

# HUMIDITY CONTROL AND MONITORING SYSTEM FOR MOISTURE SENSITIVE DEVICES (MSD)



# BACHELOR OF MECHANICAL ENGINEERING TECHNOLOGY (MAINTENANCE) WITH HONOURS

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# Faculty of Mechanical and Manufacturing Engineering Technology



KARRTHIK A/L ELANGO

Bachelor of Mechanical Engineering Technology (Maintenance) with Honours

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#### HUMIDITY CONTROL AND MONITORING SYSTEM FOR MOISTURE SENSITIVE DEVICES (MSD)

#### KARRTHIK A/L ELANGO



Faculty of Mechanical and Manufacturing Engineering Technology

## UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2022

#### DECLARATION

I declare that this project entitled "Humidity Control And Monitoring System For Moisture Sensitive Devices (MSD)" is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.



#### APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Mechanical Engineering Technology (Maintenance) with Honours.



#### **DEDICATION**

I would like to acknowledge and thank my Project Supervisor, Ts. Dr. Nor Azazi Bin Ngatiman, for his guidance. As an expert in mechanical systems theory and practice, his advice was invaluable and contributed extensively to the learning experience and also have been guiding me to finish this project successfully. Finally, my deepest appreciation will go to my friends, their patience, understanding, and flexibility throughout this undertaking has



#### ABSTRACT

The design, development, and testing of a control and monitoring system for moisture sensitive devices (MSDs) within a specified temperature and humidity range are discussed in this study. The objective of this project was to create an Arduino-based embedded device that could monitor and adjust the temperature and humidity of a storage room using the Internet of Things (IoT). This project was initiated with an idea of solving some problems in semi-conductor industries. The first problem statement was moisture is an invisible pest in the electronics production industry. The majority of components and integrated circuits (ICs) will have their unique moisture sensitivity (MSL). For industries with high mix low volume the MSD will take more time to be used. The process of keeping the MSD for a long time will require more effort to preserve the humidity because the tendency to the moisture absorbed is high. Many problems may be traced back to moisture in microelectronic packages. Moisture absorption in electronics packages can result in a variety of issues. The moisture from the industrial environment is then absorbed into the electronic packages, which will cause problems during the PCB manufacturing solder reflow process. To avoid interior damage, these MSDs must be regulated and kept against moisture in accordance with international industry standards. This project was an idea of build a storage which is able to control and monitor the humidity in it. The prototype was primarily constructed with an Arduino Mega, an ESP8266 Wi-Fi Module, and a DHT 22 sensor, which can measure the humidity and temperature of the storage and provide data to the Arduino, with real-time data being supplied to the Blynk mobile application. The Arduino Mega hardware is nothing other than a motherboard that can be used to create interactive things using an IDE (Integrated Development Environment). The project was tested and the gained data were discussed with explanation. This report is divided into two sections: a theoretical introduction to the materials, equipment utilised throughout the project, and a step-by-step approach for connection, prototype, and circuits. At the end, the project met its objectives; implementation was made feasible by the Arduino library, earlier work by another student, and related online sites where the majority of the material was available. There were also some important criteria to be changed or improved in future while doing this research for betterment.

#### ABSTRAK

Reka bentuk, pengembangan, dan pengujian sistem kawalan dan pemantauan untuk alat sensitif kelembapan (MSD) dalam julat suhu dan kelembapan yang ditentukan dibincangkan dalam kajian ini. Objektif projek ini adalah untuk membuat peranti tertanam berasaskan Arduino yang dapat memantau dan menyesuaikan suhu dan kelembapan ruang penyimpanan menggunakan Internet of Things (IoT). Projek ini dimulakan dengan idea untuk menyelesaikan beberapa masalah dalam industri separa konduktor. Pernyataan masalah pertama adalah kelembapan adalah perosak yang tidak dapat dilihat dalam industri pengeluaran elektronik. Sebilangan besar komponen dan litar bersepadu (IC) akan mempunyai kepekaan kelembapan unik (MSL). Untuk industri dengan jumlah campuran rendah, MSD akan memerlukan lebih banyak masa untuk digunakan. Proses menjaga MSD untuk waktu yang lama akan memerlukan lebih banyak usaha untuk mengekalkan kelembapan kerana kecenderungan kelembapan yang diserap tinggi. Banyak masalah dapat dikesan kembali ke kelembapan dalam paket mikroelektronik. Penyerapan kelembapan dalam pakej elektronik boleh mengakibatkan pelbagai masalah. Kelembapan dari persekitaran industri kemudian diserap ke dalam bungkusan elektronik, yang akan menimbulkan masalah semasa proses pengisian semula solder pembuatan PCB. Untuk mengelakkan kerosakan dalaman, MSD ini harus diatur dan dijaga agar tidak kelembapan sesuai dengan standard industri antarabangsa. Projek ini adalah idea untuk membina simpanan yang dapat mengawal dan memantau kelembapan di dalamnya. Prototaip ini dibina terutamanya dengan Arduino Mega, Modul Wi-Fi ESP8266, dan sensor DHT 22, yang dapat mengukur kelembapan dan suhu penyimpanan dan memberikan data kepada Arduino, dengan data masa nyata dibekalkan ke aplikasi mudah alih Blynk. Perkakasan Arduino Mega tidak lain adalah motherboard yang boleh digunakan untuk membuat perkara interaktif menggunakan IDE (Persekitaran Pembangunan Bersepadu). Projek ini diuji dan data yang diperoleh dibincangkan dengan penjelasan. Laporan ini terbahagi kepada dua bahagian: pengenalan teori mengenai bahan, peralatan yang digunakan sepanjang projek, dan pendekatan langkah demi langkah untuk sambungan, prototaip, dan litar. Pada akhirnya, projek tersebut memenuhi objektifnya; pelaksanaan dibuat oleh perpustakaan Arduino, karya sebelumnya oleh pelajar lain, dan laman web dalam talian yang berkaitan di mana sebahagian besar bahan tersedia. Terdapat juga beberapa kriteria penting yang akan diubah atau diperbaiki di masa depan semasa melakukan penyelidikan ini untuk peningkatan.

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# LIST OF SYMBOLS AND ABBREVIATIONS

MSD	-	Moisture Sensitive Device
HIC	-	Humudity Indicator Card
PCB	-	Printed Circuit Board
MSL	-	Moisture Sensitive Level
IoT	-	Internet of Things
AHU	-	Air Handling Unit
USB	-	Universal Serial Bus
SDLC	-	System Development Life Cycle
LED	- 14	Light Emitting Transmitter
Wifi	A. C.	Wireless-Fedelity
PC	EK.	Personel Computer
3D	-	Three Dimension
LCD	1 and	Liquid Crystal Display
	101	Nn
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#### **CHAPTER 1**

#### **INTRODUCTION**

#### 1.1 Background of Study

The majority of industry nowadays, particularly semiconductor and electronicsbased firms, is highly focused on the end product's ability to function. As a result, these businesses or industries will always be able to trace their products from low to high levels of traceability. In general, they will track their goods from the time it is purchased until it is delivered to the consumer. By doing this, it will be easy to pinpoint where the error occurred. These industries are concerned about traceability because it will give their customers confidence in order to maintain a high standard among competitors.

Now, when it comes to traceability at each level, it is critical for printed circuit board (PCB) manufacturing firms to be able to trace their final product down to the component level. Moisture is regarded as an invisible pest in the electronics production industry. The majority of components and integrated circuits (ICs) will have their unique moisture sensitivity (MSL). These components and ICs are also known as 'moisture sensitive devices' (MSDs), and their packing are made of plastic. To avoid interior damage, these MSDs must be regulated and kept against moisture in accordance with international industry standards.

Excess moisture in MSDs will generate into steam and might lead to issues during solder reflow process. When this happens the component packing will begin to fracture or delaminate due to the presence of unexpectedly increased temperature or heat which exposed to the component and the excess moisture which traped in the package. Steam will try to escape from the encapsulated packaging as the moisture inside the component tries to escape. Internal faults are nearly hard to identify throughout the PCB assembly and testing process.

Defects will raise the failure rate of completed electronic items, resulting in a poor perception of the manufacturing industry. This situation will result in increasing risk level. For example, circuit board breakdown during piloting flight, manufacturing of automotive, and many more.

The goal of this project is to keep moisture-sensitive electronics at a constant humidity and temperature. This initiative also focuses on preventing and monitoring MSDs considerably easier in accordance with global industry standards. In industries, this device needed in a bigger sale but in this project, the MSD storage model is minimised scale for a complete electrical circuit and software of humidity control and monitoring systems.

#### 1.2 Problem Statement

During receive the MSDs device from the manufacturers, it will arrive with the sillica bag and humidity indicator card (HIC) inside. The MSD storage humidity condition in the vacuumed bag must be around 5%. Now, for the outside of the storage place, it will require to be kept in its own state and time, according to their MSL. Apart from that, the MSD will take longer to implement in industries with a high mix of low volume. Because the tendency for moisture absorption is high, maintaining the MSD for a long period will necessitate greater effort to maintain the humidity. In terms of geographic locations, Southeast Asia is the most humid region, making it critical for companies to protect MSD in these locations.

Moreover, MSD preservation is growing more difficult by the day as electrical components get thinner in the future. While there are additional obstacles in electronic products that today's companies must address, such as the Restriction of Hazardous Substances (RoHS). Because of the need to limit the use of hazardous chemicals and enhance the use of recycled electronic components, this limitation is applied to the majority of electronics products manufactured in industries. Hazardous compounds such as lead will not be used in electronic processes, but lead-free components will be subjected to a higher solder reflow temperature, which encourages moisture to influence the component easily.

Furthermore, there is an alternative method to eliminate the moisture inside the cabinet such as using nitrogen cabinets. But it will be quite expensive and complex to implement in industries. The current technique of maintaining these MSDs is primarily manual operations, such as detecting the MSL, calculating the time required to input, and filling up log sheets. This project will minimize time-consuming methods and the possibility of human mistake.

#### 1.3 Objective

The objective of this research are:

i. To design a system to control and monitor moisture sensitive devices (MSD). Humidity plays a significant role in these electronic sectors particularly in the case of MSDs. There will be a substantial risk of final product PCB failure if the humidity level of the MSDs is not controlled.

# ii. To create a system that uses internet of things to monitor temperature and humidity of MSD's storage

This monitoring mechanism will continuously inform the MSD storage end user through the internet, allowing us to take precautionary measures to maintain the temperature and humidity levels of MSD storage from anywhere.

#### iii. To create a system that would track the MSDs' floor life

The final goal is to create a system that would track the MSDs' floor life. Because to the packing method and physical features of the substance used to connect the die, each MSL will have its own floor life. The amount of moisture absorbed by MSDs is also determined by the length of time the components are exposed to the environment as well as the ambient temperature.

#### 1.4 Scope of Research

The scope of this research are as follows:

- To design and build a humidity control system's hardware structure.
- This prototype structure will serve as a storage facility for the MSD, with humidity regulated and real-time monitoring.
- The main three primary variables that must be examined and pursued in this endeavor.
  - The mechanical design of the project, which is the construction of MSD storage, is the initial factor.
  - The electrical circuit connection design, must be properly linked in order for the system to function effectively.
  - Software development with a database of humidity and temperature saved in cloud storage so that humidity may be controlled and monitored in real time over the internet.
- Develop a prototype of humidity management and monitoring system for MSD at low cost.
- This project is mainly focusing on the reduction of failure rate of PCB fabrication in industry which might also causes damage to finished electronic products such as hand phones, camera, and etc.

#### **CHAPTER 2**

#### LITERATURE REVIEW

#### 2.1 Introduction

The purpose of this literature review is to gain some helpful knowledge for my thesis. To complete this project some researches that related to this title was done in order to gain some idea. This chapter examines previous initiatives or study into topics related to this project that can provide guidance for directing this project effectively. Different views and strategies associated with the project are also presented in this part. This chapter can also be described as the contextual analysis section, in which fresh ideas and plans from previous initiatives are presented. This literature study was completed by looking through, websites, papers, conferences, reference books and any other publications related to this project. It will also discuss additional data collected in order to determine the optimal strategy for this job.

# 2.2 Moisture Sensitive Devices (MSD)

Many problems may be traced back to moisture in microelectronic packages. Moisture absorption in electronics packages can result in a variety of issues. The breakdown occurs mostly in industries when electronic components are removed from the vacuumed bag for PCB manufacture. The moisture from the industrial environment is then absorbed into the electronic packages, which will cause problems during the PCB manufacturing solder reflow process. The solder reflow process oven has a temperature range of 220°C to 260°C. (Fan et al., 2010) During the process depicted in Figure 2.1, the quick increase in temperature will aid the moisture in vaporizing and producing high pressure inside the electronic packages. This process causes internal electrical component cracking, commonly known as the "pop-corn effect." Delamination may also develop as a result of evaporated moisture reducing the strength of the packages' internal adhesion. The temperature at which delamination propagation occurred was determined using a scanning acoustic microscope and compared to that anticipated using mixed-mode interfacial delamination mechanics. Overall, there was a lot of consensuses. The fluctuation of hygrothermal stress intensity factor and interface toughness with fracture length might be used to explain the development of the delamination. (Wang et al., 2017)



Figure 2.1 Moisture inside the MSD vaporized by 'heat'

Moisture-induced failure, in which the packages enlarge due to moisture absorption, also causes harm to electronic packages. Hygroscopic swelling is another name for this condition. (Fan et al., 2010). Over example, electronic components that have been exposed to various types of environmental conditions for an extended period of time have a significant risk of moisture- induced failure. The inner part of MSDs that corrode due to the moisture within the packages is also considered as failure. Moisture which contains high oxygen concentration assists the process of corrosion, which is a reduction oxidation on metal or copper within electronics packages. Internal corrosion will cause damage or connections break in the wire bonding between the lead frame of the component and dice shown in Figure 2.2.



Figure 2.2 Electronic Package and its Cross Section view

Moisture-sensitive components have their own international standard for handling, which is the IPC-M-109 guideline document, which includes J-STD-20 and J-STD-33 standards. The IPC J-STD-20 standard covers the comprehension of different MSD sensitivity levels. According to J-STD-20, Figure 2.3 displays the device's sensitivity level. The handling and packaging procedures of MSDs was standardized by IPC J-STD-33.(Fauty and J. 2010). For moisture sensitive components, all moisture-related precautions, preservation, and prevention are carried out in accordance with international standards.

Moisture Sensitive Level	Floor Life	Condition (°C/%RH)
1	Unlimited	$\leq$ 30/85
2	1 Year	$\leq$ 30/60
2A	4 Weeks	$\leq$ 30/60
3	168 Hours	$\leq 30/60$
4	72 Hours	$\leq$ 30/60
5	48 Hours	$\leq$ 30/60
5A	24 Hours	$\leq$ 30/60
6	TOL (Time on Label)	≤ <b>30/60</b>

Figure 2.3 Moisture Sensitive Level (MSL) per IPC/JEDEC's J-STD-20.

The HIC's spot holding a certain amount of cobalt (II) chloride will change color from blue to pink if the relative humidity is higher than the set humidity threshold. Nowadays, certain sectors are switching to cobalt-free HICs to prevent the dangers of breathing cobalt, which can lead to cancer. The cobalt-free HIC, which differs from conventional HIC, is depicted in Figure 2.4. R49 and T should be labeled on a normalHIC, indicating that it may cause cancer if breathed and toxic indication, respectively. The humidity indicator card (HIC) that was placed inside the vacuumed bag is shown in Figure 2.5. HICs are used to keep the humidity within the vacuumed bag at a safe level during transport. The relative humidity levels of 5, 10, and 60% are shown in these HICs. We can use this technique to assess the humidity level of dry packed electrical components before

they're used.



Figure 2.4 Cobalt-Free Humidity Indicator Card (HIC)



Figure 2.5 Humidity Indicator Card (HIC)

The MSDs are packed with a desiccant packet and included inside the vacuumed package along with the HIC. Figure 2.6 and 2.7 shows the desiccant and packaging label respectively. The packaging label provides the MSL of the electronic component included in the bag, as well as a warning that the container contains moisture-sensitive electronics. The label also includes the MSL-compliant technique for dealing with MSDs on the inside. If the HIC levelexceeds the appropriate moisture according to IPC/JEDEC J-STD-033, as stated in Table 2.1, the MSDs must bake according to the specifications. Figure 2.8 depicts the workflow for managing MSDs received from the manufacturer. The effect of maximum reflow temperature on observed damage response and effect was investigated, and which indicating that JEDEC/IPC moisture resistance decreases by one level for every 20/spl deg/C increasein maximum reflow temperature. Longer preheat has a net benefit only for thin, unsaturatedpackages. (Sun et al., 2021)

		Bake at 125°C		Bake at $90^{\circ}C \le 5\%$ RH	
Dackage	Moisture	Exceeding	Exceeding	Exceeding	Exceeding
Package	Sensitive	Floor Life	Floor Life	Floor Life	Floor Life
БОЦУ	Level	by>72	by ≤72	by>72	by ≤72
		hours	hours	hours	hours
	2	5 hours	3 hours	17 hours	11 hours
Thickness	2A	7 hours	5 hours	23 hours	13 hours
≤1.4mm	3	9 hours	7 hours	33 hours	23 hours
	4	11 hours	7 hours	37 hours	23 hours
Thickness	2	18 hours	15 hours	63 hours	2 days
>1 4mm	2A	21 hours	16 hours	3 days	2 days
<2.0mm	WALSAYS/4	27 hours	17 hours	4 days	2 days
	4	34 hours	20 hours	5 days	3 days
Thickness	2	48 hours	48 hours	10 days	7 days
>2.0mm	2A	48 hours	48 hours	10 days	7 days
≤4.5mm	3	48 hours	48 hours	10 days	8 days
	4	48 hours	48 hours	10 days	10 days
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Table 2.1 Baking standard for exceeding floor life per JEDEC/IPC J-STD-033



 ${\rm e}^{\pm}$ 

 $_{\rm eff}$ 

Figure 2.6 Desiccant/ Sillica Packets Inside the Vacuumed Bag



Figure 2.7 MSL indication that labeled on vacuumed Bag.



Figure 2.8 Handling Procedure of MSDs after received from Manufacturer

The overall process of conserving, protecting, and taking precautions to protect MSDs against moisture absorption follows international regulations. The stage of maintaining the MSDs in storage in the proper state is critical since the following step of the process is PCB manufacture, therefore the storage keeping must be accurate and regulated.

Manual operations may lead to concerns like human error and time consumption, thus it's important to preserve the industry before upgrading the MSD used for manufacturing to an automated system.

#### 2.3 Humidity and temperature

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Humidity refers to the quantity of water vapour in the atmosphere, which may be categorized or estimated using relative humidity. Equation 2.1 is used to compute relative humidity, as illustrated.

$$rh = rac{p}{p \ sat} = rac{actual \ partial \ water \ vapor \ pressure \ in \ the \ air}{saturated \ partial \ water \ vapor \ pressure \ in \ the \ air} imes 100\%$$

When it comes to humidity, hygrometers or humidity sensors are electrical devices that can measure the degree of humidity in the air. Humidity sensors come in a variety of kinds, including resistive, capacitive, thermal conductivity, and others. The capacitive humidity sensors use a humidity dependent condenser to monitor the humidity level, whereas the capacitive sensors detect the electrical change in the device. Thermal conductivity sensors, for example, are utilized in high-temperature environments. Figure 2.9 illustrate a comparison of different humidity sensors on the market.



Figure 2.9 Types of humidity sensor

Humidity, or the moisture level in a particular environment, is something that may be managed. Humidity may be regulated chemically and physically in a variety of ways. According to the Bulletin of Entomological Research humidity can be regulated chemically with potassium hydroxide, sulphuric acid, and other solutions.(Hodges and Ricks 2016) There are two chemical methods for controlling humidity. The first method is to create a suitable substance that releases an acceptable humidity level. The second approach involved the use of different salts in saturated solutions to manage the appropriate humidity.

In contrast, temperature is a physical quantity that shows how hot or cold an area or substance is. Most often used temperature scales are Fahrenheit (°F), Celsius (°C), and Kelvin (°K) (K). Equation 2.2, which is presented below, may be used to compute temperature changes.

$$\Delta T = \frac{Q}{mc} = \frac{amount of heat absorbed or release}{(mass of the body)(specific heat of the body)}$$

The thermometer is primarily used to measure temperature in the majority of applications. There are two sorts of thermometers available today, analog and digital. Digital thermometers are mostly utilized in the medical field. Electronic sensors such as thermocouples, resistance temperature detectors, semiconductor-based sensors are also can be used to measure temperature.

Based on energy conservation principle there is also a technology called dual air handling unit system that can manage humidity without using chemicals. In tropical climatic locations, this system is primarily utilized for interior humidity and temperature management while using less energy than a traditional air conditioning system. To create a comfortable interior atmosphere, we must minimize or eliminate humidity and temperature. (Azizi et al., 2017). A dual air handling device is proposed to regulate both humidity and temperature while conserving energy. Figure 2.9 depicts the system's schematic diagram, which includes two air handling units. The first is in charge of controlling the room's temperature, while the second is in charge of controlling the humidity level. In order to monitor and manage the system, both humidity and temperature sensors are employed.

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Other hot-humid seasons, such as spring, bring discomfort to building occupants in addition to tropical locations. Smart indoor humidity control and condensation control logic are two more approaches to resolving the issue. (Zhang et al., 2018) By establishing control logic based on people's adaptation, this smart system also helps to cut energy usage. The purpose of a smart control system is to prioritize thermal and humidification conditions, energy savings, condensation avoidance, and air quality from high to low. Some criteria and actions were used to conclude the logic of the smart control system, as shown in Figure 2.10. TSTRC represents the indoor temperature with the risk of condensation. TSTRC stands for, T1 the dew point of outside air, C the indoor carbon dioxide concentration, and K the window

open factor, 1 for completely opening, 0 for entirely closing, and 0.25 for opening a, F stands for dehumidifier open factor, with 1 indicating that it is turned on and 0 indicating that it is turned off. (Yan et al., 2017)



Figure 2.11 Flow chart Smart control logic

#### **2.4** Internet of Things (IoT)

The internet of things (IoT) is a network of connected gadgets that can communicate and exchange data over the internet. As a result, the internet became the method for connecting to and exchanging data with a platform. It is one of the century's most famous phenomenon, and it continues to grow in popularity. Connecting a patient's health monitoring device to the internet, for example, allows us to keep aware if something unusual occurs. This platform allows people to be interdependent on the things they need to improve in their everyday lives. We can better utilize the resources we have by using the internet of things service and reducing human effort from needless duties. Apart from that, it saves us time by eliminating the need to perform various tasks manually.(Lunardi et al., 2018) Connecting items to the platform is the first of three processes in establishing an internet of things platform. The data collected from the linked items should then be analyzed. Finally, integration to improve the end-user experience. Figure 2.12, 2.13, 2.14 depicts an illustration of how the internet of things works.



Figure 2.12 Example of IoT application



Figure 2.13 Example of IoT application



Figure 2.14 Example of IoT application

Humans work is made easier by using a control and monitoring system which is connected to the internet. For example, a system has been created to provide a web monitor for press shop assembly to monitor and manage field parameters effectively. (Priyanka et al., 2018). This internet of things-based industrial monitoring and control system contributes to decrease commercial hardware and software costs. The developed project employs distinct cloud-based software to gather pressure and temperature data in order to monitor and run the system while fine-tuning press shop assembly. Figures 2.15 and 2.16 show the system's architecture for managing and monitoring the temperature and pressure of the 'press' shop assembly, as well as a flowchart of the system's working sequence. The Raspberry Pi serves as the system's brain, and it is programmed in the Python programming language. Things Speak is a platform for the internet of things that collects, monitors, and analyses data of the project.



Figure 2.15 Architecture For Monitor and Control



Figure 2.16 The Operation Sequence of the System

By incorporating artificial intelligence into the internet of things (IoT) platform, we can enhance our daily lives even more since the system can make decisions for us. Individuals with memory impairment, particularly elderly people, can benefit from human action and prediction based on the internet of things in their everyday routines. Artificial intelligence will store knowledge on an online platform to assist people in making decisions, such as proposing or adopting the best course of action.

## 2.5 Summary of literature review

Doing some research on the topics related to this project helps alot to proceed with implementation. From the literature review it can be conclude that identifying the MSL and the method of handling the moisture sensitive devices (MSD) is the crucial part for the control and monitoring system of humidity and temperature. The gathered information of method of handling MSD's are helped to identifying the set point of the humidity and temperature need to be controlled. On the other hand, it also attribute on developing idea to build a control system for this project. Research about Internet of Things (IoT) guided this project on how to minimize time taken and human effort used for manually done works with the use of internet connecting things to collect and analyze data from sensor

#### CHAPTER 3

#### METHODOLOGY

#### 3.1 Introduction

This chapter is used to describe the steps and methods that was used to carry out the project during Bachelor's Degree Project 1. Primarily, effective planning and execution are important to ensure that a project is finished successfully. This chapter will provide a detailed overview of the technique used to finish the project. Many methodologies and findings from journals were referred to and researched in order to enhance the project. As illustrated in Figure 3.1, a methodology based on the System Development Life Cycle (SDLC) is employed to meet the project's goal.



Figure 3.1 SDLC Phase

Overall, Figure 3.2 illustrates the procedures performed for this project's planning, analysis, design, implementation, maintenance, and support to provide a clear picture of the technique employed.


Figure 3.2 SDLC for this project

## 3.2.1 Equipment

This sub-chapter covers the equipments, devices, components needed to complete this project. This project can be devided into 2 parts which are hardware and software. Hardware is the prototype/model or body which carry the software system. While software is the system which combination of some components that makes the prototye model to work. It is literally a circuit connection.

Equipments/components	Usage
Mounting board	• To make the body of the prototype.

Table 3.1	Equipments	used for	this	projet
				F - J





Table 3.2 Components used for this project

Components	Function
ESP01 Wifi Serial Transceiver Module (ESP8266)	• To connenct the circuit system to mobile app (Blynk)

Adapter 12V 2A (UK Plug)	
	• To supply power to pc fans
2 Channel 5V Active Low Relay Module	
R Construction of the second s	• To open and close the circuit system. To on and off the heater
Arduino Mega 2560 R3-Main Board	
	• For serial communication
LED 5mm (red and green)	
	<ul> <li>To show the ON and OFF status of the system</li> <li>اويور سيتي نيك</li> <li>MALAYSIA MELAKA</li> </ul>
Resistor 0.25W 5% (1K) & (330R)	
	• To adjust the current flow to the LED and fans.
Transistor 2N2222	
	• To control and generate electrical signal in the circuit where the fans are connected.

Jumper wire	• To complete connection in the circuit.
25 WATT incandescent lamp	• To suppy heat. Act as a heater

# 3.2.2 Parameters

3.2.2 Parameters	Table 3.3 Parameters of components used
E	
COMPONENTS	PARAMENTERS/SPECIFICATIONS
.1.1	• Internal 96 KiB of data RAM, 64 KiB of instruction RAM,
2 Ma	and external QSPI flash memory of 512 KiB up to 16 MiB is
UNIV	• Excellent performance with up to 80% of the processing
	power available for user application programming and
	development.
ESP01 8266 Wifi	• Out-of-the-box cloud connectivity with Wi-Fi Direct (P2P)
Module	and soft-AP.
	• Wake up and transmit packets in less than 2ms with a standby
	power consumption of under 1mW (DTIM3) and power down
	leakage current of not more than 10 $\mu$ A.
	• Its maximum working voltage is 3.6V. Do not power it
	directly from 5V dev board or PC serial port. It is not capable
	of logic shifting 5V to 3V and requires an external logic level
	converter.

	Operating voltage is 5V
	• Input voltage is 7-12V
	• 54 digital I/O pins (15 for PWM output)
Arduino Mega	• 16 Analog input pins
2560	• DC Current per I/O pin is 20Ma
	• DC Current for 3.3V pin is 50Ma
	• 256KB Flash Memory
	• 16MHz Clock Speed, 101.52 mm length, 53.3 mm width
	• Operating Voltage is 3.5V to 5.5V
	• Operating current is 0.3mA (measuring) 60uA (standby)
Humidity and	Output: Serial data
Temperature	• Temperature Range is from -40°C to 80°C
Sensor	Humidity Range is from 0% to 100%
a start le	• Resolution: Temperature and Humidity both are 16-bit
THE A	• Accuracy: $\pm 0.5^{\circ}$ C and $\pm 1\%$
TE	
Tool State	

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## 3.3 Flow Chart



## 3.4 Block diagram



Figure 3.4 Project block diagram



Figure 3.5 Printing settings on Ultimaker Cura software

Pin classification	Pin indicator	Detail		
Power	V <sub>in</sub> , 3.3V, 5V, GND	Vin: Supply voltage when an external		
		source of power is used.		
		5V: Regulated power source for the		
		microcontroller and other board		
		components.		
		3.3V: 3.3V On-board voltage controller		
		generated supply. The current drawing		
		maximum is 50mA.		
		GND: ground pin.		
Reset	Reset	To reset the microcontroller.		
Analog Pins	A0 – A16	For the supply of analogue input in the 0-		
St. M.	May	5V range.		
Input/Output	Digital Pins 0-13	Optional for input or output pins.		
Serial	<b>0:</b> 0 (RX),1 (TX)	Used for TTL serial data receipt and		
Field	1: 19 (RX),18 (TX)	transmission.		
"SAING	2: 17 (RX), 16 (TX)			
) ملاك	<b>3:</b> 15 (RX), 14 (TX)	اونيةم سية تبك		
External Interrupts	2 (interrupt 0),	Interruption will be triggered.		
UNIVEF	3 (interrupt 1), KAL	MALAYSIA MELAKA		
	18 (interrupt 5),			
	19 (interrupt 4),			
	20 (interrupt 3),			
	21 (interrupt 2)			
PWM	3, 5, 6, 9, 11	8-bit PWM output.		
SPI	10 (SS), 11 (MOSI),	Used for SPI communication.		
	12 (MISO) and 13			
	(SCK)			
Inbuilt LED	13	To activate the build in LED.		
TWI	A4 (SDA), A5 (SCA)	TWI communication.		
AREF	AREF	To provide reference voltage for input		
		voltage.		

rubic 5.+ midulio mega pli classification
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The Arduino Mega and ESP8266 Wi-Fi Module were chosen as the controller board because they are inexpensive and simple to utilize with a Wi-Fi connection. Because there are more inputs and outputs to operate the system, the Arduino Mega is utilized instead of the Arduino UNO. While the ESP8266 Wi-Fi Module is a self-contained SOC with an inbuilt TCP/IP protocol stack that can provide access to our Wi-Fi network to any microcontroller. Blynk is an IoT platform that is used to gather and analyze data in order to regulate the storage humidity level. Figure 3.6 and 3.7 depicts the ESP8266 Wi-Fi Module with pin description and Blynk application and its working concept.



Figure 3.6 Pin description of Wi-Fi Module ESP8266



# Figure 3.7 Operating Principle of 'Blynk' application

The programming component is divided into three levels: library, variable declaration, output and input, and programme body. The library used for programming must be downloaded and included in the script at the first level since it is a collection of non-volatileresources needed in programming. Individuals that need to develop a higher-level programme script, for example, can use a library to make system calls rather than repeatedlyrunning those system calls. The declaration of variables, inputs, and outputs, which is a crucial component of the programming process since it initializes all of the pins required forthe project and describes the input and output characteristics, is the second level of programming. Finally, there is the programme body, which is the most essential part of the script since it commands every action of the system's hardware and software. The whole software was provided at the appendices. The previously planned and designed procedure of developing hardware, circuits, and software was carried out. The built project should function as the desired control and monitoring system as shown in figure 3.10.

```
#include <Blynk.h> //library for blynk|
#include <DHT.h> //library for DHT22 sensor
#include <SPI.h>
#include <Adafruit_Sensor.h>
#include <DHT_U.h>
#include <DHT_U.h>
#include "DHT.h"
#include <SimpleTimer.h> //library for timer
#include <ESP8266_Lib.h> //library for using ESP8266 Wi-Fi module
#include <BlynkSimpleShieldEsp8266.h>//library for using ESP8266 Wi-Fi module
```

Figure 3.8 Program Library Included for the Project

```
#define DHTPIN A0
                           //define data pin of the sensor to analog pin A0
#define DHTTYPE DHT22
                           //define type of sensor used
                           //define relay pin to digital pin 30
const int relaypin = 30;
DHT dht (DHTPIN, DHTTYPE);
                                  //initialize the sensor to the analog pin
int out=9;
             //define PWM pin 9 as out
int out1=10;
             //define PWM pin 10 as out1
void setup()
ł
                           NIKAL
                                    MAL
                                          AYSIA MELAKA
 Serial begin(9600);
 pinMode(relaypin, OUTPUT);
                                  //define the relay pin as output
 pinMode(45,OUTPUT);
                           //define the pin 45 as output
 pinMode(47,OUTPUT);
                           //define the pin 47 as output
 pinMode(out,OUTPUT);
                           //define the out pin as output
 pinMode(out1,OUTPUT); //define the out1 pin as output
```

Figure 3.9 Declaration of Pins and Data Type



Figure 3.10 The Working Flow Chart of the Control and Monitoring System







## 3.7 Summary

After all the mechanical, electrical, and software components have been done, testing process was continues to improve the errors in the system. Testing is carried out in order to troubleshoot any issues that may arise once the system was turned on. This procedure is critical before the project or product is delivered to the final user. When run this project, the end user must have a comprehensive and satisfying experience. As a result, proper product testing, as well as maintenance and mistake correction, are required to ensure that no consumer complaints or unhappiness arise.



## **CHAPTER 4**

### **RESULT & DISCUSSION**

### 4.1 Introduction

This chapter will go over the results and data collection of this prototype. Furthermore, this chapter will focus on the outcomes and analysis of the data received during the test that was conducted. The data obtained from the project was explained with some discussions and also the problems that occured during the process.

## 4.2 Result of hardware

The actual prototype was built as planned earlier. It was in good condition and the final work of it was so neat. No flaws in the size and dimension of the prototype. Figure 4.1 and Figure 4.2 shows the actual view of the developed MSD storage using mounting board, pvc pipe, and plastic cover.



Figure 4.1 Outcome prototype of MSD Storage (Front View)



Figure 4.3 Outcome Prototype of MSD Storage (Overall View)

The sensor was positioned at the center of the MSD storage so that it can measure the humidity and temperature inside prototype. The sensor position within the enclosure was shown in Figure 4.4. The project's circuit is located outside and behind the model as shown in figure 4.2.



4.3 Application of the Blynk system

The planned outcome of the project is to enable controlling and monitoring the floor life of MSD storage in the Blynk application with the help of IoT. Figure 4.5, Figure 4.6, and Figure 4.7 depict the Blynk application's user interface. Based on the current temperature and humidity of the storage, the fan speed and incandescent bulb which act as a heater function automatically. Table 4.1 displays the fan's speed as well as the state of the incandescent light in terms of temperature and humidity.



Figure 4.5 Control, Monitor, Fan speed and Heater Tabs in Blynk Application

Temperature	Fan	Fan	Incandescent	Fan	Humidity
(())	Below	Above	lamp status	Below	(%)
0.0 - 30.0	0%	0%	OFF	0%	0 - 59.9
30.1 - 31.0	10%	10%	ON	100%	60 - 100
31.1 - 32.0	20%	20%		I	I
32.2 - 33.0	30%	30%			
33.1 - 34.0	40%	40%			
34.1 - 35.0	50%	50%			
35.1 - 36.0	60%	60%			
36.1 - 37.0	70%	70%			
37.1 - 38.0	80%	80%			
38.1 - 39.0	90%	90%			
39.1 - 40.0	100%	100%			
TEK		Ş			
EI			UILE	111	

Table 4.1 Fan Speed and the Lamp Status with Humidity and Temperature

In addition, the project's other objective is to keep track the MSD storage's floor life time to time and set it. The MSDs have their own floor life, which must be monitored and maintained in order to avoid device failure during solder reflow. Figure 4.6 depicts the floor life timer. The green and red LED indicates the start and end of the floor life. Once the system if turned off an email will send to the authorised personel. The email received from Blynk after the floor life expired is shown in Figure 4.7



Figure 4.7 Email Notification of Blynk for Floor Life Time End

The system also includes various safety features, such as a warning signal when the humidity or temperature reaches a particular threshold. There is also an indicator that the MSD storage is not connected to the Blynk programme, and authorised personel will be notified if the sensor fails to sense, which will allows to intervene if the system has an error. Figure 4.8 depicts the email and notice received when the temperature or humidity exceeds the defined threshold, whereas Figure 4.9 depicts the notice that the Blynk application is not linked to the system.



Figure 4.8 Notification and Email from Blynk "Please Check Your System"



UNIVERSITI TEKNIKAL MALAYSIA MELAKA be sent as an excel file if needed. Figures 4.10 and 4.11 demonstrate how data can be sent in

an email and how data can be received in an email from the Blynk application, respectively.



Figure 4.11 The Data Received in Email from Blynk

## 4.4 Result and Data Analysis

The collected data sent through email from the Blynk application is only kept for 30 minutes. Table 4.2 shows the temperature and humidity readings combined in a table format. For analysis purpose the data in table was calculated for its average reading. Table 4.3 shows the average reading obtained from the data.

TIME	HUMIDITY	TEMPERATURE	TIME	HUMIDITY	TEMPERATURE
(PM)	(%)	(°C)	(PM)	(%)	(ºC)
20:15:00	75.13	29.22	20:30:00	55.65	30.41
20:16:00	78.87	28.14	20:31:00	55.11	30.81
20:17:00	72.24	29.59	20:32:00	53.44	31.29
20:18:00	70.52	2 <mark>9.</mark> 42	20:33:00	52.46	31.23
20:19:00	67.69	30.44	20:34:00	52.13	30.84
20:20:00	65.31	32.32	20:35:00	54.33	28.21
20:21:00	63.66	33.24	20:36:00	53.42	32.17
20:22:00	61.72	32.56	20:37:00	55.66	29.56
20:23:00	59.37 JNIVERSI	36.79 TI TEKNIKAI	20:38:00	54.45 YSIA MEL	AKA <sup>29.12</sup>
20:24:00	60.08	32.53	20:39:00	58.49	30.64
20:25:00	57.41	33.82	20:40:00	60.47	30.44
20:26:00	56.29	34.15	20:41:00	57.72	30.63
20:27:00	55.60	35.18	20:42:00	55.16	28.62
20:28:00	55.37	36.91	20:43:00	53.38	30.25
20:29:00	54.52	30.23	20:44:00	52.44	31.23

Table 4.2 Temperature and Humidity reading for 30 minutes

The data from the Blynk database is plotted on a graph and analysed using the readings obtained from it. The curve of the humidity and temperature readings for 30 minutes is shown in Figure 4.12.



Figure 4.12 Graph of Time Vs Humidity and Temperature

TIME 🧃	HUMIDITY	TEMPERATURE	TIME	HUMIDITY	TEMPERATURE
(PM)	(%)	(°C)	(PM)	و (%) - ي	(ºC)
10:00:00	74.24	TE 28.21 (AL	10:15:00	SI/56.54 L/	KA 30.23
10:01:00	77.76	26.14	10:16:00	55.31	30.65
10:02:00	73.38	28.63	10:17:00	55.46	31.07
10:03:00	72.43	28.45	10:18:00	53.56	31.28
10:04:00	69.58	29.43	10:19:00	54.13	30.89
10:05:00	67.31	30.32	10:20:00	54.67	29.61
10:06:00	64.65	31.77	10:21:00	55.54	31.37
10:07:00	62.69	32.16	10:22:00	55.18	29.71
10:08:00	59.67	35.39	10:23:00	54.45	30.02
10:09:00	60.18	31.33	10:24:00	55.59	30.64
10:10:00	58.37	33.82	10:25:00	58.27	29.54
10:11:00	57.53	35.15	10:26:00	57.68	30.87

Table 4.3 Temperature and humidity reading of trial 2

10:12:00	56.64	35.18	10:27:00	55.56	29.73
10:13:00	55.55	36.31	10:28:00	54.56	30.15
10:14:00	54.63	35.53	10:29:00	53.49	31.57



Figure 4.13 Trial 2 graph of Time VS Temperature and humidity

TIME	HUMIDITY	TEMPERATURE	TIME	HUMIDITY	TEMPERATURE
(PM)	(%)	(°C)	(PM)	(%)	(ºC)
15:30:00	62.34	32.15	15:45:00	56.13	31.73
15:31:00	63.57	31:87	15:46:00	55.79	31.35
15:32:00	64.68	34.26	15:47:00	54.68	30.67
15:33:00	64.26	33.75	15:48:00	56.15	32.28

Table 4.4 Temperature and humidity reading of trial 3

15:34:00	65.06	31.63	15:49:00	55.63	32.49
15:35:00	64.43	30.66	15:50:00	54.55	31.71
15:36:00	63.79	31.08	15:51:00	55.24	33.67
15:37:00	62.69	30.86	15:52:00	55.18	32.71
15:38:00	61.54	32.36	15:53:00	56.45	31.63
15:39:00	61.78	31.83	15:54:00	57.39	30.47
15:40:00	60.67	30.82	15:55:00	58.67	29.34
15:41:00	59.83	32.35	15:56:00	57.18	30.17
15:42:00	58.24	34.28	15:57:00	56.36	29.73
15:43:00	56.85	33.51	15:58:00	55.36	30.35
15:44:00	55.71	34.33	15:59:00	54.69	31.17



Figure 4.14 Trial 3 graph of Time VS Temperature and humidity

	AVERAGE HUMIDITY (%)	AVERAGE TEMPERATURE (C°)
TRIAL 1	57.6	29.4
TRIAL 2	59.82	31.17
TRIAL 3	58.83	31.84
TOTAL AVERAGE	58.75	30.80

Table 4.5 Average Humidity and Temperature reading of 3 trials



Figure 4.15 Graph of average Humidity and Temperature reading of 3 trials

### 4.5 Costing

Since this project was a making of a control and monitoring system prototype, it involves software and hardware as well. In this sub-chapter, the total cost for the hardware and software were listed and explained. For the hardware making process some parts, equipment and components were purchased as listed below. While, the software use to control and monitor the system is totally free which can be downloaded in the 'Playstore'. Initially the Blynk App users will be provided with some basic features but in order to use additional features, it costs some money.

A DEALSTON AND A DEALSTON							
COSTING FOR HARDWARE							
NO	NAME	PRICE/UNIT(RM)	AMOUNT	TOTAL(RM)			
1	Mounting Board	3.60	3	10.80			
2	Hot glue gun	10.90	1	10.90			
3	Polystyrene	3.00	1	3.00			
4	Pvc pipe	9.60	1	9.60			
5	Bathroom mat	5.00	1	5.00			
6 🇯	Plastic cover	0.50	- 3	1.50			
	TOTAL COSTING HARDWARE RM40.80						
UNIVERSITI COSTING FOR CIRCUIT SYSTEM A MELAKA							
NO	NAME	PRICE/UNIT(RM)	AMOUNT	TOTAL(RM)			
1	ESP Wi-Fi Module	9.20	1	9.20			
2	Adapter 12V 2A	9.00	1	9.00			
3	Relay Module	5.90	1	5.90			
4	Jumper Wires	2.50	3	7.50			
5	LED	0.50	2	1.00			
6	Arduino Mega	179.00	1	179.00			
7	Transistor	0.40	2	0.80			
8	Resistor(1K&330R)	0.05	2	0.10			
	TOTAL	RM212.50					
COSTING FOR BLYNK APP							
NO	NAME	PRICE/PACK	PACK	TOTAL(RM)			
1	Energy Pack ×1000	12.90	1	12.90			
	TOTAL CO	RM12.90					
			GRAND				
			TOTAL	RM266.20			

Table 4.6 Costing for the project

### 4.6 Discussion

According to the graph, the total average relative humidity and temperature of 3 trials were 58.75% and 30.80°C, respectively. The international standard of IPC/J-STD-20 and JEDEC state that the minimal requirements for maintaining relative humidity and temperature are less than 60 percent and 30 degrees Celsius, respectively(Fauty and J. 2010). There are several reasons for this, including the fact that the temperature obtained from the project is higher than the temperature necessary for storage. The high value in temperature might because of the fact that certain errors arise as a result of a technical issue, such as an unreliable internet connection. This has an impact on data gathering in the Blynk app, as there is poor and no connectivity between the system and the app. On the other hand, the material used for storage also has a significant impact on creating temperatures that are greater than the acceptable temperature.

Besides, this prototype is effective to use in high mix low volume semi-conductor industry because the MSD's stored in the warehouse will take more time to used. So, during the long period of time if the MSD's are not kept with suitable environment, there are alot of chances for the MSD's get moistured inside which will causes cracking or delamination during solder reflow process. This prototype will ensure the MSD's are in good and desirable condition until they are used. It also helps to reduce and/or prevent the failure of finished electronic products. Thus, the failure analysis test process can be eliminated and also save time. It is important to understand that this prototype was built in a smaller scale whereas in real life industries it is needed in a bigger scale because normally users will buy large number of MSD's at a time.

#### **CHAPTER 5**

### **CONCLUSION & RECOMMENDATION**

### 5.1 Conclusion

As a result, the project has met its goal of controlling the humidity and temperature levels of the MSD storage and monitoring them over the internet. Inside the storage, the optimal temperature and humidity must be less than 30°C and 60%, respectively. This project was successful in preserving relative humidity levels, but when it comes to temperature the result was slightly higher than the needed optimum temperature. This was because there were some interuption while data collecting process. The floor life monitoring was also accomplished by including a feature in the Blynk programme that allows users to define custom timing and monitor it within the app.

The LED status may also used to monitor the floor life. At the start, the green LED will be in on status, and at the end, the red LED will be in on status. This initiative should benefit all electronic manufacturing companies by making it easier to preserve and prevent moisture sensitive components, as well as reducing the time spent focused on MSDs. By eliminating human mistakes, this system will be less expensive and more effective for use in industries. It will also minimise PCB manufacturing failure of finished products.

### 5.2 Recommendation

Here are some suggestions for future researchers on how to improve this project. For this project, there are several limitations and suggestions to make the product more userfriendly and stable. This prototype is made of mounting board, which has the ability to trap heat (Avrilmis et al., 20080. The inner part of the storage box, it is recommended to use mineral wool, fibre glass, or polystyrene as a heat insulator (Al-Homoud and M. S. 2004). The system also has to be improved in order to make it more stable and commercially viable. For now, the semiconductors with moisture sensitivity levels of 5a and 6 may be monitored throughout the project's floor life, which is shorter than 24 hours. So, as a recommendation the time period for all moisture sensitive level devices can be enhanced for future development. This project system also requires some manual monitoring that is connected to the controller and may be used as backup monitoring when there is no internet connection available. Due to a failing and poor internet connection, data will not be sent or saved to the system, and the monitoring procedure will fail. When the user does not have access to the internet, manual monitoring will be useful. Aside from that, during the testing process the heating process has to be improved by adding a level of heating so that the temperature and humidity within the model can be maintained. With the addition of a regulated degree of heating, the system will be more stable.

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### **APPENDICES**

### APPENDIX A Gantt Chart for PSM 1



#### APPENDIX B

### Gantt Chart for PSM 2



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# UNIVERSITI TEKNIKAL MALAYSIA MELAKA

## BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA

## TAJUK: HUMIDITY CONTROL AND MONITORING SYSTEM FOR MOISTURE SENSITIVE DEVICE (MSD)

SESI PENGAJIAN: 2021/22 Semester 1

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Ts Dr Nor Azazi Bin Ngatiman

Cop Rasmi:

Ts Dr Nor Azazi Bin Ngatiman Pensyarah Fakulti Teknologi Kejuruteraan Mekanikal & Pembuatan, UTeM

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