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The induction motor's monitoring and protection system against vibration disturbances

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ABSTRACT

The industrial arena, the use of induction motors is an important element used in various aspects of industrial activities. Prolonged operation of an induction motor can lead to various mechanical failures. Mechanical failures can be identified by monitoring abnormal vibrations in motor components. Vibration monitoring is carried out using a vibration sensor, the ADXL345 accelometer sensor, which is attached to the induction motor body. The measurement results from this sensor are processed on the Arduino Mega and visualized into graphs on the ILI9341 TFT LCD. The vibration monitoring system is equipped with an induction motor protection device using a relay connected to coil A1 of the contactor. The contactor functions to cut off the electrical voltage from the 3-phase AC source to the induction motor being monitored. The relay will protect the induction motor when abnormal vibrations with an amplitude value of >3 g are found. System testing uses an induction motor connected to a VSD to vary the induction motor frequency. The results of the monitoring test are obtained and the vibration value will increase as the frequency of the applied voltage is increased and when the frequency is increased to 35Hz the maximum vibration detected is with a value of 3.75g, then the relay cuts off the voltage on the contactor coil and deactivates the induction motor.

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1. INTRODUCTION

The use of induction motors is very common in various industries. Induction motor is a device that converts electrical energy into mechanical energy in the form of rotating power [1]. Induction motors have a working principle based on electromagnetic induction from the stator coil to the rotor coil, the induction motor stator coil is connected to a 3-phase voltage source and produces a rotating magnetic field [2]-[3]. Induction motors are generally quite reliable, but the work environment, installation and production factors can cause damage to the rotor and stator [4]. Induction motors that are operated continuously will experience the motor aging process and can cause damage to the motor being operated. One of the damage that occurs in induction motors is mechanical failure, this mechanical failure can be detected based on the vibration produced by the induction motor while in operation. The level of vibration detected indicates the level of disturbance that occurs, the higher the vibration value detected indicates a disturbance that can cause damage and even motor failure [5].

Vibration is the movement of an alternating system, the movement can be simple harmonic or complex [6]. The operating induction motor causes mechanical vibration, namely the movement that arises due to the mechanical system around the position or balanced point [7]. High vibration in the motor is an indication of abnormal occurrence in the motor [8]. If this abnormal vibration is too late to be detected, the induction motor can experience more severe damage and cause the production process that requires this motor to stop. Therefore, operators are needed to monitor the condition of the motor on an ongoing basis [9].

Activities to maintain induction motors must be scheduled and monitored in order to reduce damage and minimize damage that occurs suddenly to induction motors [10][11]. One of the tools used for induction motor maintenance is using vibration sensors. There are 3 parameters used in vibration measurements, namely displacement, velocity and acceleration [12]. In this study, the parameters used use accelerometer sensors, accelerometers are sensors that function to measure linear acceleration due to the motion of an object or the acceleration of the earth's gravity [13]. The accelerometer sensor used, the ADXL345 sensor, is a sensor that measures acceleration in 3 axes (x, y and z). This sensor has a sensitivity of 16 g, so it can detect detailed vibration acceleration.

The use of relays and contactors in this study serves to protect excessive vibration in induction motors. Relay is an electronic switch that works by utilizing a magnetic field consisting of a coil and a plate that functions as a switch, when there is an electric current field it will cause a magnetic field that attracts the plate [14]. While the contactor is a magnetic switch that works with a magnetic force that flows and breaks the current in a 3-phase induction motor [15].

2. METHOD

The method used in this research is the literature study method and the experimental method. The literature study carried out includes knowing the vibrations that occur in induction motors while in operation. The experimental method includes 3 stages, system planning, system assembly and system testing. The process of planning and assembling the system starts from designing software, hardware and mechanics. The software design process consists of making system diagrams and flowcharts to ensure that the system can be built properly. Figure 1 below is a system diagram of the designed system.

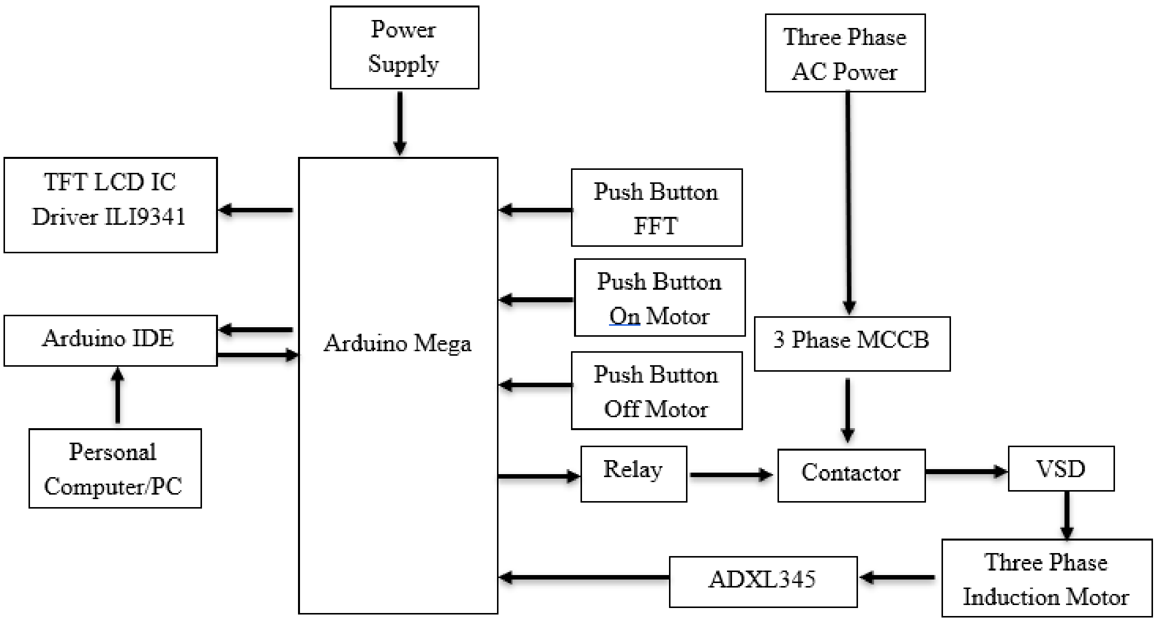


Figure 1. Block diagram of system design

The system design block diagram in Figure 1 illustrates all the components used in the system. Arduino mega is used as the main microcontroller that processes all programs created in the Arduino IDE application on a personal computer. Arduino mega requires a power source from a 9 volt power supply to run the system. The 3-phase AC source is connected to a 3-phase MCCB as an induction motor voltage source. The ADXL345 sensor detects vibrations on the induction motor, the detection results are processed using Arduino Mega and displayed on the TFT LCD ILI9341. This system is controlled through a push button connected to the arduino mega, the push button is used to turn on and off the induction motor through a relay that functions as a control signal through the contactor.

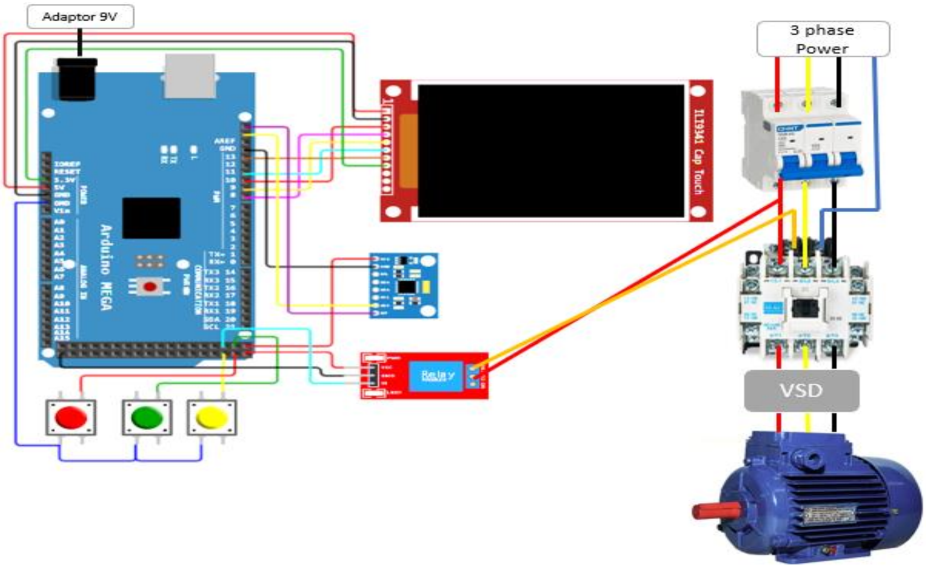


Figure 2. System Electrical Circuit Design

Figure 2 shows the electrical circuit design of the system to be designed and assembled. This design displays the configuration and relationship between components in the system. This design includes all elements involved in the operation of the system, ranging from Arduino Mega, ADXL345 sensors, TFT LCD ILI9341, push buttons, relays, induction motors and other components. Figure 3 below is a flowchart image that will be applied to the system.

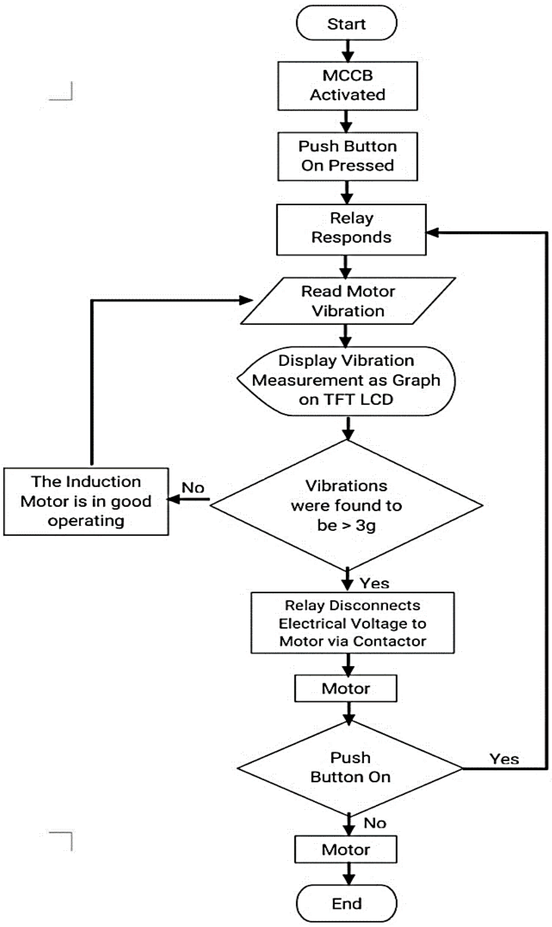


Figure 3. System Flowchart

Figure 3 there is a sequential system workflow design starting with activating the MCCB (Motor Control Circuit Breaker), then the system waits for the "On" button to be pressed. After the "On" button is pressed, the relay responds and starts the vibration measurement process, the vibration sensor reads the motor vibration data, the vibration data read is visualized in graphic form on the TFT (Thin Film Transistor) screen. Based on the data displayed the system checks the vibration data read, if the vibration exceeds 3 g, the system will cut off the voltage through the relay as a signal to the contactor to cut off the electricity to the motor and the motor stops operating then the system waits for the "On" button to be pressed, if the "On" button is not pressed, the motor remains in a dead state and the system stops operating. However, if there is no vibration that exceeds 3 g, the system will continue to operate by following the flow of the system that has been designed.

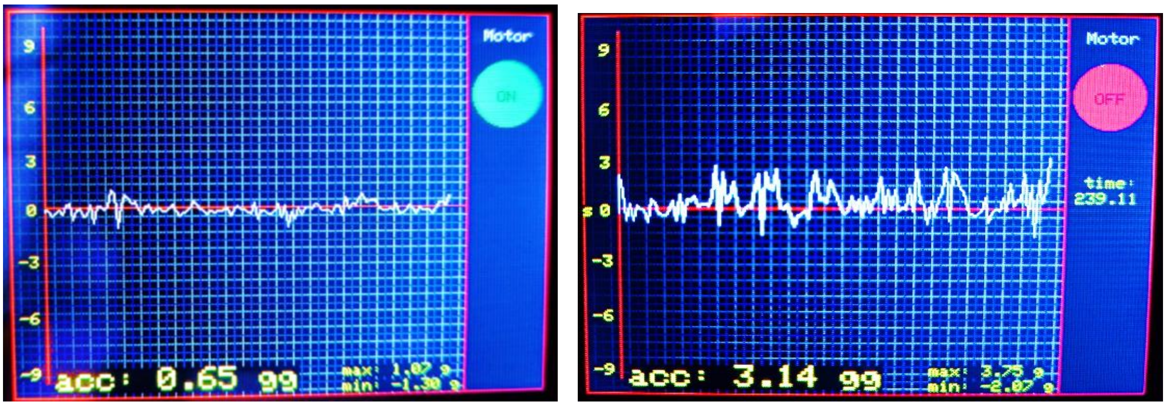
3. RESULTS AND DISCUSSION

Testing of this research uses an induction motor that will be operated with a varied voltage frequency. The vibration that occurs at each voltage frequency will be recorded and it will be observed at what voltage frequency the relay will work to protect the induction motor. The ADXL345 sensor is attached directly to the motor body so that there are no other vibrations that affect the sensor during the monitoring process. The following is a table of test results of monitoring vibrations that occur at each varied frequency.

Table 1. Vibration test results

Voltage Frequency (Hz)	Maximum Vibration (g)	Minimum Vibration (g)	Average Vibration (g)	Relay
10	0,79	-0,42	0,60	High
15	1,07	-1,30	1,18	High
20	1,55	-1,48	1,51	High
25	2,47	-1,92	2,19	High
30	2,85	-1,93	2,39	High
35	3,75	-2,07	2,91	Low

The test results recorded in Table 1 are visualized in graphical form on the TFT LCD ILI9341. At an induction motor frequency of 35 Hz, the ADXL345 sensor detects a vibration of 3.75g which causes the relay to protect by cutting off the voltage to the contactor and turning off the induction motor. Figure 4 below is the result of vibration monitoring visualized in graph form on the TFT LCD ILI9341.



(a) (b)

Figure 4. Vibration monitoring (a) Relay On, (b) Relay Off

Figure 4 shows the graph in the vibration monitoring system measured using the ADXL345 accelerometer sensor. In Figure a the vibration detected is normal in the range -1.30g to 1.07g so that the relay remains in the high position and the contactor continues to connect the voltage to the induction motor, while in Figure b the vibration results are obtained which exceed the amplitude in the range -2.07g to 3.75 g which means that the amplitude value exceeds 3g which is the threshold value made in the program to protect the induction motor, so the relay is in the low position and the contactor disconnects the voltage to the induction motor.

4. CONCLUSION

The vibration monitoring and induction motor protection system in this study uses the arduino mega 2560 which is programmed in the arduino IDE application. This system is designed to monitor the condition of the motor and stop its operation if abnormal vibrations occur. Abnormal vibrations can indicate a problem with the motor, such as imbalance or bearing damage. By stopping the motor when abnormal vibration occurs, the system can prevent more serious damage to the motor. The test results of monitoring vibrations that occur at varying induction motor voltage frequencies get various vibration results, where when the motor frequency is increased the vibration that occurs in the monitored induction motor also increases. The protection system that is made also works well with the help of a signal from a relay connected to an active contactor if a vibration is detected that exceeds 3g which is applied as the vibration threshold that occurs in this study, the motor will be turned off.

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