WIRELESS DETECTION OF ELECTROSTATIC DISCHARGE (ESD) EVENT THROUGH ELECTROMAGNETIC INTERFERENCE (EMI)

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ABSTRACT

Detecting ESD Events (Electrostatic Discharge) in a semiconductor company is one of the most common problems, although several actions and preventions that takes in place in order to prevent and eliminate the ESD events, the detection or build ups of ESDs on the particular area are not easy to detect.

Several occurrences of walking wounded PCBAs encountered during manufacturing and test process of our products that result to low yield performance of our production triggers our interest that PCBA failures can possibly cause by ESD events which occurred on our process stations even it is ESD protected area, and our personnel is wearing an ESD protected equipment. Determining areas where ESD events mostly is a need to improve our ESD protection

This study introduces other mediums of Electrical phenomenon to detect an ESD event. This study also aims to create a low cost but effective detector of an ESD event wirelessly.

1.0 INTRODUCTION

ESD events, is one of the problems if we are producing products that is sensitive to ESD even though we have some preventive actions on how to prevent this kind of phenomenon.

Detecting ESD events on the particular area or surface can help to identify the weak points or areas that is prone or vulnerable to ESD, and if its already identified, we can now easily modify or contained that area to be able to isolate our materials or products and prevent it from damages.

By using a device that can detect an Electromagnetic Interference on a particular area, we can also determine that area has an ESD event.

1.1 Electrostatic Discharge

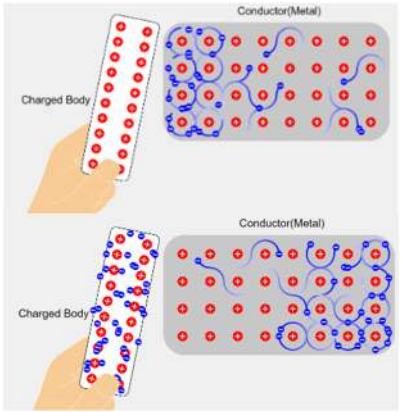
Electro Static Discharge, (ESD) is a sudden and momentary flow of electric current between two electrically charge objects caused by contact.

Electro Static Charging Causes

1.2 Tribo Charging - Is a type of contact electrification on which certain materials become electrically charge after they are separated from a different material with which they are contact.

(Figure 1: Cat furs has electrically charged particles resulting to attract the Styrofoam chips into cat's furs, it is due to cat's motions and scratch to other objects)

1.3 Electrostatic Induction – Also known as electrostatic influence is redistribution of electric charge in an object that is causes by influence of nearby charges in the presence of charge body



(Figure 2: Shows the 2 types of Electrostatic induction where in either positive or negatively charge induction)

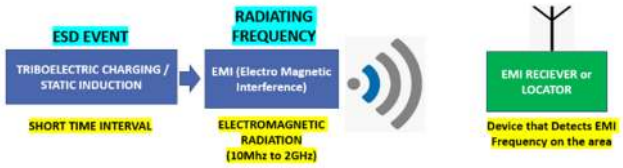
2.0 REVIEW OF RELATED WORK

According to ESD Association Standards, when there is ESD event, the discharge time is usually in a bit of second or less, the energy radiated by these events in this short time interval is creating an electromagnetic radiation usually from 10MHz to 2 GHz frequency range and at the same time, it is also radiated heat that can damages electronic components. This electromagnetic radiation is the EMI (Electromagnetic Interference) that can affect the operation or can be damage the device or equipment on the certain area.

(Figure 3: Shows the ESD event are radiating frequency thru the air, this radiating frequency is the EMI that can damage an ESD sensitive devices.)

2.1 Using an EMI as Detector of ESD Event

If there is a ESD event occur on the particular area, we can say that there is also an EMI or Electromagnetic interference phenomena on it, if this so, we can say that detection of ESD event is most likely detecting also the EMI or Electromagnetic Interference, as being said lately that EMIs are producing a frequency variation or ranges which is being radiated in the air and this radiated frequency will be detected thru EMI detectors or EMI locators.



(Figure 4: Shows the radiating frequency produced by ESD event and this will receive by an EMI Receiver or Locator.)

Source: ESD Association Standards – Test Methodologies for detecting ESD Events in Automated Processing Equipment.

3.0 METHODOLOGY

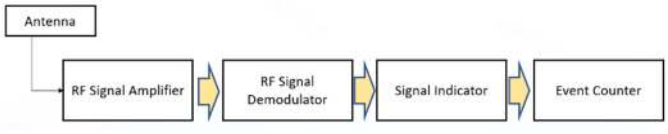
It is said recently that ESD events creates an EMI or Electromagnetic Interference which radiated a frequency variation, and this radiated frequency can travel thru the air, if this so, these frequencies radiated can be received wirelessly and detected. A simple Device for how we can detect or receive Electromagnetic Interference is to have an AM Receiver Radio, that is being set off tuned to any AM broadcast station (Blank Frequency Range).

(Figure 5: A crackling or popping sound is heard on the background which an indication of interference near the area where the radio is placed.)

3.1 DESIGNING THE EMI DETECTOR OR RECEIVER

By creating a device capable of detecting a RF Interference (Radio Frequency), we can also detect the presence of EMI or distortion which the ESD is being occurred

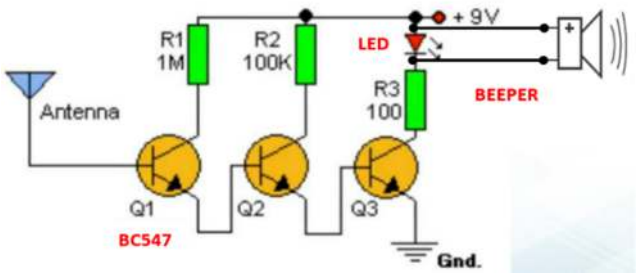
BLOCK DIAGRAM OF SIMPLE EMI DETECTOR



(Figure 6: The simple block diagram of EMI receiver showing the essential stages for able to receive the Electromagnetic interference thru the air and indicate its counts and occurrences. RF Signal Amplifier will amplify what is being received by the antenna, then it will convert and into digital signal by RF demodulator stage which is being received by signal indicator and counted by the event counter.)

3.2 EXPERIMENTATIONS

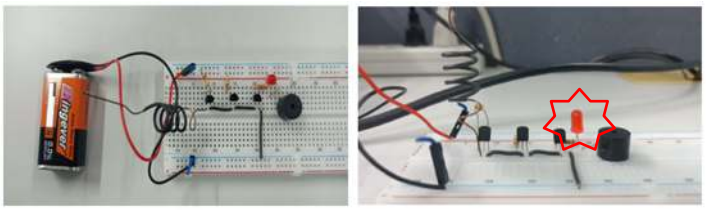
In order to realize the simple block diagram of RF interference receiver, we build the prototype receiver using the BC547 Bi-Polar general-purpose Transistor and using LED as an indicator and also add an audible Beeper as additional sense indicator.



(Figure 7: Simple schematic EMI Receiver)

3.3 PROTOTYPE TESTING:

- Place the device on the area where are probable occurrence of ESD Event
- Red LED lit, and the BUZZER must beep when it senses a Static Discharge occurrence within 4 feet on the area
- Monitor this event in a minimum of 30 mins



(Figure 8: Actual Prototype model of EMI Receiver as the Figure 7 Schematic Diagram is showing.)

RESULT:

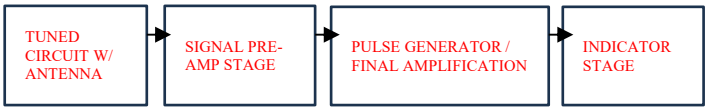
- Test Duration – 30mins
- LED lit Occurrence – 15 counts
- Location: Office Table
- Detection distance: Approx. 4 feet

OBSERVATION:

- It was observed that when there is someone on the nearby area which is scratching their feet, the RED LED lit detecting the presence of interference nearby on the area
- The Buzzer are not beeping on the static events recorded.

3.4 TUNED RECEIVING CIRCUIT & PULSE GENERATOR CIRCUIT

In order to have good indicator of interference within the circuit, the circuit must have a pre – amplifier circuit and the pulse generator or the final signal amplifier stages on the circuit, the signal coming from the antenna must go through the 1st Pre – amplifier stage and after 1st amplification, it will come through the pulse generator or in the final amplification. This combination of circuits will result to the good signal indicator that is enough to drive indicator components such as LED and Beeper.



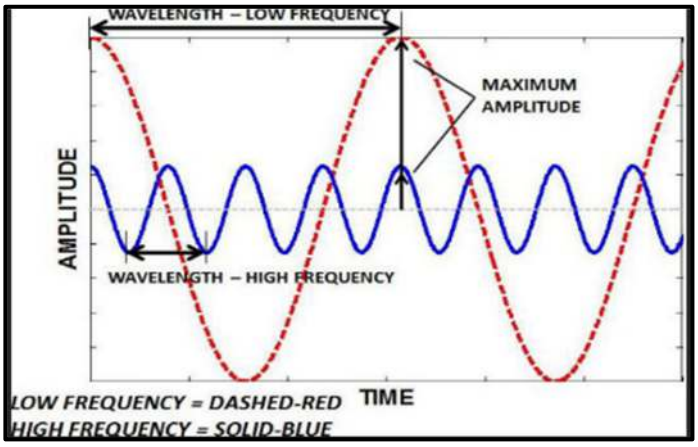
(Figure 9: Block diagram for EMI signal amplification stages showing that the signal coming from receiving antenna was pass through from the 1st pre – amplifier stage and it will pass through to the pulse generator circuits before it will go through the indicator stages such as LED and Beeper.)

3.5 DESIGNING THE FINAL EMI/ESD Event Detector Circuit

It was learnt during the simulation of protype circuit that the EMI/ESD receiver must have stationary tuned to a low frequency circuit in order to received or detect the interference or ESD event. A Low frequency tuned device has more sensitive to receive a high frequency and consider it as their interference

Name	Symbol	Frequency Range	Wavelength	
Extremely Low Frequency	ELF	3 Hz - 30 Hz	10,000 km – 100,000 km	
Super Low Frequency	SLF	30 Hz - 300 Hz	1,000 km – 10,000 km	
Ultra Low Frequency	ULF	300 Hz - 3 kHz	100 km – 1,000 km	
Very Low Frequency	VLF	3 kHz - 30 kHz	10 km – 100 km	
Low Frequency	LF or LW	30 kHz - 300 kHz	1 km – 10 km	TUNED DEVICE / RECEIVER
Medium Frequency	MF or MW	300 kHz – 3,000 kHz	100 m – 1 km	
High Frequency	HF or SW	3 MHz – 30 MHz	10 m – 100 m	
Very High Frequency	VHF	30 MHz – 300 MHz	1 m – 10 m	10Mhz - 2GHz ESD EVENT RANGE
Ultra High Frequency	UHF	300 MHz – 3,000 MHz	10 cm – 100 cm	
Super High Frequency	SHF	3 GHz – 30 GHz	1 cm – 10 cm	
Extremely High Frequency	EHF	30 GHz – 300 GHz	1 mm – 10 mm	

(Figure 10: Showing the RF Spectrum Table. Determining the frequency ranges of an ESD Event from High Frequency to Ultrahigh frequency. Our device must be tuned into a low frequency circuit in order to received the high frequency interference coming from ESD events.)



(Figure 11. Low frequency wave interfered by a high frequency interference)

Final Schematic Diagram for EMI/ESD Event Detector

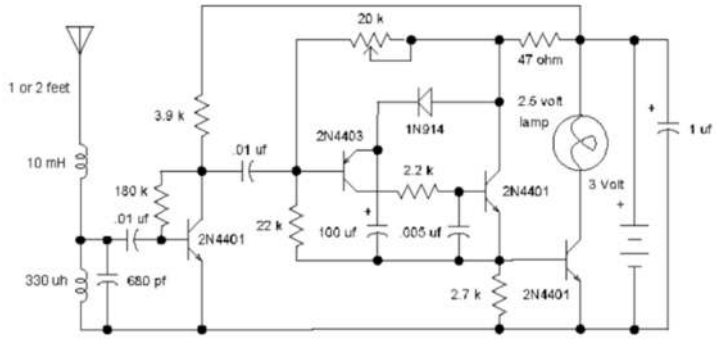
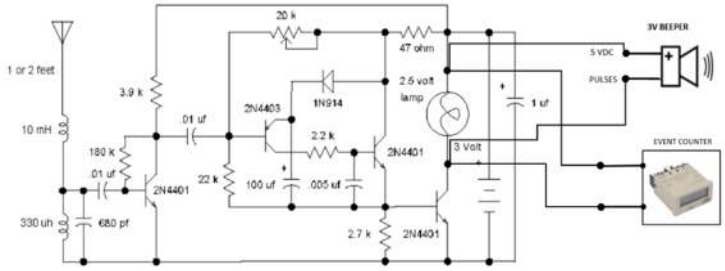


Figure 12: An EMI/ESD detector circuit showing from 300Khz tuned receiving antenna down to 1st transistor amplifier stage going to pulse generator circuit and indicator circuit

As seen on Figure 12 schematic, the circuit is complete with lamp indicator stage but in order to enhance the indicator circuit, I add an audible alarm and event counter circuit to enhance the event monitoring capabilities of the device.



(Figure 13 Additional indicator, alarm and event counter circuit to be added on the main circuit (Figure 12) to complete the ESD event indicator stage.)

3.6 THEORY OF OPERATION

The 10mH and 330uH inductors form a resonant tuned circuit of about 300khz low frequency that can received an interference when there is Electrostatic discharge occurred within the range area, effective detection distance is 5 feet, then it was feed on the 1st low power amplifier (1st PNP Transistor) and will feed the signal to the pulse generator circuit, and it will trigger the LED or Lamp to lit, an indication that there is a signal feed to it. Pulses from the lamp will also trigger the Piezo beeper to have audible signal and also trigger the counter to monitor the pulses counts. Passive electronic components such as resistor, capacitor, will act as biasing, signal coupler, and current regulator circuits, to feed the transistors and diode a right amount of current signal and amplify to drive the LED lamp, Beeper, and counter device.

The device is powered by 3 volts DC (2xAA Size Battery) and can be converted into DC adaptor supply for the sustaining and continuous supply features.

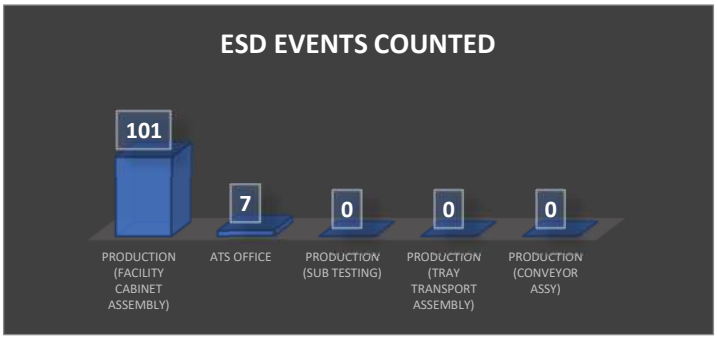
(Figure14: ESD Event Detector Device (no counter is shown)).

4.0 RESULTS AND DISCUSSION

The device was tested on the different areas wherein ESD event is suspectedly occurring.

After the device was tested on the different areas wherein suspected ESD events are occurring, it was recorded that the highest ESD events was in the Production wherein processing of electronic devices and assemblies is built such as installation of computer assembly, power supply modules, and safety controllers that has electronic components that is sensitive to ESD. During testing on the station, it was observed that ESD events are occurring during using of ungrounded electric torque driver.

AREA / LOCATION	ESD EVENTS COUNTED	TEST DURATION	REMARKS
PRODUCTION (FACILITY CABINET ASSEMBLY)	101	30 mins	During simulation, Technician is using a ungrounded Electric Torque driver during process. (the torque driver is not connected on the ground with respect on the AC outlet)
ATS OFFICE	7	30 mins	Normal office movement of people
PRODUCTION (SUB TESTING)	0	30 mins	During functional Testing of Sub Assembly
PRODUCTION (TRAY TRANSPORT ASSEMBLY)	0	30 mins	During Tray Transport Assembly processing
PRODUCTION (CONVEYOR ASSY)	0	30 mins	During Conveyor Assembly processing



(Figure 15: Recorded ESD event counts per area, duration of test time is 30mins.)

During testing, it was observed that the device is recording an ESD event when made a contact with another person with opposite electrical charge, it proves that the device is working.

4.1 COST ASSESSMENT OF DEVICE

If the only requirement is to detect an ESD event, building this device is more economical than the devices that are already available in the market.

Device cost = **Php 1045.68 / $ 19.06**

Market Price (ESD Detector) = **Php 64,334.29 / $ 1,173.8**

4.2 REPLACEMENT TO A HIGH-COST DEVICE

Some manufacturing industries only need to determine how frequent is the ESD event occurrence on a certain station or area for them to assess how their ESD protection on the particular area take in place, investing for a high-cost ESD event detector which has additional features aside from counting of events can be replaced by this low-cost device.

		
MODEL	**SCS CTM082**	**DIY ESD DETECTOR**
FEATURES		
ESD event detection	Detect Electrostatic Discharges that are harmful for sensitive components	Detect Electrostatic Discharges that are harmful for sensitive components
ESD EVENT COUNT	4 Digit Counter	8 Digit Counter
EMI DETECTION	Waveform analysis	Can detect ESD and EMI only
PORTABILITY	HAND-HELD	DESKTOP
SENSITIVITY	1- 1000V	Not indicate
DISCHARGE POLARITY	BOTH	BOTH
MAGNITUDE	LED BAR	SINGLE LED
EFFECTIVE DETECTION RANGE	Not mentioned	5 Feet (Based on simulations)
ESD EVENT INDICATION	LED Bar, BUZZER	LED, BUZZER
EMI EVENT REJECTION	CDM Mode Select, all events select	EMI and ESD are detected simultaneously
POWER	9V Alkaline Battery	3V AA Size Battery
COST	$ 1,173.80	$ 19.06

(Figure 16: Specs and Cost comparison between commercial ESD detector and DIY ESD Detector.)

5.0 CONCLUSIONS

This Study shows that the detection of ESD events needs less investments by creating a simple device that can detect and count ESD events. Commercial ESD can be replace by this simple DIY ESD detector if you need only a device that can detect and count an ESD event. By putting this DIY ESD detector on the ESD critical areas within the production, we can now identify the frequency of occurrence of an ESD event which could be harmful to ESD sensitive devices and as a result, those identified areas ESD protection could be contained and enhance.

6.0 RECOMMENDATIONS

It is recommended to have deeper studies and series of simulations on how we could enhance the features of this ESD detector device by using other mediums or other technology that is less cost but effective. This DIY ESD detector can now be use on manufacturing during processes to monitor if their area is vulnerable to harmful electrostatic events that can possibly lead to malfunctioning or even catastrophic damages of the ESD sensitive components that resulting to low quality of the product.

7.0 ACKNOWLEDGMENT

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9.0 ABOUT THE AUTHOR

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