Development of Small Volume Watering & Soil Cooling System By Using Microcontroller

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electronic Engineering Technology (Industrial Electronics) with Honours.

BY

NG LIAW YONG
B071410168
921221-13-5627

FACULTY OF ENGINEERING TECHNOLOGY
2017
TAJUK: Development of Small Volume Watering & Soil Cooling System Using Microcontroller

SESi PENGAjIAN: 2017/2018 SEMESTER 1

Saya NG LIAW YONG mengaku membenarkan Laporan PSM ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (✓)

☐ SULIT (Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia sebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972)

☐ TERHAD (Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)

☐ TIDAK TERHAD

Disahkan oleh:

______________________________   ______________________________
Alamat Tetap:                   Cop Rasmi:
LOT 716, KAMPUNG ENTULANG
95000 SRI AMAN
SARAWAK

Tarikh: ________________________   Tarikh: ________________________

** Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkann surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD.
DECLARATION

I declare that this thesis entitled Development of “Small Volume Watering & Soil Cooling System by Using Microcontroller” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :..........................................
Author’s Name : NG LIAW YONG
Date :.............................................
This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Engineering Technology (Industrial Electronic) (Hons.). The member of the supervisory is as follow:

Signature: :..............................................
Supervisor name : IR. NIK AZRAN BIN ABDUL HADI
Date: :..............................................
ABSTRACT

Important of water to the plant ignite the creation of intelligence watering system. Small scale smart watering system such as microcontroller based watering system can be seen during these days. Thus for this project a small volume watering system and soil cooling system will be developed. Current small scale microcontroller based watering system is not good enough and not suitable able for some plants in term of watering volume. for example strawberry plant are very sensitive to water logging, using water pump based smart watering system might cause water logging and the risk of rotten strawberry plant crown. besides that, strawberry seed required specific soil temperature for germinate where state Melaka, Malaysia soil temperature is not suitable for strawberry seed germination due to out of temperature range. So in methodology, to control the water volume of watering system, a small plastic tube will be use to control the water flow to the soil based on the plastic tube bending angle that controlled by the servo motor. The water flow rate will be monitored by a sensor that acts as feedback to the microcontroller for regulated water flow rate accordingly. As for soil cooling system for seed germination purpose, a Peltier module that controlled by the microcontroller will be used to coil down the soil to a temperature value. From the results, the small volume watering system are capable to supply vary small water volume to the soil range from minimum 15 micro liter of water per minute to maximum 0.3milli liter of water per minute. As for soil cooling system, it is capable to cool down soil temperature from approximately 30°C to lowest temperature 20°C. From the project finding, during the small volume watering system development process, the bending angle of the plastic tube doest has linear relationship with the water flow rate. As a conclusion, small volume watering system has high potential in commercial and used for others application such as in medical field, agricultural field, chemical field and etc.
**ABSTRAK**

Kepentingan air untuk tumbuhan menyalakan penciptaan sistem penyiraman perisikan. Sistem penyiraman pintar kecil seperti sistem penyiram mikrokontroler boleh dilihat pada hari-hari ini. Oleh itu untuk projek ini, sistem penyiraman isipadu kecil dan sistem penyejukan tanah akan dibangunkan. Sistem penyiraman mikrokontroler berskala kecil masih tidak cukup baik dan tidak sesuai untuk beberapa jenis tumbuhan dari segi jumlah air. contohnya pohon strawberi sangat sensitif terhadap takongan air, menggunakan sistem penyiraman pintar berasaskan pam air boleh menyebabkan takongan air dan risikonya tumbuhan akan menjadi busuk. Selain itu, benih strawberi memerlukan suhu tanah tertentu untuk bercambah di mana negeri Melaka, Malaysia suhu tanah tidak sesuai untuk percambahan benih strawberi kerana keluar daripada julat suhu. Oleh itu, dalam kaedah untuk mengawal jumlah air sistem penyiraman, tiub plastik kecil akan digunakan untuk mengawal aliran air ke tanah berdasarkan sudut lenturan plastik yang dikendalikan oleh motor servo. Kadar aliran air akan dipantau oleh sensor yang berfungsi sebagai maklum balas kepada mikrokontroler untuk mengawal kadar aliran air. Bagi sistem penyejukan tanah untuk tujuan percambahan benih, modul Peltier yang dikawal oleh mikrokontroler akan digunakan untuk menyejukkan suhu tanah. Dari hasilnya, sistem penyiraman isipadu kecil mampu membebalkan isipadu air kecil dari minimum 15 liter mikro air per minit kepada maksimum 0.3milli liter air per minit. Bagi sistem penyejukan tanah, ia mampu menyejukkan suhu tanah dari kira-kira 30 °C hingga suhu paling rendah 20 °C. Dari hasil projek, semasa proses pembangunan sistem penyiraman isipadu kecil, sudut lenturan plastik tidak mempunyai hubungan linear dengan kadar aliran air. Sebagai kesimpulan, sistem penyiraman kelantangan kecil mempunyai potensi tinggi dalam perdagangan dan digunakan untuk aplikasi lain seperti medan medis, medan pertanian, medan kimia dan sebagainya.
DEDICATION

I would like to dedicate my appreciations and gratitude to my supervisor IR. NIK AZRAN BIN ABDUL HADI for guiding me during the Projek Sarjana Muda I (PSM1) and Projek sarjana Muda II (PSM2) as well as my family and friend who support and helps during this year to make this project possible.
ACKNOWLEDGEMENT

First of all, I would like to say thanks to my parents who always support me while I studying in UTeM and also for every decision that I made. Secondly, I would like to thank my only supervisor IR. NIK AZRAN BIN ABDUL HADI for his invaluable advice and guidance to this project. His experience and knowledge has taught me how to make a proper report and definitely shaping up my project. Special thanks go to laboratory assistant EN. ARIFF for always welcoming and assisting me for this project.
TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABSTRACT</td>
<td>VI</td>
</tr>
<tr>
<td>ABSTRAK</td>
<td>VII</td>
</tr>
<tr>
<td>DEDICATION</td>
<td>VIII</td>
</tr>
<tr>
<td>ACKNOWLEDGEMENT</td>
<td>IX</td>
</tr>
<tr>
<td>TABLE OF CONTENTS</td>
<td>X</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>XIII</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>XIV</td>
</tr>
<tr>
<td>LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE</td>
<td>XVI</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>1.1 Overview</td>
<td>1</td>
</tr>
<tr>
<td>1.2 Problem Statements</td>
<td>2</td>
</tr>
<tr>
<td>1.3 Objectives</td>
<td>6</td>
</tr>
<tr>
<td>1.4 Project Scopes</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>LITERATURE REVIEWS</td>
<td>7</td>
</tr>
<tr>
<td>2.1 Introductions</td>
<td>7</td>
</tr>
<tr>
<td>2.1.1 Literature Review on Flood Prone Plant</td>
<td>7</td>
</tr>
<tr>
<td>2.1.1.1 Flood Prone Plant (Strawberry Plant)</td>
<td>9</td>
</tr>
<tr>
<td>2.1.2 Journal and Article Review for Microcontroller Based Watering System</td>
<td>12</td>
</tr>
<tr>
<td>2.1.2.1 Smart Watering System using Wireless Sensor Networks</td>
<td>12</td>
</tr>
<tr>
<td>2.1.2.2 Garden Watering System Based on Moisture Sensing &amp; Automated Plant Watering System</td>
<td>14</td>
</tr>
<tr>
<td>2.1.2.3 Weather Based Smart Watering System Using Soil Sensor and GSM</td>
<td>16</td>
</tr>
</tbody>
</table>
2.1.2.4 GSM Activated Watering System Prototype 18
2.1.3 Journal and Article Review for Soil cooling Technology 21
  2.1.3.1 Seed Germination charts 21
  2.1.3.2 A Simple Method for Cooling down the Soil in Bench 23

METHODOLOGY 25

3.1 General flowchart 25

3.2 Development of Small Volume Watering System 26
  3.2.1 System Operation Concept 27
  3.2.2 System Development Process 30
  3.2.1 Small Volume Watering System Microcontroller Program Algorithm 31
  3.2.2 Electronic Device and Component 32
    3.2.2.1 Drip Sensor 32
    3.2.2.2 90SG Servo 35
    3.2.2.3 Water Tank 36
    3.2.2.4 Microcontroller PIC18F1939 37

3.3 Development of soil cooling system 38
  3.3.1 System operation concept 38
  3.3.2 System Development Process 41
  3.3.1 Soil Cooling System Microcontroller Program Algorithm 42
  3.3.2 Electronic Device and Component 43
    3.3.2.1 Peltier Module 43
    3.3.2.2 DS18B20 Digital Temperature Sensor 44
    3.3.2.3 DC Water Pump 45
    3.3.2.4 Copper Tube and Plastic Tubing 46

RESULTS & DISCUSSIONS 47

4.1 System/Product Appearance 47

4.2 Small Volume Watering Systems Analysis 50
  4.2.1 Small volume Watering System Analysis 50
    4.2.1.1 3 Seconds per Drip, Supplied Water Volume in Every 5 Minutes 51
    4.2.1.2 The Relationship between Water Drip Rate and Servo Motor Angle 52
  4.2.2 Soil Cooling System Analysis 54
    4.2.2.1 Minimum Achievable Water Temperature with Fixed Water Volume (No Pump) 55
CONCLUSIONS

5.1 Conclusions
  5.1.1 Results and Discussion Summary
    5.1.1.1 Small Volume Watering System
    5.1.1.2 Soil Cooling System

5.2 Future Improvement

5.3 Commercials Value Based on This Project
  5.3.1 Low Cost Large Scale Small volume Watering System
  5.3.2 Used In Chemical Labs
  5.3.3 Hospitals

REFERENCES

APPENDICES
LIST OF TABLES

Table 2-1: Hardware Comparison .................................................. 15
Table 3-1: Light Dependent Resistor (LDR) Specifications ............. 32
Table 3-2: LED Specifications ...................................................... 33
Table 3-3: Plastic Pipe Specifications .......................................... 34
Table 3-4: Towerpro Sg90 Servo Specifications ............................. 35
Table 3-5: Water Tank Specifications ........................................... 36
Table 3-6: Microchip PIC16F1939 Specifications ......................... 37
Table 3-7: Peltier TEC-12706 Specifications ................................ 43
Table 3-8: DS18B20 Digital Temperature Sensor Cable Specifications 44
Table 3-9: DS18B20 Digital Temperature Sensor Technical Specifications 44
Table 3-10: DC Water Pump Casing Specifications ...................... 45
Table 3-11: DC Water Pump Technical Specifications .................. 45
Table 3-12: Copper Tube Specifications ....................................... 46
Table 3-13: Plastic Tube Specifications ........................................ 46
Table 4-1: Mean, Max, Min and Range for all 4 Tests .................... 57
Table 4-2: Water Temperature at Specific System Scan Time ........... 61
Table 4-3: Water Temperature Different With or Without Copper Tube 66
LIST OF FIGURES

Figure 1-1: Water Flood on the Soil (Haber, 2016) 2
Figure 1-2: Water Flood on the Soil (Svsembedded, 2017) 3
Figure 1-3: Water Flood on the Soil (Ottevangers, 2016) 3
Figure 1-4: Water Flood on the Soil (watch, 2017) 4
Figure 1-5: Water Flood on the Soil (Hack, 2016) 4
Figure 2-1: Plant Cell Membrane 8
Figure 2-2: Strawberry Plant Shallow Roots 9
Figure 2-3: Dripping System for Strawberry Plant (A, B, C, D) 11
Figure 2-4: The Solenoid Valve Used for the Irrigation 12
Figure 2-5: Wireless Transmitter for Soil Moisture Sensor 12
Figure 2-6: Illustration Of Low Cost Soil Probe 14
Figure 2-7: Soil Moisture Sensor 14
Figure 2-8: Teensy 2.0 14
Figure 2-9: Arduino Uno 14
Figure 2-10: Dc Water Pump 15
Figure 2-11: Dc Water Pump 15
Figure 2-12: Garden Watering System Based On Moisture Sensing Journal 15
Figure 2-13: Weather Based Watering System Using Soil Sensor and GSM 16
Figure 2-14: Weather Based Watering System Using Soil Sensor and GSM 17
Figure 2-15: GSM Activated Watering System Prototype Operation 18
Figure 2-16: GSM Activated Watering System Prototype Overall System 19
Figure 2-17: GSM Activated Watering System Prototype SMS 19
Figure 2-18: GSM Activated Watering System Prototype Overall Hardware 20
Figure 2-19: Seed Germination Soil Temperature Chart (Anon., 2010) 21
Figure 2-20: Seed Germination Days (Anon., 2010) 22
Figure 2-21: Soil A:No Cooling, Soil B:Pipe Cooling, Soil C:Evaporating Cooling 23
Figure 3-1: Working Plan 25
Figure 3-2: Small volume Watering System Block Diagram 27
Figure 3-3: Small volume Watering System Signal Transmission 28
Figure 3-4: Small volume Watering System Block Diagram 28
Figure 3-5: Small volume Watering System Development Process 31
Figure 3-6: Small Volume Watering System Algorithm 31
Figure 3-7: Light Dependent Resistor (LDR) 32
Figure 3-8: 3mm Orange Color LED 33
Figure 3-9: Plastic Tube 34
Figure 3-10: Drip Sensor Working Concept 34
Figure 3-11: Water Tank 36
Figure 3-12: Microchip PIC16F1939 37
<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-13</td>
<td>Soil Cooling Concept</td>
<td>38</td>
</tr>
<tr>
<td>3-14</td>
<td>Soil Cooling System Illustration</td>
<td>39</td>
</tr>
<tr>
<td>3-15</td>
<td>Soil Cooling System Development Process</td>
<td>41</td>
</tr>
<tr>
<td>3-16</td>
<td>Soil Cooling System Microcontroller Program Algorithm</td>
<td>42</td>
</tr>
<tr>
<td>3-17</td>
<td>Peltier TEC-12706</td>
<td>43</td>
</tr>
<tr>
<td>3-18</td>
<td>Digital Temperature Sensor DS18B20</td>
<td>44</td>
</tr>
<tr>
<td>3-19</td>
<td>DC Water Pump</td>
<td>45</td>
</tr>
<tr>
<td>3-20</td>
<td>Copper Tube and Plastic Tube</td>
<td>46</td>
</tr>
<tr>
<td>4-1</td>
<td>System Overall View</td>
<td>47</td>
</tr>
<tr>
<td>4-2</td>
<td>System Side View</td>
<td>48</td>
</tr>
<tr>
<td>4-3</td>
<td>System front View</td>
<td>48</td>
</tr>
<tr>
<td>4-4</td>
<td>System Top View</td>
<td>49</td>
</tr>
<tr>
<td>4-5</td>
<td>Small volume Watering System Side View</td>
<td>50</td>
</tr>
<tr>
<td>4-6</td>
<td>Water Tank with Servo Motor Installed for Valve Control</td>
<td>50</td>
</tr>
<tr>
<td>4-7</td>
<td>Supplied Water Volume for Every 5 Minutes (3 Seconds per Drip)</td>
<td>51</td>
</tr>
<tr>
<td>4-8</td>
<td>The Relationship between Drip rate and Servo Angle</td>
<td>52</td>
</tr>
<tr>
<td>4-9</td>
<td>Soil Cooling System Side View</td>
<td>54</td>
</tr>
<tr>
<td>4-10</td>
<td>Soil Cooling System Labeling</td>
<td>54</td>
</tr>
<tr>
<td>4-11</td>
<td>Water Cooling Process</td>
<td>55</td>
</tr>
<tr>
<td>4-12</td>
<td>Lowest Archive Able Temperature Test</td>
<td>56</td>
</tr>
<tr>
<td>4-13</td>
<td>Maintaining Water Temperature at a Value</td>
<td>58</td>
</tr>
<tr>
<td>4-14</td>
<td>Temperature Fluctuation Test</td>
<td>59</td>
</tr>
<tr>
<td>4-15</td>
<td>Water Temperature Reading Concept</td>
<td>60</td>
</tr>
<tr>
<td>4-16</td>
<td>Cold Water Is Circulating Through Copper Tube</td>
<td>62</td>
</tr>
<tr>
<td>4-17</td>
<td>Minimum Archive Able Temperature with Copper Tube</td>
<td>63</td>
</tr>
<tr>
<td>4-18</td>
<td>Soil Pot with Copper Tube and Plastic Piping</td>
<td>64</td>
</tr>
<tr>
<td>4-19</td>
<td>With or Without Copper Tube Lowest Temperature</td>
<td>65</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>--------------</td>
<td>----------------------------------</td>
<td></td>
</tr>
<tr>
<td>LDR</td>
<td>Light Dependent Resistor</td>
<td></td>
</tr>
<tr>
<td>UART</td>
<td>Universal Synchronise Receiver Transmitter</td>
<td></td>
</tr>
<tr>
<td>LDR</td>
<td>Light-Emitting Diode</td>
<td></td>
</tr>
</tbody>
</table>
CHAPTER 1

INTRODUCTION

1.1 Overview

Nowadays, many task was done by robot or intelligent system for reduce human work load. This intelligence system can be found in many places or field. For example at home which are washing machine, home automation system, anti-theft system and etc. existing for these intelligent systems let the human to focus more important thing in their life and reduce their daily repeating task. Beside the intelligence system that take care of human things, there is also have intelligence system that take care specifically for plants like vegetables, flower, herbs and etc. This kind or intelligence may take care the plant grow required parameter such as, intensities of sunlight, irrigation amount, fertilizer amount humidity and some others parameter that affect the plants life. Water is important to plant as well for human. Water has many roles to play for a plant to growth. Water allow constituent of protoplasm and dissolved nutrient to let the plants absorb. Water also used for transport nutrients from the soil to green plant tissues beside for photosynthesis. And also, Water is essential for the germination of seeds, growth of plant roots. When the weather is hot human need shower to cool down their body same for plant, Water regulates the temperature and cools the plant. Thus, important of water to the plant ignite the creation of intelligence watering system. Small scale smart watering system such as microcontroller based watering system can be seen during these days. Most commonly use Arduino and Microchip. Beside plant need water; temperature also is one of the important parameter for a plant to grow.
1.2 Problem Statements

Microcontroller such as Microchips, Arduino and others microcontrollers has been wildly used for plant watering system that watering automatically. Mostly small scale microcontroller based watering system utilizes a water pump or solenoid to allow or disallow the water supply to the target soil. With a specified program on the microcontroller, the microcontroller can control the water pump either on or off depending on the condition as stated in the program to watering the plant on a pot or ground. Some microcontroller based watering systems utilize GSM, WIFI or Bluetooth as support/feature for its user to control this system from far distance for plant watering purpose. However, the microcontroller based watering system by using water pump and solenoid has issue in some condition. Following figure show the microcontroller based watering system using water pump or solenoid for control the water flow.

Figure 1-1: Water Flood on the Soil (Haber, 2016)
Figure 1-2: Water Flood on the Soil (Svsembedded, 2017)

Figure 1-3: Water Flood on the Soil (Ottevangers, 2016)
From the figure above, there is a water pump which is connected to water tank using water pipe so that the water from the tank can be supply to the target flower pot. At figure 1-5, as soon as the water pump activated by the microcontroller, the water was splash everywhere when it hit the soil/plant in the flower pot. At figure 1-1~1-4, the flower pot was filled with water on the top of soil when water pump was
continuously turned on. Some plant might can tolerance with water that filled on the top of soil but not for some plant. So there is a risk of plant die due this type of watering system which uses water pump or solenoid to control the water to the soil. Also with strong water flow rate to the soil for seed germination is not suitable. So there is a need for control the water volumes to the soil so that this problem can be avoid.

Next, the soil temperature also important for a plant to grow especially during the seed germination stage, correct temperature range allows the seed to germinate and grow. Thus, specified range of soil temperature need to be monitored, maintain and control.
1.3 Objectives

- To develop small volume watering system in the purpose of control water volume to the soil.
- To develop soil cooling system in the purpose of maintains and control soil temperature for seed germination.

1.4 Project Scopes

To know more about which plant is water sensitive plant literature review will be carrying out. Next, current technology regard small scale microcontroller based watering system will be studied and compared for each others. An automated small scale microcontroller based watering system that can control the water volume to the soil can be expected at the end of this final year project.

After the hardware is completed, analysis will be carry out. The analysis will be on the range of the water volume in minutes that can supply by the gentle watering system and it output tolerance.

This project also aims to be low cost as possible while remain it effectiveness and functionality. To reduce the chance of unexpected product failure during operation, product evaluation and improvement will be made to make sure long term functional to let the user peace of mind for not worrying too much about their planting.

For controlling soil temperature, the microcontroller based temperature control system journey will be disuses. Next, the soil temperature required for general flower/plant to germinate will be reviewed.
CHAPTER 2

LITERATURE REVIEWS

2.1 Introductions

This section will be discussed about the type of plant which is sensitive to water. Next, current microcontroller based watering system and the soil cooling system will also be mentioned and discussed.

2.1.1 Literature Review on Flood Prone Plant

As with other climatic factors, water can possibly cause unfavorable effects on plant growth and development. Excess water in the soil can injure flood prone plants, like corn (maize), due to lack of oxygen. In this case water stress due to flooding means oxygen stress by deficiency (hypoxia) or total absence (anoxia).

Excess water within the plant can also cause injury. Edmond, et al. (1978) explained that under conditions that favor high absorption and low transpiration rates, there is build-up of high turgor pressure in the region of cell elongation which causes maximum swelling of the cells. This results to the development of leggy seedlings.

The water pressure inside plant cells is called turgor pressure, and it is maintained by a process called osmosis. Osmosis is the movement of water across a differentially permeable membrane from a place where water concentration is higher to one where the concentration is lower.
The cell membrane is "differentially permeable," that mean salt contained water molecules can enter, but the salt molecules are too large to escape. The result is that water pressure builds inside the cell, causing the cell membrane to exert pressure on the cell wall.
According to article Vanderlinden (2017) and Domenghini (n.d.) both of the authors mention that strawberry plant has shallow root systems and watering should be done regularly. This prevents the plants from stress or dry due to insufficient water (Vanderlinden, 2017). Furthermore, regular watering also help the shallow root system from dry out especially during warm weather (Domenghini, n.d.).