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DESIGN SMART HOME HYDROPONIC GARDENING SYSTEM USING RASPBERRY PI 3

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Abstract - Harmful chemicals in foods are issues of concerns for many consumers. Eating hydroponics is an alternative to avoid toxins, but it will certainly cost more expenses, especially in the long term. Hence planting one's own vegetables at home is the solution. Growing vegetables using the hydroponic method allows consumer to control various chemicals efficiently and harvest freshly natural. Today, small computers are offered and less expensive. With sensors, motor pump, and raspberry pi 3. The automatic planting systems at home will make growing organics easier and happier. Allowing less care for plants during the growth process, but growing vegetables are efficiently and easily, and reduce long-term costs for consumers.
In this paper, we propose the system design of a smart home hydroponic gardening using a raspberry pi 3 model B. The purpose of this research is to design, develop, and make the blueprint of a hydroponic gardening in the households possible with an inexpensive system, but the system could perform efficiently and easily.

Keywords - Smart Home Gardening, Hydroponics, Raspberry PI3, Embedded System Design, and Framework

I. INTRODUCTION

At present, concerns about health care are becoming an imminent issue for our society. It is a common fact that regular exercises and healthy diet are essentials for healthy and live long life [1]. Nevertheless, some foods may still contain harmful chemical ingredients and that is why organic foodsbecome important and need in demands. Despite the increasing demand for organics, the high price, rigid to reach, and limited supply are the reasonssome consumers have difficulty eating organics.As those products require special production procedures which include no harmful chemical substances.
Vegetables may be among the most common organic foods because it is easy to grow. However, growing vegetables indoors is a different matter since one has to consider the availability of many factors, such as soil, water, nutrients and sunlight. Caring for the soil is a matter of concerns because soil may contain various substances, including chemical which is hard to detect. Using inorganic compounds or hydroponics is the solution to this problem [2]. Hydroponic comes from (hydro) or water, (ponos) work and (ics) which stands for science or art. In short, it is a science or an art about working water. Essential nutrients for a plant growth are nitrogen (N), phosphorus (K), potassium (P), etc. Controlling these nutrients in the water is feasible with a current technology at a tangible cost. This research aims to develop a smart hydroponic planting systemwhich combineNutrient Film Technique(NFT)hydroponics cultivationwith various sensors connected to the internet of things (IOT) to create an automatic system fora household usage.
This automatic planting system consists of sensors that detect the various values necessary for a plant growth. The sensors will send information to Raspberry Pi3, followed by the process of checking fault values and making correction [3]. The soil moisture sensor will send a set of instructions to the pump, when the moisture or nutrients are not enough. A light sensor will send instructions to relay to turn on the growth light incase there is not enough a natural light. User can simply plant the sapling down and the system will maintain a plant growth automatically. This system will save time for planting, save the cost for organic food purchases, andhas the chance to be developed toward industrial production.

II. LITERATURE SURVEY

The hydroponics system has many advantages. The most outstanding one is that it is more productive and grow faster crop than the soil-crop system.Due to the plants ability to grow solely fromabsorbing nutrients. User can provide adequate nutrients for plants through a designed system.Coupled with pH and light control, yielding consistent quality and quantity.
Despite its many merits, the hydroponics system does have a few disadvantages in terms of starting cost.The equipment for creatinghydroponics system cost significantly more than the soil-crop system,and it takes time andprecise calculation to setup the system, especially the pump. Hydroponics system is incomplete without a pumpas it is the main equipment for supplying nutrients to plants. If the pump is damaged or broken for too long the plants will also die.
There are 6 hydroponics systemdesigns available as shown in figure 1.Each with unique pros and cons (1) Deep Water Culture (DWC), (2) Wick, (3)Ebb&Flow/Flood, (4)Drip, (5) Aeroponics, and (6) Nutrient Film Technique (NFT).The popular hydroponic system is the DWC and NFT system.In this section, we select the NFT system because it is thesimplestand most economical for solutions and variables control.Additionally, it will be easier toexpand the production scale due to the controlling of

various variables in a single point. Which will allow industrial production at original cost.Commercial NFT techniques are used worldwide for sustainable productionfor successful production with 70 to 90% saving of water [4].

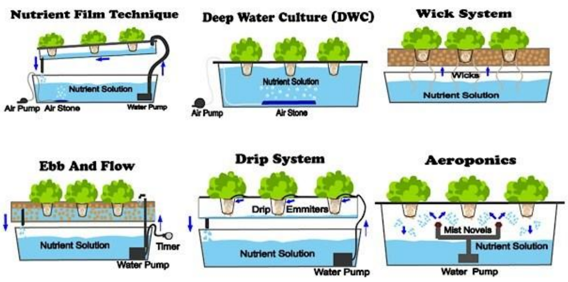

Figure.1.Hydroponic System

III. NFTSYSTEM

Nutrient Film Technique: - NFT was developed by Allen Cooper of the British Greenhouse Crop Research Institute (GCRI) in the 1960s and remained a popular choice for hydroponics until these days. The working principle of the system is touse water flow and solution that contains nutrients to feed plants root. The tank is designedwith flat bottom rail that allows water to flow through the surface, such as the film rails,allowingmore oxygen in the water as illustrated in figure 2. Which also result in plants root being able to absorb more oxygen as well.NFT systemprovides high productivitycompared with traditional planting. The system has a measurablepesticide and nutrientscost reduction [5]. The plants grow in this system also accumulated less disease due to water circulation.

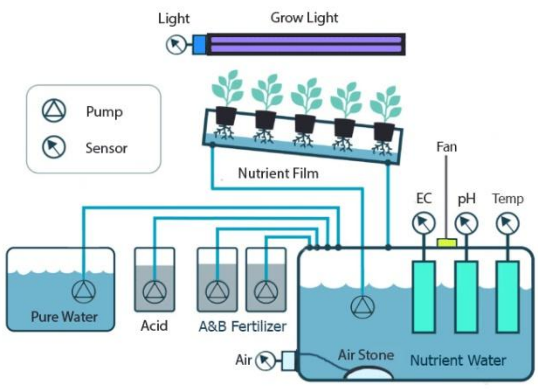

Figure.2.Block diagram of NFT System

IV. CONTROLLING PARAMETERS

Controlling factors of growth plants depend on the following as illustrated in table 1.

A. EC control

Electrical Conductivity or ECare among the essential factors for plant growth. If the EC is too low, plants growth will reduce. If too high, the plants are exposed to salinity. It is necessary to determine the appropriate EC value,said value should be obtained from experiment [6].If the sensor measuring result is lower than the threshold.System will order the EC pump to add more EC substance to the tank.

B. pH control

pH is a measure for acidity. The range of pH values in hydroponics crops rangefrom5.5 to 6.5 [7]. The pH value effectsboth plants ability toabsorb solution and growth rate. ThepH value can be controlled by adding more acid incase it is below the threshold value.And add more water vice versa.

C. Light intensity control

While light is the most critical factorfor plant growth and survival. Artificial light allows plants to grow faster because natural light is an uneven light, which cause unbalancedgrowth in plants [8]. Light sensor will detect light intensity and if lower than threshold, call for artificial light from the system.

D. Temperature control

Thermal control is acrucial factor in hydroponic planting system.Due to the fact thatplants root absorption capability differs at various temperature range. Past experiment on hydroponics suggested that the optimum temperature for plants nutrient absorption isbetween20-25 °C [9].This planting system will rely on a sensor to measure temperature value. Which will send a set of data to the main system to activate fan if the temperature is higher than the specified threshold.

Crops	EC (dSm-1)	pH	Crops	EC (dSm-1)	pH
Asparagus	1.4 - 1.8	6.0 6.8	Ficus	1.6 - 2.4	5.5 - 6.0
African Violet	1.2 - 1.5	6.0 - 7.0	Leek	1.4 - 1.8	6.5 - 7.0
Basil	1.0 - 1.6	5.5 - 6.0	Lettuce	1.2 - 1.8	6.0 - 7.0
Bean	2.0 - 4.0	6.0	Pak Choi	1.5 - 2.0	7.0
Banana	1.8 - 2.2	5.5 - 6.5	Peppers	0.8 - 1.8	5.5 - 6.0
Broccoli	2.8 - 3.5	6.0 - 6.8	Parsley	1.8 - 2.2	6.0 - 6.5
Cabbage	2.5 - 3.0	6.5 - 7.0	Rhubarb	1.6 - 2.0	5.5 - 6.0
Celery	1.8 - 2.4	6.5	Rose	1.5 - 2.5	5.5 - 6.0
Carnation	2.0 - 3.5	6.0	Spinach	1.8 - 2.3	6.0 - 7.0
Courgettes	1.8 - 2.4	6.0	Stawberry	1.8 - 2.2	6.0
Cucumber	1.7 - 2.0	5.0 - 5.5	Sage	1.0 - 1.6	5.5 - 6.5
Egg plant	2.5 - 3.5	6.0	Tomato	2.0 - 4.0	6.0 - 6.5

Table 1. Optimum range of EC and pH value for hydroponic crops

V. SYSTEM DESIGN

This part will be focusing on automatic system design.The system as a whole use Raspberry PI 3 Model B as the operating system.With sensors to detect data and send to Raspberry PI 3 for processing via GPIO pins as illustrated in figure 3. Then the Raspberry PI 3 will send commands via relay to the light and pump as illustrated in figure 4.

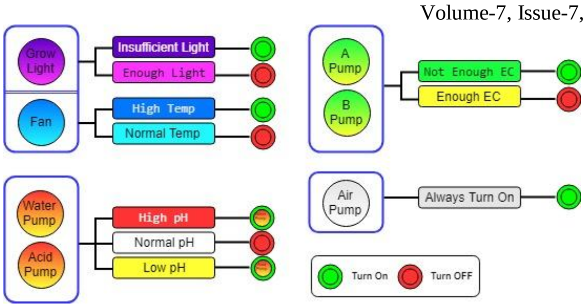

Figure. 3. Block diagram of controlling system conditions

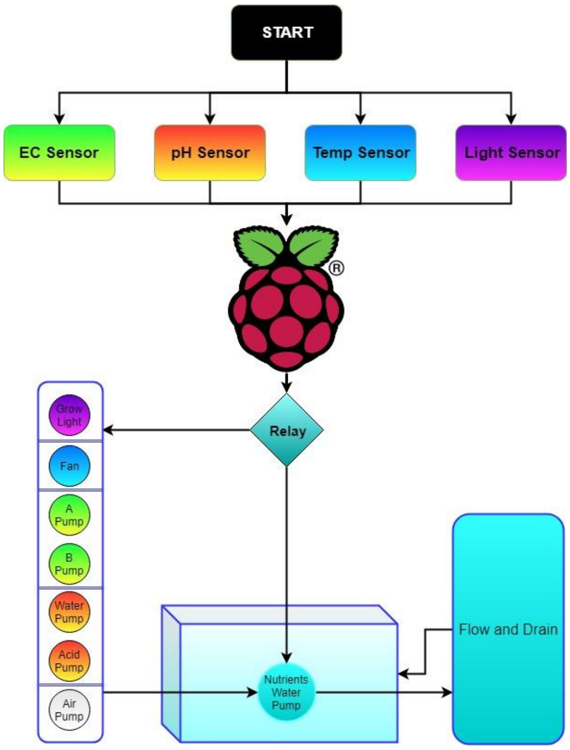

Figure.4.Block diagram of controlling system

VI. HARDWARE SETUP

Our hardware sets up as a blueprint or a framework of the smart home hydroponics gardening system as the following.

A. Raspberry PI 3

Raspberry PI 3 Model B is a powerful and lightweight computer on a Single-board. Raspberry pi is having different communication media [10]. With the capability to connect to amonitor via HDMI port. The PI has rows of GPIO pins which consist of single digital signal pin use as general-purpose input/output. It works bothon Linux and window 10 operation system.When plugged in, it works and has the same ability as computer in general. With PI user may work on documents, using entertainment features, even create a Web Server. This microcomputercost less and has far less memory because the developer intended to create the device as a teachingmethod for beginner worldwide. In this design we used Raspberry Pi 3 as a processor and commander. Figure 5 illustrates the components of raspberry pi 3 model B that uses in the system. Figure 6 illustrates the GPIO connector pins of raspberry pin 3 model B.

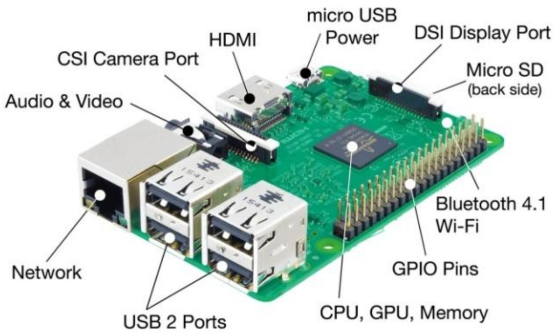

Figure. 5. Raspberry PI 3 Model B

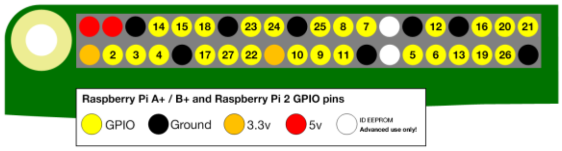

Figure6. Raspberry PI GPIO Pins

B. EC Sensor (Electrical Conductivity Sensor)

Electrical Conductivity Sensor is used to measure nutrients in water. Then send the measure value to the Raspberry PI via BNC connector.VCC pin is connected to 5V.RX pin is connected to 3.3V. TX pin is connected to GPIO. GND is connected to ground. PRB connected to BNC interface to connected EC sensor as shown in figure 7.

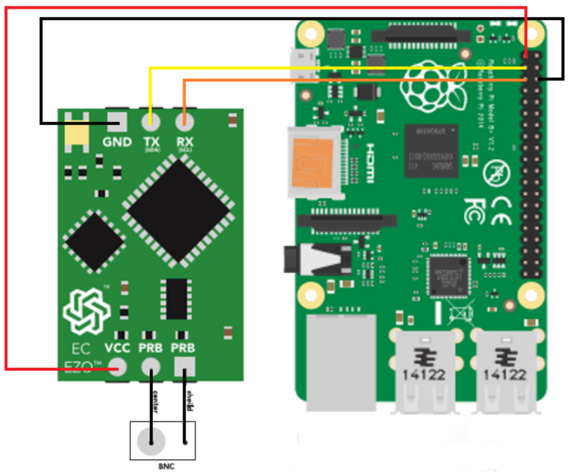

Figure. 7.EC BNC connector via Raspberry PI

C. pH Sensor (Potential of Hydrogen ion Sensor)

A pH Sensor is used to measure the acidity of water. Then send the measure value to the Raspberry PI via BNC connector.VCC pin is connected to 5V.RX pin is connected to 3.3V. TX pin is connected to GPIO. GND is connected to ground. PRB connected to BNC port to connected EC sensor as shown in figure 8.

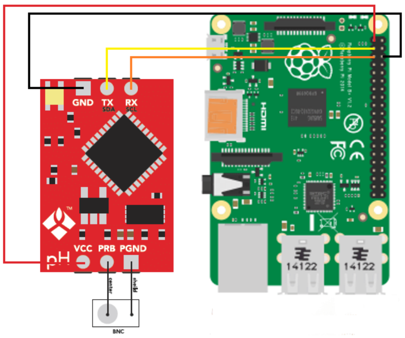

Figure. 8. pH BNC connector via Raspberry PI

D. Light Photosensitive Sensor

Light Photosensitive Sensor is very sensitive to an ambient light andit is very suitable for detecting brightness of an ambient light. When the light falls below the threshold value system will send commands to turn on a grow light. V pins connected to 3.3V.D pin are connected to GPIO pins as a digital output. A pin is connected to GPIO as analog output. An G pin is connected to ground as shown in figure 9.

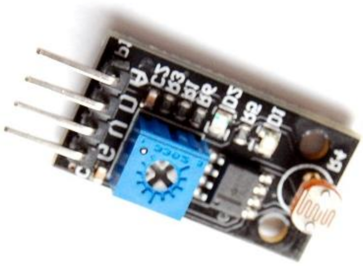

Figure.9. Light Photosensitive Sensor

E. Temperature Sensor

Temperature Sensor is used to measure the temp of nutrients water. Then send the measure value to the Raspberry PI. Red line is connected to 3.3V. Yellow line is connected to GPIO. Black line is connected to ground. R1 4.7K Ohms needs to be connected between the 3.3V and GPIO pins to act as a ‘pull-up’ resistor as illustrated in figure 10.

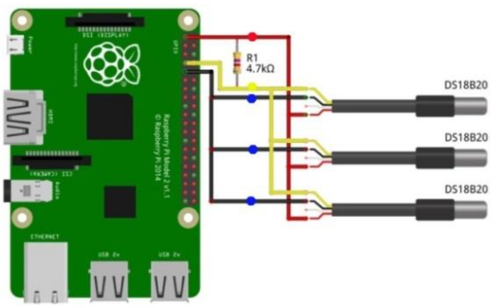

Figure. 10. Temperature Sensor

F. 8 Channel Relay

Relay isan electromagnetic switch operated by a relatively small electric current that can turn on or off a much larger electric current. VCC pin is connected to 5V.IN1-IN8 pin is connected to GPIO. GND is connected to ground as in illustrated in figure 11.

Figure. 11.8-Channel Relay

G. Grow Light

Grow light is an artificial light that stimulates plant growth. As illustrated in figure 12, the design wavelengths close to natural light.A range of bulb types can be used as grow lights, such as incandescent, Fluorescent lights, high-intensity discharge lamps (HID), and light-emitting diodes (LED).

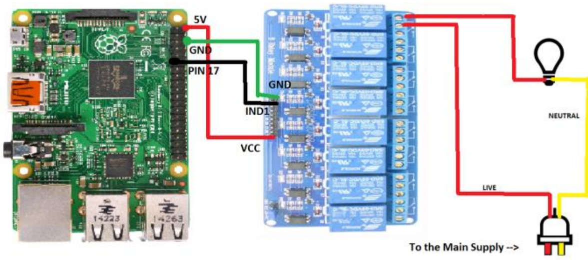

Figure. 12. Grow light connected Raspberry PI via relay

H. Water Pump

Water pump serves various types of water into the system. In this system, we use 5 pumps, consisting of pure water pump, solution A pump, solution B pump, Acid pump and nutrients water pump. Various pumps will work open, closed according to the command from the relay.Example of pumps connected with relayfigure 13.

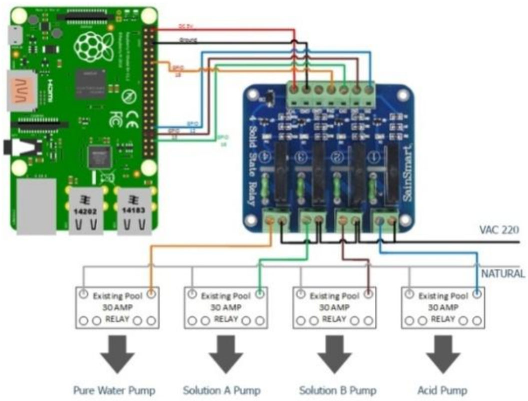

Figure. 13.Pumps connected with Relay

I. Air Pump

Air pump serves the air into the tank to increase oxygen in the watertank. Theair pump works through relay as well as water pump as illustrated in figure 13. Air Stone

Air stone is a piece of limewood or porous stone. Purpose is to gradually diffuse air into the tank as shown in figure 14.

Figure. 14. Pumps connected with Relay

J. Fan

Fan connected to relay. Is responsible for reducing the nutrients water temperature in the tank Will turn on when the temperature higher than the threshold value.

VII. CONCLUSION

This project has shown that we can set up our own the smart home hydroponic gardening systemusing sensors and pump based on raspberry pi 3.We propose the system components used to develop the architecture of the system. When you have your own a smart home hydroponic gardening system, you can growth plants at home with efficiently and easily. The system could give you availability, easily, and ability to control and modify any devices. It does not have any limitation.You can make it scalable to the larger system as much as you need.

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