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Codes Development of Industrial Mechatronic System

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Abstract. Industrial Mechatronic System (IMS) is a system designed focuses on the simulation of industrial production activities. This study aims to re-operate Industrial Mechatronic System and robot arm as a whole system by means of treating and repairing some of the components and develop the universal and partial codes. The system consists of six stations and a robot arm with different functions. Some of the stations and the robot arm cannot be operated properly and cannot move per-station by using the factory default codes. To operate each station required the development of coding using Programmable Logic Controller (PLC) additional reserve to avoid deletion of codes that exist in the main PLC with according to it's work principle. The results showed that the Industrial Mechatronic System can be used to simulate the production system on a PLC-based industry that can be operated universal and partial.

1. Introduction

Developments in science and technology are so rapid has brought a considerable impact on human society to learn and develop science. In every industry fast and precise work required to face the demand. To face these needs, it is not enough just to rely on human power itself, but also the technology and more advanced controllers. Today many industrial equipment that is equipped with a fully automated equipment.

Along with the advance of the mindset of human resources so as to exclude ideas and creative mind to create a wide variety of human needs aiming device to facilitate human life. One of them in the development of mechatronic products. Mechatronics is a discipline that combines or synergy of engineering, electronic engineering, informatics and engineering techniques arrangement (or engineering control) to design, create or produce, operate and maintain a system to achieve the desired goal. Currently it has many universities open mechatronic majors, and not a few students who are interested to cultivate this science.

Due to this mechatronic system has been widely used in the industrial world, we must first recognize this system in college before plunging into the world of industry. On campus we have been there a system that includes already using mechatronic systems. This tool is a means of supporting the Mechatronics Laboratory practicum at the Polytechnic of Ujung Pandang. This tool is called Industrial Mechatronic System, which this tool serves to provide information or a shadow to the students of mechatronic systems in the industry. This tool control system using PLC (Programmable Logic Control).



However, today these tools cannot be used as a whole, because there are some damaged components and problems on the configuration. As for the condition of Industrial Mechatronic System in this time that the conveyor does not run smoothly, several stations and a robot arm that cannot be operated properly and this tool cannot move a per-station for using the factory default program.

To address the shortcomings outlined above, we as students of Mechatronics feel motivated to make improvements and refinements of existing tools, and create a new control system that uses a system of Programmable Logic Controller (PLC). So that the tool is no longer using the default control system of the plant and also can be controlled independently, which means that the tool can be moved per-station.

2. Literature Review

2.1. Definition of Industrial Mechatronic System (IMS)

Industrial Mechatronic System (IMS) provides a simulation system that is similar to the existing system in the industry with varying degrees of difficulty. Industrial Mechatronic System (IMS) is a modular system that can be run freely and module design is also easily expanded. This means it can add to the knowledge of students before knowing and also expand knowledge after knowing and studying these systems [1][11].

As for the parts of the Industrial Mechatronic System that is:

- Selection station serves to place the workpiece on the workpiece carrier.
- Assembly station serves to combine or unite the workpiece.
- Processing station serves to lock or process the workpiece.
- Testing station serves to check the workpiece. storage station responsible for maintaining or developing the workpiece on each shelf / place based on the color and material of the workpiece.
- Robot arm used to move the workpiece from the storage station to disassembly station.



Figure 1. Industrial Mechatronic System

2.2. Composer Components Industrial Mechatronic System (IMS)

2.2.1. *Industrial Mechatronic System (IMS)*. Industrial Mechatronic System consist of: Sensor is a device for detecting / measuring something that is used to change a variety of mechanical, magnetic, heat, light and chemistry into a voltage and electric current. The sensor itself consists of a transducer with or without an amplifier / signal processor which is formed in the sensing system. In an environment control systems and robotics, sensors give equality resembling the eyes, ears, nose, tongue then be processed by the controller as the brain [2].

As for the various sensors used in Industrial Mechatronic System are:

- Magnetic sensors serve to monitor / monitoring the movement of the cylinder.
- Sensors monitor the mechanical function of the level of the workpiece.
- Inductive sensors detect metal function.
- The optical sensor function identifies white superstructure.
- The capacitive sensor serves to detect the presence of the workpiece and raise the stopper.

An electric motor is an electric machine that converts electrical energy into mechanical energy. Construction of motor and generator is basically the same. DC motor develops a big moment and allows setting the number of rounds without stages. The number of motor rotation can exceed the rotational field [3].

In industrial mechatronic system (IMS) only uses two types of cylinders are single acting cylinders and double-acting cylinder. The explanation of the second cylinder in Table 1. as follows:

Table 1. Various Kinds of Linear Actuators

NAME ACTUATOR	INFORMATION	SYMBOL
Single work cylinder	<ul style="list-style-type: none"> • Cylinders with pressure only work in one direction (step forward) • Step back with the external force 	
Single work cylinder	<ul style="list-style-type: none"> • Step back by spring 	
Double work cylinder	<ul style="list-style-type: none"> • Cylinders with pressure can work in both directions (step forward and backward): With a single piston rod 	
	<ul style="list-style-type: none"> • With double piston rod 	

The vacuum generator is used to produce air vacuum or air suction. Used in conjunction with a suction cup to move a variety of workpieces. This tool works on the principle of venturi meters (vacuum) [4].

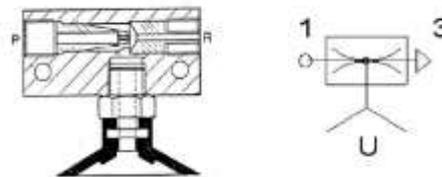


Figure 2. Vacuum Generator

2.2.2. *Robot Arm (Manipulator)*. Industrial Mechatronic System consist of: The robot arm includes part of the tool Industrial Mechatronic System. There are many types of robot arm RS03N one type robot with specification shown in Table 2.

Table 2. Specifications Robot Arm Type RS03N and Controller E76

Type Robot	RS03N
degrees of Freedom	6 DOF (Degree of Freedom)
Weight	20 kg
Motorcycle	Brushless AC Servo Motor
Battery Type	Maxell Lithium Battery 3.6V AA ER6C
Controller Type	E-Controller E76
Memory capacity	8 MB
interface checker	USB, Ethernet, RS232C



Figure 3. Robot Type RS03N

Type of controller used for robot arms are E-Controller E76, where in the controller is very compact and is designed specifically for small arm robot as RS03N, 05N, 05L, 06L and 10N. although compact in design, these controllers offer the performance and the ability to upgrade high and high-performance CPU provides accurate control, high-speed program execution as well as the loading and storage of files very quickly. [5]



Figure 4. E-Controller E76



Figure 5. Teach Pendant.

2.3. Configuration Control on Industrial Mechatronic System

2.3.1. *Programmable Logic Controller (PLC)*. Industrial Mechatronic System consist of: Programmable Logic Controller (PLC) is a specialized type of microprocessor-based controller that utilizes a programmable memory to store instructions and to implement functions such as logic, timing, counting and arithmetic to control machines and processes [6]. PLC concept is as follows:

- Programmable; demonstrated that can easily be customized program created and ability in terms of program memory that has been made.
- Logic demonstrate the ability to process input arithmetic and logic, which perform operations compare, add, multiply, divide, subtract, and negation.
- Controller; demonstrate the ability to control and manage the process so as to produce the desired output.

2.3.2. *PLC programming structure*. Programmable Logic Controller (PLC) provide various types of user program blocks which relate to data that can be stored. Depending on the purpose of the process, the program can be arranged in a different block.[7]

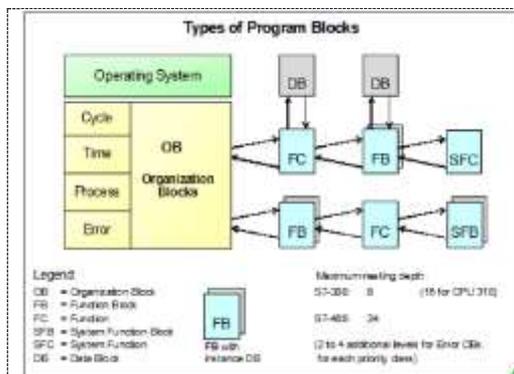


Figure 6. Type of Program Block

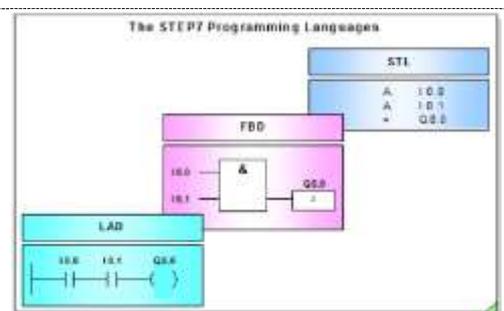


Figure 7. PLC Programming Language

There are several options that can be used programming languages in STEP 7 as follows:

- Ladder Diagram (LAD), a programming language that is similar to the circuit diagram. This programming language is often an attraction for programming that has a background as an electrical drafting and, because it uses symbols such as coil, contact, etc.
- Statement List (STL), which are sets of instructions statement STEP 7. This programming language is preferred by programmers familiar with using various programming languages.
- Function Block Diagram (FBD), a programming language that uses a box-box functionality. FBD benefit can be used by "non-programmer" for every box-box has indicated a specific function such as operation logic functions. [8]

2.3.3. Communication Profibus. Some important aspects required in a PLC system as the interconnection network PLC. PROFIBUS is a good solution for network interconnection between the PLC, and the PLC with other interfaces. Profibus is an interconnection in the PLC network covering both types of cables, connectors, and interfaces such as the Repeater, Power Rail Booster and many others. PROFIBUS standardized in accordance with the International Electrotechnical Commission (IEC) 61 158 on the standardization of field bus specifications. Profibus is available in many forms for various applications [9].

According to the Profibus functions are divided into three types of PROFIBUS, the PROFIBUS DP, PROFIBUS PA, PROFIBUS FMS. PROFIBUS Distributed Input / Output (PROFIBUS DP) This connection is used for the distribution of field devices such as SIMATIC ET 200, or drivers with a very fast response time. PROFIBUS DP has a standard - compliant components from a wide variety of tools and producer's addition Siemens also can connect. PROFIBUS Process Automation (PROFIBUS PA) is a development of PROFIBUS DP with Intrinsically Safe Transmission technology in its reference to the standard IEC 61158-2. PROFIBUS Field bus Message Specification (PROFIBUS FMS) is a PROFIBUS that is designed specifically for field bus communication process. [10]

2.3.4. Maintenance Tool. Maintenance tool consist of:

Treatments are activities undertaken to improve, maintain, and restore the equipment in good condition and ready to use. In relation to the care of laboratory equipment, maintenance is intended as a preventive effort that equipment is not damaged or maintained in good condition, ready to operate. Besides, the treatment is also intended as an attempt to set or restore laboratory equipment is already damaged or less decent, so ready to be used for practicum students.

The Goals of Treatment are to Maintenance of laboratory equipment include:

- In order for the laboratory equipment is always primed, ready to be used optimally
- Extend lifespan
- Ensure smooth learning activities

- Ensure safety and comfort for the users
- Knowing early damage or injury symptoms
- Avoid sudden failure

Maintenance is the ways or methods to conduct laboratory equipment maintenance work that can be done among others by:

- Prevention, for example by giving a warning through drawing or writing, regulations, codes of conduct for users of laboratory / workshop, gave preservatives.
- Store, for example storing laboratory equipment in order to avoid damage.
- Cleaning, so that the laboratory equipment is always clean from dirt which could damage, such as dust and moisture that can cause corrosion.
- Maintain, for example, with oiling of mechanical equipment.
- Inspect or check the condition of laboratory equipment to determine the presence of symptoms.
- Realign or tune-up, calibration of equipment for the facility or the equipment under normal conditions or standards.
- Repair minor damage that occurs in the laboratory equipment limit certain damages that may still be repaired, so ready for use in practicum students.
- Replace components of laboratory equipment that is damaged.

3. Research Methods

The design diagram as a guide in the research process, development codes, repair and maintenance tool Industrial Mechatronic System as follows:

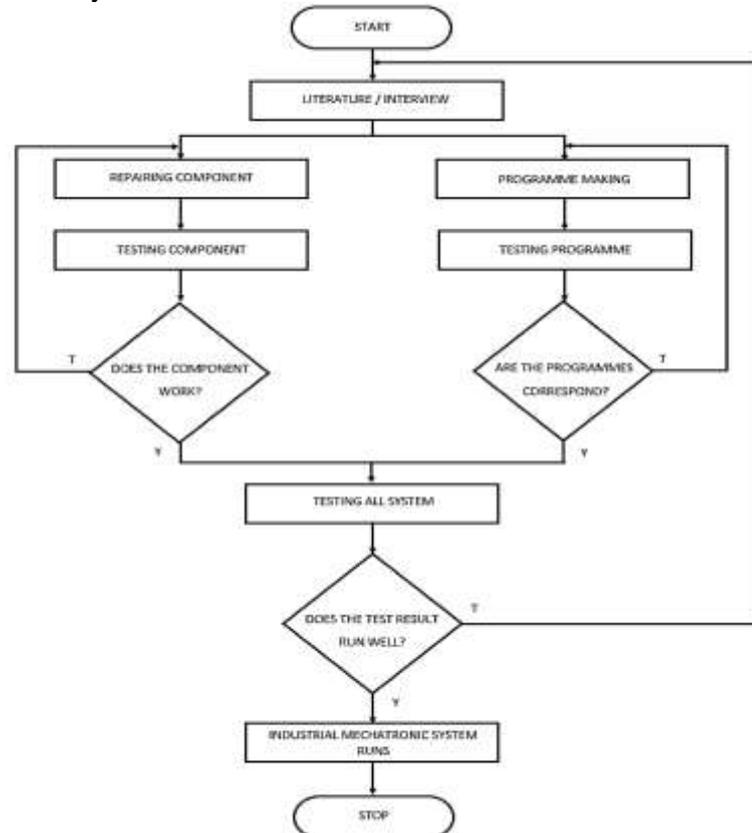


Figure 8. Flowchart System Design

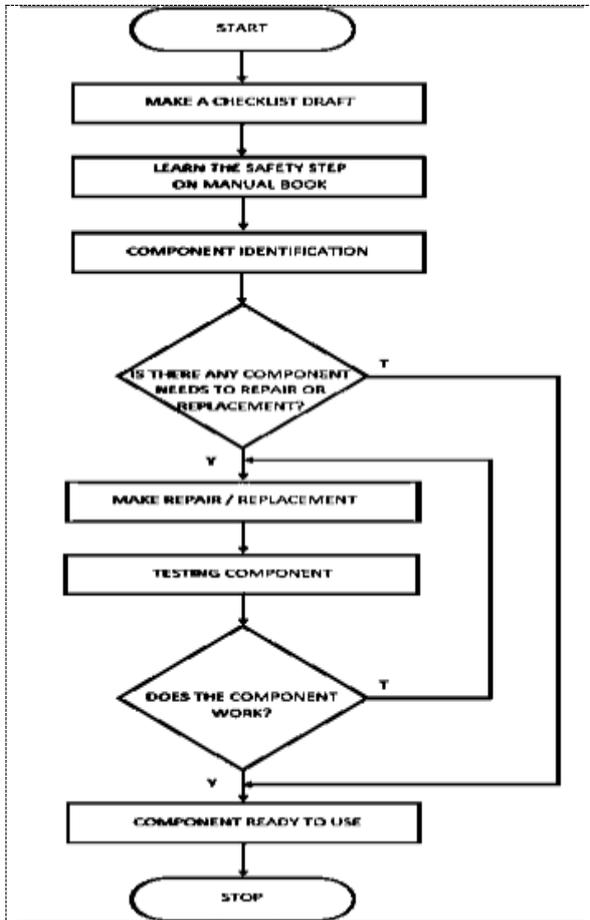


Figure 9. Flowchart Maintenance and Repair

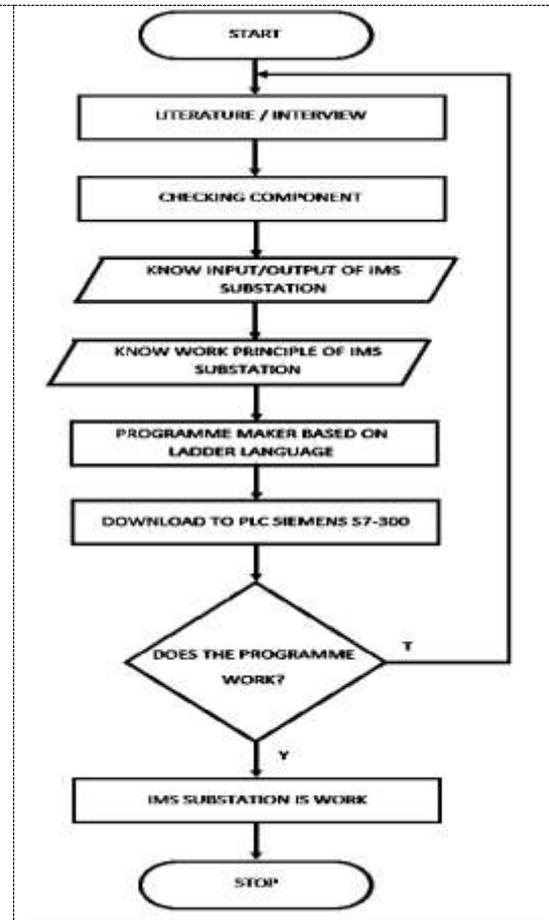


Figure 10. Programming Flowchart

3.1. Literature/Interview

In a research tool, the first step to do is to find as much data as well as information via CD-ROM Lab Soft, various print and electronic, weblogs, videos, as well as a general encyclopaedia.

3.2. Simulation

Trying to simulate sub-station by using the system UniTrain-1 as an introduction and to check the function of each component of IMS sub-station. UniTrain-1 system is a simple application with didactic structured introduction to the control of each sub-system and a preparation for integration and process control of production lines with industrial standard equipment using PLC.

In addition to using the tool to simulate the system UniTrain-1, can also be simulated directly using the factory default program so it can be observed working principle and function of components.

Once all components are functioning properly, then the next simulation is done is communicate between sub-station. Communication used for interconnection of the sub-station Industrial Mechatronic System is a Profibus DP interface. Cable connections to Profibus is the length of 1,5meter and 2x connection plug, Profibus line with two terminals for the Master and Slave unit.

Profibus DP is commonly used in industry and is a realistic application in automation engineering. The basics of this system is presented in graphic and practice-oriented using automation techniques Uni-Train-1.



Figure 11. System UniTrain-1



Figure 12. System UniTrain-1 with Profibus Communication

3.3. *Manufacture Program*

After doing a simulation and already know all of the code, byte and Profibus adress, then the tool is set for the program.

4. Result and Discussion

4.1. *Result*

4.1.1. *Maintenance tool.* The maintenance carried out by the authors, namely, Cleaning components of Industrial Mechatronic System. The author's purpose cleaning components Industrial Mechatronic System is that the components Industrial Mechatronic System always clean from dirt which could damage, such as dust and moisture that can cause corrosion.

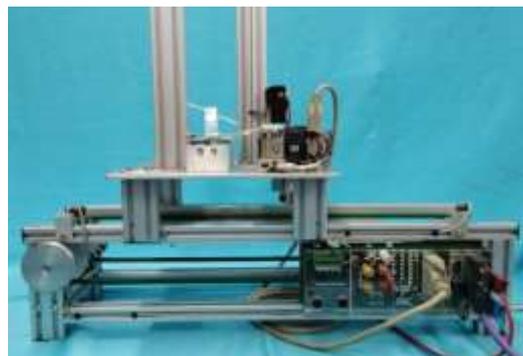


Figure 13. Components that have been cleared

Then, The author's intent installing the parts correctly in order for the tool Industrial Mechatronic System in normal and safe to operate.

The components are installed properly as follows:

- Equitable pedestal subsystem
Levelling pedestal subsystem is very important. If the pedestal subsystem uneven, will lead the process in the subsystem is not running smoothly. Therefore, the authors smoothing pedestal subsystem so that the process runs smoothly and safely. So as to maintain the smooth operation of the learning.
- Improvements position sensor

The position sensor that can affect whether or not the tool runs smoothly. Therefore, in the final project writer, fix all the incorrect position of the sensor, so that the tool can function properly and there are no unwanted errors.

- Repair vacuum position

The author's purpose in order to improve the position of vacuum is a vacuum can suck the workpiece exactly so that when the workpiece moves up, the workpiece remains stable.

Making the list this checklist aims to examine or check the existence of early equipment failure or the presence of symptoms. While the manufacture of SOP is intended as a precaution. Because the SOP contains warnings through pictures or writing, regulations, codes of conduct for laboratory users. So, before doing practicum student must pay attention to the SOP and fill in the checklist tool if the tool is ready to use or not.

4.1.2. Repair tool. As for some of the components that have been made by the author of the repair process, namely:

- Repair limit sensor processing station

Improvements made to the author of the limit sensor processing station that broke caused concussion of the carrier during the process of practicum connect sensors with sensor stand.



Figure 14. Limit Sensor Repaired



Figure 15. DC motor which has been tensioned between Pulley with Shaft

- Improvements to the Z-axis DC motor of storage station

Improvements to the DC motor as the Z axis on storage station only on mechanical improvements. Repairs on the author is tighten bolts with shaft pulley. As the lead screw is loose when the practicum, students forcibly pull belt to reach the starting position the Z axis storage station (B1). The cause of the Z axis does not reach its initial position when the storage station to operate sometimes water flow sensor is inactive due to several things like air pressure compressor which does not reach a minimum pressure of 6 bar and no workpiece on the carrier. This causes the Z-axis DC motor continues to rotate until the emergency sensor is active, so the storage station ceased to operate and cannot return to the starting position despite the reset button has been pressed.

- Battery replacement robot arm

Weak battery voltage causes the robot arm cannot be operated either manually or automatically, the authors replace the battery with a new battery that has the same voltage is 3.6 V.



Figure 16. New Battery had Mounted on a Robot Arm

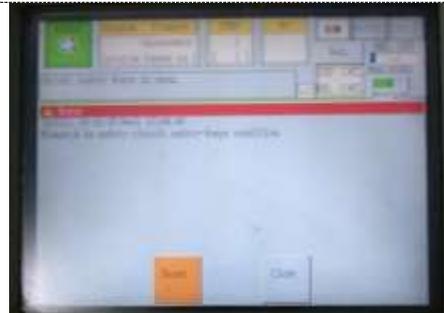


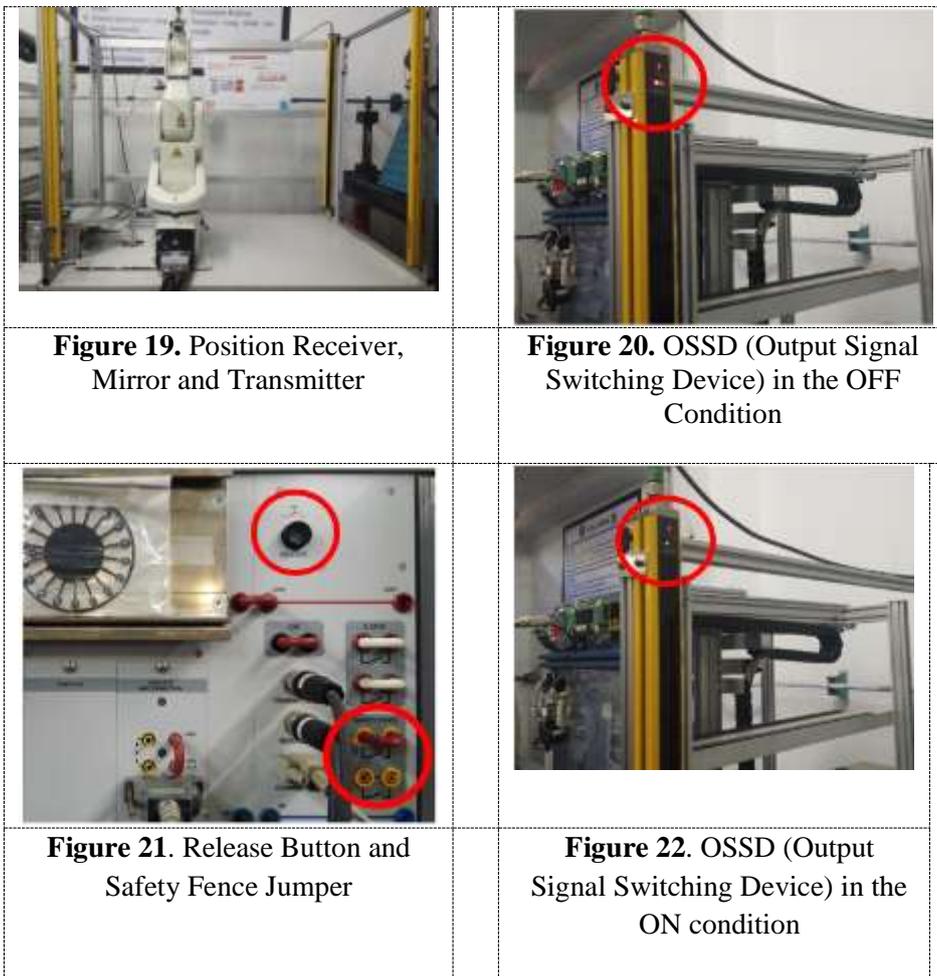
Figure 17. Error Display on Teach Pendant Shows Safety Fence is Open

- Enabling automatic mode of robot arm
Robots have to operate but still a manual mode, the authors seek mode to activate automatic configuration of robots. The cause of the automatic mode is not active because of safety fence jumper on PLC panel is not connected. After the author connects the safety fence jumper on PLC panel, error safety fence is open on the teach pendant can be reset and the robot has to operate automatically.



Figure 18. Jumper Safety Fence Panel PLC

- Enabling people safety sensor robot arm
When the robot arm operates automatically, then the movement according to the steps of the program without human control and therefore needed a sensor that serves as a safety of human beings or objects that can interfere with the movement of the robot. The sensor is also not active simultaneously with a robot arm that is inactive due to a weak battery voltage. After the author looking for a configuration to activate the sensor, such as finding the angle right between the receivers, mirrors and transmitter, installation of jumpers safety fence on the panel PLC correctly that only one jumper that connects and activates the OSSD (Output Signal Switching Device) by pressing release on the panel PLC then safety sensors have been active people.



4.1.3. Programming development.

- Programming development of station 1 to station 5
 In this final project, the author has developed the programming on Industrial Mechatronic System without removing the factory default program that is to create a program partial and universal. That is the program partial namely, Industrial Mechatronic System has been able to operate on a per-station or in whole. The byte address and Profibus address to create manual and automatic program are:

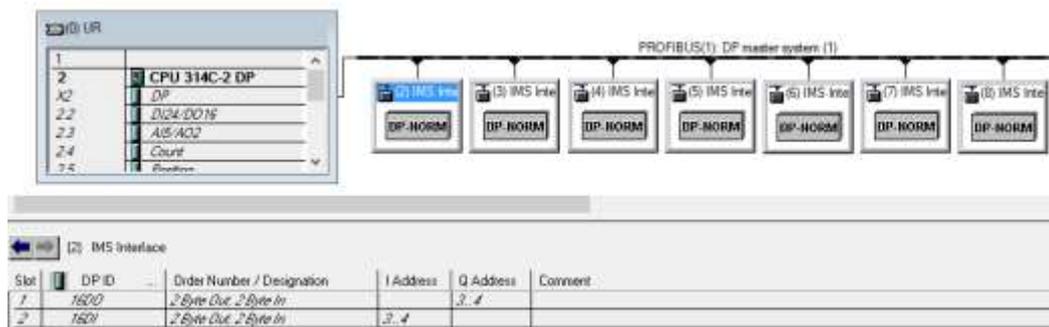


Figure 23. Byte Address and PROFIBUS Address

Below is a table Byte and PROFIBUS address.

Table 3. Byte and PROFIBUS Address

No	Sub-Station	Profibus Address	Byte Address	Nilai X
1	Selection Station	2	3...4	3
2	Assembly Station	6	11...12	11
3	Processing Station	4	7...8	7
4	Testing Station	3	5...6	5
5	Storage Station	8	15...16	15
6	> Storage Station	5	9...10	9
7	< Selection Station	7	13...14	13

- Home position robot arm (manipulator)
 Due to the long arm robot is not operated, this led to the starting position the robot arm is not in the home position in the teach pendant and there is no program to return to the home position. Meanwhile, in order to operate properly robot arm should be in a state home position. Therefore, in the final project, the authors conducted a programming development program was the production of home position. Writer inputting programs into the home position teach pendant, this so young students can restore the robot arm into the home position.
- Editing program arm robot (manipulator)
 The author did a little modification to the default program robot arm, the program at the time of the robot arm will be put one by one part of the workpiece.



Figure 24. Home Position Robot

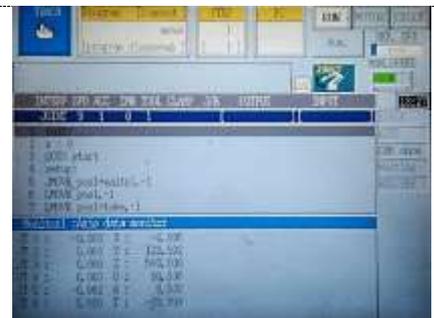


Figure 25. Program Display the Home Position Robot Teach Pendant

4.1.4. *Making the learning module and job sheet.* Job sheet learning modules and is designed to help students achieve the purpose for doing practical work. Job sheet learning module and this is a learning tool that provides materials, methods, SOPs and check lists listing tool.

4.2. *Discussion*

In initial tests of the tool, the authors do not use the system simulation UniTrain-1 because there are some CDs to install Lab soft has been damaged, so the authors studied the working principle and configuration tools Industrial Mechatronic System of built-in program.

PLC is part of the Industrial Mechatronic System that serves as the controller, while PROFIBUS is used to communicate between stations, thereby reducing the use of wires and use the input output (I / O) PLC.

Use of PROFIBUS on Industrial Mechatronic System that communicates between the PLC with other interfaces, using the type of PROFIBUS-DP (Distributed Input / Output). Where the PROFIBUS types, matched with the PLC used in the final project the author.

Since all the stations on Industrial Mechatronic System has the same device, thereby using PROFIBUS addressing to differentiate the devices from one another.

In the Industrial Mechatronic System also has the disassembly station that serves to separate parts of the workpiece. The process to move a workpiece from the storage station to disassembly station using the help of a robot arm.

The robot arm using a separate controller that is E-Controller E76 connected to the connector on the panel PLC robot Industrial Mechatronic System uses DB-9 cable to communicate with all the station robotic arm on Industrial Mechatronic System.

Robot arm people equipped with safety sensors to prevent accidents caused by human error or other factors. People Safety sensor works automatically, a system that has been programmed with a coherent and in some cases are not in the program cannot be avoided so that people safety sensor serves as a feedback tool when something happens that is not in accordance with the procedure.

5. Conclusion

Form the research conducted, it can be concluded that:

1. Has developed a system of partial control on Industrial Mechatronic System and robot arm which can simulate the working system in the industry with some components of the pneumatic, DC motors and sensors.
2. Has developed a system of automatic control on the Industrial Mechatronic System and robot arm which can simulate the working system in the industry with some components of the pneumatic, DC motors and sensors.
3. Job sheet been prepared containing the overall experimental procedure stations, operational standards implementation, and check the list of learning modules PLC to support the process of student practicum.

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