IoT based solar powered smart irrigation system

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Abstract: The basic and essential survival needs on earth is Water. In Recent times, the water scarcity is increased due to increase of population and deforestation. This paper based on development of an Internet of Things with solar powered irrigation using embedded method which is effective in agricultural field. Our project is to design a model of PIC for irrigation system which is supervised using Wi-Fi module (ESP8266). The WiFi module is operated using a (PIC) 16F877A from Microcontroller via utilizing the energy from the solar panel, run the motors which irrigates the field by sensing the moisture in the soil. The water above the marked level is pumped out by a motor by the information from the level sensor. The advancements of technology like IoT has vast demand in various operations. This system can easily access by the farmer to control the irrigation from anywhere in the world in an effective way.

Keywords: Solar, Internet, embedded, microcontroller, solar panel

1. Introduction

The worldwide major source of all living beings is Agriculture. 66% of a land totally available on earth is used for the agriculture, and it consumes 80% clean water available. The mentioned level of using water increases every decade due to globalization and population growth. The developing technologies are widely improved and useful in recent development. The problems in industries can be resolved by using various technologies[1]. The hybrid components usage are increasing rapidly. The systems coupled with electronic components paves a way to the emerging technology. The usage of advanced components available in real life. The electronic components or systems available are used in industries such as mechanical and aeronautical industries in an effective format. These usage of components are merged to get a desired output system. The main unit is the microcontroller which is an electrical component which is a high performance CPU unit which controls the entire system.
Initially, the required power was generated from the solar panel, by converting the light energy to electrical energy by using the photovoltaic effect, the output power from the panel is stored in the external battery. The voltage in the battery is not up to the marked level to operate the system [1]. To balance the acquired voltage by giving the 230V AC to the Step-Down Transformer, it converts 230V to 12V AC power, then the 12V AC is passed through the rectifier which converts the AC power to DC which operates the entire system and PIC microcontroller. The crystal oscillator generates the pulse of 20MHz [1]. Different crops are irrigated under different techniques [2]. In case of excess water staged in the field above the mentioned level, the level sensor senses the excess water and the pump gets operated and releases the excess water from the field. The WiFi module which is build up with the system is contributed to transfer the field data from any part of the world by using ADAFRUIT IO server or any other platforms to get and view data from the field. The IoT module helps to control the model from anywhere, by the usage of webpage or apk developed. The monitoring and controlling of model can be done in respective time intervals as possible. Refer as depicted in figure 1.

2. Materials and Methodology:

2.1. Relay:

The relay is the electrical device which used to operate a switch mechanically. It is used to control several circuits by single output. The amplifiers are the first relay telegraph circuits. The first work of the amplifiers is that they transfer the signal [3,4]. Relays are used as switches. Solid State Relays is used in the place of semiconductor device due to its high efficiency. Relays with calibrating features which protect project. In the modern electronic systems, the “protective relays” are used to avoid overloading [4]. The relays are the devices which is programmable to a time delay of 1 second. In this project, the powerful and most effective 5-Channel relay is used by referring the journals below [3,4]. The three pins on the relay are NO, NC & C [5].

Figure 1. Working of Internet of Things
2.2. PIC Microcontroller

The PIC -Peripheral Interface Controller. The Operating speed varies from 0 to 20 MHz, 200 ns instruction cycle, the microcontroller executes 5 million instructions per second. It’s Operating voltage ranges from 2.0-5.5V. It works in (-40° to +85°C). It can be used for operating 35 single-word instructions. The advantage of PIC microcontroller is more efficient than other microcontrollers. It executes 1 command in 1 clock cycle (Tcyc). The code is fed into the PIC16F877A using a device called PIC KIT. The microcontroller produce the signal [6]. The microcontroller consumes less power to operate. PIC16F877A consists of 40-pin compared to other microcontrollers. The PIC microcontroller is less in cost and high performance comparing with other microcontroller. The main advantage of the PIC microcontroller is the IC consists of 40 pins for input terminals and output terminals[1]. It works under RISC CPU where the inputs are processed in a faster rate and the output is displayed in a faster rate compared to other microcontrollers. It has Few addressing modes. The PIC 16F877A microcontroller have five I/O ports and internal resources of the PIC MCU [7].

![Figure 2. Microcontroller setup](image)

2.3. Solar Panel

The solar panel is a device which converts light energy obtained from the sun and converts into electrical energy for the operations of any systems [8]. Solar panel is made of photovoltaic (PV) cells. When the PV cell converts the light energy to electrical energy and the electrical energy is stored in the external battery. It helps to run the system [9]. The cells in the solar panel gets energized when the sun rays hits it. The excitement of the cells results in enlarge the heat energy and the terminals which is constructed in the back end of the supporting structure carries the generated heat energy and converts into the electrical energy and the electrical energy is carried through the wires and stored in the external battery. When the panel is kept under the sun light for a duration of 16 hours the panel generates theoretically 5.5 hours of total energy, in which 80% of energy is consumable without loss[10]. Solar insolation is radiation process which is measured in kWh/m2/day. Comparing a clear day, the efficiency from the sun is less during the cloudy day, hence the energy generated is low compared to clear day.
Similar Latitudinal regions have many cloudy days, will have much lower average insolation levels than, say, the Sahara desert [11]. This system uses batteries and a charge regulator, depends on the proposed design. Batteries plays a important role when the sun is too low to produce energy for the system. Battery-less systems are simple and easy to operate and maintain [12].

2.4. ESP8266 WiFi Module

An ESP8266EX Wi-Fi module is controlled by using TCP/IP protocol that can access any kind of wireless connectivity network. ESP8266 WiFi Module is cost efficient, requires minimum circuit connections, high performance in terms of storage and processing of the data. It allows connection of different sensors to the WiFi module through GPIO pins. It processes the sensor data in minimum amount of time. It is built with one chip self calibrated RF allows to work under different conditions. The Wi-Fi module microchip is fixed with a microcontroller where the data is processed and acts as a carrier which transfers the data from the sensors and other linkage systems to the server created using ADAFRUIT IO. The sensed data is processed by binary codes and gets transferred wirelessly through the data lines or data connecting factors such as receiver and transferring ports to the server. The basic features of ESP8266 WIFI MODULE consists of Integrated 10bit ADC working in the module and its Frequency range varies from 2.4GHz - 2.5GHZ. It works on the Operating voltage of 3.0v~3.6v. It has a connectivity of WiFi 2.4 GHz. It supports WPA/WPA2 Security. Adafruit IO header files contains APIs to fixed with a server. A server contains maximum of 8 feeds. This system processes three feeds namely Soil Moisture percentage, Field Atmospheric Temperature. Moreover, the troubleshooting is also made effective by using the ADAFRUIT IO server. [13].

2.5. Transformer

In our project, we utilized the step down transformer due to its purpose and function. In our system, the 230 V which is arrived from storage is more than the required voltage, therefore, the voltage has to be reduced before reaching the components as it may damage the components in a drastic way [14].

2.6. Sensors

In our project, sensors plays a crucial role in detecting the moisture content in the field, measuring the humidity content in the atmosphere, measuring the water content of the field, for detecting the remaining voltage in the external battery. [15]. Moreover, each sensor is dedicated for each purpose. The sensors are sensitive in nature. The list of sensors used in our system are:

2.6.1 Moisture Sensor

- Reactivity: it is defined as the capability to react to the system and provide the measured data to the user.
- Robustness: It is defined as the principal of working of the sensor in the outdoor environment.

This system is constructed using the LM393 moisture sensor. his moisture sensor be made up of detection probe, and sensor working board. It provides various output modes such as digital, analog, and serial. The sensor will measure the moisture content of the soil around it. The capability of the moisture sensor detection is around 1 sq ft. If the detected moisture content is low the module displays the output through the microcontroller by transferring the data through output pins. If the detected moisture value is stable, the flow of output remains in neutral conditions. This moisture sensor works on the principle that it passes the current to the soil through the two probes available in it, and the moisture content is detected by calculating the difference of the resistance levels available between the two probes. The water available in the land plays a vital role in the working of the moisture sensor, when the field or system consists of the water content, the electricity is conducted easily through the field and the detection of moisture is done easier where as in dry field the resistance of the field or system
increases [16]. The aim of our moisture sensor is to monitor continuous variations in surface moisture content over time. The changes in surface moisture produces consequences in the water balance and recharge of groundwater [15].

2.6.2 Temperature Sensor

The temperature and humidity sensor sense the temperature and water vapor in the field [18] and it ranges from 55°C to 1500°C. It produces the analog output from the microcontroller it consumes 5V of DC supply and shows the output in analog \((\text{temp} = \text{temp} \times 500; \text{temp} = \text{temp} / 1023)\) [2]. The function of the LM35 is direct-to-digital temperature sensor [17].

![Figure 3. Water requirements of crops](image)

2.6.3 Voltage Sensor

It is an electrical sensor which senses the voltage in the external battery. It consists of two terminals input and output. It directly senses the value and displays the voltage level in LCD display. The output is in analog format. The ADC converter in MC converts the analog signal to digital which is understandable by the microcontroller. According to the dependance of the channel or battery the voltage sensor provides the voltage. The voltage sensor detects the battery feedback and produces the output voltage by transferring the output voltage value to the microcontroller [19].

2.7 DC Motor

The working principle of DC motor is to convert the electrical energy to mechanical energy. In this system, the DC motor consumes the electrical energy from the power supply and converts it to the mechanical work by pumping the water from the external tank to the field. The main usage of the DC motor is used for speed control and load characteristics according to the system. The main advantage of the DC motor is the easy controllability and precise output so application of DC motor is large for commercial purpose. Speed control of DC motor is important so it is needed to be fulfill all the requirement of DC motor [20]. When the DC motor is on, it takes certain time to reach at full speed.

2.8 Crystal Oscillator

Crystal oscillator is an electronic device which is made of piezoelectric material that produces very precise frequency by the principle of mechanical resonances of a vibrating crystal. This frequency from the oscillator is used to provide a stable clock signal in digital integrated circuits. The example of crystal oscillator is Quartz crystal oscillator.
2.9 ADC Circuit

Analog-to-digital converters (ADCs) is a component which is essential in signal processing units, such as mobile communications, radar, satellite communications. ADC converts analog signal to a digitalized form by converting the data. Analog-to-digital converters (ADCs) is a circuit which helps to convert the data acquired from human recognizable form to computer-recognizable form. The limitations of ADCs are determined according to the capability of the integrated circuit (IC) process.

![Figure 4. ANALOG SIGNAL](image)

3. Proposed Methodology

The components are connected with the PIC microcontroller which is the CPU of our system. The moisture sensor is kept in the soil of the field. The temperature sensor is kept in the atmosphere of the field. The level sensor is kept at a desired height from the field. The voltage sensor is connected along with the battery which is also called as battery feedback sensor. The IoT module continuously extracts and delivers the sensor’s and field’s data to web developed using ADAFRUIT IO. The sources of power to operate the system is achieved by three different components: solar panel (solar energy), transformer, battery (electrical energy). The LCD display which is placed in the PIC microcontroller helps to analyze the field condition in person. The main power supply of 230V AC is converted to 15V DC through transformer circuits. The PIC microcontroller works only on 5V DC. When the moisture sensor sends the field data to the microcontroller, the microcontroller analyzes the data and commands the system whether the DC motor must be ON or OFF. If the moisture value is less than denoted value the motor gets turned on. If the water level hits the level sensor float it turns on the another DC motor which extracts the extra water from the field.

![Figure 5. Digital Signal](image)
4. Results and Discussion

The proposed design is directly connected with the ADAFRUIT IO server through the IoT WiFi Module which is situated in the system to transmit the field values from the design to the server. With the help of data sensed from the field using the following sensors {Temperature sensor, Level Sensor, Moisture sensor, Voltage Sensor}, the data is arranged in the webpage designed. The temperature sensors detect the temperature in the field and displays in the webpage in the unit of Degree Celsius. The Moisture Sensor Analyzes the water content present in the field in a continuous manner and it is connected to the IoT and displays the value of moisture in the measured value in the ADC value. The other sensor system that acts in the system is Voltage Sensor, it detects the voltage that is stored in the external battery circuit where the solar panel is connected, the voltage sensor measured value is represented in the unit of Volts. The Designed and the IoT Webpage that is created using ADAFRUIT IO is displayed with the sensed values and the working status of motors.

5. Conclusion

In the normal irrigation pattern, the water wastage is high since it is done manually. This proposed system consists the advantage of both manually operated as well as automatic irrigation pattern, which paves the path for the increased yield. The added advantage of this system is that the system does not allow the stagnant water to stay inside the field, analyzing the required water level for each crops. The process of excess water removal from the field is done using the additional pump connected to the system. The efficiency of this system is increased compared to the existing system available. The components utilised in this system is cost efficient.

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