

## Faculty of Electrical and Electronic Engineering Technology



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**Bachelor of Electrical Engineering Technology (Industrial Power) with Honours** 

2021

# MONITORING AND PROTECTION ON THREE-PHASE MOTOR BY USING GSM MODEM

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A project report submitted in partial fulfillment of the requirements for the degree of Bachelor of Electrical Engineering Technology (Industrial Power) with Honours



Faculty of Electrical and Electronic Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

#### UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2021

#### DECLARATION

I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Electrical Engineering Technology (Industrial Power) with Honours.

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#### APPROVAL

I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Electrical Engineering Technology (Industrial Power) with Honours.



#### **DEDICATION**

My dissertation is dedicated to my family and many friends. A special gratitude to my loving parents ALI BIN MOHAMED & NORLISSHA BINTI SAHALI. Not forget to my friends and my supervisor CHE WAN MOHD FAIZAL BIN CHE WAN MOHD ZALANI for helping me to complete my project report.



#### ABSTRACT

Because of its ease of use, high durability and high efficiency, the three-phase electrical motor is the most important driver mchinery and widely use in industries. Without a proper maintainence and wrong environment, three-phase electrical motor easily can have problem such as overheating or single-phasing. This project proposes monitoring system for three-phase electrical motor which monitor temperature of the motor and prevent from single-phasing. AT89C51 microcontroller is used in the circuit to receive data from LM35 temperature sensor and send data to buzzer, contactor, and GSM modem.

The temperature sensor's output was first an analog signal and ADC 0804 is used to convert data from temperature sensor into digital signal then send back the data to microcontroller. The intention of this project is to protect three-phase electrical motor from occur abnormal condition such as overheating and single phasing and to develop a system that can monitor motor's condition. The result from this project can contribute to industries in the future.

#### ABSTRAK

Kerana kemudahan penggunaannya, ketahanan tinggi dan kecekapan tinggi, motor elektrik tiga fasa adalah mesin pemacu yang paling penting dan banyak digunakan dalam industri. Tanpa penyelenggaraan yang betul dan persekitaran yang sesuai, motor elektrik tiga fasa mudah menghadapi masalah seperti terlalu panas atau menjadi fasa tunggal. Projek ini mencadangkan sistem pemantauan untuk motor elektrik tiga fasa yang memantau suhu motor dan mencegah dari menjadi fasa tunggal. Mikrokontroler AT89C51 digunakan dalam litar untuk menerima data dari sensor suhu LM35 dan mengirim data ke buzzer, contactor dan modem GSM.

Output sensor suhu adalah merupakan isyarat analog dan ADC 0804 digunakan untuk menukar data dari sensor suhu menjadi isyarat digital kemudian menghantar kembali data ke mikrokontroler. Tujuan projek ini adalah untuk melindungi motor elektrik tiga fasa daripada keadaan yang tidak normal seperti terlalu panas dan menjadi fasa tunggal dan juga dapat mencipta sistem yang dapat memantau keadaan motor. Hasil akhir dari projek ini dapat menyumbang kepada industri pada masa akan datang.

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## LIST OF SYMBOLS

- Voltage angle Omega δ -
- ω \_



## LIST OF ABBREVIATIONS

V	-	Voltage
Ν	-	Revolution Per Minute (RPM)
$Tsh$ or $T_L$	-	Load
Nm	-	Newton Metre



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#### **CHAPTER 1**

#### **INTRODUCTION**

#### 1.1 Background

Three-phase electrical motor is the most important driver machinery and widely used in industries because easy to use, high durability and high efficiency. Three-phase electrical motor divided into two which is asynchronous motor and synchronous motor. The main part of the motor is stator, rotor, and the enclosure. Induction motor known as asynchronous motor that operates by using electromagnetic induction principle. According to Alkadhim S.A.S. SSRN Electronic Journal (2020), An A.C. motor is an induction motor (also known as an asynchronous motor). The motor line current flows through the stator windings, creating a flux known as the main flux or stator flux, which passes through the air gap and is cut by the rotor windings' conductors. As a result, an electromotive force is generated in the rotor windings, causing currents to circulate in the rotor windings, resulting in rotor flux.

The interaction of the two fluxes (stator and rotor fluxes) causes the rotating component of the motor to rotate (rotor). The rotor receives electrical power in the same way that an electrical transformer's secondary winding receives power from the primary winding via electrical induction.

That is why an induction motor is also known as a revolving transformer, since the primary winding remains stationary while the secondary rotates freely. Usually, these motors are usually placed in different environment and conditions which lead damage to motor parts.

Short circuit on the stator, overheating and single phasing are a few internal parts problems that always happen which can bring damage to the motor.

One of the causes of external problem in a three-phase induction motor is one of the phases disconnect which cause single-phasing disturbances in three-phase induction motor. An electrical motor failure will make production being halted and delay, resulting a lot of losses in financial. In electrical motors, condition monitoring and fault detection described as methods for predicting failure ahead of time such that repair, and maintenance can be done to save motor and keep operation running. To monitor an electrical motor, it must give attention to different types of faults that seem to be normal in these machines.

The Electric Power Research Institute of Canada and the General Electric Company of the United States have conducted an evaluation study to establish how efficient motors are. (Bin Hassan and colleagues.) They put 4797 people through their paces, with 872 failing once or numerous times and 1227 failing altogether on the first try. Furthermore, 335 out of 1227 motors failed on more than one occasion. Failures of the bearings and stator windings are the most common causes of failure, accounting for approximately 80% of all failures. Only 10% of the failures were caused by rotor flaws, with the remaining 90% being caused by other reasons.

#### **1.2 Problem Statement**

Usually, all electrical motor failure is cause by lack of monitoring system in electrical motor system as the technician take a long time to identify the problem. Overheating is one of the main problems and defined as rise in a motor's temperature level beyond a standard limit during its operation. Motor overloading, interference supply voltage, poor cooling capability and unbalanced supply voltages are all the causes of motor overheating. Overheating can contribute such a big problem such as insulation failure, electrical fire and motor lifespan is reduced due to earlier wear and tear of the motor windings. Furthermore, if one of the three phases supplying voltage to a three-phase motor fails, this phenomenon is known as single phasing. Single phasing is when one of a motor's line links is disconnected, resulting in a single-phase motor. A single-phase condition causes an abnormal voltage imbalance in the motor, resulting in high currents and motor heating. According to (Ivana Z. Giceva, Vasilija J. Sarac, Saso A. Gelev, and Vlatko T. Cingoski on 23rd International Scientific-Professional Conference on Information Technology, IT (2018)), If one of the three phases of a three-phase induction motor is disconnected, the motor will run in a physically two-phase mode and will not function. Humming sound was produced as the motor struggled to start in these situations. The continuation of this regime has no physical or operational significance because the motor will not start and can cause minor motor damage in some cases. A start or run capacitor is used in induction motors that are designed to run on a single phase to ensure that the motor starts and runs in the correct direction.3-phase motors depend on the phase sequence of the power supply to ensure that they start and decide their rotation, but with just two lines attached, it's impossible to know whether or not a motor will start and, if it does, in which direction it will rotate. If a singlephasing motor starts, it can be able to run under light loads without tripping simple overload breakers or fuses. When the load on the motor is increased, the current may rise well above the motor's maximum load current, or the rotor may lock up entirely. Both will trip the correct sized motor safety long before the pump reaches the expected output.

#### **1.3 Project Objective**

- i. To design protection system to protect electrical motor from severe effects such as overheating and single phasing during abnormal conditions.
- ii. To develop a system that can easily monitor motor's condition on any occasions.
- iii. To evaluate performance of the motor system to reduce risk damage.

# 1.4 Scope of Project

In this study, a hardware circuit is design to avoid three phase motor from overheat and single phasing whenever one of the two happens, the motor from the supply is disconnect. LCD screen is used to monitor status of the motor by showing current temperature and the phases currently present are indicated by bulbs. During irregular conditions happens, the user is notified by an alarm and SMS was sent to the user's mobile phone. AT89C51 microcontroller use in this circuit sense abnormal conditions. The 4-pole contactor de-energize which disconnects the motor from the supply, by sounding a buzzer and sending SMS to the user's mobile phone via a GSM modem. Three single phase transformers are used and connect with star connection which primary is connected to the 3phase supply. The secondary ends of the 6V are connected in parallel resulting in a net output voltage of 0V when all phases are present and nearly 6V when one of the phases fails. To sense the motor's temperature, LM35 temperature sensor is use in this circuit. The temperature sensor's output is an analogue signal. As a result, it is converted to a digital signal and send the data to microcontroller via an Analog/Digital converter ADC0804 and send to microcontroller. The current motor temperature can be continuously tracked in the LCD screen. The microcontroller buzzes an alarm, sends an SMS, and disconnects the supply from the load if the motor temperature reaches the hot spot or critical temperature.

#### **1.5 Thesis Outline**

On the first chapter in bachelor's degree Project is introduction. In introduction consists of project background, problem statement, objectives, and scope of study. In Chapter 2, the literature review will be discussed. On this chapter, some related journal articles and previous research papers were study to gain a better understanding to relate and how current projects are developed as well as to identify gaps and similarities in previous similar research. The project's system and method of data for the guide to continue bachelor's degree Project, equipment used, and applications will be discussed more in chapter 3. Finally, in final chapter for the bachelor's degree Project will clarify the findings that will be raised to assess the project's success.

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#### **CHAPTER 2**

#### LITERATURE REVIEW

#### 2.1 Introduction

Electric motors are such an integral part of our daily lives that we rarely think about them. Induction motors are one of the most well-known forms of electric motors. Because of their robust design and ease of operation, induction motors are used to drive loads in textile mills, agriculture, and almost all manufacturing industries. An induction motor consists of two parts which are stator and rotor. The stator is made up of different stampings with slots for three-phase windings to pass through. It's bound to fit a certain number of poles. The windings are separated by 120 degrees symmetrically. Induction motors use two types of rotors: squirrel cage rotors and wound rotors. The system does not need any DC field current to operate.

The rotor is the electromagnetic circuit's rotating part. The squirrel cage rotor is the most common type of rotor. A cylindrical laminated core with axially spaced parallel slots for holding the conductors makes up the rotor. A copper, aluminum, or alloy bar is placed in each slot. In three-phase induction motors, the rotor is often used as an anchor. The anchor shape of the rotors used in early electrical devices is the inspiration for this name. The anchor's winding is caused by the magnetic field in electrical equipment, but in three-phase induction motors, the rotor takes this role.

Rather than being physically bound by wires, rotor voltage is induced in the rotor windings. The magnitude of the force varies directly with the strength of the magnetic field and the volume of current flowing in the conductor, according to the basic theory of the induction motor. The operation of a three-phase induction motor is not always reliable; certain issues occur because of failing to prepare ahead of time. Irregular maintenance, constant use of a three-phase induction motor, lack of a three-phase induction motor control system, overcurrent, and overload, causing the motor to overheat and a variety of other issues may occur.

Heat is produced on the motor windings when a three-phase induction motor is used as a drive. According to (JAREE-Journal on Advance Research in Electrical Engineering Volume3, Number 2, October 2019), This energy is not only transformed into motion energy, but it also dissipates into heat at a rate of 10-20%, which is referred as motor losses. The industrial process may be interrupted that cause from motor not full operated in 100% condition.

#### 2.2 Single-Phasing on Three-Phase Induction Motor

Three-phase induction motor could not start if one of the motor's phases is disconnected, causing the motor to run in a two-phase mode. Humming sound could appear in such situations, and the motor would fail to start. Since the motor will not function, and in some cases, minor motor damage will occur, continuing to operate such a device has no physical or operational benefit. A loaded induction motor with rated or less than rated load loses one of its phases for various reasons such as a blown fuse, a broken power supply line, or a bad terminal link, can cause the motor to work only with the remaining two phases.

If any safety steps are not taken in a timely manner, this so-called single phasing operation mode could cause many operational problems for induction motors, which could very likely result in rapid deterioration of motor parameters and burnout. Depending on whether the input supply is single-phase AC or three-phase AC, there are two types of induction motors: single-phase induction motors and three-phase induction motors. The three-phase synchronous rotational electromagnetic field is produced by the spatial distribution of the stator windings and the phase distribution of the three-phase input supply. Nevertheless, this is not always the case for single-phase induction motors. In the case of a single-phase induction motor, it is important to ensure that the single stator winding is divided into two, normally identical, spatially spaced windings along the stator and supplied with two currents with phase differences as near as possible at 90° during the motor's construction.

According to 2(3rd International Scientific-Professional Conference on Information Technology (IT) on Single Phasing of Three Phase Induction Motors under Various Load Conditions research by Ivana Z. Giceva, Vasilija J. Sarac, Saso A. Gelev, and Vlatko T. Cingoski (2018)) mentioned that further induction motor failure analyses reveal that a large number of induction motors are severely impaired as a result "single phasing," which bring into a sudden rise in stator currents, overheating, and burnouts. Companies suffer long-term downturns, lost production, and financial losses as a result from this situation. Motors are usually shielded against current overload by fuses and various safety relays, as well as thermal overload by bimetal relays. However, they are not always capable of providing complete induction motor defence during single phasing.

#### 2.3 Type of Microcontroller

The AT89C51 is a CMOS 8-bit microcomputer with 4Kbytes of Flash programmable and erasable read-only memory (PEROM). The device is made with Atmel's high-density non-volatile memory technology and uses the MCS-51 instruction set and pinout, which is industry standard. The on-chip Flash memory can be reprogrammed in-system or with a conventional non-volatile memory programmer. The Atmel AT89C51 is a powerful

microcomputer that combines a versatile 8-bit CPU with Flash on a monolithic chip to provide a highly scalable and cost-effective solution to many embedded control applications.



Figure 2.0 AT89C51 Microcontroller

Arduino is a physical programmable board that can be programmed. This board can connect to a variety of sensors, and it may be used in conjunction with an Arduino code to link to a number of third-party libraries. Arduino hardware components are less expensive when compared to other types of controller design and programming, such as PLC programming. The authors of an article in the (International Journal of Scientific and Technology Research (2020) on the role of Arduino in real world applications, Kaswan K.S., Singh S.P., and Sagar S.,) state that Arduino is used in many industries because of its simple programming environment, signal styles, and ease of adaptation in new setup. Small legacy industrial systems may be enhanced with remote control and monitoring capabilities using Arduino boards, which are a low-cost and dependable alternative to typical industrial equipment.



Figure 2.1 Arduino Uno

According to Labihari Barik's article on (IOT Based On Temperature and Humidity Controlling Using Arduino and Raspberry Pi International Journal of Advanced Computer Science and Applications, Vol. 10, No.9, 2019 by Labihari Barik), the Arduino is a more flexible system that can obtain a more accurate value. Known for its low-cost Linux servers, the Raspberry Pi is a well-known platform for building such. It is claimed by Sanjay Kale and Bhagwat (2016) that utilizing the Raspberry Pi delivers greater performance than utilizing other microcontrollers since it has a faster CPU and greater memory than other microcontrollers.



Signals containing a continuous stream of values are known as analogue signals (there are some cases where it can be finite). Sound, light, temperature, and motion are all examples of these types of signals. The signal is broken down into sequences that rely on the time series or sampling rate, while digital signals are represented by a sequence of discrete values.

2.3.1



Figure 2.3 ADC0804

Microcontrollers are unable to read values unless they are represented as digital data. The reason for this is that microcontrollers can only perceive voltage "levels," which are defined by the resolution of the ADC and the voltage of the system being controlled. During the conversion of analogue signals to digital signals, ADCs follow a set of procedures. They sample the signal, then quantify it to determine the signal's resolution, before establishing binary values and transmitting it to the system, which then reads the digital signal from the sampler. The sampling rate and resolution of the ADC are two important characteristics to consider.

#### 2.3.2 AT89C51 Microcontroller

The AT89C51 is an 8-bit microcontroller from the Atmel family that has been around for quite some time. It uses the well-known 8051 architecture, and as a result, it is still widely used by novices. It's a 40-pin IC with a 4Kb flash memory chip. It features four ports and 32 programmable GPIO pins altogether. It lacks an ADC module and support using USART

communication. Although external ADC ICs such as the ADC084 or the ADC0808 can be used.

#### 2.3.2.1 How to program the AT89C51 (8051) Microcontroller

It is possible to program the Atmel microcontroller using a range of software packages that are readily accessible on the market. Arduino and Keil uVision, to name a couple of the most popular platforms, are examples of this. An IDE (Integrated Development Environment), which serves as a programming environment for the Atmel microcontroller, is required in order to program the microcontroller. A compiler translates source code into HEX files that can be read by microcontrollers. With the help of an IPE, the hex file is loaded into MCUs (Integrated Programming Environment).



Figure 2.4 AT89C51 (8051) programing circuit

## 2.3.2.2 Detailed Features

AT89C51 Detailed Features			
CPU	8-bit 8051		
Architecture	8051		
Program Memory Size (Kbytes)	4K Flash		
Ram (bytes)	128		
EEPROM/HEF	-		
Pin Count	40		
Max CPU Speed (MHz)	24		
Peripheral Pin select (PPS)	No		
Internal Oscillator	No		
No. Of Comparators	2		
No. Of Operational Amplifier	اويور سيتي تيڪ		
No. Of ADC Channels	MALAYSIA MELAKA		
Max ADC Resolution (bits)	NA		
ADC with Computation	No		
Number Of DAC Converter	0		
Max DAC Resolution	0		
Minimum Operating Temperature	-55		
Maximum operating Temperature	125		
Minimum Operating Voltage (V)	4		
Maximum Operating Voltage (V)	5.5		
High Voltage Capable	No		

## Table 2.0 Detailed feature of AT89C51

#### 2.4 LM35 Temperature Sensor

Temperature sensor (LM35) whose output voltage changes in response to the temperature of the environment around it. It's a tiny, low-cost integrated circuit that can monitor temperatures ranging from -55°C to 150°C in a single measurement. ADC functions on any microcontroller, and it may be easily attached to any programming platform, such as the Arduino development board. Connect the input pin of the IC to a controlled voltage, such as +5V (VS), and the ground pin of the IC to the ground pin of the circuit.



Figure 2.5 LM35 sensor output

#### 2.4.1 Pin Configuration

Pin Number	Pin Name	Description
1	Vcc	Connect with input voltage
		with +5V
2	Analog Out	Every 1°C temperature
		raise will be 10mV
		increase. Range -1V
		(-55°C) to 6V(150°C)
3	Ground	Connect to the ground of
		the circuit

Table 2.1	Pin	configurati	on for LM35
		()	

#### 2.4.2 LM35 Temperature Sensor Configuration

- 35V and -2V are the minimum and maximum input voltages, respectively. 5V is the most common voltage.
- Temperatures range from -55°C to 150°C
- The output voltage is directly proportional (linear) to temperature. For every 1°C

increase in temperature, the output voltage rises by 10mV (0.01V).

#### 2.5 GSM Module

GPRS modules and GSM modules are chips or circuits that are used to connect a mobile device or a computer to a GSM or GPRS system. A GSM Module is a GSM Modem, such as the SIM 900, for example. The GSM Module is coupled to a PCB that has a variety of different outputs, including TTL Output for Arduino, 8051, and other microcontrollers, among others. (To interface directly with a PC, use the RS232 output) (personal computer). Pins or facilities for attaching a microphone and speaker, as well as for disconnecting the

+5V or other power and ground connections, will be included on the circuit board. The type of provisions varies depending on which module is being discussed.

#### 2.5.1 Functions of GSM Module

- Send SMS messages to user
- Charging status and battery charge level can be monitor
- Signal strength can be monitor
- Phone book entries can be read, written, and searched



Figure 2.6 GSM Module

#### 2.6 IC MAX232

To convert from TTL/CMOS to RS232, the IC MAX232 is utilized. Microcontrollers (PIC/ARM/Atmel) employ TTL/CMOS logic, with which they communicate using either 0V or +5V logic levels, whereas computers utilize RS232 logic, with which they communicate using logic levels of -24V or +24V logic levels, respectively. To link these microcontrollers to a computer, the TTL/CMOS logic must be converted to RS232 logic.

The IC requires +5V to work properly; thus, the Vcc pin must be connected to +5V and the ground pin must be connected to circuit ground. Additionally, the IC requires four capacitors, with values ranging from 1uF to 22uF, to work properly.



#### 2.7 IOT Based Health Monitoring System for Electrical Motors

This study was prepared by Naveed Khan, Faizan Rafiq, Faisal Abedin, and Farid Ullah Khn from the University of Engineering and Technology in Peshawar, Pakistan, and published in Engineering and Technology. This article was about a three-phase motor monitoring system that was used to examine the performance of the motor. In this section, the circuit is theoretically investigated, and all module ratings are computed. The most crucial components of the circuit include a microcontroller, current sensor, vibration sensor, temperature sensor, GSM modem, and LCD display. Connections to the microcontroller include a vibration sensor, a current sensor, and a thermocouple, among other things. Sensor data is received by the microcontroller and sent through GSM by the microcontroller to the rest of the system. The status of the sensors will be presented on the display. Electric motors now have an issue detection system that is based on a wireless monitoring system that has been developed. A testing bed is used for experiments, in which an electrical motor is driven in a normal (healthy) state to collect normal data, and then a problem (which could be electrical, mechanical, or electromechanical) is introduced to collect faulty data. Experiments are carried out on the testing bed to collect faulty data. Everything is done on a testing bed, with an electrical motor tightly attached to the nuts and bolts to ensure that nothing moves throughout the experiment. Aside from that, the circuit is linked to the Wi-Fi module. It is configured using a microcontroller. TCP/IP (transmission control protocol/internet protocol) is supported by the Wi-Fi module, which enhances the microcontroller's capacity to connect to a Wi-Fi network. The Wi-Fi module is comprised of a system on a chip (SOC) that supports TCP/IP (transmission control protocol/internet protocol). The Wi-Fi module can transmit data from the sensors on the microcontroller to the Thingspeak server. The ESP8266 Wi-Fi module is then used for data monitoring via the Internet of Things, which is implemented on the ESP8266. The data may be accessible from anywhere in the world thanks to the Thingspeak server. The GSM network is used to send data in the case that the internet is not available. In addition, the microcontroller will be connected to a DAQ card, which will be controlled by the LabVIEW program, allowing inlab analysis. Using LabVIEW, we can gather and analyze the data from the accelerometer and current sensors in detail, allowing us to acquire a better understanding of how the operation works in both normal and abnormal scenarios.



Figure 2.8 Circuit diagram of a health monitoring system for the electrical motor using
Proteus software

A variety of sensors are used to detect any type of electrical, mechanical, or electromechanical problem in an electric motor. The system is made up of several sensors (vibration, current, and temperature). It was decided to use the Arduino mega 2560 as the microcontroller for this configuration. The readings from the sensors in the control panel are shown on an LCD display (16 x 2) in the control panel. The accelerometer ADXL 335, which is a tri-axial accelerometer, is used to detect vibrations. When it comes to current measurement, the ACS 712 current sensor is used, which has a current measuring capacity of up to 20 A. The GSM SIM 900A is used to transfer the signals from the sensors to the receiver. The K-type thermocouple is used for temperature sensing and is capable of
monitoring temperatures in the range of 0-600 degrees Celsius. The thermocouple is attached to the MAX6675 module through a pigtail connector. This module is intended to increase the signal strength of the thermocouple. The actual signal from the thermocouple is rather weak, and it must be amplified before it can be used to interface with the Arduino microcontroller. Sending data to a web server is accomplished through the usage of the ESP8266 Wi-Fi module. The sensor data is uploaded to the Thingspeak server, where it may be accessed and seen by anybody in the world who has access to the Thingspeak server.

As for the location of the sensors, two accelerometers are installed on the electrical motors, while the current sensor is placed in the circuit box and connected to the supply line of the motor. The temperature sensor is situated within the motor, near the stator windings, and measures the temperature of the motor. The current sensor is connected to the phase wire by means of accelerometers, which are positioned on nuts and bolts on the stiff section of the electrical motor and are used to measure the speed of the motor. The temperature sensor (thermocouple) is located near to the stator windings, which makes it easy to read. Because it is linked to the live wire of the electrical motor, the clamp meter is capable of displaying real-time information on the current flowing through it. The LCD also shows the magnitudes of the current, voltage, accelerometer, and temperature measurements, among other things. The Arduino receives power from the adapter at a voltage of 8V and 1A.

#### 2.8 Design and Implementation of Protection Relay 3 Phase Induction Motor

The authors of this study are Kukuh Widarsono, Abdillah Fashiha, and Alfian Rejeki from the State Polytechnic of Madura Sidoarjo in Indonesia, who conducted the research. On the basis of the findings of the prior investigations, an investigation was conducted to contribute to the safety relay in those prior studies, which was successful. A safety system known as the "Design and Implementation of 3 Phase Induction Motor Safety Relay" was developed to resolve the defects and defects that still exist in the system today. Speed, accuracy, dependability, and sensitivity are just a few of the advantages that this safety system provides. This project will involve the development of a three-phase induction motor safety system that guards against overcurrent (Over Current) and excessive heat (Overheat) while also showing the rotational speed of the motor. When the current value, voltage, and temperature in the motor match the values on the name plate, the motor is deemed to be in proper operating condition. This is because the sensor only communicates current data to the LCD for display. The sensor also communicates voltage and temperature to the LCD. Any time an overcurrent disturbance (over current) happens, the sensor will detect it and send the information to the control, which is in the form of an Arduino Mega, which will result in the relay receiving logic 0. The relay will then make contact with the contactor, which will result in the electrical supply being cut off completely. As a result, the voltage supplied to the motor is switched off, and the motor is forced to shut down completely.



Figure 2.9 The block diagram protection relay for three-phase induction motor

CT sensor is a current AC sensor that detects whether the current required by a three-phase induction motor is within its capability or not.



Figure 2.10 Current sensor circuit

NTC (Negative Temperature Coefficient) thermistor is an electrical component that sensitive to temperature. Thermistor operating temperatures typically vary from -90 to 130 degrees Celsius. A 100k ohm resistor is placed in series with the circuit of this component.



Figure 2.11 A series of temperature Sensor Circuit

It is important to note that the usage of an NTC Thermistor sensor in this situation corresponds to the NEMA Standard (The National Electrical Manufacture Association) At a certain temperature or temperature range, the resistance of an electromotor's wire coil is classified as an Insulation Class, which is a grouping or division of classes. In accordance with this standard, insulation classes are separated into four categories, which are as follows: insulation class A, insulation class B, insulation class F, and insulation class H. A three-phase induction motor operating at a frequency of 50 Hz is designated as Insulation Class F in this situation. In this case, the maximum operational temperature is 155 degrees Celsius, and the hottest hot spot or temperature point increases by 10 degrees Celsius. In order to

calculate the maximum authorized operating temperature NTC, the total of the ambient temperature readings (40 degrees Celsius) and any increasing temperature or rise in the authorized temperature plus the hot spot must be added together. It was decided to use an NTC Thermistor on the stator winding. An induction motor's winding stator is made up of a series of direct-connected windings. Its purpose is to determine the real temperature of the motor.

# 2.9 Comparison with Previous Study

Year &	Author	Description	Hardware & Software
Title	APH MALAYSIA		
2016 –	Alam Afif	Using Prony brake loading,	• Matlab/Simulink
Analisis	Makarim,	this work investigates the	• 3-Phase
Ketidakseri	Tejo	imbalance voltage and	1HP/0.75kW
mbangan	Sukmadi,	temperature rise that occur in	induction motor
Tegangan	Bambang	3-phase induction motors	ELAKA
Dan	Winardi	when single-phasing is	
Kenaikan		disrupted in zero and load	
Suhu Pada		circumstances. As a result, the	
Motor		impact of single-phasing	
Induksi 3		interference on imbalance	
Fasa Akibat		voltage and temperature rises	
Gangguan		from its normal state must be	
		investigated.	

Table 2.2 Comparison with previous study

2019 –	Abdillah	Based on the findings of prior	Contactor
Design and	Fashiha	investigations, an inquiry was	• Microcontroller
Implementa	Ilman	conducted to contribute to the	Speed Sensor
tion of	Kukuh	safety relay in those earlier	• NTC Thermistor
Protection	Widarsono	studies. To address the	Sensor
Relay 3	Alfian	problems and shortcomings	• LCD Display
Phase	Rejeki	that still exist, a safety system	• Relay
Induction		dubbed "Design and	• ZMCT103C
Motor		Implementation of 3 Phase	Current Sensor
	AVE	Induction Motor Safety	
	stal MALATONA	Relay" was created. This	
	TEKN	safety system's advantages	
	LLIS &	include speed, accuracy,	V
	Alun	reliability, and sensitivity.	
	ليسيا ملاك	A three-phase induction motor	اوىيۇم
	UNIVERSITI	safety system will be created	ELAKA
		to protect against overcurrent	
		(Over Current) and excessive	
		temperature (Overheat), as	
		well as to display the motor	
		rotational speed.	

2019 – IoT	Naveed	The purpose of this paper	• Arduino mega
Based	Khan,	was to discuss a	2560
Health	Faizan	monitoring system for	• GSM SIM 900A
Monitoring	Rafiq,	assessing the performance	• LCD (16 x 2)
System for	Faisal	of three-phase motors. All	display
Electrical	Abedin,	module ratings are	• K-type
Motors	Farid Ullah	computed, and the circuit	thermocouple
	Khan	is theoretically studied.	• ACS712 Current
		The circuit's most crucial	Sensor (20A)
		components are a	• ADXL335
	ARL MALAYSIA	microcontroller, current	(Vibration
	TEKW	sensor, vibration sensor,	Sensor)
	Linge	temperature sensor, GSM,	• ESP8266 Wi-Fi
	AINO	and LCD display.	module
	ليسيا ملاك	<sub>ا</sub> سىتى ئىكنىكى م	LabView
	UNIVERSITI	FEKNIKAL MALAYSIA MI	• Matlab

# 2.10Citation and Reference

Year	Title	Author	Summary
2016	A Survey of Efficiency-	Thomas G.	Monitoring the condition of electric
	Estimation Methods for	Habetler,	motors helps to prevent costly
	In-Service Induction	Ronald G.	repairs. Unexpected motor failures
	Motors	Harley, Bin Lu,	result in financial losses and enhances
			the system's dependability and
			maintainability.
2016	Methodology For	Gonzalez-	This paper introduces a new
	Overheating Identification	Cordoba, J. L.,	technique for assisting preventive
	On Induction Motors	Granados-	maintenance in multiple induction
	Under Voltage Unbalance	Lieberman, D.,	motors installed in industrial facilities
	Conditions In Industrial	Osornio-Rios,	by identifying and diagnosing
	Processes.	R. A., Romero-	unwanted overheating conditions. In
	UNIVERSITI	Troncoso, R. J.,	the presence of voltage unbalance,
		De Santiago-	the identification is carried out by
		Pérez, J. J., &	monitoring the voltage in the
		Valtierra-	electrical system and the temperature
		Rodriguez, M.	characteristic curve of the motor
			obtained via infrared (IR)-
			thermography.
2016	Analisis	Alam Afif	One phase stator may become
	Ketidakserimbangan	Makarim, Tejo	damaged and stop working in a 3-

# Table 2.3 Reference

Tegangan Dan Kenaikan Sukmadi, and phase induction mot	tor due to a lack
Suhu Pada Motor Induksi Bambang of maintenance	and a poor
3 Fasa Akibat Gangguan Winardi environment. This	causes single-
Single-Phasing phasing problems, w	which result in an
unbalanced voltage a	and an increase in
motor temperature.	
2016 Causes and Effects of William H. In this paper, we'll h	ook at three
Single-Phasing Induction Kersting different ways that a	single-phase
Motors induction motor can	function. Any
state in which the th	ree line-to-line
voltage phasors appe	ear on the same
line is considered "s	ingle phase"
2018 An Experimental Mahdi Atig, Potential flaws in	the three-phase
Investigation of Heating Mustapha induction machine	include stator
in Induction Motor under Bouheraoua, faults, broken roto	r bars and end
Open Phase Fault Arezki Fekik rings, bearings, a	nd eccentricity-
related faults. The	occurrence of
these failures causes	s a misalignment
in the motor'	s temperature
distribution.	
2018Single Phasing of ThreeIvana Z. Giceva,Industrialelectric	drive systems
Phase Induction Motors Vasilija J. Sarac, commonly emplo	y three-phase
under Various Load Saso A. Gelev, induction motors.	
Conditions	

		and Vlatko T.	These motors, despite being
		Cingoski	extremely durable, versatile, and easy
			to maintain, often experience single
			phasing, or the loss of one of their
			phases.
2018	Single-Phasing Protection	Fernando J. T. E.	Electrical and mechanical faults may
	of Line-Operated Motors	Ferreira, André	occur in motors. Overvoltage, voltage
	of Different Efficiency	M. Silva, Aníbal	drop, voltage unbalance, and phase
	Classes	T. de Almeida	failure/loss are examples of electrical
			faults that cause current fluctuations
	AL WALAYSIA MA		as well as short-circuits, causing the
		NKA	current to exceed levels capable of
	Lingh		damaging the motor windings.
2019	Design and	Abdillah	Although the three-phase induction
	Implementation of	Fashiha Ilman,	motor is the most widely used in
	Protection Relay 3 SITI T	Kukuh AL MAL	manufacturing, problems such as
	Phase Induction Motor	Widarsono,	overcurrent and overheating are still
		Alfian Rejeki	popular which can lead damage to the
			motor.
2019	IoT Based Health	Naveed Khan,	For the maintenance of various
	Monitoring System for	Faizan Rafiq,	industrial systems, health monitoring
	Electrical	Faisal Abedin,	is considered. Machine condition
	Motors	Farid Ullah	monitoring is needed to anticipate
		Khan	any functional abnormalities and to

			conduct regularly maintenance
			activities in a timely manner.
2019	IoT based Temperature	Lalbihari Barik	Through using networks to monitor
	and Humidity Controlling		electronic devices, the Internet of
	using Arduino and		Things (IoT) plays an important role
	Raspberry Pi		in our everyday lives.
			Controlling is accomplished by
			meticulously monitoring key
			parameters that produce critical
			information about the operation of
	HALAYSIA 44		these electronic devices.
2019	Problem-Based Learning	Ihtiari	In a three-phase induction motor, the
	Model for Three-Phase	Prastyaningrum	understanding of electromagnetic
	Induction Motor	and Hendrik	induction material is essential.
	مليسيا ملاك	Pratama	اونيۇم سىتى تى
2020	Role Of Arduino In Real	Kuldeep Singh	The physical programmable board is
	World Applications	Kaswan, Santar	known as Arduino. This board can
	World Applications	Kaswan, Santar Pal Singh,	known as Arduino. This board can connect to a wide range of sensors,
	World Applications	Kaswan, Santar Pal Singh, Shrddha Sagar	known as Arduino. This board can connect to a wide range of sensors, and several third-party libraries can

#### 2.11Summary

What can be summarized from this chapter is that a few studies on three-phase motor monitoring and protection may be utilized as a reference and be incorporated into my project. To give an example, consider the article by Naveed Khan, Faizan Rafiq, Faisal Abedin, and Farid Ullah Khn from the University of Engineering and Technology Peshawar, Pakistan, which is about a monitoring system to evaluate the performance of a three-phase motor using a current sensor, a thermocouple, an Arduino board, a GSM module, and an LCD display. I am considering adding a few components to my project, like as an ESP8266 Wi-Fi module, which will allow me to transfer data to a web server. Another user can access and view the data that is sent by the sensor data to the Thingspeak server using the Thingspeak server. Then there is another paper by Kukuh Widarsono, Abdillah Fashiha, and Alfian Rejeki from the State Polytechnic of Madura Sidoarjo in Indonesia that describes how to build a current sensor circuit and a temperature sensor circuit that may be used to gather data for my project. The component was referred to as an NTC (Negative Temperature Coefficient) thermistor, and it performed the same function as the LM35 sensor. The difference between an NTC and JNIVERSITI TEKNIKAL MALAYSIA MELAKA an LM35 sensor is that an NTC can work between -90°C and 130°C, whilst an LM35 sensor can monitor temperatures between -55°C and 150°C.

#### **CHAPTER 3**

#### METHODOLOGY

#### 3.1 Introduction

On this chapter will explain about method and process that use for project prototype and simulation as to achieve objective of the project. By this chapter also will include project flow more detail on how the hardware is operating to specify input and output functions of the project and get the output result. The approach for finishing the project is clearly defined and developed by the approach utilized for its implementation. It is also considered while allocating time during project development and design. This project entails both hardware and software configuration. Finally, this chapter also covers every stage of the project's development, from the beginning to the end.

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## 3.2 Methodology

When an aberrant situation such as single phasing or overheating is detected in the hardware circuit, the AT89C51 microcontroller is employed to detect it. GSM Modem will be used by Buzzer to communicate with the user's mobile phone and send SMS messages to the user's mobile phone. The 4-pole contactor is de-energized, which causes the load to be disconnected from the power source. Three single phase transformers, each having its primary connected to the three-phase supply, are used in a star arrangement to provide the three-phase power. During normal operation, the secondary ends of the 6V are linked in parallel, resulting in a net output voltage of 0 V and approximately 6 V when one of the phases is not functioning properly. It is the temperature sensor LM35 that determines how hot the motor is running at any given time. The output signal from the temperature sensor is

an analogue signal. Therefore, an Analog/Digital converter ADC 0804 is used to convert the signal into a digital format, which is then sent on to the microcontroller for further processing.

## 3.2.1 Phase Sensor Block



Figure 3.0 Phase sensor block

This project is made up of the building components listed in Figure 3.0 phase. A significant portion of it is made up of two key constituents. Temperature and phase sensors are integrated in the block's design. The phase sensor block is often used to detect single phasing, whereas the temperature sensor block is often used to detect motor overheating. One set of three single phase potential transformers is connected in a star configuration on the main side of the Phase sensor block, while another set is connected in a delta configuration on the secondary side of the Phase sensor block. As a last step, the output of

the delta linked transformers is fed back into the rectifier and regulator circuits to complete the circuit. A rectifier and regulator circuit generates an output voltage of 5V until all of the phases are present; otherwise, the output voltage is a value of 0V. This results in either 5V or 0V being sent to the AT89C51 microcontroller, which it uses to regulate the relay that is attached to the AT89C51. When it comes to sensing and regulating the temperature of the motor, that responsibility falls to the temperature sensor. Whenever the temperature of the motor rises over the specified temperature of the motor, the microcontroller trips the relay, so cutting off power to the load. Several peripherals are connected to the AT89C51 CPU block, including a GSM module, an LCD display, and a buzzer. The GSM modem will send a message to the user's mobile device if one of these scenarios happens, notifying them of the present state of the motor and activating a buzzer. This circuit's design protects the motor against overheating and single-phasing effects because of the way it is constructed.

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#### 3.2.1.1 Flow Charts



Based on the flow chart above the operation start when LM35 temperature sensor sense abnormal temperature which is already set 100°C on microcontroller. If the LM35 temperature sensor sense temperature over 100°C, the data from microcontroller will triggered the contactor to cut off the power supply. Same operation if the single phasing detected. If any one of the abnormal conditions whether overheating or single phasing, contactor eventually cut the power supply to prevent motor getting risk damage. The data from microcontroller then send to LCD and eventually will display "MOTOR IS IN DANGER NEED MAINTAINENCE" to give indicate user nearby that motor need maintenance as soon as possible. At the same time, buzzer will be ringing to give an alert to user if they don't see the display and data from microcontroller will also send to GSM modem. GSM modem will operate by sending a SMS to registered user and the registered user will get a message "MOTOR NEED MAINTAINENCE AS SOON AS POSSIBLE" when abnormal condition happens to the induction motor.

	2	
alley and a second	Synchronous Motor	Induction Motor
Speed	Runs at synchronous speed	Runs below synchronous speed
DC Field	DC field current is needed	Does not need DC field current
Construction	Slip rings and brushes	• Squirrel cage does not have slip ring and brushes
		• Wound rotor features slip
		rings and brushes
Rotor Type	Salient pole rotor	Squirrel cage or wound
P.F	Leading, lagging and unity	Lagging
Cost	Expensive	Cheap
Maintenance	Required extra maintenance	Little maintenance required
Slip	It rotates at synchronous speed	The amount of slip is always
	and slip = 0	greater than zero but less than
		one.

3.2.1.2 Difference between Induction Motor and Synchronous Motor

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Rotor	Winding over the rotor	Rotor bars is short circuited to end
Construction		rings

#### 3.3 Result and Analysis

In the case of a motor that is started from a complete stop with the rated stator voltage provided, the starting current can be as high as six to eight times the rated current of the motor. The starting current of a large induction motor may create an excessive voltage drop along the feeder, which may be disruptive or unpleasant to other loads connected to the same feeder as the large induction motor. The Matlab program was used to run a simulation of three phase induction (Asynchronous motor) under various load situations, as shown in Figure 3.1. There are four different types of loads that have been configured: full load, half load, one-fourth of the load, and zero load. The power supply to the asynchronous motor is connected in a star arrangement, as shown in the diagram below. Several things should be observed from this simulation, including the change in motor load from zero load to full load at 3 seconds, half load at 5 seconds, one-fourth of the load at 10 seconds, and finally zero load after 10 seconds, as well as the effect on stator current and rotor current, as well as the effect on motor speed and motor torque of the asynchronous machine.





	i ka		
🚹 Block Parameters	: Asynchronous Machine SI Units		×
Asynchronous Mac Implements a three modeled in a select are connected in w	hine (mask) (link) a-phase asynchronous machine (v table dq reference frame (rotor, s ye to an internal neutral point.	yound rotor, squirrel cage ( ator, or synchronous). Sta	or double squirrel cage) tor and rotor windings
Configuration F Rotor type: Preset parameters Squirrel-cage pres	Parameters Load Flow Squirrel-cage et model: 15: 5.4 HP (4KW) 4	ليبي نيڪ 00 V 50Hz 1430 RPM	اونيور. MELAKA
Double squirrel-ca	ge preset model:	Open paramet	ter estimator
Double squirrel-ca Mechanical input:	ge preset model: Torque Tm	Open paramet	ter estimator
Double squirrel-ca Mechanical input: Reference frame:	ge preset model: Torque Tm Rotor	Open paramet	ter estimator
Double squirrel-ca Mechanical input: Reference frame: Measurement outp	ge preset model: Torque Tm Rotor Dut	Open paramet	ter estimator
Double squirrel-ca Mechanical input: Reference frame: Measurement outp	ge preset model: Torque Tm Rotor put es to identify bus labels	Open paramet	ter estimator
Double squirrel-ca Mechanical input: Reference frame: Measurement outp	ge preset model: Torque Tm Rotor put es to identify bus labels	Open paramet	ter estimator ▼ ▼

Figure 3.2 The parameters of the asynchronous machine

Figure 3.2 shows an asynchronous machine with power rating 5.4 HP (4KW), supply voltage 400V, frequency 50Hz and speed 1430RPM was used to run this simulation. 400V is Vrms value and to convert into peak amplitude (V), the formula is:

$$Vmax = \frac{\sqrt{2} \times Vrms}{\sqrt{3}}$$

$$Vmax = \frac{\sqrt{2} \times 400}{\sqrt{3}}$$
$$= 326.60 \text{ V}$$



The value of the peak amplitude (V) is 326.60V by applying formula  $Vmax = \frac{\sqrt{2} \times Vrms}{\sqrt{3}}$ 

The phase angle for Va is 0°, for Vb is -120° and for Vc is 120°. In theory, any power generator contains a rotor with magnets and a coil on the circumference, and one rotor rotation equals one 360-degree cycle. When the angles between phases are 120°, the sum of the voltages is always zero.



Figure 3.4 Magnitude of every phase

The frequency has been set to 50Hz as the asynchronous machine was used 50Hz of frequency. The rotor of the generator rotates 50 times per second, the current changes 50 times per second back and forth, and the direction changes 100 times per second. That is to say, the voltage changes 50 times per second from positive to negative and from negative to positive voltage.

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When the frequency is increased, the copper and steel consumption of the generator and transformer decreases, resulting in weight and cost savings, but inductances of electrical equipment and transmission lines increase, reducing capacitances and increasing losses, lowering transmission efficiency. If the frequency is too low, the materials used in electrical equipment will rise, making it heavier and more expensive, and causing lights to flash. The use of 50 Hz and 60 Hz frequencies has been proven to be effective.

#### **3.3.1** Type of Torques in Induction Motor

the formula:

There a few types of torques in induction motor which are gross mechanical torque or motor torque ( $T_{a}$ ), loss torque due to friction, windage and iron losses ( $T_{lost}$ ) and load torque ( $T_{sh}$ ) or ( $T_L$ ). To find load torque ( $T_{sh}$ ) or ( $T_L$ ), a formula was applied which is:

Power (Pout) =  $Tsh \times \omega$  $Tsh = \frac{Pout}{\omega}$ 

P<sub>out</sub> was given based on figure 3.2 which is 4000 watts. Then to find the value of  $\omega$ :

$$\omega = \frac{2\pi \times N}{60}$$

N is speed of the motor based on figure 3.2 which is 1430RPM, then substitute the value into

 $\omega = \frac{2\pi \times 1430}{60}$  $= 149.75 \ rad/sec$ 

All the value that already get apply to the formula Tsh which is:

$$Tsh = \frac{4000}{149.75}$$
  
= 26.71Nm

In this simulation, 4 different types of load were apply to the motor which are full load, half load, <sup>1</sup>/<sub>4</sub> of load and zero load. The value of the full load is 26.71Nm and to find the value of half load and <sup>1</sup>/<sub>4</sub> of load, the formula use is

$$Half \ Load = \frac{TL}{2}$$
$$\frac{1}{4}load = \frac{TL}{4}$$

Then we substitute Tsh value into half load and 1/4 load formula:

$$Half \ Load = \frac{26.71}{2}$$
$$Half \ Load = 13.36 Nm$$
$$\frac{1}{4} load = \frac{26.71}{4}$$
$$\frac{1}{4} load = 6.68 Nm$$

~ - - -

## 3.4 Expected Result

From motor load signal graph in figure 3.5, what can be observed that zero load was not apply and after 3 seconds the signal increase to 26.71. Then, the signal graph decreased when the time reach 5 second as the signal graph drop to 13.36. When signal graph reaches 10 seconds, the value drops again to show the load was reduced as the value was 6.68 and the graph back to 0 when the time reach 15 second to show there is no load was applied to the motor during that period.

🖪 Motor Load				-		×
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			Min	-1.000e-02	13.0	000
			Peak to Peak	2.672e+01		
-20		-	Mean	9.140e+00		
			Median	6.670e+00		
			RMS	1.255e+01		
45		•	∓ ▼ Cursor Me	asurements		۶X
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MALMON						

Figure 3.5 Motor load signal graph

Based on Figure 3.6 and Figure 3.7, what can be observed are speed and motor torque give effects to stator and rotor current. Firstly, speed of the motor remains constant and when the time reach 3 second which full load was applied, the speed of the motor drop slightly and torque of the motor decreased. Then after 2 seconds, half load was applied to the motor and what can be see are speed of the motor increase slightly and torque of the motor decreased as 13.36Nm of load was apply and again the speed of the motor increase and motor torque decreased when time reach 10 seconds for the <sup>1</sup>/<sub>4</sub> of load apply to the motor and after 15 seconds no load was apply to the motor.



Figure 3.7 Stator and rotor current

On Figure 3.7, what can be observed are before the load was apply to the motor, stator current and rotor current remain constant and when the time reach 3 second which 26.71Nm of load was apply to the motor, the current for stator and rotor increases drastically, after 2 seconds, stator and rotor current decreased as 13.36Nm of load was apply to the motor defined as half load. Again, when <sup>1</sup>/<sub>4</sub> of the load was apply, rotor and stator current decreased as 6.68Nm of load apply to the motor which happen at 10 seconds and during zero load, both current almost back to first condition before load was apply to the motor

#### 3.5 Summary

What can summarize from this chapter are able to describes the strategy and procedure used for project prototype and simulation to reach the project's goal This chapter will go over the project flow in greater detail, including how the hardware works to specify the project's input and output functions as well as the output result. The method for completing the project is clearly defined and developed by the method for implementing it. Finally, on sub chapter result and analysis, a simulation by using Matlab software was created to study speed and motor torque bring effect to stator and rotor current when different load was applied.

# 3.6 Gantt Chart for PSM 1

PROJECT	ACADEMIC WEEK															
ACTIVITY	STATUS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Selection of PSM	PLAN								S							
1 itie	ACTUAL															
Briefing on PSM 1	PLAN								E							
	ACTUAL															
Study Background Project	PLAN								Μ							
	ACTUAL															
Review of the	PLAN								Е							
Problem Statement	ACTUAL															
Explore the	PLAN								S							
Information,	ACTUAL	10														
Journals and		LAKA								1						
Academic papers		-					F									
Literature Review	PLAN							-	Т							
Implementation	ACTUAL	1		_	<		·			. •	1					
Identification of Hardware and	PLAN	0		-1			9	and a	E							
Software of project	ACTUAL	EK	NIP	CAL	M/	ALA	YS	AI	IEL	AK	A					
Preparation Flow Chart for	PLAN								R							
Methodology	ACTUAL															
Implementation of	PLAN								В							
Methodology	ACTUAL															
Review on PSM 1 Report	PLAN								R							
	ACTUAL															
Presentation PSM 1	PLAN								Е							
to panel	ACTUAL															
Improvement and modify the	PLAN								Α							
Report	ACTUAL															
PSM 1 Report	PLAN								K							
submission	ACTUAL															

# 3.7 Gantt Chart for PSM 2

	ACADEMIC WEEK															
PROJECT ACTIVITY	STATUS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Briefing on PSM 2	PLAN								S							
	ACTUAL															
Identify and list out the component used	PLAN								Е							
	ACTUAL															
Study Background Project	PLAN								M							
	ACTUAL															
Review of the Problem Statement	PLAN								Е							
	ACTUAL															
Create Simulation circuit and source	PLAN								S							
code	ACTUAL	EL														
Starting Project Assembly	PLAN	KA				Т			Т							
	ACTUAL			l			ŀ	ļ		1						
Identification of	PLAN							2	E	4						
Software of project	ACTUAL	. 1	<	2.	2	0					1					
Preparation on Result and	PLAN	0		-1			Ċ.	u <sup>A</sup>	R							
Discussion UNIV	ACTUAL	<b>EK</b>	NIF	(AL	M/	ALA	YS	AI	1EL	AK	A					
Implementation of	PLAN								В							
Discussion	ACTUAL															
Review on PSM2 Report	PLAN								R							
	ACTUAL															
Presentation PSM 2 to panel Improvement and modify the	PLAN								Е							
	ACTUAL															
	PLAN								A							
Report	ACTUAL															
PSM 2 Report submission	PLAN								K							
	ACTUAL															

## **CHAPTER 4**

#### **RESULTS AND DISCUSSIONS**

## 4.1 Introduction

This chapter provides the results of the experiments. Three studies are being made which is first to study what happen to the prototype if the temperature rises. Next, is to studies time taken at certain temperature that already set on prototype and finally what can be obtain from the experiment is to studies the percentage error and the differences between set temperature and actual temperature that have been recorded.

#### 4.2 Results and Analysis

## 4.2.1 During Normal Condition

At this condition, 10W lamp was light up indicate there is supply running on the motor and 4 LEDs is turn off. During this condition, buzzer will not make sound and SIM 900A GSM will send message to the user that motor is on including current temperature as well as set temperature. To increase the critical temperature value, press the increase button and after that press the set button. To decrease the value of critical temperature, the decrease button is press and after that press the set button. To start or stop the simulation, can use START/STOP button. LCD display 16x2 are used to display an actual temperature value and set temperature value.



# 4.2.2 During Abnormal Condition

At this condition, 10W lamp will turn off to indicate there is no supply running on the motor as microcontroller detected set temperature has been reached, automatically relay will cut off the supply and 4 LEDs is turn on. During this condition, buzzer also will make sound to alert the user that critical temperature of the motor have been reached and SIM 900A GSM will send message to the user that motor is off including current temperature value as well as set temperature value. To reset back to normal condition, the reset button can be press and the system will reset back to normal condition.



Figure 4.2 Circuit in abnormal condition

#### 4.2.3 Time Taken to Reach Set Temperatures

There are four experiments were conducted to identify the time taken to reach set temperatures. Start with 50°C, 60°C, 70°C and finally 80°C. LM35 sensor was used on this experiment as well as hair dryer to raise up the temperature for the sensor. There two types of setting that used on hair dryer which is on low mode and high mode. During low mode condition, the hair dryer was set in medium position which mean the temperature generate by the hair dryer is in medium hot while on high mode, hair dryer was set in maximum position which the temperature blow from the hair dryer generates higher temperature which make the sensor triggered faster than lower mode. Hair dryers play a role as motor load and motor speed. The higher the speed of the motor for the motor the higher the chances of motor temperature increase. When the load of the motor is increased, the torque of the motor will increase as well as current for stator and rotor will also increase, and this situation will cause temperature rise.



The Temperature Set at 50°C



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Figure 4.6 Temperature at 80°C (Low Mode)

What can be observed from the four graphs above are time taken during low mode conditions. The time taken to reach temperature value 50°C is about 3 minutes and the time taken to reach 60°C is about 4 minutes. Then time taken to temperature of the motor reach 70°C 4 minutes and 15 seconds and finally the time taken to temperature of the motor reach of 80°C 5 minutes and 9 seconds. Time taken to reach top temperature which is 80°C take much longer in low mode is because in real situation, the torque of the motor as well as current use is low.



The Temperature Set at 50°C

Figure 4.7 Temperature at 50°C (High Mode)

# The Temperature Set at 60°C





#### The Temperature Set at 80°C



What can be observed from the four graphs above are time taken during high mode conditions. The time taken to reach temperature value 50°C is about 1 minutes and the time taken to reach 60°C is about 1 minutes and 28 seconds. Then time taken to temperature of the motor reach 70°C 2 minutes and 18 seconds and finally the time taken to temperature of the motor reach of 80°C 3 minutes. Time taken to reach top temperature which is 80°C is faster in high mode rather in low mode is because in real situation, the torque of the motor as well as current use is high. The temperature of the motor could easily rise quickly.

## 4.2.4 Comparison Table Between Low Mode and High Mode

Temperature	Low Mode	High Mode					
	Time	Time					
50°C	3 minutes	1 minutes					
60°C	4 minutes	1 minutes 28 seconds					
70°C	4 minutes and 15 seconds	2 minutes 18 seconds					
80°C	5 minutes and 9 seconds	3 minutes					

Table 4.1 Comparison table between low mode and high mode

## 4.2.5 Percentage Error Between Set Temperature and Actual Temperature

Set temperature is the value that have been set before running the simulation while actual temperature is the value obtain from the LM35 sensor. The data was sent through microcontroller and receive by SIM 900A GSM then send SMS to the user the value of temperature ( $^{\circ}$ C)

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وىبۇم Table 4.2 Set temperature (°C) and actual temperature (°C) UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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Set Temperature (°C)	Actual Temperature (°C)
50°C	51.3°C
60°C	61.9°C
70°C	72.5°C
80°C	81.5°C

Below is a formula to calculate percentage error between set temperature and actual temperature.

Set Temperature (°C)	Actual Temperature (°C)	Percentage error
50°C	51.3°C	$\frac{50 - 51.3}{51.3} \times 100 = 2.53\%$
60°C	61.9°C	$\frac{60 - 61.9}{61.9} \times 100 = 3.07\%$
70°C	72.5°C	$\frac{70 - 72.5}{72.5} \ x \ 100 = 3.45\%$
80°C	81.5°C	$\frac{80 - 81.5}{81.5} \ x \ 100 = 1.84\%$

Table 4.3 Percentage error

From the result above what can be seen is all the percentage error of the temperature is acceptable due to all value is below 10 %.

### 4.3 Summary

From the simulation that have been done, there are a few circumstances that been changed to make this simulation could reach its objective. The first problem occurred is when LCD display 16x2 does not show any display. LCD display 16x2 is an important output as its shown condition of the motor such as during motor in normal or abnormal condition among actual temperature and set temperature obtain from the LM35. Troubleshooting have been done including identify the connection of the LCD display through source code, but LCD display still does not show the display according to its operation in this project. The solution that has been made is by adjusting the source code so the condition of the motor could be display using the GSM 900A. The second problem is the phase sensor does not available in the market. Phase sensor could act as phase detection in the circuit, if one of the phases is not available, relay will cut off the supply and GSM 900A will send message to

the user as phase is not available and buzzer will on and 4 LED will light up. This operation is the same with overheat situation as the title of this project suggest monitoring and protection of three phase motor using GSM modem. Finally, the third problem that been identify is three-phase supply because of the higher power requirements and demands, single-phase power is more typically found in personal houses, but 3-phase power is preferred for larger homes, industrial, office, or corporate use. Currently this project using single phase supply as phase sensor is not available and personal house use single phase supply which is rate 230 volts. This project capable in single phase and three phase system.



## **CHAPTER 5**

## CONCLUSION AND RECOMMENDATIONS

### 5.1 Conclusion

This study is present a method on how to protect motor from the harmful effects of overheating during abnormal situations by implementing this project. When an abnormal condition develops, a buzzer sounds. When failures are occurs, the motor is removed from the three-phase supply through a relay. Additionally, the user is warned of overheating conditions by SMS sent via GSM 900A. Using a setting button on the microcontroller board, the critical temperature of the three-phase load according to our needs and motor rating. The program in the microcontroller can be altered to change the message that is sent to the user when any abnormal problem occurs.

Essentially, the study is informed in this thesis has contributed to a better understanding of the significance of monitoring system of three-phase motor. All these motors are extremely expensive; thus, they must be protected. Bimetallic strips and thermal protection relays were previously utilized to protect the motor from overheating. However, because the temperature in this project is a digital data, we can set the critical temperature of the motor, view the current temperature, and temperature variation at any time.

# 5.2 Future Works

For future improvements, the estimation data could be more easily and accurate using a few methods as follows:

- Using other type of microcontroller such as Raspberry PI or Arduino uno to collect the data as they are much easier and faster to receive the data compare to AT89C51 microcontroller.
- ii. Include study to find a better and accurate value of the temperature of the three-phase motor.
- iii. Compare the result between experimental setup used for validating the thermal model three phase induction motor and simulation setup.



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# APPENDICES

NO	PAREMETERS
1.	Set Temperature – Actual Temperature
	Actual Temperature x 100
2.	$Power (Pout) = Tsh \times \omega$
	$Tsh = \frac{Pout}{\omega}$
3.	$Vmax = \frac{\sqrt{2} \times Vrms}{\sqrt{3}}$
4.	$\omega = \frac{2\pi \times N}{60}$
5.	$\frac{1}{4}load = \frac{TL}{4}$ $Half Load = \frac{TL}{2}$

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