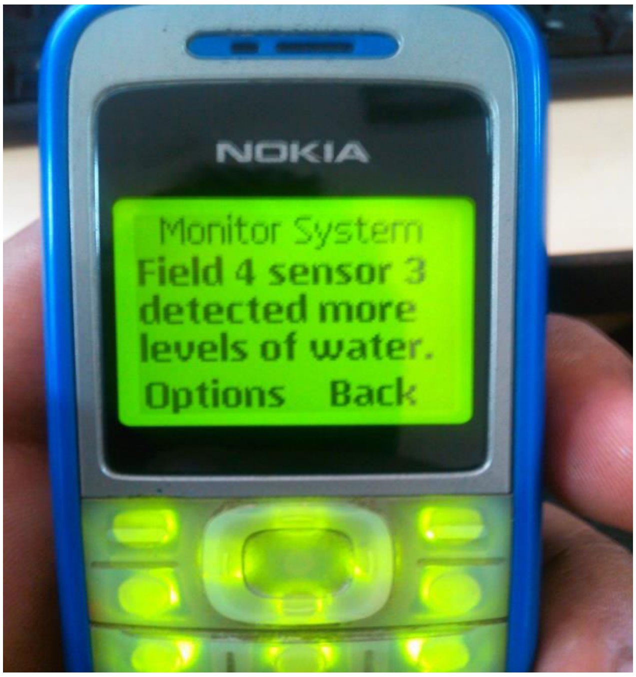

Figure-12. SMS received on the farmer's cellphone.

Figure-13 shows the HMI application developed using Microsoft Visual C++. This application is used to display the 16x6 sensor values to the user. The application uses Serial Communication between the microcontroller and the computer for displaying the sensor values. Since the microcontroller used here is having a clock frequency of 16MHz, each iteration is so fast and continuous that it cannot be perceived by human eyes, hence appearing as continuous display on the Software application window.

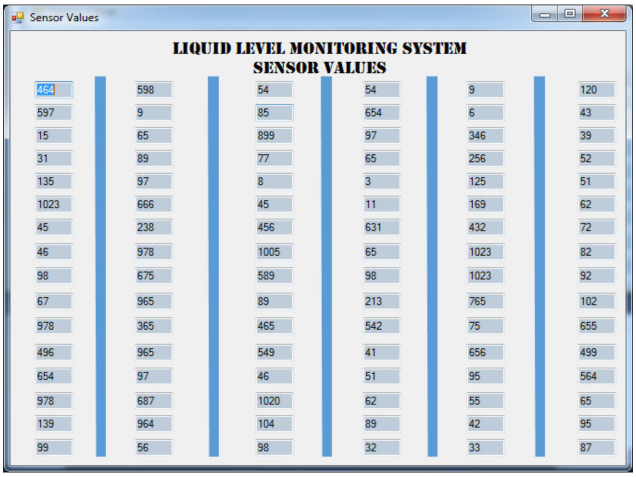

Figure-13. Software application displaying real time sensor data.

5. CONCLUSIONS

Crop loss due to water logging is very common during the peak monsoon season and also a result of human errors in case of over watering of crops. The liquid level sensors can be effectively used to measure the water levels in the field so as to perform farming conforming to the standards of commercial farming. For monitoring water levels in large fields, several sensors will be required which in turn necessitates several microcontrollers. This necessitates the need for a novel sensor network, which can interface several sensors. Hence the proposed sensor network which is capable of interfacing 6 x N number of sensors, wherein N can be any large number can be effectively utilized for agricultural application namely crop loss reduction due to water logging.

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