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Solar Power Based Hydroponics Monitoring System

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***Abstract*: As the demand for nutrient rich food is increasing day by day, but our traditional soil-based agriculture technique face some major challenges, one of which is land availability. It is more relevant to practice soil-less agriculture methods to overcome this problem. Hydroponics is one of the most popular and well organized soil-less cultivation method. It is a type of cultivation where the roots of the plants are submerged into nutrients filled fluid. The aim of the project is to create a fully automated hydroponics system using different sensors and taking appropriate control measures. Temperature, relative humidity, light intensity of greenhouse, pH level and nutrient level of nutrient solution is regulated. The main objective is to control pH level and nutrient level of nutrient solution within the desired intervals for growing spinach.**

***Keywords*: Solar power, Hydroponics.**

1. Introduction

Hydroponics is a method of growing crops without soil. This used to be considered a system where there was no growing media at all, such as the nutrient film technique (NFT). But today it is accepted that a soil-less growing medium is often used to support the plant root system physically and provide for a favourable buffer of solution around the root system and will be automated to prevent many disadvantages that have in manual system. In the past setting up a hydroponics system required research, many installations steps and daily monitoring to ensure proper growth.

Currently, with the knowledge about the type of plant to be grown with proper nutrient and pH level as it varies for different plants. Once this information is known and the plant is selected, accordingly the system can be set up correctly. In this project by using NFT technique we grow Spinach as it is easy to grow and produce large yield. This technique requires daily monitoring pH level, nutrient level, temperature, humidity and light intensity. Solar energy is used as the power supply and Wi-Fi technology for communication purpose.

This system helps the farmers to increase the efficiency. Gives better yield. The solar power used is most energy-efficient, eco-friendly to the plants, but the efficiency reduces during the rainy and cloudy day. Requires constant monitoring in case system failure occurs in the system. It is used in terrace farming or gardening, also in large scale farming. It requires less water compared to the conventional growing method, no harm fertilizers are used, plants can be grown in any season.

The NFT system is a hydroponic technique where in a very shallow stream of water containing all dissolved nutrients required for plant growth is re-circulated past the bare roots of plants in a watertight gully, also known as channels. This system is often used to grow smaller and quick growing plants like spinach. The major downside of this system is that the plants are very sensitive to interruptions in the flow of water and plants will begin to wilt very quickly any time the water stops flowing through the system.

Fig. 1. Hydroponic spinach plants

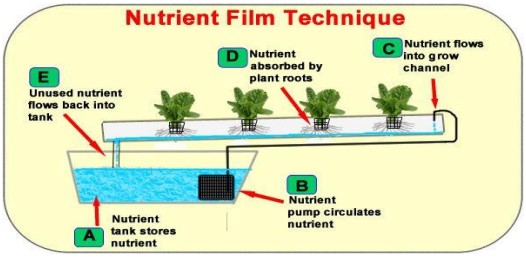

Fig. 2. NFT technique

A. *Motivation for Research*

NFT hydroponics system lets anyone to farm his or her own hydroponics plants using a simple automated system. It relieves

the user from a lengthy setup and daily maintenance. This system will perform all daily testing necessary, adjust system levels of pH, nutrients and water as necessary and notify the user about the problem requiring action and log all testing data for analysis.

B. Goal of Research

- Solar powered.
- Wireless updates to phone.
- Low maintenance.
- Ability to farm their own hydroponic plants using automated system.
- To make hydroponic gardening as simple with better yield.

C. Objectives of the Research Program

1. To design a system to convert solar energy to electricity.
2. To Alert the owner through smartphone using Wi-Fi module.
3. To monitor and control the Temperature and humidity of Greenhouse.
4. Monitoring and controlling of water pH level in accordance to the plants requirement.
5. To monitor and control the light intensity of the greenhouse.

D. Problem Statement

Faster growth combined with relative freedom from soil diseases, and very consistent crops, the quality of produce being excellent. The benefits of this system, it can be raised in any season and the plant nutrients are dissolved in the water used in hydroponics and are mostly in inorganic and ionic form. Hydroponics is more efficent and earth friendly than convential farming.

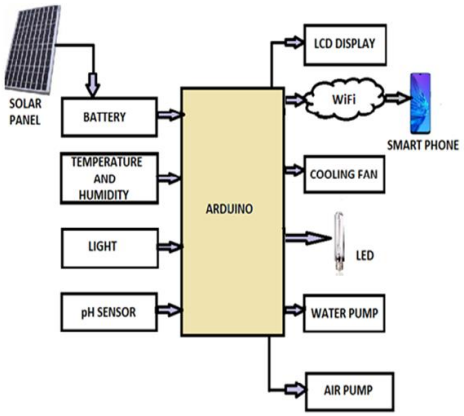

Fig. 3. Block diagram

2. Methodology

Objective 1: To design a system to convert solar energy to electricity.

Solar panels produce electricity to power electric equipment in the greenhouse like fans, pumps or lights.

In our model, we have planned to develop a 3x3 hydroponic model. For this 8W of power is required and it costs $3-$5 per watt.

How do solar panels work to generate electricity?

A standard solar panel (also known as a solar module) consists of a layer of silicon cells, a metal frame, a glass casing, and various wiring to allow current to flow from the silicon cells. Silicon is a non-metal with conductive properties that allow it to absorb and convert sunlight into electricity. When light interacts with a silicon cell, it causes electrons to be set into motion, which initiates a flow of electric current. This is known as the "photovoltaic effect," and it describes the general functionality of solar panel technology.

- *The photovoltaic effect*

The science of generating electricity with solar panels boils down to the photovoltaic effect. It was first discovered in 1839 by Edmond Becquerel and can be generally thought of as a characteristic of certain materials (known as semiconductors) that allows them to generate an electric current when exposed to sunlight.

The 19 Volts that the solar power generated will blow the pump if connected directly. There are two options to reduce it to 12 Volts that the pump can accept without blowing, using Solar Charge Controller or DC-DC Converter.

Solar charge controller, in addition to converting the solar panel output to 12 Volts, also able to charge 12 Volts battery. The charge controller will also switch the power from solar panel to battery at night to keep the equipment running. However, most solar charge controller available in the market require a battery to be attached to operate properly. This makes it less suitable for our design, as we don't need the battery to run the pump at night

Solar based power supply for Arduino board

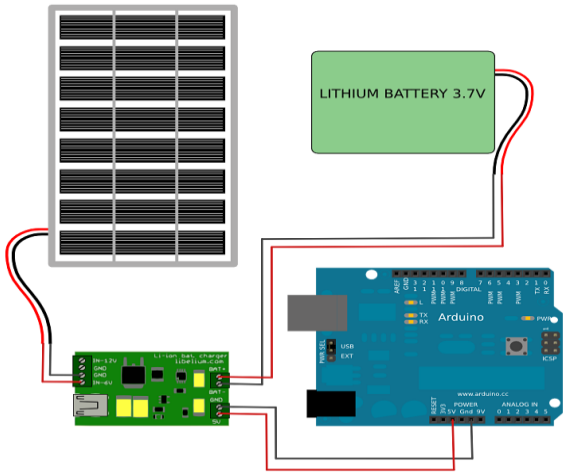

Fig. 4. Solar power for Arduino board

The board is based on a charger for Li-ion batteries and a DC-DC converter to supply the 5V. The SquidBee mote needs, and

includes three different inputs: a couple of pin connectors (VCC and GND) for more than 6V cells, another couple of pin connectors for up to 6V cells and a mini USB connector. The two last connections go directly to the battery charger, but the first one goes through a voltage regulator whose output is limited to prevent the charger from any damage caused by a too high voltage. The mini USB connector has been added in order to allow the battery to be charged when it is not possible neither to attach a solar cell or to connect it to the main power.

We have selected a MAX1555 charger from Maxim to energize the battery. This module can handle two different inputs, one that bares voltages from 3.7V. to 7.0V. that will be used to charge the battery from a DC source and another one that bares voltages from 3.7V. to 6.0V., used to carry out the charge from the USB. The MAX1555 output to the battery provides a typical charging current of 280mA and a voltage of about 4.2V, though it may change depending on the battery and its state.

Objective 2: to alert the owner through smartphone using Wi-Fi module

Most people call ESP8266 shown in the fig.2.1 as a WIFI module, but it is actually a microcontroller. ESP8266 is the name of the microcontroller. This microcontroller has the ability to perform WIFI related activities hence it is widely used as a Wi-Fi module**.** After few tweaks in the IFTTT website we will able to get a HTTPS URL which when triggered will send a predefined Text message to a specific mobile number. Now, this URL has to be called by our ESP8266 module when needed and your SMS will be fired to your mobile number.

To code the ESP8266 using Arduino IDE we Navigate to Tool > Boards > Board Managers. Search for ESP8266 by esp8266 community and click on install. After installing should go to Tools > Boards > Generic ESP8266 modules.

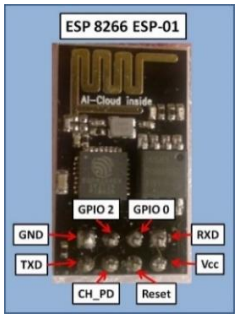

Fig. 5. ESP8266

Connections of ESP8266 to the Arduino UNO. First we connect the Arduino uno board's 3v3 (3.3V) output to ESP8266. The ESP8266 works with 3.3V and not 5V. Connect the RES pin, when you ground the reset pin, the Arduino works as a dumb USB to serial connector, which is what we want to communicate with the ESP8266.TX pin of one to the RX of the other (send goes to receive and the opposite). Here Arduino does not communicate directly to the ESP8266 though, our computer does the communication *via* the Arduino. Connect GND and VCC as shown in the fig. 6.

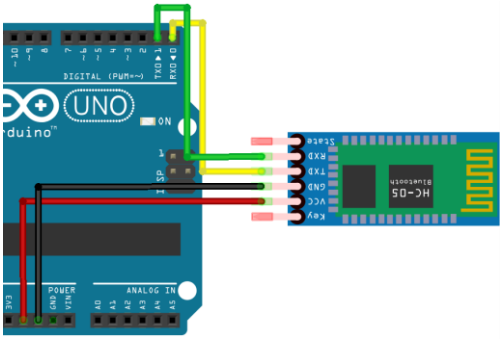

Fig. 6. ESP8266 connections to the Arduino Uno

Algorithm:

Step 1. It monitors the output of DHT11 sensor (pin A0) and pH sensor (pin A1).

Step 2. If the temperature crosses 32 degree celsius it sends an SMS saying the temperature has crossed the treshold.

Step 3. If the pH sensor output bcomes more than 7 it sends a SMS mentioning that nutrient soulution has become basic and if it is less than 7 it mentions that nutrient solution has become acidic.

Step 4. Else repeate step 1.

Objective 3: To maintain and control the temperature and humidity

The plants are very sensitive to fluctuating temperature and humidity, if both of these parameters are high; the plants lack their ability to transpire. Thus, it has an adverse effect on their growth. However, they adapt to a higher humidity range once their roots have matured, hence it is important to maintain temperature and humidity.

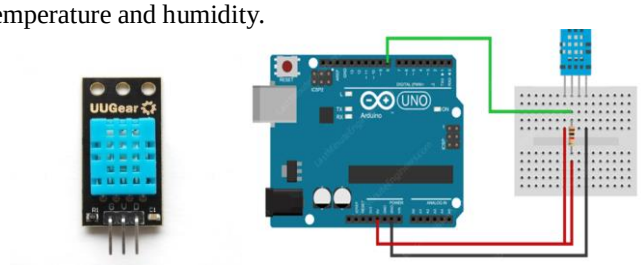

Fig. 7. DHT11 sensor and connect to Arduino Uno

As we are growing spinach plants, it requires around 18 to 32 degree Celsius and 50% of humidity. Hence we set 32 degree Celsius as the threshold. The Dht11 sensor reads and displays the output on the LCD. If the temperature is beyond 32 degree Celsius, fan turns ON else remains OFF. And the humidity threshold is set to 50%. The sensor displays the humidity level on the LCD. If humidity level is beyond 50% pump turns ON else remains OFF.

Objective 4: Monitoring and controlling of water pH level in accordance to the plants requirement.

pH level

The control of pH is extremely important, not only in hydroponics but in soil as well. Plants lose capability to absorb

different nutrients when the pH differs. Different plants have a particular pH that is optimal for them, generally though most plants prefer a slightly acid growing environment. An ideal pH level is between 5.5 and 7. Changing the pH level too quickly is not a good idea as thus will stress the plants out too much. pH scale range is from 0 – 14,where 7 is neutral,0-6 is acidic and 8-14 is alkaline.

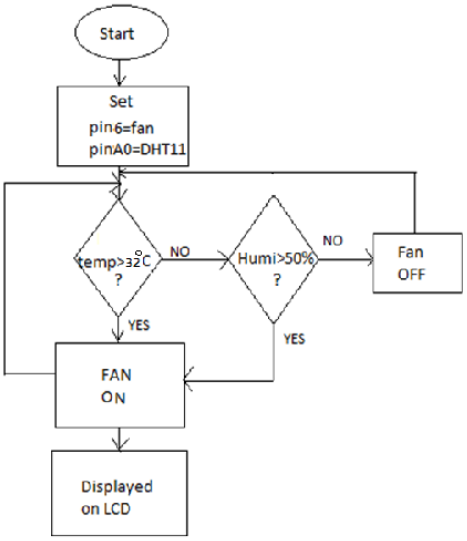

Fig. 8. Flowchart

Fig. 9. pH(SEN0161) sensor

The pH range required to grow spinach is 5.8-6.6. Initially pH lowering buffer is added, containing 81% phosphoric acid into a reservoir containing tap water. After stabilization a pH increasing buffer is added, containing 50% phosphoric hydroxide and later nutrient solution is added. This water solution is pumped to the pipe where the plants roots are submerged. The pH sensor is placed in the water containing pH and nutrient solutions. The output of sensor is analog, and the probe is connected to the analog input of arduino.ph sensor senses the pH range continuously. If pH range is less (i.e. less than 5.8) Arduino sends message to the owner showing the accurate pH range and potassium hydroxide is added to raise pH. Similarly, if pH range is more (i.e. more than 6.6) phosphoric acid is added to low the pH range. Later nutrient solution is added.

Nutrient solution:

Nutrients are the main factors influencing plant growth and development. Nutrients solutions are basically composed of macro-nutrients and micro-nutrients which are shown in the table given below.

Macro-nutrients		Micro-nutrients	
Nitrogen(N)	125pm	Iron(Fe)	0.94pm
Phosporous(P)	31ppm	Manganese(Mn)	0.14pm
Potassium(K)	215pm	Boron(B)	0.16pm
Calcium(Ca)	84ppm	Copper(Cu)	0.03pm
Magnesium(M)	24ppm	Zinc(Zn)	0.13pm
Sulphur(S)	35ppm	Molybdenum(Mo)	0.03pm

Objective 5: To monitor and control the light intensity of the greenhouse

A light dependent resistor (LDR) or photo resistor or photocell is a light controlled variable resistor. Its resistance changes with the light intensity that falls on it. There sensitivity varies with the wavelength of light incident on them. They are made up of semiconductor material having high resistance.

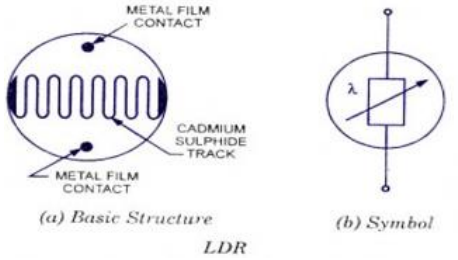

Fig. 10. Basic structure of LDR

The snake like track shown in above fig is Cadmium Sulphide(Cds) film which also passes through the sides. On the top and bottom are metal films which are connected to the terminal leads. It is designed in such a way as to provide maximum possible contact area with two metal film. LDR works on the principle of Photo Conductivity. When the photons fall on the material the electrons in the valence band are excited to the conduction band. So photons must have energy greater than the band gap of the semiconductor material. When light falls on LDR the resistance decreases. When an LDR is kept in dark its resistance is high then transistor turns on and led glows. LDR sensors are non-linear and are light sensitive. LDR sensors are passive and doesn't produce any electrical energy. If a constant voltage is applied the intensity of light increased and current increases. The fig below shows the curve between resistance vs. illumination curve for a particular light dependent resistor.

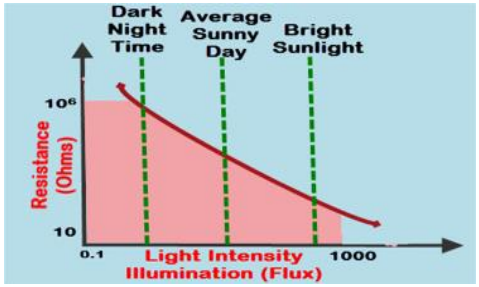

Fig. 11. Light intensity vs. LDR resistance

As shown in the below fig, we give 5v power supply to the circuit. When light falls on the LDR sensor the resistance decreases, current flow increases and transistor is turned on and that signal is given to the Arduino at pin 8 as the input, then we get the output through pin 9, the current flow from pin 9 and 5v power supply already present gets cancelled out and led doesn't glow. When light doesn't fall on the LDR sensor resistance increases and no current, therefore no input to the pin 9. 5v power already present supplies current to the led and it glows.

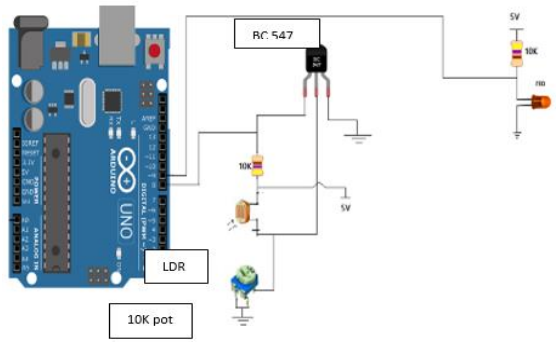

Fig. 12. LDR connection to Arduino board

3. Advantages and Disadvantages

Advantages:

- *No soils needed:* Ina sense, we can grow crops in places where the land is limited, does not exist, or is heavily contaminated. Also, Hydroponics has been considered as the farming of the future to grow foods for astronauts in the space (where there is no soil).
- *Make better use of space and location:* We can grow in small apartments. Plants roots usually expand and spread out in search of foods, and oxygen in the soil. This is not the case in Hydroponics, where the roots are sunk in a yank full of oxygenated nutrient solution and directly contact with vital minerals. This means you can grow your plants much closer, and consequently huge space savings.
- *Climate control:* Can have total control over the climate, temperature, humidity and light intensification. In this sense, we can grow foods all year round regardless of the season. Framers can produce foods at the appropriate time maximise their business profits.
- *Hydroponics is water saving:* Plants grown hydroponically can use only 10% of water compared to field grown ones. In this method, water is recirculated. Plants will take up the necessary water, while run-off ones will be captured and return to the system.
- *Effective use of nutrients:* In hydroponics, we have a 100% control of the nutrients that plants need. Nutrients are conserved in the tank, so there are no losses or changes of nutrients like they are in the soil.
- *Better growth rate:* Plants are placed in ideal conditions, while nutrients are provided at the sufficient amounts, and come into direct contacts with the root systems. Thereby, plants no longer waste valuable energy searching for diluted nutrients in the soil. Instead they shift all of their focus on growing and producing fruits.

Disadvantages:

- *A Hydroponic system requires our time and commitment:* Just like any things worthwhile in life, hardworking and responsible attitude gives satisfactory yields. However, in soil borne counterparts, plants can be left on its own for days and weeks, and they still survive in a short time. Nature and soils will help regulate if something is not balancing. That's not the case in Hydroponics. Plants will die out more quickly without proper care and adequate knowledge.
- *Experiences and technical knowledge:* We are running a system of many types of equipment, which requires necessary specific expertise for the devices used, what plants we can grow in a soilless environment.
- *Water and electricity risks:* In a Hydroponics system, mostly we use water and electricity. Should be aware of electricity in a combination of water in close proximity.
- *System failure threats:* We are using electricity to manage the whole system. So suppose we do not take preliminary actions we do not take preliminary actions for a power outage, the system will stop working immediately, and plants may dry out quickly and will die in several hours.
- *Initial expenses:* Much money is required to purchase equipment like containers, lights, a pump, a timer and nutrients. Once the system is placed, the cost will be reduced to only nutrients and electricity.

4. Conclusion

Solar based hydroponics monitoring system using Arduino is proposed to control and monitor the plants growth. In this system we use solar panels for power supply and Wi-Fi for communication purpose. The system automatically detects and controls the temperature, humidity, pH level and light using different sensors. It also saves wastage of water and fertilizers, gives better yield as compared to soil system. The sensor results are sent to Arduino Uno microcontroller and communication with an android smartphone.

5. Future Scope

With hydroponic farming method, the arable space problem in India will be solved in the future. More cultivars of staple crops can be grown, and consumption of soil and water will be reduced, or just not required. Finally, the hydroponic farming will reduce pests and weed production on alarming levels. For future research, it is expected that future developers can to detect viscosity, oxygen, and other aspects.

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