Implementation of Ladder Diagram on Schneider PLC for Prevention of Simultaneous Starting Electrical Loads

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Abstract. This paper describes the research results in a PLC application system with a ladder diagram design and its implementation using a Schneider PLC to prevent electrical loads in a building from starting simultaneously. This paper discusses the problems that exist in the industry and proposes a solution technique using PLC. The problem is that more and more electrical loads containing electric motors use ON and OFF automation to control the motors to save electrical energy consumption. But the electric motor is an inductive load that consumes much electrical energy in the starting process. If the starting process coincides with other electrical loads, it will cause the energy supply through the electrical panel becomes unstable. To deal with this real problem in the industry, a PLC-based electronic device management system was developed in the research. The ladder diagram of the made PLC system is presented in this paper. From system testing and data taken during research in the laboratory, the system created in this study has successfully prevented the electrical loads from starting simultaneously. This can be proven from the application of the system where the three electrical loads that use the Air Conditioner (AC), which contains a motor, are not started simultaneously.

Keywords: PLC, starting simultaneously, electrical loads, ladder diagram.

1 Introduction

Nowadays, many electrical loads have inductive properties in consuming electrical power. This inductive nature exists because the electrical loads have an electric motor. The inductive nature of consuming electric power causes instability in the use of electric power [1]. Examples of electrical loads with inductive load properties are Air Conditioners (AC) and Refrigerators. These electrical loads consume energy fluctuate [2]. At first, turned on, these loads will consume a large amount of electrical energy that can reach twice the energy when it usually operates [3]. As a result of this condition, a building installed with many electrical loads with inductive load

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properties must allocate electrical energy far greater than the average electrical energy requirement. In addition, this condition will cause a trip in the electrical panel when these electrical loads are on simultaneously. In the case of modern technology, the automation system contained in these electrical loads controls itself to turn on and off. For example, in an Air Conditioner, this electrical load will turn off the electric motor contained in it when the cold temperature has been reached. And will turn on the electric motor again when the cold temperature is not reached. Electrical loads like this will have fluctuations in energy consumption. If some of the electrical loads installed are high fluctuations in energy consumption, the electrical panel also trips. A system to prevent the simultaneous starting of electrical loads installed in a building will significantly help to reduce the allocation of electrical energy in a building. This paper discusses the research carried out in the form of an electrical load prevention system that uses a Schneider PLC. The topics discussed included: the proposed system, flowchart, ladder diagram, system creation, testing, and discussion.

2 Proposed system

This research uses a PLC system to control three electrical loads with inductive properties. The electrical loads such as Air Conditioners (AC) have a block, as shown in the diagram. Since these electrical loads turn on and off based on environmental conditions, they are controlled by a control unit [4]. The control unit will control an electric motor through a contactor. In the system made in this study, the control line is added to another contactor where a PLC controls this contactor. When the control unit gives a signal to start the electric motor, this signal will first be picked up and processed by the PLC. After that, the PLC will signal the contactor to pass the electric power into the motor [1].

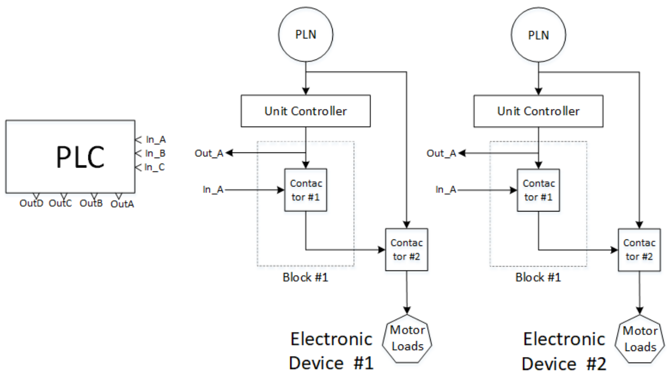

Fig. 1. Block diagram of simultaneous starting electric load prevention system.

Figure 1 shows that the electrical loads have a Controller Unit to turn off and turn on the electric motor load. Block1 Unit Controller will turn off the electric motor contained in it through Contactor2. Then restart the electric motor via Contactor 2 as well. Turning it off and on often happens because the electrical loads' device equipped with an automation system is designed that way. As a result of this process, a transient increase in electrical energy caused by an electric motor will occur.

3 Flowchart

The system's workings in the form of a flow chart are shown in **Figure 2** below. There are two inputs from the system: a request to turn off the electric motor and a request to turn on the electric motor. When an electrical load provides feedback to turn on the electric motor, there will be a logic check in the PLC whether the start time of other electronic devices is not smaller than 2 seconds. There is a conditional algorithm to check if every connected device is on for more than 2 seconds. If it is confirmed that everything has passed the time, the PLC will issue an ON signal to turn on the contactor and record the starting time. If there is a request to turn off the electric motor from the device, the PLC will directly signal the contactor to turn off the electric motor.

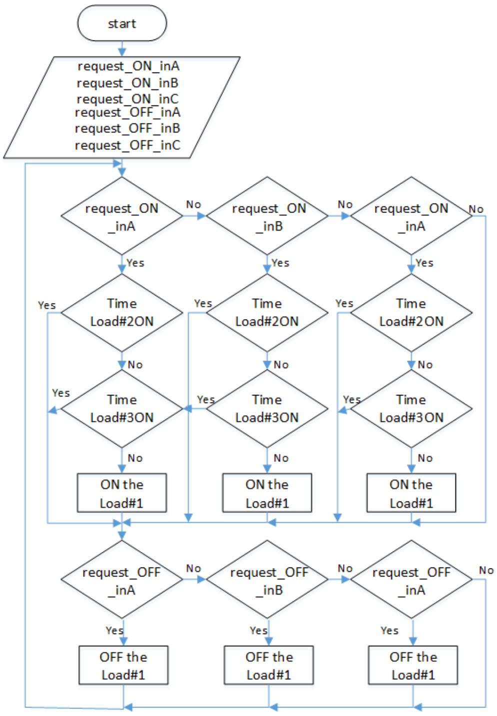

Fig. 2. Flowchart of simultaneous starting electric load prevention system.

4 PLC schneider

In this research, the system is made using PLC Schneider SR3 B261FU, as seen in **Figure 3**. This PLC uses a 220 V PLN supply voltage. Has 10 relay outputs. The number of inputs is 10. This input voltage uses a 220 Vac PLN voltage [5][6].

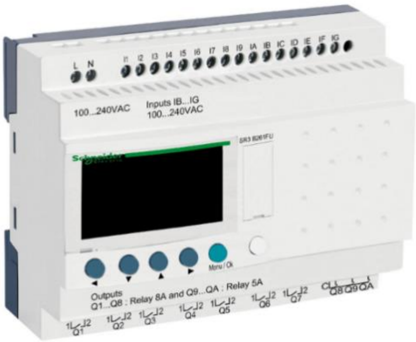

Fig. 3. Schnieder PLC used in building the system.

The input-output system of this PLC is illustrated in **Figure 4** below. The input uses PLN electricity phase cable. So it must be ensured that the input gets a phase source. While the output of this PLC is a connection or relay connection. This output is not voltage [7].

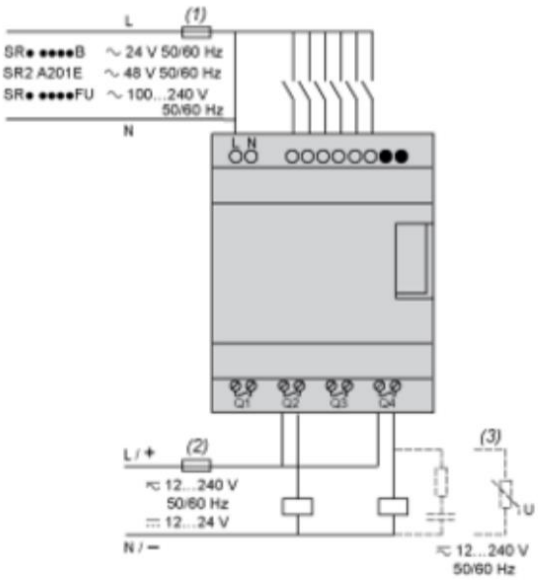

Fig. 4. The structure of the input and output terminals on the Schnieder PLC used.

5 Ladder diagram

Ladder diagrams are the commands in programming PLC [8][9][10]. The ladder diagram of the system can be shown in **Figure 5**. Input I1 is to turn on the Load1 coil. While the I2 input is to turn off the Load1 coil. When turning on the Load1 coil, the Load1 coil will turn on if there is a request from the I1 input and the contact controlled by the timer. This contact will be connected if the timer waiting time is 0. When the Load1 coil is turned on, the next step is to set the timer to 1 second. If the timer has reached 1 second, then the timer contact will be closed. For the same case, Inputs I3 and I4 are for Load2 control. While Input I5 and I6 are for Load3 control. All these processes are synchronized with a timer.

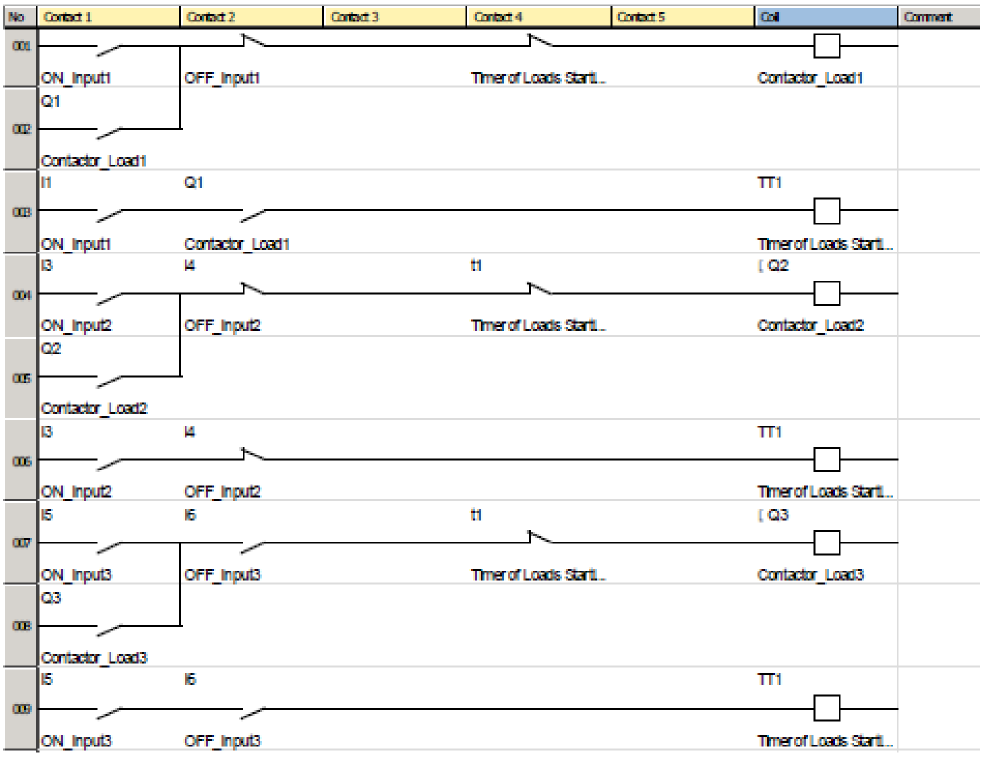

Fig. 5. Ladder diagram of simultaneous starting electric load prevention system.

6 Implemented system

The implementation of the system in a laboratory is shown in **Figure 6** below. These two push buttons represent electrical loads in turning on and off the electric motor, which is part of the loads. Electric motors, as part of electrical loads, are replaced by incandescent lamps, each with a power of 100 Watts. Push button as a signal from electronic devices such as AC in controlling electric motors. PLC Schnieder is the main control brain of the system.

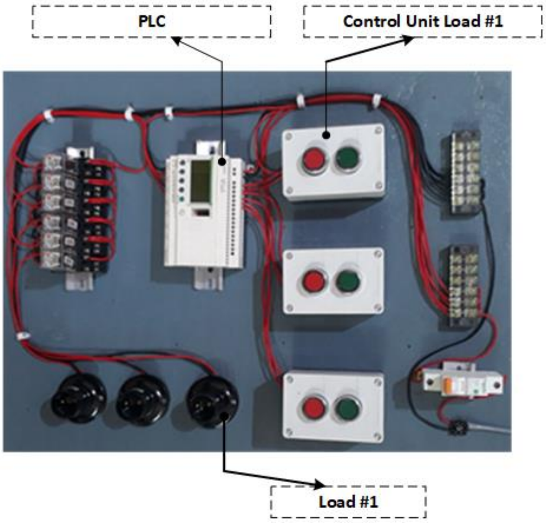

Fig. 6. The electrical load prevention system starts simultaneously which is made in the research.

7 Data and analysis

Tests are carried out randomly by turning on or off the electrical loads. The purpose of this test is to ensure that no electrical loads are starting at the same time. **Table 1** it can be explained as follows. In the first experiment, I1, I3, I5 had condition Signal (S), which means that the Control Unit of electrical loads 1, 2, and 3 wanted to turn on. But in this condition, only L1 has START status while L2 and L3 have OFF status. In the second experiment, I3, I5 had an S condition, while I1 had a No Signal (NS) condition. At this time, Load1 (L1) is ON because it was in the previous process. Furthermore, because two electrical loads want to turn on, device number three is allowed so that L3 is in START condition.

Table 1. Test results data from the system.

No	I1	I2	I3	I4	I5	I6	L1	L2	L3
1	S	NS	S	NS	S	NS	START	OFF	OFF
2	N	NS	S	NS	S	NS	ON	OFF	START
3	NS	NS	NS	S	NS	NS	ON	START	ON
4	NS	S	NS	S	NS	S	OFF	OFF	OFF
5	S	NS	S	NS	S	NS	OFF	START	OFF
6	S	NS	NS	NS	S	NS	START	ON	OFF

In the fourth experiment, all electrical loads sent a signal to turn off. In this condition, the system will allow the shutdown process so that all electrical loads are OFF.

7 Conclusion

From testing the system that has been made, this system can already work to prevent the electrical loads from starting simultaneously. Tests are carried out randomly in starting the electrical loads, but these loads do not allow to start simultaneously with the others. In this research, the system is made to handle three electrical loads. For real applications in the field, if this system is implemented, it must adjust the amount of load that will be used. The ladder diagram needs to be added one block for each additional load to be included. The application of this system is custom, so it cannot be made for the public because the cases in the field have different specifications. The design and implementation of the system are appropriate based on the testing and data analysis that has been done.

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