

Design and Development of Cost Effective Real Time Soil Moisture based Automatic Irrigation System with GSM

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Abstract - Presently, available automatic irrigation systems irrigate the crops on volume and or time based and not as per exactly crop water requirement and finding difficulty to maintain soil moisture content to field capacity always due to their certain operating mode and limitation. Due to high initial cost, regular maintenance, the need of recalibration and skilled manpower requirement, the existing automatic irrigation systems available in the market are out of reach of the marginal and small farmer and finding difficulty to adopt those. Therefore, cost effective real time soil moisture based automatic irrigation system with GSM is designed and developed. It has the facility to fix the lower and upper limit of the soil moisture content i.e. wilting point and field capacity after knowing the properties of the particular soil under consideration by the Android phone and or Desktop / laptop. It facilitates to monitor to sense continuous soil moisture content. Additionally, once it calibrated there is no need to recalibrate even after electricity failure except change in the field. If the soil moisture is below the desired lower limit but above the wilting point starts the solenoid valve and pump at once. At the same time the system intimate about starting of the pump in the form of text message to the user. When soil comes up to the desired upper limit at field capacity or close to field capacity due to continuous sensing and processing the system automatically stops the pump.

Key Words: Automatic Irrigation, Artificial Intelligence, Precision Agriculture, Precision Irrigation.

1. INTRODUCTION

India is the second-largest populated country in the world. The demand for food from these people is huge. Hence, there is a need to increase per unit area productivity to fulfill the demand for food. Irrigation plays a key role to increase per unit area productivity. In India, most of the farmers adopting surface irrigation techniques [Sherine M et al. 2013] such as border irrigation, check basin irrigation, furrow irrigation. This method has several limitations; conveyance losses, deep percolation, leaching of soil nutrients, erosion due to flooding, water wastage and creation of non-congenial root environment. However, it is reported that 40 % of the freshwater used in agriculture were lost in developing countries due to the above mentioned limitations in irrigation methods [Shah N. G. and I. Das, 2012]. The unfavourable root environment created due to temporary water stagnation / logging in the root zone stops the uptake of water and nutrient which hampers the growth, ultimately the yield. Therefore it is a challenge, to keep the field always to the field capacity or to reduce the time period of temporary water stagnation / logging in the field so the root shall be more active.

An automatic irrigation system is a prudent technology to overcome this limitation of conventional irrigation method. But the time base or volume base irrigation system is used in most of the cases in which scheduling is tried on a climatological approach. This type of automatic irrigation systems is not applied water as per the actual crop water requirement. If one wants to apply water precisely, the real time soil moisture based criteria by which precision in irrigation can be achieved [Munoth P et al., 2016]. Therefore, an attempt was made to design the real time soil moisture based automatic irrigation system with GSM. It not only irrigates the field as per the requirement of the crop automatically but also monitors the available soil moisture content continuously 24 hrs. It facilitates to receive the irrigation event on and off on the mobile. It also has the facility to fix the lower and upper limit of the soil moisture content (SMC) through mobile phone.

2. Design of controller of automatic irrigation system

2.1 Materials used in a controller for an automatic irrigation system

The cost effective real time soil moisture based automatic irrigation system with GSM consists of different readily available hardwares such as Arduino Mega (microcontroller), soil moisture sensor, relay for pump and solenoid valve, GSM module and Bluetooth module.

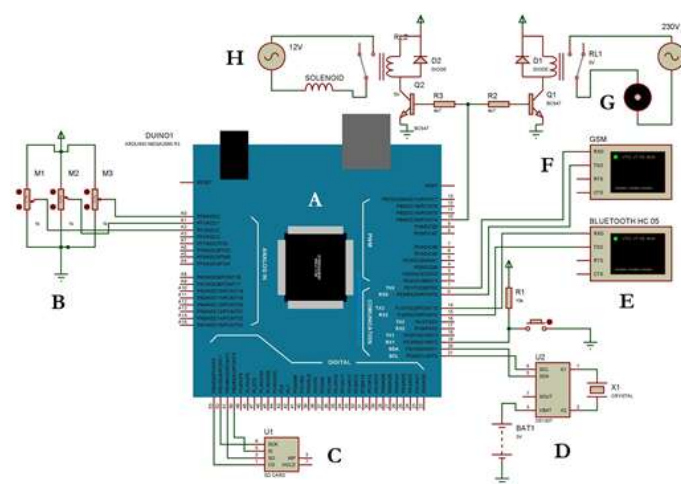
- a) **Microcontroller:** The Arduino Mega, is used as a microcontroller in this system. This microcontroller is programmed in Arduino IDE to run the irrigation system automatically based on soil moisture sensing [Louis, 2016].
- b) **Soil moisture sensor:** It is a device which gives the analog readings of the soil moisture in terms of voltage. Dual probe, antioxidant and anticorrosive soil moisture sensors were used to measure the moisture content from the soil. Conductance based soil moisture sensors are used to record the soil moisture [Nagarajapandian *et al.*, 2015].
- c) **GSM module:** GSM module is a chip or circuit. It is used to establish communication between the mobile device and the computing machine at a very reasonable cost. It requires SIM (Subscriber Identity Module) card and by using that SIM card it operates all activities [Veena D. K *et al.* 2013].
- d) **Relay:** A relay is an electronic switching device that switches ON or OFF when a small external voltage is applied across its control terminals [Verma *et al.*, 2015].
- e) **Solenoid valve:** A solenoid valve is an electromagnetically operated valve. Multiple solenoid valves can be placed together on a manifold [Sairaz and Yogesha, 2014].
- f) **Bluetooth module:** It is used to connect the smartphone to the controller. The threshold values required for system operation can be updated by using the mobile application and it is connected through Bluetooth interface [Purnima and Reddy, 2012].
- g) **Pump:** The pump is used to transfer energy from a power source to a fluid and as a result, it creates a flow or lifts greater pressure on the fluid. The pump is controlled by the relay so as to irrigate the field when there is depletion in the moisture content [Jadhav and Hambarde, 2015].

2.2 Power supply

Soil moisture sensors, Arduino mega, relay and GSM module works on 5 volt DC supply. The 9-12 volts DC @ 5 ampere supply is used to power Aurdino Mega (controller). Soil moisture sensors, relay, Bluetooth module, SD card module and GSM module are powered through Arduino 5 volt output pin.

2.3 Hardware parts of the automatic irrigation system

The unit of automation of the irrigation system was done by assembling the different components of the system such as a microcontroller, sensors, GSM module, etc. The hardware connection and connectivity is given in the circuit diagram and shown in Fig. 1.



A- Arduino Mega Microcontroller, B- Soil moisture sensors, C- SD card module, D- Real time clock, E- Bluetooth module, F- GSM module, G- Pump, H- Solenoid valve.

Fig. 1: Circuit Diagram

2.4 Operation and system setting

The controller will start after plugging into the power supply. The mobile application Serial Bluetooth is a freeware used for setting the lower and higher set point. It is easy to operate and requires three clicks to set lower and higher set point. The

system has the facility to view the presently available soil moisture content of the field and previous day's operational data with date and time as shown in Fig. 2, 3 and 4.

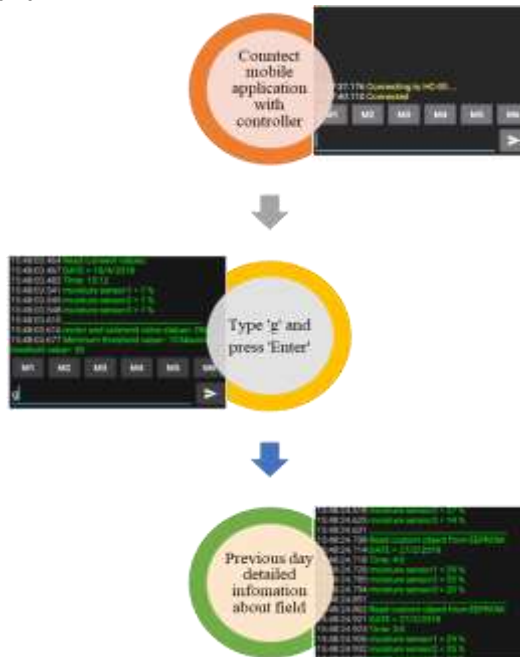


Fig. 2: Steps to view the previous day's operational data

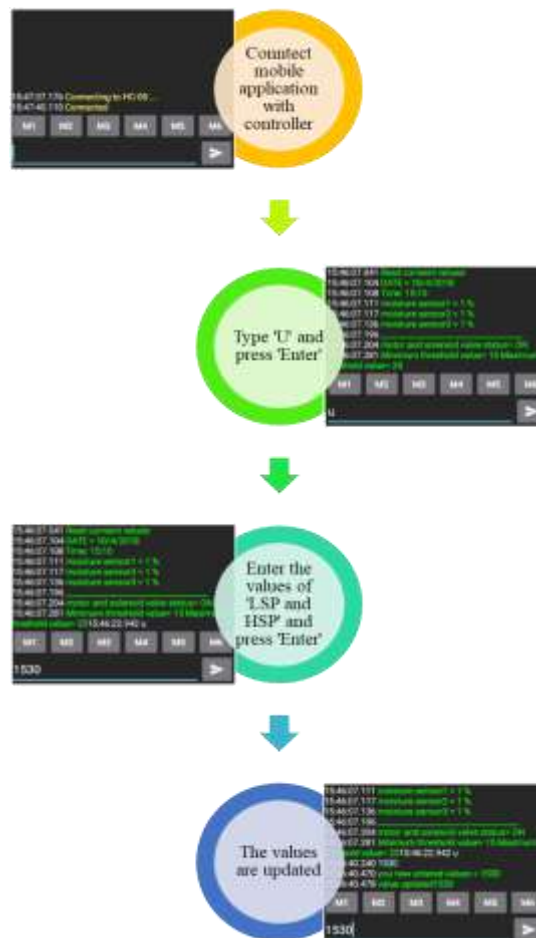


Fig. 3: Steps to set the LSP and HSP

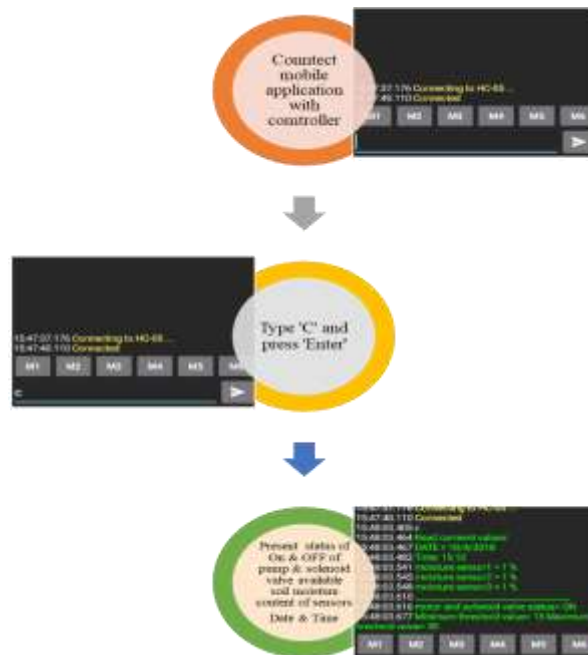


Fig.4: Steps to view the present status of the field

3. Results and Discussion

3.1 Development of controller of automatic irrigation system

The controller of the automatic irrigation system was developed at Laboratory of Department of Irrigation and Drainage Engineering, College of Agril. Engg. and Tech., Dapoli (INDIA). The pictorial inner and outer view of the controller is shown in Fig. 5.

3.2 Steps for automation of the irrigation system

The soil moisture sensor buried in the effective root depth of the particular crop. The smartphone / computer is connected to the system for setting the lower and higher set point. The soil moisture sensor is continuously sensing the moisture content in soil and sending the data towards the microcontroller. The microcontroller sends the signal to the relay to ON/OFF depending upon the soil moisture which controls the solenoid valve and the pump. The text message intimate the user about solenoid valve and pump operation. The required programming is done in the Arduino IDE. The steps for automation of the irrigation system are given in the flow chart as shown in Fig. 6.

A- Fan, B- Relay, C- Arduino Mega, D- GSM module, E- Bluetooth module, F- SD card module, G- Transformer, H- Real time clock, I- Socket for solenoid valve, J- Socket for pump

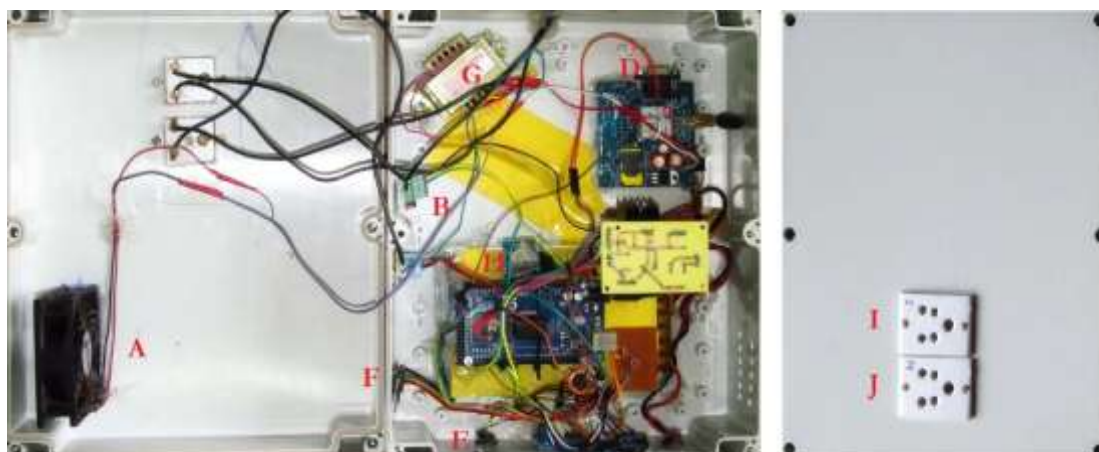


Fig. 5: Inner and Outer view of the controller of an automatic irrigation system

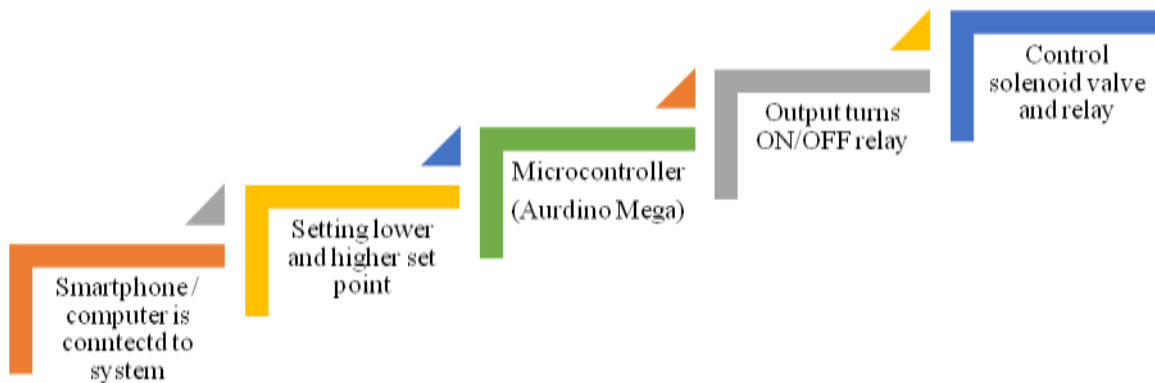


Fig. 6: Steps for automation of irrigation system

Table-1: Soil moisture readouts at gravimetric moisture content

| Sr. No. | Wt. of water added to 1000 g oven dried soil sample (g) | Moisture content (%) | Sensor Readout (mV) |
|---------|---|----------------------|---------------------|
| 1. | 0 | 0 | 1023 |
| 2. | 50 | 5 | 893 |
| 3. | 100 | 10 | 821 |
| 4. | 150 | 15 | 778 |
| 5. | 200 | 20 | 583 |
| 6. | 250 | 25 | 483 |
| 7. | 300 | 30 | 247 |
| 8. | 350 | 35 | 230 |
| 9. | 400 | 40 | 218 |

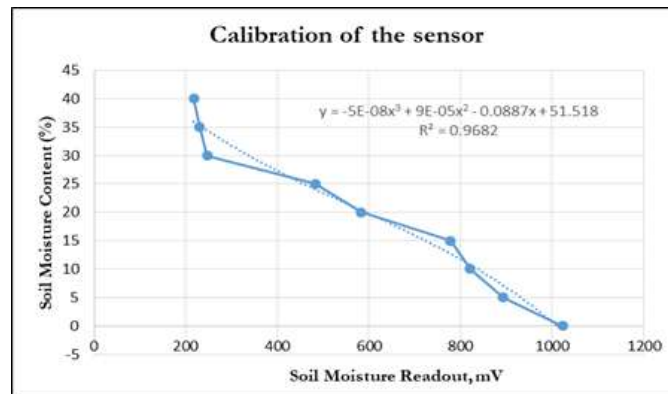


Chart -1: Graph of soil moisture readout Vs Moisture content (%)

3.3 Calibration of the sensor

From the Table 1, it is revealed that when we add 0 ml/ nil amount of water in 1000 g of oven dried soil then the sensor readout was observed to be 1023 mV, the soil moisture content by the gravimetric method was obtained as 0 %. When the amount of water is increased i.e., from 50 to 400 ml with an increment of 50 ml the sensors readout were observed to be decreased i.e., from 893 mV to 218 mV while the soil moisture content trend was observed to be increased and i. e., from 5 to 40 %. From Table 1, it is observed that the soil may be at field capacity (26.81 %) when the amount of water between 250 ml to 300 ml in 1000 g of oven dried soil sample when the sensor readout is to be obtained 483 mV and 247 mV, respectively. The readout approaches nearly close to field capacity between 25 to 30 percent moisture content, which is in close agreement as stated by Nallani and Hency, 2015 and Bowlekar, 2017.

The non-linear polynomial equation of degree 3 in terms of 'x' and 'y' was developed and the other values of corresponding moisture content were determined using interpolation. The graphical trend of moisture content and readout in nonlinear interpolation is shown in chart -1. The soil is heterogeneous in nature. Which means the readout obtained from soil varies from place to place. This calibration method is enough flexible to cope up with this condition and by using this method one can calibrate any type of soil.

3.4 Operation and system setting

A) Setting of lower set point (LSP)

The lower set point was the 50 % depletion in available moisture content. The available moisture content is the difference between the field capacity and the wilting point. If we consider the field capacity is 26.8 % and the wilting point is 11.6 %, so the available moisture content is 14 %. Further, the 50 % depletion of available moisture content about 20 % was considered to start the system.

B) Setting of higher set point (HSP)

The higher set point was set to the field capacity. The higher set point (HSP) was set by considering the field capacity as 27 % to stop the system.

C) Setting of LSP and HSP by mobile phone/laptop/ desktop

Immediately after deciding the LSP and HSP, The steps were followed as shown in Fig. 3 to set LSP and HSP by using mobile application or laptop.

D) Steps to know the present available soil moisture content

The present status of available soil moisture content in soil was obtained using mobile application Serial Bluetooth along with date and time by clicking the two-click as shown in Fig. 4. This was used during the calibration to know the present soil moisture content of soil sample and data were presented in Table 1.

E) Steps to view the previous day operational data

The system saved 6 readings daily and by using the mobile application it was possible to know with date and time by clicking two clicks as shown in Fig. 5. So whenever the user wants to know previous day moisture content, instantly mobile app easily provide that as shown in Fig.7.

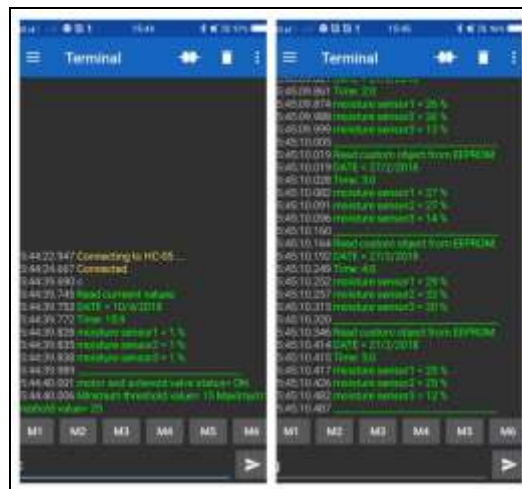


Fig. 7: Screenshot of the Mobile Application



Fig. 8: Screenshot of ON and OFF SMS obtained on the mobile

3.5 Working of an automatic irrigation system

The main hypothesis of the system is to apply the right amount of water at right time to fulfill the water requirement of the crop and to maintain the soil always at field capacity with allowable 50 % available soil moisture depletion. For achieving this condition sensors could be installed at the effective root zone of a specific crop in undisturbed soil. After installing the sensors, set a lower set point (LSP) and a higher set point (HSP). When the available soil moisture content is below the LSP, the sensor sends signals to controller to start the irrigation system to deliver water up to the field capacity (HSP) and at the same time, it sends the text message to user's mobile about ON and OFF of pump.

Once the soil has reached at HSP the sensors send a signal to the microcontroller. The microcontroller stops the pump and at the same time text message sent to the user. The detail of the solenoid valve and pump operation is sent to the user's mobile in the form of text SMS as shown in Fig.8. The controller hourly save the soil moisture content in memory card over the entire crop period, so one can easily get information about field condition of entire crop period.

Presently the controller has a capacity and facility to store the data of soil moisture content in field two years and it can be increased.

3.6 Cost of a unit of automatic irrigation system

The total cost incurred for the design of cost effective real time soil moisture based automatic irrigation system with GSM along with accessories is Rs. 11,330/-. The cost of the available automatic irrigation systems in India quoted by the firms is ranging from Rs. 100000/- to Rs. 400000/-. Thus, the developed system is a low cost system.

4. Conclusions

- The developed unit of automatic irrigation system works in any type of soil.
- The designed and developed unit of automatic irrigation system avoids or minimizes the recalibration compared to other automatic irrigation systems available in the market.
- It is possible to fix the upper and lower limit of soil moisture content to facilitate ON and OFF the irrigation system by mobile phone or laptop etc. using Serial Bluetooth mobile application.
- The automatic irrigation system having the facility to view the presently available soil moisture content and the previous day operation data within just two clicks.
- The designed automatic irrigation system minimizes and or rid manual interventions in ON and OFF the system and recording the observations of available soil moisture content in the field.
- It automatically starts even after the energy failure during the earlier event and it delivers the remaining water requirement of the crop hence no need to input or recalibrate the system.
- It has the facility to receive details of ON and OFF through SMS to mobile phone.
- It has the facility to store soil moisture data and can be downloaded.
- The system was designed with the low cost i.e. Rs. 11,330/- per hectare.

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