An Architecture Of Plc Ls Xbc-Dr30e Based Clean Water Controlling System

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Abstract: In the industrial field, the good controlling system is definitely required to improve the working efficiency of a system. The type of controller, PLC (Programmable Logic Controller), used in "Clean Water Controlling System in Electrical Workshop with PLC LS XBC-DR30E". Furthermore, such system consistently uses two types of component, they are Relay and Timer. The clean water pump control aims to pump the water in well A to storage tank B. The pump will work when water-contained well A is marked by "sensor level well A on" and the water inside storage tank B is under level 3. When the water inside storage tank B is under level 2, both pumps (M1 and M2) will work to fill storage tank B. on the contrary, when storage tank B is above level 2, only one pump (M1) works until the tank reach level 3. In addition, when storage tank B is above level 3, both pumps will stop working. However, along with the advancement of recent technology, the above system can be controlled by using PLC (Programmable Logic Controller). Therefore, it is possible to apply the controlling method of PLC as the semester V's practical module. Based on the trial performed, the PLC-based clean water system is well-functioned as the working description compiled before the operation of the tool.

Index Terms: PLC LS XBC DR-30E, SENSOR LEVEL, FLOW SWITCH, WATER PUMP.

1 INTRODUCTION

The controlling of such system remains to use two types of controller, they are relay and timer. The practice with such module may be categorizes with simulation. However, along with the advancement of recent technology, the loads can be controlled only by using PLC. PLC refers to a specific unit designed for handling an automatic control system in the industrial machines. Adding the practical module in semester V with the new controlling method, in this case is PLC LS XBC-DR30E, and not the simulation ones should be significantly possible

2 Basic Theories

Description of Clean Water Controlling System

Clean water pump control aims to pump the water in well A to storage tank B. the pump will work when well A contains water and marked with sensor level "ON" and the water inside storage tank B is under level 3. But, the first step to be performed by operator before operating the clan water pump control should be checking whether both motors may work well and all sign lamps are in their good condition and ready to operate. This should be performed by rotating the selector switch/ pump 1, switch /pump 2 to the testing position and push the "push" button during the testing of sign lamp. When motor 1, motor and sign lamps are in their good condition, the control system is ready to operate. Normally, the working sequence of clean water pump control is as follow:

1. When the water inside the storage tank is in level 3, both pumps (M1 and M2) will work to fill the storage tank until it reaches the level 3. After that, the pumps are off.
2. When the water inside the storage tank turns down to level 2 due to usage (consumer), only one pump (M1) works until the tank reaches level 3.
3. When the water inside the storage pump turns down to level 2 again, then the second pump (M2) works to fill the tank until it reaches level 3.
4. When the water inside storage tank is in level 4, then the alarm goes off.

Definition of Programmable Logic Controller (PLC)

The raid development of control technology affects each process in human's life such as in the field of health, education, industry and even household. Since the better control unit by conventional system is in demand, the discovery of PLC becomes significantly critical. Also, the wide use of PLS, such as in the system of conveyor belt, traffic light, industry of control robot, molding injection, building automation, lift control, car manufacture, advertisement light, weaponry technology, automatic factory and so many other using PLC as the control unit. Programmable Logic Controller (PLC) means a user-friendly electronic computer that has its control function for various types with numerous degree of difficulty. PLC is also an electronic system with digital operation, which is designed for industrial environment's usage. Furthermore, this system uses particular memory that is able to internally save instruction implementing specific functions such as logic, sequence, timing, enumeration and arithmetical operation to control machine or process through digital as well as analog I/O module. (*Capiel, 1982*)

Programming Instruction

Ladder Logic refers to a programming method used in this PLC LS XBC-DR30E. the programming sequence in ladder method is fairly simple, based on the relay logical sequence with a contact in the form of magnet field for switching, in which when the voltage is applied to relay coil, the magnet field will be created. Such magnet field may utilized as the drawer of the relay's supporting contacts. In general PLC programming that uses several basic logics such as OR, AND, NOT and the other logics applied in Ladder Logic utilized in programming PLC LS XBC-DR30E. In order to represent the instruction of its ladder logic' controlling, the following Mnemonic bases and ladder symbolization need to be comprehended :

1. LOAD for input to be inserted is called the beginning of a programming. The LD instruction refers to the switches in conventional circuit functioned as the breaker and connector of supply to load or also, to activate the subsequent instruction, such as timer counter or the other functions. The symbol of LOAD itself is presented in Figure 2.8.

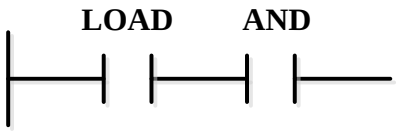

Figure 2.1 *LOAD Symbol*

2. The converted value against LOAD is called LOAD NOT. This instruction means the reverse input provided by PLC. Typically, the use of this function is the input by sensor, limit switch or external device. Figure 2.9 shows the symbol of LOAD NOT.

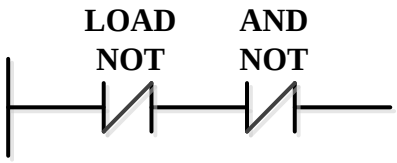

Figure 2.2 *LOAD NOT Symbol*

3. AND refers to input changed to be series with the previous input. In other words, this instruction is used when the contact position (in ladder diagram) is connected with the previous contact in series way. Figure 2.10 shows the symbol of AND.

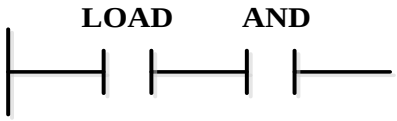

Figure 2.3 *AND Symbol*

4. The opposite instruction of AND is AND NOT, where this value will revers the state of AND. When the AND's value is positive, then AND NOT should be negative. Figure 2.11 is the symbol of AND NOT.

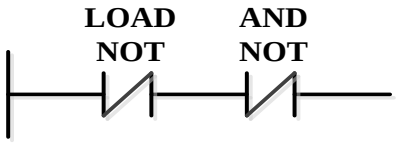

Figure 2.4 *AND NOT symbol*

5. OR is inserted when the position of input to be inserted is parallel towards the previous one. The symbol OR is presented in Figure 2.12.

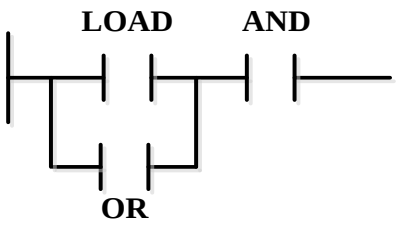

Figure 2.5 *OR symbol OR*

6. OR NOT is the opposite instruction of OR. The symbol of OR NOT can be seen in Figure 2.13.

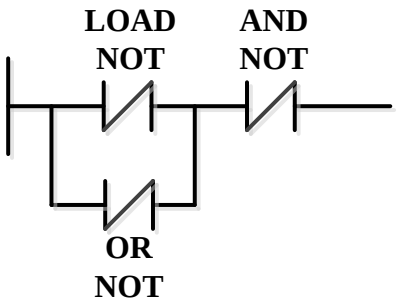

Figure 2.6 *OR NOT Symbol*

7. NOT is used along with LD, AND and OR and the other sequential instructions. The value of NOT will reverse all of the inserted input or be used to define the inverse output. Figure 2.14 shows the symbol of NOT.

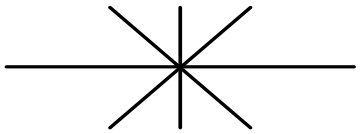

Figure 2.14 *NOT Symbol*

8. OUT → COIL OUTPUT, refers to the instruction showing the output of a circuit. Typically, this output is the relay of contractor, lamp, or the other load (coil). Figure 2.15 shows the symbol of OUT.

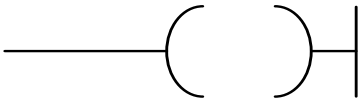

Figure 2.7 *OUT Symbol OUT*

9. TIMER, functions to calls the timing function to be used. The general timer instruction used is TON and TOFF. Figure 2.16 represents the symbol of TON.

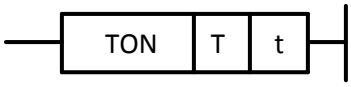

Figure 2.8 *TON Symbol*

TON is a type of timer that will postpone the ON of an instruction or output. Meanwhile, the T symbol means the location of timer address we use, and t refers to the value or variable of intended timer's duration.

10. TOFF is the reverse type of TON. TOFF works to postpone the OFF or the received output's OFF. Similar with TON, the T symbol is located in the address of timer we use, while t refers to the value or variable of intended timer's duration.

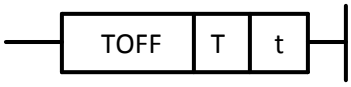

Figure 2.17 *TOFF Symbol*

11. END refers to the function used to end the execution process of a program. In Figure 2.18, you can see the symbol of END.

Figure 2.18 *END Symbol*

Providing Bit Number

P000-P11 means providing bit number for PLC input, where such input may be switch, censor, etc. For example, the design of this system consists of 7 censors. Thus, the provision of bit number should be as follow : P000 for censor 1, P01 for censor 2, P03 for censor 3, P04 for censor 4, P05 for censor 5, P06 for censor 6, P07 for censor 7, so the provision of bit number must be sequential (censor 1 and 2 must be different and so on). Similar way must also be done for the provision of bit number bit for output, starts from P40 to P4A, i.e. for servicing 2 water pumps, bit40 will be given to Pump 1 and P41 to Pump 2

2.1.8. Operating Motor with Two Indicator Lamps of ON and OFF

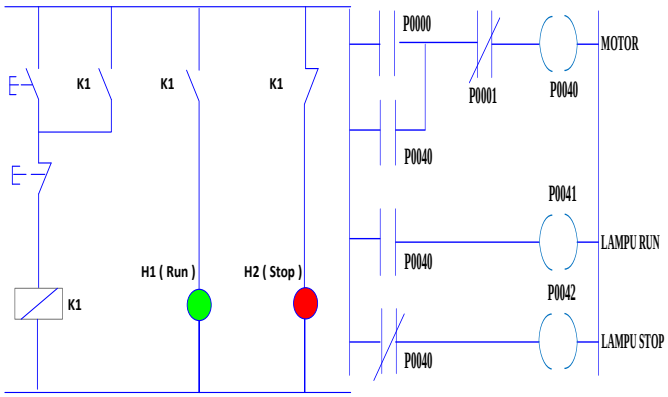

Figure 2.9 *Conventional Diagram with Relay and Ladder*

In Figure 2.19, the ladder diagram located in the right side is equivalent with the next conventional circuit of relay contractor (left).

1. RUNG 1
   First, bit input of P0000 (LOAD) identifies the start button on the conventional circuit. Next, it remains in series with bit input of P0001 (AND NOT). The latter identifies the stop buttion in conventional which is series with start button. At the tip of rung 1, bit P0040 (OUT) acts as the output, in which it becomes the load/motor and is identified with the lamp Furthermore, bit P0040 (OR) functions as the supporting contact of K1 (13, 14) in conventional circuit. This bit also functions as the address latch in address memory.
2. RUNG 2
   Bit output of p0040 (LD) refers to the bit following the bit output in Rung 1, so it does not matter how the condition in OUT, Rung 1 will be the same with the OUT in this second RUNG, in which it is represented by the bit output of P0041. In its conventional circuit, this rug is equivalent with the supporting contact of K1 (23.24) = P0040 (LD) and sign lamp of H1 = P0041 (OUT).
3. RUNG 3
   There is bit of P0040 (LD NOT) with the logic of NOT in this rung, in which it identifies that every result of the output in Rung 1 will be in reversal with the logic in this sequence. Also, this Rung is equivalent with K1 (21.22) = P0040 (LOAD NOT) and sign lamp of H2 (STOP)= P0042 (OUT).

Timer

The function related to this component in each PLC may be varied. However, there are relatively three general functions that is mostly used. They are:

1. Timer ON (ON delay Timer)
   On delay timer means postponing the time of ON in particular period.
2. Timer OFF (OFF delay Timer)
   Off delay timer means postponing the time of OFF in particular period.

Operating Three Phase Motor with Star-Delta Circuit

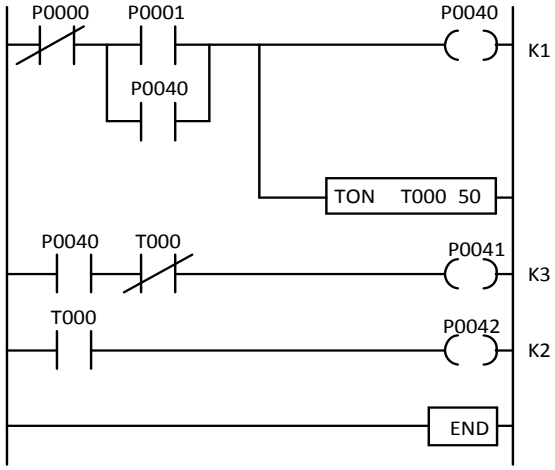

Figure 2.10 *Conventional Diagram with Relay and Ladder Diagram*

O figure 2.20, ladder diagram on the right side is equivalent to conventional series of relay and timer contractor on the left side.

4. RUNG 1
   Starting with the input bit P0000 (LOAD) identifies the start button on conventional series. Then. Then series contain bit input P0001 (AND NOT), this bit identifies stop button which is also series with the start button. On the tip of rung 1, there is bit P0040 (OUT) which becomes the output, in this conventional , it turns to be Contratctor 1 (K1) and also there is Timer (TON) which will delay the ON of an instruction within the specified time limit.
5. RUNG 2
   Bit output P0040 (LD) is a bit that follow bit output in Rung 1, it is under the same series of bit T000 which will execute

the command as having been instructed toTimer (T000). Then in the tip of Rung 2, there is bit P0041 (OUT) which serves as the output, and in this conventinal series, it turns to be Contractor 3.

6. RUNG 3
   In this rung also looks bit T000 (LD), it's identified that this bit T000 will depend on the intruction which has been given on Timer (T000) in rung 1. Output (P0042) in this rung 3 is equivalent with K2 (21.22).

Counter

The basic function of PLC counter is as up and down counter. Calculation of function counter depends on the value entered in that function. For up counter, the counting starts from 0 and that added 1 in each pulse on from counter input. When the setting value is acheived, so the output will be energized. The activiation of reset input will cause the counter will be reverted into the first value, that is 0 and also will be resetting the counter output. Within the operations of down counter which equals to the up counter, to which the counter starts from the setting value and when it reaches 0 Value, so it will activate the counter output. One of the programmes with the use of Counter is as shown on Figure 2.21.

Figure 2.11 Example of Ladder Diagaram with Counter

In rung 1, it can be seen an input with bit P000 which is identified as first movement sensor and bit input P0001 as the sencond movement sensor, every time these sensors detect if there is a movement, so these sensors will send the singal into PLC input and then the Counter will start counting. There is bit COOO in Rung 2 which will do an execution based on the Counter setting, output P0040 (OUT), then, will serve as a load.

Miniatur Circuit Breaker (MCB)

Definition of MCB

MCB (Miniature Circuit Breaker) is a switch or electromechanical device that serves as a protective circuit of electrical installations from an occurrence of over current. The occurrence of over current can be caused by several circumtances, such as: short circuit and overload. MCB actually has the same function as the fuse, which will break the flow of electric current in the circuit when there is over current interference. What distinguishes the two is when the interference occurs, the MCB will trip and when the circuit has returned to a normal condition, the MCB can be re-ON (resetted) manually, while the fuse will be disconnected and can not be used again. The physical form of MCB can be seen in Figure 2.22.

Figure 2.12 *Miniatur Circuit Breaker (MCB)*

Magnetic Contactor (MC)

Definition of Magnetic Contractor

The contactor is a type of switch that works magnetically, by which the contact will work when the coil is energized. The National Manufacture Association (NEMA) defines magnetic contactor as a magnetically actuated device for connecting and unlocking electrical power. Unlike relays, contactors are designed to connect and unlock power circuits without damaging effect. Those loads include lamps, heaters, transformers, capacitors, and electric motors. The electromechanical type of magnetic contactor can be seen on Figure 2.23.

Figure 2.13 *Physical Form of Magnetic Contact*

How Magnetic Contacts Work

A contactor consists of a coil, some Normally Open (NO) and some Normally Close (NC) contacts. When a contactor is in normal condition, NO will open and when the contactor is working, NO will close. Whereas NC contact is, otherwise, under normal circumstances, NC contact will close and will open when it is under a working state. The coil is a twist in which it is given with a voltage, it will be energized and draw its contacts so that it changes or works. The electromagnetically operated contactor is one of the most useful mechanisms ever designed for closing and opening of electrical circuits, so the image of how the magnetic contactor works can be seen on Figure 2.24.

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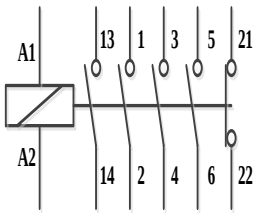


Kontak Utama	: Main Contact
Kontak Bantu	: Contact Help

Kontak Utama : 1,3,5 dan 2,4,6

Kontak Bantu NC : 21 dan 22

Kontak Bantu NO : 13 dan 14

Figure 2.14 *Symbols of Magnetic Contacts*

A contactor is classified as a magnet-driven switch type as described above. When the clasp A1 and A2 of the magnetic coil are applied, the magnet draws the anchor so that the

primary contact is closed and the auxiliary contact is closed, while the NC auxiliary contact becomes open. The paired voltage can be an alternating current (AC) and a direct current (DC) voltage, depending on how the magnet is designed. For some purposes, a (non-voltage) current coil is also in use, but in terms of the production, it is preferable as the voltage is generally normalized and does not depend on the needs of a particular user.

Thermal Over load Relay (TOR)

Definition of Thermal Over Load

Thermal overload relay (TOR) is a component of an electrical installation that serves as a security installation against an occurrence of over loads. This TOR works as it utilises the bimetal plate that will break if there is an electrical current exceeding the capacity limit. How it works is almost identical to the work mechanism of the Miniature Circuit Breaker (MCB) in securing the over current that flows on the lighting installation and power installation. On Figure 2.25 shown below is a physical form of the Thermal Overload Relay.

Figure 2.15 *Physical Form of Thermal Over Load Relay*

Figure 2.26 below is an image when Thermal Over Load is connected to a Magnetic Contactor:

Figure 2.26 *TOR connection with MC*

On Figure 2.26, it can be seen that the 3 primary legs on the thermal over load are connected to a phase- 3 source voltage source via Magnetic Contactor and 3 other main legs connected to phase-3 motor terminals. Within the occurrence of over load, there is NO contact namely on leg 97-98 and NC on leg 95-96 as seen in Figure 2.27

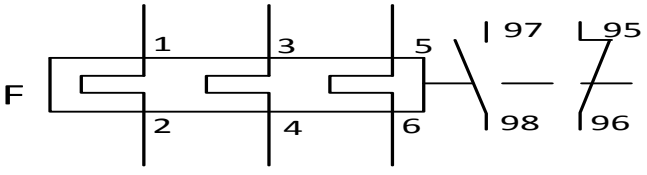


Figure 2.27 *TOR Symbols and Numbering*

Suppose there is an over load on the motor then the current will increase and break the bimetal. Then NO and NC contacts on overload will also work. NC contact is used to disconnect the control circuit that controls the Magnetic Contactor. With the opening of the control to the Magnetic Contactor controlling the main circuit the motor will stop working. While the NO contact can be connected with the indicator light the occurrence of more load on the circuit. Thermal overload relay (TOR) has a more effective and economical protection level, namely:

1. Overload protection.
2. Protect from phased failure imbalance.
3. Protect from loss / loss of phase voltage (Phase Loss).

Relay

Definition of Relay

A relay is a device used to connect or disconnect a large electric current by utilizing a small electrical current. Relays are switches that work by using electromagnetic principles. The relay is capable of handling an over power than its working power. According to the operating voltage the relay is divided into 2 relay types, namely AC Relay and DC Relay. To be able to know whether the required working voltage can be aware with the technical information written on the body. DC relays generally work on voltages of 6 Volt 12 Volts, 24 Volts, 48 Volts, while for AC Voltage of 220 Volts. In Figure 2.28 is the physical form of the relay.

Figure 2.28 *Physical Form of Relay*

Relays have an important role in an electrical circuitry system to drive a device that requires large currents without connecting directly with a small current control device. Thus relays can serve as a safety. Relay consists of 3 main parts, namely:

1. Common, is a part that is connected with Normally Close (under normal circumstances).
2. Coils, are the main components of relays used to create magnetic fields.
3. Contact, which consists of Normally Close and Normally Open.

How Relay Works

In a relay there are 4 important pieces of Electromagnet (Coil), Armature, Switch Contact Point (Switch), and Spring. In Figure 2.29 is how the relay works.

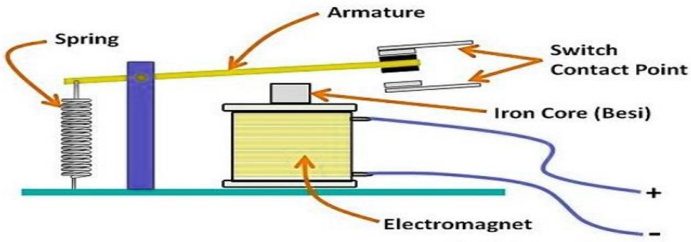


Figure 2.29. *How Relay Works*

When the coil gets electrical energy (energized) will cause electromagnetic force. The magnetic force generated will pull the armature, so the NO contact will become NC and the NC contact will be NO (Switch Contact Point).

Water Pump

Definition of Water Pump

A water pump is a device or machine used to move liquids from one place to another. The pump operates by making a pressure difference between the suction and the discharge portion.

Figure 2.30. *Water Pump*

How Water Pump Works

The way the water pump works is basically very simple, ie sucking water from a lower place and pushing the water to a higher place or to a water container. When the ON pump produces fluid pressure. The pressure pushes the suction valve on the suction channel, the suction becomes open and then the pressure emerging from the water will drop down and open the gas valve (bearing). Here are the pump specifications used: Voltage 220-240 AC, Frequency 50 Hz, Power wattage 125 watts, 200 watt input power, Class B insulation winding, Pipe 1 " x 1 ", Max capacity 30L / min, IP X4, PPM 2850, Maximum liquid temperature of 350C, Maximum height maximum 37 m, High doron 28 m, High suction 9m

Level Sensor

To measure the height of the water level on this water control system using liquid level sensors. Where on this sensor there is a buoy, following the physical form of level sensors.

Figure 2.31. *Level Sensor*

How Level Sensor Works

The level sensor contact will be interconnected if the buoy on the sensor rises as a result of an increased water level and the sensor level contact will be off if the sensor buoy does not detect any increase in water level. Below is the level sensor specification: Made of material: polypropylene Maximum contact rating: 10W Operating temperature: -10 ~ 85 ° C Maximum switching voltage DC: 100V Maximum switching current: 0.5A Maximum breakdown voltage: 220V DC Maximum load current: 1.0A, Maximum contact resistance: 0.1 ohms Ω, Weight: 13g.

Flow Switch

Definition of Flow Switch

A flow sensor is a device for detecting fluid flow rates. Typically the flow sensor is the sensing element used in the flow meter to detect the fluid flow. Here's a physical image flow switch.

Figure 2.32. *Flow Switch*

How Flow Switch Works

Contact flow switch will be on when there is fluid flow passing through the flow switch and will off if there is no flow through the flow switch. Below is the specification of the flow switch used in this design.

Spesifiction:
Working voltage: DC 5V-24V, Maximum current: 15 mA, Load capacity: ≤ 10 mA, Working temperature: ≤ 80 ℃, Maximum contact resistance: 0.1 ohms Ω.

Conductor (Cable)

Conductor can be either cable or a wire conductor. Cable is conductor of insulated metal. If the amount of the metal carrier is more than one then the entire insulated cable is supplemented with a protective sheath. The cable used in this design is NYAF, where the cable is a type of fiber cable, PVC insulated with copper as its conductor and this cable is used for panel installation.

DESIGNING AND CREATING THE SYSTEM

Design of The Water Control System

The design of Water Control System consists of two main components, namely Panel Framework and Panel Box.

Design of The Panel Framework

The basic dimension of the panel box is the dimension of the components to be placed therein. This Panel Box has 60 cm height, 40 cm length, and 20 cm width (60x40x20 cm) or as seen in Figure 3.1.

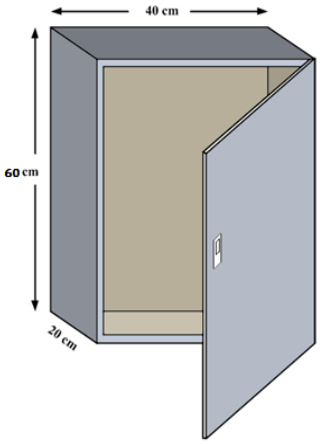


Figure 3.1 *Panel Box*

Before installing the components to the panel box, the writer has to determine the position of each component of the panel box door and also the content of panel box. The discussion will be described as follows:

The Content of Panel Box

On the content or inside of panel box, there are several components installed as shown in Figure 3.2 below is the image of component positions on the content of panel box.

Figure 3.2 *Installment of Components on Panel Box*

Table 3.1 *Inner Components of Panel Box*

No.	Component	Quantity
1.	12 pin terminal block	3 pieces
2.	MCB 2A,230 VAC	3 pieces
3.	PLC LS XBC-DR30E	1 piece
4.	LS AC3 contractor,220-240 VAC	2 pieces
5.	Thermal Over Load Relay (TOR) LS (1-2 A)	2 pieces
6.	Relay Omron MY2N-J 5 A,250 VAC	8 pieces
7.	NYAF cable (red blue) 0.8 mm^2	Sufficiently

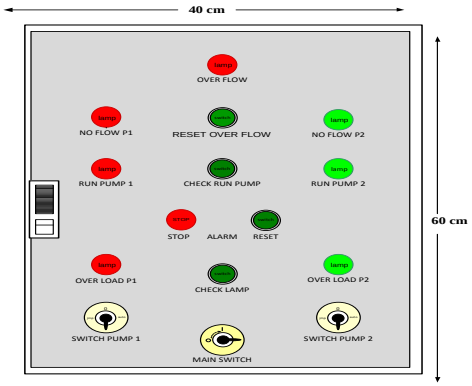
The Panel Box Door

At the panel box door, there are several components installed as shown in Table 3.2.

Table 3.2 *Components at Panel Box Door*

No.	Component	Quantity
1.	Push Button 6A,250 VAC	5 pieces
2.	Sign Light (Red and Green)< 20mA	7 pieces
3.	Selector Switch 5A,250 VAC	3 pieces

Figure 3.3 is an image of the component positions of panel door and also the size of panel door



The System Design and Depiction

This system design has the measurements as shown in Figure 3.4.

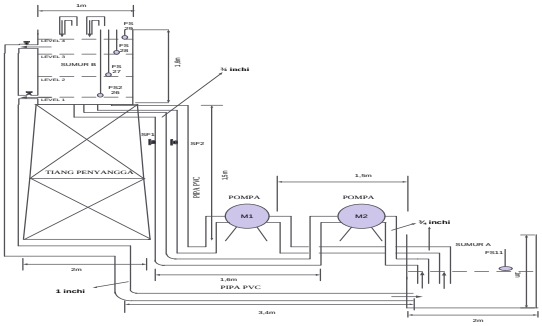


Figure 3.4 *Design of Water Control System*

The system shown in Figure 3.4 will be explained as follows:

1. From the well there are two pipelines and leads to a water storage tank. Furthermore, at the bottom of the tank there is a drain pipe to homes, buildings or industries.
2. FS26 (Sensor of Level 1), FS27 (Sensor of Level 2), FS28 (Sensor of Level 3), FS29 (Sensor of Level 4) are the sensors of the water storage tank. Those sensors will be an indicator of the water level in the tank. Explanation of the four sensors will be explained below:

- FS26 is Sensor 1, which indicates that the water level in the tank reaches level 1.
- FS27 is Sensor 2, which indicates that the water level has reached level 2.
- FS28 is Sensor 3, which indicates that the water level has reached level 3
- S29 is Sensor 4, which indicates that the water level has reached a predetermined threshold.

3. FS2 and FS1 are the components of No Flow Sensor Pump 1 and No Flow Sensor Pump 2. This switch replaces the function of the water flow detection sensor in the pipe.
4. FS11 is a sensor of the well. The function of this sensor is as a detection of the presence of water in the well.
5. Warning alarm. This alarm will sound if there are some disturbances in the water control system, including disturbance of: No Flow, Over Load and Over Limit.

The System Programming

Work Description

The design of this Water Control System aims to pump water that will be channeled from the water source (well) to the storage tank and then distributed to the user (consumer). Water will be absorbed from the water source (well) to the water storage tank through two pipelines. By using two Water Pumps (Pump 1 and Pump 2), which are placed to each of its pipelines. In the water storage tank there are four sensor levels. At each level, the two pumps will work according to the stipulated condition. If the water in storage tank is at level 1, the two pumps will work simultaneously to absorb water from the well (water source) and pump it to the storage tank until the water reaches level 2. After the water has reached level 2, the both pumps keep working. Subsequently, the two pumps will be OFF after the water in the tank has reached level 3. If the water in storage tank is reused until the water in storage tank reaches level 2, the pump 1 works and pumps 2 OFF, until the water in storage tank rises back to level 3 and so on, when the water decreases from level 2 to level 1 then the two pumps will work in turn. Subsequently, in a condition when the water level in the tank reaches level 4 (over limit) due to failure of level 3 sensor operation (level 3 sensor is damaged) and rain water comes into the storage tank due to the opening of the storage tank cover, the over limit sensor (level 4 sensor) will work and sound an alarm. Some of the disturbances that can be made in this water control system are as follows: Over Limit Condition, No Flow Condition, P1 Over Load. Over Load. The input section number 1 of Block Diagram is Power (100-240V AC) PLC, while the inputs number 3, 4, 5 and 6 are inputs derived from two selector switches. Furthermore, the inputs number 10 - 14 or the red ones above are sensors that detect any interference. The other inputs are components consisting of a single switch and push button (Normally Open). The PLC will be ON after the power (100-240V AC) is supplied to the Power Supply terminal on the PLC output section, marked by the PWR LED light of the PLC. In order for the system to work, the water source sensor (well) must be in ON condition. Sensors and Push Button when in ON condition is tantamount to give input signal to PLC input terminal then PLC will execute all instructions that have been installed into PLC. The output terminal of PLC is 12 and has a voltage of 24Volt / 50Hz which is connected to the Com terminal (common terminal). The loads connected to this PLC output terminal are Lamp, Sign Light and Alarm. The work sequence of the water control system is as follows: Main Power is ON as the first step to operate the system, the "Well" Sensor is ON as a sign that there is sufficient water availability at the water source, then the PLC lamp gets input signal so that the system will be ready to run. The work control of both water pumps depend on the water surface detection sensor on the storage tank. Marked by four sensor levels: Level1, Level 2, Level 3, Level 4 (Over limit), when the water in storage tank is empty or has not reached level 1, the PLC will get input signal which causing the Pump 1 and Pump 2 work simultaneously and fill the water storage tank, Once the water passes level 1 and reaches level 2, the PLC will get the input signal which causing one of the Pumps works, Pump 2 will work and Pump 1 will stop working. When the water has reached level 3, the PLC will get an input signal which causing the two pumps stop working. To cause over limit disturbance (the water level in the tank that exceeds the threshold), the level 3 sensor is made as if a work failure, which will cause one of the pumps work continuously until the water level reaches the over limit level. Level 4 sensor (over limit sensor) will give input signal to the PLC to be able to sound the Alarm and turn on the sign light of "Over Limit" in panel box. Continuing the point number 6 (six) above, when the water in storage tank decreased to level 2 then pump 1 will work. When the water level returns to level 3, then the input signal that comes into the PLC causing the two pumps back to OFF, to cause the Over Load Pump 1 and or Pump 2, the component of "Thermal Over Load" will give input signal to the PLC, and then will cause the Alarm sounds and sign light of Over Load Pump 1 and or Pump 2 will be on, from the three types of disturbance that occur above, namely: No Flow P1 and P2, Over Limit, and Over Load P1 and P2. Those disturbances will cause the Alarm sounds, that is why Alarm must be turned off by pressing Push Button "STOP", by pressing the button will send input signal to the PLC and then turn off the sound of Alarm. Push Button "Reset" is pressed to restart the water control system after the Alarm is turned off, Push Button "Check Run Pump" is pressed to check whether both Pumps (Pumps 1 and 2) are working or not, Push Button

"Check Lamp" is pressed to check the condition of the sign light.

PLC LS XBC-DR30E Programming

Introduction of XG5000 Software

PLC Programmer XG5000 Software is a GUI (Graphic User Interface)-based programming series. The PLC LS XBC-DR30E programming used in this water control system is XG5000 version 3.6 and based on Windows 7 Ultimate 32bit operating system. This software also supports programming for four series of PLC from LS, that is XGK, XGB, XGI and XGR series, while the supported programming languages is LD (Ladder Diagram) or ladder logic-based relay logic, SFC (Step Function Chart) is a programming in the form of diagram chart and ST (Structure Text) is a programming method that uses text instruction-based programming language such as C / C ++, BASIC, PASCAL and other programming languages.

XBC-DR30E Programming with XG5000 Software

By default, programming that can be executed against the XBC-DR30E CPU series is programming with Ladder Logic or in other words not being able to accept SFC or ST programs.

Ladder Diagram

There is water in the well, the well sensor (P0000) will be closed/connected, the coil (M0000) will be energized, so the help contact NO (M0000) on Rung 2,3,7,10,11,14,17,19,21,23, 24,25,31,34,37,41,42,44,45,50 and 54 will be closed/connected. Press the Push Button of Check lamp (P0009), the coil (M0007) will be energized, then the help contact NO (M0007) on Rung 9,16,29,33,37,50 and 53 will be closed/connected, so the Indicator Lamp of NO FLOW 1 (P0045), NO FLOW 2 (P0046), OVERLOAD 1 (P0042), OVERLOAD 2 (P0043), OVER LIMIT (P0044), RUN PUMP 1 (P0040) and RUN PUMP 2 (P0041) will be on as long as the Push Button of Check Lamp is pressed, the Selector Switch of Pump 1 is positioned as JMP (P000F), the coil (P0048) will be energized (Pump 1 will work), the Selector Switch of Pump 2 is positioned as JMP (P0010), the coil (P0049) will be energized (Pump 2 will work), the Selector Switch of Pump 1 AUTO (P0007), P0005 (Flow Switch) is connected, the coil (P0048) will be energized and Pump 1 will work, the Selector Switch of Pump 2 AUTO (P0008), P0006 (Flow Switch), the coil (P0049) will be energized and Pump 2 will work. When the water in storage tank reaches sensor of level 1 (P0001), the coil (M0003) will be energized, so the help contact NO (M0003) on Rung 34 will be closed/connected, the help contact NC (M0003) on Rung 4 and 12 will open, so the Pump 1 (P0048) and Pump 2 (P0049) will work. When the water in storage tank reaches sensor of level 2 (P0002), then coil (M0005) is energized, so the help contact NC (M0005) on Rung 13 will open and the help contact NO on Rung 27.24 will be connected so the Pump 2 (P0049) and Pump 1 (P0048) will keep working. When the water in storage tank reaches sensor of level 3 (P0003), the coil M0004 is energized, so the help contact NO (M0004) on Rung 17, 21 and 29 will be closed/connected and the help contact NC (M0004) on Rung 3,11,13,19 and 23 will open, so the Pump 1 (P0048) and Pump 2 (P0049) will be Off/does not work. When the water in storage tank drops to level 2 (due to usage), the sensor of level 2 (P0002) will open, so the coil (M0002) is energized, so the help contact NO (M0002) on Rung 3 will be connected and the help contact NC (M0002) on Rung 11 will open, so the Pump 1 (P0048) will work and Pump 2 (P0049) is off, then the water in storage tank reaches level 3, the Pump 1 will stop working/Off and Pump 2 remains Off. When the water in storage tank drops to level 2 (due to usage), the sensor of level 2 (P0002) will open, so the coil (M0002) is not energized, then the help contact NO (M0002) on Rung 3 will open and the help contact NC (M0002) on Rung 11 will be connected, so the Pump 1 (P0048) is off and Pump 2 (P0049) works, then the water in storage tank reaches level 3, so the Pump 1 will stop working/Off and Pump 2 remains Off, the Push Button of Check Run Pump (P000A) is pressed, when the Timer Off Delay (T003) is set for 5 seconds, and in this case the NO Timer (T003) on Rung 49 and 52 will be connected, so the indicator lamps of Run Pump 1 and Run Pump 2 will be on according to the condition of which pump is working, then the Indicator Lamp will be Off. The Over Limit Test/when the water in storage tank reaches the sensor of level 4 (P0004), the coil (M0006) will be energized, so the help contact NO (M0006) on Rung 35 will be closed/connected, the coil (M0013) will be energized, the help contact NO (M0013) on Rung 36, 37 and 45 will be closed/connected and Lamp Over Limit Indicator (P0044) will be on as well as the Alarm (P0047). Afterwards, the things we do: Pressing the Push Button of Stop Alarm (P0001), the coil M0008 will be energized, so the help contact NO (M0008) on Rung 41 will be connected/closed and the help contact NC (M0008) on Rung 43 will open, so the Alarm P00047) will be Off, make sure that the Selector Switch of Pump 1 and Pump 2 is in Off position, immediately repair, Reset the Over limit (P000C), Reset the Alarm (P000B), so coil (M0019) will be energized, the help contact NC (M0019) on Rung 40 will open, so that if there is any disturbance occurs, the Alarm (P0047) will sound.

1. Over Load Pump 1 Test: if there is an overload on Pump 1, the help contact NO TORL (P000E) will close, so the coil (M0011) will be energized and the help contact NO M0011 on Rung 30 and 45 will close, the indicator lamp of Over load Pump 1 (P0042) will be on, the Alarm (P0047) will be on/sound and Pump 1 will be Off. Then what we do:
   - Push the Push Button of Stop Alarm (P0001), the coil (M0008) will be energized, so the help contact NO (M0008) on Rung 41 will be connected/closed and the help contact NC (M0008) on Rung 43 will open, so the Alarm (P00047) will be Off.
   - Set the Selector Switch of Pump 1 and Pump 2 to Off.
   - Immediately repair
   - Reset the Alarm (P000B), so the coil (M0019) will be energized, the help contact NC (M0019) on Rung 40 will open, so if there is a disturbance occurs, the Alarm (P0047) will sound.
2. Over Load Pump 2 Test: if there is an overload on Pump 2, the help contact NO TORL 2 (P000D) will close, so the coil (M0012) will be energized and the help contact NO (M0012) on Rung 33 and 44 will close, the indicator lamp of Over load Pump 2 (P0043) will be on, the Alarm (P0047) will be on/sound and Pump 2 will be Off. Then what we do:
   - Push the Push Button of Stop Alarm (P0001), the coil (M0008) will be energized, so the help contact NO (M0008) on Rung 41 will be connected/closed and the help contact NC (M0008) on Rung 43 will open, so the Alarm (P00047) will be Off.

- Set the Selector Switch of Pump 1 and Pump 2 to Off.
- Immediately repair
- Reset the Alarm (P000B), so the coil (M0019) will be energized, the help contact NC (M0019) on Rung 40 will open, so if there is a disturbance occurs, the Alarm (P0047) will sound.

3. NO FLOW PUMP 1 TEST: if there is NO FLOW at Pump 1, then flow sensor (P0005) will open, so the Pump 1 (P0048) will be Off, the Indicator of No Flow Pump 1 (P0045) will be on and the Alarm (P0047) will sound. Then what we do:
   - Push the Push Button of Stop Alarm (P0001), the coil M0008 will be energized, so the help contact NO (M0008) on Rung 41 will be connected/closed and the help contact NC (M0008) on Rung 43 will open, so the Alarm (P00047) will be Off.
   - Set the Selector Switch of Pump 1 and Pump 2 to Off.
   - Immediately repair
   - Reset the Alarm (P000B), so the coil (M0019) will be energized, the help contact NC (M0019) on Rung 40 will open, so if there is a disturbance occurs, the Alarm (P0047) will sound.
4. NO FLOW PUMP 2 Test: if there is NO FLOW at Pump 2, then the flow sensor (P0006) will open, so that Pump 2 (P0049) will be Off, the Indicator of No Flow Pump 2 (P0046) will be on and the Alarm (P0047) will sound. Then what we do:
   - Push the Push Button of Stop Alarm (P0001), the coil M0008 will be energized, so the help contact NO (M0008) on Rung 41 will be connected/closed and the help contact NC (M0008) on Rung 43 will open, so the Alarm (P00047) will be Off.
   - Set the Selector Switch of Pump 1 and Pump 2 to Off.
   - Immediately repair
   - Reset the Alarm (P000B), so the coil (M0019) will be energized, the help contact NC (M0019) on Rung 40 will open, so if there is a disturbance occurs, the Alarm (P0047) will sound.

Tools and Materials

The tools and materials used are as shown in Table 3.3.

Table 3.3 *Tools and Materials Used*

No.	List of Component	Quantity
1.	Sign Light (red, green) <20mA	7 pieces
2.	Panel Box	1 piece
3.	PLC LS XBC-DR30E	1 piece
4.	LS AC3 contractor,220-240 VAC, 13 A, 50/60 Hz	2 pieces
5.	Thermal Over Load (TOR) LS (1-2 A)	2 pieces
6.	MCB 2A, 230 V AC	3 pieces
7.	Push Button 6A, 250 V AC	5 pieces
8.	Selector Switch 5A, 250 VAC	3 pieces
9.	12 pin Terminal Block	3 pieces
10.	Alarm	1 piece
11.	Wiring Channel	Sufficiently
12.	Cable	Sufficiently
13.	Relay Omron MY2N-J 5A, 250V AC	8 pieces

TESTING AND ANALYSIS

Uninterrupted Condition Testing

Pump Working Test based on Water Surface Level in Tank

Based on previously designed work description, the work of both pumps depends on the water surface sensors in storage tank of Sensor 1 (Level 1), Sensor 2 (Level 2), Sensor 3 (Level 3) and Sensor 4 (Over Limit).

From the result of experiments that have been done, the data obtained are as listed in Table 4.1 below.

Table 4.1 *Table of Pump Working Test*

No.	INPUT			OUTPUT	
	Sensor 1	Sensor 2	Sensor 3	Pump 1	Pump 2
1.	OFF	OFF	OFF	OFF	OFF
2.	ON	OFF	OFF	ON	ON
3.	ON	ON	OFF	ON	ON
4.	ON	ON	ON	OFF	OFF
5.	ON	ON	OFF	ON	OFF
6.	ON	ON	ON	OFF	OFF
7.	ON	ON	OFF	OFF	ON
8.	ON	OFF	OFF	ON	ON
9.	ON	ON	OFF	OFF	ON
10.	ON	ON	ON	OFF	OFF

Based on Table 4.1 above, it is obvious that when the water level reaches the sensor of level 1 in storage tank, the two pumps will work simultaneously, then the two pumps will work alternately each time the water level reaches the sensor of level 2. Finally, every time the surface water reaches level 3, then both pumps will stop working (OFF).

Interrupted Condition Testing

No Flow P1

To make the No Flow Pump 1 in this design, it can be done by closing the faucet of pipe 1 which is installed in the suction pipe of Pump 1 and the No Flow P1 sensor will detect that No Flow has occurred. In the program, the timer count has been set for 10 seconds after the Pump 1 is working, the No Flow P1 sensor will be ON, if the sensor detects any flow (ON) below or less than 10 seconds after Pump 1 works, the warning Alarm will not sound and also the sign light of No Flow P1 will not turn on, until the time has reached 10 seconds.

No Flow P2

To make the No Flow Pump 2 in this design, it can be done by closing the faucet of pipe 2 which is installed in the suction pipe of Pump 2 and the No Flow P2 sensor will detect that No Flow has occurred. In the program, the timer count has been set for 10 seconds after the Pump 2 is working, the No Flow P2 sensor will be ON, if the sensor detects any flow (ON) below or less than 10 seconds after Pump 1 works, the warning Alarm will not sound and also the sign light of No Flow P2 will not turn on, until the time has reached 10 seconds.

Over Load P1

Over Load occurs when there is an excess load on the pump. Overload can be made by manually pressing the button on the component of Thermal Overload Relay so it will get the

contact NO 97-98 closed and the contact NC 95-96 connected to Pump 1 will open.

Over Load P2

Over Load occurs when there is an excess load on the pump. Overload can be made by manually pressing the button on the component of Thermal Overload Relay so it will get the contact NO 97-98 closed and the contact NC 95-96 connected to Pump 2 will open.

Over Limit

Over limit disturbance or a condition when the water level has reached the predefined limit of the storage tank. So it can be done by making the water in storage tank reaches level 4 (Over Limit), which is positioned (keep pressing) the Selector Switch of Pump1 to JMP 1 and the Selector Switch of Pump2 to the position of JMP 2. So when the water level rises and reaches level 4 (over limit), the alarm sounds and the Over Limit Sign Lights on the Panel will light up as a warning.

Conclusion and Suggestion

Conclusion

Based on the result obtained from the testing of water control system, it can be concluded that:

1. The Water Control System with PLC LS XBC-DR30E works in accordance with the job description.
2. The number of limited PLC output terminals (12 terminals), makes this system cannot be developed with the addition of load or other indicator lights, unless when expanding/adding the number of output terminals.

Suggestion

The writer suggestion on the Design of Water Control System in Electric Workshop with PLC LS XBC-DR30E is: The Design of Water Control is expected to be used as a learning material for electrical engineering courses, especially in workshop.

REFERENCES

[1] Iwan Setiawan, 2006. Programmable Logic Controller (PLC) dan Teknik Perancangan Sistem Kontrol, Edisi Pertama. Penerbit Andi.

[2] Suhendar, 2005. Programmable Logic Controller. Edisi Pertama. Penerbit Graha Ilmu.

[3] William Bolton, 2003. Programmable Logic Controller (PLC) Sebuah Pengantar. Edisi Ketiga. Penerbit Erlangg