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

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A thesis submitted
in fulfillment of the requirements for the degree of
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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.

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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.

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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 been admirable.

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	-	Light Emitting Transmitter
Wifi	-	Wireless-Fedelity
PC	-	Personel Computer
3D	-	Three Dimension
LCD	-	Liquid Crystal Display

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

The majority of industry nowadays, particularly semiconductor and electronics-based 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)

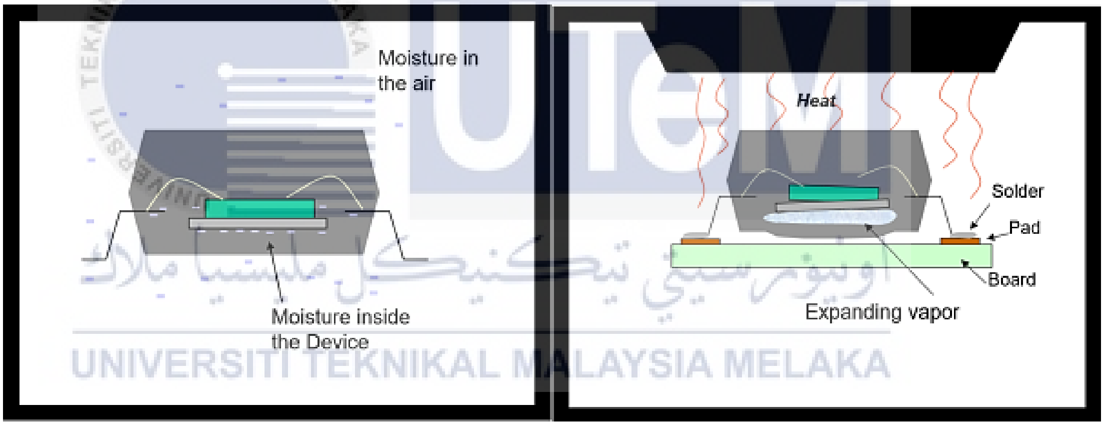

Figure 2.1 Moisture inside the MSD vaporized by ‘heat’

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.

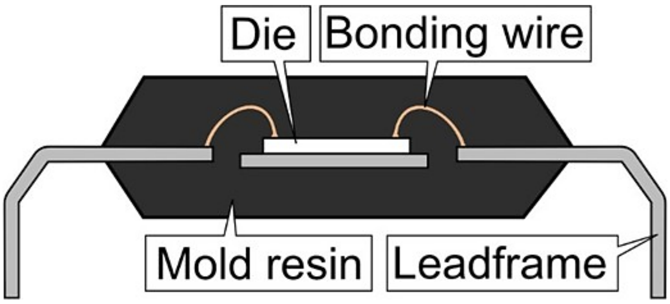

Figure 2.2 Electronic Package and its Cross Section view

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	≤ 30/85
2	1 Year	≤ 30/60
2A	4 Weeks	≤ 30/60
3	168 Hours	≤ 30/60
4	72 Hours	≤ 30/60
5	48 Hours	≤ 30/60
5A	24 Hours	≤ 30/60
6	TOL (Time on Label)	≤ 30/60

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.

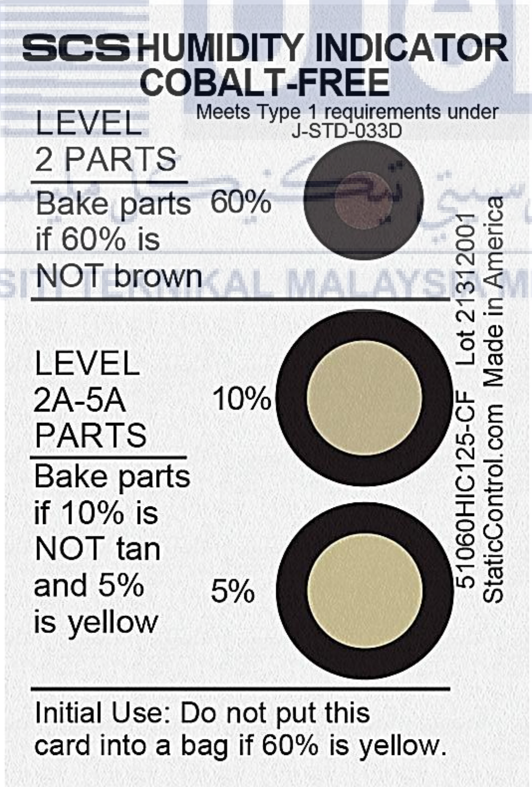

Figure 2.4 Cobalt-Free Humidity Indicator Card (HIC)