Automation of Hydroponic System

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Abstract

Hydroponics is a technique to grow the plant without use of the soil. This paper presents an efficient hydroponic system which has been automated to monitor plant living conditions and adjust plant pH and temperature to maintain optimal nutrient uptake by plant root systems. The microcontroller will act as the brain to the system and it will poll the sensors for information about the nutrient solution. If the solution is not within the range, the microcontroller will initiate the steps to correct the pH and temperature of solution.

Keywords: Hydroponics, sensor, pH and temperature, nutrient enriched solution, microcontroller, relay

I. INTRODUCTION

The word hydroponics comes from two Greek words, "hydro" meaning water and "ponics" meaning labor. Hydroponics means the growth of plants using a nutrient enriched water source without the use of soil. Plants are grown just like in a traditional garden, but they have their roots submerged in water. Most of us confuse soil with nutrients. In fact, soil provides structure, not the actual food itself, for plant roots. The food comes from other materials mixed in the soil, such as compost, broken-down plant waste or fertilizers. Instead of soil the plants are grown in an inert medium such as gravel, rockwool, clay stones and coconut coir. These mediums do not supply any nutrients to the plants but much like soil they supply the plants with a place to anchor.

While providing the nutrient enriched water, pH levels are important in hydroponic systems. A nutrient enriched water source is simply water doped with mineral nutrients called micronutrients or trace elements. The mobility of the nutrients is determined by the pH of the solution. When these micronutrients become more mobile they are absorbed by the plants rapidly and in excess of what the plant actually needs. This results in toxicities in the plant. When the micronutrients are less mobile the plant has trouble absorbing the nutrients, which then leads to plant deficiencies. Hence balancing the pH in hydroponics system is incredibly important to the health and vitality of crop. If the pH is not in the correct range then essential nutrients and micro nutrients will not be available for uptake by plant. This can lead to nutrient deficiencies and eventually death. The automated pH monitoring system used in this project will accurately determine the pH levels of the nutrient enriched solution as well as maintain these levels within a range for optimum plant growth.

Also the temperature of a nutrient solution in a reservoir is one of the most important factors affecting the dissolved oxygen content of the solution. In fact, water’s ability to hold oxygen is directly related to its temperature. As the temperature of the water (or the nutrient solution) gets warmer, the dissolved oxygen potential decreases. As the temperature of the water gets colder, the dissolved oxygen potential increases. Since oxygen is good for the plant’s roots, a grower should try to have the coldest nutrient solution possible. If the temperature gets too cold, a whole new set of problems are created. Temperatures that are too cold will cause the plant’s growth to slow and eventually stop altogether. For this temperature sensing system has been adopted.

II. SYSTEM OVERVIEW

The system can be broken into main components that as a whole incorporate all aspects of the project design. Each section is described below with a semi-technical description about their operation and purpose.

A. Plant Reservoir

It is a well suited tank for holding nutrient enriched water and mounting scientific equipment too. The volume that the liquid reservoir can sustain is up to 4 gallons.
B. pH Sensor

One of the important requirements of this automated hydroponics system is to measure and adjust the pH of the hydroponics reservoir. It is important that the pH value stays balanced for a given plant type that is growing in the plant reservoir. The plant will constantly affect the pH, so the system needs to be able to alter the pH of the reservoir using a chemical pH balancing solution. The optimum pH range for hydroponics is within the range of 5.5-6.8. In order to know when the pH chemical needs to be added to the hydroponics reservoir, a sensor reads the pH continuously.

The simplest version of a pH sensor consists of a glass electrode probe that is sensitive to the hydrogen ion concentration, which gives a voltage reading that corresponds linearly with pH. At 25°C, electrode sensitivity is 59.16 mV/pH and the output of the electrode will swing from 
\[-7 \text{ pH} \times -59.16 \text{ mV/pH} = +414.12 \text{ mV (pH 0 strong acid)}\] to 
\ [+7 \text{ pH} \times -59.16 \text{ mV/pH} = -414.12 \text{ mV (pH 14 strong base)}\].

<table>
<thead>
<tr>
<th>VOLTAGE (mV)</th>
<th>pH VALUE</th>
<th>VOLTAGE (mV)</th>
<th>pH VALUE</th>
</tr>
</thead>
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<tr>
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<td>0.00</td>
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</table>

C. Temperature Sensor (PT100)

It is based on resistance measurement principle. It offers excellent accuracy over a wide temperature range (from −200 to +850 °C). The relationship between temperature and resistance is approximately linear over a small temperature range. Material is platinum and resistance value is 100 ohm at temperature 0 °C. Platinum has a positive resistance temperature factor; resistance increases with rising temperature. Resistance variation is a function of temperature; 0.39 ohm/1 °C

D. Microcontroller

The brain of system is AT89C51ED2 which is high performance CMOS Flash version of the 80C51 CMOS single chip 8-bit microcontroller. It contains a 64-Kbyte Flash memory block for code and for data. It has on-chip 2048 Bytes EEPROM Block for Data Storage.

E. Sub-reservoirs

Apart from the main reservoir, the system will also have three sub-reservoirs viz. pH up, pH down and chilled water. The pH up and pH down reservoirs will hold Potassium Hydroxide and Phosphoric Acid solution respectively. Reservoir containing chilled water is used for temperature control.
III. DESIGN IMPLEMENTATION

The AT89C51ED2 polls the pH sensor for information about the nutrient solution. If pH is less than the optimum value then it will drive the pH up relay to raise the pH. If pH is greater than optimum value, it will drive the pH down relay to lower the pH. The microcontroller also polls temperature sensor and if the temperature is greater than room temperature then it will drive relay of chilled water.

A. Signal conditioning

The data collected from pH sensor cannot be given directly to the microcontroller. So signal conditioning is done for manipulating an analog signal from pH sensor such that it meets the requirements of the microcontroller for further processing. Following are the steps that need to be carried out

1) Pre amplifier
   It takes high-impedance pH electrode signal and change it into low impedance signal which the analyzer or transmitter can accept. The pre amplifier also strengthens and stabilizes the signal, making it less susceptible to electrical noise.

2) Level shifter
   pH sensor produces a bipolar signal. Most applications such as AT89C51ED2 operates on single supply. So the bipolar signal sent by pH sensor is shifted to unipolar signal to be used in single supply systems.

3) ADC
   The output of level shifter will then need to be supplied to an A/D converter. This converts the analog signal to a digital signal that the microcontroller can understand.

B. Display unit

The values of pH and temperature are displayed on seven segment display using decoder and shift register.

IV. CONCLUSION

The goals of this project were to interface a pH sensor and temperature sensor with the microcontroller, to create a sensing module that will accurately read the pH and temperature of a nutrient enriched solution, and to have the ability to add respective solutions with ease. The goal of controlling pH is successful and the work related to temperature control is in the process.

REFERENCES