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DISSEMINATING AN AUTOMATED IRRIGATION SYSTEM USING SOLAR ENERGY IN PERSPECTIVE OF BANGLADESH

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ABSTRACT

Bangladesh is mainly an agricultural country. Agriculture is the most important occupation for the most of the Bangladeshi families. This study is conducted to develop an automated irrigation mechanism which turns the pumping motor ON and OFF by detecting the moisture content of the earth using the soil moisture sensor without the intervention of human. This Smart irrigation system project is using an Arduino Uno micro-controller, Solar Panel, Battery, Boost module, Relay Module, Soil Moisture Sensor, DC Motor etc. Arduino Uno that is programmed to collect the input signal according to moisture content of the soil and its output is given to the op-amp that will operate the pump. The benefit of employing this technique is to decrease human interference and it is quite feasible and affordable.

Keywords: Solar Panel, Pump, Soil Moisture Sensor, Battery, Boost Module, Relay Module.

INTRODUCTION

Irrigation of plants is usually a very time consuming activity which has to be done in a reasonable amount of time; it requires a large amount of human resources. All the steps were executed by humans traditionally. Nowadays, some systems use technology to reduce the number of workers and to reduce the time required to water the plants. With such systems, the control is very limited and many of the resources are still wasted. Water is one of these resources which is used excessively. This traditional method represents massive losses since the amount of water given exceeds the plants' needs. The excess water gets discharged by the holes of the pots, or it percolates through the soil in the fields. In addition to the excess cost of water, labor is becoming more and more expensive. So introducing IoT based automation is one of the advanced options to control irrigation system that can reduce mainly the labor cost and time. However, it also needs to be highly efficient with quality assurance and precision. So the objective of this study is set to provide a combination of manual supervision and partial automation and is similar to manual set-up in most respects but it reduces the labor involved in terms of Irrigation design which is simple, easy to install, microcontroller-based circuit to monitor and record the values of temperature, soil moisture (Transistor circuit) that are continuously modified and controlled in order to optimize them to achieve maximum plant growth and yield. It also involves the use of easily available components that reduces the manufacturing time. This design is quite flexible as the software can be changed any time. It can thus be made to the specific requirements of the user (Badescu, 2008). Finally, this study proposes a system that could be an economical, portable and a low maintenance solution for greenhouse applications, especially in rural areas and for small scale agriculturists.

Photovoltaic

Photovoltaic (PV) systems use semiconductor materials for the direct conversion of light into electricity by the photoelectric effect, which was first observed by Heinrich Hertz in 1887 and explained by Albert Einstein in 1905. The amount of electricity produced by the photoelectric effect is a function of semiconductor composition and the intensity and wavelength of solar radiation available to the PV device (Perlin, 2004).

Concentrating Solar Power

Concentrating solar power (CSP; defined here to exclude CPV) converts solar radiation to thermal energy to produce steam that powers an electrical generator or to operate an external combustion engine/generator combination. This utility-scale application relies on direct (beam) solar radiation, as described below, to generate tens to hundreds of megawatts of electrical power from a CSP system. There are several methods for concentrating solar radiation on a thermal receiver to produce working temperatures from 500 degree Celsius to more than 1000 degree Celsius. Solar-power towers use hundreds to thousands of heliostats (2-axis Sun-tracking mirrors) to reflect solar radiation onto a central tower-mounted receiver. The receiver is an efficient heat exchanger used to transfer solar-thermal energy to a working fluid, typically a molten salt, stored in large tanks. The heat is used to drive a turbine generator in a manner similar to that in conventional fossil-fueled power stations (Islam, 2014).

Solar Power, Solar Irradiance and Insolation

Solar irradiance is expressed as a radiant flux density or power density (W/m^{-2}). The amount of solar-power available to a conversion system is the solar-irradiance incident to the collector(s) multiplied by the system's total effective collector area ($W/m^{-2} \times m^2 = W$). Insolation is the total amount of energy that has been collected on a surface area within a given time. While the irradiance denotes the instantaneous rate in which power is delivered to a surface, the insolation denotes the cumulative sum of all the energy striking the surface for a specified time interval. This interval must be specified in order to make sense, and the typical unit of time measurement is the hour. Since energy is equal to the rate of power P being delivered for a specified time T, the resultant insolation equation is as follows:

Insolation = Power * Time / Area (Marion et al., 2006)

Justification of the Study in Perspective of Bangladesh

In future to set up Assembly Smart Solar pumps in Bangladesh as the country needs a huge number of solar pumps for irrigation. It will be easy for Bangladeshi people to get the pumps with low cost prices.

Electricity is the key to economic growth and development for a country like Bangladesh. And to reduce the burden on the national grid, the country needs to develop solar energy to meet the demand for fuel without affecting the environment Expansion of solar irrigation will cut dependency on diesel and electricity. Presently, Bangladesh has 1.34 million diesel pumps and these consume at least 1 million tons of diesel worth $900 million per year. The government provides huge subsidy to keep its price affordable for farmers (Kanojia, 2019).

On the other hand, about 3.20 lakh pumps are run by electricity to irrigate crops on a total of 54.48 lakh hectares in the dry season and some1,700-1,800 megawatts of electricity are consumed for irrigating rice fields. An increased number of people are getting interested in smart solar irrigation pumps due to their financial viability and lower cost. A farmer has to pay Tk 3,000-Tk 4,000 for each bigha of land as irrigation charge during a crop season for diesel or electricity run pump, whereas for solar irrigation pumps it is Tk 2,500-Tk 2,800 (Kanojia, 2019).

The potential of solar irrigation system in Bangladesh is huge. The average capacity of a solar irrigation pump is 18.5 Kw and it can irrigate 130 bighas of land. The pump of 18.5 kW size is capable of lifting 25 – 30 Lac liters of water per day in local solar irradiation condition. Most of the solar pumps have been installed in the north and eastern regions as during the dry season, farmers cannot irrigate crop fields properly as they do not get water in their shallow tube wells for lowering of the water table in the aquifer. Farmers also remain anxious about whether they can irrigate the fields timely. Now, they do not face any problem in getting water during the dry season. The installation of a 8.82 kW solar pump. The scarcity of land makes solar-based irrigation on a large scale difficult. So, a well plan should be taken during installing these devices for getting maximum benefit. We are installing the solar panels in such a way that the farmers can grow other crops on the land used for the solar irrigation pump. Solar pumps are contributing to improve farmers' livelihoods, increase climate change resilience of the agriculture sector and strengthen food security. Smooth supply of water for irrigation will help to increase agricultural productivity. In the remote off grid areas, the farmers remained worry over getting water for irrigation for a good harvest. In every Boro season, they had to hire a diesel-run pump and buy diesel to grow crops on land. Moreover, the machine could not pump out enough water due to depleting water level there and they got poor yield. With the installed solar irrigation pumps, farmers can now irrigate their lands without any hassle and make more profit than before as earlier they had to wait for days to get diesel for running their pumps for irrigation. The World Bank and several other organizations were supporting the initiative. The solar power based smart irrigation system grants to set up irrigation schemes run by renewable sources with a view to reducing dependency on diesel (Kanojia, 2019).

MATERIALS

Arduino Uno

Arduino is an architecture that combines Atmel microcontroller family with standard hardware into a board with inbuilt boot loader for plug and play embedded programming. Arduino Software comes with an IDE that helps writing, debugging and burning program into Arduino. The IDE also comes with a Serial Communication window through which can easily get the serial data from the board. It is an open source physical computing platform based on simple input/output board and a development environment that implements the Processing language (www.processing.org). Arduino can be used to develop standalone interactive objects or can be connected to software on your computer. The boards can be assembled by hand or purchased preassembled; the open source IDE (Integrated Development Environment) can be downloaded for free from www.arduino.cc

Figure 1. Arduino Uno

Pin Description of Arduino Uno

The Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. Each of the 14 digital pins can be used as an input or output, using pin Mode (), digital Write (), and digital Read () functions. They operate at 5 volts. Each pin can provide or receive 20 mA as recommended operating condition and has an internal pull-up resistor (disconnected by default) of 20-50k ohm. A maximum of 40mA is the value that must not be exceeded on any I/O pin to avoid permanent damage to the microcontroller.

Pin Specification

Serial: 0(RX) and 1(TX). Used to receive (RX) and Transmit (TX) TTL serial data.
External Interrupts: 2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change invalue.

PWM: 3, 5, 6, 9, 10, and 11. Provide 8-bit PWM output with the analog Write () function.

SPI: 10(SS), 11(MOSI), 12(MISO), 13(SCK). These pins support SPI communication using the SPIlibrary.

LED: 13. There is a built-in LED driven by digital pin13.

TWI: A4 or SDA pin and A5 or SCL pin. Support TWI communication using the wire library. The Uno has 6 analog inputs, labeled A0 through A5, each of which provide 10 20 bits of resolution. By default, they measure from ground to 5 volts, through is it possible to change the upper end of their range using the AREF pin and the analog Reference () function. There are a couple of other pins on the board. AREF Reference voltage for the analog inputs. Used with analog Reference.

Atmega328p Microcontroller

The high-performance Microchip 8-bit AVR RISC-based microcontroller combines 32KB ISP flash memory with read-while-write capabilities, 1KB EEPROM, 2KB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART, a byte-oriented 2-wire serial interface, SPI serial port, 6-channel 10-bit A/D converter (8-channels in TQFP and QFN/MLF packages), programmable watchdog timer with internal oscillator, and five software selectable power saving modes. The device operates between 1.8-5.5 volts. By executing powerful instructions in a single clock cycle, the device achieves throughputs approaching 1 MIPS per MHz, balancing power consumption and processing speed.

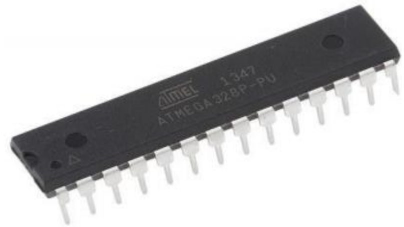

Figure 2. Atmega328P Microcontroller

Resistors

A resistor is a passive two-terminal electrical component that implements electrical resistance as a circuit element. In electronic circuits, resistors are used to reduce current flow, adjust signal levels, to divide voltages, bias active elements, and terminate transmission lines, among other uses. High-power resistors that can dissipate many watts of electrical power as heat may be used as part of motor controls, in power distribution systems, or as test loads for generators. Fixed resistors have resistances that only change slightly with temperature, time or operating voltage. Variable resistors can be used to adjust circuit elements (such as a volume control or a lamp dimmer), or as sensing devices for heat, light, humidity, force, or chemical activity.

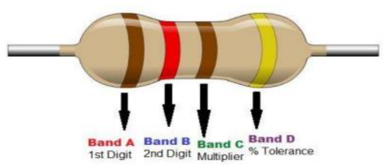

Figure 3. Resistors

LED

A light-emitting diode (LED) is a semiconductor light source. LEDs are used as indicator lamps in many devices and are increasingly used for general lighting. Appearing as practical electronic components in 1962, early LEDs emitted lowintensity red light, but modern versions are available across the visible, ultraviolet, and infrared wavelengths, with very high brightness. When a light emitting diode is switched on, electrons are able to recombine with holes within the device, releasing energy in the form of photons. This effect is called electroluminescence, and the color of the light (corresponding to the energy of the photon) is determined by the energy band gap of the semiconductor. An LED is often small in area (less than 1 mm), and integrated optical components may be used to shape its radiation pattern. LEDs have many advantages over incandescent light sources including lower energy consumption, longer lifetime, Improved physical robustness, smaller size, and faster switching.

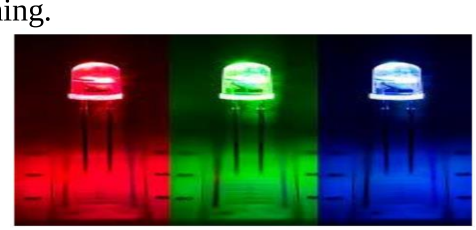

Figure 4. LED

Relay Module

A relay is an electrically operated switch. It consists of a set of input terminals for a single or multiple control signals, and a set of operating contact terminals. The switch may have any number of contacts in multiple contact forms, such as make contacts, break contacts, or combination.

Figure 5. Relay Module

Relay Circuit Diagram

Relays are used where it is necessary to control a circuit by an independent low power signal, or where several circuits must be controlled by one signal. Relays were first used in long-distance telegraph circuits as signal repeaters; they refresh the signal coming in from one circuit by transmitting it on another circuit. Relays were used extensively in telephone exchanges and early computers to perform logical operations. The traditional form of a relay uses an electromagnet to close or open the contacts, but other operating principles have been invented, such as in solid-state relays which use semiconductor properties for control without relying on moving parts. Relays with calibrated operating characteristics and sometimes multiple operating coils are used to protect electrical circuits from overload or faults; in modern electric power systems these functions are performed by digital instruments still called protective relays.

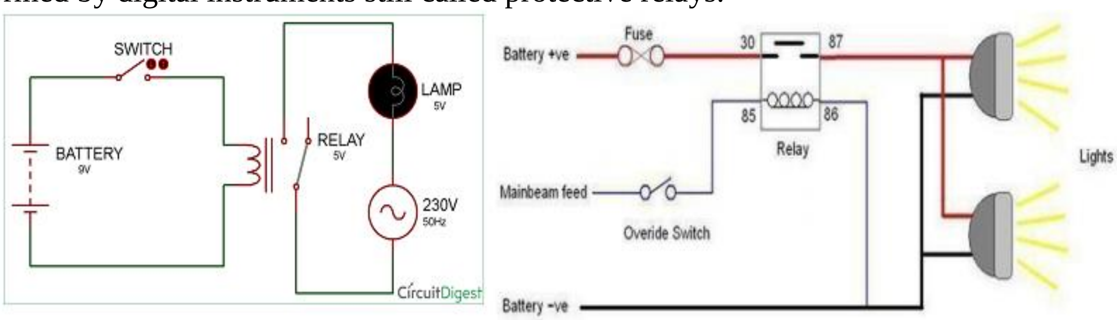

Figure 6. Relay Circuit Diagram

Relays are switches that open and close circuits electromechanically or electronically. Relays control one electrical circuit by opening and closing contacts in another circuit. As relay diagrams show, when a relay contact is normally open (NO), there is an open contact when the relay is not energized. When a relay contact is Normally Closed (NC), there is a closed contact when the relay is not energized. In either case, applying electrical current to the contacts will change their state. Relays are generally used to switch smaller currents in a control circuit and do not usually control power consuming devices except for small motors and Solenoids that draw low amps. Nonetheless, relays can "control" larger voltages and amperes by having an amplify.

Soil Moisture Sensor

An automatic moisture sensing and watering system detects a moisture level within the soil. The automatic moisture sensing and watering system may be implemented in combination with a conventional automatic watering system to accurately control a moisture content of a plot of soil. Since a plant draws water directly from the soil, the automatic moisture sensing and watering system is Adapted for controlling the moisture content of the soil itself, by measuring the moisture content within the soil. The watering period of an automatic watering system may be changed, based upon detected moisture content within a plot of soil. Alternatively, an amount of water to be applied at a next watering period may be changed, based upon a detected moisture content within the plot of soil.

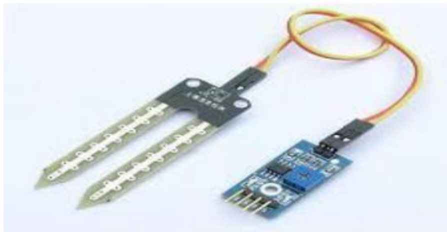

Figure 7. Soil Moisture Sensor

Water Pump

The DC motor is contained in a sealed case attached to the impeller and powers it through a simple gear drive. In the center of the motor is a rotor with coils around it. Around those coils are magnets, which create a permanent magnetic field that flows through the rotor. When the motor turns on, electricity runs through the coils, producing a magnetic field that repels the magnets around the rotor, causing the rotor to spin around 180 degrees. When the rotor spins, the direction of the electricity in the coils flips, pushing the rotor again and causing it to spin the rest of the way around. Through a series of pushes, the rotor continues to spin, driving the impeller and powering the pump. The impeller spins very fast. The curved blades channel water into the eye, or center of the impeller, but that water flows along to the outside of the blades. Because the impeller moves fast, the centrifugal force compresses the water against the outside of the blade. This pressure causes the water to rocket forward in a high-speed jet out of the impeller. This speed creates pressure on the outlet side of the pump, pushing the water through the pipe.

Figure 8.Water Pump

Jumper Wire

A jump wire (also known as jumper wire, or jumper) is an electrical wire, or group of them in a cable, with a connector or pin at each end (or sometimes without them – simply "tinned"), which is normally used to interconnect the components of a breadboard or other prototype or test circuit, internally or with other equipment or components, without soldering.

Figure 9. Jumper Wire

Individual jump wires are fitted by inserting their "end connectors" into the slots provided in a breadboard, the header connector of a circuit board, or a piece of test equipment.

Bread Board

A breadboard is a solder less device for temporary prototype with electronics and test circuit designs. Most electronic components in electronic circuits can be interconnected by inserting their leads or terminals into the holes and then making connections through wires where appropriate.

Figure 10. Bread Board

Vero Board

Vero board is a brand of strip board, a pre-formed circuit board material of copper strips on an insulating bonded paper board which was originated and developed in the early 1960s by the Electronics Department of Vero Precision Engineering Ltd.

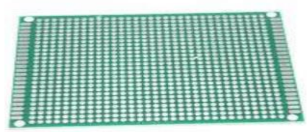

Figure 11: Vero Board

METHODS

There are two types of designing methods, one is Top-down method and the other is Bottom-up method. This work adopts the Top-down method. The design is a solution, the translation of requirements into the way of meeting them. The design will determine the success of the system. Based on the proposed system objectives, the major modules are identified and the operations to be carried out are determined. In the design phase of the system the data flow diagrams, flowcharts, data base tables, inputs, outputs and screen are designed by using all the necessary fields in a compact manner.

Major Blocks

There are different major blocks in the case of Automatic Irrigation System.

1. Power Supply
2. Arduino Uno
3. Extension Board
4. Moisture sensor
5. Plants
6. Water Sprinkler
7. Water Pump
8. Temperature sensor
9. IoT

The block diagram of Automatic Irrigation System on Sensing Soil Moisture Content project comprises three main components namely an ATmega328p, comparator and relay. This project uses an ATmega328p microcontroller which is programmed in keil software. When the sensor arrangement senses the moisture of the soil, it sends the signal to the microcontroller by using a comparator. Here, comparator acts as an interface between the sensing arrangement and the microcontroller. Sensing arrangement is made by using two stiff metallic rods placed into the field at a distance. Once the microcontroller receives the signal it generates the output that drives a relay and prompts the motor to pump water to the plants. The status of the water pump and soil is displayed on LCD which is interfaced to the microcontroller.

Thus, this automatic plant-irrigation system depends on the output of the humidity sensors. Whenever there is a need of excess water in the desired fields, then it is impossible to use sensor technology. But, by using DTMF technology we will be able to irrigate the desired field in desired quantity.

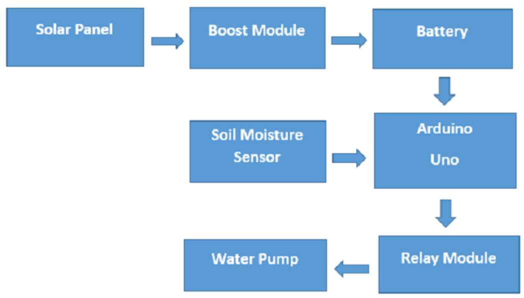

Figure 12. Project Block Diagram

RESULTS

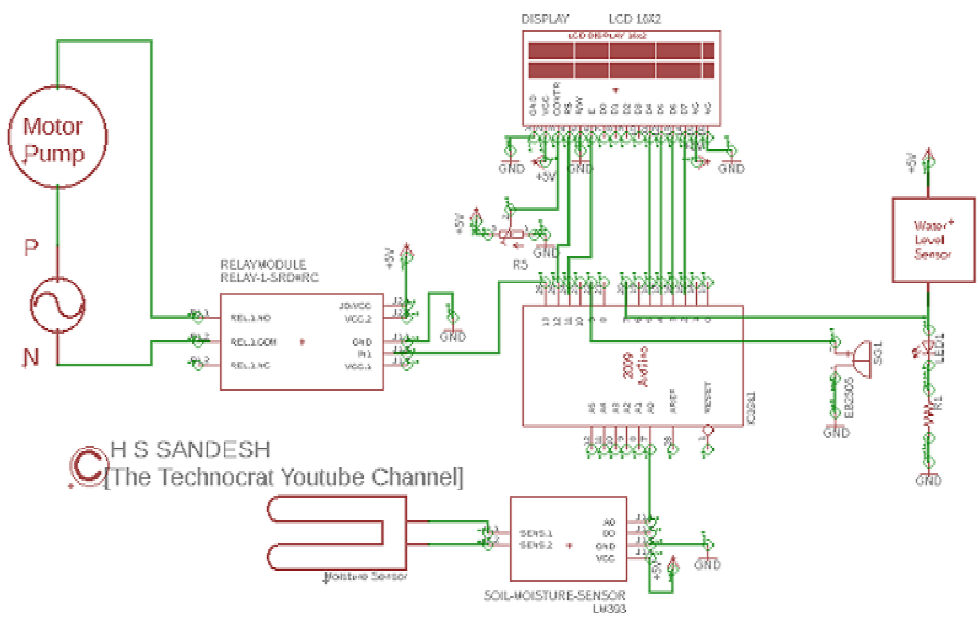

Figure 13. Circuit Diagram of IoT Based Irrigation System

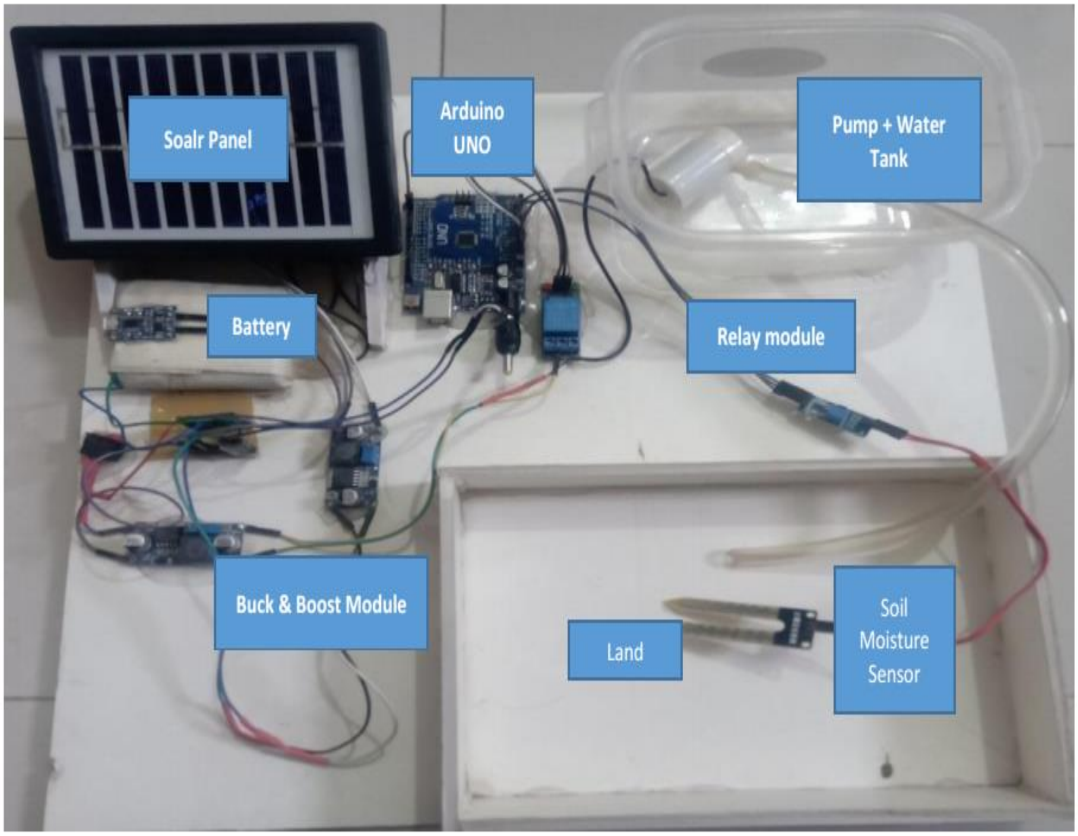

Figure 14. Pilot Project Model

Description of Circuit Diagram

The soil moisture sensor module used here have two output pins (Digital output and Analog output). The output from the probe of the moisture sensor is compared with a reference value using a lm393 comparator. The reference value can be changed by turning the potentiometer in the module. The digital pin gives an active low output when the soil is wet. Here we are using the analog output from the module by connecting it to one of the analog pins of Arduino. While using the analog output the wet detection value can be set/adjusted within the program itself.

As shown in the circuit diagram (**Figure 13**), a float switch is connected to one of the analog pins of Arduino and a 1K Ohm resistor is used to pulled up the line. Analog pins of Arduino can also be used as digital inputs. The status of the tank is identified by checking the output of the float switch. Arduino reads the voltage dropped across the pull up resistor for sensing the level of water in the tank. Â Two LEDs are connected to the 2nd and 3rd pin of Arduino to show the moisture status and tank status respectively. And the 4th pin links to the base of a BC547 transistor which in turn drives the 12 V DC motor.

A 16×2 LCD is connected with Arduino in 4-bit mode. JHD162A is the LCD module used here. JHD162A is a 16Ã—2 LCD module based on the HD44780 driver from Hitachi. The JHD162A has 16 pins and can be operated in 4-bit mode (using only 4 data lines) or 8-bit mode (using all 8 data lines). Here we are using the LCD module in 4-bit mode. Control pin RS, RW and En are directly connected to arduino pin 13, GND and 12. And data pin D4-D7 is connected to 11, 10, 9 and 8 of arduino.

Table 1. Cost Required

Serial No.	Components Name	Price
1.	Arduino Uno	430 Taka
2.	Solar Panel	450 Taka
3.	Soil Moisture Sensor	135 Taka
4.	Battery	500 Taka
5.	Water Pump	180 Taka
6.	Diode	05 Taka
7.	Relay Module	90 Taka
8.	Boost Module	140 Taka
9.	LCD 16*2	160 Taka
		Total= 2090 Taka

DISCUSSION

Thus the "solar power based smart Irrigation system based on solar power and soil moisture using Arduino" has been designed and tested successfully. It has been developed by integrated features of all the hardware components used. The system has been tested to function automatically. The moisture sensors measure the moisture level (water content) of the different plants. If the moisture level goes below the desired and limited level, the moisture sensor sends the signal to the Arduino board which triggers the Water Pump to turn ON and supply the water to respective plant. When the desired moisture level is reached, the system halts on its own and the water Pump is turned OFF. Thus, the functionality of the entire system has been tested thoroughly and it is said to function successfully.

Application of this Circuit

- Irrigation in Fields
- Irrigation in Garden Parks
- Very Efficient for Paddy Fields

Advantages

- Automation eliminates the manual operation of opening or closing valves.
- Possibility to change frequency of irrigation and fustigation processes and to optimize these Processes.
- Adoption of advanced crop systems and new technologies, especially new crop systems That are complex and difficult to operate manually.
- Use of water from different sources and increased efficiency in water and fertilizer use.
- System can be operated at night, water loss from evaporation is thus minimized.
- Irrigation process starts and stops exactly when required, thus optimizing energy requirements.

Disadvantages

- The systems can be very expensive (Table 1).
- Self-help compatibility is very low with big-scale systems, which are very complex. Most automated irrigation systems need electricity. For crops like rice we cannot use this same project because of excess need of water. We will use DTMF technique in the fields where large amount of water is needed.

CONCLUSION

Bangladesh faces many difficulties in cultivation. The agricultural sector hampered due to changes in climatic pattern. Rainfall anomalies e.g. heavy rainfall or scarcity of rainfall create floods and droughts in every year. The agriculture sector of the country is being affected and facing less productivity. The solar irrigation pumps can provide water for cultivation especially during dry season. Electricity often create problems in the rural areas. So introducing the solar irrigation pumps can help the farmers by providing uninterrupted water supply for their cultivation. The solar irrigation pumps can reduce farmers' dependences on diesel run irrigation pumps that are usually costly for farmers especially in remote rural areas. Moreover, this PV-module based solar irrigation plays a significant role for the environment by reducing the carbon emission. So there is a huge potential of this study in the field of solar irrigation system in Bangladesh.

REFERENCES

Badescu, V. (2008). Modeling Solar Radiation at the Earth's Surface Recent Advances. Springer Verlag.

Kanojia, C. (2019). Solar Power to Revolutionize Bangladesh Irrigation. The Financial Express. Retrieved from https://thefinancialexpress.com.bd/views/solar-power-to-revolutionise-bangladesh-irrigation-1552917511

Perlin, J. (2004). Silicon Solar-Cell Turns 50. NREL Report No. BR-520–33947.

Marion, B., Anderberg M., and Gray-Hann P. (2006). Recent Upgrades and Revisions to PVWATTS. In: Campbell-Howe, R. (Ed.), Proceedings of the Solar-2006 Conference, Denver.

Shafiqul, M. I. (2014). Prediction of Solar Irradiance for Bangladesh Using Neural Network. Thesis Report. Dhaka University of Engineering and Technology, Gazipur, 1700, Bangladesh. Retrieved from https://www.duet.ac.bd/wp-content/uploads/2019/09/Thesis_092231P.pdf