Items' Filling System Prototype with Sorting System According to the Color and Height of the Conveyors based on PLC Omron CPE1E

Sumardi Sadi[1], Sri Mulyati[2], Didik Agung Kurniawan[3]

[1,3]Electrical Engineering Study Program, Faculty of Engineering, University of Muhammadiyah Tangerang
[2]Informatic Engineering Study Program, Faculty of Engineering, University of Muhammadiyah Tangerang

---***---

Abstract - *Technological developments, especially in the industrial world, are increasing rapidly. It demands developments in production efficiency. Optimization is needed both from the performance and production results, so that maximum work efficiency can be obtained. One of the optimization processes is a filling system with sorting system according to the color and height of the container based on CP1E PLC OMRON. The purpose of the prototype system of filling the items with a separator system in containers based on color and height is to detect different colored and high containers that are moved by a conveyor, then the filling process uses two types of marbles which will fall into containers with different amounts and colors . This tool uses the main PLC OMRON CP1E-E40DR-A control. The method used is the manufacture of a control system using Omron CP1E-E40DR-A PLC with a DC motor as a conveyor drive and charging system. For color and height detection, the container uses the TCS3200 sensor configured with Arduino Uno and the LDR sensor circuit, and also an infrared sensor circuit to detect the number of marbles falling into the container. The need for Regulator IC 7805, 7806 and 7809 to reduce 12VDC voltage to 5VDC, 6VDC and 9VDC to drive DC motors, Arduino Uno, LDR sensor circuits and infrared sensor circuits. The TCS3200 sensor reading distance to the container is 10mm, the LDR sensor to the container is 20mm and the infrared sensor distance to the photodioda is 20mm.*

*Key Words***: Sorting System, PLC, Conveor, Sensor, Arduino.**

1. INTRODUCTION

1.1 Background of The Study

The development of control systems in the industrial world leads to production automation. Conveyor system is a technology for goods transportation in the industry from one part to another, both for the purposes of quality control, product packing, assembly and others. This technology is very important for industrial process automation. The purpose of production automation itself is not only to increase productivity and reduce costs of working, but also should be able to run automatically and computerized.

However, the fact is that the replacement of the type of goods on production process in the conveyors is conducted manually by human labor. So, there are some disadvantages of using a manual system includes the need for costs of labor, having to use a shift system due to limited human labor, human error due to humans who tend to get bored to do routine work. To overcome the existing problems, we need a system that can run automatically in replacing the type of goods on production process to replace the role of humans.

The purpose of this study has the following tendencies:

- Optimizing and increasing productivity in the industry.
- Saving production costs in the industry.
- Designing prototypes that are flexible and practically applied in life.

2 LITERATURE REVIEW

2.1 PLC *(Programmable Logic Controller)*

PLC is a system that can manipulate, execute, and monitor process conditions at a very fast rate, with a data base that can be programmed in an integral microprocessor-based system. PLC receives input and produces output of electrical signals to control a system. The PLC is specifically designed to handle an automatic control system on industrial machines or non-industrial applications. The inside look of the PLC CPU can be imagined as a set of thousands of relays. However, it does not mean that there are many relays in a very small size. The inside part of PLC contains digital electronic circuits that work as NO contacts and NC relay contacts. The difference with relay is that one relay contact number (both NO and NC) on the PLC can be used multiple times for all basic instructions other than output instructions. In general, PLC has five

basic components. These components are the Power Supply Module, Central Processor Unit, Input / Output Module, Memory.
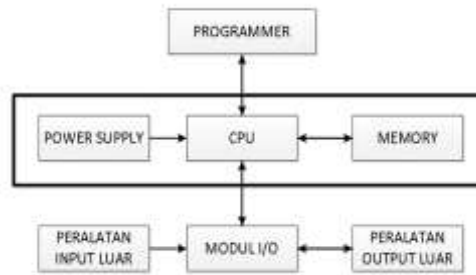
Picture 2.1 Parts of PLC [11]

2.2 Arduino ATMega328

Arduino Uno is an ATMega328 based microcontroller board. It has 14 input pins from digital output, which 6 input pins can be used as PWM (Pulse Widht Modulation) output and 6 analog input pins, 16 MHz crystal oscillator, USB connection, jack power, ICSP header, and reset button. To support the microcontroller so that it can be used, just connect the board Arduino Uno to the computer using a USB cable and AC adapter as a supply or battery to run it. The advantages of Arduino are that it does not need a chip programmer device because there is already a bootloader that will handle upload programs from the computer, Arduino already has a USB communication tool, so laptop users who do not have serial / RS323 ports can use it. Its programming languages are relatively easy because the Arduino software is equipped with a fairly complete set of libraries, and Arduino has a ready-used module (shield) that can be plugged into the board Arduino.
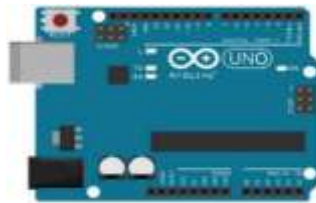
Picture 2.2 Arduino Uno [9]

The following Arduino Uno specifications are as follow:

- Microcontroller chip : ATmega328P
- Operational voltage   : 5V
- Input voltage : 7V - 20V
- Digital I/O pin : 14 pieces, 6 of them are PWM
- Analog Input pin : 6 pieces
- DC current per pin I/O : 20 mA
- DC current 3.3V : 50 mA
- Memori Flash : 32 KB, 0.5 KB for bootloader
- SRAM : 2 KB

2.3 Sensor Warna TCS3200

The TCS3200 color sensor module uses the TAOS TCS3200 RGB chip. This module has been integrated with 4 LEDs. The TCS3200 color sensor can detect and measure the intensity of visible colors. Some applications that use this sensor include: color reading, items grouping based on color, ambient light sensing and calibration, color matching, and many other applications. The Chip TCS3200 has several photodetectors, with each color filter such as, red, green, blue and clear. These filters are distributed in each array. This module has an oscillator that produces square pulses which frequency is the same as the color detected. This sensor has several features including:

- *Power*: (2.7V to 5.5V)
- *Interface:Digital* TTL
- *High-Resolution Conversion of Light Intensity to Frequency*
- *Programmable Color and Full-Scale Output Frequency*

- *Power Down Feature*
- *Communicates Directly to Microcontroller*
- *Size*: 28.4x28.4mm

Picture 2.3 Sensor TCS 3200 [5]

2.4 Infrared Sensor

Infrared is an electromagnetic wave which wavelength is more than visible light, which is between 700 nm and I mm. Infrared light is an invisible light. When we see it by a light spectroscope, infrared radiation will appear in the electromagnetic spectrum with wavelengths above the wavelength of red light. With this wavelength, this infrared light will not be visible to the eye but the heat radiation it causes can be felt / detected.

Picture 2.4 *Infrared Sensori*[7]

2.5 LDR (*Light Dependent Resistor*)

LDR *(Light Dependent Resistor)* is a light sensor. It is one type of resistors which resistance value is influenced by the light it receives. The LDR has characteristics that if there is light falling on it, the value of the resistance will decrease and the resistance will increase if the light intensity decreases. The LDR will have very large obstacles when there is no light (dark). In the dark conditions of the LDR resistance, it can reach 1 Mohm. However, if it is exposed to light, the LDR resistance will drop drastically to a value of only a few tens of Ohms.

Picture 2.5 LDR (*Light Dependent Resistor*)[6]

3 RESEARCH METHOD

3.1 Procedure of Control Device Assembly

This control device consists of several parts, including DC voltage power supply that will be used by Arduino and other supporting devices, Arduino uno as the main controller in the color selection system in the container, TCS 3200 sensor as Arduino input for color reading in the container, relay songle SRD 5VDC as the output of Arduino uno and also an input device for PLC, PLC is the main device as the controller of the entire system from this prototype and the push button as input for PLC input.

**Picture 3.1** Block Diagram of Power Control

3.2 Working Process and Mechanism

In making this final project, a prototype was designed using a conveyor which carries different color and height labels with containers. The way the system works is, at first, the filling object in the form of marbles with two different colors are placed on the filling point that has been made on the conveyor. After that, the container is placed on the conveyor when the container approaches the color sensor and LDR sensor. The sensors will detect the container, then it will be processed by the PLC. It will fill the container with the color and number of marbles that have been determined. The number of marbles falling into the container will be detected by an infrared sensor. After filling the marbles, the conveyor will move again.

3.3 Design Procedure of Conveyor Mechanic dan Filling objects

In the mechanical design of the conveyor, such as, designing a prototype using the Autocad 2013 software. The use of basic materials for conveyor mechanics includes 24x14mm allumunium elbow as thick as 1 mm, 8 mm thick wooden board, and ½ inch pvc pralon pipe. The size of conveyor belt's width is 125 mm, conveyor's length is 630 mm, width 230 mm and height 430 mm. Then for containers sized 75 mm x 95 mm with two different types of heights which are 102 mm and 142 mm, which is made of 8 mm thick wooden board.

The author uses marbles as an ingredient for filling items with a diameter of marbles of 18 mm. The height distance of filling items with the base of the container is 170 mm.
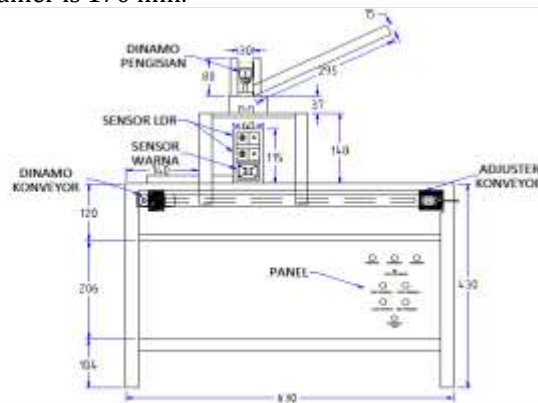
**Picture 3.2** *Prototype* Front Look
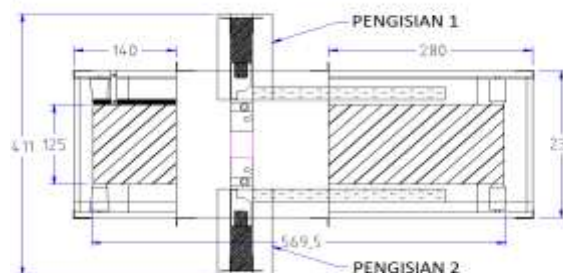
**Picture 3.3** *Prototype* Upper View

3.4 Hardware Design

This schematic diagram will become a rule in assembling each component. Control devices are designed to be one board that includes several sub-functions as in the control diagram block. Therefore, to get the components that are in accordance with the specifications of the needs, adjustments are needed based on the datasheet so that no errors occur in their use.

In this case, the author has classified each sub-section in the overall design into four parts. The first part is the 9VDC, 6VDC and 5VDC Regulator circuit, the second part is the LDR Sensor Light (Light Dependent Resistor), the third part is the Arduino with the TCS 3200 color sensor and the 5VDC relay module, the fourth part is the Infrared Sensor component. Overall, the hardware device is explained in the block diagram
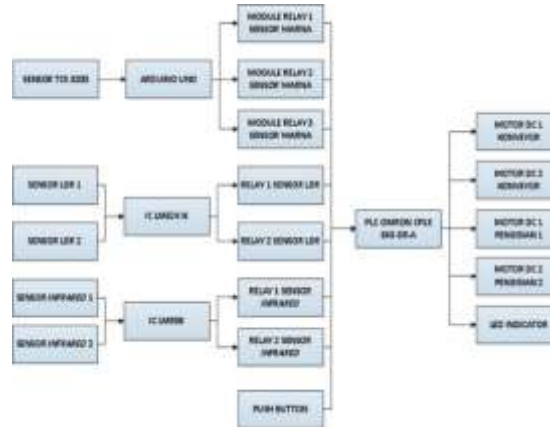
Picture 3.4 Block Diagram Hardware
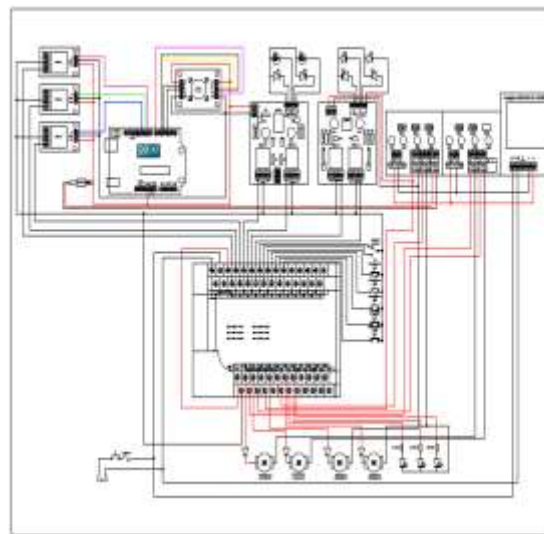
Picture 3.5 Overall Schematic Circuits

## 3.5 Regulator Circuits of 9VDC, 6VDC and 5VDC

The voltage regulator used in the controller device are three types, 9V regulator, 6V regulator and 5V regulator. In this case the component used is a regulator IC with types 7809, 7806 and 7805. Based on the datasheet, this regulator IC has an output voltage tolerance of ± 4%. So that the output voltage range of IC 7809 is 8.69V, IC 7806 is 5.85V while output IC 7805 is 4.97V. This is still sufficient tolerance to supply the circuit
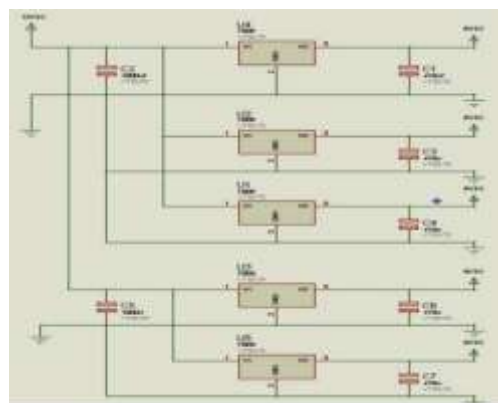
Picture 3.6 *Regulator* Circuits 9VDC, 6VDC dan 5VDC

### 3.6 LDR Sensor Circuit *(Light Dependent Resistor)*

LDR sensor (Light Dependent Resistor) is used to detect the height of the container placed on the conveyor. This LDR sensor circuit uses the LM324 OP-AMP IC as a comparator and transistor BC547 as a switch circuit to control the relay. This series of sensors are made of two circuits, divided into: the first circuit to detect containers with a height of 102 mm and the second circuit for containers with a height of 142 mm.
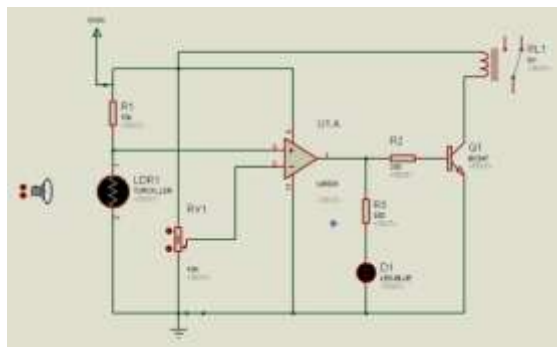
Picture 3.7 Rangkaian sensor LDR *(Light Dependent Resistor)*

3.7 Arduino Uno with TCS 3200 Color Sensor and 5 VDC *Module* Relay

Arduino uno is supplied with a 9VDC voltage, which is the output from regulator 7809. TCS 3200 color sensor is used to detect the type of color that is configured with Arduino Uno and relay module as output. The colors detected are red, yellow and blue.
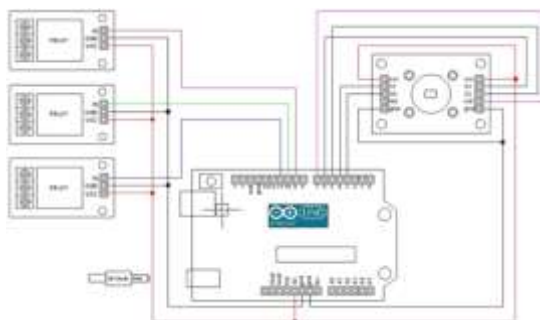
Picture 3.8 TCS 3200 Color Sensor Circuit with Arduino uno and module relay 5VDC

3.8 Infrared Sensor

Infrared sensor is used to detect marbles that fall into containers placed on conveyors. This Infrared sensor circuit uses OP-AMP LM358 IC as a comparator and transistor BC547 as a switch circuit to control the relay. This series of sensors are made of two sets, divided into: the first series for calculating black marbles and the second for white marbles. Installation of the Infrared beam transmitter sensor is placed perpendicular to the photodioda.
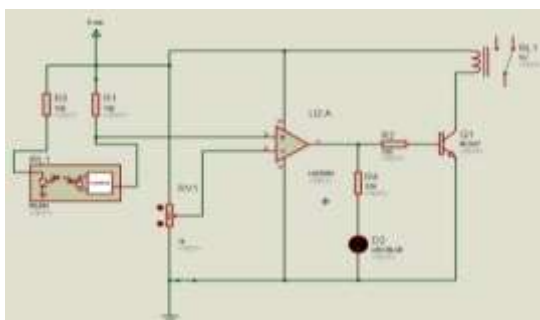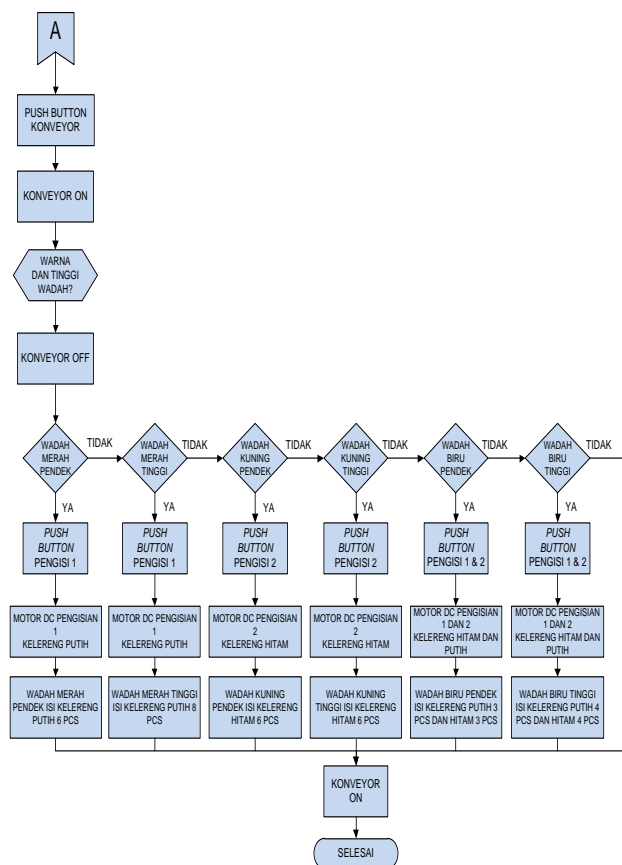

Picture 3.9 Infrared Sensor Circuit

3.9 Flowchart
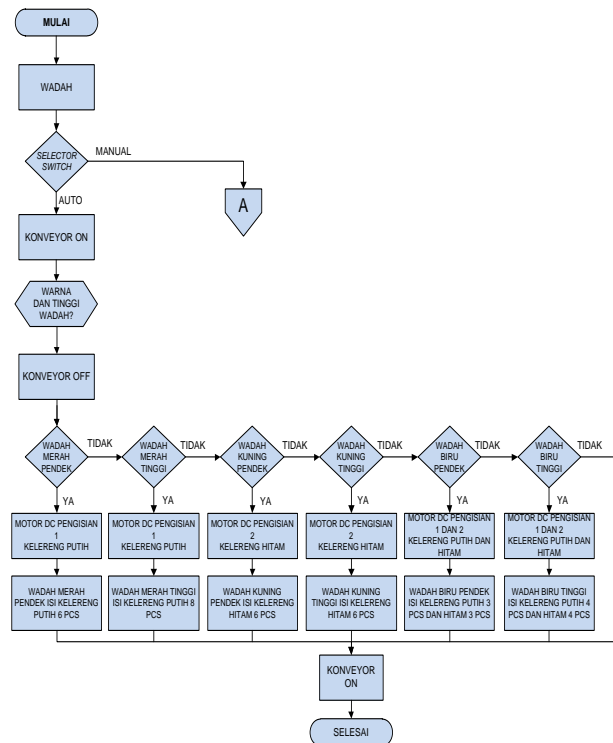
Picture 3.10 Flowchart of Overall System (part one)

Picture 3.11 Flowchart of Overall System (part two)

4 RESULTS AND DISCUSSION

4.1 Testing of 12VDC Power Supply and Regulator IC7805, 7806 dan 7809

12 VDC	220 vac	12,15 vdc
7805	12,15 vdc	4,97 vdc
7806	12,15 vdc	5,85 vdc
7809	12,15 vdc	8,69 vdc

4.2 Testing of Arduino with TCS 3200 Color Sensor and *Module* Relay

Pins	Colors	*Module* Relay 1		*Module* Relay 2		*Module* Relay 3	
		Output Voltage of pin 9	Relay Status	Output Voltage of pin 10	Relay Status	Output Voltage of pin 11	Relay Status
9	Red	0,53 DC	OFF	3 VDC	ON	3,50 DC	ON
10	Orange	3,84 DC	ON	0,99 DC	OFF	0,75 DC	OFF
11	Blue	3,55 DC	ON	3,30 DC	ON	1,39 DC	OFF

4.3 sting of LDR Sensor Circuit

Sensor	Distance of Sensor to Containers	Detected	Voltage at pin out IC LM324 N	Voltage Relay	Relay Status
LDR 1	2 cm	blank	3,04 vdc	4,81 vdc	ON
LDR 1	2 cm	short container	-4,68 vdc	0,01 vdc	OFF
LDR 2	2 cm	blank	2,98 vdc	4,81 vdc	ON
LDR 2	2 cm	High container	-4,68 vdc	0,01 vdc	OFF

4.4 Testing of Infrared Sensor Circuit

Sensor	Distance of Sensor to Containers	Detected	Voltage at out pin IC LM358	Relay Voltage	Relay Status
infrared 1	2 cm	No	3,12 vdc	4,50 vdc	ON
infrared 1	2 cm	white marbles	-4,91 vdc	0,01 vdc	OFF
infrared 2	2 cm	No	3,13 vdc	4,50 vdc	ON
infrared 2	2 cm	black marbles	4,90 vdc	0,01 vdc	OFF

4.5 Testing of DC Conveyor's Motor and Filling

DC Motor	Dioda Input Voltage	Dioda Output Voltage	Descriptions
1 DC Motor 0f Conveyor	5,85 vdc	5,15 vdc	Operated
2 DC Motor 0f Conveyor	5,85 vdc	5,15 vdc	Operated
1 DC Motor 1 Filled	4,96 vdc	4,25 vdc	Operated
2 DC Motor 2 Filled	4,96 vdc	4,25 vdc	Operated

4.6 Testing of PLC *Input Output*

No	Address *Input*	Tools	Indicator of PLC	Descriptions
1	0.00	*Module* relay 1	ON	Operated
2	0.01	*Module* relay 2	ON	Operated
3	0.02	*Module* relay 3	ON	Operated
4	0.03	Relay LDR 1	ON	Operated
5	0.04	Relay LDR 2	ON	Operated
6	0.05	Relay *infrared* 1	ON	Operated
7	0.06	Relay *infrared 2*	ON	Operated
8	0.07	Toggle switch Auto	ON	Operated
9	0.08	Toggle switch Manual	ON	Operated
10	0.09	PB *On* konveyor	ON	Operated
11	0.10	PB *Reset*	ON	Operated
12	0.11	PB Pengisian putih	ON	Operated
13	1,00	PB pengisian hitam	ON	Operated
14	1.01	*Emergency stop*	ON	Operated

No	Address *Output*	Tools	Indicator at PLC	Descriptions
1	100.00	Conveyor DC Motor	ON	Operated
2	100.01	Conveyor DC Motor	ON	Operated
3	100.02	DC Motor filled of white	ON	Operated
4	100.04	DC Motor filled of black	ON	Operated
5	100.05	LED indicator conveyor	ON	Operated
6	100.06	LED indicator filled of white	ON	Operated
7	100.07	LED indicator filled of black	ON	Operated

4.7 Device Testing Analysis

Manual Testing	Color	Type	Push Button of Filling 1	Push Button of Filling 1	Sum of Filling
1	Red	Short	6	-	6
2	Red	High	8	-	8
3	Orange	Short	-	6	6
4	Orange	High	-	8	8
5	Blue	Short	3	3	6
6	Blue	High	4	4	8

Otomatic Testing	Color	Type	Filling 1	Filling 2	Sum Filling
1	Red	Short	6	-	6
2	Red	High	8	-	8
3	Orange	Short	-	6	6
4	Orange	High	-	8	8
5	Blue	Short	3	3	6
6	Blue	High	4	4	8

4.8 Discussion

From the test results, it is found that the 12 VDC power supply has a good output voltage of 12.15 VDC, but to turn on the sensor must use a voltage of 5 VDC for DC motors using a voltage of 6 VDC and for Arduino uno using a voltage of 9 VDC to reduce the voltage VDC to 5 VDC uses a regulator IC 7805, 6 VDC using IC 7806 and 9 VDC using IC 7809. From table 4.1, the output voltage results for each regulator are 4.97 VDC, 5.85 VDC and 8.69 VDC which the voltage of IC regulator output is still enough tolerance. After the flow of power flows across all 5 VDC voltage systems used for LDR sensors and Infrared sensors, the 6 VDC voltage is used for the DC motor conveyor and the charging DC motor and the 9 VDC voltage will be used for Arduino Uno and TCS3200 color sensor.

The TCS3200 color sensor is configured with Arduino Uno to detect three types of colors which are red, yellow and blue with three relay modules as output. From the results of table 4.2, it is obtained if the sensor detects red so relay module 1 will turn off, if it detects the yellow relay modules 2 and 3 will turn off then if it detects blue then relay module 3 will turn off. The LDR sensor is used to detect the height of the container where there are two LDR sensors. The first LDR sensor is for detecting containers with a height of 10 cm and a second LDR sensor to detect containers with a height of 14 cm. The detection distance of the LDR sensor with a container is 2 cm. Infrared sensors are used to detect the number of marbles that enter the container where there are two infrared sensors. The first infrared sensor to detect the number of white marbles and the second infrared sensor to detect the number of black marbles. The infrared sensor detection distance with marbles is 5 cm.

From the results of the tools testing in tables 4.8 and 4.9 that is if a red container with a height of 10 cm is detected, it will be filled with 6 white marbles while the red container with a height of 14 cm will be filled with 8 white marbles. If a yellow container with a height of 10 cm is detected, it will be filled with 6 black marbles while the yellow container with a 14 cm container will be filled with 8 black marbles. If a blue container with a height of 10 cm is detected, it will be filled with 3 white marbles and 3 black marbles while the blue container with a 14 cm tall container will be filled with 4 white marbles and 4 black marbles.

Acknowledgements.

5 CLOSING

5.1 Conclusion

Based on the problems, results and testing of tools, it can be concluded that::

1. TCS3200 color sensor can be used to detect colors and be configured with Arduino Uno and 3 5 VDC relay modules as the output of the color sensor. The 5 VDC module relay will be used as an input device for the CP1E OMRON PLC.
2. From each sensor, it is known that the factor that mostly influences the stability of the sensor response is the distance of the sensor with the object detected. The sensor distance is TCS3200 which is 10 mm, the LDR sensor is 20 mm and the infrared sensor is 5 mm.

5.2 Suggestion

Beberapa hal yang perlu diperhatikan dalam proses realisasi unit prototype sistem pengisisan barang dengan sistem pemisah pada wadah berdasarkan warna dan tinggi berbasis PLC OMRON CP1E serta pengujian keefektivitasannya adalah: Several things that need to be considered in the process of realization of the items' filling system prototype unit with a separator system on the container based on the PLC OMRON CP1E color and height and the effectiveness test are:

1. The use of an LDR sensor should be replaced with a proximity sensor. So it is safer and less risk of being exposed to light interference from outside.
2. The TCS3200 color sensor is replaced by a color sensor that is more accurate in color detection.

3. With the final assignment of the design of the prototype system for filling the items in the industry is equipped with a separating system based on the color and height of the containers, the packaging system and final sorting of the container can be added.
4. In the filling system a detection sensor can be added for reject items.
5. Added a button to set the parameters for the number of items loaded.

REFERENCES

[1] Abel Putra Hidayah. 2016, RANCANG BANGUNALAT PENGATUR KESTABILAN SUHU PADA EGG INCUBATOR DENGAN METODE PID BERBASIS ARDUINO, Skripsi, Jurusan Teknik Elektro Universitas Muhammadiyah Tangerang, Tangerang

[2] Agfianto Eko Putra. (2017). PLC : Konsep, Pemrograman dan Aplikasi (Omron CPM1A/CPM2A dan ZEN Programmable Relay), Gava Media, Yogyakarta.

[3] Bambang Tri Wahjo. 2012, Rancang Bangun Aplikasi Sistem Parkir Mobil Menggunakan Sensor Infra Red di Rumah Sakit Aminah Blitar, Jurnal JITIKA, Vol. 6 No. 2, Agustus 2012: 1-7.

[4] Christoforus Yohannes. 2011, Sistem Penghitung Jumlah Barang Otomatis Dengan Sensor Ultrasonik, Jurnal Ilmiah "Elektrikal Enjiniring" UNHAS, Vol. 9 No. 2, Mei - Agustus 2011: 66-71.

[5] Dinda Novita, Abdul Jabbar Lubis dan Arnes Sembiring. 2012, Perancangan Alat Pendeteksi Warna Berbasis Arduino Uno (FOKUS SOFTWARE), jurnal :1-9

[6] Emir Nasrullah, Agus Trisanto dan Kurnia Ramdhani. 2012, Model Sistem Kontrol Pemilahan Produk Berbentuk Kotak, Jurnal Ilmiah Elite Elektro, Vol. 3 No. 1, Maret 2012: 49-58.

[7] Erni Setyaningsih, Dhidik Prastiyanto, dan Suryono. 2017, Penggunaan Sensor Photodioda sebagai Sistem Deteksi Api pada Wahana Terbang Vertical Take-Off Landing (VTOL), Jurnal Teknik Elektro, Vol. 9 No. 2, Juli - Desember 2017: 53-59.

[8] Fadly Okfianto Muin. (2012), Elektronika Terapan dan Panduan Membuat Robot Line Follower – Jumat, 31 Agustus 2018 http://visualbasicpark.blogspot.com/2013/01/elektronika-terapan-panduan-membuat.html#!/tcmbck)

[9] Helmi Guntoro, Yoyo Somantri, Erik Haritman. 2013, Rancang Bangun Magnetic Door Lock Menggunakan Keypad Dan Solenoid Berbasis Mikrokontroler Arduino Uno, Jurnal Electrans, Vol. 12 No. 1, Maret 2013: 39-48.

[10] Herman Dwi Surjono. (2009). Elektronika Lanjut, Cerdas Ulet Kreatif, Jawa Timur.

[11] Muhammad Imron. dan Andi Setiawan. 2018, Pemilah Barang Logam Dan Non-Logam Berbasis Plc Omron CP1E-N30SDT-D, Jurnal Teknik Elektro, : 22-28.

[12] Setiyo Budiyanto. 2012, Sistem Logger Suhu dengan Menggunakan Komunikasi Gelombang Radio, Jurnal TeknologiElektro, Vol. 3 No. 1, Januari 2012: 1-7.

BIOGRAPHIES

Graduated from the Electrical Engineering of University of Educatioan Indonesia, 1986. Graduated from Institut of Sains and National Technology Indonesia (ISTN) Jakarta, 2002. I have been Studying Doctoral Programe in Department of Fisheries Resources Utilization Faculty of Fisheries and Marine Sciences, Bogor Agricultural University, 2015 – 2018.

	Informatic Engineering Study Program Faculty of Engineering, University of Muhammadiyah Tangerang.
	2018, Graduated from Electrical Engineering Study Program Faculty of Engineering, University of Muhammadiyah Tangerang