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Design and Implementation of Automatic Hydroponics System using ARM Processor

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ABSTRACT: In this paper a two electrode sensor for measuring water conductivity for the hydroponics system is presented. The sensor is designed to measure the conductivity of nutrient solution which is in the range of millisiemens (mS). These electrodes are used to regulate the nutrient in hydroponics solution according to the plant's requirement. The automatic hydroponic system is based on low cost ARM processor that monitors and control the need of hydroponics plants. Automatic hydroponics system will boost the production by controlling the different parameters.

KEYWORDS: Hydroponics, EC, electrodes, Soil-less Cultivation, nutrient solution, PSoC4.

I. INTRODUCTION

Now a day's due to increasing industrialization, the vegetative land area is decreasing or in other words the effective land for vegetation is becoming infertile and thus demand-supply of food is not meeting the requirement. Also due to this farm lands are being rapidly converted into housing plots that result is reduction in crop grown area especially for the vegetable which in turn cause's heavy impact on economy.

The growth by convention system has its own limits like conventional method of farming needs manpower to control need of plant where everything should have to be manually monitored. For example to monitor the electrical conductivity (EC) one should use electronic meter to read the value and it's a time consuming process and in this manner there is a need of periodically monitoring.

Now a day's every system become smarter and automatic in that way there is a need of revolution in agriculture industry there is a need to find a new way for cultivation and require more accurate system for cultivation so that major thrust is needed to be given to the technology development and proliferation of vegetable production in small areas. Vegetable farming in top of building, inside areas and in poly-houses is an approach to address this concern. In that circumstances hydroponics is one of the best alternatives of conventional cultivation.
Hydroponics is a method of growing crops and vegetables without soil with the help of nutrient solution. It is the way to grow the fruits and vegetables for the year around in such places where the soil is not present or it is contaminated.

The system has following advantages-

- It reduces the excess use of fertilizer.
- It fosters the plant growth
- It reduces manpower
- It improves product quality.
- And high rate of production

Paper shows the implementation of automatic hydroponics system with the help of two electrode conductivity cell including system description, prototype implementation and graphical results. Measurement is done in different conditions in terms of solution concentration, time and solution conductivity.

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II. RELATED WORK

Hydroponics is one of the best alternatives of conventional cultivation but it is used in small level because of its limitations so there is a need of improvement in field. Paper published in some journals in hydroponics system in the last few years they suggested how the hydroponic system works, Plants which are best suited for hydroponic system also the use of microprocessor for nutrient control [3]. According to Kumar and Cho hydroponics waste nutrient solution can be reusable [6]. Processor based hydroponics growth chambers used in ecological life support systems this paper is all about controlling the system through virtual instrument using Lab VIEW [1]. Another paper is Development of an automatic microcontroller system for Deep Water Culture (DWC), starting of this paper gives the basic idea of deep water culture which is one type of hydroponics system later in this paper discussed the methodology used for measuring the pH value from the sensor and maintaining it to certain level also the level of the water in the reservoir is continuously maintained [2]. Research of hydroponics nutrient solution control technology this paper describe constitute of the control system of hydroponic nutrient solution and analysis the affecting factor and controlling difficulties also in this paper discussed a problem coming during the automation [4]. Control process of Electrical conductivity and pH is highly non linear process and coupling with pure time delay.

NASA has also looked to utilize hydroponics in space. Kennedy space life science lab's plant physiologist believes that hydroponics will create advances with in space travel he terms this as a bio generative life support system [5]. Hydroponics system used in many countries especially in Israel also in some places in India but rate of production is very less and in small level. Defense Research Laboratory Haldwani in Uttaranchal made extensive work on hydroponics and suggested a model [5].

As far as water conductivity is concerned, several solutions have been proposed. The main problems associated with water-conductivity measurements are sensitivity to external disturbances, initial conductivity of water and measurement dynamic range [7].

III. SYSTEM DISCRIPTION AND PROTOTYPE

There are basically 6 types of hydroponics system and each one has their own advantages and use. For this experiment NFT system has used which is nutrient film technique system this system is a simplest system among all. For making the system cost effective plastic bottles are used which are generally used in beverages and cold drinks. There are some advantages of using these bottles irrigation system that is they are the good insulator of electric conductivity also have good water holding capability. These bottles are connected with each other and kept in a fixed angle for maintaining proper flow. Coco peat, perlite and vermiculite are used as a composed material for holding the plant in water.

Hardware unit

In a figure.1 hardware unit of automatic system is shown below the existing system and practice is insufficient to produce enough quantities of vegetable for the households so modern cultivation practices like hydroponics with advance technology is very productive.The system have electrodes which works as a conductivity sensor also called probes, microcontroller unit PSoC 4 CY8CKIT-049-42xx Prototyping kit having ARM cortex m0 processor, display device (LCD 16x2), motor driver IC(L298N), a power supply IC(7805), relay, nutrient pump, starrer, leds and buzzer. The ARM processor is a heart of whole system and used to perform major operation of system, it is embedded on PSoC4 kit which is designed by the cypress semiconductor. PSoC4 has32-bit ARM7 microcontroller in a tiny TQFP package and has many advantages like low cost, low power consumption, high speed operation and on chip component like 10-bit A/D converter and many more. Also the advantage of using this kit is that it is on chip programmable means the programming can be done with the help of USB port. In hydroponics system nutrient solution is very crucial which is controlled by microcontroller unit with the help of nutrient pump. Flow rate of nutrient pump is calculated manually and used those results during automation.

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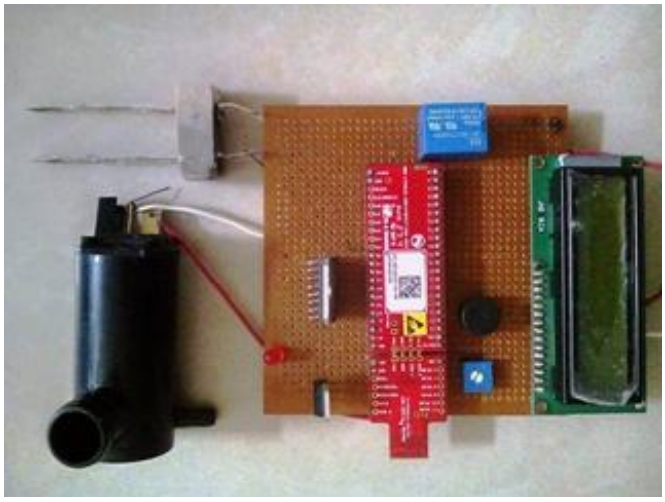

Fig .1 Basic Hardware unit of System

Basic structure of hydroponics system

The physical implementation of bottles irrigation system for tomatoes plants are shown below in fig.2 each unit of bottle is connected to other bottle for proper circulation of nutrient. Substrate of coco peat, vermiculite and perlite are kept in small cups and keep these cups inside the bottles. The substrate has very good water absorbing capability which is very useful in hydroponics. The nutrient solution flows continuously inside the bottles. The major objective of this system is to promote eco-safe vegetable production unit. It produces self sufficient, safe and sustainable vegetable production.

Fig .2 Bottles based structure of hydroponics

The system shown above has designed to ensure regular availability to vegetable by increasing the productivity through the optimization of time and space. It's a new farming system in which the vegetable crops are grown in the intensive manner and taking care that crop are getting sufficient amount of nutrient and micro nutrient. Different vegetables can be cultivated with the help of this system only there is a need of modification of required solution. Project has remedy of major pests and diseases and has fortified growing media. The major issues involve in soil cultivation are not present or having less effect in hydroponics gardening.

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IV. PROCESS FLOW AND WORKING OF SYSTEM

In this work, some of the primary objectives are to regulate the nutrient solution according to plant need which enable to reduce a unnecessary use of fertilizer and make the system affordable because as mentioned above high cost of a system is one of the big problem in hydroponics so there is need such kind of system which can control the operation, improve performance and give the desire output at lower cost.

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The electrodes are kept inside the solution reservoir and operated periodically with the help of microcontroller. Timer is set by microcontroller that in starting of each hour electrodes will work, when electrodes conduct the current flows inside the nutrient solution which is totally depends on the ions present inside the solution. Because ions are directly related to the water resistance means resistivity and conductivity both depends on no. of ions. Those current after that converted in to voltage and sensed by controller, microcontroller operates periodically and make decision according to need and repeat this whole procedure continuously.

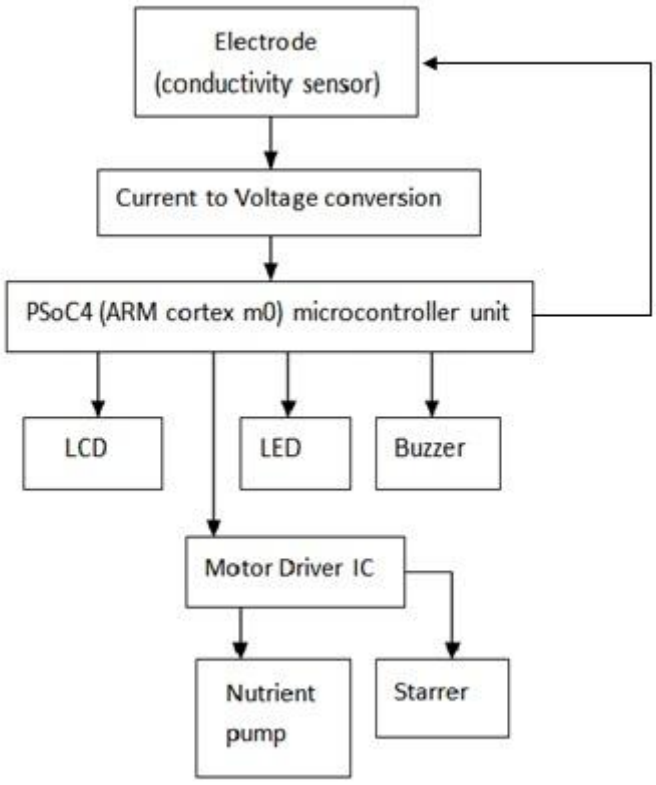

Fig .3 Basic Process flow of Automatic system

In figure.3 shown above is a representation of basic process flow of automatic hydroponics system. System starts working with the help of conducting electrodes. The output of these electrodes is feed to current to voltage conversion unit and resultant of this unit is sensed by the brain of the system which is nothing but the ARM processor. Processor sensed this voltage and compares it with pre stored value and makes decision. User can see the percentage of nutrient on LCD. If the level of nutrient is less than a fixed value then processor turns on the nutrient pump. Nutrient pump is not directly connected with processor, motor driving IC is used to connect it with PSoC kit.

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V. SIMULATION/EXPERIMENTAL RESULTS

In a table below results are show which indicating that by increasing the concentration of the solution conductivity also increases, there is also variation in conductivity for the same concentration. Table also shows the temperature variation which brings crucial research challenge for temperature compensation.

Concentration	Conductivity (µS)		Difference	Temperature (°C)
	Min.	Max.		
0 gm	242	245	3	33.4
1 gm	1006	1011	5	32.5
2 gm	1602	1596	6	32.6
3 gm	1960	1969	9	32.3
4 gm	2437	2429	8	32.1
5 gm	2819	2814	5	32.0
Average			6	

Table1 Conductivity variation with concentration

Table 1 also show an average variation of conductivity for 1liter water. After the 6 reading has been made, deviation in reading is approx 6 µS with average temperature of 32.4°C. This value has been used as a reference.

The graph shown below is a variation of result of PSoC4 ADC output with increasing the nutrient concentration, that result is obtained from ADC over LCD and taken with the help of conducting probes.

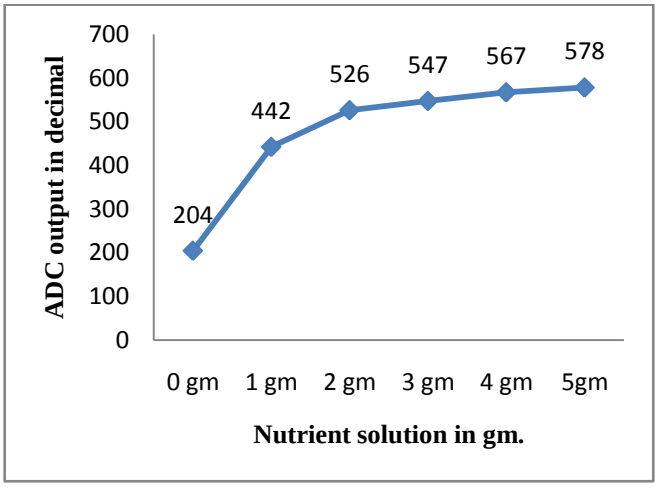

Fig .4 Nutrient solution Vs Output of ADC

Also in Fig 4, Nutrient Solution Vs ADC output, ADC output is measured in a fixed interval of nutrient solution. Output of ADC is nothing but an output voltage in decimal form which is further used to calculate conductivity.

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VI. CONCLUSION

Design and implementation of automatic hydroponic system are presented in this paper mainly focused on measurement of conductivity of nutrient solution. Results are in the range of mS for the nutrient solution of tomatoes. Designed system is very helpful for reducing the system cost and manpower. The EC firstly measured on drinking water for reference purpose and after that conductivity is measured of nutrient solution with different concentration. In both cases obtained result are acceptable. The system is useful in hydroponics cultivation and suitable for small space, low cost, low power and able to recycle the nutrient solution which is already used by plant. However there is need to make this system more advanced more accurate and cost effective so that formers can use this system in large scale which is challenge that must be addressed in a future, and hence system become fully automatic by controlling the other parameter such as pH, temperature, light intensity, ambient humidity, oxygen level in water. The designed prototype ensures of high rate of production. This system effectively makes the rural and urban household self sustained in vegetable consumption.

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