DEVELOPMENT OF AN ELECTROSTATIC DISCHARGE (ESD) EVENT DETECTOR SYSTEM FOR AN ELECTRONIC MANUFACTURING PRODUCTION LINE

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MECHANICAL ENGINEERING
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JANUARY 2020

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Dissertation submitted in partial fulfillment of

the requirements for the

Bachelor of Engineering (Hons)

(Mechanical)

JANUARY 2020

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CERTIFICATION OF APPROVAL

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Approved by,

____

Dr Mark Ovinis

Date : 10-APRIL-2020

UNIVERSITI TEKNOLOGI PETRONAS

SERI ISKANDAR, PERAK

JANUARY 2020

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except saspecified in the references and acknowledgments, and that the original work contained herein has not been undertaken or done by unspecified sources or persons.

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AHMAD FARIS ASLAM BIN AHMAD SHAKARIA

Date : 10-APRIL-2020

ABSTRACT

An electrostatic discharge (ESD) event detector system, known as Electromagnetic Interference (EMI), was developed for an electronic manufacturing production line based on strength system to detect an ESD event and determine the efficiency of ESD prevention measures. The detector is composed of two EMI detectors estimates an ESD event and localizes the event using an enhanced trilateration method. The EMI detector was built using Arduino with data transfer by wireless module. Stationary nodes provide reference positions, with mobile nodes equipped with an EMI detector used throughout the production line to detect ESD event. The evaluation results indicate the detector worked well and that ESD event can be detected. The data was subsequently used for an ESD control program.

KEYWORD — ELECTROSTATIC DISCHARGE (ESD), ELECTROMAGNETIC INTERFERENCE (EMI),

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Chapter 1

INTRODUCTION

1.1 Background

Electrostatic Discharge (ESD) is a rapid transfer of charges between two bodies with different electrostatics caused primarily by contact, dielectric breakdown and electrical shortness. Triboelectric charging (contact method) or air / liquid (contactless method) can form a static electricity. If two objects were in contact, ESD occurs, creating a dielectric breakdown that often creates visible sparks.

Electrical sparks created from ESD can be seen, but they may not be seen or heard yet are high enough to cause damage to sensitive electronic devices, especially in high voltage production floors. For the occurrence of electrical sparks, field strength of 40 kV / cm is required in the air. Corona discharge and brush discharge may also be included in other forms of ESD.

An ESD from an individual touching an electronic device or system can produce thousands of volts and multiple amperes that can easily damage or destroy an integrated circuit (IC). ESD / EOS damage accounts for nearly one-third of IC failures, and about 10 percent of customer returns are due to ESD problems alone.

Within today's factories, there are countless objects that can store thousands of volts within electrostatic charges, but it takes only 25 volts of electrostatic volts to permanently damage the integrated circuit. Electrostatic discharge (ESD) has been a common phenomenon in the semiconductor and nanoelectronics industries that has long caused electronic device failures. But until the advent of two advanced technologies: high-scale integrated circuits and radio-frequency communications, it was not a serious threat. These technologies are of ultra-small sizes and operate at low voltage that make a higher risk of ESD. The two forms of ESD threats are the ESD electric current that causes device damage and the electromagnetic interference (EMI) that causes operation malfunction. Voltage can be a form of threat, but the damage is accomplished by current [1].

ESD is a phenomenon of load balancing system at different potential between two items. Usually, due to the friction between different types of materials, static electricity can be generated, and the accumulated electrostatic charge can be transferred to the object at lower potential spontaneously. ESD events usually give a mild shock to humans in our daily lives, which is a bit annoying, but if the same amount of ESD pressure is introduced into a nano-scale microelectronic element, it could be dangerous. ESD incidents on electrical devices often include high voltage (kV) and high current (1-10 A).

1.2 Problem Statement

The main problem:

i. Poor ESD protection in production line resulting in failure of semiconductor ICs, photomask defects, magneto-resistive (MR) read head defects in disk drives, and failures of drive circuits for the flat panel displays (FPD)

ii. Uncontrol ESD event make the company face unscheduled downtime, increased maintenance requirements, and frequently, product scrap

1.3 Objective

The objectives and scopes of study is proposed in the following part to ensure the project is conducted with a set target, and at the same time does not exceed the defined boundary of the research to produce the desired output.

Based on the initial study, objectives of the project are listed:

i. To minimized ESD events to less than 25 volts by developing ESD free production line and improve ESD protection in production floor by implement ESD event detector and use ESD control program to measure the ESD event that occur.

1.4 Scope of Study

The scope of study for this project is as listed below:

i. To develop an EMI detector to detect the ESD event **to locate** the ESD event the occur at the production line
ii. **To minimize and control the ESD event** that occur during production line running time

The involved initial project research theory on the material selection, selected deformation process and related testing is documented in the next part of the report for a deeper understanding on the decision-making process and project execution.

Chapter 2

LITERATURE REVIEW

An ESD event rapid load distribution at different electrostatic potentials between two bodies. Typically, ESD incidents are overlooked because of:

i. Lack of awareness and attention
ii. Inability to ascertain damage
iii. Believe of local high humidity making ESD non-existent
iv. Damage occurring below human sensitivity

2.1 Wireless ESD Event Locator Systems in Hard Disk Drive Manufacturing Environments by Prince of Songkla University at Seagate Technology (Thailand)

Four ESD locator systems that successfully locate and view ESD event in the manufacturing environment of Hard Disk Drive, Thailand, are mentioned in this prime work. Both systems are based on EMI power and are based on RSSI. Manufacturing of highly sensitive devices is one of the processes of hard disk drive (HDD) manufacturing. This uses a so-called "giant magneto resistive" (GMR) detector to detect the tiny magnetic field on the spinning media disk from the stored parts. Nowadays, it involves small size and higher sensitivity of GMR sensor with increased data capacity of HDDs. This growing increases the damage to the GMR sensor from ESD.

Therefore, to specify the risk area for inspection and remove accused devices from assembly processes, it necessary to aware of ESD events that occur. These actions can increase the reliability of product and save time for process maintenance and downtime. The former consists of 4 EMI detectors and uses an improved trilateration approach to estimate an ESD event location. The approximate location error 10.3 cm for a 1.5 m /

1.5 m test area, but when this device was implemented in a larger area, the error increased enormously. However, since the EMI-strength-based system does not require any modification of production tray, it is sufficient to locate ESD events in area that usually difficult to place within EMI detectors.

EMI-Strength-Based System

This system uses EMI strength data from EMI detectors to estimate ESD event positions. At least three EMI detectors are used at each detector's antenna to generate analog signals related to amplitude of EMI signal. We can measure distance from ESD origin to an EMI detector using the intensity of EMI from the theories discussed in Section II. With the trilateration method from which distance information is already calculated, the position estimation can be started. Finally, in 2-D Cartesian coordinates, the estimated position is the output.

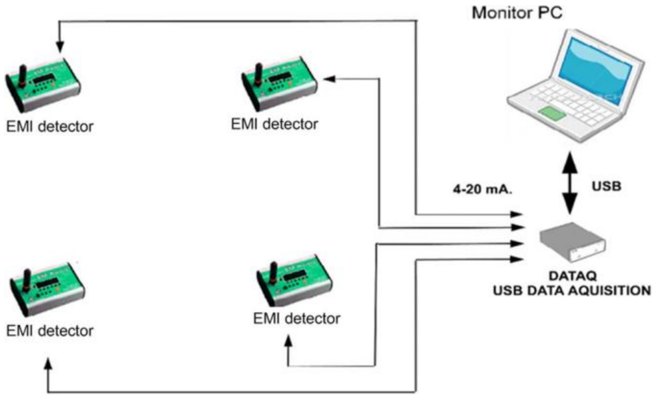

Figure 2.1 : EMI-strength-based system

Received Signal Strength Indicator (RSSI)

Many transceivers, including the PSU-mote sensor node, support reading the RSSI. 1 Reading the RSSI values directly from the CC2500 transceiver chip in digital format. In the communication channel between a transmitter and a receiver, transmitted signals are attenuated. Thus, the receiver-determined RSSI is lower than the sender's signal. The log-normal-shadowing path-loss model will define the RSSI at distance d.

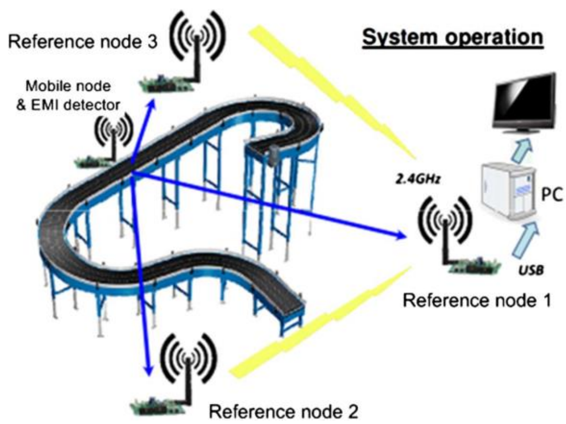

Figure 2.2. : RSSI-based EELS

2.2 Design of Electrostatic Discharge Event Detector

This primary work on designing the electrostatic discharge event detector because there are three processes that are highly sensitive to ESD, which are the process of manufacturing semiconductors, the process of manufacturing IC and the process of manufacturing HDD. Semiconductor-based devices may be damaged by ESD event during the manufacturing process of semiconductors if the immunity of these devices is lower than the strength of ESD voltage. It shows the location on a bipolar transistor of ESD damage. The overvoltage resulting from ESD can result in junction destruction or melting of wiring film in IC manufacturing. Most parts are sensitive to ESD events in the manufacturing process of HDDs, particularly GMR heads. Therefore, these parts are usually in a workplace controlled by ESD. Wrist straps, GMR heads and other HDD components are usually used to prevent or stop ESD issues.

ESD Model

HBM is the first ESD model to test GMR heads or electronic devices for ESD effects.This waveform enables us to know ESD signal characteristics; this will help us to design an ESD detection circuit in a reasonable manner.

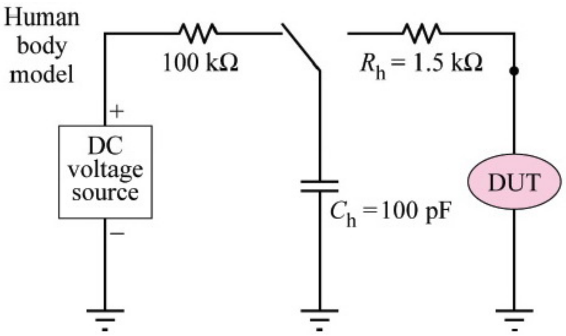

Figure 2.3 : Equivalent circuit to test ESD

This is the initial ESD detection circuit prototype. The prototype in a shielded box will be well protected. As mentioned in this paper, the proposed ESD detection circuit can detect ESD signals. Although its efficiency is not as good as it is aware of commercial EM, it has much lower costs than the commercial one, which is one of its attractive points. In order to verify the performance of this ESD detection circuit, it is tested using an ESD gun to generate ESD signal through metal plate, and then oscilloscopically visualize the ESD signal detected by this circuit.

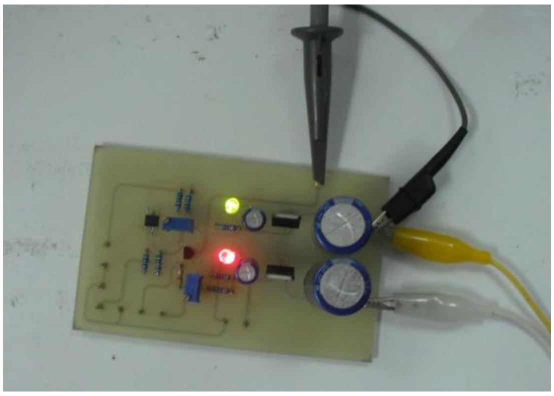

Figure 2.4 : ESD prototype circuit

2.3 Common sources of static electricity

Object/Process	**Material or Activity**
Floors	Common vinyl tiles, waxed, sealed concrete
Chairs	Fibreglass, wood finished, vinyl
Assembly area	Blowers, cathode ray tubes, plastic tools, spray cleaners, heat guns
Work surfaces	Painted or plastic surfaces, waxed,
Clothes	Synthetic materials, non-conductive shoes, common smocks,
Packaging	Plastic bags, foam, tote boxes, trays,

Table 2.1 : Common source of ESD

As Electrical Overstress (EOS), however the term for ESD always been miss interpreted. EOS can be corelated with the occurrence of the ESD but it is unnecessarily determined as EOS case.

2.3 Differences between ESD and EOS

EOS	**ESD**
System Event	Handling Event
Duration of event are usually less 50ms	Shorter transient
Commonly occurred as blown metal lines and melted silicon at weakest link	Not always easily visible
Wunsch-Bell model used characterize power density threshold to failure	Speakman model is used
Damage due to the higher energy event	Damage low due to limited energy and energy loss from absorption by other elements in the path

Table 2.2 : Difference between EOS and ESD

ESD events are insidious, when a person feels shock, he / she feels 3000V electrostatic discharge generation, and electrical components could be deadly. Smaller charges may not be felt or identified, but the electrical components could also be harmed. In some cases, damage by electrostatic discharge can be as low as 10V as a more sophisticated component.

Latent Failure

Unlike others, ESD failures may produce latent failures that factory testing can not screen out and later appear as field failures. These devices with ESD deficiencies are called wounded walking, which has been defined as degraded but not destroyed. Such event occurred when an ESD event occurred, but not high enough to kill a computer permanently, but causes damage. The damaged device continues to work but is reduced over time within a threshold limit. Continuous exposure to successful waves of ESD will further degrade the device, leading to catastrophic failure. Such devices are given ESD coverage because they are unable to screen walking wounded devices to prevent further damage.

Catastrophic Failure

Catastrophic failure can be characterized as exposure to ESD event by electronic devices causing it to cease to function. The event may have caused the circuitry to be permanently damaged by melting, dielectric breakdown or oxide failure. Direct failure or latent failure may be a catastrophic failure. In the case of direct failures, the components or devices are pronounced "dead" to the point where they cannot function properly, resulting in the IC's complete malfunction. Despite the downside, the least expensive type of ESD damage is catastrophic failures and is easiest to detect especially during initial testing. Swapping the damaged part will solvethe problem immediately.

Common Causes of ESD

There are many causes of ESD, such as lack of awareness and personal grounding, insufficient controls to use indirect materials on the floor, etc. These are set and regulated very easily. Proliferating the widespread use of automated systems and having fewer workers working on the production floor, it is important to give due consideration to the type of materials used in the system design. The Charge Device Model (CDM) describes the phenomenon of ESD devices being charged due to mechanical handling and rapid discharges when contacting ground.

2.4 Common sources of static electricity

In the Beginning

Since the dominance of Greek civilization years ago, phenomena have been present in the Starting Electrostatic Discharge (ESD). People are familiar with the effect of ESD in low humidity environments and during the winter season have frequently experienced them indoors.

The transition of electrical components from tubing to solid state was a problem for industries in the 1950s due to damage to electrical components and disruption of electrical machinery operation.

The 1960s and 1970s

The Human Body Model (HBM) is the oldest and most widely used by companies to test their products for ESD. Depending on the size and height, humans are estimated to have potential ranging from 100 to 250 picofarad. The HBM is modelled through a switch and 1.5 k series resistor using a 100 pF condenser.

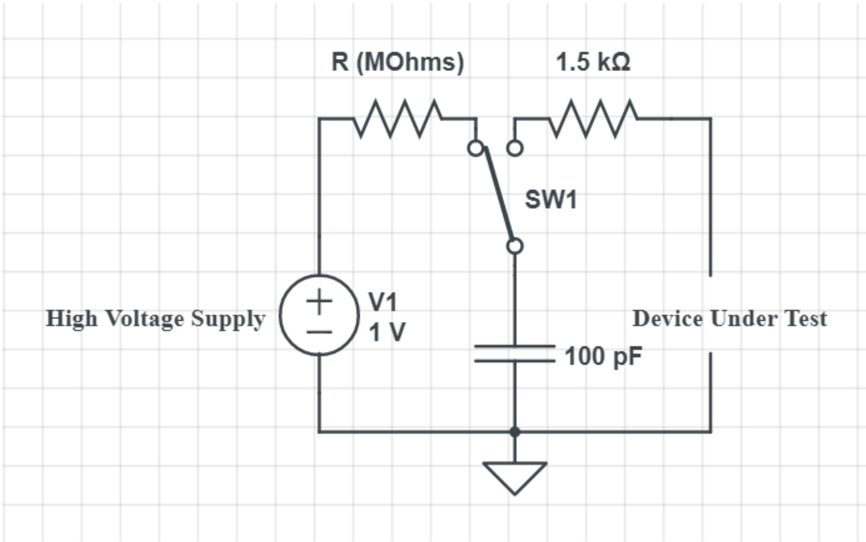

Figure 2.5 : Human Body Model (HBM)

The 1980s

The first edition of the International Electrotechnical Commission (IEC) Regulation 801 – 2 issued in 1984 was entitled Electromagnetic Compatibility for Industrial Process Measurement and Control Equipment – Part 2: Electrostatic Discharge Requirements. ESD generator specifications back in 1984:

1. Output voltage of 2 kV to 16.5 kV
2. Discharge resistor – 150 ohms +/- 5%
3. Energy Storage Capacitor – 150 pF +/- 10%

Results:

1. Pulse width was approximately 30 ns +/- 30%
2. Rise-time of the discharge current was 5 ns +/- 30% at 4 kV

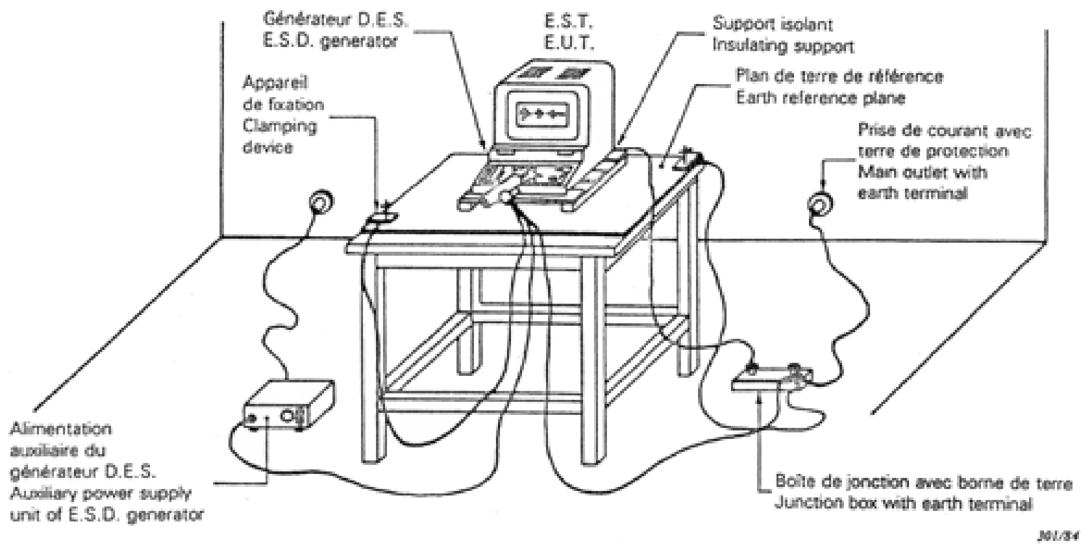

FIG. 5. – Installation d'essai pour des matériels de table, essais en laboratoire.
Test set-up for table-top-mounted equipment, laboratory tests.

Figure 2.6 : Illustration of the test

2nd Edition of IEC 801 – 2 in 1991

The major change was the method of contact discharge, which was better than the method of air discharge.

1st Edition of IEC 1000 – 4 – 2

ESD Generator's parameters from the 1991 801 – 2 standards remain unchanged. The version of 1995 was larger horizontally, with a vertical coupling plane, ground reference plane and cables for grounding.

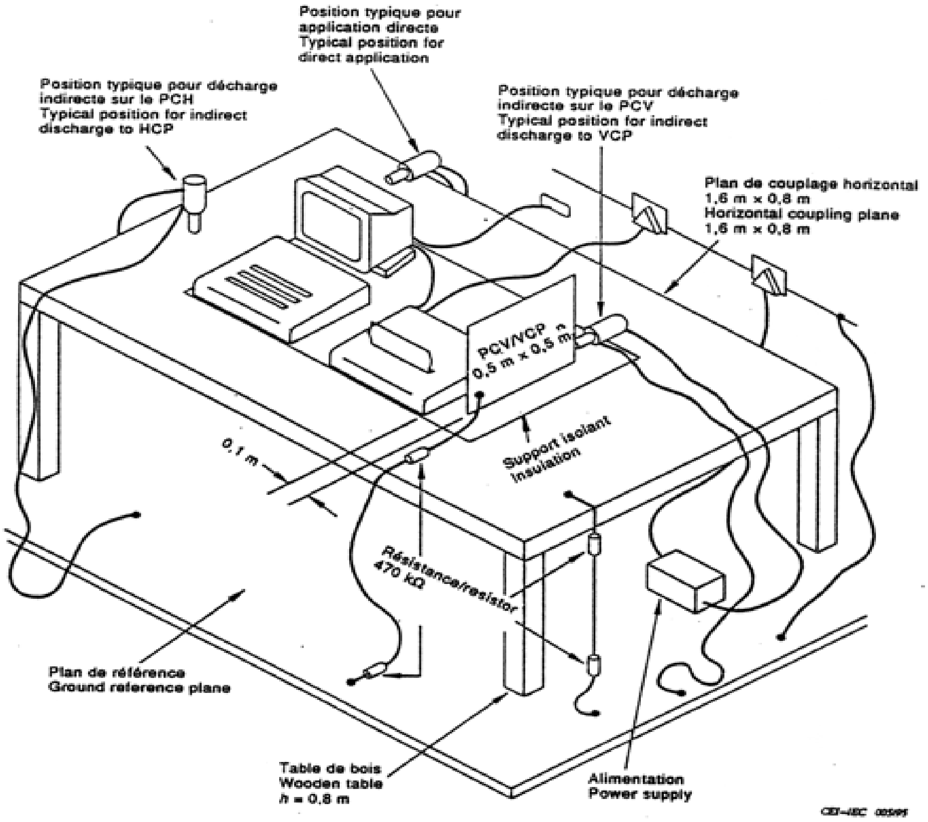

Figure 2.7 : 1995 version of IEC 1000-4-2

2nd Edition of IEC 61000 – 4 – 2

Published the second edition, it replaced the first version of 1995, which was published in 1995.

Chapter 3

METHODOLOGY

3.1 Experimental Design

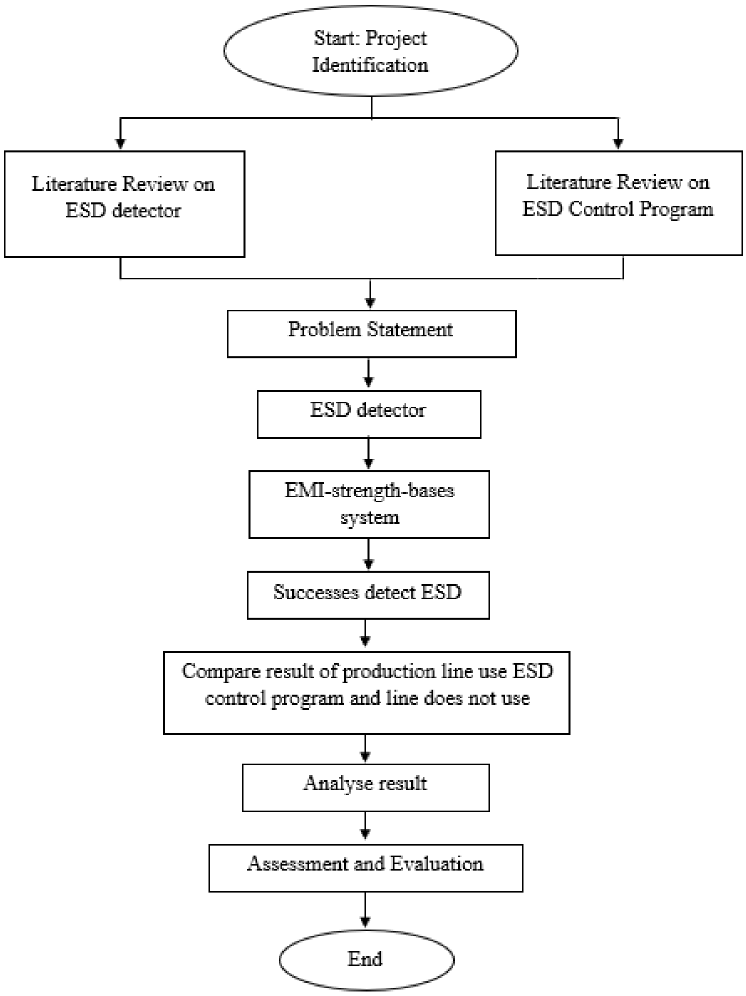

Figure 3.1 : Flow Chart

3.2 Experiment work

This experiment consists of 2 main experiment which are ESD Event Detector and ESD Control Program and the data of experiment being record. The equipment, materials, and quantity used will be discussed below along with the procedure.

3.3 ESD Event Detector

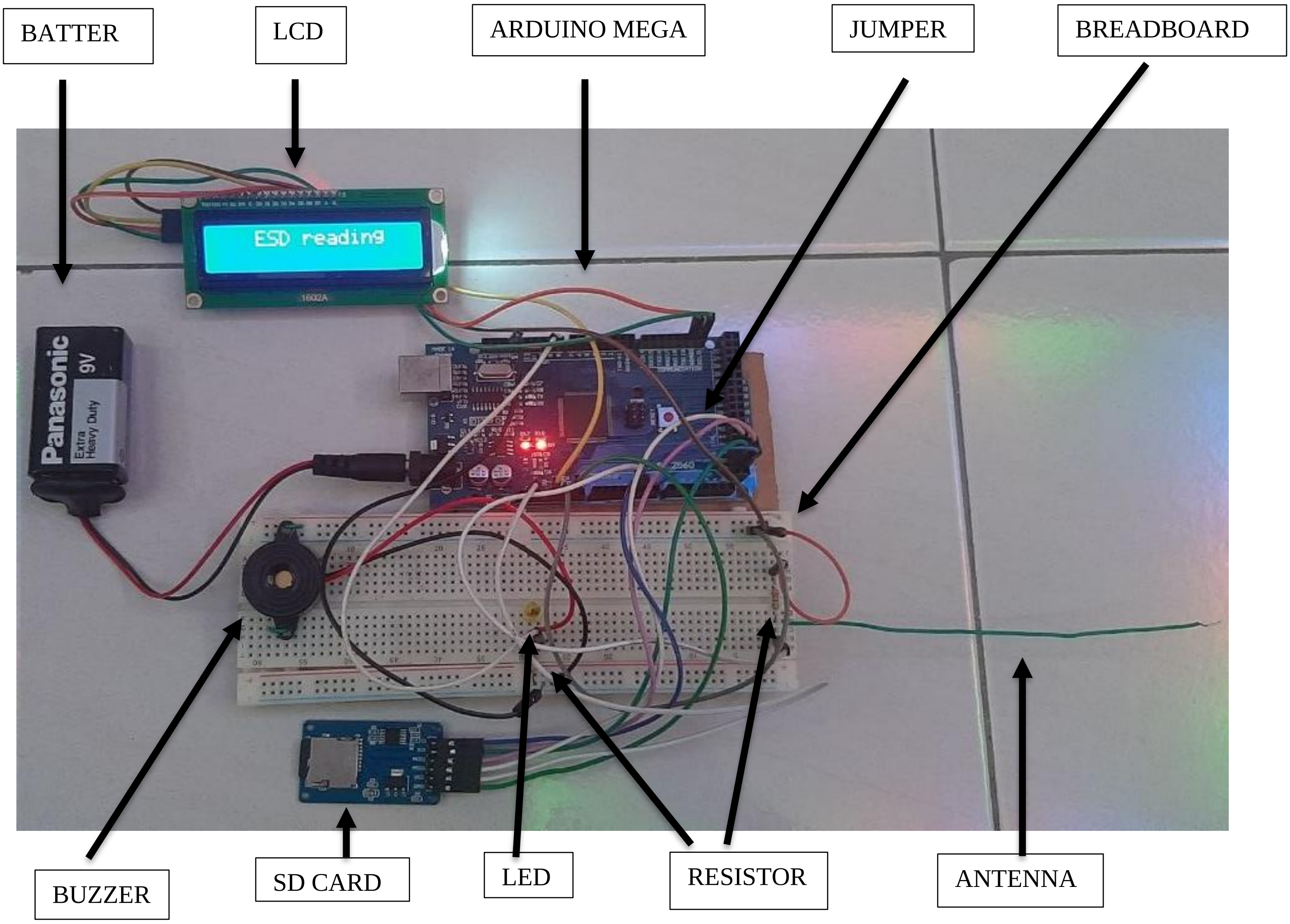

Figure 3.2 : ESD Event Detector

3.3.1 List of Material

Hardware		
Quantity	Part Type	Properties
1	Arduino	Processor ATmega256; variant Arduino MEGA 2560 R3
1	Micro SD Card	Arduino SPI ICSP interface micro SD card adapter reader module
1	LCD	Arduino serial IIC I2C LCD 1602(16x2) liquid crystal display module
1	LED	Led yellow color
1	Battery	9V Panasonic Battery and adaptor
1	Buzzer	Black buzzer
2	Resistor	330 Ohm resistor and 3.3M Ohm resistor
2 set	Jumper	1 set jumper wire male/male and 1 set male/female
1	Breadboard	A breadboard is a rectangular plastic board with a bunch of tiny holes in it.

Table 3.1 : List of Hardware

Software	
Name	Description
Arduino IDE	A cross-platform application designed for processing programming language

Table 3.2 : List of Software

3.3.2 Coding Develop

```
// Ahmad Faris Aslam ESD Detector Feb 28th 2020
// ahmadfarisaslam46@gmail.com

#define sample 300                    //this is how many samples the device takes
per reading
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#include <SD.h>
#include <SPI.h>

LiquidCrystal_I2C lcd(0x27,20,4);          //more information for #define
http://arduino.cc/en/Reference/Define

int inPin = 5;                         //analog 5
float val;                             //where to store info from analog 5
int pin11 = 8;                         //output of yellow led

int array1[sample];                    //creates an array with number of elements
equal to "sample"
                                      //more information about arrays
http://arduino.cc/en/Reference/Array


unsigned long averaging;               //the program uses this variable to store the
sum of each array it makes
File myFile;

void setup() {
```

```
 Serial.begin(9600);

 lcd.begin();
 lcd.backlight();
 lcd.setCursor(3,0);
 lcd.print("ESD reading");

  Serial.print("Initializing SD card...");
  // On the Ethernet Shield, CS is pin 4. It's set as an output by default.
  // Note that even if it's not used as the CS pin, the hardware SS pin
  // (10 on most Arduino boards, 53 on the Mega) must be left as an output
  // or the SD library functions will not work.
   pinMode(53, OUTPUT);

  if (!SD.begin(4)) {
    Serial.println("initialization failed!");
    return;
  }
  Serial.println("initialization done.");

}

void loop() {

for(int i = 0; i < sample; i++){              //this code tells the program to fill each
element in the array we made with
   array1[i] = analogRead(inPin);             //information from the antenna wire coming
out of the Arduino
   averaging += array1[i];                   //more information about for loops
http://arduino.cc/en/Reference/For
```

```
}                                   //the averaging line is simply saying: add averaging to whatever is in array position i
                                    //averaging += array[i] is the same as averaging = averaging + array[i]
                                    //for more information about += http://arduino.cc/en/Reference/IncrementCompound




val = averaging / sample;           //here the program takes the sum of all numbers in array1, and divides by the number of elements "sample"

val = constrain(val, 0, 100);       //this constrains the variable value to between two numbers 0 and 100
   val = map(val, 0, 100, 0, 255);  //for more information about constrain http://arduino.cc/en/Reference/Constrain
   analogWrite(pin11, val);         //the map statement tells the program to map out 0-100 to 0-255, 255 is
                                    //the threashold of analogWrite for more information about map http://arduino.cc/en/Reference/Map
   averaging = 0;                   //this line of code sets averaging back to zero so it can be used again

 Serial.println(val);               // use output to aid in calibrating

 lcd.setCursor(2,1);
 lcd.print(val);
 Serial.println(val);

  // open the file. note that only one file can be open at a time,
  // so you have to close this one before opening another.
```

```
  myFile = SD.open("test.txt", FILE_WRITE);

  // if the file opened okay, write to it:
  if (myFile) {
    Serial.print(val);
    myFile.println(val);
  // close the file:
    myFile.close();
    Serial.println("done.");
  } else {
    // if the file didn't open, print an error:
    Serial.println("error opening test.txt");
  }

  // re-open the file for reading:
  myFile = SD.open("test.txt");
  if (myFile) {
    Serial.println("test.txt:");

    // read from the file until there's nothing else in it:
    while (myFile.available()) {
      Serial.write(myFile.read());
    }
    // close the file:
    myFile.close();
  } else {
    // if the file didn't open, print an error:
    Serial.println("error opening test.txt");
  }
 delay(100);
}
```

3.4 ESD Control Program

The main purpose of ESD Control Program is to protect ESDs electrical or electronic parts, equipment and assemblies from subjected to any critical ESV thresholds or Charge Device Model (CDM) effects. There are two classes of controls, primary and secondary controls. Primary controls are those minimum controls that play an important role in ensuring that the ESDs items do not experience an ESD event. Example of controls:

1. Primary
    a. Use of conductive packaging materials
    b. Personnel are grounded
    c. Equipment does not produce CDM effects
2. Secondary – Mainly to provide additional protection.
    a. Installation of ionizers
    b. Use of conductive VDU grids
    c. Humidity > 40%

Primary	**Secondary**
Conductive wrist straps	Humidity < 40%
Conductive smock	Conductive flooring
Grounded workstation	Conductive shoe
Common point ground	Conductive chair
Dissipative mat	Ionizer
Conductive packaging	Continuous strap monitor
Warning signs/labels	Mobile equip ground
Processing equipment < 200 volts	Conductive curtain
Equipment grounding	Conductive VDU grids
Conductive indirect material	Training

Table 3.3 : List of Control

3.4.1 Tools Required and Measurement Methods

As mentioned in the problem statement section, there are a few tools needed to measure and record the values in this research. The steps on how to use those tools to measure the values will be shown below:

Multimeter

Also known as VOM (volt-ohm-milliammeter). A tool that is capable of measuring several functions (voltage, current and resistance) in one device. Using the multimeter, students can measure the resistance flowing from the assembly stations to the groundings. Measuring resistance across the lab tools: driller, grinder and sonofile and grounding. The measurements are taken and repeated to get an average value. The outcome is compared to the value required for safety and protection of workers and products in the production floor.

Static Electricity Measuring Instrument

Using the static electricity measuring instrument, students are to measure the value of static voltage flowing through the ESD containers in the assembly stations. Before measuring, the surface of containers is rubbed off with a cloth to get the most accurate value. The measurements are taken and repeated to get an average value. The outcome is compared to the value required for safety and protection of workers and products in the production floor.

Surface and Volume Resistance Meter

With the surface and volume resistance meter, students can measure the resistance readings across the ESD mats which are install on every assembly/rework stations in the lab as well as measuring the resistance across production floor. It can also be used to measure resistance across wearables like smocks, gloves and shoes. To measure, two electrodes are needed and placed across each other to get the readings. The measurements are taken and repeated to get an average value. The outcome is compared to the value required for safety and protection of workers and products in the production floor.

3.4.2 Experiment Activity

PCBA Conveyor test

<u>Measuring device requirements</u>

1. Up to 1.0×10^5 – Open circuit, 9V – 11V
2. Up to 1.0×10^{11} – Open circuit, 100V
3. Electrodes – Two cylindrical bodies, 2 – 3kg, diameter = 61 – 66mm, shore A hardness of 50 to 70
4. Electrodes should be non-corrosive
5. Electrodes of D = 75mm permissible (DIN EN 1000015-1)
6. Resistance between electrodes on metal surface not to exceed $1 \times 10^4\Omega$ at ±10V

<u>Taking measurements</u>

1. Limits < 10^8
2. Measuring device: Megohmmeter
3. Procedure:
    a. Place electrode A in the sleeve
    b. Place electrode B at specified location to measure
    c. Repeat measurement at other locations
    d. For garment with grounding point, place electrode A at the grounding point.
    e. Place electrode B at specified location.
    f. Repeat measurement at other locations.

Information card voltage test

<u>Taking measurements</u>

1. Limits: U < 50V
2. Measuring device: Charge plate monitor
3. Procedures:
    a. Zero the charge plate

b. Start test
c. Conduct repeated readings, up to five readings
d. Calculate the mean values

Workbench grounding point test

Measuring device requirements

1. Resistance should be ranging from 0.1Ω to $1 \times 10^7 \Omega$
2. Voltage reading should be at least 1.5V

Taking measurements

1. Measuring device: Ohmmeter
2. Procedures:
    a. Test the EBP earth facility/ground
    b. Max value: > 2Ω

3.5 Gantt Chart and Milestone

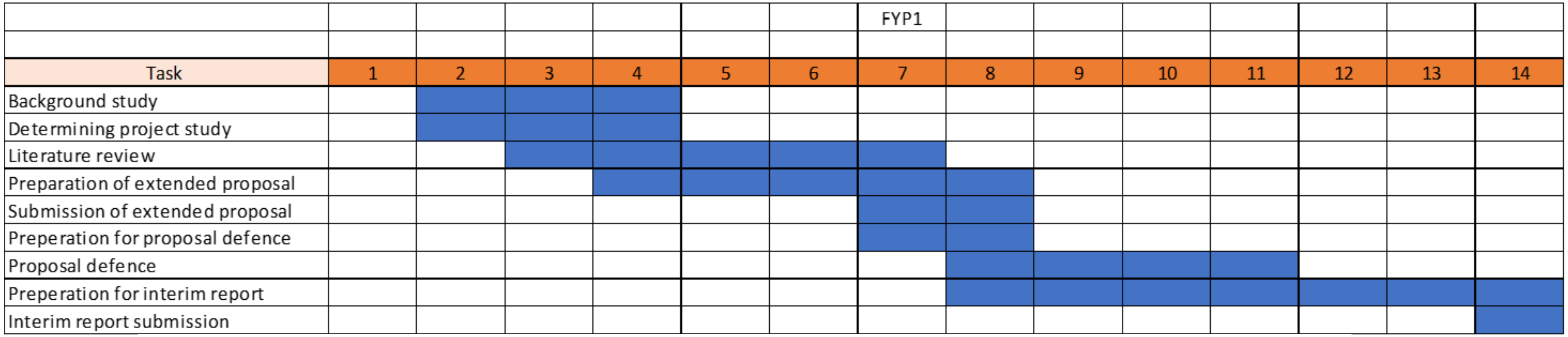

Figure 3.4 : FYP 1 Gantt Chart

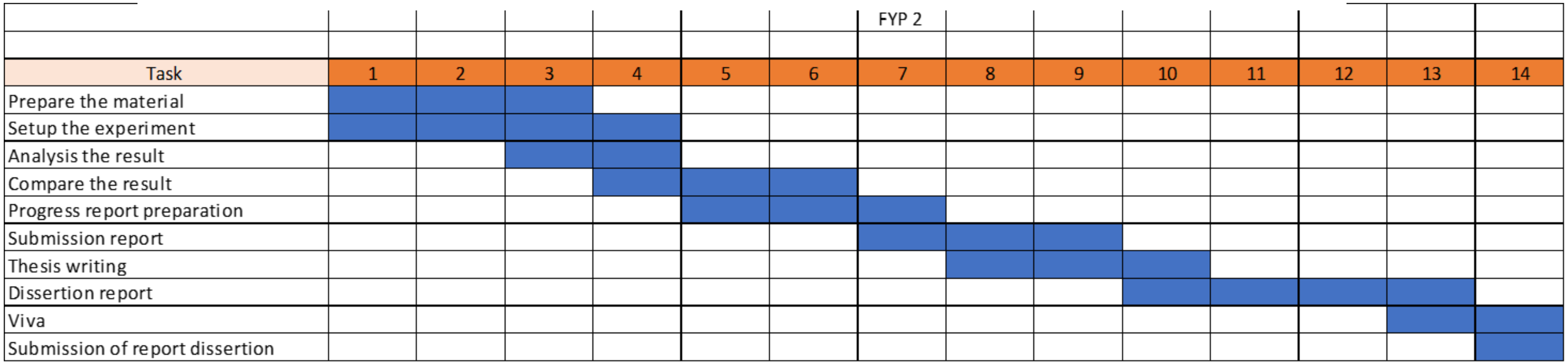

Figure 3.3 : FYP 2 Gantt Chart

Chapter 4

RESULT AND DISCUSSION

4.1 Result

Test Number	ESD Event Detector (V)	ESD Control Program (V)
1	5.00	20.00
2	7.00	30.00
3	7.00	10.00
4	5.00	10.00
5	7.00	30.00
6	7.00	30.00
7	7.00	20.00
8	5.00	30.00
9	5.00	10.00
10	5.00	10.00
Average	6.00	20.00
Standard Deviation	1.00	8.94

Table 4.1 : ESD at PCBA Conveyor

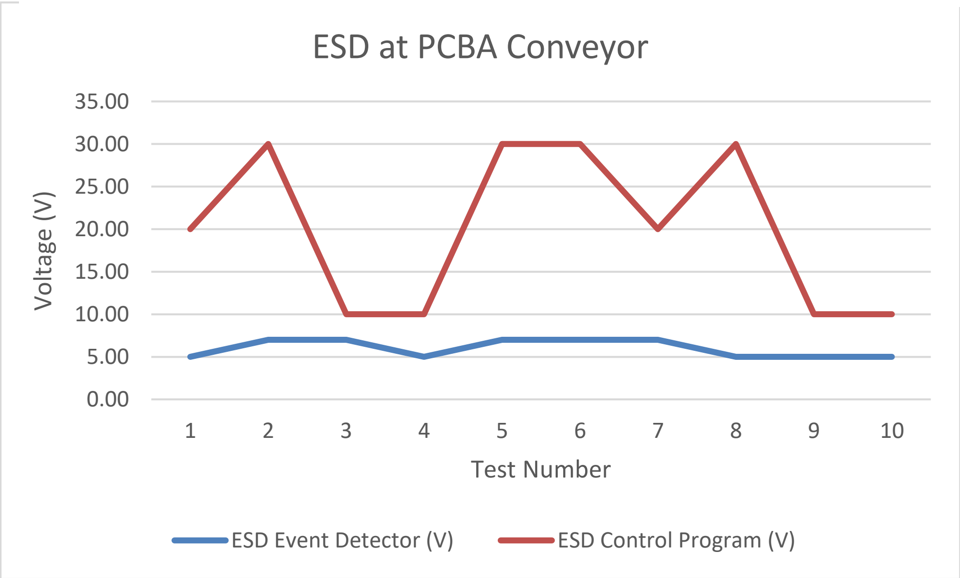

Figure 4.1 : ESD at PCBA Conveyor

The reading of ESD control program is more higher that ESD event detector because the sensitivity of the megohmmeter is higher than ESD event detector and megohmmeter is reliable to take the reading compare to ESD event detector at PCBA conveyor.

Test Number	ESD Event Detector (V)	ESD Control Program (V)
1	17.00	50.00
2	17.00	40.00
3	17.00	10.00
4	17.00	10.00
5	20.00	20.00
6	15.00	30.00
7	17.00	10.00
8	15.00	40.00
9	17.00	20.00
10	15.00	20.00
Average	16.70	25.00
Standard Deviation	1.42	13.60

Table 4.2 : ESD at Information Card

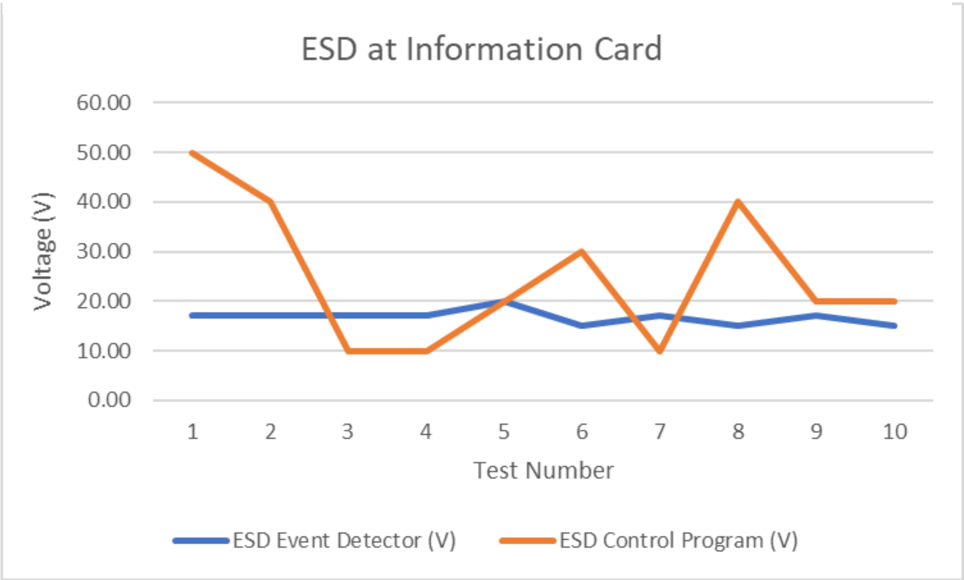

Figure 4.2 : ESD at Information Card

The reading of ESD control program is more higher that ESD event detector because the sensitivity of the megohmmeter is higher than ESD event detector and megohmmeter is reliable to take the reading compare to ESD event detector at information card.

Test Number	ESD Event Detector (V)	ESD Control Program (V)
1	2.00	0.60
2	0.00	0.20
3	0.00	0.30
4	0.00	0.20
5	2.00	0.40
6	0.00	0.10
7	2.00	0.50
8	2.00	0.60
9	2.00	0.20
10	2.00	0.30
Average	1.20	0.34
Standard Deviation	0.98	0.17

Table 4.3 : ESD at Workbench Grounding

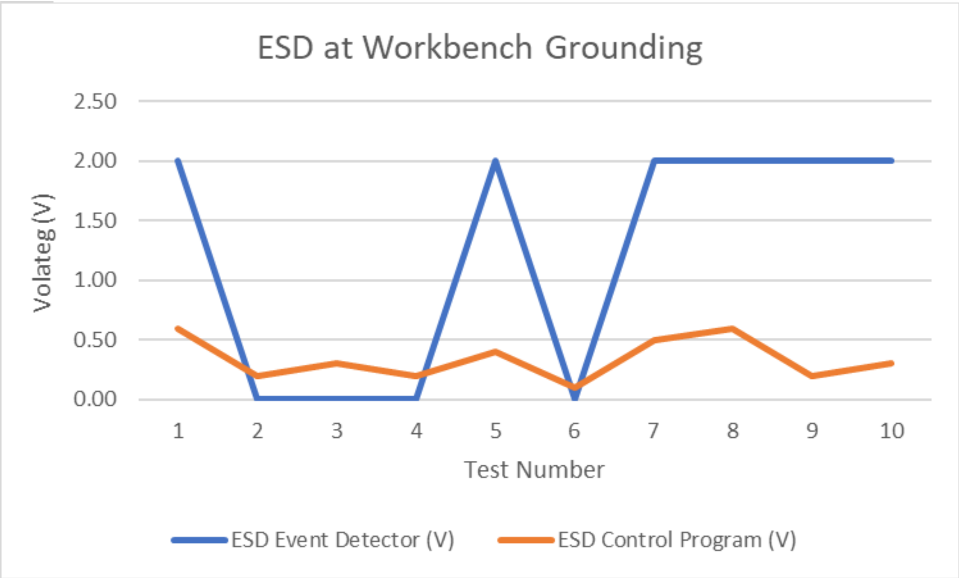

Figure 4.3 : ESD at Workbench Grounding

The reading of ESD control program is more detail than ESD event detector because the sensitivity of the megohmmeter is higher than ESD event detector and megohmmeter is reliable to take the reading compare to ESD event detector at workbench grounding.

4.2 Discussion

Electrostatic Discharge or ESD is important in modern day industries. Small devices or components are easily damaged by ESD. It takes merely around 25V to cause latent or catastrophic failures. It is crucial for the personnel or staffs to protect their ESD-sensitive devices and components from the beginning of assembly stage towards the shipping process.

The data collection show that the reading of ESD control program is more higher that ESD event detector because the sensitivity of the megohmmeter is higher than ESD event detector and megohmmeter is reliable to take the reading compare to ESD event detector at PCBA conveyor ,information card and workbench grounding. But the ESD event detector get more stable result compare to megohmmeter. To overcome this supposedly use more quality ESD detector with is EM Aware.

The threshold voltage that require at PCBA conveyor, information card and workbench grounding are 50V,50V and 2V. The measurement result cannot exceed that require threshold to prevent from the PCBA electronic part face high ESD event and very dangerous to the product that may damage it.

At this point, the worker is aware of ESD occurrences or events taking place in the production line such as rubbing of safety boots on the production floor, charged human bodies contact with components and even sliding of components on insulative materials.

To prevent these incidents from happening, the worker has come out with a solution which is the ESD Control Program. This program can be separated into two classes: primary and secondary controls. In this program, there are listed solutions or methods on how to minimalize the occurrences of ESD events in the production floor. For example: work bench grounding, ESD mat, ESD mat grounding, ESD wrist strap etc.

Chapter 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

In conclusion, it is proven that Electrostatic Discharge (ESD) is present around us. Since 1950s towards 1990s, researchers have come out with various ways to overcome damages ESD can cause to manufacturing industries from Human Body Model (HBM), Charge Device Model (CDM), Machine Model (MM) to International Electrotechnical Commission (IEC) Standards. People are aware that ESD voltage as low as 25V is able to permanently damage the components in a circuit. The damages can be categorised into two: Latent Failure and Catastrophic Failure. Latent failure cannot be screened out because the damage is minimal but increases over time. For catastrophic failure less risks are taken due to immediate action taken, replacing the damage parts.

Awareness on Importance of ESD is crucial in modern day industries. Static electricity is generated from materials rubbing against each other. Even safety boots sliding against the production floors could produce static electricity and leave a significant damage on your electrical components/devices. With the current technologies, products and components are getting smaller which increases the risks of ESD occurrences. Successful build ESD detector to control ESD event.at manufacturing production line. Last but not least, ESD control program also can reduce ESD event that occur.

5.2 Recommendations

Despite managing to prove the production line is safe for sample building assemblies, there is always room for improvements. Instead of measuring ESD frequently, use a computer to collect data automatically for wrist strap and footwear testing. For workstations, ESD mats and floors, ground continuous monitors can be done. Ionizer inspection and testing should be done more frequently and considering the option of using a computer to collect data automatically or self-monitoring ionizer. Measuring static electricity more often is a must for tools or ESD containers so the static voltage is not above the threshold required.

For personnel/staffs it is possible to conduct a training for ESD-awareness. Not just the staffs, vendors and suppliers should also be given training. To achieve better results, the training should be improvised and enhanced especially on the proper way to handle the test equipment as well as enhancing training on proper ESD protection/prevention program and IEC standards.

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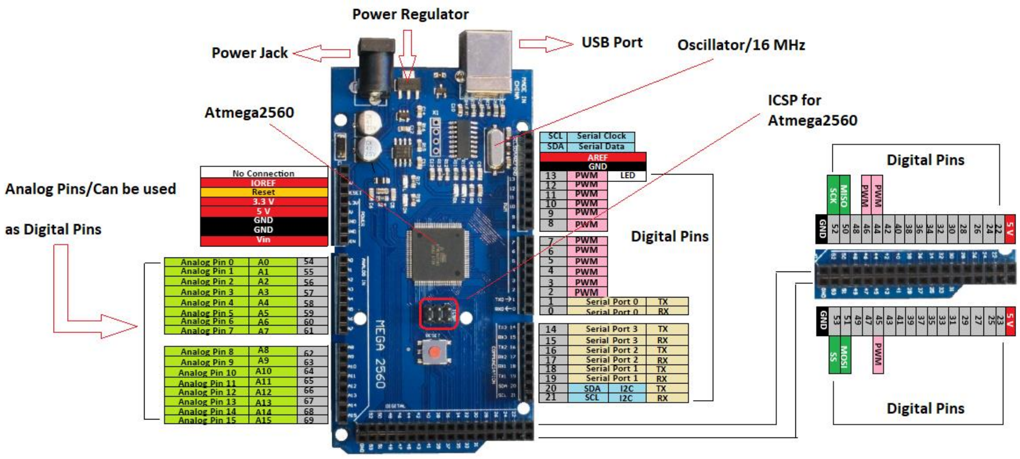
APPENDIX A



Arduino Mega 2560 Pinout

Microcontroller	Atmega2560
Operating Voltage	5V
Input Voltage	7V – 12V
USB Port	Yes
DC Power Jack	Yes
Current Rating Per I/O Pin	20mA
Current Drawn from Chip	50mA
Digital I/O Pins	54
PWM	15
Analog Pins (Can be used as Digital Pins)	16 (Out of Digital I/O Pins)
Flash Memory	256KB
SRAM	8KB
EEPROM	4KB
Crystal Oscillator	16 MHz
LED	Yes/Attached with Digital Pin 13
Wi-Fi	No
Shield Compatibility	Yes

Arduino Mega 2560 Specifications

PIN Description

5V & 3.3V. This pin is used to provide output regulated voltage around 5V. This regulated power supply powers up the controller and other components on the board. It can be obtained from Vin of the board or USB cable or another regulated 5V voltage supply. While another voltage regulation is provided by 3.3V pin. Maximum power it can draw is 50mA.

GND. There are 5 ground pins available on the board which makes it useful when more than one ground pins are required for the project.

Reset. This pin is used to reset the board. Setting this pin to LOW will reset the board.

Vin. It is the input voltage supplied to the board which ranges from 7V to 20V. The voltage provided by the power jack can be accessed through this pin. However, the output voltage through this pin to the board will be automatically set up to 5V.

Serial Communication. RXD and TXD are the serial pins used to transmit and receive serial data i.e. Rx represents the transmission of data while Tx used to receive data. There are four combinations of these serial pins are used where Serail 0 contains RX(0) and TX(1), Serial 1 contains TX(18) and RX(19), Serial 2 contains TX(16) and RX(17), and Serial 3 contains TX(14) and RX(15).

External Interrupts. Six pins are used for creating external interrupts i.e interrupt 0(0), interrupt 1(3), interrupt 2(21), interrupt 3(20), interrupt 4(19), interrupt 5(18). These pins produce interrupts by a number of ways i.e. providing LOW value, rising or falling edge or changing value to the interrupt pins.

LED. This board comes with built-in LED connected to digital pin 13. HIGH value at this pin will turn the LED on and LOW value will turn it off. This gives you the change of nursing your programming skills in real time.

AREF. AREF stands for Analog Reference Voltage which is a reference voltage for analog inputs.

Analog Pins. There are 16 analog pins incorporated on the board labeled as A0 to A15. It is important to note that all these analog pins can be used as digital I/O pins. Each analog pin comes with 10-bit resolution. These pins can measure from ground to 5V. However, the upper value can be changed using AREF and analogReference() function.

I2C. Two pins 20 and 21 support I2C communication where 20 represents SDA (Serial Data Line mainly used for holding the data) and 21 represents SCL(Serial Clock Line mainly used for providing data synchronization between the devices)

SPI Communication. SPI stands for Serial Peripheral Interface used for the transmission of data between the controller and other peripherals components. Four pins i.e. 50 (MISO), 51 (MOSI), 52 (SCK), 53 (SS) are used for SPI communication.

Programming Arduino Mega 2560 can be programmed using Arduino Software called IDE which supports C programming. The code you make on the software is called sketch which is burned in the software and then transferred to the board through USB cable. This board comes witha built-in bootloader which rules out the usage of an external burnerafor burning the code into the board.

The bootloader communicatesausing STK500 protocol. Once you compile and burn the program on the board, you can unplug the USB cable which eventually removes the power from the board. When you intend to incorporate the board into your project, you can power it up using power jack or Vin of the board. Multitasking is another feature where Arduino mega comes handy. However, Arduino IDE Software doesn't support multitasking feature but you can use other operating systems like FreeRTOS and RTX to write C program for this purpose. This gives you the flexibility of using your own custom build program using ISP connector. Arduino Mega is comparatively larger than other boards available in the market. It comesa4-inch length and 2.1-inchawidth. However, USB port and power jack are slightly extended from the given dimensions.

Applications Arduino Mega 560 is an ideal choice for the projects requiring more memory space to used with more number of number pins on the board. Following are the main applications of the Arduino mega boards.

- Developing 3D printer
- Controlling and handling more than one motors
- Interfacing of number of sensors
- Sensing and detecting temperature
- Water level detection projects
- Home automation and security systems
- Embedded Systems
- IoT applications
- Parallel programming and Multitasking

APPENDIX B

Micro SD Card Adapter Reader Module

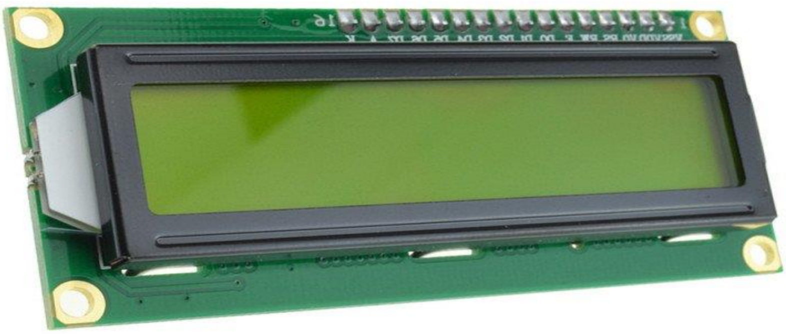
Introduction

The module (MicroSD Card Adapter) is a Micro SD card reader module, and the SPI interface via the file system driver, microcontroller system to complete the MicroSD card

Specification

- Supports micro SD card (<=2G), micro SDHC card (<=32G) (high-speed card)
- Level conversion circuit board that can interface level is 5V or 3.3V
- Power supply is 4.5V ~ 5.5V, 3.3V voltage regulator circuit board
- Communication interface is a standard SPI interface
- 4 M2 screw positioning holes for easy installation
- Size: 4.1 x 2.4cm
- A total of six pins (GND, VCC, MISO, MOSI, SCK, CS), GND to ground, VCC is the power supply, MISO, MOSI, SCK is the SPI bus, CS is the chip select signal pin.
- LDO regulator output 3.3V as level converter chip, Micro SD card supply.
- Micro SD card into the direction of signals into 3.3V, MicroSD card toward the direction of the control interface MISO signal is also converted to 3.3V, general AVR microcontroller system can read the signal
- 4 M2 screws positioning hole diameter of 2.2mm, the module is easy to install positioning, to achieve inter-module combination

APPENDIX C



Product details of Arduino Serial IIC I2C LCD 1602 (16x2) Liquid Crystal Display Module LCD1602

- LCD type : LCD1602 (16*2)
- IIC / I2C module soldered on LCD.
- 4 Pinout with VCC,GND,SDA,SDL
- IIC Address : 0x27
- Size : 82mm * 36mm* 18mm
- Blue Background , White colour word display
- Related Item :
- LCD1602 Display
- LCD IIC I2C Module
- LCD2004 with IIC I2C Module

APPENDIX D


Arduino_EMF_detector | Arduino 1.8.10
File Edit Sketch Tools Help
Arduino_EMF_detector
// Ahmad Faris Aslam ESD Detector Feb 28th 2020
// ahmadfarisaslam46@gmail.com
#define sample 300
//this is how many samples the device takes per readir
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#include <SD.h>
#include <SPI.h>
LiquidCrystal_I2C lcd(0x27,20,4);
//more information for #define http://arduino.cc/en/Re
int inPin = 5;
//analog 5
float val;
//where to store info from analog 5
int pin11 = 8;
//output of red led
int array1[sample];
//creates an array with number of elements equal to "s
//more information about arrays http://arduino.cc/en/F
unsigned long averaging;
//the program uses this variable to store the sum of ea
File myFile;
void setup() {
Serial.begin(9600);
lcd.begin();
lcd.backlight();
lcd.setCursor(3,0);
lcd.print("ESD reading");
Serial.print("Initializing SD card...");
Done uploading.
Sketch uses 15660 bytes (6%) of program storage space. Maximum is 253952 bytes.
Global variables use 1230 bytes (15%) of dynamic memory, leaving 6962 bytes for local variables. Maximum
24
Arduino/Genuino Mega or Mega 2560 on COM5

APPENDIX E

Submit: Single File Upload

STEP

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« Page 1 »


DEVELOPMENT OF AN ELECTROSTATIC DISCHARGE (ESD) EVENT DETECTOR SYSTEM FOR AN ELECTRONIC MANUFACTURING PRODUCTION LINE

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MECHANICAL ENGINEERING
UNIVERSITI TEKNOLOGI PETRONAS
JANUARY 2020