JLP CABLE ASSEMBLY AND HARNESS CYCLE TIME REDUCTION THROUGH AUTOMATIC CONTINUITY TESTING

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ABSTRACT

Power and electricity throughout the machine is transmitted by cable assemblies and cable harnesses. To guarantee that its electrical connections conform to the assembly drawing and/or schematic diagram, continuity testing is being conducted.

Over the years, P. IMES conducts continuity testing by manual pin-to-pin checking. This process contributes 42% of the total cycle time of JLP machine. The aim of this paper is to reduce the cycle time of cable and harness testing by introducing automatic continuity testing tool. This results to 49.79% cycle time reduction in cable and harness testing and have a $3.75 savings of every JEDEC Load Port (JLP) machine.

1.0 INTRODUCTION

JEDEC Load Port (JLP) is an automated tray handling system that transports JEDEC trays to and from other SMEMA-Equipped process tools. The main configuration of this machine is to:

- Stack – Accept incoming trays from an adjacent process tool via a SMEMA conveyor and transfer to a manual tray cart.
- De-Stack – Remove trays from a manual tray cart onto the SMEMA conveyor, and then transfer them to adjacent process tools.

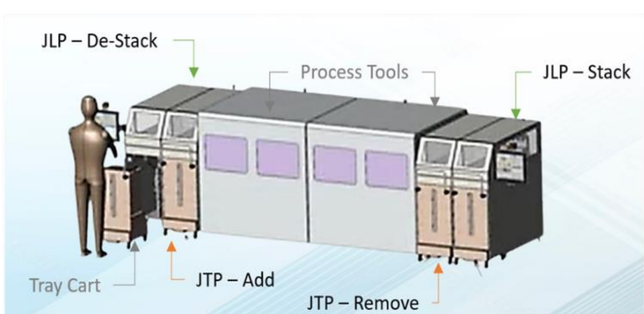

Figure 1. JEDEC Load Port (JLP) machine operation

The machine design consists parts from Cable Assembly and Harness, Fabrication Parts, Mechanical Parts, Electrical Parts, and machine frame and covers. See Figure 2.

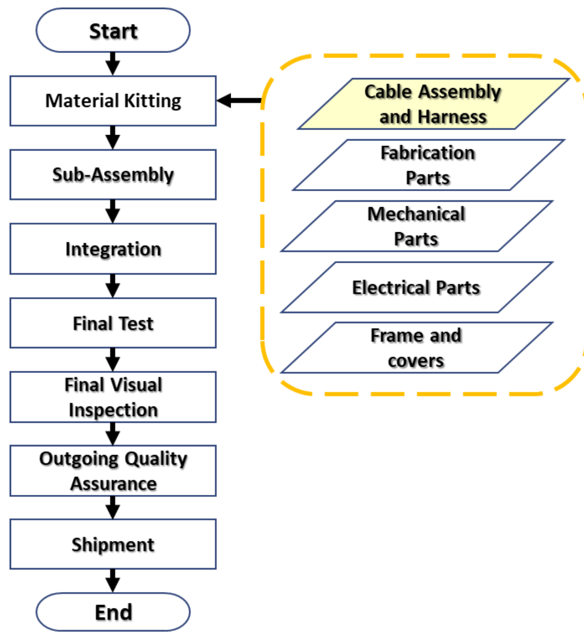

Figure 2. JEDEC Load Port (JLP) Production Flow

Cables and harnesses integrated to JLP machine are produced in cable assembly production inside P. IMES. It is manufactured in compliance to customer requirements and processed in reference to IPC/WHMA-A-620C. Testing is done to assure the quality and function of the cable. In current production, testing method is through continuity test which is manually performed using improvised continuity tester to verify the point-to-point wire connection. This is a slow process considering the time and motion of the operator to conduct the testing repeatedly in a single cable assembly. Based on data, 42% of overall cycle time of JLP product was derived from cable assembly. See Table 1.

ITEM	DESCRIPTION	CYCLE TIME (HRS.)		
		SUB-ASSY	SUB TEST	CABLE ASSY
1	Tray Stack Lift	8	2	79.3
2	Cart Docking Mechanism	8	1	
3	Facility Cabinet	12	2	
4	Conveyor Drive Assy	8	1	
5	Conveyor Assy	7	1	
6	Tray transport Assy	14	2	
7	Frame Assy	4	-	
8	Integration	17	-	
OPTIONS	Kit, JLP, Air Knife Option	5	1	6.49
	Kit, Tray Flip Mechanism, JLP G2	12	6	18.14
	Kit, Manual Tray Platf, JLP G2	8	0.5	3.71
9	Final Test	32	-	-
TOTAL CYCLE TIME	JLP w/ Tray Flip Mechanism, Manual Tray Platform & Air Knife	259.14		

Table 1. JEDEC Load Port (JLP) Overall Cycle Time

1.1 SMEMA

SMEMA stands for Surface Mount Equipment Manufacturers Association and merged with IPC to create standard to promote the electrical and mechanical concepts of the machine interface and operation.

1.2 Digital Multimeter

Standard test tool used in electrical/electronics industries. It is a measurement device used to measure electrical values and test for continuity.

Figure 3. Digital Multimeter

1.3 Improvised Continuity Tester

A continuity tester is a simple device consisting of two testing probes, a light (LED) and buzzer indicator powered by a cell battery. It is used to detect the presence of continuity or a break in between the end-to-end connection to which the testing probes is connected.

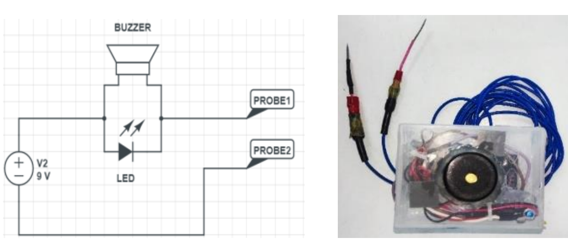

Figure 4. DIY Continuity Tester

2.0 REVIEW OF RELATED WORK

In recent years, many have studied and invented different tester for cables and wires which helps and allows users to check and troubleshoot connections.

According to a project entitled, "How to build Multi Wire Cable Tester" by Andy Collinson.

"The circuit comprises transmitter and receiver, the cable under test linking the two. The transmitter is nothing more than a "LED chaser" the 4011 IC is wired as astable and clocks a 4017 decade counter divider. The 4017 is arranged so that on the 9th pulse, the count is reset. Each LED will light sequentially from LED 1 to LED 8 then back to LED 1 etc. As the 4017 has limited driving capabilities, then each output is buffered by a 4050. This provides sufficient current boost for long cables and the transmitter and receiver LED's. The receiver is simply 8 LED's with a common wire."

According to a project entitled, "Multi-wire Cable Tester" by Tamanna Sharma

"We have used four wires to demonstrate 4 wire Cable Tester. If the wires are not defective then it allows the current to conduct through them and feed to the LED and the LED goes HIGH. If there is any fault, break in the wire the LED will not glow. By which we will get to know that there is some defect in the wire."

3.0 METHODOLOGY

In 2019, cable assembly production was established to produce cables for modules and machine assembly with increasing demand and lessen long lead time cause by procuring from external source. Process sequence, tools and equipment, and product requirements were studied and demonstrated to provide good quality of products. It is also an opportunity to bring in more business and introduce new products. But to have a competitive quality and cost, process improvement should take place to optimize performance and efficiency.

3.1 Cycle Time

Cycle time in cable assembly production was gathered for each part number of cable assembly in JLP unit and total cycle time as shown in Figure 6. Based on the data, the highest cycle time occurs in two simultaneous processes of visual inspection and testing (20%) performed by 1 operator. See Figure 5 and 6.

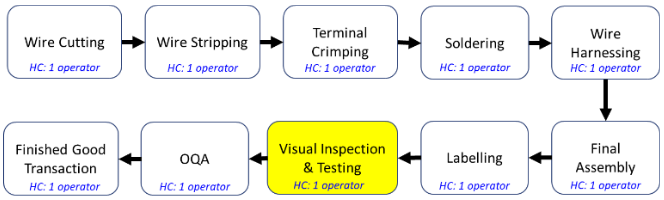

Figure 5. Cable Assembly Process Flow

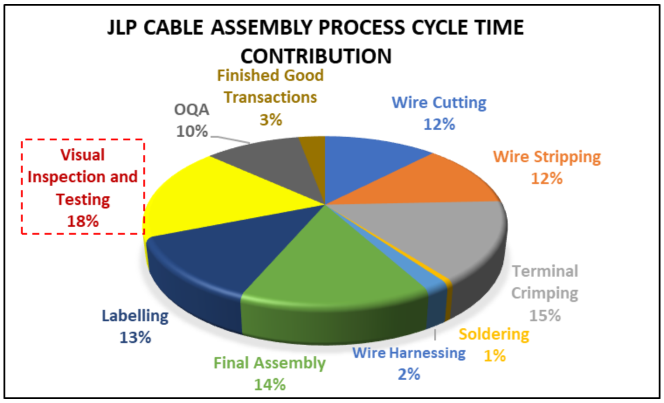

Figure 6. Cable Assembly Process and Cycle Time

Continuity check is the method used during testing. It is performed using continuity tester and is manually check all pin-to-pin connection in a single cable or harness. It is a combination of LED and buzzer that will go HIGH if the connection is Good and LOW if there is a fault or miswired on the cable and harness.

Aside from cables and harnesses, the production produces standard cables and ribbon cables for JLP. Evaluating the list of cables and harnesses that undergo testing, 66 out of 83 part numbers are selected which is equivalent to 79% of JLP cables and contributes 95% of testing cycle time. The selected cables and harnesses are considered to have an automated continuity testing.

CATEGORY	PART NUMBERS	%	REMARKS
Cable Assembly	61	73%	For auto continuity test
Harness	5	6%	For auto continuity test
Ribbon Cables	10	12%	with Tester
Standard Cables	7	8%	with Tester
TOTAL	83		

Table 2. JLP Cables and Harness

PART NUMBER	MODULE	TESTING CYCLE TIME (mins.)	REMARKS
8333047001	Assy Conveyor	3.17	CABLE
8337930001	CDA	3.02	CABLE
8333041003	CDA	2.14	CABLE
8333043002	CDA	4.25	CABLE
8333054001	CDA	2.51	CABLE
8331121005	CDM	4.81	CABLE
8331121006	CDM	4.81	CABLE
8331121009	CDM	4.81	CABLE
8331121010	CDM	4.81	CABLE
8338197003	CDM	2.76	CABLE
8338197004	CDM	2.76	CABLE
8338197007	CDM	2.76	CABLE
8338197008	CDM	2.76	CABLE
8331142001	CDM	0.47	CABLE
8331142002	CDM	0.47	CABLE
8331142003	CDM	0.47	CABLE
8331142004	CDM	0.47	CABLE
8331142005	CDM; MTP	2.38	CABLE
8331142006	CDM; MTP	2.38	CABLE
8333041001	Facility	2.14	CABLE
8333084001	Facility	2.80	CABLE
8333017001	Facility	6.25	CABLE
8333021001	Facility	8.17	CABLE
8333022001	Facility	1.00	CABLE
100030813	Facility	0.71	CABLE
8338635001	Facility	0.53	CABLE
8333060001	Facility	1.80	CABLE
8333081001	Facility	10.70	HARNESS W/ BOARD
8333082001	Facility	2.94	HARNESS W/ BOARD
8333085001	Facility	12.93	HARNESS W/ BOARD
8338736001	Facility	21.00	HARNESS W/ BOARD
8338878001	Facility	4.64	HARNESS W/ BOARD
8333040003	Flipper	0.99	CABLE
8333060002	Flipper	1.80	CABLE
8333059001	Flipper	2.22	CABLE
8333059002	Flipper	2.22	CABLE
8333063001	Flipper	6.15	CABLE
8333013001	Frame Assy	2.16	CABLE
8333013002	Frame Assy	2.16	CABLE
8333013003	Frame Assy	2.16	CABLE
8333018002	Frame Assy	0.54	CABLE
8333018001	Frame Assy	0.54	CABLE
8333040001	Frame Assy	0.99	CABLE
8333040002	Frame Assy	0.99	CABLE
8333040004	Frame Assy	0.99	CABLE
8331122001	Frame Assy	3.75	CABLE
8331122002	Frame Assy	3.75	CABLE
8337777001	Frame Assy	1.20	CABLE
8336355001	Frame Assy	0.75	CABLE
8338315001	Frame Assy	7.17	CABLE
8333064001	Kit Ionizer	9.00	CABLE
8335609001	Kit Ionizer	1.50	CABLE
8335610001	Kit Ionizer	1.50	CABLE
8331132002	Lift Assy	1.45	CABLE
8331133001	Lift Assy	1.45	CABLE
8331136001	Lift Assy	5.81	CABLE
8331140001	Lift Assy	2.70	CABLE
8331141001	Lift Assy	5.60	CABLE
8331128001	Tray Transport	1.38	CABLE
8333045001	Tray Transport	7.90	CABLE
8333049001	Tray Transport	3.28	CABLE
8333053001	Tray Transport	3.70	CABLE
8333055001	Tray Transport	3.28	CABLE
8337930002	Tray Transport	3.02	CABLE
8333041004	Tray Transport	2.14	CABLE
8333043003	Tray Transport	4.25	CABLE

Table 3. JLP Cable Assembly for automation

To reduce the cycle time, it is deemed to improve the process from manual to automated. The concept and idea is to create an automatic multi wire cable tester that will test the cable and harness with less time.

3.2 Automatic Continuity Tester

3.2.1 Hardware

The automatic continuity tester consists of LED Box, Cable Multiwire Tester, Connectors.

- LED Box – an open circuit box consists of a 12V/2A power source, Arduino Mega 2560, 220Ω resistors, and 2V 20mA LED's. Programmed to sequentially check the continuity of each wire per cable or harness.

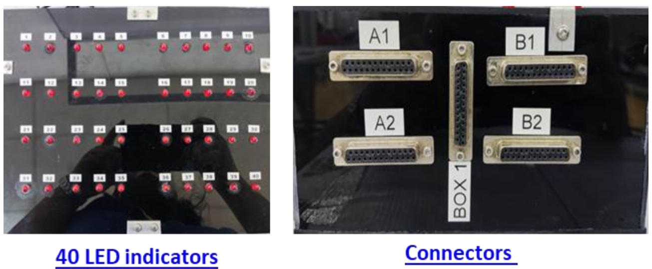

Figure 7. LED Box

- Cable Multiwire Tester – open end-to-end connection for cable. Connectors are embedded and configured per cable assembly.

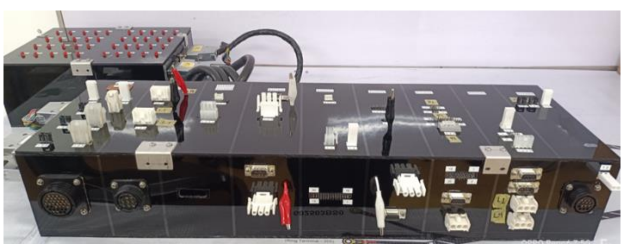

Figure 8. Cable Multiwire Tester

- Harness board – open end-to-end connection for harness. Serve as guide for routing and labelling of the harness and improved to include testing.

Figure 9. Harness board

- Connectors – used to connect LED Box into Cable Multiwire Tester.

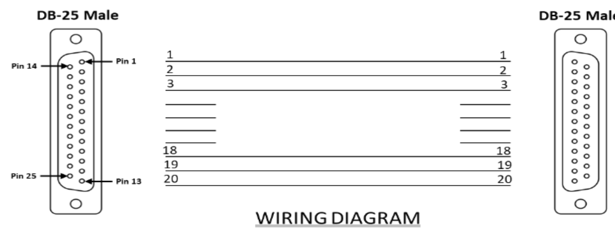

Figure 10. Cable connectors wiring diagram

3.2.2 Testing

The 3 hardware are connected in series as shown in Figure 11 and 12. First is to power up the LED Box by plugging in 220V AC source and connect to the Multiwire Tester using the Connectors. To start the test, connect the cable assembly end-to-end to Multiwire Tester and switch on the LED Box. If the cable is Passed, each LED will go HIGH in the order specified by the wiring diagram's pin number allocation. If the LED is OFF, there is no connection, and if the sequence fails, miswiring occurs.

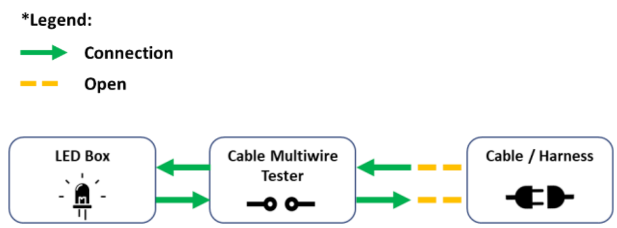

Figure 11. Automated Continuity Tester Operation for Cable

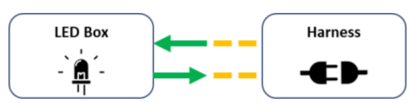

Figure 12. Automated Continuity Tester Operation for Harness

4.0 RESULTS AND DISCUSSION

The automated continuity testing of cable and harness was introduced March 2023. This improved process will help to address the long cycle time of testing in cables and harnesses, resulting in considerable improvements in production efficiency, quality, and obtaining the customer and business unit goal in cost-reduction.

4.1 Cycle Time Result

Based on Table 4, the result of **49.79%** reduction on the testing cycle time from the 66 cables selected and **$3.75** savings for every JLP unit. This also concludes a total savings of **$78.80** from March to July 2023.

	Per 1 JLP unit			
	Before (hrs.)	After (hrs.)	Time Reduction	Cost Saving
JLP Cables and Harness (66 Part Nos.)	3.77	1.89	**1.89 (49.79%)**	**$3.75**

Table 4. JLP Cable Test Cycle Time result and Cost Saving

Based on Figure 13, the comparative cycle time of JLP cable production before and after implementation of the automatic continuity testing.

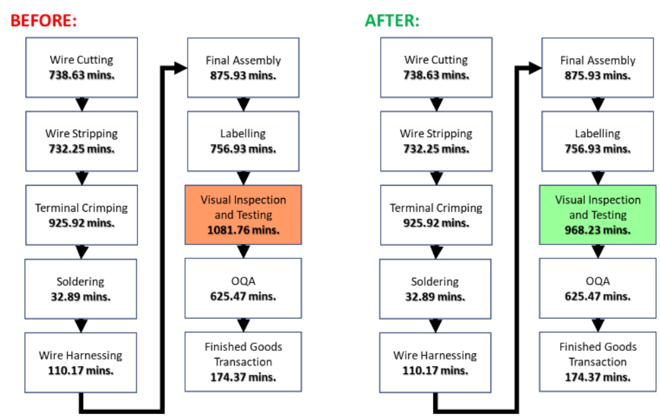

Figure 13. JLP Cable Production Cycle Time Comparison

4.2 JLP Cable Production Efficiency

Based on Figure 14, the result shows the production efficiency from Quarter 1 of 2022 up to Quarter 2 of 2023. An increase of **9%** efficiency from Q1'23 to Q2'23 in between the implementation of the automated testing.

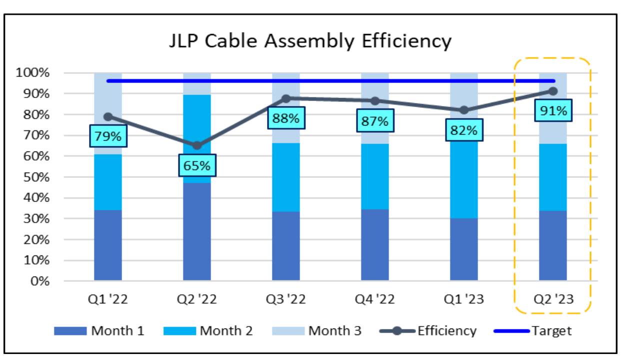

Figure 14. JLP Cable Production Efficiency trend quarterly

4.3 JLP Cable Quality

Based on Figure 15, 28 occurrences of miswiring were reported from 2020-2022, however none were reported as of Q1 up to Q2 of 2023 to which the automatic continuity testing has been implemented.

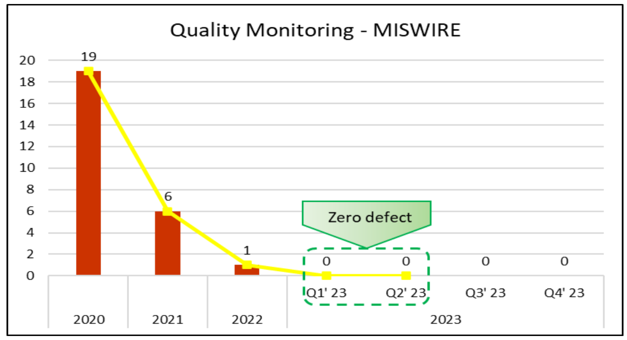

Figure 15. Quality Monitoring

4.4 Return on Investment

Based on Table 5, the data compares the unit cost of the automated continuity tester to the savings realized from reduced cycle time. The investment will be refunded with 86 JLP units by the second quarter of 2024.

Unit Cost	$	321.32
Savings	$	3.75
ROI	**86 JLP units**	

Table 5. Return on Investment (ROI)

5.0 CONCLUSION

The data and results show that automated continuity testing of cable and harness is therefore effective in reducing cycle time and improving production. A total of 49.79% test cycle time was decreased from 66 selected cables and harnesses, resulting in a total savings of $3.75. The tester also makes significant contributions to the detection and prevention of miswiring.

6.0 RECOMMENDATIONS

Automation has a significant impact on cycle time and process efficiency. The use of automatic continuity testing in this project considerably improves the process. Thus, it is recommended to expand the automated testing to other products such as Offline Binning (OLB) and Pick and Place (PnP) MATRIX.

7.0 ACKNOWLEDGMENT

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