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Autonomous Sensor Technology in Hydrophonics for Monitoring and Controlling of Plant Growth

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Abstract: The emerging fast paced development in the field of Hydroponics has demanded the need for a fully autonomous sensor based control system that can independently monitor and control the Hydroponic eco system. The proposed system uses real time data to influence active and counteractive steps. The paper aims to build a fully Autonomous Hydroponics Control system that Measure – Process and Control based on the real time information received from various sensors.
We use Arduino Mega as the main controller to measure and control the flow of nutrient solution based on various logical conditions. The controller also measures and logs all critical parameters which are vital for the growth of the plant.
Keywords: Autonomous, Hydroponics, Arduino, Technology, Sensors, Measure, Control, Log parameters, Nutrients, growth.

I. INTRODUCTION

Technology invariably has become an integral part of our day to day life. Witth computing devices becoming more and more affordable and user-friendly adaptability has also increased. Devices now can communicate with other devices easily and with speed while doing on the fly processing and decision making based on logic.

This paper aims at bridging the gap of incorporating technology in the field of hydroponics by using sensors to read various vital parameters of the Plant Eco system like Temperature, Humidity, pH, Conductivity, Nutrients, Light, etc. and Control the environment inside the poly house to create a favorable condition for the plant growth.

We have used below system sensors

1) *Controller:* Arduino Mega
2) *Display:* 3.5 Inch TFT Touch Screen
3) *Sensors*
   a) Ambient Temperature
   b) Ambient Humidity
   c) Water temperature
   d) pH Sensor
   e) Turbidity Sensor
   f) Water flow
   g) RGB Sensor
   h) C02 Sensor
4) *Control*
   a) Dosing Pumps
   b) Flow pump
   c) LED RGB Lights
   d) Relay Board

II. METHODOLOGY

Hydroponics is an innovative method to grow the plant without using the soil. This technique ensures the plant gets all nutrients as needed for growth of the plant from the water solution which is made to flow with charged Nutrients. Although there are different types of hydroponics techniques. The Deep Water Culture (DWC) method is one of the hydroponics techniques that is common, and easy to adapt Deep water culture is a technique that grows the plant by supplying the nutrient directly to the root of the plant until the plant is fully grown and can be harvested. In this method, the plant root will be always submerged into the water that contains essential nutrient and oxygen in a controlled manner.

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However, in this technique the pH of the water is manually controlled, which has the potential to give bad effect to the growth of plant. In this research, the pH level in water solution will be automatically maintained by controller and measured by sensors. The PH in the tank is controlled by Dosing a pH+ or pH- using dosing pumps intern maintaining the required pH level as required by plant. The system shall automatically adjust the pH by Continuous measurement of PH in the tank until the required pH is maintained in the DWC system. And able to change the pH in the tank without changing the entire nutrient.

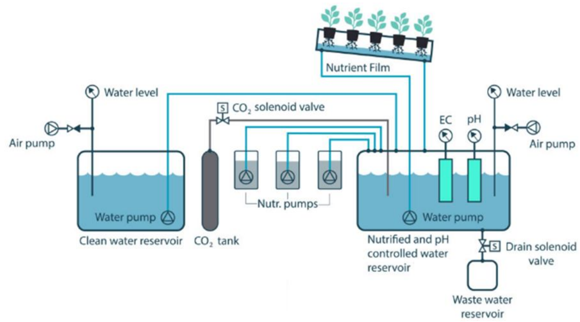

Fig -1 – System Diagram of system

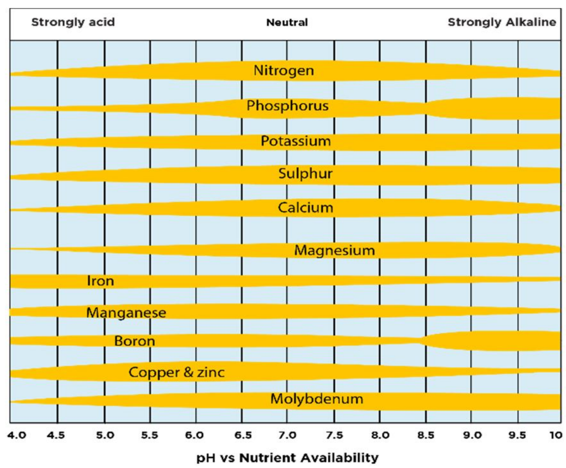

Table 1 – pH vs. Nutrient Availability

Table1 shows relationship between pH and nutrient availability in the solution. Hence it’s essential to maintain required pH levels to provide the required essential nutrients to the plants.

Plants	pH		EC	
	Min	Max	Min	Max
Beetroot	6.0	6.5	0.8	5.0
Broad Bean	6.0	6.5	1.8	2.2
Broccoli	6.0	6.5	2.8	3.5
Brussell Sprout	6.5	7.5	2.5	3.0
Cabbage	6.5	7.0	2.5	3.0
Capsicum	6.0	6.5	1.8	2.2
Carrots	6.3	6.3	1.6	2.0
Cauliflower	6.0	7.0	0.5	2.0
Lettuce	5.5	6.5	0.8	1.2
Marrow	6.0	6.0	1.8	2.4
Okra	6.5	6.5	2.0	2.4
Peppers	5.8	6.3	2.0	3.0
Bell peppers	6.0	6.5	2.0	2.5
Hot Peppers	6.0	6.5	3.0	3.5
Tomato	5.5	6.5	2.0	5.0

Table -2 recommended pH, EC

Table -2shows the relationship between pH and EC required to be maintained for various plan

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III. IMPLEMENTATION

The System block diagram is as below. The Control system is centered on the most popular and low-cost controller Arduino mega. The system is divided into 3 major sections

1) Read – Sensor DATA
2) Process / store Sensor DATA
3) Control section to control Pumps and Nutrients.
4) Display and user Interface

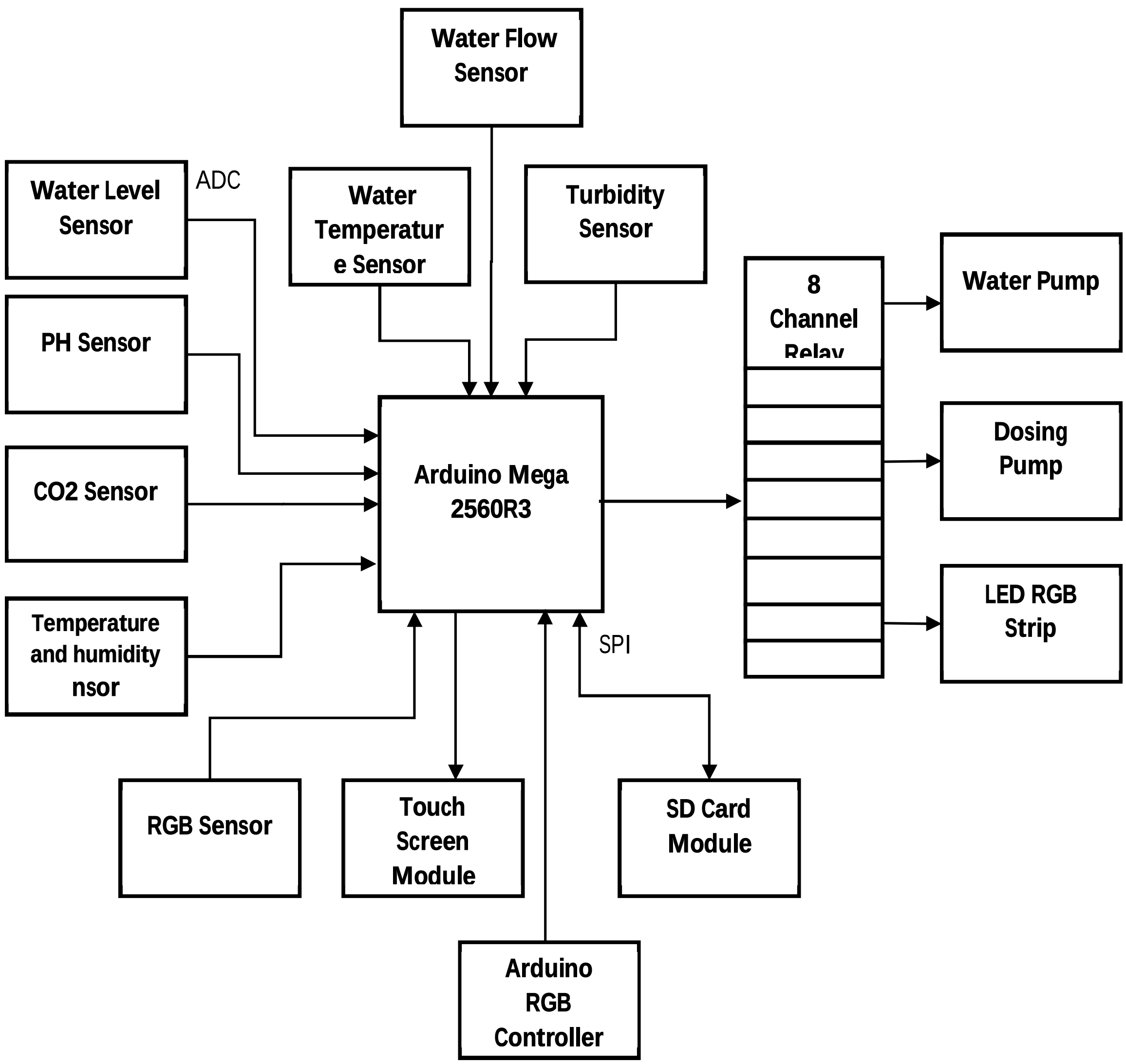

Fig -2 System Block Diagram

The Control Section is designed using Arduino Mega ready development board with below features. The board is selected due to its versatility and low cost nature. This board truly gives a bang for the money spent with below features to integrate almost all types of sensors to the board and above all the entire IDE is OPEN SOURCE.

a) Digital I/O pins: 54 (14 provide PWM output)
b) Analog input pins: 16
c) Flash Memory: 256 KB, 8KB used by boot loader
d) SRAM: 8 KB
e) EEPROM: 4 KB

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A. pH Sensor

pH (potential of hydrogen) is a numeric scale of hydrogen ion concentration of a solution. These ions are composed of positive (hydrogen - H+) and negative (hydroxyl - OH-). If solution contains more positive hydrogen than negative ions, the solution ends up acidic.

Similarly if solution contains more hydroxyls than positive ions lead the solution to be alkaline/basic.

Normal water has a neutral pH, mixing with chemicals and nutrients causes the water parameters to turn either acidic or basic. So pH is a crucial indicator changes in water with respect to the chemical nature.

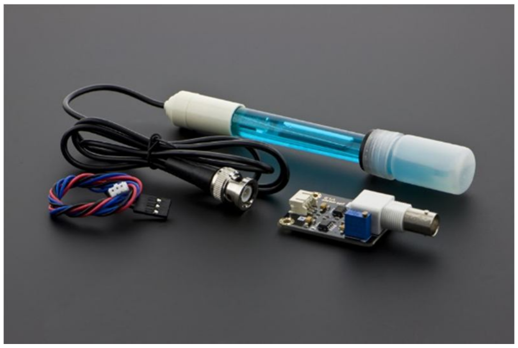


Fig -3 pH Sensor

Specifications:- Sensor Measuring Range: 0 - 14PH with an Accuracy: ± 0.1pH (25 ℃) and Response Time: ≤ 1min

B. Temperature and Humidity

Humidity is one of the most important parameters in hydroponic system. In order to have a successful crop it is critical monitor and maintain humidity at the required levels.

There is phenomenal difference between relative and absolute humidity. Although we understand humidity as the amounts of water in the air but what we usually measure in hydroponics is “relative humidity” (RH) which does not measure how much water is present in the air but what percentage of the available capacity we are using.

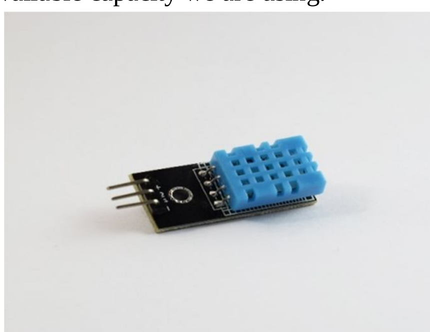


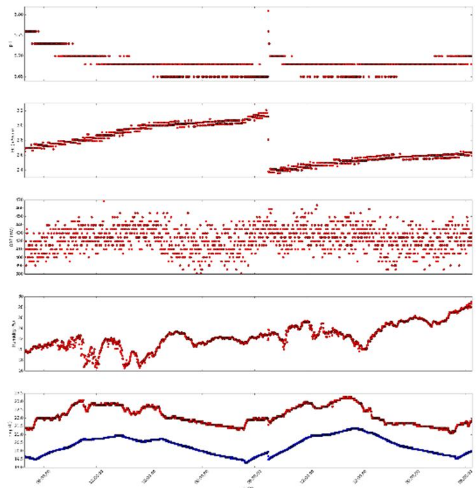
Fig – 4 – Temp and Humidity Sensor

C. Other Sensors

1) *Water level Sensor:* Used to measure water levels
2) *C02 Sensor:* Used to measure carbon dioxide levels in the greenhouse
3) *RGB Sensor:* Used to measure RGB /Light levels inside the green house. This is used to control the artificial light inside the grow house to enhance photosynthesis.
4) *SD card Module:* Module used to store all data for analysis and case studies. The data can be retrieved based crop life cycle.
5) *Water Temperature:* Water temperature is to be maintained as per individual crop requirement.
6) *Turbidity Sensor:* Sensor is used to measure and monitor water quality by measuring turbidity and alerts user in case of algae formation.
7) *Relay Module:* Relay module used to control Flow pump and dosing pumps and other electrical equipment’s like Fans, Humidifier, Lights etc.

IV. RESULTS & CONSLUSIONS

The system is able to measure and monitor pH levels at an interval of 2 minutes and with a variability of 0.5 pH by running the dosing pumps for pH+ and pH- nutrients. The readings from the sensor eco system is continuously logged and data processed to take necessary control logic to maintain the required levels within the poly house.



The method when compared with conventional manual methods of maintaining pH was found to be more effective and controlled with the fully autonomous sensor technology for control and monitoring plant growth.

V. FUTURE PLANS

In the future upgrades we intend to implement

A. Preprogrammed pH, EC values for various plants.
B. Remote access of data through cloud servers
C. Remote control of equipment and controls through internet.
D. Productize the concept to market
E. User settable values through HMI
F. Artificial intelligence to keep learning based on data from last growth cycle.

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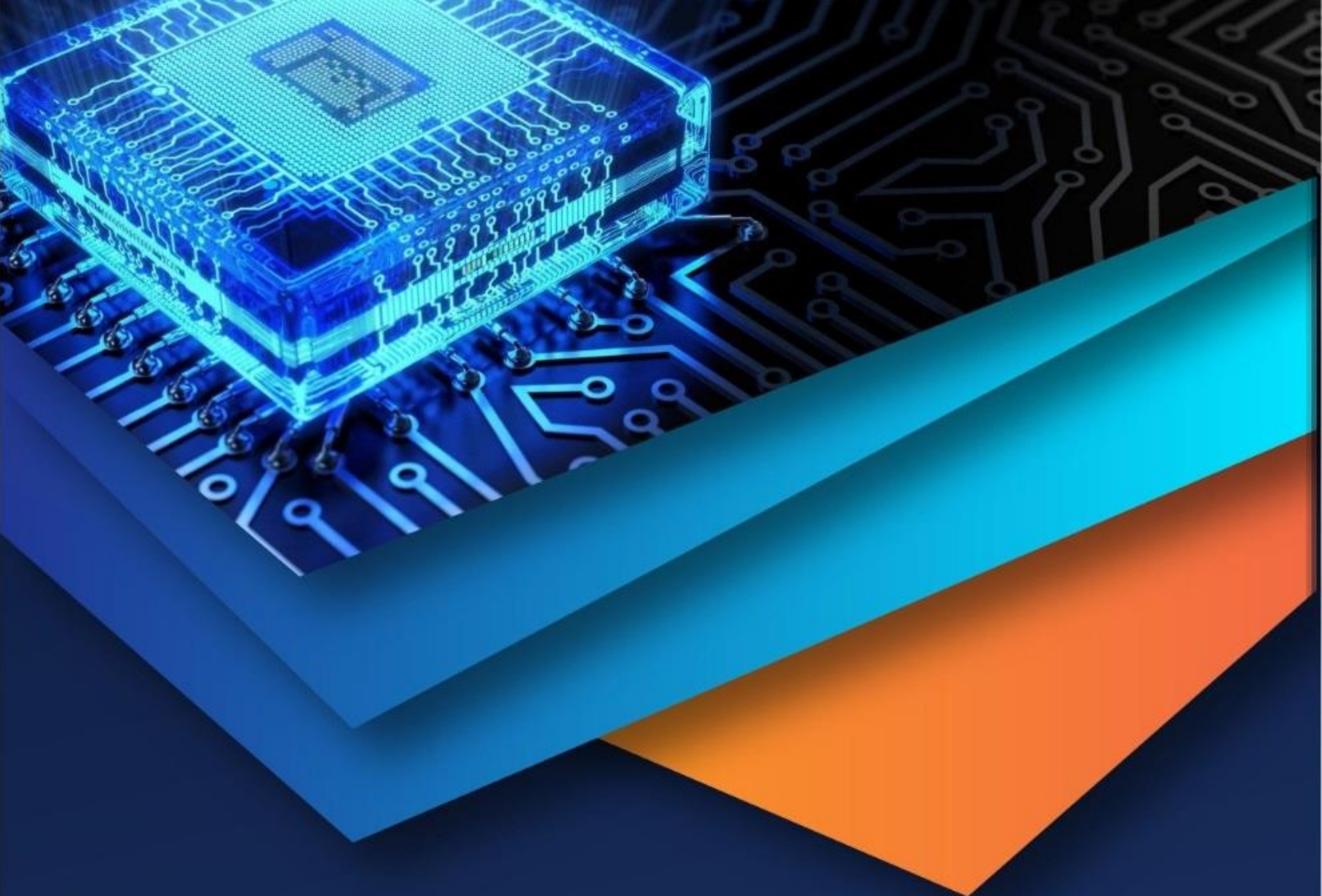

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