I hereby declare that I have read through this report entitle “Development of Hydro-Atomized Spraying System For A Controlled Environment Aeroponic Farm” and found that it has comply the partial fulfilment for awarding the degree of Bachelor of Mechatronics Engineering.

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DEVELOPMENT OF HYDRO-ATOMIZED SPRAYING SYSTEM FOR A
CONTROLLED ENVIRONMENT AEROPONIC FARM

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A report submitted in partial fulfillment of the requirements for the degree
of Bachelor of Mechatronic Engineering

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YEAR 2012
I declare that this report entitle “DEVELOPMENT OF HYDRO-ATOMIZED SPRAYING SYSTEM FOR A CONTROLLED ENVIRONMENT AEROPONIC FARM” is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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ABSTRACT

Aeroponic system is a process that the plants growth in a soilless environment. The plants get the nutrition by spraying water and nutrient to their roots. Most of this system is using timer control spraying system. The water and nutrient will be spray to the roots according to the timer pre-set interval regardless to the humidity and moisture level of the system. In this case, the system will not be reliable. Therefore, a microcontroller controlled spraying system is proposed in this project. The microcontroller will automatic detect spray water and nutrient whenever humidity and moisture level inside the system are low and stop spraying when the level is saturated. The system detects humidity level by using an analogue capacitive humidity sensor placed inside the aeroponic chamber. Through research and study, the understanding of the theory and mechanism of the sensors and microcontroller are deeper. The understanding of the sensor is important in order to design an effective hydro atomized spraying system. Besides, several experiments will be conduct to understand the factor that will affect system humidity. By using drawing software and circuit simulation software, the hardware design and circuit design can obtain.
ABSTRAK

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Chapter 1

1 Introduction

1.1 Project background

Aeroponic is a type of plantation process that grows plants in air or mist environment without using any soil or aggregate medium. Unlike hydroponic, aeroponic did not use water as growing medium. In hydroponic, plant’s roots are submerged into water to get water and nutrient to support its life. But for aeroponic, the nutrient is supply through mist spray by sprinkles or nozzles to plant’s roots.

An aeroponic farm system can set up with a few main components like a pump, nozzles, and growing chamber. There are a few types of aeroponic currently exist like low pressure type, high pressure type and commercial system. Different type of aeroponic required different kind of component to set up but the working concept is about the same.

1.2 Problem statement

Human population is growing rapidly nowadays as well as the development of the industry. However, the land on the earth does not grow as we wish. Many countries are facing land shortage problem. Land reclamation is a very popular solution for countries that are facing such problem. Yet, it does not solve the problem.
Urban residents face limited space problem, especially for those living in apartments and condominiums. It is impossible for them to undergo conventional farming in their housing area. Traditional flower pot might be able to plant, but the harvest is limited. In order to get desire quantity of harvest, a number of flower pots are needed. This will eventually make the space problem worse.

Domestic aeroponic farming system uses timer to control spraying period. The timer will activate the system following the pre-set time regardless of the condition inside the chamber. The timer will still activate the spraying system after a time interval even though the humidity and moisture level inside the chamber is saturated. In this way, the system has low reliability.

1.3 Objective

1) To develop a home use farming system as an alternative way to farming, by applying mechatronic system.
2) To develop an automatic spraying system that is able to give feedback to aeroponic system by using microcontroller and sensor.
3) To control the nutrients release and moisture fed to the roots of plant.
4) To investigate relationship between humidity and time with different spraying interval.
5) To determine a suitable controller between timer-based controller and sensor controller to be used in the system.
1.4 Scope

The scope of this project is to build a hydro atomized spraying system by using humidity sensor as measurement sensor and microcontroller as main control system. The system will spray water and nutrient automatically when the humidity sensor detects the humidity level is low and stops spraying when the humidity is saturated to certain level. This project is to support small demand of plantation due to limitation of the design dimension. The sensor types that will be considered in this project are analogue capacitive type sensor and analogue resistive type sensor. Note that the study of pump is not included in the scope of study.
Chapter 2

2 Literature review

2.1 Introduction

In this section, sensor theory and literature review will be delivered. Sensor is a device used to measure or determine physical quantity so that we can manipulate these physical quantities. Sensors can be divided into 2 groups, digital and analogue. Either digital or analogue sensor, both have the same function. The difference is the output of the sensors. In this section, only the analogue sensor is studied.

Next, this is the study of the humidity sensor. After studying a number of relevant topic paper, three papers are chosen to compare the performance of humidity sensor[1]. The sensors that are compared are analogue capacitive type and analogue resistive type.

Then, the study on the pattern of spraying at different pressure is done. A comparison of three different pressure result in three different pattern of spraying. A suitable pressure of spraying will be chosen to get desired spraying pattern.
2.2 Theory and mechanism

2.2.1 Analogue sensor

An analogue sensor is a type of sensor that produce a continuous output signal or voltage that is proportional to the measurement quantity. There are many types of analogue quantities in the nature such as temperature, speed, pressure humidity etc[2].

Analogue sensors measure analogue signals by using different parameter like resistance, capacitance, thermal conductivity etc. The output of the sensor are smooth and continuous signals[3]. Figure 2-1 shows the output signal of an analogue sensor.

![Analogue sensor output](image)

Figure 2.1 Analogue sensor output

Usually an analogue sensor will have a voltage output that is in certain ranges. To read the data measured by the analogue sensor, an A/D converter is required to convert the analogue signal into digital value[4].
2.2.1.1 Resistive humidity sensor

Resistive humidity sensors measure the changes in electrical impedance of a hygroscopic medium such as a conductive polymer, salt, or treated substrate. Resistive sensors normally consist of noble metal electrodes. A resistive humidity sensor detects relative humidity by measuring the change in the resistance of an element corresponding to the ambient humidity. Salt or conductive polymer is coated on the substrate and when it is melted or suspended in a liquid binder, it will equally coat the sensor. The substrate may be treated with activating chemicals such as acid. The sensor absorbs the water vapour and ionic functional groups are disassociated, resulting in an increase in electrical conductivity. The impedance change is typically an inverse exponential relationship to humidity as shown in Figure 2-2[1].

![Resistance vs RH](image)

**Figure 2.2 The exponential response of resistive sensor**
2.2.1.2 Capacitive humidity sensor

Capacitive relative humidity (RH) sensors made up of a substrate on which a thin film of polymer or metal oxide is placed between two conductive electrodes. The sensing surface is coated with a porous metal electrode to protect it from contamination and contact to condensation. Typically the substrate is glass, ceramic, or silicon. The variation in the dielectric constant of a capacitive humidity sensor is approximately directly proportional to the relative humidity of the surrounding atmosphere as shown in Figure 2-3. Typically the change in capacitance is 0.2–0.5 pF for a 1% RH change, while the bulk capacitance is around 100 to 500 pF at 50% RH at 25°C. This type of sensor is characterized by low temperature coefficient, ability to function at high temperatures (up to 200°C), full recovery from condensation, and reasonable resistance to chemical vapors[1].

![Capacitive humidity sensors diagram]

Figure 2.3 A near linear response of capacitance changes vs humidity at 25°C
2.3 Comparison study

2.3.1 Sensor study

1) Humidity sensitivity of Multi-Walled Carbon Nanotube Networks Deposited by Dielectrophoresis

An investigation on the humidity sensitivity of deposited multi-walled carbon nanotube network using ac dielectrophoresis is presented. A type of material call Carbon nanotubes (CNT) was deposited on the electrode of the resistive type humidity sensor. Dielectrophoreisis is a method to deposit and align CNTs on electrodes of the sensor. The purpose of this deposition of carbon nanotubes is to improve the performance of a resistive type humidity sensor [6].

The experimental results in the study show that by increasing the relative humidity from 25% to 95% RH with a sensitivity of 0.5%/RH, the resistance increases linearly. The response time and recovery time for Multi-Walled CNT networks that have a reversible humidity sensing capacity is about 3 s and 25 s, respectively. The resistance is relying on temperature with a negative coefficient of about -0.33%/K in a temperature range from 293 K to 393 K[6].
Figure 2.4 Resistive-relative humidity data and linear fit of a MWCNT network obtained at room temperature[6].

Figure 2.5 Schematic diagram of MWCNT deposition on IDEs by ac dielectrophoresis to increase sensitivity of sensor [6].
2) A Capacitive Humidity Sensor Based on Multi-Wall Carbon Nanotubes

An new type of capacitive humidity sensor with two plate electrodes coated with multi-wall carbon nanotubes film and four pieces of isolating medium at four corners of the sensor is introduced. This type of sensor used capillary condensation concept to determine relative humidity. The dielectric constant of the sensor will change due to the condensation of the water modules and hence the capacity of the sensor is varying at different relative humidity level[7]. For an increase in humidity, the water molecules tend to condense in capillary pores in the film with a radius below the Kelvin radius \( r \), which is defined as function[7]:

\[
\frac{-2\gamma V_l \cos \theta}{RT \ln(p/p_0)}
\]

Equation 1: Kelvin radius equation

\( \theta \)– Contact angle of liquor and wall of capillary pore.
\( V_l \)– The molecular volume of liquor.
\( \gamma \)– The surface tension of liquor.
\( R \)– Gas constant \((R = 8.314 \text{ J} \times (\text{mol} \times \text{K})^{-1})\).
\( T \)– Absolute temperature (K).
\( r \)– Kelvin radius of the capillary pores.

The RH increase dramatically when the Kelvin radius increase.

The experiment in the study about the response and recovery time is done at room temperature at two relative humidity points: 11 % (RH) and 86 % (RH). The response time is 45 s and the recovery time is 15 s[7].
3) A standard CMOS humidity sensor without post-processing

A capacitive humidity sensor was developed by using CMOS technology without post-processing. The paper discusses the problem to overcome in order to integrating humidity sensor in CMOS. To integrating humidity sensors in CMOS, the most suitable approach is sensing the humidity with hygroscopic polymer films. An electrical flux must be confined to the hygroscopic film in order to get a large relative capacitance change. Therefore a woven lateral array of electrodes implemented in it, and capacitance-to-voltage on chip converter is implemented as well[9].