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Double Water Pump Prototype using Three Phase Induction Motor for Flood Drain

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ABSTRAK

Artikel ini menyajikan purwarupa sebuah pompa air ganda untuk menguras genangan akibat banjir menggunakan dua buah motor induksi tiga fasa dan unit kontrol. Rancangan ini memiliki dua sensor elektroda Water Level Controller (WLC) 61F-G sebagai pendeteksi ketinggian air. Detektor digunakan untuk mengatur kinerja dua mesin pompa air dalam proses pengurasan air. Hasil simulasi pengujian menunjukkan bahwa ketika genangan air berada pada level 5 cm dan titik sensor elektroda E3a, E2 dan E1a terendam, maka WLC 61F-G pertama secara otomatis menyalakan (ON) motor induksi 3 fasa pertama, dan jika genangan air berada pada ketinggian 10 cm dan merendam titik sensor elektroda E3b, E2b dan E1 maka WLC 61F-G kedua akan mengaktifkan motor induksi 3 fasa kedua. Namun, jika ketinggian air di bawah 5 cm maka kedua mesin OFF atau tidak bekerja. Harapan dari penelitian ini adalah disain sistem dapat diimplementasikan dan dapat ditempatkan di daerah rawan banjir khususnya DKI Jakarta.

Kata kunci*: Pompa Air Ganda; Banjir; Sensor WLC 61F-G*

ABSTRACT

This article presents a prototype of a dual water pump to drain inundation due to flooding using two three-phase induction motors and a control unit. This design has two Water Level Controller (WLC) 61F-G electrode sensors as a water level detector. The detector is used to regulate the performance of two water pump machines in the process of draining water. The test simulation results show that when the puddle is at a level of 5 cm and the electrode sensor points E3a, E2 and E1a are submerged, the first WLC 61F-G automatically turns on (ON) the first 3 phase induction motor, and if the puddle is at a height of 10 cm and immersing the electrode sensor points E3b, E2b and E1 then the second WLC 61F-G will activate the second 3-phase induction motor. However, if the water level is below 5 cm then both machines are OFF or not working. The hope of this research is that the system design can be implemented and can be placed in flood-prone areas, especially DKI Jakarta.

Keywords*: Dual Water Pumps; Flood; Sensor WLC 61F-G*

1. INTRODUCTION

Floods are natural disasters that often occur in Indonesia, especially in big cities such as Jakarta. The definition of flood is a condition where an area is submerged by a large volume of water. The presence of floods can be predicted from rainfall and water flow. However, floods can come suddenly as a result of the damage or collapse of the embankment which is usually called a banjir bandang. Several factors that cause flooding include high rainfall; low land level compared to sea level; areas with little water catchment; there are buildings along the banks of the river; the presence of garbage that causes the river flow is not smooth. Several efforts to minimize the effects of flooding have been carried out to reduce losses, including: rearranging river basins in an integrated manner, not constructing buildings on riverbanks, constructing infiltration wells, normalizing rivers and installing pumps and sluices in flood-prone areas **(Fathaya et al., 2020) (Apriadi & Saggaf, 2021) (Aji Laksana & Pratiwi, 2020)**. To help anticipate the arrival of floods is to build an early arrival warning system floods and water levels through short message technology so that residents can immediately prepare themselves in the event of a flood disaster **(Ferdiansyah et al., 2020) (Attia et al., 2019) (Wan Hassan et al., 2019) (Abana et al., 2019)**. Sensors or detecting the presence of overflowing water play a very important role in building early warning equipment for flood arrivals. Nyoman Arun Wiratama, created an Android-Based Water Level Monitoring System using a Transistor Water Level Sensor. There are 4 transistor water level sensors integrated with Arduino, ESP8266 module, camera module, relay, automatic water faucet and LCD. Each sensor is used to determine the water level with 5 different statuses, namely Zero, Safe, Alert, Alert, and Danger. **(Wiratama et al., 2020)**. The Arduino Uno-based water level control monitoring tool uses the LM016L LCD in outline consisting of ultrasonic sensors, relays, and water pumps. This device is applied for monitoring the water level in the reservoir automatically **(Amin, 2018) (Alawiah & Rafi Al Tahtawi, 2017)**. Steven, Rainhard, used fluid sensors and water flow sensors to prevent flooding in the basement of a building **(Andreas et al., 2018).** Hairulnizam Mahdin, built a water level monitoring system using RFID Radio Frequency Identification. This technology has the potential to be used in tank water level monitoring although there are disadvantages such as high implementation costs **(Harun et al., 2017)**. In addition to ultrasonic and RFID sensors, there are several researchers who use variable resistors. A multiturn trimer potentiometer (trimpot) type variable resistor can be used as a sensor element where changes in water level will turn a knob or a variable trimer resistor. This will produce a change in voltage which is an analog input for the microcontroller which is then processed to be displayed in the form of water level **(Sutono, 2015)**.

Studies and research on flood prevention are currently being carried out. Henny Sudjatmiko, made an approach to hydrological and hydraulic parameters at the Jati Pinggir Polder, namely the formation of zones, formation of drainage systems, evaluation of channel capacity, determination of repair needs, alternatives for adding pump capacity, alternative wells. The result is that the existing capacity in Drainage at Polde Jati Edge of the West Flood Canal DKI Jakarta requires additional pump capacity **(Sudjatmiko et al., 2017**) . Friska Natalia Ferdinand created three interactive dashboard clustering systems based on water level data covering the Angke, Pesanggrahan, and Cisadane rivers. Three clustering methods were applied, namely K-Medoids, DBScan, and x-means, to separate water level data taken from four stations obtained from the Ciliwung Cisadane River Basin Center (BBWS). This data is used as information about periodic flood patterns. on the three rivers **(Ferdinand et al., 2019)**. Nur Ashikin Harun, uses the Apriori algorithm to build a flood area prediction model in determining the rules used in flood prevention **(Harun et al., 2017)**. Stagnant water due to slow receding floods will result in several losses, among others, disrupted traffic, damage to ecosystems and the environment, material losses, disruption of health and so on. To reduce the volume of puddles, several ways can be done, namely improving drainage facilities and draining water using a water suction pump. Some researchers use more than one water pump machine to speed up the process of draining puddles. Rizka Arbaningrum, analyzed the modeling of the operational pattern of the pump system in the polder design. the operational pattern uses the elevation-discharge function, where this function forms the operational pattern of each pump that will operate based on the water level elevation criteria for each pump. With this operational pattern, it will reduce operational and maintenance costs. Rozi Yusuf, made a pump simulation in a reservoir pond using the water balance method. The discharge is calculated using the Rational method and the IDF curve using the Mononobe method. Pond reservoirs measuring (65m x 65m x 2m) require a pumping capacity of 0.5 m^3/second to handle the overflow. So a 0.5 m3/second pump can pump water from ponds to the sea as a drain. **(Yusuf et al., 2002)**. Rahmia Fauziah, built a water pump and simulated reservoir ponds and pumps with a water balance. The discharge is calculated using the Rational method and the IDF curve using the Mononobe method. Reservoir ponds (100m x 50m x 3m) require a pumping capacity of 4 m3/second to deal with flooding. The 4m3/second pump can be used as a pump to drain water from the pond to the Dumai River as a drain.**(Fauziah et al., 2015)**. On the other hand, the selection of pump types depends on the needs and availability of pumping machine equipment. Direct current motor water pumps offer a simpler system compared to alternating. motor based pump system. In addition, Permanent Magnet DC motor (PMDC) systems are more reliable, and the number of items required is lower than AC pump systems **(Attia, 2019)** Another type of water pump machine is an AC machine, because this type of machine is preferred in industrial applications, it is easy to obtain in the market and the price is relatively cheaper than a DC motor **(Gunabalan & Subbiah, 2015).**

The use of induction machines as water pumps has been widely used, namely converting motor motion energy into fluid energy. This machine has a simple construction, affordable price, robust high efficiency but has a complicated speed regulation. At the start of this machine draws a large current (5 to 7 times the nominal current) so a method is needed to reduce the starting current. In her research, Nana Subrana installed an ON OFF switch on a water pump using an induction motor to reduce energy losses .The problem of flooding does have a bad impact on the environment, but there are some people who use this flood water to be processed into a source of clean water that can be used for life.**(Fuady, 2016).** This study aims to make a miniature pump for draining puddles using two three-phase induction motors with a Water Level Controller (WLC) 61F-G in the form of a rod electrode as a water level sensor.

2. RESEARCH METHOD

The method used in this research is to build a prototype of a drainage system using equipment such as a water reservoir, two induction motors that function as water suction machines (pump 1 and pump 2), star/delta switch and two 6IF-G sensors as sensors. water and two WLC (Water Level Controller) 61F-G controls as water level sensors.

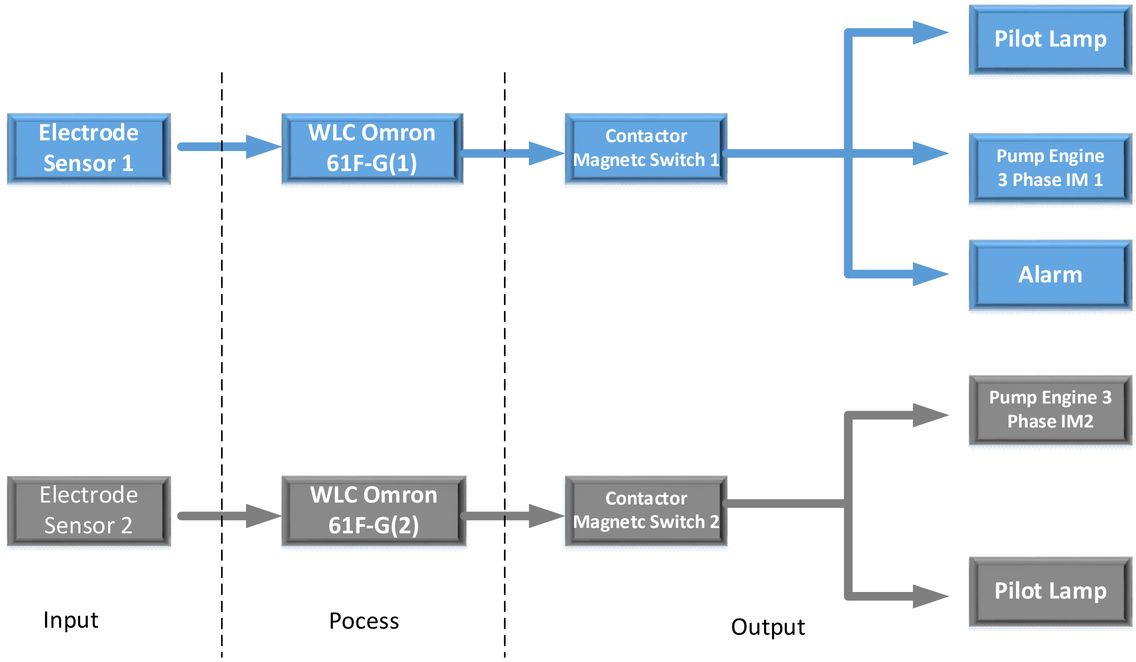

Figure 1. Main Parts of the System Design and Research Workflow

Figure 1 is a workflow of a miniature drainage system to cope with flooding automatically using two units of a 3-phase induction motor with an electrode sensor based on WLC (Water Level Controller) 61F-G. The system consists of input blocks, process blocks, and output blocks. The input block contains an electrode sensor, which functions as a water puddle detector. When the electrode sensor is submerged in water, the electrode sensor will send an electric current and be processed by the WLC (Water Level Controller) 61F-G. WLC functions as a magnetic contactor switch driver to connect a three-phase power source with a 3-phase induction motor that acts as a water pump. Lights and alarms serve as indicators of the system.

Figure 2 is a water drain system design. The design consists of input blocks, process blocks, and output blocks. The input block contains an electrode sensor, the electrode sensor functions as a detector of standing water when water soaks the electrode sensor, when the electrode sensor is submerged in water, the electrode sensor will send an information signal and be processed by the WLC (Water Level Controller) 61F-G. Then WLC serves as a control to determine the resulting output. The output of this system is a high and low logic electrical signal to drive a magnetic contactor connected to a star / delta relay switch. This star delta switch is used to reduce the starting current when the pump engine is turned on. This machine has the technical specifications Brand: Teco Model/Position : Horizontal (Foot Mounting) Power (Hp / kW): 0.5 / 0.37 Voltage : 220/380 Connection : Delta/Star RPM (r/min) : 1500 Pole : 4. Two three-phase induction motors that work as water pumps are supplied with a voltage of 230/380V 50 Hz.

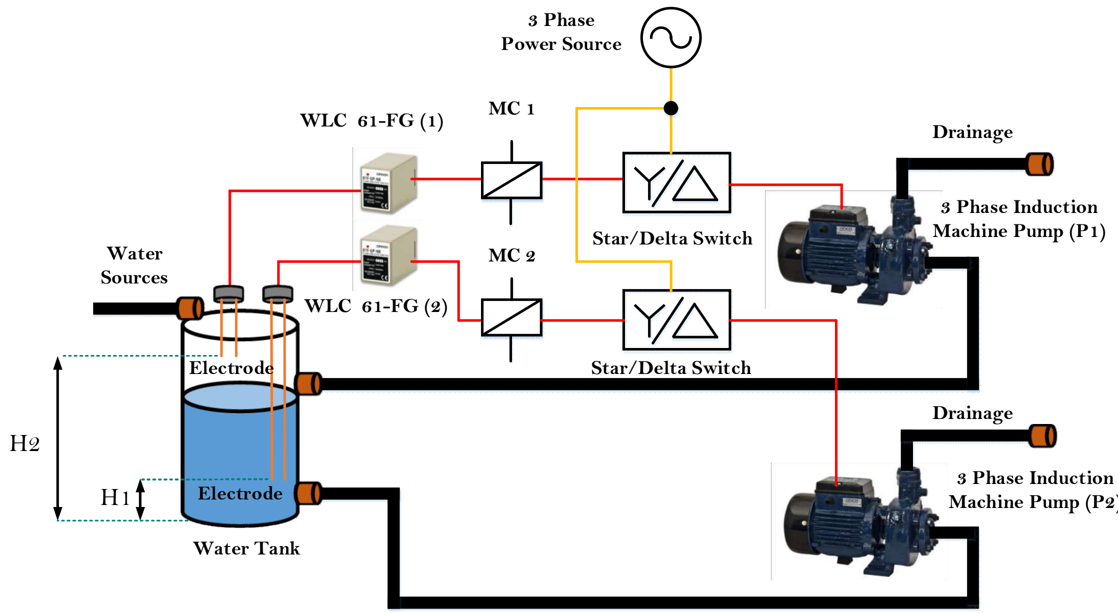

Figure 2. Architecture of Dual Water Pump Prototype System for Flood Management

2.1.Control System Diagram on Pump 1 & 2

Figure 3 is a control scheme for the pump engine 1. The input section of the water level is set at the 5cm level. The water level at the output will be detected by the feedback system, namely the electrode sensor 1. If a puddle of water immerses the electrode 1 sensor at a height of 5cm or more, the sensor will send information to the controller, namely WLC (Water Level Controller) 1. This signal is obtained when electrode 1 contacts short-circuited by the immersing water. Thus, WLC 1 will automatically turn on the actuator, namely pump 1 (ON), so that pump 1 will drain the water from the plant, namely puddles. When the water is reduced from a height of 5 cm, the electrode contact point is not connected, resulting in not sending information in the form of an electrical signal to the contactor. Thus the contactor will return to its original position (OFF), so that pump 1 will again not work. This information becomes feedback for the electrode sensor which detects the height of the water level so that this system will continue to loop (looping).

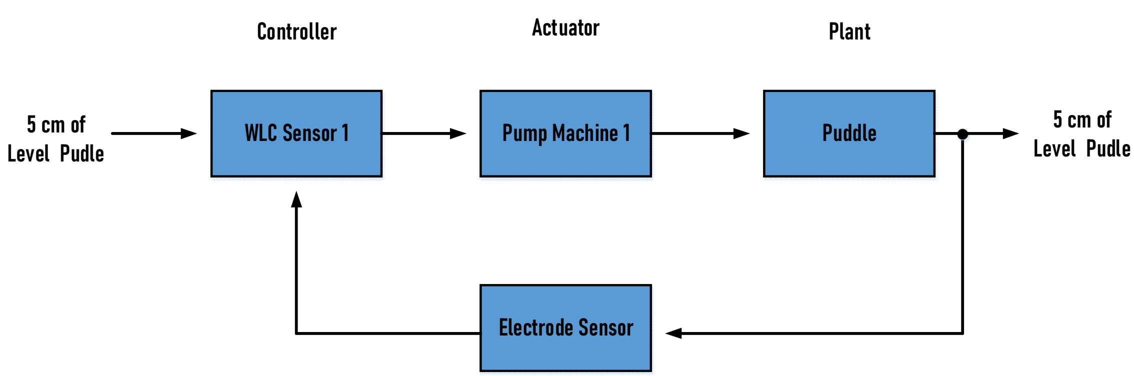

Figure 3. Block Diagram of Control System on Pump 1

The control system block diagram for pump 2 is the same as the control system block diagram for pump 1, the difference is in the input value, if pump 1 the input value is at the 5 cm level, while for pump 2 the input value is at the 10 cm level.

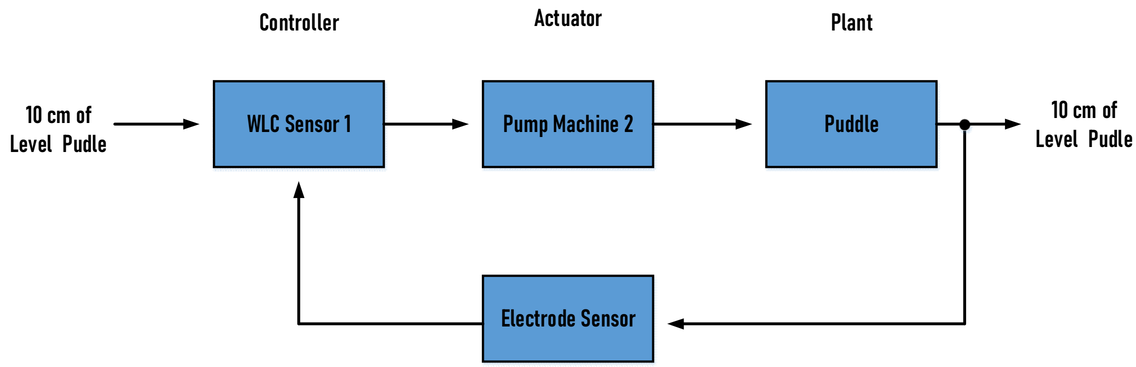

Figure 4. Block Diagram of Control System on Pump 2

Figure 4 is the control system for pump 2 at the input part of the puddle set to a height of 10 cm. The water level at the output will be detected by the feedback system, namely the electrode sensor 2. If the water level immerses the electrode sensor 2 at a height of 10cm or more, the sensor will send an electric current to the controller, namely WLC (Water Level Controller) 2. WLC 2 will automatically turn on the actuator namely pump 2, where when it is on, pump 2 will drain the water from the plant, namely puddles. When the water draining process takes place, the water level will be the input value to activate or deactivate the electrode on the output side. If the water level is above 10 cm, the electrode contact point will be connected so that pump 2 will be active, but when the water level is below 10 cm, the electrode 2 contact point will be disconnected so that pump 2 will stop working. Thus the drain at the 10 cm level stops but pump 1 is still in working condition until the water level is brought to 5 cm. This system will continue to loop (looping), the electrode sensor will work to detect changes in water level in puddles. So it can be said that the function of pump 2 is as a back up from pump 1 when the water level is getting higher, where when the water level touches the electrode sensor 1 at a height of 5cm then pump 1 will drain the water, if the water level gets higher and touches the electrode sensor 2 at a height of 5 cm. a height of 10cm then pump 2 will drain the water to help pump 1 so that the puddle can drain faster and prevent the water level from getting higher.

2.2.Schematic Design of WLC 61F-11 with Sensor Electrodes

WLC 61F-11 schematic design with electrode sensor set with relay unit 61F-11, in the schematic design, to drain water automatically, the pins connected to the magnetic contactor are Ta pins and Tc pins. Figure 5 shows a schematic of the WLC 61F-11 with a sensor electrode. When electrode E1 is submerged in a puddle of water, relay U will operate to change contacts from c2 – b2 to c2 – a2 and change contacts Tc – Tb to Tc - Ta. The E2 electrode functions as self-holding, where the E2 sensor will lock the contact changes when the E1 electrode is submerged in a puddle of water. Figure 6 shows the timing diagram on how the WLC 61F-11. Figure 6 shows a timing diagram of how the WLC 61F-11 works. when the water reaches the sensor points E3a and E2a then the 3-phase induction motor (1) is OFF (inactive), if the water reaches the point E1a then the 3-phase induction motor (1) is ON (active). When the water drops and reaches point E2a, the 3-phase induction motor is still ON with the prerequisite that the water has previously touched the E1a point. 3-phase induction motor (1) will OFF when the water drops below E2a. If the water rises back to points E3b and E2b then the 3-phase induction motor (1) is ON but the 3-phase induction motor (2) is OFF, if the water continues to rise to point E1b then the 3-phase induction motor (1) and (2) will be active. The 3-phase induction motor (2) will turn OFF when the air placement touches point E3b.

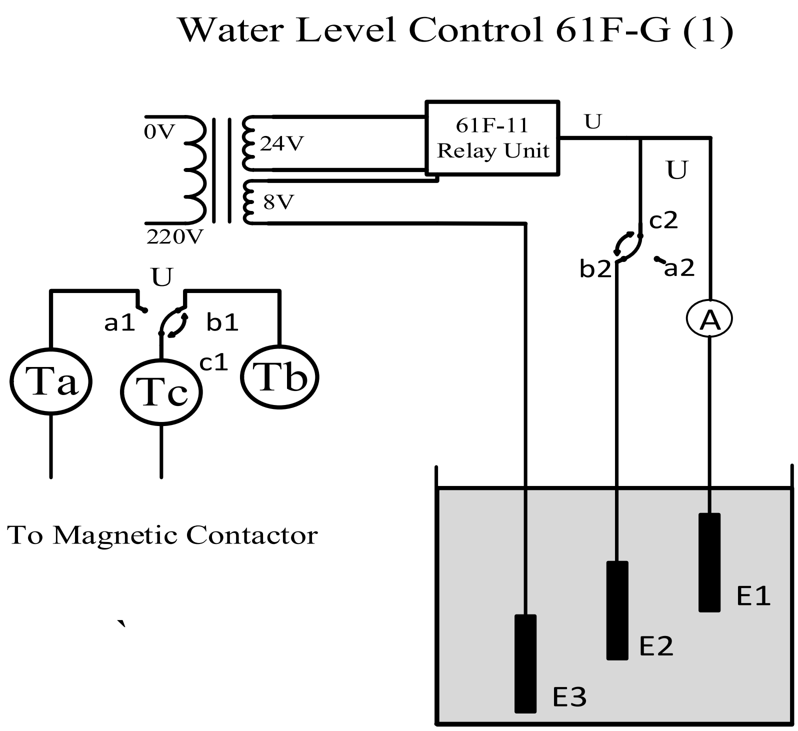

Figure 5. Schematic of WLC 61F-11 with Sensor Electrodes

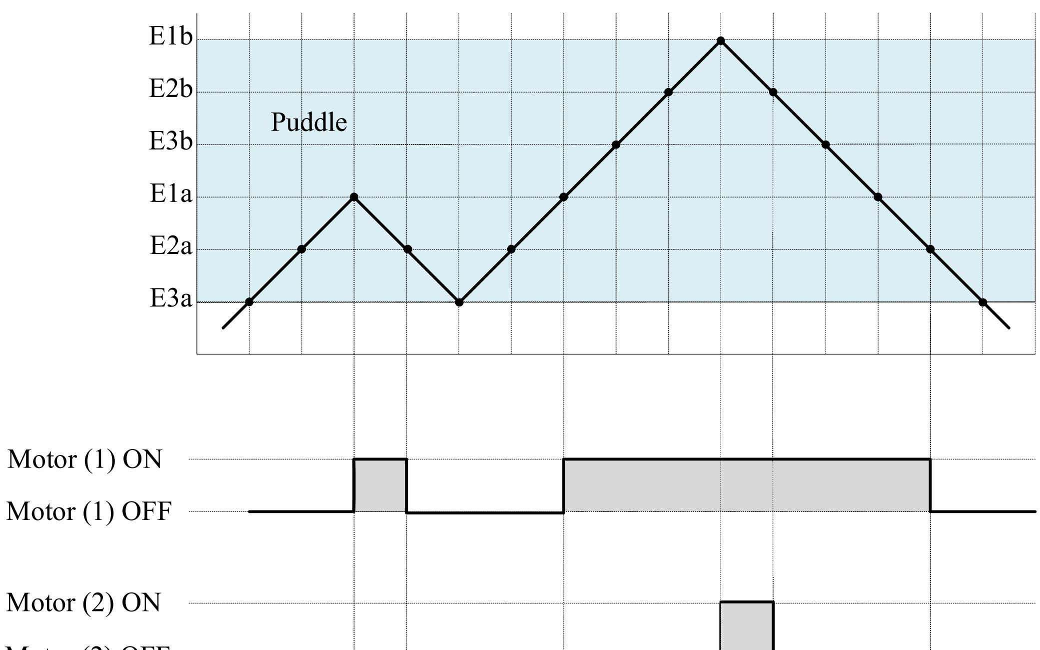

Figure 6. Timing Diagram Perfomance of WLC 61F-11

2.3.Tool Wiring Diagram

Figure 7 shows the wiring circuit of a dual water pump system to drain puddles of water due to flooding automatically using two 3-phase motor units with a 61F-G WLC (Water Level Controller) based electrode sensor. Figure 8 is a miniature tool that was built and tested in the electrical engineering laboratory of Gunadarma University .

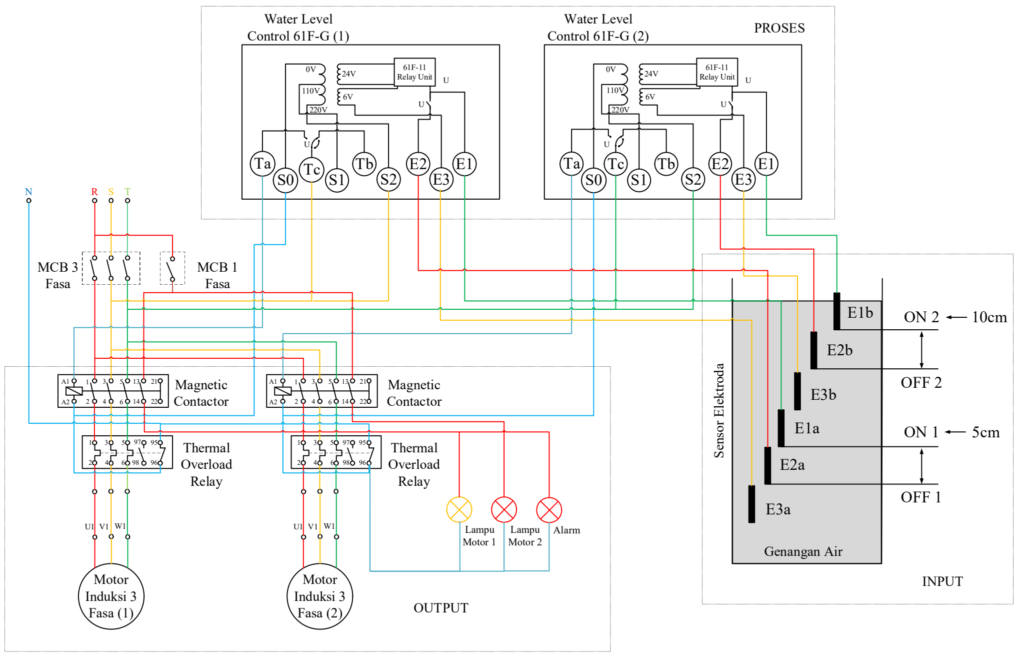

Figure 7. Water Draining Circuit Automatically

Figure 8. Miniature Puddle Drain Pump Using 3-Phase Induction Motor

3. RESULTS AND DISCUSSION

3.1. System Performance When Pump 1 Works

Based on Figure 4, namely when a puddle soaks the E3a sensor, but has not immersed the E1a and E2a sensors, the 3-phase induction motor (1) is still in the OFF state (inactive), whereas when the puddle reaches a level of 5cm or more until the sensor electrode E3a, E2a and E1a are submerged, then the Tc switch on the WLC will move from the Tb pin to the Ta pin, this will make the coil sections A1 and A2 active and the magnetic contactor will switch NO (Normally Open) to NC (Normally Close). Thus the 3-phase induction motor (1), motor light indicator 1 and alarm will be ON (active) as long as the E2a and E1a sensors are submerged.

3.2. System Performance When Pump 2 Works

According figure 4, how the whole circuit works on the pump (2), namely when a puddle of water soaks the E3b sensor but has not immersed the E1b and E2b sensors, the 3-phase induction motor (2) is still in the OFF state (inactive) while the 3-phase induction motor (1) is still active, if the puddle reaches a level of 10cm or more until the electrode sensors E3a, E2a and E1a are submerged, then the Tc switch on the WLC will switch from the Tb pin to the Ta pin, this will make the coil parts A1 and A2 active and the magnetic contactor will switch NO (Normally Open) to NC (Normally Close), thus 3 phase induction motor (2), motor light indicator 2 ON (active) as long as sensors E2b and E1b are submerged. In this case, if the water level reaches a level of 10 cm or more, the two 3-phase induction motors will be active to drain the puddle. Therefore, the use of these two 3-phase induction motors aims to make the water drain faster and prevent the water from getting higher.

Table 1. Testing During a Flood Hit

Water Level (cm)	Sensor State						Motor State		Lamp Indicator		
	E3 a	E2 a	E1 a	E3 b	E2 b	E1 b	Motor 1	Motor 2	Yelow Pilot Lamp	Alarm	Red Pilot Lamp
0	X	X	X	X	X	X	OFF	OFF	OFF	OFF	OFF
1	O	X	X	X	X	X	OFF	OFF	OFF	OFF	OFF
2	O	O	X	X	X	X	OFF	OFF	OFF	OFF	OFF
3	O	O	X	X	X	X	OFF	OFF	OFF	OFF	OFF
4	O	O	X	X	X	X	OFF	OFF	OFF	OFF	OFF
5	O	O	O	X	X	X	ON	OFF	ON	ON	OFF
6	O	O	O	O	X	X	ON	OFF	ON	ON	OFF
7	O	O	O	O	O	X	ON	OFF	ON	ON	OFF
8	O	O	O	O	O	X	ON	OFF	ON	ON	OFF
9	O	O	O	O	O	X	ON	OFF	ON	ON	OFF
10	O	O	O	O	O	O	ON	ON	ON	ON	ON

O = Submerged in Water , • X = Not submerged in water

Table 1 on the pump (1), when a puddle immerses the E3a sensor but has not immersed the E1a and E2a sensors, all motors and indicators are OFF, while when the puddle reaches a height of 5cm or more until the electrode sensors E3a, E2a and E1a are submerged in water , then the pump (1), the yellow light indicator and the alarm will be ON as long as the E2a and E1a sensors are submerged. The pump will continue to operate if the puddle is at a height of 5cm. If the puddle increases in height until the sensors E3b and E2b are submerged at a height of 6-9 cm, then the 3-phase induction motor (1) is operating while the 3-phase induction motor (2) is not operating. However, if the puddle continues to increase until the E1b sensor is submerged at a height of 10cm, the 3-phase induction motor (2) and the red light indicator will be ON (active). So at a height of 10cm or more then two 3-phase induction motors, red, yellow and alarm light indicators will be ON (active).

Table 2. Testing The Tools When The Flood Recedes

Water Level (cm)	Sensor state						Motor State		Indicator		
	E3 a	E2 a	E1 a	E3 b	E2 b	E1 b	Motor 1	Motor 2	Yelow Pilot Lamp	Alarm	Red Pilot Lamp
10	O	O	O	O	O	O	ON	ON	ON	ON	ON
9	O	O	O	O	O	X	ON	ON	ON	ON	ON
8	O	O	O	O	O	X	ON	ON	ON	ON	ON
7	O	O	O	O	O	X	ON	ON	ON	ON	ON
6	O	O	O	O	X	X	ON	OFF	ON	ON	OFF
5	O	O	O	X	X	X	ON	OFF	ON	ON	OFF
4	O	O	X	X	X	X	ON	OFF	ON	ON	OFF
3	O	O	X	X	X	X	ON	OFF	ON	ON	OFF
2	O	O	X	X	X	X	ON	OFF	ON	ON	OFF
1	O	X	X	X	X	X	OFF	OFF	OFF	OFF	OFF
0	X	X	X	X	X	X	OFF	OFF	OFF	OFF	OFF

O = Submerged in Water , • X = Not submerged in water

Table 2 when the puddle recedes to a height of 7-9cm, then pump (2) is still ON, even though the electrode sensor E1b is not submerged by puddles, the motor is still ON because E2b, which acts as self-holding, will maintain ON condition after receiving a trigger from E1b. The 3-phase induction motor (2) will turn OFF when the puddle recedes at a height of 5-6cm. Pump (1) is still ON if the puddle height is still at 6cm and the sensors E3a, E2a and E1a are submerged, if the puddle is receding to a height of 2-4cm and the electrode sensor E1a is not submerged, then pump (1) is in ON state, because E2a which acts as self-holding will maintain the ON state after receiving a trigger from E1a. The pump (1) will be OFF when the puddle recedes at a height of 0-1cm.

3.3. Electrode Sensor Test

Testing the electrode sensor using the WLC (Water Level Controller) 61F-G control. WLC receives information from the electrode sensor then it will control the performance of the 3-phase induction motor and indicators.

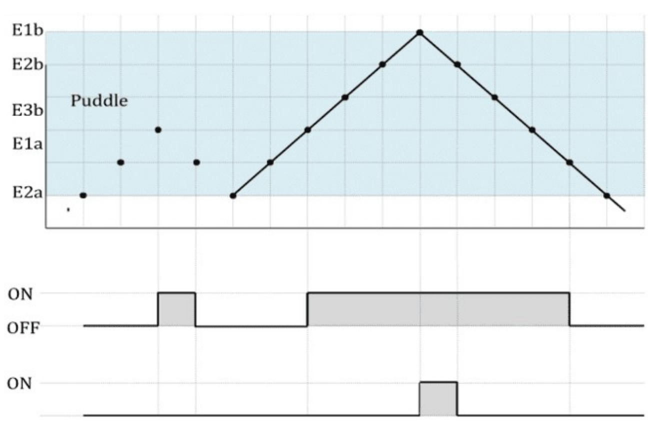

Figure 9. Timing Diagram of Electrode Sensor Performance

Figure 9 is when the puddle reaches the sensor points E3a and E2a then pump (1) is OFF (inactive), if the puddle reaches point E1a then pump (1) is ON (active). When the puddle drops and reaches point E2a, the 3-phase induction motor is still ON provided that the previous puddle has touched point E1a. The 3-phase induction motor will turn OFF when the puddle drops below E2a. If the puddle rises again until it touches points E3b and E2b then pump (1) is ON but pump (2) is OFF, if the puddle continues to rise until it touches point E1b then pumps (1) and (2) will be active. Pump (2) will be OFF when the puddle touches point E3b.

4. CONCLUSION

The tool is made to run well and work as expected. The starting and control system of two 3-phase induction motor units as water pumps using a WLC (Water Level Controller) 61F-G-based electrode sensor is one solution to overcome flooding by draining puddles automatically. The system works based on the results of the detection of the electrode sensor, where the electrode sensor will detect changes in the height of the puddle. when a puddle soaks the E3a and E2a sensors but has not immersed the E1a sensor, the 3-phase induction motor (1) is still in the OFF state (inactive), whereas when the puddle reaches a height of 5cm or more until the electrode sensors E3a, E2a and E1a are submerged then WLC (1) will activate the 3-phase induction motor (1) automatically. If the puddle is at a height of 10cm or more and immerses the E3b, E2b and E1b sensors, the WLC (2) will activate the 3-phase induction motor (2) automatically. In this case, the use of two units of a 3-phase induction motor is useful so that the water drains faster and prevents waterlogging from getting higher. The results of this study need to be implemented to support flood prevention methods, especially in large cities that are densely populated, such as Jakarta so that the impact of losses due to floods can be minimized.

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