PREVENTION OF MOTOR AND SENSOR ASSEMBLY FAILURES FLOW-OUT BY INTRODUCING IMPROVISED TESTING EQUIPMENT

Renalyn B. Alminaza
Ian Balais
Refan C. Ongi

Automation Technology and Solution - New Product Introduction Engineering
P. IMES Corp., Block 16, Phase IV, CEZ, Rosario, Cavite
ralminaza@pimes.com.ph ibalais@pimes.com.ph rongi@pimes.com.ph

ABSTRACT

Motors and sensors are commonly used parts in Semiconductor Equipment Manufacturing. Motors and sensors becoming increasingly more complex and technical, keeping them running at peak performance continues to be a growing concern. However, in cable assembly line, failed motors and sensors are usually detected during the final testing of Semiconductor Handler. This leads to high rejections of parts causing interruption to delivery, affecting quality and overall product's cost.

This problem could be detected earlier if there was equipment that could perform testing of raw motors and sensors.

This study aimed to detect motor and sensor failures before undergoing assembly process by introducing improvised testing equipment which utilizes the same components used in an actual Semiconductor Handler. This equipment eliminates the occurrence of motor and sensors failure in final testing and improves the overall performance of cable assembly testing.

1. 0 INTRODUCTION

Automation Technology and Solutions (ATS) is one of the business units of P. IMES Corporation specializes in manufacturing semiconductor equipment and cable assemblies.

Fig. 1. An illustration of a Semiconductor Handler.

Semiconductor Handler requires customized motors and sensors such as servo motors, linear actuator motors, and photoelectric sensors into cable assemblies.

1.1 Type of Sensors

A sensor is a device that detects or measures a physical property and records, indicates or otherwise response to it. The following are the types of sensors used in Semiconductor Handler.

1.1.1 Photoelectric Sensors

This type of sensor is used in various applications to determine the distance, absence, or presence of an object. This works by using a light transmitter, often infrared, and a photoelectric receiver.

1.1.2 Proximity Sensors

This type of sensor detects the presence of nearby objects without any physical contact.

1.1.3 Optical Sensors

This type of sensor detects and measures various properties of light, such as intensity, wavelength, or polarization, and converts them into electronic signals.

1.1.4 Pressure Sensors

This type of sensor is a critical component in a variety of applications, serving to measure and monitor the pressure of gases or liquids.

Fig. 2. An example of types of sensors in Semiconductor Handler.

1.2 Types of Motors

A motor is a device that converts electrical energy into mechanical energy, typically used to provide motion. The following are the types of motors used in Semiconductor Handler.

1.2.1 Servo Motors

This type of motor is used for precise control of angular or linear position, velocity, and acceleration.

1.2.2 Linear Actuator Motor

This type of motor is a device that creates motion in a straight line, as opposed to the rotational motion of an electric motor.

1.2.3 Stepper Motors

This type of motor is used in a wide range of applications due to its ability to precisely control the position and speed of the motor shaft.

Fig. 3. An example of types of motors in Semiconductor Handler.

1.3 The problem

In year 2021-2023, total of 69 pieces of failed motors and sensor (55 motors, 44 sensors) were detected during the final testing of finished Semiconductor Handler. Overall cost of poor quality in the production process is $4,879.54.

Table 1. Total cost of defective motor and sensor found in Semiconductor Handler from 2021-2023.

PART NUMBER [a]	TYPE [b]	QTY [C]	COST [d] ($)	TOTAL COST [e] ($)
3604156	Photoelectric Sensor	19	43	817.00
3604166	Photoelectric Sensor	14	55.56	777.84
3604152	Photoelectric Sensor	22	33.45	735.90
2101306	Linear Actuator Motor	6	168.8	1012.80
2101243	Servo Motor	8	192	1536

[a] Part Number is the number coding for particular material.
[b] Type is the of sensor and motor.
[C] Qty. is the total number of defective motors and sensors.
[d] Cost is the amount of product per piece.
[e] Total cost is the overall amount of product times quantity.

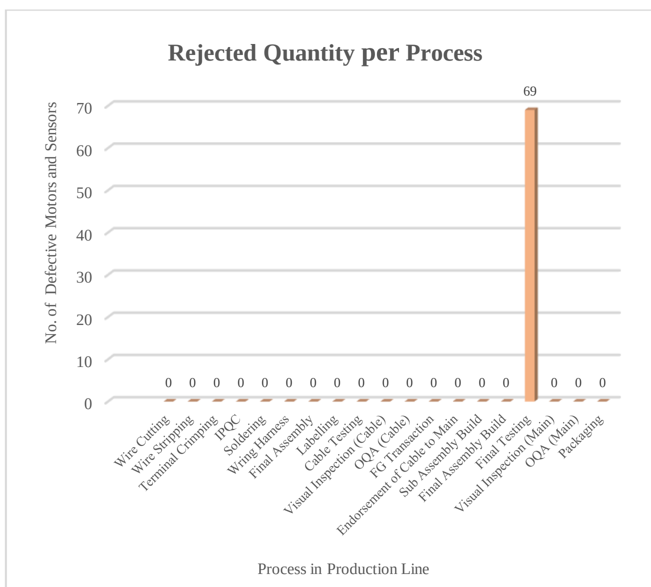

Fig. 4. Production line rejection per process for motor and sensors from 2021-2023.

Defective motors and sensors are only recognized during the final testing of the finished Semiconductor Handler. This leads to reworking of motors and sensors, causing interruptions in delivery and affecting the quality and overall cost of the products. Defective motors and sensors are subject for scrap and are not valid to return to the supplier since they have already been processed.

2.0 REVIEW OF RELATED WORK

Not Applicable.

3.0 METHODOLOGY

To determine whether the cause is incurred by which factor, a root cause analysis was performed.

Fishbone analysis was conducted to check potential cause/s of motors and sensors failure during final testing.

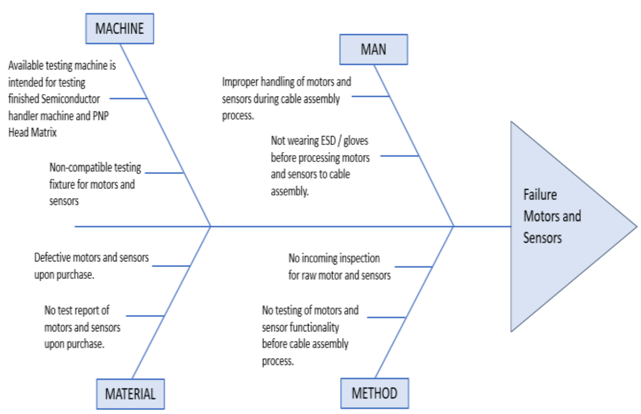

Fig. 5. Fishbone Diagram for potential root causes of failed motors and sensors.

2.1 Failure Analysis and Validation of Potential Factor

Potential factors from fishbone diagram were affirmed through series of simulations to further validate the cause/s of motors and sensors failures during final testing of finished Semiconductor Handler.

2.1.1 Man

Assembly and test technicians responsible for the processing of raw motors and sensors into cable assembly, respectively, are trained and certified. Therefore, this is not a factor of the problem.

2.1.2 Machine

The machine used for processing motors and sensors are properly maintained and calibrated. Therefore, this is not a factor for the problem.

2.1.3 Method

Assembly and test technicians responsible for the processing of raw motors and sensors into cable assembly, respectively, are following the procedures. Therefore, this is not a factor of the problem.

2.1.4 Material

Upon investigation, the motors and sensors used in cable assembly were already defective prior processing in the manufacturing line. Therefore, this is the factor of the problem.

2.2 Corrective action

To detect the motors and sensors failures before undergoing assembly process, advance testing must be performed for raw motors and sensors. To support the advance testing for raw motors and sensors, creation of an improvised testing equipment must be created. The assembly of the parts must be the same as on the actual assembly in Semiconductor Handler.

2.2.1 Creation of Improvised Test Equipment for Motors and Sensors.

The following are the things considered in creating improvised test equipment.

Measurement Accuracy – The improvised testing equipment should be able to detect the function of raw motors and sensors. Installations of its parts must be the same of the actual routing of the Semiconductor Handler.

Measurement Range- The improvised testing equipment should be able to test different types of raw motors and sensors.

<u>*Functionality*</u> – The improvised testing equipment must be installed with appropriate software to detect the functionality of raw motors and sensors.

<u>*User Safety*</u> - The improvised testing equipment should be enclosed in a transparent acrylic box.

<u>*Prototype Size*</u> - The improvised testing equipment should be compact in size to be able to install in the working area and easy to transfer to other locations.

<u>*Energy Consumption*</u> – The improvised testing equipment must be operated at 24V for sensors and 72V for motors.

2.2.2 Parts of Improvised Testing Equipment

Identifying all the important factors to be considered, the engineer proceeds with the actual creation of improvised testing equipment. Improvised testing equipment will be composed of following items:

Table 2. Summary of parts to be installed in improvised testing equipment.

COMMODITY [a]	DESCRIPTION [b]	QTY [C]
PCB	PWA, CANOPEN DIO 3232 ROHS	2
Elect	Drive, Copley ADP-090-36	1
Elect	AC/DC PWR SPLY, 24V 2.5A 60W	1
Elect	Tower, Signal, 24VDC, 5LED, DIR MT	1
Elect	Power Supply, 24VDC 960W, 40A	3
PCB	PWA Controller	1
PCB	TCA, AD/DC Power Module	1
Elect	Power Supply, 24VDC 960W, 40A	1
Elect	Computer Assy, Vision PC	1
Software	CME V8.0	1

[a] Commodity refers to the classification of materials.
[b] Description refers to the actual name of materials.
[C] Qty. is the total number of required materials.

2.2.3 Verification of Sensor and Motor Function.

In creating improvised testing equipment to be used in advanced detection of functionality of raw motors and sensors, specifications of the material particular in voltage must be defined. Through checking of datasheets, specifications of the materials are easily defined.

Table 3. Summary of Voltage Required of Motors and Sensors.

Type [a]	Description [b]	Required Voltage [C]
Photoelectric Sensor	Sensor, Opposed, Receive, 2M Range	10-30 VDC
Photoelectric Sensor	Sensor, Refl. DO, 15mm Range	10-30 VDC
Photoelectric Sensor	Sensor, Opposed, Emit, 2M Range	10-30 VDC
Linear Actuator Motor	Motor, Servo, XVM-402-Tons-D001	75VDC
Servo Motor	Motor, Size 17 2.33VDC Hybrid	2.33 VDC

[a] Type refers to the type of material.
[b] Description refers to the actual name of materials.
[C] Required Voltage refers to the voltage requirement of material.

2.2.4 Assembly of Improvised Testing Equipment

In assembling improvised testing equipment, the parts must be the same as the actual arrangement in Semiconductor Handler. Block diagram for connection of parts must be establish.

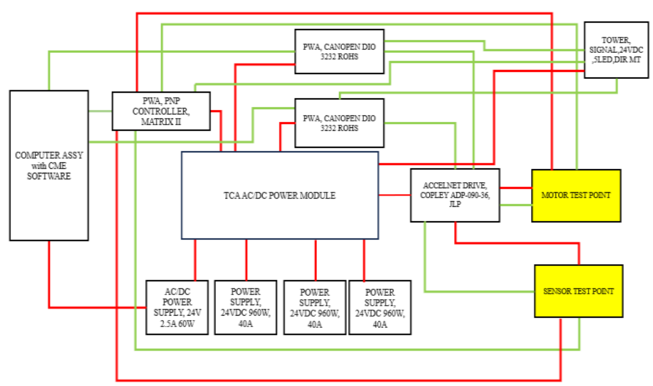

Fig. 6. Block diagram for Improvised Testing Machine.

To test the function of the raw motors and sensor, software Copley Motion Editor (CME) V8.0 must be installed in a Computer Assy connecting to improvised testing machine. This software is the same software installed on the actual Semiconductor Handler machine.

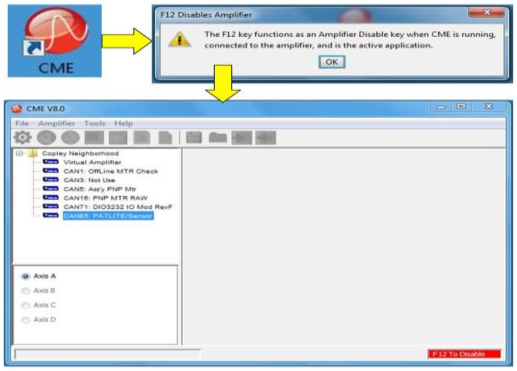

Fig. 7. An illustration of CME Software installed in Computer Assy of Improvised Testing Equipment.

An AC/DC Power Supply,24V 2.5A 60W will supply power to Computer Assy and TCA AC/DC Power Module. Since motors have different voltage and sometimes requires 72V above, additional power supply must be installed. Use additional three pieces of Power Supply 24VDC 960W 40A to double or triple the voltage.

To create motor test point (part of testing equipment where motor is being connected and tested) and sensor test point (part of testing equipment where sensor is being connected and tested) and a Tower Signal 24VDC, 5LED DIR MT (red light indicator for defected motor and sensor), two pieces of PWA, CANOPEN DIO 3232 ROHS, one piece of PWA Controller and one piece of Drive Copley ADP-090-36 must be installed.

PWA Controller will be connected directly from Computer Assy for CME Software connection and will be powered by TCA AC/DC. PWA Controller to power on Tower Signal, 24VDC,5LED DIR MT, Motor Test Point and Sensor Test Point.

Two pieces of PWA, CANOPEN DIO 3232 ROHS will be connected directly from Computer Assy for CME Software connection and will be powered by TCA AC/DC Power Module. PWA, CANOPEN DIO 3232 ROHS will be connected to Tower Signal, 24VDC, 5LED, DIR MT and Drive Copley ADP-090-36.

Drive Copley ADP-090-36 will power on Motor Test Point and Sensor Test Point where the raw motors and sensors will be tested.

Assembled improvised equipment must be enclosed with a transparent acrylic box for safety purposes.

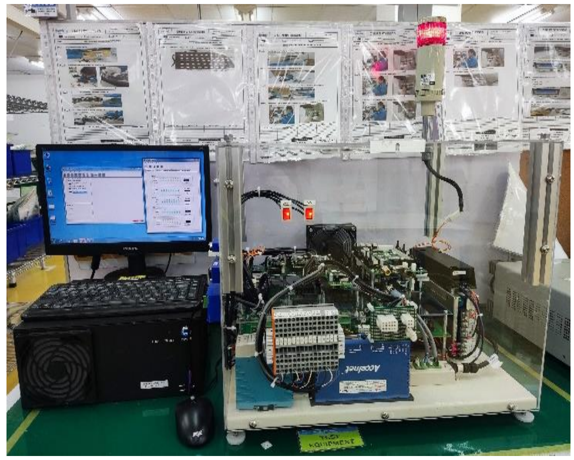

Fig. 8. Assembled Improvised Testing Equipment.

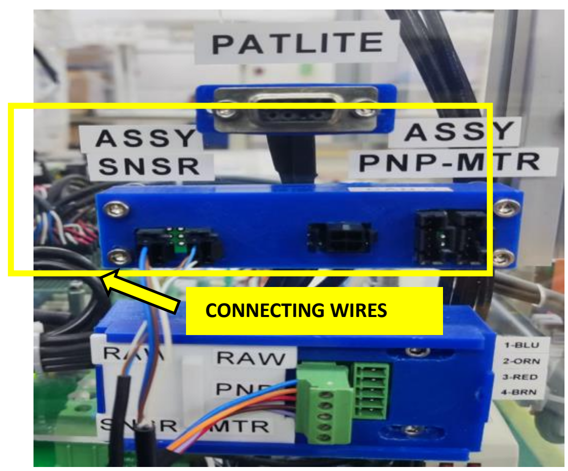

Fig.9. An illustration of motor and sensor test point.

2.2.5 Testing of Sensor in Improvised Testing Equipment

To test sensor with emitter and receiver, wires of the sensor will be installed on the sensor test point. Green light on the top of the sensors and red light on the front side of the receiver sensor will turn on. Face the emitter and receiver sensor to each other to detect contact between sensors then move away the receiver for no contact. Input 1 and State 0 will show on CME Software for sensors with contact state while Input 1 and State 1 for no contact.

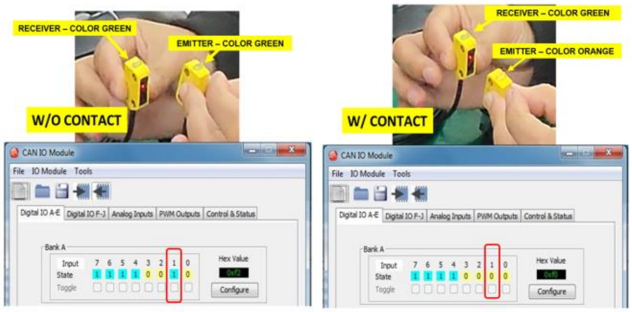

Fig. 10. An example of the actual testing of sensor.

Below are the characteristics of a failed sensor:

- No green light on top of the sensor after being installed on the sensor point
- No red light on the front side of the receiver sensor after being installed on the sensor point.
- No orange light on the emitter sensor in contact state.
- State on the CME Software did not change from 1 to 0 upon contact.
- Red light on the tower signal of the improvised testing machine will turn on.

2.2.6 Testing of Motor in Improvised Testing Equipment

To test the raw motors on improvised testing equipment, motor must be installed on the motor test point. Set appropriate velocity on the CME Software RPM then click Move PCS to power on raw motor.

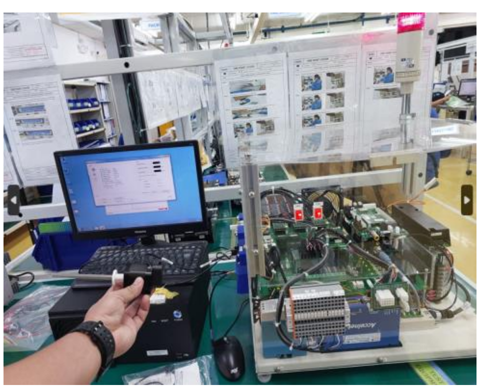

Fig. 11. An example of actual testing of motor.

Below are the characteristics of a failed motor:

- Motor will not power on after setting the appropriate velocity and clicking Move PCS on the CME Software
- Red light on the tower signal of the improvised testing equipment is will turn on.

2.2.7 Standard Process Instruction for Improvised Testing Equipment

A standard process instruction was created to ensure appropriate use of the improvised testing equipment in cable assembly line process. Standard Process Instruction contains step by step process for testing different kind of raw sensors and motors.

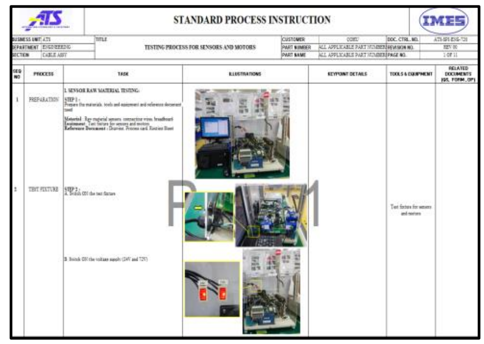

Fig. 12. Standard process instruction for Improvised Testing Machine.

2.2.8 Implementation of using Improvised Testing Equipment in Cable Assembly Production.

The production line will perform incoming test inspections of raw motors and sensors before starting the cable assembly process. Operators are able to accurately test the sensors and motors by integrating CME software into the improvised testing equipment for raw motors and sensors and by following the standard process instructions.

4.0 RESULTS AND DISCUSSION

November 6, 2023, is the full implementation of using improvised testing equipment in production line which eliminates the use defected raw motors and sensors.

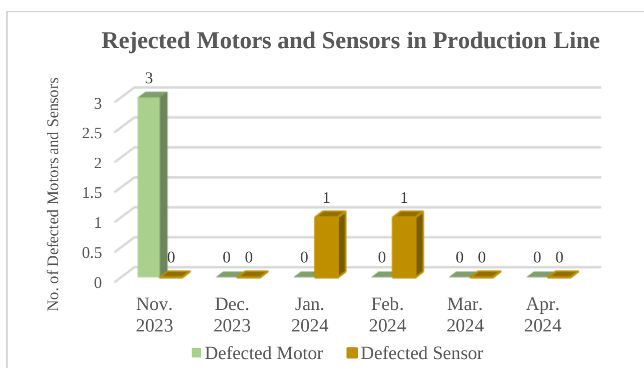

Fig. 13. Total numbers of rejected raw motors and sensors in cable production line using improvised testing equipment.

Using the improvised testing equipment, a total of 5 motors and 2 sensors are detected defective before it was being assembled in the cable production line, preventing it from being processed as cable assembly. Thus, with this result the detected defective motors and sensors are now subject for return to vendor (RTV) since the parts are still raw material and not being process and the warranty is not yet void nor expired.

5.0 CONCLUSION

Improvised testing equipment plays a vital role in detecting the defective motors and sensors prior entering the cable assembly line process. With this improvised test equipment, cable assembly production eliminates the occurrence of motor and sensors failure in final testing and improves the overall performance of cable assembly testing.

6.0 RECOMMENDATIONS

Motor and sensors becoming increasingly more complex and technical, keeping them running at peak performance continues to be a growing concern. Equipment failure can result in high monetary losses both from potential motor or parts replacement. This project methodology created a window of opportunity for other products in cable assembly. It is highly recommended that this improvised testing equipment should be executed also in upcoming new products in cable assembly.

7.0 ACKNOWLEDGMENT

The authors of this technical study would like to show their deepest gratitude and appreciation to the Automation Technology and Solution Engineering Team for the suggestions, comments and guidance in the development of the improvised testing equipment, Production and Planning team for lending the raw motors and sensors for testing and for providing inventory list and to our Manager Sir Jermie De Mesa for reviewing and helping establishing the contents of the technical study since day one.

8.0 REFERENCES

1. https://us.rs-online.com/product/banner-engineering/q12rb6r/70167361/

2. https://us.rs-online.com/product/banner-engineering/q12rb6ff15/70167351/

3. https://www.bannerengineering.com/be/en/products/part.806634.html

4. https://www.haydonkerkpittman.com/products/linear-actuators/hybrid-stepper/size-17

9.0 ABOUT THE AUTHORS

9.1 Author

RENALYN B. ALMINAZA is a graduate of the Bachelor of Science in Mechanical Engineering at the Technological University of the Philippines, Manila. She is currently working as a New Product Introduction Engineer at P. IMES Corporation under the Automation Technology and Solution Engineering Department for one year and five months.

9.1 Co-Authors

IAN BALAIS is a graduate of the Bachelor of Science in Electronics and Communication Engineering from Eastern Visayas State University. He is currently a Product Engineer in P. IMES Corporation under Automation Technology and Solution Engineering Department for two years.

REFAN C. ONGI is a graduate of the Bachelor of Science in Mechanical Engineering at Andres Bonifacio College, College Park, Dipolog City. He is currently working as a New Product Introduction Engineer at P. IMES Corporation under Automation Technology and Solution Engineering Department for almost a year.

10.0 APPENDIX

Not Applicable.