Smart Irrigation System Autonomous Monitoring and Controlling of Water Pump by using Photovoltaic Energy

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Abstract

In this world irrigation of various crops in different regions are indeed playing very dominant and challenging role. Crops yielding is very much dependent on various factors such as ambient temperature, pH value of soil, water level in the field etc. In this research paper the main intention is to improve the yielding of crops by controlling the above parameters using Sensors, Global System for Mobile (GSM) module and with the help of an 8 bit ATMEL microcontroller AT89s52. Another important resource which is required for the irrigation is the water supply which is inter dependent to the fields because the water supply can be from various origins as it can be supplied by the nature (or) from the wells (or) through the rivers (or) from the water pumps using pumping motors. Major cases where the water is being supplied to the fields using water pumps and which in turn requires power as a source to pump the water to the fields. Here the power for the entire system is given using the best photo voltaic cells (PVC) and the irrigation system is monitored autonomously using GSM via microcontroller and various sensors like pH sensor, temperature sensor (LM35), level sensor etc connected to the microcontroller and Vice Versa. In this paper authors have discussed about different sensors utilization in the fields through microcontroller and GSM module. The implementation of the PVC, GSM and control of pumping motor or shunt motor to entire irrigation system is done using embedded C programming and Keil Software in real time.

Keywords — *Sensor, Global System for Mobile (GSM) module, Photo Voltaic cells (PVC), Sensors, ATMEL Microcontroller and Keil Software.*

I. INTRODUCTION

Recently in Andhra Pradesh and Chennai major coastal areas and many hectares of fertilizing land were drowned due to heavy rain fall. This natural calamity brutally made farmers to suffer a lot by losing their hard spend money and time on their agriculture. To decrease the worst situation of their loss authors proposed a work to autonomously monitor the water level in the field by using Sensors, Microcontroller and GSM module. The entire system works using photo voltaic cells energy. Authors got the motivation from the Joao. Victor Mapurunga Caracas et. al., implemented a high efficient, high lifetime low cost autonomous photo voltaic water pumping system [1]. Agriculture is one of the most important sectors for human’s growth. It is the crucial factor based on that the country socio-economic depends. Indian climatic condition will vary considerably and leads to poor irrigation. Scattered field sensors based irrigation system gives a better solution for site specific irrigation management that increases the productivity and saving water [2]. In the proposed work various modules are implemented such as a) Sensors b) Analog to Digital Converter (ADC0808) c) Microcontroller (AT89S52) d) Universal Asynchronous Receiver and Transmitter e) GSM f) Relay g) Motors and h) Photo Voltaic Cells.

II. OBJECTIVE

The main objective of this proposed work is to reduce the cost of power by using renewable photo voltaic cells energy for the power supply, and also to autonomously monitor the water supply, temperature, pH value of the soil. Crops are monitored by means of different sensors at different places. The water level in the field and the well water (or) the underground water is sensed by using floating ball sensor. The pH value of the soil is sensed by using pH sensor. The input low level analog signals from the sensors are given to Analog to Digital Convertor IC ADC0808. The output from the ADC is 8 bit which is fed as input to the ATMEL microcontroller 89s52. The microcontroller monitors the sensor values and sends the status to the user's cell phone via GSM module. If the water level in the field is low, the temperature level goes high; if it reaches above a threshold then the pumping motor is switched ON. The required hydrogen content in the field is monitored using pH sensor since every crop has a predefined value of pH for its better yielding. When fertilizers are added to the soil the pH value will vary then the sprinkling motor is switched ON the value of the pH is monitored for various crops. The Sprinkling motor will be switched OFF when the pH value of the soil reaches required level. The shunt motor is switch ON when the water in the field goes beyond a level due to heavy rain fall or other water natural calamities. The pumping motor, shunt motor and sprinkling motor is being operated and controlled by using GSM module through user's mobile and even manually.

III. LITERATURE SURVEY

Joao. Victor Mapurunga Caracas et. al., proposes a new three phase induction motor for water pumping, the power is used from the photovoltaic energy without the use of batteries to run the motor. It has been developed to achieve more efficient, reliable, maintenance free and cheaper than the ancient dc motors or low voltage synchronous motors. The result shows that the peak efficiency is 91% for the dc to dc conversion and three phase voltage source inverter. A peak efficiency of 93.64% for just dc to dc converter [1].

pH preference values for various crops, plants is given in the below table 1 for better yielding [3].

TABLE 1. PH VALUES OF CROPS or PLANTS

S.No	pH Values of the crops or plants	
	Common Name	**pH Preference values**
1	Almond	6.0 – 8.0
2	Apple	5.5 – 6.5
3	Banana	6.8 – 7.0
4	Coffee	5.0 – 6.0
5	Corn	6.0 – 7.0
6	Grapes	6.0 – 8.0
7	Lemon	5.5 – 7.0
8	Onion	5.0 – 7.0
9	Orange	5.0 – 7.0
10	Peanut	5.0 – 6.0
11	Potato	6.0 – 8.0
12	Radish	6.0 – 8.0
13	Rice	6.0 – 7.0
14	Soybean	6.0 – 7.0
15	Spinach	6.4 – 7.0
16	Sugarcane	6.0 – 8.0
17	Sunflower	6.0 – 8.0
18	Tobacco	5.0 – 8.0
19	Tomato	6.0 – 7.0
20	Watermelon	6.0 – 7.0
21	Wheat	6.0 – 7.0

B. Karthikeyan et. al., proposes an embedded system for unmanned irrigation system. Wireless Sensor networks where a group of sensors like pH sensor, Temperature sensor are used for automatic control of irrigation system. In this paper the required level of water for the agricultural farm is concentrated to avoid water wastage. Here the authors discussed about the pest damage crops and its protection to the crops [4].

Joaquin Gutierrez et. al., proposes automated irrigation system using WSN and GPRS module, the system posses wireless network of soil moisture and temperature sensors kept in root zones of the plants. An algorithm was developed with threshold values of temperature and soil moisture. The entire systems were powered by photovoltaic panels and also possess a duplex communication link based on cellular and internet. Up to 90% of water was saved and sage crop was tested [5].

S. Harishankar et. al., proposes cost effective solar power for smart irrigation system. Authors in their work suggested to use solar power for water pumps and also automatic water flow control was done using moisture sensor. This work has been carried out to conserve electricity from the grid power and also water loss [6].

Mahir DURSUN and Semih OZDEN, proposes his research work designing an automatic drip irrigation of dwarf cherry trees with solar powered brushless DC Motors in Turkey. Two motors are used with solar power to pump water from deep well to storing pool and the second one is used for pool to drip irrigation. Sun tracking system was used in connection with solar panels to increase the efficiency of the solar panels [7].

IV. BLOCK DIAGRAM OF REAL TIME FIELD SENSING UNIT

The Photo Voltaic cells and sensors are connected to the 8 bit ADC whose resolution is 255 bits. The AT89S52 has four ports to interface with other peripherals. The ADC is connected to the first port of 8 bit Atmel Microcontroller 89S52. The second port is connected to the relay which in turn connected with the pumping motor, sprinkling motor and shunt motor. The UART is connected to the GSM module to give the information or status to the subscriber connected with it the implemented hardware diagram is shown in below Fig. 1.

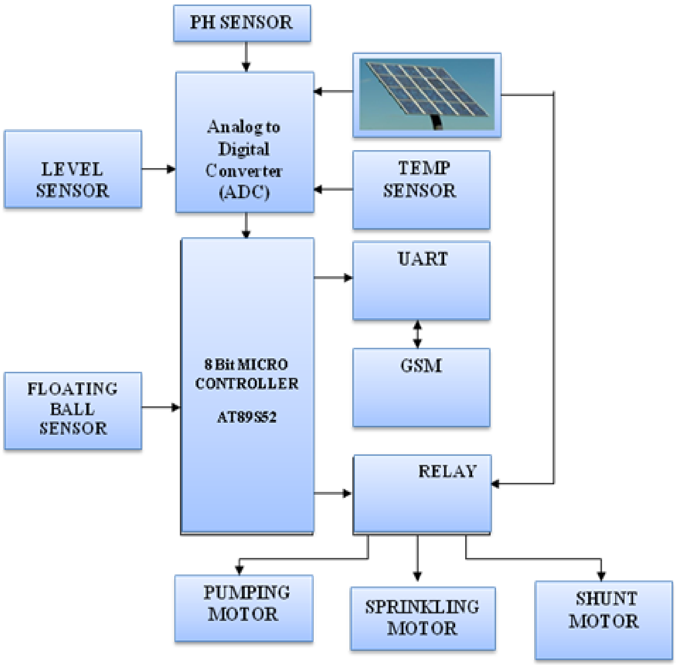

Fig. 1 Real Time Field Sensing unit using AT89S52

V. IMPLEMENTATION OF THE SMART AUTONOMOUS IRRIGATION SYSTEM

A. Calculation of Photovoltaic Energy

The formula to calculate the energy generated output from the photovoltaic system is given by the equation 1[8].

$$\text{Energy} = A * r * H * PR \qquad (1)$$

Where
A is the total solar panel area in m².
r is the solar panel yield in %.
H is the solar radiation per annum.
PR is the performance ratio coefficient for losses.
PR ranges from 0.5 to 0.9.
The efficiency of a solar cell is calculated using the incident power and maximum power and it is defined as in the equation 2.

$$\eta = \frac{P_{max}}{P_{in}} \qquad (2)$$

Where

$$P_{max} = V_{oc} I_{sc} \, FF \qquad (3)$$

V_{oc} is the open circuit voltage.
I_{sc} is the short circuit current.
and
FF is the fill factor.
V_{oc} increases logarithmically with light intensity as shown in the equation 4 below

$$V'_{oc} = V_{oc} + \frac{nkT}{q} \ln X \qquad (4)$$

Where *'X'* is the concentration of sunlight.
To calculate the electrical energy produced from the PV panel per one day is done by using equation 5

E(PV Produced) = E(Daily Consumed) / (EE *BC*DE) (5)

Where
EE is Electronic Efficiency.
BC is Battery Charge.
DE is Discharge efficiency.

B. pH Sensor

In the process world, pH is an important parameter to be measured and controlled. The pH of a solution indicates how acidic or basic (alkaline) it is. The pH term translates the values of the hydrogen ion concentration which ordinarily ranges between about 1 and 10 x -14 gram-equivalents per litre - into numbers between 0 and 14.

On the pH scale a very acidic solution has a low pH value such as 0, 1, or 2 (which corresponds to a large concentration of hydrogen ions; 10 x 0, 10 x -1, or 10 x -2 gram-equivalents per liter) while a very basic solution has a high pH value, such as 12, 13, or 14 which corresponds to a small number of hydrogen ions (10 x -12, 10 x 13, or 10 x -14 gram-equivalents per liter). A neutral solution such as water has a pH of approximately 7[9].

A pH measurement loop is made up of three components; they are measuring electrode, reference electrode and temperature sensor; a preamplifier; and an analyser or transmitter.
A pH measurement loop is essentially a battery where the positive terminal is the measuring electrode and the negative terminal is the reference electrode. The measuring electrode, which is sensitive to the hydrogen ion, develops a potential (voltage) directly related to the hydrogen ion concentration of the solution. The reference electrode provides a stable potential against which the measuring electrode can be compared.

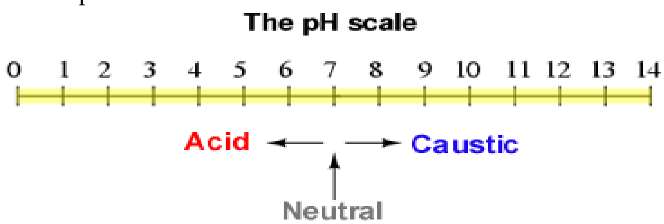

Fig. 2. pH Scale to Check the Solution State

The pH scale is shown in the above Fig - 2. If the pH level is below 7 the field requires water to be sprinkled to the field which is done through the relay switches and if the pH level is above 7 the shunting motor is switched on to remove water from the field.

C. *Temperature Sensor LM35.*

The temperature sensor LM35 is a precision temperature measuring IC used to sense the ambient temperature in degree centigrade scale. The operating temperature range is from -55°C to 150°C. The output voltage varies by 10mV in response to every 1°C raise/fall in ambient temperature; its scale factor is 0.01V/°C. The quantization step size of ADC is given by the equation 5 and 6.

$$\text{Stepsize} = ((+V_{ref}) - (-V_{ref}))/256 - 1 \quad (5)$$

$$D_{out} = \frac{V_{in}}{\text{Stepsize}} \quad (6)$$

The temperature sensor LM35 is interfaced with ADC 0808 with the above step size, the digital output of the ADC in terms of temperature is calculated as given in the below.

0.0C ---- 0000 0000
0.5C ---- 0000 0001
1.0C ---- 0000 0010
1.5C ---- 0000 0011
till
100.0C ---- 1100 1000

D. *Level Sensor*

Variable resistors are widely used in fuel level sensing. A wiper connected to a level arm with a float moves across continuous resistive track as shown in Fig 3. The sensor works on potentiometric measuring principle. Current is made to flow through the resistance the voltage drops linearly across this resistance. Slider across this resistance is connected to a float. Voltage output is taken between the slider and one end of the resistance. Thus the varying fluid levels, slider moves and the output voltage varies. A variant of this type uses conductivity of the liquid under measurement. Current pulses are sent through a sensor electrode. When sensor electrode is immersed into a conductive liquid an electrical connection is created. The electrical potential is proportional to the liquid level and is measured via a counter electrode or the tank level. It is used for continuous filling level measurement and is suitable for all electrically conductive liquid [10].

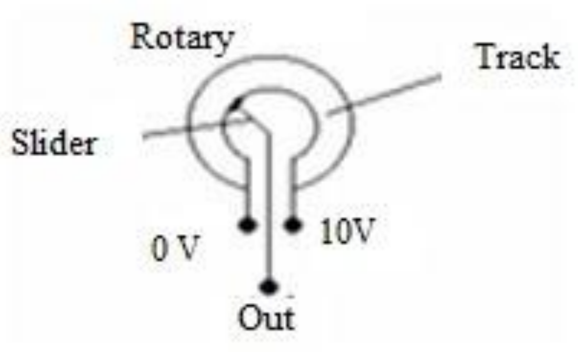

Fig.3 Resistive Sensor

E. *Interfacing ADC with AT89s52.*

Port 1 of AT89S52 is used to interface the ADC 0808 the output of each sensor is fed parallel to the ADC with separate timings as required; the ADC in turn gets connected with the Microcontroller. The flash programming timing diagram is shown in below Fig 4.

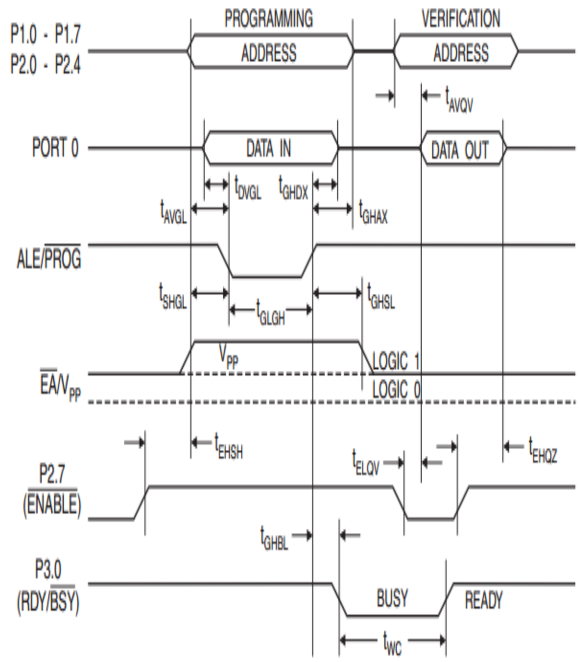

Fig. 4 Flash Programming and Waveform for Parallel Mode

The programming is done using embedded C in KEIL software and the implemented hardware is shown in Fig 5.

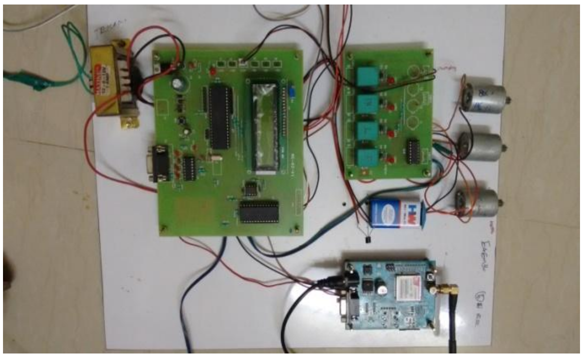

Fig. 5 Implemented Hardware for Smart Irrigation System

F. GSM Technology for Monitoring the Fields

Efforts have been taken to develop smart intelligent system to monitor the fields in every specific part and however if the field is very large it is better to develop an Internet Cloud environment to monitor the crop in the field by which we can improve the throughput of the field in the required manner. The GSM module designed for this smart irrigation system is shown in Fig. 6

The GSM module has the interfacing with the UART present in the AT85S52 microcontroller, the user get the information about the functioning of every sensor and the running of the specified motor so accordingly the farmer can be alert to use required fertilizer to improve the productivity the crop.

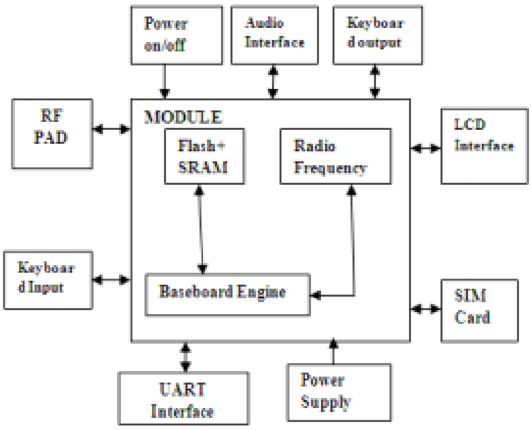

Fig.6 GSM Module for Field Monitoring

VI. RESULTS

The work was implemented using Embedded C program and Keil Software has been used. The synthesised output was generated and it is shown in the Fig. 7. The pH levels for different crops were test and implemented. The water conservation was also achieved.

VII. CONCLUSION AND FUTURE SCOPE

Irrigation process is the more significant requirement for human's civilization and it is treated as backbone of our country. In the current circumstances saving of water is of high concerned. This work is attempts to save the natural resources by continuously monitoring the status of the soil, controlling of water flow and thereby reduce the wastage. By knowing the status of pH level and temperature through GSMwith the use of pH sensor and temperature sensors, water flow can be controlled by using AT85s92 microcontroller. Since the system is automatic, they do not require continuous monitoring by labour. By this system the farmer can get the status of water level, temperature sensor and pH level in soil through SMS generator by microcontroller. The system has an incorporated with GSM monitoring which reduces the problem of range with other techniques as Bluetooth and WiFi. The design is low power, low cost, small size, robust and highly versatile. Thus, this system avoids over irrigation, under irrigation, top soil erosion and reduce the wastage of water. The main advantage is that the system's action can be changed according to the situation (crops, weather conditions, soil etc.). By implementing this system, agricultural, horticultural lands, parks, gardens, golf courses can be irrigated. Thus, this system is cheaper and efficient when compared to other type of automation system. In large scale applications, high sensitivity sensors can be implemented for large areas of agricultural lands. A stand by battery or solar cells can be implemented which comes into use in case of power cuts. A secondary pump can be used in case of failure of the pump. The future of agriculture should be smart in India as shown in the above Fig. 8.

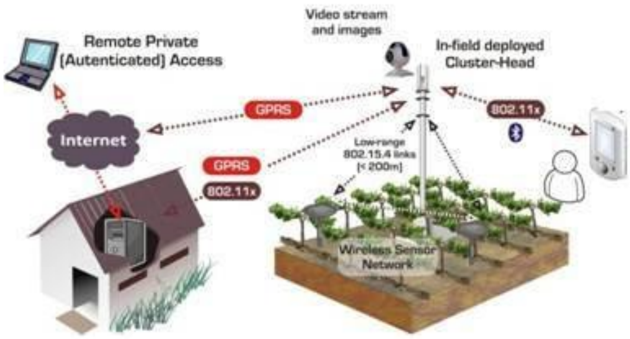

Fig.7 Future of Agriculture using WSN

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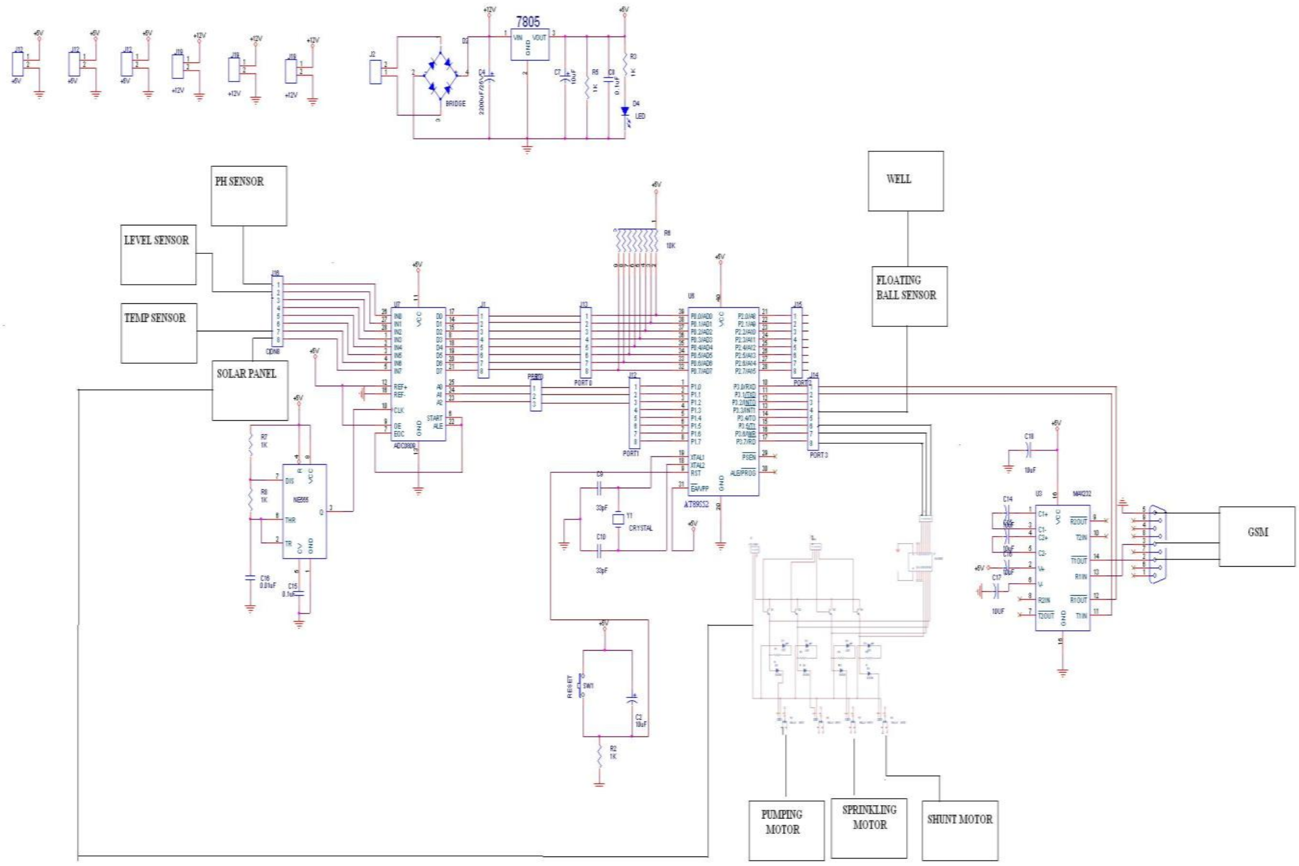

Fig. 7 Chip Level Layout of the Smart Irrigation System