DEVELOPMENT OF AUTOMATIC HOME PLANT WATERING SYSTEM USING SOIL MOISTURE SENSING

Submitted in accordance with the requirement of the University Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Hons.)

by

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirement for Degree of Manufacturing Engineering (Hons). The member of the supervisory committee is as follow:

…….....

(Dr. Silah Hayati Binti Kamsani)

ABSTRAK

Kebanyakan orang yang mempunyai tanaman di rumah lebih menyukai jika mereka memiliki sistem pengairan automatik kerana kesuntukan masa untuk melakukan penyiraman secara teratur disebabkan jadual yang sibuk. Walau bagaimanapun, sistem pengairan automatik yang berasaskan pemasa akan menyebabkan pembaziran air jika penyiraman berlaku ketika hujan. Oleh itu, projek ini bermula dengan penyelidikan terhadap sistem pengairan automatik dengan menggunakan penderiaan kelembapan tanah yang boleh didapati pada masa kini untuk kegunaan domestik. Rekabentuk sistem tersebut akan mempertimbangkan cara untuk memperbaiki prestasi sistem di samping mempunyai harga yang lebih rendah supaya orang kebanyakan juga dapat memiliki dan menggunakan sistem tersebut. Projek ini dimulakan dengan fabrikasi struktur sistem penyiraman, sebelum dilengkapi dengan sistem elektrik dan elektronik. Kemudian, sistem yang dibina, pengaturcaraan menggunakan mikrokontroler Arduino dilaksanakan untuk sistem untuk mengendalikan penyiraman secara automatik apabila kelembapan tanah mencapai tahap tertentu. Kemudian, ujian dilakukan untuk menilai ketepatan dan kecekapan sistem penyiraman automatik ini. Kategori analisis termasuk kos yang dibelanjakan untuk sistem penyiraman automatik dari segi air dan elektrik. Kesimpulannya, analisis yang diperoleh menunjukkan bahawa penderiaan kelembapan tanah berdasarkan sistem penyiraman automatik mempunyai prestasi yang lebih baik daripada sistem penyiraman automatik yang berasaskan pemasa di mana ia menggunakan kuasa sebanyak 2.33% kurang dari segi penggunaan elektrik. Cadangan yang diberikan kepada projek ini adalah untuk menambah aplikasi mudah alih yang digunakan untuk memantau dan mengawal sistem penyiraman untuk menyiram tumbuhan yang sentiasa dipromasikan dalam Industri 4.0 dan Internet of Things (IoT).

ABSTRACT

Most people would prefer an automatic irrigation system to water their home plants regularly due to time constraint on their busy schedule. However, a timer-based automatic irrigation system will cause water wastage if watering occurs during rain. Therefore, this project starts with a research on automatic irrigation systems using sensible soil sensors that are currently available for domestic use. The design of the system will consider how to improve system performance while having lower prices so that most people can also have and use the system. This project is started with the fabrication of the watering system structure before being equipped with electrical and electronic systems. Then, the built up system, programming using an Arduino microcontroller are implemented for the system to handle watering automatically when the soil moisture reach a certain level. Then, several tests were done to assess the accuracy and efficiency of this automatic watering system. Categories of analysis include the cost spent on the automatic watering system in terms of water and electricity. In conclusion, the analysis obtained shows that the soil moisture sensor based automatic watering system has the better performance than the timer-based automatic watering system where it consumed 2.33 % less power in term of the electric consumption. The recommendation given to this project is to add a mobile app that can be used for monitoring and controlling the watering system to water the plants which is always promoted in Industry 4.0 and Internet of Things (IoT).

DEDICATION

Only

my beloved father, Lau Jian Huat

my appreciated mother, Ng Suat Yong

my adorable brother and sisters,

Lau Ghee Hoong

Lau Chooi Ling

Lau Ghee Boon

my supportive friends,

For giving me moral support, money, cooperation, encouragement and also understandings.

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PCB	-	Printed Circuit Board
TDR	-	Time-Domain Reflectometry
VDC	-	Volts DC
SDI	-	Subsurface Drip Irrigation
VMC	-	Volume Moisture Content
IoT	-	Internet of Things
USB	-	Universal Serial Bus
AC	-	Alternative Current
DC	-	Direct Current
IDE	-	Integrated Development Environment
UARTs	-	Universal Asynchronous Receiver-Transmitter
ICSP	-	In Circuit Serial Programming
PLC	-	Programmable Logic Control
CPU	-	Central Processing Unit
PC	-	Personal Computer
I/O	-	Input/Output
PVC	-	Polymerizing Vinyl Chloride
BOM	-	Bill of Material
LED	-	Light-Emitting Diode
kWh	-	Kilowatt Hour
BOM	-	Bill of Material
Ah	-	Amp Hour
TNB	-	Tenaga Nasional Berhad
SAMB	-	Syarikat Air Melaka Berhad

LIST OF SYMBOLS

MHz	-	Megahertz
ε_a	-	Apparent Dielectric Permittivity
dS/m	-	Conductivity Unit
m^3	-	Cubic metre
cm	-	Centimetre
Vol%.	-	Volume Fraction
mV	-	Millivolt
°C	-	Degree Celsius
mA	-	Milliamps
%	-	Percent
mm	-	Millimetre
VSW	-	Volumetric Soil Water Contents
V	-	Volt
kPa	-	Kilopascal
ms^{-2}	-	Metre Per Second Square
MPa	-	Megapascal
k	-	kilo
m	-	Metre
ml	-	Millilitre
W	-	Watt
A	-	Ampere
RM	-	Ringgit Malaysia
L	-	Litre
μF	-	Microfarad
”	-	Inches
g	-	Grams

CHAPTER 1

INTRODUCTION

1.1 Project Background

In the 21st century, world is meeting the new technology era and many of the labour works are replaced gradually by automation and/or robotics. Nowadays, plenty of family have planted a lot of plants in the house garden for various reasons. These reasons can be as their hobby or as decoration for their home. With the development of technology, the latest watering method is the automatic watering where water is carried by the connected pipe with the water supply around the garden. An automatic watering system consists of many components such as soil moisture sensor, timer-based circuit, piping system, controller system and other circuit components.

From the old days, hand watering is used to water plants in the family area. A common and very simple technique for manual irrigation is the use of self-make watering cans or pails as it can be found in everywhere especially in house garden. Hand watering is one of the popular methods used in house garden area because there is no special equipment needed. It only uses a hose that connected to the water supply to water the plant manually at any time.

With the development of technology, Todd (2008) has described that the automatic watering system is an automatic system that work on gradual release of water. Automatic watering is a small scale watering system that takes water from the water supply to the plants through a basic electrical system in the garden. It can be controlled physically or by a timer. These automatic watering systems are normally setup with a timer so that the watering system will automatically waters the plant within the setting time (Reiter *et al.*, 1987). Besides that, automatic watering systems will cut-off water at the set time.

Automatic watering system with soil moisture sensor is one of the latest automatic watering systems. It is an automatic watering system which measures the soil moisture and automatically turns on or off the water supply system. Malaysia has tropical climate which is affected by monsoonal climate due to its latitude and longitude. Tropical climate will gives hot summer that contributes to low humidity level (Zakaria *et al.*, 2017). Weather either sunny or raining, will affect the soil moisture of the plant. Hence, a properly designed soil moisture sensor for automatic watering system can save up to 60% of water utilized. In particular, soil moisture sensors can reduce the number of unnecessary irrigation (Archana and Priya, 2016). Even though, soil moisture sensor-based automatic watering system helps to save time, the removal of climatic conditions is isotropic, since there is still an error in adjusting the available soil moisture content (Vagulabranan *et al.*, 2016).

1.2 Problem Statement

Nowadays, gardening is a hobby that is more prevalent in many residence areas. Besides that, garden decoration by using house plant is also widely used in commercial area. Examples of house plant in Malaysia are *bougainvillea papillon*, *wrightia*, and, *ixora duffii*.

Even though many families have their own plant or mini garden but due to their busy schedules, sometimes the plants are not watered regularly. This is especially true when they are on an extended holiday. Some hire gardeners to take care of their plants. Nevertheless, another method to counter this watering problem is by using an automatic watering system. The most common automatic watering system is based on timer. However, different types of plants have their own water requirement. Furthermore, if it is raining, then the water is wasted on an already damped ground.

Therefore, by using a soil moisture sensor, an automatic watering system can use the input of soil moisture level to determine whether the plant is indeed needed watering. As mentioned earlier, since the water required for every different plant is also difference, thus, an average water amount for various house plants is needed when the automatic watering system is activated at the same time.

1.3 Objective

The objectives of this project are as follow:

i. To identify various type of automatic watering system available in the market.
ii. To develop the automatic watering system by using soil moisture sensor to be applied in a mini garden.
iii. To prove that the performance of automatic watering system by using soil moisture sensor is better than other watering systems by measurement of amount of water used, electric used, and the cost to build up the system.

1.4 Scope of the Project

This section describes the scopes of this project. Referring to objective 2, this project shall be implemented only in a typical mini garden in Malaysia which is only comprises three home plants in poly bags. Only three types of house plant that are commonly available and suitable with Malaysia climate shall be considered in the watering system testing process. The irrigation type used is drip irrigation and not sprinkler system because sprinkler is assumed to waste more water than drip irrigation. Moreover, sprinkler irrigation is not suitable for small garden area. The soil moisture sensor used in this project shall be the capacitance-type and the controller is a microcontroller of Arduino brand.

1.5 Thesis Outline

In this project, it contains five chapters in forming the organization of the report. In the first chapter, it is begin with project background, problem statements, objectives and scope are depicted all together to define the development of automatic home plant watering system based on soil moisture sensing in this thesis. Chapter 2 literature reviews consists of the previous study and research that related to the watering system, watering method, soil moisture sensor, controller and valve. For the next chapter, Chapter 3 methodology describes all the raw materials, mechanical and electrical built up method used for carrying on the system built up. Besides that, the testing method used will be state in the Chapter 3.

Chapter 4 analyse the result of the water level on the container after watering then discuss that whether the development of the watering system does increase the performance or not. In Chapter 5, conclusion and recommendation about this project are concluded.

CHAPTER 2
LITERATURE REVIEW

This chapter reviews the existing automatic watering system especially the ones that based on the soil moisture sensor. It also includes surveys on watering method, and the related components such as soil moisture sensor, controller, and valve used.

2.1 Watering System

Watering system is a system of supplying water by means of artificial canals, ditches or others to promote the growth of the plants crop. Watering system has been developed into automation control from manual watering.

2.1.1 Manual watering system

The oldest method of manual watering is by using a container normally called watering can to fill up water, and carrying it to water the plant. Further development sees the creation of hose as a widely used method of irrigation. A hose that is connected to water supply, can reach anywhere easily with its long length, and flexible body design. Normally, manual watering is used for house gardening due to low in cost than installing an automatic system, which only requires some equipment, and low maintenance to maintain the system.

2.1.2 Automatic timer watering system

Automatic watering system is referring to the operation of system with less labour input when watering. In practical, most of the watering system is automated with the timer. Thus, the watering process can be performed more efficiently, so that user can focus on other works. In this type of system, timer is a basic instrument to supply water in the necessary quantity at the right time. A timer begins and stops the water system process. Timer can lead to an under or over watering if the programme is wrongly input or the water amount is computed erroneously. Usually, time of operation is computed by volume of water required and the normal stream rate of water (Rajakumar *et al.,* 2008).

The advantages of the automatic watering system are it reduced the watering work time and cost. As the user is not required to constantly monitor the progress of the system, user is available to perform other tasks at the same time. In addition, there is reduction in costs of water used in an automatic watering system because the water amount is the same used every time in watering the plants (Prima *et al.*, 2016). Automatic watering system is more likely to irrigate when plants need water. Automatic watering system is better than the manual watering system in term of the timing is changing or cut-off the water flows when watering to save more water costs Regarding to Reiter *et al*. (1987), a disadvantage of system with the pre-set clock or timer is turned on regardless of soil moisture or weather conditions.

In addition, the installation of a completed automatic watering system is high in cost and extremely complex, which required experts to plan, and execute it. It also increasing the level of maintenance works need to be performed on the system and other tools to make sure that the system is working properly every time.

2.1.3 Sensor-based automatic watering system

A sensor-based automatic plant watering system is a model of controlling watering system. It utilizes sensor innovation to detect soil moisture with a microcontroller so as to make a smart switching device to help a huge number of individuals (Đuzić, 2017). This automatic watering system senses the moisture content of soil and automatically switches

the system –ON" to supply water for watering. A proper utilization of this watering system is critical in light of the fact that the principle reason is the shortage of land reserved water due to lack of rain, unplanned use of water as a result large amounts of water goes to waste. Thus, this automatic watering system is exceptionally helpful in every single climatic condition.

The advantages of this system are mostly the same with the timer based watering system but the difference is in water conservation. This system can sense the soil moisture content but the timer based system will water the plant by following the setting time without considering the soil moisture. For example, there is raining season in Malaysia at the end of every year, so there will always be rain water day by day. The soil moisture of the plant will be affected due to raining and there is no watering needed on that day. Hence, the sensor will detect this moisture content so that no more watering will be performed on that day until the soil moisture content goes below its limit.

2.2 Watering Method

Selection of watering method is essential because it will affect the performance of the watering system in cost and other factors. Any wrong selection of equipment can damage the plant, affect the soil moisture, and reduce the efficiency of the water absorption of the plant. Each different watering method is designed for specific purpose such as watering area, type of plant, and cost. The most common watering methods used nowadays in modern agriculture are sprinkler and drip.

2.2.1 Sprinkler irrigation

Sprinkler is promoted to world-wide to save water in irrigation (Burt *et al*., 1997; Louie *et al.*, 2000; Ouazaa *et al.,* 2016; Tang *et al*., 2017). Sprinkler has been simplifying the watering process in lawns and gardens without the handling of a hose to water the plants. Water is supplied through a pipe system usually by pump. Sprinkler irrigation can reduce water spend, improve crop productivity, save labour, and improve crop quality (Santos *et al*., 2003; Wrachien *et al*., 2006). It sprays water into the air through the