International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 09 | Sep 2020 www.irjet.net p-ISSN: 2395-0072

Auto Irrigation System (Solar Powered and using I2C Technology)

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Abstract - *The primary objective of the project is to provide a solution to twin problems of unavailability of power and unavailability of nearby water sources for irrigation. The problem is faced by the majority of farmers in our country, especially those in western, central and the north-western states. This raises the questions of socio-economic problems to the farmers and to the country as a whole. Farmers are unable to produce a satisfactory yield due to unavailability of water or absence of grid power near their remotely located fields, are reliant on the state government to provide subsidies and grants to them This appears as an economic burden to the Government. Our dissertation paper aims to solve both these problems by taking a two-pronged approach. This project is based on the renewable source of energy which is solar power. There is no chance of pollution of environmental degradation. This microcontroller based project is automated with multi-dimensional possibilities.*

***Key Words*: Automatic, Solar, Microcontroller, GPIO extender, I2C technology.**

INTRODUCTION

Natural resources and non-renewable energies have a limit of use. Non-renewable energy sources are used for many reasons like conservation of renewable resources, diversification of fuel, energy security. Solar power is a common and clean energy source which is popular nowadays[1].

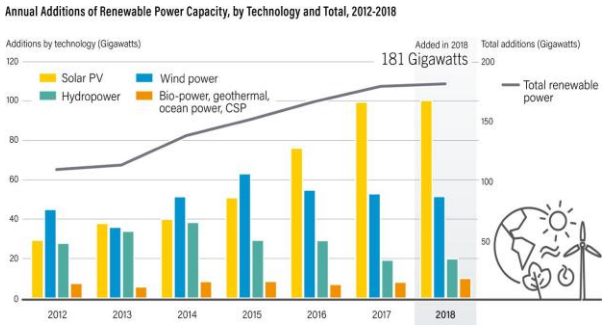

Fig 1: Diagram of the additions of renewable energy(Source:[1])

India receives sunlight all 12 months and it is effectively utilized. People try to reduce effort and want to get the work done. Watering fields at regular intervals is a rigorous task so the need for automation is. A microcontroller automates the process of irrigation with the solar power driven power circuit by a specific algorithm set in it. Moisture sensor in the field detects the moisture level in the soil and sends a signal accordingly and the microcontroller controls the whole process. The choice of the motor for irrigation, power inverter, battery for storage and the solar PV cells are made according to the ground size and power requirement. The dc-ac conversion makes the stored dc power by solar panel convert to ac power to run the motor using a power inverter. The motor is switched off when the field gets sufficient water automatically. The single Arduino Uno can control irrigation on the other fields with the PCF8574 GPIO extender and I2C technology. Separate power circuits are required for them but the control circuit is centralized. The system is designed considering the operating cost, maintenance cost, ease of control and operation, optimization of power and water. It is a self-sufficient system which does not depend on the grid power having many possibilities.

Objectives:

- To resolve the farmer pain points for irrigation
- To make the irrigation process smart, automatic and user friendly.
- To make use of the renewable energy resource in irrigation.
- Reduce the cost of irrigation with improved quality and accuracy.
- To find the opportunities and recommendations of the system.
- To use the system for environmental aspects.

COMPONENTS:

A.ARDUINO UNO: It is a microcontroller which is based on the open source C libraries and microcontroller ATmega328P. The boards contain analog and digital I/O pins. The pins are used to interface other general purpose input/output boards and circuits. The Arduino IDE is used for programming the microcontroller using libraries via a type B USB cable[2].

Fig1: Arduino UNO(Source: [2])

B. Soil Moisture Sensor: Soil moisture sensor detects moisture in the soil and sends a signal to the Arduino board. It works on the measurement of other properties of soil such as resistance, dielectric constant. If the moisture is high in the soil then it sends a 5v signal to the Arduino board to turn the motor off and if the moisture in soil is less than threshold, it sends a low signal or 0v[3].

Fig2: Soil Moisture Sensor(Source:[3])

C. Solar Panel: Solar panel supplies power in the system for operation. The photovoltaic cells use the photovoltaic effect to generate the DC electricity and stores in the battery for power requirements. To integrate the solar panel with the battery, inverter and motor, a solar panel with specific rating should be chosen. Sometimes an array of solar panels is used[4].

Fig 3: Solar Panel(Source: [4])

D. A.C single phase motor: Single phase A.C motors are used for pumping water to the fields. The power is supplied by the battery through an inverter to run the motor. 230v-1 HP single phase A.C motor is used in the system. The motor is a 4 pole cast iron motor which runs at less than synchronous speed[5].

Fig 4: Single phase A.C motor(Source:[5])

E. Inverter: The inverter is used to convert DC electricity to A.C electricity to run the motor. The battery supplies 30v D.C to the inverter and it converts it to 230v A.C power to run the A.C motor. The power rating of the inverter is 1K.W to integrate with the other equipment[6].

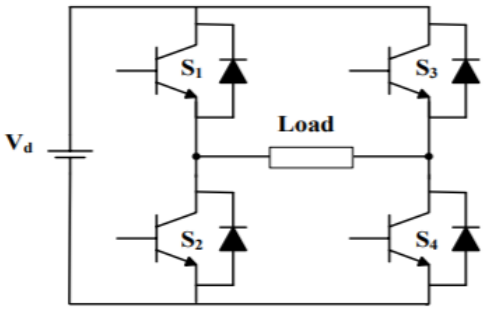

Fig 5: Circuit diagram of single phase inverter(Source:[6])

F. PCF8574 GPIO Extender: The PCF8574 GPIO extender is used for the expansion of digital I/O pins of the arduino board. The GPIO extender operates with I2C bus technology interfacing with the microcontroller. Eight digital I/O pins and three address inputs are available. Two types of PCF8574 IC boards are available in the market whereas a complete IO expander module is used in the system[7].

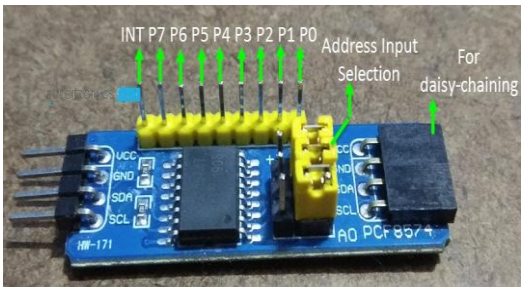

Fig 6: PCF8574 GPIO Extender(Source:[7])

G. Battery: Battery is used to store dc power from the solar panel. It is also used to power the irrigation motor, the microcontroller and the GPIO extender. The battery is

chosen as 167Ah, 30v to interface with the solar panels and inverter. Lithium ion batteries are used[8].

Fig 7: Solar battery(Source:[8])

H. Solar Charge Controller: Solar charge controller is used to control the charging of the battery from the solar panels. It reduces the chance of overvoltage and overcurrent and thereby battery lifespan increases and battery performance remains the same after years. It also controls discharge of the batter to avoid the drainage of power[9].

Fig 8: Solar Charge Controller(Source:[9])

I.Regulator IC: IC7805 is used to supply the operating voltage 5v to the Arduino board. The regulator IC steps down the 30v voltage of the battery to 5v to power the Arduino board for operation[10].

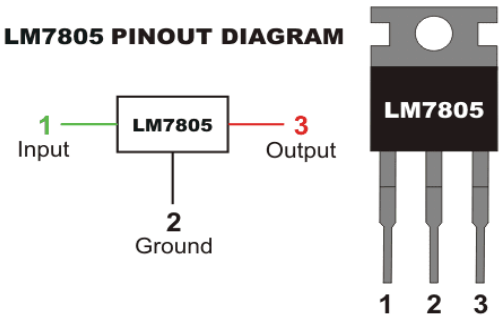

Fig 9: IC7805(Source:[10])

J. Relay: The motor control relay is used to control the A.C motor using the D.C power The 5 pin relay operates to switch on or off the motor according to the command of the microcontroller which is controlled by the signal from the moisture sensor The 12.v relay operates with the NO and NC pin to control the motor[11].

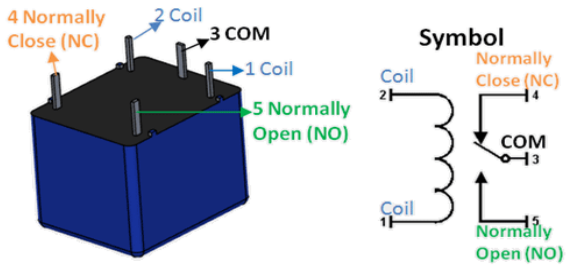

Fig 10: !2V Relay (Source:[11])

Design of the System:

The auto irrigation system using microcontrollers needs the successful integration of all the equipment for operation. The design can be divided in two sections, control circuit and the power circuit. The control circuit which is the low voltage circuit consists of the Arduino, GPIO extender, relay, soil moisture sensor. The power circuit is the high voltage circuit, it consists of the solar panel, battery, inverter and motor. The solar panel is connected to the solar charge controller and it connects the battery. The battery connects the Arduino with a regulator IC to power it. The Arduino is programmed with a specific algorithm using the Arduino IDE. The soil moisture sensor is connected to an analog pin of the Arduino. The battery is connected to the inverter. Inverter converts the DC-AC and supplies power to the motor. The motor pumps water from a water source, possibly pond. The motor is controlled with the relay which is controlled by the signal of the microcontroller. The GPIO extender extends the number of digital pins to21 which can be used to control other sensors. Similarly other power circuits can also be controlled using the single Arduino. This reduces the complexity of designing separate systems to water other fields. An LCD module is used for quick monitoring of the system[12].

Implementation of the System:

The design is implemented with the equipment of proper ratings. To water a field, the horsepower of the motor determines the amount of the water to be supplied to the field or vice-versa. In our system, we have chosen a 1HP single phase A.C motor to pump the water. The motor specifications determine the power required from the solar panel. The solar panel has the capacity of 800 watt to run the 746 watt motor. Inverter rating should be greater than the 25% rating of the total load. The load is considered as 800 watt, so the inverter rating should be 1000 watt or 1kw. Battery rating is 167 Ah,30v , so the watt-hour is 5010 which is 6 hrs backup for 800w load.

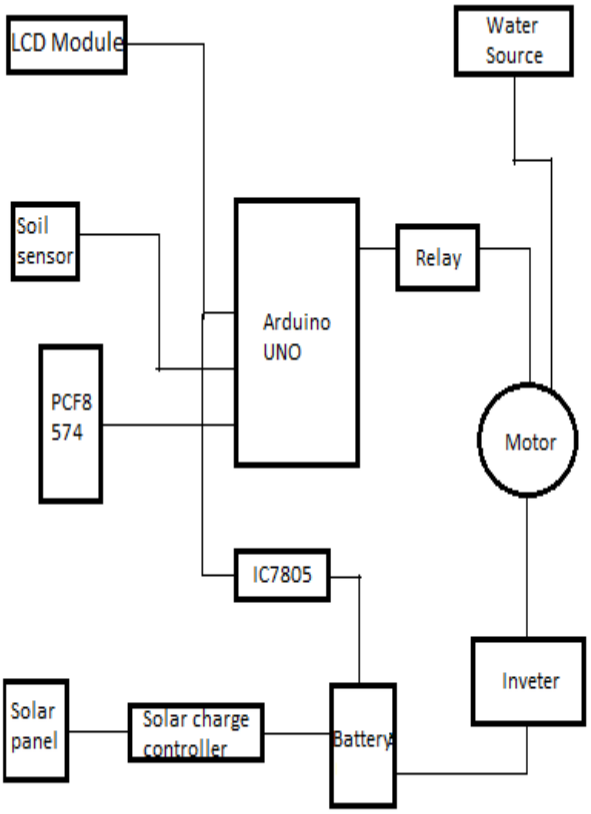

Fig 11: Block Diagram of the System

The charging current is 1/10th Ah of the battery, in this case it is 16.7 A. If the losses are considered while charging, and the charging current is 10 A, it takes almost 16 hours to fully charge the battery. So smaller the losses, quicker would be the charging of the battery. The power rating of all the equipment in the power circuit is chosen as the same for hazardless integration and interface. The soil moisture sensor is connected to the A0 analog pin generally. The relay is connected to the serial clock digital pin of the arduino[13].

Working of the System: The whole system works on a specific algorithm. The soil moisture sensor detects the moisture level on the ground and sends a high signal of 5v if the moisture in the ground is greater than the threshold level. The threshold moisture level is set by a potentiometer which is included in the sensor. It sends a low signal of 0v which turns on the motor by energizing the relay. If the moisture in the soil is alright then it sends a signal to the Arduino to turn off the motor by energizing the relay. The power is supplied by the battery depending on the time of watering.

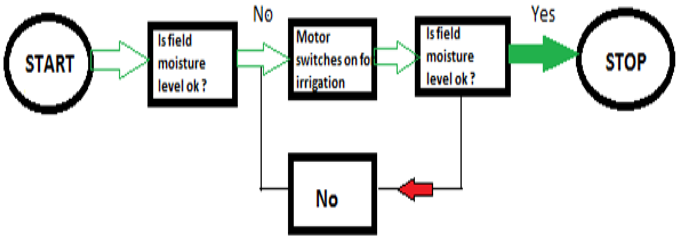

Fig 12: Flow chart of working of the system

In the appendix, the program is given which is run on the Arduino IDE using SoftwareSerial library. The Wire library is used to communicate with the I2C bus. The communication with the I2C bus is not included in the code. The GPIO extender is kept in the system for backup and future expansion of the system. The connection of the PCF8574 with the Arduino is simple, the SCL and SDA pins of the PCF8574 are connected with the SCL and SDA pins of the Arduino which are the A5 and A4 pins. The P0-P7 pins are kept open to connect other sensors[14].

Maintenance of the System:

Although we have tried our best to create the perfect system, it is not devoid of flaws. A few components are susceptible to flaws, most commonly the IC 7085 which powers the Arduino microcontroller. The common problems and their solutions are:

Dust accumulation on the solar panel: The surface of the solar panel needs to be wiped regularly in order to ensure maximum exposure to direct sunlight for maximum power generation.

Cooling system for IC7805: When IC7805 is exposed to high temperature condition, it is prone to burning out due to overheating. To prevent this, a cooling system can be employed as long as the cost does not outweigh the benefit since IC7805 is a cheap component.

Maintenance of the motor: The motor needs to be stored in a cool and dry place. A thorough cleaning needs to be performed every three months for proper operation of the motor. Such as blowing out dirt from grooves, checking and replacing worn out brushes, checking and replacing lubricating oil in the ball and sleeve bearings[15].

Cost Estimation:

The cost estimation gives an overview of the total cost of the installation of the system. Prices are collected from the internet and those are the standard prices. The price might vary a little but the total cost will be around the calculated cost.

Table 1: Cost Estimation of the system

Component	*Specification*	*Price (in INR)*
LCD Module	LM1061 custom	100
Arduino UNO	-	600
Regulator IC	IC 7085	20
Moisture sensor with probe	LM 393	250
12V Relay	12V	150
GPIO Extender	PCF8574	300
Solar Charge Controller	20 Amp, 12/24 V	1000
Power Inverter	30V-230V, 1 kW	5000
Solar Panel	800W, 24V	27000
Battery	167 Ah, 30V	30000
Total Cost:		Rs. 64,420

Cost of the motor is not included as the motor is already available for irrigation. The system is to connect the motor and make the whole process of irrigation automatic. Including the costs of motors, the cost would be around 1 lakh. The cost increases if we connect a separate solar panel-battery-inverter-motor with the system which is controlled by the GPIO extender through relay.

The Environmental Impacts :

All of us are aware of the scarcity of fresh and potable water, danger to aquatic life-forms, and water pollution. Keeping such factors in mind we have designed the system in a manner that will help safeguard the water sources surrounding it.

Our system ensures that excess water is not wasted

Once the motor has pumped water into the irrigation field, the moisture sensor senses it, and sends a signal upstream through the logic circuit which turns off the motor, thus preventing excess water from flowing into the field.

Smart usage of water leads to prevention of bio-magnification in local water bodies.

Bio-magnification is the phenomenon due to which excess run off water from the agricultural field flows back into local water bodies, taking with it the pesticides and insecticides used by the farmer. These chemicals serve as nutrition to algae colonies present in the water bodies. This causes a boom in algal growth, which results in higher oxygen consumption, lowering the dissolved oxygen level in water and killing other aquatic life, such as fishes, snails, crabs, plants, etc[16].

Improvements, Modifications and Recommendations:

The system can be improved and extended for many other aspects. The proposed system is constrained by some factors like cost. For better control of the irrigation process, other sensors, GSM modules and gate valves can be included.

1. GSM Module: With the integration of a GSM module (SIM 900A) into the system and the tweaking of the program of the microprocessor, we can control the motor remotely (by smartphone) to allow a greater degree of control over the irrigation process.

Fig 13: GSM Module(Source: [11])

2. Water level sensor: To bring accuracy in the irrigation process, water level sensors can be used to measure the water level in the ground. Each soil has different permeability so only the moisture sensor is not sufficient to control the irrigation.

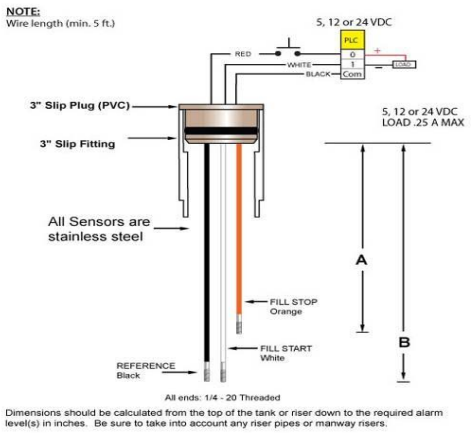

Fig 14: Water level sensor(Source:[12])

3. Storage of water: Motor pumps water from the pond but in summer, ponds become dry so separate storage of water is necessary. The storage can be filled with a separate pumping system.

Other sensors like noise sensors make the farmer aware about any hazard in the field, motion sensors detect any movement of the trespassers or birds or animals. This smart irrigation approach has the benefits of many fold. The gate valves help the single motor to irrigate other fields if the separate motor system is not used for economic factors.

Conclusion:

The project objectives are met with the proposed system. The primary aim was to make the process automatic in this digital era. PLC or microcontroller is used to automate the process but to make the cost-effective, Arduino microcontroller is used. The Arduino UNO is used in the system with the GPIO extender. Arduino Mega can be used in spite of Arduino UNO and extender but the project is to get an idea about the GPIO extender and I2C technology in irrigation. The GPIO extender can also be used with Arduino Mega for connecting a large number of equipment. Monocrystalline solar panels are used for better efficiency and lower space. But the cost has increased. Lithium-ion batteries are used generally to store the power as it has the longest life and requires less maintenance. Sine wave IGBT based solar inverter is used for running the motor which is a stand-alone inverter.Single phase A.C motor is used soit needs maintenance as it is not robust as D.C motors. The objective of designing a smart and automatic system is met. The cost is the main concern considering the financial conditions of the farmers. The installation cost of the system is apparently high but it saves money in the long run. There is no cost of electricity as the whole energy comes from solar power. The solar panels or battery requires replacement or repair after 5-10 years. In the rainy season, rain serves the purpose of watering depending on the region. So, in rainy seasons, the system can be maintained. In summer, the system needs to operate overtime.

References(IEEE):

[1]"Vox - Understand the News", Vox, 2020. [Online]. Available: https://www.vox.com/.

[2]"Arduino Official Store | Boards Shields Kits Accessories", Store.arduino.cc, 2020. [Online]. Available: https://store.arduino.cc/.

[3]"San Gabriel Valley Municipal Water District", Sgvmwd.org, 2020. [Online]. Available: http://sgvmwd.org/.

[4]"Business News Live, Share Market News - Read Latest Finance News, IPO, Mutual Funds News", The Economic Times, 2020. [Online]. Available: https://economictimes.indiatimes.com/.

[5]"ElProCus - Electronic Projects for Engineering Students - ElProCus is an educational website on electronic projects for ECE and EEE students.", ElProCus - Electronic Projects for Engineering Students, 2020. [Online]. Available: https://www.elprocus.com/.

[6]"Circuit Digest", Circuitdigest.com, 2020. [Online]. Available: https://circuitdigest.com/.

[7]"Electronics Hub - Latest Free Electronics Projects and Circuits", Electronics Hub, 2020. [Online]. Available: https://www.electronicshub.org/.

[8]"IndiaMART - Indian Manufacturers Suppliers Exporters Directory, India Exporter Manufacturer", IndiaMART, 2020. [Online]. Available: https://www.indiamart.com/.

[9]"Home - Ultra Heat Energy", Ultra Heat Energy, 2020. [Online]. Available: http://ultraheatenergy.com/.

[10]"Try Something Innovative", Trybotics, 2020. [Online]. Available: https://trybotics.com/.

[11]"Components101 - Electronic Components Pinouts, Details & Datasheets", Components101.com, 2020. [Online]. Available: https://components101.com/.

..[12]"2000+ Electronic Circuits, Projects, Tutorials & More - CircuitsToday", Electronic Circuits and Diagrams-Electronic Projects and Design, 2020. [Online]. Available: https://www.circuitstoday.com/.

[13]"Water Level Controls | Automatic Water Level Controllers", Water Level Controls, 2020. [Online]. Available: https://waterlevelcontrols.com/.

[14]"Yours for the making - Instructables", Instructables, 2020. [Online]. Available: https://www.instructables.com/.

[15]"San Gabriel Valley Municipal Water District", Sgvmwd.org, 2020. [Online]. Available: http://sgvmwd.org/.

[16]"Consumer Guide to Home Solar Panels | LetsGoSolar.com", Lets Go Solar, 2020. [Online]. Available: https://www.letsgosolar.com/.

APPENDIX

```
#include<SoftwareSerial.h>

SoftwareSerial Serial1(2,3);

 #include<LiquidCrystal.h>

LiquidCrystal lcd(14,15,16,17,18,19);

int led=13;

int flag=0;

String str="";

#define motor 11
```

```
#define sensor 7
 void setup()
{
 lcd.begin(16,2);
 Serial1.begin(9600);
 Serial.begin(9600);
 pinMode(led, OUTPUT);
 pinMode(motor, OUTPUT);
 pinMode(sensor, INPUT_PULLUP);
 lcd.print("Water Irrigation");
 lcd.setCursor(4,1);
 delay(2000);
 lcd.clear();
 lcd.print("Circuit Digest");
 lcd.setCursor(0,1);
 lcd.print("Welcomes You");
 delay(2000);
 lcd.clear();
 lcd.print("System Ready");
}
void loop()
{
 lcd.setCursor(0,0);
 lcd.print("Automatic Mode ");
 if(digitalRead(sensor)==1 && flag==0)
 {
 delay(1000);
 if(digitalRead(sensor)==1)
 {
 digitalWrite(led, HIGH);
 lcd.begin(16,2);
 lcd.setCursor(0,1);
 lcd.print("Motor ON ");
 digitalWrite(motor, HIGH);
 delay(2000);
 flag=1;
 }
 }
 else if(digitalRead(sensor)==0 && flag==1)
 {
 delay(1000);
 if(digitalRead(sensor)==0)
 {
 digitalWrite(led, LOW);
// sendSMS("Soil Moisture is Normal. Motor turned OFF");
 digitalWrite(motor, LOW);
 lcd.begin(16,2);
 lcd.print("Motor OFF");
 lcd.setCursor(0,1);
 lcd.print("Motor OFF");
 delay(2000);
 flag=0;
        }}}
```

BIOGRAPHIES

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