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+Research Article

Design of Automatic Irrigation Water Supply Monitoring and Control System

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Keywords

Automatic irrigation, Control system,
Moisture content,
Soil moisture sensor, Temperature sensor.

Abstract

Design of Automatic Irrigation Water Supply Monitoring and Controlling System was pursued to create an automatic irrigation controlling device for efficient water use and turning pumping motor 'On' or 'OFF' by sensing the moisture percentage in the field surface throgh moisture sensor. Objective was to reduce the involvement of man power for field irrigation monitoring purposes and reduce water requirement. This method can insure the proper use of water without wastage and save water for future. With the konwledge of moisture value in soil, we can estimate how much and when to irrigate crops. When the moisture content level on the output of the sensor or soil becomes less than 30% (desired value), then sensor generated an alarm and turns the motor on automatically. Displayed as 'motor On'in the LCD display and soil level was shown as 'dry soil'. Per hour machine data was received and shown in data table. A digital LCD Thermometer hygrometer Humidity Temperature sensor was also used to detect the temperature and relative humidity of the atmosphere with moisture content level was shown. Different field tests with crop and without crop were done. Total design cost was 4790 taka. Wet soil was tested with oven dry method to get accurate moisture level of the soil. Almost similar moisture percentage with moisture sensor was found. Temperature and relative humidity was also observed with weather station and found similar with sensor reading. Overall designed control and monitoring system was found satisfactory with minor errors.

1. Introduction

Soil moisture is a volatile factor. It is the volume of water found among the spaces of soil particles, normally expressed in volume or weight. Water available above 10 cm of ground surface is considered as soil moisture, when root area moisture in above 200 cm is considered as available moisture for plants. Through evaporation and transpiration in the atmosphere and earth surface, it can exchange heat and water energy for controlling manner. Primary objective of this work is to save these natural resources, use adequate percentage of water at accurate time, reduce stream over flow losses from watering, save time, eliminate human involvement in maintaining soil moisture level. Worlds 'population is increasing with time. But natural resources have their limitation. So, with efficient use of these resources, only we can survive smoothly. Water obviously a valuable natural resource and limited. Its high time to save these natural resources and utilize them in efficient manner. Liang et al. (2022) done a framework for comparison of water use efficiency across scales and to identify areas for future initiatives. Irrigation water distribution system can highly benefit with the knowledge of moisture in soil. Relationship among moisture and biophysical variables was examined with rain prone and irrigation field in Nebraska (eastern), USA. Hunt et al. (2015) explained a case for utilization of short-term drought indices for prolonged dry spell with drought identified a water stress of a rainfed field. Jacobson examined that soil moisture was affected by the spatial and temporal data distribution of temperature of ground, evaporative fluxes and radiative fields (Jacobson et al. 1999). Mustafa et al. (2017) examined the effect of biodegradable paper and plastic mulches effect on "as polythene mulches. Surface water, ground water from spring or well, lakes, reservoir or any other sources or treated waste water can be best source for irrigation. Peng et al. (2017) used remote sensing data to estimate soil moisture level. Olumide et al. (2022) used solar radiation data in soil moisture diagnostic equation for estimating root zone soil moisture and found accuracy. Moisture in is one of main elements of soil surface in relation with proper plant growth. Any issue with its availability can hamper plants optimum growth or yield as well as production. Various methods are designed to control or maintain proper moisture in plant root zone and reduce moisture level. Xu et al. (2022) improved subsurface soil moisture prediction from surface soil through integration of the (de)coupling effect. Soil sensor can maintain an optimum moisture level for favorable crop production.

By monitoring soil moisture, water usage can be optimized, enhance crop yield, produced high quality crops, minimize water resource deterioration and ensure economically feasible use of water. Rahmani et al. (2015) done an experiment for examining the soil water level in Iran with GIS and analysis the data. Soil saturation plays a important rule in atmospheric hydrologic cycle, both small and large range agricultural land/atmospheric model work area. Moisture availability at root zone is more valuable in crop growth and vegetation than chance of precipitation occurrence. In proper farm irrigation system design, Water budget as well as water scheduling requires local soil moisture data and plants crop water requirement. Clemens et al. (1990) applied an open loop system where amount of water to be applied and time for irrigation was decided by operator. Asharaf et al. (2012) found an impressive impact of advance monsoonal data on rainy season precipitation. Microcontroller gives an authentic result irrigation system gives a real time feedback about the soil energy situation. Onion cultivation within grey terrace soil in Gazipur was analyzed with different moisture level and found Various data irrigation water/ cumulative evaporation pan ratio in Bangladesh

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(Sen et al. 2006). Remote sensing data for soil moisture can initiate this monitoring and controlling system with its spatial and temporal data. Precipitation distribution and monsoon data was responsible for qualitative change of soil moisture variations in India (Sing et al.2004).

Agricultural is one of the vital sources of revenue in Bangladesh. Most of the farmers directly or indirectly depend on small-scale agriculture. In Bangladesh, almost 85% of irrigation systems operated manually and a huge amount of water is a wastage. Total water requirement for Tomato crop was reduced by 40%-50% and (70% reduction in 0.15 bar pressure) after tensiometer was used in Florida region (Dukes et al. 2010). Plants can intake only required water without drainage and overland flow. Now a day, water without which no human, animal or plant can survive is in a most vulnerable condition. So, for efficient water use, controlling and monitoring practices must be adopted. This system can be one of those practices.

Various types of soil moisture sensor are ferequently used in several agricultural projects horticultural design, farm irrigation design, meterological research work including solute transfer as well as subsidiary sensors for measurement of respiration system. Nogueira et al. (2003) examined the 'Data acquisition and irrigation controller' with subsurface drip irrigation using two tapes and sensor and fabricate a period-based automatic irrigation control system. Moisture sensors determine the volumetric moisture content in the soil. One type of sensors calculates the another parameter of moisture in ground surface named water potential; This sensor generates an alarm and monitor the moisture content in soil with proper amount of moisture %. Levido *et al.* (2014) worked on soil moisture sensor in rice field and got desirable result. Rossini et al. (2021) done a framework to determine the number and locations of sensorsin agricultural fields. World was having scarcity of water day by day which continuously infecting the agricultural and hence the food production process (Munoth et al. 2016). Mahya et al. (2021) designed a sensor based irrigation management to increase water use efficiency (WUE) in soilless micro green production. Shruti et al. (2021) designed a microcontroller bases iriigation supply and fertilisation system using soil moisture sensor and ph sensor. Michael et al. (2020) designed a soil moisture sensor based irrigation control system for crops under greenhouse conddition. Wilks et al. (2020) designed a sensor based irrigation to maximize the efficiecy of water for soybean yield and return the above irrigation cost, thus found efficient. Mohammod et al. (2020) found current water content (%) and status of pump operation (on/off)in their study.

Objective of this project was to design a device for automatic irrigation supply monitoring and controlling system with minimum water wastage and evaluate the device's working efficiency in soil surface.

2. Materials and Methods

2.1. Materials

Materials used for the project were micro controller AT 895S2,16×2 LCD display, a relay,12-volt DC motor, Driving IC, OP Amplifier, Soil moisture sensor, alarm, a power supply, an adapter power source or a battery power source, a bridge rectifier with long time. The device used Microchip with high consistency, fixed memory technology. A 16x2 LCD was used that can screened 16 alphabets per line and contain 2 perspective lines. Having 5x7 pixel matrix, each character of those lines was shown. To control a circuit, relays were used with a separate low power signal, or one signal can control multiple circuits. Total volumetric water content in ground surface was calculated by soil moisture sensor. Soil hygrometer humidity and soil moisture detection sensor Arduino was also used. various gravimetric processes such as collecting, drying, and weighing of sample can be manually measure free soil moisture. But soil moisture sensors estimated the water content by volume using other soil properties like electrical resistance, dielectric constant, or interaction with neutrons, as an instant for the moisture content.

Figure 1. Microcontroller, LCD display, 12volt, soil moisture sensor, DC motor, relay.

2.2. OP Amplifier

An operational amplifier (or an op-amp) is mainly an integrated circuit (IC).it is mainly a voltage amplifying device produced to use with capacitor, resistors etc. It is dc coupled high gain amplifier which has high voltage amplifier indicates input signal is lower than output signal. Non inverting amplifier has a good stability and high input impedance. It had two inputs of opposite polarity. Following diagram shows an op-amplifier with a circuit diagram.

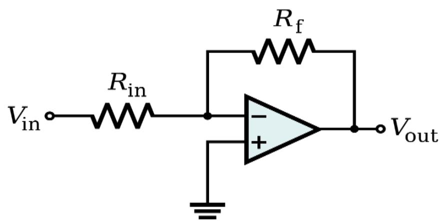

Figure 2. OP Amplifier

2.3. Field setup and application

"When ground surface is in dry condition, closed loop configuration produces a non-inverting amplifier. Electrical resistance of soil between the positive supply and non-inverting input becomes high resulting in positive supply less than the inverting entry and comparator shows the logic unit in output signal as 'low'. This logic command was given to the microcontroller. When soil moisture status was low, the module output was at higher level; else the output was at lower level. An alarm generated with low value of moisture. In this situation, the microcontroller outputs become logic high that switched the relay 'On' due to the transistor of relay driving and turned pump motor on. Then water initiated to flow. Soil moisture sensors was drilled into the ground at 5-7 cm deep. Once the soil had arrived in desire moisture percentage, soil moisture sensor read the level and sent a signal to the micro controller about surrounding moisture level. A low tech turned on the relays, which control the motor. In this sensor, the two probes were used to pass electricity through domain of farming, for utilizing proper moisture content. The moisture content was giving input gesture to an Arduino board which operated on AT895S2 micro-controller, was programmed to collect the input signal of variable dampness circumstances of the earth. Finally, result was displayed in the LCD display in two lines. Alarm was set to convey soil condition massage in generic to observer. Digital LCD Thermometer Hygrometer Temperature Sensor was also set to detect the temperature with moisture level. Figure 3 shows a total block diagram of the system and figure 4 shows the full assembling process.

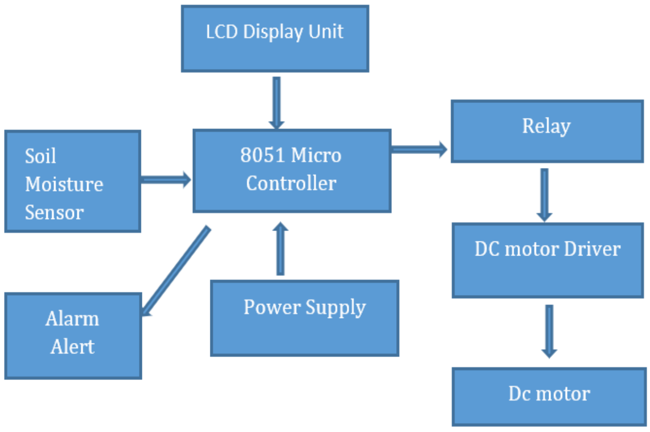

Figure 3. Block Diagram of Automatic Irrigation Using Soil Moisture Sensor

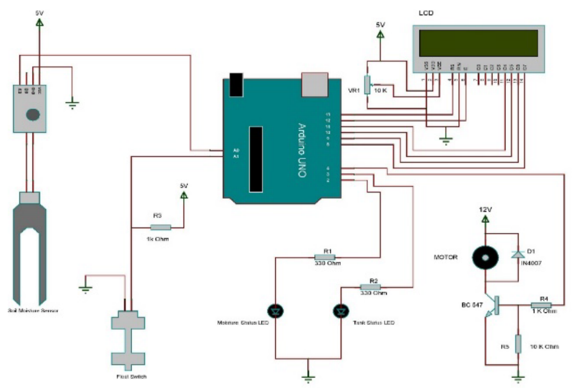

Figure 4. Set-up view of Automatic Irrigation System

3. Results and discussions

Device was designed and was setup in Aman rice field at the west side project field near to HSTU Residence area to get practical outputs. Figure 5 shows a typical setup view of the device in the field.

Figure 5. Field Set-up view of Automatic Irrigation System

Machine gave approximately an accurate and desired results about soil saturation "On and Off" mechanism worked properly with moisture content level as output of the comparator. when the comparator was logic less than 30%, motor turned 'On' and comparator was logic more than 60%, motor turned 'Off'. Alarm was generated properly with moisture level below 30%. The comparator and logic can be varied by changing programming conditions for different moisture content. System was flexible, low cost, simple to use and offered real-time monitoring. High quality soil sensors can be recommended for long time use. Field test with various crop variety with different water requirement can also recommended for further study. This device did not need any continuous operator. Only random checking was done and cross checked for proper working condition. Field soils sample was collected for measuring moisture level with different moisture percentage. Oven dry methods was used and found proper matching with sensor data. Small scale irrigation field was covered satisfactorily. This device was applied in Aman rice field. Awati et al. (2012), Rashid et al. (2013), Venkata et al. (2013) and Harishankar et al. (2014) also designed automatic irrigation monitoring and controlling system which was approximately separated from our design. But those data given us strength to improve this design with using a sensor for automatic moisture level detection. Sensor data was taken in the field with different time intervals. Temperature Sensor detect the temperature in degree celsius and showed in the display. Motor starting was observed and found frequent. Relative humidy was measured in mobile sensor. No additional requirement was set for humidity measurement. Moisture content was denoting as 'm.c.' in display for space limitation in screen. No continuous time interval data was taken, because this project focused on moisture level and water supply system monitoring. Overall project was capable of giving data signal for m.c., generate alarm and turning on/off the pumping motor.

Table 1. Soil moisture sensor and Temperature Sensor's data

Time	Day	Moisture content, %	LCD display	Temperature,^{0}c	Machine status
12.30 p.m	Day 1	55	Wet,55% m.c,35.3^{0}c	35.3	Motor off
1.0a.m	Day 2	41	Wet,41%m.c, 35.8^{0}c	35.8	Motor Off
8.00 a.m	Day 3	31	Dry,31%m.c., 37.1^{0}c	37.1	Motor On
5.00 p.m	Day 4	33	Dry,33%m.c., 36.2^{0}c	36.2	Motor On
12.00 a.m	Day 5	58	Wet, 58%m.c.,35.9 ^{0}c	35.9	Motor off
8.00a.m	Day 6	35	Wet,35%m.c., 34.6^{0}c	34.6	Motor Off

Table 2. Moisture condition and alarm data

Moisture content in field soil, %	LCD Display Reading	Alarm	Motor Condition
35	Wet, 35% m.c., 34.6^{0}c	Off	Off
30	Dry, 30% mc, Turn Motor On	On	On
60	Wet, 60% m.c., 35.6^{0}c, Turn Motor Off	On	On
65	Wet, 65% m.c., 36.6^{0}c c	Off	Off

Table 3. Economic evaluation

Items name	Amount	Cost
8051 Micro-controllers	1*1050/-	1050/-
LCD display (16*2)	1*280/-	280/-
12volt relay	1*450/-	450/-
Digital LCD Thermometer hygrometer Temperature and relative Humidity Sensor	1*640/-	640/-
soil moisture sensor	1*1600/-	1600/-
12 volt DC motor	1*450/-	450/-
alarm	1*320/-	320-

Total =4790/-

Table 4. Temperature, relative humidity and field moisture content data from sensors at same time

Time (12.00 p.m)	Temperature, ^{0}C	Relative Humidity, %	Moisture Content in Field, %
Day 1	35.3	73	55
Day 4	37.2	73	35
Day 7	31.3	67	53
Day 10	32.6	68	38
Day 13	31.1	72	45
Day 17	28.2	65	36
Day 20	29.2	72	31

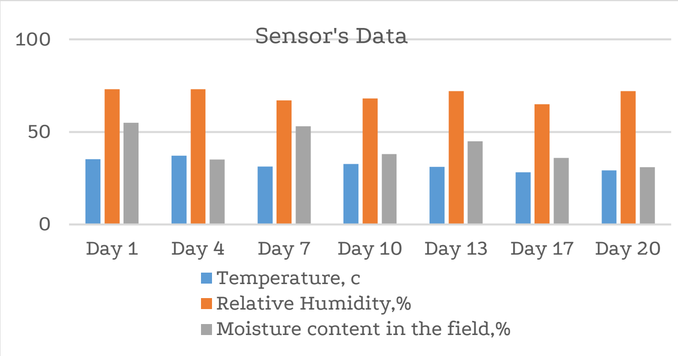

Figure 6. Sensor reading of temperature (^{0}c), relative humidity (%) and moisture content (%)

Following data was exerted from the system display and automatic started or stopped the existing motor. Display also showed the existing moisture level, temperature and motor status on it. A relationship among temperature, moisture level and relative humidity was shown for understanding whole system. Economic feasibility was given. Sensor data shown in LCD display for various time frame was also given.

Nomenclature

mc: moisture content in soil expressed in %.
HSTU: Hajee Mohammad Danesh Science and Technology university.
X: Number of day when sensor data was observed.
Y: amount of Temperature (^{0}c), relative humidity (%) and moisture content (%).

Declaration of Conflict of Interests

The authors declare that there is no conflict of interest. They did not get any financial supply, interest, and no personal relationships that could impact the work reported in this paper.

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