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Real-time Identification of Electric Motor Faults Using Arduino

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ABSTRACT

The reliability of electric motors is very important in various industries. Damage to electric motors caused by disturbances that are not detected early results in large losses, both in terms of time and cost. This research aims to design and build an Arduino-based electric motor fault detection device equipped with a PZEM-004t sensor, buzzer as an alarm, relay to turn off the motor when there is a disturbance and LCD I2C 16x2 to display the measured value. This tool is designed to provide protection to the motor from overvoltage, undervoltage and overcurrent disturbances. Based on the results of testing and analysis, the designed tool can detect and protect the motor from interference. The buzzer functions effectively as an alarm when the voltage and current values are close to the fault occurrence value. The relay can respond well in breaking the current in the motor when a disturbance occurs. Thus, this tool has the potential to be applied as a practical solution in preventing damage to electric motors in industrial environments.

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1. INTRODUCTION

Technological developments demand cheaper, more efficient systems, both in terms of equipment, measuring instruments and others. Induction motors are motors that have good construction, are cheaper, easy to adjust speed, stable when loaded and have high efficiency. Induction motors have a very important role in industry, because it has many advantages compared to other types of electric motors, such as simple construction, easy and cheap maintenance and so on. [1]-[4]. Three-phase induction motors must work well and safely. Many types of disturbances have the potential to disrupt motor performance or even damage the motor itself, including power instability which includes over-phase voltage, phase voltage drops and over-phase currents [5]-[8].

One of the causes of poor quality electricity supply is unbalanced 3-phase voltage that exceeds the specified tolerance price. This can cause damage to the electric motor if it is continuously left without any handling. If the supplied voltage is of good quality, the induction motor can work optimally. Conversely, if the supplied voltage is of poor quality, the performance of the motor will be disrupted [9]. Some disturbances in voltage and current such as overvoltage, undervoltage and overcurrent that can interfere with the performance of the motor in operation [10]-[15].

This research aims to design and build a tool to detect and protect electric motors from disturbances that occur. With simple features, this system can provide real-time information on motor conditions through sensor readings that measure voltage and current. The values obtained from the PZEM-004t sensor will be processed using Arduino UNO and displayed on the I2C 16x2 LCD. If there is an increase in voltage and current that is approaching a disturbance, the system will issue a warning via a buzzer. If this condition continues and a disturbance occurs, the relay will be activated to turn off the motor, so that damage to the motor can be prevented.

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2. METHOD

When determining what parts to use for the final project, designing the tool is an important step to take. The purpose of this design process is to ensure that the tool created works as intended, so that the results obtained can be used correctly and optimally. This final project was designed and created using a comprehensive research method, which includes designing and creating hardware and software. The inventor application, which is intended to create a 3D design of the component placement construction, allows us to design and visualize how the components will be arranged in the tool before its physical creation. Conversely, in software design, the Fritzing application helps describe the relationship between the various electronic components, and the Arduino IDE helps write, test, and upload code to the microcontroller that will control the tool [5].

In this final project, the process of creating the tool begins with creating the hardware, which involves placing all the components in a safe place and in accordance with the design that has been made. After the hardware is complete, the next part is to program the sensors and other components using the Arduino IDE to ensure that the tool can operate according to its design [6]. The following block diagram shows all the components used in this final project. This diagram shows how each component relates to each other and how they function in the designed system.

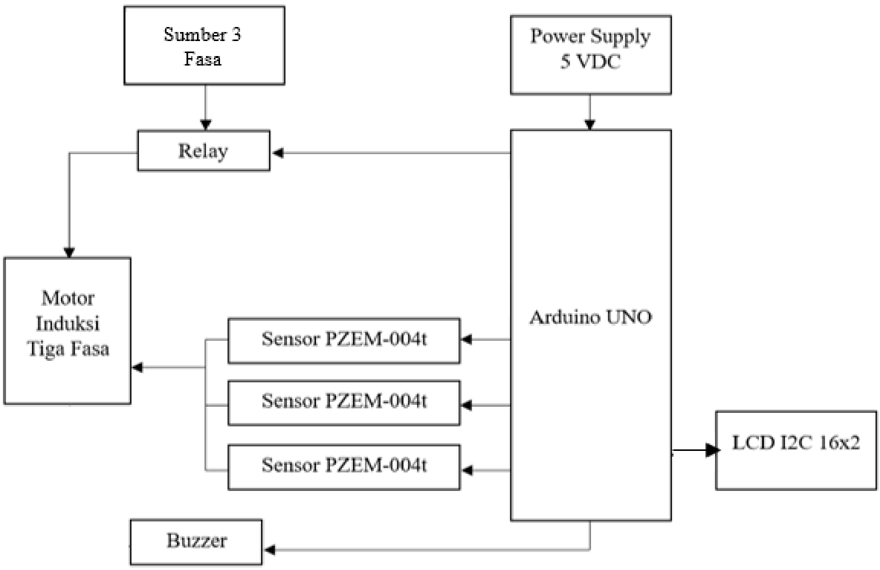

Figure 1. Diagram block of proposed system

Based on the block diagram above, the function of each part is: 1) Three-phase induction motor as the object of application of this tool, 2) PZEM-004t sensor which is the input to the microcontroller in detecting voltage and current, which if there is a disturbance in the voltage and current will be an indicator for the buzzer and relay to turn on or not, 3) Arduino is used to program and process input data from several sensors and also to control turning on the relay and buzzer connected to the motor, 4) LCD I2C 16x2 is used as a tool to display the values that have been detected by the installed sensors, 5) Relay as an output from the microcontroller which is used as an on/off switch or protection on the three-phase induction motor, 6) Buzzer is used as an alarm or early warning if the temperature, current, and voltage indicators reach the set limit and 7) Power supply is used to supply Arduino and the sensors that will be installed.

The working principle of this tool is by processing data from the voltage and current on the motor through reading the PZEM-004t sensor. The data received from the sensor will be processed through the Arduino Uno which will then initiate the buzzer as an alarm and the relay as protection. This data will also be displayed on the I2C 16x2 LCD screen. The PZEM-004T sensor is used to monitor overvoltage, undervoltage and overcurrent. In the design of this tool, the setting limit for overvoltage interference is not more than 110% of the nominal voltage and the undervoltage does not drop 90% of the nominal voltage. The voltage on each phase R, S, T with Neutral from its provisions is 220V. If the voltage increase approaches 110% and the voltage decrease approaches 90% of the nominal voltage, the system will work by giving a signal to the buzzer as an alarm. When the voltage increase has reached 110% and the voltage decrease has reached 90%, the relay will work by turning off the motor. In the design of this tool, the current value setting that has been stated in the motor specification is set at 1.78 A. For the excess current setting limit of 1.98 A. If there is an increase in current exceeding 1.78 A, the buzzer will turn on. If the current has reached the setting limit of 1.98 A, the signal will enter the relay to turn off the motor.

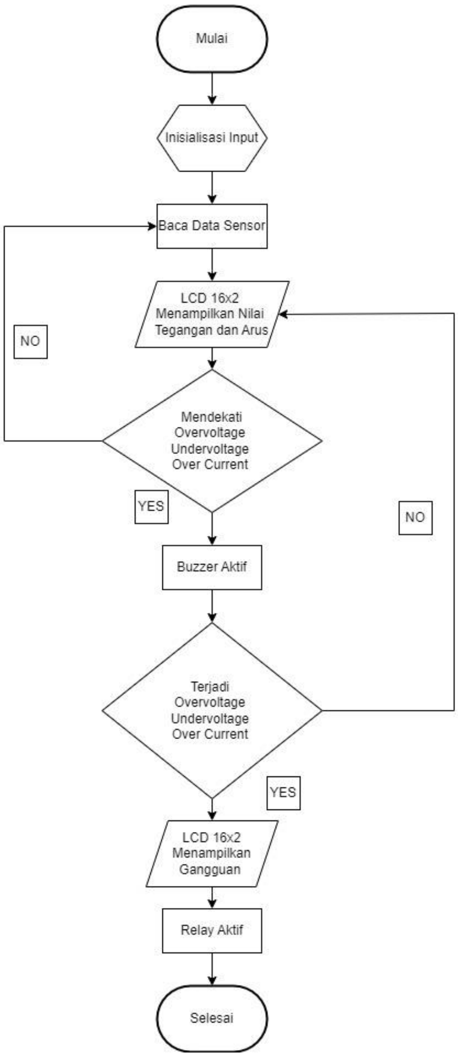

Figure 2. Flowchart of proposed system

Figure 2 above is a flowchart of a three-phase induction motor fault detector that explains how the device works. The process begins with reading the voltage and current data on the induction motor by the PZEM-004t sensor. After that, the voltage and current values that are read will be displayed on the I2C 16x2 LCD. If the detected voltage and current are close to the fault, the buzzer will be active to give a warning, otherwise the system will continue to read the voltage and current on the motor. If after the buzzer is active the voltage and current values on the motor continue to increase and reach the fault, the LCD will display the fault that is occurring and the relay will turn on to turn off the motor as protection, otherwise the system will re-read the voltage and current data on the motor. The process ends after all steps are completed and the motor is in a safe condition.

Figure 3 shows the design of a three-phase induction motor fault detector that uses acrylic as a place to place components. In this design, there are various components such as the PZEM-004t sensor, power supply, Arduino UNO as a data processing center, relay for protection to turn off the motor if there is a fault, buzzer as an alarm if there is a fault, and LCD I2C 16x2 which functions to display the data that is read. This tool is designed with dimensions of 250 mm in length, 200 mm in width, and 100 mm in height. The position of the LCD is placed on the side, so that it can see the values that are read easily. Overall, the design of this tool aims to create a tool that is effective in protecting induction motors, as well as easy to use and durable.

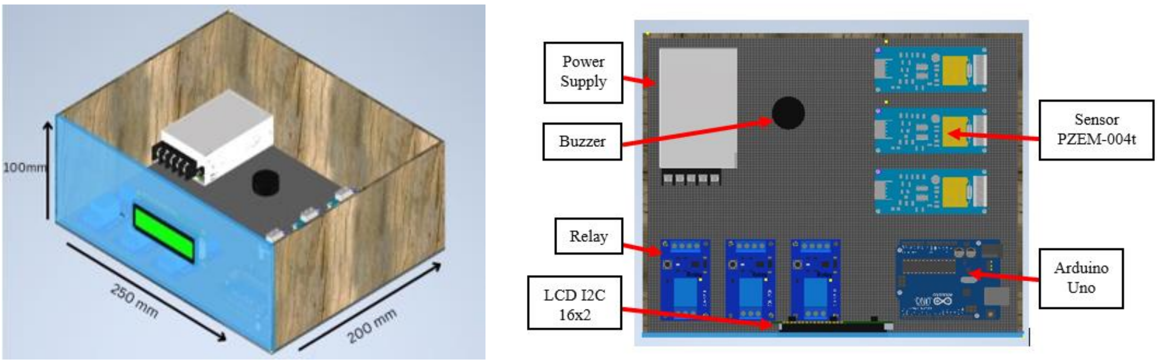

Figure 3. Design of Three-Phase Induction Motor Fault Detection

Figure 4 shows the complete design of the components used in this tool. To facilitate the assembly of the design of this tool, a control circuit is used to show how the components used and the connections on each component. In the tool to be designed, the voltage and current will be connected by the PZEM-004t sensor, relay as protection, buzzer as alarm, power supply, LCD 16x2 as monitoring which is connected as a whole with the Arduino Uno microcontroller.

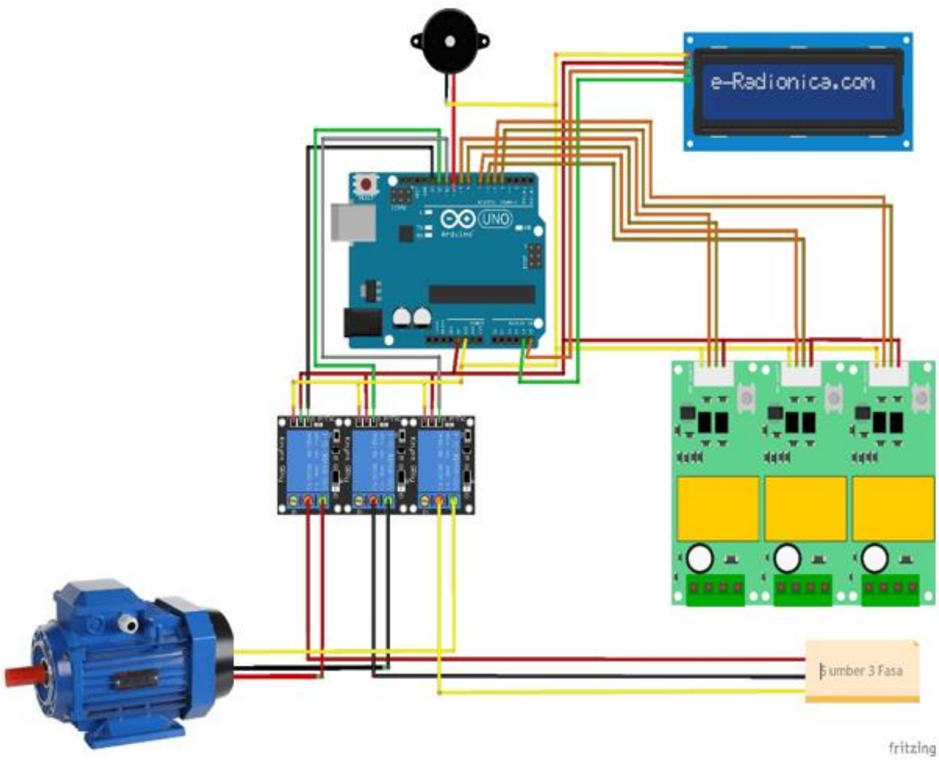

Figure 4. Circuit design of Three-Phase Induction Motor Fault Detection

3. RESULTS AND DISCUSSION

This test is carried out in several stages, such as setting the setting limits to test the protection system, operating the motor and observing and recording the values of the voltage and current on the motor. With a good reading of each component, then carry out testing by running the components as a whole. A good reading of each component can carry out the protection system properly to prevent damage to the motor caused by interference. This is indicated by the presence of interference that occurs, the protection system runs by turning on the buzzer and relay to turn off the motor. Figure 5 shows the hardware test installation.

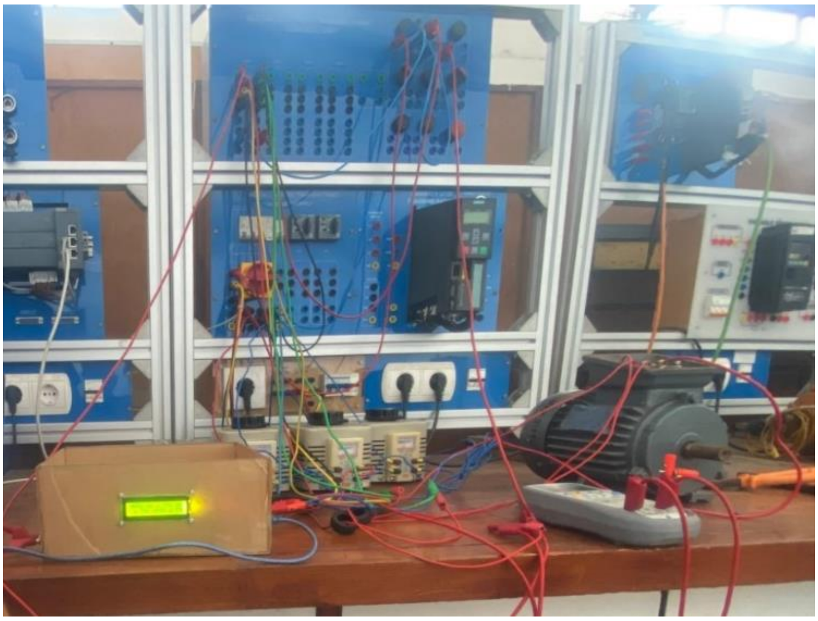

Figure 5. Hardware installation for experimental

The first test was carried out to see the action of the tool when given excess voltage using an autotransformer. The test results are described in Table 1.

Table 1. Overvoltage testing on three-phase induction motors with Autotransformers

Time (Sec)	Voltage (V)			Condition	
	R	S	T	Buzzer	Relay
5	223	219	219	OFF	OFF
10	223	221	223	OFF	OFF
15	223	223	223	OFF	OFF
20	226	225	223	OFF	OFF
25	227	226	229	OFF	OFF
30	234	232	233	OFF	OFF
35	237	232	233	ON	OFF
40	237	238	239	ON	OFF
45	240	238	239	ON	OFF
50	242	242	239	ON	ON

It can be seen in Table 1 that up to 30 seconds the motor can run safely, with the voltage value on each phase still below 235 V or not yet approaching overvoltage. At 35 seconds to 45 seconds the motor approaches the overvoltage value with the voltage value already exceeding >235 V, which is indicated by the buzzer in the on condition and the relay in the off condition. At 50 seconds, the voltage on the motor has reached 242 V and the motor experiences overvoltage, so the relay automatically turns off the motor as indicated by the buzzer in the on condition and the relay in the on condition. Figure 6 shows the overvoltage indicator on the LCD when an overvoltage fault occurs.

Figure 6. Overvoltage indicator on the LCD when there is an overvoltage disturbance

Next, the motor is treated with a voltage below the rating to see the undervoltage indicator on the device. The test results are described in Table 2 .

Table 1. Undervoltage testing on three-phase induction motors with Autotransformers

Time (Sec)	Voltage (V)			Condition	
	R	S	T	Buzzer	Relay
5	216	220	225	OFF	OFF
10	216	216	218	OFF	OFF
15	214	216	218	OFF	OFF
20	211	216	215	OFF	OFF
25	207	212	214	OFF	OFF
30	207	203	210	ON	OFF
35	207	203	210	ON	OFF
40	202	199	209	ON	OFF
45	202	199	203	ON	OFF
50	195	199	199	ON	ON

Table 2 shows that up to 25 seconds the motor can run safely, with the voltage value on each phase still above 205 V or not yet approaching undervoltage. At 30 seconds to 45 seconds, the motor voltage approaches the undervoltage value with the voltage value already passing <205 V, which is indicated by the buzzer in the on condition and the relay in the off condition. At 50 seconds, the voltage on the motor has passed 198 V and the motor experiences undervoltage, so the relay automatically turns off the motor as indicated by the buzzer in the on condition and the relay in the on condition. Figure 7 shows the LCD indicator when there is a motor voltage disturbance below the rating.

Figure 7. Undervoltage indicator on the LCD when there is an undervoltage disturbance

The third test was conducted to see the performance of the device when an overcurrent occurs. The test results are described in Table 3.

Table 2. Overcurrent testing on three-phase induction motors

Time (Sec)	Current (A)			Condition	
	R	S	T	Buzzer	Relay
5	0,64	0,56	0,74	OFF	OFF
10	0,64	0,56	0,74	OFF	OFF
15	0,64	0,56	0,74	OFF	OFF
20	0,64	0,56	0,74	OFF	OFF
25	0,62	0,62	0,71	OFF	OFF
30	0,61	0,64	0,70	OFF	OFF
35	0,58	0,70	0,67	OFF	OFF
40	0,58	0,76	0,65	OFF	OFF
45	0,73	0,69	0,61	OFF	OFF
50	0,59	0,59	0,90	ON	ON

Table 3 shows that up to 45 seconds the motor can run safely, with the current value not reaching overcurrent. At 50 seconds, the current in the motor reaches 0.90 A and the motor experiences overcurrent, so the relay automatically turns off the motor as indicated by the buzzer in the on condition and the relay in the on condition. Figure 8 shows the overcurrent indicator on the LCD. All test results show that the proposed tool has worked well.

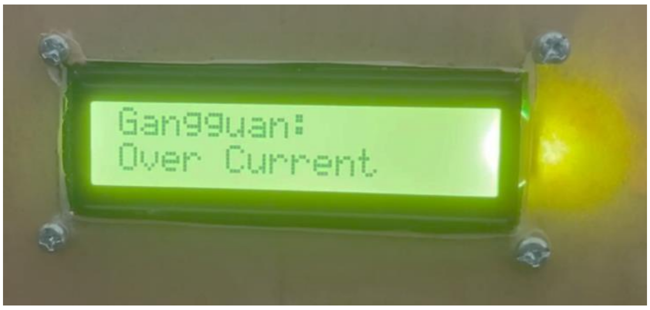

Figure 8. Overcurrent indicator on the LCD

4. CONCLUSION

Based on the results of the tests and analysis that have been carried out, it can be concluded that the designed tool can work well. In the voltage and current tests, this tool proves that it can detect and protect against disturbances such as undervoltage, overvoltage and overcurrent which are displayed on the I2C 16x2 LCD. When the voltage and current values approach the disturbance value, the buzzer can function properly as an alarm that indicates that the voltage and current are approaching the disturbance. The relay functions to turn off the motor when the voltage and current values have reached the disturbance limit.

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